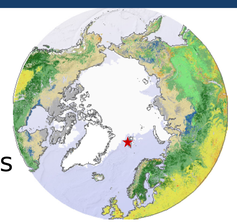
Low level mixed-phase clouds in an Arctic environment

R. Gierens[1], T. Marke[1], S. Kneifel[1], C. Ritter[2], M. Maturilli[2], U. Löhnert[1]

[1] Institute of Geophysics and Meteorology, University of Cologne (Germany), [2] Alfred Wegener Institut (Germany)

Arctic Amplification and Clouds



- Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms (AC)[3]
  – German collaborative research project to investigate the key processes contributing to Arctic Amplification
- Low-level stratiform liquid containing clouds have a major influence on Arctic surface radiation balance[1]
- **Focus on mixed-phase cloud micro-physics**
- How does the environment at measurement site influence cloud properties (life cycle, altitude, geom. thickness, water content…)?

Cloud Observations at AWIPEV, Ny Ålesund

Comprehensive cloud observations carried out at the AWIPEV station in Ny Ålesund (78.9°N). Measurements are affected by

- Heterogeneous surface type (open water / snow / tundra with seasonal variation)
- Orography
- Near-by glaciers

…

Photo: Pavel Krobot/Kerstin Ebell

How regionally representative are the observed clouds?

Materials

Ground-based remote sensing
- Cloud radar-radiometer[2] (94 / 89 GHz) since June 2016 → 2 year dataset

Instrument synergy: CLOUDNET classification

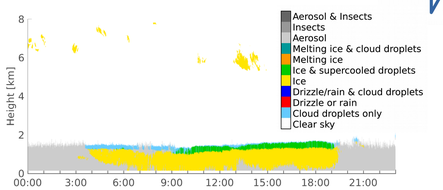


Fig 1. Example of the CLOUDNET[4] target classification product that combines cloud radar, microwave radiometer and ceilometer (Nov 23rd 2016).

Circulation weather type based on wind at 850 hPa (from ERA-Interim)[3]

Criteria for **persistent low-level mixed phase clouds**
- Co-located ice and liquid found
- Liquid layer persists > 1h
- Cloud liquid located close to cloud top
- Cloud top < 2.5 km

Persistent Mixed Phase Clouds (PMPC) Above Ny Ålesund

Occurrence vs season and weather type

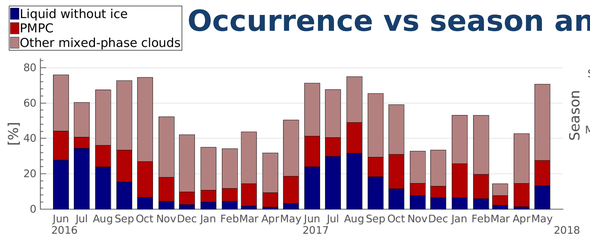


Fig 2. Monthly occurrence of liquid containing clouds, based on CLOUDNET classification product.

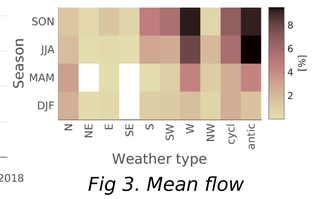
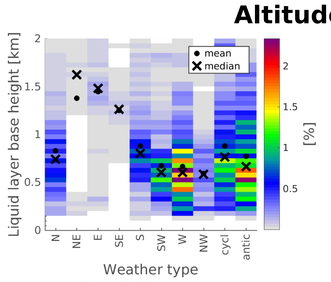


Fig 3. Mean flow associated with PMPC in each season.

- PMPC more often in summer and autumn, large inter-annual variability
- Most often associated with westerly winds

Liquid layer

Altitude



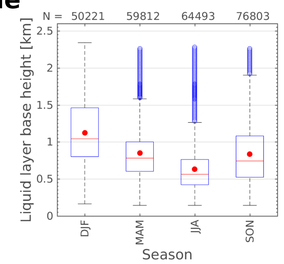


Fig 4. The height (a.s.l) of liquid layer base in each flow regime (left) and season (right).

Geometrical thickness

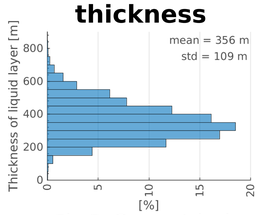


Fig 5. Geometrical thickness of the liquid layer.

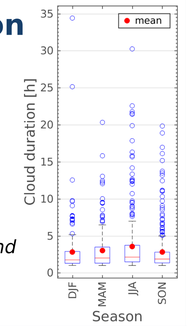
Liquid water path
- on average 35 g/m²
- lowest with E and highest with SW wind

- Cloud liquid is located higher in easterly (NE to SE) flows, lower for W and NW
- Lowest in summer and highest in winter
- Liquid layers 300-400 m deep
- Thickness independent of season; high clouds slightly thinner
- Very low LWP

Cloud duration

- PMPC last longer in summer
- Very persistent clouds in all seasons

Fig 6. Duration (time between appearance and disappearance of the cloud) of each identified cloud.



- Most PMPC advected to the station from the sea (both more common wind direction and favourable for PMPC)
- Clouds coming to the site from inland are higher, thinner and have less liquid
- PMPC in summer are lower and live longer, in winter higher and on average not as persistent

→ More humidity available at the sea for cloud formation?

→ Cloud fields east to the site can't cross the mountains?

Surface Coupling of PMPC

- The thermo-dynamical coupling of the cloud to the surface constrain the extent of interactions possible with the underlying surface
- Surface is a potential source of humidity and aerosol (CCN and INP)
- First estimate: using potential temperature profiles from sounding to determining the coupling state

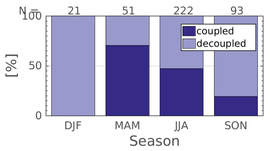


Fig 7. Seasonal surface coupling based on soundings (preliminary results).

Soundings only give a snapshot
→ aim to continuously evaluate coupling together with cloud evolution

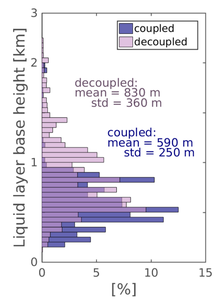


Fig 8. Coupled clouds are on average lower than decoupled ones.

Conclusion

- Long term cloud observations set-up at Ny Ålesund
- Low-level mixed phase clouds (PMPC) characteristics vary with season and large scale flow
- Next step: ice in PMPC
  How is precipitation/glaciation connected to other cloud properties?
  Dependence on turbulence/coupling?
- Future work: Using radar Doppler moments to dive into micro-physics

References

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Acknowledgements:
This work was supported by the German Research Foundation (Deutsche Forschungsgemeinschaft) within the Transregional Collaborative Research Center (TR 172) "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms (AC)³". We wish to thank our colleagues from Alfred Wegener Institute for Polar and Marine Research (AWI) for their support, sharing of data as well as research infrastructure at AWIPEV.

rgierens@uni-koeln.de