Challenges and chances in observing aerosol-cloud interaction in the Arctic with a ship-borne remote sensing supersite.

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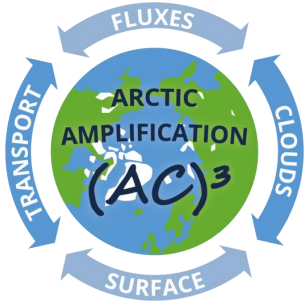
1 Leibniz Institute for Tropospheric Research, Leipzig, Germany



International Symposium on Tropospheric Profiling (ISTP)
21 May 2019, Toulouse
Validation, instrument synergies, and field experiments

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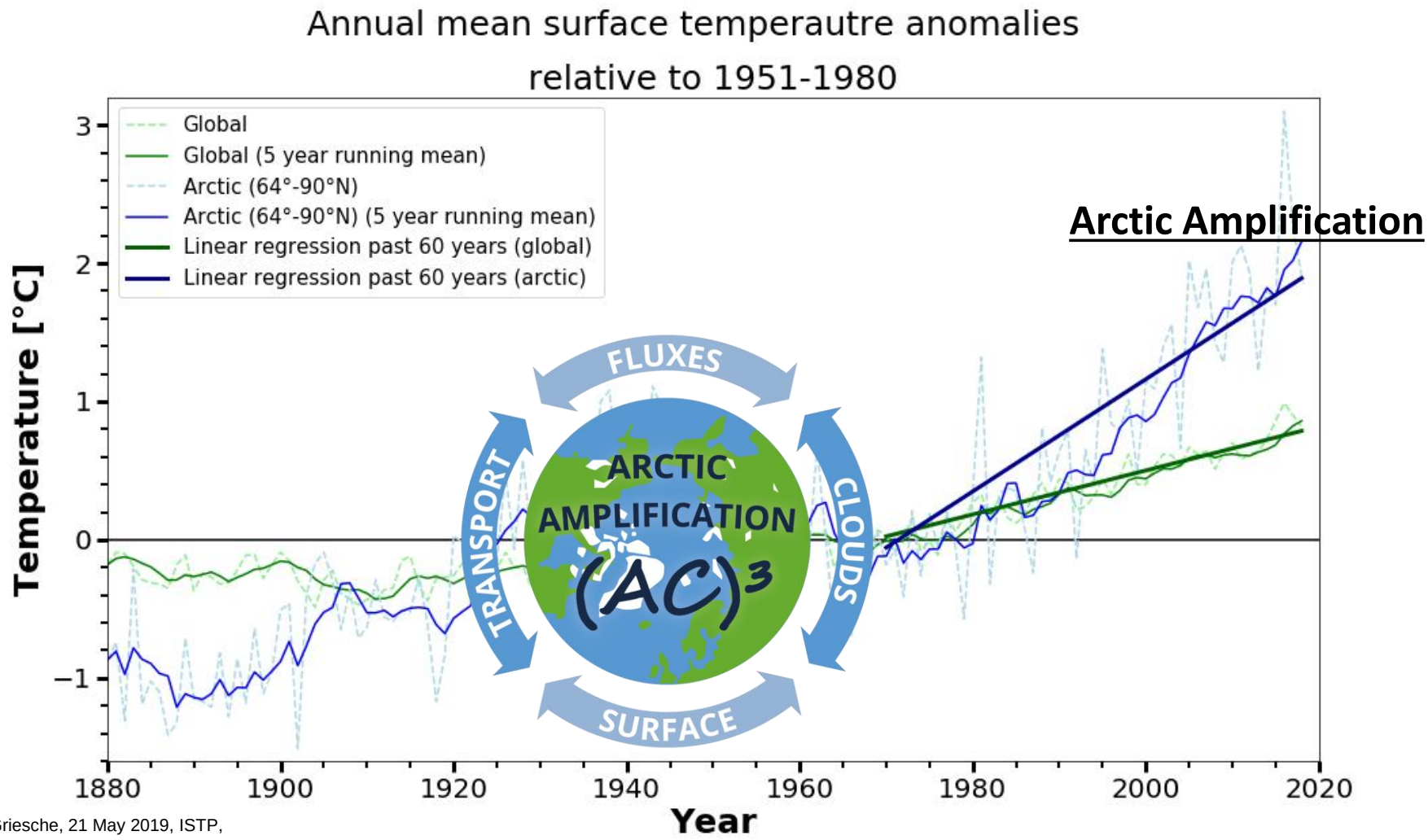
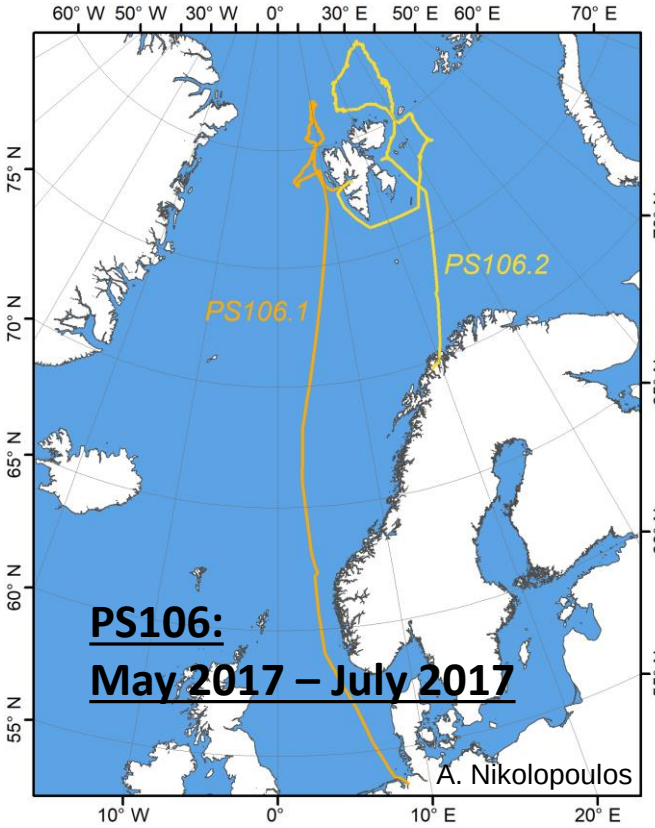
Leibniz Institute for Tropospheric Research

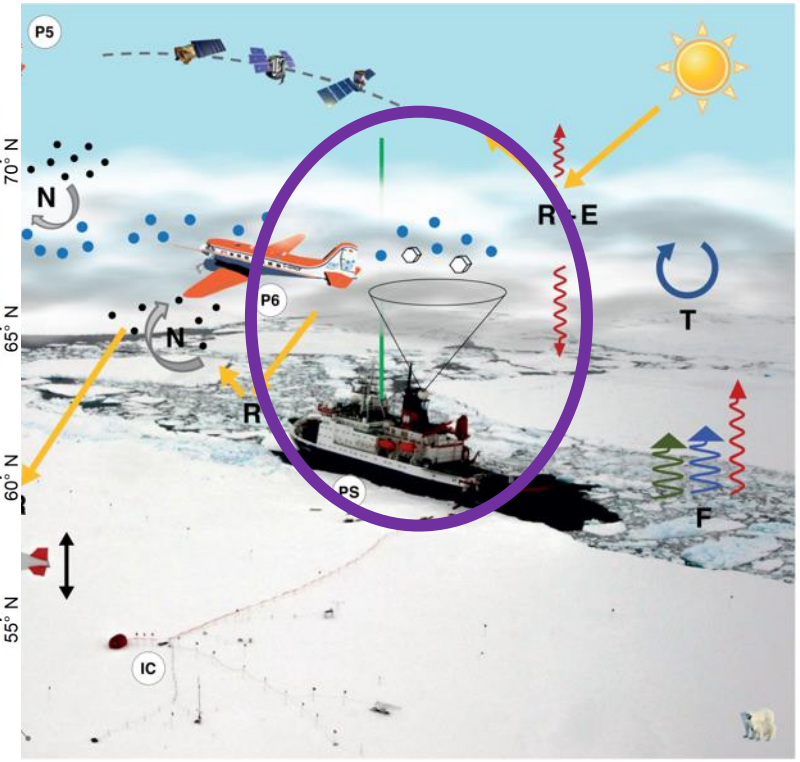


Arctic Amplification

THE ARCTIC CLOUD PUZZLE

Using ACLOUD/PASCAL Multiplatform Observations to Unravel the Role of Clouds and Aerosol Particles in Arctic Amplification





