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

**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

Clouds are one of the crucial components of the hydrological and energy cycles and thus affect the global climate. Arctic clouds usually occur at low altitudes and often contain highly concentrated tiny liquid drops. During winter, spring, and autumn such clouds tend to conserve the long-wave radiation in the atmosphere and, thus, have a warming effect in the Arctic. In summer though clouds efficiently scatter the solar radiation back to space and, therefore, induce a cooling effect. An accurate characterization of the net effect of clouds on the Arctic climate requires long-term and precise observations of cloud properties.

## 2. Cloud observations

Only few measurement sites exist which perform continuous, vertically resolved observations of clouds in the Arctic, e.g. in Alaska, Canada, and Greenland.

**Why do we need measurements at Ny-Ålesund?**

- located in the warmest part of the Arctic
- climate change is highly visible
- to complement the understanding of cloud formation and development in the Arctic
- to complement the information from other Arctic supersites

<u>Scientific questions:</u>

- To what extent and with which accuracy can we gain insight into the thermo-dynamic, trace gas, aerosol and cloud properties at Ny-Ålesund?
- What is their impact on the radiation and energy budget throughout the vertical extent from the surface to the lower mesosphere?
- How representative are the Ny-Ålesund observations across other Arctic sites?

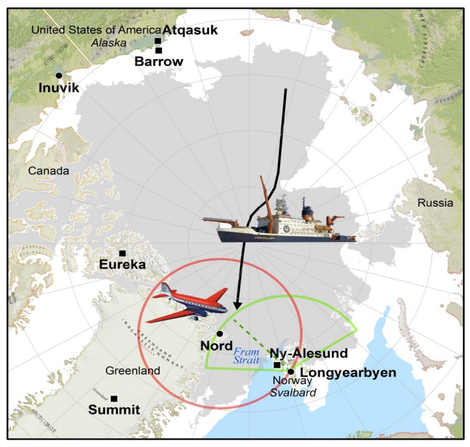


***Fig. 1**: Map of Arctic atmospheric observatories and (AC)³ campaign activities.*

***Fig. 2**: German-French Research Station AWIPEV at Ny-Ålesund, Svalbard.*

## 3. Instrumentation

**Synergy of ground based instruments**

<u>Active instruments</u>

**94 GHz FMCW cloud radar**

**Specifications:**
- Passive channel at 89 GHz
- Range resolution ~ 10 m
- Doppler resolution ~ 1 cm $s^{-1}$
- Measurements since June 2016

**Observations:**
- Cloud geometry
- Cloud microphysics

**Ceilometer CL51**

**Specifications:**
- Maximum Range 15 km
- Range Resolution 10 m
- Temporal resolution 6–120 s
- Wavelength 910 nm
- Measurements since 2011

**Observations:**
- Cloud base
- Detection of supercooled liquid

<u>Passive instruments</u>

**Microwave radiometer**

**Specifications:**
- Frequencies
  22.24 – 31.4 GHz,
  51.0 – 58.0 GHz
- Temporal resolution ~1 s
- Measurements since 2013

**Observations**
- Continuous temperature, humidity profiles
- Liquid water path
- Integrated water vapor

<u>In-situ instruments</u>

**Radiosonde**

Measurements since 2007

**Observations**

Temperature, pressure, humidity, and wind profiles

## 4. Microwave radiometer retrievals

Comparison of integrated water vapor from radiosonde and microwave radiometer data from 2013 to 2016 at Ny-Ålesund.

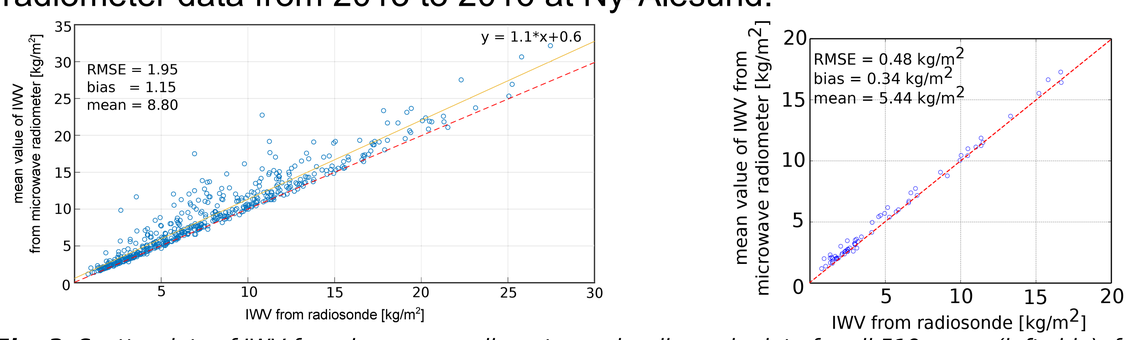


***Fig. 3**: Scatterplots of IWV for microwave radiometer and radiosonde data for all 519 cases (left side), for clear sky 72 cases (right side).*

## 5. Instrument synergy for cloud observations

CLOUDNET encompass a set of retrievals providing a target classification and cloud microphysical products based on a synergy of ground-based remote sensing instruments.

