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Detecting hydrological changes through conceptual model

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Natural changes and human modifications in hydrological systems coevolve and interact in a coupled and interlinked way. If, on one hand, climatic changes are stochastic, non-steady, and affect the hydrological systems, on the other hand, human-induced changes due to over-exploitation of soils and water resources modifies the natural landscape, water fluxes and its partitioning. Indeed, the traditional assumption of static systems in hydrological analysis, which has been adopted for long time, fails whenever transient climatic conditions and/or land use changes occur.
Time series analysis is a way to explore environmental changes together with societal changes; unfortunately, the not distinguishability between causes restrict the scope of this method. In order to overcome this limitation, it is possible to couple time series analysis with an opportune hydrological model, such as a conceptual hydrological model, which offers a schematization of complex dynamics acting within a basin. Assuming that model parameters represent morphological basin characteristics and that calibration is a way to detect hydrological signature at a specific moment, it is possible to argue that calibrating the model over different time windows could be a method for detecting potential hydrological changes.
In order to test the capabilities of a conceptual model in detecting hydrological changes, this work presents different "in silico" experiments. A synthetic-basin is forced with an ensemble of possible future scenarios generated with a stochastic weather generator able to simulate steady and non-steady climatic conditions. The experiments refer to Mediterranean climate, which is characterized by marked seasonality, and consider the outcomes of the IPCC 5th report for describing climate evolution in the next century. In particular, in order to generate future climate change scenarios, a stochastic downscaling in space and time is carried out using realizations of an ensemble of General Circulation Models (GCMs) for the future scenarios 2046-2065 and 2081-2100. Land use changes (i.e. changes in the fraction of impervious area due to increasing urbanization) are explicitly simulated, while the reference hydrological responses are assessed by the spatially distributed, process-based hydrological model tRIBS, the TIN-based Real-time Integrated Basin Simulator.
Several scenarios have been created, describing hypothetical centuries with steady conditions, climate change conditions, land use change conditions and finally complex conditions involving both transient climatic modifications and gradual land use changes.
A conceptual lumped model, the EHSM (EcoHydrological Streamflow Model) is calibrated for the above mentioned scenarios with regard to different time-windows. The calibrated parameters show high sensitivity to anthropic variations in land use and/or climatic variability. Land use changes are clearly visible from parameters evolution especially when steady climatic conditions are considered. When the increase in urbanization is coupled with rainfall reduction the ability to detect human interventions through the analysis of conceptual model parameters is weakened.