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Statistics on clouds and their relation to thermodynamic conditions at Ny-Ålesund using sensor synergy

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Clouds play a significant role for the radiation budget, especially in the Arctic regions where climate change is faster in comparison with other regions. Despite the importance of clouds in the Arctic, climate models strongly differ in the representation of clouds implying a large uncertainty. In order to improve the representation of clouds in models, long-term, accurate and high vertically resolved observations of clouds are needed. Such observations also allow for the detailed characterization of the clouds radiative effect on the Arctic climate. Currently, only a few sites with such detailed observations exist in the Arctic, e.g. in Alaska, Canada, Greenland and since recently in Svalbard.

Within the Transregional Collaborative Research Center (TR 172) "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms $(AC)^3$" comprehensive observations of the atmospheric column are performed at the German-French Research Station AWIPEV at Ny-Ålesund, Svalbard. Ny-Ålesund is located in the warmest part of the Arctic where climate experiences significant maritime influence by the warm ocean. Thus, measurements at Ny-Ålesund will complement our understanding of cloud formation and development in the Arctic.

This particular study is devoted to a characterization of cloud macro- and microphysical properties at Ny-Ålesund and the atmospheric conditions under which clouds form and develop. To this end, the information of the various instrumentation at the AWIPEV observatory is synergistically analysed: information about the thermodynamic structure of the atmosphere is obtained from long-term radiosonde launches. In addition, a microwave radiometer HATPRO provides information on liquid water path (LWP). A set of active remote sensing instruments performs cloud observations at Ny-Ålesund. A ceilometer operating since 2011 is now complemented with a novel 94 GHz FMCW cloud radar. As a first step, the CLOUDNET algorithms, including a target categorization and classification have been applied to the observations.

In this study, we will present cloud statistics at Ny-Ålesund including occurrence of clouds and hydrometeors, cloud geometry (cloud base, cloud top, and thickness), and cloud type (liquid, ice, mixed-phase) as well as the analysis of cloud properties. Cloud formation strongly depends on meteorological conditions that have pronounced seasonality in the Arctic. High occurrence of temperature and humidity inversions over the Arctic can provide additional moisture for clouds and therefore has a strong impact on cloud life cycle and precipitation efficiency. Thus, different types of clouds are also set into context to the environmental conditions such as temperature, amount of water vapour, and ice and liquid water path. An analysis of the relation of LWP/TWP and IWP/TWP provides information on the phase partitioning in mixed-phase cloud. Such information can be used to test the representation of clouds and their dependency on temperature and moisture in models.