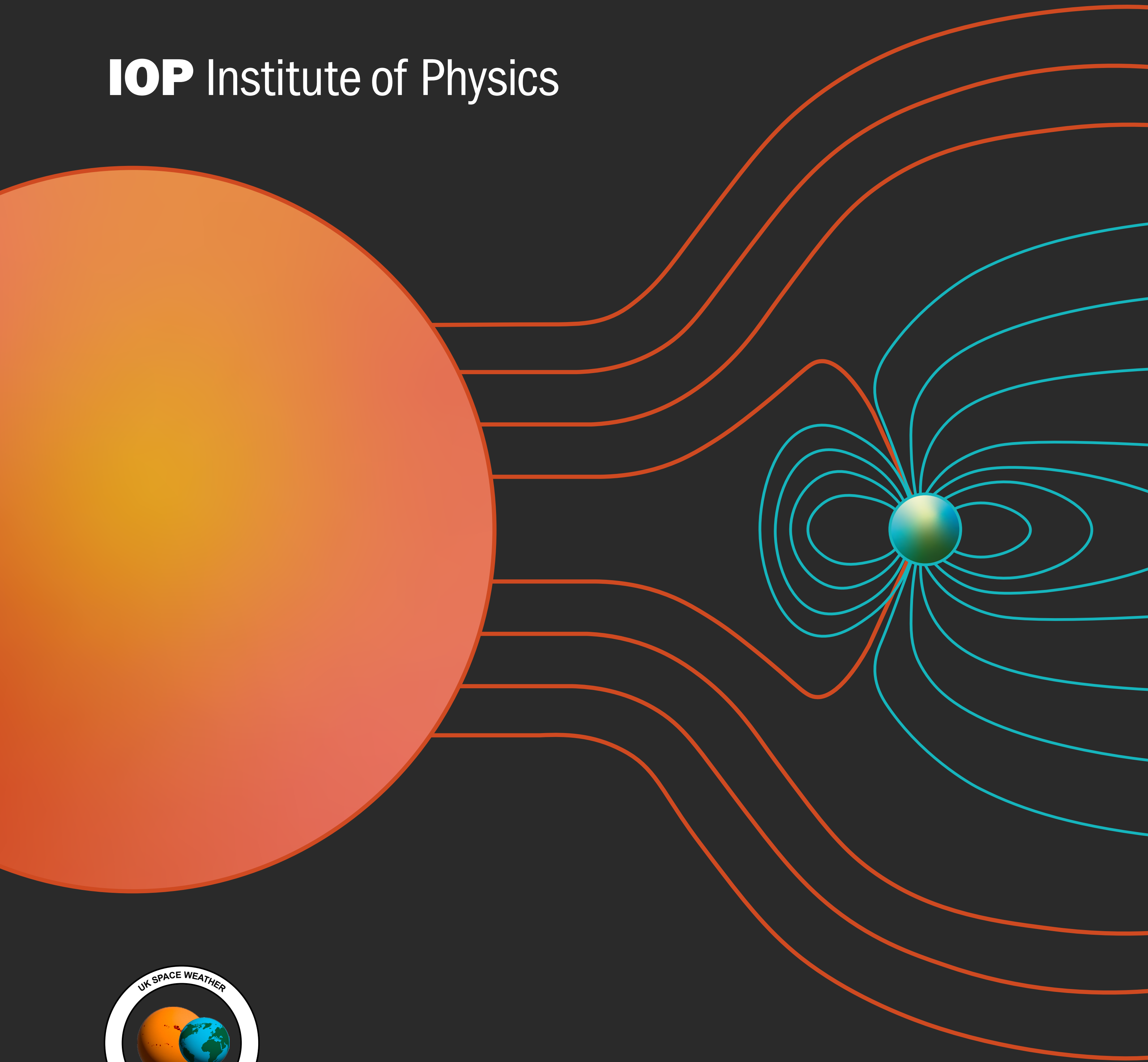
IOP Institute of Physics



UK Space Weather and Space Environment Meeting III:

Global Challenges in Understanding the Space Environment & Space Weather at Solar Maximum

8–11 September 2025

The Cutlers' Hall, Sheffield, UK

iop.org

Programme Monday 8 September 2025

10:00 AM - 11:00 AM	**Registration and Refreshments** (Room: Hadfield Hall)
11:00 AM - 1:00 PM	**Conference Opening and LOC Session** (Room: Main Hall) **11:00 AM Mario M. Bisi**: Welcome and Housekeeping **11:07 AM Oliver Allanson**: Opening and Programme Overview **11:15 AM Mike Willis**: UKSA ESA Space Safety Update **12:05 PM Julia Robbie**: DESNZ Downstream Gas & Energy Resilience **12:25 PM Wg Cdr Neal Henley**: UK Joint Force Space Component – an update since last year's conference **12:45 PM Chris Johnson**: DSIT CSA
1:00 PM - 2:00 PM	**Lunch** (Room: Hadfield Hall)
2:00 PM - 4:00 PM	**Plenary Session 1: Space Weather Operations** (Room: Main Hall) **2:00 PM Alexi Glover and Andrew Monham:** Towards European Operational Space Weather Capabilities **2:10 PM Ian Cohen:** Gauging National Preparedness for Space Weather Events – Findings from the May 2024 Tabletop Exercise **2:20 PM Salma Khan (Invited Speaker):** Experience of SANSA's 24/7 Operational Space Weather Centre **2:30 PM Patrick Perron:** Advancing Arctic Space Weather Monitoring and Forecasting through Targeted Research **2:40 PM Kasper van Dam:** What space weather can learn from meteorology: a Dutch case study **2:50 PM Major Ross Malugani:** Space Weather Enterprise: Holistic Assessment of Needs, Gaps and Future Priorities **3:00 PM Carina Alden (Invited Speaker):** Space Weather Analysis During Solar Maximum with the Moon to Mars Space Weather Analysis Office **3:10 PM Panel Session**

4:00 PM - 4:30 PM	**Lightning Talks 1** (Room: Main Hall) Each talk lasts 2 minutes **1 Martin Archer**: Characterising magnetopause surface waves within magnetosphere–ionosphere–ground coupling **2 Stephen Bannister**: Quantitative Characterisation of Magnetic Topology in Solar Active Regions for Operational Space Weather Forecasting **3 Susanna Bekker**: Response of the total electron content in the ionosphere to the impulsive and late phases of X-class solar flares **4 Damini Bhagwath**: Model Validation using Historical SEP Event Analysis of the 3D Physics-Based Forecasting Tool SPARX **5 Christopher Chen**: Examining time-dependent heliospheric solar wind properties driven by evolving WSA boundaries **6 Ingrid Cnossen**: Projected long-term decline in upper atmosphere density and its impacts on the space debris environment **7 Jackie Davies**: UK-ODESSI: A Low-Cost, Low-Earth Orbit, In-Orbit Pathfinder for UK Space Weather **8 Clive Dyer**: The Importance of Single Event Effects For Atmospheric Radiation Scales, Alerts and Actions **9 Ian Mann**: Understanding, Modelling, and Quantifying the Space Weather Effects of Geomagnetically Induced Currents (GICs) on the Electric Power Grid **10 Mike Marsh**: Atmospheric Radiation: the Met Office Pathway to Operations **11 Juliana Rinaldi-Semione**: Conceptualising ‘environment’ and ‘sustainability’ for an off-Earth future: leveraging existing expertise and frameworks to make a start **12 Christopher Chen**: Scale-by-scale accuracy of solar wind analogue ensemble forecasts
4:30 PM - 6:30 PM	**Poster Presentations and Afternoon Break** (Room: Hadfield Hall)
6:30 PM - 8:00 PM	**Drinks Reception and Buffet** (Room: Hadfield Hall)

Programme Tuesday 9 September

9:00 AM - 11:00 AM	**LOC Session** (Room: Main Hall) **9:00 AM Christian Möstl**: R2O2R at the Austrian Space Weather Office and the case for sub-L1 monitors **9:20 AM Kevin Morgan**, Navigating Solar Storms: Understanding the Operational & Performance Impacts of Space Weather on Air Traffic Management **9:40 AM Mat Hofton** NESO, **Michael Graham**, Fraser-Nash and **Ciaran Beggan**, British Geological Survey **10:20AM Harneet Sangha**, UKSA NSpOC **10:40 AM Panel Session**
11:00 AM - 11:30 AM	**Morning Break** (Room: Hadfield Hall)
11:30 AM - 1:00 PM	**Plenary Session 2: SDA/SST/SSA** (Room: Main Hall) **11:30 AM Delores Knipp:** Space-based Challenges During the 10-14 May 2024 ‘Gannon’ Geomagnetic Storm: Anecdotal & Published Reports **11:40 AM Ingrid Cnossen (Invited Speaker):** A review of global long-term changes in the upper atmosphere and their relevance to practical applications **11:50 AM Fraser Baird:** Extreme Inner Belt Charging Observed on STRV-1D Revisited after 25 Years **12:00 PM David Pitchford (Invited Speaker):** Space Weather Impacts on Spacecraft in the Constellation Era **12:10 PM Mekhi Dhesi (Invited Speaker):** Slingshot’s Eyes on the Skies: Satellite Tracking from LEO through to XGEO **12:20 PM Panel Session**
1:00 PM - 2:00 PM	**Lunch** (Room: Hadfield Hall)
1:30 PM - 1:50 PM	**Find Out More About IOP Membership** (Room: Main Hall)

2:00 PM - 3:30 PM	**Plenary Session 3: Space Weather During Solar Maximum** (Room: Main Hall) **2:00 PM Laura Hayes (Invited Speaker):** Solar Flares and CMEs at Solar Maximum: Multi-Vantage Observations in a Golden Age of Flare Science **2:10 PM Ravindra Desai (Invited Speaker):** Multi-MeV electrons observed by CRRES during the maximum of solar cycle 22 and the implications for solar cycle 25 **2:20 PM Judith de Patoul:** Advancing Operational Forecasting Capabilities with ESA's Vigil Mission: Perspectives from the Belgian Space Weather Centre **2:30 PM Jennifer O'Hara (Invited Speaker):** Space Weather Operations at SIDC/STCE: Recent Developments and lessons learnt from Service Provision during Solar Maximum **2:40 PM Panel Session**
3:30 PM - 4:00 PM	**Afternoon Break** (Room: Hadfield Hall)
4:00 PM - 6:00 PM	**Plenary Session 4: R2o2R** (Room: Main Hall) **4:00 PM Manuela Temmer (Invited Speaker):** Recent Advances in the Modelling of CME Propagation Through the Heliosphere **4:10 PM Adrian LaMoury:** Operational Global Magnetosphere Modelling in the Bergen-Imperial Global Geospace (BIGG) Project **4:20 PM Kirsti Kauristie (Invited Speaker):** Provision of space weather services for civil aviation according to ICAO regulations – lessons learnt and future visions by PECASUS **4:30 PM Lukas Vinoelst:** Building the Sun-to-Earth Connection: An Operational Event Chain Framework for Space Weather Forecasting at SIDC **4:40 PM Andrew Dimmock:** Benchmarking extreme geoelectric fields in Sweden and identifying GIC hotspots in the Swedish power grid **4:50 PM Tzu-Wei Fang (Invited Speaker):** Thermosphere and Ionosphere Products and Services at NOAA SWPC **5:00 PM Ciaran Beggan:** Research to Operations: Implementing cloud-based real-time operational magnetic, geoelectric and GIC models for the UK **5:10 PM Panel Session**

Programme Wednesday 10 September

<table>
<tr><td>8:45 AM - 10:00 AM</td><td colspan="2">Plenary Session 5: Missions (Room: Main Hall)

8:45 AM Craig DeForest (Invited Speaker): Tracking Space Weather with NASA’s Polarimeter to UNify the Corona and Heliosphere (PUNCH)
9:00 AM Jorge Amaya: A new mission to the far side of the Sun to improve space weather science and operations
9:15 AM Jonathan Eastwood (Invited Speaker): HENON: The heliospheric pioneer for solar and interplanetary threats defence
9:30 AM Maria Federica Marcucci (Invited Speaker): The ESA M7 Plasma Observatory mission and its impact for the space weather science
9:45 AM Ian Mann (Invited Speaker): Investigating Space Radiation and Atmospheric Climate Impacts with the Canadian RADICALS Mission</td></tr>
<tr><td>10:00 AM - 11:00 AM</td><td>Parallel Session 1A:
Forecasting Tools and Techniques
(Room: Main Hall)

10:00 AM Martin Archer: First detection of field-aligned currents using engineering magnetometers from the OneWeb mega-constellation
10:15 AM Richard Boynton (Invited Speaker): Assessing the performance of the NARMAX models developed for the SWIMMR SatRisk project
10:30 AM Paloma Jol: Flare forecasting using Fully Convolutional Networks to gain insight into sunspot evolution
10:45 AM Peter Gallagher (Invited Speaker): Solar Activity and Space Weather Monitoring at Radio Frequencies</td><td>Parallel Session 1B: Ionosphere
(Room: Old Banqueting Hall)

10:00 AM Susanna Bekker: Assessment of Vertical Redistribution of Electron Density in the Ionosphere During an X-Class Solar Flare Using GNSS Data
10:15 AM Emma-Claire Gurney: Evaluating Ionospheric Model Performance at Mid- and High-Latitudes Using Long-Term Ionosonde Observations from 1950 – 2022
10:30 AM Sam Lo (Invited Speaker): Ionospheric effects on GNSS Investigated Using the EISCAT/ESR Radars
10:45 AM Gareth Chisham (Invited Speaker): Can we use measurements of ionospheric vorticity to improve the representation of meso-scale ionospheric plasma flows in space weather models?</td></tr>
<tr><td>11:00 AM - 11:30 AM</td><td colspan="2">Morning Break (Room: Hadfield Hall)</td></tr>
</table>

11:30 AM - 1:00 PM	**Parallel Session 2A: Space Weather Modelling and Computational Techniques** (Room: Main Hall) **11:30 AM Ping Li**: Modelling and Prediction of Electron Fluxes with NARMAX Approach Using Data Set with Missing Data Points **11:40 AM Prateek Mayank**: Next-Generation MHD Modeling of Solar Wind Using Neural Operators **11:50 AM Helen Norman**: Investigating the Structure of Magnetised Coronal Mass Ejection models **12:00 PM Benjamin Reid**: A Simple Method To Forecast The Ionosphere Using Effective Geophysical Indices **12:10 PM Tom Daggitt (Invited Speaker)**: Reproducing ultra-relativistic electron acceleration using a coupled density and radiation belt model **12:20 PM Panel Session**	**Parallel Session 2B: GICs** (Room: Old Banqueting Hall) **11:30 AM Daniel Mac Manus (Invited Speaker)**: Space Weather risk to New Zealand: the Solar Tsunami research programme **11:40 AM Andrew Smith:** Understanding and Modelling the Geomagnetically Induced Currents caused by Sudden Commencements **11:50 AM Gemma Bower**: Interhemispheric observations of geomagnetic disturbances **12:00 PM Rosie Hodnett (Invited Speaker)**: Omega bands as a source of large dB/dt in the dawn sector **12:10 PM Samuel Fielding (Invited Speaker)**: Improving nowcasts and forecasts of geomagnetically induced currents through analysis of ground-level magnetic field perturbations **12:20 PM Panel Session**
1:00 PM - 2:00 PM	**Lunch** (Room: Hadfield Hall)	
1:30 PM - 1:50 PM	**MIST/UKSP Lunch Session** (Room: Main Hall)	

2:00 PM - 3:00 PM	**Parallel Session 3A: Solar & Heliospheric Forecasting I** (Room: Main Hall) **2:00 PM Steph Yardley (Invited Speaker)**: Solar Orbiter & Parker Solar Probe: Multi-viewpoint messengers of the inner heliosphere **2:15 PM Matthew Billcliff (Invited Speaker)**: Extended Lead-Time Geomagnetic Storm Forecasting with Solar wind Ensembles and Machine Learning **2:30 PM Daria Shukhobodskaia**: Enhancing Space Weather Forecasting with Solar Orbiter Observations **2:45 PM Rami Qahwaji**: Cross-Dataset Solar Flare Forecasting: Combining GOES X-ray and SHARP Magnetic Parameters for Improved LSTM Predictions	**Parallel Session 3B: Remote Sensing and Sun-Earth** (Room: Old Banqueting Hall) **2:00 PM Luke Nugent:** Low-latitude scintillation forecasting using a proxy for vertical plasma drift at the magnetic equator: a comparison of forecasting skill for different physics-based ionospheric models **2:15 PM Alan Wood**: Dynamic Ionospheric Notifications for Operations and Scheduling (DINOS): Using Ionospheric Observations to Support LOFAR2.0 Operations **2:30 PM Aisling O'Hare**: Quasi-Periodic Pulsations in TEC Measurements Synchronised with Solar Flare EUV Emission **2:45 PM Bernard Jackson:** World-Wide Interplanetary Scintillation Stations (WIPSS) Analysis used with Thomson Scattering Brightness
3:00 PM - 3:30 PM	**Lightning Talks 2** (Room: Main Hall) Each talk lasts 2 minutes **1 Lucie Green**: Bayesian Inference for Automated 3D CME Characterization and Uncertainty Quantification **2 Jithu Jose Athalathil**: Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks **3 Delores Knipp**: Mid-latitude Geomagnetically Induced Currents as a Manifestation of Penetrating Electric Fields **4 Timo Laitinen**: Multi-point Solar Energetic Particle observations and space weather forecasting **5 Emily Mottram:** Probing the characteristics of a pre-eruptive flux rope using novel techniques **6 Sirsha Nandy**: Solar Wind Density Pulse Effects on the Ionospheric Electrodynamics Under Variable IMF Orientations **7 Yiwei Ni**: Unravelling Filament Barb Dynamics through Pseudo-3D Hydrodynamic Simulations **8 Louisa Prattley**: Number Eight Wire: Building New Zealand's Approach to Managing Space Weather Risk **9 Ian Richardson**: Coronal Mass Ejections Associated with Solar Energetic Particle Events Observed in the Low Corona by the Mauna Loa Solar Observatory **10 David R. Themens:** Statistical modelling of high latitude Sporadic-E climatology: A Sporadic-E module for E-CHAIM **11 Bhagyashree Waghule:** Very Near-Earth Reconnection (VNERX) and its connection to the 30A GIC spike in the Eastern US **12 Samuel Wharton**: Measuring the Magnetopause Position with SMILE-SXI	

3:30 PM - 5:30 PM	Poster Presentations and Afternoon Break (Room: Hadfield Hall)
6:00 PM - 10:00 PM	Drinks Reception (Room: Hadfield Hall) Conference Dinner (Rooms: Drawing and Reception)

Programme Thursday 11 September

9:00 AM - 10:00 AM	**Plenary Session 6: Impacts** (Room: Main Hall) **9:00 AM Rick Tanner (Keynote Speaker):** Radiation risks to human health (terrestrial, air crew, astronauts) due to cosmic radiation **9:30 AM Dimitrios Millas**: Impact of recent geomagnetic storms on aviation as observed by PECASUS **9:45 AM Keith Ryden (Invited Speaker)**: The influence of space weather on electronics	
10:00 AM - 11:00 AM	**Parallel Session 4A: M-I Coupling** (Room: Main Hall) **10:00 AM Maria-theresia Walach (Invited Speaker):** Bridging AMPERE and SuperDARN: Aligning Field-Aligned Current and Ionospheric Convection Boundaries During Geomagnetic Storms **10:15 AM Sarah Vines (Invited Speaker):** The Utility of AMPERE for Space Weather Research and Applications **10:30 AM Mario Bisi**: RISER – Using LOFAR Radio Observations and Modelling of the Heliosphere-Magnetosphere-Ionosphere System **10:45 AM Liisa Juusola (Invited Speaker)**: Drivers of rapid geomagnetic variations at high latitudes	**Parallel Session 4B: Solar & Heliospheric Forecasting II** (Room: Old Banqueting Hall) **10:00 AM Harriet Turner**: Using solar wind data assimilation results to drive dynamic solar wind models **10:15 AM Harshita Gandhi (Invited Speaker):** Improving CME forecast diagnostics from pre-launch to interplanetary space: 3D Analysis, Magnetic Constraints, and Deep Learning **10:30 AM Mathew Owens (Invited Speaker):** Solar wind forecasting without magnetograms **10:45 AM Sarah Watson (Invited Speaker):** Statistical Analysis of Comet Disconnection Events Using STEREO HI and a Data Assimilative Solar Wind Model
11:00 AM - 11:30 AM	**Morning Break** (Room: Hadfield Hall)	

11:30 AM - 1:00 PM	**Parallel Session 5A: Magnetosphere** (Room: Main Hall) **11:30 AM Chiara Lazzeri (Invited Speaker):** The Geomagnetic Response to Extreme Southward Turnings of the IMF **11:40 AM Jean-francois Ripoll (Invited Speaker):** New Environment Models of Cold Electrons and Electromagnetic Waves in the Near-Earth Space and their Impact on Radiation Belt Electrons **11:50 AM Xingzhi Lyu**: Modeling MeV Radiation Belt Electron Precipitation and Its Atmospheric Impact Using VERB-4D **12:00 PM Steve Milan**: Magnetospheric responses to the October 2024 ICMEs **12:10 PM Clare Watt (Invited Speaker):** Modelling highly-variable processes in the outer radiation belt **12:20 PM Panel Session**	**Parallel Session 5B:Sun-to-Earth Forecasting** (Room: Old Banqueting Hall) **11:30 AM Lucie Green**: Checklist for CME forecasting in advance of an eruption **11:40 AM Robertus Erdelyi**: Solar Activity Monitor Network (SAMNet) - Next step in ground-based Space Weather forecasting **11:50 AM Edmund Henley (Invited Speaker):** Lift-and-shift: useful approaches from terrestrial weather **12:00 PM Mike Marsh**: pyCAT: Rearchitecting Operational CME Analysis **12:10 PM Ruth Hyndman (Invited Speaker):** Investigating SEP transport using observations and simulations **12:20 PM Panel Session**
1:00 PM - 2:00 PM	**Lunch** (Room: Hadfield Hall)	
2:00 PM - 3:00 PM	**Parallel Session 6A: Space Environment** (Room: Main Hall) **2:00 PM Ralph Dinsley (Invited Speaker):** Neglected Orbits and the Emperor's New Clothes: The Critical Gap in UK Space Situational Awareness **2:15 PM Ashley West**: AEGIS: Advancing Protective Space Weather Science through Agile Rideshare Missions **2:30 PM Ben Clewer**: The next generation of the Surrey Space Centre's SAIRA atmospheric radiation monitors **2:45 PM Matthew Brown (Invited Speaker):** Improving thermospheric density forecasts for space domain awareness in Low Earth orbit with AENeAS	**Parallel Session 6B: Sun-to-Earth Science** (Room: Old Banqueting Hall) **2:00 PM Yiwei Ni**: Magnetic Transients Associated with a Solar Moreton Wave and Its Local Enhancement **2:15 PM Philippa Browning (Invited Speaker):** Oscillatory reconnection in coalescing magnetic flux ropes **2:30 PM David MacTaggart (Invited Speaker):** The application of magnetic topology approaches to the problem of solar flare and CME prediction **2:45 PM Pauline Teysseyre**: Real-time detection and characterisation of solar flares from ground-based VLF data

3:00 PM - 3:30 PM	**Afternoon Break** (Room: Hadfield Hall)
3:30 PM - 5:00 PM	**Plenary Session 7: Keynote Speaker and UK-International Community Discussion** (Room: Main Hall) **3:30 PM Suzy Bingham:** International Collaboration Beyond SWIMMR **4:00 PM Discussion** **4:10 PM Richard Horne:** The May 2024 Storm: Recommendations from the SEIEG Report **4:30 PM Ian Mccrea:** Space weather instrumentation, measurement, modelling and risk (SWIMMR) **4:50 PM Closing remarks**
5:00 PM - 5:15 PM	**Close** (Room: Main Hall)

Oral Presentations

Space Weather Analysis During Solar Maximum with the Moon to Mars Space Weather Analysis Office

Carina Alden
[1]*The Catholic University of America, United States*

Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

Founded in 2020, the Moon to Mars Space Weather Analysis Office (M2M SWAO) at NASA's Goddard Space Flight Center carries out human-in-the-loop real-time analysis to assess the space weather conditions in support of NASA's human and robotic missions. In 2024, the M2M SWAO space weather analysts provided support during the peak phase of Solar Cycle 25. During this period, the space weather community experienced notably high levels of activity, during which the M2M SWAO team prototyped experimental capabilities in real time. In particular, the events observed during May and October of 2024 involved 360-degree analysis to track notable drivers of enhanced space weather activity (such as NOAA Active Region 13664). The M2M SWAO team's analyses carefully followed the solar eruptions that led to impactful arrivals and associated aurora in different planetary environments.

In this talk, we present our unique experience as analysts with the M2M SWAO team during solar maximum. We will reflect on the challenges we've faced, the lessons we've learned, and how this pertains to preparations for future exploration to the Moon, Mars, and beyond.

A new mission to the far side of the Sun to improve space weather science and operations

Dr. Jorge Amaya[1]
[1]Esa/esoc, Darmstadt, Germany

Plenary Session 5: Missions, September 10, 2025, 08:45 - 10:00

Reconstructions of the solar corona show that the global magnetic field structure is affected by far side solar active regions (Perri et al. [1]). This impacts not only the location of the open and close field lines, but also the total structure of the Heliospheric Current Sheet (HCS) with a direct effect on space weather characteristics on Earth, even during quiet times without CMEs or flares. Emergence of active regions on the far side can drastically change the outcome of our current heliospheric models.

Alternatives to cope with the missing information from the far side are still inaccurate and can not replace actual observed data.

The ESA Concurrent Design Facility (CDF) has developed a concept for a mission to the far-side of the Sun. The Antichthon L3 mission will be stationed near the Lagrangian point L3. It will carry remote imagers, in-situ plasma instruments, and radiation monitors to maintain an operational surveillance of the solar activity on the far-side.

In this presentation I will present the continuous efforts to improve the monitoring and forecasting of space weather, including the results of the CDF study of the Antichton L3 mission.

This presentation is based on the results produced by the ESA CDF study team for the Antichthon L3 mission, with a CDF Study Report reference CDF-225(A), December 2024.

First detection of field-aligned currents using engineering magnetometers from the OneWeb mega-constellation

Martin Archer[1], Vincent Evans[2], Jonathan Eastwood[2], Louis-Ashley Camus[2], Cara Waters[1], Patrick Brown[1], Fabien Armogathe[2]
[1]Imperial College London, United Kingdom, [2]Eutelsat OneWeb, United Kingdom
Parallel Session 1A: Forecasting Tools and Techniques, September 10, 2025, 10:00 - 11:00

Field-aligned currents are the main physical mechanism behind magnetosphere–ionosphere coupling, with these currents communicating environmental changes between the two regions of geospace. Field-aligned currents are thus a key factor in monitoring space weather, both from an operational and scientific perspective. While the AMPERE project has demonstrated that engineering fluxgate magnetometers on commercial satellite constellations can be assimilated to estimate the field-aligned currents across the entire polar cap, a limiting factor in the spatio-temporal resolution of this assimilation is the coverage of measurement points. However, in recent years much larger satellite mega-constellations have been launched into low Earth orbit which might offer unprecedented opportunities. Here we leverage engineering anisotropic magnetoresistive magnetometer data from the OneWeb constellation for the first time. A case study during the 12 May 2021 geomagnetic storm is presented. We show conclusive evidence that OneWeb engineering magnetometers were able to detect field-aligned current signatures present during this event by validating against AMPERE magnetic field and current maps from the same time. However, this result was despite significant challenges due to the OneWeb spacecraft instrumentation, data availability, and magnetic cleanliness, which we discuss in detail. Finally, we provide an outlook on the next steps required for OneWeb magnetic field data to provide valuable contributions to space weather science and operations.

Extreme Inner Belt Charging Observed on STRV-1D Revisited after 25 Years

Dr Fraser Baird[1], Keith Ryden[1], Chris Davis[1], Clive Dyer[1], Paul Morris[1], Fan Lei[1]
[1]*University Of Surrey, United Kingdom*

Plenary Session 2: SDA/SST/SSA, September 9, 2025, 11:30 - 13:00

STRV-1D was a UK satellite which launched into GEO in November 2000. The satellite carried a SURF instrument for measuring internal charging currents under different shielding depths. Despite operating for only two weeks, the observations made by SURF remain useful to this day. The observations are particularly notable because the currents observed in the inner belt were more severe than the outer belt.
This contribution will review the observations and the space weather context in which they were made. Contemporaneous independent measurements of the trapped electron flux will be discussed. Finally, the implications of the SURF observations, particularly for the debate about MeV electrons in the inner belt, will be presented.

