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

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Motivation

- Growing wind industry
- Unique/ limited data for 80 m
  - Not extrapolated from surface
- Energy density proportional to the wind speed cubed

Data: Observed

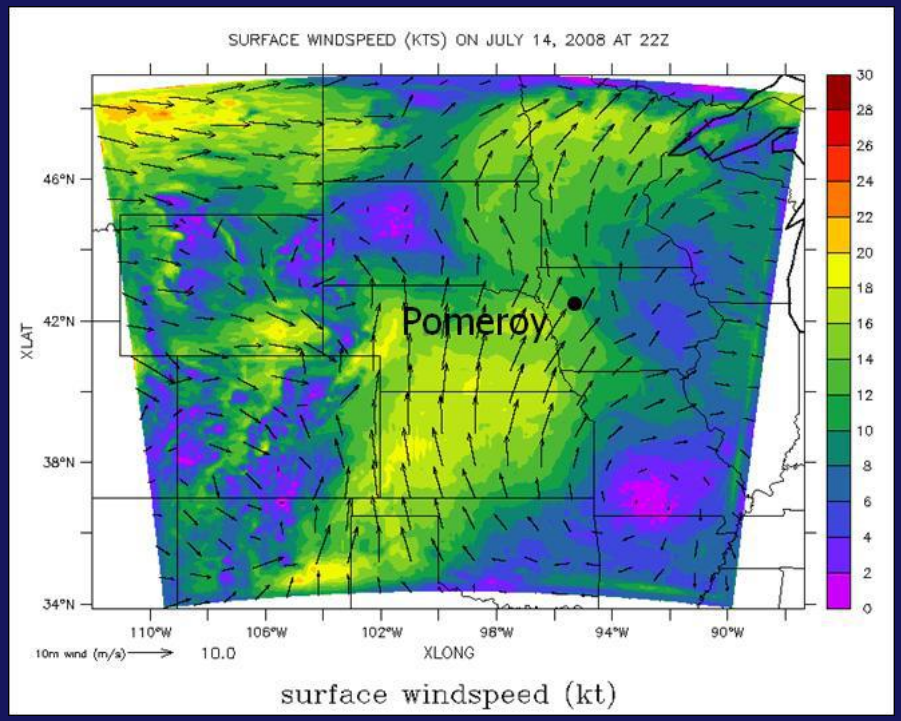
- Provided by MidAmerican Energy Corporation (MEC)
  - Pomeroy, IA meteorological tower
  - 10 min intervals, averaged hourly
  - “bad” data excluded
  - Total of 32 cases, 8 per season

Data: Forecasted

- Provided by Adam Deppe
- planetary boundary layer schemes
  - WRF: MYJ, MYNN 2.5, MYNN 3.0, Pleim, QNSE, and YSU
  - MM5: Blackadar
- GFS and NAM initializations
  - Ensemble means

Data: Forecasted

- 10 km grid resolution, domain of Iowa and surrounding states



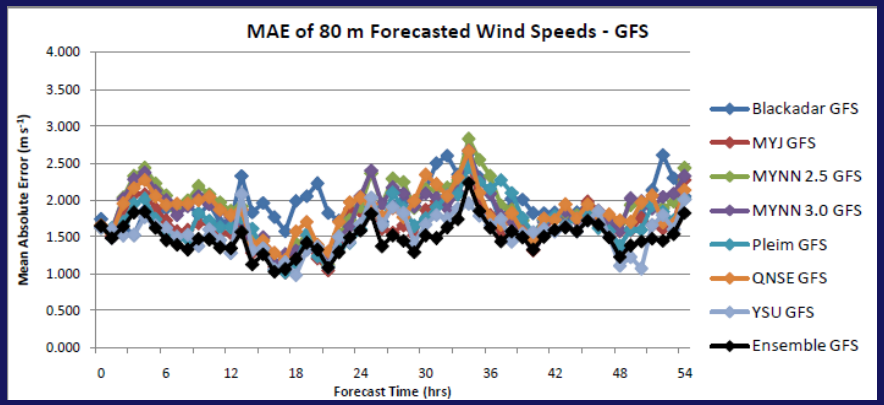
Hypothesis

- 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%.

