Evaluation of Extreme Weather Impacts on Utility-scale Photovoltaic Plant Performance

PRESENTED BY

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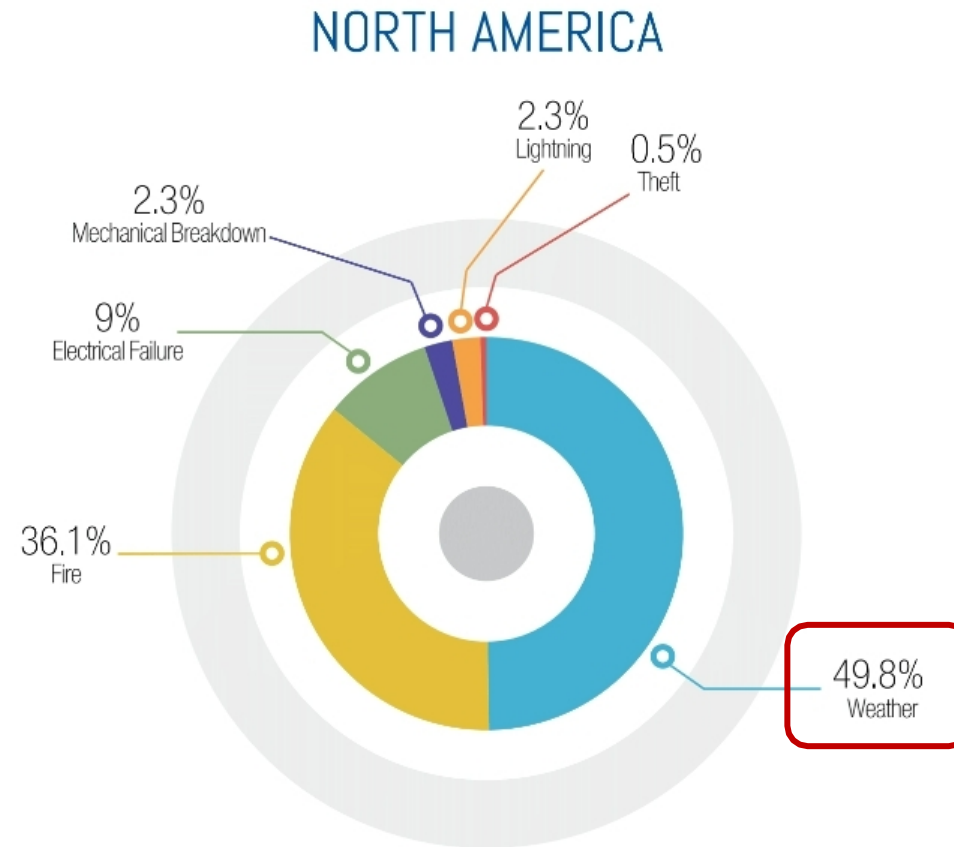

(BMR Energy 2017)

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 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
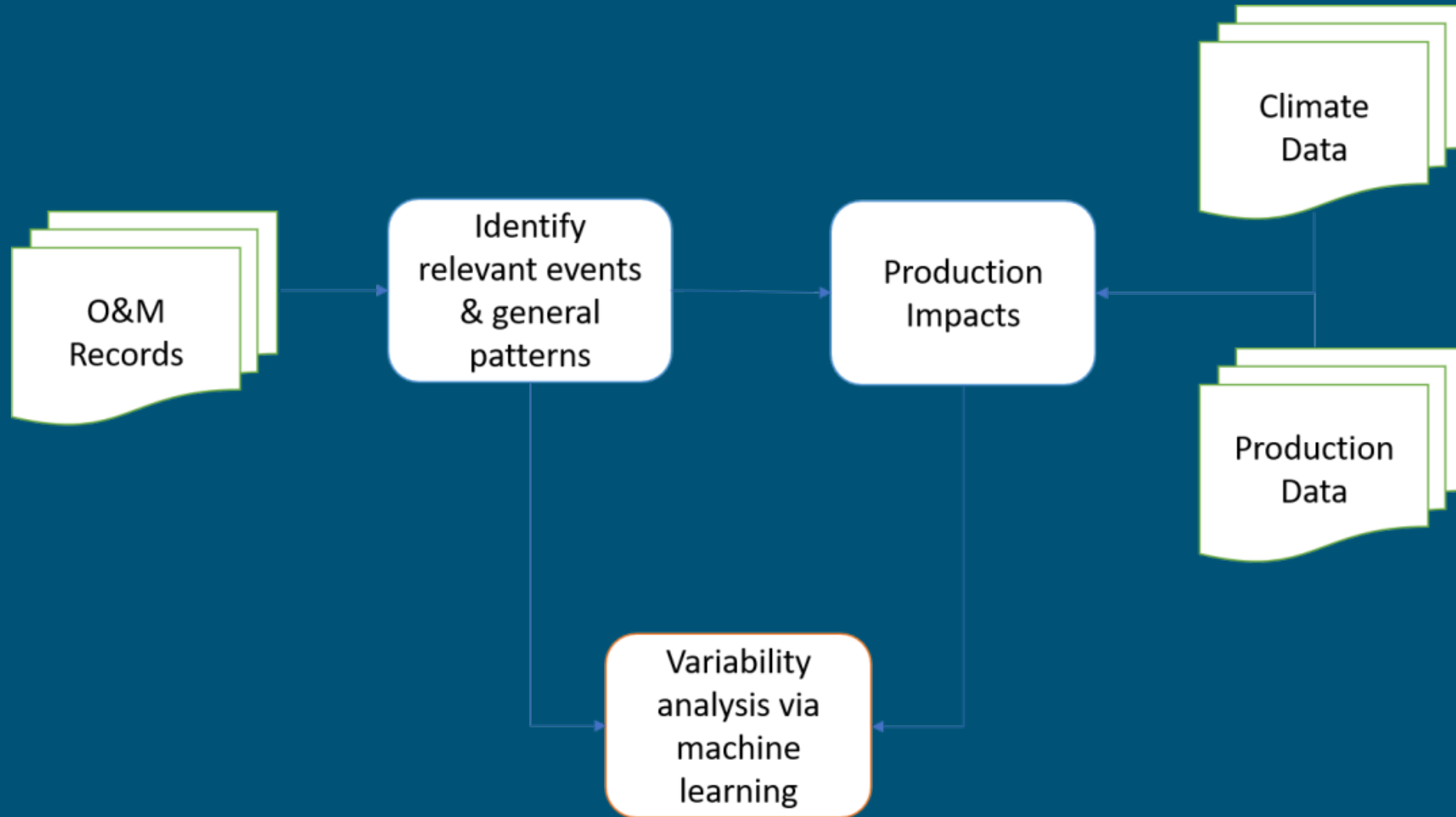
Climate Data

