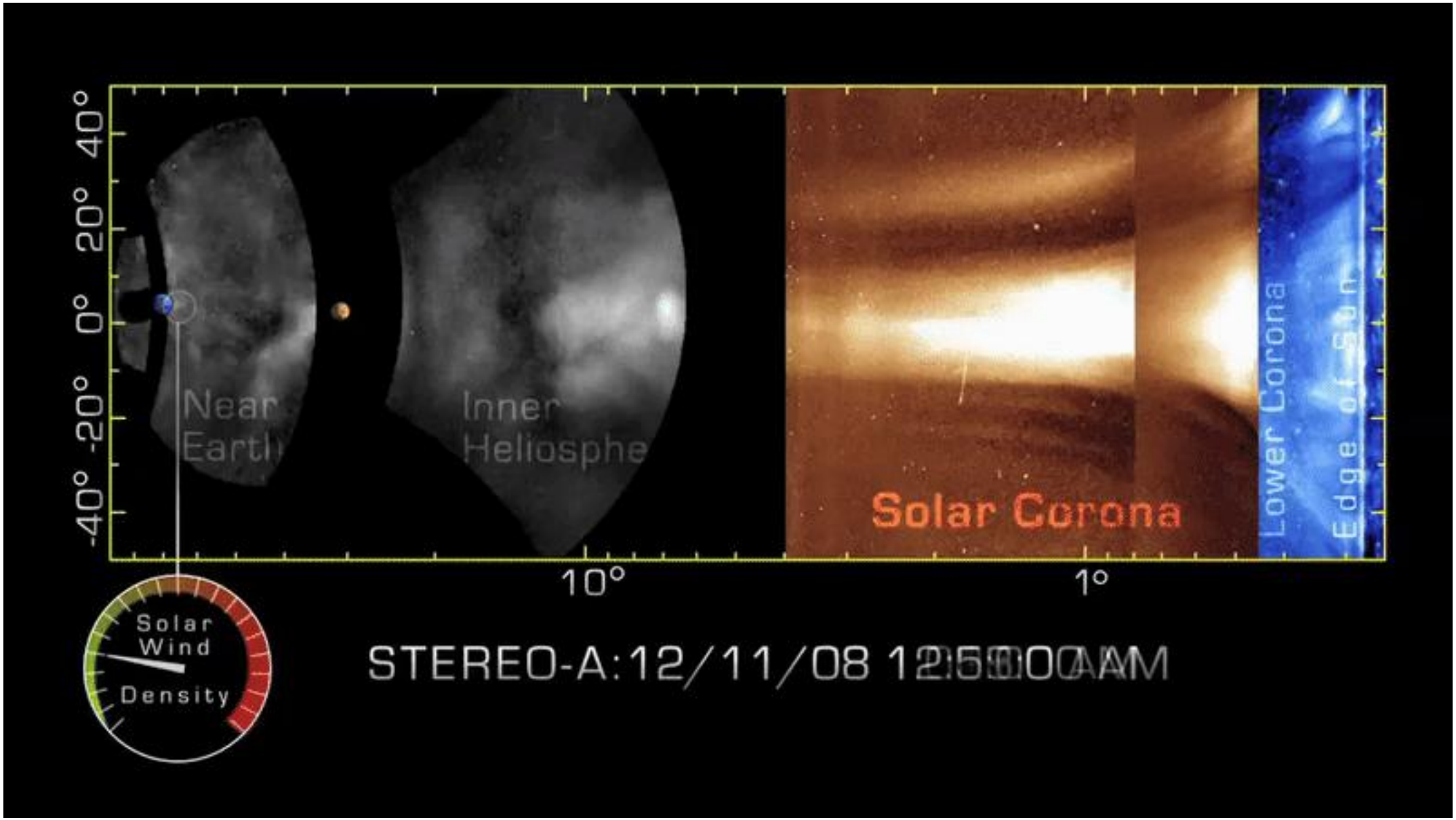
Agenzia Spaziale Italiana

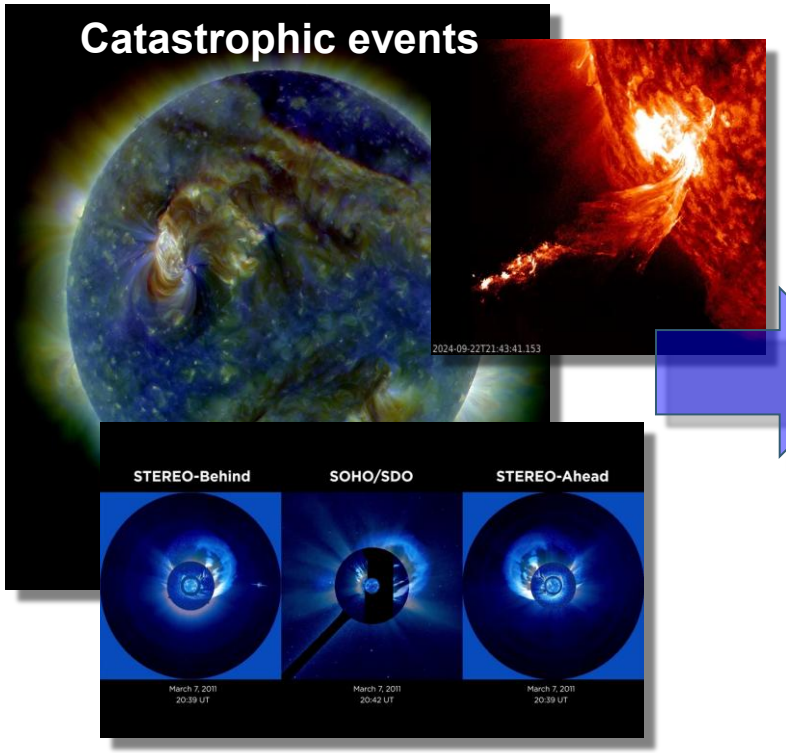
SIU! Days

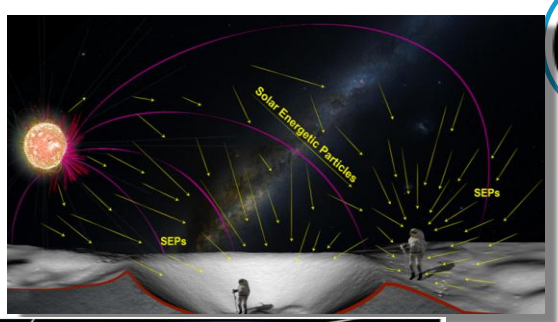
Florence
January, 26-28

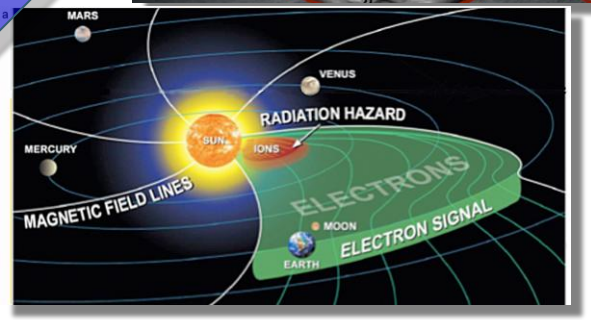
SPOKE 6: **PROTECTION OF CRITICAL INFRASTRUCTURES AND SPACE WEATHER**


40°
20°
0°
-20°
-40°
Near Earth
Inner Heliosphe
Solar Corona
Lower Corona
Edge of Sun
10°
1°
Solar Wind Density
STEREO-A:12/11/08 12:56:00AM

Spoke 6:
Protection of Critical Structures and Space Weather







- ·Expanding and improving theoretical models of the heliospheric environment and its dynamics;
- · Studying innovative space architectures and developing payload breadboards for SWE
- · Developing software tools for SWE forecasting
- · Evaluate the SWE effects on ground and space-based infrastructures

The Team

Spoke 6 Work Packages

6.3 Innovative Space Architectures

Provides requirements to mission and P/L

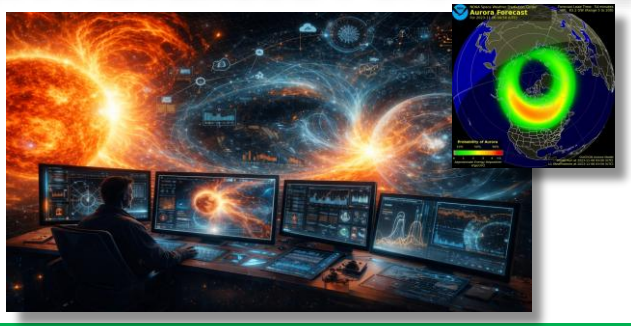
6.2 Enabling Science

modeling & data analysis

6.5 Experimental Activities

Provide models

6.4 Advanced Forecasting



WP 6.3 – Innovative Space Architectures

(S. Fineschi & F. Berrilli)

