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Bias correction with consistent quantile trends – regression quantile mapping and its application to selected Euro-CORDEX simulations

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During the last years, accumulating evidence for climate change has triggered a rising demand for reliable climate projections and associated risk assessments. To ensure plausible and physically realistic projections, climate impact studies require unbiased and meaningful climate model data as input. However, state-of-the-art General Circulation Models (GCMs) or Regional Climate Models (RCMs) still commonly exhibit large systematic biases resulting from a multiplicity of factors like erroneous boundary conditions, imperfect parameterizations, coarse resolution or general misrepresentations of atmospheric processes.

In order to cope with these biases, statistical bias correction methods are commonly applied before employing climate model outputs for further studies. Most notably, quantile mapping (QM) is frequently used to correct systematic biases in multiple quantiles of the distribution of a climatic variable. It shows remarkable results in removing biases in climate simulations and outperforms simpler correction methods, which only address biases in the mean or the variance of the variable of interest. However, it has been shown that QM tends to unintentionally modify the simulated climate trends. Therefore, trend preserving versions of QM have been introduced in the form of detrended quantile mapping (DQM) and quantile delta mapping (QDM). Still, all versions and applications of QM struggle to fully respect the time-dependent character of the quantiles over the investigated period, which can be misleading in the context of a changing climate.

Here, we propose the alternative approach of regression quantile mapping (RQM), a novel combination of linear quantile regression (QR) and the classical QDM method, which provides a consistent, time-dependent and trend adjusting bias correction of climate simulations. In order to study the performance of this new algorithm, we present a systematic application to climate simulations of three di[U+FB00]erent RCMs from the Euro-CORDEX ensemble. Using historical runs (1960 - 2005) in comparison with observations (E-OBS), we demonstrate the efficiency and reliability of our method. Subsequently, we employ the accordingly derived bias correction to RCP 4.5 scenario runs of the same three models for the period 2055 – 2100. Our results demonstrate that RQM already generates accurate trends when using a simple regression model consisting of only an annual cycle and linear trend. Additionally, the spatial distribution and annual cycle of precipitation after bias correction is markedly improved as compared to the common QDM method. For the projected period, we identify overall more intense precipitation trends in those regions of Europe which already showed a considerable climate change effect in the historical period. A systematic analysis of the relative change between the historical and the future period shows consistent opposite behaviors above the northern parts of Europe and the regions around the Mediterranean Sea, with Northern Europe exhibiting increasing and Southern Europe decreasing precipitation.