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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Spatial distributions and seasonal cycles of aerosol climate effects in India seen in global climate-aerosol model" *by* S. V. Henriksson et al.

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We thank Anonymous Reviewer 4 for the comments and suggestions for improvement, which have now been addressed in the revised manuscript. Below are the original Reviewer comments in italics and our answers together with actions taken in the revision.

The authors used a climate model with interactive aerosols to conduct a series of equilibrium experiments with the goal of improving the current understanding of aerosol-climate interactions over India and the role of aerosols on the seasonal and regional climate. The topic of aerosol-monsoon interactions has received a lot of attention across

the scientific community in the last few years and is widely debated. A number of uncertainties still remain and make the problem challenging. However, the manuscript has a major weakness related to the design which I deem very important and needful of a major improvement before the work might be acceptable for ACP.

The authors use fixed SST in their experiments, despite the atmospheric forcing changes from one experiment to another due to different combinations of aerosols. SST plays a major role in driving the monsoon annual cycle and is an integral component of the monsoon system. Interactive SSTs could for example be obtained by conducting experiments with a mixed-layer model, if a couple model is computationally too expensive. Along this line, the choice of reducing the meridional SST gradient by 0.5K is arbitrary and might not be consistent with the model response to the forcing.

Mixed-layer simulations were made to address this concern. One estimate of the aerosol effects on SSTs was obtained by comparing 50-year simulations with and without aerosols. According to these experiments, the north Indian Ocean cools more uniformly due to aerosols than assumed in the SSTMODIF experiment. The SSTMODIF experiment is now treated as a sensitivity calculation in the Supplementary Material and the mixed-layer ocean simulations instead in more detail. The same main message of that the total aerosol effect on precipitation is negative in the model, is strengthened by these simulations. Remaining limitations are discussed.

In addition, the authors conduct experiments for 6 years only, of which 5 are averaged in the analysis, which is a very short period. To sample internal variability, simulations should cover at least 20 years.

Making 20-year simulations would be ideal, but was considered unrealistic in practice. As discussed in the text, statistical significance for the precipitation anomaly signs due to aerosol light absorption were reached already with 5 years of data. However, to increase the reliability of the results, the simulations except for the NUDGE experiment were extended to 8 years, of which 7 years were analysed.

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Furthermore, the same SST distribution is used in a number of different experiments, despite the forcing is different. This is not clearly realistic. Note also that the prescribed SSTs already include part of the forcing by aerosols and thus, assuming linearity, differences between the responses should be better computed.

The default prescribed SSTs do not include effects of aerosol forcing as they were produced with greenhouse gas forcing but without aerosol forcing. Thus, no "double counting" of aerosol forcing has happened in any of the experiments.

In the new mixed-layer ocean experiments, the SSTs now do respond to the forcing.

The discussion of the results is at time confusing and lacks of depth, especially on the mechanisms and processes responsible for the changes shown in the figures. NOABS setting: is SSA set to 1 for all aerosols?

Yes, SSA is set to 1 for all aerosols. This is now mentioned in the text. Discussion has also been deepened along the lines requested by Anonymous Reviewer 4 and the other reviewers.

Page 18039, line 25: How do you attribute the warming to the EHP hypothesis? This is just 2-m temperature, and it is not collocated with the largest aerosol forcing. You need to provide more evidence.

The connection with the EHP hypothesis was argued by the references (Gautam et al., 2009) and (Lau and Kim, 2010). Our claim was simply that the warm anomaly in March-May is probably caused by aerosols, due to any collection of mechanisms, as the anomaly is positive when aerosols are included. An important part of the mechanism seems to be smaller climatological cloud cover in March-May, which allows solar radiation to reach the absorbing aerosols and heat the air in those months. This is now clarified further in the text.

The choice of the northern and southern India domains is arbitrary, and not meaningful considering the low resolution of the model. Why do not you show the spatial pattern

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of the precipitation changes?

Yes, the choice is to some extent arbitrary. Showing spatial patterns at monthly or seasonal level for all simulations would mean far too many plots for the readers. However, spatial pattern plots from the mixed-layer ocean simulations have been added.

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