Geophysical Research Abstracts
Vol. 20, EGU2018-11457-2, 2018
EGU General Assembly 2018

Reducing equifinality by carrying out a multi-objective evaluation based on the bias, correlation and standard deviation errors

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Equifinality is observed when multiple parameter sets results in equally acceptable model outputs. As it means that we can only model past and future events in an uncertain way, it is regarded as an undesirable property of our models.

This contribution shows the results of a study that tested if we were able to reduce equifinality by carrying out a multiobjective evaluation based on the KGE (Kling-Gupta Efficiency) components, which are the bias, correlation and the standard deviation. The analysis tested two approaches: (i) using the error components for constraining the model outputs and (ii) using the error components for constraining the model parameters which could result in fewer equifinal parameters.

The results showed that the bias, correlation and standard deviation errors could be used for differentiating between parameter sets that are equifinal with respect to the KGE value, i.e. that parameter sets resulting in similar KGE values had considerable differences in the values of the error components. A positive aspect of this approach is that its ability for reducing equifinality does not decrease as more complex models are considered.

We further found that the bias, closely followed by the standard deviation, is the most adequate error component for constraining the model outputs as it gives the most consistent results when considering other periods. The correlation has the lowest consistency across periods and therefore the least suitable for constraining the model outputs, especially for shorter evaluation periods.

With respect to the ability of the error components for constraining the parameter sets we found that there are only few parameters that show a structure and therefore have a potential for constraining the model outputs. A disadvantage of this approach is that the ability for constraining the parameters decreases as more complex models are used.

We also found that the bias and the standard deviation errors tend to be negatively correlated, i.e. they compensate each other, which results in a higher variability of these components in comparison to the correlation for a set of equifinal parameters with respect to the KGE.