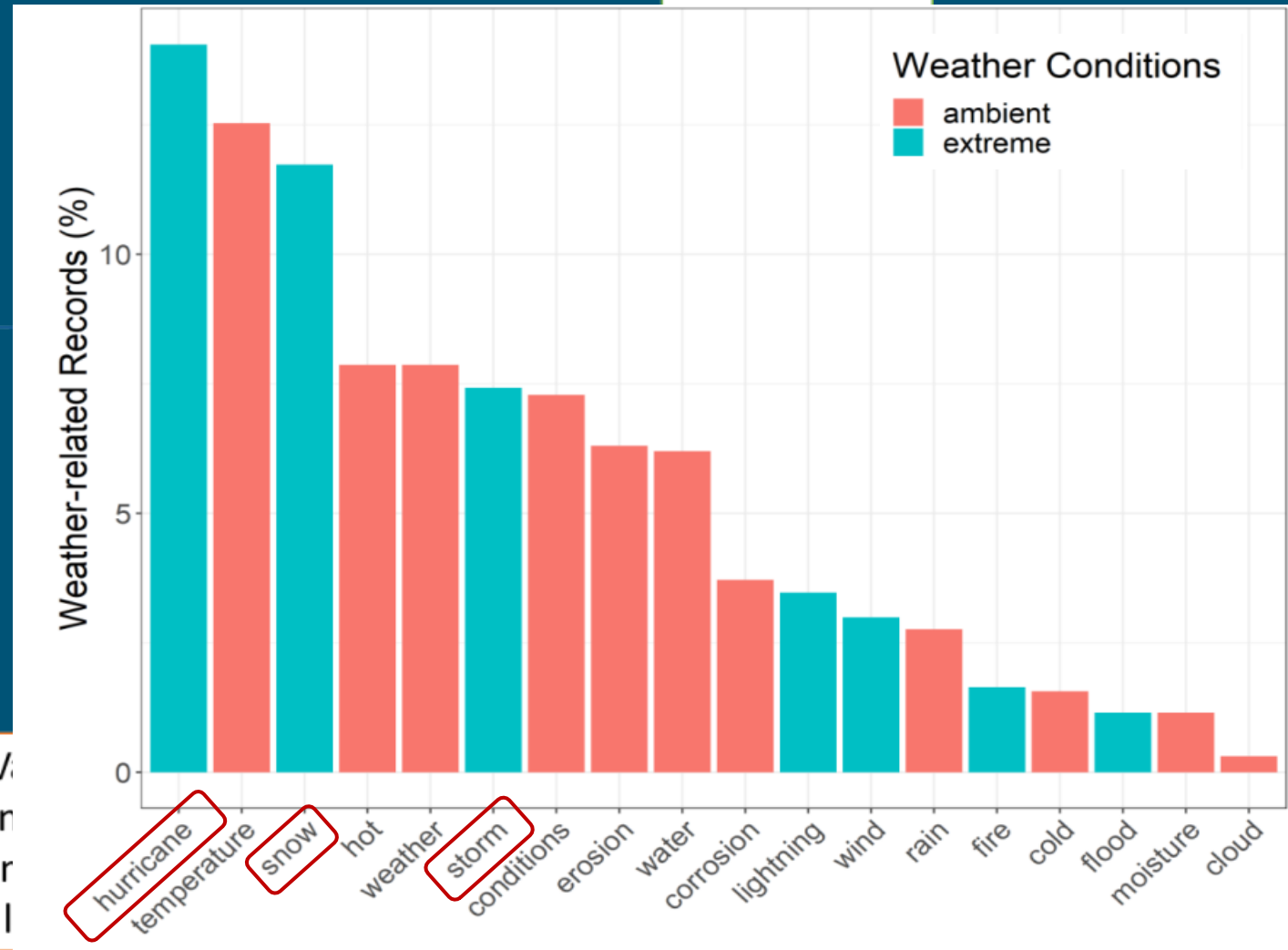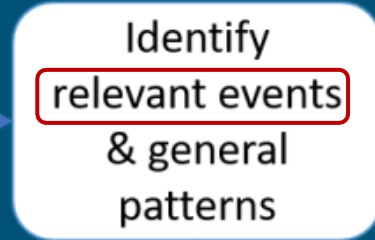### GHCN Weather Stations
- Precipitation
- Snow

