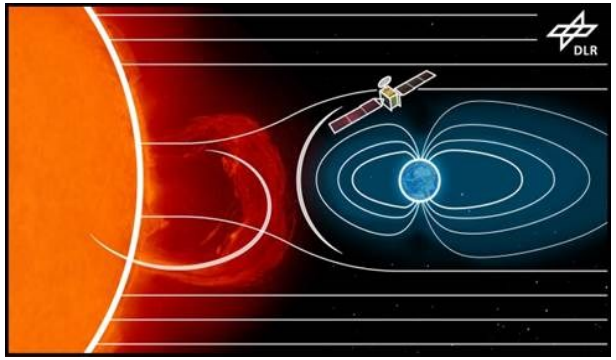
Space Weather Research and Operations at the German Aerospace Center (DLR) Institute for Solar-Terrestrial Physics

J. Berdermann



DLR

German Aerospace Center - Site Neustrelitz

Over **100 years research on** the interaction of electromagnetic waves with the **atmosphere/ionosphere**.

20 years of **space weather research** with a focus on the ionosphere (preoperative ionospheric service since 2004).

On 27.06.2019 the **new DLR Institute for Solar-Terrestrial Physics** is put into operation by decision of the DLR Senate.

Range measurements of radio waves at the "Versuchsfunkstelle Strelitz – VFSS" of the Telegraphen-Versuchsamt (TVA) Berlin (1913)

Site of the **Heinrich-Hertz-Institute for Solar-Terrestrial Physics** Berlin-Adlershof (Academy of Sciences GDR)

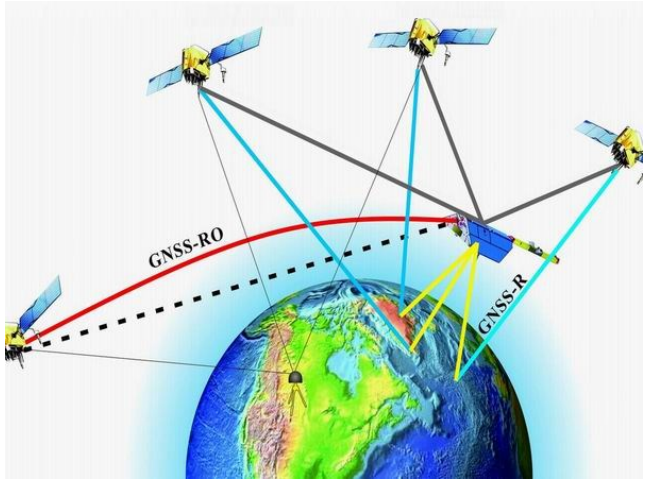
Institute Vision

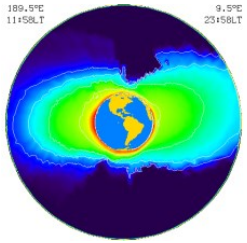
To establish and apply the scientific and technological capability to:

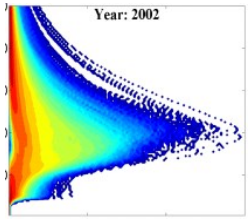
- Provide timely, accurate and reliable space environment observations
- Develop user relevant space weather products and forecasts
- Foster the resilience of critical technological infrastructures of our society by dedicated vulnerability assessments and space weather impact studies

Space Environment Observations	User Products and Forecasts	Safeguard Critical Infrastructures

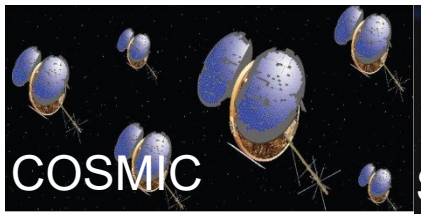
Space Based Observations

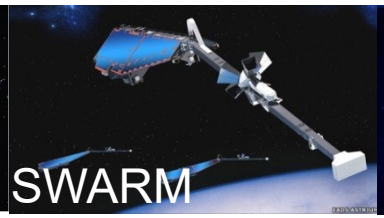


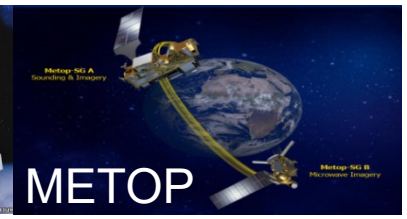




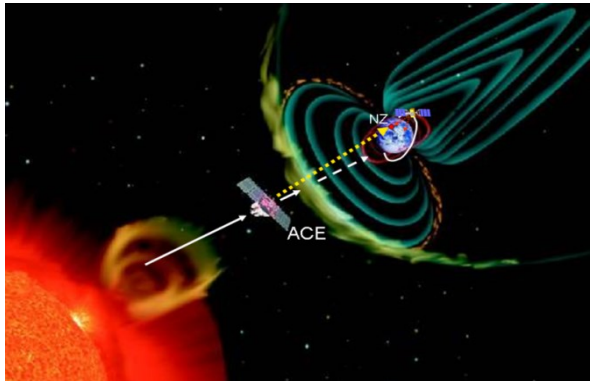
- **GNSS measurements on board LEOs** will play a key role in ionospheric monitoring
- long-term experience in data retrieval and scientific use of both techniques

