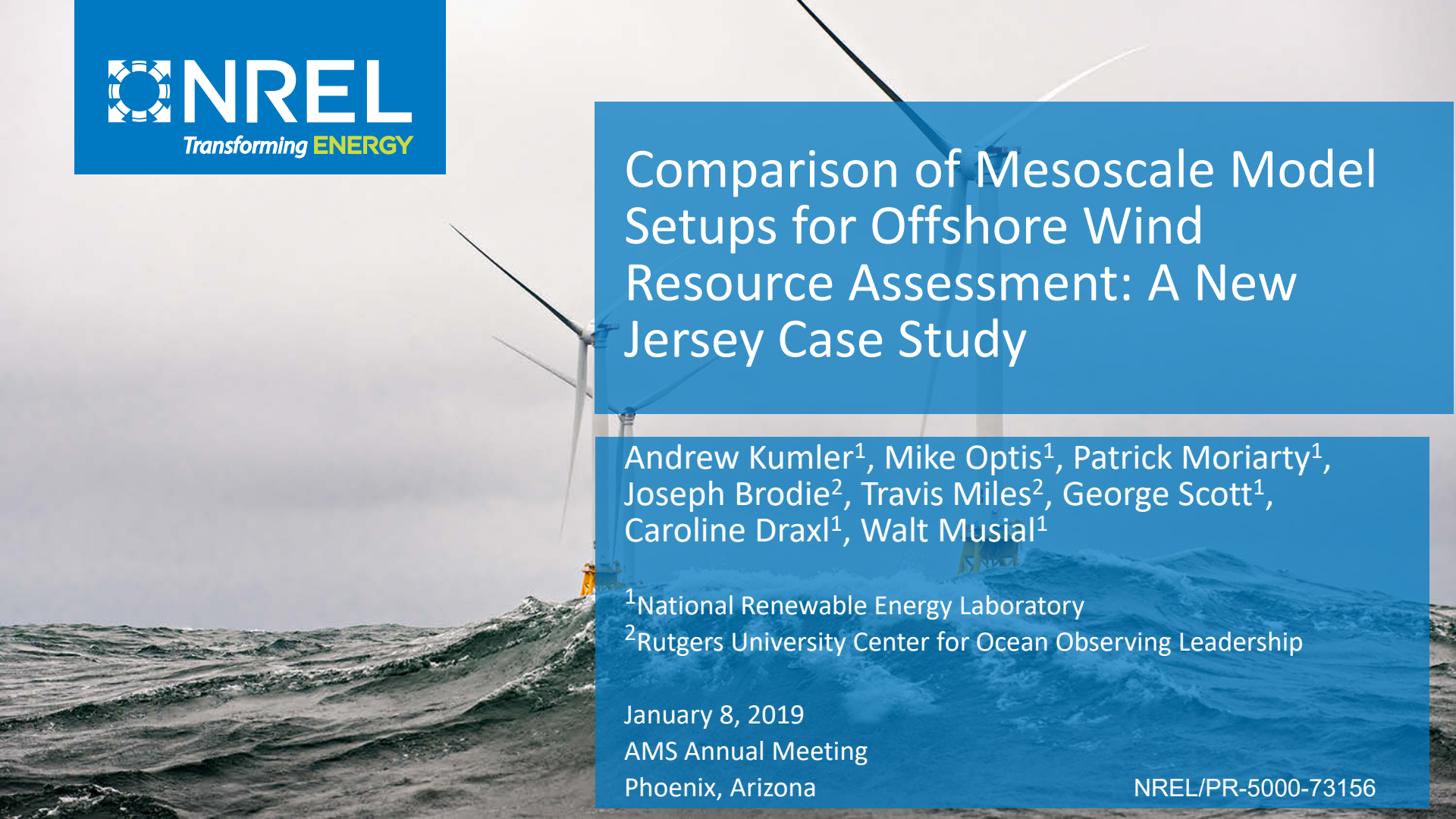

Comparison of Mesoscale Model Setups for Offshore Wind Resource Assessment: A New Jersey Case Study

