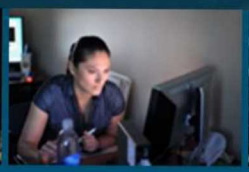
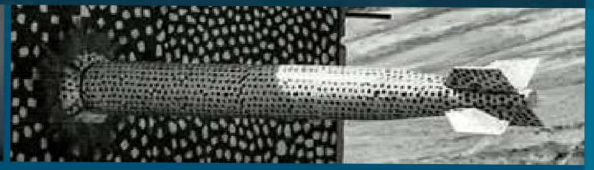
SAND2020-2351C

Sandia National Laboratories

Multi-site assessment of extreme weather impacts on PV plant performance and reliability





PRESENTED BY

Nicole D. Jackson

PV Reliability Workshop

February 26, 2020

SAND XXX

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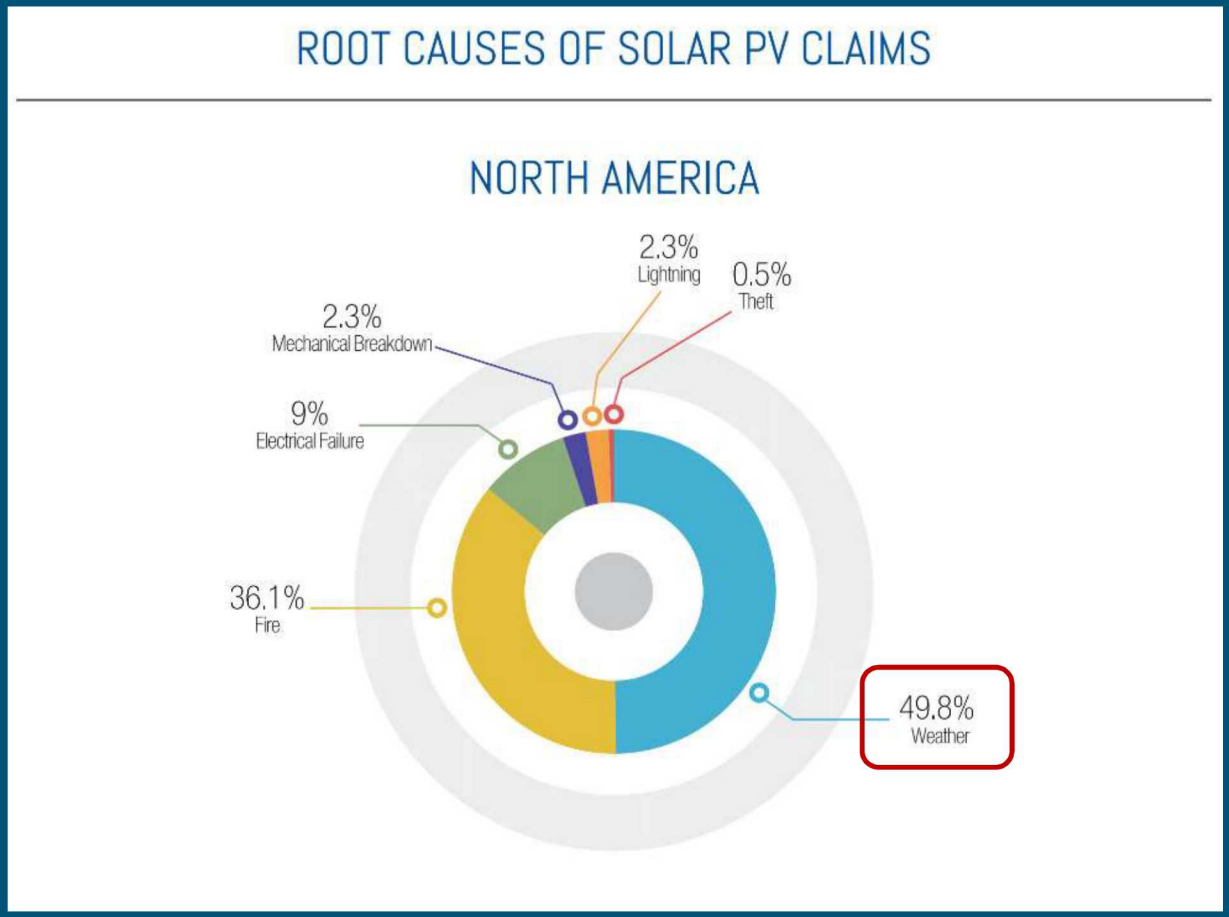
PV plants can be exposed to disruptions due to weather events such as hurricanes and hail storms

