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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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General comments

This short paper (Goessling and Reick, 2013, hereafter GR13), communicates some novel findings about the process of continental moisture recycling. The authors show that theoretically, when using some simplifying assumptions, continental moisture recycling can be regarded as a Poisson process. As far as I could see all derivations are correct, and generally well explained. I have some general comments to perhaps further improve the manuscript in a way that it might be easier linked with (future) real world studies of the continental moisture recycling process. Moreover, I have some specific comments to parts of the paper where I think a little more explanation is required.

Poisson distribution and the continental precipitation recycling ratio

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:

$\rho_c = 1 - f_0$. (C1)

Continental precipitation recycling ratios have been calculated globally in several studies (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:

$1 - \rho_c = e^{-\lambda}$. (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:

$1 - \rho_c = 1 - r^c$. (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 $\frac{r^c}{1-r^c} = 0.67$. Interestingly, Savenije (1995)

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and Ent10 argued that their continental precipitation multiplier:

$m_c = \frac{1}{1-\rho_c}$, (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 $n = m_c - 1$. 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.

Specific comments

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.

5063-18: "Where E^c is total continental evaporation"

It is not entirely clear what this 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.

Equations (8) and (9)

When combining these equations 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).

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5067-1: "and $r^c = \overline{E}^c / E$ "

It would be helpful to the reader if the authors could explain here in words what the quantity r^c means.

Section 4

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.

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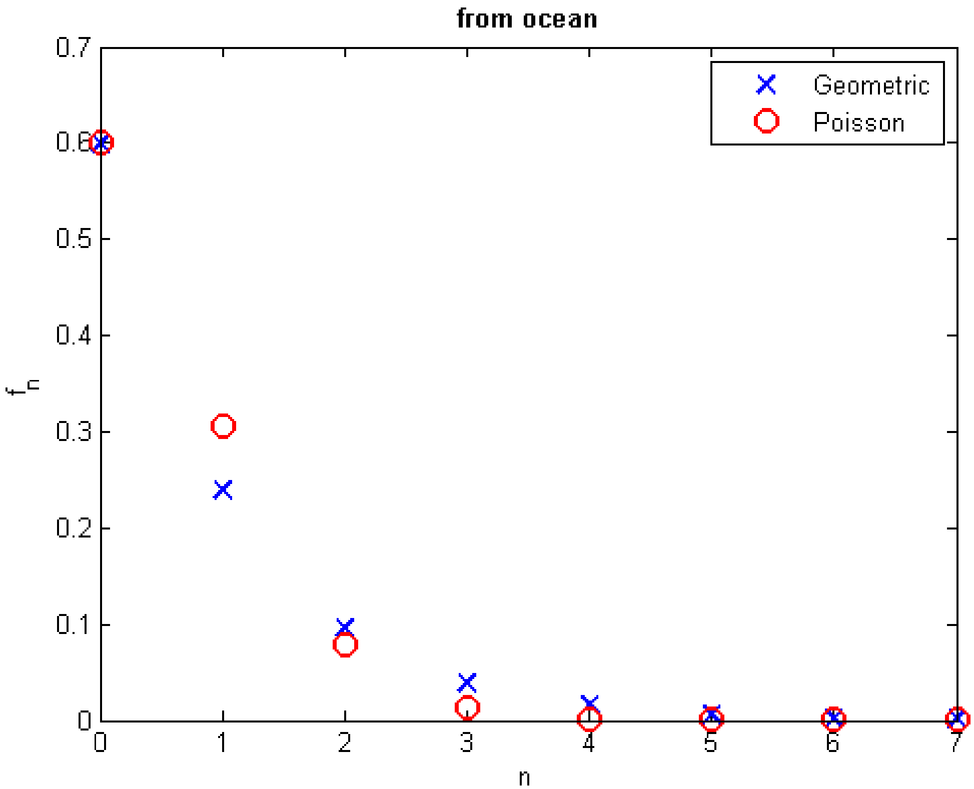

Fig. 1. Frequency distributions of the number of continental recycling events corresponding to a continentally average precipitation recycling ratio of 0.4.