Response letter to comments (egusphere-2024-1321)

The following is a point-to-point response to reviewer #2's comments.

We appreciate these comments/suggestions. They would help to significantly improve the quality of this study. Specific revisions and responses to each comment are provided in detail below. Please note that the comments from the reviewer are in ***italics*** followed by our responses in **regular** text.

Response to the comments of Reviewer #2:

Comment 1

This paper evaluates methods to calculate Potential Evapotranspiration (PET) by comparing them with PET simulated by STEMMUS-SCOPE model at 170 sites. It calculates Irrigation Water Requirement (IWR) as the difference between PET and Actual Evapotranspiration (ETa) simulated by STEMMUS-SCOPE.

1.1 It seems that these two objectives are not well connected as the results of PET methods does not add any information to the calculation of IWR.

1.2 If the authors aim to use STEMMUS-SCOPE ETa and ET0 to calculate IWR, why needs to validate other 6 methods considering simulated ET0 as the reference?

1.3 What is the relevance or significance of calculating IWR for natural land covers (i.e., forest, shrubland)? Why do we need to (know how much to) irrigate these natural vegetation and wetlands?

<u>Response:</u>

1.1: Thank you for your comments on the Introduction section. Reviewer #1 also noted that the comparison of PET methods and the calculation of IWR are not well connected. We will revise these sections for better clarity and connection.

1.2: This study aims to calculate Irrigation Water Requirement (IWR) using a process-based model and to evaluate commonly used PET models. Currently, PET or ETc must be calculated to determine IWR. This leads to significant difficulties and uncertainties in application. Thus, we first evaluated commonly used PET methods.

1.3: We agree that calculating IWR for natural vegetation or wetlands seems less significant. The primary aim of calculating IWR is to evaluate drought severity. Therefore, it is more appropriate to refer to it as Plant Water Deficit (PWR) for the natural sites. We used the term IWR because it is commonly used in agriculture. With the calculated IWR, we can evaluate the drought condition of each site. In the revised version, we will use PWR instead of IWR.

Comment 2

The paper seems to assume that FAOPM ET0 and PET (of other 5 methods) estimate the same quantity, which is inaccurate by definition. FAOPM is not comparable to other PET methods. It is the only of the 6 methods that calculates PET for a hypothetical reference crop, hence called Reference ET. Even Allen et al. (1998, chapter 1) strongly discouraged using the term PET due to its definition ambiguities, which distinguishes this method from other PET methods. Raza et al. (2022) also showed the difference in definition and purpose of RET (ET0) and PET through a systematic review. Indeed, hydrologists should not use FAOPM RET as a reference to compare with PET by other methods (also mentioned in L58). Then why is FAOPM RET compared with other PET methods here?

Response: As stated in this study, many previous studies use ET0 as a benchmark for evaluating other PET methods. I fully agree with your suggestion to calculate ETc or PET using the crop coefficient (Kc) and then compare it with other PET methods. To ensure clarity, we will consistently use the term PET in the revised version.

Comment 3

This difference in definition might also be the reason for FAOPM to differ greatly from other methods, except when the authors compare them over a vegetation surface with closer characteristics to the FAOPM hypothetical reference crop (e.g., GRA, CRO in Figure S2.1-4). It would make more sense to compare PET methods with FAOPM ETc which is closer to PET definition: the crop evapotranspiration under well-watered and optimal agronomic conditions.

Response: Thank you for your suggestion. We calculated the daily Kc for each site and found significant seasonal variability. Therefore, it is challenging to provide a reasonable Kc for each site, especially for forest sites. In the revised version, we will try to calculate Kc using LAI and climate data. With the calculated Kc, PET can be derived based on the FAO56 method. Thus, the PET calculated by FAO56 PM method can be compared with other common PET methods. For the PM method, we will also adjust the calculation of canopy conductance which currently set as a constant. In the revised version, we will try to calculate it based on LAI.

Comment 4

Figure 2: Why does the distribution of ET0s look remarkably lower than ETas for DBF, ENF, GRA, and MF? Can WSF be greater than 1? By definition, ETa should never be higher than ET0 (Fisher et al., 2010). This makes the method to derive ET0

by using STEMMUS-SCOPE simulated ETa and WSF seem not reliable. If so, it should not be used as a reference to evaluate the other PET methods.

Response: Thank you for highlighting this issue. We thoroughly examined the site with these problems and identified two causes: Firstly, the energy constraint was applied on an hourly scale, leading to underestimation at night due to negative available energy. So, we will adjust the energy constraint to apply only during the daytime. Secondly, we found missing values in the Rn or G data while ETa data was available, causing underestimation of ET0 by the STEMMUS-SCOPE. We will solve this issue by omitting these data or using the mean daily value in the next version.

