#Reviewer 2

The study develops a methodology to investigate the sensitivity of ecosystem response to changes in solar radiation, modified through geoengineering. This geoengineering link is very unclear both space and time scales-- whether or not actual geo-engineering implemented in a model, and what short- and long-term sensitivities are. The introduction should give a more thorough explanation of the problem, and the methods section should be more clear. Perhaps each of the four sensitivity approaches can be written in a separate paragraph.

Response:
Thanks for your comments. We will modify the introduction to provide further explanation of the link with geoengineering of the presented analysis. The four approaches to study how a change in solar radiation can modify ecohydrological variables are summarized at the beginning of section 2 and we will separate this section into different paragraphs to clearly illustrate what each approach entails. Essentially three simulation scenarios (the second/third/fourth approaches in the article) are using actual CMIP6 geoengineering simulations and we are using sensitivities of climate variables to these imposed changes in radiation to look at long-term climate feedback (abrupt-solm4p/abrupt-solp4p for the period January 1900 to December 1949), short-term climate feedback (abrupt-solm4p/abrupt-solp4p for the period from January 1850 to December 1859), and no temperature feedback (G1). Our aim is to compute changes in climate sensitivity due to changes in solar radiation that can be subsequently used to run ecohydrological simulations and thus study potential impacts of geoengineering projects, but more generally of changes in solar radiation, on the ecohydrological variables analyzed.

The results show that ecosystem response is relatively small, some fraction of the changes in ET, which is understandable. Although this sort of muted response is expected for the given sensitivities in the model forcing of 115 sitess, but I am unsettled with the way climate sensitivity is introduced based on the mean annual changes as reported in Figure 1. The future climate will bring a lot more variability across the globe, and that variability would potentially have a wider range of sensitivities than the sensitivity calculated using the global averages. In addition, sensitivities may also very more significantly when at least growing and non-growing season sensitivities are separated, as opposed to using sensitivities derived using global mean annual outputs. It is also unclear how climate sensitivities were implemented in each of the 115 sites. Are you doing something like bias correction in a time series obtained from a GCM somehow. Anyhow I detailed some of these issues below. Could be an interesting study after making all these issues clear.

Response:
I think Figure 1 might have generated a misunderstanding as it is indeed providing climate sensitivities at the global scale over land areas. However, the climate

sensitivities have been computed for each grid cell over the land area (Figure S3), including the 115 analyzed locations, and they have indeed a greater variability than the global average. In Figure 2 the red boxes show the global distribution of sensitivities when compared to the sensitivity distribution over the 115 sites and as you can see we sample most of the global variability using these sites. All sensitivities used for local-scale simulations are based on local values instead of global mean annual values. However, it is true that a single sensitivity in time is used without distinguishing for growing and non-growing seasons. We will test what is the difference in sensitivities across different seasons, to evaluate if this is indeed an important factor to consider.

There is no bias correction of the CMIP6 model outputs as climate sensitivities, e.g., how many mm day-1 the precipitation is changing per 1 W m^{-2} of solar radiation change are then applied to the local meteorological observations of a given site that are available from the base case. So we just perturb the local observations. CMIP6 simulations are simply used to compute the local climate sensitivities using the closest pixel to the location of interest. We will clarify this methodological aspect in the manuscript.

More comments:

What is the scale of you modification of the solar radiation, local or global, because your simulations seem to focus on local hydrometeorology but when you are discussing those 4 scenarios you are mixing scales, local versus global and regional. Please give example of this solar radiation manipulation methods and their corresponding scales. At the end of the day I was not sure if any of your GCM runs actually incorporated ang geo-engineering methods. Or are you just grinding through the data to obtain delta Rn versus Delta other weather variables. The paper repeatedly uses short-term climate feedback and long-term climate feedback without describing neither. Is this like you implement a solar manipulation and look at the surface variables over and short and long durations later.

