**Atmospheric
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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 the referee Michael Bosilovich for his valuable comments. We feel that the issues raised are mostly due to a lack of clarity in our manuscript, which lead to misunderstanding. Furthermore, the reviewer points out that the advantage of the newly introduced length scales remains somewhat unclear. We shall clarify both issues below and we shall revise the final manuscript accordingly.

Time frequency of used data

The referee assumed we used monthly data as input to our accounting scheme. However, we used publicly available ERA-Interim 3 hourly data of precipitation and

evaporation, and 6 hourly data of specific humidity, zonal and meridional wind speed at the lowest 24 pressure levels (175–1000 hPa) and surface pressure. In fact, we use a half hour time step in the calculations (disaggregating the 3 hourly and 6 hourly data) to maintain a sufficiently small Courant number. We shall clarify this in the final manuscript in Sect. 2.5.

Quality of ERA-Interim reanalysis

The referee rightly points out that ERA-Interim reanalysis has an imbalance in its water budget, mostly affecting precipitation and evaporation. Any study using (reanalysis) data as input data is limited by the validity of this input data itself. We also acknowledged this fact in our previous paper (van der Ent et al., 2010, Sects. 2.2, 3.2 and 3.3) where we compared the ERA-Interim data with other global estimates of the hydrological cycle. We will clarify the limitations of ERA-Interim reanalysis in Sect. 2.5 of the final manuscript.

Underestimation of either ERA-evaporation or ERA-precipitation will lead to overestimation of the recycling length scale, and obviously an overestimation of the replenishment time and depletion time, while overestimation of evaporation or precipitation works the other way around. Notion of this effect of errors in the input data will be added at the end of Sect. 3.1.

Scale- and shape-independence of length scales λ_ρ and λ_ε

The referee notes: *"My interpretation of the length sales is that it quantitatively incorporates moisture transport into the recycling diagnostic. If that is so, then what is gained over a thorough budget analysis including an evaluation of the moisture transport? On Page 9 lines 5-6: "We believe that these length scales (Fig 5) have more physical meaning than the scaled regional recycling ratios." In this case the more seems to be the moisture transport, but that could be identified without the length scale calculation.*

Mostly I'm just trying to clarify what is gained from the calculation, and so weigh the significance of the paper and results."

In our view, any regional moisture recycling metric incorporates moisture transport as it evaluates the significance of regional moisture feedback compared to moisture originating from outside of the region. Thus, the advantages of our metrics lie elsewhere, which will be clarified below.

A previously, widely used, metric for regional land-atmosphere interactions is the regional precipitation recycling ratio ρ_r, which is known to be scale-dependent. Previous studies have tried to overcome this issue by scaling to a common reference area (e.g. Dirmeyer and Brubaker, 2007), but this approach had four significant drawbacks. Firstly, these studies did the scaling with a formula that does not respect the very nature of the regional recycling ratio, which requires it to vary between 0 (in a point) and 1 (whole Earth). Secondly, the coefficients in these formulas (Table 1) are not dimensionless. Thirdly, in one particular study it was derived that the scaling could be done with only one exponent (0.457), but there was in fact a significant spread (Dirmeyer and Brubaker, 2007, Table 1). Finally, this approach did not take into account the effect of the orientation of the moisture flux compared to the orientation and shape of the grid cell.

The new length scales λ_ρ and λ_ε do not suffer from any of these problems and thus allow for a fair comparison among regions and seasons. This is further explained in lines 21870-19 to 21871-15 and Table 1. Also, this is referred to in the concluding remarks, lines 21880-13 to 21880-17.

Physical meaning of length scales λ_ρ and λ_ε

Another advantage of the length scales λ_ρ and λ_ε is their physical interpretation: they are process scales. The inverse value of λ represents the spatial gradient of the recycling process and λ is a length scale of the spatial variability of recycling. The length

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scales λ_ρ and λ_ε can be visualized as the average distance a water particle travels through the atmosphere given the hydrological and climate conditions of the grid cell for which they have been derived. So, in addition to scale- and shape-independence, which allows a fair comparison among regions and seasons, these metrics also provide an indication of the distance moisture travels, which in turn is an indication for the number of times a water particle recycles over land.

In addition, looking at recycling from an evaporation and precipitation perspective, as opposed to a precipitation perspective only, is also very new since this has, as far as we know, only been done in our previous study (van der Ent et al., 2010).

At the end of Section 3.3, we shall more clearly discuss the advantages of the proposed length scales and their physical interpretation.

References

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