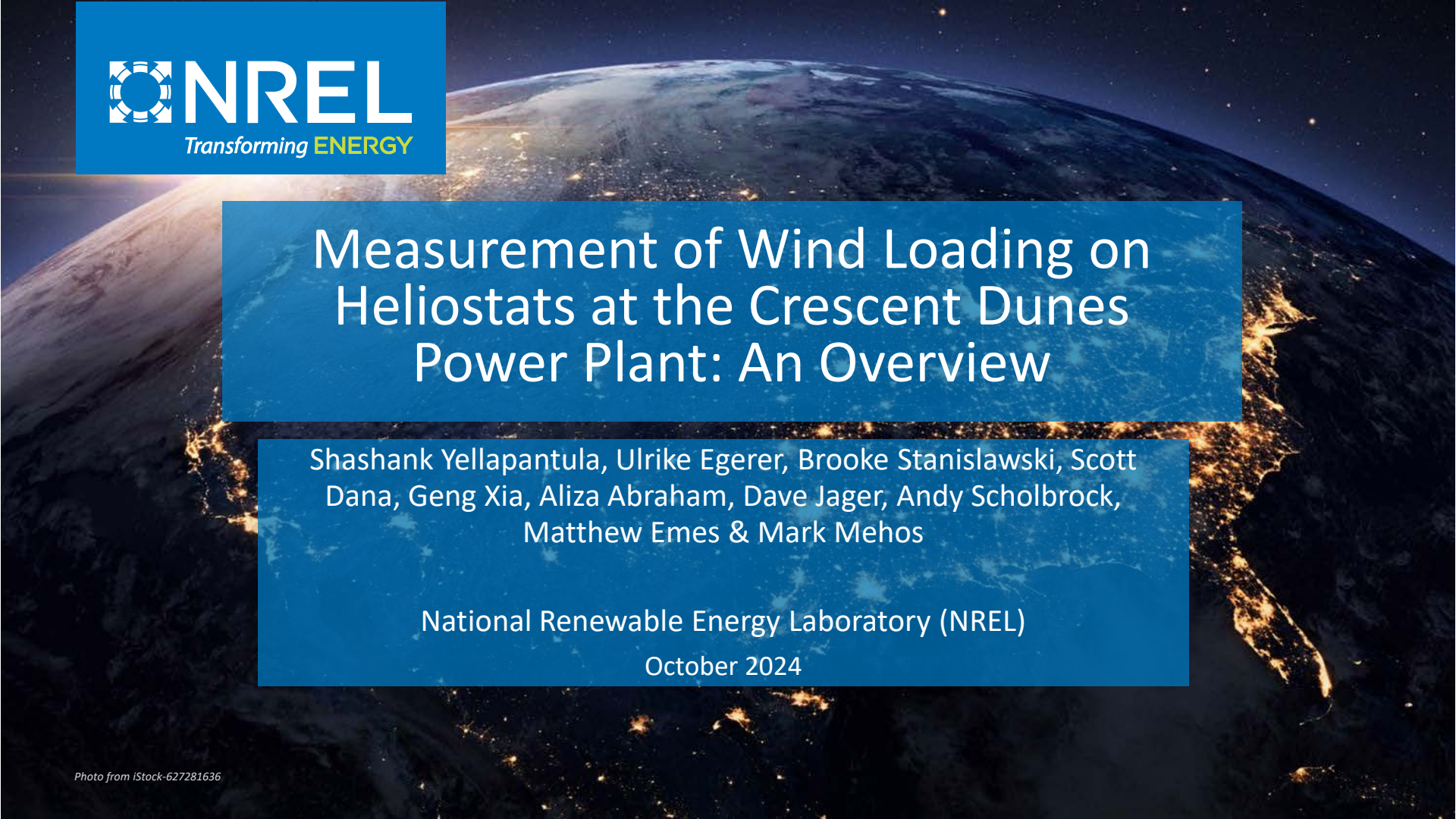


Measurement of Wind Loading on Heliostats at the Crescent Dunes Power Plant: An Overview

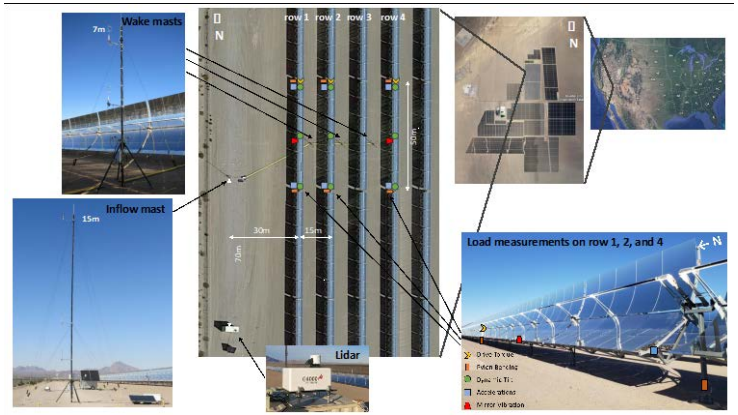
Shashank Yellapantula, Ulrike Egerer, Brooke Stanislawski, Scott Dana, Geng Xia, Aliza Abraham, Dave Jager, Andy Scholbrock, Matthew Emes & Mark Mehos

