Dear dr. Alexander Gruber,

Thank you for giving us the opportunity to further revise our manuscript “Local moisture recycling across the globe” for *Hydrology and Earth System Sciences*. We would also like to thank dr. Ruud van der Ent and the anonymous reviewer for reviewing the revised manuscript and for their valuable feedback. We were happy to see only minor changes are requested to improve our manuscript. To improve our manuscript, we made some changes to clarify the newly added analyses, the novelty of our study and rephrased some sentences to improve the text overall. In addition to the changes made to the manuscript following the feedback from the reviewers, we made some additional corrections. First, we included an updated version of Figure 5. Second, we included a copyright statement in the caption of Figure A4.

Below, we discuss all comments of reviewers and describe how we implemented them in our revised manuscript. We do this for each review separately. Our response to each comment is presented in blue.

We hope that our manuscript is now considered suitable for publication in *Hydrology and earth System Sciences*. In case of further questions or requests, please let me know.

On behalf of all authors,

Yours sincerely,

Jolanda Theeuwen

Review by Dr. Ruud van der Ent

The authors did a lot of work improving this paper, perhaps even more than was necessary.

We thank the reviewer for acknowledging the work we put in our revised manuscript.

My comments were all addressed appropriately, but I do have new comments related to the new comparison analysis with WAM2layers results

Figure 2 should be extended by a panel showing the annual Utrack results
We included this extra plot in Figure 2.

In Figure 2It surprises me a lot that it appears that WAM2layers has higher local recycling. Surprising as I remember from previous papers using Utrack that it had higher continental recycling than WAM2layers. Moreover the differences are not so strong for the evaporation length scale comparing visually your Figure A10 with Van der Ent (2014, Figure 3.4b). If anything Utrack length scales are generally lower, implying higher local recycling. Thus, please double check that you are actually comparing 1.5degree results with 1.5degree results are compare length scales instead.

We checked whether we are actually comparing 1.5 degrees results with 1.5 degrees results in figure 2 and we can confirm that this is the case. However, Fig. A10 shows the evaporation recycling length scale calculated at a resolution of 0.5 degrees, which might explain the differences in length scale compared to the result of Van der Ent (1.5 degrees resolution).

As the recycling ratios obtained from WAM2-Layers are larger than our results obtained with UTrack, we would expect the length scale to be smaller for the output of WAM2-Layers compared to our results obtained with output from UTrack, as explained by the reviewer. However, we cannot properly compare the evaporation recycling length scale, as originally, we calculated the evaporation length scale at a resolution of 0.5 degrees. Therefore, for this revision, we calculated the evaporation recycling length scale at a resolution of 1.5 degrees to enable a comparison. The results are presented below.

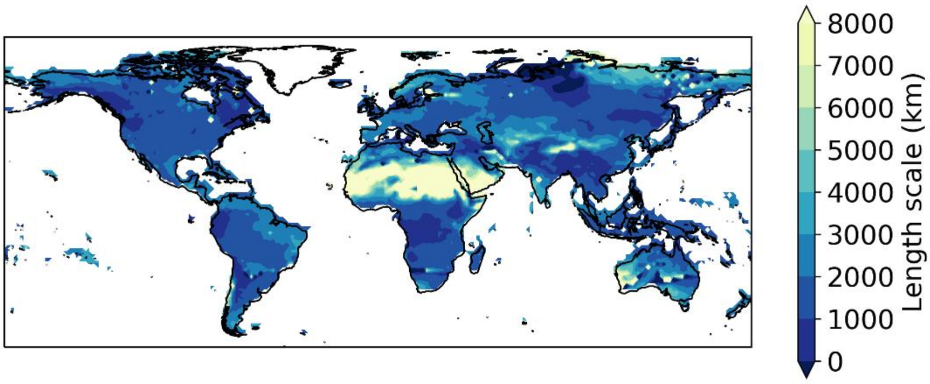

Figure R1. Length scale of evaporation recycling calculated from a resolution of 1.5 degrees obtained with output from the UTrack model. We used the data from Tuinenburg et al. (2020)

