Hydrol. Earth Syst. Sci. Discuss., 10, C4200–C4203, 2013
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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Continental moisture recycling as a Poisson process" *by* H. F. Goessling and C. H. Reick

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Received and published: 16 August 2013

Referee comments are repeated in italics.

It would be interesting if the authors can link the Poisson distribution to the more commonly used continental precipitation recycling ratio ρ_c (van der Ent et al., 2010, hereafter Ent10). If I understood GR13 correctly, I think the relation between these two metrics can be determined as follows: Let f_n be the frequency distribution of the number of continental recycling events for precipitation from any ocean, then it holds that:

$\rho_c = 1\text{-}f_0$. (C1)

Continental precipitation recycling ratios have been calculated globally in several stud-

ies (Numaguti, 1999; Bosilovich et al., 2002; Yoshimura et al., 2004; van der Ent et al., 2010; Goessling and Reick, 2011). By simply assuming either a Poisson distribution or a Geometric distribution as indicated by GR13 one can now directly determine the frequency distribution of recycling events globally. Combining Eq. (C1) with Eq. (8) from GR13, the Poisson distribution of recycling events can be calculated from a known ρ_c as follows:

$1\text{-}\rho_c = e\text{-}\lambda$. (C2)

Solving for λ gives:

$\lambda = ln\left(\frac{1}{1-\rho_c}\right)$. (C3)

Combining Eq. (C1) with Eq. (14) from GR13, the Geometric distribution of recycling events can be calculated from a known ρ_c as follows:

$1\text{-}\rho_c = 1\text{-}r^c$. (C4)

Meaning that in fact $\rho_c = r^c$. Continentally average Ent10 calculated that $\rho_c = 0.4$. This would corresponds to a Poisson distribution, with a mean value $\lambda = 0.51$, or a Geometric distribution with a mean value $r^c = 0.67$. Interestingly, Savenije (1995) and Ent10 argued that their continental precipitation multiplier:

$m_c = \frac{1}{1}\text{-}\rho_c$, (C5)

i.e. the amplification of precipitation due to continental evaporation, is, averaged over a year and all continents, also the average number of times a water particle has sequentially fallen on the continent. This relates to the average number of recycling events as defined in GR13 as $n = m_c\text{-}1$. Consequently, Ent10 actually estimated a global continental mean value of recycling events of $n = 0.67$, which exactly corresponds with the Geometric distribution. The analysis in GR13, however, nicely shows that the real mean probably lies somewhere in between a Poisson distribution and a Geometric distribution. When plotted for these number both distributions actually look very similar

(Fig. 1 of the comment). Thus, based on the numbers in Ent10 the global continental mean value of recycling events probably lies between 0.51 *and* 0.67*. It would be nice if the authors can incorporate some of the analysis above in their revised manuscript.*

We fully agree with these elaborate considerations and incorporated important aspects into the revised manuscript. Equation (C1) is now explicitly mentioned in Sect. 4.1, par. 4. We have also added a paragraph on the relation between the geometric distribution and the recycling multiplier introduced by Savenije (1995) and Ent10 (Sect. 2.6, last par.).

The use of the symbols E^c, T^o, r^c, *etc. is rather confusing, especially because for other symbols, e.g.* λ^n*, the superscript is reserved for an exponent.*

We have changed the notation such that superscripts are, as suggested by both reviewers, reserved for exponents.

It is not entirely clear what "Where E^c *is total continental evaporation" (5063-18) means. I think it means all the evaporation from the oceanic boundary to the considered point, but this would not be clear to all readers.*

If fact, what is meant is just the instantaneous rate of continental evaporation. The term *total* shall indicate that *all species* are included, i.e. $E^c = \sum_{n=1}^{\infty} E_n$. To avoid this confusion we decided to omit the term *total* here.

When combining Eqs. (8) and (9) with Eq. (C1), and assuming a certain behaviour for $E^c(t')/\widehat{q}(t')$*, the authors should be able to come up with a figure that shows the behaviour of the parameter of the Poisson distribution as well as the continental precipitation recycling ratio when travelling inland (see e.g., Savenije, 1995; van der Ent and Savenije, 2011; Schaefli et al., 2012).*

This is indeed possible, but we do not really see the gain such a figure would bring to the reader: assuming that $E^c(t')/\widehat{q}(t')$ is temporally constant, λ just increases linearly and $1 - R_c$ just decays exponentially.

5067-1: "and $r^c = \bar{E}^c/E$*"; It would be helpful to the reader if the authors could explain here in words what the quantity* r^c *means.*

We agree and added a corresponding statement right behind Eq. (13b).

It is important to note here, that the results of Numaguti (1999) are not necessarily the truth. When I correctly understood the paper of Numaguti (1999), the tracers that yielded the frequency distributions of recycling events were also tracked through the soil reservoir of the GCM. However, they also noted that there was only one soil layer. As such, it seems logical (also based on what the authors themselves explain in Section 3.3) that their results correspond very well to a Poisson distribution. This should be mentioned in the revised version.

The model used by Numaguti (1999) explicitly represents the amount of tracer species in the soil reservoir, meaning that the validity of our steady-state assumption is not presumed and, thus, the consequences of its invalidity can be investigated. The simplicity of the representation of the soil water ("single bucket") indeed implies that the composition of the surface evaporation with respect to the different tracer species can not be computed very accurately. We do however not agree that, as a consequence of the simple soil hydrology formulation, "it seems logical that Numaguti's results correspond very well to a Poisson distribution". We think that, in fact, the opposite is the case: since the model used by Numaguti features no skin (interception) reservoir, and because also the remainder of the soil is represented by one single hydrological layer, any precipitation is instanteneously mixed completely with older water. By contrast, in reality water from recent precipitation is overrepresented in evaporation, one reason being the fraction of evaporation that stems intercepted water. In the penultimate paragraph of Sect. 6 we concede that "the N99 results are not comprehensive enough to sufficiently assess the transferability of our theoretical solutions to real conditions on Earth".

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 5057, 2013.