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Profiling Arctic tropospheric water vapor using the Differential Absorption Radar GRaWAC

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Low-tropospheric water vapor is a central component of multiple feedback processes known to contribute to amplified warming in the Arctic. Continuous, highly resolved all-weather profiling observations are key to advance the understanding of the Arctic water cycle in a rapidly changing Arctic climate and to improve the representation of PBL mixed-phase clouds in modeling. Current state-of-the-art measurement techniques, yet, are limited by the occurrence of clouds, precipitation, and polar night, or lack the needed temporal or vertical resolution. The newly emerging Differential Absorption Radar (DAR) technique can overcome some of these challenges as in-cloud water vapor profiles can be derived continuously.

We illustrate the advantages of this novel technique for the Arctic PBL based on 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 suite includes observations from AWIPEV station, Ny-Alesund, from the central Arctic aboard a RV Polarstern cruise, and along the Norwegian coast aboard AWI's Polar-6 research aircraft. 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 in clear-air conditions.

We investigate advantages and limitations of water vapor profiles derived from the stand-alone DAR technique including cloud properties, retrieval resolution, and accuracy. Additionally, we illustrate alternative water vapor retrieval methods by making use of the synergy with passive microwave radiometer or conventional cloud radar measurements. 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.

Session A.01.08.: Planetary Boundary Layer from Space

The planetary boundary layer (PBL) plays an essential role in weather and climate, which are critical to human activities. While much information about the temperature and water vapor structure of the atmosphere above the PBL is available from space observations, EO satellites have been less successful in accurately observing PBL temperature and water vapor profiles and in constraining PBL modelling and data assimilation. Improved PBL models and parameterizations would lead to significantly better weather and climate prediction, with large societal benefits.

In the latest US National Academies' Earth Science Decadal Survey, the PBL was recommended as an incubation targeted observable. In 2021, the NASA PBL Incubation Study Team published a report highlighting the need for a global PBL observing system with a PBL space mission at its core. To solve several of the critical weather and climate PBL science challenges, there is an urgent need for high-resolution and more accurate global observations of PBL water vapor and temperature profiles, and PBL height. These observations are not yet available from space but are within our grasp in the next decade. This can be achieved by investing in optimal combinations of different approaches and technologies. This session welcomes presentations focused on the PBL, from the observational, modeling and data assimilation perspectives. In particular, this session welcomes presentations focused on future EO PBL remote sensing missions and concepts, diverse observational approaches (e.g., active sensing, constellation of passive sensors, hyperspectral measurements, high-altitude pseudo satellites) and potential combinations of techniques to optimally depict the 3D structure of PBL temperature and water vapor.

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