

Examples of recent achievements from the *Swarm* mission on the low latitude space environment and combinations with other satellite missions

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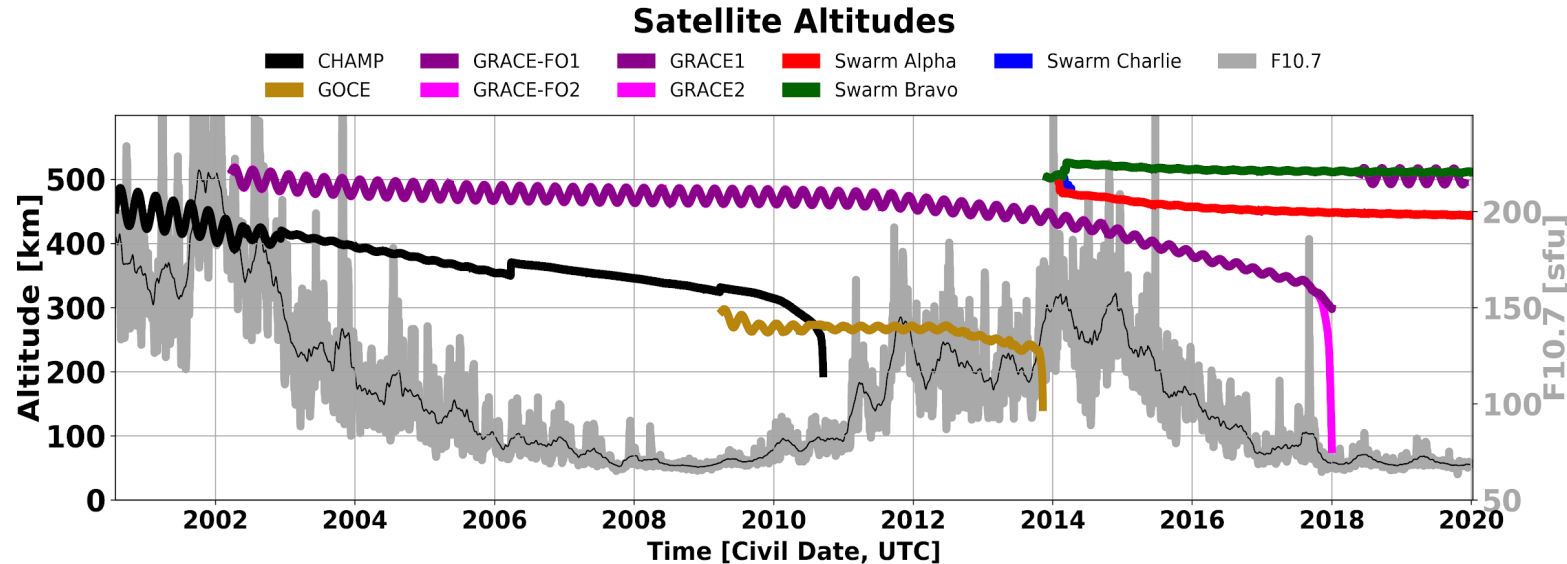
claudia.stolle@gfz-potsdam.de



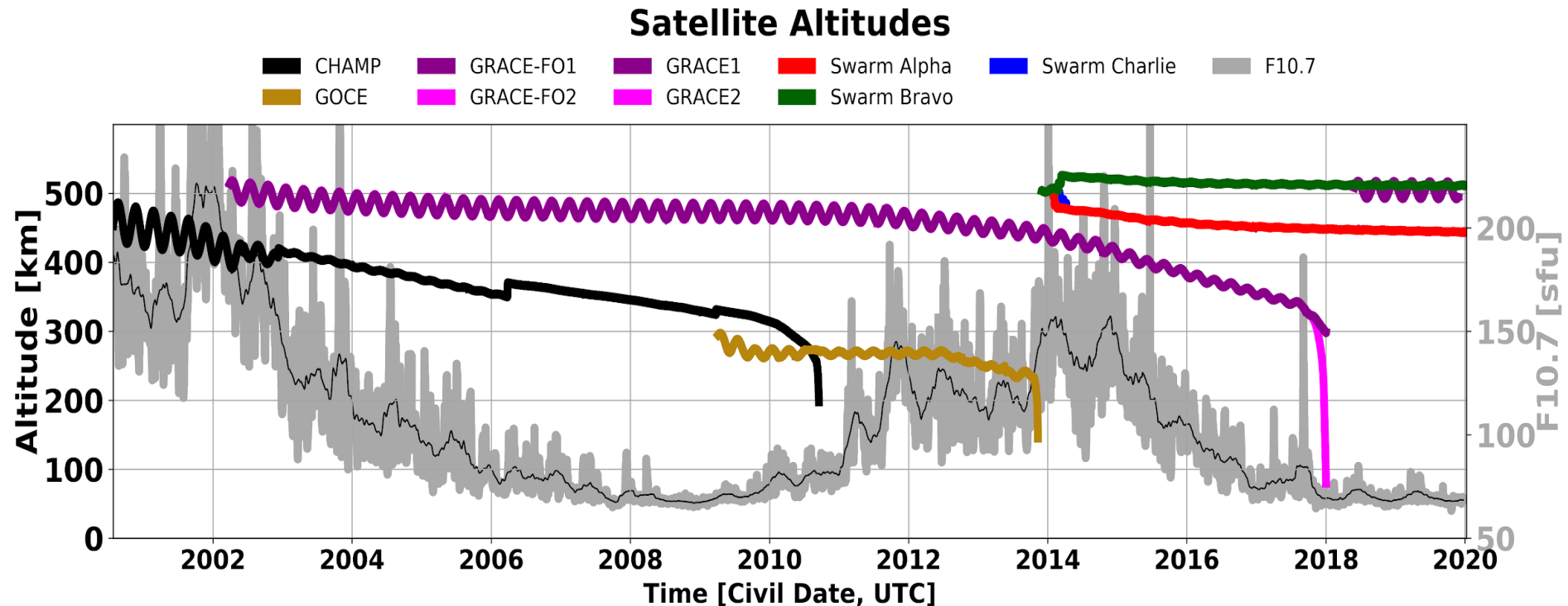
EMPR 2.2: Stolle et al., 6 May, 8:30-10:15



