Geophysical Research Abstracts
Vol. 19, EGU2017-17295, 2017
EGU General Assembly 2017

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

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Low level mixed phase clouds occur frequently in the Arctic, and can persist from hours to several days. 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 Svalbard. In addition, an aircraft campaign collecting in situ measurements inside mixed phase clouds above the station is planned for May-June 2017. The in situ data will be used for developing and validating retrievals for microphysical properties from Doppler cloud radar measurements. Once observational data for cloud properties is obtained, it can be used for evaluating model performance, for studies combining modeling and observational approaches, and eventually lead to developing model parameterizations of mixed phase microphysics.

To describe the low-level mixed phase clouds, and the atmospheric conditions in which they occur, we present a case study of a persistent mixed phase cloud observed above the AWIPEV station. In the frame of the Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms ($(AC)^3$) -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 also 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, a three-dimensional wind field is be obtained from a Doppler wind lidar.

Furthermore, 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, is used for identifying mixed phase clouds. The continuous measurements carried out at AWIPEV make it possible to characterize the macro- and micro- physical properties of mixed-phase clouds on a long-term, statistical basis. The Arctic observations are compared to a 5-year observational data set from Jülich Observatory for Cloud Evolution (JOYCE) in Western Germany. The occurrence of different types of clouds (with focus on mixed-phase and super-cooled clouds), the distribution of ice and liquid within the clouds, the turbulent environment as well as the temperatures where the different phases are occurring are investigated.