Statistics of ice containing clouds at Ny-Ålesund

Nomokonova T.[1], K. Ebell[1], U. Löhnert[1] and M. Maturilli[2]
[1] Institute of Geophysics and Meteorology, University of Cologne, Cologne
[2] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Potsdam

1. Abstract

Arctic clouds often contain ice particles which form and develop at different environmental conditions. Atmospheric temperature and humidity are 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 at Ny-Ålesund (Svalbard, Norway).

2. Ice-containing clouds at Ny-Ålesund

Instrumentation:
MW radiometer
Ceilometer
94-GHz FMCW Cloud radar

Processed products:
Global data assimilation system (GDAS)
Cloudnet categorization

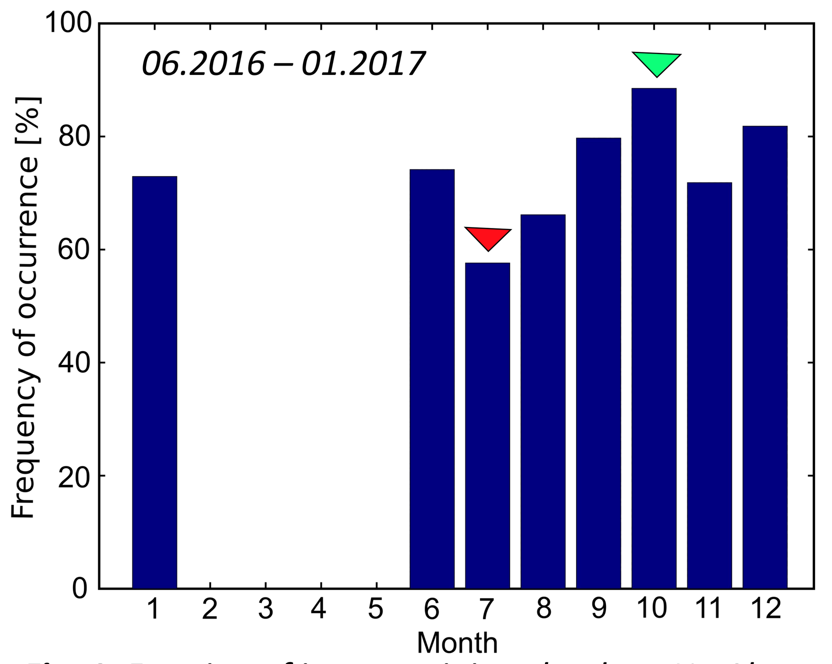

Fig. 1: Fraction of ice-containing clouds at Ny-Alesund. Red and green markers indicate months with minimum and maximum fraction, respectively.