(BMR Energy 2017)

SBS News (2018)

There is an increasing prevalence of weather impacts to PV



(GCube 2016)

Study Objectives

- Analysis of site-level performance and weather data to identify trends
- Identification of performance variabilities across sites, climates, and event types

Multiple tropical storms affected the Carolinas in Fall 2018

- Hurricane Florence

NOAA (2018)

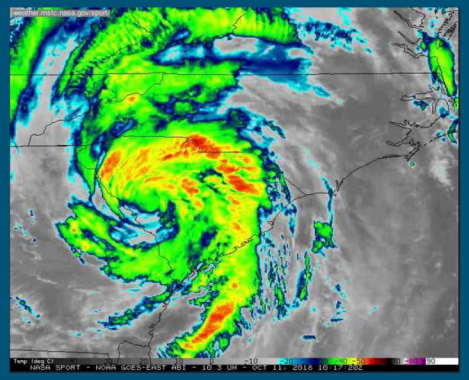
09/01
Named tropical storm

09/05
Becomes a hurricane

09/14
Makes landfall in NC

09/18
Hurricane downgraded

- Hurricane Michael



NASA (2018)

10/07
Named tropical depression

10/08
Becomes a hurricane

10/11
Reaches the Carolinas

10/12
Hurricane downgraded

Multiple datasets are combined to link performance, weather and O&M records

Industry Data

Site Characteristics

- DC Size
- Climate zone
- Latitude
- Longitude
- Asset clipping limit

Measured data

- Date
- Irradiance
- Energy delivered
- Output power
- Expected energy

O&M Logs

- Failure details
- Event duration

Site Metrics

Yield Loss

- Final system yield
- Reference yield

Performance metrics

- Performance ratio
- Energy performance index

Climate Data

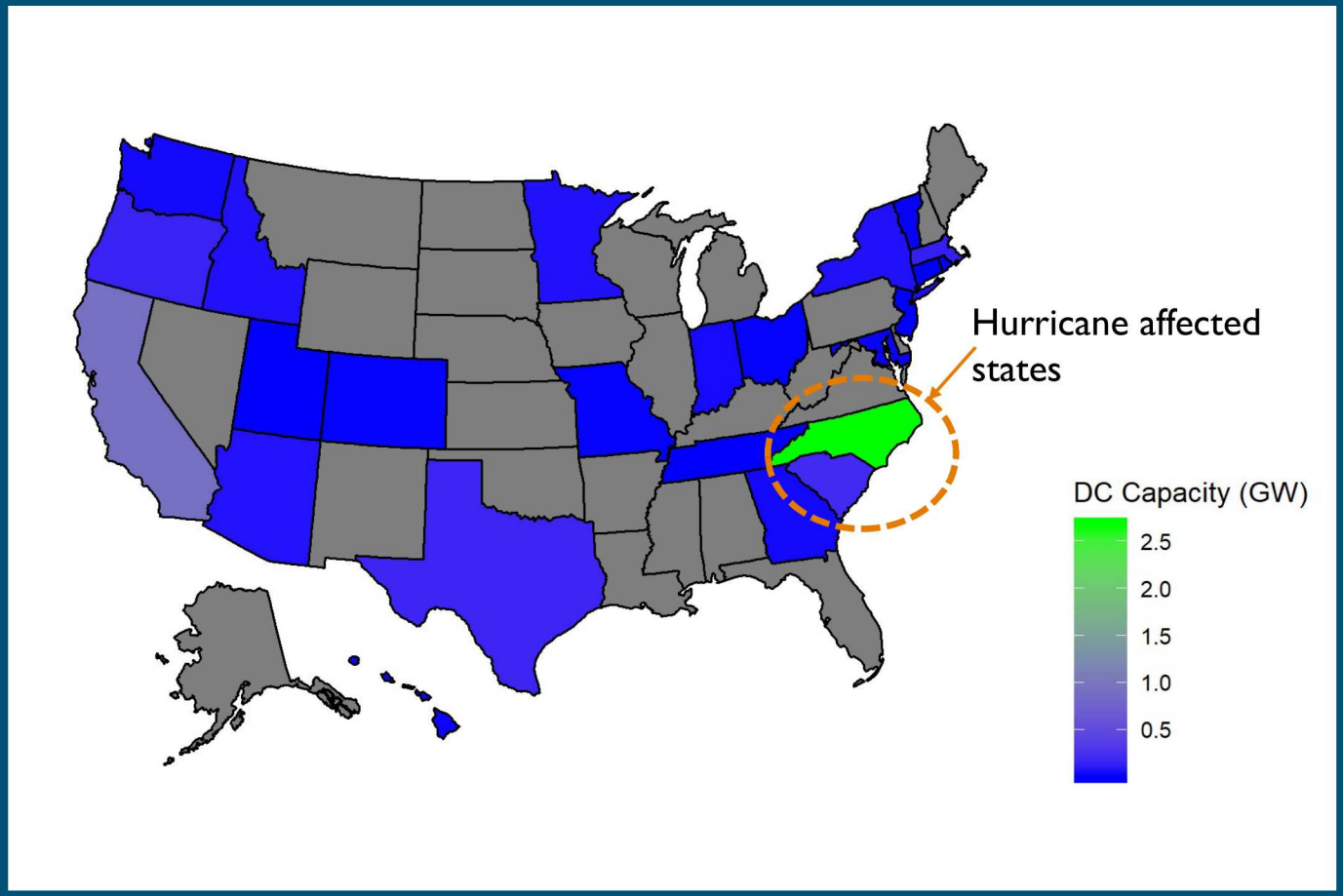
GHCN Weather Stations

- Precipitation
- Snow

PRISM

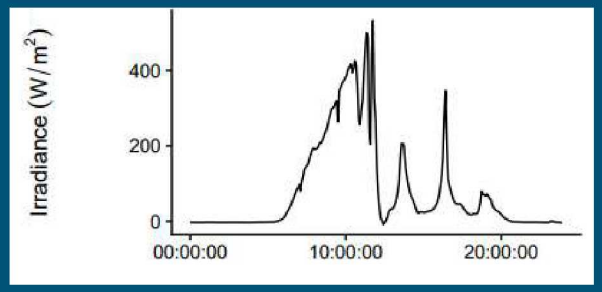
- Maximum temperature
- Minimum temperature

Performance data in the Carolinas can be paired with PVROM data for the period 2018-2019

