NREL
Transforming ENERGY

In Situ Wind and Turbulence Measurements in a Field of Full-Size Parabolic Trough Collectors

Ulrike Egerer, Geng Xia, and Shashank Yellapantula
24th AMS Symposium on Boundary Layers and Turbulence
Jan. 11, 2023

SOLAR ENERGY
TECHNOLOGIES OFFICE
U.S. Department Of Energy

Photo by Ulrike Egerer, NREL

Motivation: Wind Loading on Parabolic Troughs

Background

- Wind loading is one of **the primary drivers of structural design costs** of concentrated solar power (CSP) collector structures.
- To date, the design of these structures **has relied on data from wind tunnels** that do not adequately capture the dynamic effects observed at scale.
- **Field measurements at a full-scale operational power plant** will help to better understand wind loading on collector structures.

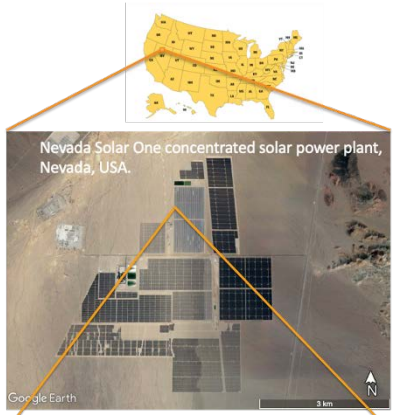
Parabolic Trough Measurement Campaign

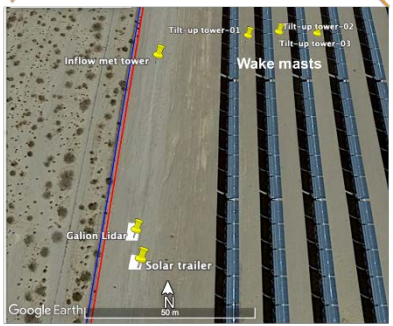
The team collects detailed characterization of prevailing wind and turbulence conditions and resulting operational loads on parabolic troughs in a full-scale CSP plant.

Parabolic trough rows at the **Nevada Solar One (NSO)** solar power plant with damaged mirrors on the outer edge of the field. *Photos by Ulrike Egerer, NREL*

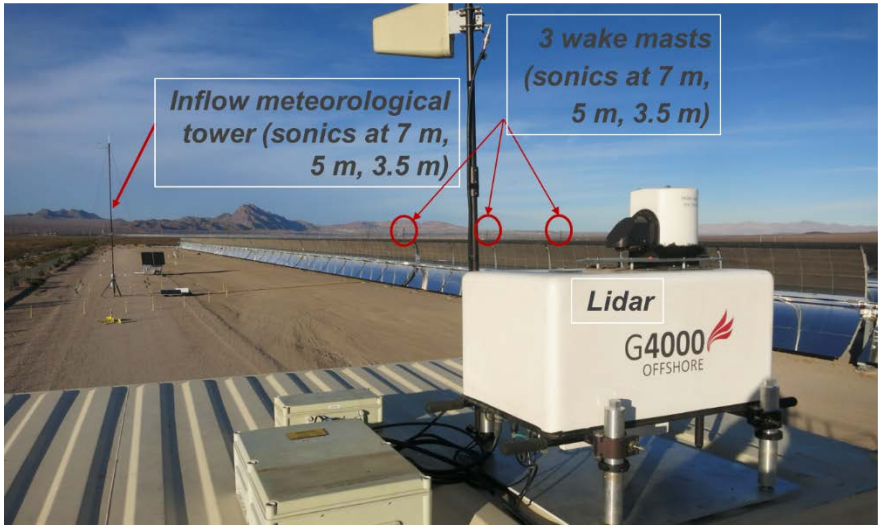
Methods: Wind and Turbulence Measurements

Wind and turbulence measurements at the Nevada Solar One (NSO) power plant
November 2021–April 2023



