



PECASUS activities and interest in upper-atmospheric products for space weather service provision

Y. Maneva and the STCE PECASUS team

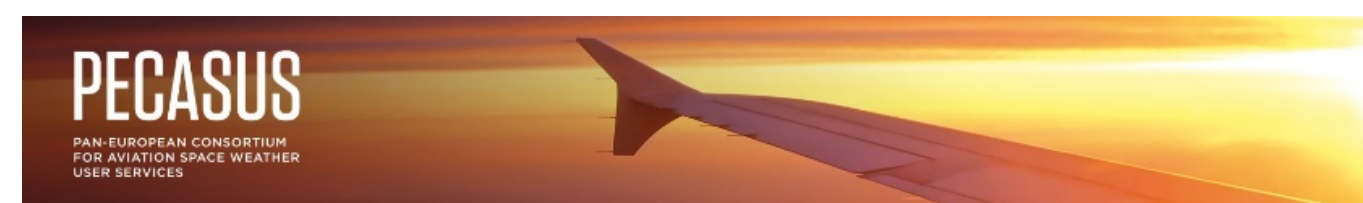


Royal Observatory
of Belgium

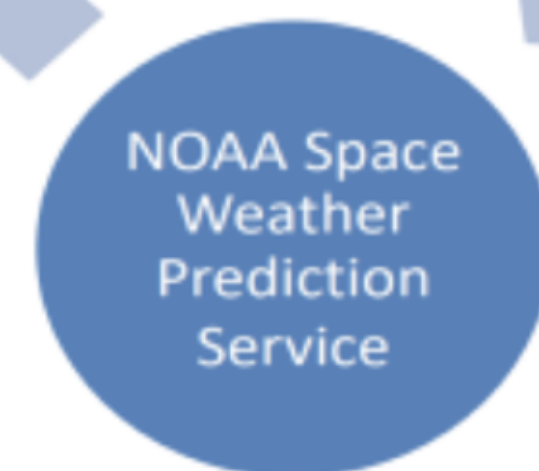


Solar Influences
Data analysis Centre
www.sidc.be

PECASUS: a global SWX center serving ICAO



ODC = On duty Center
PBC = Primary Backup Center
SBC = Secondary Backup Center
MOC = Maintenance & Observations Center



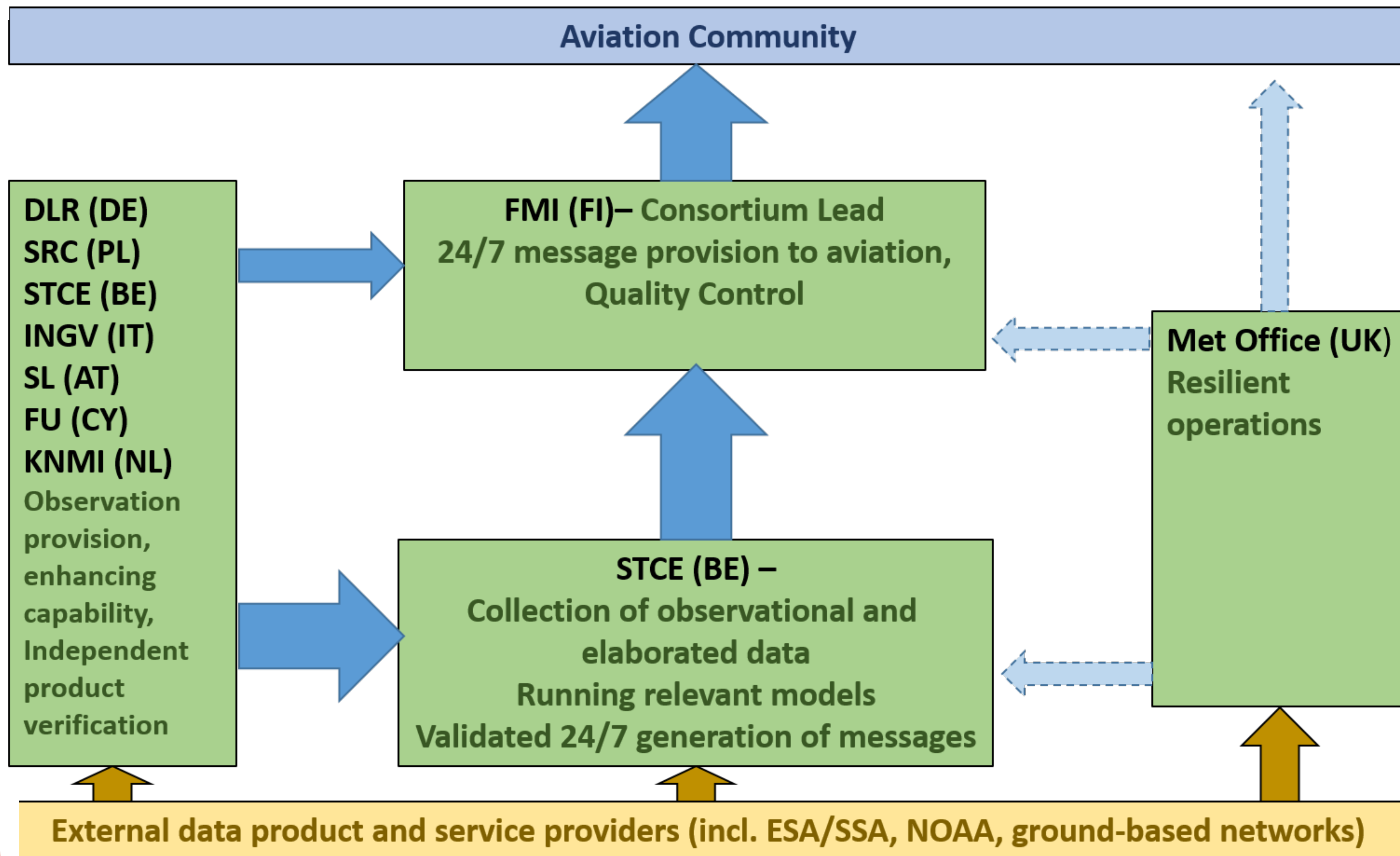
- Two week shifts in the responsibility of advisory validation and dissemination
- All centers will monitor space weather continuously.



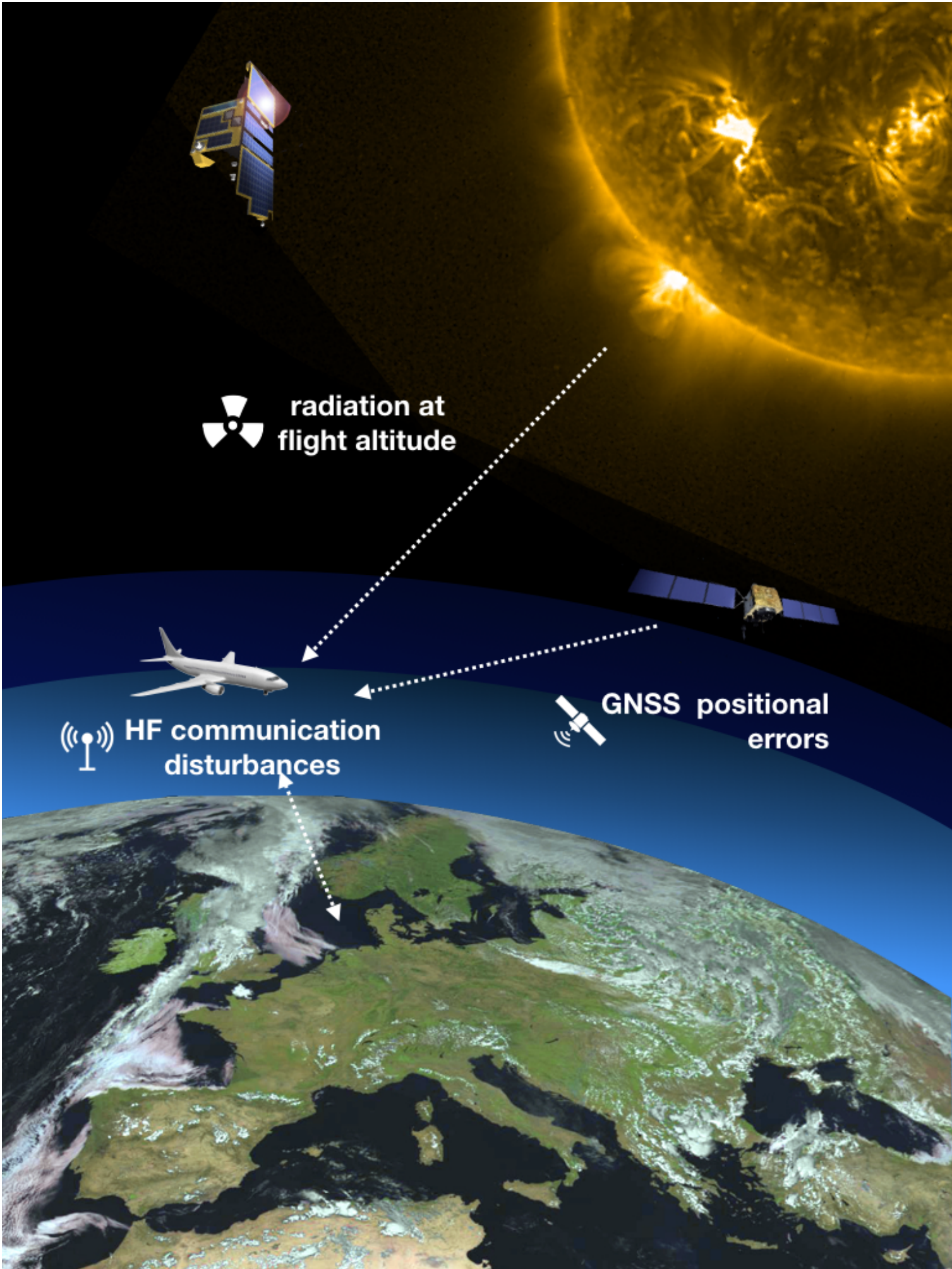
24/7 SWX service
NRT advisories since Nov 2019
impact-based, worldwide



