Review
HESS #2017-224
"Grey water footprint reduction in irrigated crop production: effect of N application rate, N form, tillage practice and irrigation strategy"

Summary

In the present study, the authors explore the extent to which fertilizer use and other agricultural management practices impact the agricultural Grey Water Footprint (GWF). The results of the study show that the GWF, which is defined as the amount of freshwater required to assimilate pollutants to meet specific water quality standards, can be reduced by 91% with a decrease in fertilizer application to corn to 50 kg/ha-y. However, with this decrease in the GWF there is also an approximately 70% decrease in yields as well as increase in the blue and green water footprints of crop production. The authors find that the overall water footprint (grey + green + blue) can be minimized with an N application rate of 150 kg/ha-y, with N being applied to the crops as manure and with changes in other management practices (no-till, deficit irrigation). Under this water-optimized scenario, crop yields decrease by 20%. Importantly, the paper shows that there are clear, quantifiable tradeoffs between environmental costs and the human benefits of crop production, and also tradeoffs between avoiding water pollution and reducing water consumption (green and blue water).

General Comments/Suggestions

Lines 49-50	How does phosphorus play into your assumptions here? Obviously the P content of runoff also contributes to the GWF. In particular, if you are using manure to meet the N requirement, you are (based on typical N:P ratios in manure) almost surely applying excess P, which would increase the GWF of the farming system. You should be explicit about your assumptions here and make clear that, even if P pollution is outside the scope of your analysis, you are likely underestimating the GWF under these scenarios.
Lines 49-73	Very nice discussion of the complex tradeoffs among various agricultural management practices.
Lines 94-96	One of the strengths of the paper is that you explore tradeoffs associated with optimizing for multiple objectives (grey water footprint, blue/green water footprint, crop yield). I think it would be useful to more explicitly include this larger goal here when you state your objectives.
Lines 99-101	Why is Badajoz, Spain a relevant site for your purposes?

Lines 110-114	You are using a model-based approach that would also allow you to estimate losses of N to the atmosphere. Although you are specifically interested in water footprint effects here, it is also worth mentioning that managing N use also has impacts on greenhouse gas production. Optimizing for minimal pollution to the atmosphere would add additional complexity to your discussion of tradeoff. Although this is certainly beyond the scope of the present study, it would be valuable to mention this part of the agricultural management puzzle.
Figure 1	The labeling on the figure is messed up—maybe this is just a function of the pdf creation, but please check.
Line 205	How is the beta-value defined here different from the Tier-2 mass balance approach? It seems that beta is also based on a mass balance.
Section 3.2	What about soil health under the low-fertilizer scenarios? Do yields decrease over time at low fertilizer application rates?
Section 3.2	How do things vary from year to year? How do calculated GWF rates vary under different temperatures and rainfall quantities?
Figure 2	This is a good figure, but it might be easier to understand if the bars were all the same height (0-100%), so we could see the proportions of the different fluxes varying under the different application rates. As it is, it is very difficult to see or understand the flux magnitudes at the lower application rates.
Figure 3	Nice figure—the portrayal of the GWF under the normalized and non-normalized conditions is very useful.
Lines 332-333	It is not clear in your discussion how the use of manure N compares to that of commercial N fertilizer in terms of runoff/leaching. It has been shown that N leaching is usually greater with manure application (Edmeades, 2003, “Long-term effects of manures and fertilisers on soil productivity and quality: a review”), but your results do not seem to support this. Do the specific conditions of your simulations have an impact on these results?
Line 485	Your statement here again goes back to the issue of why this study site was selected. It may not be feasible to represent, in this study, a range of climatic conditions to represent all of Europe. On the other hand, your model results should provide some information regarding how your estimate of GWF effects could vary across varying climates. Would the

GWF be larger or smaller in a more humid climate? How might the recommended regime for optimizing GWF/BWF/GrWF values change across a distribution of climates and landscapes? As your stated objective is to explore how management practices and N application rates impact the water footprint (not just the water footprint in a semi-arid region of Spain), it would be beneficial to include some comments regarding the wider applicability of your findings.