DOE/OE Transmission Reliability Program

Baseline Studies and Analyses

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"Big Picture" Objective

Power grid related data (PMUs, State Estimators, Load, etc)

Analytical Tool that provides:
- **Real time analytics, monitoring the state of the grid**
- **Capability to look at historical trends and events**
- **Reliable predictions about the forthcoming state of the grid**

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Project Objectives

- **Investigate power grid data**
  - **Eastern Interconnect (EI) Project**
    - 3 different "chunks" of PMU data (down-sampled to 1 sec)
  - **BPA Project**
    - 2+ years of PMU data (60 samples per second)

- **Identify atypical events** and characterize **typical patterns**.

- **Frequently meet with EI TAG** (Technical Advisory Group) and **BPA domain experts** to review results and iterate the methodology.

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Major Accomplishments during the Past Year
DISAT (BPA PMU data analyses)

- Installed at BPA a near-real time tool that currently reads and stores data from 54 PMUs (60 Hz)
  - Performs data quality on new data
  - Classifies new data into pre-determined groups
  - ~30 seconds to process 1 minute of data
- Installed at BPA a baselining tool which updates the mathematical baseline from previous data
- Installed at BPA the DISAT viewer which allows the user to apply the most recent baseline and view anomaly results.

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Major Accomplishments during the Past Year
Eastern Interconnect Baselining

- Met quarterly with **EI TAG** (Eastern Interconnect Technical Advisory Group) to discuss baselining methodology and results.

- Found atypicalities across PMU data from the EI for 3 different time periods.

- Used statistical clustering to determine possible phase angle pairs to add to baselining activities.

- Helped organize and spoke at a panel discussion on Big Data Analytics at the Fall 2014 NASPI meeting.

- Worked with the **NASPI Engineering Applications Task Team**

Major Accomplishments to be Completed for FY15

- Continue reviewing and iterating analyses with the EI TAG.

- Compare events found from DISAT to WECC events.

- A year end report is being written from FY2014 and FY2015 activities.

- Produce a journal article on data quality.

- Continue participation with the **NASPI Engineering Applications Task Team** (including the NASPI meeting in October).

Deliverables and Schedule

#	Milestone / Deliverable	Target Date
1	FY2014 EI Baselining and Analysis Technical Report	7/31/2015
2	Draft EI Baselining & Analysis Report to participating ISOs containing PMU based results	2/28/2016
3	Draft Report of the WECC Event and DISAT Comparison	3/31/2016
4	FY2015 EI Baselining and Analysis Technical Report	4/30/2016
5	Final WECC Event and DISAT Comparison	4/30/2016
6	Draft data quality article submitted to a peer reviewed journal	5/31/2016

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Risk Factors Affecting Timely Completion of Planned Activities and Movement Through the R&D Cycle

- Obtaining additional data from the Eastern Interconnect that might help support further understanding into atypical events.

- PMU data are sampled at 1 per second, meaning events that occur within a second will not be discovered.

- Determining a "good" journal to submit data quality paper to.

Possible Follow-on Work to be Considered in FY16

- Use the findings from the DISAT and WECC event comparison to **build classifiers** to attach possible categories to atypical events.

- Study mathematical correlations using PMU and other data sources to **look for pre-cursors to events**.

- Model atypical events in order to **build predictive capabilities** into the system.

