RAISEARTH

Research Infrastructure Services Advancing Frontier Knowledge in Sun-Earth Interactions

RAISEARTH Research Nodes

Anna Belehaki (Project Coordinator) & RAISEARTH Consortium

ESWW2026 | Florance | 2-6 November 2026

RAISEARTH Research Nodes

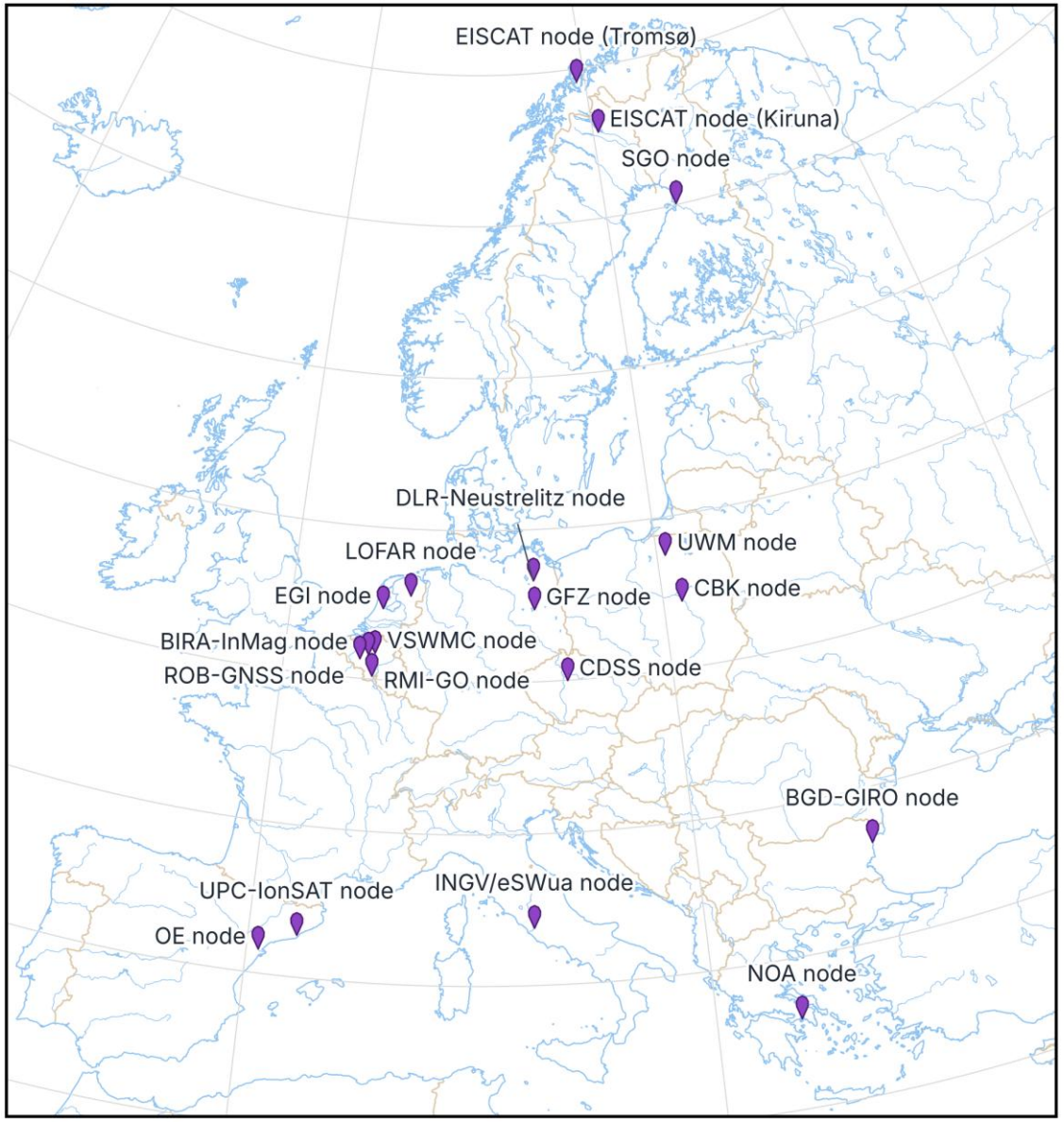
18 nodes offering Trans-National Access (TNA) and/or Virtual Access (VA)

Integration

- ✓ Observations, experiments, data, and models across the entire Sun-Earth system, from solar activity to the ionosphere and thermosphere

Access

- ✓ TNA & VA to European instruments, FAIR datasets, event catalogues, and model outputs
- ✓ AI-enabled services for event detection, forecasting, semantic discovery, data quality control, and machine-learning workflows



NOA node *(NOA, Palaia Penteli, Greece)*

TNA & VA activities

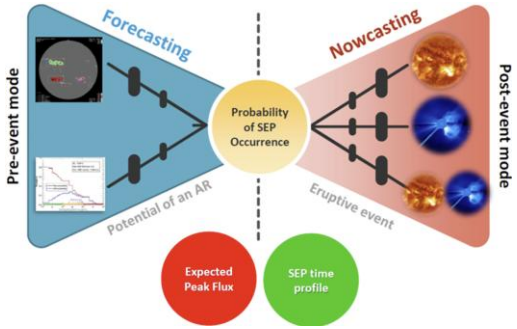
SOLAR / SEP CONTEXT
SAWS-ASPECS
energetic-particle alerts

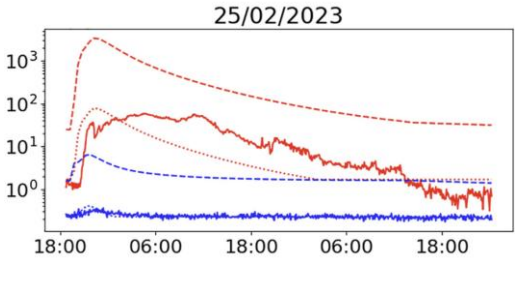
GEOMAGNETIC RESPONSE
ENIGMA
GIC indices

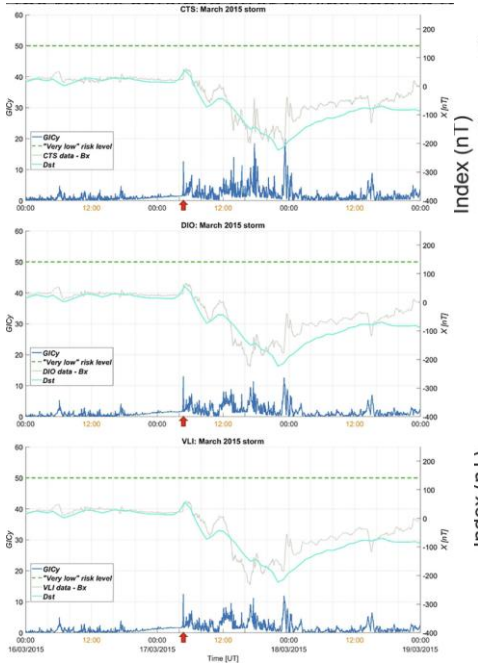
GLOBAL ACTIVITY
Swarm-derived
SYM-H • AE • ULF

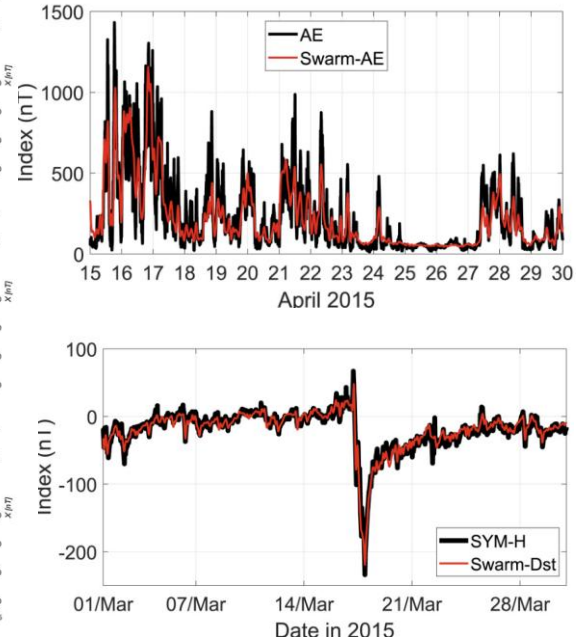
IONOSPHERIC RESPONSE
Athens Digisonde
real-time + archive

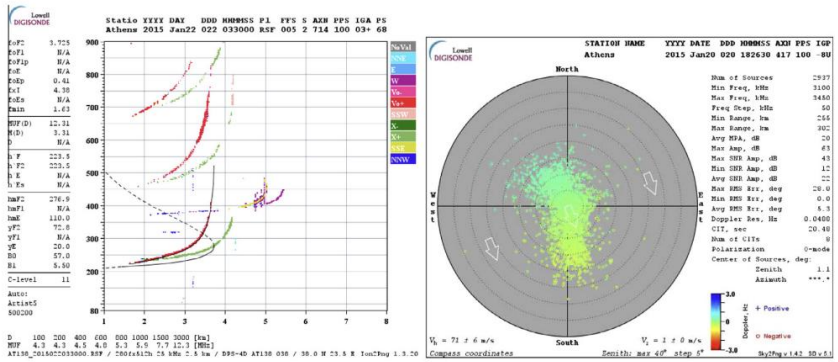
DISTURBANCE SERVICES
DIAS
TechTIDE • T-FORS

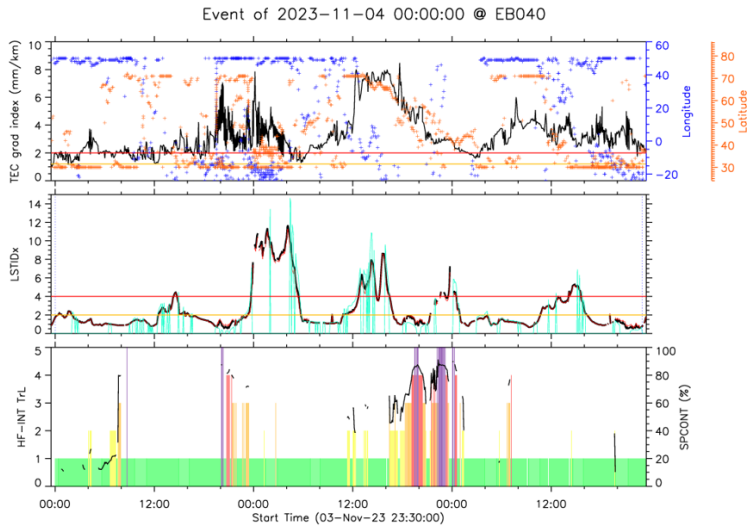












NOA contributes observations and services at several points in the chain, from energetic-particle context to geomagnetic and ionospheric response.