Research to Operations: Implementing cloud-based real-time operational magnetic, geoelectric and GIC models for the UK

Dr Ciaran Beggan[1], Edmund Henley[2], Gemma Richardson[1]
[1]British Geological Survey, United Kingdom, [2]Met Office, United Kingdom

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

The enhanced variation of the magnetic field during severe to extreme geomagnetic storms induces a large geoelectric field in the subsurface. Grounded infrastructure can be susceptible to geomagnetically induced currents (GICs) during these events. Modelling the effect in real time and forecasting the magnitude of GICs are important for allowing operators of critical infrastructure to make informed decisions on potential impacts. As part of the UK-funded SWIMMR programme, we implemented nine research-level models into operational codes capable of running consistently and robustly to produce estimates of GICs in the Great Britain high voltage power transmission network, the high-pressure pipeline network and the railway network.
The models rely on real time ground observatory data and solar wind data from satellites at the L1 Lagrange point. A mixture of empirical machine learning and numerical magnetohydrodynamic models are used for forecasting. In addition to nowcast capabilities, contextual information on the likelihood of substorms, sudden commencements and large rates of magnetic field change were developed. The final nowcast and forecast codes were implemented in a cloud-based environment using modern software tools and practices. We describe the on-going process to move from research to operations (R2O) and give examples of the new developments to make the last move from Application User Level 8 to 9.

Assessment of Vertical Redistribution of Electron Density in the Ionosphere During an X-Class Solar Flare Using GNSS Data

Dr Susanna Bekker[1]
[1]*Queen's University Belfast, United Kingdom*

Parallel Session 1B: Ionosphere, September 10, 2025, 10:00 - 11:00

The impact of solar flares on the Earth's ionosphere has been studied for many decades using both experimental and theoretical approaches. However, the accuracy of predicting ionospheric layer dynamics in response to variations in solar radiation remains limited. In particular, understanding the vertical redistribution of charged particles in the ionosphere during flares with different spectral characteristics presents a significant challenge. In this study, a method is presented for reconstructing the temporal evolution of the vertical electron concentration (Ne) profile based on GNSS (Global Navigation Satellite Systems) measurements of total electron content along partially illuminated satellite-receiver paths. Using this method, vertical profiles of Ne were reconstructed during various phases of the X13.3-class solar flare that occurred on 6 September 2017. The resulting profiles correctly respond to the observed variations in solar extreme ultraviolet and X-ray radiation, and they show good agreement with incoherent scatter radar measurements and theoretical estimates. This indicates that the method can be effectively applied to analyse other powerful solar events.

Extended Lead-Time Geomagnetic Storm Forecasting with Solar wind Ensembles and Machine Learning

Matthew Billcliff[1], Andy Smith[1], Mathew Owens[2], Luke Barnard[2], Nathaniel Edward-Inatimi[2], Wai Lok Woo[1], Jonathan Rae[1]
[1]Northumbria University, United Kingdom, [2]University of Reading, United Kingdom
Parallel Session 3A: Solar & Heliospheric Forecasting I, September 10, 2025, 14:00 - 15:00

Geomagnetic storms disrupt the Earth's magnetosphere, threatening satellites, power grids, and communication systems. Current forecasts rely on L1 satellite data, limiting lead times to just a few hours—often too short for effective mitigation. Extending these lead times is critical for protecting infrastructure and ensuring operational continuity.

This work explores long-lead geomagnetic storm forecasting using solar wind data from the computationally efficient 1D HUXt model. Unlike resource-intensive 3D-MHD models, HUXt enables generation of large solar-wind ensembles, capturing spatial and propagation uncertainties more efficiently. We build on prior work in binary storm classification to develop regression-based forecasts of the Hp30 geomagnetic index, which offers higher temporal resolution (30 minutes) than the widely used Kp index (3 hours).

Solar wind ensemble outputs are processed through machine learning regression models trained on individual profiles. Forecasts are aggregated to produce a final prediction, with uncertainty estimated from ensemble spread and historical correlations between HUXt and observed OMNI data. Using 30 years of historical data, we evaluate model performance across lead times from 1 to 36 hours and across storm intensities.

We assess various machine learning architectures and input combinations, focusing on reducing Mean Absolute Error and improving R-squared scores. Our results demonstrate that combining fast numerical solar wind modelling with machine learning can significantly extend the lead time of accurate Hp30 forecasts.

International Collaboration Beyond SWIMMR

Dr. Suzy Bingham[1], Jesse Andries[2], Mario Bisi[3], Joaquim Costa[4], Sergio Dasso[5], Alexi Glover[6], Mamoru Ishii[7], Kirsti Kauristie[8], Masha Kuznetsova[9], Ian Mann[10], Mauro Messerotti[11], Mpho Tshisaphungo[12]

[1]Met Office, United Kingdom, [2]World Meteorological Organization (WMO), Switzerland, [3]RAL Space, UKRI-STFC, United Kingdom, [4]National Institute for Space Research (INPE), Brazil, [5]Argentinian Space Weather Laboratory (LAMP), Argentina, [6]European Space Agency (ESA), Germany, [7]National Institute of Information and Communications Technology (NICT), Japan, [8]University of Alberta, Canada, [8]Finnish Meteorological Institute (FMI), Finland, [9]NASA Community Coordinated Modeling Center (CCMC), United States, [11]National Institute for Astrophysics (INAF), Italy, [12]South African National Space Agency (SANSA), South Africa

Plenary Session 7: Keynote Speaker and UK-International Community Discussion, September 11, 2025, 15:30 - 17:00

The final stages of transitioning SWIMMR models into operational use are underway at the Met Office. Alongside this, SWIMMR instrumentation and data streams are being integrated to help ensure modelling systems remain responsive and scientifically relevant. The connections formed during the SWIMMR study on impacts to Critical National Infrastructure are being maintained to keep services aligned with stakeholder needs.

To sustain momentum beyond SWIMMR, it’s widely recognised that an R2O2R follow-on programme is essential – not only for those directly involved in SWIMMR, but for the broader community. The challenge – and opportunity – is to maintain and enhance current models, instrumentation and data, while continuing to advance state-of-the-art modelling and innovation. Planning for an R2O2R programme is underway. Embedding SWIMMR models into the Met Office’s O2R framework will support continuous improvement of operational capabilities, with verification and benchmarking remaining central throughout the R2O2R cycle, to ensure model reliability and performance.

A key opportunity in this next phase is to continue strengthening international collaboration, actively integrating UK efforts with global initiatives. The UK’s commitment to international collaboration is at the heart of the UK Severe Space Weather Preparedness Strategy, which highlights the importance of working collectively to meet the challenges of severe space weather.
This talk will focus on international collaboration, highlighting a growing effort to strengthen coordination in space weather. In response to a 2021 invitation from the United Nations Office for Outer Space Affairs (UNOOSA), on behalf of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), three organisations - WMO, ISES and COSPAR – agreed to lead efforts to improve global coordination of space weather activities, working together with other relevant actors. To support this goal, they jointly established the International Space Weather Coordination Forum (ISWCF).

The ISWCF promotes focused collaborative activities – bringing together international organisations that have a shared challenge to solve. The aim of the forum is to optimise efforts to advance collective progress in space weather capabilities. Key priorities identified by the forum include: Coordination of global ground-based observing assets; Assessing capabilities across the international community; Engaging end-users through unified approaches; and Coordination of future space research missions.

The ISWCF is open to participation from all international organisations and initiatives. The UK is well-placed to contribute to and benefit from ISWCF projects, helping ensure that national investments are aligned with and amplify global progress. Through collaborative efforts, we can more effectively address the shared ‘Global Challenges in Understanding the Space Environment and Space Weather’.

Acronyms:
COPUOS: United Nations Committee on the Peaceful Uses of Outer Space
COSPAR: Committee on Space Research
ISES: International Space Environment Service
ISWCF: International Space Weather Coordination Forum
R2O2R: Research-to-Operations-to-Research
SWIMMR: Space Weather Instrumentation, Measurement, Modelling & Risk programme
UNOOSA: United Nations Office for Outer Space Affairs
WMO: World Meteorological Organization

RISER – Using LOFAR Radio Observations and Modelling of the Heliosphere-Magnetosphere-Ionosphere System

Richard Fallows[1], Dr Mario Bisi[1], Biagio Forte[2], Steve Milan[3], David Jackson[4], Bernard Jackson[5], Dusan Odstrcil[6,7], Edmund Henley[4], Oyuki Chang[1], David Barnes[1], Siegfried Gonzi[4], Paul Kinsler[2], Tianchu Lu[2]

[1]UKRI STFC RAL Space, United Kingdom, [2]Department of Electronic and Electrical Engineering, University of Bath, United Kingdom, [3]School of Physics and Astronomy, University of Leicester, United Kingdom, [4]Met Office, United Kingdom, [5]Department of Astronomy & Astrophysics, University of California, United States, [6]George Mason University, Department of Physics and Astronomy, United States, [7]NASA Goddard Space Flight Center, Heliophysics Division, United States

Parallel Session 4A: M-I Coupling, September 11, 2025, 10:00 - 11:00

The UK's NERC-funded Radio Investigations for Space Environment Research (RISER) project 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.

Since March 2025 LOFAR-UK has been used full time for RISER observations, recording over 100 observations interplanetary scintillation (IPS) per day across the inner heliosphere to input into tomographic reconstructions to visualise and track conditions throughout the inner heliosphere. The reconstructions are also used as input into drive a variant of Enlil, currently under test at the Met Office. This period has encompassed increased levels of space weather activity. A vital component of the RISER project is to link the heliospheric conditions near Earth via magnetospheric modelling to conditions in the ionosphere. Observations of the strong radio source Cassiopeia A are taken overnight using LOFAR-UK, along with single-frequency all-sky imaging data (since May 2025) to measure broadband ionospheric scintillation and refractive effects. We provide an overall summary of results to date with an outlook of the next steps to come.

Interhemispheric observations of geomagnetic disturbances

Gemma Bower[1], Suzie Imber[1], Steve Milan[1], Anna Willer[2]
[1]University of Leicester, United Kingdom, [2]DTU Space, Denmark

Parallel Session 2B: GICs, September 10, 2025, 11:30 - 13:00

Geomagnetic disturbances (GMDs) are rapid changes in the magnetic field of the Earth that are known to cause ground induced currents (GICs). When the change in the magnetic field is sufficiently rapid (greater than 5nT/s) the resulting GIC could be potentially harmful for infrastructure, causing issues such as transformer failures and rail signaling failures. GMDs are typically measured with ground-based magnetometers of which there are more stations in the northern hemisphere. In order to compare the interhemispheric nature of the GMDs we used the four station pairs which lie at approximately the same magnetic latitudes from the Antarctic and Greenland magnetometer networks. We identify GMDs using a previously tested algorithm on the 10 second average magnetometer data between 2011 and 2016 finding over 6000 GMDs across the 8 stations with rate of change greater than 50 nT per 10 seconds. GMDs are considered to be occurring in both hemispheres simultaneously if the GMDs occur within two and a half minutes of each other. We find that GMDs can occur in both hemisphere at the same time or only in one hemisphere. We investigate the differences between these types of GMDs.

Assessing the performance of the NARMAX models developed for the SWIMMR SatRisk project

Richard Boynton[1], Michael Balikhin[1], Hua-Liang Wei[1], Mahdi Mahfouf[1]
[1]*University Of Sheffield, United Kingdom*
Parallel Session 1A: Forecasting Tools and Techniques, September 10, 2025, 10:00 - 11:00

For the SatRisk project, models were developed to forecast the electron fluxes at GEO, the electron counts between L=2 to 8, and the Kp index. These were developed using system identification methods based on Nonlinear AutoRegressive Moving Average eXogenous (NARMAX) models, which, similar to machine learning, is a data based method where the models are trained on input output data. All these models have been running in real time since September 2023. This study investigates the real time performance of these models using a number of metrics and skill scores over different forecast horizons from 1 hour to 48 hours ahead.

Improving thermospheric density forecasts for space domain awareness in Low Earth orbit with AENeAS.

Matthew Brown[1], Sean Elvidge[1]
[1]SERENE, University Of Birmingham, United Kingdom

Parallel Session 6A: Space Environment, September 11, 2025, 14:00 - 15:00

There is an accelerating growth in the number of satellites in low Earth orbit, where atmospheric drag and thermospheric density is the largest uncertainty in propagating orbits and quantifying collision probabilities. Climatological thermospheric models like NRLMSISE-00, or even half-century old models like CIRA-72 are often used by default in orbital propagation. These models have issues with bias and capturing physical phenomenon. The Advanced Ensemble electron density [Ne] Assimilation System, AENeAS, model assimilates data in near-real time, mitigating bias, and has a numerical background model, simulating the chemistry, physics and dynamics of the thermosphere and ionosphere self-consistently. In addition, AENeAS uses a form of the ensemble Kalman filter, from which non-Gaussian uncertainties of atmospheric density can be calculated.

AENeAS is being operationalized at the Met Office Space Weather Operations Centre (MOSWOC), from where output will be provided. This talk will explore how this output can be converted into products and invite feedback on what kind and level of products are desired by the community. For example, in addition to the absolute density, one product will be the rate of change in density, as this can inform operators of a quickly changing environment, within which orbital propagation uncertainties can rapidly rise. We also look further along the chain of model to operator decision-making, exploring how the non-Gaussian thermospheric density uncertainties feed through to positional uncertainties, resulting in “bananas” rather the often-considered error ellipsoids, and how this affects collision probabilities.

Oscillatory reconnection in coalescing magnetic flux ropes

Philippa Browning[1]
[1]The University Of Manchester, United Kingdom
Parallel Session 6B: Sun-to-Earth Science, September 11, 2025, 14:00 - 15:00

Within the solar corona, twisted magnetic flux ropes may coalesce as large-scale loop structures interact, and also on smaller-scales involving plasmoids within a current sheet. The reconnection process in flux rope coalescence is dynamic and can have an oscillatory phase, in contrast with standard paradigms of steady reconnection models. This has many applications, including the interpretation of Quasi-periodic pulsations (QPPs) which are often observed in solar flare emissions. These could provide an important diagnostic of time-dependent reconnection in flares and of the physical parameters of flaring plasma. We describe 2D resistive magnetohydrodynamic simulations exploring the dynamics and consequences of magnetic reconnection as two flux ropes merge: including oscillations propagating outwards from the reconnection site, the role of the resistivity on the reconnection dynamics and the generated oscillations, and the generation of multiple magnetic nulls and plasmoids around the reconnection site in two dimensions. Furthermore, forward modelling of gyrosynchrotron emission provides a prediction of the observable signatures in microwaves emission. An alternative approach to QPPs considering the kink instability of a single twisted flux rope is also considered.

Can we use measurements of ionospheric vorticity to improve the representation of meso-scale ionospheric plasma flows in space weather models?

Dr. Gareth Chisham[1]

[1]*British Antarctic Survey, United Kingdom*

Parallel Session 1B: Ionosphere, September 10, 2025, 10:00 - 11:00

Joule heating of the high-latitude atmosphere at times of increased geomagnetic activity can result in significant changes in thermospheric density and the drag on satellites in low Earth orbits. For space weather models such as TIE-GCM and WACCM-X to accurately estimate Joule heating they require reliable models and/or measurements of the electric field associated with plasma flow in the high-latitude ionosphere. At the present time, these larger models employ simple models of the electric field (e.g., Weimer, Heelis), that consider the averaged large-scale nature of the flow only, and its variation with driving factors such as the Interplanetary Magnetic Field (IMF). However, meso-scale flow structures are ubiquitous in the high-latitude ionosphere, and are typically associated with larger electric fields, and consequently, localised increases in heating. Using line-of-sight velocity measurements made by SuperDARN (The Super Dual Auroral Radar Network) radars with overlapping fields of view, it is possible to estimate the vorticity of the ionospheric plasma flow over a range of spatial scales. By making certain assumptions, we can statistically separate probability density functions (PDFs) of vorticity made at any location in the ionosphere into two populations: (i) That due to the large-scale plasma flow driven primarily by magnetic reconnection, and (ii) that due to meso-scale flow structures driven by processes such as turbulence and transient events. The spatial variation of large-scale vorticity is controlled by the average flow as presently seen in models, which is highly dependent on the IMF direction. The spatial variation of meso-scale vorticity appears independent of the IMF direction, and has a different character in the polar cap, the cusp, the auroral region, and the sub-auroral region. Understanding the controlling factors behind the behaviour of these meso-scale variations may help to integrate them into electric field models and hence improve the estimation of Joule heating.

The next generation of the Surrey Space Centre's SAIRA atmospheric radiation monitors

Dr Ben Clewer[1], Paul Morris[1], Keith Ryden[1]
[1]*University Of Surrey, United Kingdom*

Parallel Session 6A: Space Environment, September 11, 2025, 14:00 - 15:00

As global interest grows in operating airborne radiation monitors, in particular the SAIRA instruments produced at the Surrey Space Centre, we will present the current development of the next generation, and post SWIMMR, SAIRA instruments. The core focus will be on the Space Centre's progress towards real-time data streaming, as well as miniaturising and optimising the instruments for expanding deployment capabilities.

In addition, we aim to present the most recent data collected to date, including by citizen science and commercial airline partners if possible.

A review of global long-term changes in the upper atmosphere and their relevance to practical applications

Dr Ingrid Cnossen[1], John Emmert[2], Rolando Garcia[3], Ana Elias[4], Martin Mlynczak[5], Shun-Rong Zhang[6]

[1]British Antarctic Survey, United Kingdom, [2]U.S. Naval Research Laboratory, United States, [3]National Center for Atmospheric Research, United States, [4]Universidad Nacional de Tucuman, Argentina, [5]NASA Langley Research Center, United States, [6]MIT Haystack Observatory, United States

Plenary Session 2: SDA/SST/SSA, September 9, 2025, 11:30 - 13:00

The climate of the upper atmosphere, including the mesosphere, thermosphere and ionosphere, is changing. As data records are much more limited than in the lower atmosphere and solar variability becomes increasingly dominant at higher altitudes, accurate trend detection and attribution is not straightforward. Nonetheless, observations reliably indicate that, on average, the upper atmosphere has been cooling and contracting. This has caused a long-term decrease in the density of the thermosphere and a downward shift of ionospheric layers. These global mean changes can be largely attributed to the increase in CO2 concentration. The decline in thermospheric density is particularly relevant from a practical viewpoint, as this reduces atmospheric drag and thereby increases orbital lifetimes and the build-up of space debris. Long-term changes in the ionosphere can have further practical implications and are not only driven by the increase in CO2 concentration, but also by changes in the Earth's magnetic field. The empirical models that are widely used in industry as well as in science to characterize the state of the upper atmosphere do not yet account properly for long-term trends in the mesosphere, thermosphere and ionosphere. This is problematic when long-term future projections are needed or models rely strongly on older data. I will share some thoughts on how this may be addressed.

Gauging National Preparedness for Space Weather Events – Findings from the May 2024 Tabletop Exercise

Dr. Ian Cohen[1], Dipak Srinivasan[1], Ruth Vogel[1], Anne Roberts-Smith[1], Drew Turner[1], Daniel Meidenbauer[1], Lisa Turner[1], Larry Paxton[1], John Hicks[1], Angelos Vourlidas[1], Julee Rendon[1], Megan Toms[1], Ben Sheppard[1]
[1]JHU Applied Physics Laboratory, Laurel, United States
Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

On 8–9 May 2024, the United States government held the first-ever end-to-end Space Weather (SWx) Tabletop Exercise (TTX), which provided opportunities for participants to better understand the preparedness and response challenges associated with the threat of an impending space weather event. Jointly sponsored by NOAA, NASA, NSF, and FEMA, the exercise incorporated federal, state, local, and tribal considerations to improve our nation's whole-of-government preparedness for space weather events.

The TTX scenario involved a series of solar events that drove a range of adverse space weather effects, including i) intense radiation exposure to satellites, astronauts, and commercial aviation; ii) radio communications outages and disruptions; iii) loss of functionality or degraded performance of GPS for precision navigation and timing; iv) degraded ability to communicate with and track on-orbit satellites; and v) local- to regional-scale power outages.

It is important to note that, by chance, the SWx TTX occurred at the same time that a significant real-world space weather event—the largest geomagnetic disturbance in more than 20 years (i.e., the "Gannon Storm")—began. These extraordinary events required key participants to divide their time between the simulated actions of the TTX and real-world needs.
The TTX was designed to provide a low-stress, no-fault environment for generating dialogue about the challenges of preparing for and responding to an impending SWx event. Participants from over thirty government departments and agencies, including senior leaders, interacted at two locations: the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland, USA and FEMA Region 8 (R8) in Denver, Colorado, USA.

Reproducing ultra-relativistic electron acceleration using a coupled density and radiation belt model

Dr Tom Daggitt[1]
[1]*British Antarctic Survey, United Kingdom*

Parallel Session 2A: Space Weather Modelling and Computational Techniques, September 10, 2025, 11:30 - 13:00

The background cold plasma density can significantly alter the rate of diffusion of radiation belt electrons by chorus waves within the magnetosphere, and the range of energies at which diffusion is effective. We describe a coupled density and radiation belt model based on the British Antarctic Survey Radiation Belt Model that uses spatially and temporally varying values of fpe/fce to drive a statistical model of electron diffusion due to chorus waves. We demonstrate that this approach of including the variance in fpe/fce recreates the acceleration of electrons up to MeV energies better than other previous approaches to including fpe/fce.

Advancing Operational Forecasting Capabilities with ESA's Vigil Mission: Perspectives from the Belgian Space Weather Centre

__Dr Judith de Patoul__[1], Daria Shukhobodskaia[1], Lukas Vinoelst[1]
[1]*Royal Observatory of Belgium, Belgium*

Plenary Session 3: Space Weather During Solar Maximum, September 9, 2025, 14:00 - 15:30

Operational space weather forecasting depends critically on accurate monitoring and early detection of solar disturbances. ESA's upcoming Vigil mission, strategically positioned at the L5 vantage point, promises substantial advancements in forecasting capabilities and lead-time improvements. This presentation outlines how the Solar Influences Data Analysis Center (SIDC) at the Royal Observatory of Belgium (ROB) is preparing to integrate Vigil's observational capabilities into existing forecasting systems. Particular focus is placed on the anticipated contributions of Vigil's instrumentation, including the Joint EUV coronal Diagnostic Investigation (JEDI), to track sunspot evolution and associated flaring activity, as well as coronal holes and their related high-speed solar wind streams. By consolidating our observational record of event chains extending from the solar surface through interplanetary space to Earth's geomagnetic and ionospheric environment, Vigil will enable the to better characterize, monitor, and refine forecasting models. We discuss strategic preparations, anticipated challenges, and how Vigil's data will enhance operational resilience and forecasting accuracy for end-users, thereby strengthening Europe's capacity to mitigate adverse space weather impacts.

Tracking Space Weather with NASA's Polarimeter to UNify the Corona and Heliosphere (PUNCH)

Craig DeForest, S.E. Gibson, R. Killough, R. Colaninno, G. Laurent, M. Hughes, S. Van Kooten, J. Davies, S. J. Tappin, PUNCH Development Team

Plenary Session 5: Missions, September 10, 2025, 08:45 - 10:00

The Polarimeter to UNify the Corona and Heliosphere is a NASA constellation mission launched in March of 2025 to understand the solar corona and heliosphere as parts of a single, unified system. A major science objective is to track space weather events from Sun to Earth, using its polarimetric 3-D capabilities and extremely wide (90°) field of view. On 31-May-2025, PUNCH observed its first halo CME and tracked it to an elongation angle of 45° from the Sun, roughly 95% of the way from the Sun's surface to impact from Earth. PUNCH visible-light polarized image sequences are collected on a 4 minute cadence, and cover the full 90° field of view approximately every 32 minutes. I will give an overview of the mission, its potential impact on forecasting, and how to access and use PUNCH data (which are available to all).

Multi-MeV electrons observed by CRRES during the maximum of solar cycle 22 and the implications for solar cycle 25

Ravindra Desai[1], Jamie Perrin[1], Nigel Meredith[2], Sarah Glauert[2], William Johnston[3]
[1]University Of Warwick, United Kingdom, [2]British Antarctic Survey, United Kingdom, [3]Air Force Research Laboratory, United States

Plenary Session 3: Space Weather During Solar Maximum, September 9, 2025, 14:00 - 15:30

The Combined Release and Radiation Effects Satellite (CRRES) launched in 1990 into the maximum of solar cycle 22 and provided unprecedented advances in our understanding of radiation belt dynamics. These observations include the radiation belt response to a solar cycle much more active than recent ones, and include multiple severe geomagnetic storms. In this study, we re-examine data from the CRRES High Energy Electron Fluxometer (HEEF) dataset to determine the extent and scale of energetic electron injections throughout the outer belt and into the slot region and inner belt. We find that electron injections into the slot region occur throughout the mission and find multiple cases of electrons from less than 1 MeV through to multi MeV energies persisting and decaying as a function of geomagnetic activity. We present the decay rates for these high energy electrons and assess whether theoretical predictions are able to explain these observations.

Slingshot's Eyes on the Skies: Satellite Tracking from LEO through to XGEO

Dr. Mekhi Dhesi[1]
[1]*Slingshot Aerospace, United Kingdom*

Plenary Session 2: SDA/SST/SSA, September 9, 2025, 11:30 - 13:00

Slingshot Aerospace is a world-leader in commercial space domain awareness. The Slingshot Global Sensor Network contains over 210+ sensors in 20+ locations, worldwide. Slingshot sensors track resident space objects (RSOs) in daytime and nighttime, in LEO through to XGEO. This data is then fed into Slingshot's space-object data fusion software MFAST (Multiple frame Assignment Space Track) to correlate observations and generate accurate orbit determination of RSOs. How space weather affects these observations and resulting analysis will be discussed.

Benchmarking extreme geoelectric fields in Sweden and identifying GIC hotspots in the Swedish power grid

Andrew Dimmock[1], Lisa Rosenqvist[2], Vanina Lanabere, Andreas Johlander, Sven Molenkamp, Alice Wallner, Stephan Buchert, Johan Setréus
[1]Swedish Institute Of Space Physics, Sweden, [2]Swedish Defence Research Agency, Sweden

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

Dynamic spatiotemporal variations in the electrical currents flowing in the ionosphere and near-Earth space result in rapid fluctuations in the time derivative of the geomagnetic field at ground level. Given the conductive nature of the ground, geomagnetic induction generates a geoelectric field capable of inducing an undesired current when aligned with a large-scale conductor on the ground, known as Geomagnetically Induced Currents (GICs). As a high-latitude nation, Sweden experiences large amplitude geoelectric fields due to the intense and dynamic auroral currents and significant variations in ground conductivity on both local and national scales. Consequently, there have been GIC-related disturbances in the Swedish power grid, the most severe being the well-known Malmö blackout, and more recently, a few minor impacts.

Until recently, a comprehensive benchmarking of the geoelectric field in Sweden has not been conducted. Furthermore, no statistical study was dedicated to power grid-related disturbances and their spatial distribution. A recent project (2022-2025), led by the Swedish Institute of Space Physics and the Swedish Defence Research Agency, in collaboration with the Swedish power grid, has addressed these knowledge gaps. This presentation will summarise the findings from this project while also providing some insight into the impacts of the recent Gannon storm (May 2024). Lastly, we will outline the subsequent steps in Sweden after this project.

Neglected Orbits and the Emperor’s New Clothes: The Critical Gap in UK Space Situational Awareness

Ralph Dinsley[1]
[1]3S Northumbria, United Kingdom

Parallel Session 6A: Space Environment, September 11, 2025, 14:00 - 15:00

The rapid expansion of human space activity in the last two decades has seen a dramatic increase in the number of human-made space objects contributing to the growing congestion of Earth’s orbital environment. This increase presents unparalleled challenges for the safety, security, and sustainability of human space activity. While the UK has made notable strides in addressing the issues posed by space weather and promoting high-profile space initiatives, a critical vulnerability persists: the lack of comprehensive space situational awareness (SSA) data and robust tracking capabilities. This discussion will argue that, despite increased governmental and industry attention, the tracking and monitoring of the orbital environment remain underdeveloped and underfunded relative to other, more visible space projects.

Recent efforts, such as the establishment of the National Space Operations Centre (NSpOC) and the commissioning of Borealis, highlight a recognition of the importance of SSA. These initiatives are nonetheless in their infancy, with the benefits yet to be realized. Accordingly, the UK remain almost wholly reliant on international partners for critical SSA data. The UK SSA infrastructure is nascent, and the nation continues to operate with a limited sensor network, leaving significant gaps in the detection, identification, and tracking of objects in orbit. As a result, the UK’s ability to independently assess and mitigate risks from orbital debris, conjunction events, and uncontrolled re-entries is dramatically constrained. Additionally, the international dependence on the US to provide up to date SSA support is failing.

This discussion will highlight how the prioritization of flagship space missions and headline-grabbing projects has inadvertently sidelined the essential, but less glamorous, work of building a resilient SSA framework. The consequences of this neglect are increasingly apparent, as the frequency of collision warnings and uncontrolled re-entries rises, and as the UK’s commercial and strategic interests in space grow more vulnerable. This discussion will call for a recalibration of national priorities: advocating for sustained investment, international collaboration, and policy focus on SSA and space tracking as foundational pillars for the future of the UK’s space enterprise.

