Investigation of Arctic mixed-phase clouds during ACLOUD with the novel active and passive microwave package MiRAC

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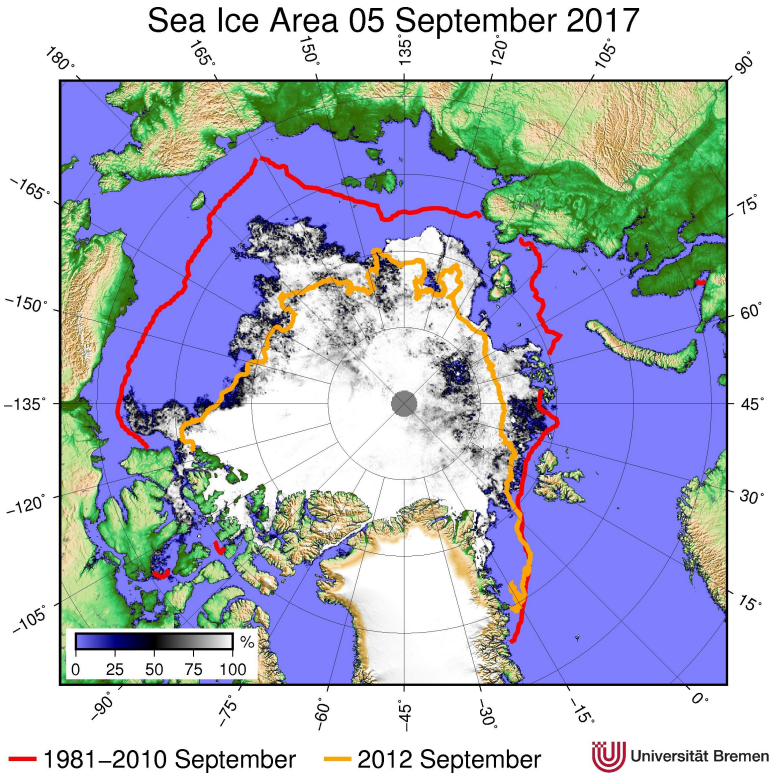
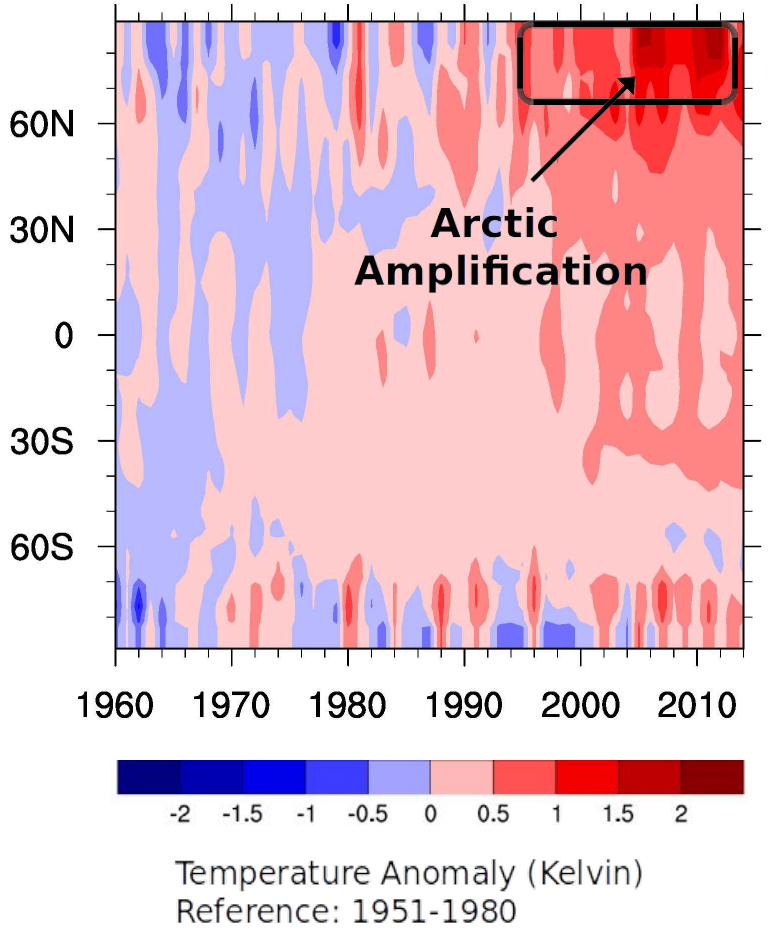




Wendisch et al. (2017)

https://seaice.uni-bremen.de/sea-ice-concentration/arctic-sea-ice-minima/

ArctiC AmplificationC: ClimateC Relevant AtmosphericC and SurfaCe Processes, and Feedback Mechanisms (AC)³

Overarching goals:

