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SPACE SAFETY

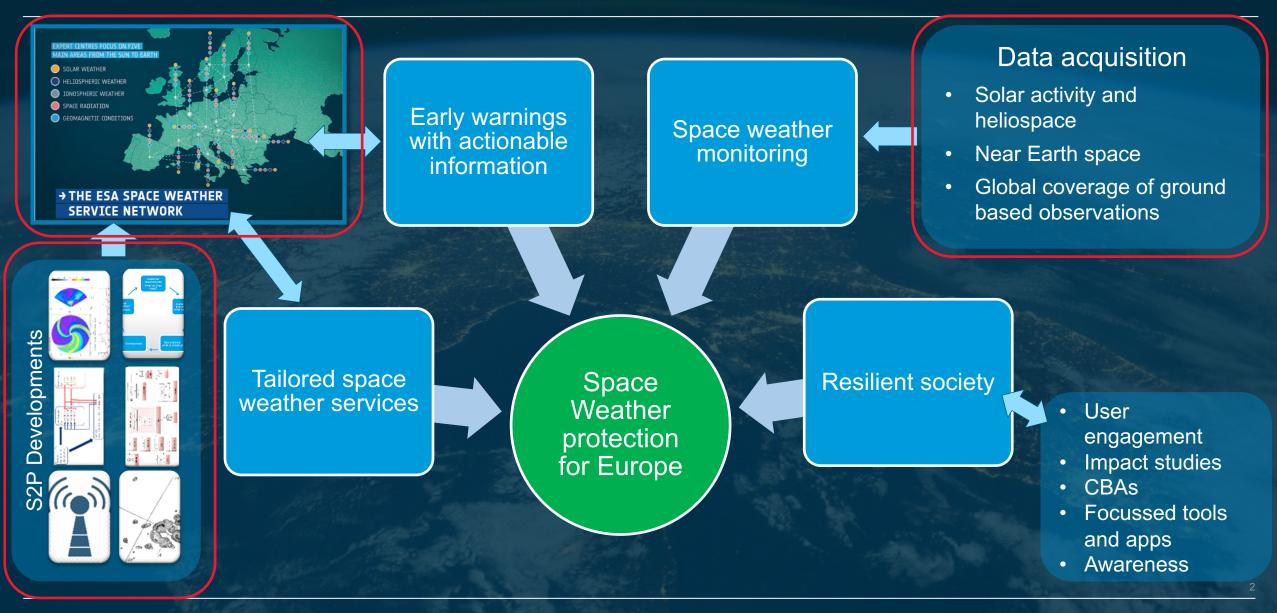
Heliophysics in ESA Space Weather Office

Juha-Pekka Luntama, Alexi Glover, Melanie Heil, Stefan Kraft, Jorge Amaya Space Weather Office European Space Agency ESA Heliophysics in Europe, 30 Oct – 3 Nov, 2023

ESA UNCLASSIFIED - For ESA Official Use Only

ESA Space Weather System Objectives





ESA vision of enhanced Space Weather Monitoring System

Sun, solar wind and Impact & state **CME** monitoring monitoring: D3S LÍ Ground & L5 space sensors Forecasting & Event detection

Distributed Space Weather Sensor System (D3S)



Monitoring of SWE impact near Earth

- Observation needs:
 - magnetic field
 - neutral/charged particles
 - plasma environment
 - auroral imaging
 - ➢ ionosphere
 - cislunar and lunar environment

Instrument Name	Satellite	Start of data provision	S2P Period
SOSMAG	GEO-KOMPSAT-2A	operational	SSA P3
NGRM/RMU	EDRS-C	operational	SSA P3
NGRM/RMU	Sentinel-6	operational	S2P P1
ICARE-NG	HOTBIRD-13F	2024	S2P P1
ICARE-NG	HOTBIRD-13G	2024	S2P P1
NGRM/RMU	MTG-I1	2024	S2P P1
ERSA	Lunar Gateway	2025	S2P P2
MiniRMU	Lunar Pathfinder	2025	S2P P2
NGRM/RMU	MetOp-SG A1	2025	S2P P2
NGRM/RMU	MTG-S1	2025	S2P P2
NGRM/RMU	MTG-I2	2026	S2P P2
NGRM/RMU	MetOp-SG B1	2026	S2P P2



