## Response to Reviewers' comments

We sincerely appreciate Dr Paul Stuart Blackwell for the valuable and constructive comments, which will greatly help us improve the quality of our manuscript. We have carefully considered all comments and will revise the manuscript accordingly. The point-to-point responses to the comments and our plans for revision are listed below.

***Replies to Comments:***

*1. "a multi-decadal global daily land surface actual evapotranspiration dataset enhanced with explicit soil moisture constraints in remote sensing retrieval"*

*Could the title possibly be better expressed, thus-?*

*"Global daily evapotranspiration estimated from land surfaces by remote sensing over multiple decades, including explicit soil moisture constraints to remote data retrieval."*

**Response:**

We sincerely thank the reviewer for the thoughtful suggestion regarding the manuscript title. We agree that the proposed version improves fluency and places helpful emphasis on "global daily evapotranspiration." While our original title was indeed longer, it aimed to reflect the dataset's key characteristics and methodological foundation, consistent with the conventions of *Earth System Science Data (ESSD)* data description papers. For reference, similar titles in ESSD include:

- *CAMELE: Collocation-Analyzed Multi-source Ensembled Land Evapotranspiration Data*
- *A global 5 km monthly potential evapotranspiration dataset (1982–2015) estimated by the Shuttleworth–Wallace model*
- *A daily and 500 m coupled evapotranspiration and gross primary production product across China during 2000–2020*
- *A global terrestrial evapotranspiration product based on the three-temperature model with fewer input parameters and no calibration requirement*

In consideration of the reviewer's valuable feedback and to better align with ESSD's style and audience expectations, we propose revising the title to:

**P-LSHv2: A multi-decadal global daily evapotranspiration dataset enhanced with explicit soil moisture constraints**

We believe this revised title improves clarity and conciseness while preserving the necessary level of detail and methodological specificity.

*2. "We integrated this approach into the process-based land surface 20 ET/heat fluxes algorithm (P-LSH, or P-LSHv1), developing an improved version, P-LSHv2. Using observations from 106 global flux towers, we calibrated biome- and* *climate-specific parameters and quantified moisture constraints across diverse climates and land cover types. P-LSHv2 achieves notable improvements in ET estimation, with a reduced Root Mean Square Error (RMSE) of 0.67 mm $d^{-1}$ and an increased correlation coefficient (R) of 0.81, outperforming its predecessor, P -LSHv1, particularly in arid regions."*

*A most efficient description of complex processes, but, should (R be $R^2$)?*

**<u>Response:</u>**

We thank the reviewer for the positive feedback and the insightful question. In this context, we used the **Pearson correlation coefficient (R)** to assess the linear agreement between the estimated and observed evapotranspiration (ET) values across flux towers. Since our focus is on evaluating consistency rather than the proportion of explained variance—as would be the case with the coefficient of determination ($R^2$)—we believe that reporting **R = 0.81** is appropriate.

To avoid any potential confusion, we will clarify this explicitly in the revised manuscript. The sentence has been revised as follows:

"…P-LSHv2 achieves notable improvements in ET estimation, with a reduced root mean square error (RMSE) of 0.67 mm $d^{-1}$ and an increased **Pearson correlation coefficient (R)** of 0.81, indicating strong agreement with flux tower observations. As a result of these improvements, P-LSHv2 outperforms its predecessor, P-LSHv1, particularly in arid regions…"

*3. "Leveraging the P-LSHv2 algorithm, we have produced a long-term global daily ET dataset spanning 1982–2023, providing a valuable resource for research on terrestrial water and energy cycles and climate change. The dataset is freely available at https://doi.org/10.11888/Terre.tpdc.301969 (Feng Jin, 2025)."*

*This is a very generous offer of free access to your data, Jin.*

*I just question your choice of the word 'Leveraging'. I know I am a 72-year old, old fashioned bloke who still used printed map books to figure out where to drive in the city, but still have a more than adequate mental map of the whole of SW Australia to call on from long years of driving around helping agriculture. But the point is that the word 'Leveraging' primarily reminds me of the very skilled Aussie tyre fitter who I often had to call upon to change a tyre or two on the government car I was driving around. So maybe for the sake of a broad readership of your extensive paper, the word 'employing' may be a more suitable one in these circumstances? Just a respectful suggestion.*

**<u>Response:</u>**

We sincerely thank the reviewer for the kind words and for the thoughtful suggestion regarding word choice. We appreciate the perspective on the term "leveraging," and agree that "employing" may read more naturally and be more widely accessible to a broad readership. To improve clarity and tone, we have revised the sentence as follows:

"**Employing the P-LSHv2 algorithm**, we have produced a long-term global daily ET dataset spanning 1982–2023…"

We are grateful for the reviewer's attention to both language and accessibility, which contributes meaningfully to improving the manuscript.

