Wind Farm Forecasting Using WRF

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The goal of this study is to test different options within the Applied Research Weather Research and Forecasting (WRF-ARW) Model in order to find the best short range forecast for predicting wind downtimes, as well as extreme wind events.

WRF is used to forecast 80 meter wind speeds for the PrairieWinds ND1 wind farm, located near Minot, ND. The PrairieWinds ND1 wind farm consists of 77 turbines, which total 115.5 megawatts.

Power production data from the wind farm was supplied for 2010.

Four, seven day time periods from 2010 are studied (1-7 April 2010; 1-7 July 2010; 1-7 October 2010, 1-7 January 2011). Each time period covered a different meteorological season. Different boundary layer schemes are tested for each time period. For each WRF run, a twenty-four hour forecast is provided every six hours, including the assimilation of regional surface observations, and soundings, through the larger week-long forecast period.

To evaluate each boundary layer scheme, forecast output is compared to power production data from the wind farm. Output was also compared soundings from the two nearest sounding sites, Glasgow, MT and Bismarck, ND.

We used the same physics schemes were used for all of the options, with the exception of the planetary boundary layer schemes, and the corresponding surface layer schemes. We used the following schemes: Microphysics--Ferrier, Longwave Radiation—Rapid Radiative Transfer, Shortwave Radiation—Dudhia, Land Surface—Noah, Cumulus—none.

Results presented today are for the week of July 1 to July 7, 2010. For the July run, we tested the YSU, MYNN 2.5, and MYJ boundary layer schemes. The MYJ forecast was eliminated because it was the least accurate. The following table shows the three schemes and descriptions.

Boundary Layer Scheme	Description
Yonsei University (YSU)	Uses many grid points to parameterize turbulence using the K Theory. Also has an explicit entrainment layer.
Mellor-Yamada Nakanishi and Niino Level 2.5 (MYNN 2.5)	Uses sub-grid points to parameterize turbulence.
Mellor-Yamada-Janjic (MYJ)	Uses each grid point to solve for turbulence.

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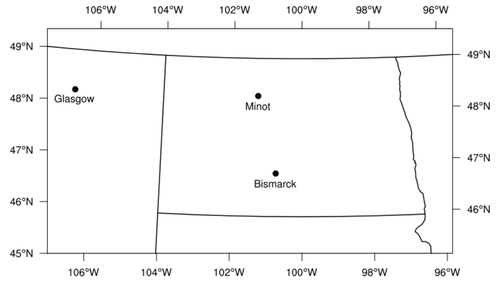

Figure 1. The location of the PrairieWinds ND1 wind farm (Minot, ND) and the sounding sites.

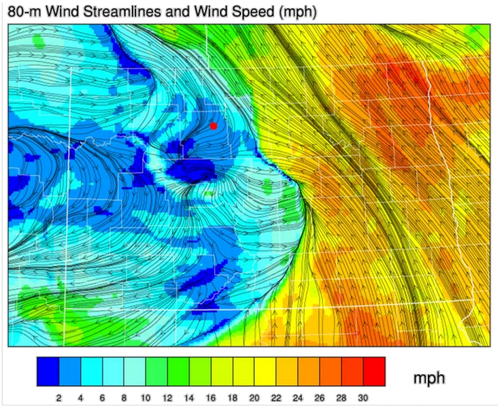

Figure 2. An example of a forecast wind plot. The colored contours show the 80 meter wind speed, from 0 mph to 32 mph. The streamlines show divergent and convergent wind at 80 meters.

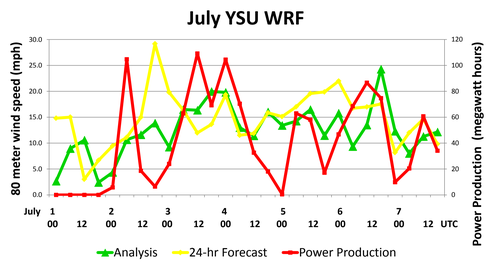

Figure 3. The power produced at the PrairieWinds ND1 wind farm (red), with the YSU forecast analysis (green) and the 24 hour forecast (yellow).

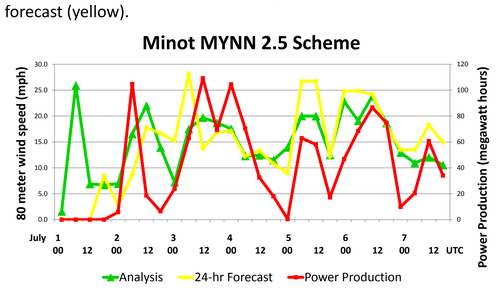

Figure 4. The power produced at the PrairieWinds ND1 wind farm (red), with the MYNN 2.5 forecast analysis (green) and the 24 hour forecast (yellow).

