Description of dataset

General Information

Project name: Aerodynamic characterization of single-axis solar trackers (SATs)

Institution: The University of Western Ontario

Laboratory: Boundary Layer Wind Tunnel Laboratory

Facility: Tunnel-II

Test type(s): High-frequency pressure integration (HFPI) test

Test date: July 18-31, 2023

Objective: to *generate a high-quality, comprehensive benchmark BLWT dataset for SAT arrays to support LES validation and design code comparison*

Corresponding paper: *Eshete, T. G., Geleta, T. N., & Bitsuamlak, G. T. (2026). Aerodynamic characterization of SAT arrays to support CFD validation and design standards. Journal of Wind Engineering and Industrial Aerodynamics, 273, 106409.*

Introduction

This project entails conducting HFPI wind tunnel tests on a solar tracker array comprising nine rows under straight ABL wind. Figure 1 illustrates the geometric parameters of a SAT array, panel numbering and wind direction. B represents the chord width, L is the tracker's wingspan, α is the tilt-angle, H is torque-tube height, G is ground clearance and S denotes center to center row spacing. The torque-tube height, H, measured to the top of the torque tube or mid-span of the panels, serves as the reference height in this study. Wind direction is denoted by θ, with $\theta = 0°$ corresponding to the "Nose Up into Wind" stow strategy.

There are seven isolated and thirty-five array configurations by varying the tilt-angle (0°, 5°, 10°, 15°, 45° & 60°), spacing (163mm & 190mm in model-scale), height (50mm & 57mm in model-scale) and terrain exposure (E2 & E3). Table 2 in Eshete et al., 2026) details the geometric parameters of each configuration and the nomenclature used in the dataset. Two boundary layer wind profiles, E2 and E3, with aerodynamic roughness lengths of $z0 = 0.03\ m$ and $z0 = 0.05\ m$, respectively, are simulated targeting open terrain condition (ESDU, 1985, 1983, 1982). Further information and aerodynamic discussion can be found in the corresponding paper.

