The Atmospheric Raman Temperature and Humidity Sounder: Highlights of Three Years of Ground-based and Ship-borne Boundary Layer Measurements with Turbulence Resolution

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Since there are only a very few suitable measurements, the thermodynamic field of the lower troposphere is mostly still Terra Incognita. To close this gap, we developed a thermodynamic profiler based on the Raman lidar technique. We call this instrument Atmospheric Raman Temperature and Humidity Sounder (ARTHUS) (Lange et al. 2019). ARTHUS can be operated on ground-based, ship-borne and airborne platforms.

Due to an advanced design of the transmitter and the receiver, simultaneous profiling of temperature (T) and water-vapor mixing ratio (WVMR) is possible with unprecedented accuracies and resolutions. Typical resolutions are a few seconds and meters in the lower troposphere. With the measurements themselves, also the statistical uncertainties are derived. The design of the system permits measurements in all weather conditions and even in clouds and rain up to an optical thickness of approx. 2.

Stable 24/7 operations over long periods were achieved during several field campaigns and at the Land Atmosphere Feedback Observatory (LAFO) accumulating almost a year of data until now and covering a huge variety of weather conditions.

During the EUREC4A field campaign (Stevens et al, 2020), for example, ARTHUS was deployed on board RV Maria S Merian, to study ocean-atmosphere interaction, (18 Jan to 18 Feb 2020). ARTHUS was combined with one Doppler lidar in vertically staring mode and a second one in a 6-beam scanning mode.

Between 15th July and 20th September 2021, ARTHUS was deployed at Lindenberg Observatory from the German Weather Service (DWD). The objective of the campaign was to demonstrate the potential of ARTHUS in the framework of a ground-based measurement campaign and the evaluation of the data obtained. The long-term stability, accuracy and high resolution of ARTHUS during the day and at night were demonstrated.

Since we started measuring, we demonstrate that ARTHUS is capable of resolving (1) the strength of the inversion layer at the atmospheric boundary layer (ABL) top and thus the ABL depth zi, (2) elevated lids in the free troposphere, and (3) turbulent fluctuations in WVMR and T. In combination with Doppler lidar, the latter permits measurements of sensible and latent heat flux profiles in the convective ABL and thus flux-gradient relationships (Behrendt et al. 2020). Consequently, ARTHUS can be applied for process studies such as land-atmosphere feedback, weather and climate monitoring, model verification, and data assimilation in weather forecast models.

At the conference, highlights of the measurements during the last three years will be shown.