HENON: The heliospheric pioneer for solar and interplanetary threats defence

Jonathan Eastwood[1]
[1]Imperial College London, United Kingdom

Plenary Session 5: Missions, September 10, 2025, 08:45 - 10:00

HENON (Heliospheric pioneer for solar and interplanetary threats defence) is a new technology demonstration mission conceived to address the widely recognized need to make a leap forward in space weather forecasting and sciences. To do this, HENON will be launched into a distant retrograde orbit in the Sun-Earth system. Following a quasi-elliptical path around the Earth, HENON will ‘orbit’ the Earth once per year and will spend a significant period of time upstream of the Earth at 0.1 AU distance, x10 that of the L1 point. HENON will carry a miniaturised space weather payload as a pathfinder to demonstrate increased warning times for space weather conditions at Earth.

HENON is developed by a European consortium led by Argotec (Prime) and INAF (Italy) and conducted under the auspices of the ESA CubeSat Office. The payload includes a radiation monitor, a solar wind instrument, and a magnetometer, MAGIC, to be provided by Imperial College London. HENON is currently planned to launch with Plato in late 2026/early 2027. In this contribution I discuss the HENON mission goals focussing on: the demonstration of new miniaturised technologies in deep space; advancing our ability to predict space weather; and advancing our understanding of heliophysics and the solar wind. I will also discuss how HENON will lay the foundations for future sub-L1 solar wind monitoring, and the opportunities for wider community participation.

Solar Activity Monitor Network (SAMNet) - Next step in ground-based Space Weather forecasting

Robertus Erdelyi[1]
[1]University Of Sheffield, United Kingdom

Parallel Session 5B:Sun-to-Earth Forecasting, September 11, 2025, 11:30 - 13:00

Flares and CMEs are one of the greatest risks to our technosphere. The question is not anymore "whether" but "when" a large solar eruption may disrupt the functioning of our tech-driven socio-economic system. Therefore we need to develop a reliable and accurate warning system that can predict these larges eruptions in our Solar System. Here, I report one solution: The Solar Activity Magnetic Monitor (SAMM) Network (SAMNet).

SAMNet is a UK-led consortium of ground-based solar telescope stations. SAMNet, at its full capacity, will continuously monitor the intensity, LoS component of magnetic and Doppler velocity fields at multiple heights in the lower solar atmosphere (LSA). SAMM sentinels with identical telescopes equipped with magneto-optical filter (MOFs) may take observations in K~I and Na~D spectral bands.

The objectives of SAMNet are i) to cater LoS magnetic and Doppler data for space weather research and ii) forecast. The goal is to achieve an operationally sufficient lead time of e.g. flare warning of up to 24 hours, and provide much sought-after continuous synoptic maps of the LSA with spatial resolution limited only by seeing with a cadence of 10-min. The individual SAMM sentinels link into their master HQ hub at Gyula Bay Zoltan Solar Observatory (GSO) where data are processed and flare warning issued up to 38 hrs in advance. We present briefly the MOF concept, the science behind forecasting with SAMNet and show first-light images. We also discuss why such a ground-based system may complement reliably and very economically space-borne instrumentation and their data.

Thermosphere and Ionosphere Products and Services at NOAA SWPC

Tzu-Wei Fang

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

NOAA's Space Weather Prediction Center (SWPC) has developed various thermosphere and ionospheric products to enhance our services to the satellite industry and GNSS users. These physics-based and data-assimilative models have gone through years of iterations to be implemented into the operational environment. Continuous product verification and validation become critical once the tools are officially released to understand the performance under the operational settings and to provide information for product improvement. These operation-to-research (O2R) activities further help to drive development activities in the research community. Throughout all these processes, gathering customers' needs and feedback is an extremely important step to ensure the requirements are set accurately and that these products/tools will be useful. In this talk, SWPC's efforts in several research-to-operation (R2O) projects will be discussed, future capacities that align with SWPC's long-term strategies will be presented, and the interactions/feedback from our users on this domain will also be shared.

Improving nowcasts and forecasts of geomagnetically induced currents through analysis of ground-level magnetic field perturbations

Samuel Fielding
[1]*University of Edinburgh, United Kingdom*

Parallel Session 2B: GICs, September 10, 2025, 11:30 - 13:00

Geomagnetically induced currents (GICs) are a major hazard caused by variations in the near-earth space environment. With the increasing dependence of human activity on critical infrastructure vulnerable to GICs, it is beneficial to improve predictions of GIC activity. A large value of the time derivative of the horizontal magnetic field is an indicator of potentially damaging GICs in grounded infrastructure, and can be calculated from measurements at geomagnetic observatories. In this project, we investigate how GIC forecasts and nowcasts might be improved using the time derivative of the horizontal magnetic field. We begin by showing that the method used when calculating the time derivative can have a strong impact, with one method being based on temporally-consecutive differences of the horizontal field intensity scalar while the other method takes the vector difference between the consecutive measurements, allowing for a change in direction to be taken into account. We then explore the potential for transformer-derived machine learning models to improve existing data-driven approaches to forecasting space weather impacts at ground level. A multivariate time series of satellite data and geomagnetic observatory measurements are input to predict magnetic field perturbations, which we demonstrate at observatories within the United Kingdom. We use the OMNI dataset from L1 satellites to predict geomagnetic field perturbation up to 8 hours in advance.

Solar Activity and Space Weather Monitoring at Radio Frequencies

Peter Gallagher[1]
[1]Dublin Institute for Advanced Studies, DIAS Dunsink Observatory, Ireland

Parallel Session 1A: Forecasting Tools and Techniques, September 10, 2025, 10:00 - 11:00

Solar flares and coronal mass ejections are associated with the accelerating of particles and plasma, which are important drivers of space weather impacts at Earth. These phenomena can also generate radio emission which can be observed with a range of ground- and space-based radio instruments, such as the Low Frequency Array (LOFAR). Here, I review how solar radio bursts are generated, the instrumentation used to monitor them, and how they can be of use to monitoring solar activity and space weather-related phenomena. I will also give overview of space weather service providers and the radio-based products that they routinely provide.

Improving CME forecast diagnostics from pre-launch to interplanetary space: 3D Analysis, Magnetic Constraints, and Deep Learning

Harshita Gandhi[1], Alexander James[1], Lucie Green[1], Huw Morgan[1]
[1]*Aberystwyth University, United Kingdom*
Parallel Session 4B: Solar & Heliospheric Forecasting II, September 11, 2025, 10:00 - 11:00

Coronal mass ejections (CMEs) are eruptions of large scale magnetised plasma expelled from the Sun and are major drivers of space weather, impacting Earth from geomagnetic storms to the disruption of communication and satellites. Effectively characterizing CMEs in the coronagraph data remains a challenge due to their high speed (fewer observations), faintness, Earthward orientation (halo CMEs) and predicting their three-dimensional (3D) properties, linking these to their source region magnetic environments. Any diagnostic tool that aids in the early identification of CME speed is valuable for accurately forecasting their Earth-directed parameters, making it a critical need in current space weather research.
This talk will present findings that addresses these challenges through two complementary studies. The first is an observational and statistical investigation of the relationship between critical heights in active regions- derived from manual and automated methods with 3D CME speeds. Our results demonstrate that for 37 CMEs, the near-real-time automated calculation of the critical height for active regions can provide a rough estimate of the speed of any CME that may erupt, which is evidently beneficial for forecasting. This initial speed estimate can also complement or serve as a useful starting point for subsequent speed measurements obtained from coronagraph observations.
The second study applies a data-driven approach using Machine Learning method trained on synthetic multi-viewpoint coronagraph images to predict CME parameters, including longitude, latitude, tilt-angle and 3D speed. The model achieves strong predictive performance and offers a proof-of-concept for automated interpretation of CME geometry from real coronagraph data. Together, these studies combine observations, magnetic field diagnostics, and machine learning to enhance both our understanding and forecasting potential of CMEs, and offer valuable improvements to existing space weather prediction models.

Towards European Operational Space Weather Capabilities

Dr Alexi Glover[1], Andrew Monham[2]
[1]European Space Agency, France, [2]EUMETSAT, Germany

Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

Within the framework of the Space Situational Awareness and Space Safety Programmes, over the last 15 years ESA has implemented a system-wide approach to space weather developments, including space segment, ground and service segment activities. This has led to the implementation of an extensive network of entities from across Europe collaborating in order to test and demonstrate reliable service capabilities, disseminating the results to end users through a framework increasingly able to demonstrate operational readiness while also collecting important feedback from end users on their needs for space weather information. It has also led to the deployment of multiple sensors providing reliable near-realtime data from space and on ground in order to underpin improved services. Looking ahead, missions in development such as Vigil and Aurora are further set to enable major enhancements in space weather forecasting capabilities in the coming years.

As the European operational satellite agency for monitoring weather, climate and the environment, EUMETSAT has been exploring the potential to leverage its capabilities to support the provision of operational space weather data.

As European space weather capabilities mature and recent major events demonstrate the increasing need for operational provision tailored to European users, this presentation will discuss space weather related activities currently being undertaken by ESA and EUMETSAT. The presentation will reflect on the organisations respective infrastructures and expertise and highlight potential areas for closer cooperation as space weather in Europe evolves towards meeting Europe’s needs for operational services.

Checklist for CME forecasting in advance of an eruption

Lucie Green[1]
[1]UCL/Mullard Space Science Laboratory, United Kingdom

Parallel Session 5B:Sun-to-Earth Forecasting, September 11, 2025, 11:30 - 13:00

Current forecasting approaches related to coronal mass ejections focus on the arrival time of the CME, and estimate quantities such as speed and plasma density upon arrival at Earth. The fastest CMEs have a Sun-Earth transit time of less than one day, a short transit time that potentially leaves little advance warning of the impending CME impact. An additional challenge for forecasters is that Earth-directed CMEs may originate near disk centre, producing what is known as a halo CME that encircles the Sun. Halo CMEs appear faint in coronagraph imagery, making them harder to detect than CMEs that erupt from a region closer to the limb of the Sun. In order to be able to provide a more confident assessment of the occurrence of an Earth-directed CME with enough time to take risk mitigation actions, it is clear that a wide range of data must be used. In addition, knowing that a region on the Sun is likely to produce a CME in the near future would enable probabilistic forecasts of CMEs several days ahead of their arrival at Earth. In this talk we present the development of a checklist for CME forecasting, created in collaboration with solar physics researchers and space weather forecasters.

Evaluating Ionospheric Model Performance at Mid- and High-Latitudes Using Long-Term Ionosonde Observations from 1950 - 2022

Emma-Claire Gurney[1], David Themens[1], Matthew Brown[1], Sean Elvidge[1]
[1]Space Environment and Radio Engineering Group (SERENE), University of Birmingham, United Kingdom

Parallel Session 1B: Ionosphere, September 10, 2025, 10:00 - 11:00

Accurate modelling of the high-latitude ionosphere-thermosphere system is critical to understanding the impacts of space weather on modern technology, such as communications and navigation systems. At low and mid latitudes, both physics-based and empirical models are well-developed and capture the variability of the ionosphere to a good degree of accuracy. At high latitudes, however, the complex chemistry and dynamics due to interactions with the solar wind and magnetosphere, added to lack of observations, presents challenges to such models. This study evaluates the climatological performance of the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM), the Whole Atmosphere Community Climate Model with thermosphere and ionosphere extensions (WACCM-X), and the Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) for the period 1950 – 2022. Model outputs are compared to observational foF2 data from the high-latitude Resolute Bay ionosonde and the mid-latitude Chilton ionosonde to assess the limitations of models in reproducing the variability of the high-latitude ionosphere. Preliminary results from TIE-GCM and WACCM-X exhibit strong winter anomaly behaviour at all times of day at high latitude, which is not present in observational data. An equinoctial asymmetry is also present, with elevated electron densities in March compared to September, even during low solar activity. In contrast, E-CHAIM shows significantly better agreement with observations, more accurately reproducing seasonal and solar cycle trends. These findings highlight the need for improved representation of high-latitude processes in physics-based models.

Solar Flares and CMEs at Solar Maximum: Multi-Vantage Observations in a Golden Age of Flare Science

Laura Hayes[1]
[1]Dublin Institute For Advanced Studies, Ireland
Plenary Session 3: Space Weather During Solar Maximum, September 9, 2025, 14:00 - 15:30

Solar flares are impulsive, energetic events that release vast amounts of magnetic energy in the form of radiation, accelerated particles, and large-scale plasma flows. Often associated with coronal mass ejections (CMEs), these are a key drivers of space weather impacts across the heliosphere. As solar activity intensifies toward solar maximum, we are not only observing more frequent and powerful flares - we are also uniquely positioned to study them in greater detail than ever before.

We are now in a golden age of flare science, enabled by a constellation of solar observatories that span multiple vantage points and wavelengths. High-energy X-ray observations, combined with EUV, UV, and white-light data, allow us to probe the full chain of flare energy release and its heliospheric consequences. ESA's Solar Orbiter mission plays a key role in this effort, offering new views of flare-accelerated particles and coronal evolution from outside the Sun-Earth line. Instruments such as STIX (X-ray imaging spectroscopy) and EUI (high-cadence EUV imaging) provide new diagnostics of the timing, structure, and spatial complexity of flare energy release - including backside and limb events not seen from Earth.

In this talk, I will highlight recent flare observations from this multi-vantage era, with an emphasis on how combined datasets, particularly those involving Solar Orbiter, are transforming our understanding of flare morphology, particle acceleration, and their link to CME initiation. These advances are not only improving our understanding of flare physics, but also improving our ability to assess and predict their space weather impacts

UK Joint Force Space Component – an update since last year's conference

Mr Neal Henley[1]
[1]Space Command, United Kingdom

Conference Opening and LOC Session, September 8, 2025, 11:00 - 13:00

An update on Space Weather activity with JFSC activity with a focus on No 1 Space Operations Squadron, the military component of the UK National Space Operations Centre.

Lift-and-shift: useful approaches from terrestrial weather

Edmund Henley[1], Mario Bisi[2], Maria M. Kusnetsova[3], Martin A. Reiss[3], David R. Jackson[1]
[1]Met Office, United Kingdom, [2]RAL Space, United Kingdom, [3]NASA Goddard Space Flight Center, United States
Parallel Session 5B:Sun-to-Earth Forecasting, September 11, 2025, 11:30 - 13:00

There are many ways in which space weather and terrestrial weather differ. However, the two domains are physically linked, and share many similarities in the approaches needed to successfully deliver skilful forecasts. This talk outlines various approaches used to good effect in terrestrial weather, which merit attention from the space weather enterprise. We also discuss some structural differences, and consider what these imply. Areas to be discussed include:

- practices for observations and model data (timeliness, monitoring, metadata and sharing)
- approaches for improving models and observing systems, and making the case for these
- areas where there are libraries or expertise which can be leveraged, notably in verification (validation) and data assimilation
- effective interdisciplinary approaches, especially with social sciences, e.g. around user engagement, co-production, and theory of change
- accounting for the different goals, incentives, and characteristics of research and operations when designing collaborative R2O2R programmes and infrastructure

Omega bands as a source of large dB/dt in the dawn sector

Dr Rosie Hodnett[1], Steve Milan[1]
[1]University Of Leicester, United Kingdom

Parallel Session 2B: GICs, September 10, 2025, 11:30 - 13:00

Omega bands are a dawn-sector phenomena which appear as wave-like structures in the aurora, which often look like a chain of the Greek letter Ω. Omega bands have recently been shown to be responsible for large variations in dB/dt which can trigger geomagnetically induced currents (GICs), which are a significant space weather hazard. Signatures of an omega band event are visible in the European Incoherent SCATter (EISCAT) data at Tromsø, Norway (69.6 °N, 19.2 °E), alongside observations from multiple instruments situated near Tromsø. The omega band is clearly identifiable in the Tromsø all sky camera data from 00:00 – 03:00 UT as it propagates eastward. This event is of interest for several reasons. During this event, the polar cap and field aligned current systems are expanded, and there are negative excursions in the AL index. These features are often misidentified as substorms, however in this case the fluctuations in the westward electrojet result from the omega band. Large ground-based magnetic perturbations are visible, and associated 'spikes' in dB/dt are identified in the auroral dawn sector. Data from the EISCAT UHF and VHF radars allow us to see enhancements in the ionospheric electron density which occurred as the upwards field aligned current and luminous aurora passed overhead. Electron density enhancements at low altitude were observed in addition to the usual auroral precipitation, which correspond to enhancements in cosmic noise absorption measured by nearby riometers. This leads to large Hall conductances and hence large magnetic perturbations observed on the ground.

The May 2024 Storm: Recommendations from the SEIEG Report

Professor Richard Horne[1]
[1]British Antarctic Survey, United Kingdom

Plenary Session 7: Keynote Speaker and UK-International Community Discussion, September 11, 2025, 15:30 - 17:00

The May 2024 Geomagnetic storm was the largest storm for over 20 years and reached G5 on the international scale. It was in fact a 1 in 12.5-year event, and the impacts were relatively minor. The Space Environment Impacts Expert Group (SEIEG) summarised what happened in a report, with a focus on the UK, and made recommendations which were sent to Government Departments. Here we present the main recommendations from the SEIEG report.

Investigating SEP transport using observations and simulations

Ruth Hyndman[1], Silvia Dalla[1], Timo Laitinen[1]
[1]*University Of Central Lancashire, United Kingdom*
Parallel Session 5B:Sun-to-Earth Forecasting, September 11, 2025, 11:30 - 13:00

Solar energetic particles (SEPs) are accelerated by flares and shocks driven by coronal mass ejections and then travel through the heliosphere from the Sun. When they reach the Earth we observe space weather effects including the harmful effects of SEPs on humans and electronic equipment in space. We discuss the investigation of the transport of SEPs using simulations and observations in tandem, and discuss how understanding SEP transport better will aid in future space weather predictions.

World-Wide Interplanetary Scintillation Stations (WIPSS) Analysis used with Thomson Scattering Brightness

Dr. Bernard Jackson[1], Kazumasa Iwai[2], Ken'ichi Fujiki[2], Mario Bisi[3], Richard Fallows[3]
[1]A&A, University of California, United States, [2]ISEE, Nagoya University, Nagoya, Japan, [3]UKRI-STFC, RAL Space, Oxfordshire, United Kingdom

Parallel Session 3B: Remote Sensing and Sun-Earth, September 10, 2025, 14:00 - 15:00

Remotely sensed interplanetary scintillation (IPS) data from the Institute for Space-Earth Environmental Research (ISEE), Japan, has allowed a global determination of solar wind velocities and densities throughout the inner heliosphere in near real time since the year 2000. The LOFAR group has now taken the step of operating their data-collection system from the UK LOFAR arrays in near real time. The use of different world radio sites simultaneously enables far more IPS observations to be obtained and the ability to provide them from different longitudes around the world to give the best temporal and sky spatial coverage. With real-time analysis intent, the University of California, San Diego programming now combines IPS data into a single system along with heliospheric Thomson scattering data to give far higher resolutions of heliospheric densities and velocities in our iterative time-dependent three-dimensional (3-D) reconstructions to heliospheric mesoscale sizes. Initiated originally for use with the US Air Force/NASA Solar Mass Ejection Imager spacecraft instrument, IPS velocities have currently been incorporated with both STEREO A HI data sets as well as the Parker Solar Probe WISPR data sets. These are best implemented in a newer type 3-D iterative reconstruction system that bases the line-of-sight segmentation lengths on the resolution of the spherical coordinate system. This gives the best analysis near and far from the Sun over solar latitude and longitude in the same programming sequence for both IPS and Thomson-scattering remote sensing processes. Here we show recent examples of these analyses from several events of interest.

Flare forecasting using Fully Convolutional Networks to gain insight into sunspot evolution

Paloma Jol[1], Stephane Regnier[1], D. Shaun Bloomfield[1]
[1]Northumbria University, United Kingdom

Parallel Session 1A: Forecasting Tools and Techniques, September 10, 2025, 10:00 - 11:00

Solar flares are large eruptions of electromagnetic radiation from the Sun that can affect Earth's atmosphere and our technologies (e.g., radio communications). Flares are identified by the arrival of their energetic photons at Earth, meaning that their space-weather effects occur at the same time we become aware that a flare is in progress - this makes it essential for us to forecast them in advance. 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 2013 to 2023, 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 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.

Drivers of rapid geomagnetic variations at high latitudes

Liisa Juusola[1], Ari Viljanen[1], Andrew P. Dimmock[2], Mirjam Kellinsalmi[1], Audrey Schillings[3], James M. Weygand[4]
[1]Finnish Meteorological Institute, Finland, [2]Swedish Institute of Space Physics, Sweden, [3]Department of Physics, Umeå University, Sweden, [4]Department of Earth, Planetary, and Space Sciences, University of California Los Angeles, USA

Parallel Session 4A: M-I Coupling, September 11, 2025, 10:00 - 11:00

We have examined the most intense external (magnetospheric and ionospheric) and internal (induced) (amplitude of the 10 s time derivative of the horizontal geomagnetic field) events observed by the high-latitude International Monitor for Auroral Geomagnetic Effects (IMAGE) magnetometers between 1994 and 2018. While the most intense external events at adjacent stations typically occurred simultaneously, the most intense internal (and total) events were more scattered in time, most likely due to the complexity of induction in the conducting ground. The most intense external events occurred during geomagnetic storms, among which the Halloween storm in October 2003 featured prominently, and drove intense geomagnetically induced currents (GICs). Events in the prenoon local time sector were associated with sudden commencements (SCs) and pulsations, and the most intense values were driven by abrupt changes in the eastward electrojet due to solar wind dynamic pressure increase or decrease. Events in the premidnight and dawn local time sectors were associated with substorm activity, and the most intense values were driven by abrupt changes in the westward electrojet, such as weakening and poleward retreat (premidnight) or undulation (dawn). Despite being associated with various event types and occurring at different local time sectors, there were common features among the drivers of most intense external values: preexisting intense ionospheric currents (SC events were an exception) that were abruptly modified by sudden changes in the magnetospheric magnetic field configuration. Our results contribute towards the ultimate goal of reliable forecasts of and GICs.

Provision of space weather services for civil aviation according to ICAO regulations – lessons learnt and future visions by PECASUS

Kirsti Kauristie[1]
[1]Finnish Meteorological Institute, United Kingdom

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

ICAO space weather services are today maintained by four global centers (ACFJ, CRC, PECASUS and SWPC). The first regional center to be operated by SANSA will join the effort soon. The set-up of these services is approaching some regulated updates as controlled by the Amendment 82 of ICAO Standards and Recommended Practices Annex III (to be in force in Nov 2025). With these updates the services will become more compliant with the feedback from their user community. It is recognized, however, that the services will achieve widely accepted and well-established status only by sustained coordination and information exchange among the key players: service providers, users, and research community. The coordination group among the centers and dedicated working groups under the ICAO Meteorological Operations Group (MOG) have taken active roles in this long-term development work.

In the presentation we will share some views from PECASUS perspective about the joys and challenges experienced during the first ~ five years of ICAO space weather operations. With approaching Amendment 82 it is now a good time to revisit the ICAO original Space weather Manual from 2018 and discuss its updating needs. Also, for this meeting particularly it will be interesting to compare the experiences from ICAO services with the resolutions and recommendations of the recently published SWIMMR report on Severe Space Weather Impacts on UK Critical Infrastructure.

Experience of SANSA's 24/7 Operational Space Weather Centre

Mpho Tshisaphungo[1], Salma Khan[1]
[1]South African National Space Agency, South Africa
Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

The space weather forecasting and predictability of extreme events is critical in building a resilient nation against the impact. South African has invested in building a 24/7 operational space weather capability through training and skills development within the region. Prior to being a 24/7 operational Centre, SANSA had limited research and development in space weather forecasting and has now grown its proficiency through national, regional, and international collaboration. The South African National Space Agency (SANSA) operates a 24/7 Regional Space Weather Centre since November 2022 as designated by the International Civil Aviation Organisation (ICAO). The role of a Regional Centre is to support the four ICAO Global Centres' in the provision of space weather information to the aviation sector. As a designated regional centre, it is important to collaborate with the other ICAO designated global centres to ensure a consistent and reliable service that serves Africa's interests. SANSA will demonstrate experiences of establishing and running a 24/7 operational Centre as well as maintaining regional partnership for ground-based instrumentation network expansion within the African region. The capability has positioned SANSA to participate in the Global Challenge of Space Weather.

Space-based Challenges During the 10-14 May 2024 'Gannon' Geomagnetic Storm: Anecdotal & Published Reports

Prof Delores Knipp[1]

[1]*University Of Colorado Boulder, United States*

Plenary Session 2: SDA/SST/SSA, September 9, 2025, 11:30 - 13:00

We present a collection of anecdotal reports and statistical information related to satellite operations in the Low Earth Environment (LEO) and Geosynchronous Orbit (GEO) during the May and October 2024 storms. The highly compressed dayside magnetosphere required some GEO spacecraft to operate outside Earth's magnetosphere. Several High LEO operators (altitudes > 650 km) reported challenges with pointing and altitude maintenance. In mid-LEO (450-600 km) where neutral density increased by a factor of 5 above background values, autonomous orbit maneuvers by thousands of satellites occurred during the peak of the storm, vs the October 2003 storm during which the bulk of orbit maneuvering was in the post-storm phase. In Very Low Earth Orbit (VLEO < 400 km) reports show that active and inactive 'cubesats' met an early orbit demise. Many space operators paused normal activities or noted that data products had to be reprocessed because of the storm. Although not comprehensive, we believe this collection of reports is illustrative of future storm-time operations and challenges in the statistically more 'active' declining phase of odd-numbered solar cycles.

Operational Global Magnetosphere Modelling in the Bergen-Imperial Global Geospace (BIGG) Project

Dr Adrian LaMoury[1], Mike Heyns[1], Jonathan Eastwood[1], Norah Kaggwa Kwagala[2], Johan Engevik[2], Siri Kallhovd[2], Thomas Röblitz[2]
[1]Imperial College London, United Kingdom, [2]University of Bergen, Norway

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

For understanding and predicting the behaviour of the near-Earth space environment in changing solar wind conditions, physics-based modelling is extremely powerful, though often comes at considerable computational expense, making it generally unsuitable in operational contexts. The Bergen-Imperial Global Geospace (BIGG) project is a collaborative effort to provide a new forecasting service to the ESA Space Weather Service Network. It combines two 3D magnetohydrodynamic (MHD) magnetosphere models, the Space Weather Modelling Framework (SWMF) and GorgonOps (developed at Imperial College London). Both have been optimised to run in faster than real time using only modest computational resources. Taking real time solar wind measurements at L1 as simulation inputs, the two models run simultaneously, creating forecasting products including magnetopause standoff distance, Kp, and dB/dt at a range of synthetic ground stations. In this presentation, we will demonstrate the newly developed BIGG system. This includes an interactive visualisation dashboard as well as an API service, allowing users to retrieve the latest forecasts instantly. The multi-model federated approach is such that it can be expanded to incorporate new models, further increasing forecast diversity and redundancy.

The Geomagnetic Response to Extreme Southward Turnings of the IMF

Chiara Lazzeri[1], Andrey Samsonov[1], Colin Forsyth[1], Graziella Branduardi-Raymont[1], Yulia V. Bogdanova[2]

[1]*Mullard Space Science Laboratory, UCL, United Kingdom,* [2]*Rutherford Appleton Laboratory, United Kingdom*

Parallel Session 5A: Magnetosphere, September 11, 2025, 11:30 - 13:00

The interplanetary magnetic field (IMF) north-south component, Bz, plays a crucial role in the interaction between the solar wind and the Earth's magnetosphere, affecting the energy transferred into the magnetosphere.
This study presents a statistical analysis of the magnetospheric response to particularly large and rapid southward turnings (STs) of the IMF. We identified 98 STs in which Bz changed from strongly northward (>3 nT) to strongly southward (<−3 nT) within a 5-minute period. These events were further categorised based on their association with interplanetary coronal mass ejections and corotating interaction regions, and their associated IMF and solar wind properties were analysed.

To investigate the magnetospheric response to these STs, we identified the maximum responses and corresponding timescales of key geomagnetic indices such as SML, SMU, SYM-H, and PCN. These indices were then employed to determine the occurrence of geomagnetic phenomena such as substorms, enhanced magnetospheric convection, and geomagnetic storms following the southward turnings.

Modelling and Prediction of Electron Fluxes with NARMAX Approach Using Data Set with Missing Data Points

Dr Ping Li[1], Hua-Liang Wei[1], Richard Boynton[1], Michael Balikhin[1]
[1]*The University Of Sheffield, United Kingdom*

Parallel Session 2A: Space Weather Modelling and Computational Techniques, September 10, 2025, 11:30 - 13:00

High levels of the energetic electrons can have harmful effect on modern technological systems, such as satellites in both low Earth orbit and geostationary Earth orbit (GEO) and may lead to temporary or permanent loss of system functions, it can also be hazards for humans in space. The prior knowledge about fluences of energetic electron can help to mitigate the adverse effect of the high fluxes of the energetic electrons, and this will require the reliable predictions of electron fluxes in space around the satellite orbits. The electron flux is known to be correlated with solar wind parameters, and a lot of effort has been devoted to developing modelling methods for making reliable predictions using the observed solar wind parameters. In this presentation we use NARMAX, a transparent, interpretable and parsimonious data-driven approach, to build predictive models for 1.5 MeV electron fluxes. A challenge in 1.5 Mev electron flux modelling is that there are many missing data points in the available dataset. To overcome the challenge, an effective model identification scheme that allow us to identify a single model from multiple datasets is introduced and the models are identified using two different model term selection methods. The prediction performance between models will then be compared to provide some guidelines for choosing modelling methods. We will also discuss best practices, limitations and caveats to consider when building prediction models from a given/or an available data set with missing data points.