PRISM
- Maximum temperature
- Minimum temperature
- Precipitation

NOAA Storm Events Database
- Snow
- Storms
- Hurricanes

Integrated assessment of uses inputs from multiple datasets

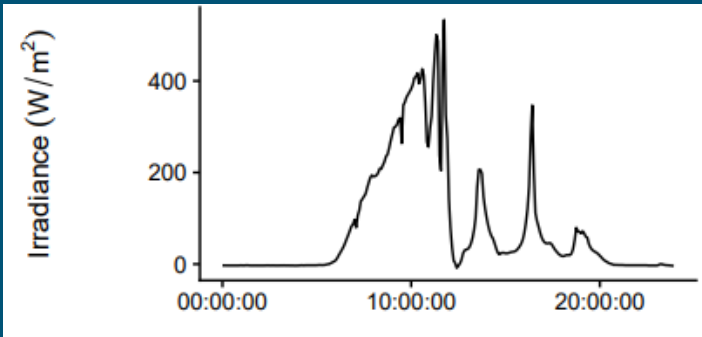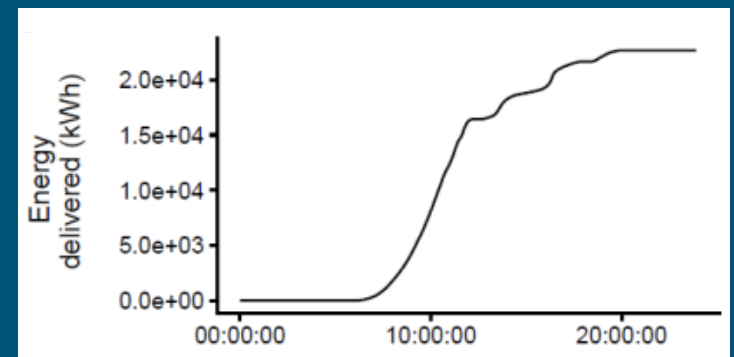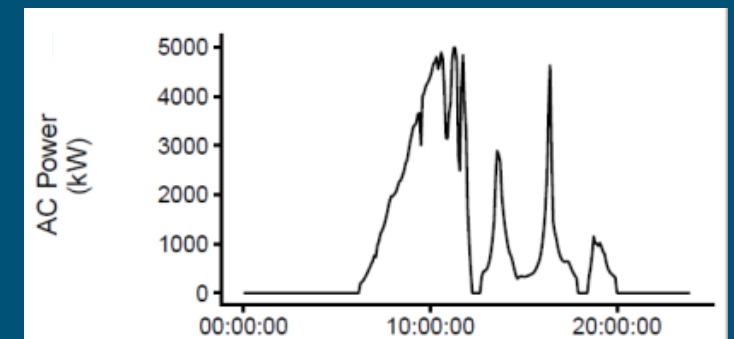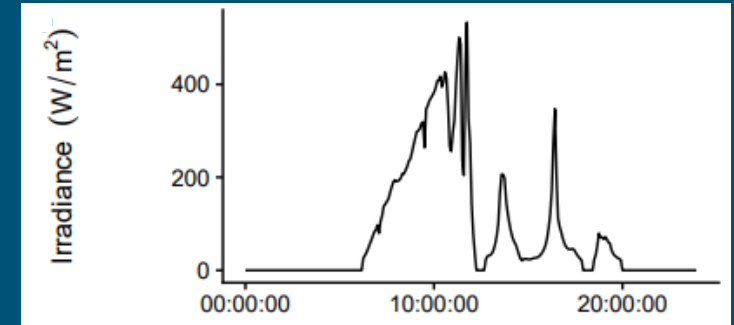# Text analysis of PVROM's O&M records helps identify the most prevalent weather events

Data processing of site-level raw production data

Raw Data

Clean Data

Removed negative values

Entries with negative irradiance have AC power = 0

Removed errant spikes in cumulative energy delivered to grid

Multiple site metrics are evaluated at the daily time scale

Yield losses

➤ Final system yield

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

➤ Reference yield

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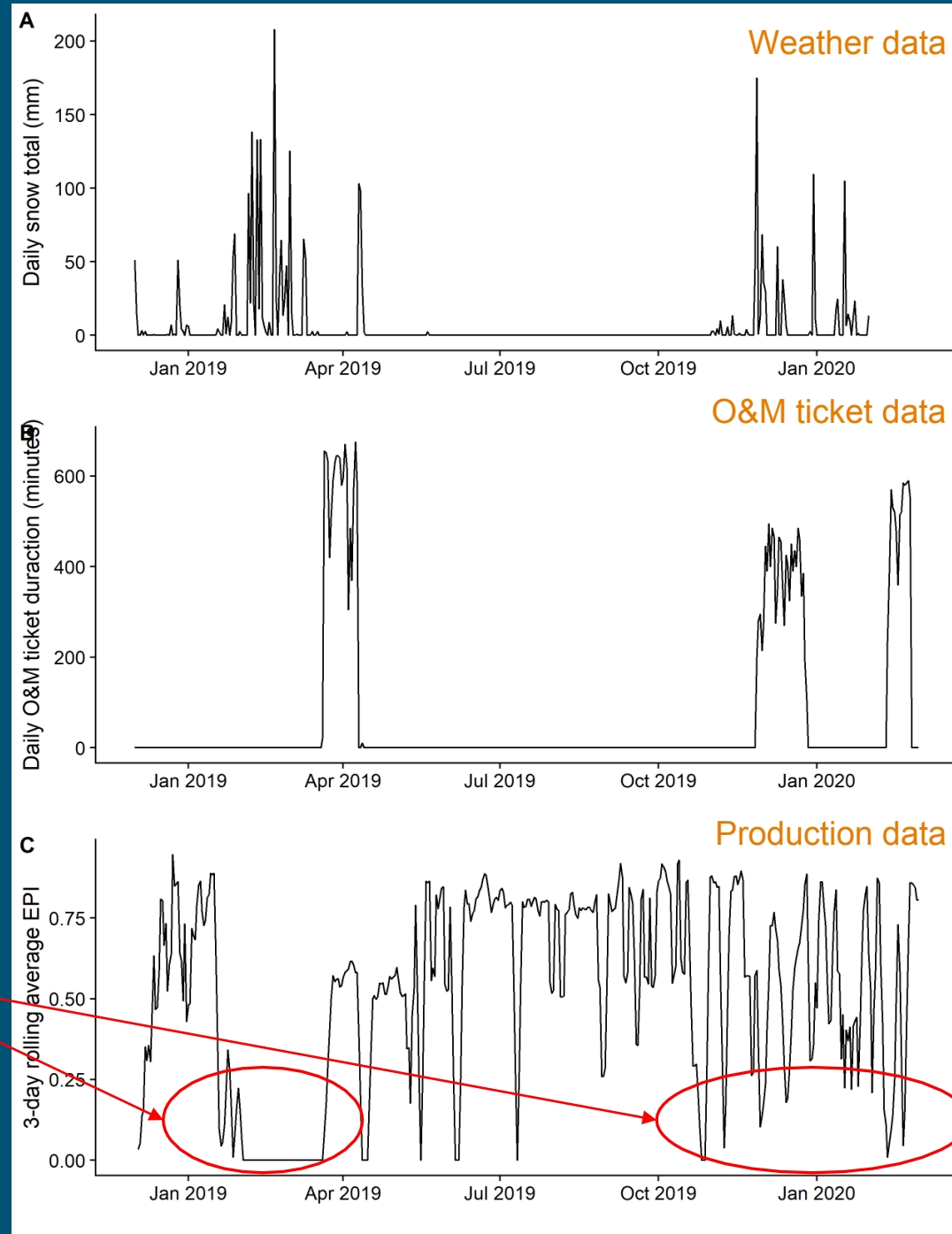
Performance metrics

