European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION HEL1

VERDE ROOM – SECOND FLOOR
Monday November 2: 15:15-16:30
Tuesday November 3: 10:00-11:15, 16:30-17:30

POSTER CODE: P1HEL102

Title
Preparing for Earth-Independent Operations with the Mars Space Weather Dashboard

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Body
Space Weather has traditionally explored the Sun's immediate influence on the Earth system and its technology, including direct impact to humans. With the future of increased human and robotic missions to Mars, it is important to fill critical gaps and establish robust capabilities for predicting, monitoring, and mitigating space weather effects beyond Earth. The Mars Space Weather Dashboard was created with the goal of developing near real-time products for space weather activity directed towards Mars and is hosted on the NASA Community Coordinated Modeling Center's (CCMC) Integrated Space Weather Analysis (ISWA) system. This dashboard includes near real-time particle, field, and solar flare data from NASA's MAVEN mission, Curiosity/RAD (Radiation Assessment Detector), and ESA's Mars Express. Furthermore, data from Curiosity/Mastcam, Perseverance/Mastcam-Z, and Mars Odyssey/High-Energy Neutron Detector (HEND) will soon be available to provide near real-time measurements of surface radiation, sunspots images, and neutrons at Mars. Additional datasets and models will be continuously added to expand this dashboard as a tool for space weather analysts to assess activity and response at Mars. The ISWA dashboard provides a proof-of-concept that is being prototyped by NASA's Moon to Mars Space Weather Analysis Office (M2M SWAO) for analyzing predictions of space weather events directed towards Mars. CCMC is enabling access to Mars near real-time data and working with model developers to implement new Mars space weather forecasting capabilities. Additionally, NASA's Space Radiation Analysis Group (SRAG) plays a key role by establishing safety limits on radiation exposure received by astronauts, which provides guidance to the tools being developed. We aim to identify, understand, and fill gaps in space weather research and monitoring at Mars.

Keywords: Mars,Space weather,Earth-independent operations

POSTER CODE: P1HEL103

Title
Classifying the Cislunar Plasma Environment: A Semi-Supervised Approach using 13 Years of ARTEMIS Data

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Body
As the number of missions operating in cislunar space is increasing, identifying which plasma environment a spacecraft is experiencing at a given time is important both operationally and scientifically. A spacecraft in lunar orbit experiences several distinct environments, including the solar wind, magnetosheath, plasma sheet, and magnetic lobes, but automated classification of these regions at lunar distances remains limited. We use 13 years of THEMIS-B (ARTEMIS-P1) ion and magnetic field measurements (1.46 million observations, August 2011–January 2025) to develop a semi-supervised classifier for these four regions.
The model, a Contrastive Multi-Modal Autoencoder (C-MMAE), encodes ion energy spectra and scalar plasma parameters through separate networks and combines them in a shared latent space, trained with a combined reconstruction and supervised contrastive loss. Using only 2.27% hand-labeled data (33,180 samples), the model achieves 99% test accuracy (macro F1 = 0.984) after filtering lunar wake contamination. A self-organizing map trained on the learned embeddings provides a physically consistent representation of the latent space, with smooth transitions between regions. The resulting classified dataset enables systematic statistical analysis of the plasma sheet and lobe at cislunar distances, which has previously been limited by the lack of automated region labels.

Keywords: Cislunar space,Magnetotail,Plasma region classification,Machine learning,ARTHEMIS

POSTER CODE: P1HEL104

Title
The Longitudinal Extent of Solar Particle Events Observed at Mars with MSL RAD

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Body
The Radiation Assessment Detector (RAD) on the Mars Rover Curiosity has been effectively serving as a space weather monitor on the surface of Mars since Curiosity landed on the red planet in 2012. RAD has measured the impact of more than a dozen solar storms, with the frequency of events increasing as the Sun approaches solar maximum. Two relatively large events (Sept. 10, 2017 and Oct. 28, 2021) were observed as Ground Level Events (GLEs) at both Earth and Mars, separated by 180 degrees in longitude. Most recently, RAD observed its largest event to date as part of the May 2024 solar storms that impacted both Earth and Mars. We will discuss these events and their implications for space weather predictions, as well as the need for heliosphere-wide space weather monitoring to support future human exploration to Mars and beyond.

Understanding and predicting the longitudinal extent of CME and SPE propagation is important for Space Weather Prediction and All-Clear Forecasts. Even events occurring on the far side of the Sun can have significant impact on EVAs and other Operational Space Activities. The Heliophysics and Space Weather community is just beginning to take full advantage of the heliospheric network of spacecraft assembled (HSO, etc.). MSL/RAD and Mars assets (Maven, Escapade, etc.) are a key part of this...!

Multi-spacecraft observations help us characterize these extreme events (and extreme conditions), even when they aren’t directed at Earth...Ultimately, to support human exploration to Mars and beyond, we will need to provide heliosphere-wide space weather monitoring, prediction & early warning for these missions!

Keywords: RAD,MSL

POSTER CODE: P1HEL105

Title
Space Weather at Mars and Venus: Mars Express and Venus Express Datasets

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Body
ESA's Mars Express (MEX) spacecraft has operated in Mars orbit since 2004. On-board MEX, the ASPERA-3 (Analyser of Space Plasma and EneRgetic Atoms) instrument is providing a unique dataset of the space plasma near Mars for more than 22 years.
ESA's Venus Express (VEX) spacecraft operated in Venus orbit 2006-2014. On-board VEX, the ASPERA-4 instrument provided a unique dataset of the space plasma near Venus.
The ASPERA-3 and -4 instruments comprises five sensors: An ion mass spectrometer, an electron spectrometer, and three energetic neutral atom (ENA) sensors.
Here we present an overview of the data sets that are available from ASPERA-3 and -4. These European data sets enables studies of space weather at Mars and Venus.

Keywords: Mars,Venus

POSTER CODE: P1HEL106

Title
The hunt for the Mars aurorae and high altitude clouds

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Body
In 2005, the space mission Mars Express discovered aurorae in the Mars ionosphere (Bertaux et al., 2005). However, these were measured in the UV range and therefore, not all scientists agreed to call them “aurorae” since aurorae are usually meant to be visible with the naked eyes. Ten years later, it was foreseen through laboratory experiments and further modeling that these emissions have their counterparts in the visible range: blue and green at 140 km height, red at 160 (Lilensten et al., 2015). These aurorae should be intense enough to be seen by the naked eyes. In 2025, the first detection of the green line was published thanks to the Mars Perseverance Rover experiment (Knutsen et al., 2025).

Still, our group came with the idea to benefit from the regular Mars opposition to monitor the Mars aurorae from the Earth, with the help of astrophotographers. In 2020, we had a positive detection. However, a thorough analysis proved that it was not aurorae, but high altitude clouds (92 km height). A radiative transfer model showed that they are probably due to CO2 crystal ice, but water crystal cannot be fully ruled out at time (Lilensten et al., 2022). The next opportunity will be early 2027. The number of astrophotographers throughout the world increased to reach more than 60. The optical observations will also be carried out with high-resolution spectrometers, providing complementary spectral diagnostics operated by a network of about ten observers. Finally, we will try to get support from major professionnal facilities. The goal is to cover all latitudes, all continents, so as to insure a positive observation with twofold: to characterize these amazing clouds and to see, for the first time from the Earth, the Mars aurorae,

In this talk, we will present these series of discoveries and call for your participation, explaining what observations are necessary.

Keywords: Mars,Aurorae,Citizen Science,Spectroscopy,Optical Observation

POSTER CODE: P1HEL107

Title
Characterizing the Martian Radiation Environment: A Solar Cycle of Observations from Curiosity's RAD Instrument

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Body
The Radiation Assessment Detector (RAD) aboard NASA's Curiosity rover has continuously monitored energetic particles on the Martian surface since its landing on August 6, 2012, providing an unprecedented record of radiation exposure spanning an entire solar cycle.
Understanding the Martian radiation environment is critical for assessing astronaut health risks and guiding the design of future crewed missions. Mars' radiation field arises from complex interactions between primary galactic cosmic rays (GCRs), solar energetic particles (SEPs), with the planet's atmosphere and surface. These interactions generate secondary particles, creating a dynamic and variable radiation environment influenced by factors such as atmospheric pressure, seasonal cycles, heliospheric modulation, surface topography, and subsurface composition.

In this study, we analyze the extensive dataset collected by RAD over the past 12 years to investigate temporal variations in particle fluxes on Mars. Our analysis encompasses multiple particle species and captures long-term trends over an entire solar cycle, enabling a detailed examination of particle interactions within the Martian environment. By exploring species-specific flux variations and their temporal evolution, this work advances our understanding of Mars' complex radiation dynamics and their implications for future human exploration. The findings offer critical insights into radiation shielding, subsurface processes, and broader considerations of Martian habitability, helping to assess the feasibility of sustained human presence on Mars.

Keywords: MSL RAD Curiosity,Martian Radiation Environment

POSTER CODE: P1HEL108

Title
Real-time Analysis and Prediction for Space Weather at the Moon and Mars by NASA GSFC's Moon to Mars Space Weather Analysis Office (M2M SWAO

Authors
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Body
The Moon to Mars Space Weather Analysis Office (M2M SWAO), located within the Heliophysics Science Division (HSD) at NASA Goddard Space Flight Center (GSFC), conducts real-time, human-in-the-loop space weather analysis to safeguard missions across the heliosphere. As NASA expands its footprint at the Moon and Mars, M2M SWAO supports the prototyping and transition of research to operations (R2O) to characterize how solar transients evolve beyond 1 AU and impact diverse planetary environments from orbit down to the surface. Through strategic collaborations with the Community Coordinated Modeling Center (CCMC), the Space Radiation Analysis Group (SRAG), and the Mars Space Weather Collaboration, M2M SWAO leverages advanced modeling techniques and near real-time data streams to evaluate cross-scale space weather throughout the solar system. This presentation provides an overview of our current operational capabilities for predicting and assessing space weather at the Moon, Mars, and beyond. We highlight recent analyses to demonstrate how data streams and prediction capabilities can be used to support upcoming missions. We also outline ongoing collaborative efforts to identify and address critical data, infrastructure, and forecasting gaps. Ongoing efforts to prototype new predictive capabilities are essential steps in improving our cross-scale understanding of the heliosphere, ultimately ensuring the safety and success of a sustained human and robotic presence at the Moon and Mars.

Keywords: Solar,Heliospheric,Space Weather,Operational Analysis,Solar System

POSTER CODE: P1HEL110

Title
A Virtual Space Weather Monitor for Mars Enhanced with OMNI-like, Multi-Mission Support

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Body
Mars lacks a dedicated upstream solar wind monitor to provide context for the geometry and evolution of its space environment, critically limiting studies into the planet's space weather. Instead, solar wind propagation models or in-situ data from orbiting spacecraft are typically used to characterize Mars's solar wind-magnetosphere interaction. There are drawbacks to both of these approaches: solar wind propagation models tend to have large, difficult-to-quantify uncertainties; in-situ data, while precise, offer only semiregular glimpses of the pristine solar wind along the spacecraft's orbit, rather than continuous results at a consistent location. As Martian space weather becomes increasingly important for both scientific and operational concerns, the need for continuous, accurate upstream solar wind monitoring will continue to grow.
Here we will outline ongoing development of an OMNI-like virtual space weather monitor for Mars which synthesizes multi-mission data into a single, quasi-continuous estimate of the solar wind mapped to the nose of Mars's bow shock. This resource is an extension of the vSWIM effort [Azari et al. 2024] to multi-mission spacecraft measurements, incorporating data from the ESA Mars Express, NASA MAVEN, and CNSA Tianwen-1 missions. Where OMNI collates multi-mission data according to a predefined hierarchy, this resource instead combines cross-calibrated in-situ data to provide an informed solar wind estimate with quantified uncertainties using Gaussian process regression (GPR). GPR is a class of non-parametric machine learning methods with particularly robust uncertainty quantification, making them well-suited to modeling the solar wind. We will demonstrate the performance of this virtual solar wind monitor and conclude with an outlook toward its applications to still-open scientific questions at Mars, as well as inclusion of data from NASA’s ESCAPADE mission, which is scheduled for orbital insertion in 2027.

Keywords: Mars,Space Weather,Solar Wind,Machine Learning

POSTER CODE: P1HEL112

Title
Radiation Analysis of Lunar and Martian Environments Using GRAPPA with GRAS/Geant4

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Body
The interactions of galactic cosmic and solar energetic particle radiation with planetary atmospheres and surface regolith/bedrock may lead to significant modification to the local surface environment due to the attenuation of the primary radiation and secondary particle production in the materials. This paper describes the GRAS Pre-processor for Planetary bodies and Asteroids (GRAPPA) developed under the ESA HIERRAS Project to generate GDML geometries, magnetic field data and other associated inputs needed to perform 3D Geant4-based GRAS simulations of Martian and lunar radiation environments. The geometries generated by GRAPPA are position-, seasonal- and local time-dependent based on:

1. Either the European Mars Climate Database or NASA GRAM Suite to define the Martian atmospheric composition and density as well as the surface precipitates.
2. GRAPPA can use position-dependent surface composition data calculated using gamma-ray spectrometer observations from either the Lunar Prospector or Mars Odyssey missions (Prettyman et al [2006], Goncalves et al [2008]).
3. Martian local magnetic field models of Cain et al (2003) or Purucker et al (2000), or the crustal field model of Tsunakawa et al (2015, 2023) for lunar environments.
4. Alternatively, the user may provide their own definitions for the surface, atmosphere, and magnetic field properties.

Geometries from “local” scales (~10 metres) to planetary scales may be generated by GRAPPA. Together with the latest version of ESA’s GRAS application, it is relatively straightforward to combine local scale surface geometries from GRAPPA with representations of habitat geometries, mission equipment, and anthropomorphic phantoms. This therefore permits very detailed analyses of 3D radiation transport and effects on astronauts for different operational and shielding conditions. The design of GRAPPA also allows easy extension of the software to treat other planets and moons, such as Earth, Jupiter, Ganymede, and Saturn.

Keywords: Geant4,Ionising radiation,Radiation shielding,GRAS

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SESSION HEL2

VERDE ROOM – SECOND FLOOR
Monday November 2: 15:15-16:30
Tuesday November 3: 10:00-11:15, 16:30-17:30

POSTER CODE: P1HEL201

Title
Updated SOLPENCO2 simulations for the SAPPHIRE-2S SEP environment model.

Authors
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Body
Solar Energetic Particles (SEP) events, especially those showing particle intensity enhancements up to hundreds of MeVs represent a threat to interplanetary missions and need to be considered by spacecraft designers. Given that the majority of SEP data is collected near the Earth environment, physics-based models describing how the magnitude of SEP events varies with the heliocentric radial distance are needed to develop solar energetic particle environment models for missions travelling across the solar system.

In previous projects, we developed the SOLPENCO2 model that provides predictions of the dependence of the peak intensity and fluence of gradual proton events on the heliocentric radial distance between 0.2 au and 1.6 au, and for protons in the energy range from 5 to 300 MeV. In the frame of the ESA's FIRESPELL project we have revisited and updated the simulation of a set of 10 reference events, now including up to 26 energy channels ranging from 0.05 MeV to 700 MeV. These simulations aim to provide peak intensity and the fluence radial dependences for the heliocentric radial component of the SAPPHIRE-2S particle environment model.

We present here the comparison of model results with observations for the 10 selected events. The simulated intensity-time profiles are obtained by using the 1-D Shock-and-Particle (SaP) particle transport model and the same shock particle emission model used in SOLPENCO2. The SaP model allows for the prediction of peak intensities and fluences up to 1.6 au. For larger heliocentric distances, and for a subset of events, we use radial dependences derived from the 3D particle transport model PARADISE. Finally, we comment on how we apply these results to the 452 SEP enhancements included in the event list (from 1974 to 2017) used by SAPPHIRE-2S.

FIRESPELL is a project funded by ESA (Contract No. 4000142510/23/NL/CRS).

Keywords: Solar energetic particles,Particle transport,Environment SEP models

POSTER CODE: P1HEL202

Title
Ground Level Enhancement 77 Observed in Unprecedented Spatial Resolution Using UK Soil Moisture Network

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Body
Ground level enhancements (GLEs) are space weather events where high energy (>500 MeV) solar protons traverse the geomagnetic field and interact with the atmosphere, driving an increase in atmospheric ionising radiation above the background generated by galactic cosmic rays. The enhanced ionising radiation field present in the atmosphere during a GLE is a hazard to aircraft avionics, as well as passengers and crew. On November 11th 2025, GLE 77 was observed across the UK in the COSMOS-UK network, which employs the cosmic ray neutron sensing technique to establish soil moisture from neutron detector data. This contribution will present the data from the network during this event, showing the spatial extent of the event at a previously unseen spatial resolution.

Keywords: Ground Level Enhancements,Atmospheric Radiation,Solar Energetic Particles

POSTER CODE: P1HEL203

Title
COMMISSIONING AND FIRST RESULTS FROM THE HAWAII NEUTRON MONITOR STATIONS

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Body
The Hawaii neutron monitor (NM) stations at the summit of Mt. Haleakal¯a became fully operational in late 2025, with continuous data acquisition beginning in January 2026. Located in the central Pacific at a vertical cutoff rigidity of 12.9 GV, the high-altitude NM64 instruments (HLEA and THIMON) measure high-rigidity Galactic Cosmic Rays (GCRs) and provide sensitivity to Solar Neutron Particles (SNPs). The data stream is integrated into real-time pipelines supporting the University of Hawai‘i Space Weather and Mission Control Center, which serves, together with the U.S. center at the University of Delaware, as one of the two primary U.S. hubs for processing and dissemination of Simpson Neutron Monitor data in coordination with the international NMDB network. We present the first calibrated and pressure-corrected count rates and comparisons with the global NM network. Initial observations include several Forbush decreases associated with interplanetary coronal mass ejections, with amplitudes consistent with expectations at this rigidity. We also report on a preliminary search for SNPs using hightime-resolution data. These results demonstrate the stability and scientific value of the Hawaii stations as a strategic new node in the global neutron monitor network.

Keywords: cosmic rays,neutron monitor,space weather,space radiation

POSTER CODE: P1HEL204

Title
Forbush Decreases Observed with Mirya-m1

Authors
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Body
Mirya-m1, developed at Istanbul University, is Turkey’s largest cosmic ray detector dedicated to space weather research. Operating at the Turkish National Observatories Eastern Anatolia Observatory (DAG) site since the beginning of 2024, the detector has measured cosmic-ray-induced muon flux variations during numerous solar events throughout the maximum of Solar Cycle 25 in 2024, 2025, and 2026. The primary objective of this study is to present the operational processes and initial observational data of Mirya-m1, specifically focusing on the creation of a catalog of Forbush decreases. Utilizing eight photomultiplier tubes, the detector records muon count rates which are subsequently corrected for atmospheric conditions to isolate systematic variations. These recorded events are correlated with preceding solar activity and compared with data from various international detectors and neutron monitors in the literature. Furthermore, this work highlights the strategic advantages and scientific synergy between muon and neutron data following the commissioning of the Mirya-n1 neutron monitor, emphasizing its impact on the accuracy of space weather forecasting and scientific analysis.

Keywords: Forbush decrease,Cosmic rays,Space weather,Neutron monitor,Solar activity

POSTER CODE: P1HEL205

Title
Helium-3 Enrichment in Gradual Solar Energetic Particle Events: Evidence for Jet-Supplied Seed Population

Authors
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Body
The contribution of flare-accelerated particles to gradual solar energetic particle (GSEP) events remains a long-standing question. Because 3He enrichment is a distinctive signature of impulsive SEP material, its presence in gradual events provides a sensitive tracer of a flare-related contribution. In addition, flare-produced suprathermal ions are pre-accelerated relative to the ambient coronal and solar-wind populations, facilitating their injection into the CME-driven shock acceleration process. We investigate the origin of 3He enrichment in high-energy (25-50 MeV) solar proton events observed by SOHO that coincide with <1 MeV/nucleon 3He-rich periods detected by ACE during 1997-2021. In some cases, the 3He-rich periods result from superposition with independent impulsive 3He-rich SEP events, and two high-energy proton events themselves exhibit impulsive-event characteristics. After removing these cases, 15 GSEP events remain in which the 3He enhancement is consistent with re-acceleration of suprathermal flare material. Extreme-ultraviolet imaging from SDO and STEREO reveals jet-like eruptions in the parent active regions of about 60% of these events. The four largest 3He/4He ratios all occur in jet-associated events, which generally show fewer pre-event 3He counts. We find a positive correlation between 3He/4He and Fe/O, strongest for jet-associated sources. These results support a scenario in which coronal jets provide fresh 3He- and Fe-rich suprathermal seed particles that are subsequently re-accelerated by CME-driven shocks, while residual suprathermal populations may contribute in other events.

Keywords: Solar energetic particles,3He enrichment,Suprathermal seed populations,CME-driven shocks,Coronal jets

POSTER CODE: P1HEL206

Title
Algorithm for real-time Forbush-decrease detections onboard spacecraft

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Body
Solar activity affects the galactic cosmic rays (GCRs) traversing the heliosphere. Forbush decreases are sudden decreases in GCRs that last several hours and tend to be associated with coronal mass ejections (CMEs), which are major drivers of space weather. Forbush decreases can be identified in measurements taken by ground-based neutron monitors and in space-based particle measurements. The soon-to-be-launched Heliospheric Pioneer for Solar and Interplanetary Threats Defence (HENON) mission will operate from a Distant Retrograde Orbit (DRO) and significantly enhance our space-weather forecasting abilities. HENON will achieve this by providing early warnings, some of which rely on the onboard identification of space-weather related phenomena, like Forbush decreases. We present an algorithm for real-time, onboard identifications of Forbush decreases which will be employed by HENON, triggering its spinning mode and resulting in higher-cadence measurements of passing CME structures. The algorithm relies on in-situ energetic proton measurements that will be taken by HENON's Relativistic Electron and Proton Experiment (REPE) instrument, and its effectiveness has been evaluated using particle measurements from other spacecraft.

Keywords: Cosmic rays,Forbush decreases,Onboard detection algorithm,HENON mission

POSTER CODE: P1HEL207

Title
Forbush Decreases Across Cosmic-Ray Energies: Insights from AMS-02 and Numerical Modeling

Authors
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Body
Since its launch, the Alpha Magnetic Spectrometer-02 (AMS-02) has become a key instrument for high-precision measurements of cosmic-ray (CR) spectra, facilitating significant scientific advancements. However, measurements at lower energies are greatly influenced by temporal variations in solar activity, which affect CR intensities. The daily flux measurements provided by AMS-02 allow us to systematically investigate Forbush decreases across a broad energy range. In this study, we compare the Forbush decreases observed by AMS-02 with predictions from numerical models, examining particle propagation in the interplanetary medium alongside the evolution of magnetic disturbances generated by Coronal Mass Ejections (CMEs) and Corotating Interaction Regions (CIRs). By conducting a population study of 142 events detected by AMS-02 up to 2019, we analyze both the common features and the differences among these events to enhance the reliability of numerical models used for interpreting AMS-02 observations in the context of solar activity. In this presentation, we report on the latest status of our analysis and share both preliminary and consolidated results.

Keywords: Forbush,Cosmic Rays,CME,HPC

POSTER CODE: P1HEL209

Title
Sun-to-Earth multi-spacecraft analysis of the January 2026 coronal mass ejection and its peculiar impact on the galactic cosmic rays

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Body
A fast Earth-directed coronal mass ejection (CME) was launched on 18 January 2026 in association with a long-duration X1.9 solar flare. The eruption drove a strong shock, as evidenced by its white-light morphology and an accompanying type II radio burst, and was further associated with a major solar energetic particle (SEP) event. EUV observations reveal a multi-stage, large-scale eruption involving extensive coronal dimming, a filament eruption, and large-scale loop reconfiguration spanning multiple active regions, suggesting the eruption of a complex magnetic system. The CME impacted Solar Orbiter and subsequently arrived at L1 on 19 January, producing exceptionally strong magnetic fields together with high solar wind speeds. These conditions triggered a severe geomagnetic storm, with Kp reaching 9, and were accompanied by a rare and exceptionally large depression in galactic cosmic ray flux. We present a comprehensive Sun-to-Earth multi-spacecraft study of this event, with particular emphasis on its unusual impact on galactic cosmic rays as observed by Solar Orbiter and ground-based neutron monitors. This research is funded by European Union (project SPEARHEAD, No 101135044). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

Keywords: coronal mass ejections,forbush decreases,galactic cosmic rays,solar orbiter

POSTER CODE: P1HEL210

Title
Global Multi-Species Modelling of the Widespread SEP Event on May 20, 2024

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Body
We present a global numerical modelling study of the early evolution and global propagation of several species of solar energetic particles (SEPs) during the intense, widespread, impulsive event of 20 May 2024, focusing on the region between 30 solar radii and 1 au. The simulations employ an expanded and modified version of the Energetic Particle Radiation Environment Model (EPREM), coupled to an observation-driven heliospheric plasma and magnetic-field configuration derived from a Magnetohydrodynamics Around a Sphere (MAS) model magnetohydrodynamic solution. This framework enables a self-consistent treatment of SEP transport in a structured inner heliosphere. The event was exceptionally well observed by Parker Solar Probe and Solar Orbiter, which were separated by nearly 90 degrees in heliolongitude. It was also observed near Earth with some delay, further separated from PSP by 80 degrees. The observations thus provide stringent constraints on the longitudinal extent, timing, and spectral evolution of the multi-ion (H, He, O, Fe) fluxes. We study the early-time SEP intensities throughout the domain and compare them to the fluxes observed at widely separated heliocentric locations. We explore how transport processes modified the SEP time profiles and energy spectra during the first several days of the event. By tracking multiple ion species, the study lays the groundwork for assessing how rigidity-dependent transport effects may produce apparent temporal variations in elemental ratios, even in the absence of intrinsic changes in source composition.

Keywords: solar energetic particles,transport effects,numerical modelling,multispecies

POSTER CODE: P1HEL211

Title
Operational response of the GLE Alert++ system during the GLE77 event

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Body
On 11 November 2025, the first major Ground Level Enhancement (GLE) event of Solar Cycle 25, classified as GLE77, was observed under highly disturbed heliospheric and geomagnetic conditions. Associated with an X5.1-class solar flare and an intense G4 geomagnetic storm, GLE77 ranks among the strongest GLEs recorded to date. The event was detected by ground-based detectors of the worldwide neutron monitor network, as well as by gamma-ray and muon detectors. The lower-energy component of the event, corresponding to the associated Solar Energetic Particle event, was simultaneously recorded by multiple space-borne detectors.
This study evaluates the timely and successful operational performance of the GLE Alert++ system, developed by the Athens Cosmic Ray Group at the National and Kapodistrian University of Athens and operating within the ESA Space Weather Service Network. Unlike typical alert conditions where only a few stations enter alert mode, GLE77 triggered a total of 16 different stations. Due to the complex temporal evolution of the event, three successive warning notifications were automatically disseminated to registered users of GLE Alert emails over the course of 2 hours.This presentation will detail the timelines of these alerts as well as the system's response to this complex event, and highlight the critical role of automated, multi-station alert networks in mitigating radiation risks for aviation and space assets.

Keywords: Ground Level Enhancement(GLE),Neutron Monitor Network,Solar Energetic Particles(SPEs,Alert

POSTER CODE: P1HEL213

Title
Monitoring Solar Activity from the Heights of Anatolia: First results from Mirya-m1 muon detector and expansion with a neutron monitor.

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Body
As Solar Cycle 25 approaches its maximum, high-altitude ground-based monitoring of cosmic rays has become increasingly vital for understanding heliospheric disturbances and improving space weather forecasting. We introduce the Mirya-m1 Cosmic Ray Detector, the largest and only facility of its kind in Türkiye. Located at the Turkish National Observatories Eastern Anatolia Observatory (DAG) at an altitude of 3,099 meters, Mirya-m1 is one of the highest-altitude cosmic ray detectors globally. The detector utilizes two stacked 1 m² scintillators and eight photomultiplier tubes (PMTs) to measure muon flux and investigate cosmic ray anisotropy.
Operational since the beginning of 2024, Mirya-m1 has demonstrated its sensitivity to solar-induced variations, successfully capturing nearly all major Forbush decreases (FDs) recorded during this period, including the significant events of March and May 2024 associated with G4 and G5 geomagnetic storms. We provide a comparative analysis of these detections with global networks, such as the Oulu neutron monitor, highlighting the detector's capabilities.
Furthermore, we announce the upcoming expansion of our space weather station with the installation of a dedicated neutron monitor. This new instrument will consist of three LND2061 BF3 proportional counters, significantly enhancing our ability to monitor the nucleonic component of cosmic rays alongside the existing muon data. This multi-component approach will provide a more comprehensive view of solar modulation and atmospheric effects, strengthening Türkiye's contribution to the broader space weather community.

Keywords: cosmic rays,Forbush decrease

POSTER CODE: P1HEL214

Title
Latitude Survey of Neutrons and Muons during Solar Maximum

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Body
Cosmic Ray Neutron Sensing (CRNS) is a ground based technique that utilises epithermal neutron measurements as a proxy for environmental hydrogen content. Similarly, to other ground based cosmic ray detectors (e.g. neutron monitors), CRNS detectors observe the solar cycle and space weather events. Typically, these effects must be corrected, but CRNS detectors have also been specifically used to observe space weather. The specific sensitivity of CRNS detectors to the primary spectrum and the relationship to other cosmic ray measurements is not fully understood. During the maximum of solar cycle 25 a latitude survey utilising a mini neutron monitor, two CRNS detectors of different design and a muon telescope was undertaken onboard the German Research Vessel Polarstern. The observations are used to derive differential response functions and yield functions for two neutron detectors. While the differential response, between neutron detectors is similar, it strongly deviates between muon and neutron detectors.

Keywords: latitude survey,yield function,epithermal neutron detector,mini neuton monitor,muon detector

POSTER CODE: P1HEL215

Title
Energy-Dependent Development of Cosmic-Ray Showers Across the Atmosphere (1–100 GeV) Using DYASTIMA

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Body
This study investigates cosmic ray cascade simulations as generated from DYnamic Atmospheric Shower Tracking Interactive Model Application (DYASTIMA), developed from NKUA Cosmic Ray Group and available as a federated product on the ESA SWE Portal under the Space Radiation Expert Service Centre. Monochromatic proton simulations spanning 1 GeV to 100 GeV were performed across the full atmospheric column (0–86 km), using the FTFP_BERT_HP physics list within the Geant4 framework and an ICRU tissue-equivalent sphere as the sensitive detector.
The Regener–Pfotzer maximum (the altitude of peak secondary particle production) is clearly reproduced across all energies. The multi-energy comparison reveals that higher-energy primaries produce larger secondary cascades and drive the Pfotzer peak to lower altitudes, shifting from ~18 km at 1 GeV down to ~10 km at 100 GeV. While the secondary particle yields follow a power-law scaling N =k E^a with exponent a = 0.727 (R^2 = 0.9989), quantifying shower growth across two orders of magnitude of primary energy.
Shower composition is also examined through per-component ionizing energy deposition profiles. The electromagnetic and hadronic component dominates near the shower maximum, while the mesonic component sustains deposition at lower altitudes.
Dosimetric quantities are calculated for 1 GeV, 10 GeV, and 100 GeV and show a clear energy dependence, with higher primary energies producing greater radiation exposure. Radiation weighting factors vary mainly for neutrons, which exhibit a strongly variable wR (~5–9), while remaining consistent with reference values for other particles.

Keywords: Cosmic ray cascades,Regener Pfotzer maximum,Radiation dosimetrY,DYASTIMA / Geant4 simulations,Secondary particle production

POSTER CODE: P1HEL216

Title
Probing Solar Activity and Cosmic Ray Modulation with the Muon Antarctic Telescope at Concordia Station

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Body
Secondary atmospheric muons offer a unique window into cosmic-ray cascades and their interactions with the heliosphere, serving as a powerful tool for space-weather monitoring. To exploit this proxy, the Muon Antarctic Telescope (MAT) has been developed and successfully deployed at the polar outpost of Concordia Station, Antarctica. Thanks to the minimal geomagnetic cutoff rigidity at polar latitudes, MAT is uniquely positioned to detect subtle variations in both Galactic Cosmic Rays (GCRs) and Solar Energetic Particles (SEPs). This presentation focuses on the performance and sensitivity of the first operational MAT unit. We evaluate the telescope's response to solar-induced variations, highlighting its capabilities for tracking transient space-weather events such as Forbush decreases. Crucially, we discuss how ground-based muon detection at polar latitudes acts as a vital, high-energy complementary data stream to traditional neutron monitor networks, enhancing our understanding of particle modulation profiles. Furthermore, we explore the potential of expanding this infrastructure into a coordinated polar network to deliver real-time, directional data for global space-weather forecasting.

Keywords: cosmic rays,heliosphere,space weather,forbush decrease,ground-based observations

POSTER CODE: P1HEL217

Title
Cosmic ray observations with Error Detection and Correction data on Jupiter Icy Moon Explorer

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Body
Spacecraft can provide valuable information on Galactic Cosmic Ray (GCR) variability not only through dedicated radiation instruments but also by exploiting indirect onboard proxies. One of such proxies is the error detection and correction (EDAC) data recorded in error counters. When an energetic particle interacts with electronic components, such as memory devices, it can induce Single Event Upsets (SEUs), typically manifesting as bit flips in stored data. These events are usually non destructive and can be detected and corrected onboard using EDAC algorithms. Each detected and corrected event increments an internal EDAC counter.
Over long time periods, EDAC counters show a steady increase driven by the persistent GCR background, while SEP events and SEFIs cause abrupt rises due to enhanced particle fluxes and memory errors. Previous EDAC studies based on Mars Express, Venus Express, Rosetta and other missions have demonstrated that EDAC can be considered as a proxy to long term GCR activity in different parts of the Solar System, showing that the GCR time lag varies significantly with solar activity and heliospheric distance [e.g., Rimbot et al 2024 ; Knutsen et al 2021]
ESAs Jupiter Icy Moon Explorer (JUICE) mission is currently in its third year of cruise and can contribute to the line of analysis done on EDAC counters providing an additional observation point in the solar system. The presentation focuses on selected EDAC counters that show a strong anti correlation with solar activity, evaluates the strengths and limitations of using EDAC data as a GCR proxy, and discusses lessons learned that are applicable to radiation monitoring strategies for the JUICE mission. These observations may enable the derivation of the GCR gradient with heliocentric distance. These parameters could provide important observation points in the outer solar system once JUICE reaches it during its cruise phase.

Keywords: Error detection and correction,Jupiter Icy Moon Explorer,Galactic cosmic ray proxi,Radiation environment,Spacecraft electronics

POSTER CODE: P1HEL218

Title
Characteristics of Ground Level Enhancement 74 event on 11 May 2024

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Body
A complicated as temporal evolution and analysis of ground-level enhancement (GLE), ws observed on 11 May 2024. The event occurred during the deep phase of a strong Forbush decrease (FD) and one of the strongest observed geomagnetic storms. Solar eruptions, including a major X5.8 flare on 11 May 2024 and a halo coronal mass ejection (CME), accelerated solar ions to relativistic energies. The solar ions were observed by space-borne and ground-based neutron monitors (NMs). The event produced a moderate count-rate increase over the variable background; it was most pronounced in the records of high-altitude polar NM stations South Pole and Dome C. The majority of the NMs showed marginal increases in count rate. The exceptional geomagnetic storm and the FD made the analysis of this event particularly challenging. Herein, we de-trended the NM records for the recovery phase of the FD. In addition, we explicitly accounted for the reduction of the rigidity cutoff, caused by the geomagnetic storm. Then, using the de-trended NM records and employing a state-of-the-art analysis method, we derived the rigidity spectra and angular distributions, that is, the pitch angle distribution, of the incoming GLE-producing solar protons in their dynamical evolution throughout the event. A comparison with GOES satellite measurements was also performed.

Keywords: ground level enhancement,solar eruptions,neutropn monitor

POSTER CODE: P1HEL219

Title
Cosmic radiation hazards from near Earth orbits to deep space

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Body
Galactic cosmic rays propagating through the heliosphere are affected by the turbulent solar magnetic field in a process known as solar modulation. This phenomenon produces time-dependent variations in the cosmic-ray flux, from a few MV to several tens of GV, primarily driven by the quasi-periodic 11-year solar cycle and other solar phenomena. To describe and predict the cosmic-ray flux near Earth, we developed a numerical framework for solving the transport equation, incorporating the main physical processes experienced by charged particles in the heliosphere, including diffusion, convection, adiabatic energy losses, and drift effects. The model is coupled to solar-activity observables through a set of data-driven filtering and correlation procedures. Using this approach, we are able to reproduce long-term solar-modulated galactic cosmic-ray fluxes near Earth with uncertainties below 10% for nuclei up to nickel, across rigidities ranging from a few MV to several tens of GV, above which solar modulation becomes negligible.

Extended space missions expose astronauts and onboard instrumentation to significant radiation environments that must be accurately characterised. In low-Earth orbit, such as aboard the International Space Station (ISS), cosmic-ray fluxes are shaped both by solar modulation and by the interaction between the ISS trajectory and Earth's geomagnetic field. In this work, we combine our latest solar modulation model with an effective description of the geomagnetic rigidity cutoff under different orbital and heliospheric conditions to predict the near-Earth cosmic-radiation environment for nuclei from hydrogen to nickel (Z=1-28). We further estimate the radiation dose due to cosmic rays for astronauts aboard the ISS, on the lunar surface, and in deep-space environments, while also accounting for selected instrumental effects. Model predictions are compared with available experimental dosimetric measurements.

Keywords: Solar Modulation of GCR,Geomagnetic Field,Radiation Dose in Space,Rigidity Cutoff,Instrumentation Dose

POSTER CODE: P1HEL220

Title
SPEARHEAD: Delivering Open Datasets, Catalogues and Analysis Tools for Space Weather Research

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Body
SPEARHEAD (SPEcification, Analysis & Re-calibration of High Energy pArticle Data) is a Horizon Europe project advancing the analysis of high-energy particle populations in the heliosphere through coordinated use of space- and ground-based observations. The project focuses on solar energetic particles (SEPs), Galactic Cosmic Rays (GCRs), and Forbush decreases (FDs), with the aim of improving event characterization, instrument calibration, and data interoperability across the heliophysics community. To achieve this, SPEARHEAD develops new instrument response functions, cross-calibrates particle detectors, and combines observations with plasma and particle-transport modeling. Its outputs include open-access datasets and tools, as well as catalogues covering SEP events observed by SOHO at energies above 100 MeV; Solar Orbiter electron and protons, including 1 MeV electrons and 8, 25, and 50 MeV protons; and FD catalogues derived from SOHO, Solar Orbiter, Helios, neutron monitors, and the Mars Science Laboratory. The project also delivers recalibrated high-energy datasets from SREM above 200 MeV, SOHO/ERNE above 100 MeV, and SOHO/EPHIN across multiple energy channels. In parallel, SPEARHEAD provides dedicated analysis and calibration tools, including Bowtie, FDAT (Forbush Decrease Analysis Tool), G4VM (GEANT4 Virtual Machine), SEP-PACT (Solar Energetic Particle Analysis and Calculation Tool), and VDA (Velocity Dispersion Analysis), supporting instrument response studies, SEP analysis, and FD characterization. This presentation summarizes the project's major achievements to date. With more than 70% of its objectives already completed, SPEARHEAD is delivering revised datasets, validated methodologies, and interoperable open-access resources that strengthen research in heliophysics and space weather.

Acknowledgement: This work has received funding from the European Union's Horizon Europe programme under grant agreement No 101135044 (SPEARHEAD).

Keywords: SOLAR ENERGETIC PARTICLES,HELIOPHYSICS,FORBUSH DECREASES

POSTER CODE: P1HEL221

Title
Over Five Solar Cycles of Cosmic Ray Modulation: Gnevyshev Gap and Forbush Decrease Frequency Observed by the Rome Neutron Monitor

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Body
The galactic cosmic ray (GCR) intensity is modulated by solar activity and serves as an indirect probe of the heliospheric conditions. For instance, the GCR intensity follows the approximately 11-year solar cycle, exhibiting a well-known anti-correlation with solar activity. On shorter time scales, Forbush Decreases (FDs), i.e. drops in GCR intensity lasting from hours to days, are driven by transient solar wind structures, such as Interplanetary Coronal Mass Ejections (ICMEs).
Understanding the link between long- and short-term variations is essential for a comprehensive description of solar activity and heliospheric environment and space weather–space climate coupling.
A particularly interesting feature emerging at solar maximum is the temporary decrease in solar activity known solar cycle double peak or Gnevyshev gap (GG). In this work, we investigate the specific relation between the occurrence of FDs and the solar cycle characteristics, including GG, over the course of more than five solar cycles. The GCR intensity data are provided by the SVIRCO (Studio delle Variazioni dell'Intensità dei Raggi COsmici) Observatory, i.e. the neutron monitor located in Rome (Italy), characterized by a geomagnetic cutoff rigidity of 6.27 GV.
We perform a statistical analysis of the occurrence of coronal mass ejections and geoeffective ICMEs as a major driver of FDs, identifying similarities and differences with respect to FD occurrence during the different phases of the solar cycles. We discuss how the frequency and magnitude of FDs evolve in response to the structuring of the solar cycle. Our results confirm the presence of the GG in FD occurrence. Furthermore, we investigate a possible dependence of FDs on the odd-even parity of the solar cycles.

Keywords: Cosmic Ray Modulation,Forbush Decrease,Gnevyshev Gap,Neutron Monitor,Coronal Mass Ejections

POSTER CODE: P1HEL223

Title
A global network of low-energy cosmic-ray neutron sensors as a potential tool for space weather monitoring

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Body
Cosmic-Ray Neutron Sensors (CRNS) are compact epithermal neutron detectors, originally deployed in hydrological applications such as soil moisture monitoring, irrigation management, or snow estimation. CRNS sensors respond to epithermal ground-albedo neutrons and are thus indirectly sensitive to space weather events, such as Forbush decreases or Ground Level Enhancements. With more than 1000 sensors distributed across the globe, CRNS networks hold great potental as a resource for space weather monitoring. They offer unprecedented spatial coverage compared to the network of neutron monitor (NM) stations — potentially filling critical observational gaps in ground-based cosmic ray detection.
However, translating the CRNS signal into operational space weather monitoring requires a thorough understanding of the relative response of neutrons to environmental, atmospheric, and geomagnetic factors. Space weather events are visible, but need to be separated from hydrological effects. Differences in atmospheric depth, geomagnetic cut-off rigidity, and particle production pathways must be carefully characterized before CRNS data can be systematically integrated into space weather monitoring frameworks. On the other hand, knowledge about the influence of environmental effects on neutron detectors could be also used to support data processing and interpretation of traditional NMs.
We present CRNS data across a wide range of cut-off rigidities from deserts to the arctic to demonstrate the sensitivity of neutron detectors to both, hydrological processes and space weather signals. First results suggest that the existing and rapidly growing global CRNS infrastructure could serve as a spatially dense, low-energy complement to neutron monitor networks, opening a new pathway for ground-based space weather monitoring — and an unexpected but promising bridge between hydrology and space science.

Keywords: Cosmic rays,Neutron Monitors,Neutron Detectors,Space Weather Impact,Environmental Observatories

POSTER CODE: P1HEL224

Title
Effect of Solar Energetic Particle Source Size Variation and Solar Wind Turbulence in Space Weather Forecasting

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Body
A reliable description of key mechanisms involved in the acceleration and transport of solar energetic particles (SEPs) remains a challenging aspect in SEP space weather forecasting. Turbulence permeating the heliosphere has significant effects on SEP intensities. Furthermore, the width of the CME-driven shock is known to be vital to the overall spatial distribution of the particles.
In an effort to mitigate SEP radiation risk and improve operational forecasting, a three-dimensional physics-based SEP forecasting tool SPARX (Marsh et al. 2015) was previously developed. SPARX incorporates full-orbit test particle simulations where SEPs are injected close to the Sun at a region depicting a CME shock source. The model utilises a pre- generated database of model outputs that are used to generate SEP forecasts, triggered by a solar flare >M1.0. In the absence of real-time information on the extent of the CME shock, SPARX employs an assumed constant shock width in the forecasting context.
In this study, we use SPARX to investigate how CME width and turbulence affect the heliolongitudinal extent of SEPs at 1 AU, SEP arrival times and peak intensities. We analyse how the particle injection region size affects SPARX's ability to reproduce SEP events through a skill-based sensitivity analysis comparing simulated outputs with particle observations from GOES. We identify a size of injection region within SPARX that optimises statistical agreement between modelled and observed SEP event detections while balancing forecast skill and false-alarm rates. We also present preliminary results on how turbulent field line random walk affects the heliolongitudinal extent of SEP events. A novel analytical turbulence model (Laitinen et al. 2023) is used which comprises 2D and slab components transverse to the large-scale Parker spiral. We further discuss the importance of the SEP source width and turbulence on SEP operational forecasting.

Keywords: SEPs,Solar Wind Turbulence,operational SEP forecasting,CME-driven shocks,Physcs-Based modelling

POSTER CODE: P1HEL225

Title
Acceleration and Transport of Relativistic Particles during GLE75

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Body
Ground Level Enhancements (GLEs) are rare events in which solar energetic particles (SEPs) reach relativistic energies during periods of high solar activity, when the heliosphere is already disturbed by preceding CMEs. GLE74 (11 May 2024) was a clear example of this, occurring as five interacting CMEs impacted Earth. One solar rotation later, the same active region (AR 13697, S17W72) produced GLE75 on 8 June 2024, this time associated with an M9.7 flare and fast CME but under quiet interplanetary conditions. SEP fluxes above 100 MeV were recorded by GOES and SOHO/ERNE at Earth, and by STEREO-A/HET at 60–100 MeV. Neutron monitors at Dome C and South Pole confirmed the GLE.

We reconstruct the CME-driven shock in 3D using EUV and coronagraph observations from SDO, SOHO, and STEREO-A, and derive its properties using coronal MHD modeling. The shock was already strong and quasi-perpendicular at the time of magnetic connection to Earth. Velocity dispersion analysis gives apparent path lengths around 1.9 AU, much shorter than the 3–4.6 AU found for GLE74, suggesting a simpler transport geometry closer to a Parker spiral. We compare the two events to show how the presence or absence of magnetic flux ropes in the interplanetary medium changes the arrival time, path length, and spectral evolution of relativistic SEPs at 1 AU.

Keywords: solar energetic particles,ground level enhancements,coronal mass ejections,CME-driven shocks

POSTER CODE: P1HEL226

Title
The Role of Spacecraft Path through a Flux Rope in Forbush Decreases

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Body
Forbush decreases (FDs) are short-term reductions in galactic cosmic ray intensity and are commonly observed as in-situ signatures of interplanetary coronal mass ejections (ICMEs) throughout the heliosphere. Their profiles often show a two-step structure, with the first decrease linked to the shock/sheath region and the second to the magnetic structure, modeled here as a flux rope. In this study, we focus on the second FD step and investigate how the spacecraft trajectory through the flux rope affects the observed cosmic ray decrease.
To describe this flux-rope-related part of the FD, we use the ForbMod model (Dumbovic et al., 2018; 2020). ForbMod assumes the gradual filling of an initially depleted flux rope by cosmic rays. In this model, the FD amplitude depends on cosmic ray diffusion into the expanding flux rope, as well as on the flux rope magnetic field, size, and propagation time. We use this framework to examine the role of the impact parameter, p, defined as the spacecraft distance from the flux rope axis. We test whether different values of p can lead to changes in the depth profile of the observed FD. This work combines theoretical modeling with selected observational examples to assess the importance of spacecraft crossing geometry in interpreting FD signatures. This research was funded by the European Union (project SPEARHEAD, No 101135044). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

Keywords: FORBUSH DECREASES,ICME

POSTER CODE: P1HEL227

Title
Superposed epoch analysis of solar energetic particle events observed in solar cycle 25

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Body
Solar energetic particle (SEP) events are major outbursts of energetic charged particles from the Sun, associated with solar flares and fast coronal mass ejections (CMEs). They consist of energetic protons, electrons, and heavier ions that can produce solar radiation storms. SEP events affect spacecraft electronics and satellites and pose radiation hazards to astronauts and aircraft on polar routes. SEPs also interact with the ionosphere, disrupting radio communication and radar systems. Therefore, reliable warning systems are needed to predict SEP occurrence and intensity.

This work contributes to improved space weather forecasting. We analyzed 45 large SEP events observed during the early phase of solar cycle 25, between November 2020 and May 2023, using data from Solar Orbiter, SOHO, Wind, STEREO A, BepiColombo, and Parker Solar Probe. These observations produced about 100 single-spacecraft event observations.

We used time-intensity profiles of >25 MeV protons and ~100 keV and ~1 MeV electrons and performed superposed epoch analysis on normalized SEP intensity profiles. Events were divided into magnetically well-connected (|angular separation| is less than or equal to 35°) and poorly connected (|angular separation| > 35°) categories, where angular separation is the longitudinal separation between the observer's magnetic footpoint and the flare site.

Normalized profiles were fitted with exponential and power-law models to characterize average rise and decay phases and compare parameters for different particle energies and observing sectors. Results were also compared with diffusion and Weibull-function models by Wang et al. [1] and Kahler et al. [2]. We found a strong similarity between electron and proton mean rise profiles. The dataset is being extended to the peak phase of solar cycle 25 to derive average SEP profiles for that period.

References
[1] Wang et al., 2022 ApJ 940 67
[2] Kahler et al., 2017 Sol. Phys. 292 (4) 59

Keywords: solar energetic particles,intensity profiles,forecasting,space weather,magnetic connection

POSTER CODE: P1HEL228

Title
Muon meteorology: retrieval of atmospheric profiles from surface observations of muon flux, pressure, and temperature

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Body
Ground-level muon detectors are traditionally corrected for atmospheric pressure and temperature. Here, this correction is instead treated as an inverse problem: retrieving the atmosphere's mass overburden profile from a muon measurement together with surface pressure and temperature. Atmospheric variability is represented by a low-dimensional principal component basis, linked to the ground-level muon spectrum by a physics-based forward model (CORSIKA air showers + a Gaussian process emulator), validated against real CAPRICE94 balloon data. In a cross-validated synthetic study, pressure and temperature alone already constrain the two leading modes of atmospheric variability ($r = 0.999$, 0.994), leaving a third mode essentially unrecovered ($r = 0.085$); a muon measurement supplies exactly this missing information ($r = 0.732$). Real data from the Nagoya muon telescope confirms this independently, using only a total muon count and a simpler regression-based retrieval, raising the third mode's correlation from $r = 0.053$ to $r = 0.671$. Muon detectors, paired with instruments already common at many sites, carry independent information about the atmosphere's vertical structure.

Keywords: cosmic ray muons,temperature effect,atmospheric profile retrieval

POSTER CODE: P1HEL229

Title
Global test-kinetic simulation of solar energetic particles interaction with the Earth's magnetosphere in the vicinity of the Moon: preliminary results

Authors
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Body
The magnetosphere has the potential to shield the circumlunar environment from the impact of solar energetic particles for up to 25% of the Moon's orbit. However, the shielding effect is far from being clearly understood and continues to be an active research topic in space physics and lunar space weather. To date, there is not a consensus in the scientific community on this topic. Various theoretical models, numerical simulations and in-situ data observations yield different and sometime conflicting results. We simulate the interaction of the solar energetic particles with the Earth's magnetosphere in the vicinity of the Moon's orbit and make an estimation of the shielding under various space weather conditions. The magnetospheric dynamics covers a wide range of spatial and temporal scales, therefore self-consistent modelling approaches (e.g., particle-in-cell, Vlasov or hybrid) are virtually unaffordable in this context. Instead, the test-kinetic simulation method provides an alternative less demanding in computing resources. In the framework of the ESA projects SMEDEG and REENOM, we develop and test highly-parallelized relativistic test-kinetic codes to simulate the interaction of solar energetic particles with the magnetosphere under various circumstances. We discuss here the approach and some preliminary results.

Keywords: solar energetic particles,magnetosphere,test-kinetic simulations,shielding effect,Moon

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION HEL3

BALLATOIO
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2HEL301

Title
Chromosphere modeling of solar active regions observed at K-band frequencies using INAF single-dish radio telescopes under the SunDish Project

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Body
Modeling the solar atmosphere at radio frequencies is essential for understanding the complex magnetic environments of active regions (ARs). By combining radiative transfer with magnetic field extrapolations and accounting for free-free and gyroresonance opacities, recent studies have significantly advanced our understanding of these regions (e.g. Selhorst et al. 2008; Pellizzoni et al. 2022; Oliveira e Silva et al. 2022; Marongiu et al. 2024), allowing for a detailed reconstruction of the thermodynamic and magnetic structure of the solar atmosphere, but the transition between the chromosphere and the corona remains a challenge. In this talk, we present a detailed modeling of AR total-intensity maps using high-resolution radio data from the SunDish project. We focus on observations in the under-explored K-band (18-26 GHz) using the INAF single-dish radio telescopes (Medicina 32-m and SRT 64-m). This work builds upon some ARs studied by Mulas et al. (2026), who analyzed their radio maps produced by the same radio telescopes up to some hours before/after the flare event. By performing linear force-free extrapolations using simultaneous SDO/HMI magnetograms, we coupled magnetic field configurations with radiative transfer modeling accounting for the aforementioned radio mechanisms. This approach ensures an accurate characterization of the chromosphere, the layer where gyroresonance develops. Following the approach of Amaro (2023), we included Doppler broadening for the 3rd and 4th harmonics of gyrofrequency, considering the gyroresonance sources. Our results show the kinect temperature, density, and magnetic profiles of ARs under different boundary conditions. By linking these physical parameters with the timing of eruptive events, we demonstrate how K-band radio observations can help identify important precursors of solar flares.

Keywords: Chromosphere modeling,Active region atmosphere,Magnetic field extrapolation,gyroresonance,free-free

POSTER CODE: P2HEL302

Title
From Continuous Monitoring to High-Resolution Imaging: Comparative Solar Radio Burst Observations with CALLISTO, RSTN, and LOFAR

Authors
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Body
Solar radio observations provide important diagnostics of eruptive solar activity and its impact on near-Earth space, making coordinated ground-based monitoring networks highly valuable for space weather applications. In this study, we compare solar radio burst observations from CALLISTO, RSTN, and LOFAR, focusing on their complementary capabilities for event detection and characterization.

The international e-CALLISTO network comprises more than 250 instruments worldwide, with around 80 stations currently providing observational data across frequencies from approximately 10 to 1600 MHz. Within this framework, DLR operates compact CALLISTO spectrometers covering 10–80 MHz, 45–860 MHz, 800–1000 MHz, and 1.0–1.6 GHz. These observations support investigations of flare-accelerated electrons, shock-associated radio emission, and coronal mass ejection signatures. Complementary observations are provided by the Radio Solar Telescope Network (RSTN), covering 25–180 MHz with near-real-time event reporting via NOAA/SWPC. LOFAR observations in the 10–90 MHz and 110–240 MHz ranges provide significantly higher spectral and temporal resolution, enabling detailed studies of fine structures and early coronal radio emission processes.

We analyse selected solar radio events and compare the sensitivity, spectral resolution, and detection performance of the different systems. In addition, we present a filtering approach to harmonize heterogeneous spectral data, suppress radio-frequency interference, and improve automated burst detection and classification. Our results demonstrate the complementarity of global monitoring networks and high-resolution radio arrays, highlighting the value of combined multi-instrument observations for future space weather monitoring and solar radio research.

Keywords: Solar radio bursts,Space weather monitoring,CALLISTO,LOFAR,RSTN

POSTER CODE: P2HEL303

Title
Type II Solar Radio Bursts and Geomagnetic Storm Severity During Solar Cycle 25

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Body
Type II solar radio bursts are signatures of CME-driven shocks and are frequently associated with geomagnetic disturbances. However, it remains unclear whether their spectral characteristics can help distinguish weak from severe storm responses. In this study, Type II bursts observed during Solar Cycle 25 are investigated using a Type-II-centred approach. CME candidates reported in the SOHO/LASCO-CDAW and CACTus catalogues within ±2 h of the Type II onset are examined with the Kp response in a 17–96 h window after the radio start time.
In the preliminary sample, 172 of 456 Type II candidates are associated with Kp greater than or equal to 5 activity within this window, corresponding to 37.7% of the sample. This indicates that many Type II events can be examined in relation to geomagnetic storms, while also confirming that Type II occurrence alone is not a deterministic indicator of storm intensity.
To this end, storm-associated Type II events are grouped by Kp response as G1–G2, G3, and G4–G5. CME speed, angular width, halo/partial-halo morphology, Type II–CME delay, and the delay between Type II onset and Kp maximum are compared among these groups. Selected events are further analysed using e-CALLISTO and LOFAR dynamic spectra. Spectral parameters, including frequency drift rate, band splitting, and harmonic structure, are investigated where possible. For clear band-splitting cases, the upper-to-lower lane frequency ratio is used to estimate the shock compression ratio, and physically valid points are considered for approximate Alfvén Mach number estimates. Drift rates are also used to obtain first-order, model-dependent estimates of shock propagation.
By combining radio spectral diagnostics with CME parameters and geomagnetic response levels, this study tests whether Type II spectral morphology can provide additional precursor information for distinguishing geomagnetic storm severity beyond CME occurrence alone.

Keywords: Type II radio bursts,Geomagnetic storms,Coronal mass ejections,Dynamic spectra,25th solar cycle

POSTER CODE: P2HEL304

Title
Radio Investigations for Space Environment Research (RISER): Overview and Plans at the end of Year 3

Authors
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Body
RISER: Radio Investigations for Space Environment Research project, is a NERC-funded project that comprehensively addresses the chain of events through which the Sun creates adverse space-weather conditions at Earth and within the Earth's space environment. RISER aims to investigate how the LOw Frequency ARray (LOFAR) can be utilised for continuous and accurate tracking of inner-heliospheric and ionospheric plasma structures, combined with magnetospheric modelling, leading to more-precise and advanced forecasts of space-weather conditions and their impacts at Earth. RISER will provide a comprehensive understanding of the Earth's space-environment through the use of novel radio observations and modelling techniques to investigate coupling between solar-driven inner-heliospheric structures and the Earth.

Space weather is well known as a global concern which needs to be tackled from blue-skies research through to the operational forecasting of the Earth's environment. Space weather has widely-varying impacts worldwide, regionally, and locally, making its impacts difficult to predict. RISER is, nominally, a five-year project which commenced on 01 September 2023 which includes key partners from across the UK and the USA, bringing unique expertise in: radio analyses and propagation, modelling, and observational capabilities, across the heliosphere, magnetosphere, and ionosphere sub-domains of heliophysics.

The LOFAR-UK station has been operating in standalone for over a year (at time of writing) with automated heliospheric and ionospheric observations being scheduled and analysed. Here we provide an overview of the RISER project as a whole. We report on the progress to date for the project as a whole noting the linkages between the heliosphere, magnetosphere, ionosphere, and space-weather impacts investigated within the project, as well as an outlook to the next steps and plans going forward with highlighted key findings thus far.

Keywords: LOFAR,Space Weather,Heliosphere,Magnetosphere,Ionosphere

POSTER CODE: P2HEL305

Title
RASOR: Radio Astronomy and Space Observation Research Facility – A Future Prospect for Space Weather, Space Domain Awareness, and Astrophysics

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Body
RASOR: Radio Astronomy and Space Observation Research Facility, is a potential new facility operating at wide-band radio frequencies (10s MHz to several GHzs) to provide unique capabilities (high angular/temporal resolution) for frontier science in space weather, cosmology, astrophysics. It also addresses strategic requirements for the prediction of adverse space-weather events and characterisation of assets/debris in orbit. This advancement represents a major step-change in current capabilities with substantial near-/long-term direct economic/societal impacts beyond research. It provides exciting stand-alone opportunities with integration prospects with other facilities across Europe and more globally.

A fully-implemented RASOR would be a truly dual-use, multi-disciplinary/interdisciplinary world-class project on UK soil. It would support a very-broad, highly-engaged, diverse scientific community, providing direct access to high-resolution, rapid-response radio imaging and dedicated space-weather monitoring, unavailable anywhere else. It would also feed into Met Office space-weather monitoring requirements across the Sun-Earth chain and has potential to feed into the wider space situational awareness needs of the UK's National Space Operations Centre (NSpOC).

At his stage, this is a large-scale infrastructure opportunity for consideration in the UK. The current concept is based on a two-year preliminary project, followed by a four-year full roll-out. There are prospects of advancements to the rollout in the form of a "Super-RASOR" which would include a transmitter and additional stations/sites as well as guaranteed 10 years operational capability. Here, we will give an overview of RASOR with a focus on space weather and the space environment, an overview of the project plans and progress to date, and where we are in terms of obtaining funding for the future and future avenues that could be open for investigation.

Keywords: Radio Observations,Space Weather,Space Domain Awareness,LOFAR,SKA

POSTER CODE: P2HEL307

Title
Studying the ionospheric effects of solar flares as observed by radio-quiet observations by European mid-latitude ionosondes

Authors
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Body
The ionosphere acts as a highly dynamic interface between the neutral atmosphere and the outer plasma environment of near-Earth space. Transient space weather events, solar flares in particular, affect the state of the ionospheric layers significantly. Solar flares change the electron density in the different ionospheric layers, resulting in variations in the absorption of electromagnetic waves especially in the D- and E-regions. This in turn affects HF radio communication and the propagation of radio waves through the ionospheric layers.
According to a recent study based on the ionosonde fmin (minimum frequency) characteristic, the ionospheric impact of solar flares depends on the intensity of the flare, the solar zenith angle at the observatory at the time of the flare, and also on the duration of the flare (Erdey et al, 2026). In another study, Verhulst et al. (2026) showed that ionosondes can be used in a so-called radio-quiet mode, when the instrument is used as a passive receiver only, detecting the signals of HF radio transmitter of opportunity in the 10—30 MHz frequency range. Verhulst et al. (2026) demonstrated that these radio-quiet observations are sensitive to ionospheric absorption events such as those caused by solar flares.
To assess the impact of solar flares on the ionosphere, the received amplitudes of the HF transmitters of opportunity in radio-quiet mode can be used to quantify the ionospheric absorption. In the present study, we aim to demonstrate the effect of solar flares as seen in such radio-quiet data derived from ionosonde measurements from European, mid-latitude stations during solar cycle 25. We compare the impact of flares of different intensity classes, different solar zenith angles of observation, and different durations. The seasonal variation and frequency dependency of the detected absorption effect are also discussed.

Erdey et al. (2026), doi: 10.3390/rs18111675
Verhulst et al. (2026), doi:10.1029/2026RS008688

Keywords: Solar flares,HF radio-wave absorption,radio fade-out,Ionosphere,Ionosonde technique

POSTER CODE: P2HEL310

Title
High-frequency magnetic loops for monitoring solar radio bursts

Authors
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Body
Radio emissions in the HF range (typically 30 kHz to 30 MHz) provide an important diagnostic of solar activity; of particular interest are type II solar radio bursts that are produced by interplanetary shocks and are associated with geoeffective coronal mass ejections. These electromagnetic emissions have been classically detected using electric field antennas. However, their magnetic component can also be measured by means of magnetic loop antennas. These magnetic sensors consist of a small circular loop with an air core, typically with a diameter of 30 cm. Some of the major advantages of such magnetic sensors are their compact size and simple design, and their higher sensitivity for detecting radio emissions relative to the galactic noise level.

Such loop antennas have already flown on the POLAR spacecraft and the CHARM sounding rocket, measuring one component only of the HF magnetic field. In this study, we explore the potential of tailoring a three-component magnetic loop sensor to microsatellite missions and highlight their application to space weather surveillance systems.

Keywords: solar radio emissions,magnetic sensor

POSTER CODE: P2HEL311

Title
Remote sensing of solar flare dynamics with the microwave imaging spectroscopy

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Body
Over recent decade, a novel methodology that employs microwave imaging spectroscopy data opened an entirely new window to look at coronal phenomena; notably solar flares. This methodology yields evolving maps of such coronal parameters at the flare sites as the magnetic field and the thermal plasma density along with parameters of the nonthermal electrons, primarily, their number density and spectral index in their distribution over energy. These diagnostics is the key to uncover otherwise elusive physics of magnetic energy transformations and particle acceleration in solar flares. Indeed, release (decrease) of the magnetic energy due to reconnection is believed to drive such transient phenomena as solar flares, eruptions, and jets. Here, we report microwave observations of several solar flares showing spatial variations and temporal changes in the coronal magnetic field at various coronal locations. We discovered a fast decay of the magnetic field in the coronal loops and cusp regions well below the nominal reconnection X point implied by the standard model of solar flare. The field decays at a rate ranging from a fraction of Gauss up to ~10 Gauss per second in various events and locations. This fast rate of decay implies a highly enhanced, turbulent magnetic diffusivity and sufficiently strong electric field to account for the particle acceleration that produces the microwave emission. In addition, we report such phenomena, that are beyond the standard model, as bulk electron acceleration in the cusp region, where the magnetic field displays the fast decay, and a new high-energy, MeV-peaked, electron component in a corona volume. We report 3D coronal maps of such important parameters as Alfven speed and plasma beta. Finally, we review novel results on the spectral energy evolution of the nonthermal electrons accelerated in flares, oscillations of physical parameters in event(s) with quasiperiodic pulsations, and signatures of anisotropic pitch-angle distributions.

Keywords: Solar flares,Radio radiation,Coronal magnetic field,Remote sensing,Nonthermal electron beams

POSTER CODE: P2HEL313

Title
Fine Structures of Type III Radio Bursts

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Body
Type III radio bursts are signatures of electron energy deposition throughout the heliosphere, providing details about the local plasma they are generated in. Moreover, they are important for predicting space weather hazards due to their connection to other manifestations of solar activity, such as CMEs, and the diagnosis they provide of magnetic connectivity. They are characterized by intense radio emission, that drifts rapidly from high to low frequencies, and are observed at or around the local plasma frequency or one of its harmonics [1]. Generation of a type III radio burst takes place as a result of a solar energetic event, such as a flare, accelerating electrons along magnetic field lines out into the corona and solar wind. Here the electrons can resonantly interact with the ambient background plasma to grow electrostatic Langmuir waves, which consequently non-linearly convert into electromagnetic emission [2]. Parker Solar Probe (PSP) and Solar Orbiter (SolO) missions aim to give a more detailed insight to the exact mechanisms that cause this conversion. As of 2022 the first unambiguous detection of a Langmuir wave with magnetic signature was made using PSP in the inner heliosphere [3], concluding that the wave conversion of the so called slow extraordinary mode had been as a result of density fluctuations. In addition, simulations, and now direct measurements, have shown breaks in electron peak flux energy to be as a result of beam-plasma interactions [4]. The aim of this study is to use PSP and SolO events whereby the presence of a magnetic component is clear, alongside a well aligned electron beam, to try to better understand the properties of beam-plasma interactions and their effect on energy transport in the heliosphere.

[1] Jebaraj, I. et al 2023 ApJ 955 L20
[2] Reid, H. et al 2014 Res. Astron. Astrophys. 14 773
[3] Larosa, A. et al 2023 Sol Phys 298, 52
[4] Lorfing,C.Y. et al 2023 ApJ 959 128

Keywords: Space Plasmas,Radio Emission,Plasma Waves

POSTER CODE: P2HEL314

Title
Relating Long-Baseline VLF and SoLO/STIX Observations of Solar Flares

Authors
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Body
We present a new investigation of the relationship between long-baseline Very Low Frequency (VLF) observations of solar flare-induced ionospheric disturbances and hard X-ray (HXR) emission observed by the Spectrometer/Telescope for Imaging X-rays (STIX) aboard the Solar Orbiter spacecraft. Previous studies have demonstrated that the VLF response to solar flares is strongly correlated with soft X-ray flux measured by GOES, while several impulsive events exhibit near-zero or negative delays relative to the X-ray peak, suggesting a significant role of nonthermal hard X-ray emission in driving rapid D-region ionization. Using continuous VLF observations of the NPM (21.4 kHz, Hawaii) and NAA (24.0 kHz, Maine) transmitters recorded in 2025 and 2026 at the Bulgarian Polar Astronomical Observatory in St. Kliment Ohridski Base, Livingston Island, Antarctica, together with STIX spectroscopic observations, we investigate the temporal relationship between VLF amplitude perturbations, soft X-ray fluxes, and flare-associated HXR bursts. We aim to examine how flare spectral and temporal characteristics influence the ionospheric D-region response over trans-hemispheric propagation paths exceeding 11,000 km. We focus on impulsive-phase timing, frequency-dependent VLF behavior, and the occurrence of negative or near-zero lag events previously associated with RHESSI observations above 25–40 keV. This work represents the first systematic comparison between Antarctic long-baseline VLF observations and Solar Orbiter/STIX hard X-ray measurements, with implications for understanding flare energy deposition in the lower ionosphere and for future space weather monitoring applications.

Keywords: Very Low Frequency,Hard X-Ray,Solar Flares,Solar Orbiter,Ionospheric response to flares

POSTER CODE: P2HEL315

Title
Synthetic dynamic spectra of solar radio bursts from QL theory and simulations

Authors
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Body
The efforts directed at the analytical and numerical modeling of solar radio bursts are primarily motivated by the need for a realistic diagnosis of the exciters associated with energetic solar events. Remote diagnostics are intended to contribute to the forecasting of these events and their consequences within the context of space weather. Presented here are two new and distinct methods for the numerical calculation of synthetic spectra of type II and type III radio emissions within the standard electron-beam plasma model. Type II solar radio bursts are associated with the foreshock region ahead of interplanetary shocks driven by coronal mass ejections (CMEs), whereas type III bursts are induced by energetic beaming electrons originating in flare-related coronal sources. The first method proposes an advanced numerical evaluation of radio spectra including dynamic ones, based on the results of weak turbulence (WT) theory of plasma systems with (unidirectional or bidirectional) electron beams. The second method computes radio spectra for the first time based on particle-in-cell (PIC) simulations of electron-beam plasma systems, providing a dynamic, quantitative, and self-consistent dynamic model (albeit one still simplified by neglecting propagation effects such as scattering and dissipation). Synthetic dynamic spectra include the fundamental emission as well as the second and third harmonics, thereby enabling the determination of frequency bands consistent with those observed. These radio components are well-delimited in frequency and wavenumber, allowing the calculation of their wave energy density from the WT model or/and directly from PIC simulations. This establishes the prerequisites for realistic, first-principles replications of the observed dynamic spectra, with potential for application in advanced diagnostic tools.

Keywords: solar radio bursts,synthetic dynamic spectra,PIC simulations,QL theory

POSTER CODE: P2HEL316

Title
Jovian Decametric Emission as a Diagnostic of Plasma Variability from Jupiter to Near-Earth Space

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Body
Jovian decametric (DAM) radio emission provides a remote probe of plasma processes from Jupiter's magnetosphere through the heliosphere to the near-Earth environment. Its fine temporal and spectral structure reflects both source conditions and propagation effects.
We analyze high-resolution DAM observations in the 10–40 MHz range obtained with the UTR-2 radio telescope, focusing on rapidly varying spectral structures and S-burst frequency drifts. The observations show substantial changes in the drift characteristics of millisecond-scale S-bursts over very short time intervals, indicating rapid variations in the plasma conditions and electron dynamics within the emission region.
Nonlinear electron dynamics may contribute to this variability. A fully nonlinear kinetic description of multi-species magnetoactive plasma with a self-consistent electric field permits the formation of localized electrostatic structures, including solitary waves and double layers. Their potential variations can modify energetic electron distributions and affect electron cyclotron maser instability (ECMI) and the frequency drift of the emitted radiation.
DAM observations also reveal propagation effects, including scintillation and Faraday-fringe-like spectral modulation, providing information on density irregularities, turbulence, and magnetic-field variations in the intervening plasma and terrestrial ionosphere. Distinguishing source-related and propagation-related signatures is therefore essential.
Coordinated observations with UTR-2, GURT, LOFAR, NenuFAR, LWA, Juno, and JUICE can extend these diagnostics across a wide range of spatial and temporal scales. High-resolution DAM observations thus offer a powerful tool for linking fine-scale radio signatures to plasma processes from Jupiter's source region to the near-Earth space-weather environment..

Keywords: Jovian Decametric Emission,Jovian magnetosphere,radio diagnostics,the near-Earth space-weather,nonlinear electron dynamics

POSTER CODE: P2HEL318

Title
Solaris: Towards a Global Network for High-Frequency Radio Monitoring of the Sun

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Body
Building on the solar observation expertise gained with INAF's large radio telescopes, Solaris is a technological, scientific, and applied project aimed at developing an innovative solar monitoring system at high radio frequencies, based on single-dish imaging techniques.
Solaris integrates dedicated, interchangeable high-frequency receivers onto small-aperture radio telescopes already operational at laboratories in mid-latitudes and Antarctica, specifically optimized for tracking and observing the solar disk. By leveraging the exceptional atmospheric opacity conditions of the Antarctic site during the summer season, Solaris enables an observational duty cycle of nearly 20 hours per day. Currently, it represents the only observational asset capable of providing continuous solar monitoring in the 18–100 GHz range.
Looking ahead, extending the network to the Northern Hemisphere and creating synergies with other national observational resources would allow for global, uninterrupted coverage of the solar chromosphere and corona year-round. This would enable Space Weather services that can be integrated into national and international networks to mitigate geomagnetic risk. Results from the first Antarctic test campaign have confirmed the system's effectiveness: over 100 radio maps at 95 GHz were acquired, allowing for the identification and evolutionary monitoring of active regions characterized by intense flares, coronal mass ejections (CMEs), and subsequent terrestrial geomagnetic storms.

Keywords: Solar radio astronomy,Solar imaging,Space Weather forecast,Active Regions

POSTER CODE: P2HEL321

Title
EISCAT_3D – A tri-static incoherent scatter radar in the European Arctic

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Body
EISCAT AB is currently constructing the EISCAT_3D radar system, designed to become the most advanced volumetric imaging incoherent scatter radar for atmospheric, ionospheric, and near-Earth space research. The tri-static, phased-array system consists of sites in Skibotn (Norway), Karesuvanto (Finland), and Kaiseniemi (Sweden).

EISCAT_3D builds on more than four decades of EISCAT operations, including the Tromsø radars (Norway) established in 1981 and the EISCAT Svalbard Radar (ESR) operating since 1996. Once EISCAT_3D becomes operational, the Tromsø radars will be decommissioned, while the ESR and the Ionospheric Heating facility will continue to operate. EISCAT_3D is recognized as a Landmark project within the European Strategy Forum for Research Infrastructures (ESFRI) in the environmental domain.

The new system is optimized for investigating coupling processes between the mesosphere and thermosphere, the ionosphere and neutral atmosphere, and the atmosphere and near-Earth space. Its 10,000-antenna phased array provides 3.4 MW peak transmit power and full computer steering. Remote receiver sites will observe the transmitted beam at multiple altitudes, enabling flexible experiment geometries and the measurement of three-dimensional plasma velocity vectors. Rapid beam steering between pulses allows simultaneous observations over wide areas, such as meridional scans or rectangular grids. These capabilities will significantly reduce space–time ambiguity in upper-atmospheric and ionospheric studies, achieving spatial and temporal resolutions not attainable with previous systems.

Designed for continuous operation, EISCAT_3D will deliver simultaneous measurements across a large ionospheric volume above northern Scandinavia. This makes it a powerful tool for detailed investigations of space weather impacts and for validating atmospheric and ionospheric models.

We present an overview of the EISCAT_3D system, its scientific capabilities, and its current development status.

Keywords: Radar,Ionosphere

POSTER CODE: P2HEL322

Title
Observation of Jupiter's Decameter Radio Storms in 2025 Before, During, and After the Solar Coronal Eclipse

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Body
From May to July 2025, the Ukrainian URAN-2 radio telescope observed decameter radio storms on Jupiter during its eclipse by the solar corona in the elongation from -40 to +30 degrees. The URAN-2 radio telescope's antenna field is rectangular, consisting of 512 crossed Nadenenko dipoles. The URAN-2 operating band extends from 8 MHz to 33 MHz. This enables the recording of all Stokes parameters of polarized radio emission in this band. Additionally, it is possible to reconstruct the dynamics of the position angle and the changes in the rotation measure (RM). We used Jupiter's decameter storms as a point source, which has a high degree of linear polarization. This source was used to probe the solar corona. The closest effective distance from the center of the Sun at which we were able to detect Jupiter's radio storms was 2 degrees, corresponding to 7.5 solar radii where we continue to observe the linearly polarized component of this radiation. Our observations have shown that in some cases, two RMs values are detected simultaneously. We will demonstrate the dynamic spectra of RM as a function of elongation, time and the central frequency of the range in which the RMs were measured. We will further demonstrate that this parameter, together with the dispersion measure parameter, estimated from the dispersion time delay of pulsar pulses, are good radiosondes of the state of the magneto-active plasma of the solar corona. In turn, it is the magneto-active plasma of the solar corona that drives space weather. Its state and dynamics determine the velocities of the fast and slow components of the solar wind and the possibility of CME. Therefore, using Jupiter's radio storms, as well as the radio emission from pulsar pulses, is a promising method for probing the solar corona for space weather forecasting.

Keywords: Jupiter,Sun corona,Radio Storms,Rotatio Measure,Magneto-active Plasma

POSTER CODE: P2HEL323

Title
NEW EUROPIAN IONONET STATIONS

Authors
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Body
IonoNet is a collaborative initiative aimed at establishing a multistatic radar network of Pseudo-Random Code (PRC) ionosondes for oblique ionospheric sounding across Europe. This configuration facilitates the comparative analysis of ionospheric properties over distances spanning from hundreds to thousands of kilometers.
Developed at INGV laboratories, the oblique ionosondes are supported by specialized communication and data-processing infrastructure. A key feature of this system is the conversion of oblique ionograms into equivalent vertical ionograms, enabling more accurate comparisons with data from standard ionospheric observatories. The network employs the Autoscala software to automatically generate real-time electron density profiles and calculate critical propagation parameters. Based on these continuous measurements, automated alerts are issued when disturbed ionospheric conditions are detected. Ultimately, the data collected by IonoNet contributes to large-scale ionospheric mapping, the validation of global ionospheric models, the detection of localized anomalies, and the ongoing investigation of potential ionosphere–lithosphere coupling processes.
Currently, the operational IonoNet network consists of two transmitting stations in central Italy (Montelibretti and Rome) and ten receiving stations. Five of these receivers are located in Italy (Castello Tesino [Trento], Rocca di Papa [Rome], Preturo [L'Aquila], Duronia [Campobasso], and Lampedusa [Agrigento]), while the other five are distributed across Europe (Chambon-la-Forêt [France], Nicosia [Cyprus], Vihti [Finland], Sopron [Hungary], and Dourbes [Belgium]). In the coming months, the network will undergo further expansion with the integration of two new receiving stations in Jaén (Spain) and Covasna (Romania), alongside two additional transmitting facilities in Italy, located in La Spezia (North) and Gibilmanna (South).

Keywords: Software-Defined Radio (SDR),Oblique ionosonde,Ionospheric observatories

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION HEL4

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1HEL402

Title
ON CME STRUCTURE AND EVOLUTION: MULTI-SPACECRAFT OBSERVATIONS AND STATISTICAL ANALYSIS

Authors
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Body
In-situ measurements of Coronal Mass Ejections are often interpreted as spatial cuts through static or slowly evolving magnetic structures, in reality, however,CMEs can change substantially during passage time over a spacecraft. As a result, signatures commonly attributed to radial propagation, expansion, or magnetic structure may also reflect CME aging: the temporal evolution of CME properties during an in-situ crossing.
In this work, statistical analyses of large CME database are combined with multi-spacecraft conjunctions and numerical simulations to investigate the evolution, aging, and solar-cycle dependence of CMEs. Using more than 1600 events from the HELIO4CAST catalog and nearly three decades of measurements from multiple spacecraft, we examine how CME magnetic and plasma properties vary with solar activity and heliocentric distance. We also investigate the evolution of the magnetic-field components, the angular extent and coherence of magnetic ejecta, and the differences between temporal in-situ profiles and the spatial structure.
These analyses show that CME evolution cannot be described solely in terms of radial propagation or idealized flux-rope expansion. Instead, CMEs are evolving and structured three-dimensional ejecta of which measured properties depend on solar-cycle conditions, interactions with the solar wind, spacecraft location, and aging. These results provide observational constraints for more realistic CME models and for improving the interpretation of measurements used in space-weather forecasting.

Keywords: Coronal Mass Ejections,Magnetic Field,Evolution,Solar Cycle

POSTER CODE: P1HEL403

Title
CONSTRAINING CME EVOLUTION WITH PUNCH OBSERVATIONS

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Body
Understanding how coronal mass ejections (CMEs) propagate through the heliosphere is important for predicting their arrival at different locations. Observing CMEs from multiple viewing geometries provides complementary constraints on their evolution. The recently available observations from the Polarimeter to UNify the Corona and Heliosphere (PUNCH) mission offer additional heliospheric lines of sight that can complement existing observations from spacecraft at different longitudes. We investigate whether these additional observations can improve CME propagation modelling and arrival time predictions.
We study three consecutive Earth-directed CMEs observed between 9 and 11 November 2025. All three events were observed remotely by the Narrow Field Imager (NFI) and the Wide Field Imager (WFI) aboard PUNCH, the Solar Orbiter Heliospheric Imager (SoloHI), and the two Heliospheric Imagers (HI) on STEREO-A. The CMEs were also detected in situ by BepiColombo, Solar Orbiter and Wind at various stages of their interaction, providing observations at multiple locations in the heliosphere.
As a baseline, we use the STEREO-A/HI observations to model the CME propagation with ELEvoHI, which represents the CME as a self-similarly expanding elliptical front whose propagation is governed by a drag-based model. We then extend the modelling by including the additional remote-sensing observations from PUNCH, with the two lines of sight within the ecliptic plane providing complementary constraints on the CME evolution.
By comparing the arrival time predictions before and after including the PUNCH observations, we assess whether the additional heliospheric coverage can improve the modelling of CME propagation and arrival times. This study demonstrates the potential of combining PUNCH with existing heliospheric imaging observations for constraining CME evolution and improving space weather predictions.

Keywords: Heliospheric Imaging,Multipoint observations,CME Interaction,PUNCH,STEREO

POSTER CODE: P1HEL404

Title
THE ORIGIN AND EVOLUTION OF THE RECURRENT SLOW SOLAR WIND IN 2022

Authors
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Body
The solar wind is a continuous stream of plasma from the Sun that creates and shapes the heliosphere. Generally, the solar wind can be divided into two main types: the fast solar wind originating from open-magnetic field regions (Coronal Holes) and the slow solar wind associated with different sources at the Sun. Our study focuses on the origin and characteristics of the slow solar wind. We employed coordinated observations in EUV from PROBA2/SWAP, STEREO-A/EUVI, SDO/AIA, and SolO/EUI/FSI&HRI together with in-situ observations from ACE and WIND spacecraft. The studied observations were taken during the year 2022. We applied the back-mapping technique to trace the recurrent slow solar wind measured at 1 AUto its source locations at the Sun. In addition, we implemented detailed analysis and few image processing techniques to understand the dynamics of the source regions and their connection with large-scale coronal structures, which helps to determine the possible source region(s) of the slow solar wind. Based on the in-situ solar wind parameters, we are able to differentiate between different types of the slow solar wind sub-structures such as Alfvenic Slow Wind and Magnetic Structures.

