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What does reflection from cloud sides tell us about vertical distribution of cloud droplet sizes?

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Abstract. Cloud development, the onset of precipitation and the effect of aerosol on clouds depend on the structure of the cloud profiles of droplet size and phase. Aircraft measurements of cloud profiles are limited in their temporal and spatial extent. Satellites were used to observe cloud tops not cloud profiles with vertical profiles of precipitation-sized droplets anticipated from CloudSat. The recently proposed CLAIM-3D satellite mission (cloud aerosol interaction mission in 3-D) suggests to measure profiles of cloud microphysical properties by retrieving them from the solar and infrared radiation reflected or emitted from cloud sides.

Inversion of measurements from the cloud sides requires rigorous understanding of the 3-dimentional (3-D) properties of clouds. Here we discuss the reflected sunlight from the cloud sides and top at two wavelengths: one nonabsorbing to solar radiation (0.67 μm) and one with liquid water efficient absorption of solar radiation (2.1 μm). In contrast to the plane-parallel approximation, a conventional approach to all current operational retrievals, 3-D radiative transfer is used for interpreting the observed reflectances. General properties of the radiation reflected from the sides of an isolated cloud are discussed. As a proof of concept, the paper shows a few examples of radiation reflected from cloud fields generated by a simple stochastic cloud model with the prescribed vertically resolved microphysics. To retrieve the information about droplet sizes, we propose to use the probability density function of the droplet size distribution and its first two moments instead of the assumption about fixed values of the droplet effective radius. The retrieval algorithm is based on the Bayesian theorem that combines prior information about cloud structure and microphysics with radiative transfer calculations.

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