- Identify, investigate, and evaluate **key processes**
- Improve the understanding of the major **feedback mechanisms**
- Quantify their **relative importance**

http://ac3-tr.de/

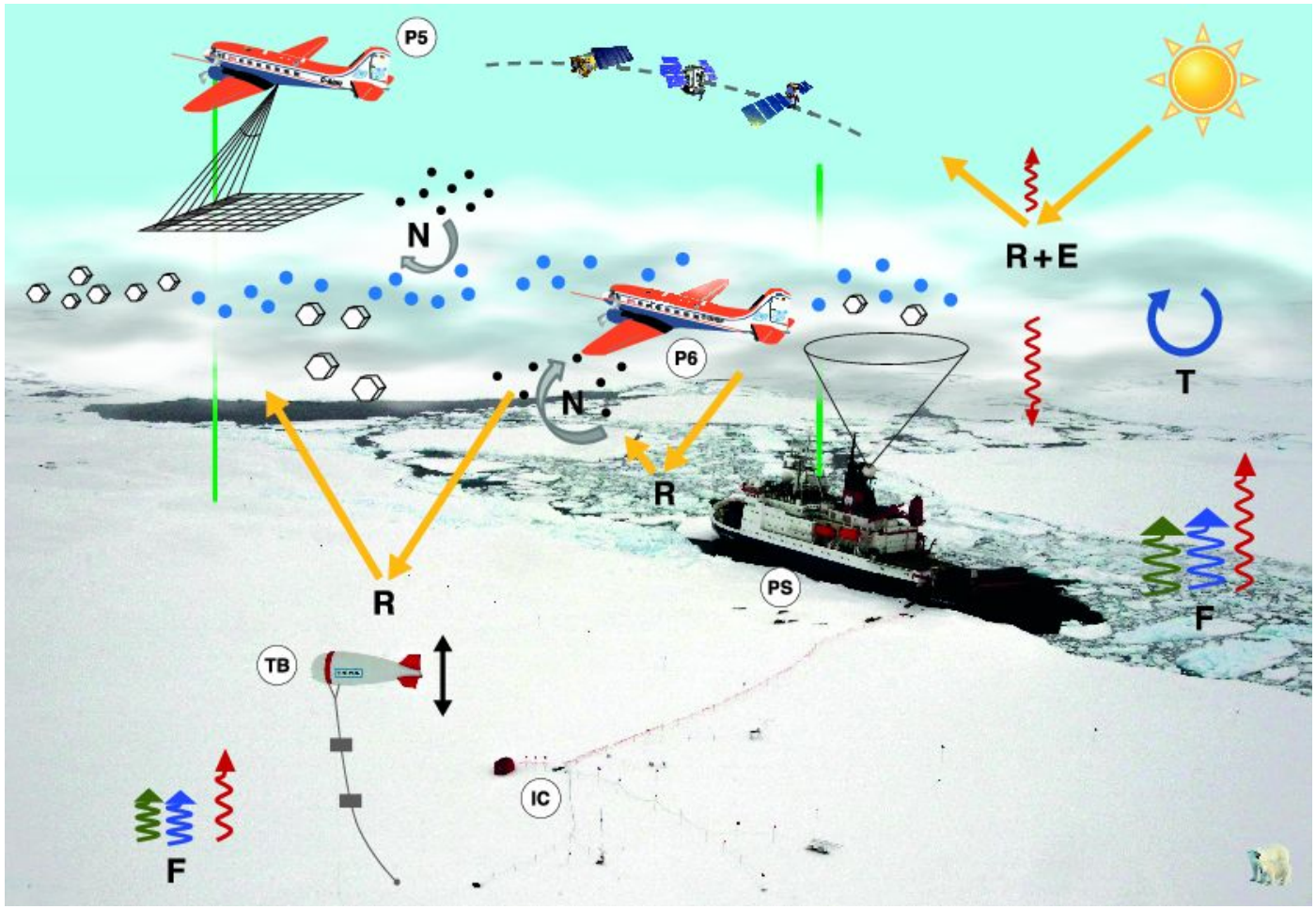
AC3: ACLOUD - PASCAL - ABEX - CONCORD

Arctic **CL**oud **O**bservations **U**sing airborne measurements during polar **D**ay (**ACLOUD**)

Physical feedback of **A**rctic PBL, **S**ea ice, **C**loud **A**nd Aerosol (**PASCAL**)

Arctic **B**alloonborne profiling **EX**periment (**ABEX**)

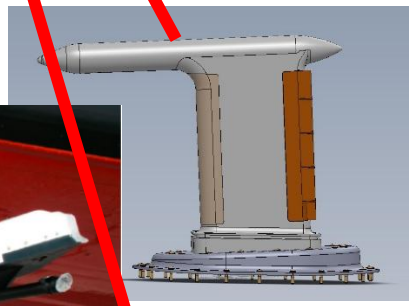
CONtinuous characterization of the Ny-Ålesund **CO**lumn and **R**adiative effects from ground-base**D** remote sensing (**CONCORD**)



Cold period — May 23–29, 2017 (7 days)
Warm period — May 30–June 12, 2017 (14 days)
Normal period — June 13–26, 2017 (14 days)

Polar 6 = In Situ

Polar 5 = Remote Sensing



Cloud and Aerosol particles

Trace gas CO/CO2

Turbulent fluxes

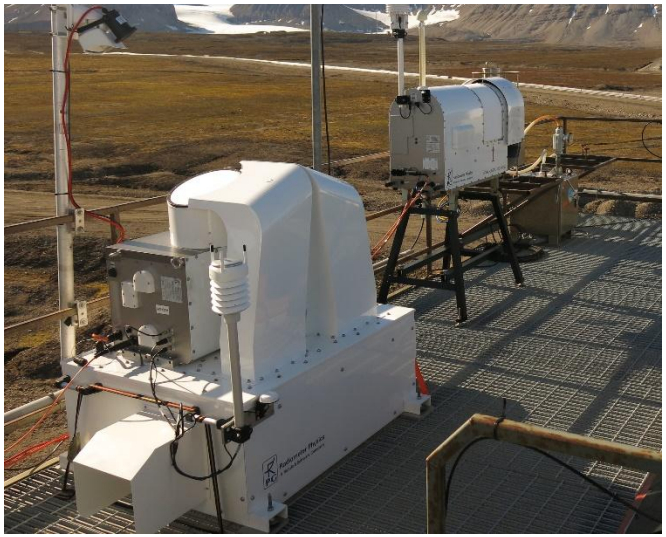
Cloud radiative properties

Vertical and horizontal variability

Turbulent fluxes

MiRAC - A Microwave Radar and radiometer for Arctic Clouds

Radar



RPG-FMCW-94-SP-G1:

