LAWRENCE LIVERMORE NATIONAL LABORATORY

LLNL-ABS-491653

# Limited Area Model-Based Data Impact Studies to Improve Short-Range Wind Power Forecasting

J. Manobianco, E. J. Natenberg, K. Waight, G. Van Knowe, J. Zack, D. Hanley, C. Kamath

August 1, 2011

AMS Annual Meeting
New Orleans, LA, United States
January 22, 2012 through January 26, 2012

Limited Area Model-Based Data Impact Studies to Improve Short-Range Wind Power Forecasting

John Manobianco, E. J. Natenberg, K. Waight, G. Van Knowe, J. Zack, and D. Hanley, AWS Truepower, LLC, Albany, NY
Chandrika Kamath, Lawrence Livermore National Laboratory, Livermore, CA

Large increases or decreases in wind power production, also known as ramp events, can be produced by modest changes in wind speed when turbines are operating in the most steeply sloping portions of the power curve. The improvement of 1- to 3-hour ahead (i.e. short-range) wind forecasts has the potential to reduce the impact of occasional ramp events on grid reliability and lower the cost of integrating wind power on the electrical grid.

One approach for improving short-range wind forecasts is to deploy additional atmospheric sensors in the vicinity of wind power production facilities. A significant issue associated with this approach is determining which locations and variables should be measured to obtain the optimal value from particular sensor deployment scenarios. This issue is being addressed as part of a multi-phased research project known as WindSENSE, funded by the Department of Energy and managed by the Lawrence Livermore National Laboratory.

The WindSENSE Phase I effort focused on short-term forecasts and ramp events in the Tehachapi Pass region of California, while Phase II concentrated on similar forecasts in the mid-Columbia Basin region of Washington and Oregon. In Phase III, the emphasis remains on the mid-Columbia Basin due to the high level of current wind power penetration on the Bonneville Power Authority (BPA) grid and the anticipation that wind penetration levels will significantly increase over the next few years. In addition, BPA is planning to expand its atmospheric sensor network within several years to include additional meteorological towers and possibly remote sensing devices such as sodars, lidars, and Doppler radars.

The completed WindSENSE Phase I and II efforts used an ensemble sensitivity analysis (ESA) technique to map the climatological sensitivity of wind speed forecasts at turbine hub heights (~80 m) to various model state variables for specific forecast look-ahead times. Climatological forecast sensitivity patterns obtained from the ESA for a particular target location provided objective guidance for the development of a sensor deployment plan. However, the ESA did not provide guidance on the number or specific types of instruments needed to make such measurements within sensitive areas or quantify the impact that such observations would have on actually reducing forecast error. Therefore the third phase of the WindSENSE project is using both Observing System Experiments (OSEs) and Observation System Simulation Experiments (OSSEs) to explore the impact of different deployment strategies on short-term forecast improvement.

The goal of the OSEs is to determine the impact of assimilating meteorological (met) tower observations in regions of ESA-predicted high and low sensitivity on the accuracy of target area forecasts. In order to achieve this goal, a three-dimensional variational (3DVAR) scheme within the Advanced Regional Prediction System (ARPS) was used to assimilate actual met tower data during a warm (1 May to 20 June 2007) and cool (1 January to 20 February 2010) season period.

For the OSSEs, ARPS was used to generate a surrogate atmosphere, often called a nature run, from which observations were extracted, representing both existing and planned instrumentation were extracted. These synthetic data were then assimilated in another series of experiments to determine the impact of various observing systems on forecast performance. The results from OSSEs are generally considered more robust if separate models are used for the nature and subsequent data assimilation runs. Therefore, the forecast experiments were performed using the Weather Research and Forecast (WRF) system. In addition, the WRF model was configured in such a manner to generate a significantly different solution from the nature simulation that approximates differences between a state-of-the-art model and the real atmosphere.

To generate nature runs, ARPS was configured with 1-km horizontal grid spacing over an ~800-km by ~700-km region centered on the mid-Columbia Basin and integrated for two different 12-day periods in early January and May 2010. Boundary conditions were provided by an outer nested ARPS grid with 12-km grid spacing. The output from the nature simulations was used to produce simulated sodar, rawinsonde, surface, and other observational data for assimilation by WRF. Several different types of sensor deployments strategies are being tested including configurations with large numbers of sodars and meteorological towers surrounding the most highly sensitive points in three main wind resource generation regions.

The WRF configuration also used nested grids with 4-km spacing on the inner most grid. Data assimilation in WRF was performed every three hours using 3DVAR and a previous 3-h WRF forecast as the background field. In order to mimic an operational forecast configuration and gauge the impact of existing as well as proposed instrumentation, 24-h forecasts were generated every six hours from the WRF data assimilation cycle.

Analysis of both the OSEs and OSSEs results during the warm and cool season periods is currently in progress. The conference presentation will highlight key points from the Phase III project including a summary of the experiment design and conclusions regarding the optimal type and distribution of observations needed to improve short-term wind forecasts for wind power production over the mid-Columbia basin.

LLNL-ABS-491653: This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DEAC52-07NA27344. The work done by AWS Truepower was supported through sub-contract B591225 on the WindSENSE project.