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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Interplay of changing irrigation technologies and water reuse: Example from the Upper Snake River Basin, Idaho, USA" *by* Shan Zuidema et al.

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We thank the referee for their comments. We will try to address the concerns here and highlight areas where we think we can make the work more understandable for readers as highlighted by the review. Other reviewers made minor points that can help clarify the methodology section, and we will attempt to clarify the description regarding the experiment structure (2.3), which we thought was the most challenging to convey.

We consider that the referees second point in a positive light because good science tends to be unsurprising in retrospect. The hypothesis the referee refers to is described in its entirety at the end of the introduction (P3,L18-21) and repeated here:

"We hypothesized that only a fraction of the reduced incidental returns from modernizing technology would be needed to maintain aquifer volume if introduced as MAR. An alternative hypothesis is that asynchronicity in recharge water availability and irrigation demand would require greater recharge rates than if water was introduced as inefficient irrigation and reused contemporaneously."

We acknowledge an alternative hypothesis because the conclusion is not forgone as this is a complex system with interfering processes (e.g. increasing efficiency both reduces recharge to the aquifer, but also reduces pumping from the aquifer). As a result of these processes, the hypothesis is supported, but in (what we consider) and interesting and non-linear way (P13,L18-20).

One of the benefits of modeling any complex system is to elucidate non-linear emergent behavior. Here, the results with regards to MAR volumes versus return flow reductions is clearly non-linear. Each aspect of the model is represented using straightforward and first-order assumptions, yet there is no clear way (to us) to evaluate which processes supersede others in a given context except to encode these assumptions into a distributed simulation model of the system. When we ascertain that the rate of reduction in non-beneficial losses from increasing irrigation efficiency outpaces the increasing rate of managed aquifer recharge, we have certainly identified a first-order process that is responsible for that outcome. But we have established that finding in concert with numerous other first-order processes that may have lead to different outcomes in a different context. This type of modeling study adds to an ongoing discussion in the literature – as cited in the introduction and discussion sections – on what metrics of efficiency and re-use are informative at the watershed management scale. Long-used metrics such as classical irrigation efficiency (CIE) which are field-scale and useful for the engineering of individual irrigation systems, and even the effective irrigation efficiency (EIE), which accounts for the reusability of return flows, fall short of this goal. Hydrologists are seeking new ways to quantify and evaluate irrigation management at watershed scales. Here, we see that certain characteristics of the watershed such as the high percolation rates, tight connection between surface water and groundwater, and the existing regulatory framework, are all important considerations when constructing an informative efficiency metric targeted at achieving local water management goals.

The referee's final suggestion is an important one, which we expect will greatly improve the manuscript. Though we allude to the robust discussion of the importance of assessing the interplay between reuse of non-consumptive losses and improving efficiency in our introduction, we can improve it to give more context describing the utility of model experimentation, and alternative methodology such as utilizing natural experiments where alternative practices are incentivized in different locations or times.

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