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Interactive comment on "Local and remote mean and extreme temperature response to regional aerosol emissions reductions" *by* Daniel M. Westervelt et al.

Anonymous Referee #2

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Review of "Local and remote mean and extreme temperature response to regional aerosol emissions reductions" by Westervelt at al.

Summary This paper quantifies the temperature response, including extremes, due to removal of aerosol emissions in six different geographical regions, with three different climate models. Such removal generally leads to warming, with the Arctic region particularly vulnerable. Similar changes occur in temperature extremes. The authors also update Regional Temperature Potentials, which are useful for estimating regional climate impacts due to regional aerosol changes in Integrated Assessment Models.

Overall, the paper is well written and contains interesting and novel results. I recom-

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mend publication with minor revision.

Comments P2 L12. See also “Emerging Asian aerosol patterns” Nature Geosci. 12 (2019) by Samset et al.

There are also several PDRMIP papers that are relevant to the discussion, that should probably be cited. For example, “Rapid Adjustments Cause Weak Surface Temperature Response to Increased Black Carbon Concentrations” by Stjern et al. JGR 2017.

Also, “Arctic Amplification Response to Individual Climate Drivers” by Stjern et al. JGR 2019. Looks like the Arctic Amplification paper is eventually mentioned on Page 6.

P4 L33. Naik reference parentheses typo.

Model Description Section. Please include some brief information of each of these model’s aerosol ERF (e.g., PD-PI). For example, in “A 21st century northward tropical precipitation shift caused by future anthropogenic aerosol reductions” by Allen JGR 2015, CESM yields - 1.52; GFDL yields -1.60; and GISS yields -0.76 W/mˆ2. So GISS has a much smaller aerosol ERF. Based on this alone, I would expect any temperature response to similar aerosol perturbations to be weakest in GISS. You may also want to mention why this is. For example, GISS lacks aerosol-cloud second indirect effects (aerosol-cloud lifetime effect). Looks like this is eventually mentioned on Page 6. Might be beneficial to mention here as well.

Although, it is interesting that GISS also has a smaller climate sensitivity to CO2, relative to GFDL and NCAR. This could also contribute to a weaker surface temperature response in GISS.

Methods Section. These simulations are designed for an instantaneous removal of aerosol emissions. Thus, there is no time evolution of the aerosol emission reductions, which would be more realistic. How does this impact the results? Maybe a few comments on this are necessary.

Methods Section. It is stated perturbation simulations are conducted for 160-200 years.

What years are actually analyzed? I assume the first several decades (hopefully more) are not used, since the model is not yet in some sort of quasi-equilibrium?

P6 L26. “Surface temperature response is strongest in the US SO_2 and Europe SO_2 simulations in all three models, with annual mean local and remote temperature increases of up to 1 K or higher.” I assume this is related to the magnitude of the aerosol emission reduction. What if you normalize by this perturbation? I guess you eventually normalize by ERF, which would be similar.

P7 L10. Regarding the weak and inconsistent BC temperature response. Again, this appears to be consistent with the Stjern PDRMIP paper above.

Also, this may be related the resulting rapid adjustments. See, for example, Smith, C. J. et al. “Understanding rapid adjustments to diverse forcing agents”. Geophys. Res. Lett. 45, 12023–12031 (2018).

And in particular, the impact of the vertical profile of absorbing aerosol on the rapid adjustments. For example, Allen, R. J. et al. “Observationally constrained aerosol cloud semi-direct effects” npj Climate and Atmospheric Science (2019) showed very different surface temperature responses to absorbing aerosol dependent on the vertical absorbing aerosol profile. Models tend to have a vertically-uniform profile, and this leads to a negative adjustment, associated with high cloud reductions. However, a vertical profile that resembles CALIPSO observations (more absorption in the lower troposphere) yields low/mid-level cloud reductions, a positive adjustment, and surface warming. Looks as if this is eventually discussed near P11.

Figure 2. Can the “Robustness %” be defined in the figure caption.

Near Page 8 L10. Can you explain why BC reductions lead to surface warming (despite having a positive RF) in nearly all cases?

How do tropical emission reductions drive Arctic warming? Is it due to direct transport of aerosol to the Arctic, or due to changes in atmospheric/oceanic circulation that then leads to Arctic warming? Are these responses robust across the three models? Perhaps this is outside the scope of the current study.

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