Analysis of WRF Model Forecast Wind Speed Skill at Various Heights over NW Missouri

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Introduction

America has set a goal to have 20% of its electrical power produced by wind by the year 2030. In order to reach this goal, power companies must rapidly expand their wind energy operations. Wind turbines generate a significant amount of wind power; however, much of it is wasted due to poor forecasting. Because the energy companies are forced to sell energy in advance, accurate forecasting models will save money for both the company and customers.

Data and Methodology

Wind data were provided by Dr. Neil Fox of the University of Missouri. Three towers located in Northwest Missouri (Mound City, Maryville, and Blanchard) were used for this study. Data obtained from the towers were collected in ten-minute intervals from April 1, 2009 through April 12, 2009. Data included wind speed and wind direction at four heights, 65m, 97m, 117m, and 137m. Equipment malfunctions at Blanchard limited trustworthy data to those from only the 137-m height.

Graduate student Adam Deppe provided forecast data produced by models with six different planetary boundary layer schemes: Mellor Yamada Janjic (MYJ), Yonsei University Scheme (YSU), Quasi Normal Scale Elimination (QNSE), Pleim or Asymmetric Convective Model (ACM2), Mellor Yamada Nakanishi Nino 2.5 and 3.0 (MYNN 2.5 and MYNN3.0). Initial conditions were provided by the GFS global model, and the forecast domain had grid resolution of 10 km. The domain stretches from west of the Rocky Mountains to central Illinois and from the Canadian border to central Oklahoma. Data from the three towers were initially analyzed to reveal basic trends of wind speed and wind direction for multiple 54-hour periods. Observed wind speeds at different heights were then compared to forecast data where mean absolute error (MAE) was calculated. Comparisons were then drawn from different locations and heights across Northwest Missouri.