T6.3.1: Scientific requirements (D. Loreggia)

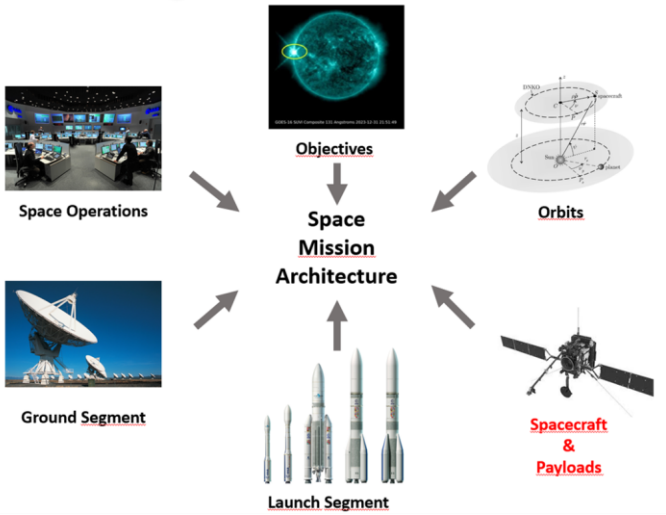
T6.3.2: Payload trade-off analysis (F. Berrilli)

T6.3.2: Orbits and mission profile definition (G. Nisticò & S. Servidio)

T6.3.4: Particle sensors breadboarding (F. Gargano)

WP 6.3 – Innovative Space Architectures

Payload trade-off analysis

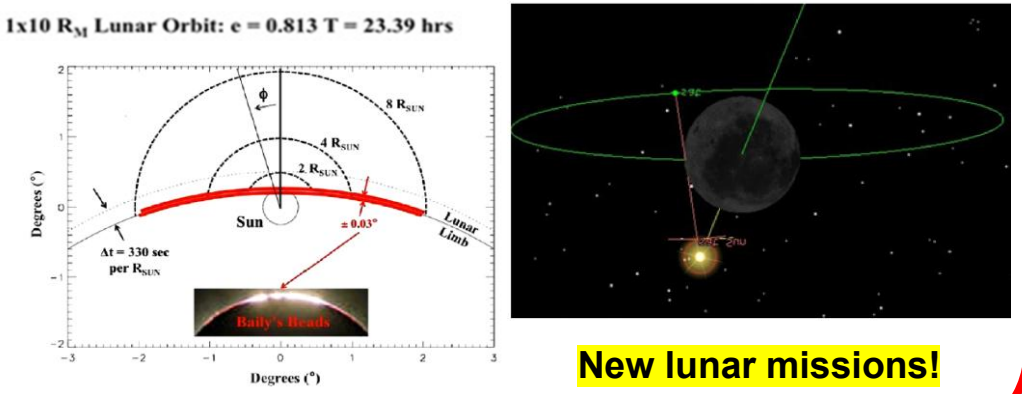


The **space mission architecture** is a multifaceted system integrated across four primary pillars:

1. mission objectives;
2. the space segment;
3. the ground segment;
1. the launch segment.

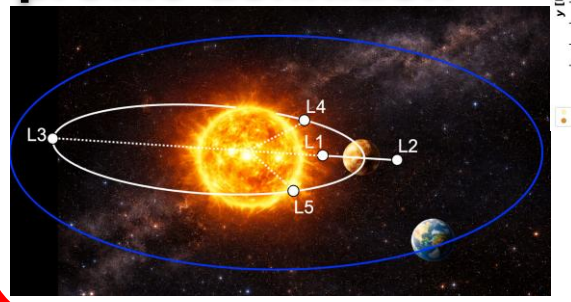
P/L trade-off metric in the Analytic Hierarchy Process!

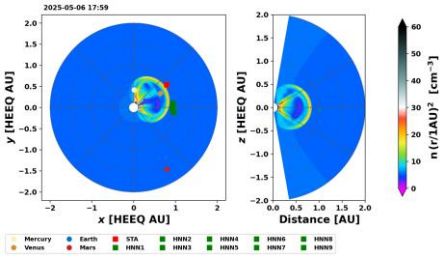
Scientific Requirements



New lunar missions!

