Response to reviewer #2 for “Potential of global land water recycling to mitigate local temperature extremes

We thank the reviewers for their positive comments and for the feedback, which helped us to improve the manuscript. In the revised version, we expanded the discussion on the limitations of our study and added a supplementary figure on extreme precipitation. Further, we made some minor improvements and corrections to the text, and added the land mean values to Figure 3.

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I am recommending that this paper be accepted, subject to a few corrections and clarifications.
Overall I found the manuscript to be fairly straightforward. The authors analyzed their simulations very carefully and got a conclusion that, while having never really been demonstrated before, is perhaps unsurprising. I will say that it’s difficult for me to get excited about this present paper.

What really interested me is lines 25-26 on page 2, as well as lines 27-29 on page 9. There is a fascinating paper to be written on how irrigation has suppressed climate change, and because groundwater is being depleted, accompanied by increasing demand due to population growth, climate change is posed to accelerate in the near future. I realize that’s a very different paper than what the authors wrote, and there isn’t really too much wrong with the present paper, so I’m not going to suggest that they rewrite their entire paper to cater to my preference.
B1: We thank the reviewer for the critical appraisal of the paper and the detailed comments.

General comments

I think some additional attention needs to be paid to caveats. The LWR scheme uses local water sources, but many of those water sources are already spoken for, generating competition among resources. This has important implications for agriculture, energy use, and transport. The authors are not well set up to address these implications (that’s what integrated assessment models are for), but they can certainly discuss the importance of representing all of these processes and how they might affect the conclusions of the study.
B2: We agree with the reviewer that the LWR scheme uses water that would not be available in the real world. We already mention in our conclusions that our scheme could lead to a depletion of rivers and strong ecological impacts. We will expand on this, mentioning other competing interests:
“Our scheme, however, imposes a large stress on runoff, leaving no residual flow in some regions. In practice this would have devastating ecological implications and dramatically reduce river sediment transport (e.g. Chen et al., 2008). Additionally, some rivers are used for transport or to produce energy which would reduce the available water for LWR. Imposing a minimum flow condition is a potential important addition to the LWR scheme

(Jaegermeyr et al., 2017), which is expected to decrease the response of the climate system."

Relatedly, the authors should discuss the feedbacks that their new scheme will have on the climate system. As an example, reducing runoff will reduce river flow, which will increase salinity in river deltas and reduce sediment transport. There are many other processes that I suspect are not included in this study. This needs to be mentioned.
B3: We agree that many relevant hydrological processes, such as river temperature, quality and salinity, sediment transport, groundwater extraction and dam management, are not included in the current LWR scheme, nor are their potential feedbacks to the climate system. Regarding potential LWR impacts on ocean-atmosphere feedbacks, here we consciously choose to prescribe SSTs to minimize the need for a larger ensemble. We will add these considerations as a caveat to the conclusions:
Further, a number of potential earth system feedbacks arising from LWR are not considered in this study. For instance, LWR effects on hydrological processes, such as river temperature and salinity, water quality, sediment transport, groundwater extraction and dam management, are not included in the current LWR scheme and hence do not contribute to the overall climate feedbacks. In addition, we prescribe SSTs in our simulations, thereby disregarding potential feedbacks from the ocean. Performing simulations with an interactive ocean would for instance allow to assess the influence of changes in salinity due to the LWR, and compare the effects of less river water inflow to the ocean on the one hand, and enhanced precipitation and reduced evaporation over the ocean, on the other hand (Table 1).

Specific comments

Page 1, line 21: "SM is prescribed to pre-defined values" such as?
B4: There are a large number of different SM conditions that were used the literature (the plant wilting point, field capacity, simulated SM from a particular year, a climatological seasonal cycle, or a smoothed seasonal cycle). To investigate the influence of SM trends on temperature the most common is probably a climatological soil moisture. We will extend the sentence as follows:
The effect of future SM trends on temperature is typically assessed with idealised sensitivity experiments where SM is prescribed to predefined values, e.g a climatology (Koster et al., 2004; Seneviratne et al., 2013; Hauser et al., 2017).

Page 2, line 4: What does "it" refer to?
B5: We will rewrite the sentence to clarify the meaning:
A separate single-model experiment came to similar conclusions, identifying that in regions which experience drying, the SM feedback is responsible for up to one third of the projected increase in temperature extremes during the 21st century (Douville et al., 2016).

Page 2, line 10: Change "is" to "are"
B6: We will correct the mistake.

Page 2, line 16: "asymmetric" is misspelled

B7: We will correct the mistake.

Figure 1: I'm having trouble understanding panel a. The caption needs to be improved so I can better understand what is going on.
B8: Thanks for pointing this out. We will expand the caption and include a description of the algorithm in panel a as follows:
The blue lines indicate the 'flow' of water in the algorithm: surface runoff and subsurface drainage is combined to total runoff. If SM is below the target threshold, this total runoff is used to water the soil (1). In case there not enough runoff is available, water is taken from the reservoir (2). Finally, any remaining runoff is then used to fill up the reservoir if necessary (3). Note that steps (2) and (3) are only carried out if the reservoir capacity is >0 mm.

Page 7, line 1: No strong remote effects. There are probably weak effects.
B9: We agree with the reviewer and will change the sentence to:
This implies that there are no strong remote effects of LWR on SM.

Table 1: Experiment name is misspelled
B9: We will correct the mistake.

Page 9, line 6: "there are some regions"
B10: We will correct the mistake.

Page 9, line 23: I don't really understand this sentence. What realistic irrigation experiments? I thought your simulations were more realistic. Are you referring to anything in particular? In which case you need a citation.
B11: Thank you for pointing this out, we will change the sentence as follows:
This is in contrast to experiments with observed irrigation amounts, where India experiences a strong cooling (e.g. Thiery et al., 2017).