

# Extreme weather events and PV systems impact

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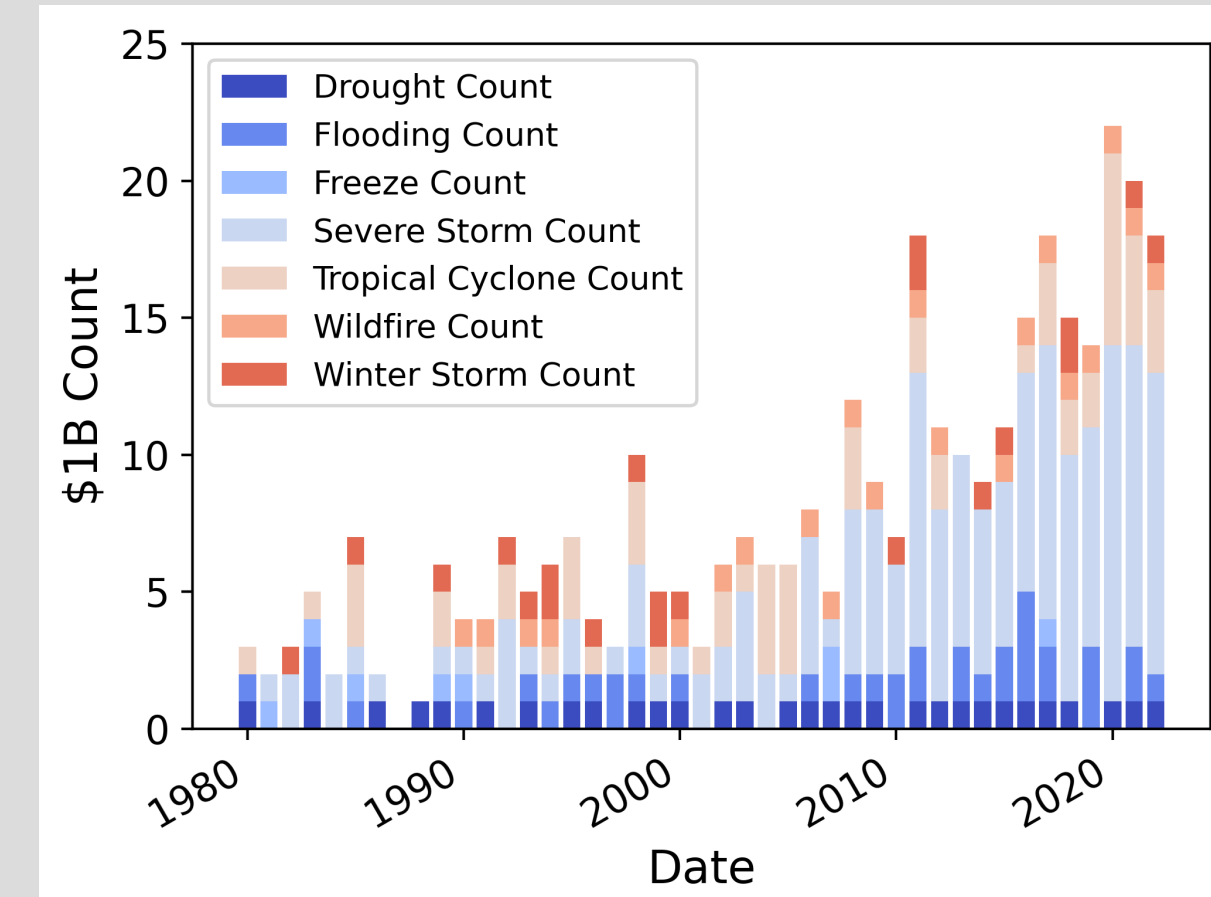
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## 1 Introduction