Join effort of nine European countries

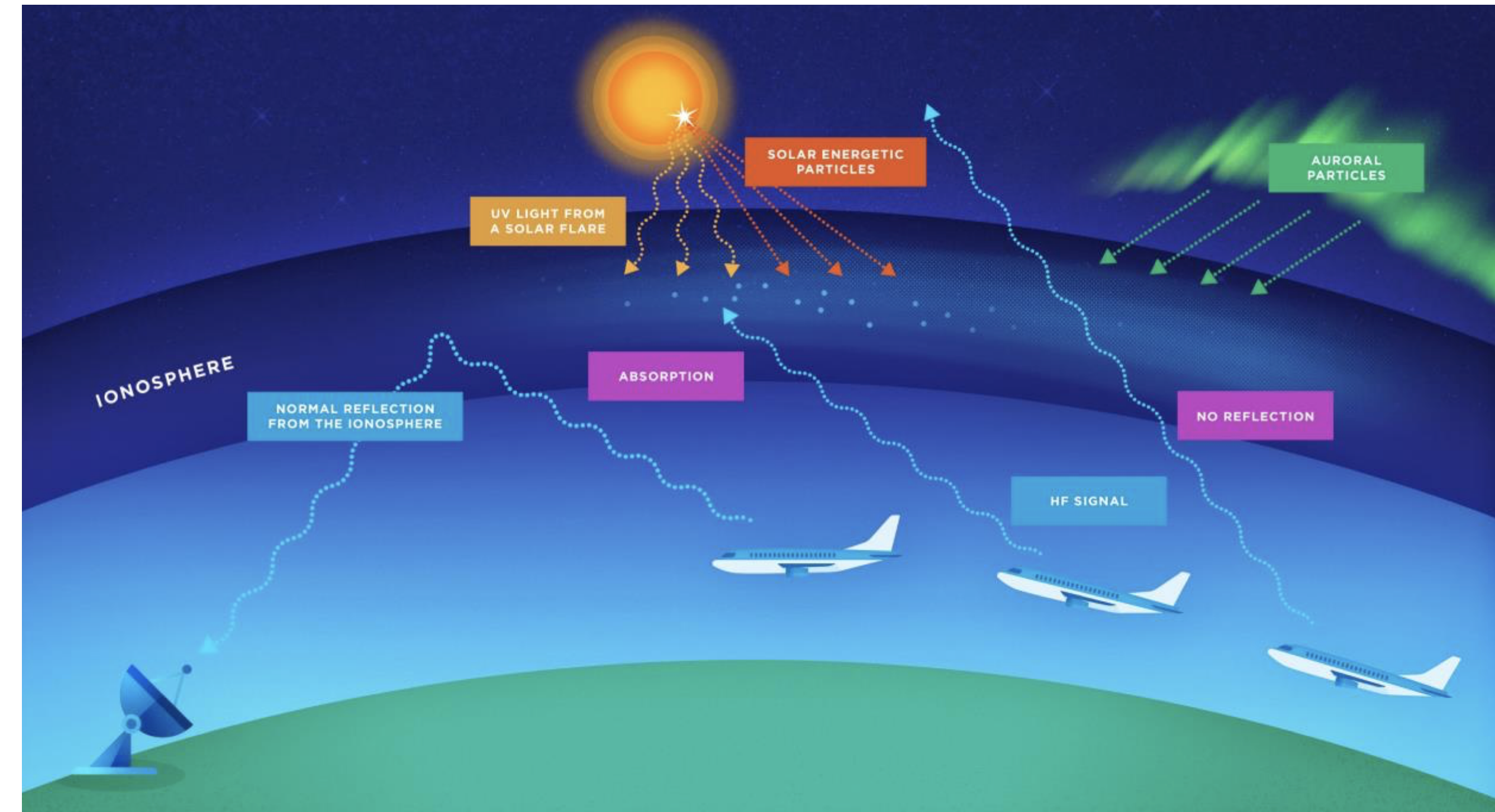
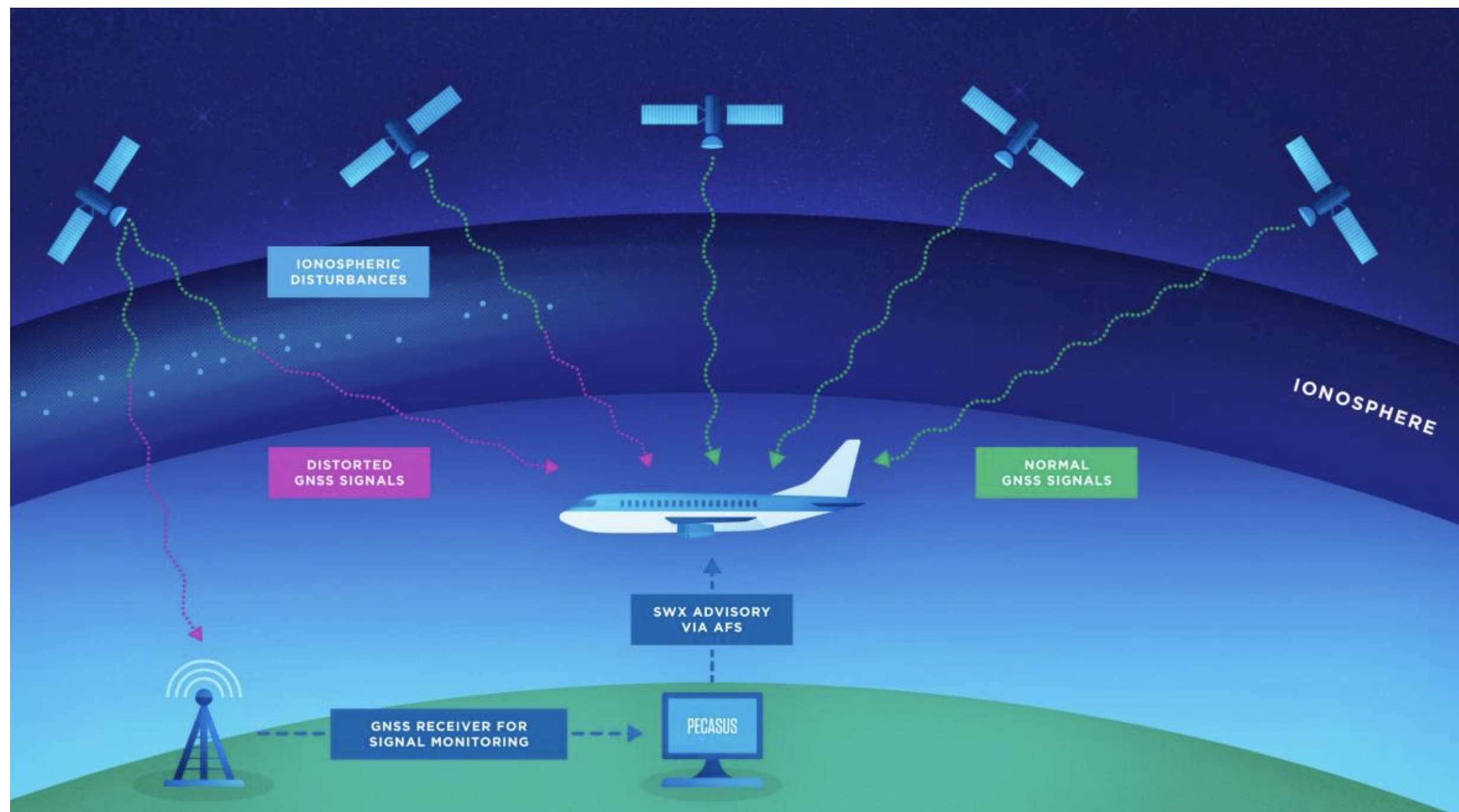


Space Weather Impacts on Aviation

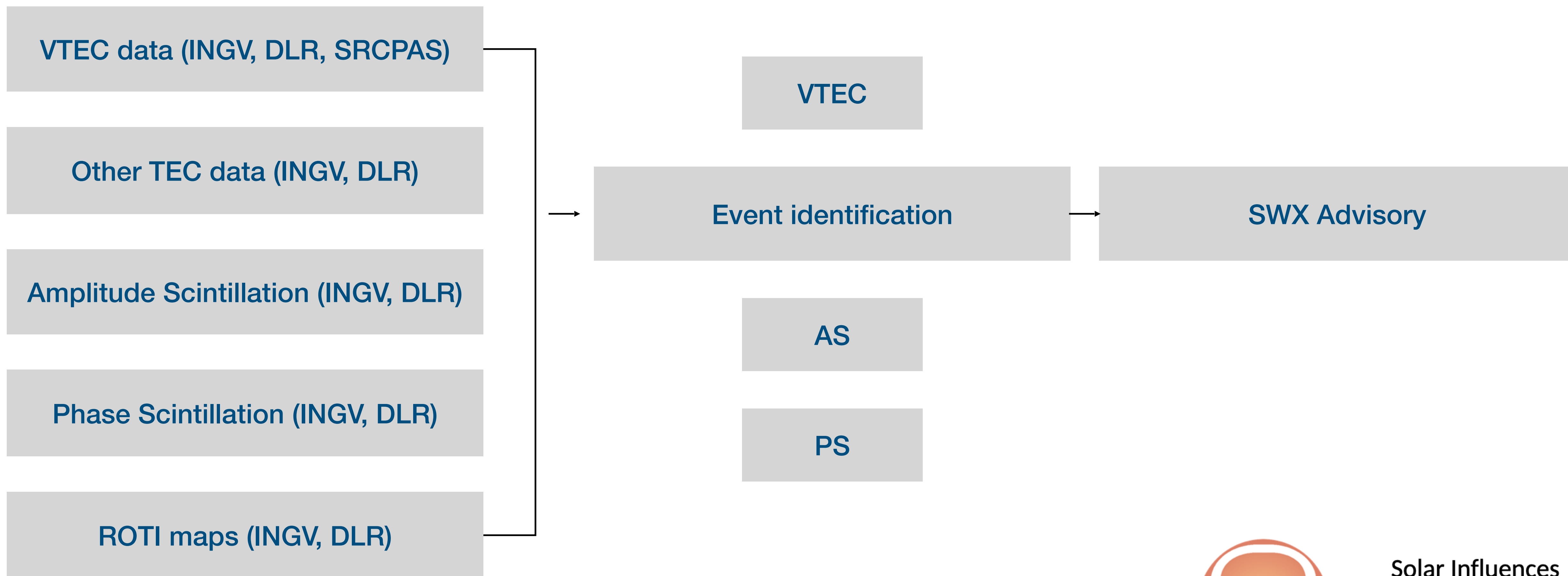


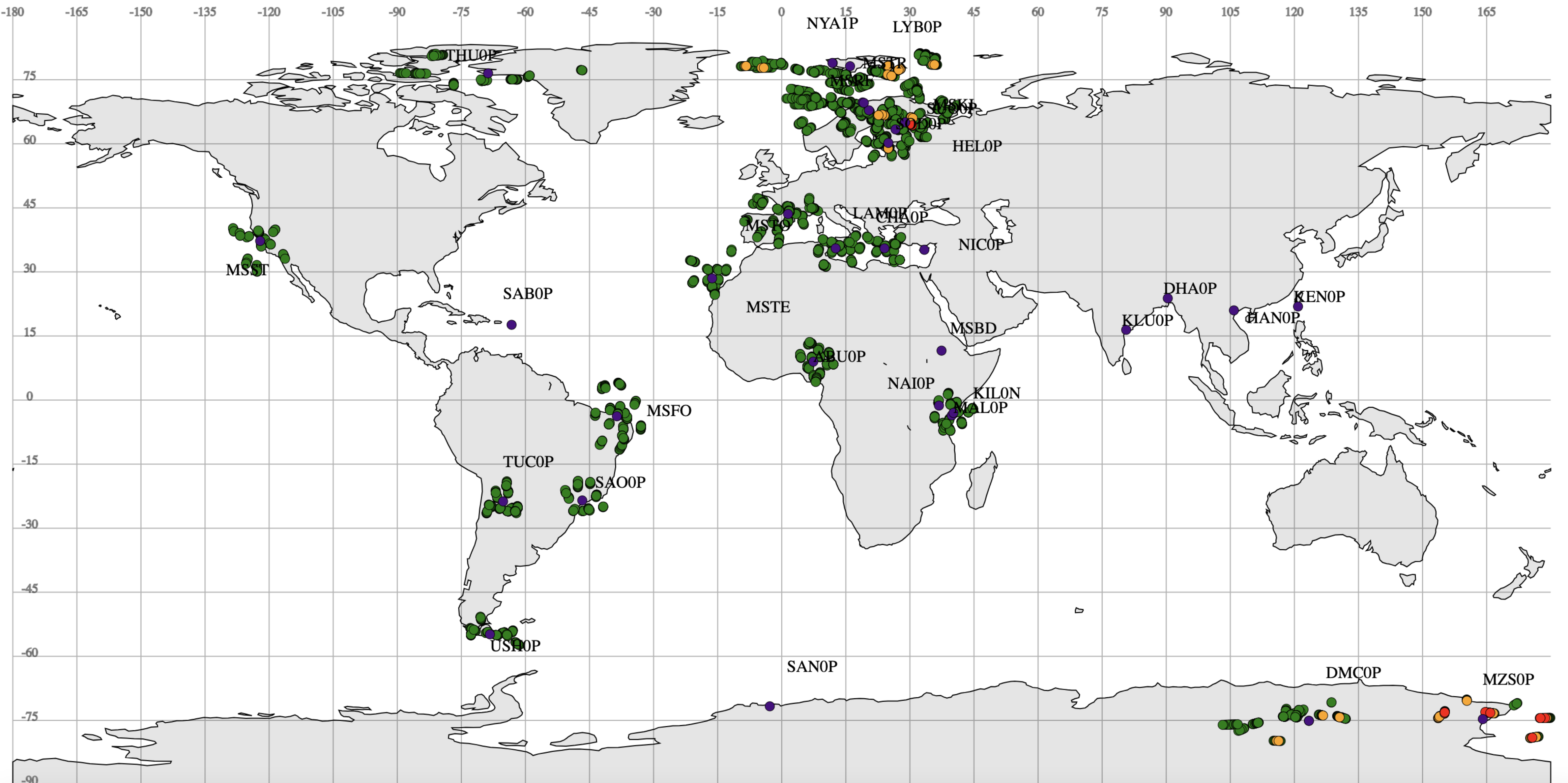
Effect	Sub-effect	Parameter used	Moderate	Severe
GNSS	Amplitude Scintillation	S4 (dimensionless)	0.5	0.8
GNSS	Phase Scintillation	Sigma-phi (radians)	0.4	0.7
GNSS	Vertical Total Electron Content (TEC)	TEC units	125	175
RADIATION		Effective dose (micro-Sieverts/hour)*	30	80
HF COM	Auroral Absorption (AA)	Kp	8	9
HF COM	Polar Cap Absorption (PCA)	dB from 30MHz riometer data	2	5
HF COM	Shortwave Fadeout (SWF)	Solar X-rays (0.1-0.8 nm) (W-m ⁻²)	1x10 ⁻⁴ (X1)	1x10 ⁻³ (X10)
HF COM	Post-Storm Depression	MUF**	30%	50%
SATCOM***	N/A	N/A	N/A	N/A

