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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 generous review of the work, and the constructive feedback provided. We agree with the comments and will address each in turn. In the revision of the manuscript, we will easily fix the confusing word choice or grammatical errors identified by the referee at: (P1, L3), (P5, L3), (P4,L4 [percolation]), and (P7, L2). We would like to respond to more substantive comments directly here.

We make passing comment (P2,L11) to the economic pressure to utilize more water, when that water is abstracted more efficiently. Contor and Taylor (2013) provided an illustrative example of this paradox in the context of the Upper Snake River Basin.

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We will more clearly capture the essence of their thesis in the revised manuscript. Basically, a more efficient irrigation system reduces non-consumptive water losses, thereby making more water available for consumptive use. In a water rights system where an irrigator has a fixed amount of water available to them and a mandate to use all of their water beneficially, reductions in non-consumptive water losses are likely to be balanced by an expansion of cropland or planting of crop with greater ET to make use of the “extra” water. This phenomenon is well known within the resource economics literature, where it is referred to as “Jevon’s Paradox”. Our revised manuscript will streamline this summary in our introduction.

In introducing our definitions of hydrologic fractions and irrigation efficiency (P4,L31), the referee points out that we did not provide a specific definition of irrigation efficiency. Though this was intentional as we wanted to focus our use of the term “irrigation efficiency” to the discussion, upon reflection we agree that it is unclear as written. We describe both classical irrigation efficiency (CIE) and effective irrigation efficiency (P15,L13) so we agree the manuscript is improved by clearly defining these early. We will provide the definition of CIE:

$CIE=B/G$

and an explicit equation for EIE, (not provided in the original manuscript, which was an oversight):

$EIE=B/(G-R)$

when we introduce hydrologic fractions. In the above equations, B, G, and R refer to beneficial consumption, gross irrigation abstractions, and reused irrigation abstractions, respectively, all in units of volume per time.

The referee requests additional clarity regarding the calculation of “consumptive and non-beneficial losses” (which will be revised to more accurately state “non-beneficial consumption”) at P7, L14. Though the details of this calculation are provided in the

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supplement, we agree that examples defining the processes involved are warranted. For example a proposed revision (P7, L14):

“The system explicitly represented non-beneficial consumption as evaporation of sprinkler mists and evaporation from canal and soil surfaces, using technology specific parameters reflecting county-wide averages from USGS water use statistics (Dieter et al., 2018; Maupin et al., 2014). A representative fraction of 4% of sprinkler applied water is evaporated as mists (Bavi et al., 2009; McLean et al., 2000; Uddin et al., 2010). Further, during the irrigation season, water is assumed to be evaporating at potential rates throughout the canal network. We assume crop ET is required (e.g. beneficial) for both transpiration and salt flushing, but water applied during an irrigation event in excess of daily crop demand wets soil above field capacity. This water evaporates (non-beneficially) at the potential rate, and unevaporated water is returned non-consumptively at the end of the timestep via either percolation, or runoff if vertical hydraulic conductivity is too low. The algorithm describing irrigation water fates is detailed in the Supplemental material.”

Reservoir data retrieved from the US Bureau of Reclamation did not include direct estimates of consumption from reservoirs (P8,L4) by either non-beneficial evaporative consumption or gross abstractions. Although we do calculate surface evaporation from reservoirs, we do not associate this flux with non-beneficial consumption as water is stored for multiple uses in all reservoirs making attribution of open-water evaporation to a particular sector (such as irrigated agriculture) problematic.

Our word choice at the opening of the paragraph referring to WBM’s use of the FAO56 (P8,L22) is confusing and will be revised. It is more accurate to say that “WBM uses” or “WBM adapted” FAO56 (Allen et al., 1998) to estimate crop water demands. Although we utilize alternative techniques for calculating reference ET (e.g. Hamon (1963) here), crop water demands follow directly from FAO56. This will be clarified in our revisions.

We thank the referee for catching our misuse of terminology in describing reference ET on (P8,L22).

In the revised manuscript we will clarify the sample duration associated with each of the four metrics used to establish model performance at P9, L2-8. This information is summarized in Table S2: monthly discharge from springs, annual gross irrigation by county, seasonal mean discharge, and seasonal mean reservoir storage.

Indeed there is a breadth of knowledge (e.g. Adam et al., 2007; Masaki et al., 2017) regarding the challenges of representing reservoir operations that we will cite (at P9,L24) in the revised manuscript. We drew from (Rougé et al., In revision) because it deals specifically with issues of using the same simulation model in the same domain, and we are confident of a successful review prior to publication of our submitted piece.

Details regarding the calculation of the partition between beneficial and non-beneficial are detailed in the manuscript's supplement. Considering the referee's comment here (P10,L16) and previously (P7,L14), we are adding a bit more detail to the body of the manuscript (presented above) and a stronger call to review the supplement for more information.

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