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Downburst peak pressures over 6 rows of solar trackers

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Summary

Under the umbrella of the ERIES projects, an experimental campaign has been conducted at the WindEEE Dome facility. One of the objectives has been to study the downburst-induced wind loads on an array of 6 rows of solar trackers. In this work, the Peaks Over Threshold (POT) method is applied to identify the peak pressures on the solar trackers located in different positions relative to the downburst axis.

Keywords: *ERIES, downburst, peak pressure, peaks over threshold (POT)*

1 INTRODUCTION

The ERIES-SOLAR project within the ERIES (Engineering Research Infrastructures for European Synergies) initiative allowed carrying out an experimental campaign to study the wind induced loads on solar trackers due to non-synoptic actions, including downbursts, tornados and Bora wind episodes, over a model composed of 6 rows of solar trackers at the WindEEE Dome facility. The present study focuses on downburst, which are non-synoptic "*intense, localised downdrafts produced in convective storms*" (Bluestein 2021), with diameters ranging from 1km up to 10km (Fujita 1981). Downdrafts are intense jets of descending air, which after impinging on the ground deflect forming an intense annular gust front, causing strong radial velocities close to the ground (Simiu and Yeo 2019; Canepa et al. 2025), reaching velocities much higher than 25m/s (Zhang et al. 2019). For the stated reasons, solar farms could be exposed to substantial damage when affected by a downburst episode. In the following a brief description of the tests and the subsequent calculations of the pressure peak values applying the Peaks Over Threshold (POT) methods will be presented.

2 FORMULATION

For calculating the peak pressures (the maximum instantaneous or short duration pressure induced by a wind event on the surface of a structure) over the solar panels, the POT has been applied to the pressure time-histories obtained from the experimental tests. The POT method, recommended in ASCE/SEI 49-21 (2022), has been implemented as in Duthinh et al. (2017). Pressure coefficients are calculated as shown in Eq. 1:

$$C_p = \frac{p - p_0}{\frac{1}{2}\rho U^2}, \tag{1}$$

where p is the pressure value, p_0 is the static pressure, ρ is the air density and U is the wind speed.

3 EXPERIMENTAL CAMPAIGN

The experimental campaign was conducted at the WindEEE Dome facility. A scheme of the facility and the model under study is provided in Figure 1. For generating the downburst wind, first pressure is build up in the upper plenum, by running the upper fans, while keeping the louvers closed. Once the designated pressure is reached the louvers are open, releasing the jet that after impinging on the floor will generate the intense radial velocities. The jet diameter of the tests was $D = 3.2m$, while the height of the chamber is $H = 3.8m$, therefore $H/D > 1.0$ indicating that the primary vortex can fully develop (Xu and Hangan 2008).

