

Active and passive microwave retrieval algorithm for hydrometeor concentration profiles: application to the HAMP instrument

E. Orlandi, M. Mech, S. Crewell, A. Lammert

Clouds and precipitation play an important role in the atmospheric water cycle and radiation budget. Unfortunately, the understanding of the processes involved in cloud and precipitation formation and their description in global and regional models are still poor. To improve our understanding of these processes and to reduce model uncertainties, new observation and retrieval techniques are needed. The upcoming Global Precipitation Mission (GPM) provides a combination of a 36 GHz cloud radar and a suite of passive microwave instruments. In the retrieval development process for this and other upcoming missions, airborne platforms are a useful tool to test the algorithms exploiting the synergy of active and passive microwave instruments, and to validate satellite retrievals.

In this respect HAMP (Microwave Package for HALO, the High Altitude Long Range aircraft), consisting of a 36 GHz Doppler cloud radar and a 26-channel radiometer, is an ideal test-bed. HAMP radiometers have frequencies along absorption lines (22, 60, 118 and 183 GHz) and in window regions, overlapping with those of AMSU A and B. HAMP will participate in early 2013 in the dedicated remote sensing HALO mission NARVAL (Next-generation Aircraft Remote-sensing for VALidation studies). During NARVAL, the HALO payload will include a water vapor lidar and drop sondes in addition to HAMP. The NARVAL campaign will thus be an excellent opportunity to test a newly developed retrieval algorithm, which exploits the synergy between passive and active microwave observations.

In this work we present a Bayesian algorithm to retrieve precipitation rate, liquid and frozen hydrometeor concentration, as well as temperature and humidity profiles from the synergetic use of active and passive microwave nadir observations. Temperature and humidity are derived solely from passive radiometer measurements while the combined cloud radar and radiometer observations are used to retrieve hydrometeor concentration profiles. Lidar measurements enable the detection of thin cloud and to constrain cloud top height. The algorithm is calibrated and tested with simulated microwave measurements. Radar reflectivities and radiometer brightness temperatures are calculated with the radiative transfer model (RTM) PAMTRA (Passive and Active Microwave TRAnsfer). The atmospheric state and hydrometeor content profiles, used as input for the RTM, are supplied by high-resolution (2.5 km) simulations from the limited area model COSMO-DE including two-moment cloud microphysics.

Numerous COSMO-DE simulations of precipitating frontal systems crossing the North Atlantic are used to create a database of clear-sky, cloudy, and precipitating profiles and corresponding brightness temperatures and reflectivities. The database is used to construct a-priori information to constrain the inverse problem solution and to provide synthetic data to estimate the error of retrieved variables. The potential of the combined active/passive microwave observations is then assessed by including various combinations of radiometer channels in the retrieval and by modulating the influence of the a-priori on the retrieved variables. These sensitivity studies shall indicate to which extent HAMP is able to validate precipitation estimates from satellite retrievals and from numerical weather prediction simulations.