2026 SWW Poster Abstracts - Thursday, 30 April, 2026

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1. Storm Archive for Learning and Anticipation with Machine Intelligence (SALAMI): A Machine Learning-Ready Dataset for Space Weather Prediction

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The mainstay phenomenon of space weather prediction is the geomagnetic storm. Predicting the onset and intensity of geomagnetic storms to a high degree of accuracy and precision requires principled determination and characterization of solar precursors, prediction of solar wind conditions that control geoeffectiveness, and rigorous quantification of energy transfer from upstream solar wind conditions to the magnetosphere-ionosphere-thermosphere system across multiple temporal and spatial scales. Achieving these objectives can be accomplished most effectively with the use of a geomagnetic storm catalogue consisting of a harmonized dataset of multichannel space weather data prepared for direct ingestion by Artificial Intelligence/Machine Learning (AI/ML) algorithms and exploration with complex statistical models. To enable the attainment of this goal, we present the Storm Archive for Learning and Anticipation with Machine Intelligence (SALAMI). SALAMI is an AI/ML-ready dataset composed of gap-filled solar and geomagnetic time series data, along with solar imagery from SDO/AIA, GOES-R/SUVI, and GONG. The dataset is accompanied by Python tools that integrate it with JSOC to provide targeted downloading of high-resolution Level 1 AIA data, as well as the CCMC Donki database, providing cross-referencing of geomagnetic storms with solar flares.
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2. Factors controlling large amplitude geomagnetically induced currents and voltages: US power grid and submarine cables

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Geomagnetic disturbances (GMDs) related to multi-scale phenomena in near-Earth space induce geoelectric fields in the Earth and in conductors at the Earth's surface, which drive electric currents known as geomagnetically induced currents (GIC) that flow through power grids, power feed equipment for submarine

cables, and other electrically conducting systems. The production of these currents is a complex interplay between geospace system dynamics, the conducting Earth, the properties of the conducting system of interest, and the spatial and temporal scales involved. In this presentation, we use publicly available GIC measurements from the North American Electric Reliability Corporation (NERC) GMD dataset to identify the largest amplitude GIC during recent geomagnetic storms. Working backwards from the measured GIC, we identify the drivers and key factors controlling the generation of these GIC using a combination of satellite and ground-based measurements. We perform a similar analysis for submarine communications cables using published voltage measurements during two historic storms. We discuss the implications of both analyses for the generation of large amplitude GIC/voltages during future storms.

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3. MissionDPT: Simulation and forecasting of radiation doses and health risks for space exploration missions

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Radiation exposure in space presents significant challenges to crew health and performance. To mitigate its impacts, research in space radiation environment, mass shielding geometry, nuclear interactions, transport codes and biological responses has been conducted for decades, offering many established models and codes. In this work, a web tool MissionDPT (Mission Dose Projection Tool) is presented which incorporates the most up-to-date version of these codes with simple input and output interfaces, enabling interested users to calculate dose quantities and estimate acute risks for low earth orbit (LEO) and beyond LEO missions. Simulation results are consistent with dosimeter measurements from the Artemis-I mission and the International Space Station (ISS) with known shielding files and trajectories. A set of solar particle event (SPE) forecasting models, University of Malaga Solar particle Event Predictor (UMASEP), are also integrated to provide dose information before or near the onset of SPEs. With archived Geostationary Operational Environmental Satellite (GOES) solar proton data from 1986 to present (real time data updated every 5 minutes), MissionDPT can be used to analyze the radiation exposure and acute health risks for historical severe SPEs and to serve as a console tool for the Flight Control Team in contingency scenarios for the upcoming lunar and Mars missions.
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4. Forecasts of 3-day Solar Wind Speed and 6-hour IMF Bz by Deep Learning

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We have developed two deep learning models to forecast two space weather components: 3-day solar wind speeds and 6-hour interplanetary magnetic field (IMF) Bz components. Firstly, the solar wind speed prediction model uses the last five days of SDO/AIA 19.3 and 21.1 nm images, along with solar wind speeds as input data. It consists of two networks: a convolutional layer-based network for images and a dense layer-based network for solar wind speeds. Our model successfully predicts solar wind speeds for the next 3 days, with a root mean square error (RMSE) ranging from 37.4 km/s (6-hour prediction) to 68.2 km/s (72-hour prediction). These

results are much better than those of previous studies. The model can accurately predict sudden increases in solar wind speeds caused by equatorial coronal holes. Secondly, the Bz prediction model is a bidirectional long short-term memory (BiLSTM) based model using solar wind data (V, N, T) and IMF (Bt, Bx, By, Bz) in OMNI from 2000 to 2022 as input data. We use the preceding 12 hours of data as input and the next 6 hours of data as target data. We consider Bz values below the negative standard deviation (about -3 nT) for at least 6 hours. We apply 12-fold cross-validation to our model, using 8 months for training sets and 4 months for test sets. Consequently, a total of 12 models are trained, and they show an averaged RMSE ranging from 1.75 nT (30-minute prediction) to 2.55 nT (6-hour prediction). Our model can capture both declining and increasing phases of Bz. Although this study presents preliminary results in Bz prediction, we find a sufficient possibility for predicting Bz under specific conditions. We plan to develop deep learning models for other space weather components, such as solar wind density or geomagnetic indices.

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5. Unraveling the Fine-Scale Tapestry of Solar Wind at 1AU

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Solar wind is a complex network of distinct magnetic flux tubes, each contained and separated by a current sheet. In this study, more than 50,000 current sheets in the solar wind are identified and characterized, for the first time, using multi-point Cluster observations during solar minimum and maximum intervals. Flux tubes at Earth are found to have an average diameter of 2.5 Earth radii, nearly 30 times smaller than previously reported. Furthermore, six years of NASA's ACE solar wind observations at Sun-Earth Lagrange point L1 is used to show that only 30% of the observed flux tubes would directly impact the Earth's magnetosphere. It is shown that flying closer to the Sun-Earth line could help to improve the prediction accuracy of ACE-like space weather monitors by 2.5 times.

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6. EMIC Waves in the Initial Phase of Geomagnetic Storms

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Using simultaneous magnetic field observations from 10 satellites and an automated detection algorithm, we identify broad regions of electromagnetic ion cyclotron (EMIC) wave activity during the initial phases of geomagnetic storms between September 2015 and October 2019. Since an initial phase is driven by compression of the dayside magnetosphere, we expect the majority of activity to be found here. However, in 56.5% of initial phases examined in this study, there is EMIC activity in the nightside magnetosphere. Occurrence of this nightside activity increases as an initial phase progresses, with a lag of at least 35 minutes before it begins. Additionally, the solar wind dynamic pressure, substorm activity level, and shock impact angle have strong positive correlations to dayside EMIC activity rates compared to nightside. With these observations, we can characterize the extent of magnetospheric response in the form of EMIC wave activity throughout the initial phase of a geomagnetic storm.
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7. Forecasting rare and extreme events with machine learning

Enrico Camporeale, University of Colorado & Queen Mary University of London

Over the past decade, machine learning has completely transformed space weather forecasting, delivering state-of-the-art predictive models across the Sun–Earth system. Despite this progress, forecasting rare and extreme events remains a major challenge. This limitation stems from the standard training paradigm, in which models minimize a loss function averaged over many samples, inherently biasing performance toward quiet conditions while underrepresenting rare but high-impact events.

We introduce PARIS (Pruning Algorithm via the Representer theorem for Imbalanced Scenarios), a principled framework designed to address data imbalance by directly optimizing the training set. PARIS computes a closed-form deletion residual, which quantifies the exact change in validation loss induced by removing an individual training sample—without requiring retraining.

