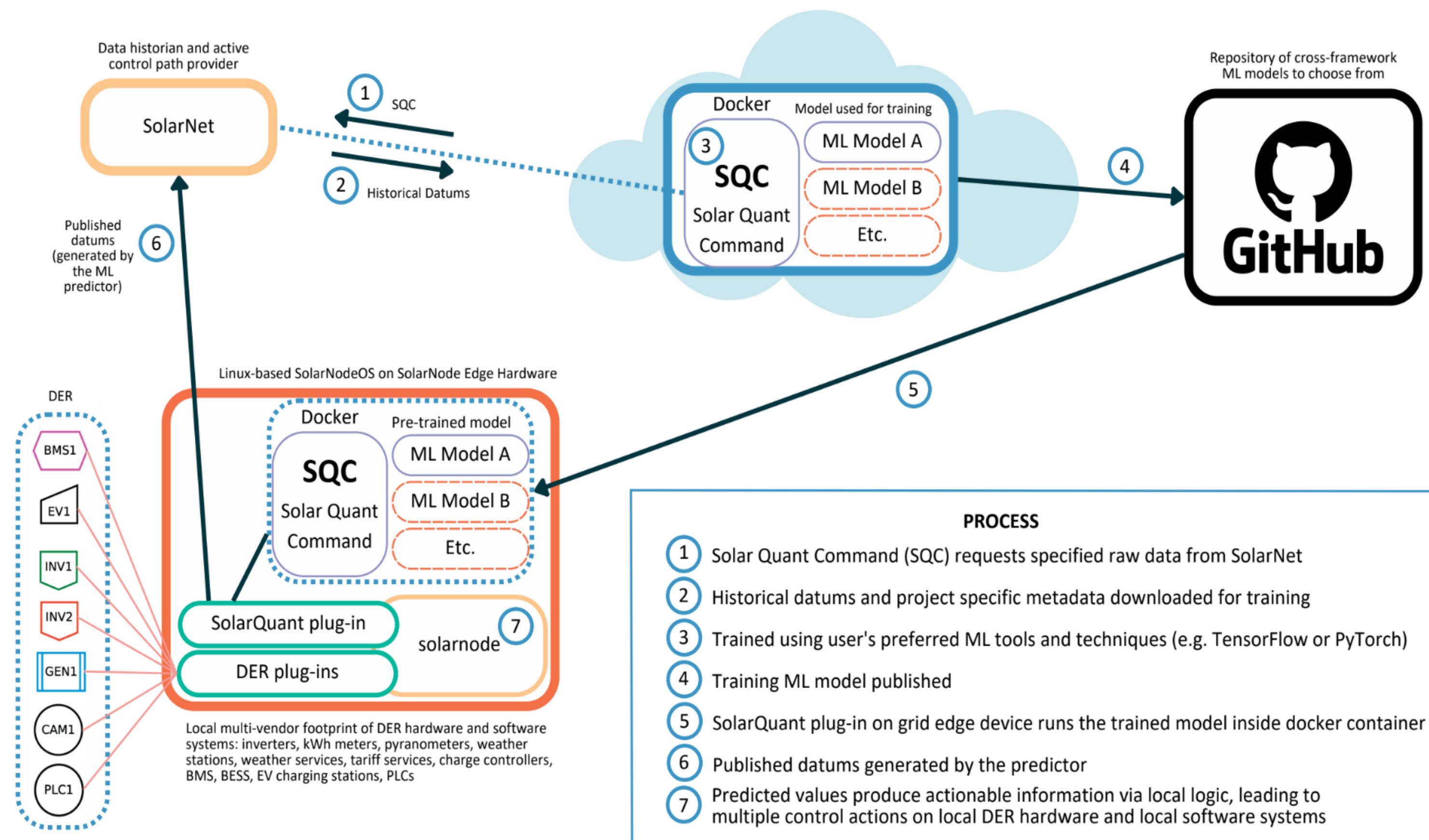# Learning-Assisted Preventive and Corrective Maintenance of PV Systems

