Monitoring of GNSS Scintillation Indices during the MOSAiC Expedition: Preliminary Results from Eight Months in the Arctic

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Photo Polarstern: Peter Lemke, AWI

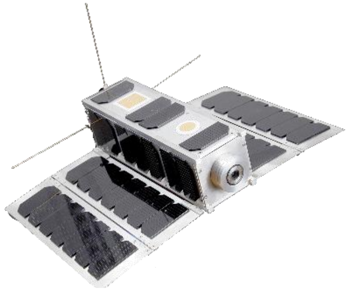
Outline

- Some Aspects of 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

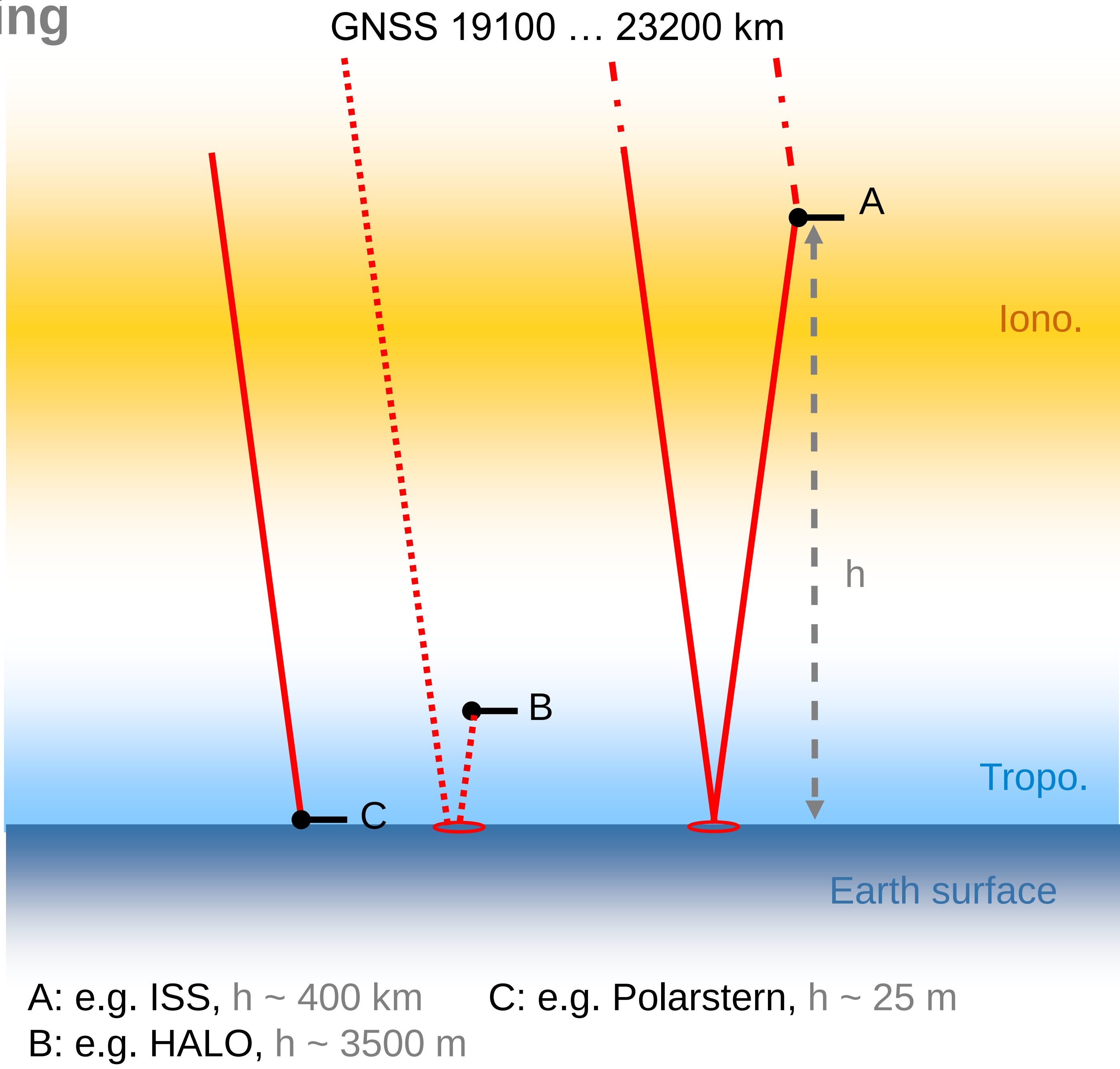
  Semmling et al. 2014
  Moreno et al. 2021

