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Interactive comment on "Virtual water highway: water use efficiency in global food trade" *by* H. Yang et al.

Anonymous Referee #2

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The manuscript addresses several scientific questions of relevance to HESS, particularly how food trade patterns affect water use efficiency on a global scale, but also attempts to distinguish between virtual water flow from rainfed agricultural practices ("green water") and flow from practices based on irrigation ("blue water"). The authors conclude that (1) water productivity is higher in exporting countries compared to importing countries, leading to a net global water saving, (2) exported products are mainly derived from rainfed agriculture, and (3) global virtual water trade mainly involves rich nations that have a choice of buying agricultural products from other countries or grow them nationally.

This manuscript was submitted to HESS shortly after a similar manuscript (Water saving through international trade of agricultural products, by Chapagain et al.) appeared on the HESSD discussion forum. The manuscripts present work which overlap in cer-

tain areas. Both have estimated the amount of global water saving arising from international trade of agricultural products, and it is interesting that the amounts are very similar (352 Gm3/yr reported by Chapagain et al., compared to 337 km3/yr reported in this manuscript) despite the fact that different numbers of products were used for the calculations. It is reassuring to see that different researchers arrive with the same result, but it will inevitably reduce the feeling of novelty of the manuscript being published last. I have read the interactive comments made by A. Hoekstra (co-author on the Chapagain et al. manuscript) and some of the comments I have overlap with these. I encourage you to write a similar comment on the Chapagain et al. manuscript.

General comments While I feel that the manuscript in general is well written and organized, it presents methods published earlier, particularly sections dealing with the calculation of crop virtual water content (section 2) and global virtual water flows (section 3), without references (i.e., Chapagain and Hoekstra 2004). As I see it, there are two ways forward. One way is to scale back on methods descriptions in sections 2-3 (referencing earlier work where necessary), and focus more in depth on the meaning of “global water saving”. Some suggestions for this discussion are given below in the next paragraph. Another way forward is to reduce sections 2-3 to a minimum and concentrating on the separation between green and blue water presented in sections 4-5. These suggestions are not exclusive of each other, and the manuscript would indeed be strengthened if both steps were taken.

It would be interesting to contrast the “water savings” with needs, benefits and efficiency to a greater extent than what is presented in the manuscript. The main conclusions of the manuscript appear positive (water is saved as a result of better utilization of mostly green water), but it would be interesting to discuss these facts from alternative angles. It is true that you can save money by buying something on sale, but only if you were going to buy it anyway. In this sense, “water savings” may be defined in different ways depending on the questions asked. Another type of “water saving” could be represented by shifting agriculture using wrong crops in the wrong places to efficient

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crops highly adapted to the prevalent climatic and geographic setting. Yet another type of water saving could be made by adapting our lifestyle and food intake to include more water-efficient products, and also adapt our consumer habits to seasonal differences in water availability. This would lead the manuscript in a different direction, but I feel it would provide a better platform for discussing “water saving” and what it means in reality.

The calculation of crop virtual water content is a fundamental step in the analysis but the uncertainty in this calculation is not discussed (p.5, lines 12-18). The meaning of the “reference crop evapotranspiration” and the “crop coefficient” is not explained, and there is no discussion of the difference between “specific crop water requirement” and actual water use by the crop. In situations where the water demand is not fully met, the theoretical and actual crop virtual water content will differ. The authors should acknowledge this and try to estimate the relative errors made in the calculations.

I would like to see the authors reflect on the scale of their study, and how the chosen scale may influence the results obtained. The study is based on national data, and the results are then grouped into subcontinental or continental units. I feel that the smaller scales may be more interesting for policy makers and managers. Since some countries span several climatic zones, it would be interesting to examine the utilization of green and blue water in these different geographic regions. This could be compared to local impacts on natural resources and how environmental stress manifests itself in different regions of the world. Even if some of this work only can be performed in hypothetically, or in a limited number of places, a study that connects local agricultural practices and its associated effects on local ecosystems to global scale trade patterns would make a significant contribution to science.

Overall, I feel that the manuscript needs substantial revision before publication. The authors should shorten sections with detailed descriptions of methods regarding the calculation of virtual water flow and reference earlier studies where necessary. In addition, the section describing the partitioning between green and blue water should be

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expanded to cover different scales of impacts.

Specific comments:

On p. 3, line 23: Change “productivity” to “productive”

On p. 8, line 16: Why is global virtual water trade abbreviated “GNVWT” and not simply “GVWT”? What does the “N” stand for?

On p. 9, line 27: Please change beginning of sentence “Individual country’sĚ” to “Each individual country’sĚ”.

On p. 10, lines 13-15: Delete the word “more” in the sentence starting with “Down to the country levelĚ”

On p. 12, equation (11): Close parenthesis on right side of expression.

On p. 13: Inconsistent use of subscripts. I suggest that you replace subscript “bw” with “irr”, and only use the term “blue water” in the text. Alternatively, change subscript “rf” in equation (12) to “gw” (green water).

On p. 13, equation (14): The term At is not defined.

On p. 20, Table 2: Check footnote reference signs: *Others should be **Others.

On p. 23 and 25, Figures 2 & 4. Remove scale bars from world maps.

On p. 26, Figure 5: Text in caption is missing (“Green virtual” should read “Green virtual water export”)

Interactive comment on Hydrology and Earth System Sciences Discussions, 3, 1, 2006.