EMS Annual Meeting Abstracts
Vol. 13, EMS2016-478, 2016
16th EMS / 11th ECAC

Future changes in precipitation statistics on high spatial and temporal resolution using a conditional stochastic model

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The General Circulation Models (GCMs) are the most suitable tools to obtain reliable future climate change projections on global scale but they are not skillful on smaller spatial scales needed by various impact studies. To get such information, the dynamical (regional climate models-RCMs) and statistical downscaling models are used. The conventional RCMs have a spatial resolution of about 25 km and the most recent ones of about 11 km, developed within the CORDEX framework, are available on daily temporal resolution. Hydrological models need sub-daily information on even smaller spatial scale to simulate extreme event such foods.

In this study a conditional stochastic models is presented to generate 6-hour precipitation on 1x1 km spatial resolution over the Birlad river basin placed in eastern Romania. This model is a combination between the statistical downscaling model based on CCA (canonical correlation analysis) and a Markov chain model of the first order. There are two parameters describing the precipitation occurrence process: the transition probability p01, the probability of a wet interval following a dry interval, and p11, the probability of a wet interval following a wet interval. As a wet interval, the case of 6-hour precipitation amount > 0.1 mm is used in this study. The variation of precipitation amount on wet 6-hour interval is described by the gamma distribution which has two parameters: the shape parameter (k) and the scale parameter (μ) representing the mean precipitation over the wet 6-hour intervals. Therefore, the conditional stochastic model (CSM) is dependent on the four parameters (p01, p11, k, μ).

The CSM performance is assessed in two steps: firstly, the performance of the CCA model in estimating the four parameters and secondly, the stochastic model performance in reproducing the observed precipitation statistics: total seasonal precipitation amount, mean 6-hour precipitation amount in wet intervals, mean number of wet intervals, maximum 6-hour precipitation amount and frequency of 6-hour precipitation amount exceeding some thresholds. The CCA model is developed for each of the four parameters, simultaneous at all grid points (19200), and each season (winter, spring, summer, autumn). Finally, 16 CCA models have been developed. The CSM have been calibrated over the interval 1976-2000 and validated over the independent data set 2001-2010. As large-scale predictors, the combination of various dynamic (SLP) and thermodynamic (T850, T500, SH1000, Sh850, SH700, SH500) variables has been considered. It was found a good performance for the CCA models for all the four parameters and all seasons, the highest skill being obtained for p01 and p11 and lowest one for k. The CSM was run by 35 times and all precipitation statistic were computed as ensemble averages.

The seasonal precipitation amount computed from the 6- hour generated amounts have been compared to similar values derived from observations. It was found a very coherent temporal evolution between the spatial average of the simulated and observed values over the validation interval 2001-2010. This model was used to generate 6 - hour precipitation time series at the 19200 grid points for the two future periods (2021-2050, 2071-2100) using the predictors simulated by ENSEMBLES GCMs (CNCM33, MPEH5C) under A1B scenario CMIP5 GCMs under rcp45 scenario (CNRM-CM5, MPI-ESM-LR). For the time horizon 2021-2050, in case of the CNCM33 (run1), the results show an increase of mean 6-hour precipitation amount on the wet intervals in winter, spring and summer and decrease in autumn. This signal is similar with those derived for the total seasonal amount and mean number of wet intervals for winter (increase) and autumn (decrease), while for spring and summer the signal is different (decrease). For the period 2071-2100 the climate signal is similar but stronger.

The results will be summarised for all analysed GCM drivers and all statistical parameter presented above. The results related to precipitation statistics aggregated on daily scale are compared to those derived directly from RCMs (11 km resolution) driven by the same GCMs.