We demonstrate the effectiveness of PARIS on Dst index forecasting. Results show that the algorithm can reduce the training set size by up to 75% while maintaining or improving overall RMSE. Moreover, PARIS consistently outperforms standard approaches such as re-weighting, synthetic oversampling, and boosting, highlighting its potential as a robust and computationally efficient solution for imbalanced learning in space weather applications.

Preprint available: https://arxiv.org/abs/2512.06950

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8. Validating AENEAS: Assessing the UK Operational Model for Space Weather Forecasting

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Accurate representation of the coupled ionosphere-thermosphere (I-T) system is critical for reliable space weather operations, as disturbances in this region can disrupt High Frequency (HF) radio communication, Global Navigation Satellite Systems (GNSS), and satellite orbit predictions. To address this need, operational data assimilation models such as the Advanced Ensemble Networked Assimilation System (AENEAS), deployed at the UK Met Office, combine physics-based models with observations to nowcast and forecast the upper atmosphere. AENEAS uses the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) as its background model and assimilates a range of measurements from GNSS, in-situ satellites, and ionosonde observations. This study presents a systematic optimisation and validation of the latest version of AENEAS, focusing on configurable model parameters governing ensemble generation and the weighting of assimilated observations. Different model configurations are evaluated under both geomagnetically quiet and disturbed conditions using statistical performance metrics to identify an optimal configuration. Global ionosonde observations of the ionospheric F2 region, specifically the critical frequency (foF2) and the height of peak electron density (hmF2), are used as an independent validation dataset, with comparisons to established upper atmosphere models providing a benchmark for AENEAS performance. Results show that targeted parameter tuning improves key ionospheric performance metrics and reduces known model limitations and biases. These findings improve understanding of AENEAS sensitivity to ensemble and assimilation settings, support the development of an improved operational configuration, and establish a foundation for comprehensive future validation campaigns.

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9. Multi-Instrument Analysis of Low Latitude Ionospheric Perturbations During Intense Geomagnetic Storm in the descending phase of solar cycle 24

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Geomagnetic storms, driven by fast-moving solar plasma from coronal holes or Coronal Mass Ejections (CMEs) interacting with the interplanetary magnetic field (IMF), induce significant disturbances in the Earth's magnetosphere-ionosphere system. This study presents a comprehensive analysis of the low latitude ionospheric response during the intense geomagnetic storm of 26 August 2018, occurring during the descending phase of solar cycle 24. The combined analysis of VLF propagation, GNSS-TEC measurements, and satellite observations provides a comprehensive understanding of the low latitude ionospheric response to geomagnetic storms over multiple altitude regions.

Using sub-ionospheric Very Low Frequency (VLF) signals from the NWC transmitter monitored at Varanasi, India, we identify a pronounced decrease in VLF amplitude during the storm's nighttime main phase. To quantify these D-region modifications, the anomalies were modeled using the Long-Wave Propagation Capability (LWPC) code. Results indicate a significant shift in Wait’s ionospheric parameters: the reference height (H') increased by approximately 7.4–7.6 km, while the sharpness factor (beta) decreased from 0.07 to 0.03 km?¹ during the main and recovery phases.

To further understand the ionospheric response, Global Navigation Satellite System (GNSS)-derived Total Electron Content (TEC) measurements were analyzed. TEC, which represents the integrated electron density along the signal path, exhibited significant fluctuations during the storm period. Furthermore, satellite data from the Defense Meteorological Satellite Program (DMSP) and SWARM missions reveal the presence of plasma depletions in the Asian sector. Interestingly, these depletions occurred in the absence of Equatorial Plasma Bubbles (EPBs), suggesting they were generated by local sources at low and mid-latitudes during geomagnetic disturbances. This multi-technique approach provides a detailed view of the coupling between solar forcing and the multi-layered ionosphere at low latitudes.

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10. CONNECTING THE PHYSICAL SPACE WITH GENERATIVE AI TO EXPLORE MANY POTENTIAL FUTURES IN SPACE WEATHER FORECASTS

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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. Generative AI can be effective in realizing the statistical underpinning of the problem and creating a forecasting

solution that is closer to the cognitive functioning of human forecaster.
We present a framework that can manipulate a solar active region (AR) along known physical trajectories using a generative model and use that manipulated image as a query to a self-supervised-learning (SSL) model for the retrieval of real matches from the past. To connect the physical space to abstract Generative model embedding 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.

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11. Improving Thermospheric Density Modeling Using SET Solar and Geomagnetic Indices

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Accurate thermospheric density specification and forecasting are essential for satellite drag modeling and space operations, but they remain challenging due to variability in solar radiative forcing and geomagnetic energy input. A solar irradiance proxy is a measurement of solar flux at a particular wavelength that is used as a surrogate for another wavelength due to strong correlations, whereas indices correspond to measurements of solar irradiance that are absorbed in the atmosphere and drive thermospheric density. While proxies provide operational stability, many are derived from ground-based observations that only indirectly represent the irradiances responsible for thermospheric heating.
This work presents an overview of Space Environment Technologies’ (SET) real-time solar and geomagnetic index dataset, JBHSGI (Jacchia Bowman HASDM Solar and Geomagnetic Indices), which provides operational inputs to the High Accuracy Satellite Drag Model (HASDM) used by the U.S. Space Force. JBHSGI includes solar indices (F10, S10, M10, Y10) and geomagnetic indices (ap, Dst), capturing variability across the FUV, EUV, and XUV spectral bands and magnetosphere–thermosphere coupling. SET leverages space-based observations (e.g., GOES EUV, X-ray, and Mg II) to better represent spectral energy deposition, while automated quality control ensures a consistent nowcast time series. The system also provides 6-day forecasts using autoregressive, physics-based, and machine learning approaches to support forward-looking density prediction, delivering consistent, high-fidelity inputs for both government and commercial thermospheric density modeling applications. In support of these efforts, we will also share analysis of the newly extended HASDM density nowcast database, now spanning 2000-2025.5, publicly released in March 2026.

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12. Suprathermal heavy ion composition in fast solar wind and ICMEs using Wind/STICS and ACE/SWICS observations

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The heavy ion composition is a crucial diagnostic to determine the coronal source region properties and acceleration processes of coronal mass ejection events and fast solar wind. The charge states of these ions are frozen-in at the corona, therefore recording the thermal properties of electron temperature and density of the plasma in the coronal origins. The sun produces large expulsions of plasma and energy from the solar corona called interplanetary coronal mass ejections (ICMEs) that carry a unique distribution of heavy ions in comparison to regular solar wind signatures. Suprathermal heavy ions are the heavy ions with a higher kinetic energy than their thermal counterparts that become more abundant during ICMEs and fast solar wind. A comprehensive study of suprathermal heavy ion composition can improve our understanding of solar wind events as they are likely the seed population of harmful solar energetic particles (SEPs) and can be used as ICME and space weather predictors. In this study, we characterize the suprathermal heavy ions throughout the mission lifetime of the Wind spacecraft. We analyze the species densities (e.g. O7+, O6+, C6+, and C5+) and charge state ratios (e.g. O7+/O6+ and C6+/C5+) in the thermal and suprathermal ranges during ICME events, shocks, and fast solar wind time periods. We find that the suprathermal particle composition has unique characteristics compared to their thermal counterparts, a key finding in the question of acceleration processes. This research provides the fundamental understanding of suprathermal density characteristics that will inform studies on shock acceleration to suprathermal speeds and source analysis of suprathermal populations. Through studying the suprathermal heavy ion composition, we evaluate the acceleration process of those ions and what factors impact their abundances.

