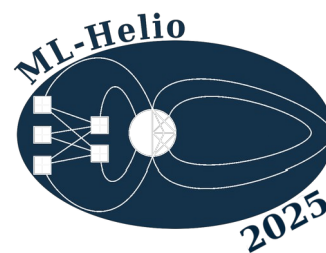# 3rd Machine Learning in Heliophysics
# Madrid, 22-26 September 2025

## Monday 22nd September

**9:30 – 10:00**    Welcome & Introductory Remarks

*Session 1 –  Chairs: TBD*

**10:00 – 10:30**    *Sabrina Guastavino* Learning the Sun: Machine Learning and Physical Insight for Space Weather Forecasting (invited)

**10:30 – 10:50**    *Anant Telikicherla* A New HOPE for Accurate Solar Flare Prediction

**10:50 – 11:10**    *Youngjae Kim* Interpretable Data-Driven Models for Solar Flare Forecasting through Deep Learning and Symbolic Regression

**11:10 – 11:40**    Coffee break

**11:40 – 12:00**    *Ekaterina Dineva* Combining Physics-Derived and Machine-Learned Features for Probabilistic Solar Flare Forecasting

**12:00 – 12:20**    *Naoto Nishizuka* Operational Use of Deep Flare Net and AI techniques for Space Weather Forecasting

**12:20 – 12:40**    *Panagiotis Gonidakis* Soft X-ray Flux Prediction for Onboard 24-Hour Solar Flare Forecasting Using CNNs and SDO/AIA Images

**12:40 – 13:00**    *Linn Abraham* Interpretable Deep Learning for Solar Flare Predictions

**13:00 – 13:20**    *Daniel da Silva* Generative Diffusion Models of the Solar Corona

**13:30 – 15:00**    Lunch


*Session 2 – Chairs:*

**15:00 – 15:30**    *George Miloshevich* Data-Driven Closures for Hybrid Plasma Models in Space Plasmas (invited)

**15:30 – 15:50**    *Prateek Mayank* Next-Generation MHD Modeling Of Solar Wind Using Neural Operators

**15:50 – 16:10**    *Hiroshi Hasegawa* Reconstruction of two-dimensional MHD and Hall MHD equilibria in space using physics-informed neural networks

**16:10 – 16:30**    *Manuel Lacal* Physics-Informed Neural Networks for Modeling Geomagnetic Storm Dynamics

**16:30 – 17:00**    Coffee break

**17:00 – 17:20**    *Jithu J Athalathil* Investigating Nonlinear Quenching Effects on Polar Field Buildup Using Physics-Informed Neural Networks

**17:20 – 17:40**    *Mingyu Jeon* Real-time Reconstruction of Coronal Magnetic Fields using a Physics-informed Neural Operator

**17:40 – 18:00**    *Clinton Groth* Merging Observational Data and Magnetohydrodynamics: A Variational Data Assimilation Approach for the Solar Wind

**18:00 – 18:30**    *Robert Jarolim* The Sun in 3D: Bridging Gaps in Solar Observations with Physics-Informed Machine Learning (invited)

**19:00 – 20:30**    Reception (on-site)


# Tuesday 23ʳᵈ September

*Session 3 – Chairs:*

**9:30  –  10:00**    *Opal Issan* Bayesian Inference and Global Sensitivity Analysis for Ambient Solar Wind Prediction (invited)

**10:00 – 10:20**    *Seungwoo Ahn* Verification of Empirical and Deep Learning Models for Solar Wind Speed Forecasting

**10:20 – 10:40**    *Matthew Billcliff* Extended Lead-Time Geomagnetic Storm Forecasting with Solar Wind Ensembles and Machine Learning

**10:40 – 11:00**    *Esraa Elelimy* Long-Horizon Prediction of Solar Wind Events with Reinforcement Learning

**11:00 – 11:30**    Coffee break

**11:30 – 11:50**    *Peter Wintoft* Gaussian Process forecast of strong geomagnetic storms using CME-ICME properties

**11:50 – 12:10**    *Hannah Ruedisser* ARCANE: An Operational Framework for Automatic Realtime ICME Detection in Solar Wind In Situ Data

**12:10 – 12:30**    *Jiahui Shan* CAMEL-II: A 3D Coronal Mass Ejection Catalog Based on Coronal Mass Ejection Automatic Detection with Deep Learning

