Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2015-533-AC2, 2016

Hydrology and Earth System Sciences Discussions
Open Access

Interactive comment on "Global root zone storage capacity from satellite-based evaporation" *by* L. Wang-Erlandsson et al.

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Received and published: 22 February 2016

We thank Referee #2 for constructive comments and positive feedback. We would here like to briefly respond to the general comments and address the specific comments in a later response. Below, Referee #2's general comments are in bold and our responses are in upright font. We refer to the manuscript for explanations of variables and abbreviations.

The beginning of Sect. 2.1 should be revised. It refers to a figure which is (for me) not really self-explaining. Also, I had problems while reading Page 9, line 10 "P and the evaporation originating form irrigation". I asked myself why is this evaporation not included in the $F_{\mathbf{out}}$ term. I suggest to write something like "the amount of effective irrigation water (that is evapotranspired by the crops)".

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We will improve the explanation of the method in the beginning of Sect. 2.1.

Whether we include it in the F_{in} or F_{out} term is not relevant for the final outcome. Since irrigation is an input to the soil moisture stock, we considered it more appropriate to include it in the inflow. On the other hand, one could also argue that the irrigated water could be subtracted from the outgoing flux, so as to compensate for the additional evaporation. From a water balance point of view, however, it is more logical to consider evaporated water as additional water that was brought into the root zone.

The irrigation evaporation does not only include that transpired by crops, but also the incremental evaporation from surface, wet soil, and ponding water at the tail end of irrigation borders. We will add the term "effective irrigation water" to the explanation for clarity.

At Section 4.3 the authors assess the improvement of the new root zone storage capacity information within the STEAM model by comparing it to the same product with which the root zone storage capacity was developed. I wonder if this is an independent benchmark product or if you should use $E_{\mathbf{CSM}}$ instead (or only $E_{\mathbf{C}}$) as benchmark. Sure, there is a lack of real observation based benchmark products for evaporation, but this is a weak point. You should select a different benchmark or rephrase the term benchmark.

We consider validation using E_{SM} to be appropriate, since the algorithms for estimating S_{R}, and for estimating E in STEAM are very different. First, S_{R} is derived based on the E overshoot over P, whereas STEAM is a process-based model where evaporation originates from five different compartments, each constrained by potential evaporation and related stress functions. This means that it is impossible to reproduce E_{SM} simply by inserting S_{R} to STEAM. If S_{R} is zero because E_{SM} never overshoots precipitation, STEAM soil evaporation and transpiration would become zero. If extreme S_{R} are produced because E_{SM} is unrealistically large, STEAM evaporation will not approach E_{SM}, since it will be capped by potential evaporation. Second, consider also that the precipitation products (CRU and CHIRPS respectively) used for deriving S_{R} differ from the precipitation forcing (ERA-Interim) used in STEAM. Third, E_{SM} and STEAM are truly independent to each other as well. Whereas STEAM is process and water balance based, the ensemble E product is based on a combination of two(E_{SM})/three(E_{CSM}) well established energy balance methods. The only difference of the new STEAM simulations is the inclusion of updated information on root zone storage so that during longer periods of drought, more realistic estimations of continued evaporation processes can be expected. Last, $S_{\mathrm{R,CRU\text{-}SM}}$ is based on a single year value of E_{SM} (i.e., the year of maximum storage deficit), whereas the analyses of improvements were based on the entire available time series of 10-11 years. Thus, the fact that $S_{\mathrm{R,CRU\text{-}SM}}$ dimensioned on one year of E_{SM} nevertheless improves E simulation in STEAM with regard to 10-11 years of E_{SM} (i.e., the overall ϵ_{RMS} decreases when $S_{\mathrm{R,CRU\text{-}SM}}$ is used in STEAM) is a strong indication that the storage capacity correction was implemented for the right reason. We maintain that the comparison with E_{SM} is useful and will clarify our arguments in the revised manuscript. Note also that STEAM is not calibrated by any means.

The referee suggests us to use E_{CSM} (or only CMRSET) as benchmark. Figure S4 (in the Supplementary Information) already shows the root mean square error (ϵ_{RMS}) improvements by latitudinal bands when using E_{CSM} as benchmark. Since E_{CSM} does not have global coverage, it was not possible to use it for the climate and land cover based analyses in Sect 4.3 and 4.4. In Figure 1 below, we also include ϵ_{RMS} improvements by latitudinal bands for the individual evaporation products CMRSET (E_{C}), SSEBop (E_{S}), and MODIS16 (E_{M}) when comparing monthly evaporation for the years 2003-2012. The use of more than one evaporation dataset decreases uncertainties related to individual evaporation products because there is simply not one single preferred model. Research executed by Hofste (2014) for the Nile basin demonstrated that the performance of an ensemble E product is significantly better than using individual E products, something that was confirmed by Simons et al. (in review) in Vietnam. Thus, we maintain that it is more useful to use an ensemble evaporation product as

Table 1. $\epsilon_{\rm RMS}$ and $\epsilon_{\rm RMS}$ improvements in evaporation simulation with $E_{\rm SM}$ and LandFlux-EVAL as benchmark respectively.

