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Reply on RC3

Alban de Lavenne et al.

Author comment on "Quantifying multi-year 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-AC4>, 2021

Thank you for this review. We will take into account the detailed comments when preparing the revised version. As we said to the previous reviewer, we will answer the main remarks here and address the rest of the review when preparing the revised version.

Time steps

We fully agree that the analysis should be done using the hydrological year and not the calendar year, which is why we start each year on October 1st. As answered to reviewer 2, our study is based on an annual water balance analysis, which makes more sense if the hydrological year is used. It avoids issues such as snow accumulating in a year and only melting in the next.

Correlation between Q/P and P/E

There is indeed the variable P in both sides of the elastic relationship between $Q/P \sim P/E$. However, we believe that it has a limited impact on our analysis for two reasons:

- It is the same P on both sides only for the current year 0: it is Q/P of year 0 that is explained by the different P/E of the previous years, which leads to a different P for years n-1, n-2... Moreover, it is reasonable to assume that each year is independent of the previous one (see comments on autocorrelation below).
- The analysis of the relationships of two correlated variables is not really a problem. We could have removed the P from one side and analysed $Q \sim P/E$. This would have led to even more highly correlated relationships with respect to $Q/P \sim P/E$. We chose to work with these ratios in order to study the relationship of two dimensionless variables. However, it is true that if Q and E were almost constant, the elastic relationship would look like $f(x)=1/x$ and the elasticity index would be negative. Our analysis shows that this does not happen, and when catchment memory is taken into account, negative elasticity indices are no longer observed. We will however add this point to the discussion in the next version.

Autocorrelation of P/E

We agree that it is necessary to check this autocorrelation of the climate inputs, in order to avoid the analysis of the climate memory instead of the catchment memory. We have carried out the analysis of the autocorrelation of the P/E and have not detected any significant autocorrelation. The median value of the Pearson correlation between a P/E and the previous P/E is 0.05. For 90% of the catchments, this correlation is less than 0.2 and a statistical test shows no significant correlation, except for the few catchment areas in south-eastern France where the correlations are still very low (and where no multi-year memory is detected). We can therefore reasonably assume that the memory we have detected is the memory of the catchment and not the memory of the climate. The next version of the paper will refer to this autocorrelation analysis.

Calibration of Gamma distribution

We prefer to fit a Gamma distribution rather than calibrate each year independently as this reduces the number of parameters: the Gamma distribution has only two parameters whereas estimating the weight of each of the previous 5 years would require 6 parameters. It also provides a more consistent description of catchment memory. In order to use the Gamma distribution at a discrete time step, we proceeded as follows: the values of the Gamma distribution are extracted from year 0 to year 5 and then rescaled so that their sum is equal to one. The three parameters needed to construct the relationship

described by equation 2 are calibrated together using a particle swarm optimisation. The objective function is a root mean square error (RMSE) of the Q/P anomalies. This will be better described in the next version.

Graphical representation of results

We tried different plotting strategies before proposing this one. Scatter plots are indeed the most direct way to approach the relationship between two variables. However, this visualisation is sensitive to outliers and the scatter of the 685 points makes the general trend difficult to visualise. We have therefore chosen to summarise the distribution by a boxplot, making the relationship much easier to interpret in our opinion. The scatter plots will be provided in the detailed response.