Analyses

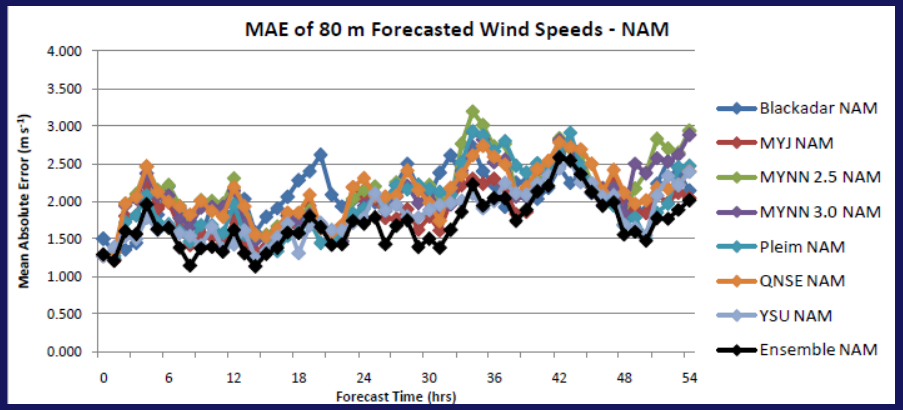
- Statistical comparisons
  - Mean absolute error (MAE)
  - Bias
  - Root mean squared error (RMSE)
  - Standard deviation (STDEV)
- Focus on day 2 daytime
  - MAE with 95% confidence interval
  - Over all cases and each season

Mean Absolute Error

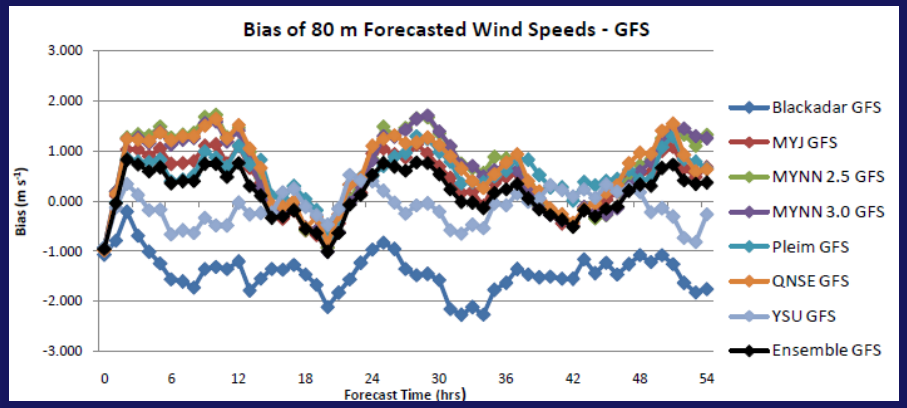


- Greater increase in MAE over time for NAM than for GFS

- 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



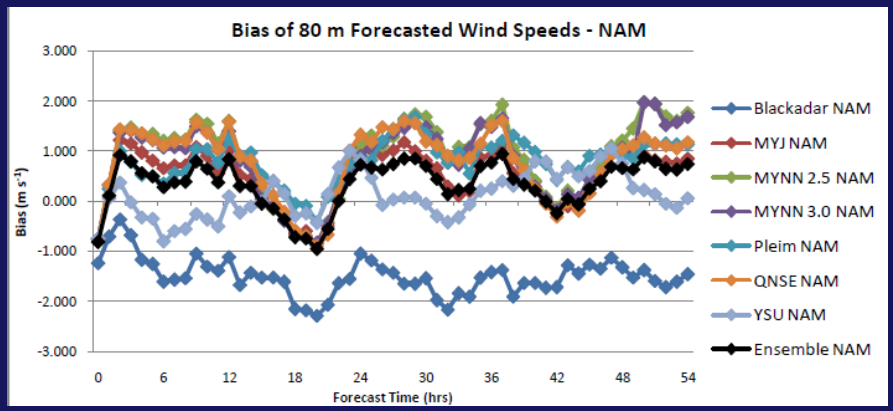
- GFS and NAM fairly comparable through the entire period

- 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})



Diurnal Cycle

- Schemes have more difficulty capturing nighttime speeds
  - 6am-6pm: average bias of -0.032 m s^{-1}
  - 6pm-6am: average bias of 0.460 m s^{-1}
- YSU captures cycle the best
  - Only around 2 m s^{-1} between time periods

Other Results

- RMSE
  - NAM with higher values than GFS
  - Ensembles perform best
  - MYNN schemes worst this time
- STDEV
  - Increasing with time, more so for NAM
  - Ensembles with lowest values, MYNN schemes with highest

Day 2 Daytime: Seasons

- Significantly better results in the spring
  - Missing data? Synoptic conditions?
  - MYNN schemes do quite well
- GFS consistent through other seasons, NAM worst in summer/ fall