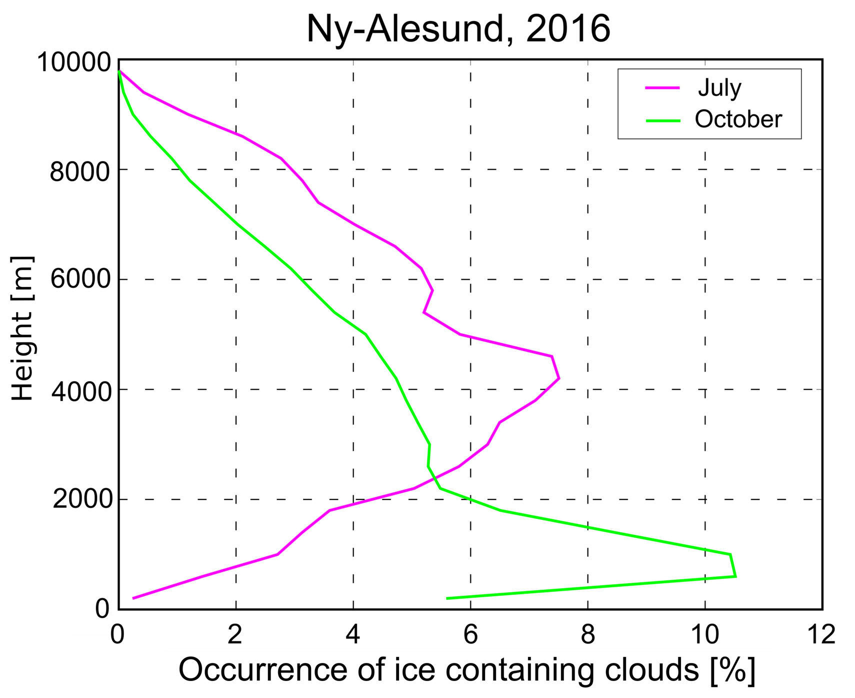

Fig. 2: Vertical distribution of ice containing clouds

Pronounced minimum of ice containing clouds in July and enhanced ice occurrence in autumn with peak in October ⇨ **Different ice formation and development processes due to different environmental conditions**

3. Atmospheric conditions

Temperature and humidity are key factors for ice formation and development

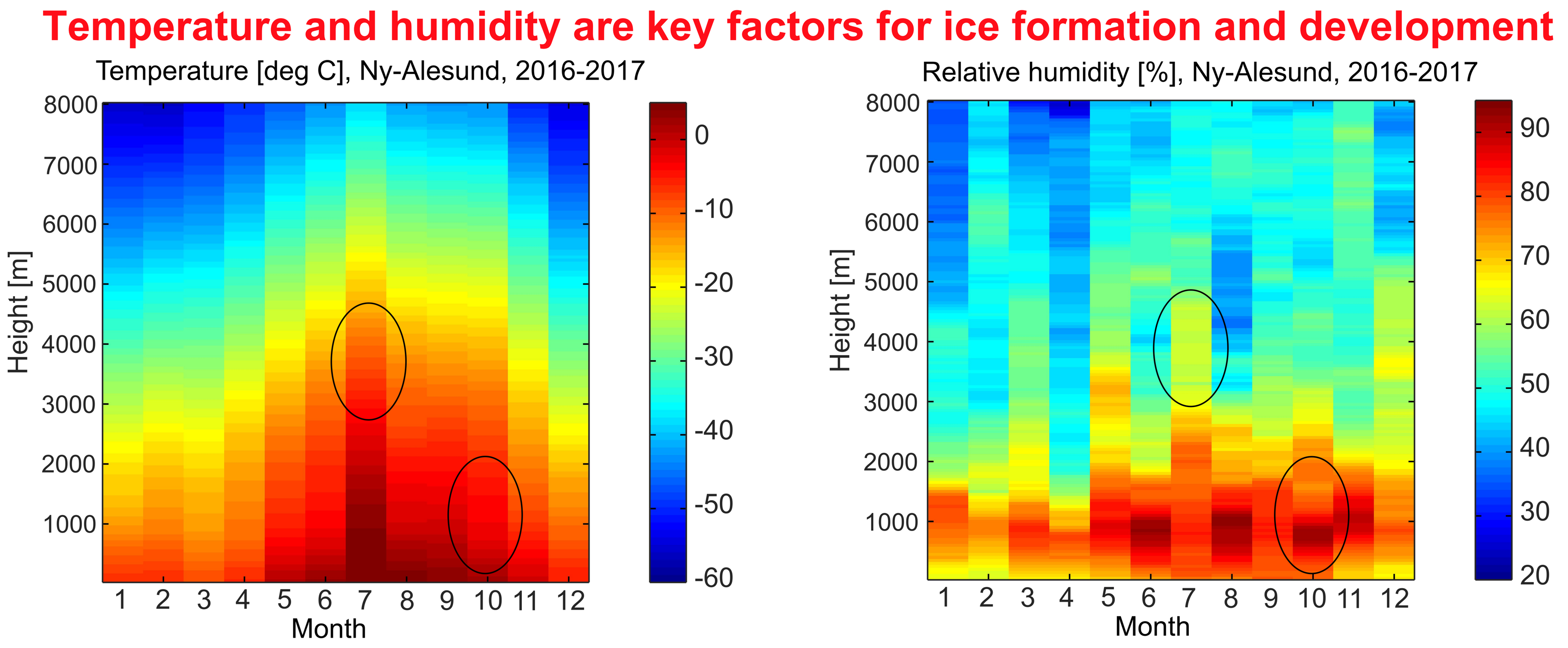

Fig. 3: Tropospheric temperature (left) and relative humidity (right) at Ny-Ålesund from radiosonde observations from 2016 to 2017 based on [1]. Ellipses show altitudes with high ice-containing cloud occurrence in July and October.

