

Atmos. Chem. Phys. Discuss., referee comment RC1
<https://doi.org/10.5194/acp-2021-133-RC1>, 2021
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Comment on acp-2021-133

Peter Irvine (Referee)

Referee comment on "Identifying the sources of uncertainty in climate model simulations of solar radiation modification with the G6sulfur and G6solar Geoengineering Model Intercomparison Project (GeoMIP) simulations" by Daniele Visoni et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-133-RC1>, 2021

This article provides a thorough analysis of the similarities and differences between the responses of the GeoMIP G6 sulfur and G6 solar experiments, and a discussion of the uncertainties involved. The article is very strong and would make a valuable contribution to the literature, and I think it is ready for publication after a few minor points are addressed.

A very minor point but I would suggest reviewing the use of parentheses as there are an awful lot of them. I would suggest reserving parentheses for those points which are truly not relevant to the thrust of the sentence, and restoring some of the details held in many back into the sentences.

The figures look great but one common issue is that they don't make use of greater than and less than arrows (triangles) on the colorbars. If all data falls within the plotted bounds, perhaps this could be stated or if not these colorbars should be changed.

One area I think that the article could elaborate on is the differences in the response to prescribed stratospheric AOD as compared to fully simulated stratospheric aerosols, covering stratospheric heating, chemistry changes, etc.

Specific comments – Note many of these are suggestions to clarify the text and should be taken on or disregarded as the authors' see fit.

L13 – should these sentences be linked by a colon? They seem distinct points to me.

L15 – aerosol's?

L19 – should that be a full stop rather than a colon?

L21 – Is there something that could be said for precipitation change?

L38 – missing space, 4x.

L60 – by the stratospheric circulation

L62 – missing close bracker.

L70 – perhaps add a short phrase linking this list of analysis to the goal of exploring these uncertainties.

L71 – experimental

L80 – distributions

L81 – put parentheses and cites after "stratospheric processes"

L93 – I think here or elsewhere it is worth reflecting on the view that RCP8.5 is not just a high emissions scenario but an implausibly high emissions scenario, or at least adding a few words of caution around this scenario. This might be raised in the conclusion or introduction instead.

L94 – I'd suggest parentheses have been overused in this document, here for example.

L95 – drop spatially, put the parenthetical statement between commas.

L105 – Perhaps flip the order of this sentence to make it easier to follow: “The teams updated the reduction in solar constant, and the prescribed aerosols ... at different intervals, two did so every decade,”

L112 – to within 0.2 C of SSP2-4.5 levels.

L114 – there are a variety?

L115 – produce a large spread for the two scenarios.

Figure 1 – there’s a lonely degree symbol, should it just be a K? I’d guess that the ensemble members have been plotted for each model but this isn’t stated.

L126 – What about radiative forcing? Surely the response to CO₂ forcing and solar forcing are related, even if the % change in insolation and the response per doubling of CO₂ are not.

L130 – Figure 2f? And does it show this? Where is the model spread without normalization? Is this a generalizable result or a chance occurrence due to the make-up of ensemble?

Figure 2d – R-squared is 0.0, is that right?

L140 – Should that be the other way round, incoming minus outgoing, i.e. positive = more energy input to the earth system?

L142 – a much more consistent

L144 – two forcings

L145 – rephrase? And drop “indeed”

L146 – is necessary

L146 – drop indeed

L148 – more in general? More generally?

L161 – models'

L171 – new paragraph?

L178 – can't be made.

L183 – Are there papers comparing the simulated Pinatubo response and observed Pinatubo response for these models? That would be a valuable point of comparison.

Figure 4 – the Pinatubo box is clunky and hard to read, is there a better way to present this information? Here and in other relevant figures, it's probably worth mentioning that the yellow and orange lines fully overlap. Panel c – the panel title is too long, how about: "G6 sulfur AOD compared with Pinatubo". In the caption: "the year with a global AOD CLOSEST to that OF Pinatubo"

L194 – this sentence is hard to follow, consider revising.

L200 – this last sentence is also a little muddled, consider revising.

L21 – I think this is reasonable, isn't there a citation to back that up?

L214 – this comparison is not fair, the forcing from Pinatubo has had only a year to act, whereas for G6sulfur it has had a few decades. This suggests that the simulated response may be weaker than the observed Pinatubo response.

Figure S1 – are there negative AOD values?

Figure 5 – Is SSP2-4.5 a typo? Should that be SSP5-8.5?

246 – difference rather than differences. And should that be radiative perturbation from CO₂.

L250 – stratospheric heating repeated?

L251 – is this inability to restore the ocean state of the same character as the other things listed? It seems to be a consequence rather than a driver of differences in response. Though perhaps I've misunderstood the point.

L255 – Is Macmartin the right reference to introduce this analysis? Won't the main point of Macmartin still hold? I.e., that the uncertain degree of warming under RCP8.5, that is absent or reduced in solar geo scenarios, is itself associated with regional climate changes and hence drives model spread (and uncertainty). The Macmartin argument applies to the spread in RCP8.5 projections as compared to those of G6.

L260 – I'd suggest not switching the order of comparison here, i.e., the spread is larger in G6 sulfur.

L261 – I think it is a mischaracterization to say that G6sulfur is unable to cool down the Northern high latitudes. It looks to me as if ~2/3 of the warming difference has been offset. This should be rephrased to make clear that it is at least partially effective.

L263 – Is this definitely due to heating rather than some other factor?

L265 – although, if I recall correctly it's of smaller magnitude than would be expected from just the difference in radiative forcing due to countervailing circulation changes, right?

Figure 6 – Why do the colorbars not have "greater than" extensions? The lack of such extensions suggests that all points in the arctic in 6c, for example, see less than 1.1C of warming. Is that correct? Should note the change in colorbar range between a and c and e.

Figure 7 – no colorbar label.

L305 – point to?

L333 – Should this be split into 2 sentences?

L345 – tends.

L346 – will occur over the tropics, rather than observed.

L358 – this last sentence is very long, consider splitting. Should that be “direct effects of CO₂”, as in the CO₂ physiological effect or is this also CO₂ radiative effects too? Changes in dynamical changes?

L360 – Could this effect be quantified, i.e., what’s the land-mean precipitation error for those two projections?

Table 1 – CMIP6 doi? Is that a typo for MPI models, i.e., should it read: “r1,r2,r3” and not “r1,r2,r”?

Table 2 – should “last decade (2081-2100)” be “last 2 decades (2081-2100)”?

Figure 10 – The side-panels don’t line up with the maps and it’s hard to read given the number of colourful lines, I’d suggest pulling them out to a separate figure as little is gained from combining them with the maps. I also would only show one experiment for absolute plots.

L370 – “reduction in global-mean precipitation” should be elaborated to make clear what that reduction is relative to, as there is also a reduction seen in SSP2-4.5 relative to SSP5-8.5.

L372 – This sentence has a strange structure, consider revising.

L385 – no need to specify air, although it could be specified in air temperature.

L386 – this second half could be rephrased.

L415 – (and more) at wrong point.

L422 – rephrase - not even the most ideal.

L425 – restoring or maintaining the ITCZ location?

Figure 11 – stratospheric aerosol intervention – first time used. “more particularly”. Just a suggestion, but this might be easier to follow if the boxes were ordered from top to bottom: stratospheric heating and aerosols top (the inputs) → stratospheric chem, dynamics and aerosol chem / microphysics → Radiative forcing + surface climate (the outputs).