Response:
As answered in the previous response, in Section 3.1, we calculated and discussed the sensitivities at the global scale (global annual mean) to illustrate the concept, but we also calculated the sensitivities for each pixel and present the global sensitivity map in Figure S3. We applied the same linear regression method (used in Figure1) to each pixel of the 115 sites, then we calculated the slope of the linear regression and applied it as the climate sensitivity at each site. These climate sensitivities are then use to perturb the local meteorological observations. The CMIP6 simulations are built around geo-engineering methods that perturb solar radiation but our purpose is more generic: it is to understand climate sensitivities to a change in solar radiation (that can or cannot be driven by geoengineering) and the consequences of these changes on the ecohydrological variables. We will further clarify this point in the article.

The short-term climate feedback and long-term climate feedback are simply referring to how climate sensitivities are obtained as the short-term sensitivities (SRsc) were

computed over the first decade (Jan.1850-Dec.1859), and the long-term sensitivities SRlc were computed for the last 50 years (Jan.1900-Dec.1949). This will be clarified further in the manuscript.

Why would you want to separate the effects of radiation change on ecohydrology from everything else anyway, what is the type of GE this may be suitable for. If you only play with radiation, then that would be like a greenhouse experiment where one can manipulate radiation and keep temperature the way they wish, but there is no reason to test something that is not realistic. Besides, models are generally linear to Radiation, so the response can be predictable by some excel calculations.

Response:
We respectfully disagree that there is no value in separating the effect of a radiation change itself from the effect that a radiation change plus all the feedbacks on climate variables is generating. There is a theoretical argument that such separation can help explain which are the physical processes responsible for a change as illustrated in Figure 3 and 4 and associated discussion. There are also more practical implications as there could be conditions where changes in solar radiation might occur locally, for instance in response to an increase or decrease in aerosol concentration in a given region (brightening or dimming) but they do not have a global impact such as to modify the Earth mean climate. Additionally there are future geoengineering programs that aim to change solar radiation but at the same time keep temperature unaltered, and so in our case we need to understand what a pure solar radiation decrease does in order to understand the potential future ecohydrological response to a GE solutions. We agree that this point was not made clear in the previous manuscript version, but it will be included in the revised version.

Material and Methods lines 80 – 90:
Four options (O) were outlined for different geoengineering solution scales for manipulating radiation, but without what type of GE that might be, so that makes the alternatives hard to picture, below are my interpretations:

Response:
We apologize for ingenerating confusion. As written above our aim goes beyond implications of specific geoengineering programs and it is to understand climate sensitivities to a change in solar radiation (that can or cannot be driven by geoengineering) and the consequences of these changes on the ecohydrological variables. The four options are simply to progressively study changes that are solely driven by solar radiation or by solar radiation inducing short and long-term feedback on climate. This will be clarified further in the article.

O1. Just change radiation, all else being constant, suitable for local scale: I cannot picture what type of geoengineering solution this might, after all these GE solutions

target large areas.

Response:
This is indeed not a geoengineering solution but more the effect of a local change in solar radiation for instance because of changes in aerosol concentrations in a specific region.

O2. "..include short-term climate feedback, in which solar radiation changes lead to a modification of other climate variables.." Isn't this a fancy way of saying we can use a reginal climate model to downscale GCM outputs. Then the question is how you would implement GE within your RCM. But I don't this this was done at all.

Response:
It is not about how it is implemented, as the implementation is always the same: we applied climate sensitivities to local observations. It is more of what these climate sensitivities obtained from global scale simulations are representative of. This case is representative of a GE intervention in the early stage, where solar radiation changes immediately lead to some local feedback, e.g., locally warmer near surface temperature but there is no time to modify the overall Earth climate yet. We will clarify this further.

O3. " … all long-term climate impacts introduced by initial modification of solar radiation…" This can be practically done by modifying your local (let's say atmospheric chemistry) and feeding your RCM into the GCM. but how was this implemented?

Response:
See our previous reply, implementation is always the same, the values and meaning of the climate sensitivities differ though. Just to clarify, we do not run an RCM.

