

Dust Devil Vortices: A Step Toward a Better Understanding of Tornadoes

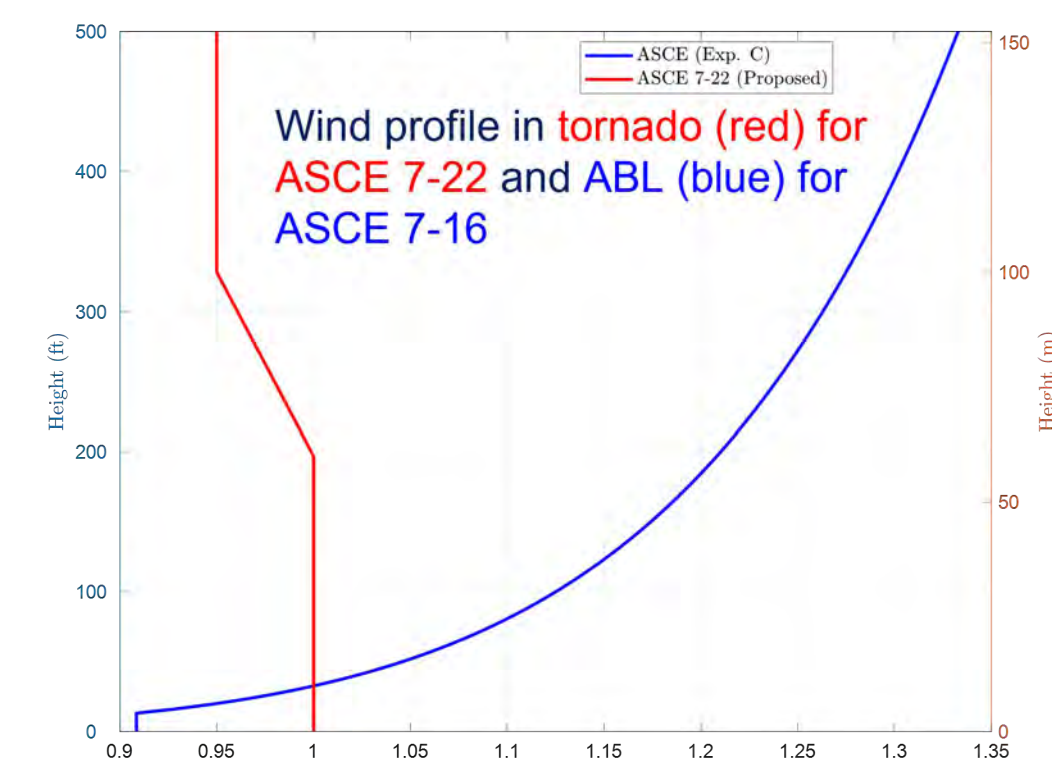


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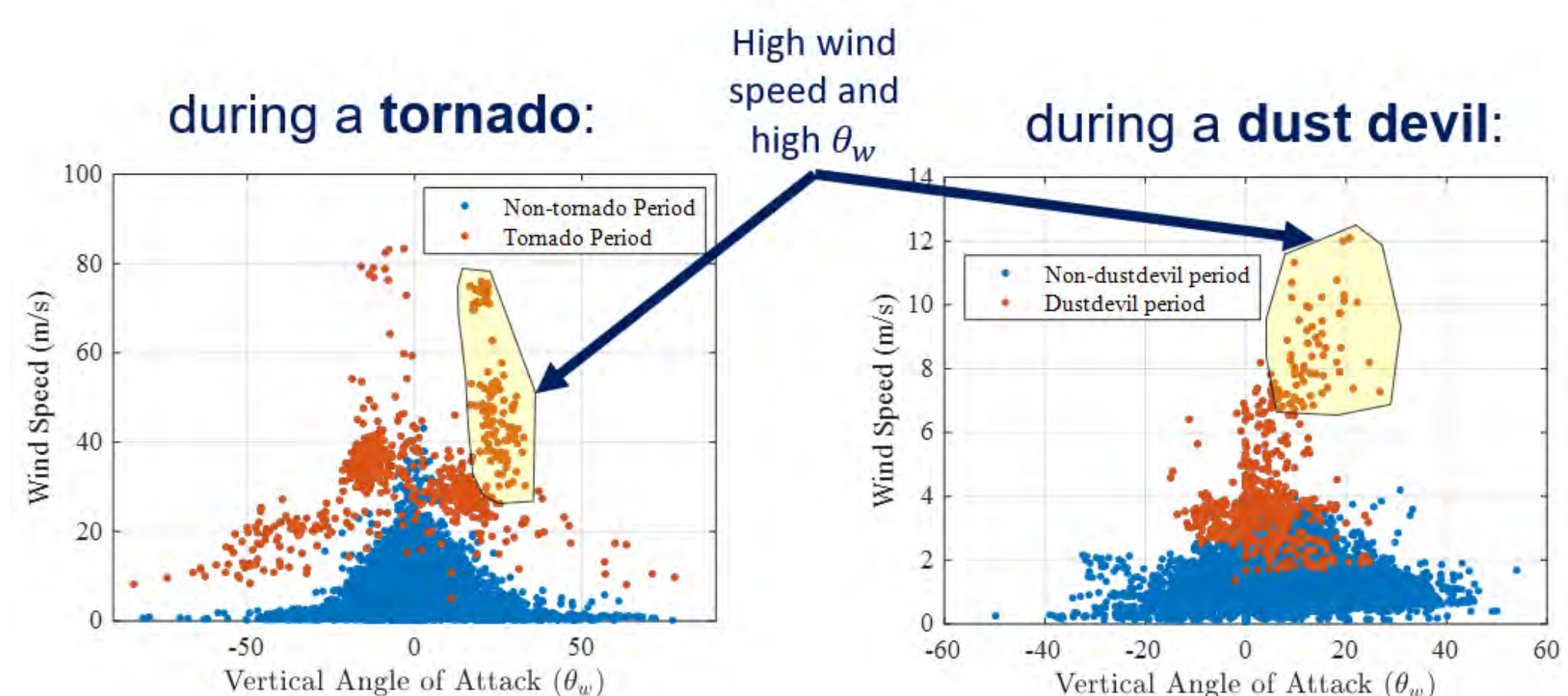
Introduction

- Tornadoes in the U.S. caused more fatalities between 1950 and 2011 than earthquakes and hurricanes combined.
- Tornadoes and thunderstorms cost \$10B in damages annually
- ASCE 7-22 now considers tornado loading for certain areas, and building categories.
- Yet, there is a lack of field measurements of tornadoes due to the challenges in predicting their location, associated risks, and their destructive nature on weather instrumentation. This scarcity hinders a comprehensive understanding of tornadoes and their impact.
- One proposed method to bridge this understanding gap is investigating dust devils, vortices driven by convection and surface-generated vorticity, which share characteristics with tornadoes.
- Dust devils, typically smaller and shorter-lived with diameters ranging from 3m to 30m and heights from 100m to 200m, offer valuable insights into tornadoes' vortices.
- Unlike tornadoes, dust devils are easier to observe and pose lower risks to researchers and equipment.
- The pictures below highlight examples of dust devils and tornadoes, showing visual similarity in their vortices.



