

Interactive comment on “Robust winter warming over Eurasia under stratospheric sulfate geoengineering – the role of stratospheric dynamics” by Antara Banerjee et al.

Anonymous Referee #2

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The paper deals with the question of a possible winter warming in Eurasia as a consequence of artificial stratospheric sulfur injections. This winter warming has been proposed after large volcanic eruptions, but the scientific community has not come to a final conclusion if the observed signal is really a consequence of the volcanic aerosols in the stratosphere. The numerical simulation of constant long lasting artificial injection of sulfur allows to get a better statistical evidence. The paper is well written, and contributes to a still not well answered scientific question. The manuscript is within the scope of the journal and it clearly meets good scientific quality.

This study shows that a winter warming develops under solar radiation management

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(SRM) when using sulfur injections. But the authors determine a very strong signal with a strong signal to noise ratio as the sulfur load is much stronger than after recently observed volcanic eruptions. The study needs to discuss this fact and should also discuss clearly the questions:

- May we expect a winter warming after a volcanic eruption? Can we conclude this from this study?
- Does the GLENS simulations with a long constant forcing help to answer this question? Forcing from SRM and volcanic forcing can be quite different. This is especially true for GLENS as the SO₂ is injected at 15 N/S and 30 N/S. The resulting distribution of aerosols differs from a distribution after a volcanic eruption. Therefore, the gradient of the temperature anomaly will differ between the two cases. This needs to be described clearly in the article.
- How important is the signal to noise ratio? You determine a very strong signal. Sulfur load is much stronger than after recently observed volcanic eruptions. Which role plays the much stronger SRM forcing in the study compare to the Pinatubo forcing? GLENS is a transient simulation. You should add a comparison to the period when the SRM forcing is of comparable strength to a Pinatubo forcing.

Please, describe the proposed mechanism for the surface warming and stratosphere-troposphere coupling better in the introduction.

The article would gain from a figure of aerosol distribution and temperature anomaly and gradients in the stratosphere.

Specific comments:

Line 39: Why should SRM be performed alongside increasing GHG concentrations? This might be the most unwanted scenario.

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Line 45: '...warm the region....' A few more words about the region, transport etc would be nice for the reader.

Line 47 'increased equator-to-pole gradient': Are you talking about the stratosphere?. Potential temperature has a minimum at the Equator. Warming of aerosols should decrease the gradient. Currently, end of November, we have -70C to -75C at 70 hPa in the tropics and -70C to -73 C at the pole (<https://earth.nullschool.net/>). This is different at 10 hPa but the aerosol of SRM will mostly be at lower altitude, as well as volcanic sulfate.

Line 51: Which ensembles? Citation missing.

Line 58: Again, it is currently 10 to 15 K warmer at mid latitudes at 70 hPa than in the tropics and in at the North Pole.

Line 68: Warmer winters compared to control, RCP8.5 or?

Line 105: I have problems to understand the setup of the GEOHEAT experiment without reading Simpson et al (2019)

Line 149: Gradient in the stratosphere or troposphere? Do you meant avoiding the over cooling of the tropics with SRM (e.g. Kravitz et al, 2012)?

Line 159: '...such as this..' Where?

Line 170: How can the signal be significant over the Atlantic in 2020?

Line 179: The forcing of SRM in this scenario differs from a volcanic forcing. GLENS injects a four points. Does this impact the results? The transient GLENS simulation allows to determine winter warming in a period when the global forcing is similar to global Pinatubo forcing.

Line 220: Could the winter response also be an ocean or ice impact?

Line 229: Please. add a figure of stratospheric zonal mean temperature anomalies.

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Line 266: Please, name the targets of GLENS again. This would be helpful for the reader.

Line 270: Warming is not only in tropical lower stratosphere in GLENS.

Figure 1: per 30 years? This is never described and the 30 years are never mentioned. Name the period and tell the reader what is the baseline.

Figure 3: Why do we see a strong positive trend in both hemispheres and why mainly in the summer hemisphere in GeoHEAT?

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