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Statistical Downscaling of Large-Scale Wind Signatures Using a Two-Step Approach

R. Haas (1), K. Born (1), A. Georgiadis (2), M. K. Karremann (1), and J. G. Pinto (1)

(1) Institute for Geophysics and Meteorology, University of Cologne, Germany (rhaas@meteo.uni-koeln.de), (2) Impact Forecasting, Aon Benfield, London, United Kingdom

Downscaling global scale climate data is an important issue in order to obtain high-resolution data desired for most applications in meteorology and hydrology and to gain a better understanding of local climate variability. Statistical downscaling transforms data from large to local scale by relating punctual climate observations, climate model outputs and high-resolution surface data.
In this study, a statistical downscaling approach is used in combination with dynamical downscaling in order to produce gust characteristics of wind storms on a small-scale grid over Europe. The idea is to relate large-scale data, regional climate model (RCM) data and observations by transfer functions, which are calibrated using physically consistent features of the RCM model simulations. In comparison to purely dynamical downscaling by a regional model, such a statistical downscaling approach has several advantages. The computing time is much shorter and, therefore, such an approach can be easily applied on very large numbers of windstorm cases provided e.g. by long-term GCM model simulations, like millennium runs.
The first step of the approach constructs a relation between observations and COSMO-CLM signatures with the aim of calibrating the modelled signatures to the observations in terms of model output statistics. For this purpose, parameters of the theoretical Weibull distribution, estimated from the observations at each test site, are interpolated to a 7km RCM grid with Gaussian weights and are compared to Weibull parameters from the COSMO-CLM modelled gust distributions. This allows for an evaluation and correction of gust signatures by quantile mapping.
The second step links the RCM wind signatures and large-scale data by a multiple linear regression (MLR) model. One model per grid point is trained using the COSMO-CLM simulated and MOS-corrected gusts for selected wind storm events as predictands, and the according NCEP reanalysis wind speeds of the surrounding NCEP grid points as predictors.
For validation purposes, the model is again applied on NCEP reanalysis data. The statistical model is able to reproduce well the observed regional scale wind signatures. Afterwards, the statistical model is applied to ECHAM5 climate simulation data to generate large numbers of downscaled wind gust signatures at high spatial resolution. For further analyses, statistical values as mean, minimum and maximum wind gust speeds are compared at every grid point.