Pacific Northwest
NATIONAL LABORATORY

The American WAKE ExperimeNt (AWAKEN): Observations of Wind Farm—Atmosphere Interactions
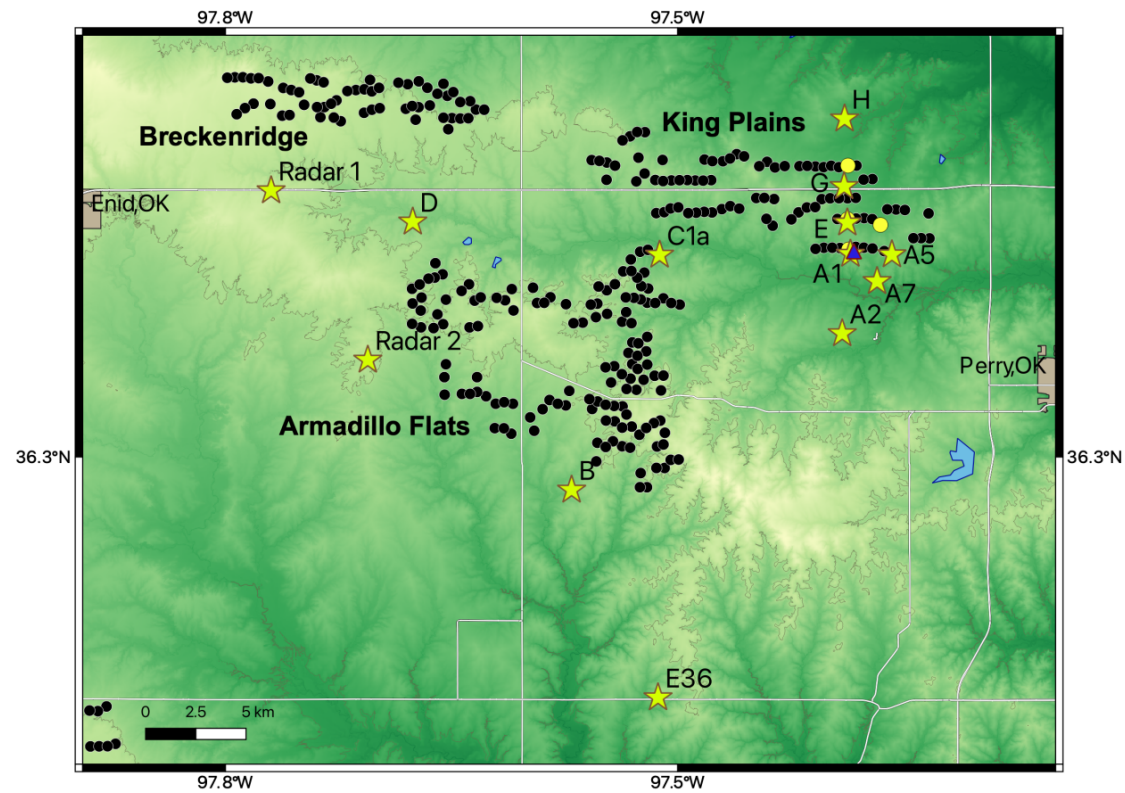
April 18, 2023

Lexie Goldberger (Presenter), Raghavendra Krishnamurthy, Colleen Kaul, Victor Morris, Donna Flynn, Rob Newsom, Mikhail Pekour, Duli Chand (Pacific Northwest National Laboratory, Richland, WA, USA), Nicola Bodini, Stefano Letizia, Patrick Moriarty (National Renewable Energy Laboratory, Denver, CO, USA)

