

# FIG WORKING WEEK 2019

22-26 April, Hanoi, Vietnam

"Geospatial Information for a Smarter Life and Environmental Resilience"

Presented at the FIG Working Week 2019,  
April 22-26, 2019 in Hanoi, Vietnam

## The Ionosphere Prediction Service: an EC project to support GNSS users

M. Angeles Aragon<sup>+</sup>, E. Guyader<sup>++</sup>, C. Cesaroni, L. Spogli, F. Rodriguez, G. De Franceschi, M. Aquino, F. Berrilli, S. V. Veetil, V. Romano, R. Ronchini, S. Di Rollo, D. Del Moro, and **J. Fortuny**<sup>+</sup>

<sup>++</sup>European Commission, Brussels, Belgium

<sup>+</sup>European Commission Joint Research Centre, Ispra, Italy

<sup>1</sup>Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

<sup>2</sup>Telespazio, Rome, Italy

<sup>3</sup>University of Nottingham, Nottingham, UK

<sup>4</sup>University of Tor Vergata, Rome, Italy



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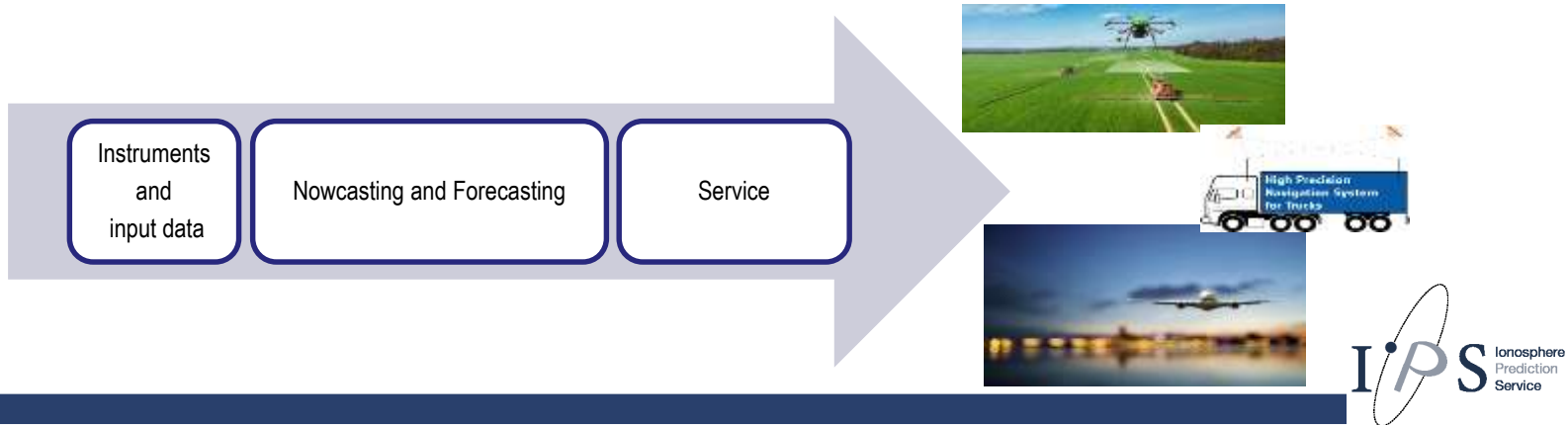


## The Ionosphere Prediction Service – General description

IPS is a EC initiative in the framework of the H2020 Galileo Programme

The aim of the IPS project is to design and develop a prototype platform able to translate the prediction and forecast of the ionosphere effects into a service customized for specific GNSS user communities.

The project team is composed by **Telespazio** (coordinator), the **Istituto Nazionale di Geofisica e Vulcanologia (INGV)**, the **University of Nottingham**, the **University of Rome Tor Vergata**, **Telespazio Vega Deutschland** and **Nottingham Scientific Ltd**