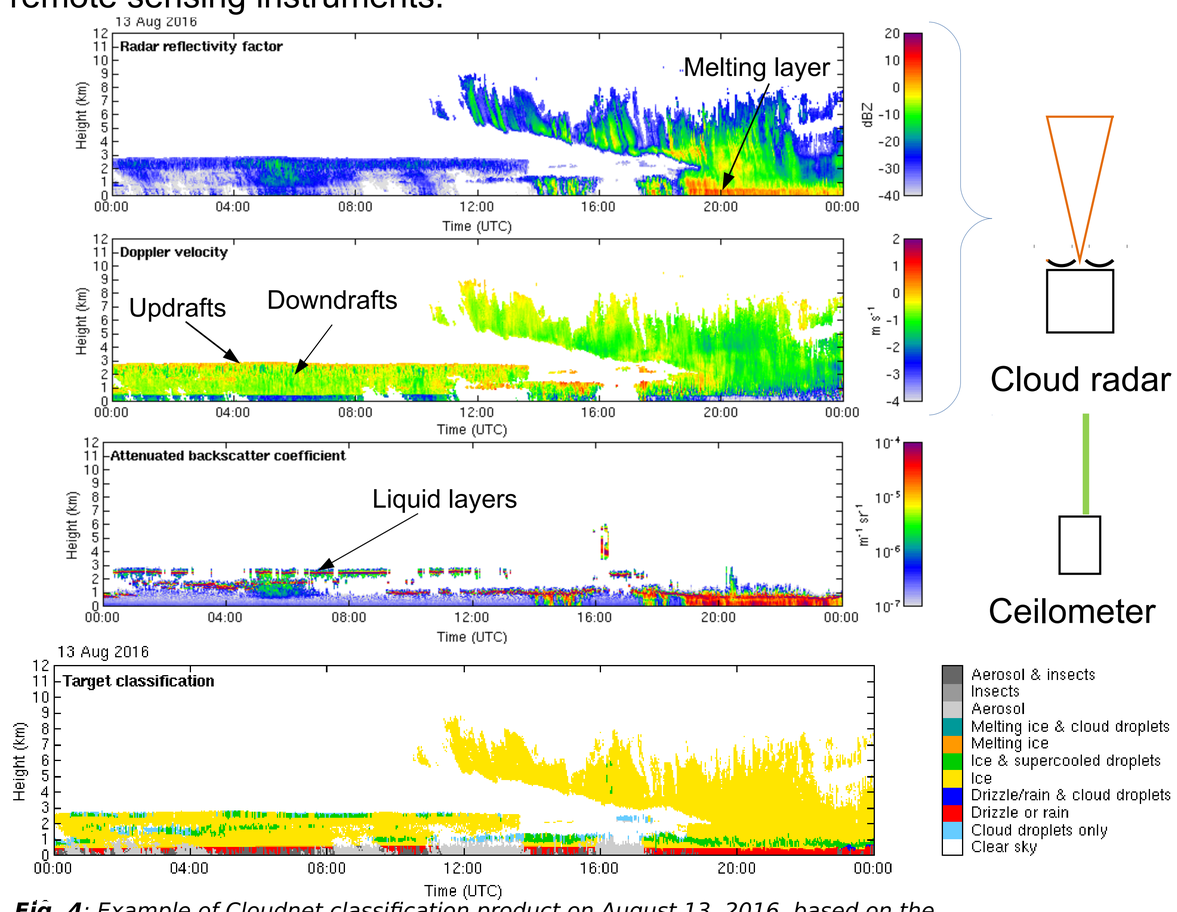


***Fig. 4**: Example of Cloudnet classification product on August 13, 2016, based on the measurements at the Ny-Ålesund.*

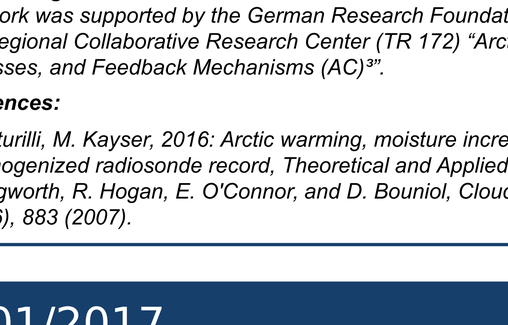


***Fig. 5**: Histogram of cloud base height measured by ceilometer from 2011 to 2016 at Ny-Ålesund*

**<u>Statistics of cloud base height</u>**

- 90 % of the observed clouds have cloud base height below 2 km
- in average cloud base height is higher during winter than summer

## 6. Summary and Outlook

- Clouds are an important component for the Arctic climate
- Sensor synergy is a powerful tool to characterize clouds in the Arctic
- Continuation of ground based observations at Ny-Ålesund
- Long-term statistics of clouds at Ny-Ålesund, for instance, cloud geometry (cloud base, cloud top, and cloud thickness), cloud type (liquid, ice, mixed-phase)
- Connection of cloud properties to certain meteorological conditions
- Measurement campaign will be held in May-July 2017

***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".*

***References:***

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