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Combining ground-based, satellite and airborne measurements in the retrieval of the atmospheric state: assessment of the information content

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The combination of multiple wavelength active and passive remote sensing instruments offers the unique opportunity to derive the atmospheric state as completely as possible. In particular, the Integrated Profiling Technique (IPT, Löhnert et al., 2008) has been successfully applied to derive profiles of temperature, humidity and liquid water by a Bayesian based combination of ground based microwave radiometer, cloud radar and a priori information. Within the project ICOS (Integrating Cloud Observations from Ground and Space – a Way to Combine Time and Space Information), we develop a flexible IPT, which allows for the combination of a variety of ground based measurements from cloud radar, microwave radiometer (MWR) and IR spectrometer as well as satellite based information from the Meteosat SEVIRI instrument. In this way, thermodynamic and cloud property profiles, i. e. hydrometeor content and effective radius, can be derived with higher accuracy throughout the profile.

As ground based observations are mainly sensitive to the lower parts of the troposphere, the satellite measurements provide complementary information and are thus expected to improve the estimates of the atmospheric state considerably in both clear sky and cloudy conditions. In order to understand the improvement by integrating the measurements of the above mentioned instruments into the IPT, sensitivity studies on information content and retrieval error estimates are performed. To this end, different measurement combinations and different assumptions in the error covariance matrix are used. Furthermore, the potential of downlooking microwave observations from satellite (AMSU-A and -B) and aircraft (High Altitude LOng range research aircraft (HALO) Microwave Package), in the retrieval is investigated. The information gain due to the incorporation of these existing instruments in the upper troposphere / lower stratosphere region is analysed. Similarly the impact of future instrument configurations, e.g., hyperspectral resolution, can be studied.

By means of these sensitivity studies, which are performed on the basis of synthetic data for a mid-latitude site, the information content is calculated and the optimal combination of instruments will be identified for the retrieval of the atmospheric profiles. The information improvement in the retrieval due to the combination of ground and satellite / airborne based measurements will be shown. Preliminary results indicate, for example, that the number of degrees of freedom, i. e. the independent pieces of information, in the retrieved temperature (humidity) profile increases by about 1 (2), if the MWR measurements are combined with the SEVIRI measurements.

Reference:
Löhnert, U., S. Crewell, O. Krasnov, E. O'Connor, and H. Russchenberg, Advances in continuously profiling the thermodynamic state of the boundary layer: integration of measurements and methods, Journal of Atmospheric and Oceanic Technology, 25, 1251–1266,
2008.