- C: Research Vessels

  Wang et al. 2019
  Semmling et al. 2019, 2022
  Semmling et al. 2023

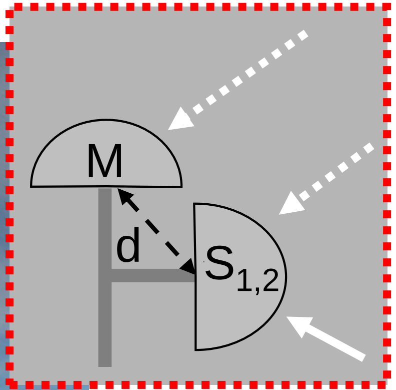
- Application

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



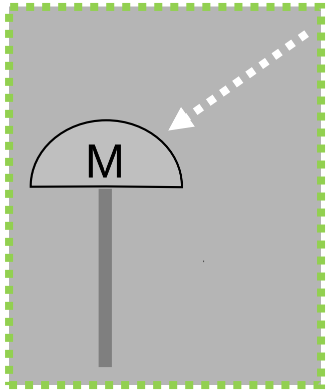
MOSAiC Expedition and Polarstern Setup

* GFZ GNSS-R setup * DLR GNSS setup

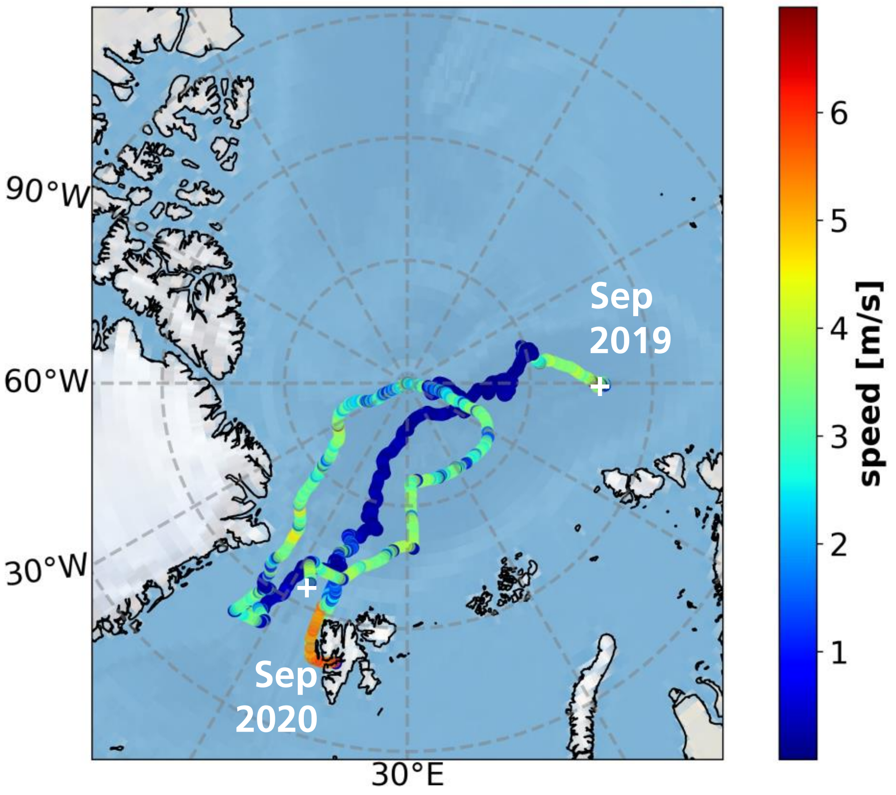


h = 22 m

d = 20 cm



MOSAiC expedition: Sep 2019 - Sep 2020

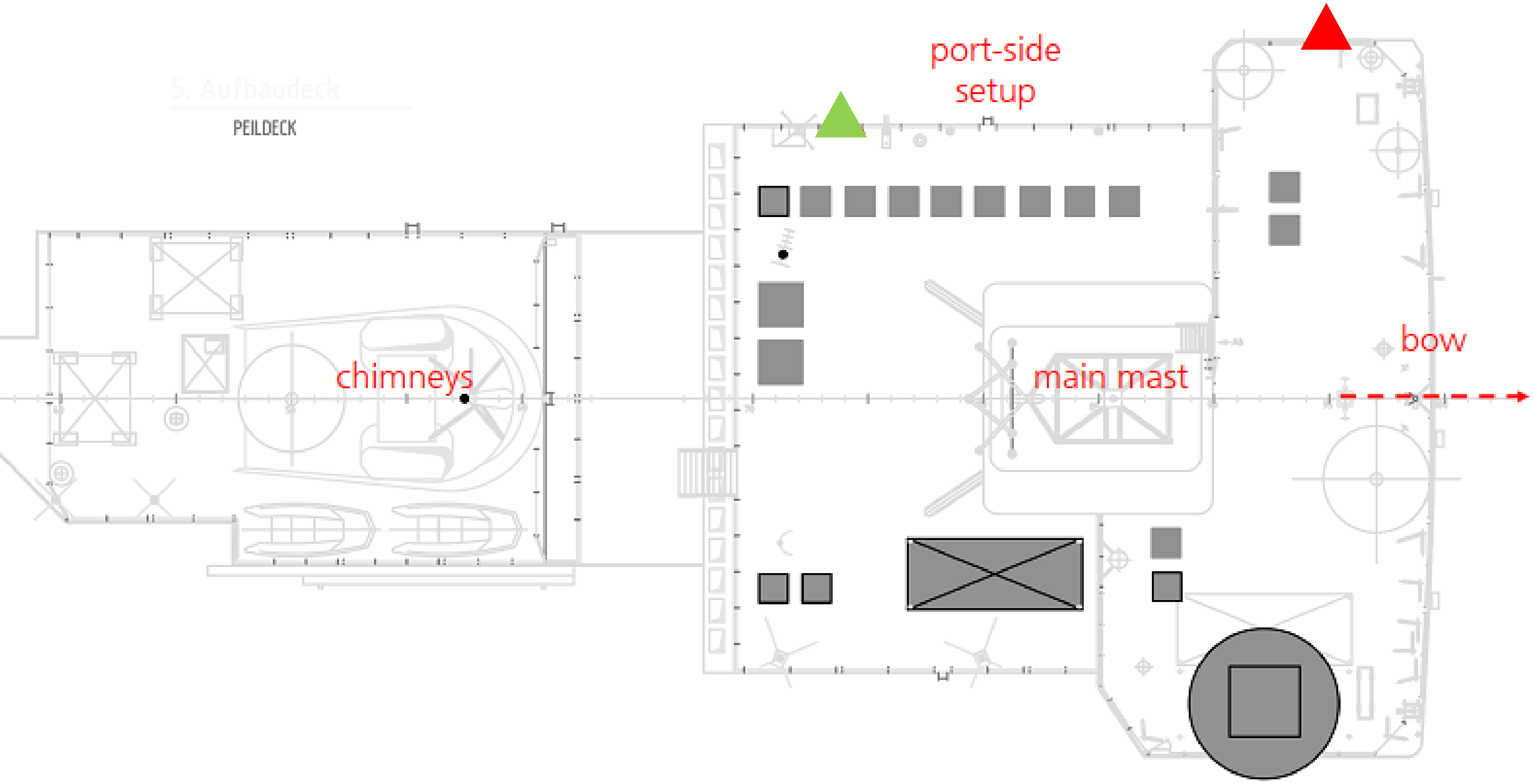


Helm et al. 2007
Semmling et al. 2013
Kriegel et al. 2017

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

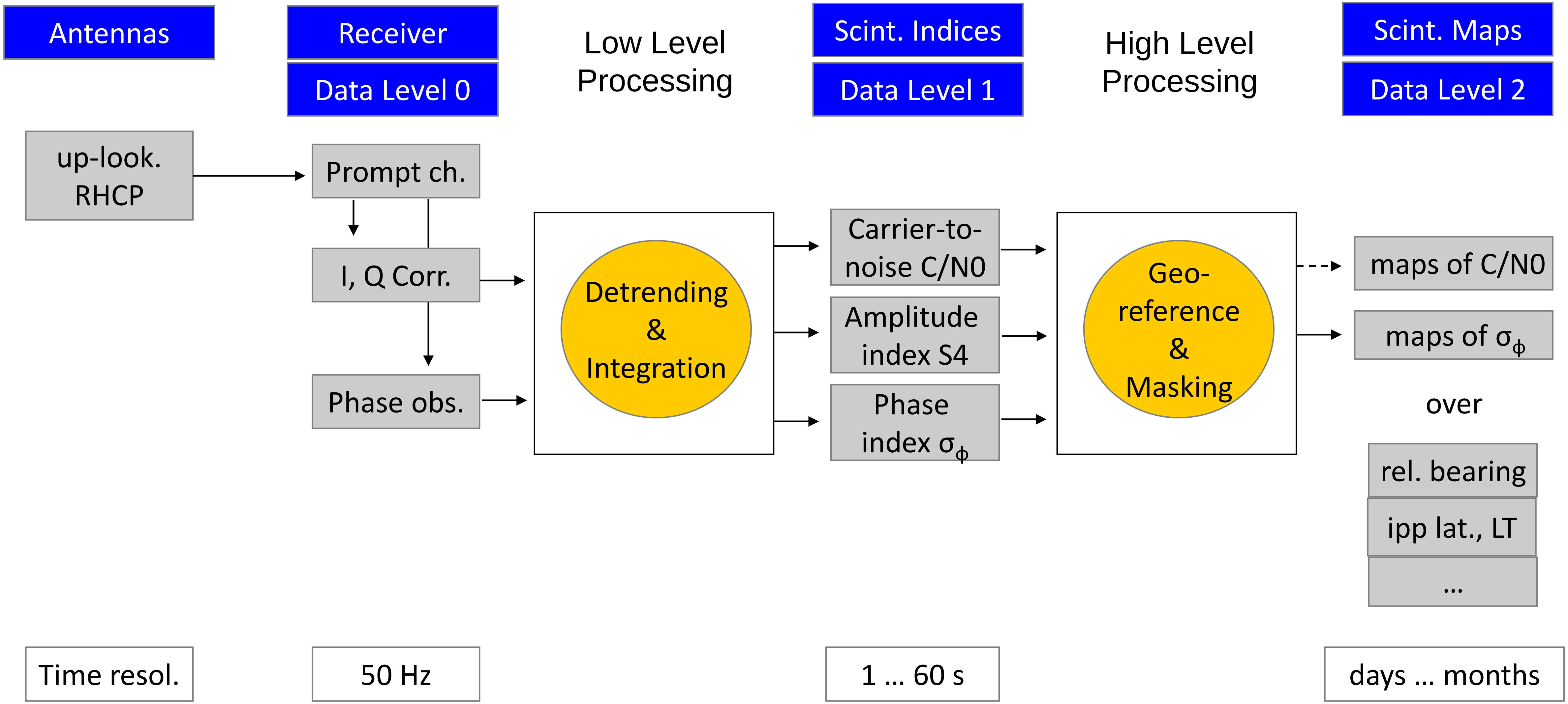
Cruising Periods: speed > 1 m/s
Drifting Period: speed < 1 m/s

