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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Reducing uncertainties in satellite estimates of aerosol-cloud interactions over the subtropical ocean by integrating vertically resolved aerosol observations" *by* David Painemal et al.

Anonymous Referee #1

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In this work, the authors investigate the correlation between the cloud droplet number concentration and aerosol properties, demonstrating the important of information on the vertical location of the aerosol. The show that when aerosol close to (but below) the cloud top is used instead of height-integrated aerosol optical depth, the correlation between aerosol and MODIS N_d is improved.

The paper is well written with appropriate figures and illustrates a useful result that had previously been suggested using model data. I have a few overarching comments about the analysis and a couple of smaller comments, but after this, I would be happy

to recommend publication in Atmospheric Chemistry and Physics.

Major points

The paper starts off by mentioning the ACI construct, but then doesn't seem to refer to the ACI again. One very interesting potential consequence of this work is the impact on the ACI of the biases identified here. Is the error in the ACI using AOD random (in which case the mean ACI and RFaci are relatively unchanged) or is it a systematic bias, which would affect RFaci quantification. This is not a large addition to the manuscript, but it would be a potentially significant result that might not otherwise stand as a paper on its own.

Secondly, there appears to be a reliance on spatial correlations across the globe. Given that cloud properties vary across the globe and that these variations might be expected to generate variations in the CCN-N_d relationship (e.g. through updraft variations), is this not slightly dangerous? One factor that might be interesting is global maps of the correlations (or ACI), which might help to identify any regional effects.

Minor comments

L34 - product of

L45 - Stier (2016) noted that vertical mismatches are important to get a high correlation, but results using other aerosol-climate models (Gryspeerdt et al, PNAS, 2017) suggested that this does not have a large impact on the inferred RFaci (as long as the PD-PI aerosol product is appropriate). This paper focuses on the aerosol-N_d correlation, which is one step further removed from the RFaci. As the initial justification of this work is based around the RFaci, it would be good to mention how these results are linked to it/might affect it.

L117 - CALIPSO with CloudSat's

Section 2.2 - It sounds like the MODIS pixels are only paired with CALIOP pixels across the track, rather than along the track. This would mean that some closer pixels are

ignored, as they might be in the along-track direction.

L142 - Zhang and Platnick (JGR, 2011 - their Fig. 14) suggest that the 3.7um channel re is (slightly) negatively biased in in-homogeneous cases. how does this fit with the reasoning here? Also, is the 'cloudy-sky' retrieval mostly limited to high CF scenes (and might this explain the weaker N_d-CF relationship)?

L149 - I am unclear on how this binning procedure works. Not much needs to be included here, but it should be specified. What CF range is used?

L161 - I was probably just being slow, but it was only once I got here that I realized the below and above cloud top σ values are separate. Perhaps just make the in L124 a plural (σs) to make is clearer?

L168 - This has been noted in previous studies (e.g. Ma et al, Nature Communications, 2018)

L176 - Is this unexpected? Several studies in the past have hinted at a saturation of aerosol effects at high AOD.

L179 - It is stated here that there is a narrower range of N_d for each value of σ_{SFC}, but that it has a lower correlation coefficient with N_d that σ_{BC}. How does these observations fit together?

L182 - Give that the relationship is non-linear, would a measure such as Spearman's rank be more appropriate that an correlation coefficient?

L198 - It is difficult to compare the contours with the MODIS N_d image. I am not sure that this needs an extra panel, but I can't see a clear alternative. It could even just be stated I think (as it is not a vital part of this work)

Fig 5 and 7 - Could these be included in Fig. 4? Especially as they are mainly here to compare to 4a

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