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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Unveiling aerosol-cloud interactions Part 1: Cloud contamination in satellite products enhances the aerosol indirect forcing estimate" *by* Matthew W. Christensen et al.

Anonymous Referee #3

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This paper examines how colocation and sampling choices made in aerosol cloud interaction studies impact the strength any aerosol cloud relationships derived in those studies. Using data from MODIS and AATSR, the authors use a nearest neighbour approach to select pairs of aerosol and cloud pixels for analysis. They show that using aerosol retrievals located more than 15km from a cloud reduces the implied aerosol forcing from the AI-cloud albedo relationship as well as the implied extrinsic forcing due to a reduced AI-cloud fraction sensitivity.

The paper is well written and makes an important point about the sampling of aerosol retrievals when used in aerosol-cloud interaction studies. Previous work has shown

that aerosol retrievals are enhanced near clouds, but this work goes further, estimating the impact of this effect on the implied radiative forcing. There are a few points and one algorithmic suggestion that I would make, but other than that it is suitable for publication in Atmospheric Chemistry and Physics.

Main points

I appreciate that the intrinsic forcing concept has been used in the past, but I am not clear that the results from this necessarily carry across to other studies using an aerosol-CDNC relationship to constrain the aerosol indirect forcing. The intrinsic forcing relies on all the properties of the cloud being uncorrelated to CF. However, Feingold et al. (2016) showed that the cloud albedo can be very strongly correlated to CF. Given that cloud properties that are correlated to the CF have the potential to generate spurious aerosol-cloud relationships (Gryspeerdt et al., 2014), this might affect the evaluation of the intrinsic forcing. It is not clear how strongly aerosol-CDNC relationships are affected by covariation with CF, so it would be very interesting to see how the aerosol-CDNC type forcing calculation (e.g. Quaas et al., 2008) is affected by near-cloud aerosol retrievals in addition to the results presented here. I think that this would be necessary if the authors are to apply their conclusions to all satellite-based estimates, rather than just those that are based on the intrinsic forcing concept.

When calculating the radiative forcing, the authors use an anthropogenic aerosol fraction from Bellouin et al., 2013. This fraction is derived from AOD, not AI, and so may be smaller than expected in some regions, especially where dust dominates. There are other possible anthropogenic aerosol produces (such as a fraction from the AeroCom models, Ghan et al., 2016), but it should be noted that this method might produce an underestimate in the forcing through a too small anthropogenic fraction.

While the authors have already produced this dataset, if they wanted to re-run their analysis (or for others who want to reproduce it), it is worth noting that there are much more efficient algorithms for finding nearest neighbours in a large dataset. Binary search trees, such as a k-d tree or VP tree would work well here. A quick test using the standard python/scipy cKDTree on a close-to-worst-case MODIS granule (MYD06_L2-2013-136-2315, about 40% cloud fraction), found nearest neighbour aerosol pixels for all the cloud pixels (∼1million) in about 1 second with no restrictions on distance. Obviously the algorithm used by the authors can provide extra information, but this might be useful for further work.

Minor points

P2L22: Is it clear that there is a co-location 'problem'? The benefit of CAPA selecting the closest aerosol-cloud pairs is not mentioned beyond increasing the number of samples.

P2L34: How are the aerosols assimilated into models affected by wet deposition (compared to the aerosols retrieved by satellite)? Perhaps this should refer to 'aerosols from reanalysis products'?

P3L6: Does this really provide improved statistics? Many of the retrievals are strongly correlated in space (and time), so it is not clear that more individual datapoints provides more information.

P5L30: Some studies (e.g. Koren et al., 2012) perform interpolation between 1 by 1 degree gridboxes, which is a larger effective scale than the 150km shown here. I don't imagine that limiting the pairs to 150km is much of an issue, but it is not obviously correct to ignore them.

P6L10: Does this interpolation then mean that there are some 10km pixels which are considered both valid and invalid when filtering for pixels 15km from a cloud?

P7L19: As mentioned above, the number of degrees of freedom is smaller than the total number of cloud-aerosol pairs. How is the error estimate then calculated (does it account for the autocorrelation in the cloud and aerosol fields)?

P8L25: 0.1Wm-2 out of 0.4Wm-2 is still quite a large discrepancy

P10L23: The apostrophe in NERCs is not rendering correctly

Fig. 9: These extrinsic forcings (for the corrected L3 data) are quite close to those proposed by Gryspeerdt et al., 2016, which could provide supporting evidence for this proposed extrinsic forcing.

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