Dear Dr. van der Ent,

Thank you for your time and the comments you provided on our manuscript: 'Local moisture recycling across the globe'. Your comments are of great value to improve our manuscript. Below we respond to each point separately to discuss how we will implement them.

what's the reason to call your metric 'local' recycling? Isn't it just regional recycling for grid cells of 0.5 arcdegree x 0.5 arcdegree?

Currently, in literature a similar concept (regional recycling) is used to describe recycling over areas with varying size. Such an area is often related to a peninsula, catchment, etc. Our metric is different from this as we provide information on a more specific and smaller scale namely 0.5 degrees. This is currently the best resolution available for such data with global coverage. We refer to our new metric as the local moisture recycling ratio, first, to highlight the difference with previous studies on regional recycling. Second, this resolution approaches a length scale where local processes have relevant contributions. Feedbacks between the land surface and atmosphere at this spatial scale are relevant for regreening projects. So, we decided to call our metric local recycling as we see potential to use it to study local feedbacks.

I find the novelty somewhat overstated. As far as I understand the novelty is simply the fact that you calculate regional recycling on a higher resolution grid than other global studies, but the conceptual calculation is very old (see reference list in van der Ent and Savenije (2011) for example).

We see there are some similarities to the work done by Van der Ent and Savenije (2011), yet we believe our work is novel. In our paper we assess the impact of the spatial scale within which the moisture recycles by calculating three different types of local moisture recycling. Furthermore, we assess potential drivers of local moisture recycling and by doing so we contribute to the physical understanding of local recycling. However, we will include the work from Van der Ent and Savenije (2011) in our introduction and we will discuss in more detail how our work compares to the work done by Van der Ent and Savenije. Furthermore, we will explain in more detail how our analyses add to the current knowledge, i.e., we can better understand the spatial patterns in local recycling by assessing its drivers. Additionally, the previous work was conducted using output from a different moisture tracking model (i.e., WAM2-layers), which assumes complete mixing of evaporated moisture within two atmospheric layers. For short time scales complete vertical mixing might not be realistic. The UTrack model distributes the evaporated moisture along the vertical moisture profile and therefore, might be more suitable for analyses on a smaller scale. However, we are thankful for this comment which helps us specifying the novelty of our research better.

<u>The following points will be addressed after the last point.</u>

A gridcell of 0.5 arcdegree in let's say Stockholm is two times smaller in area than a gridcell around the equator

moreover, that same grid cell is 3 times smaller in length in east-west direction, and, therefore the dominant wind direction is rather influential on its value.

In other words, the regional recycling metric or LMR is scale and shape dependent and as such its values cannot be compared from region to region.

The search for a relation between LMR and other quantities that do not suffer from the scale and shape dependency (precipitation, evaporation, CAPE, biomes etc.) is therefore fundamentally skewed.

In Van der Ent and Savenije (2011) I had a suggested alternative metrics, which actually have local meaning for the recycling process, which are the local length scale of precipitation recycling and the local length scale of evaporation recycling. Surely these also rely on a few assumptions, but they do not suffer (or at least to a much more limited extent) from the scale and shape dependency. Please consider this approach or think of a better way to make your metrics scale and shape independent.

We see that the spatial scale affects moisture recycling ratios, and we believe this is a very useful comment that will help us to improve the quality of our manuscript. To assess this effect for our results, we scaled the local moisture recycling ratio of each grid cell to an area of 50 km x 50 km (see Figure R1). The relatively large difference between local recycling and scaled local recycling at high latitudes indicates that the local moisture recycling is more uncertain for higher latitudes. For the rest of the globe, we find that the general patterns of local recycling we describe in our manuscript are consistent with and without scaling. The terrestrial surface at lower and mid latitudes are most important for moisture recycling and as the pattern of the scaled and non-scaled local recycling ratio are similar here, we believe the grid cell size causes only a small bias here.

Besides scaling, Van der Ent and Savenije (2011) presented another metric to describe the local moisture recycling, namely, the length scale of evaporation recycling (we will refer to this metric as length scale). They found that this metric scales with their definition of local recycling ratio and has a value typically in the order of 1000 km globally. We did calculate this length scale for our data (see Figure R2), and its patterns are similar to the patterns we found for local recycling with large values (i.e., small length scales) over tropics and mountainous regions and small values (i.e., large length scales) over desert areas. Similar to the result from Van der Ent and Savenije (2011) we find length scales in the order of 1000 km. Although it is an important metric, we believe that it is more difficult to apply it to, for instance, the impact of land use change on precipitation locally. For this, one needs to determine the amount of rain that recycles locally, and length scale does not quantify this whereas the local moisture recycling ratio does. Yet, to apply local moisture recycling locally, we believe it is important to better understand the local moisture recycling ratio first, and with our study we add to its understanding. In the discussion of our paper, we will discuss the differences between the local moisture recycling ratio and this length scale to allow readers to better assess what metric to use when addressing research questions related to moisture recycling as we do see value in using the length scale for research questions related to non-local effects.

