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Manuscript Title: Understanding ecosystem gross primary productivity, evapotranspiration, and water use efficiency of maize using ISBA-A-g_s land surface model over temperate and tropical semi-arid climates.

AUTHORS' RESPONSES TO REFEREE-1 COMMENTS

The manuscript titled "Understanding ecosystem gross primary productivity, evapotranspiration, and water use efficiency of maize using ISBA-A-gs land surface model over temperate and tropical semi-arid climates" evaluates the performance of the ISBA-A-gs model in simulating key ecohydrological fluxes (, , and) across two distinct climate regimes (temperate France and tropical semi-arid India). The authors successfully calibrated site-specific parameters to capture carbon-water dynamics under different irrigation practices. While the application of a process-based model to cross-climatic regimes is interesting and relevant, the manuscript is excessively lengthy and dense, which occasionally makes it difficult to understand the core findings. Streamlining the text and restructuring the presentation of results will significantly improve readability and impact.

- We sincerely thank the reviewer for the positive feedback and for recognizing the significance of applying the process-based ISBA-A-g_s land surface model to investigate ecosystem carbon-water dynamics under contrasting climatic conditions and irrigation practices. In response to the reviewer's suggestions, we have thoroughly revised the manuscript to improve its clarity, conciseness, organization, and overall readability.

Specifically, we propose the following revisions:

- **Introduction:** In the revised version, the introduction was condensed by removing the redundant texts, with logical orientation and distilled scientific review on the significance and need for understanding ecosystem gross primary productivity, evapotranspiration, and water use efficiency. The newly written introduction is expected to enhance the overall logical flow of the text.
- **Results:** In the revised version, we logically reorganize the results section to improve clarity and better align with the objectives of the study. The revised structure is as follows: **Section 3.1 - Dynamics of Gross Primary Productivity, Evapotranspiration, and Water Use Efficiency** characterizes the observed seasonal dynamics of GPP, ET, and WUE under the contrasting hydro-climatic conditions, thereby addressing objective (i).

Section 3.2 - Model Calibration describes the optimized site-specific parameters, evaluates their role in simulating carbon and water fluxes, and discusses their implications, thereby directly addressing objective (ii).

Section 3.3 - Model Performance evaluates the ability of the calibrated ISBA-A-g_s model to reproduce the seasonal and cumulative dynamics of GPP, ET, and WUE under contrasting hydro-climatic conditions and irrigation treatments using statistical performance metrics, thereby directly addressing objective (iii).

Section 3.4 - Diagnostic Analysis assesses the model's capability to reproduce the underlying eco-physiological mechanisms governing carbon-water interactions using the uWUE and EF-VPD relationships, thereby directly addressing objective (iv).

- Section 3.1 (Sites meteorology and vegetation characteristics) of the previous version will be integrated with Section 2.1 (Experimental sites description) to avoid repetition.
- **Discussion:** In the revised version, the discussion will be reorganized into three focused paragraphs that address (i) model calibration, (ii) model performance under contrasting hydro-climatic conditions, and (iii) the eco-physiological insights obtained from the diagnostic analyses.
- We carefully revised the manuscript throughout to improve the logical flow, reduce redundancy. Key findings and their implications are presented in a more concise and accessible way. We believe that this systematic revision will improve the readability, scientific rigor, and overall quality of the manuscript.

The Introduction provides an excellent, comprehensive background on , maize agro-ecosystems, and the history of the ISBA model framework. However, it is excessively long, making it difficult to understand the overarching research gap until lines 196–201. I recommend streamlining the introduction to establish a more direct line of sight to the study's novel contributions. Furthermore, the alignment between the stated objectives and the results should be tightened. Specifically, it is not immediately clear how objectives (iii) and (iv) are systematically isolated and resolved in the text. Please restructure the Results and Discussion sections to explicitly map back to these objectives.

