

## ***Interactive comment on “Source attribution of Arctic aerosols and associated Arctic warming trend during 1980–2018” by Lili Ren et al.***

**Anonymous Referee #2**

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This study uses source apportionment method to study the changes Arctic BC and Sulfate concentration, and the contributions from worldwide 16 other regions. They also performed sensitivity analysis to discuss the contribution of Arctic warming from the different source regions.

In general, I think the paper has an interesting theme. However, the method is not well presented, and the discussion is not well structured neither. The paper heavily focusses on the model results, and was not strong to make adequate discussions on why the simulated results happen.

Main comment:

I suggest the authors reorganize the abstract from L32-43: think about the order of

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discussing the sulfate/BC radiative forcing changes, local vs long-range transport, temperature changes from aerosol-direct and indirect effects.

It has been known that there are very large discrepancies for the emissions in China from MEIC emission inventory and CMIP6 (Paulot et al., 2018). Comment how this discrepancy could affect the main results.

Reference: Paulot, F., Paynter, D., Ginoux, P., Naik, V., and Horowitz, L. W.: Changes in the aerosol direct radiative forcing from 2001 to 2015: observational constraints and regional mechanisms, *Atmos. Chem. Phys.*, 18, 13265–13281, <https://doi.org/10.5194/acp-18-13265-2018>, 2018.

Beginning from section 3, when the authors discuss the trends analysis, I did not find anywhere how the authors performed the trend analysis, as well as the significance test. Those are very basic concepts when we discuss trend analysis. A few example: line 245–line 248; line 251–252, and Table 2, Fig. 8.

Line 269–270: when the authors discuss the “largest contribution of East and South Asia”, does the authors mean East and South Asia contributes most at this altitude compared with other regions, or this altitude is where East and South Asia contributes most for their contributions at different altitudes? As a matter of fact, I think these several paragraphs are terribly written (line 264–290). Keep in mind that, when you talk about the contribution, you are comparing between different source regions as well as the altitudes. I highly suggest the authors reorganize these several paragraphs.

Editorial comments: Line 35: explain what “61%” is compared to.

Line 38: the snow/ice albedo effect from BC refers to local or other source regions?

Line 98: add from which year for the 2–3% changes.

Line 122: change “observational” to “observation”

Line 153: EAST was already defined.

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Line 181-182: Technically, neither Fig 1 nor Fig 2 showed the emission changes from “1980-2010” “from the 16 source regions”.

Line 209-210: Please put reference or show precipitation/wet deposition plots to confirm the theory.

Line 212-213: I thought local BC reduction by 38% in Arctic are pretty high. So are you sure the BC concentration changes are dominated by the emission changes from other source region? Meanwhile, I got different conclusion from Fig. 5 as the ARC clearly dominated the total BC changes.

Line 256: how did the “+/- 1-3%” come from? It looks like uncertainty range to me.

Line 262-263: the authors conclude to reduce local sources in the Arctic to control the sulfate and BC. Can the authors give some specific suggestions on the sectors which the local source should be reduced?

Line 272-273: If I am reading the plots right, I think Europe also has largest contribution for both sulfate and BC below 2km, compared with Arctic? That being said, I still can not figure out what the authors refer to when they say “largest contribution”.

Line 287-288: Again not clear how to comprehensive the “increasing trend” contributed by East Asia and South Asia. Also, the authors have a theory why East Asia and South Asia are larger high altitudes, any references or evidences? Please explain.

Line 317-322 Here is redundant to discuss the radiative forcing changes in other NH regions since this is not the focus of this paper. Remember the paper's interest is on the transport of other source region on the reception region (Arctic).

Line 329-330: The authors previously showed that the sulfate concentration changes over Arctic are dominated by other source regions than local. So why the authors conclude the local sulfate change for the radiative forcing increases?

Line 330-333: again these are not relevant to this study. I think it is Ok if the authors

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want to compare the radiative forcing changes in Arctic with other regions for the past 4 decades, but not necessary to distract the main point of the paper.

Line 356-358: please explain why the BC changes over mid-latitude and tropics have positive climate effect and expand to Arctic?

Figures:

In Fig. 2 title, add the references that abbreviations for the regions could be found in Fig. 1

Fig. 3 I saw crosses, triangles, rectangles and dotted circles which are not explained in the legend. In the stacked contour plots, I think the authors refer light green for the Arctic? The Y axis for plots St. Nord Ny-Alesund and Kevo seems not right to me.

In Fig 5 and figures below, the authors only show a list of the source regions, not all of them. I suspect that's because other regions' contribution to BC and sulfate in Arctic are very negligible? If so, how much is it? Is it magnitude level smaller than the CAS to sulfate, and EAS to BC? Also, how did the authors make the relative contribution equal to 100% if not all the regions included? I would also suggest the authors to reorganize the plot, so maybe the contour plots will be seen as smaller to largest, or vice-versa.

Fig 9: this study's focus is on Arctic. This fig is not easy to distinguish the spatial patterns of temperature changes in Arctic.

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