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Comment on egusphere-2022-612

Anonymous Referee #1

Referee comment on "Local moisture recycling across the globe" by Jolanda J. E. Theeuwen et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-612-RC1, 2022

Summary

Theeuwen et al. illustrate the local moisture recycling ratio (LMR) globally, i.e. the fraction of evaporation that rains out over the same region or its neighborhood. Using simulations from UTrack driven with ERA5 reanalysis from 2008-2017, they compare the LMR over different neighborhood sizes and illustrate its seasonality. To unravel the drivers of LMR, they calculate the Spearman correlation of the defined LMR to other variables, such as orography, latitude, convective available potential energy, and so on. The discussion centers around the use of these LMR estimates to guide land- and water management practices.

Recommendation

The manuscript is generally well written, but it is, in my opinion, missing novelty and/or a fresh perspective on moisture recycling indices that aim to guide land- and management strategies. Thus, the manuscript requires some major revisions and potentially a slightly different direction to make it a novel and interesting contribution. I will elaborate on my major concerns below.

Major points

1. Novelty

The manuscript repeatedly claims that local moisture recycling ratios are calculated "for the first time" (l. 9) and that "it is unknown which fraction of moisture recycles within its source location, and how this recycling varies across the globe" (l. 22-23). However, this is not the first study to do exactly this: Van der Ent et al. (2010) and Van der Ent & Savenjie (2011) already featured such local evaporation recycling ratios and calculated them globally. Furthermore, 'evaporationsheds' (see e.g. Van der Ent & Savenije, 2013) contain the exact same information and papers and data sets have been published on this, see e.g. Link et al. (2020).

Unfortunately, I also cannot consider the approach or the objective referred to in the discussion novel: the perspective on understanding the potential influence of land cover, and land- and water management practices via moisture recycling is not new either. Keys et al. (2016), for example, describe this in the context of 'ecosystem services' or 'water security' (Keys et al. 2020) - to name just a few examples. And this is also the subject of all 'green water' studies (e.g., te Wierik et al., 2021; te Wierik et al. 2020).

2. Moisture recycling drivers

I do, however, like the idea of looking at the drivers of moisture recycling; but the current analysis of the drivers is rather simple. In particular, I am a bit hesitant about the variables used to unravel the drivers of LMR, and the methodology used to do so. First of all, while I understand that there is a latitudinal dependence of moisture recycling, I wonder if 'latitude' is the real driver here. Shouldn't it rather be wind, incoming solar radiation and maybe even the underlying area of a grid cell (that differs with latitude)? Similarly, is it fair to use 'evaporation' and 'precipitation' as drivers of LMR? Isn't LMR defined based on these two fluxes? Of course, there is a dependency on both fluxes then... Second, calculating (globally averaged?) Spearman correlations to unravel drivers of LMR is a cheap way of doing this. LMR and any variable in Tab. 1 may be correlated through a third variable that represents the 'true' driver. Or in other words: a correlation does not imply causality.

3. Issues of scale

The definition of what is considered 'local' is rather random. The authors claim that the LMR is based on approx. 50km around the source; however, they also illustrate different definitions of this scale parameter, i.e. 1 grid cell, 9 grid cells and 25 grid cells. The argument for chosing 9 grid cells is rather vague: "To keep the spatial scale as small as possible but to still have a spatial pattern that we can explain physically" (l. 88-89). Could the authors explain why other patterns cannot be explained physically? Is there some lower limit to what the forcing and/or the model can represent? If so, could this limit be determined in a reasonable manner?

Some suggestions

To make this a novel and interesting contribution in the field of moisture recycling, a bit more effort may be needed. The authors could, for example, compare their evaporation recycling ratios to the ones from Link et al. - I assume that much more could be learned from the difference of these data sets. Alternatively, the 'true' drivers of moisture recycling could be assessed, using a more sophisticated method to do so. Or the issue of scale and what can be considered local, given the spatio-temporal resolution of the forcing, could be put into focus... these are, however, just some suggestions that I could envision and that would make this paper novel and interesting to me. The authors do not need to follow those.

Minor points

- l. 52-53: "Parcels are tracked for up to 30 days or up to the point at which only 1% of their original moisture is still present. " - can this be longer than 30 days?
- Eq. 1-3: this refers to different areas across the globe; where do the 50km from the abstract come in?
- Uncertainty of UTrack is not assessed at all; at least assumptions in the model should be summarised in the Methods section as well.
- Fig. 1: it should probably be "grid cell" and not "grids" in the subtitles
- l. 85-85: "These results seem to indicate that the tracking method we use is not sufficient to define recycling within one grid cell."; maybe it's not the tracking method but the (temporal) resolution of the forcing that is used, or the number of parcels tracked?
- l. 86-87: "Finally, scaling recycling to the number of grid cells, we find r9 and r25 do not relate linearly." Could you elaborate how you scaled this? P is not uniformely distributed across the 9 or 25 grid cells considered here, so I would not expect that there is a linear relationship?
- A suggestion: a uniform color scheme for Figs. 1-2 would be helpful
- l. 111-114: "Both convective and large-scale precipitation correlate with LMR (Table 1), however neither the fraction of convective precipitation nor the fraction of large-scale precipitation correlates with LMR (Table 1). Furthermore, evaporation correlates positively with LMR (Table 1, Fig. 3) indicating that the strong relation between P and LMR is not the only factor that causes a correlation between wetness and LMR." - does it make sense to correlate LMR with P? And as LMR is based on E and P, it needs to be correlated to E as well, right? E could also correlate with LMR because of P... there are so many dependencies here that it is difficult to unravel the real drivers.
- The relation between LMR and convection is not surprising; however, what would be novel was if large-scale and convective precipitation were tracked separately...
- l. 146ff: Are the correlations, especially with convective precipitation and large scale precipitation, subject to spatial and temporal scales?
- l. 155-174: discussion on biomes and deforestation a bit misplaced; not motivated in the introduction at all
- l. 179-181: well-mixed assumption is often hidden in many tracking studies; as far as I understand this is also the case for UTrack - and a recent study illustrated the impact using another Lagrangian model (Keune et al., 2022)
- l. 185ff: this should really be described in the methods, in my opinion
- l. 207: relation to agricultural water management remains unclear to me
- l. 234f: while I understand that you aim to use the LMR as a proxy for regions, in which land and water management may help foster moisture recycling, I don't think this scales at all. To assess the potential of the LMR as a proxy, it would be useful to know if, e.g. an increase in local E by say 10% also leads to an increase of local P by 10%. As you discuss correctly: there are many more factors that play a role here - not just the average recycling ratio; and I am missing an attempt to look at the 'true' drivers of LMR or at least an analysis that moves towards a better suited proxy to estimate the benefit/loss of water due to land- and water management practices in the conext of moisture recycling...

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