Navigation & Radio Communications



Model/data workflow for GNSS advisories



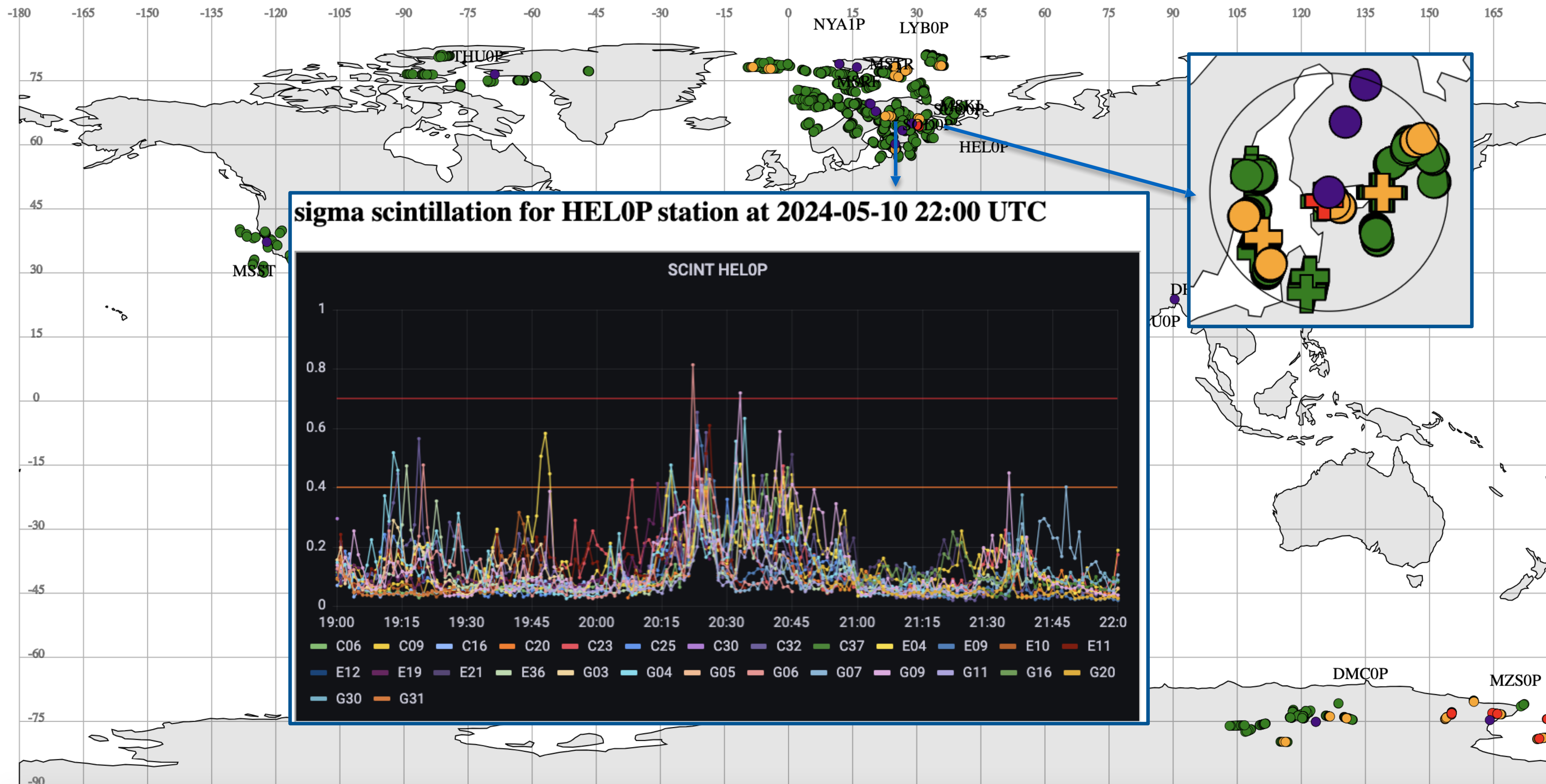




ROYAL OBSERVATORY
OF BELGIUM

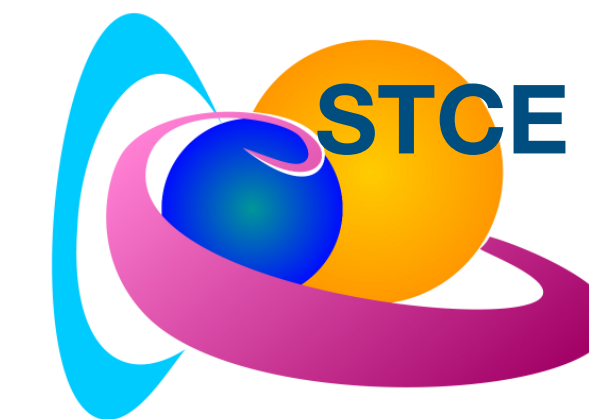


Scintillation Events

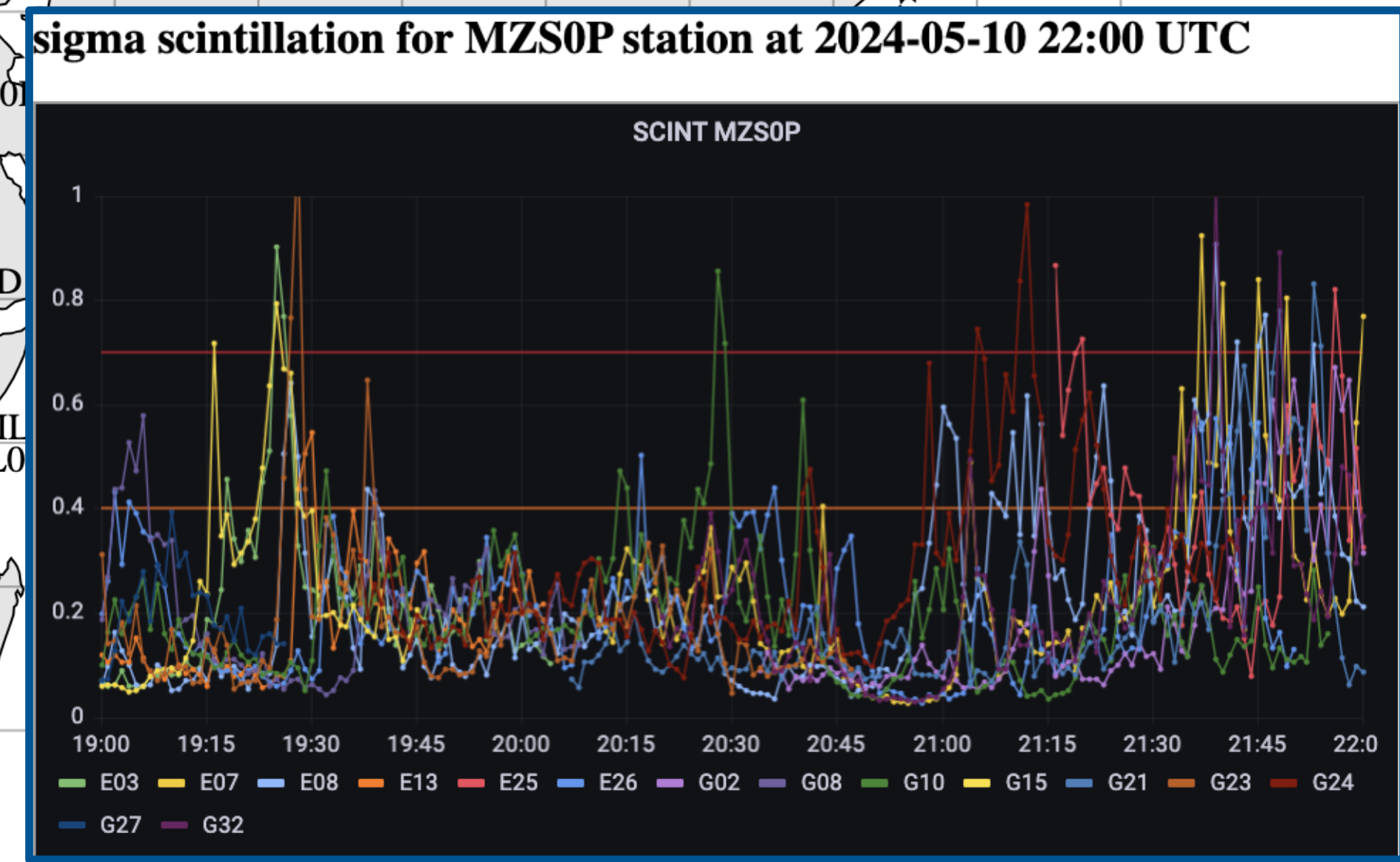
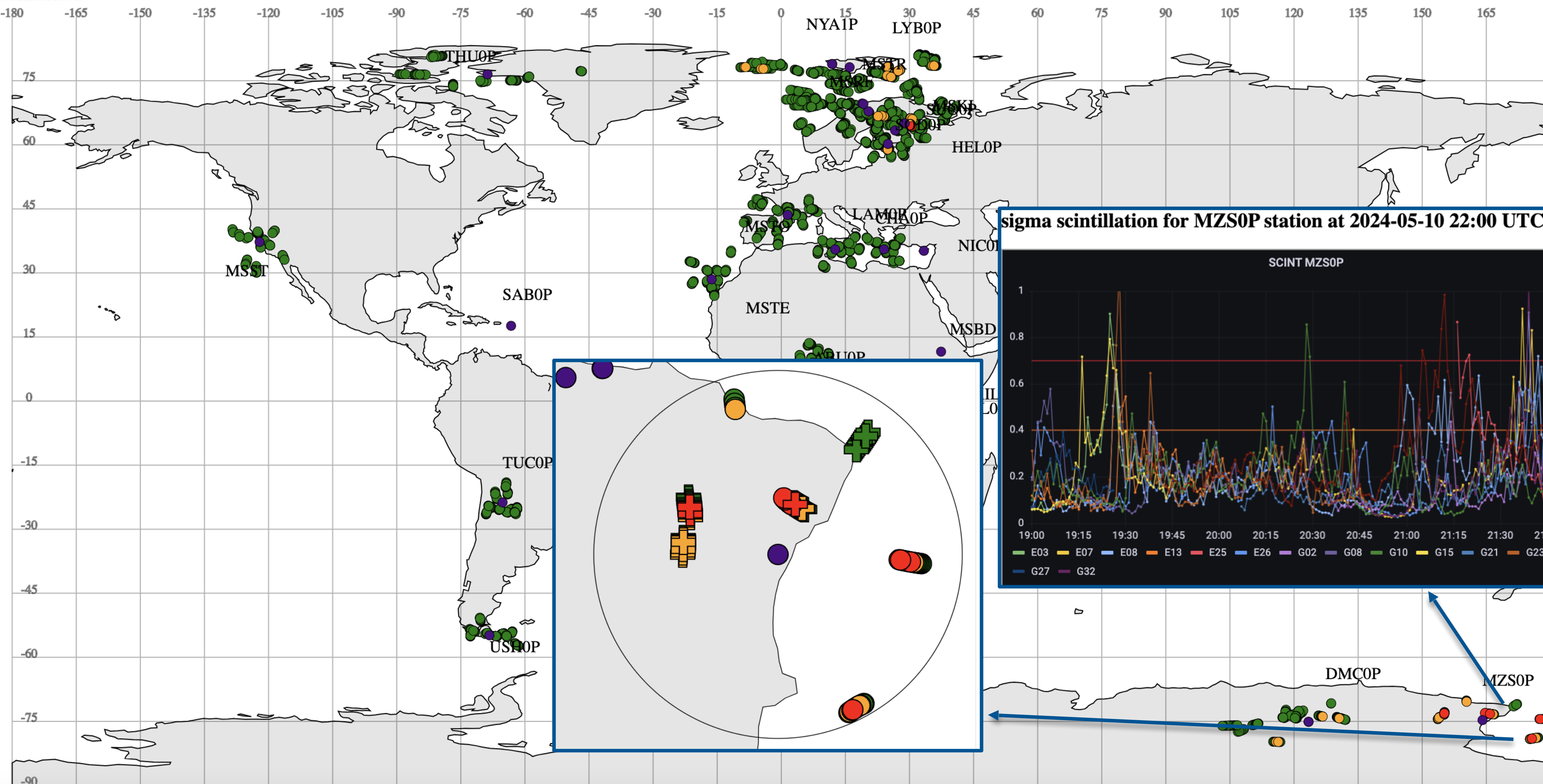




