# Arctic Mixed-Phase Clouds: The NASCENT 5-Days Case Study with HoloBalloon

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The Arctic is warming faster than the rest of the world. Clouds influence downwelling solar and upwelling terrestrial radiative fluxes, which determine the surface radiative energy budget. The role of clouds is particularly complex in the Arctic because of complicated ice-albedo and cloud-radiation mechanisms and lacking direct solar radiation during the winter. The cloud phase partitioning within mixed-phase clouds (MPCs) containing cloud droplets and ice crystals especially influence the atmospheric radiation balance. Additionally, the lifetime of MPCs depends on the spatial distribution of cloud droplets and ice crystals, i.e. whether they are homogenously distributed or occur in clusters. Despite its importance, the cloud phase partitioning and the processes responsible for ice crystals formation in Arctic clouds are poorly understood due to the limited availability of in-situ measurements.

We conducted in-situ cloud microphysical measurements in Ny-Ålesund, Svalbard, during October and November 2019 as part of the NASCENT[1] (Ny-Ålesund AeroSol Cloud ExperimeNT) campaign. The main instrument used was a holographic cloud probe imaging cloud droplets and ice crystals, mounted on the tethered balloon system HoloBalloon. Additionally, ambient ice nucleating particles (INPs) and cloud condensation nuclei were quantified. The in-situ cloud measurements were complemented by remote sensing instruments profiling the entire troposphere and additional radiosondes were launched.

Here we will present the observed cloud microphysical properties of MPCs measured during five consecutive days from November 8 to 12, 2019. During the first two days, an occluded front and a low- pressure system influenced the formation of the MPCs. On November 10, despite temperatures below -15 °C, the glaciation of the cloud was inhibited by a low INP concentration and an absence of secondary ice processes. On November 11, regions with high ice crystal concentrations up to 150 $L^{-1}$ were observed between 300 and 800 m a.s.l. indicating active secondary ice processes at temperature between -2 °C and -7 °C. The observation of elongated columns, frozen and broken droplets, and combinations of columns 'stuck' to frozen water droplets suggests droplet fragmentation as an active secondary ice process as well as the growth and following break up of columns on frozen droplets. On November 12, the cloud evolved gradually from a turbulent state, in which ice crystals grew quickly through riming to a state where concentrations up to 90 $L^{-1}$ of small pristine hollow columns were observed together with frozen droplets and rimed particles at temperatures between -5 °C and -8 °C. This indicates secondary ice production through droplet fragmentation and rime splintering and the subsequent growth of splinters to columns.

The observations obtained during this 5-days case study will help to quantify the importance of different processes relevant for ice crystal formation and phase partitioning in Arctic MPCs

depending on the ambient atmospheric conditions and to relate them to ice crystals and cloud droplets spatial and temporal distributions.

[1] https://www.aces.su.se/research/projects/the-ny-alesund-aerosol-cloud-experiment-nascent-2019-2020/