- The **Swarm** three satellite constellation mission:
 - high resolution and high-quality observations of the Earth's magnetic field and of multiple parameters of the ionosphere
 - new knowledge on the Earth's interior and space environment
 - space weather effects on space technology
- **Swarm in combination** with other missions:
 - additional aspects on long-term variations of the space environment
 - enhanced temporal and spatial resolution on global or regional scales



- Four examples will be highlighted on these slides:
 1. **Statistical model** of the occurrence rate of equatorial plasma depletions derived from **CHAMP** and **Swarm**
 2. Phase and amplitude **scintillation** characteristics at **GOCE** and **Swarm**
 3. Equatorial **plasma depletions** observed with **GOLD** and **Swarm**
 4. Middle-upper **atmosphere coupling** during SSW events from **AURA/MLS** and **Swarm** observations



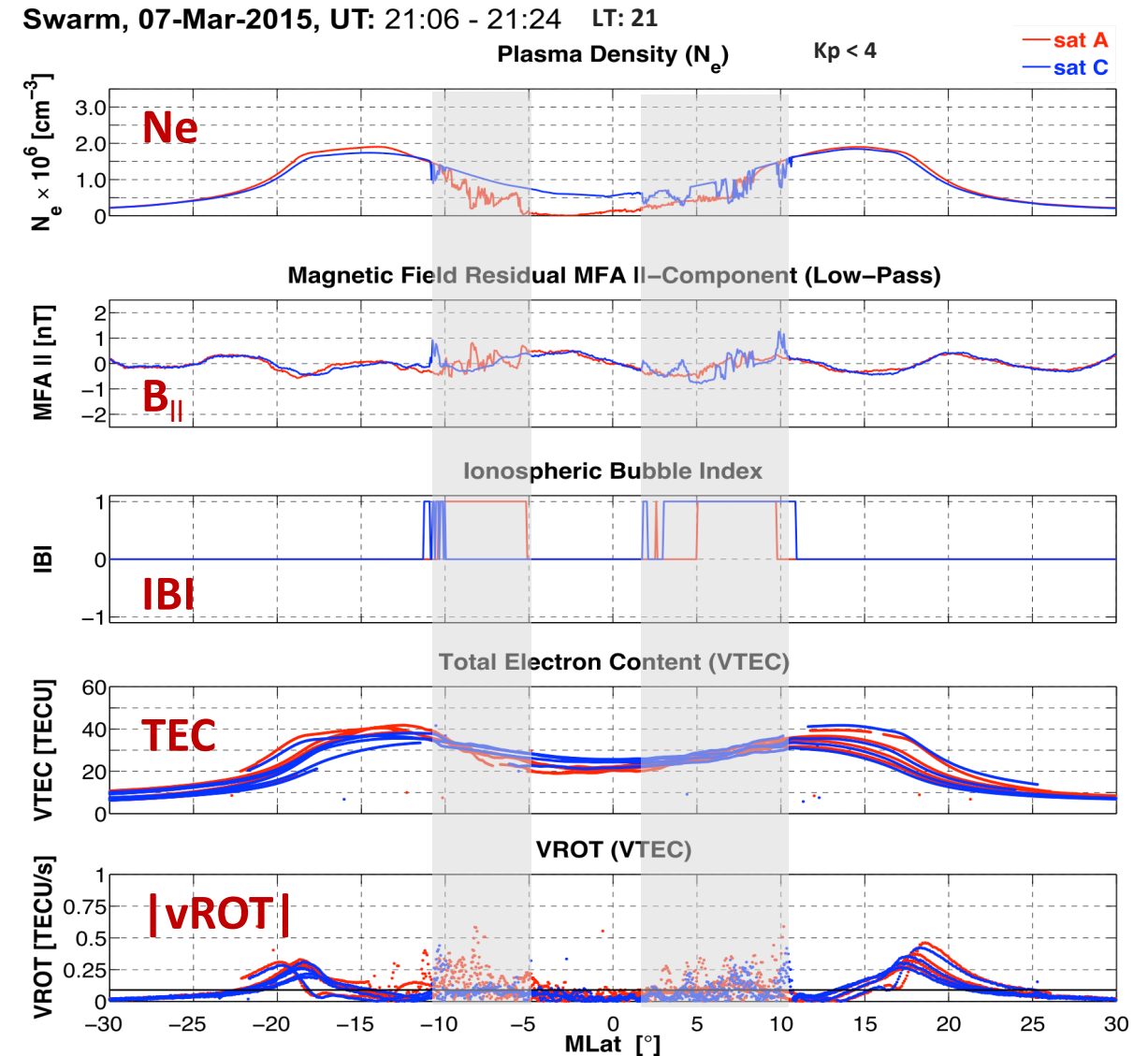
Equatorial plasma depletions

- detected in satellite plasma density and magnetic observations
- affect GNSS (at ground and in space)

Statistical model:

Predicts occurrence probability of plasma depletions for a given:

- month
- local time
- longitude
- solar flux level F10.7



Input data: magnetic fluctuations at CHAMP and Swarm, verified by electron density records (IBI index)

CHAMP:

