

## ***Interactive comment on “Beijing Climate Center Earth System Model version 1 (BCC-ESM1): Model Description and Evaluation” by Tongwen Wu et al.***

**Anonymous Referee #2**

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### **General**

The paper presents a description and an evaluation of the tropospheric aerosols included in the Beijing Climate Center Earth System Model. The paper consists of a quite general overview and my main concerns relate firstly to the description of the aerosol scheme which is rather vague in several parts. Furthermore, it is not so clear what is specific or not to this aerosol scheme, what has been developed and/or adjusted, compared to other schemes already in place in other climate models. Secondly, the evaluation is mostly qualitative, and when some quantitative information is provided, it often refers to quite old references.

Both issues needs to be addressed quite thoroughly for the paper to progress in the  
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review process. This requires quite some work. My list of particular points appears below.

### Questions/remarks

1. paragraph “Model description”: this paragraph needs some rewriting as some features, eg ACGM3, AVIM2, are presented twice
2. L146: what is the reference for the “weighted-combination”? Please provide more details.
3. L156: is turbulent transport included? if not, then you are missing sub-grid scale transport and the overall distribution of chemical species would be quite different considering this sub-grid scale transport. Please explain what is your rationale for presenting an evaluation without these processes.
4. L173: the Wesely approach has 3 terms. Why did you retain only two terms? Please indicate if you compute the terms interactively or not. This is at the moment not clearly stated.
5. L179: it seems to me that the reactions listed in Table 2, and their reaction rates, are the same as the ones that appear in Lamarque et al. 2012. This should be noted in the paper, as therefore both the chemistry and the aerosol modules of the BCC-ESM1 and CAM-Chem used for generating what the authors refer as the “CMIP5 recommended” aerosol concentrations are quite similar. This should be made quite clear in the paper. Possibly a paragraph in the paper could be dedicated to what is specific to this scheme, if this is relevant.
6. L182: there is no reference to DMS in Benkowitz 1996. Please clarify what you mean

7. L191: is there a reference for this assumption?
8. L215: please clarify why in this paragraph about OC and BC you write about "soluble gases"?
9. L224: what are the values of this scaling factor?
10. L252: Wu et al 2019 is not in the list of references ; and what do you mean by "it is parameterized", what is "it"? Do you refer to the aerosol first indirect effect or to the first and second effects? Please provide further details, in particular if you parameterize the second indirect effect of aerosols that not all climate models consider
11. L257: "historical" is not an AerChemMIP simulation but rather a CMIP6 simulation that will be a basis for a large number of CMIP6 analyses, including some AerChemMIP analyses, but also other MIPs analyses. Please correct this wording throughout the document.  
If the simulation you present is an historical CMIP6 simulation, please indicate the baseline name of the corresponding files on the ESGF. Do you present one ensemble member or several members?
12. L264: "only O<sub>3</sub> is a prognostic variable": what about CH<sub>4</sub>, it is part of the chemistry scheme and therefore it is also a prognostic variable isn't it? what about also CO<sub>2</sub>?
13. L274: the CMIP6 anthropogenic emissions are meant to cover all that is required for a climate model. Can you explain why this was not the case for your model?
14. L276: to my knowledge there is no such CMIP6 recommendation for hydrophobic and hydrophilic forms. Please rephrase your sentence.

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15. L279 and following: please describe in more details the formation of Secondary Organic Aerosol from vegetation that you consider? what comes out of MEGAN2.1, are they related to OC2 only, and not OC2 and OC1? ...
16. L291: factor 2-4 high: this is a strong affirmation! The Ge et al. 2016 study is older than the CMIP6 data. How do they relate? And furthermore, do you have a stratospheric aerosol scheme that uses these data? If yes, please describe the scheme, if not please clarify your sentence.
17. L304: please clarify what the MOZART2 data package include, data? chemistry code?...
18. L307: to my knowledge the CMIP6 data package does not include neither CH<sub>4</sub>, nor N<sub>2</sub>O: what do you refer here to?
19. Table 1 and Table 4: there are incoherences between species listed in both Tables. For example, CH<sub>3</sub>COCHO is not emitted in Table 1 and has emissions in Table 4. Please carefully check consistency between these tables.
20. L318: "only a small warming": please quantify this
21. L324: mean and uncertainty should not be of different orders. Please correct here and in other places in paper.
22. L331: these are not concentrations but rather loads, and what is the reference for these "CMIP5 recommended concentrations"?
23. L338: why do you think there is such a distribution?
24. L350: in addition to pointing out similarities, please address differences between CMIP5 and BCC-ESM1 outputs, and why there are such differences/similarities
25. L376: what is this particular "NCAR data package"

