Response to Reviewer 1

R1C1: In their submitted paper 'Simulation of crop yield using the global hydrological model H08 (crp.v1)', the authors enhance the H08 crop sub-model with parameter calibration and algorithm improvement. Thereby, the CO_2 fertilization effect and the effect of vapor pressure deficit change has been included to the model. Additionally, a model calibration has been applied. In order to evaluate the model results, simulated yields are compared with statistical yields and other global crop models for the major 4 crops (maize, wheat, rice, soybean) at country and grid-level. The paper is well written and understandable. Nevertheless, the paper has a main weakness: If you calibrate your model towards yields that you also use to validate/evaluate your model, it's not a surprise that R^2 is >0.99. But does that mean that your model improved? I wouldn't say so. It just says that the calibration was successful.

Response: We thank the reviewer for the constructive comments. We thoroughly revised unclear and incomplete points and incorporated all remarks.

Specifically, we conducted new simulations (see Table 1 and Fig. 1 for details) and added the results to explain the effects of CO_2 fertilization, vapor pressure deficit, and the combined effects of CO_2 fertilization and vapor pressure deficit on yield and crop water productivity before model calibration. Details are given in section 3.1 (see response R1C3).

Table 1. Simulations setting

Simulation ID	CO2 effect	VPD effect	Calibration
D	No	No	No
C	Yes	No	No
V	No	Yes	No
CV	Yes	Yes	No
CVC	Yes	Yes	Yes

We have also modified relevant text by replacing the "improved simulations" with "calibrated simulations" as the comment said in R1C2.