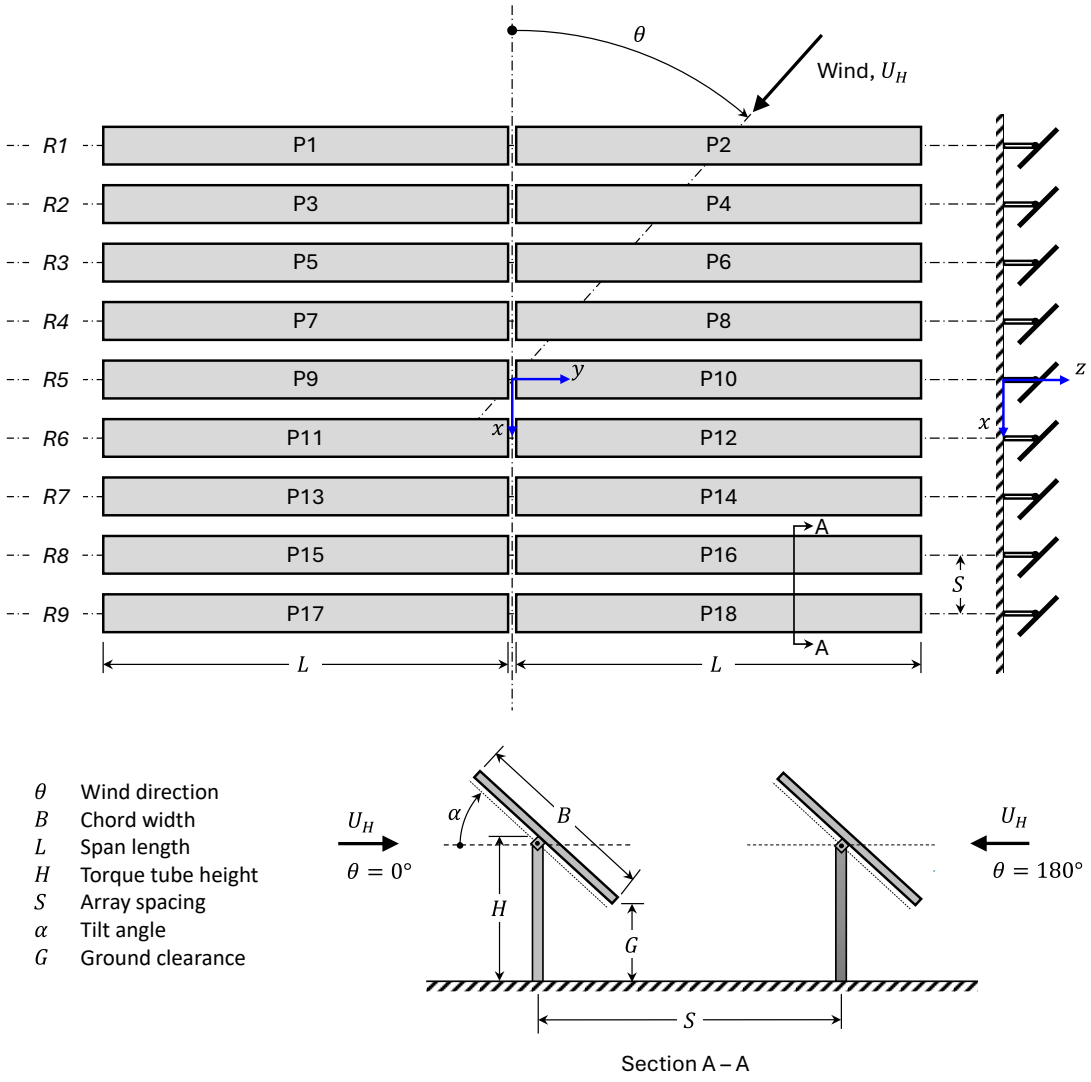


Figure 1: Geometric parameters of a SAT array and wind direction definition

Data structure and information

The dataset contains pressure time histories, approach flow time histories and supporting information such as pressure tap information,

Pressure time histories

Each pressure time-history file is named according to the array configuration (following the nomenclature defined in Table 2 of Eshete et al., 2026) and the corresponding wind direction. For example, the file SA_T00S163H50E2_180_procTH.mat represents the pressure time-history data for Array Configuration 15 ($\alpha = 0°, S/B = 2.4,\ H/B\ = 0.75$ & $E2$) and wind direction $\theta = 180°$. The pressure data are sampled at a frequency of 400 Hz over a total duration of 260 seconds. There are 665 pressure-time history files corresponding to 35 configurations with 19 wind directions.

Each procTH.mat file contains a single MATLAB structure named CpTH. This structure has 10 fields that store metadata, experimental parameters, and measured velocity and pressure data during the HFPI test.

Field Descriptions

1. **README**
    - Type: 1×1230 character array
    - Description: Contains textual information describing the experiment and data acquisition system.
2. **WITDATALOG**
    - Type: 1×1 struct
    - Description: Nested structure containing additional metadata from the data acquisition system such as sample rate, table angle, wind voltage etc.
3. **caseName**
    - Type: Character array
    - Description: Identifier for the specific test case during the experiment phase.
4. **AoA (Angle of Attack)**
    - Type: Scalar (double)
    - Description: The angle of attack or wind direction corresponding to the pressure data.
5. **TapNo**
    - Type: 1×944 double array
    - Description: defines the tap numbers corresponding to each column in the pressure data matrix (CpOfT). A total of 59 scanners, each with 16 ports, were used during testing. 912 pressure taps were connected to 58 scanners, while the 59th scanner was dedicated to Pitot measurements. The pressure tap layout and scanner assignments are provided in Appendix A of Eshete et al. (2026). Note that the last four ports of scanners 4, 8, 54, and 58 were unused.
6. **SampleRate**
    - Type: Scalar (double)
    - Value: 400
    - Description: Sampling frequency of the data acquisition system (Hz).
7. **velRatio**
    - Type: Scalar (double)
    - Value: 1.6021
    - Description: Velocity ratio between the pitot height and the reference height (H), obtained from the profile (cobra probe measurement). This parameter is already used

to re-reference the pressure coefficient data from the Pitot height to the reference height.

8. **UhOfT**
    - Type: 104000×1 double array
    - Description: velocity time history at the reference height (H) simultaneously recorded as the pressure data.
9. **CpOfT**
    - Type: 104000×944 double array
    - Description: Time-resolved pressure coefficient data for all taps. The pressure coefficient is obtained by normalizing the measured pressure with the dynamic pressure at the reference height (H).
    - Rows represent time steps, and columns correspond to individual pressure taps.

    Note: Tap **4506** is identified as faulty; therefore, its pressure time-history data should be excluded from all analysis.
10. **AnalogData**
    - Type: 104000×16 double array
    - Description: Additional analog signals recorded during the experiment (e.g., sensors, reference channels).

