

# Performance Loss Rate Determination

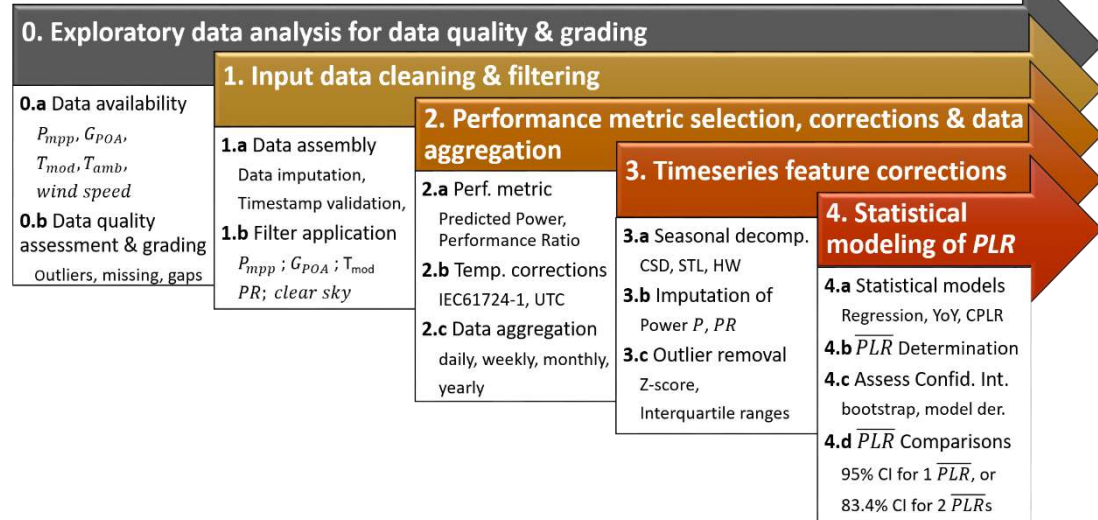


## Accurate determination of PV System's Performance Loss Rate (PLR)

- Critical for assessing PV system operation, maintenance and production

## Four main steps in *PLR* determination

- 0. Data Quality assessment
- 1. Cleaning & Filtering
- 2. Metric Selection
- 3. Feature Corrections
- 4. Statistical Modeling



# Exploratory Data Analysis & Dataset Grading

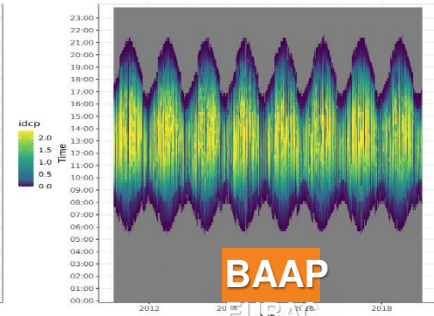
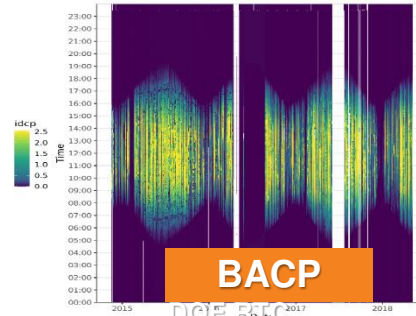
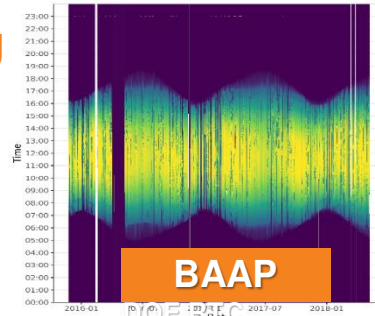


Performance of *PLR* algorithms, strong function of dataset “missingness”