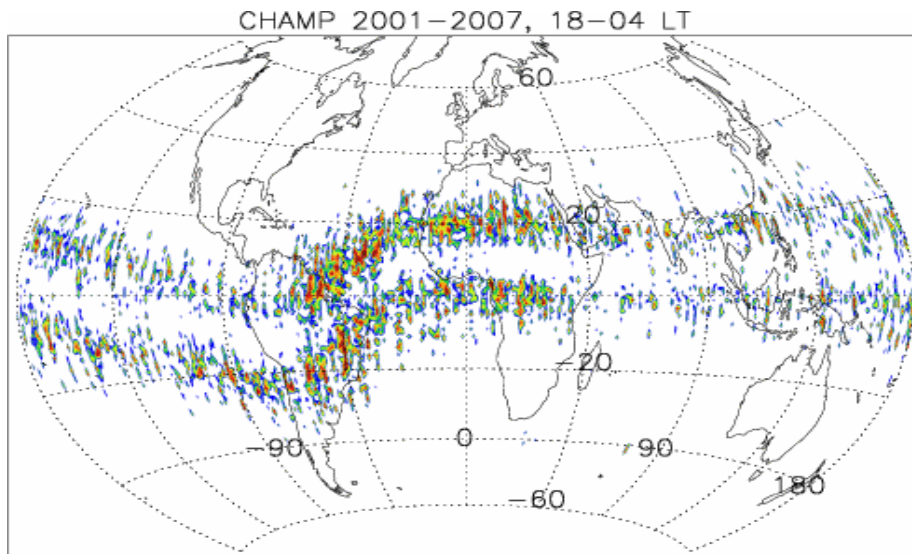
Years: 2000-2010, Altitude: 300-480km

Detection threshold: 0.25nT

cc with e-density not considered

Declining solar cycle 23 ($F_{10.7} > 80$ sfu)

“IBI” detections at CHAMP



Swarm:

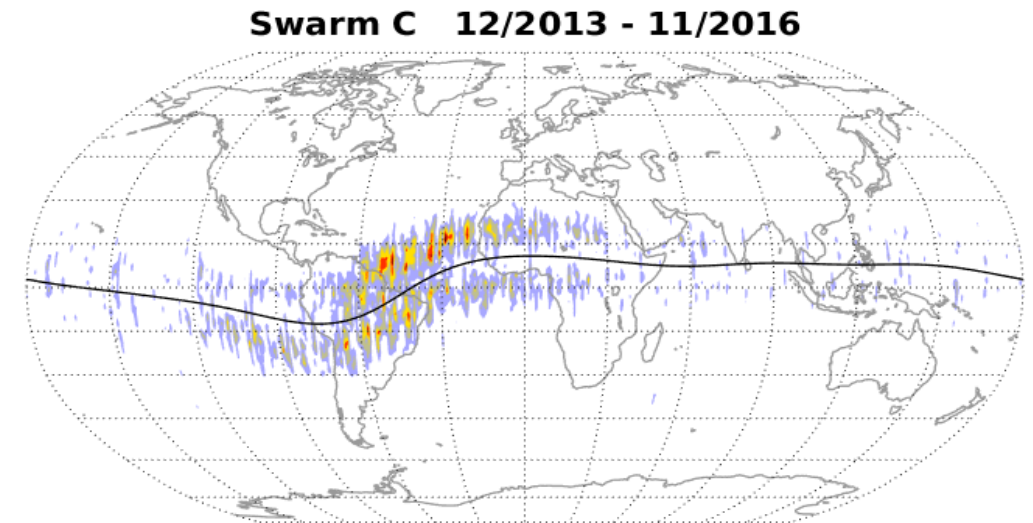
Years: 2013-2018 - *Swarm* A,B,C, Altitude: 450-520km

Detection threshold: 0.15nT

cc with e-density: > 0.7

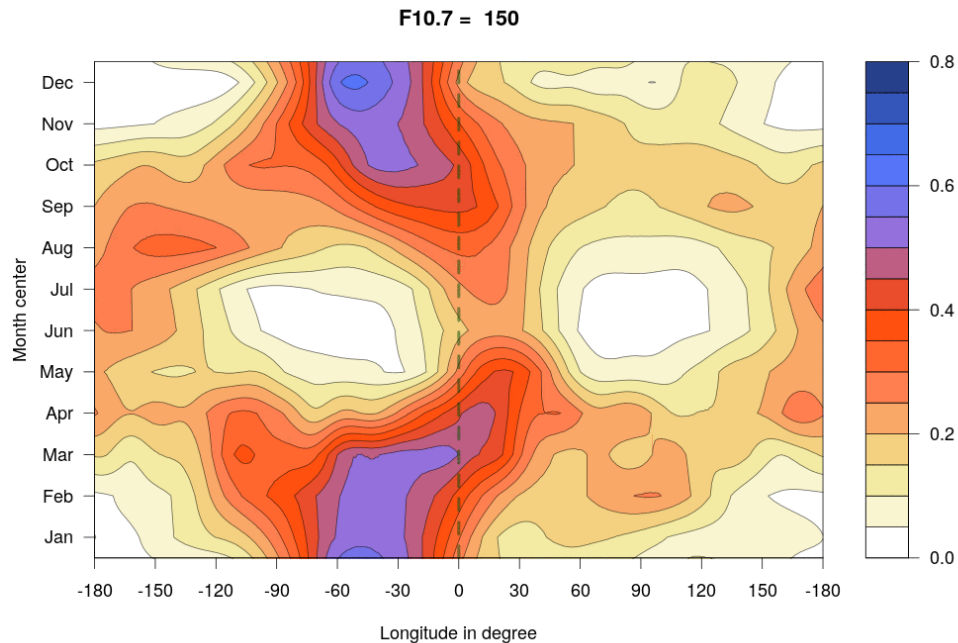
Declining solar cycle 24 ($F_{10.7} > 80$ sfu)