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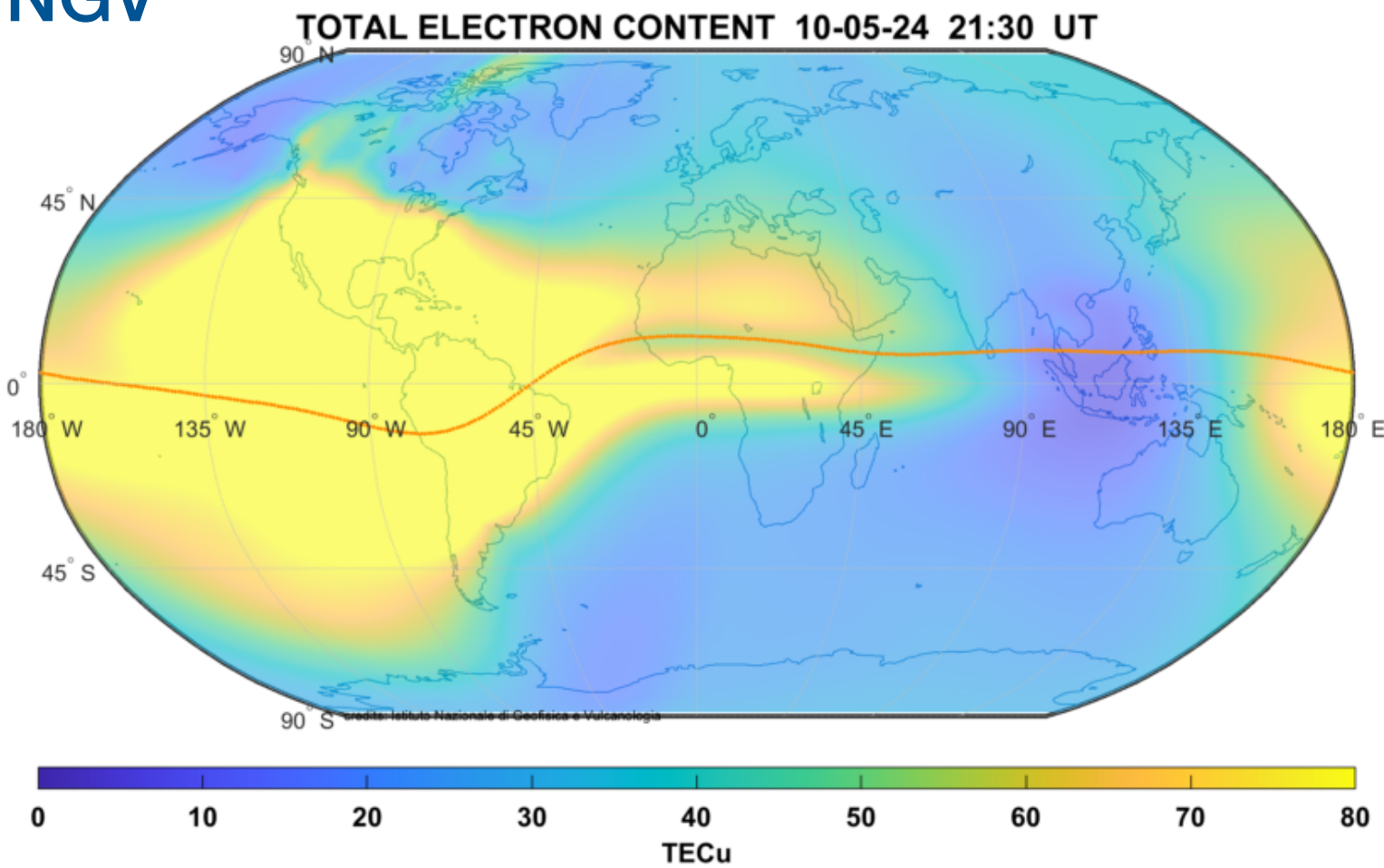


Scintillation Events



VTEC models used within PECASUS

INGV



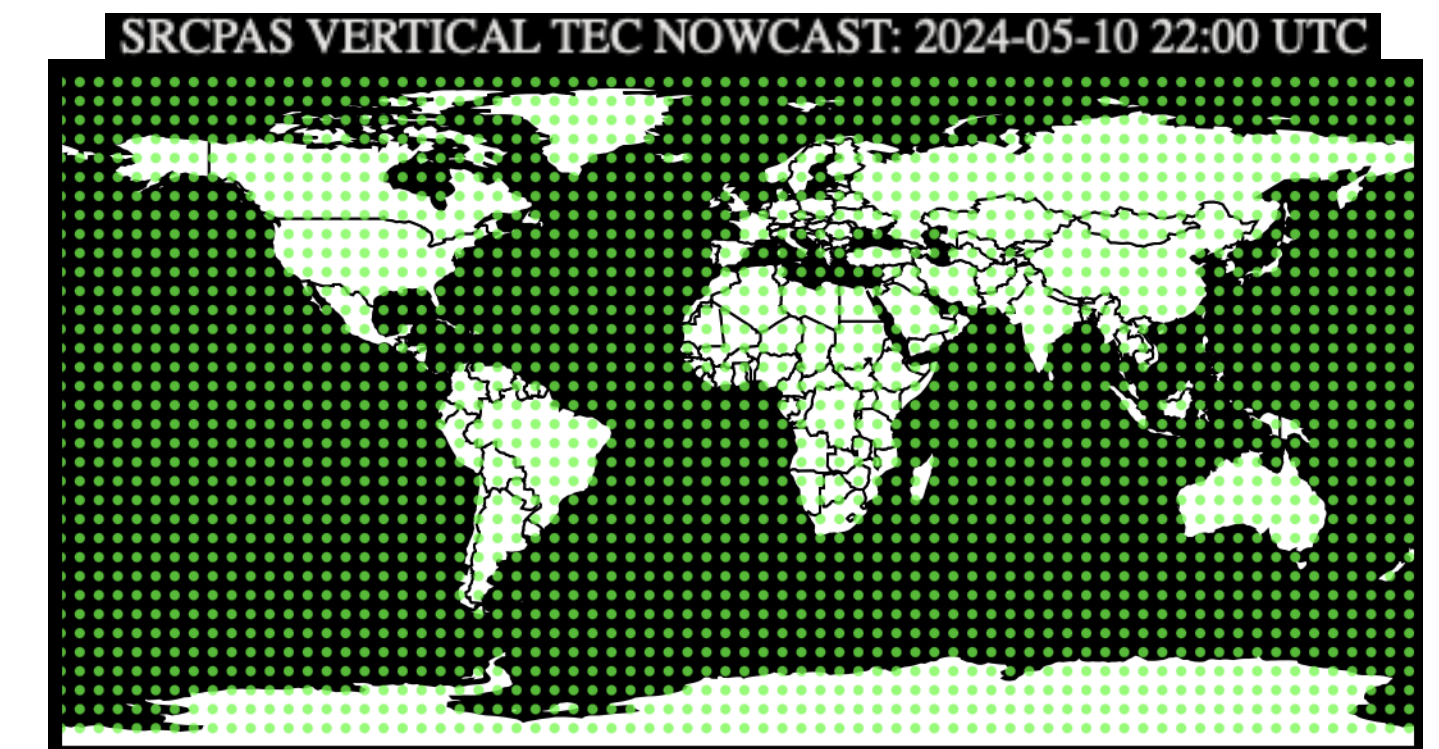
SRCPAS global VTEC model

- 15 min cadence
- worldwide coverage
- Galileo-NeQuick
- Nowcast

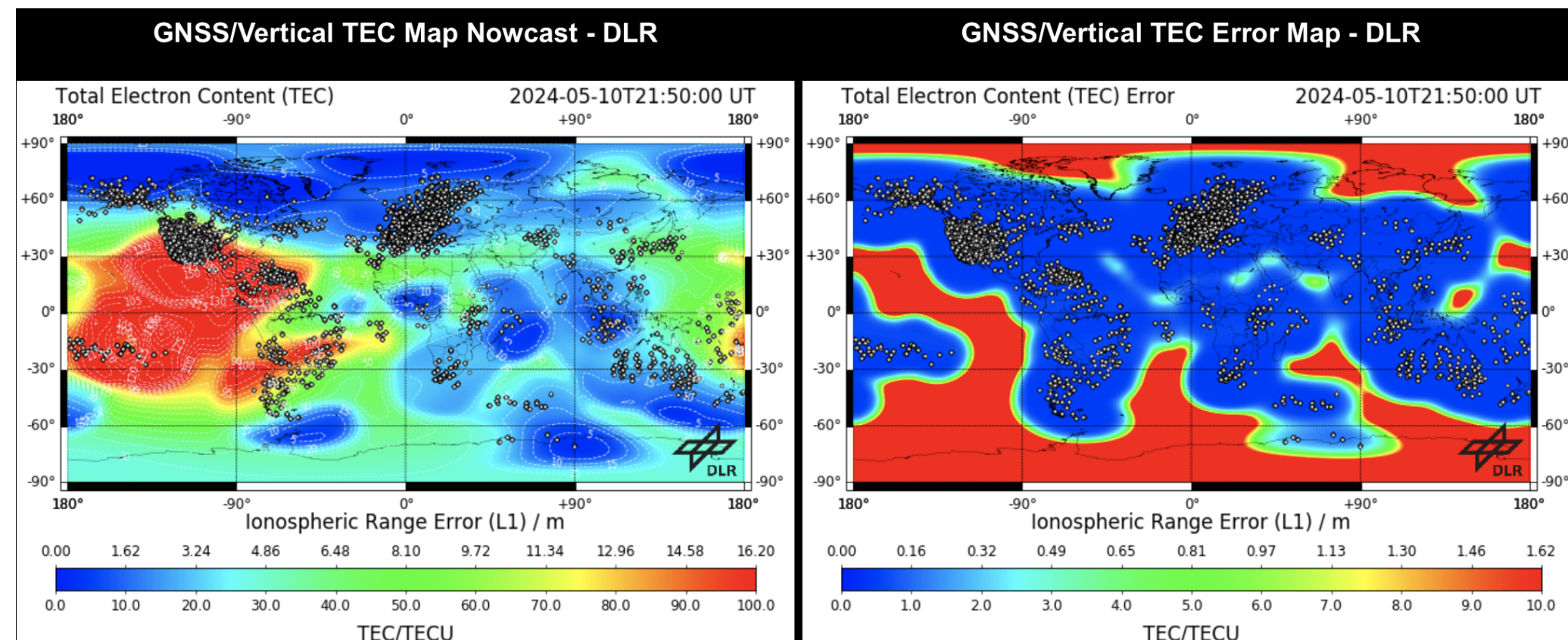
INGV global VTEC model:

- 15 min cadence
- worldwide coverage
- Nowcast
- IGS stations ingested into NeQuick2 model