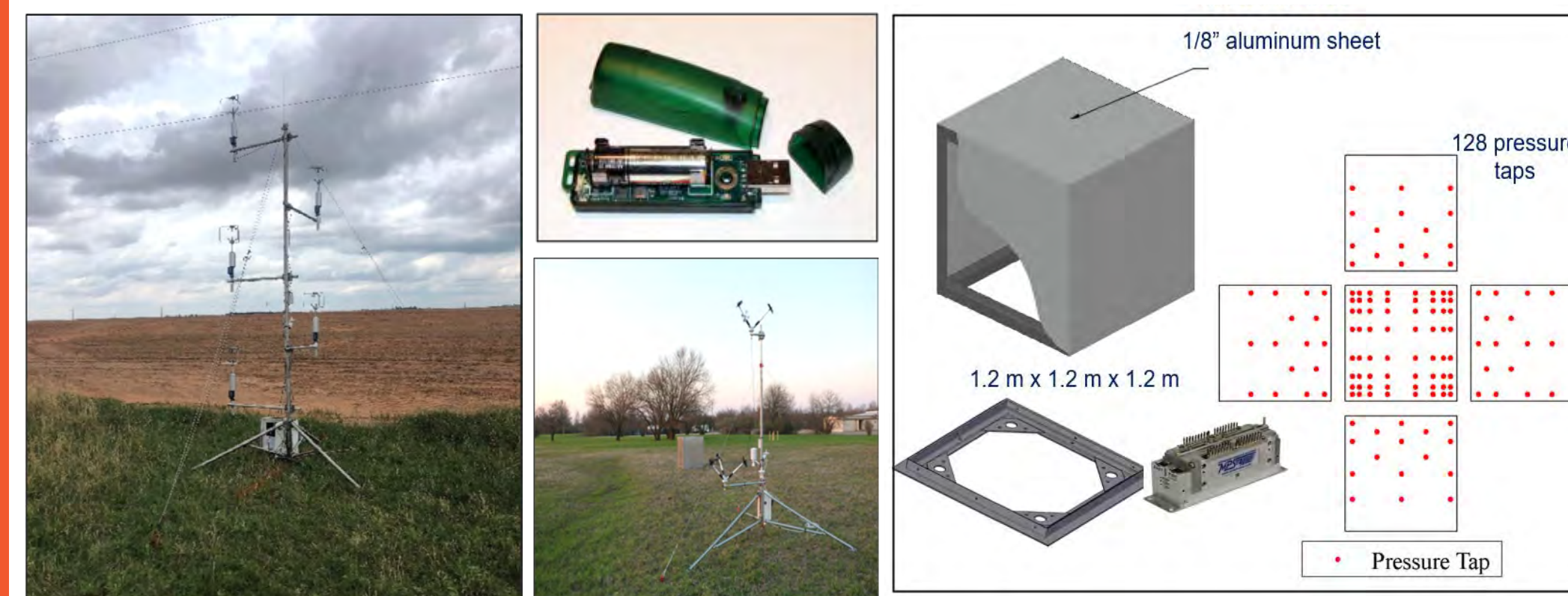
An example of a dust devil An example of a tornado An example of a dust devil (Copyright: John Roenfeldt-Inflow Images)

- Additionally, Lombardo et al. (2023) highlighted from previous experiments similarities between the characteristics of dust devils and tornadoes as shown below



Data Collection

- The project involved data collection spanned 27 days over 3 years (2021-2023) at La Jornada Experimental Range in New Mexico, USA.