**12:30 – 12:50**    *Julio Hernandez Camero* Bayesian Inference for 3D CME Characterization and Uncertainty Quantification

**12:50 – 13:10**    *Matthew Rutala* Data-driven, Probabilistic Solar Wind Reconstruction Beyond the Earth

**13:10 – 13:30**    *Sadaf Shahsavani* Kp Prediction from Solar Wind Parameters Using Sparse Library Regression

**13:30 – 15:00**    Lunch

*Poster Session 1*

**15:00 – 18:30**    Poster session 1

# Wednesday 24th September

**9:30 – 10:20**    ESA lab tutorial

**10:20 – 10:50**    *Caitriona Jackman* How to creatively account for the lack of an upstream monitor at planets other than Earth (invited)

**10:50 – 11:20**    *Paul Wright* From Model to Impact: Engineering Machine Learning for Space Weather Forecasting (invited)

**11:20 – 11:50**    Coffee break

*Session 4 – Chairs:*

**11:50 – 12:10**    *Abigail Azari* Towards Operational Planetary Space Weather with A Virtual Solar Wind Monitor at Mars

**12:10 – 12:30**    *Daragh Hollman* Classifying MESSENGER Magnetospheric Boundary Crossings Using a Random Forest Model

**12:30 – 12:50**    *Gautier Nguyen* Auto-encoder based reduced order emulation of the Earth electron radiation belt modeling

**12:50 – 13:10**    *François Ginisty* SPARTAI – an AI-based forecasting pipeline for energetic electrons in the Earth's radiation belts

**13:10 – 13:30**    *Dylan Weston* A threshold-based random forest forecasting model for the Outer Radiation Belt

**13:30 – 15:00**    Lunch

*Poster Session 2*

**15:00 – 18:30**    Poster session 2

# Thursday 25th September

**9:30 – 10:00**  *Henrik Eklund* Deep learning across multi-dimensional data (invited)

**10:00 – 10:20**  *Daniel Gass* Dataset Creation for ML Applications in Heliophysics - Lessons from ARCAFF

**10:20 – 10:40**  *Bhishek Manek* Cross-Calibrated Video Super-Resolution for Solar Dopplergrams

**10:40 – 11:00**  *Léa Zuili* MLOps for Reproducible Machine Learning in Space Science: Insights from ESAC

**11:00 – 11:30**  Coffee break

*Session 6 – Chairs:*

**11:30 – 11:50**  *Mohamed Nedal* Short-Term Solar Energetic Proton Flux Forecasting using Transformer Architectures

**11:50 – 12:10**  *Paulina Quijia Pilapana* Automatic Identification of Magnetic Reconnection to Assess its Role in Collisionless Turbulent Plasmas Using Unsupervised Machine Learning

**12:10 – 12:30**  *Joanna Slawinska* Koopman Operator Theory and new Data-Driven Approach to Modeling and Signal Processing of Spatiotemporal Data

**12:30 – 12:50**  *Junmu Youn* Aurora Detection in Sequential e-POP/FAI Images Using Deep Learning and Explainable AI

**12:50 – 13:10**  *Katherine Keegan* An AI-powered Surface Flux Transport model to measure high-resolution velocity fields and forecast magnetic flux emergence

**13:10 – 13:30**  *Francesco Carella* Transient-Oriented Clustering of Solar Wind Observations at 1 AU

**13:30 – 15:00**  Lunch

*Poster session 3*

**15:00 – 18:30**  Poster Session 3

**Friday 26th September**

*Session 7 – Chairs:*

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|---|---|
| **9:30 – 10:00** | Early career awards |
| **10:00 – 10:30** | *Jonathan Citrin* TORAX: A Fast and Differentiable Tokamak Transport Simulator in JAX (invited) |
| **10:30 – 10:50** | *Nikita Balodhi* Bayes in Space: A Bayesian Deep Learning approach for Coronal Temperature estimation |
| **10:50 – 11:10** | *Andrés Muñoz-Jaramillo* HelioFM a foundation model in heliophysics |
| **11:10 – 11:30** | *Sergio Sánchez Hurtado* Toward Uncertainty-Aware Thermospheric Drag Forecasting via Time Series Foundation Models |
| **11:30 – 12:00** | <u>Coffee break</u> |
| **12:00 -- 13:30** | Open discussion |
| **13:30 – 15:00** | Farewell lunch |