4. Measurement accuracy

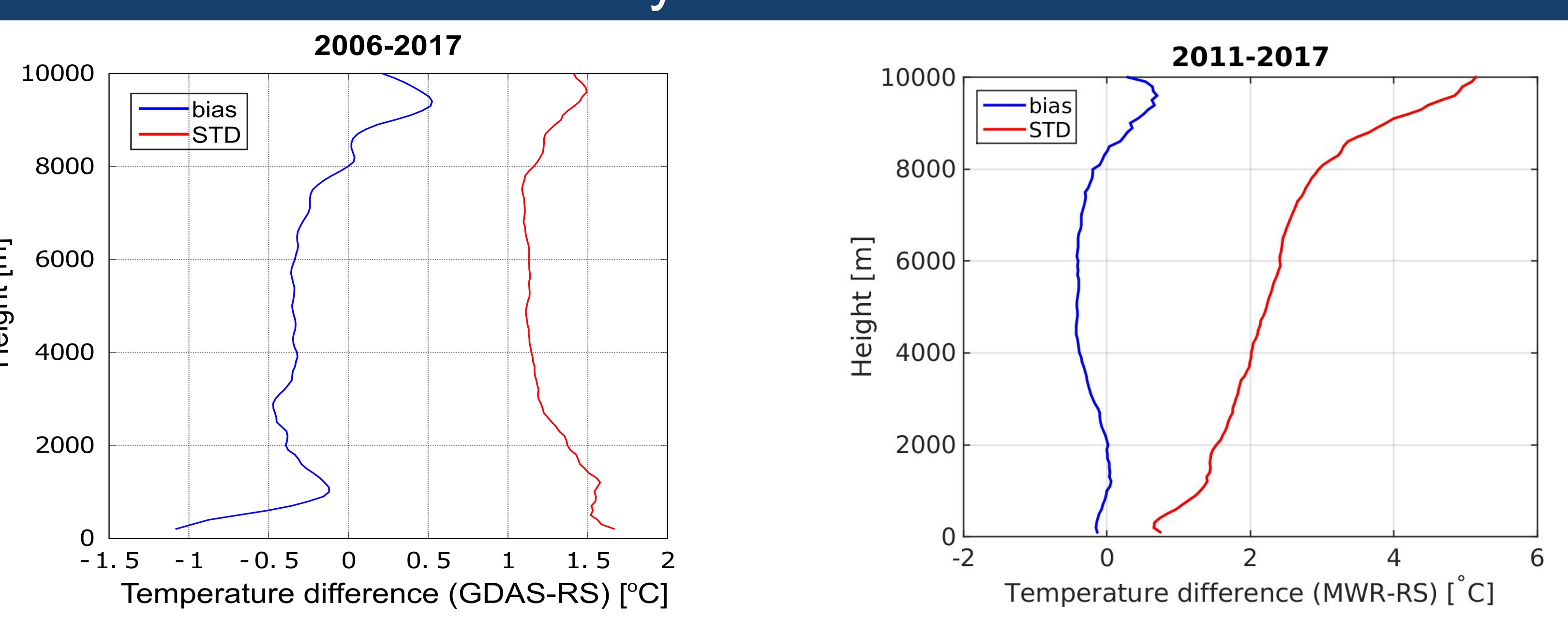

Fig. 4: Temperature difference between MWR and GDAS (left) and MWR and radiosonde (right) with height.