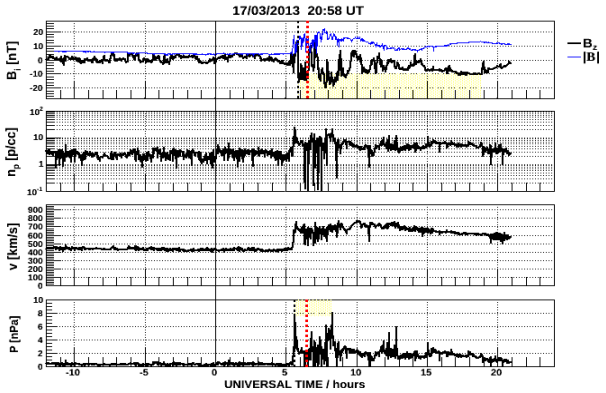






DLR is a **member of the Real Time Solar Wind (RTSW) observation network** involved in the data transfer and the analysis of NASA's Advanced Composition Explorer (ACE) and the Deep Space Climate Observatory (DSCOVR) satellite



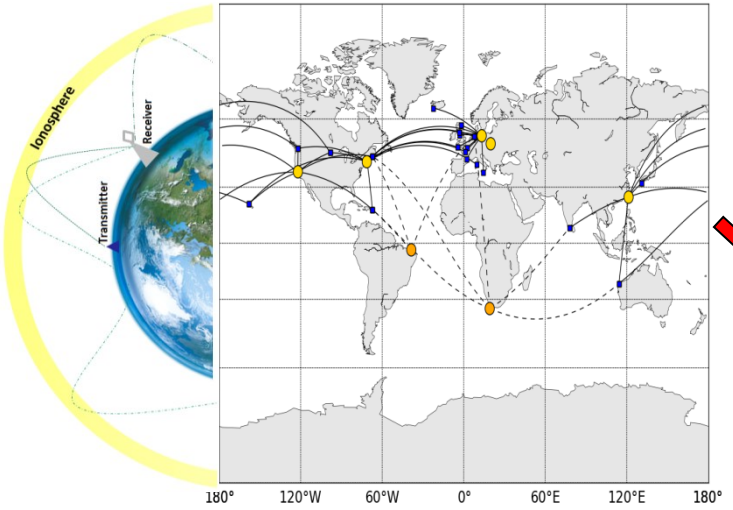


➔ **Reliable Space Weather information and forecasts at the earliest opportunity**

Ground Based Observations

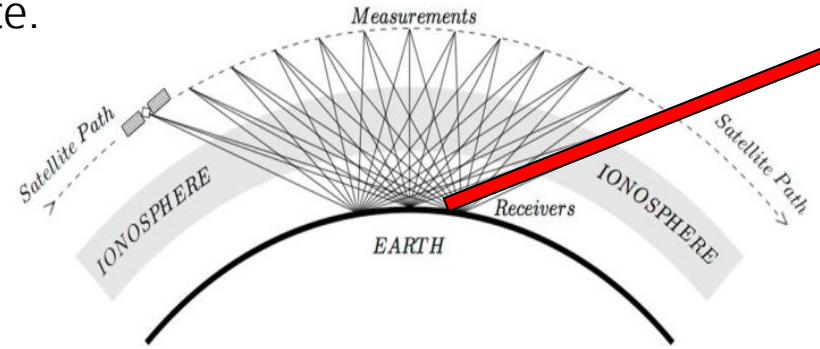
GIFDS: Global Ionospheric Flare Detection System

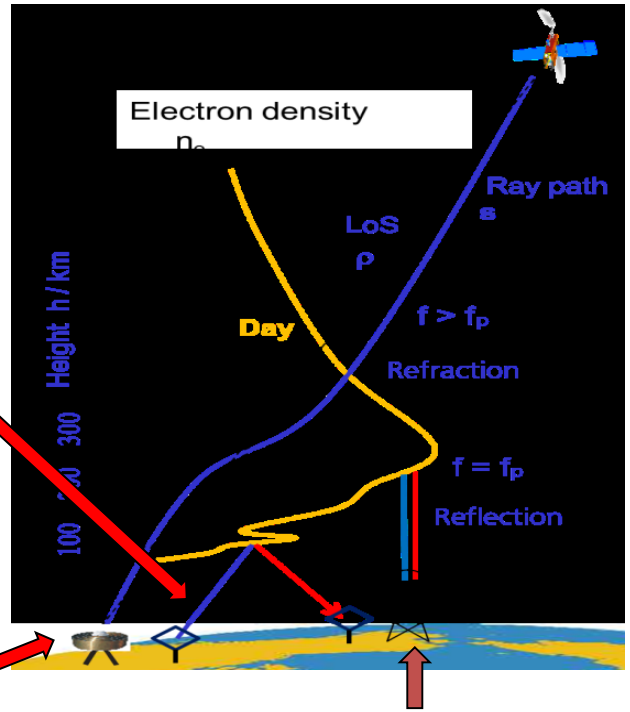
- Reception of very Low Frequency (VLF) signals
- Detection of particle precipitation at high latitudes is important for transpolar flights



GNSS TEC measurements are most important data source for research and space weather service.

