# Improving Winter Power Outage Forecasts with a Snow Index

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OPM Overview

- Initial efforts started in 2011/2012
- Four OPM models:
  - Rain & Wind
  - Thunderstorm
  - Winter
  - High Impact
- Operational Forecasts for Eversource start in 2017
  - Over 450+ storms forecasted
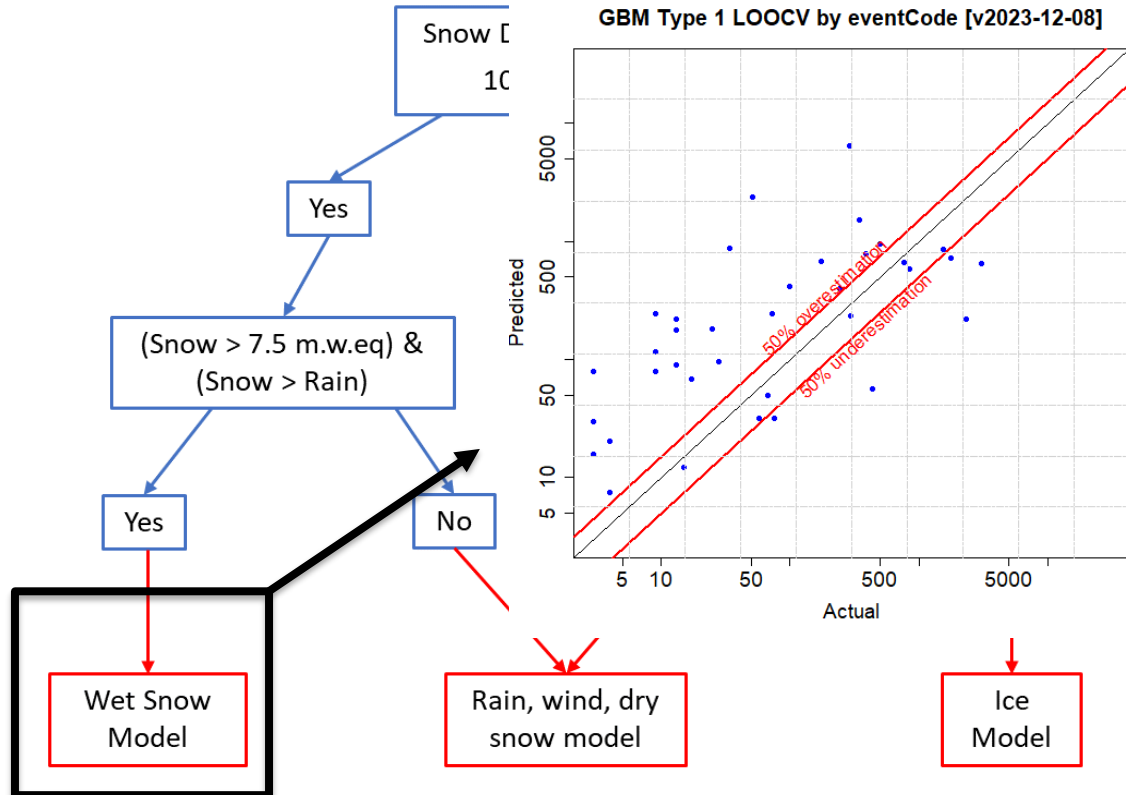- Projects with Eversource, Avangrid NY, ISO-NE, Dominion, and Exelon