Comment 5

*Section 2.5 mentions FAO for the calculation of IWR, but lack references. If the authors referred to the FAO-56 guideline, this method is inaccurate according to the definition in this guideline. Allen et al. (1998) defined IWR = CWR – Peffective, where CWR is ET0 * Kc and Peffective is calculated as detailed in Doorenbos et al. (1977). Therefore, IWR is not the same as ET0 – ETa, which is equal to (1-Kc)*ET0. The equation 9 and 10 seem to be authors' own derivation based on Figure 4. I wonder why the sign of Percolation is negative on the right side of these equation. Shouldn't it have the same sign as Runoff, since they are both 'outflows' from the crop root zone to groundwater storage? Why does Recharge have an upward arrow in Figure 4?*

Response:

In this study, the Irrigation Water Requirement (IWR) was calculated as ET0 minus ETa. It should be noted that ETa equals Ks*Kc*ET0, not Kc*ET0, where Kc*ET0 represents ETc in FAO56. Effective precipitation refers to the portion of total precipitation available for plant use, corresponding to ETa. Thus, this study assumes that $P_{effective}$ equals ETa, based on eq. (10): $P_{effective} = P – R + PR – (M1 – M0) = ETa$

"Recharge" refers to the capillary rise from groundwater to the root zone, while "Percolation" denotes water flow from the root zone to groundwater. To clarify, we will revise the terms to:

"PR - Percolation to the groundwater and capillary rise recharge from the groundwater (mm)"

$$\mathrm{P + IWR = ET0 - PR + (M1 - M0) + R} \quad (9)$$

$$\mathrm{P = ETa - PR + (M1 - M0) + R} \quad (10)$$

$$\mathrm{IWR = ET0 - ETa} \quad (11)$$

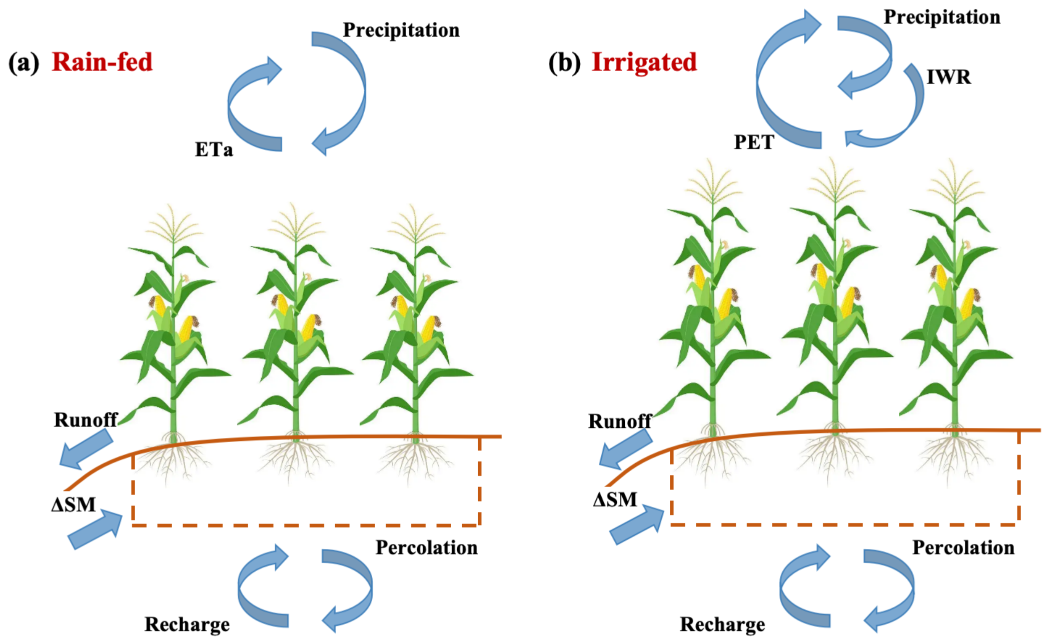

Figure 1. Diagrams of the soil-water balance of a crop root zone under the (a) rain-fed and (b) irrigation scenarios

Comment 6

Introduction lacks a lot of references. The whole paragraph L44-L56, there's not a single reference to any of the claims.

Response: Thanks, you and Reviewer #1, for pointing this issue. We will reconstruct the Introduction section and add relevant references.