Frequency & impact of extreme weather events is increasing

US\$ 1 billion extreme weather events in the USA

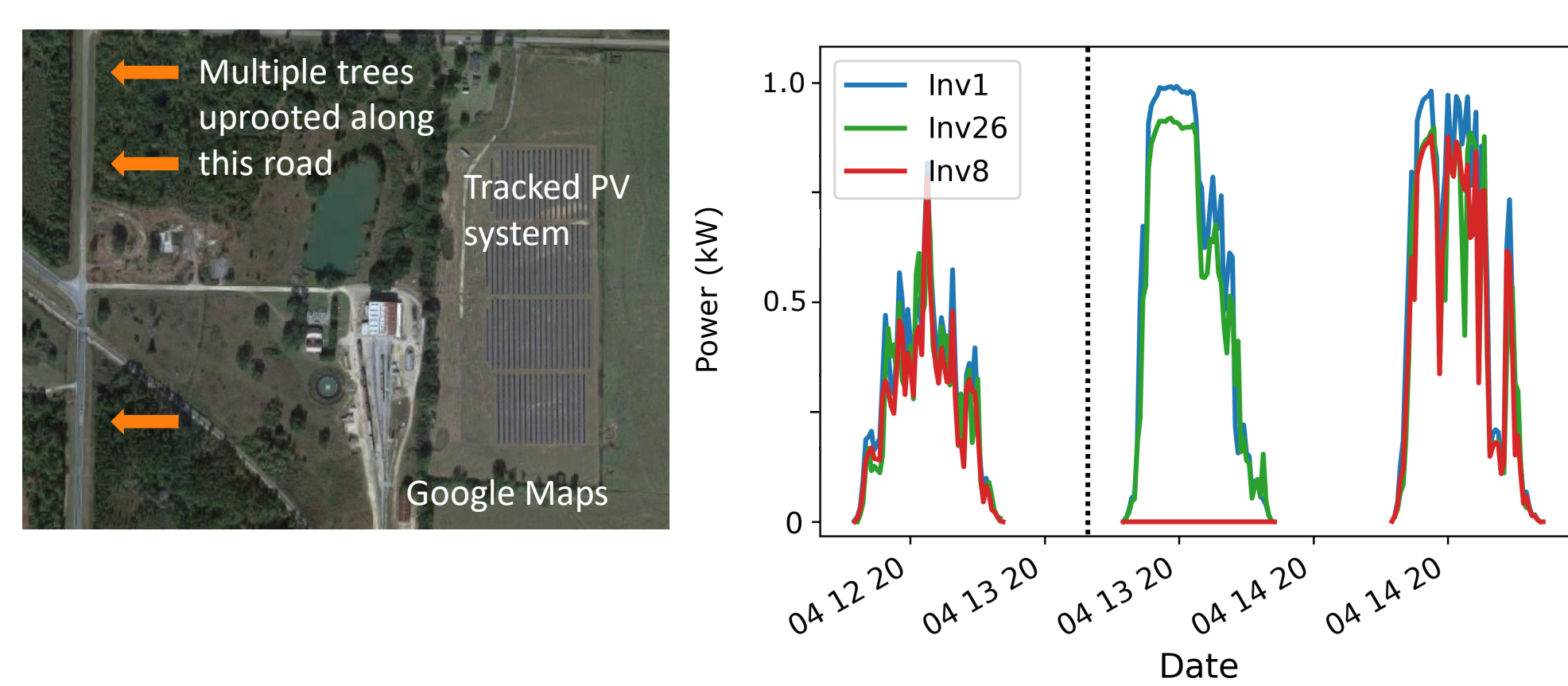


NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023).

Some case studies have been published but little is known about overall countrywide impact

