Geophysical Research Abstracts
Vol. 18, EGU2016-6876, 2016
EGU General Assembly 2016

Statistical downscaling allowing for non-stationarities in the predictors-predictand relationships

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Statistical downscaling methods have been developed to obtain regional to local climate change information from large-scale general circulation model (GCM) output. Typically relationships of the large-scale atmospheric predictors and regional climate variables (predictands) are considered in an observational period. In the scope of transferring these relationships to other time periods (validation and future projection periods) than the one used for model set-up (calibration period), it is assumed that the predictors-predictand relationships remain the same through time. However, there is substantial evidence that these relationships are varying. Non-stationarities emerge from substantial modifications of the atmospheric circulation, which lead to significant changes of regional climate characteristics, like regional temperature and precipitation patterns.
Two novel approaches have been developed to allow for non-stationarities in the framework of statistical downscaling. One approach is based on the results from running calibration periods. The observational period is split into appropriate sub-periods (e.g. 31-year periods), each shifted by 1 year. A statistical model is calibrated for each sub-period and subsequently validated in the years outside of the calibration period. Non-stationarities are then detected by comparing the model performance of an individual sub-period to the overall model performance or to the model performance under stationary conditions. The second approach comprises a change point analysis within generalized linear models. Composites of the atmospheric characteristics before and after a change point are also used within a cumulative sums approach to identify the change points in the predictor data only.
The approaches are illustrated by means of statistical downscaling of precipitation in the Mediterranean area until the end of the 21st century. It is shown that there is a great variability in the circulation of the North-Atlantic-European sector in the observational data and in the GCM data; this variability can cause non-stationarities in the relationships between large-scale circulation and Mediterranean precipitation. Since different statistical models can be selected according to the prevailing predictor characteristics, the non-stationary downscaling approaches allow for a flexible estimation of future precipitation changes in response to these predictor changes.
This research project has been funded by the German Research Foundation DFG.