ESA Space Weather System for GNSS Applications

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ESA ESOC
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Space Weather hazards on infrastructure

- Astronaut radiation
- Solar cell degradation
- Radiation damage, charging/discharging
- Increased atmospheric drag
- Satellite navigation errors
- Increased radiation doses in aviation
- Telecommunication disturbances
- Geomagnetically induced currents in power grid
- Increased atmospheric drag
- Aurora
- Errors in directional drilling
Space Weather protection for Europe

Early warnings with actionable information

Space weather monitoring

Tailored space weather services

Resilient society

Data acquisition
- Solar activity and heliospace
- Near Earth space
- Global coverage of ground based observations

User engagement
- Impact studies
- CBAs
- Focused tools and apps
- Awareness

Data acquisition

S2P Developments

 ESA Space Weather System - Objectives
How to Develop Space Weather System

Customer requirements: What is needed?

Available data and products: What can we do?

Gap analysis: What is missing?

Developments

Service construction/ improvement
Identification of User Needs

- Space Weather Customer Requirements Document (CRD)
  - Defines the user needs targeted by ESA Space Weather System
  - Initial version in 2010 based on Consultation with ESA Space Situational Awareness (SSA) User Representative Group
  - Continuous collection of user needs and feedback during development, testing and validation activities in SSA and Space Safety Programme (S2P)
- Three dedicated studies for regional user needs:
  - Tailoring SWE services for the Arctic region” (2015 – 2016)
- Consultation of S2P Advisory Group, ESA Space Weather Working Team, dedicated user sessions in European Space Weather Week,…

=> Latest update of CRD in spring 2023
## Communication and Navigation Users in ESA Space Weather CRD

<table>
<thead>
<tr>
<th>User Types</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>USR-01</td>
<td>Users of GNSS <strong>Single frequency services with average accuracy, no integrity</strong> (e.g. GNSS mass market user)</td>
</tr>
<tr>
<td>USR-02</td>
<td>Users of GNSS <strong>Single frequency services with average accuracy, using integrity</strong> (e.g. EGNOS user)</td>
</tr>
<tr>
<td>USR-03</td>
<td>Users of <strong>multi-frequency GNSS systems with average multifrequency accuracy, no integrity</strong> (commercial services, PRS)</td>
</tr>
<tr>
<td>USR-04</td>
<td>Users of <strong>multi-frequency GNSS systems with average accuracy, integrity</strong> (aeronautical multifrequency)</td>
</tr>
<tr>
<td>USR-05</td>
<td>Users of <strong>multi-frequency GNSS systems with very high accuracy</strong> (e.g. GNSS geodetic users, RTK)</td>
</tr>
<tr>
<td>USR-06</td>
<td>Users of <strong>satellite data communications with high availability/continuity</strong> (e.g. Search-and-Rescue, Air Traffic Control/Management via Satellite, <strong>high availability/continuity data networks</strong> such as Galileo Ground Segment Data Network). Other <strong>space-based services/products users affected by the ionosphere</strong> (UHF - C-band radars, GNSS-R altimetry, UHF/low microwave radioastronomy and deep space communications)</td>
</tr>
</tbody>
</table>
### Service Description

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near real-time TEC maps</td>
<td>Provide near real-time TEC maps</td>
</tr>
<tr>
<td>Forecast TEC maps</td>
<td>Provide forecasted TEC maps</td>
</tr>
<tr>
<td>Quality assessment of ionospheric correction</td>
<td>Provide information on whether standard corrections to GNSS signal are applicable.</td>
</tr>
<tr>
<td>Near real-time ionospheric scintillation maps</td>
<td>Provide near real-time estimate of scintillation conditions.</td>
</tr>
<tr>
<td>Monitoring and forecast of ionospheric disturbances</td>
<td>Provide monitoring and estimate of the occurrence risk of ionospheric disturbances</td>
</tr>
</tbody>
</table>
ESA Space Weather Service Portal and 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

https://swe.ssa.esa.int
ESA Space Weather Services for GNSS Users
Welcome to the Transionospheric Radio Link - Quality Assessment of Ionospheric Correction service

Overview

The service "Transionospheric Radio Link - Quality Assessment of Ionospheric Correction" aims to provide information on whether standard corrections to GNSS signal are applicable, including for the TEC core products a posteriori and estimated parameters and near-real-time alerts to indicate the level of degradation of ionospheric correction models with respect to the actual state of the ionosphere. This latter assessment shall be established by considering the update rate for the different service users among the following:

- Users of GNSS Single frequency services with average accuracy, no integrity (e.g. typical GNSS mass market user)
- Users of GNSS Single frequency services with average accuracy, using integrity (e.g. EGNOS user)
- Users or multi-frequency GNSS systems with very high accuracy (e.g. GNSS geodetic users, RTK).

This service is implemented through a combination of products, tools and alerts which can be found through the following sections along with expert support provided by the teams constituting the SME network. Should you require further guidance in the use of this service, or have specific questions about any aspects of the service presented here, don’t hesitate to contact the Helpdesk.