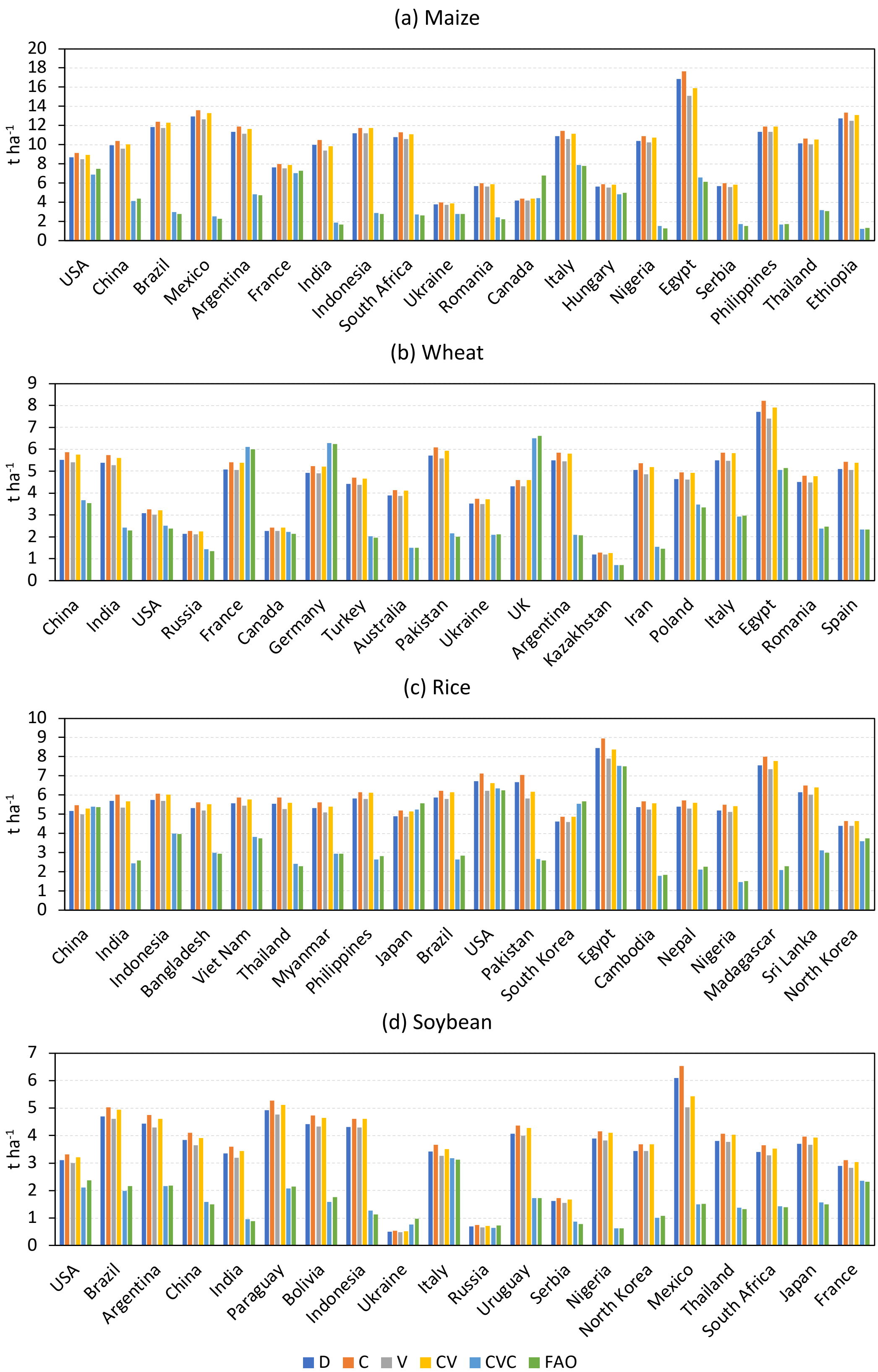

Fig. 1 Comparison of the mean yield from 1986 to 2015 of different simulations and FAO statistics. (a) maize, (b) wheat, (c) rice, and (d) soybean. Further details on five utilized simulations (D, C, V, CV, and CVC) are listed in Table 1.

R1C2: First, I'd suggest to say 'calibrated simulations' and 'default simulations' instead of 'improved' and 'default' simulations throughout the manuscript.

Response: We replaced the "improved simulations" with "calibrated simulations"

R1C3: Second, given the fact that you added the effects of CO_2 and vapor pressure deficit to the H08 model, it would be interesting in this study to quantify the difference between considering these effects and not. As in Deryng et al. (2016) I would encourage you to quantify the difference of CO_2 effect on crop water productivity for C3 and C4 crops.

Response: We added the requested results to explain the effects of CO_2 fertilization, vapor pressure deficit, and the combined effects of CO_2 fertilization and vapor pressure deficit on the yield (Fig. 1) and crop water productivity (Fig. S1):

"3.1 Effects of CO2 fertilization and vapor pressure deficit

When only considering the CO_2 fertilization effect (simulation C), there was a positive impact on crop yield, as compared to default simulations (simulation D) (Fig. 1). In addition, similar to previous studies (e.g., Deryng et a., 2016), the CO_2 fertilization effect is larger for C3 crops (wheat, rice, and soybean) than for C4 crops (maize). In contrast, when only considering the vapor pressure deficit effect (simulation V), there was a negative impact on crop yield in comparison with default simulation. When considering the effects of both CO2 fertilization and vapor pressure deficit, there was a positive impact on crop yield for the majority of the top 20 largest producer countries, while a negative impact was found for some countries (e.g., India and Egypt for maize). These impacts were also reflected in crop water productivity (CWP, defined as the ratio of crop yield to evapotranspiration). The averaged change of CWP in the top 20 largest producer countries was 4.8%, −2.3%, and 2.5% for maize under simulations C, V, and CV, compared to simulation D (Fig. S2). The corresponding values were (6.4%, −1.1%, 5.3%), (5.8%, −3.4%, 2.3%), and (7.1%, −3.6%, 3.4%) for wheat, rice, and soybean, respectively."

R1C4: A calibration can be done in a next step but after the validation. The quantification of water flows would require to validate crop evapotranspiration, which is not done in this study. Given the contextual and structural deficits in this study, I'd suggest major revisions.

Response: We revised the manuscript and show the effects of CO_2 fertilization and vapor pressure deficit on crop yield in section 3.1 and calibration results in section 3.2. The main objective of this study was to calibrate the model for crop yield and to add two new functions to determine the impact of CO_2 fertilization and vapor pressure deficit change on crop yield. Regarding crop evapotranspiration, a comprehensive analysis of blue water, green water, and crop evapotranspiration has been performed in an earlier study by Hanasaki et al., (2010). Note that the validity of overall hydrology is thoroughly discussed in Hanasaki et al. (2018).

Specific Comments:

R1C5: Abstract ln 1: 'Food and water are essential for life'. To me, this is trivial and a bit pathethic.

Response: We removed this sentence.

R1C6: Abstract ln 19: What means 'reasonably'? Can you quantify that with a statistical value?

Response: Detailed scientific discussions of case study results are not permitted in this journal, as noted by the editor in the initial editor review, and we have therefore revised this sentence. It now reads as follows (Lines 16–18):

"Using the enhanced model, we quantified the contributions of irrigation to global food production and compared our results to an earlier study."

R1C7: Line 35: You could add the PROMET model to this list of models, because it is also a hydrological model with an enhanced crop growth module included that has been applied at global (Zabel et al. 2019) and regional scale (Degife et al. 2021).

Response: Thank you. We added the PROMET model.

R1C8: Line 76: Is it still a 'process-based model', after calibrating parameters to match statistical yields that are subsequently used for model evaluation?

Response: We were referring to the original method of Fader et al. (2010), which was also implemented within the global, process-based model LPJmL. As the reviewer clarified, our model is not a rigorous "process-based model" after calibration. Therefore, we removed "process-based model", and the sentence now reads as follows (Lines 75–77):

"Then, we adopted the method of Fader et al. (2010) for parameter calibration because of its robust performance, minimal computation costs, simplicity of implementation, and because the method requires only national yield data which are easily accessible and generally reliable."

