

Response to Referee #1

The authors have provided a point-by-point response to the previous round of reviews and have indicated their intention to revise the manuscript accordingly. While the response is courteous and acknowledges several limitations, I find that the two most fundamental scientific concerns raised previously have not been substantively addressed. The authors' strategy relies primarily on acknowledging limitations and citing literature to justify the use of ERA5 data, rather than providing concrete remediation or new analyses. Consequently, the core weaknesses regarding model validation and data bias remain unresolved.

1. Lack of independent validation against observational data (Major Concern)

Acknowledging a limitation does not remedy it. Citing other studies only demonstrates that ERA5 is a commonly used dataset, not that the predictions from the specific model proposed here are reliable for real-world drought events. The reported high performance (e.g., R^2 , RMSE) may largely reflect skillful fitting to the internal structures of the reanalysis product rather than genuine predictive capability for actual hydrological or agricultural droughts. Without any form of independent validation against in-situ observations (e.g., station-based soil moisture, streamflow, reservoir levels, or satellite-based products such as SMAP or GRACE), the practical utility of the proposed model remains unsubstantiated.

2. Systematic bias from ERA5-derived AET – omission of irrigation (Major Concern)

The Huaihe River Basin is an agriculturally intensive region where irrigation significantly modifies actual evapotranspiration (AET) and soil moisture, especially during growing seasons. Ignoring this process likely leads to a systematic overestimation of drought severity. Citing studies on cloud water resources or general ERA5 applicability does not address this specific physical bias. The authors must add a substantive discussion of this bias in the revised manuscript.

Response: Thank you very much for the reviewer's important and constructive comments. We fully agree that the two issues raised are critical to the reliability and practical applicability of this study. In particular, we acknowledge that simply stating the limitations of ERA5 data and citing previous studies to support its general applicability is not sufficient to demonstrate the reliability of the model proposed in this study. We also agree that model performance evaluated solely against ERA5-derived target variables may partly reflect the model's ability to reproduce the internal structure of the reanalysis product, rather than fully representing its predictive capability for real-world drought processes.

1. Lack of independent validation against observational data

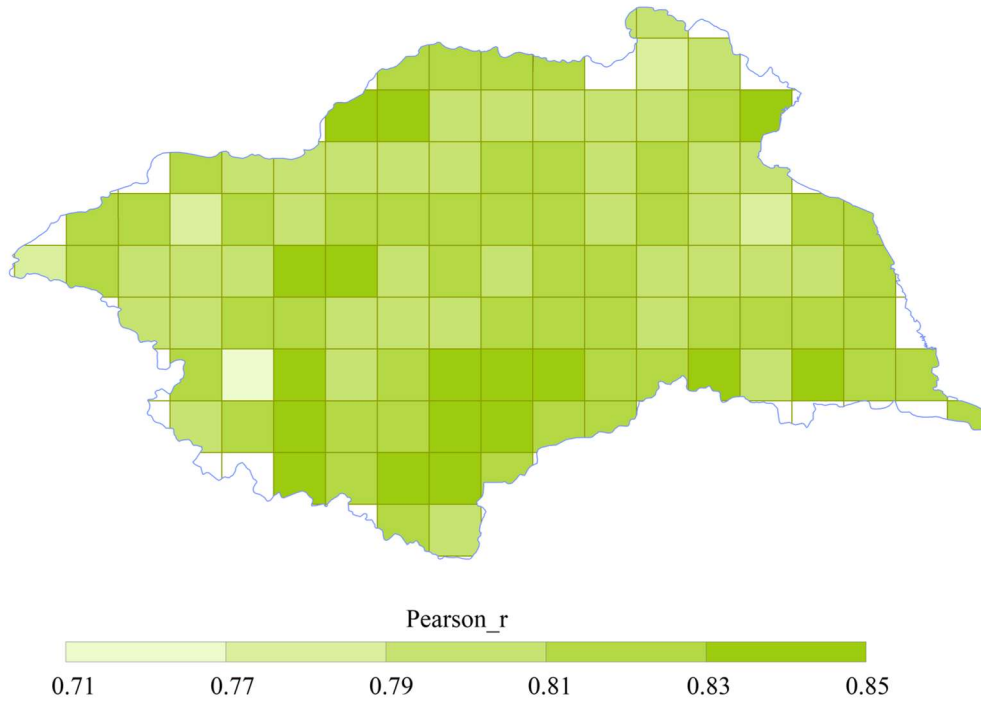
To address this concern, we additionally introduced an independent gridded evapotranspiration dataset during the revision process, namely the Global Gridded Evapotranspiration Dataset (1982–2024) provided by the National Tibetan Plateau Data Center (<https://data.tpdc.ac.cn>). This dataset was used to conduct a data-level cross-comparison of ERA5 variables and the drought indices derived from them.

