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Seminar über Microwavephysics and Atmospheric Physics

Referent: Dr. Maria Barrera Verdejo, Institute for Geophysics and Meteorology, University of Cologne, Germany

Titel: Lidar and Microwave Radiometer Synergy for High Vertical Resolution Thermodynamic Profiling

Continuous monitoring of thermodynamic atmospheric profiles is important for many applications, e.g. assessment of atmospheric stability and cloud formation. Nowadays there is a wide variety of ground-based sensors for atmospheric profiling. Unfortunately there is no single instrument able to provide a measurement with complete vertical coverage, high vertical and temporal resolution, and good performance under all weather conditions, simultaneously. For this reason, in the last decade instrument synergies have become a strong tool used by the scientific community to improve the quality and usage of the atmospheric observations. Aiming to overcome the specific sensor limitations, the microwave radiometer (MWR) and lidar synergy has been developed.
On the one hand, lidar measurements can provide water vapor or temperature measurements with a high vertical resolution albeit with limited vertical coverage, due to overlapping function (OVF) problems, sunlight contamination and the presence of clouds. On the other hand, MWRs receive water vapor, temperature and cloud information throughout the troposphere though their vertical resolution is poor. The retrieval algorithm combining these two instruments is called Lidar and Microwave Synergetic Optimal Atmospheric Profiler (LIME SOAP) and is based on an Optimal Estimation Method (OEM). The main advantage of this technique with respect to other retrieval algorithms, e.g. neural networks, Kalman filters, etc., is that an OEM allows for an uncertainty assessment of the retrieved atmospheric products.
LIME SOAP combines measurements, i.e. MWR brightness temperatures and lidar water vapor mixing ratio and/or temperature profiles, with a priori atmospheric information taking the uncertainty of both into account. The method is applied to two different scenarios, i.e. ground based measurements during a two months campaign in Germany, and airborne measurements over tropical and subtropical Atlantic Ocean, for retrieving high vertical resolution profiles of absolute humidity (AH), temperature (T), relative humidity (RH) and liquid water path (LWP). For all retrievals, the studies in terms of theoretical error and degrees of freedom per signal reveal that the information of the two sensors is optimally combined. In addition, the vertical resolution of the products is improved when the MWR+lidar combination is performed with respect to the instruments working alone.
Results show that, for example, when applying the LIME SOAP for ground-based AH profiling, on average the theoretically determined absolute humidity uncertainty is reduced by 60% (38%) with respect to the retrieval using only-MWR (only-Raman lidar) data, for two-months data analysis. For temperature, it is shown that the error is reduced by 47.1% (24.6%) with respect to the only-MWR (only-Raman lidar) profile, when using a collocated radiosonde as reference.
The benefits of the sensor combination will be shown, being especially strong in regions where lidar data is not available, whereas if both instruments are available, the lidar measurements dominate the retrieval.

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