IBI detections at *Swarm*



Statistical model: Validation, Documentation, Forward code

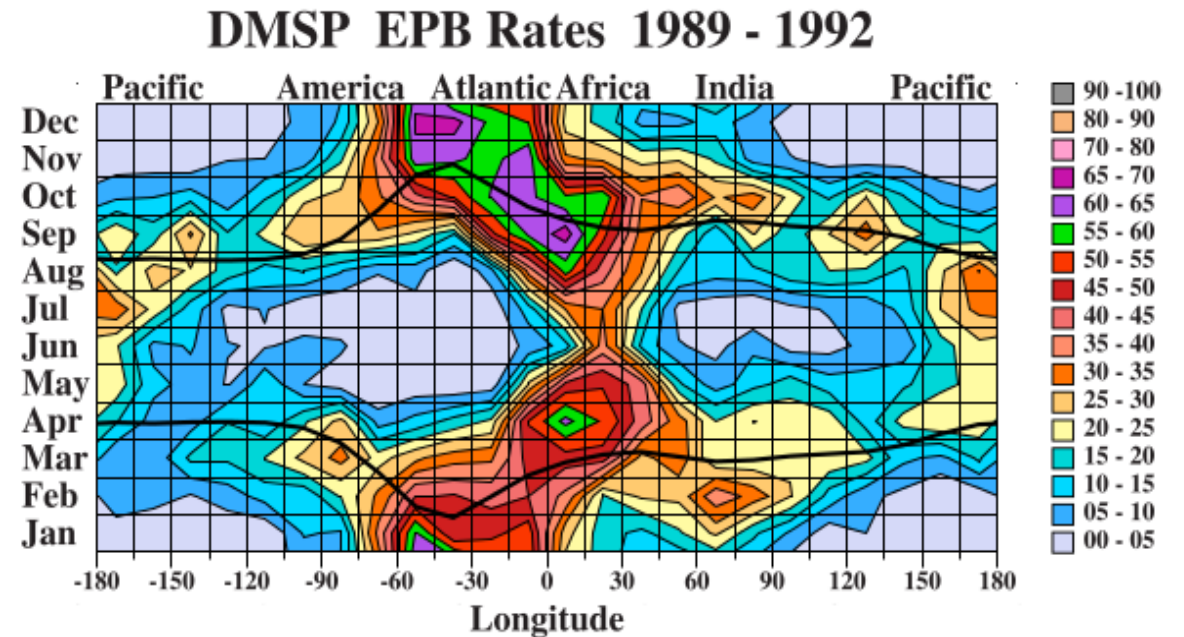
CHAMP/Swarm forward model, 19-23LT