Wendisch, 2018, BAMS

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Instrumentation during Polarstern cruise PS106

Tethered balloon
- Turbulence
- Radiation

➢ **Talk Ulrike Egerer Friday 09:00**

Microwave radiometer (MWR) Hatpro
- Liquid water path

Pyranometer
- Radiation

Optical Disdrometer
- Rain rate

Doppler cloud radar Mira-35
- Radar reflectivity
- Doppler velocity
- Linear depolarization

Raman Lidar Polly-XT
- Backscatter coefficient
- Depolarization ratio
- Extinction coefficient

Radio sounding
- T, RH, p, u, w

Aerosol container
- Particle number concentration + size
- Filter samples

Picture: N. Fuchs

Challenges with a ship-borne remote sensing supersite: Ship motion

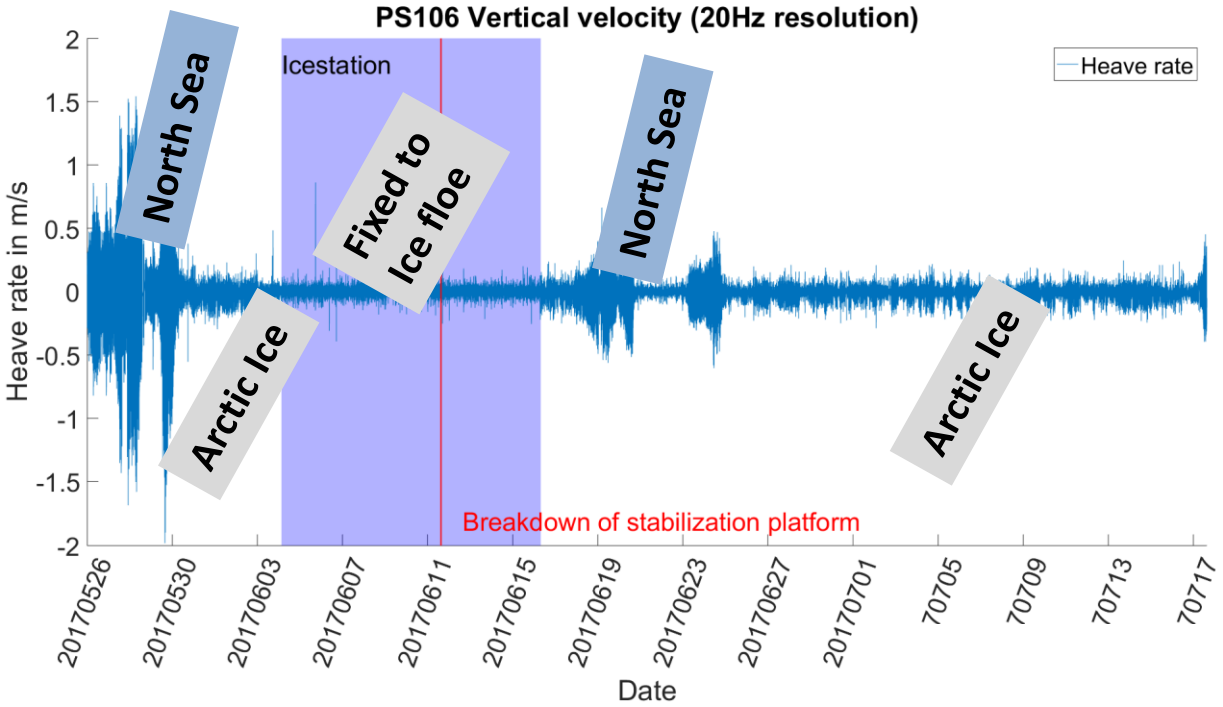
Cloud radar Mira-35

Motion stabilized ± Heave corrected

MWR Hatpro

Disdrometer

Lidar Polly-XT



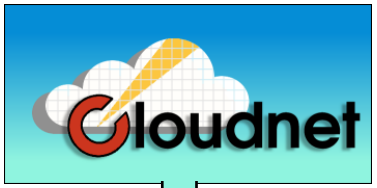
Chances in observing aerosol-cloud interaction in the Arctic with remote sensing supersite

Cloud radar Mira-35
Stabilized
+
Corrected

MWR Hatpro

Disdrometer

Lidar Polly-XT



Aerosol properties
- Distribution
- Typing

Profiles of cloud properties
- Boundaries
- Phase partitioning
- Particle mass + size
- Turbulence

