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Diagnosing non-stationary behaviour in a hydrological model

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The stationarity of hydrological models is increasingly being called into question, due partly to changes in land cover as well as natural and anthropogenic climate change. This issue is manifest in model parameters which change over time, creating challenges in calibration and validation (as the joint distribution of model parameters is conditional to the period used for model calibration), and in prediction when one wishes to investigate runoff properties in the future. This paper describes the incorporation of non-stationary parameters into a well established rainfall-runoff model – GR4J – using a Bayesian framework for calibration and prediction, and the use of an information theoretic approach to evaluate whether the inclusion of non-stationary parameters was justified. A subcatchment of the Onkaparinga river in South Australia was used as a case study, and it was found that GR4J parameter 'x1' varied significantly seasonally and also exhibited a longer-term increasing trend over the calibration period from 1974 to 1999. The inclusion of this non-stationary parameter in the model reduced the over-prediction in the drier validation period from 2000 to 2010 from 25% to 1.5%. Whilst including non-stationarity parameters provided substantial improvements in prediction, it is advocated that this non-stationary parameters be used as a diagnostic tool to identify model deficiencies, rather than for prediction. Techniques to reduce the non-stationarity by enhancing the model structure will to include one or more missing processes will be discussed.