Response to reviewer #1 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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General comments

In the present paper the authors assess the potential to keep soil moisture at a certain level by means of sustainable land water recycling (LWR), and analyze the impact on temperature extremes and on the hydrological cycle. A relatively simple (but conclusive) LWR scheme is introduced, and coupled to an Earth system model (CESM). Sensitivity experiments are carried out using different LWR settings. The results indicate that (in the present simulations) sustainable LWR (i) reduce the land area with decreasing soil moisture, (ii) lead to an increase of precipitation in mid-latitudes and a reduction in monsoon regions, and (iii) reduce hot temperature extremes.

I think that this is an interesting paper, which on the one hand analyses the impact of sustainable water management (irrigation), and on the other hand indicates how this can be incorporated into Earth system models in a relatively easy way. The methodology is sound, the paper is well written and structured, and provides new and valuable results. Thus, I recommend publication. I have only minor comments the authors may like to consider.

A1: We thank the reviewer for the encouraging comments.

Specific comments

1) P10L8-10: The authors state that changes in the radiation budget are responsible for the decrease in temperature, and a decrease of downward thermal radiation (LWin) indicates higher cloud cover. This seem to imply (perhaps unintentional) that the change in LWin is the most important factor. I may be wrong, but I would expect that higher cloud cover (and more moisture due to enhanced evapotranspiration) would increase the downward thermal radiation if the atmospheric temperature stays the same. Thus, the decrease in LWin may be a subsequent effect due to cooling of the atmosphere in response to a colder surface caused by higher evapotranspiration and less solar radiation (more clouds). This may need to be clarified.

A2: We agree with the reviewer - a higher cloud cover should go along with a higher LWin, given the same surface temperature. Thus, the lower LWin in our simulations is likely caused by the lower atmospheric temperature, while the smaller SWnet is due to the change in cloud cover. We will rewrite the paragraph as follows:

“The decrease in SWnet is caused by a higher cloud cover (Figure S7), in line with the observed increase in precipitation in this region (Figure 3). The lower LWin, on the other hand, is likely a response to the decreased boundary layer temperatures.”

2) P12L13-P13L2: In the sensitivity experiments SST and sea ice are prescribed. In my view this is a reasonable approach to analyze the (local) response for land areas, as it is done in most of the study. However, I think it is difficult to obtain robust conclusions for global and long-term properties (the global long term trend) without using interactive ocean and sea ice.

A3: While we agree that there would be a feedback with the ocean, we argue that the temperature change is too small to substantially alter the long term trends. This is corroborated by the analysis of Hirsch et al., 2018, who showed that the trend in regional temperatures is similar with and without irrigation throughout the 21st century. We will update the paragraph as follows:

“Thus, our LWR scheme is able to locally offset the warming from half a degree additional warming. It does, however, not change the general warming trend due to rising greenhouse gases, which are almost the same in the LWR experiments and REF (Figure S8). This finding has to be taken with caution as we prescribe SSTs which will dictate the global mean warming. Nonetheless, they are in accordance with a similar study using an interactive ocean who also showed that the trend in regional temperatures is similar with and without irrigation throughout the 21st century (Hirsch et al., 2017).”

3) Precipitation: One main conclusion (and study-focus according to the title) is that LWR can reduce temperature extremes. However, also precipitation seems to change substantially. I’m wondering whether there is also a change of precipitation extremes. We may mitigate heat wave at the expense of having more flash floods in certain regions. Perhaps, the authors have looked at this, and may like to add a comment.

A4: We analysed annual maximum precipitation and will add Figure S5 as well a short discussion in the main text:

“We have limited the analysis of extreme precipitation to annual maximum 1-day precipitation amount (Rx1day, Figure S5). The detected changes in Rx1day between EXP and REF are generally smaller than 15 % and nonsignificant. The spatial pattern closely follow the change of mean precipitation shown in Figure 3.”

Technical corrections

1) P13L26: 1.06 -> -1.06 (?)

A5: We will correct the mistake.