National Renewable Energy Laboratory (NREL)

October 2024

Photo from iStock-627281636

Overall Project Goals



Collect Wind and Loads data from a parabolic trough power plant, Nevada Solar One (NSO)

Image Credit Dave Jager (NREL)

Collect Wind and Loads data from a power tower plant, Crescent Dunes

Collected Long-term Wind and Loads on collectors in two operational power plants

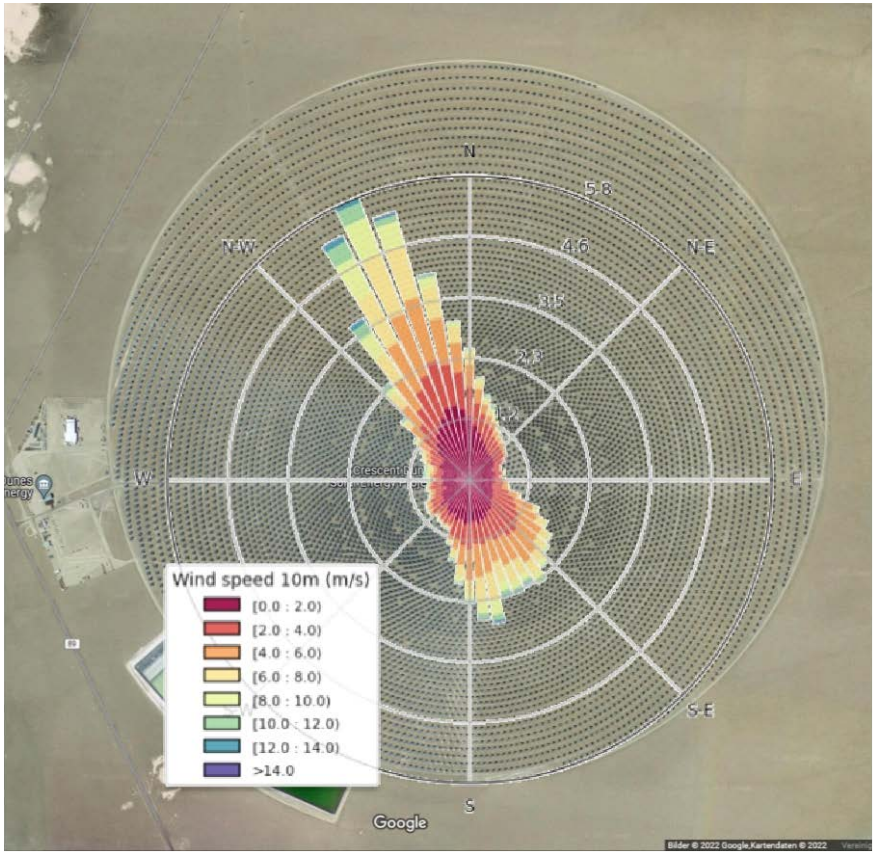
Parabolic Troughs – Dataset

1. Full 300 GB dataset with access scripts published in OEDI
2. Several papers published and in preparation
3. Unique dataset – Long term characterization of wind profiles close to the ground. Also useful for PV design studies
4. Dataset already being used by CSP industrial organizations and academic organizations

OEDI

Nature Scientific Data Paper

Goals: Crescent Dunes Field Campaign



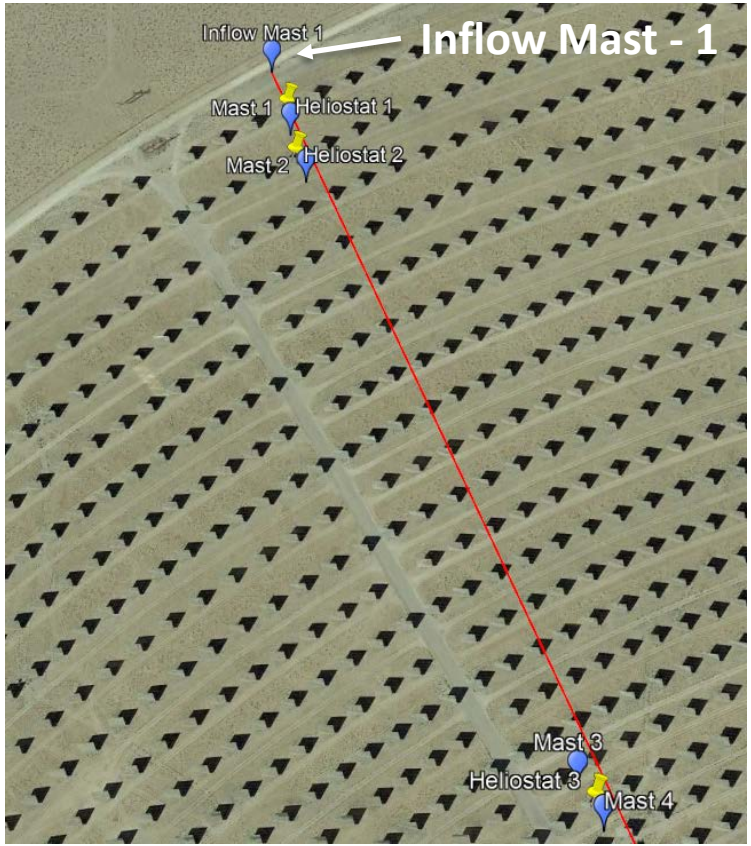
01 Long term wind and loads data collection campaign

