FINDINGS ON THE OCTOBER EFFECT

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What is the October effect?

Fall effect:

- Deviation of VLF amplitude from expected values based on the solar zenith angle
  → Spring-Fall Asymmetry (Slow increase, rapid decrease)
  Macotela et al. (2021)

October effect:

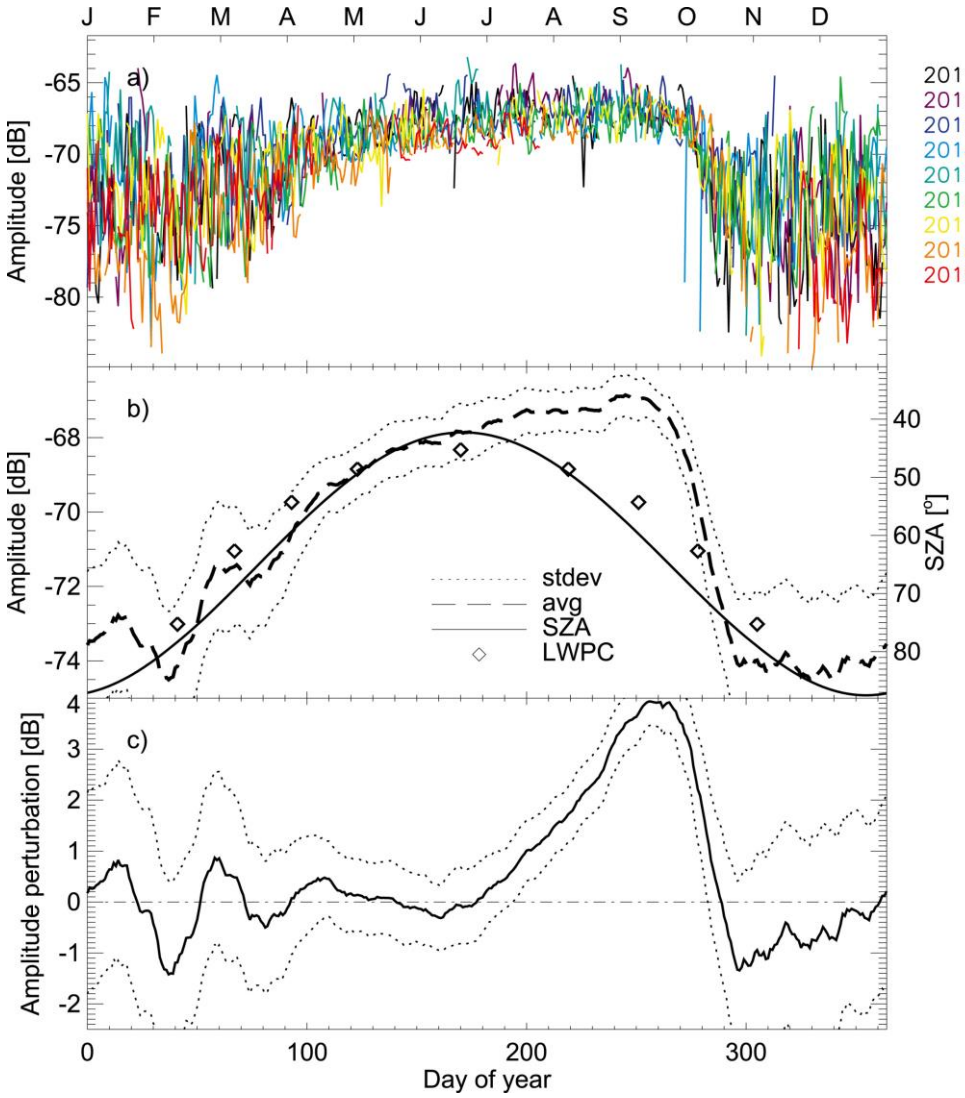
- Rapid decrease of VLF amplitude in October
  Pancheva and Mukhtarov (1996)

→ **No satisfactory explanation for both effects**

October Effect …

- … occurs after the zonal wind reversal from summer to winter conditions
- … coincides with temperature increase in 70 - 80 km
- … coincides with a sudden change of S2 in 70 - 80 km (semidiurnal atmospheric solar tide)