Concerning the comment on the impact of wind direction, we fully agree that the dominant wind direction affects the value of LMR. We can imagine that especially on higher latitudes, where variation between grid cell shape and size is relatively large and the difference between the zonal and meridional length of the grid cell is large, wind direction might have a strong impact on local recycling as you indeed pointed out. We will clarify the impact of dominant wind direction in our discussion to create awareness of this effect amongst the readers.

Finally, you state that the analysis in which we study correlations between the local recycling and different variables is fundamentally skewed due to the scale and shape dependency, which some of the other variables don’t have. We agree that the set-up of our study may result in skewed output, which is intrinsic to our data. Therefore, there is no perfect method to make a comparison between recycling ratios in different regions to study the correlation between the local moisture recycling ratio and other variables. However, to address research questions related to quantifying local hydrology, the local moisture recycling ratio is useful and currently no other metric is available to quantify this globally. A comparison of the recycling ratio among different grid cells is difficult to physically interpret (Van der Ent and Savenije, 2011). Therefore, we need to gain a better understanding of the local moisture recycling ratio. We build this understanding by identifying some of its drivers. However, based on this comment we plan to account for this effect by conducting another analysis in which we classify the data based on latitude and calculate correlation coefficients for the data in these different classes. The grid cell sizes within each class will then be more comparable to minimize the skewness of the analysis. Furthermore, because mainly the higher latitudes are skewed, we excluded Antarctica from our analysis.

To summarize, we will use your comments to address the issue of scaling in more detail in our manuscript. This allows readers to put our results better in perspective. To support this, we will add figures R1 and R2 in the appendix of our manuscript. We would like to thank you for your constructive feedback as it is valuable for improving our manuscript.

On behalf of all authors,

Jolanda Theeuwen

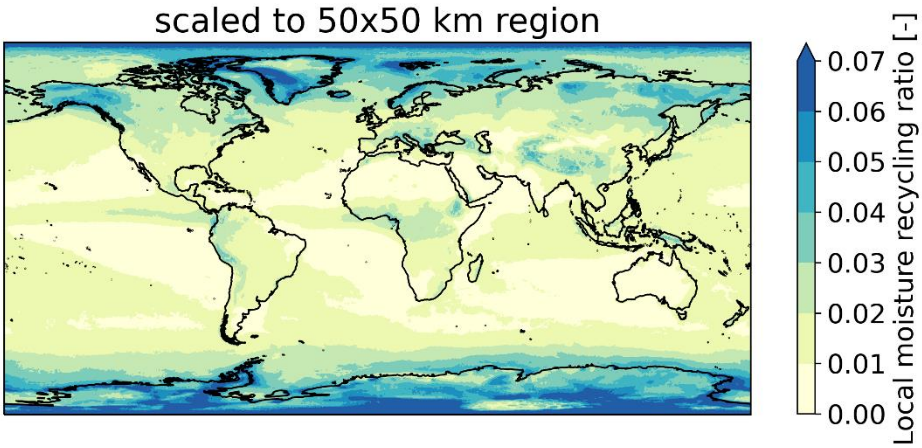

Figure R1: The local moisture recycling ratio scaled to a grid cell size of 50 km x 50 km. The plot shows the average of 2008-2017. We divided the original local moisture recycling ratio by the area of the grid cell and multiplied it with 2500 km^2.

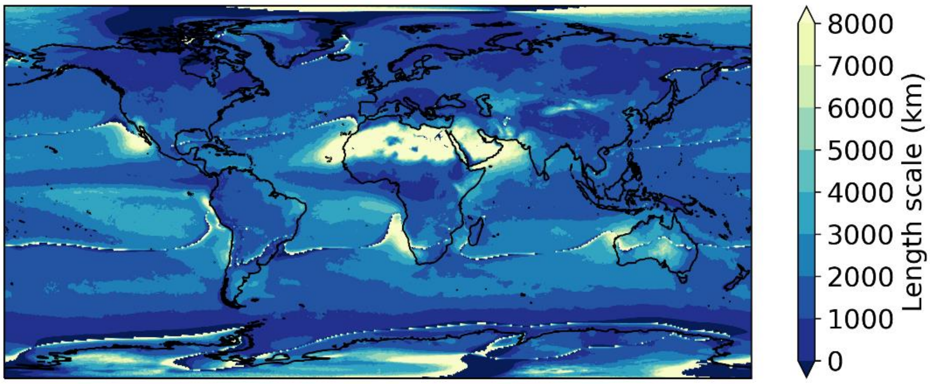

Figure R2: Evaporation recycling length scale as defined by Van der Ent and Savenije (2011) for each grid cell of 0.5x0.5 degrees. The plot shows the average of 2008-2017.