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Hydrology and Earth System Sciences Discussions

Interactive comment on "Propagation of soil moisture memory to runoff and evapotranspiration" *by* R. Orth and S. I. Seneviratne

Anonymous Referee #1

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This is an interesting paper that contributes to the analysis of soil moisture memory in the climate system. The persistence time scale computations at the end are very interesting, particularly the identification of asymmetrical behavior in dry and wet anomalies. I found the discussion of the "coupling diagnostic", however, confusing and non-intuitive; I think that part of the analysis should be refined or replaced.

Major comments:

1) The definitions of the coupling strengths in equation 4 and 6 are not intuitive, at least to me. Why are these useful constructs? Why is the correlation between evaporation

and radiation subtracted in equation 6, and how is the coupling strength computed with equation 4 affected by the fact that w_n and P_n are strongly correlated with each other? What does it mean for the coupling strength to be about -1 rather than 0 in Figure 5 or 8? The equations are provided without explanation, and substantial explanation is needed. It's not obvious, for example, why the authors didn't try to isolate the impacts of different contributions to memory through, for example, a multiple regression analysis.

Intuitively, it seems like the raw correlations between runoff or evaporation and soil moisture should be the most relevant things to consider. If the authors are trying to show in equation 6 that the variance of R_n reduces the evaporation-soil moisture memory connection, they should note that this reduction is already effectively accounted for in the term rho(E_n,w_n) by itself. For me, Figure 8 has great but unmet potential; it would be much more informative if the y-axis was the evaporation or runoff memory or even the correlations between evaporation or runoff and soil moisture.

2) Given that the runoff consists of contributions from past precipitation events (equation 2), some quantitative statement is needed regarding how the timescale parameter tau is imprinted onto the calculated runoff memories. Analytically, you would think that if you knew tau exactly, you would know precisely what part of the runoff memory is associated with that tau alone (as opposed to the part of the memory associated with precipitation or soil moisture memory). The knowledge that tau affects the runoff memory diminishes the illustrated link between runoff and soil moisture memory; the reader will want to know precisely by how much. Statements such as that on p. 12121, lines 10-12, seem to imply that the contribution of tau to the runoff memory is negligible.

3) On a related note, the discussion in the first paragraph of section 4.3.2 is a little confusing regarding P_n*. It seems like P_n* should have two sources of memory: that associated with the prescribed timescale tau, and that associated with true memory in the precipitation forcing. I think that the text is implying that the latter is negligible, but it doesn't have to be. Some separation of the timescale and background forcing

contributions to P_n* is needed; it would be nice to state unambiguously the impact of forcing memory on soil moisture memory.

4) The dots in Figure 4 (and in the other Europe figures) are difficult to read; I don't have a suggestion for fixing this, other than to make the dots much larger and accept that there will be overlap. The differences between the dry and wet cases in Figure 10 (as discussed in the 2nd paragraph of section 4.5) are very difficult to pick out.

5) More importantly, though, it seems like the runoff memory maps (and mean duration maps) should be supplemented with maps generated from the actual runoff observations, so that the features pointed to are demonstrated to be more than just a reflection of model assumptions. This will lend substantial credibility to the results. One thing would be especially nice: can the authors demonstrate with observations alone that persistence time scales for runoff are lower for the dry cases, as suggested by Figure 9?

6. Overall, the paper would benefit from further discussion on why evaporation and runoff memory is important. Runoff memory is presumably important for water resources, but how about evaporation memory? The evaporation memory of relevance for, say, weather forecasting is probably that for E/Rnet rather than E.

Minor comments:

6. Figure 1 should show (perhaps with tiny dots) the locations of the catchments generally not considered (though used in Figure 2).

7. Figure 3a: The total water holding capacity of the soil should be stated in the caption, so that people can interpret the values on the x-axis.

8. Section 4.3, introduction. Here the reader should be reminded that the memories plotted fall out of a calibrated model rather than from direct observations of soil moisture, evaporation, and runoff (though see comment 4 above regarding runoff). Another such reminder is appropriate on p. 12122, line 17.

9. Section 4.3.1, first paragraph. "The 1-month-lag memories are higher…" This is probably also because the latter part of month n is very close to the first part of month n+1, and this proximity finds its way into the calculations with the monthly averages.

10. p. 12117, line 14. This is confusing; the memory of cumulative weighted precipitation is not equivalent to a "forcing memory"; it is some combination of a true forcing memory and a fitted recession timescale (see comment 3 above). The same confusion regarding "forcing memory" finds its way into the "summing up" paragraph at the top of p. 12118.

11. Section 4.4.1, first paragraph. There are a lot of different time scales considered in this paper: the runoff recession time scale, the applied lag, and the averaging time scale. In this paragraph I would label the time scale as the "averaging time scale", for clarity.

12. Figures 9 and 10 are discussed out of order.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 12103, 2012.