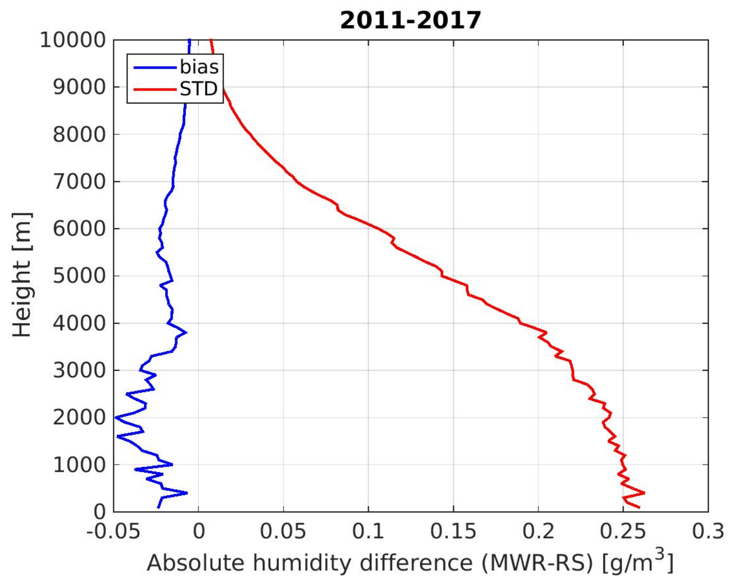

Fig. 5: Absolute humidity difference between MWR and radiosonde with height.

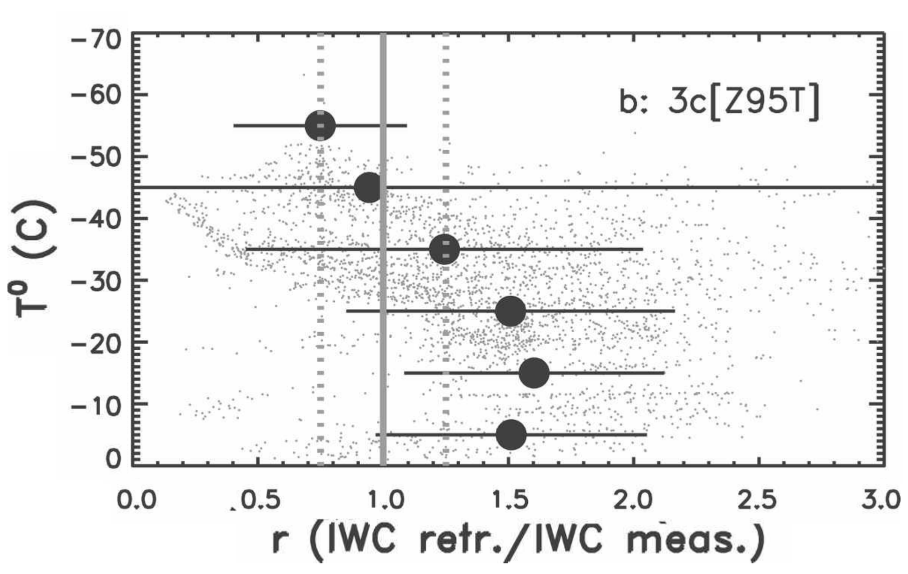

Fig. 6: Ratio of retrieved [Hogan et al 2006] and measured IWC as a function of cloud top temperature (for 94 GHz cloud radar) [Heymsfield,2007]

