

Interactive comment on “Differing precipitation response between Solar Radiation Management and Carbon Dioxide Removal due to fast and slow components” by Anton Laakso et al.

Anonymous Referee #1

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General comments

The authors studied the climate responses to two different geoengineering approaches: sulfur injections and carbon dioxide removal. Using the Gregory regression approach, the authors separated temperature-independent (fast adjustment) and temperature-dependent (slow responses) components and then quantified their contributions to the total precipitation change in an RCP based scenario. The authors also compared the total amount of aerosols needed under various scenarios and the spatial pattern changes. The paper is well written and contributes to our understandings of the hydrological cycle responses to different geoengineering forcing. I would recommend

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publication after the authors addressed the following comments.

Specific comments

My understanding is that during the simulations using MPI-ESM and CESM, you directly used the “equilibrium” aerosol distributions patterns estimated from ECHAM-HAMMOZ under the 1, 2, 3, 4, 5, and 6 Tg(S)/yr emission rates (in Fig.8 you used discrete injected sulfur rates). In the real world, if you change the emission rate of aerosols in year N, it takes time to adjust to a new equilibrium state. Therefore, there is a difference between your simulations and the real-world implementations (maybe it’s worth to point out?). Do you have any idea how much the difference could be? The discussion of regression in Section 3 is good. But in general, I think that the authors could add more information to support their statements and help the reader to better understand. For example, it would be very helpful if the author could show numbers at least for those regression slopes. It’s hard to identify and compare these regression lines with statements in the paper by eyes. Another example is shown in lines 258 to 260: the authors stated that “There was no large difference in surface albedo change between models” and “clear-sky SW absorption was linearly dependent on surface temperature”. Can you remind me where I can find figures or data for such statements? For each of the two models, the authors used regression results from three 20-year simulations (preindustrial, 2xCO₂, and 4xCO₂) and applied a logarithmical fit to estimate the coefficient “c” (the fast CO₂ effect to precipitation) (lines 362 to 364). You have only three data points during the curve fit, so I am wondering how good the curve fit is? The fast precipitation response to CO₂ change not only relates to the CO₂ radiative effect but is also partly attributed to the physiological effect. It’s fine to use the logarithmical form (I think the first paper used this relationship is in Cao et al., (2015)), but I think you might want to point it out here.

Technical corrections

Line 34: Add “increase” to “maintain the global mean temperature increase within 2°C

...”

Line 39: When the author says “a reduction of energy use”, do you mean energy use associated with fossil fuel burning only? Because energy consumption provided by renewables and biofuels will not deteriorate the climate warming target.

Line 47: Missing “)” here: “(Luderer et al., 2018, IPCC 2018)”

Line 67: “. . . SRM would decrease global mean precipitation through the direct radiative effect described above”. The hydrological cycle responses to solar geoengineering depend on magnitudes of geoengineering deployments and which case you are comparing with (the pre-industrial or high-CO2 world without SRM). I think the statement here should be more specific.

Line 80: add “for” to: “. . . continue to change for decades. . .”

Line 89: “separate” to “separates”, “totally” to “total”

Line 94: “a” to “the”

Line 134: delete “the”

Line 182: what do you mean of “business as usual scenarios” here?

Line 196: add “into” to “taken into account”

Line 217: add “as”

Line 224: “were” to “was”

Line 232: Please define “Preind” before using it

Line 293: “warned” to “warm”

Line 294 and 325: the font is different

Line 315: “Fig.1” should be “Fig.6”

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Line 324: “2010-2020” should be “2080-2100”

Line 355: there is an additional “a” in Eq. (1)

Reference

Cao, L., Bala, G., Zheng, M., & Caldeira, K. (2015). Fast and slow climate responses to CO₂ and solar forcing: A linear multivariate regression model characterizing transient climate change. *Journal of Geophysical Research: Atmospheres*, 120(23), 12–37.

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