Macotela et al. 2021



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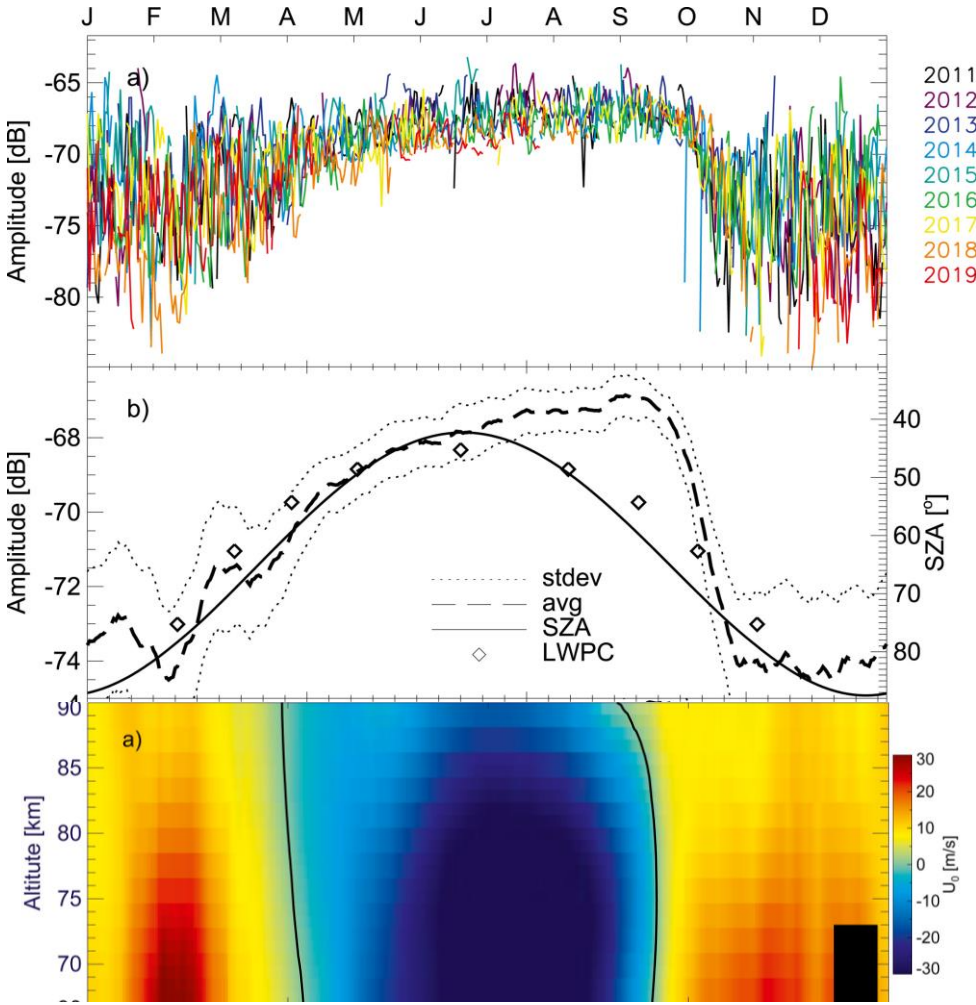

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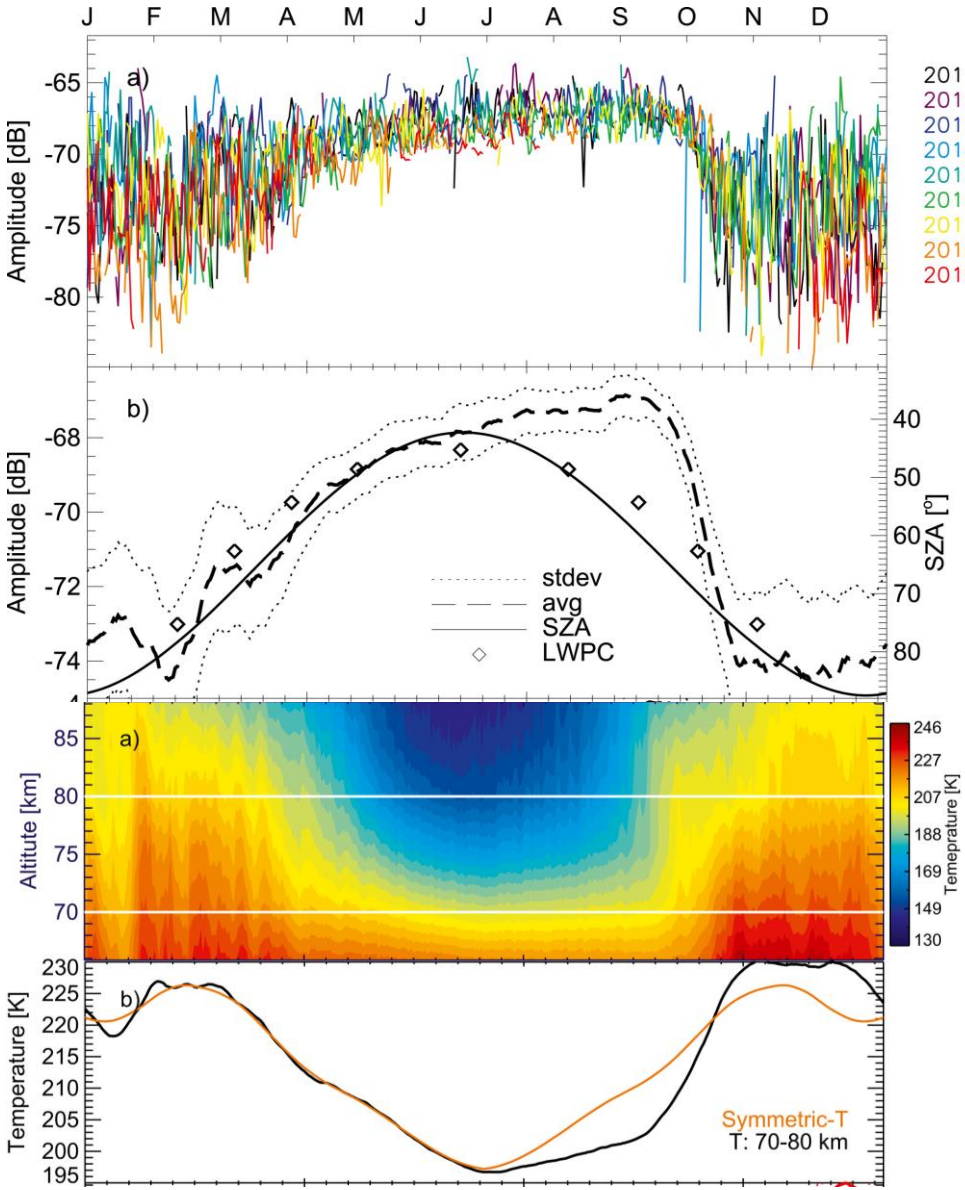