Avangrid NY

Eversource

Exelon

Dominion
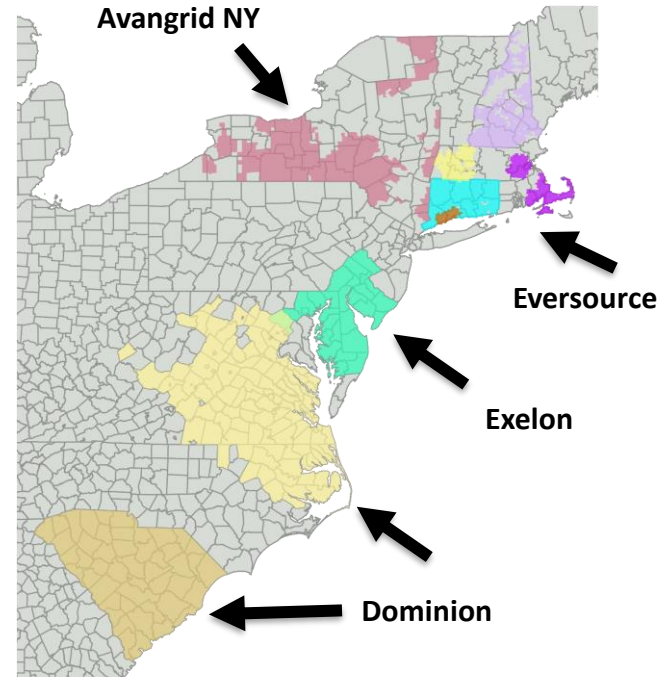
OPM Architecture
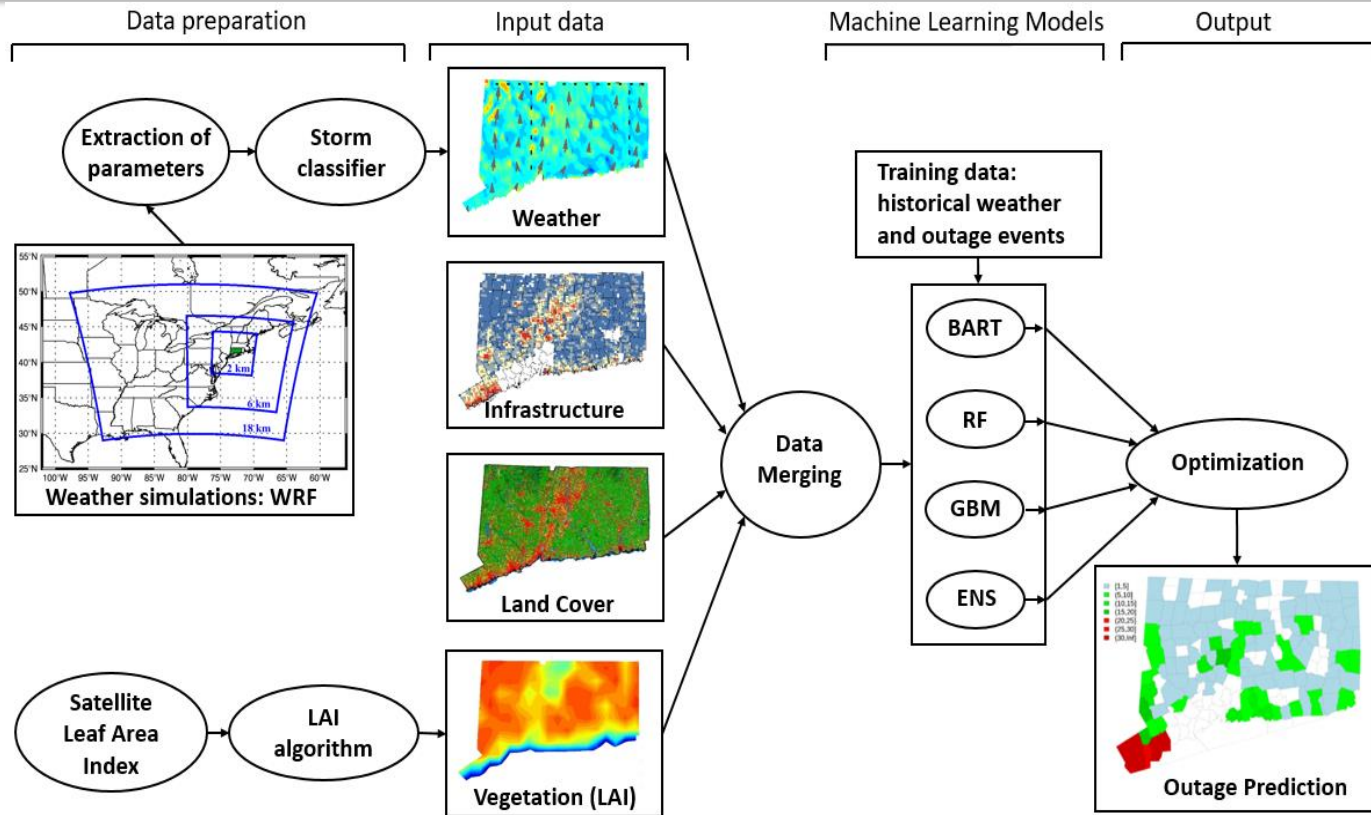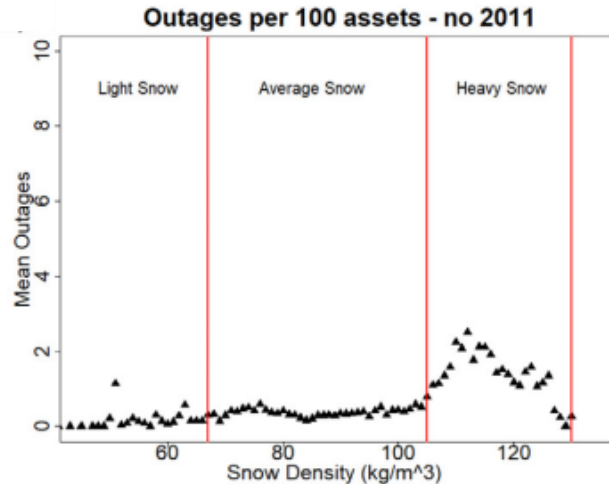

