Investigating mixed phase clouds using a synergy of ground based remote sensing measurements

R. T. Gierens[1], T. Nomokonova[1], S. Kneifel[1], U. Löhnert[1]
[1]University of Cologne, Institute for Geophysics and Meteorology, Pohligstr. 3, 50969 Cologne, Germany
e-mail: rgierens@uni-koeln.de

Clouds have a strong influence on the Earth's radiative budget, and specifically in the Arctic low-level stratiform clouds are a major contributor to cloud radiative forcing at the surface[1]. These occur frequently as mixed phase clouds in the Arctic and can persist from hours to several days[2]. However, the processes that lead to the commonality and persistence of these clouds are not well understood. The aim of our work is to get a more detailed understanding of the dynamics of and the processes in Arctic mixed phase clouds using a combination of instruments operating at the AWIPEV station in Ny Ålesund, Svalbard. In order to study micro-physical processes, retrievals for micro-physical parameters from Doppler cloud radar will be developed, utilizing data collected during the ACLOUD campaign.

To better describe the micro-physical properties of low-level mixed phase clouds, we investigate the potential of the radar Doppler spectra during a case study of a persistent mixed phase cloud observed above the AWIPEV station. In the frame of the $(AC)^3$ -project, a millimeter wavelength cloud radar was installed at the site in June 2016. The high vertical (4 m in the lowest layer) and temporal (2.5 sec) resolution allows for a detailed description of the structure of the cloud. In addition to radar reflectivity and mean vertical velocity, we utilize the higher moments of the Doppler spectra, such as skewness and kurtosis. To supplement the radar measurements, a ceilometer is used to detect liquid layers inside the cloud. Liquid water path and integrated water vapor are estimated using a microwave radiometer, which together with soundings can also provide temperature and humidity profiles in the lower troposphere. Moreover, profiles of the three-dimensional wind vector are obtained from a Doppler wind lidar. The variability in the vertical wind component can be used to estimate the amount of turbulence, and makes it possible to identify stable and turbulent layers in the boundary layer (wind lidar) and in the cloud (radar).

The Cloudnet scheme (www.cloud-net.org), that combines radar, lidar and microwave radiometer observations with a forecast model to provide a best estimate of cloud properties[3], is used for identifying mixed phase clouds. The continuous measurements carried out at AWIPEV make it possible to characterize the micro-physical properties of mixed-phase clouds on a long-term, statistical basis. Furthermore, the synergy of instruments allows studies of the interaction of dynamics and micro-physical processes in the cloud.

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

[1] M. D. Shupe, and J. M. Intrieri, *J. Climate*, **17**, 616–628 (2004).
[2] M. D. Shupe, *J. Appl. Meteo. Clim.*, **50**, 645–661 (2011).
[3] A. J. Illingworth, R. J. Hogan, E. J. O'connor, D. Bouniol, J. Delanoë, J. Pelon, A. Protat, M. E. Brooks, N. Gaussiat, D. R. Wilson, D. P. Donovan, H. Klein Baltink, G.-J. van Zadelhoff, J. D. Eastment, J. W. F. Goddard, C. L. Wrench, M. Haeffelin, O. A. Krasnov, H. W. J. Russchenberg, J.-M. Piriou, F. Vinit, A. Seifert, A. M. Tompkins, U. Willén, D. R. Wilson, and C. L. Wrench, *Bull. Amer. Meteor. Soc.*, **88(6)**, 883-898 (2007).