This multi-domain coverage positions NOA to support coordinated, event-driven experiments with complementary RAISEARTH Nodes.

NOA node *(NOA, Palaia Penteli, Greece)*

NOA integrates ionospheric, geomagnetic and heliospheric facilities with modelling and data infrastructures

Athens DPS4D Digisonde

TNA + VA | 5-min cadence; real-time + archive; custom experiments

ENIGMA geomagnetic array

TNA + VA | Magnetometer data; derived GIC indices

DIAS upper atmosphere service

VA | Ionosphere/thermosphere/plasmasphere nowcasts, forecasts + database

TechTIDE / T-FORS / DISPEC ionospheric products and workflows

VA | Real-time TID detection + AI-based LSTID forecasts + Data filters for ionogram-extracted data series

SAWS-ASPECS

TNA + VA | Solar energetic particle alerts / radiation-environment services

Swarm activity indices

TNA + VA | SYM-H, AE and ULF activity indices

EISCAT node *(EISCAT Tromsø ISR, Norway; EISCAT Kiruna ISR, Sweden)*





UHF transmitter and receiver (500 MHz)
Two parabolic dishes (32 m and 42 m)
Peak transmit power: 1.0 MW

UHF transmitter and receiver (929 MHz)
Parabolic dish (32 m diameter)
Peak transmit power: 2.0 MW

VHF transmitter and receiver (224 MHz)
Parabolic cylinder (40 m × 120 m)
Peak transmit power: 1.6 MW

EISCAT node *(EISCAT Tromsø ISR, Norway; EISCAT Kiruna ISR, Sweden)*

- Access to incoherent scatter radar experiments (custom or pre-defined)
- Historic data archive (since 1981), searchable and downloadable
- Derived ionospheric parameters (Ne, Te, Ti, plasma drift)
- Opportunities for user-driven experiments, with EISCAT support as a support instrument

CBK node *(SRC PAS, Warsaw, Poland)*

CBK PAS Node for Ionospheric Research

Warsaw HQ

Data from operational instruments and models are accessed and processed here.

Borówiec

Hosts LOFAR station PL610, enabling dedicated/local-mode ionospheric and solar observations.

Hornsund

Polish Polar Station: GNSS receivers and high-latitude scintillation measurements.

- ✓ **Scientific contribution:** expertise in high-latitude ionospheric variability, space-weather impacts on radio propagation, and polar communication performance.
- ✓ **RAISEARTH contribution:** access to data, models, observational campaigns and analytical expertise; multi-node research can combine CBK measurements with GNSS, ionosondes, riometers or other RI datasets.

CBK node *(SRC PAS, Warsaw, Poland)*

Archival observations

LOFAR PL610 dynamic spectra; ionosonde data; GPS L1/L2 phase & amplitude scintillation at 1/50 s resolution.

Models & products

Polar Radio Link (PRL1.8) data/model products;
To be considered: development of PRL3.5 for polar HF communication research.

Dedicated campaigns

LOFAR PL610 local-mode campaigns on request – when available in local mode (currently suspended due to LOFAR2.0 upgrade)

Research expertise

Luxembourg effect, fading, polar HF links, lower-ionosphere diagnostics, auroral-region dynamics and model validation.

OE node *(OE, Roquetes, Spain)*

OE Facilities

Ionospheric Facilities DPS4D Digisonde

- ✓ **DPS4D Ionosonde (EB040 Station):** Active since 2011 (upgraded from the 1955 legacy sounder) providing vertical incidence data at a 5-minute cadence, actively contributing to GIRO. Performs oblique drift measurements in synchronous operation with other European DPS4D systems.
- ✓ **Continuous Doppler Sounding System (CDSS):** Active since 2026, operating transmissions at 3.60 MHz and 7.04 MHz to detect Traveling Ionospheric Disturbances (TIDs) and infrasound activity in the ionosphere, with real-time data automatically integrated into the IAP Doppler Data Repository.

Geomagnetic & GIC Facilities

- ✓ **Geomagnetic Station (EBR):** Dedicated to continuous geomagnetic field monitoring and actively contributing to INTERMAGNET.
- ✓ **Geomagnetically Induced Currents (GICs) Monitoring:** Operational infrastructure in power transformers using Hall effect sensors and in power lines and gas pipelines using the Differential Magnetometer Method.

Livingston Island (Antarctica) Facilities:

- ✓ **AIS Ionosonde:** Operational sounder providing ionospheric measurements exclusively during the austral summer season.
- ✓ **Geomagnetic Station (LIV):** Continuous geomagnetic field monitoring.

OE node *(OE, Roquetes, Spain)*

Ionospheric, Geomagnetic & GIC Services

Ionospheric Services

- ✓ **Datasets & Archives:** Access to ionosonde datasets, historical archives (1955–present), expert-scaled ionograms, and the LSTIDs Catalogue over the European region.
- ✓ **Models & Software Tools:** Advanced climatological models and automated tools designed to detect and track TIDs, Equatorial Plasma Bubbles (EPBs), HF radio absorption caused by Solar Flares, as well as to model hmF2 variability under quiet and disturbed conditions, and the F-layer thickness and shape under quiet conditions.

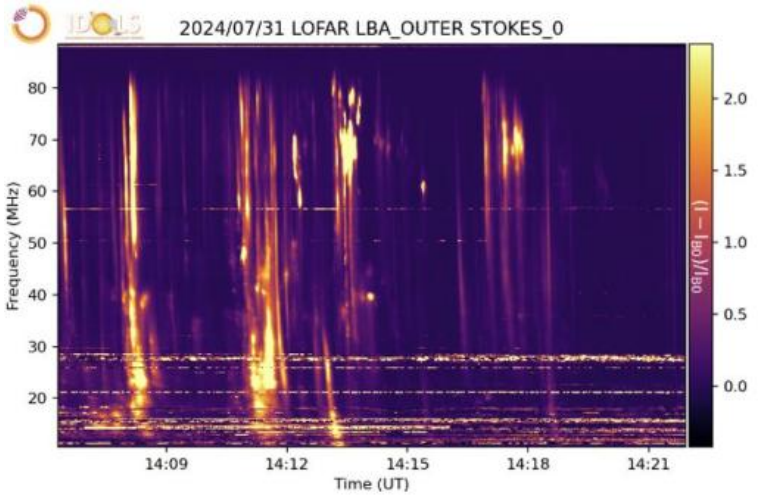
Geomagnetic & GIC Facilities

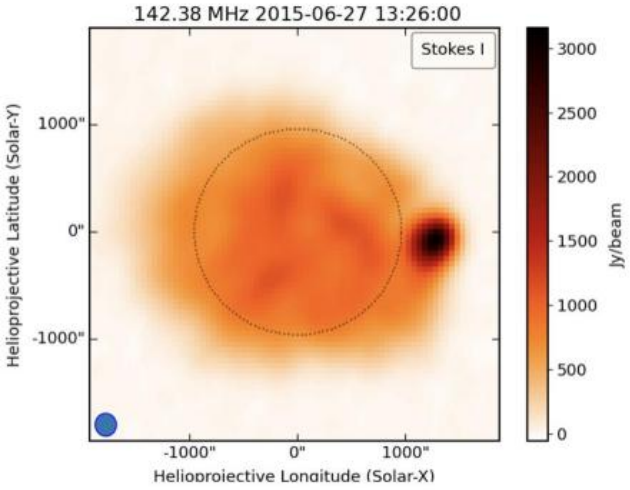
- ✓ **Geomagnetic Field Data:** High-resolution continuous observations of horizontal field components (X, Y) and their temporal derivatives (dX/dt, dY/dt), to identify and analyse Rapid Magnetic Variations (Storm Commencements and Solar Flare Effects).
- ✓ **Geomagnetic Storm Index:** Local K-index computed from horizontal components to quantify magnetic disturbances and classify geomagnetic storm levels.
- ✓ **Induced Electric Fields:** Real-time estimations of North (E_x) and East (E_y) geoelectric field components near the OE site.
- ✓ **GIC Monitoring and Modelling:** GIC direct measurements in power transformers and indirect measurements in power lines and gas pipelines. Quasi-real-time simulations across the entire Spanish power and gas transmission grids.
- ✓ **Expert Consultation:** Expertise in the design, instrumentation setup, and deployment of new geomagnetic stations.

LOFAR node *(NWO-I ASTRON, Dwingeloo, The Netherlands)*

LOFAR solar data products

- ✓ Solar dynamic spectrum (Background subtracted and calibrated)
- ✓ Solar interferometric radio images (Using LOFAR core baselines and SIMPL pipeline)





Solar Pipelines

- ✓ Dynamic spectra
  - Pipeline status
    - Background Subtraction
    - Calibration with CasA beam
    - Instrument beam correction
    - Full automatic run and catalogue
- ✓ Imaging
  - Pipeline status
    - Calibration of Core stations
    - Full automatic run and catalogue

LOFAR node *(NWO-I ASTRON, Dwingeloo, The Netherlands)*

LOFAR ionospheric data products

- ✓ Scintillation data
  - Power
  - S4
  - Plasma drift velocities

  PNG, JSON, FITS data files

- ✓ Calibration data products
  - Differential integrated total electron content
  - Differential Faraday rotation

  Hdf5 data files

Ionosphere Pipelines

- ✓ Dynamic spectra
  - Pipeline status
    - Power spectra, S4 index, velocities
    - Full automatic run and catalogue

- ✓ Calibration Data
  - Pipeline status
    - Hdf5 file creation automatic product from standard LOFAR pipelines
    - Extract and catalogue