➤ Performance ratio

$$PR = \frac{Y_f}{Y_r}$$
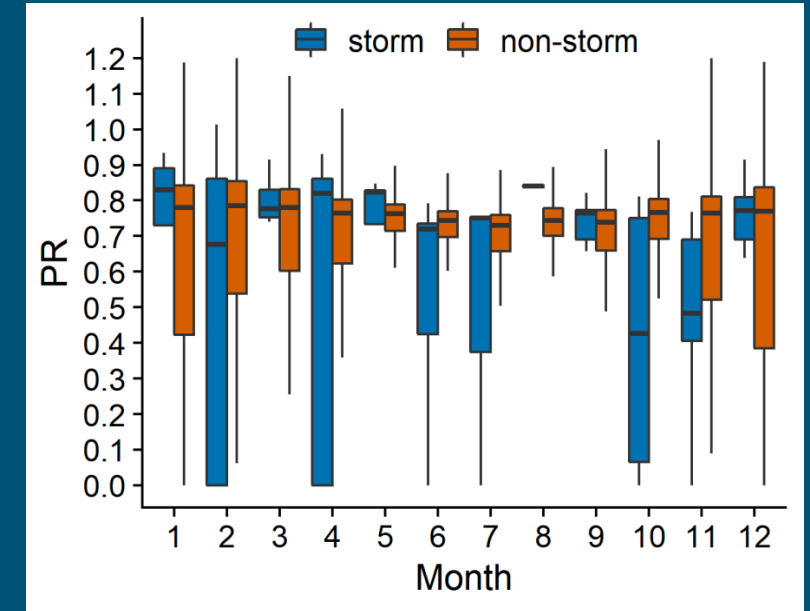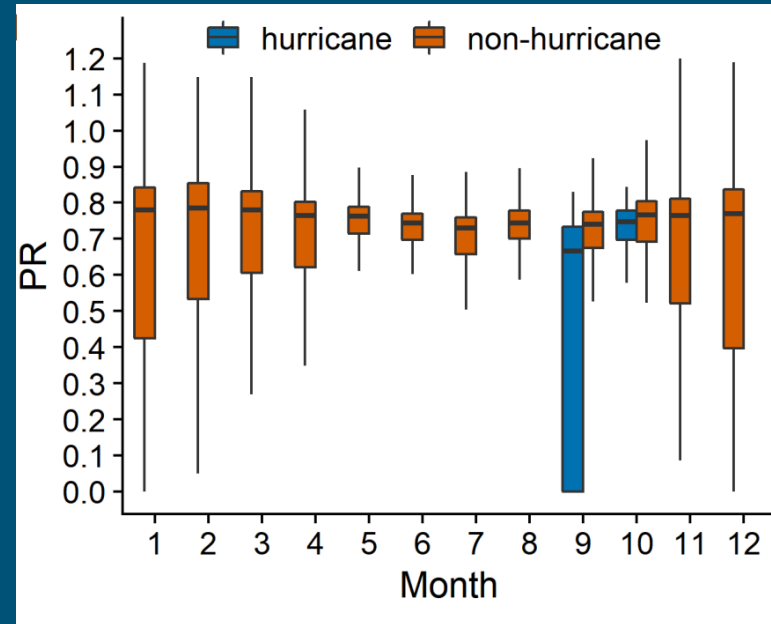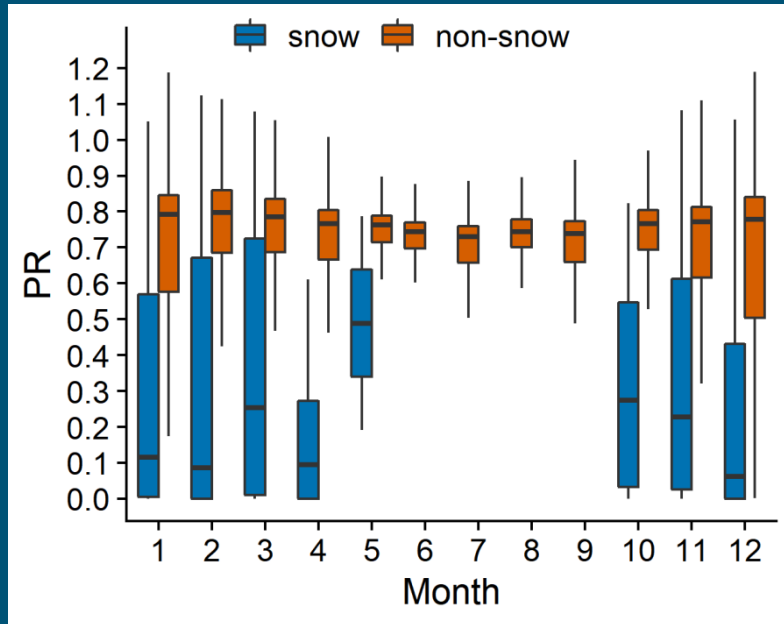
➤ Energy performance index