- Model predictions compare well with earlier findings from independent data

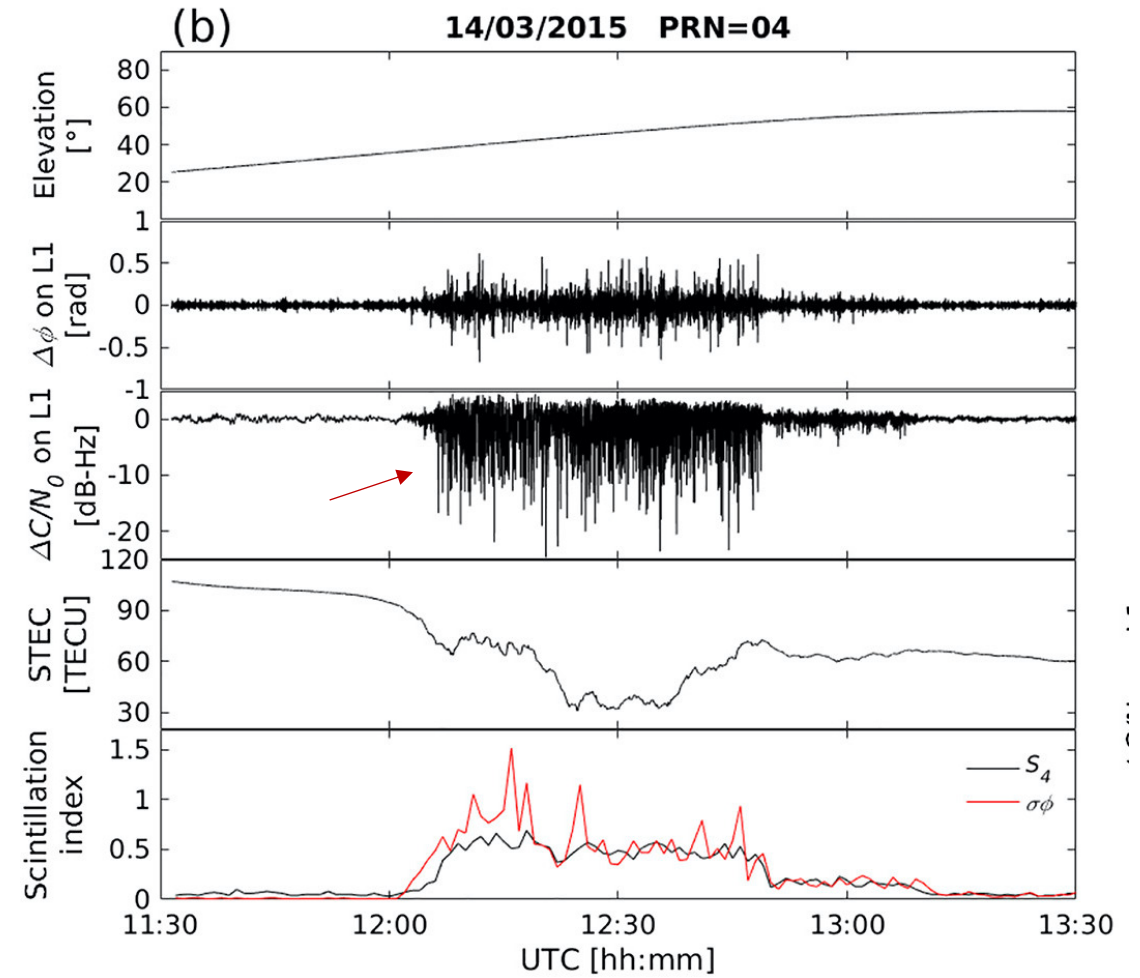
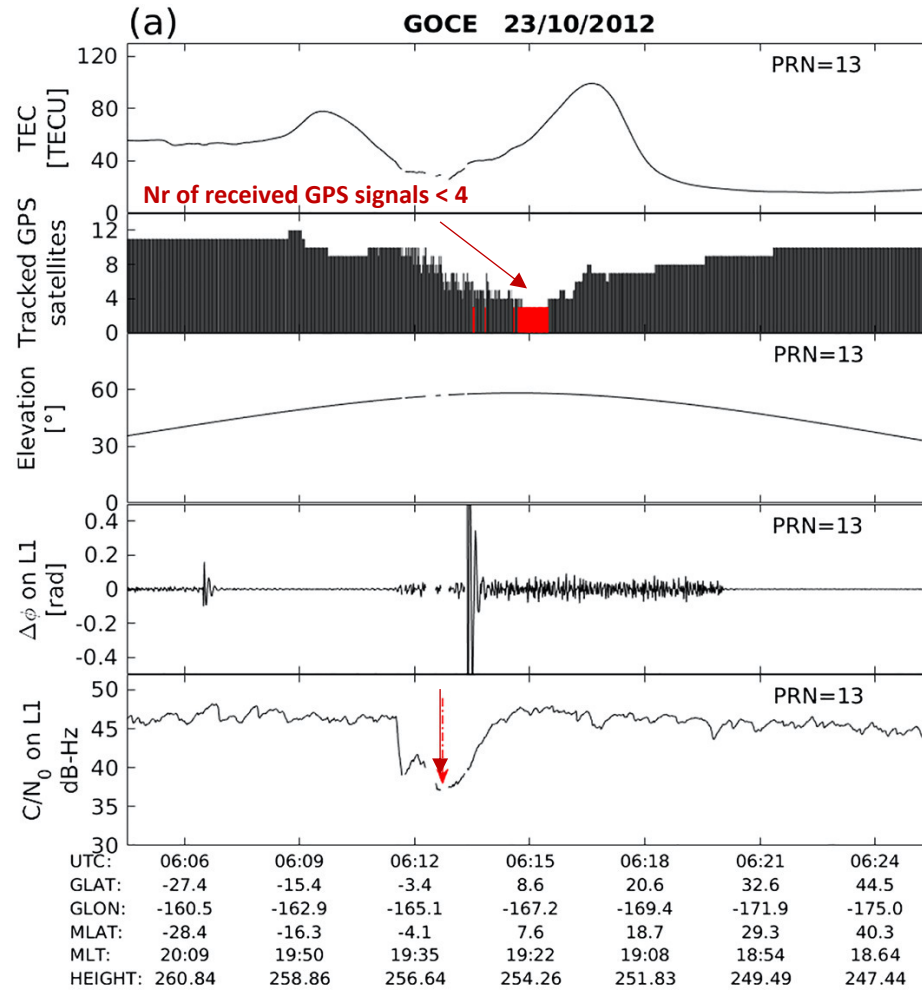
DMSP plasma depletions, 19-22LT, high solar flux years