- We sincerely thank the reviewer for the positive comments on the Introduction. Following reviewer suggestion, we have substantially revised and streamlined the introduction to provide a clearer progression from the general background to the research gap, novelty,

and study objectives. In the revised manuscript, we plan to organize the introduction more sequentially as follows:

1. The first paragraph introduces the significance of water-carbon coupling and ecosystem water use efficiency (WUE). It highlights the importance of simulating water-carbon coupling through land surface models (LSMs).
2. The second paragraph is followed by the ISBA-A-g_s land surface model, summarizes recent developments in its Multi-Energy Balance (MEB) configuration, and highlights its limited application for simulating coupled carbon-water dynamics under tropical semi-arid and temperate climates and contrasting irrigation practices.
3. The third paragraph discusses the importance of maize as a globally significant crop, emphasizes the contrasting hydro-climatic characteristics of temperate and tropical semi-arid agro-ecosystems, and explains the need to evaluate land surface models across these contrasting environments.
4. The fourth paragraph focuses on irrigation management, contrasting irrigation practices in France and India, and introduces the eco-physiological basis of carbon-water coupling together with the importance of diagnostic metrics for evaluating model performance.
5. The fifth paragraph describes the existing research gap at the outset, highlights the novelty of the present study, and states the research objectives of the present work.

- Overall, these revisions substantially reduce redundancy, improve the logical flow of the Introduction, and establish a clearer and more direct connection between the background, the identified research gap, and the novel contributions of the present study.
- Regarding the connection between the research objectives and the corresponding results and discussion, we reorganized the results and discussion sections to directly align with the four research objectives presented in the Introduction.

For example:

- Section 3.1 describes the dynamics of gross primary productivity, evapotranspiration, and water use efficiency (characterizing the observed seasonal dynamics of GPP, ET, and WUE under the contrasting hydro-climatic conditions, thereby addressing objective (i)).
- Section 3.2 discusses model calibration describing the optimized site-specific parameters, evaluating their role in simulating carbon and water fluxes. It will further discuss their implications, thereby directly addressing objective (ii).

- Section 3.3 shows the model performance evaluating the ability of the calibrated ISBA-A-g_s model to reproduce the seasonal and cumulative dynamics of GPP, ET, and WUE under contrasting hydro-climatic conditions and irrigation treatments using statistical performance metrics, thereby directly addressing objective (iii).
- Section 3.4 presented the diagnostic analysis assessing the model's capability to reproduce the underlying eco-physiological mechanisms governing carbon-water interactions using the uWUE and EF-VPD relationships, thereby directly addressing objective (iv).
- Similarly, the discussion section was reorganized to interpret the major findings corresponding to (i) model calibration, (ii) model performance across contrasting hydro-climatic conditions and irrigation treatments, and (iii) the diagnostic analyses of ecosystem carbon-water interactions.
- This revised organization thus establishes a clear and systematic correspondence between the study objectives, the results, and their interpretation, thereby improving the overall logical flow and readability of the manuscript.

The Results section reads more like an extended narrative and contains text that belongs elsewhere. For example: Section 3.1 (Site Meteorology and Vegetation): This section describes the environmental forcing data rather than new experimental or model findings. To tighten the manuscript, this text should be significantly condensed and integrated into Section 2.1 (Experimental sites description) within the Materials and Methods section.

- We agree with the reviewer, we revised the manuscript by integrating the original Section 3.1 (sites meteorology and vegetation characteristics) into Section 2.1 (Experimental sites description). This restructuring eliminates redundancy by presenting the environmental and vegetation characteristics together with the site description, allowing readers to understand the study conditions before the model simulations are introduced.

Section 3.3 (Model Calibration): This section is redundant as it essentially reiterates the exact numerical values already clearly presented in Table 5 and Table 6. The text should be condensed to focus strictly on the biophysical interpretation of why these parameters shifted between the sites and irrigation treatments, rather than repeating the data tables.