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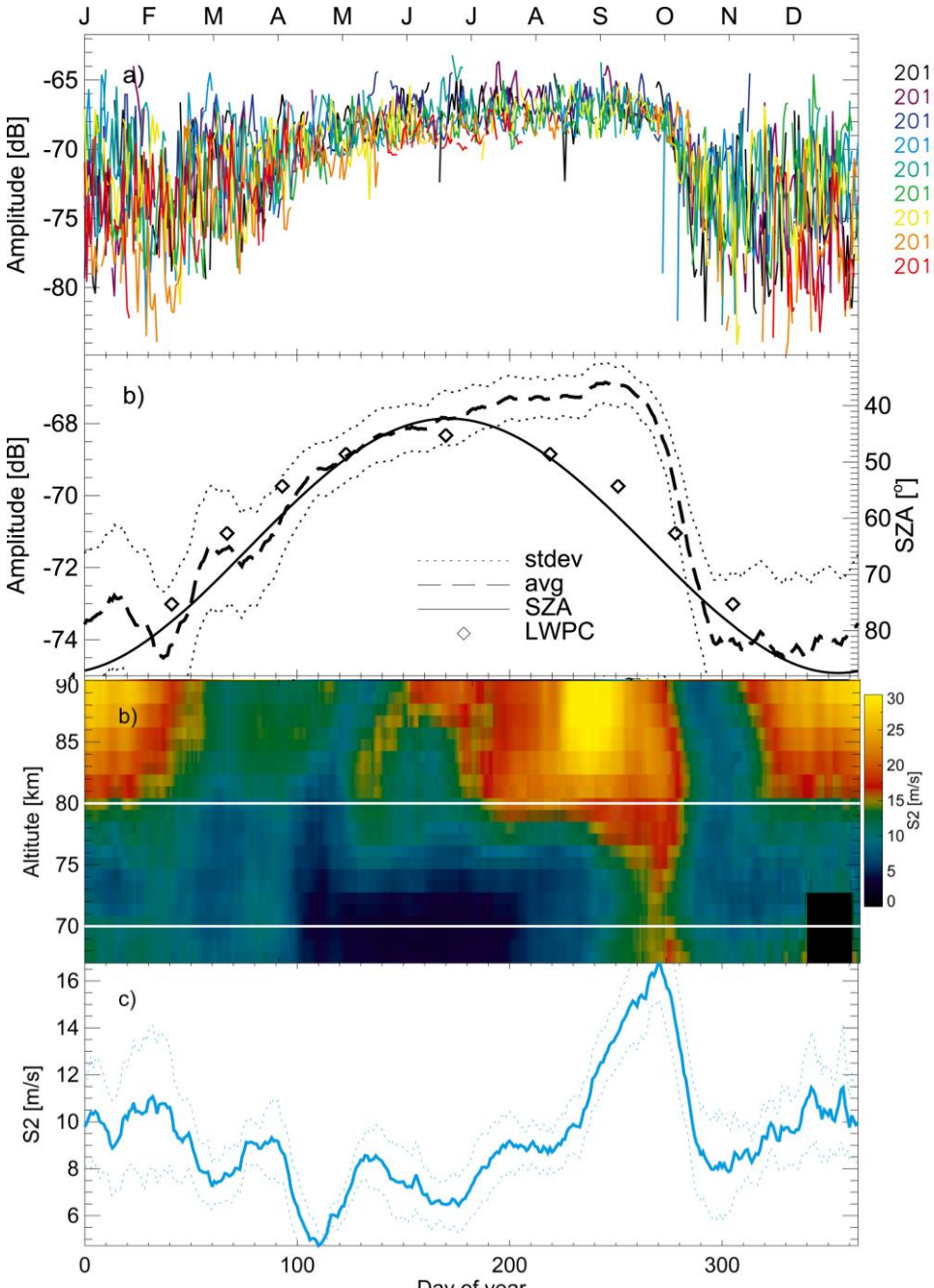

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Characteristics in VLF amplitudes

