

Interactive comment on “Stream flow recession patterns can help unravel the role of climate and humans in landscape co-evolution” by P. W. Bogaart et al.

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Dear Editor,

We thank our colleagues David Rupp and Ross Woods (Rupp and Woods for short) for their insightful comments on our paper. They raise several issues to which we would like to reply. These issues can be summarized as:

1. Our definition of a timescale does not provide a single timescale for each catchment.

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2. a is not, in general, a recession time scale.
3. The use of the units ‘day’ for $1/a$ in Figure (4) is erroneous.
4. Because of the non-physical relationship between a and b , and a not being a time scale, interpretation of differences in a is nonsensical.
5. Trends in a cannot be understood without first accounting for the dependence on trends in b .
6. Q_0 is ill defined.

For the sake of clarity, we address these issues in a slightly different order, starting with the last one.

Issue 6: Q_0 is ill defined. — Parameter Q_0 was introduced in Eqn (5) as “a characteristic discharge at the start of the recession” (line 9871/3). Although we did mention that T is “the timescale for which half of the initial reservoir storage is depleted” (page 9870/line 21) we evidently failed to mention that these definitions are coupled: $Q_0 = Q(0)$ is assumed to be consistent with initial storage $S(0)$. Several choices can be made regarding the precise meaning of $Q(0)$ and $S(0)$. Is it the storage/discharge at the start of an individual recession event? A characteristic ‘wet conditions’ storage/discharge for that catchment or a characteristic storage/discharge combination for the whole of Sweden? We regret that we have not been more precise here. Since the goal of recession analysis is to study the characteristic response of catchments, the first interpretation is excluded. In the remainder of this reply, we use both the second and the third interpretation: Either Q_0 is, for each catchment, the discharge exceeded 5% of time (Q_5 , representing wet / high flow conditions), or Q_0 is fixed at 10 mm/day for all catchments. We did not look at trends in Q_0 (second interpretation) over time.

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Issue 1: Our definition of a timescale does not provide a single timescale for each catchment. — These two definitions of Q_0 , when used in Eqn (5), both result in a single and unique timescale for each catchment.

Issue 2: a is not, in general, a recession time scale. — We agree with Rupp and Woods that, in theory, neither a nor $1/a$ can be used as a time scale directly, because the effect of b and Q_0 in Eqn (5) cannot be ignored. However, in practice, this impact is limited. We used the two interpretations of Q_0 as explained above (i.e. either fixed 10 mm/day, or the 5% exceedance probability discharge per catchment) to compute the ‘proper’ time scale as per Eqn (5) and plotted them against $1/a$ (Figure 1 of this Reply). From these results, it is clear that proper time scale T and its approximation $1/a$ are strongly correlated. For $Q_0 = 10$ mm/d, 83% of the variance in T is explained by $1/a$ (linear regression; using the adjusted R^2 ; outliers removed) while for $Q_0 = Q_5$ this is 72%. However, Brutsaert-Nieber type of recession analysis traditionally focus on a and b , and therefore we decided to present a and $1/a$ rather than T .

Issue 3: The use of the units ‘day’ for $1/a$ in Figure (4) is erroneous. — Indeed, as mentioned under Issue 2, the use of the units for the quantity $1/a$ in Figure 4 is erroneous, and a mistake from our side. It will be corrected in the revised manuscript. Still the interpretation of Figure 4 holds.

Issue 4: Because of the non-physical relationship between a and b , and a not being a time scale, interpretation of differences in a is nonsensical. — What we aim to do is to identify how combinations of a and b relate to land use, landscape and climate and how these combinations change over time. Despite any correlation between a and b , and regardless of the meaning of a or b , we do think that there is scope for a cluster analysis as performed in Figure 4: For similar values of a multiple clusters of b are found, and vice versa. The strong correlation of $1/a$ and T , as demonstrated here warrants an interpretation in terms of time

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scale as long as differences in $1/a$ are pronounced (i.e. taking the uncertainty in the $1/a$ – T relationship into account). In the revised manuscript, we will include this analysis.