U.S. DEPARTMENT OF ENERGY *BATTELLE*

Background

Map of campaign area in OK, USA

Campaign Approach

Instruments installed at site A1. Photo from Raghavendra Krishnamurthy

Instrumentation
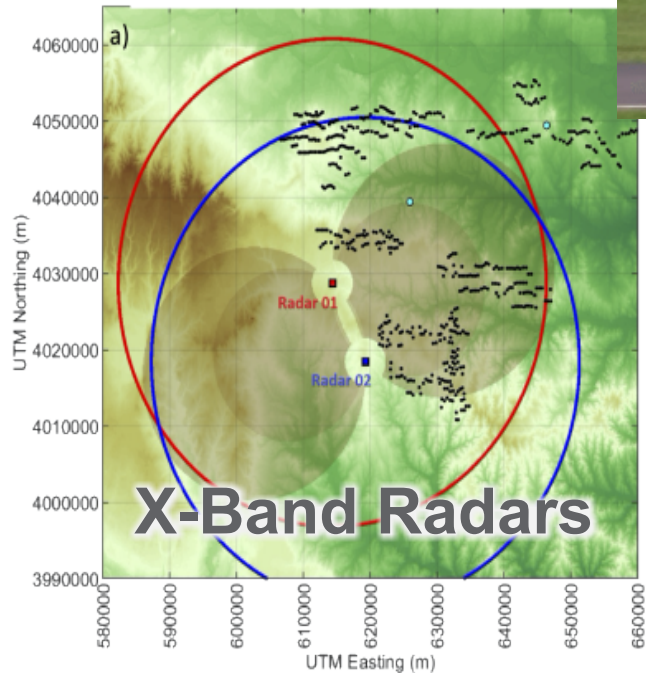

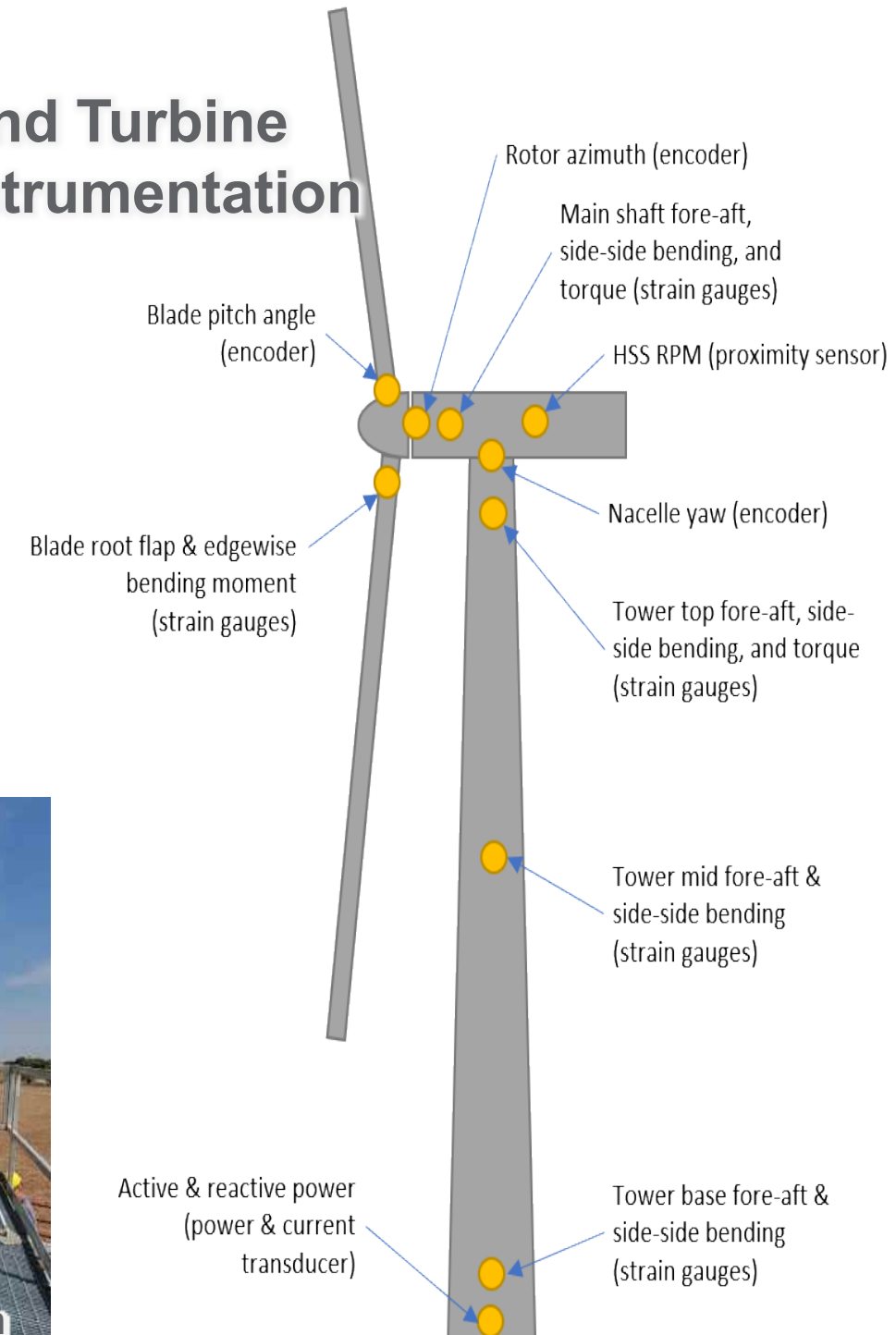Surface Meteorological Stations

AERI and LiDAR

Aircraft

Wind Profiler

X-Band Radars

Atmospheric Radiation Measurement User Facility instrumentation

Wind Turbine Instrumentation

Rotor azimuth (encoder)