SRCPAS



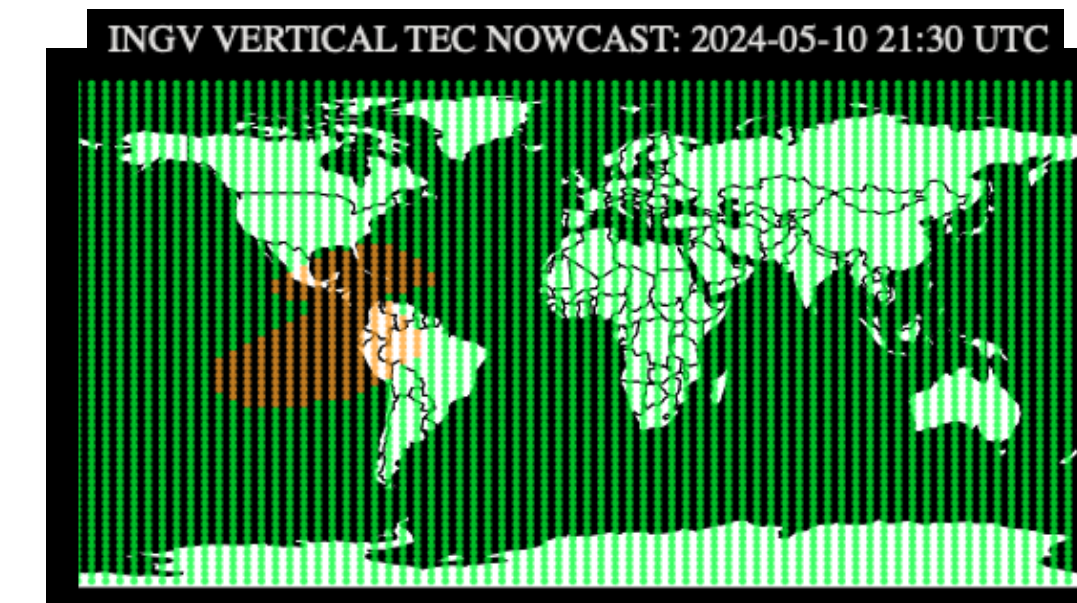
DLR



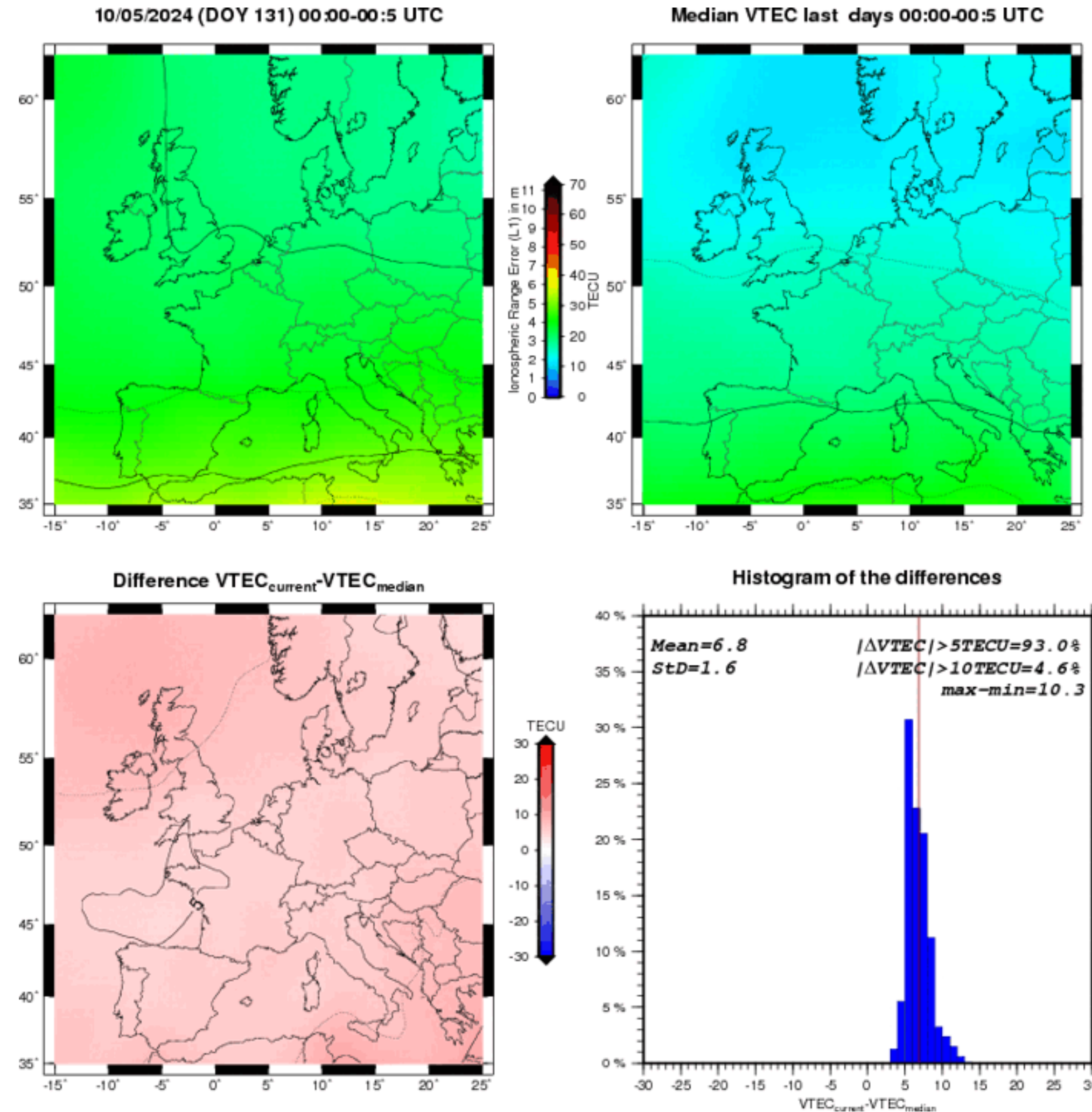
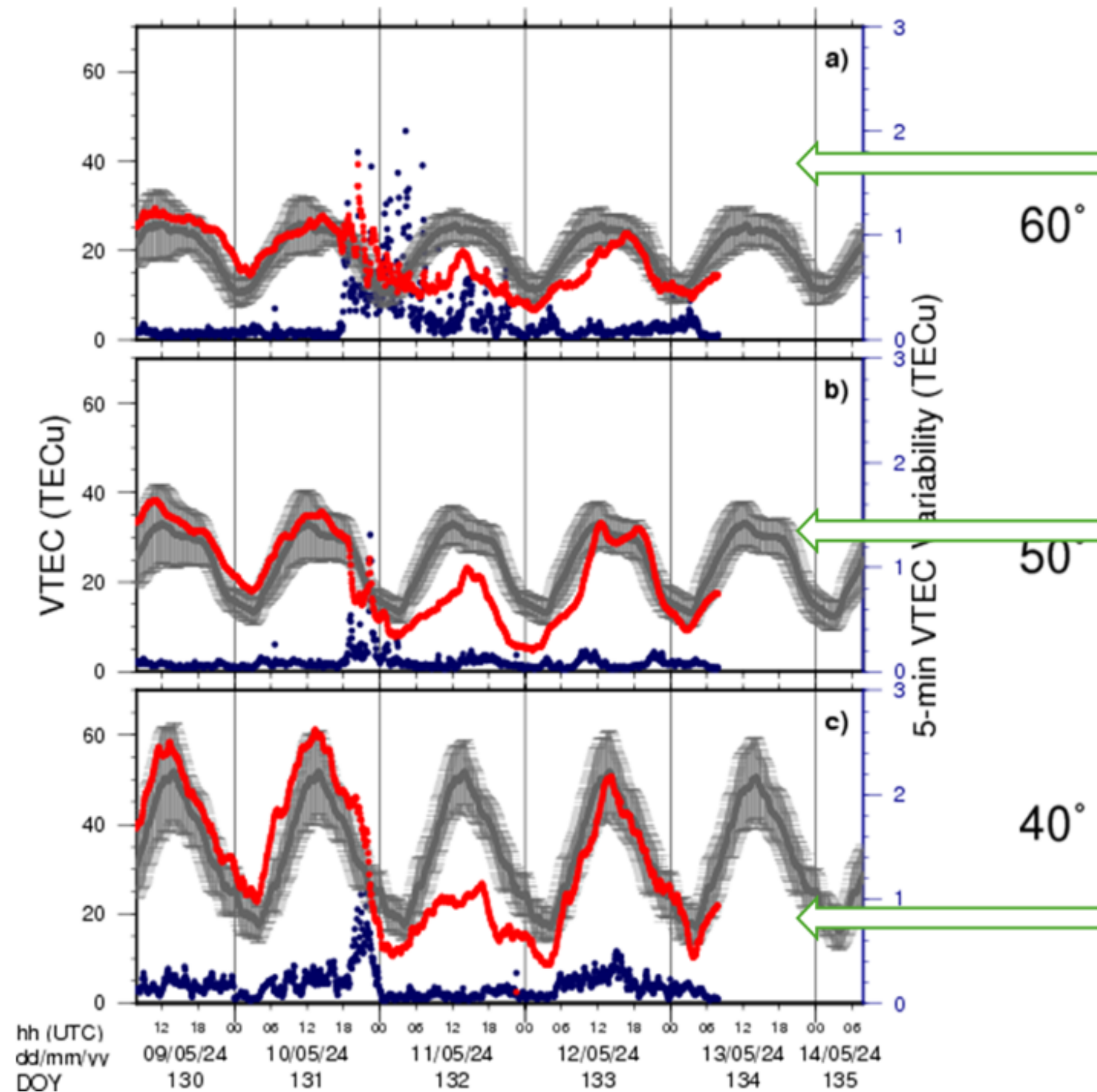
DLR global VTEC model:

- 5 min cadence
- worldwide coverage
- ground based GNSS measurements assimilated into an empirical TEC model (NTCM)
- Nowcast and Forecast

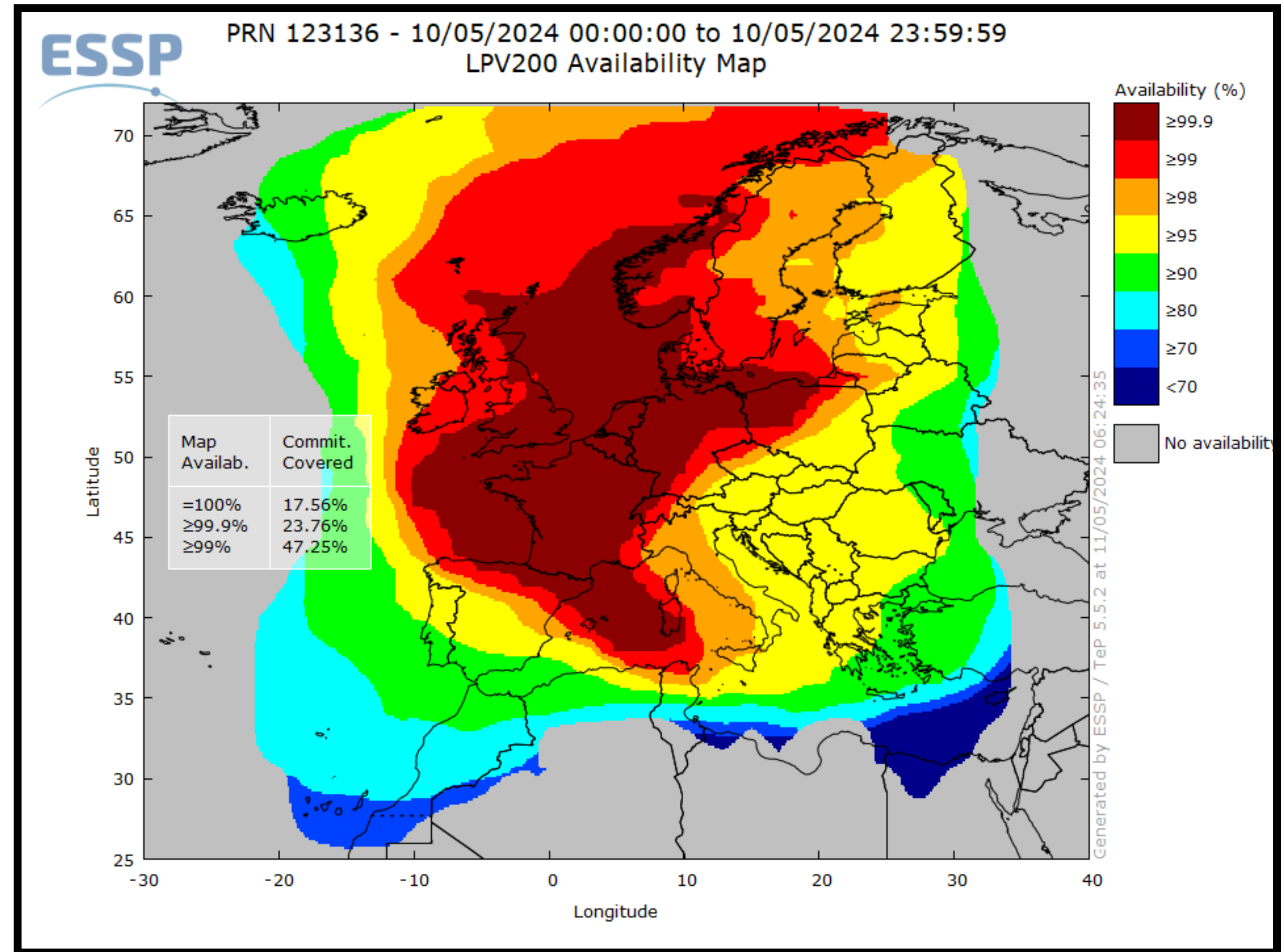
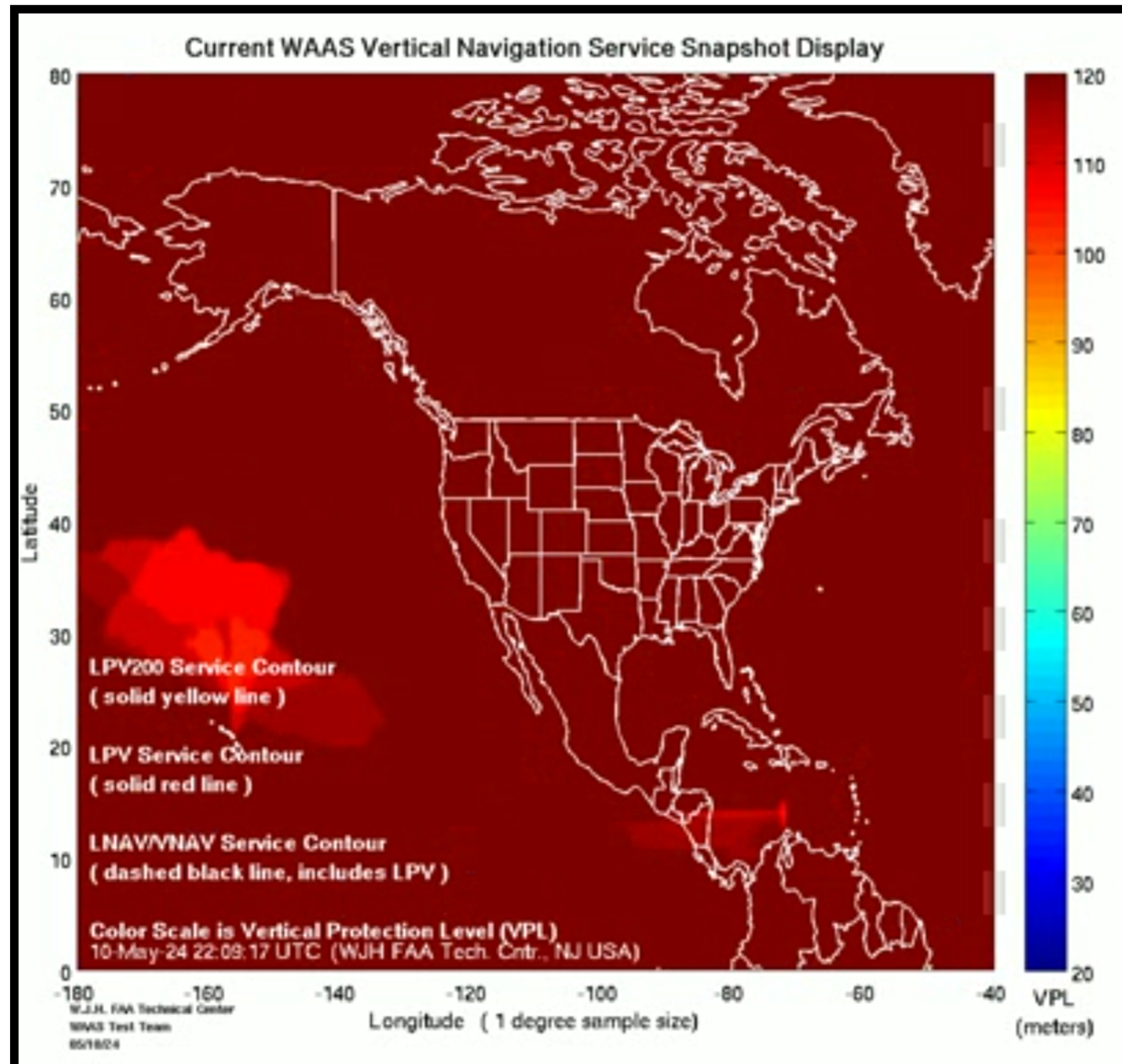
INGV



