

EGU25-6928, updated on 07 Jan 2026

<https://doi.org/10.5194/egusphere-egu25-6928>

EGU General Assembly 2025

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Observations and Analysis of Cirrus Clouds in the Arctic during Warm Air Intrusions

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Cirrus clouds permit much of the incoming solar shortwave radiation to pass through while trapping and reemitting the Earth's outgoing longwave thermal radiation. This results in a net warming effect globally at the top of the atmosphere. They are found almost over every region, but their impact can differ depending on latitude. The arctic is a unique and fascinating area. Over the last few decades, scientists have shown that its average temperature is increasing at an accelerated rate compared to global warming. This phenomenon has been labeled Arctic Amplification and cirrus clouds are considered a potential contributor. Another arctic-specific phenomenon linked to arctic amplification are Warm Air Intrusions (WAI). During such events, warm, water-vapor- and aerosol-rich airmasses are meridionally transported into the arctic from the midlatitudes. Apart from the transport of sensible heat and water vapor, a strong greenhouse gas, these events can potentially alter properties and effects of the cirrus clouds that form in the arctic. The positive trend found in the frequency and longevity of these events further highlights the importance to understand how they affect the macrophysical and optical properties of cirrus clouds in the arctic.

In March and April of 2022, the HALO-(AC)³ field campaign was conducted. The main goal of this campaign was to investigate WAI events and airmass transformations in the arctic. One of the platforms employed during this campaign was the German research aircraft HALO. It was used to perform remote sensing measurements at high altitudes over cirrus clouds. Among the instruments aboard HALO, were the combined water vapor differential absorption and high spectral resolution lidar system WALES and the HAMP package including a cloud radar and radiometers. Measurements from these two instruments form the basic dataset analyzed in this study. The cirrus clouds detected during this campaign are classified as either WAI cirrus or AC cirrus depending on if they were measured during an active WAI or during undisturbed arctic conditions. In order to better classify the clouds and provide a more in-depth analysis their backwards trajectories were calculated using the Lagrangian analysis tool LAGRANTO and the CLaMS-Ice model, which combines the Chemical Lagrangian Model of the Stratosphere (CLaMS) with two-moment ice microphysics.

In this presentation we are comparing the geometrical and optical depths of WAI and AC cirrus as

measured by WALES. From the same instrument we also calculate the supersaturations with respect to ice and get a first insight into the probable nucleation processes. The backwards trajectories reveal more details regarding the origin, formation process, nucleation pathway and microphysical properties of the two cloud types. The analysis of the microphysical properties is further strengthened by analyzing the combined radar-lidar products.