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26. L376: sentence "This decrease trend possibly results from the prescribed emissions have not year-to-year variations and ..." is not clear
27. L386: the sentence "The trends of global BC and OC burdens are similar 387 to that of sulfate, but they showed continuous increases from 1950 to present." is not clear
28. L390: "was slightly enhanced from 1950 to 2000" : I rather see a similar burden in 1950 and in 2000. Please be clearer, and do you have evidence of increasing soil dryness during that period?
29. L400: "largely due to stronger wind speed": differences could be due to differences in underlying DMS concentrations in the oceans. What supports your affirmation?
30. L406: air traffic is part of anthropogenic activities; please rephrase your sentence, and what about biomass burning emissions?
31. L407: you indicate that volcanic emissions are not included. I wonder in Figure 3 what corresponds to the area of large loads of sulfate around Central America?
32. L423: it seems that the total of 45.2 Tg/yr for OC is incoherent with what appears in Figure 4b; please correct.
33. L490: please provide some quantitative information with these plots, as for instance appears in the AeroCom web page with scatter plots ([https://aerocom.met.no/cgi-bin/surfobs\\_annualrs.pl](https://aerocom.met.no/cgi-bin/surfobs_annualrs.pl))
34. L500: please provide some quantitative elements on the extinction coefficients, also single scattering albedo and asymmetry parameters
35. L502 (and paragraph): do you show a 1997-2003 average or the 2008 year as indicated in the figure; please provide quantitative information (bias, rmse..., or C5

normalized figures as you prefer). This comment is valid for all figures. They should all be accompanied with some quantitative information.

36. L516: I don't feel the evaluation is "comprehensive" so far. Please review this affirmation as you make some progress in a future version of the paper.
37. L530: you indicate that you used prescribed concentrations for CH<sub>4</sub>, and in Table 4 you indicate that you consider CH<sub>4</sub> emissions. Please clarify.
38. L541: there is no such comparison of all of these aerosols with observations. Please be more precise.
39. L560: I don't understand "How about the GHGs simulations in the AeroChemMIP historical run?" please be clearer and more precise.
40. Figure 4: please add biomass burning emissions, if not done yet, or indicate if they are already part of the figure
41. Figure 14: do you compare monthly observations averaged over 1998-2005 with monthly model outputs averaged over 1998-2005? please formulate more precisely

#### Minor questions/remarks

1. L1: the title is misleading and should be changed at the paper focuses on tropospheric aerosols
2. L49: "Besides gaseous"
3. L51: aerosol are particles; so change "aerosol particles" to "aerosols"
4. L59, and others: homogenise writing of chemical compounds, for instance O<sub>3</sub>

5. L99: "BCC-ESM1 is a fully-coupled global climate-chemistry-aerosol model ": it seems to me that BCC-ESM1 is more than that; I would say it is an "Earth System Model with interactive chemistry and aerosol components" if you want to insist on these components
6. L120: change "used" to "uses"
7. L122: please clarify "ranged to"
8. L145: it is not clear whether deposition velocities are computed interactively, as in Wesely, or consist of monthly means.
9. L198: remove "Its"
10. L238: please be more precise on the Web page
11. L252: Wu et al 2019 is not in the list of references ; and what do you mean by "it is parameterized", what is "it"?
12. L263: AGCM-Chem1: is this the correct name of the model?
13. L264: please reformulate "at each model step and interacts with radiations"
14. L276: add "see Table 4"
15. L283: MEGAN acronym already introduced
16. L310: change "1850 AD conditions" to "1850 conditions"
17. L317: change "600" to "450"
18. L317: Figure 5b-5d
19. L385: early 1980s

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20. L513: please correct the North American coordinates; and correct also in Figure 14 the European coordinates ; and furthermore the coordinates you indicate in the text do not correspond to those of Figure 14
21. L543: in relevant literature
22. Table 1: please indicate that interactive surface emissions are considered for sea salt and dust
23. Table 5: I could not find figures for the sinks of DMS in Liu 2005 Table 4. Where do your figures come from?
24. Table 6: f for Ginoux 2001
25. Figure 1: change SAT into tas official CMIP6 variable
26. Figure 5: what is the "20th historical simulations"? Same question in caption of Figure 11
27. Figure 5: change "blue" to "black"

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