## 4 Example

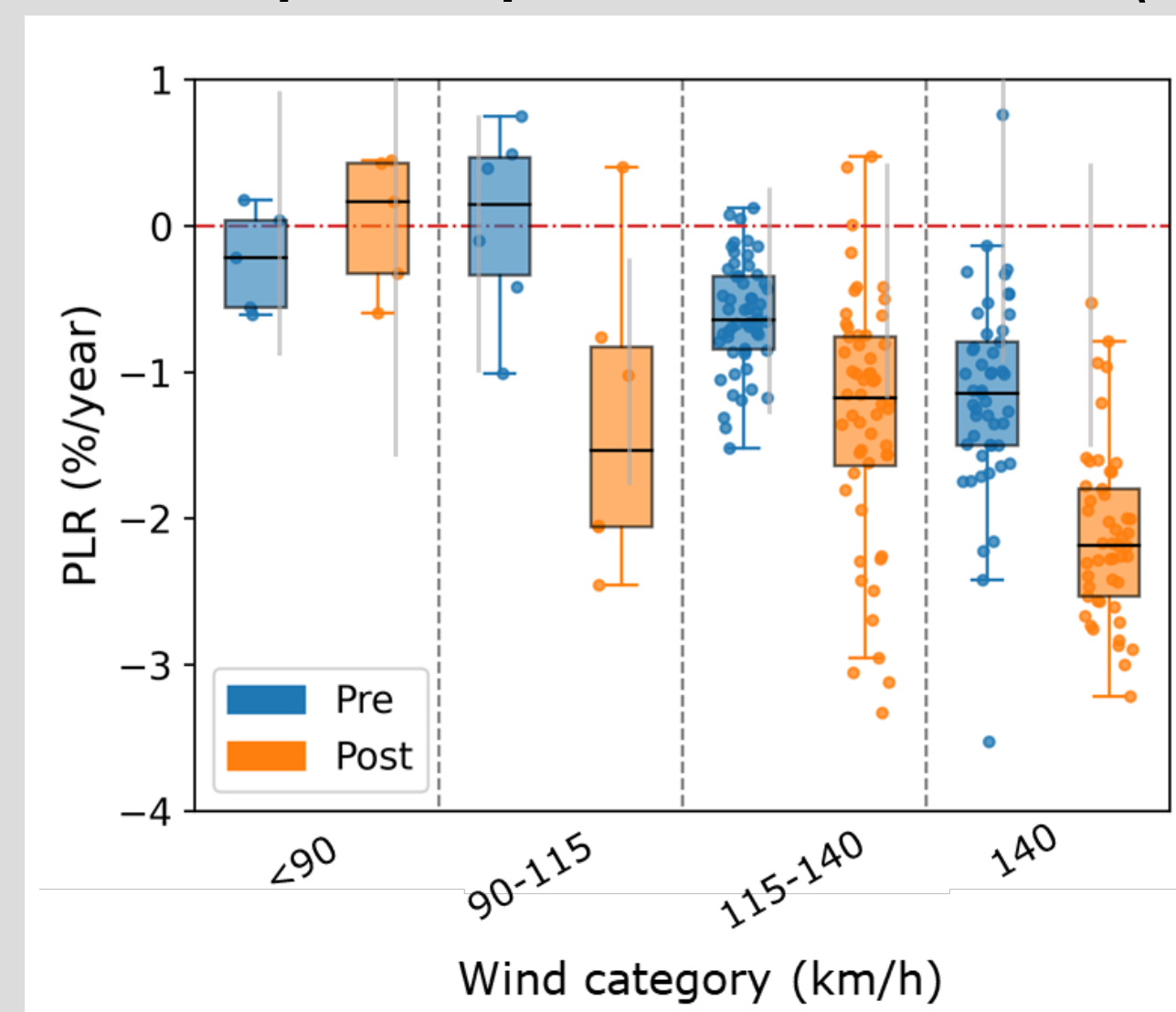
Tracked system affected by wind storm



1 inverter out of 26 impacted for 1 day

## 7 Long-term Impact - Wind

Wind impact on performance loss rate (PLR)