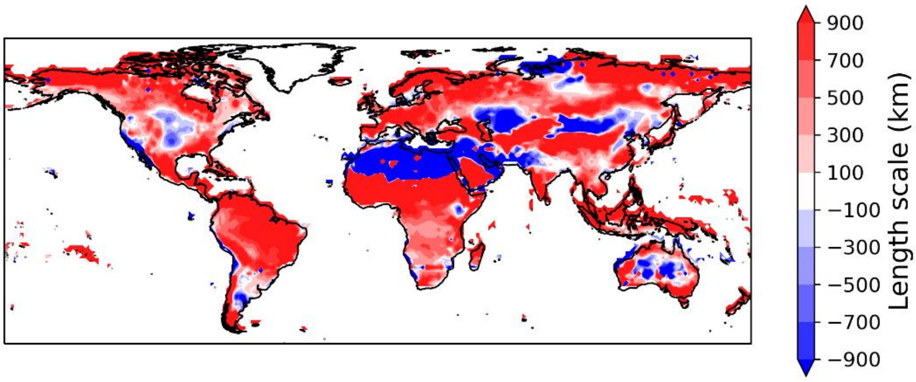

Figure R2. Difference in length scale of evaporation recycling calculated from a resolution of 1.5 degrees obtained with output from UTrack and WAM2-Layers. This plot presents length scales obtained with UTrack minus length scales obtained with WAM2-Layers. We used the data from Link et al. (2020)

First, comparing the length scale of evaporation recycling calculated from a resolution of 0.5 degrees and 1.5 degrees (Fig. R1), we find the length scales are larger for the latter, suggesting we cannot compare the length scale of recycling obtained at different resolutions. A smaller length scale obtained from recycling within 0.5 degrees, compared to the length scale of 1.5 degrees could be the result of a non-linear relation between precipitation and distance to the source.

Second, comparing the length scale at similar resolutions for the output of the two different models, we find that the length scale is larger for the output of UTrack, which suggest lower recycling ratios (Fig. R2). Additionally, the length scale calculated from a resolution of 1.5 degrees is no longer smaller than the length scale found by Van der Ent and Savenije (2011).

To summarize, in the comment of the reviewer the evaporation recycling length scale was calculated at a different resolution, causing the surprising deviation. Furthermore, the evaporation recycling length scale and recycling ratios of 1.5 degrees complement each other. For UTrack, we find lower recycling ratios and larger length scales than for WAM2-Layers.

As the local recycling ratios are really small numbers, especially over dry areas, the relative differences as shown in Figure 2 are not necessarily so meaningful to compare.
We thank the reviewer for pointing this out. In the first revision of the manuscript, we referred to the difference in the recycling ratios produced by UTrack and WAM2-Layers over drylands and deserts, as here, large deviations are found. In our second revision we included a statement that the relative differences are less meaningful (lines 190-191): "*However, over drylands and deserts recycling ratios are relatively small and therefore, the relative difference as presented in Figure 2 has less meaning here.*"

In A5 you are comparing different resolutions isn't it? At a minimum mentioning it would be good to mention, but perhaps just scale this to a common 1.5 degree again.

In Figure A5 we are making a comparison of recycling within one grid cell of 1.5 degrees obtained from the output from Link et al. (2020) and recycling within one grid cell of 1.5 degrees obtained from the output from Tuinenburg et al. (2020). So, we did scale the latter to a 1.5 degrees resolution. We clarified this in the caption of Figure A5: "*The 10-year climatology (2008-2017) of the recycling within one grid cell of 1.5° calculated with the dataset by Link et al. (2020), i.e., the output from the Eulerian moisture tracking model WAM2-layers (top) and the difference with the The 10-year climatology (2008-2017) of the recycling within one grid cell of 1.5° calculated with the dataset by Tuinenburg et al. (2020).*"

In Equation (4) 'i=jan' and 'dec' should swap position.

We thank Ruud van der Ent for pointing this out. We corrected it as suggested.

The code and data availability statements are not following the HESS policy https://www.hydrology-and-earth-system-sciences.net/policies/data_policy.html. Code to a least reproduce the figures should be available or a good reason why not should be provided. Data underlying the manuscript should be your produced data, not your input data, which was already mentioned in the methods section.

