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A virtual remote sensing observation network for continuous, near-real-time monitoring of atmospheric instability

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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. Often, 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 (i.e. 2 m) 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 (Extramural Research Programme) is to overcome this observational gap and to design an optimized network of ground based microwave radiometers (MWR) and compact Differential Absorption Lidars (DIAL) for a 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 (i.e. Cimini et al., 2015) before the initiation of deep convection, especially in the atmospheric boundary layer. 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 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 (i.e. SEVIRI, AMSU) is used to complement observations from a virtual ground-based microwave radiometer network based on the reanalysis of the COSMO model for Europe.
In this contribution, we present a synergetic retrieval algorithm of stability indices from satellite observations and ground-based microwave measurements based on the COSMO-DE reanalysis as truth. In order to make the approach feasible for data assimilation applications at national weather services, we simulate satellite observations with the standard RTTOV model and use the newly developed RTTOV-gb (ground-based) for the ground-based radiometers (De Angelis et al., 2016). For the detection of significant instabilities, we show the synergy benefit in terms of uncertainty reduction, probability of detection and other forecast skill scores.
The overall goal of ARON is to quantify the impact of ground-based vertical profilers within an integrated forecasting system, which combines short-term and now-casting.