Hydrol. Earth Syst. Sci. Discuss., 11, C5440–C5443, 2014
www.hydrol-earth-syst-sci-discuss.net/11/C5440/2014/

Hydrology and Earth System Sciences
Discussions

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

A. Chiverton et al.

andchi@ceh.ac.uk

Received and published: 3 December 2014

The authors would like to thank the reviewer for their comments enquiring about why variograms are used.

Background

This paper is part of a larger project aiming to identify how catchment characteristics influence a river response to climate variability. Current ongoing work is examining how catchment characteristics influence how much observed river flow change can be explained by precipitation; the underlying motivation is to explain widely observed heterogeneities in river flow variability. Variograms are used in earlier work by the same authors (Chiverton et al, 2014), showing that the shape of the global variogram

is a useful analogue for the precipitation-to-river flow relationship which is moderated by catchment characteristics. Therefore it is hypothesised that changes in the shape of the variogram over time are also influenced by the catchment characteristics.

This work needed to establish how precipitation characteristics influence the different variogram parameters and how much of the temporal changes can be described by precipitation alone. This enables the next part of the work to evaluate if the catchment characteristics influence the amount of temporal variability in the variogram parameters which is explained by precipitation. Hence, our initial motivation to use variograms was influenced by the wider study framework, but in undertaking this investigation we believe we have demonstrated that the variogram approach has significant potential for wider application to change detection when applied to hydrological time series.

Uncertainty in the variogram parameters

The relative goodness of fit was looked at for each moving window. However, because there is only one realisation of the variogram for the data, calculating uncertainty estimates would require running Monte Carlo simulations for each moving window for every catchment (over 2,500 simulations). This would be a considerable endeavour and would certainly constitute an interesting follow-on from the current study. We note in the paper that there will be uncertainty around the parameter estimates but we consider here the relative difference between the estimates and place less value in the absolute numbers.

Why use variogram parameters?

The question of why to use variograms was also asked by reviewer number 3. When thinking about why the paper has used variograms, perhaps it is indeed more appropriate to think of the variogram parameters as indicators of river flow. However, as a composite indicator of a range of potential changes in flow dynamics, the variogram does have some advantages for use in change detection. Firstly, variograms can detect changes which other indicators may not be able to (e.g. changes in variability at a

range of scales). Secondly, as the reviewer points out, a variogram provides information about a mixture of properties in the river flow time series (e.g. standard deviation, seasonality, linear trends). Therefore using variograms provides an approach which does not rely on the user extracting a pre-conceived aspect of the river regime (e.g. high or low flows) selected for each month/year/season of interest, and conducting trend analysis. The variogram approach takes the correlation structure of the entire river flow series and uses the emergent variogram parameters as an efficient way of summarising variability in each window. Therefore, this prevents the disregarding of much of the data which occurs when calculating some indicators (e.g. 7 day min or max).

However, if the desire of the user is to investigate a specific aspect of the river flow then this may not be the most appropriate method. The paper will be re-worded to acknowledge that the variogram can be considered as an indicator of river flow (characterising the temporal dependence) and will point out that (as with any change detection technique) it depends on the user's needs as to whether this method is appropriate. We will also add more material on the specific merits of the variogram as listed above.

With regards to the comment of why add an extra step between precipitation and river flow (precipitation-variogram-river flow), we did not intend there to be an extra step. We see this study as precipitation – river flow, but with the variogram being used to characterise river flow. Our intention of the particular periods of river flow in the discussion was to provide an (albeit descriptive) evaluation of how well the TSV approach captured changes in river flow variability that have previously been characterised using more simple indicators of seasonal and annual flows, or high/flow indicators. Variograms have not been used before to identify temporal changes in river flow dynamics, so we spend some time corroborating the TSV results with known river flow changes. This motivation behind our discussion will be made clearer in the paper. It is important to note that the discussion does go beyond validation, as we also shed new light on the meteorological drivers of known periods of river flow volatility. There has been

widespread interest in questions of whether hydrological extremes have become more severe/frequent in the recent past, but some of these recent periods have been characterised by pronounced variability across the full flow range. Our new approach provides a way to characterise this volatility efficiently and to link it to changes in particular rainfall characteristics.

Reference

Chiverton, A., Hannaford, J., Holman, I., Corstanje, R., Prudhomme, C., Bloomfield, J., and Hess, T. M.: Which catchment characteristics control the temporal dependence structure of daily river flows?, Hydrological Processes, (in press), 10.1002/hyp.10252, 2014.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 11763, 2014.