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Probabilistic forecasts of wind turbine icing in Central Europe

Lukas Strauss (1), Stefano Serafin (1), Manfred Dorninger (1), Saskia Bourgeois (2), and Thomas Burchhart (3)
(1) University of Vienna, Department of Meteorology and Geophysics, Vienna, Austria (lukas.strauss@univie.ac.at), (2) Meteotest, Bern, Switzerland, (3) VERBUND Hydro Power, Vienna, Austria

Probabilistic prediction of wind speed for wind energy power production has received significant attention in the past years. The ICE CONTROL project, an Austrian research initiative, aims to extend the probabilistic approach towards the forecasting of turbine icing conditions, responsible for considerable losses of wind power production at sites located in cold climates or in complex terrain. ICE CONTROL includes an experimental field phase, consisting of two measurement campaigns at a wind farm located in hilly terrain in Rhineland-Palatinate, Germany, during the winters 2016/17 and 2017/18. The comprehensive measurement data allow to verify probabilistic icing forecasts, assessing their value for wind energy producers.

In this contribution, we present verification results from the first winter campaign for the period Nov 2016 to Feb 2017, during which a few severe and a number of lighter icing cases occurred at the wind farm. To predict meteorological icing conditions, the Weather Research and Forecasting (WRF) model is used at resolutions of 12.5 km (outer domain) and 2.5 km (inner domain covering Germany). Two 10-member mesoscale model ensembles, both coupled to global ensemble forecasts by the European Centre for Medium-Range Weather Forecasts (ECMWF EPS) are compared: (i) a dynamically downscaled (DD) ensemble, making use of only one WRF physics configuration, and (ii) a multi-physics (MP) ensemble, taking advantage of 10 different WRF configurations.

The ensemble model verification of temperature, humidity, wind speed, ice rate and ice load (as derived using the Makkonen icing model) shows encouraging skill of both the DD and MP ensembles to predict icing conditions in the 60-h time frame. However, at a model resolution of 12.5 km, both ensembles are underdispersive (i.e. do not fully capture the observational variability of temperature etc.). The MP ensemble generally shows greater sensitivity (i.e. a higher hit rate) at forecasting icing conditions than the DD ensemble, albeit at a somewhat higher rate of false alarms. Simulations at 2.5 km resolution are currently under way and results will be presented.

The probabilistic forecasting approach allows to prescribe optimal actions for turbine operators, e.g., the use of de-icing procedures, whenever the forecasted icing probability exceeds the user's cost/loss ratio (cost/loss analysis).