The complexity of variational retrieval of liquid cloud properties

The combination of multiple wavelength active and passive remote sensing instruments offers the unique opportunity to derive the atmospheric state as complete 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 content (LWC) by a Bayesan based combination of ground-based microwave radiometer (MWR), cloud radar and a priori information. This technique has been recently extended to also retrieve profiles of droplet effective radius (REF) including also updated prior information on LWC and REF and a new forward model to simulate the cloud radar reflectivities from LWC and 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.

Next, we will apply the retrieval to cloud observations at the Jülich Observatory for Cloud Evolution (JOYCE). As a precondition, measurements have to be checked first thoroughly for biases/offsets. The sensitivity of the retrieved profiles to the bias/non-bias corrected measurements will be discussed. In addition, the results of the IPT will also be set into context to other commonly used cloud radar - MWR cloud retrieval algorithms.

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