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

Data fusion of snow, production, and & O&M data show nearness of phenomena

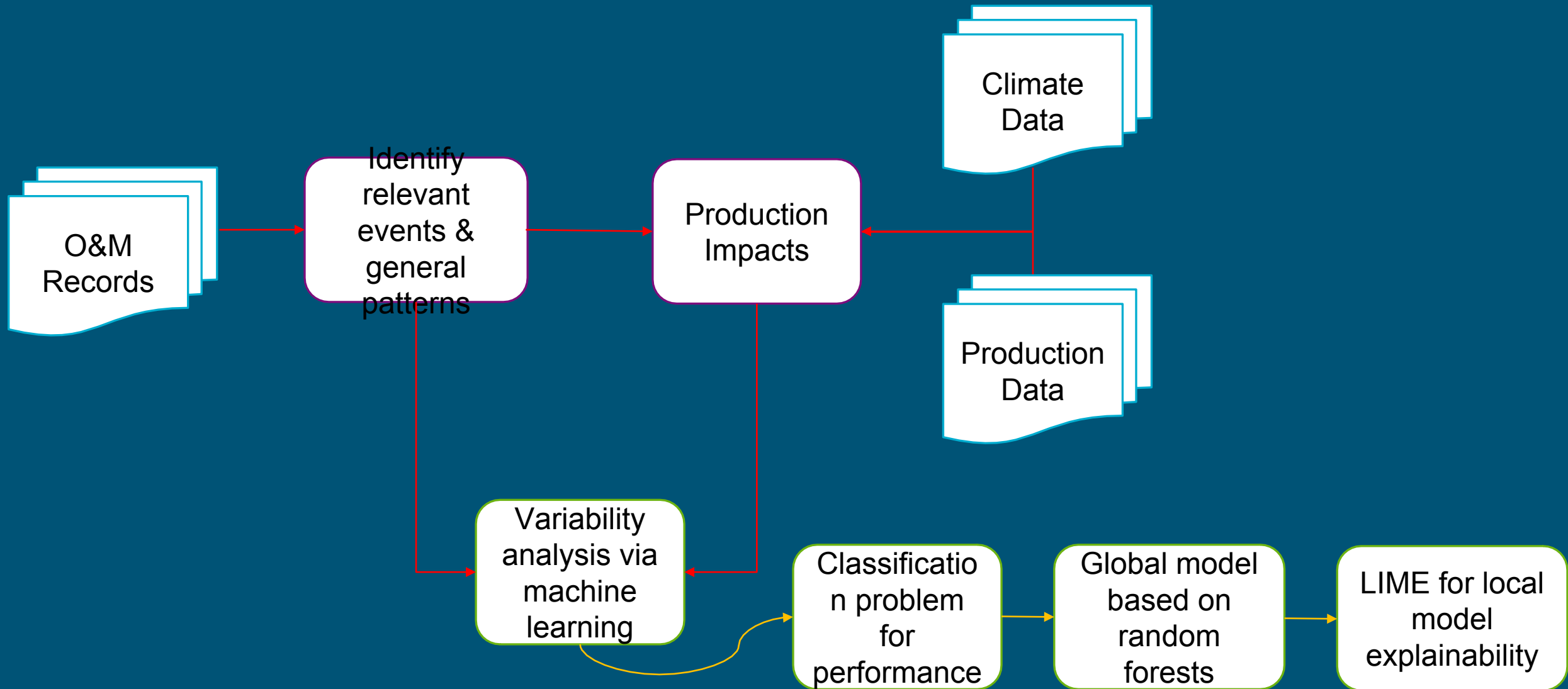"low" performance

Event and non-event days show variable response across months and weather types

Mean PR by event status

	Snow	Hurricane	Storm
Event	0.296	0.594	0.627
Non-event	0.650	0.669	0.634

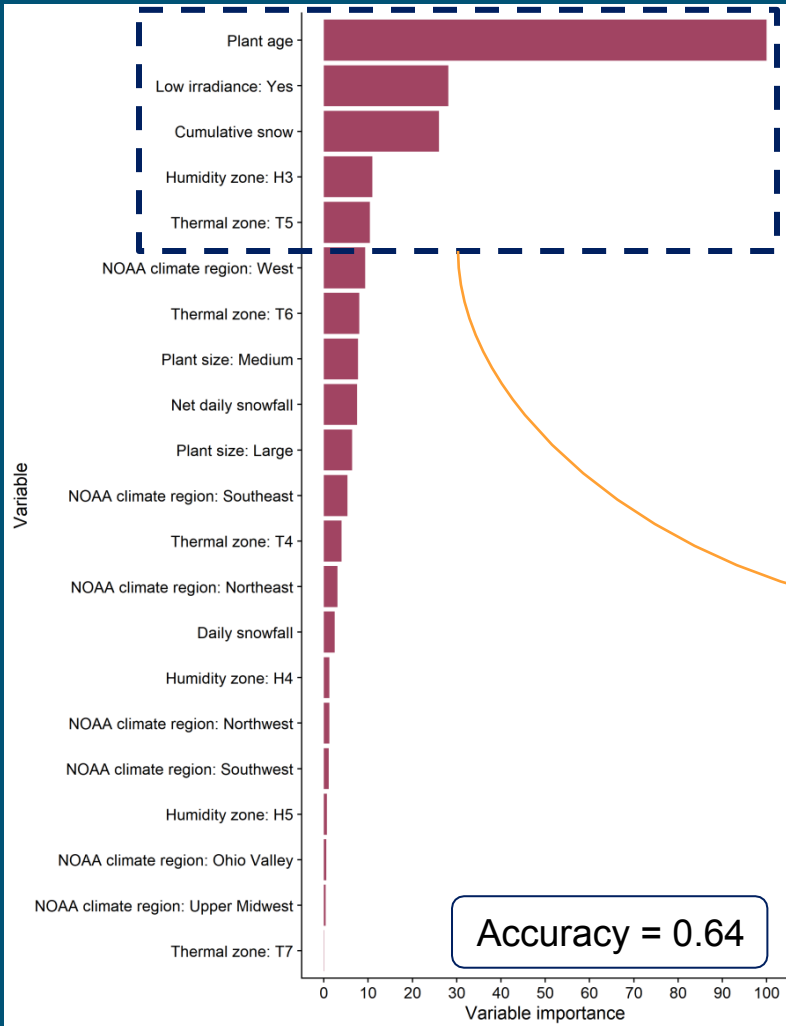# Machine learning used to gain insights into drivers of performance during weather events