In the revised Supplementary Material, we added a description of the TPDC dataset and the corresponding independent cross-dataset validation procedure. Specifically, ERA5-derived AET, PET, and DEDI were compared with the corresponding variables derived from the independent gridded evapotranspiration dataset. Pearson correlation coefficients, QQ plots, boxplots, and drought-frequency statistics were used to conduct a cross-comparison between the ERA5-derived variables/DEDI index and the independent gridded evapotranspiration dataset in terms of correlation, distributional characteristics, and drought-category frequencies.

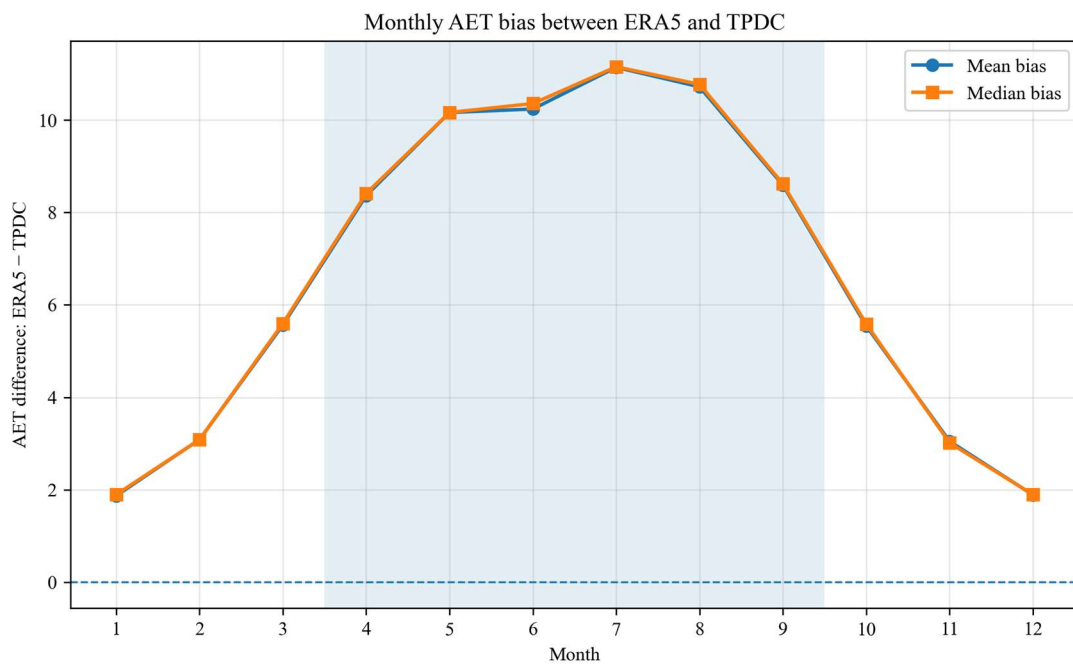
The detailed validation results have now been included in the Supplementary Material. Figure S1 presents the spatial consistency analysis of AET and PET between ERA5 and the independent gridded evapotranspiration datasets. Figure S2 shows the QQ plots of DEDI derived from the two datasets. Figure S3 presents a boxplot comparison of DEDI distributions, and Table S1 compares drought occurrence frequencies at different drought levels. The results show that ERA5-derived AET/PET and DEDI are generally consistent with those derived from the independent gridded evapotranspiration dataset. For example, the Pearson correlation coefficients range from 0.77 to 0.85 for AET and from 0.80 to 0.90 for PET. The DEDI distributions and drought occurrence frequencies derived from the two datasets also show broadly similar characteristics. These results provide further external support that the ERA5-derived DEDI used in this study does not merely reflect the internal structure of ERA5, but shows good correspondence with the independent gridded evapotranspiration dataset in terms of correlation, distributional structure, and drought-category frequencies, thereby supporting its use as a regional drought characterization index.

