Spatiotemporal responses in crop water footprint and benchmark under different irrigation techniques to climate change scenarios in China

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Authors' responses to Referees' comments

We are very grateful to Editor Professor Monica Riva and Referees for the opportunity of minor revision and the valuable comments and suggestions. We have carefully addressed all the comments and provided our detailed responses below them, responding point by point. The revised parts are colored in RED in the revised manuscript.

Editor comments:

Comments to the author:

The Authors have seriously taken in consideration the main comments of the reviews and provided a stronger revised manuscript. Some additional (minor) changes are still requested in order to better convey the main message of the manuscript. In this spirit, I encourage the authors to further review their work. Then I will be in the position to finalize the assessment of the manuscript.

Response: We thank Editor very much for handling our submission and constructive suggestions on improving the study. We carefully address each of the following comments and revise the manuscript accordingly.

Anonymous referee #1:

Dear authors,

You did a good job in responding to the reviewer comments and revising the manuscript. I have a few more follow-up questions based on your responses to my earlier comments, namely:

Response: Thank you very much for the positive words!

a) About your response to comment #2: What you call a "calibration method" isn't really a calibration, but rather a post-simulation correction (scaling) of Y. The method itself is fine and indeed widely applied, but I suggest to not call it a calibration, which suggests that you changed certain (sensitive) parameters in the model with the goal of improving some objective function value. Furthermore, I suspect that you make the implicit assumption that the crop parameters (e.g. the WP* parameter in AquaCrop) for the current/historic situation are still applicable in climate change scenarios. I think you can assume that, but please make the assumption explicit.

Response: We deeply appreciate your valuable comment. We correct the word "calibration" into "scaling" accordingly (Line 159). The crop parameters which were assumed as being consistent in the climate change scenarios are clarified in the text (Line 162).

"With the consistent scaling factors for the Y simulation and crop parameters including the crop calendar, WP*, HI_0, and the maximum root depth which represent the existing agricultural production level, climate was the only variable for future scenario simulations."

b) About your response to comment #4: It is good that you added this information and Table S6. I think Table S6 should definitely be part of the main manuscript (not the supplement), since it contains important information to interpret your results. I also have a couple of questions about Table S6's contents:

Response: As suggested, we move Table S6 from the supplementary material to the manuscript as current Table 2 (Line 175).

i) What depth criterion did you use? Back to field capacity (FC) when the time criterion is reached? Or add 10 mm when the time criterion is reached?

Response: The depth criterion we used was the "Back to field capacity (+/- mm)". The value of Back to field capacity used here was 10 mm, which means the extra 10 mm of water on top of the amount of irrigation water required to bring the root zone back to field capacity (Raes et al., 2017). We clarify the text (Line 173) and the explicit information is now available in Table 2.

ii) You should explain your choices for the specific values that you put in for the time criterion, the water quality and the surface area wetted. Did you base this on literature? For example, why is irrigation applied earlier (lower trigger value), and the water quality better, in the case of micro irrigation?

Response: The parameters values of three irrigation techniques were selected according to the reference manual of AquaCrop model (Raes et al., 2017). The time criterion we used was Allowable depletion (%), namely the percentage of the Readily Available soil Water (RAW) that can be depleted before irrigation water has to be applied. The Water quality was expressed by the Electrical conductivity (dS m^{-1}) of the irrigation water. The Soil surface wetted (%), an indicative value for the fraction of soil surface wetted, can be used to select irrigation techniques. We add the explanation in the text (Lines 167-171). Table 2 shows the values of each of above parameters for different modeling scenarios. The Allowable depletion and Electrical conductivity of micro irrigation were lower. Due to the lower Soil surface wetted, micro irrigation usually starts earlier, which results in the lower Allowable depletion. The equipment of micro irrigation has the higher requirement for water quality, which results in the lower Electrical conductivity.

Table 2. Parameters of three irrigation techniques.

