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Hydrology and Earth System Sciences
Discussions

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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SC1 - John Ding 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.

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 overempha-

sized (Table 1,Row Streamflow).Considering a catchment on a continental scale as either a linear, Q=kS=C1S, or a quadratic storage,Q= (C2S)2, the baseflow can be linearized as follows (Beck et al.,2013, cited by authors; Azmi et al., 2020, SC1 therein; Ding, 2020):logQ(t) = logQ(t0)−C1(t−t0),(1)Or:−1/$\sqrt{}$Q(t) =−1/$\sqrt{}$Q(t0)−C2(t−t0),(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,C1andC2, 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 (Lines424-427). 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 mthroot (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 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. This follow-up will illustrate a comparison of the universal logarithmic and the newNISR transformation as represented, in SC1, by Equations (1) and (2). Figure 2 summarizes result of a new recession flow analysis for year 1962 for BigSpring near Van Buren, in Missouri, a regional-scale limestone karst having a drainage of 1500 km2.The graph shows a long recession hydrograph from May to August of 1962 (Florea and Vacher, 2006, Figure 2C). The recession literally started one day after the last ofthe major peaks and ended at the start of the next noticeably uptick. It also includes the log and NISR transformation of the observed flow.In their absolute value, from untransformed, to log-, and finally NISR-transformed recession hydrograph, the correlation coefficient

improves incrementally; and the recession slope flattens successively by one order of magnitude.

References: Azmi, E., Ehret, U., Weijs, S. V., Ruddell, B. L., and Perdigão, R. A. P.: Technicalnote: ”Bit by bit”: A practical and general approach for evaluating model compu-tational complexity vs. model performance, Hydrol. Earth Syst. Sci. Discuss.,https://doi.org/10.5194/hess-2020-128, in review, 2020. Ding, J. Interactive comment on "Technical note: Pitfalls in using log-transformed flowswithin the KGE criterion" by L ÌĄeonard Santos et al., Hydrol. Earth Syst. Sci. Discuss.,https://doi.org/10.5194/hess-2018-298-SC5, 2018. Ding, J. Interactive comment on ”Technical note: ”Bit by bit”: A practical and general approach for evaluating model computational complexity vs. model performance” by Elnaz Azmi et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-128-SC1, 2020. Florea L.J. and Vacher H.L.: Springflow hydrographs: eogenetic vs. telogenetic karst.Groundwater. 44(3):352-61, 2006 Santos, L., Thirel, G., and Perrin, C.:Technical note:Pitfalls in using log-transformed flows within the KGE criterion, Hydrol. Earth Syst. Sci., 22, 4583-4591,https://doi.org/10.5194/hess-22-4583-2018, 2018.

Thank you for this remark. As stated in Lines 144 and 155, we encourage using groundwater representations that are able to simulate hydraulic heads instead of storages, regardless whether linear, quadratic, or any other non-linear approximation, in order to consider capillary rise of groundwater and groundwater-surface water interactions. But we agree that in respect to model evaluation, non-linear streamflow recession characteristics have a huge potential to evaluate large-scale groundwater models, especially in cases like the karst spring example elaborated in Figure 2 of this comment. We also agree that stream flow and spring flow observations, which have become largely available, allow the evaluation of large-scale models for their performance in simulating linear and non-linear recession characteristics. We have updated section 3.1 and Table 1 accordingly.

Please also note the supplement to this comment:
https://hess.copernicus.org/preprints/hess-2020-378/hess-2020-378-AC4-supplement.pdf

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