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14. Historical Events of Solar Cycle 25: Comparisons of the MLK Day and Gannon Storms from the Perspectives of the Moon to Mars Space Weather Analysis Office

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In May 2024, Active Region 13664 produced over 90 flares, 6 of which were associated with the main Earth-directed coronal mass ejections that impacted the near-Earth environment on May 10th. The Moon to Mars Space Weather Analysis Office monitored, analyzed, and documented these events as they unfolded including the historical arrival of these CMEs. Much of the space weather community sees these May storms, also known as the Gannon Storms, as a historic event with numerous CMEs arriving and producing the strongest geomagnetic storm witnessed since Solar Cycle 23. However, Solar Cycle 25 was not finished with creating historical events.

In January 2026, a single X-class flare from Active Region 14366 produced a fast Earth-directed CME, accelerating particles towards Earth causing the strongest solar energetic particle event seen since October 2003. The arrival of the CME only increased the level of the solar energetic particles before they dropped below threshold on January 22nd.

Both of these events were historically significant, but for very different reasons. In this poster we compare these different historical cases and show the complexity of the two events from a space weather analyst's perspective with the Moon to Mars Space Weather Analysis Office at NASA Goddard Space Flight Center.

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15. ChatGeo-Magi: Enhanced geomagnetic data access and customer support through a RAG-aided LLM

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The geomagnetism group at NOAA/CIRES develops and distributes magnetic field models essential for navigation, exploration, and research. However, accessing these specialized datasets often requires domain expertise to navigate complex interfaces. We introduce ChatGeo-Magi, a conversational AI agent that leverages Retrieval-Augmented Generation (RAG) and structured tool calling to provide intuitive, grounded access to geomagnetic resources. We compare two architectures: a two-LLM system for reliable single-stage API interactions and an agentic framework enabling multi-step reasoning. The system can query NOAA geomagnetic APIs, perform calculations for magnetic field components, and generate time-series plots and contour maps, in addition to answering domain specific questions. Evaluation across three local models reveals that simply expanding the RAG corpus with proprietary support emails yields limited improvements, highlighting that data quality and retrieval precision matter more than corpus size alone. The agentic system demonstrates superior flexibility for complex queries, demonstrating the potential of LLMs in geoscience applications while underscoring the need for high-quality domain data.
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17. An investigation of geomagnetic effects on modern submarine cables: power feed configuration, uncertainties, and frequency response

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Modern submarine cables form the backbone of global connectivity, yet their vulnerability to extreme geomagnetic disturbances remains insufficiently quantified. We assess the impact of the May 10–11, 2024 ‘Gannon’ superstorm and the October 2024 geomagnetic storm on a representative modern submarine cable system, using the Australia–Japan Cable (AJC) as a case study. Using the SCUBAS (Submarine Cable Upset By Auroral Streams) modeling framework driven by magnetometer observations, we computed storm-time induced geoelectric fields along the cable route. We show that cable topology, including route orientation, configuration, and water depth, strongly controls the spatial distribution and magnitude of induced voltages. Even under identical geomagnetic forcing, different segments of the same system experience substantially different electrical impact, underscoring the need for route-specific risk assessment. To support operational confidence, we quantify uncertainty arising from gaps in magnetometer coverage over oceanic regions. We quantified uncertainties related to (1) limitations in constraints for water depth along the cable route and (2) data gaps related to limited magnetometer coverage along the cable route. We also conducted spectral coherence analysis of data and model which further shows that the model produces reliable output during largescale voltage excursions associated to

magnetic fluctuations. We also examined how the model is performing during different phases of the storm. These results provide an uncertainty-quantified, physics-based framework to inform industry mitigation strategies, monitoring thresholds, and resilience planning for modern submarine cable infrastructure.
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18. Climatological Survey of Geomagnetically Induced Current Waveforms near Virigina, USA

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In the United States, Geomagnetically induced current (GIC) measurements have historically been limited. Following a 2014 directive from the Federal Energy Regulatory Commission (FERC) to address geomagnetic disturbance risks to the power grid, the North American Electric Reliability Corporation (NERC) established a publicly accessible GIC monitoring database providing operational measurements during space weather events. Using this dataset, we analyze 29 geomagnetic storms from 2015–2024 recorded at a mid-latitude NERC station in Virginia, USA. Because the operational data are of mixed quality, quality-assessment algorithms were developed to identify research-grade intervals. This study presents the first climatological survey of two GIC waveform types: Large-Amplitude Short-Duration (LASD) and Moderate-Amplitude Long-Duration (MALD) disturbances. These patterns are important for grid resilience because impulsive GIC spikes (LASD disturbances) can cause voltage instability and thermal hotspots, while sustained currents (MALD disturbances) may lead to transformer core saturation and overheating. Waveforms are quantified using frequency-band integrated wavelet power derived from the continuous wavelet transform. Three bands are analyzed—Pi2 (<150 s), Pc5 (<10 min), and Ps6 (>10 min)—to examine associations with magnetospheric drivers. Results show that GIC spikes and long-duration disturbances exhibit distinct local-time and storm-phase preferences, consistent with ultra-low-frequency statistical studies from magnetometers and inner-magnetosphere observations. Understanding when and where different GIC waveforms occur near a region hosting critical national infrastructure and the world's largest concentration of data centers is important and timely. These results are directly relevant for power-system operators and space weather forecasters.

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19. Improving Solar Flare Forecasting Using the Time Evolution of SHARP Parameters

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We investigate whether incorporating the time evolution of active-region magnetic properties improves solar flare forecasting beyond models that use only a single-time magnetic snapshot. Using an SDO/HMI SHARP data set, we compare baseline classifiers trained on 20 SHARP-based parameters at one time with augmented classifiers that additionally include temporal-difference features, constructed over a range of pre-flare intervals. We evaluate three representative machine-learning models: a random forest classifier (RFC), quadratic discriminant analysis (QDA), and a support vector machine (SVM), for binary prediction of major (M/X) versus non-major (B/C and no-flare) events using leave-one-out cross-validation. Forecast skill is assessed with the True Skill Statistic (TSS) and Heidke skill score (HSS). We find that adding temporal-difference features improves performance for all three models, with the most consistent gains occurring when the endpoint of the delta construction is 23–24 hr before flare onset. The improvement is stronger and more robust for RFC and QDA, and more variable for SVM. TSS and HSS show consistent behavior, indicating that the benefit is not

metric dependent. These results show that a compact representation of SHARP-parameter evolution provides useful predictive information beyond single-time-point features, and they identify a ~1-day pre-flare timescale as particularly informative for major-flare forecasting.

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20. I-ALiRT Cloud Architecture and International Ground Station Integration for IMAP

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The Interstellar Mapping and Acceleration Probe (IMAP) mission includes the Active Link for Real-Time (I-ALiRT) system to measure Space Weather phenomena. IMAP I-ALiRT continually broadcasts data 24/7 from the IMAP observatory in orbit about the L1 Sun-Earth Lagrange point, facilitated by NASA's Deep Space Network (DSN) of ground stations as well as antenna partners across the globe. The IMAP Science Operations Center (SOC) at the Laboratory for Atmospheric and Space Physics (LASP) receives I-ALiRT raw data from ground stations and implements a real-time, low-latency processing pipeline. I-ALiRT utilizes AWS cloud resources to facilitate efficient data ingest and processing. Launch for the IMAP mission was September 24, 2025. Data became public on Feb 1, 2026.

