

Interactive comment on “Recasting catchment water balance for water allocation between human and environmental purposes” by S. Zhou et al.

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Comments: The objective of this paper seems to be to partition ET into human and ecological ET. The authors conclude that humans have been capturing a greater and greater share of ET over time until recently, when this trend has begun to reverse. Questions about whether humans are capturing too much have been raised by many previous scholars – particularly ecologists who asked what fraction of primary production was being captured by humans (see work by Stuart Pimm, Peter Vitousek in the 1990s). In the ecologists’ case they were concerned by how much was left for other species and the implications for the earth’s carrying capacity. In this paper, my concern is that it’s not clear to me why this analysis is interesting and what the analysis

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contributes beyond what we already know from the land ratios. Initially, I thought that perhaps the ET ratios would turn out to be wildly different from the land ratios (which would be interesting). But Figure 3 and Figure 4 suggest that both the ET and GPP more or less follow the land area ratios.

This study aims to advance social-hydrology by developing social-hydrologic catchment water balance in which water use is partitioned into use for societal systems and use for ecological systems, instead of conventional catchment water balance in which precipitation is partitioned into runoff and ET. We aim to understand the historical human-water relationships and to provide the basis for water allocation between societal systems and ecological systems. The conventional water balance approach was developed for providing the basis for water supply management and planning in the development stage of water resources. In practice, our approach, which integrates land and water analysis at river basin scale, can explain the interactive impacts of land and water use, which land use analysis or the water balance approach could not provide.

Yes, both ET and GPP more or less follow the land area ratios. This happens because the MDB lies in the semi-arid region where about 95% of precipitation was consumed as evapotranspiration. The irrigated area only accounts for 2% of the total land area and the crop pattern is relatively uniform. However, it would be different in the cases where there are diverse crop patterns.

Comments: The authors argue in several places that there is some kind of an “ideal” ET ratio. I find this unconvincing. Most decisions about how much water to leave for environmental uses are made with the objective of sustaining either biodiversity or ecosystem services. To justify this analysis – the authors would need to make the case that the ET ratio is a magical number that is not perfectly correlated with simpler, easily available indices like land area ratio AND yet it is also correlated to something societies care about. The paper does not make the case for an ET-ratio being relevant well.

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Thanks for this comment. What we meant in our manuscript was that it is hoped that an ideal ratio of ET in terms of interaction of land and water between societal systems and ecological systems in future research should be determined for each river basin, which would be extremely useful to provide the basis for integrated river basin management in a sustainable way, for example, to support decisions with the objective of sustaining either biodiversity or ecosystem services. But we agree that this is not a realistic goal. We will revise our manuscript to delete the discussion of the “ideal ratio”.

Comments: In the particular case of MDB, as I understand it, the ecological concerns that drove the buybacks of irrigation water rights, were over freshwater ecological flows (the blue water or runoff component which the paper does not address) and not diminishing area under native vegetation (the green water component this paper does discuss). So an interesting insight that could come out of this analysis – for MDB at least – is the opposite of what the authors are arguing. It seems to me from the analysis presented, converting the land from cropland to native vegetation may not generate much additional stream flow at all because natural vegetation transpires up as much as much as cropland. This contradicts what I understood from other papers on the MDB, that stream flow has in fact slightly increased a bit after restoration efforts. So native vegetation must be transpiring less water than irrigated cropland. However, this doesn't emerge from this analysis because the ET ratios track the land ratios so closely. But perhaps the authors are finding that land conversions to natural vegetation result in less streamflow than expected because their ET has not been accounted for? This cannot be discerned from the paper as such - but this seems worth exploring further. Would have been good to see just the three ET values for cropland, grassland and native vegetation - but this was never clearly presented anywhere. It cannot be read off Figure 2, as effects of the restoration phase comes at the very end of the time-series. Figure 3 only displays the ratios and not the absolute numbers

We considered the whole MDB as the study area. In the recast catchment water balance, R was the runoff flowing into the sea. So the blue water or runoff component

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within the catchment has been considered as water diversion which was finally transformed into ET.

