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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Length and time scales of atmospheric moisture recycling" *by* R. J. van der Ent and H. H. G. Savenije

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We would like to thank Heini Wernli and Harald Sodemann for there detailed comments. They note that the paper proposes a novel approach in order to overcome the scale- and shape-dependence of regional moisture recycling ratios resulting in length and time scale metrics (we prefer to talk about metrics rather than parameters). However, they note that the assumptions to derive these metrics is not properly discussed and say the length scale metrics might lead to wrong conclusions about the moisture transport in the atmosphere. We find that this conclusion stems from misinterpretation of the manuscript and we will clarify this and other issues raised below.

"(1) As mentioned in the review by F. Dominguez, the assumptions (and simplifications) behind the approach used in section 2.2 should be discussed in greater detail."

We replied to this issue in the reply to Francina Dominguez; with the use of (Dominguez et al., 2006, Eq. 20) instead of (Savenije, 1995, Eqs. 14 and 17) our Eq. (7) is no longer subject to these assumptions.

"(2) The derivation of a length scale for moisture recycling is not very clearly presented and contains unconsolidated aspects (see review by F. Dominguez, her point 3). The added value of the parameter does not become obvious."

As mentioned in the previous replies, the added value of λ is the very fact that this metric is scale- and shape-independent and thus allows for a fair comparison of regional moisture recycling between seasons and regions as opposed to the scale- and shape-dependent regional precipitation recycling ratio ρ_r.

"The dimensionless recycling ratios ρ_r (and ε_r) are monotonously transferred into a measure of dimension [L] by dividing the quantity Δx by a rather complicated expression which only contains ρ_r (or ε_r). Eq. (14) describes this monotonous transformation from the quantities λ_r into λ_γ. The additional new parameter is Δx, which mainly serves to account for smaller grid box sizes with higher latitude. Why this Δx would be the "representative length of the grid cell" (pg. 21875, L. 1) is not clear without better justification. It would be insightful to provide plots of how Eq. (14) is mapping values of γ_r to values of γ_γ for the range of Δx occurring at a 1.5 $\times$ 1.5 deg resolution."

We assume that the reviewers mean the transformation of γ_r into λ_γ, since this is what Eq. (14) does. We like to note that the quantity Δx is not 'new' since all Eqs. (6) to (14) have an distance or length component x. Once again, Δx is the length of a trajectory, which for a grid cell is its representative (or trajectory) length as defined in Eq. (16). Equation (14) does nothing more than providing an exact solution for solving

Eq. (8), (10) or (12) with respect to λ_γ. This 'scaling law' (Eq. (14)) follows directly from the basic process equation, which in the new manuscript will be Eq. (C5) based on Dominguez et al. (2006, Eq. 20). Please refer to our reply to Francina Dominguez for more details.

"Comparing Fig. 4c and 5a (or 4d and 5b) apart from the color scale does not reveal any clear differences, as would be expected from a monotonous transformation".

In this case one should compare Figs. 4a and 5a (or Figs. 4b and 5b) as this is what Eq. (14) solves. From the comparison of these figure one can in fact observe clear differences.

"(3) In the abstract it is claimed that the authors present an approach to quantify the spatial and temporal scale of moisture recycling, independent of the size and shape of the region under study. However, this is in fact not explicitly demonstrated in the manuscript. To support this claim, it would be necessary to show a thorough comparison of the measures calculated for areas of different size and shape. The example in Table 2 does not suffice to make such a claim, since only two differently sized areas from two different regions are compared. Instead, several differently sized areas in the same region would have to be compared with one another."

The claim is supported by the mathematical derivation of the length and time scales. So, in fact it is demonstrated in the manuscript that the presented metrics are independent of size and shape of the region under study. We like to stress that different grid cell sizes would not lead to different values λ_γ, but would only show less or more detail. Maybe this is difficult to be seen from Eqs. (13) and (14), but imagine a case were both γ_r and Δx are small and the moisture trajectory Δx is equal to the width of a grid cell. In this case Eq. (13) can be simplified further to:

$$\lambda_\gamma \approx \frac{\Delta x}{2\gamma_r} \tag{C11}$$

If now the width of the grid cell Δx would increase with a factor 2, also the regional recycling ratio γ_r would increase by a factor 2, thus meaning that λ_γ remains equal. For larger γ_r and Δx one has to make use of a 'scaling law'. The scaling law (Eq. (14)) proposed here follows directly from the basic process equation, which in the new manuscript will be Eq. (C5) based on Dominguez et al. (2006, Eq. 20). This is better than all previously proposed scaling laws (see Table 1), who did not use a process equation but merely a curve fitting.. Furthermore, scale- and shape-independence of the metrics is demonstrated by comparison of Figs. 4 and 5, where clear differences can be observed. In addition, it is illustrated in detail in Table 2.

Physical interpretation of λ_ρ and λ_ε

Both points 4 and 5 of the reviewers relate to the physical meaningfulness of the moisture recycling length scales λ_ρ and λ_ε. The reviewers wonder what is meant by: "if all ... conditions would be the same upwind?" Certainly we do not assume moisture recycling to remain constant along an atmospheric pathway which is longer the grid cell width. Instead, we meant to stress that λ_ρ and λ_ε should indeed be interpreted with caution as they are only valid for the grid cell for which they have been calculated. As indicated in the reply to Michael Bosilovich, λ_ρ and λ_ε are process scales and not actual travel distances. Because our formulation lead to misunderstandings we shall revise the paper accordingly: in the final manuscript we will make note of the difference between our 'local' length scales of atmospheric moisture recycling and actual travel distances (e.g. Sodemann et al., 2008).

References

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