The Influence on Cracked Solar Cell Degradation from Hurricane Dorian Wind Loading Events and the Influence of *RailPad* Bracing Elements

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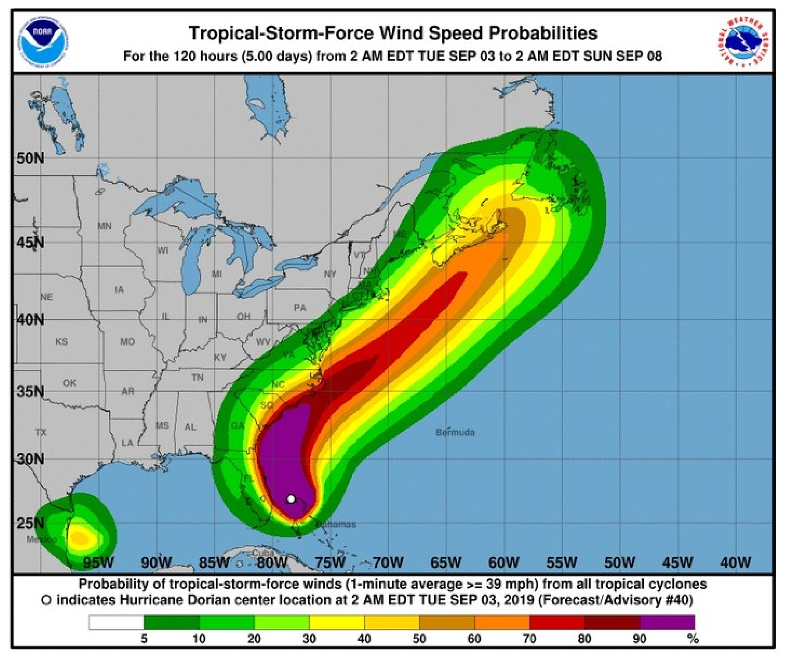
Introduction

- Cracks evolve over time and so do their influence on the overall power degradation of PV modules [1-3] as well as their safe operation [4].
- Incidents leading to crack formation, propagation or subsequent opening can occur at all stages of the PV module life including manufacturing [5-7], transportation [8], installation [9], and field operation [10-11].
- This work investigates the effect of moderate wind loading events on PV module with pre-existing cracks together with the influence of *RailPad* bracing elements from *BrightSpot Automation* [12].

Case Study: Hurricane Dorian

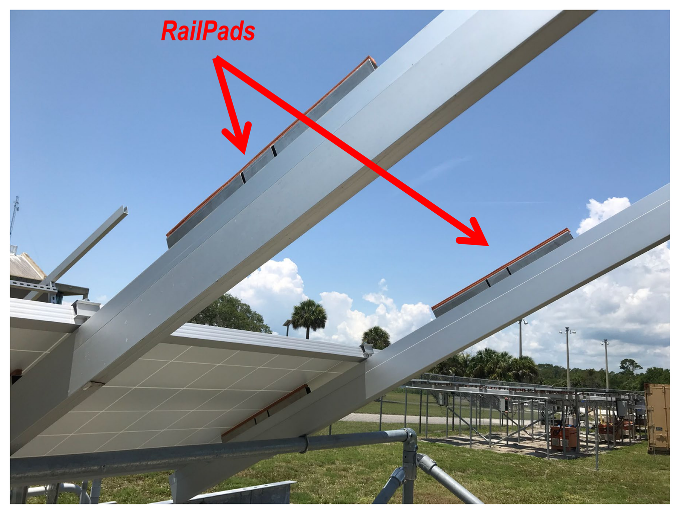
- Hurricane Dorian's nearby trajectory off the Florida coast produced 1-min average wind speeds up to 64 km/h (40 mph) at our facility.

