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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Estimations of Global Shortwave Direct Aerosol Radiative Effects Above Opaque Water Clouds Using a Combination of A-Train Satellite Sensors" *by* Meloë S. Kacenelenbogen et al.

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We thank the referee for their kind remarks and their very thorough reading of our lengthy manuscript.

1.a. AR#3: The analysis is restricted to clouds that are determined to be opaque, but the method by which opaque clouds are distinguished from clouds that are not opaque is not clear. In the appendix it is noted that the "CALIOP opacity flag" is used. There should be a brief mention in the body of the paper of the physical basis for the "opacity

flag".

Our answer: We now include this short description of the physical basis for the CALIOP opacity flag at the beginning of section 2.1: "Because the CALIOP backscatter signal is totally attenuated below the lowest "feature" detected within any profile [Vaughan et al., 2009], this lowest feature is defined as being opaque. Approximately 69% of the time, the opaque feature detected in a profile is the Earth's surface [Guzman et al., 2017]. In the remainder of the cases, the opaque feature is either a water cloud, an ice cloud, or, very rarely, an aerosol layer." (. . .) "(1) only one cloud can be detected within a 5 km (15 shot) along-track average (. . .) and (2) this one cloud must be opaque (i.e., lowest feature detected in a column, and not subsequently classified as a surface return)."

1.b. AR#3: Are there particular regimes where low clouds are prevalent but transparent?

Our answer: Yes. As shown by Figure 5 in Leahy et al. [2012], while transparent low clouds occur globally, they are much more prevalent in the southern oceans and, to a lesser extent, in the northern Pacific.

1.c. AR#3: There is a vague reference to "clouds such as the ones reported in Leahy et al. (2012)". A more specific description would be better.

Our answer: Our revised description of the Leahy reference now reads as follows in section 2.1: "However, because the DR retrieval technique requires backscatter measurements from opaque water clouds [Hu et al., 2007b], it cannot be used to retrieve AOD from aerosols lying above the low, transparent water clouds that are frequently observed over remote oceans, especially in the southern hemisphere (e.g., Leahy et al. [2012]; Mace and Protat [2018]; O et al. [2018])."

2. AR#3: Figure 1 indicates that the Southern Ocean is the most prominent place on the globe for uniform single layer clouds, but panel b suggests that they are not suitable for the depolarization ratio method. Perhaps it is not of great importance if

most of this region has little appreciable aerosol above the cloud layer. Nevertheless, I was left wondering why. Is it a quality of the clouds? Or merely a lack of aerosol optical thickness?

Our answer: Please see our response to the previous comment. The issue is the quality of the clouds; i.e., the clouds in the Southern Ocean are often transparent, and transparent clouds are not suitable for analysis using the DR method. We hope that the additional references (i.e., Mace and Protat [2018]; O et al. [2018]) will provide some further insights into the nature and causes of these geometrically and optically thin clouds.

3. AR#3: Panel d of figure 1 shows a substantial underestimate of cases of aerosol above cloud compared to a similar statistic based on the standard CALIOP aerosol optical thickness product for continents and for oceanic regions dominated by dust plumes. This is discussed in a couple of places in the manuscript, but nevertheless I remained confused as to the cause. The only indication in the body of the paper on line 316 where it says ". . .filtering out of 'unobstructed' but potentially aerosol-contaminated OWCs." The paper does not make clear what "obstructed" or "unobstructed" means in this context or why such clouds would be filtered. This sentence is in dire need of some plain English.

Our answer: In response to the referee's remark, we made numerous changes to the text in this paragraph. In particular, we replaced this sentence: "One reason for the lack of AAC cases offshore from the west coast of Africa in our dataset is the filtering out of "unobstructed" but potentially aerosol-contaminated OWCs (see section B3 in the appendix for more details)" with this more in-depth explanation: "The lack of AAC cases offshore from the southwest coast of Africa in the DR method dataset is the result of our conservative data filtering strategy. Because the IABs of aerosol-contaminated OWCs can differ significantly from those measured in pristine, aerosol-free conditions, OWCs suspected of being aerosol-contaminated (which are ubiquitous in this part of the world and very common over continents) are specifically excluded from our DR

method analyses (see appendix section B3 for more details)."

4. AR#3: Another place where the description is so technical as to hide the point is in the discussion of the extinction-to-backscatter ratios in sections 3.2.2 and 3.2.3. My sense is that there is an important point in these sections and that differences in the probability distributions in figure 6 must be significant. But it was not clear what that point is or what the significance to the main result of the paper is.

Our answer: This comment was particularly helpful to us. Thank you. The article under review is the result of many years of analysis. There was a time when this work was separated in two parts describing, on the one hand, our AAC aerosol optical depths (AOD) paired with CALIOP AAC extinction-to-backscatter values (S_AAC) and, on the other, the Direct Aerosol Radiative Effects above clouds (DARE_cloudy). The S_AAC values were there to illustrate the different aerosol types present above clouds. Our ultimate goal in this paper now being the calculation of global DARE_cloudy, and knowing that S_AAC values are not needed in our calculation of DARE_cloudy, these S_AAC are more of a distraction to the reader. As a consequence, we have deleted section 3.2.2, 3.2.3, appendix B4 and all of its dependencies. We plan to publish these results separately.

5. AR#3: Minor point: In the sentence beginning in line 308 the authors state ". . .negative (positive) values in blue (red) show the number of AAC cases that are missed (gained). . ." Way back in 2010 Prof. Robock pleaded with us to end this misuse of parentheses [Robock, A. (2010), Parentheses are (are not) for references and clarification (saving space), Eos Trans. AGU, 91(45), 419–419, doi:10.1029/2010EO450004]. My understanding is that one of the publishers in our field has specifically written it out of their style guide. I read pretty widely and the only genre of writing where I have experienced this application of parentheses is in the atmospheric sciences journals. I hope the authors will consider rewriting this sentence.

Our answer: We have re-written the sentence. Many thanks for the Robock reference.

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