Adapted from:
Cerrai et al., 2019a

Winter OPM

- Winter storms produce a variety of hazards for the power grid

- Thresholds can cause limitations

- Wet Snow cases are the most difficult ones to forecast

- Goal: Build an index value to help highlight wet snow events and associated impact

Snow D[
10[

Yes

(Snow > 7.5 m.w.eq) &
(Snow > Rain)

Yes

No

Wet Snow
Model

Rain, wind, dry
snow model

Ice
Model

GBM Type 1 LOOCV by eventCode [v2023-12-08]

Predicted

Actual

50% overestimation

50% underestimation

Snow Density & Outages

- Snow density (kg/m^3, inverse of snow to liquid ratio) depends on many factors

- It is not explicitly predicted by numerical weather models; estimated by postprocessing methods

- $Snow\ Density = \dfrac{Snow\ Water\ Equivalent}{Total\ Snowfall}$

Outages per 100 assets - no 2011

Light Snow   Average Snow   Heavy Snow

Mean Outages

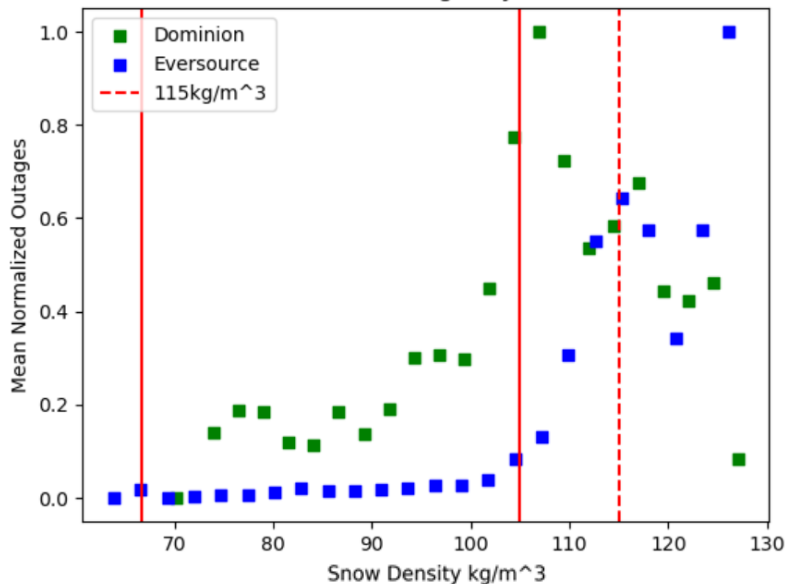Snow Density (kg/m^3)

Cerrai et al. 2020-
Eversource Only

Snow Index Development

- Goal: Isolate cases where snow density is main cause behind power outages
- Remove all grid cells:
  - <= 7.5 mm of SWE
  - >10 mm of Ice/Sleet,
  - > 75th percentile Mean wind speed and gusts by grid cell
- Bin grid cells by snow density
- Average and normalize the outages by maximum outages and assets
- Ranges from 63-128 kg/m^3 (16:1 – 7.8:1 SLR)
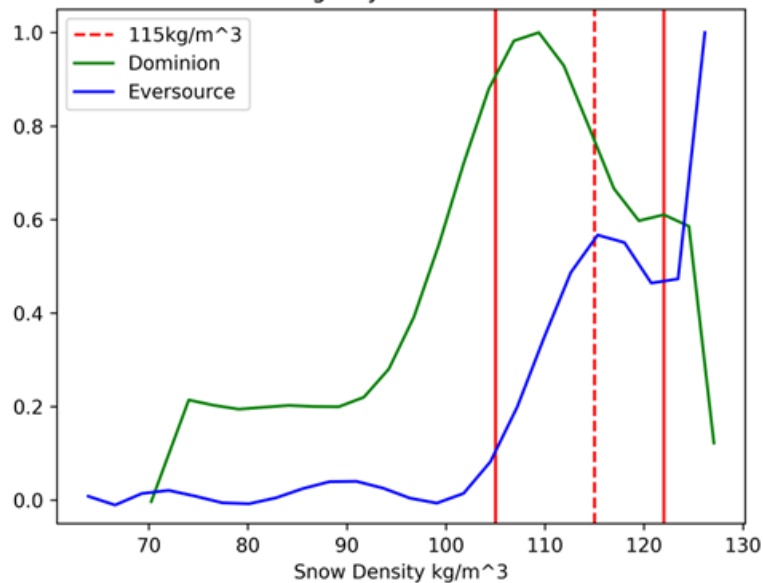- Apply Polynomial function to represent normalized outage impact points

