Radiation & Climate - Gordon Research Conference 16.-21.7.2017

Investigating Arctic 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 French-German Arctic Research Base AWIPEV in Ny Ålesund, Svalbard. The corner stone of our study is a novel frequency modulated continuous wave radar (94 GHz) installed at the station in June 2016 within the frame of the Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms $(AC)^3$ -project. The high vertical (5 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. To supplement the radar measurements, liquid layers inside the cloud are detected with a ceilometer. Furthermore, a Doppler lidar is used to obtain a three-dimensional wind field, which we utilize to describe the turbulent state of the boundary layer.

To describe the dynamics of low-level mixed phase clouds, we present a case study of a persistent mixed phase cloud observed above the AWIPEV station. Using radar reflectivity and Doppler velocity obtained with high resolution, combined with the liquid water path retrieved from the (perfectly beam matched) passive channel of the instrument, we show that liquid is produced and the ice production enhanced in localized updrafts near cloud top. Further more, the radar Doppler spectra provide means for locating the liquid water within the vertical column, as well as estimating vertical air motions. With these parameters we can characterize the vertical and horizontal length scale and the intensity of the updraft in these vertical plumes, which is relevant information for modeling studies aiming for explicitly describing cloud top processes in mixed phase clouds. Moreover, the environmental influence (e.g. coupling to the surface, synoptic scale forcing) on the cloud is considered. In the future we wish to estimate the ice and liquid water contents to provide more detailed description of the liquid and ice forming processes and extend the analysis to larger data set.

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 $(AC)^3$". We are grateful for the Alfred Wegener Institute for Polar and Marine Research (AWI) for sharing the data from their measurements as well as providing the research infrastructure at AWIPEV. The Graduate School of Geosciences, University of Cologne, (Grant No. GSGS-2017C-T18) as well as the Department of Energy, National Science Foundation, NASA, and the Gordon Research Conference financially supported the attendance of the conference.