Response to Reviewers' observations on manuscript "Validation of a new global irrigation scheme in the land surface model ORCHIDEE v2.2"

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Reply to topic editor

Reviewer 1, in their re-review, did not feel that the additional analyses and discussion sufficiently addressed their concerns. However, I feel that the additions go a long way toward improving the manuscript to a point where it can be published after minor revisions. Some requests based on Reviewer 1's re-review:

We thank the topic editor and the anonymous reviewers for the time they spent reading and commenting on our paper.

1.) Please add discussion of how negative biases caused by the (in Reviewer 1's words) "missing irrigation between sowing and greening (defined by the threshold LAI)" could be addressed in future model developments.

We added a discussion on the possibilities to address the missing irrigation between sowing and greening, and in general, on rules to trigger and stop irrigation (after line 511 of the submitted manuscript, in bold the changes):

Some rules could change the moment when irrigation is triggered and increase the amount (for instance allowing irrigation some days before the crop emergence) or decrease ***it*** *(for instance, preventing irrigation during maturity of the crop,* ***shortening the growing season****, or preventing continuous irrigation during more than a certain number of days).* ***Implementing these sets of rules for irrigation strategies in ORCHIDEE is feasible, for instance the definition of the growing season (with trigger of irrigation before sowing and stop before harvesting) could be based on the prescription of start and ending dates as done by Yin et al., 2020, or could use the phenology information simulated by the model (as in the version used here, or using a crop-specific module as in Wu et al., 2016). But defining the set of rules and parameter values would need a careful tuning and evaluation process, with local data at sub-yearly scale.***

2.) Please discuss how the global parameterization work performed here can fail to address regional errors caused by missing processes etc. This should be tied in with the Discussion text added about the model's limitations.

We discussed how some of the limitations listed at the beginning of discussion could have an impact on regional errors observed in results. We did so by using some of the observations and ideas from reviewer 1. We also added a general view on how to improve these errors. We added these paragraph after line 495 of the submitted manuscript, so it is directly related to the list of model's limitations:

These shortcomings and limitations could induce positive or negative biases in the simulated regional irrigation amounts; this as a result of differences in regional landscape, hydro-climatic conditions and local irrigation practices not well represented or absent in our scheme. For example, the missing representation of paddy irrigation induces under-irrigation in paddy rice areas, the joint representation of rainfed and irrigated crops induces over-irrigation in areas with other crop types and irrigation techniques, and the simplistic parameter tuning could tend to minimize the overall net bias, while increasing regional biases. These limitations (some shared with other global LSMs) call for further model developments that aim at a better representation of the water supply (fossil groundwater and water adduction to list two mentioned in the results) and the water demand (a separate water budget for irrigated areas, the inclusion of other irrigation techniques, new irrigation rules such as irrigation before sowing or interruption of irrigation before harvest). In addition to the improvements noted here that focus on model developments, the irrigation representation can be improved by using new input datasets and regional parameter values to include local practices (if these datasets exist at the coarse model resolution in the global domain, and for historical period or future scenarios). For instance, to prescribe regional β values, or to prescribe the start and end of the growing season.

3.) Please revise figures and equations as suggested by Reviewer 1. Please also review figures and equations not mentioned for similar issues.

We revised figures and equations. Please see responses to reviewer 1 below.

4.) Please convert all tables in the Supplement to text, rather than images. This is important for readability and accessibility.

We converted the tables in the Supplementary to text.

Review comments on 'Validation of a new global irrigation scheme in the ORCHIDEE land surface model' by Arboleda-Obando et al.

I was the Reviewer #1 in the previous review round. The authors agreed with the major technical flaws in the proposed irrigation scheme in ORCHIDEE I pointed in the previous review. The flaws can cause either positive (sub-grid-scale parameterization scheme) or negative (missing irrigation between sowing and greening stages) biases in irrigation. The authors correctly acknowledged the issues the flaws can cause and added additional discussions and supporting results (e.g., Figure S9) that demonstrate it.

We thank the anonymous reviewers for the time he spent reading and commenting on our paper.

However, the revised manuscript makes no effort of attempting (or at least proposing solutions) to address the flaws other than just acknowledging the issues. It is understandable that some of the deficiencies in the proposed irrigation scheme cannot be readily fixed for the manuscript, but the authors should be able to propose ways to improve them. For example, missing irrigation between sowing and greening (defined by the threshold LAI) can be easily added because ORCHIDEE already considers phenology information even if the model used in this work is not the version of Wu et al. (2016).

We thank the reviewer for this observation. We added a paragraph that partially explains some ways to improve the irrigation limitations (see response to observation 3 from the editor) and we add some specific ideas for the missing irrigation between sowing and greening (see response to observation 2 from the editor).

