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Interactive Comment

Interactive comment on "Biotic pump of atmospheric moisture as driver of the hydrological cycle on land" *by* A. M. Makarieva and V. G. Gorshkov

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This is an interesting paper, that I hope will trigger ample discussion. I cannot fully judge the meteorological part of the paper, but I want to comment on the moisture recycling which is an important factor in sustaining continental rainfall.

1. The authors write that forest evaporation is (mostly) transpiration, but this is not true. On page 2629 they write "When the soil moisture content is sufficiently high, transpiration, which makes up a major part of total evaporation from the surface, E, is dictated by solar energy." However, evaporation from interception is as important, or even more important than transpiration in this case. In tropical forests evaporation from

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interception can amount to more than 50% of the total evaporation (Savenije, 2004), and also in temperate forests (Gerrits et al. 2006). Interception has less resistance to evaporation than transpiration, and even less than open water evaporation. Only when you consider the important contribution of interception (both canopy and forest floor interception) to the total forest evaporation, can you make it plausible that forests evaporate more than open water or the sea. So in fact mentioning that interception accounts for about 50% of the evaporation only strengthens your case. You could say, "When the soil moisture content is sufficiently high, transpiration is dictated by solar energy. Interception, both from the canopy, understorey and the forest floor, which can be more than 50% of the total evaporation (see Savenije, 2004), is also dictated by solar energy, with a much lower resistance to evaporation than transpiration or even open water evaporation. So if there is sufficient soil moisture, then evaporation from dense forest is merely constrained by the energy balance, driven by solar radiation, which can be more efficient than sea water evaporation"

2. I am not sure that rainfall is proportional to the flux. Rather to the moisture content over a threshold (see Savenije, 1996b). But this may not be very important since it results into the same equation (3). In the theory on moisture recycling described by Savenije (1995), which the authors refer to, the decrease of the precipitation along the trajectory of the moisture transport is caused by the runoff and the recharge to groundwater (see Savenije, 1996a). Only if there is 100% moisture recycling can there be constant rainfall along a trajectory. Here lies the main difference between the work of the biotic pump and the theory on moisture recycling. The authors in fact imply that the biotic pump is able to compensate for the drainage of moisture by runoff.

3. The reasoning on the top of page 2629 is not correct (although it does not necessarily affect your conclusion from the reasoning). The authors state: "High stationary (dW/dt=0) soil moisture content is inseparably associated with a significant runoff, i.e. loss of water by the ecosystem." This is not true. What you should say is: "A high amount of soil moisture (average over the year) implies significant runoff, i.e. loss of

water by the ecosystem (because R is a function of W)". One should realise that maintaining a high moisture content does not mean that dW/dt=0 (stationarity). At the short temporal scales dW/dt is never zero, it varies with the difference in phase of P, E and R, but at the average annual scale, you can indeed say that stationarity implies that dW/dt=0. However, this does not mean that the annual average W is high and constant along the x-axis. The condition of stationarity can apply to both a low and a high average moisture level. What the authors mean with stationarity is that in the long run (over several years) P=E+R (the long term average of dW/dt=0). Although this is true at any point along a trajectory, it does not mean that dW/dx=0. The situation can be stationary and still have a longitudinal gradient. What you can say is that if dW/dx=0 then dR/dx should be zero as well, because R=f(W). Subsequently, the fact that R=P-E implies that d(P-E)/dx=0. This in fact implies that the difference between P and E is constant. One solution is that both P and E are constant along the trajectory. And this is what you conclude. But a steady state solution also occurs if the difference between P and E is constant, while both are decreasing. However, you indeed observe that in some cases (Amazon and Congo) dP/dx=0, and that then indeed implies (in your reasoning where dR/dx=0) that also dE/dx=0. In the case of the Yenisey, however, you have dP/dx$>$0, which means that also dE/dx must be larger than zero, increasing along a trajectory. So it is not as simple as the authors state in the first paragraph of page 2629.

4. I do not understand completely how the biotic pump works. I am not a specialist in meteorology and atmospheric circulation, but with the Yenisey case, you certainly have a strong indication that something special is happening here. So from my point of view I give the authors' theory the benefit of the doubt.

5. When you write on the bottom of page 2630:" Thus, precipitation over forests increases up to the maximum value possible at a given constant runoff (i.e., coefficient k in Eq. (2), the precipitation/runoff ratio, is maximized for a given R.)." In Savenije 1996b, I called this coefficient k the "multiplier", or, in an earlier paper, "the return rate", the inverse of the runoff (Savenije 1996a). Indeed when the multiplier is large, then the

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recycling is large. With zero runoff, the multiplier is at its maximum (approaching infinity) and the recycling approaches 100%, resulting in constant rainfall along a trajectory (dP/dx=0) and P=E. I think that the term "multiplier" is also appropriate in your case.

6. The fact that you demonstrate that one can actually get constant or increasing P while there still is runoff, means that apparently there is an additional mechanism at work, besides recycling. If that is indeed your biotic pump, then you have made an important contribution to understanding the continental moisture balance.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 3, 2621, 2006.