



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

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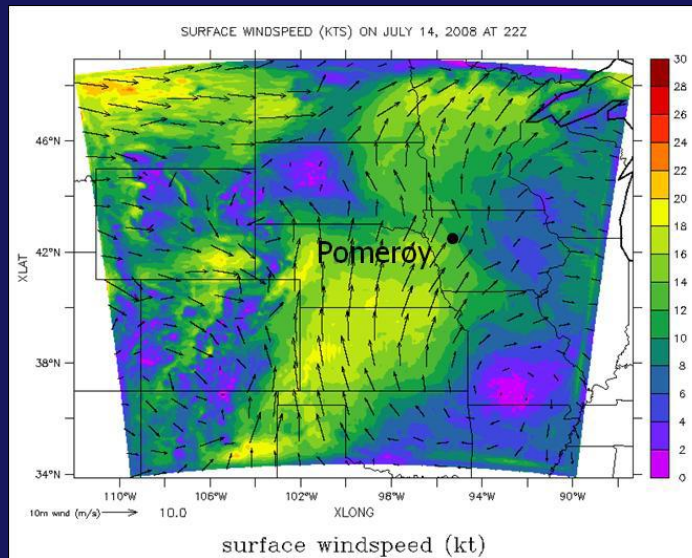
Mentors: Eugene Takle, Adam Deppe

# 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  $2.0 \text{ m s}^{-1}$  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%.

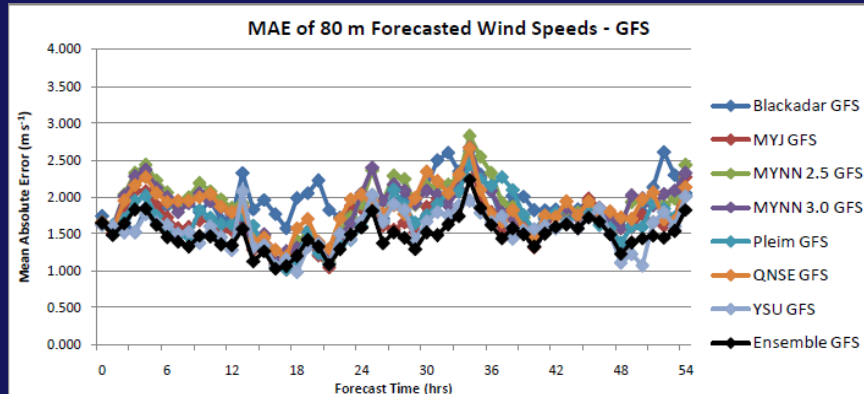
# Data

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



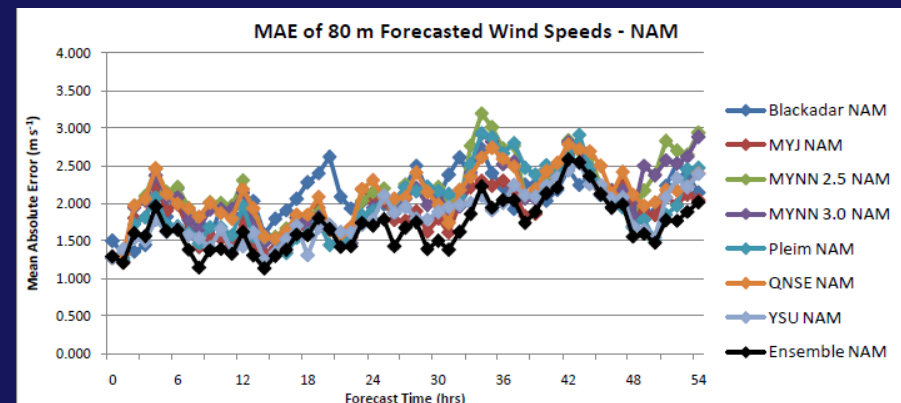
- Forecasted:
  - 7 PBL schemes and ensemble mean
  - GFS and NAM initializations

# Mean Absolute Error

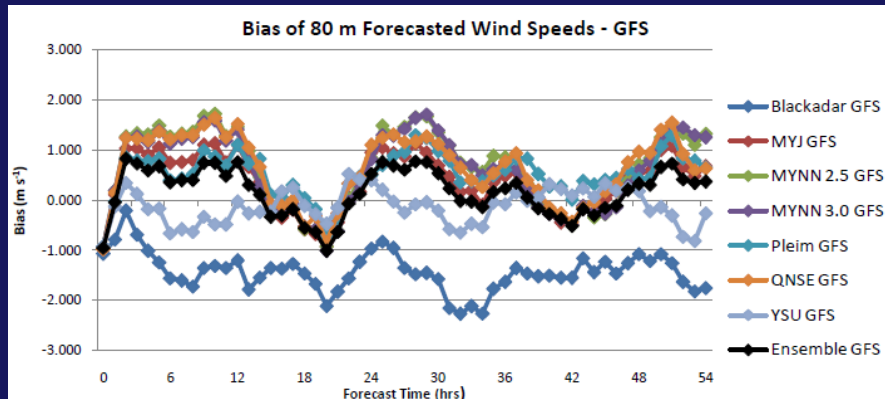


- Greater increase in MAE over time for NAM than for GFS

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

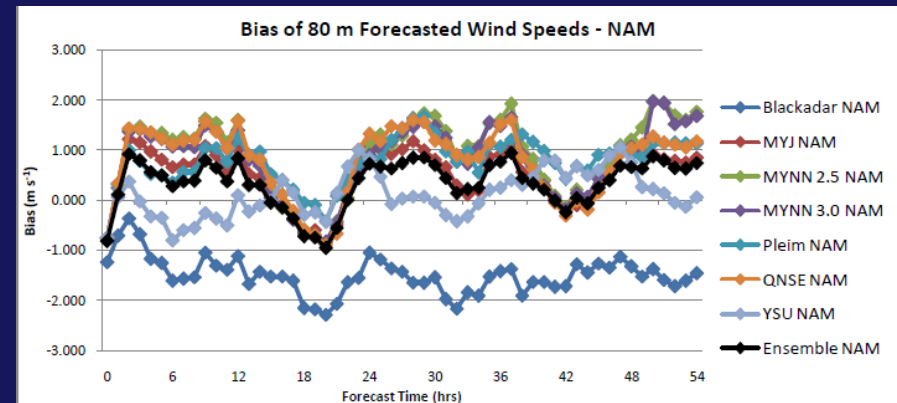


# Bias



- GFS and NAM fairly comparable through the entire period

- YSU has lowest avg. bias through period ( $-0.130 \text{ m s}^{-1}$ ;  $0.106 \text{ m s}^{-1}$ )
- Blackadar has highest by almost a factor of two ( $-1.424 \text{ m s}^{-1}$ ;  $-1.500 \text{ m s}^{-1}$ )



# Day 2 Daytime

- Significantly better results in spring?
- Ensembles have lowest error
  - 1.529 m s<sup>-1</sup> vs. 2.098 m s<sup>-1</sup>
- Blackadar (1.806 m s<sup>-1</sup>) worst - GFS
- QNSE (2.421 m s<sup>-1</sup>) 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  $2.0 \text{ m s}^{-1}$  threshold (by  $<0.1 \text{ m s}^{-1}$ )
- 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

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