Read more about this service

Highlights

- GNSS Performance Indicator
- UBIQ-GSM - rapid 15-minute resolution global VTEC maps
- Global Scintillation Indices
- Nowcasting of TEC over Italy

Announcements

Update: New Service Page design for release 3.7. Let us know what you think about our services in our Survey.

Products and Alerts

The following products are associated with this service:

- Ionosphere, Nowcast
- Ionosphere, Archives

- Ionospheric Disturbance Detection

Full product

Provided by: German Aerospace Center
Monitoring and Forecasting Ionospheric Disturbances

Federated products from the Ionospheric Group of the National Observatory of Athens (NOA)

TechTIDE Home
Perturbation maps
GNSS TEC gradient
LSTID detector maps
LSTID station plots
LSTID activity index
AATR indicator maps
AATR daily plots
CDSS Doppler shift
MSTID index maps
MSTID daily plots
TID activity report
Acknowledgements

The maps shown here provide an indication of the ionospheric background activity, which is based on the perturbation of the electron density in respect to median conditions. The perturbation is calculated using the relative standard deviation of the electron density at pre-defined ionospheric altitudes. Based on this...
ESA Space Weather Services: Alerts

Welcome to the General Overview

The General Alert service provides access to alerts and warnings from various space weather services. This service is implemented through a combination of teams constituting the SWF Network. Should you require further assistance, please contact the General Alert service at: general-alert-service@esa.int

Read more about this service.

Products

Alert products

- All Quiet Alert
- End-of-quiet Alert
- Solar Flare Detection
  - UGraz/KSO Latest Solar flare alert
  - SIDC Latest Solar GOES-flare alert
  - SIDC Latest Solar GOES-flare alert
  - Latest ICAO Space Weather Advisory browser
- Solar Flare Detection and Location
  - CME Onset
  - Halo CME Onset
  - Coronal Hole Notification
  - CIR Alert
  - Solar Particle Event Onset
  - Geomagnetic Storm Warning / Solar Wind Shock Arrival
  - Geomagnetic Storm Onset
  - Ionospheric Disturbance Detection
    - Latest ICAO Space Weather Advisory browser
    - EIS Alerts for ionospheric disturbances in the European sector
    - SISTED warning
    - SOLERA-drift warning
    - TechTIDE LSTID detector maps
    - TechTIDE LSTID parameters over station
    - TechTIDE LSTID Activity Report
- Micro Particle Flux Warning
- Debris Cloud/Meteorid Stream Warning
- All Archive
- Ground Level Enhancement Detection
Ionospheric Services for User Domains: Aviation

Aviation Services
The purpose of the Service to Aviation dashboard is mainly to provide graphical information about the impact of solar activity on the radiation environment and ionospheric conditions. The dashboard is organised in three sections (columns) according to the main impact domains i.e. Radiation - GNSS - HF communication.

Further products, data and archives can be found in the specific service listed below.

Service to Aviation

Radiation
AVIDOS Current cosmic radiation map

Effective dose rate in μSv/h
Altitude: 9.00 km
Last Update: 25.10.2023 18:31

Latest GNSS Advisory:
0000046601
FNXX01 KWNW 211609
SWX ADVISORY
DTG: 20231021/1609Z
SWXC: SWPC
ADVISORY NR: 2023/280
NR RPLC: 2023/279
SWX EFFECT: GNSS MOD
OBS SWX: 21/1601Z NO SWX EXP
FCST SWX +6 HR: 21/2300Z NO SWX EXP
FCST SWX +12 HR: 22/0500Z NO SWX EXP
FCST SWX +18 HR: 22/1100Z NO SWX EXP
FCST SWX +24 HR: 22/1700Z NO SWX EXP
RMK: THE IONOSPHERIC DISTURBANCE HAS ENDED. SCINTILLATION RELATED GNSS SIGNAL DEGRADATION IS NO LONGER EXPECTED.
NXT ADVISORY: NO FURTHER ADVISORIES
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
Vigil mission to L5

- 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: 2030

Coronagraphy: CCOR
Heliospheric Imaging: HI
Magnetography: PMI
EUV imaging: NIO
Solar wind: PLA
IMF: MAG

https://www.esa.int/Space_Safety/Vigil
ESA Space Weather Services: Helpdesk and Feedback

Welcome to the ESA Space Weather Service Network
Please note that all ESA-SWE Services are under review/construction

Contact the Helpdesk /

ESA Space Weather Services - User Survey

The ESA Space Weather Services provide targeted data and information addressing the needs of a number of targeted user communities, from spacecraft operators to auroral tourism. This survey has been prepared in order to ask for feedback on your experience, our current capabilities and recommendations for future evolution. By sharing your experience this will help ensure that we provide the most useful services for all of our users. Thank you in advance for your participation!

This survey contains 30 questions and will take around 10 minutes to complete. Note that not all questions are compulsory and all feedback given will be anonymous.

There are 30 questions in this survey.

Next
THANK YOU

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