Baselining Analysis

- Read and store PMU data
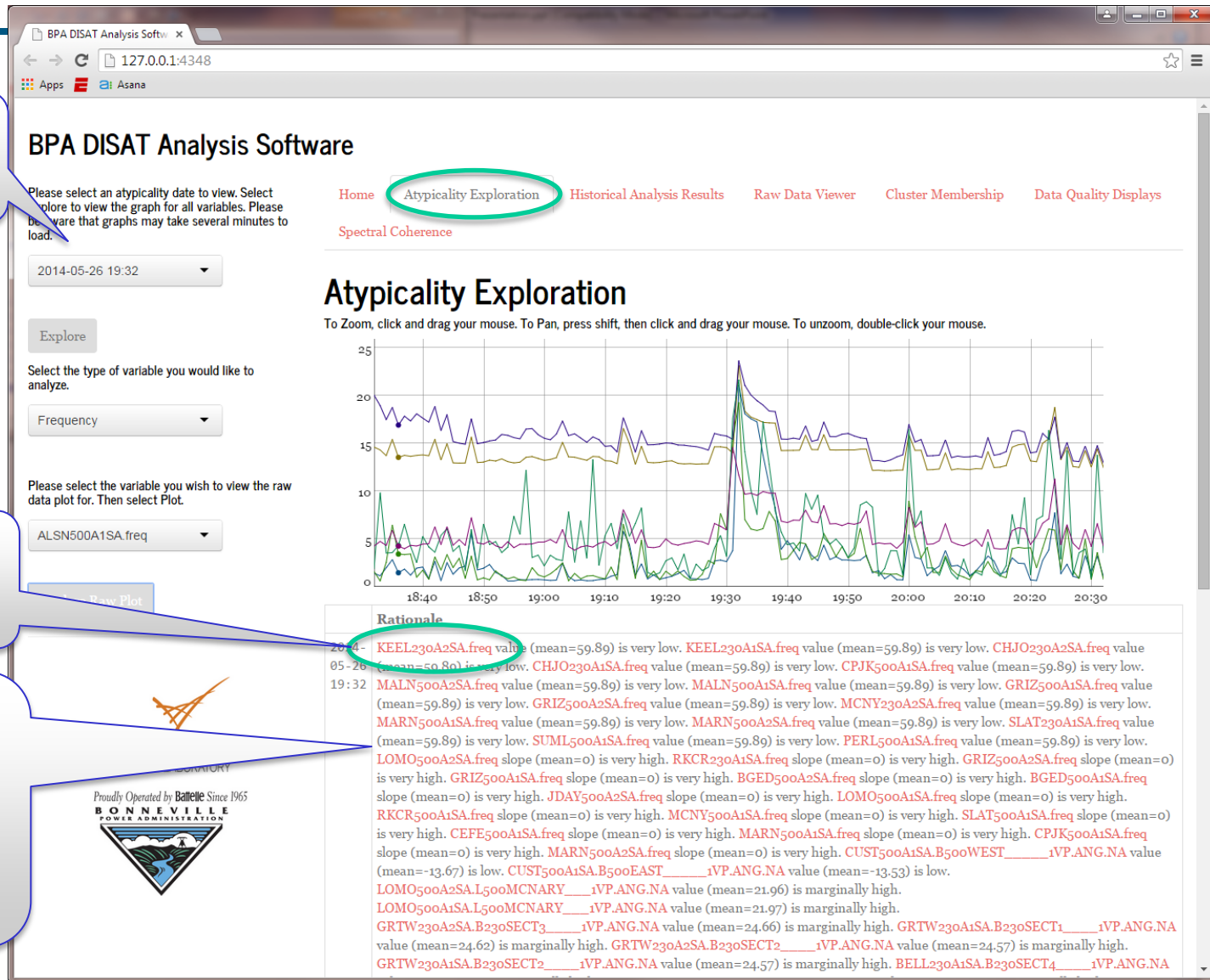
- Apply a data quality filter and calculate signatures (features) for analysis

