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Reply on RC2

Prashant Chavan et al.

Author comment on "The outflow of Asian biomass burning carbonaceous aerosol into the upper troposphere and lower stratosphere in spring: radiative effects seen in a global model" by Prashant Chavan et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-494-AC2, 2021

Replies to Reviewer-II

General comments:

The study by Chavan et al. discusses the transport pathway of Asian biomass burning aerosol to the UTLS during boreal spring and its radiative impacts using a CCM coupled an aerosol module. The topic is of great interest and of scientific importance. However, I have some doubts in the design of the experiments and the relative interpretations of the results, which will be mentioned in detail in the major comments. Besides, there are some missing information and improper presentations throughout the paper, which gave readers difficulty to understand. Thus, I would suggest the authors to reconsider the design of experiments and clarify the missing information before a more detailed revision. In general, I would suggest a major revision before publication.

Reply: We thank the reviewer for valuable suggestions. We have now clarified the details of the design of the experiment in the revised manuscript (L132-144). We have incorporated other suggestions given by the reviewer. The changes are indicated in blue color in the revised manuscript and the corresponding line numbers are also mentioned in the replies given below.

Major comments:

(1) Based on the description of configuration of two runs and "We performed 10-member ensemble runs starting between 1 and 10 January 2012 and ending on 31 December 2013... ", I would guess that the BB aerosol should also be treated differently for two runs ("on" and "off") during the "spin-up" year 2012 (if I understand it wrong, please correct me). Therefore, the simulated aerosols and its effects during MAM 2013 should be combined and accumulated results of the whole simulation period beforehand. Here the aerosol transport time-scale from PBL to UT/LS and shallow BDC, the circulation changes related to the radiative effect from aerosol and water vapor as well as the complicated feedbacks should be all relevant. The whole paper is, to a large extend, misleading, which attributes the complex effects of BB aerosols only to the spring Asian BB. Thus, one possible solution is to revise the design of experiments to isolate the effect of carbonaceous aerosols from Asian BB during the spring; another idea is to make some discussions that clarify the accumulated effects.

Reply(1): Sorry for not being clear in describing our model runs, which led to doubts on the experimental design. In the revised version, we clarify that in our experiments, emissions were the same during the spin-up period. We have now re-written it at L132-144 as below:

"We performed two sets of emission sensitivity experiments; in one set of the simulations, the aerosol emissions from biomass burning were kept on (referred to as BMaeroon simulations) and in another set of the simulations, the aerosol emissions from biomass burning were kept off (referred to as BMaerooff simulations). We adopted an ensemble mean approach (with ten ensemble members) for the above two experiments. Ten spin-up simulations were performed from 1-10 January 2012 up to 28 February 2013 to generate stabilized initial fields for the ten ensemble members. Emissions were the same in each of the ten members during the spin-up period. In the BMaerooff simulations (ten ensemble members each), the biomass burning aerosols were switched off since 1 March 2013. The BMaeroon and BMaerooff simulations ended on 31 December 2013. To investigate the effects of biomass burning aerosol emissions in spring (i.e., since 1 March 2013), we analyze the difference between BMaeroon and BMaerooff simulations for the spring season in 2013. "

In the past, many different studies have used different periods for spin-up (six-month to one year). For example, the study by Kokkola et al., 2018 used a 1-year spin-up period. Bergman et al. (2008) used a spin-up spanning six months. Also, Vozella et al (2012) used a one year spin-up period.

Kokkola et al., 2018**,** SALSA2.0: The sectional aerosol module of the aerosol–chemistry–climate model ECHAM6.3.0-HAM2.3-MOZ1.0, Geosci. Model Dev., 11, 3833–3863, 2018.

Vozella et al : Aerosol optical depth over the Arctic:A comparison of ECHAM-HAM and TM5 with ground-based, satellite and reanalysis data, Atmospheric Chemistry and Physics 12(15):8319-8353, DOI: 10.5194/acp-12-6953-2012, 2012>

Bergman et al., 2008, Evaluation of the sectional aerosol microphysics module SALSA implementation in ECHAM5-HAM aerosol-climate model, Geosci. Model Dev., 5, 845–868, 2012

Minor comments:

(1) L105, some references or a website should be added for "AEROCOM-ACCMIPII".

Reply(1) : As suggested we have added a reference for AEROCOM-ACCMIPII at L116.

(2) L107-108, why there are three datasets for BB emissions (GICC, RETRO and GFED V2)? What is the indeed used in the simulations?

Reply(2): We have used emissions from ACCMIP-II. The ACCMIP-II emissions are derived from harmonization of data from GICC (Mieville et al. 2010), RETRO (Schultz et al., 2008), and GFED v2 (Van Der Werf et al., 2006). However, to avoid confusion it is removed now. The text is re-written as "The anthropogenic and fire emissions were obtained from the ACCMIP-II (Emissions for Atmospheric Chemistry and Climate Model Intercomparison Project) emission inventories and are interpolated for the period 2000-2100 by using Representative Concentration Pathway 4.5 (RCP4.5) (Lamarque et al., 2010; van Vuuren et al., 2011). (L112-116).

