

GNSS Remote Sensing: Preliminary Results of the MOSAiC Expedition

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Outline

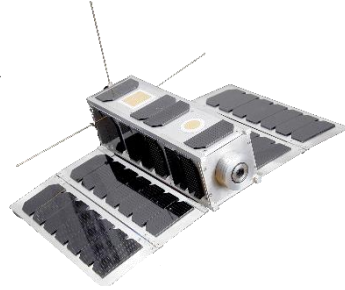


- Motivation GNSS Remote Sensing
- MOSAiC Expedition and Polarstern Setup
- Processing and Masking of Ship-based Data
- Preliminary Scintillation Results
- Conclusions

Motivation GNSS Remote Sensing

■ A: Low Earth Orbiter

Wickert et al. 2016
Semmling et al. 2016



■ B: Aircraft

Semmling et al. 2014
Moreno et al. 2021



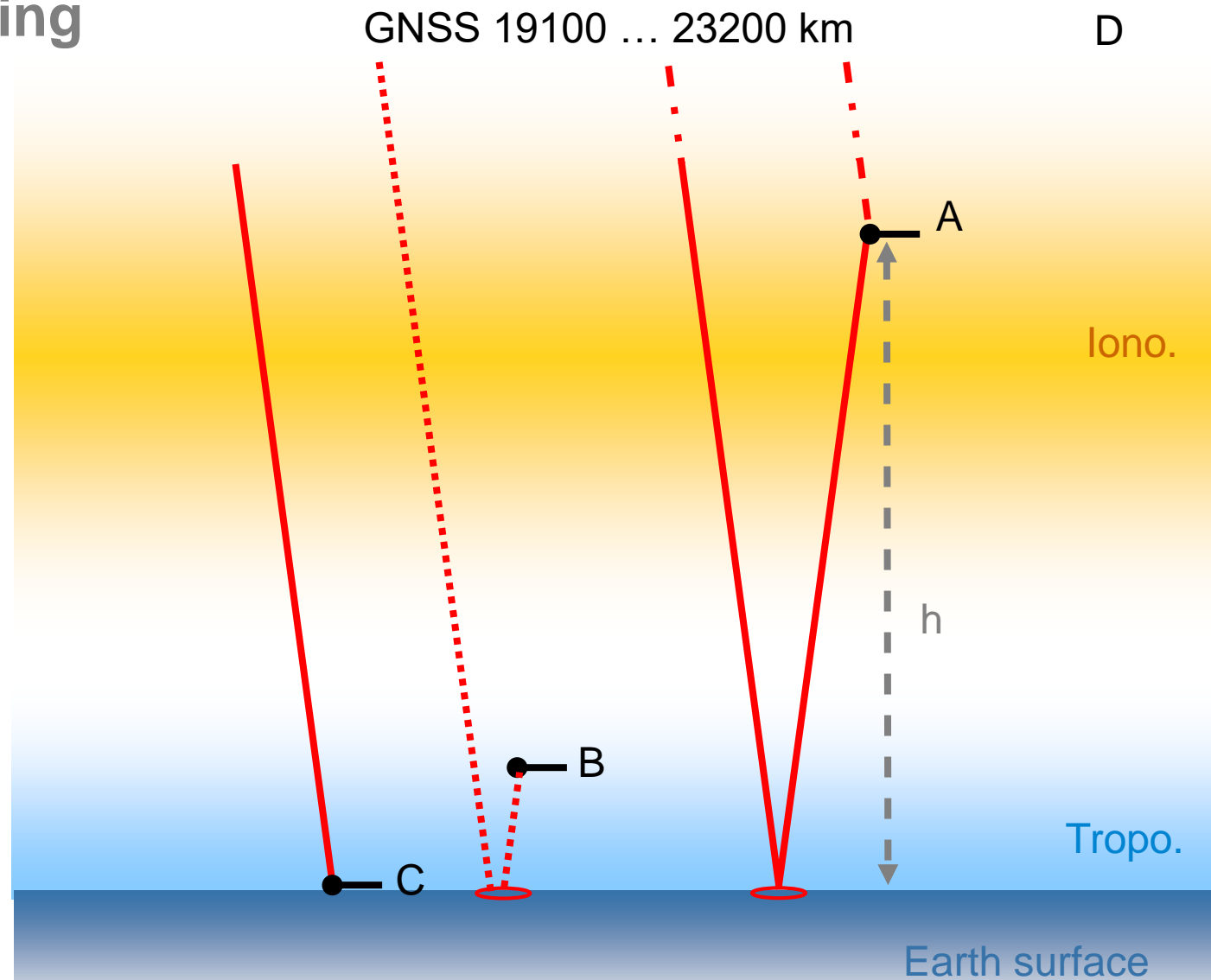
■ C: Research Vessels

Wang et al. 2019
Semmling et al. 2019, 2022
Semmling et al. 2023 (accepted)



■ Application

sea surface altimetry water vapor estimation
sea state estimation iono. scintillation detection
sea-ice detection

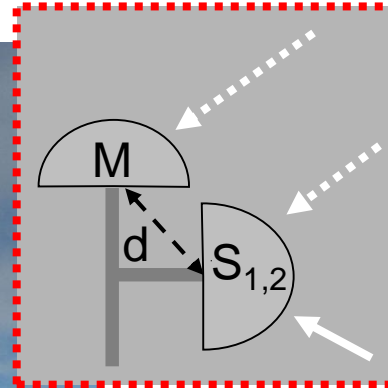
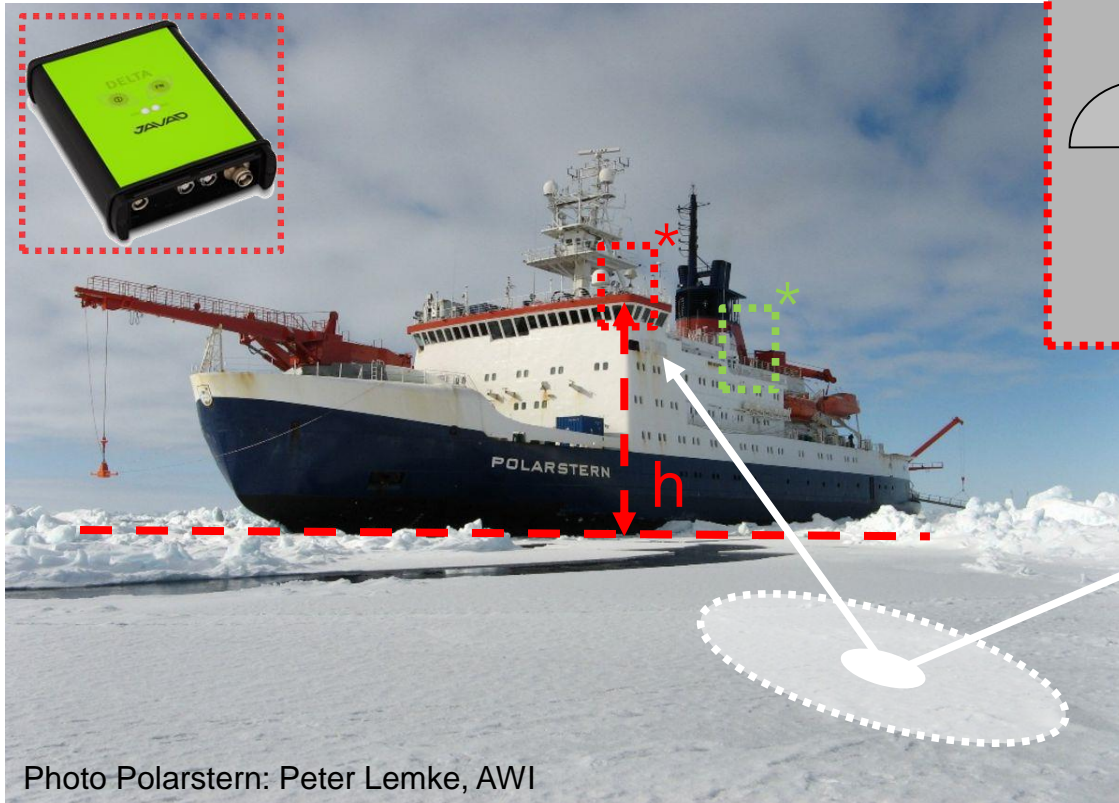