Model evaluation

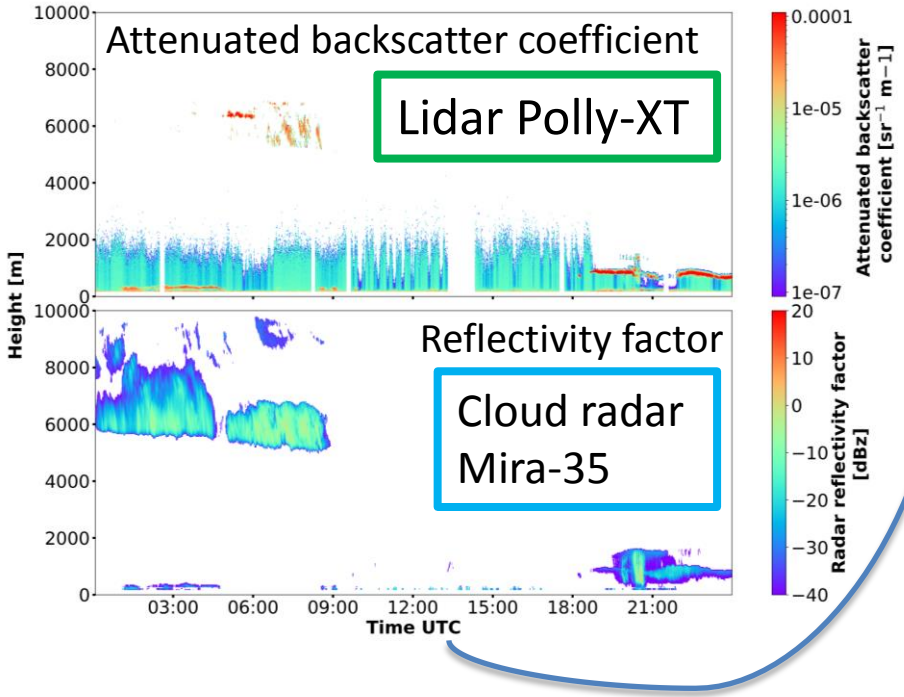
Radiative transfer calculations

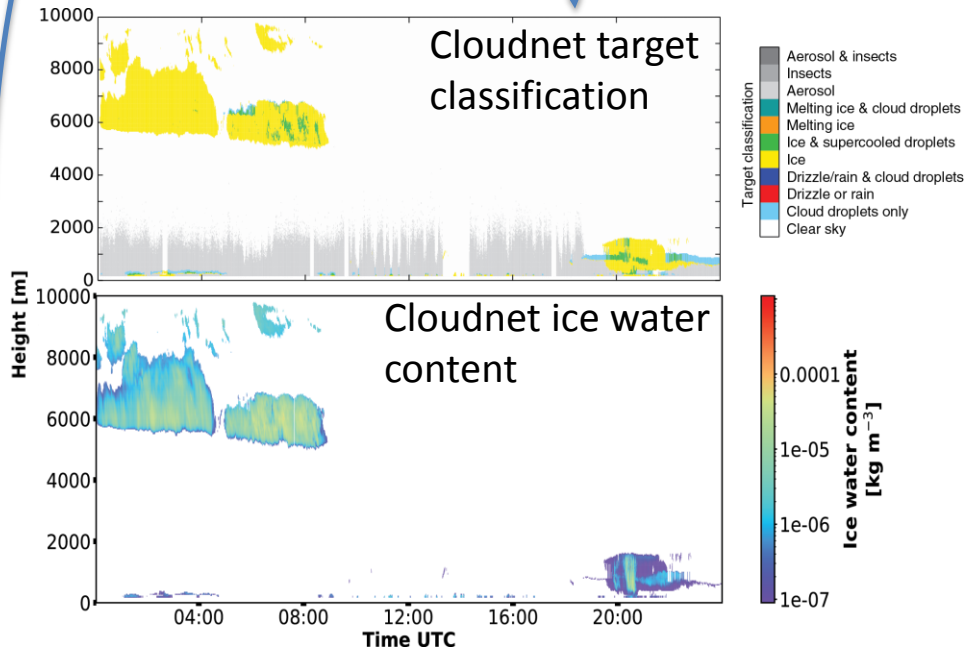
Aerosol-cloud interaction

Closure studies

Remote sensing at the ice flow

…on 8 June 2017





Model evaluation

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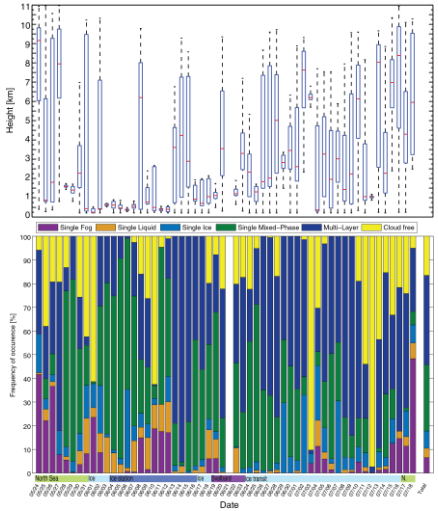
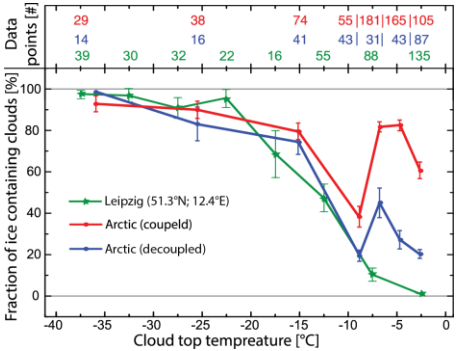
Cloud statistics



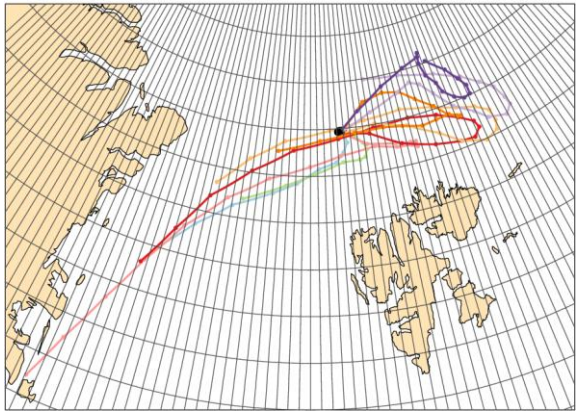
Chances in observing aerosol-cloud interaction in the Arctic with a remote sensing supersite

Cloudnet

Cloud studies



LES-evaluations



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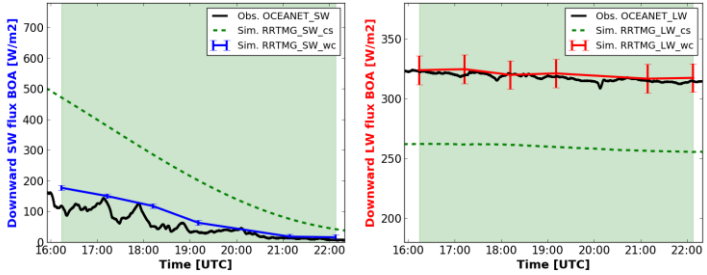
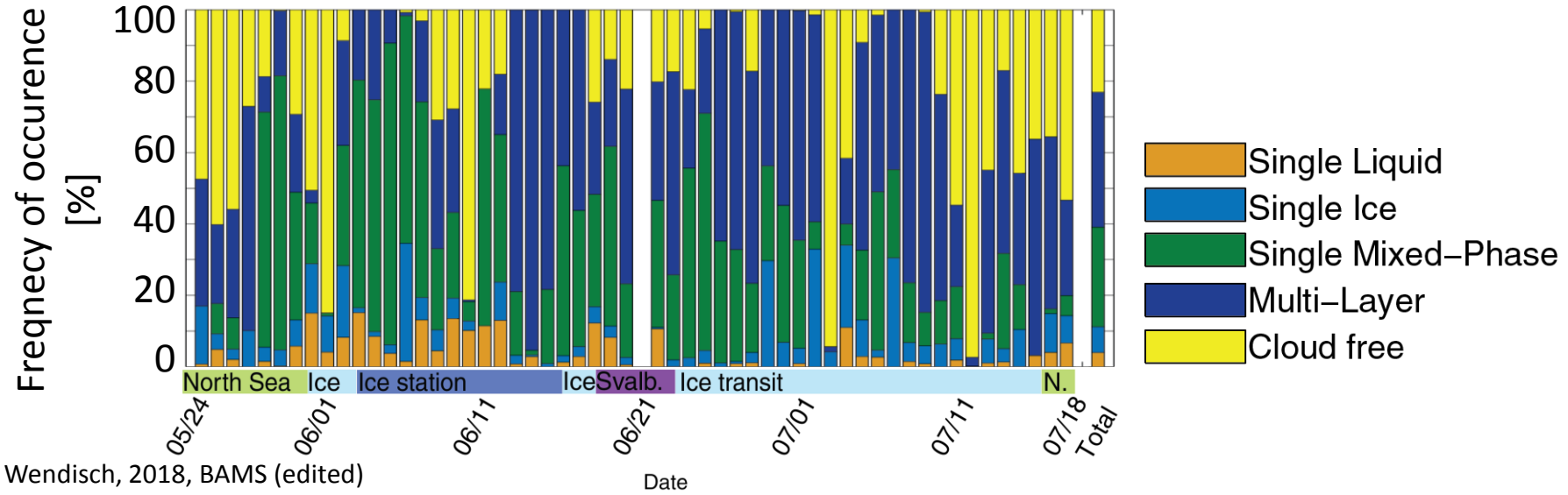
Radiative transfer calculations



Chances with a remote sensing supersite in the Arctic:

Cloud statistics during PS106



Wendisch, 2018, BAMS (edited)