State Estimator Data

1 Yr = 5 GB

PMU Data

1 Yr (45 PMUs) = 3 TB

Remove bad data
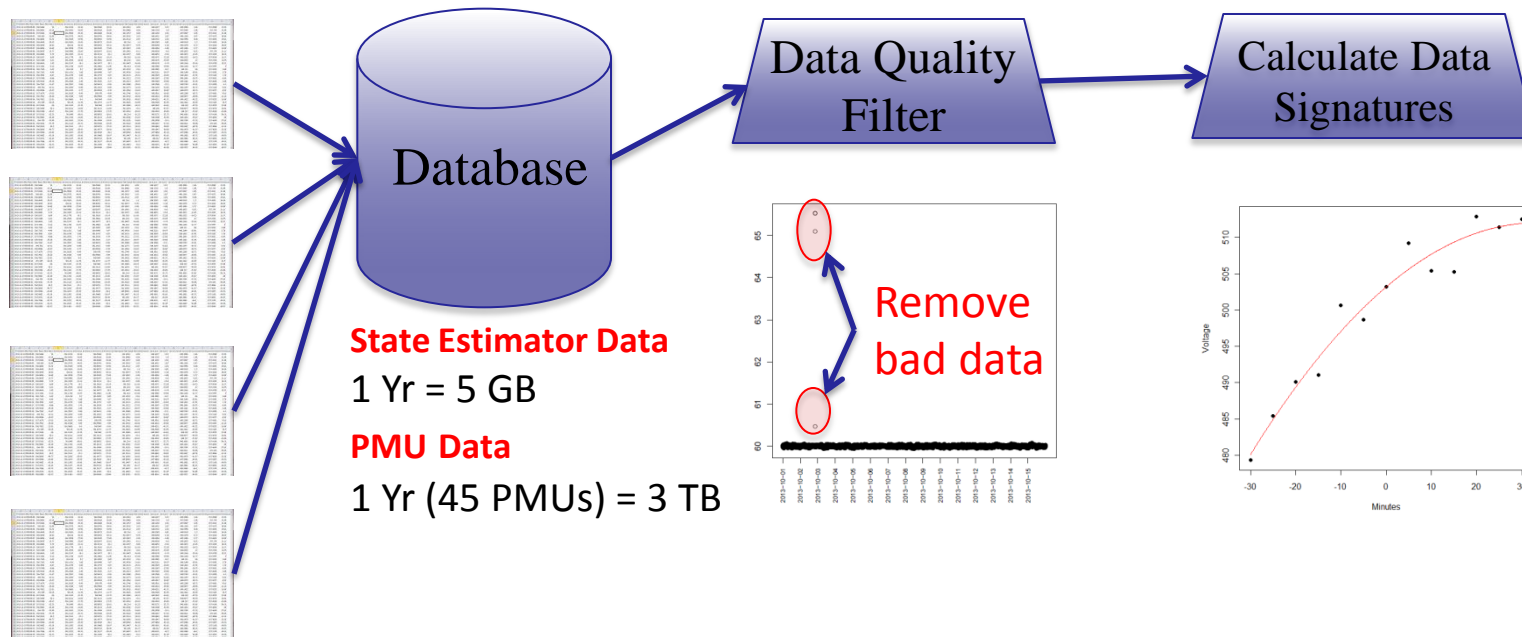
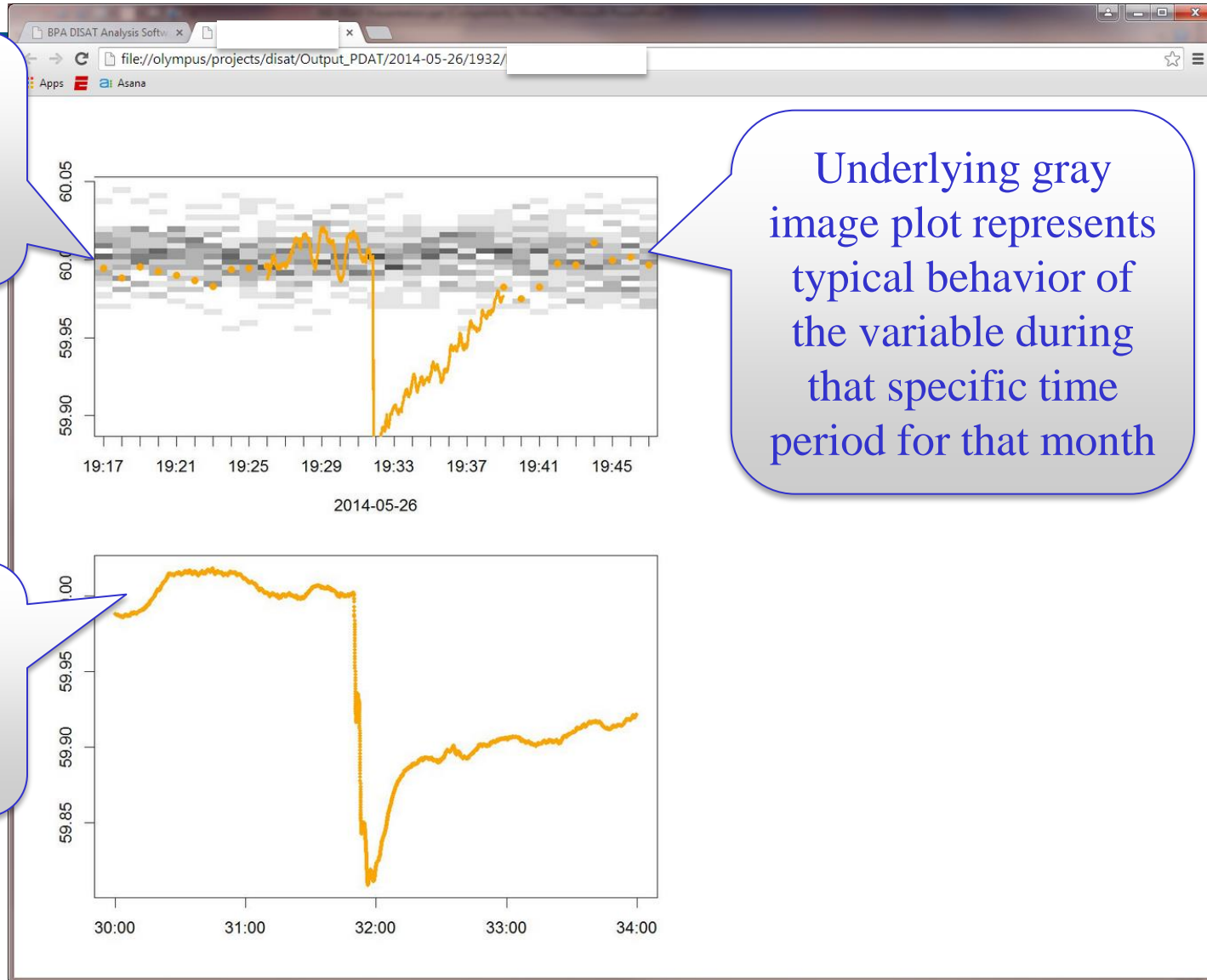# DISAT Viewer – Atypicality Exploration