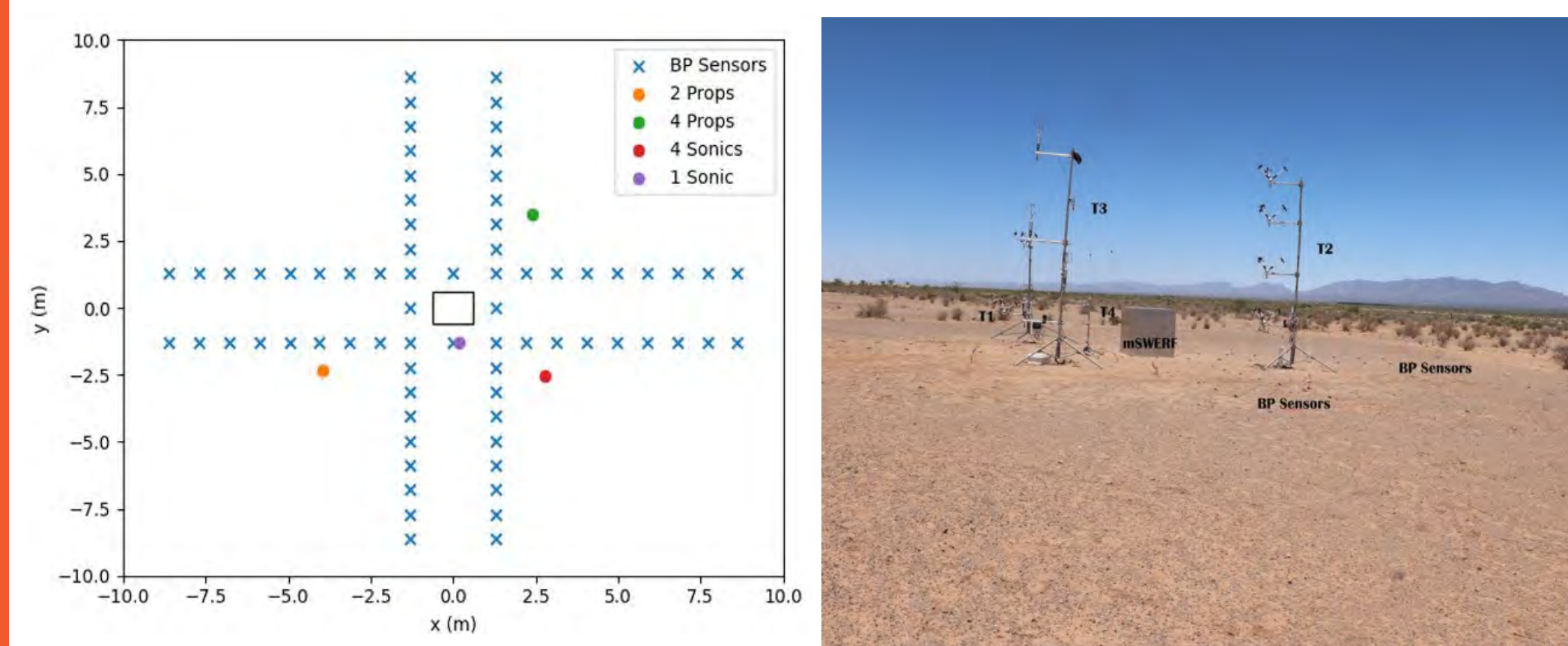
Data collection equipment

Output of the Project

- 100+ cases of dust devils were captured by some of the equipment.
- Time scale ranges between a few seconds to a few minute.
- Vortex structure: single cell, two cell, multi-vortex.
- For the first time, the loading on a bluff induced by an atmospheric vortex was measured.
- Deficiencies in the current design practices were highlighted.
- Comparison between the aerodynamics of Atmospheric Boundary Layer and atmospheric vortices was conducted.