- Global coverage
- Multi-frequency, multi-GNSS
- Good horizontal resolution





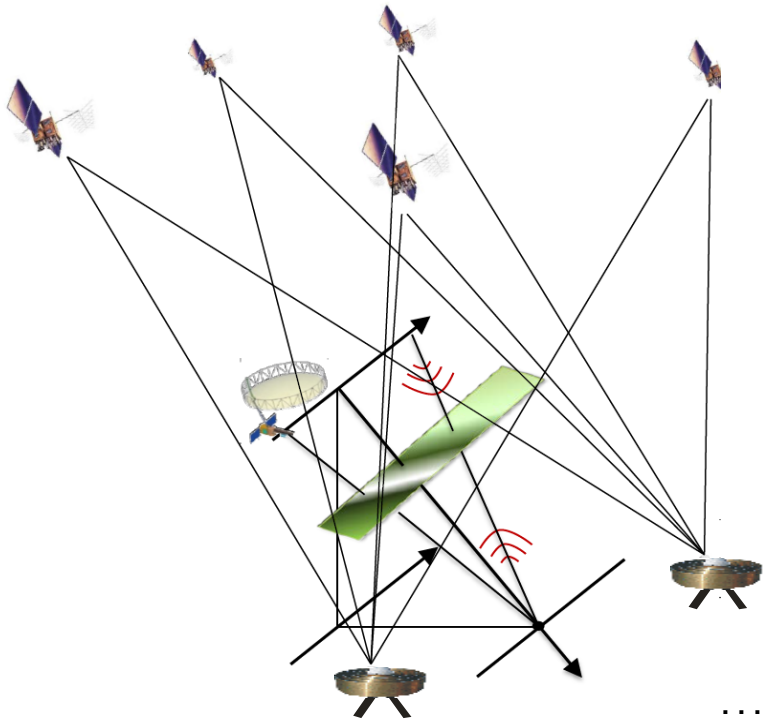
Vertical sounding

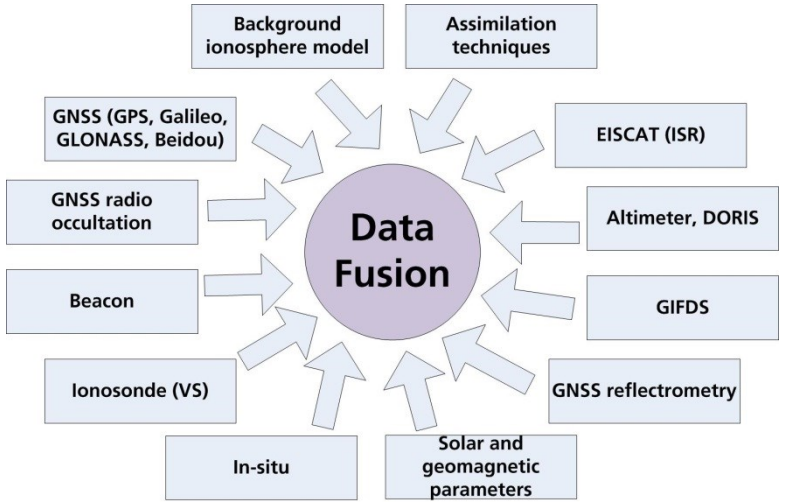
- Ionosonde stations provide information on the vertical electron density distribution.
- Good vertical resolution and complementary to GNSS based sounding

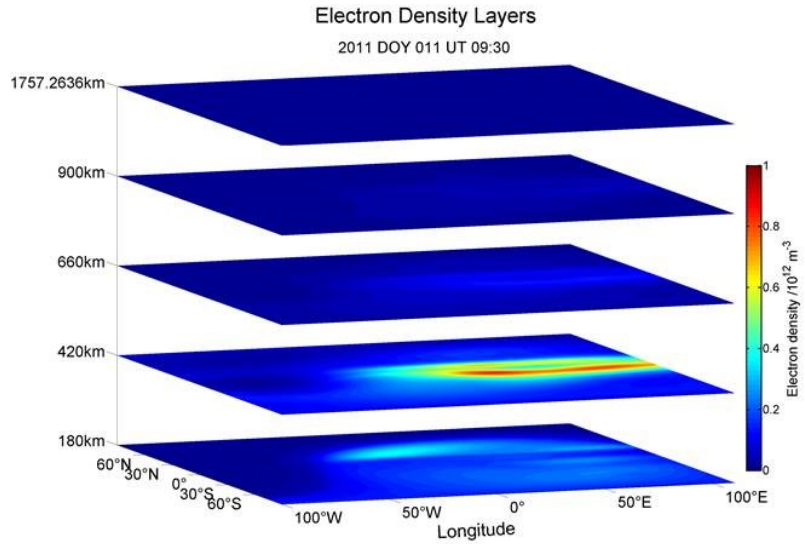
Data Fusion and Reconstruction

One goal is to generate 3D electron density reconstructions of the geo-plasma environment with high temporal and spatial resolution by means of data fusion and reconstruction.

