

Cloud and precipitation characteristics during marine cold air outbreaks in the North Atlantic Arctic from recent ground- and aircraft-based campaigns

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Marine cold-air outbreaks (MCAOs) are a common large-scale phenomenon in the Arctic where cold and dry polar air is advected from land or ice masses over the relatively warm open ocean. During this process, the air mass undergoes a strong transformation with high latent and sensible heat fluxes from the ocean surface into the atmosphere. This strong convective boundary layer regime is accompanied by organized mesoscale cloud and precipitation structures where cloud streets typically form close to the sea ice edge and develop to a more cellular structure downstream. Still the understanding of MCAO properties and the associated processes is poor and pose a challenge to numerical weather prediction and climate models.

Recently, two field campaigns targeted cold-air outbreaks in the North Atlantic Arctic, the Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE; Geerts et al., 2022) and the aircraft-based HALO-(AC)3 campaign. During COMBLE, enhanced ground-based observations including remote sensing and in-situ measurements of clouds, precipitation and aerosol were performed near Andenes (69°N, 16°E) and to some extent on Bjørnøya (Bear Island; 75°N, 19°E) from December 2019 to May 2020. For the latter site, a micro rain radar of the University of Cologne was operated, providing detailed information on the vertical precipitation structure. In contrast to continuous ground-based observations (Eularian view), HALO-(AC)3 (7 March-12 April 2022) pursued a quasi-Lagrangian approach. In doing so, three research aircraft being equipped with in-situ and remote sensing instruments followed air masses during their transformation including both, MCAOs and moist and warm air intrusions. The flights were performed from the Norwegian Sea up to the North Pole.

In this work, we will present precipitation statistics based on the 6-month long COMBLE observations at the two sites but also look in more detail into the cloud structures as observed from the Polar5 aircraft during specific MCAO events during HALO-(AC)3. From the MRR measurements during COMBLE, we find a total precipitation amount of 507 mm (1372 mm) for Bjørnøya (Andenes) with 21% (15%) of the precipitation being attributed to MCAO events. However, air masses at Bjørnøya and, thus, cloud and precipitation structures are often influenced by the orography of Spitsbergen, Svalbard, making the interpretation even more complex. During HALO-(AC)3, targeted flights over the sea ice edge and open ocean across the cloud streets allow to characterize the cloud and precipitation development during the air mass transformation in more detail: lidar, radar and dropsonde measurements clearly indicate an increase in radar reflectivity, boundary layer and cloud top height with distance to the sea ice.

These data sets will help us to gain a better understanding of MCAOs. In particular, setting the observations in context to model simulations, e.g. high-resolution modeling, will further help to disentangle the processes involved.