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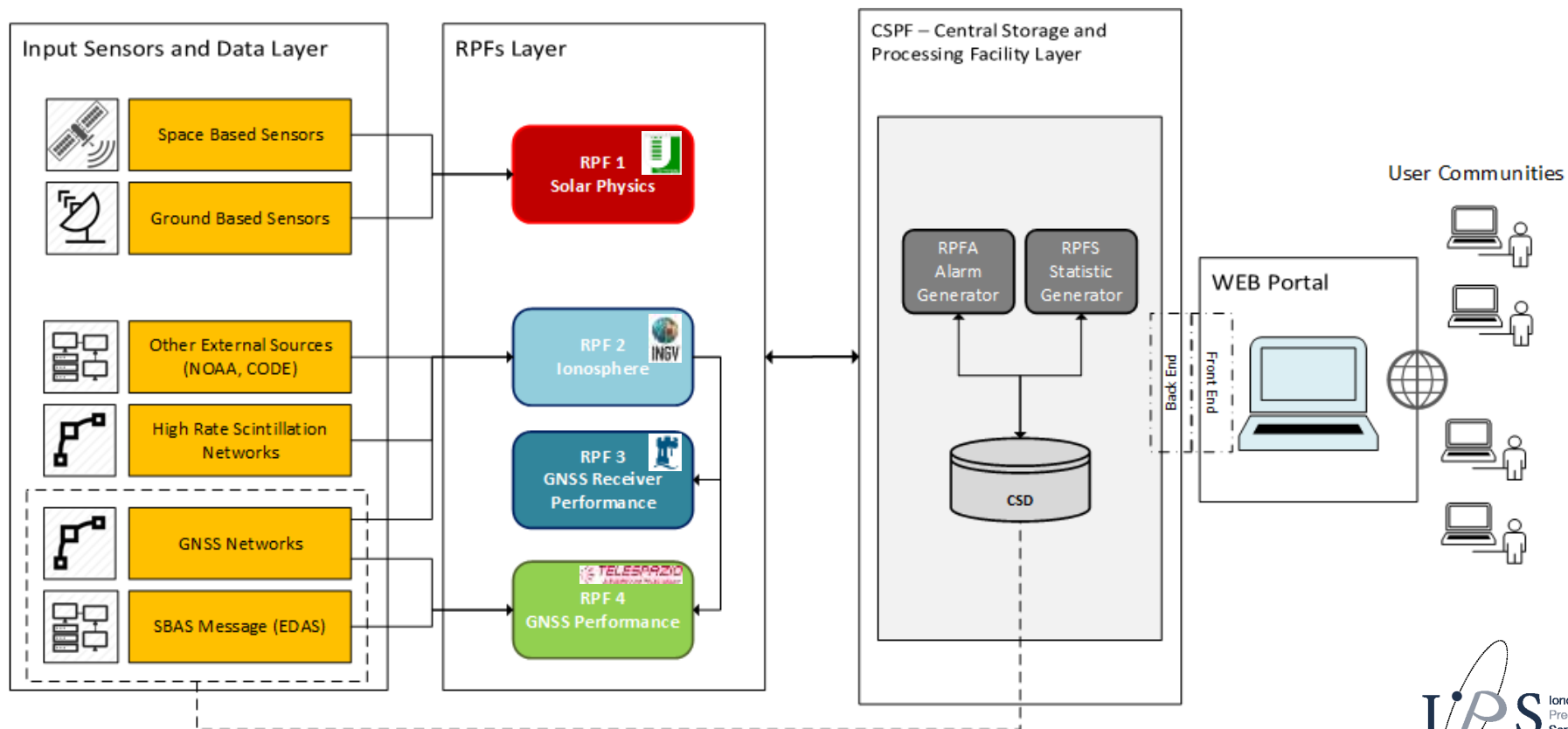


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## The Ionosphere Prediction Service - Architecture



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## Instruments and input data

### Solar Observations

- GOES X-ray flux (SWPC)
- H $\alpha$  full-disk images (GONG)
- Full-disk images (SDO/AIA)
- Full-disk magnetograms (SDO/HMI)
- LASCO images (SOHO)
- CME CACTUS catalogue

### in a near future...

- Magneto-Optical filters at Two Heights (MOTH)
- High-Energy Particle Detector (CSES/HEPD)

### Ionospheric Observations

- Global GNSS network (IGS)
- European GNSS network (EUREF)
- Mediterranean GNSS network (RING)
- 50 Hz GNSS network (INGV/UNOTT)