- Data originating from different sources have to be harmonized







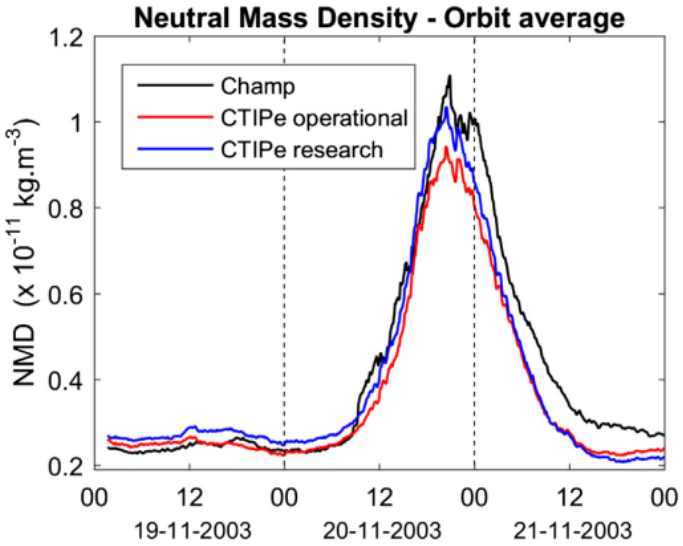
… different area
… different altitude
… different sounding geometry

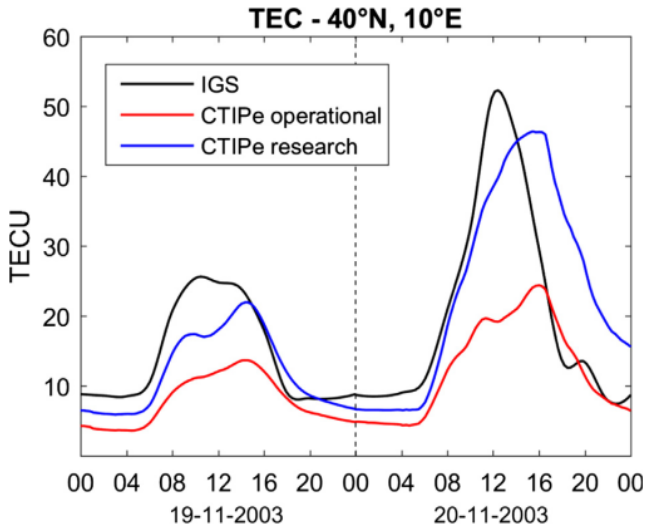
… different time resolution
… different latentcy
… different accuracy