TNA: Training, support and usage of historic data products

SGO node *(UOULU, Sodankyla, Finland)*

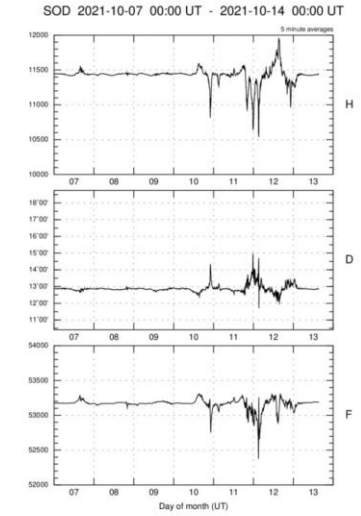
Trans-National Access Services

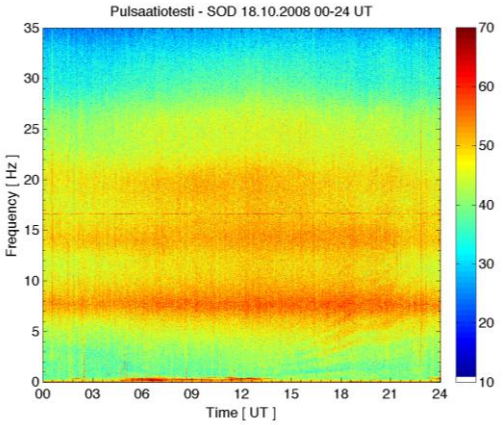
Services offered

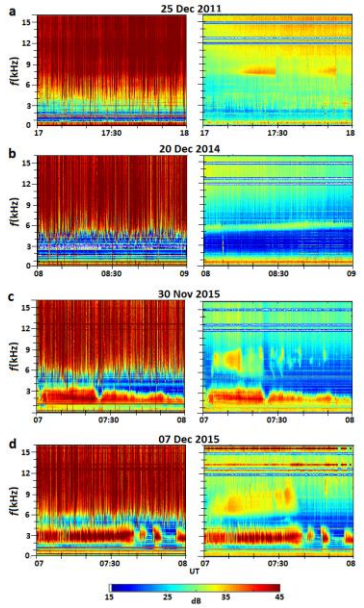
- ✓ Access to magnetometer/pulsation magnetometer/riometer networks.
- ✓ Access to space weather observational facilities (ionosonde, all-sky, and KAIRA datasets).
- ✓ Access to experimental innovations (coordinated EISCAT – KAIRA - LOFAR – CDSS campaigns).
- ✓ Analysed ELF-VLF data.
- ✓ Access to cosmic ray data

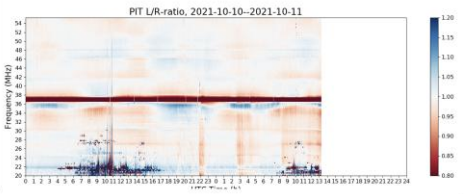
New Areas Opening to Users

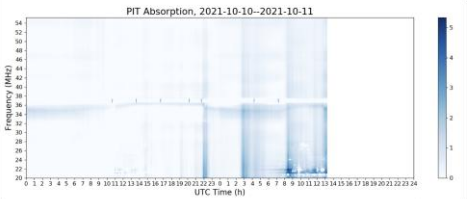
- ✓ CHAMOS and SIC introduction for different scientific topics.
- ✓ New ionospheric data products.

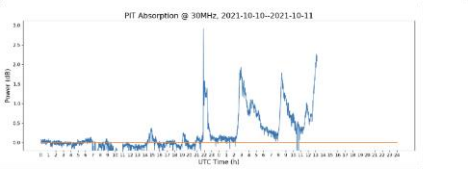












SGO node *(UOULU, Sodankyla, Finland)*

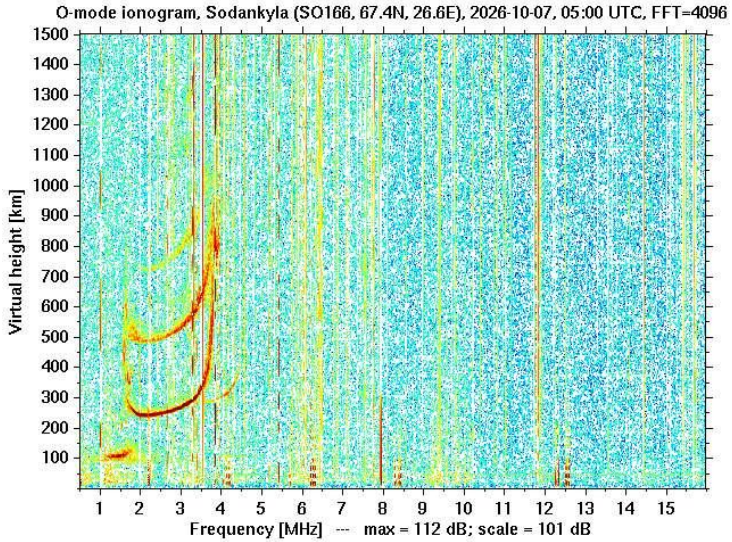
Virtual Access Services

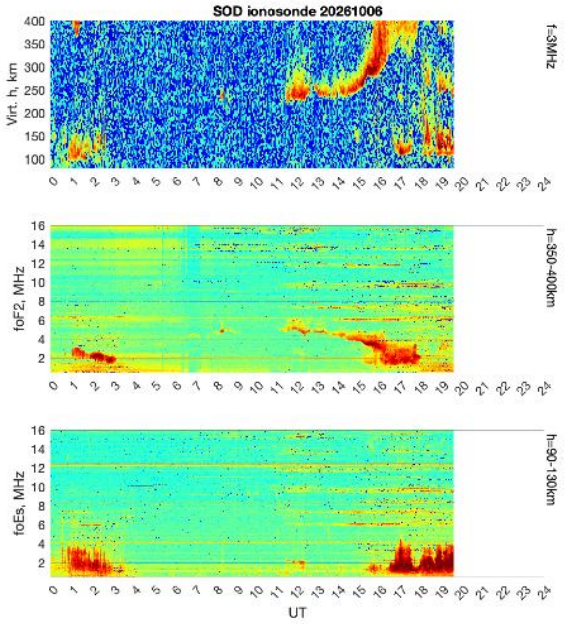
Services offered online

- ✓ Substorm catalogues and geomagnetic pulsations Pc5
- ✓ Access to all data mentioned in TNA

AI-enhanced Services (via e-Science Centre)

- ✓ Ionospheric irregularities from ionosondes; substorms from magnetometers





UPC-IonSAT node *(UPC, Barcelona, Spain)*

Trans-National Access Services

Offered Services

- ✓ Real-time VTEC GIMs (IGS products) for GNSS service providers and aviation.
- ✓ Solar flare detection tools (SISTED, SOLERA) operating at 30s cadence.
- ✓ Scintillation monitoring (ROTI) for GNSS degradation awareness.
- ✓ Medium Scale Travelling Ionospheric Disturbances monitoring (SRMTID).
- ✓ Access to long-term tomographic archives (1996–today) via e-Science Centre (DISPEC HORIZON project).
- ✓ Support for training and visiting PhD/postdocs using datasets and tools.

Users & Access

- ✓ UPC-IonSAT products are routinely used by IGS, ESA, and aviation stakeholders. Each year, the node supports around 5–10 international scientific teams combining data with their own models. Several PhD students and postdocs visit annually; others access remotely due to funding or logistical constraints.

New Areas Opening to Users

- ✓ GNSS bias studies for improved positioning and navigation.
- ✓ LEO-GNSS based ionospheric modelling projects.
- ✓ Mitigation techniques for scintillations and HF radio interference
- ✓ Multi-node collaboration for improving radio astronomy corrections (e.g., Faraday rotation for LOFAR).

UPC-IonSAT node *(UPC, Barcelona, Spain)*

Virtual Access Services

Virtual Access to

- ✓ Global Ionospheric Maps (GIMs): final, rapid, and real-time products of vertical TEC (VTEC), updated every 15 minutes to 2 hours.
- ✓ Real-Time GNSS data streaming: over 200 worldwide stations.
- ✓ Solar flare detectors (SISTED, SOLERA-DRIFT): identify and characterise solar flares from GNSS data.
- ✓ Scintillation and MSTID proxies: ROTI and SRMTID activity derived from GNSS networks.
- ✓ Historical two-layer tomographic ionosphere maps and derived products since 1996, local, and, since 2026, via e-Science Centre (DISPEC).

VSWMC node *(KU Leuven, Leuven, Belgium)*

Virtual Space Weather Modelling Centre (VSWMC)

KU Leuven provides federated space weather services to the ESA Space Weather Network: Virtual Space Weather Modelling Centre (VSWMC)

- ✓ An open end-to-end (Sun-to-Earth) space weather modelling system,
- ✓ enabling interactive running (≠ CCMC) & "coupling" various space weather models in an integrated tool (≠ CCMC),
- ✓ with the models located either locally or geographically distributed (≠ CCMC)

VSWMC models

Solar corona models

- ✓ Multi-VP
- ✓ Wind-Predict
- ✓ EUHFORIA-corona (WSA)
- ✓ COCONUT
- ✓ COCONUT-TDm/RBSL

Inner heliosphere wind and CME evolution models

- ✓ EUHFORIA
- ✓ ICARUS
- ✓ HELIOCAST

SEP models

- ✓ SPARX
- ✓ PARADISE (/PARASOL)

Magnetosphere models

- ✓ GUMICS-4
- ✓ GORGON-Space

Inner magnetosphere models

- ✓ CTIP (limited)
- ✓ NARMAX-SNRB
- ✓ BPiM (Plasma sphere)
- ✓ NARMAX-SNGI (Kp + Dst)
- ✓ Dst, Kp, magnetopause stand-off distance
- ✓ MCM-DTM
- ✓ DICTAT & IMPTAM
- ✓ CTIP extended

(operational and operational soon)

VSWMC node *(KU Leuven, Leuven, Belgium)*

Trans-National Access Services

Offered services

- ✓ Access to the Virtual Space Weather Modelling Centre (VSWMC).
- ✓ Support for user simulation campaigns.
- ✓ Model coupling experiments.

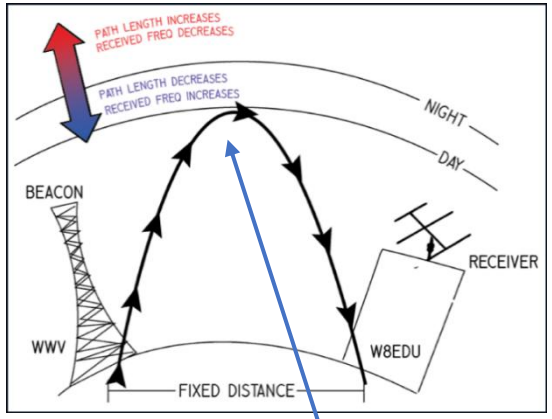
Virtual Access Services

Users & Access

- ✓ End-to-end Sun-Earth simulations.
- ✓ Coupled solar-heliosphere-magnetosphere-ionosphere modelling workflows.
- ✓ Access to approximately 20 space weather models and 20 model couplings.

