Wind Forecast Improvement Projects 1-3

Caroline Draxl, Senior Scientist,
co-operating agent IEA Wind Task 51
Dublin, Sep. 12-13, 2022

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WFIP 1

Improved initialization of forecast models

Northern Study Area (NSA)	Southern Study Area (SSA)
WindLogics	AWS Truepower
NextEra Energy Resources	MESO, Inc.
Midcontinent Independent System Operator (MISO)	Electric Reliability Council of Texas (ERCOT)
South Dakota State University (SDSU)	Texas Tech University (TTU)
	University of Oklahoma's Center for Analysis and Prediction of Storms (OU CAPS)
	North Carolina State University (NCSU)
	ICF International
NOAA	**DOE Laboratories**
Earth System Research Laboratory	National Renewable Energy Laboratory
Air Resources Laboratory	Argonne National Laboratory
NWS/National Centers for Environmental Prediction	Lawrence Livermore National Laboratory
	Pacific Northwest National Laboratory

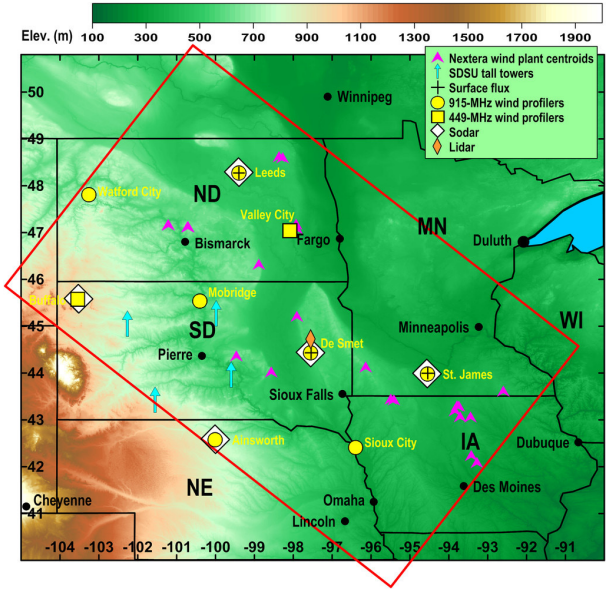
- Funded by the U.S. Department of Energy (DOE)
- The principal objectives were to
  - **Collect observations** to **improve** short-term (0 - 6 hr) wind power forecasts through the **assimilation** of targeted remote sensing and surface observations with an enhanced model ensemble forecast system. Focus is NOAA's weather models.
  - one full year of data collection, forecasting, and economic evaluation: July 2011–July 2012.
- ***WFIP demonstrated that improved initialization of forecast models, especially with upper-air data, significantly improved hub-height forecasts out to six hours; ramp forecasts especially improved; Development of Ramp Tool and Metric by NOAA.***

a substantial reduction (12%–5% for forecast hours 1–12) in power RMSE was achieved from the combination of improved numerical weather prediction models and assimilation of new observations; 6% improvement came from the new observations

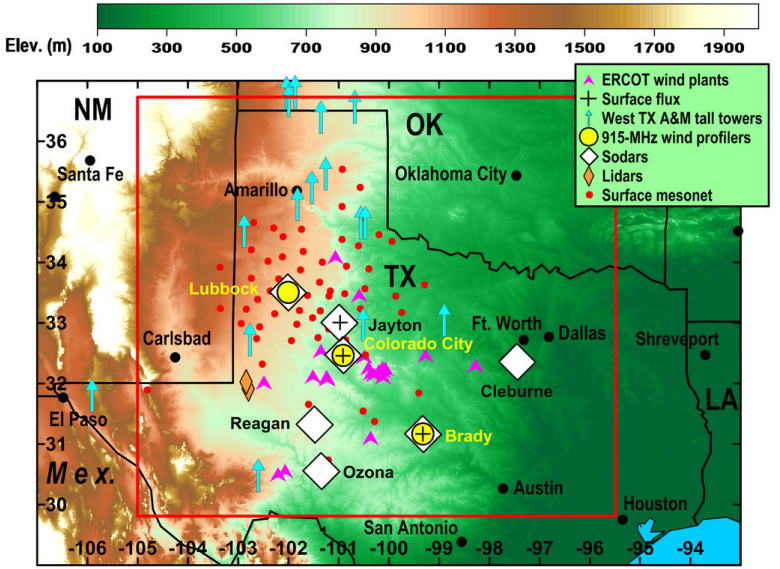
https://journals.ametsoc.org/view/journals/bams/96/10/bams-d-14-00107.1.xml