- 94 GHz FMCW ± 100 MHz
- Transmitter power 1.5 W typical
- Antenna gain 51.5 dB
- Beam width 0.48° FWHM
- Polarisation V
- Typical Dynamic range (sensitivity) with 1.5 W transmitter @ 3 s sampling time:
  - -60 dBz to +20 dBz (at 500 m/5 m vert. res.)
  - -50 dBz to +20 dBz (at 2 km/10 m)
  - -47 dBz to +20 dBz (at 4 km/30 m)
- Max. vertical resolution 1 m
- Doppler range ± 9 m/s (0-2500 m), ± 4.2 m/s above
- Doppler resolution ± 1.5 cm/s
- Profiles of reflectivity, Doppler spectra, higher Moments
- passive 89 GHz for liquid water path estimation
- Belly pod underneath aircraft
- Ground operation on stand

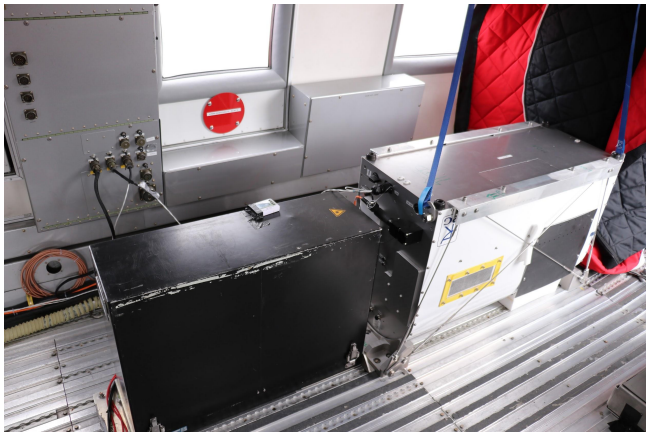
Installation

Belly pod with 25° backward angle

Radiometer Physics
A Rohde & Schwarz Company

MiRAC - P Microwave Radar and radiometer for Arctic Clouds

Radiometer



RPG-LHUMPRO-243-340-G4:

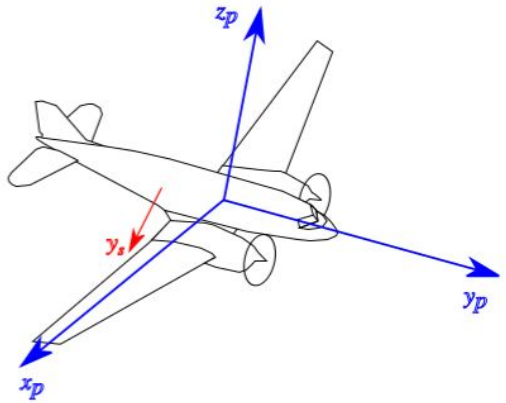
- Passive channels overlapping with Ice Cloud Imager ICI: 6 DSB at 183 GHz H_2O line for humidity profiling, 243 and 340 GHz for opacity estimation and ice cloud observation
- Absolute brightness temperature accuracy 1.0 K
- Channel bandwidth 200 MHz @ 183 GHz, 4 GHz @ 243 and 340 GHz
- Optical resolution HPBW 1.3°
- Integration time ≥ 0.4 seconds
- Absolute calibration with internal ambient & external cold load
- Stability better than 0.03 K over full operating temperature range
- Ground operation on stand

