Retrieving 2-D Water Vapor Fields with Two Microwave Radiometers

Water vapor plays a key role in the the hydrological cycle, but its influence on initiation and strength of atmospheric convection is poorly known. A better understanding of this process would help to improve the quantitative precipitation forecast. To this end, highly resolved measurements of the water vapor field are mandatory.

In order to derive 2-dimensional water vapor fields on the meso-scale, a tomographic method with two microwave radiometers is investigated with synthetic observations. First, simulations of measurements between 22 and 31 GHz are carried out with a radiative transfer model using water vapor fields, for a Large Eddy Simulation (LES) model. The LES has been setup with a horizontal resolution of approximately 500 m for realistic cloud free cases around the Jülich Observatory for Cloud Evolution (JOYCE), Germany. A baseline of 6.7 km between two microwave radiometers that perform elevation scans towards each other is considered. Second, the measurement simulations are input to an algorithm in order to compute the water vapor field. This algorithm, which is based on the optimal estimation approach, requires additional information, i. e. an a priori water vapor field that is derived from the LES model.
This methodology allows to compare the retrieval performance for various measurement geometries. The structure of the original field is better reproduced by using two microwave radiometers, than by one radiometer. The uncertainty in the derived water vapor field decreases and the information content increases by 65 %. Even doubling the number of elevation angles for one radiometer does not reach this quality level. However increasing the number of elevation angles for two radiometers cannot infinitely improve the results. For the atmospheric conditions investigated, the optimal number of angles lies between 18 and 36. Apart from the number of elevation angles, the distribution of the angles over the measurement field is crucial for the quality of the computed water vapor field. The angles should be distributed in such a way that most measurements stem from those regions where the a priori field exhibits the largest uncertainties.

To validate the results of the theoretical study, a measurement campaign is planned, in which a scanning water vapor differential absorption lidar (DIAL) will measure simultaneously with two microwave radiometers. Furthermore, comparisons to GPS measurements and model output will be performed.