Keywords: Solar Wind,Slow Solar Wind,Large Scale Coronal Structures,Active Regions,Coronal Holes

POSTER CODE: P1HEL405

Title
DYNAMIC SOLAR WIND AND CMES MODELED BY ICARUS AND OBSERVED BY PUNCH

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Body
Space weather, a field that studies the conditions in the solar atmosphere and their effects on the heliosphere, is of paramount importance, particularly in understanding the space environment of the Earth. The main drivers of interplanetary shocks and space weather disturbances are Coronal Mass Ejections (CMEs). The potential impact of strong CMEs directed towards Earth is severe, and their prediction is crucial in mitigating possible damage. This underscores the necessity of efficient space weather prediction tools, which can produce timely forecasts for the CME arrival at Earth and their strength (shock, momentum density, magnetic field, etc.) upon arrival.

The heliospheric model Icarus (Baratashvili et al. 2025), a product of the MPI-AMRVAC framework (Keppens et al. 2023), revolutionizes our ability to model the heliospheric solar wind and real CME events. By solving the MHD equations in the co-rotating reference frame with the Sun, we achieve a stationary solution after obtaining the relaxed solar wind in the domain for a particular magnetogram. To enhance the simulations, we've implemented advanced techniques, such as adaptive mesh refinement and gradual radial grid stretching.

Recently, the model was upgraded to support dynamically upgrading inner boundary conditions, where magnetograms are upgraded hourly. This way, the solar wind is no longer stationary in the domain as new information propagates from the inner boundary. Additionally, CMEs are injected on top of the varying solar wind. Baratashvili et al. 2025 found that the non-magnetized and magnetized CME models evolve differently when travelling in the steady and dynamic solar wind. With the most recent PUNCH data, we focus on a CME propagation observed by PUNCH on September 21, 2025 and model it with a magnetized and a non-magnetized CME model in Icarus. The generated synthetic white-light images are compared to PUNCH observations to estimate a more realistic CME model representation.

Keywords: Dynamic solar wind,Heliosphere,Space Weather,CMEs,Heliosphere modelling

POSTER CODE: P1HEL409

Title
THE ROLE OF THE FINE STRUCTURE OF THE SOLAR WIND IN DEFORMATION AND TIMING OF CME SHOCK FRONTS

Authors
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Body
We investigate the effect of the fine structure of the ambient solar wind on the propagation of an Interplanetary Coronal Mass Ejection (ICME) using the Reverse In-situ and MHD Approach (RIMAP), a data-driven model that reconstructs solar-wind conditions in the solar equatorial plane from in situ measurements by combining analytical backmapping with PLUTO MHD simulations. RIMAP preserves longitudinal variability and small-scale structures, such as thin streams, sharp gradients, and localized inhomogeneities, that are often smoothed out in standard reconstructions.
This makes RIMAP a suitable framework to study the propagation of solar transients through a realistic, structured interplanetary background and to assess distortion, compression, and deflection effects induced by the ambient wind. We focus on the strong CME of 18 January 2026 and compare two otherwise identical MHD simulations: one using the finely structured RIMAP background and one using a smoother longitudinal wind structure. The ICME is injected at the inner boundary with parameters constrained by coronagraphic observations.
We generally obtain a very good matching of the arrival time at 1 AU with the actual one. However, in the structured RIMAP background, the CME front develops localized protrusions and recessed sectors due to differential drag from neighboring solar-wind streams. These structures are strongly damped in the smoothed-background case, where the front remains more regular. The resulting arrival-time differences reach about 3 hours, showing that mesoscale ambient-wind structuring can affect Space Weather forecasts by several hours.

Keywords: Coronal Mass Ejections,Numerical Simulation

POSTER CODE: P1HEL410

Title

INVESTIGATING CME FLUX ROPE HANDEDNESS IN IN-SITU DATA VIA A WAVELET-DERIVED 2D MAGNETIC HELICITY PROXY

Authors

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Body

Understanding the internal topology and chirality of Coronal Mass Ejection (CME) flux ropes is a primary objective in heliophysics research. As a fundamental magnetohydrodynamic quantity, magnetic helicity measures the twist and linkage of magnetic field lines within CME flux ropes. However, the true 3D magnetic helicity cannot be directly calculated from standard in-situ spacecraft measurements, which are restricted to collinear observations. Previous studies have proposed the use of a 2D proxy of magnetic helicity derived from in-situ interplanetary magnetic field measurements to capture rotations potentially associated with flux ropes in the plane perpendicular to the sampling direction. Building on previous research introducing a wavelet-based computation of this quantity, this preliminary work employs that same wavelet analysis to reconstruct the helicity spectrum through a simultaneous investigation of both time and frequency domains. Specifically, we investigate how the sign of such a quantity, which reflects the sense of rotation of the sampled magnetic field within this perpendicular plane, can support the identification of observed flux rope chirality in in-situ data. This technique is applied across various synthetic flux rope profiles generated using the 3DCORE model, which provides the corresponding in-situ magnetic field profiles; additionally, the analysis is extended to real CME profiles at L1, aiming to establish a link between the magnetic helicity sign and established flux rope categories

Keywords: Coronal Mass Ejections,Magnetic Helicity,Chirality,Wavelet Analysis,In-Situ Measurements

POSTER CODE: P1HEL411

Title
ON THE GEOEFFECTIVENESS OF CLUSTERED SOLAR WIND REGIMES

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Body
Understanding the solar wind and its interaction with the Earth's magnetosphere is crucial for heliospheric physics and space weather forecasting. Traditionally, the solar wind has been classified according to proton speed measurements. However, Zhao et al. (2009) and Xu and Borovsky (2015) provided classifications based on the solar origin of the wind. With the growth of machine learning, both supervised algorithms—such as the Gaussian Process approach by Camporeale et al. (2017)—and unsupervised schemes—such as the k-means clustering proposed by Heidrich-Meisner and Wimmer-Schweingruber (2018)—have been tested and compared with traditional frameworks. In this work, we assess the geoeffectiveness of solar wind regimes identified by a combination of clustering methods, specifically Self-Organizing Maps and K-Means.
This approach identifies four distinct classes: slow solar wind (SSW) associated with sector-reversal origins and helmet streamers; highly Alfvénic wind associated with coronal holes and pseudostreamers; compressed solar wind (CSW) associated with stream interaction regions (SIRs) and interplanetary coronal mass ejection (ICME) sheaths; and ejecta mostly associated with magnetic obstacles. For each class, we compute the average interplanetary Kp index and the cluster percentages within temporal windows where Kp values exceeded the geomagnetic storm threshold (Kp >= 4). The results reveal that the CSW and ejecta regimes are the main drivers of geomagnetic storms. These findings play an important role in understanding the interaction of the solar wind with the Earth's magnetosphere and offer potential improvements for predicting geomagnetic storms using supervised learning techniques.

Keywords: Space Weather,Solar Wind,Unuspervised Learning,Geomagnetic Storms,Interplanetary Transients

POSTER CODE: P1HEL412

Title
INVESTIGATING THE LOCAL AND GLOBAL EXPANSION OF CMES USING IN SITU MULTI-SPACECRAFT OBSERVATIONS: INSIGHTS FOR FUTURE UPSTREAM SOLAR WIND MONITORS

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Body
In preparation for future upstream solar wind monitors, it is important to know how in situ properties of coronal mass ejections (CMEs) change as they evolve between measuring spacecraft. Multi-spacecraft observations of CMEs across varying longitudinal and radial separations provide valuable insights into their general properties, expansion, and interactions with the solar wind environment during propagation. By tracking the properties of individual events, we often find significant variability compared to average trends, making mapping procedures between upstream solar wind monitors and L1 difficult.

The global expansion is well determined by measurements of the magnetic field strength with increasing heliocentric distance, however, determining the local expansion requires measurements of the solar wind plasma speed, mostly only available at 1 au prior to the launch of Parker Solar Probe and Solar Orbiter. Previous studies have found weak correlations between global and local expansion measures. In this study, we use the HELIO4CAST lineup catalogue (https://helioforecast.space/lineups) which includes ICMEs observed by Parker Solar Probe, Solar Orbiter, BepiColombo, STEREO A, and Wind. We investigate the local expansion of ICMEs measured at spacecraft in the inner heliosphere and 1 au for individual events, comparing these to the global expansion rate. We present examples of events that follow previously determined relationships and those that deviate, including events where there are discrepancies between local expansion at different spacecraft, demonstrating the limitations of such measurements for constraining space weather forecasts.

Keywords: coronal mass ejections,expansion,upstream solar wind monitors,evolution,multi-spacecraft

POSTER CODE: P1HEL413

Title
DATA-DRIVEN SOLAR TRANSIENT MODELING USING PUNCH POLARIMETRY

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Body
The PUNCH data pipeline is nearing completion and will soon produce fully corrected, science quality polarized and total radiance images. Assuming successful completion of this process, we will analyze a solar transient, considering both polarized and total radiance images, and their ratio. Using this event, we will demonstrate how the PUNCH polarization ratio (PR), which can be obtained from Wide-Field Imager (WFI) observations in heliospheric field-of-view, can be used to obtain three-dimensional location and structural information as a function of time.

Keywords: PUNCH,Polarimetry,Transients

POSTER CODE: P1HEL414

Title
POLARIZATION-BASED 3D RECONSTRUCTION OF CMES: METIS–PUNCH SYNERGIES FOR SPACE WEATHER APPLICATIONS

Authors
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Body
Understanding the three-dimensional structure and kinematic evolution of coronal mass ejections (CMEs) is essential for constraining their physical nature, eruption mechanisms, and impact throughout the heliosphere. Polarization-based diagnostics, such as the polarization ratio technique (PRT), enable the reconstruction of CME topography by providing quantitative information on the distribution of coronal plasma along the line of sight and its height relative to the plane of the sky. Metis aboard Solar Orbiter and the PUNCH mission both provide polarization measurements, a relatively rare capability among coronagraphic observations.

We present a newly developed tool, PRICM3 (Polarization Ratio Interactive CME Modeling in 3D), for the interactive three-dimensional visualization of PRT results, designed to facilitate the analysis and interpretation of reconstructed CME structures from multi-viewpoint observations. PRT results are derived and presented for several CMEs and compared to traditional techniques, such as tie-point triangulation or Graduated Cylindrical Shell (GCS) modeling, to which we find good agreement. With this, we show novel opportunities, with the tool PRICM3 enabling an intuitive exploration of the inferred plasma distribution and CME geometry, supporting comparisons between different observing configurations and reconstruction methods.

PRICM3 allows not only the characterization of CME morphology, but also the determination of their 3D propagation direction and kinematics, offering a powerful tool to constrain CME structure and evolution, whose robustness is enhanced when combined with multi-vantage and multi-mission observations. Accurate determination of CME propagation direction and geometry is highly relevant for space weather applications, as it provides important constraints on CME directivity and forecasting capabilities.

Keywords: Space weather,CMEs,Solar Orbiter/ Metis,PUNCH,polarization diagnostics

POSTER CODE: P1HEL415

Title
INFLUENCE OF WSA SAMPLING RESOLUTION ON SOLAR WIND BOUNDARY CONDITIONS IN EUHFORIA

Authors
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Body
This study focuses on the 3D MHD model EUHFORIA (European Heliospheric Forecasting Information Asset), a state-of-the-art model for solar wind and CMEs, that uses the WSA (Wang-Sheeley-Arge) model to compute boundary conditions at 0.1 AU. EUHFORIA's coronal part computes a potential-free magnetic field, and samples it through a two-way field-line tracing at a user-defined angular resolution. Studies with EUHFORIA, as well as its operational Space Weather forecasting applications, typically use a sampling resolution lower than the magnetogram resolution to reduce the computation time. We investigate how sampling resolution affects the WSA output velocity maps to understand its impact on the modelled solar wind at 0.1 AU and at Earth. We modelled the solar wind using the GONG, GONG-ADAPT and HMI synoptic magnetograms on June 29, 2026.
Our results show that increasing the sampling resolution can strongly affect specific regions in the velocity maps, significantly reducing their area, changing their shape, or even causing them to disappear. We show that, at low sampling resolution, the distance to the nearest coronal hole (CH) boundary can be overestimated because of undersampling the magnetic field, yielding too-high velocities. Two effects can explain our results. Firstly, at low sampling resolution, small open-field regions in the photosphere can be missed during upward field-line tracing. As a result, the distance to the nearest CH boundary for downward-traced field lines ending in this region is overestimated. Secondly, at higher sampling resolutions, CH areas can contain small bipolar regions that are not resolved at lower resolution. If such a region appears, the nearest CH boundary distance will change within the CH. To obtain accurate solar wind modelling results and reduce the risk of overestimating solar wind velocity, the maximum possible resolution should be used.

Keywords: solar wind modelling,EUHFORIA,WSA model resolution

POSTER CODE: P1HEL417

Title
DETECTING IN SITU DIRECTIONAL DISCONTINUITIES IN THE SOLAR WIND AT MERCURY'S ORBIT

Authors
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Body
As the solar wind approaches the Sun, it becomes increasingly structured, and directional discontinuities (DDs) provide key insight into the physical properties of its embedded structures. Using magnetic field measurements from MPO-MAG and ion observations from SERENA/PICAM aboard BepiColombo during its cruise phase, we investigated the occurrence and nature of DDs close to Mercury's orbit (0.32-0.35 au) between 5 and 16 October 2021. DDs were identified through the magnetic field attitude gradient method and classified via minimum variance analysis. Among 960 detected DDs, the majority (83%) were rotational (RD) or either-type (ED); conditioning on low magnetic compressibility (C_B<0.03) raised this fraction to 94%, consistent with boundaries of Alfvénic solar wind structures. PICAM observations revealed ion energy enhancements and particle deflections correlated with magnetic field reversals, particularly in low-compressibility intervals, suggesting field-aligned ion populations that do not reverse their pitch angle. These results indicate that BepiColombo observed a series of DDs compatible with the boundaries of magnetic switchbacks. Extending the analysis to a favourable alignment with Solar Orbiter (0.67 au) and STEREO-A (~1 au) during the same period, we found consistent statistical DD signatures at increasing heliocentric distances, confirming that the same switchback cluster evolves outward from Mercury's orbit while retaining its Alfvénic, low-compressibility character. Obtained during BepiColombo's cruise phase, these results open new perspectives for the nominal mission, when the spacecraft's proximity to Mercury may allow the impact of these Alfvénic structures on the Hermean magnetosphere to be investigated directly.

Keywords: SUN,MAGNETIC FIELD,SOLAR WIND

POSTER CODE: P1HEL418

Title
ON THE CLUSTERING OF LARGE-SCALE RECONNECTION OUTFLOWS TOWARD STREAM INTERACTION REGIONS

Authors
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Body
We perform a superposed epoch analysis of 144 reconnection outflows wider than 1000 ion inertial lengths, as measured by the Wind satellite over a 10-year period, to assess if stream interaction region (SIR) compressions have a universal impact for a presence of wide outflows. The analysis confirms a strong clustering tendency of wide exhausts to SIR compressions at 1 au. A superposed epoch analysis of a geomagnetic SYM-H index reveals a ring current intensification to the fast solar wind of a post-epoch interval as expected. We examine the electron strahl and confirm that less than 10% of the outflows are associated with a heliospheric current sheet. In contrast, more than 60% of wide outflows occur at current sheets resulting from heliospheric magnetic field inversions of open field topology. SIR compressions result in weak, recurring geomagnetic storms. However, they also appear to be an important driver of reconnection onset across large-scale solar wind current sheets.

Keywords: Stream Interaction Regions,Large-scale Reconnection,Ring Current

POSTER CODE: P1HEL419

Title
ACME: A SYNOPTIC REPRESENTATION AND VISUAL CATALOG OF CORONAL MASS EJECTION ACTIVITY

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Body
Coronal mass ejections (CMEs) are among the main drivers of severe space weather, yet their analysis typically requires the inspection of extended coronagraph image sequences. This poster presents ACME (Angular-time Coronagraph Map of solar Ejecta), a method that condenses a sequence of coronagraph observations into a single two-dimensional map of CME activity as a function of position angle and time. The method preserves key observational properties of CMEs, including their angular extent, propagation direction in the plane of the sky, brightness, and temporal evolution. Applied to the full STEREO/SECCHI COR2 archive, ACME produces a homogeneous catalog covering observations since March 2007. Originally developed for operational monitoring within the Spanish Space Weather Service (SeNMEs), ACME provides a compact synoptic view of coronal activity suitable for scientific analysis, event reconstruction, and machine-learning applications. This poster introduces both the ACME methodology and the resulting visual catalog available on Zenodo.

Keywords: Coronal mass ejections (CME),Image processing techniques,Catalogs

POSTER CODE: P1HEL420

Title
MAGNETIC TWIST SHAPES COUNTERSTREAMING SUPRATHERMAL ELECTRON SIGNATURES IN CMES

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Body
Counterstreaming suprathermal electron beams are a key signature of closed magnetic field structures within coronal mass ejections (CMEs). We investigate how the internal magnetic configuration of flux rope CMEs, particularly magnetic twist, controls the focusing and mirroring of trapped electrons and shapes bidirectional beam signatures at 1 au.

We simulate flux rope CMEs with varying twist using the Flux Rope in 3D (FRi3D) model within the EUHFORIA framework, a three-dimensional magnetohydrodynamic model of the solar wind and CME evolution. Based on these outputs, we perform test-particle simulations with the PARADISE code, which stochastically solves the focused transport equation.

Suprathermal electrons (1–1.5 keV) are injected into both legs of flux ropes with twist values of 1, 2, and 3, while the parallel mean free path is varied between 5 and 15 au. The simulations show that flux ropes efficiently confine electrons and produce clear counterstreaming signatures at 1 au. Beam focusing depends on both magnetic twist and parallel mean free path. Moderate twist combined with mean free paths of 10–15 au yields well-defined and symmetric bidirectional beams, indicating reduced scattering inside flux ropes compared to the ambient solar wind (~0.1–1 au).

Simulations without a CME produce no counterstreaming, confirming that closed flux rope topology is essential. These results demonstrate that suprathermal electrons are sensitive probes of CME magnetic structure and internal transport, highlighting the importance of realistic three-dimensional modeling for interpreting in-situ heliospheric observations.

Keywords: Bidirectional electron beams,Flux-rope CMEs,Test particle simulations,Magnetic twist

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION HEL4

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2HEL401

Title
ION-SCALE WAVE SIGNATURES AND ICME-HCS INTERACTION: A CONJUNCTION STUDY OF PSP, SOLO, AND WIND

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Body
The interaction between interplanetary coronal mass ejections (ICMEs) and other large-scale structures, such as the heliospheric current sheet (HCS), can lead to complex multi-scale evolution of the surrounding plasma environment. Ion-scale waves, i.e. waves with frequencies near characteristic ion length/timescales, have long been hypothesized to play vital roles in heating the solar wind, but their roles in the non-adiabatic heating of ICMEs are less clear. For instance, near perihelion of Parker Solar Probe's (PSP's) Encounter 22, a longitudinal conjunction occurred between PSP, Solar Orbiter (SolO), and the Wind spacecraft, during which each spacecraft crossed the HCS. At approximately the time that Solar Orbiter crossed the HCS, the leading edge of an ICME impacted and warped the HCS, as well as compressing the nearby plasma. Measurements of the small-scale magnetic helicity show clear signatures of ion-scale waves coincident with the layer of enhanced density. We compare and contrast the ion-scale wave properties observed by each spacecraft in Encounter 22 and other encounters, as well as discuss possible generation mechanisms for the observed waves. We hypothesize the effect of ICME-HCS interactions on the turbulence properties of plasma in and around ICMEs, with implications for the dominant local heating mechanisms.

Keywords: ICMEs,HCS,ion-scale waves,turbulence

POSTER CODE: P2HEL402

Title
IDENTIFYING AND PREDICTING CORONAL MASS EJECTION OCCURRENCE: OBSERVATIONAL CHECKLISTS FOR SPACE WEATHER FORECASTERS

Authors
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Body
Space weather forecasters are tasked with monitoring the Sun on a daily basis and issuing actionable information to various sectors that are impacted by solar activity. For example, the aviation sector, electricity distributors and satellite operators. The aim being to mitigate the risks posed by the Sun's activity. One particular form of solar activity can be particularly impactful at the Earth; coronal mass ejections (CMEs). Currently, space weather forecasters do not have a method by which CMEs can be forecast ahead of their occurrence. Instead, coronal mass ejection arrival time at Earth is forecast once an event has been confirmed to occur. In this talk, we discuss our assessment of fifty years of solar physics research in the area of the science of CMEs. We identify trends that emerge in how CME source regions evolve and signatures that CME source regions display in the hours before eruption. From this we have created checklists for space weather forecasters to enable an assessment of when a CME has occurred and also the likelihood of CME occurring in the following hours or days. We present the checklists and also look to the future potential of forecasting of CMEs once Vigil observations become available.

Keywords: CME forecasting,CME source regions

POSTER CODE: P2HEL403

Title
A STATISTICAL STUDY OF THE DEPENDENCY OF MAGNETIC SWITCHBACK OCCURRENCES DURING PARKER SOLAR PROBE ENCOUNTERS

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Body
Magnetic switchbacks are sharp and highly Alfvenic deflections in the magnetic field lines, based on the widely agreed definition by the community. Even though, their existence has been known since the 90s, with the in-situ data from missions such as Ulysses and Helios, the launch of the Parker Solar Probe (PSP) in 2018 showed that these structures are highly abundant in the young solar wind. In the light of this new discovery, extensive studies have been carried out in recent years to understand the properties, formation mechanisms, and effects of switchbacks on other phenomena in the solar wind mostly relying on the PSP observations. PSP provides a wide spectrum of data due to its unique orbit providing in-situ measurements between 9 to 50 Rs, as well as covering nearly half of a solar cycle. In our study, we use the first 17 PSP encounters which involve measurements during minimum and the ascending phase of the solar cycle, as well as radial distances extending from 11 Rs to 50 Rs. We aim to shed light on the dependency of the occurrence of switchbacks on some of the key variables such the spacecraft radial distance, the solar wind speed, and the sunspot number. We use statistical methods to disentangle the separate contributions of these three highly correlated variables, and find that the level of solar activity has a significant impact on the occurrence rate of switchbacks.

Keywords: Switchback,Solar wind,Magnetic field

POSTER CODE: P2HEL404

Title
NEW INSIGHTS INTO QUIET TIME SOLAR WIND AND CME-DRIVEN ENERGETIC IONS DYNAMICS FROM ASPEX ON-BOARD ADITYA-L1

Authors
Aakash Gupta [1], Dibyendu Chakrabarty [1], Santosh Vadawale [1], Shiv Kumar Goyal [1], Jacob Sebastian [1], Bijoy Dalal [1], Abhishek Kumar [1], M Shanmugam [1], Anil Bhardwaj [1]

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Body
Suprathermal ions, spanning energies from a few keV to several MeV, occupy the intermediate, non-thermal regime of heliospheric particle populations, bridging the ambient solar wind and high-energy cosmic rays. They are important seed particles for Solar Energetic Particle (SEP) events, which can disrupt space-borne technologies and pose radiation risks to astronauts. Under quiet solar wind conditions, where the interplanetary medium remains largely undisturbed, multi-directional observations by ASPEX-STEPS on-board Aditya-L1 reveal that suprathermal ions (150 keV to 1.3 MeV) exhibit near-isotropic distributions. This provides observational support for the isotropy assumption in the Parker transport equation, indicating a well-mixed solar wind reservoir. In this state, suprathermal ions likely consist of remnant particles from earlier solar activity that have been redistributed and homogenized over time. In contrast, during the passage of Coronal Mass Ejections (CMEs), ASPEX-STEPS observations reveal three distinct classes of particle flux variations: dispersed events, dispersion-less events, and mixed cases exhibiting signatures of both behaviors. Comparative analysis with ACE-EPAM measurements indicates that energetic electrons can significantly influence the observed ion flux variations during some ICME events. Furthermore, simultaneous magnetometer observations from Aditya-L1 show distinct changes in magnetic helicity corresponding to these different event classes. This investigation provides valuable insight into the directional characteristics, transport behavior, and source processes of the suprathermal ion population during the maximum phase of Solar Cycle 25. The observational results and their implications for heliospheric particle dynamics and SEP seed populations will be discussed in this presentation.

Keywords: Solar Wind,Heliosphere,ICME,Solar Energetic Particles

POSTER CODE: P2HEL406

Title
THE SBCROSS CATALOG

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Body
Heliospheric sector boundary crossings (SBCs), composed of the Heliospheric Current Sheet (HCS), Heliospheric Plasma Sheet (HPS), and surrounding plasma halo, represent fundamental structures in the solar wind that influence interplanetary dynamics and space weather. We present the SBCross catalog, an automated, publicly available database containing 1,076 SBC events derived from in-situ observations spanning more than 30 years (1995–2026), covering Solar Cycles 23 and 24 alongside the rising and maximum phases of Solar Cycle 25. By combining interplanetary magnetic field (IMF) and 255 eV suprathermal electron pitch angle distribution (PAD) data, our algorithm reliably captures large-scale polarity transitions, with 76% of detected SBCs exhibiting clear HPS signatures (beta > 1, n_peak > 10 cm^-3). Across the catalog, we find an average occurrence rate of ~2.6 events per Carrington rotation, a median event duration of 9.0 hours, and a median physical thickness of 7.4 × 10^6 km. Furthermore, approximately 15% of detected SBCs interact with interplanetary coronal mass ejections (ICMEs), with this proportion rising up to 40% during solar maximum. These ICME-associated events exhibit systematically longer durations (median of 11.0 hours), 54% larger physical thicknesses, and higher average solar wind velocities. Notably, all high-velocity SBC events (> 550 km/s) are exclusively driven by ICME interactions, demonstrating local plasma pile-up and structural entanglement resulting from fast CMEs overtaking the ambient slow background. The SBCross catalog serves as an updated successor to the classic SBC list by L. Svalgaard, delivering a standardized, open-access resource for the heliophysics community to systematically investigate sector boundary transitions.

Keywords: solar wind,hcs,sector boundary crossing

POSTER CODE: P2HEL407

Title
SPACE WEATHER CAPABILITIES OF THE POLARIMETER TO UNIFY THE CORONA AND HELIOSPHERE

Authors
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Body
The Polarimeter to UNify the Corona and Heliosphere (PUNCH) is a NASA mission that tracks space weather events (including CMEs) continuously across the inner solar system. PUNCH began normal science operations in June 2025. Its four spacecraft have captured nearly 2 million images, with a 4 minute cadence for polarized image sets. The Science Operations Center (SOC) combines raw images into near-seamless mosaics forming a single virtual instrument that views the entire inner solar system. The special QuickPUNCH pipeline, developed for NOAA, yields forecast-grade products in near real time, with latency measured in hours rather than days. I will give an overview of the mission and SOC status with an emphasis on the data products (which are free to all and compatible with most existing analysis tools). In particular, PUNCH data both enable new scientific views of the solar wind and CMEs, and allow forecast-grade tracking of halo CMEs and other solar effects, as they evolve and interact with the interplanetary medium.

Keywords: solar wind,PUNCH,space weather

POSTER CODE: P2HEL409

Title
REVEALING THE 3D STRUCTURE OF CORONAL MASS EJECTIONS WITH PHYSICS-INFORMED NEURAL RADIANCE FIELDS

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Body
Coronagraphic observations provide direct monitoring of coronal mass ejections (CMEs) through Thomson-scattered light from free electrons, but inferring the 3D plasma distribution from 2D images remains challenging because the corona and heliosphere are optically thin and inherently line-of-sight integrated.
We present SuNeRF-CME, a physics-informed tomography framework for 3D CME reconstructions from multi-viewpoint coronagraphic observations. The method uses a neural representation to model the time-dependent electron density and plasma evolution throughout the inner heliosphere. By explicitly modeling Thomson scattering and imposing physics-based constraints on plasma flow and propagation, SuNeRF-CME recovers CME direction, speed, morphology, and acceleration from a limited number of viewpoints.
Using synthetic CME observations, we show that reliable CME structures and kinematics can be obtained from only two viewpoints, while additional viewpoints substantially improve the reconstruction of the 3D plasma distribution. We further present a first application to observational data by combining STEREO-A/COR2, GOES/CCOR, and PUNCH observations into a unified physical representation to infer the dynamic 3D density and velocity field from 3 to 100 solar radii. This enables us to trace the evolution and deformation of the CME, characterize interactions with ambient solar-wind streams, and identify source regions associated with different solar-wind velocities using white-light observations alone. The framework intrinsically accounts for instrument calibration differences, stray-light effects, and F-corona contributions, and can be constrained and validated with in-situ measurements from PSP and Solar Orbiter.
This work demonstrates the potential of physics-informed, data-driven tomography for improved CME characterization and space-weather forecasting.

Keywords: CME,Tomography

POSTER CODE: P2HEL411

Title
CHARACTERIZING ALFVÉNICITY AND PROTON TEMPERATURE DISTRIBUTIONS IN ICME MAGNETIC CLOUDS

Authors
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Body
We investigated a comprehensive sample of 474 Interplanetary Coronal Mass Ejection (ICME) events observed by the Wind spacecraft to examine the Alfvénic characteristics within their magnetic cloud
regions. The analysis focuses on identifying in-phase and out-of-phase Alfvénic fluctuations of the magnetic and velocity field components. Our results reveal that approximately 73% of ICME magnetic
cloud regions are non-Alfvénic, while 27% exhibit clear Alfvénic signatures, predominantly characterized by outward (in-phase) fluctuations. Furthermore, the temperature distribution shows a substantial enhancement in Alfvénic regions compared to non-Alfvénic ones, with proton temperatures elevated up to 33 eV. These findings suggest that Alfvénic fluctuations may play a significant role in the localized plasma heating within ICME structures and provide potential constraints on their broader contribution to space plasma environments.

Keywords: Transients,Coronal Mass Ejections,Alfven Waves,Plasma Heating

POSTER CODE: P2HEL412

Title
STATISTICAL ANALYSIS OF SOLAR WIND RECOVERY AND INTERACTION FOLLOWING ISOLATED INTERPLANETARY CORONAL MASS EJECTIONS

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Body
This study presents a refined methodology for identifying and analyzing isolated Interplanetary Coronal Mass Ejections (ICMEs) to better understand their impact on the downstream solar wind. Using a multi-spacecraft approach we apply a filtering procedure to identify isolated events at 1 AU, removing those affected by Co-rotating Interaction Regions (CIRs) and other ICMEs.
We perform a Superposed Epoch Analysis (SEA) to characterize the evolution of plasma parameters during the passage of these structures. Preliminary results indicate that the presence of a sheath in the ICME significantly influences the recovery dynamics of the solar wind, particularly regarding the magnitude of change in density and magnetic field strength. Furthermore, we define a stability time and relaxing time to quantify how long the solar wind requires to recover to its quiet-time state after an ICME passage. Our initial findings suggest that density and magnetic field tends to recover more rapidly than solar wind speed across both sample groups. Moreover, ICMEs without sheaths appear to allow a faster return to quiet solar wind conditions, suggesting that the disturbances originated by the sheath have a more persistent effect on the heliospheric environment. This research provides new insights into the relaxation processes of the solar wind and the long-term impact of transient solar disturbances on the solar wind characteristics. The results will ultimately help to better predict the dynamic space environment around Earth.

Keywords: Isolated ICMEs,Relaxing time

POSTER CODE: P2HEL413

Title

UNDERSTANDING THE COMPLEX MORPHOLOGY OF A CME: HOW TO CREATE A SEVERE GEOMAGNETIC STORM

Authors

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Body

On April 21, 2023, a complex filament eruption produced an Earth-directed coronal mass ejection (CME) that triggered the first severe geomagnetic storm of solar cycle 25. The primary objective of this work is to understand the physical origin of the severe impact of CMEs on Earth. We explore the CME's complex morphology by simulating the eruption using the thermodynamic magnetohydrodynamic (MHD) model CORHEL-CME. We model the source region as two intertwined magnetic flux ropes and validate the early evolution of the eruption with extreme-ultraviolet and white-light observations. We then compare the simulated CME arrival time and structure with in situ measurements, finding that the CME merged with a co-rotating interaction region (CIR) before reaching Earth. This interaction compressed the CME sheath, producing a sustained negative Bz component that later triggered the geomagnetic storm. The internal configuration of the magnetic flux rope, which also maintained a sustained southward component during its propagation toward Earth, intensified the storm into severe.

This model-data comparison underscores the power of using MHD simulations, when validated by multi-viewpoint observations, to reveal hidden dynamical processes and improve the understanding and prediction of space weather impacts.

Keywords: Solar coronal mass ejections,Solar magnetic fields,Heliosphere,Magnetohydrodynamical simulati

POSTER CODE: P2HEL415

Title
MOTHER'S DAY 2024: MODELLING AN EXTREME SOLAR EVENT AND LEARNING HOW TO IMPROVE SPACE WEATHER FORECASTING

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Body
Between 10 and 14 May 2024, the Sun produced an extraordinary sequence of eruptions, the Mother's Day event, culminating in the most intense geomagnetic storm in decades. This event was driven by at least ten interacting coronal mass ejections (CMEs), accompanied by solar flares and filament eruptions, forming highly complex heliospheric structures with exceptional geoeffectiveness. Such CME–CME interactions present significant challenges for operational space-weather forecasting.
This study addresses the complexity of modelling extreme events within operational space weather frameworks. A key difficulty lies in constraining CME and solar wind input parameters, especially for halo and partial-halo CMEs, where parameter sensitivity is heightened. Accurate representation of CME–CME interactions necessitates physics-based magnetohydrodynamic (MHD) modelling rather than empirical approaches. We employ multi-point remote observations in white light and extreme ultraviolet to identify CME sources and derive their kinematic and geometric properties. These parameters drive three-dimensional MHD simulations of CME evolution and heliospheric propagation using the EUHFORIA model. Our best-performing simulation reproduced the storm's arrival time within approximately two hours and estimated its peak intensity with approximately 70% accuracy. Crucially, the inclusion of all contributing CMEs was essential for achieving this level of predictive reliability. Our findings underscore the need for improved observational infrastructure and enhanced modelling capabilities to address the inherent complexity of extreme space-weather events. Advancing the speed and accuracy of MHD-based forecasting tools is critical for mitigating the impacts of future solar superstorms. We highlight how this event serves as a benchmark for understanding the limitations of current models and a call for the urgent requirement for community-wide investment in both observational and computational resources.

Keywords: CME-CME interactions,Superstorm,Mother's Day event,Geomagnetic impact,Operational forecasting

POSTER CODE: P2HEL416

Title

SIMULATION OF SPACECRAFT CHARGING DYNAMICS DURING A CORONAL MASS EJECTION ENCOUNTER

Authors

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Body

Throughout their operational lifetime, spacecrafts constantly experience surface charging induced by the interaction with the surrounding space plasma environment. This interaction results in the accumulation of a net electrostatic charge on external and internal surfaces, as well as within dielectric materials. These charging phenomena can disturb scientific plasma measurements, as well as lead to electrostatic discharges and onboard electronics anomalies.

Spacecraft Plasma Interaction Software (SPIS), developed by ONERA and Artenum in cooperation with an international network of industrial and academic partners, is the reference tool for this kind of analysis and allows the user to simulate transient environments. By exploiting this feature, we propose to investigate the dynamic charge redistribution on a simple spacecraft composed of both conductive and dielectric materials during a Coronal Mass Ejection (CME) passage in the near-Earth solar wind environment.

The plasma data used as input for the environment comes from in-situ measurements. The goal of this study is to observe the temporal evolution of surface potentials and differential voltages across different material interfaces during extreme solar weather conditions.

Keywords: CME,Plasma,SPIS,Spacecraft Charging

POSTER CODE: P2HEL417

Title
ENSEMBLE MAGNETIZED CME MODELLING WITH FLAG: ANALYSIS OF OCTOBER 2024 EVENT AND FORECAST FRAMEWORK

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Body
One of the largest challenges in forecasting of coronal mass ejections is the ‘Bz problem’ – the geoeffectiveness of a CME can vary widely based on the orientation of its magnetic field, and current forecasts with hydrodynamic CME models do not have the ability to determine the magnetic structure of a CME before it is observed by an in-situ spacecraft. CME magnetic fields are excluded from forecasting mainly due to the lack of remote observation of a CME magnetic field, however the propagation of CMEs within an MHD model can also be affected by the magnetic field of the CME, so incorporating a forecast model with magnetized CMEs offers an additional perspective that can be compared to traditional ‘cone’ MHD CME models. We present results from the solar wind component of the FLAG forecast framework, which runs ensemble forecasts in real time with a 3D coronal model including insertion of pre-computed Gibson-Low flux rope CMEs, at 0.1 AU. The model outputs for the period around October 10 2024 will be shown, where strong CME signatures were seen at Earth and other nearby spacecraft. We show that it is possible to use magnetized CME models in forecasting tools in real time, and these frameworks should be developed, particularly in anticipation of additional upstream solar wind monitoring that can be provided by missions such as HENON and SHIELD.

Keywords: Magnetohydrodynamic modelling,Coronal Mass Ejection,Space Weather Forecasting,Multispacecraft Obeservations,Extreme Space Weather

POSTER CODE: P2HEL418

Title
DERIVING AN INTERPRETABLE CME TRAVEL TIME FORMULA BY SYMBOLIC REGRESSION

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Body
In this study, we derive an empirical formula for the travel time (TT) of coronal mass ejections (CMEs) using symbolic regression. For this we use a data set constructed by Napoletano et al. (2022), which consists of 216 interplanetary CME (ICME) events from 1997 to 2018 based on the Richardson and Cane ICME catalog and the coordinated data analysis workshop (CDAW) CME catalog. We also use 1-hour interval solar wind speed data provided by OMNI. As input parameters for the model, we use the CME speed and acceleration at 20 solar radii, the solar wind speed at Earth when the CME passes 20 solar radii, and the solar wind speeds at 26, 25, 24, and 23 days prior to that time. Our major results are as follows. First, the primary parameter selected by the model is the CME speed, which is the most important factor in predicting the TT, as already well known. Second, the next selected parameter is the solar wind speed 23 days prior, which corresponds to the background solar wind speed of previous solar rotation if its traveling time is assumed to be 4 days. This suggests that background solar wind speed is also important for the TT of CMEs and it can be approximated estimated as that of the previous solar rotation. We will examine additional parameters such as CME source location and corona hole properties to identify the main parameters controlling CME TT.

Keywords: CME Travel Time,Symbolic Regression

POSTER CODE: P2HEL420

Title
TURBULENCE AND KINETIC EFFECTS IN THE INNER HELIOSPHERE: IN SITU OBSERVATIONS AND NUMERICAL EXPERIMENTS

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Body
Turbulence in plasmas involves a complex cross scale coupling between electromagnetic fields and distortions of particle velocity distributions, giving rise to non thermal features. How the energy contained in large scale fluctuations cascades down to kinetic scales — and how this turbulent energy interacts with particles — remains one of the major open questions in plasma physics.
Using new measurements from Solar Orbiter, we investigate the radial evolution of turbulent magnetic fluctuations near ion scales during solar wind expansion. Ion scale turbulence is characterized by non compressive coherent structures, including current sheets, vortex like features, and wave packets identified as ion cyclotron modes. These structures are key contributors to solar wind intermittency are strongly associated with localized energy dissipation. Significant particle energization, temperature anisotropies, and marked departures from Maxwellian distributions are observed inside and around these structures, in both in situ data and numerical simulations. Furthermore, we examine kinetic effects in protons and alpha particles in the presence of switchbacks — large magnetic field deflections coincident with sudden increases in radial solar wind speed. Notably, we find a clear correlation between switchbacks and alpha particle temperature, but not proton temperature, suggesting that magnetic field deflections may preferentially heat heavier ions. In parallel, we explore kinetic features in a multi-component turbulent plasma through Vlasov–Maxwell simulations. Machine learning methods are also being employed to automatically identify coherent structures, classify non thermal particle distributions, and detect subtle correlations that are often missed by traditional analysis. These techniques significantly enhance our ability to interpret complex multi parameter datasets and provide new insights into the small scale processes that govern plasma heating.

Keywords: Solar Wind,Turbulence,Observations,Simulations,Machine Learning

POSTER CODE: P2HEL421

Title
TIME-DEPENDENT DATA-DRIVEN MODELLING OF ACTIVE REGION EVOLUTION AT GLOBAL AND LOCAL SCALES

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Body
Time-dependent observation-driven modelling of the solar coronal magnetic field has emerged as a new tool for unraveling the dynamics of solar active regions in particular. Driven directly by observed changes of the photospheric magnetic field, these models hold the promise of self-consistently capturing the complex chain of events from the formation to the destabilisation and subsequent eruption of structures hosted in active regions. Detailed modelling of this kind has typically been carried out in local Cartesian domains, whereby any longer-range interaction between active regions is neglected, and dynamics in the extended corona cannot be studied.

In this work, we present our efforts to extend our coronal modelling capabilities to global full-Sun domains while retaining high spatial resolution in localised areas via mesh refinement techniques. The use of a hierarchy of computational meshes requires special attention when constructing the photospheric electrograms that drive the model. More pressingly, constructing global photospheric electrograms over large spatiotemporal domains introduces unique challenges due to the limited availability of high-quality vector magnetogram observations. In this work, we describe our model and methodology and showcase recent results of eruptive structures that can now be followed to the upper corona and nascent solar wind.

Keywords: Coronal mass ejections,Modelling,Data-driven,Active regions

POSTER CODE: P2HEL422

Title

RADIAL EVOLUTION OF THE CORONAL HOLE AREA – HIGH SPEED STREAM VELOCITY RELATION: MULTI-POINT OBSERVATIONS FROM PSP AND SOLAR ORBITER

Authors

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Body

The relationship between coronal hole (CH) area and the properties of associated high-speed solar wind streams (HSS) at 1 AU has been widely studied, with a positive correlation established between CH area and peak solar wind speed. However, the evolution of this relationship in the inner heliosphere has yet to be studied. This study investigates the CH–HSS connection across multiple radial distances using high-resolution in-situ measurements from the Parker Solar Probe (PSP) and Solar Orbiter (SO). These missions provide a unique opportunity to obtain observations from the inner heliosphere (~ 0.05 AU) through to near-Earth space at 1 AU.

Solar wind plasma and magnetic field data from the SWEAP and FIELDS instruments onboard PSP, as well as corresponding observations from SO are combined with EUV imaging from Solar Dynamics Observatory (SDO) to identify coronal hole sources and quantify their areas. Results from PSP data show that the correlation between CH area and peak solar wind speed persists even in the near-Sun region, i.e., the peak velocity of HSS increases with increasing CH area. A Pearson correlation coefficient of ~0.517 ($p < 0.001$) is obtained which is comparable to values reported at 1 AU and this correlation does not show any significant dependence on radial distance. Further, Solar Orbiter observations at intermediate heliocentric distances are used to extend the radial coverage of the study across the inner heliosphere.

These results suggest that the CH area-peak HSS speed relationship is not primarily introduced by interplanetary propagation but is likely established close to the Sun. The lack of radial evolution indicates that coronal hole properties such as their magnetic structure and open-field topology control the initial acceleration of the fast solar wind. Finally, these findings imply that the basic characteristics of high-speed streams are determined at the source region, providing observational constraints for solar wind models.

Keywords: High Speed Solar wind stream,Coronal Holes,Inner heliosphere,Parker Solar Probe,Solar Orbiter

POSTER CODE: P2HEL423

Title
TRACING SOLAR WIND VARIABILITY AT 1 AU: THE ROLE OF FLOW-TYPE DOMINANCE IN THE DELAYED RESPONSE TO SOLAR ACTIVITY

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Body
Although the precise origin of each component is still debated, the solar wind originates primarily from the expansion of the solar corona and is driven by the solar magnetic field. While the 11-year solar cycle modulates the bulk characteristics of this wind, the coupling is non-linear. Consequently, fluctuations in solar wind properties exhibit discrepancies in both amplitude and phase timing when compared to traditional solar activity indicators.
This study investigates the evolution of the relationship between a chromospheric proxy, the Ca II K index, and 1 AU solar wind properties (speed, temperature, and dynamic pressure) over the period 1965–2024, spanning the last five solar cycles. Our cycle-based analysis reveals significant variations in time lag, correlation coefficients, and fit slopes (amplitude). Specifically, we find evidence of a linear relationship between the yearly time lag and the slope of the fit that characterizes how solar wind properties depend on the intensity of the magnetic cycle.
Furthermore, the study examines these fluctuations in the context of different solar wind flow types, specifically CME-related, corotating-stream, and slow-wind components. We find the cycle-to-cycle time lag primarily reflects the corotating-stream component, which dominated SC 20–23. However, in SC 24, the slow wind became the dominant contributor as CME flows nearly halved. These phase variations emerge from an interplay between components with distinct cycles: CME flows are in-phase with the solar magnetic cycle, while the slow wind is in anti-phase. This amplitude modulation explains the observed phase shifts and supports future modeling using in-phase and quadrature components to link specific solar wind flows to space climate.

Keywords: Space Climate,Ca II K,Time lag,Solar cycle,Solar wind components

POSTER CODE: P2HEL424

Title

ANALYSING THE EVENT OF 26TH OCTOBER USING METIS OBSERVATIONS AND PHYSICS BASED MODELLING

Authors

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Body

The METIS Coronagraph onboard Solar Orbiter provides us with a multi wavelength aspect as it observes simultaneously in Visible (VL) band between 580 and 640 nm and Ultraviolet (UV) band at 121.6 nm. It also observes at a high spatial and temporal resolution, thus, allowing a comprehensive interpretation of solar events.

In our study, we particularly analyse the Coronal Mass Ejection (CME) event of 26th October 2024, which was a complete halo as observed through the Metis viewpoint and had in-situ signatures across four spacecrafts separated over a 100 degrees. We further analyse an homologous event on 24th October 2024 that precedes our event. In particular, we apply the triangulation method on both the CME events where they are fitted using the Graduated Cylindrical Shell (GCS) model. For this purpose, along with the VL Channel data from Metis, white light coronagraph data from LASCO C2/C3 and STEREO COR2A were used. Presence of multiple viewpoints result in accurate measurement of the position, speed and direction of propagation of both of these events.

Furthermore, we employ the 3D Magneto hydrodynamic models EUHFORIA and WSA-Enlil to predict the arrival times at all these locations and compare them with the in situ signatures. In this work, I will present the arrival time comparisons for cases with and without taking into account the previous event as well as emphasise the importance of choosing the right solar wind background.

Keywords: Sun-Heliosphere,ICMEs- Modelling,Multi-spacecraft

POSTER CODE: P2HEL425

Title

IMPACT OF FAR-SIDE MAGNETOGRAM INFORMATION ON CME ARRIVAL TIMES DURING THE MAY 2024 GEOMAGNETIC STORM

Authors

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Body

In this work, we use ADAPT-HMI global photospheric maps to drive heliospheric simulations with the WSA+Enlil+Cone modeling framework. Focusing on the May 2024 period, we perform simulations both with and without far-side magnetogram information from the Polarimetric and Heliospheric Imager onboard Solar Orbiter. We particularly model the coronal mass ejections (CMEs) associated with the intense geomagnetic storm that occurred during that time. Our goal is to quantify the differences in the CME arrival time and duration between the two simulations, and discuss the implications of incorporating far-side observations for improving heliospheric modeling accuracy and operational space weather forecasting.

Keywords: Solar wind,Solar Orbiter,Far-side magnetogram info,CMEs,Arrival times

POSTER CODE: P2HEL426

Title

MULTI-VIEW VECTOR SYNOPTIC MAPS FROM SO/PHI AND SDO/HMI AS BOUNDARY CONDITIONS FOR CORONAL MODELING

Authors

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Body

Synoptic maps of the solar photospheric magnetic field are widely used as boundary conditions for data-driven coronal and heliospheric models in space weather applications. Current maps, commonly generated from a single Earth-based viewpoint, require approximately 27 days to complete, introducing temporal inconsistencies that can affect the accuracy of coronal models and their forecasts. With deep-space missions operating from different orbital perspectives, such as Solar Orbiter and Vigil, complementary viewpoints become available, allowing for faster and more temporally consistent maps.

In this work we present recent developments in synoptic maps combining observations from Solar Orbiter Polarimetric and Helioseismic Imager Full Disk Telescope (SO/PHI-FDT) and Solar Dynamics Observatory Helioseismic and Magnetic Imager (SDO/HMI), with particular focus on vector synoptic maps. While line-of-sight magnetic field synoptic maps are predominantly used, vector synoptic maps provide access to the full magnetic field vector and improve the derivation of the radial field where line-of-sight assumptions break down. We first discuss the implications of combining different observations for synoptic maps, namely the cross-calibration, noise levels and differences in data coverage. We further assess the impact of multi-view vector synoptic maps on coronal modeling by comparing models using different types of input maps: SO/PHI-SDO/HMI combined maps and SDO/HMI-only maps, evaluating both line-of-sight derived and full vector cases. Finally, we illustrate the relevance of our work for the development of space-weather data-products from the upcoming Photospheric Magnetic field Imager (PMI) aboard ESA's Vigil mission.

Keywords: Vector Synoptic Maps,Multi-View Synoptic Maps,Data-driven Coronal Modeling,SO/PHI,Vigil/PMI

POSTER CODE: P2HEL427

Title
MAY 2024 CMES ARRIVAL TIMES WITH EUHFORIA AND THE CONE MODEL

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Body
Many questions must be answered before understanding the relationship between the emerging magnetic flux through the solar surface and the extreme geoeffective events. To address this problem, we consider the events of May 2024 and use two models:
1) TMF time-dependent magneto-friction for setting up an initial non-potential magnetic field in the active region. A zero-beta MHD model for tracing the magnetic evolution of active regions.
2) EUHFORIA, the "European heliospheric forecasting information asset" for interplanetary CME propagations.
For eruptive flares with CMEs, magnetic energy is computed alongside data-constrained MHD simulations for the May 2024 events. We show the consistency between the data-initiated realistic simulation of the May 2024 big event and energy scaling from an idealised simulation of a bipolar eruption using OHM. The estimated free magnetic energy did not exceed 5.2 × 1032 erg.
Good arrival-time predictions (<3 hours) are achieved with the EUHFORIA simulation using the cone CME model. We note the interest in coupling all the chains of codes from the Sun to the Earth and developing MHD models.

Keywords: MHD simulatioons,Solar Wind,CME,May 2024

POSTER CODE: P2HEL429

Title

SOLAR WIND EXPANDING PARCEL TRACKING (SWEPT): A WEB TOOL FOR THE IDENTIFICATION OF PLASMA LINEUPS

Authors

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Body

Multi-spacecraft in-situ observations of the solar wind across a wide range of heliocentric distances have become a cornerstone of inner heliosphere research. Periods of radial alignment between spacecraft offer unique opportunities to study the radial evolution of solar wind plasma and magnetic structures along the same flux tube, provided that the plasma connection between spacecraft can be reliably identified. We present the Solar Wind Expanding Parcel Tracking (SWEPT), an open-source toolkit designed to identify radial alignments between arbitrary pairs of heliospheric spacecraft, taking into account the travel time of plasma parcels. The current release supports Parker Solar Probe, Solar Orbiter, STEREO-A, Wind and ACE; the architecture is designed for straightforward extension to additional missions. The method propagates plasma parcels observed at the inner spacecraft forward in time using measured solar wind velocities, and evaluates their trajectories relative to the outer spacecraft. Both constant-velocity and constant-acceleration propagation models are implemented. The framework provides automated retrieval of spacecraft ephemerides from the JPL Horizons service and plasma measurements from the NASA CDAWeb archive, propagation modeling, and diagnostic visualization. An interactive web application implemented using the Streamlit platform allows a user friendly exploration of alignment events. We present a case-study for illustrating the functionalities of the toolkit and we discuss possible future improvement of the application.

Keywords: Solar wind,Radial Alignments,Open source web application

POSTER CODE: P2HEL430

Title

AUTOMATIC CMES IDENTIFICATION AND TRACKING FROM LASCO IMAGES VIA A SEMI-LAGRANGIAN APPROXIMATION

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Body

Coronal Mass Ejections (CMEs) consist in eruptions of magnetized plasma from the corona of the Sun towards the heliosphere and, when directed towards the Earth, can potentially cause geomagnetic storms, disrupting human technologies, such as satellites, power grids or communication devices. Therefore, real-time analysis of these phenomena, through accurate identification and tracking of CMEs, is essential to be able to provide an alert on Earth and prepare adequate countermeasures.

In terms of coronagraph images, a CME is defined as a new white light object moving with outward velocity into the heliosphere over a period of minutes to hours. Due to the high luminosity emanating from the corona and the consistent presence of noise typical of astronomical images (see, e.g., Roscani et al., A&A, 2020), the visualization of a CME is not an easy task.

Starting from coronagraph images, in particular C2 and C3 images from the Large Angle and Spectrometric Coronagraph (LASCO), we propose a simple and efficient procedure for the detection and tracking of CMEs, based on time-differencing and contrast enhancing techniques to preprocess the images, and on the level-set method (Osher and Sethian, JCP, 1988) for their segmentations. More in detail, we use a Semi-Lagrangian scheme (Falcone and Ferretti, SIAM, 2014) for the Chan-Vese model (Chan and Vese, IEEE Trans. Image Process., 2001) to process sequences of running differences (RD) in the detection step, which also provides the time interval of the event, and sequences of the associated base differences (BD) in order to follow the evolution of the CMEs.

The proposed procedure is fully automatic, independent on manual thresholding parameters typical of classical procedures, and provides reliable results in real-time on a wide range of test cases, which are compared with state-of-the-art methods.

Keywords: Coronal Mass Ejections,Semi-Lagrangian Schemes,Active Contours,LASCO C2 images,LASCO C3 images

POSTER CODE: P2HEL431

Title

THE PHYSICS OF INTERPLANETARY DISTURBANCES: IDENTIFYING SOLAR WIND STRUCTURES AND TRANSIENTS THROUGH UNSUPERVISED ANOMALY DETECTION

Authors

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Body

Interplanetary coronal mass ejections (ICMEs) and stream interaction regions (SIRs/CIRs) are among the main drivers of heliospheric variability and geomagnetic activity. Their evolution and geoeffectiveness strongly depend on the structure of the ambient solar wind and on the interaction between transient and recurrent solar wind regimes. In this context, their robust identification is crucial for understanding heliospheric dynamics and improving space weather forecasting capabilities.

In this work, we investigate data-driven methodologies for the automatic detection of anomalous solar wind structures using in-situ measurements. Unsupervised anomaly detection techniques are applied to multivariate time-series representations of plasma and magnetic field parameters in order to identify intervals associated with interplanetary disturbances and large-scale structures, without imposing predefined event thresholds or event-specific assumptions. The proposed framework highlights statistically unusual configurations of the heliospheric plasma environment, including compressed regions, magnetic enhancements, and transitions between different solar wind regimes. Comparisons with independent ICME catalogs show that many detected anomalous intervals overlap with known interplanetary transients, while ongoing investigations are exploring the relationship between the detected structures and recurrent solar wind interaction regions such as CIRs/SIRs. The methodology also reveals complex or mixed configurations that may be difficult to characterize through standard classification approaches alone.

Ultimately, these results offer new insights into how the heliospheric plasma configures itself, establishing a more robust physical foundation for understanding the drivers of severe geomagnetic storms

Keywords: Space Weather,Data-Driven Strategies,Anomaly Detection,Geomagnetic Storms

POSTER CODE: P2HEL432

Title
INFLUENCE OF MORPHOLOGY OF HELIOSPHERIC CURRENT SHEET ON THE MODELED SOLAR WIND

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Body
EUHFORIA 2.0 (EUropean Heliospheric FORecasting Information Asset, Pomoell & Poedts, 2018) is a space weather prediction tool that simulates the time-evolution of the inner heliospheric plasma environment using a combination of empirical and physics-based modelling approaches. The default coronal model employed in EUHFORIA consists of the potential field source surface extrapolation (PFSS), Schatten current sheet (SCS) model, and semi-empirical WSA model, which simulate the plasma and magnetic conditions at the inner boundary (0.1 au). Key parameters within this modelling, such as the PFSS source-surface height (SSH) and the inner boundary of the SCS model significantly influence the location and geometry of coronal holes and consequently the modeled solar wind. Recent study (Valentino et al in prep) indicates that varying these two parameters also very strongly changes the shape of the heliospheric current sheet (HCS).

In this study, we first address the changes in the modeling accuracy of the solar wind at the positions of Parker Solar Probe (PSP) during the first 10 close approaches (distance range of 0.10–0.40 au). We modified the EUHFORIA's default value pair of SSH and SCS from (2.6, 2.3) to (1.7, 1.4). Both modeled time series are confronted with observations. We then selected one interval of the PSP observations covering the larger distance range than in the closest approach, i.e. 0.10–0.75 au. We first inspected the shape of the HCS in the 3D domain for both pairs of (SSH, SCS) and then studied how the changes in the HCS impact the modeled solar wind at increasing distances from the Sun.

Keywords: EUHFORIA model,Solar wind,Heliospheric current sheet,Parker solar probe,PFSS source-surface height

POSTER CODE: P2HEL433

Title
MODELING ENERGETIC PARTICLES DURING SOLAR ERUPTIONS

Authors
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Body
In recent literature, the role of solar eruptions in solar energetic particle events has become increasingly important. Eruptions such as coronal mass ejections are linked to the initial acceleration of SEPs, but how SEP events evolve remains under discussion. Current sheets have been highlighted as a possible highway for the particles to move along. Moreover, current sheets are found in the complex magnetic field near the Sun's surface as well as the broadly spanning heliospheric current sheet through which all SEP events travel. Linked to the current sheet, we should also account for magnetic reconnection. When magnetic current sheets reconnect, they release energy, which can further accelerate SEPs. Thus, magnetic reconnection directly impacts the evolution of SEP events. This makes current sheets and magnetic reconnection important factors that could influence evolving SEP events.
The research presented in this poster investigates the combined role of solar eruptions and current sheets in the development of SEP events. Using 2.5D global simulations of the solar atmosphere, we generate an SEP event through the use of shear-induced CME simulations. This CME will be embedded in the complex magnetic structure of a helmet streamer, along which the evolution of particles are followed. The impact of magnetic reconnection on the evolution of these particles will be highlighted.

Keywords: Heliosphere,CME,Solar Energetic Particles

POSTER CODE: P2HEL434

Title

CORE DIMMINGS AND THEIR RELATION TO FLUX ROPE FOOTPOINTS AS INFERRED FROM SOLAR CORONAL MODELLING

Authors

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Body

Coronal dimmings are sudden decreases in brightness in the solar corona, observed in EUV and soft X-rays that accompany solar eruptions. Pairs of deep localised dimmings that appear close to the eruption site are traditionally referred to as core dimmings and are interpreted to mark the density depletion from the footpoints of the eruption flux rope. However, little investigation of whether these dimmings properly mark the flux rope footpoints utilising coronal magnetic field modelling has been done. Thus, we present a time-dependent data-driven magnetofrictional model simulation of AR12975 and study the dimmings and flux rope evolution in detail. AR12975 features a filament prior to a confined C2 class flare. Shortly afterwards, a new filament forms with the northern footpoint rooted in the same region. However, the southern footpoint is now rooted at a remote location within the active region. This configuration was clearly unstable, as the filament erupts just about 1.5 hours after the C2 class flare with an M4 class flare. The flux rope, that develops in our time-dependent simulation, follows the observed topological reconfiguration of the active region's magnetic field well. We then track the flux rope footpoints along with the observed dimmings and investigate their overall match, area and magnetic flux in detail.

Keywords: Coronal Dimmings,CMEs,Solar Modelling,Magnetic Field,Observations

POSTER CODE: P2HEL435

Title
MANY ROADS TO 1/F IN SPACE WEATHER: DISTINGUISHING MECHANISMS BEHIND BROADBAND POWER-LAW FLUCTUATIONS

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Body
Power-law-like power spectral densities — often loosely called 1/f noise — appear throughout solar wind and geomagnetic time series, from interplanetary magnetic field fluctuations to auroral and ring-current indices. A well-known ambiguity, recognised since the earliest 1/f-noise literature, is that many distinct generative mechanisms can produce indistinguishable spectral slopes: self-organized criticality and avalanche models, Superposition of Ornstein-Uhlenbeck Processes (SOUP/eSOUP-type models), fractional or long-range-dependent stochastic driving, and renewal or multiplicative processes can all yield broadband power-law spectra over some finite range. Spectral shape alone therefore cannot discriminate between these roads to 1/f — doing so requires additional statistics (higher-order structure functions, non-Gaussianity, surrogate-data testing) that probe structure beyond the power spectrum.

We survey this landscape as it applies to solar wind turbulence and geomagnetic indices, drawing on generative toy models (sum-of-squared Gaussians, eSOUP, ...) alongside surrogate-based statistical testing. As a concrete illustration of why this matters practically, we examine a recent machine-learning claim that turbulence descriptors improve short-term AE forecasting beyond mean-field solar wind parameters (Waters et al. 2026). Reimplementing the published pipeline and testing it against a phase-randomized, spectrally-matched Gaussian surrogate — a substantially stricter null than the original i.i.d. control — shows that a large but horizon-dependent fraction of the apparent turbulence advantage is attributable to spectral shape alone, with a smaller, consistently positive residual surviving at every forecast horizon tested. The same ambiguity that complicates identifying which generative mechanism underlies an observed 1/f spectrum also complicates deciding what features of turbulence an engineered machine-learning feature has captured.

Keywords: Turbulence,1/f,Null models

POSTER CODE: P2HEL436

Title
SYNTHETIC POLARIZED WHITE-LIGHT IMAGING OF EVOLVING CORONAL MASS EJECTIONS

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Body
We present the latest results from our ongoing efforts to generate realistic, synthetic remote white-light images of coronal mass ejections (CMEs) near the Sun and throughout their propagation and evolution in the heliosphere. Our simulations now include the capability to generate synthetic polarized white-light images, specifically tailored for comparison with observations from the recently launched PUNCH mission. This technique accommodates a diverse range of CME geometries, from standard GCS-like torus structures to highly deformed and twisted flux ropes with non-circular cross-sections. The electron density of the CME, which is the observable, is highly configurable, utilizing an analytical function within the coordinate space that defines the geometry. By employing a volume splatting technique, we simulate white-light images without the computational expense of traditional ray-tracing calculations. This highly efficient approach enables the rapid creation of synthetic images, making it feasible to produce complete time-series for dynamically evolving CME structures on the fly. In this presentation, we provide examples of how our approach can be used to analyze recent observations.

Keywords: Coronal Mass Ejections,Heliospheric Imaging,Polarization

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SESSION IOM1

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2IOM101

Title
Impact of Far Side Magnetic Fields on Coronal and Solar Wind Predictions

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Body
Modeling of the corona and solar wind is challenging, as it is highly dependent on global photospheric magnetic field maps, which serve as the boundary conditions to all coronal models that drive solar wind models. Unfortunately, less than half of the Sun's photospheric magnetic field is reliably measured from any given vantage point and thus it is common for the maps to have highly dated and unreliable measurements in them. While Solar Obiter (SolO) now provides for the first time the opportunity to have simultaneous measurements of nearly the entire surface magnetic field of Sun (e.g., when SolO/PHI measurements are combined with those from SDO/HMI), the required alignment to accomplish this occurs only occasionally. Further, coronal models are extremely sensitive to the strengths of the polar magnetic fields of the Sun, which remain poorly observed. Recently, efforts to mitigate this problem include using flux transport models such as the Air Force Data Assimilative Photospheric Flux Transport (ADAPT) model, which evolves the field forward in time using well known transport processes occurring on the Sun. However, these models do not normally account for far-side emergence of new magnetic flux, which can significantly impact coronal and solar model predictions. The ADAPT model now includes the ability to include far-side active regions (e.g., determined via helioseismology or direct observation from Solar Orbiter) into the output maps it generates. Using newly developed tools for quantitatively comparing coronal and solar wind predictions with observations, we explore and quantify the impact of including far-side active regions in ADAPT on coronal and solar wind predictions at Earth and other locations such as near L5 and L4.

Keywords: Solar Wind,Corona,Space Weather Forecasting,Photospheric Magnetic Fields,Solar Far Side

POSTER CODE: P2IOM102

Title
Preparing for the Future Vigil Mission: how RIMAP and L5 Observations will sharpen Space Weather Forecasting

Authors
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Body
Understanding the propagation of solar eruptions is vital for space weather forecasting. While models like ENLIL (Odstrcil, 1994, 2003; Odstrcil et al., 2023), a 3-D MHD code that simulates solar wind and Coronal Mass Ejections (CMEs) through the inner heliosphere, and EUHFORIA (Pomoell & Poedts, 2018), a forecasting tool for CME geo-effectiveness, are standard, they rely on remote-sensing observations and complex coronal models. This approach can result in simulations that only partially agree with in situ measurements.

A new method, RIMAP (Reverse In situ and MHD APproach - Biondo et al., 2021), offers a paradigm shift. Instead of propagating from the Sun outwards, RIMAP uses in situ plasma measurements at 1 AU to reconstruct the inner heliosphere. It applies a back-reconstruction technique to remap these observations to an inner boundary at 0.1 AU. The plasma is then re-propagated outward by solving the MHD equations on the equatorial plane using the PLUTO code (Mignone et al., 2007, 2012). This data-driven approach generates a stable 2-D solution of the heliospheric plasma, including the magnetic Parker spiral, that agrees better with observations and captures small-scale features missed by other methods. A new version of RIMAP is now under development to account for the effect of turbulence in the back-propagation of solar wind flowlines, thanks to the project funded by PRORIS.

RIMAP's methodology is particularly relevant for the future ESA Vigil mission (Eastwood et al., 2024). Positioned at the Sun-Earth L5 Lagrange point, Vigil will observe solar activity and the solar wind from a unique vantage point, providing data on structures before they rotate into view from Earth. This L5 perspective will provide the crucial input for RIMAP to reconstruct the heliospheric plasma structure that will impact Earth approximately 4.5 days later, significantly enhancing forecasting precision.

Keywords: Numerical Modeling,In situ data,Parker spiral

POSTER CODE: P2IOM103

Title
ONBOARD DETECTION AND TRACKING OF CMEs: FOURIER FILTERING AND KALMAN ESTIMATION FOR HARDWARE-ORIENTED ARCHITECTURES

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Body
The ESA Vigil mission will operate from the Sun–Earth Lagrangian point L5, providing continuous observations of the inner heliosphere to improve space weather nowcasting and forecasting. As a dedicated operational mission, its primary objective is the timely and reliable identification of CMEs. Its Heliospheric Imager (HI), consisting of two wide-field visible-light cameras (HI-1 and HI-2), is designed to detect faint solar wind structures with brightness levels down to a few percent of the coronal background, building on the heritage of the HI onboard the STEREO mission. To achieve this sensitivity, the instrument relies on long-exposure acquisitions (20–30 s) and temporal integration over ~30 minutes. However, such observing conditions significantly increase susceptibility to spurious signals induced by Solar Energetic Particles (SEPs) interacting with the CCD detector.
We present a proposed architecture for autonomous onboard identification of CMEs. The acquired images are processed directly on-board, allowing an optimization of payload resources in terms of data traffic and memory occupation. This approach ensures that the instrument's computational capabilities are dedicated to the operational goal: CME identification and tracking. This also benefits the ground segment by reducing the infrastructure required to constantly receive, process, and archive data.
The algorithmic pipeline operates in sequential stages relying on 2D Fast Fourier Transform and Kalman filtering, allowing it to successfully discriminate the coherent spatial propagation of a CME from residual stochastic noise.
Validation on representative heliospheric imaging data demonstrates the method's effectiveness in isolating and tracking faint CME fronts under highly degraded SNR conditions, offering a robust, hardware-ready solution for next-generation space weather early-warning systems.

Keywords: CME detection and tracking,Fourier Filtering,Onboard processing,early warning,ESA Vigil

POSTER CODE: P2IOM104

Title
Synthetic Solar Wind to reconstruct the interplanetary medium with RIMAP using STEREO observations at L5

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Body
Reconstructing the ambient heliospheric plasma parameters is crucial for understanding the propagation of coronal mass ejections (CMEs) through the interplanetary medium. The Reverse In situ data and MHD Approach (RIMAP; Biondo et al., 2021) models the plasma and magnetic field conditions in the Parker Spiral, binding them to in-situ measurements collected at different heliospheric distances. However, reconstructing the background solar wind becomes challenging when CME signatures contaminate the in-situ observations.
In this work, we propose a method to identify and filter out CME signatures from in-situ observations using clustered solar wind data. Then, the removed intervals are replaced with synthetic solar wind time series, generated as a stochastic Fourier signal that maintains the same spectral slope of the ambient solar wind parameters (proton density, bulk speed, and magnetic field) fitted on the measurements of the day preceding the removed event.
To ensure physical consistency among the reconstructed parameters, we use empirical relationships between proton speed and density derived from identified solar wind clusters, associated with distinct solar wind regimes (slow vs. highly Alfvénic). For the highly Alfvénic-like wind, velocity generation is based on a simplified model that reproduces typical Alfvénic fluctuations. We validate this methodology using a test case from STEREO-A observations in which the spacecraft was near the L5 Lagrange point.

Keywords: Solar Wind,Interplanetary Transients,Modelling,Space Weather,Unsupervised Learning

POSTER CODE: P2IOM105

Title
One Simple Trick for Calibrating a Coronagraph: Use Sun-Like Stars

Authors
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Body
Absolute photometric calibration of white-light coronagraphs typically depends on detailed knowledge of instrument throughput, spectral response, and pre-flight calibration. We present a simpler approach based on Sun-like stars selected from the Gaia catalogue.
For stars with spectral energy distributions closely matching the Sun, the star-to-Sun flux ratio is nearly independent of the observing bandpass. Gaia photometry can therefore be used to predict stellar brightness directly in units of mean solar brightness (MSB), while the corresponding stellar signal is measured in coronagraph images in DN s^-1. Their ratio provides an empirical conversion between detector signal and MSB without requiring an existing absolute calibration or detailed knowledge of the instrument spectral response.
We apply this method independently to both CCOR-1 and CCOR-2, demonstrating its ability to recover and monitor their photometric calibration using routine science observations alone. The stellar measurements also provide a direct means of tracking changes in instrument response over time and distinguishing them from variations in the coronal and stray-light background.
Because the method relies primarily on catalogue photometry and the presence of suitable solar analogs in the field of view, it is readily transferable to other broadband white-light coronagraphs. Sun-like field stars can thus provide a simple, independent, and repeatable on-orbit radiometric calibration standard for current and future operational coronagraphs.

Keywords: Coronagraph,Photometric calibration,White light

POSTER CODE: P2IOM106

Title
Observing the Solar Corona from Off-the-Sun-Earth-Line with an Innovative Class of Coronagraphs

Authors
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Body
A coronagraph is an essential instrument in solar missions for studying and monitoring the highly dynamic plasma of the outer atmosphere of the Sun: the corona. Off-the-Sun-Earth-Line (OSEL) observations from vantage points such as Sun-Earth L4 and L5 as well as from a polar orbit provide unique opportunities for 3D view of the optically-thin corona and, at the same time, pose challenges to the instrumentation. Limited spacecraft's resources in OSEL missions impose stringent requirements in terms of envelope, mass, etc., for remote-sensing instrumentation.

This presentation will illustrate an innovative concept for low stray-light, small-size (length < 1-m) coronagraphs that build upon the successful design of the Solar Orbiter Metis coronagraph. The inverted-occultation scheme in Metis does not require a pylon supporting the external occulter, considerably reducing the diffracted light off the external occultation and into the telescope. The polarized visible-light emission of the K-corona demands a more stringent stray-light rejection requirement, that is, less than one-billionth of the solar disk brightness. We will show how Metis has met this requirement and will compare its performance with other currently operating space coronagraphs.

We have compacted the design of this inverted-occulted coronagraph so that it can fit in future deep space L-points (L1, L4, L5) and solar polar missions. This concept can be adapted to the ESA initiative for the development of an European Coronagraph – EUCOR for Vigil follow-on, or to the South-Korean L4 mission, as well as to the solar polar missions Solaris proposed to NASA. We will present the simulated coronal imaging that could be acquired by this innovative class of coronagraphs. We will discuss also augmentations to this concept to extend the coronal imaging into the heliosphere, beyond ~20 heliocentric heights improving, in this way, the tracking of the coronal mass ejections that can affect the Earth environment.

Keywords: Solar Coronagraphs,Heliospheric Imagers,Space Weather,Coronal Mass Ejections

POSTER CODE: P2IOM107

Title
Bridging the Gap: Automated CME Segmentation from Coronagraphs to Heliospheric Imagers

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Body
Coronal mass ejections (CMEs) are the primary drivers of severe space weather, yet their automated detection and tracking across the full range of coronagraph and heliospheric imaging data remains an open challenge. Classical segmentation methods perform well in coronagraph data but struggle with the lower signal-to-noise ratios of heliospheric imagers as well as diffuse morphologies. Deep learning approaches have shown promise but are typically limited to single instruments, narrow fields of view, or closed-source implementations, leaving a critical gap for both scientific analysis and operational space weather forecasting.
We present a dual-network architecture designed to segment continuously from the low corona to the heliosphere. A first network (NN1), trained on inner coronagraph data from LASCO/C2 and STEREO/COR2, detects and segments CMEs close to the Sun and passes its outputs as contextual priors to a second network (NN2) operating on wider field-of-view data from LASCO C3 and STEREO/HI. Where NN1 produces no detection, NN2 operates independently, ensuring that faint CMEs visible only at larger elongations are not missed. This cascaded design allows each network to generalise across instruments with comparable fields of view, including future missions such as ESA Vigil and the newly launched PUNCH. Both attention-based networks are applied over temporal image sequences and trained on a dataset of over 8000 annotated images.
We present preliminary segmentation results across multiple instruments and discuss the architecture's performance, its robustness to varying image quality, and its ability to maintain temporal consistency across large fields of view. We further contextualise this work within a broader automated pipeline that includes differentiable 3D CME reconstruction, and discuss its implications for space weather forecasting and large-scale statistical studies of CME kinematics, angular width, and volumetric expansion across the heliosphere.

Keywords: CME,Machine Learning,Detection,3D Reconstruction

POSTER CODE: P2IOM108

Title
P2D - A Two-Dimensional Multi-Spacecraft Solar Wind Persistence Model

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Body
Solar wind high-speed streams are a key component in space weather forecasting due to their geoeffectiveness as well as their role in shaping the environment in which coronal mass ejections propagate and evolve. Due to the long lifetimes of coronal holes, the source regions of high-speed streams, the solar wind plasma parameters exhibit a strong autocorrelation with a period equal to the average solar rotation rate, particularly at solar minimum. We make use of this property and developed a solar wind velocity and density persistence model with input from multiple spacecraft (Solar Orbiter, Parker Solar Probe, STEREO-A, STEREO-B and OMNI). The model ballistically propagates in-situ data from the position of their measurement radially away from the Sun, as well as longitudinally with the solar rotation rate, producing 2D maps of solar wind parameters. These can be extracted at any point in the heliosphere for a solar wind forecast. From Earth's perspective, it performs best during times, when there are spacecraft located between Earth and Lagrange point L5. During these times the mean absolute error of the solar wind velocity decreases by roughly 35% in comparison to the benchmark 27day persistence model.

Keywords: Solar wind,Persistence,Heliospheric weather,Multi-spacecraft,Solar Orbiter

POSTER CODE: P2IOM109

Title
The European Coronagraph (EUCOR): INAF Contributions to the Pre-Phase-A Study

Authors
Gianalfredo Nicolini [1], Silvano Fineschi [1], Andrea Alberti [2], Gerardo Capobianco [1], Fabio Frassetto [3], Federico Landini [1], Alessandro Liberatore [1], Davide Loreggia [1], Enrico Magli [4], Valeria Marras [5], Radek Melich [6], Sergio Mottini [7], Jeffrey Newmark [8], Maurizio Pancrazzi [1], Emma Perracchione [4], Marco Romoli [9], Clementina Sasso [10], Luca Zangrilli [1]

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Body
Operational space weather forecasting requires continuous, autonomous monitoring of Coronal Mass Ejections (CMEs) and other solar wind structures from stable vantage points like the Lagrange points. To ensure this critical capability, the European Space Agency (ESA) initiated the European Coronagraph (EUCOR) Pre-Phase-A study. This talk presents the comprehensive activities performed by the Astrophysical Observatory of Turin of the Italian National Institute for Astrophysics (INAF-OATo) during this preparatory phase, laying the groundwork for a future European operational coronagraph for Space Weather applications.
We provide an overview of the instrument's conceptual design following the mission's dual-track philosophy by discussing two distinct architectural pathways: a fast-track solution designed to leverage existing European technologies for rapid manufacturing within four years, and a longer-term solution incorporating advanced concepts to enable enhanced performance and new key observational capabilities to further space weather prediction within an eight-year development window.
Key technical contributions highlighted in this presentation include the baseline optical designs drafted for both configurations, with a dedicated focus on the critical challenge of straylight suppression—a paramount factor for high-fidelity coronal imaging. We outline the preliminary set of derived technical requirements and provide a preliminary performance assessment demonstrating compatibility with operational space weather workflows. Finally, we showcase the implemented End-to-End (E2E) model. This modelling framework simulates both the space and ground segments chain, enabling a robust trade-off analysis between optical performance, image recording, and readout strategies.

Keywords: CME,Coronagraph,L5

POSTER CODE: P2IOM110

Title
Predicting the Solar Corona Through a Multi-Messenger Perspective: Preparing for the VIGIL Mission

Authors
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Body
The 3D magnetohydrodynamic (MHD) global modelling of the solar corona and heliosphere constitute a powerful tool to predict their space and time evolution, thereby enabling the anticipation of potential geomagnetic effects induced by solar coronal mass ejections. However, such tool should be validated using observational data.
The current multi-messenger era, characterized by several observatories simultaneously positioned in different location around the Sun, provides favorable conditions for the validation of these models. The availability of multi-viewpoint observations makes it possible to move beyond the traditional single-perspective representation of the Sun and heliosphere.
This work aims at validating the 3D polarized brightness (pB) structure of the solar corona predicted by the WindPredict-AW model for 15 January 2021. For comparison with the observations, this study uses pB data from the SOHO/LASCO, STEREO/COR2, Solar Orbiter/METIS instruments, achieving thus the coverage of the whole 3D corona.
This work will illustrate the advantage what could be achieved through the additional observations expected from the forthcoming VIGIL mission.

Keywords: Magnetohydrodynamics,pB,Solar Orbiter,Vigil

POSTER CODE: P2IOM111

Title
Evaluating sunspot tracking and rotating algorithms for Vigil data.

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Body
Sunspot dynamics, such as sunspot rotation, have been known to build up energy within an active region that is released during events such as solar flares. Currently we are able to analyse the energies built up and released by active regions only when they are Earth facing, however many active regions release solar flares shortly after they rotate onto the visible solar disk, so we are unable to determine how the energy for the solar activity was built-up. New space missions such as Vigil provide the opportunity to observe these active regions up to 5 days before they become Earth-facing. Sunspot rotation is a slow process, typically of the order of 1-2° per hour, with a fast-rotating sunspot achieving up to 50° rotation per day, so the additional observation days provided by Vigil will capture meaningful extra sunspot rotation (and therefore significant stored energy) before the active region becomes Earth facing. In this talk we test whether key sunspot analysis codes such as SSTrack and ROTSS can be run on Vigil-style data and provide the information we need with Vigil spatial resolution and cadence. A three-month sample of continuum data (April – June 2024) from the Solar Dynamics Observatory Helioseismic and Magnetic Imager is resampled to replicate the plate-scale of the future Vigil Photospheric Magnetographic Imager at a 30-minute cadence. Sunspot codes SSTrack and ROTSS are applied to the data, and the performance of the 'Vigil-style' data is evaluated against the full SDO results.

Keywords: sunspot,rotation,active region,solar flare,tracking

POSTER CODE: P2IOM112

Title
Bridging Solar Orbiter Heritage to Vigil: Highlights and Lessons Learned from the Metis Coronagraph

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Body
As the heliophysics community prepares for the ESA Vigil mission and its pivotal role in L5-based operational space weather monitoring, leveraging the heritage of current cutting-edge instrumentation is essential. The Metis coronagraph, on board the ESA/NASA Solar Orbiter mission, represents a cornerstone in this lineage, providing unprecedented simultaneous imaging of the solar corona in both visible light (580-640 nm) and ultraviolet (H I Ly-alpha, 121.6 nm) wavelengths.Since its launch, Metis has achieved significant scientific milestones, including the first multi-channel characterization of the solar wind's acceleration region with the Doppler dimming technique, the detection of waves in the outer corona and the detailed tracking of Coronal Mass Ejection (CME) evolution from a unique, close-range perspective. These achievements have served as a testbed for automated feature detection. This presentation discusses the technical and operational heritage of Metis as it relates to the upcoming Vigil mission. We highlight key lessons learned regarding instrument calibration in a deep-space environment, the management of complex telemetry constraints, and the optimization of Doppler dimming techniques to derive plasma velocity maps. By evaluating the transition from scientific discovery on Solar Orbiter to the robust, continuous monitoring required for Vigil, we provide a roadmap for maximizing the scientific of future heliospheric missions.

Keywords: Solar corona,Doppler dimming,Polarimetry

POSTER CODE: P2IOM113

Title
EUCOR – Provisional design of a visible light solar coronagraph for space weather monitoring

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Body
In the framework of EUCOR project of European Space Agency we are elaborating the design of a visible light solar coronagraph for space weather monitoring. Until now, several optical layouts have been used for space coronagraphs, including internally occulted (LASCO C1, STEREO COR1, Aditya VELC), simplified externally occulted (BITSE, CODEX, CCOR-X, PUNCH/NFI) and full externally occulted (LASCO C2/C3, STEREO COR2, ASPIICS, Metis/Solar orbiter). All these designs have advantages and drawbacks, the main ones being sensitivity to diffraction/stray light and compactness. While externally occulted coronagraphs – either simplified or full – traditionally have better diffraction/straylight rejection performance and are used within large FOV up to several tens of solar radii, details of their design can significantly affect their final performance. We are considering provisional designs, discussing major sources of straylight and possibilities for its mitigation.

Keywords: coronagraph,imaging

POSTER CODE: P2IOM114

Title
Towards 2031 Vigil Mission: Self-tuning algorithmic and data-driven segmentation of coronograph data and dynamic 3D Reconstruction of Coronal Mass Ejections

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Body
The ESA Vigil mission, scheduled for launch in 2031, will provide unique solar and space weather observations from the Sun–Earth Lagrange point L5, capturing Earth-directed coronal mass ejections (CMEs) simultaneously observed from L1 and Earth. NASA's STEREO mission demonstrated the power of such stereoscopic observations by revealing CME three-dimensional structure through multi-angle imaging. Previously, we developed an algorithmic, wavelet-based method for recognizing solar eruptive features and demonstrated its performance on ground- and space-based coronagraphic and EUV observations. We then introduced a data-driven CBF and filament segmentation using CNNs pre-trained on the wavelet output. Here we extend this approach to the set of physically relevant Compact Coronagraph (CCOR) events, improving the wavelet-based algorithms with grid-search heuristic scoring and bayesian optimization for parameter tuning. We then present CNN models trained on the wavelet pipeline's output pushing automatization further, preparing our methodology for future Vigil observation. Possibility of reconstruction of three-dimensional structure of CME fronts is demonstrated on a limited set of events, which demonstrates potential of moving beyond oversimplified geometric assumptions by incorporating neural surface representations (NeRF). We plan to evaluate 3d reconstruction methods using synthetic CME datasets with known 3D ground truth and historical multi-spacecraft observations.These developments lay the groundwork for exploiting Vigil's unique L5 perspective, enabling stereoscopic tracking and accurate 3D reconstruction to advance real-time space weather predictions and mitigate risks to technological infrastructure.