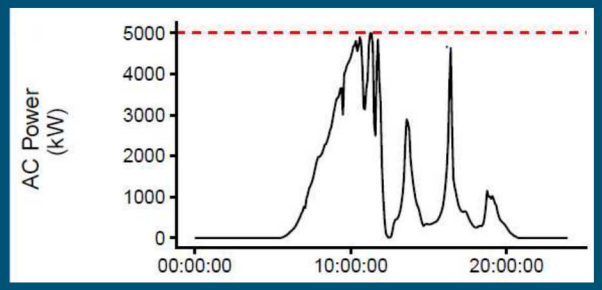


Data processing of site-level raw data

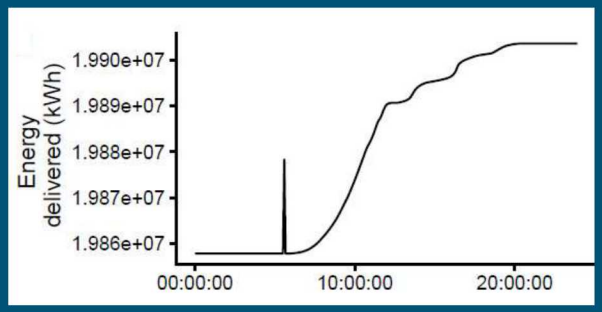
Raw Data



Removed negative values

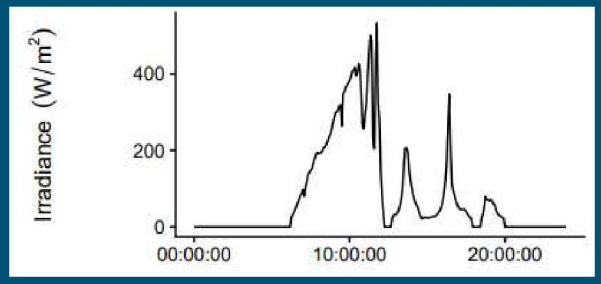


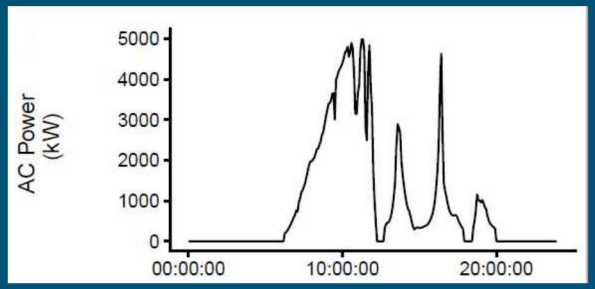
Entries with negative irradiance have AC power = 0

