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Discussions

Interactive comment on “Trade-offs of Solar Geoengineering and Mitigation under Climate Targets” *by* Mohammad M. Khabbazan et al.

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We are very grateful to the reviewers for the concise and constructive reports on our MS *“Trade-offs of Solar Geoengineering and Mitigation under Climate Targets.”* We have made a point-by-point reply to the reviewers’ comments, which can be found under https://doi.org/10.5194/esd-2020-95-AC1 and https://doi.org/10.5194/esd-2020-95-AC2. Here, we present our Final Response, which includes our main plan for revising our MS upon permission. Our Final Response here can be seen as a summary of our detailed responses to the reviewers’ comments.

1. We strive at making the point clearer that while our guardrails are merely hypothetical, they are ethically unique in the sense that they can readily be derived

from the global 2°C target. Hence, they provide the straightforward regionalization of that global temperature target.

2. Based on the following two arguments: (i) Due to the climate pattern mismatch between SRM and CO2-induced climate changes, we need to generalize a global target to a set of regional targets, and (ii) Temperature (Asseng et al. (2011)) and precipitation (Portmann et al. (2010)) are highly relevant for agricultural productivity, the pattern mismatch of precipitation is of a larger order of magnitude than that of temperature (Kravitz et al. (2014)). Therefore, we will clarify that temperature and precipitation are the only relevant climate predictors for agricultural productivity or the functionality of ecosystems in general, but we acknowledge precipitation limits as a necessary boundary condition within a target-based framework.

3. We will clarify Section 2 by adding equations and probably a table to show the differences between cases. The key point of our ms is to extend the decision-analytic framework of global mean temperature-based decision-making to a situation where global mean temperature ceases being a good predictor of regional climate.

4. We will clarify all of the points about including the level and time profile of SRM, geographical application of SRM, and starting points in the revised version.

5. We will transfer the definitions from Section 3 to Section 2.

6. We will present our results in a better way as suggested.

7. We will make the point clearer that the economy module in our model is global, i.e., there are no regional economic specifications. Therefore we are unable to provide further information on regions. However, we would like to stress that for our research question, global rather than regional mitigation costs are sufficient. Quite the contrary, for SRM, the side-effect category we investigate here lives

on regional climate pattern discrepancies, for which reason we need to model climate in a regionalized manner. We will use reviewers' comments and explain this point more clearly in the main text and elaborate on how multi-regional model results could differ from ours.

8. We will further ask colleagues and a professional language editor to assure the readability of our manuscript.

9. We will clarify the point that we utilize ‘uncertain’ in the sense of IPCC AR5 WGIII Annex I: It includes any lack of knowledge; in particular, it also covers probabilistic knowledge (IPCC (2014)).

10. Based on the discussion (including the one cited in our twin paper on SRM Roshan et al. (2019)), we will make the innovative aspect of our MS much clearer. None of the cited articles tackles a joint mitigation / SRM integrated assessment, including regional pattern mismatches induced by SRM. More specifically, Smith and Rasch (2013) focus on the main effect of SRM and answer how much SRM is to be added for a given greenhouse gas emission scenario if a certain global mean temperature target is to be complied with. Ekholm and Korhonen (2016) consider the effect of the timing uncertainty about when SRM can be deployed. Emmerling and Tavoni (2018) investigate the effects of uncertainty about SRM effectiveness and anticipated future learning about it on first-period decisions. Lawrence et al. (2018) present a meta-assessment on whether SRM can play a significant role in compliance with temperature targets at all. None of them discusses a new metric to extend the ethics represented by the 2°C target to assess one category of side-effects of SRM.

11. We will cite Kriegler and Bruckner (2004) for clarifying what we mean by ‘admissible,’ that is, ‘in compliance with a certain environmental target or further constraints.’

12. We strive at expressing clearer that we add regional environmental constraints without removing the global 2°C target.

13. By this MS, we present a solution to the conceptual evaluation problem that SRM destroys the correlation between the global indicator ‘global mean temperature’ and regional climate. This means that for decision-makers who accepted compliance with a global mean temperature target as a guideline for decision-making, this can no longer work as a guideline once SRM is applied. By this article hence, we strive to close this evaluation gap. We ask: ‘What are the regional analogs, if not to say ‘derivatives’ of the global mean temperature interval [0. . . T*], which would have been acceptable for a proponent of a T*-target? Which regional climate change does correspond to T*?’ (Within our case, T*=2°C.) We will make this point clearer in the revised version.

14. We will clarify that ‘scaling’ refers to ‘pattern scaling’ (see, e.g., Frieler et al. (2012) and Osborn et al. (2016)). The idea is that regional climate can, in first-order Taylor expansion, be predicted from a few global variables such as CO2-induced temperature change vs. SRM-induced temperature change. Again, we will add the relevant equations.

15. We will state more explicitly that the extra admissible area is not based on any calculation of the impacts that the additional change in precipitation could bring about, and these are used only in an illustrative manner.

16. We will briefly introduce what the Giorgi regions stand for or present.

17. We will describe how our model is a more realistic model than Nordhaus’s DICE model and compares it to more complex climate-energy-economy models.

18. We will explain the economic module in our model more precisely in the method section with appropriate equations. Also, we will add that the “splitting approach”

is possible because, from the economic module, we only infer the mitigation costs. As we will explain clearer here, the globally aggregated approach is of sufficient complexity to substitute for spatially resolved economic models.

19. We will clarify that the normalized values of 0 and 1 are not the max and min from the ‘observations’ between preindustrial and 2C scenarios, but they include the 5% or 10% leeway.
20. We will try to make Figures 3 and 4 more informative by adding vertical grids to the figure and explaining the effects.
21. We will make the point on mitigation costs clearer.
22. We will point out the literature where SRM is discussed from a ‘last resort’ perspective, under delayed scenarios and tipping points.
23. We will condition our statement more precisely on the regional targets’ tolerance levels.
24. We will revise Figure 1 as suggested.
25. Figure 3 describes at a glance the effects of qualitatively different scaling coefficients (or ratios thereof) on regional scenarios and their interaction with various targets. We will explain it more carefully.
26. We will strive at making our points clearer regarding Figure 5.
27. We will include more informative titles for the subfigures for Fugures 3, 4, and 5.
28. We will change our title to reflect the reviewers’ comments.
29. We will provide a detailed explanation of the procedure followed for obtaining scaling coefficients.

30. We will present our data as well as AOGCMs more properly and straightforwardly. Regarding the methodology to calculate CSRM and CCo2, we will explain precisely the procedure.
31. We will sharpen the abstract. We indeed want to study the inclusion of one crucial category of side-effect of SRM into an ethical framework coherent with a temperature target. This is our innovation, and its effects can be studied best if applied to the combination SRM+mitigation.
32. We will comply with the journal's data policy and present a proper reference to our data.

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