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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Constraining the aerosol influence on cloud liquid water path" *by* Edward Gryspeerdt et al.

Anonymous Referee #2

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This manuscript is another valiant attempt to improve our understanding of whether the consequences of aerosol-cloud interactions ("aci") can be detected using satellite observations. There are major things I like in this paper: a fabulous dedicated section elucidating what processes may be actually happening during aci and what we may be seeing (or think we're seeing) from satellites instead; the hypothesis of the existence of two regimes where the aerosol effects on droplet numbers (Nd) and cloud evolution may be completely different depending on the base state of the cloud; and the potential use of cases of "natural experiments" to distinguish actual from perceived aerosol effects. However, I have a fundamental, philosophical uneasiness with using notoriously unreliably-retrieved cloud variables such as Nd and LWP as basis for the analysis. The authors try to ameliorate things by moving away from MODIS-based LWP (at least for

some of the analysis), but AMSR-E has its own issues and a mismatch in the reff and LWP retrieval scales is introduced. [Digression]: It always amazes me that from the reflectance of two MODIS channels one can retrieve four pieces of information, optical depth, reff, LWP and Nd. Yes, I understand they are related and this provides a weak (because of the many assumptions) constraint. But let's pull back and think about it: many combinations of droplet concentrations and sizes can give the same LWP and optical depth. There is a reason Nd is not included as a MODIS product, it's just too uncertain. When the first unofficial Nd products started to creep up, retrievals were performed on only overcast or near-overcast areas; now we started retrieving everywhere all the time, even if f_ad may be varying wildly. It is also unknown whether assumptions about linearly increasing LWC are better than the vertically constant LWC adopted in the official MODIS product. The authors are aware of most of these issues, as suggested by lines 16-23 of p. 3 (even though I should point out that the greatest worry is not random but systematic errors in OD and reff retrievals). Another problem is that Nd from MODIS corresponds to near cloud top (something that should have been disclosed earlier than the discussion section), while LWP is a vertically integrated quantity. In the context of aci does it make sense to correlate the two since aerosols will mostly affect Nd near the cloud base? I guess one implicitly assumes that Nd is constant with height, which then has implications about droplet size vertical profiles when LWC is increasing with height. I admit that I'm unsure whether all these caveats can alter the qualitative characteristics of the Nd-LWP histograms (or is it just a matter of shifting values in the same direction?) which are the centerpiece of the analysis, but I'm nevertheless uneasy with taking Nd and LWP retrievals at face value.

– Even though I have the same philosophical reservations I expressed here, this contemporaneous ACP paper may be worth taking a look at and perhaps citing, https://www.atmos-chem-phys-discuss.net/acp-2018-697/.

– As with many studies of this type, the authors should make clear that they do not examine the temporal co-evolution of Nd and LWP to understand how they interact/relate

as individual clouds thicken, thin out, produce/suppress precipitation. They rather compare different (static) incidences or cloud snapshots at 1 degree of scales.

– Lines 3-4 of p.5: Are you using the QA flags of the retrievals at all? I believe MODIS identifies edge pixels. Given your selection/filtering method, what is the range of CF at 1° degree scales?

– p. 6, first paragraph: Are you served well by a single global histogram given systematic changes of SZA with latitude?

– p.6, lines 27-30: May be it's just me, but I don't understand what you're saying here. Perhaps it can be written more clearly.

– p. 9, lines 1-7: Cluster 1 seems to be more frequent in the tropics than Cluster 2, so I'm not sure that characterizing Cluster 1 as "subtropical" and Cluster 2 as occurring "mostly in the tropics and extratropics" is accurate. Confusion is furthered by essentially calling Cluster 2 a low liquid-CF cluster, and also the main cluster of the Malavelle et al. (2017) study which I don't believe looked at low liquid-CF clouds. Are you sure that two clusters are sufficient to describe the diversity of Nd-LWP histograms?

– Fig. 7a shows, I believe, what has been previously called "cloud susceptibility" (Platnick and Twomey 1994; Oreopoulos and Platnick 2008) and it's a missed opportunity to not identify it as such.

– p. 18. Lines 3-5: Mid-latitude storm tracks also have very high CFs. Your mainly Cluster 2 southern oceans are covered by overcast supercooled liquid clouds.

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