MOSAiC Expedition and Polarstern Setup

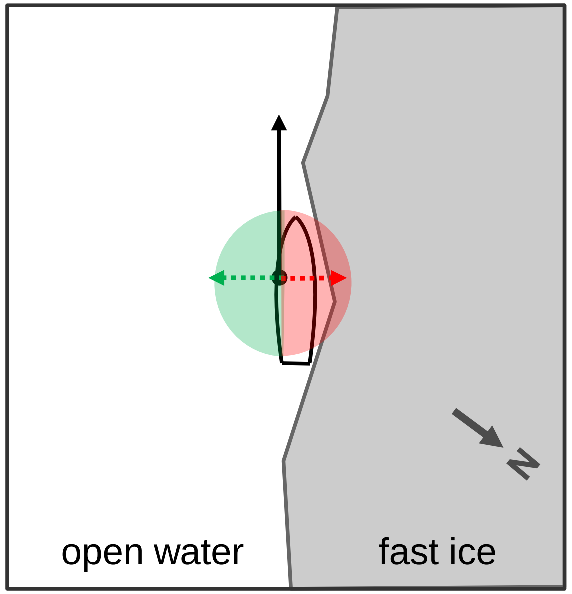


Processing and Masking of Ship-based Data

Scintillation Data Processing



Limits of Visibility from the Ship

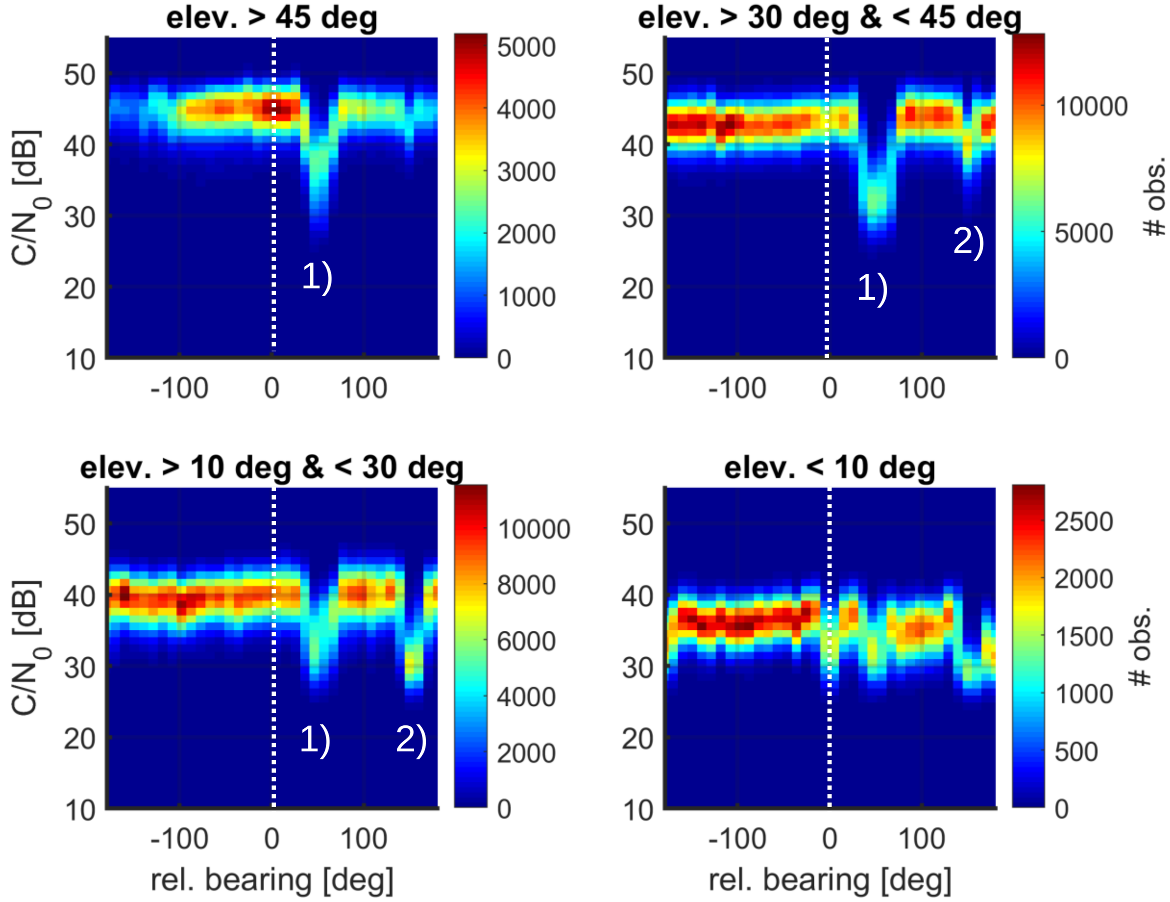


clear view
to port-side

left rel. Bearing:
-180° to 0°

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

C/N0 over rel. bearing

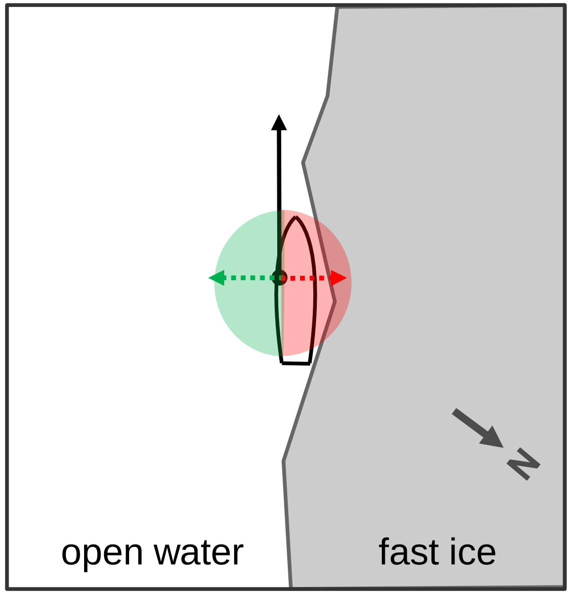