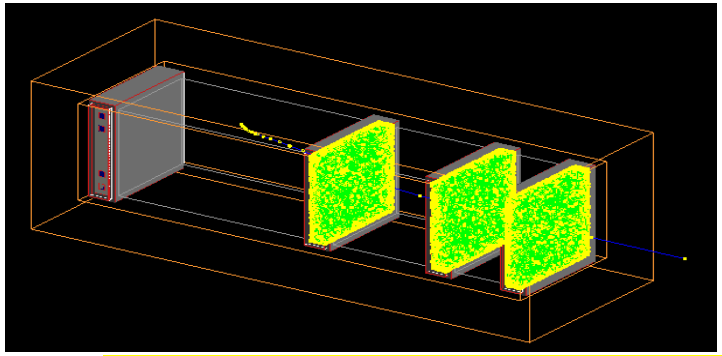
Orbits & mission profile definition





New mission concepts!

Particle sensors breadboarding



An initial prototype & preliminary tests!

WP 6.5 – Experimental activities, equipment, external services

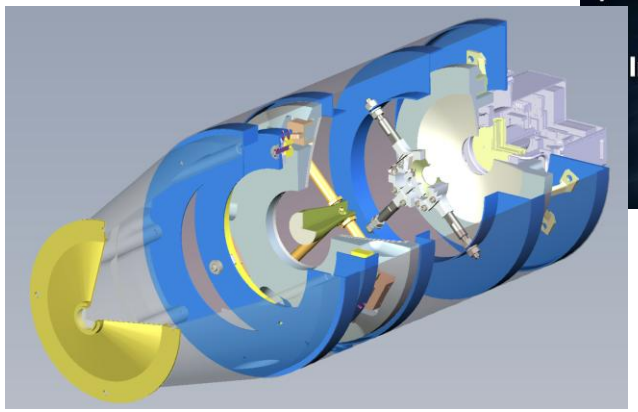
(S. Ivanovski, F. Gargano)

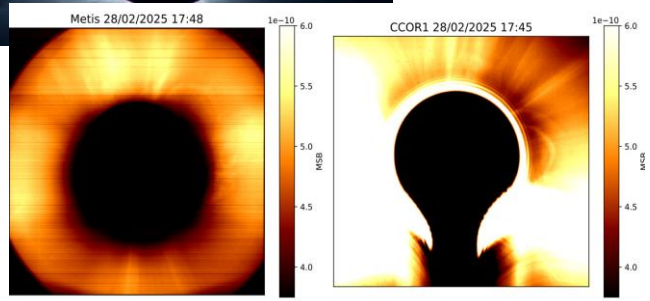
T6.5.1: System-level SWE instruments breadboarding (F. Landini)

T6.5.2: Forecast Networking (L. Biasiotti)

WP 6.5 – Experimental activities, equipment, external services

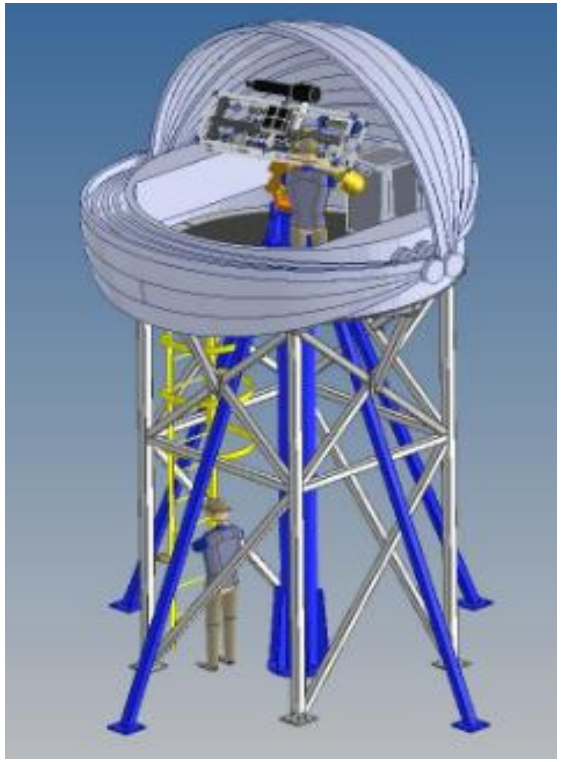
Instruments breadboarding





A prototype of a compact visible light solar coronagraph!

