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Comment on acp-2022-97

Anonymous Referee #1

Referee comment on "The dependence of aerosols' global and local precipitation impacts on the emitting region" by Geeta G. Persad, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-97-RC1, 2022

Comments on: **The Dependence of Aerosols' Global and Local Precipitation Impacts on Emitting Region**

By Geeta G. Persad

In this paper the author uses a series of single model simulations with variations in the aerosol emission's geographical location to study the dependence of precipitation on aerosol emission location. The manuscript is well written, nicely organized and study interesting and important topic. However, I have a strong concern that many of the results are not significantly differ from changes one can get just due to internal variability. In the global mean, the changes presented here are in the range of ~ 0.002-0.02 mm/day. I have calculated the pre-industrial (PI) CESM1 global mean precipitation to be 3.044 mm/day, i.e., the changes seen here are in the range of 0.07-0.7% of the global mean. A question which is central to this paper is whether the changes reported here are statistically significant compared to the natural verbality of the system. The range of the 40-year running mean global mean precipitation in the CESM1 PI is 3.037 – 3.051 mm/day, i.e., a range of 0.014 mm/day just due to natural viability. That means that at least some of the difference in the global mean precipitation seen here are within the range possible only due to natural variability (all thought some of them are outside this range). Looking on the significant test in Fig. 1, suggests that the same might be true for the local precipitation changes (the changes in the vast majority of places aren't significant). In addition, statistically significant local precipitation variations between two realizations could also be driven by natural variability and not by the external (aerosol) forcing.

The way to overcome this issue, and to make sure that the differences are driven by the aerosol forcing and not by natural variability is to simulate more realizations (i.e., conduct initial-condition large-ensemble) (Diao et al., 2021), or run the model for very long times (Fiedler & Putrasahan, 2021). I feel bad to ask such a revision as I understand the amount of work it might require. However, I hope that, if the author will accept my suggestion,

the paper could become much more convincing. If conducting a large-ensemble is beyond the reach of the author, I believe that conducting one or two more simulations for each aerosol location (with slightly different initial conditions) will improve the confidence in the results (in case they are similar to the initial results) or demonstrate the need in more realizations (in case they are not similar, thus suggesting a large role of natural variability).

In addition, I believe that presenting Fig. 4 in relative terms will be more appropriate as the difference in the background precipitation between these places is very large.

Diao, C., Xu, Y., & Xie, S.-P. (2021). Anthropogenic aerosol effects on tropospheric circulation and sea surface temperature (1980–2020): separating the role of zonally asymmetric forcings. *Atmospheric Chemistry and Physics, 21*(24), 18499-18518.

Fiedler, S., & Putrasahan, D. (2021). How does the North Atlantic SST pattern respond to anthropogenic aerosols in the 1970s and 2000s? *Geophysical research letters, 48*(7), e2020GL092142.