AMELIE

Analysis of the **ME**sosphere and **L**ower **I**onosphere fall **E**ffect

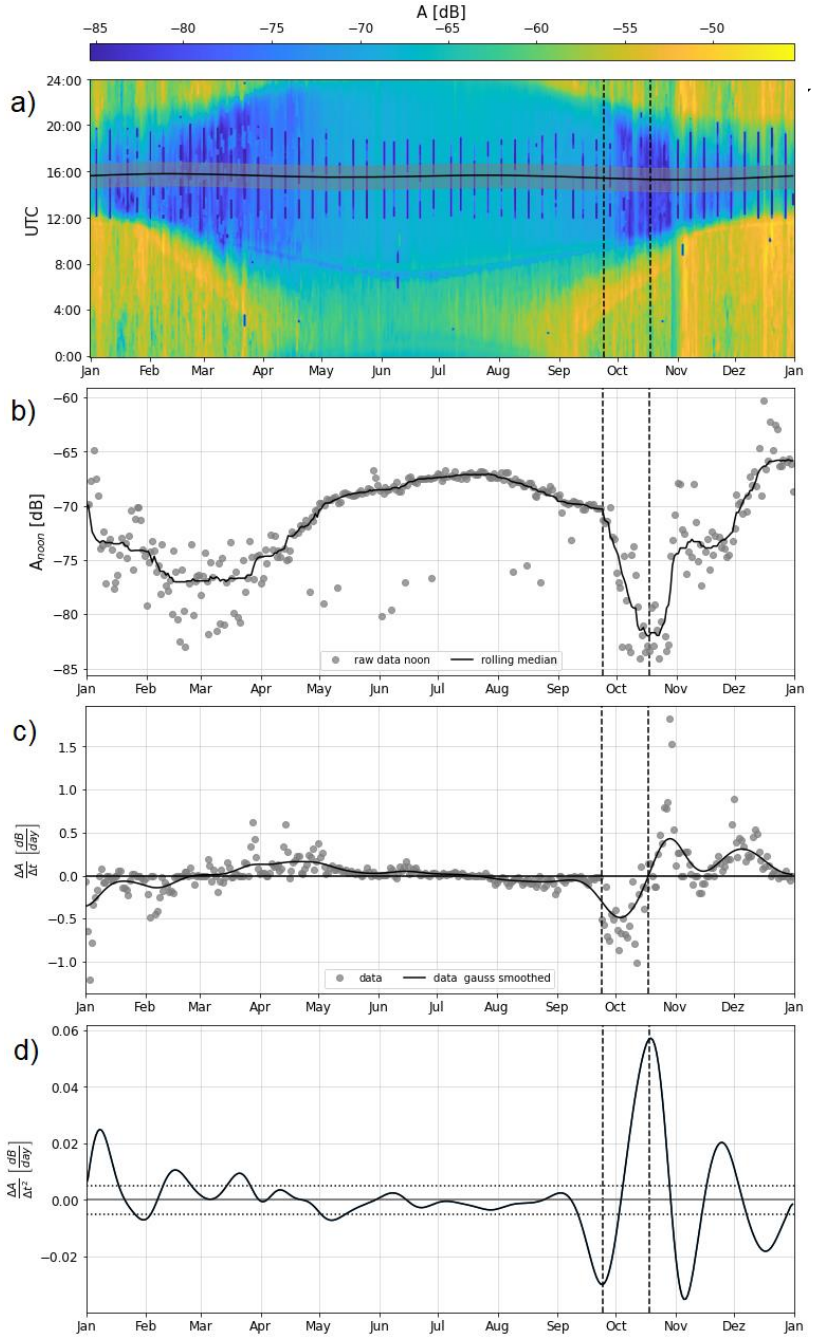
- Joint project of DLR and IAP + external partners (BAS,CRAAM, NCAR/UCAR, Graz University)

Data

- AARDDVARK and GIFDS network
- Difficult to compare between different VLF links → concentrate on links with similar characteristics (transmitter frequency, path length + bearing, receiver sensitivity, etc.)

Automated detection of the October effect

- **raw data:** 10 min median
- **noon curve:** 1 hour window around noon (at mid subreflective point)
- **1. derivative:** smoothed with a gaussian filter to filter out short term fluctuations for automated detection
- **2. derivative** local minimum after 15. September is used as the start of the October effect and the following local maximum as the end



Hansen et al. 2023, in progress

Characteristics in VLF amplitudes

Difficult to compare between different VLF links
→ concentrate on links with similar characteristics

Average characteristics over all links:

