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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Technical note: Pitfalls in using log-transformed flows within the KGE criterion" *by* Léonard Santos et al.

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Answer to the comments by S. Mylevaganam

We would like to thank S. Mylevaganam for his comments on the technical aspects of our manuscript and the Associate Editor for framing our answer regarding the issues which are out of the scope of the technical discussion.

- 1) From the reader's point of view, considering the current discussion, the current version of the manuscript needs to be reviewed by qualified referees who are

specialized in the subject that is presented in the manuscript. Since this is a technical note, the need for more technical evaluation by the referees is required. Moreover, the referees' role should not be harbored to state whether or not the referees "like/hate/love" the manuscript.

  This comment is not about the paper content and we therefore refer to the Editor's reply.

- 2) As per the authors [see P-2 LN-2], Gupta et al. (2009) clearly demonstrated that discharge variability is not correctly taken into account for the evaluation. Therefore, Gupta et al. (2009) proposed a new criterion, Kling-Gupta efficiency (KGE), which provides direct assessment of four aspects of discharge time series, namely shape and timing, water balance and variability[see P-2 LN-6]. As far as I remember, in 2006, this piece of idea was introduced by a graduate student. Therefore, respecting Mr. Donald Trump's intention of preventing people from stealing someone's ideas/works/technologies, it would be more appropriate for the authors to evaluate the originality of Gupta et al. (2009)'s work.

  The objective of the paper was to discuss a specific application of a criterion previously published in an international journal after peer-review (Journal of Hydrology) and which has been widely used then. If there is a possible concern about the KGE criterion, the reviewer should directly contact the authors or the editors of Journal of Hydrology. We agree with the Editor that this discussion and our article are not the right place to discuss this issue. We are not aware of the graduate student work mentioned by the reviewer, for which no detail is given and therefore we are not able to evaluate the originality of the work.

- 3) As per the authors, The KGE' criterion (Kling et al., 2012, denoted EKG in Eq. 1) is written as a sum of the distances to 1 (perfect value) of three components of the modelling error [see P-2 LN-20]. What is meant by "sum" of the "distances" to 1? What is the mathematical formula that is used to compute the distance?

If we consider a three dimensional space (i.e., x-axis=ratio-1, y-axis=ratio-2, z-axis=ratio-3), isn't the square root component merely the distance from the origin (i.e., [1, 1, 1])?

These questions show that our sentence is not precise enough. Mathematically speaking, the KGE' is a linear transformation of the Euclidian distance from the ideal point (i.e., [1, 1, 1]) in the three-dimensional space defined by the three ratios (Eq. (2) to (4)). In Eq. (1), this Euclidian distance is represented by the square root component and the computed linear transformation of this distance is $f : x \mapsto 1 - x$. This function is used to allow the KGE' to have the same range of values as for the NSE. We thank the reviewer for pointing out this and will attempt to be more precise in the manuscript by modifying the page 2 line 20 sentence.

- 4) What is the physical meaning of equation (1)? Let's say that the right-hand side of the equation (1) has two components. The first component is "1". The second component is the square root component that includes the ratios (e.g., beta). Why would you subtract the second component (i.e., square root component) from the first component (i.e., 1)? What is the physical meaning of the second component? What is the physical meaning of the first component? If the second component of the equation (1) represents the distance (see the definition), as per dimensional theories, the first component needs to be a distance. Otherwise, the operator (i.e., negative sign) becomes meaningless. What is the distance represented by the first component? What is the origin for the distance that is represented by the first component?

First of all, regarding the dimensional theories, the KGE' expression is right. Indeed, a Euclidian distance in a space of dimensions without units (it is the case of the three ratios that form the KGE') is dimensionless. Thus, linearly transforming this dimensionless Euclidian distance is not wrong mathematically speaking.

However, the choice of the transformation f can be discussed. As said in the answer of the reviewer comment 3), the distance is subtracted to 1 to have the

same range of values as the NSE criterion. This is clearly due to legacy because a lot of rainfall-runoff modellers are used to the NSE and to analyse its values. This subtraction can be discussed as the Euclidian distance stands for itself as an evaluation criterion but, because the transformation of this distance in the KGE' is linear, the interpretation of the KGE' values remains the same as for the Euclidian distance. Consequently, it has no impact on the evaluation of the performance of the model.

Regarding the physical meaning of the KGE', we will answer in our response of comment 6).

- 5) Does your equation (3) evaluate the water balance error? What is meant by water balance? What is the range of your beta value? Assume that we have the following monthly observed flow values :5,5,4,5,5,5,5,5,6,5,5,5. Assume that we have the following monthly simulated flow values :5,5,6,5,5,5,5,5,5,5,5,4.As per your equation(3), if we consider all the flow values, the beta value is 1.However, if we consider the first six months, the value of the beta is not equal to 1. Is your beta value time dependent?

The beta ratio represents the quantitative aspect of the simulation. If it is greater than 1, the model overestimates the discharge and if it is lower than 1, the model underestimate the discharge. We agree that the value of beta depends on the time as it is the case of all the other ratios. We used a split-sample test to limit the impact of this time dependency.

To avoid misunderstanding we will replace "water balance" by "bias".

- 6) Assume that the ratio-1=1 (i.e., equation (2)), ratio-2=1 (i.e., equation (3)), and ratio-3=0.5 (i.e., equation (4)). As per your equation (1), the value of KGE is 0.5. Now, assume that the ratio-1=1 (i.e., equation (2)), ratio-2=0.5 (i.e., equation (3)), and ratio-3=1 (i.e., equation (4)). As per your equation (1), the value of KGE is 0.5. What is the physical meaning of the KGE values?

The physical meaning of the KGE value itself is not well defined. It is simply an aggregated representation of the model error over the studied period. To understand its value, the modeller needs to have a look on the three components of the criterion separately. This is stated in the Gupta et al. (2009) publication and it is often done by the KGE users (for example in the work of Ficchí et al., 2016, cited in the present manuscript). Moreover, depending of the modeller's objectives, Gupta et al. (2009) also proposed to weight each component of the KGE.

- 7) As per your equation (4), the ratio-3 is a function of your beta value. In other words, your ratio-3 is a function of ratio-2 (i.e., equation (3)). This gives an indication that the ratio-3 that is accounted in your equation (1) repeats the influence of ratio-2 in equation (1).

  In the publication that introduces the KGE', Kling et al. (2012) stated that: "For the variability ratio γ we used $\frac{CV_s}{CV_o}$ instead of $\frac{\sigma_s}{\sigma_o}$, which was proposed in the original version of the KGE-statistic (Gupta et al., 2009). This ensures that the bias and variability ratios are not cross-correlated, which otherwise may occur when e.g. the precipitation inputs are biased.". In other words if the bias ratio is bad, the ratio of standard deviation will also be affected. To avoid the impact of average discharge error on the variability component, the standard deviation ratio is normalised by the bias ratio.

Léonard Santos, on behalf of co-authors

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