Three-dimensional Tomography of Cloud Microphysics by Combining Microwave Radar and Radiometer Measurements

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The retrieval problem of microwave cloud tomography is highly ill-posed when only a few passive sensors are used

Cloud tomography is a technique for imaging cloud structure from multi-angular emission measurements. Retrievals are very sensitive to small measurement and/or numerical errors.

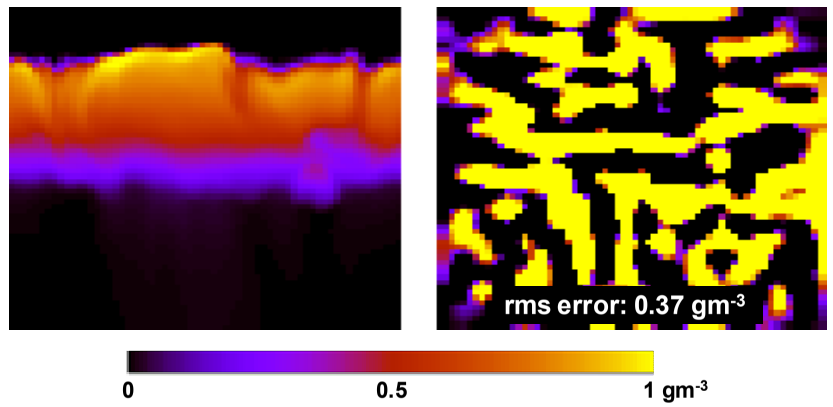

Fig 1. Demonstration of the ill-posed tomographic retrieval problem assuming a dual-radiometer configuration. The left panel shows the retrieved cloud water distribution (in a 5 Km wide 1.5 Km high domain) with noise free data. Adding a 0.2 K random noise to the radiometric data results in a very unrealistic retrieval (right panel).

To beat down the ill-posedness, more data are needed, e.g., radar measurements

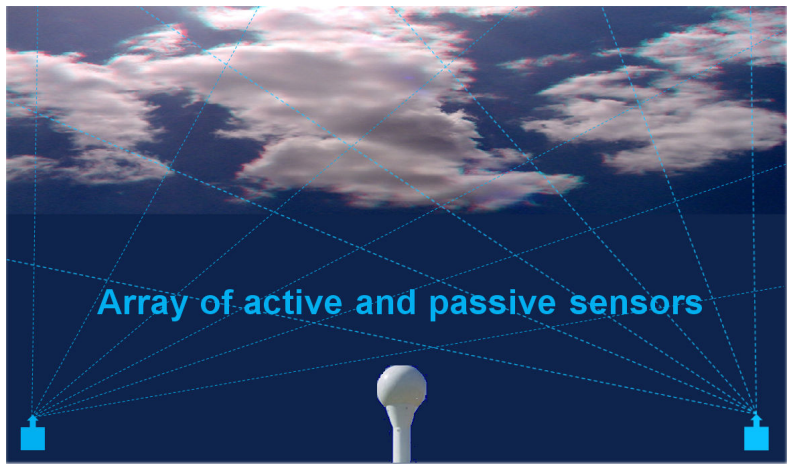

Fig 2. Schematic of ground-based cloud tomography using a combination of two scanning microwave radiometers and one scanning radar.

Combining tomography and radar data improves the retrieval of cloud liquid water distribution

The dual-frequency data provide an initial guess of liquid water distribution (Hogan et al., 2005).

