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Discussions

Interactive comment on "Minimum dissipation of potential energy by groundwater outflow results in a simple linear catchment reservoir" *by* Axel Kleidon and Hubert H J. Savenije

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Wouter Berghuijs raised an important point about the steady-state assumption in our manuscript. He described that the linear reservoir describes behavior of catchments that are not in steady state and hence asked how our result using the steady-state assumption would apply.

In the manuscript, we used the steady state assumption because we argued that the development of connecting structures would take place over time scales much longer than the discharge after a wetting event. The time scale that we derived from the optimization in steady state then also applies to the discharge on time scales of the

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discharge after a wetting event. This is because the time scale that characterizes the exponential recession curve and the mean discharge over the same time period is the same. This can be seen as follows:

The drainage after a single wetting event is described by (Eq. 2 in the manuscript)

$$Q(S) = \frac{S}{\tau} \tag{1}$$

where $Q(S)$ is the discharge (which is a function of S), $S(t)$ is the active storage of groundwater (which is a function of time t), and τ is the characteristic time scale. The exponential recession curve is then described by

$$Q = Q_0 e^{-t/\tau} \tag{2}$$

where Q_0 is the discharge at time $t = 0$.

When averaged over a time interval Δt, the mean drainage Q_{mean} during this time is described by:

$$Q_{mean} = \frac{1}{\Delta t}\int_0^{\Delta t} Q_0 e^{-t/\tau} dt = \frac{1}{\tau}\frac{Q_0(1 - e^{-\Delta t/\tau})}{\Delta t} \tag{3}$$

Active storage S varies with time in a similar fashion, and is described by

$$S = Q(t)\tau \tag{4}$$

When averaged over the same time interval Δt, the mean value of active storage S_{mean} is described by

$$S_{mean} = \frac{1}{\Delta t}\int_0^{\Delta t} S_0 e^{-t/\tau} dt = \frac{Q_0(1 - e^{-\Delta t/\tau})}{\Delta t} \tag{5}$$

where $S_0 = Q_0\tau$ is the active storage at time $t = 0$. The time scale derived from the ratio of mean active storage to mean discharge then yields the same time scale as in the linear reservoir:

$$\tau_{mean} = \frac{S_{mean}}{Q_{mean}} = \tau \tag{6}$$

In other words, the time scales that characterize the mean behavior and the instantaneous behavior in the linear reservoir are identical.

Hence, the time scale that we derived from the steady-state assumption by optimization describes the transient behavior after a wetting event as well.

We will clarify this point in the revision of the manuscript.

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