Radiative transfer calculations

Aerosol-cloud interaction

Model evaluation

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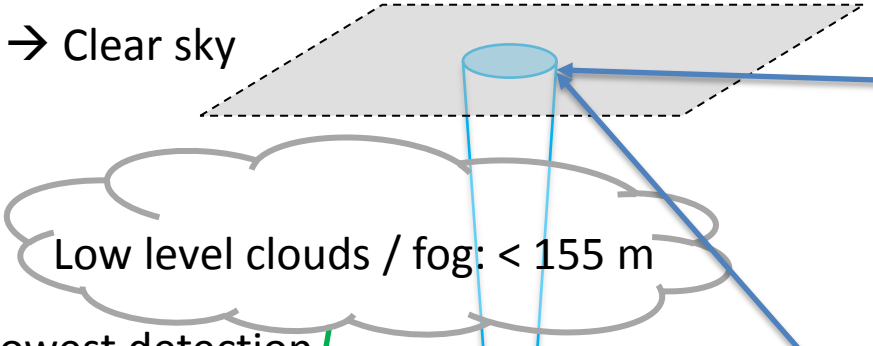
Challenges with a remote sensing supersite in the Arctic:

Low level clouds

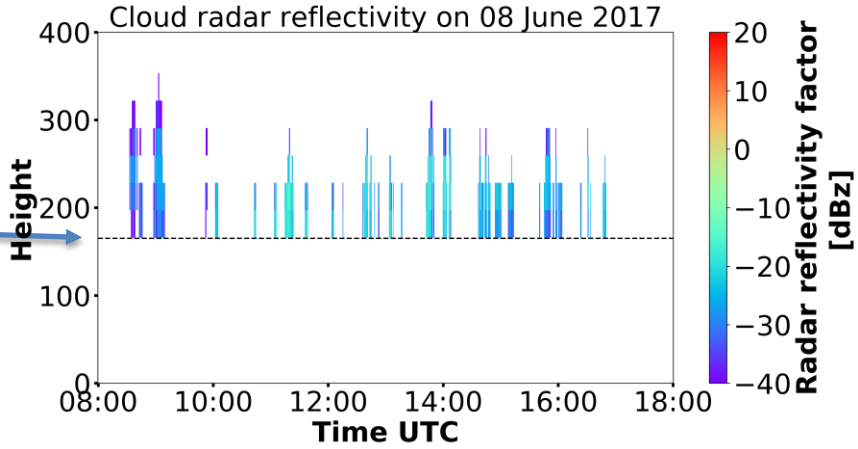
Cloud radar: lowest detection range 155 m

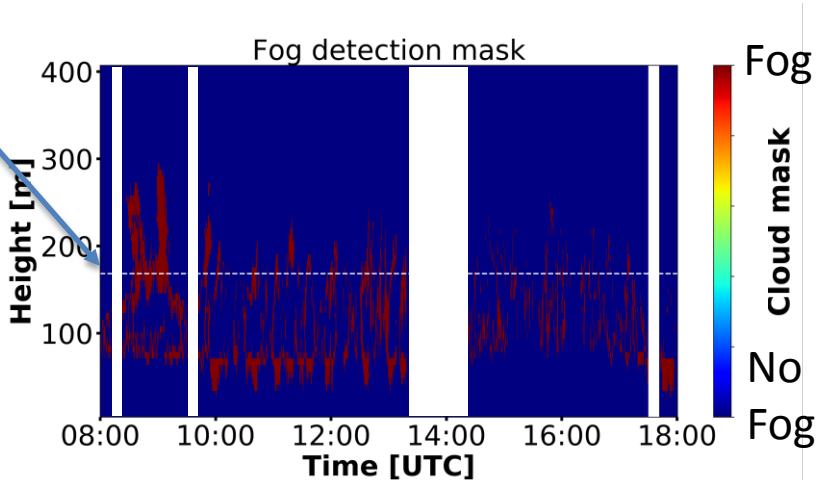
→ Clear sky



Lidar: lowest detection range < 155 m

→ Fog detected



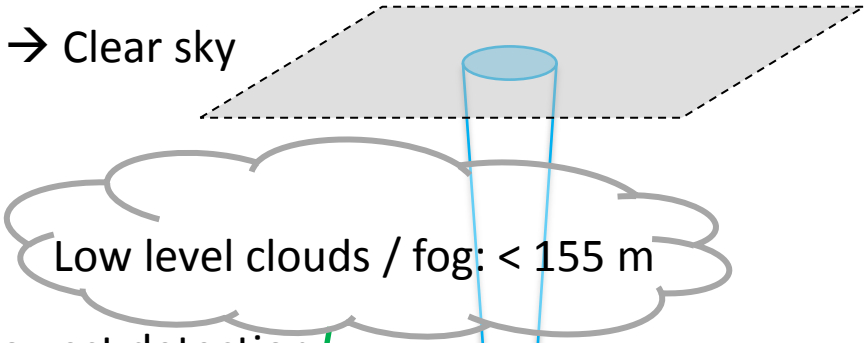


Challenges with a remote sensing supersite in the Arctic:

Low level clouds

Cloud radar: lowest detection range 155 m

→ Clear sky



Lidar: lowest detection range < 155 m

→ Fog detected

Cloud base frequently below 100m

- **Consider lowest detection limit of remote sensing instruments for cloud statistics**

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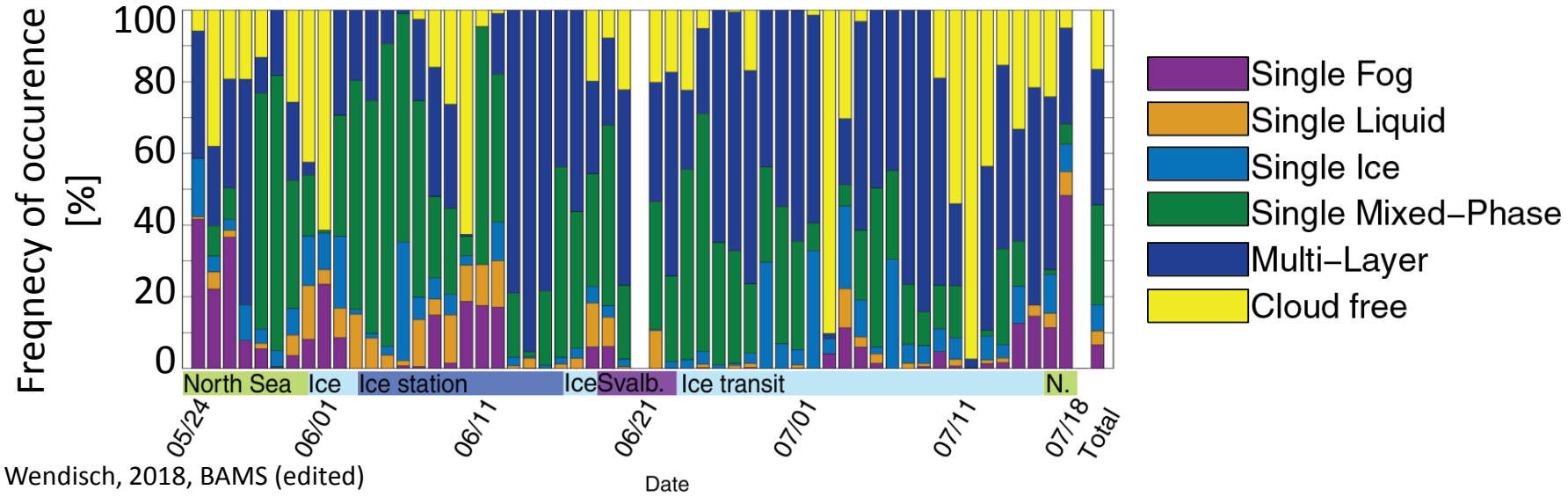
Chances with a remote sensing supersite in the Arctic:

Cloud statistics during PS106



Wendisch, 2018, BAMS (edited)

