

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

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Referee comments are repeated in italics.

At the moment, the Poissonian nature of the recycling events is presented only as “falling out” of the analytical framework, as the solution of the differential equations. It would be nice to discuss the relevance of the underlying stochastic process properties (namely the memorylessness, the fact that the recycling events are independent, the exponential distribution of interarrival times). Furthermore, it should be explicitly stated how these stochastic process properties are altered if the number of events are not Poisson distributed. These considerations might not be obvious to many readers but important for the hydrologic interpretation of the results.

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We have followed this excellent suggestion by adding a whole new section entitled “Stochastic interpretation”. While the preceding section “Theory” now treats only the macroscopic equations, the new section comprehensively treats the relation of the macroscopic equations to master equations, the corresponding transition matrices, and the molecular interpretation in the different limit cases. This includes a discussion of the typical Poissonian properties. The section also contains the additional insight that (in case B and the low intensity limit) moisture recycling can be interpreted as a continuous-time analog of a Bernoulli trials process.

Discussion of the assumptions: it would be nice to have some references for the numbers you use to discuss your assumptions (the moisture content, evaporation rates, transpiration rates etc).

We added a common reference to the used estimates.

The paper derives the frequency distribution of the number of recycling events n but in the comparison with Numaguti 1999 (p. 5070 line 1), the discussion is about the Poisson distribution of f_n , where f_n is the ratio of moisture having experienced n recycling events to total moisture. Why are the two (f_n and n) used interchangeably here?

The difference between the distribution of n and f_n is merely the normalisation. However, we agree that it is more elegant to use just one of them when talking about the Poisson distribution. We now consistently use f_n in this context.

p. 5070, line 17: this sentence states that the steady-state assumption given by Eq. (6a) holds if either the atmospheric moisture composition is constant or if evaporation is fed by precipitation that occurred just before evaporation. Is it not the other way round, i.e. Eq. (6a) holds if either the system is in steady state or if evaporation is fed by precipitation that occurred just before evaporation?

In our view both formulations are correct. One has to keep in mind that we define our terminology in the last paragraph of Sect. 2.3 as follows: “In the following we denote

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the simplification given by Eq. (6a) the “steady-state” assumption, keeping in mind that it is exact not only in steady state but also if evaporation is fed by water that precipitated immediately before.”

p. 5072: “The similarity of the Poisson distributions with the simulated data suggests that violations of the ‘well-mixed’ assumption and the ‘steady-state’ assumption are small.” Personally, I would probably rather say that these findings suggest that the developed theory describes well the natural process. Given the many simplifications in an analytical framework, I would not put too much emphasis on these two assumptions (there are of course many more).

In fact we do think that these two are by far the most relevant approximations made, and thus think that this formulation is justified.

p. 5072 starting line 14: this is hard to follow; what is “with such a law”? what is the mean value 1.5 as opposed to the fitted value 1.71 (fitted to what)? what is the value 1.68, what are the “corresponding factors”?

“Such a law” refers to the law that is described in the preceding sentence, namely an “exponential law for subsequent generations ($f_n = 0.6 \cdot f_{n-1}$)”. The “corresponding factors” are those factors that are given by f_n/f_{n-1} (which, in case of the Poisson distribution, is a function of n). We have enhanced the explanation of how we fitted the analytical distributions to the results of Numaguti (1999) (Sect. 5, 3rd par.).

Conclusion: here you insist that only two assumptions (steady-state, well-mixed) are required but the description of a complex natural system with simple equations implies of course many more assumptions.

As already stated above, we think that these two are by far the most relevant approximations made. If the referee has particular additional assumptions in mind, we would be keen to learn about them.

In the conclusion, you use once the term “traverse”, otherwise you use crossing for two

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different things i) crossing a boundary, ii) traversing a continent or an ocean. I think that it would help the reader if “crossing” was only used for case i) and traversing otherwise (or perhaps “travelling accross”).

We fully agree and now use the terms consistently.

It would be nice to have an outlook on how understanding the stochastic nature of recycling events might be useful to gain new insights into the land-atmosphere coupling.

This is admittedly a point that is not fully clear to us. First of all we consider the theoretical insights set forth in the paper as an interesting piece of understanding on its own. It would be great if future, more practical studies could benefit in one or the other way from these results, but we were so far not able to come up with a decent idea about this.

The recycling ratio “all of a sudden” appears in the discussion. It would be useful to explicitly discuss how it is related to the recycling events. Otherwise it cannot be invoked to explain the physical limits as in the sentence “The fact that the recycling ratio does not stay constant along the westerlies implies that the low intensity limit is not valid.”

We have added the mathematical relation between the recycling ratio and f_n , and have enhanced the part where we discuss how previous results on recycling ratios can be used to infer something about the intensity limits (Sect. 4.1 par. 4).

As far as I see, the difference between evaporation from intercepted water and transpiration is only introduced on p. 5070. It could be useful to state somewhere right at the beginning that evaporation includes both types of exchanges between the land and the atmosphere.

We have added such a statement at the end of the first sentence of the introduction.

Throughout, the paper, the two possible situations are discussed: i) recycling events are Poisson distributed, hence recycling is a Poisson process, ii) recycling events are

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geometrically distributed. The abstract (and the conclusion) ends however with the statement that continental moisture recycling can be interpreted as a Poisson process. It is not entirely clear how this conclusion is obtained. Is it because recycling on continents (as opposed to recycling over oceans) mostly/always satisfies conditions for case i)? Is it because comparison to numerical results (Numaguti, 1999) suggests that case i) always/mostly holds?

In the new section "Stochastic interpretation" it should become clear why continental moisture recycling can be considered to be primarily Poissonian (see in particular the last paragraph of Sect. 3.3).

I agree with reviewer 1 that it is not clear why exponents are used to distinguish between different variables

We changed the notation accordingly.

p. 5070, line 1: why distribution of " f_n 's" instead of f_n ?

We changed this sentence accordingly.

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