Image: @ noaa.gov



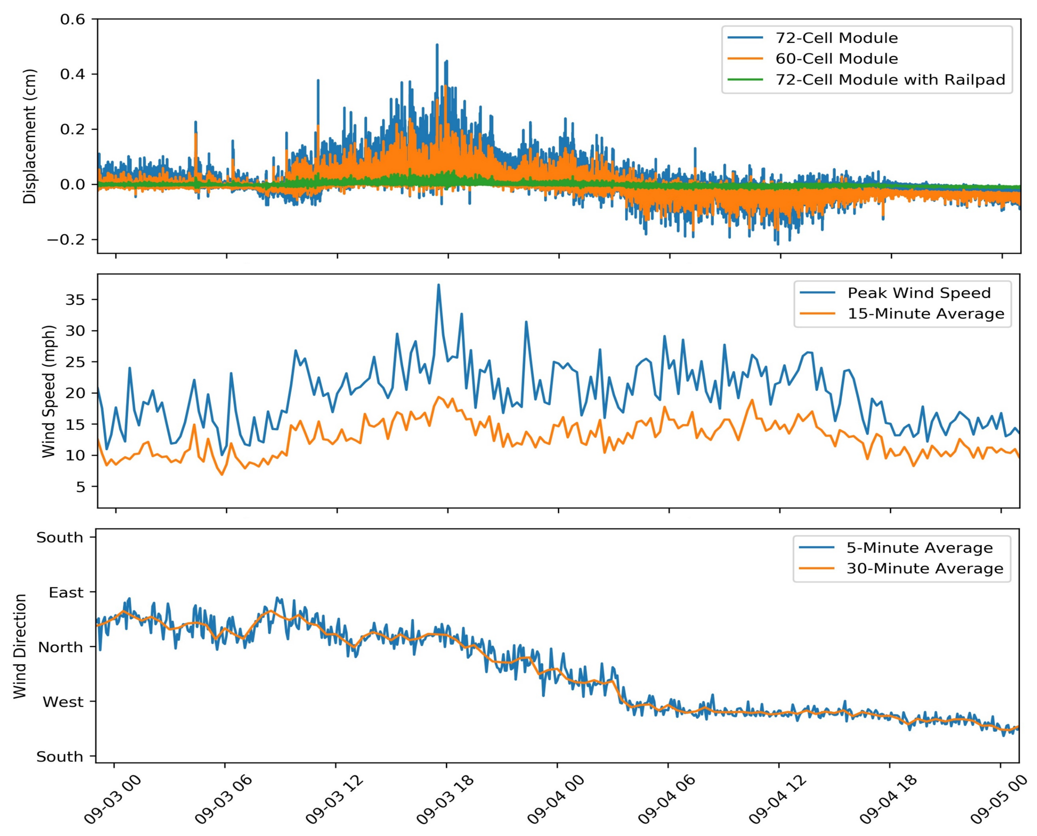
Experimental Setup

- 4 Modules installed
  - 2 multi-PERC 60-cell modules (4 busbars) called A1 and A2
    - Cracks created with a 5400 Pa static load
    - No *RailPads* used
  - 2 multi-PERC 72-cell modules (5 busbars) called B1 and B2
    - Cracks initiated with ½TC (-40°C) then propagated with a 2400 Pa Load
    - Module B1 is installed with *RailPads*
- 1 second displacement data
- 1 minute weather data
  - Wind speed, wind direction, temperature, RH, atmospheric pressure, etc.



Results

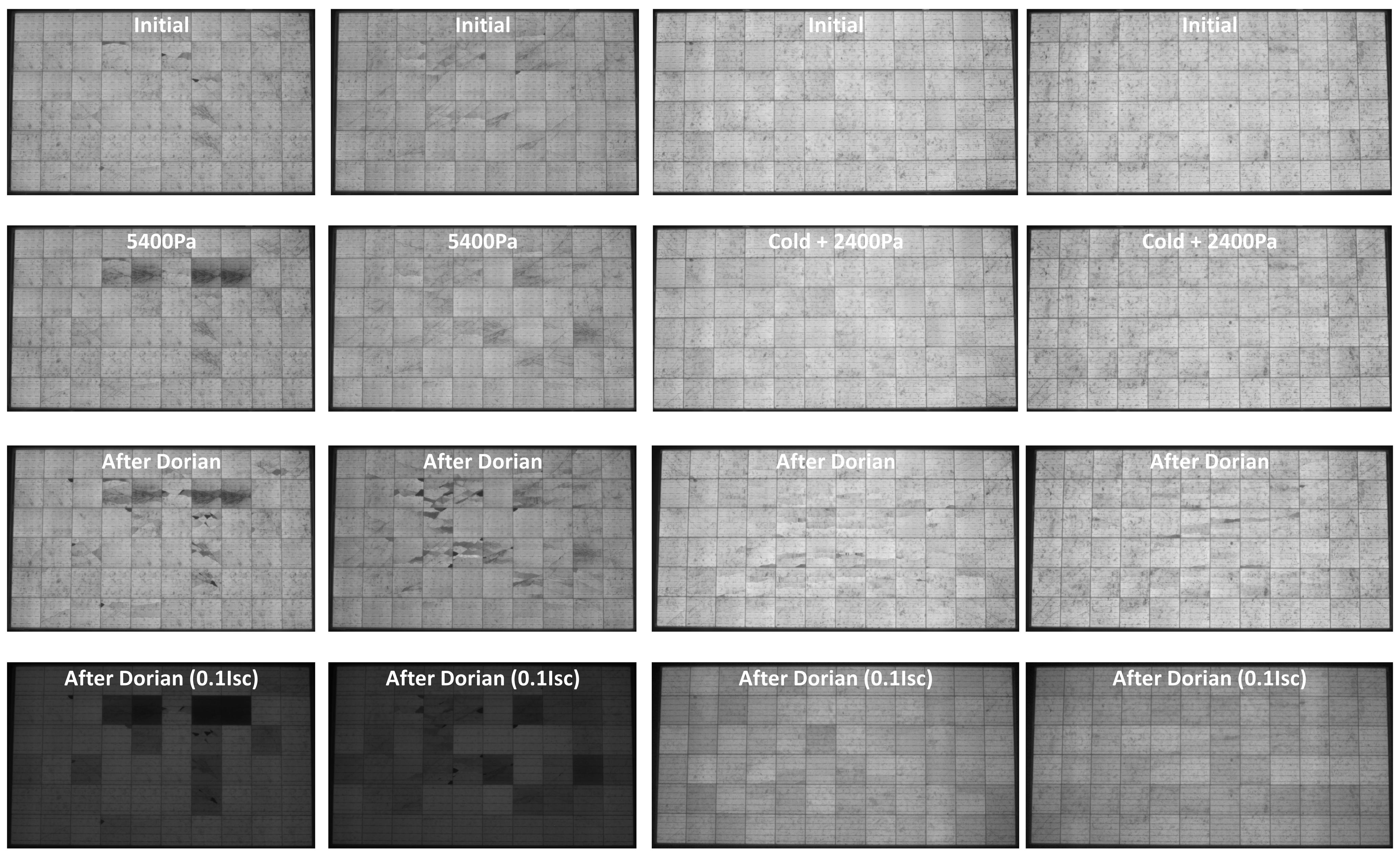
Displacement data as a function of Wind Speed and Wind Direction