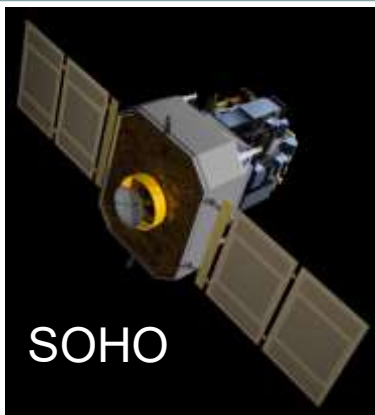
### External input data

- R12 or SSN
- Kp

INGV/UNOTT 50 Hz GNSS



MOTH



SOHO



SDO

Solar Dynamics Observatory



IGS



RING

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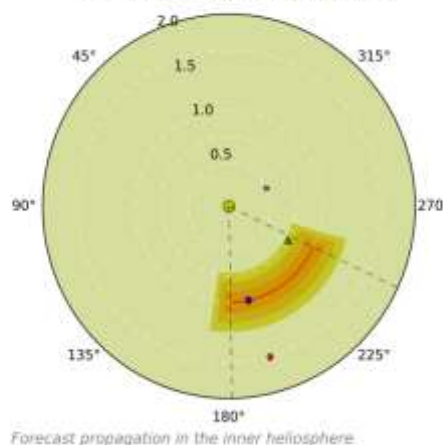
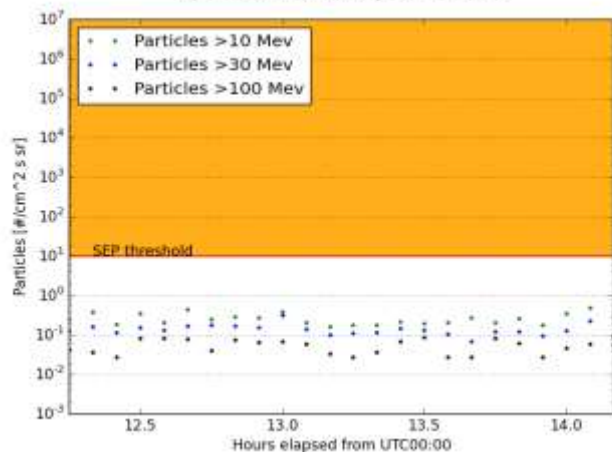
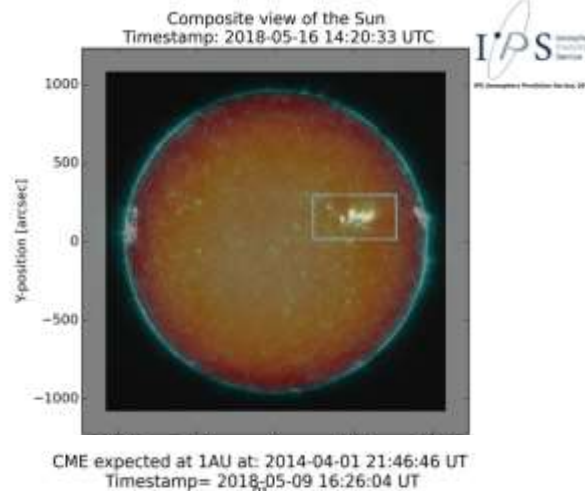
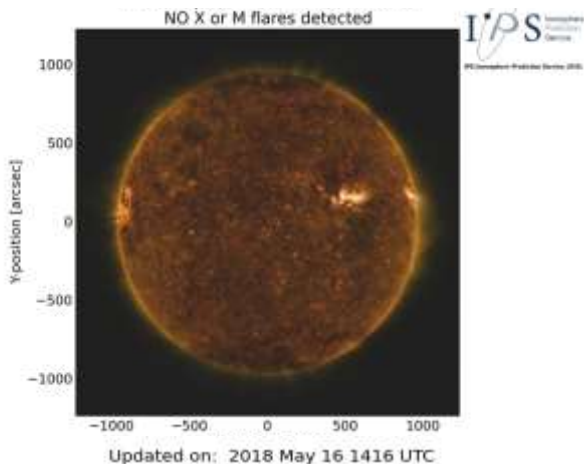


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## Nowcasting and Forecasting – Solar products



### Nowcasting:

- FLAREs position and flux
- CME detection
- SEP flux near Earth

### Long Term Forecasting (>24 h):

- FLARE Probability
- CME Probability of hitting Earth
- CME arrival time
- SEP flux

### Retro-validation of forecasts:

- Flare Probabilities
- CME arrival times
- SEP fluxes



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Total: 18 products available for the users