Gentile et al., 2006, Radio Science

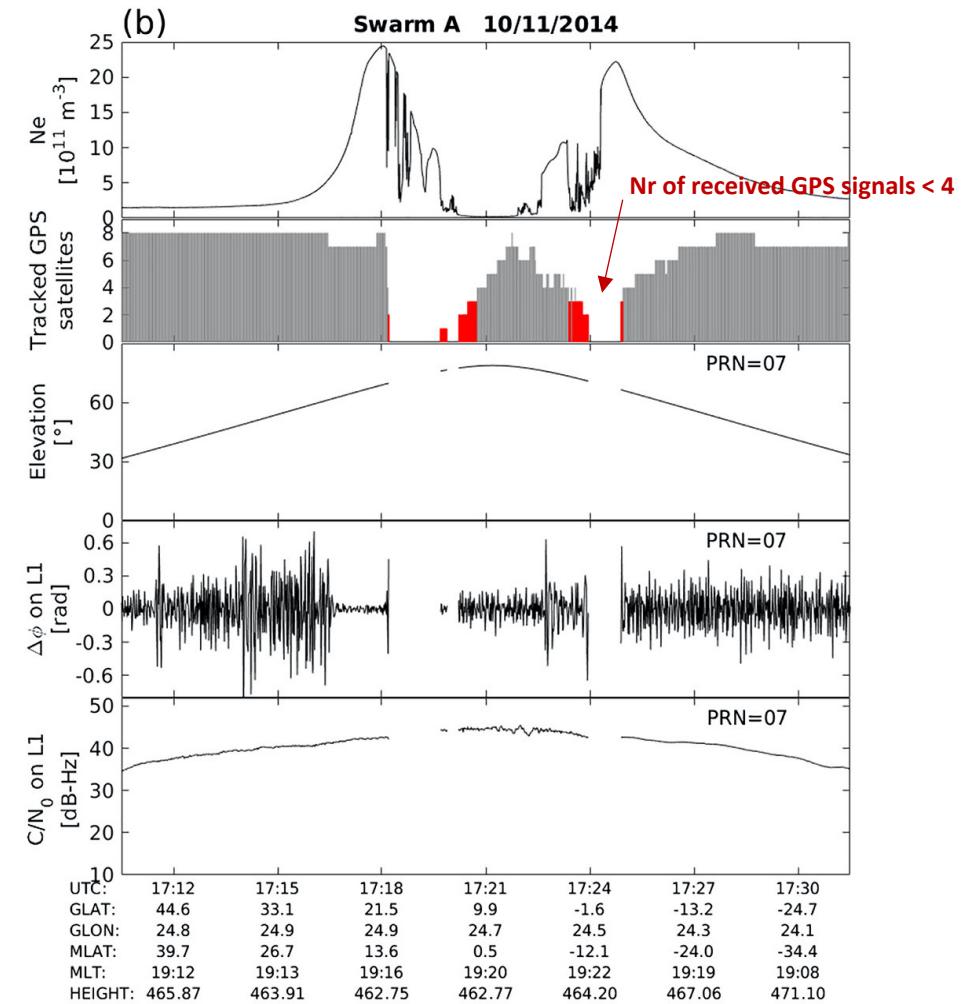
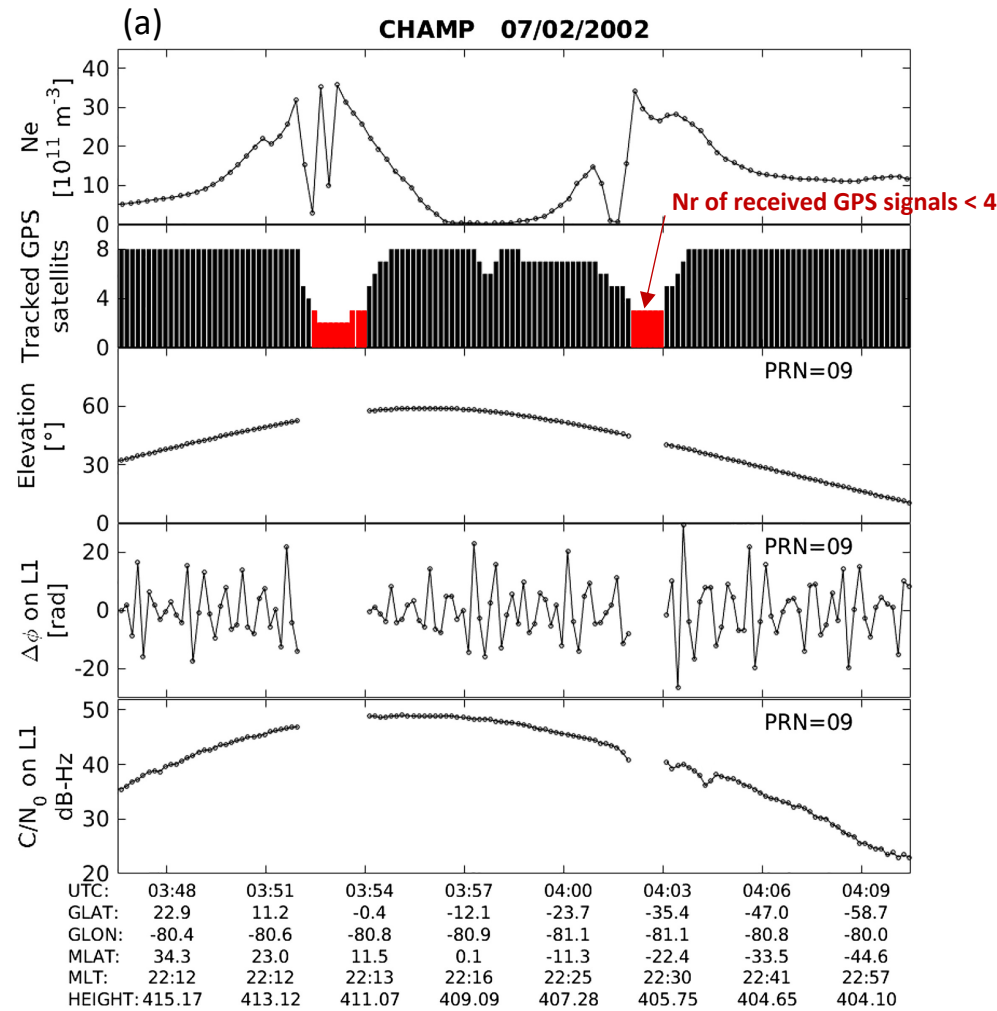


- Coefficients, forward model, descriptions available at <https://gitext.gfz-potsdam.de/rother/ibp-model>
- Swarm product: [IBP CLI 2](#)