Another major issue relevant to above is that the authors do not link the apparent specifics of output errors to the deficiency in the current model. Instead, potential error factors in irrigation scheme, parameter tuning, and forcing data are listed in isolation from the result in the beginning of the Discussion. For example, while the added discussion and figures (see Figure S9) show positive bias in irrigation (over-irrigation) likely caused by irrigating the whole grid cell that contains a small fraction of the cell, the bias becomes negative gradually with increasing irrigated cropping fraction. It can be interpreted that, while over-irrigating fractional 'irr cells' causes +ve bias, late-start of irrigation (LAI based thresholding) may cause overall -ve bias (under-irrigation), with their net bias minimized by tuning beta. If this is the case, minimizing the global irrigation bias caused by a combination of systematic biases can explain the large regional irrigation biases. Current discussion does not provide useful insights to improve the specific issues reported in the manuscript.

We thank the reviewer for this observation. We felt that clearly stating the flaws of our approach was sufficient to enlighten the ways to the representation, and we apologize for this misjudgement. We added a sentence linking output errors and model deficiencies based on these observations from reviewer 2, and added a general view on the ways to address some of these flaws (see response to observation 3 from the editor).

As a result, although the manuscript reports some improvement in ET bias in comparison with FLUXCOM and small improvement in TWSA against GRACE, overall efficacy of the proposed irrigation scheme is not very convincing, particularly at regional scales. I recommend that the manuscript can be considered for publication after addressing comments listed above and convincingly explain specifics of errors with quantitative tests rather than generic speculations.

• Comment: Figure 9 inset text: Reduce the font size to make the whole text visible

• Reply: We corrected a small typo in the inset text, but we do not fully understand which text is not visible in this figure. We propose to discuss with the editor to correct this observation.

Part of the inset text '-633.9 km3/year' is still trimmed by the subfigure frame and the inset text is distinctively unbalanced in size in comparison with the other subfigures in the same figure. In fact, overall quality control of figures in the main text and supporting material is in poor quality and not acceptable for published articles. I will list just some of them below.

We thank the reviewer for clarifying this observation. We balanced the size of the inset text, and we reduced the font size of the subfigure. We also corrected the superscript units.

• Figure 2: 3 in km3 and 2 in m2 should be in superscript

We corrected the superscript units.

• Figure 3: km3

We corrected the superscript units.

• Figure 4: km 3 and inconsistent use of ‘y’, ‘year’, and ‘Year’ in unit

We corrected the superscript units and the inconsistent use of ‘year’.

• Figure 5: Consistency between mm/day or mm/d throughout the manuscript

We corrected the inconsistent use of mm/day to mm/d in the figures to be consistent with the manuscript.

• Figure 6: m2

We corrected the superscript units.

• Figure 7: Incorrect y axis label (TWSA)

We added TWSA to the y axis label so the variable is clearly stated.

• Figure 8: Missing y axis label

We added a y axis label, with variable and units

• Figure 9: gap between d) and subfigure title; inconsistent font size of subfigure titles and color index tick labels; inset texts font size

We corrected the gap between d) and the subfigure title; we set the font of the subfigures to the same size. We set the tick labels size and the inset text font size.

• Equations 1-2 in Supp: Period (.) is not for ‘product’ operator

We are sorry for this typo. We changed the Period operator by the product (×) operator

• Figure S1: km3

We corrected the 3 and set it as superscript.

• Figure S2: m^2; missing units in the subfigure title; (c) and (d) in the figure caption; too large font size of subfigures

We corrected m^2 and put it as superscript. We added figures and time steps to the subfigures title, and reduced the font size. We corrected figure captions c and d. We corrected the 3 and set it as superscript.

• Figure S3: m^2 and missing ‘degree’ symbol in temperature unit; too large font size of subfigures

We corrected the ^2 as superscript, added the degree symbol and reduced the font size of the subfigures. We added figures and time steps to the subfigures title.

• Figure S4: too large font size of subfigures

We set the smaller font size of subfigures

• Figure S5: inconsistent font size in inset and color bar

We corrected the inconsistencies in font size in the color bar, we deleted one of the color bars as they were the same for both figures.

• Similar errors in the subsequent figures (I will stop here)

We corrected superscript errors and the subfigures font size inconsistencies in the subsequent figures. We thank the reviewer for taking the time to point out these errors and inconsistencies.

• Table S1: poor-quality screenshot?

The table was converted to text, and it was set to fit the page size.

• Table S2: a little bit better quality but still a screenshot?

The table was converted to text, and it was set to fit the page size.

• Inconsistent fonts between tables

Font size was set to fit the document, and inconsistencies were corrected.