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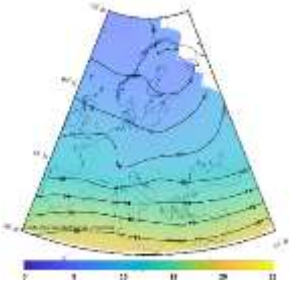
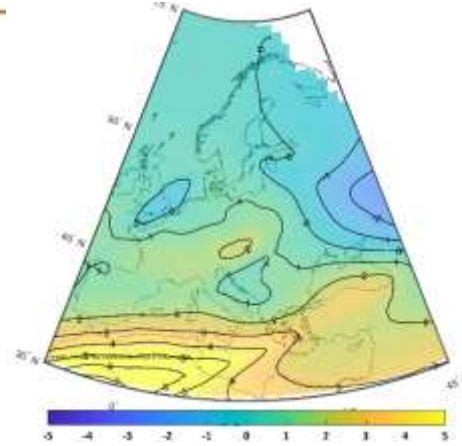
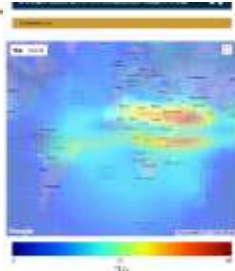
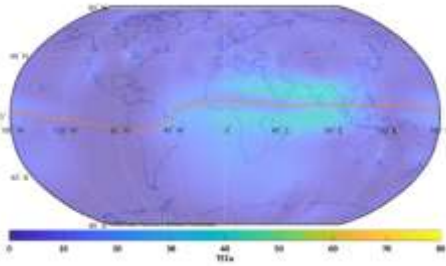


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## Nowcasting and Forecasting – Ionospheric products (TEC)



### Nowcasting:

- TEC over Italy
- TEC over Europe
- TEC global

### Short Term Forecasting (30 min):

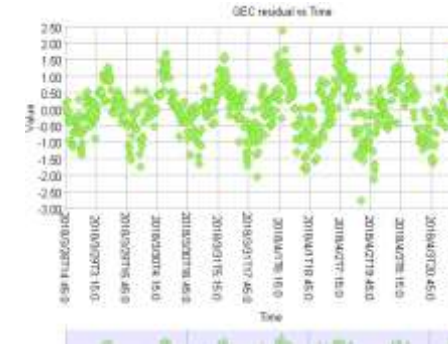
- TEC over Italy
- TEC over Europe
- TEC global

### Long term prediction (24 hours)

- TEC global

### Cross-validation

- UPC Product TEC Global
- ROB TEC over Europe



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**Total: 67 products available for the users!**

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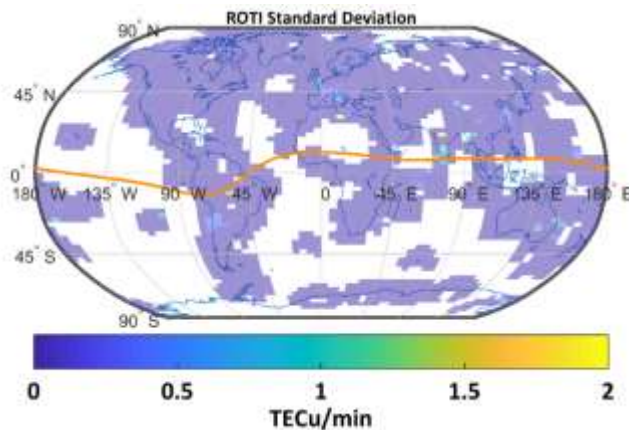
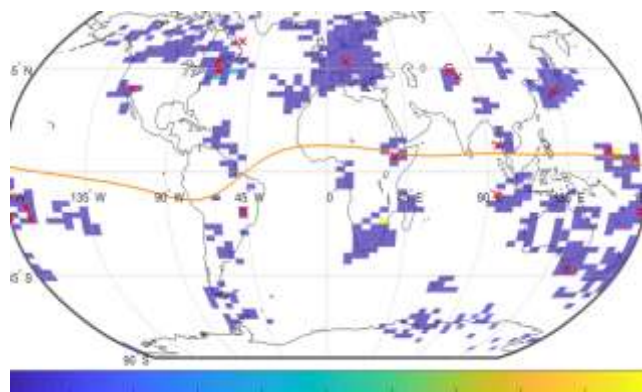
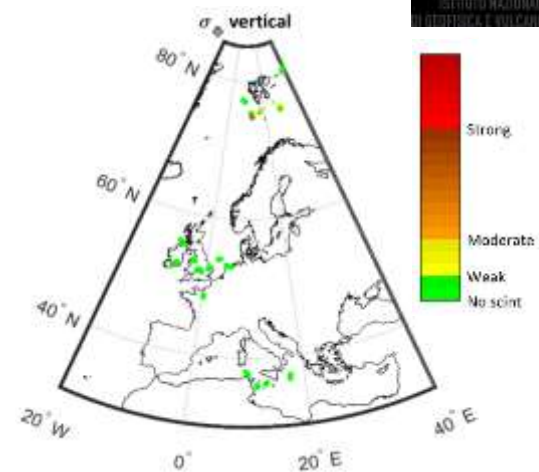
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## Nowcasting and Forecasting – Ionospheric products (Scintillation)