A: e.g. ISS, $h \sim 400$ km C: e.g. Polarstern, $h \sim 25$ m
B: e.g. HALO, $h \sim 3500$ m

MOSAiC Expedition and Polarstern Setup



* GFZ GNSS-R setup * DLR GNSS setup



$h = 22 \text{ m}$
 $d = 20 \text{ cm}$

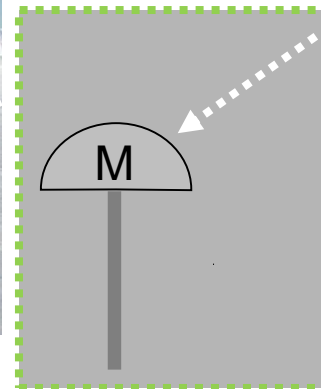
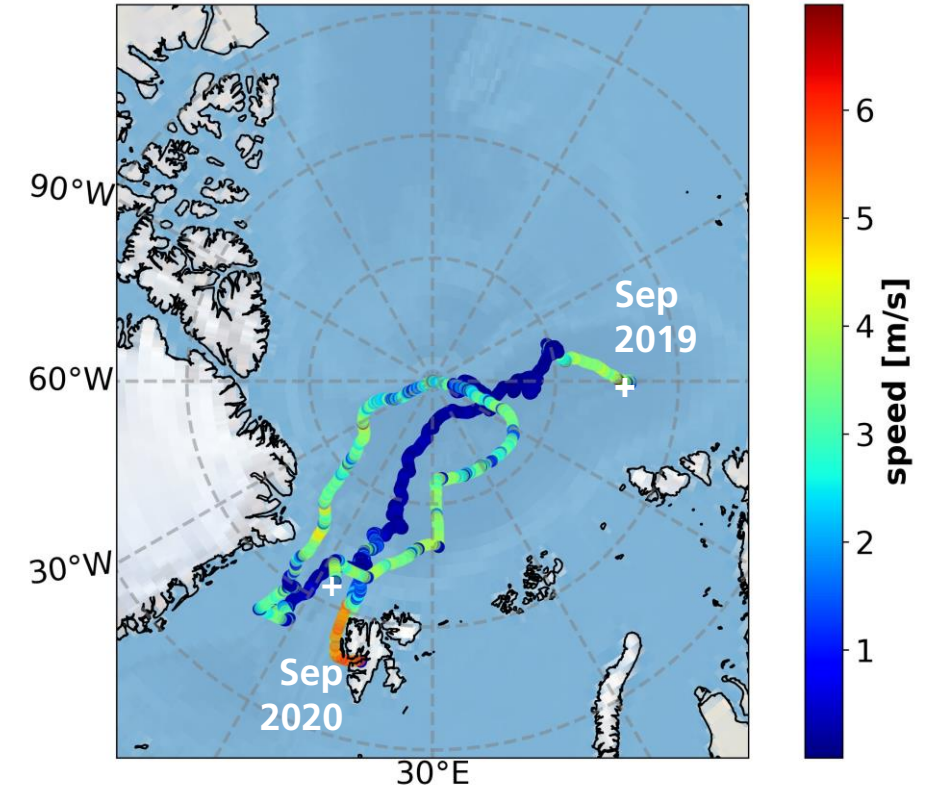


Photo Polarstern: Peter Lemke, AWI

Helm et al. 2007
Semmling et al. 2013
Kriegel et al. 2017

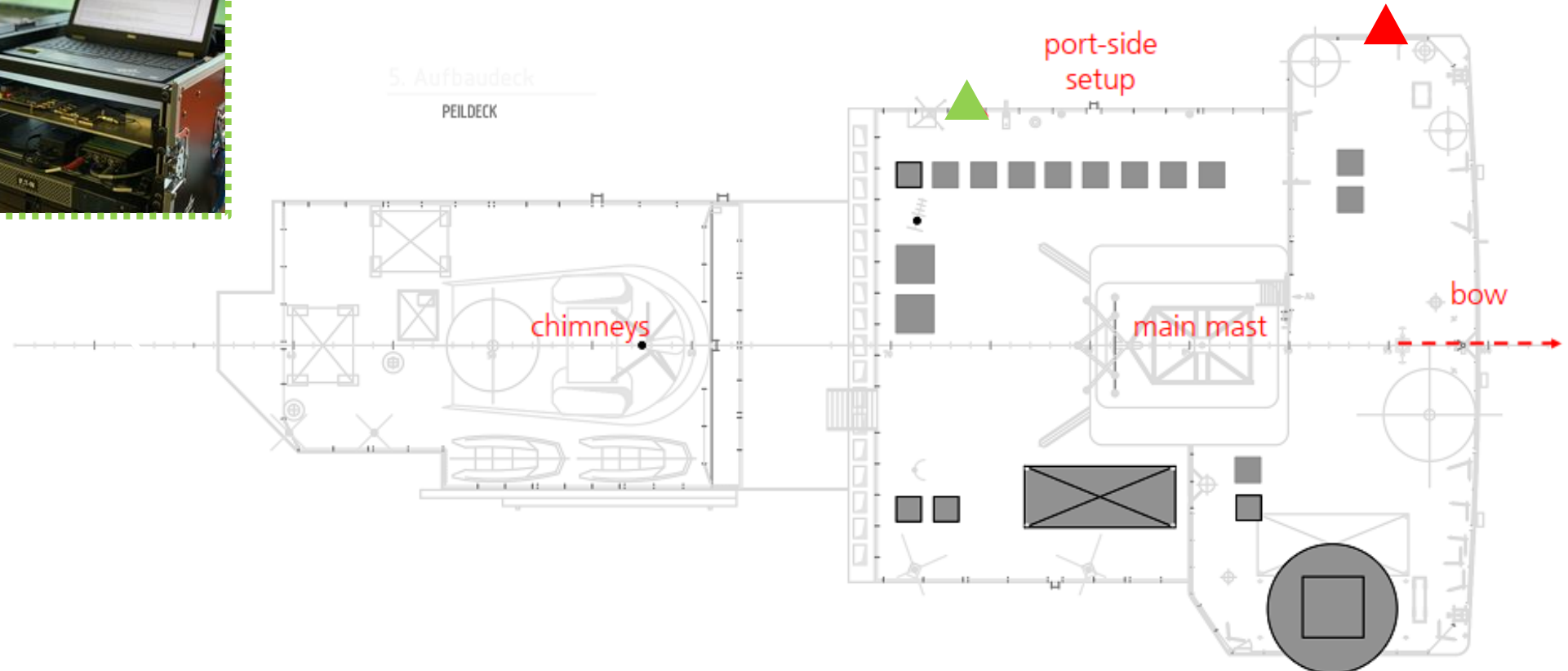
Master link (M): up-looking ant.
Slave links (S_{1,2}): side-looking ant.