02 Focus on N-W quadrant of the plant (First 6 months) and then move to southern section of the plant

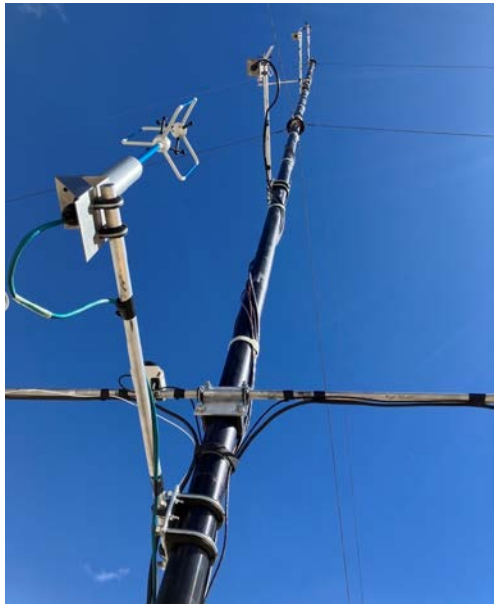
03 Characterize Wind profiles at the edge and in the interior

04 Measure loads on 3 heliostats – Two at the edge and one in the interior

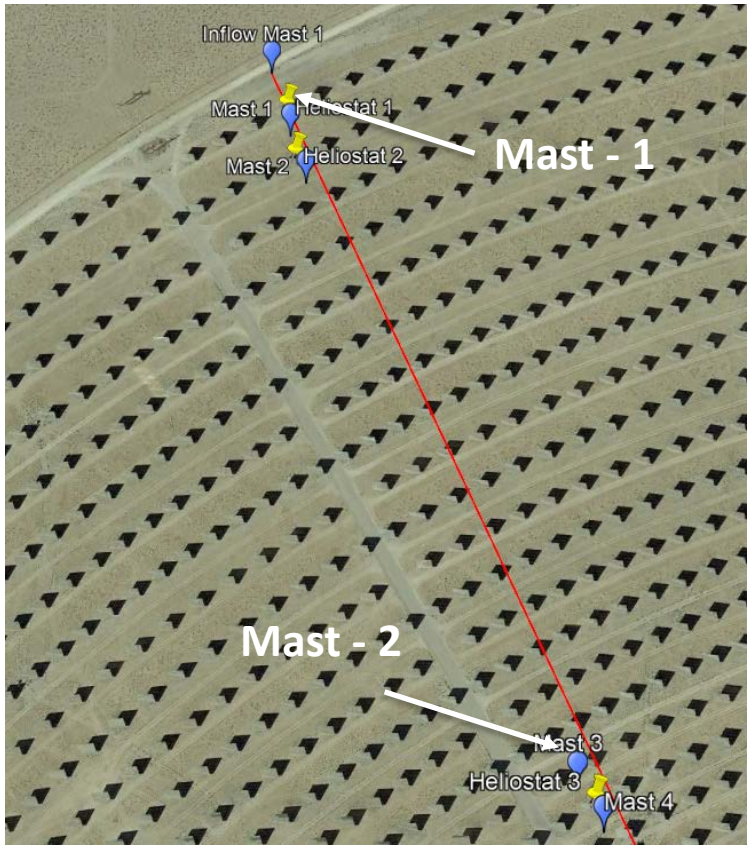
Crescent Dunes Wind Measurement



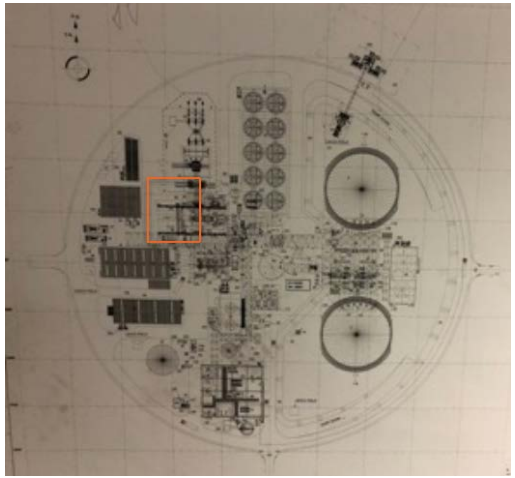
Inflow Mast - 1



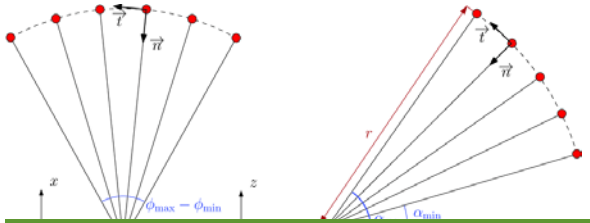
Crescent Dunes Wind Measurement



Crescent Dunes - Lidar



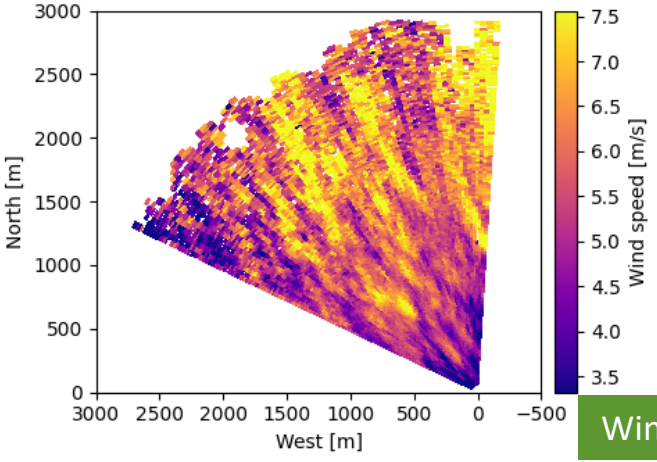
Vertical and Horizontal scans



