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Correlations and Variability of Wind Speed Fields and Wind Power in Europe

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Many scenario studies (like www.OffshoreGrid.eu) use time series of wind power production from all European wind farms that have to be integrated into future electricity grids.
For this purpose, we calculated 3-dim wind field time series over the North Atlantic, Europe and its seas using mesoscale weather simulations. We used global weather analysis data from ECMWF and NCEP/NCAR, own mesoscale model runs (WRF) and operational weather analysis data from the German Weather Service (COSMO model). We validated, compared and blended the different model results to obtain time series of 10 years with hourly resolution and 7km grid spacing.

The wind speed time series were calculated for all relevant hub heights, e.g. 70m, 90m and 100m. Special attention was paid to the vertical wind profiles in different thermal stratifications, which were modeled here with an improved MYJ-scheme for the atmospheric boundary layer.
In order to model the output of onshore and offshore wind farms, newest investigations on real-life (dynamic) power curves, array losses due to wake effects, electrical losses and turbine availabilities were used.

We calculated European wind resource maps and detailed statistics of local, clustered and regional wind power production. The analysis quantifies spatio-temporal correlations, gradients, extreme events and ramps in wind speed and produced power. Important results are the magnitudes of smoothing effects in a pan-European SuperGrid.

Based on the time series, we developed a new way of visual interpretation with European maps showing different statistical properties of the wind power production for every grid point in Europe.
One of these innovative maps shows the correlation of wind power production in each grid box (dx=7km, on&offshore) with the aggregated power of all turbines in Europe (or any other reference time series). Not surprisingly, the map reflects that the wind power production is strongly correlated from West to East (e,g. England, BeNeLux, Germany, Denmark and Poland), but not much between North and South (e.g. Denmark/France). Besides that the main wind direction is from West to East, especially the low pressure weather systems with strong wind speeds move mainly from west to east. This leads to a correlation between England and Germany of about 0.50, in contrast to only 0.18 between France and Germany.

Therefore, Europe should invest massively in grid interconnections between regions of low weather correlation: mainly in north-south directions.