MOSAiC expedition: Sep 2019 - Sep 2020



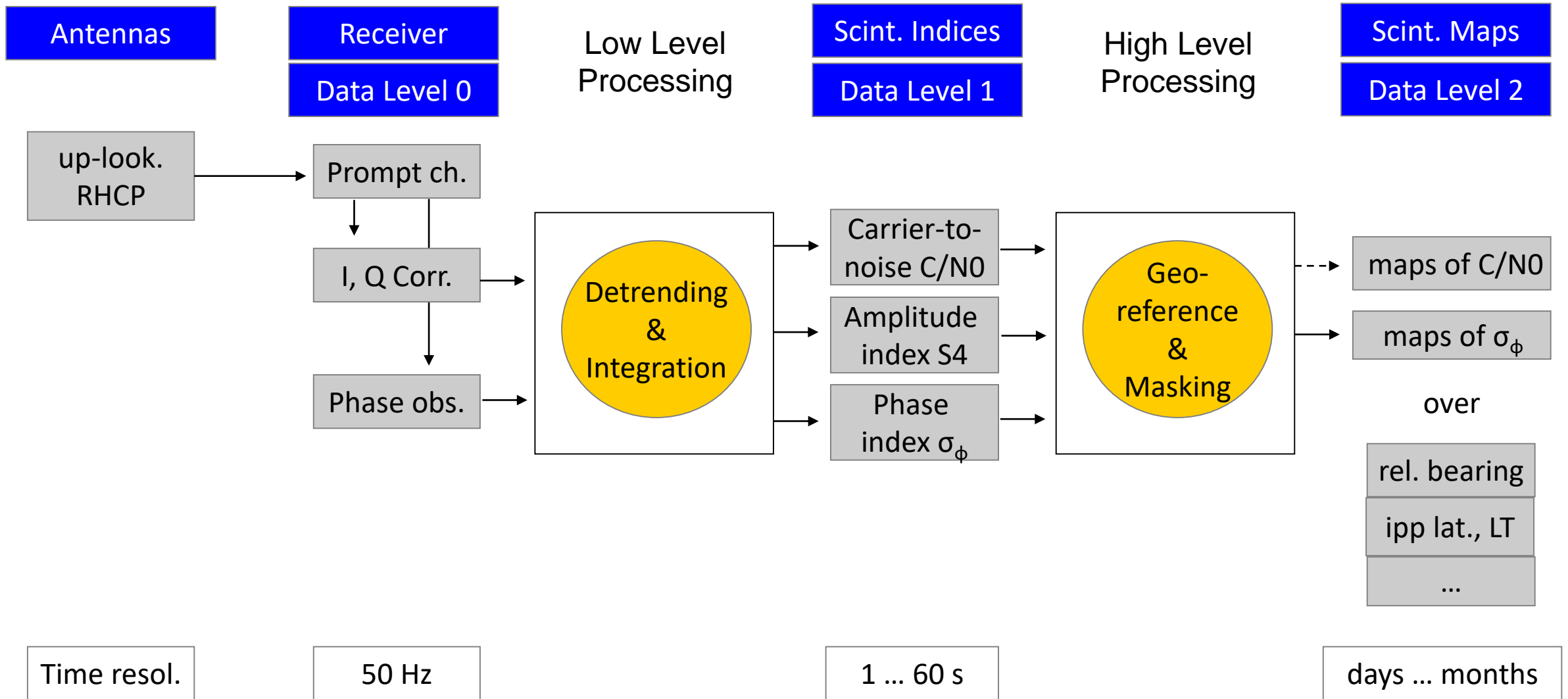
Cruising Periods: speed > 1 m/s
Drifting Period: speed < 1 m/s