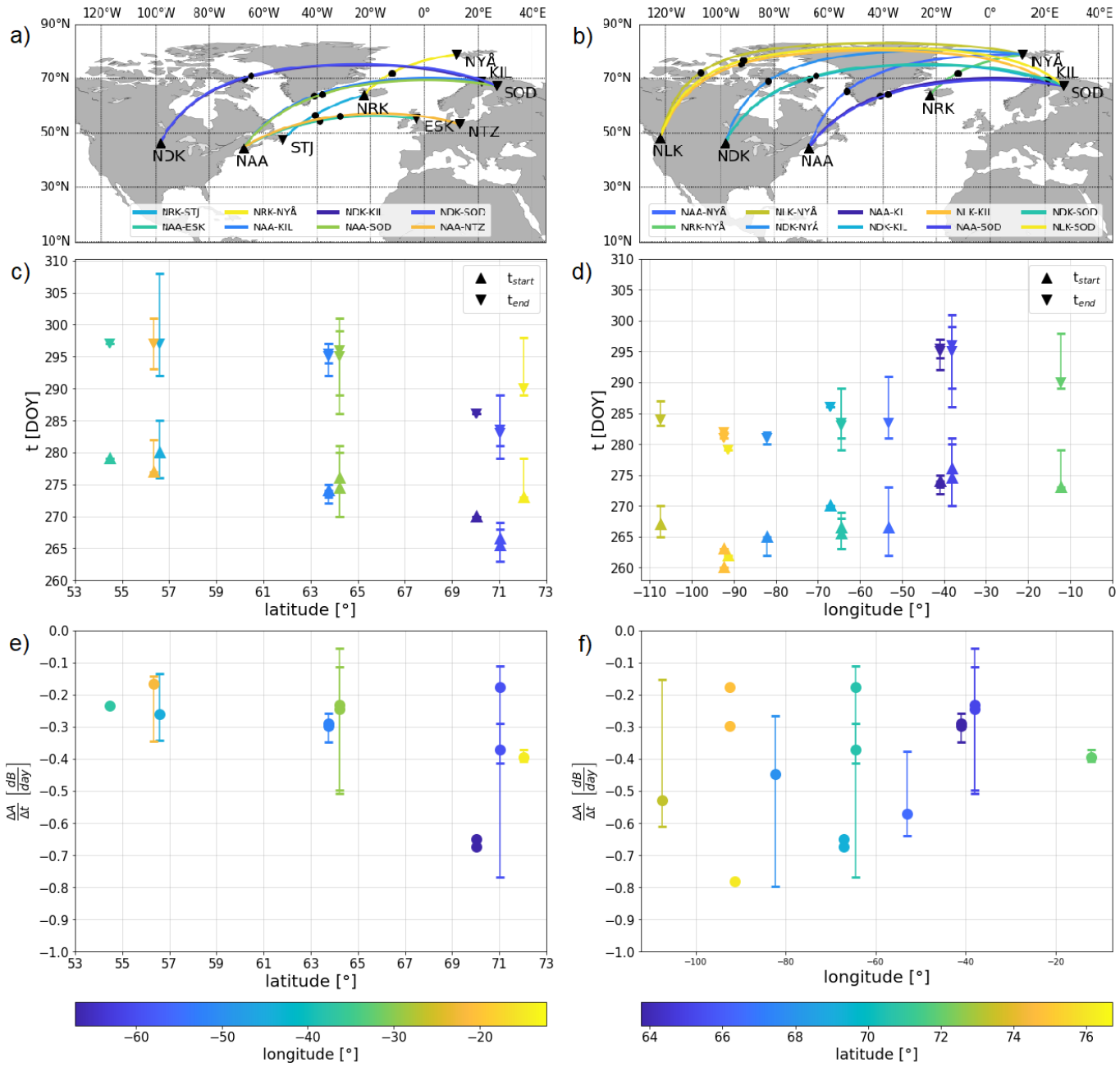
- Start: DoY 273 (September 30th)
- Length: 22 days
- Strength: 5.5 dB

Latitudinal variation:

- October effect occurs poleward of 50°N
- October effect occurs earlier in higher latitudes
- slope shows greater variation in higher latitudes

Longitudinal variation:

- October effect seems to move from the American sector to Europe
- Slope is uniformly distributed with large variance over the years