Forecast Networking



Robotic synoptic telescope: Dome prototype

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INGV

ALTEC

WP 6.2 Enabling Science (Romano)

T6.2.1 (INAF)
Study of the solar atmosphere conditions (Susino)

T6.2.2 (INAF)
Study of the interplanetary medium (Benella)

T6.2.3 (INAF)
Study of the particle radiation environment (Laurenza)

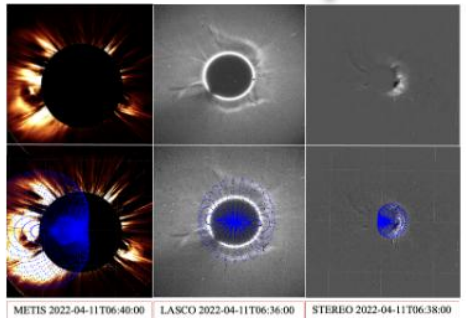
T6.2.4 (INGV)
Study of solar wind-magnetosphere-ionosphere coupling (Giannattasio)

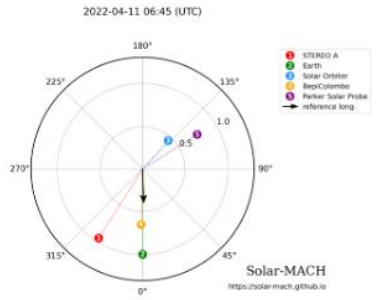
T6.2.5 (INGV)
Study of the thermosphere-ionosphere response (Sabbagh)

Across the five Tasks of WP 6.2, the activities carried out formed a coherent, interconnected effort — from fundamental physical processes to applied modelling and operational impacts — working synergistically to advance our understanding and prediction of Space Weather effects on the near-Earth environment and space assets.

WP 6.2 – Enabling Science

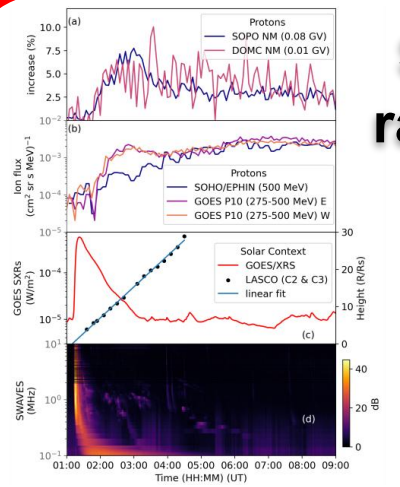
Study of the solar atmospheric conditions





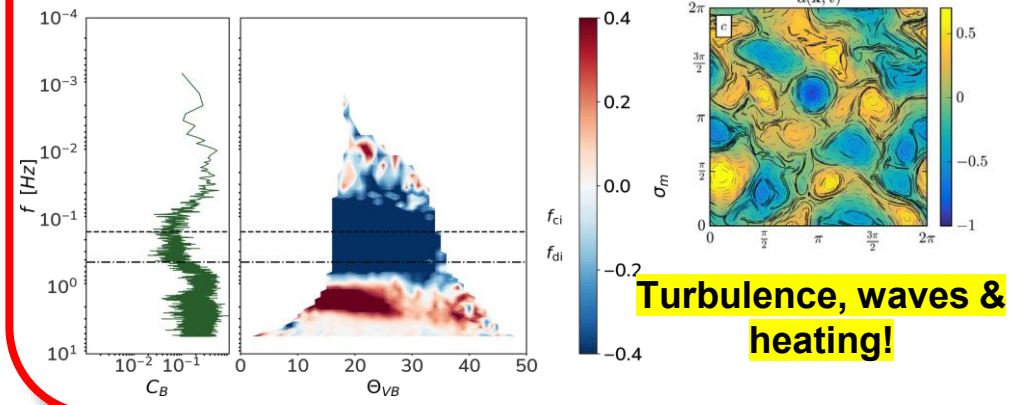
A catalog of extreme events!

Study of the particle radiation environment



Solar eruptions and high energy protons!

Study of the interplanetary medium



Turbulence, waves & heating!

