Authors' response to Interactive comments on "Benchmark levels for the consumptive water footprint of crop production for different environmental conditions: a case study for winter wheat in China"

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Dear Referee #2,

We appreciate very much for your valuable comments and suggestions on our manuscript. We have provided our responses directly below the comments.

Anonymous Referee #2

The paper presents a study for determining benchmark levels for the consumptive water footprint (WF of winter wheat production in China, considering the influence of different external environmental factors (rainfed vs irrigated, wet vs dry years, warm vs cold years, and across soil classes and climate zones). This is done using the FAO's crop water productivity model AquaCrop. Only water stress is considered as limiting factor. The objective seems to be to identify where WF reductions should be targeted. China is the main wheat producer in the world an increasing water use efficiency in wheat production is certainly a priority, especially for water stress regions. In this sense, the topic of study is certainly interesting and appealing and within the scope of the journal. However, I have several important concerns on the research presented:

1) Green and blue water inputs are not separated for irrigated agriculture, while this has been done in previous studies (eg Liu et al. (2009), Global consumptive water use for crop production: The importance of green water and virtual water, Water Resour. Res., 45, W05428). Please justify why this separation is not considered in this study. This distinction seems fundamental for the practical relevance of the study, since the WF reduction will mainly have implications in blue water, correct?

Response: We agree with Referee #2 that the separation of green and blue water consumption is important for irrigated agriculture (Liu et al., 2009). The green and blue water footprint (WF, $m^3\ t^{-1}$) of a crop within a grid cell is calculated as the actual green and blue evapotranspiration (ET, $m^3\ ha^{-1}$) over the growing period divided by the crop yield (Y, $t\ ha^{-1}$), separately. We separated the green (precipitation) and blue water (irrigation) inputs as well as the resulted green and blue WF over the cropping period through the AquaCrop modelling as following Chukalla et al. (2016) and Zhuo et al. (2016). The separation of green and blue ET, was carried out by tracking the daily green and blue soil water balances based on the contribution of rainfall and irrigation, respectively. As suggested also in the comment (3), we will add the detailed description on AquaCrop modelling and assumptions in the revised manuscript.

In the current study, we did not distinguish green and blue WF benchmarks with two reasons. Firstly, the ratio of green to blue WF of a crop heavily depends on local green water resources availability, which is defined by the climate of certain time in a certain location. Location-specific blue WF benchmarks can be developed as a function of the overall consumptive WF benchmarks and local green water availability (Mekonnen and Hoekstra, 2014). Secondly, the purpose of the current study is to find out to which environmental factor the consumptive WF benchmark is most sensitive. The conclusion for agricultural water management at a large spatial scale only can be done by looking at the combined green-blue WF benchmarks given the first reason. However, as we mentioned in the last paragraph in 3.7 Discussion that, for each specific location, the blue WF benchmark which is translated from a certain benchmark of the consumptive WF of a crop is curtail for each specific location as a function of the local green water availability.

Regarding the implications for reducing consumptive WF of irrigated crops, not only the reduction of blue WF (e.g. improved irrigation technology), but also yield increase (e.g. soil nutrient management, weed control, crop variety selection) and reduction of green WF (e.g. crop scheduling, mulching) play the main roles (Hoekstra, 2013; Mekonnen and Hoekstra, 2014).

2) Besides the previous mentioned limitation, I miss more insight on the practical interest of the results. In order to be able to deïnˇA¸ne where WF improvements are possible and what measures to take to create higher levels of water productivity, the factors that determine the current levels of water productivity must be understood. However, this approach does not really help much on this sense. Climate cannot be controlled and the influence of the managerial factors are not incorporated in this study. So for me it is unclear to what extend the differences found in WF values are just due to the local conditions and cannot be significantly modified.

Response: Crop growth and water use are driven by environmental conditions that cannot be controlled by humans (e.g. climate, soil texture) and managerial factors (e.g. fertilizer, irrigation, tillage, mulching) (Zwart et al., 2010; Brauman et al., 2013). Apparently, understanding the sensitivity of the WF reduction potential or benchmarks of growing a crop to the uncontrollable environmental factors is crucial for both managers and farmers to better and effectively modify the controllable factors to improve the crop water productivity and to reduce the consumptive WFs in practice.

The current study investigates which *environmental factors* (climate, soil) should be distinguished when determining consumptive (green and blue) WF *benchmarks* of crop production, by taking winter wheat in China as the study case. In the results, the 26-31% smaller WF benchmarks for the humid zone than for the arid zone indicates that there are significant different levels of the limit or potential of reducing consumptive WF of winter wheat for different climate zones. For water managers, it is an important information when setting WF benchmarks of a crop for a region including different climate zones. Meanwhile, such information is also fundamental for wise water allocation and fair share of water resources among different sectors for a region (Hoekstra, 2013).

We will add the sentences stating the practical significance of the current study in the Introduction of the revised manuscript.

3) The description on the modelling assumptions and calibration is too limited and it is needed for properly understanding the simulation done.

Response: Yes, as suggested, we will add the detailed description on the AquaCrop modelling process, assumptions and calibration in the revised manuscript.

References:

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