CDSS node *(IAP, Prague, Czechia)*

Continuous Doppler sounding and Ionosonde



Information on wave amplitude and phase at a specific reflection point (height obtained from ionogram)

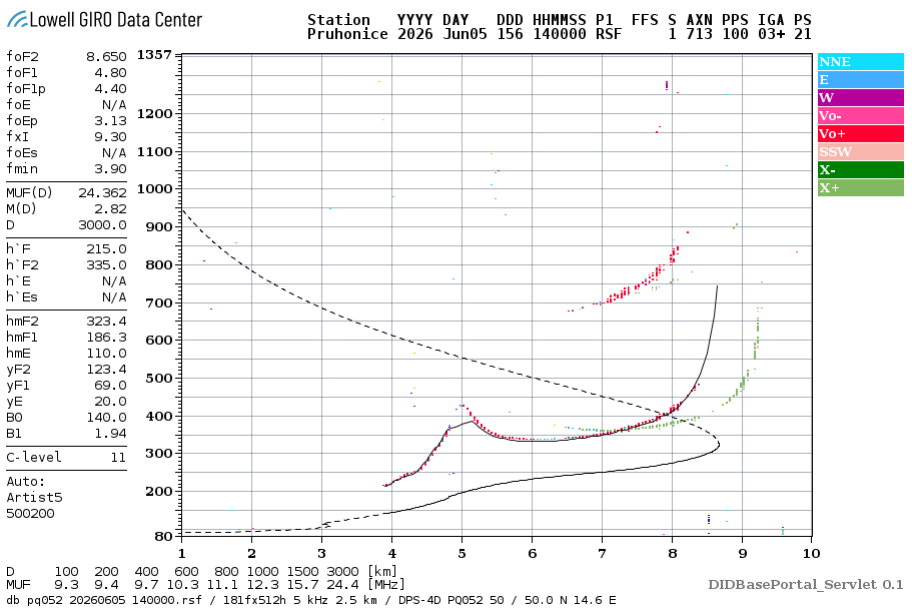
Doppler shift → Vertical oscillation velocities of plasma/air due to the waves

multi-point and multi-frequency sounding → propagation velocities from time delays between different sounding paths

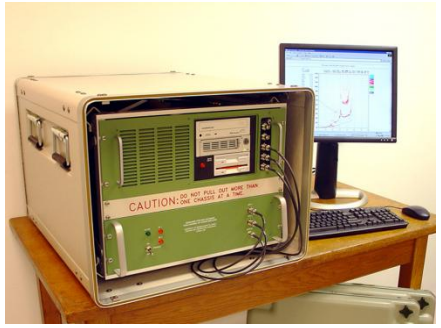
Limited spatial coverage, but high time resolution.

Continuous X **Pulse transmission**

(high time resolution) (electron density profile)







GNSS: Integral values of Total Electron Content along LOS

TEC (dTEC) maps (good spatial coverage)

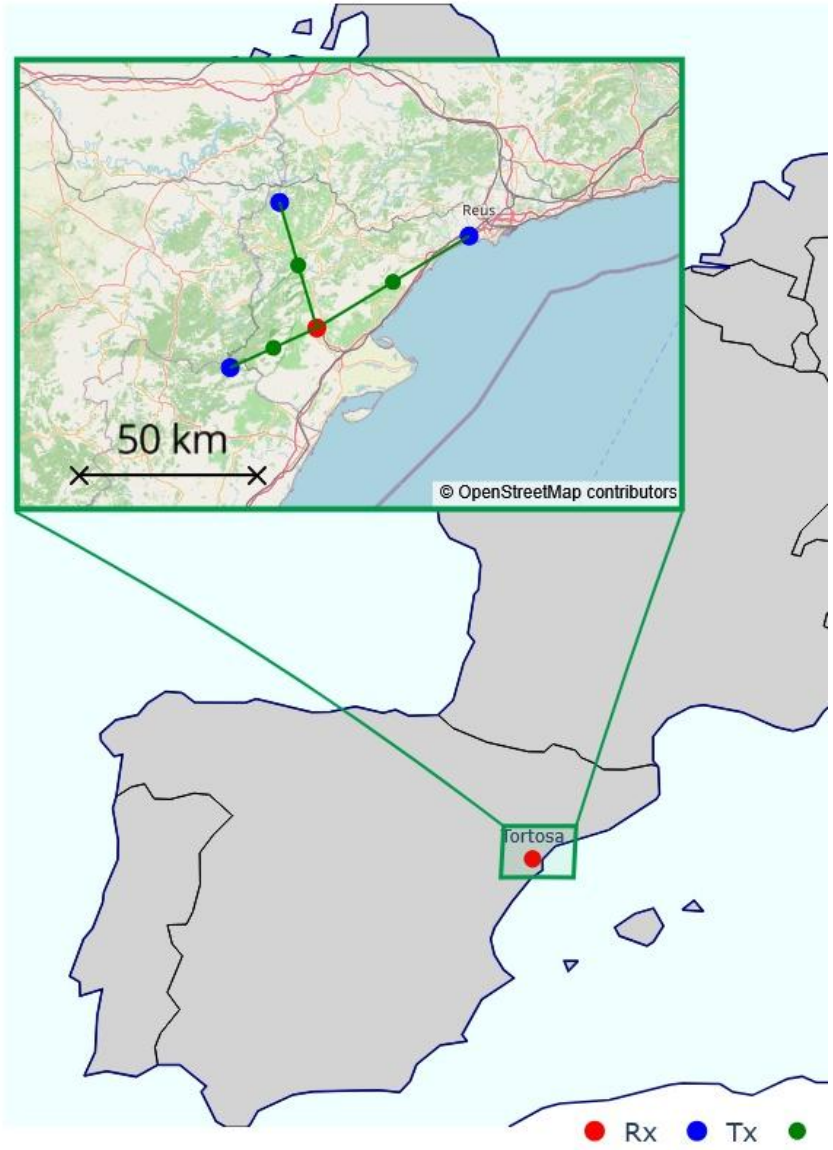
Apparent horizontal velocities from keograms (time evolution), time- distance plots

CDSS node *(IAP, Prague, Czechia)*

International network of Doppler sounding, reflection height from ionosondes)



o **Receiver**
x **Transmitter (1 W)**



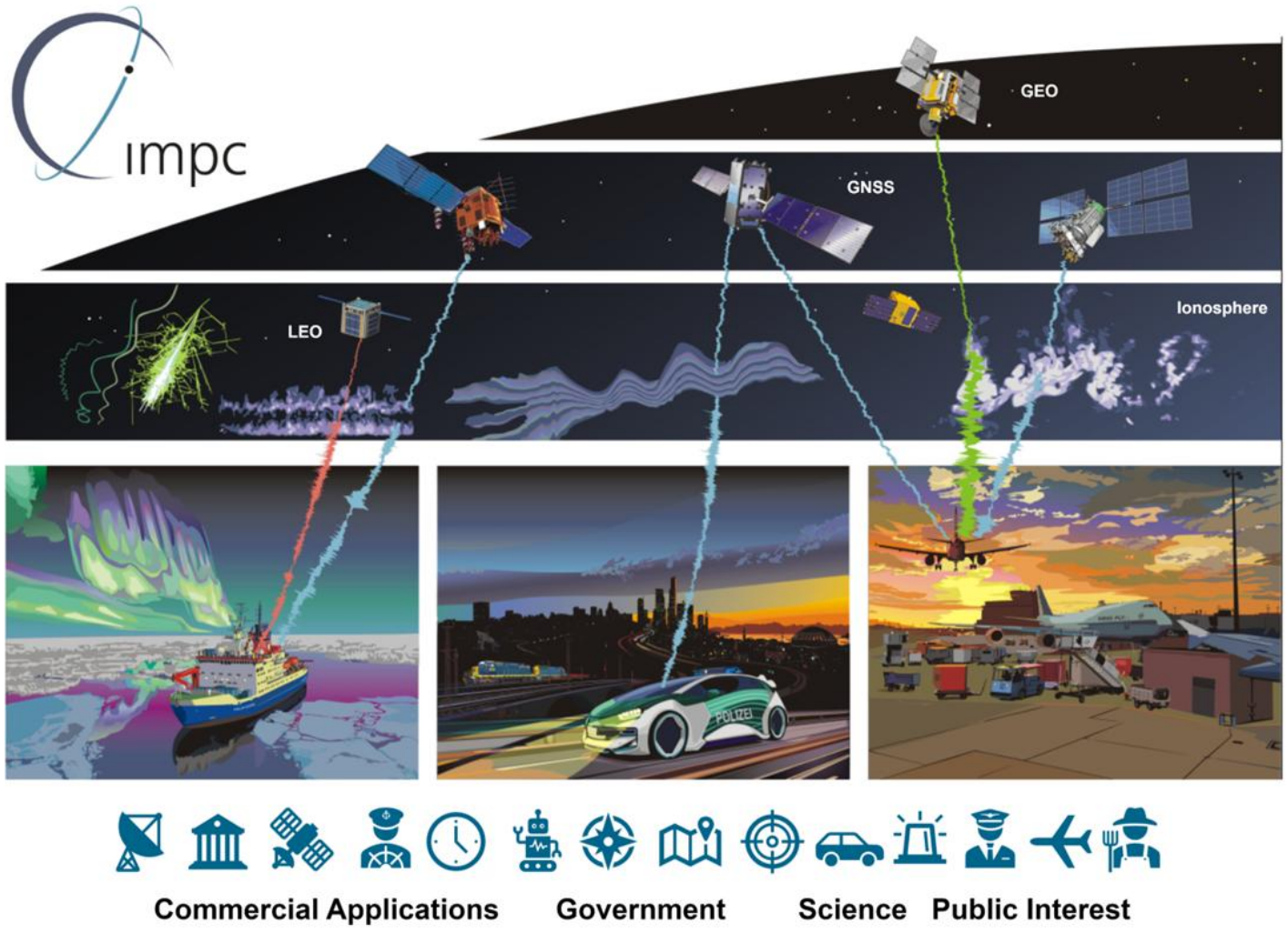
Multi-point systems
Multi-frequency sounding (Czechia, Argentina)