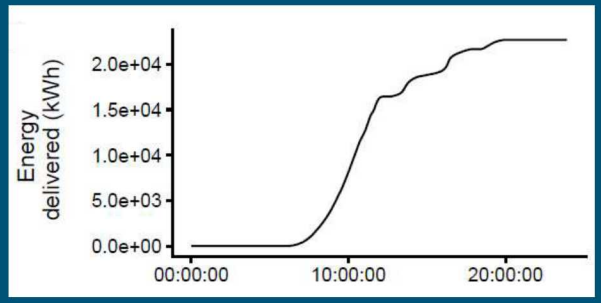


Removed errant spikes in cumulative energy delivered to grid

Clean Data







Multiple site metrics are evaluated at the daily time scale

Yield losses

- Final system yield

$$Y_f = \frac{E_{out}}{P_0}$$

- Reference yield

$$Y_r = \frac{H_i}{G_{i,ref}}$$

Performance metrics

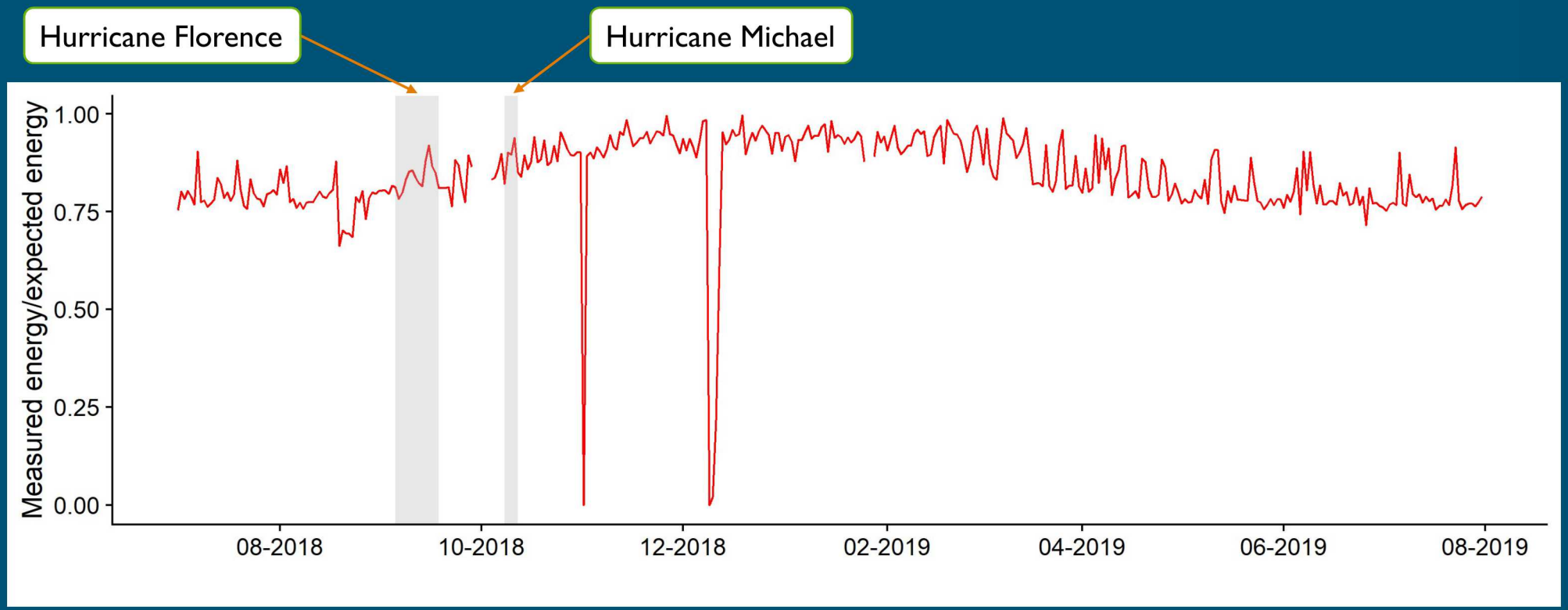
- Performance ratio

$$PR = \frac{Y_f}{Y_r}$$

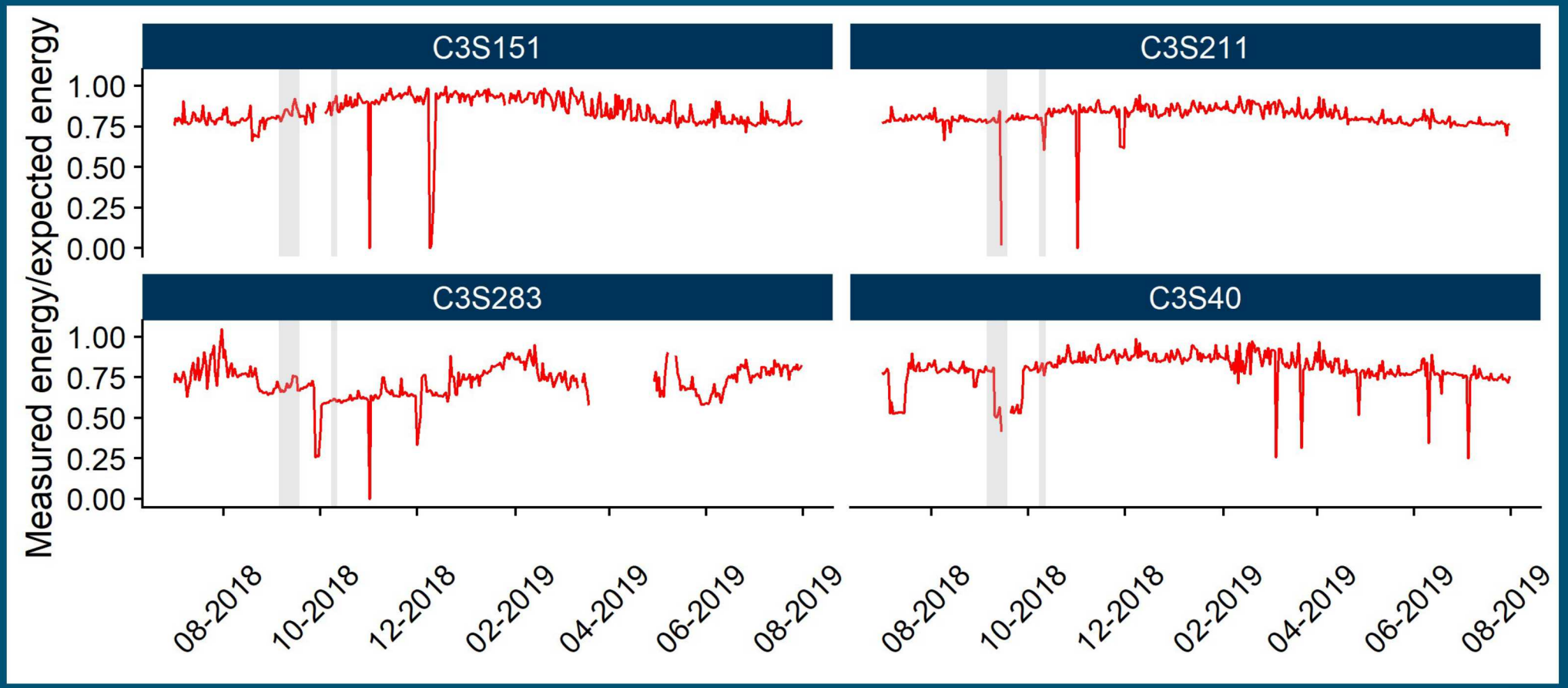
