The Impact of Convection-Permitting Rainfall on the Dryland Water Balance – Reviewer Comments

We would like to thank Dr Bo Huang for his helpful comments on our manuscript. Below please find responses to each comment, which we hope help clarify some of the points raised. Here we will provide responses to points 1-3 raised by Dr Huang, as the internal HESS response platform does not allow for easy presentation of equations needed to address the issues raised. Responses to points 4-7 raised by Dr Huang are provided in main reply.

1. **The authors use the FAO Penman-Monteith method (Section 2.2) to calculate potential evapotranspiration (PET) and list seven atmospheric variables. However, the equation itself and the role of these variables in its application are not explicitly provided. Additionally, Penman-Monteith method uses wind speed at 2m height but this manuscript does not clarify how wind speed measured at 10m height is adjusted to 2m. Please include the equation, explain the variables, and describe the methodology for converting 10m wind speed to 2m (e.g., logarithmic wind profile adjustment or FAO-recommended constants).**

Thank you for spotting this. We actually did convert wind speed from 10 to 2 meters, but we omitted to clarify this in the methods. The manuscript will be updated to include this step. We converted the original climate model output which is for 10 meters above the land surface to the required 2 metre value using the logarithmic velocity profile above a short grass surface:

$$u_2 = u_z\left(\frac{4.87}{\ln{(67.8z - 5.42)}}\right)$$

Where u_z is the wind speed at height *z* above the land surface (10 meters in this case) computed as $u_z = \sqrt{u^2 + v^2}$. It is worth noting that where the shape of the velocity profile does not follow this form, errors may arise.

For brevity we didn't include the Penman-Monteith equation itself as it is heavily documented elsewhere, but we appreciate that clarity would be improved if we explicitly outlined its use in this study. We follow the methodology outlined by Singer et al (2021).

We used the Pen-Montieth equation for reference crop evapotranspiration as described in Allen et al (1998) to compute PET at an hourly resolution (*t*) at each pixel (*x*) in our domain:

$$hPET_{x,t} = \frac{0.408\Delta(R_n - G + \gamma(\frac{37}{T_a + 273})u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where R_n is hourly net radiation (MJ m^{-2}), *G* is the soil heat flux (MJ m^{-2}), γ is the psychometric constant (kPA °C^{-1}), Δ is the slope of saturation vapour pressure (kPA °C^{-1}), T_a is hourly air temperature (°C), e_s is saturation vapour pressure (kPa), e_a is the actual vapour pressure, and u_2 is the converted (from 10 m above the land surface) wind speed (m s^{-1}) at 2 m above the land surface.

For use in the above equation, e_s and e_a are calculated using the Tetens equation (Tetens, 1930) using hourly air temperature (T_a) and dew point temperature (T_{dew}) as detailed below (calculations are in in °C after converting from K):

$$e_s = 0.6108\exp\left(\frac{17.27 * T_a}{T_a + 237.3}\right)$$

$$e_a = 0.6108\exp\left(\frac{17.27 * T_{dew}}{T_{dew} + 237.3}\right)$$

Slope of saturation vapour pressure (Δ) and the psychrometric constant are calculated as follows:

$$\Delta = \frac{4098 e_s}{(T_a + 237.3)^2}$$

$$\gamma = \frac{C_p * P}{\varepsilon * \lambda}$$

Where P is atmospheric pressure, C_p is the air's specific heat at constant pressure based on the ideal gas law with a value of 1.013×10^{-3} MJ kg^{-1} per °C, ε is the ratio of the molecular weight of water vapor to that of dry air (0.622), and λ is the latent heat of vaporization, (2.45 MJ kg^{-1}).

Net radiation (R_n) is estimated using net solar (R_s) and thermal radiation (R_t) as (all values in MJ m^{-2}):

$$R_n = R_s - R_t$$

Finally soil heat flux (*G*) is estimated as:

$$G = \begin{cases} G_{day} = 0.1 * R_n \\ G_{night} = 0.5 * R_n \end{cases}$$

Where the soil heat flux (*G*) is estimated to be 10% of net radiation (R_n) during the day and 50% during the night (as the night-time heat flux is negative). At each pixel we use net solar radiation to define day and nighttime periods. Unlike many other PET datasets, nighttime PET values have not been automatically set to zero.

2. **The climatological analysis appears to aggregate data across the entire study period. Are there any differences between wet and dry seasons? Given the region's likely seasonal contrasts (Figure C1), will the results/signal change in wet and dry seasons?**

Thank you for this comment which makes a good point. Yes, we did also analyse at the seasonality in the rainfall metrics. For brevity and to reduce the number of figures we decided to only report the annual results. However, we can add the below figure to supplementary material, which shows the 'drizzle' effect in P25 is evident in all the seasons including the MAM and OND rainy seasons and the dry season(s) JF and JJAS.