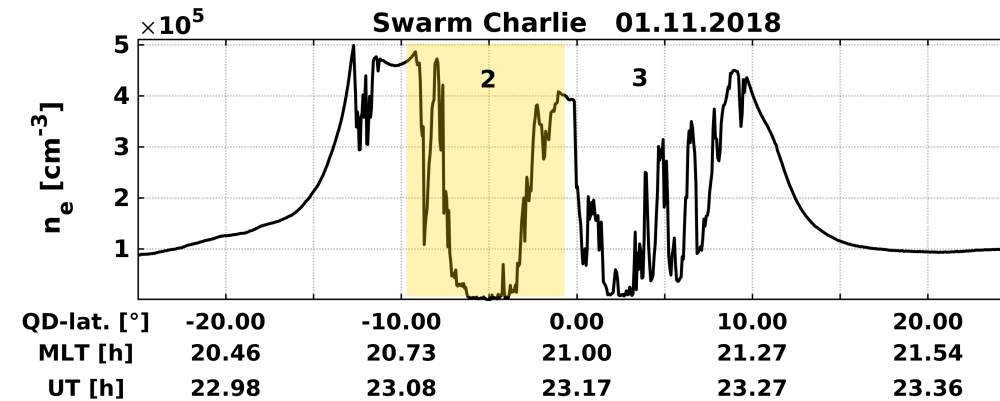
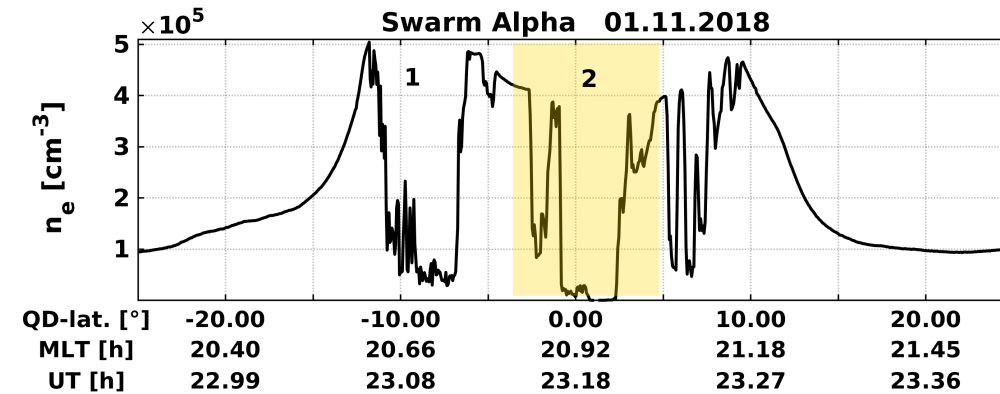
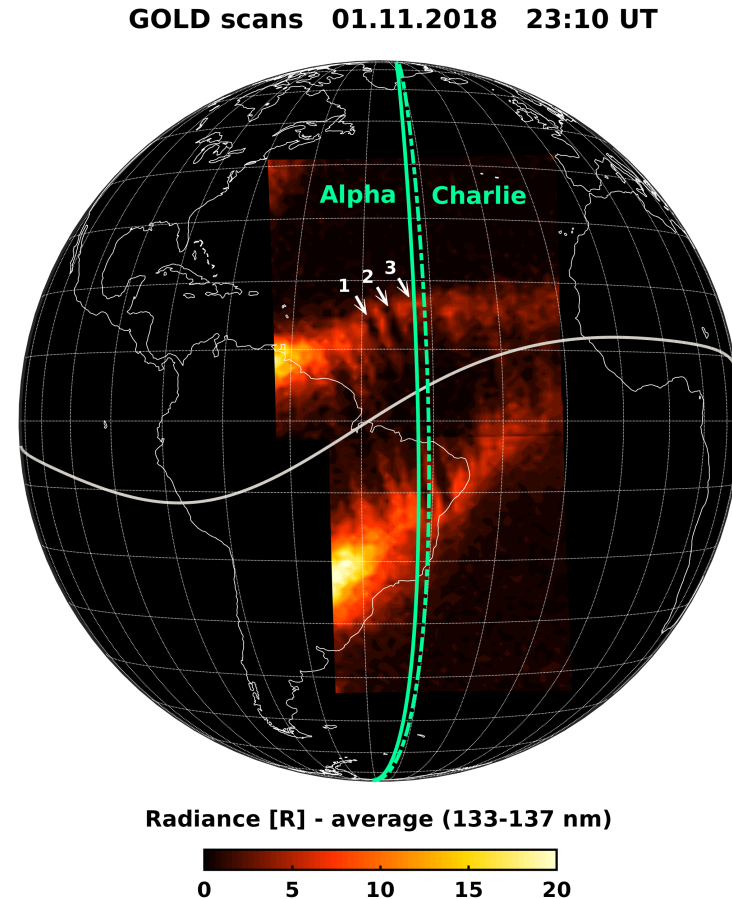
- Low latitude post-sunset plasma depletions maximize in the F-region (350-500 km altitude)
- GNSS signals received at a distance to a plasma depletion show both significant phase (Φ) and amplitude (C/N) scintillations, such as onboard GOCE (a) (ca. 250km) or at ground (b)



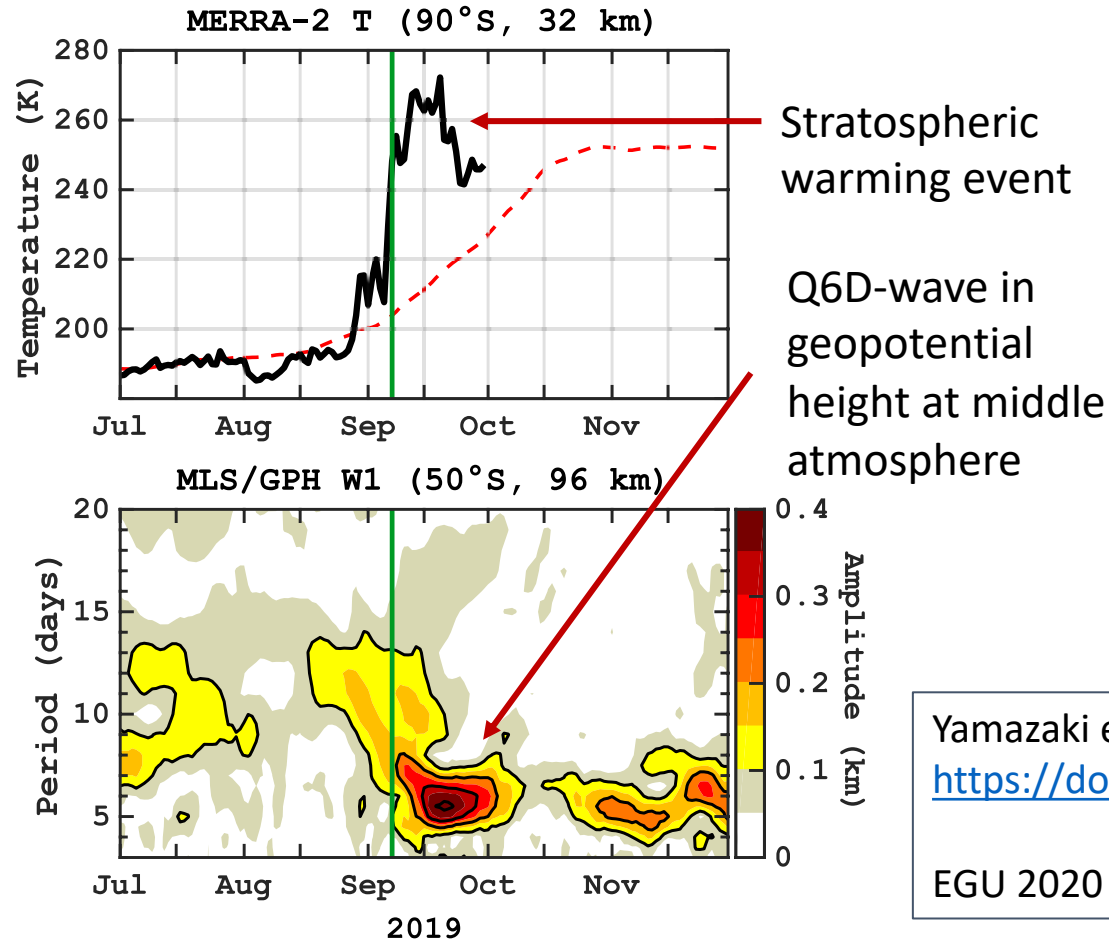
- GNSS signals received near or within the plasma depletions show significant phase (ϕ) and low or no amplitude (C/N) scintillation, such as onboard CHAMP (a) or *Swarm* (b) (ca. 400-500 km)
- Phase scintillations alone can cause loss of signal lock