# List of posters

## Poster session 1

1) *Idowu Raji* A Multi-Stage Self Organizing Map-Autoencoder-LSTM Model for Total Solar Irradiance Prediction

2) *Simon Joyce* Revealing the Martian ionosphere using AI and 20 years of Mars Express data

3) *Samuel Abaidoo* CIR-Driven Geomagnetic Storm and High-Intensity Long-Duration Continuous AE Activity (HILDCAA) Event: Effects on Brazilian Equatorial and Low-Latitude Ionosphere—Observations and Modeling

4) *Simon Wing* Information theory based system level Babcock-Leighton flux transport model-data comparisons

5) *Armando Collado-Villaverde* Dst Forecasting with REDst: Pushing the Limits of Real-Time L1 Data

6) *Rong Sun* Automatic Detection of Lyman-alpha Solar Flares Based on GOES/EUVS Flux and ASO-S/SDI Images

7) *Maria Hasler* Unsupervised analysis of dangerous space weather: Combining ground and space-based measurement

8) *Yasmin Machuca* Automatic Identification of CMEs images using synthetically trained neural networks

9) *Shi Tao* Automated Detection of Foreshock Transients Using Machine Learning Techniques

10) *Emanuel Jeß* Discovering heat flux closures using machine learning methods

11) *François Ginisty* Augura Space Nowcast Platform: A Research-Focused, Open Demonstrator for Space Weather Data Integration and Visualization

12) *Emerick Laborde* Physics-Informed Deep Learning for the characterization of the electron radiation belts dynamics

13) *Daniele Telloni* Transition to a Critical State of Active Regions: Identifying Solar Flare Precursors

14) *Dibya Mishra* Neural Network-Based Detection of Plages in Historical Solar Drawings

15) *Alexandre Suteau* DeepHelio - Predicting Solar Wind Speed at L1 Using Solar Imagery and Deep Learning

16) *Samuel Burles* Data-Driven Plasma Closure Relation for Landau Damping in One Dimension

17) *Mariano Sanchez Toledo* Automatic GCS reconstruction of CMEs using synthetically-trained neural networks

18) *Ji-Hye Baek* DeepSDO: A Deep Learning-Based Approach for Automated Detection and Visualization of Solar Events

19) *Paloma Jol* Flare forecasting using Fully Convolutional Network to gain insight into active regions

20) *Verena Heidrich-Meisner* Anomaly detection applied to solar wind composition measured by SOHO/CELIAS/CTOF and ACE/SWICS

21) *JUNMU YOUN* Stereoscopic DEM Analysis Using Solar Orbiter/EUI and AI-Generated Data

22) *KD Leka* SuperSynthia LOS: Learning to Estimate Photospheric Vector Fields from Line-of-Sight Magnetograms

23) *Andy Smith* Self Supervised Encoding to Find Similar Observations

24) *Francesco Ramunno* Enhancing image resolution of solar magnetograms: A latent diffusion model approach


## Poster session 2

1) *Benjamin Grison* Comparison of automatic and machine-learning detections of EMIC waves

2) *Qiushuo Wang* Modeling Ring Current Oxygen Ions Using Neural Network

3) *Giuseppe Consolini* On timescale of geomagnetic storm recovery phase.

4) *Hiroshi Hasegawa* Revisiting the cold-dense plasma sheet formation mechanism using causal inference and information-theoretic analysis

5) *Daeil Kim* Solar EUV Channel Selection with Magnetogram via Multi-domain image Translation

6) *Poshan Belbase* Reconstructing Historical Solar Activity Indices to Model Past Space Weather Events

7) *Edoardo Legnaro* Solar Active Region Classification with Deep Learning

8) *Veronique Delouille* Mitigating hallucination with non-adversarial strategies for image-to-image translation in solar physics

9) *Atuel Villegas* High resolution TEC forecasting using transformers models

10) *Francesco Ramunno* AIA2STIX: Bridging the gap between UV and X-ray in solar imaging

11) *João Felipe Pereira* Comparing Machine and Deep Learning Techniques for Solar Flare Prediction