Main shaft fore-aft, side-side bending, and torque (strain gauges)

Blade pitch angle (encoder)

HSS RPM (proximity sensor)

Nacelle yaw (encoder)

Blade root flap & edgewise bending moment (strain gauges)

Tower top fore-aft, side-side bending, and torque (strain gauges)

Tower mid fore-aft & side-side bending (strain gauges)

Active & reactive power (power & current transducer)

Tower base fore-aft & side-side bending (strain gauges)
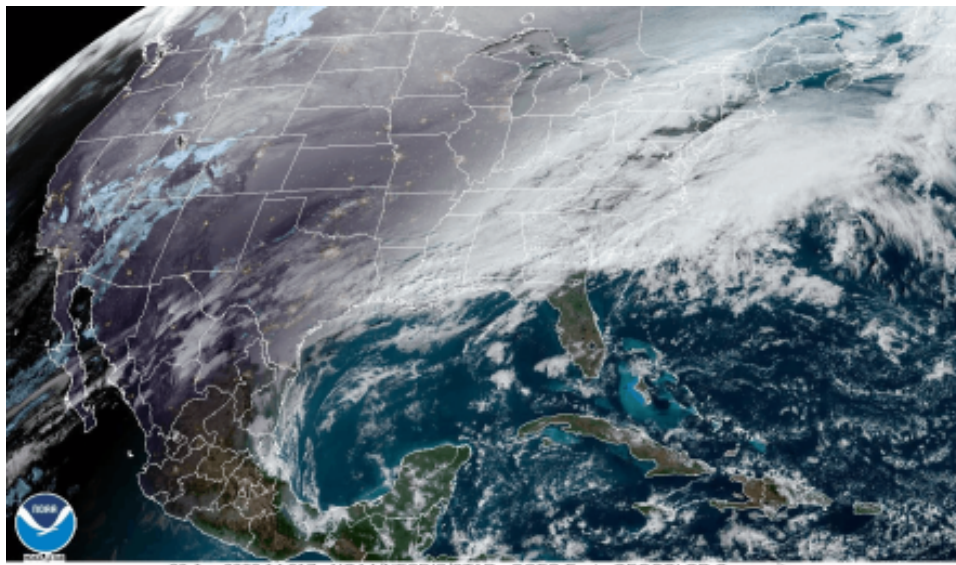
Research Question

