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Synergy of Raman lidar and microwave radiometry for high vertically resolved atmospheric profiles

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Atmospheric humidity and temperature are important variables to describe any meteorological event. Highly resolved, accurate and continuous measurements of these parameters are required to better understand atmospheric processes. Unfortunately, remote sensing instruments available nowadays are not able to provide sufficient spatial resolution to describe short time scale processes. In order to overcome the specific limitation of a given sensor, instrument synergies are gaining importance in the last years. Here, we present a synergy of a Microwave Radiometer (MWR) and a Raman Lidar (RL) system.

The retrieval algorithm that combines these two instruments is an innovative scheme, based on an Optimal Estimation Method (OEM). It allows a complete error description of the retrieved profiles. The method is designed for clear sky periods. Firstly, the OEM has been applied to the two months dataset of HOPE, a field campaign in Jülich, Germany. Different experiments are performed to evidence the improvements of the synergy. We demonstrate that, when applying the combined retrieval to the whole HOPE period, the absolute humidity error can be reduced by 59.8% and 37.9% on average, with respect to the retrieval using only-MWR data or only-RL, respectively. The algorithm is also applied to a single case study of temperature and relative humidity profiles. For temperature, it is shown that the error is reduced by 47.1% and 24.6% with respect to the only-MWR and only-RL profiles, respectively. We further show that the joint use of temperature and humidity measurements provides improved relative humidity estimates, which will be especially useful to study cloud formation in the vicinity of cloud edges.

In addition to the ground-based application during HOPE, the algorithm is used with aircraft-based measurements. High Altitude and Long-range research aircraft (HALO) data, collected over the Tropical Atlantic in December 2013, are analyzed and preliminary results are presented.

In general, the benefits of the sensor combination are especially strong in regions where Raman Lidar data is not available (i.e. overlap region, poor signal to noise ratio), whereas if both instruments are available, RL dominates the retrieval.