# The complexity of a 1D-Var retrieval for temperature, humidity and warm clouds

K. Ebell, E. Päschke, U. Löhnert, E. Orlandi, S. Crewell

Warm clouds, consisting of liquid droplets only, are assumed to be the simplest cloud type to be observed. However, retrieved warm cloud properties, i.e. liquid water content and droplet effective radius, may differ significantly among different retrieval methods. Uncertainties may arise from retrieval assumptions but also from measurement biases.

Here, we will present the results of a 1D-Var retrieval method, the Integrated Profiling Technique (IPT, Löhnert et al., 2008), which combines ground-based microwave radiometer (MWR), cloud radar and a priori information to derive profiles of temperature, humidity, liquid water content (LWC) and droplet effective radius (REF). In contrast to other commonly used cloud radar-MWR-methods, which retrieve LWC and REF from simple relations (e.g. Frisch et al., 1995, 1998), the IPT provides physically consistent profiles implying that the measurements can be reproduced from the retrieved profiles within their assumed errors.

First, we will test the retrieval performance using synthetic observations. Knowing the "truth", i.e. the true T, q, LWC, and REF profiles, we can simulate what the instruments would observe. In this way, we can test how the retrieval behaves under ideal conditions. Ideal means that no (often unknown) instrument biases exist and the forward model and the corresponding assumptions in the forward model are appropriate. On the one hand this approach allows to test if the retrieval and its equations have been set up properly, on the other hand it allows to analyze the interplay of prior, measurement and forward model uncertainties in the retrieval. In the "real world", it is likely that measurements are biased due to calibration errors or drifts in the instrument. Furthermore, the forward model might not be appropriate; e.g. the droplet size distribution assumed in the forward model might not represent the true one. We will also assess how such discrepancies affect the retrieved cloud property profiles.

In addition, the application of the IPT to the cloud observations at the Jülich Observatory for Cloud Evolution (JOYCE) and the Richard Aßmann Observatory (RAO) will be presented. The results will also be set into context to other commonly used cloud radar - MWR cloud retrieval algorithms.

Frisch, A., G. Feingold, C. Fairall, T. Uttal, and J. Snider, On cloud radar and microwave radiometer measurements of stratus cloud liquid water profiles, Journal of Geophysical Research, 103, 23195–23197, 1998.

Frisch, A., M. Shupe, I. Djalalova, G. Feingold, and M. Poellot, The retrieval of stratus cloud droplet effective radius with cloud radars, Journal of Atmospheric and Oceanic Technology, 19, 835–842, 2002.

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