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TELESPAZIO a LEONARDO and THALES company
INFN
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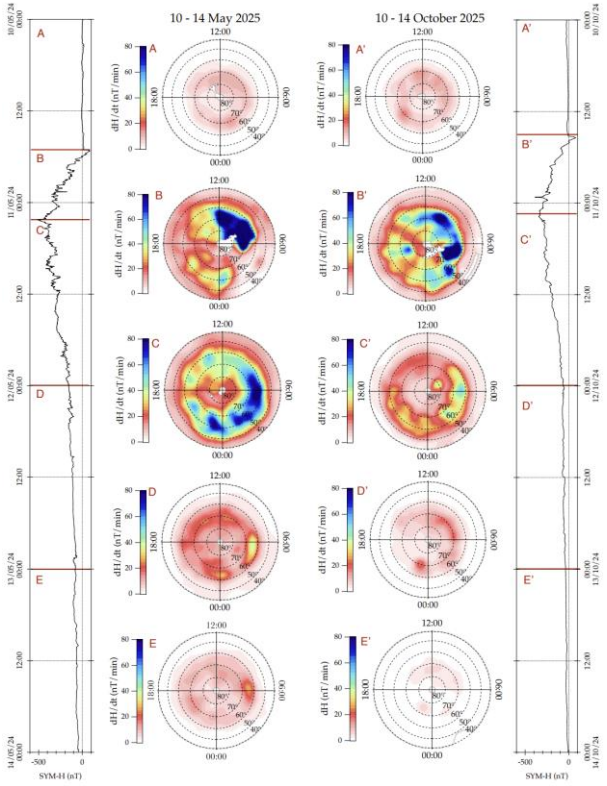
INGV
UNIVERSITAS STUDIORUM ATHESINA

WP 6.2 – Enabling Science

Solar wind-magnetosphere-ionosphere coupling



Geomagnetic disturbances from "*The 2025 Events*"!

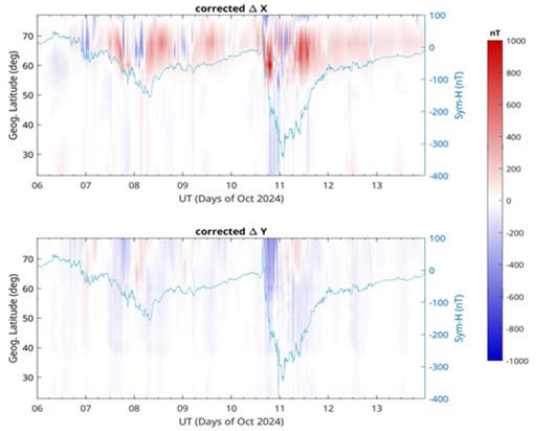
Thermosphere-ionosphere response

Semi-empirical Model Development (INGV)

Developing a semi-empirical model for ionospheric and thermospheric variability under diverse SWE conditions at regional scale. Reconstructing electron density, ionospheric dynamics, and thermospheric composition.
Target events: Geomagnetic storms of October 2024 and January 2025.

Operational Impacts & Forecast (Telespazio)

Study on operational impacts and potential failures associated to solar events.
Development of models to relate GNSS performances to ionosphere behavior.
Development of forecast capability to support planning and contingency decisions.



High thermospheric variability during adverse space weather events!

WP 6.4 – Advanced Applications for Space Weather Forecasting and Nowcasting

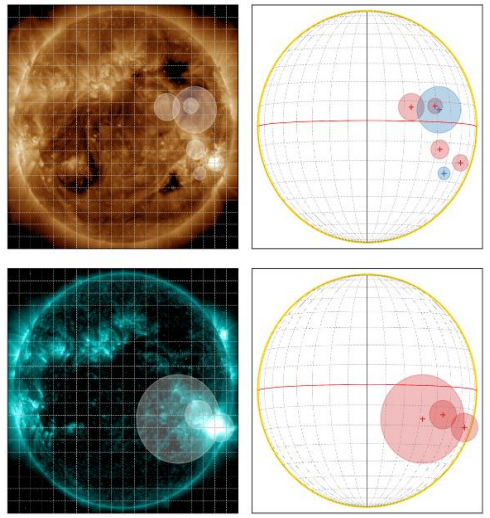
(M. Laurenza, L. Alfonsi)

T6.4.1: Forecasting and nowcasting techniques (M. Laurenza)

T6.4.2: Automated nowcasting of SWE drivers (C. Magnafico)