Field campaign

Instrument	NSA	SSA
915-MHz W-P radar	7	3
449-MHz W-P radar	2	
Doppler W-P sodar	5	7
W-P lidar	1	2 (short term)
Surface flux station	3	3
Surface meteorological station	8	63
Tall towers	133	51
Nacelle winds	405	—



Northern Great Plains
Led by WindLogics



Southern Great Plains
Led by AWS Truepower

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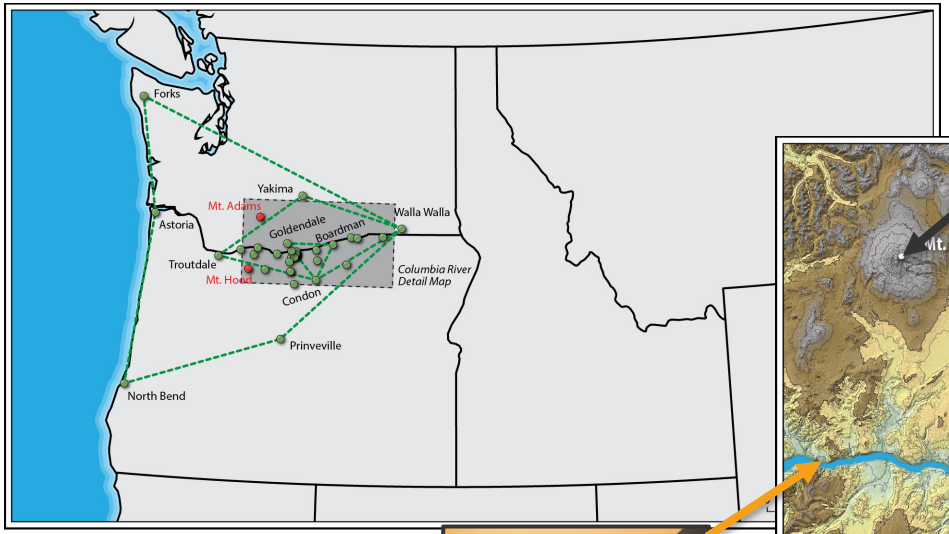
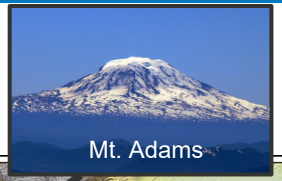
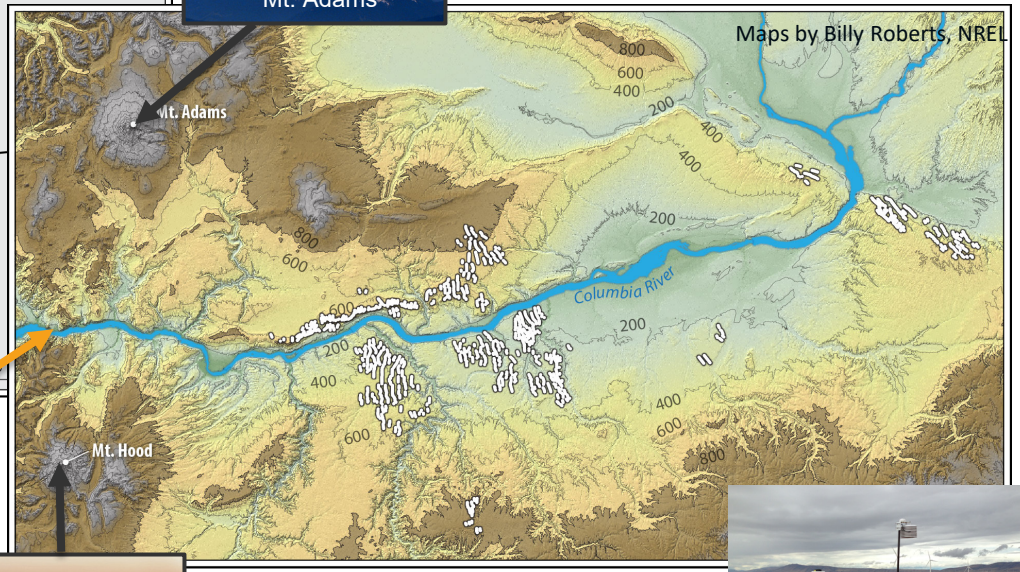
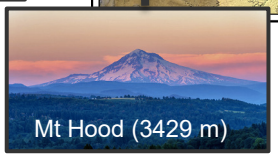
WFIP 2