We uploaded the local moisture recycling ratio data to the Zenodo archive (10.5281/zenodo.7684640). and uploaded the scripts that can be used to plot these data to GitHub (https://github.com/jtheeu/LocalMoistureRecycling). In the revised code and data availability statements we included links to the data and scripts.

Review by anonymous reviewer

* Summary and recommendation

I thank the authors for answering all comments in detail and acknowledge that many comments have been addressed. In particular, I appreciate the attempt to compare the recycling ratios with another data set (Link et al., 2020) and the discussion thereof. The manuscript structure and the introduction have improved considerably.

We thank the reviewer or acknowledging the improvement of our manuscript.

However, honestly speaking, I still miss the novelty and the plausibility of this research, which stems from a few shortcomings:
- The concept of "local moisture recycling" (whichever grid cell size and model you use) is not

novel.
- The analysis of "factors influencing local moisture recycling" remains superficial and does not provide much insights.
- There remain a few logical inadequacies.
- The analysis is based on 10 years of simulations only. I could ignore this, but in combination with the points above, this really limits the novelty and the scientific findings that could be achieved.

Following this reasoning, I am afraid that I suggest another round of major revisions.

I elaborate on all issues (except the latter one) with a bit more detail below.

*** Novelty of the concept**

I acknowledge that the authors did an effort to improve the description of the novelty of the study and I thank them for clarifying a few (minor) differences. I still think that the novelty is lacking though, for two main reasons:

First of all, because the concept of the LMR is not new and the authors 'just' calculate it over a different scale and with a different model than previous studies. Statements such as
l. 9-12 "For the first time, we calculate the local moisture recycling ratio (LMR) as the fraction of evaporated moisture that precipitates within a distance of 0.5° (typically 50 km) from its source, identify variables that correlate with it over land globally and study its model dependency."
l. 234-235 "but for the first time, we analysed the local moisture recycling ratio (LMR) (of evaporated moisture) across the globe at 0.5° resolution"
are on the edge of what you can call "for the first time", in my opinion. There is no scientific novelty in that other than the fact that you use another resolution.

We removed 'for the first time' from both the abstract and discussion in lines 9-12 and 234-235.

Second, the correlation analysis that 'replaces' the driver of moisture recycling idea does not add much information for me either. In fact, the entire section 3.2 became a bit difficult to read because the authors have to remain superficial with their statements. However, if I do not consider the concept novel, this is the only part that could provide novel insights. At the moment, I struggle seeing any novel insight though.
Throughout the entire paragraph we rephrased sentences to improve the readability (lines 197-222)

*** Drivers / "important factors for local moisture recycling"**

The authors decided to stick to the calculation of correlations (instead of using causality measures) and refer to variables that correlate with LMR as "important factors for local moisture recycling" instead of "drivers". That is better, although it also implies a direction through the "for", i.e. that the other variable is important for LMR. However, it could also be the opposite: LMR influences the other variable or LMR is important for the other variable. Example: P is not influencing local moisture recycling, but local moisture recycling is influencing P. Which way is it? I honestly don't think even this simple example is easy to answer, and this may be my problem with the setup of this analysis. The way this analysis is referred to and presented in the manuscript is tricky in several parts because of this. A few examples:
- l. 130 "to identify factors that affect recycling"

- l. 133 "To identify factors that affect LMR, …"
- l. 234-236 "but for the first time, we analysed the local moisture recycling ratio (LMR) (of evaporated moisture) across the globe at 0.5° resolution, and which factors affect it."
- l. 254-255 "As both correlations are similar, this suggests that the type of precipitation does not affect LMR."
- l. 284-285: "We aimed for a general analysis to identify the main factors that influence LMR" and others. I do understand that expert knowledge is used for some of this, but I really struggle to understand this.