2. Systematic bias from ERA5-derived AET due to the omission of irrigation processes

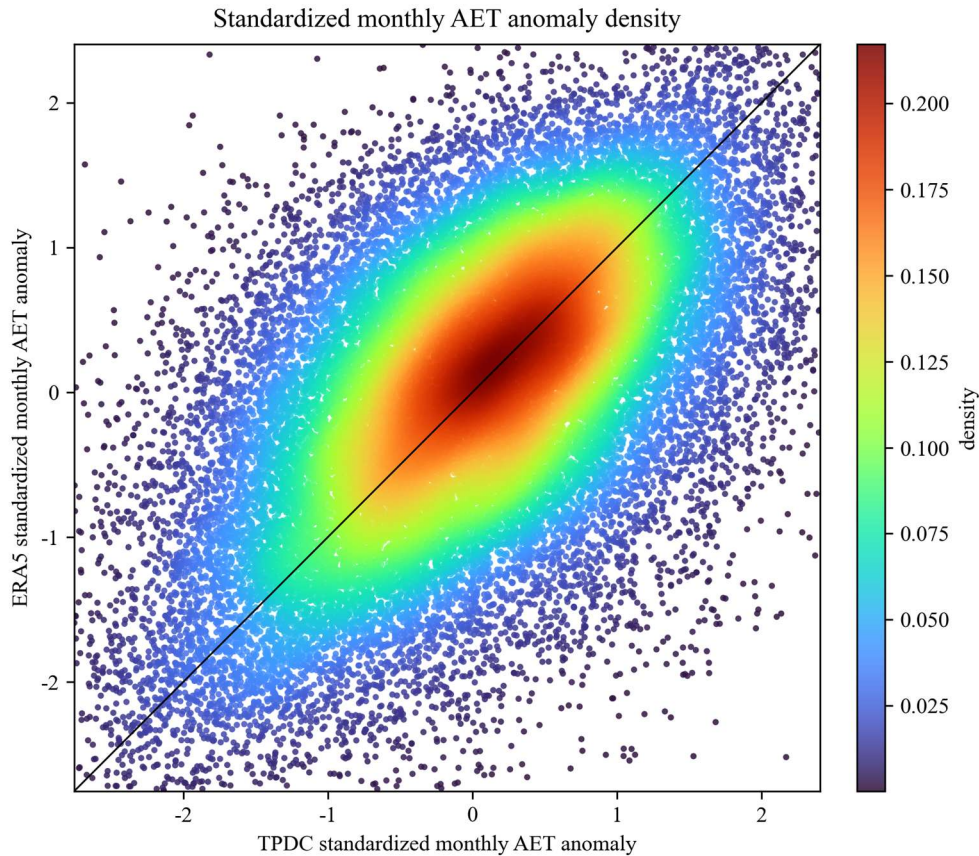
We agree with the reviewer's comment that irrigation is an important anthropogenic process affecting AET and soil moisture in the Huaihe River Basin, especially during the crop growing season. We also agree that simply citing studies on the general applicability of ERA5 cannot address this specific physical bias.



(a) Spatial distribution of Pearson correlation coefficients between ERA5-derived AET and the independent gridded evapotranspiration dataset.



(b) Monthly AET bias between ERA5 and the independent dataset, calculated as ERA5 minus TPDC. The shaded areas indicate the crop growing season from April to September.



(c) Density scatter plot of standardized monthly AET anomalies derived from ERA5 and the independent dataset. The black line indicates the 1:1 reference line.