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Phoenix, Arizona

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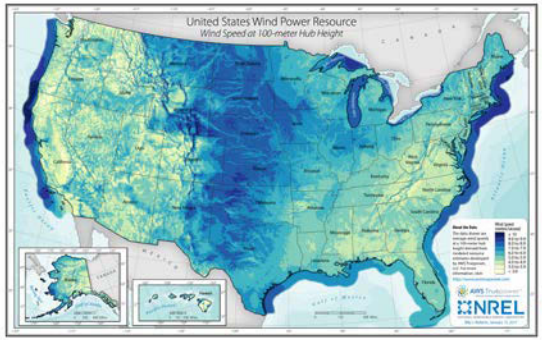
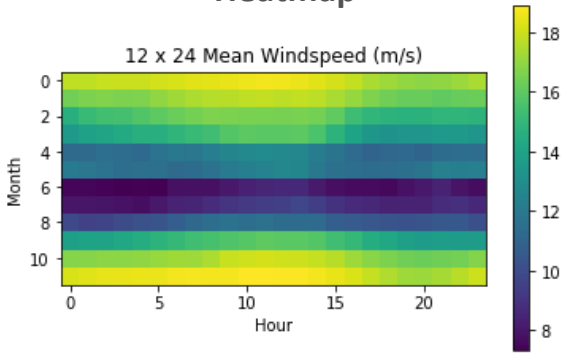
Evolution of Wind Resource Modeling

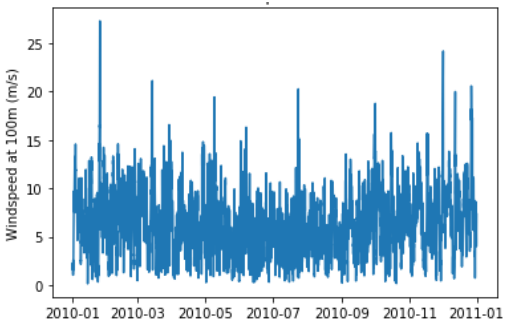
Typical Annual Average Wind Speed Map



Typical 12x24 (month x day) Heatmap



Typical Timeseries of Wind Speed



- Site assessment
- Strategic planning

+

- Site characterization
- Basic energy modeling

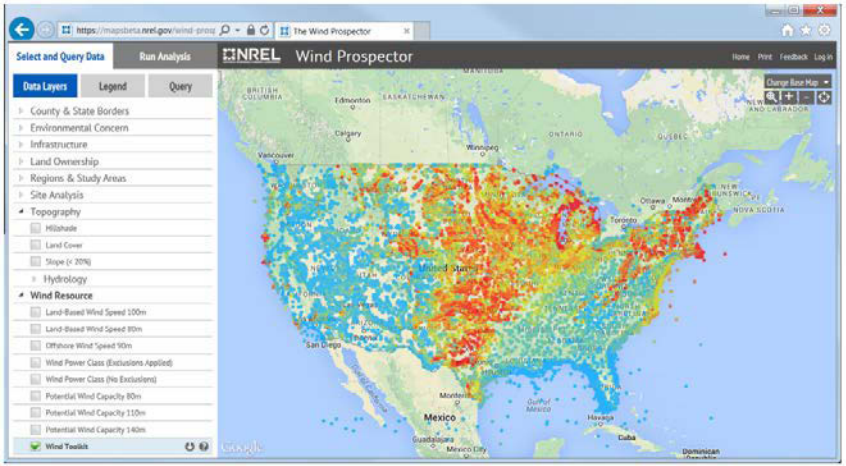
+

- Grid integration
- Economic modeling
- Capacity expansion
- Wind plant modeling

Mesoscale Model Uncertainty?

- Wind Integration National Dataset (WIND) Toolkit is a modern data set allowing for timeseries-based analyses:
  - Weather Research and Forecasting Model (WRF)
  - Two-kilometer (km) spatial resolution, 5-minute time resolution, 2007–2013 simulation period
  - 50 terabytes easily available to public, 500 terabytes by request
  - Applications in grid integration, capacity expansion, and resource assessment