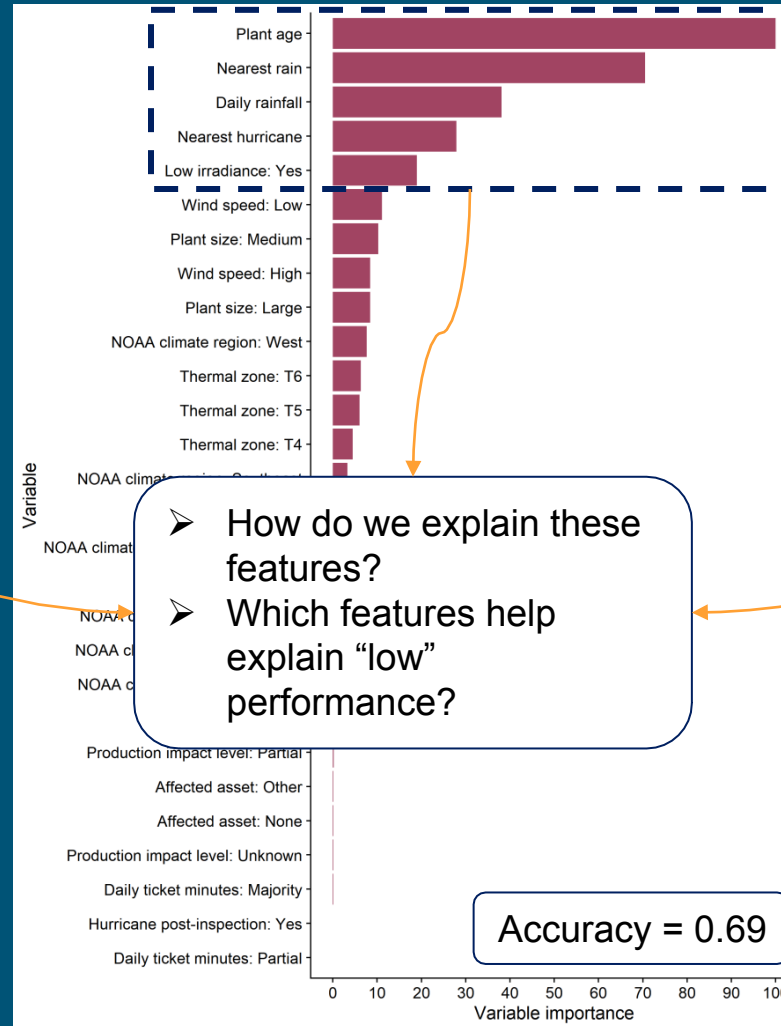# Random forest machine learning implementation gives insight to feature importance and accuracy for global models

