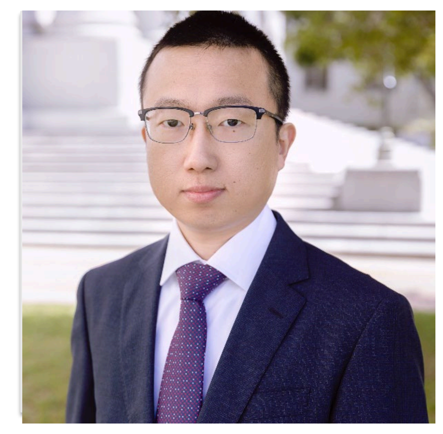
Detached-eddy simulation of wind loads on a ground-mounted solar array



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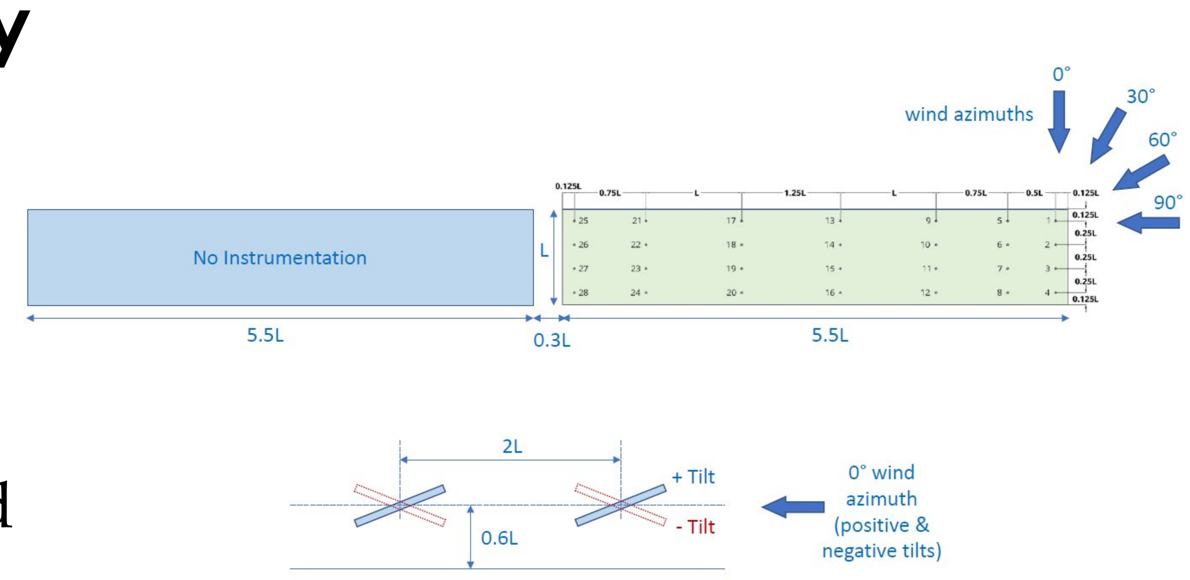
Significant damage occurs every year to **ground mounted solar arrays**, often at below design wind speeds. Designers are not required to consider the **dynamic, cyclic loading** on the structure, and using wind tunnel testing to determine the loading can be cost prohibitive. The results from wind tunnel tests and detached-eddy simulation have **good agreement** in terms of mean, standard deviation, and frequency contents of pressure coefficients.

Introduction

- Observed damage to solar structures often due to repeated loading resulting in walking or fatigue of connections, at wind speeds below those used in designs.
- It is important to understand the dynamic cyclical loading on these structures rather than just their peak loads.
- Computational fluid dynamics (CFD) is a relatively cheap way to estimate frequently occurring wind loads on solar arrays.