Keywords: Coronograph,CCOR,wavelet,wavetrack,CNN

POSTER CODE: P2IOM115

Title
Performance Assessment and Signal Cleaning Strategies for the Vigil Heliospheric Imager

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Body
The Vigil mission will be the first operational space weather mission operating from the Sun–Earth Lagrangian point L5 (SEL5), providing continuous observations of the Sun and inner heliosphere from a vantage point outside the Sun–Earth line. The mission aims to enhance operational space weather forecasting through advanced monitoring and early detection of Earth-directed Coronal Mass Ejections (CMEs).
Within the Vigil mission framework, Leonardo is leading the industrial team responsible for the development of the Heliospheric Imager (HI), a visible-light wide-field instrument specifically designed for CME detection and tracking during their propagation in interplanetary space. The instrument includes two cameras, HI-1 and HI-2, covering elongation angles from 4° to 50° along the ecliptic and ±30° out of the ecliptic. The design combines optimized optics, straylight suppression solutions, detector architecture and onboard processing to achieve the radiometric sensitivity required for observing faint heliospheric structures in a high-background environment.
This contribution presents the current development status and performance assessment of the HI instrument following successful completion of the Preliminary Design Review (PDR) in November 2025. The analysis focuses on radiometric performance, straylight rejection capability, Solar Energetic Particle (SEP) effects on detector data, and instrument availability and reliability during Severe Space Weather Events. Dedicated mitigation techniques for SEP-induced transient artifacts are presented, together with their capability to preserve low-contrast CME signatures and diffuse solar wind structures.
The results demonstrate the effectiveness and robustness of the overall HI design, including optical, radiometric, processing and operational aspects, confirming the capability of the instrument to provide reliable, low-latency observations compliant with operational space weather forecasting requirements.

Keywords: VIGIL,HELIOSPHERIC IMAGER,CME,PERFORMANCE ASSESSMENT

POSTER CODE: P2IOM116

Title
The Vigil Mission

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Body
The ESA Vigil mission will be the first dedicated space weather mission positioned at the Sun–Earth L5 Lagrange point, providing a unique vantage point for continuous monitoring of solar activity and interplanetary space. By complementing observations from the Sun–Earth line, Vigil will enable improved early-warning capabilities for space-weather forecasting and operational decision-making. The mission's six baseline instruments—four dedicated to remote sensing and two to in-situ measurements—will deliver high-quality, low-latency observations spanning the solar surface, corona, heliosphere, and local plasma environment, supporting both real-time space-weather services and solar physics research.

Although primarily designed as an operational mission, Vigil will also provide unprecedented high-cadence observations from a unique perspective for the scientific community, improving our understanding of space weather, from the evolution of the Sun's magnetic field at the surface to the solar atmospheric processes that drive eruptions and heliospheric disturbances.

In this presentation, I will provide a mission update, including instrument status and characteristics, and discuss current activities aimed at improving mission readiness. This includes engagement with both operational and scientific communities to refine data products, develop new analysis tools, and maximise the scientific and operational impact of the mission.

Keywords: space weather,forecasting,instrumentation

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION IOM2

BALLATOIO
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2IOM201

Title
The SSA Space Environment Simulator: A unified tool for trajectory-based modelling of the space environment under nominal and extreme conditions

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Body
Understanding the space environment is critical for spacecraft safety and mission success, but relevant models remain siloed. By unifying open-access space environment models, the Saudi Space Agency (SSA) Space Environment Simulator enables mission scientists and operators to model the space environment along near-Earth trajectories. Originally developed to support the interpretation of onboard space weather measurements from SSA's space weather mission (SHMS), the simulator has been generalized to support both spacecraft operators and space scientists. The spacecraft trajectory is defined in GMAT and evaluated under nominal and active conditions. The nominal component simulates the space environment using statistical radiation belt and background cosmic ray models, including IRENE. The active component simulates extreme solar events by fetching observational data from international repositories including NASA (OMNI database), NOAA (GOES satellites), and Kyoto University (Dst geomagnetic index). The simulator was applied to the trajectory of SHMS, which flies a highly elliptical orbit whose apogee sweeps annually through the dayside bow shock, the flanks, and the magnetotail, spending most of each orbit above 36,000 km. Modelling four representative orbital geometries under nominal conditions and three historical solar events spanning one-in-five to one-in-twenty-year severity, the simulator reproduces the large variability encountered by SHMS, including an X-ray dynamic range of five orders of magnitude between quiescent background and flare peak, magnetic field variations exceeding three orders of magnitude during each perigee pass, and trapped particle exposures that differ by several-fold between orbit orientations at the same altitude. The simulator provides a unified approach for modelling nominal and extreme space environments along arbitrary near-Earth trajectories, supporting both mission planning and interpretation of in situ space weather observations.

Keywords: Space Environment Modelling,Space Weather,Space Mission Operations,Trajectory-Based Modelling,Near-Earth Space Environment

POSTER CODE: P2IOM202

Title
An operational space weather mission to the far-side of the Sun

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Body
Current space weather prediction systems are fundamentally limited by incomplete observational coverage of the Sun. In particular, only one hemisphere of the solar surface can be directly, and continuously, observed from Earth and near-Earth space, leading to significant uncertainties in modelling the global solar magnetic field and its evolution.

The Antichthon L3 mission concept addresses this limitation by enabling continuous, near-real-time monitoring of the far side of the Sun. By positioning a spacecraft near the Sun–Earth Lagrange point L3, the mission would provide direct observations of solar regions that are currently unobservable, significantly enhancing global solar coverage and enabling full 4π characterisation of solar activity.

The primary scientific goal of the mission is to improve the accuracy and reliability of solar and heliospheric models through the provision of far-side observations, including magnetic field measurements, radiative emissions, and solar wind properties. These data are expected to enhance data assimilation in forecasting systems, enabling more accurate and timely predictions of solar eruptions and their impacts across the heliosphere.

Antichthon is designed to complement existing and planned missions, such as Vigil, by closing the observational gap in solar monitoring and allowing continuous tracking of active regions across the full solar sphere. This capability is essential to extend forecast lead times and reduce uncertainties associated with the emergence and evolution of solar activity on the far side of the Sun.

The results of a Concurrent Design Facility (CDF) study indicate that such a mission is technically and programmatically feasible, providing a viable pathway towards a next-generation operational space weather monitoring system.

Keywords: Space Weather,Mission,Sun,Far-side

POSTER CODE: P2IOM203

Title
Space Weather Observations with the HEPD-02 Detector on Board the CSES-02 Satellite

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Body
The High-Energy Particle Detector HEPD-02, on board the CSES-02 satellite, provides continuous measurements of charged particles in Low Earth Orbit (LEO), covering electrons, protons, and light nuclei over an energy range particularly relevant for Space Weather studies. Thanks to its near-polar orbit and large geometrical acceptance, HEPD-02 is well suited for the investigation of Solar Energetic Particle (SEP) events, Coronal Mass Ejections (CMEs), geomagnetic storms, and solar flares, including intense X-class events.
The instrument is capable of monitoring rapid variations in particle counting rates during disturbed geomagnetic conditions, while also performing precise measurements of proton and helium fluxes over a broad energy range. These characteristics make HEPD-02 an effective tool for studying the dynamics of the near-Earth radiation environment and its response to solar activity throughout the current solar cycle.
In this work we present an overview of the observations collected during the first year of HEPD-02 operations, with particular attention to the major Space Weather events observed in the 2025–2026 period. Among these are the sequence of X-class flares and associated SEP events of November 2025, generated by repeated eruptions from the same active region, and the intense geomagnetic storm of January 2026 triggered by an Earth-directed halo CME. The analysis focuses on the temporal evolution of proton counting rates at different energy thresholds and on their dependence on geomagnetic latitude, L-shell, and local magnetic conditions, including the response observed inside and outside the outer radiation belts.

Keywords: Space Weather,HEPD-02,CSES-02

POSTER CODE: P2IOM204

Title
The UV imager payload on board the SEE mission

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Body
The Sun cubE onE (SEE) is a 12U CubeSat mission in LEO that will investigate Gamma and X-ray fluxes and UV solar emission to support studies in Sun-Earth interaction and Space Weather.
One of the main objectives of the SEE mission is to operate a high-performance imager at 280 nm to take full-disk images of the Sun from Low Earth Orbit (LEO). A suitable CMOS sensor was therefore selected to meet the stringent requirements of this spectral range. This sensor was chosen for its high quantum efficiency (QE) in the UV, as well as for its reduced size and cost. We assessed the camera linearity, photon transfer curve (PTC), read noise, bias, and dark current. Furthermore, CMOS sensors require a more nuanced analysis of spatial artefacts. In compliance with the EMVA 1288 standard for the characterisation of image sensors and cameras, we characterised both dark signal non-uniformity (DSNU) and photo response non-uniformity (PRNU), and analysed the temporal noise characteristics of rows, columns and pixels.

Keywords: Imager UV,Mg II,CMOS,PTC,Sun cubE onE

POSTER CODE: P2IOM205

Title
Observing the Earth’s Plasmasphere and Ionosphere from the Lunar Surface

Authors
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Body
We present the analysis of the first lunar-based observational characterization of the Earth's plasmasphere and ionosphere using Global Navigation Satellite Systems signals tracked from the lunar surface by the Lunar GNSS Receiver Experiment (LuGRE). The Earth-Moon geometry enables limb sounding of the plasmasphere at altitudes exceeding 3000 km, bridging a critical observational gap. We compared Total Electron Content measurements from GPS and Galileo satellites’ signals with predictions from the Global Core Plasma Model. While the model captures the general morphology of the plasmasphere, significant discrepancies emerge in the ionosphere/plasmasphere transition region. Specifically, LuGRE data reveal a overestimation of electron density by the model during the dayside phase indicating a lower plasma refilling efficiency than currently parameterized and an underestimation during the nightside phase. These results demonstrate the capability of lunar-based GNSS measurements to continuously monitor the global plasma environment, paving the way for future permanent observatories on the Moon

Keywords: GNSS,Moon,Ionosphere/Plasmasphere,LuGRE

POSTER CODE: P2IOM206

Title
SWING data products: Transforming Space Weather Measurements into Actionable Space Weather Data Products

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Body
The Space Weather and Ionosphere Nanosat Generation (SWING) mission is an ESA Space Safety Programme nanosatellite demonstration mission, developed within the Distributed Space Weather Sensor System (D3S) and planned for launch in late 2027 or early 2028. Operating in a low Earth, Sun-synchronous orbit at approximately 550 km, SWING combines observations of solar activity, the ionosphere, energetic particles, and the local spacecraft plasma environment. This integrated data set supports space weather models and data services for monitoring, nowcasting and forecasting the near-Earth environment.

A key objective of SWING is to investigate ionospheric variability and its effects on communication and navigation. The multi-needle Langmuir Probe (m-NLP) provides in-situ measurements of electron density, spacecraft potential and thermal plasma parameters, while the AQUILA GNSS radio occultation receiver provides ionospheric electron density profiles and scintillation measurements of rapid fluctuations in trans-ionospheric radio signals. Together, these data support ionospheric model validation and data assimilation, as well as assessment of impacts on GNSS positioning and radio communication. The DREAM radiation monitor characterises the low-Earth-orbit radiation environment through measurements of energetic protons, electrons and ions. The X-ray Flux Monitor (XFM) measures spectrally resolved solar X-ray flux to detect and characterise solar flares, enabling links to the ionospheric response measured by m-NLP and AQUILA.

This contribution presents the SWING mission, payload, operational concept, and data processing chain from raw telemetry to Level-1 products. Processing and resulting products are described for each instrument and its potential for scientific exploitation and operational space weather applications are discussed.

Keywords: SWING,Nanosat,ionosphere,space weather monitoring,operational data products

POSTER CODE: P2IOM207

Title
Beyond DMSP: Constellation-Ready Plasma Instrumentation for Real-Time Space Weather Nowcasting

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Body
3DCAM Sensors aims to industrialise a compact plasma spectrometer for deployment as a distributed sensor network across low Earth orbit constellations, providing nowcast space weather data to satellite operators.

Operational plasma monitoring in LEO currently depends on the US Defense Meteorological Satellite Program (DMSP) and its SSJ5 spectrometer. SSJ5 measures along six fixed sectors with 1-second cadence and no angular resolution in its standard mode, therefore not being able to resolve the angular structure of precipitating particle fluxes. The DMSP fleet is also aging well past its design life and is being progressively decommissioned, opening a gap in global plasma coverage. Relying on a single foreign military program for this data is a sovereignty concern for European operators.

3DCAM addresses both limitations. It resolves 64 simultaneous viewing directions across a full hemispherical field of view, delivering complete angular distributions once per second, eight times faster and with ten times more angular resolution than SSJ5. At 1.8 kg, 17 cm diameter, and 4 W, it fits standard LEO buses and is constellation-ready: multiple units can fly across a fleet for continuous distributed coverage, rather than the sparse sampling of one legacy platform. It can also be adapted for integration onto future European LEO constellations, such as IRIS² and OneWeb Gen 2, leveraging existing space infrastructure rather than requiring dedicated missions. 3DCAM will be tested in orbit in early 2028, under a CNES-funded qualification program targeting demonstration on a commercial LEO platform.

Keywords: Plasma instrumentation,LEO constellations,operational data

POSTER CODE: P2IOM208

Title
Probing the Ionosphere from Above: The Evolution and Impact of Topside Sounding Systems

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Body
The ionosphere is a critical, highly dynamic component of the Earth's upper atmosphere, significantly influencing satellite communication, navigation systems, and radio wave propagation. While ground-based ionosondes have provided invaluable data for decades, they are limited to probing the region below the peak density height (F2 peak). To fully characterize the ionospheric structure and the dynamic processes of the near-Earth space environment, 'topside sounding' from spaceborne platforms has become crucial. By employing sweep frequencies from altitudes of about 800-1000 km down to the F2 peak, such radio sounders can investigate the topside ionospheric electron density profile, which is otherwise inaccessible to ground-based instruments. In this context, data from the Alouette and ISIS topside sounders proved invaluable. However, their design faced several inherent issues which proved challenging for the time. In this work we assess the scientific legacy and technological evolution of topside ionospheric sounding systems, highlighting the significant contribution given by the analysis of such data to ionospheric research and modeling. These technological advances make a new generation of topside sounders technically feasible and potentially capable of filling one of the major observational gaps in operational ionospheric monitoring for Space Weather.

Acknowledgments:
This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under contract n. 2024-5-E.0 CUP n. I53D24000060005.

Keywords: Topside Ionosphere,Topside Ionspheric Sounding,space-based ionosonde

POSTER CODE: P2IOM209

Title
Standardizing Space Weather Data for Radiation Belt Modelling

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Body
Reliable real-time forecasting of the near-Earth radiation environment depends on robust software that turns heterogeneous external data into standardized, model-ready inputs. We present two open source Python packages developed at the GFZ Helmholtz Centre for Geosciences that form the software backbone of the ESA funded FLAG project (Forecasts and Long-term probabilistic data Assimilative prediction of the effects of Geomagnetic storms).

SWVO provides unified access to space weather data and geomagnetic indices through a common reader contract. All readers follow the same API: download data, cache it locally, and return UTC-enforced pandas DataFrames. Supported products include Kp, Hp30, Hp60, Dst, SYM-H, F10.7, SME, solar wind, ensemble forecasts, plasmasphere density predictions from multiple sources (OMNI, SWPC, Niemegk, GFZ, ACE, DSCOVR, SuperMAG, etc). Data directories are configured through environment variables, downloads happen on demand, and ensemble readers return one DataFrame per member for direct forecast verification against observations.

EL-PASO (ELaborative Particle Analysis from Satellite Observations) streamlines the download, processing, and saving of satellite particle data to prepare standardized inputs for radiation belt modeling. It reads CDF, NetCDF, ASCII, and JSON files, stores all processing steps as metadata alongside the data for full traceability, and offers parallelized processing built on the IRBEM library, including time binning, pitch angle distributions, adiabatic invariants, and phase space density for magnetic field models such as T89, T96, and TS04. Two concepts are central: a DataSet provides one unified in-memory representation of instrument data regardless of mission or file format, and a DataStandard enforces metadata and format conventions, converting units and checking names, dimensions, and cross-variable consistency, with PRBEM and GFZ standards included. Ready-made recipes cover the Arase, GOES, PROBA-V, ESA NGRM, etc.

Keywords: Space weather,Radiation belt forecasting,Data standardization,Open source software

POSTER CODE: P2IOM210

Title
Diagnosing the Radiation Belts: The Case for a Global X-ray Auroral Imager

Authors
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Body
The Earth's aurora is a key indicator of space weather activity and a direct reflection of the dynamical conditions of energetic particle precipitation and the Van Allen radiation belts. Energetic electrons precipitating from the belts not only drive auroral activity but pose hazards to operational infrastructure, such as degrading HF radio communications and increasing satellite drag. X-ray aurora, produced by bremsstrahlung radiation, is a particularly powerful diagnostic providing a global and illumination-independent proxy for the energisation and deposition of charged particles into the upper atmosphere.

Yet, we have very limited capability in imaging the global state of the aurora. The Polar Ionospheric X-ray Imaging Experiment (PIXIE) aboard the Polar spacecraft remains the only instrument to have successfully provided global X-ray auroral images to date, providing simultaneous coverage of the entire auroral zone across the 2 – 60 keV energy range. Using available PIXIE data, we investigate the spatial and temporal characteristics of X-ray aurora as a function of geomagnetic activity, building a robust picture of how energetic electron precipitation evolves across magnetospheric conditions.

These results directly inform the scientific and operational case for a next-generation X-ray auroral imager. We discuss the scientific, operational, measurement and technical requirements an X-ray auroral mission would require, linking key physical observables to measurement requirements, providing a foundation for future mission and instrument proposals.

Keywords: Aurora,X-ray Imager,Instrumentation,Science Case,Operations Case

POSTER CODE: P2IOM211

Title
Development of ESA's Space Weather Mission SAWA

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Body
As part of the Space Safety Programme, ESA’s Space Weather Office is implementing a Distributed Space weather Sensors System (D3S), which has the purpose of monitoring the interaction of the Earth with the Sun and to assess and measure the actual conditions in the proximity of the Earth. One objective of D3S is the monitoring of the Earth's proximity and to provide measurements that enable to derive the state of the magnetosphere–ionosphere–thermosphere and its coupling. The monitoring requires in-situ measurements of the geomagnetic field vector, plasma wave spectra, plasma density, thermospheric neutral density, and atomic oxygen density in Low Earth Orbit (LEO).
ESA has initiated the implementation of a small demonstration satellite that carries three instruments, which is expected to be placed in LEO at about 500 km to provide the relevant measurements. We will report about the mission status, the mission concept, its objectives, the planned instrumentation and the expected measurements that shall be provided.

Keywords: Space weather missions,Ionosphere,Magnetosphere,Thermosphere,Small satellites

POSTER CODE: P2IOM212

Title
SAS4 intelligent plasma wave instrument

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Body
The aims of SAS4 (Signal Analyzer and Sampler) are a) to develop a new, intelligent plasma wave instrument, that is capable to detect and process the major plasma wave phenomena occur in the Magnetosphere in real time. The instrument records six components of the electromagnetic waves in ULF-ELF-VLF frequency range. The wave phenomena include whistlers, fractional hop whistlers, choruses, hisses, triggered emissions and EMIC waves. The wave phenomena detection is made by r custom neural network, complemented with event post processing. The inferred parameters are the key parameters for Radiation Belts nowcast/forecast models, wave particle interaction, Plasmasphere dynamics and Ionospheric perturbations; b) performance demonstration of the new instrument in an IOD on a polar LEO, orbital height is ~600-800km, inclination is 85-90 deg. The new instrument is superior to existing plasma wave instruments as the latter ones are able to record the waves in low resolution mode only continuously and apply only basic data processing, while the new instrument is capable to record, identify and process the key wave phenomena on-board and in real-time.
The major characteristics of the instrument:

1. measures six components of the electromagnetic waves in the ULF-ELF-VLF range up to 40 (80)kHz
2. detects and segments the major wave phenomena by neural network
3. extracts the key parameters for SWE purposes in real time:
   -cold electron density by whistler inversion for Plasmasphere
   - cold electron density from measurements of 6 component of whistler mode waves through cold plasma dispersion relation for plasmatrough
   - ULF and VLF wave power inferred from the spectrogram of detected event
   - ionospheric TEC or density profile derived from the detected fractional hop whistlers
4. transmits the extracted data to the ground in real-time

A proposal has been submitted to PRODEX Call for Ideas, consolidated phase.

Keywords: plasma waves,plasmasphere,ionosphere,radiation belts,plasma wave instrument

POSTER CODE: P2IOM213

Title
Solar Orbiter, STEREO-A and L1 Measurements of Coronal Mass Ejections and Energetic Storm Particle Events: Lessons for Future Space Weather Missions

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Body
In recent years, STEREO-A and Solar Orbiter took measurements of the solar wind and interplanetary magnetic field in relatively close proximity to the Sun-Earth line. This provides opportunities to investigate the propagation of coronal mass ejections (CMEs), the longitudinal dependence in the properties of CMEs and energetic storm particle (ESP) events and to pave the way for future multi-spacecraft space weather missions in the inner heliosphere, such as ESA SHIELD. Here, we present a summary of the STEREO-A-Earth measurements of CMEs and ESPs over the maximum of solar cycle 25 and dive into a particularly interesting period where 3-spacecraft measurements of CMEs, ESPs and stream interaction regions were made by Solar Orbiter, STEREO-A and L1. We confirm recent studies showing that the CME front is titled along the Parker spiral and discuss how this must be taken into account for future measurements sunward of L1 and off the Sun-Earth line.

Keywords: coronal mass ejection,energetic storm particle,Sub-L1

POSTER CODE: P2IOM214

Title
The X- and Gamma-ray payload on board the SEE mission

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Body
The Sun cubE onE (SEE) is a 12U CubeSat mission in LEO that will investigate Gamma and X-ray fluxes and UV solar emission to support studies in Sun-Earth interaction and Space Weather.

The mission is developed in the frame of the ALCOR program of the Italian Space Agency by a team composed of Tor Vergata University of Rome, Argotec, INFN, School of Aerospace Engineering, OPTEC, NEAT and NEXT. SEE's main objective is to monitor the emission of solar flares, from soft-X to Gamma rays, and the solar activity through images of the Sun in the Fraunhofer Mg II doublet (280 nm).

The X- and Gamma-ray payload will study with unprecedented temporal resolution and with a multi-wavelength approach the X- and Gamma-ray fluxes from the keV to the MeV range of energies and with a cadence up to 10 kHz, to unveil the sources of the solar flares. The X- and Gamma-ray payload consists of four SiPM-based detectors.

Keywords: x and gamma emissions,solar flare,cubesat

POSTER CODE: P2IOM215

Title
An AI-Enabled Approach for Calibrating Radio Occultation TEC into GNSS-Equivalent TEC for Operational Space Weather Systems

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Body
Global ionospheric monitoring relies on Total Electron Content (TEC) derived from ground-based GNSS observations, but these measurements are spatially sparse over oceans and under-instrumented regions. Satellite radio occultation (RO) missions such as COSMIC provide near-global coverage, yet they systematically underestimate TEC due to incomplete sampling of the topside ionosphere and plasmasphere, limiting their direct use in operational space weather applications.
We present a supervised machine learning framework that calibrates RO-derived TEC to GNSS-consistent values using neural network models trained on co-located COSMIC and GNSS data spanning 2006-2025. The model uses ionospheric profile parameters and spatiotemporal descriptors, with an optional inclusion of solar and geomagnetic activity indices.
The calibrated output shows substantial improvement in agreement with GNSS observations. The mean bias is reduced from ~7 TECU in raw RO data to near-zero levels (~0.02-0.03 TECU), while overall errors decrease by 50-75% across latitude, local time, and seasonal bins. Error distributions also become more Gaussian-like, with skewness reduced from >2 to <1, enhancing suitability for data assimilation. Performance of the developed framework is globally robust, with lowest errors (~1-3 TECU) at mid-latitudes and slightly higher uncertainties in equatorial and high-latitude regions due to increased ionospheric variability. Including inputs of solar and geomagnetic indices provides only marginal improvement (~0.2 TECU RMSE reduction), indicating that most variability is already captured by the observational inputs. The system operates in near real-time, producing calibrated TEC estimates from incoming RO measurements, and enabling operational use of TEC from the COSMIC mission.

Keywords: COSMIC Missions,Total Electron Content,GNSS,Ionosphere,Radio Occultation

POSTER CODE: P2IOM216

Title
Advanced Modelling of Geospace (AMOG) Using Satellite Platform Magnetometers

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Body
Continuous monitoring of electric current systems in Earth's environment, including the ionosphere and magnetosphere, is essential for characterising geospace. Such observations are required, for example, to determine the energy input into the upper atmosphere and to monitor disturbances in the space environment and associated hazards. This monitoring can be achieved through magnetic field measurements acquired both on the ground and in space.

The spatio-temporal sampling provided by dedicated magnetic satellite missions such as Swarm and MSS can be significantly enhanced by incorporating platform magnetometer data from non-dedicated missions, including CryoSat-2, GRACE, and GRACE-FO.

This presentation reports recent achievements in using platform magnetometer data for space weather monitoring within a study funded by ESA's General Support Technology Programme (GSTP). We present the operational processing, calibration and provision of magnetic field data from the satellites CryoSat-2, GRACE, GRACE-FO, and Aeolus.

Keywords: Low Earth Orbiting satellites,satelitte AOCS magnetometer,platform magnetometers,magnetometer calibration

POSTER CODE: P2IOM217

Title
METIS Operations Facility: Advancing Space Weather and Climate Research

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Body
METIS is the coronagraph of the scientific payload of Solar Orbiter, a joint ESA-NASA mission aiming at studying the Sun poles and the circumsolar region. METIS telemetry and operations are handled via the Metis Operations Facility (MOF), which is built, run, and maintained by ALTEC in Turin in close collaboration with INAF. The MOF empowers the scientific analysis and exploitation of data acquired by METIS in different ways:

- Data retrieval and processing: the METIS raw telemetry is fetched on a daily basis from MOC and transformed up to L3 data products. This is achieved via automatic orchestration of processing pipelines, which are developed by INAF and then integrated and executed in ALTEC;
- Data archival: METIS data products are indexed and preserved to enable their use in different scientific fields, such as solar physics and space weather applications;
- Data exploration: the scientific team can use the metadata catalogue (composed of a wide set of both scientific and infrastructural keywords) to explore the MOF products archive;
- Data analysis and validation: reports about METIS data products are generated in order to allow the scientific team to detect observed solar events of interest like CMEs and flares. Validated data is eventually published on the long-term archive for METIS data, the SOAR;
- TM/TC Monitoring: METIS telemetry stored in MOF can be exploited to perform further analysis about the instrument and spacecraft status.

The approach, techniques, and technologies employed by the MOF to address common challenges and objectives in scientific ground segments will be presented. Alongside, the data access and exploitation functions exposed by MOF to end-users will be analysed to show how METIS data can be leveraged to advance research in the Space Weather and Solar science domain and to promote the collaboration with other Space Weather-related datasets, centres, and missions.

Keywords: Metis Operations,Ground Segment,Data Exploitation

POSTER CODE: P2IOM218

Title
Preparatory Space Weather Simulations for the HENON Mission: CME Evolution and Solar Energetic Particle Acceleration

Authors
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Body
Space missions play a key role in predicting natural hazards like Coronal Mass Ejections (CMEs) and high fluxes of solar energetic particles that hit the Earth. In this work we carry out a preparatory study for the interpretation of the data that will be collected by a new space mission under development by the Italian ASI. The space mission is the HEliospheric pioNeer for solar and interplanetary threats defeNce (HENON) and its aim is to improve the forecasting capabilities of Space Weather hazards such as SEPs/CMEs events and geoffective interplanetary disturbances.
We use the 3D-MHD numerical code EUHFORIA with the FRi3D module which allows to describe the initial CME magnetic field. We insert the possible trajectories of the Henon spacecraft in EUHFORIA and we simulate the evolution of CMEs varying the initial parameters of the code. We determine from the simulation the VBz parameter, namely the product of the solar wind speed and the southward component of the magnetic field Bz, that allows us to understand if a specific event can be dangerous for the environment around the Earth or not. In this way we make a forecasting analysis in order to understand what are the events potentially dangerous for space weather.
We also use a test particle code which simulates the proton acceleration in the regions around an interplanetary shock. Protons are scattered back and forth around the shock, considering both normal diffusion and superdiffusion, with simulation parameters similar to those of interplanetary shocks. We explore the parameter space to understand which shocks are most effective in accelerating particles, and find that protons can be accelerated to energies of 1-2 MeV and more in the case of very fast shocks.
This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under Contract Grant Nos. 2024-5-E.0-CUP and I53D24000060005.

Keywords: CME,MHD,Turbulence,Space Weather,Spacecraft

POSTER CODE: P2IOM219

Title
A Metric for Space Weather Payload Trade-Off Analysis

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Body
Over recent years, access to space has shifted from large systems toward smaller, more affordable, satellites driven by rapid advances in electronics and software. Tasks once reserved for large spacecraft can now be accomplished by small satellites, such as CubeSats, or by satellite constellations. This shift offers key advantages, including reduced mission costs and flexible launch options. Consequently, both scientific and commercial sectors are increasingly adopting these platforms, particularly for space weather monitoring. In this context, identifying payload configurations that achieve an optimal trade-off between scientific performance and strict platform constraints (mass, volume, and power) is essential. As part of the Space It Up project, this work defines a quantitative metric to evaluate and compare scientific payloads across distinct space mission classes.

Keywords: Trade-Off Analysis,Payload

POSTER CODE: P2IOM220

Title
In-Flight Commissioning of the SOLAR-1 Fluxgate Magnetometers

Authors
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Body
The Space Weather Observations at L1 to Advance Readiness - 1 (SOLAR-1, formerly SWFO-L1) NOAA mission was launched on September 24, 2025 and entered its orbit about the first Sun-Earth Lagrange point (L1) on January 23, 2026. The SOLAR-1 observatory will be used to observe incoming solar wind particles and fields before they reach Earth. The in situ magnetic field, measured by two fluxgate magnetometers located on a boom at 3.9 and 5.6 m from the spacecraft, will serve as a key parameter for operational prediction of space weather events. As the observatory cruised to L1, the magnetometer team began the in-flight instrument commissioning campaign. In collaboration with NASA, the Southwest Research Institute and the University of New Hampshire, NOAA performed several commissioning tests, including the quantification of instrumental offsets and stray magnetic fields originating from the spacecraft (thrusters, reaction wheels, solar array, etc.). To help end-users remove spurious signals from their analyses, we developed quality flags for inclusion in the data files. Finally, we compared the data from the observatory's inboard and outboard sensors, and compared the fields measured by the primary (outboard) magnetometer with data from other observatories at L1. We find that the L1 magnetic field measurements exhibit a high level of correlation that decreases with increased spatial separation between observatories. As such, the proximity of the SOLAR-1 and NASA Interstellar Mapping and Acceleration Probe (IMAP) observatories, which were launched together on a rideshare and flew within 5000 km of each other during cruise, has enabled an unprecedented level of cross-calibration between the two observatories' fluxgate magnetometers. Following an evaluation of these commissioning results, the SOLAR-1/MAG data reached Provisional maturity on March 31, 2026, permitting use in operations and release to the public.

Keywords: SOLAR-1,SWFO,magnetometer,IMAP,L1

POSTER CODE: P2IOM221

Title
Mission proposal for a 3 satellites constellation to generate real-time equatorial TEC data based on a methodology developed for deriving TEC from in-situ electron density measurements in highly eccentric equatorial orbits from Tan Ce 1 data

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Body
This paper presents a mission proposal for a six satellites constellation to generate real-time equatorial total electron content (TEC) data, based on a methodology developed for deriving TEC from in-situ electron density measurements in highly eccentric equatorial orbits from the Chinese – ESA Double Star - Tan Ce 1 (TC1) data.
Such a future mission will be launched in the equatorial belt, providing the opportunity to generate real-time high precision data source for satellite communication, satellite internet and navigation applications as well as an archived source for better understanding of the Appleton anomaly Effects on TEC, including hitherto not very well understood Plasmaspheric Electron Content. That mission will be ideally have six satellites, with one pair sharing the same line of apsides, and the three pairs equally spaced around the globe (with 120 degrees in between their line of line of apsides) . The two satellites with the same Line of Apsides will ideally Inclination angles of + 10 degrees and - 10 degrees , thus covering the Appleton Anomaly region, comprehensively. The three Lines of Apsides will be strategically arranged to cover the three equatorial regions of interest namely, Southeast Asia/South Asia, Africa/ Middle East and Caribbean/South America.
The methodology used is developed using data from the PEACE instrument in the Chinese – European Space Agency Double Star TC1 satellite, which with its highly eccentric equatorial orbit provides an excellent opportunity to build comprehensive TEC including the Upper Plasmaspheric Electron Content (UPEC) components in the equatorial region. The data are from the empirical in-situ measurements of electron density along the orbit in the 20000km to 40000km altitude range. The technical details of the methodology, its adaptation for the proposed constellation mission and the technical details of the mission itself are presented in the paper.

Keywords: Space Weather,Space Weather Forecast,Space Weather Nowcast,Space Weather Nowcast,Appleton Anomaly

POSTER CODE: P2IOM222

Title
Daedalus+ : A science mission for the in-situ exploration of the Lower Thermosphere - Ionosphere at altitudes below 200 km.

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Body
At the interface between the atmosphere and space, within the Lower Thermosphere and Ionosphere (LTI, altitudes roughly between 100 and 200 km), complex processes take place due to the interactions between neutral and charged particles in the presence of electric and magnetic fields. These processes uniquely characterise and shape this region and determine the majority of space weather effects that are felt on the Earth. Even though a wealth of information comes from remote sensing measurements, understanding and quantifying the physical processes related to ion-neutral interactions within this region requires co-temporal and co-spatial measurements with high spatial resolution, such that can only be provided by in-situ sampling. Required measurements include plasma density and temperature, ion drifts, neutral density and wind, ion and neutral composition, electric and magnetic fields, and energetic precipitating particles. In this talk we will provide an overview of key processes within this region related to energetics, dynamics and chemistry that require such comprehensive measurements for their unambiguous characterization; we will summarize the current status of understanding as indicated by discrepancies in the representation of these processes in current global circulation models and methodologies based on remote sensing measurements; and we will make the science case for Daedalus+, a proposed in-situ scientific mission targeting to provide the first ever systematic and comprehensive measurements to resolve key open questions within this critically unexplored region. Together with modeling, such mission would enable significant advancements in the understanding of neutral-ion interactions and other related science and space weather topics in this critical region of Geospace.

Keywords: Lower Thermosphere Ionosphere,Ion neutral interactions,Upper atmosphere,Collisional Electrodynamics,Daedalus

POSTER CODE: P2IOM223

Title
End-to-End Software Suite for Space Weather Sub-L1 Multi-Spacecraft Mission Planning and CME Early Warning

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Body
Accurate forecasting of Earth-directed Coronal Mass Ejections (CMEs) and their geo-effectiveness requires advanced early warning capabilities that exceed the limitations of current single-point L1 monitors. Sub-L1 multi-spacecraft architectures offer a highly promising solution.

In this contribution, we present a novel software pipeline designed to comprehensively simulate and analyze data from sub-L1 multi-spacecraft space weather missions. The software generates a realistic 2D spatial domain featuring an intermittent and turbulent background solar wind. This background is dynamically populated with key large-scale structures, including Corotating Interaction Regions (CIRs), Heliospheric Current Sheet (HCS) crossings, and transient CMEs. By modeling these interplanetary structures in 2D, the tool accurately reproduces the distinct, location-dependent solar wind conditions encountered by a distributed constellation of spacecraft.

To bridge the gap between physical models and mission engineering, the pipeline incorporates instrument transfer functions, effectively translating the simulated space environment into realistic, telemetry-like in-situ sensor responses. Furthermore, the software features an integrated ground-segment analysis module tailored for multi-point data. This module demonstrates advanced operational techniques, including the use of magnetic helicity for robust automated CME detection. Crucially, the software implements geometric interferometry across the simulated spacecraft network to accurately estimate the propagation direction of CMEs—a vital measurement for predicting Earth-impact that is fundamentally impossible with traditional single-spacecraft observations.

Ultimately, this software suite serves as a powerful mission planning tool. We will demonstrate how it can be utilized to define strict scientific requirements for CME early warning and optimize scientific payload configurations.

Keywords: Coronal Mass Ejections (CMEs),Sub-L1 Space Weather Missions,End-to-End Software Tools

POSTER CODE: P2IOM224

Title
Thermospheric density retrieval from GNSS-based precise orbits of LEO satellites: potential, limitations, and future prospects

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Body
Precise orbit determination (POD) using onboard GNSS receivers offers a pathway to thermospheric mass density retrieval from any LEO satellite carrying a geodetic-quality receiver, independent of dedicated accelerometers. This study evaluates the method for deriving non-gravitational accelerations using Swarm and GRACE-FO precise orbits as starting points, verifying the accelerations against accelerometer measurements and the NRLMSISE-00 empirical model across a multi-year period spanning low and high solar activity.
We show that for a satellite orbiting at approximately 500 km altitude during geomagnetically quiet, low solar activity conditions, the method reaches the limits of its sensitivity: thermospheric drag signal variations within one orbital revolution (e.g., dayside-nightside differences) fall below the noise floor set by orbit accuracy and residual force model errors, particularly those arising from solar radiation pressure mismodelling and numerical differentiation of the reduced-dynamic orbit. Minimum requirements are established for each step of the processing and orbit accuracy, force model fidelity, differentiation scheme, and temporal resolution below which density retrievals become unreliable.
In contrast, during storm-time and elevated solar activity conditions, when thermospheric density enhancements are large, the same satellite would recover POD-derived densities well compared to both accelerometer data and model predictions, demonstrating clear scientific value for space weather studies and orbit prediction. The storm-time response of the thermosphere captured by Swarm and GRACE-FO is discussed in the context of multi-spacecraft coverage. The results make a case for treating every LEO satellite hosting a geodetic-quality GNSS receiver as a potential thermospheric density sensor, provided minimum requirements are met.

Keywords: thermospheric densities,atmospheric drag,non-gravitational acceleration

POSTER CODE: P2IOM225

Title
Mission overview of CENSSAT-1: Bifrost – a space situational awareness satellite

Authors
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Body
CENSSAT-1: Bifrost is an upcoming university satellite that aims to investigate central topics in space situational awareness. The 16U CubeSat is in development at the Centre for Space Sensors and Systems (CENSSS) at the University of Oslo (UiO). The scientific goals include monitoring space weather events, detecting space debris in-orbit and be a proof-of-concept for future space-based neutron-lifetime measurements. CENSSAT-1 will operate in a Low-Earth, polar Sun-synchronous orbit.

Seven experiments will be on board. A novel particle detector will characterise Solar Energetic Particles, gamma-ray transients and background radiation in LEO, and thermal-to-epithermal neutrons. A camera will regularly image the airglow, and measure peak emissions of three auroral spectral lines during active solar storms. A multi-needle Langmuir probe will measure ionospheric plasma density fluctuations on scales smaller than 100 m. A novel space debris radar will attempt to make the first observations of mm-sized debris in orbit. CENSSAT-1 will also serve as a technology demonstrator for TychoBoB, an edge processing platform, and for UHF TACSAT, a deployable spring antenna coupled with a Software Defined Radio. Finally, the software experiment DRAg COntrol (DRACO) will investigate passive regulation of the orbital motion. A FlatSat model of the satellite is currently used to test data and electronics interfaces with the payloads.

The observation strategy will enable simultaneous measurements of the space environment in LEO, and facilitate the nowcasting of solar storms. The observation principles demonstrated on CENSSAT-1 could be applied to other missions in other locations where forecasting solar storms may be more difficult.

The CENSSAT-1 mission is also training MSc, PhD, and postdoctoral researchers by being a platform to develop skills in mission design, payload development, testing and operations. The mission is currently in Phase C, and is scheduled for launch in Q3/Q4 2027.

Keywords: CubeSat,Aurora,Particle detector,Langmuir probe,Solar storms

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION IOM3

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1IOM301

Title
REACH (RESPONSIVE ENVIRONMENTAL ASSESSMENT COMMERCIALLY HOSTED) DOSIMETER DATA AVAILABILITY AND SCIENTIFIC USE CASES

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Body
Daily data from the Aerospace Corporation's REACH constellation are now available and provide significant opportunities for scientific study. REACH consists of dosimeter pairs hosted on 32 Iridium NEXT satellites spread across 6 orbital planes at ~800 km altitude. Each satellites hosts two dosimeters, for a total of 64 dosimeter measurements, allowing global, high temporal resolution measurements of particle populations ranging from ~50 keV to ~5 MeV electrons, and ~600 keV to ~50 MeV protons, covering many aspects of the space environment which can lead to spacecraft hazards, including total dose, internal charging, and single-event effects.

In this presentation I discuss data availability, documentation, and a Python analysis tools developed to access and utilize the 32 datasets. To better advertise the dataset capabilities to the scientific community, I give several scientific use cases for both the nominal (5-sec) and burst (10 Hz) data.

POSTER CODE: P1IOM302

Title
UPDATING DTM WITH DATA ASSIMILATION CAPABILITY (DTM_NRT)

Authors
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Body
The first DTM_nrt (near real time), developed in 2013, used exospheric temperature corrections inferred from observed densities essentially for debiasing. We have started the development of an updated DTM_nrt, which uses the more precise DTM2020 as background model, and more precise density data (CHAMP, GRACE, GOCE, Swarm-A, and GRACE-FO) calculated by TU Delft, as well as updated Stella daily-mean densities. This presentation shows the significant progress since ESWW in 2025.
Two versions of the new DTM_nrt model are under development: one trained on temperature values of the 5 previous days, as well as one based on temperature variations relative to an 81-day trailing mean (presented last year). The first approach allows the model to be used rapidly after launch, but at the cost of reduced precision. Both models use a Gated Recurrent Unit-based autoencoder.
The model performance will be more comprehensively presented in this poster. They are presently compared with independent test data sets, e.g. a model constructed with GRACE data is tested with CHAMP and Swarm data, and the performance is determined as a function of solar and geomagnetic activity.

POSTER CODE: P1IOM303

Title
SPARSE RECONSTRUCTION OF 3D NEUTRAL DENSITY VIA DIFFERENTIABLE ORBIT PROPAGATOR

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Body
Accurate knowledge of thermospheric neutral density is critical for predicting LEO satellite trajectories and ensuring space situational awareness, especially during geomagnetic storms. In this project, we aim to produce a global three-dimensional thermospheric density model by combining high-precision orbit data with modern modeling tools. We will ingest precise GPS-based ephemerides from low-Earth orbit missions (CHAMP, GRACE/GOCE, Swarm) as well as public catalogs (e.g., Space-Track).

A PyTorch-based orbit propagator (including Earth gravity, J2, atmospheric drag, etc.) will be implemented to allow differentiable mapping from density to orbit errors. We will formulate an inverse problem to extract along-track density from measured orbit perturbations. These along-track estimates will be assimilated into a global density grid, using climatological models as priors. In parallel, we will train a neural network (e.g. a U-Net) to map solar and geomagnetic indices to 3D density fields using the assimilated dataset.

The expected outcome is a data-driven density model that captures storm-time variations and reduces orbit prediction errors. This would enhance operational forecasts of satellite drag and re-entry risk. Our data-driven framework is designed to rapidly update thermospheric densities during geomagnetic storms, bridging gaps between empirical models and sparse measurements. The work is ongoing, and while results are preliminary, the approach is feasible and highly novel. These initial results encourage further development. In summary, this novel approach bridges traditional physical models with machine learning to directly link space weather drivers to density. Its operational potential is significant for collision avoidance and mission planning.

POSTER CODE: P1IOM304

Title

THE FORIND SPACE WEATHER SERVICE AND THE SFAC INDEX – CORRELATION WITH NEUTRAL DENSITY MODELS

Authors

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Body

Our team at the Institute of Space Science, Romania, is in charge of hosting the FORIND service as part of the ESA Space Weather network. This service provides registered user with access to 40 geomagnetic and solar indices. The users can view the indices in a graphical form or access the data values directly. The service is also accessible via a machine-to-machine REST interface. The FORIND data is used, among others, by the Met Office UK to compute the density of the neutral atmosphere, ATMDEN.

We plan to further expand our contribution to the ESA Space Weather network by introducing the new product SFAC (Sheet Field Aligned Current). Presently, SFAC is computed starting from magnetic field data provided by the Swarm satellites and its correlation with other geomagnetic indices is addressed in our recent GRL paper "Investigation of space weather effects by Swarm magnetic field data: The SFAC index", https://doi.org/10.1029/2024GL112430.

We also plan to explore the correlations between the SFAC index and the neutral density estimates provided by ATMDEN and 3 other models: MSIS, TIDA and CTIPe

POSTER CODE: P1IOM305

Title
THE 1.4 GHZ SOLAR FLUX FROM THE SMOS MISSION

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Body
This work presents the latest reprocessed Solar flux measurements derived from ESA SMOS mission level 1 dataset. SMOS (Soil Moisture and Ocean Salinity) spacecraft has been in orbit since November 2009, and it is equipped with the Microwave Imaging Radiometer with Aperture Synthesis (MIRAS), providing full-polarization measurements at 1.4 GHz (corresponding to a wavelength of approximately 21.4 centimeters) and an integration time of 1.2 s. The solar signal is retrieved from MIRAS images and converted into solar flux.
The relation between SMOS solar flux and independent solar radio flux at other wavelengths (e.g. F10.7, F30) is stable and does not exhibit the discontinuity recently identified in the Radio Solar Telescope Network (RSTN) 1.4 GHz channel. This makes SMOS very valuable for studying the long-term behavior of the solar flux, thanks to its calibration stability, operation continuity, and capability to characterize the circular polarization of solar radio burst events in a technologically relevant frequency.
The comparison of SMOS solar flux with solar activity proxies and ionospheric and geomagnetic parameters demonstrated a strong agreement with daily solar flux data at different frequencies. This makes SMOS data suitable as a stable input for solar flux frequency interpolation models, potential diagnostic references for satellite missions lacking dedicated ground-based observations at a given frequency.
SMOS solar flux showed a good correlation also with the MgII, that is another index monitoring the ionospheric variability, and with other key ionospheric parameters, like the Total Electron Content (TEC) and the F2-layer critical frequency (foF2), whose variability is mainly driven by solar activity. These indices have been traditionally modeled using F10.7 as a proxy. Recent studies hint that F30 may provide improved performance; this work demonstrates that a model based on SMOS solar flux data can provide similar or even superior results than F30.

POSTER CODE: P1IOM306

Title
MAKING SPACECRAFT HOUSEKEEPING TELEMETRY SPACE WEATHER–READY

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Body
Spacecraft housekeeping (HK) telemetry is routinely generated for spacecraft and instrument health monitoring, yet it can also contain signatures of energetic particles and other Space Weather phenomena. Examples include EDAC/SEU counters, particle-induced star-tracker artefacts, detector background variations and instrument status events. Recent studies have demonstrated the value of such signals, but their exploitation remains largely mission-specific.
We propose a standardized framework for identifying, documenting and archiving Space Weather–relevant HK parameters throughout the mission lifecycle. The framework defines a common taxonomy of potentially useful observables and recommends minimum metadata describing the physical origin of the signal, sensitivity, temporal resolution, dynamic range, quality information and relevant spacecraft context.
A key objective is to make these data discoverable and interoperable across missions, while distinguishing direct particle proxies from radiation-induced event indicators and indirect environmental signatures. Existing examples from missions such as Rosetta and Swarm illustrate the potential of this approach.
Standardized, Space Weather–ready HK telemetry could provide a low-cost, distributed source of opportunistic observations, complementing dedicated Space Weather instruments and enabling the future reuse of engineering data for Space Weather research and operational applications.

POSTER CODE: P1IOM307

Title
CHARACTERIZING SOLAR ROTATION SIGNATURES IN GLOBAL THERMOSPHERIC DENSITY WITH STARLINK DATA

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Body
The thermosphere plays a key role in atmospheric dynamics and influences various space-based activities, including satellite operations and navigation. Understanding its density and how it changes is important for safe operations of Low-Earth Orbiting (LEO) satellites, including orbital predictions, reentry estimates, and collision avoidance. Thermospheric density varies with latitude, longitude, and time due to variable internal forcing, e.g., atmospheric dynamics and waves, and external drivers, such as solar extreme ultraviolet (EUV) flux changes and solar wind disturbances. Improved data on thermospheric density can lead to better modeling of satellite behavior, enhancing the accuracy of orbital predictions, and improving collision avoidance efforts. Precise Orbit Determination (POD) solutions of neutral density from the Starlink constellation were analyzed to examine thermospheric variability at satellite altitudes. The data set used in this study covers the period of April 2022-2023. In this paper, we show the response of thermospheric density to changes in the F10.7 solar flux and EUV fluxes. We will show that the 27-day thermospheric density modulation is better described by EUV flux variations than by the F10.7 index. The relative contribution of each GOES-R EUV irradiance channel (or combination of channels) to characterizing thermospheric density modulation will also be discussed.

POSTER CODE: P1IOM308

Title
SWARM FAST LEVEL-2 DATA FOR NEAR-REAL-TIME SPACE WEATHER MONITORING

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Body
The European Space Agency (ESA) launched the Swarm mission on November 22, 2013, to continuously monitor Earth's geomagnetic field and its changes over time in unprecedented detail. The mission consists of three identical satellites, Alpha (A), Bravo (B), and Charlie (C), which orbit near-polar Low Earth Orbit. Swarm A and C fly side by side about 470 km above Earth, while Swarm B remains higher at around 520 km. Each satellite carries six advanced scientific instruments, including magnetometers, a star tracker, an electric field instrument (Langmuir probe and thermal ion imager), a GPS receiver, and an accelerometer. For over a decade, Swarm has provided high-quality data and valuable insights into Earth's magnetic field, the ionosphere, and other dynamic processes in the near-Earth environment.

The Swarm Level-1b fast-track (FAST) data have been delivered since November 2023 at a significantly higher frequency and with much lower latency, multiple times per day, than standard operational (OPER) products, which are typically available after several days. FAST processing is designed to minimise the delay between measurement and availability, enabling near-real-time access to key observations. This rapid delivery enhances capabilities for space weather monitoring and forecasting. In particular, Level-2 (L2) FAST data products, which are generated from Level-1 (L1) inputs, are important for space weather applications. Here, we present products derived within the GFZ FAST processing chain (see https://swarm-diss.eo.esa.int/#swarm/Fast/Level2), which complement our understanding of ionosphere–thermosphere–magnetosphere coupling and related phenomena that are key components in studying and characterising space weather.

POSTER CODE: P1IOM309

Title

GEOMAGNETIC STORM IMPACTS ON LEO SATELLITE DRAG: EVENT STATISTICS, ALTITUDE DEPENDENCE, AND EMPIRICAL ESTIMATION

Authors

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Body

Geomagnetic storms enhance thermospheric density and increase atmospheric drag on low Earth orbit satellites, resulting in accelerated orbital decay. In this study, we examine storm-time orbital decay responses using GRACE and GRACE-FO observations for 22 geomagnetic storm events classified from G1 to G5 according to the NOAA geomagnetic storm scale. Quiet-time and storm-time decay rates were derived from 24-hour moving-averaged satellite altitude variations to quantify the enhancement of LEO satellite drag during geomagnetic disturbances. The results show that orbital decay enhancement generally increases with storm intensity. The mean decay-rate enhancement rises from 77.2% for G1 storms to 166.5% for G5 storms, and most events exhibit enhanced decay within one to two days after storm sudden commencement. This indicates a rapid response of LEO satellite drag to storm-time thermospheric density enhancement. However, several low-altitude events show strong decay enhancement even during relatively weak storms, suggesting that geomagnetic storm intensity alone is not sufficient to explain the observed drag response. Satellite operation altitude is therefore an important factor in determining the magnitude of storm-time orbital decay. To further quantify these dependencies, we developed a simple empirical multiple linear regression model for estimating the storm-time decay rate using quiet-time decay rate, maximum Kp index, operation altitude, and satellite mass. The model shows good agreement with observations, with $R^2 = 0.91$ and RMSE = 12.3 m/day. These findings highlight the combined roles of geomagnetic activity and satellite orbital conditions in controlling LEO satellite drag and provide useful information for improving orbit prediction and assessing space weather impacts on satellite operations.

POSTER CODE: P1IOM310

Title

TURBULENT DYNAMICS OF THE UPPER IONOSPHERE OBSERVED BY SWARM MAGNETIC FIELD RECORDS AND ITS IMPLICATIONS FOR SPACE WEATHER

Authors

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Body

Small-scale plasma irregularities are ubiquitous in the upper ionosphere and can severely distort GNSS radio signals, causing loss of lock events and ground scintillations. We characterize the magnetic signatures of these irregularities using the high-frequency (50 Hz) vector field magnetometer (VFM) records of the ESA Swarm mission triplet.

We investigate ionospheric turbulent dynamics through intermittent fluctuations in sliding-window segments of the Swarm magnetic field records. Intermittency is measured via a flatness-based proxy derived from probability density function (PDF) analysis of magnetic field increments, which quantifies deviations from Gaussian statistics. Besides, multifractal spectrum (MFS) analysis is also applied to provide Hölder exponent ranges and the multifractal P-model parameter of fluctuations along the orbits of the Swarm spacecraft. We extend this framework with automated spectral analysis — yielding power-law scaling ranges, exponents, and transverse–compressional anisotropy.

In the presentation we show that the strongest transverse intermittency appears in two oval-shaped regions around the geomagnetic poles, consistent with auroral oval boundaries and the ionospheric footprint of the plasmapause. Besides, we also find compressional and transverse intermittent fluctuations near ±10° dip latitude, which are linked to equatorial plasma bubble (EPB) events. Regarding space weather impact, equatorial IMI anomalies correlate with on-board GNSS loss-of-lock events and are also associated with amplitude scintillation events recorded at ground GNSS stations.

The new spectral and MFS databases, compiled for the full Swarm record (2014–present), are being developed within the SWIFT project, supported by ESA.

POSTER CODE: P1IOM311

Title
PIC ASSESSMENT OF PLASMA SHEATH EFFECTS ON LEO LANGMUIR PROBE MEASUREMENTS

Authors
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Body
Langmuir probes are essential instruments for in situ measurement of ionospheric plasma parameters, including floating and plasma potentials, density, and electron temperature. Understanding the interactions among the probe, the spacecraft body, and the orbital environment is crucial for determining whether specific geometries and environmental conditions could interfere with LP observations. This study examines how transient Magnetosphere–Ionosphere–Thermosphere (MIT) coupling electrodynamic processes can drive variations in local plasma density and temperature, biasing in situ Langmuir Probe diagnostics and impacting data quality.

We used a Particle-In-Cell (PIC) approach, in particular the SPIS and PTetra simulation frameworks, to quantify spacecraft-induced sheath interference on Langmuir probe measurements by simulating the coupled probe–spacecraft–plasma system. To accomplish this task, a realistic computer-aided design (CAD) model of an ionospheric plasma probe is constructed with a three-dimensional finite-element mesh generator, Gmsh. Particular attention was devoted to the interdependence of input parameters, defining a consistent hierarchy between them. This structured data processing approach also highlighted the operational limitations of the used simulation frameworks.

The numerical results, and their resulting implications for instrumentation geometry and operational characteristics under space weather forcing, are then compared and integrated with real observations from active Low-Earth Orbit (LEO) satellites, specifically Swarm and CSES.

POSTER CODE: P1IOM312

Title
SWARM FOR SPACE WEATHER: STATUS AND EVOLUTION OF FAST L1 DATA PRODUCTS

Authors
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Body
After nearly 13 years in orbit, ESA's Swarm Earth Explorer mission continues to operate in excellent health, delivering high-quality measurements that support a broad range of scientific investigations. These span from probing Earth's deep interior (core, mantle, and lithosphere) to characterizing the ionosphere and its complex interactions with the solar wind.
Thanks to its unique multi-satellite constellation and highly accurate observations of electromagnetic and plasma parameters in near-Earth space, Swarm provides an exceptional platform for the development of innovative Space Weather products and applications.
In November 2023, a "Fast" processing chain was successfully transitioned into operations, enabling the generation of Swarm Level-1B products, including orbit, attitude, magnetic, and plasma data, with minimal delay from acquisition. Furthermore, an optimized data downlink strategy introduced in September 2025 has increased telemetry availability and reduced latency. This enhances the timeliness and effectiveness of near real time data products for monitoring Space Weather conditions and supporting improved modelling and nowcasting of geomagnetic and ionospheric disturbances.
This work presents the implementation and current status of the Swarm "Fast" L1 data processing chain, along with planned developments and future applications in space weather monitoring.

POSTER CODE: P1IOM313

Title

THE NORM EXPLOITATION AND UTILISATION SYSTEM FOR THE MONITORING OF GEOSPACE ENERGETIC PARTICLE ENVIRONMENT

Authors

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Body

Since its launch on board ASBM-2 on August 2024, the Norwegian Radiation Monitor (NORM), has been surveying the particle radiation environment near Earth, measuring the populations of energetic electrons and protons. To facilitate the use of its data and enhance our monitoring of the radiation environment in near-real-time the NORM Exploitation and Utilisation System (NEXUS) was implemented. NEXUS allows for the quick visualization of NORM measurements, as well as data from other publicly available operational satellites of similar capabilities, while also providing access to higher level data products built upon NORM outputs, such as the electron and proton fluences and the expected radiation dose encountered by the ASBM2 satellite, for three shielding geometries (spherical, semispherical, slab) at various shielding depths. Two additional state of the art models are included within NEXUS; a new Machine Learning model for the nowcasting of the trapped electron fluxes for energies from 180 keV to 4 MeV and an updated implementation of the S2S model for the prediction of the time series fluxes of incoming solar protons, for energies from 6 up to 240 MeV. These models provide a full description of the state of the energetic particle environment and will be invaluable to users of the platform for the accurate characterization of the state of the magnetosphere and the risk estimation for satellite and human operators in geospace.

The NEXUS platform will be made freely available to users in the future. This will be announced by the Galileo programme through the usual communication channels and on the European GNSS Service Centre (GSC), with practical instructions on how to request access and terms and conditions for the usage of the platform. This work has been implemented under NORM Exploitation and Utilization System (NEXUS) project supported by the European Commission, Directorate-General for Defence Industry and Space under contract EC-DEFIS/2024/OP/0012.

POSTER CODE: P1IOM314

Title

PRELIMINARY ASSESSMENT OF IONONET DATA DURING QUIET AND GEOMAGNETICALLY ACTIVE CONDITIONS IN MARCH 2026

Authors

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Body

The ionosphere is highly variable and affected by both solar and geomagnetic forcing, as well as by atmospheric processes from below.

IonoNet is an oblique ionosonde infrastructure managed by INGV (Italy), which provides coordinated ground-based ionosonde observations across Europe, delivering real-time key ionospheric parameters for space weather monitoring and nowcasting applications.

A key objective of the project is the validation of datasets derived from the verticalization of oblique ionograms against vertical sounding references from the INGV observatories of Rome and La Spezia (Italy). An analysis is performed to study the uncertainties introduced during the oblique-to-vertical conversion process and automatic scaling procedures. The study verifies whether the verticalized oblique data consistently capture the development of the March 2026 geomagnetic storm, and whether storm related signatures are also reflected in Maximum Usable Frequency (MUF) observations on the Montelibretti (Italy) to Chambon-la-Forêt (France) radio link.

These preliminary results investigate the potential of IonoNet to provide prototype ionospheric data products for operational space weather monitoring and nowcasting over Europe.

POSTER CODE: P1IOM315

Title

TROPOMI AS A SPACE WEATHER SENSOR: DAILY MG+ DAYGLOW MAPPING OF THE SPORADIC-E LAYER

Authors

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Body

Sporadic E (Es) layers are thin ion enhancements near 90-120 km. At mid-latitudes they are formed by wind-shear convergence of long-lived metal ions of meteoric origin (e.g. Fe+ and Mg+). Though named 'sporadic', mid-latitude Es recurs regularly with a summer maximum. Es is a hard-to-forecast source of HF propagation anomalies. Es has been studied extensively from the ground with ionosondes and incoherent scatter radar, via radio occultation from LEO satellites and in-situ with rockets. However, no single technique has combined daily cadence with global, spatially continuous coverage over multiple years.

Mg+, one of the most abundant Es metal ions, has a resonance doublet at 279.6/280.3 nm that is unobservable from the ground due to stratospheric ozone absorption. Previous measurements have been done by rockets and dedicated satellite remote sensing. GOME (nadir) and SCIAMACHY (limb) revealed a patchy, summer-maximum, mid-latitude Mg+ enhancement consistent with Es. We extend this heritage to the TROPOspheric Monitoring Instrument (TROPOMI) on Sentinel-5P, a sun-synchronous LEO satellite whose UV band 1 (270-300 nm, 0.5 nm resolution) nadir spectra resolve the Mg+ doublet, enabling daily (13:30 local solar time) global Mg+ maps from 2018 onward.

As part of an initial exploration, we compute monthly averages of the Mg+ distribution and find a mid-latitude summer maximum in both hemispheres, consistent with earlier Es measurements. In addition, we see clear signatures aligned with the magnetic equator as well as occasional patches at high latitudes in summer. TROPOMI's long, continuous record makes this a promising tool for further investigations into atmosphere-ionosphere coupling and HF propagation forecasting.

POSTER CODE: P1IOM316

Title

IMPROVING THERMOSPHERIC NEUTRAL DENSITY SPECIFICATION, NOWCASTING AND FORECASTING IN LEO

Authors

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Body

Accurate specification of thermospheric neutral density (ND) is critical for orbit determination in Low Earth Orbit (LEO). Thermospheric ND is highly dynamic with day-to-night, altitude, and solar activity variations. The scarcity of thermosphere ND observations limits our ability to predict dynamic upper atmospheric changes. The ND data shortage creates critical uncertainties in modeling space weather, satellite drag calculations, and LEO satellite orbit trajectory predictions. NOAA NESDIS Office of Space Weather Observations is supporting a study to develop and test a framework and data processing software for thermosphere neutral density from SpaceX Starlink satellite orbit ephemerides and other relevant information. Preliminary evaluations of the neutral density data with the High Accuracy Satellite Drag Model (HASDM) model show promising results. A data assimilation (DA) system to ingest the orbit-averaged neutral density into the Whole Atmosphere Model (WAM) is being developed to support the ND nowcasting and forecasting capability development in NOAA. This presentation will highlight the ND data processing framework and the DA system development, preliminary results, and ongoing development effort.

POSTER CODE: P1IOM317

Title

IRF ACTIVITIES IN SPACE WEATHER, SPACE DEBRIS, AND THE NATURAL SPACE OBJECT ENVIRONMENT

Authors

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Body

The Swedish Institute of Space Physics (IRF) conducts a broad range of activities spanning space weather research, space weather operations, and monitoring of the space object environment. Within space weather, IRF has for several years advanced the understanding of Sun-Earth interactions and their impact on the Swedish power grid, particularly through studies of the induced geoelectric field and geomagnetically induced currents.

Operative activities include the development and maintenance of solar flare forecasting models, models for risk of G4/G5 from CMEs and models for forecasting ground magnetic conditions, including Kp, Dst, AE and dB/dt forecasts. IRF also monitors auroral activity through its Aurora Alert system.

A wide range of ground based instruments supports our monitoring of the near Earth environment in Sweden, including magnetometers, ionosondes, all sky cameras and riometers. These measurements are complemented by space based observations from missions such as Swarm, SMILE and MMS, Solar Orbiter, which provide in situ plasma and field data essential for scientific research.

IRF also contributes to the EISCAT radar program, providing high resolution measurements of ionospheric plasma parameters essential for both scientific research and operational space weather applications and monitoring of the space object environment. In addition, IRF is developing a space object observation data-processing pipeline for EISCAT/EISCAT_3D, accounting for the variable high-latitude ionospheric effects on radio wave propagation.

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION IOM4

VERDE ROOM – SECOND FLOOR
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2IOM401

Title
South Atlantic Anomaly Suite Detectors (SAMA-Suite): Radiation Belt Electron Proton Monitor

Authors
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Body
Variations in the solar-terrestrial environment modify Earth's radiation belts and can therefore affect satellite operations and other technological systems within the low-latitude South Atlantic Magnetic Anomaly (SAMA) region. The inner boundary of the inner radiation belt is closest to Earth in the SAMA, producing effects in the ionized and neutral atmosphere that resemble those that occur in the high-latitude ionosphere during geomagnetic storms. Conditions within the SAMA increase the risk of radiation damage to low-earth orbit spacecraft, aircraft, and International Space Station crews. However, the limited availability of charged particle flux measurements in this region constrains the development of accurate models for relativistic particle fluxes and space weather hazard mitigation. This work presents a scientific overview of the whistler wave-particle interactions that occur at low L-shells (< 2) within the plasmasphere during disturbed geomagnetic times. These interactions can scatter charged particles into the Earth’s atmosphere. It then presents a conceptual design, feasibility assessment, and development plan for an instrument designed to monitor energetic electron and proton fluxes over a broad energy range from low Earth orbits. The proposed instrument concept is part of the SAMA-Suite payload, which also includes a plasma density monitor for the Galileo Solar Space Telescope mission. In-situ observations within the SAMA region will improve our understanding of magnetosphere-ionosphere-mesosphere-thermosphere coupling at low latitudes

Keywords: Radiation Belt,Electron-Proton Monitor,Design Conception,SAMA,whistler waves

POSTER CODE: P2IOM402

Title
Response of AMORE a Novel Secondary Cosmic Rays Detector During a Mid-latitude Scientific Aircraft Flight

Authors
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Body
The Airspace Measurements of Radiation Environment (AMORE) is a novel radiation monitor for the atmospheric environment characterization. The instrument is meant to be deployed both during commercial aircraft and stratospheric balloon flights. The resulting data will be organized in a database and displayed alongside Space Weather observables and other radiation-monitor measurements. To date, the first Demo Model (DM) has been realized and calibrated. It consists of three BC-400 plastic scintillator units in a DeltaE-E-DeltaE stack configuration. Instrument features include: sensitivity to neutral and charged particles, tunable energy ranges from tens to hundreds of MeV, particle identification trough the DeltaE-E method and possibility of setting coincidence and anti-coincidence trigger patterns between the different detectors. The instrument has been widely tested with neutral and charged-particle as: proton and carbon ion beams, electrons, gammas and neutron sources. Recently, the first aircraft flight campaign has been successfully concluded. The detector has been deployed on board of a Cessna Citation 2 aircraft, during the 8th Swiss Parabolic Flight Campaign. Unlike typical commercial aircraft flights, this plane operated at different altitudes within a restricted airspace over Switzerland, corresponding to a vertical cutoff rigidity of approximately 4.5 GV. The instrument was tuned to record energy spectra in the region between 2-70 MeV. Data analysis included: study of the detector response versus the flight profile altitude, both in terms of energy spectra and trigger rates with different trigger patterns. Furthermore, a comparison has been done with ground-based acquisitions done with the same instrument from nearby locations.. This content will provide an overview of the above mentioned results.

Keywords: Space Weather,Aircraft,Secondary Cosmic Rays,Atmosphere,Scintillator

POSTER CODE: P2IOM403

Title
The Energetic Particle Telescope on board PROBA-V: space weather products, lessons learned and future plans

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Body
On 7 May 2013, a demonstrator model of the Energetic Particle Telescope (EPT) was launched aboard PROBA-V into a polar Low Earth Orbit at an altitude of 820 km, with a nominal mission lifetime of 2.5 years. While PROBA-V's primary mission – Earth vegetation monitoring – concluded in June 2020, its space weather activities, established in 2016, have continued. To date, the EPT has delivered quasi-continuously over 13 years of spectral flux measurements for electrons (0.5–8 MeV), protons (9.5–248 MeV), and α-particles (38–980 MeV) with a 2-second time resolution. Data are downlinked approximately three times per day and processed into various space weather products within hours. Available products range from orbital flux time series to daily estimates of total ionizing and non-ionizing dose for the 820 km LEO environment.

This presentation will summarize the EPT data products available at the ESA Space Weather Service Network, share experience from this extended mission, highlight key lessons learned, discuss the evolution of observations with satellite operations, and propose improvements for future instrument models and its routine operation.

Keywords: Particle spectrometer,Radiation,Space weather products

POSTER CODE: P2IOM404

Title
dvancing Radiation Belt Monitoring: The Pulse Shape Analysis based PRISE Instrument

Authors
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Affiliations
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Body
Monitoring radiation belts is crucial for both advancing our understanding of their complex dynamics and developing high-performance specification models. These models are vital for industry actors to accurately qualify space missions. Radiation monitor development faces several key challenges, including measurement contamination in mixed environments, signal-to-noise ratio limitations, and saturation effects. Under the ESA project PRISE (Particle Radiation Instrument and Spectrometer for Europe), a new monitor is being developed to address these constraints. The instrument leverages a novel approach within the space community: Pulse Shape Analysis (PSA). This technique overcomes the intrinsic limitations of traditional monitors that rely solely on deposited energy. This presentation will cover the progress of the PRISE project, focusing on the development of low-energy and high-energy detection heads designed to provide pure, or negligible contaminated, electron and proton measurements. Detection performances will be detailed through representative case studies in LEO, GTO, MEO and GEO orbits.

Keywords: Radiation monitor,Pulse shape analysis

POSTER CODE: P2IOM405

Title
Omnidirectional Proton Flux Derivation from Sentinel 6 - MF NGRM Observations

Authors
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Body
Accurate detector response modelling is essential for interpreting particle flux measurements in space radiation environments and for improving the characterisation of the low-Earth-orbit proton radiation environment. In this work, we derive a high-fidelity angular response function for the Next Generation Radiation Monitor (NGRM) unit on-board Sentinel-6 Michael Freilich (S6-MF) using Monte Carlo simulations implemented within ESA's GEANT4 Radiation Analysis for Space (GRAS) toolkit. The response function is used to reconstruct proton pitch-angle distributions (PADs) and to derive accurate S6-MF/NGRM omnidirectional fluxes using the Level 1 Version 1 directional proton differential flux measurements.
The PADs are parameterised using a sin^n(α) functional form, enabling the calculation of the anisotropy index n. For comparison, we also implement a smoothed top-hat response function to quantify the uncertainties introduced by simplified angular response models. We show that S6-MF/NGRM observations are strongly directional, and that uncorrected directional fluxes can substantially underestimate omnidirectional fluxes.
We highlight that realistic detector response modelling is critical for robust radiation belt characterisation, particularly under strongly anisotropic conditions. The framework developed is transferable to other missions with constrained viewing geometries, including LEO Sentinel-6B and SSO MetOp-SG that carry NGRM units, supporting the derivation of consistent and high-quality space radiation measurements.
A synergistic use of proton omni-directional measurements from the NGRM units on-board these LEO missions can lead to the development of near-real-time SW products that provide consistent proton flux maps and related products, e.g. warnings related to proton belt reconfiguration (e.g. May 2024 event) to the community accounting LEO and SSO.
This work was carried out during the first author's internship at ESA/ESTEC.

Keywords: Detector Response Modelling,GEANT4/GRAS,Pitch-Angle Distributions,LEO Radiation Environment,Omnidirectional Proton Fluxes

POSTER CODE: P2IOM406

Title
First Simultaneous Observations of Ground Level Enhancements using Antarctic Water-Cherenkov Detectors for Space Weather Monitoring and Alerts: Results from Argentine Stations

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Body
Ground Level Enhancements (GLEs) represent some of the most extreme Space Weather events, characterized by a sudden increase in the flux of high-energy solar energetic particles (SEPs) detected at Earth's surface. These events pose significant radiation risks to aviation, electronics, and satellite operations. Traditionally monitored by the global network of Neutron Monitors (NMs), we present the first simultaneous observations of GLEs recorded by a new network of Water-Cherenkov Detectors (WCDs) specifically designed for Space Weather applications in Antarctica.
This study focuses on data obtained from WCDs located at two independent Argentine stations located at Marambio and San Martín, separated by approximately 700 km. This dual-station configuration allows for a more precise characterization of the event. The WCDs show high sensitivity to the secondary particle showers produced by relativistic solar protons, offering a robust and cost-effective complement to traditional NMs.
Crucial for operational Space Weather, the data are transmitted in near real-time from the Antarctic continent to the servers of the Laboratorio Argentino de Meteorología del esPacio (LAMP) in Buenos Aires. As LAMP serves as the Regional Warning Center (RWC Argentina) of the International Space Environment Service (ISES), these observations are integrated into a dedicated pipeline for monitoring and issuing automated alerts. Our results demonstrate the effectiveness of WCD networks in providing warnings for extreme GLE events, enhancing the global capability to mitigate ionizing radiation hazards in the near-Earth environment.

Keywords: cosmic rays,GLEs

POSTER CODE: P2IOM407

Title
Bridging the Measurement Gap between MeV and GeV Particles in Space: Design and First Results of the CHerenkov Atmospheric Observation System (CHAOS)

Authors
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Body
Solar energetic particles are of major importance for understanding space weather. While numerous spaceborne instruments measure the particles with energies below several MeV and ground-based measurements address the particles with energies above approximately 1 GeV, the intermediate energies are sparsely covered. The CHerenkov Atmospheric Observation System (CHAOS) is a particle detector for solar energetic particles and galactic cosmic rays that bridges this gap in energy coverage. CHAOS uses multiple solid state detectors and a bismuth germanium oxide scintillator to enable energy-resolved measurements of different particle species using the dE/dx-dE/dx method. Furthermore, an aerogel Cherenkov detector serves as a velocity threshold detector. The Cherenkov detector allows a clean measurement of protons with kinetic energies of tens of MeV up to 2.1 GeV, free from electron contamination.
We describe the design of CHAOS and show first results to demonstrate the instruments capabilities. For this, we use measurements obtained during a stratospheric balloon flight as part of the BEXUS 35 campaign as well as measurements conducted at the e CERN-EU high-energy Reference Field and compare them with GEANT4 Monte Carlo simulations.

Keywords: Cherenkov effect,Aerogel,Solar energetic particles,Galactic cosmic rays,BEXUS

POSTER CODE: P2IOM408

Title
Final Report of ESA's Future Exploration Radiation Facility Definition Team

Authors
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Body
In 2025, ESA commissioned a Facility Definition Team (FDT) to define requirements for radiation instrumentation for future exploration missions and to investigate measurement techniques and instrument concepts that could meet them. The FDT's work focusses on the main destinations (Earth orbit, Moon, and Mars) covered by ESA's Directorate of Human and Robotic Exploration (HRE).

Within HRE, Exploration Science covers two categories of scientific questioning: exploration-focussed science, needed to enable the exploration programme, and exploration-enabled science, exploiting the programme's missions to answer scientific questions. The FDT's requirements cover radiobiological protection, spacecraft design and operations, resource prospecting, heliophysics, and fundamental physics, with space weather being a prominent aspect linking these fields.

The team derived a catalogue of instruments and required resources (e.g., volume, mass, power, and data volume), summarising the physical and logical principles utilised by the catalogued instruments. The requirements were assigned priorities and candidate instruments to inform resource allocation for future exploration missions.

The FDT identified concepts, detector elements, and instruments warranting further development to meet the requirements primarily in support of exploration-focussed science but optionally covering exploration-enabled science. This is intended to inform the scope of future ESA technology development contracts in this domain.

This presentation discusses the work of the FDT and the rationale for each of the judgments made. It presents a vision of what a network of radiation observatories supporting exploration missions and helping to safeguard future generations of ESA astronauts and robotic explorers might look like. The final report of the FDT, which is summarised in this presentation, will be made available for community feedback.

Keywords: Radiation,energetic particles,dosimetry,spectrometry,secondaries

POSTER CODE: P2IOM409

Title
Ion Measurements with the Lorentz Electron and Ion Analyzer - Combining Low-Energy Detection with dE/dx vs total E Measurements

Authors
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Body
Energetic ion measurements are a key diagnostic for understanding plasma acceleration and transport in geospace and beyond. We present the Lorentz Electron and Ion Analyzer (LEIA), a prototype instrument concept using magnetic particle separation and a modified dE/dx-E detector stack. Unlike conventional magnet-foil instruments, LEIA avoids the use of foils in order to reduce electron–ion cross-contamination.

This contribution focuses on the ion measurement concept and the associated detector trade-offs. LEIA aims to detect ions from approximately 30 keV while also enabling ion species discrimination at higher energies once particles penetrate the thin front detector. Lower detector thicknesses reduce the energy threshold for species discrimination, but increase susceptibility to electronic noise and thus compromise low-energy ion detection performance.

We present ongoing detector optimization studies and performance estimates for different detector configurations. The results demonstrate the potential of LEIA to combine low-energy ion sensitivity with species-resolved measurements in a compact instrument concept for future space weather and magnetospheric missions.

Keywords: Solid State Detector,dE/dx vs Total E,Suprathermal Ions,Electronics,Instrumentation

POSTER CODE: P2IOM410

Title
Hight Energy Proton Instrument (HEPI) Developments – Modelling and Implementations

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Body
The High Energy Proton Instrument (HEPI) is a compact charged particle detector and telescope currently being developed in Surrey, with support from ESA and UKSA. Unlike traditional solid-state proton detectors (SSD), HEPI detects clear Cherenkov radiation from relativistic protons, allowing it to distinguish these particles from the ionising signals found in SSDs. At present, HEPI is at technology readiness level 4/5, having produced a breadboard prototype and achieved notable success in beam testing and modelling. Ongoing projects include developing an engineering model for HEPI, enhancing low-energy detection using integrated SSDs, and creating flight-ready modules for ESA missions such as VMMO and SWORD.

Keywords: Cherenkov Radiation,High Energy Charged Particles,Detector, Telescope,SiPM,Compact

POSTER CODE: P2IOM411

Title
The radiation exposure during the Artemis II mission measured by the M-42 detectors

Authors
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Body
NASA Artemis II was the first crewed mission reaching the orbit of the moon since the Apollo era. It launched on 1 April 2026 for a 9-day journey towards the moon and back. The crewed Orion spacecraft crossed the inner and outer radiation belt during its outbound and inbound trajectory, traversed translunar space for a moon flyby and returned to Earth. Attached at different locations inside Orion were four units of the DLR M-42 EXT radiation detector, measuring dose rates and energy deposition spectra of the potentially harmful ionizing cosmic radiation during the mission. This work will show results of the measured mission dose, dose rates and energy spectra from the radiation belts and galactic cosmic radiation outside the Earth's magnetosphere during the mission, complemented by derived radiation protection quantities estimated from numerical Monte-Carlo simulations. The results from the M-42 detectors on ARTEMIS II will be put in context with previous measurements performed during the uncrewed 25 days-long predecessor mission Artemis I and the Matroshka Astrorad Experiment (MARE).

Keywords: Galactic Cosmic Radiation,Radiation Belt,Artemis,Radiation exposure,Radiation protection

POSTER CODE: P2IOM412

Title
Small Instrument, High Energies: The Design, Simulation and Calibration of the Galactic Ray high-Energy TELescope, GRETEL

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Body
The measurement of high-Z particles in low Earth orbit is a crucial part of space weather and space safety. With the Galactic Ray high-Energy Telescope (GRETEL), we present a new particle instrument for the detection of relativistic protons and heavy ions. GRETEL is designed to comply with the tight constraints imposed by CubeSat missions. The detectors themselves are very similar to the High Energy Telescope (HET) on board Solar Orbiter, namely a bismuth germanium oxide scintillator accompanied by two stacks of double-layer silicon detectors. Great changes have been made to the front-end electronics in both hard- and software. GRETEL uses a new design with a smaller form factor, a more efficient electronics layout, and redesigned readout logic, saving space and reducing power consumption and costs. In a low polar orbit, Earths magnetic field can be used as a giant magnetic spectrometer, making use of the fact that the spacecraft probes different geomagnetic cutoff rigidities along its trajectory, enabling the measurement of ionic charge states. We plan to fly GRETEL on the CubeSat mission HANS (Hamburg Autonomous Northern lights Survey), developed by the Orbital Research team of the Hamburg University of Technology (TUHH).

Keywords: Galactic Cosmic Rays,Solar Energetic Particles,Scintillator,CubeSat,Polar Orbit

POSTER CODE: P2IOM413

Title
Microscintillator Radiation Detector for Space Weather Studies

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Body
The development of lightweight, compact and portable detector systems is critical for balloon-borne and space applications due to strict payload constraints. In this study, the development and flight performance of a scintillation detector for space weather measurements is presented. The MRD (microscintillator radiation detector) is a compact, portable device with approximate dimensions of 5 x 11 cm2 and total mass of about 30 g. The detector consists of a CsI:Tl scintillator coupled to a PiN photodiode for the detection of ionising radiation. The scintillation detector provides calibrated radiation measurements up to 10 MeV and spectral discrimination with the energy resolution of 17.6 keV. It operates reliably over a wide temperature range, including temperatures going down abroad as as low as minus 60 °C which makes it suitable for high-altitude balloon applications. The MRD is suitable for deployment as a balloon payload or a ground-based sensor. In this presentation we will describe the device and show analysis of the detector's response to Ground Level Enhancements and Forbush decreases. We believe these results are some of the first energy spectra of ionising radiation measured at the surface during space weather events. A series of data in a high-altitude weather balloon flight is collected by MRD and enabled generation of altitude profiles for count rate and gamma energy spectra. The MRD provides special capability for upcoming flights during space weather events.

Keywords: Space Weather,Radiation Detection,Atmospheric Ballooning,Cosmic Rays,Scintillation

POSTER CODE: P2IOM414

Title
A Prototype Detector for Near-Relativistic Protons and Helium: ProHEPaM

Authors
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Body
The detection of energetic particles in the range between conventional space-based instruments and ground-based observations remains a key challenge in heliophysics. This energy band lies between a few 100 MeV and several GeV. Building on the successful demonstration of the CHerenkov Atmospheric Observation System (CHAOS) during the BEXUS 35 campaign, we present the design of ProHEPaM, a prototype for the Advanced High-Energy Particle Monitor (AHEPaM). ProHEPaM incorporates five double-sided silicon strip detectors (SSDs), three BGO scintillators, and an aerogel Cherenkov detector to extend particle identification capabilities towards GeV energies. The instrument design uses the combined dE/dx–dE/dx technique and velocity threshold measurements and reflects insights gained from CHAOS.
This contribution presents the design evolution, experimental approach, and how ProHEPaM aims to validate and consolidate the measurement methodology for near-relativistic ions.
On top of this, the experiment will also provide relativistic electron measurements.

Keywords: Cherenkov,high-energy,prototype

POSTER CODE: P2IOM415

Title
Use of Drift Echoes to Characterize Long-term Effects of Radiation Damage on GOES Ring Current Proton Channel Energies

Authors
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Body
RIng current proton fluxes (10's-to-100's of keV) observed by NOAA's solid state telescopes in low-earth-orbit (LEO) and geostationary orbit (GEO) have been observed to decrease gradually with time. This decrease has been attributed to the growth of a dead layer in the first few micrometers below the silicon detector surface caused by radiation damage by the same protons. As the dead layer grows, protons deposit less energy in the active part of the detector. Higher incident proton energies are thus required to satisfy the fixed channel logic. As a result, the channel effective energy increases and the observed fluxes decrease with time. We have used the energy-dependent periodicities of drift echoes observed in geostationary orbit to characterize changes in GOES-16 Magnetospheric Particle Sensor - High Energy (MPS-HI) channel energies. This physics-based method was originally used to cross-calibrate electron measurements from multiple Van Allen Probes instruments (O'Brien+, JGR, 120, 2076, 2015). We identified drift-echo candidates automatically by applying an iterative CLEAN (Inceoglu & Loto'aniu, Scientific Reports, 15, 36661, 2025) spectral algorithm to high-pass-filtered MPS-HI flux time series in fixed sliding windows, with the high-pass cutoff scaled to the expected drift period at geostationary orbit. Within each window, the dominant FFT peak was localized via a Hanning-window-aware sinc^2 fit, its sinusoidal component subtracted from the residual, and its significance assessed against AR(1) red-noise surrogates re-fit to the residual at each iteration. The application of this method to 8 years of data from GOES-16 MPS-HI reveals that, while electron channel energies were stable, proton channel energies increased of order 100 keV with time. The collected drift echo detections have also been used to study the behavior of drift echoes at all local times as a function of several environmental parameters.