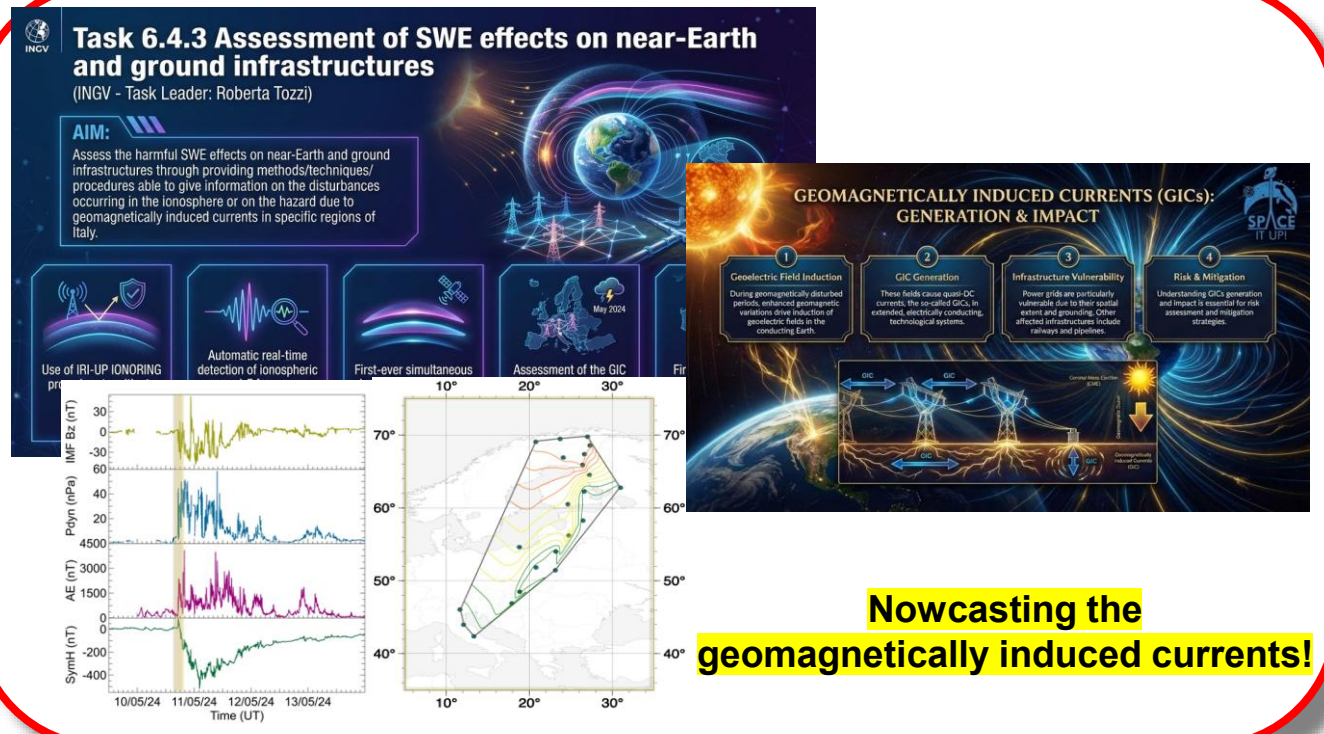
T6.4.3: SWE effects on near-Earth and ground infrastructures (R. Tozzi)

WP 6.4 – Advanced Applications for Space Weather Forecasting and Nowcasting



Forecasting & nowcasting techniques

Automated identification of early CME!



Nowcasting the geomagnetically induced currents!

Spoke 6

7 Talks @SIU-Days (Session P1)

- Solar & Heliospheric Models & Data Analysis, P. Romano (INAF-OACT)
- Simulations & Virtual Spacecraft Validation, S. Servidio (UniCal)
- Forecasting/Nowcasting Space Weather Tools, M. Laurenza (INAF-IAPS), L. Alfonsi (INGV)
- Space Weather Effects on Technological Systems, D. Sabbagh (INGV)
- Innovative Coronagraphs for Space Weather Missions, F. Landini (INAF-OATO)
- SELENE – CubeSat Lunar Space Weather Mission, S. Fineschi (INAF -OATO)
- Payload Trade-Off Methodology, F. Berrilli (UniRoma2)