- Energy performance index

$$EPI = \frac{\text{Measured energy}}{\text{Expected energy}}$$

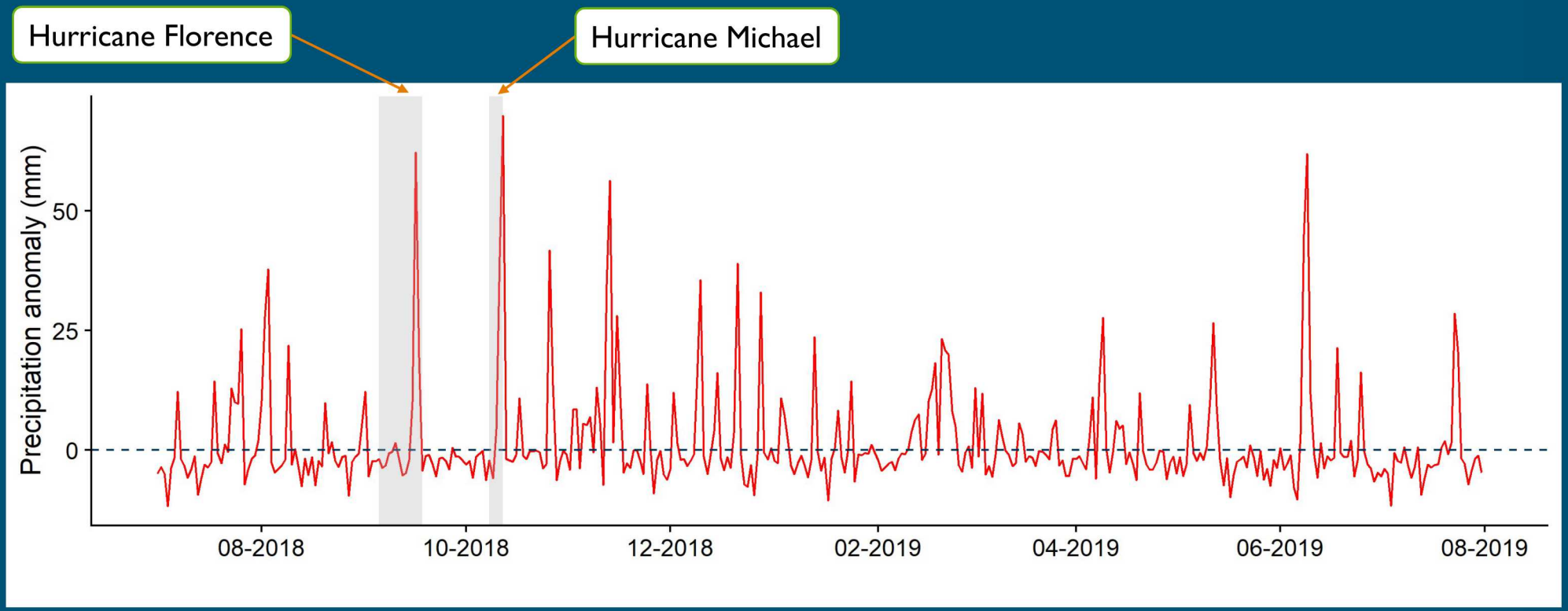
Sample daily performance for a North Carolina site with the hurricanes indicated