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21. Solar Spectral Irradiance (SSI) from the COronal DEnsity and Temperature (CODET) model: applications for studying Earth and Mars atmospheres

Jenny Rodríguez-Gómez, The Catholic University of America and NASA Goddard Space Flight Center
Solar variability and solar spectral irradiance (SSI) are important for studying planetary atmospheres, particularly the ionosphere–thermosphere–mesosphere (ITM) system, and planetary exospheres. SSI in EUV wavelengths is essential for understanding drivers of space weather effects. The COronal DEnsity and Temperature (CODET) model is a physics-based model (Rodríguez-Gómez 2017; Rodríguez-Gómez et al. 2018). This model uses the relationship between the magnetic field, density, temperature, and EUV emission. This model provides a mean daily SSI time series in EUV wavelengths on long time scales from days to solar cycles at different heliocentric distances. New SSI time series from the CODET model were obtained at different geocentric distances (CODET Re model) to study the Earth's exosphere and at different heliocentric distances, such as Mars distances (CODETMars model). SSI from the CODET Re model was obtained at 3.0Re, 6.6Re, and 8.0Re, in 21.1nm and 19.3 nm wavelengths. Additionally, SSI from the CODETMars model was obtained at Mars' distance ~1.5 AU for 28.4 nm and 21.1 nm (Rodríguez-Gómez 2025b). The CODET model provides SSI time series, fills observational gaps, and delivers reliable long-term datasets to support the study of space weather effects in the atmospheres of Earth and Mars.

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22. Ionospheric Sporadic E response to super magnetic storms and meteorological forcing

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The sporadic E (Es) layer is a prominent ionospheric irregularity that strongly impacts HF communicaitons. Driven dominantly by vertical wind shear at mid-latitudes, it is sensitive to both geomagnetic forcing and lower atmosphere forcing that can influence the neutral wind in the mesosphere and lower thermosphere region at various time and spatial scales. This work gives 3 examples that demonstrate Es as an indicator for these vertical coupling processes. This includes Es responses to magnetic storms at the scale of a day, SSW at the scale of weeks, also to increasing CO2 at the scale of decades.

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23. Longitudinal variation of ionospheric irregularities and response of the ionosphere during 10-13 May and 10-13 October 2024 geomagnetic storms

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We examine the response of the ionosphere to the 10-13 May 2024 and 10-13 October 2024 geomagnetic storms, the two recent great geomagnetic storms of solar cycle 25. We identified the occurrence of ionospheric irregularities during the two geomagnetic storms. We used percentage change in vertical total electron content (?VTEC%) computed using VTEC data from three equatorial ground-based global navigation satellite system (GNSS) receivers in the American, African, and Asian sectors, to study the ionospheric response. In order to determine the occurrence of ionospheric irregularities, we employed the rate of change of electron density (Ne) index (RODI) from Swarm satellite-A (Sw-A) and the rate of change of TEC index (ROTI) from the GNSS TEC. Our results revealed a positive ionospheric storm over the African and Asian sectors during the main phase of May storm; whereas a negative ionospheric response was recorded over the American sector. In contrast, during the October storm, a positive ionospheric storm effect was observed over the American and African sectors and negatively over the Asian sector. Additionally, we identified that the October storm had a higher percentage irregularity occurrence rate than the May storm, although the May storm's G5 level was higher than the October storm's G4 level. Sw-A showed a longitudinal trend in the occurrence rate of irregularities during the May storm, with America having the lowest rate, followed by Africa and Asia. During the October storm, this longitudinal dependence is reversed.

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24. Accuracy of Vertical Total Electron Content (VTEC) by comparison between VHF-derived and GNSS (L-band)-derived VTEC measurements

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Vertical total electron content (VTEC) has been a key measure used in ionospheric maps and models for decades. The primary measured input for VTEC has been GNSS (L-band: GHz) receiver data. While these receivers have been becoming more ubiquitous and cheaper recently, allowing for better ionospheric coverage over land, measurements of VTEC over oceans are still limited. While the precision of L-band VTEC measurements is extremely good (< 0.1 TECU), a key limitation of VTEC derived from L-band measurements has been the "leveling" factor, or how accurately the absolute VTEC is known (2-4 TECU). Previous work has shown that impulsive events measured in the Very-high-frequency (VHF: 30-300 MHz) regime can also be used to provide VTEC estimates without the leveling requirement. Comparisons between one year (2018) of VHF VTEC to L-band VTEC were able to constrain the absolute errors in JPL GIM and Open Madrigal Global GNSS VTEC values. An additional 4.5 years of VHF-derived VTEC measurements have recently been released (https://www.ngdc.noaa.gov/stp/space-weather/satellite-data/satellite-systems/lanl_vtec/). Using this years-long dataset, this work will study the variability in VTEC estimates between Open Madrigal and JPL GIM over time, location, and season.

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25. The Science of Space weather Observations at L1 to Advance Readiness

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The Space weather Observations at L1 to Advance Readiness (SOLAR) project will launch a set of observatories to provide measurements in four foundational and integral observations: Coronal Mass Ejection (CME) imagery, solar wind, magnetic field, and solar X-ray irradiance. Each observatory will include a solar coronagraph, a solar wind plasma instrument, a magnetometer, a solar X-ray irradiance sensor, a suprathermal ion sensor, and the accommodations for a partner contributed instrument. These instruments will provide continuity of measurements from SOLAR-1 (previously SWFO-L1). Here we discuss the necessity of these measurements and the scientific advancement that these measurements provide.

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26. Integrating Space Weather Science into Artemis Mission Science: Current Frameworks and Future Opportunities

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NASA's Artemis program represents the next giant leap in crewed deep space exploration, establishing a sustained human presence on and around the Moon. This ambitious architecture includes the Orion spacecraft, Lunar Gateway, Human Landing Systems, and Commercial Lunar Payload Services (CLPS), all of which will present crew and hardware to environments beyond the low-earth orbit we have been exploring for decades. Such a program demands the rigorous integration of space weather science to ensure operational safety and advance fundamental heliophysics. Beyond Earth's protective magnetosphere, characterizing the dynamic space environment is critical for mitigating radiation risks from Solar Energetic Particles (SEPs) and Galactic Cosmic Rays (GCRs) to both crew and avionics. Artemis also offers unprecedented vantage points for space weather observation. Platforms like the Lunar Gateway, which will host instrument suites such as HERMES, and surface landers provide crucial nodes to study solar wind interactions, Earth's magnetotail dynamics, and the deep space radiation environment. This presentation will provide an overview of the Artemis science structure, detailing how heliophysics and space weather objectives are integrated into cross-divisional mission planning. We will highlight active and upcoming pathways for the space weather community to participate, including future payload calls, research solicitations, predictive modeling efforts, and collaborative data analysis. By bridging human exploration needs with fundamental space weather research, we aim to spark dialogue and encourage the scientific community to leverage Artemis infrastructure to advance the next generation of deep space heliophysics.