MOSAiC Expedition and Polarstern Setup

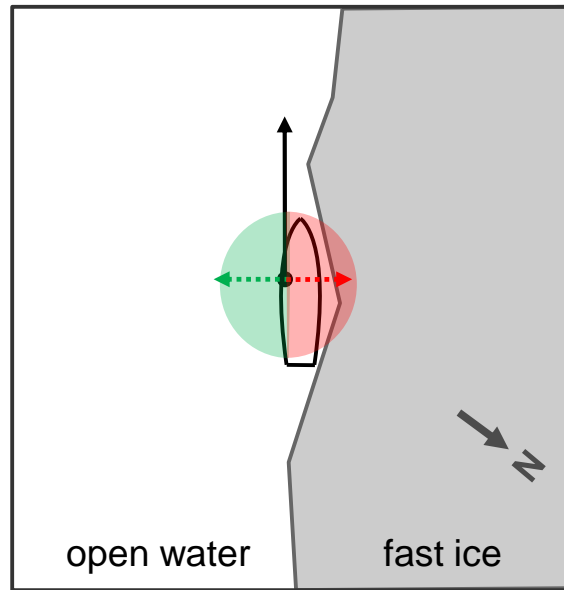


Processing and Masking of Ship-based Data

Scintillation Data Processing






Limits of Visibility from the Ship

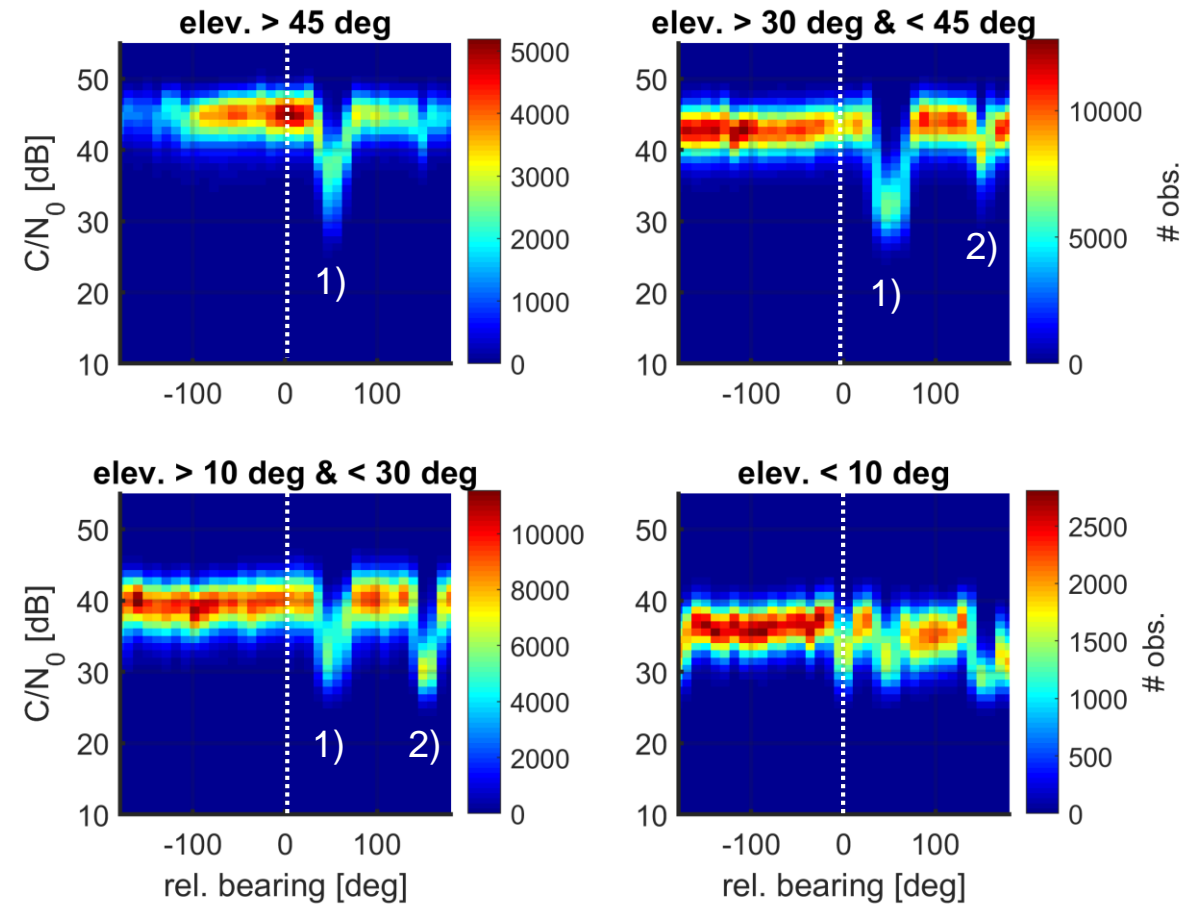


clear view
to port-side

left rel. Bearing:
 -180° to 0°

-  heading of the ship
-  right rel. bearing (blocked)
-  left rel. bearing (clear)