Issue 5: Trends in a cannot be understood without first accounting for the dependence on trends in b . — We agree that much of the trend in a is related to the trend in b . We do not claim that they change independently of each other. Nevertheless, our results that response time scales have been increasing over time still holds, even after correction for b . In Figure 2 of this Reply, we show trends in $1/a$ and T (using $Q_0 = 10$ mm/day to compute the latter). For $1/a$, 81 catchments show a significant increasing trend, and for T this is 65, suggesting that indeed part, but certainly not all of the trends in a or $1/a$ are caused by the trend in b .

Again, we thank Rupp and Woods for their careful reading of our manuscript and the insightful comments they expressed. We are confident that the additional analyses and associated discussion, as presented here, will add to the quality of our final revised paper.

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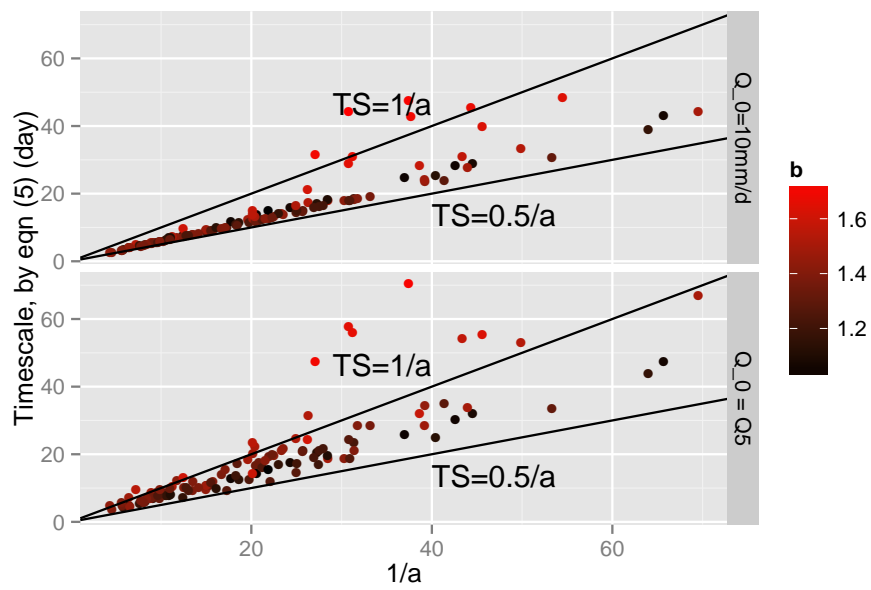


Fig. 1.

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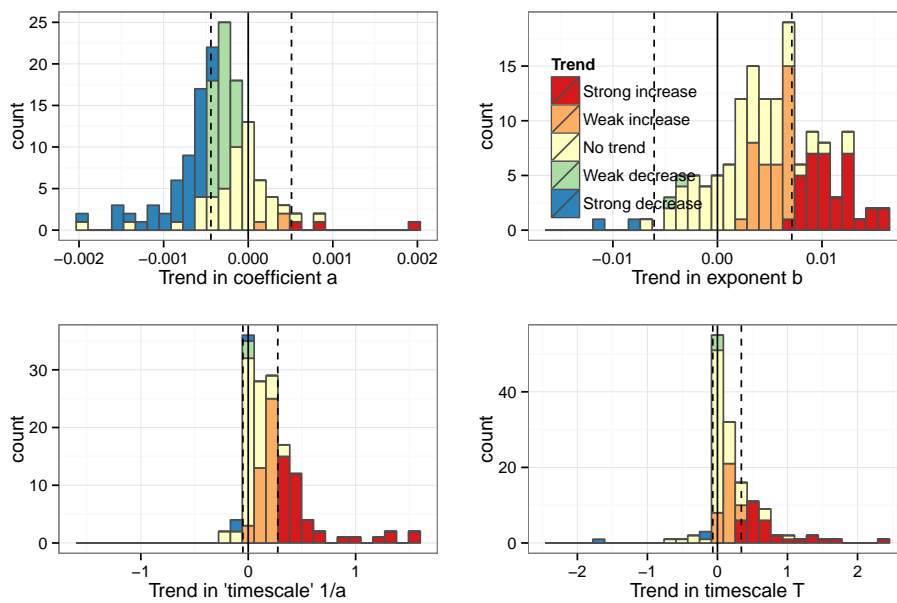


Fig. 2.

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