Improve wind speed forecasts in the turbine rotor layer in complex terrain





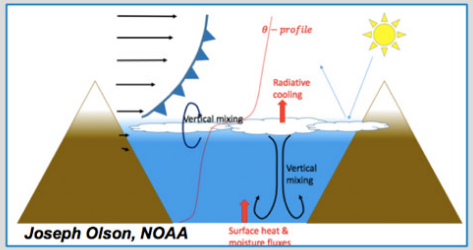




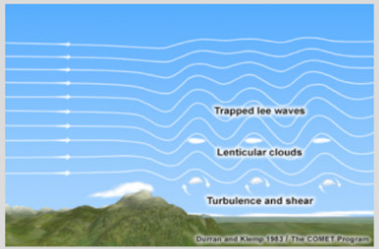
Forecast Challenges in Columbia River Gorge

Gap Flows

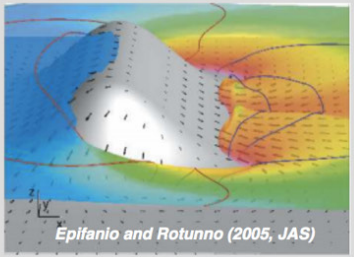
Cold Pool Mix-Outs



Mountain Waves

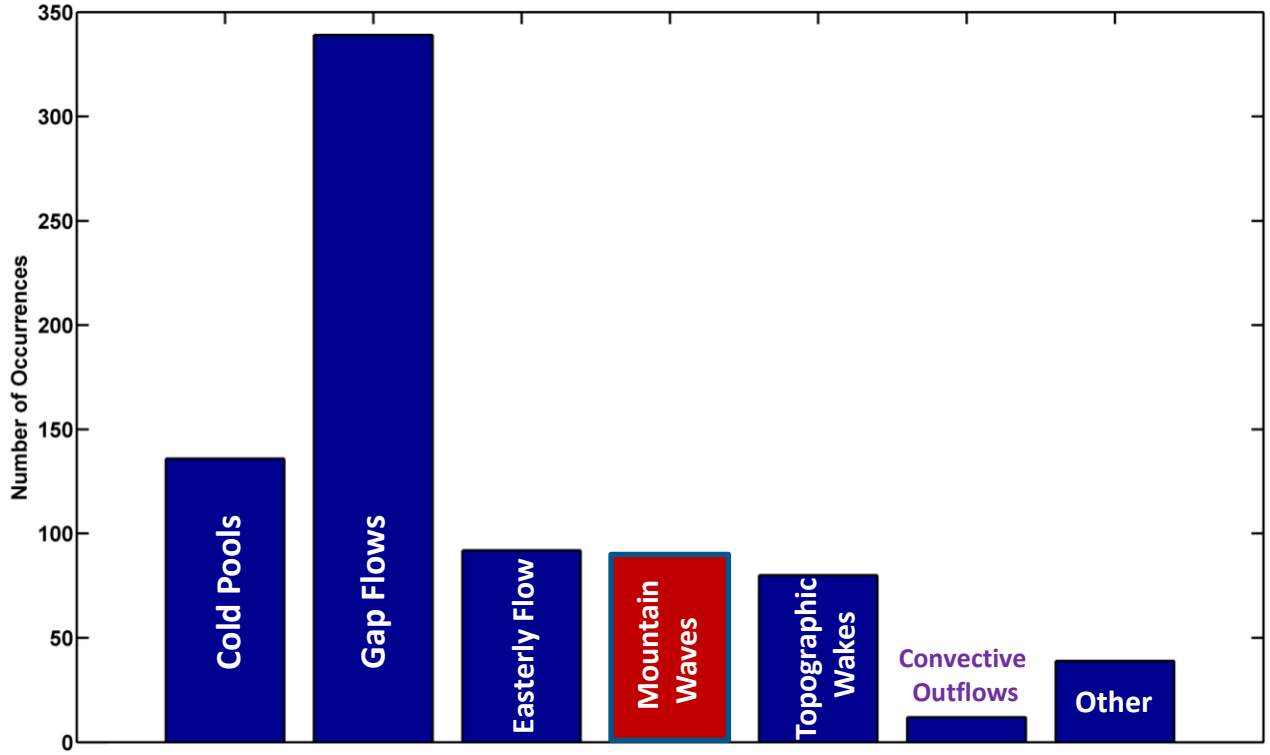


Orographic Wakes



Marine Pushes/Thermal Troughs

Forecast Challenges in Columbia River Gorge



Data Archive and Portal

- Secure data archive (> 18 million files; 168 TB)
- visualization

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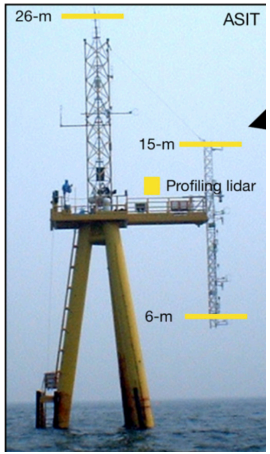
WFIP 3

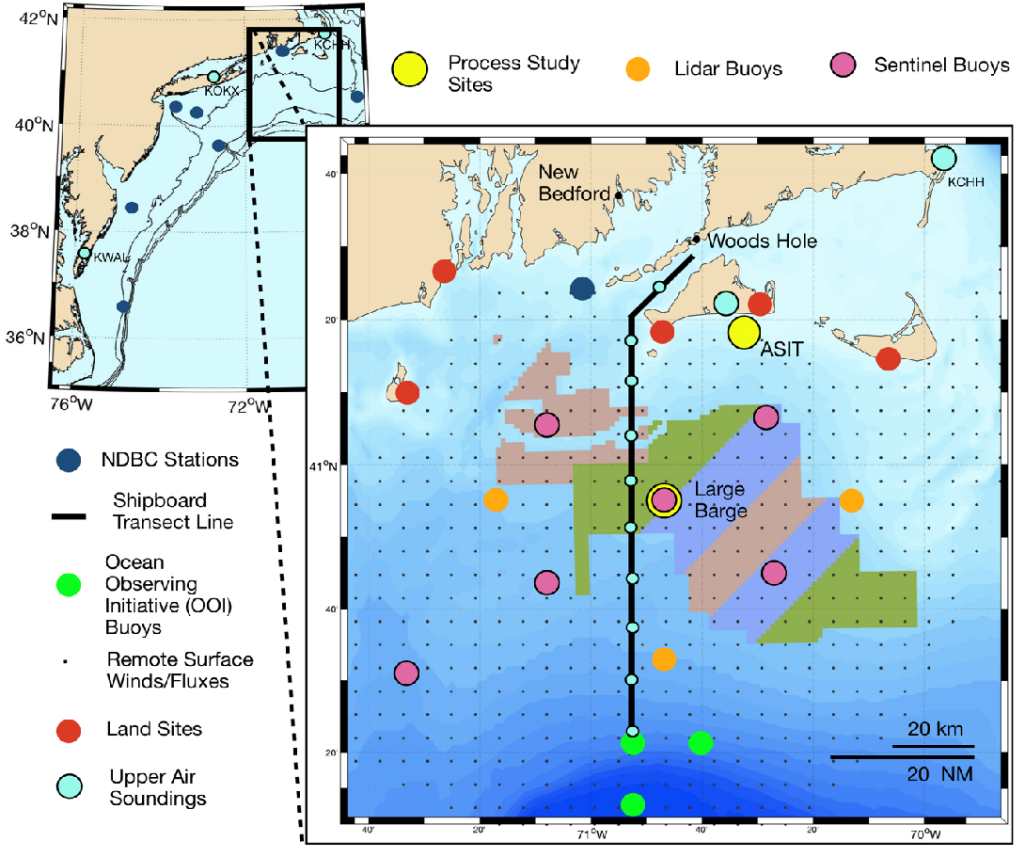
Improve the physical understanding of meteorological and oceanographic processes that affect wind resource characterization in the U.S. East Coast offshore environment

- Improve foundational numerical weather prediction models (NOAA) and other physics-based atmospheric and oceanographic models to improve wind energy forecasts (microscale models, wave models, coupled models, air-sea interaction)

- Led by Woods Hole Oceanographic Institution
- Industry involvement: focused research that addresses challenges articulated by wind industry
- Comprehensive observations of joint atmosphere and ocean conditions freely available for industry use
- Model improvements ultimately part of NOAA's operational forecast models

Observational Field Campaign





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Airborne Wind Energy Forecasting

NREL report about State of the Art

Airborne Wind Energy

Jochem Weber, Melinda Marquis, Aubryn Cooperman, Caroline Draxl, Rob Hammond, Jason Jonkman, Alexsandra Lemke, Anthony Lopez, Rafael Mudafort, Mike Optis, Owen Roberts, and Matt Shields

National Renewable Energy Laboratory

Goal was to propose a research plan to US DOE.