1) ship‘s main mast
2) ship‘s chimney

Sep 2019 … Sep 2020

Semmling et al. 2023

Limits of Visibility from the Ship

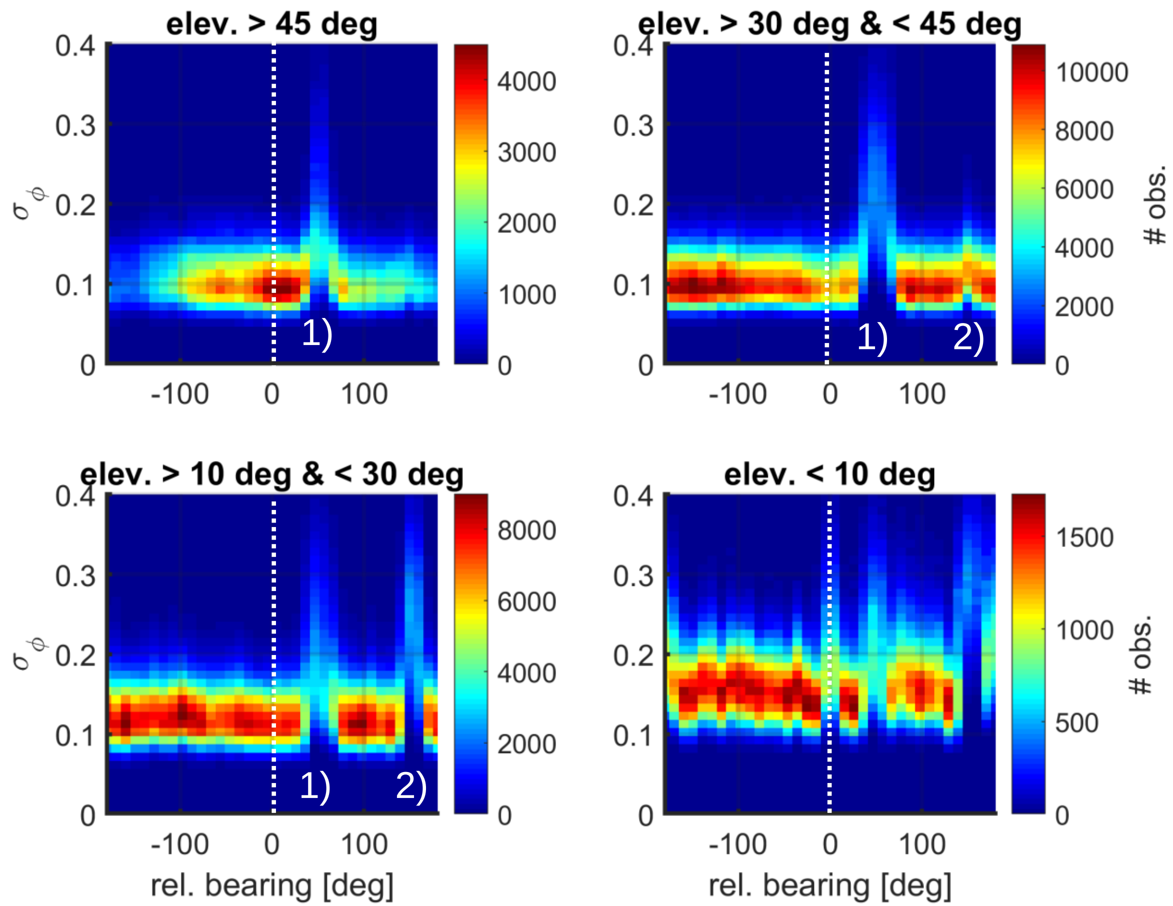


clear view
to port-side

left rel. Bearing:
-180° to 0°

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

σ_φ over rel. bearing



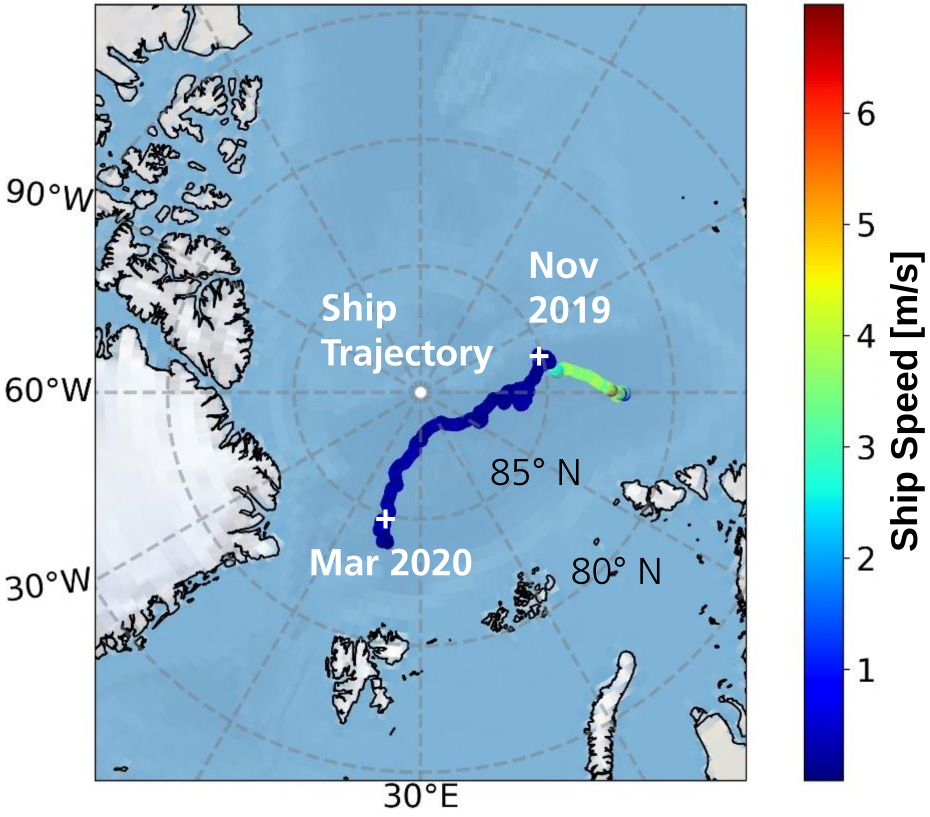
1) ship‘s main mast
2) ship‘s chimney

Sep 2019 … Sep 2020

