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Comment on acp-2021-503

Anonymous Referee #4

Referee comment on "Impact of stratospheric aerosol intervention geoengineering on surface air temperature in China: a surface energy budget perspective" by Zhaochen Liu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-503-RC4, 2021

Review of "**Impact of stratospheric aerosol intervention geoengineering on surface air temperature in China: A surface energy budget perspective**" by Zhaochen Liu and others

This paper investigates the effect of the solar radiation modification on the downwelling solar radiation at the surface over China and hence on the surface temperature. For this purpose, it uses the simulation data from the G4 experiment from 3 climate models of the Geoengineering Model Intercomparison Project (GeoMIP). In G4, SO_2 is injected into the stratosphere at a rate of 5 Tg SO_2 per year on the RCP4.5 emission scenario. The analysis in this paper focuses on the contribution of key processes involved in the reduction of solar radiation at the surface. Four processes are assessed: AOD changes in the atmosphere due SO_2 injections, water vapor changes due to tropospheric cooling, changes in clouds and surface albedo. A simple 1-layer atmosphere model is used to facilitate the understanding. This decomposition of changes in downwelling shortwave radiation at the surface by a simple model is an elegant approach that helps to understand the complex interaction between various physical processes in climate models. The presentation is fine but could be improved in the revision. The paper could be accepted for publication after the main and specific comments listed below are addressed.

Main comments:

Clear insight into the contribution of water vapor changes and albedo changes should be provided in the revision. A colder atmosphere holds less water vapor – 7% decrease in water vapor per deg C decrease in temperature. Reduced water vapor causes reduced absorption of solar radiation that is coming down. In the case of surface albedo, colder temperatures are likely to lead to an increase in snow on the surface which would reflect more sunlight and hence a reduction in net surface shortwave radiation.

The authors find that there is decrease in clouds over China in the G4 experiment (Figures 7, S1 and S2). This decrease allows more net solar radiation at the surface. Some insight into the reason for the decrease in cloudiness in G4 should be provided in the revision.

Equations 8-11: How are these equations implemented in this work to estimate the 4 contributions discussed in section 4.3? This should be briefly discussed right after the derivation of these 4 equations. Also, the connection between these 4 equations and discussion in section 4.3 should be discussed in the beginning of section 4.3

Why does this focus on China? Why not the entire global domain? The rationale for the choice of the domain should be discussed in the revision.

Specific comments:

- Line 45: delete "simulating"
- Line 50: change "the decreasing" to "decrease".
- Lines 53-55: the overcooling of the tropics and undercooling of the polar regions would happen only if SRM is designed to offset the entire global mean surface temperature change. This important point should be included in the discussion here.
- Lines 55-59: SRM does not address the ocean acidification problem caused by increasing levels of CO_2 in the atmosphere. This deficiency of SRM should be also mentioned here.
- Line 70: Why do the author assess only surface temperature change? Why not the other important climate variables such as precipitation?
- Line 79: change "the simulations in the G4 experiment" to "the G4 experiment"?
- Line 79: provide a reference for the first phase of GeoMIP.
- Lines 108-118: What is the rationale for using the 1-layer atmosphere model in this study? What are its advantages and disadvantages? This should be briefly discussed.
- Line 122: For clarity, change "R is the fraction of reflection" to "R is the fraction of solar radiation reflected by the atmosphere"
- Line 155: "All the SCC are significant at the 99% level" How is this assessment made? Taylor diagram does not provide an assessment of the significance level of the correlation efficient. The method used for the statistical assessment should be briefly discussed.
- Line 180: the lack of differences in trends between G4 and RCP4.5 is expected because the magnitude of the radiative forcing is the same in the experiment except in the beginning when aerosols are suddenly injected in the G4 experiment.
- Line 205-208: The sign convention of LW is not clear in this paper. Is upward or downward LW is considered positive? This should be clarified in the revision.
- Lines 211-212: The figures show a decrease in clouds, but the text says clouds increase. The authors should carefully check their analysis.
- Lines 215-216: The link between the deficit of downward LH and flux and increase in cloud cover is not clear. Either delete this discussion or provide clarity.
- Line 220-223: The discussion is unclear. Revise the text
- Lines 251-253: The message from this sentence is not clear. Revise the text for clarity.
- Line 303: The Tilmes et al. 2018 paper discusses injection at multiple locations and not regional injections.

- Figure 1: I believe cs and cl are interchanged in the illustration. Should be corrected.
- Figure 2: The last line of the caption: The oblique dotted line cannot be seen in the figure. Revise the figure or the caption.