Author’s Response of Merk et al. (EGUSPHERE-2025-3836)

Dear Keirnan,

On behalf of all authors, I want to thank you for your editorial, for the management of the reviews, your comprehensive feedback on our work, and your suggestion moving forward. We want to thank you also for your quick response after we asked for a status update.

It’s a pleasure to learn that one reviewer is happy with the study the way it has become, while the other remains critical with the LAI-proxy conclusion. It looks like we found a spot for our paper where there is still a lot of discussion going on in the hydrological modeling community. Hopefully, with the publication of this study, others will join in, find new perspectives to, or deepen this discussion.

Please find below a point-by-point response to the remarks including all relevant changes made in the manuscript.

With kind regards on behalf of all authors
Fabian

Editor comment #1

To me, the problem isn't so much that you don't have the evidence to support your claim, but rather that you don't articulate it in a prominent manner. It seems that the following points are the main supports for the claim that LAI can act as a proxy for AET:

- Calibrating to LAI improves AET seasonal pattern; and

- The climate-sensitivity of an LAI calibrated model is similar to a model calibrated to both LAI and AET; both cases provide significantly different outcomes in future projection (i.e. higher AET) compared to a streamflow-only calibrated model.

These aren't stated very clearly in a prominent place. This is a problem because the claim itself is stated prominently in the abstract and conclusion. Even if you disagree with my framing, the action I need from you is to ensure the evidence to support the claim is stated more clearly in both the conclusion and abstract (for the latter, an alternative option is to remove both the claim and the evidence from the abstract). This responds to the reviewer's concern that "performance alone does not demonstrate that LAI reliably captures AET dynamics" because you are telling the reader what the evidence is and allowing them to judge for themselves.

Answer:

We thank the editor for this feedback and the detailed suggestion. We adjusted both the abstract and conclusion. We added more explanation and associated results, while, at the same time, avoid to directly speak of the prove for LAI to be a AET-proxy. There is more research necessary to completely understand whether LAI can be a proxy for AET.

We further added a table which lists the simulated future annual AET values for each GCM-SSP scenario:

Table 5. Overview of the multi-model mean values of the future annual AET. The baseline reference is the evaluation period 2001 to 2015 simulated with W5E5. The values show the mean value for each GCM, emission scenario, and the 20 sets of parameters in mm yr^{-1}. The changes to the baseline (in brackets) are percentage changes. See Table A8 in Appendix for further future water balance components.

Future SSP scenario	Near future			Far future		
	Q	Q + LAI	Q + LAI + AET	Q	Q + LAI	Q + LAI + AET
SSP1–2.6	858 (+5.6)	900 (+5.9)	917 (+7.2)	846 (+4.0)	886 (+4.2)	925 (+8.3)
SSP3–7.0	860 (+5.7)	898 (+5.8)	915 (+7.1)	880 (+8.2)	918 (+8.0)	932 (+9.1)
SSP5–8.5	847 (+4.2)	888 (+4.5)	904 (+5.7)	889 (+9.3)	911 (+7.2)	926 (+8.3)

Please find the changes in Abstract, Conclusion, and full text in the updated manuscript.

Editor Comment #2

- I may have missed it, but why can't any of the calibration methods fix the bias in AET? Is this a water balance issue?

Answer:

Thank you for this important question. We assume that the water balance is the main issue in the bias of AET due to the combination of applied AET-FLUXCOM data and the E0 computation in SWAT-T. Although AET-FLUXCOM is validated for the given site, it remains its characteristic of “modeled AET” data, which can introduce a bias even if the fit at EC systems is fine. Further, the AET computation is based on LAI and results from an alfalfa grass assumption for E0 (or potential ET) in SWAT-T (see Chapter 2.1). A bias-adjustment of ET can help solve the gap. Yet, we preferred a parameter-based modeling to conduct the climate impact assessment.

In other studies, we modeled the Ouémé Catchment (of which Bétérou is a subcatchment) with HBV (Affewe et al., 2025[1]) and SWAT (Annan et al., 2025[2]) and figured similar bias issues with simulated AET to reference AET. In both studies, monitored precipitation and temperature data is used. The results are however not published in the articles due to different research objectives. Likely, there is a bias in AET-FLUXCOM, yet it is quantitatively still the best match for the region (see validation in manuscript, Figure A10 in Appendix).

Editor Comment #3

- Please clean up the conclusion, perhaps by using dot points for the different statistics and using clearer topic sentences and paragraph structure.

Answer:

We thank the editor for this suggestion. We rephrased the Conclusion (see Comment#1). We are not sure whether dot points are within the layout demands of Copernicus/HESS. As far as we know, full text over bullet points is preferred in the layout of Copernicus/HESS. We prefer to keep the full text layout.

Further, we checked for topic sentences, which are:

- This study couples comprehensive parameter estimation with climate impact assessment, and uses multiple near-optimal parameter sets for each calibration strategy.
- The calibration approach can influence the future AET projections.
- Further, this study highlights the value of plant growth (LAI) for AET estimation, particularly when applying the ecohydrological model SWAT-T.
- This study aligns with the well-document findings the application of the ISIMIP3b (CMIP6) data can have for climate impact assessment in West Africa.
- In hydrological climate impact assessment, GCM uncertainty remains most challenging.