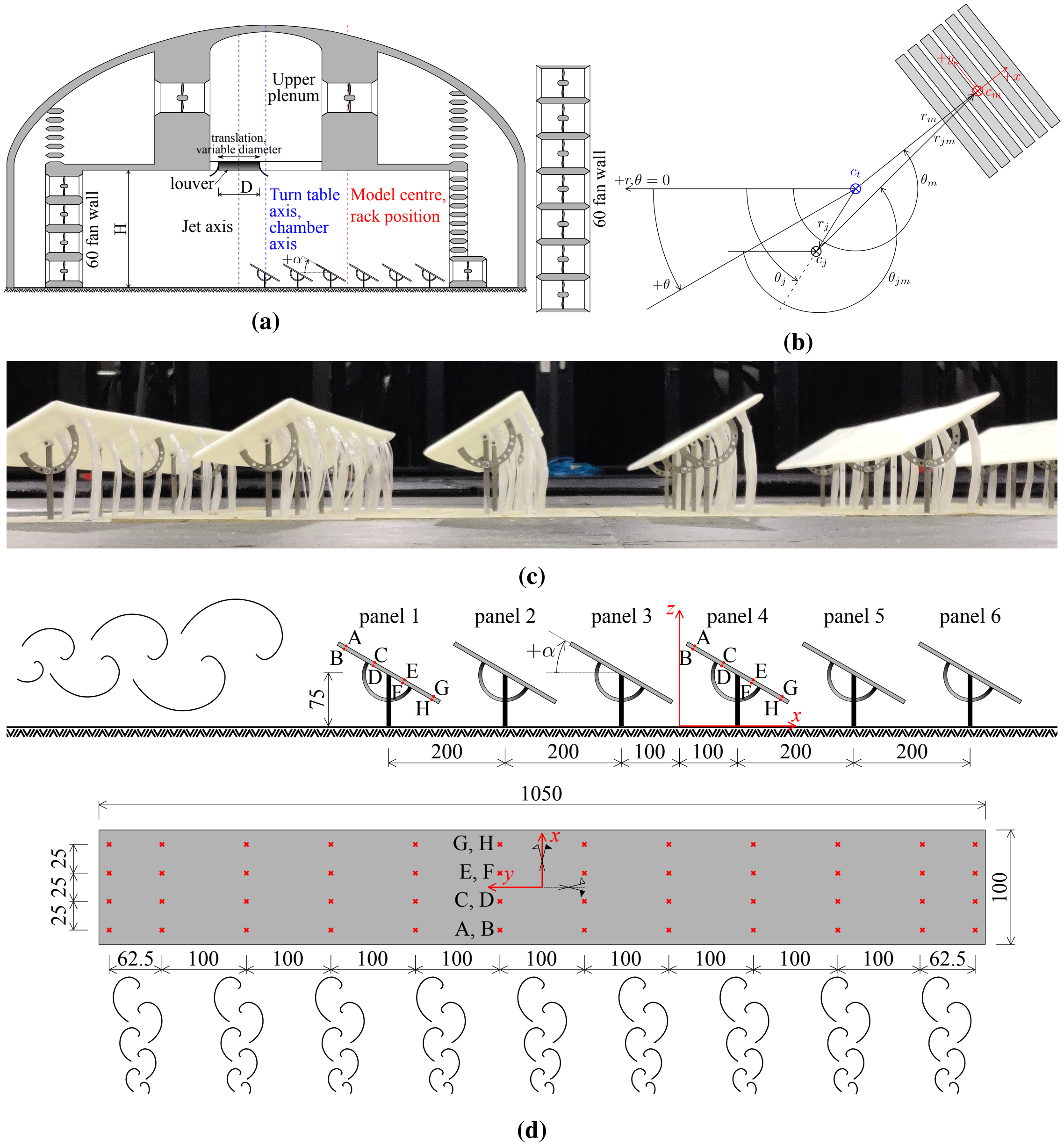

Figure 1: WindEEE Dome facility and test configuration. (a) Front view, (b) top view, (c) model under study and (d) pressure taps positioning.

4 RESULTS

In Figure 2 the peak pressure coefficients of the net pressures on the panels, calculated as the difference between the top pressure taps (A,C,E,G in Figure 1d) and the bottom pressure taps (B,D,F,H in Figure 1d). The net pressures provide the means for calculating the internal forces and moments of the panels. It can be seen how maximum peak values appear in the windward corners of the panels, specially as they are further away from the first row, for $\alpha = -30°$. On the other hand, for $\alpha = -30°$ the peak values are somehow distributed over the windward edge of the panels, the length on this edge featuring large peak values increases as the rows are further away from the first row.