Select atypical time period

Click variable name for drill down plot.

Produces a rationale explaining what was atypical during this time period
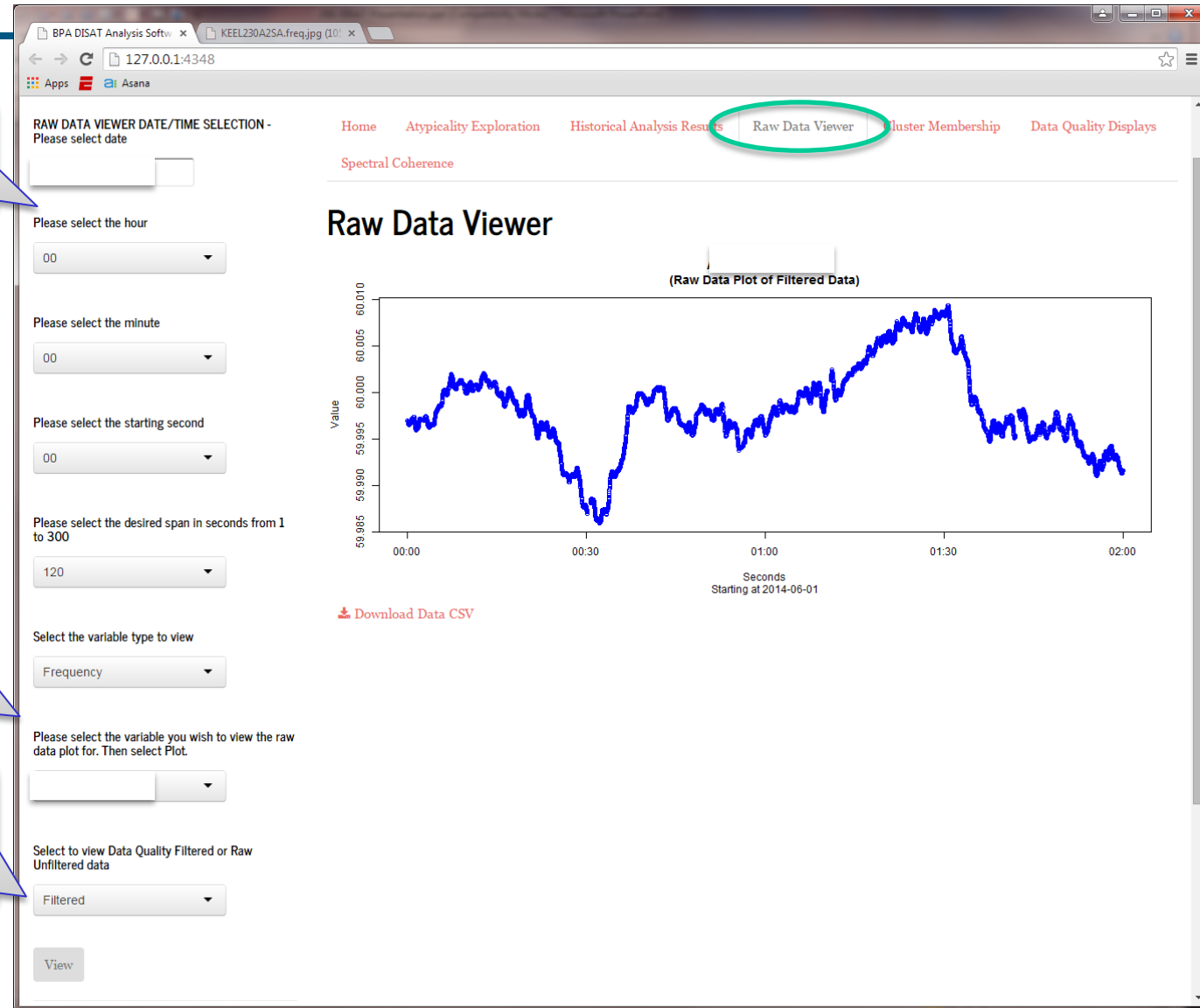
DISAT Viewer – Performance Envelopes

DISAT Viewer – Raw Data Viewer

Select Date/Hr/Min/Sec and length to view

Select variable type and variable to plot

View plot with data quality filter applied or not
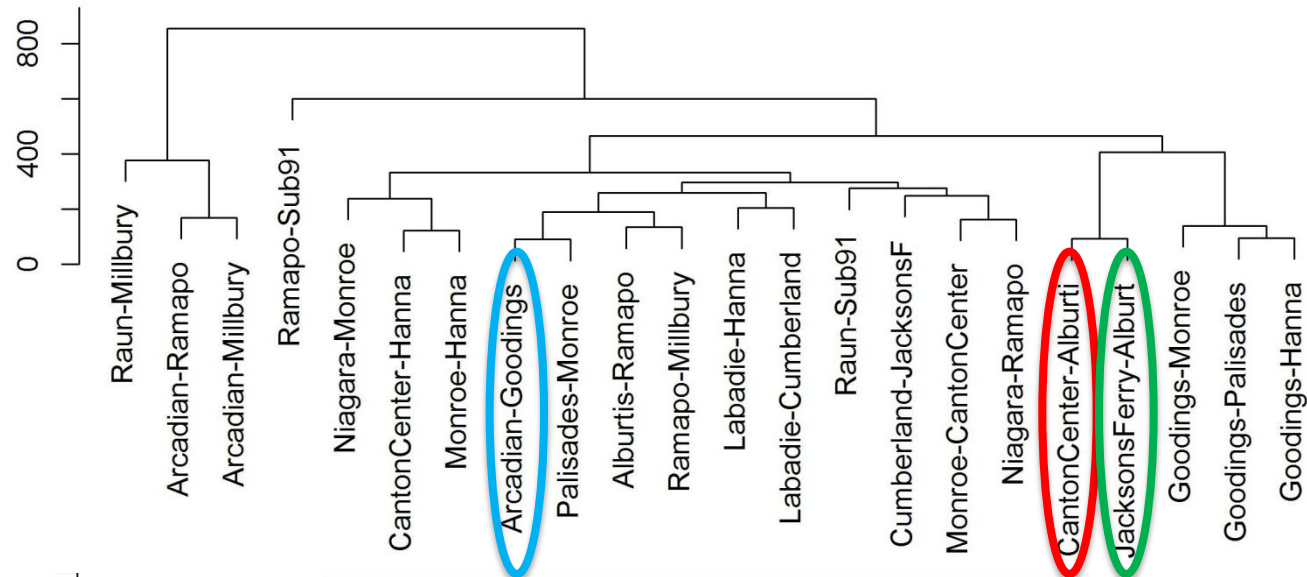
Clustering Phase Angles