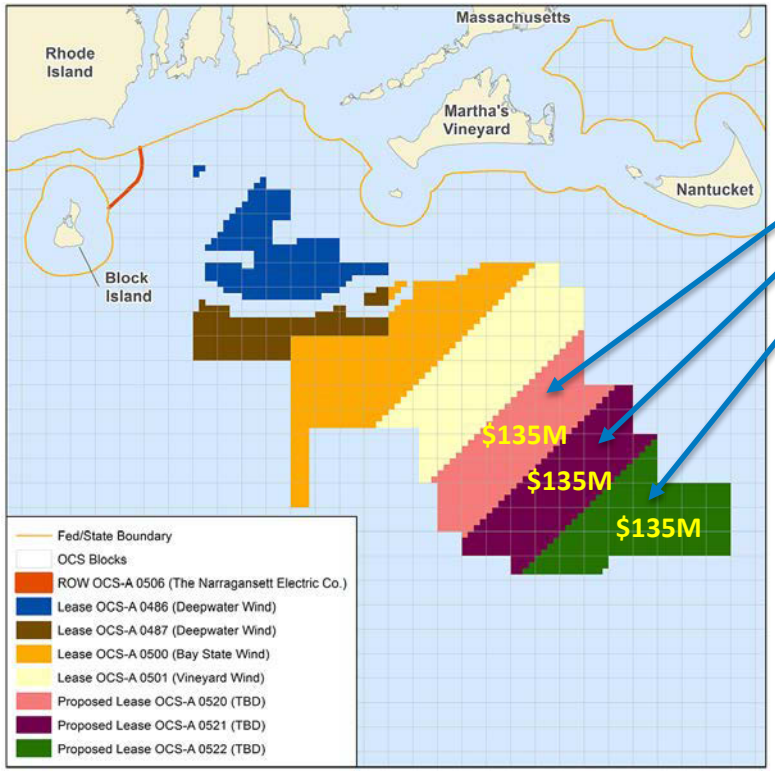
National Renewable Energy Laboratory Wind Prospector



- Wind Toolkit is **one particular setup** of WRF (input data, schemes, etc.)
- Small differences (e.g., 0.5 meters per second) can affect downstream decision-making (e.g. cost modeling)
- Ensemble modeling can quantify that uncertainty/risk
  - Well established in weather forecasting.

High Stakes for Offshore Development

Wind Energy Lease Areas in Massachusetts



Source: Bureau of Ocean Energy Management (2018): Massachusetts Activities (https://www.boem.gov/Massachusetts/)

Recent lease auctions show a promising but risky future

How confident are we in the:

- Annual energy production?
- Infrastructure needed to get power to the grid?
- Ability to integrate with the grid?

Ensemble mesoscale modeling can begin to provide those answers

National Renewable Energy Laboratory and Rutgers Collaboration

- National Renewable Energy Laboratory partnered with Rutgers Center for Ocean Observing Leadership (RU-COOL)
- RU-COOL running their own WRF version with custom 'coldest-pixel' sea surface temperature (SST) data
- Design a set of ensembles to quantify uncertainty on various timescales, gauging sensitivity to:
  - Model setup, or 'namelist' (i.e., planetary boundary layer (PBL) schemes, vertical resolution, etc.)
  - Reanalysis input
  - **WRF Version**
  - **SST input**.