Reference experimental study

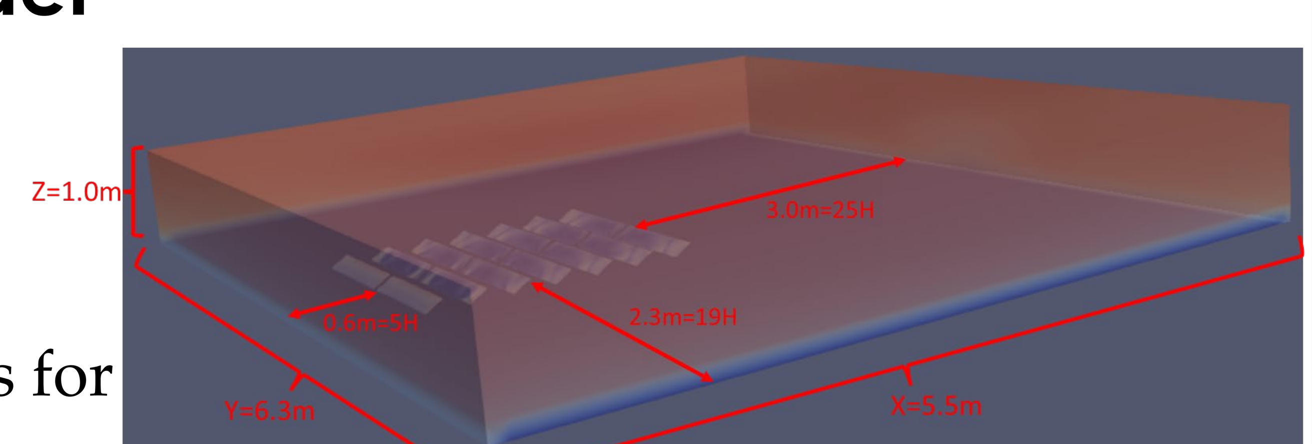
- Pressure coefficient data from wind tunnel tests of a solar array provided by RWDI.
- 7 rows with 2 tables per row
- One table in each row instrumented with 28 pressure taps
- The model-scale chord length L is 143 mm. The tilt angle is ±30°.



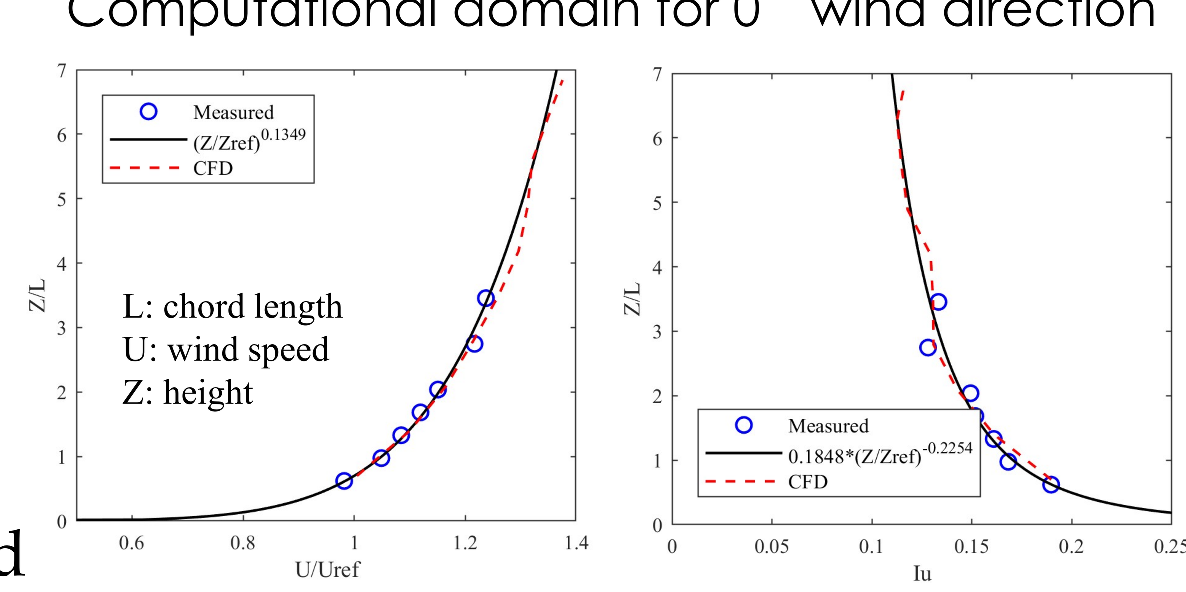
Geometry and instrumentation layout of the solar array model

Description of the CFD model

- SpalartAllmarasDDES model[1] for treatment of turbulence
- Transient solver, pisoFoam, used.
- 13 million cells, requiring 32 hours for a 20-second model-scale simulation
- Wall turbulence modeled using wall functions kqRWallFunction and nutUSpaldingWallFunction
- NHERI SimCenter Turbulence Inflow Tool (TInF)[2] is adopted to reproduce the characteristics of the incident wind profiles reported in the wind tunnel