Irrigation technique	From day	Time criterion: Allowable depletion	Depth criterion: Back to field capacity	Water quality: Electrical conductivity	Soil surface wetted
		(%)	(+/- mm)	(dS m^{-1})	(%)
Furrow	1	50	10	1.5	80
Micro	1	20	10	0	40
Sprinkler	1	50	10	1.5	100

c) About your response to comment #8: Sorry, I wasn't clear in the formulation of my comment. I wanted to see the absolute benchmark values that you have estimated, e.g. "xxx m^3/tonne for sprinkler-irrigated and xxx m^3/tonne for micro-irrigated wheat". Can you add that information in the abstract?

Response: Accordingly, we add pointed absolute benchmark values in the abstract. The relative text is as below (Lines 28-31).

"The WF benchmarks of maize and wheat in the humid zone (~overall average at 680 m^3 t^{-1} for maize and 873 m^3 t^{-1} for wheat at 20th percentile) are 13–32 % higher than those in the arid zone (~overall average at 601 m^3 t^{-1} for maize and 753 m^3 t^{-1} for wheat). The differences in WF benchmarks among various irrigation techniques are more significant in the arid zone, which can be as high as 57%, for 20th percentile WF benchmarks of 1020 m^3 t^{-1} for sprinkler-irrigated wheat and 648 m^3 t^{-1} for micro-irrigated wheat."

d) About your response to comment #10: Figure 1 is a nice addition. I only find the term "Planting modes" strange. That sounds to me like different ways to plant the seeds. Would the term "Growing modes" or "Irrigation modes" (with rain-fed being "no irrigation (rain-fed)" be better? Furthermore, you state that: "To ensure that the simulation results of future climate change scenarios are still reliable and meaningful, the baseline year was determined." I don't understand what you intend to say here. Can you rephrase? Setting a baseline year (or average of years) is needed for a comparison between future and current conditions, bur setting a baseline doesn't affect the scenarios (so doesn't make them more reliable or meaningful).

Response: We are very sorry for our unclear expression and use of incorrect word. We correct the "planting modes" into "growing modes" in both Figure 1 and text. In addition, we realize that the sentence "To ensure that the simulation results of future climate change scenarios are still reliable and meaningful, the baseline year was determined." in Section 2.2 Determining the baseline year is inaccurate and modify it to the following sentence (Line 124).

"Determining the baseline year is needed for a comparison between future and current conditions."

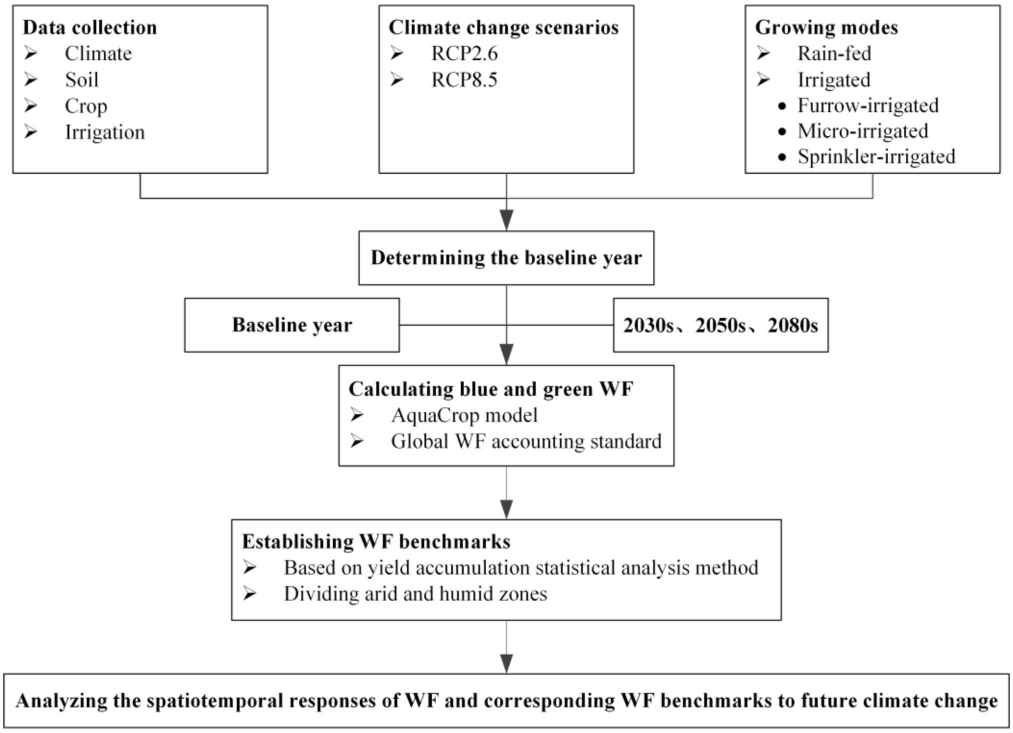

Figure 1. Flow chart for the study.