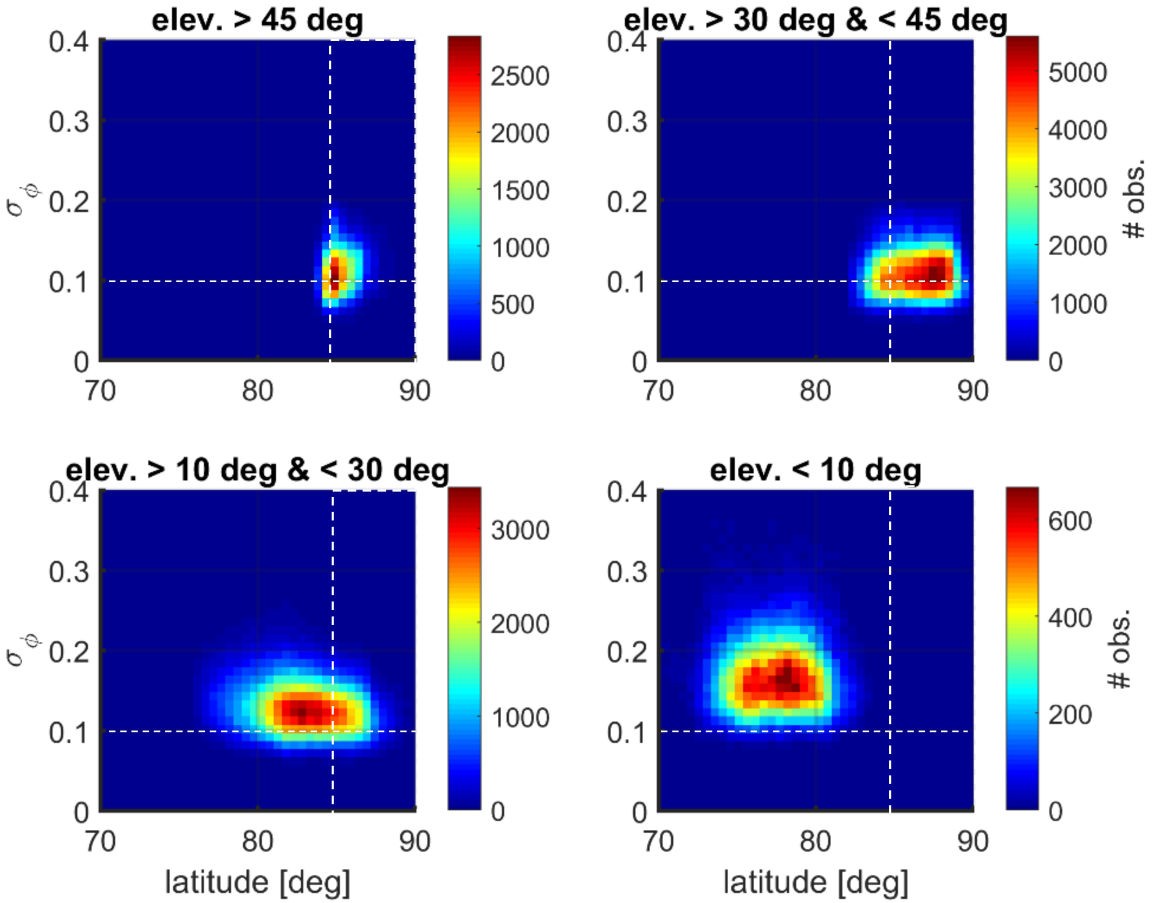
Preliminary Scintillation Results

High Arctic Winter

GNSS obs. in the Central Arctic



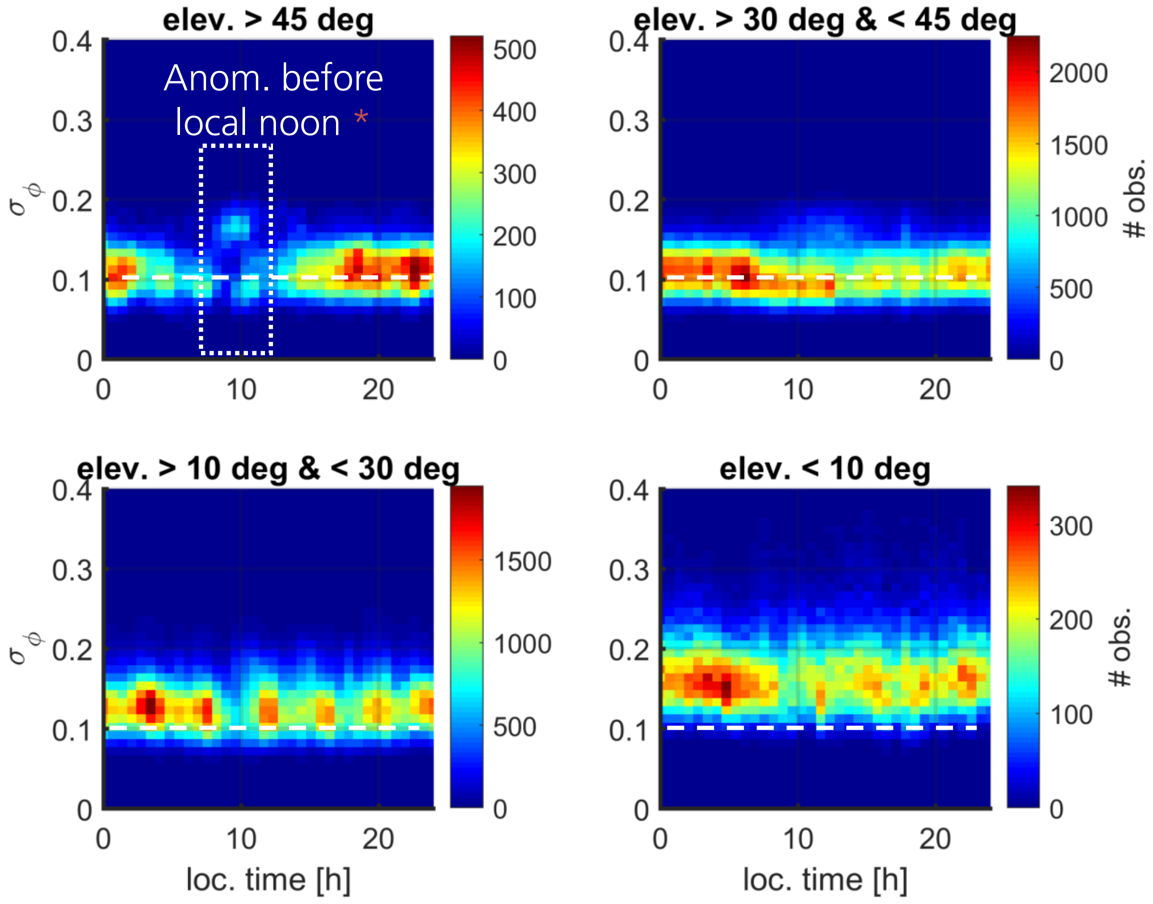
σ_φ over lat. at IPP (height 350 km)



Nov 2019 … Mar 2020

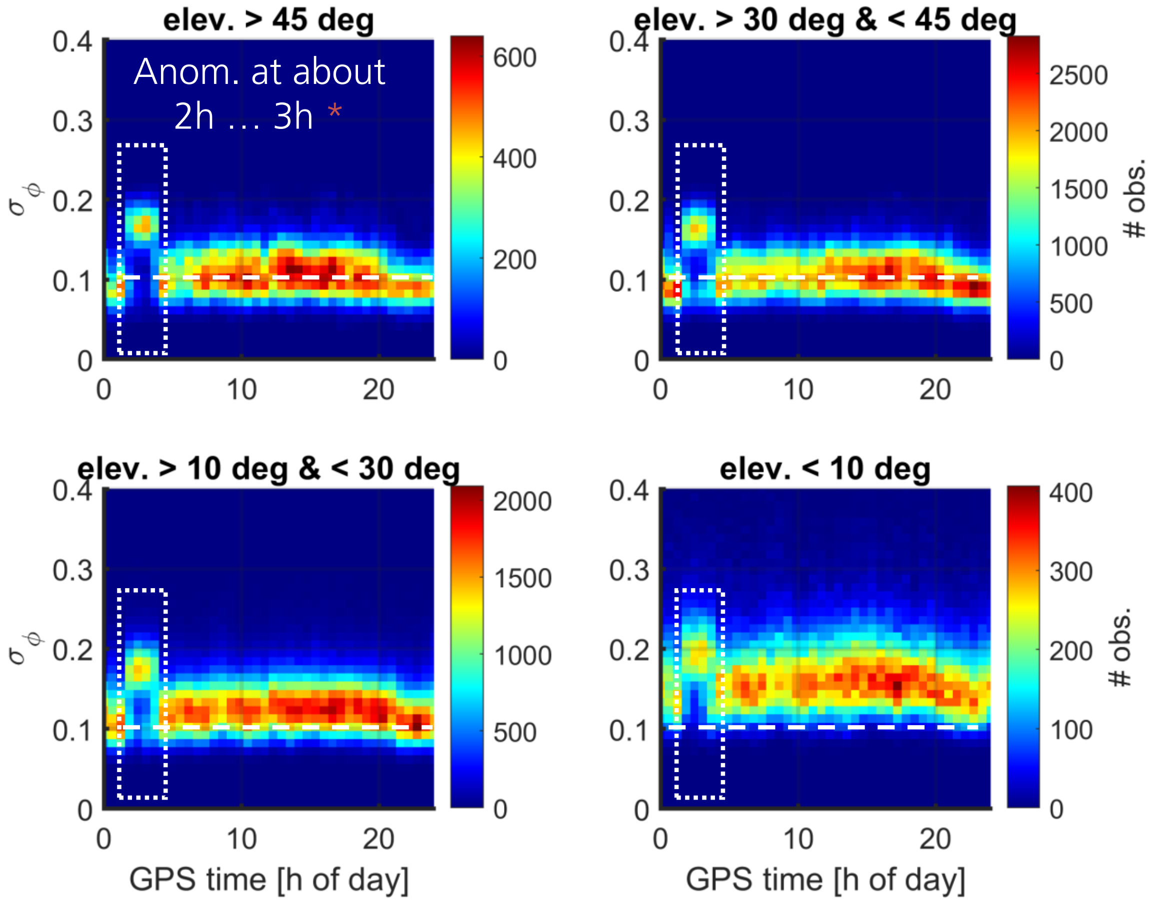
High Arctic Winter

σ_φ over local time at IPP (height 350 km)



Nov 2019 … Mar 2020

σ_φ over GPS time at PS (~ UTC)

