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Discussions

Interactive comment on "Using variograms to detect and attribute hydrological change" *by* A. Chiverton et al.

Anonymous Referee #1

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This study proposes and tests a methodology to detect a) changes in stream flow, b) discriminate them into different types and c) relate them to changes in meteorological drivers. Key idea is to calculate variograms of log transformed stream flow anomalies for moving window of 5 years and to characterize these variograms based on their partial sill, range, semi variance at a lag equal to 50% of the range and the semivariance averaged over the 3 smallest lag times. Changes in these parameters are defined as significant when dropping outside of the 90 confidence band of the corresponding parameters characterizing the variogram calculated for the full range time series of 30 years. These confidence limits are derived from 1000 bootstraps. After the sensitivity of the methods is demonstrated using artificial test cases, the method is applied to 94 catchments in the UK.

Although proposed study addresses an important topic and the results are potentially of high interest, I have major concerns about the proposed method:

- Geo-statistics relies at least on the assumption of weak stationarity, otherwise the nugget + sill are not equal to the total variance. Seems a little difficult to use a method which assumes stationarity to detect non-stationarity. Calculating variograms for five years intervals assumes stationarity within this period, this can be checked based on the distribution of the residuals, which should be uncorrelated in time and standard normally distributed. Is this the case?

- Non-linear transformations (such as the log transformation) destroy the auto covariance structure of the stream flow data, in the sense the original data have a different autocorrelation time. How to infer on changes of the autocorrelation of the original data with the given method?

- Working with anomalies relies again implicitly on stationarity of the mean and variance. If the stream flow data have e.g. a trend in the mean, but you use a constant mean to calculate the anomalies this will appear as trend in variability as the anomalies get larger in direction of the trend.

- The presented test cases corroborate that the method attributes trends in the mean or an emergent periodicity (which is trend in where stream flow is expected/ a deterministic pattern) partly to changes in the sill (thus changes in the randomness). This is an intrinsic weakness of the variogram per se when being used in data sets containing trends.

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