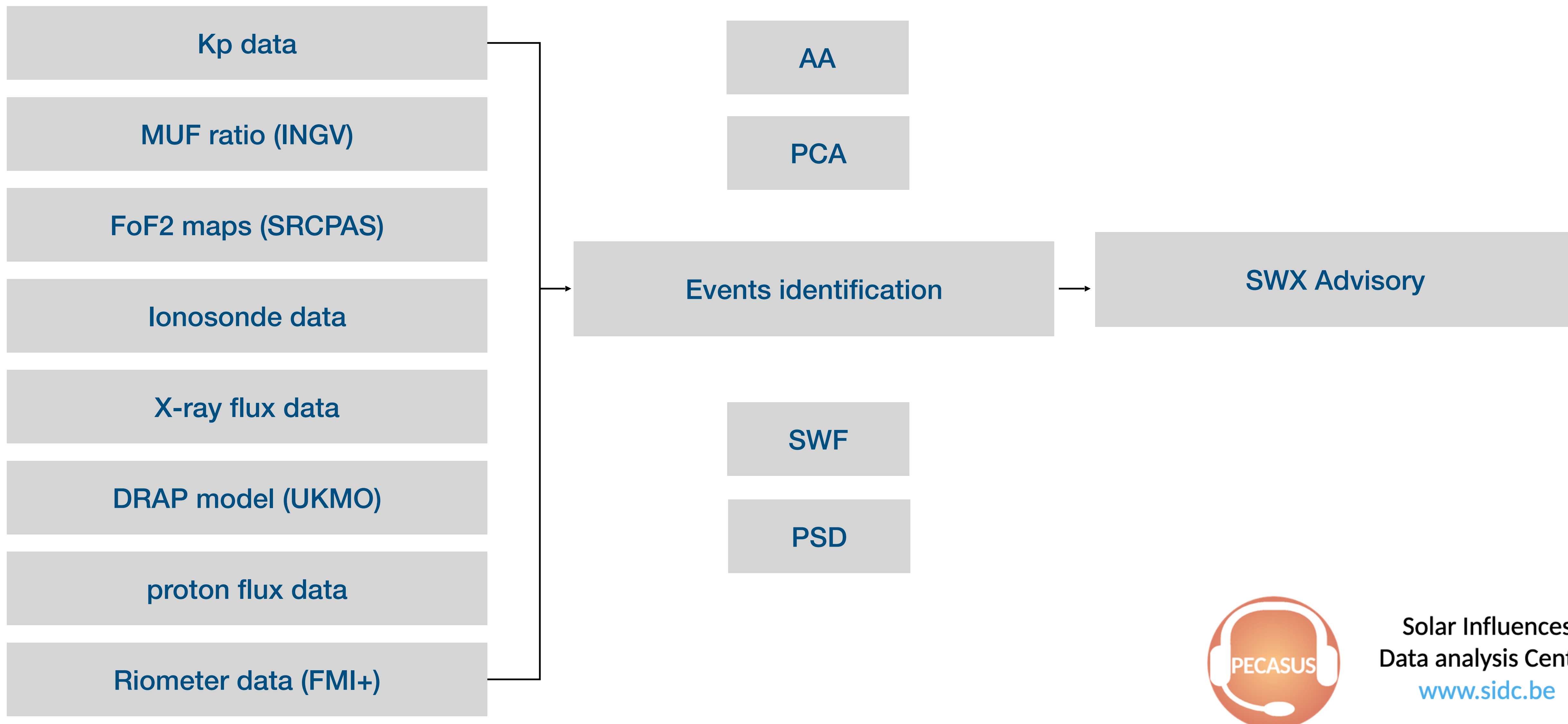
MAY 10-12 — GNSS degradation over Europe



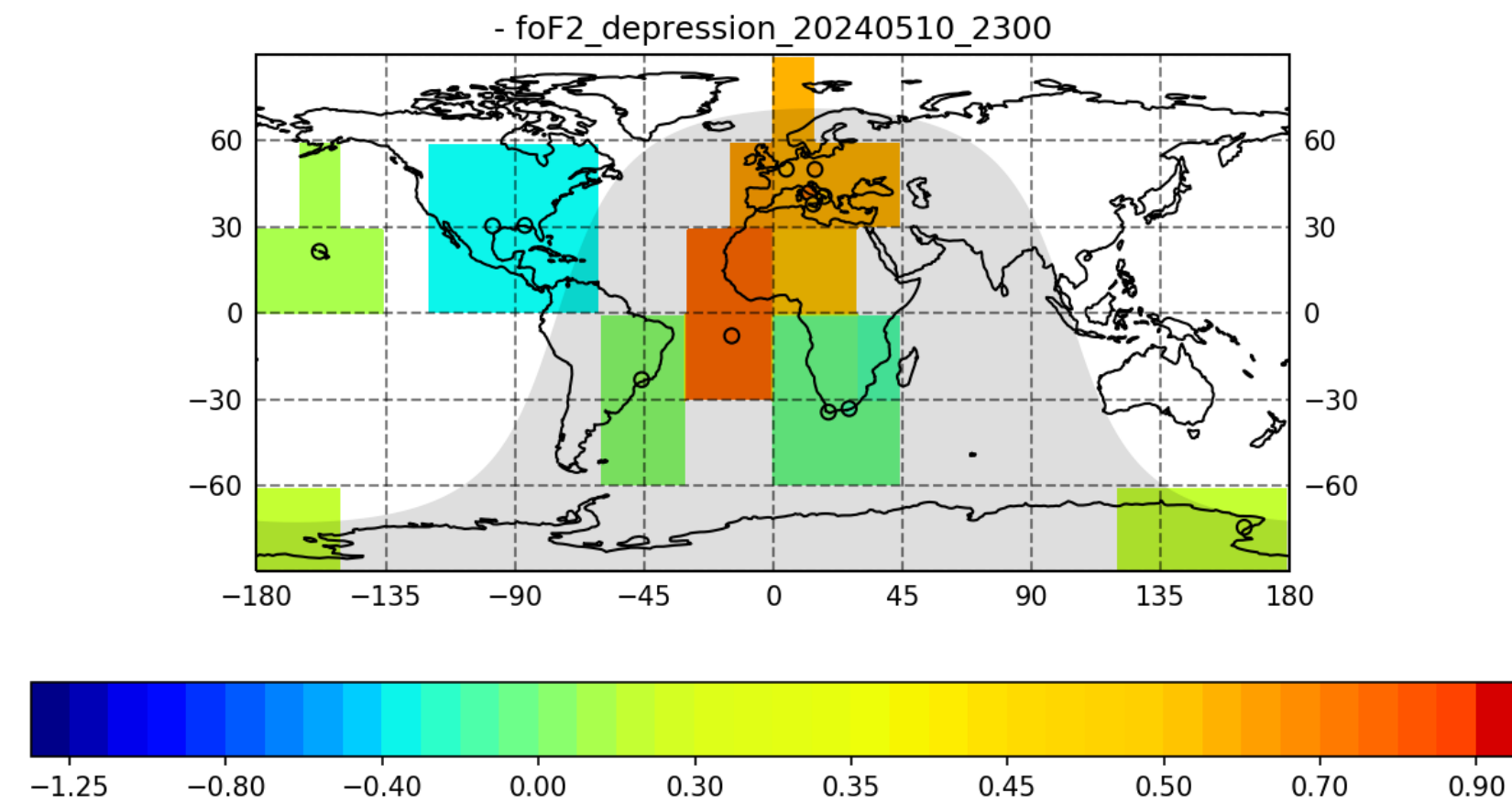
WAAS and ESSP service degradation on MAY 10-12 (no official aviation reports about GNSS problems yet)



Model/data workflow for HF COM advisories



PSD models used within PECASUS

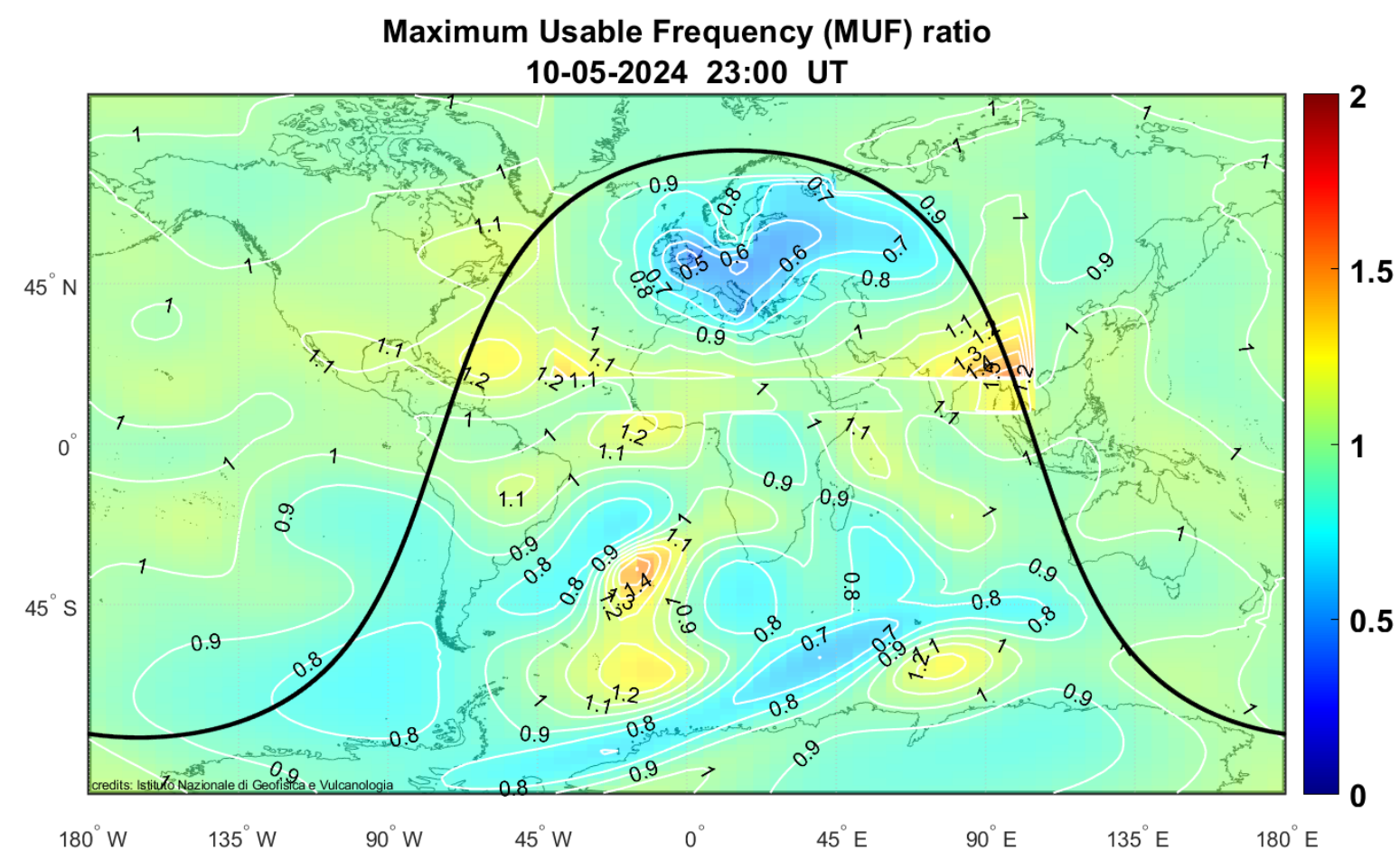


SRCPAS nrt FoF2 depression warnings

- based on ionosonde data
- 15 min depressions cadence
- worldwide coverage from > 70 stations
- product maps with better spatial resolution exist, but better world coverage needed (more ionosondes)