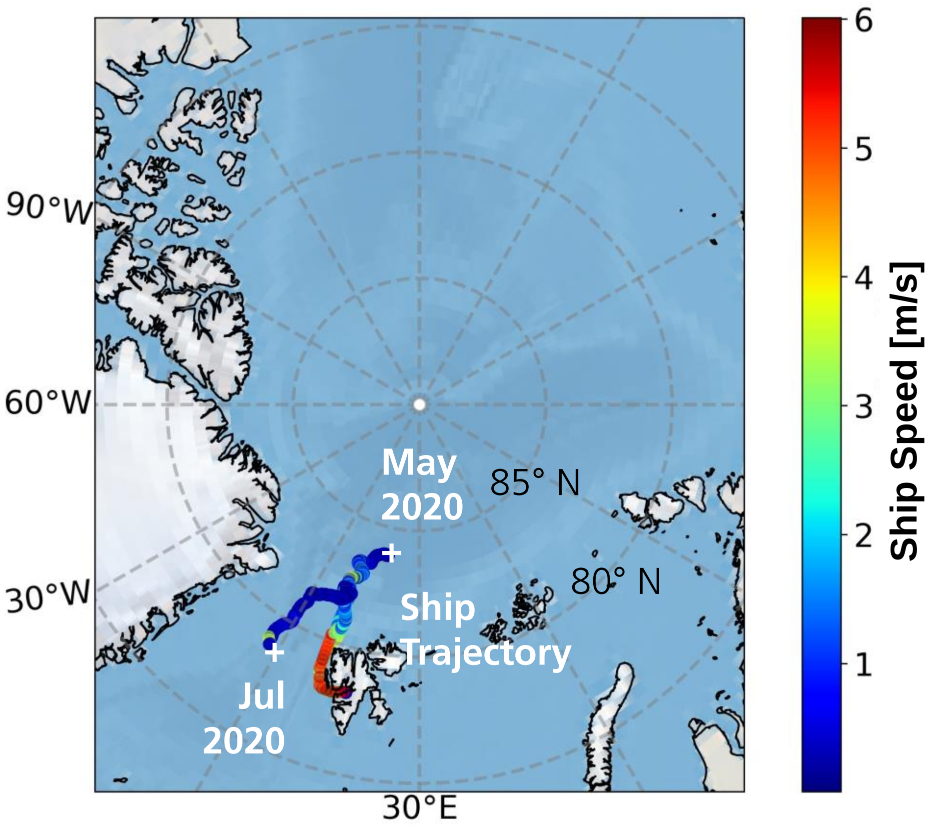


Nov 2019 … Mar 2020

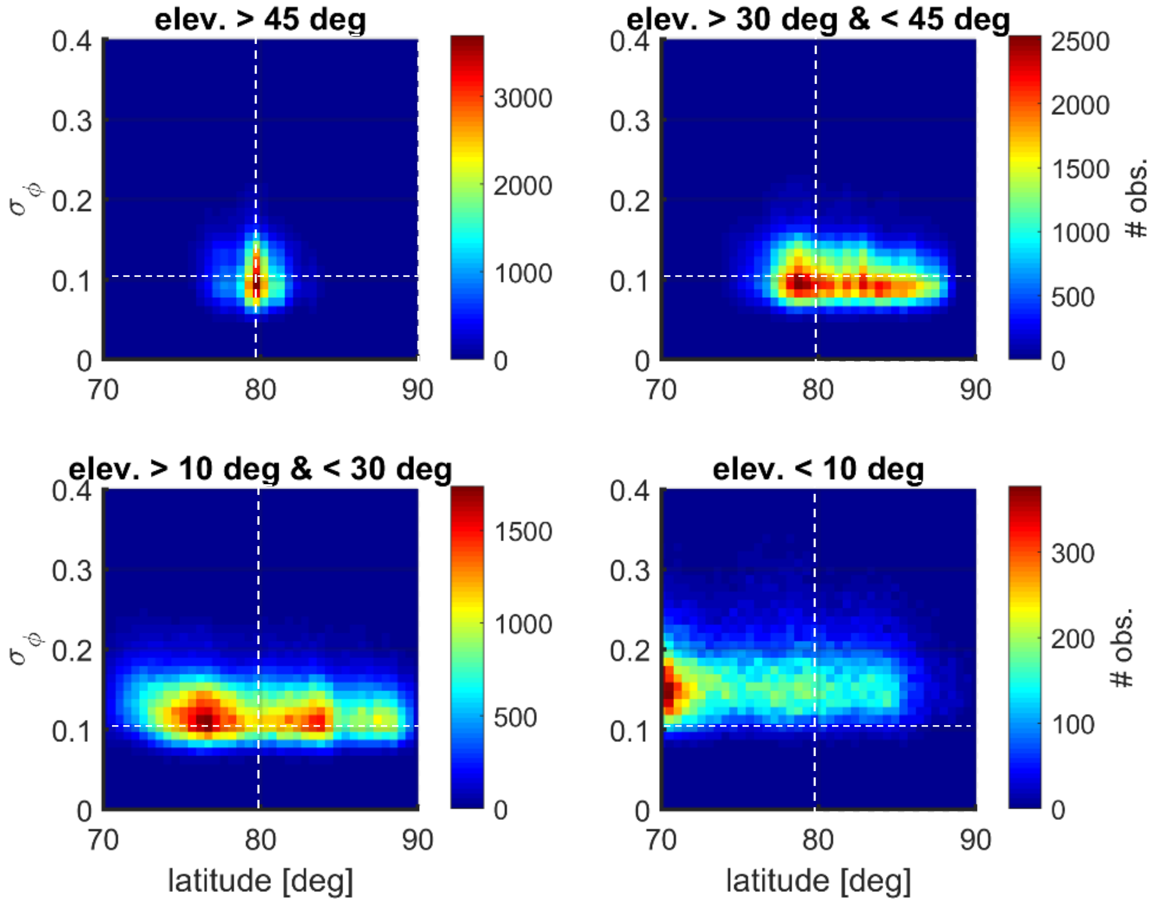
* cusp influence ?

Spring & Summer in Fram Strait

GNSS obs. in the Central Arctic



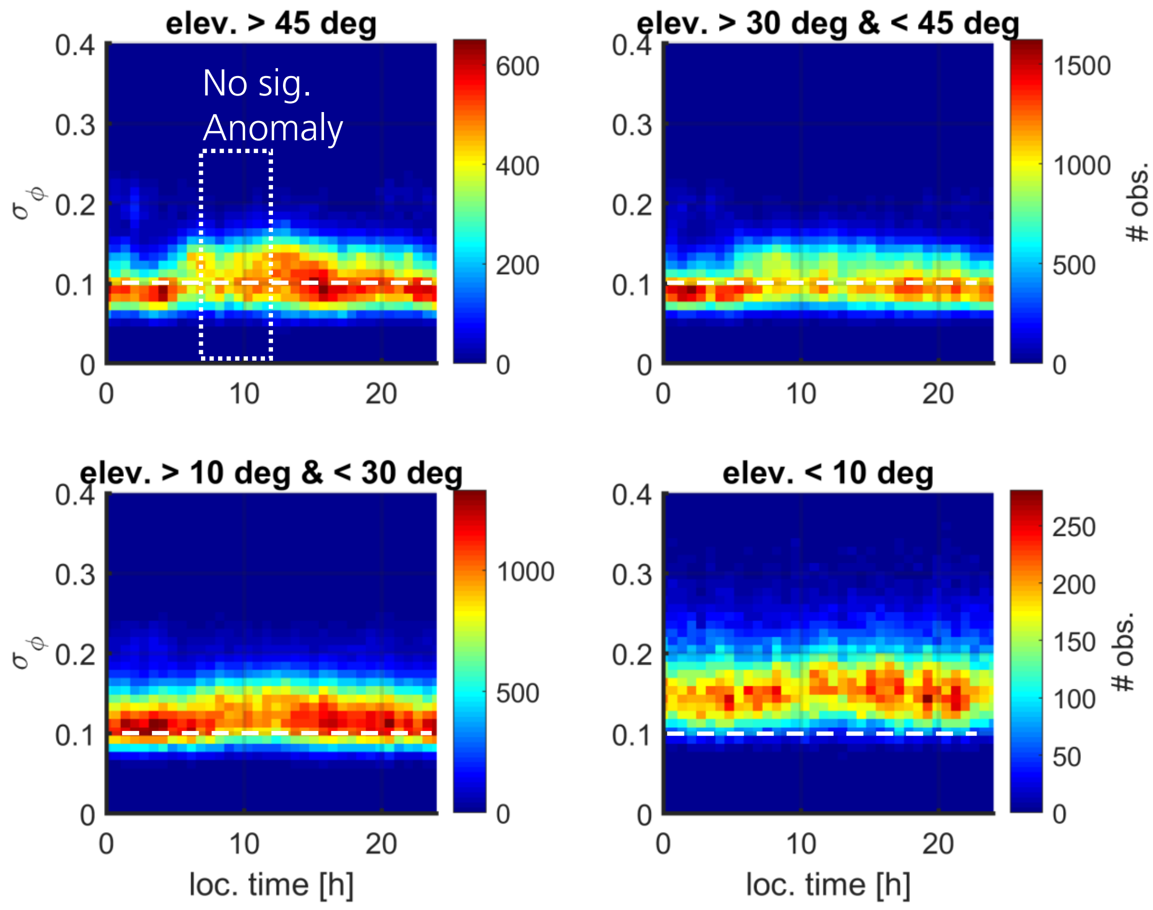
σ_φ over lat. at IPP (height 350 km)