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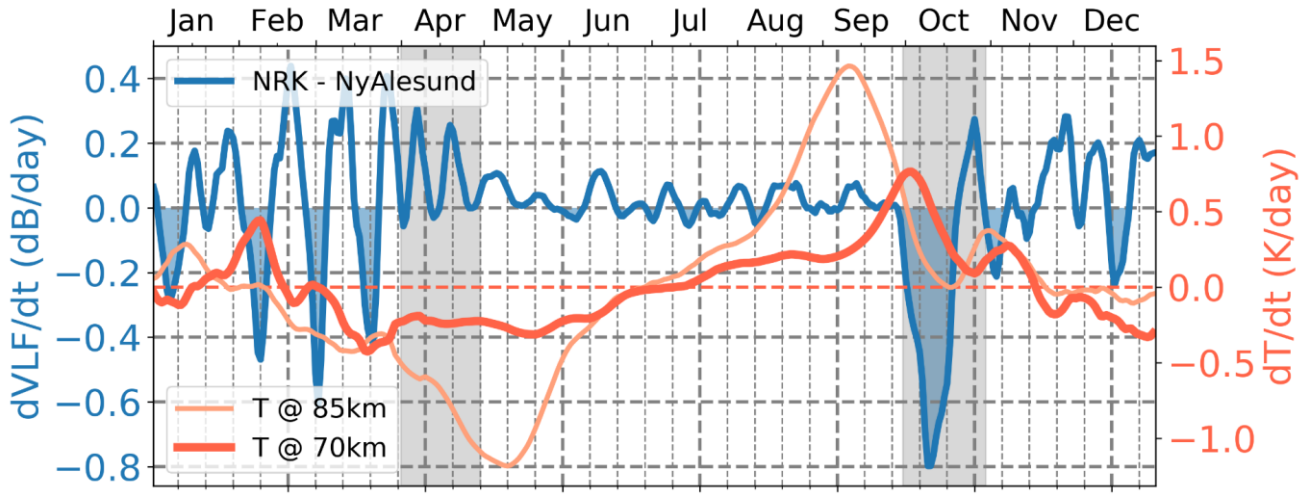
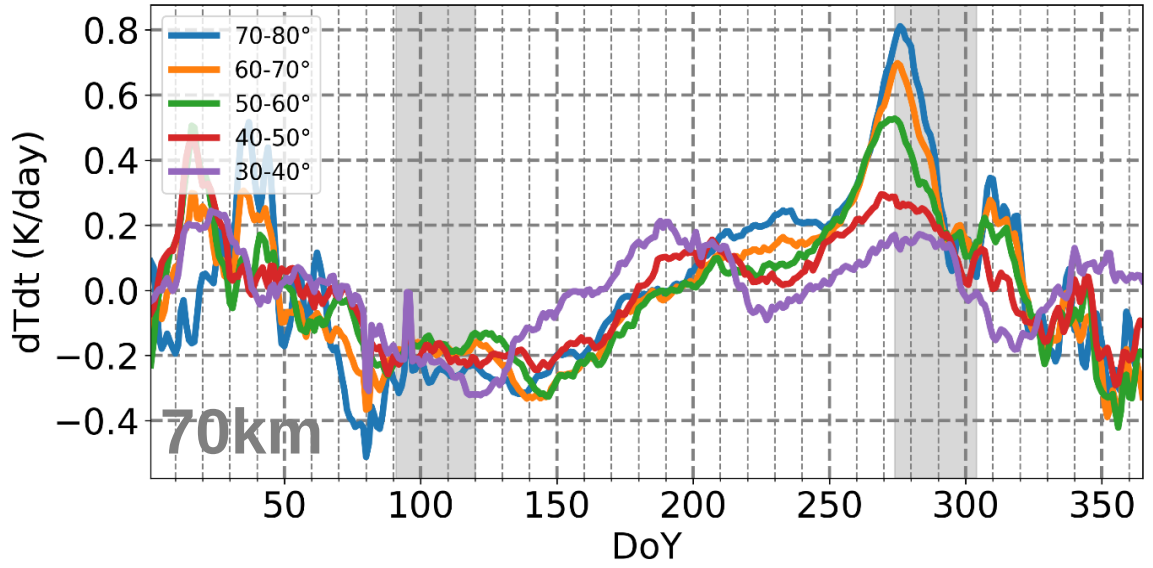
Atmospheric Impact

Investigating the connection between October Effect and neutral atmosphere dynamics

- Comparison with zonal mean temperature using global satellite data from MLS onboard Aura satellite
- Seasonal variation of zonal mean temperature reveals different behavior at 70km (VLF daytime reflection height) and 85km (VLF nighttime reflection height)
- Seasonal **symmetric** behavior at **85km**: cooling in spring and warming in autumn
- Seasonal **asymmetric** behavior at **70km**: steady cooling in spring, steady and rapid warming in autumn
  → similar to VLF amplitude behavior
- **Latitudinal Dependency:** stronger and rapid warming in higher latitudes





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Atmospheric Impact

Stratosphere: Seasonal variation of zonal mean temperature shows symmetric behavior

Upper mesosphere: follows solar zenith angle variation

60 - 75km: Asymmetry between spring + autumn

- Co-responsible for occurrence of October Effect

→ **The October Effect is not observed during nighttime in VLF**

- due to the limitation of the strong regional warming to 60-75km + the higher reflection height during nighttime

