A Success Story: Advancing Outage Prediction Modeling Capabilities for Decision Making

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November 24, 2022

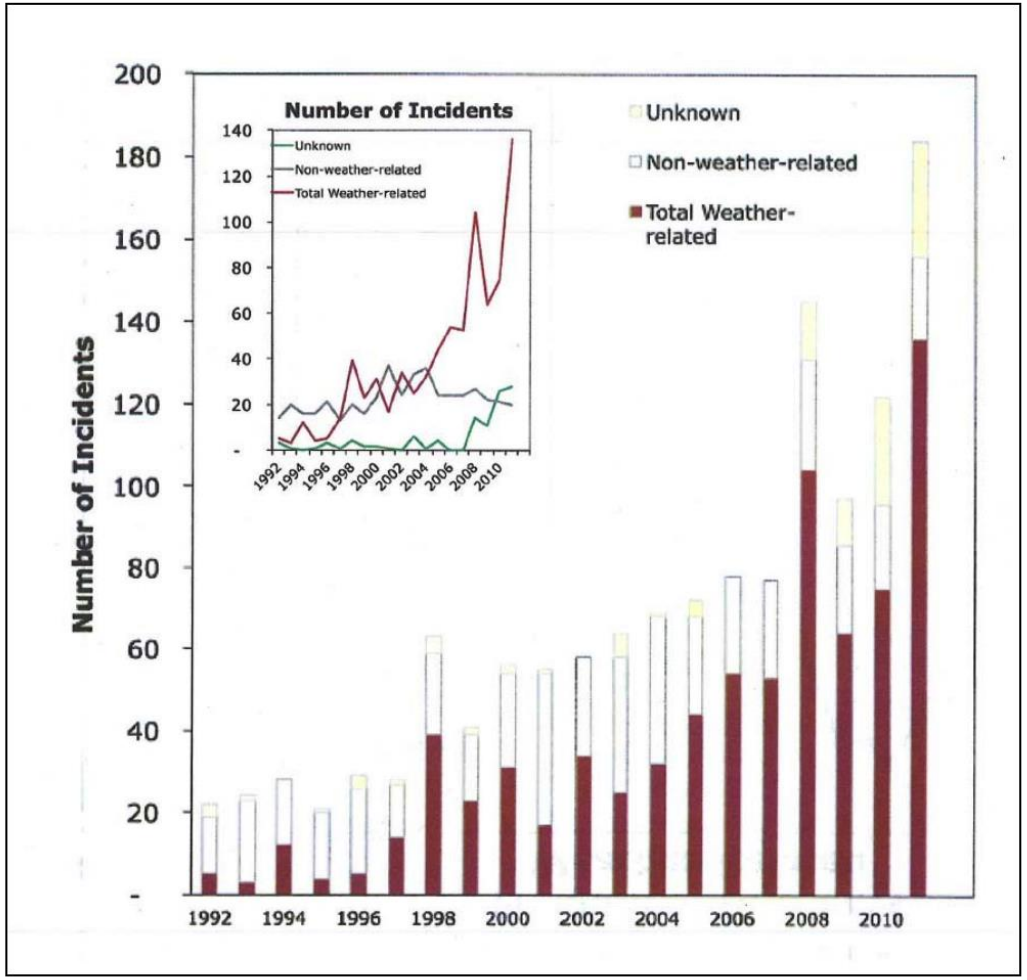
Abstract

Every year millions of people in the US are affected by power outages, disrupting the economy and daily life. Many of these outages are caused by events such as strong winds, heavy rains, thunderstorms, floods, tropical storms and hurricanes. At the University of Connecticut an outage prediction model (OPM) has been developed for forecasting outages during storms. The OPM has been operational since 2015 serving utilities in the Northeastern US. It uses variables describing weather events, infrastructure, land cover and elevation. Non-parametric machine learning (ML) ensembles generate the predictions. The first version of the model served Connecticut exclusively and was characterized by large uncertainty in predictions due to the dataset limitations of a small service territory and limited historical dataset. Over time, the model expanded to include utility territories in Massachusetts and New Hampshire, the dataset grew, the understanding between environmental forcing and outages improved, and probabilistic operational forecasts began to be produced. The relationship between UConn and the utility stakeholders has grown to where operational forecasts are now used as part of response planning to storm events by the utility. This work leverages knowledge from the UConn OPM and utilizes a similar ML framework in combination with non-utility-owned customer outage data to build a community OPM for predicting customer outages along the US Eastern Seaboard for large scale events. Proxies for proprietary infrastructure are used including road and publicly available transmission line data. Variables including tree type and ecoregion data are used to account for regional diversity of the larger domain. To validate the customer outage reference data, correlations are shown between customer outages and utility trouble spots in the Northeast where outage data from utilities is known. Model performance evaluated at county and state levels shows that the model is capable of predicting the peak number of customer outages with great accuracy, demonstrating promise for the ultimate goal of determining return periods of outages under current and future climate scenarios to help the public and utilities with resiliency and response planning.

