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Mid-latitude and Arctic supersaturations observed during Cirrus-HL

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The Cirrus-HL field campaign with the German research aircraft HALO took place out of Oberpfaffenhofen, Germany, in the summer month June and July 2021. The main objective was to probe cirrus clouds in the mid-latitudes and arctic upper troposphere. We operated the cloud spectrometer NIXE-CAPS (Krämer et al., 2016, 2020) to measure size distributions and number concentrations (N_{ice}) of ice particles. In addition, the hygrometer FISH (Meyer et al., 2015) was installed to obtain water vapor mixing ratio outside of clouds and derive ice water content (IWC) from total water inside of clouds. As the IWC measurement from the total water instruments can only used as indicator aboard HALO (Afchine et al. 2018), we derive the IWC from the NIXE-CAPS particle size distributions in the size range 3 to 937 µm. Gas-phase water vapor concentration inside of clouds is provided by the SHARC hygrometer and additionally converted into relative humidity wrt. ice (RHi) for the analysis. In total, 28.2 hours (18.9 hours in Mid-latitudes (< 60°N) and 9.2 hours Arctic (> 60°N)) of measurements inside of cirrus clouds in the temperature range between 208-240K during the 23 science flights were conducted.

In this study, we analyze the humidity conditions inside and outside of cirrus clouds as well as the cirrus cloud properties in the two different geographical regions (Mid-latitude and Arctic) with a special focus on the appearing supersaturations (RHi > 100 %). Especially in the Arctic region we find higher supersaturations inside but also outside of cirrus clouds in contrast to the mid-latitudes. As the RHi and also the Nice inside of clouds depends on the vertical updraft we correlate these quantities with the measured vertical velocity and can find only a vertical updraft effect in the Mid-latitudes but not in the Arctic. However, the particle size distributions in the two regimes exhibit a clear difference with generally less and larger ice particles in the Arctic cirrus clouds. Homogeneous ice nucleation occurs typically at higher supersaturation compared to heterogeneous nucleation which means freezing of ice nucleating particles (INP). The observations could indicate the dominant role of homogeneous nucleation in the Arctic under low updraft unpolluted conditions (low INP concentration). The high supersaturations found outside of clouds further confirm this hypothesis, as heterogeneous nucleation typically occurs at lower supersaturations. In summary, we present in-situ observations with higher supersaturations in- and outside of cirrus clouds as well as small and large ice particles indicating a clean summer Arctic upper troposphere in contrast to the Mid-latitudes.

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