2023 Experimental Setup

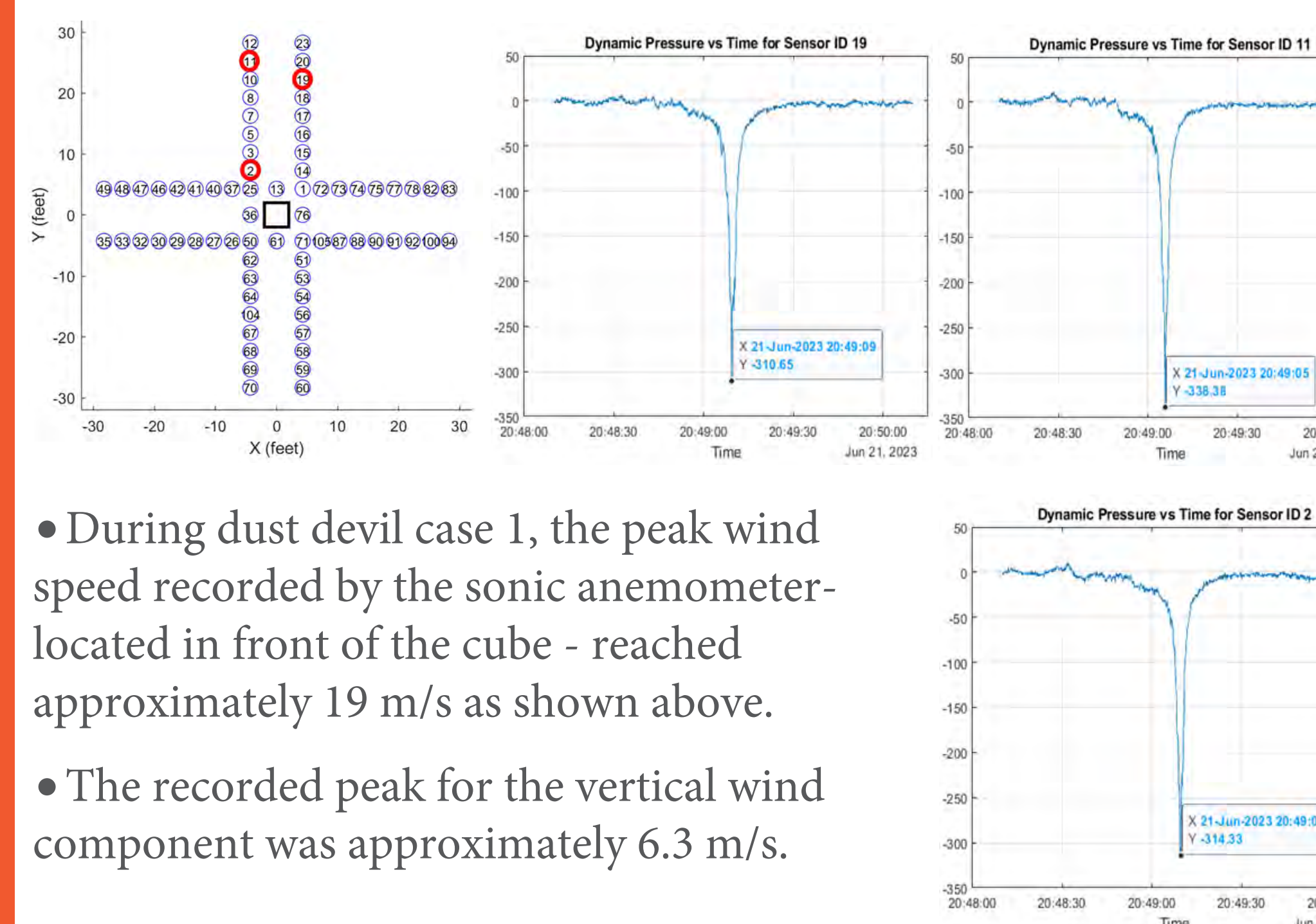