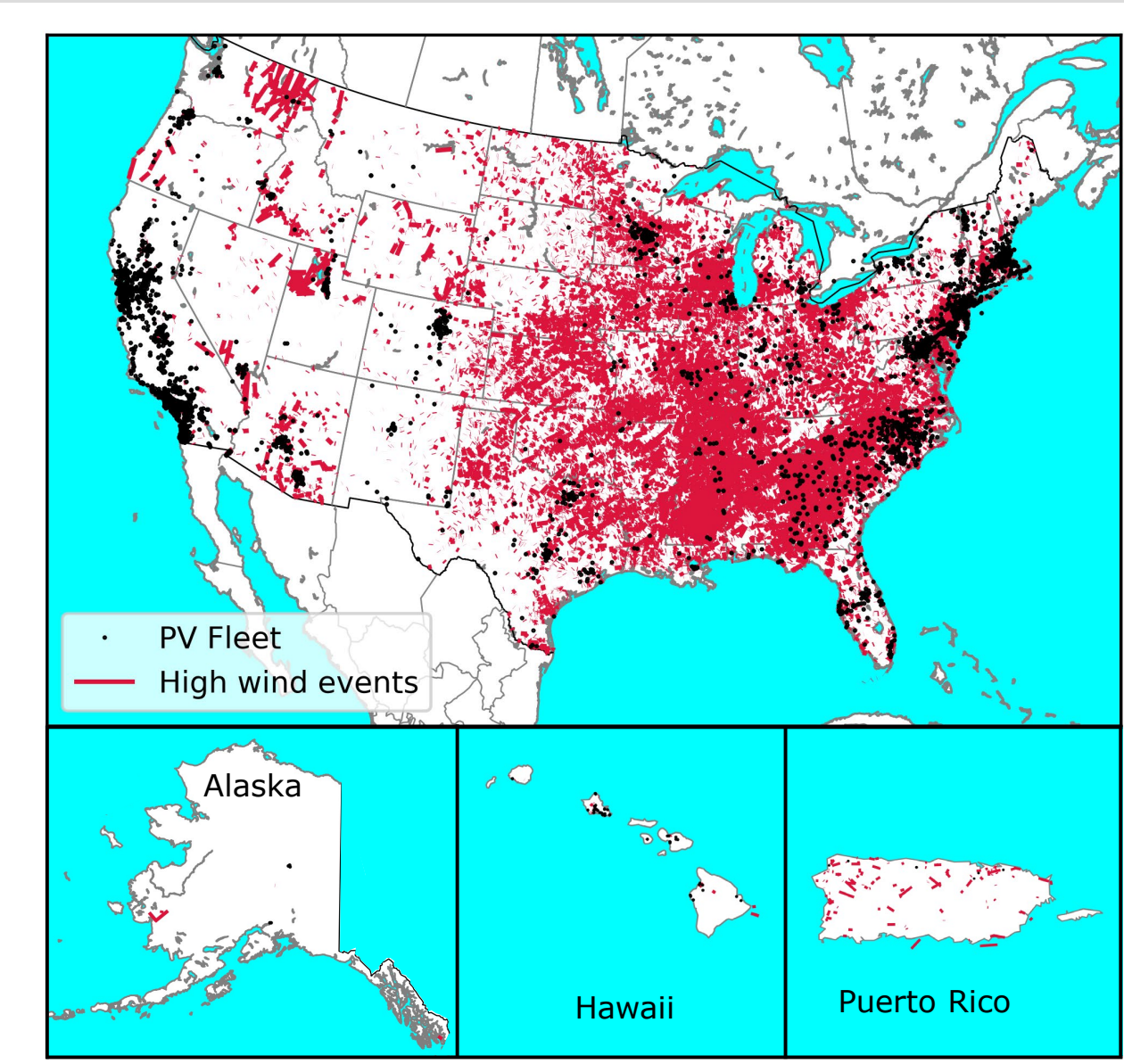


Needed 2 years of data before & after impact for RdTools analysis

High wind → statistically significant higher PLR after storm

## 2 Method

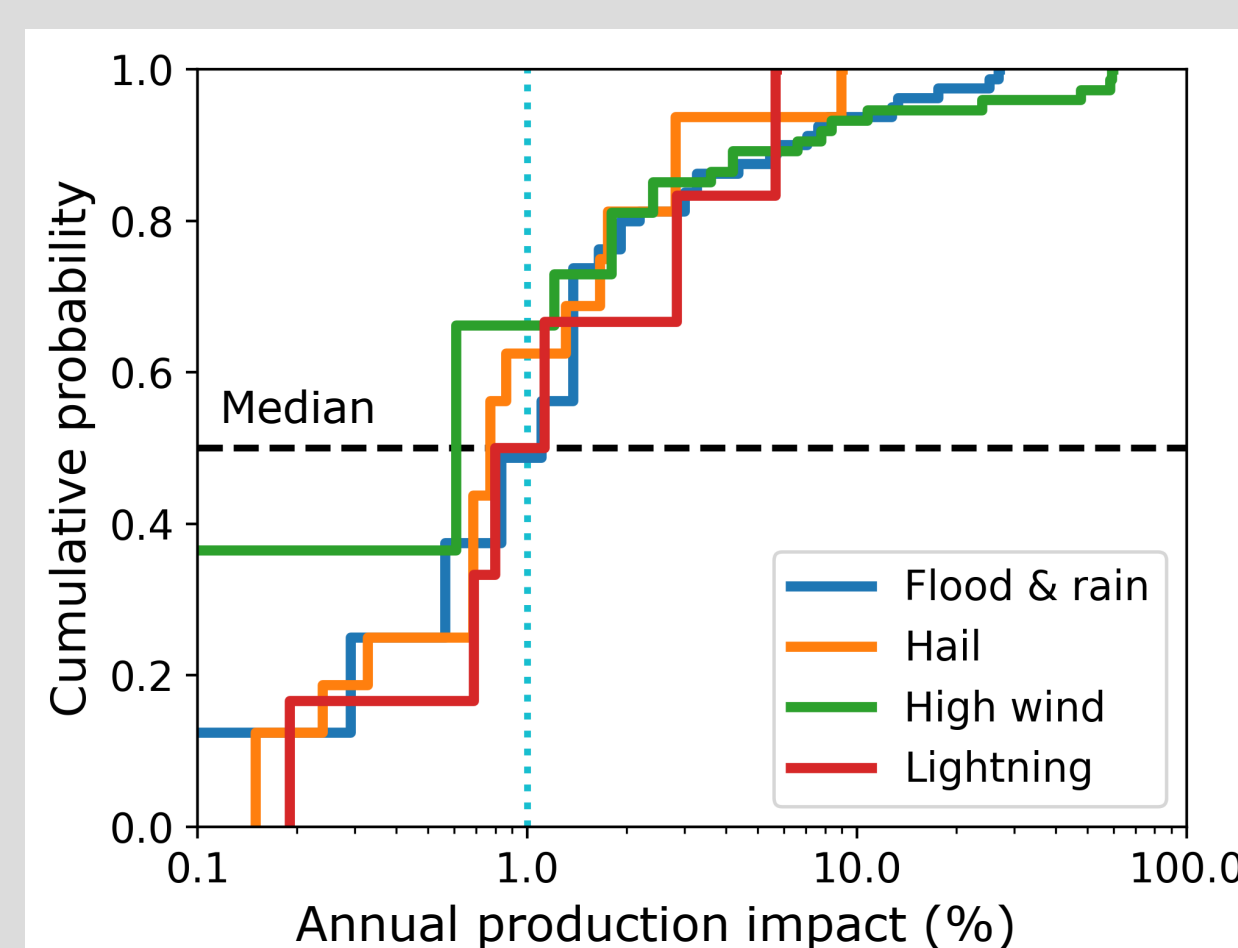
Compare NOAA database on extreme weather with PV Fleet time series



Determine events that came within 10 km of an existing PV system

## 5 Short-term Impact

Cumulative distribution function (CDF) of lost annual production (%)



Median lost production is around 1% of annual production

Long tail for flooding & high wind events (up to 60% lost production)

Statistically extreme weather leads to ca. 1% lost production  
High risk manifested in long tail.