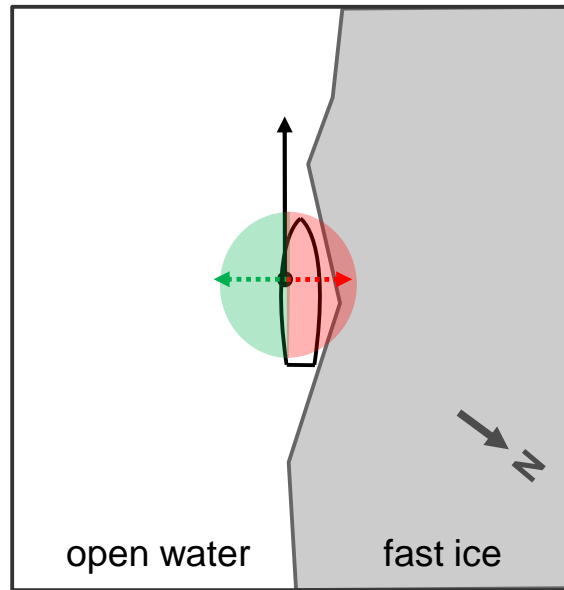
C/N₀ over rel. bearing



- 1) ship's main mast
- 2) ship's chimney

Sep 2019 ... Sep 2020

Limits of Visibility from the Ship

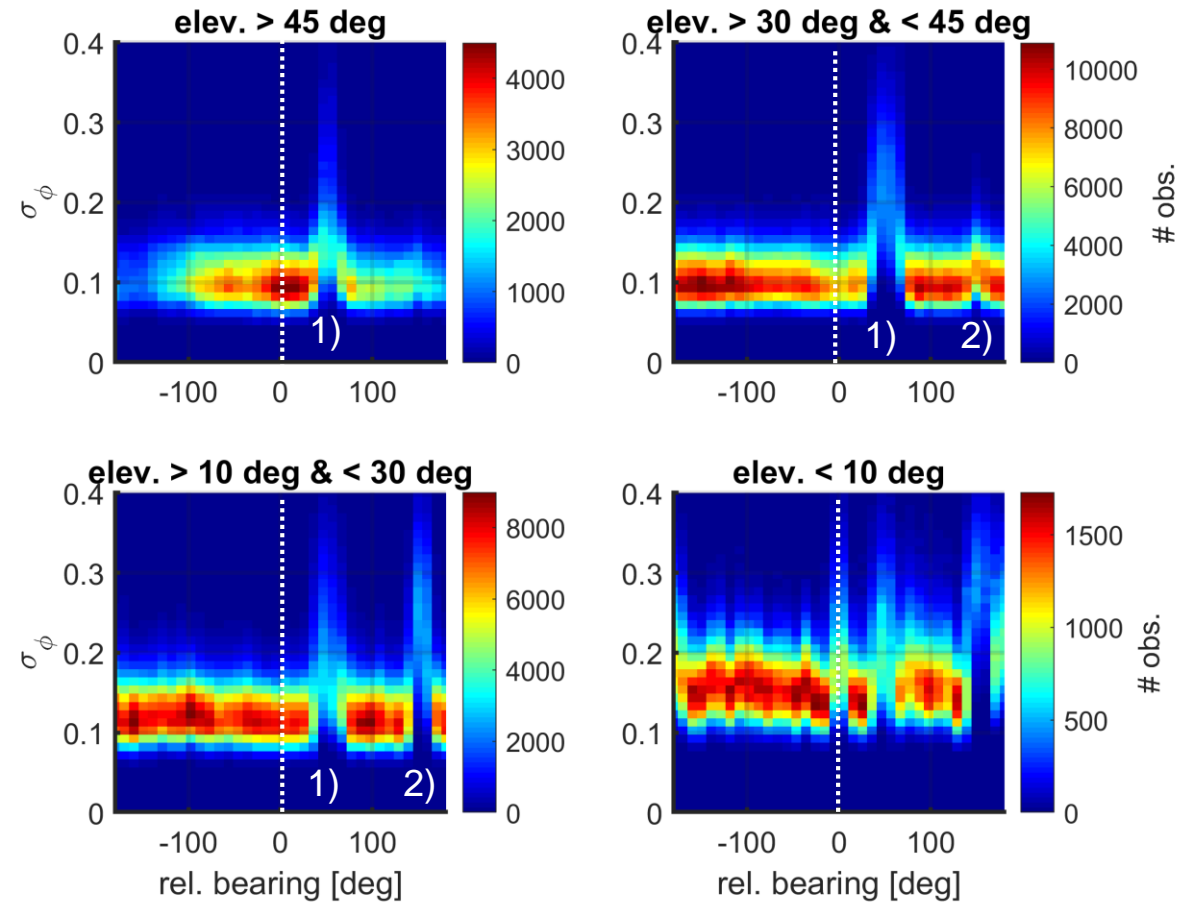


clear view
to port-side

left rel. Bearing:
-180° to 0°

- heading of the ship
- right rel. bearing (blocked)
- ← left rel. bearing (clear)

σ_ϕ over rel. bearing



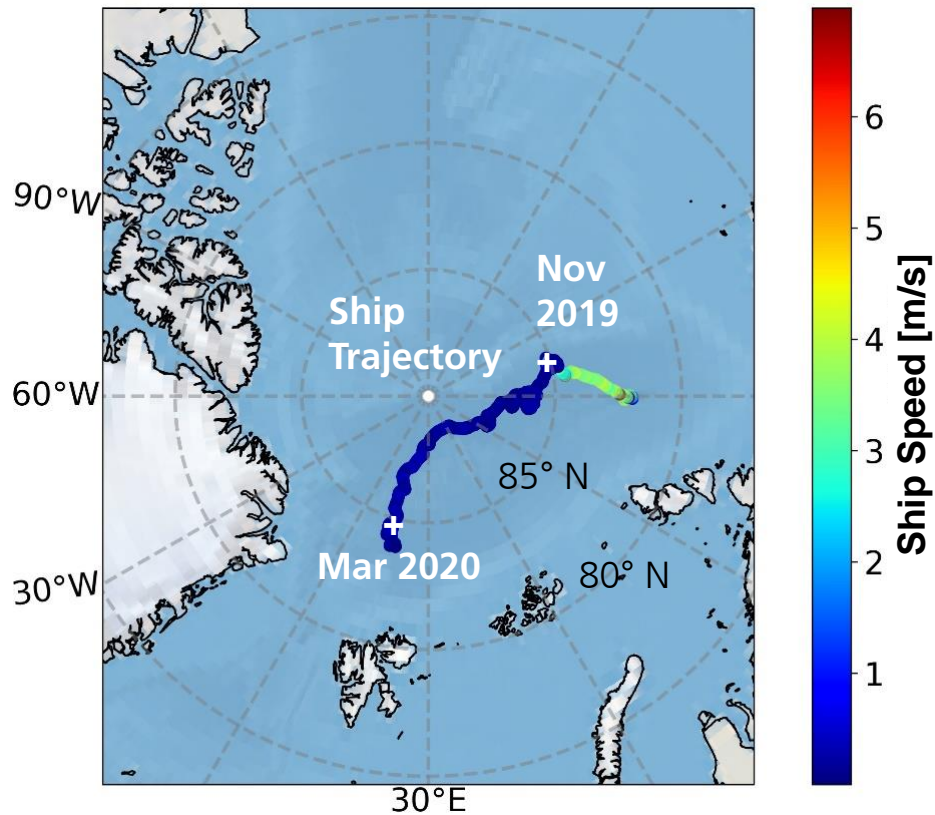
- 1) ship's main mast
- 2) ship's chimney

Sep 2019 ... Sep 2020

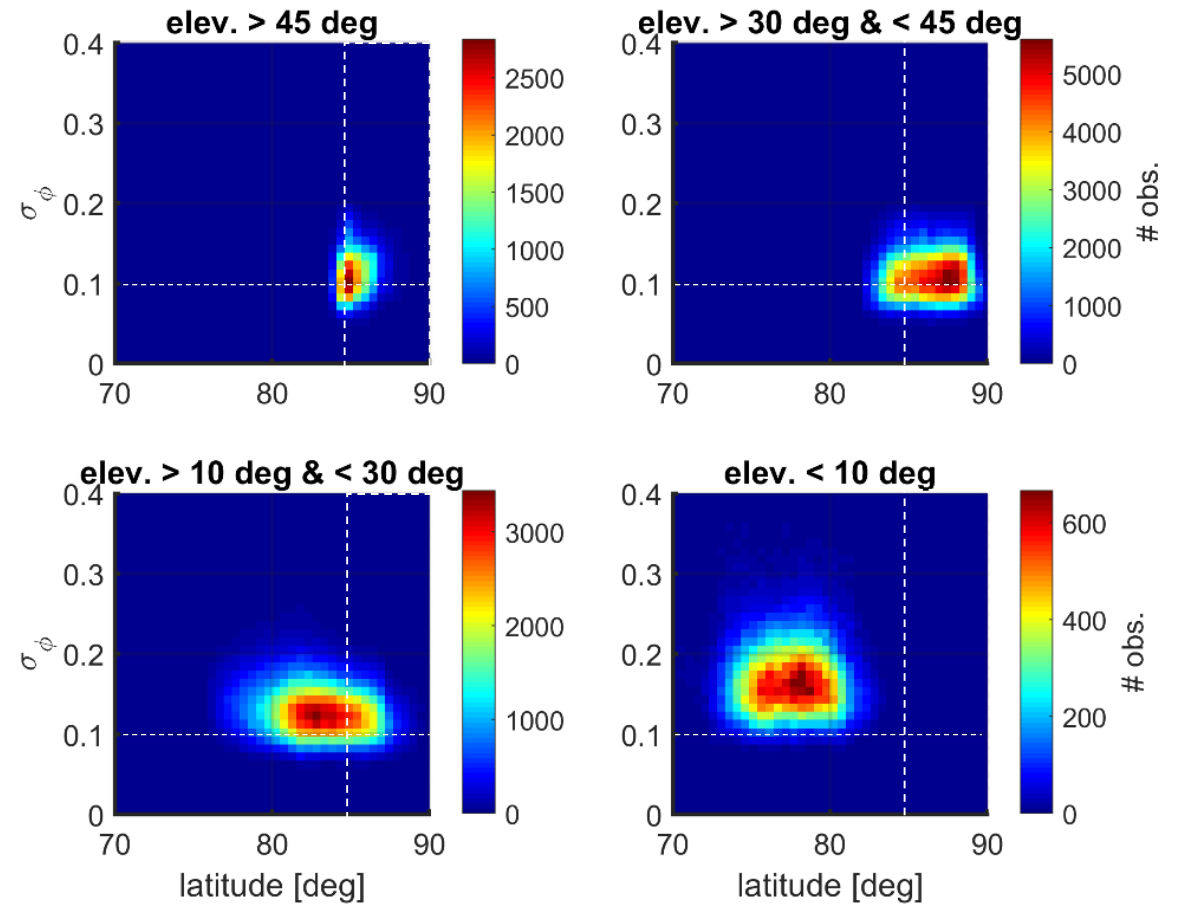
Preliminary Scintillation Results

High Arctic Winter

GNSS obs. in the Central Arctic



σ_ϕ over lat. at IPP (height 350 km)