Keywords: geostationary orbit,radiation damage,protons,electrons,drift echoes

POSTER CODE: P2IOM416

Title
ESA's Space Radiation Monitors: Past, Present and Future Contributions to Space Weather Monitoring and Exploration

Authors
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Body
Space radiation is a major hazard to spacecraft systems, astronaut health, and mission operations. Accurate monitoring is therefore essential for characterizing solar energetic particles (SEPs), galactic cosmic rays (GCRs), trapped radiation, and transient space-weather events across orbital and deep-space environments.
Over the past two decades, the European Space Agency (ESA) has developed and flown a broad range of radiation monitors for scientific research and operational space-weather monitoring. Building on the Standard Radiation Environment Monitor (SREM), ESA's instrumentation now includes particle telescopes, dosimeters, spectrometers, and miniaturized next-generation sensors deployed on missions in diverse orbits.
This contribution reviews ESA's radiation-monitoring activities and recent advances in detector technology and instrument architecture. The poster features key instruments—including SREM, EPT, RADEM, NGRM, and NORM—together with emerging Timepix-based systems and novel silicon detectors. It also examines the transition towards compact, low-power, radiation-tolerant sensors that provide real-time measurements.
Data from ESA monitors help refine radiation models, inform spacecraft design, and improve understanding of variability in near-Earth and deep-space environments. Coordinated detector networks spanning multiple missions also enable distributed observations of energetic-particle events and strengthen future monitoring capabilities.
The poster further describes ESA's preparations for future lunar and deep-space missions.
Together, proven instruments and innovative detector technologies are enhancing Europe's ability to monitor, understand, and mitigate space-radiation hazards for robotic and human exploration.

Keywords: Radiation Monitoring,Detectors and dosimetry,Radiation Measurements,Instruments,Space weather

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION MIT1

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1MIT104

Title
IONOSPHERIC RESPONSE TO SOLAR FLARES AT MID-LATITUDES DURING GEOMAGNETICALLY QUIET PERIODS BASED ON PRUHONICE IONOSONDE DATA 2023–2024

Authors
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Body
The ionosphere is the ionized region of the atmosphere, extending roughly from 60 km to 1000 km in altitude. During flares, the near-Earth space is subjected to high-energy X-ray and EUV (extreme ultraviolet radiation) radiation, which also impacts the ionosphere. The changes in the ionospheric parameters measured by ionosondes, namely the fmin (minimum frequency) and foF2 (F2-layer ordinary-mode critical frequency) values, were examined during solar flares that occurred in geomagnetically quiet conditions (Dst (Disturbance Storm Time index) < 40 nT, Kp (planetary K-index) < 4). The necessary data were obtained by manually evaluating ionograms recorded by the Czech DPS4D ionosonde at Pruhonice (PQ052). The degree of variation was compared to quiet reference days, allowing for the determination of the deviations in the required values (dfmin, dfoF2). The time series of the deviations were investigated. Furthermore, the relationship between the deviations and a “geoeffectiveness” parameter of the solar flare was also examined. The X-ray flux, the solar zenith angle of the station at the time of the event, and the position of the flare on the solar disk were also taken into account for the determination of the “geoeffectiveness” parameter. A positive correlation was observed between dfmin and the geoeffectiveness parameter of the flare, which was more significant than the correlation between the dfoF2 and the geoeffectiveness parameter.

POSTER CODE: P1MIT105

Title
MULTI-POINT OBSERVATIONS OF THE GLOBAL MAGNETOSPHERIC RESPONSE TO THE 20-22 DECEMBER 2015 CORONAL MASS EJECTION

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Body
We present an event study of the global magnetospheric response to a Coronal Mass Ejection (CME) that arrived at Earth between 20 and 22 December 2015, driving an intense geomagnetic storm with a Dst minimum of -160 nT. Among other substructures, the event is characterised by a distinctive rotation of the interplanetary magnetic field from negative Bz to negative By, with comparable magnitudes.

Upstream solar wind conditions are well constrained using ACE on the sunward side, enabling estimation of the flux-rope geoeffectivenes. With MMS located in the solar wind near the bow shock nose, we obtain an accurate determination of the CME's arrival time ahead of any bow shock motion, supporting accurate timing analysis of the disturbances linked to substructures embedded within the CME. MMS dayside magnetosheath measurements, recorded near its second apogee during the event, capture parts of the magnetosheath response, with THEMIS providing complementary coverage of the magnetotail region during the same interval. These measurements are combined with field-aligned current observations from AMPERE and ground-based magnetic perturbations from SuperMAG to characterise the global magnetospheric response to the CME.

We discuss the timing and magnitude of the magnetospheric and ionospheric responses to the Bz-to-By transition, and assess the extent to which the rotational character of the driving field shapes the development of the geoeffective response across multiple magnetospheric domains and scales.

POSTER CODE: P1MIT107

Title

NEUTRAL MASS DENSITY SCALE HEIGHT IN THE UPPER THERMOSPHERE ESTIMATED FROM LEO SATELLITE MEASUREMENTS

Authors

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Affiliations

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Body

Scale height in the upper thermosphere is a key parameter for describing the altitude profile of a neutral gas. Experimental estimation of the scale height is difficult. However, this can be done when two low-Earth-orbit (LEO) satellites are coplanar (similar local solar times at their ascending/descending nodes) with neutral mass density measurement. During 2014-2024, we found six coplanar periods between two satellites of the Swarm, GRACE, and GRACE-FO missions, spanning more than 600 days in total and occurring during both high- and low-solar-activity years. Using the neutral mass density measured by those satellites, we can estimate the neutral mass density scale height in the upper thermosphere. The results are used to perform a statistical analysis showing how the neutral mass density scale height depends on solar EUV radiation (F10.7 index as a proxy), local solar time (LST), latitude, seasons, solar EUV radiation (F10.7 index as a proxy), and geomagnetic activity. Our main findings include: (1) the neutral mass density scale height is highly correlated with F10.7P index between 09 and 18 LST at low and mid latitudes, indicating a dominant effect of solar EUV radiation, which increases hemispheric neutral temperature and thus increases the scale height; (2) In the winter hemisphere, the scale height increases at mid- and high latitudes, particularly when F10.7P index is low, indicating winter Helium bulge at the satellites' altitudes; and (3) the scale height increases during geomagnetic storms due to an increase of neutral temperature associated with high-latitude Joule heating.

POSTER CODE: P1MIT108

Title

CHARACTERIZING THE IONOSPHERIC RESPONSE OF A HIGH-LATITUDE STEVE EVENT DURING THE LATE RECOVERY PHASE OF A GEOMAGNETIC STORM

Authors

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Body

The high- and mid-latitude regions are characterized by complex magnetosphere–ionosphere coupling processes that can result in a variety of ionospheric responses. In recent years, a newly recognized optical phenomenon known as Strong Thermal Emission Velocity Enhancement (STEVE) has attracted considerable attention from both citizen scientists and the scientific community. Although STEVE resembles an auroral structure, it differs fundamentally from aurora because it is not primarily driven by particle precipitation and exhibits a continuum emission spectrum. In this work, we investigate an unusual STEVE event observed on 27 March 2023 at higher latitudes than typically reported and during the late recovery phase of a geomagnetic storm under relatively quiet geomagnetic conditions. A multi-instrument approach is employed to characterize the ionospheric response associated with this event with the aim to learn more about STEVE generation mechanism, still not fully understood. Using high-precision Global Navigation Satellite System (GNSS) receivers in Alaska together with data from the NOAA Continuously Operating Reference Stations (CORS) network, we analyze ionospheric scintillation indices and Total Electron Content (TEC) variations. These observations are complemented with measurements from the Swarm satellite constellation and ionosonde data to investigate the electrodynamic and plasma conditions associated with the event. Our preliminary results show the dynamics and the spatial evolution of the ionospheric irregularities likely associated with STEVE to reveal new insight on the phenomenon.

POSTER CODE: P1MIT109

Title

MMS OBSERVATIONS OF KINETIC ALFVEN WAVE TURBULENCE AND STEEP KINETIC-RANGE SPECTRA IN THE OUTER PLASMA SHEET BOUNDARY LAYER

Authors

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Body

Energy dissipation and particle acceleration in the collisionless magnetotail plasma remain incompletely understood. While Kinetic Alfven Waves (KAWs) are widely hypothesized to mediate these processes, observational characterization of their spectral properties and dissipation signatures in magnetotail boundary layers remains limited. We report observations of KAW turbulence and parallel electric fields in the outer Plasma Sheet Boundary Layer (PSBL) using high-resolution burst-mode data from the Magnetospheric Multiscale (MMS) mission.

For a crossing event on May 31, 2017, we identify broadband KAW turbulence characterized by a normalized electric-to-magnetic field ratio of 2.5 ± 1.2 exceeding the MHD limit, a spectral break near ion scales, a steep kinetic-range spectral slope (α = -3.48 ± 0.13), and low magnetic compressibility of approximately 0.03. We observe impulsive parallel electric field structures (up to 15 mV/m) and large-amplitude density fluctuations (up to 68%) during intervals of enhanced wave activity.

The steep spectral slope, steeper than theoretical predictions for undamped KAW cascades (-7/3 to -8/3), is consistent with substantial energy removal from the cascade at kinetic scales. The near-zero correlation between the parallel electric fields waveform and density fluctuations (r approx -0.03) suggests that the observed parallel electric field structures are not straightforwardly organized by compressive density variations, consistent with dissipation through direct wave-particle interaction. Attribution to a specific damping channel (e.g., Landau damping) is not uniquely constrained by the present diagnostics. These observations support collisionless damping of KAW turbulence at kinetic scales in the intermediate-beta, outer PSBL of the terrestrial magnetotail.

POSTER CODE: P1MIT110

Title

STATISTICAL ANALYSIS OF THE IONOSPHERIC RESPONSE TO GEOMAGNETIC STORMS IN THE EASTERN NORTH ATLANTIC MID-LATITUDINAL ZONE

Authors

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Affiliations

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Body

Ionospheric response to a geomagnetic storm depends on several factors. Strength of a storm, commencement time and type, season and the observational site location, phase of the solar cycle and a type of the solar origin of a geomagnetic storm (e.g., CME or HSS) are among them.

Here we present an analysis of eighty moderate to major geomagnetic storms that took place during the declining phase of the solar cycle 24 from 2015 to 2019.

The ionospheric response to these storms was analysed using the total electron content (TEC) data obtained from three geodetic receivers located in Portugal: Lisbon (Continental Portugal), Furnas (Azores) and Funchal (Madeira). Two of the receivers (Lisbon and Furnas) are located at about the same latitude (~39ºN) while the third receiver (Funchal, ~33ºN) is positioned quite well to the south. Also, the receivers are distributed in longitude from 9ºW to 25ºW.

Statistical analysis of the observed TEC variations allowed us to detect specific patterns (such as the type of the ionospheric response, first peak time and its amplitude, duration of the disturbance, etc.) in the ionospheric response to storms with different characteristics. Special attention was given to the analysis of the longitudinal and latitudinal (dis)similarities in the ionospheric variations, observed at the three studied locations.

The obtained results will be used later to develop ionospheric forecasting models which take into account individual features of geomagnetic storms.

POSTER CODE: P1MIT112

Title

EXTREME BIRKELAND CURRENTS ARE MORE LIKELY DURING GEOMAGNETIC STORMS ON THE DAYSIDE OF THE EARTH

Authors

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Affiliations

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Body

We examine the statistical distribution of large-scale Birkeland currents measured by the Active Magnetosphere and Planetary Electrodynamics Response Experiment in four unique categories of geomagnetic activity for the first time: quiet times, storm times, quiet-time substorms, and storm-time substorms. A novel method is employed to sort data into one of these four categories, and the categorizations are provided for future research. The mean current density is largest during substorms and its standard deviation is largest during geomagnetic storms. Current densities which are above a low threshold are more likely during substorms, but extreme currents are far more likely during geomagnetic storms, consistent with a paradigm in which geomagnetic storms represent periods of enhanced variability over quiet times. We demonstrate that extreme currents are most likely to flow within the Region 2 current during geomagnetic storms. This is unexpected in a paradigm of the current systems in which Region 1 current is generally larger.

POSTER CODE: P1MIT114

Title
MACHINE LEARNING-BASED PREDICTION OF THERMOSPHERIC DENSITY AT FOUR ALTITUDES

Authors
Luca Giovannelli [1], Raffaele Reda [1], Emanuele Santinami [1], Francesco Berrilli [1], Simone Chierichini [1], Dario Del Moro [1], Giuseppina Nigro [1], Tiziano Ortolani [1], Daniele Soldati [2], Luca Spazzacampagna [2], Daniele Santese [3]

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Body
The thermosphere, ranging from 80 to 800 km, experiences significant density variations driven by changes in solar radiation and energetic particle flux reaching Earth. These variations occur over a wide range of timescales, primarily following the 11-year solar activity cycle. Enhanced solar emissions, particularly in the ultraviolet (UV) range, can substantially influence Earth's upper atmosphere. Although increased thermospheric density ultimately reduces the long-term debris population through accelerated deorbiting, it also shortens satellite lifetimes. Moreover, sudden density enhancements can induce significant deviations from predicted orbits, posing additional challenges for collision-avoidance systems. In this work we focus on the time scales from daily to decadal, with the aim to explore the effects of the different regimes of the solar activity on the prediction metrics of the thermosphere density based on a machine learning approach. To achieve this goal we model the daily thermospheric density at four different altitudes usingmachine learning techniques trained on in-situ data from GOCE, GRACE A, and Swarm B/C satellites. By employing a gradient boosting regressor algorithm based on solar and geomagnetic indicators, we demonstrate that the models accurately reproduce in-situ density variations, offering a promising tool for nowcasting thermospheric conditions.

POSTER CODE: P1MIT115

Title
LEVERAGING CITIZEN SCIENCE FOR AURORAL RESEARCH: ARCTICS AND BEYOND

Authors
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Body
In the past decade, the rapid improvement of commercial cameras and smartphones together with the social media boom has made it easier than ever to photograph the aurora without being an expert or even having prior experience being an aurora chaser. This was illustrated during the recent strong geomagnetic storms of solar cycle 25, after which spectacular pictures of auroral displays down to the midlatitudes were posted online and reproduced in local and national media articles alike. How much science can be done using such images as data? This is a question that motivated the ARCTICS (Auroral Research Coordination: Towards Internationalised Citizen Science) Working Group sponsored by the International Space Science Institute (ISSI) in Bern in 2024–2025, which has brought together academic researchers and citizen scientists from Europe, North America, and Oceania to investigate auroral and subauroral physics. Initially proposed as a way for the STEVE and dune aurora communities to join efforts and learn from each other, ARCTICS has exceeded its foreseen objectives and created momentum in auroral citizen science that will outlive the working group itself. In this poster, we present a selection of scientific results achieved by ARCTICS and discuss other forms of outputs and newer projects that form part of its legacy.

POSTER CODE: P1MIT116

Title

AI-DRIVEN ANALYSIS OF SPACE WEATHER: FINDING DOMINANT MODES IN SPACE-BASED MEASUREMENTS

Authors

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Body

A specific aspect of space weather that remains poorly understood is the exchange of information from space to the ground through the ionosphere. A central component of this process involves understanding how current systems such as field-aligned currents transfer energy and momentum between the magnetosphere and the ionosphere. However, the non-linear behaviour of these current systems poses significant challenges for identifying the drivers of ionospheric currents and understanding the inner dynamics of the ionosphere itself.

To tackle these complexities and their effects on the ground, we adopt a data-driven approach using space-based observations from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE). Specifically, we focus on gaining insights into what drives these current systems by finding underlying statistical patterns (dominant modes) in the data using unsupervised machine learning methods. To do so, we employ β- Variational Autoencoders (β-VAEs), which have been proven useful in identifying patterns in unlabelled observational data.

We extract dominant modes and connect them to physical drivers of the system with a two-step approach. First, we quantify model performance using a physically motivated goodness-of-fit metric to ensure that the learned model reconstructions capture the essential dynamics in the current system. Second, we analyse the model's latent space, representing a compressed representation of the high dimensional input data. We then analyse the latent space and connect the influence of the individual latents to physical drivers of the system through the usage of the OMNI dataset. This approach enables a systematic interpretation of the model's internal representations in terms of underlying physical processes.

POSTER CODE: P1MIT117

Title

IONOSPHERIC CURRENT PATTERN DURING TRAVELING IONOSPHERIC DISTURBANCES INDUCED BY GEOMAGNETIC ACTIVITY DRIVEN BY A CORONAL HOLE CONNECTION

Authors

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Body

Spherical elementary current systems (SECS) provide a method for modeling ionospheric currents and other ionospheric vector fields. Recently we developed a differentiable alternative for the original SECS and showed how to regularize the SECS system with Bayesian tools using intuitive, physically meaningful prior parameters. We have now applied the method with Kalman filtering to SuperMAG and AMPERE data to derive a timeseries of current maps coinciding with observations of large scale traveling ionospheric disturbances over Europe on 26.03.2025 associated with an HSS driven geomagnetic storm. Space and time variations of ionospheric and field aligned currents based on our SECS analysis are compared with ionospheric tomography results and DMSP particle precipitation data.

POSTER CODE: P1MIT118

Title

THERMOSPHERIC DENSITY VARIATION ACCORDING TO ALTITUDE – SWARM OBSERVATIONS COMPARED WITH SEMI-EMPIRICAL MODELS

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Body

Accurate neutral density prediction at low Earth orbit (LEO) altitudes are essential for satellite orbit determination, collision avoidance, and maintaining accurate satellite catalogues. Semi-empirical thermospheric models are valuable tools for density prediction, as physics-based models require substantially greater computational resources and accurate initial and boundary conditions. Many semi-empirical models assume the Walker-Bates temperature profile, which is an important factor controlling also the altitude profile of density.

We investigate the performance of semi-empirical thermospheric models by comparing density predictions from DTM2020 (operational and research) and MSIS2.0 to HASDM data base and Swarm B and C neutral density observations from two different altitudes (~460 and ~510 km). The analysis covers observations from June 2014 to April 2026. Simultaneous satellite observations from two altitudes were identified by subtracting the radial distance of the satellites from the total three-dimensional distance and limiting the remaining tangential distance to be < 100 km. A total of 1028 coincident pairs were identified. Model and HASDM densities were evaluated at the corresponding observation times and locations with the Swarm density estimate by the Precision Orbit Determination product. In the poster we present comparison results as categorized according to season, latitude, local time, and hemisphere.

POSTER CODE: P1MIT119

Title
CROSSING THE ATMOSPHERE-SPACE BOUNDARY AT AURORAL LATITUDES

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Body
Using 17-years data of meteor radars and conjugate ionosonde observations at auroral latitudes (Sodankylä Geophysical Observatory, Finland), we studied mechanisms of the atmosphere-ionosphere-magnetosphere coupling and generation and propagation of atmospheric gravity waves into the ionosphere. These studies focus on the mesosphere – low thermosphere (MLT) region comprising the height range between 80 and 100 km, which is the least explored of all regions of the Earth's atmosphere and, therefore, sometime called the "ignorosphere". The main problem is that the air density there is too low for aircrafts and balloons to fly, while at the same time there is enough air to brake satellites, such that this layer is considered as a boundary between Earth's atmosphere and outer space. One of the most interesting results was obtained from a comparison between statistics of the atmospheric gravity waves (AGWs) near the mesopause and their signatures in the ionospheric ionization at 250-350 km height (traveling ionospheric disturbances, TIDs). It has revealed that when the atmospheric circulation is changing from summer- to winter-type, some processes occurring between 90 and 120 km prevent downward propagation of AGW generated in the auroral electrojet. Other results relate to statistics of the AGWs and TIDs and their dependences on the solar and geomagnetic activity.

POSTER CODE: P1MIT120

Title

PROJECT ESPIRE: ANALYSIS OF SOLAR STORM IMPACTS ON THE UPPER ATMOSPHERE AND SATELLITE ORBITS

Authors

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Body

Extreme space weather events observed during Solar Cycle 25 highlight critical shortcomings in empirical thermosphere models and demonstrate the urgent need to understand the complete physical chain from solar storms to upper-atmospheric response and satellite orbit decay. The interdisciplinary national project ESPIRE (Earth and Space Weather: Interdisciplinary research) addresses these challenges by combining satellite geodesy, heliospheric physics, and upper-atmospheric aeronomy. This poster presents the current status and preliminary findings of the project. We investigate the interaction between coronal mass ejections (CMEs), solar flares, and co-rotating interaction regions, with a special focus on possible preconditioning effects. Regarding storm-induced satellite orbit decays, we present a new release of neutral mass density estimates for the low Earth orbiting satellite missions GRACE-FO and Swarm. Finally, concerning the atmospheric modeling, we present a completely revised and updated version of the THP-MoCaCo model. This combined multidisciplinary analysis aims to improve our physical understanding of solar–terrestrial coupling for orbit determination and space safety applications in low Earth orbit.

POSTER CODE: P1MIT121

Title

IONOSPHERIC AND GROUND RESPONSES TO NEAR-EARTH BURSTY BULK FLOWS ON 7 DECEMBER 2023

Authors

Vanina Lanabere [1], Stephan Buchert [1], Adrian Blagau [2], Harriet George [1], Sota Nanjo [3], Liisa Juusola [4], Andrew P. Dimmock [1], Samuel Wharton [5], Heikki Vanhamäki [6], Octav Marghitu [2], Louis Richard [1], Lei Cai [6], Alice V. L. Wallner [1,7], Daria Kotova [8], Yaqi Jin [8], Theresa Hoppe [4], Jennifer A. Carter [5], Anita Aikio [6]

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Body

On 7 December 2023, between 18:00 and 22:00 UT, six bursty bulk flow (BBF) intervals were detected by THEMIS at XGSE~-8 RE, with clear dipolarization signatures in the last four intervals. These flows map to the pre midnight magnetic local time sector over northern Fennoscandia, where the ionospheric response is examined using horizontal equivalent current density derived from the IMAGE magnetometer network and auroral emissions from all sky cameras. Throughout the BBF activity, the horizontal ionospheric current density reorganizes rapidly around the mapped footpoints, and the auroral arc intensifies simultaneously with THEMIS enhancements of 9-20 keV electron fluxes. During the fourth BBF, the Swarm A/C orbit intersected the mapped BBF footpoint, revealing a strongly localized pair of upward and downward field aligned currents spanning 35-50 km in latitude, with the upward current colocated with a discrete auroral arc. When dipolarizations were detected, the ground magnetic disturbances showed increases peaking at about 200 nT/min, and the rate of change of total electron content exhibited larger irregularities during stronger dipolarizations. These results demonstrate clear space weather effects driven by near Earth BBFs/dipolarization.

POSTER CODE: P1MIT122

Title

STUDY OF THE COMPOSITION AND EVOLUTION OF THE RING CURRENT DURING THE MAJOR STORM OF MAY 2024

Authors

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Body

This thesis investigates the evolution of the Earth's ring current during the intense geomagnetic storm of May 2024, one of the strongest storms of the past few decades, during which the SYM-H index reached a minimum value of -518 nT. The storm was driven by the successive arrival of multiple interplanetary coronal mass ejections (ICMEs), which originated from the merging of two active regions on the Sun.

The study is based on measurements from the MEP-i instrument onboard the Japanese Arase (ERG) mission, which measures the omnidirectional differential flux of ions (H+, O+, He++) in the energy range of 10-180 keV/q with mass-discrimination capability. Using these measurements, the energy density of each ion species was computed, and its temporal and spatial evolution was examined across different L-shell ranges and throughout the various phases of the storm.

The results revealed a significant change in the composition of the ring current as the storm progressed. Under quiet conditions the current consists mainly of protons, whereas during the main phase of the storm the composition reverses and ionospheric O+ becomes the dominant species at the storm's peak, with the energy content of oxygen becoming increasingly concentrated deeper within the inner magnetosphere. During the recovery phase, the ion populations follow distinct decay patterns, with O+ being lost more rapidly and protons maintaining an enhanced presence owing to their longer lifetimes. This behavior indicates that the recovery of the SYM-H index does not necessarily imply a full restoration of the ring current to its prestorm levels.

Overall, this thesis highlights the contribution of ionospheric heavy ions to the ring current during intense geomagnetic storms and underlines the importance of analyzing particle composition, beyond classical geomagnetic indices.

POSTER CODE: P1MIT126

Title

MACHINE LEARNING APPROACH TO THERMOSPHERE DENSITY FORECASTING WITH DAILY RESOLUTION

Authors

Tiziano Ortolani [1], Luca Giovannelli [1], Francesco Berrilli [1], Dario Del Moro [1], Giuseppina Nigro [1], Simone Chierichini [1], Raffaele Reda [1]

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Body

Accurate modeling of thermospheric density is a fundamental requirement for predicting satellite drag and ensuring the safety of space operations in Low Earth Orbit. Variations in solar activity, primarily through extreme ultraviolet radiation and geomagnetic disturbances, drive the continuous thermal expansion and contraction of the upper atmosphere. These interactions are typically monitored using solar and geomagnetic indicators, such as the F10.7 and F30 radio fluxes alongside the MgII index, which serve as essential proxies for the energetic inputs that govern thermospheric heating. While traditional empirical models provide a physically consistent baseline, their rigid analytical formulations often struggle to capture the complex, non-linear responses induced by impulsive space weather events. To address these limitations, in this study we first implement a ML framework based on a GBR and a Multi-Output Regressor architecture to nowcast and forecast daily atmospheric density at four distinct altitudes. These models are trained using in-situ measurements from the GOCE, GRACE, and Swarm satellite missions, spanning over 20 years. Moreover, we perform a systematic regression analysis on a similar dataset, to optimize the analytical Bates-Walker density profile through a least squares refinement of the exospheric temperature coefficients, aiming to reduce the systematic biases inherent in standard empirical models. Our results demonstrate that the data-driven architectures significantly outperform the optimized analytical formulations, particularly in the Very Low Earth Orbit regime where density signals are more strongly anchored to stable physical drivers. We also identify a critical twenty-three-day forecasting limit that corresponds to the mean rotational period of the Sun. This dual-stage methodology provides a robust tool for Space Situational Awareness

POSTER CODE: P1MIT127

Title

INVESTIGATING THE RELATIONSHIP BETWEEN GEOMAGNETIC STORMS AND SOLAR ACTIVITY - CAN SUNSPOT NUMBER BE USED TO PREDICT GEOMAGNETIC STORM OCCURRENCE?

Authors

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Body

A geomagnetic storm is a significant and prolonged disturbance of the Earth's magnetic field caused by an enhancement of the ring current. Storms are typically identified using magnetic field measurements from multiple ground-based magnetometers, and the corresponding dates and times of multiple storms can be collated to form a storm list. There is currently no quantitative definition of a geomagnetic storm, so the contents of a particular storm list are highly dependent on the identification criteria that were used to generate it. The differences in definition may cause lists to be biased to certain parts of the solar cycle, which will affect studies into the relationship between solar activity and storm occurrence. We consider multiple similar storm lists to attempt to quantify the effects of these differences on forecasting results.

We investigate the relationship between geomagnetic storm occurrence and sunspot number, and calculate the cross correlation between the timeseries in order to find the time lag between peak sunspot number and maximum storm occurrence. We find that for most storm lists the correlation coefficient peaks at -135 +/- 27 days, which implies that there is a mechanism by which the sunspot number drives the occurrence of geomagnetic storms which has a time lag of roughly 135 days. We also find that the correlation coefficients remain above the 0.7 level for over 500 days, implying that the occurrence rate of storms may be able to be predicted by looking at the occurrence rate from up to 500 days in the past.

POSTER CODE: P1MIT128

Title

THERION: ADVANCING GROUND-BASED THERMOSPHERIC RETRIEVALS TO SUPPORT SATELLITE DRAG MONITORING DURING SPACE WEATHER EVENTS

Authors

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Body

THERION — THERmospheric parameters from IONosonde observations — retrieves self-consistent aeronomic parameters from ground-based ionosonde data. It addresses the scarcity of thermospheric observations needed to characterize storm-time variability and impacts on Low Earth Orbit (LEO) satellites, where enhanced drag may cause major orbital perturbations or satellite loss.

THERION combines the ionosonde-derived F2-layer critical frequency at local noon and plasma frequency at 180 km between 10 and 14 LT with solar and geomagnetic indices and, when available, satellite neutral-density observations. It retrieves neutral composition at fixed altitude, exospheric temperature, solar EUV flux, and vertical plasma drift, providing insight into thermosphere-ionosphere coupling under quiet and disturbed conditions.

Within Space It Up! project, THERION has been applied to recent geomagnetic storms over European and North American mid-latitude sectors. Results show that it captures variability associated with ionospheric storm phases, including composition changes, temperature increases, and wind-related plasma-drift variations, while improving the representation of day-to-day variability under disturbed conditions compared with standard empirical models.

Future work will assess THERION's pre-operational potential through a feasibility study at the Rome INGV Ionospheric Observatory using ionosonde data automatically scaled by Autoscala. It will test robustness under disturbed conditions and sensitivity to input-data availability and quality.By leveraging existing global ionosonde networks, THERION could help address the shortage of routine thermospheric observations and support ground-based monitoring of Space Weather impacts on the thermosphere-ionosphere system.

This study is carried out within the Space It Up! project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under contract n. 2024-5-E.0 - CUP n. I53D24000060005.

POSTER CODE: P1MIT129

Title

RESPONSE OF THERMOSPHERIC NITRIC OXIDE (NO) COOLING DURING EVENTS OF STRONG SOLAR WIND PRESSURE

Authors

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Body

NO infrared emissions are a notable indicator for varying thermospheric energy budget during geomagnetic storms. Storm time NO radiative cooling and associated temperature variation can impact the density in thermosphere. Thermospheric temperature variations due to both heating and cooling mechanisms are responsible for the thermospheric density variations and associated satellite drag during geomagnetic storms. While these mechanisms have been investigated for geomagnetic storm time (southward Interplanetary Magnetic Field (IMF) conditions), the energy coupling between solar wind, magnetosphere, and thermosphere under northward IMF conditions remains to be elucidated. In this study, we present the first investigation on the response of NO cooling emissions during northward IMF conditions. Twenty three isolated events spanning over 23 years between 2002 to 2024 have been considered in this study. For December 5, 2004 event the peak solar wind pressure was about 25 nPa and dSYMH/dt was 21 nT/min., where a clear enhancement in NO infrared emissions was observed. The geomagnetic indices, energetic particle precipitations, and thermospheric composition response during this event are investigated in detail. This study indicates that events showing enhanced NO infrared radiative cooling during positive IMF-Bz and elevated solar wind pressure are also accompanied by dominant soft electrons (< 1 keV) and ions (> 10 keV) precipitation.

POSTER CODE: P1MIT131

Title

OBSERVATION OF STRONG IONOSPHERIC RESPONSE TO CIR/HSS-DRIVEN WEAK GEOMAGNETIC STORM OCCURRED IN OCTOBER 2008

Authors

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Body

In this case study, we investigate the effects of a co-rotating interaction region (CIR)/high-speed solar wind streams (HSS)-driven weak geomagnetic storm that occurred during 28–30 October 2008 on the ionosphere–plasmasphere system at mid-latitudes over the European region. The storm was characterized by a prolonged (~20 hours) sudden storm commencement (SSC). Multi-instrument observations from ionosondes, incoherent scatter radar (ISR) (Kharkiv, Ukraine), ground-based Global Navigation Satellite Systems (GNSS) receivers, and DMSP satellite missions were analysed. Observation-based simulations were performed using the field line interhemispheric plasma (FLIP) physical model, which is constrained by selected ISR measurements.

The main result is the detection of a pronounced nighttime electron density enhancement (up to ~2 times) at the F2-layer peak and in the topside ionosphere during the prolonged SSC interval, indicating a positive ionospheric storm. A strong enhancement in total electron content (TEC) was also observed in the evening sector. Comparison with FLIP simulations provides insight into the ionosphere–plasmasphere coupling mechanisms responsible for this unexpected enhancement, as well as the challenges associated with ionosphere and thermosphere modelling. These results demonstrate that CIR/HSS-driven weak geomagnetic storms can have significant and long-lasting effects on the near-Earth space environment and therefore warrant dedicated consideration in space weather research and prediction.

POSTER CODE: P1MIT133

Title

COMPARISON OF IRI-2016 AND IRI-2020 MID-LATITUDE TOPSIDE ELECTRON-DENSITY BACKGROUNDS AT LEO ALTITUDES DURING THE 2009 EXTREME SOLAR MINIMUM

Authors

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Body

Characterizing the topside ionosphere at Low Earth Orbit (LEO) altitudes is essential for interpreting in situ plasma measurements and assessing variability relevant to satellite operations. Electron density (Ne) variations can be detected and quantified only relative to a representative background, which must account for spatial, seasonal, local-time, and solar-activity dependences. Backgrounds may be derived either from empirical ionospheric models or from satellite observations, though the latter approach remains less explored due to the scarcity and uneven distribution of in situ measurements.

In previous work, we developed satellite-based mid-latitude Ne backgrounds using Langmuir-probe measurements from CHAMP and Swarm over years spanning different solar-activity levels. Measurements were grouped by geographic location, season, and local time, and the resulting backgrounds were compared with corresponding IRI-2016 backgrounds at the reference altitude. The comparison revealed systematic overestimation by IRI-2016 around local noon, whereas agreement generally improved at night and with increasing solar activity. The largest discrepancies occurred in 2009, during the unusually deep minimum between solar cycles 23 and 24.

Here, we apply the same methodology and selection conditions to construct IRI-2020 backgrounds for 2009, including the solar-activity correction introduced for the topside electron density profile. The IRI-2020 backgrounds are compared with their IRI-2016 counterparts to quantify the effect of the update under extremely low solar activity.

This analysis provides the basis for extending the characterization to the most recent solar minimum (2018–2020), using observations from Swarm and CSES-01 together with satellite-derived and IRI-2020 backgrounds.

POSTER CODE: P1MIT134

Title

TALOS DOME AS A POLAR-CAP SENTINEL: HIGH-LATITUDE CURRENT SYSTEMS AND ULF WAVE ACTIVITY DURING THE MAY 2024 GEOMAGNETIC STORM

Authors

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Body

Remote observatories at high latitudes can record distinct magnetic signatures produced by intense substorm activity, even when they are located poleward of the expanded auroral oval. Consequently, these stations serve as valuable sentinels for monitoring the upstream drivers of the magnetosphere–ionosphere system. In the present study the May 2024 geomagnetic storm is investigated through a distinctive longitudinal array of Antarctic stations that includes the temporary established remote Talos Dome station. High-resolution magnetic measurements from this site are integrated with observations from the coastal stations of Terra Nova Bay and Scott Base, the polar-cap observatory at Dome C, Southern Hemisphere auroral indices, and field-aligned current data to study high-latitude current systems and ultra-low-frequency wave activity. At Talos Dome, the storm produced a marked magnetic-local-time dependence in the H component, consistent with polar-cap convection. The simultaneous detection of coherent magnetic bays along approximately 80°S magnetic latitude during substorm intervals indicates that intense electrojet activity at lower latitudes influences polar-cap currents. Persistently elevated ultra-low-frequency wave power below 1 mHz was detected throughout the network.
These observations offer an essential ground-based reference for assessing satellite data and global models in a region where measurements remain extremely limited. Furthermore, these results confirm the reliability of the Talos Dome station and highlight the fundamental role of distributed observatory networks incorporating remote and undisturbed locations in unraveling the complex, multilevel interactions associated with extreme events.

This study was carried out in part within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under contract n. 2024-5-E.0 - CUP n. I53D24000060005.

POSTER CODE: P1MIT135

Title
DOES THE DIPOLE TILT ANGLE MODULATE THE DAYSIDE RECONNECTION RATE?

Authors
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Body
The dayside magnetic reconnection between the interplanetary magnetic field (IMF) and the Earth's magnetic field is the principal driver of magnetospheric convection and geomagnetic activity. Some theoretical and MHD modeling studies have suggested that the dipole tilt angle (the angle between the geomagnetic dipole axis and the GSM z-axis) modulates the dayside reconnection rate. However, this has not been empirically verified. We performed the first ever large-scale statistical study to test this hypothesis. We identified 1,345 isolated substorms in 2010-2023 and used the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) measurements to determine the ionospheric open magnetic flux variations and estimates of the dayside reconnection rate during these substorm events. We performed a superposed epoch analysis and found that a greater amount of open flux is stored in the tail prior to the expansion phase during low than large dipole tilt. This is due to a higher dayside reconnection rate for low dipole tilt, and possibly another mechanism operating in the magnetotail, allowing for larger flux accumulation prior to the substorm onset. These results imply that the dipole tilt angle may play a significant role in magnetospheric and ionospheric space weather effects.

POSTER CODE: P1MIT136

Title

INVESTIGATING THERMOSPHERIC DENSITY VARIATIONS INDUCED BY STRONG SOLAR FLARES DURING SOLAR CYCLE 25

Authors

Alexander Scheicher [1], Barbara Süsser-Rechberger [1], Manuela Temmer [1], Andreas Strasser [2], Sandro Krauss [2]

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Body

Space weather events significantly aIect satellites operating in low Earth orbit (LEO). Solar phenomena such as coronal mass ejections (CMES) or solar flares cause variations in thermospheric neutral density, resulting in enhanced atmospheric drag and additional orbit decay. Within the framework of the FWF project Earth and Space Weather: Interdisciplinary research (ESPIRE), we are, among other factors, analysing isolated strong solar flares, which allow us to study their influence on the thermosphere's response independently from CMEs. Our research focuses on investigating whether these flares can produce measurable thermospheric density enhancements, and on exploring their potential role in atmospheric preconditioning. Particular emphasis is placed on the magnitude and temporal evolution of the density response following a solar flare. For this purpose, the analysis combines thermospheric neutral densities derived from satellite accelerometer data and GNSS based kinematic orbit data (Swarm and GRACE-FO) with OMNI solar wind observations. In this study we show representative case studies together with a statistical analysis of thermospheric density variations following strong solar flares during Solar Cycle 25. These results provide a basis for future investigations of thermospheric preconditioning.

POSTER CODE: P1MIT137

Title

ON THE STATISTICAL RELATIONSHIP OF JOULE HEATING AND TOPSIDE SMALL-SCALE STRUCTURING IN THE ARCTIC IONOSPHERE

Authors

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Body

We investigate the relationship between Joule heating (JH) and small-scale plasma structuring in the high-latitude topside ionosphere using a combined dataset of Northern Hemisphere JH maps and 16 Hz Swarm plasma observations. The climatology reveals a marked seasonal mismatch: JH is strongest in summer, when solar-driven conductivity favours electromagnetic energy dissipation, whereas small-scale irregularities are strongest in winter, when the background ionosphere is more susceptible to instability growth. The dayside cusp is the main exception, where strong energy input and intense structuring frequently co-exist. To test whether a clear statistical relationship emerges under disturbed conditions, we focus on the main phase of ICME-driven storms and compare JH with Swarm irregularity metrics across seasons, regions, and scales. A strong association appears only under restricted conditions, namely in the summer cusp during intense storms with SymH < -80 nT. The relationship is strongest when storm-maximum values are considered rather than storm-mean values, and at the smallest resolved scales. These results indicate that background ionospheric conductivity strongly modulates how magnetospheric forcing is expressed, either as enhanced heating or as topside plasma structuring.

POSTER CODE: P1MIT138

Title

THERMOSPHERIC NEUTRAL DENSITIES, WIND AND ORBITAL DECAY DURING RECENT CME-INDUCED GEOMAGNETIC STORMS

Authors

Andreas Strasser [1], Sandro Krauss [1], Barbara Suesser-Rechberger [2], Alexander Scheicher [2], Manuela Temmer [2]

Affiliations

[1] Graz University of Technology, Graz, AUSTRIA, [2] University of Graz, Graz, AUSTRIA

Body

The Graz University of Technology processes thermospheric neutral densities for several satellite missions, primarily by making use of accelerometer measurements and precise orbit determination. Combining these time series yields a dataset spanning approximately 25 years - a suitable timeframe in which to study the effects of space weather. During this period, numerous geoeffective CMEs occurred, which are clearly visible in the density time series. This study emphasises the impact of recent solar storms on thermospheric densities and winds. We present these extreme events and contextualise them within the last two solar cycles. To support further research, we outline our publication process and provide download links.

POSTER CODE: P1MIT139

Title
TRANS-NATIONAL ACCESS TO PLASMASPHERIC, IONOSPHERIC AND THERMOSPHERIC RESEARCH FACILITIES THROUGH RAISEARTH

Authors
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Body
RAISEARTH (Research Infrastructure Services Advancing Frontier Knowledge in Sun-Earth Interactions) is a collaborative project between European facilities and infrastructures that are producing services to the international community of upper atmosphere researchers.

One of the objectives of the RAISEARTH project is to provide effective and convenient access to the best European research facilities for observations of the upper atmosphere. The individual RAISEARTH nodes provide access to key experimental and data processing facilities for studies and modelling of physical processes acting in the Earth's plasmasphere, ionosphere and thermosphere. The facilities connected to the nodes are geographically distributed over Europe, as well as internationally, and their expertise and dedication span over a wide range of topics within the research area. This variety of expertise and techniques, allows for common ground and a platform for a better understanding of the many different complex couplings and interactions in the uppermost atmosphere.

Access to the nodes is organised through a Trans-National Access (TNA) programme and provides an opportunity for researchers and other users to execute and carry out their own projects at one of the RAISEARTH research facilities. Users can request either physical access (a one-week visit at the node with support at the site) or remote access (one-month access from a distance with weekly support). Users with granted projects will learn how to work with the facilities during the complete access cycle, from setting up a campaign to the collection, analysis and finally exploitation of data with the help of tools and services provided by RAISEARTH via the e-science centre. Access to the TNA programme can be requested by scientific users from academia, Small and Medium Enterprises, large companies and public organizations by proposing a scientific project and applying through the RAISEARTH website.

POSTER CODE: P1MIT140

Title
3D MODEL OF THE MIDLATITUDE IONOSPHERIC TROUGH AND ITS ROLE IN SUBAURORAL DYNAMICS

Authors
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Body
The subauroral ionosphere is the transition zone between the convecting and corotating plasma and plays an important role in magnetosphere–ionosphere (MI) coupling. The midlatitude ionospheric trough (MIT), a longitudinally extended depletion in electron density, is a prominent feature of this region. Various formation mechanisms have been proposed, but some of the underlying physical processes and their relative contributions remain poorly understood.

The MIT exhibits a strong dependence on magnetospheric activity and magnetic local time (MLT). This dependence has been captured by empirical models describing the location of the MIT (e.g., Deminov and Shubin, 2018; Werner and Prölss, 1997).

In this study, we present an empirical machine-learning model that describes both the location of the MIT electron density minimum and the density profile aroud the trough. The model is based on an extended version of the Swarm-PRISM MIT product, in which MIT features are identified using Langmuir probe measurements from the ESA Swarm mission. The model uses MLT and geomagnetic activity, represented by space-weather indices, as input parameters. More than 220,000 MIT events have been identified, enabling a detailed description of the spatial and geomagnetic-activity dependence of the trough.

The model output is compared with ionospheric plasma drift observations derived from Defense Meteorological Satellite Program (DMSP) measurements. This comparison allows us to characterize how the MIT is coupled to magnetospheric dynamics through ionospheric electric fields.

The resulting model provides a tool for monitoring subauroral and magnetospheric processes and contributes to a better understanding of the mechanisms responsible for MIT formation and evolution. The development of the model is part of the ongoing MOnitoring the Sub-Auroral magnetosphere-Ionosphere Coupling at LEO (MOSAIC) ESA project.

POSTER CODE: P1MIT141

Title

PATTERN OF THE REALISTIC GEOEFFECTIVE INTERPLANETARY MAGNETIC FIELD, IMF, FROM IN SITU DATA VERSUS PREDICTIONS OF THE IDEALIZED IMF FROM RUSSELL–MCPHERRON MODEL

Authors

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Body

We compared the realistic geoeffective, southward IMF (Bs) given in the GSM frame with that based on idealized, spiral IMF from Russell–McPherron (RM) model at a high 16-second resolution. Idealized IMF is obtained by neglecting the fluctuation of the IMF in the GSEQ frame Z-direction. The results of our study are summarized as follows: the absolute value of Bs based on satellite measurements is larger than the one from idealized IMF; realistic Bs polarity fields exist in all seasons, while those from idealized IMF exist only around spring/fall when the IMF points toward/away from the Sun; idealized Bs fields is in line with the predictions of the Russell–McPherron model almost ideally. This study has revealed the patterns and absolute values of the realistic Bs fields and those from the RM model that assumes an idealized IMF. It confirms again that Bz,GSEQ plays an important role for the pattern of Bs.

Understanding the true pattern of Bs fields add values for better understanding the space weather disturbances in the near Earth's space environment.

POSTER CODE: P1MIT142

Title

IN PURSUIT OF A MAXIMUM CREDIBLE EVENT (MCE) FOR SPACE WEATHER: SCENARIO DEVELOPMENT AND MODELLED IMPACTS

Authors

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Affiliations

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Body

A vital task in space weather research and applications is the ability to specify a Maximum Credible Event (MCE): a scenario that remains within the limits of reality but characterizes the most-extreme conditions. The value of a well-specified MCE is very high, allowing forecasters and agencies to prepare for the hazards posed by an extreme space weather event while engineers and operators could harden their systems for that scenario. However, obtaining a reasonable space weather MCE remains elusive and challenging. Maximally extreme conditions push beyond space age observational data sets and test the limits of physics-based models.

Our presentation will evaluate recent efforts to specify an MCE and assess its impact through first-principles-based modeling. Solar wind conditions and interplanetary magnetic fields (IMF) for MCEs are generated through a simple estimation [Tsurutani & Lakhina, Geophys. Res. Lett., 2014] and through scaling of superposed epoch medians. The MCE conditions are then fed into several different configurations of the Space Weather Modeling Framework (SWMF) to translate the interplanetary conditions to the magnetosphere-ionosphere system. Different ionospheric conductance models are considered, including empirical and physics-based approaches. Ground magnetic perturbations are calculated for each event. Our results will explore the impact of season and Universal Time onset of the extreme event. The discussion will focus both on the differences in the simulation results and on the outstanding limitations we face while trying to construct and apply MCEs for extreme space weather analysis.

POSTER CODE: P1MIT143

Title
STORMWALL: TERRESTRIAL SPACE WEATHER PROTECTION THROUGH HUMAN-PRODUCED MASS-LOADING

Authors
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Body
While humans become more reliant on Earth's space environment, the potential for significant harm from severe space weather continues to grow. As structures from the Sun reach Earth's magnetosphere and space environment, they deposit energy that fuels geomagnetic storms. Currently, space weather researchers work to predict the timing and intensity of space weather events, often providing warnings of several days prior to the initiation of a strong geomagnetic storm. Here a new paradigm is presented where, rather than prediction alone, active steps are taken to mitigate the impact of solar wind structures through temporarily modifying Earth's magnetosphere. We show a new mission concept, called StormWall, capable of greatly diminishing the strength of a geomagnetic storm by mass loading the dayside reconnection zone. Global magnetohydrodynamic simulations are used to demonstrate that artificial mass-loading Earth's dayside magnetosphere can fortify Earth's space environment against strong space weather events. The simulations and supporting analysis use realistic mass-loading from model spacecraft at geosynchronous orbit to show the validity of the enabling physics as well as technical feasibility with current technology. The results demonstrate that with modern technology, the intensity of a major geomagnetic storm (e.g., polar cap potential, auroral electrojet index, and surface dB/dt) could be actively reduced by 50% or more, protecting technology and human life.

POSTER CODE: P1MIT144

Title
SOUNDING THE IONOSPHERIC IRREGULARITIES USING LONG-DISTANCE HF PROPAGATION

Authors
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Body
The Space Research Centre of the Polish Academy of Sciences (CBK PAN) has a long-standing tradition of developing operational space weather services. As part of the PECASUS consortium, CBK PAN calculates in near-real time the global maps showing depressions in the critical frequencies of the ionospheric F-layer (foF2), as well as warning maps identifying regions where the level of depression reaches significant thresholds (30% for moderate and 50% for severe levels) and delivers them to operational control panel.
It seems logical to use the probe HF radio paths to verify ionospheric models and operational maps of foF2. Radio signals of time service radio stations looks like the best for that needs since they have highest time and frequency stability. We have traditionally used signals from RWM and CHU stations (unfortunately, CHU ceased broadcasting on June 22, 2026). The signals on three RWM frequencies and three CHU frequencies have been regularly receiving and processing since May 2010 at the Ukrainian Akademik Vernadsky Antarctic station. Analysis of averaged variations allowed us to identify four different mechanisms for signal propagation from the Northern Hemisphere to Antarctic Peninsula area such as along the forward and backward great-circle arcs, by resonant aspect-sensitive scattering on plasma irregularities in polar ovals, and due to focusing on global plasma irregularities associated with the solar terminator. For each mechanism, it is possible to analyze differences in current propagation conditions compared to the average ones, thereby validating models and maps of ionospheric conditions, as well as for estimating the parameters of ionospheric plasma irregularities of different scales.
The paper demonstrates diurnal, seasonal, and interannual variations in average propagation conditions on probe radio paths, and also examines individual situations related to the impact of space and terrestrial weather on the propagation conditions of HF radio waves.

POSTER CODE: P1MIT145

Title

HF RADIO WAVE ABSORPTION MODELING ALONG HAMSCI LINK BUDGETS: IRI-2020 AND PHARLAP RAY TRACING VALIDATION AGAINST WWV-TO-W2NAF OBSERVATIONS

Authors

Gamal Zayed [1], Kuldeep Pandey [2], Nathaniel Frissell [3]

Affiliations

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Body

This work investigates ionospheric absorption at 5 and 10 MHz along propagation paths from two NIST-operated transmitting stations — WWV in Fort Collins, Colorado, and WWVH in Kekaha, Hawaii — to the Personal Space Weather Station (PSWS) receiver W2NAF, located near Scranton, Pennsylvania. W2NAF is a GPS-disciplined Great Radio Amateur Propagation Experiment (GRAPE) receiver operating as part of the Ham Radio Science Citizen Investigation (HamSCI) network. We employ the International Reference Ionosphere (IRI-2020) model and the PHaRLAP ray tracing toolkit to compute HF absorption along ray paths connecting each WWV transmitter to W2NAF via 1-, 2-, and 3-hop links. Modeled absorption values are compared against observed signal strength from the GRAPE receiver W2NAF. Furthermore, observations/model RMSE analysis has been undergone. Results demonstrate that modeled absorptions are broadly consistent with signal strength observations on geomagnetically quiet days. The findings contribute to the HamSCI link budget framework and underscore the potential of citizen science HF networks for ionospheric and radio propagation studies

Acknowledgment-- Special thanks to the HamSCI Community, led by The University of Scranton, Department of Physics and Engineering W3USR, in collaboration with Case Western Reserve University W8EDU; the University of Alabama; the New Jersey Institute of Technology, Center for Solar Terrestrial Physics K2MFF; the MIT Haystack Observatory; TAPR; additional collaborating universities and institutions; and volunteer members of the amateur radio and citizen science communities.

The results published in this work were obtained using the HF propagation toolbox, PHaRLAP, created by Dr Manuel Cervera, Defence Science and Technology Group, Australia (manuel.cervera@dsto.defence.gov.au). This toolbox is available by request from its author.

This work is supported by the U.S. National Science Foundation Grant AGS-2432821, AGS-2432823, and NASA 80NSSC23K1322.

POSTER CODE: P1MIT147

Title

CHARACTERIZATION OF LSTIDS DURING CIR/HSS EVENTS USING DIGISONDE AND DOPPLER SOUNDING OVER PRUHONICE
AND DOPPLER SOUNDING OVER PRUHONICE

Authors

Mosna Zbysek [1], Dalia Buresová [1], Jaroslav Chum [1], Daniel Kouba [1], Petra Koucká Knízova [1], Jan Lastovicka [1], Katerina Podolska [1]

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Body

We analyze ionospheric response to three CIR/HSS events from October-November 2023 in the midlatitudinal ionosphere above the Pruhonice station using the Digisonde and Continuous Doppler Sounding System (CDSS) measurements. We monitored changes in ionospheric variability, primarily focusing on detecting the occurrence of LSTIDs
and determining their main parameters as the direction and period. The analysis reveals presence of LSTIDs in foF2 for all three events, even though one of them was a weak storm. Their southward propagation from auroral latitudes was detected by CDSS measurements, whereas wavelet analysis of foF2 provided their periods and temporal evolution. TIDs were accompanied by enhanced vertical drift variability. We detected coherent domains of wavelet power at periods corresponding to both LSTIDs and MSTIDs probably indicating a common underlying physical forcing.

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION MIT2

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1MIT204

Title
THE PLASMA INSTABILITIES IN THE EQUATORIAL AND AURORAL IONOSPHERIC ELECTROJETS AS A SOURCE OF IRREGULARITIES CAUSING SCINTILATION

Authors
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Body
The scintillations of radio signals are most frequently registered in the equatorial and auroral regions. Both regions are site of strong currents –equatorial electrojet and auroral electrojet. The intensity of them is related to geomagnetic activity. The different plasma intabilities can develop within these structures. We will discuss Farley – Buneman and ionization instabilities in context of sizes of generated irregularities and direction of their propagation. Farther discussion of this in relation to disturbances during superstorms and possible cause of scintillaton will be given. The attempt to see of the satellite registrations of the concentration irregularities will be done.

POSTER CODE: P1MIT207

Title
THE SEASONAL SATURATION OF GNSS-BASED DAILY MAXIMUM IONOSPHERIC TEC WITH F10.7

Authors
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Body
Quantifying the variability of ionospheric Total Electron Content (TEC) is important for GNSS-based positioning, navigation and timing, and for the operations of satellites in Low Earth Orbit (LEO). It has been shown that TEC correlates with the daily F10.7 index, a proxy for solar Extreme Ultraviolet (EUV) radiation used in ionospheric modelling - a linear relationship is seen between both the global average, and regional TEC with daily F10.7, however there is evidence of saturation of the daily maximum TEC with F10.7.

Using 15-minute Global Ionospheric Maps (GIMs) from the Jet Propulsion Laboratory (JPL), we demonstrate a seasonally dependent saturation of daily maximum TEC between 83–128 TECU for daily F10.7 values > 78–85 SFU. This saturation is not found when performing this analysis on averaged F10.7, such as F10.7A and F10.7p. By analysing the statistical distributions of the fit residuals as a function of F10.7, we find that a tanh function out-performs a linear function for F10.7 > 150 SFU. We discuss sensitivity of our results to the ground station distribution used to construct the JPL-GIMs. By quantifying the upper bound of daily maximum TEC as a function of season and solar cycle, our results directly inform the specifications for systems sensitive to extremes of TEC, useful for LEO mission planning, and provides a benchmark for ionospheric models forecasting the space weather response of TEC.

[1] Cafolla et al. (2026), AGU Space Weather, DOI: 10.1029/2025SW004745

POSTER CODE: P1MIT209

Title
PROBING THE COUPLED IONOSPHERE-THERMOSPHERE SYSTEM USING GROUND-BASED OPTICAL AND RADIO MEASUREMENTS

Authors
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Body
Airglow emissions are produced by various photochemical processes in the upper atmosphere. The Global Airglow (GLOW) numerical model (Solomon et al., 2017) has been widely used to derive attitude profiles of key constituents of the ionosphere-thermosphere (IT) system and temperatures from line-of-sight intensity measurements of prominent airglow features and their morphology.

GLOW uses temperature as well as densities of key neutral constituents and electrons as inputs and computes the Volume Emission Rates (VER) of airglow emissions. For aeronomic calculations, the standard GLOW implementation uses the MSISE-00 model (Picone et al, 2002) for the thermosphere, the IRI-90 model for the ionosphere (Bilitza et al., 1993) and the EUVAC solar extreme ultraviolet (EUV) flux model (Richards et al., 1994).

We used simultaneous measurements of red (630 nm) and green (557.7 nm) nightglow emissions to infer neutral densities. The observations were made by the High-Throughput and Multi-slit Imaging Spectrograph (HiT&MIS, Chakrabarti et al., 2012) from Lowell, Massachusetts, USA during geomagnetically quiet times. This HiT&MIS had a spectral resolution of 0.02 nm and a 0.1deg X 16 deg field of view and its slits were pointed vertically in the 42-deg NE direction where it observed emissions in 28 deg - 44 deg in elevation. Due to the wide field of view of our observation geometry, we developed and used a 2-D version of GLOW in our analysis.

In this talk, we will describe our instrument, the data collected during late January to early March, 2022 and our modeling results. We found that the GLOW model, using IRI-90 electron density profiles scaled to the Vertical Total Electron Content (VTEC) derived from near-simultaneous GNSS measurements, did not produce nightglow intensities that matched our observations. A numerical inversion by matching the GLOW model intensities to HiT&MIS observations, however, produced VTEC comparable to near-simultaneous Digisonde and GNSS measurements.

POSTER CODE: P1MIT211

Title

A CROSS-SOLAR-CYCLE CLIMATOLOGY OF LARGE-SCALE TRAVELING IONOSPHERIC DISTURBANCES OVER EUROPE FROM GNSS-TEC DATA (2015–2025)

Authors

Marco Guerra [1], Claudio Cesaroni [1], Luca Spogli [1]

Affiliations

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Body

A Cross-Solar-Cycle Climatology of Large-Scale Traveling Ionospheric Disturbances over Europe from GNSS-TEC Data (2015–2025)

We present an 11-year climatological study of Large-Scale Traveling Ionospheric Disturbances (LSTIDs) over the European sector, extending the automatic detection methodology introduced by Guerra et al. (2025, Space Weather) to cover the period 2015–2025. The detection algorithm, based on image processing of dTEC keograms derived from a network of GNSS receivers across Europe and RANSAC-based wavefront fitting, is applied to the full dataset to extract LSTID horizontal apparent velocity, period, wavelength, and amplitude on a systematic basis. The resulting 11-year catalog enables a statistically robust characterization of LSTID occurrence rate, propagation properties, and intensity as a function of geomagnetic activity level, as quantified by the Hp30, SYM-H, and IMAGE IE indices. The extended temporal baseline, spanning from the declining phase of Solar Cycle 24 through the maximum of Solar Cycle 25, allows us to investigate how LSTID climatological properties vary across different phases of the solar cycle, including periods of both low and high geomagnetic forcing. Seasonal and local time dependencies of LSTID occurrence are revisited with improved statistical significance with respect to the 4-year dataset of the reference study. The results contribute to a more complete picture of the magnetosphere-ionosphere coupling and ionospheric dynamics over Europe.

POSTER CODE: P1MIT212

Title
PAN-ARCTIC GNSS SCINTILLATION DURING THE BLUE MONDAY STORM

Authors
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Affiliations
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Body
On January 19 2026 a fast CME impacted Earth, sparking a strong geomagnetic storm.
The storm was named the Blue Monday Storm by the E-SWAN naming committee, as it came out of the blue on Blue Monday.
The study is based on data from networks of scintillation receivers in Canada, Greenland, Iceland, Faroe Islands, Norway and Finland.
This combined network provides coverage of a large part of the Arctic, allowing a large-scale picture of the spatial distribution of scintillation and how this changes in time during the storm.
We present an overview of scintillation in the Arctic along with ionospheric equivalent currents calculated from magnetometer measurements and other supporting data to contextualize the observations.
The spatio-temporal occurrence of scintillation is discussed in relation to the ionospheric current patterns, revealing connections to physical processes.

POSTER CODE: P1MIT213

Title
ON THE USE OF DUAL-FREQUENCY SMARTPHONES TO INFER THE TEC

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Body
GNSS receivers from the IGS are an important source of information to infer the TEC and feed models {1}. Unfortunately, these stations are scattered and some are even operating alone {1}. Thus, models have to linearize or predict the TEC by only using physics and mathematics in much places. Nowadays, we know that using dual-frequency smartphones could be of great interest for the future of ionosphere sensing since there is many of them all around the world {2,3}. The problem of these receivers is that they aren't so precise alone because firstly, the phase data isn't easy to get continuously and secondly because of the linear antennas that they are made with {3}. This way, working with the pseudo-range should be the only way to get a maximum of data yet, but this is also a really noisy measurement because of multipath for example {3}. Here, we want to show a comparison between some low-cost receivers and a local GNSS Septentrio receiver. The aim of this work is to investigate the number and the quality of phone measurements required to reach the precision of expensive receivers. Later, it would be of great interest to infer those parameters during a strong geomagnetic event.

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POSTER CODE: P1MIT214

Title

LOW- AND MIDLATITUDE SPREAD F RESPONSES TO THE NOVEMBER 2025 GEOMAGNETIC STORM OVER ARGENTINA

Authors

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Body

We investigate the ionospheric response over the Argentine sector during an intense, two-step geomagnetic storm on 12-13 November, 2025, driven by the arrival of two interplanetary coronal mass ejections. The event was characterized by sudden storm commencements at 00:16 UT and 20:10 UT on 12 November, with corresponding SYM-H minima reaching -254nT and -165nT, respectively.

Automatically scaled and manually validated ionograms, together with GNSS-derived total electron content (TEC) and rate-of-TEC-index (ROTI) observations, were analyzed at two stations: a low-latitude site in Tucuman and a midlatitude site in Bahia Blanca, Argentina.

In the South American low-latitude region, Spread F (SF) is known to display a marked seasonal variability, with its highest occurrence during the December solstice season (November-February). Although post-sunset SF is commonly observed at low latitudes, its detection at Bahia Blanca is noteworthy because such signatures are rarely reported at this midlatitude location.

ROTI maps reveal enhanced ionospheric irregularities extending from 20S to 40S magnetic latitude during the storm. During the first storm interval, SF developed before midnight and was short-lived at both stations. In contrast, during the second interval, SF initiated before midnight and persisted into the post-midnight sector, with longer duration at Tucuman than at Bahia Blanca. At Tucuman, a pronounced reduction in foF2 relative to the 27-day mean was observed throughout the recovery phases of both storm intervals. This behavior is consistent with storm-time disturbance dynamo electric fields driven by altered thermospheric circulation. Additional support for this interpretation is provided by GUVI O/N2 observations over Argentina, which reveal decreased values on 12 November, a pronounced minimum on 13 November, and partial recovery on 14 November.

POSTER CODE: P1MIT215

Title

TEC GRADIENTS AT MIDDLE LATITUDES IN THE EURO-AFRICAN LATITUDINAL SECTOR DURING DISTURBED AND QUIET GEOMAGNETIC PERIODS

Authors

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Body

Spatial TEC (total electron content) gradients may serve as a useful parameter to reveal ionospheric irregularities at specific spatial scale and their relations with geophysical conditions, both during the geomagnetic disturbances and quiet periods.

In this work, we use TEC gradients calculated from GNSS-based TEC maps (e.g., GIMs, ISEE TEC maps) and LEO satellite data (Swarm TEC gradients) for several month-long intervals containing strong-to-severe geomagnetic storms. The area under study is the middle latitudes (25º-45º N) of the Euro-African longitudinal sector (35º-0º W).

The TEC gradient maps are decomposed using the principal component analyses (PCA) to extract the main modes of the spatiotemporal variability. The obtained modes represent distinct spatial patterns that are intensified during geomagnetic storms and other events.

The ground-based TEC gradients calculated using GIMs and ISEE TEC maps and their PCA modes were compared between each other, with TEC gradients obtained from the satellite data, with the ionospheric scintillation data and with geomagnetic field variations observed in the studied area. Conclusions on the origin of the TEC gradients' variability are made by considering the ionospheric currents' dynamics during the studied time intervals as well as other features, including spill-over events of the equatorial plasma bubbles.

POSTER CODE: P1MIT216

Title

IONOSPHERIC RESPONSE TO SUDDEN STRATOSPHERIC WARMINGS OF 2024: MIDDLE TO LOW LATITUDES OF THE EURO-AFRICAN SECTOR

Authors

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Body

Ionosphere is forced both by space weather (e.g., geomagnetic storms and solar UV flux variations) and internal atmospheric (e.g., events associated with atmospheric waves such as sudden stratospheric warmings, SSW) events.

In this work we studied ionospheric response to a series of the sudden stratospheric warmings observed in the first half of 2024: four SSW during the boreal winter and 1 SSW during the austral winter.

The ionospheric total electron content (TEC) data were obtained at six locations: near the western coast of the Iberian Peninsula (latitude 27-41ºN, 9ºW), at Madeira (32ºN, 17ºW) and at the Canary Islands (28ºN, 16.5ºW) allowing to study latitudinal variability of the ionospheric response to the atmospheric events.

One of the found features is the delayed increase of the TEC variability associated with the SSW onsets.

POSTER CODE: P1MIT217

Title

ENHANCING THE IONOSPHERIC SCINTILLATION MONITORING (ISM) PRODUCT GROUP: GLOBAL GNSS NETWORK DENSIFICATION AND PROCESSING OPTIMIZATION

Authors

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Body

CLS develops and maintains the Ionospheric Scintillation Monitoring (ISM) group of SWE products accessible via the portal of the ESA Space Weather Service Network. The products provide operational S4, SPHI, and Total Electron Content (TEC) maps and grids to meet the needs of users and scientists working in various fields of Earth observation, particularly Space Weather. These products are generated by combining GNSS-derived proxies with modeled data from the Global Ionospheric Scintillation Model (GISM), originally developed by IEEA and currently maintained by the German Aerospace Center (DLR). The modeled data are used to complement GNSS observations in regions where the station coverage is limited. The current GISM implementation is designed for equatorial regions, where ionospheric scintillation effects are most pronounced, resulting in pre-operational products that are predominantly tailored to these regions.

To support future evolutions of these products, CLS is preparing for the integration of an extended version of GISM currently under development by DLR. This version is intended to provide modeled ionospheric data across all latitude regions, beyond the equatorial regions covered by the current version. In parallel, CLS is densifying the GNSS station network on a global scale to extend observational coverage accordingly and prepare the ISM application for this evolution. The combination of broader coverage and extended modeling is expected to enable the generation of more globally representative S4, SPHI, and TEC products.

The significant increase in the number of processed GNSS stations also requires improved computational performance to maintain operational production schedules. To address this challenge, parallelization has been introduced within both the GNSS processing chain and the observation-model combination stages. These optimizations reduce processing time and improve the operational robustness while supporting a larger GNSS network.

POSTER CODE: P1MIT218

Title

PERSISTENT GNSS LOSS-OF-LOCK FROM SWARM MISSION DURING HIGH SOLAR ACTIVITY AND BEYOND

Authors

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Body

High solar activity can significantly affect Global Navigation Satellite System (GNSS) signals, causing loss-of-lock (LoL) events in satellite-based receivers. Here, we analyze Swarm satellite observations from 2014 through 2026, extending a previous work whose dataset stopped in 2020. The study confirms that LoL events generally correlate with the level of solar activity, the higher the solar activity the greater the LoL occurrence. At the same time, in 2022–2026 we identify a subset of events over Eastern Europe that cannot be explained by ionospheric irregularities. These unexplained events spatially and temporally coincide with regions and periods where independent reports document widespread GNSS interference associated with military operations. This study highlights the capability of scientific satellite constellations to detect and characterize GNSS interference in near real time, with important benefits for space weather research, technological infrastructure resilience, and situational awareness in conflict regions.

POSTER CODE: P1MIT220

Title

IONOSPHERIC SCINTILLATION ANALYSIS USING A LOW-COST GNSS RECEIVER UNDER RFI CONDITIONS AT LOW-LATITUDE STATIONS

Authors

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Body

With growing interest in developing new indices for ionospheric scintillation monitoring, most previous studies have generated the S4c-based amplitude scintillation index using common geodetic and low-cost receivers. However, generating the S4c index in regions affected by radio-frequency interference (RFI) is challenging, especially with low-cost GNSS receivers. Therefore, this work analyzes ionospheric scintillation characteristics using various GNSS receivers in the low-latitude equatorial region and applies noise filtering techniques to mitigate RFI effects.

In this work, we utilize two GNSS receivers: a low-cost receiver (KLC1) and a geodetic receiver (KMI6), both connected to the same antenna installed in the 12-storey Engineering building at King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, located at geodetic coordinates (13.7278 N, 100.7724 E), in an RFI-affected area. To minimize spatial ionospheric variability, the comparison was performed using common satellites, similar elevation angles, during both quiet and disturbed events. The carrier-to-noise density ratio (C/No) and S4c index from these two receivers were compared with the S4c and S4 indices from the ISMR receiver at CPN1 station (10.7247 N, 99.3744 E), which is in an RFI-free region near the magnetic equator. The results from the low-cost receiver were similar to those from geodetic receivers, as validated by the S4 index from the ISMR receiver. The non-scintillation and scintillation events selected for observation occurred on January 18, 2026, and April 29, 2025, respectively. Comparative results of C/No between KLC1 and CPN1 show good agreement, with average RMSE and average MAE below 2.0592 and 1.7254, respectively, for all GPS satellites in both events after noise filtering. Additionally, the S4c indices between KLC1 and CPN1 are comparable, with average RMSE below 1 and average Pearson correlation coefficient for all GPS satellites above 0.5 by filtering out external noise.

POSTER CODE: P1MIT221

Title
SWIGPOD: UPGRADED GNSS PERFORMACE INDICATORS AIMED AT END USERS' NEEDS.

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Body
The ESA S2P-S1-SW-21 SWIGPOD project is devoted to extensively upgrade the GNSS Performance Indicators also taking advantage of additional ESA SWESNET products.
As Space Weather has significant impact on wide range of GNSS-based modern technologies and also critical infrastructures as many GNSS user communities experience, the Space Weather Service providers are asked to provide simple to understand, but accurate nowcasting or ideally forecasting services for various use cases and user communities. The consultations of the planned service provided suggestions for improvements from the users point of view.
The new SWIGPOD warning system will thus gather relevant real-time monitoring and partially forecasting services based on the use-case-driven synthesis of the SWESNET products. Alhough focused on GNSS, SWIGPOD will provide also indicator for radioastronomy end-users like LOw Frequency ARray (LOFAR) telescope for suitable observing conditions, i.e. disturbed by the ionosphere than the specifically obtained threshold as ionospheric hindcasts for purposes of LOFAR are applicable for selecting only suitable measurements for processing, which is very energy demanding.

POSTER CODE: P1MIT222

Title

FROM IONOSPHERIC IRREGULARITY MONITORING TO RTK USER DECISIONS: A QUANTILE-BASED GNSS RISK INDICATOR

Authors

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Body

Ionospheric irregularities can degrade real-time kinematic (RTK) positioning even when a receiver reports a fixed ambiguity solution. Space-weather information available to surveyors, however, is often too general to support an immediate field decision. We present RTK-RISK, a regional GNSS-based indicator that translates ionospheric variability into the operational classes TRUST, CAUTION, and POSTPONE.

The method combines two complementary observables derived from a ground-based CORS network: the rate of TEC index (ROTI), representing temporal variability along individual satellite–receiver paths, and the spatial gradient of vertical total electron content (VTEC), representing regional spatial structuring. Both components are normalised against empirical quantiles and combined into a dimensionless composite indicator adapted to mid-latitude conditions in Latvia.

The indicator was evaluated using multi-constellation GPS and Galileo observations and an approximately 50 km LGIA–LVR1 baseline processed in RTKLIB during quiet and disturbed ionospheric periods. RTK performance was assessed using ambiguity status, horizontal positioning error, and ambiguity ratio. Increasing RTK-RISK was associated with higher horizontal error (Spearman ro = 0.265) and lower ambiguity ratio (ro = minus 0.265; $p < 0.001$), together with reduced fixed-solution availability during disturbed conditions.

The results demonstrate a practical pathway from regional GNSS monitoring of ionospheric irregularities to an interpretable, user-oriented space-weather service. Because it uses routinely available CORS observations, the approach can complement global alerts with local information relevant to field operations. The current prototype supports near-real-time situational awareness for RTK users; ongoing work focuses on real-time implementation, wider validation, uncertainty characterisation, and short-term forecasting using space-weather drivers.

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION MIT3

VERDE ROOM – SECOND FLOOR
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2MIT301

Title
The midlatitude ionospheric trough as an ionospheric signature of the plasmapause and plasmaspheric plumes

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Body
The plasmasphere is a torus of cold plasma frozen into Earth's magnetic field, supplied by the ionosphere. Its outer boundary, marked by an abrupt drop in density, is called the plasmapause. During disturbed periods, the storm-time electric field drives plasma out of the plasmasphere through drainage channels known as plasmaspheric plumes. The midlatitude ionospheric trough, a zone of depleted plasma density in the subauroral ionosphere, is controlled by the same electric field, which is transmitted between the ionosphere and the distant magnetosphere along geomagnetic field lines. While the conjugacy between the plasmapause and the ionospheric trough, and between plasmaspheric plumes and the ionospheric storm-enhanced density (SED) plumes, is well established, the spatial relationship between plasmaspheric plumes and the ionospheric trough has been neglected in previous studies. Our findings shed new light on the dynamical coupling of these plasma structures and on the role of the electric fields that shape them.

Keywords: plasmasphere,ionosphere,magnetosphere,midlatitude ionospheric trough,plasmaspheric plume

POSTER CODE: P2MIT302

Title
Revisiting XMM/ERMD data set 2000-2026

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Body
XMM/ERMD radiation monitor has been collecting electron and proton data since January 2000 and mission extensions are foreseen up to 2040. Such a long-term coverage, over more than two solar cycles with a potential of four solar sycles, makes the data very unique for the community. Counts to flux conversion were first performed in mid-2000 considering only a bowtie approach. While the bowrie method performs well for instruments with highly selective energy channels, where response functions can be reasonably approximated by a Heaviside function (integral channel) or a boxcar function (differential channel) it has been found that it is a rough approximation to the XMM/ERMD instrument. Recent progress in inversion methods allows revisiting the counts to flux conversion. The stable and efficient Richardson-Lucy approach has been customized to the XMM/ERMD response functions, leading to very high-quality electron and proton fluxes. The results obtained are compared to third party data sets, like RBSP to validate the new data set. This new data set will be freely available to the community and might be used for cross-calibration activities, particularly when considering the data quality and long term coverage.

Keywords: Radiation monitor,Radiation belts,XMM/ERMD

POSTER CODE: P2MIT303

Title
Physics-based modelling of radial diffusion in the outer Van Allen belt

Authors
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Body
Electrons in the outer radiation belt (L > 3) can occasionally reach ultra-relativistic energies exceeding 10 MeV (γ > 20, where γ is the Lorentz factor). Understanding the physical mechanisms responsible for this extreme energization remains a major challenge in space physics. Two principal mechanisms are considered responsible for the acceleration of relativistic electrons in the outer radiation belt: (a) inward radial diffusion and (b) local acceleration through wave–particle interactions. In the case of radial diffusion, fluctuations in the magnetospheric electric and magnetic fields violate the third adiabatic invariant, causing electrons to diffuse earthward, while conserving the first adiabatic invariant, resulting in an energy increase. In this work, we investigate the radial transport and evolution of relativistic electrons by numerically solving the time-dependent Fokker–Planck equation for fixed values of the adiabatic invariants μ and K. The solution is obtained using radial basis function (RBF) collocation methods, allowing us to examine the suitability of different RBF formulations for modelling radial diffusion processes in the outer Van Allen belt. Model outputs are evaluated against in situ measurements of electron phase space density, f (μ, K, L*, t), derived from observations of geomagnetic storm events by the Van Allen Probes mission. A systematic analysis is performed for multiple RBF types and shape parameters, while diffusion coefficients from the EMERALD model are incorporated to improve the physical realism of the simulations. Finally, we extend the model by employing phase space density calculations derived from Himawari-8 electron flux observations at geostationary orbit, using them as initial and boundary conditions to investigate inward radial diffusion from GEO towards the heart of the outer radiation belt.

Keywords: radial diffusion,radiation belts,modelling,nowcasting

POSTER CODE: P2MIT306

Title
An SEP-analogue approach for event-based modelling of the outer radiation belt environment.

Authors
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Body
During radiation belt enhancements the fluxes of energetic electrons can increase by several orders of magnitude and last from days to weeks and even months. These high energy electrons pose danger to space systems, as they can lead to malfunctions and physical damage of instruments and vital satellite systems. Therefore, the knowledge of the radiation environment and the accuracy of the associated models have become more important than ever. Radiation Belt specification models are used to provide estimates of the radiation a mission will encounter over the course of large periods. These specification models are principally empirical in origin, and do not capture the fluctuations explicitly.
On the contrary, Solar Energetic Particle (SEP) specification models typically provide confidence levels for the expected radiation levels which are derived by statistically modelling SEP radiation storms. In the frame of the VERSE project we aim to develop an analogue event-based model for the outer Van Allen belt, leveraging existing SEP tools and methodologies. In this work we present the baseline investigations towards the creation of this event-based model for the outer Van Allen belt. To that end we perform a dimensionality reduction of the electron fluxes by deriving the double integral flux (integral flux of >400 keV equatorial electrons which is further integrated in the available 4.5 – 7 L* range), which is used to define the flux enhancement events, as well as their peak flux and fluence. Then we perform a thorough statistical analysis with several parameters/indices and showcase the usefulness and physical relationships of these proxies. Finally, we also highlight its potential use in a predictive model.

This work has received funding from the European Space Agency under the EVENT-BASED ELECTRON BELT RADIATION STORM ENVIRONMENTS MODELLING (VERSE) activity under ESA Contract No 4000141351/23/UK/EG.

Keywords: Radiation belts,Geomagnetic Storms,SEP,Modelling

POSTER CODE: P2MIT307

Title
Statistical Characteristics of Plasmaspheric Hiss Based on Van Allen Probes and Arase Observations

Authors
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Body
Plasmaspheric hiss is a type of whistler-mode emission occurring within Earth's plasmasphere and plays a crucial role in loss of radiation belt electrons. In this study, we present a comprehensive statistical analysis of plasmaspheric hiss using combined observations from the Van Allen Probes and the Arase spacecraft spanning 2012-2024. The dataset covers more than one solar cycle and extends the spatial coverage of hiss measurements to magnetic latitudes (MLAT) up to ±45°. Our results show that hiss intensity exhibits only slight year-to-year variation over the solar cycle. Hiss intensity is positively correlated with various geomagnetic activity indices and solar wind parameters except for solar wind dynamic pressure. From a spatial perspective, hiss intensity is stronger near the magnetic equator for $L < 4$, while for $L > 4$, the intensity becomes stronger at higher magnetic latitudes, indicating a systematic transition in latitudinal structure with increasing L-shell. Our results provide comprehensive statistical characterization of the distribution and variability of plasmaspheric hiss waves, and can be used for future modeling of plasmaspheric hiss and radiation belt dynamics.

Keywords: Plasmaspheric hiss,Whistler-mode waves,Van Allen Probes,Arase,Geomagnetic activity

POSTER CODE: P2MIT308

Title
Analysis of Proton Flux Profiles in the South Atlantic Anomaly with the RadMap Telescope

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Body
Unlike many other radiation monitors, the tracking calorimeter at the heart of the RadMap Telescope can reconstruct particle trajectories with nearly omnidirectional sensitivity – i.e., across almost the entire solid angle – with a resolution of 2° ~ 5°. We present an analysis of data from the International Space Station recorded inside the South Atlantic Anomaly that shows how this capability can be used to reconstruct flux profiles (i.e., angular distributions) of protons in the inner radiation belt. We also discuss how we employed simulation and test-beam data to validate our track reconstruction and to determine the response functions and uncertainty matrixes that we use to derive flux profiles from measured data.

Keywords: Earth's inner radiation belt,Angular distribution,Protons,South Atlantic Anomaly,International Space Station

POSTER CODE: P2MIT309

Title
Multi-Spacecraft Investigation of Ring Current Density Using Cluster and THEMIS

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Body
The terrestrial ring current is a major component of the inner magnetosphere and an important contributor to geomagnetic disturbances. We investigate its spatial structure using several years of magnetic-field and plasma observations from the Cluster and THEMIS missions. For Cluster, the full current-density vector is derived using the conventional four-spacecraft curlometer technique. For the three-spacecraft THEMIS configuration, the component normal to the spacecraft plane is obtained from magnetic-field gradients. In addition, an independent current-density vector is calculated from the THEMIS ion and electron plasma moments using the relative motion of the two particle populations. Projecting this plasma-derived current onto the normal of the THEMIS spacecraft plane enables a direct comparison between the plasma-moment and three-spacecraft curlometer estimates. The locally measured current densities are also compared statistically with the ground-observatory-based Dst index to examine their relationship with the global strength of the ring current. The results provide information on the spatial distribution and variability of the ring current and allow us to assess the applicability and limitations of four-spacecraft, three-spacecraft, and plasma-moment-based current-density estimates in the inner magnetosphere.

Keywords: Ring current,Curlometer technique,Multi-spacecraft measurements,Magnetosphere

POSTER CODE: P2MIT310

Title
Shallow Internal Charging as a Distinct Space Weather Hazard

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Body
Space weather charging hazards occur when charged particles (primarily electrons) accumulate on spacecraft surfaces, within internal dielectrics, or on isolated conductors, generating high voltage that result in electrostatic discharges which can degrade or destroy sensitive electronics and materials. These hazards are traditionally categorized into only two regimes: surface charging, driven by electrons with energies up to 50 keV, and deep dielectric charging, caused by enhanced fluxes of MeV electrons. Each mechanism exhibits characteristic charging timescales and magnetic local time (MLT) distributions.

Using GOES Magnetospheric Particle Sensor High-Energy (MPS-HI) and Low-Energy (MPS-LO) data from 2017 to 2021, we investigate operational anomalies in the Space Wire telemetry from the EXIS instruments aboard the GOES-16 and GOES-17 s/c. We find that these anomalies are statistically correlated with enhancements in electron fluxes at intermediate energies of 100- 300 keV falling between standard surface and deep dielectric charging regimes. Solar wind driver analysis indicates that the anomalies tend to cluster and are strongly associated with high-speed streams (HSSs). The fraction of clustered anomalies occurring during HSS periods reaches 0.83 for GOES-16 and 0.91 for GOES-17. The MLT distribution of these anomalies exhibits a pronounced peak in the morning-to-noon sector, distinguishing them from both surface charging (which peaks in the midnight-to-morning sector) and deep dielectric charging (which lacks a strong MLT dependence).

We suggest that 100-300 keV electrons accumulate in a thinly shielded dielectric, justifying the term ‘shallow internal charging’. This study emphasizes the critical role of the 100-300 keV electron population in driving spacecraft anomalies at geosynchronous orbit (GEO), particularly during HSS events, and highlights the value of onboard environmental monitoring payloads for isolating the causes of spacecraft anomalies.

Keywords: surface charging,GEO orbit,inner magnetosphere,deep dielectric charging,ring current electrons

POSTER CODE: P2MIT311

Title
Downscaling Methods Applied to Numerical Simulation of the Earth's Radiation Belts

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Body
Earth radiation belts form a highly dynamic environment in which particle densities evolve over time and are driven by solar activity. High-energy particles in the radiation belts can pose a threat to space systems if they are not properly shielded, a task which can only be done if the dynamics of near-Earth space are well understood and modeled.