Ionospheric effects on GNSS Investigated Using the EISCAT/ESR Radars

Ben Boyde[1], Sam Lo[1], Biagio Forte[1], Tianchu Lu[1], Paul Kinsler[1]
[1]*University of Bath, United Kingdom*

Parallel Session 1B: Ionosphere, September 10, 2025, 10:00 - 11:00

The state of the ionosphere was investigated by combining evidence from Global Navigation Satellite Systems (GNSS) and from both EISCAT Tromsø and EISCAT Svalbard Radar (ESR) radar systems during various campaigns. The GNSS observations are used to consider both propagation effects on signals from individual satellites and the overall impact of ionospheric disturbances on GNSS positioning accuracy. The observations cover both quiet and disturbed periods of ionospheric conditions, with propagation disturbances likely associated with particle precipitation. Radar measurements are used to infer the types of ionospheric structure likely to be responsible for the observed scintillation: this information can be used to model the effect of ionospheric structures on trans-ionospheric radio wave propagation.

The results are discussed in the context of the forthcoming EISCAT_3D system, illustrating the value of its improved capabilities for accurately determining the nature and origin of the ionospheric irregularities causing disturbances to GNSS signals. The modelling is used to assess the impact of various assumptions regarding ionospheric conditions along the GNSS line of sight based on the radar observations. This is used to investigate whether the nature of the ionospheric structures responsible for the observed scintillation can be uniquely determined with the available observations. The impact on GNSS positioning at various stations is compared between 30s and 1s measurement cadences, with improved resilience to ionospheric disturbances with higher cadence.

Modeling MeV Radiation Belt Electron Precipitation and Its Atmospheric Impact Using VERB-4D

__Dr. Xingzhi Lyu__[1], Dedong Wang[1], Yuri Shprits[1,2,3], Bernhard Haas[1,2], Miriam Sinnhuber[3]
[1]Gfz German Research Center For Geosciences, Germany, [2]Institute of Physics and Astronomy, University of Potsdam, Germany, [3]Department of Earth, Planetary and Space Sciences, University of California, United States, [4]Institute for Meteorology and Climate Research – Atmospheric Trace Gases and Remote Sensing (IMK-ASF), Karlsruhe Institute of Technology, Germany

Parallel Session 5A: Magnetosphere, September 11, 2025, 11:30 - 13:00

Energetic particle precipitation (EPP) into the atmosphere can influence the chemical composition from the upper stratosphere to the lower thermosphere. The impact of precipitated relativistic electrons from the radiation belt on atmospheric chemistry and dynamics remain unresolved. In this study, we use the VERB-4D code to simulate radiation belt electron dynamics during geomagnetic storms, incorporating wave-particle interactions with chorus, hiss, and EMIC waves. Special attention is given to MeV electrons due to their rapid scattering into the atmosphere. We compute the global distribution of MeV electron precipitation and investigate the relative contributions of Earth's dipole versus non-dipole magnetic field structures. Model results are compared against Low Earth Orbit (LEO) satellite observations for validation. The simulated MeV precipitating fluxes are then used to estimate ionization rates in the upper atmosphere , providing insight into their role in atmospheric processes.

Space Weather risk to New Zealand: the Solar Tsunami research programme.

Daniel Mac Manus[1], Craig Rodger[1], Andrew Renton[2], Tanja Peterson[3], Mark Clilverd[4], Tim Divett[5], Malcolm Ingram[5], Johnny Malone-Leigh[1], Andrew Lapthorn[6], Gemma Richardson[7], Wiebke Heise[3], Jessa Barder[8], Mark Sigley[9], Daniel Welling[10], Ting Wang[11]
[1]Department of Physics, University of Otago, New Zealand, [2]Transpower New Zealand Limited, New Zealand, [3]GNS Science, New Zealand, [4]British Antarctic Survey (UKRI- NERC), United Kingdom, [5]Victoria University of Wellington, New Zealand, [6]University of Canterbury, New Zealand, [7]British Geological Survey (UKRI- NERC), United Kingdom, [8]Otago Museum, New Zealand, [9]First Gas Ltd., New Zealand, [10]University of Michigan, United States, [11]Department of Mathematics and Statistics, University of Otago, New Zealand

Parallel Session 2B: GICs, September 10, 2025, 11:30 - 13:00

As society's dependence on advanced technology continues to grow, the importance of understanding and addressing space weather has become increasingly significant on a global scale. In New Zealand, efforts have focused predominantly on safeguarding electrical transmission networks and gas pipeline infrastructure. The reliable provision of energy remains essential to the operation of modern societies and the broader economy.

The New Zealand government MBIE-funded Solar Tsunamis Endeavour Programme, led by the University of Otago, represents a global initiative dedicated to examining the potential impacts of extreme space weather events on New Zealand's energy infrastructure. Key questions critical to protecting New Zealanders from the most severe effects of space weather have been identified by industry partners within the energy sector. Our research has been focused on addressing these questions, resulting in the development of evidence-based mitigation strategies aimed at safeguarding the power network during intense space weather events. These strategies were successfully implemented during the notable space weather occurrence in May 2024. Peak GICs observed after the mitigation strategy was in place reached ~113 A at a transformer in the city of Dunedin. Without mitigation, modelling shows that a peak GIC of ~200 A through the neutral would have occurred, exacerbated by the tripping of a transformer at a neighboring substation. A coordinated response framework involving the wider New Zealand electricity industry (system operator and main generating companies) and core governmental agencies is being developed to strengthen preparedness, response, and recovery for future severe space weather phenomena.

The application of magnetic topology approaches to the problem of solar flare and CME prediction

David MacTaggart[1]
[1]University Of Glasgow, United Kingdom

Parallel Session 6B: Sun-to-Earth Science, September 11, 2025, 14:00 - 15:00

Solar flares and coronal mass ejections (CMEs) are manifestations of the energy released from the magnetic field in the solar atmosphere. More than this, they are closely related to the structure and connectivity of the magnetic field. These two elements fall under the umbrella of magnetic topology, which is characterized by quantities such as magnetic helicity and winding, and descriptions of where field line connectivities change rapidly. The purpose of this talk is twofold. First, I will provide an overview of the key characteristics of magnetic topology and how they relate to flares and CMEs. Secondly, I will describe how calculations of magnetic topology are being used in efforts to predict flares and CMEs, discussing some successes and challenges that remain.

Space Weather Enterprise: Holistic Assessment of Needs, Gaps and Future Priorities

Major Ross Malugani[1,2], Alessandra Pacini[3], Jeff Johnson[2]
[1]United States Air Force, United States, [2]Space Weather Prediction Center, United States, [3]National Centers for Environmental Information, United States

Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

This project synthesizes findings from recent reports, surveys, and workshops to identify community-defined needs, gaps, capabilities, and priorities across the space weather enterprise. Drawing on input from user needs surveys, modeling and data science workshops, and targeted
gap analyses, the work organizes these insights into a traceable, structured format—such as a database—to inform strategic planning and investment.
Key findings reveal persistent observational gaps tied to data quantity, quality, coverage, and accessibility. Specific needs include improved solar magnetic field coverage, localized data for sectors like electric power and space traffic management, radiation and atmospheric density measurements for human spaceflight, and greater continuity and redundancy in key observations. While current capabilities exist, limitations remain. These include inconsistent ground-based infrastructure, limited satellite redundancy, and reduced quality or continuity in operational data
compared to research-grade data. Processing challenges center on the need for standardization, robust data curation, low-latency access, and the creation of FAIR-aligned, machine learning–ready data ecosystems. Data preparation remains complex and time-consuming. Planned activities emphasize systems-based approaches to address these challenges. Observing System Simulation Experiments (OSSEs) emerge as critical tools for prioritizing investments. The community also highlights the need for improved modeling (e.g., ensemble modeling, data assimilation, physics-informed ML), upgraded infrastructure, stronger Research-to-Operations and Operations-to-Research (R2O2R) pathways, workforce development, and automation in data workflows. This synthesis offers a comprehensive, evidence-based reference for guiding coordinated
progress in space weather research and operations.

Investigating Space Radiation and Atmospheric Climate Impacts with the Canadian RADICALS Mission

Prof. Ian Mann[1], Chris Cully[2], Robert Fedosejevs[3], Steven Knudsen[3], David Milling[1], Greg Enno[1], Michael Lipsett[4], Robert Zee[5], Robert Rankin[1], Martin Connors[6], Kathryn McWilliams[7], William Ward[8], Robyn Fiori[9], Leonid Olifer[1], Louis Ozeke[1], Robert Marshall[10], David Cullen[1], David Barona[1], Andrew Howarth[2], Andrew Yau[2]

[1]Department of Physics, University Of Alberta, Canada, [2]University of Calgary, Canada, [3]Department of Electrical and Computer Engineering, University of Alberta, Canada, [4]Department of Mechanical Engineering, University of Alberta, Canada, [5]University of Toronto, Canada, [6]Athabasca University, Canada, [7]University of Saskatchewan, Canada, [8]University of New Brunswick, Canada, [9]Natural Resources Canada, Canada, [10]University of Colorado at Boulder, USA

Plenary Session 5: Missions, September 10, 2025, 08:45 - 10:00

The RADiation Impacts on Climate and Atmospheric Loss Satellite (RADICALS) mission, scheduled for launch in mid-2027, is a Canadian small satellite mission designed to investigate the impacts of energetic particle precipitation on Earth's atmosphere. Energetic particle precipitation (EPP) plays a critical role in altering atmospheric chemistry, particularly through the production of NOx and HOx, which catalytically destroy ozone in the middle atmosphere. RADICALS will focus on measuring the energy input from precipitating energetic particles into the atmosphere, shedding new light on the connection between space weather and climate. Operating in a polar orbit, the RADICALS payload contains dual High Energy Particle Telescope (HEPT) suites (each comprising high and low energy telescopes, and a high temporal resolution scintillator), and dual X-Ray Imager (XRI) suites. When mounted on the spinning RADICALS spacecraft they will provide pitch angle distributions of trapped radiation belt electrons and solar energetic protons, and the associated Bremsstrahlung X-rays from atmospheric interactions. The mission's unique back-to-back HEPT suite design will measure both down-going and up-going particles simultaneously, while the XRI will remotely sense particle precipitation via X-ray emissions as well as monitoring lower energy electrons as a secondary product. The payload also includes a pair of boom-mounted fluxgate magnetometers and a 3-axis and search coil magnetometer to substantiate particle measurements with the local magnetic wave activity. By resolving the electron loss cone and quantifying the energy flux of precipitating particles, RADICALS will provide essential data for understanding how space radiation influences atmospheric chemistry, particularly during geomagnetic storms.

The ESA M7 Plasma Observatory mission and its impact for the space weather science

Maria Federica Marcucci[1], A. Retinò[2], M. G. G. T. Taylor[3], T. Amano[4], Y. K. Khotyaintsev[5], C. Norgen[6], A. Simionescu[7], J. Soucek[8], J. Stawarz[9], F. Valentini[10], M. Berthomier[2], M. Dunlop[11], M. Fraenz[12], H. Hietala[13], M. Kretzschmar[14], R. Nakamura[15], M. Palmroth[15], J. Rae[9], H. Rothkaehl[17], A. Vaivads[18], V. Angelopoulos[19], S. Bale[20], R. D'Amicis[1], J. De Keyser[21], A. Dimmock[5], C. Forsyth[22], H. Fu[23], A. Galli[24], G. Giono[15], L. Griton[25], K. Kauristie[26], L. Kistler[27], H. Kucharek[27], K. Issautier[25], B. Lavraud[28], O. Le Contel[2], I. Mann[29], L. Matteini[30], M. Maksimovic[25], E. Panov[15], F. Plaschke[31], Y. Saito[32], M. Yamauchi[33], R. Vainio[34], R. F. Wimmer-Schweingruber[35], M. Alho[16], S. Benella[1], A. Chasapis[36], L. Comisso[37], G. Cozzani[17], J.-L. Ripoll[38], O. Pezzi[39], D. Trotta[40], U. Derz[3], A. Stankov[3], T.-M. Bruendl[3], A. Carpentier[3], T. James[3], B. Ordoubadian[3], A. Walsh[42], The Plasma Observatory Science Team

[1]INAF-IAPS, Italy, [2]LPP-CNRS, France, [3]ESA-ESTEC, Netherlands, [4]University of Tokyo, Japan, [5]IRF-U, Sweden, [6]University of Bergen, Sweden, [7]SRON, Netherlands, [8]IAP-CAS, Czechia, [9]Northumbria University, United Kingdom, [10]University of Calabria, Italy, [11]RAL, United Kingdom, [12]MPS, Germany, [13]QMUL, United Kingdom, [14]LPC2E-CNRS, France, [15]IWF-OEAW, Austria, [16]University of Helsinki, Finland, [17]CBK, Poland, [18]Univversity of Ventspils, Latvia, [19]UCLA, United States, [20]UCB, United States, [21]BIRA, Belgium, [22]MSSL, United Kingdom, [23]University of Beihang, China, [24]University of Bern, Switzerland, [25]LIRA, France, [26]FMI, Finland, [27]UNH, United States, [28]LAB-CNRS, France, [29]University of Alberta, Canada, [30]ICL, United Kingdom, [31]TUB, Germany, [32]ISAS-JAXA, Japan, [33]IRF-K, Sweden, [34]University of Turku, Finland, [35]University of Kiel, Germany, [36]LASP, United States, [37]Columbia University, United States, [38]CEA, France, [39]CNR-ISC, Italy, [40]ESA-ESAC, Spain

Plenary Session 5: Missions, September 10, 2025, 08:45 - 10:00

The Earth's Magnetosphere is complex and highly dynamic with massive energy transport and particle energization occurring at boundaries and boundary layers. Understanding plasma energization and energy transport is a grand challenge of space plasma physics that has important implications for the advancement of Space Weather science for which particle energization and energy transport are key topics. The largest amount of energy transport and particle energization occur at fluid and ion scales through multi-scale processes. Here we present the Plasma Observatory (PO) mission and highlight its importance for the Space Weather comprehension. PO is a multi-scale mission concept tailored to study plasma energization and energy transport in the Earth's Magnetospheric System simultaneously at both fluid and ion scales. Fundamental processes such as shock formation, magnetic reconnection, turbulence, wave particle interaction, plasma jets braking and their combination initiate and govern particle energization and energy transport. The comprehension of these fundamental processes will allow us to finally understand how our planet works with impact for Space Weather science and solar, planetary and astrophysical plasma. Plasma Observatory is one of the three ESA M7 candidates, which have been selected in November 2023 for a competitive Phase A with a mission selection planned in 2026 and launch in 2037.

pyCAT: Rearchitecting Operational CME Analysis

Mike Marsh[1], Anders Englyst[1], George Millward[2], Mark Miesch[2], Manasi Gopala[3], Charlotte Martinkus[2], Scott Burns[3], Richard Lee[4], Will Thomas[1], Liz Harrison[1], Katie Bennet[1], Francois-Xavier Bocquet[1]
[1]Met Office, United Kingdom, [2]CU/CIRES NOAA/SWPC, United States, [3]NOAA/SWPC, United States, [4]BJSS Consultancy, United Kingdom

Parallel Session 5B:Sun-to-Earth Forecasting, September 11, 2025, 11:30 - 13:00

Observation, analysis and modelling of CME events is critical to space weather forecasting and preparedness. CME arrival at Earth can affect the magnetosphere, near Earth environment and produce impacts down to ground level due to a resulting geomagnetic storm. The CME forecasting process begins with observation of CME eruption in coronagraph imagery and an analysis of the CME event to estimate its size, direction and speed. This is done via parameterising the CME using a simple cone model defined by 5-parameters. The CME Analysis Tool (CAT) to perform this critical analysis was developed by NOAA Space Weather Prediction Center (SWPC) in 2010 and has been used in operations ever since and was similarly adopted at the Met Office when the Met Office Space Weather Operations Centre (MOSWOC) became fully operational in 2014.

Motivated by modern application technologies, evolving working environments and the prospect of the first operationally supported coronagraph instrumentation, the Met Office and SWPC undertook a joint project to rearchitect the CAT into a modern web-based user interface application that can also be deployed in a cloud-based environment allowing CME analysis to be performed anywhere, enhancing forecast continuity. This new application is called pyCAT and is designed to be modular, extensible and future-proof to allow new observational capabilities such as GOES-19/CCOR1, SWFO/CCOR2 and eventually Vigil/CCOR3. We provide an overview of the pathway from an initial idea, brilliant collaboration to delivery into operations.

Next-Generation MHD Modeling of Solar Wind Using Neural Operators

Prateek Mayank[1], Enrico Camporeale[1], Zhenguang Huang[2], Gabor Toth[2]
[1]SWx TREC, University of Colorado Boulder, United States, [2]University of Michigan, United States

Parallel Session 2A: Space Weather Modelling and Computational Techniques, September 10, 2025, 11:30 - 13:00

Traditional magnetohydrodynamic (MHD) solvers are essential tools for simulating heliospheric plasma dynamics, yet their high computational costs and limited scalability present significant challenges for ensemble forecasting and real-time space weather prediction. In this study, we introduce a novel computational framework utilizing neural operators to rapidly emulate 3D solar wind conditions based directly on high-fidelity MHD simulation datasets. Our methodology incorporates multi-channel, observationally-derived input data and employs a hybrid training strategy, blending data-driven supervised learning with physics-informed constraints enforced via embedded conservation laws. The developed neural operator showcases robust generalization performance, effectively capturing complex heliospheric structures such as stream interaction regions and heliospheric current sheets.

By integrating physical consistency with high accuracy relative to simulation data, our approach provides a scalable and computationally efficient alternative to traditional MHD models. This framework enables the near real-time generation of comprehensive 3D solar wind solutions, significantly outperforming conventional methods in computational speed. We address critical computational challenges, including training stability, the accurate resolution of sharp spatial gradients, and ensuring realistic physical behavior, and discuss strategies such as coordinate-aware inputs and gradient-based diagnostics. Our work highlights the potential of neural operators to substantially advance the field of computational space weather modeling and forecasting.

Space weather instrumentation, measurement, modelling and risk (SWIMMR)

Dr Ian Mccrea[1]
[1]STFC Ral Space, United Kingdom

Plenary Session 7: Keynote Speaker and UK-International Community Discussion, September 11, 2025, 15:30 - 17:00

Magnetospheric responses to the October 2024 ICMEs

Steve Milan[1]
[1]University Of Leicester, United Kingdom

Parallel Session 5A: Magnetosphere, September 11, 2025, 11:30 - 13:00

October 2024 saw intense geomagnetic responses to a number of ICME arrivals, resulting in two storms with minimum Sym-H of -150 and -350 nT on 8th and 11th Oct, respectively. We summarise the magnetospheric and ionospheric responses to these two storms, including the magnitude and extent of field-aligned currents, the behaviour of geomagnetic indices, and the occurrence of large dB/dt on the ground. We analyse the relative geoeffectiveness of the ICME sheath and magnetic obstacle regions, and discuss how the magnetospheric response is modulated by variability within the solar wind parameters.

Impact of recent geomagnetic storms on aviation as observed by PECASUS

Dr Dimitrios Millas[1], Yana Maneva[1], Daria Shukhobodskaia[1], Judith de Patoul[1]
[1]Royal Observatory Of Belgium, Belgium

Plenary Session 6: Impacts, September 11, 2025, 09:00 - 10:00

Since its operational launch on November 7, 2019, the Pan-European Consortium for Aviation Space weather User Services (PECASUS) has been providing real-time space weather monitoring and issuing ICAO-compliant advisories to the global aviation sector. PECASUS has played a pivotal role in mitigating aviation risks associated with HF communication disruptions, GNSS degradation, and increased radiation exposure at flight altitudes. We will present an overview of selected, significant geomagnetic storms as observed via the operations of PECASUS. We provide a brief history of these events (source, evolution) and analyse their effect via the PECASUS advisories. In addition, we will also discuss their impact on ground- and space-based infrastructure, highlighting the importance of space weather monitoring and forecasting. The results showcase how geomagnetic storm analysis can contribute to improving aviation safety. Finally, we will address ongoing and future developments within PECASUS, aiming to further improve the services provided

Navigating Solar Storms: Understanding the Operational & Performance Impacts of Space Weather on Air Traffic Management

Mr Kevin Morgan[1]
[1]Nats Ltd, United Kingdom

LOC Session, September 9, 2025, 09:00 - 11:00

Solar storms and associated ionospheric disturbances present significant challenges to aviation, particularly in the North Atlantic region where reliance on HF communications and GNSS-based surveillance is greatest. During periods of heightened geomagnetic activity, HF propagation can become unreliable and GNSS accuracy degraded, necessitating conservative operational responses. A common mitigation is the southward displacement of North Atlantic Organised Track Structures (OTS) to maintain communications and navigation integrity.

While these adaptations ensure safety, they reduce the effective volume of available airspace, compressing tracks into narrower corridors and increasing density in lower-latitude sectors. This introduces systemic effects through the European Air Traffic Flow and Capacity Management (ATFCM) process: displaced traffic interacts with already complex European flows, constraining sector capacities and limiting tactical flexibility. The result is not only localised rerouting but measurable increases in network-wide delay, as demand is redistributed across constrained sectors.

R2O2R at the Austrian Space Weather Office and the case for sub-L1 monitors

Dr. Christian Möstl[1]
[1]*Austrian Space Weather Office, GeoSphere, Austria*

LOC Session, September 9, 2025, 09:00 - 11:00

I give an update of the progress and future plans of the Austrian Space Weather Office. We were founded in 2022 to accelerate the R2O2R feedback cycle for space weather forecasts. Being part of the Austrian critical infrastructure and the federal weather and geophysical service (GeoSphere Austria), we provide the government, public and stakeholders with warnings about real-time space weather events. Our researchers themselves carry out real-time, impact-based forecasts within a multi-hazard service. Concerning heliophysics research, we focus on solar wind and coronal mass ejection (CME) modeling, using semi-empirical models of CME magnetic fields, drag based models for CME evolution, and AI methods for automatic CME detection in in situ and imaging data. We also provide open source data products, like CME catalogs, for the research community. A key unsolved issue are predictions of the southward Bz magnetic field in CMEs. Recent results using STEREO-A and Solar Orbiter as sub-L1 upstream monitors are promising. A future combination of real time data provided by probes at L1 (NOAA SWFO-L1), L5 (ESA Vigil), polarized imaging provided by PUNCH or a similar mission in Earth orbit, as well as a potential sub-L1 mission (ESA SHIELD) could bring a disruptive improvement to prediction lead times and their accuracy.

Magnetic Transients Associated with a Solar Moreton Wave and Its Local Enhancement

<u>Mr Yiwei Ni</u>[1,2], Pengfei Chen[2], Jinhan Guo[2], Chuan Li[2], Yikang Wang[2], Guoyin Chen[2], Chun Xia[3], Mingde Ding[2], Cheng Fang[2], Duncan Mackay[1]
[1]University Of St Andrews, United Kingdom, [2]Nanjing University, China, [3]Yunnan University, China
Parallel Session 6B: Sun-to-Earth Science, September 11, 2025, 14:00 - 15:00

The Sun is dynamic, producing eruptions such as solar flares and coronal mass ejections. These eruptions often drive large-scale shock waves. When propagating in the tenuous solar corona, strong shock waves would leave imprints at the solar surface in the chromosphere, which are called Moreton waves. For the first time, we report propagating magnetic transients in the solar photosphere cospatial with the chromospheric Moreton wave on 2022 October 2. Besides, Moreton waves generally decay as they move away. With the spectroscopic observations from the first Chinese solar satellite, CHASE, we report that the Moreton wave is significantly enhanced in the midway of propagation. Combining the magnetic observation from Solar Dynamics Observatory, we found that the location of the Moreton wave enhancement corresponds to the magnetic topology called magnetic separatrix. We suggest that mode conversion is responsible for the local enhancement.

Investigating the Structure of Magnetised Coronal Mass Ejection models

Helen Norman[1], Ravindra Desai[1], Tony Arber[1], Keith Bennet[1], Hannah Rüdisser[2], Emma Davies[2]

[1]Centre for Space, Fusion and Astrophysics, University Of Warwick, United Kingdom, [2]Austrian Space Weather Office, GeoSphere Austria, Austria

Parallel Session 2A: Space Weather Modelling and Computational Techniques, September 10, 2025, 11:30 - 13:00

Coronal Mass Ejections (CMEs) are large parcels of plasma expelled from the sun that contain strong magnetic fields, and cause space weather effects when they impact the Earth's magnetosphere, where the geo-effectiveness of these phenomena can be highly varied and difficult to reproduce. Current forecasting models primarily use non-magnetised CMEs, as magnetised models are more computationally expensive and the initial field orientation is not well constrained by remote observations, but the impact of geomagnetic storms is influenced strongly by a CME's magnetic field, therefore it is vital to investigate and develop magnetised models. We will discuss 3 different models, an analytic flux rope, an MHD flux rope and a spheromak, used for reconstructing the evolution of CMEs in the inner heliosphere, and compare their results at L1 for the CME that caused the October 2024 geomagnetic storm. We also investigate the differences in magnetic structure between the models with the aid of test-particles representing galactic cosmic rays, which show transient decreases in flux due to the passage of CMEs. Through comparing these CME models, and their particle data, we aim to gain a greater understanding of how to more accurately reproduce observed CME structure and in-situ particle data in both forecasting and scientific models.

Low-latitude scintillation forecasting using a proxy for vertical plasma drift at the magnetic equator: a comparison of forecasting skill for different physics-based ionospheric models

Luke Nugent[1], Sean Elvidge[1], David Themens[1], Matthew Brown[1]
[1]*University Of Birmingham, United Kingdom*

Parallel Session 3B: Remote Sensing and Sun-Earth, September 10, 2025, 14:00 - 15:00

Equatorial plasma bubbles, resulting from Rayleigh-Taylor instability and occurring mainly in the evening sector, can cause severe disruptions in Global Navigation Satellite System (GNSS) availability and performance. To better anticipate these disruptions, and potentially mitigate their impact at a receiver level, forecasting of their formation has become a considerable interest in the GNSS user community.

A proxy for vertical plasma drift (PVPD) at the magnetic equator between 1830 and 2000 LT has previously been shown to have forecasting skill as a predictor for whether low-latitude scintillation will occur during the subsequent evening. PVPD scintillation forecasting has demonstrated skill both when using ionosonde observations or using output from the physics-based Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM). As ionosondes do not have adequate global coverage and suffer from processing limitations, the capability of using output from an ionospheric model for PVPD scintillation forecasting is advantageous. Climatological ionospheric models, however, have previously been shown to be unsuitable for PVPD scintillation forecasting. As such, physics-based models remain the most viable option. In this work the impact of the choice of physics-based ionospheric model (TIE-GCM vs WACCM-X: Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension) on PVPD forecasting will be assessed to determine whether forecasting skill can be improved under certain conditions by using ionospheric models other than TIE-GCM. The impact of the choice of external electric field model will also be assessed to determine the optimal configuration for operational use. Subsequent work will explore the optimization of the use of existing operational models.

Space Weather Operations at SIDC/STCE: Recent Developments and lessons learnt from Service Provision during Solar Maximum

Dr Jennifer O'Hara[1], Judith De Patoul[1], Yana Meneva[1], Daria Shukhobodskaia[1]
[1]*Solar-terrestrial Centre Of Excellence - STCE, SIDC, Royal Observatory Of Belgium, Belgium*
Plenary Session 3: Space Weather During Solar Maximum, September 9, 2025, 14:00 - 15:30

The challenges faced by operational space weather forecasters naturally intensify during periods of solar maximum. Increased solar activity leads to a corresponding rise in both the number and complexity of forecasting tasks—not only due to more frequent large-scale eruptive events, but also due to increased public awareness and more frequent interactions with end users. In parallel, routine activities such as sunspot classification, flare probability forecasting, CME tracking, and event cataloguing become increasingly data-intensive.
Additionally, the volume and variety of observational data available to forecasters has grown significantly, with inputs now coming from a wide network of space-based assets. This evolving landscape has driven the need for improved forecasting workflows, tools, and presentation layers.
In this presentation, we highlight recent activities of the SIDC forecaster team and associated developments aimed at supporting operational forecasting under these demanding conditions. These include both tools and interfaces developed over the past years to streamline forecasting processes, improve data and event cataloguing, and improve product quality. We will demonstrate how these tools are integrated into daily operations and discuss their impact on service delivery across multiple end-user sectors.