High resolution scanning Lidar installed on the heater bay for full field wind mapping

Crescent Dunes - Lidar

2024-09-15 23:59:43 to 2024-09-16 00:01:13 local time
Wind speed from met tower: 4.6 m/s
Wind direction from met tower: 325.2 deg



Horizontal scan

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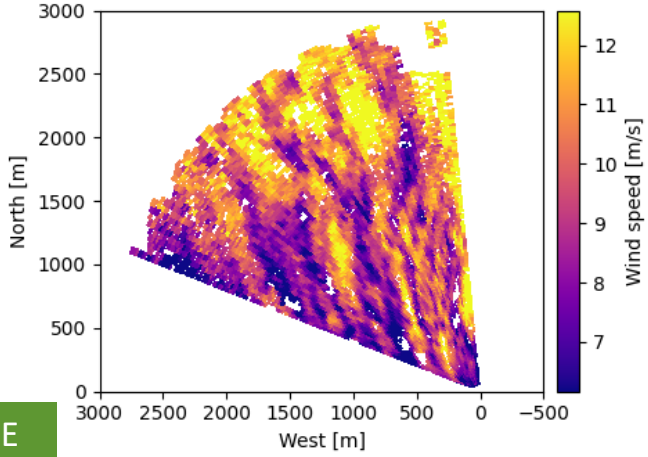

Wind from N-NW

Wind from S-SE

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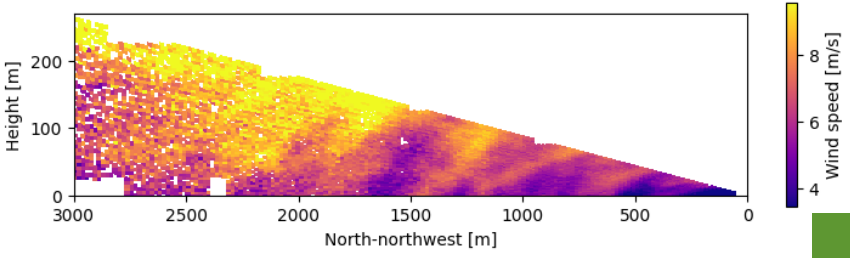

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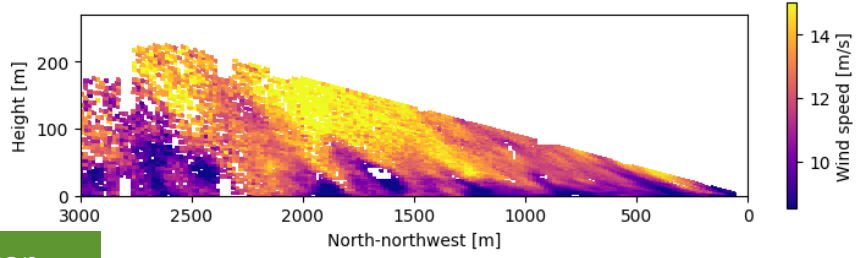
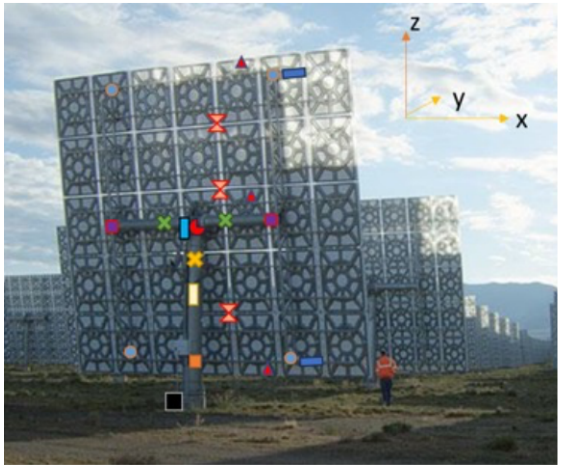