| ID   | Station                       | Lat (°N) | Long (°E) | Sector        | Receiver Type    |
|------|-------------------------------|----------|-----------|---------------|------------------|
| NYA0 | Ny-Alesund (Dirgibile Italia) | 78.92    | 11.93     | High latitude | GSV4004 /PolaRxS |
| NYA0 | Ny-Alesund (Kartveek)         | 78.92    | 11.93     | High latitude | GSV4004          |
| LYB0 | Longyearbyen                  | 78.17    | 15.99     | High latitude | GSV4004          |
| TRON | Trondheim                     | 63.41    | 10.41     | High latitude | GSV4004          |
| NOTT | Nottingham                    | 52.95    | -1.19     | Mid Latitude  | PolaRxS          |
| CYPR | Cyprus                        | 35.18    | 33.38     | Mid Latitude  | PolaRxS          |
| LAM0 | Lampedusa                     | -22.07   | -51.24    | Mid Latitude  | GSV4004          |



### Nowcasting:

- Scintillation indexes over Europe
- Proxy scintillation indexes global

### Long term prediction (24 hours)

- Proxy scintillation indexes global

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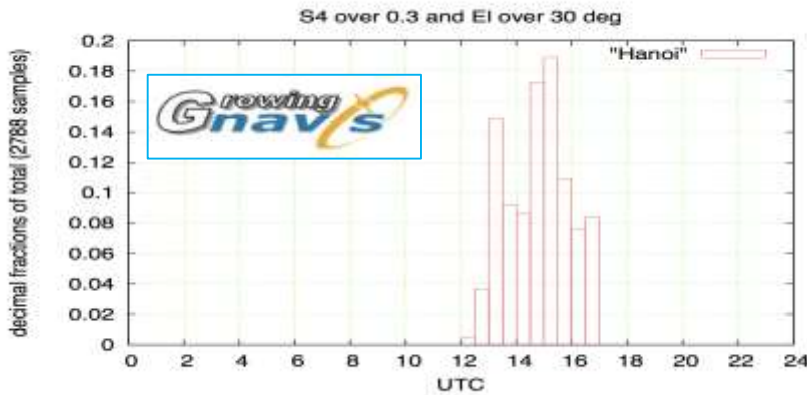
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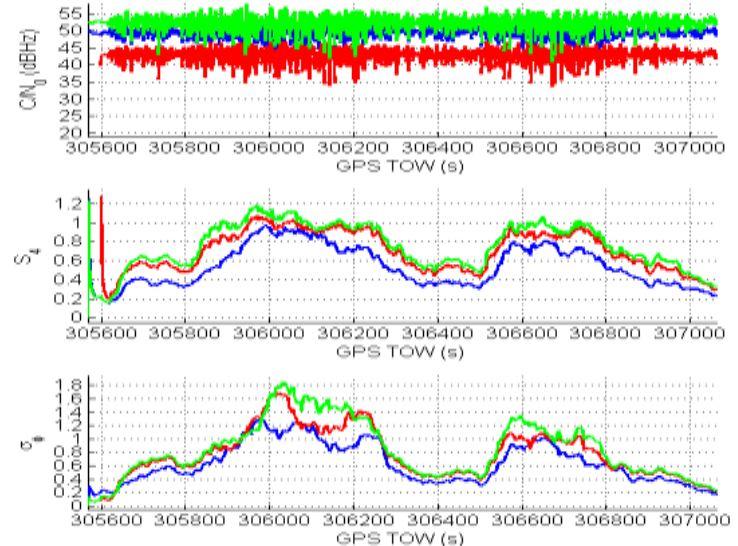