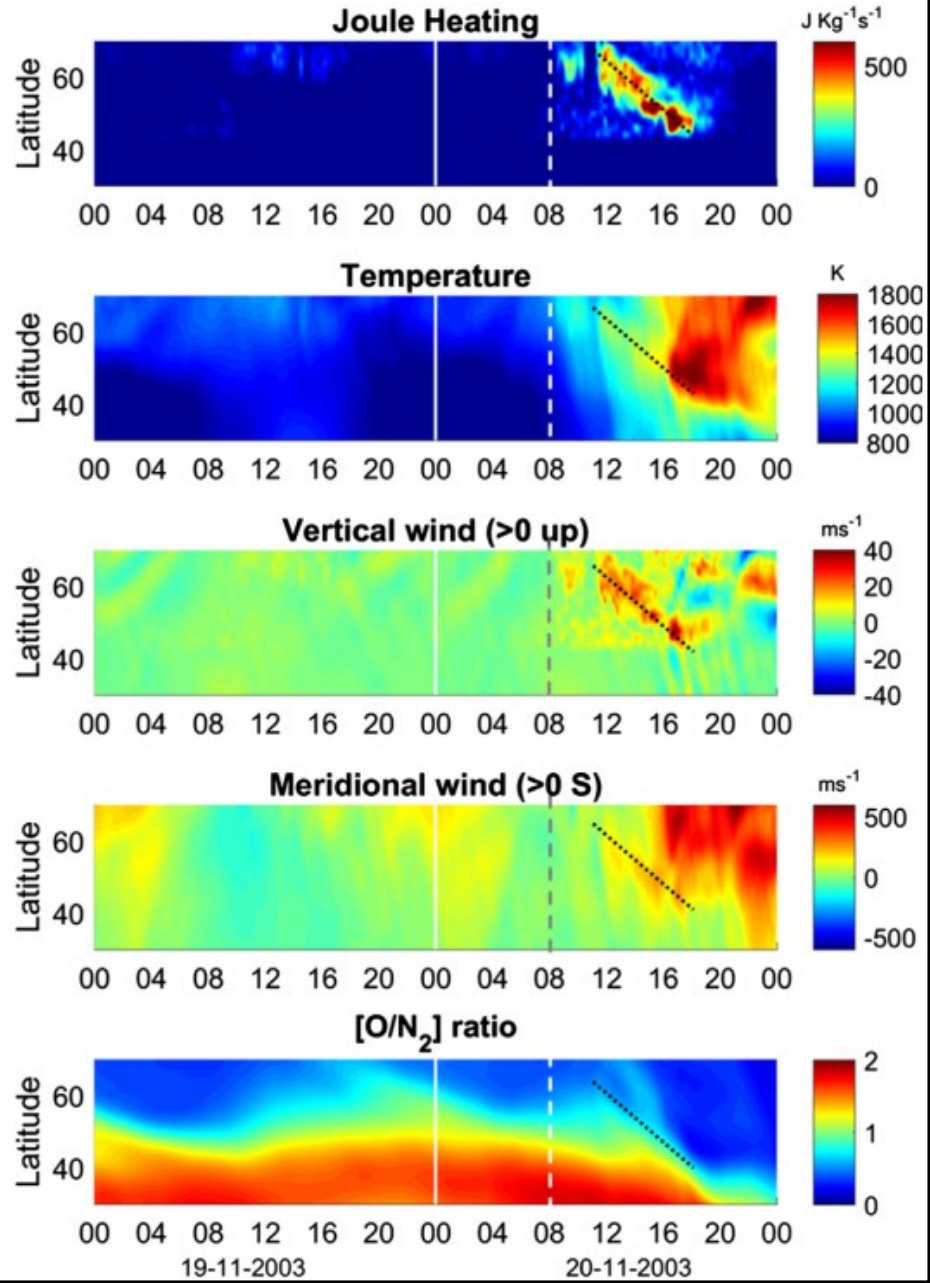
Physical Modelling

Storm dynamics at z=400km reproduced with CTIPe

Validation of CTIPe results with neutral density from CHAMP and TEC from IGS







I. Fernandez-Gomez, M. Fedrizzi, M. V. Codrescu et al., On the difference between real-time and research simulations with CTIPe, Advances in Space Research, https://doi.org/10.1016/j.asr.2019.02.028

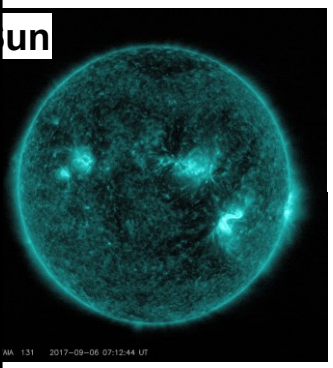
Space Weather Impact Studies (Space Weather Events on 06/09/2017)