Vertical scan

Crescent Dunes Load Instrumentation

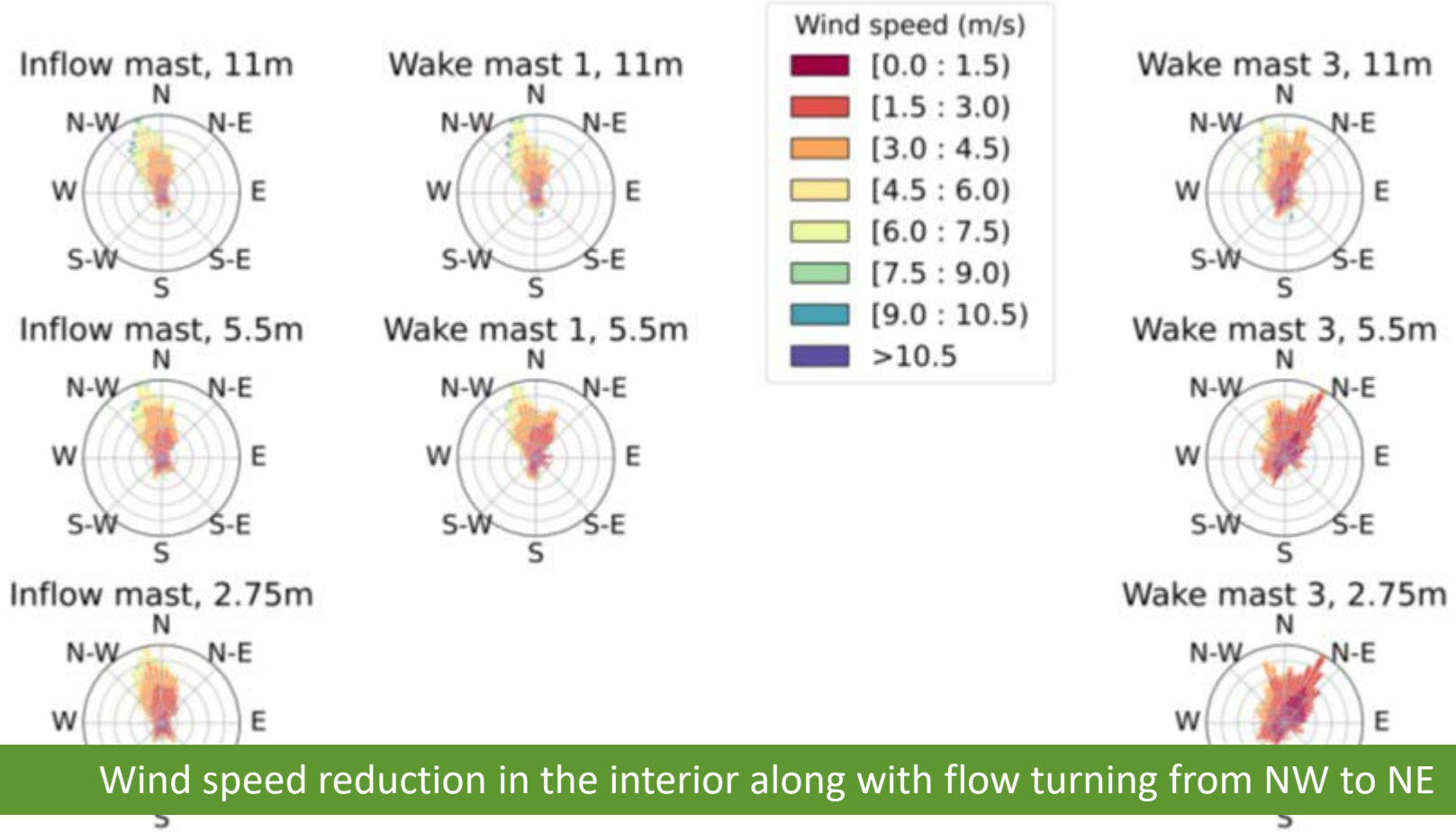


- Pedestal bending moments (M_x and M_y) to determine foundation loads and validate load distribution on the mirror
- Torque along the torque tube to obtain validation of load distribution along the x-axis and proxy for torque actuator loads
- Torque of the pedestal to assess asymmetrical loading across mirrors and proxy for azimuth drive loads
- Pedestal axial load, to access lift
- Accelerometers across support frame to validate mode shapes, accelerations, spectral content of the facet support structure, and elevation angle
- Mirror displacements to validate cyclic loading response and facet spectral content
- Dynamic tilt to measure elevation angle and torque tube dynamics
- Azimuth position (encoder or altitude sensor)
- Differential pressure for lift/drag/stall measurements

Loads instrumentation installed on 3 Heliostats (2 at the edge of the plant and 1 in the interior)

- 3 torque bridges, 2 on torque tube and 1 on the pedestal
- 2 bending bridges on the pedestal near the base
- 1 full axial bridge on the pedestal
- 2 half bending bridges on the support structure of the mirror, top, and bottom end of the mirror
- 2 inclinometers, one on each end of the torque tube
- 1 rotary encoder
- Pressure differential on 3 locations
- 4 Accelerometers on each 4 corners, triaxial accelerations, backside, and in plane