e) About your response to comment #11: I totally understand now why you updated HIo, but I have my doubts whether this FAO-56 recommendation (from 1998) for Zx is better than the Zx given in the calibrated AquaCrop crop parameter files for wheat and maize. Is there a large difference between those values (FAO-56 vs. AquaCrop)? And if so, why would you think this rather old reference value is better?

Response: We deeply appreciate your valuable comment. Following Table R1 shows the comparison of the maximum root depth (Z_x) for maize and wheat between FAO-56 recommendation (Allan et al., 1998), AquaCrop manual (Raes et al., 2017) and our study. The FAO-56 recommendation gives a reference range for the Z_x, which enables to distinguish the differences between irrigated and rainfed fields. While the AquaCrop manual files only give the upper criteria for certain crops. Furthermore, the differences between winter wheat and spring wheat are not shown in the model default parameter values. Therefore, we prefer to use the FAO-56 recommendations. We add the brief explanation in the text (Lines 197-198).

Table R1. The comparison of the maximum root depth (Z_x) between FAO-56 recommendation, AquaCrop mannual and the current study.

Crop	Z_x (m)			
	FAO-56 Report	AquaCrop Mannual	Current study	
			Irrigated	Rain-fed
Maize	1.0 ~ 1.7	Up to 2.80	1	1.7
Spring Wheat	1.0 ~ 1.5	Up to 2.40	1	1.5
Winter Wheat	1.5 ~ 1.8	Up to 2.40	1.5	1.8

f) Finally, I have one more comment in response to your updated novelty statement: You say that "this analysis is also the first to explore large-scale changes in WF benchmarks under future climate change scenarios." I think you can nuance that statement. There are several studies that assessed the WF under climate change scenarios. See for example the recent study by Karandish et al. (https://doi.org/10.1029/2021EF002095) and some of the references therein.

Response: We deeply appreciate your valuable comment. Karandish et al. (2022) also assess the effectiveness of three adaptation strategies, off-season cultivation, early planting, and water footprint (WF) benchmarking, on Iran's blue water savings in future. While the differences between different irrigation techniques were not considered. We clarify the text accordingly (Lines 102–106).

"Compared to existing literatures on evaluation of WFs of crop production under climate change scenarios (e.g., Karandish et al., 2022), the innovations of the current research are embodied in two points. The present study clarifies large-scale spatiotemporal responses of WF to future climate change scenarios under different irrigation techniques for the first time. This analysis is also the first to explore the large-scale future changes in WF benchmarks under different irrigation techniques."

I hope these comments are helpful in making some minor revisions to this manuscript.

Response: Thank you again for your efforts and valuable comments!

References

Karandish, F., Nouri, H., and Schyns, J. F.: Agricultural adaptation to reconcile food security and water sustainability under climate change: the case of cereals in Iran, Earths Future, https://doi.org/10.1029/2021EF002095, 2022.

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Allen, R. G., Pereira, L. S., Raes, D., and Smith, M.: Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56, 300, FAO, Rome, Italy, 1998.

Karandish, F., Nouri, H., and Schyns, J. F.: Agricultural adaptation to reconcile food security and water sustainability under climate change: the case of cereals in Iran, Earth's Future, 10, e2021EF002095, https://doi.org/10.1029/2021EF002095, 2022.

Raes, D., Steduto, P., Hsiao, T. C., and Fereres, E.: Reference manual, Chapter 2, AquaCrop model, Version 6.0, Food and Agriculture Organization of the United Nations, Rome, Italy, 2017.