Analysis of WRF Model Ensemble Forecast Skill for 80 m Winds over Iowa

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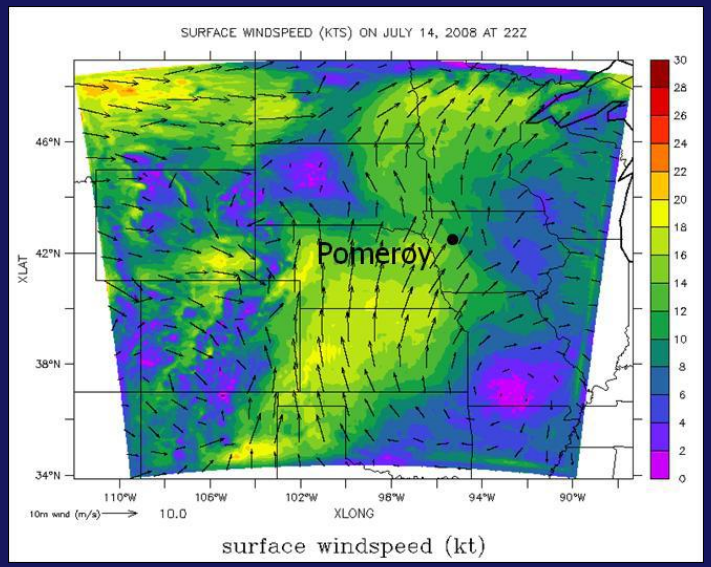
Motivation and Objective

- Growing wind industry
- Unique/ limited data for 80 m
  - Not extrapolated from surface

- Hypothesis: WRF can forecast wind speeds at 80 m with an average mean absolute error less than 2.0 m s^{-1} for the forecast period 38-48hr (approximately 8am-6pm on day 2 of the 54hr forecast period) in all seasons with a confidence level of 95%.

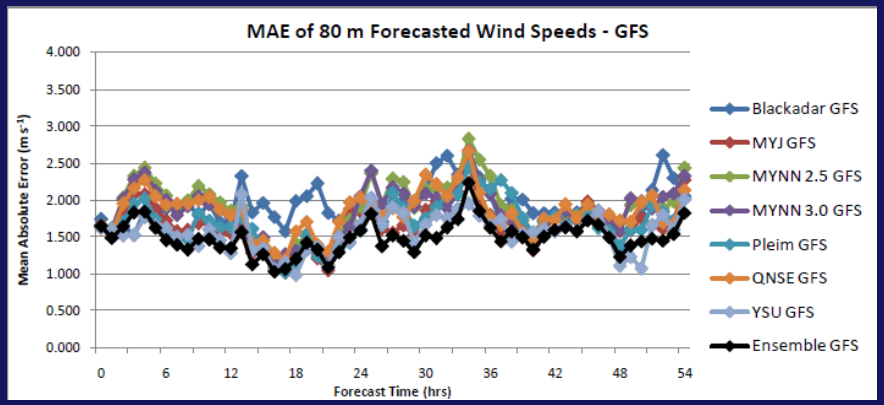
Data

- Observed: provided by MidAmerican Energy Corporation (MEC)
  - 10 min intervals, averaged hourly
  - Total of 32 cases, 8 per season



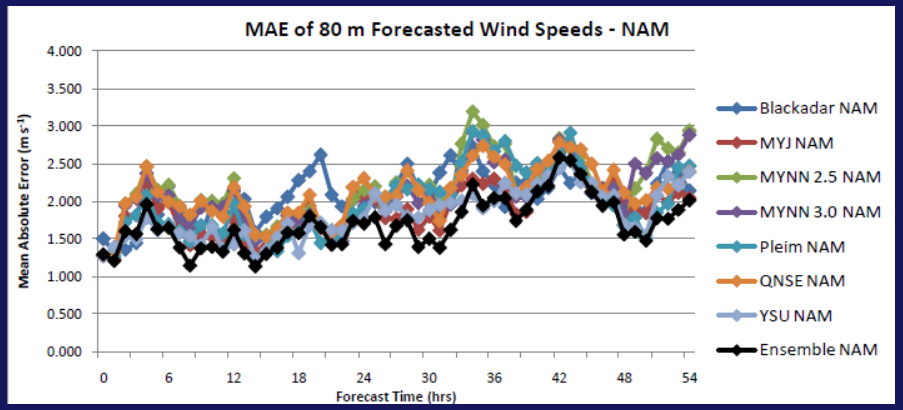
- Forecasted:
  - 7 PBL schemes and ensemble mean
  - GFS and NAM initializations

Mean Absolute Error

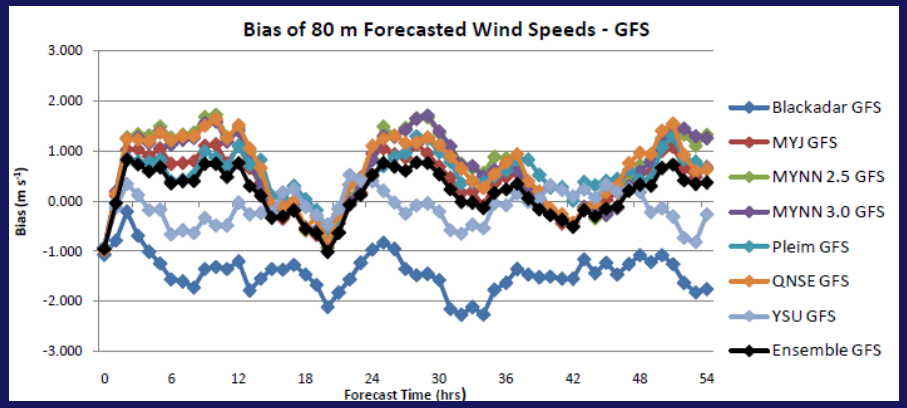


- Greater increase in MAE over time for NAM than for GFS

- Ensemble mean performs best
  (1.497 m s^{-1}; 1.700 m s^{-1})
- YSU close (+0.1 m s^{-1})
- Blackadar (1.927 m s^{-1}) and QNSE (2.106 m s^{-1}) perform worst