Approach flow information

The approach flow data consists of velocity measurements obtained using a Cobra probe at 28 vertical locations, positioned 15 cm upstream of the first row of the array. There are two .mat files with profile information, ProfE2.mat and ProfE3.mat corresponding to terrain E2 and E3. The velocity data are sampled at 1250 Hz over a duration of 180 seconds, except at the reference heights (H = 50 mm and 57 mm, model scale). Measurements were taken at a lower tunnel speed to prevent vibrations of the Cobra probe rig.

Each profile.mat file contains a structure a single MATLAB structure named TH. This structure has 7 fields that store meta data and velocity time history.

Field Descriptions

1. **UofT**
    - Type: 1×28 cell array
    - Description: Time-series of the streamwise velocity component (U) at each of the 28 vertical measurement locations. Unit is m/s
2. **VofT**

- Type: 1×28 cell array
- Description: Time-series of the lateral velocity component (V) at each measurement location. Unit is m/s

3. **WofT**
    - Type: 1×28 cell array
    - Description: Time-series of the vertical velocity component (W) at each measurement location. Unit is m/s
4. **Z**
    - Type: 28×1 double array
    - Description: Vertical positions corresponding to the 28 measurement points. The unit is in meters and in model scale.
5. **dt**
    - Type: Scalar (double)
    - Value: 8.0000e-04
    - Description: Sampling time-step between successive data points
6. **exposureName**
    - Type: Character array
    - Description: Identifier for the specific exposure or experimental condition.
7. **cobraInfo**
    - Type: 1×28 cell array
    - Description: Additional metadata for each measurement location, containing probe configuration, sampling rate etc.

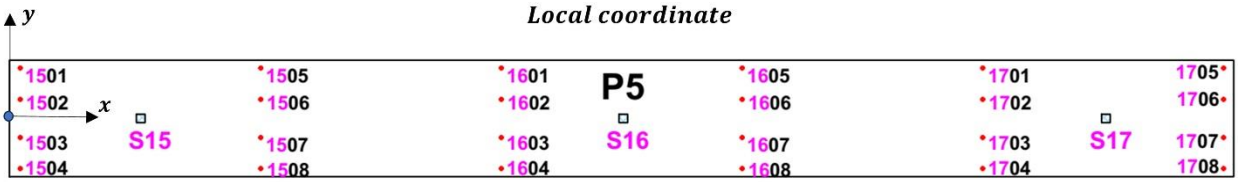
Tap information

The TapInformation.mat file contains the spatial coordinates and identification details for each pressure tap used in the BLWT tests. The pressure tap layout and scanner assignments are provided in Appendix A of Eshete et al. (2026).

Column	Description
Tap NO	Unique identifier number for each pressure tap.
Panel ID	Identifier for the panel or section of the array to which the tap belongs.
Surface	Surface indicator, i.e., 0 represents upper surface, 1 represents lower surface
X (mm)	Local X-coordinate position of the pressure taps in millimeters.

Column	Description
Y (mm)	Local Y-coordinate position of the pressure taps in millimeters.

The local coordinate is at the middle left of each panel as shown below and the dimensions are given in model-scale.



Note: Tap **4506** is identified as faulty; therefore, its pressure time-history data should be excluded from all analysis.

Note: The dataset comprises a total of 665 pressure time-history files, 2 velocity time-history files, and pressure tap information .mat files. Data cleaning and uploading are still in progress, so not all cases may be available at this time.

References

ESDU, 1985. Characteristics of Atmospheric Turbulence Near the Ground. Part II: single point data for strong winds (neutral atmosphere). Engineering Science Data Unit (ESDU) Data Item 85020.

ESDU, 1983. Strong winds in the atmospheric boundary layer, Part 2: Discrete gust speeds. Engineering Science Data Unit (ESDU) Data Item 83045.

ESDU, 1982. Strong winds in the atmospheric boundary layer, Part 1: mean hourly wind speeds. Engineering Science Data Unit (ESDU) Data Item 82026.

Eshete, T.G., Geleta, T.N., Bitsuamlak, G.T., 2026. Aerodynamic characterization of SAT arrays to support CFD validation and design standards. Journal of Wind Engineering & Industrial Aerodynamics 273, 106409. https://doi.org/10.1016/j.jweia.2026.106409