R1C9: Line 125: Nitrogen and phosphorous stress are implicitly considered in your calibration procedure! It possibly one of the main factors that influences your calibration.

Response: We agree and revised the sentence (Lines 138–140):

"Nitrogen and phosphorous stress were not considered in the original model (Hanasaki et al., 2008a) and were indirectly represented in the calibration simulation in the present study."

R1C10: Line 224: Two full stops.

Response: Thank you. We deleted one full stop.

R1C11: Line 222-231: See above comment on calibration and validation.

Response: We replaced "improved simulations" with "calibrated simulations".

R1C12: Line 233-239: Interannual yield variabilities are much higher in both, calibrated and default simulations than in observations. Can you explain why?

Response: Using maize as an example (Fig. 3), the yield anomaly magnitude becomes closer to FAO data for the majority of the top 20 countries after calibration. We noted that, for some countries, including USA, France, Ukraine, and Canada, the yield anomalies were still higher compared to FAO data, which is likely to be because the default simulations were already comparable to the FAO data and the calibration resulted in limited improvement (Fig. 1a and Fig. 2a). Therefore, the anomaly magnitudes in these countries did not improve much after calibration. We added these results in Lines 258–261:

"*Note that the calibrated model showed a similar performance to that of the default model in some countries (e.g., in USA, France, Ukraine, and Canada for maize) because the default simulations were already comparable to yield reported by the FAO, meaning that the calibration resulted in limited improvement (see Figs. 1a and 2a).*"

R1C13: Line 243: According to the GGCMI phase 3 protocol, none of the models in Jägermeyr et al. (2021) are calibrated to yields.

Response: We agree that the GGCMI participating models were not specifically calibrated for the protocol of GGCMI 3. However, at least for some models, the model description papers indicate that their parameters were calibrated during development. For example, for the model CROVER used in Jägermeyr et al. (2021), the crop parameters were calibrated using the GDHY yield dataset at the grid-cell level (Okada et al., 2018; Okada et al., 2015). In addition, for LPJmL model, the parameters were calibrated to FAO data (Bondeau et al., 2007; Fader et al., 2010).

R1C14: Line 295: Same problem than with constant irrigation occurs for the crop calendar, I guess?

Response: The crop calendar used in our simulation varies yearly based on differences in meteorological inputs. The crop calendar for H08 was determined as follows: first, the crop sub-model calculated harvesting date and yield for a crop planted on every day from January 1 to December 31. If the air temperature during the period dropped below the temperature threshold for cold death, crops would have perished and yield would have been zero. The planting date that resulted in the greatest yield over the year was assumed to be the planting date for the tested crop and location, and the yield for that date is represented the potential yield.

R1C15: Line 305: What means 'remain good references'? Don't you contradict yourself with what is said before? Of course, we need better data and this is a strong limitation.

Response: Thank you. We removed the sentence.

R1C16: Line 307: 'factors' or better say 'processes' here.

Response: Thank you. We replaced "factors" with "processes".

R1C17: Line 317: Therefore, it would be required to validate simulated crop evapotranspiration. If you can reproduce yields, it does not mean that evapotranspiration is simulated correctly.

Response: We focused on crop yield calibration and did not consider hydrological modelling, including evapotranspiration. The model outputs on bule water, green water, and total evapotranspiration were analyzed in an earlier study (Hanasaki et al., 2010) during the development of H08. In addition, the validity of overall hydrology was thoroughly discussed in Hanasaki et al. (2018).

R1C17: Line 331: You just mentioned that irrigated areas are kept constant over time, which impacts the results. Another question is the amount of irrigation that is applied. Do you consider only full irrigation, or do you also consider deficit irrigation?

Response: Thank you. We only consider full irrigation.

R1C18: Line 336: As I understood, H08 had the capacity to simulate yields before. You added two processes and applied a calibration.

Response: Thank you. we revised the sentence (Lines 360–361):

"In this study, we determined the effects of CO_2 fertilization and vapor pressure deficit on crop yield using the global hydrological model H08. Then, we calibrated the yields of four major staple crops: maize, wheat, rice, and soybean."

R1C19: Line 343: Please avoid qualitative statements like 'a good tool'. Nobody can say what is a good tool.

Response: We removed "good".

R1C20: Figure 1: Font size too small. Country names, etc. are very hard to read, even after zooming in.

Response: Thank you. We revised the figure and increased the font size.

R1C21: Figure 3: Interesting to see R and RMSE values as a bar plot, which is not intuitive. I'd suggest to show a Taylor diagram or a scatterplot.

Response: Thank you. We understand that Taylor diagram is able to simultaneously present the R and RMSE in one figure. However, this is not the main purpose here, as our intention was to compare the calculated metrics (R and RMSE) from our study with those reported in Fig. S10 in Jägermeyr et al. (2021). In addition, to generate a Taylor diagram, we require the data of both observation and simulation, but the original data used in Fig. S10 in Jägermeyr et al. (2021) are not available. Therefore, we chose to present the metric score comparison in a bar plot. We hope you understand.

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