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Compact Operational Tropospheric Water Vapor and Temperature Raman Lidar with Turbulence Resolution

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We present the Atmospheric Raman Temperature and Humidity Sounder (ARTHUS), a new tool for observations in the atmospheric boundary layer and lower free troposphere during daytime and nighttime with very high resolution up to the turbulence scale, high accuracy and precision, and very short latency and illustrate its performance with new measurements examples. ARTHUS measurements resolve the strength of the inversion layer at the planetary boundary layer top, elevated lids in the free troposphere, and turbulent fluctuations in water vapor and temperature, simultaneously (Lange et al., 2019). In addition to thermodynamic variables, ARTHUS provides also independent profiles of the particle backscatter coefficient and the particle extinction coefficient from the rotational Raman signals at 355 nm with much better resolution than a conventional vibrational Raman lidar.

The observation of atmospheric moisture and temperature profiles is essential for the understanding and prediction of earth system processes. These are fundamental components of the global and regional energy and water cycles, they determine the radiative transfer through the atmosphere, and are critical for the cloud formation and precipitation (Wulfmeyer, 2015). Also, as confirmed by case studies, the assimilation of high-quality, lower tropospheric WV and T profiles results in a considerable improvement of the skill of weather forecast models particularly with respect to extreme events.

Very stable and reliable performance was demonstrated during more than 3000 hours of operation experiencing a huge variety of weather conditions, including seaborne operation during the EUREC4A campaign (Bony et al., 2017, Stevens et al., 2020). ARTHUS provides temperature profiles with resolutions of 10-60 s and 7.5-100 m vertically in the lower free troposphere. During daytime, the statistical uncertainty of the WV mixing ratio is <2 % in the lower troposphere for resolutions of 5 minutes and 100 m. Temperature statistical uncertainty is <0.5 K even up to the middle troposphere. Consequently, ARTHUS fulfills the stringent WMO breakthrough requirements on nowcasting and very short-range forecasting (see www.wmo□sat.info/oscar/observingrequirements).

This performance serves very well the next generation of very fast rapid-update-cycle data assimilation systems. Ground-based stations and networks can be set up or extended for climate monitoring, verification of weather, climate and earth system models, data assimilation for improving weather forecasts.

References:

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