Thanks for these extremely valuable comments which will greatly help us to improve the quality of our manuscript. To address these comments properly will make MDB a unique case to see the impacts of different catchment management practices, e.g. deforestation/re-vegetation and buy-back of irrigation water, on the catchment blue water and green water and their interaction over a hundred-year time frame, and see their implications for future catchment water management and other similar catchments elsewhere. We will expand these scenario discussions by collecting and analyzing as much data as possible when we revise our manuscript.

We used the ET values in Figure 2. We used the ratio in Figure 3 because the ratio can better express the large inter-annual change of rainfall in the MDB. We will include a much larger time resolution for the time segment at the very end of the time-series with a sub-figure in Figure 2 to illustrate the ET changes of these three vegetation types at the end of our time-series.

Comments: I also had a lot of difficulty understanding the paper. The data used come in after the methods – so it's not easy to infer that the methods are driven by the particular data sets available. As I understand it, the whole GPP thing was only brought in because that GPP is the only variable for which data are available to cross-check ET estimates. But unfortunately – this is never made clear in the paper and it took me a while to understand that the “optimization” was just a calibration of some sort. I am not familiar with this GPP dataset – so I did not delve into the technicalities and uncertainties of this analysis and cannot comment if the results are driven by the peculiarities of that dataset and the GPP-ET function chosen.

Thanks for this comment. The reason why the “whole GPP thing” was brought in was because we used it to estimate the impacts of water allocation on the societal system and ecological system at water catchments, not cross-check ET estimates. But we

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agree that we need re-write this section to make it easy to follow.

Comments: The authors seem to hint at an ideal ratio of ET for humans versus ET for ecosystems – e.g. Line 17 of Section 1 “there are no clearly defined theoretical guidelines for water allocation between humans and the environment”. As I said earlier, I am not sure why there should be theoretical guidelines at the basin scale. E.g. It may be perfectly OK to have millions of acres of corn fields in Iowa, if biodiversity rich hotspots are protected in the Amazon – why should every basin aim for a specific mix of natural vegetation and cropland?

We agree. We have addressed this comment above.

Comments: There seem to be inconsistencies between the text and the equations. The whole introduction of WUE into the equations seems strange to me, but perhaps it is just not explained well. On line 12 in Section 2.3, the authors say there is a “linear relationship between GPP and ET at a regional scale”. However, eq. 8 ultimately implies a non-linear relationship between GPP and ET.

Thanks. The WUE was defined as the ratio of GPP over ET, and the linear relationship between GPP and ET was assumed in order to estimate annual GPP using a constant WUE at a regional scale (Beer et al., 2007). However, a linear relationship is not the best expression which has been evaluated in many studies (Zhou et al., 2014). In order to improve the estimation of GPP we assumed that WUE is negatively correlated to ET per unit area because of diminishing marginal WUE when GPP is limited by other controlling factors, such as energy and nutrient. We will add several sentences to make this issue clearer when we revise the manuscript.

Beer, C., Reichstein, M., Ciais, P., Farquhar, G. D., and Papale, D.: Mean annual GPP of Europe derived from its water balance, *Geophys. Res. Lett.*, 34, L05401, doi:10.1029/2006GL029006, 2007.

Zhou, S., Yu, B., Huang, Y., and Wang, G.: The effect of vapor pressure deficit on

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water use efficiency at the subdaily timescale, *Geophys. Res. Lett.*, 41, 5005–5013, doi:10.1002/2014GL060741, 2014.

Comments: I am not sure why the Area Ratio suddenly appears in the denominator in eq. 10.

Thanks for this comment. In the manuscript, “We supposed that WUE is negatively correlated to ET per unit area because of diminishing marginal WUE (Eq. 6)”. Since the unit for ET is mm yr⁻¹ in the manuscript, ET per unit area is equal to ET (mm yr⁻¹) per unit area ratio, and the area ratio is the same for the whole catchment, thus we omitted it directly. We will add some explanations to avoid confusion when we revise our manuscript.

Comments: There were a few minor typos - Line 29 in Section 4 - pursuit should be pursuit.

Thanks. We will change them in our revised manuscript.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 12, 911, 2015.

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12, C982–C987, 2015

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