- Agreed. In the revised version, we condensed section 3.3 (model calibration) by removing redundant descriptions of the calibrated parameter values presented in Table 5 and Table 6. The revised section will emphasize the biophysical interpretation of the optimized site-specific parameters, their influence on carbon and water flux simulations, and their implications for model behaviour and ecosystem functioning, thereby providing a more concise and scientifically focused discussion.
- Furthermore, we have now expanded the discussion to interpret the differences in calibrated parameter values between the FR-Lam and Ind-IITH sites in terms of their underlying eco-physiological significance as shown in below:

"The calibrated ISBA-A-g_s framework demonstrated robust performance in reproducing the magnitude, seasonal dynamics, and interannual variability of GPP, ET, and WUE across the temperate FR-Lam and semi-arid Ind-IITH sites, demonstrating its ability to represent coupled carbon-water processes under contrasting hydro-climatic conditions. The calibrated parameter sets further revealed distinct ecosystem functioning between the two sites. Higher values of GC and D_{Max} at FR-Lam (Table 5) indicate stronger regulation by atmospheric demand, whereas higher values of gm and F2I at Ind-IITH (Table 6) reflect greater sensitivity to irrigation management and soil moisture availability. These contrasting parameter responses are consistent with the differing climatic regimes and water management practices at the two sites, highlighting the ability of ISBA-A-g_s to realistically represent site-specific ecohydrological processes governing ecosystem carbon assimilation and water use."

"This is now included in the revised manuscript."

Line 444: The description of the optimization algorithm requires more technical clarity. The authors state that a "one-at-a-time" sensitivity analysis was performed followed by 50 simulations per parameter. It is unclear if the final parameter selection was achieved via automated iterative optimization or manual tuning. Please explicitly state the exact mathematical or algorithmic approach used to isolate the final "optimal values" to ensure reproducibility.

- We agree that the original manuscript did not clearly provide sufficient detail regarding the calibration procedure. In response, we have substantially revised the model calibration section to explicitly describe the complete calibration workflow and improve its reproducibility. We included this in the revised version of the manuscript.

Specifically, we now clarify that:

- A one-at-a-time (OAT) sensitivity analysis was first performed by independently varying each parameter within its physically realistic range while keeping all remaining parameters fixed.
- For each parameter, 50 model simulations were conducted using the calibration datasets.
- Parameter sensitivity was evaluated using a Pareto-based multi-objective framework together with the Kolmogorov-Smirnov (KS) test to identify the most influential parameters.
- No automated optimization algorithm was employed. Instead, the sensitive parameters were manually refined through an iterative trial-and-error procedure, whereby parameter values were progressively adjusted within their physically realistic ranges and the resulting simulations were repeatedly evaluated using RMSE and R^2 until further improvements became negligible while maintaining physically realistic parameter values.
- We also clarified the calibration and validation strategy adopted for the FR-Lam and Ind-IITH sites, including the rationale for the absence of independent temporal validation at the Ind-IITH site. These revisions explicitly describe the workflow used to determine the final optimized parameter values and substantially improve the transparency and reproducibility of the calibration methodology.

Figures 6 and 8: In the scatter plots comparing daily observations against simulations, the authors have plotted a best-fit regression line. While a 1:1 line allows the reader to visually assess under- or over-estimation (bias) immediately. I highly recommend modifying these figures to display a 1:1 line.

- Agreed, we have revised Figures 6 and 8 by replacing the best-fit regression line with a 1:1 reference line. We will include this in the revised manuscript.

Line 199: Please explain what is meant by "climate-specific parameterization".

- The term "climate-specific parameterization" was intended to describe parameter sets calibrated separately for the two contrasting climatic environments (temperate FR-Lam and tropical semi-arid Ind-IITH). However, we agree that this terminology is too broad and

may be misleading, as the parameterization was performed individually for each study site rather than for climate types in general.

- To improve clarity, we have now revised the second study objective by replacing "climate-specific parameterization" with "site-specific parameterizations", which more accurately reflects the methodology adopted in this study.
- The revised objective now reads as:

"Calibrate and validate the ISBA-A-g_s land surface model using site-specific parameterizations under contrasting hydro-climatic conditions."

"This will be included in the revised manuscript."

Minor correction: Please correct the narrative citation style. When the authors' names are part of the sentence structure, only the year should be in parentheses (e.g., change "developed by (Noilhan and Planton, 1989)" to "developed by Noilhan and Planton (1989)"). This occurs in several places in the text (e.g., Calvet et al., 1998; Boone et al., 2017).

- Agreed, all narrative citations have been revised throughout the manuscript and will be included in the revised submission.