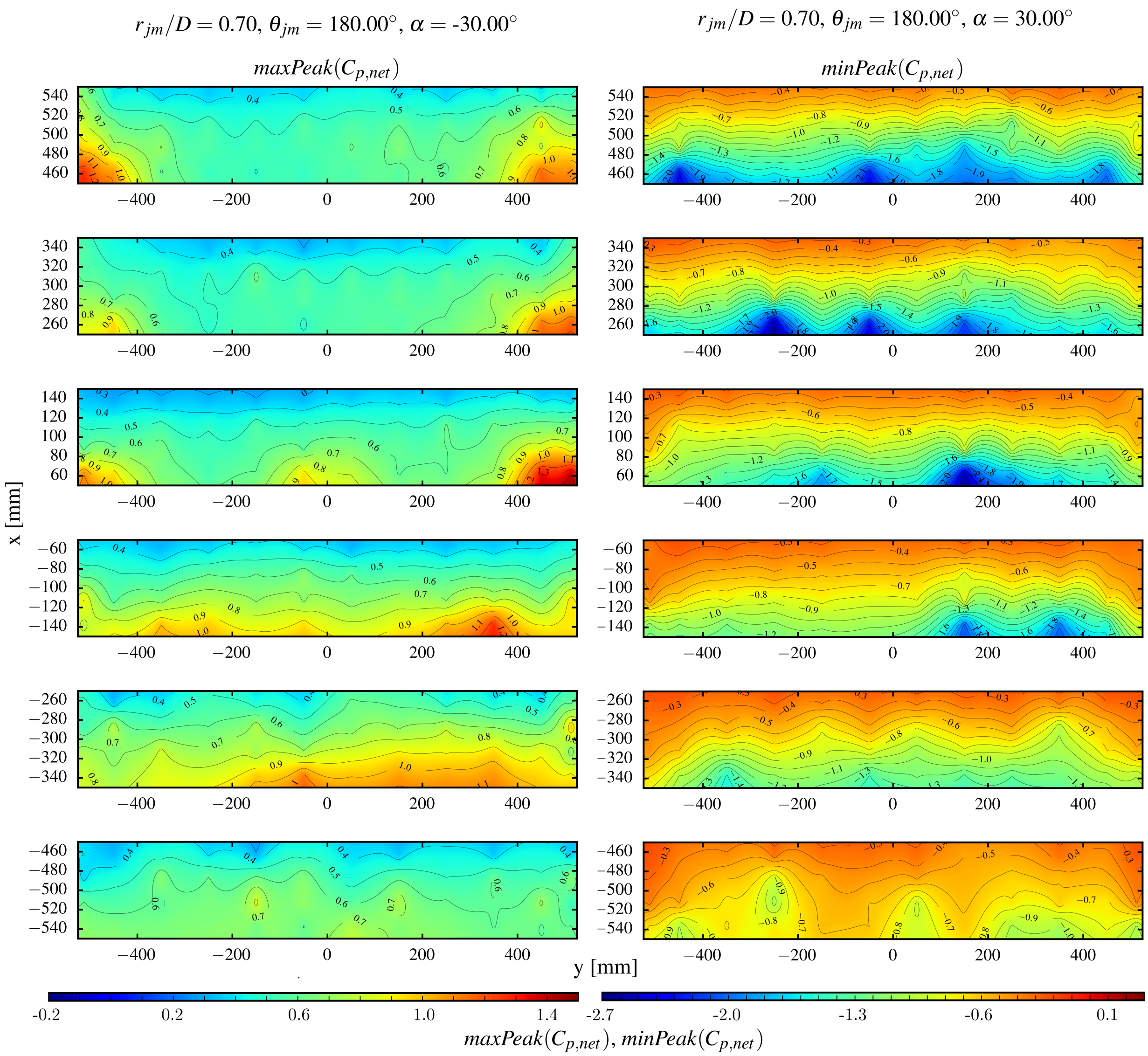

Figure 2: Peak net pressures for a distance from the jet centre to the centre of the model of $r_{jm}/D = 0.7$ (D is the bell-mouth diameter) and an azimuth angle of $\theta_{jm} = 180°$ for solar trackers with $\alpha = -30°$ (left column) and $\alpha = 30°$ (right column).

5 CONCLUSIONS

The POT method for calculating peak pressure values has been applied to ascertain the effects caused by downburst winds over 6 rows of solar trackers at the WindEEE Dome facility. It has been found out that the maximum peak pressures appear in the windward edges and corners of the panels, getting more prominent as the panels are further away from the first row. It is important to consider testing scenarios where multiple solar tracker rows are considered due to the complex interactions between the flow and the parallel solar panels.

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