Snow

Hurricane
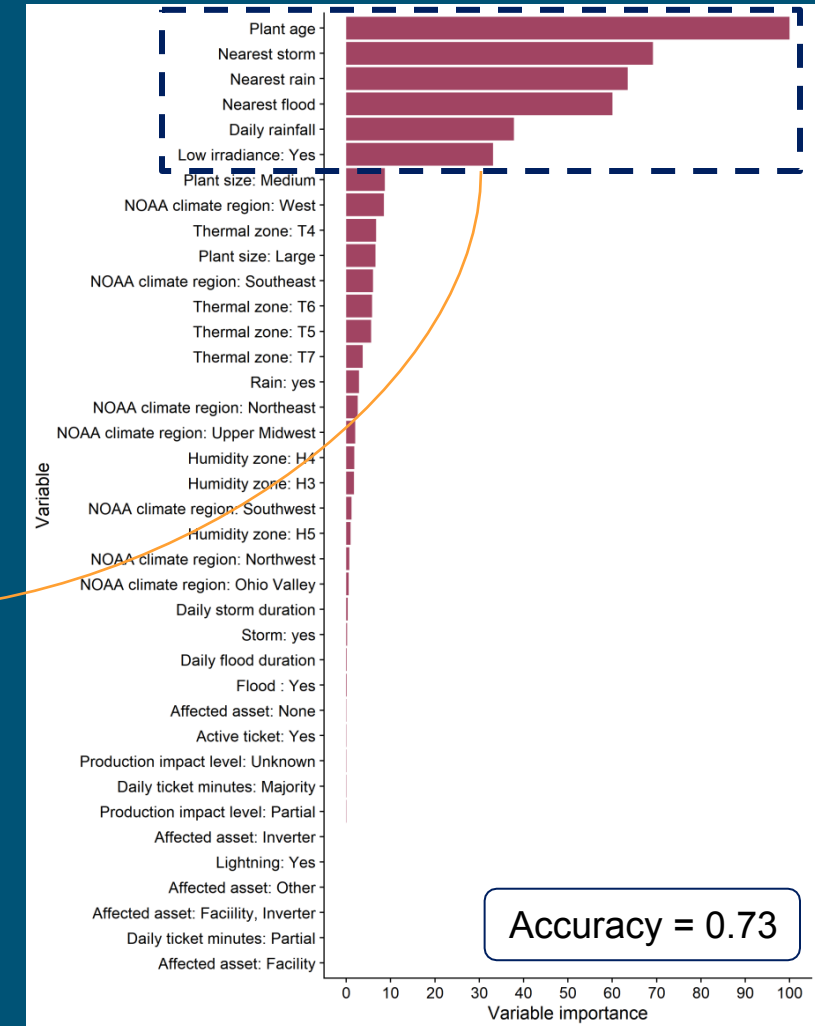
Storm

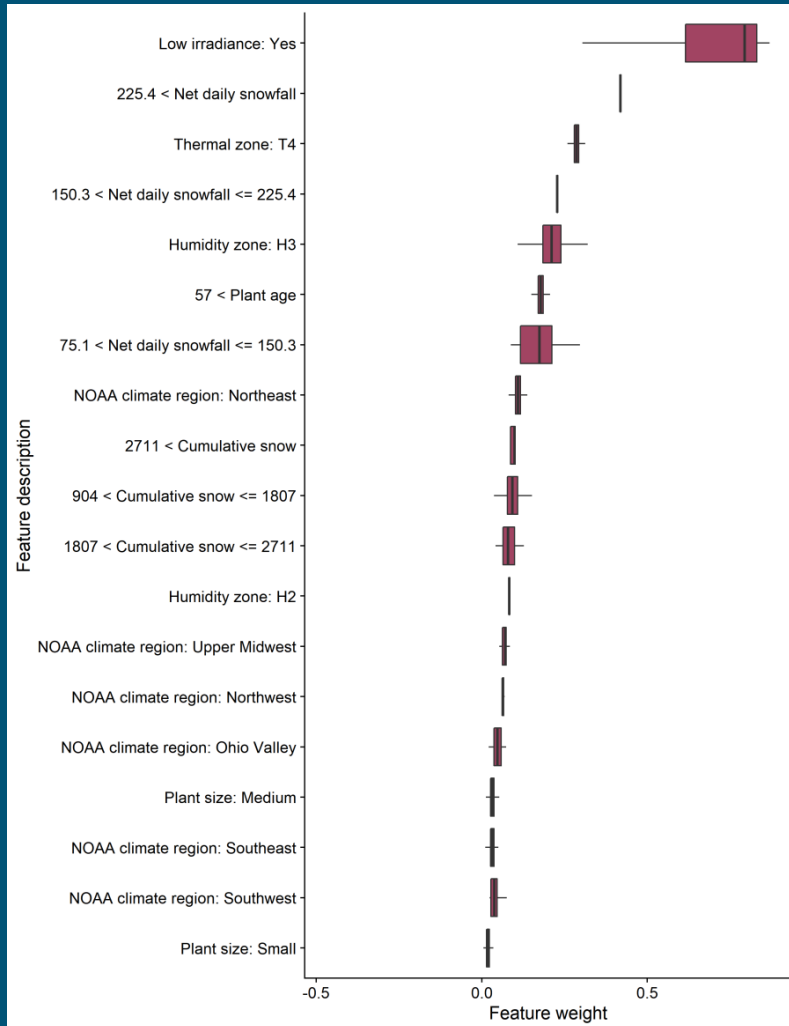> How do we explain these features?
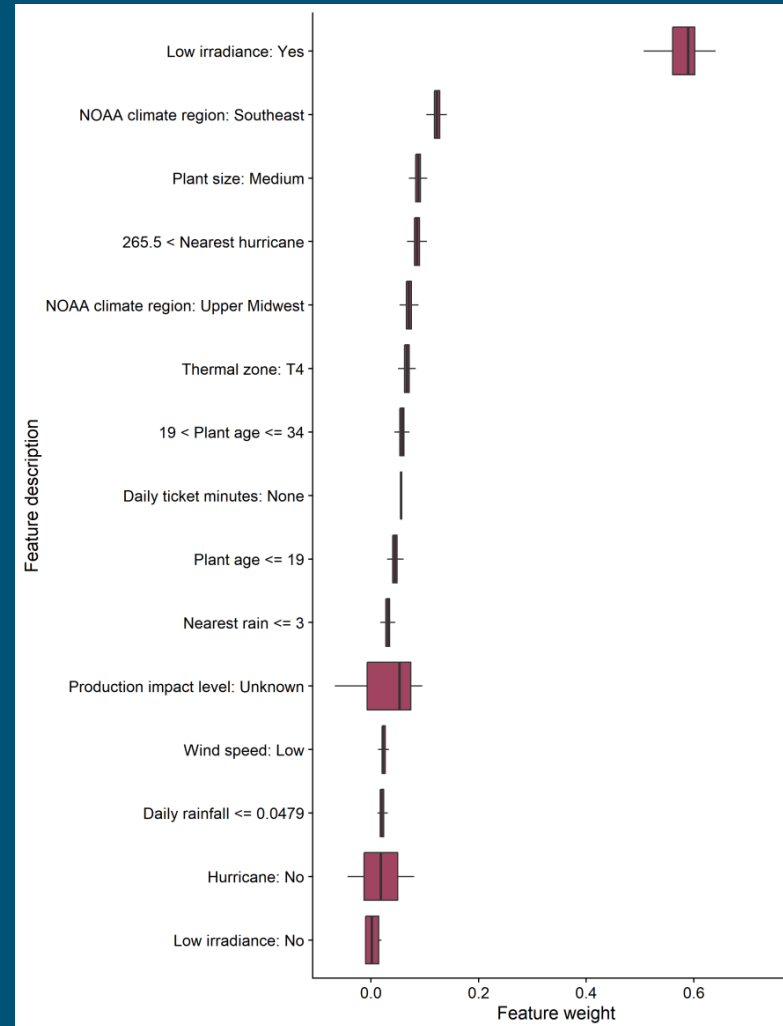> Which features help explain "low" performance?