Conceptual models and engineering tools for atmosphere—wind farm interaction typically assume steady-state conditions. How do these interactions change under transient conditions, such as those associated with a frontal passage?
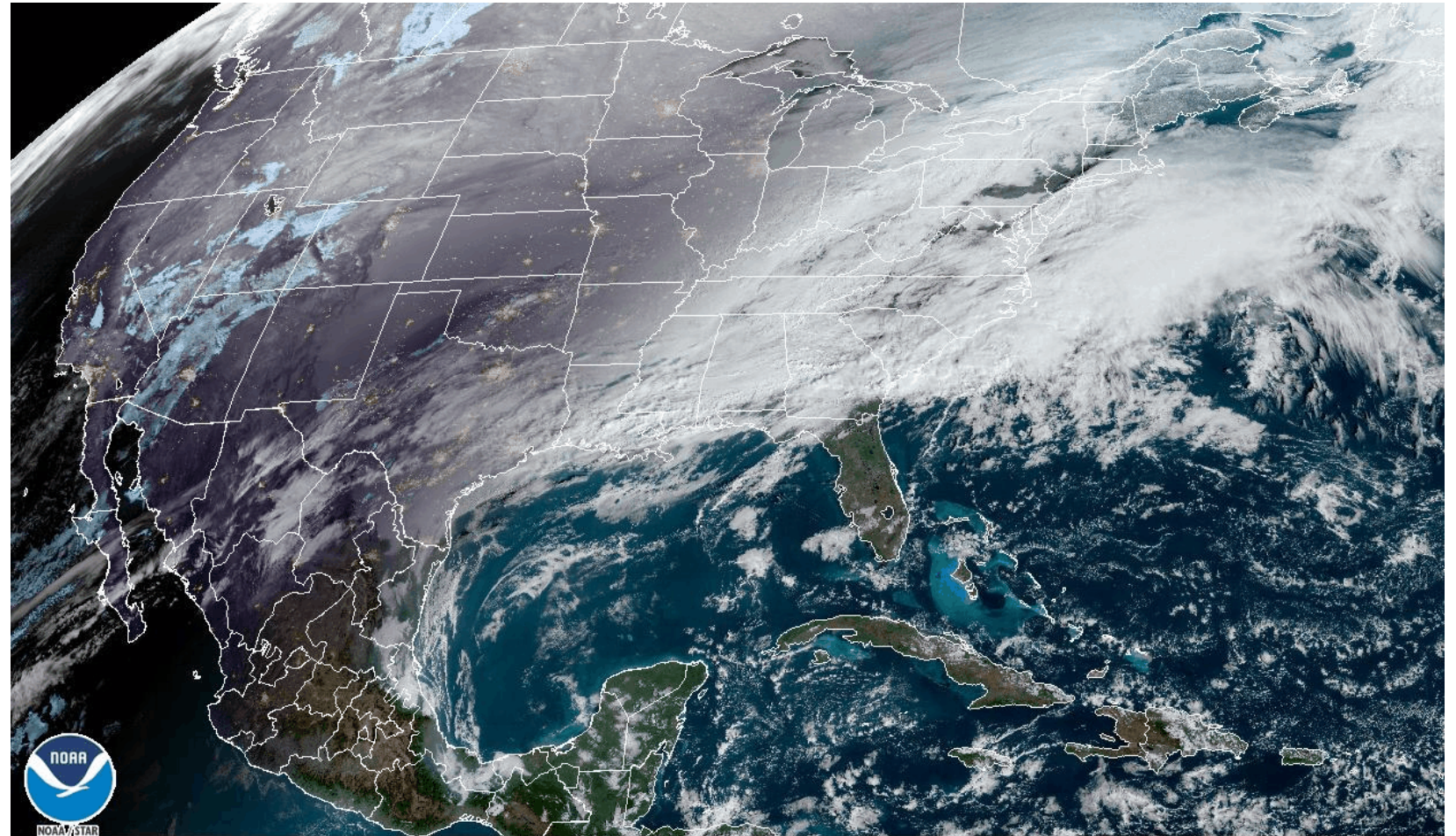
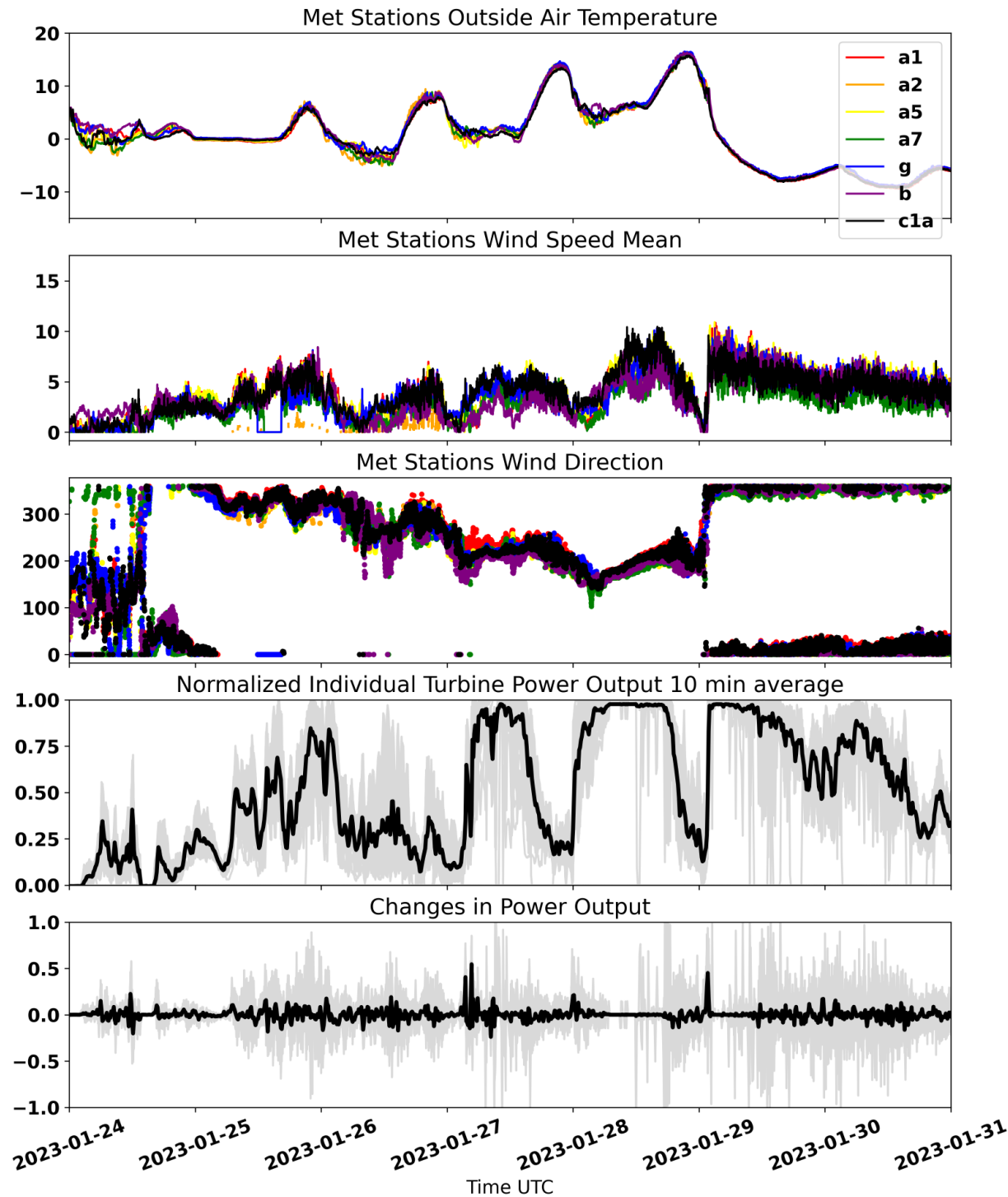30 Jan 2023 14:21Z - NOAA/NESDIS/STAR - GOES-East - GEOCOLOR Composite

