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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Accelerated increases in global and Asian summer monsoon precipitation from future aerosol reductions" *by* Laura J. Wilcox et al.

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General comments

The manuscript makes use of the available CMIP6 SSP projection simulations to evaluate the impact of changing aerosols on the hydrological cycle over South Asia and East Asia. Despite the lack of clean experiments (non-aerosol differences occur across SSPs), the authors argue that simple and robust patterns appear that fingerprint the role of aerosol uncertainty on changes in precipitation, most notably during the first half of the 21st century. It is often difficult, however, to follow the line of reasoning used in the text of the manuscript when examining the figures presented. I have made a note

of several such passages that seem to disagree with what is presented in the figures in the specific comments. There are also several points of discussion in the manuscript relating global scale and regional scale differences, but there is little evaluation presented for which scales are important for which findings. A clearer definition of what constitutes agreement with the hypotheses would make this manuscript much easier to follow. Finally, in addition to discussions about the role of GHGs vs aerosol, there is no mention of land use/land cover change and the impact of its differences between SSPs on rainfall over South Asia or East Asia in this manuscript.

Specific comments

1. The authors argue that, "If the magnitude of the anomaly decreases monotonically from SSP1-1.9, which has the largest aerosol reduction, to SSP3-7.0, which has a moderate aerosol increase, this indicates that aerosol changes are the main driver of the climate response." When looking at the global emissions of BC and SO2 presented in Figure 1, this seems reasonable, but the same logic appears to be applied regionally in this manuscript. Looking at South Asia during the 2015-2050 period, SO2 emissions are highest for SSP5-8.5 and nearly equal for SSP2-4.5 and SSP3-7.0. How are we meant to disentangle the regional and global scale impacts for this region?

2. SSP2-4.5 and SSP5-8.5 are said to have "similar aerosol pathways," and globally that appears to be the case (Fig 1). Again, however, over South Asia, the differences in BC and SO2 emissions between SSP2-4.5 and SSP5-8.5 appear to be as large as their differences relative to SSP3-7.0. This point is raised again in the discussion of Fig 4 where the authors state, "SSP5-8.5 has similar aerosol changes to SSP2-4.5, consistent with the similar changes in emissions (Figure 1)." Given how dissimilar the regional emissions are in Figure 1, it is disconcerting that the AOD pattern for SSP5-8.5 is left off Figure 4, as this would allow readers to accurately see how similar or not the regional emissions are.

3. Figures 5 and 6 show the model mean responses (as points), as well as their

interquartile spread, for global (fig 5) and regional (fig 6) metrics. The temperature responses show noticeable spread between the different pathways, particularly by 2045-2054, but the precipitation responses have far less separation between pathways. I found it difficult to parse what measure the authors use to decide whether precipitation has increased or decreased between pathways. I began by assuming they were referring to the median (which I assume is the horizontal line in each bar). If that were true, then the statement, "Global aerosol reductions in SSP1-1.9 briefly cause this scenario to warm faster than the others considered over Asia and East Asia. . ." should be changed to refer only to East Asia, as Fig 6a (left panel) does not show a larger median temperature anomaly for SSP1-1.9 than SSP2-4.5. Additionally, the statement, "Over Asia, the largest mean precipitation increase occurs, for all decades, in SSP1-1.9. . ." is difficult to parse when it isn't clear if the "mean precipitation" is even marked in the figure. Is the bar actually the multi-model mean? If that is true, then the increase in precipitation over Asia is larger in both SSP2-4.5 and SSP5-8.5 than it is in SSP1-1.9. These two figures, and their accompanying text, must be clarified before any rigorous evaluation of the conclusions can be made. I also strongly recommend adding some discussion of when differences between regional precipitation changes at the decadal scale are statistically significant, or at a minimum robust across models.

4. The cooling over India is argued as the reason for suppressed precipitation increases in SSP2-4.5 and SSP5-8.5 relative to SSP1-1.9 and SSP3-7.0, but the cooling in Figure 7 is strongest for SSP3-7.0. How does one reconcile this? On a similar note, why are the temperature anomalies for South Asia and East Asia all positive in Figure 6a when Figure 7 shows cooling for SSP2-4.5, SSP3-7.0, and SSP5-8.5 for 2025-2034?

5. The warming and rainfall change patterns for the two individual SSP2-4.5-aer simulations are difficult to compare to the multimodel mean, and even to the rainfall response in Figure S8 (owing to changes in both the range of the colorbar and the colors used). It would be useful to show a direct comparison of the full SSP2-4.5 response to

that of SSP2-4.5-aer for each of the two models available so that an assessment can be made for how much the climate responses are indeed driven by aerosols.

6. Figures are too small to be readable when printed, and the quality is so low that they are hard to read even when zoomed in on a computer. Please consider revising with vector graphics or higher DPI raster images. It would be helpful to readers to add an outline of the analysis regions (Asia, S. Asia, and E. Asia) to the map plots. Please maintain a consistent map projection for all map plots. Please also be consistent with colorscales so that metrics can be compared across figures (e.g., Fig 7 vs Fig 11, or Fig 9 vs Fig 11). Finally, please consider changing Fig 4c to be MMM-MODIS so that it is consistent with the caption.

Technical corrections

Page 2, line 34, "AA" is not defined Page 4, line 7 typo "has yet to be emerge" Page 6, line 6 typo "present - day" Figure 2 caption typo "180-2014" Figure 7, there is a change in font between subpanels

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