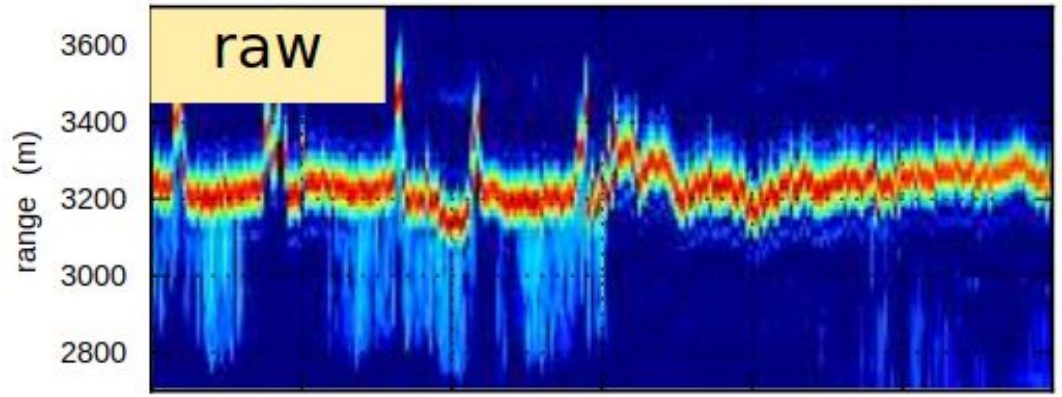
Installation

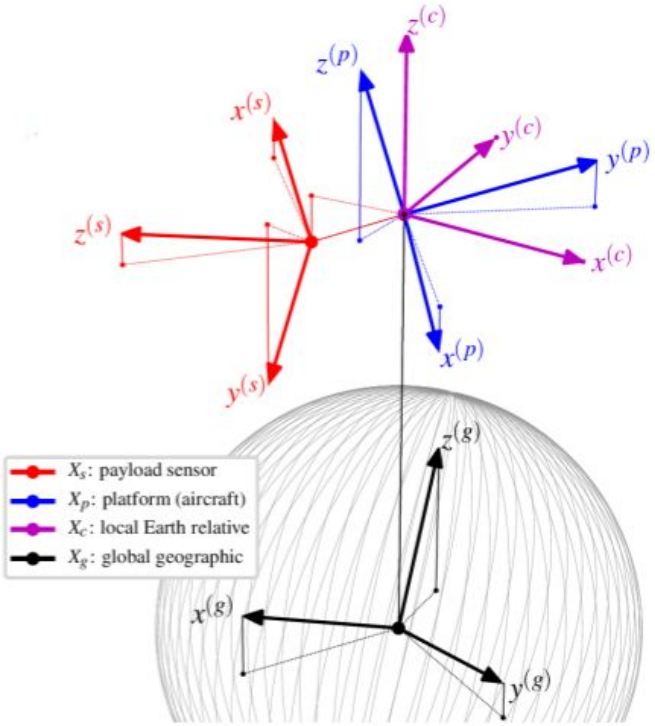
Inside cabin, nadir pointing

Radiometer Physics
A Rohde & Schwarz Company

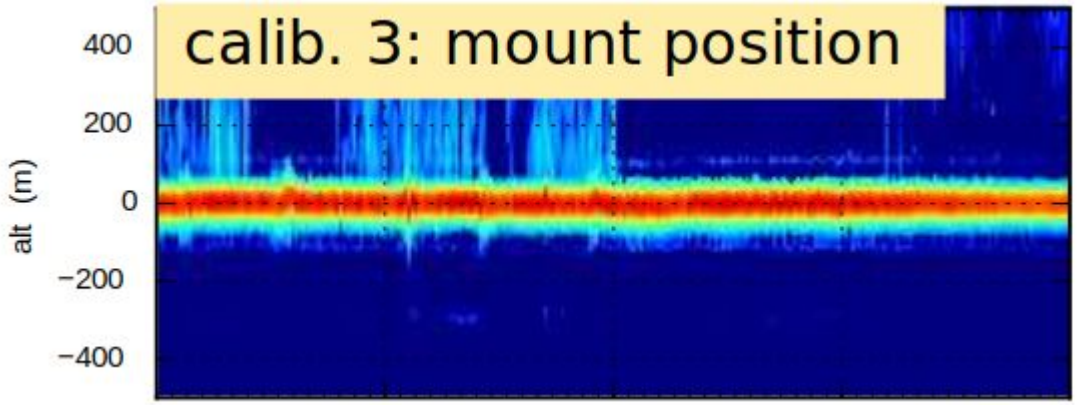
Radarsignal correction



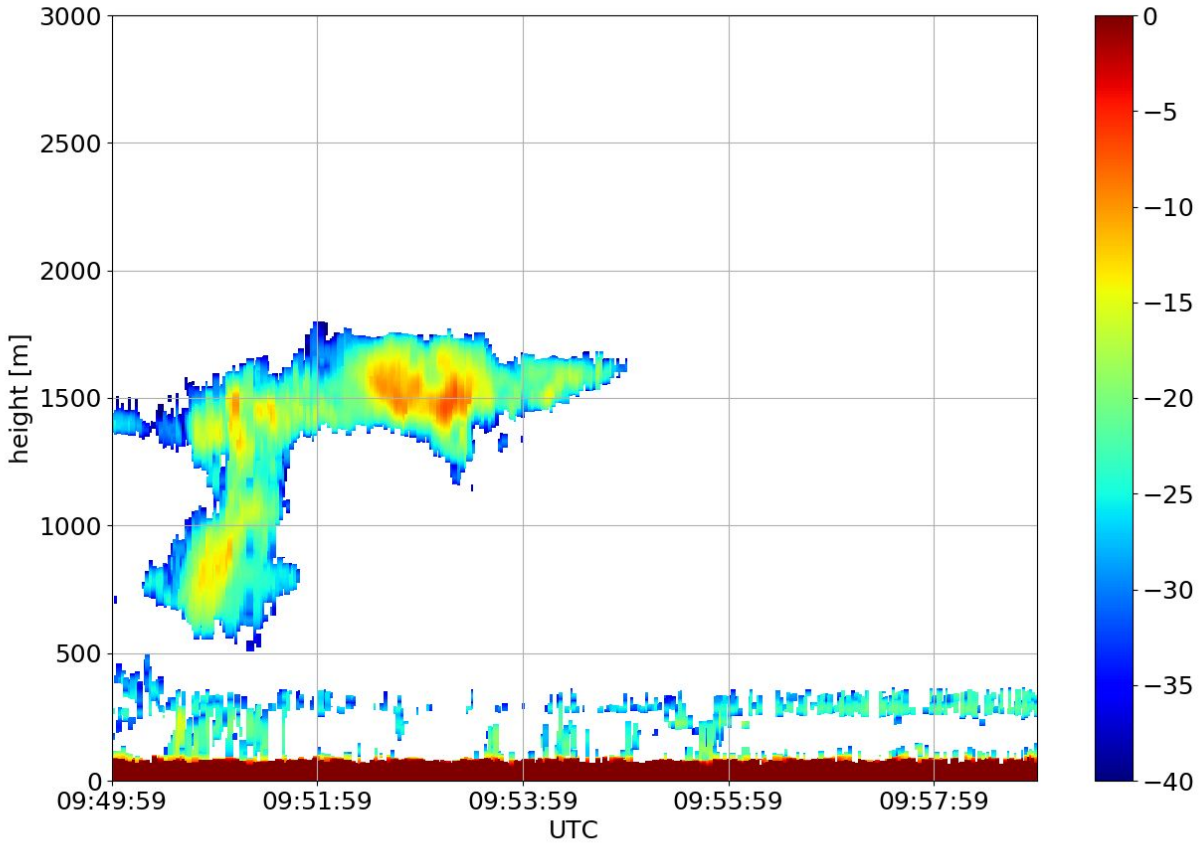




Aircraft orientation
Instrument mount
