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Long term modelling of precipitation and temperature at the continental scale

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Flood risk assessment at broad spatial scales and across catchments and countries requires the formulation of coherent stochastic modelling tools to reproduce the variability of the climatic features that drive runoff response. Such tools must i) prove robust in the reproduction of the observed characteristics of weather forcings (e.g., rainfall and temperature in the case of flood models); ii) allow an accurate representation of the space-time features of the processes involved; iii) preserve the co-varying structure of the variables at hand.

In the present work we study the space-time correlation structure of precipitation and temperature data across Europe and we develop a stochastic model for the generation of correlated random fields that, under the assumption of a stationary climate, preserve the statistical characters of the measured data. Our analysis is based on the high-resolution E-OBS gridded dataset (Haylock et al., 2008), consisting of daily precipitation and temperature observations interpolated on a rectangular grid with a pixel size of 24 km x 24 km, covering the entire European continent and the observation period $1950-2010$.

We analyze the spatial patterns of precipitation and temperature by means of a Principal Component Analysis (PCA) performed on the monthly data anomalies (properly normalized to guarantee the gaussianity of the dataset). The PCA method consists in decomposing the actual data into a set of dominant modes of variation (in the form of Empirical Orthogonal Functions, EOFs) and a vector of appropriate, normally distributed, weights (loading). In a further generation step we use the statistical properties of the loading vector to generate a stochastic set of precipitation and temperature monthly anomalies from which we can obtain the relative time series of the forcing variable. We compare two methods for reproducing the space-time correlations in the generation step: i) the target of the PCA is the combined precipitation-temperature data matrix (i.e. a collection of time series for each spatial location) obtained appending the individual data series for each location. This constrains the analysis on identifying dominant patterns that reflect both the precipitation and temperature spatial characters; ii) EOFs and the loadings for the two variables are derived independently and the correlation matrix of the loadings is imposed in the generation step.

Our results show that the stochastic model based on the principal component analysis offer an effective tool for modelling atmospheric forcings at the spatial and temporal scales involved. In particular we observed a good capability of reproducing precipitation extremes and the patterns that characterize extreme events over broad spatial scales. We prove that the two methods used for reproducing correlations between precipitation and temperature can be selected depending on the desired target, the first method being more reliable in the representation of the existing spatial correlation between the two variables, whereas the latter one ensures a better representation of the individual fields at the expenses of the correlation.

References

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