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Hydrology and Earth System Sciences Discussions



# *Interactive comment on* "Internal and external green-blue agricultural water footprints of nations, and related water and land savings through trade" *by* M. Fader et al.

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The paper describes the calculation of green and blue water footprints of nations and land and water savings through trade of crop products. The manuscript is well written, interesting and certainly of interest for a large community. The study is comprehensive, innovative and helps a lot to better understand the relation between global trade and natural resources use. Interesting also the comparisons to results of many other related studies making this article to a good overview on the state of the art in this field of research. The content of the paper fits very well to the scope of the journal. I would therefore highly recommend to consider it for publication in HESS.

Comments:

1) The authors use a modified version of the dynamic global vegetation and water balance model LPJmL to compute crop production, crop water use and related virtual water and virtual land contents of crop products. I understand that the development of such a model is always work in progress and that the recent model version is built "on top" of previously existing versions. However, I feel it difficult to really understand which methods, data and assumptions were implemented in the model version used in this study explicitly. It seems that it is required to read several publications just to understand how the green and blue virtual water content of crops was computed (see section 3.1) and that only parts of the developments described in previous publications are still used in the most recent version of the model. I would like to encourage the developer team therefore to find alternative ways for a more transparent model version documentation and description. Please provide such a more complete documentation for future articles (e.g. as electronic supplement).

2) When assuming a constant level of production, land and water savings are achieved by increasing global average crop yields and global average water productivity. This can happen in-situ by agricultural intensification (e.g. fertilizer application, plant protection, breeding) or ex-situ by replacing national crop products grown in regions of low crop yields and low water productivity by imports from regions with higher crop yields and higher water productivity. It would be very interesting to see how much global average crop yields and global average water productivity were increased as result of the trade between nations.

3) The concept used in this study to compute land and water savings by trade is assuming that a country "saves" the water and land that it would have needed to produce the related crop products (section 3.4). It is however difficult to compute these "savings" because assumptions on potential crop yields and potential water productivity in case of required domestic production are necessary. It is assumed here that crop yields and water productivity for this extra production would be similar to those computed for the



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actual production. I would like to see some discussion on this assumption because it is known that a higher domestic demand can result in an intensification of production and therefore less land and water requirements. On the other hand it also maybe required to increase production in marginal areas resulting in lower yields and lower water productivity.

4) The reported total land and water savings by trade between nations are impressive but I would highly appreciate a better distinction of flows from countries rich in land and water resources to countries with scarcity of resources and vice versa. This could help to better understand whether such virtual water and virtual land flows are intended or just a by-product of other needs. The research question behind this is non-trivial. According to the agricultural intensification theory growing population and growing demand for crop products result in shortage of agricultural land, therefore in agricultural intensification and finally in higher crop production per unit land and lower per cap cropland use. To save land by virtual land flows it is however required that flows are directed from regions with high yields to regions with low yields. Consequently, when thinking the agricultural intensification theory reversely this would mean that flows are required from regions short in agricultural land to regions without such shortages . . . . Any thoughts related to this problem?

5) Because of time constraints I could not manage to check all equations in this manuscript in detail. Please have another careful look on that, in particular that all variables are explained, that all units of the variables are reported and that the conversion between units is correct.



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Minor comments:

Page 488, lines 15-17: representing the soil in five layers in contrast to two layers before and implementation of root distributions is for sure a serious modification of the model since this will have implications for runoff generation, plant drought stress, crop yields and therefore virtual water contents as well. Did you check the consequences of this modification and can you explain a bit better how the model was improved thereby?

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 483, 2011.