Time shifts

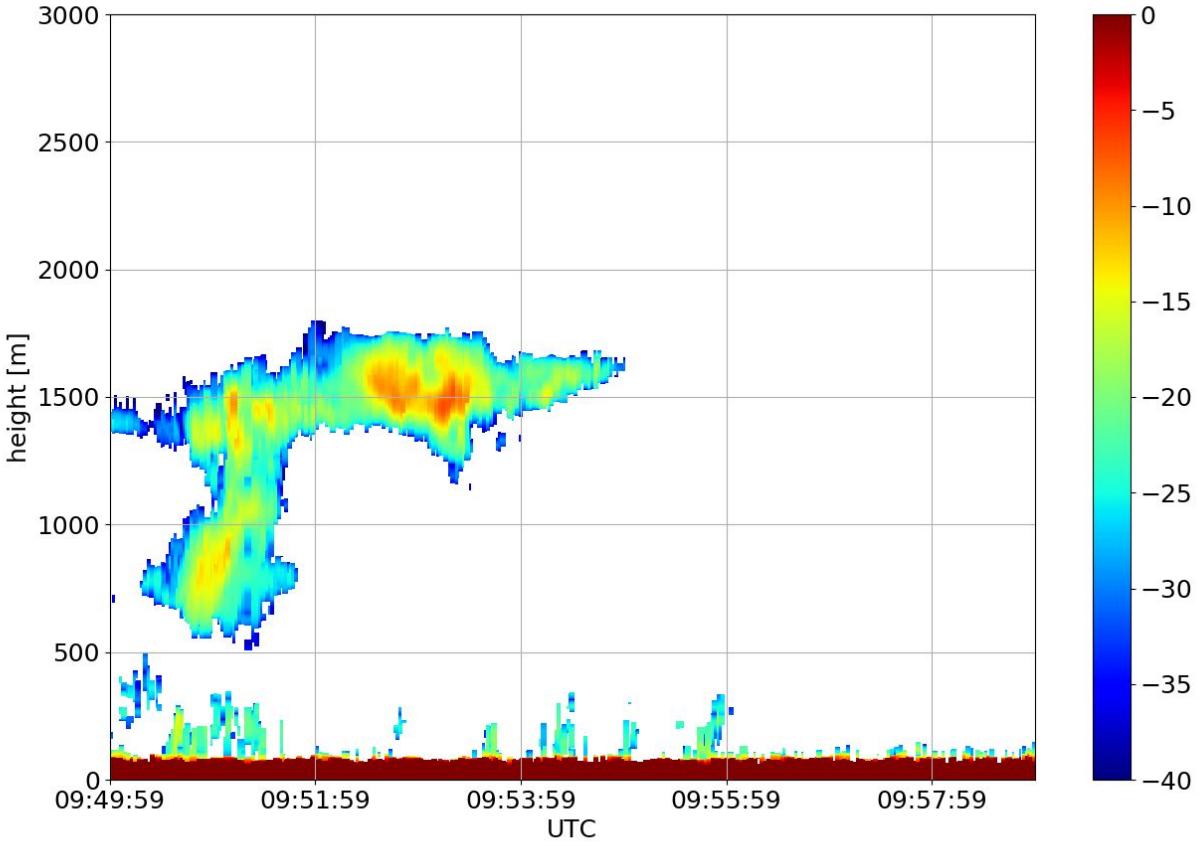


Filter data



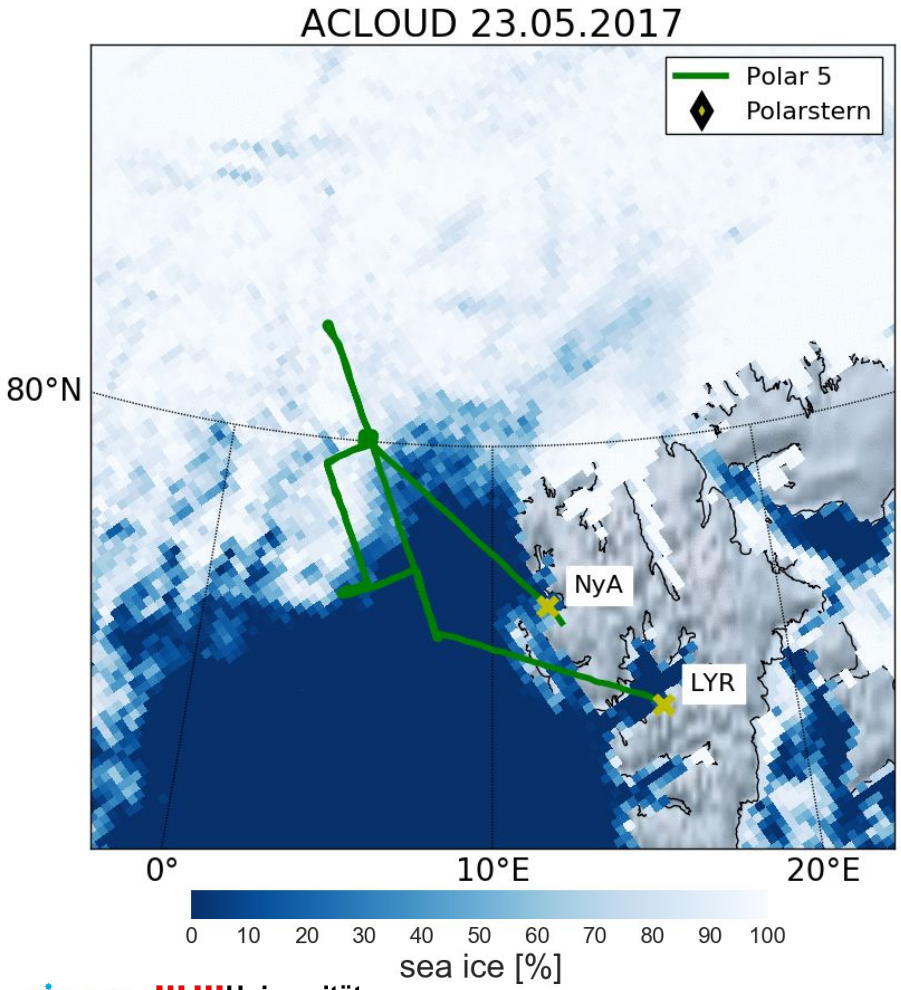
Filter detected signals for artifacts duet to FMCW method, “mirrored” signal at surface, and clutter

Filter data



Filter detected signals for artifacts duet to FMCW method, “mirrored” signal at surface, and clutter