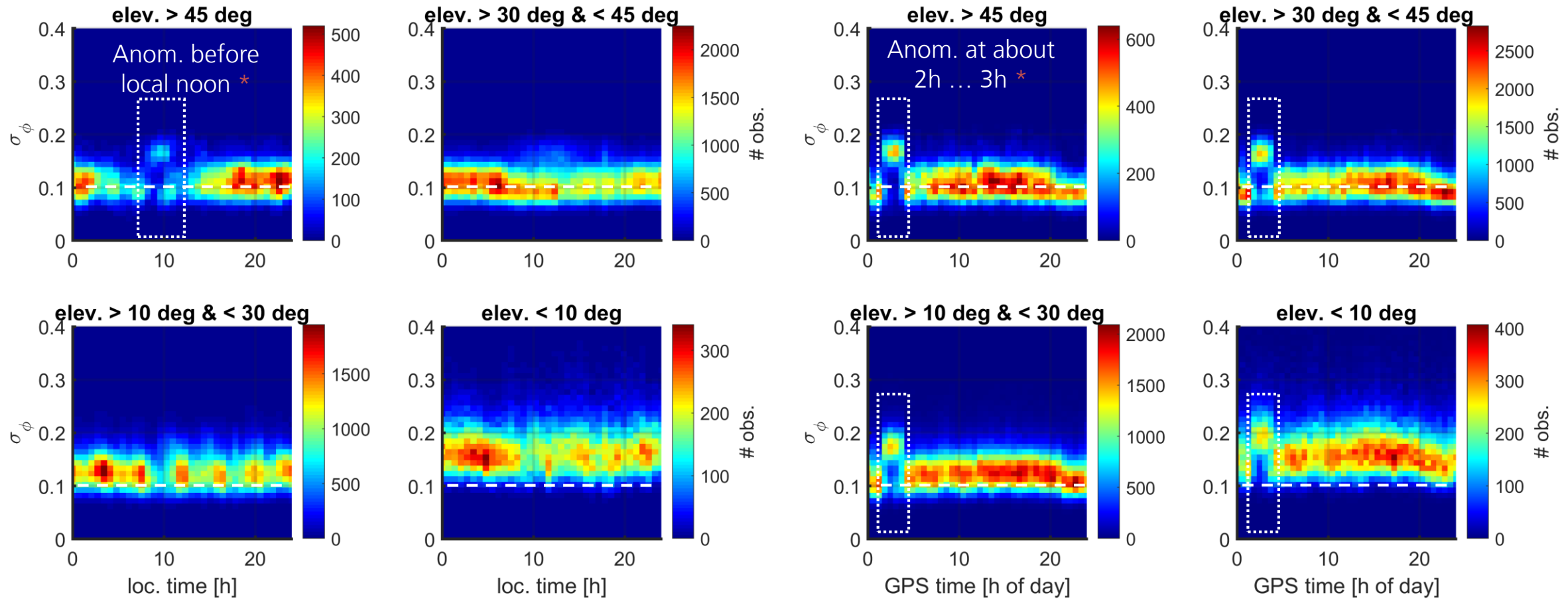


Nov 2019 ... Mar 2020

High Arctic Winter

σ_ϕ over local time at IPP (height 350 km)

σ_ϕ over GPS time at PS (~ UTC)



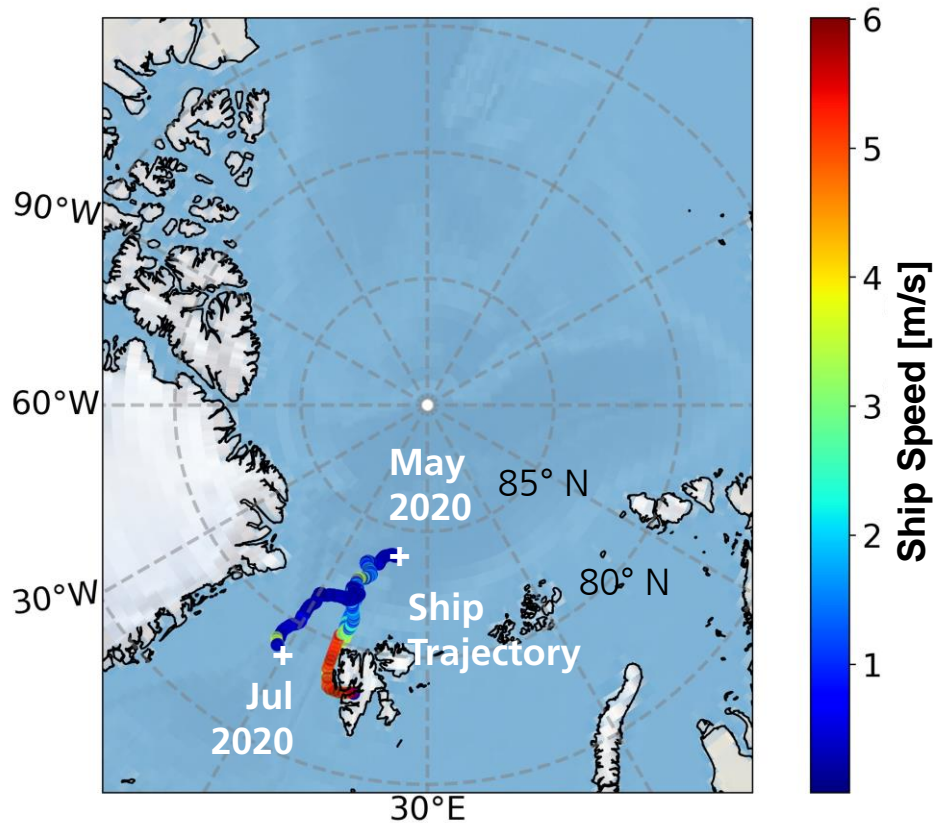
Nov 2019 ... Mar 2020

* cusp
influence ?

