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On the use of the Whittle likelihood for calibrating hydrological models parameters

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For a stationary time series, Whittle constructed a likelihood for the spectral density based on the approximate independence of the discrete Fourier transforms of the data at certain frequencies. Whittle's likelihood has been widely used in hydrology, but exclusively for estimating the parameters of stochastic processes. Whittle's likelihood provides asimptotically consistent and normally distributed estimates for Gaussian and non-Gaussian data, even in the presence of long-range dependence, which is deemed to be a possible explanation for the well-known Hurst effect. In this paper, we propose the use of the Whittle's likelihood as objective function for calibrating the parameters of hydrological models of any type, with particular emphasis on rainfall-runoff models. The spectral density function of the model is approximated here with the discrete periodogram of a long simulation provided by the model itself, with the addition of a term that allows to account for the presence of correlation in the model residuals. This latter behaviour of the Whittle's estimator constitutes a potential advantage with respect to the traditionally used objective functions, like the sum of squared errors or the Nash coefficient of efficiency. The proposed procedure is applied to the case study of a Italian river basin, for which a lumped rainfall-runoff model has been calibrated. It is shown that the Whittle's estimator can be successfully applied within the GLUE methodology, therefore being a potentially useful tool for the application of hydrological models in the presence of equifinality.