Approach

- 88 GE 2.82 MW wind turbines
- 7 surface-based Campbell Scientific meteorological stations

30 Jan 2023 14:21Z - NOAA/NESDIS/STAR - GOES-East - GEOCOLOR Composite


Weekly Data 01/24/2023

Met Stations Outside Air Temperature

Met Stations Wind Speed Mean

Met Stations Wind Direction

Normalized Individual Turbine Power Output 10 min average

Changes in Power Output

Time UTC

Largest Hourly Rate of Change of Atmospheric Variables versus Hourly Rate of Change of Power Production per Day
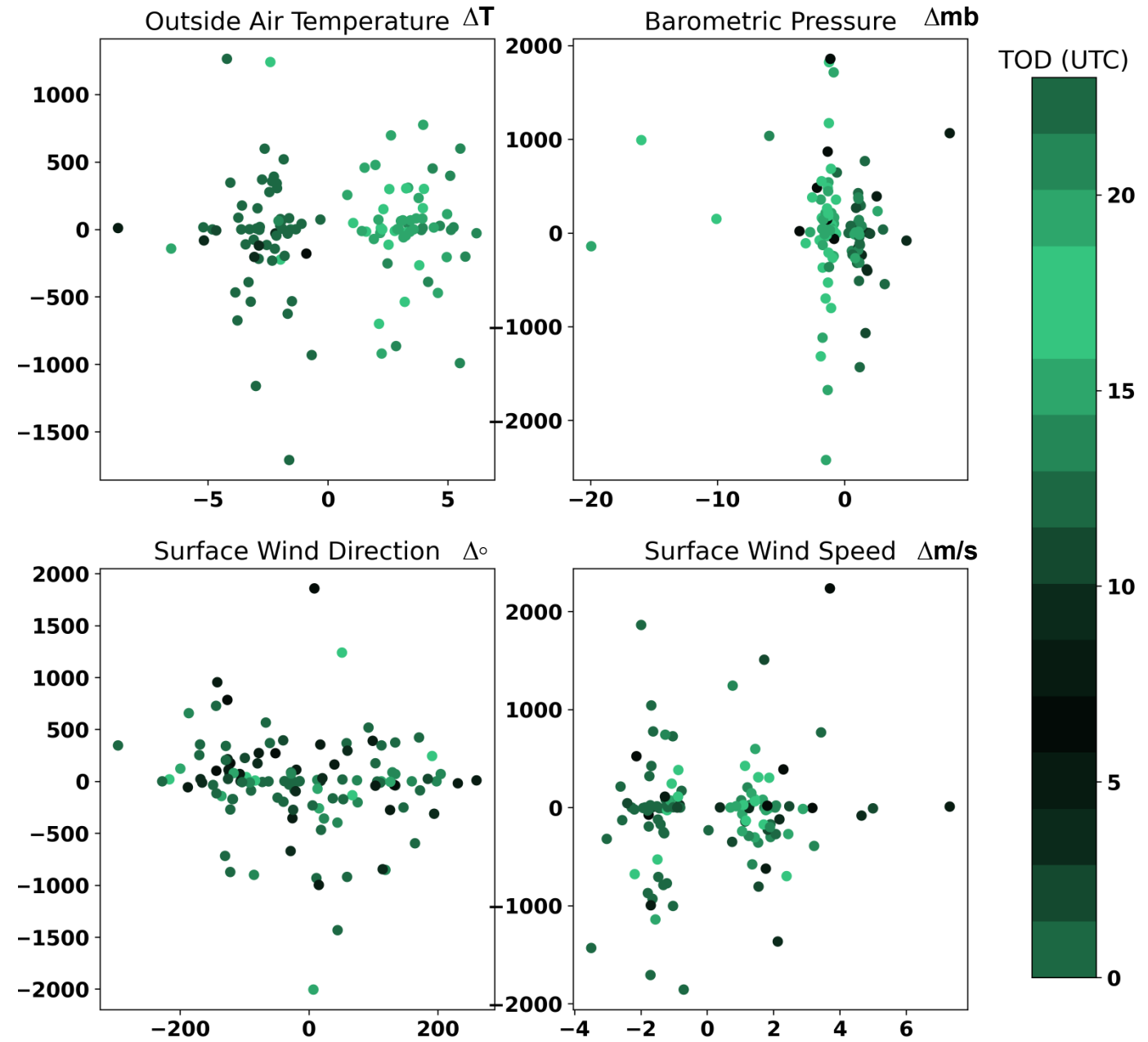
Marker color indicates time of occurrence of the daily max. Color corresponds to local daytime.