Minor comments

Comment 7

L65: FAOPM does not use alfalfa as reference. Maybe you mean ASCE method?

Response: We will delete the "alfalfa" in this sentence.

Comment 8

L66: references?

Response: A reference will be added.

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M., 1998. Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56. Fao, Rome, 300(9), p.D05109.

Comment 9

L71-72: ETas and ET0s. I suggest explaining that 's' means simulated

Response: Thanks. 's' here means the STEMMUS-SCOPE.

Comment 10

L96 & Table 1: suggest to make it clearer which methods are considered radiation-based, resistance-based, global radiation & temperature-based

Response: Thanks for your suggestion. Radiation-based include the PT and LSA_SAF method; resistance-based include the PM and FAOPM method; global radiation & temperature-based include the MAK and HRG method.

Comment 11

Section 2.3.4: How was ga calculated?

Response: The calculation of ga is as follows:

$$g_a = \frac{(K)^2 u_Z}{ln\left[\frac{z_m - d}{z_{om}}\right] ln\left[\frac{z_h - d}{z_{Oh}}\right]}$$

where g_a is the aerodynamic conductance (m/s); z_m is the height of the wind speed measurement (m); z_h is the height of the humidity measurement (m); d is the zero plane displacement height (m); z_{om} is the roughness length governing momentum transfer (m); z_{Oh} is the roughness length governing transfer of heat and vapour (m); K is the von Karman's constant (0.41); $u_Z$is the wind speed at height Z (m/s).

Comment 12

L123: even if with wet surface, the stomata cannot be as open as a water surface. Therefore, gs cannot be infinity.

Response: I fully agree with you and we used the a constant (70 s m^{-1}) in this study. In the revised version, we will try to calculate canopy conductance based on LAI.

Comment 13

L145: references?

Response: We added the reference and a detailed calculation of IWR. Here we used ETa as the effective rainfall. Please find the response to Comment 5.

Comment 14

Figure 3: some bars looks exceeding the maximum value of y-axis. It's not easy to tell if these are much higher than ymax.

<u>Response:</u> The maximum value of y-axis are adjusted**.**

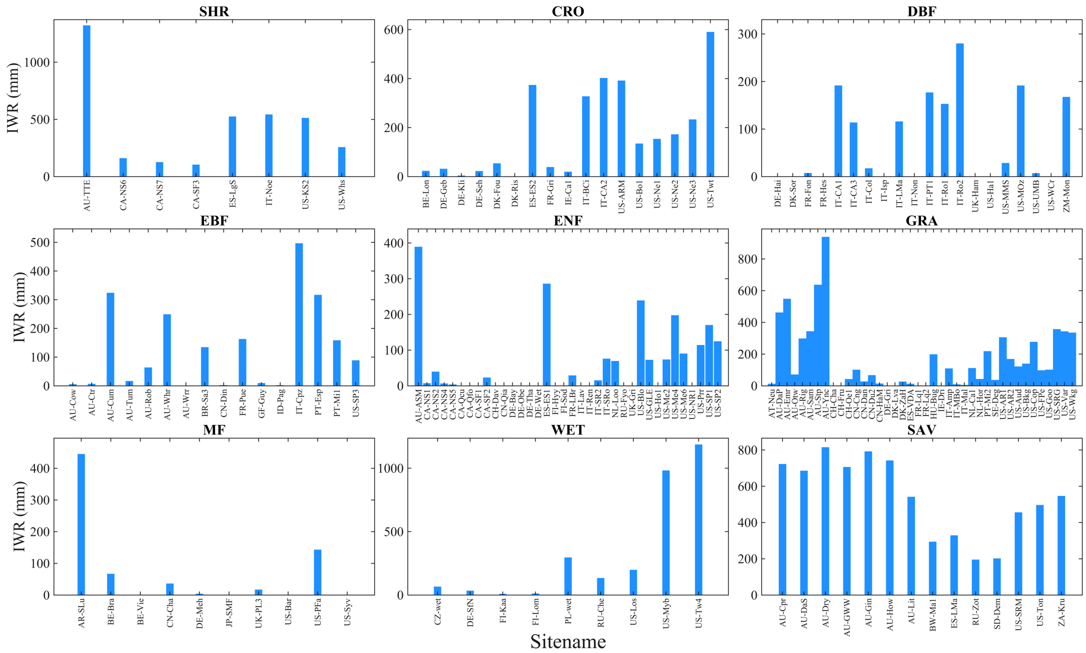

Figure 3 The calculated irrigation water requirement (IWR) by STEMMUS-SCOPE for different vegetation types at 170 flux sites.