Quasi-Periodic Pulsations in TEC Measurements Synchronised with Solar Flare EUV Emission

Ms Aisling O'Hare[1], Susanna Bekker[1], Laura Hayes[2], Ryan Milligan[1]
[1]*Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast, United Kingdom,*
[2]*Astronomy & Astrophysics Section, School of Cosmic Physics, DIAS Dunsink Observatory, Ireland*
Parallel Session 3B: Remote Sensing and Sun-Earth, September 10, 2025, 14:00 - 15:00

The extreme ultraviolet (EUV) and X-ray radiation emitted during solar flares has been shown to cause considerable increases in the electron density of the Earth's ionosphere. During flares, quasi-periodic pulsations (QPPs) in X-ray flux originating in the corona have previously been linked to subsequent pulsations in the Earth's ionospheric D-region. Similar pulsations have been detected in chromospheric EUV emission, although their impact on the Earth's ionosphere had not previously been investigated. Here, for the first time, synchronous pulsations were detected in solar EUV emission and ionospheric Total Electron Content (TEC) measurements. We present the detection of QPPs with periods on the order of 85 seconds in chromospheric EUV emission lines (304Å, 972Å and 977Å) during the impulsive phase of an X5.4 flare on 7 March 2012 using SDO/EVE. These lines contribute to the ionisation in the ionospheric E- and F-regions, resulting in subsequent variations of electron density, which was detected in TEC measurements. This work demonstrates that these layers of the Earth's ionosphere are responsive to very small fluctuations in EUV emission during flares, with time delays found on the order of 40 seconds. This may have applications in atmospheric modelling and solar-terrestrial studies, including the calculation of ionospheric recombination rates.

Solar wind forecasting without magnetograms

Prof Mathew Owens[1]
[1]University Of Reading, United Kingdom
Parallel Session 4B: Solar & Heliospheric Forecasting II, September 11, 2025, 10:00 - 11:00

Operational forecasting of the solar wind and coronal mass ejections (CMEs) in near-Earth space is typically a three-step process. 1, the photospheric magnetic field is used to constrain a coronal model, which provides an estimate of the steady-state solar-wind at 0.1 AU; 2, coronagraph observations of CMEs are used to characterise transient solar-wind disturbances at 0.1 AU; 3, a solar wind model propagates these structures out to Earth. A major limitation of this process is that only the day-side photosphere can be routinely observed, providing an incomplete coronal-model boundary condition, and that the photospheric magnetic field is only indirectly related to the subsequent solar-wind flow. This introduces uncertainty into the forecasts. Here, we demonstrate how an accurate estimate of the ambient solar wind at 0.1 AU can instead be produced from in situ solar wind observations out at 1 AU. This provides forecast resilience against loss of magnetogram data. We demonstrate the forecast skill of this system for both ambient solar wind and CMEs.

Advancing Arctic Space Weather Monitoring and Forecasting through Targeted Research

<u>Dr. Patrick Perron</u>[1], Robyn A.D. Fiori[1], David H. Boteler

[1]*Natural Resources Canada, Canada*

Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

Space weather hazards affect a wide range of technology and critical infrastructure. Due to its distinct high-latitude location and proximity to the geomagnetic pole, Canada is particularly susceptible to these effects, as they are more concentrated within the polar and auroral regions. The auroral region stretches across Canada's high and central latitudes from the east to west coast and shifts to lower, more populated, latitudes during intense space weather events. Because of this enhanced exposure, Canada is also in an excellent position to observe space weather and therefore operates country-wide network of instruments measuring geomagnetic and ionospheric activity. The Canadian Space Weather Forecast Centre (Canadian Hazards Information Service, Natural Resources Canada) monitors, researches, and forecasts space weather with the goal of mitigating risks to the safe operation of critical infrastructure. Our research has historically focussed on geomagnetic effects but is expanding to cover a range of ionospheric phenomena.

Space Weather Impacts on Spacecraft in the Constellation Era

David Pitchford

Plenary Session 2: SDA/SST/SSA, September 9, 2025, 11:30 - 13:00

Traditional commercial telecommunications operators have had to evolve drastically due to intense competition from newcomers to the industry such as OneWeb, Starlink and Kuiper. The evolution is multi-faceted: rather than the core of the industry being a (relatively) small number of large, expensive satellites (each taking years to design and build) at geosynchronous orbit the emphasis is on massive constellations of smaller, cheaper (and quicker to build) satellites at low and medium earth orbits. The new paradigm has important consequences in terms of the Space Weather impacts that must be accounted for and mitigated against in the design, build and operation of these constellations. This talk will review these aspects - the evolving Space Weather threats to the New Space infrastructure that we increasingly rely on.

Cross-Dataset Solar Flare Forecasting: Combining GOES X-ray and SHARP Magnetic Parameters for Improved LSTM Predictions

Herbert Caxton-Martins, Prof Rami Qahwaji
[1]*University of Bradford, United Kingdom,* [2]*University of Bradford, United Kingdom*
Parallel Session 3A: Solar & Heliospheric Forecasting I, September 10, 2025, 14:00 - 15:00

Solar phenomena such as flares and coronal mass ejections (CMEs) can significantly impact critical infrastructure both on Earth and in space. This underscores the need for accurate and reliable space weather forecasting tools. In this study, we present a multimodal deep learning approach that combines GOES X-ray flux and SHARP magnetic field parameters to predict solar flare occurrence and class within a 12-hour forecast window.

We develop an attention-based long short-term memory (LSTM) network that processes two GOES soft X-ray channels (0.1–0.8 nm and 1.6–12.4 nm) along with key SHARP features such as total unsigned vertical current helicity (TOTUSJZ) and the R value. SHARP's 12-minute cadence data are interpolated to match the 1-minute resolution of GOES data. Both datasets are normalized and cleaned of outliers, and sequences are labelled based on the class of the flare. The attention mechanism enables the model to capture both the gradual magnetic build-up and the rapid X-ray precursors typical of flare onset.

We evaluate the model using flare events from Solar Cycles 24 and 25. The model achieves a True Skill Statistic (TSS) of 0.78 and an area under the ROC curve (AUC) of 0.89, showing significant improvement over unimodal baselines. Temporal cross-validation confirms generalization, reducing false alarms by 38 percent compared to traditional methods. Interpretability analysis highlights TOTUSJZ as the dominant magnetic precursor and GOES flux as key for detecting imminent flare onset.

These results show that fusing multi-source solar data has the potential to enhance the accuracy and interpretability of flare prediction.

A Simple Method To Forecast The Ionosphere Using Effective Geophysical Indices

Dr. Benjamin Reid[1], David Themens[1], Sean Elvidge[1]
[1]University Of Birmingham, United Kingdom

Parallel Session 2A: Space Weather Modelling and Computational Techniques, September 10, 2025, 11:30 - 13:00

Predicting global ionospheric plasma density beyond a mere nowcast is challenging, given the variability of the system and the sparsity of available measurements. Predicting the ionospheric state, particularly on a forecast timescale of hours to days, remains a critical challenge for operational modelers. On these timescales, it's often difficult for operational models to outperform climatological empirical models, which use simple geophysical indices to produce statistically representative monthly median outputs.

These driving indices present a simple method to produce improved global ionospheric estimates. It is possible to use global ionosonde observations to optimize a small set of effective geophysical indices using data assimilation. This is a near-ideal use case for particle filtering, a nonlinear data assimilation technique.

This simple approach can run in real-time on a modest laptop computer. While this approach is able to perform surprisingly well, it is not able to capture small-scale variability in the ionospheric system. This must be taken in to account to produce a reliable ionospheric representation, even at large scales. This also has strong potential as a pre-processing step for larger, more complex data assimilation models.

New Environment Models of Cold Electrons and Electromagnetic Waves in the Near-Earth Space and their Impact on Radiation Belt Electrons

Jean Francois Ripoll[1], David Hartley[2], Scott Thaller[3], David Malaspina[4], Thomas Farges[1]
[1]CEA, France, [2]University of Iowa, United States, [3]Orion Space Solutions, An Arcfield Company, United States, [4]Laboratory for Atmospheric and Space Physics, United States

Parallel Session 5A: Magnetosphere, September 11, 2025, 11:30 - 13:00

The cold plasma electron density (< 10 eV) is a fundamental component of the near-Earth space environment, which is crucial to know and model for a variety of physical processes, including, the computation of electromagnetic wave interactions with energetic trapped electrons. Using statistics from both NASA Van Allen Probes (2012-2019) and JAXA Arase satellite (2017-), we present a series of new empirical density models developed (1) for the inner zone between (L< 3), (2) for the whole plasmasphere up to geostationary orbits at L~6 based, and (3) for describing the plasmapause (i.e. the external boundary of the plasmasphere). The variations of the density with both magnetic latitude and magnetic local time will be shown. Within this complex and varying electronic environment, electromagnetic waves exist, grow, propagate and interact. Whistler-mode chorus waves are generated outside the plasmasphere and cause strong local energization. Others, such as lightning-generated waves, are controlled by atmospheric activity, travel from the ionosphere to the plasmasphere, where density gradients can duct them and influence their propagation. Whistler-mode hiss wave power is found to adapt to the radial profile of the dynamically changing plasmaspheric density with a strong correlation. Based on this understanding, we develop new empirical wave models designed to retain the physics of coupling between the plasma density and wave power distributions. Through data and simulations, we illustrate this intimate relationship between the waves and the cold plasma, along with consequential effects on radiation belt electrons for a wide range of electron energies.

The influence of space weather on electronics

Prof. Keith Ryden[1], Clive S. Dyer[1]
[1]Surrey Space Centre, University of Surrey, United Kingdom

Plenary Session 6: Impacts, September 11, 2025, 09:00 - 10:00

Advanced microelectronics has been the great enabler of the modern space era; however, it could also be the Achillies heel in terms of vulnerability to space weather. During the recent acceleration of space activity, including deployment of mega constellations, we have experienced relatively benign space weather conditions for electronic systems compared to earlier periods, so questions loom over how resilient our infrastructure will be when we do suffer a severe or, indeed, extreme event. This talk will highlight key issues for both the space and aerospace sectors and will summarize challenges for the future.

The National Space Operations Centre: Safeguarding Civil Space Assets

Dr Harneet Sangha
[1]*UK Space Agency, United Kingdom*

LOC Session, September 9, 2025, 09:00 - 11:00

As the UK's reliance on space-based infrastructure grows, so too does the need to ensure resilience and security of space assets. The National Space Operations Centre (NSpOC) plays a critical role in monitoring and protecting the UK's space-based assets. NSpOC is a joint civil and military body led by the UK Space Agency and UK Space Command, in partnership with the Met Office.

One of NSpOC's civilian products is a digital platform known as Monitor Space Hazards which provides users with information, alerts, and support on space-domain risks and hazards. UK-satellite operators can currently access our collision avoidance service and the Met Office Space Weather Operations Centre's (MOSWOC) space weather alerts. Digitised versions of our re-entry, fragmentation and CAA support services will be hosted on Monitor Space Hazards soon.

Enhancing Space Weather Forecasting with Solar Orbiter Observations

Daria Shukhobodskaia[1], Luciano Rodriguez[1], Judith de Patoul[1]
[1]*Solar-terrestrial Centre Of Excellence – Sidc, Royal Observatory Of Belgium, Belgium*
Parallel Session 3A: Solar & Heliospheric Forecasting I, September 10, 2025, 14:00 - 15:00

Solar Orbiter (SolO) offers a unique vantage point for space weather monitoring and forecasting. By observing regions of the Sun not visible from Earth and providing in-situ measurements away from L1, it allows forecasters to better assess the origin and structure of solar eruptions and monitor the evolution of returning active regions. This leads to more accurate analysis of CMEs, offers early warnings of ICME/HSS arrivals, and leads to improved forecasts of geomagnetic disturbances. We present the integration of SolO data into daily forecast routines at Regional Warning Center Belgium hosted at SIDC and highlight its growing role in real-time operations through several illustrative cases where SolO significantly enhanced situational awareness or enabled more precise space weather predictions.

Understanding and Modelling the Geomagnetically Induced Currents caused by Sudden Commencements

Andrew Smith[1], Craig Rodger[2], Kristin Pratscher[3], Daniel Mac Manus[2], Jonny Rae[1], Daniel Ratliff[1], Mark Clilverd[4], Ewelina Lawrence[5], Ciaran Beggan[5], Gemma Richardson[5], Alexandra Fogg[6], Denny Oliveira[7], Juliane Huebert[5], Tanja Petersen[8], Michael Dalzell[9]
[1]Northumbria University, United Kingdom, [2]University of Otago, New Zealand, [3]University of Wellington, New Zealand, [4]BAS, United Kingdom, [5]BGS, United Kingdom, [6]DIAS, Ireland, [7]University of Maryland, United States, [8]GNS Science, New Zealand, [9]Transpower New Zealand, New Zealand

Parallel Session 2B: GICs, September 10, 2025, 11:30 - 13:00

Sudden Commencements (SCs) are rapid, near-impulsive changes of the geomagnetic field that are measured on the ground. SCs are caused by sudden increases of solar wind dynamic pressure (e.g., interplanetary shocks), that compress the Earth's geomagnetic cavity (the magnetosphere). Such changes in the geomagnetic field, as measured on the surface of the Earth, result in the creation of geoelectric fields in the solid Earth and consequently Geomagnetically Induced Currents in grounded, conducting infrastructure. When large, these GICs present a hazard to the continuous, safe operation of infrastructure such as power networks - we must be able to accurately predict their magnitude.
The links between the properties of the incident solar wind structure, the observed magnetic field signature at a given location and the resulting GIC are complex. In this work we explore the correspondence between these factors, introducing an analytical model to mimic the physical origin of each constituent component of the ground magnetic field signature. We explore how the each component varies across the globe, and attempt to link these underlying properties to the causal solar wind structure. We test how different types of SC magnetic signature translate to GIC within a well-documented example power network using synthetic tests and numerical models. This ultimately allows us key insights into the types of solar wind structure that will be most "geoeffective" at a given location.

Radiation risks to human health (terrestrial, air crew, astronauts) due to cosmic radiation

Rick Tanner[1], Jon Eakins[1], Luke Hager[1]
[1]*UKHSA, United Kingdom*

Plenary Session 6: Impacts, September 11, 2025, 09:00 - 10:00

In 1911 and 1912, Victor Hess measured radiation in the atmosphere during balloon ascents, thereby discovering "cosmic radiation", only about 15 years after the discovery of radioactivity. Since then, the variation of dose rate in the atmosphere has become well established with the dose rates peaking at about 55,000-60,000 ft, somewhat higher than routine commercial aviation flights. The short-term temporal variation of these dose rates is referred to as space weather.

Despite this long-standing awareness of the ionizing radiation doses that those in aviation and space receive, radiation protection legislation has been somewhat slow catching up with that for other industries. As commercial aviation expanded and human space flight increased, the need for radiation protection to cover those exposures became clear. This evolution of legislation for those exposed to ionizing radiation is reviewed and contrasted with that for other industries. The recommendations of the ICRP and the interpretations of those recommendations by EURATOM and IAEA for their Basic Safety Standards is discussed. The subsequent impact on UK legislation is also reviewed.

The sources of cosmic radiation, the radiation types and the doses that people in aviation and in space are exposed to are discussed. These exposures have two distinct sources: from outside our solar system, galactic cosmic radiation; from the Sun. Further, some of this incident radiation gets trapped in the Earth's magnetic field producing radiation belts at specific altitudes. The galactic and solar components differ in terms of the particles and energies in the radiation field, but especially in terms of how time dependent they are. Significant, short-term increases in dose rate are due to solar sources and could give relatively high doses to people in civil aviation and in space. These exposures are discussed and contrasted with radiation emergencies.

The UK preparedness to react to severe space weather events is outlined. This is put in terms of the wider context of impacts outside radiation protection. For radiation, retrospective advice is the key component of what we can do for those who have been exposed, but progress towards prompt alerting that could enable flight patterns to be altered is presented.

Recent Advances in the Modelling of CME Propagation Through the Heliosphere

Manuela Temmer[1]
[1]University Of Graz, Austria

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

Coronal Mass Ejections (CMEs) are the major drivers of space weather, with the potential to disrupt satellite operations, communications, and power systems on Earth. Reliable modelling of CME propagation from the Sun through the heliosphere is essential for improving forecasting capabilities and for understanding the interaction processes with the solar wind. Experience shows, that besides enhanced knowledge on CME propagation behavior, most of all, the structured background solar wind needs to be better understood and modeled.

In recent years, substantial progress has been made in observationally constraining models and feeding – in near real-time – models with observational data. State-of-the-art models may continuously adapt to actual conditions and with that increase their forecasting capabilities. However, especially multiple CMEs, CMEs interacting with other large-scale structures, such as co-rotating interaction regions or the heliospheric plasma sheet, pose challenges to these models. Especially, during solar maximum phases, we are frequently encountered with low accuracy forecasts, due to the complexity of the occurring eruptions.

This talk will review key advancements in modeling that could be achieved in the past years, including the integration of multi-spacecraft observations into data-driven models, the development of advanced magnetohydrodynamic (MHD) simulations, and the incorporation of ensemble forecasting techniques to capture uncertainties in CME trajectories and arrival times. It will also focus on still open science questions, that need to be addressed for improving space weather forecasting.

Real-time detection and characterisation of solar flares from ground-based VLF data

Pauline Teysseyre[1], Carine Briand[1]
[1]Lira - Observatoire De Paris, France
Parallel Session 6B: Sun-to-Earth Science, September 11, 2025, 14:00 - 15:00

Solar flares are fast increases of the solar X-ray flux, which enhance the electron density of the D-region (60 – 90 km) of the ionosphere, causing a greater absorption of the HF waves. Real-time detection of solar flares is thus needed to enable mitigation of the radio communication.

To do so, we use Very Low Frequency waves propagating in the Earth-ionosphere waveguide. The electron density rise caused by solar flares induces a change of the conductivity of the upper limit of the waveguide, impacting the propagating waves. Solar flares can thus be detected from ground-based VLF receivers. This method also enables continuous surveys of remote regions (such as oceans), which are used to send alerts.

We present here a real-time system for detection and characterisation of solar flares, based on the analysis of VLF waves received in Nançay (Sologne, France) and the incremental algorithm proposed by Guralnik & Srivastava (1999). This algorithm enables the detection of 85 % of the moderate and strong flares within a third of their rise time, and is based on the automated detection of the slope changes in the data. The X-ray flux from the Sun (which determines the strength of the flare) can then be inferred by measuring the variation of the VLF wave amplitude and phase compared to their pre-flare state. Lastly, the D-region electron density can be estimated from those measurements; from this quantity, an estimate of the HF absorption can then be derived.

Using solar wind data assimilation results to drive dynamic solar wind models.

Harriet Turner[1], Mathew Owens[1], Luke Barnard[1], Matthew Lang[2]
[1]*University Of Reading, United Kingdom,* [2]*British Antarctic Survey, United Kingdom*
Parallel Session 4B: Solar & Heliospheric Forecasting II, September 11, 2025, 10:00 - 11:00

Most near-Earth solar wind forecasting uses a coupled modelling framework. This consists of a coronal model for close to the Sun and a heliospheric model for propagating the solar wind out to Earth. The coronal model is initialised using observations of the photospheric magnetic field and when modelling the ambient solar wind, there are no further observational constraints. This means that the models are free-running, and large errors can propagate through the model, reducing the forecast accuracy. Data assimilation (DA) is a technique that combines model output with observations of a system to form an optimum estimation of reality. For space weather forecasting, we can assimilate observations from spacecraft, adjusting the inner boundary of the solar wind models.

Previous work using solar wind DA has made use of the Magnetohydrodynamics Around a Sphere (MAS) coronal model due to its availability and long archive. However, the Wang-Sheeley-Arge (WSA) model is more commonly used operationally. Here, we present how the Burger Radius Variational Data Assimilation (BRaVDA) scheme can be used with WSA model output to produce an updated inner boundary condition for the Heliospheric Upwind Extrapolation with time-dependence (HUXt) model. This involves some processing of the BRaVDA output, as this is required for use in any solar wind model, and how the output can be used to modify the WSA map for use in 3D physics-based models. We find that BRaVDA can help with WSA bias correction and show that using the optimum level of processing leads to improved solar wind forecasts.

What space weather can learn from meteorology: a Dutch case study

Kasper van Dam[1], Bert van den Oord[1], Eelco Doornbos[1]
[1]*KNMI, Netherlands*

Plenary Session 1: Space Weather Operations, September 8, 2025, 14:00 - 16:00

Based on the National Risk Assessment of 2011, the Dutch government concluded that space weather is a risk to the Dutch vital sectors. In 2015 the Royal Netherlands Meteorological Institute (KNMI) was tasked to create a national space weather service with the aim of raising awareness for space weather, to provide a 24/7 alerting service, and to work with vital sectors to improve resilience. This alerting service relies on products provided by the Met Office. Both KNMI and the Met Office are meteorological institutes that apply their experience with 24/7 meteorological service provision in their space weather services. The fact that KNMI is a governmental institute is useful when discussing vulnerabilities with vital sectors and other parts of government. KNMI's role as an Air Navigation Service Provider is helpful in our contacts with the aviation sector. In this talk we will share our experience as a national space weather service provider and our views on how space weather services could be organized in Europe.

The Utility of AMPERE for Space Weather Research and Applications

Sarah Vines[1], Brian Anderson[2], Alex Chartier[2]
[1]Southwest Research Institute, United States, [2]Johns Hopkins University Applied Physics Laboratory, United States

Parallel Session 4A: M-I Coupling, September 11, 2025, 10:00 - 11:00

Derived from the Iridium Communications satellite constellation, AMPERE produces continuous global measurements of magnetic field perturbations and radial current densities from the large-scale Birkeland currents. The development of this current system is a key phenomenon within the complex dynamics of solar wind-magnetosphere-ionosphere interactions, and is directly related to solar wind-driven geomagnetic activity. In turn, the Birkeland currents impart significant amounts of energy into the high-latitude ionosphere, which have further effects on lower latitude and lower altitude dynamics in the coupled ionosphere-thermosphere system. While AMPERE is primarily used to study magnetosphere-ionosphere coupling and electrodynamics, the dataset also has broader utility for assessment of the space environment at low-Earth orbit and impacts of extreme events giving rise to geomagnetic storms and more localized phenomena like substorms and GICs. We highlight the use AMPERE for space weather research including assessments of high-latitude energy input through investigations of field-aligned currents, Poynting flux, and Joule heating; polar cap boundaries and dynamics; and as inputs for ionospheric models with operational capabilities. We also discuss future avenues of AMPERE data products, usage with other measurements relevant for space weather monitoring, incorporation into models and assimilative techniques, and use for targeted causal analysis for space weather events. With the diversity of domains and technological systems affected by space weather events, AMPERE can provide additional key measurements for impacts particularly affecting and driving the dynamic high-latitude magnetosphere-ionosphere coupling region.

Building the Sun-to-Earth Connection: An Operational Event Chain Framework for Space Weather Forecasting at SIDC.

Lukas Vinoelst[1]
[1]Rob Sidc, Belgium

Plenary Session 4: R2o2R, September 9, 2025, 16:00 - 18:00

In modern space weather operations and forecasting, information about the operational activities themselves is often lost or not efficiently exploited. This information is of particular interest in the context of "Operations to Research" and vice versa, where it can aid in enhancing the entire symbiosis of the two aspects.

An important asset to have is a comprehensive database of space weather events that traces the entire chain of these events from the Sun to the Earth. The space weather operations team of the regional warning center at SIDC is developing a framework that consolidates several such events into these chains. This "Event Chain" framework aims to capture the full 'Sun-to-Earth' chain of space weather events including relevant operational information and store it in an accessible way.

To achieve this, a relational database model is being developed together with a forecasting interface that integrates the entire framework into the daily operational activities at SIDC. In addition to storing such chains, it is possible to keep the evolution of objects like sunspot groups by linking observations of returning objects to eachother.

Already several derived dataproducts are currently available: SIDC sunspot groups, SIDC flares, SIDC coronal holes, SIDC CMEs, forecasts (flare, high speed stream, ICME, K index). Many more events will be implemented in the near and further future to complete the full chain.

To illustrate, an example will be shown of a chain captured on October 9th using the event chain framework.

Bridging AMPERE and SuperDARN: Aligning Field-Aligned Current and Ionospheric Convection Boundaries During Geomagnetic Storms

Dr Maria-theresia Walach[1]
[1]Lancaster University, United Kingdom

Parallel Session 4A: M-I Coupling, September 11, 2025, 10:00 - 11:00

Accurate mapping of ionospheric convection across the arctic is vital for understanding space weather brought on by solar wind-magnetosphere coupling, such as during geomagnetic storms. Super Dual Auroral Radar Network (SuperDARN) radars estimate global convection, but gaps in coverage sometimes make the placement of its lower-latitude boundary, the Heppner-Maynard Boundary (HMB), uncertain.

We investigate whether field-aligned current (FAC) boundaries from the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) can supplement or constrain HMB placement during geomagnetic storms. Analysing three storm events, we find that while AMPERE and SuperDARN boundaries often align, SuperDARN tends to place the HMB equatorward of AMPERE’s FAC boundary during active periods. We find that disagreements primarily arise due to geometrical factors and a time lag in expansions and contractions of the patterns.

Both AMPERE and SuperDARN offer valuable context for space weather: These systems give a synoptic view of the ionosphere and allow us to view invisible boundaries. AMPERE offers valuable context when SuperDARN scatter is sparse, while SuperDARN adds detail when FACs are weak. Understanding disagreements in the datasets we utilise, however, is key to advancing our understanding of space weather.

Statistical Analysis of Comet Disconnection Events Using STEREO HI and a Data Assimilative Solar Wind Model

Sarah Watson[1], Chris Scott[1], Matt Owens[1], Luke Barnard[1]
[1]*University of Reading, United Kingdom*

Parallel Session 4B: Solar & Heliospheric Forecasting II, September 11, 2025, 10:00 - 11:00

Comets tails can reveal information about the local solar wind conditions. They can exhibit various signatures of interactions with the solar wind including bending, developing kinks and sometimes undergoing tail disconnections.
Comet tail disconnection events observed in the STEREO HI data during the period of 2007 to 2023 have been investigated. Using the Heliospheric Upwind eXtrapolation with a time-dependency (HUXt) solar wind model alongside novel solar wind data assimilation (DA) techniques, each disconnection event was investigated to determine its cause. The resulting statistical analysis led to three main conclusions; 1) For every Heliospheric Current Sheet (HCS) crossing predicted by HUXt that occurs when the comet is within the region of influence of DA, a tail disconnection follows, 2) For HCS crossings that occur outside the region where DA can be applied, 54.5% are followed by a tail disconnection, 3) There is an approximately linear relationship between the speed of the solar wind at the HCS crossing and the time delay to the onset of a disconnection. This aim of this research and further work is to use comets to test the efficacy of the solar wind model, leading to the eventual use of comets as in-situ probes over a wide range of locations which are currently unoccupied by spacecraft.

Modelling highly-variable processes in the outer radiation belt

Clare Watt[1], J. F. Ripoll[2], E. R. Grant[1]
[1]Northumbria University, United Kingdom, [2]Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France

Parallel Session 5A: Magnetosphere, September 11, 2025, 11:30 - 13:00

Physics-based models of the Earth's outer radiation belt are used in many cases to provide operational space weather nowcasts and forecasts. The important physical processes on which numerical models are based are known as wave-particle interactions (WPI); these describe how high-energy electrons can be transported, energised and lost in response to electromagnetic wave activity throughout the inner magnetosphere. There is a great deal of observational and theoretical evidence to support the idea that WPI are key physical processes in the outer radiation belt, but they occur on much smaller length and timescales than can be supported in a numerical model. In short, WPI are subgrid processes, similar to cloud formation, turbulent mixing or convective updrafts in atmosphere and climate models.

The significant challenge for the numerical modelling of outer radiation belt space weather is that WPI vary considerably in space and time. We have previously demonstrated the numerical consequences of temporal variation of WPI for plasmaspheric hiss, which is believed to be important in the outer radiation belt for scattering of high-energy electrons. Here, we focus instead on variability of WPI due to the wave mode known as chorus, important for both energisation and scattering of radiation belt electrons. We demonstrate with spacecraft observations the temporal variability in the plasma environment and in the wave activity, and demonstrate the consequences for high-energy electrons.

AEGIS: Advancing Protective Space Weather Science through Agile Rideshare Missions

Ashley West[1], Markos Trichas[1]
[1]BAE Systems, United Kingdom

Parallel Session 6A: Space Environment, September 11, 2025, 14:00 - 15:00

The space weather community faces a persistent observational gap between high-capability, long-lead institutional missions and the growing use of low-cost but limited CubeSats. While CubeSats have enabled innovation and access, they often lack the power, payload capacity, and resilience to deliver sustained, high-fidelity measurements. Institutional missions, by contrast, offer advanced science return but are expensive and infrequent, with development cycles typically exceeding a decade.
BAE Systems is developing a middle path: AEGIS, a payload rideshare concept designed to provide low-cost access to space for advanced sensors. Each mission will offer a 0.55 m^2 payload deck capable of hosting multiple instruments, enabling a balance of cost-efficiency, technical capability, and adaptability. Compared to CubeSats, AEGIS offers higher payload mass and power budgets, improved pointing accuracy, greater data throughput, and longer mission lifetimes. Compared to traditional missions, it supports shorter development times and rapid reconfiguration in response to emerging scientific and operational needs.
AEGIS builds on existing BAE Systems technologies, with the first launch planned for 2027 and an annual cadence thereafter. We propose to outline the scientific and implementation advantages of this approach, and to initiate a community-driven framework for payload standards, interface definitions, and data format alignment. This model presents a transformative opportunity to close the capability gap in space weather monitoring enabling more responsive, distributed, and sustainable observation infrastructure aligned with the dynamic demands of the space environment.