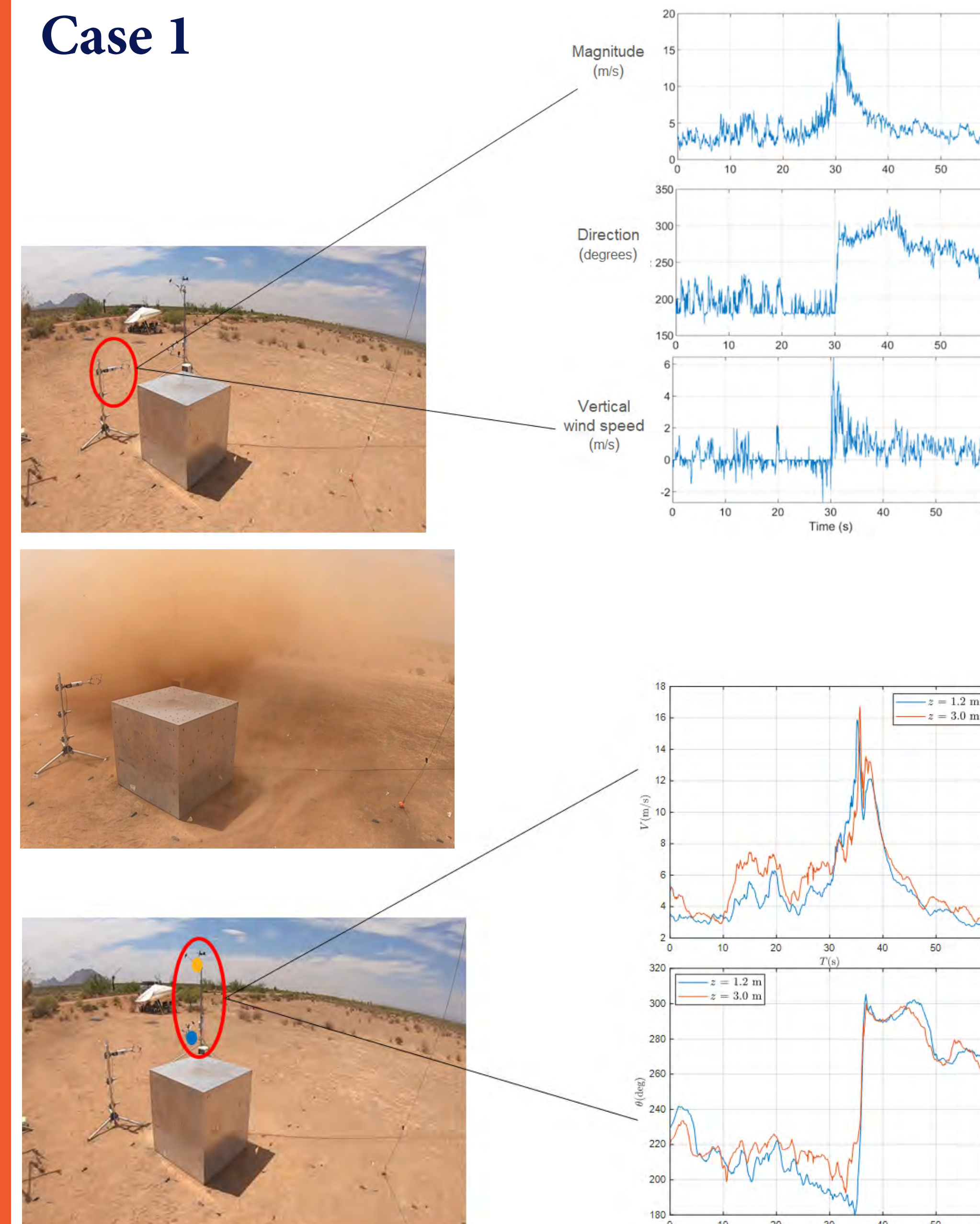


