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Combining satellite- with ground-based measurements for near-real-time monitoring of atmospheric stability, atmospheric water vapor and liquid water.

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Short-term forecasts of current high-resolution numerical weather prediction models still have large deficits in forecasting the exact temporal and spatial location of severe, locally influenced weather such as summer-time convective storms or cool season lifted stratus or ground fog. The thermodynamic instability - especially in the boundary layer - plays an essential role in the evolution of weather events. While the thermodynamic state of the atmosphere is well measured close to the surface by in-situ sensors and in the upper troposphere by satellite sounders, the planetary boundary layer remains a largely under-sampled region of the atmosphere where only sporadic information from radiosondes or aircraft observations is available.

The major objective of the presented DWD-funded project ARON is to overcome this observational gap and to design a network of ground-based microwave radiometers (MWR) and compact water vapor Differential Absorption Lidars (DIAL) for continuous, near-real-time monitoring of temperature and humidity in the atmospheric boundary layer in order to monitor thermodynamic (in)stability.

Previous studies showed that microwave profilers are well suited for continuously monitoring the temporal development of atmospheric stability (Cimini et al. 2015). However, the vertical resolution of microwave temperature profiles is best in the lowest kilometer above the surface, decreasing rapidly with increasing height. In addition, humidity profile retrievals typically cannot be resolved with more than two degrees of freedom for signal, resulting in a rather poor vertical resolution throughout the troposphere. Typical stability indices (STI) used to assess the potential of convection rely on temperature and humidity values not only in the region of the boundary layer, but also in the layers above. Therefore, satellite remote sensing is expected to complement ground-based MWR and DIAL observations.

In this contribution, we present a neural network retrieval of stability indices, integrated water vapor (IWV) and liquid water path (LWP) from simulated satellite- and ground-based measurements based on the COSMO-REA2 reanalysis as truth. In order to make the approach feasible for data assimilation applications, we simulate satellite observations with the standard RTTOV model and use the newly developed RTTOV-gb (ground-based) for the ground-based microwave radiometers (De Angelis et al., 2016). Focusing on the temporal resolution and spatial coverage, the satellite-based instruments considered in the study are the currently operational SEVIRI and the future IRS, both in geostationary orbit. We show the single instrument performance and the synergy benefit in terms of correlation, uncertainty reduction, probability of detection and other forecast skill scores. Compared to the retrieval based on satellite observations only the additional ground-based MWR/DIAL measurements were shown to provide valuable improvements not only in the presence of clouds, which represent a limiting factor for infrared SEVIRI/IRS, but also under clear sky conditions.

To assess the spatial representativeness of observations of a single ground-based MWR/DIAL and to estimate the required network density the retrieval is applied to a 150*150km reanalysis domain. The accuracy of fields of STI/IWV/LWP calculated from satellite only and from combined satellite and ground-based observations is estimated and the added value of ground-based observations in a network configuration is discussed.