Bias



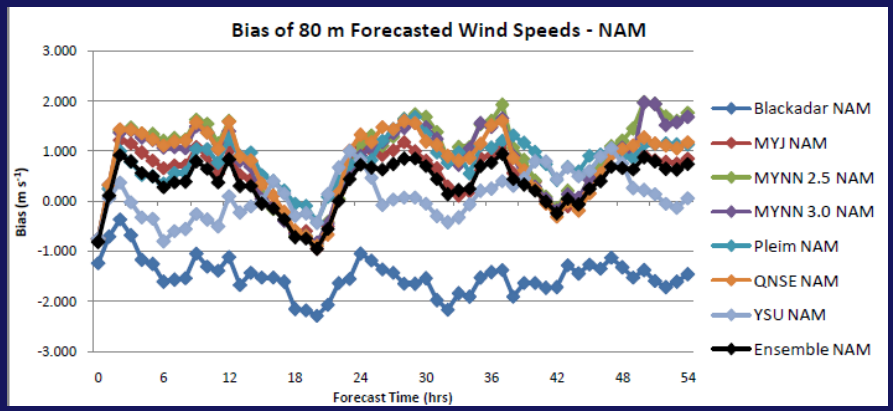
- GFS and NAM fairly comparable through the entire period

- YSU has lowest avg. bias through period

  (-0.130 m s^{-1}; 0.106 m s^{-1})

- Blackadar has highest by almost a factor of two

  (-1.424 m s^{-1}; -1.500 m s^{-1})



Day 2 Daytime

- Significantly better results in spring?
- Ensembles have lowest error
  - 1.529 m s^{-1} vs. 2.098 m s^{-1}
- Blackadar (1.806 m s^{-1}) worst - GFS
- QNSE (2.421 m s^{-1}) worst - NAM

Season	Lower 95% CI Bound	Mean MAE	Upper 95% CI Bound
Winter	1.500	1.797	2.094
Spring	1.135	1.401	1.667
Summer	1.587	1.810	2.034
Fall	1.498	1.796	2.094

GFS

Season	Lower 95% CI Bound	Mean MAE	Upper 95% CI Bound
Winter	2.167	2.377	2.586
Spring	1.250	1.555	1.860
Summer	2.032	2.553	3.073
Fall	2.481	2.719	2.957

NAM

Conclusions

- Hypothesis true for GFS over all cases, but not all seasons
  - CI pushes summer, fall, and winter over 2.0 m s^{-1} threshold (by <0.1 m s^{-1})
- Hypothesis false for NAM over all cases and all seasons
- Ensembles and YSU most accurate schemes, QNSE least accurate

Further Research

- Richardson Number
  - Model performance by stability categories
- More cases and locations
- Time of model initialization
- Model perturbation ensembles

Thank you: Eugene Takle , Adam Deppe , MidAmerican Energy Corporation, and other members of Iowa State's "wind team".

References

- Andersen, T. K., 2007: Climatology of surface wind speeds using a regional climate model. B.S. thesis, Dept. of Geological and Atmospheric Sciences, Iowa State University, 11 pp.
- Archer, C. L., and M. Z. Jacobson, 2005: Evaluation of global wind power. *J. Geophys. Res.,* ***110, D12110.***
- Dudhia, J., cited 2009: WRF Physics. [Available online at http://www.mmm.ucar.edu/ wrf/users/tutorial/200909/14_ARW_Physics_ Dudhia.pdf]
- Elliott, D., and M. Schwartz, 2005: Towards a wind energy climatology at advanced turbine hub-heights. Preprints, *15th Conf. on Applied Climatology, Savannah, GA, Amer. Meteor. Soc., JP1.9.*
- Klink, K., 2007: Atmospheric circulation effects on wind speed variability at turbine height. *J. Appl. Meteorol. and Climatol.,* ***46, 445-456.***
- Pryor S. C., R. J. Barthelmie, D. T. Young, E. S. Takle, R. W. Arritt, D. Flory, W. J. Gutowski Jr., A. Nunes, J. Roads, 2009: Wind speed trends over the contiguous United States. *J. Geophys. Res.,* ***114, D14105, doi: 10.1029/2008JD011416.***
- Takle, E. S., J. M. Brown, and W. M. Davis, 1978: Characteristics of wind and wind energy in Iowa. *Iowa State J. Research.,* ***52, 313-339.***
- University Corporation for Atmospheric Re-search, cited 2009: Tutorial class notes and user's guide: MM5 Modeling System Version 3. [Available online at http://www. mmm.ucar.edu/mm5/documents/MM5_tut_Web_notes/MM5/mm5.htm] 9
- Zhang, D., and W. Zheng, 2004: Diurnal cycles of surface winds and temperatures as simulated by five boundary layer parameteriza-tions. *J. Appl. Meteorol.,* ***43, 157-169.***
- Wind turbine image: http://www.news.iastate.edu