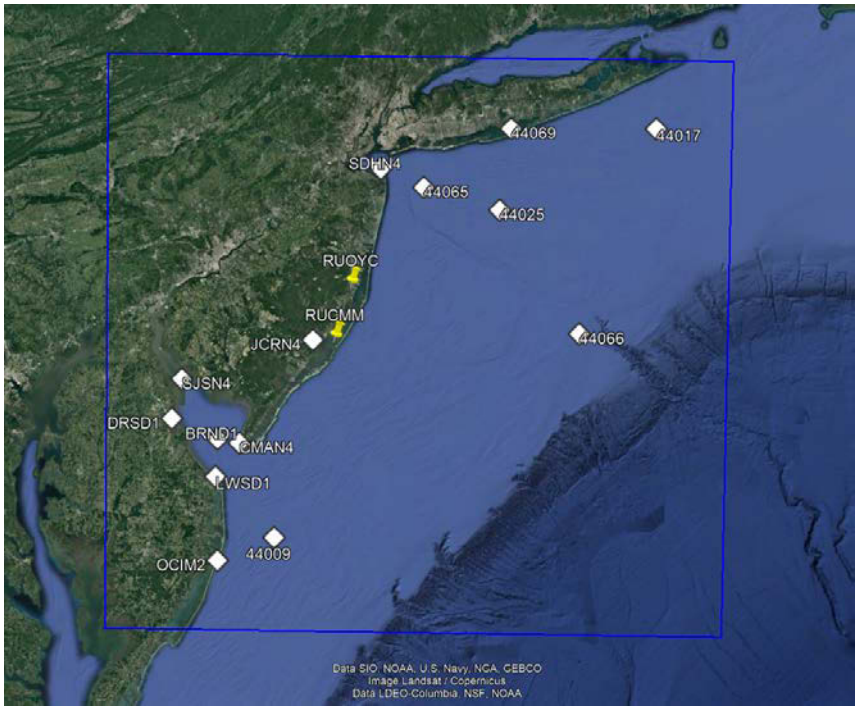
Overview of Simulations

- Domains of 9 km and 3 km with two-way nesting
- June 2015–2016 simulation period
- Network of National Data Buoy Center and Rutgers observations (validation not considered in this analysis).

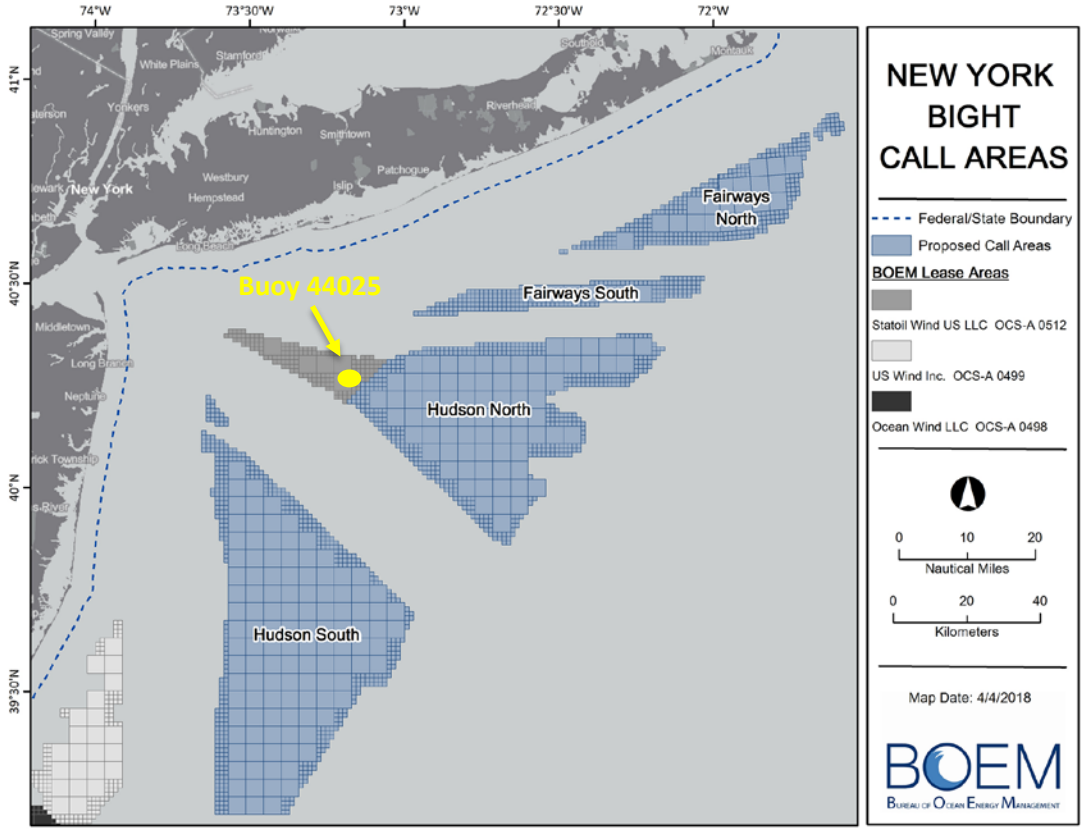
SST Data	WRF Namelists	Reanalysis Input	WRF Version
Rutgers Coldest-Pixel SST	Rutgers (MYNN 2.5 PBL)	GFS 0.25 degree	3.9
NCEP 1/12 degree SST	Wind Toolkit (YSU PBL)	ERA-interim	4.0
Reanalysis default			

MYNN=Mellor-Yamada-Nakanishi-Niino, GFS=Global Forecast System, NCEP=National Centers for Environmental Prediction, YSU=Yonsei University, ERA=European Centre for Medium Range Forecasts Reanalysis)