Outside Europe - **Taiwan, Argentina, South Africa**

Recent installations: Antarctica, **Spain** (May 2026)

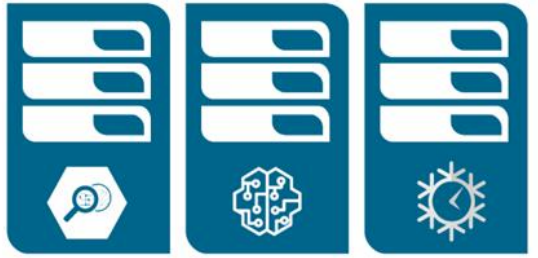
DLR-Neustrelitz node *(DLR, Neustrelitz, Germany)*

Ionosphere Monitoring and Prediction Center (IMPC)



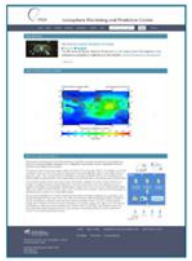


Global ground and space based observations

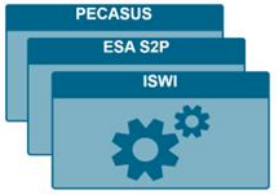




Data Archive since 1995



Web Portal



Tailored Services



User Help Desk

DLR-Neustrelitz node *(DLR, Neustrelitz, Germany)*

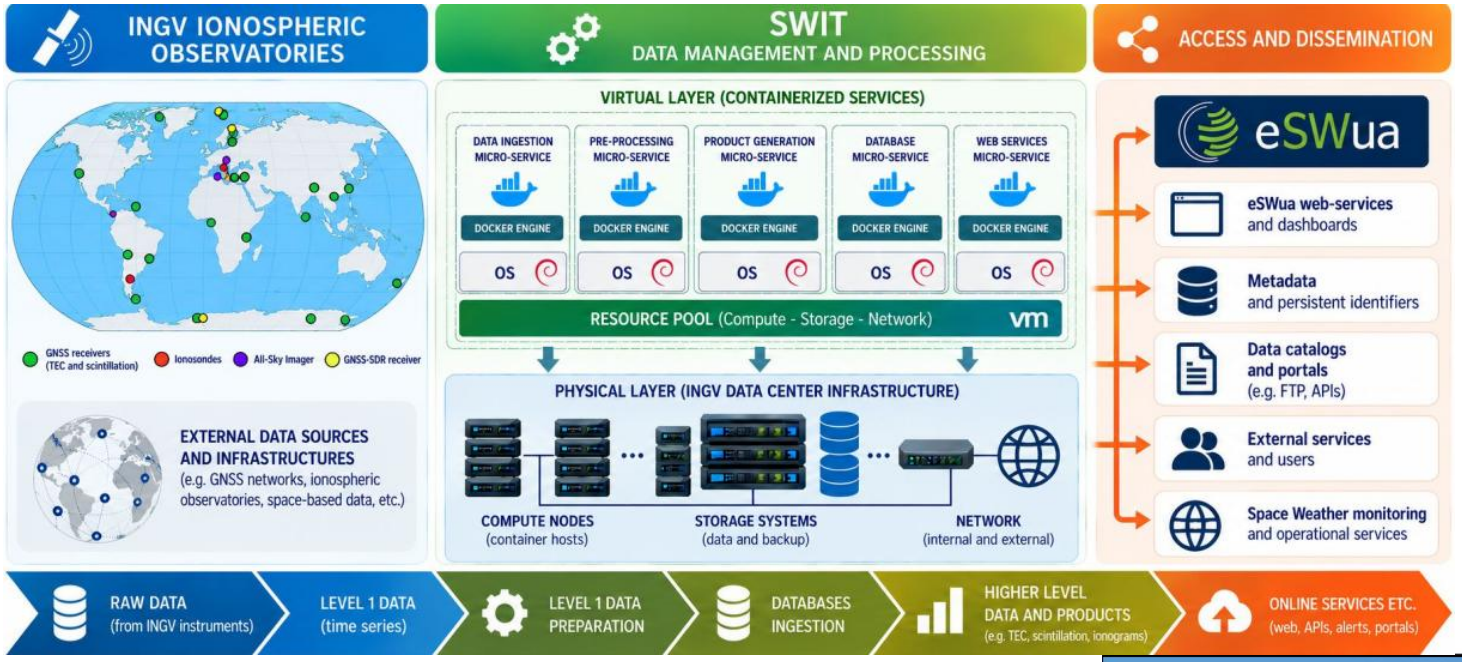
Offered Products

- ✓ TEC Nowcast & Forecast maps; Forecasting 24-Hour Global TEC with LSTM Neural Network
- ✓ ROTI maps
- ✓ Scintillation Indices
- ✓ High rate GNSS Data
- ✓ GPI
- ✓ CALLISTO - Solar Radio Burst Monitoring (Data: Broadband dynamic spectra)
- ✓ GIFDS - Solar Flare Monitoring (Data: VLF amplitude measurements)
- ✓ NEDM API
- ✓ NTCM-G API

New Areas Opening to Users

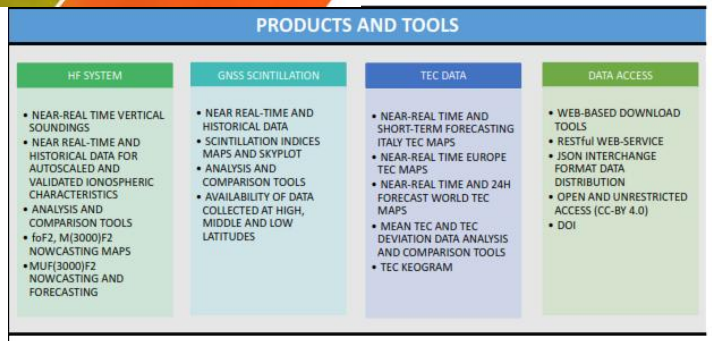
- ✓ Apply a Long Short-Term Memory (LSTM)-based Total Electron Content (TEC) model (Adolfs et al., 2024) for forecasting the ionospheric state
  - Trained on 2 solar cycles of data (1998–2020)
  - The model uses 3-day of historical TEC and predicts 1 up to 24 hours ahead
- ✓ Use real-time data to drive the LSTM-based TEC forecasting model
  - Real-time Global Ionosphere Maps (GIMs): IRTG or UADG products
  - Or TEC provided by IMPC

INGV/eSWua node *(INGV, Rome, Italy)*



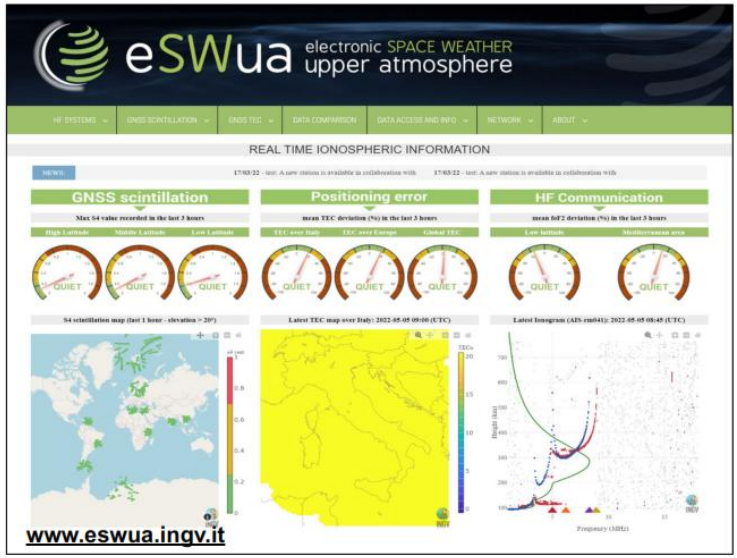
SWIT: Space Weather Information Technology system

eSWua: tools and services for web-based data access



CC BY

eSWua provides open and unrestricted access to all its data collections and products under the CC BY 4.0 license.



FAIR {REST:API} {JSON}

INGV/eSWua node *(INGV, Rome, Italy)*

Trans-National Access Services

TNA opportunities

- ✓ INGV headquarter in Rome with: AIS-INGV ionosondes; IT System for data managing and service provision; space weather monitoring room.
- ✓ Ionospheric Observatory of Gibilmanna (Sicily) with: All-sky imager; DPS-4D ionosonde.
- ✓ Ionospheric observatory of La Spezia with: AIS-INGV Ionosonde.

Virtual Access Services

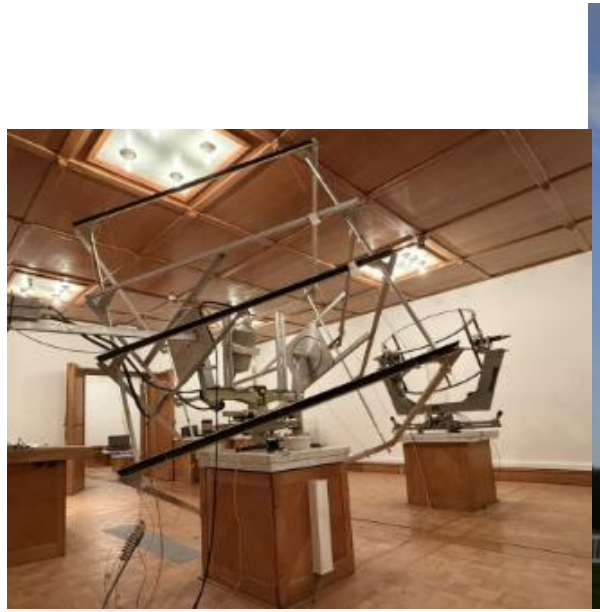
Offered products

- ✓ GNSS TEC data and products; GNSS TEC alerting maps
- ✓ GNSS Scintillation data and products; GNSS Scintillation alerting maps
- ✓ Ionosondes data and products
- ✓ Forecasting of Large Scale Travelling Ionospheric Disturbances over Europe
- ✓ Nowcasting of LSTID and dTEC Keogram over Europe

RMI-GO node *(RMI, Dourbes, Belgium)*

The Geophysical Observatory operates a wide range of instruments useful for space weather research

