Differential absorption G-band radar operated on an airborne platform for Arctic clouds and water vapor observations

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The Arctic climate is changing at a fast pace. The contribution of low-level clouds to the Arctic energy and water cycle remains challenging to quantify due to the lack of high-quality observations in the demanding Arctic environment and atmospheric models differ substantially. Advancing the understanding of governing processes in mixed-phase clouds, ubiquitous in the Arctic, calls for temporally high-resolved measurements of cloud and precipitation microphysical properties as well as simultaneous quantification of water vapor amount and profiles.

We present the novel and worldwide unique G-band Radar for Water vapor profiling and Arctic Clouds (GRaWAC) system operated on an airborne platform and on the ground, suitable to deliver these measurements. GRaWAC is a FMCW G-band radar with Doppler-resolving capabilities and simultaneous dual-frequency operation at 167 and 175 GHz. The Differential Absorption Radar technique is applied to the measurements to derive temporally continuous water vapor profiles in cloudy and precipitating conditions, which closes a current gap in observational state-of-the-art instrumentation. Furthermore, its ability to provide information on liquid and ice clouds and precipitation allows a thorough assessment of the atmospheric water cycle.

We show first measurements collected during a two weeks campaign (HAMAG – Humidity profiles and Arctic Mixed-phase clouds as seen by Airborne G-W-band radars) with Polar 6 aircraft out of Kiruna (Schweden) in February 2024 to illustrate GRaWAC’s potential for water vapor, cloud, and precipitation profiling measurements. In addition to the G-band radar, we operated a FMCW W-band radar, a water vapor and sub-millimeter radiometer and launched dropsondes. During the six research flights we could perform measurements of clouds over a mature cold air outbreak with open and closed cells. In addition we could investigate the performance of the suite to sense the difference in cloud structure over sea ice and open water, where the seeder-feeder effect in different cloud layers has been observed. Depending on the water vapor load of the atmosphere and the cloud thickness and structure, differential absorption signals of up to 7 dB were observed. The presentation will illustrate GRAWAC's potential and ideas for its further deployment.