Atmospheric Science and Wind Energy Technology: Pathways Ahead

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An atmospheric-oceanographic background

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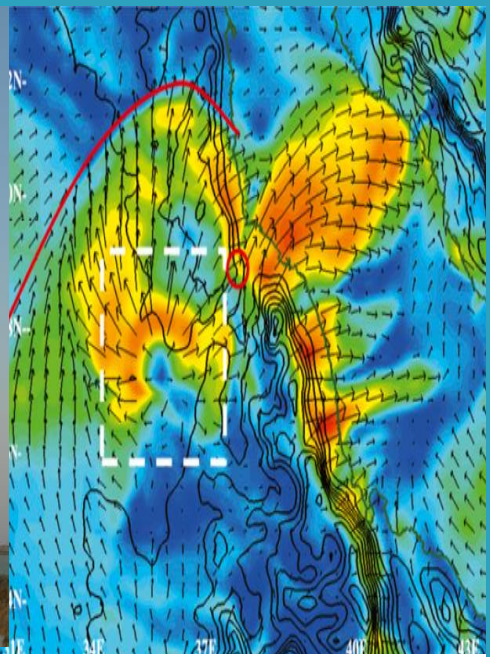
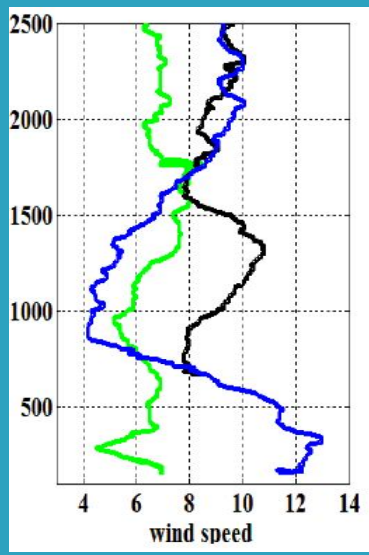
- Lower atmospheric dynamics
- Winds over complex terrain
- Air-sea processes and structure of the MABL
- Atmospheric transport
- Mesoscale-climate scale modelling
- Ocean-atmosphere observations
- Remote sensing





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Atmospheric Science Vision:

- Advance research to lead and support evolving wind energy technology
- Innovate new capabilities in atmosphere/wind modelling
- Provide new data and new data access in conjunction with new computational tools and numerical models
- Build on the foundation of current successes

The Collaborative Foundation

- "The overall objective of A2E is to optimize the power production of wind plants as a whole rather than by individual turbine." –*Shaw et al., BAMS 2020*

- A2E (Atmosphere to Electrons): an achievement in collaboration

- Comprehensive, multi-lab, multi-project program in atmospheric science

- Collaboration and coordination between
  - Federal Agencies
  - Industry
  - Academia

Challenges to Atmospheric Science

1) Better characterization of the lower atmosphere (*what does that mean?)*

-New observations: field campaigns, new types of measurements, new observational platforms

-Better representation in model physics
- improved surface-atmospheric coupling
- resolve local turbulence

2) Enhanced ability to observe and simulate flows from meso to microscales (from rotor aerodynamics to weather scale)

-Methods to couple models and successfully model/predict the two way interaction between scales (Milestones being achieved by MMC)

3) Increase awareness into the relationships between the resource, the wind farm and the environment around them (upstream and downstream)

New Observations for Offshore Resource Characterization

Image: Ocean Tech Services, LLC, and PNNL

- DOE lidar buoys providing
  - wind profiles
  - near surface meteo-ocean conditions
  - wave height, period, directional spectrum
- Completed 1 year+ field campaigns off the US East Coast 2014-2017
- Redeployed off the Pacific Northwest coast (10/2020)
- Data available: https://a2e.energy.gov/about/dap

New Numerical Modeling Developments

MMC:

-the critical conveyor of essential physics that influence hub height winds to high fidelity modeling of plant inflow and informing turbine design

-pioneering techniques for modelling, micro-mesoscale coupling and model validation/analysis

-characterizing complex localized flows including terrain and turbine wake effects to optimize siting of turbines and accurately predict output

- developing 3D boundary layer schemes for mesoscale models

-machine learning tools for atmospheric modelling

-developing the dynamical core for the next generation atmospheric model capable of simulating and predicting flows across the meso-microscale spectrum (the Energy Research and Forecasting model [ERF])

Thank You!

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Photo courtesy of UW Conservation Magazine

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