Temperature accuracy: ±1.5° Humidity accuracy: <0.25 g/m³ IWC accuracy: ±100%

5. A closer look on clouds in July and October

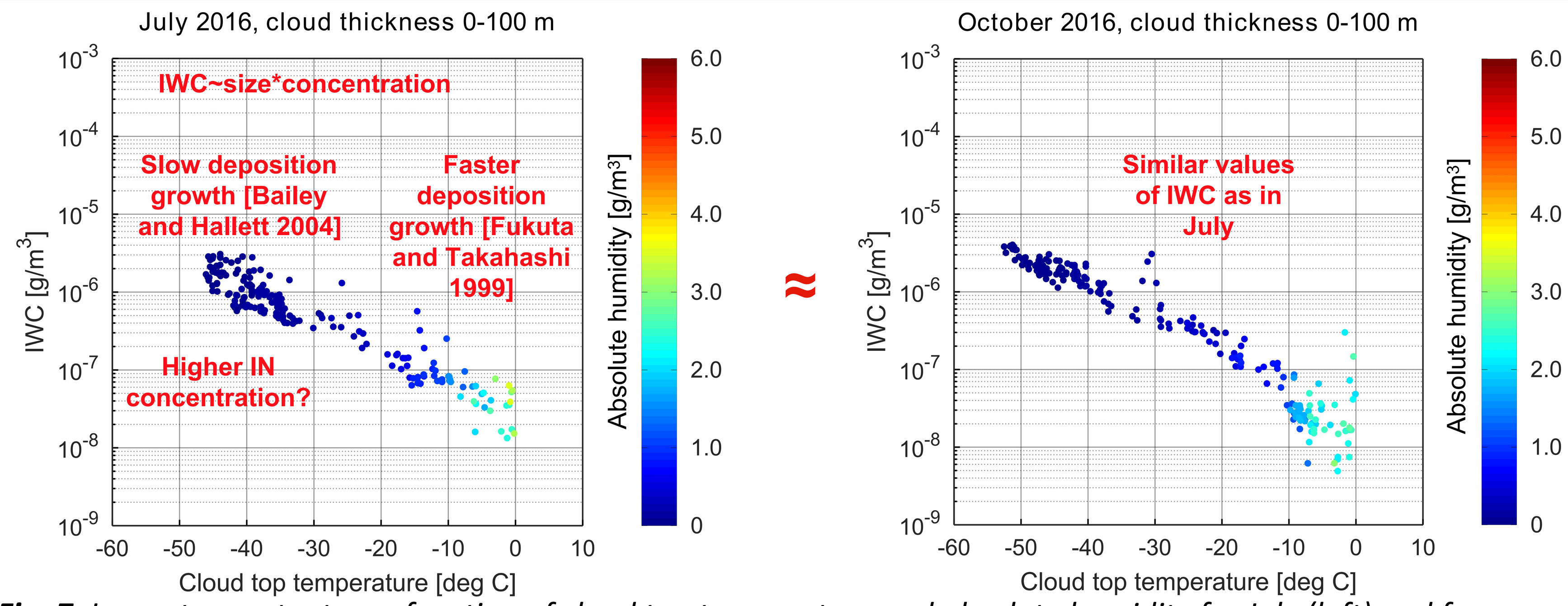

Fig. 7: Ice water content as a function of cloud top temperature and absolute humidity for July (left) and for October (right) for cloud thickness lower 100 m. Cloud top temperature is taken from GDAS, absolute humidity from microwave radiometer.

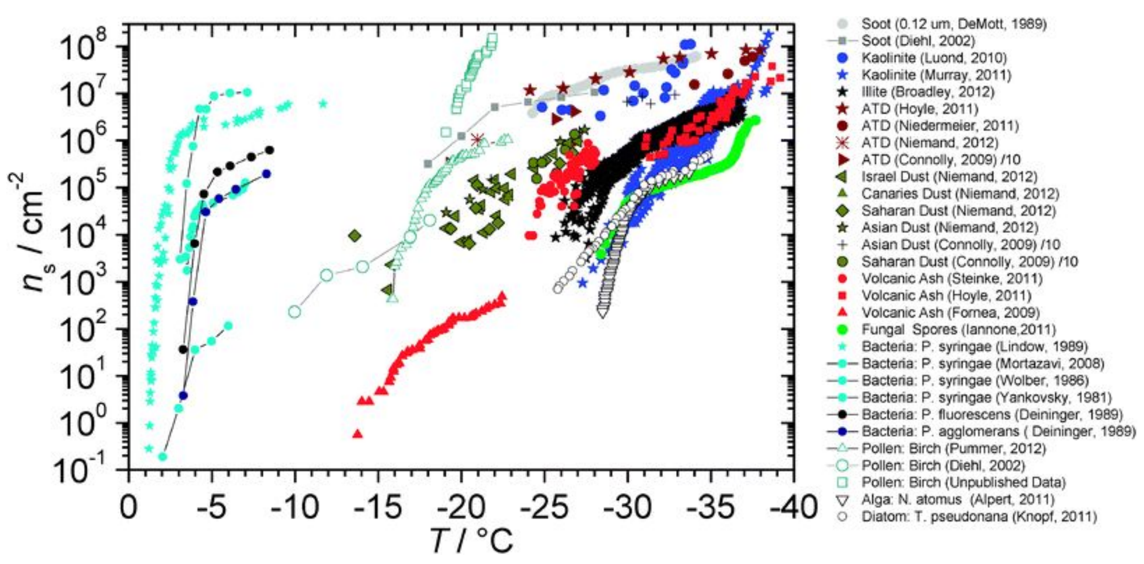

Fig. 8: Cumulative ice active site density showing ice nucleating efficiency of different materials [B. J. Murray et al, 2012]

