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A circulation-based approach for assessing daily future precipitation extremes in the Mediterranean area under consideration of varying predictor-predictand relationships

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Since large-scale circulation is subject to natural variability, only one model is often not enough to describe different states of the atmosphere comprehensively. Especially when the area of interest represents a transitional zone between two climate zones like the Mediterranean area, shifts within the large-scale circulation could lead to significant divergences with regards to precipitation behavior. For that reason, regression model ensembles were established in order to take different characteristics of the atmosphere into account for assessing heavy rainfall events on a daily scale. Here, future daily precipitation extremes were estimated not only by means of the entire regression model ensemble but also by means of the most suitable model (MSM). In order to define the MSM a comparison of specific atmospheric states (composites) within the period of interest and the corresponding states of the calibration periods was performed. The period whose composites exhibits the highest correlation with the composites of the period of interest provides the MSM.
Daily precipitation time series of 111 stations which cover more or less the second half of the 20th century and most parts of the Mediterranean were tested on homogeneity and completeness. Subsequently, by means of an s-mode principal component analysis (PCA), the remaining stations were divided into regions with similar precipitation behavior and a reference station was determined for each precipitation region, representing the predictands. As predictors different thermo- and circulation-dynamic variables of the NCEP/NCAR Reanalysis dataset of the 850hPa- and 700hPa-level were used. The respective variables were subjected to an s-mode PCA in order to create centers of variation. Both, predictors and predictands were analyzed for each season separately, summer was excluded.
A statistical downscaling approach was chosen in order to describe the relationships between large-scale circulation and precipitation extremes in the Mediterranean area within the different seasons. Here, a Three-Step Censored Quantile Regression (TSCQR) and the corresponding Censored Quantile Verification Skill Score (CQVSS) were used to define the best predictor variable combination as well as the significant centers of variation. Furthermore, the CQVSS was also applied to detect non-stationarities within the predictor-predictand-relationships. The latter was done by means of two different approaches, where the stationary approach (random sampling) specifies the range of natural variability and the non-stationary approach (running subintervals each shifted by one year) characterizes the development over time. When the time series of the non-stationary approach was outside the range of natural variability for at least three consecutive years a non-stationarity was proclaimed.
The selection process of the MSM was performed by means of the maximal period specific correlation coefficient (maps). Here, several composites of the geopotential heights on both considered levels were created for every significant center of variation within the calibration periods when it is highly or less distinct and subsequently correlated to the corresponding ones of the period of interest. The model of the calibration period which exhibits the highest mean correlation coefficient over all PCs, states and levels was then supposed to be the MSM for assessing precipitation extremes within the period of interest.