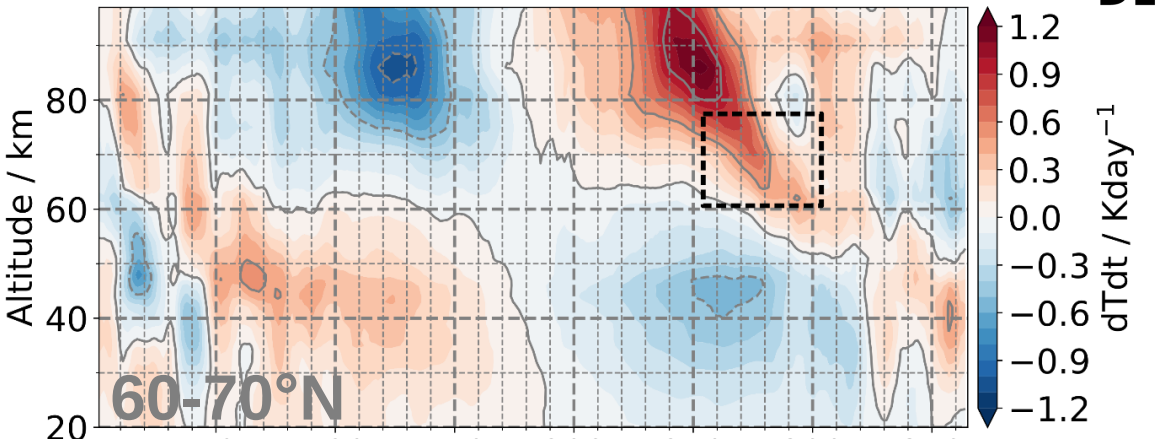
→ **Regional warming**

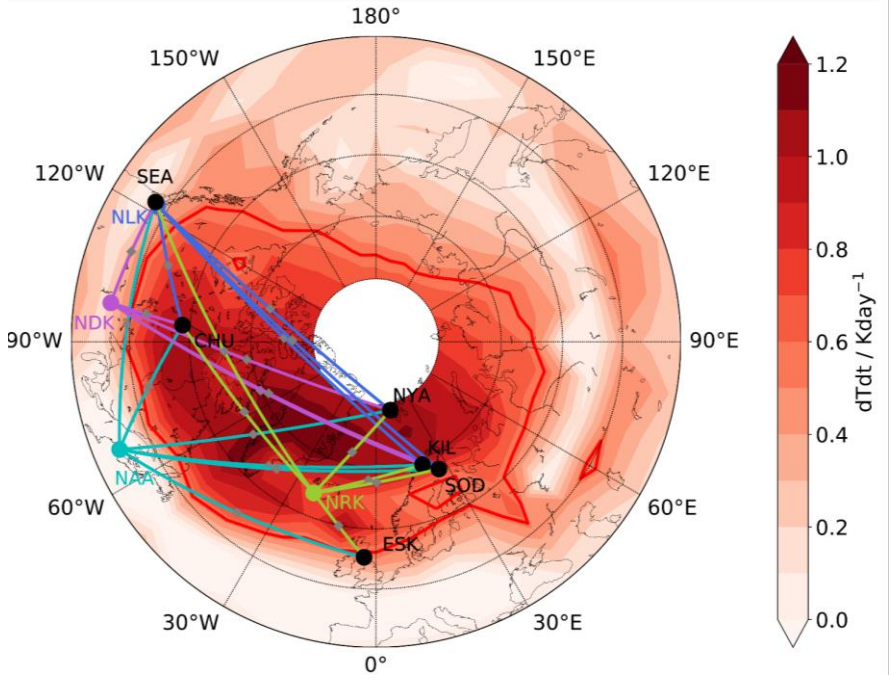
- extends from Europe over the Atlantic to North America + strongest poleward of 50°N (which is covered by AARDDVARK network)
- similar characteristics as October Effect in VLF observations

Hypothesis: There is no October Effect in Asian + Pacific region.

→ Need to check such VLF links

→ Many thanks to Morris Cohen for AWESOME data!





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Summary and Outlook

Characteristics of the October effect:

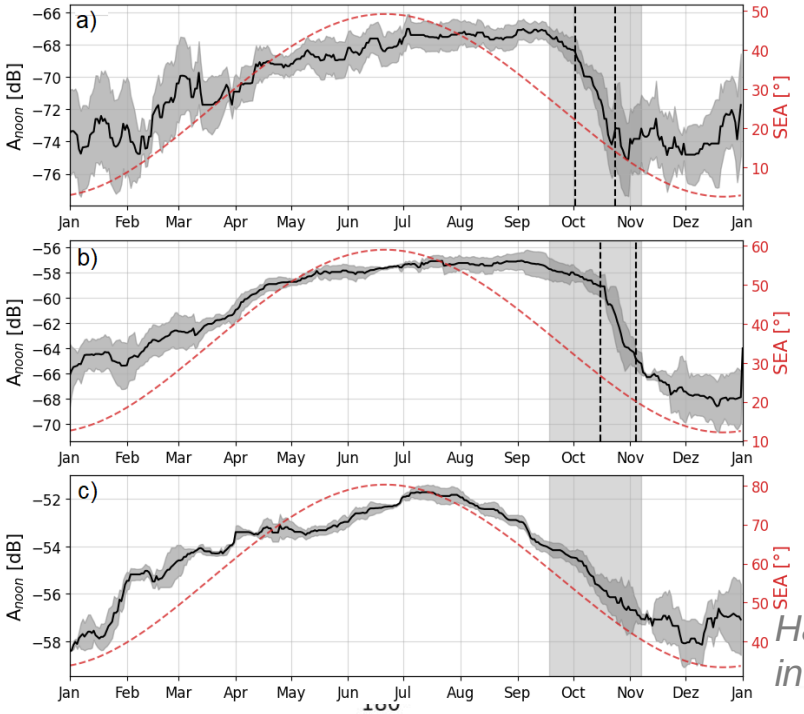
- Rapid decrease of VLF amplitude in October
- Strong latitudinal + longitudinal dependencies

What causes the October Effect?

- October Effect occurs after the zonal wind reversal from summer to winter conditions
- Temperature increase seems to have indirect impact as it occurs slightly before VLF decrease
- There are significant changes in stratopause altitude and ozone during October Effect

Next steps:

- To what extent do these changes influence the electron density and thus the VLF amplitude?
- Understanding the full mechanism