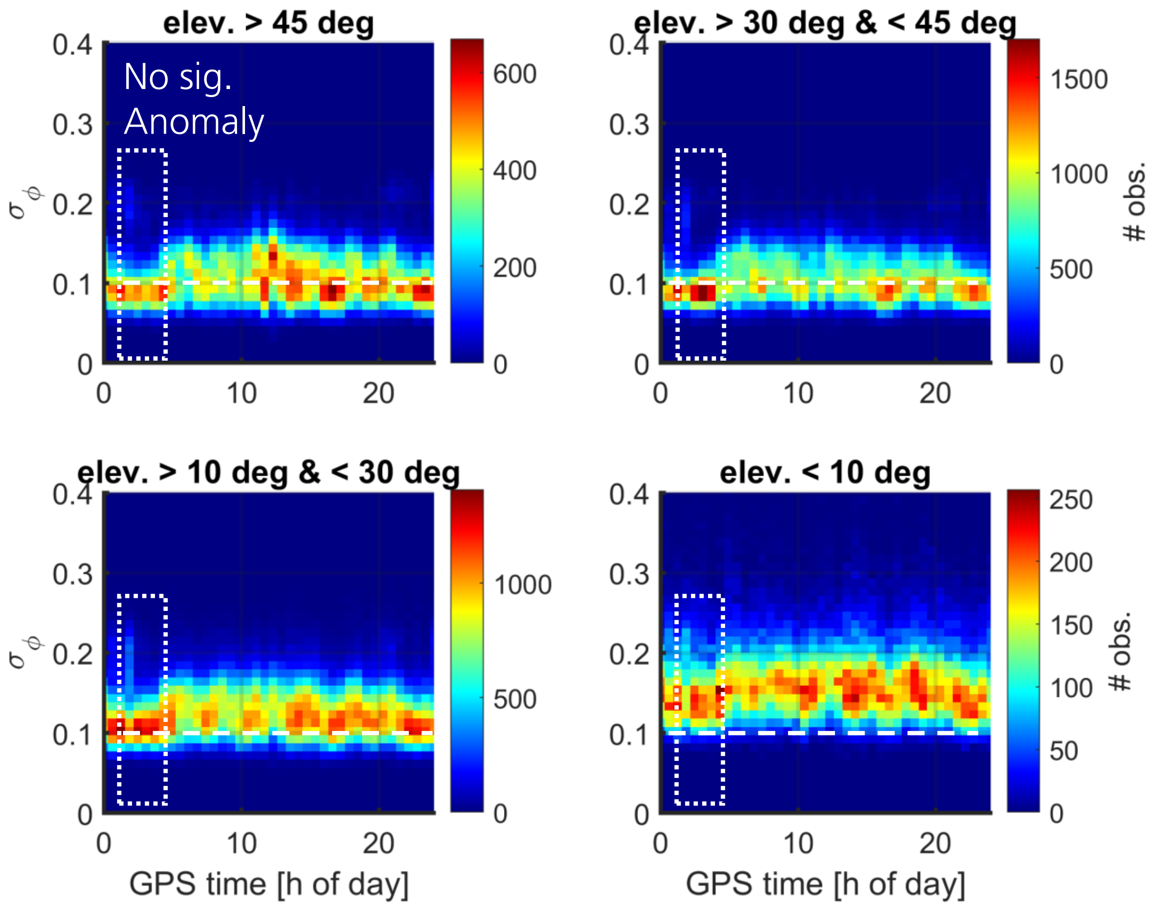
May 2020 … Jul 2020

Spring & Summer in Fram Strait

σ_φ over local time at IPP (height 350 km)



σ_φ over GPS time at PS (~ UTC)

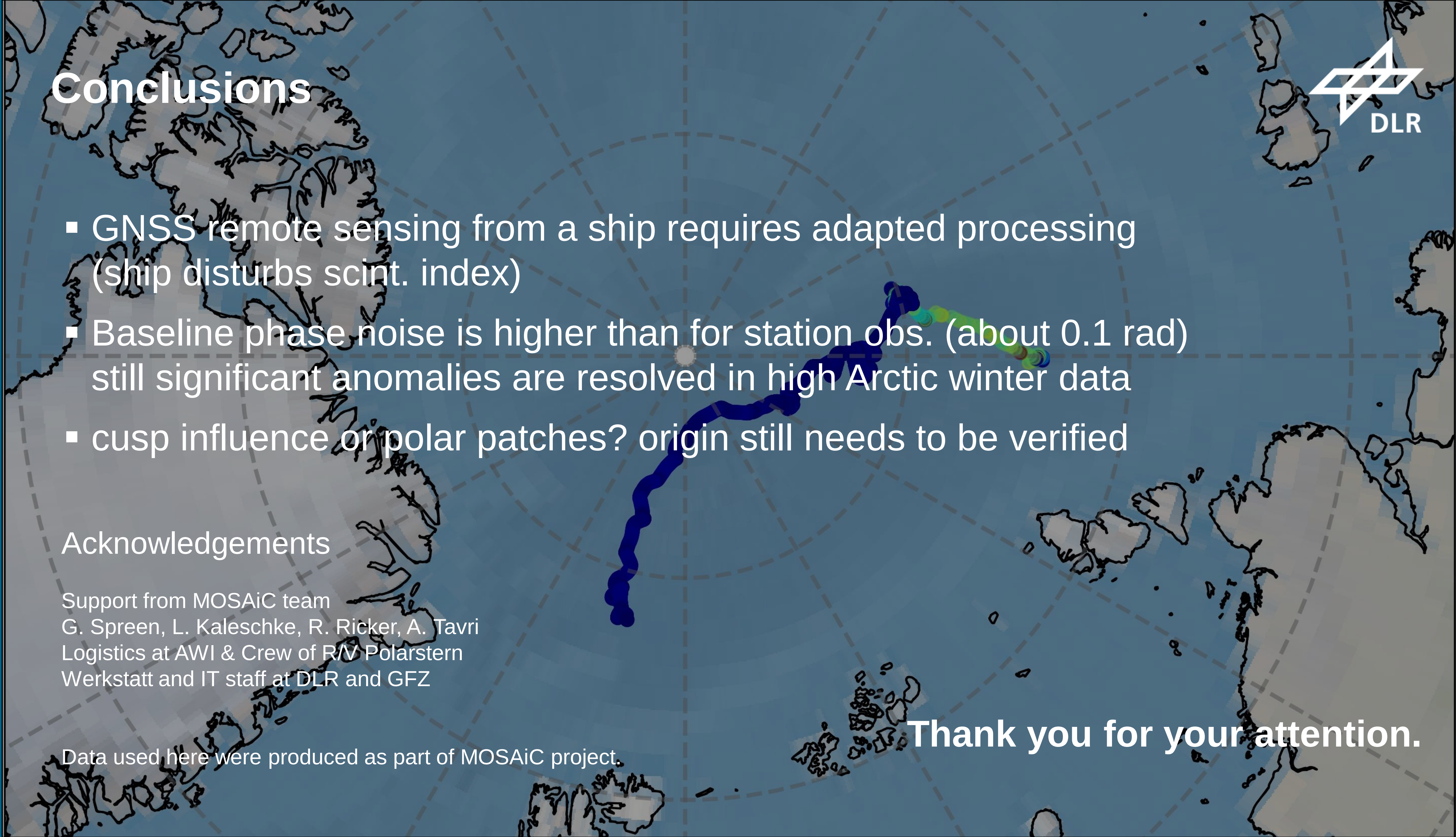


May 2020 … Jul 2020

* cusp influence ?

