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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Fast responses on pre-industrial climate from present-day aerosols in a CMIP6 multi-model study" *by* Prodromos Zanis et al.

Anonymous Referee #1

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The manuscript by Zanis et al. provides new results from simulations pursued under the AerChemMIP model intercomparison project, which analyse how present-day aerosols may have impacted the global climate system compared to preindustrial times. The focus is on three key variables, i.e. radiative forcing, temperature and precipitation, with some further analysis presented for circulation-related variables. The manuscript is very well written and well within the remit of Atmospheric Chemistry and Physics. The results are not surprising, and mostly confirm the findings of previous studies (with the exception of certain regional details), but they are clearly presented and represent the state-of-the-art of global climate models used in important assessments, therefore the study is a useful addition to the current climate science literature. I do not have any

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major objections, and I believe that the paper will be ready for publication following the minor improvements that I describe below.

SPECIFIC COMMENTS:

Page 1, Line 31: I suggest rephrasing to ". . .to shift away from the cooled hemisphere".

Page 2, Lines 30-31: I suggest extending the text in the parenthesis to read like "(affecting climate variables that are mediated by a change in surface temperature and involve the response of the oceans to the forcing)".

Page 3, Line 15: I suggest adding ". . .and variable climate sensitivity per unit aerosol forcing in models" at the end of the sentence.

Page 3, Lines 15-16: The paper by Kasoar et al. (2016) is also a key one when it comes to explaining model diversity in climate responses to aerosols.

Page 3, Lines 17-24: I would say that this paragraph is somewhat out of place here and interrupts the flow. I suggest moving it to a later part of the paper, e.g. at the beginning of the section presenting the ERF results (Sect. 3). In the place of this paragraph in the Introduction, it would be nice to see a small paragraph making it clear what is new in this study. The Introduction jumps a bit too abruptly from a nice summary of aerosol-climate interactions to a brief paragraph of what this paper will present. But a paragraph on e.g. whether some multi-model study like the current one was pursued for CMIP5 or in other single-model studies would be useful. Then followed by a paragraph outlining what the current study adds to what already exists in the literature (i.e. the final paragraph that already exists).

Page 4, Lines 22-23: "from other 3 experiments" -> "from 3 additional experiments".

Page 4, Line 28: I suggest removing "Supporting" as that initially implies to the reader that this refers to the Supplement part of the paper.

Fig. 1: It is never mentioned in Sect. 2 what types of emissions are actually varied in

the sensitivity simulation with present-day aerosol emissions. Does that include only anthropogenic or e.g. also biomass burning emissions. Looking at Fig. 1, it seems that the former is true. But it needs to be clarified.

Page 5, Lines 1-2: Arguably the Middle East has higher emissions than Europe and N. America.

Page 5, Lines 21-23: Yes, that is the most likely (and classic) explanation, but it needs to be supported by a reference or two.

Page 6, Line 6: The numbering/ordering of supplementary figures seems unusual, i.e. Fig. S9 appears in the text after Fig. S2.

Page 6, Lines 6-7: This statement is a bit rushed. The ERF of BC is comparable to (though indeed smaller than) the sulfate forcing locally over the main emission regions (e.g. East and South Asia).

Page 7, Line 1: That's mainly true for DJF, right? If so, please state.

Page 7, Lines 10-11: And what about the other two seasons not shown? Worth mentioning as they may also play a role.

Page 7, Line 9: It is certainly not 'slight' – at its peak it's actually larger than the zonal mean effect in mid-latitudes.

Page 7, Lines 18-20: Is it not relatively easy to look at land snow/ice cover changes in models, or at least at surface albedo changes? This Arctic warming is a quite pronounced feature of this analysis, therefore a more complete explanation would be desirable.

Page 7, Lines 30-31: Suggest rephrasing to "So, the heating due to present-day BC emissions cannot justify this warming in NorESM2".

Page 8, Line 13: Again, why "jump" from Fig. 7 to Fig. 9?

Page 8, Lines 18-19: Please discuss further what the mechanism of this general land drying is thought to be. Is this mostly a thermodynamic effect (due to cooling) or a dynamical effect?

Page 8, Line 23: I do not really see much of an increase anywhere around the tropics in Fig. 4a. Only in JJA.

Page 9, Line 9: I suggest rephrasing to "On an annual basis there is a characteristic dipole pattern of precipitation decreases over East Asia and increases over southern India. . .".

Page 9, Lines 19-20: How do we see a weakening of the monsoon circulation? Please explain a bit more clearly/extensively in the text, as this may not be clear to the reader.

Page 9, Line 32: Please add "fast" between "The" and "response", since Dong et al. (2016) also focused on fast responses.

Page 9, Lines 30-32: Yes, but since the ocean temperatures are kept fixed, the effect of aerosols on the monsoon is only partly realised. Which is fine, given the focus of the paper on fast responses, but it is worth stressing this again here. The studies by Ganguly et al. (2012) and Shawki et al. (2018) provide nice insight into the differing fast and slow effects of aerosols on the South Asian monsoon, as well as the complementary global and regional mechanisms that are at play.

Page 10, Lines 1-2: Does this paper focus on fast or slow responses. Please clarify this (and I recommend that this is done elsewhere in the text too when referencing findings of other papers, given how different fast and slow responses (and mechanisms) can be).

Page 10, Lines 3-4: Most of the papers cited in this sentence cannot be found in the References list of the current manuscript.

Page 10, Line 10: I am not sure I understand: the west African monsoon involves the inflow of moist air from the central Atlantic Ocean into West Africa. What I see in Fig.

9c is more a strengthening than a weakening of the monsoon.

Page 10, Lines 10-12: The study of Hodnebrog et al. (2018) is of relevance when discussing the influence of aerosols on west African rainfall (in that case biomass burning aerosols, but still relevant).

Page 10, Lines 13-15: Yes, but Westervelt et al. (2017) used a coupled ocean-atmosphere model.

Page 11, Lines 25-31: I think the second half of this paragraph needs some tightening/rephrasing.

Page 12, end of Conclusions section: I think here it would be good if the authors could add a little paragraph reminding the reader that all these results were obtained from short-term simulations (and therefore refer to the fast responses), and that the long-term responses will likely be quite different. Also, please mention if a subsequent AerChemMIP study intends to explore aerosol influences on climate on long timescales.

References:

Ganguly, D., Rasch, P. J., Wang, H., & Yoon, J.-H.:. Fast and slow responses of the South Asian monsoon system to anthropogenic aerosols. Geophysical Research Letters, 39, L18804. https://doi.org/10.1029/2012GL053043, 2012.

Hodnebrog, Ø., Myhre, G., Forster, P. M., Sillmann, J., and Sam-set, B. H.: Local biomass burning is a dominant cause of the observed precipitation reduction in southern Africa, Nat. Commun.,7, 11236, https://doi.org/10.1038/ncomms11236, 2016.

Shawki, D., Voulgarakis, A., Chakraborty, A., Kasoar, M., and Srinivasan, J.: The South Asian monsoon response to remote aerosols: Global and regional mechanisms, J. Geophys. Res.,123,11585–11601,https://doi.org/10.1029/2018JD028623, 2018.

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