Plan view of the experiment layout 2023 Experimental setup

Results

- This poster highlights two dust devil cases captured in the 2023 experiment.
- Case 1 occurred on June 21st at 20:47 Mountain Time (MT). Case 2 occurred on June 22nd at 18:17 MT.

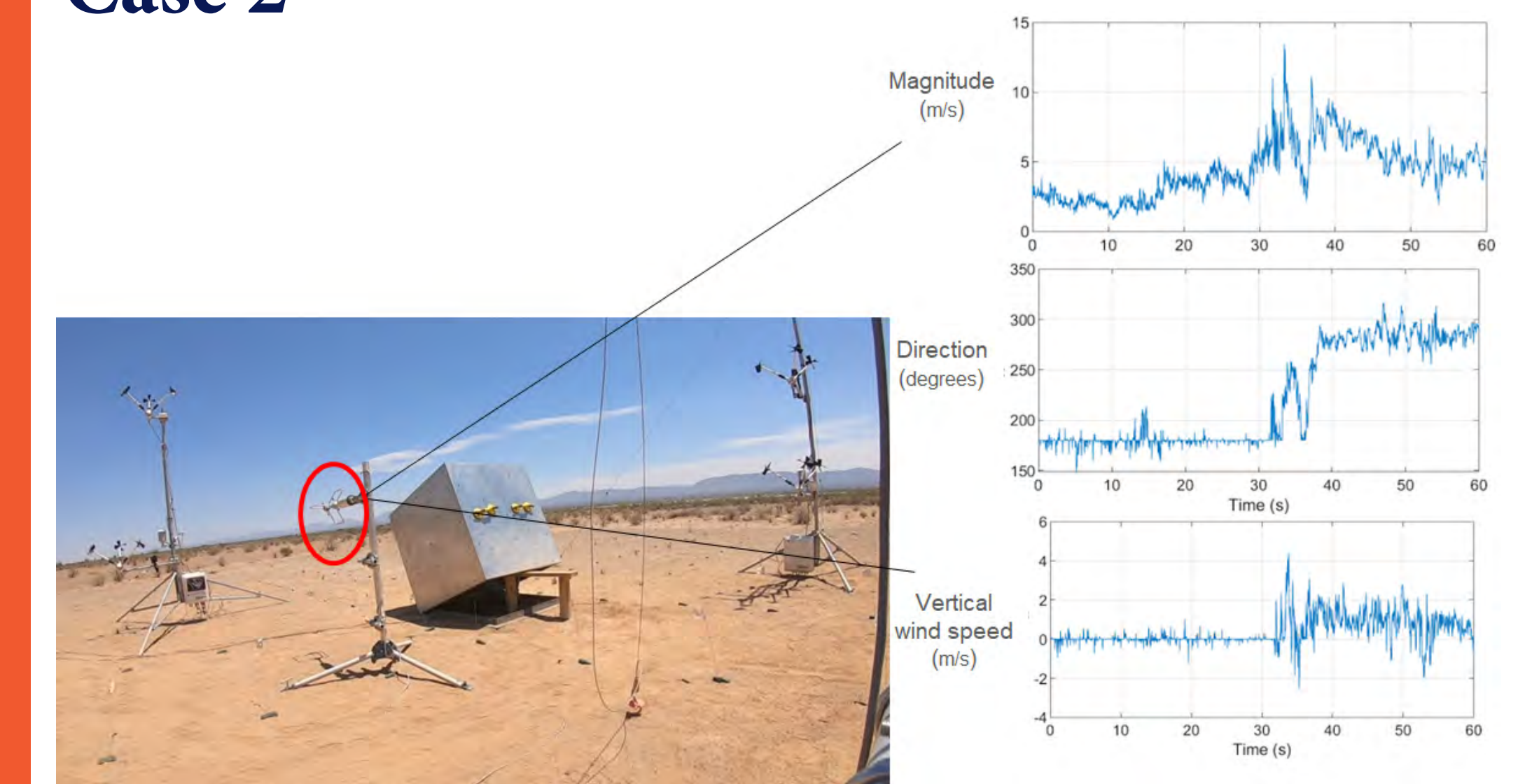
Case 1



- During dust devil case 1, the peak wind speed recorded by the sonic anemometer-located in front of the cube - reached approximately 19 m/s as shown above.
- The recorded peak for the vertical wind component was approximately 6.3 m/s.

- Case 1 highlights the maximum pressure drop (338 Pa) recorded over the span of 3 years of data collection.

Case 2



Conclusions

- Dust devil vortices are similar to tornadoes showing significant pressure drops up to 338 Pa, rapid changes in wind speeds and directions.
- The 2023 experiment showed dust devil cases with horizontal wind speeds up to 19 m/s with vertical components ranging between 6 m/s (31% of the resultant horizontal wind speed) with a vertical angle of attack of 18 degrees.

Acknowledgements

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