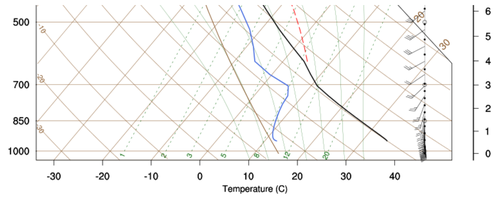

Figure 5. Our 24 hour forecast sounding for Bismarck, ND on July 2, at 00z, using the YSU scheme.

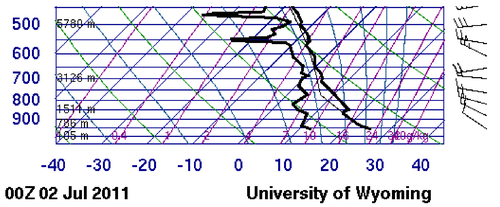

Figure 6. The actual sounding for Bismarck, ND on July 2, at 00z, using the YSU scheme (University of Wyoming).

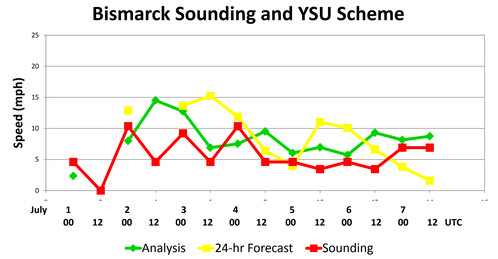

Figure 7. The 500 meter wind speed recorded by the Bismarck sounding (red), with our analysis forecast (yellow) and 24 hour forecast (orange), for the YSU scheme.

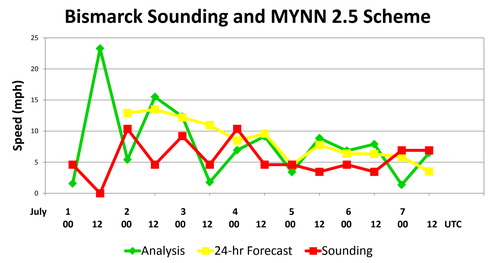

Figure 8. The 500 meter wind speed recorded by the Bismarck sounding (red), with our analysis forecast (yellow) and 24 hour forecast (orange), for the MYNN 2.5 scheme.

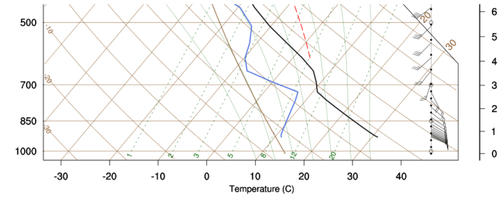

Figure 9. Our 24 hour forecast sounding for Glasgow, MT on July 2, at 00z, using the YSU scheme.

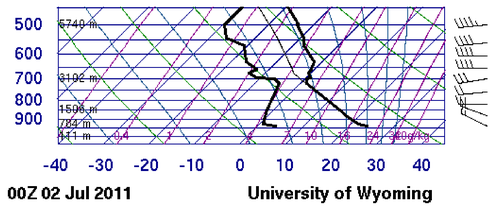

Figure 10. The actual sounding for Glasgow, MT on July 2, at 00z, using the YSU scheme (University of Wyoming).

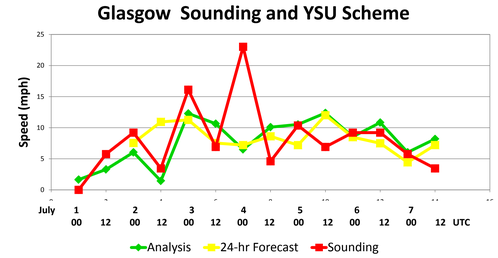

Figure 11. The 700 meter wind speed recorded by the Glasgow, MT sounding (red), with our analysis forecast (yellow) and 24 hour forecast (orange), for the YSU scheme.

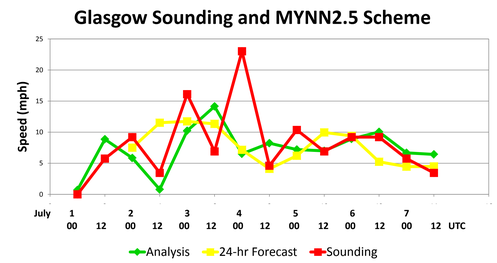

Figure 12. The 700 meter wind speed recorded by the Glasgow, MT sounding (red), with our analysis forecast (yellow) and 24 hour forecast (orange), for the MYNN 2.5 scheme.

Conclusions and Future Work

This project will be continued for the three remaining time periods. Statistical analysis will be performed and will be included in the final discussion.

1. For the July run, the best boundary layer scheme is the YSU scheme.
2. All of the schemes being used for the July run are able to predict the occurrence of convective weather.
3. All of the schemes have difficulty pin pointing the area and time of storms. The scheme that is the closest at predicting the timing and location of storms was the YSU scheme.