MOTIVATION

- Ability to evaluate national power grid vulnerability & resilience to major coastal storms
- The ability to provide non-proprietary data on the power grid to communities and stakeholders
- Requires building an outage prediction model on non-proprietary data

Figure 2. Significant U.S Grid Weather-Related Grid Disturbances
With Inset of Non-Weather- vs. Weather-Related Outage Comparison



Source: *Electric Grid Disruptions and Extreme Weather*. See http://evanmills.lbl.gov/presentations/Mills-Grid-Disruptions-NCDC-3May2012.pdf.

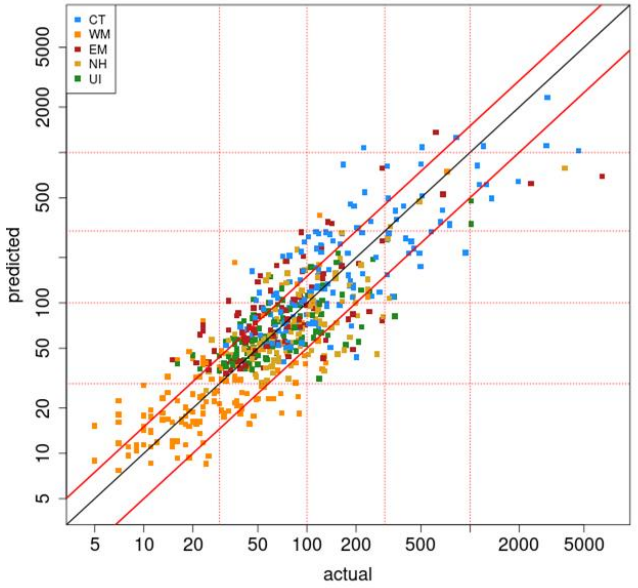
Notes: Historical "Grid Disturbance" data from the U.S. Department of Energy, Energy Information Administration. Form OE-417, "Electric Emergency Incident and Disturbance Report" (and before 1978 from the National Electric Reliability Council, Disturbance Analysis Working Group).

Figure from: Campbell, R. J. (2012, August). *Weather-Related Power Outages and Electric System Resiliency* [PDF]. Congressional Research Service.