- ✓ State of the art DPS4D ionosonde
- ✓ Supporting ionospheric instruments: RIOMeter, GNSS receivers, Doppler sounder
- ✓ Geomagnetic observatory providing real-time data at 1 Hz
- ✓ NM64 neutron monitor for cosmic-ray detection, other particle detectors soon to be operational
- ✓ Meteorological data, seismic data, meteor observations







RMI-GO node *(RMI, Dourbes, Belgium)*

Services offered

- ✓ Access to RMI-GO instruments (and know-how) for dedicated experiments & campaigns New ionospheric data products
- ✓ Access to long series of high-quality data (the Observatory was established in 1952)
- ✓ Provision of curated datasets on demand (e.g., manually scaled ionograms)



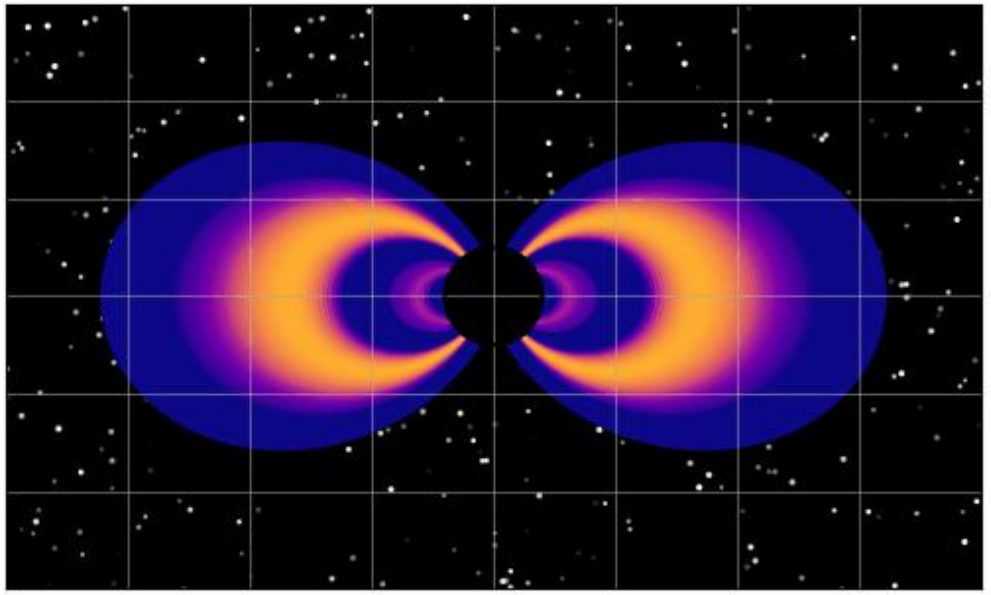
Because of its location, the RMI-GO node provides many opportunities for joint and oblique campaigns

BIRA-InMag node *(BIRA, Brussels, Belgium)*

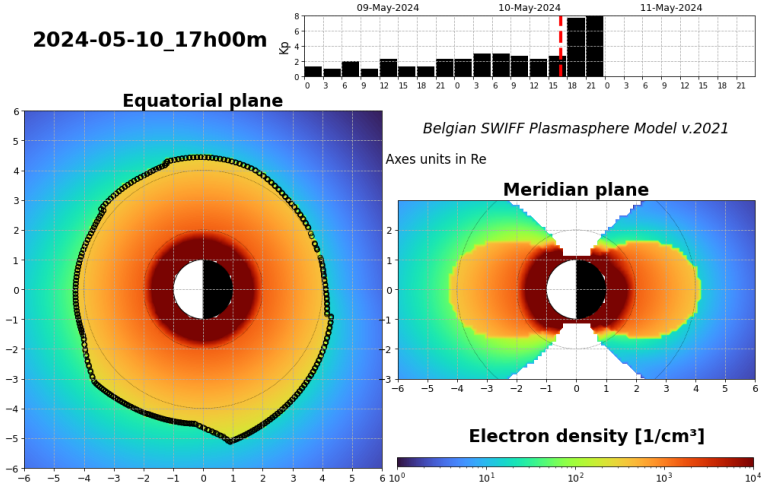
2 models of inner magnetosphere for both TNA and VA projects

- ✓ BSPM model
- ✓ ERB.AI model

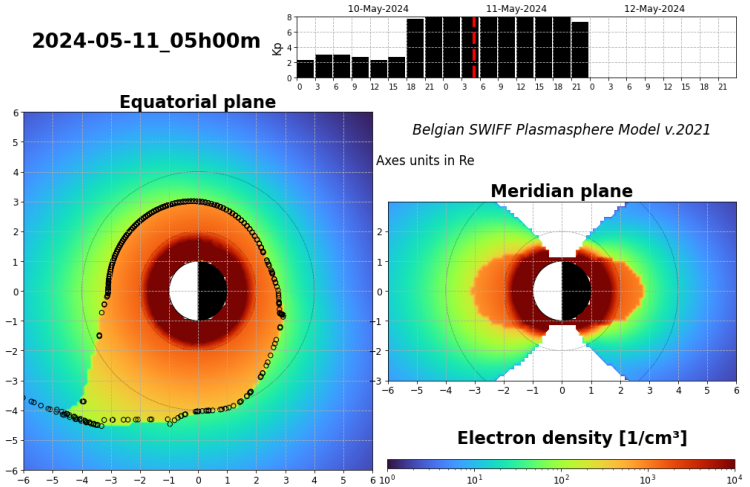
2024-05-01T12:00:00.000000000



11 May 2024 storm - Before



11 May 2024 storm - After



BIRA-InMag node *(BIRA, Brussels, Belgium)*

BSPM model

- ✓ 3D semi-dynamic kinetic model of the Earth's plasmasphere
- ✓ BSPM model of plasmasphere-ionosphere
  - PITHIA e-Science Centre https://esc.pithia.eu
  - ESA http://swe.ssa.esa.int space radiation
  - NASA https://ccmc.gsfc.nasa.gov
- ✓ BSPM Fortran-IDL ancient version
  - Routinely running since 2017 at https://swe.ssa.esa.int/bira-swiff-federated in real time

ERB.AI model

- ✓ Artificial Intelligence for Earth's Radiation Belts Understanding and predicting energetic particles in near-Earth space
  - *Data Sources:* It was trained using 11 years of space radiation measurements collected by the Energetic Particle Telescope (EPT) aboard the PROBA-V satellite, combined with solar wind and geomagnetic data.
  - *Architecture:* It utilizes a Long Short-Term Memory (LSTM) recurrent neural network architecture, making it well-suited for processing and simulating sequential time-series space data.

UWM node *(UWM, Olsztyn, Poland)*

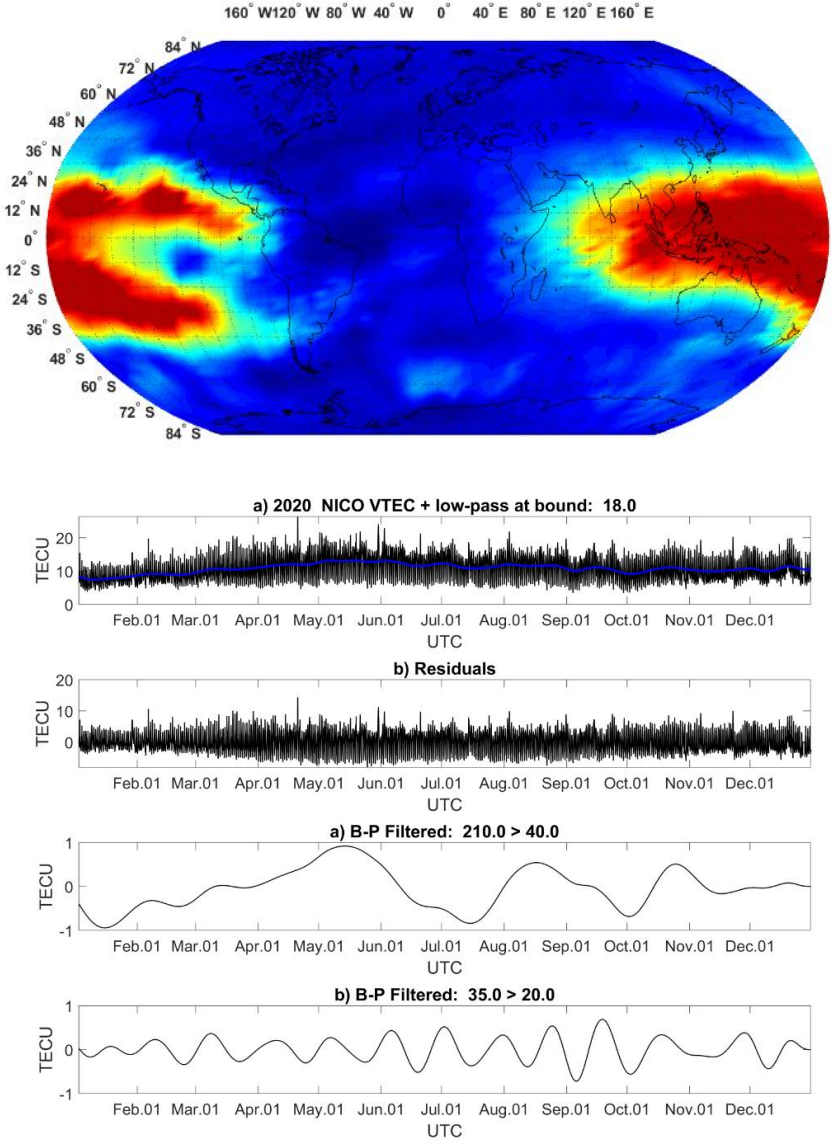
Trans-National Access Services

Offered Services

- ✓ Access to GNSS data and processing methods for ionospheric analyses (existing datasets: IGS stations, RINEX processed to TEC).
- ✓ Ionospheric data modelling (spherical harmonics/splines/kriging) (global/regional/local VTEC maps – e.g. UWMG).
- ✓ Cleaning, reconstruction and filtering of data time series with the use of spectral analysis (filtered in multiple scales: VTEC series, soalr wind (OMNI) series, Swarm Ne tracks, Swarm B-field tracks).
- ✓ Contribution to European ionospheric data networks.