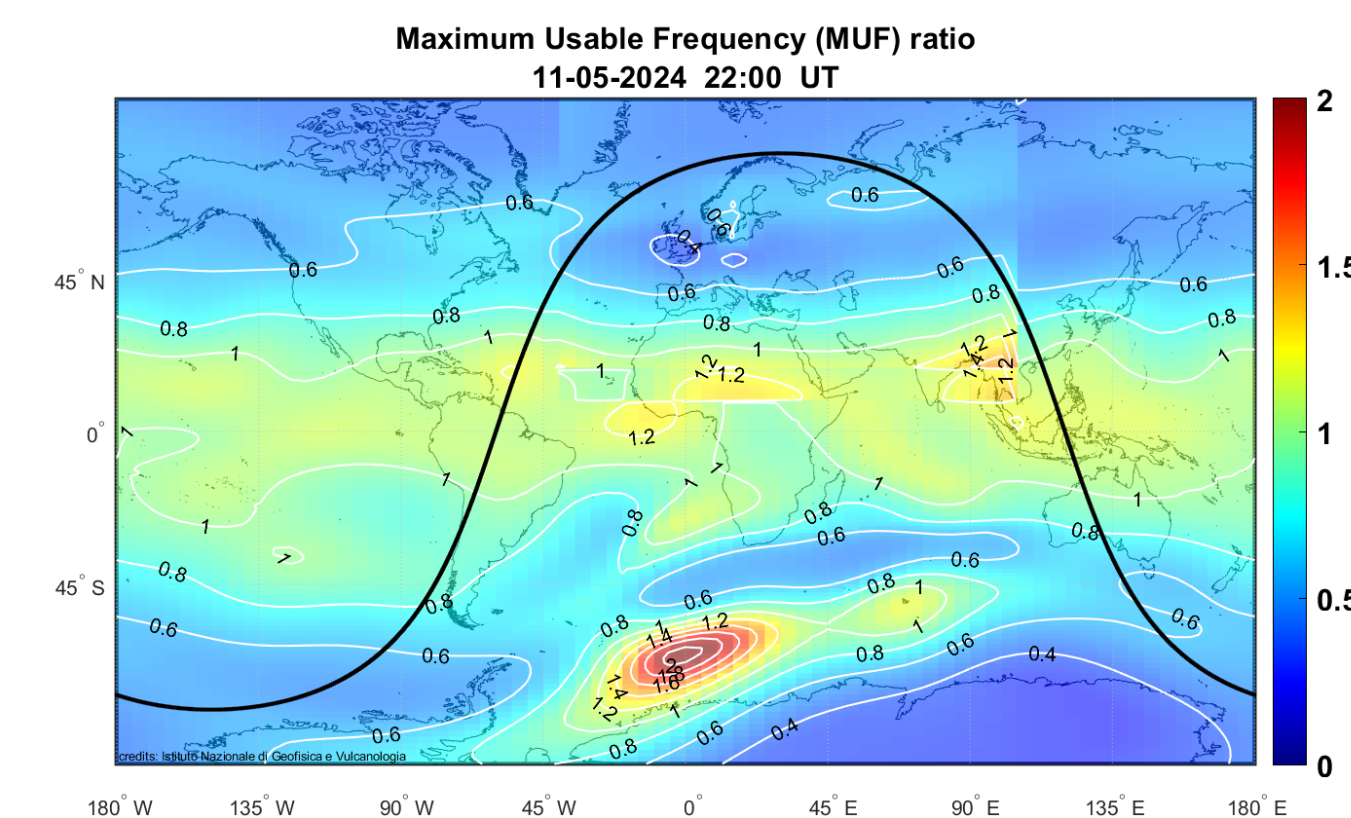
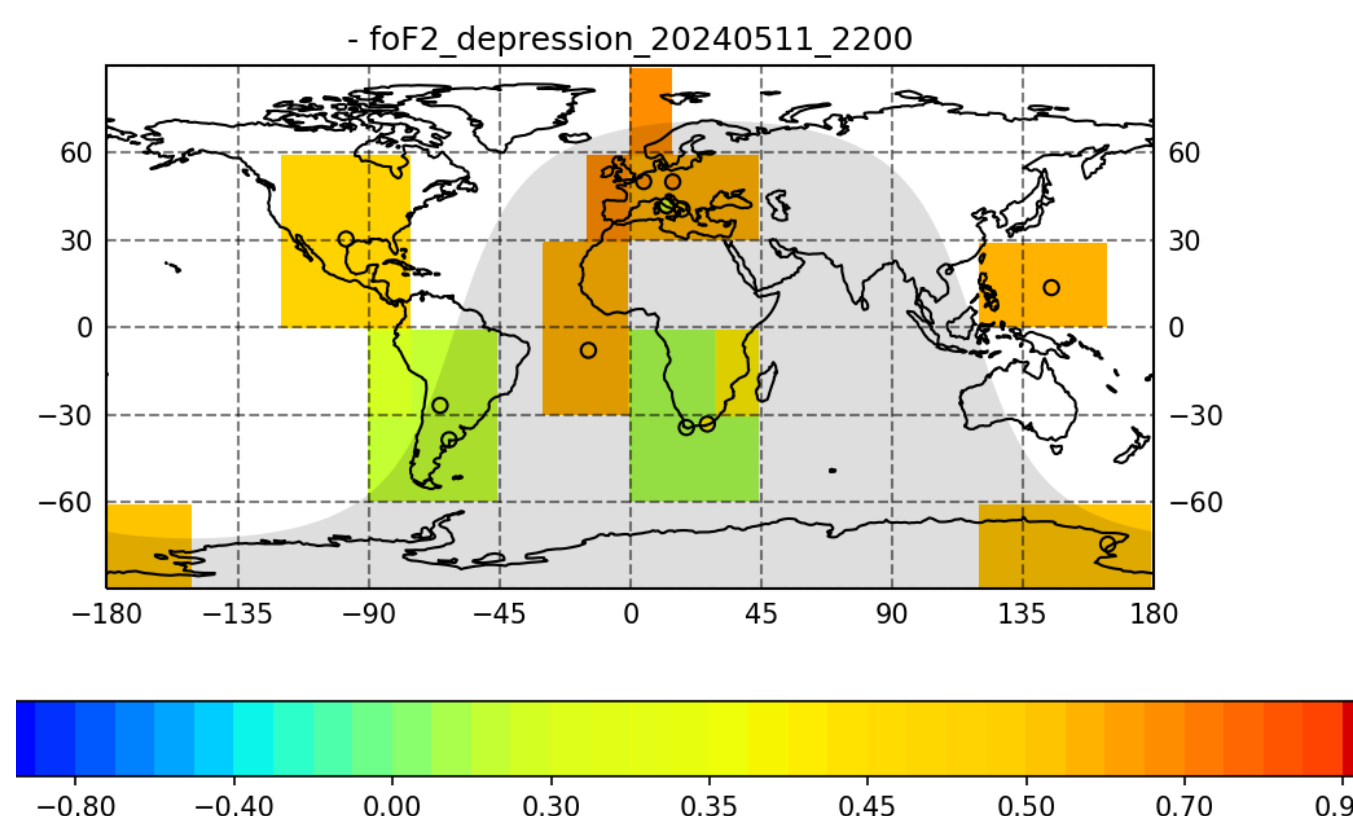
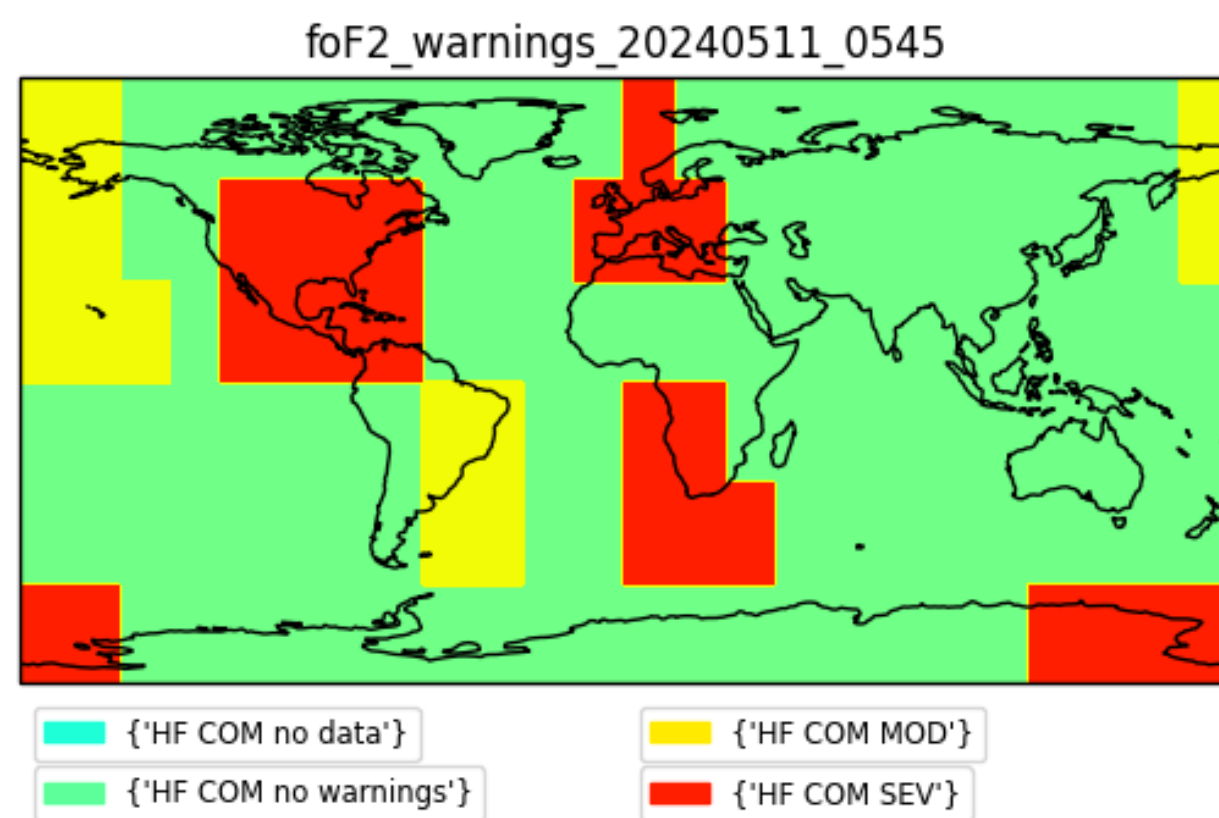
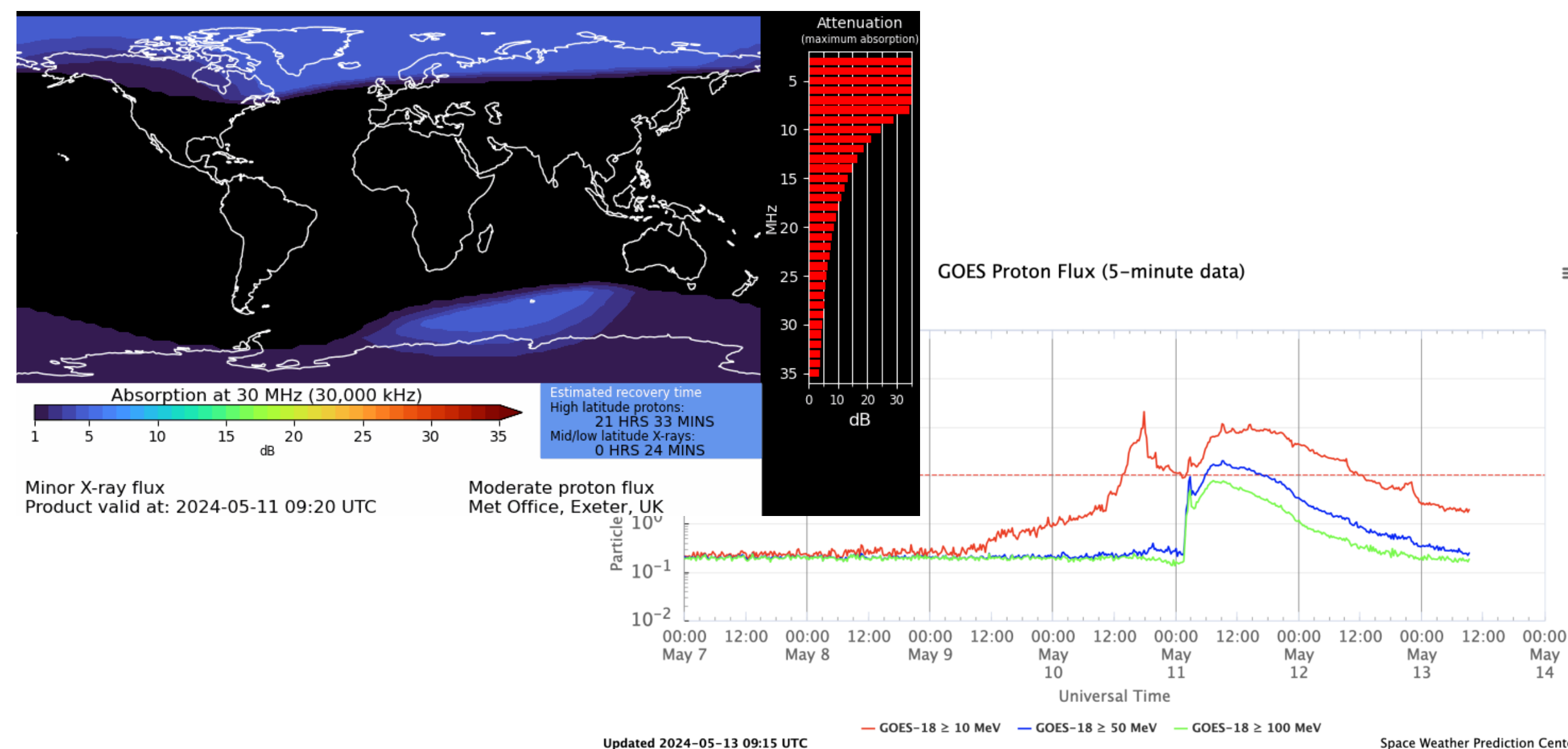
INGV global PSD model:

