Response to Dr. Franziska Aemisegger:

- at Line 486 please change to "strategies for enhancing simulation accuracy". Simulate accuracy sound strange.

Response: This statement has been changed to: “strategies for improving simulation reliability”.

- the last sentence of the paper: I think this sentence is confusing. What kind of more sophisticated techniques do you mean? I would say both methods applied here are already quite sophisticated. More evolved Eulerian methods including numerical tracers are already available in different global and regional models (WRF, COSMOtag). Is this what you mean?

Response: Thank for the comment and sorry for the confusion. We have revised this sentence to: “Furthermore, in the field of numerical moisture tracking, it would be highly beneficial to explore the reliability of forcing data, incorporate additional physical moisture tracers (such as hydrogen and oxygen isotopes), and develop improved bias-correction methods for moisture source-receptor diagnosis.”

- at Line 297: Please shortly mention that Dahinden et al. 2023 Atmospheric Science Letters investigated these "additional" processes diagnosed by the Watersip method in a study over the Sahara by combining Watersip with a high resolution simulation using numerical tracers (COSMOtag) and emphasised the importance of cloud microphysical processes, as well as dry and moist convection embedded in the heat low.

Response: Per your comments, we added one sentence here: “Some earlier studies have also indicated that this method is prone to misidentifying the convergence/divergence processes (Winschall et al., 2014; Cloux et al., 2021), particularly a study over the Sahara has further emphasized the importance of cloud microphysical processes as well as dry and moist convection embedded in the heat low (Dahinden et al., 2023).”

Response to Dr. Ruud van der Ent:

- Line 27: 'discrepancies' still suggest that it is initially wrong, but we don't know that. Maybe something more neutral like. 'The differences become smaller by increasing ...'

Response: This statement was revised to: “These differences become smaller with higher spatial and temporal resolutions...”.

- Line 31: Is that then still FLEXPART-WaterSip or does it become FLEXPART-HAMSTER?

Response: We call this “bias-corrected FLEXPART-WaterSip” in the revised manuscript. We believe this name is more accurate, given that 1) the HAMSTER is only a correction framework for WaterSip, and 2) our “two-step approach”, also as a correction method for WaterSip, is different from HAMSTER.

- Line 32: a high temporal resolution?

Response: Yes. We revised this sentence to: "we recommend using high-resolution forcing datasets, prioritizing temporal resolution over spatial resolution, for WAM-2layers" to avoid confusion.

- Line 74: Fine not to include here, but a comparison to some relevant works in the discussion section would be a good addition to the paper. No this is not mentioned at all.

Response: This sentence has been removed from our revised manuscript. We further added additional discussions to Section 8 in the revision.

- Line 462: This should be more neutral. I may be a WAM2layers issue, but it may also be a FLEXPART-WaterSip that is related to the strict 20-day cap for moisture uptakes.

Response: Thanks for pointing out this. We changed this sentence to "A notable pattern in WAM2layers, when compared to the bias-corrected …"

- Line 480: Is that really different from HAMSTER? If so, it would be good to give that a name to the new two-step approach as bias-corrected FLEXPART-WaterSip is somewhat imprecise then. Is the code for this approach available in a repository in accordance with ACP guidelines?

Response: Our two-step approach is different from HAMSTER – it is an improved correction framework, as detailed in Section 6). Given that the proposed correction method is still relatively preliminary and requires further optimization and comprehensive testing, we prefer to leave the dynamic parameter optimization, correction improvements, and official naming for a follow-up, standalone study.

- other comments in the responses part

Response: Once again, thanks for your detailed and insightful comments on our manuscript. We have made reasonable efforts to address the issues you suggested.

- We have added version numbers of the models in the code availability section.
- We have made our simulation results and codes publicly available through an online data repository: https://doi.org/10.5281/zenodo.12780143.
- We have tried to merge Fig. S1 and Fig. 6 but found that showing topography, gridded moisture transport fluxes, and vectors in one graph is extremely challenging. We therefore decided to leave the topography map in the Supplement.
- The internal model timestep is 900s for the standard 1degree simulation, and 300s for the 0.25degree simulation.
- We have clarified the four numerical experiments in the caption of Figure 8.
- We do not believe it is essential to provide the code for the "two-step bias-correction approach" at this stage, as the method currently does not require a complex computational process. It involves only some sensitivity tests and weighted multiplication operations. Our next goal is to systematically optimize this approach, which we believe is worth writing a new paper about.
- We also appreciate your suggestion on the extended tracking period, which we will

test in our future studies.

Response to Dr. Harald Sodemann:

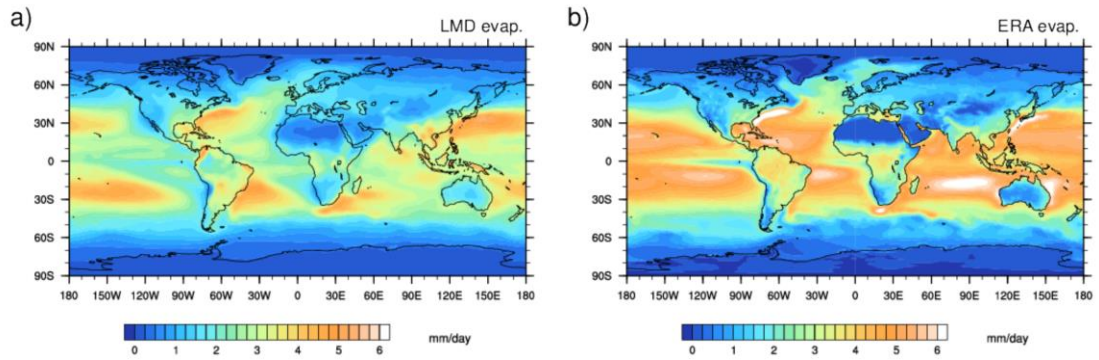
- Remove the reference to the wiki page about WaterSip from the data availability section, it is not needed since the authors implemented the code on their own. The scientific reference of Sodemann et al. (2008) used throughout is entirely sufficient for that purpose.