Computational domain for 0° wind direction



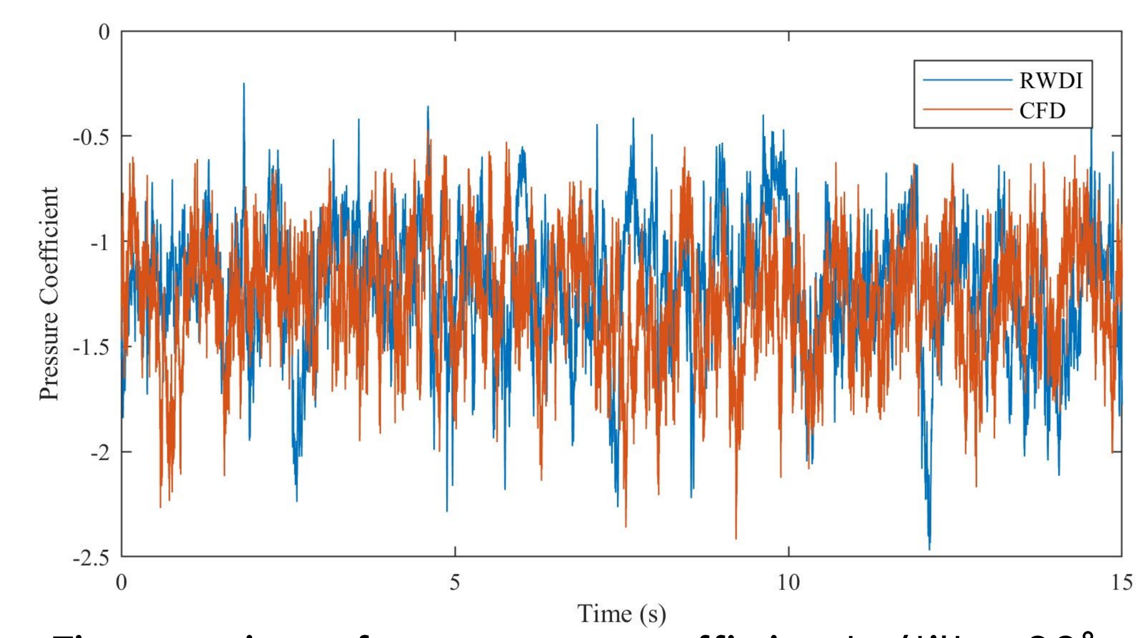
(a) (b)

Comparison of the inflow characteristics from simulation with experimental data: (a) mean wind speed profiles; (b) turbulence intensity profiles in the direction of wind flow (Iu)

