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Hydrology and Earth System Sciences
Discussions

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

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We are grateful for the constructive comments, and would here like to respond to Referee #1's specific comments. Below, referee #1's specific comments are in bold and our responses are in upright font. We refer to the manuscript for explanations of variables and abbreviations.

**P10, L13: "The resetting of this limited number of pixels." Please specify what is the percentage number of pixels for which resetting was needed.**

This is an error that slipped through. The resetting was first introduced when we allowed accumulation to persist for two years, but we later changed this threshold to three years. In fact, we do not reset any grid cells when the threshold of persistent $D$ accumulation years is set to three years. We will delete the sentences: "In addition, $D$

is reset to zero by the end of a three years period in a few grid cells where $D$ accumulation persist for three years or more. Such increases are likely the effect of lateral supply of water, or reflect erroneous combinations of $P$ and $E$. The resetting of this limited number of pixels does not affect the outcome of this study in any measureable way."

**P10, L19-23: Simply say that $S_\mathrm{R}$ is the maximum of the obtained $D$ values.**

We replace

"Finally, in addition to the moisture deficits with a specific probability of exceedance, we also define the largest value of the moisture deficits $D$ over the considered time series of observation, which, assuming the ecosystem was able to deal with this deficit, would be the estimate of the root zone storage capacity ($S_\mathrm{R}$):"

with

"Finally, the root zone storage capacity $S_\mathrm{R}$ is defined as the maximum of the obtained $D$ values:"

**P11, L8-11: This paragraph is not clear to me, please revise.**

We replace:

"During wet spells, additional fluxes from the soil system include surface runoff and drainage into groundwater. These fluxes only occur after certain levels of saturation have been achieved. Therefore, during prolonged dry spells, which are critical for sizing the root zone storage requirement, these fluxes may be neglected."

with

"During dry periods, the magnitude of surface runoff and deep drainage is usually small, and therefore is assumed to not affect root zone storage capacity calculations."

**P12, L10: The $C$ parameter values is set to a value equal to 0.1. Why? What is the**

**impact on the results? Why "$C$" in equation (7) is different from "$c$" in equation (6)?**

$C$ is in the unit of m and $c$ is dimensionless. However, we have decided to change the soil moisture stress function in STEAM in order to remove the arbitrariness of picking a parameter. Instead of the soil moisture stress function taken from (Matsumoto et al., 2008), we now use a soil moisture stress function that takes the shape of (van Genuchten, 1980)'s function for dimensionless water content:

$$f(S) = \frac{S}{S_R} \tag{1}$$

We add a comparison to the Supplement showing the differences between STEAM using the Matsumoto function and the van Genuchten function with root zone storage capacity.

**P12, L18: $S_{\mathbf{R,CRU\text{-}SM}}$ is not defined, only later in the text.**

Since $\epsilon_{\mathrm{RMS}}$ improvements are measured also for other variables than the ones exemplified in Eq. 8, we will for clarity replace the example variables $E_{\mathrm{SM}}$ and $S_{\mathrm{R,CRU\text{-}SM}}$ with the generic variable names $E_{\mathrm{benchmark}}$ and $S_{\mathrm{R,new}}$. These variable names will be explained in the text that explain the equation.

**P12, L20: The formulation of equation (8) is wrong for me. The root mean square error should be between $E_{\mathbf{SR,STEAM}}$ and $E_{\mathbf{SM}}$, not only for $E_{\mathbf{SR,STEAM}}$ or $E_{\mathbf{SM}}$. Please reformulate.**

Thank you for pointing this out, we correct Eq. 8 to:

$$\varepsilon_{RMS,imp} = \left[\varepsilon_{RMS}(E_{S_{R,STEAM}}, E_{benchmark})\right] - \left[\varepsilon_{RMS}(E_{S_{R,new}}, E_{benchmark})\right] \tag{2}$$

.

**P13, L16-17 The symbols $\sigma$ and $\sigma_{S_{\mathbf{R,CRU\text{-}SM}}}$ are missing in the text. Please correct.**

We will correct this.

**P16, L13: ERA-I evaporation is used as forcing of STEAM. What is the output of STEAM? Is it the actual evaporation? It should be clarified and clearly distinguished from potential evapotranspiration throughout the text.**

The output of STEAM is actual evaporation. ERA-I evaporation was only used to scale calculated daily values of potential evaporation to 3 hours resolution. We will reformulate as follows:

"Input ERA-I data to STEAM were at 3 h and 1.5 degree resolution and include: precipitation, snowfall, snowmelt, temperature at 2m height, dew point temperature at 2 m height, wind speed vector fields (zonal and meridional components) at 10 m height, incoming shortwave radiation, net long-wave radiation, and evaporation (only used to scale potential evaporation from daily to 3 h)."