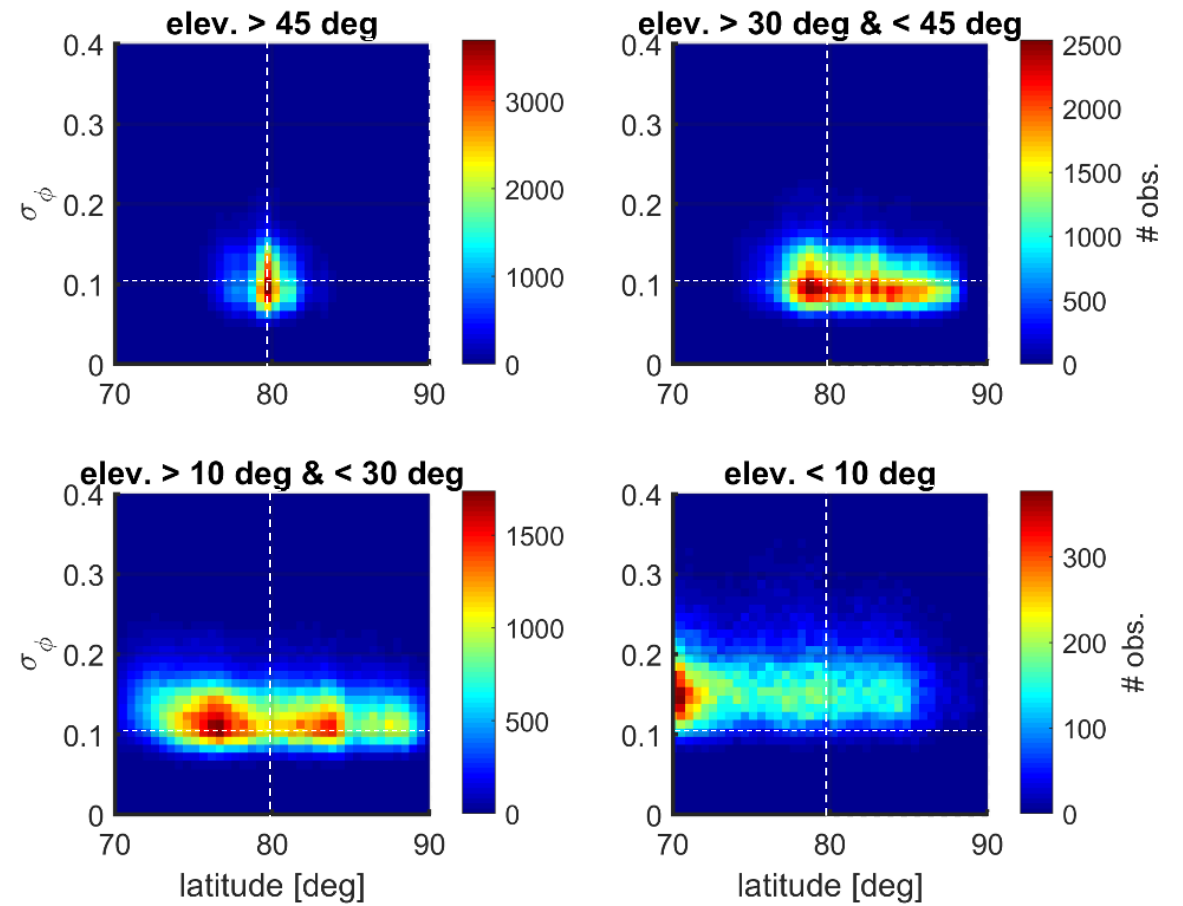
Nov 2019 ... Mar 2020

Spring & Summer in Fram Strait

GNSS obs. in the Central Arctic



σ_ϕ over lat. at IPP (height 350 km)



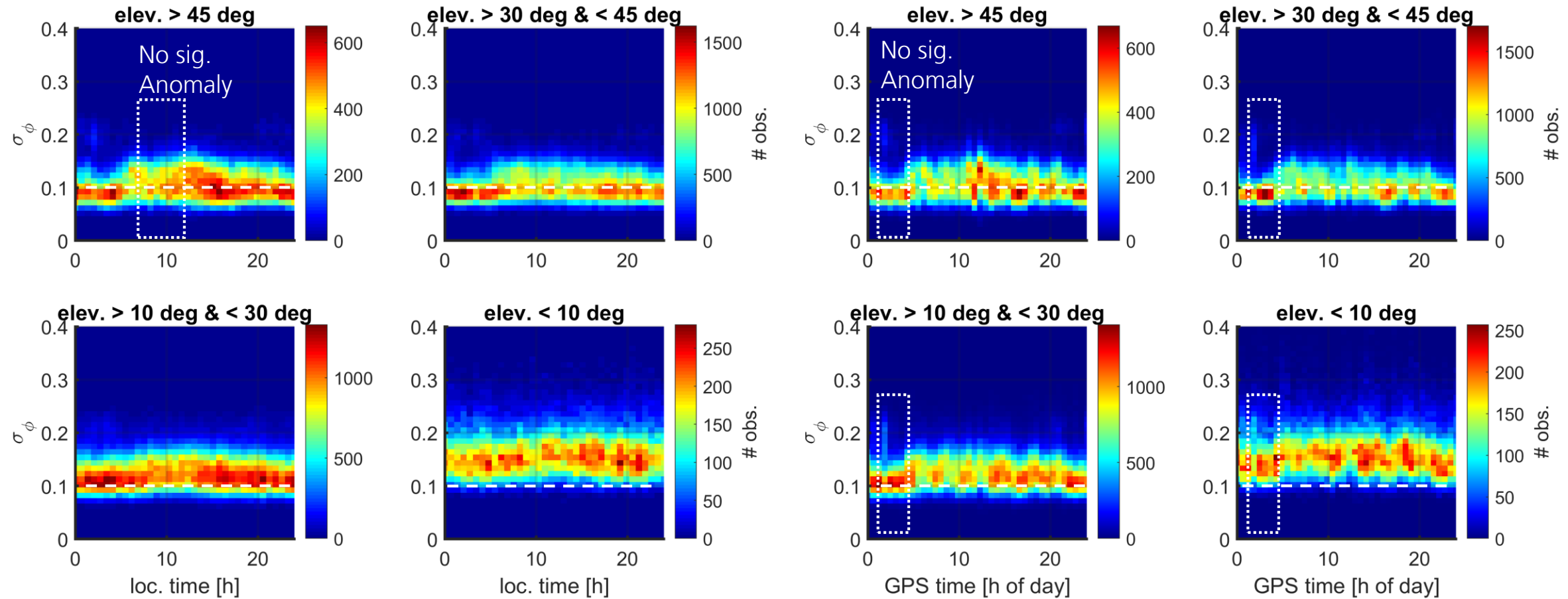
May 2020 ... Jul 2020

Spring & Summer in Fram Strait



σ_ϕ over local time at IPP (height 350 km)

σ_ϕ over GPS time at PS (~ UTC)



May 2020 ... Jul 2020

* cusp
influence ?

