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

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

Wendisch et al. (2017)
Arctic Amplification: Climate Relevant Atmospheric 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/
Arctic CLoud Observations U sing airborne measurements during polar Day (ACLOUD)

Physical feedback of Arctic PBL, Sea ice, Cloud And Aerosol (PASCAL)

Arctic Balloonborne profiling EXperiment (ABEX)

CONtinuous characterization of the Ny-Ålesund COlumn and Radiative effects from ground-baseD 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)
Cloud and Aerosol properties
Trace gas CO/CO2
Turbulent fluxes

Vertical and horizontal variability
Turbulent fluxes

Polar 5 = Remote Sensing
Polar 6 = In Situ
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
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 H₂O 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
Radarsignal correction

Aircraft orientation
Instrument mount
Time shifts

raw

 calibrated: mount position

[Diagram showing radar signal correction with aircraft orientation and instrument mount considerations]
Filter detected signals for artifacts due to FMCW method, “mirrored” signal at surface, and clutter
Research flights during A CLOUD

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
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

Upcoming campaigns:
AFLUX March/April 2019 Svalbard
MOSAiC March/April and Aug/Sept 2020

Schemann (University of Cologne)

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.