Clustered first order difference in phase angle to determine
if other angles are needed for analyses
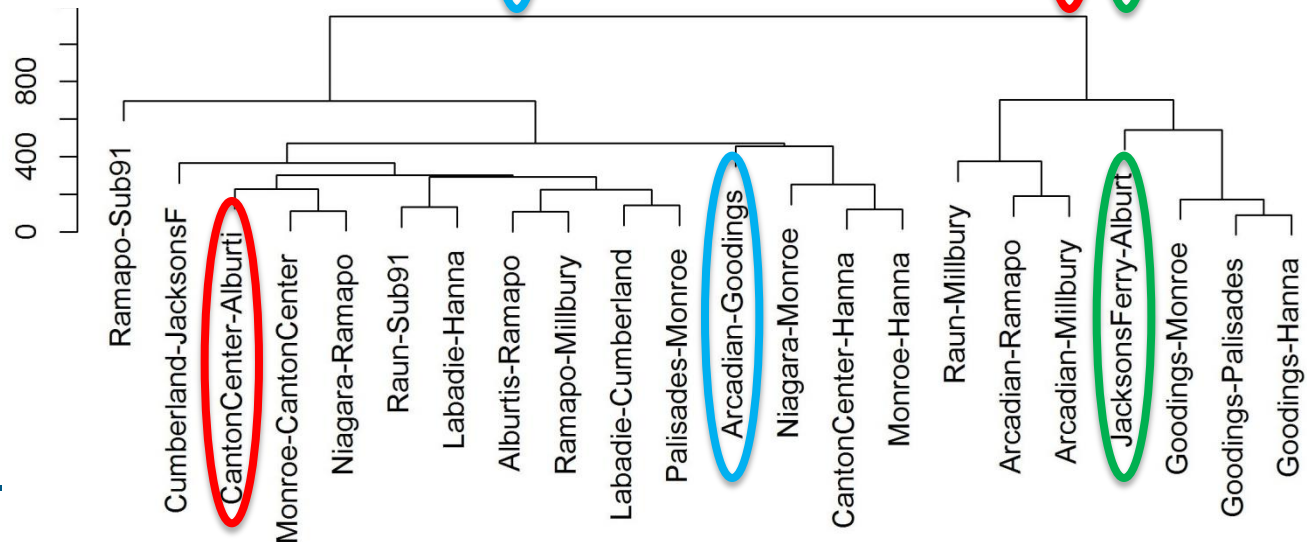
Phase Angle Pair Clustering

Winter 2014

Fall 2014

Different surrogates used for Canton Center and Jackson's Ferry

Conclusions

- **Interactions with domain experts** has been most **helpful** in iterating the methodology.

- **DISAT** has been installed at BPA and atypical events are being determined. Comparisons to WECC events and other event logs can be helpful in understanding the usefulness of DISAT.

- **Additional R&D is necessary** to continue maturing this technology to help in ways of prediction and event classification.

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