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Possible changes in wind energy potentials over Europe under future climate conditions using an RCM ensemble

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The impact of climate change on wind power generation potential over Europe is investigated considering two ECHAM5/MPI-OM1 driven regional climate models (RCMs: COSMO-CLM and REMO). Grid resolution is 0.44° for REMO and 0.2° x 0.2° for COSMO-CLM. Wind energy density in 10 m is estimated using hourly near-surface wind speed from RCMs. Additionally, wind speeds are extrapolated to a prevalent wind turbine hub height of 80 m using a power law profile, in order to estimate the energy output for an example turbine (2.5 MW).

The bias of GCM climate scenarios is assessed by comparing energy densities for recent climate conditions simulated with ECHAM5 (20C, 1961-2000) and with reanalysis data (ERA-40) driven RCM simulations. Results show similar features in both datasets, as seasonal differences and spatial patterns are comparable. However, the magnitude of energy density is typically higher in the ECHAM5/MPI-OM1 driven data for every season. Results are also sensitive to the choice of RCMs: higher energy densities are obtained for COSMO-CLM compared to REMO. The inter-annual variability is less consistent between two datasets showing high sensitivity to the boundary conditions. The bias is similar for the energy output of the sample turbine, only of lower magnitude.

In order to estimate future changes in wind energy density and inter-annual variability, data for recent (20C) and future climate conditions (SRES A1B; 2061-2100) is compared. Further, changes in the seasonal distribution and the inter-annual variability of energy density are analyzed. Results show significant changes (95% confidence level) of the mean energy density in some areas, particularly over the North Sea, Baltic Sea and Mediterranean Sea. In annual terms, there are only little changes in the mean energy density, but the inter-annual variability increases significantly in particular for Western Europe. In seasonal terms, changes are much more substantial: For northern Europe, a significant increase is projected especially during wintertime over the North and Baltic Seas, whereas the Mediterranean may experience a decrease in energy density in summer and winter. Changes are comparatively smaller in spring and autumn. Assessing the influence of future changes on performance of the sample turbine, the results are similar for annual and seasonal energy output to the changes in near-surface energy density, though of lower magnitude. Concerning inter-annual variability, significant changes occur only for small areas in Western Europe in terms of the energy output. The changes in wind energy indices are associated with alterations of the large-scale circulation over the Euro-Atlantic area during the 21st Century.