An Evaluation of the WRF Model as a Tool to Produce Wind Forecasts and Climate Statistics for Alberta, Canada

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1. Introduction

MESO, Inc. has integrated the WRF model into various systems that produce high-resolution forecasts and regional climate statistics for the wind power industry. Over the past year, WRF's performance in forecasting the winds has been evaluated as part of a wind power forecasting study for the Alberta Canada region. This paper examines the performance of WRF for the purpose of producing high resolution wind forecasts and climatologies in complex terrain for the wind power industry. Factors looked at will include the source of the land surface data, especially snow cover, and the source of initial and boundary conditions.

2. Modeling System

2.1 Climate Modeling Systems

MESO has integrated WRF into a system designed to produce climate statistics. Until the integration of WRF, the core of this modeling strategy had been the Mesoscale Atmospheric Simulation System (MASS) developed by MESO, Inc. MASS is a mesoscale model which ingests both gridded reanalysis and observational data to provide simulations of the hourly weather for any specified geographical region (Kaplan, et al. 2000). Typically, these individual daily simulations are run over a long time-range of multiple months, or even years, and these simulations form the basis for deriving statistical metrics of the underlying climate.

The climate modeling system designed for wind power assessment has been designed to optimize the model output in order to create wind climate statistics, called wind maps, to aid the wind power industry in siting new wind turbines. The wind mapping system is produced for AWS Truewind, a company that specializes in engineering and site selection for the wind industry. WRF has been added as an additional mesoscale model option when producing the wind statistics used to create the wind maps.

2.2 Forecasting Systems

MESO's real-time systems designed to produce wind energy and agricultural products can also use the WRF model. The forecasting products using WRF have been extensively evaluated and compared with another model.

3. Comparison of MASS and WRF Output

An evaluation was performed to assess the benefit of adding a high-resolution rapid-update-cycle WRF simulation to a suite of model simulations and statistical methods used to produce wind power forecasts in Alberta. The individual forecasts are input into an optimized ensemble algorithm that uses a weighted average based on recent performance to combine the forecasts into a single delivered forecast.

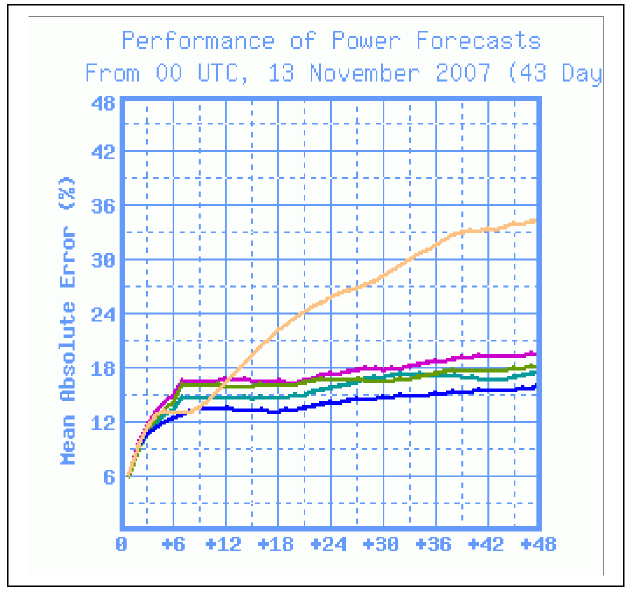
On October 1, 2007, MESO implemented a 4 km resolution simulation (WRF-RUC) using the WRF model based on the National Centers for Environmental Prediction (NCEP) Rapid Update Cycle (RUC) model. This simulation was run every 3 hours for 12 hours. It was available about 2 hours after the initialization time, considerably earlier than the other models which must wait several additional hours for the initial data to become available.

It was hoped that this model and a statistical method based on it's output would significantly improve the 3-9 hour forecast by making frequent, relatively recent model runs available for these forecast times. This was indeed the case for the first 43 days of forecasting. However, starting on November 13, the model forecast quality degraded significantly. After considerable research, it was discovered a bug in the WRF code caused WRF to read the real-time snow cover data improperly. As a result, snow cover was greatly underrepresented in WRF. WRF is a community model. Since AWST did not develop this complex community NWP model, it would require considerable effort on our part to fix this bug. For the most part, we must rely on the WRF developer community to address bugs; however, this happens on their schedule, not ours.

Figure 1 shows the WRF-RUC's statistical method performance versus statistical methods based on several other models and the delivered optimized ensemble for (A) the period before significant snow cover was present in the mountains and (B) after significant snow cover developed in the mountains. During the snow free period, the WRF-RUC had the best forecast for the 6-10 hour period. During the snowy period, it was the worst for nearly all hours. Poor performance continued through the winter until about March 20.

After March 20, the WRF RUC once again performed well. During this period, significant snow cover was present in the mountains, however, the shorter nights, the presence of older snow which behaves more like bare ground in its effects on the atmosphere, and likely a lack of significant snow on the lower eastern slopes of the mountain, made snow cover less of an issue for wind forecasting in the plains. Other than the periods of March 30-April 2 and April 20-26, it once again had the best performing forecast, this time from about 3-4 hours through 10 hours. The two exception periods were both times of snow cover in the existing facilities region due to spring snowstorms. Figure 2 shows an example of spring-time performance during a snowy and snow free period.