2D-images of GOLD provide comprehensive background to interpret data along *Swarm* orbits



Evidence of Quasi-6-day wave enhancement in the ionosphere following the southern SSW event on Sept. 2019



Stratospheric warming event

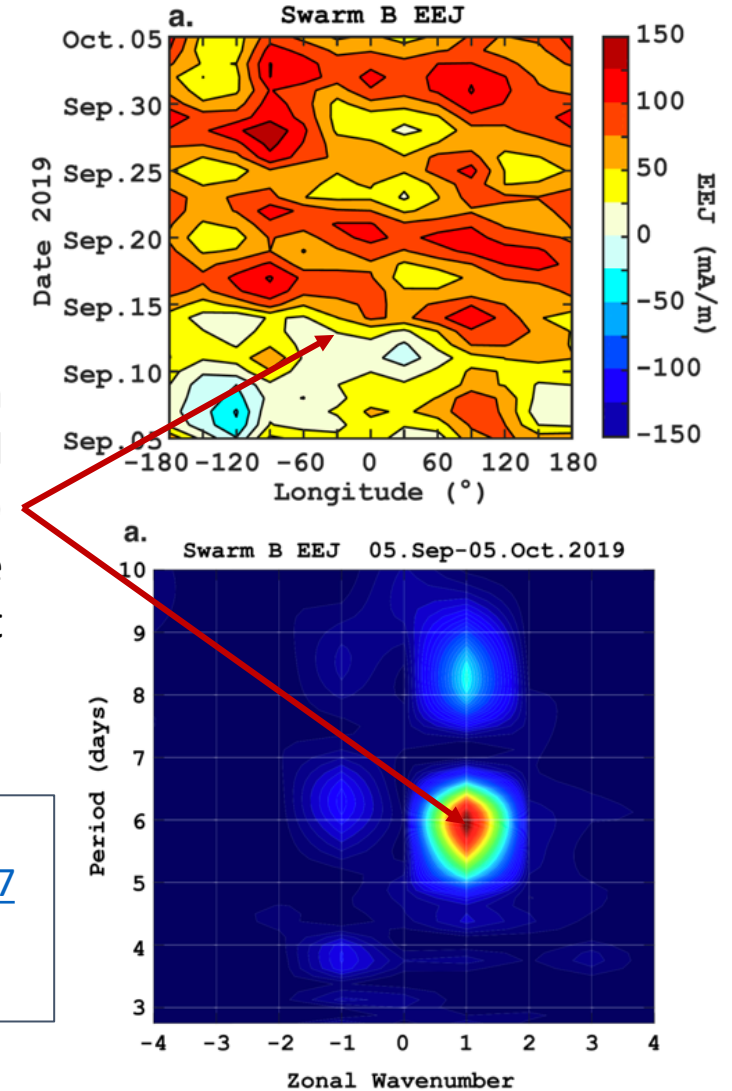
Q6D-wave in geopotential height at middle atmosphere

Q6D-wave in the equatorial electrojet (EEJ) following the SSW onset

Yamazaki et al. (2020)

<https://doi.org/10.1029/2019GL086577>

EGU 2020 [display](#), Friday 14:00-15:15



Announcement

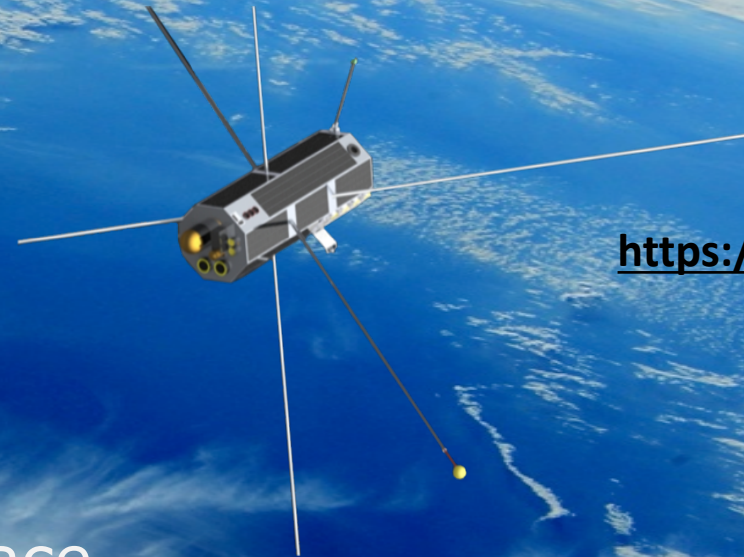


Workshop on Daedalus

EGU-related splinter

Online, May 8, 14-17 CEST

**A Low-flying Spacecraft
For The Exploration Of The
Lower Thermosphere – Ionosphere**



<https://daedalus.earth>

Daedalus

Where atmosphere meets space

ESA's Earth Explorer 10 (EE-10) candidate



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