23 Posters @SIU-Days

- Design and test of a radiation monitor for space applications, P. Loizzo
- From Large-Scale Structures to Turbulence: Advancing Virtual Spacecraft Diagnostics for Space Weather Forecasting, G. Prete
- Novel Multiple Spacecraft Techniques for Measuring Turbulence in Space, S. Servidio
- Advancing Solar Flare Forecasting with a Deep Learning Approach using Multi-Model Inputs, E. Doria Rosales
- Advanced Shock-Capturing Numerical Models for Geophysical Processes, A. Congacha Ortega
- Generalized Third-Order Law in MHD Turbulence with Distinct Dissipation Mechanisms, E. M: Fortugno
- From Solar Flare Properties to Atmospheric and Magnetospheric Response, L. Biasiotti
- Ray-Tracing Simulations of CMEs Observed from the Sun–Venus Lagrangian Points, G. Nisticò
- 8th April 2024 Total Solar Eclipse E-KPol Observation Campaign, R. Chiartano
- LOFAR unique cababilites under extreme ionospheric conditions: The Mother's Day Superstorm, R. Ghidoni
- "Storm-Time Geoelectric Fields in Italy: Observations and Modelling for Space Weather Risk Assesment", M. De Girolamo
- "Probing the May 2024 Geomagnetic Storm from the Remote Talos Dome Station", L. Santarelli
- Coordinated observations of Metis/Solar Orbiter and ASPIICS/Proba3 space coronagraphs, L. Abbo
- Automatic recognition of CME signatures in remote-sensing EUV solar data, S. Fineschi
- Signature of the saturated Hanle effect in the linearly polarized coronal Fe XIV emission line, E. Amato
- A Dual Beam UV-Polarimeter for the Solar Corona, L. Zangrilli
- Iterative Determination of Solar Coronal Temperature Using Metis Coronagraph Measurements, A. Liberatore
- Mapping Solar Wind Speed with Metis/Solar Orbiter Observations, S. Giordano
- Validating the ESPERTA model for forecasting solar energetic particles, N. Chrysaphi
- Trade-Off Analysis for Innovative Space Architecture , R. Reda
- Algorithms for Trajectory analysis and Optimal Control of Satellites, D. Stocco
- Impact of Geomagnetic Superstorms on GNSS Systems: A Preliminary Analysis, G. Martiniello
- Comparing Northern Hemisphere Mid-Latitude Thermosphere-Ionosphere Response to Two Recent Geomagnetic Storms, D. Sabbagh

>20 new hirings!

- Antonella Congacha, assegno, UNICAL
- Vincenzo Capparelli, assegno, UNICAL
- Giuseppe Prete, assegno, UNICAL
- Elizabeth Rosales, assegno, UNICAL
- Antonella Congacha, dottorato, UNICAL
- Elisa Maria Fortugno, dottorato, UNICAL
- Sara Bertone, dottorato, UNICAL
- Zbigniew Plebaniak, assegno, INFN Tor Vergata
- Michele De Girolamo, TD, INGV
- Roberta Pillera, assegno, INFN Bari
- Daniele Belardinelli, TD INAF-IAPS
- Nicolina Chrysaphi, TD INAF-IAPS
- Raffaele Reda, Contratto di Ricerca, UniRoma2 Tor Vergata
- Davide Stocco, assegno, Università di Trento
- Gianluca Santagati, TD INAF-OACT
- Federico Dogo, TD, INAF- OATS
- Lorenzo Biasiotti, TD, INAF-OATS
- Riccardo Chiartano, dottorao, Univ. Trento & INAF-OATO
- Alessandro Liberatore, TD, INAF-OATO
- Giuseppe Martiniello, TD, Telespazio

> 45 Publications

Task ↓ / Spoke →	Spoke 1 Enabling Technologies for Novel Near-Earth and Exploration Missions	Spoke 4 Next-generation detectors of ionizing radiation and fields for remote sensing	Spoke 5 Planetary protection and geohazards mitigation	Spoke 8 Robotic and Human Exploration of Extraterrestrial Habitats, Architectures and Infrastructures	Spoke 9 Life Sciences and Human Protection in Space
Solar atmosphere	asset protection, servicing requirements, radiation constraints	coronal inputs for detector design, solar-event signatures	boundary conditions for SWE models, CME catalogs	radiation environment constraints for habitats and systems	solar event drivers for biological-risk assessment
Interplanetary medium & SWE forecasting	plasma conditions for mission design & GNC robustness	turbulence & ICME data for detector calibration	solar-wind/ICME parameters for extreme-event simulations	interplanetary environment constraints for exploration systems	particle-transport inputs for biological dose modelling
Particle radiation environment	radiation constraints for sensors & spacecraft technologies		SEP/GLE datasets for hazard assessment		radiation environment ↔ biological exposure modelling
Solar wind – magnetosphere – ionosphere – thermosphere coupling	ionospheric/geomagnetic variability for system robustness		external-driver discrimination, topside-sounder requirements		storm-driven radiation/upper-atm. effects for bio-risk