## Scintillation Events at NAVIS Center HUST



### Events recorded in 2013

- Tri-lateral agreement between EC JRC, NAVIS Center and Linksfoundation
- 499 20-min long recordings of IF data made (8bit, 5 MS/sec) at NAVIS Center
- 6+TB of data collected
- 40% of events with  $S_4 > 0.3$  in SVs above 20 deg Elv



### Scintillation event recorded in 2015

Hanoi April 8<sup>th</sup> 2015 - with triple-frequency measurements, E1/L1, L2, E5a/L5

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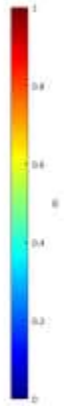
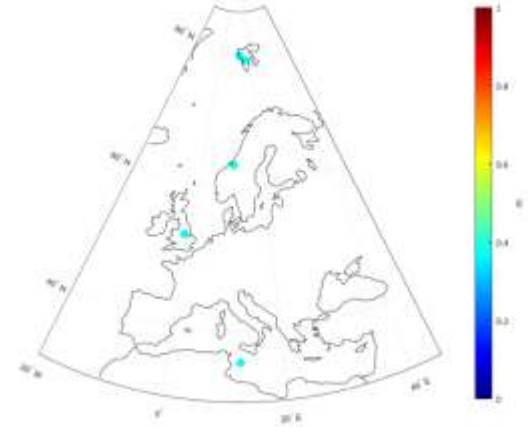
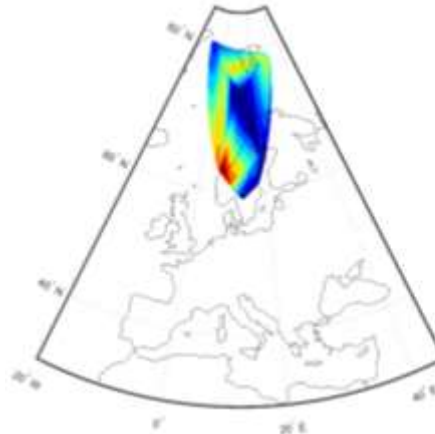
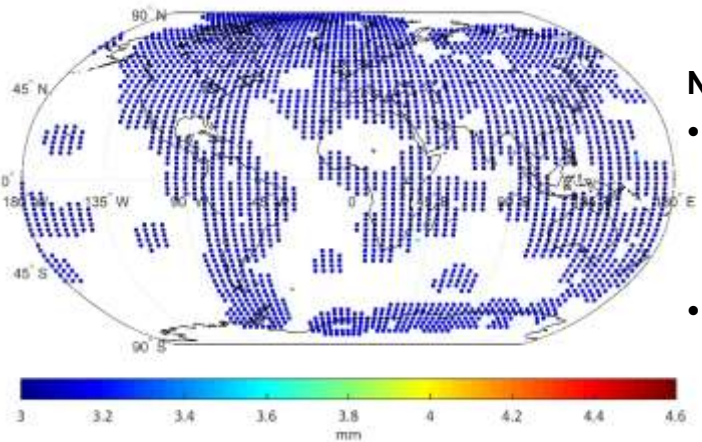
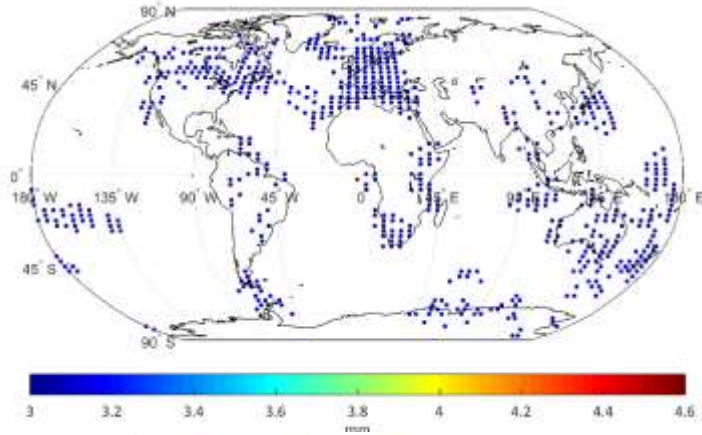