Dynamic Ionospheric Notifications for Operations and Scheduling (DINOS): Using Ionospheric Observations to Support LOFAR2.0 Operations

Alan Wood[1], Gareth Dorrian[1], Maaijke Mevius[2], Ben Boyde[1], Richard Fallows[3], David Themens[1], Emanuela Orru[2], Jaroslav Urbář[4], Aleksandar Shulevski[2], Pietro Zucca[2], Katarzyna Beser[5], Pawel Flisek[6], Sean Elvidge[1]

[1]Space Environment and Radio Engineering (SERENE) research group, University of Birmingham, United Kingdom, [2]ASTRON – The Netherlands Institute for Radio Astronomy, The Netherlands, [3]Science and Technology Facilities Council (STFC) Rutherford Appleton Laboratory, United Kingdom, [4]Institute of Atmospheric Physics CAS, , Czech Republic, [5]New Jersey Institute of Technology, USA, [6]University of Warmia and Mazury in Olsztyn, Poland

Parallel Session 3B: Remote Sensing and Sun-Earth, September 10, 2025, 14:00 - 15:00

The Low Frequency Array (LOFAR) is one of the most advanced radio telescopes in the world. When radio waves from a distant astronomical source traverse the ionosphere, structures in this plasma affect the signal. It is currently being upgraded to LOFAR 2.0, which will increase the sensitivity of the telescope, but it will also be more vulnerable to ionospheric variability.

The Dynamic Ionospheric Notifications for Operations and Scheduling (DINOS) project is using ionospheric results to attempt to mitigate the ionospheric effects on LOFAR observations. A database of 2,911 hours of observations is used to determine the quality of the radio astronomy observations on these occasions. The ionospheric conditions associated with these observations are established, using different approaches with different instruments. These approaches include using ionosondes, magnetometers and HF Continuous Doppler Sounding Systems. Different approaches provide information on different scales of plasma density variations. The suitability of these approaches to forecast when ionospheric conditions will be appropriate for low-frequency radio astronomy is determined. Such a forecast could reduce the number of observations which later need to be discarded due to the ionospheric conditions, optimizing the usage of telescope time, and making the operations more sustainable by reducing the computational and storage resources required. These methods could also predict when the ionosphere will be extremely depleted, enabling observations at lower frequencies than have been routinely possible to date. Such observations would be extremely beneficial for several of the key science cases.

Solar Orbiter & Parker Solar Probe: Multi-viewpoint messengers of the inner heliosphere

Steph Yardley[1]
[1]Northumbria University, United Kingdom
Parallel Session 3A: Solar & Heliospheric Forecasting I, September 10, 2025, 14:00 - 15:00

ESA/NASA's Solar Orbiter and NASA's Parker Solar Probe are encounter missions that are currently both in their nominal science phases, venturing closer to the Sun than ever before. These complementary spacecraft are operating together in order to combine in situ measurements of solar wind plasma in the inner heliosphere with high-resolution remote sensing observations of their source regions in the solar atmosphere. This talk highlights the recent results from and the synergetic science that these multi-viewpoint messengers enable and how they are working together to significantly advance our understanding of the physical processes that are important for solar wind formation, the eruption of coronal mass ejections and their space weather effects.

Poster Presentations

Radiation belt wave-particle interaction theory and modelling: What do we know and what are we yet to understand?

Dr Oliver Allanson[1]
[1]University Of Birmingham, United Kingdom; University Of Exeter, United Kingdom
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Understanding the dynamics of energetic electron populations in the Earth's outer radiation belt presents unique opportunities to grapple with the fundamental physics of relativistic charged particle trapping, loss, and acceleration in our own 'back-yard'.

On the one hand our understanding of radiation belt dynamics has evolved a great deal in the 60+ years since their discovery. However (and perhaps as ever?), there are many aspects whose basic description and importance in this domain are yet to be fully understood, incorporated, or effectively parameterized and incorporated into global scientific and operational models.

We present a survey of fundamental theory and modelling approaches, focusing on best current understanding of wave-particle interactions and some key milestones in the 21st century. We will focus on some current cutting-edge developments pertaining to wave-particle interactions, and outline exciting future directions.

These will include developments towards understanding and incorporation of: quasilinear and nonlinear interactions; stochastic parameterization; fast and MLT dependent radial transport; the existence (or otherwise) of an upper limit to flux; and new modelling paradigms such as stochastic pdes “on top” of fluid-based approaches.

Diffusion coefficients for resonant relativistic wave-particle interactions using the PIRAN code

Dr Oliver Allanson[1], Thomas Kappas[2], James Tyrell[2], Gregory Cunningham, Adrian Garcia, Sean Elvidge
[1]University Of Birmingham, United Kingdom; University Of Exeter, United Kingdom, [2]University of Birmingham, United Kingdom, [3]LANL, United States

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Quasilinear diffusion coefficients can be used to characterise the statistical response of charged particles to perturbations by plasma waves, via resonant wave-particle interactions. The calculation of these coefficients is sufficiently complicated and arduous to render it prohibitive to many potential users, because of the expense in time spent developing the code. We present and describe the open-source PIRAN software package (“Particles In ResonANce”). This package is written using Python, and allows the user to calculate local and bounce-averaged relativistic diffusion coefficients in energy and pitch angle space via the two main current proposed methods in the literature. The code is available @ https://github.com/RB-ENVIRONMENT/PIRAN with documentation @ https://rb-environment.github.io/PIRAN/ , and an accompanying journal article is under review.

Characterising magnetopause surface waves within magnetosphere–ionosphere–ground coupling

Martin Archer[1], Mike Heyns[1], David Southwood[1]
[1]*Imperial College, United Kingdom*
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The interface to the solar-terrestrial interaction, the magnetopause, is in continual motion in response to external driving and plasma instabilities. Such disturbances to the boundary, theoretically described as magnetohydrodynamic surface waves, generate field-aligned currents that couple the magnetosphere to the ionosphere and lead to ground-based impacts. To better understand these potential impacts across a wide range of wave and system properties, we develop a simple numerical model to explore the effects magnetopause surface waves have. Amplitudes of ground magnetic oscillations of order 100's of nanoTesla are found to be typical and we uncover scaling relations for each component of ground magnetic field perturbations which differ from the widely-used expression derived assuming plane body waves. The result is polarisation changes from the magnetosphere to the ground and decay scales which, in the case of small to mesoscale wavelengths, may not be resolved by typical ground magnetometer chains. Geoelectric fields of up to 1000's of milliVolts per kilometre are found to be possible, particularly for large wavelengths and ground skin depths. Therefore, magnetopause surface waves can be a significant source of ground magnetic and geoelectric field variations. Finally, we discuss how the model might also be adapted for other known localised sources of oscillatory field-aligned currents such as field line resonances and flux transfer events.

Lerwick Compact Neutron Monitor: Instrumentation and First Resuts

Dr Fraser Baird[1], Keith Ryden[1], Ben Clewer[1], Fan Lei[1], Clive Dyer[1]
[1]*University Of Surrey, United Kingdom*

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Increases in atmospheric radiation driven by high energy solar protons, known as ground level enhancements, are a major space weather hazard for aviation activities. The events are typically monitored by measuring the neutron flux at ground level using neutron monitors: large instruments employing several tons of lead.

In April 2025, a new Compact Neutron Monitor was installed at the Met Office Observatory in Lerwick, Shetland through the SWIMMR programme. The instrument is significantly smaller and lighter than a traditional neutron monitor. In this contribution, the instrumentation and its installation is described. The data from the first months of operation is presented and discussed. Comparisons are made to the data from the compact neutron monitor in Guildford, and to traditional neutron monitors.

Quantitative Characterisation of Magnetic Topology in Solar Active Regions for Operational Space Weather Forecasting

Stephen Bannister[1], Shaun Bloomfield[1]
[1]*Northumbria University, United Kingdom*

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Active regions are distinct, localised areas on the Sun where subsurface magnetic flux has emerged. The degree of magnetic complexity within these regions is well-known to influence the frequency of eruptive events in the surrounding plasma, including solar flares and coronal mass ejection events. Consequently, quantifying active region magnetic complexity is essential for improving forecasts of flare frequency and active region evolution from a space weather perspective.

One of the most widely used magnetic classification schemes in operational space weather forecasting is the Mount Wilson system, which is categorical and thus insensitive to variations within each class. This means that two active regions with the same classification can differ substantially in both magnetic complexity and eruptive behaviour.

We present a novel method for quantifying magnetic complexity via the Polarity Inversion Measure (PIM), which characterises complexity as a continuous variable, offering a higher level of detail than these broad category labels. We conduct a statistical study of over 1,400 active regions observed since the launch of NASA's Solar Dynamics Observatory, comparing the temporal evolution of PIM with changes in Mount Wilson classifications. Our results demonstrate the advantage of using a quantitative complexity metric over discrete, human-assigned daily labels.

Finally, we explore PIM's potential operational applications by assessing its predictive skill for next-day Mount Wilson classifications and flare frequency using Poisson-based modelling, underscoring its value in transitioning from research to operations in space weather forecasting.

A field-deployable absolute vector quantum magnetometer for geomagnetic research

Dr Ciaran Beggan[1], Stuart Ingleby[2], Mark Bason[3], Chris Turbitt[1], Dominic Hunter[2], Mike Salter[3], Robert Lyon[1], Adam Filip[3], Tom Martyn[1], Josie Parrianen[1], Marcin Mrozowski[2]
[1]British Geological Survey, United Kingdom, [2]University of Strathclyde, United Kingdom, [3]RAL Space, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Quantum magnetic sensing offers several powerful advantages over the classic combination of triaxial fluxgate and proton precession magnetometers. Advances in quantum technology, such as optically-pumped magnetometers (OPMs), have enabled single sensors to make full-field, high-frequency, temperature-insensitive measurements of the natural field (i.e., 0-60μT). The low noise, high bandwidth OPMs can be used to detect absolute changes in the field arising from secular variation as well as rapid variations in the Earth's natural magnetic field from space weather activity. Our newly developed OPM consists of a Cs-vapour cell magnetometer in a double-resonance configuration with two orthogonal coils to provide a full field and vector measurement capability.
As part of a three-year programme, we are building and deploying five ground-based OPMs using state-of-the-art sensor technology from the University of Strathclyde in combination with back-end electronics for the laser driver and high-speed digital signal processing developed by RAL Space. The BGS-run geomagnetic observatory at Eskdalemuir will allow the OPM systems to be compared and checked against the highest scientific standards for observatories (INTERMAGNET-standard). The sensors will then be deployed to five field locations around Britain in 2025. This will reduce the spacing between operational observatories and variometers in the UK to less than 200 km. The systems will return data in near-real-time, allowing one of the densest magnetic networks in the world to be created. We describe the progress to date, including the results from a performance comparison at Eskdalemuir and the first field deployments in England and Wales.

Response of the total electron content in the ionosphere to the impulsive and late phases of X-class solar flares

Dr Susanna Bekker[1], Ryan Milligan[1]
[1]Queen's University Belfast, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The problem of studying the response of ionospheric layers to natural disturbances caused by solar radiation variations is still open and is being actively developed at present. Variations in X-ray and UV irradiance during solar flares lead to a noticeable increase in the electron concentration in the illuminated part of the Earth's ionosphere. Due to the large amount of experimental data accumulated by the Global Navigation Satellite Systems, the total electron content (TEC) response to the impulsive phase of a solar flare has been studied quite well. At the same time, recent studies have shown that approximately 40% of X-class flares have second strong peak of warm coronal emission (which is called "EUV late phase"), whose influence on the ionisation of ionospheric layers is not yet clear. We numerically estimated the ionospheric response to the impulsive and late phases of the X2.9 (3 November 2011), X2.4 (23 October 2012), and X2.0 (25 April 2014) solar flares which are characterised by different spectrum and localisation on the solar disk. It has been demonstrated that the TEC increment during the EUV late phase can exceed the response to its impulsive phase and reaches 0.6-0.7 tecu. The energy of the EUV late phase of more powerful event than those considered in this work can be much higher, so the obtained result indicates a serious need to consider the late emission of warm coronal lines when modelling and forecasting the ionospheric response to variations in solar radiation.

Model Validation using Historical SEP Event Analysis of the 3D Physics-Based Forecasting Tool SPARX

Miss Damini Bhagwath, Timo Laitinen, Silvia Dalla, Mike Marsh
[1]University of Central Lancashire, United Kingdom, [2]University of Central Lancashire, United Kingdom, [3]University of Central Lancashire, United Kingdom, [4]Met Office, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The transport mechanisms governing the propagation of Solar Energetic Particles (SEPs) through the interplanetary space remain a challenging aspect of space physics. To mitigate the radiation risk posed by SEPs while accounting for their complex transport dynamics, operational space weather forecasting is beginning to adopt physics-based approaches. Three-dimensional models offer a framework for incorporating the effects of the interplanetary magnetic field and solar wind turbulence on the intensity and timing of SEP arrival at Earth. The forecasting tool SPARX (Marsh et al. 2015) employs a relativistic full-orbit test particle approach to generate synthetic flux profiles. A solar flare exceeding magnitude M1.0 triggers SPARX to generate these profiles from a pre-generated database, forecasting expected observations at 1 AU.

We focus on model validation through systematic SEP event analysis. We extend the performance evaluation methodology of Dalla et al. (2018) by compiling a list of X-class solar flares from 1997 to 2024, with SPARX operated in forecast mode for each event. Skill scores such as Probability of Detection (POD) and Critical Success Index (CSI) are calculated to evaluate model performance across a significantly expanded dataset. We present an analysis of SPARX's current efficiency in reproducing intensity profiles and onset times. These outputs are compared with multi-spacecraft observations from SOHO, STEREO-A, and SOLO, using a >20 MeV proton threshold for consistency. This assessment informs model improvements and supports bridging the gap between physics-based modelling and real-time forecasting. Future development will incorporate cross-field transport to assess its impact on predictive capability.

Advancing Forecasting Capabilities through Operations-to-Research at the Met Office Space Weather Operations Centre

Dr. Suzy Bingham[1], Rebecca Spalton[1], Francois-Xavier Bocquet[1]
[1]*Met Office, United Kingdom*

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

An effective Operations-to-Research (O2R) process is fundamental to sustaining and enhancing the forecasting capabilities of the Met Office Space Weather Operations Centre (MOSWOC). It enables forecasters to provide structured feedback on the performance of operational models and data, ensuring that challenges and opportunities for improvement are systematically captured, resolved and used to guide research priorities through practical operational insight. The current O2R framework, centred on the Space Weather Issues and Reviews Log (SWIRL), has been in place since 2020. The SWIRL framework was tailored to meet the needs of space weather operations whilst drawing on best practices from terrestrial weather O2R. It is timely to revisit and improve the O2R process, particularly with the imminent increase in models available to MOSWOC, as systems developed under the SWIMMR programme approach operational readiness.

In the terrestrial context, forecasters submit Daily Forecast Assessments to report model issues. When a bias is identified, a model ticket is raised and logged in a Model Characteristics document to support both forecast interpretation and research planning. MOSWOC maintain similar documents outlining model strengths and limitations, though there is scope to enhance these by integrating with a structured R&D ticketing system and evolving them into living resources.

We explore enhancements to the current framework to better support identifying, tracking, and prioritising model and data improvements - enabling deeper insight into model behaviour and associated space weather impacts, strengthening feedback mechanisms to research, and ultimately improving the resilience and effectiveness of MOSWOC's operational forecasting services.

Technical Development of the NM-2023 Ground Level Monitor

Dr Cory Binnersley[1], Michael D Aspinall[2], Tilly Alton[2], Steven Bradnam[3], Stephen Croft[2], Malcolm Joyce[2], David Lloyd[1], Dakalo Mashao[2], Lee Packer[3], Darren Shaw[1], Tony Turner[3], James Wild[4]
[1]Mirion Technologies (Canberra UK) Limited, United Kingdom, [2]School of Engineering, Lancaster University, United Kingdom, [3]Culham Centre for Fusion Energy, United Kingdom Atomic Energy Authority (UKAEA), United Kingdom, [4]Physics Department, Lancaster University, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Ground-Level Enhancement (GLE) events are studied using a global network of ground-based neutron monitors (NMs). These NMs, originally developed by Simpson (ca. 1948), are used to study primary cosmic rays by detecting the secondary particles produced by cosmic rays interacting with the Earth's atmosphere. The current network of NMs is composed of approximately 50 operating stations, which mostly utilise the standard 1964 Carmichael design (NM-64). The NM-64 is designed around the 14.5 cm diameter Chalk River BP2822 BF_3 gas-filled proportional counters.
Mirion Technologies, in collaboration with Lancaster University and the UK Atomic Energy Authority, have developed a new NM design, known as the NM-2023. The NM-2023 design has been developed around modern 1″ ^3He proportional counters and is benchmarked against a 6-NM-64 monitor. This presentation will discuss aspects from the technical development of the NM-2023 system, focusing on the mechanical and data acquisition design of the instrument. Furthermore, prior to installation at the Met Office Camborne site, a series of measurements were performed to assess the response characteristics of the instrument, such as efficiency, neutron population die-away time and deadtime. The results from these measurements will also be discussed.

RASOR: Radio Astronomy and Space Observation Research Facility – A Future Prospect for UK Sovereign Capabilities Across Space Weather, Space Situational Awareness, and Radio Astronomy

Dr Mario Bisi[1], Michael Garrett[2], Marco Martorella[3], Simon Garrington[2], Biagio Forte[4], Robert Beswick[2], Richard Fallows[1]

[1]UKRI STFC RAL Space, United Kingdom, [2]Jodrell Bank Centre for Astrophysics, The University of Manchester, United Kingdom, [3]Department of Electronic, Electrical and Systems Engineering, University of Birmingham, United Kingdom, [4]Department of Electronic and Electrical Engineering, University of Bath, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

RASOR is a potential new facility operating across a wide range of radio frequencies. It would enable unique observational and monitoring capabilities for frontier science across space weather, cosmology, astrophysics, and also in addressing strategic requirements for the prediction of adverse space-weather events and characterisation of assets/debris in orbit. This advancement, when realised, represents a major step-change in current capabilities, addresses up to 13 of the 23 of the UKRI STFC Science Challenges in the UK, strong links into several UN Sustainability Development Goals, and will have substantial near- and long-term direct economic and societal impacts beyond research. It also has the option of being a UK sovereign infrastructure, or with direct links into infrastructures across Europe and further afield.

A fully-implemented RASOR would be a truly multi-disciplinary/interdisciplinary world-class facility on UK soil with UK resilience at its heart. It would be capable of crucial space-satellite/space-debris tracking, space-weather observations across the Sun-Earth chain, and improvements to current UK radio-astronomy capabilities. RASOR would go beyond current and planned capabilities, providing direct access to high-resolution, rapid-response radio imaging and dedicated space-weather monitoring, unavailable anywhere else, and it would also feed into Met Office space-weather monitoring requirements and has potential to feed into the wider space situational awareness needs of the UK's National Space Operations Centre (NSpOC). In addition, if also equipped with a dedicated transmitter, further enhancements in Space Situational/Domain Awareness can be forthcoming. Here, we will provide an overview of RASOR with a focus on space weather and the space environment.

The COSPAR PSW-ISWAT 2025+ Space Weather Roadmap

Dr Mario Bisi[1], Masha Kuznetsova[2], Edmund Henley[3], Angelos Vourlidas[4], Martin A. Reiss[2], Sean Bruinsma[5], Manuela Temmer[6], Biagio Forte[7], Yihua Zheng[2], Yihua Yan[8], Kathryn Whitman[9], Ioanna Tsagouri[10], Camilla Scolini[11], Ian G. Richardson[12,13], Alexei A. Pevtsov[14], Evangelos Paouris[4], Hermann J. Opgenoorth[15,16], Sophie A. Murray[17], Joseph I. Minow[18], Arnaud Masson[19], Richard A. Marshall[20], Ian R. Mann[21], Insoo Jun[22], Vania Jordanova[23], David R. Jackson[3], Mamoru Ishii[24,25], Stephan G. Heinemann[6], Jingnan Guo[26], Manolis K. Georgoulis[4,27], Shing F. Fung[28], Joaquim E. R. Costa[29], C. Nick Arge[30], Chiu Wiegand[2]

[1]UKRI STFC RAL Space, United Kingdom, [2]NASA GSFC/CCMC, United States, [3]Met Office, United Kingdom, [4]Johns Hopkins University Applied Physics Laboratory, United States, [5]GET/CNES, France, [6]Institute of Physics, University of Graz, Austria, [7]Department of Electronic and Electrical Engineering, University of Bath, United Kingdom, [8]State Key Laboratory of Solar Activity and Space Weather, National Space Science Center, China, [9]KBR, United States, [10]National Observatory of Athens, Institute for Astronomy, Greece, [11]European Research Council Executive Agency, Belgium, [12]Heliophysics Science Division, NASA Goddard Space Flight Center, United States, [13]Department of Astronomy, University of Maryland, United States, [14]National Solar Observatory, United States, [15]Department of Physics, Umea University, Sweden, [16]Department of Physics and Astronomy, University of Leicester, United Kingdom, [17]Astronomy & Astrophysics Section, School of Cosmic Physics, Ireland, [18]NASA Marshall Space Flight Center, NASA Engineering and Safety Center, United States, [19]European Space Agency, European Space Astronomy Center, Spain, [20]Bureau of Meteorology, Australia, [21]Department of Physics, University of Alberta, Canada, [22]Jet Propulsion Laboratory, California Institute of Technology, United States, [23]Los Alamos National Laboratory, United States, [24]Radio Research Institute, National Institute of Information and Communications Technology, Japan, [25]Institute for Space-Earth Environmental Research, Japan, [26]University of Science and Technology of China, China, [27]RCAAM of the Academy of Athens, Greece, [28]NASA Goddard Space Flight Center, United States, [29]National Institute for Space Research, Brazil, [30]NASA Goddard Space Flight Center, United States

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

In February 2020, right at the start of the COVID-19 Pandemic, the COSPAR Panel on Space Weather (PSW) in conjunction with the COSPAR International Space Weather Action Teams (ISWAT) Initiative embarked upon a multi-faceted update to the 2015 COSPAR International Living With a Star (ILWS) space-weather roadmap (Schrijver et al., 2015).

The approach to be taken was for a community-driven space-weather roadmap to be developed within 2-3 years of commencing, including papers across two distinct Special Issues of the COSPAR Advances in Space Research journal. With various delays initiated by the pandemic, and then other factors coming into play, the first Special Issue was only released in December 2023. This special issue focussed primarily on the research as a driving force for advancing space weather through ISWAT.

The second special issue (at time of abstract submission) has all its papers submitted with an expected publishing date in late Northern hemisphere summer of 2025 (just ahead of the UKSWSE III Meeting). This second Special issue focusses on overarching sub-domains of space weather, key impact pathways, international collaboration and coordination, learning from terrestrial forecasting, an overview of the COSPAR ISWAT Initiative, and an overarching high-level summary (Bisi et al., 2025) of all the key recommendations across the ~60 papers collectively making up the COSPAR PSW-ILWS 2025+ Space Weather Roadmap.

With the completion of final papers of this, now, near-six year endeavour, we will present the journey of the space-weather roadmap update and provide a high-level summary of the many outcomes and recommendations.

Met Office post-SWIMMR Research to Operations Activities

Francois-Xavier Bocquet[1], Suzy Bingham[1], Anders Englyst[1], Siegfried Gonzi[1], Edmund Henley[1], Richard Mace[1], Mike Marsh[1], David Jackson[1], Daniel Etheridge[1]
[1]*Met Office, United Kingdom*
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The SWIMMR (Space Weather Instrumentation, Measurement, Modelling and Risk) programme concluded in March 2025, successfully delivering a range of new modelling and observational capabilities to the Met Office. This presentation outlines the subsequent steps in progressing towards full operational implementation onto Met Office systems. We will look at the work to be done on improving the Research to Operations (R2O) platform, required to support further model developments.
We will then address work being undertaken on software quality assurance, model updates, end-user engagement activities focused on gathering feedback for current and future products and finally forecaster training designed to ensure that forecasters can use these tools to improve their situational awareness and disseminate information to end-users.
This work is being undertaken as a collaboration between academic partners from the various SWIMMR consortia as the model experts, and the Met Office for the operational expertise, to ensure an efficient implementation into operations.
Looking ahead, it is anticipated that the improved R2O platform design used for the post SWIMMR phase will be employed for other R2O projects, thus ensuring a durable legacy for the programme.

Observing Travelling Ionospheric Disturbances with the LOFAR Radio Telescope

Ben Boyde[1,2], Alan Wood[1], Gareth Dorrian[1], Maaijke Mevius[3]
[1]University of Birmingham, United Kingdom, [2]University of Bath, United Kingdom, [3]ASTRON - The Netherlands Institute for Radio Astronomy, Netherlands

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The LOw Frequency ARray (LOFAR) is a radio telescope centred in the Netherlands with stations spread across Europe. While it is primarily used for radio astronomy, signals from astrophysical radio sources are distorted as they pass through the ionosphere, and these distortions can be used to study structures in the ionosphere. For example, travelling ionospheric disturbances (TIDs) are waves which propagate in the ionosphere, primarily driven by atmospheric gravity waves (AGWs) in the neutral atmosphere.

Observations of intensity variations in a single bright source from a single station can contain quasi-periodic features which are highly structured in both frequency and time. By comparing a case study of such observations to a simple phase screen model the parameters of the TID responsible can be estimated, showing that the TIDs responsible typically have short wavelengths (~15-30 km).

As well as single station observations, the results of interferometric imaging observations using the LOFAR network combined can be used to study TIDs. For astronomical imaging, the ionospheric distortions must be mitigated, through a procedure known as self-calibration. This produces extremely precise (~1 mTECu) measurements of the differences in Total Electron Content (TEC) between different stations in the LOFAR network. Using these calibration solutions for ~2,700 hours of observations, a climatology of daytime TIDs in the European mid-latitudes is developed, showing systematic differences between TIDs of different periods. In addition, short period (<~ 5 min) waves are identified which are shown to be field-aligned structures in the plasmasphere.

Scale-by-scale accuracy of solar wind analogue ensemble forecasts

Pauline Simon[1], Christopher Chen[1], Mathew Owens[2], Chaitanya Sishtla[1], Florian Koller[1]
[1]School of Physical and Chemical Sciences, Queen Mary University of London, United Kingdom, [2]Department of Meteorology, University of Reading, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The non-linear dynamics of the solar wind cover multiple decades of scales. These scales are not independent and are linked by turbulent processes. For instance, the energy will cascade from the largest scales determined by the dynamics and structure of the corona, to the smallest scales where kinetic dissipation and heating of the plasma occur. Mesoscale structures larger than one minute can be induced or affected by the turbulent cascade of energy or generate a cascade. They have the right size to interact quasi-stationarily with the magnetosphere. However, are they well reproduced in space weather forecasts? Can we predict intermittent structures, such as the rotations of the magnetic field?

We question the scale-by-scale accuracy of solar wind ensemble forecasts using turbulent-state diagnostics and suggest improvements to the methodology to capture these fluctuations more realistically. These forecasts are obtained from the analogue ensemble methodology applied to L1 measurements. This method predicts the future by considering similar occurrences of the last measurements in a historical dataset. We will discuss the implications of our results for space weather forecasting.

Examining time-dependent heliospheric solar wind properties driven by evolving WSA boundaries

Chaitanya Sishtla[1], Christopher H.K. Chen[1], Jens Pomoell[2], Luke Barnard[3]
[1]School of Physics and Astronomy, Queen Mary University of London, United Kingdom, [2]Department of Physics, University of Helsinki, Finland, [3]Department of Meteorology, University of Reading, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Solar wind at L1 is often modelled by coupling two distinct domains: the corona and the heliosphere. The transition between them occurs once the wind becomes supersonic and super-Alfvénic, typically at 0.1 AU. Boundary conditions at this interface are commonly defined by the Wang–Sheeley–Arge (WSA) model, which provides the magnetic field and estimates solar wind speed using a potential field approach. These are then used to drive heliospheric magnetohydrodynamic (MHD) simulations.

However, while the solar wind is intrinsically time-dependent, many simulations use a steady-state approximation based on a single WSA map or "snapshot". This approach neglects temporal evolution, potentially missing dynamic features. Prior studies using evolving WSA maps have shown improved forecasting and the presence of inverted magnetic fields near changing boundary regions.

