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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 #2

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Review of : Fast responses on pre-industrial climate from present-day aerosols in a CMIP6 multi-modelstudy. By Zanis et al.

This manuscript proposes an analysis of the fast response of climate to anthropogenic aerosol forcing based on CMIP6 models. Although there is no "big surprise" in the results presented and the protocol and analysis is standard (focusing mostly on seasonal mean response) the main interest of the study is of course to provide an updated view based on state of the art model intercomparison in the context of CMIP6. Some discussions on the response regional patterns are also proposed and interesting. This manuscript is thus relevant to ACP and the AerChemMIP special issue. On the form,

the manuscript and figures are clear and well written. I have nevertheless some questions and comment that could be addressed before publication to ACP.

Section 1.

Fast response vs. slow response discussion. I understand the use of these concepts, especially in view of intercomparing models. Imagine you have to talk to a wider audience interested in the "effective response" of climate to aerosol forcing in a naturally coupled climate system. What can the fast response analysis tell us about that ? I also understand that this concept and related time scale have more meaning on a global scale, but for regional analysis it is not that simple right ? Finally slow response is calculated only via ocean feedback, but there could be also continental reservoir (soil water) with much slower response than atmospheric processes which could induce delayed feedbacks in theory. In some region the oceanic mixed layer could also adjust to radiative perturbation on "intermediate" time scale (between fast and slow response).

Section 2.

Information on the emission sectors should perhaps be a bit discussed. It is not not clear for example if biomass burning emissions are taken or not into account. Are parameterizations of natural emission also enabled (see my point about dust feedback in the following comments) .

Table 1. There are a couple of models with "no interactive aerosol" , if they also differ from the "prescribed aerosol" category, how can they use the proposed emission scenario. ? Also Is the prescribed climatology consistent with the emission scenario and year used by other models (which consider year 2014 , i.e. when concentrations had already drastically decreased for some regions compared to the peak of the 70-80's). How are the models dealing with indirect effects (some might have no indirect effects), perhaps that could be a usefull info in the table) ?

Section 3.1.

L20 -24 : I was in fact a bit surprised to see such a positive ERF over the Sahara. I thought that the aerosol mixture (dominated by sulfate as mentioned by the authors , organics, and little bit of BC . . .) would be essentially diffusive enough to stand close to or over the "critical single scattering albedo" as determined by desert albedo : -Is it an effect of only BC (did not seem evident in supplement material) ? -I assume that cloud response contribution to ERF effect might be limited here (but maybe not for high clouds?). -But also could there be a positive feedback of dust aerosol (more absorbing and usually associated to a positive forcing over desert) contributing to the ERF – in response to dynamical changes ? (assuming of course that ESM account for on-line dust emissions). This "feeling" is reinforced by the result of e.g. CESM2 which clearly show a strong positive ERF signal over well known dust sub regions in Arabia and Thar desert. If such is the case, i.e. if simulated dust burden generally increase , that could be an interesting side conclusion.

An other feature of interest to me was the rather strong negatve ERF change over south-eastern pacific (along southern America-coast) . How to explain this signal ? Is it a signature of aerosol interaction with low clouds amplifying the aerosol forcing ?

Section 3.2.

The results confirm previous studies. A question perhaps relevant is : has CMIP6 model climate sensitivity also changed with regards to aerosol radiative forcing / emissions compared to CMIP5 models, as is the case for GHG forcing (considering for example possible different cloud responses) ?

Section 3.3

Precipitation response: If we look closely we can notice that over tropical region (take west Africa fro example) there is a sharp inversion of the signal from land to sea. The precipitation shift due to the large scale differential hemispheric cooling should produce a precip signal more continuous from land to ocean. I think there is in addition also an influence of local surface forcing and response here. Continental surface reacts to

aerosol dimming (less surface flux, enhanced stabilization) whereas only atmospheric absorption is effective over the ocean when SST is kept constant and the precipitation signal becomes positive over the ocean. If you take into account a slight effect of aerosol dimming on SST (e.g. using slab ocean and without considering necessarily a long time scale) you might end up with a negative precipitation signal consistent with land counterpart. This remark perhaps illustrate my earlier concern about the interpretation of "fast response".

There is a robust increase of Indian and SEA monsoon in terms precipitation (in term of wind anomaly it is difficult to see on the figure, but it seems that there is a cyclonic anomaly). However the text is stating a weakening of the monsoon (line 25) linked to southward ITCZ shift. This is a bit confusing. The precip signal obtained is in fact opposite to several studies relating a weakening of Indian monsoon precip due to regional anthropogenic aerosol, in model and observation analyses (as noted by the author a bit later p10 L1-5). Given the importance of this hot spot region, perhaps the author should develop a bit more the analysis of their results here (an interesting paper could be the one of Bollasina et al., 2014, GRL) ? Could these results be also linked to the forced SST set up as air sea coupling might be particularly important in this region?

Summer precipitation and dynamics over Europe. In term of radiative forcing summer and winter show similar patterns over europe. Intuitively we understand the anticyclonic anomaly generated via regional forcing over Europe for winter, but we would also expect the same for summer (i.e. regional strengthening of stable conditions by mostly diffusive aerosol). Instead the Icelandic cyclonic anomaly extends over the euro-mediterranean domain associated with increased precipitations. Would that imply that summer aerosol impact over Europe is not driven by regional emissions but rather responds to global scale adjustment to global emissions? Do the authors have some indications that the signal is robust when considering ocean coupling and slow response (from PDRMIP for example) . Looking at model to model variability , it would be good perhaps to have information on effective optical properties (e.g. total and absorption AOD, effective singe scattering albedo) for perhaps understanding the sensitivity of response pattern to aerosol parameters.

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