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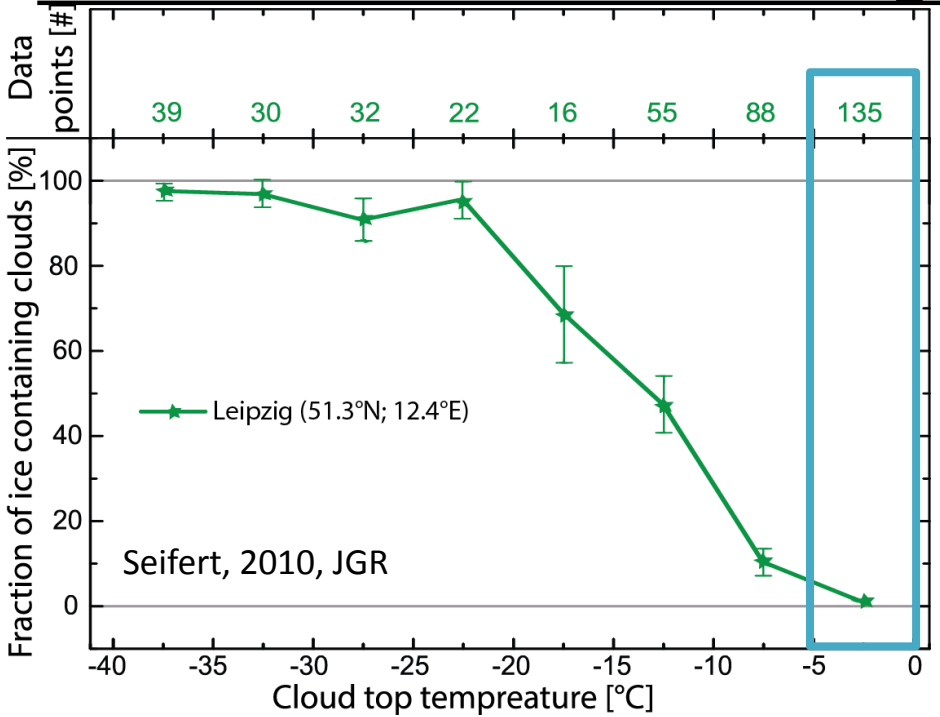
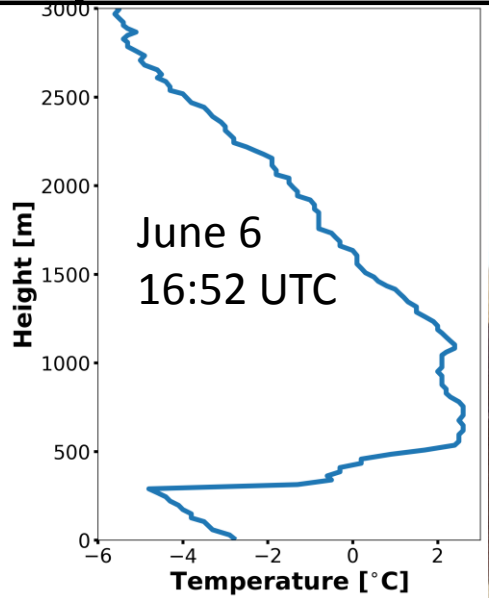
Chances with a remote sensing supersite in the Arctic:





Cloud studies

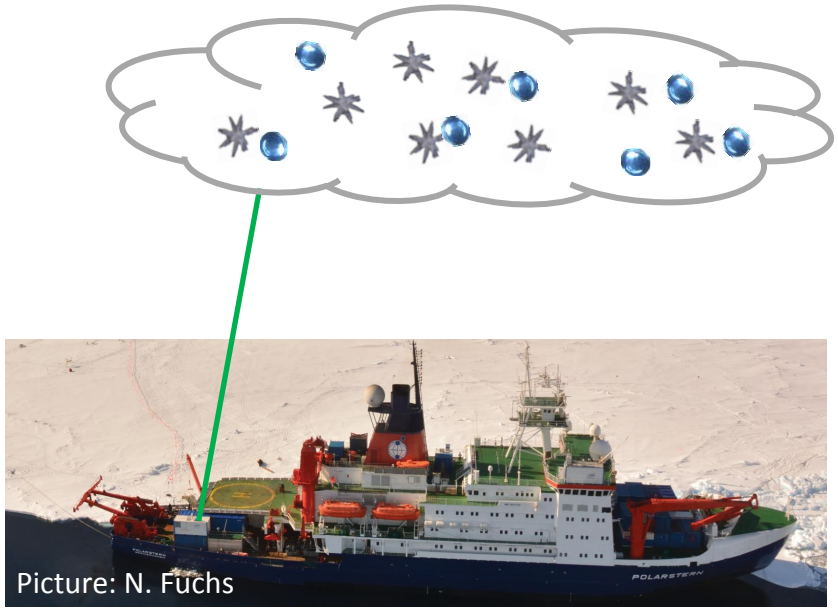
Ice frequently produced at supercooled temperature above -5°C

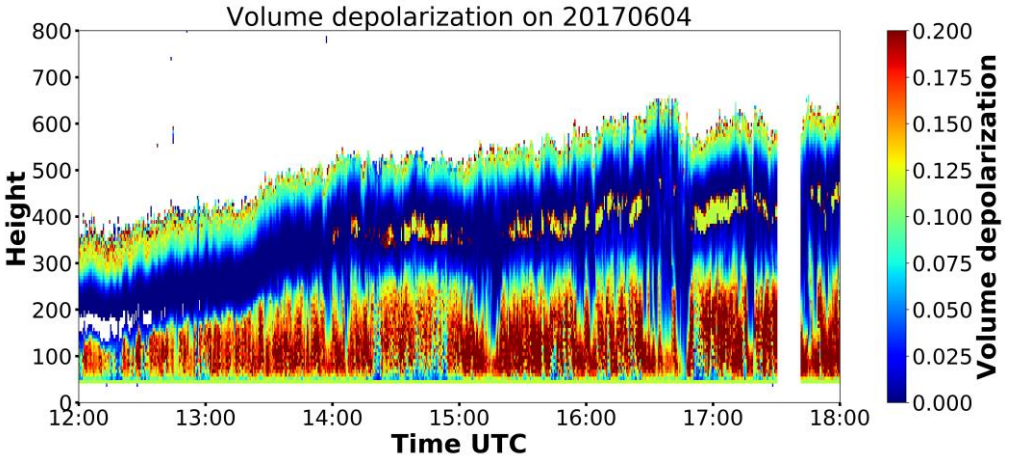
Chances with a remote sensing supersite in the Arctic:

Detection of ice clouds

Clouds with ice:

