Characterization of the cloud conditions at Ny-Ålesund using sensor synergy and representativeness across Arctic sites

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1. Abstract

Arctic clouds often contain ice particles which form and develop at different environmental conditions. Atmospheric temperature and humidity are one of the main factors affecting ice particle shape, deposition growth rate, aggregation and riming efficiency, and ice multiplication. This study presents preliminary statistics of ice-containing clouds (pure ice and mixed-phase) at Ny-Alesund observatory (Svalbard, Norway) where a novel 94 GHz cloud radar has been operating since June 2016. The results are compared with observations from the Barrow site (Alaska, US).

2. Ice-containing clouds at Ny-Ålesund and Barrow

- Cloudnet categorization [2] was used to find profiles containing ice particles at Ny-Alesund. Cloudnet for Ny-Alesund utilizes temperature information from Global Data Assimilation System (GDAS).

- For Barrow site vertical profiles of the radar reflectivity from the 35-GHz cloud radar KZAR and interpolated radiosondes (ARM database) were used. Profiles with radar scattering at temperatures below 0 ºC were considered as ice-containing.

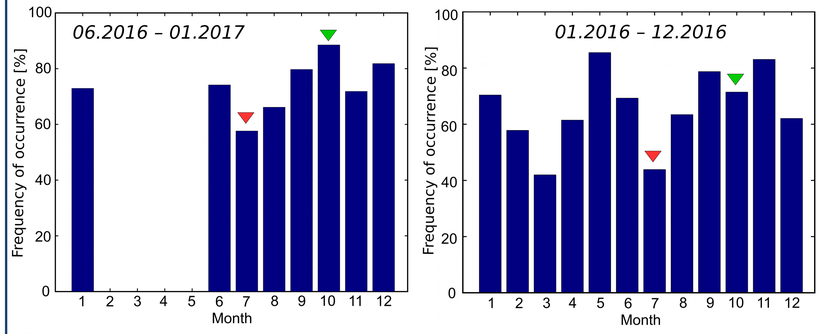

***Fig. 1**: Fraction of ice-containing clouds at Ny-Alesund (left) and Barrow (right). Red and green markers indicate months with minimum and maximum fraction at Ny-Alesund, respectively. Corresponding months are marked for Barrow.*

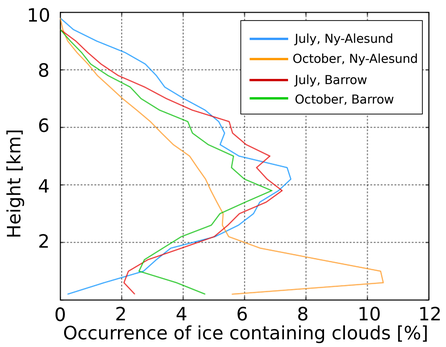

***Fig. 2**: Vertical distribution of ice containing clouds*

Pronounced minimum of ice containing clouds in July at both sites

Enhanced ice occurrence in autumn with peaks in October (Ny-Alesund) and November (Barrow)

Vertical distribution of ice-containing clouds at Ny-Alesund in October differs from the one at Barrow

Different ice cloud formation and development processes due to different environmental conditions

3. Long-term characterization of the atmosphere

Temperature and humidity are key factors for ice formation and development

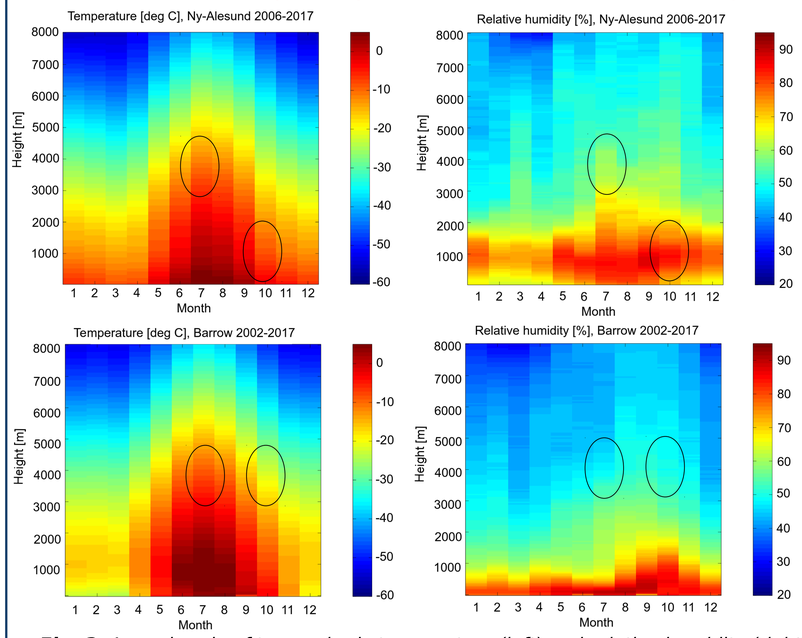

***Fig. 3**: Annual cycle of tropospheric temperature (left) and relative humidity (right) from radiosonde observations at Ny-Alesund from 2006 to 2017 (upper panels) and at Barrow from 2002 to 2017 (lower panels). Ellipses show altitudes with high occurrence of ice-containing clouds in July and October (see Fig. 2).*

4. Thin single-layer ice-containing clouds

As a first step, thin (< 1000 m) non-precipitating single-layer ice-containing clouds were chosen for the analysis. Such clouds are relatively easier to characterize due to less microphysical processes in comparison to deep precipitating cloud systems.

