

## ***Interactive comment on “Responses of Arctic Black Carbon and Surface Temperature to Multi-Region Emission Reductions: an HTAP2 Ensemble Modeling Study” by Na Zhao et al.***

**Anonymous Referee #2**

Received and published: 22 February 2021

This study investigated the responses of Arctic BC concentrations and surface temperature to 20% anthropogenic emission reductions from six source regions (East Asia, Europe, Middle East, North America, Russia-Belarus-Ukraine, and South Asia) by using several global aerosol models. The contribution from East Asia was estimated to be the largest (18.1-54.1%) among the six source regions. The authors also showed that the source contributions of the Arctic BC vary with altitude and latitude and the responses of the Arctic BC to emission reductions from the six source regions decrease with latitude. Finally, this study indicated that the reductions of global BC emissions are important for the Arctic climate by showing that the response of the Arctic air temperature to BC reduction is larger than that of the global air temperature.

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The results of this study are useful for understanding the current status of the estimation of the source contributions of Arctic BC by global aerosol models. However, as shown below, there are some important problems that need to be clearly described.

Major comments:

1)

This study uses six global models. Two models (CHASER) overestimate the BC concentrations in the Arctic by a factor of two, and four models (CAMchem, GEOS-chem, GOCART, and OsloCTM3) underestimate BC by more than 50%. The authors use the averages of these six model results and describe that the averages reproduce the observed BC concentrations in the Arctic well (lines 268-271). However, none of these models can simulate Arctic BC well. It is not meaningful to show as if the agreement with observations was improved by averaging the multiple model results that cannot reproduce the Arctic BC. The authors need to describe more clearly why it makes sense to use the averages of the model results that cannot reproduce the observations well.

2)

As described in the comment (1), two models (CHASER) overestimate Arctic BC by a factor of 2 and four models underestimate it by more than 50%. Therefore, the two CHASERs have about 4 times higher concentrations than the other four models. Then, the simple averages of these models strongly depend on the results of the two CHASERs with their contributions of about 2/3 to the total (CAMchem: CHASER\_re1: CHASER\_t106: GEOS-chem: GOCART: OsloCTM3 = 1: 4: 4: 1: 1: 1). If this is correct, the multi-model averages shown in this study will not be very different from the results of CHASER (the contributions of the other models will be too small).

Considering these points, I suggest the authors to revise the manuscript for the three points below. First, please discuss the spatial distributions and source contributions of BC in the Arctic for each model. Second, please use one CHASER, not two. Third,

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please consider using medians instead of averages, as has been done in other multi-model studies.

3)

Section 3.3.2 discusses the vertical profiles of Arctic BC. However, they are not validated by observations. Because several aircraft measurements such as HIPPO, ATom, and ARCTAS are available, the authors should use such data to validate the simulated vertical profiles of Arctic BC.

4)

Several observational and trajectory-based studies have shown that the contribution from Asia (especially South Asia) to the near-surface BC concentration in the Arctic is limited (e.g., Stohl, 2006; Matsui et al., 2011). Please clarify whether the results of this study are consistent with the findings of these previous studies.

Stohl (2006): doi:10.1029/2005JD006888, Matsui (2011): doi:10.1029/2010JD015067

Specific comments:

5) Lines 35 and 37

18.1 – 54.1%: Please clarify the meaning of the range.

6) Lines 118 – 119

Please add the amount of global BC emission flux from anthropogenic sources and describe how different it is from the CMIP6 emissions.

7) Lines 141 – 144, Table 1

Please describe how the authors determined the monthly variations of BC emissions. Please add the values of global emissions.

8) Line 209

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What is “m” in equation (1).

9) Line 314

1.0 – 1.7 ng m-3, 1.9 – 3.8 ng m-3: Please clarify the meaning of the ranges.

10) Line 329

The sum of the six sources (from 20% emission reductions) is about 2 ng m-3. I suspect that the contributions from sources other than the six regions (e.g., anthropogenic sources in the Arctic, biomass burning sources) are large.

11) Line 333

0.3 – 1.9 ng m-3, 18.1 – 51.4%: Please clarify the meaning of the ranges. Please show the contributions of anthropogenic and biomass burning sources other than the six sources. Are the contributions of the six sources to total BC in the Arctic dominant?

12) Lines 342 – 343

Please clarify the meaning of the ranges.

13) Line 356

Section 3.3.2: the vertical profiles of BC should be validated by the available aircraft measurements.

14) Line 433

How important are these two peaks? Is this consistent with observations?

15) Lines 449 – 451

Please clarify how important these concentrations are.

Please show the contributions of these sources to total BC.

16) Line 457

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10 years: What does this mean? The time scale of BC impacts on Arctic temperatures is probably much shorter than 10 years.

17) Lines 460 – 461

What do these temperatures mean? It's unclear how they correspond to actual temperature changes.

18) Line 475

The authors conclude that South Asia will be important. Is this consistent with previous studies (e.g., Stohl, 2006)?

19) Line 522

Are the two CHASERs different enough to be considered as different models?

20) Line 534

Is the correlation coefficient of 0.98 due to the two CHASERs? I think the value is too high as a correlation between independent models.

21) Lines 536 – 537

I don't think it makes sense to show as if the agreement with observations was improved by averaging the multiple models that overestimate and underestimate observations. None of the models in this study can simulate Arctic BC reasonably well.

22) Line 543

Please clarify the meaning of the range.

23) Lines 545 – 547

Is this consistent with observations?

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1176>, 2020.