Source

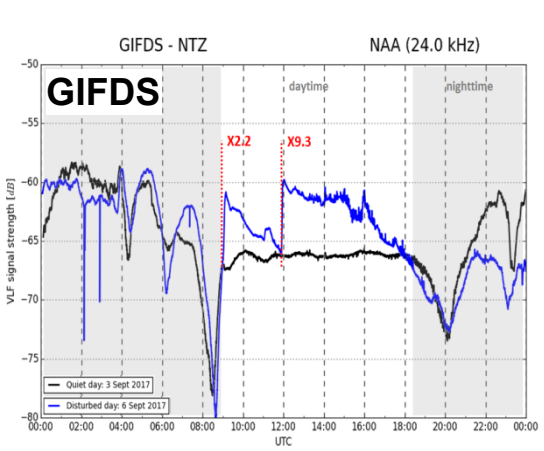
Observation

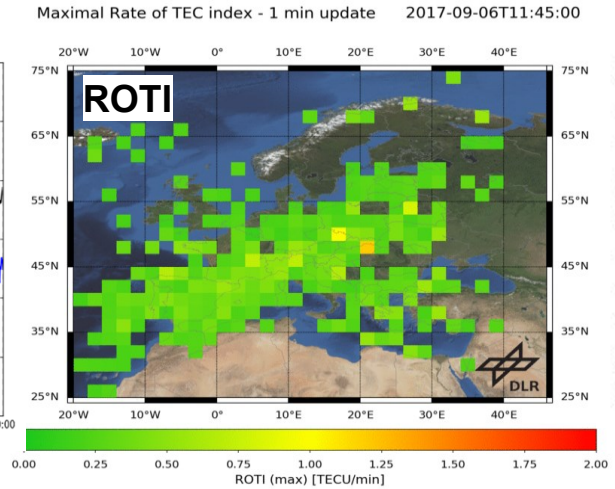
Impact Studies

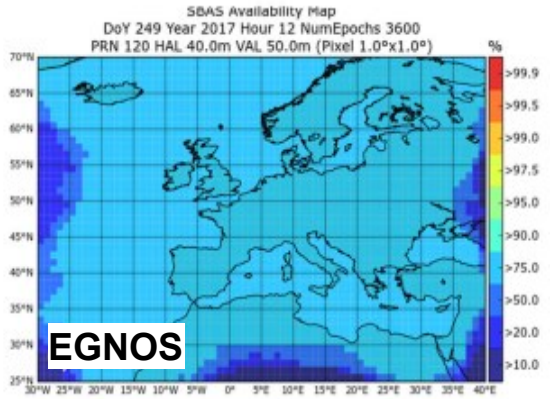
Solar Flare

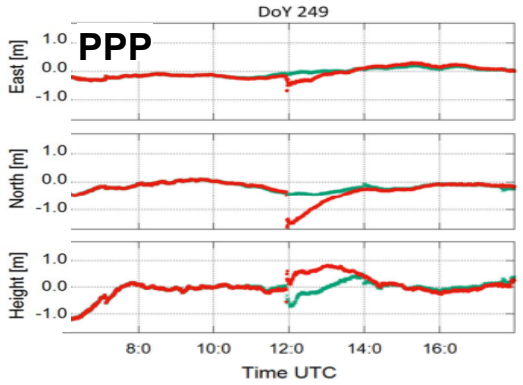


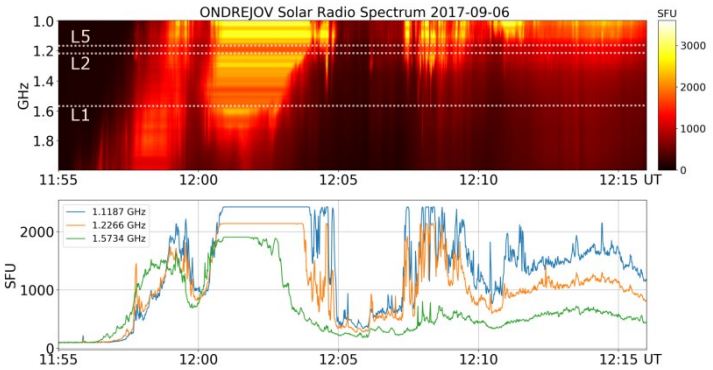
Radio Burst

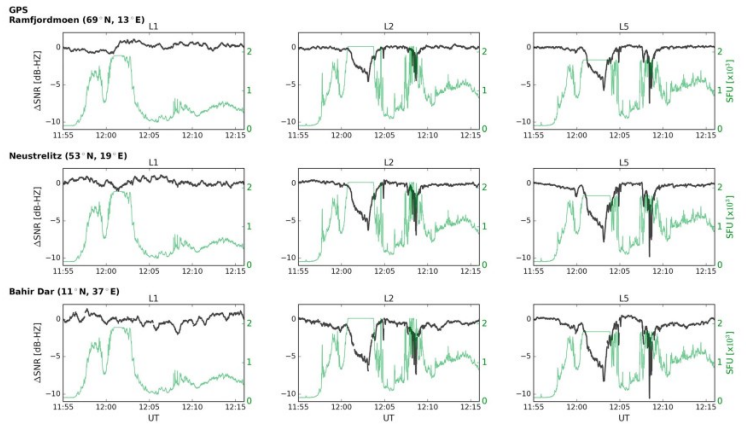


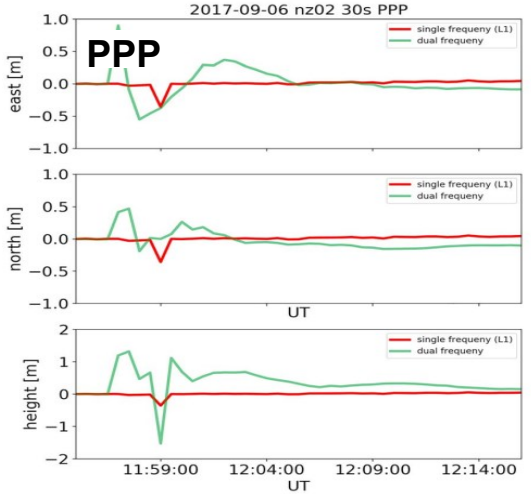








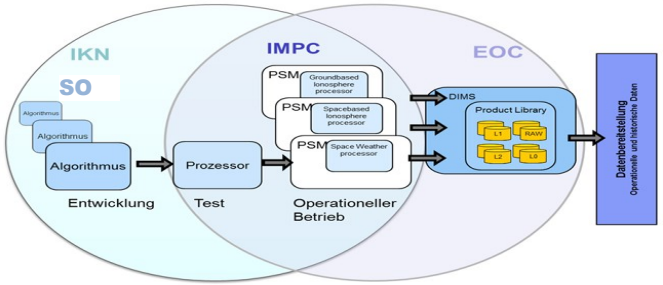




- *Berdermann, J., Kriegel, M., Banys, D., Heymann, F., Hoque, M. M., Wilken, V., et al.* ***(2018****). Ionospheric response to the X9.3 Flare on 6 September 2017 and its implication for navigation services over Europe.* ***Space Weather, 16****.* *https://doi.org/10.1029/2018SW001933*
- *Sato, H. , Jakowski, N. , Berdermann , J. , Jiricka, K., Heßelbarth, A. , Banyś, D. , Wilken V.* ***(2018)****, Solar Radio Burst Events on 6 September 2017 and Its Impact on GNSS Signal Frequencies.* ***Space Weather, 16****. https://doi.org/10.1029/2018SW001933*

Pre-operational Services and Validation

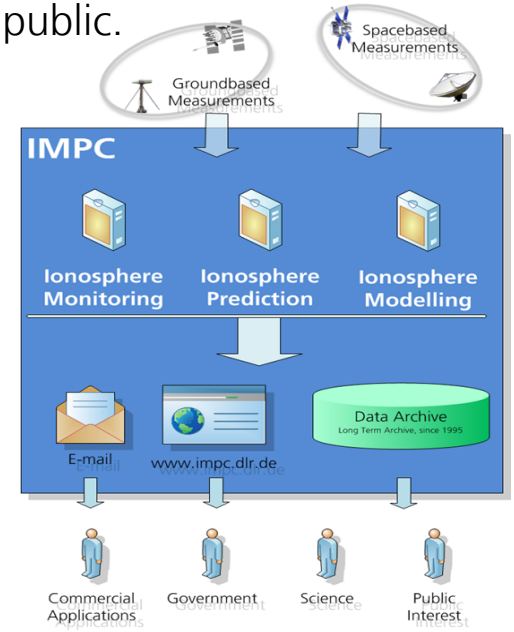
Development of prototypical services and applications at the **DLR Institute for Solar-Terrestrial Physics**



Provision of web services and data products by the **DLR Earth Observation Center**