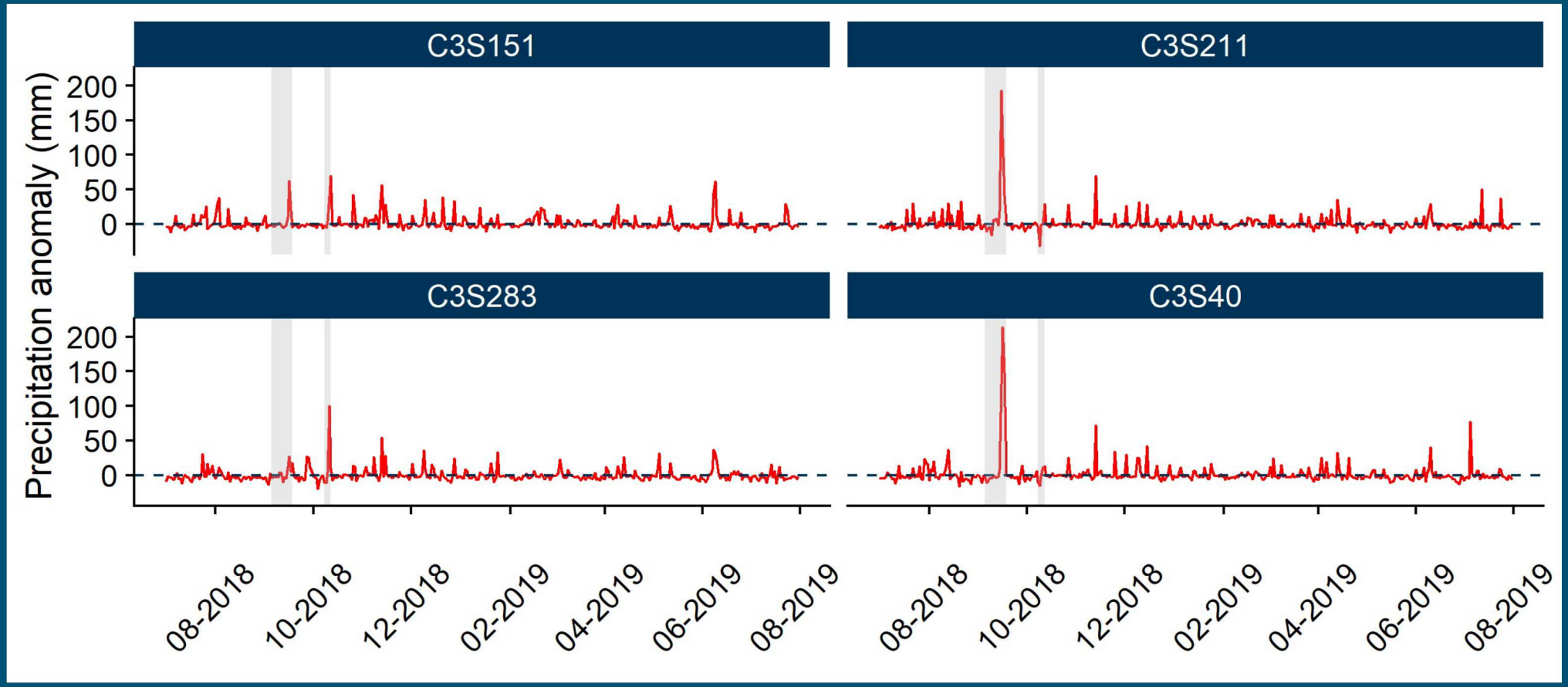
Site-level differences in performance response to hurricanes