High lidar depolarization





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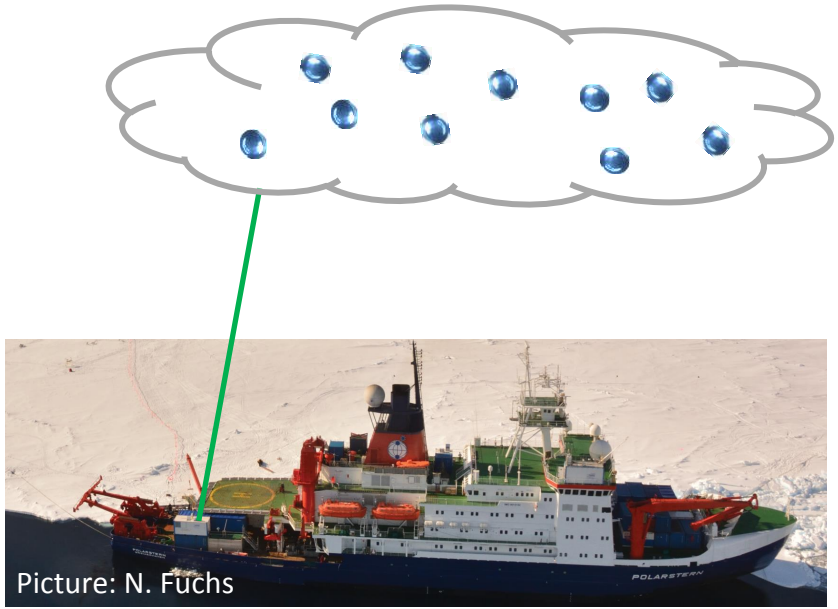
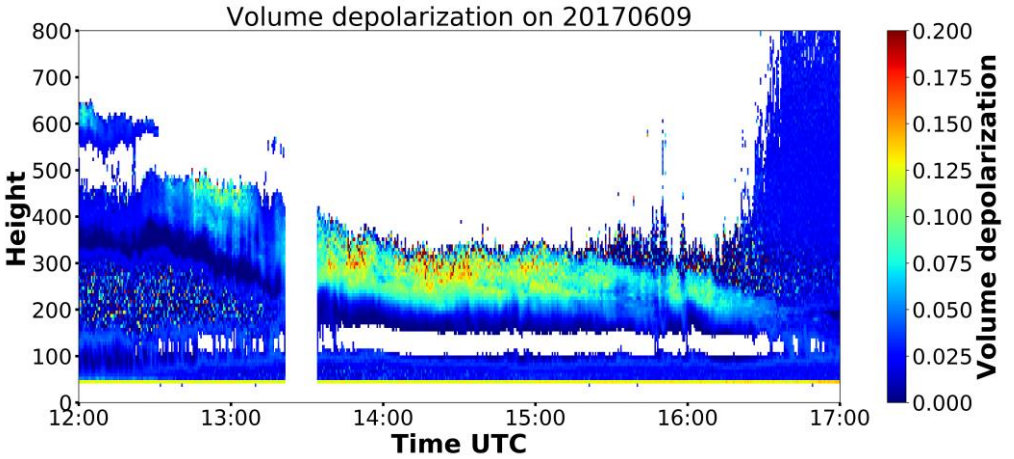
Chances with a remote sensing supersite in the Arctic:

Detection of ice clouds

Clouds without ice:

Low lidar depolarization





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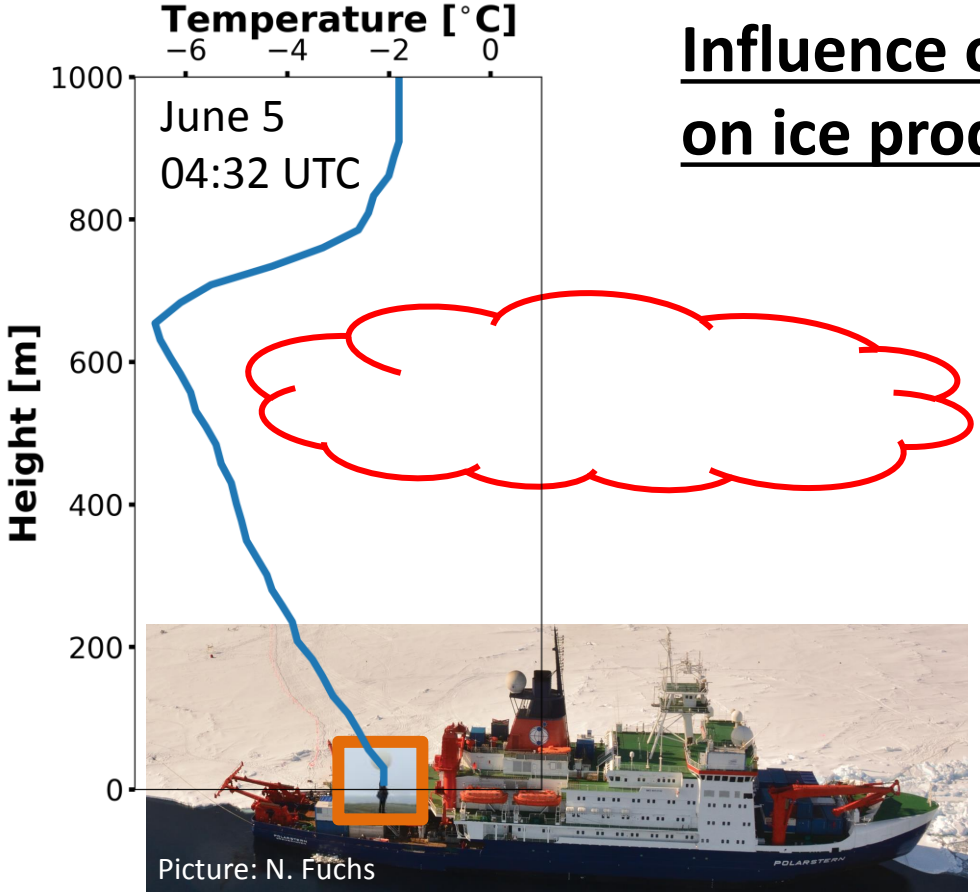
Chances with a remote sensing supersite in the Arctic:

Influence of cloud surface coupling on ice production



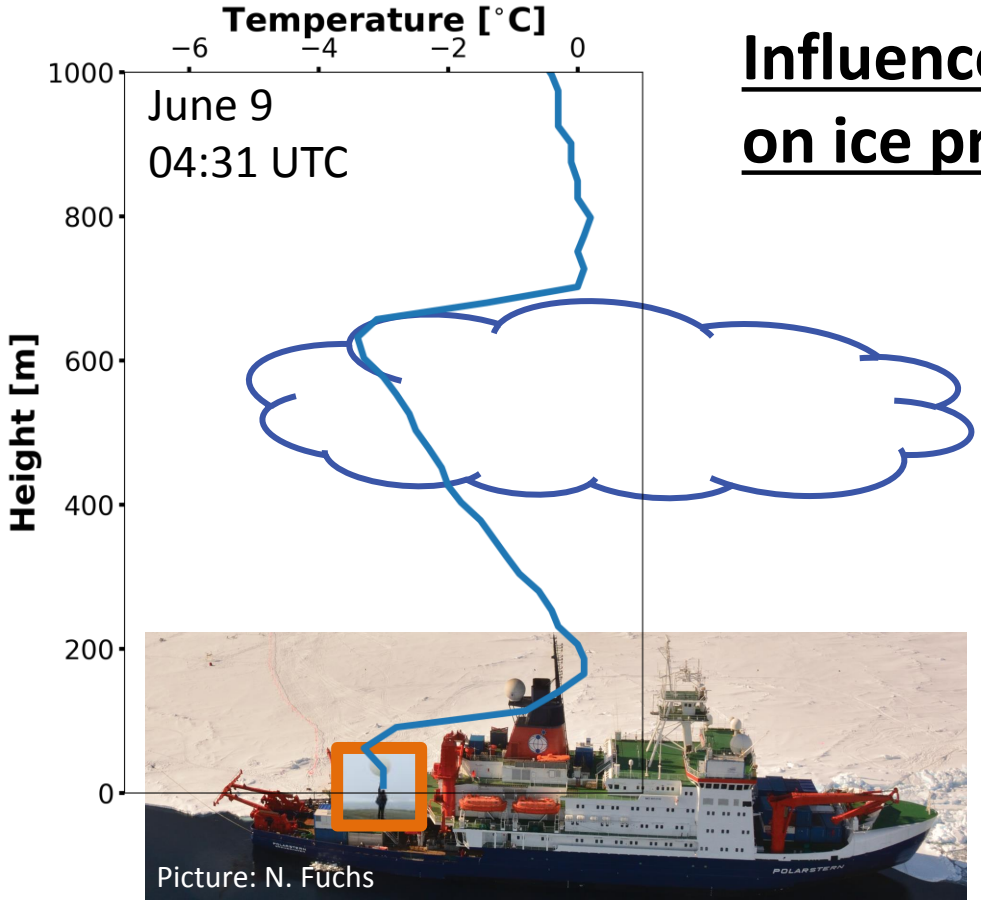
Coupled clouds:

No temperature inversion between cloud and surface

TROPOS

Chances with a remote sensing supersite in the Arctic:

Influence of cloud surface coupling on ice production



Decoupled clouds:

Temperature inversion between cloud and surface

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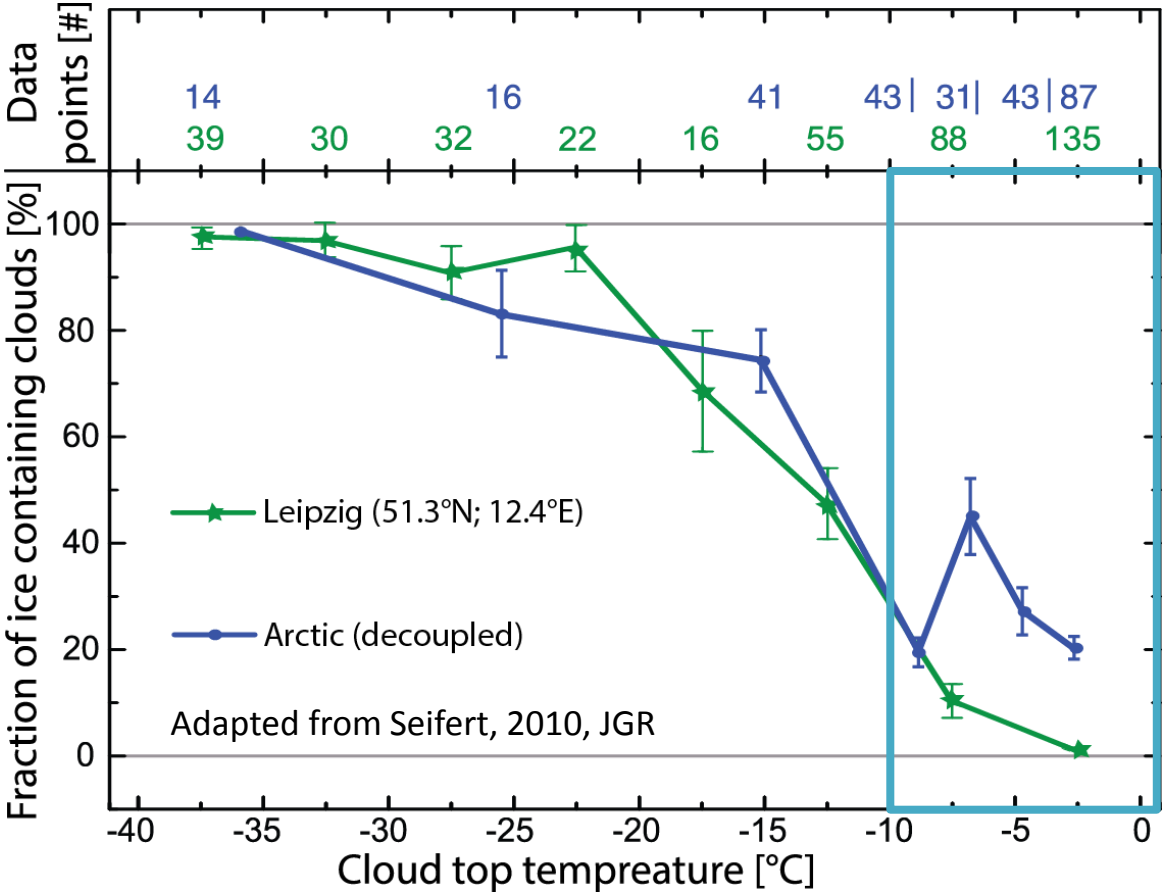
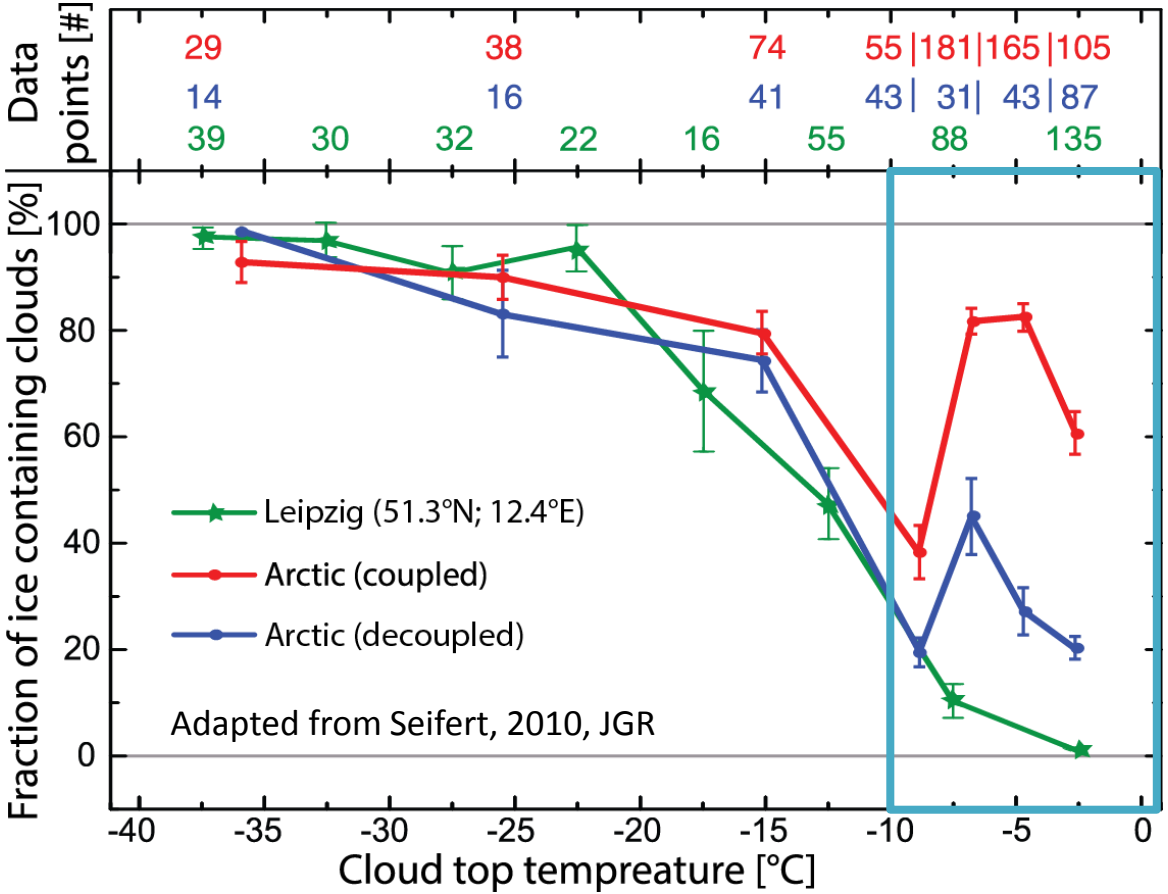
Influence of cloud surface coupling on ice production



- Ice formation in the Arctic similar to Leipzig, Germany at cloud top temperature < -10°C

Influence of cloud surface coupling on ice production



- 72.2% coupled clouds contain ice
- 30.2% decoupled clouds contain ice

- Strong surface coupling effects for Arctic clouds at cloud top temperature > -10°C
  - Blowing snow?
  - Biological production from the Ocean?
  - Recycling of INP?