New Areas Opening to Users

- ✓ Expansion of GNSS-based space weather monitoring.
- ✓ Validation of new ionospheric models using various data types.
- ✓ Opportunities for integration with multi-node projects.

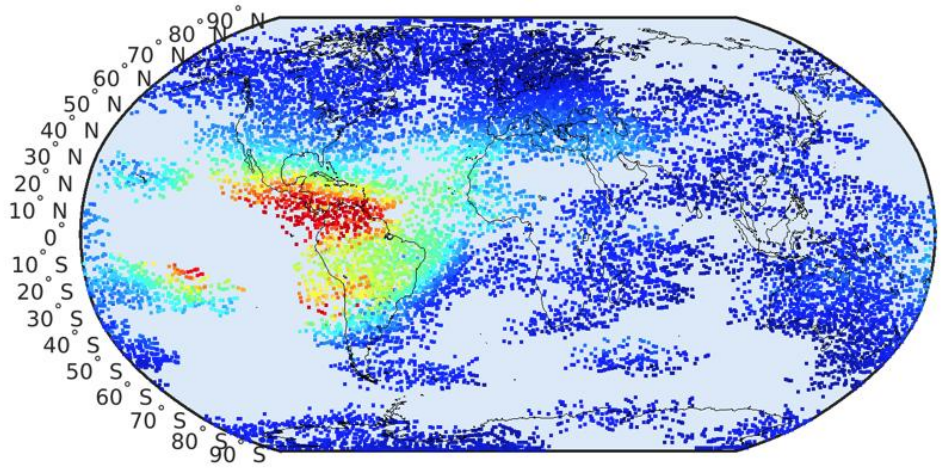


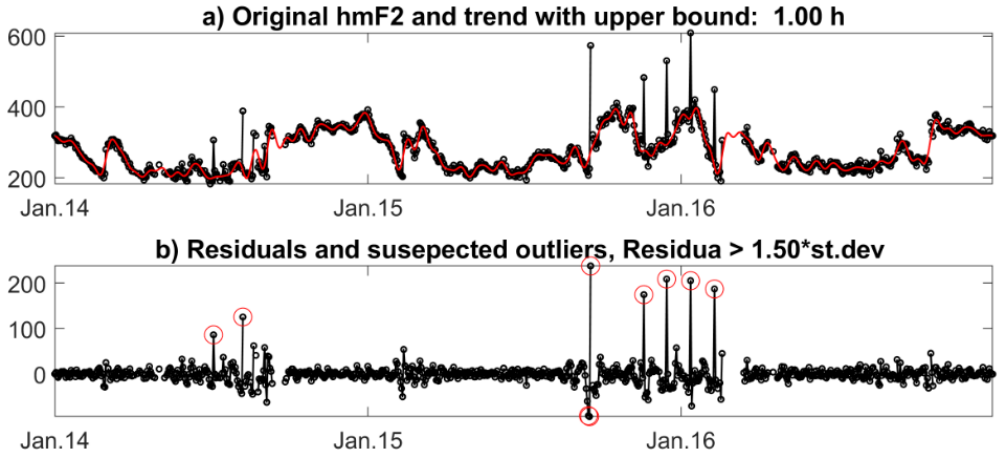
UWM node *(UWM, Olsztyn, Poland)*

Virtual Access Services

Offered Services

- ✓ RINEX to TEC conversion software (STEC/VTEC)
- ✓ Frequency-domain data processing: outlier cleaning, gap filling and detrending (time series or along-track data, or other series ... 1D)
- ✓ Database of event-related data (ground-based and satellite data) processed in frequency-domain (solar/ionospheric storms, solar flares, Bz variations, Bt increase ...)





EGI node *(EGI, Amsterdam, The Netherlands)*

Operates the PITHIA e-Science Centre web portal

- ✓ Supports discovery and re-use of data covering all physical processes in the Sun–Earth interactions
- ✓ Provides centralised access to datasets and models for near-Earth space domain from all other RAISEARTH nodes
- ✓ Offers storage for datasets generated as model outputs
- ✓ Hardware resources at CNRS in Strasbourg, France (100 vCPUs, 380 GB RAM, 12 TB storage)

New Areas Opening to Users

- ✓ Full-chain integration from Solar activity to ionospheric/thermospheric responses
- ✓ AI-powered services for event detection, semantic discovery, quality control, and forecasting

EGI node *(EGI, Amsterdam, The Netherlands)*

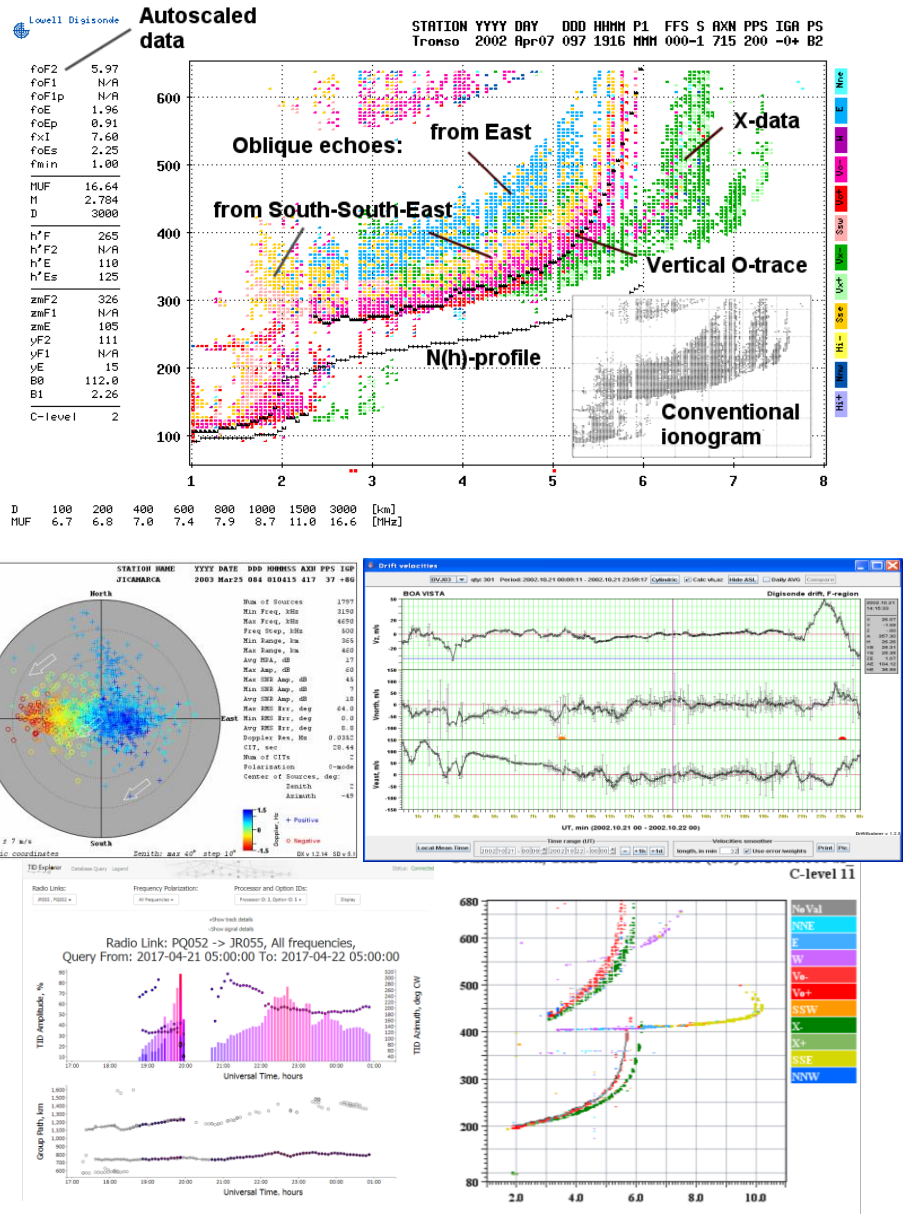
Services and Tools in the e-Science Centre

- ✓ Web portal w/ harmonized VA access to key EU national and regional observation facilities and RIs
- ✓ Included data sources:
  - Solar monitoring: Data from LOFAR-solar mode and satellite missions
  - Solar wind and interplanetary medium: Data from ACE, DSCOVR
  - Magnetosphere / plasmasphere: CLUSTER, Swarm, ground-based magnetometer arrays, auroral cameras
  - Ionosphere and thermosphere: EISCAT, LOFAR, Swarm, CHAMP, DEMETER, Ionosonde & Digisonde stations, Doppler Sounders, VHF receivers, riometers, VLF receivers, GNSS receivers
  - Coupling data products: Solar-to-ionosphere coupling indices
- ✓ Included services:
  - Event catalogues: Solar flares, Solar Energetic Particles, Coronal Mass Ejections, high-speed streams, geomagnetic storms, substorms, LSTIDs, MSTIDs
  - Prediction services: Near-real-time (NRT) solar wind propagation models (EUHFORIA), magnetospheric forecasts, solar-wind-driven forecast models
  - Data assimilation products: Coupled reconstructions that integrate ground + satellite data across domains (e.g. NOA Hybrid-NeQuick-TaD model, the DLR NEDM model, UPC Tomography maps)
- ✓ Included AI/ML tools:
  - Core AI-enabled services: data harmonization, demo forecasting tools, smart semantic search
  - AI-enhanced services: automated event detection; data curation tools; forecasting, uncertainty quantification, and explainability tools
  - User-facing AI utilities and VREs where users can apply ML pipelines to RI data

BGD-GIRO node *(BGD, Varna, Bulgaria)*

Sensor instrumentation of Global Ionosphere Radio Observatory (GIRO)

- ✓ Ionosondes
  - Multiple data products at LGDC
- ✓ Ground GNSS receivers
  - On-demand download high-resolution VTEC data: Madrigal
  - On-demand download global VTEC maps: GIM (Olsztyn, Poland), also 27-day average GIM
  - In progress: MEDUSA (Multi-source Engine for Data Unification and Satellite Analysis)
    - OASIS open-source engine for RINEX-to-VTEC conversion, etc.
    - Why Lowell? NRT monitoring is pursued for data fusion with ionosondes; current latency is too high
- ✓ Model computations at LGDC: IRTAM 3D and RayTRIX