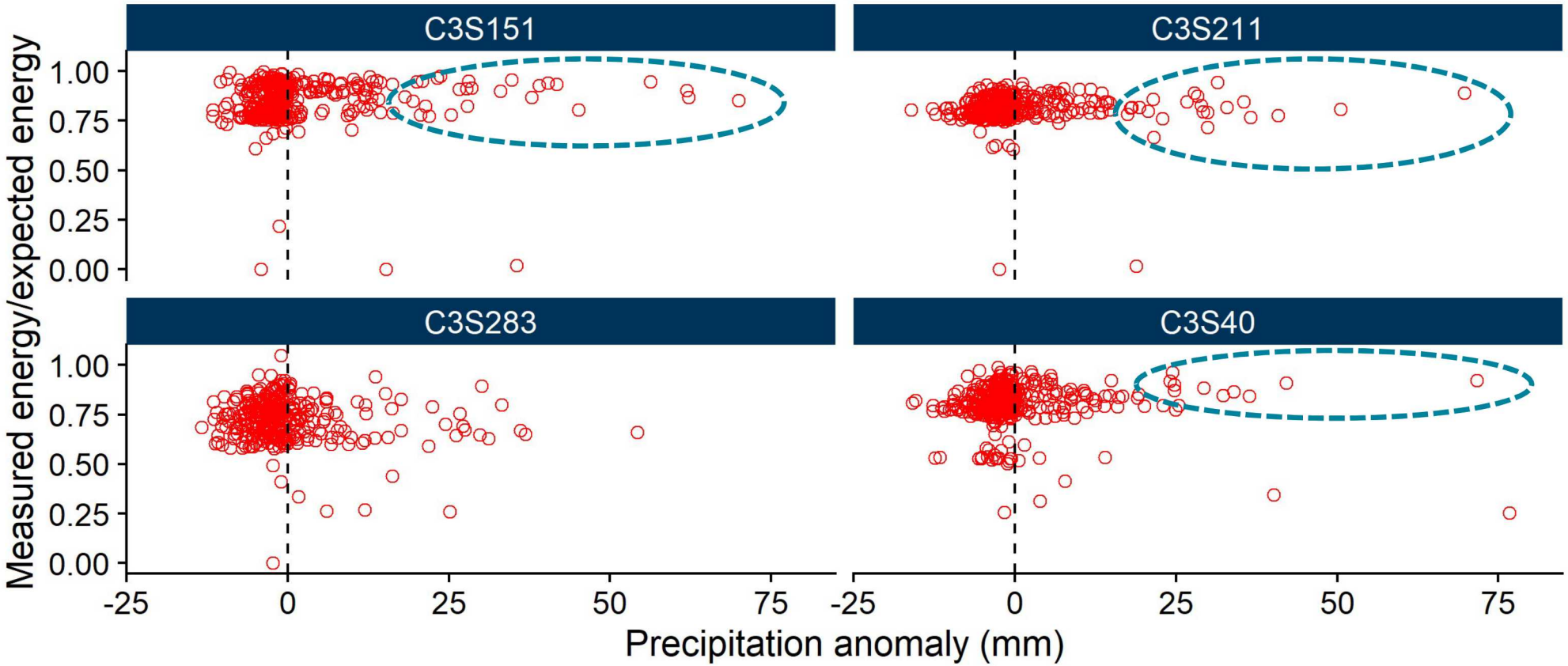
Precipitation anomalies developed by comparing daily precipitation data to its 30-year historical mean



Site-level differences in exposure to precipitation anomalies during hurricane events

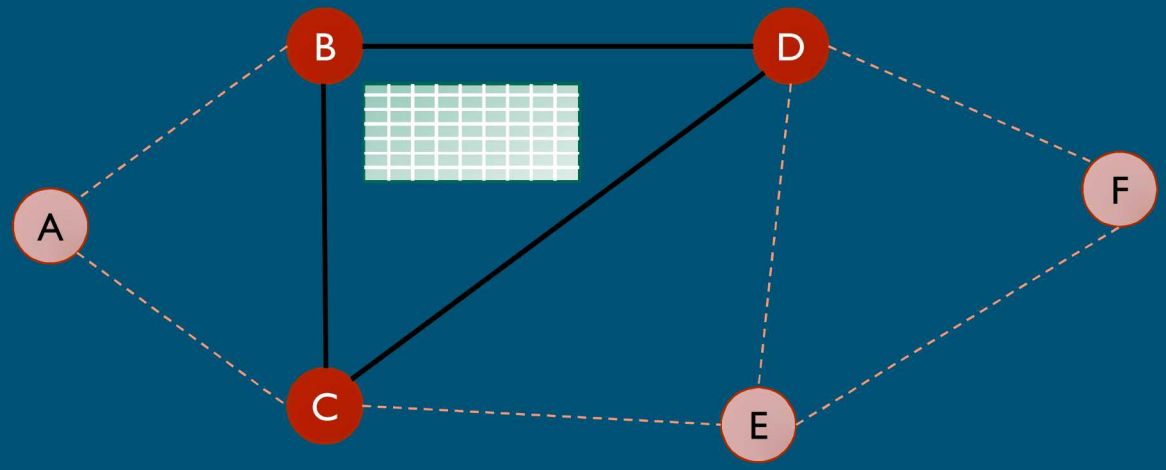


Multi-site comparison of precipitation anomalies with daily site performance suggest presence of other confounding factors



Ongoing work

- Continue analysis of performance data for remainder of sites
- Integrate remaining O&M records with weather and performance data
- Refine processing of site-specific climate data



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Thank you for your time!

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