Reply on RC1

Alban de Lavenne et al.

Author comment on "Quantifying pluriannual hydrological memory with Catchment Forgetting Curves" by Alban de Lavenne et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-331-AC1, 2021

Thank you for taking the time to review our paper and for all your remarks. We will take into account the detailed comments when preparing the revised version. For now, we would only like to answer to the following key remarks you made:

- **The main result that elasticity values are underestimated using a normal approach seems questionable.**

This is basically what Figure 6 shows, and we agree that epsilon_2 > epsilon_1 can be explained mathematically. Equations 1 and 2 both quantify how Q/P varies with P/E_o. However, Eq. 1 uses only one P/E_o value whereas Eq. 2 uses a weighted average of past P/E_o values. We could expect this averaging to smooth the values of P/E_o and, because we use the anomalies of these ratios, to lead to a value closer to zero (which is the long-term average value of P/E_o anomalies). Lower absolute value of anomalies of P/E_o could then be compensated by higher elasticity values.

Although it is mathematically logical, we do think that it is interesting to discuss how we evaluate this elasticity when catchments have a long-term memory. The important buffering role played by the catchment may prevent a correct estimation of the elasticity when considering each year independently (like in Eq. 1), which is the reason why we propose Eq. 2. We do not aim to emphasise the absolute difference between epsilon_1 and epsilon_2 as a main result of this paper (we may even avoid a comparison in absolute terms if it brings confusion), we rather want to emphasise the relative difference between these two approaches. This is done by the relative comparison of spatial distribution in Figure 9. Figure 6 also shows with two colours that catchments with pluri-annual memory usually have higher relative differences (in the sense of a distance to the abscissa) than the rest of the catchments. In this sense, we mean that the elasticity values may be underestimated when catchment memory is ignored. We will better distinguish the

hydrological discussion from the mathematical explanation in the revised version.

- **How it is possible that so often a particular year's aridity explains that year's runoff ratio so poorly?**

This is not the case: as you did expect,
a particular year's aridity explains usually very well that year's runoff ratio (also, we do use water years). Only a few catchments show
a lack of relationship (the relationship is then lagged by one year), but it is the exception and not the rule. You may have got this impression because we used one
of these exceptions as example in Figure 1.
This is probably a bad choice and we will add a "normal" example in the revised version

- **Short-term vs. long-term memory**

We wrote in lines 22-24:

"we start with a first-order simplifying assumption: We hypothesize that a catchment may have both a short-term and a long-term memory; we consider the short-term memory to be seasonal, and will not address it in this paper in order to focus on the long-term (pluriannual) memory effects."

We agree with you that the memory of hydrological systems is a continuum and that there is some arbitrariness in separating the pluriannual/long-term and the seasonal/short-term memories. But we believe that we needed to make this simplification to make the method simpler to understand, as we wanted to be able to address the memory effect with annual values.

- **Catchment memory vs. water age**

Because many colleagues will have a tendency to associate memory issues with water residence time, we believe that to avoid misunderstandings it was essential to mention water age, and the difference between water celerity and velocity, just to underline that our method cannot address this issue (as you mention, addressing it would require water quality considerations).