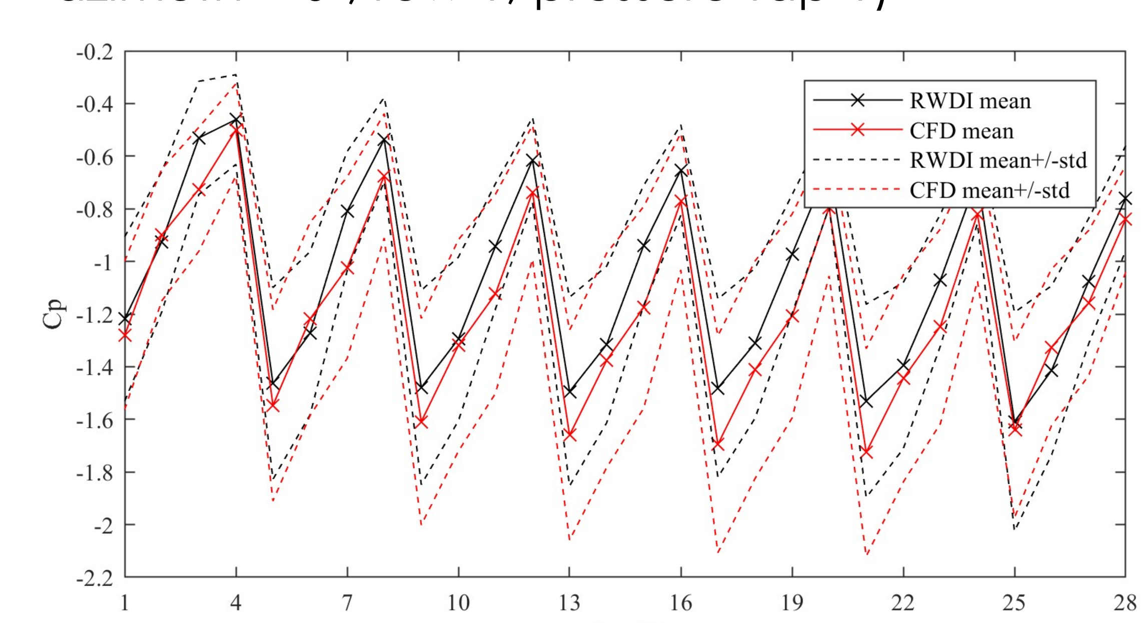
References

1. Spalart, P. R., Deck, S., Shur, M. L., Squires, K. D., Strelets, M. K., and Travin, A. (2006). "A new version of detached-eddy simulation, resistant to ambiguous grid densities." Theoretical and computational fluid dynamics, 20, 181-195.
2. Peter Mackenzie-Helnwein, jiaweiwan-jay, & Frank McKenna. (2020). NHERI-SimCenter/TurbulenceInflowTool: version 1.1.0 (v1.1.0). Zenodo. https://doi.org/10.5281/zenodo.3988635

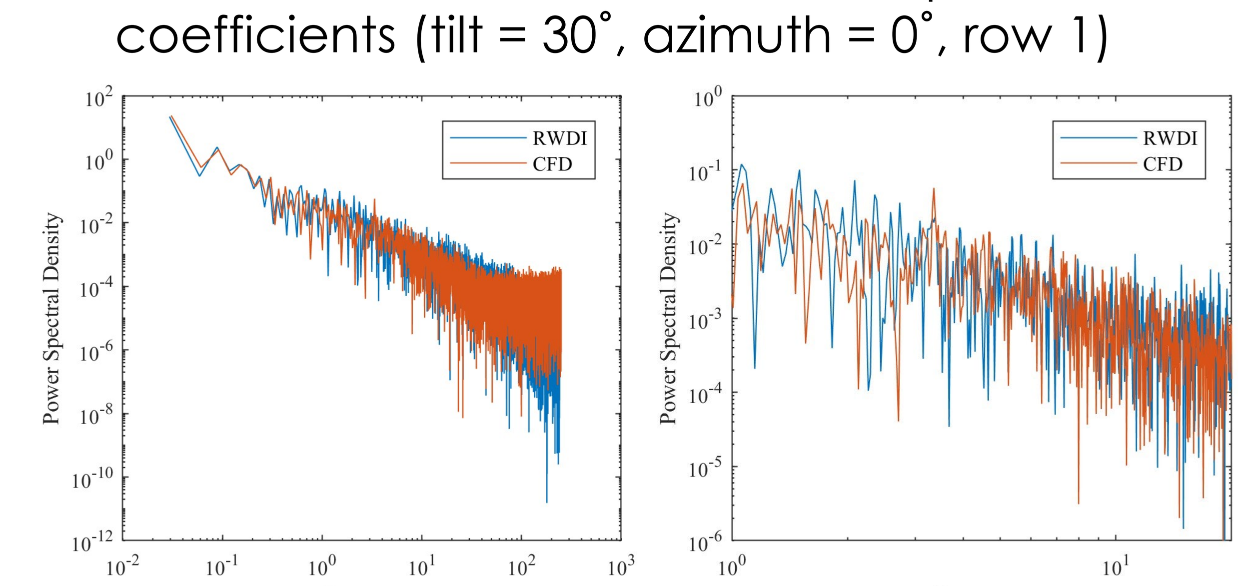
Results



Time series of pressure coefficients (tilt = 30˚, azimuth = 0˚, row 1, pressure tap 1)



Mean and standard deviation of pressure coefficients (tilt = 30˚, azimuth = 0˚, row 1)



(a) (b)

Frequency contents of pressure coefficients (tilt = 30˚, azimuth = 0˚, row 1, pressure tap 1): (a) the entire frequency range; (b) the range of interest for solar PV structures

Conclusions

The CFD results match well with the experiments results in terms of the mean, standard deviation, and frequency contents of pressure coefficients. Thus, the CFD can be used to predict dynamic loading for structures of this type.

Acknowledgements

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