

Atmos. Chem. Phys. Discuss., referee comment RC3
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Comment on acp-2022-688

Anonymous Referee #3

Referee comment on "Possible evidence of increased global cloudiness due to aerosol-cloud interactions" by Alyson Rose Douglas and Tristan L'Ecuyer, Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-688-RC3>, 2022

This paper demonstrates a novel method for isolating aerosol impacts on global cloudiness from meteorological variability. Using a variety of decision-tree based methods, the paper shows that these decision trees can predict cloudiness and suggests that the difference between clean and average aerosol conditions can provide an indicator of the anthropogenic aerosol perturbation to cloud fraction. This is suggested to be independent of the estimated aerosol perturbation.

This work focuses on a difficult but important area, using a new set of methods to try and make progress on this problem. It is clearly within scope for ACP, but there are a number of areas I think should be addressed before publication.

Main points

It is not clear to me that clean conditions are a good proxy for the pre-industrial. There are significant sources of aerosol in the pre-industrial atmosphere and some processes (such as nitrate formation), may replace pathways in the present day atmosphere. As the authors state, their method does not directly calculate sensitivities and multiply them by an anthropogenic fraction. However, this is only because the assumptions about the anthropogenic fraction are already included in the method (that clean conditions are a valid proxy for the pre-industrial). There should be more clarity on this (and perhaps an adjustment of some of the relevant statements).

I am a little concerned by the stronger inferred change in cloud fraction in the southern hemisphere. I am not sure why this would be the case and it is not discussed in much detail. I understand that the southern hemisphere may contain more sensitive clouds, but the aerosol perturbation is larger in the northern hemisphere. Could the authors address this in more detail?

The uncertainty range is very narrow. I understand that this represents the range in uncertainty from the different methods used, but in light of some of the points above (particularly that about the assumed anthropogenic fraction), there should be some clarification about what this uncertainty range actually represents.

Minor points

L12 - There is a more recent IPCC report that might have updated information

L28 - Rosenfeld 2019 had a significant error in the LWP calculations (see the correction). Perhaps something like Christensen et al (2022), for a measure of shiptrack works, Bellouin et al (2020) for the large scale relationships, Malavelle et al (2017) is also a good example.

L28-31 - This sentence is very complex

L40 - How do these methods compare to Andersen et al (2017), as another ML paper that attempts a similar task?

L70 - I am not sure it is clear that this method is independent of aerosol retrievals, as the retrievals are used at the very least for identifying clean conditions.

L75 - Section 2 and 3 appear to overlap

L80 - aerosol index is written here, but only becomes an acronym later

L143 - Why SST from AMSR-E, when it could also come from MERRA-2 (or some other source)?

L156 - presumable the warm-cloud SWCRE?

L229 - I am not clear how removing clear scene eliminates the impact of cloud feedbacks?

Some cloud feedbacks can modify CRE and cloudiness, not just in cases that are clear at a 1 degree scale.

L267 - I am not clear how choosing SPRINTARS might cause this effect?

Fig 4 caption - what does 'weighted by warm cloud occurrence' mean here?

L287 - I though Gryspeerd et al (2019) used joint histograms to represent the relationship, with more ability to account for non-linearities?

L305-308 - This sentence is again very long and unclear

L322 - Again, I am not quite clear how cloud feedbacks are included in your estimates for the aerosol forcing.

Fig. 11 - The two panels here appear to be identical. Is that the point? I would have assumed some differences.