Review of "Improving the representation of major Indian crops in the Community Land Model version 5.0 (CLM5) using site-scale crop data, K. Narender Reddy, Somnath Baidya Roy, Sam S. Rabin, Danica L. Lombardozzi, Gudimetla Venkateswara Varma, Ruchira Biswas, and Devavat Chiru Naik"

Summary

The article focuses on improving the representation of two major Indian crops, spring wheat and rice, in the Community Land Model version 5.0 (CLM5) to enhance its accuracy in simulating crop phenology, yield, and associated land-atmosphere interactions. Using a newly created, comprehensive site-scale crop data set from India, the study calibrated and adjusted key parameters in the CLM5 crop module, such as sowing dates, growth parameters, and base temperature. The modified model versions (CLM5_Mod1 and CLM5_Mod2) demonstrated significant improvements in simulating crop growth, water and carbon fluxes, and irrigation patterns compared to the default CLM5 version. These modifications underscore the importance of region-specific parameters for global land models and provide a basis for better understanding land surface processes and their role in climate scenarios. The study's findings have implications for regional agricultural management and policy, as well as for enhancing climate modeling accuracy.

Title

The title generally works well with the content of the manuscript but mentioning the specific crops worked on in the title would provide readers with some clarity on what to expect.

Abstract

The abstract provides a concise summary of the study's goals, methodology, and findings, stating that the modified CLM5 performs better in simulating crop phenology, yield, and fluxes. For instance, it mentions that the Pearson's *r* for monthly LAI improved from 0.35 to 0.92 and monthly GPP from -0.46 to 0.79 compared to MODIS data.

While the abstract states that it aims to improve the representation of Indian crops, it could be more specific earlier on by naming the two crops (spring wheat and rice). This would immediately inform the reader about the study's focus. Consider revising the sentence: "Our study aimed to improve the representation of these crops in CLM5" to "Our study aimed to improve the representation of spring wheat and rice in CLM5."

The abstract could briefly mention the broader implications of these improvements. For example, it could say, "These improvements can enhance the accuracy of land-atmosphere interaction studies and inform regional agricultural management and policy."

Introduction

The introduction effectively outlines the importance of accurately simulating cropland processes in Land Surface Models (LSMs), which impact energy, water, and carbon fluxes. It provides sufficient background on the Community Land Model (CLM) and its development up to version 5.0.

While the introduction cites several relevant studies (e.g., Elliott et al., 2015; Lombardozzi et al., 2020), it could benefit from a few more recent references to highlight the current state of crop modeling. For example, "Recent studies provide valuable insights for enhancing the accuracy of simulating biogeophysical and biogeochemical processes..." could include more studies published after 2020 to strengthen this point.

The introduction mentions that "CLM5 simulations of rice and wheat over the Indian subcontinent show large biases," but it could be clearer about what specific biases (e.g., underestimation of yield, incorrect phenology timing) the current study addresses. Adding a sentence such as, "Specifically, the model has been shown to inaccurately simulate the timing of planting and harvesting for spring wheat and rice, leading to incorrect estimates of carbon fluxes and water use," would provide a clearer problem statement.

Materials and Methods

The description of the CLM5 model and its modifications (CLM5_Mod1 and CLM5_Mod2) is comprehensive, outlining the data sources, simulation setups, and parameter modifications. The distinction between site-scale and regional-scale simulations is also clearly made.

The detailed methodological description would benefit from a flowchart or diagram summarizing the process, from data collection to model calibration and evaluation. For example, Figure 1 in the document effectively shows the sites used for calibration, but a flowchart could visually represent the steps outlined in Sections 2.1 to 2.3.1.

The manuscript describes various parameter changes (e.g., base temperature, planting dates), but it could provide more justification for selecting these specific parameters for sensitivity analysis. For example, the section "Improvements in CLM5" states, "The base temperature and maximum GDD control the longevity of each phase in crop growth," but it does not explain why these were chosen over other potential parameters. A brief explanation could be added, such as "These parameters were chosen based on their significant influence on phenological development stages in crops, as indicated by previous studies (cite studies)."

Results

The results are presented with clear visualizations, such as the Taylor diagrams and time-series plots, that compare model versions against observational data.

While the Taylor diagrams (e.g., Figure 4) effectively show improvements in the model's performance, they could benefit from a brief explanation of how to interpret them. For example, "Higher correlation, lower RMS error, and smaller standard deviation characterize the most accurate CLM5 configuration, as seen in the closer proximity of CLM5_Mod2 markers to the observational reference point."

The results section presents the remaining biases in yield and growing season length (e.g., "The growing season length simulated by CLM5_Def is very low with a mean growing season of just 69 days, compared to 129 days in observations"), but it could discuss potential reasons for these biases in more detail. For example, it could mention model assumptions, data limitations, or unaccounted-for environmental factors that could contribute to these discrepancies.

Discussion

The discussion appropriately links the results to the study objectives, emphasizing the importance of region-specific parameters in LSMs for improving crop simulation accuracy.

The manuscript mentions, "Such improved land models will be a great asset in investigating global and regional-scale land-atmosphere interactions and developing future climate scenarios," but it could expand on specific applications. For instance, how could this model be used to inform irrigation management practices or forecast agricultural productivity under different climate scenarios?

The discussion would benefit from a dedicated section on limitations and future directions. For example, the text could state, "While the modified models showed significant improvements, there are still biases that could be addressed by incorporating more diverse site data or accounting for multi-cropping practices in the model," and suggest specific future research that could address these limitations.

Conclusion

The conclusion reiterates the key findings and reinforces the need for region-specific model calibration.

The conclusion could be strengthened by including a call for further studies or actions, such as "Future work could focus on extending this modeling approach to other major crops in India or integrating socio-economic factors to better inform policy-making."

Figures and Tables

Figures and tables are generally well-presented and labeled, effectively supporting the text.

Consider adding more comparative visuals that summarize the improvements across different metrics and model versions. For instance, a bar chart comparing MAB, RMSE, and Pearson's *r* values for CLM5_Def, CLM5_Mod1, and CLM5_Mod2 could provide a quick visual reference for readers.

References

The references are relevant and extensive, covering a range of studies on LSMs and crop modeling.

Include more recent references (post-2020) to ensure the manuscript reflects the latest advancements in the field. For example, search for recent studies on crop modeling in LSMs that may have incorporated new methodologies or datasets.

General Comments

The manuscript is generally well-written with a clear technical style suitable for the target audience. However, some sections could benefit from simplified language to increase accessibility for readers from diverse scientific backgrounds.

The manuscript follows a logical flow, but the Methods and Discussion sections could be further refined for clarity and depth.

Final Recommendations

Provide more justification for the choice of specific parameters in the sensitivity analysis and model modifications.

Include a discussion on the potential policy and practical implications of the findings and suggest specific areas for future research.

Consider adding more comparative figures and diagrams to succinctly showcase the differences between model versions and their performance improvements.

By addressing these critiques, the manuscript can be strengthened to ensure a robust and impactful contribution to the field. If you need further assistance with more detailed critiques on specific sections or figures, let me know!