Numerical simulation is often used to study radiation belts as it allows monitoring particle densities across the entire near-Earth environment. The Salammbô code, developed at ONERA, computes the evolution of the radiation belts over time by solving the Fokker-Planck equation using a implicit finite volumes solver. The results are electron distribution functions expressed on a 3D grid. The equation is computationally expensive to solve, which is a problem given that Salammbô is often used to simulate long periods of time, or in the context of Ensemble-Based Data Assimilation where dozens of simulations are needed. The classical approach is to make a trade-off, where the number of points on the grid is reduced in order to reduce computational costs. However, the physical accuracy of the results is impacted as the precision of the numerical solver depends on the resolution.

Downscaling techniques aim at reconstructing high-resolution results from low-resolution simulations with sufficient precision. Applied to numerical simulation of the radiation belts, such methods allow users to avoid the resolution trade-off : high-resolution results with high physical accuracy can be obtained at a fraction of the original cost.

In this work, we compare several downscaling techniques on the reconstruction of high-resolution electron fluxes from low-resolution Salammbô simulations. We show that Neural Network-based downscaling techniques make high-resolution simulations affordable while providing results that match conventionally obtained high resolution data from Salammbô within an acceptable margin of error.

Keywords: Radiation belts,Down scaling,Neural Networks

POSTER CODE: P2MIT312

Title
The IRENE-AE9/AP9 Next Generation Radiation Specification Models – Progress Report

Authors
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Body
The International Radiation Environment Near Earth Model (IRENE), formerly AE9/AP9/SPM, has provided the global satellite design community with enhanced specification capabilities over legacy models since 2012. Based on feedback from the community we have continued to improve and expand capabilities of the model suite. We have recently released updates to version 1.5 providing more features for capturing statistics such as variable timescale fluences and worst-case quantities. Pending updates will incorporate data sets including Pamela, PROBA-V, EPT, SREM, NASA's Van Allen Probes (remaining data), and AFRL's DSX. Version 2.0 will provide a new module-based architecture supporting additional hazard models (e.g., solar protons), new module-specific capabilities (e.g., local time dependence for plasma), and improved stitching between models. We will provide an update on development status and plans for future versions.

Keywords: radiation climatology,satellite design,radiation belts,solar particle events

POSTER CODE: P2MIT313

Title
Identifying the Drivers of Radiation Belt Electron Phase Space Density Across the Adiabatic Coordinates

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Body
By factoring out the impacts of diabatic processes, the analysis of electron phase space densities (PSD) as a function of the three adiabatic invariants provides major insights into the local acceleration mechanisms responsible for the electron enhancements and losses occurring within the dynamic radiation belt environment. Despite this, the highly complex and nonlinear relationships between radiation belt electron behaviour and various solar wind and geomagnetic parameters make the numerical modelling of PSD evolution a significant challenge, necessitating the use of appropriate analysis techniques.

Within this study, coordinated Van Allen Probe (VAP) and OMNI measurements are subjected to a Nonlinear Auto-Regressive Moving Average model with eXogenous inputs (NARMAX)-based Error Reduction Ratio (ERR) analysis methodology to map the primary solar wind and geomagnetic drivers of PSD evolution throughout the adiabatic coordinate space (μ, K, L-star). Here, a range of averaging cadences is compared to maximise the model performance by accounting for slower radiation belt processes such as sustained chorus activity, radial diffusion, and storm-time transport. A corresponding effective time delay analysis is presented to quantify the driving effects of time-lagged terms upon electron PSD resulting from various radiation belt electron acceleration mechanisms.

Overall, this study offers new insights into the complex and nonlinear drivers of radiation belt electron phase space density, and contributes to the improved modelling of outer belt radiation belt dynamics.

Keywords: Radiation Belts,Phase Space Density,NARMAX,Machine Learning,Electron Behaviour

POSTER CODE: P2MIT314

Title
Extending Radial Diffusion Theory from Earth to Saturn’s Electron Radiation Belts

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Body
Radial diffusion is a key process controlling the dynamics of relativistic electrons in planetary radiation belts. In Earth’s outer belt, the radial diffusion coefficient DLL is typically derived from well-established analytical formulations that relate electromagnetic field fluctuations, particularly ultra-low frequency (ULF) waves, to stochastic radial transport. For Saturn, by contrast, available DLL descriptions are often reduced to simple power-law dependencies on radial distance, without explicit consideration of the magnetospheric conditions that may control particle transport. However, the direct application of these formulations to Saturn remains uncertain due to the planet’s distinct magnetospheric environment, including rapid rotation, the presence of moons and rings, and the lack of continuous in-situ or upstream measurements. This work investigates how classical terrestrial formulations of radial diffusion can be adapted to Saturn’s relativistic electron belt. The study revisits the analytical derivations used to construct DLL from the Fokker-Planck equation, with emphasis on the assumptions that relate the radial diffusion coefficient to wave power and other associated parameters. It then assesses how this framework must be adapted for Saturn, identifying which components can be retained and which require reformulation to account for the planet’s magnetospheric environment and the processes governing its electron radiation belt dynamics. The goal is to establish a physically consistent pathway for extending terrestrial radial diffusion theory to Saturn. This provides a theoretical foundation for future efforts to quantify radial diffusion and develop parameterizations of Saturn’s radiation belts.

Keywords: Radial diffusion coefficient,Ultra-low frequency waves,Saturn's radiation belt

POSTER CODE: P2MIT315

Title
Influence of Plasmaspheric Density Representations on Simulated Ultra-Relativistic Electron Dynamics: A Statistical Study

Authors
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Body
The behavior of relativistic and ultra-relativistic electrons in earth's radiation belt is quite different. The relativistic electrons consistently respond to almost all geomagnetic storms, while ultra-relativistic electrons only show up to some intense storm events and they suddenly disappear. These extreme energetic particles may pose a severe threat to satellite infrastructure through deep dielectric charging, yet their acceleration via wave-particle interactions depends heavily on a factor external to traditional radiation belt frameworks: the surrounding cold plasma density of the plasmasphere. While single-event case studies have shown that background density modulates these local acceleration conditions, a lack of long-term statistical validation remains.
This study provides a comprehensive statistical validation of how cold plasma density affects the evolution of 7.7 MeV electrons across the Van Allen Probes era from October 2012 to December 2017. We utilized the Versatile near-Earth environment of Radiation Belts and ring current (VERB) code to run three groups of simulations where the wave-particle diffusion coefficients were scaled by different density inputs: a static empirical model, in-situ observations from the Van Allen Probes, and physics-based predictions from the VERB-Convection Simplified (VERB-CS) model.
Our results demonstrate that the accuracy of ultra-relativistic electron simulations depends strongly on the chosen cold plasma representation. We show that coupling radiation belt models with more realistic, time-dependent plasmaspheric models significantly improves the reproduction of observed enhancements. This highlights the necessity of improving plasmaspheric modeling to better predict the behavior of the most energetic electrons in the magnetosphere and to accurately characterize the wave-particle diffusion environment.

Keywords: Magnetospheric dynamics,Radiation belt physics,Space weather modeling,Ultra-relativistic electrons,Wave-particle interactions

POSTER CODE: P2MIT316

Title
RECENT DEVELOPMENTS IN THE VERSATILE ELECTRON RADIATION BELT (VERB) CODE AND DATA ASSIMILATION APPLICATIONS

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Body
Accurate specification and forecasting of Earth's radiation belt electron environment remain critical for understanding radiation belt dynamics and mitigating space weather hazards to spacecraft. The Versatile Electron Radiation Belt (VERB) code has become a widely used physics-based model for simulating the evolution of relativistic electrons through radial diffusion and wave–particle interactions. In recent years, substantial advances have been made to enhance the physical realism, numerical performance, and data assimilation capability of the VERB framework.

In this work, we present an overview of recent developments in the VERB code, including improvements to diffusion coefficient parameterizations and optimization of the numerical solver for increased computational efficiency. Particular emphasis is placed on the integration of modern data assimilation techniques within VERB. We describe the implementation of ensemble- based and Kalman filter–type approaches to incorporate in situ observations from missions such as Van Allen Probes, GOES, ARASE and other relevant datasets. These upgrades enable more accurate reconstruction of phase space density and improved nowcasting and forecasting capability.
Case and long-term studies are presented demonstrating the impact of assimilation on reproducing observed radiation belt dynamics during geomagnetically active periods. Quantitative validation against independent measurements shows that the updated VERB framework significantly reduces model–data discrepancies and improves predictive skill relative to stand-alone simulations. Ongoing work focuses on further coupling with global magnetospheric models, machine-learning-assisted parameter estimation, and real-time applications for space weather operations.

Keywords: Numerical modelling,data assimilation,space weather hazards,radiation belts

POSTER CODE: P2MIT317

Title
Kinetic versus cold-plasma dispersion in quasi-linear diffusion coefficients for whistler-mode waves

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Body
Quasi-linear diffusion coefficients are an important input of physics-based radiation belt models, determining how e.g., whistler-mode chorus waves scatter and accelerate energetic electrons. These diffusion coefficients are generally computed from a cold-plasma dispersion relation, even though the surrounding medium is warm and structured. The cold-plasma description becomes singular at the resonance cone, where the refractive index diverges and the wave becomes quasi-electrostatic, which is a regime that oblique chorus waves can approach.

We investigate how sensitive pitch-angle diffusion coefficients are to the choice of the dispersion relation, and under what conditions the cold-plasma treatment remains adequate.

To address this, we have coupled the kinetic dispersion solver WHAMP to the Full Diffusion Code, so that refractive index, wave polarisation and group velocity are evaluated from a hot-plasma dispersion relation while the wave model, resonance conditions and integration scheme are left unchanged. The implementation is verified in the vanishing-temperature limit against the cold-plasma formulation, and a per-resonance accounting diagnostic attributes any remaining differences to individual factors in the diffusion integrand.

Preliminary results for a low-density chorus scenario indicate that the two formulations agree closely for resonances whose cold-plasma resonance cone lies outside the modelled wave-normal-angle range, while systematic differences appear once the cone falls inside it. In the latter case, the cold-plasma normalisation of the wave-normal distribution is sensitive to numerical resolution, whereas the kinetic refractive index remains finite. The results suggest that the sensitivity of diffusion coefficients to the underlying dispersion relation deserves attention when quantifying uncertainties in radiation belt models.

Keywords: wave-particle interactions,quasi-linear theory

POSTER CODE: P2MIT319

Title
Models and Tools at CCMC relevant to Space Plasma and Radiation Effects: Status Update

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Body
The Community Coordinated Modeling Center (CCMC) hosts the largest openly accessible collection of space science and space weather models, spanning diverse heliophysics regimes from the solar corona to the Earth's upper atmosphere, and to the ground. In this presentation, we focus on CCMC's models and tools for the near-Earth space environment and radiation and plasma effects models relevant to aviation, human exploration, and space hardware.

We present the current status of key capabilities, including radiation belts, ring current models, and plasmasphere models; our radiation impact model NAIRAS, and tools relevant to anomaly analyses. We highlight recent updates and enhancements in model realtime and post-processing capabilities, accessibility through CCMC's web-based interfaces and API services.

We outline near-term plans for expanding the model collection to address emerging needs, including improved radiation environment specifications for cislunar space in support of sustained human presence beyond low-Earth orbit, modeling and tool needs for NASA’s Moon 2 Mars Program.

Central to all CCMC activities is sustained collaboration with the broad community. We actively partner with modelers to host and disseminate research tools, with data providers to establish validation benchmarks and real-time inputs, and with operational entities and end users to define requirements and assess model performance. We welcome dialogue with European and international partners on coordinated model development, validation, and transition to serve the growing user community.

Keywords: Space Plasma and Radiation,space weather,Models

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION OPS

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2OPS01

Title
Results of the Awareness and Preparedness Survey for Pilots and ATCs in Indonesia

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Body
Space weather can disrupt aviation operations through its effects on high-frequency (HF) communication, Global Navigation Satellite Systems (GNSS), and other technologies used in modern aviation. While technical impacts have been widely studied, the awareness and preparedness of aviation professionals remain less explored, particularly in Indonesia.
This study investigates awareness and preparedness related to space weather among pilots and air traffic controllers (ATCs) in Indonesia, as well as factors associated with differences in familiarity and operational understanding.
An online survey was conducted among Indonesian aviation professionals, collecting responses from 87 participants, including pilots and ATCs. The survey included questions related to familiarity with space weather, understanding of operational impacts, operational experience, preparedness, and training. Descriptive statistics were used to summarise response patterns, while Bayesian ordinal logistic regression models were applied to examine factors associated with familiarity with space weather.
The results indicate generally low levels of familiarity and understanding of space weather among respondents. Most participants reported learning about space weather through informal sources such as media or self-study rather than formal training or workplace briefings. It showed that professional role and years of experience were not strongly associated with familiarity. In contrast, respondents with prior operational exposure to space weather conditions showed higher levels of familiarity and awareness.
Awareness and preparedness related to space weather remain limited within the Indonesian aviation sector. The findings highlight the importance of improving training, operational guidance, and access to space weather information in order to strengthen aviation resilience and support safer operations.

Keywords: Aviation,User Survey,Statistics,Air Traffic Management,Space Weather

POSTER CODE: P2OPS02

Title
The AGATA Scientific Research Programme: an open platform for collaboration in the polar regions

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Body
International collaboration is essential for studying the upper atmosphere and solar-terrestrial phenomena in the polar regions, facilitating both data sharing and dedicated research campaigns. This collaborative approach is especially critical in the Antarctic due to limited accessibility, sparse infrastructure, and challenging logistics, enabling continuous monitoring of the upper polar atmosphere and its response to geomagnetic forcing. The Antarctic Geospace and Atmosphere ReseArch (AGATA) Scientific Research Programme (SRP) of SCAR began its 8-year activities in 2025.

AGATA addresses key scientific problems:
i) How are different atmospheric layers coupled in the polar regions?
ii) How does the upper polar atmosphere respond to increased geomagnetic activity,including energy transfer?
iii) How does the whole polar atmosphere impact short- and long-term climate variations?

To establish a global context, AGATA adopts an interhemispheric perspective, comparing the Antarctic and Arctic to understand their role in global atmospheric processes. The program also contributes to preparations for the next International Polar Year (IPY).

AGATA is structured around Working Groups, focused on physical processes like coupling between atmospheric layers and between neutral/ionized parts, and Task Groups, addressing coordination, data management, and capacity building.

To date the AGATA community counts more than 350 members and is working on review papers and data survey to make a gap analysis and build up an effective roadmap. This collaborative effort aims to ensure an effective coordination of: fieldwork at the poles, polar data management and preparation of joint scientific papers.

This presentation summarizes AGATA achievements, current status and future plans, aiming to welcome new members onboard.

Keywords: International collaboration,atmospheric coupling,polar atmosphere

POSTER CODE: P2OPS03

Title
Operational Solar Radio Flux Observation at the Geodetic Observatory Wettzell

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Body
Despite their importance as a widely used, reliable and consistent proxy for solar activity, F10.7 and F30 are only provided worldwide by one civilian agency each at the operational level. F30 is only provided by the Nobeyama Radio Observatory (NRO). F10.7 is provided by the Dominion Radio Astrophysical Observatory (DRAO) in Penticton, Canada. In this context, Elvidge et al. recently posed the legitimate question in the Space Weather journal: “What to Do When the F10.7 Goes Out?” [10.1029/2022SW003392].

With the Solar Flux Telescope 1 (SFX1/CLT) at the Geodetic Observatory Wettzell (GOW), which went into operation in January 2024, a second civilian facility, the Federal Agency for Cartography and Geodesy, is helping to ensure that this does not happen. The analog receiving system of the radio telescope is designed for a flexible selection of measurement frequencies between 1 and 6 GHz with bandwidths of up to 100 MHz. The F10.7 measurements are currently framed by three additional measurement frequencies at 3.33 GHz, 4.98 GHz and 5.98 GHz above the L-band and below at 1.0 GHz, 1.415 GHz and 1.665 GHz.

The CLT is designed for a robust solar flux observation. The system therefore includes an automated radio frequency interference (RFI) detection procedure, temperature stabilization of the full analog signal processing chain and further metadata acquisition (like environmental conditions, calibration state etc.), which serve for data validation purposes. Availability is achieved through its integration into the GOW’s operations. These are: quality control and reporting, round-the-clock monitoring of equipment and data, technical on-call service, security access control, and availability insurance. Taken all together, these aspects form a solid foundation for long-term, stable measurement operations complementary to the other stations. Furthermore, in order to reduce necessary maintenance outages, a second redundant Solar Flux Telescope is currently being planned.

Keywords: solar radio flux measurement,F10.7 index,F30 index

POSTER CODE: P2OPS04

Title
Resilient space weather monitoring for security purposes

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Body
Some of the most important real-time space weather data we use for monitoring comes directly from satellite measurements. While these measurements are highly accurate, it is exactly this space infrastructure that could be disrupted in extreme space weather events. As an example, the X-class solar flare in November 2003 overwhelmed and saturated the X-ray detectors onboard GOES, meaning that other methods had to be used to estimate its intensity and monitor its progress. It should be further considered that next to natural events, political developments could also influence the availability of this data.

In this talk, I will outline some of the methods which we are currently researching and testing for the purposes of autonomous, real-time, ground-based, resilient space weather monitoring. This includes monitoring solar flares and solar proton storms using radio measurements, infrared measurements and measurements of ionospheric attenuation. While the general accuracy of these methods is not comparable to the existing services and a 1-to-1 translation between indices cannot always be made, these measurements will act as a reliable backup in case the primary satellite sources of data become unavailable. Ideas from the audience on other possibilities of real-time space weather monitoring are very welcome.

Keywords: Defence,Resilience,Data,Monitoring,Real-time

POSTER CODE: P2OPS05

Title
The New and Improved TSST: Advancing Toward a Robotic Solar Facility for Continuous Space Weather Monitoring.

Authors
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Body
The Tor Vergata Synoptic Solar Telescope (TSST) is a robotic, cost-effective, ground-based facility designed to provide continuous full-disk observations of the Sun, in support of solar physics research and space weather monitoring. The TSST is designed to acquire simultaneous line-of-sight velocity and magnetic field maps (Dopplergrams and magnetograms) of the solar photosphere together with chromospheric Halpha images, enabling the investigation of plasma–magnetic field interactions that drive solar activity and eruptive events. The facilty is the result of a collaboration between the University of Rome Tor Vergata, the University of L'Aquila, and Georgia State University; it aims to establish a new node within the Global Automatic Telescopes for Exploring the Sun (GATES) network.

The TSST is a dual channel telescope: the first channel employs a Magneto-Optical Filter (MOF) centered on the potassium KI D1 line (769.9 nm), enabling the acquisition of Dopplergrams and magnetograms with high stability, narrow spectral bandwidth, and an absolute wavelength reference. The second channel, based on an Halpha filter, provides complementary information on chromospheric structures and flare detection.

We present the final optomechanical assembly and telescope structure which enhanced the overall stability of the system. Additionally, we present test observations carried out to assess instrument performance and to validate the data acquisition and reduction pipeline. TSST magnetograms were then compared with observations from established synoptic facilities, like GONG and SDO/HMI. With the site selection finalized and the robotic dome in its final realization phase, the TSST is approaching operational readiness as an autonomous and continuous, ground-based space weather monitor.

Keywords: Synoptic Telescope,Instrumentation,Magneto Optical Filter

POSTER CODE: P2OPS06

Title
METEOSPACE: automated monitoring of the solar chromosphere at the Calern Observatory

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Body
METEOSPACE is a solar imaging instrument installed on the Calern plateau (Côte d'Azur Observatory, 1270 m). It consists of three automated telescopes observing the solar chromosphere in the H-alpha and Ca II K lines, with narrow filters allowing it to probe different heights of the solar atmosphere. The instrument operates in a fully robotic manner and acquires images of the entire solar disk every 10 seconds, with a spatial resolution of less than 1 arcsecond, enabling near-continuous monitoring of chromospheric activity.

The main scientific objective is the monitoring of dynamic phenomena associated with
solar activity, such as flares, filamentary instabilities, Moreton waves, or the initial phases of coronal mass ejections. These observations allow the identification and tracking of their early chromospheric signatures, providing important information for the study and forecasting of space weather disturbances.

The entire system is designed to operate without an operator: meteorological control, image acquisition, processing, and archiving are automated, enabling continuous data production and its rapid dissemination to the scientific community.

METEOSPACE data are freely accessible via an FTP server and a web interface allowing near-real-time visualization. images, including comparison with measurements of solar X-ray flux from the GOES satellite used for the detection and classification of eruptions. To facilitate use by the international community, a data access service based on DaCHS (Data Center Helper Suite) has been implemented, making all images queryable via the Virtual Observatory tools and the TAP (Table Access Protocol). A selection of data (one image per hour and per wavelength) is also distributed via the BASS2000 solar database, ensuring integration into the historical archives of solar observations.

Keywords: H-alpha monitor,Groud-based observations,Chromosphere,Filaments,Moreton waves

POSTER CODE: P2OPS07

Title
Recommendations for Advancing Heliophysics and Space Weather Modeling through Open Science

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Body
We present a community-wide effort to develop a strategy and action plan to advance heliophysics and space weather modeling through open science [1,2]. While open science has the potential to enhance the quality and pace of scientific discovery, its application to scientific modeling requires more careful consideration regarding open data and open software guidelines, as scientific models differ significantly from data analysis software.

We gathered feedback from modeling teams worldwide through a living survey and discussion sessions at the 2024 Open Science Workshop in College Park, USA, and at the 2025 COSPAR ISWAT Working Meeting in Cape Canaveral, USA. We complement these findings with lessons learned from almost 25 years of experience at the Community Coordinated Modeling Center in enabling open use of models. We identify key roadblocks in current open science practices and guidelines and offer recommendations for future progress across four overlapping themes: open use models and simulation results, open validation, open development, and open collaboration.

An essential outcome of the discussion is the need for model developers and model users to speak with a united voice and promote the role of models in future open science efforts. We introduce a new cross-domain community initiative called the Heliophysics Open Modeling Environment (HOME), which will be integrated as an overarching activity within COSPAR ISWAT. HOME will serve as a platform for modelers and model users to work together, facilitate community modeling, improve the scientific return on modeling investment, and advance understanding, modeling, and forecasting in heliophysics and space weather.

[1] https://doi.org/10.1029/2025SW004922
[2] https://doi.org/10.1029/2026SW005194

Keywords: Open science,Modeling

POSTER CODE: P2OPS08

Title
Space weather research in Slovakia and related observational activities

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Body
Space weather research in Slovakia is performed at 4 leading institutions: (1) Astronomical Institute, Slovak Academy of Sciences, Tatranska Lomnica (Department of Solar Physics); (2) Institute of Experimental Physics SAS, Kosice (Department of Space Physics); (3) Earth Science Institute, Slovak Academy of Sciences, Bratislava (Division of Geophysics, Geomagnetic Observatory Hurbanovo); (4) Slovak Central Observatory Hurbanovo (Research and Observational Department). This contribution presents the main research fields and related projects and activities performed in Slovakia.

Keywords: space weather,ground-based observations,satellite components

POSTER CODE: P2OPS10

Title
SOLER Open-Source Python Tools for the Analysis of Energetic Solar Eruptions

Authors
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Body
The recently expanded fleet of heliospheric spacecraft presents unique opportunities for exploring solar eruptive phenomena such as coronal mass ejections (CMEs) and solar energetic particles (SEPs) from multiple vantage points. However, the task of integrating diverse observations collected by different instruments across various spacecraft poses a notable challenge. To maximize the utilization of this data within the broader scientific community, the EU Horizon Europe project SOLER (Energetic Solar Eruptions: Data and Analysis Tools) offers a versatile array of tools. These tools, provided as open-source Python Jupyter Notebooks, cater to scientists with limited programming expertise. The offered functionalities start from automatic downloading & visualizing SEP intensity-time profiles and various other in-situ measurements by the whole heliospheric spacecraft fleet. Further analysis tools allow to determine and SEP event energy spectra as well as SEP Pitch-Angle Distributions (PADs) and first-order anisotropies, including methods for background subtraction. Another set of tools is dedicated to the analysis of SEP onset times, offering a regression method and a hybrid Poisson-CUSUM-bootstrapping approach. Recently added were tools to fit SEP spectra and to analyze their spatial distribution. Here we provide an overview of the available toolkit and instructions on its utilization, which can be seamlessly accessed on the project's dedicated JupyterHub server in the cloud.

Keywords: Solar Energetic Particles,SEP

POSTER CODE: P2OPS11

Title
Space Weather Forecasting Using AI for Belgian Defence

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Body
The AIDefSpace project aims to develop advanced artificial intelligence (AI), driven capabilities for forecasting and modelling space weather phenomena relevant to Belgian Defence operations and infrastructure resilience. Space weather events, primarily driven by solar and its interaction with Earth's magnetosphere, can significantly affect satellite systems, communication networks, navigation accuracy, radar performance, and critical ground-based infrastructure.

The project focuses on three major research objectives. First, it will develop an automated forecasting system to predict the probability of solar flare activity within the next 24 hours, enabling improved anticipation of impacts such as satellite orbit decay, radio blackouts, radar interference, and disruptions to satellite communications and geolocation services. Second, the project will develop a data-driven numerical model of the global geomagnetic environment by combining empirical models with machine learning techniques trained on historical and real-time observations. This model will reconstruct and forecast the spatial distribution of geomagnetic field variations at the Earth's surface, improving the assessment of risks such as radio propagation anomalies, spacecraft charging, power grid disturbances, and space tracking errors Third, AIDefSpace will establish a machine learning enhanced global model of present and near-future ionospheric plasma conditions, with particular emphasis on key peak parameters such as the F2-layer height (hmF2) and critical frequency (foF2). The model will serve both operational purposes, supporting reliable communication and navigation and scientific objectives, with the potential to be extended toward 3D electron density reconstruction.

By combining a probabilistic flare forecast, state-of-the-art AI geomagnetic and ionospheric modeling, we seek to enhance operational awareness, forecasting accuracy, and strategic preparedness for defence and security in the space domain.

Keywords: Defence and Security,Space weather impact,Forecasting and thresholding,Flare forecasting,geomagnetic, ionospheric model

POSTER CODE: P2OPS12

Title
An Analysis of Eruptive Events Observed with the Hvar Observatory's Double Solar Telescope

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Body
We performed a Sun-to-Earth analysis of Earth-directed eruptive events observed with the Halpha solar telescope of the HVAR Observatory. First, we associated filaments/prominences (283) and flares (91) reported in the HVAR catalog (2011-2019) with coronal mass ejections (CMEs) observed with white-light coronagraphs and cataloged in the SOHO/LASCO catalog. We created a sample of 42 HVAR Halpha eruptive events associated with CMEs. Next, we linked remote CME observations with in situ measurements of their interplanetary counterparts, ICMEs, near Earth. For this purpose, we used the Drag-Based Model (DBM), for the heliospheric propagation of CMEs and its probabilistic version DBEMv4. We cross-matched the identified ICMEs with three different ICME catalogs. This provided a rough estimate of the CME-ICME associations. To further refine the sample and confirm the CME-ICME association, we performed a 3D reconstruction of the CMEs and ran DBEMv4, as well as analyzed in situ signatures of ICME arrival. In this way, we found eight reliable HVAR Halpha eruptive event-CME-ICME associations, for which we performed a detailed analysis using remote and in situ measurements. We estimated axial field orientation, inclination, and chirality, if possible. We found only one event with fully matching physical properties of the flux rope (FR) between the Sun and Earth. This shows that it is quite challenging to relate the properties at a distance and in situ when dealing with ”coincident” events. Nevertheless, we show that the Halpha observations used are a relevant source of information for remote signatures of eruptions.

Keywords: Low Coronal Signatures,Coronal Mass Ejections,Flares Dynamics,Coronal Mass Ejections Interpl,Magnetic Fields

POSTER CODE: P2OPS13

Title
Maintaining a sub-nanotesla magnetic field by external-reference compensation and internal magnetic feedback in the ZBL

Authors
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Body
Achieving a sub-nanotesla magnetic field is not only a problem of field reduction but also of long-term stability. The Zero Magnetic Field Laboratory (ZBL) at the Széchenyi István Geophysical Observatory combines active geomagnetic field compensation with a double-layer mu-metal shielding chamber. While the external compensation system follows the continuously varying geomagnetic field using observatory measurements, residual fields inside the shielding chamber are additionally affected by shielding remanence, relaxation, temperature dependence and spatial field gradients.
To improve long-term stability, an internal feedback approach has therefore been developed. A reference fluxgate magnetometer located in the experimental region is complemented by three three-axis magnetometers distributed inside the shielded volume. Their orientations, offsets and temperature dependencies were experimentally characterised before implementation in the feedback system.
The external observatory-based compensation first establishes the nominal near-zero field state. Subsequent corrections are derived from the internal magnetometer measurements and applied to the active compensation system. Recent experiments demonstrate that updating the compensation parameters approximately every 15 minutes using this internal magnetic feedback can maintain the residual magnetic field below approximately 0.5 nT.
The poster presents the combined external-reference/internal-feedback control concept, sensor characterisation procedure and first stability results, demonstrating a practical approach to maintaining a controlled sub-nanotesla environment over extended measurement periods.

Keywords: low magnetic field,controlled zero magnetic field,magnetic shielding chamber,Zero Magnetic Field Laboratory

POSTER CODE: P2OPS14

Title
The Zero Magnetic Field Laboratory: a dual active–passive system for controlled sub-nanotesla magnetic environments

Authors
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Body
The Zero Magnetic Field Laboratory (ZBL) at the Széchenyi István Geophysical Observatory (NCK), Hungary, has been developed through a collaboration between HUN-REN EPSS and HUN-REN Wigner RCP to provide a large-volume, highly controlled ultra-low magnetic field environment. The facility combines active compensation of the local geomagnetic field with passive magnetic shielding.
The active compensation system is based on a triaxial Merritt coil arrangement surrounding the laboratory building. Compensation currents are calculated from real-time geomagnetic observations at the observatory, allowing both the main field and its natural temporal variations to be suppressed. The residual field is further reduced by a double-layer high-permeability mu-metal shielding chamber, resulting in a five-order-of-magnitude reduction of the ambient geomagnetic field.
The completed system provides a stable sub-nanotesla magnetic environment over an extended experimental volume. Different operating configurations allow the static and dynamic components of the geomagnetic field to be controlled separately or simultaneously, enabling experiments under tailored magnetic conditions.
The poster presents the design and operation of the active–passive compensation concept, its integration with geomagnetic observatory measurements, and recent experimental performance of the completed ZBL infrastructure. The facility provides a unique environment for instrument development, space-related technology testing, material science and controlled investigations of physical and biological systems under extremely weak magnetic fields.

Keywords: low magnetic field,controlled zero magnetic field,magnetic shielding chamber

POSTER CODE: P2OPS16

Title
Development, Implementation and Operational Behaviour of RLDi

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Body
RLDi is a local geomagnetic disturbance index designed to characterize the disturbed magnetic field relative to local quiet conditions at individual observatories. Following the conceptual redefinition of LDi presented previously (ESWW 2025), RLDi has now been developed into a fully automated operational workflow.
The index is obtained as the residual between the observed horizontal magnetic field and an adaptive local quiet reference composed of a time-varying baseline capturing both secular and seasonal evolution, together with the regular solar daily variation, Sq. The processing chain automatically updates the required data, constructs both reference components from historical and recent observations, handles changes in data availability and discontinuities, and generates RLDi at one-minute resolution.
The current operational implementation is integrated with INTERMAGNET services, allowing the same workflow to be executed for different observatories whenever sufficient historical coverage and near-real-time data are available. The underlying approach is therefore not tied to a single station and is intended to provide a scalable framework for local geomagnetic disturbance monitoring.
We present the development from concept to operational implementation, selected diagnostic views of the baseline and Sq construction, and examples of RLDi during quiet and disturbed periods at multiple observatories. These examples illustrate how removal of the locally estimated quiet contribution isolates the disturbed component while retaining the station-dependent response of the geomagnetic field.
The resulting system brings RLDi from a methodological concept to a reproducible, automated and extensible operational product based on standard geomagnetic observatory data.

Keywords: Local geomagnetic indices,Operational monitoring,Space weather monitoring,Geomagnetism,Geomagnetic disturbance

POSTER CODE: P2OPS18

Title
Modelling Coronal Mass Ejections from the Middle Corona to the Heliosphere with EUHFORIA+

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Body
In this work, we present results from the space weather modelling capability EUHFORIA+, a newly developed next-generation update of the magnetohydrodynamics model EUHFORIA. A key feature of the new model is the extended spatial domain, wherein the middle corona is included in the modelling domain, thereby encompassing a spatial domain starting at ~5 solar radii and extending out to the heliosphere. Including the sub-Alfvénic middle corona presents several challenges distinct from the standard heliospheric paradigm, while also providing unique opportunities for exploiting available coronagraph observations for more accurate data-constrained modelling. A recently developed novel feature is the capability for successive injection of flux-rope coronal mass ejections into the model. The new paradigm enabled by EUHFORIA+ provides a unique capability to efficiently perform physics-based data-driven dynamic modelling of CMEs from the middle corona to the heliosphere.

Keywords: Coronal mass ejections,Middle corona,Heliosphere,MHD,Space weather

POSTER CODE: P2OPS20

Title
Shift in the Center of the South American Magnetic Anomaly: Discrepancies Between the Locations of Minimum Geomagnetic Intensity and Maximum Proton Flux

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Body
The South American Magnetic Anomaly (SAMA) is a region of the Earth characterized by anomalously low values of total geomagnetic field intensity (F) compared with those expected for a purely dipolar field. The center of the SAMA can be defined in at least two ways: first, by considering the point of minimum F at the Earth's surface; and second, by considering the location of maximum precipitation of electrically charged particles from the inner Van Allen radiation belt, as detected by low-Earth-orbit satellites. However, the SAMA center positions determined using these two criteria do not coincide. Owing to the predominance of protons in the inner radiation belt, this study investigates the divergence between the SAMA center defined by F and that defined by maximum proton flux, with a focus on the internal geomagnetic field. The IGRF-14 model was used to obtain F, the non-dipolar component of F (Fnd), horizontal intensity (H), vertical intensity (Z), and inclination (I). Proton data were obtained from satellites of the former Soviet Union (1960, 1991, and 1998) and from the International Space Station (2003), which operated during different phases of the solar cycle. Geomagnetic maps overlaid with proton flux data revealed an expansion of the SAMA from 1960 to 2003, while the minimum F decreased from 21,291 nT to 19,223 nT. Over this 43-year period, the position of minimum F shifted 0.02° /year northward and 0.16° /year westward. Simultaneously, the position of maximum proton flux migrated 0.12° /year northward and 0.54° /year westward. The westward displacement and reduction in F were accompanied by a decrease in H, increases in Z, I, and the non-dipolar contribution. This configuration, combined with Earth-Sun interactions, may explain the observed spatial divergence. Further investigation of these processes is essential for mitigating risks to instruments aboard satellites used in telecommunications and georeferencing systems.

Keywords: SOUTH MAGNETIC ANOMALY,PROTON FLUX,GEOMAGNETIC FIELD

POSTER CODE: P2OPS21

Title
Aviation Radiation Mitigation Strategy Validation

Authors
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Body
A strategy for aviation radiation hazard mitigation in development for decades has been validated using two commercial airline flights in 2024 and 2025. This poster reviews activities leading to that strategy, including aviation radiation awareness emergence and the biological effects of radiation exposure influenced by altitude, latitude, and geomagnetic conditions upon aircrew, frequent flyers, and commercial space travelers. We highlight collaborative efforts by global aviation and radiological bodies to establish mitigation to ensure long-term occupational and public health safety. The validation of the As Low As Reasonably Achievable (ALARA) radiation mitigation strategy was accomplished using two United Airlines (UAL) commercial flights between San Francisco and Paris on B777-200 aircraft for separate dates and under different space weather conditions. Each flight carried the same Automated Radiation Measurements for Aerospace Safety (ARMAS) FM7 radiation monitoring instrument. One flight occurred during the extreme geomagnetic storm (Gannon storm) May 10–11, 2024 and one flight occurred during quiet geomagnetic conditions June 8–9, 2025. The flights' results validated the ALARA strategy during extreme space weather where aircraft operations protocols reduced the dose measured in the aircraft. One protocol is to fly lower magnetic latitudes to gain more Earth magnetic field shielding; the other is to fly lower altitudes to use atmosphere depth shielding. Both shielding methods can be controlled by airline fleet operational planning and by air traffic management. These protocols have now been validated with total dose measurements by ARMAS. This study shows the effectiveness of deviating flight paths to lower magnetic latitude routes and lower altitudes during major geomagnetic storms. It also suggests recommendations for future air safety within the atmospheric radiation environment.

Keywords: aviation radiation mitigation,ALARA,ARMAS,Gannon storm,radiation shielding

POSTER CODE: P2OPS22

Title
The EU OSCARS-FSD project and the SOLARNET Virtual Observatory

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Body
Developed in the framework of the FP7 and H2020 SOLARNET projects, the Solar Virtual Observatory (SVO) aims at making solar data more Findable, Accessible, Interoperable and Reusable (FAIR) for the solar physics community. The SVO allows searching across multiple datasets and lets you search for data that overlaps with events from the Heliophysics Event Database (HEK). These capabilities will help researchers in discovering and accessing solar datasets from synoptic observations as well as solar data taken during short observation campaigns. At the heart of the SVO lies a database populated with meta-data from datasets taken by space- and ground-based telescopes. It is designed to be easily interoperable with external tools and is accessible through a web interface as well as python and IDL clients. As part of the EU OSCARS Federation of Solar Data project new datasets have made available through the SVO, including simulation datasets. The SVO is described in length, including use-case examples, in Mampaey et al, 2025 (doi: 10.1007/s11207-025-02424-0)

Keywords: SOLARNET Virtual Observatory,FAIR-principles,Open data access

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION OTH1

BALLATOIO
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2OTH101

Title
Empirical Solar Energetic Proton (E-SEP) Model

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Body
Solar energetic protons (SEP) can drive shielding requirements and parts selection and therefore it is critical to have a good prediction of the SEP environment. Previous comparisons of leading SEP models found that the various fitting functions used struggled to match observed data for the large infrequent SEP events that drive mission dose. None of the fitting functions used in those models are derived from physics but rather were chosen arbitrarily. Since the only metric for assessing the goodness of an SEP model is SEP data, we propose to build a non-parametric data-driven SEP model. This Empirical Solar Energetic Proton (E-SEP) Model utilizes the virtual timeline method based solely on the statistics of an input data set without analytical fitting functions. We compare the results of the E-SEP method to those of the JPL and SAPPHIRE methods using the same event list for each. E-SEP predictions fall between JPL and SAPPHIRE predictions when using the same input event list. We note that how events are defined, even when using the same raw data, can have as much or even more influence on SEP environment predictions than choice of SEP model.

Keywords: Solar Energetic Protons,Radiation Environment Modeling,Space Climate,Statistical Methods,Model Comparison

POSTER CODE: P2OTH102

Title
Deployment of the Advanced Ionospheric Data Assimilation (AIDA) into the ESA Space Weather Portal

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Body
The Advanced Ionospheric Data Assimilation (AIDA) has recently been included in the ESA Space Weather Service Portal as part of the ionospheric weather Expert Service Centre (ESC). AIDA is a real-time data assimilation model of global 3D ionosphere and plasmasphere electron density.

Real time ionospheric characterisation is necessary since changes in the local space environment can occur on very short timescales, particularly during disturbed geomagnetic conditions. To do this, AIDA ingests NTRIP (Networked Transport of RTCM via Internet Protocol) data streams from over 2000 Global Navigation Satellite System (GNSS) receivers as well as ionosphere layer characteristics derived from ionosondes. These measurements are assimilated into a background model comprising NeQuick and the Neustrelitz Plasmasphere Model (NPM). The assimilation is performed using a particle filter and the GNSS receiver Differential Code Biases are also solved for self-consistently in the process.

AIDA consists of a real-time Ultrarapid model (produced on a five minute time interval) and a near-real-time Rapid model at a 90-min latency (which can assimilate a larger set of data). Every five minutes, 0.5, 1.5, 3 and 6 hour forecasts are produced from both the Ultra-Rapid and Rapid AIDA output. Thus, AIDA produces two separate specifications of the current ionospheric state (Ultrarapid and the 90-min forecast of the Rapid product) which allows investigation of the impact of the data and the forecast step in both quiet and disturbed conditions.

This paper will describe the process of moving AIDA from research to operations and federating it into the ESA portal; the data assimilation scheme and how it has evolved over the time frame of the project, and finally recent validation results.

Keywords: Ionosphere,Data Assimilation,R20

POSTER CODE: P2OTH103

Title
Comparing Observations of Spacecraft Internal Charging to Predictions Derived from VERB-4D and GRAS

Authors
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Body
Internal charging is a hazard posed to satellites by Earth's radiation belts, which can be enhanced during severe space weather and lead to malfunctions and failures. Dynamic models of the radiation belts may be employed in conjunction with Monte-Carlo models of charge deposition to predict charging rates in an effort to mitigate the associated risk to satellites. This paper presents an assessment of the performance of a charging model, obtained by combining the Versatile near-Earth environment of Radiation Belts and ring current 4D (VERB-4D) and Geant4 Radiation Analysis for Space (GRAS) tool, to the observations of a SURF detector onboard the Demonstration and Science Experiment satellite. The comparison is made for a mild enhancement of the observed charging rates in August 2019. The combined model performs well in reproducing the onset and approximate magnitude of the event, however it does produce some small over- and under-predictions of charging rates within a factor of 2.

Keywords: Space Environment Effects,Radiation belt modelling

POSTER CODE: P2OTH104

Title
Operational Implementation and Validation of a Physics-Based Solar Flare Prediction Scheme for Warning Development

Authors
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Body
Electromagnetic radiation from solar flares can immediately reach Earth, meaning that impacts on HF communications may already have occurred by the time a flare is observed. Therefore, issuing warnings prior to flare onset remains a critical challenge in space weather forecasting operations. In this study, we report on efforts toward the development of a solar flare warning system aimed at providing alerts before flare occurrence, based on the κ-scheme, a physics-based flare prediction framework that evaluates the magnetic stability of solar active regions.

To implement the κ-scheme within the operational space weather forecasting framework at NICT, we evaluated its predictive performance using near-real-time observational data available for operations, rather than research-oriented definitive data. We also optimized computational procedures to ensure that processing times satisfy the constraints of daily forecasting operations, enabling continuous execution of κ-scheme-based flare predictions as part of routine activities. Furthermore, we developed an application for operational forecasters that allows quantitative visualization of flare productivity for all active regions on the solar disk. This capability improves operational forecasting by enabling objective decisions on both escalation and downgrading of forecast alert levels.

In addition, we conducted benchmark evaluations of the operational version of the κ-scheme using major flare events. The results confirm that the operational implementation maintains flare prediction performance compared to that reported at the research stage, while achieving the computational speed required for operational use. Finally, we present case studies of successfully predicted major flares and events that remained difficult to predict, and discuss the effectiveness, limitations, and future improvement of physics-based solar flare prediction schemes for operational warning development.

Keywords: Solar Flare Prediction,Physics-based Prediction,Research to Operation (R2O)

POSTER CODE: P2OTH105

Title
R2O2R experience from SEPFORECAST: a re-implementation and continued validation

Authors
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Body
Accurate prediction of Solar Energetic Particle (SEP) events remains a major challenge in space weather forecasting due to the complex and not yet fully understood processes involved in SEP acceleration and propagation. As a result, many prediction models rely on empirical relationships between precursor signatures and SEP event characteristics. The SEPForecast model, initially implemented within the COMESEP Alert System, issues an alert following the observation of an M- or X class flare and incorporates flare location as well as Coronal Mass Ejection (CME) speed and width when available. Because this information may only be available after the initial flare detection, SEPForecast issues updated predictions accordingly.
In this study, we first present a validation campaign to assess the influence of flare location and CME parameters on the performance of SEPForecast predictions of occurrence probability and expected peak proton flux with E > 10 MeV. Using the event list from the recent ISWAT (International Space Weather Action Teams) SEP Event Challenge campaigns, we quantify the impact of various input parameters on various performance metrics.
In the second part, we present the lessons learned from the validation and operation of SEPForecast and how they are guiding future developments. The reimplementation of the SEPForecast module as a stand-alone tool was designed to supersede the SEP forecasting capability of the COMESEP Alert System which will retire in October 2026. SEPForecast 2 is currently integrated into the ESA SWE Portal, where users can consult ongoing and past alerts through the web-service, e-mail subscription, or by using a dedicated API. As part of a continuous effort to improve SEPForecast 2 for operation, we discuss other ongoing validation campaigns, the addition of SEPForecast 2 to the NASA CCMC SEP Scoreboard, and planned improvements based upon the SEPForecast validation results.

Keywords: Solar Energetic Particles,Prediction model,ESA SWE Portal,Validation,R2O2R

POSTER CODE: P2OTH106

Title
Is Kp an Accurate Proxy for Users Affected by Geomagnetic Storms?

Authors
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Body
During the January 2026 geomagnetic storm, auroral emissions were widely reported across Spain, including periods when the planetary Kp index indicated only quiet to moderately disturbed geomagnetic conditions. This apparent discrepancy raises an important question for operational space weather services: to what extent does Kp accurately and timely represent the geomagnetic conditions experienced by users at regional and local scales?
To address this issue, we reviewed several major historical geomagnetic storms and selected space weather events. For each case, planetary Kp values were compared with local geomagnetic measurements from observatories, with particular emphasis on mid-latitude European locations. The analysis examined both the temporal correspondence and the amplitude agreement between global and local indicators, as well as their capability to characterize phenomena of direct relevance to users, including auroral visibility and geomagnetic field perturbations.
This poster discusses the extent to which reliance on the Kp index alone is sufficient for assessing geomagnetic impacts on regional users and operational services.

Keywords: Geomagnetic storms,Nowcasting,Accurate proxy

POSTER CODE: P2OTH107

Title
Validation of the MAIRE+/MAIRE-S atmospheric radiation model during GLE77 using UK balloon and transatlantic aircraft dose measurements

Authors
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Body
Ground-level enhancement 77 (GLE77), on 11 November 2025, was the first GLE of the current solar maximum to coincide with a uniquely rich set of dedicated operational UK detectors at aviation altitudes. We present validation results for the MAIRE+ algorithm (sometimes referred to as MAIRE-S for internal versions of the software), the operational atmospheric radiation model running at the UK Met Office. Outputs from the model are analysed against three UK Met Office balloon flights launched from Lerwick, UK and Camborne, UK, and two transatlantic flights equipped with SAIRA detectors. Regions of both agreement and disagreement between the model results and experimental data during GLE77 have been found to be very interesting, and give insights into possible influences of anisotropy, heavy ion fragments, and heavy ion particle showers on radiation dose rates during the event.

Keywords: MAIRE+,GLE77,atmospheric radiation,solar particle event,cosmic rays

POSTER CODE: P2OTH108

Title
Assessment of Current Thermosphere Density Models Across Different Space Weather Conditions

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Body
As the population of objects in low Earth orbit continues to grow, accurate thermospheric neutral density representation has become essential for satellite drag modeling, orbit prediction, re-entry estimation, and collision avoidance across all levels of space weather activity. In this work, we evaluate current thermosphere density models during quiet, active, and disturbed conditions using a set of events spanning multiple years and different geomagnetic conditions. The evaluation includes 27 models, including physics-based, empirical, assimilative, and machine-learning models, such as NRLMSIS 2.0, JB2008, DTM, the physics-based TIE-GCM, the assimilative HASDM, and the machine-learning model KARMAN. We benchmark the models against density observations from spacecraft such as GRACE, GRACE-FO, GOCE, and Swarm across different altitudes in the thermosphere. Model performance is assessed using statistical comparisons to observations, such as mean ratios, standard deviations, and correlation coefficients, together with metrics based on orbital error to examine variations in behavior with changing altitude and geomagnetic activity. This dual approach allows model skill to be characterized not only in an absolute density sense but also in terms of its practical consequences for orbit determination. Results show meaningful differences in model performance across conditions, with some models demonstrating stronger overall agreement with observations under quiet conditions and others showing greater sensitivity to altitude or low skill during disturbed times. Discrepancies tend to grow during geomagnetic storm intervals and at low altitudes. Overall, the study highlights both the progress and remaining challenges in thermosphere density modeling, clarifies the regimes in which individual models are most and least reliable, and supports continued efforts to improve model accuracy, robustness, and operational applicability.

Keywords: Thermosphere,Satelite Drag,vLEO,Neutral Wind,Space Weather models

POSTER CODE: P2OTH109

Title
The RB-FAN framework providing Space Weather information for radiation belts induced risks for Space Operators: 2026 current status

Authors
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Body
In the frame of the ESA Space Safety Programme's Space Weather Service Network (S2P), the Radiation Belt Forecast And Nowcast framework 2 (RB-FAN 2) is currently developed to nowcast and forecast the particle populations and their dynamics within the radiation belts. This new version (see RB-FAN from ESA Space Situational Awareness Program) aims at providing new risk orbit, to improve the forecast of Earth radiation belts impact on spacecraft and human spaceflight.
This new framework version studies all aspects from the architecture design to the user requirements, including modelling/simulation consideration, and provision of products to end-users.
Composed of several models, the framework relies on VSWMC, the Virtual Space Weather Modelling Centre to manage several models: EUHFORIA, IMPTAM, PLASMA (plasmasphere density evolution and location and shape of the plasmapause), EMERALD (radial coefficient inside radiation belt as a time function) and finally Salammbô which provides the forecast of the radiation belts dynamics, using previous model outputs, both for electrons (100 keV up to 8MeV) and protons (1MeV up to 400MeV). A data assimilation process is also used to enhance and correct the radiation belt dynamics, using in situ measurements coming from different databases (ONERA -IPODE, BIRA-IASB and SPARC). UNSPELL model, executed continuously in parallel provides SEP event alerts in the coming 24 hours, as well as estimation of the total fluence of the expected/ongoing event.
The website is also upgraded in order to enhance the end-users experience. In addition to new indicators, end-users will be able to build their own orbit product on demand.
RB-FAN 2 is expected to be available during this year, whereas RB-FAN 3 project started in May, and will focus on model uncertainties.

Acknowledgement: This work is supported by the S2P S1-SW-14.2 Space Environment Nowcast and Forecast Development – Part 2 activity RB-FAN2 under contract number 4000140076/22/D/KS

Keywords: RB-FAN,Forecast,Space Weather,swe.ssa.esa.int

POSTER CODE: P2OTH110

Title
Automated Validation Framework for Solar Wind Models

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Body
Solar wind models (coronal and heliospheric) play a vital role in space weather by estimating solar wind conditions, and their reliability tends to improve over time through validation. For coronal models, the scientific community has used several diagnostic tests to validate them. In this work, we use Coronal holes (CHs), Current sheet (HCS), Connectivity, and UV & WL emissions to validate the WindPredict Polytropic (WP-γ) model. As a first step we try to validate the WP- γ model by coupling it with our latest CH detection tool (Prevision of phenomena through coronal hole outline recognition with neural network: POP-CORN). The goal of the validation tool is to estimate the CHs for the user-given date from the POP-CORN, and compare them with the WP-γ results. Later, we provide users with the optimal values for the free parameters of the WP-γ model using an AI algorithm that is part of the validation tool. The free parameters we consider here are the polytropic index (γ), the sound speed (Cs/Vesc), and the cutoff harmonic of the input map (Lmax). In the automated validation tool, the user can provide the date and the free parameters directly. Based on the quantitative comparison of the contours obtained for the CH estimations from the WP-γ, we compare them with the observations (POP-CORN). Later, we will provide the user with a quantitative score (global-score). If the score is poor or lower, we will provide the best values from our AI algorithm so they can rerun the simulation, thus providing a feedback loop to optimize the solar wind prevision. We plan to show that our automatic validation framework provides optimal solar wind results and can identify CH regions that will affect solar wind conditions during solar cycles 24 and 25.

Keywords: Neural Network (NN),Coronal Holes (CHs),Solar Cycle,Solar Corona (SC),Model Validation

POSTER CODE: P2OTH111

Title
Space weather services for precise GNSS applications (WeGA)

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Body
The ionosphere is one of the major error sources for operations of Global Navigation Satellite Systems (GNSS). Ionospheric perturbations can degrade the accuracy, continuity, availability, and integrity of GNSS applications. Within the scope of the WeGA (Space Weather services for precise GNSS Applications) project funded by the Ministry of State Mecklenburg-Vorpommern, Germany, we have developed several new products describing the ionospheric state and dynamics. The Neustrelitz Total electron Content Model for Galileo (NTCM-G), developed by the German Aerospace Centre (DLR), is adopted as an alternative ionosphere model by the European Commission for Galileo Open Services (OS). As a new product, Galileo Az coefficients are generated by optimizing the NTCM-G model using a distributed GNSS receiver network. The NTCM-G model provides better performance when driven by the new Az parameters. In addition, two new products representing the actual spatial gradients and temporal variations of the ionosphere, namely the Gradient Ionospheric Index (GIX) and the Sudden Ionospheric Disturbance indeX (SIDX), have been developed. The GIX and SIDX are able to estimate the degree of disturbance of the ionosphere instantaneously without historical measurements.
Since the customers are mainly interested in forecasts, and ionospheric indices and related scales require international acceptance or standardization, collaboration with the SAPOS (Satellite Positioning Service of the German National Surveying), BSH (Federal Maritime and Hydrographic Agency), SWEPOS (Swedish Network of Permanent Reference Stations), Technical University of Dresden and IRF (Swedish Institute of Space Physics) Uppsala have been initiated within the WeGA project. This involves not only GNSS data exchange but also conducting case studies of ionospheric storms when SAPOS and SWEPOS services were degraded.

Acknowledgement: WeGA project is partly funded by the German Federal State of Mecklenburg-Vorpommern.

Keywords: GNSS,ionospheric gradients,ionospheric delay correction,Space Weather,GNSS positioning

POSTER CODE: P2OTH112

Title
Regional Validation and Sensitivity Assessment of SAMI3 TEC Variability

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Body
Reliable prediction of ionospheric total electron content (TEC) variability is essential for understanding and mitigating space weather impacts on communication, navigation, and satellite systems. Physics-based ionospheric models such as the Sami3 is Also a Model of the Ionosphere (SAMI3) provide a framework for investigating ionospheric responses to solar and geomagnetic forcing; however, model performance can vary with geographic region, background conditions, and the magnitude of external drivers. Establishing when and where model predictions can be trusted remains a fundamental challenge for space weather applications.
This study presents a systematic assessment of SAMI3 TEC variability through regional validation and controlled sensitivity experiments. A baseline simulation is performed for the week of 20 June 2020, and additional simulations are generated by independently varying F10.7 solar flux, Kp, and Ap inputs. These experiments quantify the sensitivity of modeled TEC variability to changes in solar irradiance and geomagnetic forcing while maintaining realistic time-dependent driver behavior.
Model capability is evaluated across ten geographically diverse regions. Regional skill scores are calculated through comparison with GNSS observations to characterize spatial variations in SAMI3 performance and identify geographic regions where modeled TEC is more or less sensitive to changes in external forcing. The same validation framework will be applied to a geomagnetically active period containing a major storm event.
By comparing model response and validation skill across quiet and storm-time regimes, this study investigates the conditions under which physics-based ionospheric predictions are reliable. The results provide insight into the relative importance of solar and geomagnetic drivers in controlling regional TEC variability and contribute toward improved confidence assessment for operational space weather modeling.

Keywords: SAMI3,GNSS TEC Validation,Skill Scores

POSTER CODE: P2OTH113

Title
Probabilistic Verification of CME Forecasting

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Body
Accurate forecasting of Coronal Mass Ejections (CMEs) at Earth remains a significant challenge in space weather forecasting. Current approaches for assessing forecast accuracy largely depend on linking in-situ measurement signatures to solar eruptions observed close to the Sun, which are used as inputs to heliospheric models. Most models provide deterministic (single-scenario) forecasts of CME propagation, and forecast verification is therefore based on comparisons with single-value arrival estimates. This method becomes increasingly unreliable during periods of high solar activity, when multiple CMEs interact, making post-event attribution more uncertain. Ensemble modelling of CMEs would alleviate some of these limitations, and has been developed and used in an operational setting. However, its outputs are still typically summarised as a single arrival-time and speed estimate accompanied by an uncertainty range derived from the ensemble spread, making them broadly comparable in form to deterministic forecasts. For mitigation of space weather effects, the essential requirement is not necessarily the unambiguous identification of the causative CME, but a reliable assessment of whether Earth is experiencing CME conditions. In this work, we extend the use of ensemble modelling to produce fully probabilistic forecasts of CME occurrence at Earth. We evaluate these forecasts using probabilistic verification techniques, drawing on methodologies from meteorology, to quantify forecast skill and reliability.

Keywords: Probabilistic Forecast,Probabilistic Verification,Ensemble modelling,Coronal Mass Ejections

POSTER CODE: P2OTH114

Title
Latitudinal Bands vs Polygons: assessing the added value of impacted region identification for Aviation Space Weather Services

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Body
PECASUS provides operational space weather services to Aviation, including ICAO-compliant advisories for impacts on GNSS and HF communication. At the Royal Observatory of Belgium (STCE/SIDC), these services rely on continuous monitoring, operational data flows, and 24/7 advisory production based on ICAO thresholds. A recent evolution in the ICAO advisory format is the transition from broader latitudinal bands to multi-point polygons to describe affected regions and thus to provide more targeted information to aviation users. However, the effect of this transition on information quality, spatial precision and the number and the complexity of advisories needs now to be assessed. We present a methodology for an automated detection of GNSS and HF impacted regions for ICAO advisories. The workflow identifies regions where impact criteria are met consistently and converts them into polygon-based areas suitable for operational advisory production. Using selected geomagnetic storm cases, we discuss the robustness and operational value of this approach. We examine the sensitivity of the identified (impacted) regions to data coverage, model resolution, thresholds, smoothing, and temporal variability. This provides a basis for evaluating when polygon-based advisories improve spatial specificity and user relevance, and when broader regional descriptions remain more appropriate. This work contributes to the validation of operational space weather services by linking impacted region detection, uncertainty awareness, and user-oriented advisory formats. It addresses a practical research-to-operations challenge: providing more geographically specific aviation space weather information while remaining consistent with the limitations of current monitoring and modelling capabilities.

Keywords: space weather services,aviation advisories,impacted areas,GNSS, HF,validation

POSTER CODE: P2OTH116

Title
Towards Reliable Solar Energetic Particle Event Prediction: Validation of ASPECS within ADVISOR

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Body
Solar Energetic Particle (SEP) events can adversely affect both space- and ground-based technological systems, impacting satellite operations, navigation and communication services, spacecraft electronics, aviation, power systems, and future human exploration missions such as Artemis. As reliance on space weather services continues to grow, the need for reliable and actionable SEP forecasting capabilities becomes increasingly critical. In this context, rigorous validation of forecasting models is essential to ensure operational readiness, reproducibility, and confidence in real-world decision-making. In this work, we present the validation results of the nowcasting (post-eruption) component of the newly updated ASPECS (Advanced Solar Particle Event Casting System), using the SEPVAL 2023 (SEP Model Validation) sample. Particular emphasis is placed on the comparison of different input datasets and event catalogs, and on how these affect the overall performance of the tool. The study evaluates multiple ASPECS modules through established verification metrics, including the Probability of Detection (POD), False Alarm Rate (FAR), Percent Correct (PC), Heidke Skill Score (HSS), and True Skill Score (TSS). In addition, comparisons between predicted and observed SEP peak proton fluxes and time profiles at energies above 10 MeV and 100 MeV are discussed. This work contributes to ongoing community efforts toward standardized, reproducible, and operationally relevant validation frameworks for space weather forecasting systems, supporting the transition of SEP prediction capabilities from research to operations.

Acknowledgement: This work This work was supported through the ADVISOR - OptimizAtion, DeliVery & Installation of the ASPECS tOol for Space WeatheR research within ISEP project, contract SMS0016862 (https://members.noa.gr/atpapaio/advisor/).

Keywords: SOLAR ENERGETIC PARTICLES,VALIDATION,PERFORMANCE

POSTER CODE: P2OTH117

Title
Monitoring the HF Ionospheric Channel during the May 2024 Superstorm through IRI&LKWnewUP Nowcasting Maps

Authors
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Body
This work presents the IRI&LKWnewUP procedure, which generates nowcasting Maximum Usable Frequency (MUF) maps and corresponding skip distances over Europe. IRI&LKWnewUP is a four-step procedure based on: (1) deriving two effective values of the 12-month running mean of the sunspot number (R12) according to autoscaled foF2 and M(3000)F2 ionosonde measurements; (2) using these two values of R12 as input for the International Reference Ionosphere (IRI) model to calculate the ordinary critical frequencies foE and foF2 of the E and F2 layers, respectively, and the obliquity factor M(3000)F2; (3) feeding the Lockwood algorithm with these values of foE, foF2, and M(3000)F2 to compute a discrete grid of MUF values; and (4) mapping these grids of values to generate nowcasting maps of MUF and corresponding skip distances. The maps cover the European sector from 9°W to 45°E in longitude and from 34°N to 65°N in latitude, with a 1°×1° spatial resolution, with 15-minute time resolution. They are centred on six selected transmitting points: Stockholm (18.1°E, 59.3°N), Warsaw (21.1°E, 52.2°N), Pruhonice (14.6°E, 50.0°N), Paris (2.3°E, 48.8°N), Rome (12.5°E, 41.9°N), and Athens (23.7°E, 37.9°N). The procedure's effectiveness is tested by comparing retrospective MUF nowcasting maps generated for the main and recovery phases of the May 2024 extreme geomagnetic storm with their corresponding quiet-time and climatological counterparts. Results confirm that IRI&LKWnewUP provides a reliable nowcasting monitoring of the high frequency ionospheric channel, supporting surveillance, civil protection, aviation, and defence systems, particularly under adverse space weather conditions as those characterizing the superstorm occurred in May 2024.

Keywords: Maximum usable frequency,Skip distance,IRI model,Lockwood algorithm

POSTER CODE: P2OTH118

Title
Towards an improved NeQuick Topside Ionosphere model based on Radio Occultation and POD TEC observations

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Body
NeQuick is a global empirical model of the ionosphere and plasmasphere, designed to provide the electron density distribution and fast total electron content (TEC) estimates along trans-ionospheric links. Its topside ionosphere formulation describes electron density from the F2-layer peak to the plasmasphere through a semi-Epstein profile whose height-dependent effective scale height is controlled by three topside parameters: H0, g, and r. In the current model, H0 is coupled to bottomside parameters, while g and r are fixed, limiting the representation of topside ionosphere and plasmasphere variability.
We developed an observation-driven framework to revise this formulation. Analytical inversion of the semi-Epstein layer allowed the effective scale height to be retrieved from electron density observations and to optimize the three topside parameters. Application to about 1.8 million COSMIC-1 radio occultation (RO) profiles revealed strong spatial, diurnal, seasonal, and solar activity dependences, demonstrating the need for dynamic parameterization of the three topside parameters. However, COSMIC-1 RO altitude coverage cannot robustly constrain r, which controls the upper topside and plasmasphere. We therefore combined RO profiles with COSMIC-1 precise orbit determination (POD) TEC observations in a two-step optimization: H0 and g are constrained by RO, while r is refined using the POD TEC above the satellite orbit. The optimized parameters improved the topside ionosphere and plasmasphere effective scale height description.
These results provide the observational and methodological basis for a new NeQuick topside model currently under development. In the revised formulation, H0, g, and r will vary with relevant geophysical drivers, with the goal of improving electron density and TEC modeling for GNSS, trans-ionospheric propagation, and space weather applications.

Keywords: Topside Ionosphere,NeQuick model,Modelling,Radio Occultation

POSTER CODE: P2OTH119

Title
Characterizing the radiation environment at the surface and low Lunar Orbits

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Body
The renewed interest towards the Lunar environment and habitability of the Moon requires us to explore it's radiation environment further. The MoonRad satellite project of the European Space Agency (ESA) is a unique opportunity to provide real time cosmic particle and dose measurements near the Moon. The expected orbit of the satellite is few hundred kilometers, relatively close to the surface.
The Lunar environment is outside of Earth's magnetic field except when passing the magnetotail. It has no global magnetic field but anisotropies in the crust could create local magnetic anomalies.
The present work focuses on modelling the radiation environment at low Lunar orbit and how we could extrapolate that data to surface dose values and what is the expected flux and energy distribution of charged particles. Methods include Geant4 and GRAS simulations. Results contain assessment on how the ESA Network of Models like Ax8, CREME96, ESP/PSYCHIC and ISO-15390 GCR could be modified to reflect the expected radiation fluxes and energy distributions at low Lunar orbit.

Keywords: LUNAR,CHARGED PARTICLES,DOSE MEASUREMENT,MOONRAD

POSTER CODE: P2OTH120

Title
From space weather forecasts to spacecraft charging risk: validation and operationalisation of a physics-based forecasting service

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Body
Spacecraft charging is a major space-weather-related risk for satellite operations, particularly in the presence of energetic electron populations in the radiation belts. However, environmental parameters alone do not directly quantify the risk for a given spacecraft, as charging depends on the spacecraft geometry, materials, shielding and configuration.

We present an operational forecasting approach that translates space-weather predictions into spacecraft-specific internal and surface charging risk indicators. Developed within the H2020 PAGER project, the forecast charging service combines space-environment forecasts with physics-based spacecraft charging simulations to provide short-term, orbit and mission specific risk assessments.

A key aspect of the approach is its validation against in-flight observations and previously observed charging events. Results demonstrated the capability of the modelling chain to reproduce observed internal charging behaviour under variable space-environment conditions.

Building on this validation, the forecasting chain is integrated into an operational service providing daily updated charging risk predictions. The service provides actionable information, with risk indicators designed to support spacecraft operators and engineers in anticipating potential charging hazards to complement conventional space-weather environmental indicators.

Keywords: Spacecraft charging,Space weather forecasting,Internal charging,Operational forecasting,Spacecraft risk assessment

POSTER CODE: P2OTH121

Title
Validating an automated pipeline for short-term CME magnetic field forecasting

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Body
Forecasting the magnetic field structure of coronal mass ejections (CMEs) at Earth remains a major challenge in space weather forecasting. Here, we present an automated pipeline for short-term CME magnetic field forecasting at L1 and focus on its validation under realistic operational conditions.

The pipeline combines three main steps: CME arrival time estimates from a drag-based arrival time model (ELEvo) triggered by entries in the CCMC DONKI database; automated detection of the magnetic obstacle in real-time L1 in situ data using the machine learning model ARCANE; iterative flux rope reconstruction with the semi-empirical 3DCORE flux rope model. Once a magnetic obstacle is detected at L1, 3DCORE is fitted to the available part of the in situ data and used to forecast the remaining magnetic field structure, with iterative updates as more in situ measurements become available.

Using archived real-time data products, we evaluate how forecast quality evolves with increasing amounts of available in situ data and assess the challenges of validating such an automated forecast chain. This provides insight into both the potential and limitations of real-time CME magnetic field forecasting in a research-to-operations context.

Keywords: Coronal Mass Ejections,Short-Term Forecast,Automated Pipeline

POSTER CODE: P2OTH122

Title
The performance of near-real time ionospheric data assimilation systems: weighing operational approaches against user needs

Authors
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Body
A number of 3D near-real time operational ionospheric data assimilation systems have become publicly available over the last few years, including the US Space Weather Prediction Center's Global Total Electron Content (GloTEC) model, the Assimilation Canadian High Arctic Ionospheric Model (A-CHAIM), the Advanced Ionospheric Data Assimilation system (AIDA), the IRI Real-Time Assimilative Mapping (IRTAM), and the Advanced Ensemble Networked Assimilation System (AENeAS). These models provide an ionospheric specification for a wide variety of users and operational environments: GloTEC being the official operational model for NOAA; A-CHAIM providing operational specification for Defence applications in Canada; AIDA providing pre-operational ionospheric specification for the European Space Agency's SWE Portal; IRTAM being used broadly in defense and civilian communications applications; and AENeAS providing ionospheric and thermospheric specification for the UK Met Office. Given the representative role that these models play in space weather operational systems, there is considerable need for a comprehensive assessment of their performance in their near real time operation.

We here use a wide variety of ionospheric observations that were not assimilated to assess model performance in ionospheric specification. Through this comparison we weigh the performance of these models against typical operational requirements for applications, such as High Frequency (HF) remote sensing, and assess the relative strengths and weaknesses of these systems in these operational contexts. The limitations of each model are diagnosed using manually scaled bottomside ionosonde observations as a further assessment of their performance in HF applications. GloTEC, in particular, is found to exhibit considerable artificial gradients in the bottomside ionosphere, presenting a considerable barrier to the use of the model in HF applications.

Keywords: Ionosphere,Data Assimilation,Validation,Ionosonde,Operations

POSTER CODE: P2OTH123

Title
Year-Long Comparison of EGNOS Ionospheric Corrections and the Helgeo2-PT Model Over Europe in 2025

Authors
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Body
The year 2025, characterized by elevated solar and geomagnetic activity during Solar Cycle 25, provided favorable conditions for investigating the performance of regional ionospheric models under both quiet and disturbed space weather conditions. This study presents a year-long comparison between ionospheric corrections derived from the European Geostationary Navigation Overlay Service (EGNOS) and outputs from the Helgeo2-PT (H2PT) regional ionospheric model over the European region.
The analysis is based on EGNOS ionospheric correction data operationally provided on a 5° × 5° latitude–longitude grid and corresponding H2PT model outputs generated for the same period. The comparison focuses on the temporal and spatial consistency of the modeled ionospheric parameters throughout 2025, including both geomagnetically quiet periods and intervals of enhanced geomagnetic activity.
The results provide an overview of the agreement between the H2PT model and operational EGNOS ionospheric products under varying geomagnetic conditions in 2025.vices.

Keywords: Space Weather,EGNOS,Ionospheric Modeling

POSTER CODE: P2OTH124

Title
Space Weather in Mid-latitude and the Role of the Thermospheric Wind

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Body
Mid-latitude thermospheric winds enhanced strongly during geomagnetic storms due to the high latitude Joule heating. By examining the recent extreme storm events like May 11, 2024, and Nov 11, 2025, we can investigate the geomagnetic storm impact on the thermospheric wind. Observations from ground based Fabry Perot interferometers in the NH and SH will be analyzed. Observations from recent HIWIND balloon observations in the southern mid-latitude during geomagnetic quiet time will also be investigated to compare with the storm time conditions. TIEGCM simulations will be used to interpret the observations of thermospheric winds. Recent extreme events will give an opportunity to examine the performance of the TIEGCM in the extreme conditions. Moreover, TIEGCM has recently been upgraded to version 3.0 with new improvements this will be a good test for the new version of the model. Mid-latitude region is important for understanding how geomagnetic storms propagate from high- to low-latitude regions and significant for space weather forecast research.

Keywords: Thermospheric Wind,Fabry Perot interferometer,TIEGCM

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION OTH2

BALLATOIO ROOM
Monday November 2: 15:15-16:30
Tuesday November 3: 10:00-11:15, 16:30-17:30

POSTER CODE: P1OTH201

Title
AIMS: Arctic Ionosphere Monitoring System

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Body
High-latitude ionospheric disturbances can severely degrade Global Navigation Satellite System (GNSS) performance, affecting positioning accuracy, navigation reliability, and radio signal quality across the Arctic. Existing ionospheric monitoring products are often map-centric and focused on reconstructing the ionosphere itself, while operational users experience disturbances along individual satellite-to-receiver signal paths. This creates a gap between ionospheric monitoring products and the impacts experienced by real systems and users.

We present the Arctic Ionospheric Monitoring System (AIMS), an operational framework designed to provide receiver-relevant situational awareness of ionospheric disturbances in Arctic environments. AIMS adopts a receiver-centric and path-aware approach that explicitly accounts for satellite geometry and the locations where GNSS signals traverse the ionosphere. The framework integrates observations from heterogeneous GNSS networks, including both conventional geodetic receivers and specialized scintillation-monitoring instrumentation.

AIMS uses a hierarchical equal-area tiling architecture to aggregate and visualize disturbance-related observations in real time. The framework distinguishes between quantities describing ionospheric structure and quantities describing the resulting impact on radio signal propagation and navigation performance. These observations are combined into tile-level disturbance descriptors that support operational monitoring without requiring full ionospheric reconstruction.

The system is intended for real-time and near-real-time Arctic applications including GNSS integrity awareness, scintillation monitoring, resilience assessment, and short-horizon operational advisories. Prototype implementation results and ongoing Arctic deployment activities are presented.

Keywords: Arctic Ionosphere,Receiver-Centric Mapping,GNSS disturbances,Operational monitoring,Situational awareness

POSTER CODE: P1OTH202

Title
The Space WEather Lab in Turin Observatory - status of the project

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Body
The SWELTO project (Space WEather Laboratory in Turin Observatory) is a scientific platform developed at the INAF - Turin Astrophysical Observatory for the monitoring and analysis of Space Weather (SW) phenomena. Designed as a development and testing environment, SWELTO processes space- and ground-based data in near real time to study solar activity and its effects on Earth's magnetosphere, technological infrastructures, and space systems.

Within the international SW framework, SWELTO is connected with initiatives such as the NOAA Space Weather Prediction Center and the European Space Agency SWENET/SSA programs. Entirely developed within INAF, the platform combines hardware resources for data acquisition and storage with software pipelines for visualization, forecasting, and scientific analysis. Its modular architecture supports continuous ingestion of data from international missions and local instruments.

The online platform (https://swelto.oato.inaf.it/), provides access to processed datasets and scientific products generated through automated pipelines. SWELTO currently includes nine operational modules. "SunNow" enables real-time solar monitoring using SDO/AIA, HMI, SOHO/LASCO, and GOES/CCOR imagery. "EUVmonitor" detects active regions and eruptive structures, while "CorDens" estimates coronal plasma density. The "SolarWind" modules reconstruct solar wind velocity, and the "InSitu" module visualizes L1 measurements from ACE data. Additional tools include "RIMAP," reconstructing the Parker spiral through MHD simulations, and "CMEtool," dedicated to CME detection and mass estimation. SWELTO also supports geomagnetic monitoring through the OATo magnetometric station, local Dst-index estimation, and regional mapping of geomagnetically induced currents (GICs).

SWELTO represents both a research environment and a potential operational infrastructure supporting national and international SW monitoring activities.

Keywords: Space Weather services

POSTER CODE: P1OTH203

Title
Project SWEET - Space Weather Exploration and Evaluation Technologies

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Body
Space weather influences environmental conditions in the atmosphere and is critical to the safety and operation of ground- and space-based infrastructure. The solar wind dynamic and especially solar storms can have significant impacts on technologies like GNSS. Therefore, it is essential to develop a precise understanding of space weather and to model its effects. The DLR SWEET (Space Weather Exploration and Evaluation Technologies) project aims to develop a precise empirical four-dimensional model for space weather analyses accessible to scientists and industrial users. The model has the potential of assimilating multi-instrument multi-satellite ground and space-based data such as LEO Topside, radio occultation, in-situ electron density, and vertical ground-based sounding data to feature high spatial and temporal resolution. In addition, a state-of-the-art infrastructure is being developed to enable the processing, storage, and visualization of this complex model data. This allows experts to explore the data interactively in a browser and perform targeted analyses to study the behavior and effects of space weather. We will demonstrate the SWEET model application and show its analysis potential for recent space weather events.

Keywords: Ionosphere,Space Weather,GNSS,modelling,LEO

POSTER CODE: P1OTH204

Title
SCSS-Net: Deep-Learning Segmentation of Coronal Holes and Active Regions - from Proof of Concept toward Operational Service

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Body
Reliable and automated identification of solar coronal structures is an important input to space-weather monitoring and forecasting. We present the results of the ESA RPA-funded SCSS-Net activity, which advanced an earlier deep-learning concept for segmenting coronal holes and active regions in extreme-ultraviolet solar images, mainly developed by Technical University of Kosice and Institute of Experimental Physics, to proof of concept demonstrator. Datasets from SDO/AIA and GOES/SUVI were prepared using SPoCA-derived reference annotations, and multiple U-Net- and Pix2Pix-based configurations were trained and evaluated. Separate Pix2Pix models for coronal-hole and active-region segmentation were selected for the demonstrator. Model performance was assessed quantitatively using IoU and Dice metrics on test data from both instruments, and qualitatively against established solar-map products. The resulting demonstrator integrates the models through a RESTful backend and supports the segmentation of single or multiple PNG and FITS images, providing segmentation masks and lists of detected areas at selectable conservativeness levels. We also started cooperation with our expert partner from SCSS-Net activity(Royal Observatory of Belgium) and new industry partner (Global Singularity), where we discuss the strengths and current limitations of the models and outline the next steps toward an operational SCSS-Net service: automated daily processing, evaluation under real-time conditions, feedback from forecasters, development of an ESA SWESNET-compliant federated interface, and a user validation campaign. These results establish a practical basis for further scientific validation and transition toward operational solar-corona segmentation services.

Keywords: solar corona,coronal holes,segmentation,deep learning,services

POSTER CODE: P1OTH205

Title
How SWPC Forecasters Evaluate When to Issue Kp Warnings and Alerts

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Body
Issuing Kp watches, warnings, and alerts (the NOAA G-Scale) is a large part of the forecaster's duty cycle at NOAA's Space Weather Prediction Center (SWPC). While every scenario is unique to a degree and there is no codified forecasting method, SWPC forecasters do have some conventions and rules of thumb for making these decisions. Here, I describe how SWPC forecasters evaluate the Earth and near-Earth environment to determine whether or not to issue a Kp warning or alert. I will cover (1) what data streams we monitor; (2) how we decide when to issue, extend, or cancel a warning; and (3) what challenges we grapple with while doing so. I then walk through the sense-making and issue decision processes for two case studies from early 2026 where I was the SWPC forecaster-on-duty, as examples of the practical application of these conventions. Other than the insight into a forecaster mindset, this talk aims to highlight (1) the difficulty of interpreting real-time solar wind time series and (2) the benefit to forecasters from sub-L1 observations.

Keywords: Operational procedures,Geomagnetic indices,Forecasting walkthroughs,Solar wind environment

POSTER CODE: P1OTH206

Title
NSF-NOAA GONG: Operations and Engineering Support

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Body
The U.S. National Science Foundation (NSF) Global Oscillation Network Group (GONG) operations team supports 24/7/365 instrument monitoring. This team monitors the health of the instruments via the GONG Monitor Tool, https://monitor.nso.edu/, and remote login to the site workstations. As part of the operations support, the team travels to each network site for preventive maintenance or emergency repairs. The GONG network maintains two engineering instrument shelters, located in Boulder, CO. The engineering shelters are used for testing repaired hardware prior to re-deployment to the network sites, new hardware & software development, and component acceptance tests. For the initial testing, repairs, and development of electronics, the team uses the Sonora Lab, an electronics copy of a GONG shelter without a light feed.

Prior to the 20th anniversary of the deployment of the GONG network, the NSF approved the funding of a refurbishment project that allowed the project to replace or spare failing and outdated components and subsystems. The scope of the refurbishment project included the replacement of computer workstations, liquid crystal modulators, and cameras. A significant engineering effort was required for replacing the SMD/DALSA 1M60 cameras with the Emergent Vision Technologies HB-1800-S-M cameras. The GONG refurbishment program formally ended with the replacement of the camera at the Tenerife, Spain site in May 2025. The full refurbishment of the Mauna Loa site is pending the reopening of the Mauna Loa Observatory. Now that GONG has passed its 30th anniversary, a higher level of operations and engineering support is anticipated.

Keywords: Engineering,Operations,GONG

POSTER CODE: P1OTH207

Title
A Modular and Scalable Platform Architecture for Operational Integration of Space Weather Models, Data and Services

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Body
Space weather (SWE) events can affect critical infrastructures, from satellite operations and GNSS services to aviation and power networks, as well as humans in space. Operational centers like NOAA SWPC and ESA SWESNET demonstrate the need to translate complex models and scientific data into actionable information for scientists and end-users. As new space missions and scientific models emerge, software platforms shall integrate heterogeneous datasets and expose them through interoperable services.
This work presents the design of a scalable software platform supporting the operational deployment of SWE analysis, nowcasting and forecasting capabilities. Rather than focusing on specific models or products, the platform addresses the challenges of integrating heterogeneous data sources, orchestrating scientific processing chains, and delivering information to diverse user communities. The proposed architecture follows a modular approach in which data acquisition, processing, storage and service delivery are implemented as independent, interoperable components, coordinated by a central, event-driven data manager. This decoupling provides a plug-and-play environment for onboarding new scientific models developed by scientific partners, and new data sources, including upcoming missions, without re-architecting the core infrastructure. An advanced ETL (Extract, Transform, Load) layer abstracts heterogeneous physics-model outputs into standardized products for downstream consumption. Particular attention is given to interoperability, scalability and machine-to-machine access, through REST, GraphQL and HAPI-oriented interfaces, alongside GIS-based spatial services for integration onto infrastructure networks.
The work builds on previous Italian SWE data infrastructure activities (ASI Space Weather Infrastructure, Laurenza et al. 2023) and collaboration with the national scientific community, representing a design effort towards sustainable, operational SWE services.

Keywords: Space Weather services,Operational architecture,Interoperability,Scalability,Models/services orchestration

POSTER CODE: P1OTH208

Title
Operational Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) for plasma radiation environment in the inner Earth's magnetosphere

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Body
The Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM) provides ion (H+, O+, He+) and electron fluxes in the energy range from 1 to 300 keV and pitch angle distributions everywhere in 3D inner magnetosphere at distances from 2 to 10 RE, with specific output at GEO, GTO and MEO orbits. IMPTAM is a flexible, module-based model. The model can be used for both science and space weather application (e.g., surface charging) purposes, with the model outputs available in near real-time via imptam.engin.umich.edu, imptam.fmi.fi and CCMC's ISWA system (https://ccmc.gsfc.nasa.gov/models/IMPTAM~1/). IMPTAM is driven by (1) solar wind number density, (2) dynamic pressure, (3) velocity, (4) total strength and Y- and Z-components of IMF and (5) Dst and (6) Kp indices. Model long-term validation on GOES, Van Allen Probes and ARASE particle data is presented. Accurate predictions of keV electron flux is crucial for surface charging estimates but defining of the model's uncertainties and performance metrics is not straightforward. keV electron fluxes vary by several orders of magnitude, scale-dependent accuracy measures such as simple model error or mean error can be problematic, since it can result in very large values due to the high-flux outliers. Outliers influence the model performance significantly more than small deviations from the observations. We estimate several performance metrics, including correlation coefficient, normalized Root-Mean-Squared Deviation (NRMSD), median symmetric accuracy (MSA) ? and Symmetric Signed Percentage Bias (SSPB), binary event analysis like Heidke skill score, hit rate, and false alarm rate, and event analysis calculations of relative operating characteristic (ROC) curves and sliding threshold of observation for numerical evaluation (STONE) curves.

Keywords: plasma radiation environment,inner magnetosphere,operational model,data-model validation,performance metrics

POSTER CODE: P1OTH209

Title
Augura Space Nowcast Platform: A Research-Focused, Open Demonstrator for Space Weather Data Integration and Visualization

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Body
Augura Space has developed the Augura Space Nowcast Platform, an open-access, research-oriented tool designed to support the space weather scientific community by providing centralized access to key space environment parameters in near-real time. The platform consolidates publicly available data from European and international providers focusing on solar wind, interplanetary magnetic field, energetic particle fluxes, geomagnetic indices, ionospheric parameters, and solar imagery. Its objective is to offer a complete and user-friendly demonstrator, facilitating rapid situational awareness, cross-disciplinary studies, and data exploration by broad users including researchers, students, and engineers. The development addressed several technical challenges: Harmonizing multi-source data streams with diverse formats and cadences. Implementing a robust, modular infrastructure for data ingestion, archiving, and visualization. Ensuring traceability, transparency, and systematic referencing of data sources in line with FAIR data principles. The platform complements ongoing efforts by offering a research-oriented, freely accessible environment to foster scientific use, training, and collaboration, as well as enhance its accessibility towards new potential users. It also provides a testbed for future evolutions toward more sector-specific applications.