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## Nowcasting and Forecasting – GNSS performance products



### Nowcasting:

- Over Europe
  - Receiver tracking errors
  - User 3D positioning errors
  - Probability of loss of lock
- Global
  - Receiver tracking errors
  - User 3D positioning errors
  - Probability of loss of lock

### Long term forecasting:

- Global
  - Receiver tracking errors
  - User 3D positioning errors
  - Probability of loss of lock



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**Total: 28 products available for the users!**

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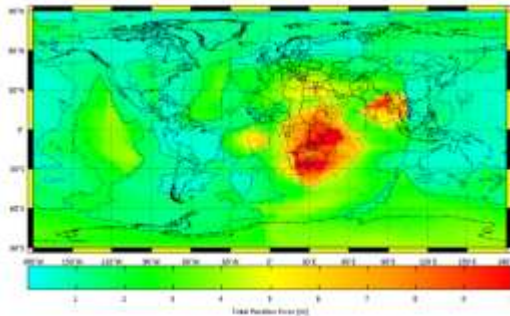
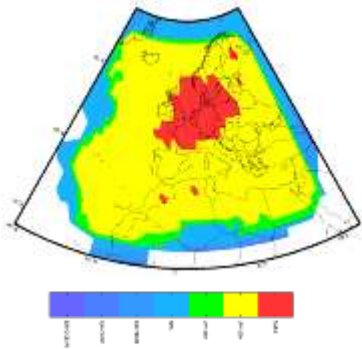


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## Nowcasting and Forecasting – GNSS performance products at application level



### •Position and integrity analysis:

- Un-augmented GPS L1 PVT (without integrity);
- Un-augmented GPS L1 ABAS PVT solution, integrating RAIM-FDE capabilities compliant with RTCA MOPS DO-316;
- GPS L1 SBAS augmented PVT, emulating the processing of a SBAS-capable airborne receiver compliant with RTCA MOPS DO-229D for both LP and LPV navigation modes.

### •Performance analysis reports:

- Position error and integrity analysis provided as plot and report table;
- Statistical analysis (95% - 99% position error accuracy, PDF/CDF plots, Normality tests, etc);
- Analysis of satellite geometry (Dilution of Precision parameters timeseries);
- Availability and continuity diagram for different aircraft operations;
- Constellation status analysis (URE/URA analysis satellite health status, condition usage in the position calculation, signal power level);
- Horizontal and vertical integrity diagram (Stanford Diagrams) for both ABAS and SBAS solutions;
- RAIM FDE performance diagrams.

GNSS Station Performance Report Table (High Rate) - 10/05/19 14:00:30

Information

10-May-2019 14:00:00-14:59:59 - Network Performance Report

| STATION            | NAV MODE | STATUS  | HPR MAX | VP1 MAX | HP2 MAX  | VP2 MAX | HBCCYS  | V |
|--------------------|----------|---------|---------|---------|----------|---------|---------|---|
| Bolzano-Borov (IT) | LNAV     | WARNING | 1.581 m | 0.090 m | 31.983 m | 0.000 m | 1.400 m | 3 |
| Kiruna (SW)        | LNAV     | WARNING | 2.315 m | 0.060 m | 16.541 m | 0.000 m | 1.160 m | 4 |
| Nicosia (GR)       | LNAV     | OK      | -       | -       | -        | -       | -       | - |
| Boynikov (BG)      | LNAV     | OK      | -       | -       | -        | -       | -       | - |
| La Palma (ES)      | LNAV     | WARNING | 2.583 m | 0.230 m | 16.477 m | 0.000 m | 0.010 m | 4 |
| Itzehou (FI)       | LNAV     | WARNING | 2.398 m | 0.580 m | 20.313 m | 0.000 m | 1.980 m | 4 |
| Inverness (GB)     | LNAV     | OK      | 1.883 m | 0.819 m | 25.587 m | 0.000 m | 1.130 m | 2 |
| Hofgeest Int. (DE) | LNAV     | OK      | 1.313 m | 0.216 m | 30.187 m | 0.000 m | 0.730 m | 2 |
| Borov (SR)         | LNAV     | OK      | 2.727 m | 7.473 m | 27.538 m | 0.000 m | 0.070 m | 3 |
| Vardø (NO)         | LNAV     | WARNING | 1.788 m | 0.127 m | 21.518 m | 0.000 m | 1.340 m | 4 |