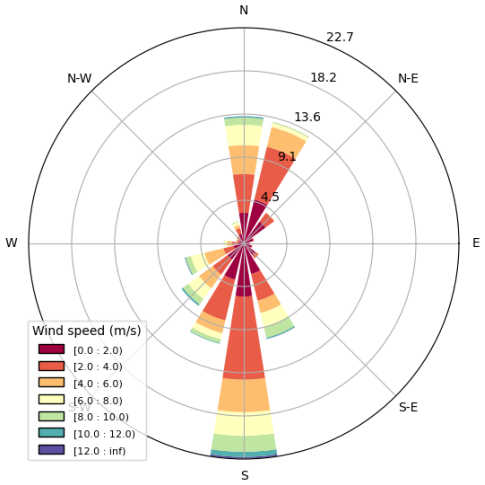


Images from Google Earth



Sonic anemometers within and above the trough field at the inflow mast and wake masts. *Photo by Dave Jager, NREL*

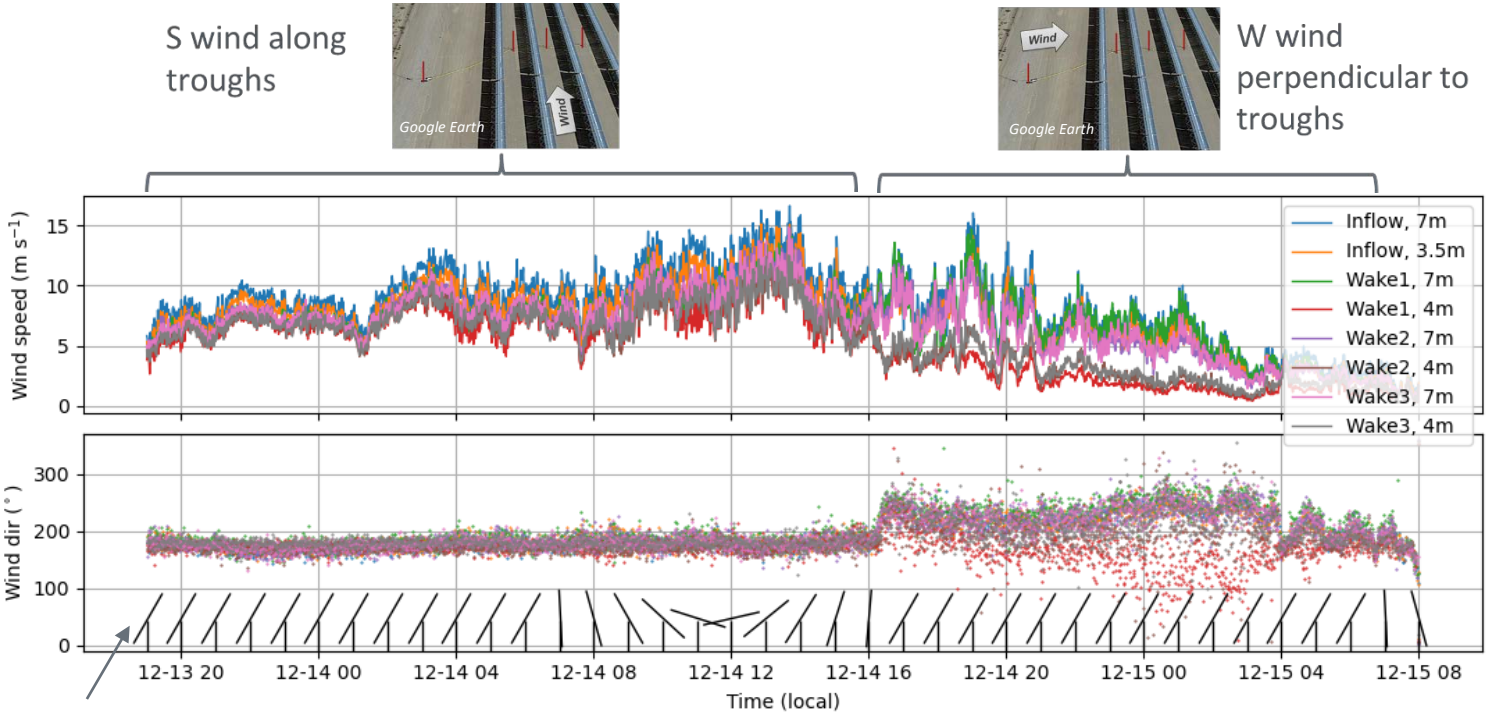
Inflow wind characterization



Credit Ulrike Egerer, NREL

Case Study: Changing Wind Conditions

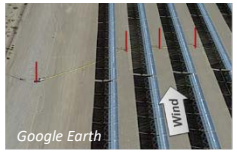
Dec. 14–15, 2021: Front passage with strong wind changing from south (S) to west (W).

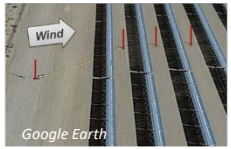


Trough angle (stow = 30°down to east)

