Abstract for AMS Conference on Polar Meteorology and Oceanography, Denver, 12-16 May 2025
submitted to session: *Observational Advances in Polar Cloud Physics and Chemistry*

Observing the Arctic water cycle using the Differential Absorption G-band Radar GRaWAC

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The Arctic water cycle is rapidly changing in warming Arctic climate conditions. Continuous, highly resolved all-weather observations are not only key to monitoring occurring changes, but also to advancing the representation of mixed-phase clouds, precipitation and vertical water vapor distribution in modeling. Current state-of-the-art measurement techniques, yet, are limited by the occurrence of clouds, precipitation, or polar night, and lack the needed temporal or vertical resolution.

Cloud radars operating at high frequency in the G-band can close some of these observational gaps. The high radar frequency promises increased sensitivity to small hydrometeors compared to conventional cloud radars operating in Ka- or W-band. When applying the newly emerging Differential Absorption Radar (DAR) technique to measurements at differently attenuated channels, continuous in-cloud water vapor profiles can be retrieved at a resolution of up to 200m.

We illustrate these advantages with recent measurements obtained from the novel and unique G-band Radar for Water vapor and Arctic Clouds (GRaWAC). GRaWAC is a Doppler-capable, FMCW G-band radar with simultaneous dual-frequency operation at 167 and 175GHz. Our recent measurement set includes observations from AWIPEV station, Ny-Alesund, the central Arctic aboard a RV Polarstern cruise, and an airborne field study with flights along the Norwegian coast and the Gulf of Bothnia.

We apply the DAR technique to our measurements to derive temporally continuous in-cloud profiles in cloudy and precipitating conditions. When deployed from aircraft, we additionally retrieve the column amount from the ground return in clear-air conditions. Advantages and limitations of water vapor profiles derived from the stand-alone DAR technique are investigated including cloud properties, retrieval resolution, and accuracy. By embedding GRaWAC measurements in a multi-frequency cloud radar synergy, we find fingerprints of precipitation-forming processes, and highlight the potential of our measurements for future model evaluation studies.