WRF 3km domain and validation stations



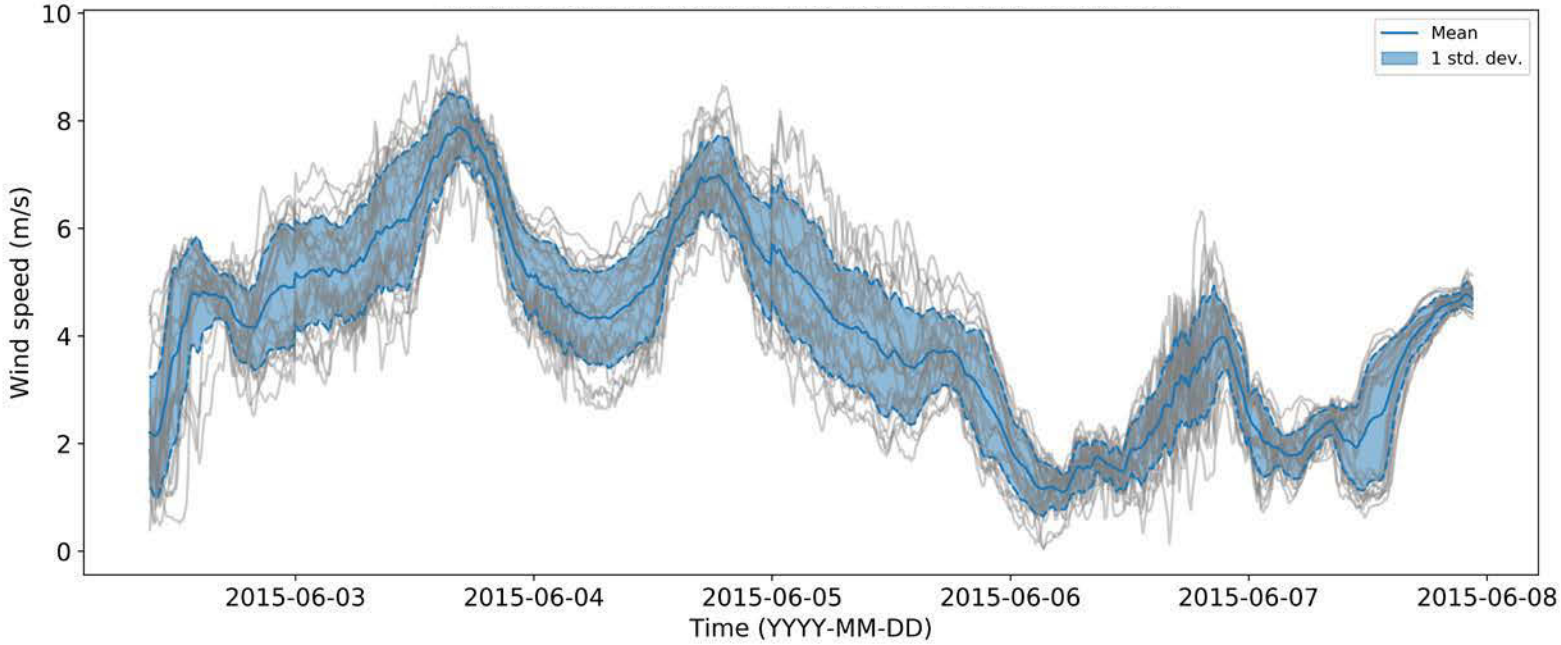
Buoy 44025 – Active Lease Area



Source: Bureau of Ocean Energy Management (2018): New Jersey Activities (https://www.boem.gov/New-Jersey/)

