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Modelling daily precipitation over the territory of Bulgaria using hidden Markov models

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Non-homogenous hidden Markov Models (NHMMs) have found widespread application in meteorology and hydrology in Australia and New Zealand, North and South America, e.g., in studies of climate variability or climate change, and in statistical downscaling of daily precipitation from observed and numerical climate model simulations. (See, e.g. Zucchini and Guttorp (1991), Hughes and Guttorp (1994), Hughes et al. (1999), Charles et al. (1999), Bellone et al. (2000), Charles et al. (2003) and Charles et al. (2004), Robertson et al. (2004), to name just a few.) However, the NHMM methodology has not been yet employed for similar purposes in Europe. The NHMM links large-scale atmospheric patterns to daily precipitation data at a network of rain gauge stations, via several hidden (unobserved) states called the "weather states". The evolution of these states is modelled as a first-order Markov process with state-to-state transition probabilities conditioned on some indices of the atmospheric variables. Due to these weather states the spatial precipitation dependence can be partially or completely captured (see Hughes et al., 1999). In the present study various NHMMs are used to relate daily precipitation at 30 rain gauge stations covering broadly the territory of Bulgaria to synoptic atmospheric data. At each site a 40-year record (1960-2000) of daily October through March precipitation amounts is modelled. The atmospheric data consists of daily sea-level pressure, geopotential height at 500 hPa, air temperature at 850 hPa and relative humidity at 700 hPa on a 2.5˚ x 2.5˚ grid based on NCEP-NCAR reanalysis dataset 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 evaluation. Detailed model validation is carried out on various aspects. The identified weather states are found to be physically inter-

pretable in terms of regional climatology.

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