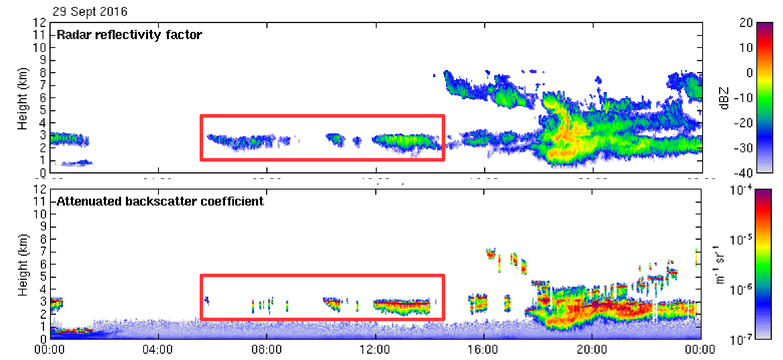

***Fig. 4**: Example of single-layer clouds, Ny-Alesund, 29 Sept 2016. Shown are the radar reflectivity factor (upper panel) and lidar attenuated backscatter coefficient (lower panel) from Cloudnet [2].*

5. A closer look at clouds in July and October

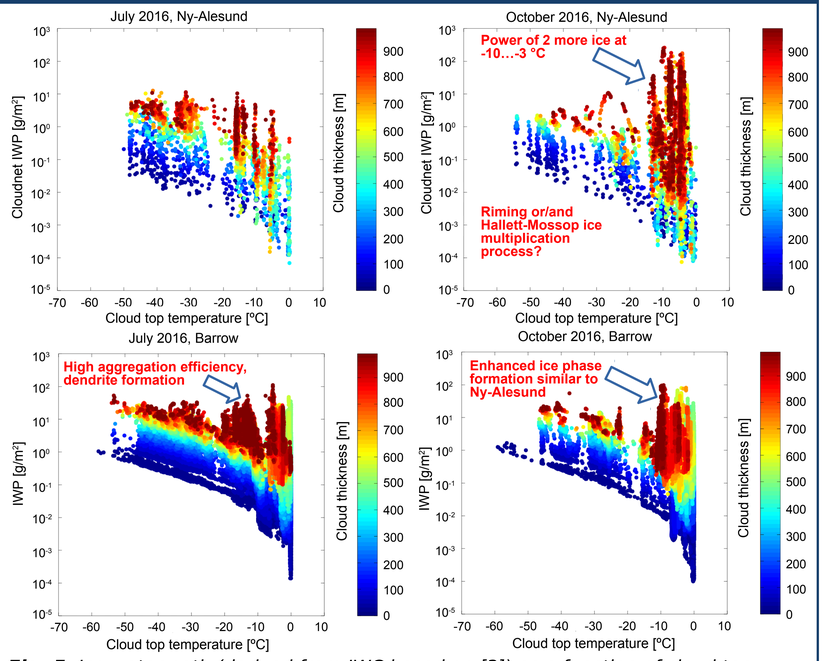

***Fig. 5**: Ice water path (derived from IWC based on [3]) as a function of cloud top temperature and cloud thickness for July (left) and for October (right). Cloud top temperature is taken from Global Data Assimilation System for Ny-Alesund (upper panels) and from VAP interpolated radiosonde for Barrow (lower panels).*

6. Summary and Outlook

- Preliminary analysis of ice containing cloud occurrence and phase of clouds at Ny-Ålesund and Barrow
- Minimum of ice occurrence in July at both sites
- Evidence of enhanced ice production in autumn
- Indications of riming and/or multiplication processes were found in October
- In-situ observations during the measurement campaign in May – July 2017 will be gathered and compared with remote sensing observations.
- Doppler spectra analysis

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References:

1. *M. Maturilli, M. Kayser, 2016: Arctic warming, moisture increase and circulation changes observed in the Ny-Ålesund homogenized radiosonde record, Theoretical and Applied Climatology, doi: 10.1007/s00704-016-1864-0.*
2. *A. Illingworth, R. Hogan, E. O'Connor, and D. Bouniol, 2007: Cloudnet, Bulletin of the American Meteorological Society, 88(6), 883.*
3. *R. Hogan, M. Mittermaier, A. Illingworth, 2006: The retrieval of ice water content from radar reflectivity factor and temperature and its use in evaluating a mesoscale model, Journal of Applied Meteorology and Climatology, 45, 301-317 p.*