May 2020 ... Jul 2020

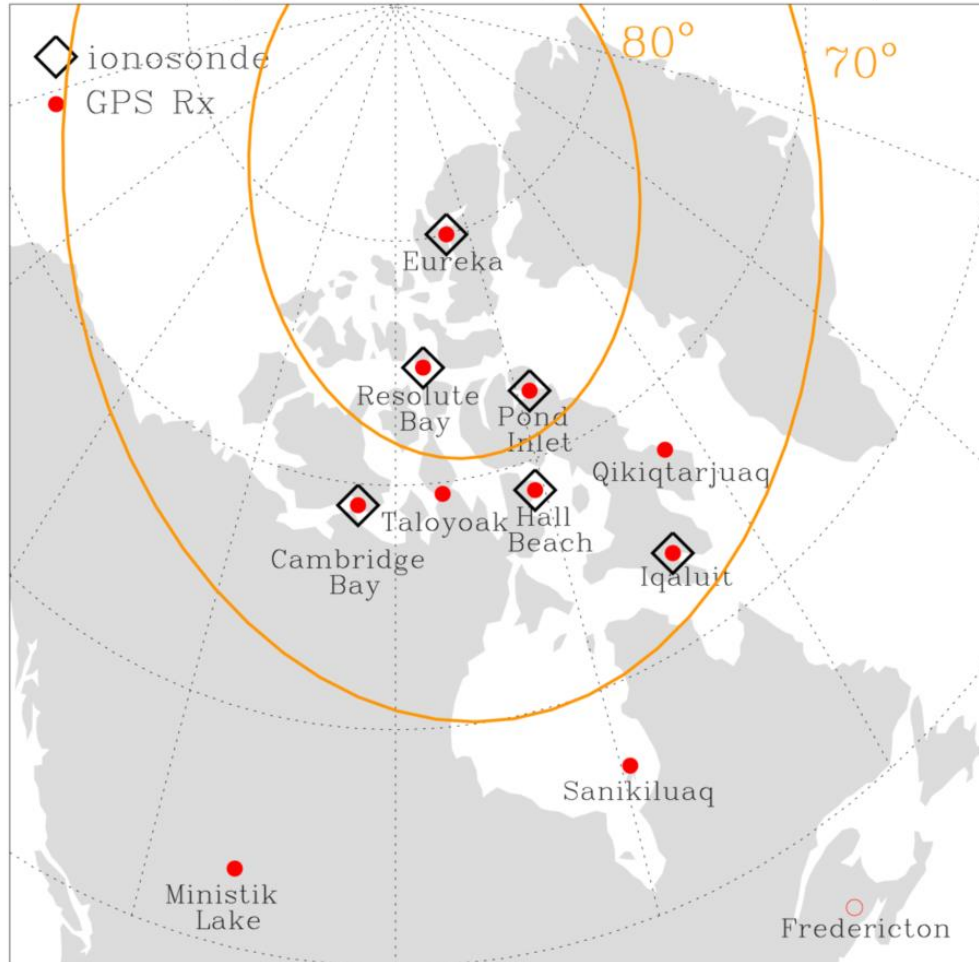
Findings & Next steps



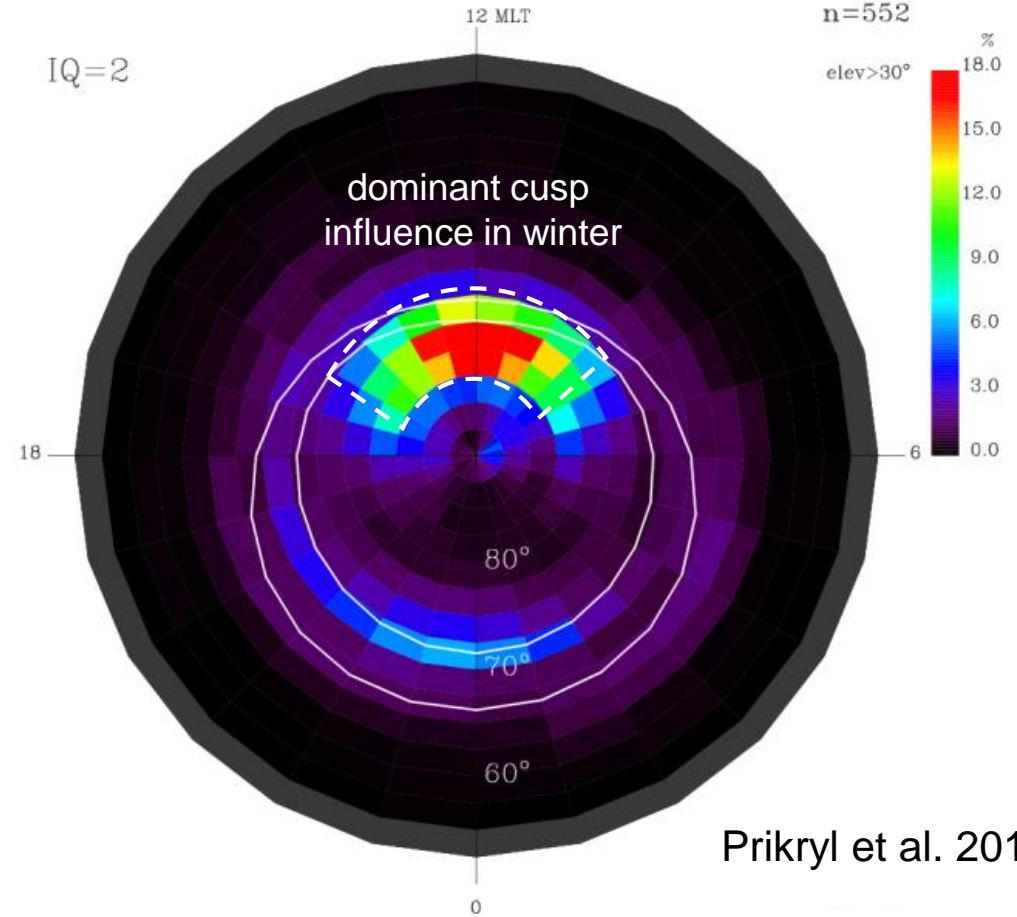
- We found: most significant anomaly in σ_ϕ at about 2h to 3h UTC in high arctic winter for almost all elevation angles
 - > expect relation to cusp influence
- In a next step: identify cusp influence by range of corr. geomag. latitude (CGM lat.) and mag. Local time (MLT) according to Prikryl et al. [2015]
 - > CGM lat.: 72.5° N ... 80.0° N
MLT: 9 h ... 15 h

Climatology of scintillation based on GNSS station data

Canadian High-Arctic Ionospheric Network (CHAIN)



CHAIN NOV–JAN 2008–2013: OCCURRENCE OF $\sigma_\phi > 0.1$ ($h_{\text{IPP}}=350$ km)



Prikryl et al. 2015

Conclusions

- GNSS remote sensing from a ship requires adapted processing (ship disturbs scint. index)
- Baseline phase noise is higher than for station obs. (about 0.1 rad) still significant anomalies are resolved in high Arctic winter data
- cusp influence is expected at given latitudes, still need to be verified

Acknowledgements

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Werkstatt and IT staff at DLR and GFZ

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Thank you for your attention.

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