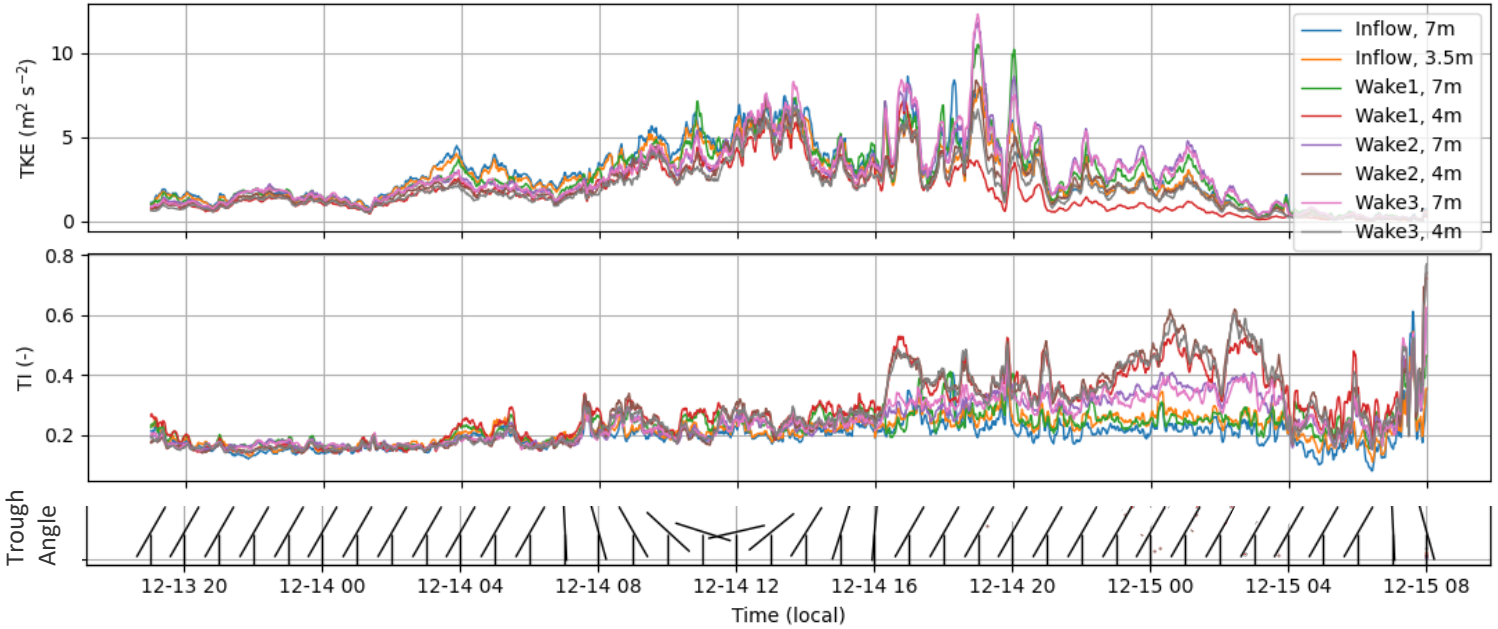
Credit Ulrike Egerer, NREL

S wind along troughs





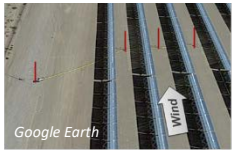
W wind perpendicular to troughs

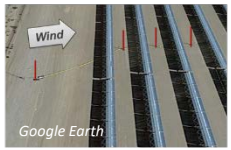


TKE: turbulent kinetic energy
TI: turbulence intensity

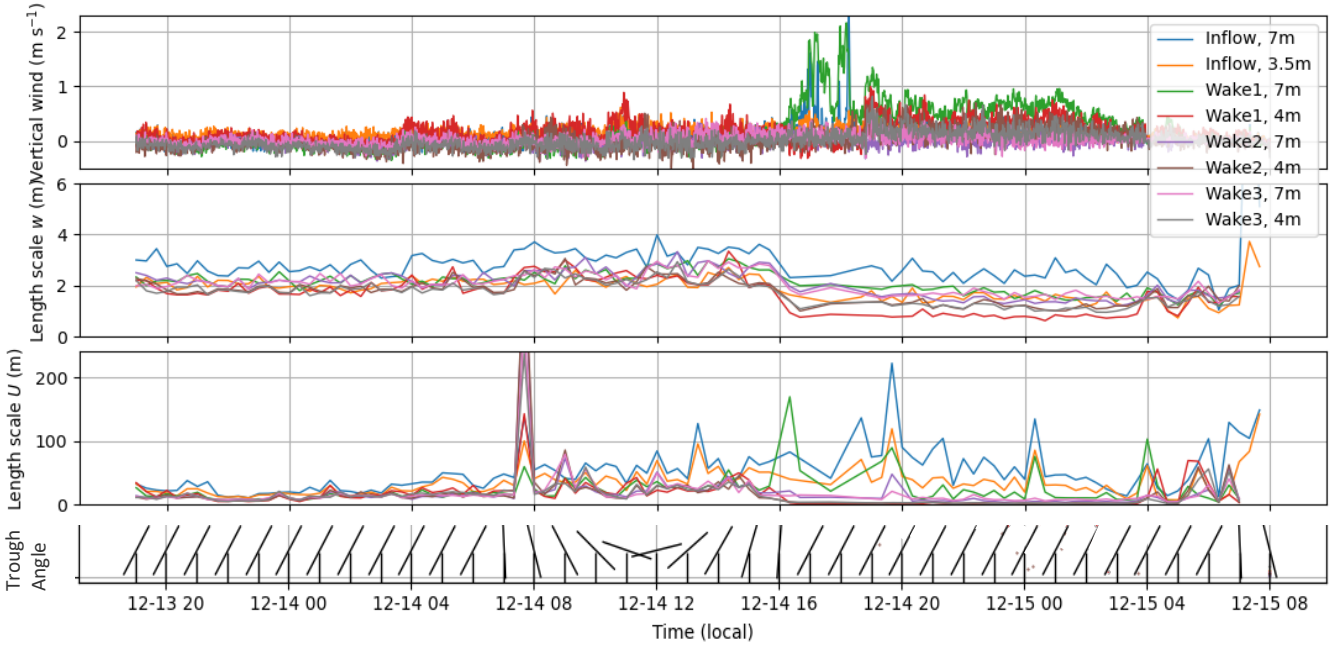
Credit Ulrike Egerer, NREL

S wind along troughs





W wind perpendicular to troughs

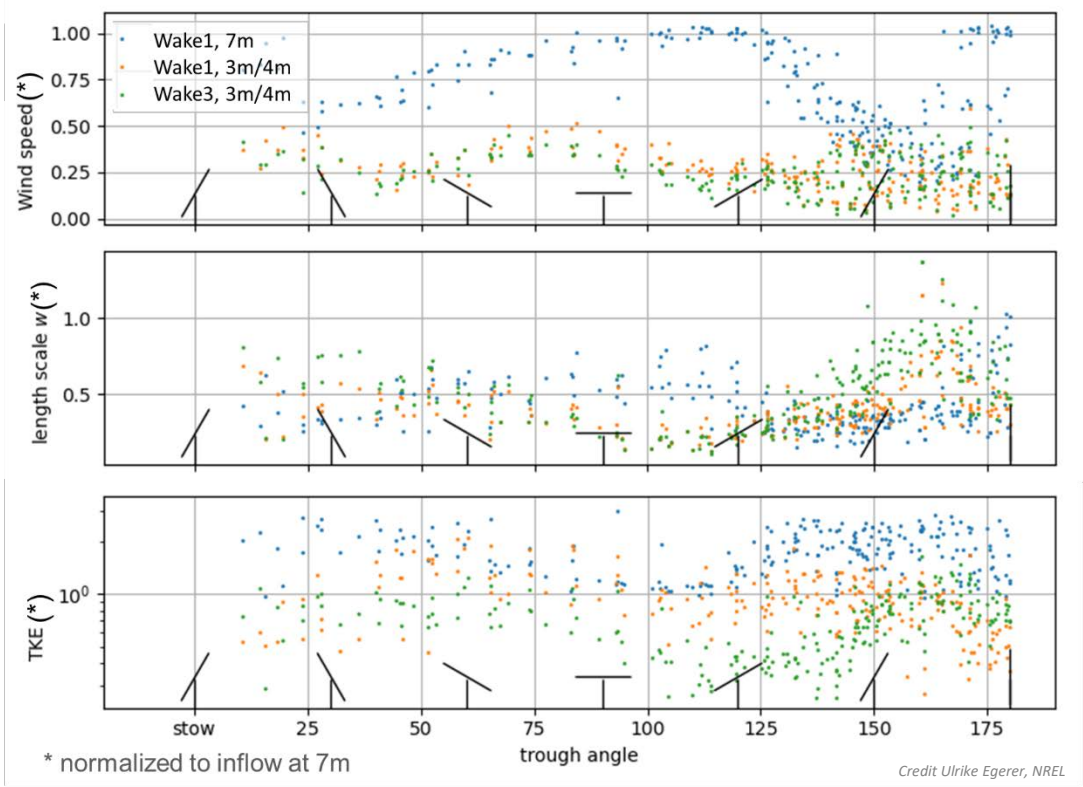


Wind direction relative to the trough rows determines how the wind field is modified.

Credit Ulrike Egerer, NREL

General Patterns in the 1-Year Data Set

How does the trough angle influence flow properties of perpendicular winds?