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

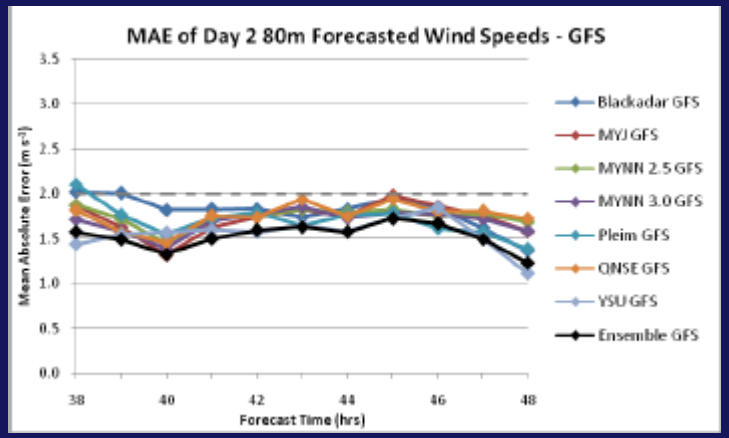
GFS

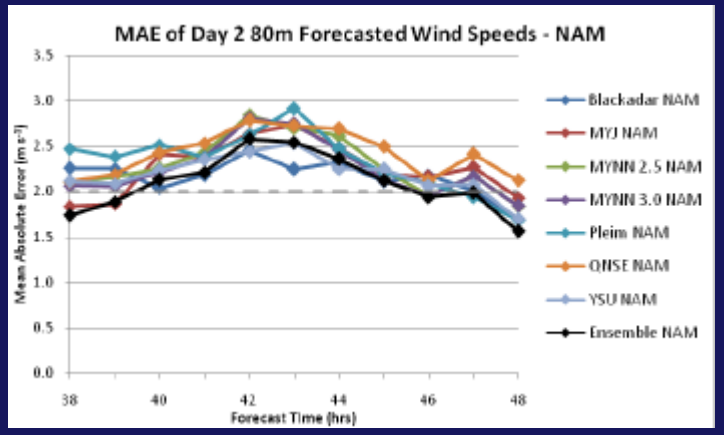
Season	Lower 95% CI Bound	Mean MAE	Upper 95% CI Bound
Winter	2.167	2.377	2.586
Spring	1.250	1.555	1.860
Summer	2.032	2.553	3.073
Fall	2.481	2.719	2.957

NAM

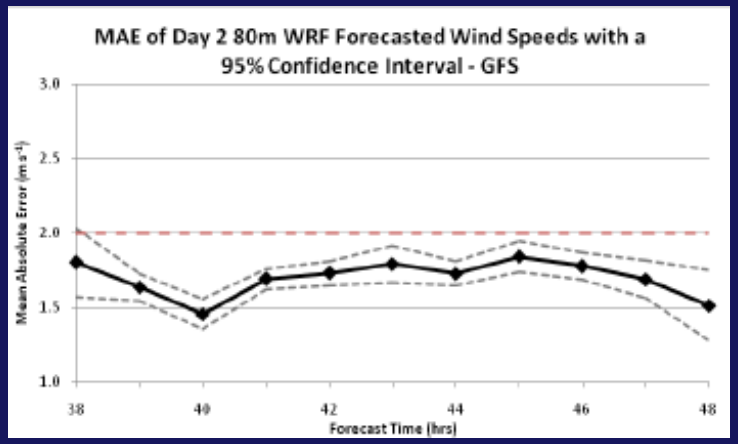
Day 2 Daytime: Schemes

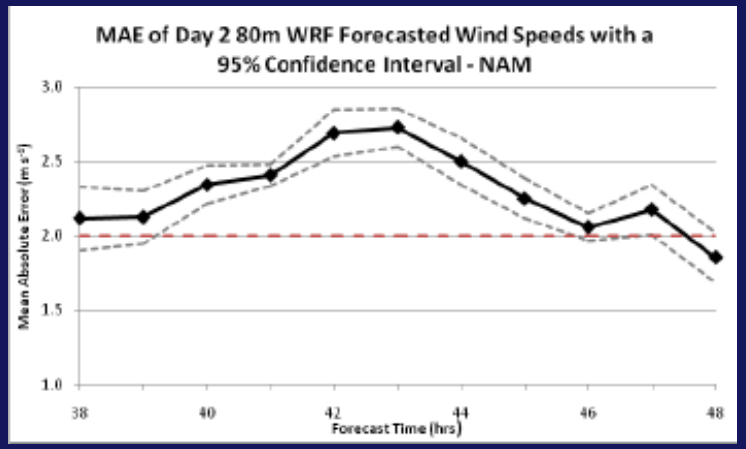
- Ensembles have lowest error
  - 1.529 m s^{-1} vs. 2.098 m s^{-1}
- Blackadar (1.806 m s^{-1}) worst - GFS
- QNSE (2.421 m s^{-1}) worst - NAM





Day 2 Daytime: Initializations





- GFS less error than NAM
  - Averaged, 1.696 m s^{-1} vs. 2.294 m s^{-1}
  - GFS CI: 1.575 m s^{-1} to 1.817 m s^{-1}
  - NAM CI: 2.149 m s^{-1} to 2.440 m s^{-1}

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

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- Wind turbine image: http://www.news.iastate.edu

- Further Research
  - More cases without any missing data
  - Diurnal cycle
  - Synoptic conditions
  - Inter-annual variability

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