<u>Author Responses to Anonymous Referee #1</u>

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Received and published: 2 September 2020

Dzambo et al. 2020 Oracles CWP/RWP, Review

The authors have developed a routine that uses multiple aircraft-borne instruments to discern cloud properties in the SE Atlantic Stratocumulus deck, with a focus on partitioning cloud liquid water and rain water. The routine is mostly sensitive for thicker, drizzling stratocumulus, but has a greater amount of uncertainty for more heavily precipitating convective-type clouds. Case studies show reasonable performance, with drizzling stratocumulus clouds containing far more cloud water than rain water, but heavier raining clouds containing more rain water (though results are less uncertain). The routine is stated to be insensitive to aerosols in the environment, making retrievals from this platform ideal for studying the aerosol-cloud interactions in the SE Atlantic.

We thank you very much for taking the time to review and comment on this manuscript! We have responded to each of your comments in blue text (indented after and below each comment), and hope that each of our comments sufficiently addresses each of your concerns. Updates or changes to the manuscript text are denoted in red text.

The manuscript is well explained, cleanly presented, and results are well supported by the material and figures presented. The RWP/CWP data from ORACLES will provide significant scientific value for the community. The paper is in no need of significant revisions and the routine presented is not particularly controversial as it relies on a great deal of established science. Given the purposes of ORACLES, to specifically study aerosol/cloud interactions, I would like to see a more detailed assurance that the routine is insensitive environmental aerosols. I recommend that the article be accepted in its present form, but with a few small details addressed.

This is an excellent point, and one that we definitely feel needs to be addressed in this manuscript. Ultimately, we do need to demonstrate (or at minimum, clearly state any related limitation) how sensitive our algorithm is to overlying aerosols. In short, the RSP cloud effective radius products are insensitive to overlying aerosol, but the cloud optical depth products are likely somewhat sensitive to overlying aerosol. We have written a more thorough response below, which we believe addresses this concern.

Comment:

Parts of this routine (not the radar part) rely on optical properties of cloud tops. I'm somewhat surprised that overlying aerosols have no effect on cloud bow properties and reflectances. It would benefit the paper to state directly how we can be certain that the routine is insensitive to overlying scattering aerosols, and whether this has been tested. It's possible that this is explained in the referenced material, but a quick explanation here would be beneficial.

Thank you for bringing this to our attention. We were unclear with this important aspect: RSP cloud top effective radius is *not* sensitive to overlying aerosol, but the cloud optical depth is sensitive to overlying aerosol. Aside from the references provided in the RSP methodology sections, we are unaware of any studies evaluating the effect of overlying aerosols on RSP COD retrievals (visible radiances). We have updated the text to ensure these points are very clear.

"Cloud optical depth (COD) is retrieved using ***radiometric reflection in the non-absorbing 864 nm band***, which may be affected by overlying aerosols, ***and the droplet size retrieval*** [cf. Nakajima and King, 1990]. Unlike the reflectance-based COD retrieval, multi-angle polarimetric cloud-top retrievals rely ***only*** on the shape of the cloudbow, not its intensity, and therefore ***is nearly*** unaffected by above-cloud aerosol layers and cloud 3-D effects [Alexandrov et al., 2012]."

Minor Fixes:

For stratocumulus, use the 'Sc' abbreviation.

We have taken care to update all former "StCu" abbreviations into "Sc" abbreviations throughout the text.

Page 6: were there any limitations or changes in results when CAS wasn't available and CDP was the only option for n(D)?

This is an interesting question. We did not explicitly check to see how different CAS and CDP n(D) in cases where they were both operating. With this in mind, the CAS and CDP instruments were mounted next to each other on the P-3, and we expect there to be minimal differences. In any case, this question will be investigated further and will ensure by final publication that CAS and CDP n(D) were not significantly different when operating together.

At some point around page 7, mu is replaced by u

We reviewed the text around page 7, and found no mention or use of "mu" or "u" on our part. We thank you for bringing this up regardless.

Line 20/21, page 10, not sure what you mean concerning RWP and CWP, are you implying that the a-priori rate keeps the algorithm from returning unrealistic RWP and CWP?

Thank you for bringing this to our attention. Yes, the entire intent and design of the a priori constraint is to ensure the final retrieved precipitation rates, RWP and CWP are within reasonable boundaries and prevents unrealistic CWP and RWP values from being returned. The last part of this sentence: "while also providing reasonable estimates for each" is inaccurate, and thus we eliminated this part from the text.

CWP is basically invisible in Figure 2. This could be by design to highlight how little RWP exists in the cloud compared to CWP, but maybe you could find a way to plot the lines in a semi-transparent way to highlight the overlap?

This is a very good suggestion. Indeed, the design of this figure was to optimize visibility as best as possible given there's admittedly a lot of data, and we intended to show that CWP dominates this scene. We will provide an update version of this figure that will show CWP/RWP/total (and rain/cloud optical depths in the bottom panel) much more clearly, either by using different sized lines or semi-transparent lines.

Line 21 The 2016 ORACLES campaign... Were there any other reasons that the RWP could be lower? Differences in EIS or other environmental variables? This isn't really important for the results, but may be worth looking into.

We were unsure which page you were referring to Line 21, but have done our best to address this question. There are many reasons (we think) RWP could be potentially lower. First, in 2016, a few flights took place very close to the African coast (where boundary layer heights were very low, often less than 800 meters) and a substantial fraction of measurements were taken just off the coast during routine flights. Clouds here were very thin, and hence RWP could reflect sampling of these environments conducive for thinner cloud. Second, EIS indeed is generally a lot higher in these low PBL altitude regimes. Finally, the peak of biomass burning season occurred during the 2016 experiment, so aerosols could very well have played a role (or contributed majorly) explaining why RWP was much lower. These questions are all being investigated, and appreciate your thought-provoking question here!

Figure 8: The text makes it clear, but can you mention in the caption that the obs are quasi-simultaneous?

We thank you for bringing this to our attention. In order to emphasis the methodology within the text, we followed your suggestion and updated the caption to the following (new addition is italicized here for clarity):

"A comparison of WCOD derived CWP versus cloud probe estimated CWP (top panel) and RWP (bottom panel). *Quasi-simultaneous WCOD profiles occurring within 5 minutes and 0.125 degrees latitude (~13 km) of an in-situ profile are included in this comparison.* The box and whisker plots represent 95% of all data, and the red squares represent the mean values. In the top panel, WCOD CWP is the combination of all WCOD based retrieved CWPs estimated by the algorithm. Any flight with a missing APR-3, RSP or cloud probe dataset was excluded from the statistics presented for each campaign year."

Upon reviewing this portion of the text, the code generating Fig. 8 actually used a lat/lon threshold of 0.125 degrees, and thus updated the text to reflect this correction (not 0.25 degrees as originally written and implied).