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Downscaled precipitation projections in the 21-century in the middle and lower Danube basin by means of nonhomogeneous hidden Markov model

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The goal of this study is to estimate the changes in the precipitation in the 21 century over the middle and lower Danube basin, changes which have impact on the occurrence of the hydrological events.
In the first step our approach is based on fitting a hidden Markov model (HMM) to the daily precipitation network for the months March, April and May, for the period 1961-1990. This network consists in 66 grid points within the area 41 N- 48 N and 16 E - 29 E, representative for the middle and lower Danube basin.
Then a nonhomogeneous HMM (NHMM) is applied to historical precipitation associated with the information about historical atmospheric circulation. The atmospheric predictors are derived from: sea level pressure (SLP), geopotential, temperature, specific and relative humidity at 850 hPa. The region for the atmospheric predictors is larger then the area for precipitation and it is limited by 35 N – 55 N and 10 E - 30 E. The number of hidden states (seven) and optimal combination of predictors are determined by means of the Bayesian information criterion (BIC).
Both historical simulations (20-century) and data from SRES scenarios (A1B) for 21-century for precipitation and atmospheric variables are extracted from outputs of four models (CNRM-CM3, ECHAM5-MPI, EGMAM and IPSL-CM4), models achieved within stream1 experiment in the ENSEMBLES project, available on the CERA database (http://cera-www.dkrz.de/).
For the 21-century two periods of 30 years (in order to be compared with historical data from 1961-1990) are chosen: 2021-2050 (S1) and 2071-2100 (S2). The persistence of the cyclonic and anticyclone states increases in the 21-century comparative with the reference period from the 20-century. In the S2 period, the persistence of these atmospheric states is higher than in the S1 period of the 21- century. The significant increase of persistence is observed in the anticyclone type circulation. These results lead to the conclusion that an increase of the extreme hydrological events occurrence in the 21- century is expected, with the predominance of the drier episodes towards the end of this century.