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A hidden Markov model for downscaling atmospheric circulation patterns to precipitation along Danube basin

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This study is based on fitting nonhomogeneous hidden Markov models (NHMMs) to daily spring precipitation records on a network of 20 meteorological stations, along the Danube basin for the period 1958-2001, incorporating synoptic atmospheric information. The precipitation time series are obtained from the archive carried out within ECA&D project. First we estimate optimal number of hidden states, applying only a homogeneous hidden Markov model, taking into account both the Bayesian Information Criterion (BIC) behavior and our final scope, namely hydrological applications to estimate extreme events in Danube basin discharges. We decide that a HMM with 7 states is appropriate for the present investigation. Then, NHMMs with 7 states were fit to precipitation occurrence using information about atmospheric circulation over Atlantic European region. The atmospheric data consists of three fields: daily geopotential at 1000 and 850 hPa and specific humidity at 850 hPa (ERA-40), obtained from ECMWF data server. In order to compress information about atmospheric variables, decomposition in Multivariate Empirical Orthogonal Functions (MEOF) is achieved. The contribution of atmospheric variables to precipitation occurrence is quantified by significant principal components (PCs) of MEOF decomposition, incorporating as covariates. The number of introduced components is decided by means of BIC. The precipitation amounts are modeled using a mixture of distributions, consisting of a delta-function at zero and a set of exponentials or gamma distributions. The most-likely state sequence is estimated by means of Viterbi algorithm, which helps us to construct composites of atmospheric circulation and also to reevaluate transition ma-

trix. For a physical interpretation, the 7 the atmospheric patterns are analyzed together with distributions of amounts associated with respectively probabilities for the 7 states of precipitation. We estimate the atmospheric circulation associated with precipitation states which can be considered extreme events in some portions of the Danube basin or over entire basin. The NHMMs are useful tools for statistical downscaling of global climate scenarios for hydrological impact analysis.