Includes information collected at a 2-day workshop in 2021 with more than 90 participants.

https://www.nrel.gov/docs/fy21osti/79992.pdf.

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Wind resource potential analyzed based on literature reviews and 20-year 2-km model simulations

The wind resource at altitudes viable for airborne wind energy depends on the location and changes with time of day and during the year.
In general, wind speed increases with height up to 300 m; above 300 m, average wind speed profiles seem to be mostly flat. Any increase in wind speeds with height may be negated by the effects of tether length and elevation angle, as they tend to reduce gains from higher heights (although this does not apply to all archetypes).

Gross capacity factors calculated for 5-MW airborne wind energy devices are like gross capacity factors for traditional wind turbines at the sites analyzed.

The windiest spots for traditional wind turbines are also the windiest spots for AWE devices, therefore AWE competes with traditional wind energy for sites if altitude considerations are neglected.

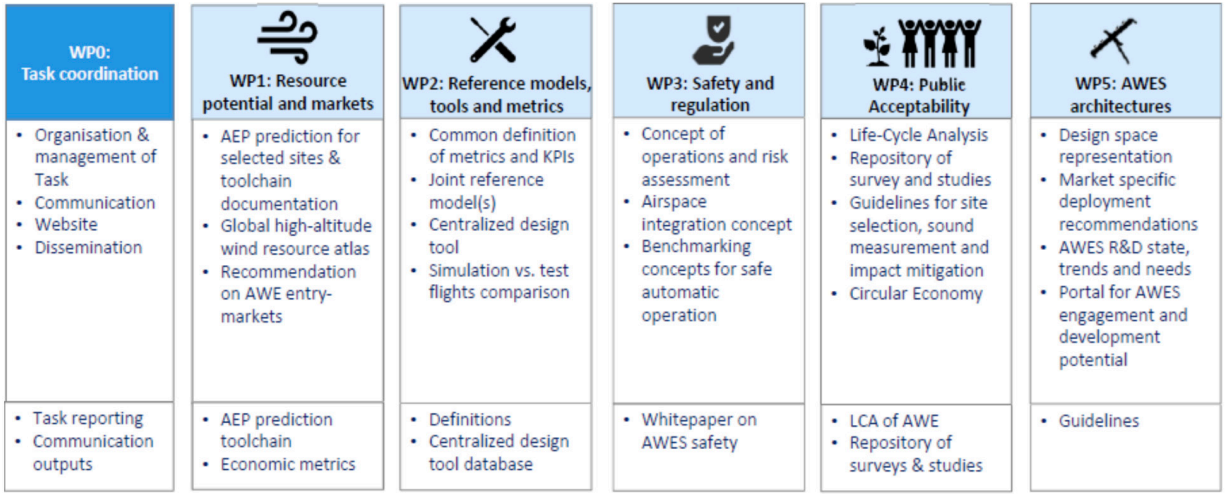
Between ~100 and 500 m above ground, wind shear is important to consider. Power output fluctuations related to wind shear can occur when the AWE flight path spans a range of altitudes.

Technical potential is dependent on social, environmental, and licensing constraints.

Recommendations for future research

- Gain a better understanding of turbulence, gusts, fluctuations, and intermittency of the airborne wind energy resource. Information needed during launching and landing of the kite.
- Experts recommend evaluating AWE devices regarding high-wind performance, high-wind controls, and safety relating to gusts (e.g., how to dampen out instantaneous power surges).
- Future research should also address climate impacts on the wind resource, wakes, and extreme events.

- Instrumental campaigns to quantify the resource and understand turbulence, gusts, and fluctuations of the wind resource at altitudes up to 500 m. Observations above the ocean.
- Wake modeling
- Climate modeling

Partnering

- Airborne Wind Europe: two Horizon projects; Universities, companies, NREL
- IEA Wind Task 48 on Airborne Wind Energy