12) *Raman Mukundan* Towards an Interpretable Model of Localized Geomagnetic Disturbances in Terms of Solar Wind and M-I Processes

13) *Brianna Isola* ML-IMEF: A Machine Learning Approach to Global Modeling of the Inner Magnetospheric Electric Field

14) *Stefan Lotz* Solar wind - geomagnetic disturbance coupling predicted and interpreted with KnowIt

15) *Jihyeon Son* Time-Resolved Causal Analysis of Geomagnetic Storms Using Information Theory

16) *Iván Maseda-Zurdo* An Interpretable Approach to SYM-H Geomagnetic Index Forecasting

17) *Jakub Juranek* Self-improving solar events prediction system: exploring potential of Darwin Gödel Machine agentic AI framework for cosmic weather forecasting.

18) *Maria Elena Innocenti* Bridging Kinetic and Fluid Scales: Addressing the Plasma Closure Problem with ML

19) *Carl Shneider* Proxy Sensing of Space Weather Events Using Solar Panel Telemetry

20) *Herman le Roux* Automated Detection of Solar Radio Bursts Using Detectron

21) *Liam Smith* Using TEC to Enhance 3D Electron Density Models

22) *Silvia Kostárová* Opportunities for early detection of CMEs and CIRs by Vigil data and machine learning approach

23) *Subhamoy Chatterjee* Deep Generative model that uses physical quantities to generate and retrieve solar magnetic active regions

24) *Jan Raath* Machine Learning in Galactic Cosmic Ray Propagation


## Poster session 3

1) *Stefan Lotz* TEC and Transfer Learning

2) *Francesco Ramunno* Predicting partially observable dynamical systems via diffusion models with a multiscale inference scheme

3) *Nina Bonaventura* Estimated high-resolution photospheric flows using an AI surface flux transport model

4) *Simon Mackovjak* Deep Learning Classification of Low-latitude Ionospheric Structures in Airglow Images

5) *Karen Júlia Ferreira* CIR-Driven Ion Injections and EMIC Wave Dynamics: Implications for Wave Generation Mechanisms and Outer Radiation Belt Variability

6) *Raphael Attie* CHESS: Coronal Hole Extraction with Semantic Segmentation

7) *Shiva Kavosi* Ground Signatures of Magnetopause Surface Waves

8) *Nathaniel Laurent* World Coordinate System Framework to enhance AI applications in PyTorch

9) *STEPHEN TETE* Bayesian and Machine Learning for Geomagnetic Activity forecast: Where Causality augments Explainability

10) *Jose Espinoza Acosta* CCA-Informed Neural Networks for Predicting Plasma Sheet Conditions from Solar Wind Drivers

11) *Tania Varesano* Investigating plasma composition with deep learning

12) *Jacob Bortnik* Using interpretable AI to discover the drivers of acceleration vs depletion events in the radiation belt

13) *Dominique Stumbaugh* Reconstructing Equatorial Electron Flux Measurements from LEO

14) *Daniel da Silva* Data-Mining Similar Scenarios for Uncertainty Quantification of Solar Wind Predictions at L1

15) *Robert Jarolim* 3D Tomographic Reconstruction of Coronal Plasma Density and Temperature Using Neural Radiance Fields

16) *Pete Riley* Feature Detection and Tracking in White-Light Observations from WISPR using Machine Learning

17) *Sanjali Vuriti* Data Analysis for Multi-Hazard Risk Science: Risk and Resilience of Societal Critical Infrastructure to Space Weather and Compounding Natural Hazards

18) *Paraksh Vankawala* A Computer Vision Guided Detection and Classification of Plasma Waves in the Inner Magnetosphere

19) *Xiangning Chu* Unraveling Near-Earth Space Dynamics with Machine Learning

20) *Sandor Kruk* ESA Datalabs: Digital Innovation in Space Science

21) *David O'Ryan* AnomalyMatch: A Detection Method of Astrophysical Anomalies in Imaging Data

22) *Jan Reerink* The Heliophysics Extended Survey Environment

23) *Griffin T. Goodwin* An EUV Extension to the SWAN-SF Flare Forecasting Dataset

24) *Aikaterini Pesini* Solar Radio Burst Tracker: A citizen science initiative to identify Type III solar radio bursts

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