

## ***Interactive comment on “Low-level liquid cloud properties during ORACLES retrieved using airborne polarimetric measurements and a neural network algorithm” by Daniel J. Miller et al.***

**Anonymous Referee #3**

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The paper by Miller et al. developed a neural network (NN) approach for estimating droplet size and cloud optical depth from a combined set of radiometric and polarimetric datasets that RSP acquired during ORACLES. Proper weighting is performed by accounting for uncertainties with total and polarized radiance measurements. To correct the retrieval bias with effective radius (as compared to standard polarimetric cloud retrieval), the algorithm applied a correction. On such a basis, the NN and standard parametric polarimetric (PP) cloud retrievals of RSP ORACLES 2016 data give consistent results, e.g.  $R = 0.756$  and  $RMSE = 1.74\mu m$  for droplet effective radius and  $R = 0.950$  and  $RMSE = 1.82$  for cloud optical thickness.

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I read paper with much interests and have the following comments for the authors to consider:

1. The Nakajima & King approach uses the radiances in two bands for deriving an effective droplet size while polarimetric retrieval uses the angular distribution of cloud-bow polarization to estimate droplet size. These two approaches are a) subjected to different error sources (e.g. 3D for NK approach and cloud-top region only for polarimetric retrieval) and b) may carry information about the cloud droplet size for different regions. By combining two different types of datasets of retrieval, it is possible that error sources couple with each other and it becomes harder to disentangle their impacts on the retrieval products. In this sense, the authors need to be more clear about the essence of performing a combined retrieval.
2. The difference of retrievals in Figure 6 and 7 stems from the correction of NN retrieval of effective radius using both radiance and polarization using PP based retrieval using polarization only. This means PP retrieval of effective radius is still used as more accurate and standard data. Then would it be more sensible to directly derive effective radius from PP method and apply the combined dataset retrieval to just get cloud optical depth ?
3. When weighting the total and polarized radiance in NN retrieval, were the modeling errors included ? As the authors pointed out, radiances more subjected to plane-parallel modeling errors (while polarization is less subjected). How do the authors account for such an effect at the weighting step ?
4. As the authors pointed out, the above-cloud aerosols are expected to impact the NN retrieval (especially the cloud optical depth part). Could some immediate work be done by performing a numerical test to assess its impact ? For example, the authors can still use the plane-parallel model to generate radiance (but with the addition of absorbing aerosols above cloud). Then run the NN retrieval that excludes aerosols. With this extra work, it would be very helpful to track the aerosol induced errors and make their

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analysis in the current work more robust.

5. One of the advantages of polarimetric retrieval is to determine the effective variance ( $veff$ ) of cloud-top droplet size distribution, which means the information are in the polarimetric measurement. But on Page 5, the authors states “... an indication that this network cannot adequately retrieve  $veff$ ” ? I wonder if the NN algorithm somehow removes the information originally residing in the measurements.

Some editorial changes:

Abstract: the authors state that “This approach could be particularly advantageous for more complicated atmospheric retrievals such as when an aerosol layer lies above clouds like in ORACLES”. But the above-cloud aerosol effect was not accounted for in NN retrievals presented in the paper.

Figure 6. Unit (microns) needed to be added to RMSE of effective radius in the legend.

P. 15: “...after the RMSE in the  $veff$  evaluation after training is enough to span the possible state space” – an indication that this network cannot adequately retrieve  $veff$ ”. Here should the wording “enough” be “not enough”?

P. 28: Please add reference to the statement - “This is unlike the other RSP retrievals, which typically make use of a limited wavelengths and either polarized or total reflectance observations.”

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