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27. Continuous Advancements in Space Weather Monitoring and Forecasting in Taiwan

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Since 2015, the Space Weather Operational Office (SWOO) of the Central Weather Administration (CWA) has been responsible for providing localized space weather information and forecasts. Due to Taiwan's location near the Equatorial Ionization Anomaly (EIA), rapid plasma variations frequently impact satellite communications and navigation systems. To address these challenges, CWA has expanded its team and established a professional division of labor, separating Research and Development (R&D) from Operations and Forecasting (O&F) to ensure high-quality operational services. Currently, CWA utilizes a data-assimilated ionosphere-thermosphere coupled model for daily operations. This system integrates the TIE-GCM 1.95 model with the Data Assimilation Research Testbed (DART) framework, incorporating ground-based GNSS and FORMOSAT-7/COSMIC-2 observations to provide 6-hour forecasts. Additionally, new products are being developed to support the growing space research and industry, including a Global Ionospheric Specification (GIS) product providing a top-down view of the Northern Hemisphere from the North Pole developed by National Cheng Kung University (NCKU) and customized orbital forecasts for neutral atmospheric density. Finally, the CWA is pleased to announce that it will co-host the Asia Oceania Space Weather Alliance (AOSWA) Workshop with the Taiwan Space Agency

(TASA) in Taiwan this November. We sincerely welcome all opportunities for international cooperation and look forward to strengthening global partnerships in space weather research and operation.
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28. Calibration and Validation of the SOLAR-1 Magnetometer

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The Space Weather Observations at L1 to Advance Readiness - 1 (SOLAR-1, formerly SWFO-L1) NOAA mission was launched in September 2025, as a successor to the DSCOVR mission. The satellite will be used to observe incoming solar wind particles and fields before they reach Earth, and the in situ magnetic field will serve as a "key parameter" for operational prediction of space weather events. As the spacecraft journeyed to the L1 Lagrange point, our magnetometer team began the process of in-flight instrument commissioning. This entails calibration of the instrument and validation of its measurements, which is required before the release of data products. In collaboration with the Southwest Research Institute and the University of New Hampshire, NOAA has applied algorithms to calculate the instrumental offsets and other parameters that must be determined in-flight. We also identified the stray magnetic fields originating from the spacecraft (thrusters, reaction wheels, etc.) and quantified the magnitude of the noise. To help end-users remove spurious signals from their analyses, we generated quality flags that will be incorporated with the public data. Finally, we compared the spacecraft's inboard and outboard sensors with each other, and also compared the primary (outboard) magnetometer with similar instruments on other spacecraft orbiting the L1 Lagrange point. In this presentation, we show the outcomes of NOAA's commissioning efforts and discuss the state and quality of the magnetometer measurements, which will be of great value to the operational and scientific communities.
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29. Mid-Latitude GPS Scintillation and its Impact on Navigation: Insights from Solar Cycle 25

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Mid?latitude ionospheric scintillations and associated GNSS navigation errors have emerged as a recurring feature of several Solar Cycle 25 storms. We investigate the key drivers for producing strong phase and amplitude fluctuations at mid?latitudes duirng the disturbed space weather conditions. Our results show that Storm Enhanced Density (SED) plumes, the mid?latitude trough, and substorm?related auroral precipitation play central roles in structuring the ionosphere and triggering GPS disruptions. In addition, bubble?like depletion structures extending from low latitudes occasionally reach mid?latitude regions during the recovery phase, producing severe scintillation and rapid TEC gradients. Initial statistical analysis quantifies the occurrence of phase fluctuations across multiple storms, revealing clear dependencies on geomagnetic activity and background ionospheric morphology. These findings provide new insight into the diverse mechanisms that drive mid?latitude scintillation and lay the groundwork for improved forecasting of GNSS performance during disturbed space?weather conditions.

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30. Verification and Validation of Multi-GNSS TEC Retrieval from PlanetiQ GNSS-RO Observations at NOAA/STAR and Inter-Comparison with Other TEC Products

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Accurate retrieval of absolute Total Electron Content (aTEC) from Global Navigation Satellite System (GNSS) measurements onboard Low Earth Orbit (LEO) satellites is essential for space weather monitoring but demands rigorous calibration and correction of systematic errors. This study details the development of an end-to-end processing algorithm at NOAA/STAR to derive aTEC from PlanetiQ precise orbit determination (POD) measurements. The processing chain enhances aTEC accuracy through: 1) pseudorange multipath calibration; 2) carrier phase–pseudorange leveling; and 3) estimation of GNSS-LEO Differential Code Biases (DCBs).

The PlanetiQ GNSS-LEO mission's pseudorange multipath, caused by spacecraft reflections, introduces structured biases that degrade TEC accuracy. To mitigate this, spacecraft-specific multipath correction models were developed using four months of GNSS data, parameterized by antenna off-boresight and solar array drive angles. Additionally, an iterative approach was developed to estimate optimal LEO multi-GNSS DCBs by minimizing relative inconsistencies among inter-GNSS zenith TEC arcs. These correction methods result in significant improvements in receiver DCB stability, with substantial reductions in variability.

NOAA/STAR thoroughly evaluated the PlanetiQ aTEC products' performance, focusing on accuracy, stability, coverage, and latency. The aTEC products were assessed through two primary comparison methods: 1) inter-comparison with PlanetiQ and UCAR TEC products to examine biases and cross-GNSS consistency; and 2) comparison with collocated COSMIC-2 observations, which serve as independent reference data for verifying absolute TEC uncertainty requirements.

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31. (Re)Introducing the Mauna Loa Solar Observatory: real-time CME alerts 1 hour before CCOR

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The Mauna Loa Solar Observatory (MLSO) has been in operation as a ground-based solar coronagraph research facility since 1965, providing key observations to unlock the mysteries behind coronal heating, solar wind generation, and coronal mass ejection (CME) acceleration in the inner solar atmosphere. In November 2022, following the eruption of Mauna Loa volcano and the destruction of part of the access road, MLSO was closed except for special campaigns to support solar eclipses and NASA's Parker Solar Probe perihelion passes.

In March of this year the access road was reopened and MLSO resumed operations to provide prompt CME alerts during the NASA Artemis II mission. Due to its small internal occulter design, the MLSO K-coronagraph (K-Cor) instrument detects CMEs 30--60 minutes before they are visible in space-based coronagraphs such as NOAA's CCOR or NASA's LASCO coronagraphs. Combined with its 2.5 minute data latency, MLSO/K-Cor can provide critical near-real-time alerts of CMEs with speed, position, and acceleration measurements that can indicate the likelihood of Solar Energetic Particle (SEP) radiation storms that are the primary hazard to astronauts on deep space exploration missions to the Moon and Mars.

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32. The QuickPUNCH Project: Polarimeter to Unify the Heliosphere and Corona (PUNCH) Observations for Space Weather Operations and Research

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PUNCH is a coronagraphic and heliospheric imaging NASA Small Explorer comprising of four spacecraft: three Wide Field Imagers (WFI) and one Near Field Imager (NFI), which generates polarization-resolved observations of the corona and heliosphere between 6–180 solar radii. In addition to its science mission, PUNCH makes low-latency observations of the corona and heliosphere that can support space weather forecasting operations: the QuickPUNCH project, whose initial goal is to develop and demonstrate the required data products, pipeline, and low-latency capabilities.

We describe the space weather applications for QuickPUNCH observations, including tracking coronal mass ejections (CMEs) and solar wind outflow. We discuss the specific low-latency QuickPUNCH data products for space weather, PUNCH's more general science products, and end-user data access. We provide an overview of research-to-operations opportunities provided by these data, including the uses of polarized coronal measurements for space weather, tracing of CMEs in 3D, and the use of PUNCH data as a constraint for numerical forecasting models. We conclude with a look at recent PUNCH science data and their potential to revolutionize forecasting by tracking CMEs in 3-D as they traverse the inner solar system.

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33. You Can't Start From the Ground: Scaling the Solar Wind vs. Scaling the Ground Response

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During the space age so far, none of the geomagnetic storms that have impacted Earth's magnetosphere can be truly called extreme, nor have we witnessed the widespread destruction of technological infrastructure that may be caused by ground magnetic disturbances (GMDs) in a worst-case scenario. In the attempt to predict a 1-in-100 and 1-in-1000 year GMD event, we are therefore hampered by a lack of solar wind observations that would lead to an extreme geomagnetic storm. A commonly used approach to predicting extremes is to scale up the observations from historical storms, either the ground magnetic field data or the solar wind drivers. Using the Space Weather Modeling Framework (SWMF) to simulate geospace, we compare the GMD predictions of these two scaling methods for the Gannon storm of May 2024, scaling the storm by factors of 1.5, 2, and 3. We find that scaling the ground observations and scaling the solar wind inputs result in very different GMD predictions. We also report that scaling up the Gannon storm solar wind drivers by a factor of 3 causes the modeled geospace system to enter an unusual state which changes the interpretation of magnetic indexes like Dst. This last finding serves as a call for caution when using our familiar magnetic indexes to measure the intensity of geomagnetic storms, as the indexes may not mean what they typically do during extreme events.