For us, these topic sentences are clear and introduce the topic of the section to the reader. We argue that those sections + topic sentences summarize the relevant conclusions of the study and would prefer to not further change the sections.

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1 Afféwé, D. J., **Merk, F.,** Bodjrènou, M., Rauch, M., Usman, M. N., Hounkpè, J., Bliefernicht, J.-G., Akpo, A. B., Disse, M., & Adounkpè, J. (2025). Impact of Precipitation Uncertainty on Flood Hazard Assessment in the Oueme River Basin. *Hydrology*, *12*(6), 138. https://doi.org/10.3390/hydrology12060138

2 Annan, E., **Merk, F.,** Amponsah, W., Adjei, K. A., Disse, M., & Agyare, W. A. (2025). Impact of land use and land cover changes on water balance in the Ouémé River basin, West Africa. *Hydrological Sciences Journal*, 1–15. https://doi.org/10.1080/02626667.2025.2516831

Editor Comment #3:

- Adapting a request from the reviewer, please increase the prominence of, and strengthen your discussion of, "the conditions under which [your claim about LAI as a proxy for AET in calibration] may or may not hold (e.g., water vs energy limitation, seasonal variability), and the implications of aggregating results to the catchment scale"

Answer:

We thank the reviewer for this important limitation. We added a section to the discussion (at the end of chapter 4.1) in which we highlight the potential applicability of LAI as proxy for AET. The section reads:

The evaluation of LAI as proxy for AET is site- and model-specific. Although the Bétérou Catchment is representative of parts of West Africa, it captures only a subset of the region's diverse hydrological, phenological, and climatic conditions. The ET dynamics in the region can be generally considered water-limited, since the strong seasonal water deficit governs ecosystem functioning (Mamadou et al. 2016). From a modeling perspective, LAI can be expected to serve as a proxy for AET primarily in physical-oriented hydrological models that use LAI as a vegetation attribute in the framework of ET computation, such as the Penman-Monteith method. In contrast, the relation of LAI and AET is weaker in hydrological models that estimate ET using more simplified or empirical approaches, such as the Hargreaves method. In such models, the suitability of LAI as a proxy for AET is limited. Consequently, the conclusions regarding the suitability of LAI as a proxy for AET may be specific to water-limited environments and should be evaluated in regions with different hydroclimatic regimes as well as the hydrological model applied.

In addition, we did not add more discussion on the implications of aggregating results because there is already a larger part in the discussion starting at line 513 in the last manuscript version:

Model evaluation in this study is based on in-situ monitoring and satellite-derived reanalysis datasets (GLASS-LAI and FLUXCOM-AET). GLASS-LAI and FLUXCOM-AET have been validated by Merk et al. (2024) for two distinct locations within the Bétérou Catchment. GLASS-LAI and FLUXCOM-AET rely on models and assumptions, and are provided at a coarser resolution than the hydrological model. To address scale differences, the SWAT-T outputs, GLASS-LAI and FLUXCOM-AET data were spatially projected onto the same units. While this approach allows for a spatially explicit evaluation that reflects land cover variability within the Bétérou catchment, it also introduces some information loss, e.g., from the aggregation of AET heterogeneity. This is particularly important in the process representation of the LAI-AET interaction for localized land-atmosphere feedbacks. The subbasin-level evaluation offers a practical compromise, where spatial context is preserved at a scale appropriate for hydrological modeling. Smaller scales (e.g., HRU levels) and dynamic land use changes have not been considered given the spatial mismatch of modeled and simulated LAI and AET. As demonstrated in Yonaba et al. (2021), dynamic land use modeling can further enhance the process representation of surface runoff and AET in the region. Future research can consider a coupling of detailed LAI, AET, and dynamic land use modeling to further enhance robust hydrological modeling for the region.

Editor Comment #4:
- Also, strengthen the discussion about what types of model this claim relates to. e.g. You say "The LAI computation can be used as a proxy for AET because the plant growth and AET processes are directly connected in SWAT-T" so can you name some other models (or classes of model) the LAI-proxy finding would be relevant to, and others it wouldn't (e.g. simple conceptual rainfall-runoff models).

Answer:
We thank the reviewer for this feedback to give advice for modelers and practitioners. We added a specific part to the discussion section, Chapter 4.1. It is also part of our answer to Comment #3.
We highlight the ET computation method in the manuscript:

From a modeling perspective, LAI can be expected to serve as a proxy for AET primarily in physical-oriented hydrological models that use LAI as a vegetation attribute in the framework of ET computation, such as the Penman-Monteith method.

From our point of view, it's not necessarily about the hydrological model type but rather the implementation of ET computation and whether LAI is used within this framework. Usually, physically-based models apply approaches with LAI for ET, while more conceptual models (e.g., HBV) apply more conceptual approaches for ET (like the Hargreaves method or using ET as input time series).
We want to avoid to name model A, model B, model C, and overlook model D. Thus, we chose to focus on the ET implementation in the manuscript.