Predicting Heterogeneous Failures from Heterogeneous Data
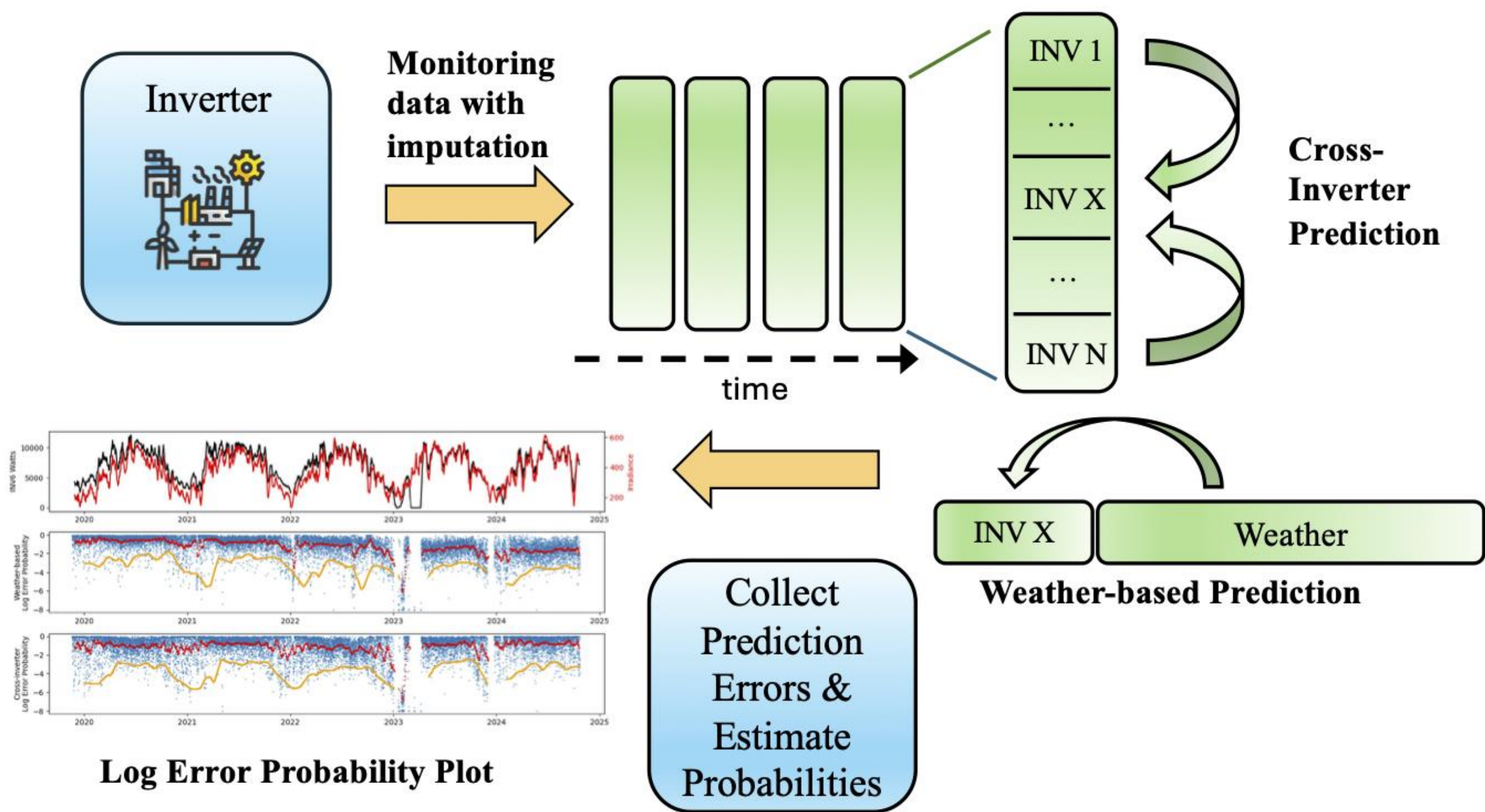
Principal Investigator: Yue Zhao, Associate Professor
Lead Organization: Stony Brook University

Stony Brook University · **ECOSUITE** · **Pacific Northwest NATIONAL LABORATORY** · **ECOGY ENERGY** · **U.S. DEPARTMENT OF ENERGY**

A variety of PV system malfunctions, which are otherwise unnoticed by asset managers, can be successfully detected based on unsupervised learning from heterogeneous data sets. Project is anticipated to <u>reduce asset owner O&M budget by 20%.</u>

SolarQuant: opensource software; a zero-friction ecosystem for DER data-driven machine learning.

PROCESS

1. Solar Quant Command (SQC) requests specified raw data from SolarNet
2. Historical datums and project specific metadata downloaded for training
3. Trained using user's preferred ML tools and techniques (e.g. TensorFlow or PyTorch)
4. Training ML model published
5. SolarQuant plug-in on grid edge device runs the trained model inside docker container
6. Published datums generated by the predictor
7. Predicted values produce actionable information via local logic, leading to multiple control actions on local DER hardware and local software systems

Local multi-vendor footprint of DER hardware and software systems: inverters, kWh meters, pyranometers, weather stations, weather services, tariff services, charge controllers, BMS, BESS, EV charging stations, PLCs