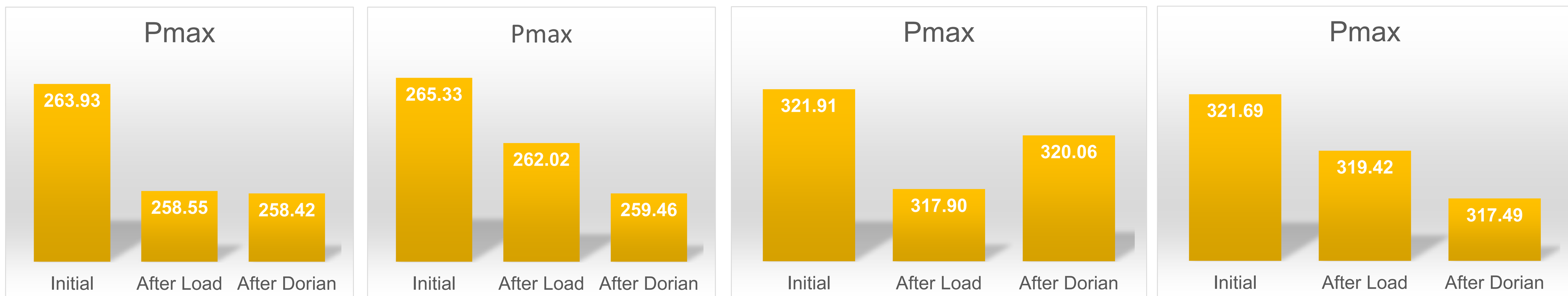


Note:
Module orientation is due south

Crack Opening and Power Degradation

Module A1 | Module A2 | Module B1 (with *RailPads*) | Module B2





Module A1	Module A2	Module B1 (with *RailPads*)	Module B2
Some crack opening	Significant crack opening	Some crack opening (note: EL taken without the *RailPads*)	Some crack opening
No degradation in Pmax after Dorian	**1% loss in Pmax after Dorian**	**1% gain in Pmax after Dorian**	**1% loss in Pmax after Dorian**

Discussion

- The measured maximum deflection of modules without *RailPads* was 0.5cm, which is equivalent to about a 150 Pa uniform load for a 60-cell module. This is *smaller* in contrast with the 2400 Pa load applied in IEC 61215 standard wind load testing.
- The measured displacement data of all modules exhibited high frequency, *much higher* in contrast to 1 to 10 cycles per minute used in the IEC 61215 standard wind load testing, and a strong asymmetry in the cycles depending on the wind direction.
- When the winds came from the North (blowing behind the module), the module without *RailPads* oscillated in a regime that put the cells in more compression.
- When the winds came from the West, the module without *RailPads* oscillated on both side of the resting position resulting in both more compression and more tension.
- When the winds came from the South-West (blowing in front of the module), the module without *RailPads* experienced oscillated in a regime that put the cells in more tension.
- The module mounted with *RailPads* showed strikingly reduced deflection and a gain 1% in maximum power after the hurricane.
- 2/3 of the modules without *RailPads* lost 1% in maximum power

Conclusion

- Moderate wind loading events can produce non-visible damage to PV module (i.e. force closed cracks to open) resulting in measurable power degradation overnight
- It is critical that avoid creating cracks at any stage of the PV module lifecycle
- The use of *RailPad* bracing elements to mitigate power degradation in already cracked module or to prevent cracks from forming in new installs is promising
- To our knowledge, this is the first publication using EL imaging to observe crack opening in the field due to cyclic loading from a single storm event

References

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