Keywords: Real-Time,Monitoring,Space Weather,Research-Oriented

POSTER CODE: P1OTH210

Title
NSF-NOAA GONG Solar Data Collection, Processing, and Distribution

Authors
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Body
The Data Center of the National Solar Observatory (NSO) Integrated Synoptic Program (NISP) plays a central role in enabling broad-based heliophysics research as well as data-driven physics-based Space Weather research and operational forecasting through the continuous acquisition, processing, and distribution of near-real-time Global Oscillation Network Group (GONG) observations and derived data products. The NISP Data Center generates and distributes many such products including H-alpha imagery, calibrated magnetograms, Doppler-helioseismic farside maps, synoptic magnetic products, and other observationally-constrained data sets. Additionally, we maintain GONG pipelines operating at the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center (SWPC) and produce U.S. Air Force Data Assimilative Photospheric Flux Transport (ADAPT) model maps using GONG magnetic field observations.

In this poster, we present an overview of the NISP/GONG observational products and data pipelines that support Space Weather modeling and prediction, as well as heliophysics research. We discuss the role of the NISP Data Center in GONG network operations and operational Space Weather forecasting support, including pipeline development and maintenance, data quality assurance, computational resource management, and community access to GONG data products.

Keywords: ground-based observations,operational space weather,helioseismology,magnetic fields,computational modelling

POSTER CODE: P1OTH211

Title
Capabilities and Impact of the JASPER System on Operational Space Weather Services in Thailand

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Body
Space weather impacts a wide range of critical systems, including satellite operations, GNSS performance, and high-frequency communications. Recognizing the need for dedicated monitoring and forecasting, the Geo-Informatics and Space Technology Development Agency (GISTDA), Thailand, has developed "JASPER"—the nation's operational space weather forecasting platform and a flagship initiative to address this knowledge gap.

JASPER integrates near real-time global and local data, including solar observations, solar wind, and geomagnetic data, as well as ground-based magnetometer and GNSS receiver data for monitoring ionospheric total electron content (TEC) and equatorial plasma bubble (EPB). These observations are combined with AI-assisted predictive models delivered through a public web-based platform (https://jasper.gistda.or.th/) that provides continuous monitoring data, automated alerts, and forecast reports. The system's operational capability was demonstrated during the severe geomagnetic storm of May 2024, in which a series of solar flares and multiple coronal mass ejections (CMEs) directed charged particles and magnetic fields towards Earth's magnetosphere. This event triggered the strongest geomagnetic storm in two decades. JASPER successfully detected the event and issued a warning about the impact of space weather for Thailand while providing authoritative information to government agencies and media to raise public awareness during this severe event.

This presents JASPER's operational framework and highlights the role of local data in enhancing space weather monitoring and forecasting capability in Thailand. It also outlines future development plans to expand system capabilities, strengthen regional and international cooperation—including with ASEAN partners, and enhance services for end-users.

Keywords: Space weather forecast,Operation and service,Public awareness

POSTER CODE: P1OTH212

Title
FLAG: Operational Orchestration of Integrated Sun–Earth Modelling

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Body
Building on the Horizon 2020 projects PROGRESS (PRediction of Geospace Radiation Environment and Solar wind parameterS) and PAGER (Prediction of Adverse effects of Geomagnetic Storms and Energetic Radiation), the ESA-funded FLAG (Forecasts and Long-term probabilistic data Assimilative prediction of the effects of Geomagnetic storms) project advances the integration and operational deployment of space weather forecasting capabilities. While earlier initiatives established ensemble-based predictions of the radiation environment and geomagnetic disturbances, FLAG focuses on reorganizing and coupling these modelling components into a unified and operationally robust framework.
At the core of FLAG lies the orchestration architecture, which coordinates numerical models describing solar wind conditions, geomagnetic indices, plasmasphere dynamics, radiation belts, ring current processes, ionospheric parameters, and spacecraft charging risks. The system integrates heterogeneous modelling approaches, including machine learning, data assimilation, and physics-based simulations, through standardized data interfaces and controlled execution logic. Each component retains operational independence while remaining interoperable within the system architecture.
The orchestration layer manages automated data ingestion, ensemble handling, execution sequencing, and structured output exchange, ensuring continuity of service even under degraded upstream data conditions. By enabling modular yet coherent integration of multiple forecasting components, FLAG strengthens the transition from advanced research models to coordinated operational space weather services within the European landscape.

Keywords: Space Weather Forecasting,Ensemble Forecasting,Data Assimilation,Machine Learning,Operational Space Weather Serv

POSTER CODE: P1OTH213

Title
Bridging the Research-Operations Gap: Stakeholder-driven, impact-based space weather communication within prototype Service Campaigns ESA's Space Weather Service Network

Authors
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Body
To enhance preparedness for space weather (SWE) events, impact or event-based messages have been implemented for delivering tailored SWE information via email, SMS and prototype dashboards to four of the high-priority ESA SWE service domains covering 'Aviation', 'downstream Global Navigation Satellite System (GNSS) services', 'Power Systems Operations' and 'Satellite Operations'.

We highlight how tailored user messages, dashboard curation combined with an alerting protocol can be fully driven through continuous engagement with the stakeholders across various high-priority domains within the frame of coordinated end-user support campaigns. User specific messages have been set up relying on impact-based thresholds and a pre-agreed communication format and delivery schedule. Textual messages are provided along with a customized dashboard to provide graphical information that is collected from various products available within the Space Weather Service Network. With the user in the loop we are able to define together the requirements and further tailor and fine-tune the products accordingly. Through these support campaigns we improve our understanding of what specific information users need and how to translate it into their language, while they learn more about space weather and how to recognize its impact on their operational systems. By using the tailored messages in their daily practices, they are able to identify missing information and shortcomings of their own processing tools needed to establish a customized space weather operational service that can be integrated in their operational procedures for mitigation.

Keywords: Impact-based thresholds,Stakeholder engagement,End-user support campaigns,Dashboards,Operational procedures

POSTER CODE: P1OTH214

Title
Integrating magnetic connectivity information into solar energetic proton event forecasting

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Body
Solar energetic particles, specifically high abundances of energetic protons, pose radiation hazards for both astronauts and technology outside the Earth's magnetosphere. The Relativistic Electron Alert System for Exploration (REleASE) uses electron flux data from L1 to forecast the oncoming protons.

Since particles propagate along heliospheric magnetic field lines, the corresponding SEP event time profiles and properties vary with magnetic connection to the flaring active region. We have developed a real-time tool detecting flares based on GOES X-ray measurements and locating them automatically using SDO/AIA EUV images. By determining the location of the flare responsible for an oncoming SEP event, we are able to categorize oncoming SEP events based on their magnetic connection.

Additionally, the intensities of X-ray, microwave and radio emission give valuable insights about the physical processes near the Sun, which allows us to gain information about the corresponding proton event. This helps to assess the significance of the resulting space weather effects in the Near-Earth environment.

We present the implementation of real-time X-ray and EUV measurements into the forecasting algorithm and provide preliminary insights into the prediction performance.

Keywords: forecasting,relativistic electrons,solar energetic particle event,automatic flare detection,EUV imaging

POSTER CODE: P1OTH215

Title
Temporal and Spatial detection of impacted areas for Space Weather Services to aviation

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Body
The operational space weather services to civil aviation rely on a fast and accurate identification of impacted areas, especially in the domains of GNSS and HF communication. In many cases, impacted areas can change rapidly with time, making their correct identification challenging in real-time operations. We present here a method developed at STCE, within the PECASUS consortium, that can automatically detect areas which are consistently affected over a selected period of time. The algorithm uses the ICAO thresholds and agreed-upon time requirements for each domain as input to define the alert state over a geographical area. The algorithm is further tuned to reflect the currently adopted 5-point polygon definitions along lines of constant latitude and longitude. The output is a set of rectangles enclosing the impacted areas, following the latest guidance from ICAO on the advisory format. The end result is an advisory-ready output, improving the area selection quality and responsiveness of the operators. We present here examples for GNSS (based on Vertical Total Electron Content maps) and HF communication (Post-Storm Depression), using data from recent geomagnetic storms.

Keywords: space weather services,aviation advisories,impacted areas,GNSS, HF,polygons

POSTER CODE: P1OTH216

Title
Near Real-Time European Mapping of Local Geomagnetic Disturbances Using the Local Disturbance Index

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Body
The Local Disturbance Index (LDi) is a station-based geomagnetic index designed to quantify local magnetic perturbations associated with geomagnetic storms. Unlike global indices, LDi preserves the regional variability of geomagnetic activity, providing more detailed information on the spatial structure and temporal evolution of disturbances relevant to technological systems.
We present a prototype operational product that generates near-real-time maps of geomagnetic perturbations over Europe using LDi values derived from ground magnetometer observatories, particularly from those on the Intermagnet network. Data from multiple observatories are processed at one-minute cadence, and the resulting values are spatially interpolated using spherical interpolation to account for the Earth's geometry and ensure continuity across longitude boundaries. The product includes a fixed color scale and day–night delimitation to facilitate interpretation and consistent visualization over time.
The maps reveal the development and propagation of geomagnetic disturbances across Europe, highlighting regional differences that are not captured by global indices such as Dst or Kp. The product is designed for operational use and is being integrated into the Spanish Space Weather Service (SeNMEs) as a situational awareness tool for monitoring geomagnetic activity. This work demonstrates how distributed magnetometer observations can be transformed into an intuitive, high-resolution regional product, bridging the gap between local measurements and actionable space weather information for operational services and end users.

Keywords: Local geomagnetic disturbance,Research to operations,Near-real-time mapping,Product validation,Situational awareness

POSTER CODE: P1OTH217

Title
GONG: A Global Ground-Based Network for Continuous Solar Observations

Authors
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Body
The US National Science Foundation's (NSF) Global Oscillation Network Group (GONG) is a network of 6 robotic telescopes around the globe to provide continuous observations of the Sun. GONG delivers full-disk observations of Doppler measurements, line-of-sight magnetograms, white light and H-alpha images at a cadence of one minute, achieving a median duty cycle of about 0.9 (90% of a 24-hour day) for fully calibrated dataset or 0.95 for quick reduced (space weather operations) data. The data are transmitted in near-real time to NOAA/SWPC and NSO/NISP Data Centers and made available for operational space-weather forecasting and for the broader research community. GONG has been in operation since 1995.

This poster presents a high-level overview of the project and introduces its three major components: network operations, data processing, and science support. Each of these components is described in more detail in coordinated posters. We also discuss current plans for maintaining GONG operations, and its future replacement: the next-generation GONG (ngGONG).

Keywords: groundbased observations,magnetic fields,helioseismology,flares,operational space weather

POSTER CODE: P1OTH218

Title
A novel Italian national centre for Space Weather: the HelioMeteo project

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Body
In recent years, the global number of in orbit satellites experienced a steady growth in number. Italy is no exception in this trend, featuring tens of satellites already deployed, and more to be launched in coming years. However, both in orbit fleet and sensitive ground infrastructures must be protected from the harsh space environment, further pushing the demand for a modern Space Weather Monitoring system. To this end, the Italian Space Agency (ASI) recently approved the development of the HelioMeteo project, coordinated by ALTEC and developed in collaboration with the Italian Nation Institute for Astrophysics (INAF-OATo, INAF-OATs) and Polytechnic of Turin (PoliTo). The system is designed to operate in real time, offering nowcasting, forecasting, and hindcasting services, with operational capabilities of issuing warnings to users. The first version of the system will be able to track any potentially dangerous event, from early stages till impact on Earth, using a complete set of tools:

- CME Propagation Tool, to monitor earthward CMEs and evaluate their geo-effectiveness impact;
- HELMET tool, to characterize solar activity level using the F1415 and the F10.7 solar radio indexes;
- SWARPS tool, to detect impulsive, right-handed polarized solar emissions at 1415 MHz, which may interfere with GNSS signals.
- Sun Disk Monitor Tool, to improve Sun disk monitoring models

The tools will be also backed by advanced machine learning for data driven models, which will further improve their capabilities. It will implement the R2O2R (Research To Operations To Research) paradigm, being able to include new data sources, sensors, algorithms and user necessities to feature new modules. Great effort will be dedicated to ease data access for users, both gathering data from different sources in a common archive and by providing a complete and intuitive interface. The system development will begin within this year, while the deployment at ASI-SSDC is foreseen in 2028.

Keywords: forecast, hindcast, nowcast,Space weather center,ASI-SSDC

POSTER CODE: P1OTH219

Title
Overview of Geo Magnetic Effectiveness tool (H103d) and the CME propagation prediction tool (H103e) in SWESNET.

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Body
The SWESNET project, part of the ESA Space Weather programme, is aimed at providing users with in real time data and information about the space weather via easily accessible products and tools. ALTEC and OATo – INAF collaborated for providing the Geo Magnetic Effectiveness tool (H103d) and the CME propagation prediction tool (H103e).
The two algorithms are developed by INAF and integrated into ALTEC proprietary infrastructure “Heliospheric Space Weather Center”, which is responsible for the data retrieval, production, and storage of scientific products, pipeline, and web interfaces.
The H103d tool pipeline computes the magnetic helicity, a quantity that can be used to identify solar activity, using data from DSCOVR. The tool produces plots of 7 quantities over a 7-days period, indicating the thresholds in key geo-activity indicators; plots are provided to users in FITS files in the SWESNET tool page.
The H103e tool pipeline operates in two parallel flows: one computes the solar wind maps from DISCOVR/FC data every 30 minutes over a 28 days period; the second is dedicated to identify the CMEs and to compute its parameters and arrival time (for which the wind map is necessary). The solar wind maps, the earthward CME propagation front movie, and two JSON files containing the CME parameters can be downloaded or browsed by users in the tool page.
The results of the tools, particularly the forecasts, are continuously validated against similar tools and catalogues (such as those for geo magnetic storms, CME arrival times, …); the tools are monitored daily, and the underlying infrastructure regularly updated to keep up with further developments.
In the talk, the pipeline of both the tools will be presented, and their components and working mechanisms will be detailed. The pages on the portal will be presented, together with some example products. Further development of the tools foreseen in the next future will be shown.

Keywords: Space Weather forecast,Space Weather monitoring,SWESNET

POSTER CODE: P1OTH221

Title
RadSight: An astronaut-based space weather monitoring platform

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Body
Human exploration beyond low Earth orbit exposes crews to space radiation environments that current operational tools do not translate into timely, actionable guidance. Outside the protection of the magnetosphere, decision-makers and astronauts lack a unified, readable view of imminent radiation events, short-term forecasts, and cumulative personal dose, forcing reliance on fragmented data sources during time-critical situations.

RadSight addresses this gap by aggregating existing space weather data streams, space weather products, and solar magnetic activity forecasting, into a single, mission-relevant dashboard. The platform is structured around three operational timescales: imminent event alerts (approximately 10 minutes to 1 hour), radiation forecasts (approximately 24 hours), and personal cumulative dose tracking against established exposure thresholds.

By converting distributed, technical space weather datasets into faster, clearer decision support, RadSight aims to improve crew safety margins for science missions, commercial space tourism, and future lunar and deep-space operations, in alignment with ESA's 2040 Strategy. This contribution presents the concept, architecture, and roadmap, seeking input on integrating additional data services to improve forecast reliability.

Keywords: Space radiation,Space weather,Radiation risk assessment,Human spaceflight,Space mission operations

POSTER CODE: P1OTH222

Title
CCMC Activities Supporting Space Weather Research, Forecasting, and Model Assessment in the Solar-Heliospheric Modeling Domain

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Body
The Community Coordinated Modeling Center (CCMC; ccmc.gsfc.nasa.gov) serves the space science and space weather community as an access point to a growing collection of state-of-the-art research models. It also supports the development of the next generation of space weather forecasting frameworks. The CCMC is dedicated to facilitating space weather and space science research, transitioning advances in research to operations (R2O), and conducting unbiased model validation in collaboration with model developers and the international research and operational communities. We will present CCMC's recent activities in space weather research and forecasting, highlighting solar-heliospheric models at different stages of the R2O pipeline: from newly installed research models of solar storms in the Runs-On-Request system to space weather modeling frameworks that are already running in real-time. We will furthermore discuss recent advances in community-wide model validation projects that aim to increase transparency in the Research-to-Operations-to-Research (R2O2R) pipeline and advance our space weather forecasting capabilities.

Keywords: Solar-heliospheric modeling,Space Weather,Model Validation,CCMC Scoreboards,ISWA

POSTER CODE: P1OTH223

Title
HF Doppler Monitoring and Automated Assessment of Ionospheric Propagation for Operational Space Weather Services

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Body
The network of geographically separated, remotely controlled HF Doppler receiving sites developed by the Radio Astronomy Institute of the National Academy of Sciences of Ukraine includes stations located at high latitudes in the Arctic (Tromso and Longyearbyen, Norway) and in the Antarctic Peninsula region (the Ukrainian Antarctic Station Akademik Vernadsky), as well as at mid-latitudes in Ukraine and Poland. This network traditionally uses emissions from HF time service stations as probe signals for Doppler ionospheric sounding because of their high carrier-frequency stability and tuning accuracy.

Several monitoring sites in Ukraine were destroyed in 2022. Instead, a new HF receiving site was established in August 2022 at the LOFAR PL610 (Borowiec, Poland) observatory, operated by the Space Research Centre of the Polish Academy of Sciences. The receiving system, evacuated from the Kharkiv region of Ukraine, has since been used to monitor HF signals from the CHU time service station (Canada). It is worth noting that numerous transatlantic air routes between Europe and North America pass along the CHU–PL610 radio path (length 6366 km). Therefore, information on propagation conditions along this path could be useful for operational space weather services supporting aviation safety.

To assess the potential of the accumulated data for space weather services, a retrospective study of propagation conditions at different frequencies along this radio path under various space weather conditions was conducted. The impact of geomagnetic disturbances on HF signal parameters was analyzed. An automated approach for determining HF propagation conditions along the CHU–PL610 path was developed and evaluated using geomagnetic activity indices. The results demonstrate the potential of multi-frequency HF path monitoring as a complementary source of information for operational space weather services.

Keywords: Space Weather Services,HF propagation,CHU,HF Doppler Monitoring

POSTER CODE: P1OTH224

Title
Identifying observational gaps for Space Weather: Updating the WMO Statement of Guidance

Authors
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Body
A central aspect of the World Meteorological Organization's (WMO) mission is to facilitate worldwide cooperation on observation requirements in meteorological, hydrological, and related Earth system observations ensuring the operation of the integrated global observing systems and the international exchange of observational data. The WMO Integrated Global Observing System (WIGOS) provides the overarching framework for these activities, including observations supporting operational Space Weather services.

Within WIGOS, the Rolling Review of Requirements (RRR) provides a systematic process for comparing observational user requirements with the capabilities of existing and planned observing systems. One of its main outputs is the Statement of Guidance (SoG), which identifies the most important gaps between observational requirements and capabilities and provides recommendations on priorities for addressing them.

An updated Statement of Guidance for Space Weather Applications is currently being developed within the WMO Expert Team on Space Weather (ET-SWx). It considers the observational needs of operational Space Weather applications across the Sun, heliosphere and near-Earth environment including both space-based and surface-based observing capabilities. It places particular emphasis on observations that are critical for operational monitoring and forecasting, their availability in near real time, continuity and sustainability, and the international exchange of observational data.

The poster will present the updated Statement of Guidance and highlight the main observational gaps and priorities identified. Feedback from the Space Weather community is particularly welcome on whether these adequately reflect the needs of operational services, and how the Statement of Guidance can be made most useful to the community.

Keywords: Observation Requirements,International Coordination

POSTER CODE: P1OTH226

Title
Proxima: a collaborative platform for operational European space weather data products

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Body
Turning scientific space weather models into operational, reusable, and interoperable data products is still a major challenge for the European space weather community. Proxima is a platform built to solve this problem. It offers a shared environment where scientists, model developers, and end users work with the same set of tools: data pipelines, AI/ML model hosting, interactive dashboards, and federated web pages that can be embedded directly into the ESA SWESNET portal.
In the first stage, Proxima will host three Slovak data products that have intention to be added to ESA SWESNET. ASPIS provides ionospheric scintillation nowcasts and forecasts. SCSS-Net is a deep-learning model that segments solar active regions and coronal holes in solar images. ESADOS is a long-term archive of the heliocentric modulation potential, used for cosmic-ray and aircrew dosimetry studies. All three products run on the same platform components, which shows how very different scientific outputs can be delivered through one common framework without losing their scientific value.
Proxima is built through a collaboration model that is becoming more important for ESA. Global Singularity provides the technical platform, the Slovak Academy of Sciences ensures the scientific quality of the data processing, and the Technical University of Košice develops the AI/ML models.
In this contribution we present the platform, the integration of the first three products, and our plan to open Proxima to data providers across Europe, making it easier to add new contributions to ESA SWESNET.

Keywords: Proxima,ESA SWESNET,space weather data products,AI/ML,science-industry collaboration

POSTER CODE: P1OTH227

Title
The ASI Space Weather Center: Infrastructure, Services, and Ionosphere-Thermosphere Applications

Authors
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Body
Developing advanced Space Weather services is a strategic asset and competitive advantage. The Italian Space Agency (ASI) is establishing its Space Weather Center to deliver real-time analysis, nowcasting, and forecasting services, building upon existing national expertise.
The initiative focuses on the ionosphere (60–1000 km) and thermosphere (up to ~600 km), where solar-driven disturbances impact radio communications, GNSS navigation, and radar, while density variations alter atmospheric drag, affecting orbital decay, satellite constellation management, and collision risks. Key services include: 1) Real-time monitoring and alerting for satellite, aviation, and navigation operators; 2) Engineered ionospheric and thermospheric density modeling for GNSS accuracy and drag prediction; 3) Enhanced positioning via advanced corrections and resilient receivers; 4) Space Traffic Management (STM) and re-entry forecasting for Space Situational Awareness (SSA); and 5) Continuous R&D.
Six strategic objectives guide the solution: building a specialized national operational infrastructure; harmonizing with reference frameworks (ESA SWE Service Network, NOAA SWPC, ASPIS); focusing on non-overlapping areas of excellence; capitalizing on national skills and investments; utilizing scientifically validated numerical codes; and actively engaging the research community.
A central platform serves as the access point for pre-operational data ingestion and processing chains. It provides automated scheduled/on-demand acquisition from external catalogs into internal repositories, customizable dashboards for near-real-time monitoring, updated catalog management, profile-based services, and extensible architecture for integrating new data sources and processing algorithms.

Keywords: Space Weather Center,Data Ingestion & Processing,Real-Time Monitoring,Data & Service Management,Space Situational Awareness

POSTER CODE: P1OTH228

Title
MiniMax: A Decade-Long Campaign Supporting Space Weather Forecasting through Non-Flare Targets

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Body
Since the weak solar maximum of cycle 24, the space weather community has increasingly recognized the importance of 'non-flare' solar phenomena in driving geomagnetic disturbances. While flare and Coronal Mass Ejection (CME) forecasting remains well-supported by established services such as SIDC and MaxMillennium, gaps persist regarding the monitoring of high-speed solar wind streams (HSSs) originating from coronal holes and the evolution of potentially eruptive filaments.

Initiated in 2014, the MiniMax24 campaign was established to bridge this observational gap. This international collaborative effort, involving teams from UNIGRAZ, the Hvar Observatory, and KSO, provides daily synthesized updates on non-flare targets. The campaign focuses on characterizing coronal hole structures, estimating the arrival speeds and impact times of HSSs, and tracking filaments prone to eruption. Beyond its analytical output, MiniMax serves as a vital platform for interdisciplinary communication, connecting a diverse network of early-career researchers and senior experts in solar and geospace physics.

In this presentation, we provide an overview of the MiniMax campaign’s methodology, its long-term contributions to the space weather forecasting community, and an assessment of its impact on operational decision-making. As we evaluate the future of this initiative, we invite feedback from the community regarding the continued utility of these services and strategies for evolving the campaign to meet the changing needs of the space weather enterprise.

Keywords: MiniMax,Filament Eruption,Coronal Holes

POSTER CODE: P1OTH229

Title
Heliospheric verification at the UK Met Office

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Body
Model verification is a necessary aspect of forecasting. Without verification, we would not know how accurate the forecasts are and where to improve. At the UK Met Office Space Weather Operations Centre (MOSWOC), 24/7 forecasting of the conditions within the heliosphere is carried out. The solar wind and coronal mass ejections (CMEs) are forecast using the Enlil model, which is initiated using the Wang-Sheeley-Arge (WSA) coronal model. This modelling system does not undergo verification in near-real-time, which could indicate when the model is not performing optimally. Therefore, we have developed a system for verification which is accessible to the forecasters on the bench at MOSWOC. This includes an expandable workflow that can be adapted to the needs of the forecasters, to best support their decision making. Here, we present the exploration and development process as well as the initial findings from the system being in place for the first few months.

Keywords: Heliospheric verification

POSTER CODE: P1OTH230

Title
FAIR BY DESIGN: ADVANCING THE VIRTUAL SPACE WEATHER MODELLING CENTER

Authors
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Body
Over the past decade, a wide range of space weather models has been developed, covering processes from the eruption and propagation of coronal mass ejections to the dynamics of the magnetosphere and ionosphere. The Virtual Space Weather Modelling Center (VSWMC) provides an integrated environment where users can request and execute runs of these distributed space weather models within a unified framework.
A first operational version of the VSWMC has been available since May 2019 under the HESC umbrella on the ESA SSA Space Weather Portal. The platform enables the coupling of heterogeneous models and supports end-to-end Sun-to-Earth simulation workflows. The models themselves remain installed on premise at multiple partner locations and are coordinated through a central run orchestration system.
In line with the FAIR principles and the broader Open Science vision, the VSWMC is evolving toward improved findability, accessibility, interoperability, and reusability of both models and simulation outputs. Recent upgrades include expanded model couplings, routine daily model chain executions, and ongoing standardisation of metadata, interfaces, and workflow management.
We present an overview of the current state of the VSWMC, demonstrate the upgraded system capabilities, and discuss ongoing developments in support of FAIR-compliant open science infrastructures for the space weather and heliophysics communities.

Keywords: Space Weather,Modelling,Coupling,Forecasting

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION OTH3

BALLATOIO ROOM
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1OTH301

Title
NEURAL NETWORK-BASED ELECTRON DENSITY MODELLING USING MULTI-MISSION SATELLITE DATA

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Body
A deeper understanding of ionospheric processes can be achieved by utilizing the ever-growing electron density database collected by various satellite missions. However, using satellite data directly can be challenging due to the sparse global coverage with respect to all local times. Machine learning (ML) techniques can be used to overcome these challenges. Therefore, in this work we apply fully connected neural networks (FNNs) to model the electron density from different satellite missions. We train the FNNs using data from the Gravity Recovery and Climate Experiment Mission (GRACE) and Swarm mission. These missions use different techniques to measure the electron density, such as K-band ranging and Langmuir probes (LPs), respectively. However, the satellite data must be used with caution because they can contain systematic errors. Considering this, we filtered out outliers and unrealistic data before using them for training models.

Using the ML-based models, predictions can be made where underlying phenomena such as the Nighttime Winter Anomaly (NWA) can be investigated in-depth. This small-scale ionospheric feature becomes visible during low solar activity periods at nighttime in the Northern Hemisphere at the American sector and in the Southern Hemisphere at the Asian sector. We trained two NN-based models where one is trained with Swarm electron density and another with GRACE data. Furthermore, we trained another model using the Swarm Langmuir probe Ion Drift, density and Effective Mass (SLIDEM) dataset. This method uses the Swarm faceplate current data, LP data and orbital-motion limited (OML) theory to relax some of the assumptions that are currently used for the density estimations.

In this work we show the models' capabilities to reproduce the NWA using ML-based modelling techniques trained on the different datasets. This study contributes to an improved understanding of topside ionospheric modelling and monitoring.

POSTER CODE: P1OTH303

Title
DISTRIBUTIONAL FORECASTING OF HP30 WITH SOLAR WIND ENSEMBLES

Authors
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Body
Geomagnetic storms are large scale disturbances in the Earth's magnetosphere that under the right circumstances can have significant impact on modern infrastructure. Satellites, communications, power grids are all susceptible to such events leading to technological and economic damage. Current forecasting models utilise L1 satellite data, constraining lead time to a few hours, often insufficient for effective mitigation. Accurate long-lead probabilistic forecasts would help protect infrastructure and ensure operational continuity.

We investigate how to extend the lead times of geomagnetic storm forecasts by using solar data. Associated spatial and propagation uncertainties of solar data are captured with a solar-wind ensemble from the computationally efficient one-dimensional HUXt numerical model, allowing us to simulate significantly more solar wind profiles. This work advances beyond previously studied probabilistic occurrence of geomagnetic storms, to provide a distributional forecast of daily maximum of the Hp30 index.

Rather than producing a single point forecast, we train a Multilayer Perceptron (MLP) to directly predict the parameters of a LogNormal probability distribution. This allows us to extract, directly from the cumulative distribution function, the forecasted probability of any specified storm strength. We investigate a variety of loss functions for training, including Negative Log-Likelihood and CRPS-based objectives, and evaluate model performance using RMSE and CRPS across a range of storm intensities and solar wind event types using 30 years of historical data.

Overall, we demonstrate that coupling computationally fast numerical solar wind modelling with probabilistic machine learning provides meaningful long-lead forecasts of geomagnetic storm intensity, offering both actionable probability estimates and improved lead times.

POSTER CODE: P1OTH304

Title
MODELLING THE TOTAL ELECTRON CONTENT WITH THE EXPECTED SPREAD OF OBSERVATIONS

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Body
Models of the Total Electron Content (TEC) are needed for different user applications, e.g. the correction of the ionospheric error in single frequency GNSS applications or evaluating TEC observations against the quiet background ionospheric state. So far, TEC models provide the expectation value but the expected range of the actual state deviating from the expectation value is missing. This gap is filled with a new model approach. As most TEC models, it is based on a regression of TEC with a solar activity estimate. The novelty is the transformation of the regression problem into the logarithmic domain.
The new TEC model is constructed using machine learning. 20 years of global ionospheric maps are used as observational base for the model development. In contrast to classical modelling, not the actual TEC is ingested for learning. As a form of data reduction, multiple local regression coefficients are computed using the relationship between TEC and solar activity. Thus, the input data is a large data cube of local regression coefficients. Different classical and deep learning methods are tested for the selection of the best performance. The resulting model provides the regression parameters and RMSE from which the actual TEC and prediction interval (spread of observations) are computed.

POSTER CODE: P1OTH305

Title
DEEP LEARNING MODELS FOR FORECASTING RELATIVISTIC ELECTRON DYNAMICS IN THE OUTER RADIATION BELT

Authors
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Body
Radiation belt dynamics pose a major challenge for space weather forecasting and spacecraft safety. High-energy electrons in the outer Van Allen belt can charge satellite surfaces and damage electronic components, as seen in the Intelsat-K incident that left a spacecraft inoperative for months (Bedingfield et al., 1996). Understanding and forecasting these variations is therefore essential for protecting space infrastructure.

However, the belts' highly variable behaviour remains difficult to predict, especially during geomagnetic storms. At times, existing physics-based models can reproduce some of the dynamics, but in general still struggle to reproduce the dynamics of the outer Radiation Belt (NASA NRTS; Walker et al. 2022).

Here, we investigate the ability of modern Deep Learning architectures to forecast relativistic electron dynamics in the outer belt, such as Long Short-Term Memory (LSTM) and Transformer architectures. These models are trained on a set of solar-wind and geomagnetic parameters to capture any linear and nonlinear relationship with flux. We compare and contrast our results against available observations and physics-based modelling runs, and show the relevant metrics on how well relatively simple Deep Learning architectures can reproduce the dynamics of the outer Radiation Belt region

POSTER CODE: P1OTH306

Title

TOWARD AN AI-READY VLF/LF DATASET FOR DETECTING SOLAR X-RAY FLARE INDUCED IONOSPHERIC DISTURBANCES

Authors

Peter Butka [1], Martin Sarnovsky [1], Peter Bednar [1], Aleksandra Kolarski [2], Aleksandra Nina [2], Filip Arnaut [2], Vladimir Sreckovic [2]

Affiliations

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Body

We present the objectives and methodology of the ongoing Slovak-Serbian bilateral project (AI in Practice: Automatic Detection of VLF/LF Ionospheric Disturbances using Machine Learning), which aims to enhance the application of machine learning to data obtained in monitoring the lower ionosphere by Very Low Frequency/Low Frequency (VLF/LF) radio signals. The project relies on the analysis of data collected by VLF/LF receivers located in Belgrade, Serbia (Absolute Phase and Amplitude Logger (AbsPAL) and Atmospheric Weather Electromagnetic System for Observation Modeling and Education (AWESOME)) over a period of more than two decades. The recorded signals originate from various locations worldwide, enabling the observation of different regions defined by signal paths (from transmitters to receiver) and the detection of both local and global disturbances. Plans include the development of procedures to distinguish ionospheric responses caused by solar flares from standard diurnal variability, instrumental errors, signal noise, transmitter outages, and other anomalous patterns. Separating physical ionospheric responses from background variability and technical artifacts is crucial for reducing false detections and developing reliable classifiers. Following signal cleaning, transformation, segmentation, and feature extraction, machine learning and deep learning approaches, including Random Forest, XGBoost, and neural networks, will be trained and compared using precision, recall, and F1-score metrics. Special attention will be devoted to generalizing the model across various propagation paths, time periods, and levels of solar activity. The dataset and methodological process resulting from this project are intended to support systematic research into lower-ionosphere disturbances at mid-latitudes caused by solar flares, as well as to provide a foundation for the automated, near-real-time analysis of VLF/LF measurements for space weather monitoring purposes.

POSTER CODE: P1OTH307

Title

GENERATED MAGNETOGRAMS FROM MULTI-WAVELENGTH INPUTS AND THEIR IMPACT ON SOLAR WIND MODELLING

Authors

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Body

Synoptic photospheric magnetograms are the main observational inputs for global 3D magnetohydrodynamic (MHD) models, such as COCONUT (Perri et al. 2022) and EUHFORIA (Pomoell & Poedts, 2018). The accuracy of these models strongly depends on the quality of the input magnetic maps. Building on the work of Yeong et al. (2022) and Li et al. (2024), we develop a multi-wavelength generative adversarial network (Solar-GAN) designed to reconstruct HMI-like synoptic magnetograms. The model is trained on extreme ultraviolet (EUV) observations from the 193 Å and 304 Å channels of the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO) and benchmarked against magnetograms from the Helioseismic and Magnetic Imager (HMI). While the 304 Å channel provides chromospheric and transition region data, the 193 Å channel captures coronal structures such as loops, active regions, and coronal holes, thereby enabling the network to incorporate multi-layer atmospheric context. We compare our model with the Transfer-Solar-GAN approach of Li et al. (2024)—which relied solely on the 304 Å channel—to quantify the added value of including coronal information. The AI-generated synoptic magnetograms are then used as inner boundary conditions for the MHD simulations. The modeled solar wind outputs are evaluated against simulations driven by standard Global Oscillation Network Group (GONG) magnetograms and validated using in situ solar wind observations from multiple spacecraft at various heliocentric distances.

POSTER CODE: P1OTH308

Title
PHYSICAL SYMBOLIC OPTIMIZATION FOR SOLAR FLARE CLASSIFICATION PROBLEM

Authors
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Body
Solar flare forecasting remains a challenging problem in space weather due to the intrinsic complexity and still partially unknown physics of solar active regions. Recent advances in deep learning methods have achieved promising predictive performance, often at the cost of reduced physical interpretability.
In this work, we investigate the application of the physics-inspired method φ-SO to solar flare classification problem using SHARP features. Based on reinforcement learning techniques and originally developed for dimensionally constrained symbolic regression problems, φ-SO is here recasted into a classification framework. The proposed approach uses physically consistent symbolic expressions to optimize classification performance.
We first validate the proposed methodology on synthetic benchmark datasets derived from known physical laws under different noise levels and class imbalance conditions. Binary classification problems are constructed by computing physical quantities, perturbing them with noise, and binarizing them using thresholds chosen to control class imbalance. Results show that the classification formulation recovers symbolic solutions consistent with those obtained by solving the original regression problem while maintaining robust classification performance.
The method is then applied to SHARP dataset for M+ and C+ flare prediction. Since the physical quantity governing the classification problem is unknown, multiple dimensionally constrained searches are performed by imposing different physical units on the symbolic expressions.
Our results show that the proposed symbolic classification framework achieves competitive, compact and physically interpretable symbolic solutions. The method offers a physics-consistent alternative for solar flare forecasting.

POSTER CODE: P1OTH310

Title
PROBING MANY POTENTIAL FUTURES IN SPACE WEATHER FORECASTS WITH SELF-SUPERVISED-LEARNING AND GENERATIVE AI

Authors
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Body
Deterministic AI models, aiming to produce a single definitive answer to a space weather (SW) forecasting problem, create a cognitive mismatch with human forecasters. Human forecasting is fundamentally statistical, informed by prior experience in which similar initial conditions have led to multiple plausible outcomes. AI models that map similar data close to each other in an abstract `embedding' space can help create a forecasting solution that is closer to the cognitive functioning of human forecaster.

We first train a self-supervised-learning (SSL) model to map solar active region (AR) images to an embedding space, then for a query AR use nearest neighbor search in embedding space to retrieve real matches from the past. We enhance the framework using a deep generative AI model to manipulate the query ARs along known physical trajectories. To connect the physical space to Generative latent space, we train a classifier to learn a decision boundary dividing embedding space into high and low values of physical parameters. We then manipulate ARs along directions normal to decision boundaries to produce ARs with desired physical properties, use those as queries to SSL and retrieve matching real ARs. We find visual and quantitative physical match between the generated query and the retrieved ARs. We then extract the known future of the retrieved ARs in terms of SW events (e.g., flares, CMEs, SEPs) to understand future possibilities for query AR. This approach elevates Generative AI from a synthetic data generator to a novel scientific data mining tool, acting as a helping hand for human forecasters to visualize and make a fair statistical judgment of the future.

POSTER CODE: P1OTH311

Title

FORECASTING POLAR IONOSPHERIC ELECTROSTATIC POTENTIALS PATTERNS USING SCORE-BASED DIFFUSION MODELS AND SOLAR WIND DRIVERS

Authors

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Body

We present a preliminary study on forecasting electrostatic potential maps in the polar ionosphere using external drivers, including the interplanetary magnetic field (IMF) and solar wind velocity (SWV). We employ advanced machine learning techniques, focusing on score-based diffusion models, which are capable of generating realistic data by reversing a noise-corruption process and are well suited for capturing complex spatial patterns.

The model is trained on a dataset of two-dimensional ionospheric potential maps derived from SuperDARN observations in the Southern Hemisphere (years 2020-2025, 2-minute cadence), combined with corresponding IMF and SWV measurements. Using a 30-minute input window, the model directly predicts future map sequences while enforcing physical consistency through the inclusion of solar wind conditions.

Results show high predictive accuracy on short timescales (a few minutes), successfully reproducing both spatial structures and global indicators such as the Cross Polar Cap Potential. Performance degrades beyond 10-20 minutes, reflecting the intrinsic dependence of ionospheric dynamics on future external conditions. However, by incorporating upstream measurements at L1 and accounting for propagation delays, the model enables forecasts with up to ~1 hour lead time.

These findings demonstrate the potential of diffusion models for ionospheric prediction, while highlighting fundamental limits in system predictability and the need for improved solar input characterization and expanded training datasets.

POSTER CODE: P1OTH312

Title
FROM SOLAR STRUCTURE SEGMENTATION TO SOLAR FLARE FORECASTING USING FULL-DISK SDO OBSERVATIONS AND ARTIFICIAL INTELLIGENCE

Authors
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Body
Space weather events, particularly solar flares, can significantly impact satellite operations, communication systems, navigation services, and power-grid infrastructure. Accurate and timely flare forecasting is therefore essential for both scientific understanding and operational space-weather mitigation. Recent advances in machine learning have demonstrated strong potential for automated analysis of the large-scale solar observations continuously provided by instruments such as the Solar Dynamics Observatory (SDO).

In this work, we investigate machine-learning approaches for solar flare forecasting through the integration of full-disk solar imagery and automated solar-structure segmentation. We first explore deep-learning models trained directly on full-disk Extreme Ultraviolet (EUV) observations from the Atmospheric Imaging Assembly (AIA) onboard SDO for flare prediction tasks. Building upon these baseline approaches, we then incorporate additional physically meaningful information extracted from automated segmentation of key solar structures, including active regions, coronal holes, and filaments.

We evaluate both solar flare forecasting models and solar structure segmentation approaches, comparing them with state-of-the-art frameworks through quantitative and qualitative analyses using multiple evaluation metrics and challenging use cases.

This study highlights the role of solar-structure segmentation as a complementary source of information for space-weather forecasting systems and discusses the potential of integrating machine learning into operational flare prediction pipelines as well as onboard on future spacecraft missions.

The research that led to these results was subsidised by the European Union (ASAP: Grant Agreement No 101082633). This study was additionally supported by the Belgian Defence – Royal Higher Institute for Defence (RHID) (contract no 22DEFRA006) and the Belgian Federal Science Policy Office (BELSPO) (B2/202/P1/DELPHI).

POSTER CODE: P1OTH314

Title
SUN-AS-A-STAR OBSERVATIONS AS A USE CASE FOR MACHINE LEARNING APPLICATION: INSIGHTS FOR SOLAR AND STELLAR SPACE WEATHER

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Body
We focus on the large catalogues of solar extreme-ultraviolet (EUV) full-Sun imaging observations by SDO/AIA, SOHO/EIT, and other instruments. These enormous datasets contain decades of observations of all kinds of solar activity with unprecedented detail. As such, they represent a prime testing ground for the application of various ML techniques.

One specific use case is Sun-as-a-star datasets that reduce the information density of full-Sun imaging observations into light curves of integrated intensity over the entire field of view of imaging instruments.

Advantages of Sun-as-a-star data are twofold. First, these light curves are equivalent to stellar light-curve observations. They can thus be used for a better understanding of stellar space weather.

We demonstrated the usefulness of this approach on the example of the detection technique for stellar eruptive prominences. However, there are broader implications of using Sun-as-a-star EUV observations for studies of stellar flares, stellar space weather and its impact on the atmospheres and habitability of exoplanets.

The second advantage is the low data volume of Sun-as-a-star integrated observations. This would allow small spacecraft to continually observe the Sun from many vantage points and, crucially, provide the observed data with low latency. Such datasets, combined with the knowledge of various signatures of solar activity obtained from existing full-disk imaging catalogues, would be a useful addition to operational space weather forecasting.

In any such study, use of advanced machine learning techniques is imperative due to the massive volumes of observed data and the need to derive correlations between resolved active solar phenomena and their signatures in Sun-as-a-star light curves.

POSTER CODE: P1OTH315

Title

A WALK THROUGH THE FOREST: A CLOSER LOOK AT HOW THE CHOICES WE MAKE FOR AN ML MODEL CHANGE ITS OUTPUTS.

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Body

The choices we make when starting a project and constructing the hypothesis, analysis, or model can have profound impacts on the results, our interpretation, and the ease of use for others. In machine learning and artificial intelligence, the choice of inputs or features, the training data, and the model algorithm all affect the results. Here, we consider a recent random forest model developed to predict the neutral density at 400 km altitude. We examine how different choices impacted our results. For instance, the choice of the number of inputs, and which inputs affected the model's usability and accuracy. The training data set, including its time interval, also has a significant effect. We also consider which model type to use, and the original choice of a random forest yielded the best results for future operational purposes.

POSTER CODE: P1OTH317

Title
A TIME-TO-EVENT FRAMEWORK FOR SUBSTORM ONSET FORECASTING

Authors
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Body
Substorm onset forecasting is critical: substorms inject energetic particles into the ionosphere, producing spectacular visual phenomena such as the aurora borealis, but also inducing surface charging on satellites and disrupting communications. Current approaches typically frame forecasting as a binary classification problem — will a substorm onset occur within the next hour, yes or no — limiting both temporal resolution and predictive lead time. In this work, we take a fundamentally different modelling direction. We first propagate solar wind measurements from L1 to the bow shock, yielding a variable lead time governed by the solar wind speed. We then employ a Mixture Density Network to predict time-to-onset distributions, capturing distinct regimes of magnetospheric loading. This approach improves both the temporal lead time and the spatial localisation of substorm onset forecasts across magnetic latitude and longitude, while also providing principled quantification of prediction uncertainties.

POSTER CODE: P1OTH318

Title
AI-BASED ONBOARD COMPRESSION OF SDO DATA USING JETSON ORIN NANO

Authors
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Body
To alleviate downlink bandwidth constraints in satellite observation data, we evaluate a deep learning-based onboard AI compression system on the NVIDIA Jetson Orin Nano. As future deep space missions demand increasingly high data rates, onboard compression is becoming a critical technology for reducing communication costs. Applying the CompressAI (Cheng2020) model to NASA SDO solar images (211Å, 193Å), we demonstrate a nearly 8-fold increase in compression ratio compared to JPEG while achieving a near-lossless Multi-Scale Structural Similarity (MS-SSIM) of approximately 1.00. Experiments are conducted on the Jetson Orin Nano (8GB, 15W mode) using 1024×1024 downscaled images due to memory constraints, with compression performance measured in terms of Bits Per Pixel (BPP), PSNR, MS-SSIM, and power efficiency. Although onboard AI-based compression has higher power consumption and processing latency due to deep learning inference overhead, our results confirm that it can significantly reduce transmitted data volume. As a next step we will focus on hardware-specific optimization (e.g., TensorRT) and Differential Emission Measure (DEM)-based physical validity verification.

POSTER CODE: P1OTH319

Title
GAP FILLING IN SOLAR WIND TIME SERIES

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Body
This study evaluates methods for reconstructing missing solar wind data in the OMNI2 database using realistically simulated gap scenarios. The statistical properties of data gaps were analyzed to define representative gap scenarios and determine the minimum interval required for simulating gaps in solar wind speed, interplanetary magnetic fields (IMF) components, and proton density.

Several gap filling methods were evaluated, including linear interpolation, nearest-neighbour averaging, database-wide averaging, cubic spline interpolation, modified Akima cubic Hermite interpolation, the analogue ensemble method, nonlinear autoregressive polynomial extrapolation, moving-average extrapolation, reconstruction from geomagnetic indices (REG), and its adaptive version (REGa). Their performance was assessed using a new evaluation coefficient, the sum of scaled errors (SSE), proposed in this study. SSE combines scaled errors of the correlation coefficients, root mean square error (RMSE), and six statistical characteristics: mean, minimum, maximum, standard deviation, skewness, and kurtosis.

The results demonstrate that effective gap filling methods must preserve both the accuracy of the reconstructed values and the statistical properties of the original time series. Among the evaluated methods, REG and REGa show the best overall performance, achieving approximately 95% agreement across all investigated parameters. The obtained results indicate the effectiveness of the proposed methods for reliable reconstruction of missing solar wind data.

POSTER CODE: P1OTH320

Title
FLARE FORECASTING USING FULLY CONVOLUTIONAL NETWORKS TO GAIN INSIGHT INTO ACTIVE REGIONS

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Body
Solar flares are sudden, intense eruptions of electromagnetic radiation from the Sun that pose a significant threat to Earth's atmosphere and technological infrastructure. Flares are identified by the arrival of their energetic photons at Earth, meaning their space-weather effects occur the moment we become aware a flare is in progress, making advance forecasting essential. This work aims to predict solar flares within a 24-hour window using a Deep Learning model. We use 3D vectormagnetic images obtained from the Solar Dynamics Observatory (SDO) Space-weather HMI Active Region Patch (SHARP) data series, specifically the solar-radial component of the magnetic field. By using whole active region full-resolution images as input we want to improve our understanding of the physics leading up to flares and thus also improve forecasting accuracy. We use radial-field images from 2012 to 2024, inclusive, at a cadence of 24 hours along with the corresponding Geostationary Operational Environmental Satellites (GOES) X-ray flare events in the next 24 hours to create the image and flare-outcome label pairs. Filtering is performed to limit our data set to images containing a single NOAA-numbered active region within ±75° longitude. With HARP separated data sets for training and testing, we implement a Fully Convolutional Network (FCN) for the binary classification of flare events with GOES X-ray flare class above C1. We present a statistical evaluation of the model's predictive performance using various classification metrics, assessing its ability to distinguish between flare and non-flare events over time.

POSTER CODE: P1OTH321

Title
FORECASTING GLOBAL GEOMAGNETIC KP AND HPO INDICES VIA LOCAL PREDICTIONS

Authors
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Body
Predicting geomagnetic activity is vital for protecting modern infrastructure from the effects of space weather. Using indices like Kp and the newer high-resolution Hpo, we can monitor large-scale magnetic disturbances driven by solar activity that threaten everything from satellite operations and power grids to global communication networks. These indices provide a broad, global perspective by pulling data from a network of 13 observatories worldwide. However, there is a trade-off: because these indices are designed to give a big picture view, they can sometimes mask the important local dynamics and physical variations occurring at individual observatory sites.

Rather than forecasting global geomagnetic indices directly, we introduce a novel approach that predicts activity at the level of individual observatories. We maintain physical consistency by predicting local data first; we then apply standard methods to derive the final global index, mirroring the way these values are originally calculated. This shift allows the model to capture the nuanced spatial and temporal variability of geomagnetic disturbances that global-scale forecasts might miss. The framework is designed to be model-agnostic; while we demonstrate its efficacy using a supervised neural network (multi-layer perceptron classifier), it can just as easily accommodate empirical or hybrid modelling techniques. We validated this method using the 3-hourly Kp index and the high-resolution Hpo indices (Hp60 and Hp30), the latter providing hourly and half-hourly resolution without the Kp upper limit of 9. Even when the solar wind data contains temporal gaps or is sparsely sampled, the model accurately tracks key trends and patterns. The method is adaptable to other indices, such as Dst and AE. Detailed results and implementations are available via the GFZ space weather portal.

POSTER CODE: P1OTH322

Title

INTERPRETABLE DATA-DRIVEN MODEL REVEALS CURRENT HELICITY EVOLUTION AS KEY TO SOLAR FLARE FORECASTING

Authors

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Body

Solar flares are explosive coronal events that influence near-Earth space weather. Their prediction remains challenging because photospheric magnetic conditions governing flare onset, including current helicity, remain incompletely characterized. Empirical models and deep learning approaches based on magnetic parameters have advanced solar flare forecasting, yet the former rely on simplified statistics and the latter act as black boxes, leaving the physical origin of their predictions unclear. In this Letter, we present interpretable major (M- and X -class) flare forecasting models that combine deep learning with Symbolic Regression (SR) using time-series Active Region magnetic parameters. Our SR models achieve True Skill Statistics (TSS) and Heidke Skill Score (HSS) of 0.50±0.17 and 0.36±0.04, fully comparable to deep learning baselines (TSS 0.38-0.56 and HSS 0.30-0.54), using analytical formulae with over four orders of magnitude fewer degrees of freedom. A representative formula reveals that flare probability is driven by magnetic flux near the polarity inversion line (R value) through a nonlinear gating mechanism, activated only when the product of total and absolute current helicity exceeds a critical threshold. This helicity interaction term, which is strongly correlated with the squared sum of current helicity at the largest spatial scales, accounts for 77% of the predicted variance. This formula successfully identifies many major flares in ARs 12673 and 13664 missed by NASA CCMC flare scoreboard models. These results suggest that large-scale helicity accumulation serves as a primary physical driver of major flare onset. This finding has immediate implications for operational space weather forecasting.

POSTER CODE: P1OTH323

Title
FORECASTING SOLAR LIMB FLARES FROM EUV IMAGES USING DEEP LEARNING AND EXPLAINABLE AI

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Body
Building on Lee et al. (2024), who investigated limb flare prediction using EUV intensity information from SDO/AIA observations, we extend their approach by incorporating full EUV images and explainable AI (XAI). Existing flare prediction models often underperform near the solar limb because they rely on magnetograms and white-light data, which suffer from severe projection effects in this region. Daily EUV images of the solar limb region at 00:00 UT (2010–2022) were labeled based on whether a major flare (M1.0 class or higher) occurred within the subsequent 24 hours. We developed convolutional neural network (CNN) models using these images to forecast major limb flares. Unlike the previous study, which relied on integrated EUV intensities, our models leverage full spatial images as input. This image-based approach allows for the application of XAI, revealing which specific regions contribute most to each prediction. Consequently, while the previous intensity-based method could only predict whether a limb flare would occur, our approach also identifies where the flare-relevant features are located near the solar limb. We present the forecasting performance of these CNN models alongside XAI results that highlight these contributing regions. Finally, we discuss the EUV features associated with upcoming limb flares and demonstrate how this spatial interpretability advances limb flare forecasting beyond previous limitations.

POSTER CODE: P1OTH324

Title

AI-BASED DENOISING OF SDO/AIA IMAGES AND ITS APPLICATION TO DECAYING KINK OSCILLATIONS

Authors

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Body

In this study, we develop deep learning models to denoise solar EUV images, specifically for the Solar Dynamic Observatory (SDO)/Atmospheric Imaging Assembly (AIA) 94 Å channel. We compare self-supervised and supervised learning models, along with a conventional noise-gating technique, using data from 2011 to 2021. The self-supervised model learns from single-frame data alone, while the supervised model is trained on pairs of single-frame and stacked data. Our main results are as follows. First, the supervised model demonstrates the best performance among the three methods. It achieves a background noise level of 0.03 DN/s, a Signal-to-Noise Ratio (SNR) of 85.73, and a Contrast-to-Noise Ratio (CNR) of 64.44. These values are significantly better than those of the original observation (noise level: 0.21 DN/s, SNR: 14.17, CNR: 11.15). Second, we find that incorporating 193 Å as an additional input further enhances the model performance, particularly in restoring fine scale structures. Third, using the denoised data, we successfully detect a transverse coronal loop oscillation with a period of 299 ± 4 s, which was difficult to detect in the original observation. This oscillation period is consistent with the result of 302 ± 14 s obtained from the 131 Å by R. S. White et al. (2012). Our study suggests that deep learning-based denoising models can be useful tools for investigating coronal phenomena in low-SNR EUV data.

POSTER CODE: P1OTH325

Title

AUTOMATED MULTI-CLASS AIRGLOW IDENTIFICATION AND SEGMENTATION: UNLOCKING THE POTENTIAL OF ALL-SKY IMAGER DATA IN QUIET SPACE WEATHER STUDIES

Authors

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Body

The global network of All-Sky Imagers operated by Boston University has accumulated a vast archive of optical airglow images, but manual processing and annotation across such massive volumes are no longer feasible. To solve this, we developed two specialized models: a multi-class image classifier that categorizes images into Equatorial Plasma Bubbles (EPBs), Medium-Scale Traveling Ionospheric Disturbances, Ambiguous structures, Clear skies, and Cloudy skies, alongside a dedicated semantic segmentation model focused on isolating EPB structures. This pipeline efficiently isolates targeted events, generating a structured dataset optimized for analyzing how space weather drivers manifest within the upper atmosphere. Leveraging the quiet space weather dataset established by Mackovjak et al. (2025), this automated approach enables targeted investigation of EPB formation mechanisms during non-storm conditions, specifically examining their coupling with moderate solar wind drivers like Corotating Interaction Regions. Moving forward, we aim to extract quantitative morphological parameters directly from the EPB segmentations to build a comprehensive dataset for statistical studies of EPB occurrences and characteristics.

POSTER CODE: P1OTH328

Title
CLASSIFYING SOLAR WIND SPEEDS USING TOPOLOGICAL DATA ANALYSIS ON SDO/AIA IMAGE DATA

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Body
Solar wind High-Speed Streams (HSSs) originate from coronal holes, regions of open magnetic field configuration. While coronal holes are predominantly confined to the poles during solar minimum, the emergence of equatorial coronal holes particularly during solar maximum can channel HSSs directly along the ecliptic, making them potentially highly geo-effective. Anticipating the speed and, in turn, arrival of these streams based on the characteristics of their source regions is therefore a critical challenge for Space Weather forecasting. In this talk, we present a novel approach leveraging Topological Data Analysis (TDA) on Extreme Ultraviolet (EUV) solar disk images from SDO/AIA. We extract topological signatures of coronal holes across different homology dimensions, capturing their morphological structures. By correlating these topological features with in-situ L1 plasma measurements, we develop machine learning models capable of predicting whether coronal holes will generate a potential geo-effective HSS exceeding 500 km/s. Furthermore, by mapping the learned topological features which result to be of interest for the classification back to the original image space, we can effectively identify and isolate the corresponding source regions, achieving a novel, physics-driven segmentation of coronal hole boundaries. We will present the preliminary results of this study, highlighting how a purely topological approach can potentially extract meaningful physical information, leading to effective classification and segmentation models for operational Space Weather applications.

POSTER CODE: P1OTH329

Title
ADAPTIVE HYBRID DISTRIBUTION MODELING OF RADIATION BELT ELECTRONS

Authors
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Body
The Earth's radiation belts host electron populations that frequently deviate from thermodynamic equilibrium, exhibiting pronounced suprathermal tails and anisotropies driven by wave–particle interactions. Accurately representing these non-Maxwellian features is essential for understanding acceleration processes and improving predictive capabilities. In this work, we introduce an adaptive hybrid distribution-modeling framework for radiation-belt electrons. The method automatically identifies the optimal functional representation of the observed electron flux among Maxwellian, kappa, bi-Maxwellian, bi-kappa, and hybrid Maxwellian–kappa distributions. Model selection is performed algorithmically based on goodness-of-fit metrics, enabling a data-driven characterization of the underlying plasma regime. The selected distribution parameters are then used to reconstruct the electron flux density and to provide physically interpretable quantities such as density, characteristic temperature, and suprathermal index. Building on this representation, we implement a neural network forecasting model that leverages the fitted distribution parameters to predict electron-flux variability. This adaptive framework provides a unified, physically grounded approach to modeling and forecasting radiation belt electron populations, capturing both near-equilibrium and strongly non-thermal regimes.

POSTER CODE: P1OTH330

Title
HOW DO MAGNETIC FEATURES CONTRIBUTE TO SOLAR FLARE FORECASTING OVER TIME?

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Body
As space-based infrastructure grows, endeavors to improve solar flare forecasting capabilities continue and remain critical.
Many forecasting frameworks rely on fixed prediction horizons, often chosen to be 24 hours, resulting in a ‘flare vs non-flare’ classification scheme. However, new approaches to the flare prediction problem continue to emerge, including some that overcome this binary classification approach.

In this context, we introduced deep survival analysis in a previous work, which allows for continuous time-to-flare predictions. Building on this, we utilize Shapley values to analyze the contributions of photospheric vector-magnetogram features to the forecast on a time-continuous basis. At each time step, we dynamically quantify which magnetic field properties amplify or dampen the probability of a future M- or X-class flare, resulting in continuous feature-importance curves that can be compared between different active regions. We find that some flares appear to be driven by the evolution of singular features, such as unsigned current helicity, while others depend on a wider range of features, starting from Lorentz force components to net currents per polarity.
This analysis is done on multiple prediction models to compare attribution discrepancies.

With our setup, we provide an avenue for continuous, and interpretable, probabilistic risk predictions for solar flare occurrences.

POSTER CODE: P1OTH331

Title
A RADIOASTRONOMY-DRIVEN FRAMEWORK FOR CONSISTENT SPACE WEATHER PREDICTION WITH OPTIMIZED GENERATIVE MODELING

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Body
Space weather prediction still faces an important practical limitation: many forecasting approaches depend on several observational inputs, heterogeneous data sources, or complex machine learning models that are not always easy to reproduce under limited data availability. This is particularly relevant for estimating the transit time (TT) of coronal mass ejections (CMEs), where the number of well characterized events is limited and the consistency of the input data is critical.

This work proposes a radioastronomy-driven framework for CME TT prediction using the CME propagation speed (Vp) as the main input parameter. In this approach, Vp is derived directly from microwave radio observations, following Salas-Matamoros et al. (2017). The corresponding TT values are obtained from reported CME arrival information in OMNIWeb data products (NASA GSFC) and checked using in situ proton temperature criteria for ICME identification, following Elliott et al. (2005). This allows the construction of a compact but physically grounded dataset linking radio-derived CME speed with observed arrival behavior near 1 AU.

To address the limited number of available events, the framework incorporates Generative Evolutionary Synthetic Data (GESD), an informed synthetic data generation method based on artificial genes (Meza-Obando et al., 2024). The objective is not only to increase the number of samples, but to do so while preserving the physical relationship between Vp and TT and reducing inconsistent cases. In this way, the augmented dataset can support more stable predictive models under scarce data conditions.

The main contribution is a reproducible and operationally oriented workflow for CME transit time estimation based on radioastronomical observations. The framework is also relevant for the future use of the ROSAC radio telescope in Costa Rica, as it provides a concrete path toward intelligent data processing tools for space weather applications.

POSTER CODE: P1OTH333

Title

TEMPORAL SHARP FEATURES FOR CME-ASSOCIATED FLARE DISCRIMINATION: A MACHINE LEARNING BENCHMARK

Authors

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Body

Predicting whether a solar flare will be accompanied by a coronal mass ejection (CME) remains a major challenge in operational space weather forecasting. Most previous studies rely on instantaneous photospheric magnetic parameters derived from SDO/HMI SHARP data, while the value of temporal magnetic evolution remains insufficiently explored.

This work presents a benchmark study comparing three SHARP-based representations for CME-associated flare prediction: (1) instantaneous magnetic snapshots at fixed pre-flare times, (2) temporal statistical descriptors of magnetic evolution, and (3) full multivariate time series. The temporal statistical representation includes mean, standard deviation, slope, skewness, kurtosis, delta, autocorrelation, and FFT energy for each SHARP parameter. Prediction windows from 3 to 48 hours before flare onset are evaluated for M+ class flares cross-matched with the DONKI CME catalog.

A key contribution is a strict leakage-aware evaluation framework. HARP-number exclusivity is enforced across cross-validation folds, while a chronological holdout test set prevents both active-region morphology leakage and temporal leakage that can artificially inflate skill scores. Under this operationally realistic setup, preliminary Random Forest models using temporal statistical features achieve test-set AUC values of 0.57–0.62 and TSS values of 0.02–0.16. These scores are lower than those obtained using random splits (AUC = 0.60–0.65), highlighting substantial temporal nonstationarity in SHARP magnetic descriptors across solar cycles.

Additional benchmark experiments using Linear Discriminant Analysis, Support Vector Machines, XGBoost, MiniRocket, and Transformer models are ongoing. This work also aims to release a fully reproducible, machine-learning-ready benchmark dataset and preprocessing pipeline, enabling fair comparison of CME prediction models across the space weather community.

POSTER CODE: P1OTH334

Title
REANALYSIS - THE ENABLING TECHNOLOGY FOR A NEW SPACE WEATHER R2O PARADIGM

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Body
A reanalysis is typically the result of a long-term, data assimilative, physics-based model run. As such, it combines observations and simulations into an optimal global or regional estimated state of the environment. Recent advances in tropospheric weather prediction have shown that machine learning (ML) models trained on decades of reanalysis data can match and even surpass conventional numerical weather prediction models that solve partial differential equations (PDEs) in real time with data assimilation. It is likely far easier to deploy and maintain an ML space weather forecast model in operations, compared to the complex super-computing environments often required for PDE solvers. This is partly a consequence of the relatively simpler computing resources needed to evaluate a trained ML model, like a neural network. It is also partly a result of being able to use established software libraries that can perform core ML functions in a variety of computer languages suitable for operations. To realize these potential operational benefits, first we must build reanalyses on which to train the ML models. This will require detailed understanding and curation of our long-term data sets, introduction of data assimilation into new space weather domains, execution of long-term reanalysis runs, and training and deploying large operational ML forecast models.

POSTER CODE: P1OTH335

Title

RETHINKING INPUT DESIGN IN NEURAL NETWORK MODELLING OF FOF2 AND HMF2 USING GLOBAL RADIO OCCULTATION OBSERVATIONS FROM THE COSMIC SATELLITE MISSIONS

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Body

The accurate representation of the ionospheric F2-layer peak parameters, including the critical frequency (foF2) and peak height (hmF2), is fundamental to space weather applications, including HF communication, navigation, and ionospheric specification. While machine learning approaches have significantly improved modelling capabilities, the role of input feature design in shaping model performance remains insufficiently explored. In many existing studies, input variables are selected based on convention rather than systematic evaluation, despite their direct impact on model accuracy, robustness, and physical interpretability.

This study presents a global, data-driven modelling framework for foF2 and hmF2 based on neural networks trained with long-term radio occultation observations from COSMIC missions under geomagnetically quiet conditions. Beyond model development, the work introduces a structured investigation into how different representations of key input variables influence model behavior. Specifically, the analysis examines the effects of temporal encoding (Universal Time versus Local Time), spatial representation (geographic versus geomagnetic latitude), inclusion of physically meaningful parameters such as solar zenith angle, and the choice between joint and parameter-specific modelling strategies.

The results reveal that input representation plays a decisive role in capturing the underlying ionospheric climatology. Certain configurations significantly enhance the model's ability to reproduce global diurnal and latitudinal structures, while others introduce systematic biases or reduce generalization capability. The findings highlight that physically informed input choices (particularly those aligned with solar-driven ionospheric processes) lead to more consistent and interpretable model outputs. Independent validation using ground-based ionosonde observations confirms the robustness of the optimized configurations across diverse geophysical conditions.

POSTER CODE: P1OTH336

Title

A ROBUST CNN-BASED APPROACH FOR DETECTING EQUATORIAL PLASMA BUBBLES FROM ALL-SKY IMAGES

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Body

Equatorial plasma bubbles (EPBs) are ionospheric irregularities that can significantly disrupt satellite communication and navigation systems, particularly in equatorial regions. Accurate detection of EPBs in all-sky imager data is essential for space weather monitoring; however, manual identification is labor-intensive and unsuitable for real-time applications. Machine learning, especially convolutional neural networks (CNNs), provides an effective alternative by automatically learning discriminative visual features from image data.

In this study, we developed a CNN-based framework to classify all-sky images into three categories: EPB, cloudy, and non-EPB conditions. The model is trained on labeled datasets and learns to distinguish the characteristic spatial patterns associated with plasma bubbles, even in the presence of noise and cloud contamination. To enhance robustness and reduce model uncertainty, multiple CNNs are trained on different subsets of the data, and their predictions are combined through an ensemble strategy to produce the final classification.

The developed CNN framework achieves an overall classification accuracy of ~99%, with strong separation between EPB, cloudy, and non-EPB classes. The ensemble approach further improves reliability by reducing misclassifications in ambiguous cases, particularly where cloud structures resemble EPB features. The resulting confusion matrix shows near-perfect performance, with only a few misclassified samples across all classes, highlighting the effectiveness of the ensemble strategy in enhancing prediction stability and accuracy.

POSTER CODE: P1OTH337

Title

ML READY DATABASE OF MAJOR SPACE WEATHER DRIVER CHARACTERISTICS AND TOOLS FOR NOWCASTING AND SHORT TERM FORECASTING THEIR GEOEFFECTIVENESS

Authors

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Body

Since we are highly reliant on space-based technology, running human exploration in near-Earth space, building datasets, preparing model pipelines, and developing user-friendly web-based tools for nowcasting and forecasting the risk posed by major solar transients have become one of our prime interests. We construct a benchmark dataset of multiple magnetic and plasma features within the major space weather drivers-interplanetary coronal mass ejections (ICMEs), including their compressive structures (sheaths) and coherent magnetic structures (obstacles) at upstream Earth (L1) over the different phases of solar cycles. We examined more than 20 features those most effectively capture ICME characteristics including magnetic helicity, plasma beta, normalized magnetic field fluctuation, compressibility, proton velocity, density, magnetic field intensity, temperature, ratio of alpha to proton number density, observed to expected proton temperature, Alfvén speed, Mach number, total pressure, and entropy to characterize solar wind within magnetic obstacles and sheaths of ICMEs. The dataset is useful for performing statistical studies of ICME characteristics and for training and validating AI/ML models to classify solar wind across different phases of the solar cycle. We demonstrated how the dataset can be used to auto-detect ICMEs and their sub-structures and perform short term predictions of their geoeffectiveness, including associated uncertainties, by training multiple supervised ML models. Furthermore, we developed two web-based tools—one that allows users to curate the database by solar activity phases and geoeffectiveness, and another that delivers short term forecasts of ICMEs and geomagnetic storm intensities using an ML framework.

POSTER CODE: P1OTH338

Title

AI-BASED SUPER-RESOLUTION OF UNSATURATED SUVI/EUV DATA USING SDO/AIA FOR EXTENDED SOLAR CORONA MONITORING

Authors

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Body

The Solar Ultraviolet Imager (SUVI) on NOAA's GOES-16 spacecraft offers unsaturated EUV observations with a larger field of view (FOV) but with relatively low spatial resolution (~2.5 arcsec) and temporal cadence (~4 minutes). In this study, we present an AI-based approach to generate a homogenous, unsaturated, and extended EUV dataset with improved spatial resolution. First, we generate synthetic SUVI/EUV L2 HDR data from SDO/AIA data with the same spatial and temporal resolution. Next, we train an AI-based super-resolution model with SUVI/EUV L2 HDR (1k x 1k) as input and synthetic SUVI/EUVI L2 HDR (4k x 4k) as output. A total of 1440 pairs of SDO/AIA data and SUVI/EUVI L2 HDR are considered for training, validation, and testing from 2020 January to 2025 December. The results from this study are as follows. First, our AI-model generated unsaturated AI-generated EUV data with higher spatial resolution. Second, the AI-based super-resolution model enhances the spatial resolution of low-resolution SUVI/EUV L2 HDR data 4 times both on the solar surface and the limb area up to 3 solar radii. Third, the AI-generated EUV data are evaluated not only using quantitative image quality metrics (RMSE, MS-SSIM, correlation coefficients) but also through differential emission measure (DEM) comparisons, providing a physically motivated validation. These results make it possible to construct a high-quality, unified dataset spanning from 2011 to 2040, covering approximately three solar cycles.

POSTER CODE: P1OTH339

Title
A CME DETECTION-TO-IMPACT PIPELINE FOR GEOMAGNETIC STORM PREDICTION

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Body
Detection and prediction of Interplanetary Coronal Mass Ejections (ICMEs), a main driver of geomagnetic storms, is a well-known and difficult problem. Storm predictions triggered by in-situ solar-wind measurements at L1 (e.g. DSCOVR, ACE) typically offer only about an hour of lead time, while coronagraph-based methods provide longer lead but with large arrival-time uncertainty. The most informative signal for a neural-network forecast would be the velocity and density profile from onset through transit. For this reason, we are building a full detection-and-prediction pipeline. Real-time CME detection from LASCO coronagraph images, velocity and onset-time approximation, transit time prediction, and finally the generation of a synthetic transit profile to feed a Dst/SYM-H prediction model. CME detection is done with CACTus-inspired approach, fitting a straight line to a ridge in a J-map, more precisely bright features in the J-map are thresholded and morphologically grouped into clusters, to which a RANSAC regression line is fitted; this stage reaches a velocity mean absolute error of 160 km/s, consistent with the standard CACTus method and validating it as the pipeline's front end; the parameters of this line then approximate velocity and onset time. We next use a physics-informed neural network (PINN) to predict transit time, which is in turn used to reconstruct the velocity time-series during transit, from onset to arrival. This gives the prediction model a much earlier warning, and information about the shape of the incoming impact, than current operational technologies. This approach lets us predict the magnitude of a geomagnetic storm not just a few hours ahead, but 10 or more hours — potentially more than a day — and directly addresses the ESWW2026 theme of combining data-driven and physics-based, cross-scale forecasting.

POSTER CODE: P1OTH340

Title
PHYSICS–INFORMED MACHINE LEARNING MODELING OF PLASMASPHERIC COLD ELECTRON DENSITY

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Body
Machine learning (ML) methods are increasingly used in space weather research, but their performance is often limited by sparse observations during extreme events and a lack of physical constraints. Physics-based models, by contrast, rely on empirical parameterizations and simplifying assumptions that can constrain their accuracy. Bridging these two approaches offers a pathway toward more reliable and generalizable models of the near-Earth plasma environment.

In this study, we investigate plasmaspheric electron density modeling using a physics-based model (VERB-CS) [1], a purely data-driven neural network model (PINE) [4], and three hybrid physics–machine learning configurations. The hybrid frameworks are driven by geomagnetic indices and their time history, together with spacecraft location and in situ electron density measurements. In each configuration, density outputs from the physics-based model are incorporated into the neural network at different stages of training, enabling varying degrees of physical guidance.

Model performance is evaluated against independent in situ observations [2] and global plasmaspheric imaging [3]. The hybrid approaches consistently outperform both purely data-driven and purely physics-based models, achieving lower root-mean-square errors, reduced bias, and improved generalization under both quiet and disturbed geomagnetic conditions. These results demonstrate that embedding physical information within machine learning frameworks enhances predictive capability, particularly during periods of elevated geomagnetic activity.

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[3] https://doi.org/10.1023/B:SPAC.0000007511.47727.5b
[4] https://doi.org/10.1002/2017JA024406

POSTER CODE: P1OTH341

Title

BENCHMARKING PRETRAINED FOUNDATION MODELS AGAINST PINE FOR PLASMASPHERIC ELECTRON DENSITY PREDICTION

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Body

Accurate specification of plasmaspheric electron density is essential for modeling wave–particle interactions, radiation belt dynamics, and space weather applications. The PINE model (Plasma density in the Inner magnetosphere Neural network-based Empirical) maps a multi-day history of geomagnetic indices to equatorial electron density through a feedforward neural network trained on Van Allen Probes and, in its most recent revision, Arase upper-hybrid resonance densities. Despite its strong performance, it remains an open question whether large pretrained foundation models can match or exceed PINE by leveraging representations learned across heterogeneous domains.

In this work, we benchmark several recent foundation models, including general-purpose time-series transformers (e.g., Chronos, Moirai, TimesFM), against the latest PINE configuration on the task of reconstructing equatorial plasmaspheric electron density as a function of geomagnetic indices, L-shell, and magnetic local time. We compare zero-shot, linear-probe, and LoRA-finetuned regimes against fully supervised PINE, reporting RMSE and bias with particular attention to storm-time performance.

Preliminary results indicate that finetuned foundation models are competitive with PINE during quiet conditions and offer measurable gains during disturbed intervals and in undersampled regions, while pure zero-shot performance remains substantially behind. We discuss the operational deployability of real-time plasmasphere nowcasting and outline the implications of incorporating foundation-model representations into coupled physics–ML frameworks.

POSTER CODE: P1OTH342

Title
IMPROVING SOLAR FLARE FORECASTING USING THE TIME EVOLUTION OF SHARP PARAMETERS

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Body
We investigate whether including the time evolution of active-region magnetic properties improves solar flare forecasting compared with models based only on single-time magnetic snapshots. Using the SDO/HMI SHARP data set, we compare baseline classifiers trained on 20 single-time SHARP parameters with augmented classifiers that also include temporal-difference features, or “deltas.” These are defined as the difference between SHARP parameters at two preflare times:

Delta SHARP = SHARP at the lead time minus SHARP at an older time.

We construct these delta features over a range of preflare intervals. We evaluate three representative machine-learning models: a random forest classifier, quadratic discriminant analysis, and a support vector machine. The task is binary prediction of major flares, meaning M- and X-class events, versus non-major events, meaning B- and C-class flares and no-flare cases. Model performance is evaluated using leave-one-out cross-validation. Forecast skill is measured with the True Skill Statistic and the Heidke Skill Score 2.

We find that adding temporal-difference features improves performance for all three models. The most consistent gains occur when the endpoint of the delta construction is 23 to 24 hours before flare onset. The improvement is stronger and more robust for the random forest classifier and quadratic discriminant analysis, and more variable for the support vector machine. The True Skill Statistic and Heidke Skill Score 2 show consistent behavior, indicating that the benefit is not dependent on the choice of metric.

These results show that a compact representation of SHARP-parameter evolution provides useful predictive information beyond single-time-point features. They also identify an approximately one-day preflare timescale as particularly informative for major-flare forecasting.

POSTER CODE: P1OTH343

Title
TOWARDS IMPROVED KP INDEX FORECASTING USING DEEP LEARNING

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Body
The Kp index is a widely used proxy for geomagnetic activity and improving its forecasting beyond short horizons (typically a few hours with only a small number of operational products reaching up to 3 days) remains an important challenge for space weather forecasting. This work investigates deep learning approaches for Kp forecasting, with an initial focus on a 3-day horizon extended toward 7 days in a second step. As part of the first step, we focus on predicting the daily maximum Kp. Two complementary data sources are combined. First, solar imagery from the Solar Dynamics Observatory (SDO) is used to capture precursor signatures of geomagnetic activity such as active regions and coronal holes. Second, the Kp record is used, providing information on the recent dynamics and persistence of geomagnetic activity. Two methodologies are compared. The first is a hybrid architecture combining an image-dedicated branch with a branch for Kp history; additional exploratory work incorporates solar flare information. The second adapts Surya, a recently released open-source heliophysics foundation model (NASA/IBM), to Kp forecasting. Both approaches are evaluated across several train/validation/test splits spanning different years, and their sensitivity to input configuration such as the length of the Kp history, the sampling rate of images, and other model hyperparameters are investigated to assess robustness. Preliminary results indicate that both models are able to capture part of the Kp dynamics with encouraging performance on moderate geomagnetic activity. However, forecasting extreme storms remains more challenging and constitutes a key direction for ongoing work. Further developments, including refinement toward three-hourly resolution and improved handling of extreme events are ongoing.

POSTER CODE: P1OTH345

Title

IMPACT OF IMAGE SCALING METHODS ON THE FLARE FORECASTING PROCESS AND PREDICTIVE ABILITIES OF A CNN

Authors

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Body

The prediction of solar events allows us to mitigate their dangers, and in this sense, the use of deep-learning methods for flare forecasting rose in popularity during the last decade. Although the application of those methods may prove useful, the transfer of the methodology from the computer vision field to solar physics needs to be carefully studied. One of such method is the use of image scaling processes which can distort the information in data.

Using a deep-learning model trained for flare forecasting and unrestricted by the use of image scaling processes to fit the input size restriction of convolutional neural networks, we evaluated the evolution of the predictive performances of the model using scaled Spaceweather HMI Active Region Patch (SHARP) line-of-sight magnetograms to various amplitudes. Furthermore, we also studied its impact on the attention of the model and its method of prediction using the Gradient-weighted Class Activation Mapping method.

The evaluation of the predictive abilities of the deep-learning model using scaled images showed a non-negligible drop in performance with images scaled to a size lower than 70% or over 140% of their original sizes. Furthermore, the use of an input size between 100×100 and 250×250, which is the most common range of input size for deep-learning models, was linked to a drop of TSS between 0.55 and 0.45 for our models when classifying images preceding a flare. The attention of the model was also heavily spread all over the input image, with no apparent link to the PIL when using images resized under 60% of their original size. However, for images rescaled to over 60% of their original size, we noticed a proportional increase of attention toward pixels based on their distance to their nearest PIL. This implies a high importance of PILs in the prediction of flares using line-of-sight magnetograms.

This study heavily hints at the negative impact of image scaling methods used in deep-learning for flare forecasting.

POSTER CODE: P1OTH346

Title

BRIDGING SCALES IN THE SOLAR WIND: A DUAL CLASSIFICATION OF BULK AND FLUCTUATION STATES TO PREDICT SMALL-SCALE VARIABILITY FROM LARGE-SCALE MODELS

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Body

Large-scale solar wind models, such as MHD-based heliospheric simulations, are essential for forecasting conditions throughout the heliosphere, yet their computational cost prohibits resolving the small-scale fluctuations and turbulence that govern energy transfer and space weather impacts. Bridging this gap requires a principled mapping from the bulk plasma states these models can produce to the fluctuation states they cannot. We present a framework that provides two independent classifications of the solar wind and then evaluates the statistical relationship between them, yielding a probabilistic route to downscaling large-scale simulations.

First, we apply unsupervised machine learning clustering to fluctuation and turbulence diagnostics to identify distinct fluctuation regimes. Crucially, this classification is constructed first and optimised to maximise the separability and physical distinctiveness of these states, ensuring they carry maximal information about small-scale behaviour. We then cluster the same intervals using only bulk parameters (e.g. speed, density, temperature, magnetic field) – quantities accessible to large-scale models – and use information theoretic measures, including conditional entropy, to quantify how strongly each bulk state constrains the underlying fluctuation state and which bulk features carry the greatest predictive power. Moving beyond traditional fast-slow or source region classifications, this lets the data define both regimes and explicitly quantifies the predictability between them, enabling estimates of expected fluctuation properties given a bulk state from a large-scale model and offering a route to improved forecasting of small-scale variability relevant to space weather.

POSTER CODE: P1OTH347

Title

A PIPELINE FOR FORECASTING L-SHELL SPECIFIC OUTER RADIATION BELT RELATIVISTIC ELECTRONS

Authors

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Body

The outer radiation belt presents a significant hazard to spacecraft that pass through it, with a dynamic population of relativistic or higher energy electrons that can vary across many orders of magnitude on many different timescales. The majority of forecasting models aim to predict the exact value of electron fluxes found within this region, whilst warnings issued by space weather forecasters to stakeholders are often done on a threshold basis. We present a space weather forecasting pipeline of several machine learning models that first uses a Long Short-Term Memory network (LSTM) to now/hindcast geomagnetic conditions from solar wind data measured at L1. The resulting geomagnetic indices are then fed into a suite of random forest classifiers that can accurately predict whether 1.8 MeV electron fluxes will exceed any of five percentile thresholds for L-shells between 3 and 6, as well as GEO. We find that this framework achieves balanced accuracies above 0.7 for nowcasting, with the majority of forecasts maintaining balanced accuracies above 0.6 even at a 6-day lead time, longer than most operational models provide. We discuss the implications of this for space weather services and key stakeholders. [

POSTER CODE: P1OTH348

Title

TOWARDS RESOURCE-CONSTRAINED ONBOARD AI COMPUTING FOR AUTONOMOUS SPACECRAFT: A HIGH-LEVEL SYNTHESIS DESIGN SPACE EXPLORATION

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Body

As space missions continue to move toward greater onboard autonomy, spacecraft are increasingly expected to process data locally and support timely mission decisions while operating under strict constraints on power, computation, memory, and communication. Enabling efficient onboard AI inference is therefore becoming an important step toward reducing reliance on continuous ground interaction and supporting future intelligent space systems. While High-Level Synthesis (HLS) has emerged as a promising approach for accelerating AI workloads on reconfigurable hardware, its practical role in resource-constrained spacecraft computing remains relatively unexplored. In this work, we explore the use of HLS as a rapid design methodology for onboard AI acceleration using the BeaverCube II in-orbit computing platform as a representative CubeSat architecture. Rather than seeking a single optimal hardware implementation, we investigate the design space by evaluating multiple hardware configurations and examining the associated trade-offs among latency, resource utilization, and computational efficiency. This exploration aims to understand better how HLS can support the practical development of AI accelerators suitable for resource-constrained space platforms. Our findings suggest that systematic HLS-based design space exploration provides a flexible framework for balancing performance with limited onboard resources while shortening the development cycle of AI-enabled space computing systems. Although this work represents one step within a broader journey toward autonomous spacecraft, we hope it contributes practical insights for researchers investigating onboard edge computing, AI-assisted mission decision support, and future space-weather and Earth-observation missions operating under stringent resource constraints.