Aerosol-cloud interaction

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Summary

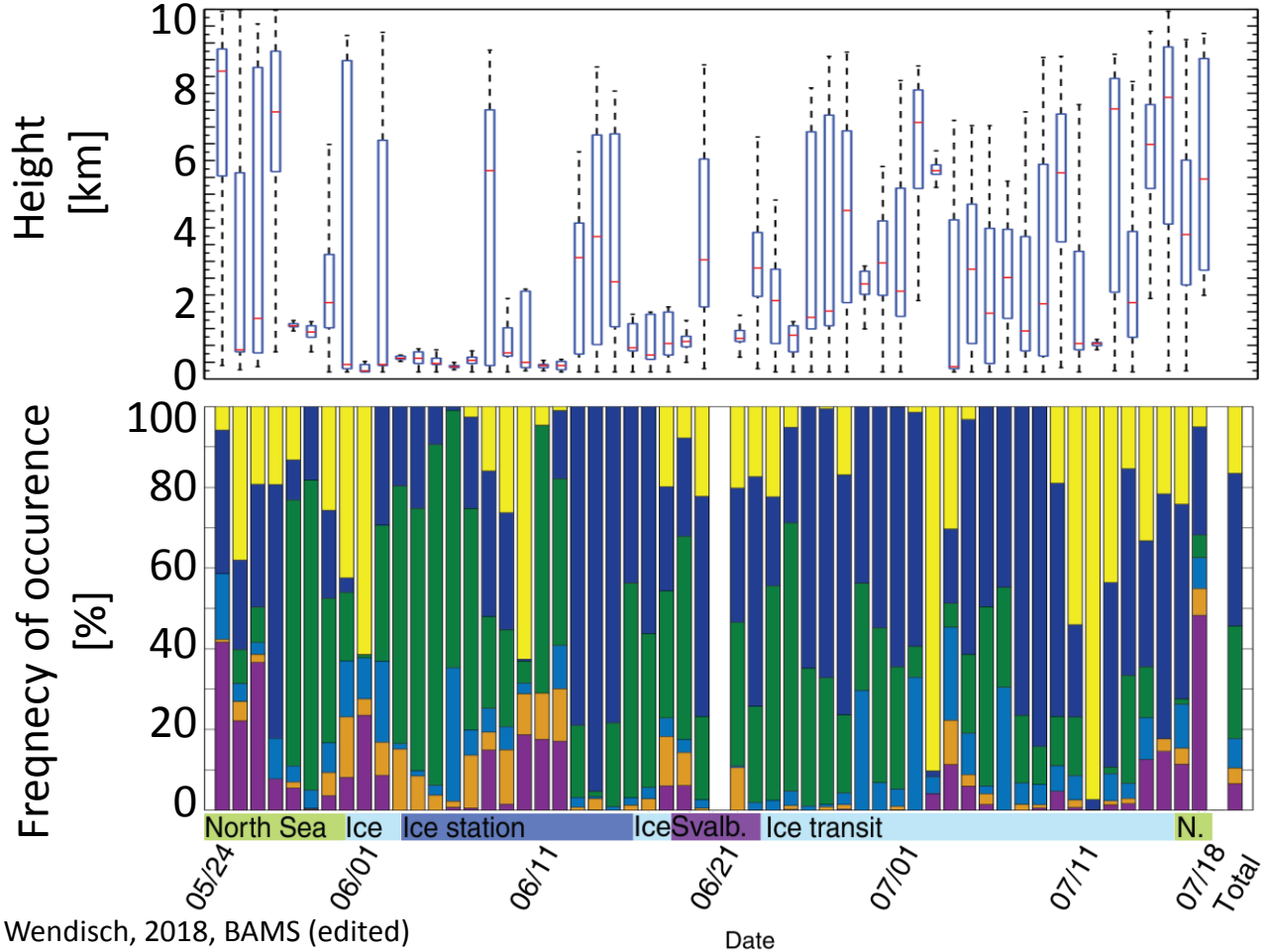
- 8 weeks of continuous remote sensing observations in the Arctic summer
  - Cloudnet products available
  - Data on Pangaea: https://doi.pangaea.de/10.1594/PANGAEA.899458

- Clouds at very low altitude missed by certain remote sensing instruments
  - ➢ Consider lowest detection limit

- Surface effects found on heterogeneous ice formation in clouds at a temperature down to -10°C

Thank you for you attention!

Remote sensing contribution to… cloud statistics during PS106



Model evaluation

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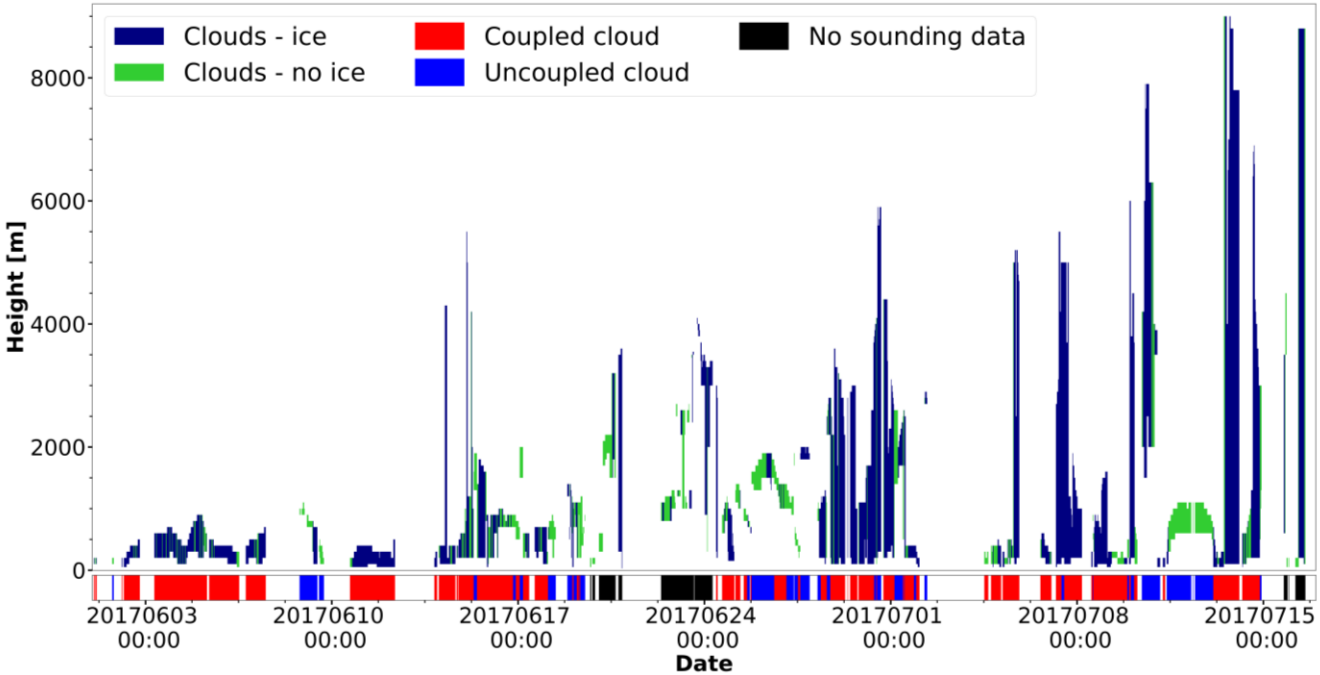
Influence of surface coupling on ice production

Dataset separated

- Coupled clouds
- Uncoupled clouds

Classified

- Clouds with ice
- Clouds without ice



Coupled clouds: no temperature inversion between cloud and surface

Uncoupled clouds: temperature inversion between cloud and surface

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Aerosol-cloud interaction