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High-resolution measurements of humidity and temperature with lidar

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3-dimensional thermodynamic fields of temperature and moisture including their turbulent fluctuations have been observed with the two scanning lidar systems of University of Hohenheim in three field campaigns in 2013 and 2014. In this contribution, we will introduce these two self-developed instruments and illustrate their performance with measurement examples. Finally, an outlook to envisioned future research activities with the new data sets of the instruments is given.

Our temperature lidar is based on the rotational Raman technique. The scanning rotational Raman lidar (RRL) uses a seeded frequency-doubled Nd:YAG laser at a wavelength of 355 nm. A two-mirror scanner with a 40-cm telescope collects the atmospheric backscatter signals. Humidity measurements are made with a scanning water vapor differential absorption lidar (DIAL) which uses a titanium sapphire laser at 820 nm as transmitter. This laser is pumped with a frequency-doubled Nd:YAG laser and injection-seeded for switching between the online and offline wavelengths. The DIAL receiver consists of a scanning 80-cm telescope. The measured temperature and humidity profiles of both instruments have typical resolutions of only a few seconds and 100 m in the atmospheric boundary layer both in day- and night-time.

Recent field experiments with the RRL and the DIAL of University of Hohenheim were (1) the HD(CP)2 Prototype Experiment (HOPE) in spring 2013 in western Germany - this activity is embedded in the project HD(CP)2 (High-definition clouds and precipitation for advancing climate prediction); (2) a measurement campaign in Hohenheim in autumn 2013; (3) the campaign SABLE (Surface Atmospheric Boundary Layer Exchange) in south-western Germany in summer 2014.

The collected moisture and temperature data will serve as initial thermodynamic fields for forecast experiments related to the formation of clouds and precipitation. Due to their high resolution and high precision, the systems are capable of resolving turbulent fluctuations of moisture and temperature in the convective boundary layer (CBL) from the surface to the entrainment zone, profiles of stability variables such as buoyancy as well as the CBL height, aerosol backscatter fields and cloud boundaries. The combination of these water vapor and temperature lidar instruments with Doppler lidar allows for deriving co-variances such as latent and sensible heat fluxes. The resulting new data sets are especially interesting for the validation and improvement of model parameterizations.