Log Error Probability Plot

Methods: Unsupervised/self-supervised pseudo tasks for training PV anomaly detectors and learning features.
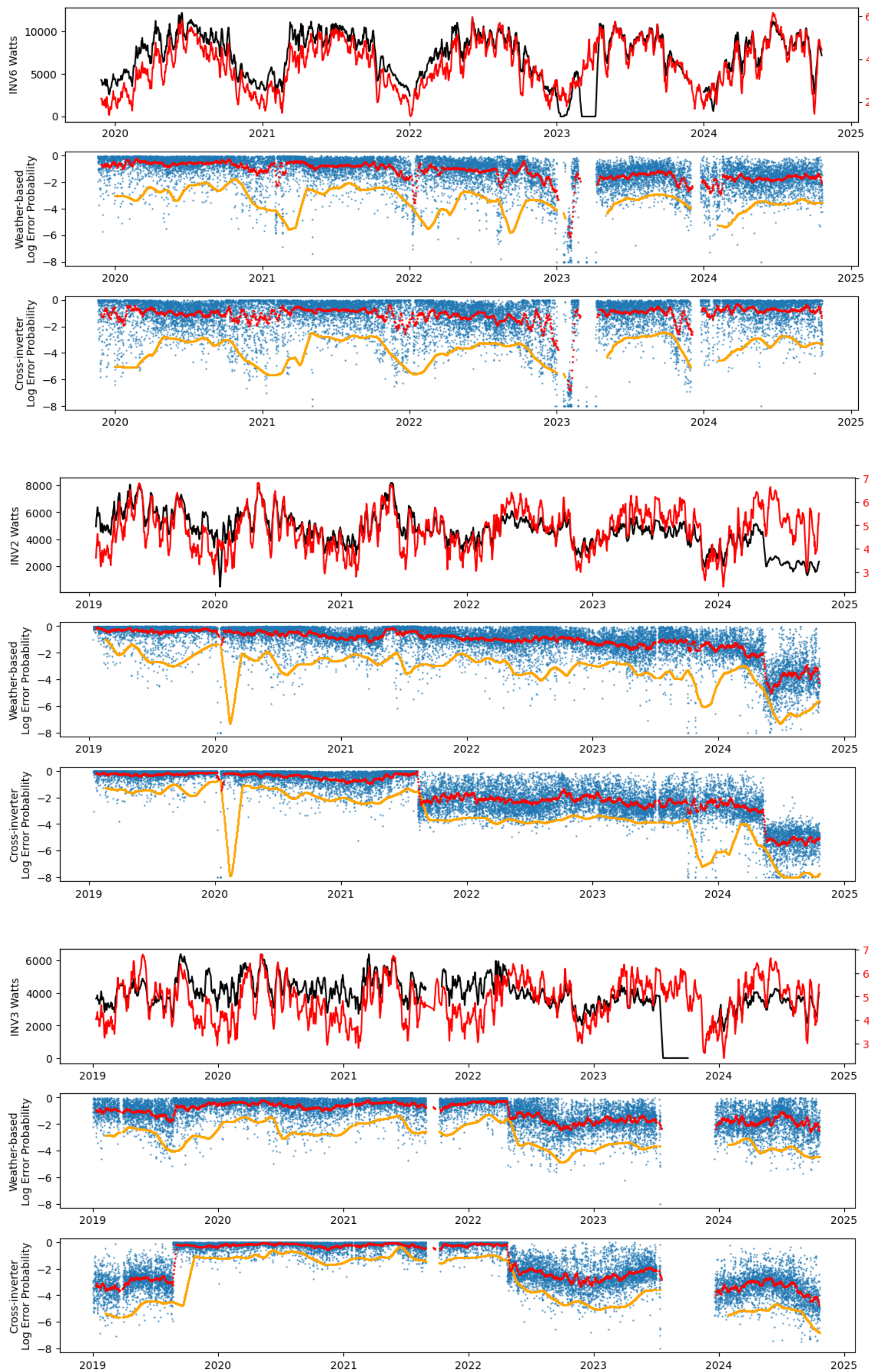
Site A, inverter 6 in Washington, D.C

Winter Performance Issues: System struggles during winter months (blue & orange curves).

Pre-Outage Decline: Performance declines before major outages in early & late 2023 (blue & red curves).

Sustained Anomalies: Issues are not random noise but significant physical system failures.

Site B, inverter 2 in Florida

Summer Performance Issues: Seasonal abnormalities occur during summer months (blue dots).

Long-Term Degradation: Performance declines over time, with a major drop since mid-2024 (red curve).

Hidden 2021 Drop: A severe performance drop since mid-2021 appears in one plot but not another.

Complementary Analysis: Different predictors reveal distinct anomalies, mitigating potential overfitting and bringing together the best of both worlds.

Site C, inverter 3 in Florida

Sustained Low Performance: Issues occurred throughout 2019 and since spring 2022.

Maintenance Impact: A fix in late 2019 resolved earlier problems.

Undetected Issues: Low performance since 2022 was previously unnoticed.

Enhanced Detection: Cross-inverter analysis confirms abnormalities more decisively, aiding faster issue resolution.