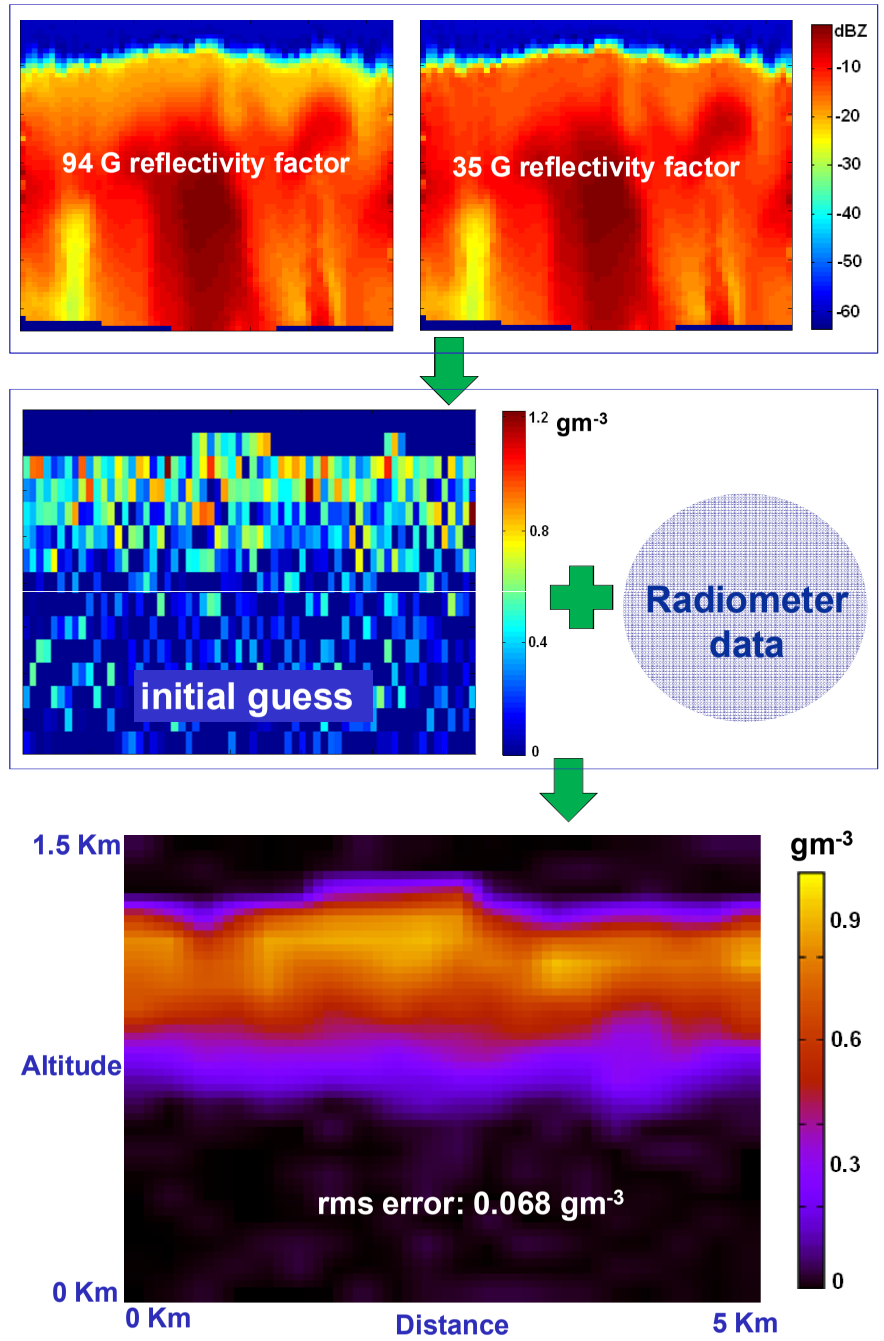

Fig 3. Dual-frequency radar data are used to derive an initial guess of the cloud liquid water distribution. The guess then serves as constraints in the tomographic algorithm. Adding radar data significantly improves the retrieval (compare to Fig. 1, right panel).

Summary

Retrieving cloud liquid water distributions with cloud tomography is ill-posed. Regularization methods can improve the retrievals, but still not enough when only a few sensors are available.

Cloud radar complements to passive sensors, and can be used to further constrain the tomographic retrievals. Adding radar data into cloud tomography greatly improves the retrieval accuracy.

Combining radar and cloud tomography offers the potential for retrieving cloud droplet number concentration and effective radius, in addition to cloud liquid water content.

Other cloud properties are also possible with the combined data

Some assumptions used in Frisch et al. (1995) can be relaxed or even eliminated, thus allow for the retrieval of more cloud properties.

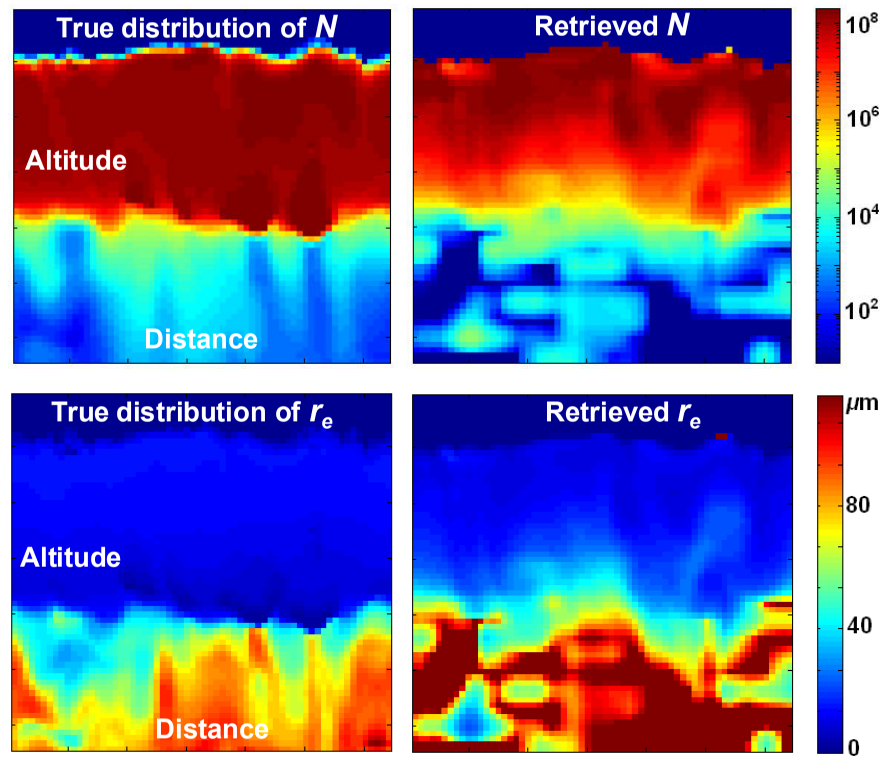

Fig 4. The true and retrieved distributions of cloud droplet number concentration N and effective radius r_e.

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