Geophysical Research Abstracts
Vol. 19, EGU2017-11846, 2017
EGU General Assembly 2017

Wind speed and wind power short and medium range predictions for complex terrain using artificial neural networks and ensemble calibration

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Reliable predictions of wind speed and wind power are vital for balancing the electricity network. Within the last two decades the amount of energy stemming from renewable sources increased substantially relying heavily on the prevailing synoptic conditions. Especially for regions with complex terrain and forested surfaces providing reliable predictions is a challenging task. Forecasts in the nowcasting as well as in the (two) day-ahead range are thus essential for the network balancing.
Predictions of wind speed and wind power from the nowcasting to the +72-hour forecast range using NWP models in regions with complex terrain need a suitable horizontal, vertical and temporal resolution (e.g. 10 – 15 minute forecasts for the Nowcasting range) requiring high performance computing. To be able to provide sub-hourly to hourly forecasts different approaches such as model output statistics (MOS) or artificial neural networks (ANN) – including feed forward recurrent neural networks, fuzzy logic, particle swarm optimizations – are needed as computational costs are too high.
To represent the forecast uncertainties additional probabilistic ensemble predictions are required increasing the computational needs. Ensemble prediction systems account for errors and uncertainties in the initial and boundary conditions, parameterizations, numeric, etc. Due to the underestimation of model and sampling errors ensemble predictions tend to be underdispersive and biased. They lack, too, sharpness and reliability. These shortcomings can be accounted for using statistical post-processing methods such as the non-homogeneous Gaussian regression (NGR) to calibrate an ensemble. These calibrated ensembles provide forecasts in the medium range for any arbitrary location where observations are available.
In this study an ANN is used to provide forecasts for the nowcasting and medium-range with sub-hourly to hourly predictions for different Austrian sites, including high alpine sites as well as low-land and hilly sites. Special emphasis will be on wind farms in complex terrain. The ANN will use, on one hand, single and a combination of different deterministic NWP models, such as the ALARO, the AROME and the AROME-Nowcasting model, and observations as input to provide a most-likely and best-forecast deterministic prediction. On the other hand, an uncertainty estimation will be provided using the calibrated LAEF-ensemble. Performance of the ANN will be estimated using cross-validation and observations.