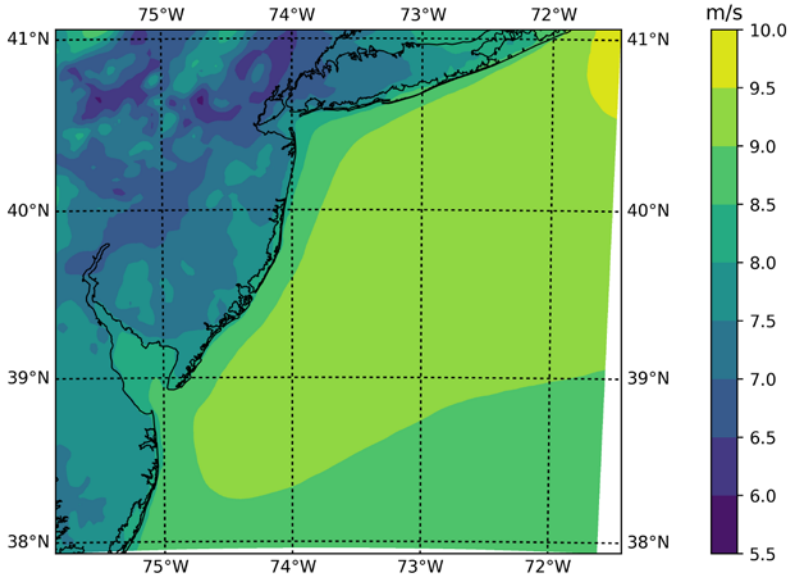
First Look…

Ensemble 100-meter Wind Speeds at Buoy 44025 over Sample 5-Day Period

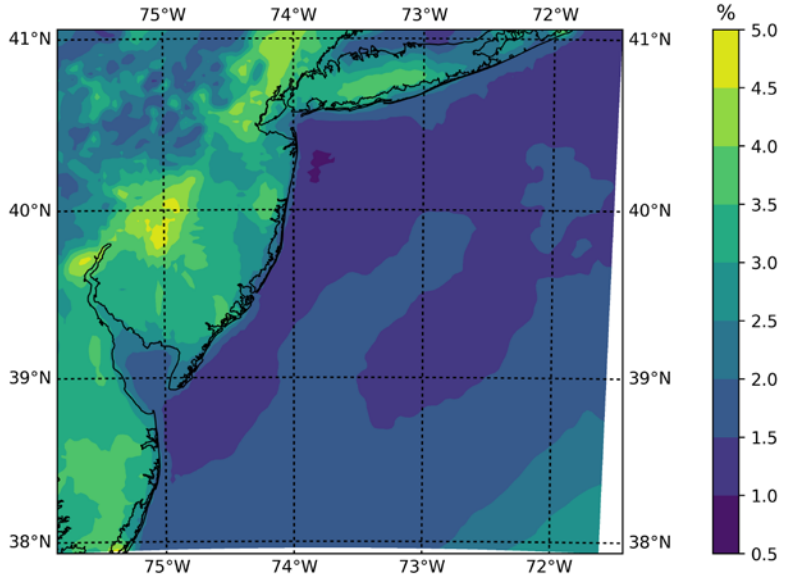


The New Wind Resource Map?

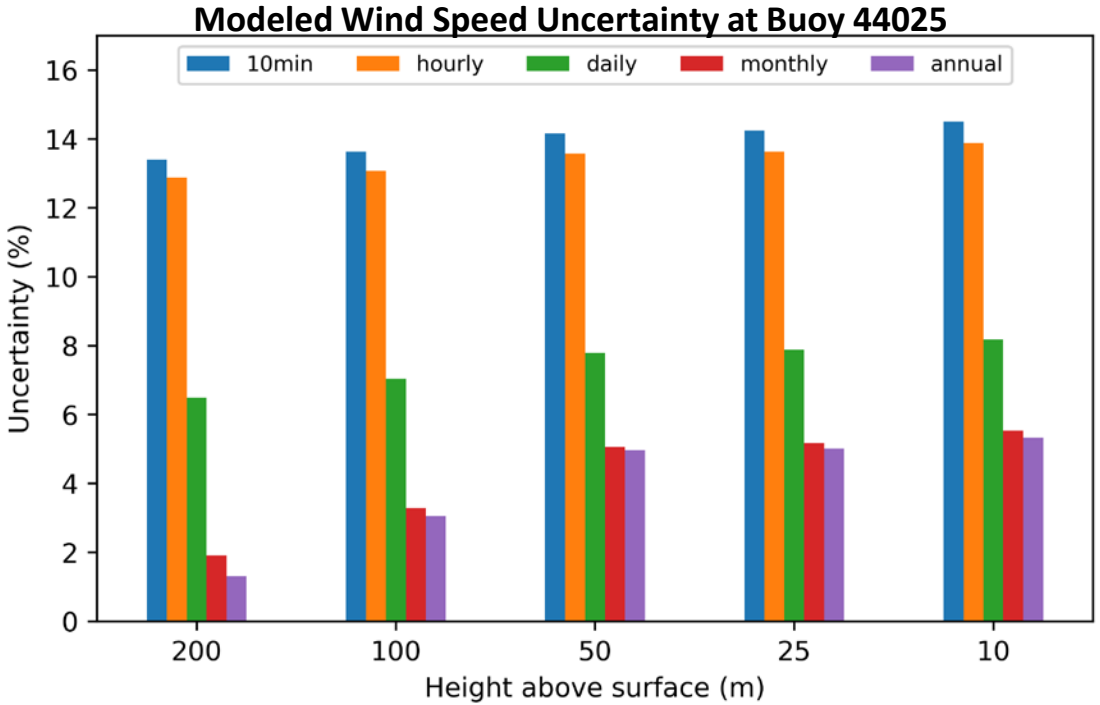
Mean 100-meter Annual Average Wind Speed



