Remote sensing of droplet size profiles in cumulus clouds using the Research Scanning Polarimeter: tests on simulated data

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The Research Scanning Polarimeter (RSP) is an airborne along-track scanner measuring the polarized and total reflectance in nine spectral channels. Its uniquely high angular resolution allows for the characterization of liquid water cloud droplet sizes using the rainbow structure observed in the polarized reflectance over the scattering angle range from 135° to 165°. We use two separate retrieval techniques. The first one is a parametric fit assuming that cloud droplet size distribution (DSD) has gamma-distribution shape and yielding its effective radius and variance. The second one, the non-parametric Rainbow Fourier Transform (RFT), is able to provide the entire DSD shape with no pre-assumptions. The RSP's high angular resolution and frequency of measurements also allows for the estimation of cumulus cloud shape and position from the collection of view-lines tangent to the cloud surface.

In this study we introduce retrievals of vertical profiles of droplet size made along the illuminated side of the cumulus cloud. First, we use the RSP's tangent view-lines to determine the position of the cloud surface. Then for each point on the bright side of this surface we aggregate view-lines passing through it, thereby constructing the polarized reflectance corresponding to that point (as a function of scattering angle). The rainbow part of this reflectance is analyzed yielding the shape and parameters of the cloud DSD. Finally, the retrievals made for all available points on the cloud surface are combined into vertical profiles.

This profiling algorithm was tested by simulating RSP measurements over LES-generated clouds using the MSCART 3D RT code. Towering cumulus clouds were selected for this numerical experiment in preparation for analyses of real RSP measurements during the upcoming Cloud, Aerosol and Monsoon Processes Philippines Experiment. The results of the comparison between the virtual RSP retrievals and the actual microphysical parameters in the LES model show agreement in the effective radius and variance within 1 μm and 0.02, respectively. Also, the non-parametric RFT algorithm was able to detect and characterize two different populations of cloud droplets: one convectively rising from cloud bottom to top, while growing in size; and the other being activated at cloud top due to condensation and consisting of small 5-μm particles. This opens the way to process-oriented remote sensing based on the RSP data.

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