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## IPS service – Web Portal

The screenshot shows the homepage of the Ionosphere Prediction Service (IPS). The header includes the IPS logo and navigation links: Welcome, IPS Project, IPS Products, Downloads, Publications, How To, and User Page. Below the header, there are sections for 'IPS Prototype Service Presentation' and 'Special Announcements'. The main content area contains a 'Welcome to the Ionosphere Prediction Service Web Portal' section, followed by a 'Current Space Weather Condition' section featuring a 'Composite view of the Sun' plot. The plot shows a circular view of the Sun with a color scale from -1000 to 1000, and axes labeled 'Longitude [arcsec]' and 'Latitude [arcsec]'. The plot title is 'Composite view of the Sun' and the timestamp is '2018-05-16 13:59:38 UTC'.

IPS project concluded successfully its «operational phase» (July 2018 – December 2018) and the prototype is now hosted at the Joint Research Centre (JRC, European Commission) in Italy.

The webportal is freely accessible (registration required)

*IPS can be reached at*  
**<http://ips.gsc-europa.eu>**

The screenshot shows the registration form on the IPS web portal. The form has fields for 'Username', 'Password', 'Email', and 'Additional information'. There are also checkboxes for 'I agree with your conditions' and 'I agree with your privacy policy'. A green 'Register' button is at the bottom. Below the button, there is a note: 'Email address is required. Send a mail by this link to request registration to IPS: [ips-helpdesk@esa.esa.int](mailto:ips-helpdesk@esa.esa.int)'.



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## Conclusions

- IPS is a prototype service capable to provide useful metrics about the status of the ionosphere to the GNSS users communities – Feedback from users is key for the future development of IPS
- The web portal makes available more than 160 nowcasting and forecasting products in real-time or near real-time
- The user can build its own web pages to exploit the products that fits with its needs
- Alerts can be configured on every single products shown in the user web page
- Retrovalidation products are available to check the reliability of the forecasting products
- If proper GNSS networks are deployed and access to data is granted, new IPS regional products could be added (e.g., Ionospheric and GNSS performance products)

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## IPS service – What can a user do?

- Register to access the service
- Look at the products into the «communities web pages»
- Create his own web page
- Set alarms
- Download products



**IPS** Ionosphere Prediction Service

Welcome | IPS Project | IPS Products | Publications | Register | How To

**IPS Prototype Service Presentation**

**Welcome to the Ionosphere Prediction Service Web Portal!**

The Ionosphere Prediction Service (IPS) is an initiative of the European Commission in the framework of the Galileo Programme.

IPS is a prototype of a service for the monitoring and prediction of the ionosphere effects on the GNSS user. It is able to translate the observations of the sun and of the ionospheric activity into a prediction of the performance of the GNSS solution at user level.

The IPS service offers dedicated products for a set of identified GNSS User Communities, like Mass Market, Aviation, High Accuracy and Scientific Communities. You can find a description of the IPS architecture at the "IPS Project" page of this web site and an overview of the available products in the "IPS products" section of this portal.

Upon request using the "registration" form of the web portal access can be granted to the GNSS users willing to test this service.

The "How to" section of this portal can provide users with a guide for the correct use of the features of the IPS service prototype provided by the IPS web portal.

For any question regarding registration or the web portal features, please send an email to [ips-helpdesk@thales.com](mailto:ips-helpdesk@thales.com)

**Special Announcements**

IPS web site under construction

Current Space Weather Condition

PS Tracking Error Long Term Forecasting at Global level  
22 May 2018 12:00:00 UTC

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## The Ionosphere Prediction Service – Consortium

| Team Member  | Type               | Roles   |
|--|--------------------|---|
| Telespazio    | Industry           | <b>Prime contractor</b><br>IPS design, development and validation<br>GNSS performances at service and application level dev |
| Telespazio VEGA Germany                                 | Industry           | statistics module dev   |
| NSL (Nottingham Scientific Ltd)                         | Industry           | User requirements collection<br>warning service module dev  |
| University of Tor Vergata                               | University         | Solar physics products dev  |
| INGV (Istituto Nazionale di Geofisica e Vulcanologia)  | Research Institute | Ionosphere related products dev   |
| University of Nottingham                              | University         | GNSS receiver performance related products dev  |

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