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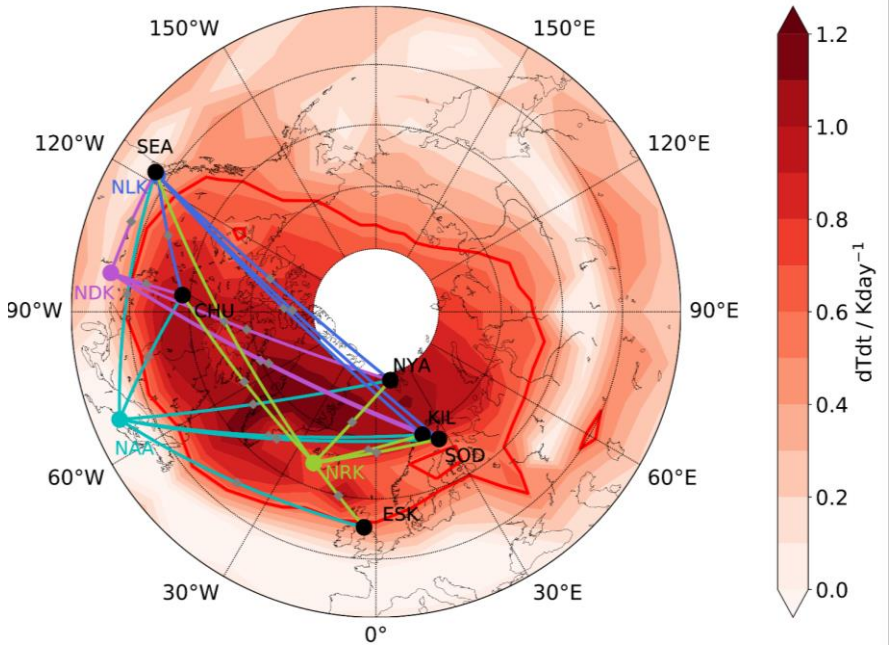

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Summary and Outlook

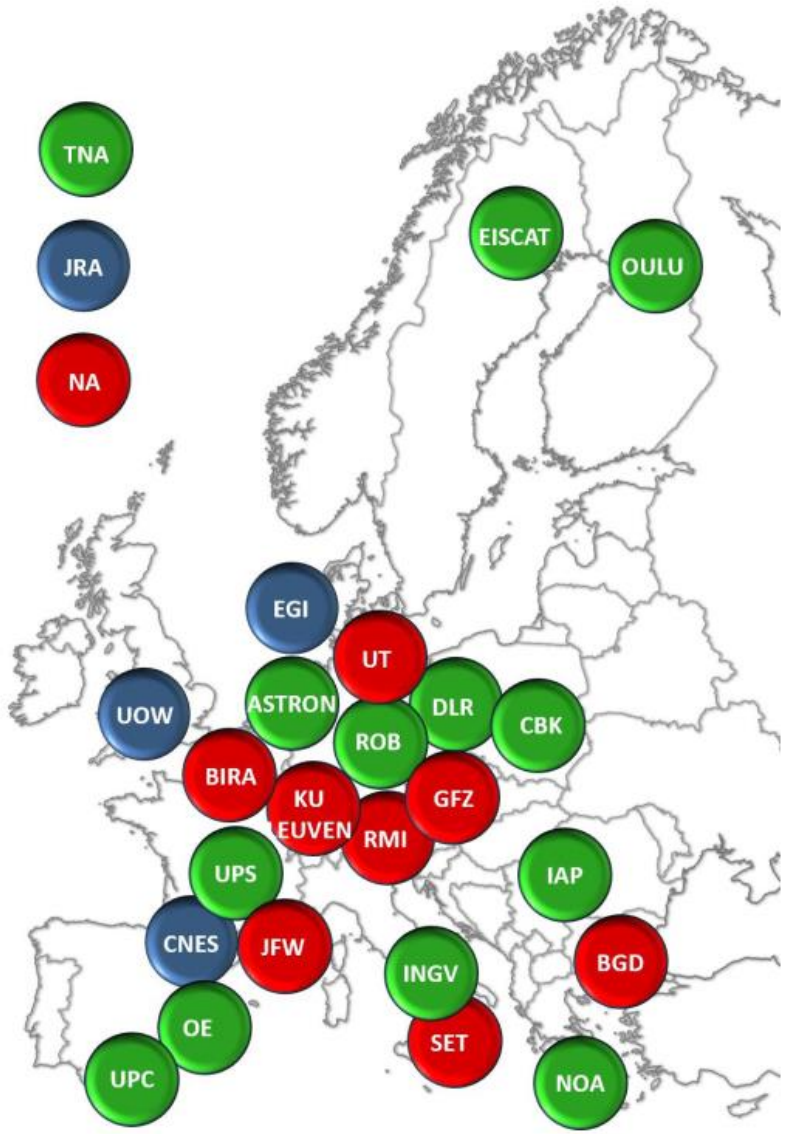
GIFDS VLF data soon available via:

PITHIA-NRF
Plasmasphere **I**onosphere **Th**ermosphere
Integrated Research Environment and **A**ccess services:
a **N**etwork of **R**esearch **F**acilities

- PITHIA-NRF consortium involves 22 administrative partners and one third party scientific enterprise
- Aims at building a European distributed network that integrates with key national and regional research infrastructures such as EISCAT, LOFAR, Ionosondes and Digisondes, GNSS receivers, Doppler sounding systems, riometers, and VLF receivers

12 nodes

- Is designed to provide organized access to experimental facilities, FAIR data, standardized data products, training and innovation services.
- DLR provides data access/distribution via IMPC: https://impc.dlr.de/



Horizon 2020
European Union funding
for Research & Innovation

Summary and Outlook

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