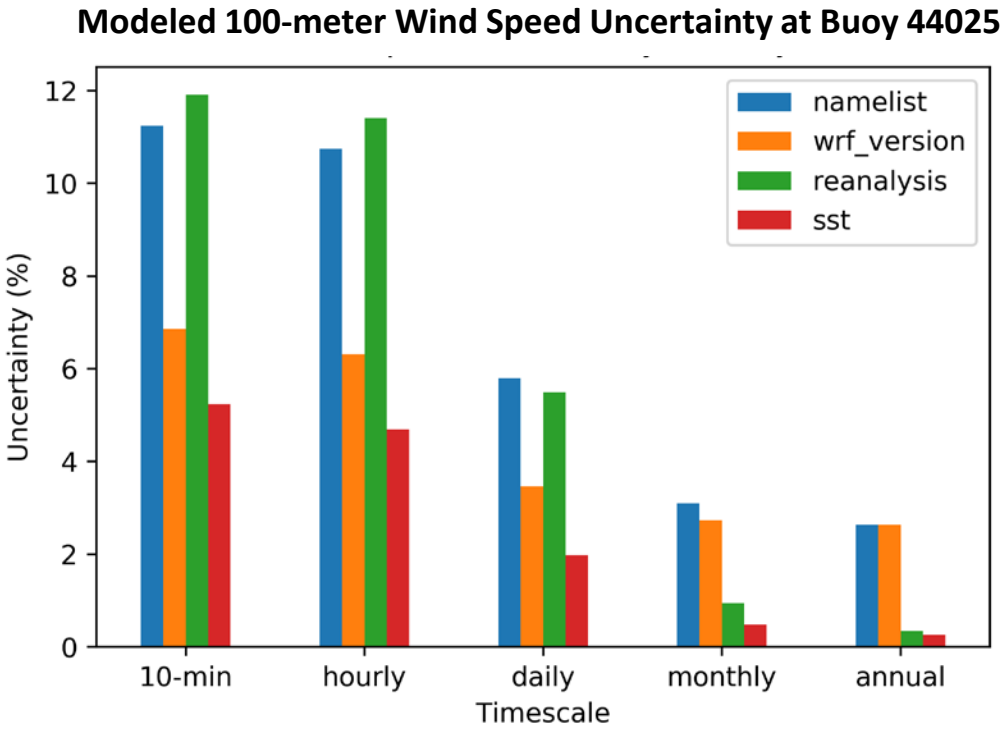
100-meter Annual Average Wind Speed Uncertainty



Uncertainty by Timescale and Height



Uncertainty by Ensemble Category



Preliminary Conclusions

- Mesoscale model uncertainty is significant, especially at subdaily timescales
- SST data source is important source of variability at subdaily timescales
- WRF version (surprisingly) important:
  - Wind Forecast Improvement Project 2 (WFIP2) MYNN improvements
- Namelist and reanalysis also important (less surprising).

Ensembles as Future of Resource Assessment?

- Uncertainty in model setup choice needs to be quantified
- Important downstream implications on annual energy production, cost modeling, grid integration, and so on.
- Increasing computational resources enable ensemble modeling
- Challenges in storing data:
  - Is it feasible to run ensembles for a national data set?

Next Steps…

- More expansive and informed ensemble members
- Validation against offshore observations (a challenge!):
  - Which model setups tend to perform best and why?
- Extension beyond New Jersey test case
- Strong need for offshore observations (e.g., floating lidars).

Thank You

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