Research flights during ACLOUD



Statistics:

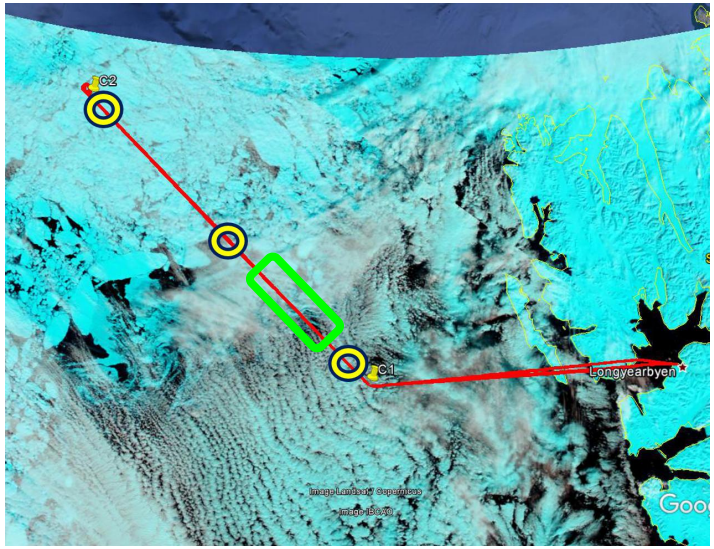
- Svalbard: 22.5.-29.6.2017
- Flight hours: Polar 5 & 6 each 80 h
- Ny-Ålesund: 13
- Polarstern: 8
- CloudSat - A-Train: 5
- Colocated Polar 5 & 6 flights
- Low level - high flights
- Ice - open water

Targets:

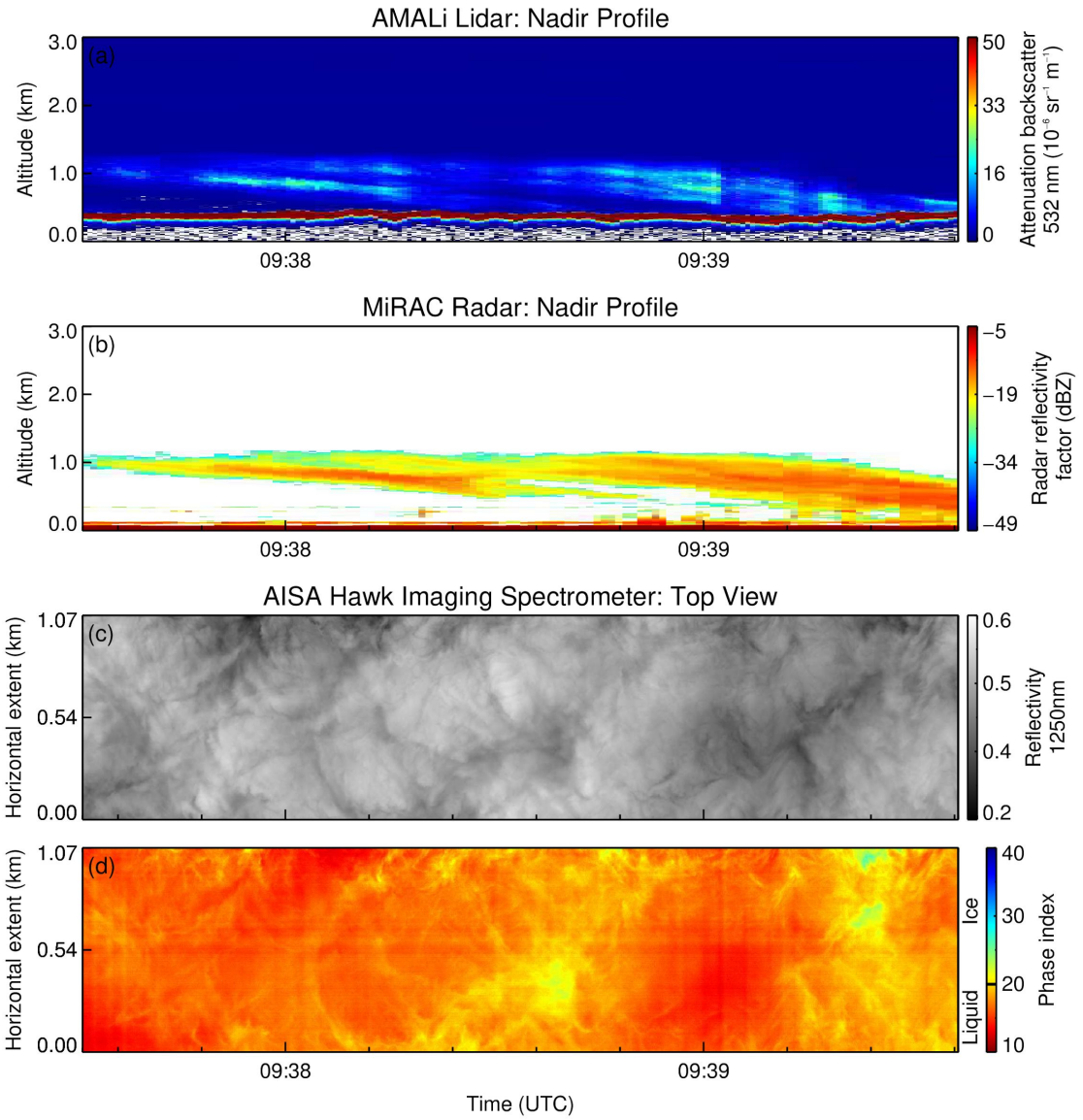
- Mixed-phase clouds
- Arctic precipitation
- Turbulence
- Radiation budget
- Satellite validation
- Surface albedo