Figure 1

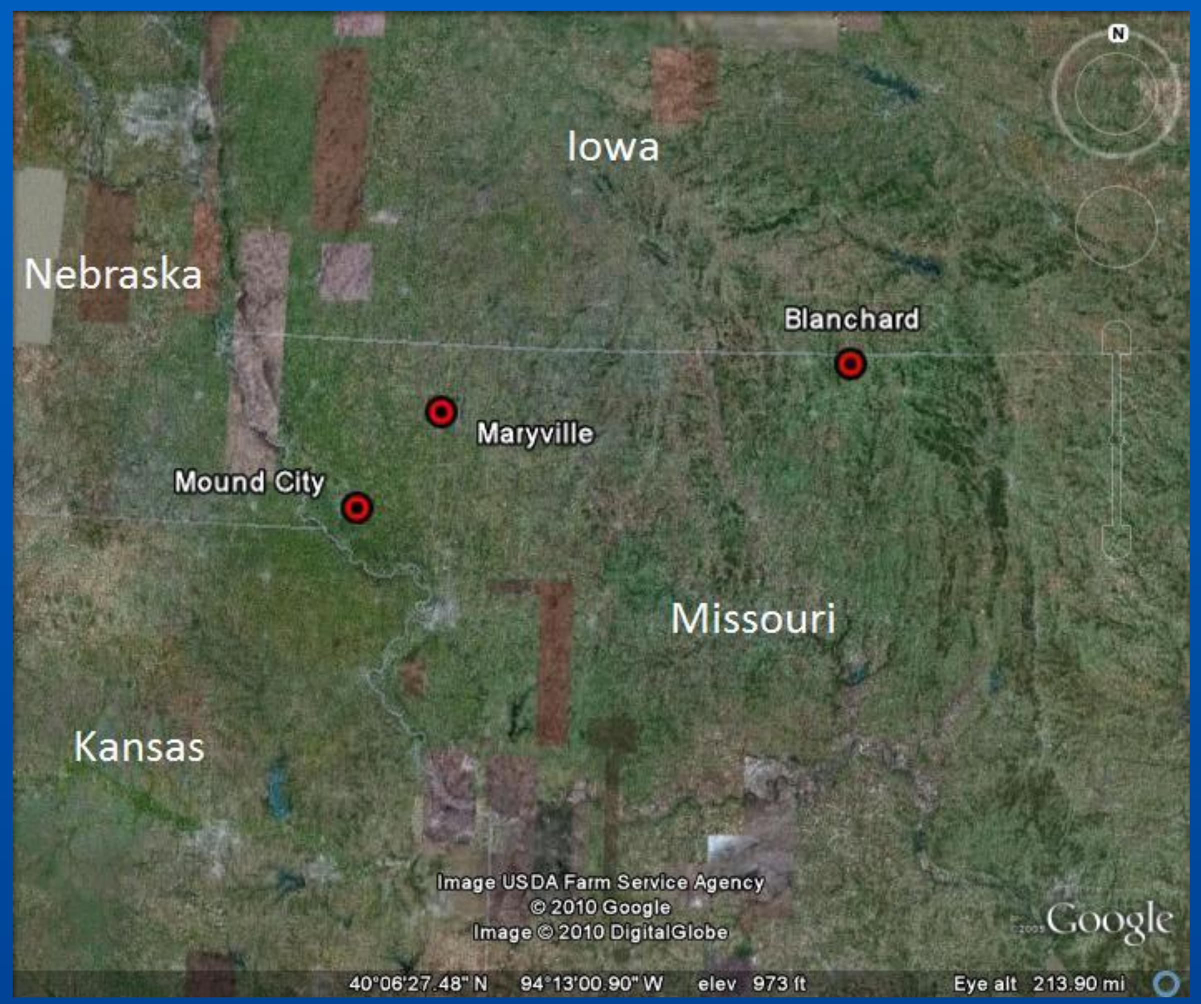

Figure 1 shows the locations of the three wind towers of which we drew data.

Results

Table 1 - 67 m Height

PBL Scheme	Maryville MAE			Mound City MAE		
	6 – 30 hr	30 – 54 hr	6 – 54 hr	6 – 30 hr	30 – 54 hr	6 – 54 hr
MYJ	1.730	1.901	1.804	2.275	2.104	2.182
YSU	1.680	1.579	1.616	2.309	2.231	2.258
Pleim	1.637	1.599	1.607	2.244	2.010	2.125
QNSE	1.827	2.023	1.913	2.429	2.138	2.271
MYNN 2.5	1.942	1.875	1.894	2.476	2.262	2.359
MYNN 3.0	1.907	1.874	1.878	2.444	2.224	2.325
Ensemble Mean	1.676	1.635	1.644	2.288	2.064	2.168

Table 2 - 97 m Height

PBL Scheme	Maryville MAE			Mound City MAE		
	6 – 30 hr	30 – 54 hr	6 – 54 hr	6 – 30 hr	30 – 54 hr	6 – 54 hr
MYJ	2.102	2.264	2.166	2.312	2.051	2.173
YSU	1.761	1.739	1.742	2.142	2.081	2.107
Pleim	1.892	1.932	1.897	2.220	2.034	2.124
QNSE	2.208	2.420	2.296	2.477	2.114	2.287
MYNN 2.5	2.158	2.147	2.135	2.411	2.177	2.289
MYNN 3.0	2.113	2.115	2.100	2.347	2.122	2.229
Ensemble Mean	1.927	1.924	1.910	2.220	1.961	2.085

Table 3 - 117 m Height

PBL Scheme	Maryville MAE			Mound City MAE		
	6 – 30 hr	30 – 54 hr	6 – 54 hr	6 – 30 hr	30 – 54 hr	6 – 54 hr
MYJ	2.266	2.417	2.321	2.552	2.222	2.373
YSU	1.813	1.807	1.803	2.130	2.012	2.064
Pleim	1.924	2.034	1.963	2.356	2.121	2.229
QNSE	2.370	2.596	2.464	2.727	2.346	2.517
MYNN 2.5	2.206	2.245	2.207	2.542	2.283	2.397
MYNN 3.0	2.128	2.187	2.143	2.444	2.188	2.302
Ensemble Mean	1.995	2.026	1.992	2.371	2.058	2.199

Table 4 - 137 m Height

PBL Scheme	Blanchard MAE		
	6 – 30 hr	30 – 54 hr	6 – 54 hr
MYJ	1.896	1.957	1.922
YSU	1.612	1.822	1.707
Pleim	1.718	1.760	1.727
QNSE	2.098	2.071	2.076
MYNN 2.5	1.881	1.865	1.864
MYNN 3.0	1.772	1.831	1.792
Ensemble Mean	1.695	1.667	1.671

Tables 1-4 depict mean absolute error for various time periods and corresponding PBL Schemes. Various heights are represented in the tables above.

Results (cont.)