BGD-GIRO node *(BGD, Varna, Bulgaria)*

Offered services

- ✓ Ionogram and ionogram-derived data in DIDBase
- ✓ IRTAM 3D global model
- ✓ RayTRIX online raytracing systems
- ✓ Doppler spectra, skymaps, and bulk velocities in DriftBase
- ✓ TID detection in D2D spectra
- ✓ Listen-only Digisonde mode
- ✓ MEDUSA system for GNSS
- ✓ GIRO data fusion products

Indicative detection/forecasting scenarios with GIRO

- ✓ Already existing:
  - Detection of TID in progress (TechTIDE)
  - Forecast of LS-TID events (T-FORS)
- ✓ Proposed for implementation:
  - Automatic detection of MUF(3000) depression areas for PECASUS
  - Detection of slab thickness anomalies above 1,500 km
  - Detection of signatures of natural hazards in the ionosphere
    - Earthquake signatures

ROB-GNSS node *(ROB, Brussels, Belgium)*

VA activities

GNSS Group Activities

Royal Observatory of Belgium

Expertise

- ✓ GNSS geodesy and network coordination
  - 500+ GNSS coordinated @ROB
  - Historical data center since 1996
- ✓ GNSS geodesy and services
  - Contribution to EPOS
    - Data Provider, GNSS services, governance and coordination
    - Development and operation of the M3G metadata system
    - GNSS network management and quality control
    - Access to GNSS data repository
- ✓ Data management and FAIR data practices
  - FAIR-GNSS Data Practices
  - GNSS.be Open Data Portal
- ✓ GNSS-based Space Weather
  - Ionospheric activity monitoring
- ✓ Space Weather Education Centre (SWEC)

Space Weather Education Centre (SWEC)

SWEC Space Weather Education Centre

Solar-Terrestrial Centre of Excellence

RMI

BIRA-IASB

Bridging space weather research, operations and user training

- ✓ Provides professional training on the Sun-Earth system, space weather phenomena, and their impacts on modern technologies.
- ✓ Combines expertise from scientific research, operational forecasting, engineering, and space missions.
- ✓ Delivers tailored training and outreach activities for end users from sectors such as GNSS, telecommunications, aviation, military and energy.

ROB-GNSS node *(ROB, Brussels, Belgium)*

VA activities

Web services to provide access to GNSS data (Belgium/EPN in EPOS)

- ✓ Integration in e-Science Centre
- ✓ Evaluation of level of FAIR-ness using FAIRsFAIR matrix
- ✓ Assessment of AI-readiness
- ✓ Improvement of web services, underlying metadata and PID

Web services to provide access to GNSS-based ionosphere products

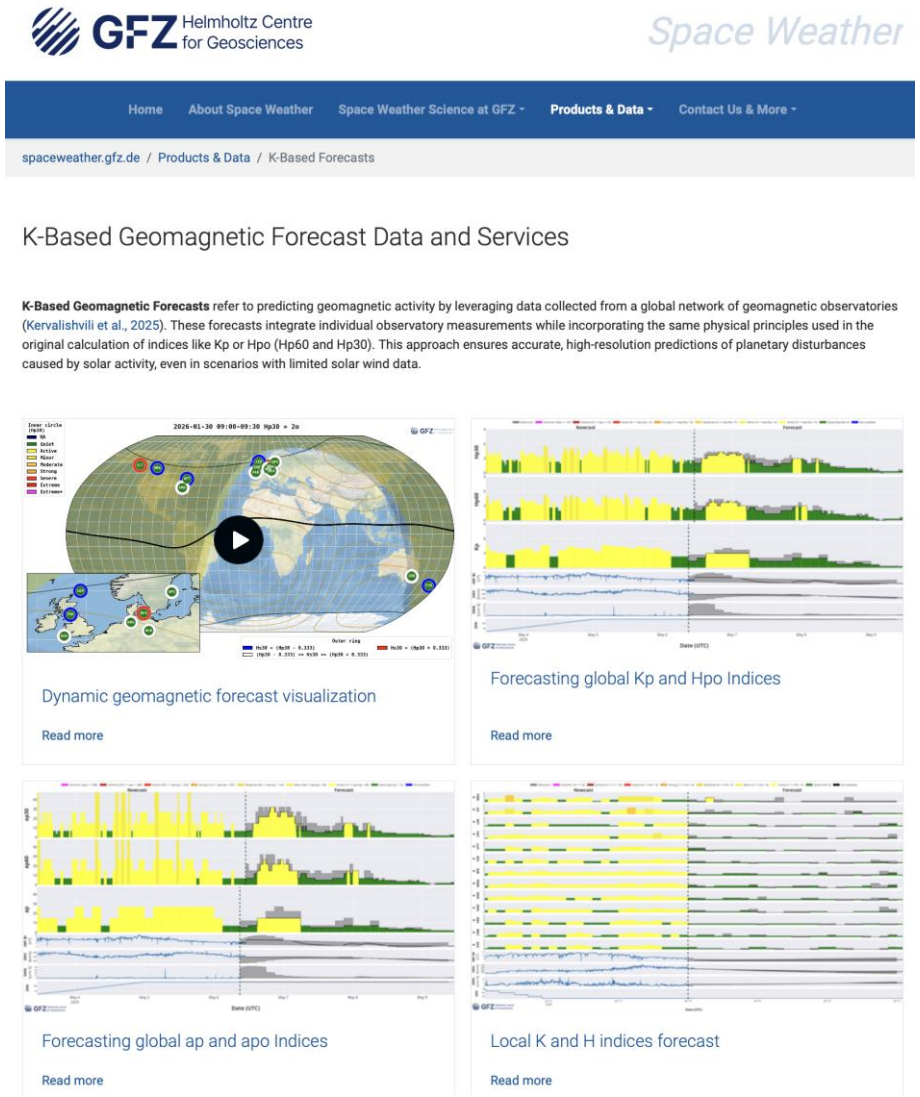
- ✓ European 5-min NRT TEC maps, short-term temporal TEC variability
- ✓ New AI-ready API for:
  - Providing integrated access to the products
  - Extracting specific TEC information to users
- ✓ FAIR development/fine tuning of metadata schema, standards, vocabulary
- ✓ Integration in the e-Science Centre

SWEC - Tailored space weather training for industry/SME's

GFZ node *(GFZ, Potsdam, Germany)*

Offered services

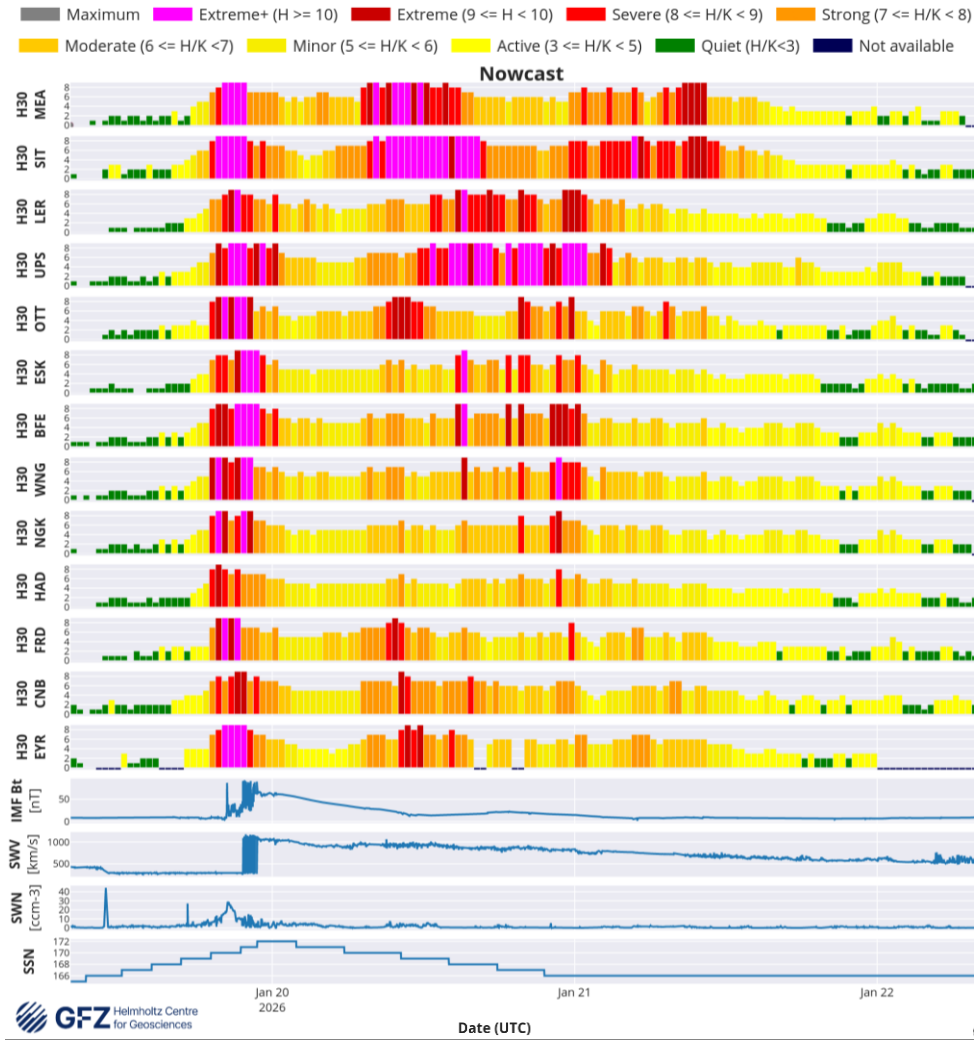
- ✓ Integration of all new web services (APIs) in the eScience centre.
  - Nowcast of
    - Kp, Hp60, and Hp30 indices
    - local geomagnetic indices for Niemegk and Wingst observatories: K, H60, and H30 indices
  - Forecast of
    - Kp, Hp60, and Hp30 indices
    - ap, ap60, and ap60 indices
    - K, H60, and H30 indices for all 13 Kp geomagnetic observatories



GFZ node *(GFZ, Potsdam, Germany)*

New services available to users

- ✓ Dynamic Forecast Visualizations: animated 3-day forecasts of geomagnetic activity derived from 13 observatories contributing to the global Kp and Hpo indices, enhancing accessibility and user engagement
- ✓ Enhanced APIs/web services for accessing index forecasts, historical data, and real-time updates
- ✓ Higher temporal resolution geomagnetic indices (e.g., Hpo, apo, H60, H30) and their forecasts, allowing finer detection of event onset and extreme disturbances



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