Snow Index (0-1)

Snow Density-
Outage Relationship

Snow Index
0 (no impact)- 1 (max impact)

Application in OPM

- Testing for Dominion Energy
  - 79 storms, GBM, LOOCV
  - Evaluate individual and overall models
  - Focus on Median (q50) APE and Mean APE
- Experiments
  - Base- Original winter model for Dominion
  - Base with Index- Optimized Base with Snow Index
  - Updated Base- Updated predictors (wind & land cover) from Base
  - Updated Base with Index- Index and snow density
 - Updated Base with Index only- Index replaces snow density

CV Results

Model:	Wet Snow			Ice			Dry Snow/Rain			Overall		
Experiment	APE q50	MAPE		APE q50	MAPE		APE q50	MAPE		APE q50	MAPE	
Base	238%	669%		87%	246%		46%	97%		47%	98%	
Base with Index	166%	660%		77%	226%		45%	97%		45%	96%	
Updated Base	155%	638%		98%	248%		49%	92%		43%	95%	
Updated Base with Index	153%	648%		146%	254%		41%	92%		44%	95%	
Updated Base with Index Only	156%	610%		169%	252%		46%	94%		45%	96%	
										44%	95%	Optimized

Improvements?

- Why 2 peaks?
- Eversource
  - Bin 125- 96.7% of 921 outages from 10/29/2011 and 3/8/2018
- Dominion
  - Bin 107- 81.5% of 3,555 outages from 12/19/2009 and 1/26/2011
- Mostly location driven

Normalized Outages by 25 bins
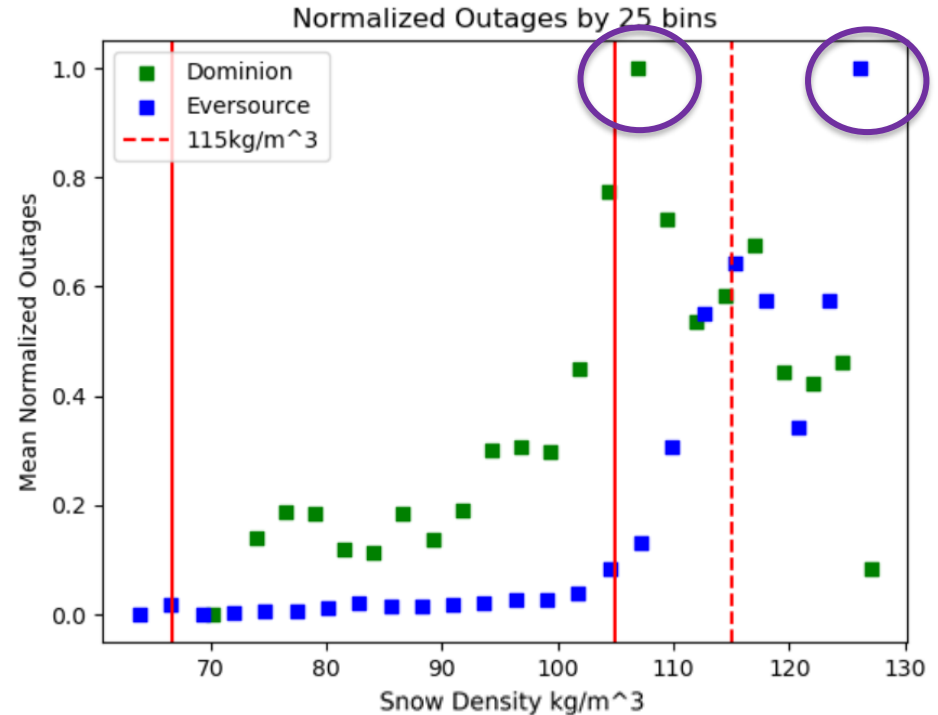
Future changes

- Expanding Index to other territories
- Restructuring the Winter OPM (2 models only/decision tree)
- Going back to basics for Snow Density
  - Improving current observations?
  - Verification of post-processing approaches
  - Focus on representation in numerical models

Summary

- Examined the role and importance of snow density
- Developed an impact-based index linking snow density and power outages
- Slight improvements to winter OPM model
- Improving the index through evaluating its limitations

Contact Us!

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More information?