POSTER CODE: P1OTH349

Title
TOWARDS RESOURCE-CONSTRAINED LANGUAGE MODELS FOR ONBOARD MISSION DECISION SUPPORT IN AUTONOMOUS SPACECRAFT

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Body
Future autonomous spacecraft will increasingly require onboard decision-support capabilities to reduce dependence on continuous ground intervention while operating under strict computational and communication constraints. Recent advances in parameter-efficient fine-tuning provide an opportunity to investigate whether lightweight language models can assist operational reasoning without requiring large onboard computing resources. Recent work on autonomous onboard satellite fault diagnosis, SatFaultSim (Anderson et al., 2024), has demonstrated reliable perception-layer fault detection and attribution, but explicitly identifies the translation of such diagnoses into planned recovery actions as an open direction for future development. This ongoing work presents the initial development of MissionReason, a lightweight benchmark for structured spacecraft operational decision support. The current prototype consists of a mission-state representation, an expert-policy engine that produces operational decisions and human-readable explanations, and an automated scenario generator capable of creating synthetic mission planning cases. These components provide a controlled environment for evaluating parameter-efficient language models on mission-level reasoning tasks. The objective of this work is not to replace existing spacecraft autonomy algorithms, but rather to investigate whether compact language models can learn expert operational policies and generate interpretable decision recommendations under resource-constrained conditions. Future work will extend the benchmark by incorporating authentic Earth-observation and space-weather variables, including communication constraints and environmental disturbances, with the long-term goal of supporting onboard autonomous operations for future Earth-observing satellite missions.

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION OTH4

VERDE ROOM – SECOND FLOOR
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2OTH401

Title
Citizen science opportunities during IPY 2032-33

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Body
Public engagement in polar research has evolved in parallel with technological change from the earliest International Polar Year (IPY; 1882–1883) initiatives to the present. In the early 20th century, new communication tools such as radio receivers enabled wider participation by allowing standardized timekeeping and the dissemination of observation campaigns. During the International Geophysical Year (1957–1959), coordinated international efforts actively engaged amateur astronomers, radio operators, and pilots in systematic observations, creating distributed observation networks relevant to geophysical and ionospheric studies.

From the 1950s onward, the growing availability of film cameras allowed skilled hobbyists to document phenomena such as auroras. However, the widespread adoption of digital cameras in the 2000s marked a turning point, enabling large-scale, high-quality citizen observations. Despite this, the fourth IPY (2007-2009) did not fully capitalize on these capabilities due to limited tools for processing citizen science data.

The expansion of the internet further accelerated data sharing and collaboration. Today, several digital observation databases are in active use. In 2011, the Skywarden site (www.taivaanvahti.fi) modernized the collection of citizen scientists' observations by providing a tool for gathering information on auroras, noctilucent clouds, polar stratospheric clouds, rocket exhaust clouds, and atmospheric halos, among others. In 2014, the Aurorasaurus project, focusing on northern lights, was launched.

Observation methods have shifted from paper-based note-taking to continuous digital photography. Mobile devices equipped with advanced cameras are available to most of the European population. In addition, inexpensive camera stations capable of recording and storing live aurora videos are already being deployed by individuals. These emerging trends could be actively leveraged during the fifth IPY.

Keywords: Citizen science,International Polar Year,Open science,Northern lights,Education

POSTER CODE: P2OTH402

Title
Collaborative research on Space Weather at the International Space Science Institute

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Body
Many of the most significant results in space weather research have been achieved thanks to collaborative teams, several of which have been funded by the International Space Science Institute (ISSI) in Bern and in Beijing.

This presentation aims to raise awareness of the important role played by such collaborative research teams funded by the ISSI. This is not just in terms of scientific production, but also as a means of helping early career scientists to expand their networks and develop their leadership skills. Several of the most active teams are or were led or co-led by early career scientists.

The presentation will present some of the tools that ISSI can provide and list examples of teams that are addressing space weather. Here are a few recently selected projects:
- Impact of Solar Energetic Particles on Mars: Enhancing Space Weather Insights for Future Exploration
- Why does the Geomagnetic Response to the Solar Wind Saturate?
- 1-100 keV Electrons in the Earth's Magnetosphere: Unique and Unpredictable?
- The Impact of Solar Flare Irradiance on the Earth's Ionosphere
- What must we learn to make accurate space-weather predictions?
- Quantifying Space Weather Impacts caused by Extreme Solar Energetic Particle Events
- Precipitation of Energetic Particles from Magnetosphere and Their Effects on the Atmosphere

Keywords: outreach,collaborative research

POSTER CODE: P2OTH403

Title
Exploring Space Weather with a comic book for kids

Authors
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Affiliations
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Body
Following the experience of Frammenti di Cielo, the first science outreach comic published by the Italian National Institute for Astrophysics (INAF), its sequel Frammenti di Cielo² – Bagliori Spaziali is now released and it is dedicated to Space Weather.
The comic book is the result of a collaboration between Gruppo Storie and Sorvegliati Spaziali, two national INAF public engagement and communication projects, together with the cartoonist matitaelettrica, who also illustrated the first volume.
The project was developed in the context of the growing public interest in phenomena such as geomagnetic storms and auroras, observed over the past two years even at Italian latitudes thanks to the recent solar maximum. The aim is to turn this spontaneous attention into an opportunity for science outreach, using an accessible and engaging narrative language.
The publication is primarily intended for children of 9-12 years old. It follows a narrative approach consistent with the first volume, in which science is woven into the story, characters and adventure-driven imagery. The comic is then followed by a dedicated section for scientific insight, where Space Weather is introduced. Starting from the Sun and its main phenomena, it then illustrates their effects on Earth, interweaving major geomagnetic storms of the past with more recent events.
One of the main challenges of the project was to address complex Space Weather topics for a young audience, seeking a balance not only between accessibility and scientific accuracy, but also between narrative structure, language, and emotional engagement appropriate to the target audience.
In this talk, we will present the comic book, the collaborative process behind its creation and its potential dissemination as an outreach tool on Space Weather for schools, events, and public engagement activities in general.

Keywords: Comics,Space Weather,Astrophysics,Education,Storytelling

POSTER CODE: P2OTH404

Title
International Capacity Building series: Machine Learning applied to Space Weather and GNSS

Authors
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Body
In recent years, machine learning (ML), Space Weather (SWx), and Global Navigation Satellite System (GNSS) applications have attracted significant attention from both the scientific and operational communities, emerging as major areas of research. However, deploying AI in these domains presents significant technical challenges for researchers, technicians, and forecasters. Key challenges include managing massive and heterogeneous datasets while ensuring quality; developing capable algorithms and software tools; addressing the complexity of the multiple spatial and temporal scales inherent to space weather; enabling real-time data streaming and seamless model integration into operational environments; and ensuring models trustworthiness to support critical decision-making.
Beyond these technical complexities lies a critical, often overlooked bottleneck: the capacity building of students, researchers, technicians, and forecasters to effectively exploit the versatility of AI tools and models. Students and researchers are frequently confronted not only with complex scientific questions but also with additional technical skill requirements that are typically not covered in standard academic curricula. To address this gap, we have organized a series of workshops aimed at building capacity and providing hands-on training in these emerging techniques. Drawing on the experiences and lessons learned from these initiatives, this presentation will discuss the impact of the training and outline prospective next steps for the continuation and expansion of this educational series.

Keywords: Machine Learning,Workshop

POSTER CODE: P2OTH405

Title
Shocking! The intense geomagnetic storm plus severe proton storm events in January 2026 and general communication to the public.

Authors
Judit Palacios [1], Diana Besliu-Ionescu [2], Jennifer O'Hara [3], Jorge Amaya [4], Alexi Glover [4], Wenda van der Berg [5], Gareth Rhys Lawrence [1], Juha Pekka Luntama [4]

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Body
The ESA Space Weather Service Network products offer a wealth of information on space weather conditions, such as nowcast and forecast data, for the different areas of the Sun-Earth system. These can be accessed via the ESA SWE Network Service Portal at https://swe.ssa.esa.int/

A very fast CME (> 1300 km/s on average) ejected on 18 January 2026 was associated to X1.9-class flare. The total magnetic field on the ICME was over 40 nT, and these intense characteristics led to the most intense geomagnetic storm in 2026 so far, leading to a Kp=8 (G4 level), and Dst ranged severe storm levels (-240 nT), ranking around the top 5 on intense geomagnetic storms of the solar cycle 25. High energetic particles were ejected and piled up in the shock/sheath, originating a severe SEP event with gradual profile, monitored by ESA Space Weather hosted payloads data as EDRS-C/NGRM. This severe event reached to S4 level, a stunning level not reached since 2003. Even though the high energies involved on the very large fluxes of the solar proton event, no Ground-Level enhancement (GLE) was detected; nevertheless a Forbush decrease was observed in neutron monitor data due to the wiping of Galactic Cosmic Rays (GCRs), which is compatible with the CME intense shock arrival timing.

The live event was communicated to the public through multiple communications channels (1,2,3), keeping an agile update on the event, from the onset to the storm impacts.

(1,2,3)
1 https://bsky.app/profile/esaspaceweather.esa.int
2 https://x.com/esaspaceweather?lang=en
3https://www.esa.int/Space_Safety/Space_weather/ESA_monitoring_January_2026_space_weather_event”

Keywords: Major geomagnetic storm,Severe proton event,Communication,Social media

POSTER CODE: P2OTH406

Title
Beyond the Clouds: A Hands-On Educational Approach to Space Weather Resilience

Authors
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Body
On September 1, 1859, Richard Carrington observed a solar flash that triggered global telegraph failures and widespread auroras. While public discourse heavily prioritizes terrestrial climate adaptation, space weather remains critically overlooked. Today, a Carrington-level event would cause catastrophic disruptions to power grids, satellite networks, and global communications. To address this awareness gap, we developed an educational STEM project with secondary school students, demonstrating that climate resilience must extend beyond Earth to encompass space-borne hazards.

The project translates space weather dynamics into three interactive physical demonstrations. First, students modeled Earth's magnetosphere using a magnetic sphere and iron filings to reproduce the interaction between CME propagation and Earth's magnetic shield. Second, geomagnetic storm compression was simulated with magnets and logged in real time using smartphone sensors via the Phyphox app, illustrating how sudden magnetic field spikes correspond to power grid failures. Finally, students built and tested Faraday cages using aluminum-lined enclosures. Empirical testing confirmed effective physical shielding, as incoming audio and wireless signals dropped instantly upon closure.

This initiative shows that space weather adaptation requires technical mitigation and public education. Upon receiving official alerts, critical infrastructure—such as school servers, financial centers, and hospital equipment—must be isolated in shielded spaces. By combining historical context, real-time sensor measurements, and practical mitigation models, this project provides a scalable framework for school-level outreach, proving that preparing for the next severe solar storm is not a question of if, but when.

This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under Contract Grant Nos. 2024-5-E.0-CUP and I53D24000060005

Keywords: CME,SPACE WEATHER,GEOMAGNETIC STORM,SOLAR TERRESTRIAL RELATIONS,SCIENCE EDUCATION

POSTER CODE: P2OTH408

Title
Bridging Science and Society: The INGV Space Weather Bulletin for the Mediterranean Area as an Educational and Outreach Tool

Authors
Dario Sabbagh [1], Emanuele Pica [1], Paolo Bagiacchi [1], Lili Cafarella [1], Gianfranco Cianchini [1,2], Igino Coco [1], Paola De Michelis [1], Domenico Di Mauro [1], Fabio Giannattasio [1], Alessandro Ippolito [1], Stefania Lepidi [1], Carlo Marcocci [1], Michael Pezzopane [1], Lucia Santarelli [1], Carlo Scotto [1], Luca Spogli [1], Roberta Tozzi [1], Massimo Viola [1]

Affiliations
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Body
Space weather education and outreach (E&O) are essential for translating complex scientific phenomena into societal awareness. In this context, the Istituto Nazionale di Geofisica e Vulcanologia (INGV, Italy) promotes public engagement through its weekly Space Weather Bulletin over the Mediterranean area.
The bulletin combines ionospheric (HF, TEC, GNSS scintillations) and geomagnetic observations (H-component magnetograms, local K-index) acquired by the INGV monitoring network with solar and interplanetary data from external providers, offering an accessible overview of space weather events and their effects. Explanatory texts and clear visualisations support interpretation by non-specialists, making the bulletin useful not only for scientists but also for radio amateurs, civil and military institutions, and other stakeholders interested in space weather impacts.
To broaden its reach, each issue of the bulletin is promoted through INGV social media channels using simplified and user-friendly content for the general public. In line with open data policies and new communication approaches, from 2026 the bulletin also provides open-access standardised JSON datasets alongside the traditional PDF version, all distributed under a CC BY 4.0 licence with a dedicated DOI [1]. This development enhances the bulletin's educational potential by enabling educators, university students, and citizen scientists to directly access weekly datasets from INGV instruments and observatories, encouraging hands-on STEM learning and practical data analysis.
This contribution presents the bulletin's design and evolution as an E&O resource, highlighting how accessible data and effective communication can strengthen the connection between space weather science and society.

[1] INGV Space Weather Bulletin Working Group (2026). INGV Space Weather bulletin over the Mediterranean area [Dataset]. National Institute of Geophysics and Volcanology (INGV). https://doi.org/10.13127/swx/bulletin.

Keywords: Space Weather Outreach,Science Communication,Open Data,STEM Education,Ionospheric Monitoring

POSTER CODE: P2OTH409

Title
Sidera: a digital guide to the places of Science and Astronomy in Rome

Authors
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Body
Sidera is a digital guide that invites the public to discover a lesser-known side of Rome: its extraordinary scientific heritage. Far from the usual image of a city of art and antiquity, Rome preserves a wealth of places tied to the history of astronomy and science in general: from the Accademia dei Lincei, Europe's oldest scientific institution and home to Galileo's early triumphs, to the astronomical observatories of the Campidoglio and the Collegio Romano, the great meridian lines of Augusto and of Santa Maria degli Angeli, and the curious water clock of the Pincio.
Through richly illustrated descriptions and an interactive map, users can explore these sites and the stories they hold: Galileo's trial and abjuration, Angelo Secchi's activity, the dawn of modern astrophysics, meteorology, and timekeeping. An interactive research assistant, powered by artificial intelligence, answers visitors' questions providing related monuments, making this heritage accessible to everyone, from scholars to casual visitors and tourists.
By blending history, culture, and AI, the project shows how technology can give new life to the history of science and open it up to an international audience.

Keywords: Rome,Astronomy,Science,Map,Guide

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION PLENARY 1

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1PL101

Title
NAVIGATING SOLAR CYCLE 25'S PEAK: OPERATIONAL LESSONS FROM M2M SWAO

Authors
Carina Alden [1], Mattie Anastopulos [2], Mary Aronne [2], Anna Chulaki [1], Tony Iampietro [1], Elizabeth Juelfs [2], Melissa Kane [1], Teresa Nieves-Chinchilla [3], Mary Pasanen [4], Michelangelo Romano [3], Chris Stubenrauch [1]

Affiliations
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Body
Established in June 2020, the Moon to Mars Space Weather Analysis Office (M2M SWAO) recently experienced its first solar maximum as a team. Throughout the peak activity of Solar Cycle 25, several intense space weather events challenged the real-time analysis capabilities for M2M SWAO. Most notable among these were the now well-studied May 2024 (Gannon), November 2025 (Veteran's Day), and January 2026 (MLK Day) storms, which required additional adjustments to nominal operations. Each of these storms were associated with significant flaring activity, coronal mass ejections (CMEs), solar energetic particle events, and geomagnetic storms but with significant solar-heliospheric differences from an analyst's perspective.

In this poster, we investigate the intrinsic nature of each event, along with the observational constraints and model limitations that challenged the M2M SWAO team. This analysis and reflections aim to capture lessons learned, reevaluate our procedures, and identify operational gaps. While every event during the recent peak activity of Solar Cycle 25 presented unique hurdles, the most significant difficulties often stemmed from the sheer volume of activity, missing data points required for high-confidence analysis, and the limitations of our current assumptions regarding underlying physical processes within heliophysics.

POSTER CODE: P1PL102

Title

HANDLING SEVERE SPACE WEATHER EVENTS IN SOLAR CYCLE 25: AN OPERATIONAL PERSPECTIVE FROM NICT

Authors

Yumi Bamba [1], Takuya Tsugawa [1], Yuki Kubo [1], Daikou Shita [1], Kaori Sakaguchi [1], Mamoru Ishii [1, 2]

Affiliations

[1] National Institute of Information and Communications Techinology, Koganei, Tokyo, JAPAN, [2] Institute for Space-Earth Environmental Research, Nagoya University, Nagoya, Aichi, JAPAN

Body

NICT is the only organization in Japan responsible for providing space weather forecasting as a public operational service. In Japan, societal awareness of space weather risks increased markedly following the X9.3 solar flare in September 2017, near the end of Solar Cycle 24. In response, NICT strengthened the redundancy of its observation systems and advanced forecasting capabilities, launching a 24/7 space weather monitoring and forecasting service on 1 December 2019. More recently, in June 2025, NICT introduced the Space weather Alert For social Impacts and Risks (SAFIR) service, which issues alerts based on expected societal and infrastructure impacts rather than solely on the magnitude of space weather phenomena.

During the September 2017 event, space weather forecasting operations at NICT were significantly disrupted by an unanticipated surge in media inquiries and public communication demands. Lessons learned from this experience directly shaped structured operational response frameworks in Solar Cycle 25, resulting in dedicated response manuals for large-scale space weather events. In addition, NICT has conducted multiple large-scale response exercises involving not only the Space Weather Forecast Service Group but also NICT's public relations office and Japan's Ministry of Internal Affairs and Communications. The extreme space weather event on May 2024 marked the first case under this enhanced framework, followed by further large-scale responses in October 2024, November 2025, and January 2026. For each event, NICT released forecasts of geomagnetic and ionospheric disturbances and, after the event, shared lessons learned from media response while conducting impact assessments using its space weather user network. This contribution presents NICT's operational workflow for handling severe space weather events and discusses key challenges and lessons learned during Solar Cycle 25 from an operational perspective.

POSTER CODE: P1PL103

Title

WHEN MODELS FALL SHORT: GLE77 RADIATION DATA REVEALS CRITICAL GAPS IN AVIATION WARNING SYSTEMS

Authors

Ben Clewer [1], Fraser Baird [1], Keith Ryden [1], Paul Morris [1], Fan Lei [1], Clive Dyer [1,2]

Affiliations

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Body

On 11 November 2025, a solar energetic particle event produced Ground Level Enhancement 77 (GLE77), temporarily elevating ionising radiation throughout Earth's atmosphere. Such events pose non-negligible risks to human health and to safety critical electronics, particularly in aviation and high altitude operations. Yet, operational decision-making still relies on conservative models without any in-situ measurements.

Here we report the most comprehensive airborne atmospheric radiation dataset ever obtained during a GLE, combining newly developed instruments operating simultaneously at ground level, on trans Atlantic commercial aircraft, and on high altitude balloons launched from the UK and the Netherlands, reaching altitudes up to 106,000 ft. Despite GLE77 being modest compared with historic events, our measurements reveal clear, statistically significant radiation enhancements across the full altitude range.

We will present: (i) an overview of the instrument suite, (ii) altitude resolved dose and dose rate profiles, and (iii) comparison to the ICAO radiation thresholds and the warnings issued at the time. A key result is that, had existing ICAO guidance been applied to our measured dose rates, radiation advisories should have been issued—moderate at typical cruise altitudes and severe at higher altitudes—yet no warnings were triggered in real time.

These findings provide a unique, data driven test of current space weather radiation risk frameworks, expose critical gaps in alerting, and demonstrate the value of coordinated international campaigns for capturing rare events. We will conclude by outlining how this dataset can be used to improve forecasting, validation of transport models, and evidence based thresholds for future global aviation radiation warnings.

POSTER CODE: P1PL104

Title
LESSONS LEARNT FROM GLE77 AND IMPLICATIONS FOR RADIATION SCALES, ALERTS AND ACTIONS

Authors
Clive Dyer [1], Keith Ryden [2], Fan Lei [2], Ben Clewer [2], Fraser Baird [2], Chris Davis [2]

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Body
Atmospheric radiation gives single event effects(SEEs) in human cells, leading to increased cancer risks, and in microelectronics where effects range from bit-flips to burnouts. Major Ground Level Enhancements, such as GLE05, can increase rates at sea-level by a factor 50 and at 40000 feet by a factor 1000, while events identified in cosmogenic nuclides could increase rates a further factor of 100. The need to control human exposure and malfunctions in avionics has led to several attempts to provide scales and warning levels. The response of avionics to GLEs is unknown but significant problems have been observed in quiet time; e.g. the recent groundings by Airbus. On 11November 2025, an X-flare was immediately followed by a rapid increase in neutron monitors worldwide. Increases at high latitude ranged from 150% to 20% showing a high degree of anisotropy. No ICAO alerts were given but in the UK we responded rapidly with balloon flights and were also able to collect data from later in the event on two transatlantic flights. Details and comparison with models are given elsewhere. The lack of alerts illustrates problems with current procedures, particularly for such anisotropic events, which are often the most intense. An initial spike of radiation arrives in an hour or less and the most intense locations are determined by the connectivity to the solar active region via the variable interplanetary and geomagnetic fields. Although GLE77 was about a factor 40 less than GLE05, the evidence is that it was certainly above ICAO MOD levels and probably above SEV levels for a significant number of flights. Problems of inadequate numbers of reliable neutron monitors, difficulties in modelling anisotropies and the importance of heavy ions have been identified and must be addressed in ongoing research. Of key importance is the need for flights of monitors and their use onboard with visibility to the pilot is arguably the best solution for allowing avoidance action being taken.

POSTER CODE: P1PL105

Title
OPERATIONAL FORECASTING AT MOSWOC

Authors
Kirk Waite [1], Krista Hammond [1]

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Body
Since 2014, the Met Office Space Weather Operations Centre (MOSWOC) has provided a 24/7 space weather forecasting service for a range of critical sectors. In this session, we will present an overview of our forecasting process. We shall show the evolution from the initial analysis using our existing observational and forecast model capability, through to how we used this to inform and engage with key customers and stakeholders across a range of sectors, and how we were able to effectively communicate the risks and potential impacts of the event. We shall also discuss what developments would lead to improvements in our forecasting process in the coming years.

POSTER CODE: P1PL106

Title
THE MAY 2024 GEOMAGNETIC STORM: UK EXPERIENCE AND PERSPECTIVE

Authors
Richard Horne [1]

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Body
The May 2024 geomagnetic storm was the largest for over 20 years. The storm was categorized as a ‘low-level’ G5, where G5 is the highest on the National Oceanic and Atmospheric Administration (NOAA) scale for geomagnetic storms, yet the individual solar eruptive events were not particularly severe, and the observed impacts were relatively minor. The impacts that were observed were due to the combined and sustained effect of five successive earthward-directed coronal mass ejections (CMEs) which drove the storm. The event exposed the weakness of the current storm classification system which does not discriminate between low impact and high impact G5 events; it exercised the UK Met Office forecasting system, communications and UK preparedness; and it highlighted key areas that need to be addressed, particularly relating to national power supplies, space traffic management, aviation, forecasting and data gaps. Here, we set out what happened, record some of the key impacts, discuss what went well and what needs to be improved. We make 14 recommendations relevant to four government departments, so that the UK can be better prepared for a low-probability, high-impact space weather event described in the reasonable worst-case scenario that informs the national risk register.

POSTER CODE: P1PL107

Title
RECENT MULTI-CME SOLAR ENERGETIC PARTICLE EVENTS IN NOVEMBER 2025

Authors
Junxiang Hu [1,2], Nariaki Nitta [3], Meng Jin [3], Claudio Corti [2,4], Clayton Allison [5]

Affiliations
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Body
The recent November 11, 2025 event (GLE #77) is an extreme SEP event associated with multiple CMEs and Energetic Storm Particles (ESP) phases. This GLE event showed a very hard spectrum with a strong ESP phase that was observed even at >500 MeV. It's an interesting case study for examining how multiple CMEs interact and shape complex SEP intensity profiles.
Here we showcase the real-time prediction results for this event from the operational iPATH pipeline hosted by NASA CCMC and discuss the challenges of space weather forecasting during periods when multiple CMEs occur in quick succession. We will then present a fine-tuned retrospective simulation for this series of SEP events, emphasizing reconstruction of the ESP features. We will explore whether the succeeding CME could enhance the preceding CME's ESP phase.

POSTER CODE: P1PL108

Title

CORONAGRAPH AVAILABILITY AND ITS IMPACTS ON REAL-TIME SPACE WEATHER ANALYSIS BY THE MOON TO MARS SPACE WEATHER ANALYSIS OFFICE DURING SIGNIFICANT PERIODS OF SOLAR CYCLE 25

Authors

Anthony Iampietro [1], Madeleine Anastopulos [2], Mary Aronne [1], Anna Chulaki [3], Elizabeth Juelfs [1], Melissa Kane [3], Teresa Nieves-Chinchilla [4], Mary Pasanen [1], Michelangelo Romano [4], Alex Young [4]

Affiliations

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Body

Through the maximum of Solar Cycle 25, the space weather community has observed several intense space weather events including periods in May and October 2024, November 2025, and January 2026, as well as the launch of high-profile missions including Artemis II and the Nancy Grace Roman Space Telescope. The Moon to Mars Space Weather Analysis Office (M2M SWAO) at NASA Goddard Space Flight Center (GSFC) provides a nominal 14-15 hours of direct space weather analysis 360 degrees around the heliosphere each day, including overnight review to monitor all space weather events, with the ability to transition to full 24/7 support for special mission support. In this poster we review the availability of coronagraph imagery from SOHO LASCO C2 and C3, STEREO A COR2, and GOES CCOR-1 and the impact it had on real-time analysis by M2M SWAO, looking back at the analysis of coronal mass ejections in real-time during these high activity periods and high-profile missions. We present our findings on how operations were delayed or affected by nominal and non-nominal conditions such as outages, data quality of available imagery, and any CME-specific observational difficulties. This is accomplished partially via the in-development CorViD tool (Coronagraph Visualizer of Downlinks) by M2M SWAO, which aims to track and record the availability of coronagraph imagery as received by M2M SWAO and its impact on the office's CME analysis in real-time.

POSTER CODE: P1PL110

Title
RELIABLE ICAO SPACE WEATHER ADVISORIES FOR AVIATION

Authors
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Body
Recent severe space-weather events have highlighted operational challenges in the provision and use of ICAO space-weather (SWx) advisories. This poster considers the relevance of radiation, HF-communication and GNSS impacts for aviation operations and decision-making.
Although ICAO SWx advisories are issued in a common format, their operational basis, regional coverage and interpretation can vary. This may affect the consistency, timeliness and practical value of information available to aviation users, especially during complex or rapidly evolving events.
Using the Nov. 11 / 12 , 2025, radiation event as an example, the poster reflects broader lessons from operational experience. Effective SWx services require more than scientific detection and forecasting. It is indispensible, a requirement, that they include clear, timely and actionable guidance that is perceived as consistant and reliable across the aviation system.
Further progress will depend on improved consistency between service providers, stronger observational and verification capabilities, and closer engagement with operational users. These measures can help ensure that ICAO SWx advisories become more reliable, trusted and useful in managing space-weather risks to aviation.

POSTER CODE: P1PL111

Title

IMPACT OF CY25 MAJOR GEOMAGNETIC STORMS ON DORIS OPERATIONS, PRECISE ORBIT DETERMINATION AND DATA QUALITY

Authors

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Affiliations

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Body

The four major solar geomagnetic storms of Solar Cycle 25 were analyzed to assess their impact on the DORIS system. This system, which is to date flying on 10 civilian satellites and was developed by the French Space Agency (CNES) and the French National Institute of Geographic and Forest Information (IGN), allows to provide accurate position of the satellites in near-real time and very precise orbits at a few days horizon. The analyzed events occurred in May 2024, October 2024, November 2025 and January 2026. After a brief description of the storms' origin, the adjusted and predicted orbit errors are evaluated for each event, compared to the usual case. The Impact on the satellites' altitude decrease is also displayed, showing that such events trigger operations (orbital maneuvers) to maintain the satellite into its nominal mission range. Besides, major storms generate high-rate variations in the ionosphere content at high latitudes, known as scintillations. This phenomenon may degrade the DORIS data quality as it is based on Doppler measurements of radio signals at 400 MHz and 2GHz.

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION PLENARY 2

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2PL202

Title
SONATA: An Analog Ensemble Tool for Probabilistic Forecasting of Radiation Belt Enhancements Using Ground-Based Geomagnetic Indices

Authors
Guillerme Bernoux [1], Vincent Maget [1], Gautier Nguyen [1], Antoine Brunet [1], Nour Dahmen [1]

Affiliations
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Body
Radiation belt (RB) electron enhancement events pose a severe threat to spacecraft. Yet, the period of greatest operational vulnerability may occur days after a geomagnetic storm begins. Although physics-based models can capture this evolution, they have limited near-real-time capabilities without promptly available drivers. This is a critical limitation, as solar-wind monitors may be absent or delayed during extreme events. To address this gap, we present a probabilistic analog ensemble method that forecasts RB enhancement event evolution once it is detected, that relies solely on promptly available ground-based geomagnetic indices.
The method identifies past events with similar driving conditions and uses them to predict current conditions. Then, it uses a long-term offline simulation, made using ONERA's Salammbô radiation belt model, to create a probabilistic scenario. This ensemble outperforms baselines such as persistence and 27-day recurrence. Performance is evaluated by assessing storm-type classification, lead-time resolved skill analysis, and flux forecast validation.
The method is implemented in SONATA (Space-weather Operational forecasting & Nowcasting using Analog ensembles of Time-series Archives), a Python package developed at ONERA. SONATA covers the full pipeline from ground-based index ingestion through analog search and Salammbô flux integration. It provides configurable similarity measures, PCA reduction, automatic cause-labeled physical-scenario construction, a probabilistic and categorical verification suite, and xarray/netCDF output for direct integration into operational workflows. SONATA is currently internal software but will be released publicly.
This approach provides a simple, interpretable, and ground-data-only forecasting tool. Rather than black-box predictions, it yields dated, probabilistic physical scenarios. This empowers satellite operators to cross-reference forecasts against anomaly databases and make informed, risk-aware decisions.

Keywords: analog ensemble,radiation belt,scenario forecast,R2O,ground-based data

POSTER CODE: P2PL203

Title
Operational 1-Minute Geomagnetic Kp Index Nowcasting for Space Weather Monitoring Using Genetic Algorithms

Authors
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Body
Geomagnetic storms are large-scale disturbances of Earth's magnetosphere driven by the efficient transfer of energy from the solar wind into the geospace environment. The planetary Kp index is one of the primary indicators used to characterize and monitor this activity. However, the official Kp index is provided only at 3-hour intervals, limiting its ability to resolve rapid geomagnetic variations triggered by dynamic solar wind conditions. In this work, we present an empirical model to estimate the Kp index at a 1-minute temporal resolution using solar wind measurements from the Sun–Earth L1 Lagrange point. The optimization is powered by the Pikaia genetic algorithm, employing crossover, elitism, and adaptive mutation. Evaluated within the EMBRACE/INPE framework to assess operational applicability, the model achieves an 80% success rate for disturbed conditions (Kp > 4) within an absolute tolerance of +/- 1. These results demonstrate that the proposed approach effectively reproduces short-timescale variations and 3-hours nowcast in geomagnetic activity. Operating with near-real-time solar wind data, the system is well-suited for operational space weather monitoring and serves as a robust baseline for future geomagnetic forecasting applications.

Keywords: Space Weather,Kp index,Nowcast

POSTER CODE: P2PL204

Title
SIDC Perspective on Operational Space Weather Prediction: Event-Chain Catalogues and R2O2R

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Body
Operational space weather prediction requires more than just better models or new AI methods. For these developments to improve real-time forecasting, they must be tested against past events, understood by forecasters, integrated into operational workflows, and evaluated against user needs.

From the perspective of STCE/SIDC at the Royal Observatory of Belgium, this contribution will focus on the operational implementation of new prediction capabilities through a Research-to-Operations-to-Research (R2O2R) framework. In practice, this means looking not only at how research results can enter operations, but also at how operational experience can identify what research should address next. Missed events, false alarms, uncertain forecasts, data gaps, and user feedback are not only operational problems. They are also essential inputs for scientific improvement.

A central point we will discuss is the use of event catalogues, forecast archives, validation datasets, and operational logs to better understand the full Sun-to-impact chain. Linking solar source regions, flares, CMEs, SEPs, heliospheric propagation, geospace responses, forecast decisions, observed impacts, and user feedback can help identify where prediction succeeds, where it fails, and why. Such catalogues are therefore not only records of past activity, but also tools for validation, model comparison, forecaster training, and operational learning.

The contribution will also discuss how AI, data-driven tools, and physics-based models can support forecasting, as long as their limitations are understood and their outputs can be be used in real time by forecasters.

The aim is to show how event-chain analysis can strengthen the loop between science, operations, and users, and help future space weather prediction systems become more useful, reliable, and operationally relevant.

Keywords: Research-to-Operations,Operations-to-Research,Space Weather Operation

POSTER CODE: P2PL205

Title
Space Weather Retro-forecasting Study Using Wide-Field Imaging from NASA's PUNCH Mission to Track Halo CMEs

Authors
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Body
NASA's PUNCH mission, the Polarimeter to Unify the Corona and Heliosphere, is a constellation of four satellites in low Earth orbit that function as a single 'ultra-coronagraph' with a FOV extending from 6 solar radii to 45° from the Sun. This permits wide-field tracking of halo CMEs over most of their trajectory from Sun to Earth. We report on an analysis of multiple such CMEs with an eye toward space weather forecasting. We find that the wide-field images, coupled with even a crude geometric model, yield arrival time forecasts that are significantly improved from the state of the art. Initial retro-forecasting results, using manual rotoscoping and a 'ludicrous ice cream cone' three-parameter geometry, suggest ±30 minute arrival time accuracy based on image data acquired up to 8 hours before CME arrival.

Keywords: Coronal Mass Ejections,Forecasting,Imaging,Data,PUNCH mission

POSTER CODE: P2PL206

Title
Improving CME Arrival Forecasting via Wide-field Imaging with PUNCH

Authors
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Body
We report on a retro-forecast study of several halo CMEs observed and tracked in visible light, with the Polarimeter to Unify the Corona and Heliosphere (PUNCH) . Comprising four coordinated, synchronized spacecraft in Low Earth Orbit, PUNCH acts as a single ultra-wide-field coronagraph with an inner field-of-view radius of 6 solar radii and an outer field-of-view radius over 45 degrees from the center of the Sun. This affords tracking CME progress across nearly the entire inner solar system, and therefore provides opportunities to refine arrival-time forecasts as the CME propagates. We demonstrate order-of-magnitude improvements in arrival time forecasting: from ~5-7 hour typical error using current methodologies and extrapolation from the coronagraphic field of view (<7.5° from the Sun) to <30 minute error using crude geometric modeling, simple constant-velocity extrapolation, and continuous refinement from the tracking data as the CME propagates.

This result demonstrates the importance of wide-field imaging to future forecasting strategies. PUNCH is a scientific mission that is not optimized for low latency operation. However, (a) PUNCH could be operated with latency of order 1-2 hours rather than its current as-operated latency of up to 24 hours; and (b) future missions designed specifically for low latency could realize in real-time the improvements demonstrated by these retro-forecasting studies.

Keywords: CME,forecasting,propagation,imaging,data

POSTER CODE: P2PL207

Title
Forecasting Solar Wind at Earth up to Seven Days Ahead from a Three-Day Look-Back of the Backmapped HUXt Boundary

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Body
Operational forecasts of the near-Earth solar wind typically couple a coronal model to a three-dimensional magnetohydrodynamic (MHD) heliospheric code such as ENLIL or EUHFORIA. Although physically comprehensive, these systems are computationally costly, which limits real-time operation and rapid coronal mass ejection (CME) scenario studies. The reduced-physics HUXt model (Heliospheric Upwind Extrapolation with time dependence) runs in seconds, but its accuracy depends on a realistic inner boundary at 30 solar radii.

We derive this boundary directly from in-situ OMNI observations at 1 AU. Following the inverse back-mapping of Owens et al. (2026), measurements are mapped inward to 30 Rs and extended to full longitudinal coverage by corotation back in time. A compact transformer (~860,000 parameters) then reads the three most recent daily longitude profiles and predicts the full 30 Rs boundary at the forecast time, learning the ~27-day recurrence of coronal-hole streams from the solar wind alone. Neither magnetograms nor coronal-model output are required.

Because all inputs lie strictly in the past, one architecture addresses any forecast horizon by translating its input window. Over 1996-2025 (Solar Cycles 23-25), forward HUXt propagation to 1 AU yields RMSE 66.1 km/s (correlation 0.73) at a five-day lead and 68.2 km/s (0.71) at seven days, so two extra days of warning cost about 2 km/s. Despite this longer lead, these values match or beat published 1 AU forecasts (Ahn et al. 2025 3-day 68.6; Collin et al. 2025 4-day 68.1; WSA-ENLIL 116.3 km/s).

Unlike black-box models that only output a time series, our model predicts a physical heliospheric boundary. This allows CMEs to be injected directly into HUXt, delivering CME-ready forecasts using only a fraction of the computing power required by full 3-D MHD models.

This work was supported by the Russian Science Foundation under grant no. 26-12-00070

Keywords: Corona,Solar wind,Space weather forecast,Machine learning

POSTER CODE: P2PL210

Title
A learning-based representation of the photospheric magnetic geometry of solar active regions : application to polarity maps and inversion lines

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Body
In this exploratory study, we aim to discover typical behaviours in the long term evolution of active regions (AR). Such behaviours might indicate whether active regions may produce solar flare or CMEs. Current prediction methods mostly use only a few observations of an active region to predict its likelihood of flare/CME production. We propose a new abstract and simplified representation space of selected AR properties, in which to search for typical evolution trajectories. This space is built using unsupervised manifold learning, from magnetic and morphological properties.

An example of such properties is the polarity inversion lines (PIL), which are related to filaments and eruptions. On this occasion, we present a new method to extract PILs. It combines previous approaches based on morphological cues and strong gradient. It avoids the fragmented segments which increase artificially the complexity of the PIL as in existing methods.

We propose an example of AR representation based on PILs and polarity maps. Future works may investigate the most informative combination of input AR properties towards more significant trajectories. Physical interpretability of this representation will also require investigation.

Keywords: Active regions,Machine learning,Polarity inversion lines,Learnt representation

POSTER CODE: P2PL211

Title
Deep-learning-based single-source multi-perspective coronagraphy (SSMPC) for coronal mass ejections

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Body
The three-dimensional structure of coronal mass ejections (CMEs) critically governs their propagation and geoeffectiveness, but remains poorly constrained because coronagraphs near the Sun–Earth line record only a projected view of an intrinsically three-dimensional phenomenon. At present, no spacecraft provides a long-term, stable vantage point at the L4 or L5 Lagrange points, so this gap in stereoscopic coverage persists. Here we introduce a deep-learning-based single-source multi-perspective coronagraphy (SSMPC) technique, trained on temporally matched observations from the Solar and Heliospheric Observatory (SOHO) and the Solar TErrestrial RElations Observatory (STEREO), that synthesizes L4- and L5-viewpoint coronagraph images from single-viewpoint observations acquired near Earth. The synthesized images reproduce the leading edge, angular extent, and dominant brightness distribution of CMEs and, when combined with an observed lateral view, enable three-dimensional reconstructions that closely match those obtained from two actual spacecraft. This approach demonstrates that physically consistent stereoscopic constraints can be derived from an existing single-viewpoint archive, offering an immediate, low-cost complement to future L4/L5 missions and a practical basis for three-dimensional CME characterization in operational space-weather forecasting.

Keywords: Corona Mass Ejection,3D Reconstruction,Deep Learning

POSTER CODE: P2PL212

Title
Design and Benchmarking of an Onboard AI for Multi-Wavelength Solar Structure Segmentation

Authors
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Body
Accurate segmentation of key solar structures, including active regions, coronal holes, and filaments, is essential for understanding eruptive events and high-speed streams, and thus improving space weather forecasting. However, current deep learning approaches remain limited by their inability to perform multi-label and multi-wavelength segmentation jointly, their poor performance on filament detection, and their high computational cost, which prevents deployment on spacecraft. This work addresses these limitations by developing lightweight deep learning models for the segmentation of active regions, coronal holes, and filaments in extreme ultraviolet images. By extending existing datasets and combining them with our newly created filament dataset, we developed a robust multi-wavelength, multi-label dataset. Using the nnU-Net framework, a self-adaptable U-Net-based segmentation scheme, various settings and strategies were evaluated, resulting in ultralight multi-class multi-wavelength U-Net models up to 61 times smaller than similar state-of-the-art U-Net-based solar segmentation frameworks such as SCSS-Ne. Following hardware-oriented optimization, the best model was deployed on an AMD DPU integrated into the ZCU104 FPGA, achieving a 47-fold inference speedup and a 10-fold decrease in energy consumption compared to the ARM Cortex-A53 CPU. Validation on the Community dataset demonstrated a 95% coronal hole detection rate at a 1% false positive level, representing a substantial reduction in false positives while maintaining a high detection rate compared to existing approaches. Additionally, a case study of a filament eruption, solar flare, and coronal mass ejection confirmed successful segmentation and detection of the complex solar structures. These results demonstrate the feasibility of accurate, real-time, energy-efficient onboard solar image segmentation for the successors of the VIGIL mission and future space weather monitoring missions.

Keywords: Active region,Coronal Hole,Filament,Artificial intelligence: U-net,onboard implementation

POSTER CODE: P2PL213

Title
AI for Space Weather and Ionospheric Forecasting: Current Progress and Future Challenges

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Body
As the space weather community is embracing the era of AI new questions emerge related to this data-driven modeling approach in terms of capabilities (e.g. forecasting, automatic event classification, among many more), evaluation, benchmarking and explainability. Moreover, fair comparison with other modeling approaches is essential for understanding the true scope and limitations of these emerging algorithms, while the implementation of hybrid models further expands the potential applications of AI in space weather. Even more, the operative side of the space weather community requires a discussion regarding technical capabilities, availability and tools from the data management to actual decision making aided by AI-based-modelling. This end-to-end pipeline should also include discussion on the role of training and capacity building as part of the cost associated with the pipeline.

Impact of space weather into the ionosphere can be critical for many applications related to telecommunications and satellite navigation. In this context, and with the scope of producing accurate and yet robust forecasting models, the ionospheric community has achieved promising results as well as new associated challenges. In this talk, I will present the latest results from our group, together with recent advances reported in the literature, and discuss future perspectives and research directions in ionospheric and space weather studies using AI techniques.

Keywords: Artificial Intelligence,Ionospherric Physiscs,Space Weather,Machine Learning,Data-driven modelling

POSTER CODE: P2PL214

Title
JHelioviewer - A versatile tool for solar data visualisation and science planning

Authors
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Body
JHelioviewer is a visualisation tool for solar and heliospheric data, developed as part of the open source ESA/NASA Helioviewer Project and increasingly used for space weather assessments. It allows users to browse petabyte-scale image repositories from numerous space missions and ground-based observatories, alongside time series of in situ heliospheric data, event lists, and magnetic field models. JHelioviewer has also become a key tool for Solar Orbiter science operations planning. In this poster, we present usage examples together with recent functionality upgrades, including new projection modes, an interface for visualising heliocentric 3D data, and enhanced customisation options.

Keywords: data visualisation,science operations,Sun,heliosphere,forecasting

POSTER CODE: P2PL216

Title
Automated Detection of Solar EUV Brightenings and Coronal Dimmings Using Density-Based Clustering

Authors
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Body
Timely identification of low-coronal signatures can support the early recognition and source localisation of coronal mass ejections (CMEs), with potential applications in space-weather monitoring.
We developed an automated pipeline for detecting EUV brightenings and coronal dimmings in full-disc observations from the Solar Ultraviolet Imager (SUVI) aboard the GOES-R satellites. Images acquired in the 131 Å and 195 Å passbands are spatially decomposed and thresholded based on the intensity, from which significant intensity variations are selected and grouped using density-based clustering techniques. Brightening detection was evaluated against the GOES soft X-ray flare catalogue using observations collected during May and June 2024. Different spectral configurations, temporal windows, feature sets, and clustering methods were compared to identify a suitable processing strategy.
The results show that the 131 Å passband is particularly effective for detecting flare-related brightenings, whereas combining multiple passbands does not substantially improve their identification. The clustering methods examined provide broadly comparable performance, although they differ in computational complexity and susceptibility to producing multiple detections. A preliminary assessment of coronal dimming detection indicates that the 195 Å passband offers a more reliable response to intensity decreases and fewer spurious detections.
These findings support a two-stage approach in which automatically detected EUV brightenings are subsequently examined for spatially and temporally associated dimmings, providing an additional indicator of potentially CME-related eruptive activity.

Keywords: SOLAR FLARES,CORONAL DIMMINGS,EUV DATA,UNSUPERVISED MACHINE LEARNING,DENSITY BASED CLUSTERING

POSTER CODE: P2PL217

Title
Machine Learning insights into the relationship between coronal mass ejection kinematics and solar energetic particle events

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Body
The Sun’s atmosphere is a highly dynamic environment in which eruptive events such as coronal mass ejections (CMEs) can expel large amounts of magnetized plasma into interplanetary space. These eruptions are frequently associated with the rapid acceleration of charged particles, producing solar energetic particle (SEP) events detectable throughout the heliosphere. Identifying which CMEs are likely to generate SEPs remains a key challenge for improving Space Weather forecasting and mitigating risks to spacecraft and human exploration.
In this study, we investigate the relationship between the three-dimensional (3D) properties of CMEs and the characteristics of associated SEP events by combining multi-spacecraft observations with machine learning techniques. We use observations from the SOHO and STEREO missions to reconstruct the 3D morphology and kinematics of CMEs, and we associate these with SEP measurements across the inner heliosphere, including data from MESSENGER, STEREO, and ACE during the period 2010–2015.
We analyze the early 3D kinematic evolution of CMEs and their associated waves, deriving key morphological (e.g., size) and dynamical parameters, such as radial and lateral expansion speeds and acceleration. These properties are compared with SEP characteristics, including peak intensities, timing, energy distributions (electrons and protons), and longitudinal extent. Machine learning models are employed to uncover underlying relationships, while feature-importance and interpretability analyses identify the most relevant CME and shock parameters driving SEP acceleration.
Our preliminary results highlight the critical role of CME lateral expansion and early kinematics in shaping SEP event properties. These findings contribute to a better physical understanding of SEP generation and provide valuable insights for the development of predictive models in Space Weather research, with comparisons to previous studies discussed.

Keywords: SOLAR ENERGETIC PARTICLES,CORONAL MASS EJECTIONS,CORRELATIONS,MACHINE LEARNING,LATERAL EXPANSION

POSTER CODE: P2PL218

Title
Space Weather Research Activities at Ruhr University Bochum

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Body
We present an overview of space weather research activities currently pursued at Ruhr University Bochum (RUB), where we increasingly connect our work on fundamental plasma physics problems across the Sun–Earth chain to space weather applications.
Along the heliospheric leg, we model the solar wind with self-consistently co-evolved turbulence transport, study CME propagation and geoeffectiveness, including the turbulent sheath ahead of the CME, and follow energetic particle propagation and shock acceleration through the heliosphere, including the superdiffusive regime that intermittent fields produce.
In the near-Earth environment, we work on turbulence and instabilities in the magnetosheath, magnetic reconnection and energy conversion, dipolarization fronts, and the dynamics of the magnetospheric system, in support of Plasma Observatory.
A parallel, long-standing effort is directed at developing and testing computational methods suited to the multi-scale, collisionless nature of these plasmas: semi-implicit and explicit numerical schemes, advanced particle-in-cell approaches, asymptotic-preserving MHD/5-moment coupling, and machine-learning-based closure models. Machine learning enters again in forecasting from solar images and in clustering observations and simulations, with several models now deployed on the RUB space weather portal.

Keywords: sun-earth chain,solar wind,magnetosphere,computational methods

POSTER CODE: P2PL220

Title
Forecast of SYM-H Index Under Strong Southward IMF Bz Condition by Deep Learning

Authors
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Body
In this study, we propose a deep learning model to forecast the SYM-H index up to 12 hours ahead under strong southward interplanetary magnetic field (IMF) Bz conditions (Bz -3nT for at least 6 hours), which is well-known as the main driver of geomagnetic storms. The input data consist of 5-min resolution solar wind parameters (IMF components, solar wind speed, density, dynamic pressure, and electric field) from OMNIWeb, averaged over 30-minute intervals, with a 12-hour lookback window. Our proposed model adopts a multi-layer perceptron-based encoder-decoder architecture following the Time-series Dense Encoder (TiDE) framework. Our results are as follows. First, our model achieves comparable or better performance in terms of RMSE and correlation coefficient relative to previous Dst and SYM-H prediction models. Second, our model successfully predicts the minimum SYM-H value and its timing within the 12-hour forecast window. Third, we demonstrate that the model produces reliable SYM-H forecast profiles during storm periods or even beyond the strict southward Bz criterion used for training. To our knowledge, this is the first study to forecast a geomagnetic index under strong IMF southward conditions, which is under an explicit condition on the state of the primary storm driver, and we expect that this approach can serve as a useful tool for space weather forecasting.

Keywords: Space weather,Geomagnetic storm,Deep learning

POSTER CODE: P2PL222

Title
SPEADIT – Space Domain Enhanced Awareness With Digital Twin

Authors
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Body
Over the last decade, the number of active and passive objects in orbit has increased significantly, making accurate modelling essential for predicting the evolution of the space environment. Although Space Traffic Management (STM) tools provide a framework for monitoring, tracking, and characterising objects in orbit, the space environment is strongly influenced by artificial and natural phenomena, including Space Weather (SW) events, which can increase orbital perturbations and the risk of impacts with critical space assets. Accurate prediction is therefore essential to prevent future losses.

The SPEADIT (Space Domain Enhanced Awareness with Digital Twin) project aims to develop a unified Decision Support System (DSS) by integrating Digital Twin (DT) modelling with Artificial Intelligence and Machine Learning (AI/ML). It addresses two complementary use cases, SW and STM, helping users identify and prioritise potentially critical situations, assess emerging hazards, and select appropriate mitigation measures.

To achieve this, SPEADIT combines data from multi-domain sensor networks in an agnostic way, promoting interoperability across different systems and data sources. This enables high-fidelity, real-time prediction of SW events and their impact on STM, together with the consequent evolution of orbital assets. In addition, data-driven and physics-based approaches are coupled through AI/ML to assess the potential impact of different threats on space-based and ground-based assets.

As a result, the system supports reconstructing past scenarios, analysing environmental evolution, predicting future conditions, and identifying potential Courses of Action to mitigate possible threats. By combining DT with AI/ML and SW analysis with STM, SPEADIT strengthens Space Domain Awareness capabilities and enables more effective and resilient decision-making.

Keywords: Digital Twin,AI/ML,Physical models,Operations,Space Domain Awareness

POSTER CODE: P2PL223

Title
Learning and propagating solar-wind forecast errors to extend cold forecast skill

Authors
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Body
Accurate forecasting of near-Earth ambient solar-wind conditions is essential to current space weather operations as it provides background conditions for the propagation and temporal evolution predicting the most severe hazards (i.e. solar transients like coronal mass ejections). However, given the dynamic nature of the system, such modelling suffers from systematic forecast errors. Here we present a novel data-assimilation-in-the-loop (DAITL) residual state forecasting framework to improve current reduced physics solar wind propagation models (e.g., HUXt). We show that a substantial fraction of the forecast error is systematic, persistent and predictable and can be represented as a time-evolving forecast-error correction. By analysing 63 observer cases (21 Carrington rotations x 3 observers; ACE, STEREO A/B), we demonstrate that the DAITL framework robustly improves forecast skill beyond the 24-hr assimilation window (i.e., skill retained during the 48-hr cold forecast). The additional forecast skill provided by the residual state decays with a characteristic memory timescale of ~18-hr, providing a quantitative diagnostic of the temporal persistence of predictable propagation model errors. We conclude that our computationally efficient DAITL framework will complement current forecast operations and has the potential to be extended to the full range of solar wind variables.

Keywords: data assimilation,ambient solar wind,forecasting,artificial intelligence

POSTER CODE: P2PL224

Title
Storm-time Dst forecast: An innovative approach

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Body
A reliable long term space weather forecast of geomagnetic storms for 3 days or longer is critical for safe operation of national and commercial assets in space. Dst and Kp are the two of the most used indices for storm monitoring and serve as inputs of many space weather models. However, the current state of the art Dst or Kp forecast models (mostly machine learning algorithms) can only provide good storm-time prediction for a few hours. Here we report a physics-based pattern recognition algorithm to predict storm-time Dst evolution from 1 hour to ~4.5 days ahead of the time of the latest observed Dst. The algorithm just needs a few observed Dst data. It has been tested for a few isolated storms and shows a good agreement between predicted and observed Dst with correlation coefficients up to ~0.9 and errors as low as ~5-10 nT. This indicates that the algorithm is feasible and reliable. We also identified some caveats and improvements for our future work, such as predicting storm-time storms and determining the conditions for storm watch, alert and warning.

Keywords: Dst index forecast,space weather,pattern recognition,geomagnetic storm,Physics-constrained model

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SCL1

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2SCL102

Title
Solar Variability Reconstruction between 15 and 9 ka BP: A Multi-Radionuclide Approach

Authors
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Body
Understanding long-term solar variability requires extending activity records well beyond the era of direct observations. Cosmogenic isotopes preserved in natural archives provide a powerful means to reconstruct solar activity over millennia. However, existing reconstructions of solar modulation and analyses of solar cycles based on cosmogenic isotopes have so far been limited to the last 9 ka, leaving earlier periods largely unexplored. Here, for the first time, we extend solar activity reconstructions further back in time, targeting the 15–9 ka BP interval, based on new 10Be and 36Cl measurements from the Talos Dome ice core (East Antarctica). We compare these records with existing tree rings 14C data, taking advantage of their high temporal resolution and absolute dating while avoiding the smoothing effects of the carbon cycle.

A particular focus is placed on the 14.6–13.4 ka BP period, for which we achieve a mean resolution of 7 years for 10Be and 20 years for 36Cl. This high-resolution window allows us to examine the solar condition during this millennium, including solar cycle amplitude and duration, as well as periods of solar maximum and minimum. Among other findings, our results confirm and refine a century-long enhancement in cosmogenic nuclide production, indicative of a Maunder-type grand solar minimum. This period appears synchronous with the Older Dryas climatic event, generally colder over Europe and Greenland.

More broadly, our results reveal a rich spectrum of solar variability, from individual cycle-scale fluctuations to longer-term modulation of activity levels, consistently identified across all cosmogenic isotope records. These findings contribute to a more physically grounded picture of solar variability on decadal, centennial, and millennial timescales, and provide a valuable reference framework for space climate studies.

Keywords: Cosmogenic isotopes,Ice cores,Deglaciation,Solar variability

POSTER CODE: P2SCL103

Title
DigiSun: A Standardized Tool and Uncertainty Budget for Long-Term Sunspot Drawing Analysis

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Body
Sunspot drawings are a unique source of information on the long-term evolution of solar magnetic activity. The Royal Observatory of Belgium (ROB) began such drawings around 1940 and continues them daily, building a collection spanning more than 80 years.
Full exploitation of this resource is limited by two factors: the lack of a fast, reliable, standardized tool for extracting sunspot parameters from drawings, and the absence of a rigorous uncertainty estimate, particularly for position calculations. A common analysis standard would ease processing, allow merging of homogeneous data across stations to fill single-site gaps, and support extension of the series using historical material. A robust uncertainty budget is essential for combining measurements from different drawing collections into consistent long-term records.
We address both issues. First, we present DigiSun, software developed by our team to measure ROB sunspot drawings and build a sunspot catalog. DigiSun computes a pixel-wise true area corrected for foreshortening, rather than a single centroid position as most existing tools do, yielding more precise area estimates. It also handles multiple drawing formats, enabling analysis of collections beyond ROB's own: used at Locarno (Specola Obs.) since 2019, and at Taipei and Kandilli since 2024, and applicable to historical drawings to extend parameter series further back.
Second, we present the first quantitative uncertainty budget for heliographic coordinates from visual sunspot drawings, based on a systematic survey of instrumental, observational, and processing error sources. Using the USET as a case study, we derive a cumulative estimate of total uncertainty in longitude and latitude.
Together, these contributions, a shareable, precise measurement tool and a quantified uncertainty framework, offer a path toward cross-calibrating heterogeneous sunspot drawing archives and integrating them into consistent, long-term reconstructions of solar activity.

Keywords: SUNSPOTS,Instrumental Effects,Instrumentation,Data Management

POSTER CODE: P2SCL105

Title
Long-Term Multi-Spectral Reconstruction of Solar Irradiance

Authors
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Body
Understanding solar irradiance variations on long-term time scales is essential for evaluating the natural forcing of the Earth's climate system. This contribution presents a consistent reconstruction of Total Solar Irradiance (TSI) based on the methodology established by Penza et al. (2024,2025), focusing on secular variability.
The proposed approach utilizes the open solar magnetic field, derived from cosmogenic isotope data, as a primary proxy for solar activity over extended periods.
By applying the Empirical Mode Decomposition algorithm, we isolate the low-frequency modulation that characterizes the evolution of grand solar minima.
Unlike models based solely on the distribution of Active Regions, this reconstruction highlights the added value of the small-scale magnetic network, which serves as a decisive factor in determining the magnitude of secular variability.
We extend this model to Solar Spectral Irradiance (SSI), covering a wide range from the ultraviolet (UV) to the infrared (IR). The UV band is fundamental for its role in the photochemical production and maintenance of the terrestrial ozone layer; despite its small contribution to total energy, it accounts for a significant fraction of total solar variability. Conversely, the IR band is vital for the Earth's thermal energy balance. Within this range, the region near 1600 nm holds particular physical significance as it corresponds to the minimum of solar atmospheric opacity. At this wavelength, we observe the deepest layers of the photosphere, where the contrast of magnetic features reaches its minimum, resulting in exceptionally low solar cycle variability.

Keywords: solar irradiance,Solar and Stellar Astrophysics

POSTER CODE: P2SCL106

Title
NSF - NOAA GONG: THE CONTINUING ROLE OF SCIENTISTS IN SUSTAINING THE GONG PROJECT

Authors
Luca Bertello [1], Sushanta Tripathy [1], Sanjay Gusain [1], Amr Hamada [1], Kiran Jain [1], Shukur Kholikov [1], Rudolf Komm [1], BiJi Lekshmi [1], Gordon Petrie [1], Alexei Pevtsov [1]

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Body
The National Science Foundation's (NSF) Global Oscillation Network Group (GONG) has provided continuous, long-term, full-disk observations of solar Doppler velocity, magnetic fields, H-alpha, and white-light intensity for decades. These observations are supported by well-established data processing pipelines that produce a wide range of science-ready data products. However, the availability of mature pipelines does not eliminate the need for scientific expertise. Scientists remain an essential component of GONG operations, providing the oversight needed to assess data quality, identify problems that may not be captured by automated procedures, and determine appropriate solutions when anomalies occur.
They also develop and implement improved instrument calibration and analysis methods as new scientific and operational needs arise. In addition, they develop novel concepts for future instrumentation, such as compact H-alpha spectroheliograph to enable Doppler observations of filament eruptions.
Maintaining consistency and reliability across a distributed observing network requires close interaction between scientists and operations personnel. This is particularly important when instruments are repaired, replaced, or upgraded, as changes to the hardware can affect the characteristics and continuity of the resulting data products.
Beyond operational support, scientists play a key role in demonstrating and expanding the scientific utility of GONG observations. Through targeted analyses and the development of new data products, they help maximize the value of the observations for space weather applications and for a broad range of solar physics research.In this presentation, we illustrate several examples that demonstrate how continued scientific involvement is essential not only for maintaining the quality and reliability of GONG data, but also for ensuring that the full scientific potential of the observations is realized.

Keywords: GONG PROJECT,SPACE WEATHER OPERATIONS

POSTER CODE: P2SCL107

Title
Long-term Solar Photospheric and Chromospheric Observations at Istanbul University Observatory

Authors
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Body
Istanbul University Observatory Research and Application Center has conducted systematic solar photospheric and chromospheric observations since 1945 as part of its long-term solar monitoring program. The observational archive currently preserves records dating back to approximately 1950, representing one of the long-standing regional solar datasets in Türkiye.
The archive includes full-disk solar observations obtained in both photospheric and chromospheric wavelengths, including ongoing H_alpha observations. These observations provide valuable information for investigating long-term solar variability, solar cycle evolution, active region development, filament activity, and changes in solar magnetic activity over decadal timescales.
In this study, we present an overview of the historical and ongoing solar observation program at Istanbul University Observatory together with the current status of the available archive. Representative examples from the observational material are presented, and ongoing efforts related to preservation, organization, and future digitization of the archive are discussed. The scientific potential of the dataset is evaluated in the context of long-term solar variability studies, including possible cross-calibration with other historical solar archives and future applications to solar activity reconstruction studies.
Istanbul University solar archive constitutes an important regional historical dataset and may contribute to international efforts focused on the preservation and scientific exploitation of long-term solar observations for studies of solar variability and space climate.

Keywords: Historical solar observations,Photospheric observations,Solar archive,Chromospheric observations,Solar activity

POSTER CODE: P2SCL108

Title
Constraining Secular Variability in Solar Irradiance

Authors
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Body
The Sun is Earth's primary external source of energy, making accurate long-term records of solar irradiance fundamental for understanding the climate system. Continuous measurements of total solar irradiance (TSI) have been available since 1978; however, these observations originate from multiple space-based instruments with relatively short operational lifetimes and significant inter-instrument discrepancies. Constructing a consistent long-term TSI record is therefore challenging and has led to the development of several composite datasets, which often imply conflicting secular trends between solar activity minima.

A variety of modelling approaches have been developed to reproduce and reconstruct solar irradiance over earlier periods. These models differ in their input data, assumptions, and treatment of solar magnetic features, and they rely on irradiance observations to varying degrees for calibration and validation. As a result, they can produce substantially different long-term irradiance trends. Reconciling the secular variability inferred from direct TSI measurements with that derived from irradiance reconstructions is therefore essential, particularly for improving our understanding of the Sun's role in driving climate variability on Earth.
I will provide an overview of the current understanding of long-term trends in direct solar irradiance measurements.

Keywords: Solar irradiance

POSTER CODE: P2SCL111

Title
Long Term Multi Solar Cycle Trend Analysis of foF2

Authors
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Body
The ionospheric critical frequency of the F2 layer (foF2) is arguably the most important parameter for high frequency (HF, 3-30 MHz) communications as it is a direct proxy for the amount of refraction one can expect an HF signal to experience enabling far beyond line of sight communication links. foF2 is defined as the maximum frequency that the ionosphere can support at a vertical incidence, and is usually measured by ionosondes. Long term trends in foF2 are of interest to HF operators when planning permanent deployments for communication links to ensure robust and cost-effective solutions. These trends can be investigated over multiple solar cycles using archives of ionosonde measurements dating back to the 1950s, or earlier in some cases. From this historical data one can investigate the relationship between foF2 and solar parameters and geomagnetic indices such as F10.7, DST, and AE. Using historical hand-scaled ionograms, it is possible to investigate if these correlations have changed over time, and if there exists a trend in foF2 independent of the solar cycle. As a result of this work a better understanding of the drivers of foF2 now and into the future can be gleaned to inform HF operators when considering deployments of communication systems. This work may also provide insight more widely into the dynamics of the ionosphere in the F-layer.

Keywords: foF2,High-Frequency Communications,Long Term Trend Analysis

POSTER CODE: P2SCL112

Title
Understanding the physics of early solar cycle prediction and predicting Cycle 26

Authors
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Body
The solar cycle is not regular. Its amplitude, in particular, displays a large variation, making the prediction of the next cycle challenging. After highlighting the various sources of fluctuations in the solar dynamo that cause variations in the solar cycle, I shall discuss the scope of solar cycle prediction using available data of solar magnetic field and sunspots. Using dynamo and surface flux transport simulations combined with observations, we show that a reasonable prediction of the amplitude of the next cycle is possible even 3-4 years before the solar minimum. We explore the physics behind this early prediction and also forecast the amplitude and its uncertainty of solar cycle 26.

Keywords: Solar cycle,Space climate prediction,Sunspots,Dynamo,Solar cycle prediction

POSTER CODE: P2SCL113

Title
Quasi-Biennial Oscillations and Rieger-Type Periodicities in a Babcock–Leighton Solar Dynamo: Generation and Possible Physical Origin

Authors
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Body
The Sun's magnetic field exhibits an approximately 11-year cycle, along with shorter periodicities such as quasi-biennial oscillations (QBOs) and Rieger-type periodicities. Although several mechanisms have been proposed to explain the origin of these periodicities, no single mechanism has gained widespread acceptance. We investigate whether a Babcock–Leighton dynamo can generate Rieger-type periodicities and quasi-biennial oscillations (QBOs), and explore their possible physical origins. We used the observationally guided 3D kinematic Babcock–Leighton dynamo model, which has emerged as a successful model for reproducing many characteristic features of the solar cycle. We used Morlet wavelet and global wavelet power spectrum (GWPS) techniques to analyze the data obtained from the model. In our model, we report QBOs and Rieger-type periods for the first time. Further, we investigated the individual Babcock–Leighton parameters (fluctuations in flux, latitude, time delay, and tilt scatter) role in the occurrence of QBOs and Rieger-type periods. We find that while fluctuations in the individual parameters of the Babcock–Leighton process can produce QBOs and Rieger-type periodicity, their occurrence probability is enhanced when considering combined fluctuations of all parameters in the Babcock–Leighton process. Finally, we find that with the increase in dynamo supercriticality, the model tends to suppress the generation of Rieger-type periodicity. Thus, our results support earlier studies suggesting that the solar dynamo operates in a weakly supercritical regime. The Babcock–Leighton dynamo model reproduces QBOs and Rieger-type periodicities consistent with those observed in various solar activity indices, demonstrating that these periodicities can naturally emerge from the dynamo process.

Keywords: dynamo,magnetic fields,oscillations,sunspots

POSTER CODE: P2SCL117

Title
Solar Cycle Reconstruction over the Past Nine Millennia

Authors
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Body
Satellite observations show that solar irradiance varies on timescales from minutes to decades, but this ~50-year record is too short to evaluate the Sun's impact on climate. While telescopic records provide a direct proxy of solar magnetic activity over about 400 years, reconstructions further back in time must rely on cosmogenic isotopes stored in terrestrial archives. However, these isotope records typically provide decadal resolution, while critical information about individual solar cycles is lost. Because the overall mean solar activity is linked to the strength and length of these cycles, we present a method to reconstruct individual solar cycles from decadal values. We first establish the relationships between decadal sunspot numbers and solar cycle parameters using direct observations from the telescopic era. After validating the method against known cycles, we apply these relationships to isotope-based sunspot numbers spanning the last 9000 years. This new reconstruction provides a critical input dataset for extending annually resolved solar irradiance records across the entire nine-millennia period.

Keywords: Sun activity,solar cycle,Cosmogenic isotopes

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SCL2

PASSI PERDUTI
Monday November 2: 15:15-16:30
Tuesday November 3: 10:00-11:15, 16:30-17:30

POSTER CODE: P1SCL201

Title
Reconstructing extreme solar particle events from radiocarbon signatures

Authors
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Body
Extreme solar particle events (ESPEs) are rare but potentially severe space-weather events that exceed the range of modern instrumental observations. Miyake events, observed as abrupt increases in tree-ring 14C, provide a unique opportunity to investigate the occurrence and characteristics of such extreme events over millennial timescales. However, interpreting these signals requires accounting for the rapid and spatially heterogeneous atmospheric production and transport of radiocarbon.

We present a new modelling approach based on the three-dimensional SOCOL:14C-Ex model, which explicitly describes 14C production by energetic solar particles and its subsequent atmospheric transport. The model was used to calculate the atmospheric response to a reference ESPE for different event dates, providing response functions that can be fitted directly to annual tree-ring Delta 14C records.

We apply this approach to seven prominent Miyake events spanning the past 14,000 years: AD 993, AD 774, 664 BC, 5260 BC, 5411 BC, 7177 BC, and 12,351 BC. For each event, the timing, strength, and background radiocarbon level are constrained simultaneously. Geomagnetic shielding and atmospheric CO2 variations are additionally considered when estimating the corresponding ESPE strengths.

The results confirm the 12,351 BC event as the strongest ESPE identified to date, while AD 774 remains the strongest event of the Holocene. The study demonstrates how dynamical atmospheric modelling can bridge cosmogenic-isotope observations and extreme solar activity, providing a new framework for investigating the frequency and characteristics of extreme space-weather events beyond the instrumental era.

Keywords: cosmogenic isotopes,ESPE,radiocarbon

POSTER CODE: P1SCL202

Title
Using Beryllium-7 cosmogenic radionuclide concentrations as a tracer of Es layer dynamic processes in connection with CIR/HSSWS-induced geomagnetic storms

Authors
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Body
Stronger solar activity can modulate galactic cosmic rays reaching the Earth, affecting the production of Beryllium-7 (Be-7) in the stratosphere and its subsequent downward transport.
Corotating Interaction Regions (CIRs) and High-Speed Solar Wind Streams (HSSWS) significantly perturb the ionosphere, altering electric fields and plasma dynamics in the ionosphere, influencing Es layer formation and behavior. Often causing Es layer formation (higher electron density, stronger critical frequency) during geomagnetic disturbances. We compare Be-7 concentrations during periods of strong solar and geomagnetic storms with periods of low solar activity in the longitudinal view in years 1986 – 2023.
We use radionuclide data (Be-7 in aerosols evaluated by the corresponding activity in aerosols on a weekly basis at the National Radiation Protection Institute Monitoring Section in Prague, Czechia) alongside ionospheric data (Es layers) to understand these interconnected space weather effects and atmospheric dynamics. Es layers, formed by dynamic processes, can influence atmospheric waves and vertical transport, potentially connecting upper atmosphere phenomena with atmospheric radionuclide levels in middle latitudes. The Be-7 concentrations are therefore a very promising indicator of the behavior of all atmospheric layers, including the mesospheric heights where the Es layer is located.

Keywords: Be-7 aerosol concentration,High-Speed Solar Wind Streams,Corotating Interaction Regions,Es-layer formation & behavior

POSTER CODE: P1SCL203

Title
From Large-Scale Structures to Turbulence: Advancing Virtual Spacecraft Diagnostics for Space Weather Forecasting

Authors
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Body
Coronal mass ejections (CMEs) are one of the main drivers of strong space weather disturbances. The interaction between CMEs and the Earth's magnetic field can cause a wide range of phenomena and the magnetic configuration and orientation are key factors in determining the geo-effectiveness of this type of events. Modeling these events accurately is an ongoing challenge, and data-driven simulations are a valuable operational and research tool, widely used by the community.
Using the 3D data-driven MagnetoHydroDynamical (MHD) heliospheric solar wind and CME evolution model EUHFORIA (European Heliospheric FORecasting Information Asset), our aim is to model CME events that can impact the Earth. Forthcoming missions, developed by ASI (Italian Space Agency), aims to improve space weather forecasting capabilities, particularly for CMEs, solar energetic particles (SEPs), and other interplanetary disturbances.
In particular SEPs events are of huge importance for Space Weather risks. It is well established that particle acceleration at shocks is linked to the turbulence characterizing the environment in which particles are propagating. Consequently, understanding the role of turbulence is of fundamental importance for the propagation, acceleration and characterization of SEP events.
As a case study, we analyse the event of 3 November 2021, observed by both ACE and Solar Orbiter (SolO), which were nearly co-located in latitude and longitude, with a radial separation of ~22 million km. Comparing EUHFORIA simulations with in situ data from both spacecraft provides valuable insight into the new mission's potential performance once operational.
This study was carried out within the Space It Up project funded by the Italian Space Agency, ASI, and the Ministry of University and Research, MUR, under Contract Grant Nos. 2024-5-E.0-CUP and I53D24000060005

Keywords: CME,MHD,Turbulence,Space Weather

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SOL1

BALLATOIO ROOM
Monday November 2: 15:15-16:30
Tuesday November 3: 10:00-11:15, 16:30-17:30

POSTER CODE: P1SOL102

Title
The impact of magnetogram selection on solar-wind modelling with COCONUT

Authors
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Body
Accurate space-weather forecasting is essential for understanding and predicting disturbances that can affect technological systems and human activities. Reliable forecasting requires accurate solar-wind modelling from its origin at the Sun to its propagation through the heliosphere. Coronal models provide the first step in this modelling chain by deriving the solar-wind conditions that are used as input to heliospheric models. The coronal solar-wind solution strongly depends on the magnetograms used as the main input. Several synoptic magnetogram products are available, based on different observations, processing methods and temporal representations. Their impact on the resulting coronal and solar-wind solutions therefore needs to be assessed.

In this study, we investigate the impact of different magnetograms on numerical coronal modelling using the COCONUT [COolfluid COroNa UnsTructured, (Perri, 2022)] model. We consider nine different magnetogram products from HMI, GONG, and ADAPT. We evaluate their performance for two case studies, representing solar maximum and solar minimum conditions. The resulting COCONUT solutions are compared in terms of the large-scale magnetic-field configuration, radial solar-wind velocity, coronal-hole and streamer structures, and the morphology of the heliospheric current sheet.

Our results demonstrate that magnetogram selection can significantly influence the predicted coronal environment and the distribution of high-speed solar-wind regions. In particular, magnetic-field processing, including zero-correction and polar-field corrections, strongly affects the extent and location of open-field regions. These effects vary between cases and with the solar-cycle phase, resulting in different levels of agreement with observations. Therefore, no single magnetogram product consistently provides the most accurate solution across all conditions; rather, its suitability depends on the solar-cycle phase and the specific case being modelled.

Keywords: Solar wind,Coronal modelling,Magnetograms

POSTER CODE: P1SOL104

Title
Time Dependent Comparison of different magnetogram products in October 2025

Authors
Martina Condoluci [1], Tinatin Baratashvili [1], Haopeng Wang [1], Rayan Dhib [1], Andrea Lani [1], Quentin Noraz [1], Hyun-Jin Jeong [1,2], Andreas Debrabandere [1,3], Jorge Amaya [4], Arianna Rigo [4], Brigitte Schmieder [1,5], Stefaan Poedts [1,6]

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Body
Space weather refers to all the phenomena driven by solar activity and their effects on the near-Earth environment.
Although all kinds of phenomena are worth studying, extreme space weather events are of particular concern because they can damage orbiting satellites, forecast services, navigation and terrestrial communications. This is why studying such events is so important.
Nowadays, different numerical codes try to simulate their behaviour from the Sun to the Earth. Among these, here we focus on the recently developed 3D data-driven coronal MHD model COolfluid COroNa UnsTructured (COCONUT). It differs from previous codes by using an unstructured grid and a time-implicit backward Euler scheme (Perri et al., 2022).
At first developed polytropic and then updated to its MHD version, nowadays COCONUT can also perform time-evolving simulations: receiving as input a series of magnetograms updated at the same time cadence, it can reproduce a solar wind flux comparable to observations (Wang et al., 2025).
Here we performed time-dependent simulations using different magnetogram products, such as GONG (Global Oscillation Network Group) and HMI (Helioseismic and Magnetic Imager).
As standard procedure, we filtered them to smooth the magnetic profile at the coronal boundary using spherical harmonics, as in Perri et al. (2022), and applied an additional factor (alpha) to this filtering, as introduced in Murteira et al. (2025).
The runs were performed over a time interval which refers to October 2025, from the 9th to the 13th.
During this period, PROBA-3 data are available, making it possible to compare the results obtained with observations. This work further highlights how different input magnetic maps can strongly affect the resulting magnetic topology and, consequently, the coronal model results.

Keywords: Solar Physics,Magnetograms,Magnetohydrodynamics (MHD)

POSTER CODE: P1SOL105

Title
Full-disk H-alpha Spectroheliograph development for GONG: Preliminary results

Authors
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Body
We present the design and preliminary test results of a full-disk spectroheliograph instrument under development as a potential upgrade to the GONG system. This instrument aims to enhance the current GONG H-alpha system by enabling full-disk Dopplergram observations, thereby facilitating the study of filament dynamics in relation to eruptive events, such as slow rise of filaments as precursor to coronal mass ejections.

Keywords: filament eruptions,precursors,CMEs

POSTER CODE: P1SOL106

Title
Doppler Dimming of the Ne VIII 770 Å Line: Implications for Coronal Magnetic-Field Diagnostics

Authors
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Body
The extreme-ultraviolet Ne VIII 770 Å emission line is a promising diagnostic of coronal magnetic fields in both on-disk and off-limb plasma. In the middle corona, however, the line includes a substantial resonantly scattered component whose intensity and polarization are modified by Doppler dimming in the presence of plasma outflows. Accurately quantifying this effect is therefore essential for interpreting future EUV spectropolarimetric observations and improving measurements of the magnetic environment that governs solar-wind formation.

We investigate Doppler dimming of the Ne VIII 770 Å line using an empirical one-dimensional coronal-hole model and a realistic three-dimensional Predictive Science Inc. Magnetohydrodynamic Algorithm outside a Sphere (PSI/MAS) simulation representative of the 2019 solar-minimum corona. We then use P-CORONA with the PSI/MAS simulation to evaluate the influence of Doppler dimming on the Ne VIII intensity and linear-polarization signals in different coronal structures at heliocentric distances of up to 3 solar radii.

Our studies found that the Doppler dimming effect is strongest in polar coronal holes, where outflow velocities are high, and is negligible in the low-velocity streamer belt. Linear polarization is substantially more sensitive to Doppler dimming than total intensity. Our results show that neglecting coronal outflows can introduce significant biases into magnetic-field diagnostics based on the Ne VIII 770 Å line, particularly in open-field regions associated with the accelerating solar wind.

Keywords: Solar Corona,Doppler dimming,Forward modelling,Polarization,Hanle effect

POSTER CODE: P1SOL107

Title
Can AI-based Magnetograms from EUV Images Accurately Reproduce Anti-Hale Active Regions?

Authors
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Affiliations
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Body
In this study, we investigate whether our AI-based solar farside magnetograms (Jeong et al., 2025) accurately reproduce the polarity of active regions (ARs), specifically focusing on rare anti-Hale ARs. While non-AI methods for estimating farside magnetograms, such as helioseismology, typically rely on Hale's law to assign polarity, our AI-based method uses EUV images together with the reference magnetic field data predicted from a surface flux transport (SFT) model. Since the performance of our AI model in generating full-disk vector magnetograms was demonstrated in Jeong et al. (2025), we further investigate whether it can accurately reproduce anti-Hale ARs as successfully as typical Hale ARs. We apply our AI model to 69 anti-Hale ARs observed by SDO from 2010 to 2022. Through visual inspection, we find that our AI model correctly determines the overall polarity of 67 out of 69 (97%) anti-Hale ARs, demonstrating that it does not merely rely on Hale's law. When the reference magnetic field input is not considered, the accuracy drops significantly to 46% (32 of 69), indicating that this input is crucial for polarity determination. We interpret from these results that SFT-predicted reference magnetic field data provide the information on the solar cycle from large-scale polarity distributions and EUV images offer the information on the connectivity from coronal loop morphology. These results indicate that our AI-based method is highly effective in determining the polarity of ARs. We will discuss the implications of our findings.

Keywords: Solar magnetic fields,Convolutional neural networks

POSTER CODE: P1SOL108

Title
Reconstructing Photospheric Vector Fields from Line-of-Sight Magnetograms with an ML-based model

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Body
Solar photospheric line-of-sight magnetograms are easier to infer than vector magnetograms since the line-of-sight component (Blos) can be obtained from total intensity and circular polarization signals only, unlike the perpendicular component, which depends on harder-to-measure linear polarization. However, Blos is generally not physically meaningful although it is used in a variety of Space Weather models and applications. To produce an estimate of the radial component (Br) a common correction is often applied that includes an assumption which is nearly always false. We present SSLOS, an ML-based model to estimate the full vector-field information from Blos, building on the recent SuperSynthIA approach that used Stokes vectors as input for simultaneous inversion and disambiguation (Wang+ 2024). As input, SSLOS accepts one or more line-of-sight magnetograms and associated metadata; as output, it estimates the full vector field in heliographic components, meaning that the physically-relevant vector components (including Br) are returned without need for further disambiguation steps or component transforms. SSLOS can allow for more complete evaluation of active regions for the likelihood of producing Solar energetic events when only using Blos, and enable significantly increased limits of distance-from-disk-center for data assimilation into models that rely on Br. We demonstrate estimates of the full vector field on unseen examples from both HMI and GONG, including examples that predate the Solar Dynamics Observatory mission. Our results show that while supervised learning is not a replacement for dedicated vector-field observing facilities, SSLOS may serve to unlock information from past data and, at the very least, provide more accurate Br maps from Blos than are created otherwise.

This work was primarily supported by NASA/MIRO 80NSSC24M0174 and NASA/LWSSC grant 80NSSC22K0892

Keywords: photospheric magnetic field,vector magnetic field,heliospheric model boundary da

POSTER CODE: P1SOL109

Title
Observational Evidence Linking Loop Length and Thermal–Nonthermal Peak Timing in Solar Flares

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Body
We investigate how the magnetic loop length of solar flares is related to the timing between their thermal and nonthermal emission signatures. This study analyzes a sample of 96 C, M, and X class flares observed between 2013 and 2015 using soft X ray, hard X ray, and extreme ultraviolet data. For each event, we measure the time delay between the hard X ray peak and the soft X ray peak. We also estimate the flare loop length from ultraviolet footpoint locations, assuming a semicircular loop geometry.

The results show that longer flare loops are consistently associated with larger timing delays. Across the full sample, we find a strong correlation coefficient of 0.88 between loop length and peak time delay. We also quantify how closely each flare follows the Neupert effect using the Neupert correlation coefficient, defined as the Pearson correlation between the time derivative of the soft X ray flux and the hard X ray light curve.

Applying a Neupert correlation threshold of 0.5 gives a subset of 87 events, with a correlation coefficient of 0.87 between loop length and peak delay. Applying a stricter threshold of 0.8 gives a subset of 46 events, where the correlation becomes even stronger, reaching 0.91.

These results show that the relationship between loop length and timing delay remains robust even when increasingly strict Neupert effect conditions are applied. Our findings provide direct observational evidence that magnetic loop geometry plays a key role in controlling the temporal evolution of energy transport in solar flares.

Keywords: Solar flares

POSTER CODE: P1SOL111

Title
Magnetic Concentration and Energy Transport in Solar Surface Magnetoconvection with PHAROS

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Body
Convective flows near the solar surface amplify and concentrate magnetic fields and transport electromagnetic energy through the photosphere. The magnitude and direction of this transport depend on the strength and geometry of the magnetic field and on the plasma motions. Distributions of magnetic energy and field strength alone therefore do not determine the vertical Poynting flux.
We introduce PHAROS, a radiative magnetohydrodynamic (MHD) code developed to study plasma dynamics in the solar interior and atmosphere. For photospheric applications, the code includes non-grey radiative transfer and a tabulated equation of state that accounts for partial ionization under the assumption of local thermodynamic equilibrium (LTE).
We present stratified solar surface magnetoconvection simulations to examine how granular and intergranular flows form magnetic concentrations and how the associated plasma motions contribute to vertical Poynting flux. The analysis relates magnetic concentrations to convective downflows and local radiative heating and cooling, and quantifies the contributions of regions with different field strengths to magnetic energy and vertical Poynting flux. We decompose the flux into terms associated with vertical and horizontal plasma motions and evaluate their contributions to upward and downward energy transport at different heights.
We report how magnetic energy evolution, field strength distributions, and vertical Poynting flux vary among simulations performed with selected numerical methods under the same physical setup. To interpret any differences in vertical Poynting flux, we also show how magnetic field strength and orientation are related to vertical and horizontal plasma velocities.