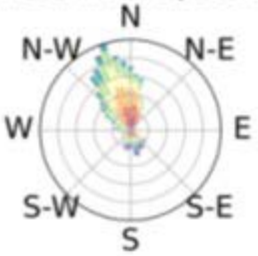
Heliostats – Wind Modification



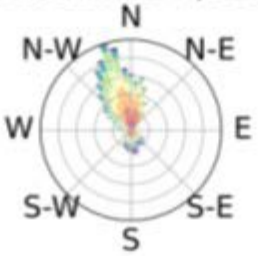
Wind speed reduction in the interior along with flow turning from NW to NE

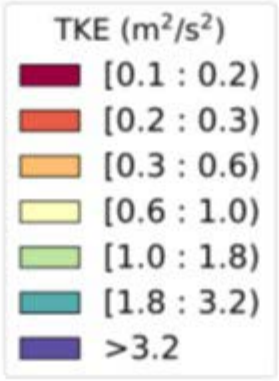
Heliostats – Turbulence

Inflow mast, 11m

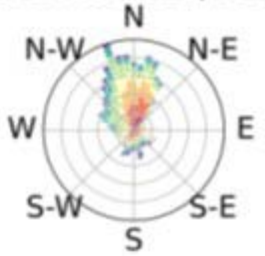


Wake mast 1, 11m

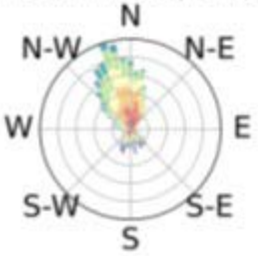




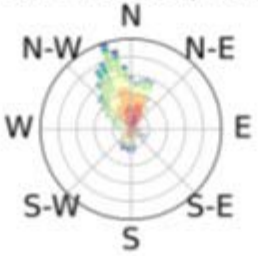
Wake mast 3, 11m



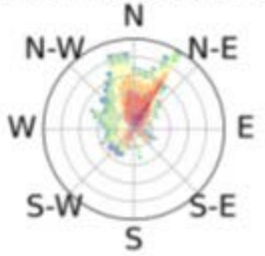
Inflow mast, 5.5m



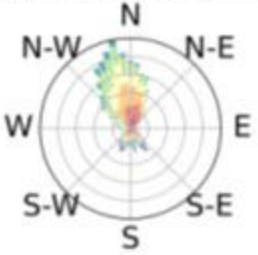
Wake mast 1, 5.5m



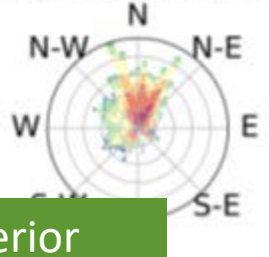
Wake mast 3, 5.5m