MiniRMU on Lunar Pathfinder

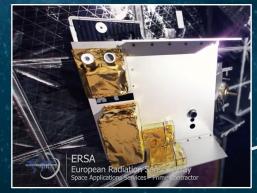
ERSA on Lunar Gateway

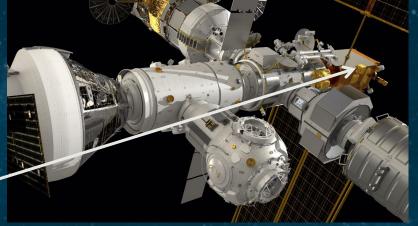
Cislunar Hosted Payload Missions



- MiniRMU on Lunar Pathfinder
 - Monitoring of high energy electrons and protons
 - Planned launch in 2025
- ERSA on Lunar Gateway
 - Comprised of several radiation monitors, dosimeters and magnetometers
 - Collaboration with NASA solar physics HERMES payload
 - Planned launch end 2025







Space Weather Nanosat Mission

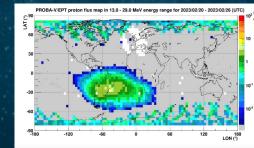
Mission objectives:

- Data on space environment and effects in LEO
- Demonstrate "new space" and commercialisation approach with mission/data-as-a-service
 - => Industry responsible for implementation, mission operation & Level 1 data processing
 - => ESA an anchor customer

Baseline measurements:

- High energy Proton and Electron flux
- Thermal electrons' and ions' flux, density and temperature
- 3D electron density in the ionosphere
- Scintillation parameters (S4, Sigma_phi)

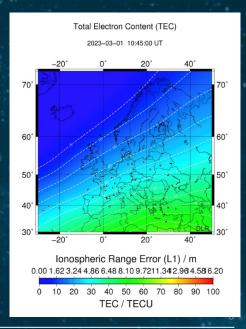
Launch: 2026



Created by UCL/ELNCSR Belgium

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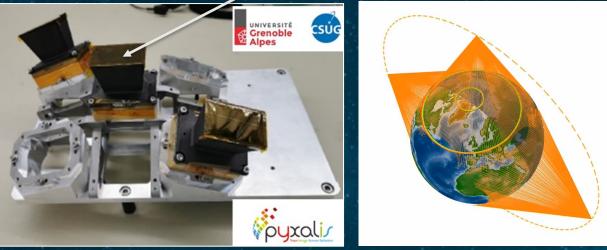




• Mission objective:

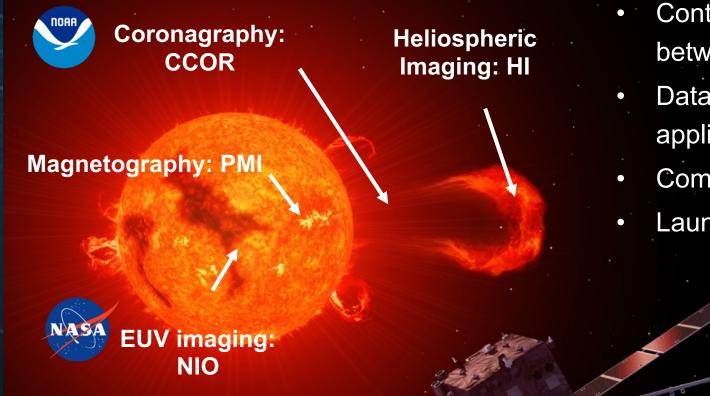
- continuous monitoring of day/night side Aurora for operational applications
- Orbit: 7000 km, polar
- Payload:
 - Wide Field Auroral Imager (WFAI)
 - Auroal Optical Spectral Imager (AOSI)
 - Auroral UV Imager (AUI)
 - Radiation Monitor & Magnetometer
- Mission implementation:
 - Aurora-D: single satellite concept demonstration: 2027
 - Aurora-C: 4 satellite constellation:
 2030 (TBC)