Accuracy = 0.64

Accuracy = 0.69

Accuracy = 0.73

Local Interpretable Model-Agnostic Explanations (LIME) used to identify drivers of low performance
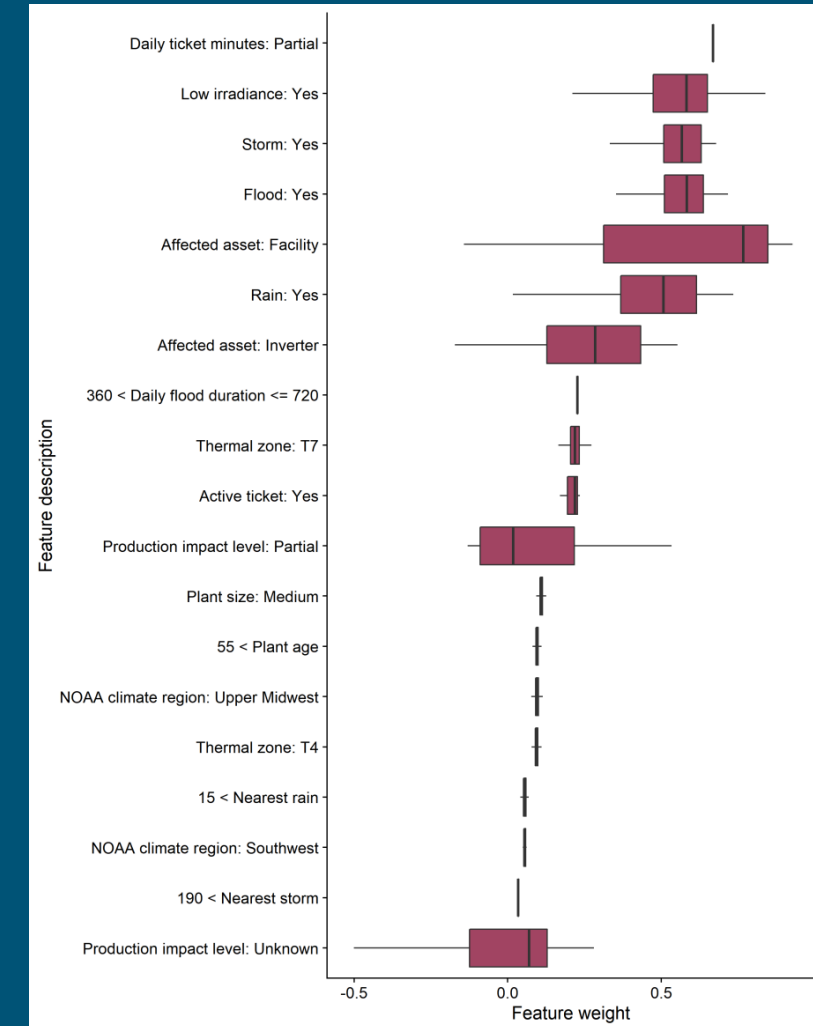
In conclusion, integrated assessment of O&M, production, and climate data shows differentiated responses to weather events
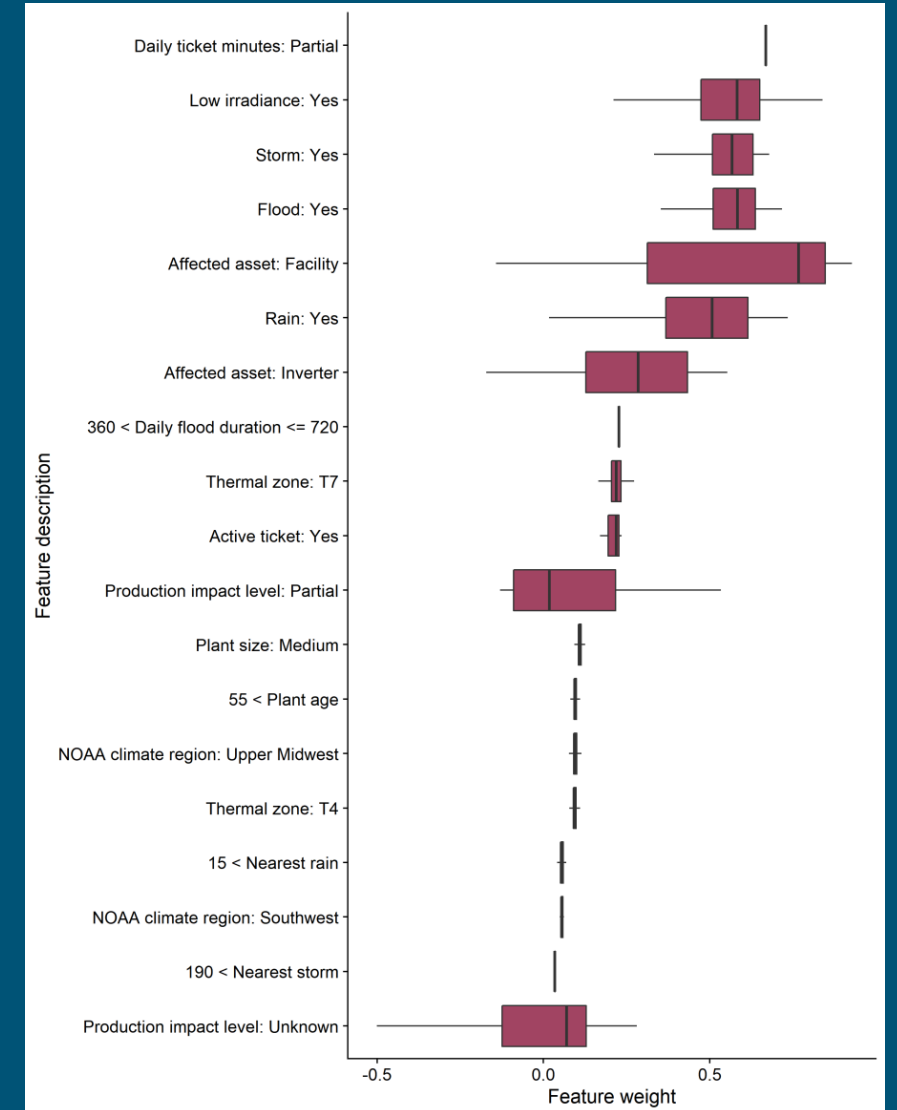
➤ Snow events have largest performance reduction

➤ Unique global models developed for each event

➤ LIME results for storms include O&M-related features

➤ Future work directions

  ➤ Comparison of "clear sky" to weather impacted days

  ➤ Incorporation of temperature effects

  ➤ Predictive modeling development for "day ahead" scenario development

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NASA (2018). Tropical Storm Michael moves into North Carolina [Digital image]. Retrieved from https://www.flickr.com/photos/gsfc/43438210310

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Thank you for your time!

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