Downscaling extremes precipitation over the territory of Bulgaria

N. Neykov[1], W. Zucchini[2], S. Sperlich[2], P. Neytchev[1], Ch. Christov[1]
National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences
Institut für Statistik und Ökonometrie, Georg-August-Unversität Göttingen
neyko.neykov@meteo.bg

Heavy precipitation events rank among natural hazards with the most disastrous impacts on human society. There is substantial empirical and climatological evidence that precipitation extremes have become more extreme during the twentieth century and that this trend is likely to continue as global warming becomes more intense. Future projections produced by Global and Regional Climate Models (GCMs, RCMs) offer a way to characterize any trends in extreme behavior. However, these models have difficulties capturing small-scale intermittent processes such as local precipitation. In order to overcome these difficulties and to link the large-scale knowledge supplied by the GCMs and RCMs outputs with measurements recorded at weather stations, statistical downscaling techniques have been developed. These downscaling techniques include modeling the daily precipitation process through multivariate probability distributions, conditional on large-scale atmospheric circulation patterns, i.e., development of stochastic precipitation models known as “weather state models” or “downscaling models” to downscaling the GCMs and RCMs atmospheric simulations to local precipitation. Once the precipitation model has been calibrated for a given territory one can use it to generate long sequences of artificial daily precipitation data. These sequences can be used to estimate statistics relating to precipitation events in exactly the way one would do so if a long sequence of precipitation data were available. In this way hazardous precipitation events can be assessed robustly. In the present study we fulfill this task developing a multi-sites daily precipitation model based on the non-homogenous hidden Markov models (NHMMs). The NHMM links large-scale atmospheric patterns to daily precipitation data at a network of rain gauge stations, via several hidden (unobserved, latent) states called the “precipitation states”. The evolution of these states is modeled as a first-order Markov process with state-to-state transition probabilities conditioned on some indices of the atmospheric variables. Due to these states the spatial precipitation dependence can be partially or completely captured. The NHMM is calibrated over daily precipitation at 30 rain gauge stations covering broadly the territory of Bulgaria. At each site a 40- year record (1960-2000) of daily precipitation amounts is modeled both in its occurrence and intensity components. The atmospheric daily data consists of sea-level pressure, geopotential height, air temperature, relative humidity taken at standard levels (subset of NCEP-NCAR reanalysis dataset) on a 2.5° x 2.5° grid covering the Europe-Atlantic sector 30°W–60°E, 20°N–70°N for the same period. The first 30 years data are used for model fitting purposes while the remaining 10 years are used for model validation. Detailed model evaluation is carried out on various aspects. The results show that the downscaled simulations reproduce satisfactorily the observed precipitation probabilities, the entire range (from low and moderate to extreme) precipitation amounts, and the wet and dry spell length distributions.