Airborne observations of Arctic mixed-phase clouds, precipitation, and water vapor with state-of-the-art remote sensing instrumentation in the vicinity of Svalbard

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The Arctic climate is changing quickly, most evident in the rise of the near-surface air temperature observed in the last decades, being more than twice as strong as the global average. The mechanisms behind that are widely discussed: many processes and their feedback mechanisms still need to be better understood. In particular, quantifying the contribution of low-level clouds and precipitation to the Arctic energy and water cycle remains challenging, mainly due to the need for more high-quality observations in the demanding Arctic environment. As a result, the representation of clouds and precipitation in atmospheric models also differ substantially. Advancing the understanding of governing processes, particularly of the ubiquitous mixed-phase clouds, calls for direct observations of their microphysical properties and simultaneous quantifying water vapor amounts and profiles. Except for a few ground-based super sites, such observations are still barely available. Satellite observa
tions often suffer from the unknown surface emissivity of the underlying ice surface.

Within the "Arctic Amplification: Climate relevant Atmospheric and Surface Processes and Feedback Mechanisms (AC)3" project, we carried out several airborne campaigns focusing on observing Arctic mixed-phase clouds and boundary layer processes and their role in Arctic Amplification. Up to three research aircraft (Polar 5 and 6 from the Alfred-Wegener-Institute for Polar and Marine Research and the German High Altitude and Long Range Research Aircraft (HALO)) equipped with state-of-the-art remote sensing and in-situ instrumentation have been deployed within these campaigns, performing measurements in the vicinity of Svalbard during spring, summer, and early autumn, covering the Arctic ocean, marginal ice zone, and closed sea ice. The suite of remote sensing instruments onboard the Polar aircraft has recently been expanded by the novel and worldwide unique G-band Radar for Water vapor profiling and Arctic Clouds (GRaWAC). GRaWAC is a frequency-modulated continuous wave G-band radar with Doppler-resolving capabilities and simultaneous dual-frequency operation at around 167 and 175 GHz, making use of the Differential Absorption Radar (DAR) technique to derive temporally continuous water vapor profiles in cloudy and precipitating conditions, closing a current gap in observational state-of-the-art instrumentation.

This contribution will give an overview of the Arctic airborne campaigns carried out in recent years and present selected research highlights based on the datasets collected during the campaigns. Furthermore, we will show results from the first airborne operation of GRaWAC and the potential to provide information on liquid and ice clouds and precipitation, allowing a thorough assessment of the atmospheric water cycle.