Figure 1. Cross-comparison of ERA5-derived AET and the independent gridded evapotranspiration dataset.

First, we would like to clarify that we did not ignore irrigation because we considered it unimportant. The DEDI index and the prediction framework in this study are constructed on a daily scale. However, available irrigation information is generally provided in the form of statistical records at administrative, annual, or seasonal scales. Such data cannot be directly incorporated into our daily gridded framework without introducing additional uncertainties from temporal downscaling and spatial redistribution.

Second, to further evaluate the reasonableness of the ERA5-derived AET, we conducted a cross-comparison with the Global Gridded Evapotranspiration Dataset from the National Tibetan Plateau Data Center, which was used as an independent gridded evapotranspiration product. The results have been added to Supplementary Material. Figure 1(a) presents the spatial distribution of Pearson correlation coefficients between ERA5-derived AET and the independent gridded evapotranspiration dataset. The correlation coefficients range from 0.71 to 0.85 across the Huaihe River Basin, with most regions showing relatively high positive correlations. This indicates that ERA5-derived AET and the independent dataset show good

correspondence in the spatial pattern of actual evapotranspiration. This result suggests that ERA5-derived AET does not merely reflect the internal structure of the ERA5 reanalysis product, but also shows good spatial correspondence with an independent evapotranspiration dataset. Figure 1(b) further shows the monthly AET bias between ERA5-derived AET and the independent gridded evapotranspiration dataset, calculated as ERA5 minus the independent dataset. The mean and median monthly bias curves are nearly overlapping, indicating that the monthly bias structure is stable and not dominated by a few extreme values. Figure 1(c) presents the density scatter plot of standardized monthly AET anomalies. Because different evapotranspiration products may differ in their algorithms, input data, and variable definitions, direct comparison of absolute AET values may be affected by magnitude differences. Therefore, we further compared standardized monthly anomalies to evaluate whether the two datasets capture similar evapotranspiration anomaly variations. The standardized anomalies derived from ERA5 and the independent gridded evapotranspiration dataset are mainly distributed along the 1:1 reference line and exhibit clear positive correspondence. This indicates that ERA5-derived AET can reasonably capture the temporal variability of regional evapotranspiration anomalies, thereby providing additional data-level support for its use in the construction of DEDI and drought prediction in this study.

Third, following the reviewer's suggestion, we have added a substantive discussion of potential irrigation-related bias to the revised manuscript. We now explicitly state that the Huaihe River Basin is an agriculturally intensive region where irrigation may increase cropland water availability, enhance actual evapotranspiration, and alleviate soil moisture deficits during dry periods. Future work should incorporate spatially explicit irrigation water-use data, crop-specific water demand, ground-based soil moisture and streamflow observations, and satellite-based products such as SMAP and GRACE to further quantify and correct irrigation-related uncertainties. Overall, the newly added cross-comparison results show that the ERA5-derived AET has good correspondence with the independent gridded evapotranspiration dataset in terms of spatial distribution and standardized anomaly variations. Nevertheless, we acknowledge that irrigation processes may still introduce uncertainty, and we have therefore added a clearer and more cautious discussion of this issue to the revised manuscript.

Response to Referee #2

We sincerely thank Referee #2 for the positive evaluation of our manuscript and for recommending acceptance. Since no specific revision comments were provided, no point-by-point changes were required in response to this report.

Response to Referee #3

Figure 7 and now is Figure S1 should have the x-axis and y-axis meaning in the figure.

For the comment that there is no independent data, the author mentioned that “we additionally incorporated an independent dataset, namely the global gridded evapotranspiration dataset (1982–2024) from the National Tibetan Plateau Data Center (<https://data.tpdc.ac.cn>), to perform cross-comparative analyses of ERA5 variables and the drought indices derived from them at the data level, thereby providing important supporting evidence for the original findings”. But I did not find the result in the revised manuscript.

Response: Thank you for this helpful comment.

1. We agree that the previous caption of Figure S1 was not sufficiently clear, because it did not explicitly indicate the meanings of the x-axis and y-axis. Since Figure S1 contains multiple subplots and the available space inside each panel is limited, we revised the figure caption to clearly define the axis meanings.