→ The trough angle has a major influence on many parameters above and within trough rows.

Which factors cause high static and dynamic loads on solar structures?

Probable factors are high winds, high TKE or TI, length scales similar to trough dimensions, or vertical wind gusts.

Future and Related Work

- **Structural load measurements** were installed at Nevada Solar One in November 2022 (with the analysis ongoing).
- **On-site wind lidar** will complement masts.
- Observations are accompanied by **simulations** (with the aim to create an open-source tool for modeling wind loading on CSP collector structures.
- **The final project goal** is to create a comprehensive, high-resolution wind-loading data set to validate simulations of wind loading on collector structures.

Photo by Scott Dana, NREL

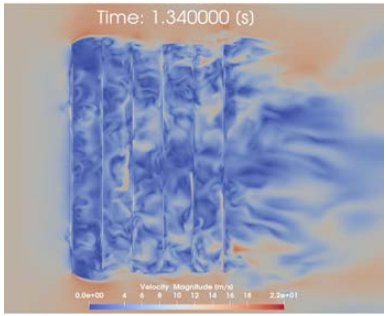


Image by Shashank Yellapantula, NREL

Summary

Key Messages

- Full-scale measurements will **help us understand** how wind conditions and structural loads interact.
- **The wind direction** relative to the rows and the **trough angle determine how wind field is modified**.
- The second part of the campaign will identify **which wind and turbulence conditions cause high static and dynamic loads** on the collector structures.

Thank you!

ulrike.egerer@nrel.gov

NREL/PR-5000-85008

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Photo by Ulrike Egerer, NREL

NREL
Transforming ENERGY