Figure 2A

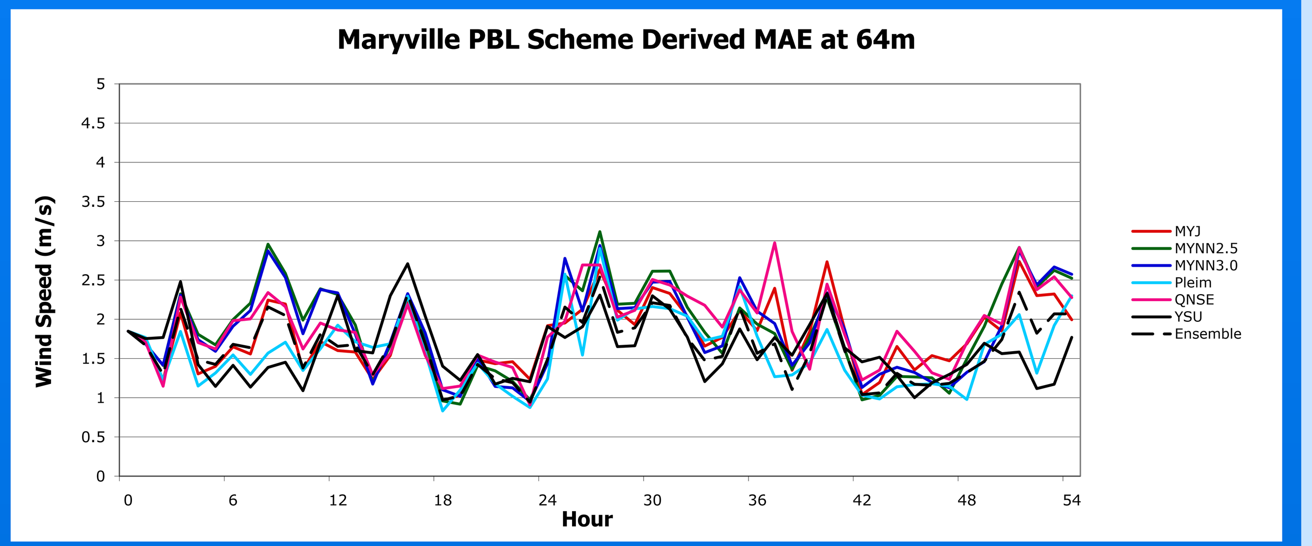

Figure 2B

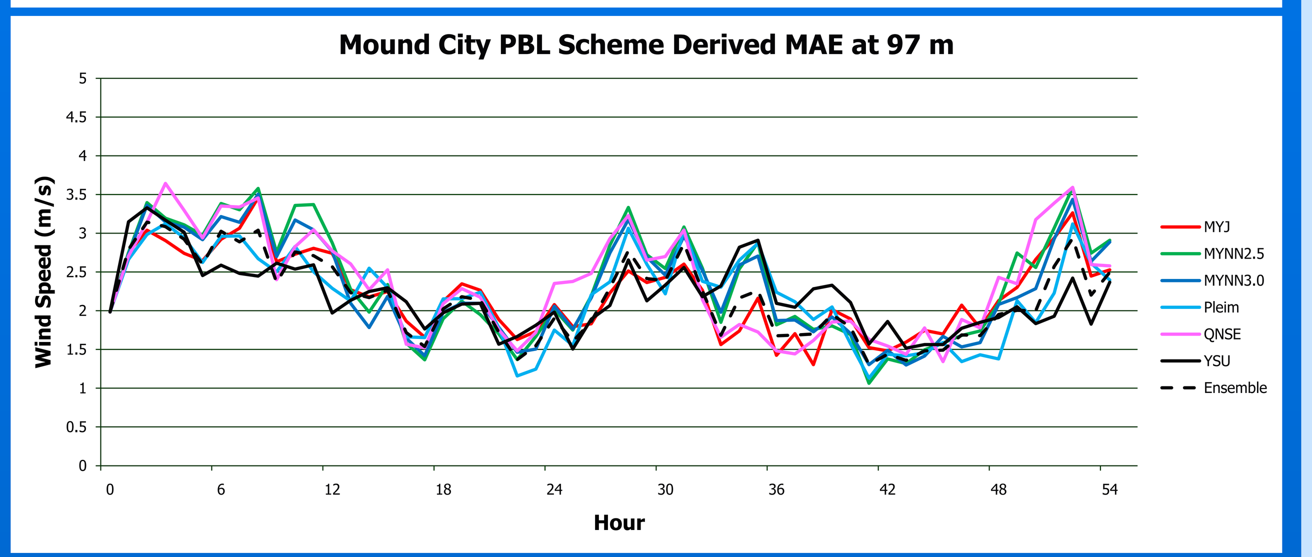

Figure 2C

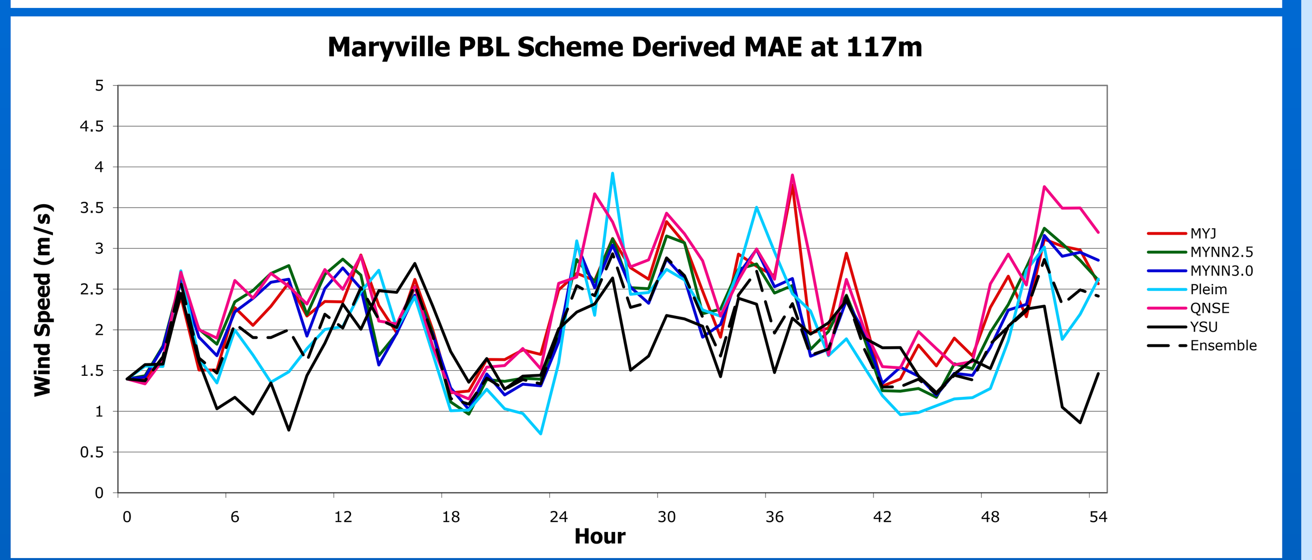

Figure 2D

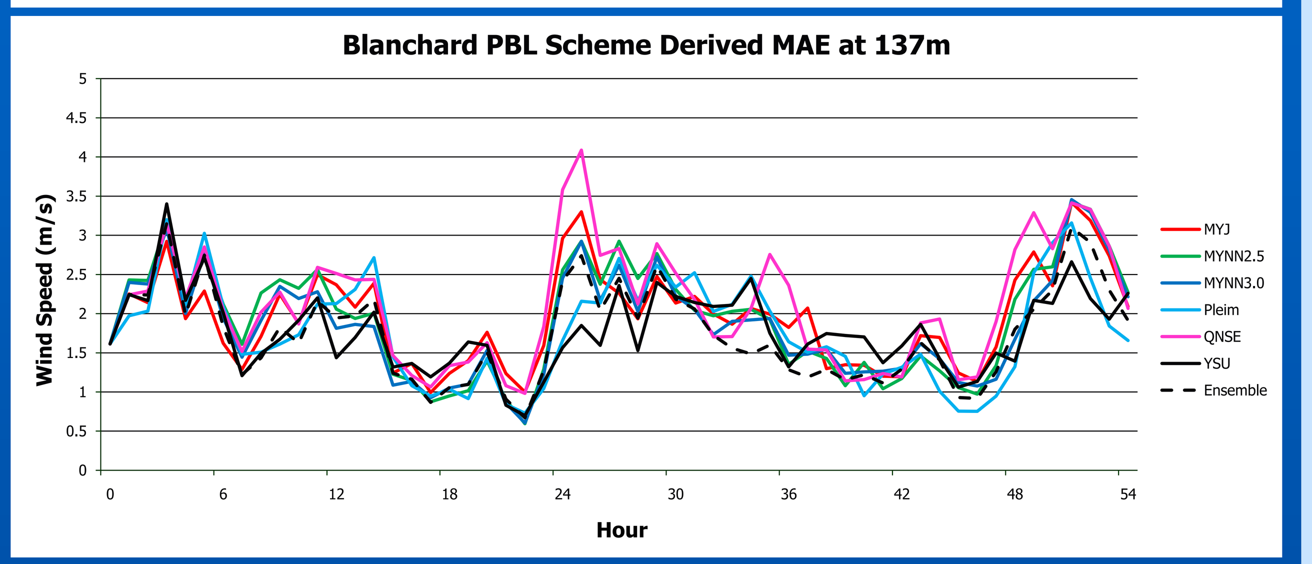

Figure 2 A, B, C, D represent the average MAE over a typical 54 hour April.

Conclusions

- In general, YSU scheme has the lowest MAE of all other schemes, and QNSE had the highest
- In general, the MAE in Maryville increases as height increases while Mound City MAE stays relatively constant over all three heights
- The MAE for Blanchard is significantly lower than the MAE of the two other sites, despite being at a higher height
- In Blanchard and Maryville, the MAE between day one (6 – 30 hr) and day two (30 – 54 hr) is fairly variable, and no precise trend can be observed. However, day two for the Mound City tower has consistently lower MAE values than day one
- The peak error, at all heights, seems to occur between hours 25 and 30

Acknowledgements

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