Inflow mast, 2.75m

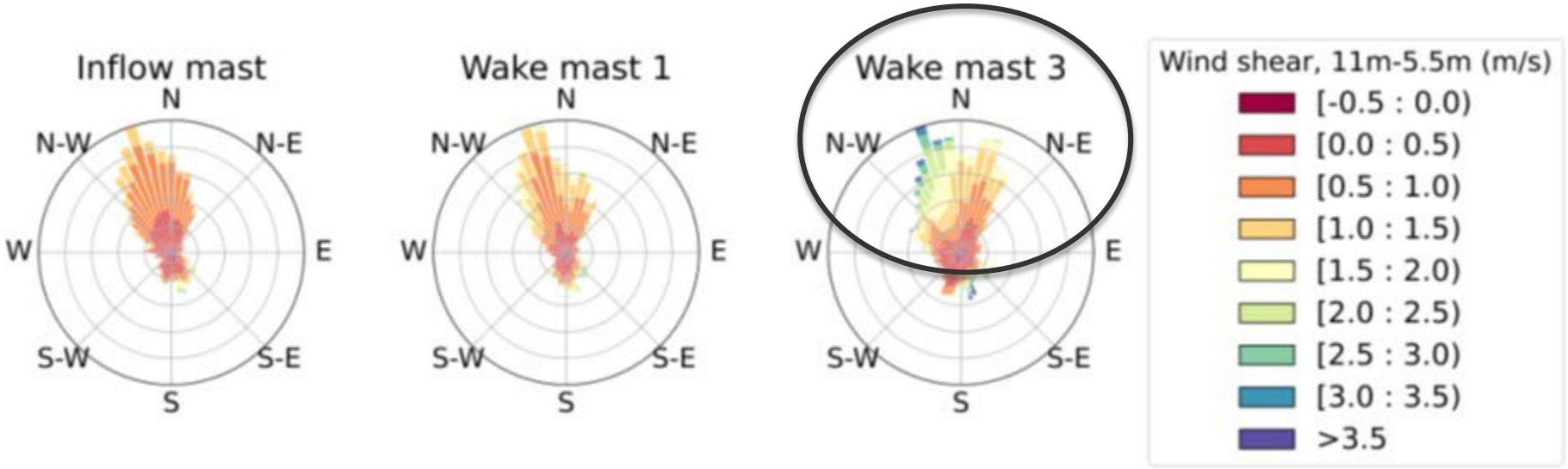


Wake mast 3, 2.75m



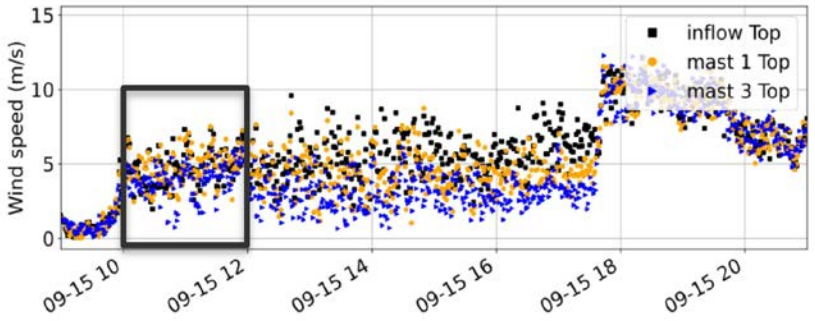
Significant turbulence generation in the interior

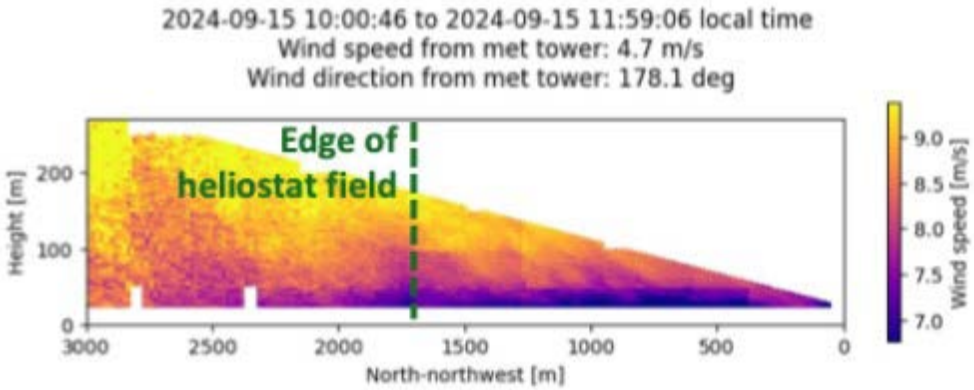
Heliostats – Plant Interior



1. Higher Wind Shear in the interior of the plant
2. Higher Wind Shear leads to higher turning moments
3. Assumption that interior collectors experience lower loads -> **Not accurate**

Heliostats – Wind Shear (Lidar)





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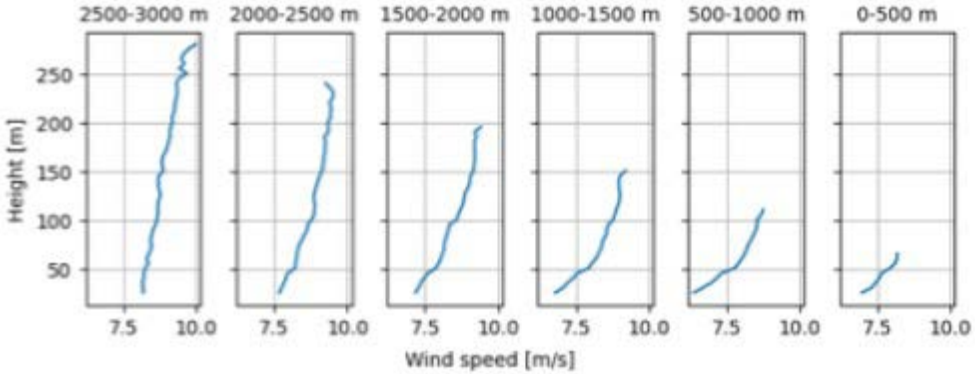
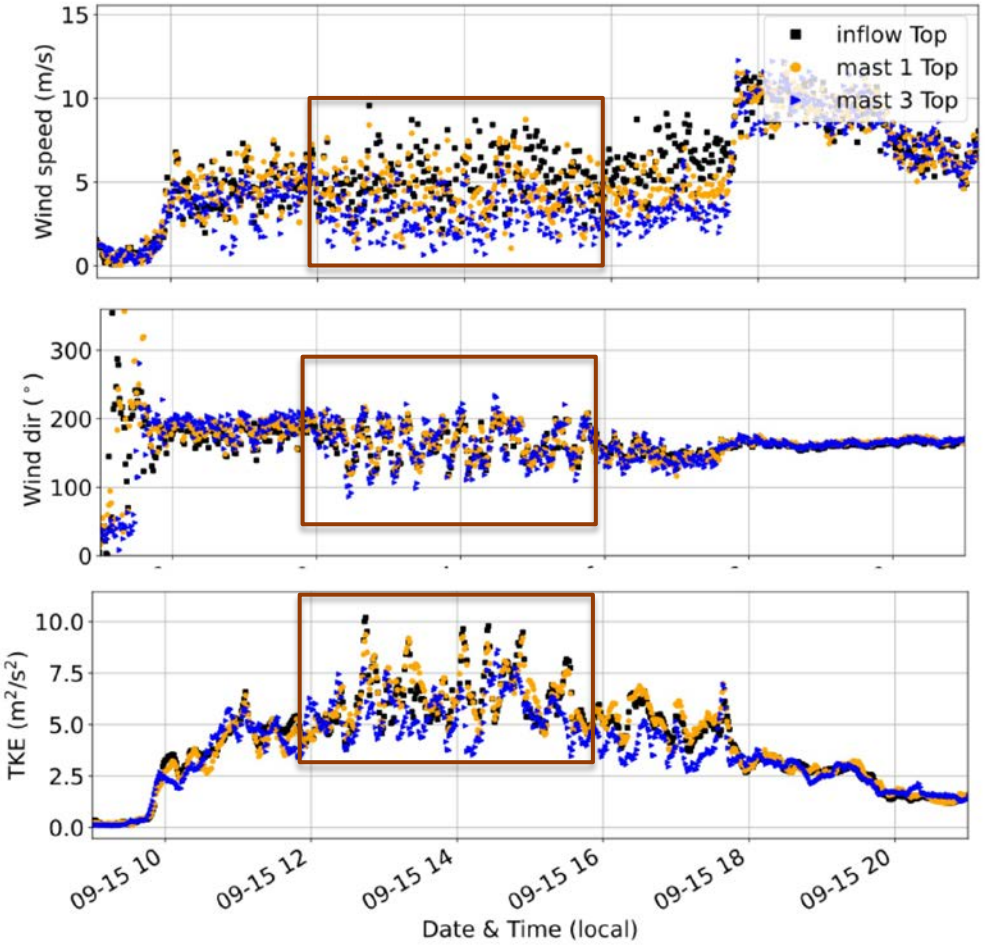