Similar dependences (IN increases with decreasing temperature) found in laboratories

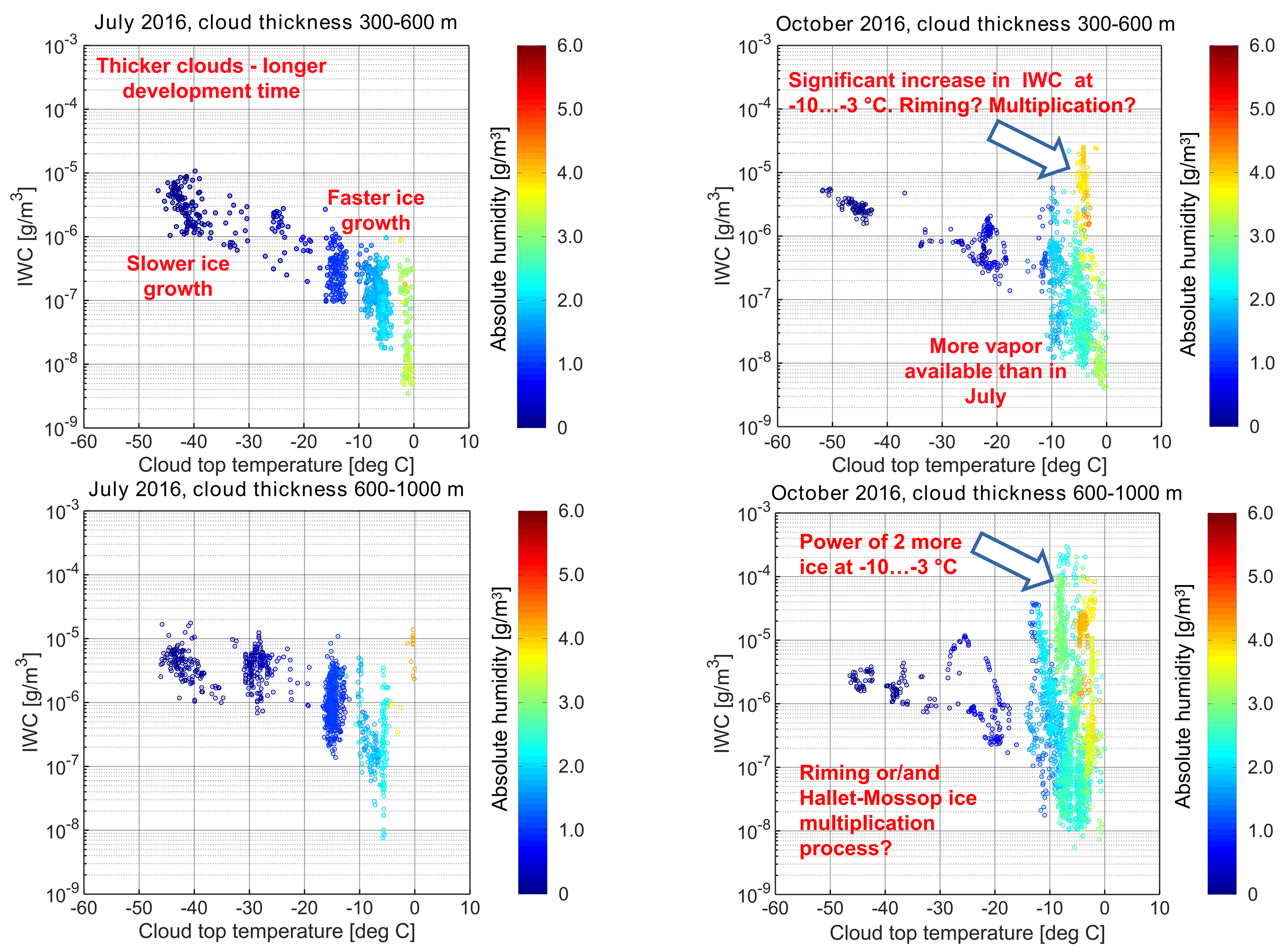

Fig. 9: Ice water content as a function of cloud top temperature and absolute humidity for July (left) and for October (right) with different cloud thickness .