Largest Hourly Rate of Change of Power Production versus Hourly Rate of Change of Atmospheric Variables per Day
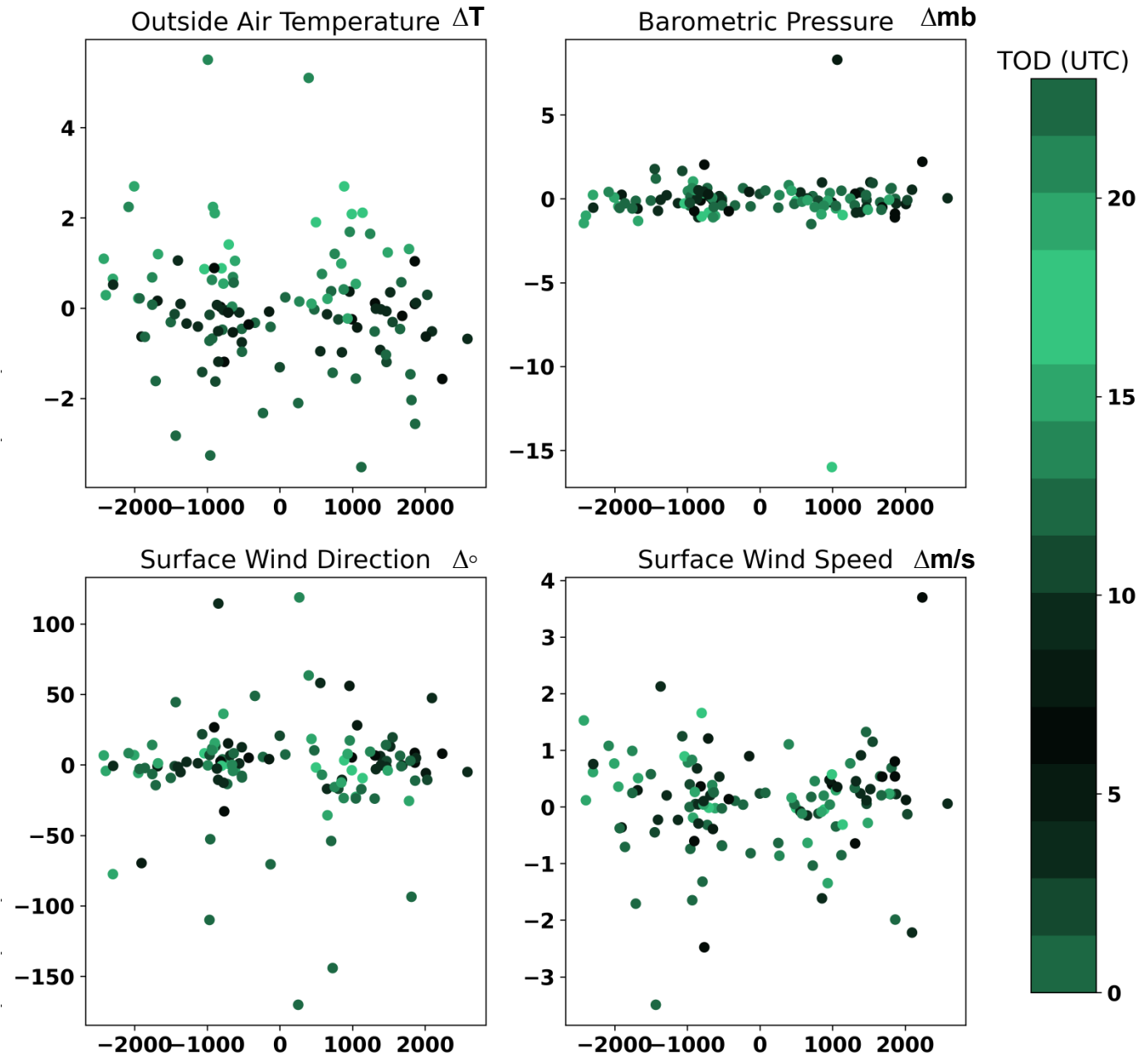
Marker color indicates time of occurrence of the daily max. Color corresponds to local daytime.

Main Takeaway

The dynamics of the atmospheric boundary layer are complex and impact wind farm performance in a variety of ways. Surface-based atmospheric measurements provide insights for understanding changes in wind farm power production under some, but not all, atmospheric conditions. Additional detailed measurements, including vertical profile data, as being collected by AWAKEN, are essential to gaining a full picture of the interactions between the atmosphere and wind farms.

AWAKEN

Go to our website to learn more:

Check out the data at:
https://a2e.energy.gov/

Thank you

By enhancing fundamental knowledge of wind-farm—atmosphere interactions and improving modeling tools, AWAKEN will help to enable optimal wind farm design and operation even as atmospheric conditions may change in a changing climate.