Spatial distribution of liquid water cloud droplet size properties retrieved from Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) observations

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Though the evolution of the cloud droplet size distribution (DSD) links radiative and microphysical climate impacts of clouds, it is traditionally hard to measure accurately from space. Radiometric bi-spectral retrievals infer cloud droplet effective radius (CDR), but biases from 3D effects [1], spatial heterogeneity [2], and insensitivity to effective variance (CDV) are known limitations. Polarimetric instruments sample clouds using a directional signal from the *polarized cloudbow* and retrieves CDR and CDV simultaneously and relatively free of the above biases. A parametric fit matches the cloudbow profile to Mie polarized phase functions for liquid water droplets, and confidence in the retrieval depends on the density of co-located view zenith angles, swath, resolution, polarization accuracy, and access to appropriate geometry (135°–165° in scattering angle). To meet these needs, the Earth and Space Institute at the University of Maryland/Baltimore County developed the Hyper Angular Rainbow Polarimeter (HARP), a wide field-of view imaging polarimeter instrument with a ±57° (±47°) along-track (cross-track) swath and 60 distinct, co-located, view angle pushbrooms at 0.67 μm. These capabilities allow cloud retrievals far perpendicular to the flight track and at narrow pixel-level resolution from space.

In this work, we discuss polarimetric cloud retrievals performed on Airborne HARP (AirHARP) cloud fields from the NASA Lake Michigan Ozone Study (LMOS) and Aerosol Characterization from Polarimeter and Lidar (ACEPOL) campaigns in 2017. AirHARP hyper-angle retrievals of CDR and CDV are performed for every masked super-pixel with applicable geometry. The resulting CDR and CDV "images" allow for phase correlation of intensity, CDR, and CDV for any cloud in the scene and scale analysis of the polarimetric retrieval itself, done by degrading the original data before the retrieval. Our retrievals confirm that CDV does not correlate with intensity, and CDV trends opposite to CDR and intensity in regions of convection. Comparisons of retrievals done at 200 and 600 m suggest that large superpixels hide heterogeneities and produce wider DSDs on cloud sides, consistent with large-eddy simulations [3]. When HARP-2 is launched on-board the Plankton-Aerosol-Cloud-ocean Ecosystem (PACE) spacecraft in the early 2020s, these CDR and CDV cloud retrievals will be performed with 2-day global coverage, < 4 km pixel resolution, and over a range of cloud types, including popcorn and convective cumulus.

References

[1] Marshak, A., *et al*., 2006: Impact of three-dimensional radiative effects on satellite retrievals of cloud droplet sizes. *J. Geophys. Res.* **111**, D09207.

[2] Zhang, Z., *et al*., 2012: Effects of cloud horizontal inhomogeneity and drizzle on remote sensing of cloud droplet effective radius: case studies based on large-eddy simulations. *J. Geophys. Res.* **117**, D19208.

[3] Miller, D. J., Z. Zhang, S. E. Platnick, A. S. Ackerman, F. Werner, C. Cornet, and K. Knobelspiesse, 2018: Comparisons of bispectral and polarimetric cloud microphysical retrievals using LES-Satellite retrieval simulator. *Atmos. Meas. Tech.* **11**, 3689–3715.

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