EGU24-5220
EGU General Assembly 2024

Clouds and precipitation in the initial phase of marine cold air outbreaks as observed by airborne remote sensing

Imke Schirmacher[1], Sabrina Schnitt[1], Marcus Klingebiel[2], Nina Maherndl[2], Benjamin Kirbus[2], and Susanne Crewell[1]

[1]University of Cologne, Institute for Geophysics and Meteorology, Department of Geosciences, Cologne, Germany (imke.schirmacher@uni-koeln.de)

[2]Institute for Meteorology, Leipzig University, Leipzig, Germany

During Arctic marine cold air outbreaks (MCAOs), cold and dry air flows from the central Arctic southward over the open ocean. There, cloud streets form that transform to cellular convection downstream under extreme surface heat fluxes. MCAOs strongly affect the Arctic water cycle through large-scale air mass transformations and can lead to extreme weather conditions at mid-latitudes. The description of air mass transformations is still challenging partly because previous observations do not resolve fine scales and lack information about cloud microphysical properties. Therefore, we focus on the crucial initial phase of development within the first 170 km over open water of two MCAO events with different strengths observed during the HALO-(AC)^{3}campaign. Both times the POLAR 5 and 6 aircraft flew several legs along the same track perpendicular to the cloud streets crossing the sea ice edge several times to allow a quasi-Lagrangian perspective. Based on high-resolution remote sensing and in-situ measurements, the development of the boundary layer, formation of clouds, onset of precipitation, and riming are studied. We establish a novel approach based on radar reflectivity measurements only to detect roll circulation that forms cloud streets.

For the event with the stonger contrast between surface and 850 hPa potential temperature (MCAO index), cloud tops are higher, more liquid-topped clouds exist, the liquid layer at cloud top is wider, and the liquid water path, mean radar reflectivity, amount of rime mass, precipitation rate and occurrence are larger compared to the weaker event. However, the width of the roll circulation is similar for both MCAO events. All parameters, moreover, evolve with distance over open water, as the boundary layer deepens and cloud top heights rise. Cloud streets form after traveling 15 km over open water. After 20 km, cloud cover increases to just below 100 % and after around 30 km, precipitation forms. We find that maxima in the rime mass have the same horizontal scale as the roll circulation. The presentation will highlight how cloud macro- and microphysical parameters vary with distance over open water and explain the differences between both MCAO events.