Keywords: Magnetoconvection,Magnetic concentrations,Radiative magnetohydrodynamics,Poynting flux,Photosphere

POSTER CODE: P1SOL112

Title
Coupling Between Solar Prominence Oscillations and the Surrounding Coronal Environment

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Body
We present an analysis of internal oscillations observed in two solar prominences located at the northern and southern limbs on 26 September 2022. Both targets exhibit a complex magnetic morphology, with the prominence axis oriented approximately perpendicular to the limb, providing favorable geometry for detecting Doppler-shift signatures. Because the prominence plasma is frozen into the magnetic field, the internal oscillations are guided along the so-called magnetic skeleton of the prominence.
Building on our earlier work, we apply wavelet analysis to 3D data to investigate oscillatory periods throughout the prominence structure using ground-based Hα observations from the Solar Dynamics Doppler Imager (SDDI), complemented by coronal observations from UCoMP Fe XIII (1074.7 nm) and the Solar Dynamics Observatory/AIA 304 Å channel.
The primary aim of this study is to compare oscillation periods detected within the prominence body with those present in the surrounding coronal environment, thereby investigating the coupling between cool chromospheric plasma and the overlying hot corona. The prominences are embedded within well-developed coronal cavities. We also present a model of the prominence magnetic structure, which will be used for further analysis.

Keywords: prominence,oscillations,magnetic skeleton

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SOL2

PASSI PERDUTI
Monday **November 2:** 15:15-16:30
Tuesday **November 3:** 10:00-11:15, 16:30-17:30

POSTER CODE: P1SOL201

Title
SULFUR FRACTIONATION IN CORONAL PLUMES AS OBSERVED BY SOLAR ORBITER/SPICE

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Body
Coronal plumes are bright, narrow structures rooted in coronal holes that contribute to the solar wind. Their composition, particularly elemental fractionation as a function of first ionization potential (FIP), provides diagnostics of plasma properties and magnetic connectivity to the heliosphere. Earlier plume studies of fractionation using low-FIP elements reached conflicting conclusions. Intermediate-FIP elements may provide additional diagnostic insight, since their fractionation is thought to involve processes beyond those affecting low-FIP species.

We investigate sulfur (intermediate-FIP element) in plumes to assess the presence of fractionation, its evolution, and its relation to wave activity. We analyzed Solar Orbiter observations of two plumes in an equatorial coronal hole during March--April 2024, using Spectral Imaging of the Coronal Environment (SPICE) to derive the sulfur-to-nitrogen ratio. EUV imaging and magnetograms provided additional context.

Both plumes showed sulfur fractionation that remained constant within uncertainties. The fractionated plasma was co-located with strong magnetic footpoints, in contrast with the surrounding interplume plasma. These results provide the evidence for sulfur fractionation in plumes and suggest, consistent with the ponderomotive force model, wave dynamics in the chromosphere as a driver.

Keywords: Solar atmosphere,Abundances,Coronal hole,Solar Orbiter

POSTER CODE: P1SOL202

Title
DATA-DRIVEN DETECTION OF CORONAL WAVE-LIKE SIGNATURES IN METIS/SOLAR ORBITER OBSERVATIONS USING EMPIRICAL MODE DECOMPOSITION

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Body
The remote-sensing suite onboard Solar Orbiter provides a unique opportunity to investigate the dynamic processes occurring in the solar corona and their role in the early evolution of space-weather relevant disturbances. In this context, the METIS coronagraph offers valuable observations of the extended corona, where faint propagating structures, transient intensity modulations and quasi-periodic wave-like signatures may be present but are often difficult to isolate from slowly evolving background emission and line-of-sight effects.

We present a data-driven workflow based on Empirical Mode Decomposition (EMD) applied to time sequences of METIS visible-light images. The goal is to separate short-timescale oscillatory components from slower background variations and to enhance coherent wave-like signatures in selected coronal regions. The EMD-based representation is compared with standard running-ratio image processing in order to assess the improvement in ridge visibility, continuity and robustness of apparent speed estimates.

Preliminary applications show that EMD can provide a cleaner representation of oscillatory components in METIS image sequences, reducing the ambiguity introduced by background evolution and improving the identification of coherent structures and waves in slit-time maps. The resulting apparent propagation speeds are interpreted as projected motions along selected slits, without assuming a direct measurement of phase speed or dispersion properties. This approach provides a flexible framework for exploiting Solar Orbiter/METIS observations in the study of faint coronal wave-train signatures and contributes to the broader effort of characterizing the early evolution of dynamic coronal disturbances relevant to Space Weather.

Keywords: Space Weather,Solar Orbiter,Empirical Mode Decomposition,coronal wave-like signatures

POSTER CODE: P1SOL204

Title
INVESTIGATING QUASI-PERIODIC PULSATIONS IN SOLAR FLARES WITH SOLAR ORBITER/EUI SHORT-EXPOSURE IMAGES

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Body
Quasi-periodic pulsations (QPPs) are nearly periodic oscillations frequently observed in irradiance time series during solar flares, and have also been reported in several stellar flares. In some cases, QPPs associated with solar flares have even been shown to induce detectable perturbations in the Earth's ionosphere.

The most likely mechanisms proposed to explain these fluctuations include spontaneous or externally driven periodic reconnection, as well as MHD waves. Disentangling these possible origins, however, remains challenging due to the lack of appropriate observations.

Among the reported periods, oscillations in the 10–30 s range are regularly reported in full-Sun integrated time series, largely independently of flare size or amplitude, and have often been associated with periodic reconnection processes. Confirming the origin of these fluctuations nevertheless requires high-cadence, spatially resolved observations that remain unsaturated in the flare core regions, datasets that are rarely available.

The EUI instrument onboard the Solar Orbiter spacecraft regularly implements a dedicated observing strategy alternating standard observations with short-exposure images acquired at cadences of 2 s. While the nominal-exposure images reveal the full flare environment, the short-exposure observations isolate the brightest emission sources without saturation. Combining both types of observations allows flare ribbon kernels as well as fine flare-loop structures to be resolved, whose spatial distribution and temporal evolution provide valuable new insight into the mechanisms underlying QPPs, as demonstrated in this presentation through several case studies.

Keywords: Solar flares,Quasi-periodic pulsations,Solar Orbiter/EUI

POSTER CODE: P1SOL205

Title

RESPONSE OF ENERGETIC PARTICLES TO INTERPLANETARY SHOCK WAVES: EXPERIENCE WITH SOLAR ORBITER DATA

Authors

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Body

Suprathermal and energetic electrons and ions streaming through the heliosphere are influenced by irregularities present in the solar wind and the interplanetary magnetic field. Interplanetary (IP) shocks are the most powerful and actively studied of these. To identify IP shocks and determine their kinetic and magnetohydrodynamic (MHD) parameters, we used data from Solar Orbiter's Solar Wind Analyser (SWA) and the Magnetometer (MAG). The year 2024 was very rich in IP shock waves of all four types: we identified 60 Forward, both fast (47) and slow (13), and 11 Reverse, also fast (1) and slow (10), shocks, which occurred at different distances from the Sun.

In order to investigate the variability in acceleration, dissipation, and dropouts of suprathermal and energetic electrons and ions across selected energy bands, we analysed data derived from the Suprathermal Telescope of Electrons and Protons (STEP), as well as the sunward-pointing Electron and Proton Telescope (EPT) and High Energy Telescope (HET). These instruments are part of the Energetic Particle Detector (EPD) suite onboard Solar Orbiter. For a quick-look analysis, we present time series of particle fluxes across a few energy ranges in the upstream/foreshock and downstream/aftershock zones. Particle energy spectrograms demonstrate upper energy limits for the acceleration of light charged particles at shock fronts. We also present some dependencies of particle characteristics on the shock wave speed, the angle between the normal to an interplanetary shock front and the upstream magnetic field direction.

Keywords: Solar Orbiter,interplanetary shock waves,Energetic Particle Detector,solar wind,upstream zone

POSTER CODE: P1SOL206

Title
A NOVEL APPROACH FOR IMAGING THERMAL DEM AND NON-THERMAL COMPONENT IN SOLAR FLARES FROM STIX DATA

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Body
Solar flares are intense bursts of radiation occurring in magnetically active regions on the solar surface. The resulting X-ray radiation is typically composed of two main contributions: thermal emission, generated by plasma at temperatures of several million degrees, and non-thermal emission, produced by energetic particles interacting with dense chromospheric layers. The Spectrometer/Telescope for Imaging X-rays (STIX), aboard the ESA Solar Orbiter mission, is designed to observe X-ray emission from solar flares. STIX employs an indirect imaging technique in which pairs of tungsten grids modulate the incoming X-ray flux, providing a limited set of Fourier components (visibilities) of the flaring sources. Image reconstruction from visibility data therefore constitutes a challenging inverse problem. Large solar flares often exhibit a complex thermal structure, typically including a hot plasma component with temperatures between approximately 5 and 25 MK and a super-hot component with temperatures exceeding 30 MK. The X-ray spectra produced by these components strongly overlap in both energy and time, making it difficult to disentangle and analyze the individual plasma populations contributing to the observed emission. To address this challenge, we introduce a novel approach, called Differential Emission Measure and Electron Flux Imaging (DEM-EF), aimed at jointly reconstructing spatially resolved emission measure maps of thermal components together with the electron flux distribution associated with non-thermal emission, directly from STIX observations. We apply the proposed methodology to STIX data and compare the obtained reconstructions with those provided by existing imaging approaches. We show that the proposed approach provides a self-consistent and complementary framework for the analysis of STIX observations, with the potential to improve the interpretation of both thermal and non-thermal processes in solar flares.

Keywords: Sun: X-rays,Flare,Emission measure,Image processing

POSTER CODE: P1SOL207

Title
STATISTICAL ANALYSIS OF ENERGY DISTRIBUTIONS OF QUIET-SUN EUV BRIGHTENINGS FROM HIGH-RESOLUTION SOLAR ORBITER OBSERVATIONS

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Body
The long-standing coronal heating problem raises the question of whether the solar corona can be heated by the cumulative effect of numerous small energy releases. Motivated by this, we investigated the smallest observable transient events in Quiet Sun. The Solar Orbiter's High-Resolution Imager observing in the 174 Å (HRIEUV) provided unprecedented observations of the lower solar corona at the finest spatial and temporal resolution to date, enabling the detection of small-scale transient EUV brightenings, the smallest such events observed so far.

We used high-cadence, high-resolution HRIEUV observations of the quiet Sun, obtained at close heliocentric distances, to perform a detailed statistical analysis of these brightenings. A wavelet-based automatic detection algorithm was applied to identify and characterize individual events, while SDO/AIA observations were used to estimate their temperatures and emission measures, allowing the derivation of thermal energies.

To robustly characterize the energy distribution, the maximum likelihood estimation (MLE) was used to fit both power-law and lognormal models. The rollover region was constrained using methods proposed by Clauset et al. (2009) and Corral et al. (2019), with additional refinements introduced in this study. Goodness-of-fit and likelihood ratio tests were used to evaluate the competing models, and the sensitivity to the choice of the lower energy bound was assessed. The resulting statistical characterization offers new insights into the energetics of small-scale EUV brightenings and their potential contribution to the coronal heating budget.

Keywords: EUV Brightenings,Energy Statistics,Power law/lognorm distribution,Differential Emission Measure,Coronal Heating

POSTER CODE: P1SOL208

Title
TOWARDS A SOLAR ORBITER EUI/FSI FLARE CATALOG

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Body
Solar flares are key drivers of space weather, and a flare catalog from Solar Orbiter's Extreme Ultraviolet Imager (EUI) Full Sun Imager (FSI) would be a valuable resource for space weather research from a vantage point beyond Earth. Building such a catalog is non-trivial: the observing cadence and compression levels change between campaigns, apparent solar disk size varies along Solar Orbiter's orbit, and both FSI channels (174 Å and 304 Å) suffer from substantial, spatially non-uniform detector degradation.

We present a first version of a fully automated FSI flare catalog using a classical image processing approach inspired by Solar Demon [Kraaikamp & Verbeeck, 2015], providing per-event location, duration, and irradiance time profiles. Where short-exposure images are available alongside regular exposures, we combine them into high-dynamic-range composites to recover otherwise saturated flare kernels. For periods when Solar Orbiter and SDO share a similar line of sight towards the Sun, we compare FSI 174 Å and 304 Å detections against AIA 94 Å detections from Solar Demon, and discuss the agreement and discrepancies between the two catalogs.

Keywords: Flares,Automatic detection,Catalog,EUI Full Sun Imager

POSTER CODE: P1SOL209

Title
HOW DO SOLAR WIND TURBULENCE AFFECT THE CLUMPINESS AND LOCAL GENERATION OF LANGMUIR WAVES?

Authors
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Body
Beams of solar energetic electrons emitted by the Sun are accelerated in the corona and into the solar wind. During their propagation in the inner heliosphere, these beams of electrons interact resonantly with the turbulent solar wind plasma to grow Langmuir waves. Wave-wave interactions are responsible for the generation of associated radio emission, seen in the form of type III bursts. The origin of solar wind turbulence, the mechanisms responsible for the dissipation of turbulent energy, and their evolution with heliocentric distance have been long-lasting science questions, studied through numerous simulations and observations since the 1970s. Previous studies looking at the role of turbulence on the clumpiness and generation of Langmuir waves have however never done so at such a high temporal resolution as offered by Solar Orbiter and at heliocentric distances closer than 1 AU. We use Solar Orbiter in-situ observations of plasma conditions at the spacecraft and associated radio emission to study the influence of density fluctuations in the solar wind on the local generation of electron-plasma waves between 0.3 and 1 AU. We present a statistical study of the role of turbulence on wave-particle interactions as a function of heliocentric distance. We focus on the relationship between density fluctuations, solar wind speed, heliocentric distance, and the clumpiness of Langmuir waves. We study the radio emission associated with the locally generated Langmuir waves to highlight the link between the intensity and maximum frequency of this emission, and the wave growth above thermal level. Understanding the mechanisms driving Langmuir waves growth in different turbulent solar wind conditions supports more accurate predictions of wave-particle interactions and solar energetic particle transport in the inner heliosphere. Our work agrees with previous theoretical work and can be complemented by measurements from the Parker Solar Probe spacecraft.

Keywords: solar radio emissions,Langmuir waves,turbulence,heliosphere,plasma

POSTER CODE: P1SOL210

Title
SPINNME: PHYSICS-INFORMED MULTI-VANTAGE MAGNETIC-FIELD INVERSIONS WITH SOLAR ORBITER/PHI AND SDO/HMI

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Body
Accurate space-weather forecasting requires reliable measurements of the solar magnetic field, which stores and releases the energy driving flares, coronal mass ejections, and solar-wind disturbances. SDO/HMI provides continuous full-disk vector magnetograms from the Sun–Earth line, while Solar Orbiter/PHI offers complementary high-resolution and off-axis views. Combining these datasets enables more physically consistent reconstruction of the magnetic boundary conditions that shape the corona and drive eruptions. We present SPINNME, a physics-informed neural-network framework for spectropolarimetric inversions of solar magnetic fields. Unlike traditional pixel-by-pixel inversions, SPINNME incorporates spatial coherence, instrumental forward modeling, and physical constraints directly into the inference process, producing magnetic-field estimates that are more robust to noise and better suited for coronal extrapolations. We describe how SPINNME can be used to cross-calibrate and jointly interpret HMI and PHI observations, exploiting HMI's long-term full-disk coverage together with PHI's higher-resolution and multi-vantage constraints. This approach can help reduce ambiguities in active-region magnetic structure, improve estimates of magnetic energy and helicity, and better constrain pre-eruptive magnetic topology. As an open, GPU-scalable inversion workflow, SPINNME enables more robust magnetic boundary conditions for modeling the solar drivers of space-weather events.

Keywords: photospheric magnetic fields,spectropolarimetric inversions,physics-informed ML

POSTER CODE: P1SOL211

Title

3D RECONSTRUCTION OF THERMAL HARD X-RAY SOURCES IN SOLAR FLARES FROM COMBINED STIX AND HXI VISIBILITIES

Authors

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Body

Since April 2023, the Solar Orbiter mission/STIX (Spectrometer/Telescope for Imaging X-rays), on board Solar Orbiter, and the ASO-S mission/HXI (Hard X-ray Imager), on board ASO-S, have been providing simultaneous hard X-ray observations of solar flares from different vantage points. STIX and HXI measure the flaring X-ray emission, which can be mathematically described as two-dimensional (2D) Fourier components, called visibilities, corresponding to the projection of the three-dimensional (3D) X-ray source along each instrument's line of sight. By combining the complementary visibility measurements provided by the two spacecraft, it becomes possible to reconstruct the 3D spatial distribution of the X-ray-emitting plasma.

In this work, we present the methodology developed to perform 3D reconstructions of thermal flare X-ray sources using joint STIX and HXI observations. As a first application, we analyze the X9.1 GOES-class flare of 3 October 2024, an ideal event because the angular separation between STIX and HXI with respect to the flare location was close to 90°. The resulting 3D reconstructions allow us to estimate the altitude of the thermal X-ray source above the solar surface, derive its radial velocity, and investigate its temporal evolution throughout the flare. These findings highlight the scientific potential of stereoscopic hard X-ray observations for investigating the geometry and dynamics of solar flares.

Keywords: Sun: X-rays,Flares,Image processing

POSTER CODE: P1SOL212

Title
CHARACTERIZING POLAR SOLAR DYNAMICS FROM HIGH LATITUDES: EARLY RESULTS FROM THE PRALINE PROJECT

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Body
Understanding the initiation and propagation of solar disturbances requires a comprehensive view of the magnetic connectivity between the solar surface and the inner heliosphere. This presentation highlights results from the Belgian project PRALINE (PolaR imaging of the Sun At high Latitude IN Euv), focusing on the characterization of polar regions as primary sources of the high-speed solar wind and potential space weather drivers.

A primary focus is placed on the observations from October 2025, where Solar Orbiter's increased orbital inclination enabled imaging of the northern solar pole. During this period, Solar Orbiter was nearly aligned with the Sun-Earth line, providing a unique opportunity to integrate EUV data with white-light coronagraphy from Proba-3/ASPIICS and Earth-based assets. By observing the Sun from high latitudes while maintaining alignment with Earth, we can better quantify the 3D evolution of plasma structures that drive space weather.

By utilizing the Full Sun Imager (FSI) for global context and the High Resolution Imagers (HRIs) for fine-scale plasma dynamics, we track features such as polar plumes and coronal holes from a high-latitude perspective. We demonstrate how this configuration allows us to quantify plasma variability in regions that are significantly foreshortened from the ecliptic plane, using the simultaneous coronagraphic measurements to bridge the gap between the solar surface and the extended corona.

Keywords: Solar Orbiter - EUI,Solar corona,Proba-3 - ASPIICS,Polar,PRALINE

POSTER CODE: P1SOL213

Title
FORWARD MODELING OF THE INTERPLANETARY DUST SCATTERING AND DIAGNOSTICS FROM METIS OBSERVATIONS

Authors
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Body
The interplanetary dust scatters the solar photospheric radiation producing what is called F-corona. The F-corona dominates the coronal emission above 3 solar radii, determining a fast decrease on the signal to noise ratio on the solar corona diagnostics (like CMEs detection). As the brightness and polarization of the solar F-corona are dependent on the observer's spatial location, F-corona modeling faces new challenges with the advent of close-in and off-ecliptic observations from Solar Orbiter/Metis. In this work, we present a 3D forward-modeling framework designed to simulate both the total brightness and linear polarization of the solar F-corona across arbitrary vantage points. By fitting F-corona observations, we place tight constraints on the spatial density distribution of interplanetary dust. Incorporating a circumsolar dust depletion zone enables our framework to accurately reproduce observed F-corona brightness profiles and the progressive circularization of inner isophotes. Furthermore, our spatial-dependent polarization model reveals that off-ecliptic observations produce pronounced structural asymmetries. The close-in, inclined orbit of Solar Orbiter offers unique geometric perspectives that tightly constrain near-Sun dust dynamics and local scattering properties.

Keywords: Solar corona,F-corona

POSTER CODE: P1SOL214

Title
A FRAMEWORK OF JOINT HIGH-RESOLUTION CORONA OBSERVATIONS WITH SOLAR ORBITER/METIS AND PROBA-3/ASPIICS CORONAGRAPHS

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Body
High-resolution space-based solar coronography provides critical insights into solar dynamics, including energy transport mechanisms and their propagation into the heliosphere. We present a framework to maximize the scientific return of two leading coronagraphic missions, Metis aboard Solar Orbiter and ASPIICS aboard Proba-3, by taking advantage of key orbital configurations. Featuring overlapping fields of view (between 1 and 4 solar radii) and complementary wavelengths at comparable spatial and temporal resolutions, joint observation programs bridge the gap between the inner and middle corona.
During periods of spacecraft quadrature, synchronizing Metis's 'Eruption Watch' campaign with ASPIICS's 'CME Watch' mode of observation enables multi-view coverage of coronal mass ejections (CMEs) from their onset through their middle-corona evolution. This dual-vantage perspective resolves the 3D structure of coronal electrons and overcomes the spatial limitations inherent to single-viewpoint imaging. Furthermore, during phases when the angular separation between the spacecraft in the orbital plane is small, the joint 'Density Fluctuations' and 'Waves' observation programmes allow for the high-resolution observation of small-scale plasma oscillations and fine dynamics within the ambient corona. Supported by context imaging from disk instruments such as SolO/EUI and SDO/AIA, and other space-based coronagraphs, this coordinated approach deepens our understanding of the fundamental physical processes regulating solar activity.

Keywords: solar eruptions,coronal waves,Solar Orbiter/Metis,Proba3/ASPIICS,solar corona

POSTER CODE: P1SOL215

Title

NEW INSIGHTS INTO THE ORIGIN AND TRANSPORT OF SOLAR ENERGETIC ELECTRON EVENTS WITH THE COSEE-CAT MULTI-INSTRUMENT DATABASE

Authors

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Body

The Comprehensive Solar Energetic Electron event Catalogue (CoSEE-Cat) is a living database of energetic particle events detected with Solar Orbiter. This catalogue contains the basic parameters for all observed events, as well as information on the associated solar events (flares, eruptive phenomena, radio bursts, CMEs) and on the conditions of interplanetary space near the spacecraft. These properties are derived from observations using eight remote-sensing and in-situ instruments on board Solar Orbiter. The second data release contains more than 500 events recorded until the end of 2023. This unique dataset enables the identification of statistically robust trends, for example pointing towards different origins for events of impulsive and gradual ion composition. Moreover, roughly 90% of the events can be associated with a solar flare detected with STIX, but a small fraction of particle events do not show any sign of activity in X-rays. I will discuss possible explanations. I will conclude with a brief description of several ongoing studies, including the combined spectral analysis of particles and STIX flares, follow-up studies of associated jets and outflows, and a systematic investigation of the effects of interplanetary context.

Keywords: Sun: particle emission,Solar flares,Heliosphere,Coronal mass ejections (CMEs),Solar radio bursts

POSTER CODE: P1SOL216

Title
INVESTIGATIVING THE ORIGINS OF SLOW SOLAR WIND NEAR CORONAL HOLE BOUNDARIES

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Body
The slow solar wind is often associated with coronal hole (CH) boundaries and other open-closed magnetic field interfaces, yet the processes releasing plasma from these regions and the origin of its variability remain poorly understood. Elemental abundances can provide a powerful diagnostic for identifying source regions of the slow wind and constraining the mechanisms that produce it. In this study, we present a systematic analysis of elemental abundances near the boundaries of low-latitude coronal holes using spectroscopic observations from Solar Orbiter/SPICE where CH boundaries are traced using simultaneous observations from SDO/AIA 193 and STEREO/EUVI 195. Specifically, we show whether the composition signature at CH boundaries shows a systematic gradient across the open-closed interface, and whether this signature depends on the type of adjacent closed structure using several observations. We further compare the relative FIP bias derived for these coronal holes with in-situ solar wind properties on magnetically connected field lines, linking near-Sun compositional signatures to their heliospheric counterparts. We present results characterizing how composition changes near boundaries of different CHs, and assess the role of boundary region processes such as interchange reconnection in shaping the slow solar wind.

Keywords: Slow Solar WInd,First Ionization Potential,Coronal Holes

POSTER CODE: P1SOL217

Title
WHAT DO WE LEARN FROM THE THINNEST CORONAL LOOPS OBSERVED BY SOLAR ORBITER/EUI/HRIEUV?

Authors
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Body
Understanding the characteristic width of coronal loops is essential for determining the spatial scale of coronal heating and assessing to what extent present-day EUV imagers resolve the corona. Previous studies with TRACE, Hi-C and Solar Orbiter/EUI have reported loop widths ranging from several megameters down to a few hundred kilometers, but it remains unclear whether these scales are intrinsic or determined by instrumental resolution and line-of-sight superposition.

We present an ongoing investigation of a sample of coronal loops observed with the High
Resolution Imager EUV telescope (EUI/HRIEUV) onboard Solar Orbiter, aimed at constraining the minimum observable loop width and evaluating to which extent coronal loops are spatially resolved by HRIEUV. We compare quiescent active region and post-flare loops observed under various matched exposure conditions.

Key preliminary result: post-flare loops observed in short-exposure HRIEUV images, obtained with 50x shorter exposure times to avoid saturation, appear significantly thinner (near the Nyquist 2-pixel limit ~200 km for perihelion observations) than loops measured in regular exposure observations.

In regular images, loop widths can be affected by lack of contrast due to scattered light and LOS integration and are more susceptible to dynamic blurring from spacecraft jitter and/or loop dynamics. In short exposures, blurring is likely negligible and post-flare loops show excellent contrast.

We discuss the implications of these measurements for the long-standing elementary-strand problem and for models of coronal heating. If the narrowest post-flare structures correspond to physically coherent magnetic strands, then the characteristic energy-release scale in the corona may be substantially smaller than typical loop widths inferred from standard EUV observations. These observations demonstrate the importance of high-dynamic-range EUV imaging for probing the transition between resolved and unresolved coronal structure.

Keywords: coronal loops,high resolution,coronal heating

POSTER CODE: P1SOL218

Title
STATISTICAL TESTS OF SOLAR FLARES WITH STIX FOR QUASI-PERIODIC PULSATIONS

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Body
Solar flares are among the most energetic events in the solar system, releasing vast amounts of energy and driving significant space weather effects at Earth. While magnetic reconnection is widely accepted as the primary driver, the detailed physical processes governing energy release, particle acceleration, and their temporal variability remain poorly understood.

Recent X-ray and extreme ultraviolet observations have revealed quasi periodic pulsations (QPPs) in flare emission on timescales of tens of seconds to minutes, offering a potential diagnostic of the underlying energy release and modulation processes. However, establishing the significance of these signals is challenging due to the inherently stochastic nature of flare light curves. In this work using STIX X-ray observations from Solar Orbiter, we perform a rigorous statistical analysis of X-ray light curves to assess the significance and physical plausibility of these QPP signatures. Our approach incorporates the stochastic nature of flare time series, including appropriate coloured noise models and underlying probability distributions. We present several compelling examples of statistically significant QPPs from our analysis, which can shed light on flare models and inform future observations.

Keywords: Quasi-Periodic Pulsations,Solar Flares,Time-series methods,Energy Release Mechanisms

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SOL3

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2SOL301

Title
Total solar eclipse 2026 prediction with COCONUT

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Body
Total solar eclipse observations present unique opportunity to probe the magnetic field configuration of the solar corona close to the Sun. Because the Sun is so bright, the features of the solar corona cannot be observed without occulting the solar disk. Total solar eclipse of 2026 will be particularly interesting as it is still in the early declining phase of the solar cycle. Total solar eclipse observations are necessary to validate and probe the global coronal models. COCONUT (Perri et al. 2022) is a 3D – MHD global coronal model that extends from the solar surface to 21.5 Rs. Source and sink terms in the energy equation guarantee the accelerated solar wind (Baratashvili et al. 2024). Baratashvili et al. (2026) demonstrated the total solar eclipse 2024 prediction capabilities at an early stage of the code development. The model could successfully reconstruct the west limb, but failed to model the east limb due to emerging active region at the back of the Sun.
For the upcoming eclipse on August 12, 2026, we have started a preparation phase in the beginning of March, testing different input magnetogram products with different mesh configurations to obtain the most accurate and detailed representation of the solar corona. PROBA-3 images are used to validate the modelled corona during the prediction phase. We start the active predictions window in July, updating our total solar eclipse predictions every day up to the day of the eclipse. The lessons learnt from the preparation phase and the updated predictions will be presented at the ESWW conference.

Keywords: Solar Corona,Eclipse,Solar Corona Modelling,COCONUT

POSTER CODE: P2SOL302

Title
Observational constraints on the large-scale coronal structure over the solar cycle: comparison with the MULTI-VP model

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Body
Understanding the long-term evolution of the solar corona over solar cycles is essential for characterizing the solar-wind environment and space weather. Constraining low-coronal plasma properties and latitudinal organization is important for inner-heliospheric solar-wind models used in forecasting. We use Mauna Loa Solar Observatory white-light polarized-brightness observations (1998–2008) to study large-scale coronal electron density during solar cycle 23, from maximum to the prolonged minimum. Density maps are derived from 2595 daily images using the classical van de Hulst inversion (Bemporad & Bertone 2025), providing an observational benchmark for global coronal models.

We compare observed density distributions with coronal model predictions from the MULTI-VP model (Pinto & Rouillard 2017; Samara et al. 2021), which provides thermodynamically consistent 3D corona/solar-wind solutions for heliospheric coupling, and can be coupled to heliospheric models for space-weather applications. Overall agreement is found in temporal evolution and latitudinal organization. However, systematic low-coronal differences remain: the model's segregation between denser and less-dense solar-wind regions matches observations only at larger distances, while observations show clear organization at ~1.5–2.0 solar radii. This suggests the low-coronal to heliospheric density transition occurs too high in the model, possibly due to limitations in coronal magnetic topology and/or heating parametrization, which we attempt to rectify.

Our results highlight the value of long-term coronagraphic observations. Different streamer configurations during the 1997 and 2008 minima show that realistic constraints are important for modelling the low corona under weak, complex magnetic fields. Extending this to more distances and solar-cycle phases may identify the physics controlling the structured low-corona to solar-wind transition, improving modelling of space-weather-driving solar-wind conditions.

Keywords: Solar Wind Modeling,Heliosphere,Solar Cycle

POSTER CODE: P2SOL303

Title
Coronal Magnetic Topology and Loop Parameters of NOAA AR 3663 via PINN-based NLFFF Extrapolation

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Body
We present a data-driven and artificial intelligence-based method for the three-dimensional characterization of coronae in active solar regions, applied to NOAA AR 3663, one of the most complex and eruptive active regions of Solar Cycle 25. The method integrates the extrapolation of the solar magnetic field using Non-Linear Force-Free Field (NLFFF), conducted by Physically Informed Neural Networks (PINNs), from SDO magnetograms, based on the work of Jarolim et al. (2024), with extreme ultraviolet (EUV) images in multiple wavelength bands obtained by AIA/SDO. Coronal loops are reconstructed through bidirectional tracking and field line mapping using the Runge-Kutta (RK4) method from the 3D cube of the trained neural network, from the NLFFF model via PINN. The physical parameters of each loop, such as length, height, and base location, are derived and validated through Differential Emission Measurement (DEM) analyses performed with the CHIANTI atomic database, which provides independent constraints on electron density and temperature distribution along the reconstructed structures. Preliminary results reveal the loop length distribution and thermal structure of the coronal field of AR 3663, offering insights into energy storage and the conditions preceding its main eruptive activity. The method demonstrates the potential of PINN-based NLFFF extrapolation as a physically consistent and computationally efficient tool for coronal diagnostics, with direct relevance to further studies on the behavior of coronal loops (in low corona) and the study of space weather in regions of origin of solar flares and coronal mass ejections (CMEs).

Keywords: Non-Linear Force-Free Field,PINNS,Coronal Loop Diagnostics,Diferencial Emission Measure,Solar Active Regions

POSTER CODE: P2SOL304

Title
Proba-3/ASPIICS observations of the early stages of an eruptive prominence undergoing leg-leg reconnection

Authors
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Body
Thanks to the unique capabilities of the ASPIICS coronagraph onboard the Proba-3 mission, we can now study the processes during the earliest phases of prominence eruptions with far greater detail than before. We will present a study of an erupting prominence undergoing leg-leg reconnection using the Proba-3/ASPIICS observations in all three channels, together with other multiwavelength observations. Such an analysis of the evolution of the magnetic fields of erupting prominences already within the innermost corona can bring new insights for further development of numerical models providing the initial boundary conditions for operational space-weather simulations.

The studied prominence first resembled a loop with crossed legs, where the ASPIICS He I D3 line shows significantly more substructure compared to the EUV He II 304 observations. As the prominence erupts, its brightest parts are found at the inner rims of both legs near the point of their crossing. During this phase, SMART telescope's filtergrams in the Ha line show converging motions of both legs. Subsequently, additional branches of the prominence appear above the crossing point. These are also visible in SDO/AIA 211, which, together with ASPIICS, shows excess Fe XIV emission, meaning that these structures have been heated. We interpreted these observations in terms of the 3D leg-leg (RR-RF) reconnection geometry using an MHD model that captures both the converging motion of the pre-reconnection prominence legs, as well as the appearance of inner branches.

These observations show that leg-leg reconnection occurs during the entire course of this prominence eruption and leads to heating of the portion of the prominence material at least to coronal temperatures. Furthermore, the observed 3D reconnection geometry removes overall flux from the flux rope, while increasing its twist. These are important mechanisms that, when not taken into account, would lead to different outcomes for space weather predictions.

Keywords: Solar flares,Solar filament eruptions,Solar magnetic reconnection,Solar x-ray flares,Solar ultraviolet emission

POSTER CODE: P2SOL305

Title
3D inference of Alfven speed and plasma beta in a solar flare

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Body
Advanced MHD modeling of erupting solar phenomena, including flares and coronal mass ejections, depends crucially on the realism of 3D distributions of such fundamental plasma parameters as Alfvén speed and plasma beta. It is difficult to observationally constrain them because direct inference of physical parameters in the very regions where free magnetic energy is released, e.g. in the flaring volume, remains challenging and rare.

Here we present the microwave imaging spectroscopy inference of the magnetic field and thermal plasma density maps in the coronal volume of solar flares based on forward modeling of spatially resolved gyrosynchrotron spectra.

We combine these microwave-derived 2D maps with stereoscopic X-ray source reconstruction to recover the 3D distributions of the coronal magnetic field and plasma density. This enables estimates of the 3D distribution of Alfvén speed and plasma beta in the flaring volume.

These new observational constraints are key for testing models of magnetic reconnection, turbulence, MHD wave dynamics, wave-particle interaction, and energy transport in the low solar atmosphere and inner corona. These measurements may also provide valuable input for broader efforts to connect low-coronal energy release with eruptive solar events and heliospheric consequences.

Keywords: Solar flares,low solar atmosphere,microwave imaging spectroscopy,coronal magnetic field,Alfvén speed, plasma beta

POSTER CODE: P2SOL306

Title
Can the Chromosphere Inform Us about Solar Energetic Events?

Authors
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Body
Solar energetic events are often eruptive, sending mass into space as Coronal Mass Ejections (CMEs). Sometimes the chromosphere shows strong ejecta as well -- as might be expected -- but sometimes it does not. We track chromospheric dynamics using Hα imaging spectroscopy from the Mees CCD Imaging Spectrograph (MCIS) in the context of inferred coronal magnetic topology and coronal kinematics. The goal of this research is to start establishing cause-and-effect relationships regarding connections between the chromosphere and corona, or even to start understanding what chromosperic characteristics are influential vs. which may be irrelevant to CME production. In this poster we present analysis methodology and the resulting inferred evolution for a few events. We find the connection between chromosphere and coronal kinematics may require an examination of what it means to have an eruptive event on the Sun.

This work was supported by the US Air Force Office of Scientific Research grant FA9550-23-1-0681 and NASA/Heliophyics Supporting Research grant 80NSSC23K0098.

Keywords: Chromosphere,Coronal Mass Ejections,Eruptive Events,Imaging Spectroscopy,Coronal Modeling

POSTER CODE: P2SOL307

Title
3D MHD Prominence Modeling from Formation to Eruption

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Body
Solar prominences are complex structures in the solar corona, showing a wide range of morphologies and dynamical evolution. They can become unstable and erupt, giving rise to coronal mass ejections. However, a significant gap remains in our understanding of their evolution throughout the entire life cycle and the mechanisms behind initial stages of the prominence eruptions. In this presentation, we report results from 3D numerical simulations with the MPI-AMRVAC code. This model includes prominence formation, dynamics, destabilization, and eruption. The simulation includes the formation of a three-dimensional magnetic flux rope in a stratified solar atmosphere comprising the chromosphere, transition region, and corona. Non-adiabatic processes, including optically thin radiative cooling and field-aligned thermal conduction, are taken into account. This self-consistent setup allows us to investigate the interaction between the forming magnetic flux rope and the lower solar atmosphere. In particular, we estimate the prominence mass the flux rope can host under the levitation-condensation scenario and the role of non-adiabatic effects and thermal instability in prominence formation. Additionally, we study the flows inside the flux rope during its pre-eruptive and eruptive phases to identify an early precursor to destabilization.

Keywords: Solar Prominences/Filaments,Prominence eruption,Numerical modeling

POSTER CODE: P2SOL308

Title
Magnetogram filtering techniques for global coronal modelling

Authors
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Body
Global coronal models for space weather forecasting often require filtered-down magnetogram data for their inner boundary prescriptions. Often, the technique of spherical harmonics decomposition is used for this purpose. However, this method leads to large oscillations of the magnetic field intensity around active regions. To avoid these oscillations (i) an adjusted version of spherical harmonics decomposition, (ii) a non-linear diffusion filter, and (iii) a Yaroslavsky filter were implemented in Python and applied to a reference magnetogram with high activity: the HMI (Helioseismic Magnetic Imager) magnetogram for 2022-11-22T01:30:00. These filters were analysed separately to show their effects and optimal parameter settings. Afterwards, four simulations with the same mesh size were run with the COolfluid COronal uNstrUcTured (COCONUT) solver to see the impacts of the new boundary prescription on the simulated density, radial velocity, and on the magnetic field topology. Validation was done against electron tomography. The new filters did not present non-physical oscillations, captured the large structures, and removed the small ones. All filters ran in the order of minutes or less of CPU time. Spherical harmonics-based filters were found to be more suitable for coarser, rapid simulations; however, they could lead to inaccurate features. The non-linear diffusion and Yaroslavsky filters were found to be more suitable for a finer grid, resulting in more accurate solution features. Validation against tomography showed a good capture of low-density regions and the equatorial streamer.

Keywords: Magnetogram,Filtering,Corona,Numerical,Boundary Conditions

POSTER CODE: P2SOL309

Title
Investigating Anomalous Expansion in Coronal Mass Ejections with Spheromak-Based MHD Simulations

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Body
Coronal mass ejections (CMEs) are among the primary drivers of extreme space weather effects on Earth, causing geomagnetic storms, satellite disruptions, and hazards to both astronauts and ground-based infrastructure. The expansion of CMEs has been statistically shown to differ across solar cycles, posing unique challenges for space weather forecasting and our broader understanding of CME propagation dynamics. This study explores the anomalous expansion of CMEs observed across different solar cycles, with a focus on understanding the underlying physical mechanisms responsible for such variability.
Magnetohydrodynamic (MHD) modeling of CMEs using flux-rope-based configurations offers a promising approach for reproducing and understanding such behavior. In this study, we present an MHD model for CME expansion based on a spheromak magnetic field configuration, implemented using the MS-FLUKSS framework. The spheromak configuration provides a self-consistent representation of the CME magnetic structure, allowing us to systematically investigate how varying background solar wind conditions influence CME evolution and expansion.
The model successfully reproduces CME expansion behavior under varying background solar wind pressures. We find that CMEs attain larger angular widths in lower-pressure backgrounds, consistent with observational studies. Furthermore, the simulations reveal that CMEs are more likely to exhibit halo morphology under low solar wind pressure conditions. These results highlight the critical role of the ambient solar wind environment in governing CME expansion rates and morphology, with direct implications for improving the accuracy of space weather forecasting models.

Keywords: CORONAL MASS EJECTIONS,MAGNETO-HYDRODYNAMICS,SPACE WEATHER PREDICTION

POSTER CODE: P2SOL311

Title
ALMA-SDO Correlation and Time-Lag Analysis of Coronal Bright Points: Evidence for Chromosphere-Corona Coupling

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Body
A major challenge in space weather forecasting is linking small-scale energy release in the lower solar atmosphere to large-scale coronal dynamics and heliospheric variability. Coronal bright points (CBPs), ubiquitous small-scale magnetic-loop structures, provide an important observational bridge between chromospheric plasma processes and coronal energy transport. We present a multiwavelength analysis of four CBPs using interferometric Atacama Large Millimeter/submillimeter Array (ALMA) observations at 3 mm together with Solar Dynamics Observatory (SDO) EUV observations at 304, 193, and 171 Å and photospheric magnetic-field measurements. For the first time, interferometric ALMA data enable full-structure spectral analysis of CBPs while resolving chromospheric loop footpoints and fine low-atmospheric structure. Temporal evolution of intensity and projected area revealed rapid and closely correlated variability across chromospheric and coronal structures. Characteristic delays between ALMA and EUV signatures were typically a few minutes or less, indicating strong chromosphere-corona coupling. Depending on the CBP, 3 mm emission led, lagged, or coincided with EUV emission, while oscillatory delay patterns suggested bidirectional propagation of disturbances along coronal loops. These signatures point to hot electron flows and/or magnetohydrodynamic waves transporting energy and plasma between atmospheric layers. Enhanced 3 mm emission is systematically associated with photospheric magnetic-flux concentrations, with fluxes of order 10^19 Mx placing CBPs in the regime of ephemeral active regions. The combined radiative, morphological, and magnetic evolution suggests that continuous injection of free magnetic energy from the lower atmosphere governs CBP dynamics. The results demonstrate that small-scale magnetic structures can rapidly modulate coronal plasma conditions and provide important observational constraints for next-generation space weather forecasting frameworks.

Keywords: Coronal bright points,ALMA solar observations,Chromosphere-corona coupling,Solar atmospheric dynamics,Energy transport

POSTER CODE: P2SOL312

Title
Two-fluid Coronal Modeling with a Full Energy Equation

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Body
Operational space weather forecasting requires predictive computational models that capture the necessary physics of the environment, from the Sun to Earth. However, these models do not resolve the lower layers of the atmosphere explicitly and rely on empirical magnetogram-driven boundary conditions. This approach bypasses the partially ionised regime, such as the chromosphere, where the single-fluid MHD description of the plasma is no longer adequate; even in the corona, Brchnelova et al. (2023) showed that, despite a small neutral fraction of one part per million, ion-neutral coupling terms, primarily charge exchange and ionisation/recombination, influence the ions' temperature by 5-10% along the coronal streamers.

In the current study, we built on the polytropic model of Brchnelova et al. (2023), based on the COCONUT code, by retaining the two-fluid assumption but upgrading the energy equation to account for coronal heating, radiative cooling, and Braginskii thermal conduction. We further implemented a two-fluid HLL flux scheme, enabling a scheme-controlled comparison with single-fluid MHD that isolates ion-neutral coupling from numerical dissipation, addressing a limitation identified by Brchnelova et al. (2023).

Our model has been tested on the 2008 solar minimum case, resulting in a stable steady-state with a bi-modal solar wind structure. We are quantitatively comparing the two-fluid model with the single-fluid model for both solar minimum and solar maximum cases. Additionally, we are coupling the two-fluid coronal output at 0.1 AU to the heliospheric model EUHFORIA, establishing a complete Sun-to-Earth pipeline for validation against the single-fluid counterpart and in-situ data at 1 AU.

This study provides the physical and numerical foundation for extending the two-fluid framework into the chromosphere and transition region, where partial ionisation is dominant and most pipelines within space weather forecasting rely on empirical inner-boundary prescriptions.

Keywords: Multifluid Plasma,Solar Corona

POSTER CODE: P2SOL313

Title
The middle corona in three dimensions as seen by Metis

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Body
Determining the three-dimensional (3D) thermodynamic structure of the solar corona is crucial for understanding the physical processes driving the solar wind (SW). To this end, solar rotational tomography reconstructs the 3D distribution of electron density and temperature from multi-view sequences of white-light (WL) or extreme ultraviolet (EUV) images. The Solar Orbiter Metis coronagraph simultaneously captures WL and HI Lyman-alpha images, enabling, for the first time, the tomographic reconstruction of the 3D Lyman-alpha Doppler dimming term. This is a diagnostic that depends strongly on solar wind speed as well as local ion kinetic temperature and magnetic field orientation, so that its 3D distribution can serve as a powerful validation tool for 3D-MHD SW models. In this work, we present preliminary results based on the latest calibration of Metis data.

Keywords: SOLAR WIND,SUN CORONA,SOLAR ORBITER

POSTER CODE: P2SOL315

Title
Total Eclipse on August 12, 2026: observations in Spain, in Space and Predictions with COCONUT and others

Authors
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Body
Total solar eclipses are a standard way of assessing coronal structures in the low solar corona (1-1.5 Solar Radius) and testing coronal models. Total solar eclipses constrain the validation period of coronal modelling, as they occur rarely. However, it was the only way to distinguish features in the low corona near the solar surface. Now a day PROBA 3 mission provides observations of the low corona during its orbit rotation. Total solar eclipses provide a single snapshot of the solar corona, whereas time-dependent simulations require continuous white-light observations. A program of space observations has been developed for the eclipse of 12 August using STEREO, Solar Orbiter, Aditya, Proba3, balloon experiment and flight to support the ground based multi-site observations in Spain obtaining the best coverage of the total solar eclipse.
COCONUT was utilised to predict the previous total solar eclipse in April 2024. In the setup demonstrated in the manuscript, a low-resolution, simplified approach is used. However, multiple developments in the COCONUT model since the previous total solar eclipse allow us to get continuous time-dependent and high resolution simulations using the performance of AI .
We plan to show the first results of the total solar eclipse on August 12, 2026, at 18:27 UT obtained on the ground in multi-sites and compare with the high-quality images obtained before the eclipse by Proba3 and the other space coronagraphs. We will show the predictions performed by the COCONUT model and other predictions obtained in US and China with synthetic white-light images.

Keywords: Corona,Eclipse,Solar Wind,Simulations

POSTER CODE: P2SOL317

Title
Faster-than-real-time and quasi-realistic Sun-to-Earth coronal and wind MHD modeling

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Body
Developing implementation-ready Sun-to-Earth coronal and solar wind MHD models that combine efficiency, accuracy, and numerical stability is crucial for enabling reliable daily space weather forecasting. In recent years, we have developed two implementation-ready time-dependent coronal MHD models, COCONUT (Wang et al. 2025a,b; 2026a,b) and SIP-IFVM (Wang et al. 2025c,d,e). Both models are driven by high-cadence, time-evolving observed magnetograms and employ accuracy-improved implicit time-integration methods to ensure both computational efficiency and robust temporal accuracy (Wang et al. 2025 a,d,e). Additionally, the numerical stability of COCONUT and SIP-IFVM is maintained by a decomposed energy equation strategy (Wang et al. 2026a) and an extended magnetic field decomposition approach (Wang et al. 2025c), respectively. Furthermore, we extend these two efficient time-evolving coronal MHD models out to 1 AU (Wang et al. 2026c), enabling a single model to cover the entire Sun-to-Earth space. This directly demonstrates that faster-than-real-time Sun-to-Earth coronal and solar wind MHD simulations can be readily achieved using a single implicit time-evolving model such as COCONUT or SIP-IFVM, eliminating the need to run a coronal model first and then drive an inner-heliosphere model with pre-saved coronal outputs. Currently, we have further incorporated the “transition region” into COCONUT, enabling Sun-to-Earth simulations directly driven by photospheric magnetograms with radial magnetic field strengths near active regions reaching up to 1000 Gauss. During this conference, we will present the development of our Sun-to-Earth MHD models, highlight how these models can benefit other researchers, and explore potential collaborations for further improving these models and extending their implementations.

Keywords: Solar corona and wind,Magnetohydrodynamic modeling,Sun-to-Earth,Numerical method

European Space Weather Week (ESWW) 2026 | 2-6 November 2026 - Florence, Italy

SESSION SWI

PASSI PERDUTI
Thursday November 5: 10:00-11:15, 16:30-17:30
Friday November 6: 10:00-11:15

POSTER CODE: P2SWI01

Title
Spectral and wavelet analyses of geomagnetic storms this year

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Body
To study geomagnetic storms, we used the complex analysis methodology described in https://www.mathworks.com, such as Time-Frequency Analysis and Wavelet Toolbox.
In this paper, we used data from the geomagnetic observatories of the INTERMAGNET network, sampled at 1 minute, for two geomagnetic storms produced this year, the periods 19-21 January and 21-23 March. The geomagnetic field varies in time and space, being a signal composed of periodic and non-periodic elements and is monitored in a triaxial system. In the paper, based on these data, we use spectral evaluation (Fourier, wavelet, signal decompositions into approximations and details with various functions on different levels, etc.) to analyze various geomagnetic phenomena (such as: geomagnetic storms, disturbances, etc.) and their degree of occurrence. The superiority of the wavelet methodology over Fourier consists in obtaining information in the form of a three-dimensional graph (time, frequency, amplitude). We obtain good temporal precision for high-frequency phenomena (at the expense of the amplitude precision of these frequencies), respectively, we will be able to know with greater precision the amplitude of the low-frequency components existing in the signal, without strictly localizing the moments in which they appear. The wavelet technique allowed us to analyze the local components of the magnetic field through variable frequency windows and different functions.
Wavelet coherence is applicable to the analysis of non-stationary signals and uses the analytical Morlet wavelet, being able to detect events such as geomagnetic field anomalies, change points and transitions. The arrows in the coherence graph indicate the phase relationship between the two signals at each time point and frequency (or period). The phase angle of the cross spectrum is the same as the phase difference between the signals. The direction of the arrows in the regions of high coherence can help to understand the phase relationship.

Keywords: GEOMAGNETIC STORMS,SPECTRAL ANALYSIS,WAVELET,MULTI-RESOLUTION,FOURIER

POSTER CODE: P2SWI02

Title
Design of the geomagnetic measurement's website dedicated to the protection of civil aviation

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Body
For the protection of critical infrastructures and the security of national air traffic, we designed a website dedicated to measuring declination at different time intervals in airport areas in Romania. Over 25 locations and over 90 measurements of declination, inclination and total geomagnetic field are represented in this application.
Declination plays a particularly important role for civil aircraft navigation, as it can vary depending on the variations in the magnetic field. The determination of the declination is made with the absolute magnetometer and is calculated at each point of interest according to the position of the geographic and magnetic meridians of the measuring station and the declination of the Sun at the exact moment of determining the position of the Sun, expressed in sexagesimal degrees.
The measurements of declination, inclination and total field that we performed were based on the measuring station in the vicinity of the airport, which was selected as a magnetic field area without anomalies, at a sufficiently large distance from sources of major industrial disturbances, high-voltage lines, roads and urban spaces.
The values of the mean declination of the Sun and the equation of time can be found in the astronomical yearbook, being calculated based on the ephemeris equations. The values thus measured were corrected for diurnal variation and then reduced to the mid-year level, based on the values from the Surlari National Geomagnetic Observatory. To obtain the updated value of the declination, the annual average value given by the International Geomagnetic Field Reference Model (IGRF) and the absolute values measured at the Surlari National Geomagnetic Observatory were used. In this way, the declinations of the airport surfaces in Romania were calculated, and the respective data were represented in ArcGIS.

Keywords: GEOMAGNETIC STORMS,GEOMAGNETIC FIELD,DECLINATION,AEROPORTUAR ZONE,CIVIL AVIATION

POSTER CODE: P2SWI03

Title
Causal inference in Geomagnetically Induced Current indices

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Body
Geomagnetically Induced Currents (GICs) constitute one of the primary ground-level impacts of space weather and can lead to disruptions or failures in power transmission systems. The GIC index is a proxy of the ground geoelectric field derived solely from geomagnetic field data. Information Theory (IT) can be used to shed light on the dynamics of complex systems, such as the coupled solar wind-magnetosphere-ionosphere-ground system. Previously, we have performed block entropy analysis of the GIC activity indices at middle-latitude European observatories around the St. Patrick's Day 2015 intense magnetic storm and Mother's Day 2024 super-intense storm. We found that the GIC index values were generally higher for the May 2024 storm, indicating elevated risk levels. Furthermore, the entropy values of the SYM-H and GIC indices were higher in the time interval before the storms than during the storms, indicating transition from a system with lower organization to one with higher organization. Recently, IT has proven itself as a powerful approach to study causal relationships among various coupled complex systems. Here, we use Conditional Mutual Information as a measure of causality which is, indeed, the mutual information between the cause and the future of the effect variable, conditioned on the history of the effect variable, to investigate the possible coupling direction and pattern of interactions among different GIC indices, various solar wind variables and geomagnetic activity indices. Causal inference may shed light on GIC cause and effects and, thus, is expected to advance GIC risk analysis and modeling.

Keywords: Geomagnetic storms,GICs,Information Theory

POSTER CODE: P2SWI04

Title
Magnetometer Prototype for Space Weather Local Real Time Geomagnetic Disturbances

Authors
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Body
Space weather is commonly assumed to be a major problem at high latitude locations. Nevertheless, space weather disturbances during intense or extreme events are detected in Southern Europe and it is important to be aware of the consequences that these events may have on end users in the Mediterranean region. In terms of the geomagnetic environment, the global indices do not provide sufficient granularity for users operating in Southern Europe, therefore, regional indices, should be provided through the SWE service network. The purpose of this activity is to develop a magnetic prototype station for SWE which generates new regional products on geomagnetic conditions as a first contribution of a potential SSA SWE Service Network to have full coverage on the required spatial range.
Once measurements of ground magnetic field will be available, local/regional magnetic indices should be computed and from them, disturbance maps and alerting products targeting end users. To solve the problem and difficulties to obtain a real time index for geomagnetic disturbance with high spatial and temporal resolution, local disturbance indices obtained with LDiñ [1] procedure should be computed.

[1] - Developing the LDi and LCi geomagnetic indices, an example of application of the AULs framework Cid, C., Guerrero, A., Saiz, E., Halford, A. J., & Kellerman, A. C. (2020). Space Weather, 18, e2019SW002171. https://doi.org/10.1029/2019SW002171

Keywords: Magnetometer,Prototype,Local disturbances,geomagnetic,Critical infrastructures

POSTER CODE: P2SWI05

Title
Low Cost Geomagnetic and Geoelectric Instrumentation: Choosing the Right Variable to Measure

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Body
The important space weather effect of geomagnetically induced currents (GIC) is produced largely by the magnetic field of incident electromagnetic waves which traverse the neutral atmosphere. Since the time of Gauss, near-surface magnetic fields have been measured with great precision, but comparable electric field measurements have been practical only in recent decades. We have developed low-cost methods to measure both fields, based on modern electronics including GPS, microcontrollers, and advanced analog-digital converters (ADC), most particularly the variant known as analog front ends (AFE). Storage and real-time data transmission are via SD cards, ethernet/Wifi, or LTE (cell data), and the devices consume little enough power to operate from solar panel/battery combinations at subarctic latitudes.
ADCs transduce electric potential differences to digital form, where the signal can arise from direct sampling of the ground at two points to determine the electric field, or from a magnetometer output in which somewhat complex and expensive sensors and circuitry change a magnetic field to a voltage. Depending on frequency range, an essentially DC field may be measured, as with a fluxgate sensor, or AC with coils. Although for stable magnetotelluric purposes special electrodes may be needed, in the space weather frequency range (effective changes at a few Hz or less), drift that is important for MT is not a problem.
We have developed and tested low-cost instruments, with emphasis on direct geoelectric field measurement. Due to one step less transduction, geoelectric instruments for space weather can be much cheaper than geomagnetic instruments. Interpretation is very sensitive to ground structure, requiring a different approach, but the low cost would allow deployment of large numbers of sensors and a more direct approach to the Ohmic effects relating ground electric fields to GIC in nearby ground infrastructure.

Keywords: Instrumentation,Geomagnetism,Geoelectricity,Magnetotellurics,GIC

POSTER CODE: P2SWI06

Title
Impacts of space weather on industrial mine shovel operations

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Body
Space weather hazards have often been associated with long, grounded infrastructure such as power transmission networks, pipelines, undersea telecommunications cables, and railways. Here, we present a novel impact of space weather related to industrial mine shovel operations. Many mine shovels operate using medium voltage (e.g., 13 kV), 3-phase power. Mine shovel trailing cables can extend >10 km from the substation, laying directly on the ground in an insulated bundle jacket. For safety reasons, the integrity of the cable is monitored using a direct current (DC) ground check wire and return wire, both in the same cable jacket. The ground check circuit is monitored by a Zener diode clamped directly to the mine shovel body at one end, and the return wire is solidly grounded at the substation terminal. The system is powered by a variable low-voltage (e.g., 30 V) DC source with a high source impedance. During a geomagnetic storm, the induced geoelectric field can provide an additional, unexpected quasi-DC voltage source to the DC ground check circuit which results in tripping the mine shovel offline. This can be a costly loss of operational time and could also lead to damage to mine shovel components depending when it loses power. We document several cases during geomagnetic storms in 2024, 2025 and 2026 which resulted in tripped mine shovels in Alberta, Canada. We present a circuit model which explains these trips which depends on geoelectric field magnitude (parallel to the line), line resistance, and earthing resistances at grounded nodes. Due to the nature of the circuit, the trip depends on geoelectric field polarity (e.g. positive or negative relative to the DC source). We also show how line length and line orientation relative to the induced geoelectric field can increase the number of trips; during the October 10-11, 2024 storm, long cable lengths resulted in an anomalous number of trips compared to other storms.

Keywords: GICs,space weather,geoelectric field,mine shovel

POSTER CODE: P2SWI07

Title
Three Sites, Three Responses: Magnetotelluric Evidence of Spatially Variable Geoelectric Hazard Across Central Italy

Authors
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Body
Quantitative assessment of geomagnetically induced current (GIC) hazard requires spatially resolved storm-time geoelectric fields. In Italy, such fields remain poorly constrained because site-specific conductivity information is sparse. We present the first multi-site, physics-based characterization of storm-time geoelectric forcing in central Italy using data from the ongoing MARGE magnetotelluric survey. Broadband impedance tensors from three geologically contrasting sites were combined with common 1-s geomagnetic observations from the Duronia observatory to reconstruct surface electric fields during four intense storms, including May 2024 and January 2026. The procedure was evaluated against simultaneous electric-field measurements at two sites. Peak horizontal fields ranged from 41 to 101 mV/km. Although driven by the same geomagnetic input within each storm, site responses differed, while both the strongest response and dominant field component changed among events. This variability shows that local conductivity and the spectral and directional characteristics of each disturbance jointly control geoelectric forcing. Enhanced |dB/dt| identified periods of increased activity, but its relationship with electric-field amplitude varied by site and forcing regime, especially at high forcing. Assuming a spatially uniform field, the peaks correspond to orientation-maximized reference geovoltages of about 4-10 V along a 100-km conductor. These values quantify geoelectric forcing over regional scales; converting them into GIC estimates requires infrastructure-specific network models. Neither a single representative site nor |dB/dt| alone can characterize regional exposure. Site-specific conductivity information, multiple storm scenarios, and realistic network parameters are required for quantitative GIC hazard assessment.

Keywords: Ground geoelectric fields,magnetotellurics,geoelectric hazard,geomagnetic storms,spatial variability

POSTER CODE: P2SWI08

Title
GEOELECTRIC FIELD AMPLIFICATION OVER THE SAMA DRIVEN BY CONJUGATE ULF WAVE DYNAMICS AT (L~1.2) DURING THE MAY 2024 SUPER-STORM

Authors
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Body
We investigated the low-latitude magnetospheric response during the geomagnetic superstorm of 10-13 May 2024 (minimum Dst=-406 nT) using magnetic field data from quasi-conjugate stations SJG and CXP (L~1.2) in the northern and southern hemispheres. Cross-phase and amplitude-ratio analyses characterized common ULF oscillations, focusing on intervals with enhanced squared coherence (>0.8). We assessed potential drivers and the role of ionospheric conductivity variations related to the South Atlantic Magnetic Anomaly (SAMA) on resulting surface geoelectric fields. Observations reveal a systematic response asymmetry, with enhanced ULF amplitudes at southern station CXP relative to northern station SJG. This hemispheric asymmetry is consistent with ionospheric conductivity and boundary condition differences, perhaps related to SAMA. Cross-phase analysis demonstrates coherent time-frequency structures across three intervals: 10 May (16-20 UT), 11 May (01-03 UT), and 11 May (09-13 UT). These intervals feature common waveforms and characteristic cross-phase changes with frequency, pointing to global magnetospheric oscillations, potentially linked to cavity mode oscillations (CMOs) in the inner magnetosphere at low L-shells. We further investigate whether these coherent low-latitude oscillations are associated with local plasmaspheric cavity modes by comparing the low-L response to that seen by additional stations at different L-shells in the same meridian. We further discuss implications of these oscillations for modeled surface geoelectric fields in the SAMA sector. Enhanced magnetic response at CXP indicates that asymmetric boundary conditions associated with SAMA may amplify ground magnetic variations and geoelectric fields relative to SJG. Findings suggest that while candidate cavity modes were driven primarily by solar wind density fluctuations, ground magnetic amplitudes and geoelectric fields were modulated and amplified by SAMA-driven conductivity asymmetries.

Keywords: Amplified geoelectric field,South Atlantic MagneticAnomaly,ULF wave dynamics,May 2024 superstorm,Solar wind drivers

POSTER CODE: P2SWI09

Title
The Rise Time and Form of Sudden Commencements at Geostationary Orbit

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Body
Electrical power grids are vulnerable to Geomagnetically induced currents (GICs) that are caused by a rapid rate of change of the geomagnetic field, dB/dt. One source is the Sudden Commencement (SC) which is a step-like change in the geomagnetic field caused by the impact of an interplanetary shock on the magnetosphere. On the ground, the SC comprises a superposition of DL and DP magnetic perturbations from magnetopause and field-aligned currents, respectively. Whilst DL amplitude is well understood and predictable from the solar wind state, DL rise time is not and hence neither is the DL contribution to dB/dt. In this study, we investigate the form and duration of the DL perturbation by examining 148 SC events between 12 and 15 MLT at geosynchronous orbit where the DP perturbation is negligible. We observe that the DL form is generally a gradual rise with sometimes a superposed decaying oscillation that is likely due to a superposed cavity mode oscillation. We find that the DL rise time is well approximated by a characteristic time scale given by 1.4 times the pre-shock geocentric distance to the subsolar magnetopause divided by the post-shock solar wind speed, which is consistent with linear theory and nonlinear MHD simulation. The result allows estimation of the DL contribution to SC dB/dt from solar wind measurements, and conversely more complete knowledge of solar wind conditions for historical SC events.

Keywords: sudden commencement,interplanetary shock,GIC

POSTER CODE: P2SWI10

Title
3D Time-Domain Simulation of the Induced Geoelectric Field in Fennoscandia

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Body
Space weather can significantly impact modern technological infrastructure. In particular, highly spatio-temporally varying ionospheric currents generate geomagnetic disturbances, geoelectric fields, and telluric currents that can produce damaging Geomagnetically Induced Currents (GICs) in, e.g., power grids. Accurate modeling of the coupled ionosphere–ground system is therefore essential for assessing space weather hazards and developing mitigation strategies. However, such modeling is computationally demanding, and most existing approaches are formulated in the frequency domain using plane-wave approximations for selected frequencies. While these models have enabled successful regional studies, they are less well suited for capturing the full spatio-temporal response to localized and rapidly varying ionospheric current systems.

In this work, we present a novel country-scale 3D time-domain framework for modeling the geoelectric fields and telluric currents generated by localized and dynamically varying ionospheric currents over Fennoscandia. Our model incorporates the highly heterogeneous Fennoscandian 3D ground-conductivity and explicitly treats ionospheric currents as the physical source input, rather than relying on impedance-matching to observed magnetic field data. To our knowledge, this is the first country-scale time-domain framework for geoelectric field modeling.

Initial simulations demonstrate our model's capability to reproduce the complex spatio-temporal ground responses associated with realistic ionospheric forcing. Our results show strong localized geoelectric responses, pronounced effects of ground-conductivity gradients on the geoelectric-field orientation, and temporal lag effects arising from the interaction between time-varying ionospheric currents and the complex ground-conductivity structure.

Keywords: Time-domain simulations,Geoelectric field,Telluric currents,Fennoscandia,GICs

POSTER CODE: P2SWI12

Title
Fast time-domain simulations of geomagnetically induced currents in New Zealand power grids using magnetic field data with gaps

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Body
Intensive geomagnetic disturbances originating from the Sun induce strong geoelectric fields in the conducting Earth. This field drives so-called geomagnetically induced currents (GICs) in the ground-based infrastructure, particularly power grids. In turns, those GICs may lead to the destruction of the transformers and, consequently, disruptions of the normal operations all the way up to long-lasting blackout. To take preventive measures against such issues power companies need a forecasting or, at least, now-casting of GICs.
Now-casting of GICs is based on the observed magnetic field and requires not only fast solvers, but solvers that can properly treat practically raw (real-time) data as input. That means, among other things, that data may contain short (seconds) and/or long (up to a few hours or even days) gaps. At the same time, most of the conventional simulations are based on Fast Fourier transform and, therefore, require the continuous time-series. This is also the case for the time-domain multi-site transfer function approach that we used to use to simulate GICs for past events.
To overcome this challenge we developed a new method based on an approach originally created for the global electromagnetic studies, where gapped time series of magnetic field are quite common. The developed method is based on the time-domain inversion of the magnetic field to obtain spatio-temporal model of the equivalent source followed by the computing GICs induced by this source.
To validate the efficiency and accuracy of the new method we used the magnetic field observed at 6 locations in New Zealand. While the formal resolution of the time series in use is 1 second, they contain multiple gaps up to a few days (depending on magnetometer location). However, the comparison between GICs modelled via our method and the ones observed in New Zealand power grid for events in May 2024, Nov 2025, and Jan 2026 shows very good agreement even for time moments with lack of observations.

Keywords: GICs,Simulations,Now casting,Time domain

POSTER CODE: P2SWI13

Title
Hybrid GIC modelling in New Zealand: Utilizing a mix of Magnetotellurics and Thin-sheet approaches to better model GICs.

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Body
Geomagnetic disturbances (GMDs) generate geomagnetically induced currents (GICs) in critical technological infrastructure, including electrical power grids. Severe to extreme GMD events can damage essential grid components, especially transformers. As a result, accurate GIC modelling and/or extensive GIC measurement data is needed to identify the transformers most vulnerable to the impacts of GMDs.

Historically, in New Zealand, a thin-sheet conductivity model (TS) has primarily been used to model electric fields and hence calculate GIC. However, as more Magnetotellurics (MT) data has become available it is now possible to apply MT to find geoelectric fields for parts of the country. This shift to MT-focused calculation follows a common route in the scientific community by which the TS method is largely disregarded if an MT model is available.

In this presentation I will describe an electric field hybrid modelling approach that uses a mix of TS and MT derived impedance tensors. This approach combines the MT data for the locations and frequency ranges where this is available but is underpinned by the TS calculations which have already been demonstrated to rather accurately model the New Zealand-observed GIC at 1 minute time resolution. This hybrid approach allows for a wider frequency range than either TS or MT impedance tensors can provide individually. By comparing the output of the hybrid calculations with the large dataset of GIC measurements in New Zealand I will show that the hybrid model produces the most accurate modelled GIC, with time resolutions down to one second.

This work has been undertaken inside New Zealand’s Solar Tsunamis and Solar Tsunamis Next Generation research programmes.

Keywords: GIC,Geomagnetic Disturbances,Transformers,Electric Fields,Impedence

POSTER CODE: P2SWI14

Title
Dynamical Network Analysis of US Power Grid GIC Data

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Body
Since 2013 the US has been collecting geomagnetic disturbance (GMD) data from 100+ power grid monitors. It now has data from 40+ geomagnetic storms with Kp$>$7. This growth in space weather data quantity, quality, and complexity provides an unprecedented opportunity to understand how critical power infrastructure responds to space weather in practice. However, current analysis methods are insufficient to operate at this scale; we require novel applications such as network science. Network theory is frequently employed to estimate the resilience of the physical power grid, and its robustness to the removal of transformers due to threats such as natural hazards and cyber-attacks. We perform the first dynamical network analysis of the US GMD dataset, applied to 26 geomagnetic storms between 2013 and 2025. In our analysis, the transformer monitors are the nodes of the network. A pair of nodes are connected when the wavelet cross-correlation between their GIC time series exceeds a threshold, and the magnitude of each is sufficiently large. The topology of these dynamical networks varies in detail from one event to another. It does not simply follow either the physical structure of the grid or the overall severity of the driving storm. We find that the same transformers, near Washington DC and Milwaukee, frequently appear as the most highly connected nodes across these events, regardless of storm size. These network hubs, or supernodes, track information about the state of the grid as a whole in real time. This suggests a targeted strategy for instrumenting critical infrastructure, to enable improved resilience planning and, potentially, forecasting of grid disturbance during extreme space weather.

Keywords: GIC,Power grid,Network science

POSTER CODE: P2SWI15

Title
Towards a Real-Time Geomagnetic Disturbance Alert System for Railway Signalling Operations

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Body
Track circuit signalling systems are widely utilised across the world, and their ability to accurately detect trains is crucial for the safe and reliable operation of a railway network. These systems use electric circuits to detect the presence or absence of trains in sections along a railway line and, as such, can be susceptible to interference from geomagnetically induced currents (GICs).

With input from a project advisory group of industry experts, a model has been developed to analyse the impact that geomagnetic disturbances have on DC track circuits along representative sections of the UK railway network. The model incorporates geoelectric field data and UK ground electrical resistivity with rail electrical parameters and track circuit components to assess conditions under which GIC-driven interference may compromise signalling operation.

This presentation will demonstrate the capabilities of this modelling framework and show that the foundational components required for an operational alert system are achievable. Given real-time geoelectric field inputs, the model can assess risk to track circuit performance across a network, providing the basis for timely, targeted warnings to railway operators. The steps required to transition from modelling capability to a deployable alert system will be discussed.

Keywords: GIC,Railway,Model

POSTER CODE: P2SWI16

Title
Developing a new operational model of geomagnetically induced currents in the European high-voltage power network

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Body
The European high-voltage power transmission system consists of a set of highly interconnected national grids spanning the continent. While significant progress has been made in recent years in modelling geomagnetically induced currents (GIC) at the national scale, comparatively little work has addressed the European network as an integrated system.

As part of the EuroGIC project, we have developed a pan-European GIC modelling framework. This model combines magnetic field measurements from observatories and variometer networks across Europe, a continental-scale conductivity model, and a power network representation derived from open-source data.

EuroGIC is being implemented within the ESA Space Weather Service Network (SWESNET) portal, where it will provide an interactive platform delivering GIC estimates in near real time, alongside simulations of historical geomagnetic storms. Users will be able to define custom alert thresholds for GIC levels, either across Europe or for selected countries of interest.

In addition, the platform will support user-specific national network models, enabling more accurate GIC estimation where detailed infrastructure data are available. These models can be incorporated securely, ensuring that sensitive network information remains confidential.

Keywords: GIC,power grids,ground effects

POSTER CODE: P2SWI17

Title
Geomagnetically Induced Currents and Reactive Power Impacts in New Zealand: Producing observationally determined relationships and looking at extreme storm impacts

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Body
Geomagnetic disturbances (GMD) lead to geomagnetically induced currents (GICs) in vital technological systems, like electrical power grids. The GIC induced by GMD leads to asymmetric half cycle saturation in transformer cores, causing thermal heating, harmonic production, and increases in reactive power absorption. The work described here is focused on reactive power changes. Internationally there are few measurements defining the response of susceptible transformers, so the majority of insights have up to now have been gained from modelling.

We are fortunate that the New Zealand power grid operator, Transpower New Zealand Ltd, has a growing interest in space weather hazards, and is willing to share their measurements and knowledge with our research team. Over the last ~3 years we have gained access to reactive power measurements made at selected NZ transformers to examine reactive power changes (i.e., MVAr) during GMD. One complexity we have had to deal with is that normal operational MVAr changes are large and common, making it challenging to discriminate between normal changes and GIC-linked MVAr changes. At the same time the observed GIC-linked MVAr changes are small, and only start after the GIC reaches a minimum amplitude (termed the 'headroom'), meaning that few transformers in the NZ system have large enough GIC.

In this presentation I will describe our analysis of the reactive power observations, allowing us to link GIC and MVAr changes for three phase three-limb and single phase autotransformers. Building on this we have produced scaled relationships to estimate additional reactive power demand across the New Zealand grid during extreme geomagnetic storm scenarios - from this we can better understand if New Zealand's new operational space weather response strategies will protect against unplanned black-outs.

Our work has been undertaken inside NZ's Solar Tsunamis and Solar Tsunamis Next Generation research programmes.

Keywords: geomagnetically induced curren,GIC,half cycle saturation,reactive power,extreme storm risks

POSTER CODE: P2SWI18

Title
Equatorward Expansion of Geomagnetic Power During Severe Storms

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Body
The March 13, 1989 geomagnetic storm caused a blackout in Québec, and the October 29, 2003 storm caused a blackout in southern Sweden. These storms had Dst minima of -589 nT and -383 nT, respectively. The May 10-13, 2024 storm was the largest storm since the 1989 storm, with its Dst reaching -412 nT. To better understand this hazard, for these three severe storms, we analyze data of 1-s to 20-s resolution from ground magnetometer stations within multiple Northern Hemisphere high latitude arrays: the International Monitor for Auroral Geomagnetic Effects (IMAGE) array, the DTU Space Greenland ground station network, and the Canadian Array for Realtime Investigations of Magnetic Activity (CARISMA). Figure 1 shows the sites used for each storm. For each event, we compute normalized wavelet power and scale-average across physics-motivated period bands (1–2 min, 2.5–10 min, and 10–40 min), enabling comparison across storms and stations spanning geomagnetic latitudes of approximately 54°–85°N.

We find that storm-time magnetic power maxima coincide with Dst minima, and that higher geomagnetic latitudes experience power peaks during storm onset while lower latitudes peak during the most disturbed periods. As storm intensity deepens, the dominant power shifts systematically equatorward, consistent with expansion of the auroral electrojet. Station-to-station differences in magnetic power decreases from approximately three orders of magnitude during quiet times to one order of magnitude at storm peak, reflecting the equatorward homogenization of the auroral zone. Comparing the spatio-temporal evolution of magnetic power across these three severe storms provides a basis for predicting space weather impacts at different latitudes. These results directly inform storm-time geomagnetic hazard assessments.

Keywords: wavelet analysis,spatial-temporal evolution,magnetic power,geomagnetic latitude,severe storms

POSTER CODE: P2SWI19

Title
A Comparative Study of Geomagnetic Storm Impacts Across Hemispheres

Authors
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Body
Geomagnetically induced currents (GICs) threaten widespread infrastructure during geomagnetic storms. Magnetotelluric (MT) derived impedance tensors provide a critical tool for translating storm-time magnetic variability into geoelectric field estimates. We present a cross-hemisphere comparative study of storm-time geoelectric hazard using MT data from the Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP) across Australia's southeastern Adelaide–Brisbane corridor (home to more than 70% of Australia's population, ~20 million people) and the USArray across the US's Northeast Corridor (home to over 53 million people).

We analyse geomagnetic observatory data from Solar Cycles 24 and 25 (2009 to the present day) and classify the data into storm phases (quiet, onset, peak, and recovery) using the Dst index. For both regions, we characterize magnetic variability through distributions of dB/dt and magnetic power across physics-based period bands: 1–2 min for irregular storm pulsations Pi1 and Pi2; 2.5–10 min for continuous storm pulsations, Pc5; 10–40 min for substorm-related pulsations, Ps6. Geoelectric fields are then estimated by convolving MT impedance tensors with ground magnetic observatory time series across AusLAMP and USArray sites in each focus region. Using controlled binning and sensitivity curve approaches, we assess how local 3D subsurface electrical conductivity (i.e. amplitude, phase, and polarization) modulates storm-time ground electromagnetic response (dB/dt, magnetic power, and geoelectric fields). By comparing these regions of Australia and the United States, we quantify the relative contributions of geomagnetic latitude, local time, and local electrical conductivity to geoelectric hazard, and evaluate the transferability of hazard assessments across hemispheres.

Keywords: ground induced currents,geomagnetic storms,space weather,natural hazards

POSTER CODE: P2SWI20

Title
A pilot study for assessing geomagnetically induced currents in the Italian power transmission grid

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Body
Geomagnetically induced currents (GICs) are among the main effects of space weather on ground-based technological infrastructures. During geomagnetic disturbances, rapid magnetic field variations induce geoelectric fields at the Earth's surface, driving quasi-DC currents in high-voltage transmission grids and potentially affecting power-system security.
We present a newly started project that, for the first time in Italy, brings together Geoprosys, Terna and INGV, to assess the level of influence of GICs on the Italian electricity transmission grid operation. Geoprosys contributed with expertise in geophysical investigations and subsurface electrical conductivity characterization, INGV contributed with the know-how in GICs and their related space weather phenomena, Terna provided access to the grid and the simulation of the operating statuses. By combining the complementary expertise of the three partners, this project represents a pilot study for the assessment and validation of GICs in selected portions of a generic electricity transmission grid.
The activities initially focused on a decommissioned transmission line, where the differential magnetometer method will be tested through the installation of two magnetometers: one beneath the line and one at a nearby reference site. The same approach will then be applied to a line on service. Geomagnetic data from INGV observatories will be processed together with the results of magnetotelluric surveys carried out by Geoprosys to reconstruct the induced geoelectric field. Modelled GICs will then be compared with values inferred from in-situ magnetic measurements and with simulations performed by Terna. At the same time, that activity made it possible to update the soil resistivity, which is functional for a better setting of the transmission power line protection system.
This work represents a first step towards an operational framework for assessing and mitigating space-weather impacts on the Italian electricity grid.

Keywords: GICs,Power transmission grids,DMM,Geoelectric field modelling

POSTER CODE: P2SWI21

Title
MagIE – The Magnetic Network of Ireland

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Body
The Magnetic Network of Ireland (MagIE; www.magie.ie) consists of magnetometers distributed across Ireland to monitor the geomagnetic impacts of space weather on the island, supported by all-sky auroral cameras.
The network currently includes an INTERMAGNET-standard LEMI installation at Met Éireann's Valentia Observatory in the southwest, together with a recently installed LEMI instrument at DIAS Dunsink Observatory, Dublin, in the east.
We are currently upgrading the LEMI installations at Birr Castle, Co. Offaly, in the midlands and at Armagh Observatory in Northern Ireland to improve their stability and overall performance.
Once all four sites are fully operational, MagIE will provide 1-second measurements of Bx, By and Bz in near-real-time. Local K-indices and higher-cadence Hpo indices will also be calculated for each location and made available online.
Auroral forecasts from the OVATION model are available through the MagIE website (www.magie.ie/aurora), alongside forecast auroral alerts based on a statistically optimised auroral viewing-probability threshold. Nowcast geomagnetic storm alerts based on real-time local K-indices are also available.

Keywords: Ground magnetometers,Ireland,GICs

POSTER CODE: P2SWI22

Title
The Nature of Geomagnetically Induced Currents in Sweden

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Body
According to Rosenqvist et al. (2025), there have been 10 confirmed power grid disturbances due to geomagnetically induced currents (GICs) in the Swedish power grid since 1999. The space weather cause and geomagnetic impact of some of these incidents have been investigated in previous case studies. However, from a closer look at the modelled geoelectric field and other GIC proxies at the time of the disturbances, it becomes clear that the impacts not always can be connected to instantaneous peaks. In the end of 2025, the Swedish power grid company, Svenska Kraftnät, started measuring the current through the neutral point of the most GIC-affected transformer in the Swedish power grid located in Karlshamn, southern Sweden. In this study, three power grid disturbances in Karlshamn are analysed by using both the measurements and a power grid model to categorise how often the GIC levels of the previous disturbances are exceeded throughout the years. The goal of this study is to find an effective precursor for the when the GIC will cause a disturbance that can explain why the threshold is sometimes exceed without a subsequent disturbance. Obtaining a deeper understanding of which signatures that are most harmful to the power grid will be important both to mitigation strategies and to be able to predict which type of space weather that poses the biggest threat.

Keywords: geoelectric field,GIC

POSTER CODE: P2SWI23

Title
An Overview of Geomagnetic Storms Observed At Valentia Observatory, Ireland, and Grouping Storms By Their Geoelectric Field Impact

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Body
The Valentia Observatory (maintained by Met Éireann) is an INTERMAGNET member that has produced over 30 years of digital magnetic field data available in hourly, 1-minute and 1-second resolutions. This ongoing study presents a statistical analysis using definitive 1-minute data between 1995 and 2022 to characterise the Solar Activity - Valentia relationship over 2.5 solar cycles. We begin by identifying geomagnetic storms of all intensities and group them into mild, intense, and super-intense. This involves examining solar parameters from OMNI (IMF B_tot, B_z, solar wind pressure), ground geomagnetic field elements and the derived local K-index from Valentia, comparing against global SYM-H and Dst index based storm classifications (Loewe & Prölss, 1997; Collado Villaverde et al, 2024). Occurrence times of the initial, main and recovery phase of each storm identified in Walach & Grocott (2019) are used to facilitate storm identification in the Valentia time series. The frequency distribution of local K-index and the inter-storm waiting times for each storm-group are presented. An epoch analysis is performed for each storm-group to compute statistics during a storm and reveal typical storm morphology in each category. This includes: peak disturbance (maximum δH, δX); rate of change (dH/dt, dB/dt per minute) - the main driver of induced geoelectric field, which in turn drives geomagnetically induced currents; solar cycle dependence and seasonal dependence. Finally, the geoelectric field at Valentia is computed using a ground conductivity model to answer the question: how does the geoelectric field response scale with storm intensity?

Keywords: geoelectric field,GICs,storm-time field disturbance

POSTER CODE: P2WI11

Title
Cumulative corrosion and extreme storm risk to the New Zealand gas pipeline network – where and why

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Body
It has long been recognized that geomagnetically induced currents (GIC) can not only lead to the risk of corrosion on buried pipelines, but in the event of extreme geomagnetic activity may also cause damage to the pipeline infrastructure. Studies of the effects of GIC on the New Zealand gas pipeline network suggest that some locations in particular are susceptible to such effects. Not only do we assess the risks to the pipeline of both long-term corrosion and extreme storms, but also how pipeline structure and topology, as well as earth structure, lead to greater or lesser susceptibility to these effects. We believe this work is internationally unusual in that we developed a model for GIC on pipelines which has been validated through industry measurements, and apply that to model to consider the site-specific hazard posed by extreme geomagnetic events.

This work has been undertaken inside New Zealand's Solar Tsunamis research programme.

Keywords: Pipelines,Extreme storms,Corrosion