Response: The reference to the wiki page has been removed.

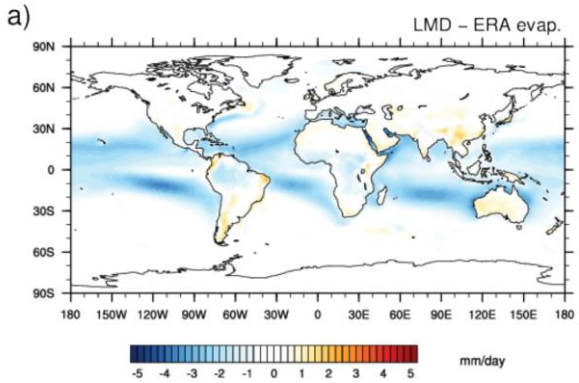
- I am confused by what is shown in Fig. 8b. The simulation setup indicates that particles were released over a limited domain only, in domain-filling mode. To make a comparison with the evaporation field from ERA5 for the same domain, also particles outside of the domain would need to be included and evaluated. Otherwise there would be a low bias in the Lagrangian evaporation estimate. However, the Lagrangian estimate is already biased high, in particular over some coastal and land regions. These biases appear to be substantially higher than previous evaluation study of FLEXPART-WaterSip using a global ERA-Interim simulation showed (Läderach, 2016; https://doi.org/10.3929/ethz-a-010741025, Fig. 3.3). Are you sure the figure is showing exactly what the caption says?

Response: To the best of our knowledge, there are currently three papers that have compared "actual evaporation" and FLEXPART-WaterSip simulations.

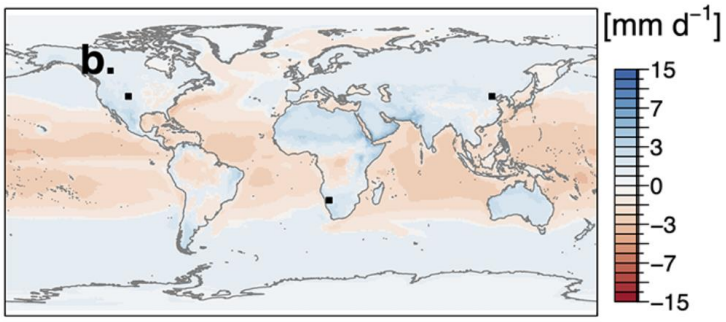
The first one is Läderach (2016) mentioned in your comment. Below are their Fig. 3.3:



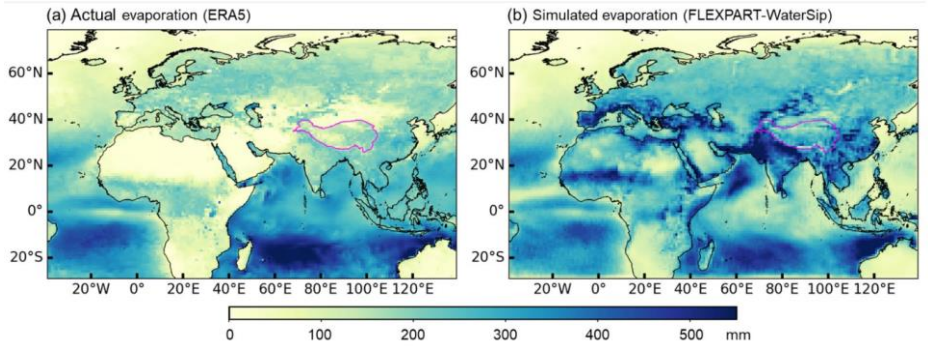
and Fig. 3.4 (bias):



The second one is Keune et al. (2022). Below is their Fig. 3 (bias):



The third one is the present study. Below is our Fig. 8:



Both Läderach (2016) and Keune et al. (2022) did global-scale simulation using ERA-Interim for long-term average. In comparison, our paper did regional scale simulation using ERA5 for only June-July 2022. Although our results are slightly different from Läderach (2016), the result shown in our Fig. 8 (sum of the two months; mm/2 months) is consistent with that of Keune et al. (2022) (daily; mm/d). For example, both studies show positive biases around the North African, the Arabian Peninsula, and the Indian Subcontinent. Therefore, we believe that our evaporation simulations are reasonable.

References:

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Dahinden, F., Aemisegger, F., Wernli, H., Pfahl, S.: Unravelling the transport of moisture into the Saharan Air Layer using passive tracers and isotopes, Atmospheric Science Letters 24, e1187, https://doi.org/10.1002/asl.1187, 2023

Keune, J., Schumacher, D.L., Miralles, D.G.: A unified framework to estimate the origins of atmospheric moisture and heat using Lagrangian models, Geosci. Model Dev. 15, 1875-1898, https://doi.org/10.5194/gmd-15-1875-2022, 2022

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