Specifically, the original caption was:

“Figure S1. Evaluation indicators of different regions within the Huaihe River Basin” has been revised to:

“Figure S5. Density scatter plots of model-predicted DEDI against ERA5-derived reference DEDI in different regions of the Huaihe River Basin (x-axis: ERA5-derived reference DEDI; y-axis: model-predicted DEDI). The diagonal line represents the 1:1 reference line, and the color bar indicates point density.”

This revision clarifies that the x-axis represents the ERA5-derived reference DEDI values, while the y-axis represents the DEDI values predicted by different models. In addition, the color scale represents the point density, and the diagonal line denotes the 1:1 reference line.

2. Thank you for pointing this out. We apologize that the location of the independent validation results was not clearly stated in the previous revision, which made these results difficult to locate. Considering that this part mainly provides a data-level independent cross-dataset validation of ERA5-derived variables and the DEDI index, it serves as supplementary supporting evidence for the reliability of the main results. Including the detailed validation procedure and results directly in the main text may affect the overall logical flow of the manuscript, which focuses on model construction, prediction performance evaluation, and result interpretation. Therefore, in the current revision, we have systematically organized the relevant independent validation analyses in the Supplementary Material, so that the validation procedure and results can be presented in a more focused and clearer manner.

In the revised Supplementary Material, we have explicitly introduced the Global Gridded Evapotranspiration Dataset (1982–2024) provided by the National Tibetan Plateau Data Center

(TPDC). We clarified that this dataset was used as an independent gridded evapotranspiration product for cross-dataset validation and was not used for model training or parameter optimization. In addition, we have added a description of the independent cross-dataset validation procedure in the Supplementary Material. Specifically, AET, PET, and DEDI derived from ERA5 were compared with those derived from the TPDC dataset. Pearson correlation coefficients, QQ plots, boxplots, and drought-frequency statistics were used to evaluate the consistency between the two datasets.

The detailed validation results have been provided in the Supplementary Material. Figure S1 presents the spatial consistency analysis of AET and PET between ERA5 and the TPDC dataset. Figure S2 presents the cross-comparison of ERA5-derived AET and the TPDC dataset. Figure S3 shows the QQ plot comparison of DEDI derived from the two datasets. Figure S4 presents a boxplot comparison of DEDI distributions, and Table S1 compares drought occurrence frequencies at different drought levels. These results show that ERA5-derived AET/PET and DEDI are generally consistent with those derived from the TPDC dataset, thereby providing additional support for the reliability of the ERA5-derived DEDI used in this study.

Response to the Editor

Public justification (visible to the public if the article is accepted and published):

Dear authors,

Thank you very much for your responses to review comments and your revision.

The reviewers have assessed your revision and have made some further comments for your consideration.

In particular, one of the reviewers suggested that you consider two critical issues:

1. Lack of independent validation against observational data (Major Concern)
2. Systematic bias from ERA5-derived AET – omission of irrigation (Major Concern)

I hope you can adequately consider these suggestions together with the more technical ones from other reviewers and submit a response and revision.

Best wishes

Bob Su

Response: Thank you very much for your letter and for summarizing the key concerns raised by the reviewers. We have carefully considered the two critical issues

highlighted in your decision letter, namely the lack of independent validation against observational data and the potential systematic bias in ERA5-derived AET caused by the omission of irrigation processes.

