Review comments on “Elasticity curves describe streamflow sensitivity to precipitation across the entire flow distribution” by Anderson et al.

General Comments

This manuscript proposes a new concept in which streamflow elasticity is estimated across the full range of streamflow percentiles in a large-sample context, which is called “elasticity curve” by authors. The aim is to develop a more complete depiction of how streamflow responds to precipitation. They find three different elasticity curve types which characterize this relationship at the annual and seasonal timescales in the USA, based on two statistical modelling approaches, a panel regression which facilitates causal inference and a single catchment model which allows for consideration of static attributes. The idea is novelty and fits well with aims and objectives of HESS. This was why I accepted the review invitation. However, there are significant shortcomings in current version so that I have to recommend a rejection (below specific comments for detail).

Specific Comments

First of all, authors clearly misunderstand the concept of elasticity precipitation of streamflow proposed by Schaake (1990) and Sankarasubramanian et al. (2001). The original formula is as:

$$\epsilon_p(P,Q) = \frac{dQ/Q}{dP/P} = \frac{dQ}{dP}\frac{P}{Q} \qquad (1)$$

However, the difficulty with this elasticity is that we never really know dQ/dP, which is often estimated from a hydrological model and, of course, the form of the hydrological model is always unknown and validation of such a model remains a fundamental challenge (Sankarasubramanian et al. 2001; Fu et al., 2007).

In order to solve this problem, Sankarasubramanian et al. [2001] introduced a specific case of (1) at the mean value of the climatic variable:

$$\epsilon_p(\mu_p, \mu_Q) = \frac{dQ}{dP}\Big|_{P=\mu_P}\frac{\mu_P}{\mu_Q} \qquad (2)$$

They (Sankarasubramanian et al. 2001 further verified that the non-parametric estimator:

$$e_P = median\left(\frac{Q_t - \overline{Q}}{P_t - \overline{P}}\frac{\overline{P}}{\overline{Q}}\right) \quad (3)$$

is a robust estimator of the precipitation elasticity of streamflow for a wide class of hydrological models that does not depend on the form of the hydrological model.

This is the formula that has been wildly used in the literature to estimate the precipitation elasticity of streamflow. That is to say, the elasticity is the median value of ratio of annual streamflow anomaly in terms of long-term means to precipitation anomaly, not the long-term mean for the 50th percentile of streamflow as author claimed.

I do understand that there are some exceptions in the literature not to take this median value. For example, the two-parameter elasticity to include temperature (Fu et al., 2007) is to plot every annual ratio is plotted in a 2-d space or fitted a linear regression with these two anomalies (Zheng et al., 2009).

$$e_{P,\delta T} = \left(\frac{Q_{P,\delta T} - \overline{Q}}{P_{P,\delta T} - \overline{P}}\frac{\overline{P}}{\overline{Q}}\right) \quad (4)$$

$$\Delta Q_i/\overline{Q} = \epsilon \cdot \Delta X_i/\overline{X}. \quad (8)$$

My main scientific concern is Eq 2 of the manuscript, which is the base of this study. This does not make any scientific sense, because the same percentile of streamflow and precipitation could happen in different time of year. For example, 95th percentile of streamflow is located in June and 95th percentiles of precipitation/PET could be in December. How possible to build a regression model between them?

$$\ln(Q^q_{i,t}) = \alpha_{i,t} + \varepsilon^q_P \ln(P_{i,t}) + \varepsilon^q_E \ln(E_{i,t}) + \eta^q_{i,t}$$

In addition, this approach requires non-zero daily streamflow for the entire study period, i.e., it cannot be applied to ephemeral rivers and streams, which limits its applications. I am surprised that it includes some rivers in Nevada and Arizona states where the number of rainfall days in a year is only 30-60 days. How can it result in a non-zero streamflow days?

Reference

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Sankarasubramanian, A., R. M. Vogel, and J. F. Limbrunner (2001), Climate elasticity of streamflow in the United States, Water Resour. Res., 37, 1771– 1781.

Schaake, J. C. (1990), From climate to flow, in Climate Change and U.S. Water Resources, edited by P. E. Waggoner, chap. 8, pp. 177– 206, John Wiley, New York.

Zheng, H., L. Zhang, R. Zhu, C. Liu, Y. Sato, Y. Fukushima (2009), Responses of streamflow to climate and land surface change in the headwaters of the Yellow River Basin. *Water Resour. Res.* 45, W00A19.