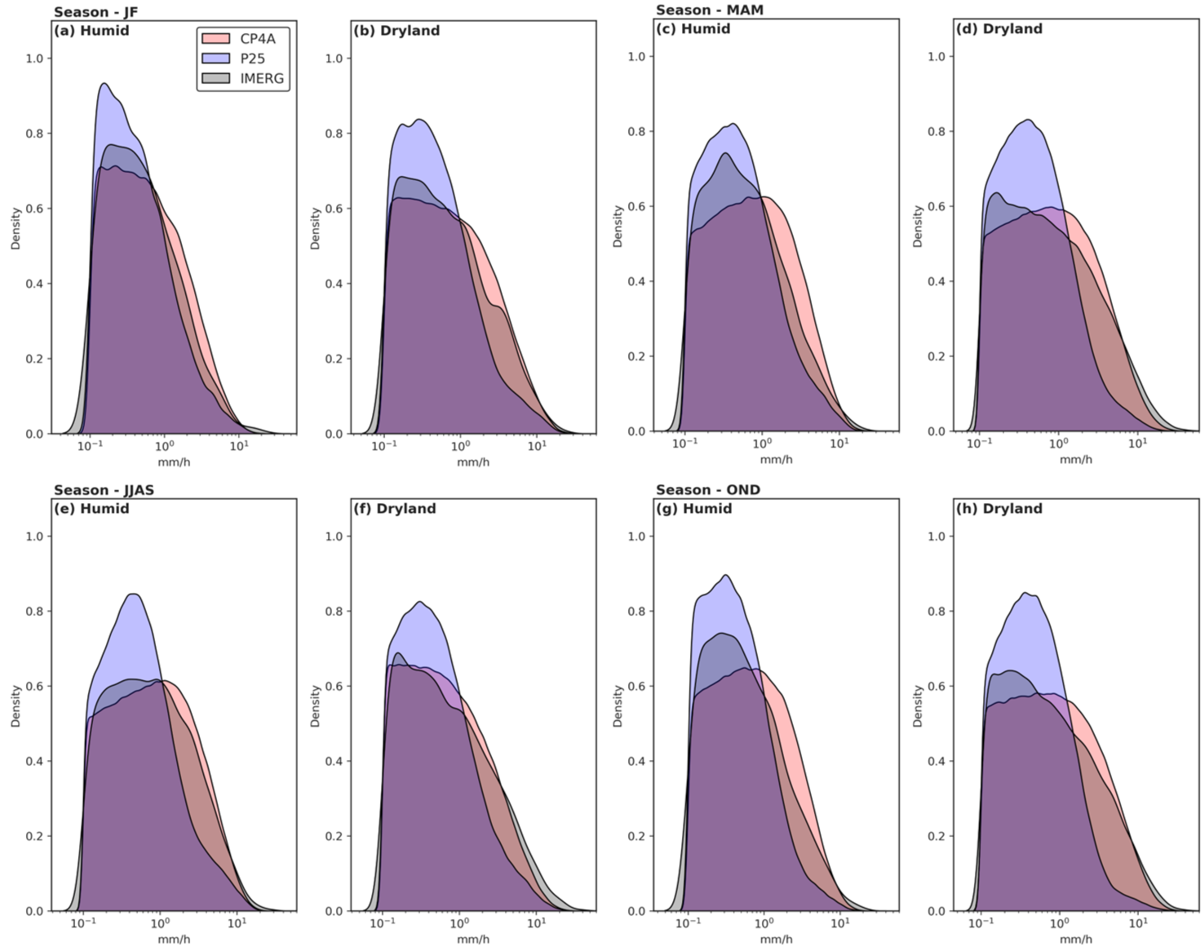

Figure 1. Rainfall KDE Plots. Kernel density estimate (kde) plots of CP4A, P25, and IMERG hourly rainfall in humid (AI >= 0.65) and dryland (AI < 0.5) regions of the Horn of Africa for JF (a-b), MAM (c-d), JJAS (e-f), and OND (g-h). Plots exclude dry hours by dropping any hours that receive < 0.1 mm/hr of rainfall.

3. **The aridity index (AI) is referenced repeatedly (Lines 37, 226, 527), but its definition (e.g., ratio of precipitation to PET or another formula) is not provided. Please clarify the specific equation or source used for calculating AI to ensure reproducibility and reader comprehension. Or directly cite the reference to indicate the four regions other than use value of aridity index.**

We use Aridity Index (AI) as P/PET (Zomer et al, 2007). Under section 2.4.2 we will add the following text and table (which will be labelled Table 1 in the main body of text): Given the sensitivity of dryland hydrology to rainfall characteristics, we wanted to establish whether relative differences in hydrological outcomes between Hydrus simulations (when forced with CP4A and P25 rainfall/PET) varied with aridity. Hence, we ran four 1-D hydrological simulations along an aridity gradient across the Horn of Africa (HOA), ranging from humid to hyper-arid (Fig. 1). Here we classify aridity based on aridity index (AI = P/PET) values taken from the CGIAR-CSI (Consortium of International Agricultural Research Centres' Consortium for Spatial Information) (Zomer et al., 2007) using the classification of Mirzabaev et al (2019).

The Aridity Index (AI) is a numerical indicator of climatic aridity based on long-term precipitation deficits relative to atmospheric water demand:

$$AI\ (Aridity\ Index) = MAP\ /\ MAE$$

Where MAP is mean annual precipitation and MAE is mean annual potential evaporation, CGIAR-CSI calculate both MAP and MAE using data obtained from WorldClim Global Climate Data (Hijmans et al, 2005). CGIAR-CSI outputs AI values at 1 km resolution, which can be used to define the climate type based on the climate classification of Mirzabaev et al, 2019, shown in Table 1.

Climate Type	Aridity Index
Hyper-Arid	AI < 0.05
Arid	0.05 <= AI < 0.2
Semi-Arid	0.2 <= AI < 0.5
Dry Sub-Humid	0.5 <= AI < 0.65
Humid	AI >= 0.65

***Table 1** – Climate classifications based on aridity index thresholds taken from (Mirzabaev et al, 2019).*

Hijmans, R.J., Cameron, S.E., Parra, J.L., Jones, P.G. and Jarvis, A., 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology: A Journal of the Royal Meteorological Society*, *25*(15), pp.1965-1978.