

Anonymous Referee #1

1. This is a big and important topic. Many research papers and even books have been written about water-plant interactions. However, in its current form, it is not clear what this review paper adds to the literature. Additionally, the paper does not make it clear why it is important to focus on water-plant interactions specifically in the Anthropocene. The paper would benefit from re-writing to make the purpose more clear.

Thank you for pointing this out. The revised version will specify more clearly the new features of this review. The line of thought is that water-vegetation interactions are not merely interesting from an ecological or hydrological perspective but that they are indeed of global relevance, as they are core processes of some fundamental Anthropocene developments. The paper shall focus on these globally relevant features rather than attempting to provide a review of literature on plant-water interactions as such.

2. There is a wide and deep literature focusing on limiting factors to plant growth. a. Historical: A bit more historical perspective should be added. For example, Liebig's law of the minimum is relevant and dates back to the 1800s. Most of the papers cited are from after the year 2000, but this has been a focus of research long before the last decade.

I will try to consider research on such fundamental principles, but avoid being too general (too far away from the topic of water-vegetation interactions as would be the case with Liebig's Law).

b. State of the literature: What is the state of the art in modeling plant growth? For example, what does it mean to model a 1/2 degree grid cell as a single plant, as many models do? The large uncertainty associated with terrestrial plant growth in state-of-the-art models should be highlighted in the paper. Much work is needed to improve the treatment of plants in global climate models, which should definitely be focused on more in this paper.

This is absolutely true, thanks for this recommendation. The revision will briefly address this question in the Discussion.

3. This paper focuses on the LPJ model. What is the reason for this? Does this model perform better for plant-water interactions? If so, please specify why. If not, please justify focusing on this model.

Will do so (LPJmL is one of very few global models that address plant growth and water relations globally for both natural and agricultural vegetation).

Additionally, what is the exact relationship (i.e. equation used?) between water and plant growth in the LPJmL model? This would help in understanding Figure 2, since, at some point, the value of adding more water must be diminished, and other factors become limiting. But in Fig 2(c) gains are demonstrated over and beyond crop growth with unlimited water supply in Fig 2(b). It is not clear how this is possible. Please explain how the treatment of plant-water interactions in LPJ is similar and different to other global models. A section comparing water-plant interactions in LPJ and other comparable global models is needed.

The way how water and vegetation interactions are treated in LPJmL is very complex and cannot be fully described in this review paper (where LPJmL results are used as some examples to highlight some processes and their global relevance). Nonetheless, the revision will provide a summary of how that works in the model. Accordingly, the results in Fig. 2 will be interpreted in more detail.

4. The paper stresses the need for crop water use efficiency. Why? For what purpose? If it is for more plant production, under what circumstances is it most beneficial? If it is for reduced

water resources use, what about the Jevons paradox, where increased resource use efficiency leads to increased resource consumption? A discussion comparable to that of the yield paradox (i.e. where increased yields may, in some instances, lead to expansion of agricultural area) is needed.

Thanks for pointing this out, this can be briefly discussed and clarified, respectively.

Minor Comments:

Abstract, Line 4: Are the simulations new for this paper? If not, “: : supported by simulations: :” is mis-leading, since this would fall under literature review.

Line 6: How is “terrestrial ecosystem integrity” defined? This is certainly more than NPP as discussed in the paper.

Lines 16-17: Aren’t there regions where irrigation demand is decreased and freshwater availability is increased under climate change?

Line 21: “quantitative knowledge” is mentioned, but the conclusions seem to focus on “softer” issues

Introduction: P3 Line 1: add “the” before “global”

P3 Lines 14-17: Please re-write this sentence, it is unclear in its current formulation

P4 Lines 12-14: The first sentence of the abstract has carbon included. Is the objective of the paper to explore the intersection of water-carbon-vegetation or just water-vegetation?

Last paragraph of this section: There is no mention of the Anthropocene, which is in the title of the paper.

Section 2: The focus of this section is on NPP. The title should be re-written to highlight this, i.e. “Water limitation of net primary production”. There are many other aspects of natural vegetation not covered here, such as ecosystem composition and diversity.

P5 Line 27, again P6 Line 4: What do you mean by “adapt”? I think you are referring to compositional shifts, since genetic adaptation occurs on much longer time scales. Please rewrite.

P6 Line 17: “This is probably due to: : :.” Seems a bit speculative. What about Duke Forest experiments where NPP did not increase with very elevated CO₂ values? This statement is inconsistent with P9 Lines 9-26.

Section 3: P7 Line 5: replace “than” with “as is” P7 Lines 9-12: This seems like a big assumption to make. Just because humans manage crops does not mean that they will adapt any less “dynamically” to climate change. If anything, perhaps price signals will lead them to adapt more quickly! (Perhaps you should explain what you mean by adapting “dynamically”).

P8 Line 1: “with their domestic arable land” Are you assuming that countries consume only what they produce? Does this seem reasonable?

P8 Lines 15-16: Please cite the HESS discussion paper “Virtual water trade flows and savings under climate change”

P9 Line 2: Discuss the difference between C3 and C4 plants in reference to CO₂ fertilization.

Section 5: Is it reasonable to expect past trends on land use and related impacts to the water cycle to continue into the future? Discussion of debate surrounding land intensification (i.e. higher crop yields) versus land extensification (i.e. cultivate more lands) is needed here. This section seems to focus on agricultural expansion. However, global populations are urbanizing, leading to forest recovery in certain areas, such as the US Northeast. These trends should also be discussed.

Conclusion: A few paragraphs would be better than one.

Figure 2: What is the relationship used to obtain (b)? What are the other limiting factors (i.e. nitrogen, phosphorous, temperature)? In what geographic regions do certain factors become more important than water? If (b) is potential crop growth under unlimited water supply, then what possible additional crop growth could be achieved under more water as in (c)?

The referee lists many valuable suggestions to improve the paper stylistically and to focus it. They will all be acknowledged in the revision.