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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 the referee Francina Dominguez for her very valuable comments. Two issues have been raised, the first one being that the benefit of this analysis is not clearly described, and the second one concerns the mathematical derivation. We shall clarify both issues below and we shall revise the final manuscript accordingly.

Benefit of the analysis

The referee points out that a lot can be learned from our paper and that it makes the interpretation of previous results (Dirmeyer and Brubaker, 2007; Dominguez et al., 2006; Trenberth, 1999) more physically meaningful. For that reason, the referee

points out that the contribution of this paper is very useful, but that this benefit only becomes clear after reading the entire paper. The referee therefore suggests that if we condense page 21877 into a motivation, this would significantly strengthen our paper. We will do so and include this as a part of the introduction and abstract.

Mathematical derivation

One of the basic equations in our paper is Eq. (7, here C1), which reads:

$$\rho(x) = 1 - \exp\left(-\frac{x}{\lambda_\rho}\right), \text{ with } x \geq 0 \tag{C1}$$

This is a simplified form of Eq. (6, here C2), which, as pointed out by the referee, serves as a basic equation for our paper, which reads:

$$\rho(x) = 1 - \left(\exp\left(-\frac{x}{\lambda_d}\right)\right)^{\frac{1-\alpha}{\alpha}} = 1 - \exp\left(-\frac{x}{\lambda_d\left(\frac{\alpha}{1-\alpha}\right)}\right) \tag{C2}$$

We are aware that there are several assumptions underlying Eq. (C2), which is also pointed out by the referee. However, we are not claiming that the following always applies:

$$\lambda_p = \lambda_d\left(\frac{\alpha}{1-\alpha}\right) \tag{C3}$$

This formula only applies under the assumptions made by Savenije (1995): 1) precipitation is proportional to the moisture content of the atmosphere and 2) evaporation

is proportional to precipitation. We fully acknowledge that these are not fully correct assumptions.

The referee suggests that we should use Eq. (20, here C4) instead, stemming from the work of Dominguez et al. (2006), which reads (using the original symbols from that paper):

$$R(\chi,\xi,\tau) = 1 - \exp\left(-\int_0^{\tau} \frac{\varepsilon(\chi,\xi,\tau)}{\omega(\chi,\xi,\tau)} \partial\tau'\right)$$

(C4)

We can show that Eqs. (C2) and (C4) are in principle the same. Rewriting Eq. (C4) making use of the Lagrangean relation that $x = ut$ (using symbols from our paper) yields:

$$\rho(x) = 1 - \left(\exp\left(-\frac{E}{S_a u}x\right)\right) \text{, with } x \geq 0$$

(C5)

Where, ρ is the precipitation recycling ratio, E is evaporation, S_a is precipitable water in the atmosphere, u is horizontal wind speed and x is distance, whereby E, S_a and u vary in time and space. Hence, the length scale of precipitation recycling λ_ρ can be written as:

$$\lambda_\rho = \frac{S_a u}{E}$$

(C6)

Using the assumptions from Savenije (1995) it can be shown that Eqs. (C3) and (C6) are identical. The first assumption is that rainfall is proportional to atmospheric moisture:

$$P = pS_a$$

(C7)

Furthermore the evaporation is assumed to be proportional to the rainfall:

$$E = P(1-\alpha)$$

(C8)

And λ_d is defined as:

$$\lambda_d = \frac{u}{p\alpha}$$

(C9)

Substitution of Eqs. (C7), (C8) and (C9) in (C3) yields:

$$\lambda_\rho = \lambda_d\left(\frac{\alpha}{1-\alpha}\right) = \frac{u}{p\alpha}\left(\frac{\alpha}{1-\alpha}\right) = \frac{S_a u}{P(1-\alpha)} = \frac{S_a u}{E} = \lambda_\rho$$

(C10)

And indeed this means that Eqs. (C3) and (C6) are equal. The advantage of using Eq. (C6) directly is that the underlying assumptions of Eq. (C3) are no longer necessary.

We thank the referee for this valuable suggestion and we shall incorporate part of this derivation in the final manuscript.

References

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