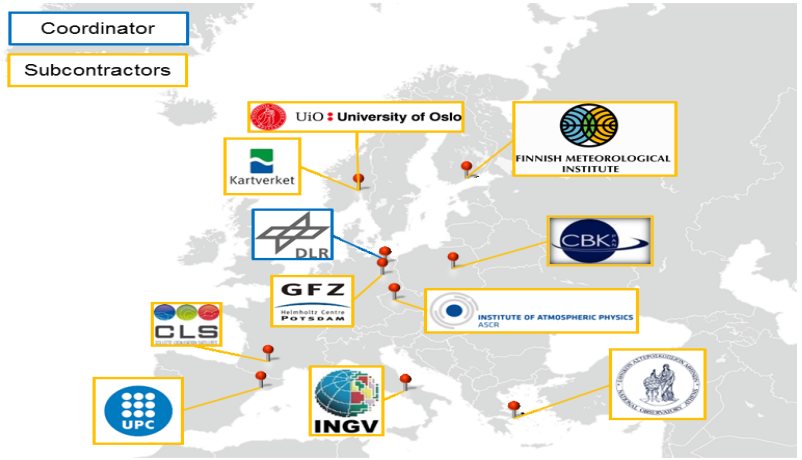
IMPC

Near real-time ionosphere monitoring and prediction of ionospheric conditions to support decision makers and the public.



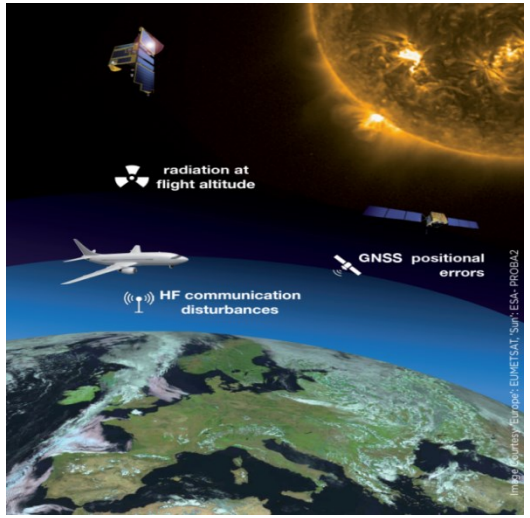
ESA SSA SWE I-ESC

DLR is responsible for the coordination and service provision of the ESA Expert Service Center Ionospheric Weather.



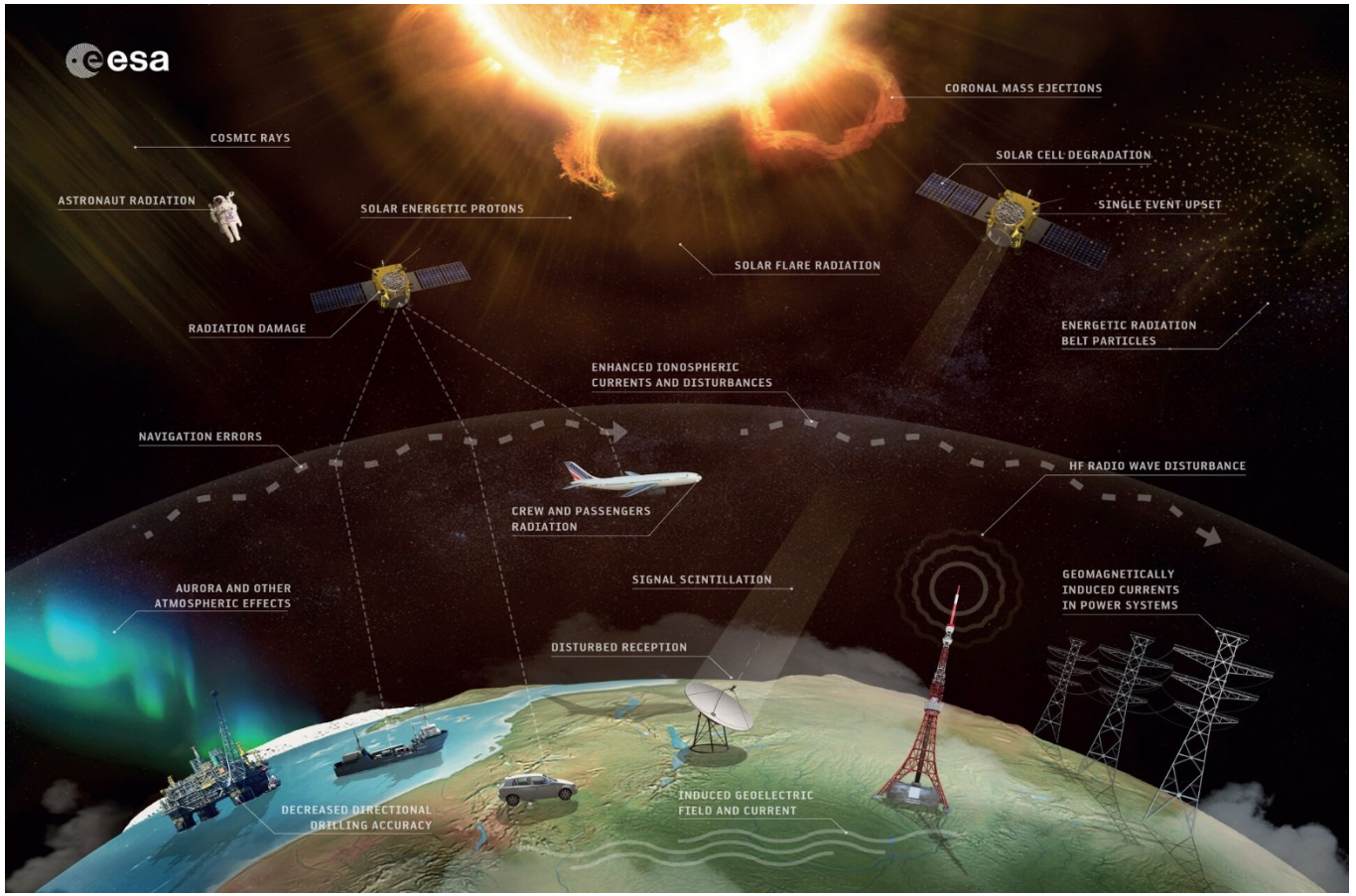
PECASUS

A Global ICAO Space Weather Centers is operated by the PECASUS consortium since Nov. 07.11.2019. DLR's role is to provide data to support GNSS user services.



