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Statistical-dynamical downscaling for wind energy potentials: Evaluation and applications to decadal hindcasts and climate change projections

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A statistical-dynamical downscaling (SDD) approach for the regionalisation of wind energy output (Eout) over Europe with special focus on Germany is proposed. SDD uses an extended circulation weather type (CWT) analysis on global daily MSLP fields with the central point being located over Germany. 77 weather classes based on the associated circulation weather type and the intensity of the geostrophic flow are identified. Representatives of these classes are dynamical downscaled with the regional climate model COSMO-CLM. By using weather class frequencies of different datasets the simulated representatives are recombined to probability density functions (PDFs) of near-surface wind speed and finally to Eout of a sample wind turbine for present and future climate. This is performed for reanalysis, decadal hindcasts and long-term future projections. For evaluation purposes results of SDD are compared to wind observations and to simulated Eout of purely dynamical downscaling (DD) methods.

For the present climate SDD is able to simulate realistic PDFs of 10m-wind speed for most stations in Germany. The resulting spatial Eout patterns are similar to DD simulated Eout. In terms of decadal hindcasts results of SDD are similar to DD simulated Eout over Germany, Poland, Czech Republic, and Benelux, for which high correlations between annual Eout timeseries of SDD and DD are detected for selected hindcasts. Lower correlation is found for other European countries. It is demonstrated that SDD can be used to downscale the full ensemble of the MPI-ESM decadal prediction system.

Long-term climate change projections in SRES scenarios of ECHAM5/MPI-OM as obtained by SDD agree well to results of other studies using DD methods, with increasing Eout over Northern Europe and a negative trend over Southern Europe. Despite some biases it is concluded that SDD is an adequate tool to assess regional wind energy changes in large model ensembles.