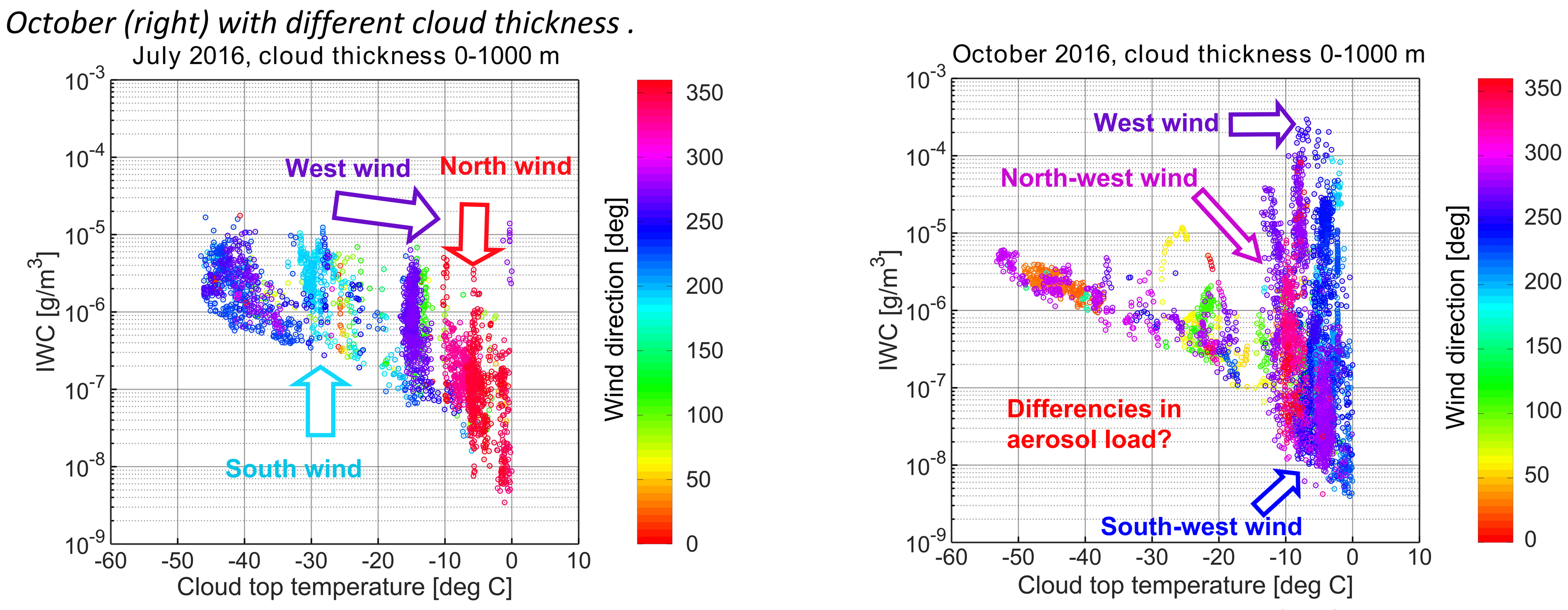

Fig. 10: Ice water content as a function of cloud top temperature and wind direction for July (left) and for October (right) for thin clouds (< 1000 m). Cloud top temperature and wind direction are taken from GDAS. 0°, 90°, 180°, 270° correspond to north, east, south, west, respectively, and show from wich direction wind blows.

6. Summary and Outlook

- Analysis of ice containing cloud occurrence and phase of clouds at Ny-Ålesund
- Minimum of ice occurrence in July
- Evidence of enhanced ice production in autumn
- Possible increase of IN concentration at cold temperatures
- Faster ice growth at warmer temperatures
- 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 observations.
- Doppler spectra will be analyzed

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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.