Monthly E compared	**$\epsilon_{\rm RMS}$ with $E_{\rm SM}$ as benchmark (mm/year)**			**$\epsilon_{\rm RMS}$ with LandFlux-EVAL diagnostic as benchmark (mm/year)**		
	Look-up	$S_{\rm R,CRU\text{-}SM}$	$\epsilon_{\rm RMS}$ improvement	Look-up	$S_{\rm R,CRU\text{-}SM}$	$\epsilon_{\rm RMS}$ improvement
Mean	234	230	4	136	126	10
Max	323	320	3	244	222	22
Min	189	181	8	143	129	14

benchmark reference.

To address the referee's concern of interdependency, we cross-check the mean monthly STEAM evaporation based on $S_{\rm R,CRU\text{-}SM}$ (2003-2013) with the mean monthly LandFlux-EVAL diagnostic ensemble evaporation (1989-2005) (Mueller et al., 2013), see comparison in Table 1 above. It appears that the $\epsilon_{\rm RMS}$ improvements are even greater (mean improvement 10 mm/year instead of 4 mm/year), but with the greatest improvements in maximum monthly evaporation instead of minimum monthly evaporation. The LandFlux-EVAL diagnostic product include the evaporation products: PRUNI, MPIBGC, CSIRO, GLEAM, and AWB. Since this product includes GLEAM, which relies on water balance calculations and soil layer depth assumptions, we consider the use of this product inappropriate for our purposes and would refrain from including this comparison in the manuscript.

Most of the figures are very tiny, and sometimes due to the choice of color very hard to read (e.g. Fig. A1). Please take care of figure size in the final production phase of the manuscript if it is accepted.

Thank you for pointing this out. We will improve the choice of colours and increase the figure sizes where needed.

References

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Mueller, B., Hirschi, M., Jimenez, C., Ciais, P., Dirmeyer, P. A., Dolman, A. J., . . . Seneviratne, S. I. (2013). Benchmark products for land evapotranspiration: LandFlux-EVAL multi-data set synthesis. Hydrology and Earth System Sciences, 17(10), 3707–3720. http://doi.org/10.5194/hess-17-3707-2013

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2015-533, 2016.

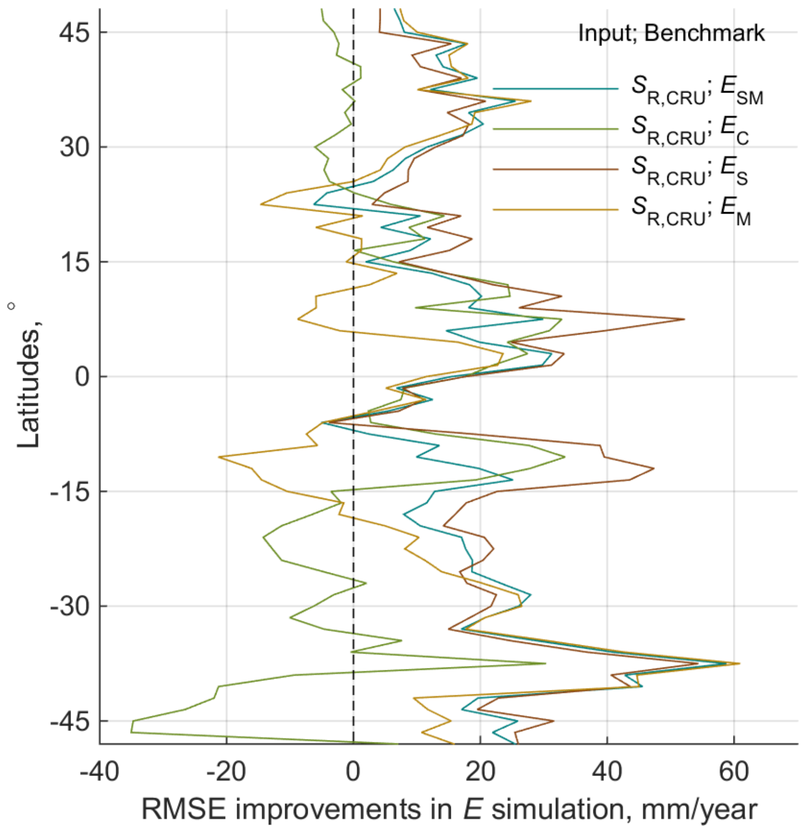

Fig. 1. Root mean square error improvements in STEAM evaporation simulation based on ${{S}_\textrm{R,CRU-SM}}$ when using various E data as benchmark reference.

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