Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-380-RC3, 2019

Atmospheric Measurement Techniques Discussions

Interactive comment on "Spatial distribution of cloud droplet size properties from Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) measurements" *by* Brent A. McBride et al.

Gerard van Harten (Referee)

gharten@jpl.nasa.gov

Received and published: 27 November 2019

RECOMMENDATION:

Minor revisions

GENERAL COMMENTS:

The authors present the retrieval of cloud droplet size distributions from Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) data collected during the Lake Michigan Ozone Study (LMOS) field campaign. The scientific relevance of the work is clearly explained, as well as the timeliness with HARP Cubesat launched earlier this month

Printer-friendly version

Discussion paper

and HARP2 in development for the 2022 PACE mission. The radiometric bi-spectral retrieval, and the multi-angle polarimetric retrieval methods are introduced, followed by an overview of multi-angle polarimetric instruments and the strengths and weaknesses of their cloud retrievals, based on how each instrument uniquely samples the parameter space. The AirHARP instrument is described, particularly focussing on the features relevant for cloud droplet size retrievals. Next, the retrieval framework is presented, including the fit quality metrics. The large dimensionality of the AirHARP data is carefully explained using simulated imagery and LMOS data. Despite the limited size of the LMOS dataset over clouds, a homogeneous and a heterogeneous region are identified based on intensity (L) and droplet size effective radius (CDR) and variance (CDV). Cloud cores are associated with high L, high CDR, and low CDV, whereas cloud periphery regions are associated with the opposite. These findings are consistent with large-eddy simulations by Miller et al. (2018). An analysis follows of the impact of instrument spatial resolution on droplet size retrievals by aggregating the polarized reflectances into 600x600 instead of 200x200 m2 superpixels, showing broadening of CDV in a heterogeneous region. Finally, limitations and error sources are discussed, including pixel-level coregistration and optical etaloning in the imagery. Several recommendations for future work are provided, including field campaigns dedicated to clouds; comparisons with HARP Cubesat, HARP2, GOES-R; etaloning correction using science data; etaloning correction using HARP2 onboard calibrator; multi-modal retrieval algorithm; multi-wavelength retrieval algorithm; pixel-level topographic algorithm. The paper is very well written, with great attention to detail in text and graphics.

SPECIFIC COMMENTS:

AirHARP's native pixel size is 50x50 m2. However, data and retrievals presented in the paper are from 200x200 m2 superpixels.

I encourage the authors to reconsider showing retrievals at 50m resolution, given the specific attention in the paper to the impact of spatial resolution on droplet size retrievals, and statements such as:

"Our retrievals from this dataset show that cloud DSD heterogeneity can occur at the 200m scale, much smaller than the 1-2km resolution of most spaceborne sensors. This heterogeneity at the subpixel level can create artificial broadening of the DSD in retrievals made at resolutions on the order of 0.5 to 1 km." (P1_31)

The motivation for binning to 200m is "to increase SNR and mitigate other potential artifacts in the data. These artifacts will be discussed in Section 6" (P10_21).

However, it is not clear to me from Section 6 what exactly is the problem at 50m resolution, and the positive results at 200m rise the question if 50m could still be usable for the paper:

Section 6 (P14_21): "Conservative cloud identification and binning pixels to 200m (4x4) resolution further mitigates the error introduced by using this mean height. ... all retrievals shown successfully fit the RMSE threshold defined above. Therefore, we believe errors in our geolocation do not contribute significantly to the results of our study."

DETAILED COMMENTS:

- P2_15: "clouds would not exist at the scale we see them today": vague

- P3_21: "Reidi" -> "Riedi"

- P4_22: "fourier" -> "Fourier"

- P4_35: "modeled correlations" -> "image-specific empirical correlations"

- P9_11: "These diagnostics ... of the LUT": hard to read

- P11_24: "... retrieved on the periphery": Point out that reduced cloud fraction should not impact polarimetric retrieval (see Eq. (4))

- P12_38: "consistent with current research and theories of cloud microphysics": Similar finding with AirMSPI (Fig. 13 in Xu et al. (2018))

- P13_24: "fourier" -> "Fourier"

- Figure 5: Indicate flight direction, because it is perpendicular to Fig. 4b

- Figure 5, caption: What is the image size?

- Figure 6, caption: “150m superpixels”, whereas: P10_18: “Figure 6 shows several examples of an AirHARP 200m superpixel retrieval” Fig. 6: text inside plots “200m grd.res.”

- Figure 9: Units missing for Intensity and Effective Radius

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-380, 2019.

Printer-friendly version

Discussion paper