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Hidden Markov models for non-stationary runoff modelling conditioned on El Niño information

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Runoff scenarios are commonly used as input for the evaluation of management policies of water resources systems. These scenarios are often produced using strictly stationary stochastic models that assume the runoff probability density function to be conditional on past streamflow information. The stationarity assumption is not suitable for estimating local and regional impacts of climate variability on the runoff regimes, especially with respect to the current signals of global climate change. Instead, the optimization of water resources system over long and short time horizons requires the ability of producing runoff scenarios that are coherent with the available climatic information. We approach the runoff modelling problem with a class of hidden Markov models (HMMs) that enable conditioning the streamflow parameters on climatic variables. The applied HMMs assume the runoff parameterization to be conditional on a hidden climate state that follows a Markov chain, where state transition probabilities are functions of the climatic information. This method weakens the assumption of stationarity by hypothesizing conditional stationarity for the observed runoff process; that is, the streamflow parameters are globally stationary as they depend on the climatic information through fixed functional relations. Moreover the implemented HMMs allow for a heteroscedastic description of the runoff process, as its parameters change according to the prevailing climate regime. The defined HMMs are applied for modelling monthly inflows to the Daule Peripa reservoir in Ecuador. El Niño – Southern Oscillation (ENSO) information is used to condition the runoff parameterization. Various ENSO – related climatic indices are used as exogenous covariates, including sea surface temperature anomalies in the eastern equatorial Pacific Ocean that seem

to perform reasonably well as climatic predictors. HMMs are applied for generating long term scenarios and for performing short term forecasts, in the perspective of both long and short term reservoir optimization.