*4. "Due to the water potential gradient between leaf and air, water is transported from soil to vegetation roots, and leaves, and then dissipated into the atmosphere through stomata. Therefore, soil water content serves as the direct water pool for vegetation and regulates the magnitude of water extracted by vegetation roots (Feng et al., 2022; Liu et al., 2020b)"*

*This is an eloquent, but oversimplified, physical explanation of evapotranspiration. It requires inclusion of the biological need and purpose of transpiration by plants and the vital role to sensory and growth behaviour that plant root tips play in semi-arid ecologies especially in landscapes with soil types of poor water-holding capacity. This text is extracted from one of the research papers I am developing.*

*"Dexter (1986) described the behaviour of plant roots seeking biopores, some concepts have been put forward, such as "trematotropism" and "oxytropism". Gregory (2009) summarised that 'Roots grow towards areas of higher water potential … and that roots could sense a water potential gradient as small as 0.5 MPa mm–1 so that hydroresponsiveness may contribute to both avoidance of drought stress and modifications to root system architecture'. This knowledge strongly suggest that the soil profile structure needs some degree of heterogeneity varying from loose structure for ease of root exploration to more dense components (clods or ridges) which allow only slow or little root growth and can retain moisture at higher potential; more readily available at times when growing conditions are drier. In a similar manner, roots seek out some nutrients along gradients of their occurrence in the soil profile as nutrients are supplied to the root surface by mass flow and diffusion'."*

*Thus, by logical deduction, the ability of root tips to search out water in the soil profile may have more control on ET that the simple vapour deficit gradient. Additionally, since most of the evaporated water is used to cool leaves on hot afternoons, any undersupply and overheating leads to a breakdown of ET pathways through the plant tissue and a reduction of ET despite a strong VP gradient. Such processes do need to be explained and included in this MS, and there may well be more research of that aspect, since I am not fully up-to date with that research sector.*

**Response:**

We sincerely appreciate the reviewer for the insightful and constructive comments. Your suggestions have significantly enriched our understanding of plant water use strategies and the underlying ecological mechanisms. Below, we summarize the key issues you raised and provide our detailed responses:

(1) Transpiration mechanism oversimplified

The explanation of plant transpiration in the manuscript is overly simplified, focusing mainly on physical processes (i.e., water potential gradients) while neglecting physiological drivers and regulatory mechanisms—especially plant responses under drought constraints.

(2) Active root sensing and hydrotropism

Plant roots are not passive in water uptake but actively sense and grow toward water through physiological mechanisms. The ability to detect subtle water potential gradients and directionally grow plays a key role in maintaining transpiration under moisture-constrained conditions.

(3) Soil structure effects on root uptake

Soil structural heterogeneity substantially influences root architecture and water availability. Loose soils promote root exploration, while compacted structures aid in water retention, thereby shaping effective water uptake and transpiration dynamics.

(4) ET limitation under drought conditions

In dryland ecosystems, root water acquisition may exert a more direct control on ET than atmospheric drivers such as vapor pressure deficit (VPD). Under drought, even high VPD may not lead to higher ET due to limited plant access to water.

In response to these points, we will revise the manuscript as follows:

**Response to Point (1):**

We acknowledge that our previous description of transpiration primarily focused on its physical pathway. In the revised manuscript, we will add further explanation of the physiological regulation of transpiration. Specifically:

"In addition to the physical gradient of water potential, plant transpiration is fundamentally driven by biological needs such as nutrient transport, turgor maintenance, and leaf cooling. These physiological functions are tightly regulated and feed back to control stomatal conductance, thereby influencing transpiration dynamics".

**Response to Point (2):**

We will revise the description of root water uptake to clarify that roots are not merely passive structures. Instead, we will emphasize their sensory and active water-seeking behavior. The revised text will include:

"Root tips are capable of sensing subtle gradients in water potential (as low as 0.5 MPa $mm^{-1}$), exhibiting behaviors such as hydrotropism to actively seek water in heterogeneous soil profiles (Gregory, 2009; Dexter, 1986). Such sensory responses provide a physiological basis for root foraging behavior, which is particularly important for sustaining transpiration under drought conditions.".

**Response to Point (3):**

We agree that soil structural heterogeneity plays a key role in root development and water availability. In our P-LSHv2 algorithm, such heterogeneity is indirectly represented by land cover and climate classifications, which is determined by the parameter *n*. We opted not to use global soil hydraulic properties due to their high uncertainty, but land cover and climate types provide a feasible proxy for large-scale heterogeneity. We will also mention the potential of incorporating higher-resolution soil hydraulic properties in future work. The following paragraph will be added to the discussion:

"Soil structural heterogeneity plays a crucial role in regulating the distribution and availability of soil water. Looser soil facilitates root penetration, while denser soil can retain water at higher matric potentials, thus extending water availability during dry periods. This spatial variation influences root distribution patterns and overall transpiration rates".

**Response to Point (4):**

We agree that in arid ecosystems, the availability of soil water may limit ET more directly than VPD. This perspective supports our inclusion of explicit soil moisture constraints in the P-LSHv2 algorithm. Our results also indicate that ET in arid ecosystems is highly sensitive to soil water availability. We will add the following explanation in the manuscript:

"In arid and semi-arid regions, even under high atmospheric demand (i.e., high VPD), the actual ET is often constrained by soil water availability and root uptake capacity. As the root-soil interface becomes hydraulically disconnected under drought, transpiration may decline despite strong evaporative demand. Thus, ET is better explained by the coupling of root foraging behavior and soil water retention characteristics in these ecosystems."

**Clarification of Study Scope:**

We appreciate your suggestion regarding the broader physiological purpose of transpiration. While such discussion provides valuable ecological context, the primary focus of our study is on improving remote sensing–based ET algorithm and dataset performance. As such, we may not delve deeply into modeling root water foraging processes. To ensure global applicability, we adopted a simplified yet robust scheme —an essential trade-off in large-scale remote sensing applications.