Since the MHD solution is determined by super-Alfvénic boundary conditions, the cadence at which WSA maps are updated directly influences the emergence of time-dependent structures. In this study, we present results from a 2.5D MHD simulation of the heliosphere, systematically varying the cadence of WSA maps to evaluate its effect on the simulated solar wind.

We find that time-dependent simulations show inverted magnetic fields and significant velocity differences near the heliospheric current sheet (HCS), especially when it crosses the equatorial plane. We also assess mesoscale density structures and deviations from the Parker spiral, quantifying their dependence on map cadence. This allows us to distinguish between physical solar wind features and artifacts introduced by insufficient temporal resolution.

Showcasing the Surrey Space Centre's new cubesat space weather payload on the UK Jovian-1 mission

Dr Ben Clewer[1], Paul Morris[1], Keith Ryden[1], Joey O'Neill[1], Fan Lei[1]
[1]*University Of Surrey, United Kingdom*

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The Surrey Space Centre has developed a new cubesat payload designed to monitor space weather and the radiation environment in low earth orbit. We will detail the payload's key features, including the in-orbit demonstration of our new high energy proton instrument, developed with ESA funding.

In addition, we will provide a brief overview of the Jovian-1 spacecraft and mission plan, which is being lead by the Space Centre for Space South Central and its partner organisations. Jovian-1 is targeting to be the first UK spacecraft to be launched from UK territory in 2026.

Projected long-term decline in upper atmosphere density and its impacts on the space debris environment

Dr Ingrid Cnossen[1], Hugh Lewis[2]
[1]British Antarctic Survey, United Kingdom, [2]University of Southampton, United Kingdom
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Over the past ~50-60 years, a decline in the density of the upper atmosphere has been observed of about 2% per decade at 400 km altitude. This is largely attributed to the increase in atmospheric CO2 concentration, which causes cooling and contraction across the stratosphere, mesosphere, and thermosphere. The reduction in thermosphere density reduces drag on active satellites and space debris, affecting orbital characteristics and increasing debris lifetimes. To manage the risk of the growing space debris population, predictions of the future climate of the thermosphere are needed. A long transient simulation with the Whole Atmosphere Community Climate Model eXtension (WACCM-X) 2.0 was carried out to provide the first realistic projection of thermosphere density up to 2070. The simulation included all known drivers of long-term change and variation, following Shared Socio-economic Pathway 2–4.5, a moderate emission scenario. Realistic assumptions on main magnetic field changes and variations in solar activity, which also affect the climate of the upper atmosphere, were also included. The predicted global mean cooling in the thermosphere and associated decline in thermosphere density for 2015–2070 is stronger than for the past, due to the more rapid increase in CO2 concentration. The Debris Analysis and Monitoring Architecture to the Geosynchronous Environment (DAMAGE) model was used to assess the effects of the projected thermosphere density trend on the evolution of the space debris population. Preliminary results suggest that the cumulative number of catastrophic collisions by 2070 is significantly higher due to the expected decline in thermosphere density.

UK-ODESSI: A Low-Cost, Low-Earth Orbit, In-Orbit Pathfinder for UK Space Weather

Jackie Davies[1], Bernardini Nicolo[2], Steve Eckersley[2], Keith Ryden[3]
[1]STFC-RAL Space, United Kingdom, [2]SSTL, United Kingdom, [3]University of Surrey, United Kingdom
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Observations are critical to implementing timely strategies for mitigating potentially damaging space weather effects. The UK has an extensive heritage in developing and deploying scientific instrumentation to study space weather phenomena, on which basis a plethora of novel developments in space-borne space weather instrumentation are currently underway in UK academic, government and industrial establishments. In order to capitalise on these innovative developments - while exploiting the potential of the new generation of small-form UK satellites to provide high-quality data at a lower cost in low-Earth Orbit (LEO) and potentially beyond - we propose a national in-orbit pathfinder mission. UK-ODESSI (UK-Orbital pathfinDEr for Space-borne, Space-weather Instrumentation) will host a suite of emergent UK-led space weather instrumentation on a low-cost small-sat platform based on existing UK heritage, located in a sun-synchronous terminator LEO at some 500-600 km altitude above Earth. Such an orbit - achievable via, for example, either a low-cost Space-X rideshare or even a dedicated UK launch - would not only provide continuous real operational data (except during short eclipse periods at one solstice) but would also act as a test bed for space weather instruments as well as satellite/ground-segment sub-systems/technologies being developed in parallel in the UK. UK-ODESSI, which would target a launch time-scale and cost envelope similar to those of an ESA mini-F-class mission, would enable the development and testing of potential new space weather service capabilities by providing additional and novel inputs for nowcast and forecast models and climatology.

Progress towards coupling a global MHD model to an inner magnetospheric model

Ravindra Desai[1]
[1]University Of Warwick, United Kingdom
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The ring current plays a crucial role in the magnetospheric system during geomagnetic storms. Ring current build-up drives region two current systems in the ionosphere, induces ground magnetic field perturbations and modulates the structure and outer boundaries of the global magnetosphere. This study presents progress towards coupling a global magnetohydrodynamic model with a kinetic inner magnetospheric model, which enables the possibility of capturing ring current dynamics under the influence of realistic magnetic fields and the impact of the ring current on the global magnetosphere. Ongoing work focuses on the implementation of first one-way and then two-way couplings between the models and benchmarking the results to understand exactly when and how the tightly coupled dynamics of the inner magnetosphere respond to upstream drivers.

ROARS: Revealing Orbital & Atmospheric Responses to Solar activity

Ravindra Desai[1]
[1]*University Of Warwick, United Kingdom*
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The Earth's upper atmosphere highly sensitive to solar activity and the solar wind-magnetosphere interaction. Magnetospheric current systems close through the ionosphere and associated ion-neutral collisions, i.e. Joule heating, together can drastically modulate the spatially- and temporally-varying outer extent of the atmosphere. Unlike the many isolated in-situ measurements carried out by space missions so far, distributed neutral, plasma and magnetic field observations by a tetrahedron of micro-satellites, in tandem with precise tracking of the satellites' orbital dynamics, offer the global view necessary to disentangle the complex transfers of energy and momentum through the tightly coupled magnetosphere-ionosphere-thermosphere system.

In this talk we outline a candidate mission architecture for the new ESA mini-Fast programme. This novel mission architecture seeks to obtain the first coordinated magnetic field, plasma and neutral measurements across a range of altitudes, latitudes and longitudes to resolve and characterise the energy entering the upper atmosphere, the pathways through which this is redistributed, and the coupling back to the geospace environment. A comprehensive ground segment will simultaneously relate information on the D- and E-region dynamics to the in-situ measurements.

In addition, we outline two enabling technology development studies relating to a fibre-coupled quantum diamond magnetometer for precise gradiometer measurements and a quantum-limited levitated nano-particle instrument for absolute measurements of the neutral atmosphere, which promise to enhance future mission concepts in this area and beyond.

The Importance of Single Event Effects For Atmospheric Radiation Scales, Alerts and Actions

Professor Clive Dyer, Fan Lei, Keith Ryden, Ben Clewer, Fraser Baird

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The atmospheric radiation field can give single event effects (SEEs) in human cells, leading to increased cancer risks, and in microelectronics, leading to effects ranging from bit-flips to burnouts. Major Ground Level Enhancements, such as GLE05 on 23rd February 1956, can increase rates at sea-level by a factor 50 and rates at 40000 feet by a factor 1000. Historic events have been identified in cosmogenic nuclides and would increase rates a further factor of 10 to 100 compared with GLE05. The need to control human exposure and malfunctions in avionics has led to several attempts to provide scales and warning levels as well as standards for the design of avionics. There is a key need for international collaboration and consistency. The SWPC S-scale for 10 MeV protons is at far too low an energy for this and leads to many false alarms. Both the D-scale and the recent ICAO levels are formulated around effective dose to humans and there is a further need to consider electronics as error and failure rates are very significant. We propose an atmospheric radiation scale for discussion. At the low end the levels are related to ICAO levels for action by aircraft operators and at the high end levels are important for ground level critical infrastructure and autonomous vehicles. These levels are defined via enhancements in ground level neutron monitors and/or high energy (>300 MeV) proton detectors on spacecraft.

MOSWOC's (Met Office Space Weather Operations Centre) Coronal Mass Ensemble (CME) Prediction System

Siegfried Gonzi[1], Francois-Xavier Bocquet[1], David Jackson[1], Vic Pizzo[2]
[1]Met Office, MOSWOC, United Kingdom, [2]Space Weather Prediction Center (SWPC), United States

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

MOSWOC runs a 24-member ensemble system for predicting the arrival time of CMEs at Earth and a deterministic forecast based on GONG-WSA-ENLIL. The deterministic CME run does not provide estimates of uncertainties. The ensemble system complements this by providing an estimate of the uncertainty of CME arrival times. The CME parameters are derived by forecasters with the CME Analysis Tool (CAT) by analysing coronagraph images. Even with the best available tools and imagery from spacecraft these CME parameters can have large errors. Fife parameters are extracted (longitude, latitude, cone angle, average speed of the CME, arrival time of the CME at 21.5 Rs) and form the basis for creating ensembles by adding random perturbations to the nominal values. These parameters are input to the heliospheric model which is run for each ensemble member and forecasters evaluate the 5-day forecast of solar wind speed and plasma density at Earth. Our method of creating ensembles is based on an empirical estimate of uncertainties in the fitting process. As part of a Research to Operations (R2O) initiative we have been exploring an ensemble creation method which is built upon fundamental mathematical concepts as outlined in Pizzo et al. (2016). We present a detailed comparison of the performance of the new method against the operational model for the years 2016—2021 and 80 CME events. Arrival time errors of the new 81-member ensemble model have not reduced. But this new system shows promise for further improvement and may replace MOSWOC's existing operational model.

Bayesian Inference for Automated 3D CME Characterization and Uncertainty Quantification

Julio Hernandez Camero[1], **Lucie Green**[1]
[1]University College London, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Accurate three-dimensional (3D) characterization of coronal mass ejections (CMEs) is essential for modelling their propagation through interplanetary space and forecasting their arrival time at Earth. However, forecasting accuracy, assessed through platforms such as the Community Coordinated Modeling Center (CCMC) CME Scoreboard, has shown minimal improvement over the past decade. Several studies underscore fundamental issues in model inputs, notably uncertainties in CME parameter characterisation from coronagraph data as well as in the solar wind conditions.

Current operational forecasting typically employs simplified morphological models such as the cone model or the Graduated Cylindrical Shell, often relying on subjective manual fitting methods that underestimate true uncertainties, introduce user biases, and complicate the creation of statistically robust ensembles. Recent analyses reveal substantial variability in parameters depending on user input or viewpoint availability.

To address these challenges, we introduce a 3D CME cone model fitting framework using Bayesian inference, significantly reducing subjectivity by rigorously quantifying both observational and model uncertainties in the parameter space. Bayesian inference provides a comprehensive posterior distribution for CME parameters, quantifying uncertainties and parameter correlations.

Using our framework, we investigate how parameter uncertainties and correlations change when expanding from a single viewpoint to two viewpoints. We model ensembles of CMEs using the HUXt model and compare the forecasted time of arrival distributions to more ad-hoc methods that do not account for parameter correlations. Additionally, the posterior distributions could offer informed priors crucial for data assimilation methods incorporating heliospheric imager (HI)-like observations, particularly valuable once missions such as Vigil become operational.

Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks

Jithu Jose Athalathil[1], Bhargav Vaidya[1], Mohammed H Talafha[2]
[1]Indian Institute Of Technology Indore, India, [2]University of Sharjah, United Arab Emirates
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The evolution of the solar magnetic field is the key factor governing space weather drivers. Accurate forecasting of space weather requires precise modelling of the magnetic field's evolution on the solar surface using methods like Surface flux transport (SFT). Conventionally used SFT modelling techniques involve grid-based numerical schemes, making them computationally expensive. In this presentation, we present a novel, mesh-independent machine learning-based approach using Physics-Informed Neural Networks (PINNs) to simulate the temporal evolution of Bipolar Magnetic Regions (BMRs) on the solar photosphere. We employ this approach to study how nonlinear effects influence SFT models, with the broader goal of improving our understanding and constraints on solar dynamo processes. In particular, we focus on two mechanisms recently proposed to modulate solar cycle amplitudes: tilt quenching (TQ), representing a negative feedback between the cycle strength and the average tilt angle of active regions, and latitude quenching (LQ), indicating a positive relationship between cycle strength and the mean emergence latitude of active regions. Using PINNs within the SFT framework, we systematically examine the nonlinearities introduced by TQ, LQ, and their combined effects. Our study aims to clarify the distinct contributions of TQ and LQ to the solar dynamo. We find that the balance between LQ and TQ effects is closely linked to the ratio of meridional flow speed to magnetic diffusivity in the SFT models. Given that LQ is better constrained through observations, it may offer a valuable benchmark for refining solar dynamo models to achieve closer alignment with solar observations.

Mid-latitude Geomagnetically Induced Currents as a Manifestation of Penetrating Electric Fields

Prof Delores Knipp[1], Bhagyashree Waghule[1]
[1]*University Of Colorado Boulder, United States*

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

During the first G3 storm of Solar Cycle 25, the passage of a solar filament on 12 May 2021 produced a strong geomagnetic storm and a rich response in Earth's magnetosphere-ionosphere-telluric-technology system. Using data from the North American Electric Reliability Corporation (NERC) to investigate the effects of the event on the power grid along the US East Coast, we find geomagnetically induced currents (GICs) and significant penetrating electric fields (PEFs) in the same longitude sector. The disturbance responses were 2-30 A GICs measure in grid monitors with coincident perturbations in ground magnetometer arrays and geomagnetic indices, and unusually robust variations in total electron content in the American sector and beyond. The largest GICs and ΔTEC occurred with a solar wind (SW) +/- pressure pulse, effects of which were observed globally at 1200-1220 UT in ground- and space-based systems. The negative pressure pulse appeared in the GIC record from the central US to Europe, showing that impulsive SW density drops can be especially impactful to engineered systems. Long duration GIC effects followed from 1230-1530 UT producing a sustained level of moderate perturbations. We discuss specific drivers in the solar wind and magnetosphere and their relation to the power grid and GNSS signals. We emphasize the value of the NERC GIC data base for Operations to Research and vice versa.

Multi-point Solar Energetic Particle observations and space weather forecasting

<u>Dr Timo Laitinen</u>[1], Silvia Dalla[1]

[1]*University Of Central Lancashire, United Kingdom*

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Solar Energetic Particles (SEPs) are accelerated during solar eruptions up to relativistic energies, and as they propagate to near-Earth space they can cause significant Space Weather hazard to technology and humans in space. SEPs propagate guided by the large-scale Parker spiral magnetic field, however they also spread across it due to turbulent field line meandering and large-scale drifts. Thus, SEP intensities can be seen to increase at a wide range of heliolongitudes, as shown by multi-spacecraft observations of SEP events. In this work, we perform full-orbit SEP simulations within the heliosphere described by our recent model of heliospheric turbulence (Laitinen et al 2023) to investigate how SEP event intensities vary at different locations in the heliosphere. By changing the SEP source size and injection profiles in the model, we investigate how similarities and differences in the time-intensity profiles at the beginning of a 1 au SEP event relate to the SEP source properties, and discuss our initial findings. We show that a narrow SEP source results in initially different SEP time-intensity profiles and at locations widely separated in longitude, whereas for a wide source such differences disappear. We discuss the implications of our findings on possible improvements of SEP forecasting based on multi-spacecraft constellations.

Analysis of Magnetospheric ULF Waves Observed Near the Arrival of an IMF Southward Turning at the Magnetosphere

Chiara Lazzeri[1], Colin Forsyth[1], Andrey Samsonov, Andrew Fazakerley, Martin Archer, Karlheinz Trattner

[1]Mullard Space Science Laboratory, United Kingdom, [2]Imperial College London, United Kingdom, [3]LASP, University of Colorado, United States

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Ultra-low frequency (ULF) waves are an important contributor to energy transport across magnetospheric regions and to the acceleration and loss, as well as radial diffusion, of relativistic electrons located in the outer radiation belt. Hence, it's crucial for us to gain a better understanding of these waves and of their driving mechanisms, which can be both external (due to solar wind driving) and internal (due to wave-particle interactions or particle instabilities).

In this work, we analyse narrowband ULF waves observed at geosynchronous orbit near the arrival time of a large and rapid southward turning of the interplanetary magnetic field (IMF). These magnetic field oscillations are in the Pc5 range (~2-7 mHz), and mostly compressional, although with a significant radial component. Additionally, after the southward turning, we observe multiple dayside magnetopause crossings in THEMIS A, D, and E, which suggest that the boundary is also oscillating at a similar frequency in the Pc5 range. We investigate potential driving mechanisms of the Pc5 ULF waves and their connection to the magnetopause oscillations, considering both external (e.g. dynamic pressure variations, Kelvin-Helmholtz instability and magnetic reconnection) and internal ULF sources (e.g. drift-mirror instability and drift-bounce resonance).

Updates to MAIRE+ for Region Dependent Nowcasting

Chris Davis[1], <u>Dr. Fan Lei</u>[1], Clive Dyer[1], Keith Ryden[1]
[1]*Surrey Space Centre, University Of Surrey, United Kingdom*
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

MAIRE+ is a nowcasting version of the Model of Atmospheric Ionization Radiation Effects we developed for the UK Met Office. It is a global model but driven by two neutron monitor stations (OULU and DRBS) data in the north-west European region. The global maps based on the regional inputs nowcasting is reasonable in normal galactic cosmic ray condition, as the GCRs are largely isotropic, however this approach is questionable for solar energetic particles, as they are not isotropic particularly in the early phase of a solar particle event.

We have updated MAIRE+ to accept arbitrary pair of neutron monitor stations data, provide they are in similar longitudes, but separated by > 2 GV in rigidity cut-off. Further, MAIRE+ can produce isotropic global nowcasting maps by combining maps generated with multiple pairs of neutron monitor stations.

In this presentation, we will discuss the algorithm the updates, its implementation, and demonstrate its applications to selected ground level enhancement events.

Updates on Development of the High Energy Proton Instrument - HEPI

Dr. Fan Lei[1], Joey O'Neill[1], Ben Clewer[1], Paul Morris[1], Keith Ryden[1]
[1]*Surrey Space Centre, University of Surrey, United Kingdom*

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The High Energy Proton Instrument (HEPI) is a compact proton telescope for measuring the relativistic, i.e. > 300 MeV, solar and trapped protons, based on the Cherenkov radiation process. With UKSA and ESA funding, we have completed the breadboard implementation and carried out a beam test campaign successfully. We report on the status of this development and show the highlights of the results obtained so far. We will outline ongoing developments and future plans.

Understanding, Modelling, and Quantifying the Space Weather Effects of Geomagnetically Induced Currents (GICs) on the Electric Power Grid

Prof. Ian Mann[1], Darcy Cordell[2], Hannah Parry[1], Stavros Dimitrakoudis[3], Andy Kale[1], David Milling[1]

[1]University Of Alberta, Edmonton, Canada, [2]Athabasca University, Canada, [3]National and Kapodistrian University of Athens, Greece

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Geomagnetic disturbances (GMD) are excited in the geospace system by a range of solar wind and related internal drivers, and whose occurrence rates change on timescales from minutes and hours, to days, months, and years, and through the solar cycle, and indeed from solar cycle to solar cycle. Here we use data from the Canadian Array for Real-time Investigations of Magnetic Activity (CARISMA; www.carisma.ca) spanning more than 35 years of operations to review a variety of solar wind drivers of GMD, and examine the characteristics of the resulting GMD on the ground. In addition, we use a province-scale model of the Alberta electric power grid in Canada to examine the geomagnetically induced currents (GICs) which result from these GMD. We focus on large geomagnetic storms during solar cycle 25, and highlight the characteristics of a number of drivers of the large GMD which also result in large GICs. We further place these characteristics from solar cycle 25 in the context of the historical measurements from CARISMA and whose dataset spans a number of solar cycles. Specifically, we derive the statistics of 1-in-100 year storm magnitudes of not only magnetic but also electric fields using magneto-telluric determined ground impedance tensors. Finally, we provide some perspectives on the interplay between the magnitudes and spatiotemporal variations of the GMD and electric fields on the GICs which result in the electric power grid, including the effects arising from the non-uniform topologies of the networks of conducing infrastructure which comprise real-world electric power grids.

Atmospheric Radiation: the Met Office Pathway to Operations

Mike Marsh[1], Anders Englyst[1], Daniel Etheridge[1], Francois-Xavier Bocquet[1], Gemma Creed[1], William Thomas[1], Christopher Pipe[1], Fan Lei[2], Ben Clewer[2], Chris Davis[2], Keith Ryden[2], Ethan Roberts[3], Keith Jones[3]
[1]Met Office, United Kingdom, [2]University of Surrey, United Kingdom, [3]BJSS Consultancy, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Atmospheric radiation due to solar and galactic particles is an important aspect of space weather, with potential impacts on technology, aviation aircrew and passengers. The ability to accurately model and assess radiation dose levels is limited, both internationally and particularly within the UK national capability. The UK Met Office is pursuing a pathway to integrate atmospheric radiation dose situational awareness into space weather operations, by following a dual approach of capacity building in modelling and measurement, in partnership with the University of Surrey. This will be achieved using the MAIRE+ atmospheric radiation model, utilisation of new UK neutron monitor measurements and a programme of new direct measurements of radiation dose using the SAIRA instrument carried onboard aircraft and launched by radiosonde from Met Office sites. We present the elements involved in laying this pathway from research to a future operational capability.

Pathways to Predicting D and E Region Ionospheric Variability

Prof. Daniel Marsh[1], Marcin Kupilas[1], Wuhu Feng[1], John Plane[1]
[1]University of Leeds, United Kingdom

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The D and E region ionospheres reside in the transition region between the upper atmosphere and geospace. They respond to forcing from above (solar radiation and energetic particle precipitation) and from below via neutral atmosphere dynamics. Here we explore how these ionized regions can be used as a tracer for the two drivers through analysis of model simulations using the Whole Atmosphere Community Climate Model (WACCM). The model is run with interactive chemistry and solves for both ion and neutral constituents. It includes the chemical species important for the photolytic and ionization processes that initiate ion reactions in the mesosphere and lower thermosphere. The model can be run with variable horizontal resolution, resolving a wide spectrum of waves from planetary waves to gravity waves. We survey the variability of the ionosphere in WACCM on timescales from hours to years and link its variability induced by variations in species such as nitric oxide and to winds and temperatures. Understanding this linkage is the first step to predictive skill in ionospheric variability and will be critical in interpreting new observations made by the new EISCAT-3D facility.

Probing the characteristics of a pre-eruptive flux rope using novel techniques

Emily Mottram[1], Lucie Green[1], Hamish Reid[1], Alexander James[1]
[1]*University College London, United Kingdom*

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Coronal Mass Ejections (CMEs) are the primary drivers of space weather phenomena.
Once a CME reaches Earth the severity of the geomagnetic response is dependent on CME properties such as speed, dynamic pressure, and the specific magnetic configuration of the CME. CMEs can be modelled with a bright front, dark cavity and core. This core is associated with a flux rope in CME models.
We present a case study of the formation and subsequent expansion of a flux rope prior to its eruption. This flux rope was observed in extreme-ultraviolet (EUV) on the 28th February 2024.
In addition to being observable in EUV images, the formation and evolution of the rope appeared to be associated with radio emissions that indicate that the energisation of electrons was taking place. The emission mechanism for the radio has been determined to be fundamental plasma emission and this emission mechanism allows for electron density to be calculated; we found that the electrons generating the radio emission range in density from 0.3e9-2.4e9 cm^-3.
It was also found that the EUV expansion pattern matched the expansion pattern the radio emission, supporting the interpretation what the EUV emission and the radio emission are both originating in the same structure.
This study shows that the value of using complementary EUV and radio data to probe the timescales over which a pre-eruptive structure forms, and how the radio emissions can be used to probe important flux properties such as plasma density.

Solar Wind Density Pulse Effects on the Ionospheric Electrodynamics Under Variable IMF Orientations

Mr. Sirsha Nandy[1], Bhargav Vaidya[1], Arghyadeep Paul[2], Diptiranjan Rout[3], Dibyendu Chakrabarty[4], Antoine Strugarek[2]
[1]Indian Institute Of Technology Indore, India, [2]Université Paris-Saclay, Université Paris Cité, France, [3]National Atmospheric Research Laboratory (NARL), India, [4]Physical Research Laboratory (PRL), India

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The energy and flux transfer from the solar wind (SW) to Earth's magnetosphere and upper atmosphere occurs through strong coupling between the magnetosphere and ionosphere, primarily mediated by field-aligned current (FAC) systems. Earth's coupled magnetosphere–ionosphere (MI) system forms a complex electrodynamic environment, where multiple current systems arise from different magnetospheric regions through distinct physical mechanisms like magnetic reconnection and viscous interactions. Studies combining in-situ Sun-Earth L1 observations with ground-based geomagnetic data reveal that the SW pressure enhancement has a significant effect on Earth's ionospheric electrodynamics. However, understanding the global ionospheric effects of such transient SW remains unclear and requires comprehensive physics-based modeling.
We performed global MHD simulations with a steady solar wind background, introducing a temporally localized density enhancement under three different IMF clock angles. To investigate the effects of the SW disturbance on the FACs and ionospheric convection cells, we used a two-way MI coupling module named MagPIE, which solves the ionospheric potential with the input of parallel current densities and relevant conductances. We observed significant changes in the FAC profile and intensities for the density enhancement for various IMF scenarios, along with a secular response in the magnetosphere. Moreover, our study also demonstrates that the efficiency of the pressure pulse to cause a prompt penetration of the magnetospheric electric field in the ionosphere depends crucially on the IMF B_y component.
In this presentation, I shall analyse the variations in field-aligned currents (FACs) and convection cells induced by solar wind disturbances and compare them under different IMF conditions.

Unraveling Filament Barb Dynamics through Pseudo-3D Hydrodynamic Simulations

Mr Yiwei Ni[1], Duncan Mackay[1], Pengfei Chen[2]
[1]University Of St Andrews, United Kingdom, [2]Nanjing University, China

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Solar filaments comprise dense plasma suspended within magnetic dips along polarity inversion lines, forming fine threads. While parasitic polarities are invoked to explain barb-like threads extending toward the chromosphere, non-uniform magnetic geometries and longitudinal oscillations produce similar structures. However, the physical mechanisms driving barb plasma dynamics, including unidirectional flows alongside counterstreaming motions, remain unresolved. Here, we combine magneto-frictional magnetic evolution with partial-ionization hydrodynamic simulations to resolve barb thermodynamics. Selecting over 1200 dipped field lines, we generate pseudo-3D volumetric renderings of plasma evolution. Our synthetic diagnostics in EUV and Hα reveal that co-spatial red- and blueshifted threads closely spaced together, matching observed counterstreaming. Notably, persistent unidirectional flows emerge in barbs, while intriguingly, barb threads maintain stable suspension in the corona without direct chromospheric connection. We suggest that asymmetric heating and dip-height gradients establish longitudinal pressure differences. This drives sustained chromospheric evaporation into coronal barbs. Concurrent condensation at one side of threads enables drainage at the opposite end, perpetuating unidirectional flow. We establish this self-sustaining evaporation-condensation cycle as the fundamental mechanism for barb stability and unidirectional mass transport.

Implications of Using Spheroidal "Cone Model" CMEs in Solar-wind Models

Prof Mathew Owens[1]
[1]University Of Reading, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Space-weather forecasting requires prediction of the arrival time and properties of coronal mass ejections (CMEs) in near-Earth space. Kinematic properties of CMEs close to the Sun -- such as speed, direction and angular width -- are routinely estimated from coronagraph images by using three-dimensional geometric models, such as the "cone model". These are used to characterise a time-dependent perturbation at the inner boundary of a numerical solar-wind model, normally at 0.1 AU, enabling a forecast of the CME arrival time and speed at Earth. This perturbation is typically spheroidal in shape. In this study we show that spheroidal CMEs exhibit four features inconsistent with observations that may limit the accuracy of space-weather forecasts: 1, Slow spheroidal CMEs intersect the model inner boundary for a long duration and hence resist acceleration by the ambient solar wind, producing longer transit times than observed; 2, The radial extent of a spheroidal CME is directly related to its angular width. Observations of CMEs at 1 AU do not display any relation between angular width and radial extent; 3, Fast-and-wide CMEs cannot be sufficiently decelerated by the ambient solar wind and arrive with higher speeds than observed; 4, Spheroidal CMEs show different magnitudes of interplanetary accelerations for different angular widths, contrary to observations. We show that fixing the CME duration at the inner boundary -- which mimics observed CME expansion -- alleviates these problems.

Number Eight Wire: Building New Zealand's Approach to Managing Space Weather Risk

Louisa Prattley[1]
[1]National Emergency Management Agency New Zealand, New Zealand
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Until recently, space weather had a relatively low-profile within New Zealand's extensive hazardscape. The Gannon Storm in May 2024 served as a powerful catalyst to rethink the NZ Inc approach and ask the question, are we really ready?

