Earth System Dynamics Discussions

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Comment on esd-2022-44

Anonymous Referee #2

Referee comment on "PInc-PanTher estimates of Arctic permafrost soil carbon under the GeoMIP G6solar and G6sulfur experiments" by Aobo Liu et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2022-44-RC2, 2022

Overall this is a good contribution, and most of my comments are with regards to the clarity of presentation (including the current version leaving out a few details that are important). Some of this is simply that as written it implicitly is stating the results of this study as if they were statements about solar geoengineering more generally, vs statements about this particular strategy (tropical injection) in this particular scenario (cooling back down only to SSP2-4.5 levels, so that the global mean temperature continues to increase, just more slowly). Relevant to that it might be useful to try and make some statements in the conclusions about what one might expect to see in other cases, e.g., if SRM were used to hold global mean temperature constant, what would happen; if injection was done at higher latitudes… obviously you can't actually say that without having looked at those simulations, but you could potentially comment at least enough to make it clear that the answers will ultimately depend on the implementation.

- L11, SG could slow, could also stop it if one wanted, could even reverse it if one wanted. Why implicitly exclude these other options? (This is written as a generic statement, not a statement about the specific simulations you conducted.)
- L14-15, I know what you mean but someone unfamiliar with G6 might not realize that the SG is *only* applied for the SSP585. Nor might it be clear to a reader that in these scenarios, SG is used not to stop warming but only to reduce it to SSP2-4.5 levels – this is important context for the conclusions! (Given that G6 appears to roughly restore permafrost conditions to SSP2-4.5 levels also, one might reasonably infer that had more SG been used, one could prevent any further permafrost loss should one choose to.) Nor would a non-SG reader know that G6solar is a solar reduction and G6sulfur is stratospheric sulfate aerosols. (The abstract should be interpretable by people who are not already intimately familiar with GeoMIP scenarios.)
- L15-18, I don't think these numbers are useful to anyone who doesn't already know what G6 scenarios are (per above comment). Might be more useful to say that sufficient SG to yield global mean temperatures consistent with the SSP2-4.5 pathway under SSP2-8.5 CO2 concentrations also leads to permafrost area and soil carbon not statistically significantly different from those under SSP2-4.5, either under solar dimming or stratospheric aerosols.

- L21-23, (i) The first part of this conclusion is not correct as written, because it is written as if it is a generically true statement about SG rather than a statement about this particular scenario. A reader might reasonably infer that SG actually couldn't do more than this, because that is what the sentence as written (making it a generic statement) implicitly says. I would assume from your results that SG could mitigate all the area loss and carbon loss if we wanted. (ii) the last part of the sentence about an income stream for the Arctic population doesn't seem like a scientific statement but a guess. This isn't an economics or IR paper. (Personally I don't have a problem speculating on this in the conclusions, but highlighting that level of speculation in the abstract of what is otherwise a scientific paper feels a bridge too far.)
- L29, missing close quotation. (Plus, there's been fair criticism of continuing to call 5-85 as BAU given the existence of policy changes and pledges; labeling it BAU is inconsistent with the first line of the intro.)
- L48 is written as if these are alternatives; the point about speed is appropriate but wording could be improved to avoid framing as an either/or. Ditto L51.
- L55… I think it would be worth defining GeoMIP somewhere in the definition of G4. I guess you do in the next paragraph…
- L63… was the target of G6 the radiative forcing, or global mean temperature? (I honestly forget, and I'm on an airplane and not bothering to pay for wifi, so can't look it up.)
- L64, repeated "more". But more to the point, this would be a great opportunity to comment on the obvious scenario dependence (including not just the amount of cooling, but things like latitudes of injection). Ultimately (future paper of course) would be good to look at some of the more recent simulations still…
- L110, should define TSL, NPP, and GPP. (Even if I know what they are… other readers might not)
- Figures 1-3, when I can't see the G6solar line, is it under G6sulfur?
- L170, why is 2015-19 in equilibrium?
- Section 2.3 more generally… there are certainly some assumptions that go into this model; it might be useful somewhere to give some indication for which ones importantly affect results and which don't, and how significantly they affect things. (E.g., if the 2.5-fold increase for 10C change was 2.0, or 3.0, would that radically change conclusions? Is that sort of uncertainty likely?)
- Section 2.4, there will be some rather critical assumptions in here too, which aren't even stated. Like ratio of C emitted as CO2 vs CH4. Or the discount rate. Again, it's ok to refer to published literature, but giving some context (to save us from looking things up) would be useful, and to the extent possible worth acknowledging degree of uncertainty.
- L205-6, minor quibble, but could you put the RCP8.5 and 4.5 in the same order as in the previous sentence?
- L211-214, not sure the G6solar vs sulfur results are even statistically significant, but worth saying more here. When people ran the simulations to achieve SSP2-4.5 temperatures (or RF), were the global mean values for G6solar the same as G6sulfur? (That is, some effect could simply be how well they executed the G6 protocol.) Or, if the modelers perfectly balanced RF in each case, did that also manage temperature equally well in both cases? Second, for same global mean temperature under the two, is the typical overcooling of tropics / undercooling of high latitudes the same for the solar and sulfur simulations? (Given that AOD is likely higher in the tropics for the specific G6 protocol, I might expect more tropical overcooling than for G6solar, leading to a physical reason why G6sulfur as specified might be worse than G6solar for permafrost, but that would be a result of the G6 specification, not a feature inherent to SAI vs solar reduction, indeed SAI would presumably give more flexibility to alter latitudinal dependence.) Or, is any difference between G6solar and G6sulfur due to something associated with the aerosols themselves somehow? (E.g., assumptions in the land model and how it handles direct to diffuse light.) I think it would be both easy and important to check the first two possible sources of difference. It would also be

worth pointing out somewhere that G6sulfur assumes tropical injection, which tends to undercool high latitudes relative to low, and that that is a choice; that other choices for injection latitude might do relatively more cooling at higher latitudes.

- L273-274, is that RPE statement for all cases? (It follows a sentence about G6; unclear whether it is intended to be specific to that)
- L281… the changed direct and diffuse ratio is only present in G6sulfur yet the sentence talks about both. (Also, relevant to that, do you know how the land models in the various models handles direct to diffuse ratio for driving vegetation?)
- And Figure 9… wow, that's remarkable! I suppose not really that relevant here, but noting that CESM G6sulfur does show the "over" cooling in summer as suggested by Jiang et al.
- L319, are the conclusions very sensitive to this highly-uncertain numbr?
- L326, whoa… I think you need to say more than just "various". What parameters did you change, and why, and for what range? Are you coming up with a range of carbon emissions (in which case, shouldn't it be in the previous section)? Or just a range of economic damages for a given carbon? (in which case, are you missing the dominant uncertainties?)
- L356, again, the statement here is worded as a generic thing (as if "implementation of SG" was a binary choice, rather than something that one could do more or less of, as well as depending on latitude of injection)
- L358, but now, for costs, you specify G6 and then say it depends on scenario? This is not well worded… (that is, the "G6 scheme" I think means specifically following G6, i.e., for SSP5-8.5 emissions, with a target of 2-4.5 levels, using tropical injection. If you meant SAI more generally, you should say that).
- L360… considerable economic benefits even if only the permafrost carbon is included in the calculation!