Characterization and Prediction of Ionospheric Disturbances

Space Weather Impact on GNSS Performance – *ESA Project SWIGPAD*



Understanding Space Weather

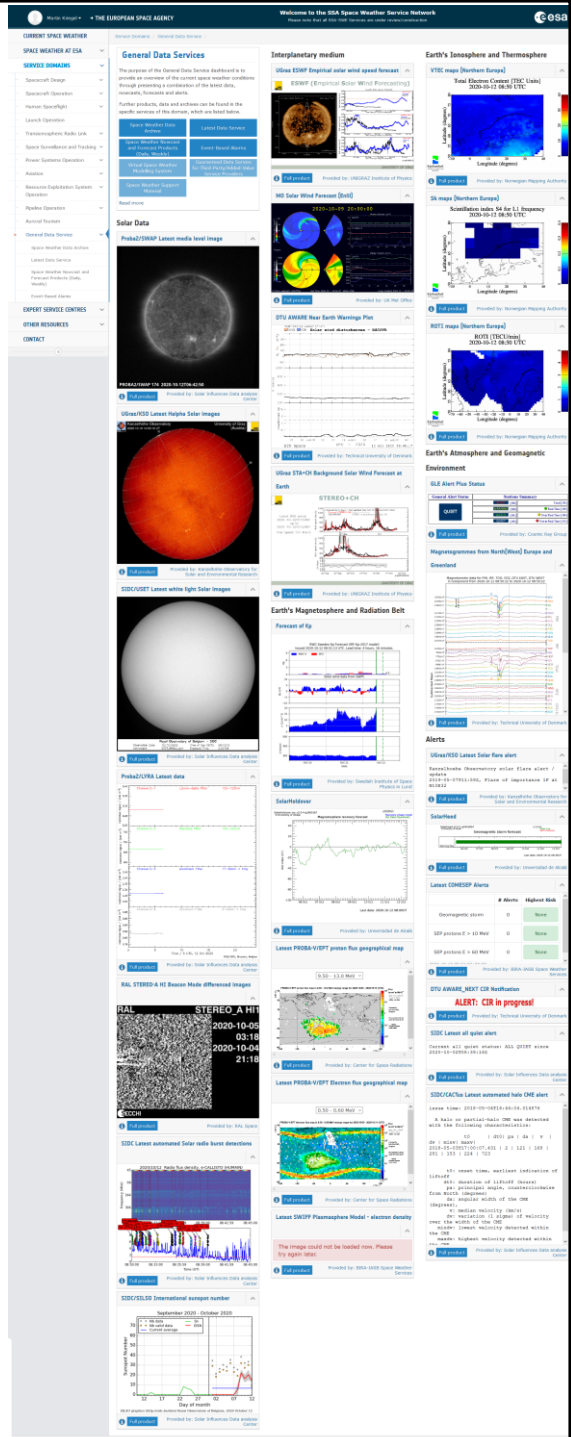
Science

and its effects on our technology

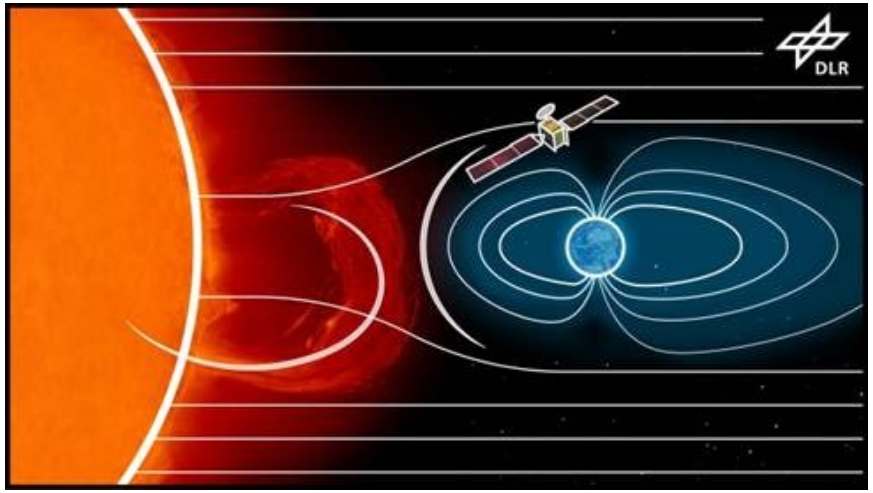
TEC, S4, σϕ
ROTI, foF2 …

GNSS User Domain

SWIGPAD



Thank you!



Contact:

Jens Berdermann
Institute for Solar-Terrestrial Physics
Department Space Weather Impact

Jens.Berdermann@dlr.de
+49 3981 480 106