Crescent Dunes - High Speed Event



1. Wind speed at 11m can be greater than 10 m/s
2. High turbulence in the same time period
3. Large change in wind direction > 90 degree shift especially in the interior mast
   - Time scale of directionality change ~ 15m
   - Induced by nearby hilly terrain?

Conclusions & Future Work

1. Generating first-of-a-kind dataset of wind and loads from an operational power tower plant

2. Unique combination of instrumentation (Met-Towers, Lidars and Loads) providing a unique insight into the wind driven loads experienced by Heliostats

3. Like troughs, increased wind shear along with turbulence is observed in the interior of the plant -> Increased turning moments

4. Wind driven loads are being analyzed to generate critical design guidelines for designing solar fields with reduced costs

5. Plan to make this dataset fully open to public to promote usage within the research and industrial community

Thank You

www.nrel.gov

NREL/PR-2C00-92268

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Transforming ENERGY

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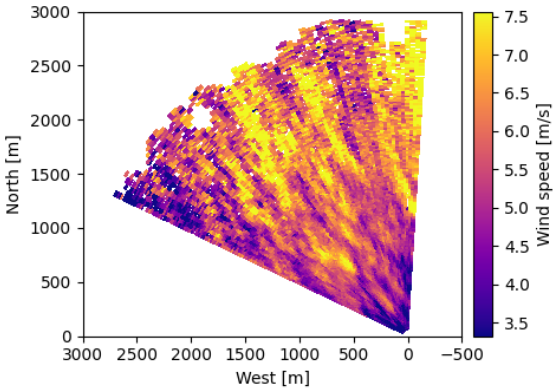

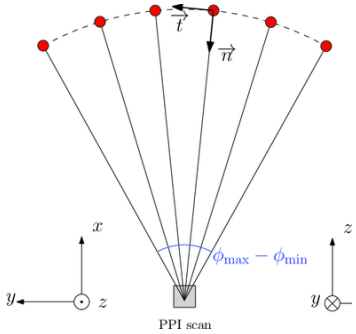

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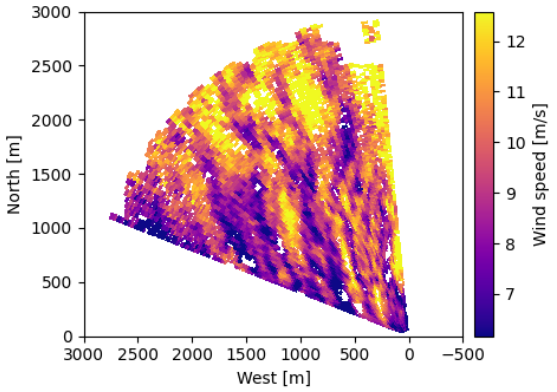

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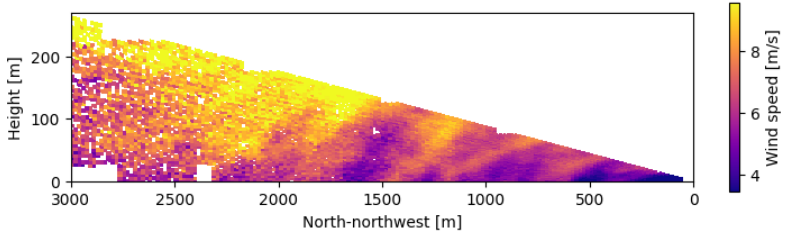

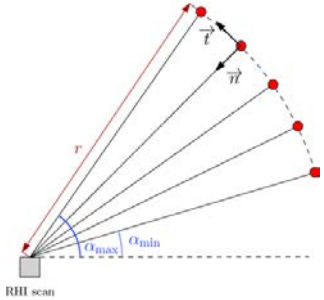

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