The manuscript should be carefully checked for such implications. If the authors wanted to assess the direction using correlations, they could include time lags in the correlation analysis.
We thank the reviewer for pointing out some examples in which we imply that we assume a relationship because of a correlation. We used these examples to rephrase the following sentences:

- Line 130: *"… to identify factors that ~~affect~~ relate to recycling to assess what factors might affect recycling."*

- Line 135: *"To identify factors that might affect LMR …"*

- Line 242: *"… and which factors might affect it"*

- Line 244: *"First, ~~we identified~~ latitude, elevation, and Convective Available Potential Energy (CAPE) seem to be ~~as~~ important factors influencing LMR (Fig. 5)."*

- Line 257: *"… ~~we find that~~ wetness ~~is~~ seems to be an important factor underlying LMR …"*

- Line 261: *"… this suggests that the type of precipitation ~~does~~ might not affect LMR …"*

- Line 291: *"We aimed for a general analysis to identify the main factors that might influence LMR"*

- Lines 450-451: *"We find a correlation between LMR and ~~that~~ orography, precipitation, wetness, convective available potential energy, and wind ~~affect~~ suggesting these variables might affect LMR."*

We also would like to thank the reviewer for the suggested analysis. We will take it into consideration for future projects.

*** Logic inadequacies**

- Spatial resolution: I got a bit confused by the spatial resolution used. First of all, in l. 87-90, the authors say "These moisture connections are a 10-year climatology (2008–2017) of monthly averages and have a spatial resolution of 0.5°. These UTrack-atmospheric-moisture data are derived using a Lagrangian atmospheric moisture tracking model by Tuinenburg & Staal (2020) that tracks evaporated moisture at a spatial scale of 0.25°. Could you clarify why there is this discrepancy? You seem to be using 0.5° after all.
The moisture tracking model UTrack, tracks moisture that is transported over grid cells that have a spatial resolution of 0.25°. Tuinenburg et al. (2020) published a dataset that was used in this study in which they stored the UTrack output on a spatial resolution of 0.5°. Tuinenburg et al. (2020) did not store this dataset with a resolution of 0.25° due to the large size of the documents. The dataset of 0.5° uses 120GB of memory in total. We specify in our manuscript that the moisture is tracked at a resolution of 0.25°, as the tracking resolution

might affect the output of the model. We clarified this by adding further explanation in line 83: *"and stored at a spatial resolution of 0.5°."*

- High-resolution local moisture recycling: in their response and in the manuscript, the authors argue that they present "high-resolution" local moisture recycling ratios for the first time. They argue that their recycling ratios are calculated over a considerably higher resolution than the 1.5° from van der Ent and Savenjie (2011), see e.g. l. 73 "Moisture recycling has not been studied before on this high-resolution scale globally." However, all recycling ratios are calculated over the source grid cell and the nine surrounding grid cells of 0.5° (r9), hence there is not much difference. In fact, this is pretty much the same 1.5° area that is considered. I am not saying that the authors cannot do this, but there is some major logical flaw in this argumentation, that, unfortunately, does not make this (technical) aspect novel either.

As the reviewer describes, we indeed calculate the recycling of evaporated moisture from 1 grid cell of 0.5° over 9 grid cells of 0.5°. However, this is different from the work done by Van der Ent and Savenije (2011) as in their study moisture evaporates from the total area of 1.5° in which it recycles. In the definition of Van der Ent and Savenije (2011) moisture flows of 1.5° are included as all moisture flows from one edge of the grid cell towards the opposite edge of the grid cell (1.5° distance) are included. In our study we only include moisture flows up to 0.5° as the source region is smaller than the target region and the source region is located in the centre cell of the target region. To clarify this we made the following changes: First, "*For r9, the distance between the center of the source grid cell and its surrounding grid cells describes the typical length of the local moisture flow, which is approximately 0.5°.*" (lines 117-118). Second, "*Compared to r_1, this r_9 includes all moisture flows with a length scale of typically 50 km (0.5°).*"(line 325).

*** Minor comments**

- Calculation of correlations: I searched through the entire manuscript but I couldn't find it. I believe the correlations in Tab. 1 are based on the climatological means in each grid cell, i.e. the authors use one P value and one LMR value for each grid cell and then calculate a correlation of all P and all LMR values in a specific cluster. Is that correct? Or do you consider the temporal dynamics in each grid cell?

This is indeed correct. We clarified this in line 139: *"For all variables we calculated the climatological mean for the years 2008-2017"*. We thank the reviewer for pointing this out as it helped to improve the clarity of our manuscript.