O4. ".. the fourth scenario is one in which solar radiation effects are isolated from global temperature changes by perturbing two variables, usually radiation is reduced, and CO2 is increased to preserve the global scale mean temperature.." I am completely lost about the relevance of this.. what sort of geoengineering is this, what scale is this done, at the global scale we are already doing this experiment by putting more CO2 in the atmosphere. Can you give more insights on this?

Response:
This is probably the most relevant scenario as geoengineering is designed to modify solar radiation and keep global temperature unmodified. In order to compute climate sensitivities for this case, we use the G1 experiment here and the perturbation conditions can be found on the CMIP6 website (please see: https://view.es-doc.org/index.html?renderMethod=id&project=cmip6&id=470998d5-c134-4684-b18b- ef551fb67293&version=1). We calculated local climate sensitivities and applied the local-scale sensitivities to the meteorological observations to run the T&C model.

The study ends up using O2 and O4 and looks at the impacts of this local hydrology, but also climate sensitivities of O3. I am not sure how this climate sensitivities of O3 was looked at, is the solar modification done globally, which model was this in the list? To put this in the language I understand, seems like O2 is essentially using GCM output in some fashion so that we can identify the ecosystem response to Delta_Solar.

Response:
We hope that the answers to the above questions have clarified how the methodology has been implemented. We apologize again for the confusion we have ingenerated. The revised version will explicitly mention that we applied the climate sensitivities to local observed meteorological variables.

Lines 95-100: are those hydromet-sensitivities calculated from GCMs from the locations of those 115 sites? It would be very tricky to downscales from GCMs to those locations, how was this done? I presume those different CO2 levels were also included in the simulations, or maybe not, it depends what these Geoengineering scenarios are. Without more guidance on geoengineering solutions, it is difficult to judge the study.

Response:
We obtained the sensitivities for each grid cell (Figure S3). The 115 local sensitivity was selected for the closest pixel to the location of interest, however, given the fact that sensitivity have a smooth geographical variability – see Figure S3, sensitivities are the same in the range of several kilometers. It was not tricky to downscale as we simply applied the climate sensitivities to local observed meteorological variables, so we only rely on GCMs for the computation of sensitivities not for the simulation of local climate conditions.
While some of the geoengineering experiment increased the CO_2, we didn't perturb the CO_2 level in the T&C simulations. This is because we want to understand the effect of solar radiation changes not the overall consequences of a specific geoengineering experiment. This will be clarified and explained better in the revised manuscript.

Lines 125: I see that the sensitivity is actually calculated using the annual values. Is there evidence that these relationships obtained from annual values represent the seasonal changes. shouldn't this be done perhaps using a moving-average that cover the seasonal trends between solar-precip-temperature etc., especially considering the fact that you have an hourly model. Or if not, how do you justify? I presume your ecohydrology model response would be most sensitive to the "growing season" however it is naturally different across the 115 locations. Again here, I would like to go back and think about how the initial downscaling was made, that also would have major implications on the local weather variables, perhaps not so much the solar.

Response:
It is true that a single sensitivity in time was used without distinguishing for growing

and non-growing season or more generally for different seasons. We will test what is the difference in sensitivities across different seasons, to evaluate if this is indeed an important factor to consider.

Lines 192-195: what is the basis and evidence for this, your analysis is global and I am not seeing any citations to support for this claim.

Response:
We concluded this from Figure S4. There are a few isolated instance where surface solar radiation can have a positive change in response to a decrease in top-of-the-atmosphere solar radiation and a negative change in response to the top-of-the-atmosphere solar radiation. These are clearly driven by atmospheric dynamics and changes in cloud patterns. We will cite Figure S4 in the revision.

Figure 1. As expected annual trends seems fairly muted.

Response:
It is true that the global annual average sensitivity is not significant, but here we only present the global sensitivity. For the actual simulations we use local sensitivities as illustrated in Fig. 2 and discussed above.

Line 225. How did you compute the climate sensitivities at those 115 locations, again wouldn't this require some sort of GCM downscaling?

Response:
Please see our replies to the above questions.