May 2020 … Jul 2020

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 or polar patches? origin still needs to be verified

Acknowledgements

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G. Spreen, L. Kaleschke, R. Ricker, A. Tavri
Logistics at AWI & Crew of R/V Polarstern
Werkstatt and IT staff at DLR and GFZ

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Thank you for your attention.

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  URSI Radio Science Letters

Appendix

Findings & Next steps

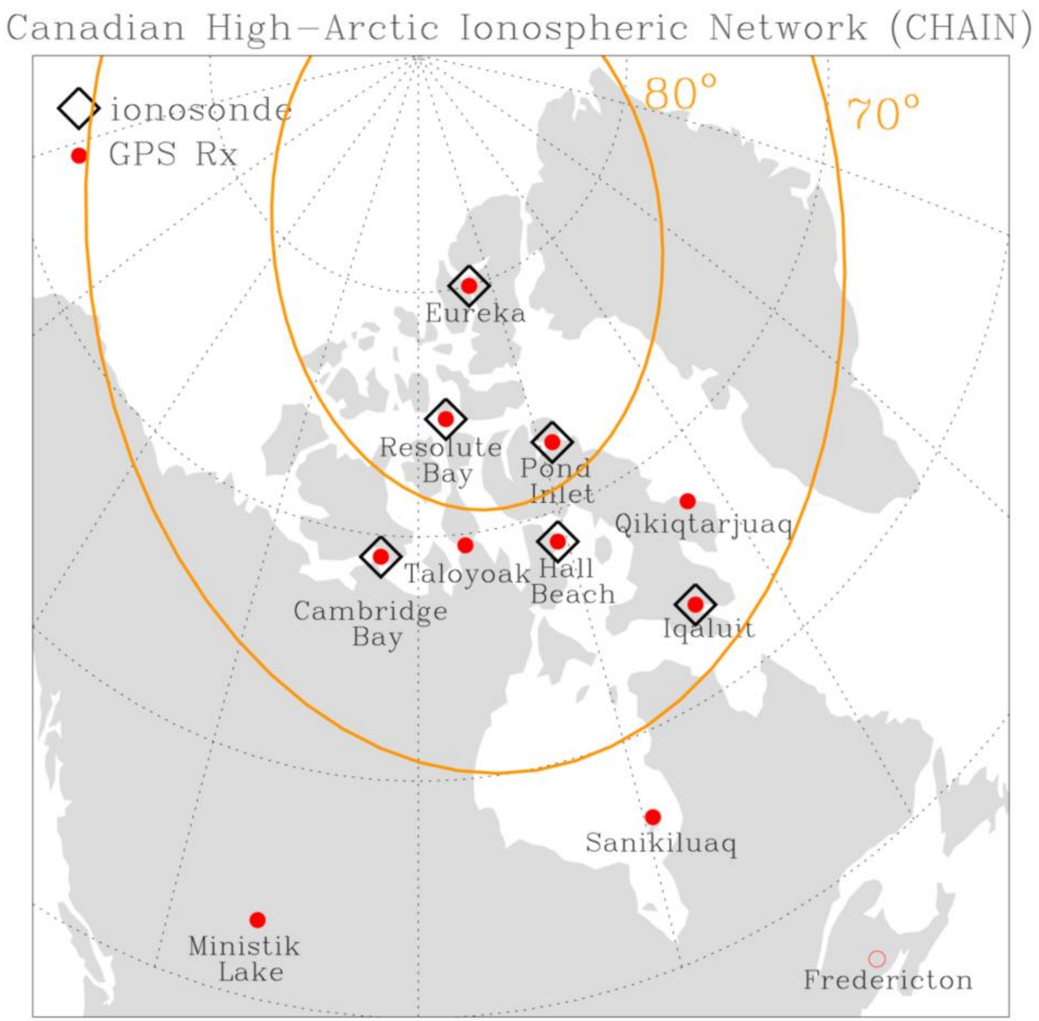
- We found: most significant anomaly in σ_φ at about 2h to 3h UTC in high arctic winter for almost all elevation angles

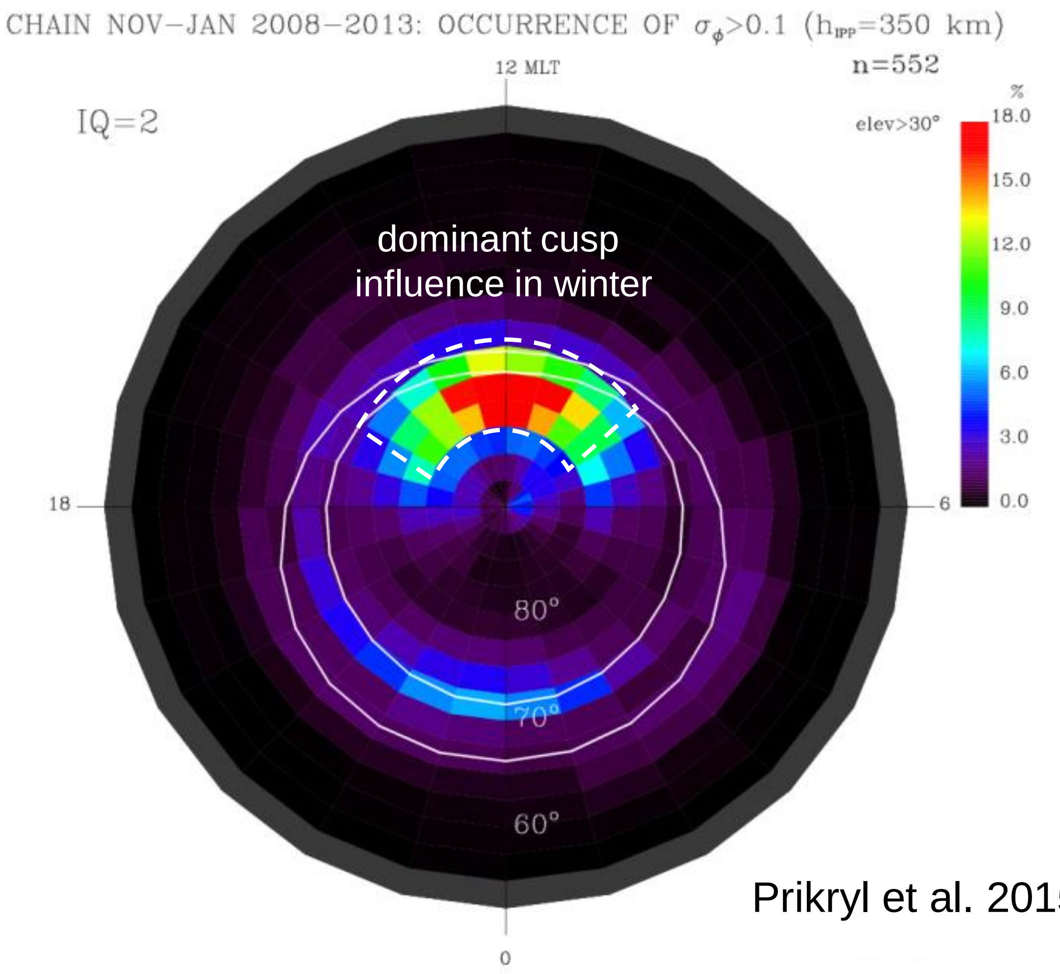
  -> expect relation to cusp influence

- 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





Prikryl et al. 2015