1. Lack of independent validation against observational data

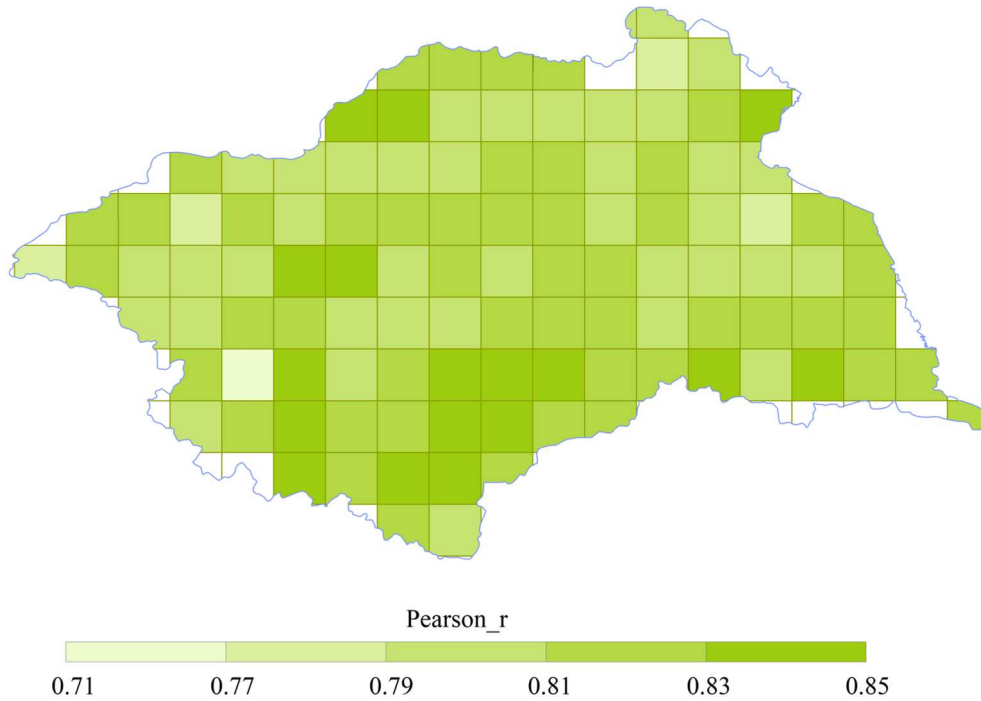
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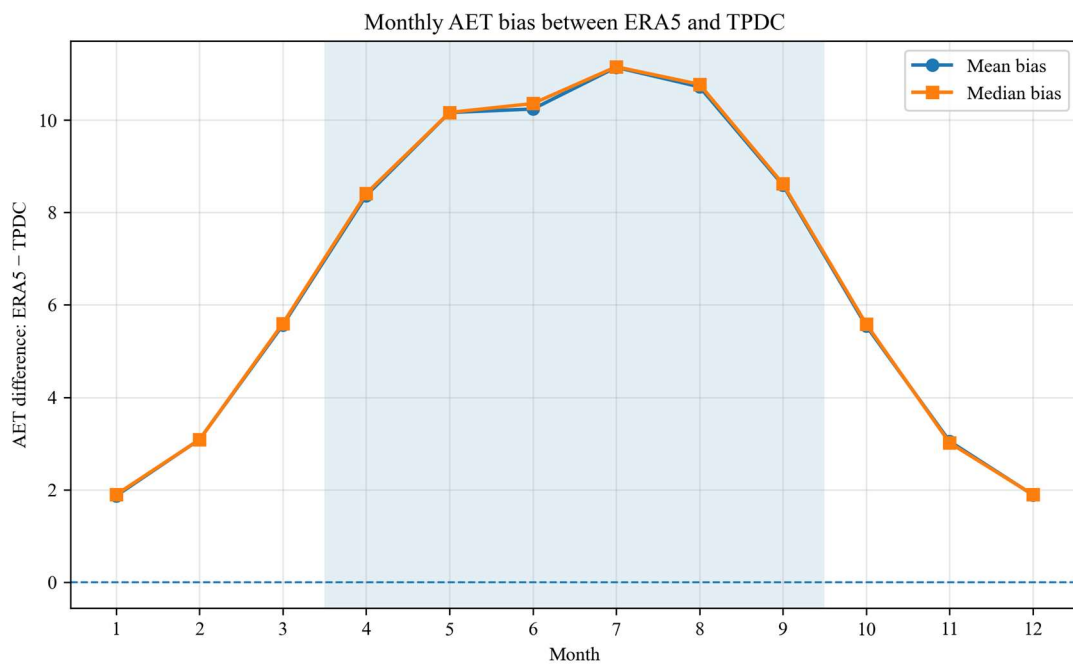
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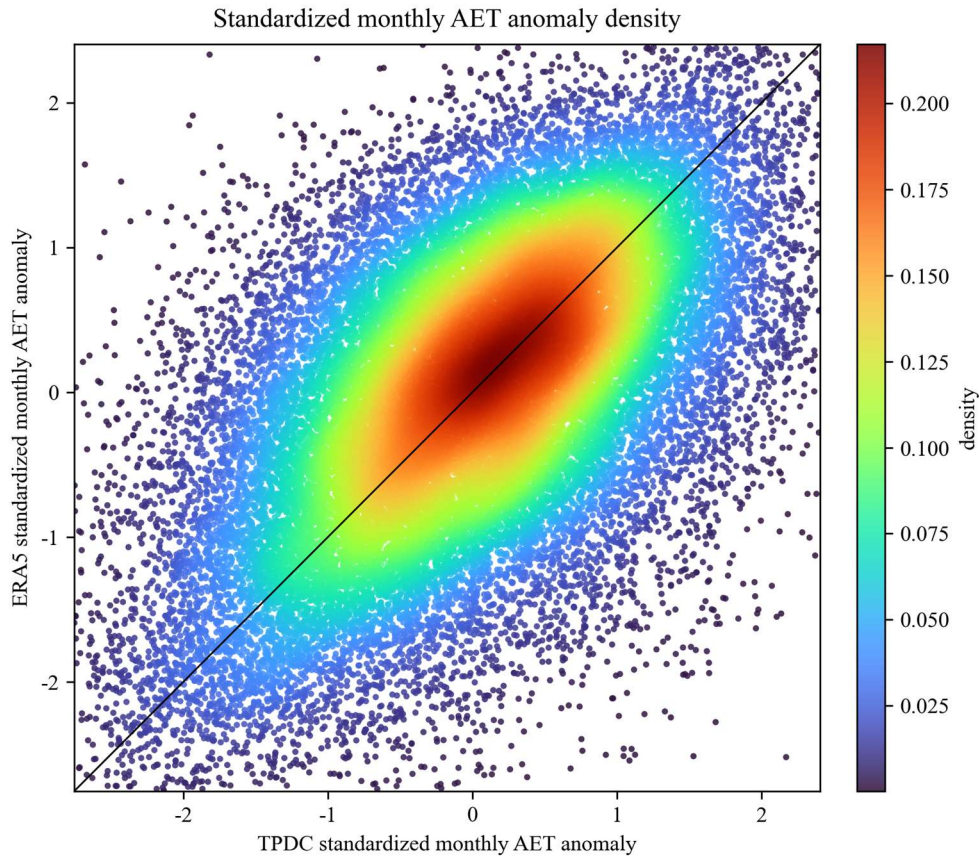
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We also state in the revised Discussion that future work should incorporate spatially explicit irrigation water-use data, crop-specific water demand, ground-based soil moisture and streamflow observations, and satellite-based products such as SMAP and GRACE to further quantify and correct irrigation-related uncertainties. Overall, the newly added cross-comparison results show that ERA5-derived AET has good correspondence with the independent gridded evapotranspiration dataset in terms of spatial distribution and standardized anomaly variations. Nevertheless, we acknowledge that irrigation processes may still introduce uncertainty, and we have therefore added a clearer and more cautious discussion of this issue in the revised

manuscript.

In addition, we have also addressed the technical comments raised by another reviewer, including explicitly clarifying the meanings of the x-axis and y-axis in the caption of the relevant supplementary figure. We hope that these revisions adequately address the reviewers' concerns and improve the reliability and transparency of the manuscript.

Overall, this round of revision further clarifies and strengthens the independent cross-dataset validation that had already been conducted in the previous revision, and systematically incorporates the relevant results into the main text and Supplementary Material. Meanwhile, we have added a discussion of the potential irrigation-related bias in ERA5-derived AET and further clarified the scope within which the model results should be interpreted. We hope that these revisions more clearly address the major concerns raised by the editor and reviewers regarding data reliability, independent validation, and irrigation-related bias.