In any case, the results show that the RUC approach holds considerable promise for improving forecasts in the 3-10 hour range, if the snow cover issue is resolved. AWST plans to address this issue with WRF in the near future.



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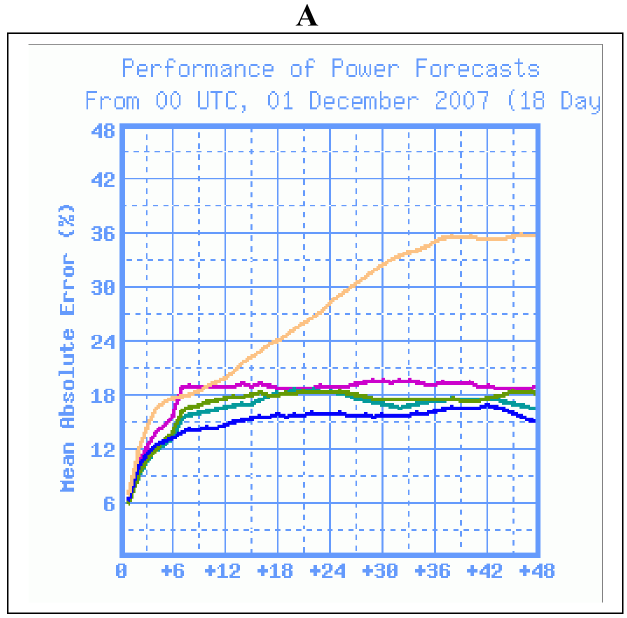

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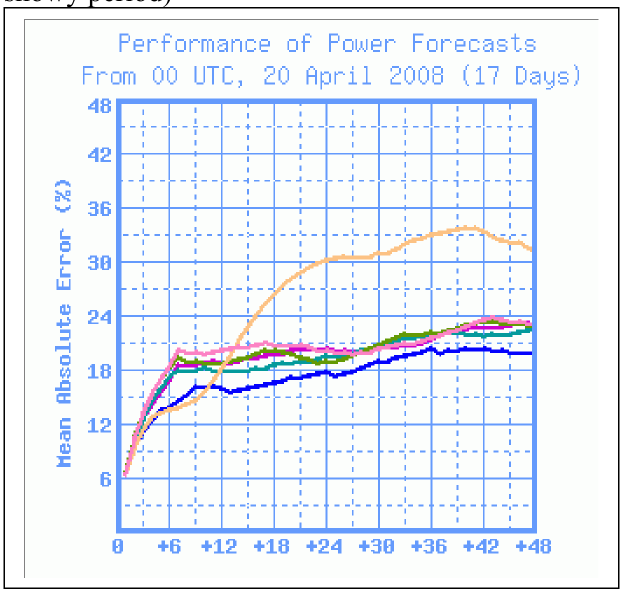
Figure 1. A comparison of the mean absolute power forecast error for the aggregate power output of 7 wind farms in Alberta for the delivered optimized ensemble forecast (blue),

the WRF-RUC's statistical method (peach) and statistical methods based on other physics-based models (other colors) for the periods of (A) October 1-November 12, 2007 (a snow-free period), and (B) November 13-30, 2007 (a snowy period)



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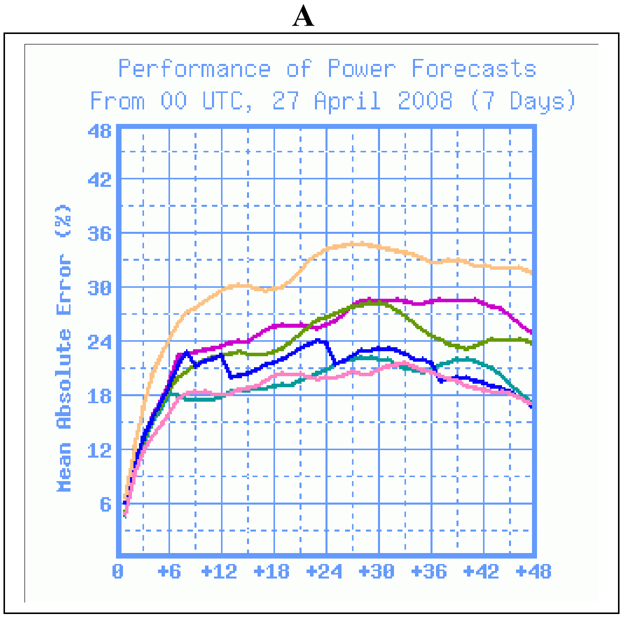

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Figure 2. A comparison of the mean absolute power forecast error for aggregate power output of 7 wind farms in Alberta for the delivered optimized ensemble forecast (blue), the WRF-RUC's statistical method (peach) and statistical methods based on other physics-based models (other colors) for the periods of (A) April 3-19, 2008 (a snow free period), and (B) April 20-26, 2008 (a snowy period).

5. References

Kaplan, M. L., Y.-L. Lin, J. J. Charney, K. D. Pfeiffer, D. B. Ensley, D. S. DeCroix, and R. P. Weglarz, 2000: A Terminal Area PBL Prediction System at Dallas-Fort Worth and its application in simulating diurnal PBL jets. Bull. Amer. Meteor. Soc., 81, 2179-2204.

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