## 8 Installation Quality

Wind speed: 90 – 115 km/h

Result: Modules blown from roof



Top-clamp fails in high wind



Partly threaded bolt

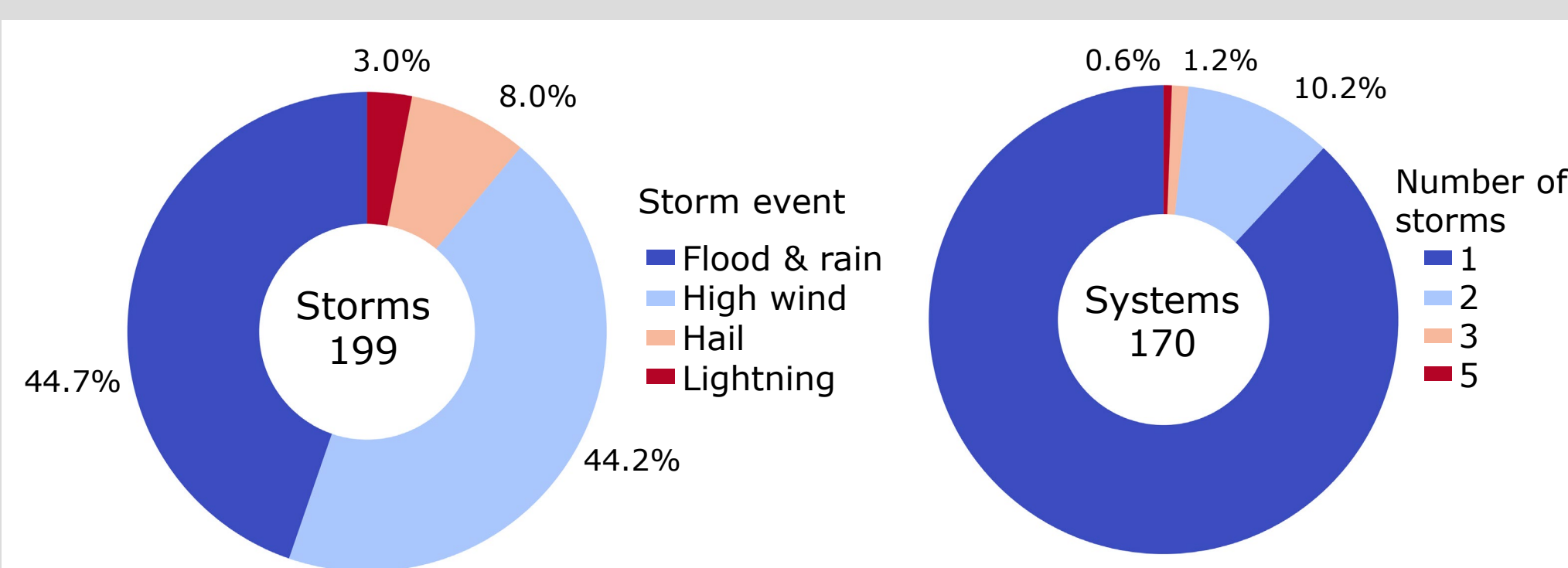


Mounting strength insufficient → bent bracket

## 3 Extreme Weather Pareto

Pareto of weather events

Number of storms impacting the same system

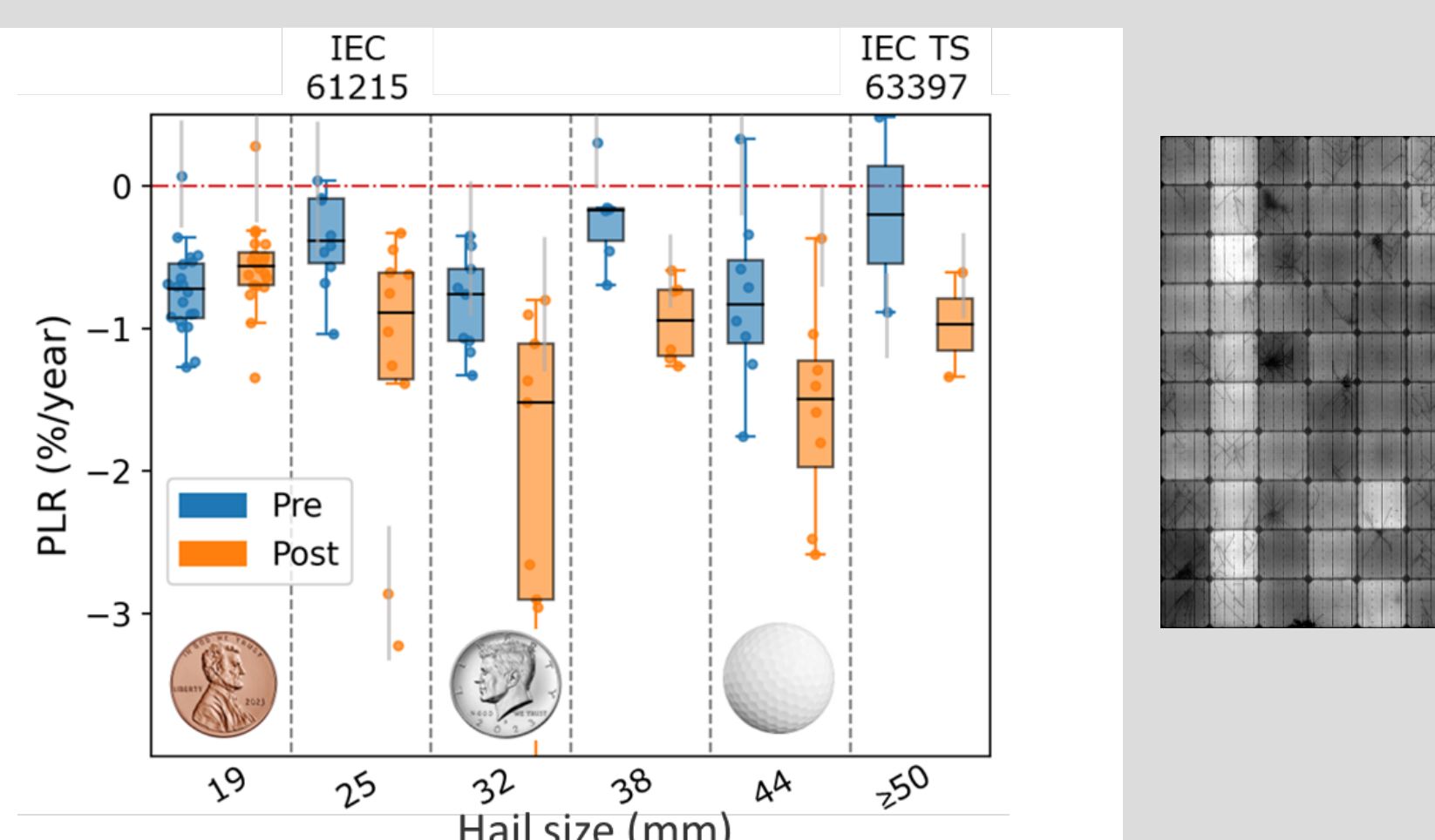


1 system was impacted by 5 severe weather events!

Flooding & high wind events are the most common storm types  
Most systems were impacted by a single extreme weather event

## 6 Long-term Impact - Hail

Hail impact on performance loss rate (PLR)



Using 2+ years of data before & after impact

Larger hail sizes may not necessarily lead to higher PLRs. Rather, higher PLRs occur if a minimum damage threshold is exceeded

Supports the development of better hail resistance testing

## 9 Conclusion

- The Good**
  - ☺ Quantified impact of extreme weather events of PV systems from a fleet perspective
  - ☺ Short-term impact (outages) lead to ca. 1% of annual lost production, at the median.
  - ☺ Installation quality can influence impact
- The Bad**
  - ☹ Distributions have a long tail that can lead to substantial annual losses (60%!)
  - ☹ Systems impacted by hail exceeding current IEC 61215 showed higher Performance loss after storm → need better hail testing (already in development)
  - ☹ All systems impacted by "storm" to "violent storm" on Beaufort wind scale showed higher PLR after storm.
- The Ugly**
  - ☹ We have only begun to quantify the impact.
  - ☹ Results may change as PV deployment increases and extreme weather events become more common.
  - ☹ Results may be different on different continents.