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Non-stationarities of Mediterranean heavy precipitation events in the second half of the 20th century related to the large-scale atmospheric circulation

Christian Merkenschlager, Elke Hertig, and Jucundus Jacobeit
University of Augsburg, Institute for Geography, Augsburg, Germany (christian.merkenschlager@geo.uni-augsburg.de)

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Christian Merkenschlager, Elke Hertig, Jucundus Jacobeit

Institute of Geography, University of Augsburg, Alter Postweg 118, D-86159 Augsburg
(christian.merkenschlager@geo.uni-augsburg.de)

In the context of analysing temporally varying relationships of heavy precipitation events in the Mediterranean area and associated anomalies of the large-scale atmospheric circulation, quantile regression models (QRMs) have been established. Different circulation and thermodynamic variables at the 700hPa and 850hPa levels of the NCEP/NCAR-reanalysis dataset (predictors) as well as daily precipitation time series of different weather stations in the Mediterranean area (predictand) have been used in these regression models. Special emphasis is put on non-stationarities in the relationships of the large-scale atmospheric circulation and heavy precipitation events.

Based on rainfall time series tested for homogeneity and completeness, a s-mode principal component analysis (PCA) yields 22 regions of similar precipitation variability for the winter season. The station with the highest PC loading represents the reference station for each region. S-mode PCAs have also been applied to reduce dimensions of the predictor data. The areas of high PC loadings reflect corresponding spatial centres of variation and their time coefficients (scores) are used as predictors in the QRMs.

Since the daily precipitation sums are not Gaussian distributed, a three-step censored quantile regression is used to assess the different quantiles. The zero precipitation line represents the censor. By means of the Censored Quantile Verification Skill Score (CQVSS) as a measure of goodness, the best combination of predictor variables can be determined. Mostly, a combination of one thermodynamic predictor and one circulation predictor provides the highest scores whereas an additional predictor does not lead to any significant improvement. In a next step, the number of PCs for both predictors has been determined according to their significance on the level of α=0.01 for every quantile.

In the scope of assessing non-stationarities in the predictors-predictand relationships, the time series are divided into a calibration and a validation period. Two different methods are used to obtain models for stationary and for non-stationary conditions. The calibration period in the stationary model consists of 31 randomly sampled years, while the calibration period of the non-stationary model includes 31 consecutive years. By means of the highest and lowest CQVSS of the stationary model, the interval of natural variability is determined. If the non-stationary model includes several consecutive years with a CQVSS outside this range, a non-stationarity is argued for.

Subsequently, composites of the predictor fields have been calculated for calibration and validation periods. Only days with scores of the significant PCs exceeding a certain threshold have been taken into account. A comparison of both periods shows differences in the large-scale atmospheric circulation which are responsible for the non-stationary behavior of heavy precipitation events at the specific weather stations.