

Interactive comment on “A Spatially Detailed and Economically Complete Blue Water Footprint of the United States” by Richard R. Rushforth and Benjamin L. Ruddell

Anonymous Referee #2

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This paper presents an update to a major data base (the National Water Economy Database v. 1.1, NWED), which the authors describe as a complete water footprint for the U.S., at least with respect to the nation’s blue water flows. It merges several otherwise disparate sources of data, including those on water use, economic production and commodity trade, transportation, demographics, as well as on electricity generation and grid configuration. It analyzes the spatial configuration of the water footprint associated with economic activity, with a particular emphasis on urban-rural contrasts and the distribution of ports for international trade. It also evaluates sources of uncertainty in the estimation procedures and proposes next steps in future research on this topic.

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Overall, this is a highly competent documentation of an important study. The authors make a convincing argument of the utility (in fact, necessity) of considering the hydro-economic redistribution of water in addition to its hydrologic dynamics, in order to accurately depict the present-day water resource picture. There is a more-or-less complete documentation of what the authors did, the assumptions they made, and the key results that they found. There was heavy lifting on the harmonization of the many diverse data sets they needed to incorporate into their analysis. The same was true of their aggregation/disaggregation approaches. While not 100% clear, they did lay out the logic for their particular simplifying and/or necessary assumptions.

I would view this work as at the current state-of-the-art and for this reason I would support its publication. At the same time, and in view of my otherwise supportive stand there are ways in which the manuscript stumbled and could be strengthened substantially.

While I have followed at least the general aspects of the virtual water debate for some time now, I found myself having to read and re-read sections of the text to make sure I understood exactly what the authors were trying to say. (Lines 490-92 giving the confusing contrast of urban vs rural water use via the terms “VW flows” vs “water footprints” is an example). A lexicon, cited at the beginning of the paper and placed at least into the supplement, showing clear definitions would have been extremely helpful. The authors could start with a definition of blue water, green water, grey water as a start to help the less initiated. Such definitions would certainly ensure a higher degree of readability among those not particularly well-versed in the VW literature.

Another major issue I had with the paper was the proliferation of maps, many of which were not particularly instructive. What was particularly striking was the absence of graphical elements that depicted the connectivity of trade and water flows, which was the heart of this paper. This detracts from its ultimate impact. For example, the maps in Figure 3, supposedly depicting the character of virtual water imports and exports fail to provide such connectivity. Perhaps showing an example of a major port and its

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major inflows and outflows could solve this problem, repeating this for the other ports in the supplement. To/from arrows which are the mainstay of virtual water mapping (e.g. from Hoesktra, Oki, etc.) are missing. In addition, the many numerics contained in the tables could have been more efficiently presented as visuals (e.g., bar graphs or box and arrow diagrams).

In addition, it seems that the issue of non-renewable groundwater use would immediately come into play, but we see very little at all on this issue beyond some general statements. Given the vulnerability question addressed in Section 3.3., there needs to be some discussion of why overdraft was not addressed, or if not, how it would be addressed in a next stage of research. A perfect place to discuss this would be in the context of the dependence of international trade to certain countries on U.S. groundwater (lines 583-86).

The policy discussions were terse, not particularly well-thought out, or convincing (e.g., lines 646-52 and 668-72).

Additional comments:

- Some of the concepts presented bear a likeness to the ideas of Weiskel et al. that should be cited (see references below).
- The term “Economically Complete” in the title, unless it is some accepted nomenclature, is awkward at best.
- ABSTRACT: The term “mesoscale” needs to be changed or requires an additional modifier (i.e., county-level).
- INTRODUCTION: The stage-setting text dwelled far too much on the issue of drought and in the end never actually analyzed its impact.
- Section 2.2: Some discussion of the need to address sub-annual fluctuations in the relationship between water supply and use is warranted. That may best be addressed in the discussion on uncertainty.

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- Section 2.7, end: A word on assuring mass conservation at the international scale is warranted.

- Line 559, 560: The total seems is comparable to Menkonnen & Hoekstra 2011 (Vol. 2 appendices) but who get a balance of -8800Mm³/y (from a greatly different set of gross values: ~30,000Mm³/y in blue water imports and ~39,000Mm³/y for exports). The VW import in Table 5 is an order of magnitude lower. Also, I was unable to reproduce the 6.3% figure for the “volume of domestic virtual water flow”. Again, this may lead back to a nomenclature problem. Authors please explain and clarify.

- I found the discussion on how the ports in question are vulnerable (e.g., to hurricanes, earthquakes, etc.) a bit of a stretch in terms of links to water vulnerability. The links to water are simply matter-of-fact. One could argue that the listed disruptions, which after all are not water-related per se, are more important to the provision of global protein or computer chips or export \$\$ than to virtual water supplies.

- I found that the description of the urban-rural geography of water-economy links were a strength of this paper (e.g., identification of the importance of medium-sized U.S. cities to the hydro-economy; geography of the importance of different areas of the country to domestic vs int'l food provision (lines 565-76); discussion of insularity of some cities like Phoenix). But some of the writing on this raised a concern. On lines 498-501, there is the sentence: “ Medium to small cities tend to be food processing hubs where farm goods are transformed into “food”, and irrigated agricultural blue water footprints are registered in those small cities rather than in the large cities where the food is largely consumed.” The authors need to comment on the “stranding” of the footprint accounting in the places where the food is “manufactured” rather than where it is consumed. What type of impact does this have on their overall conclusions?

EDITORIAL CHANGES:

Line 14: Change to “dominated by use at local and regional scales.”

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Line 75: Not known exactly what “composition” means.

Line 104: Are “attraction factors” the correct nomenclature?

Line 195: “taking”

Line 399: Missing reference

Lines 408-09. Sentence should read: “Total, surface water, and groundwater water footprints within a county match the standard Water Footprint Accounting definition of the water footprint of a geographic area (Hoekstra et al., 2012).”

Line 542: “significant”

Line 544: I’d wager that if the embodied water use by the livestock sector for feed were included this would not be so insignificant. Authors please comment.

Lines 548-50. The authors should comment on why these numbers are so small given the substantial withdrawals of fresh and saline water nationally by the thermoelectric sector.

Line 610: “is predominantly determined by the production, manufacture, and distribution of”

Lines 673-74: Cite Table SI 4-D?

REFERENCES:

Weiskel, P.K., Vogel, R.M., Steeves, P.A., DeSimone, L.A., Zarriello, P.J., and K.G. Ries, III, 2007, Water-use regimes: Characterizing direct human interaction with hydrologic systems, *Water Resour. Res.*, April 2007. <http://pubs.er.usgs.gov/publication/70030893>

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Weiskel, P. K., Wolock, D. M., Zarriello, P. J., Vogel, R. M., Levin, S. B., and Lent, R. M., 2014: Hydroclimatic regimes: a distributed water-balance framework for hydrologic assessment, classification, and management, *Hydrol. Earth Syst. Sci.*, 18, 3855-3872, doi:10.5194/hess-18-3855-2014, 2014. <http://www.hydrol-earth-syst-sci.net/18/3855/2014/hess-18-3855-2014.html>

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