- Based on EUROMAP and GDMF2 models
 - ➔ worldwide coverage for PSD with best result over Europe
 - ➔ input parameters: F10.7 flux, 3h ap indices, effective ionospheric T index, and real-time foF2 observations
 - ➔ 1h cadence
 - ➔ Nowcast and forecast



HF COM issues in May 10-12 2024 (SWF, PSD, AA and PCA)

- Highly disturbed Ionosphere and Geomagnetic field
- HF COM Advisories issued due to:
- Post Storm depression (all over the world)
- Auroral Absorption ($K_p > 8, 9$ – auroral oval)
- Polar Cap Absorption (proton flux increase – poles)
- Short wave fadeout (X flares – daylight)



Proton Event - 8th-10th June 2024– Impact on HF in BIRD

Feedback from Radio in BIRD (ATC Reykyavik, >70° N) : Usual HF Frequencies 8-11MHz, up to 17MHz if needed

Subject **Skilyrði í lofti - 08.06.2024**

Actual HF condition

0-4 N: Weak
4-8 N: Weak
8-12 N: Black out
12-16 N: Black out
16-20 N: Black out
20-24 N: Black out

Subject **Skilyrði í lofti - 09.06.2024**

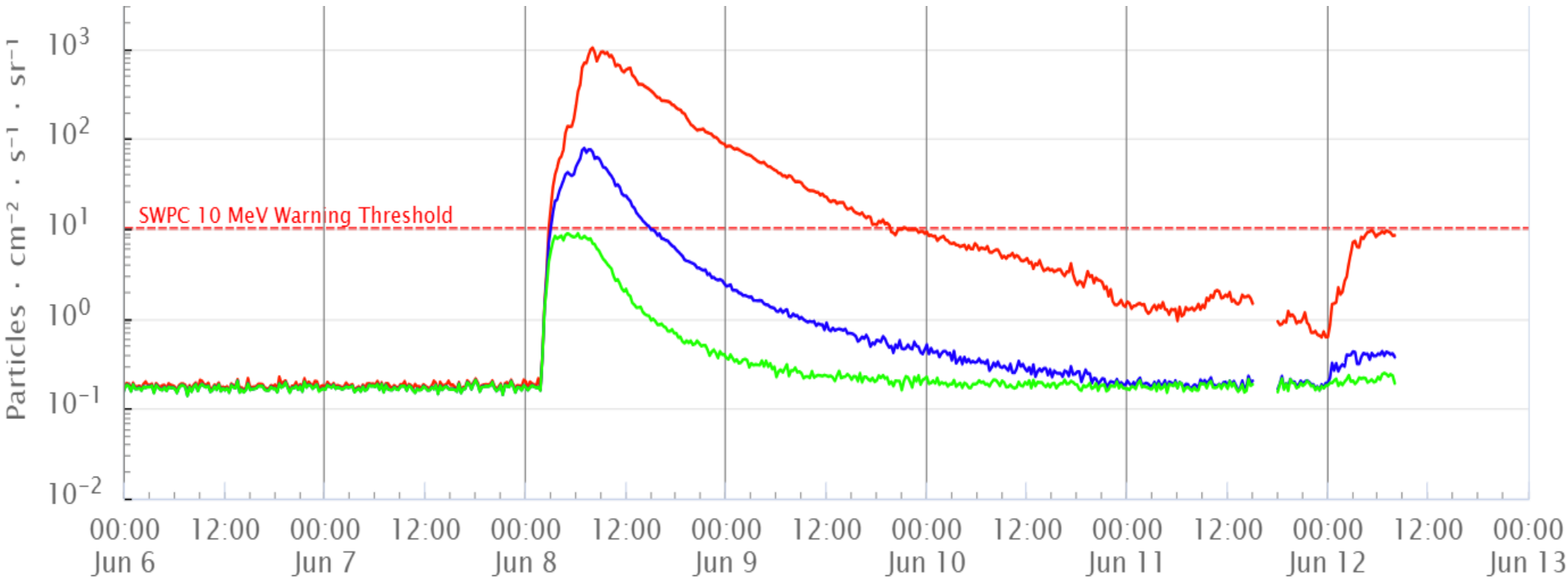
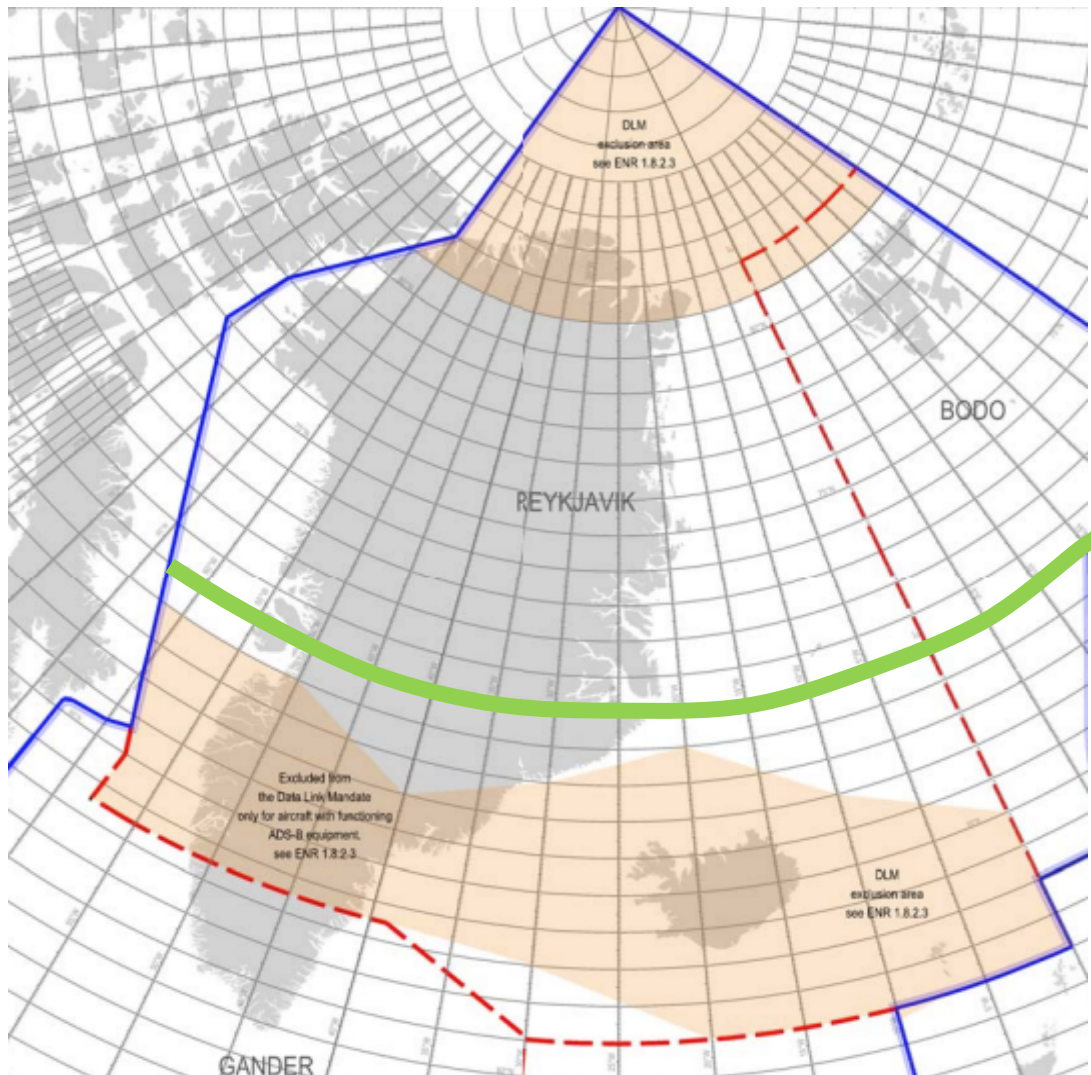
Actual HF condition

0-4 N: Black out
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8-12 N: Black out
12-16 N: Black out
16-20 N: Black out
20-24 N: Black out

Subject **Skilyrði í lofti - 10.06.2024**

Actual HF condition

0-4 N: Weak
4-8 N: Fairly good
8-12 N: Weak
12-16 N: Weak
16-20 N: Weak
20-24 N: Fairly good



Open Challenges

For GNSS service provision:

- Scintillation:
 - ➔ improve worldwide coverage
 - ➔ usage of ROTI maps as a proxy for phase scintillation?
 - ➔ utilize satellite data (COSMIC-2, ...) in NRT?
 - ➔ Reporting of seasonal effects (equatorial plasma bubbles)
- VTEC events identification:
 - ➔ significant events vs regular fluctuations
 - ➔ model and underlying dataset dependencies: which is the best model to use?

Challenges for HF COM service provision:

- PSD events:
 - ➔ improve worldwide coverage for PSD
 - ➔ diverging model results
 - ➔ reporting of sporadic events
 - ➔ real events vs regular fluctuations (eg. near daylight curve)
- Auroral Absorption
 - ➔ Improve understanding of auroral oval
- Polar Cap Absorption
 - ➔ Improve usage of riometer data

General:

- Lack of feedback on aviation impacts, particularly for GNSS advisories & for PSD advisories
- Lack of model forecasts

SWX Science/Operations Questions Or Answers?

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THANK YOU!

