November, 20^{th}, 2015

Thesis Topics - Wind Energy Meteorology

Team: Energy Weather Forecasting and Analysis (E-WAYS) Dr. Lueder von Bremen

Improving the analog ensemble method for regional ensemble wind power forecasts *(Masters-Thesis)*

Due to the strong increase in wind power capacities, there is a growing need for improving ensemble forecasts of local and regional wind power. The analog ensemble method is a state-of-the-science approach for generating ensemble forecasts from deterministic output of Numerical Weather Prediction models. In this thesis, different variants of the analog ensemble method will be developed to generate accurate and reliable ensemble forecasts of regional wind power.

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Further application of the analog ensemble method *(Bachelors/Masters-Thesis)*

The Analog Ensemble (AnEn) method is ideal to relate weather variables like wind speed, pressure, temperature, global radiation, etc. to various quantities that shall be estimated/forecasted. The advantage of the robust AnEn method is that the uncertainty of the estimation/forecast is provided. New and possible applications are: power price forecasting, load forecasting and wind/solar resource estimation.

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Ensemble wind power forecasting on the European scale *(Masters-Thesis)*

The forecast skill for a portfolio of wind power plants is significantly higher than for a single wind farm. The effect is known as 'forecast error smoothing' and happens due to uncorrelated short-term forecast errors. In this thesis, the potential of European wide forecast error smoothing will be analysed for ensemble forecasts. The 51 member ensemble predictions system of the European Center for Medium Range Weather Forecasts (ECMWF) will be used. The error smoothing in probabilistic scores will be studied and the need for ensemble calibration will be investigated.

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Analysis of renewable power flows in Europe *(Bachelors/Masters-Thesis)*

In this thesis the impact of power flows by renewable energies like wind and PV power and CSP in the European power grid will be analysed. The current status of reneweable deployment and the future status (in 2050) is looked at. Long time series of renewable generation and load (consumption) are available. Furthermore, a simple grid model with varying grid topology is provided. Through flow tracing it can be tracked which links between countries are used by which renewable source. The results indicate the risk of severe power line congestions and may provide solutions.

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Analysis of renewable power flows in Germany *(Internship (2 months))*

In this internship, power flows due to high shares of renewable energies – like wind and PV – in the German power grid shall be analysed. Data and software tools to compute power flows

will be provided. After some training the student will be able to modify the grid topology on its own and to perform sensitivity studies. Methodologies to derive optimal grid topologies shall be investigated and general insights in this complex system's behaviour shall be gained. For example the benefit of an overlay power grid that connects wind energy in the North of Germany with load centers in the South can be studied.

Literature: S. Becker, R.A. Rodriguez, G.B. Andresen b, S. Schramma, M. Greiner, 2014: Transmission grid extensions during the build-up of a fully renewable pan-European electricity supply, Energy 64, 404-418

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Wind resource assessment using the Analog Ensemble Method *(Internship (2 months))*

When planning new wind farm projects, wind observations are used to compute the long-term energy yield (wind resouce assessment). However, usually wind observations are not available for many years what leads to uncertainty in the wind resource assessment. In order to obtain a long-term reference wind data from mesoscale models is used to account for interannual variability of the wind. The Analog Ensemble method is a new innovative approach to find similar weather conditions in the long-term mesoscale data. Thus, it can be estimated how frequent the real observations might have occured in the past. All necessary data (wind observations and mesoscale model data) and all required computer source codes and scripts are provided. After some training the student is able to apply the Analog Ensemble method on its own to new observation sites and to use mesoscale data that has not been tested before.

Literature: Emilie Vanvyve, Luca Delle Monache, Andrew J. Monaghan, James O. Pinto, 2015: Wind resource estimates with an analog ensemble approach, Renewable Energy 74 (2015), 761-773

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What do you need?
Enthusiasm for meteorology and wind energy; Basic expertise in atmospheric science; Experience in statistics, data analysis and good programming skills (preferably Fortran/C and/or IDL/matlab/R)