**P16, L27-28: The methods used for downscaling/upscaling the different datasets should be described.**

For greater clarity, we will reformulate the following:

"Data with other resolutions than 0.5 have been either upscaled by averaging or downscaled by grid cell values transferring."

as:

"Data with finer resolution than 0.5 have been upscaled to 0.5 by simple averaging (i.e., assuming that the value of a 0.5 grid cell correspond to the mean of the overlapping finer grid cell values). Data with coarser resolution than 0.5 were downscaled by oversampling (i.e., transferring grid cell values assuming that the finer 0.5 grid cell values correspond to those overlapped by the coarser degree grid cell values)."

**P17, L12: "$S_\mathbf{R}$ estimated are generally larger", larger than? Please clarify.**

It should read "generally large". We will correct this in the revised manuscript.

**P19, L22-P20, L8: Too many details are given here for the description of the differences of the simulated evaporation data. It is difficult to follow, please reduce the text focusing on the most relevant differences.**

We reformulate the following at P19, L22-P20, L8:

"Figure 6 compares the STEAM-simulated evaporation when using, on the one hand, $S_{\mathrm{R,CRU\text{-}SM}}$ and, on the other, the look-up table based $S_{\mathrm{R,STEAM}}$. The effects on evaporation vary with geography and season. The differences are mainly found in South America outside the tropical wet rainforests, in the Sahel, south of the Congo rainforests and in parts of Southeast Asia. January evaporation simulated with $S_{\mathrm{R,CRU\text{-}SM}}$ is lower in particularly south of the Sahara, Central America, India, and Southeast Asia, and higher in Argentina. April evaporation shows only local increases in Central America, Sahel, and Southeast Asia, and minor decreases in South Africa, China, and Argentina. July evaporation shows the largest differences, with both strong evaporation reductions in Brazil, Canada and Europe, and significant increases in the seasonally dry tropical forests in Brazil and in Central Africa. In October, changes in evaporation are again less widespread and mainly affecting South America. It appears that $S_{\mathrm{R,CRU\text{-}SM}}$ has the greatest potential to influence model simulations for the hot and dry seasons, and for the seasonal tropical forests where the root zone storage capacity varies strongly."

to:

"Figure 6 compares the STEAM-simulated evaporation when using, on the one hand, $S_{\mathrm{R,CRU\text{-}SM}}$ and, on the other, the look-up table based $S_{\mathrm{R,STEAM}}$. In general, $S_{\mathrm{R,CRU\text{-}SM}}$ estimated higher evaporation rates in the tropics and lower evaporation

in the subtropics and temperate zone. In particular, the differences are pronounced during the warm and dry seasons. For example, the evaporation reductions with $S_{\mathrm{R,CRU\text{-}SM}}$ is widespread in the Northern Hemisphere during its summer month July. During the dry seasons (e.g., January in the Sahel, July in Congo south of the Equator), the evaporation increase is the most significant. Moreover, the change in evaporation also depend on land cover type. In South America, evaporation increases in the seasonal tropical forests of the Amazon, whereas evaporation decreases in the savannas and shrublands in the south. These results suggest that $S_{\mathrm{R,CRU\text{-}SM}}$ has the greatest potential to influence model simulations for the hot and dry seasons, in regions where the root zone storage varies strongly."

**P22, L20: Recent studies have obtained huge differences between global scale precipitation datasets (e.g., Trenberth et al. (2014), Herold et al. (2016)). It seems not true that evaporation data (on a global scale) have larger spread than precipitation data. Please reformulate.**

We reformulate the paragraph starting at L.17 as follows: "Finally, the quality of the estimated $S_\mathrm{R}$ is dependent on the quality of the input evaporation and precipitation data. In this study, the choice of remotely sensed evaporation products influenced the resulting $S_\mathrm{R}$ more than the choice of precipitation product, see the Supplement. In particular, the largest standard deviations in the ensemble evaporation products are located in central South America, the Sahel, India, and northern Australia (see Fig. 2e, 2f). To reduce uncertainty, the presented method is preferably applied using ensemble products based on reliable evaporation and precipitation datasets identified in comparison and evaluation studies (e.g., Bitew Gebremichael, 2011; Herold, Alexander, Donat, Contractor, Becker, 2015; Hessels, 2015; Hofste, 2014; Hu, Jia, Menenti, 2015; Moazami, Golian, Kavianpour, Hong, 2013; Trambauer et al., 2014; Trenberth et al., 2013; Yilmaz et al., 2014)"

**P25, L13: It seems that "and $S_{\mathbf{R,CRU\text{-}SM}}$ is missing here.**

True, we will correct this.

**Tables/Figures: Please check captions for symbols. Captions should be selfdescribing.**

We will describe all symbols in the captions.

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