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Change points in statistical downscaling relationships of the large-scale atmospheric circulation in the North Atlantic-European domain and precipitation in the Mediterranean area

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Statistical downscaling approaches are based on statistical relationships linking a set of large-scale atmospheric variables (predictors) to regional climate variables (predictands) during an observational period. Within these approaches it is assumed that the variables under consideration have time-invariant probability density functions, whose properties can be estimated from the observational record. It corresponds to the idea of stationarity, i.e. that natural systems fluctuate within an unchanging range of variability. However, climate is basically non-stationary. Time-variant climate characteristics on the intra-annual to inter-decadal time scales are often induced by changes of the effects of the atmospheric circulation on the climate of a specific region.

A widely used statistical downscaling technique is the application of generalized linear models (GLMs) where the predictand (e.g. precipitation) is assumed to be non-normally distributed. We extend this concept to generalized non-linear models in order to take non-stationarities in the relationships between the large-scale atmospheric circulation and regional precipitation into account. This is done by estimating change points in GLMs using a dynamic programming algorithm. We allow for multiple discontinuous change points and use different tests to determine the number of change points and their significance.

The approach is illustrated with the example of winter precipitation at stations located in the Mediterranean area. As predictors we use the major modes of atmospheric variability over the North Atlantic-European domain in winter as derived from s-mode principal component analysis (PCA) of area-weighted, standardized geopotential heights of the 700hPa level. We identify the North Atlantic Oscillation, the East Atlantic pattern, the Eurasian Type 1 (EU1, Scandinavia pattern) and Eurasian Type 2 patterns (EU2, East Atlantic/ West Russia pattern or North Sea-Caspian pattern). In addition we select as further predictors regional centres of variation obtained from s-mode PCA of 700hPa geopotential heights in a domain centred over the Mediterranean area. Specific change points in the GLMs of the observational data appear depending on the particular circulation pattern/pattern combination taken as predictor. Composites are calculated to assess the circulation characteristics in the periods before and after a change point. Also Earth System Model predictors, used to assess future precipitation, are evaluated regarding their specific circulation characteristics. Differing values between specific periods are related to the observational conditions, and the correspondent GLMs are selected to project future precipitation in the Mediterranean area.

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