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Comment on acp-2021-407

Anonymous Referee #1

Referee comment on "Anthropogenic aerosol effects on tropospheric circulation and sea surface temperature (1980–2020): separating the role of zonally asymmetric forcings" by Chenrui Diao et al., Atmos. Chem. Phys. Discuss.,
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Review of:

Anthropogenic Aerosol effects on Tropospheric Circulation and Sea Surface Temperature (1980–2020): Separating the role of Zonally Asymmetric Forcings

By Diao et al.

This paper utilizes the CESM large ensemble simulations and its single forcing simulations component to study aerosol effect on surface temperatures and atmospheric circulation. In addition, two new sets of ensembles of simulations with the CESM are presented. These simulations are designed to capture the shift in recent decades in aerosol forcing from the western hemisphere mid-high latitudes (USA and Europe) to the eastern hemisphere low-mid latitudes (mostly India and China). The new simulations are well executed set of numerical experiments, which presents a valuable contribution to the climate community. I agree with the authors' statement that: "The zonally heterogeneous changes in AA emissions since the late 20th century, ..., received less attention". However, I feel that this paper fails to present the current knowledge in the field. In addition, the paper is mostly descriptive and the physical explanations are lacking (please see more details below). Finally, the paper could benefit from a careful re-writing and editing as some parts are not written well and I found numerous typos. Having said that, I believe that after a major revision, this paper could make important contributions to understand aerosols' climatic impacts.

General comments

- As was mentioned above currently the paper is mostly descriptive and so little physical insight is gained. Specifically, the explanation of the circulation response is lacking. I have outline below a few examples but there are defiantly more. Hence, I would like to encourage the authors to conduct deeper thinking and to try to bring the dynamical discussion to a level suitable for publication.
- The introduction is lacking many previous studies that examined the aerosol geographical distribution effect on circulation, forcing and temperature. Although I agree that this issue should get more attention, from the current manuscript it could sound almost like it is the first time anyone looked at it. This is not the case. A few examples of papers which come into my mind are Fiedler et al., 2017; Chemke and Dagan 2018; Persad and Caldeira 2018 and Fiedler and Putrasahan 2021. In addition, the introduction focusses quite a bit on extremes. As this is not the focus of this paper, it is unclear to me why.

Specific comments

L 13-14: this sentence sounds a bit awkward. Consider re-writing.

L 92. It defiantly also played a role in the north Atlantic. The motivation of focusing only on the north Pacific is not clear.

L 115. I wouldn't call it "full" ACI representation. Obviously, there are many aspects that are missing. I suggest to change it to: "enables simulations of aerosol indirect effects" without the "full".

L239. If the AOD doesn't change so much far away from the aerosol sources, how come the cloud droplet number concentration change? Have you really checked that the CDNC change? I think that the cloud fraction changes seen here are dominated by adjustments due to changes in the SST and circulation rather than by aerosol indirect effect.

L241. I might miss something here but as far as I can tell Fig. 3 does not show any significant cloud fraction change over the North-Atlantic in response to FF.

L264. Only 2 ensembles are presented in Fig. 4a, not 3.

L 303. Changes in circulation have many implications other than extreme weather.

L 306. As was mentioned above, previous studies have also looked at the west-east contrast effect of aerosol on the circulation

The paragraph starting at L344. The "rule-of-thumb" explanation presented here is

circular and the causality here is not clear. Changes in circulations due to any forcing will derive changes in clouds and humidity, which will derive changes in radiation, which will feed back on the changes in the circulation. Hence, suggesting that the apparent end-result radiation changes (which are also driven by changes in circulation, not just directly by the external forcing) leads to the changes in the circulation is misleading. The literature is full with explanations and theories about what determines the location of the jet stream. I suggest to change the discussion here to follow the previous knowledge in the field. In addition, it is not clear here if the focus is on the sub-tropical jet or the eddy-driven jet.

L371. Obviously, the sub-tropical jet is largely linked to the geostrophic winds. This isn't a surprise.

L446. In the North Atlantic there is a clear signal of the North-Atlantic warming hole (Dagan et al., 2020; Fiedler and Putrasahan 2021;). Worth mentioning here, I think.

L430. By "warming forcing" do you mean positive forcing? Similarly, in L 435 "cooling forcing" should be negative forcing.

The explanation around L 435. This is a very descriptive explanation. It is still unclear to me why the differences in the aerosol latitudinal distribution between WH and EH impact the North-Pacific response.

Explanation around L 460. It is not clear to me how you calculated ZMMHT but I assume that it includes only the atmosphere heat transport and not the ocean transport. The surface temperature is strongly controlled also by the ocean heat transport and aerosol forcing could modulate it (Cai et al., 2006; Delworth and Dixon, 2006; Dagan et al., 2020;

Menary et al., 2020; Fiedler and Putrasahan 2021; Hassan et al., 2021). This is something that can't be ignored, definitely for the North-Atlantic. This comment about the role of the ocean circulation changes in shaping the SST (or SAT) is true also for many other parts of this paper. It can't be simply ignored.

L 481-489. This is not a main finding of this paper. The trend of a shift in aerosol forcing from the WH to the EH in recent decades is well known and was discussed in many previous studies.

Technical comments

L69: "et al., 2014". Please correct.

L 90. "Northern Hemisphere, We". Please correct.

L 95. "radiation(Sect. 3.1)"

L 217. "(1)1"

L239. "the. U"

Fig. 5 some of the y-axis are cut out.

L 429. "50 North North"

L430. "induce es strong". This all sentence is not written well.

L 468. "othe ver"

L527. "More specifically, The"

L 557. You jump from point 3 to 5.

Line 775. "(d-f) Similar to Fig. 6 (d-f)" ? it is also not clear to me if you are presenting here the EH only or also the WH? (all titles say EH).

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