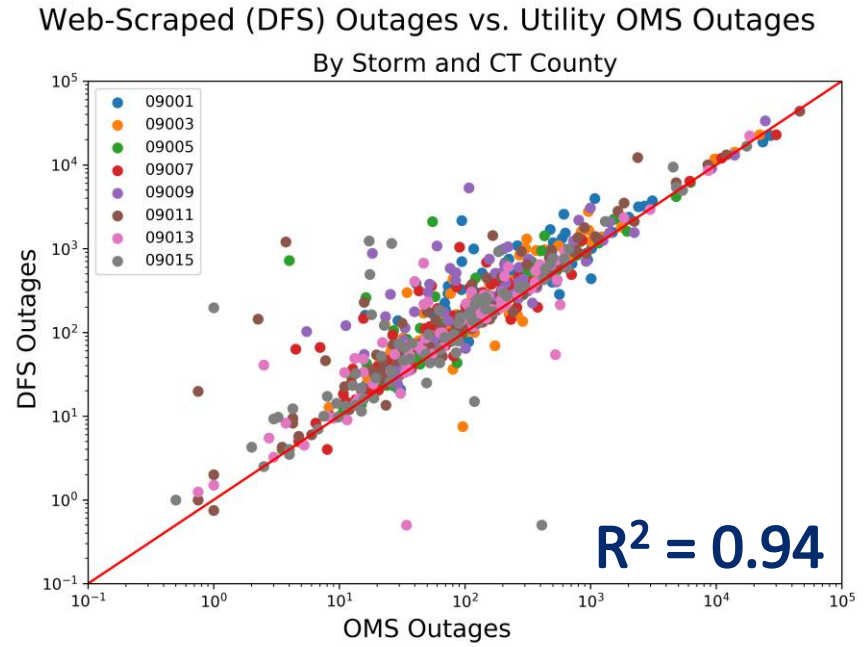
TAKEAWAYS

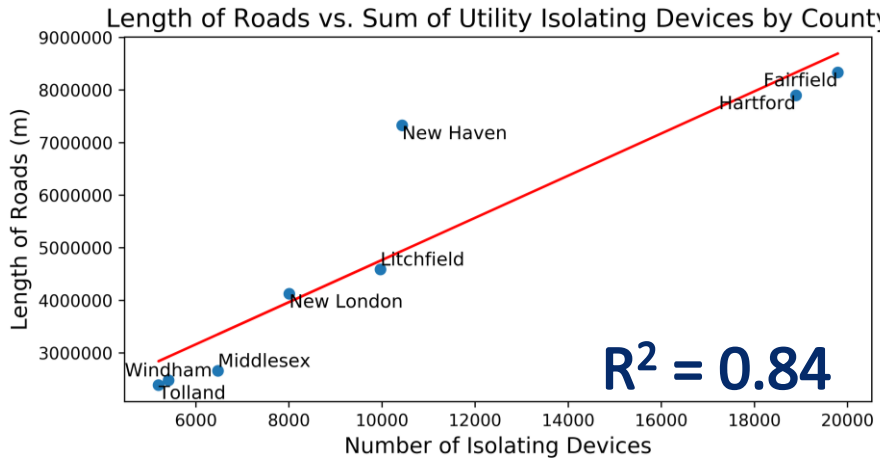
- With good correlations for proxies and outage data, similar performance to UConn Outage Prediction Model (OPM) is expected

UConn OPM Rain-Wind System Cross Validation

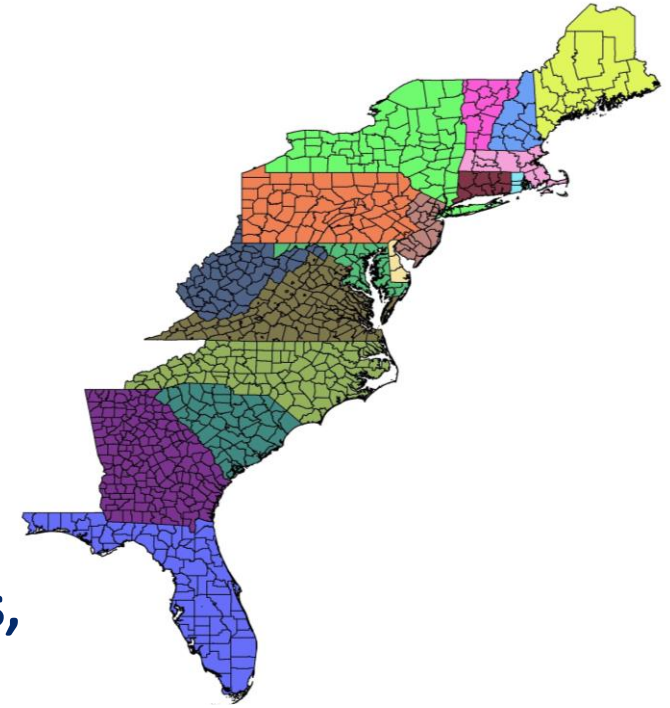


MdAPE	MAPE	NSE
38%	47%	0.32





SIGNIFICANCE



Extent

Creating OPM system that can cover large domains ranging from the Eastern Seaboard to the contiguous US

Situational Awareness

Awareness of large storm tracks in terms of total impact and spatial distribution of outages (hurricanes, Nor-easters, mesoscale convective systems)

Vulnerability/ Resilience

Evaluate the national distribution grid vulnerability/resilience to storms

- Data mine return period of resilience events
- Evaluate climate change impacts through incorporation of climate impacts
- Analyze insurance risk & potential grid resilience updates