- Missingness includes Outliers, Missing Datapoints, and Data Gaps

## Dataset Grading

A A A P  
Outliers  
Missing  
Gaps  
P/F



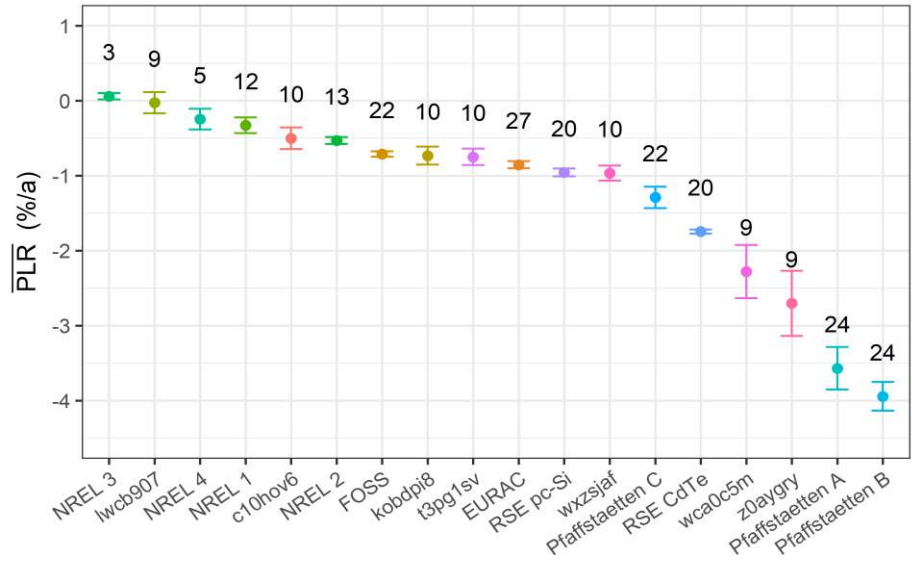
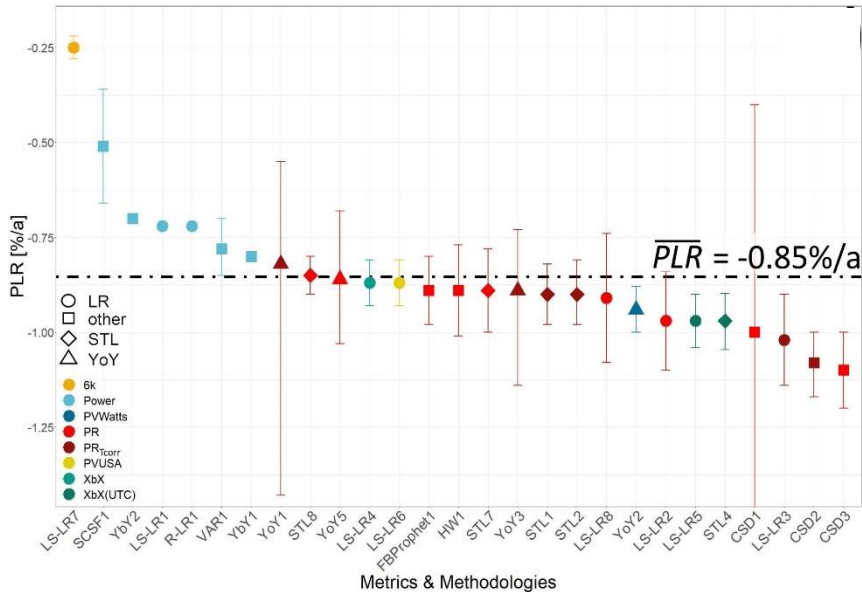
Outliers = Anomalies and Rapid Changes (can be Clouds)  
Missing = 5 or less missing data points  
Gaps = Missing data longer than 5 data points

## Interlab *PLR* Benchmarking: 27 Combinations of Filters, Metrics & Models

- On 19 PV systems + 4 Simulated Digital Power Plant datasets
- These datasets now available as open data, for others to Benchmark

• S. Lindig, A. Curran, K. Rath, A. Khalilnejad, D. Moser, and R. H. French, “IEA PVPS Task 13-ST2.5: *PLR* Determination Benchmark Study.” Case Western Reserve University, Open Science Framework, 30-Aug-2020, DOI:[10.17605/OSF.IO/VTR2S](https://doi.org/10.17605/OSF.IO/VTR2S).

# PLR of 1 System by 27 Methods. And of 18 Systems



PVPS

## PLR of the EURAC System

- By 27 Metric/Statistical Model Approaches
- Ensemble model yields mean  $\overline{PLR}$
- $\overline{PLR} = -0.85\%/annum$

## $\overline{PLR}_i$ determined for 18 PV Systems

- Using ensemble model (voting) approach
- With 83.4% Confidence Intervals
- Significant Differences among these PV systems
  - At a 5% Significance Level: “Inference by Eye”<sup>3</sup>

# Performance Loss Rate Determination



- Task 13 members and other PV researchers completed a benchmarking study of approaches for calculation of the Performance Loss Rates (*PLR*) of a large number of commercial and research PV power plants in diverse climatic zones, utilizing the PV systems' power and weather data.
- The combination of 1) data cleaning and filtering, 2) metrics (performance ratio (*PR*) or predicted power (*P*) based), temperature corrections, and data aggregation, 3) time series feature corrections, and 4) statistical modeling methods are benchmarked in terms of a) their deviation from the  $\overline{PLR}$  value, and b) their uncertainty, standard error and confidence intervals.
- These results will inform standards development for *PLR* determination, which was previously attempted with an initial proposal for a new IEC 61724-4 standard. However, the results reported here suggest that proposing a specific standardized method is still premature.