AWI Universität Bremen

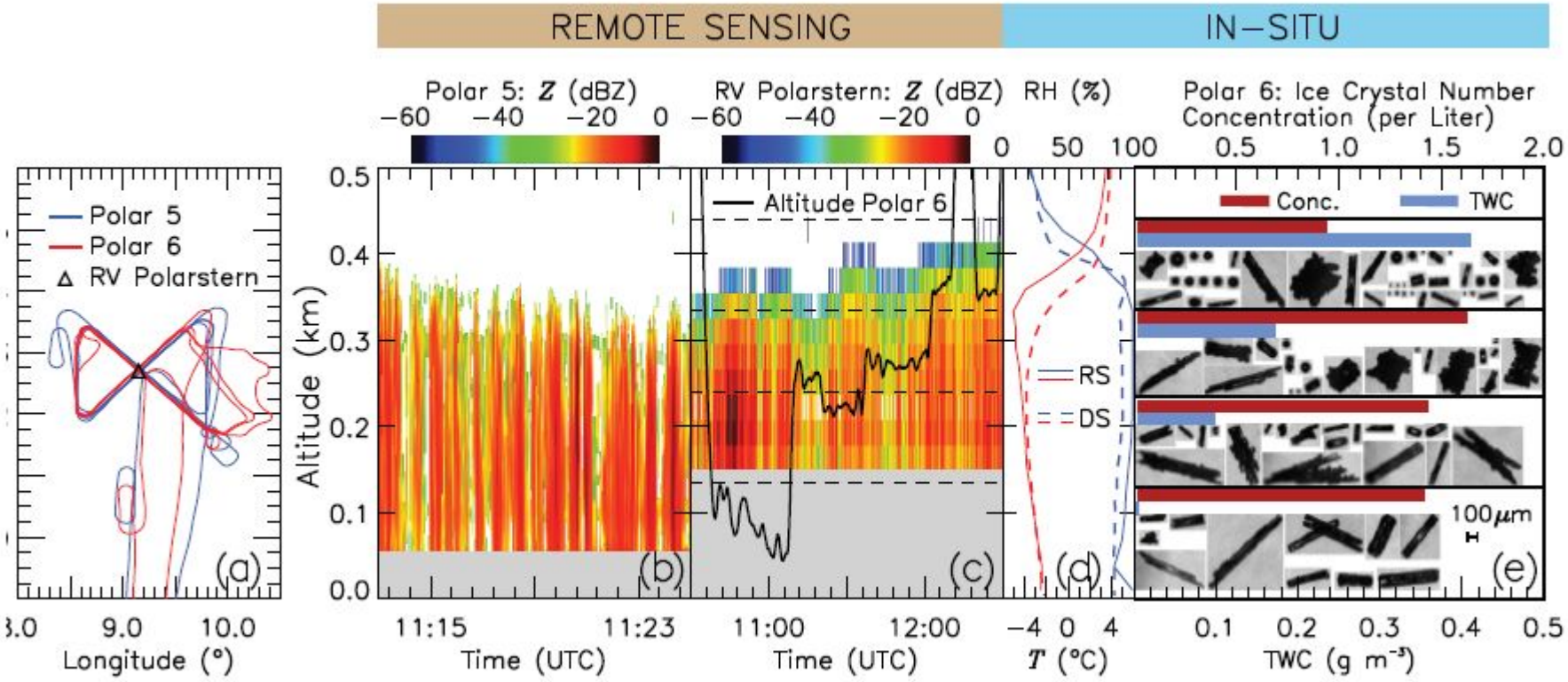
May 27, 2017 3 mins over broken sea ice



- radar/lidar reveals persistent mixed phase clouds
- most clouds occur within CloudSats blind zone and below sensitivity limit
- setup well suited to assess EarthCare performance

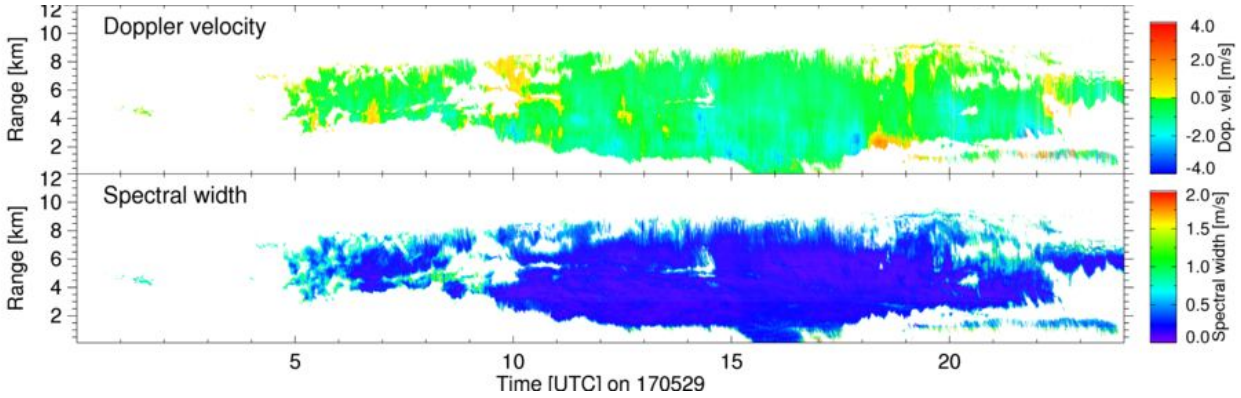


June 2, 2017 at ~82°N, 9°E

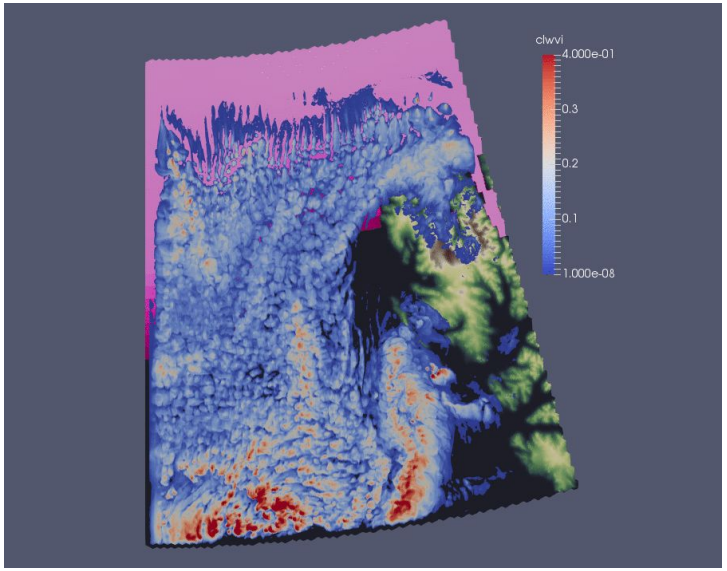


outlook

Deriving higher moments of velocity spectrum



Observation driven simulation - validation by forward simulations



Schemann (University of Cologne)

Upcoming campaigns:

AFLUX March/April 2019 Svalbard

MOSAiC March/April and Aug/Sept 2020

MOSAiC International Arctic Drift Expedition

https://www.mosaic-expedition.org/

Main messages

AC3 established to investigate process and their feedback mechanisms in the Arctic climate.

ACLOUD campaign conducted in May/June 2017 out of Svalbard to collect a dataset that will help to understand Arctic mixed-phase clouds and boundary layer processes.

MiRAC as an active and passive microwave remote sensing suite installed and operated on Polar aircraft.

MiRAC data ready to be used and observations look promising in terms of detail, resolution, and quality and serves alone or in combination with the other remote sensing instrumentation as a valuable package to validate satellite observations and models.

Wendisch et al., 2018: The Arctic Cloud Puzzle: Using ACLOUD/PASCAL Multi-Platform Observations to Unravel the Role of Clouds and Aerosol Particles in Arctic Amplification, *Bulletin of the American Meteorological Society*, submitted