Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2020-378-SC1, 2020

Hydrology and Earth System Sciences
Discussions
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Interactive comment on "HESS Opinions: Improving the evaluation of groundwater representation in continental to global scale models" *by* Tom Gleeson et al.

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Received and published: 26 August 2020

Groundwater storage as a quadratic reservoir and the value of new streamflow observations

In addition to the assumption of a linear reservoir, $Q = kS$ (Lines 144 & 155; Table 1, Row Baseflow ... recession (k)), the groundwater storage need be considered as a quadratic one.

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In the context of model evaluation (Figure 1 and Section 3.1), the importance of acquiring new streamflow data at a project site cannot be overemphasized (Table 1, Row Streamflow).

Considering a catchment on a continental scale as either a linear, $Q = kS = C_1S$, or a quadratic storage, $Q = (C_2S)^2$, the baseflow can be linearized as follows (Beck et al., 2013, cited by authors; Azmi et al., 2020, SC1 therein; Ding, 2020):

$$\log Q(t) = \log Q(t_0) - C_1(t - t_0), \tag{1}$$

Or:

$$-1/\sqrt{Q(t)} = -1/\sqrt{Q(t_0)} - C_2(t - t_0), \tag{2}$$

Equations (1) and (2) are based on the logarithmic and NISR (negative inverse square root) transformation of the streamflow Q, respectively.

On an ungauged catchment, all these two equations will need to determine their discharge coefficients, C_1 and C_2, are a minimum of three new flow measurements in the field over a period of days or weeks. These will be used to falsify the hypothesis of a linear or a quadratic storage. Direct measurements of the low to mean flow on river on a regional scale are doable, though a logistic and technical challenge (Lines 424-427). Legend or hearsay has it, ancient Egyptians measured the Nile River flow by diverting it to a side chamber where the volume of water was measured.

Figure 1 shows the data transformation diagram for the log and the negative inverse mth root (NImR) transform (Santos et al., 2018, SC5 therein; Ding, 2018). Compared to the log transform, differences are small among the first, second and third root of the NImR transform. The NI2R or NISR transform, which is derived for the outflow from a hillslope, maybe considered a representative of these fractional power ones. For

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application, a catchment can be classified either as linear or quadratic, unless dictated theoretically otherwise. Between the two, the log transformation is a low- to mid-pass filter, and the NISR a low-pass one.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-378, 2020.

Figure 1. Streamflow data transformation diagram for a nonlinear storage-discharge function, $Q = (C_n S)^n$.
If $n = 1$, $J_1(Q) = \log Q$; if $n > 1$, $J_n(Q) = -1/Q^{1-1/n}$.
Adapted from Ding, 2018, SC5.

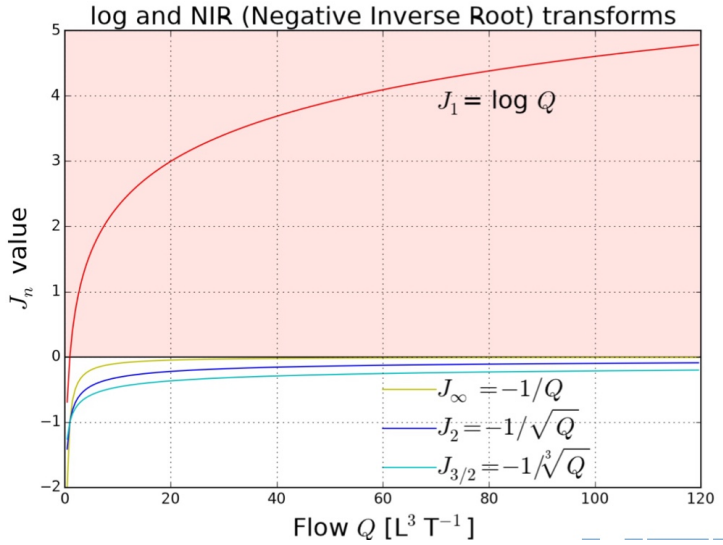

Fig. 1.

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