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34. Student internship opportunities at NOAA's Office of Space Weather Observations (SWO)

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Abstract: As our society becomes increasingly reliant on satellite technology, GPS, and power grids, observing and forecasting space weather becomes even more critical for national security and economic stability. The National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) Office of Space Weather Observations (SWO) develops, deploys, and sustains NOAA operational satellite systems that monitor space weather and safeguard society. Essential to this mission is the cultivation of new talent through summer internships, where students work directly with SWO scientists.

Recent student contributions have spanned the breadth of the field, including the analysis of ionospheric

anomalies using Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) and COSMIC-2 data, visualization of space weather data from instruments aboard the Geostationary Operational Environmental Satellite (GOES) satellites, and the quantification of Earth-produced eclipses on coronagraph imagery. Looking forward, SWO is expanding its internship projects to include analysis of Space weather Observations at L1 to Advance Readiness – 1 (SOLAR-1) data and the application of machine learning and neural networks to explore forecasting techniques/capabilities. Despite the critical nature of this work, many students in the space weather community remain unaware of funding pathways available for summer internships. Currently, SWO actively recruits or plans to recruit summer interns through two primary programs.

-The Ernest F. Hollings Scholarship: A competitive program for undergraduate sophomores providing two years of academic funding and a 10-week paid summer internship at a NOAA facility.

-The William M. Lapenta Internship Program: A 10-week paid summer program targeted at both undergraduate (sophomore/junior) and graduate students, offering robust operational and research experience.

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35. [30 years of observing the Sun's magnetic field from space]

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2026 is a double anniversary for observations of the Sun's magnetic field from space. Thirty years ago, the Michelson Doppler Imager (MDI) on the Solar & Heliospheric Observatory (SoHO) began the first continuous full-disk observations from L1. Twenty years ago, MDI was joined by the Solar Optical Telescope (SOT) on the Hinode mission at LEO commenced gathering the highest resolution and cadence vector magnetograms uncontaminated by atmospheric seeing. They have been followed by the Heliospheric and Magnetic Imager (HMI) on the Solar Dynamics Observatory (2010) and the Polarimetric and Helioseismic Imager on Solar Orbiter (2020) at GEO and heliocentric orbit respectively. Here we review the history and scientific results from these trailblazers and extrapolate how future instruments and missions will support exploration throughout the heliosphere.

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36. [Advancing Space Weather Forecasting through Artificial Intelligence: The AIMFAHR Collaborative Project]

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Machine learning (ML) is transforming heliophysics and space weather forecasting by overcoming the fundamental limitations of traditional empirical models. While empirical approaches often rely on simplified assumptions, spatial averaging, or historical climatology, ML techniques excel at capturing the highly complex,

non-linear dynamics of the Sun-Earth system directly from vast observational datasets. As the number of these powerful, data-driven models grows, there is a critical need for coordinated development and collaboration. The Artificial Intelligence Modeling Framework for Advancing Heliophysics Research (AIMFAHR) addresses this need as a collaborative effort dedicated to improving individual ML models and transitioning them into real-world space weather applications. In this presentation, we highlight the recent AI modeling efforts of the NASA Goddard AIMFAHR team, featuring multiple models that span the dayside magnetosphere and the Magnetosphere-Ionosphere-Thermosphere (M-I-T) system. Driven by OMNI and L1 monitor data, the AIMFAHR models reveal storm responses across geospace systems from a purely data-driven perspective. Specifically, they capture the spatiotemporal variation of magnetopause reconnection; cusp motion and the evolution of cusp ion energy dispersions; auroral intensification and boundary motion; increases in field-aligned currents (FACs), ionospheric conductance, and potentials; enhanced upper-atmosphere Joule heating; thermospheric density enhancements; and intensified geomagnetic field disturbances. Finally, we will discuss future AIMFAHR activities, which will focus on coupling these individual ML models, quantifying model uncertainties, and transitioning the framework toward operational applications.
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38. Observations, instrumentation, and modeling of multiscale Arctic ionosphere structure and dynamics at the Radio and Space Physics Laboratory

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Space weather has a direct impact on the Arctic ionosphere, producing plasma structure and variability that can degrade the performance of Global Navigation Satellite System (GNSS), radio, and radar systems operating in the region. The Radio and Space Physics Laboratory (RSPL) at the University of New Brunswick (UNB) is dedicated to ionospheric observations, operational model development, and instrument development to better understand the physical mechanisms driving ionospheric variability and to support critical technological systems in the Arctic.
RSPL operates the Canadian High Arctic Ionospheric Network (CHAIN), a ground-based infrastructure spanning polar, auroral, and subauroral regions. By monitoring ionospheric dynamics with 31 GNSS receivers and 10 high-frequency (HF) sounders, CHAIN enables a fundamental understanding of how space weather processes drive ionospheric structuring.
As part of ongoing CHAIN modernization, RSPL has also developed sanimut, a versatile HF measurement platform for both vertical and oblique ionospheric sounding. Fully remotely configurable with respect to pulse shape, transmit and receive frequency, and transmission schedule, sanimut serves as a primary observational framework that can coordinate multi-instrument studies with other ground- and space-based radio systems.
Based on CHAIN and other observations, RSPL develops and maintains operational models to support ionospheric research and HF and GNSS operations in the Arctic. These include the Canadian High Arctic Ionosphere Model (CHAIM) suite for baseline ionosphere specification, the Canadian High Arctic Scintillation Model (CHASM), and the Canadian Arctic Mesoscale Plasma Irregularity Model (CAMPI).
This presentation will highlight recent RSPL advances in Arctic ionosphere observation, sounding capabilities, and operational modeling for characterizing and forecasting multiscale ionospheric variability.

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39. Initial Observations from the Solar Wind Plasma Sensor on the Space Weather Observations at L1 to

Advance Readiness (SOLAR-1) mission

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The Solar Wind Plasma Sensor (SWiPS) measures the solar wind on NOAA's Space Weather Observations at L1 to Advance Readiness (SOLAR-1) mission. Launched in September 2025, SOLAR-1 establishes operational capability and continuity of space weather observational requirements which enables space weather watches, warnings, and alerts from the Sun-Earth Lagrange 1 point. SWiPS contains two nested ion sensors, each capable of measuring solar wind ions (mainly protons and alpha particles) from ~0.17 to 32 keV/q, providing solar wind velocity measurements from 200 to 2500 km/s. The SWiPS primary data products include the solar wind ion velocity, temperature, density, and dynamic pressure for these two dominant ion species, while high resolution measurements of their 3-D phase space distributions and flows are also available. SWiPS is currently undergoing commissioning and data product validation and has been measuring the solar wind since activation in early November 2025. In this presentation, we show SWiPS observations and data products for various solar conditions, including the high-speed coronal mass ejection events from November 11 – 12, 2025 and January 19 – 20, 2026. These SWiPS observations demonstrate its capabilities to produce high quality and accurate solar wind measurements which meet the operational space weather monitoring needs of NOAA's Space Weather Prediction Center. Thus, these measurements are used to assess the space weather risks to the nation's bulk electrical system and other vulnerable assets on the ground and in space.

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40. Space Weather Roundtable asks "Can the US National Space Weather Enterprise Be More Effective?"