Led by the National Emergency Management Agency (NEMA), the New Zealand Government united to rapidly improve our readiness. NEMA established a dedicated Space Weather Programme, launched the National Space Weather Response Plan, convened a Space Weather Science Advisory Panel, hosted a series of scenario-based exercises at various levels, and connected with partners domestically and internationally. Concurrently, the Ministry for Business of Innovation and Employment (MBIE) worked with infrastructure providers to raise awareness of the hazard, and the Department of the Prime Minister and Cabinet (DPMC) applied the National Risk Approach to update the position of space weather within the broader national risk governance.

We were fortunate to have a strong foundation set by domestic research leaders, particularly the Solar Tsunamis Research Programme - globally recognised research to operations initiative prioritising risk reduction strategies.

Initial efforts have also had a heavy reliance on multilateral collaboration, especially in the monitoring and warning phase, from our partners in Australia, the United Kingdom, and the United States of America.

While our approach is still in its formative stages, the nation's commitment to improving our integrated approach to emergency management provides us with opportunities for growth.

This presentation outlines New Zealand's evolving approach, sharing insights and aspirations on the path from novice to informed and resilient actor

Coronal Mass Ejections Associated with Solar Energetic Particle Events Observed in the Low Corona by the Mauna Loa Solar Observatory

Dr. Ian Richardson[1,2], O. Chris St. Cyr[1], Joan Burkepile[3]
[1]University of Maryland, United States, [2]NASA Goddard Space Flight Center, United States, [3]High Altitude Observatory, United States

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Since 1980, the Mauna Loa Solar Observatory (MLSO) has routinely observed the low corona (~1.05-3 Rs) in white light with a series of improved ground-based coronagraphs. The prediction of large solar energetic particle (SEP) events is an important element of space weather forecasting, and several SEP prediction models are currently triggered by spacecraft observations of coronal mass ejections (CMEs) in the mid-corona (above ~2 Rs). However, these observations may not be available without significant telemetry and analysis delays. The real time detection of CMEs by MLSO as they transit the low corona has the potential to provide earlier warnings of impending SEP events. We have therefore made the first comprehensive survey of the SEP-associated CMEs observed by MLSO up to the interruption of operations by the eruption of the volcano in late 2022.

Conceptualising ‘environment’ and ‘sustainability’ for an off-Earth future: leveraging existing expertise and frameworks to make a start

Dr Juliana Rinaldi-Semione[1]
[1]SDGs in Space, University Of Nottingham, United Kingdom
Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

As we begin enacting plans to inhabit space and utilise it on a larger scale, it is essential to view the space environment not only as a domain that affects us on Earth but as one in which humans will live and work. This perspective recognizes that space weather impacts on civilization will affect new infrastructure in space and on celestial bodies as well as future human settlements in orbit, on the Moon, in space transit, and beyond. To ensure the long-term sustainability of human activity in space, we must proactively address these impacts and develop strategies for mitigating space weather risks in a multi-world context.

Building on the foundation of programmes like SWIMMR, we can leverage existing expertise in space weather monitoring and prediction to inform our approach. Further frameworks, such as the UN’s relatively recent declaration of a right to a healthy environment or the Sustainable Development Goals, offer valuable insights to guide research and operations in this area. For example, near parallels from Earth-side practices around climate action, sustainable agriculture, water management, human rights, and preemptive action can help us develop effective strategies for mitigating the impacts of space weather on off-world human activities and settlements. Crucially, these frameworks also show us how the field of space weather can proactively support these human advancements.

By integrating both technical and non-technical perspectives, we can drive advances in our understanding of the space environment and space weather research and operations, ultimately supporting the long-term sustainability of human spacefaring ambitions.

Statistical modeling of high latitude Sporadic-E climatology: A Sporadic-E module for E-CHAIM

Dr David R. Themens[1,3], Christina Arras[2], Benjamin Reid[1], Anthony McCaffrey[3], Dmytro Sydorenko[4], Robert Rankin[4], Karim Meziane[3], Emma-Claire Gurney[1], Joshua Ruck[1], Sean Elvidge[1], P.Thayyil Jayachandran[3]
[1]University Of Birmingham, United Kingdom, [2]GFZ Potsdam, Germany, [3]University of New Brunswick, Canada, [4]University of Alberta, Canada

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

Sporadic-E, thin metallic ion layers in the lower ionosphere compressed via neutral wind shears or externally imposed electric fields, pose considerable challenges for High Frequency (HF) radio propagation modeling. As their name suggests, these layers can appear to be quasi-stochastic, requiring both an abundance of metallic ions and a mechanism through which to compress them into thin, dense layers; as such, modeling Sporadic-E has been a persistent and long-standing challenge in ionospheric modeling. With physics-based models now beginning to develop the capability to capture the processes that produce these structures, we here revisit empirical modeling of Sporadic-E at high latitudes and examine the capability of existing measurements to adequately constrain an empirical model. Using Radio Occultation (RO) measurements of these Sporadic-E layers, we have constructed a probabilistic model of Sporadic-E, its altitude, and its intensity over high latitude regions using neural networks. This presentation will provide an overview of this model and examine its performance via independent validation against both other RO and ground-based observations. We will furthermore examine the modeled behaviour and use the model to understand the climatological dynamics of Sporadic-E at high latitudes, which due to the additional role of magnetospherically-driven electric fields, include considerable dependence on the orientation of the high latitude electric fields. Further discussion will explore how this mode is implemented within the existing Empirical Canadian High Arctic Ionospheric Model (E-CHAIM) and will explore the interplay between magnetospheric driving and thermospheric tides in controlling the convergence necessary to form Sporadic-E layers at high latitudes.

Global MHD and Test-Particle simulations of outer radiation belt flux drop-out events

Yihui Tong[1], Ravindra Desai[1,2], Jeremie Houssineau[3,4], Sarah Glauert[5], Thomas Daggitt[5], Nigel Meredith[5], David Jackson[6], Suzie Bingham[6]

[1]Centre for Fusion, Space and Astrophysics, University of Warwick, United Kingdom, [2]Blackett Laboratory, Imperial College London, United Kingdom, [3]Department of Statistics, University of Warwick, United Kingdom, [4]Division of Mathematical Sciences, Nanyang Technological University, Singapore, [5]British Antarctic Survey, United Kingdom, [6]Met Office, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The radiation-belt electron flux exhibits dramatic variations across a range of spatial and temporal scales, including global-scale radial transport, mesoscale injections, and local-scale wave-particle interactions. Long-term variability has been successfully captured by solving the Fokker Planck diffusion equation (e.g., BAS-RBM), incorporating radial, pitch-angle and energy diffusion and imposed upon semi-empirical Tsyganenko magnetic models. However, during geomagnetic storms, non-diffusive processes become significant which can lead to significantly degraded forecasts. Enhancements in the partial ring current and induced electric fields, and associated magnetic field distortions can lead to violation of the third adiabatic invariant and rapid outward radial transport. Dropouts in the electron flux, across several orders of magnitude, are often observed in the outer radiation belt during the early phases of geomagnetic storms, hampering accurate modelling of the subsequent few days where forecasts are needed the most. These losses can occur either by precipitating into atmosphere or by escaping through magnetopause. In this study, we employ global magnetohydrodynamic and test-particle (MHD-TP) simulations to investigate the dropout mechanisms. By introducing an ensemble of test particles into the global MHD fields and tracking their trajectories, we aim to distinguish the relative contributions of magnetopause shadowing and wave–particle interactions in producing the observed rapid changes in electron flux.

Very Near-Earth Reconnection (VNERX) and its connection to the 30A GIC spike in the Eastern US

Bhagyashree Waghule[1], Delores Knipp[1], Grant Stephens[2], David Malaspina[1]
[1]University of Colorado Boulder, United States, [2]Applied Physics Laboratory, United States

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

We present an Operations-to-Research (O2R) case study where the operational Geomagnetically Induced Currents (GIC) measurements from United States (US) North American Electric Reliability Corporation (NERC) database stimulated interesting research. We provide the first observational evidence connecting Very Near-Earth Reconnection (VNERX) to mid-latitude GICs during an Interplanetary shock (IPS) passage at 23 UT on 7 September 2017. We argue that the IPS impulse produced a 20A spike which was exacerbated to 30A within 1 minute due to this close-in tail reconnection near dusk.

This duskside (18MLT) 4-minute-long spike showed a sudden rise from 20A to 30A, approximately two minutes after onset. Using systematic data fusion of observations from ground to space, we identify temporal alignment between the sudden GIC rise and a dispersionless injection signal at GOES 13 (6.6 RE) and RBSP-A (~3 RE), merely 1.75 minutes after shock arrival. The Stephens et al. (2023) machine-learned empirical model resolves a reconnection X -line at ~12 RE near dusk, validating our finding independently. Additional analysis reveals the IPS was inclined and impinged on the magnetosphere from duskside, which destabilized the current sheet in that sector, thus contributing to a VNERX event.

Comparisons with past events - October 2003 and December 2015 storms - highlight the critical role of magnetospheric preconditioning - prolonged northward IMF followed by southward turning and shock - in rapidly reconfiguring the magnetosphere. Such complex asymmetric responses are currently hard to predict. This work offers new insights for space weather event-attribution and risk mitigation.

A threshold-based Random Forest forecasting model for the Outer Radiation Belt

Dylan Weston[1], Jonathan Rae[1], Andy Smith[1], Clare Watt[1], Kyle Murphy[1,2]
[1]Northumbria University, United Kingdom, [2]Lakehead University, Canada

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The Van Allen Radiation belts are highly dynamic in both strength and location, meaning that the belts are difficult to predict for spacecraft operators. Forecasting models exist, in part, to minimise any additional damage caused by this natural hazard. Both physics-based and machine learning models already exist; physics-based models allow for a deeper understanding of the system, and machine learning models offer a computationally cheap way to make a forecast but do not necessarily provide physical insight.

We present a collection of machine learning models capable of predicting if the Outer Radiation Belt crosses set percentile thresholds with considerable skill up to 3-days in advance, and some skill up to 6-days in advance. We use a Random Forest classification model to predict if the the daily ~2MeV electron flux level across the Outer Radiation Belt exceeds thresholds from the 60th to the 95th percentiles. Each model shows a high level of accuracy at nowcasting and skill at forecasting up to 6 days in advance, a longer forecast than current operational models. Using feature importance, we determine the key inputs into each model in order to gain an insight into which drivers are important in driving increasing flux levels and over what timescales they have an impact. Crucially, we find that only a small number of geomagnetic indices are required to be able to forecast radiation belt fluxes with good skill, meaning that models such as these could be operationally viable for space weather stakeholders.

Measuring the Magnetopause Position with SMILE-SXI

Samuel Wharton[1], Jenny Carter[1], Steve Sembay[1], Yasir Soobiah[1], Simona Nitti[1], Andy Read[1], Tianran Sun[2]
[1]University Of Leicester, United Kingdom, [2]National Space Science Centre, China
Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The magnetopause is a key boundary in the Earth's magnetosphere where plasma and energy can enter from the solar wind via magnetic reconnection and Kelvin-Helmholtz waves. It's position and motion are thought to affect a whole range of space weather processes including current systems and the radiation belts. Strong CMEs can also push the magnetopause within geostationary orbit, directly affecting spacecraft there.
The joint ESA-Chinese Academy of Sciences (CAS) Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) mission carries a soft X-ray imager (SXI) amongst its payload of four scientific instruments. The SXI will image the magnetosheath via the SWCX mechanism so that we can infer the magnetopause location and structure, for up to 40 hours at a time. SMILE data up to Level 3 will be available through ESA and CAS archives. Derived magnetopause positions (at Level 4) will be made available through the SMILE Data Fusion Facility. In this talk we will show how we will analyse the SXI images to determine the subsolar magnetopause position for a range of solar wind conditions. It is anticipated that SMILE will launch in 2026 and have a mission lifetime of between three and seven years.

Investigating the Efficacy of Topologically Derived Time Series for Flare Forecasting

Thomas Williams[1], Christopher Prior[1], David MacTaggart[2]
[1]Durham University, United Kingdom, [2]University of Glasgow, United Kingdom

Poster Presentations and Afternoon Break 2, September 10, 2025, 15:30 - 17:30

The accurate forecasting of solar flares is considered a key goal within the solar physics and space weather communities. There is significant potential for flare prediction to be improved by incorporating topological fluxes of magnetogram data sets, without the need to invoke three-dimensional magnetic field extrapolations. Topological quantities such as magnetic helicity and magnetic winding have shown significant potential toward this aim, and provide spatiotemporal information about the complexity of active region magnetic fields. This study develops time series that are derived from the spatial fluxes of helicity and winding that show significant potential for solar flare prediction. It is demonstrated that time-series signals, which correlate with flare onset times, also exhibit clear spatial correlations with eruptive activity, establishing a potential causal relationship. A significant database of helicity and winding fluxes and associated time series across 144 active regions is generated using Space-Weather HMI Active Region Patches data processed with the Active Region Topology (or ARTop) code that forms the basis of the time-series and spatial investigations conducted here. We find that a number of time series in this data set often exhibit extremal signals that occur 1–8 hr before a flare. This publicly available living data set will allow users to incorporate these data into their own flare prediction algorithms.

Driving The Mid-Latitude Ionosphere from Below: Observations Made Using the International LOFAR Telescope

Alan Wood[1], Gareth Dorrian[1], Ben Boyde[1], Robin Trigg[1], Richard Fallows[2], Maaijke Mevius[3]
[1]Space Environment and Radio Engineering (SERENE) research group, University of Birmingham, United Kingdom, [2]Science and Technology Facilities Council (STFC) Rutherford Appleton Laboratory, United Kingdom, [3]ASTRON – The Netherlands Institute for Radio Astronomy, The Netherlands

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The Low Frequency Array (LOFAR) is one of the most advanced radio telescopes in the world. When radio waves from a distant astronomical source traverse the ionosphere, structures in this plasma affect the signal. The high temporal resolution available (~10 ms), the range of frequencies observed (10-90 MHz & 110-250 MHz) and the large number of receiving stations (currently 52 across Europe) mean that LOFAR can also observe the effects of the midlatitude and sub-auroral ionosphere at an unprecedented level of detail.

Case studies have shown substructure within a sporadic-E layer (Wood et al., 2024), substructure within a Medium Scale Travelling Ionospheric Disturbance (TID) (Dorrian et al., 2023), a Small Scale TID (Boyde et al., 2022) and symmetric quasi-periodic scintillations (Trigg et al., 2024). The small-scale size of many of these features (kilometres to tens of kilometres) implies a local source. A climatology of observations during daylit hours shows that ionospheric waves primarily propagate in the opposite direction to the prevailing wind, suggesting that the structures observed are the ionospheric manifestation of quasi-upward propagating Atmospheric Gravity Waves (AGWs; Boyde et al., 2025). A second statistical study shows an association between ionospheric structures observed by LOFAR and lightning activity, with a lag of two hours. This adds to the body of evidence which suggests that these features are the ionospheric manifestation of AGWs. Such waves substantially affect the global atmospheric circulation and the potential use of LOFAR to better determine the effect of AGWs on the global circulation is discussed.

Swarm-VIP-Dynamic: Models for Ionospheric Variability, Irregularities Based on the Swarm Satellite Data

Alan Wood[1], Gareth Dorrian[1], Eelco Doornbos[2], Daria Kotova[3], Jaroslav Urbář[4], Luca Spogli[5], Yaqi Jin[3], Lucilla Alfonsi[5], Kasper van Dam[2], Mainul Hoque[6], Wojciech Miloch[3]
[1]Space Environment and Radio Engineering (SERENE) group, University of Birmingham, United Kingdom, [2]The Royal Netherlands Meteorological Institute (KNMI), United Kingdom, [3]Department of Physics, University of Oslo, Norway, [4]Institute of Atmospheric Physics CAS, Czech Republic, [5]Istituto Nazionale di Geofisica e Vulcanologia, Italy, [6]German Aerospace Center (DLR), Germany

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

The ionosphere is a highly complex plasma containing electron density structures with a wide range of spatial scale sizes. Coupling of the ionosphere with the Earth's magnetosphere and the solar wind, as well as to the neutral atmosphere, makes the ionosphere highly dynamic and highly dependent on the driving processes. Thus, modelling the ionosphere and capturing its full dynamic range considering all spatiotemporal scales is challenging.

Swarm is the European Space Agency's (ESA) first constellation mission for Earth Observation (EO), comprising multiple satellites in Low Earth Orbit (LEO). During the Swarm-VIP-Dynamic project, a suite of statistical models have been developed using observations from Swarm and proxies for heliogeophysical processes. Models have been developed for the electron density and the variability in the ionospheric plasma at spatial scales between 100 km and 7.5 km. At the larger spatial scales, the model performance approaches the theoretical best values when appropriate measures of solar activity, the solar wind and the thermospheric density are included in the models. The model performance decreases at smaller spatial scales; this is attributed to instability processes which are not captured by the models.

The performance of the Swarm-VIP-Dynamic models for electron density models and the Thermosphere-Ionosphere- Electrodynamics General Circulation Model (TIE-GCM) are compared. There are substantial biases in TIE-GCM which are not present in the Swarm-VIP-Dynamic models. It is possible to assimilate the Swarm-VIP-Dynamic models into TIE-GCM to attempt to reduce these biases, and the steps which would be needed for such an implementation are discussed.

Thermospheric wind observations from different platforms

<u>Qian Wu</u>[1]
[1]Ncar, United States

Poster Presentations and Afternoon Break 1, September 8, 2025, 16:30 - 18:30

Thermospheric winds have significant impact on the ionosphere and determine how much joule heat is generated in the polar region during geomagnetic storms. Joule heating causes upwelling and the negative phase with deleted ionosphere. The negative phase then is carried to mid and low and latitudes by enhanced meridional winds. Wind speed thus determines how far the negative phase can travel to the low latitudes. In the equatorial region, the thermospheric wind dynamo causes upward or downward ion drift affecting the occurrence of the plasma bubbles. Hence, thermospheric winds affect the ionosphere at all latitudes. Thermospheric winds can be observed by Doppler remote sensing of the O 630 nm airglow emission from the ground, balloon, and satellite using Fabry Perot interferometer (FPI) instrument. We will show how these platforms can provide a more comprehensive picture of the thermosphere dynamics and support space weather research.

Poster Presentations
Monday 8 September 2025

Poster No.	First Name	Last Name	Organisation	Paper Title
1	Martin	Archer	Imperial College London	Characterising magnetopause surface waves within magnetosphere–ionosphere–ground coupling
3	Fraser	Baird	University of Surrey	Lerwick Compact Neutron Monitor: Instrumentation and First Resuts
5	Stephen	Bannister	Northumbria University	Quantitative Characterisation of Magnetic Topology in Solar Active Regions for Operational Space Weather Forecasting
7	Susanna	Bekker	Queen's University Belfast	Response of the total electron content in the ionosphere to the impulsive and late phases of X-class solar flares
9	Cory	Binnersley	Mirion Technologies	Technical Development of the NM-2023 Ground Level Monitor
11	Mario	Bisi	UKRI STFC RAL Space	RASOR: Radio Astronomy and Space Observation Research Facility – A Future Prospect for UK Sovereign Capabilities Across Space Weather, Space Situational Awareness, and Radio Astronomy
13	Mario	Bisi	UKRI STFC RAL Space	The COSPAR PSW-ISWAT 2025+ Space Weather Roadmap
15	Francois-Xavier	Bocquet	Met office	Met Office post-SWIMMR Research to Operations Activities
17	Ben	Boyde	University of Bath	Observing Travelling Ionospheric Disturbances with the LOFAR Radio Telescope
19	Christopher	Chen	Queen Mary University of London	Scale-by-scale accuracy of solar wind analogue ensemble forecasts
21	Christopher	Chen	Queen Mary University of London	Examining time-dependent heliospheric solar wind properties driven by evolving WSA boundaries
23	Jackie	Davies	STFC	UK-ODESSI: A Low-Cost, Low-Earth Orbit, In-Orbit Pathfinder for UK Space Weather

25	Ravindra	Desai	University of Warwick	ROARS: Revealing Orbital & Atmospheric Responses to Solar activity
27	Clive	Dyer	Csdradconsultancy and University of Surrey Space Centre	The Importance of Single Event Effects For Atmospheric Radiation Scales, Alerts and Actions
29	Siegfried	Gonzi	Met office, Uk	MOSWOC's (Met Office Space Weather Operations Centre) Coronal Mass Ensemble (CME) Prediction System
31	Fan	Lei	Surrey Space Centre, University of Surrey	Updates to MAIRE+ for Region Dependent Nowcasting
33	Fan	Lei	Surrey Space Centre, University of Surrey	Updates on Development of the High Energy Proton Instrument - HEPI
35	Ian	Mann	University of Alberta	Understanding, Modelling, and Quantifying the Space Weather Effects of Geomagnetically Induced Currents (GICs) on the Electric Power Grid
37	Mike	Marsh	Met office	Atmospheric Radiation: the Met Office Pathway to Operations
39	Daniel	Marsh	University Of Leeds	Pathways to Predicting D and E Region Ionospheric Variability
41	Juliana	Rinaldi-Semione	SDGs in Space/Calymru Research	Conceptualising 'environment' and 'sustainability' for an off-Earth future: leveraging existing expertise and frameworks to make a start
43	Dylan	Weston	Northumbria University	A threshold-based Random Forest forecasting model for the Outer Radiation Belt
45	Alan	Wood	University of Birmingham	Swarm-VIP-Dynamic: Models for Ionospheric Variability, Irregularities Based on the Swarm Satellite Data
47	Alan	Wood	University of Birmingham	Driving The Mid-Latitude Ionosphere from Below: Observations Made Using the International LOFAR Telescope
49	Qian	Wu	Ncar	Thermospheric wind observations from different platforms

Wednesday 10 September 2025

Poster No.	First Name	Last Name	Organisation	Paper Title
2	Oliver	Allanson	University of Birmingham, University of Exeter	Radiation belt wave-particle interaction theory and modelling: What do we know and what are we yet to understand?
4	Oliver	Allanson	University of Birmingham, University of Exeter	Diffusion coefficients for resonant relativistic wave-particle interactions using the PIRAN code
6	Ciaran	Beggan	British Geological Survey	A field-deployable absolute vector quantum magnetometer for geomagnetic research
8	Damini	Bhagwath	University of Central Lancashire	Model Validation using Historical SEP Event Analysis of the 3D Physics-Based Forecasting Tool SPARX
10	Suzy	Bingham	Met office	Advancing Forecasting Capabilities through Operations-to-Research at the Met Office Space Weather Operations Centre
12	Ben	Clewer	University of Surrey	Showcasing the Surrey Space Centre's new cubesat space weather payload on the UK Jovian-1 mission
14	Ingrid	Cnossen	British Antarctic Survey	Projected long-term decline in upper atmosphere density and its impacts on the space debris environment
16	Ravindra	Desai	University of Warwick	Progress towards coupling a global MHD model to an inner magnetospheric model
18	Lucie	Green	UCL/Mullard Space Science Laboratory	Bayesian Inference for Automated 3D CME Characterization and Uncertainty Quantification
20	Jithu	Jose Athalathil	Indian Institute of Technology Indore	Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks
22	Delores	Knipp	University of Colorado Boulder	Mid-latitude Geomagnetically Induced Currents as a Manifestation of Penetrating Electric Fields

24	Timo	Laitinen	University of Lancashire	Multi-point Solar Energetic Particle observations and space weather forecasting
26	Chiara	Lazzeri	Mullard Space Science Laboratory, UCL	Analysis of Magnetospheric ULF Waves Observed Near the Arrival of an IMF Southward Turning at the Magnetosphere
28	Emily	Mottram	University College London	Probing the characteristics of a pre-eruptive flux rope using novel techniques
30	Sirsha	Nandy	Indian Institute of Technology Indore	Solar Wind Density Pulse Effects on the Ionospheric Electrodynamics Under Variable IMF Orientations
34	Yiwei	Ni	University of St Andrews	Unraveling Filament Barb Dynamics through Pseudo-3D Hydrodynamic Simulations
36	Mathew	Owens	University of Reading	Implications of Using Spheroidal "Cone Model" CMEs in Solar-wind Models
38	Louisa	Prattley	National Emergency Management Agency New Zealand	Number Eight Wire: Building New Zealand’s Approach to Managing Space Weather Risk
40	Ian	Richardson	University of Maryland/Goddard Space Flight Centre	Coronal Mass Ejections Associated with Solar Energetic Particle Events Observed in the Low Corona by the Mauna Loa Solar Observatory
42	David R.	Themens	University of Birmingham	Statistical modeling of high latitude Sporadic-E climatology: A Sporadic-E module for E-CHAIM
44	Yihui	Tong	University of Warwick	Global MHD and Test-Particle simulations of outer radiation belt flux drop-out events
46	Bhagyashree	Waghule	University of Colorado Boulder	Very Near-Earth Reconnection (VNERX) and its connection to the 30A GIC spike in the Eastern US
48	Samuel	Wharton	University of Leicester	Measuring the Magnetopause Position with SMILE-SXI
50	Thomas	Williams	Durham University	Investigating the Efficacy of Topologically Derived Time Series for Flare Forecasting

Lightning Talks 1: Monday 8 September 2025

	First Name	Last Name	Organisation	Paper Title
1	Martin	Archer	Imperial College London	Characterising magnetopause surface waves within magnetosphere–ionosphere–ground coupling
2	Stephen	Bannister	Northumbria University	Quantitative Characterisation of Magnetic Topology in Solar Active Regions for Operational Space Weather Forecasting
3	Susanna	Bekker	Queen's University Belfast	Response of the total electron content in the ionosphere to the impulsive and late phases of X-class solar flares
4	Damini	Bhagwath	University of Central Lancashire	Model Validation using Historical SEP Event Analysis of the 3D Physics-Based Forecasting Tool SPARX
5	Christopher	Chen	Queen Mary University of London	Examining time-dependent heliospheric solar wind properties driven by evolving WSA boundaries
6	Ingrid	Cnossen	British Antarctic Survey	Projected long-term decline in upper atmosphere density and its impacts on the space debris environment
7	Jackie	Davies	STFC	UK-ODESSI: A Low-Cost, Low-Earth Orbit, In-Orbit Pathfinder for UK Space Weather
8	Clive	Dyer	Csdradconsultancy And University of Surrey Space Centre	The Importance of Single Event Effects For Atmospheric Radiation Scales, Alerts and Actions
9	Ian	Mann	University of Alberta	Understanding, Modelling, and Quantifying the Space Weather Effects of Geomagnetically Induced Currents (GICs) on the Electric Power Grid
10	Mike	Marsh	Met office	Atmospheric Radiation: the Met Office Pathway to Operations
11	Juliana	Rinaldi-Semione	SDGs in Space / Calymru Research	Conceptualising ‘environment’ and ‘sustainability’ for an off-Earth future: leveraging existing expertise and frameworks to make a start
12	Christopher	Chen	Queen Mary University of London	Scale-by-scale accuracy of solar wind analogue ensemble forecasts

Lightning Talks 2: Wednesday 10 September 2025

	First Name	Last Name	Organisation	Paper Title
1	Lucie	Green	University College London	Bayesian Inference for Automated 3D CME Characterization and Uncertainty Quantification
2	Jithu	Jose Athalathil	Indian Institute of Technology Indore	Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks
3	Delores	Knipp	University of Colorado Boulder	Mid-latitude Geomagnetically Induced Currents as a Manifestation of Penetrating Electric Fields
4	Timo	Laitinen	University of Lancashire	Multi-point Solar Energetic Particle observations and space weather forecasting
5	Emily	Mottram	University College London	Probing the characteristics of a pre-eruptive flux rope using novel techniques
6	Sirsha	Nandy	Indian Institute of Technology Indore	Solar Wind Density Pulse Effects on the Ionospheric Electrodynamics Under Variable IMF Orientations
7	Yiwei	Ni	University of St Andrews	Unravelling Filament Barb Dynamics through Pseudo-3D Hydrodynamic Simulations
8	Louisa	Prattley	National Emergency Management Agency New Zealand	Number Eight Wire: Building New Zealand's Approach to Managing Space Weather Risk
9	Ian	Richardson	University of Maryland / Goddard Space Flight Centre	Coronal Mass Ejections Associated with Solar Energetic Particle Events Observed in the Low Corona by the Mauna Loa Solar Observatory
10	David R.	Themens	University of Birmingham	Statistical modelling of high latitude Sporadic-E climatology: A Sporadic-E module for E-CHAIM
11	Bhagyashree	Waghule	University of Colorado Boulder	Very Near-Earth Reconnection (VNERX) and its connection to the 30A GIC spike in the Eastern US
12	Samuel	Wharton	University of Leicester	Measuring the Magnetopause Position with SMILE-SXI

UK Space Weather and
Space Environment Meeting III:
Global Challenges in Understanding the Space Environment
& Space Weather at Solar Maximum

8–11 September 2025
The Cutlers' Hall, Sheffield, UK

IOP Institute of Physics