(3) L113-114, the first level and second level is not an accurate description because the model level has not been introduced. "The first/second model level (~*hPa)" would be

better.

Reply(3) : Here, "First level" indicates the model's first level above the boundary layer. The second level indicates the model's second level above the boundary layer. However, the height of the boundary layer varies therefore the first level or the second level are not at fixed pressure levels. However, the above sentence is now re-written as below at L118-122. Injection heights of biomass burning emissions are documented by Val Martin et al. (2010). The majority (75%) of the emissions are evenly distributed within the planetary boundary layer (PBL) with 17% in the first model level above the planetary boundary layer and 8% in the second model level above the planetary boundary layer (Tegen et al., 2019).

(4) L125-126, how did you vary SST and SIC? And for the sentence, I would suggest not to use "explore" since the effect from varying initial conditions are not discussed.

Reply(4) We have used monthly varying SST and SIC. It is now mentioned as "Atmospheric Model Inter-comparison Project (AMIP) monthly varying sea surface temperature (SST) and sea ice cover (SIC) were used as lower boundary conditions. (L130-L132).

(5) It seems to me that the Figure 3 (c) and (d) should be relevant: one is the AOD excluding the effect from dust; one is the AOD from carbonaceous aerosols. Could you comment on this point?

Reply(5): Figure 3 (c) includes water soluble aerosols in addition to carbonaceous aerosols. However, it does not provide any additional information, hence it is removed now. We have shown the distribution of dust in the lower (Fig. S2a) and mid-upper troposphere (Fig. S2b) together with the associated circulation to show the transport of dust. (Shown in attached PDF, "Figures_for_ReviewerI_and_ReviewerII").

(6) The description of longitude range in Figure 5 (85-140E) is not consistent with main body (L304).

Reply: It is corrected now as 85°-140°E at L356.

(7) L363, it should be "Fig. 6a-h".

Reply(7): It is corrected now.

Comments on Figures:(8) Figure 2 is not well organized. I would suggest : 1) add "BMaeroon" and "OSIRIS" to the titles of (e) and (f) respectively and use the same color bar; 2) plot the locations of the ten sites on the map in (c) and avoid the repeat of the longitudes and latitudes of them in the figure description since they are already mentioned in the paper; 3) the names of sites and their bars are not well aligned in subfigure (d).

Reply(8): Figure 2 is replotted. As suggested, we have shown the location of the ten sites in Fig. 2c. We have used abbreviations for locations of the ten sites in Fig. 2d. The abbreviations are described in the figure caption (shown in attached PDF, "Figures_for_ReviewerI_and_ReviewerII).

(9) Figure 3: 1) why the range of map in (b) is different from others? 2) what are the vectors shown in (b), wind anomalies? and clearly the upright vector symbol is in a wrong scale. 3) I suggest unifying the colorbars.

Reply(9) : We show the transport of dust from West Asia to India and its influence on AOD. Wind anomalies are shown as streamlines to show the circulation pattern. It is

discussed in the manuscript at L291-297. Hence the domain for Fig. 3b was different than the rest of the panels. However, now we show the same domain in all panels in Fig.3.

As suggested, the same colorbar is now used for Fig 3(a) AOD and 3(b) dust AOD. The values of total AOD, dust AOD are higher than BC+OC AOD. Hence, we used different scales of colour bar for BC+OC AOD to show regions of high carbonaceous aerosols. This feature is suppressed if we use a unified colour bar. (shown in attached PDF, "Figures_for_ReviewerI_and_ReviewerII").

(10) Please specify what is the vectors in Figure 5 (c-d) and Figure 6 (a-h).

Reply(10): The vectors in Figure 5 (c-d) and Figure 6 (a-h) indicate circulation. It is now mentioned in the caption of Figure 5 (c-d) and Figure 6 (a-h). (Shown in attached PDF, "Figures_for_ReviewerI_and_ReviewerII").

(11) In Figure 5(c), the upwelling (if it is the meridional circulation from BMaeroon) can be found from 10N-20N, not exactly from 10S-10N. Why did you choose 10S-10N as the range for Figure 5 (d)?

Reply(11): Thank you for the suggestion. We have now shown upwelling averaged over 10°-20°N. (Shown in attached PDF, "Figures_for_ReviewerI_and_ReviewerII").

(12) "seasonal mean" are used in a lot description of figures. I suggest changing them to "spring mean (MAM)".

Reply(12): We have modified it as averaged for spring 2013 (L330, L817, L838, L841, L853-854, L880-881, L902, L904-905).

Please also note the supplement to this comment:
https://acp.copernicus.org/preprints/acp-2021-494/acp-2021-494-AC2-supplement.pdf