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Give us your ideas! The Space Weather Roundtable has held numerous meetings exploring the current state of the National Space Weather Enterprise. The Roundtable includes members from academia, government and commercial space weather service providers, and it is also attended ex-officio by representatives from NOAA, NSF, NASA and the DoD. In pursuit of its mandate from congress, the Roundtable has explored how the Nation might: (1) facilitate advances in space weather prediction and forecasting; (2) increase coordination of space weather research to operations and operations to research; and (3) improve preparedness for potential space weather phenomena.

The Roundtable is currently asking "Can the US National Space Weather Enterprise Be More Effective?", and we are looking for thoughts and opinions from the space weather community. Topics could include:
a) What does the future of the National Space Weather Enterprise look like?

b) What are the roles of NASA, NSF, NOAA and DoD in the future 'National Space Weather Enterprise'?
c) What are the roles of commercial 'Space weather service providers'
d) What is the role of Academia
e) The role of CCMC and Space Weather Testbed
f) The R2O2R program
g) Funding for Space Weather Research and technology development
h) Can we improve how space weather-related technology is transitioned to operational status?
i) How can the Space Weather community respond to evolution of the Space Industry?
j) Are there any User Needs that are not currently being met?
k) Any other ideas or topics for discussion?

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41. A New Operation-Ready Geospace Configuration with Accurate Auroral Precipitation

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The Space Weather Modeling Framework (SWMF) Geospace configuration has been in operational use at the Space Weather Prediction Center (SWPC) since October 2016. A known shortcoming is its ability to produce highly accurate electrojet predictions. The prediction of the auroras remains a unique challenge in ideal magnetohydrodynamics (MHD) models, as auroral precipitation is primarily a kinetic process that MHD cannot represent. Geospace uses an empirical auroral model that relates field aligned current strength to conductance to bypass this issue, which creates wide bands of conductance with gaps around changes of current direction. This poster presents an updated version of the Geospace configuration that uses new physics in each physical domain of the simulation. The Block Adaptive Tree Solar-wind Roe Upwind Scheme (BATS-R-US) uses anisotropic MHD when solving the solar wind and global magnetosphere, and is coupled with the fully kinetic Comprehensive Inner Magnetosphere Ionosphere (CIMI) model. CIMI's kinetic physics allow for the calculation of self-consistent diffuse auroral precipitation, which is combined with field aligned currents from BATS-R-US to create the most advanced auroral precipitation predictions ever for a fully operation ready model. Using the new configuration, Geospace can now accurately model the expansion and recovery of the auroras during geomagnetic storms and substorms. The ground magnetic disturbances (GMDs) driven by auroral conductance are improved in timing, location, and magnitude when compared to the current operational Geospace version. This poster highlights the improved accuracy of space weather predictions through comparisons to the current Geospace configuration run operationally at SWPC.

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42. The SupraThermal Ion Sensor (STIS) onboard the Space weather Observations at L1 to Advance Readiness 1 (SOLAR-1) spacecraft: The newest solar wind particle capability of the United States Space Weather Program

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The Space weather Observations at L1 to Advance Readiness 1 (SOLAR-1) spacecraft is the newest space weather satellite of the United States National Oceanic and Atmospheric Administration (NOAA). It was launched on September 24, 2025, and it is currently stationed in a stable orbit around the Sun-Earth Lagrange 1 (L1) point. It is planned to become operational in the spring of 2026. It is designed to deliver real-time observations of the solar corona to help improve forecasts of solar events that can impact Earth. One of the instruments onboard SOLAR-1 is the SupraThermal Ion Sensor (STIS). STIS has two telescopes, one for electrons and one for ions, both equipped with solid state detectors that measure electrons in the range 25-250 keV, and ions in the range 25-6000 keV. The main purpose of STIS is to measure gradual Energetic Ion Enhancements (EIEs) that result from solar wind plasma acceleration by an interplanetary shock as it propagates out from the Sun. This allows the Space Weather Prediction Center (SWPC) to provide an advance warning of an incoming geomagnetic storm (several hours to a day). The STIS data products consist of differential particle fluxes with 2-s cadence plus 1-min averages provided by NOAA's National Center for Environmental Information (NCEI) and used for space weather alerts by SWPC. In this presentation we discuss the calibration/validation steps taken to ensure accurate and reliable STIS products for operational and scientific use.

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43. Analyzing MSL/RAD Measurements to Understand the Space Weather at Mars

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To prepare for the human exploration of Mars, we need to understand how the solar and galactic radiation interacts with the planet. Exposure to space radiation remains one of the major concerns for human space exploration.

As Mars' atmosphere is relatively thin (compared to Earth's), high-energy particles such as galactic cosmic radiation (GCRs) or solar energetic particles (SEPs), emitted from the Sun, can propagate all the way to the Martian surface, thereby creating a radiation field that can be harmful to human explorers. Therefore, to assess potential health hazards to future astronauts exploring Mars, analyzing in-situ measurements of the Martian surface radiation environment are necessary.

Here, we present long-term measurements conducted by the Mars Science Laboratory / Radiation Assessment Detector (MSL/RAD) aboard NASA's Curiosity rover in Gale crater on Mars. We present radiation dose rate measurements spanning more than one solar cycle, and additionally focus on evaluation of the radiation shielding effect provided by natural terrain, such as cliff sides and hills, on the Martian surface.

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44. iALERT data reception by the DL0SHF station in Kiel-Roenne

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Sudden Solar Energetic Particle (SEP) events can have a major impact on technology and humans in space. Therefore early warning systems like the REleASE system, which utilizes the close correlation of near relativistic electrons and the slower but more hazardous protons is desirable. These systems rely on near realtime data that have been provided over the past decades by various spscecraft, including ACE, SOHO, STEREO, and since Feb. 1, 2026 IMAP. This requires constant 24/7 tracking and data reception from those spacecraft. Gground stations - like NASA DSN - to receive these data are limited. However, implementation of a low, real time rate data feed as on ACE, STEREO and IMAP enables reception also with smaller antennas (in the 7..10m diameter class). The Amateur Radio community, interested in accurate and timely space weather information for HF propagation forecasting, has significantly contributed to the 24/7 reception of these data. Among them is the station DL0SHF in Kiel-Roenne (Germany) that receives both ACE and STEREO for more than a decade and IMAP since the iALIRT beacon was turned on for commissioning shortly after launch. To fulfill NASA's requirements a new cost-efficient reception station has been set up that successfully provides data to the space weather comunity.

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45. FORMOSAT-7/COSMIC-2 Observations of Global Ionospheric Responses to Geomagnetic Storms

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Since the launch of FORMOSAT-7/COSMIC-2 constellation in the mid- 2019, there have been about 185 days with geomagnetic disturbances, ranging from minor to extreme events. The disturbances triggered intense positive variations in the low- and mid-latitude ionosphere on several occasions and long-lasting negative storm effects over a wide range of longitudes. The Global Ionosphere Specification (GIS) 3D electron density profiles constructed by assimilating slant total electron content measurements by FORMOSAT-7/COSMIC-2 constellation and ground-based global navigation satellite system receiver network are used to examine the ionospheric response during these events. A superposed epoch analysis is carried out to investigate the onset and impact of the positive response, with the time of maximum interplanetary electric field as the zero-epoch time, and the local-time and latitude variations of the GIS electron density are investigated by using previous 5-day average as the quiet-time reference. The results reveal ~200% enhancement in the average electron density over low latitudes over the longitude that falls at local-noon sector at the zero-epoch time. Maximum electron density response occurs within about 3.5-4 hours after the zero-epoch. In the night sector, the enhancement occurs after 5-12 hours of the zero-epoch. The latitude variation reveals classic storm-time behavior in solar maximum, with stronger response occurring earlier over mid- and low-latitudes and propagating to equatorial region. The storm effect lasts for about 3-days over the mid- and low-latitudes. The results are further compared with the corresponding variations of IMF parameters and the possible factors that contribute to the observed response are examined.

