Interactions between Arctic boundary layer and low level mixed-phase clouds

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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 and the processes in Arctic mixed-phase clouds and the interaction between the clouds and their environment using a combination of instruments operating at the French-German Arctic Research Base AWIPEV in Ny Ålesund, Svalbard. The Svalbard archipelago lies in the warmest part of the Arctic and is influenced by relatively large mean transport of moisture and heat from the lower latitudes, and a large variability in this transport. Moreover, the surroundings of the station exhibit large variations in surface properties (glaciers, seasonal snow cover, and open water) as well as orography. These features modify the local boundary layer and also the associated clouds.

The corner stone of our study is a novel frequency modulated continuous wave cloud radar (94 GHz) installed at the AWIPEV 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 (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 for detecting micro-physical signals. The instrument is also equipped with a (perfectly beam matched) passive channel (89 GHz) which is used to retrieve liquid water path. Supplementary instruments operated by AWI are used to detect super-cooled liquid inside the cloud: a ceilometer and a microwave radiometer. A Doppler lidar is used to obtain the vertical profile of all three wind components, which we utilize to describe the turbulent state of the boundary layer. We take advantage of synergistic approaches developed for classifying hydrometeor phase (i.e. Cloudnet algorithm) and boundary layer turbulence. In addition, an aircraft campaign collecting in situ measurements inside mixed-phase clouds above the station took place in May-June 2017, and we aim to also present first results of the combined analysis of the ground based and aircraft data.

Using the 1.5 years long time series of cloud observations available, we investigated how large scale weather conditions as well as local boundary layer processes are associated with the occurrence and physical properties of persisting low level stratiform mixed-phase clouds. We find that these clouds prefer certain weather conditions to occur, and that some macro- and micro-physical properties depend on the weather type while others seem rather independent on the large scale situation. Furthermore, to describe the micro-physical processes we have investigated selected case studies of persistent mixed-phase clouds occurring above the AWIPEV station using height-resolved Doppler spectra of the 94 GHz cloud radar.

The results presented are the first step of studying a long time series of Arctic mixed-phase clouds in Svalbard. By characterizing the cloud properties we are able to state in which regards the clouds observed at AWIPEV are similar to Arctic mixed-phase clouds observed at other sites, and what kind of special features occur. This is necessary both for our future work, as well as for many other efforts studying stratiform mixed-phase clouds in the region. Immediate next steps include further utilization of the radar Doppler spectra and available retrievals for cloud properties. Furthermore, observational data will be used for evaluating model performance, for studies combining modeling and observational approaches, and can eventually lead to developing model parameterizations of mixed-phase micro-physics.

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