Vigil mission to L5





Solar wind: PLA

IMF: MAG

Continuous observations of Sun and heliosphere between Earth and the Sun

Data availability in near real-time => operational applications

Complementing observations from Sun-Earth line

• Launch: 2031 (TBC)



https://www.esa.int/Space_Safety/Vigil

International collaboration: Agencies Taking Roles in Solar Monitoring



Next steps? Sun-Earth line: NOAA L4 region? SWFO-L1 • Backside of the Sun (L3)? GOES-U (CCOR) Sun polar regions? Measurements between Sun and L1 International collaboration necessary for full coverage of the Sun! Near Earth space & CIS lunar and lunar: Many actors Away from SEL: ESA => data sharing Vigil mission to L5 •

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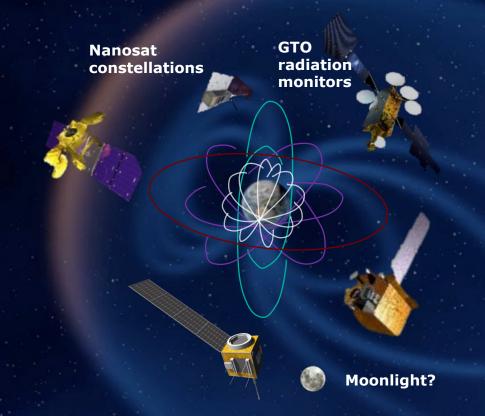
Distributed Space Weather Sensor System (D3S)



Foreseen next steps:

- Expanding nanosatellite constellation => radiation monitoring in MEO/LEO
- => plasma environment
- => Earth's magnetic field
- => ionospheric electron density
- => thermospheric density
- Cislunar and lunar environment monitoring
- Radiation monitoring from GTO
- Nanosat mission to Henon orbit

Global coverage of ground based observations



Horizon Europe: HE-SWE-01



Focus areas and non-exhaustive list of R&D areas:

Flux rope disruption Flare/CME initiation Global 3D corona CME characterization Quiet Solar Wind Kinetic Solar Wind SEP forecasting One-way couplings

Remote data assimilation

In-situ data assimilation

Forward & inverse UQ

Sun-Earth end-to-end coupling with UQ

Fully coupled geospace environment

Global hybrid models

Global multi-fluid methods

Global multi-moment

Mass/Energy injection

Solar wind/Aurora cplng

I/M/T coupling

Inner mag. current system

GIC forecasting

GCM and ionosphere

Horizon Europe: HE-SW-02





Objectives of the first call:

- Measurement targets:
 - Earth's magnetic field
 - Solar and trapped radiation
 - Galactic background radiation
 - Magnetospheric and interplanetary plasma
 - Thermosphere
 - lonosphere
- Technology objectives
 - Sensor and instrument miniaturisation
 - Performance improvement
 - Reliability
 - Ease of mounting as hosted payloads
 - Nanosat form factor

Focus of the first call

Near Earth space environment

ITT released on 31 July, Closing date 14 Nov

ESA Space Weather Service Network





- 29 pre-operational services based on >250 products
- Service user support and staffed helpdesk
- European Service Network of >50 participating entities
- > 4000 registered users
- > 3M hits on service portal monthly
- Coordinated Communication Protocol for major events

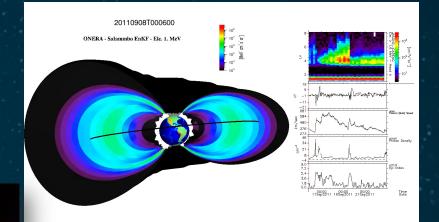
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HER RESOURCES ~	For a detailed overview of the current conditions, as well as access		
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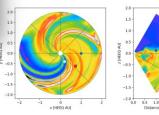
End-To-End Space Weather Modelling

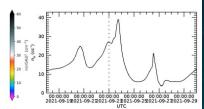


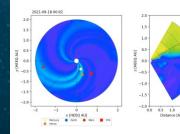
- Targeted core model development including e.g.
 - solar event onset modelling
 - CME propagation and solar wind modelling
 - global magnetospheric modelling
 - radiation belt modelling
 - 3D ionospheric modelling
- Development of **VSWMC** framework
 - Architecture for coupling models from their home environments
 - Access to all necessary observation data
 - Core model developments targeting increased accuracy
 - End-to-end modelling capability
 - Nowcasting/forecasting capability

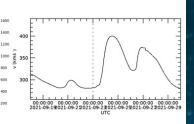


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THANK YOU

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