46. Observations of E > 13 MeV Solar Proton Events at Mars During Solar Cycles 24 and 25

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Mars is weakly shielded from space weather due to its tenuous atmosphere and a lack of a global magnetic field. Thus, the space weather impacts and effects on human explorers and supporting infrastructure at Mars (in orbit and at the surface) can be more severe than those experienced at Earth. Continuing to improve our understanding of the high-energy particle radiation environment at Mars will be important for both scientific and exploration purposes. For example, charged particle radiation can cause ionization in the lower and middle Martian atmosphere and subsequently alter the atmospheric chemistry and ionospheric structure, thereby affecting communications. At higher energies, the charged particle radiation can pose a clear health hazard for humans in orbit and at the surface.

We will present the energy spectra for > 13 MeV solar protons that are derived from particle count rate data measured in orbit around Mars by the MAVEN SEP instrument and discuss the peak fluxes and fluences for some of the largest SEP events observed. Some of this discussion includes the peak fluxes in the context of the NOAA Solar Radiation Storm Scale (S-scale). We will also present the event-integrated fluence spectra and compare the spectral hardness for several of our largest events, some of which are considered to be ‘Mars-GLE’ events since they were detected at the surface by MSL/RAD.

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47. Analysis of Positioning Error Impacts due to Large-Scale Spatial Gradients in Ionospheric Density

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Understanding the functionality and performance effects of ionospheric density structures on GNSS receivers is vital for informing various end-users such as emergency management, precision agriculture, and autonomous transportation, of the impact of space weather on their specific application. Small-scale ionospheric plasma irregularities (< 1 km) can significantly alter Global Navigation Satellite System (GNSS) signals leading to receiver loss of lock and degradation of positioning accuracy. Studies have shown that plasma density gradients caused by large-scale phenomena such as storm-enhanced density (SED) plumes and the midlatitude ionospheric trough (MIT) can also modify the amplitude and phase of GNSS signals. However, the impact of such modifications on subsequent positioning errors is unclear. In this study, we analyze GPS receiver data during a collection of SED and MIT events that caused large spatial plasma density gradients overthe continental United States and determine the effect on real-time kinematic (RTK) positioning error. We evaluated the effect on the signal-to-noise ratio of signals traversing these density gradients, the number of losses of lock on the signal during the events, as well as the spatial and temporal rate-of-change of the total electron content (TEC). Finally, we performed a superposed epoch analysis of the RTK single-point positioning (SPP) and precise point positioning (PPP) error of multiple stations during the SED and MIT events as well as a case study of the 2024 Gannon Storm. We found that the 3D SPP error at three stations for a collection of SED and MIT events ranged from 7-23 meters and showed only marginal increases during the events as compared to geomagnetically quiet periods when the ionospheric phenomena was not present. During the Gannon storm, SPP error reached as large as 30 meters. The PPP errors for all events was less than 1 meter. Thus, for many GNSS receiver dependent end-users that can tolerate meter(s) level accuracy, such as emergency management users, effects due to gradients

associated with large-scale phenomena will have minimal impact on their operations except in the most extreme cases.

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48. Automatically Identifying Interplanetary Coronal Mass Ejection, Stream Interaction Regions, and High Speed Streams from In Situ Observations

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With the launch of several new missions, the space weather community will have access to more solar wind observations than ever before. Here, we examine the feasibility of automatically identifying solar wind structures using real-time in situ measurements to produce an initial classification of the solar wind in near real-time with a slight delay to observe enough of a given structure. Such a list can be used to understand the source of space weather impacts in near real-time. For in situ observations, the NOAA SOLAR-1 (formerly known as the Space Weather Follow on at L1 (SWFO-L1) and NASA Interstellar Mapping and Acceleration Probe (IMAP) missions are providing solar wind plasma, composition, and interplanetary magnetic field data in real-time. Here, we explore the possibility of identifying the solar wind structures in real-time using a simple set of criteria for the Interplanetary Coronal Mass Ejections (ICMEs), Stream Interaction Regions (SIRs), Corotating Interaction Regions (CIRs), and High Speed Streams (HSS). Once points are flagged point by point with a set of criteria, we then examine the index values to see if flagged points are adjacent. We explore ignoring small gaps in flagged indices to identify continuous and nearly continuous intervals for which we can produce start and stop times. For ICMEs, we can look for times when the plasma beta ratio for protons is low, the field strength is high, and the proton temperature is low. Many of the new observations have either just come online or soon will come online. Therefore, we do most of our initial testing using prior OMNI solar wind observations that are equivalent to those on IMAP and SOLAR-1 and compare with published event lists. IMAP plasma proton and magnetic field observations recently came online, and the SOLAR-1 plasma and field observations will soon be available. Therefore, if possible, we plan to do some initial case studies comparing identification using public OMNI science observations to new public real-time observations from SOLAR-1 and IMAP. Solar wind heavy ion composition ratios are planned to be a part of the real-time feed for the IMAP mission, which will provide additional criteria to do more definitive solar wind structure identifications, but here we setup an initial framework using the solar wind protons and interplanetary magnetic field measurements.

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49. A Prototype Auroral Forecast Dashboard for the Aurora-Chasing Community

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Aurora chasing is becoming more accessible through consumer cameras, smartphones, and online communities, creating new opportunities for public engagement and for scientifically useful observations. Aurora observers often operate outside the fields of view of fixed instruments, and their images and reports can complement traditional measurements by documenting visible aurora occurrence, morphology, and rare phenomena.

We present a proof-of-concept implementation of a HexaF-developed auroral forecast dashboard designed for the aurora-chasing community. Rather than replacing existing forecast products, this effort brings together the most useful auroral decision support tools within a unified, user-centered interface tailored to common questions such as “Should I go out tonight?” and “What is happening right now?” The platform is designed to incorporate

physics-informed and data-driven approaches to improve short-term auroral prediction and interpretation of geospace conditions.

The proposed dashboard combines real-time and short-term auroral guidance, contextual solar wind and geomagnetic inputs, and magnetometer visualizations to support interpretation of substorm potential. A central concept is the incorporation of ground-truth observations through scientific all-sky imagers and, eventually, community reporting streams such as Aurorasaurus and social media, which can better constrain what is visible from the ground.

Beyond improving forecast usability for chasers, photographers, and tour operators, this framework supports auroral research and operational applications. The platform can help strengthen trust in science, support citizen-science participation, improve preparedness for documenting auroral activity, and contribute to richer ground-based datasets. At the same time, it offers potential value for commercial and operational users who benefit from more actionable auroral forecasts.

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50. Imaging One Year of Space Weather with PUNCH

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NASA's Polarimeter to Unify the Corona and Heliosphere (PUNCH) launched on March 11, 2025. Its four satellites have been in Sun-synchronous twilight low Earth orbit since then. Since late 2025 May, 2025, PUNCH has been collecting polarized science images covering 90° of sky (centered on the Sun), on a four minute cadence. PUNCH data products have revealed the context of our environment in the solar system and, uniquely, permit retrospective tracking of all CMEs and SIRs throughout the inner solar system. NOAA's QuickPUNCH project delivers PUNCH data on forecast-relevant time scales, to prototype using direct real-time tracking, rather than extrapolation, for forecasting arrival of space weather systems at Earth. This poster describes the PUNCH mission, indicates photometric challenges of coronagraphic and heliospheric imaging and how PUNCH overcomes them, shows the current status of the QuickPUNCH pipeline, and displays highlights from a successful year of science operations.