Power Outage Prediction and Grid Resilience:
Scaling from Utility-Specific Forecasts to Regional and National Models

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UConnOPM
OUTAGE PREDICTION MODEL

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ESIG Summer Workshop, Denver, CO, USA

The Eversource Energy Center

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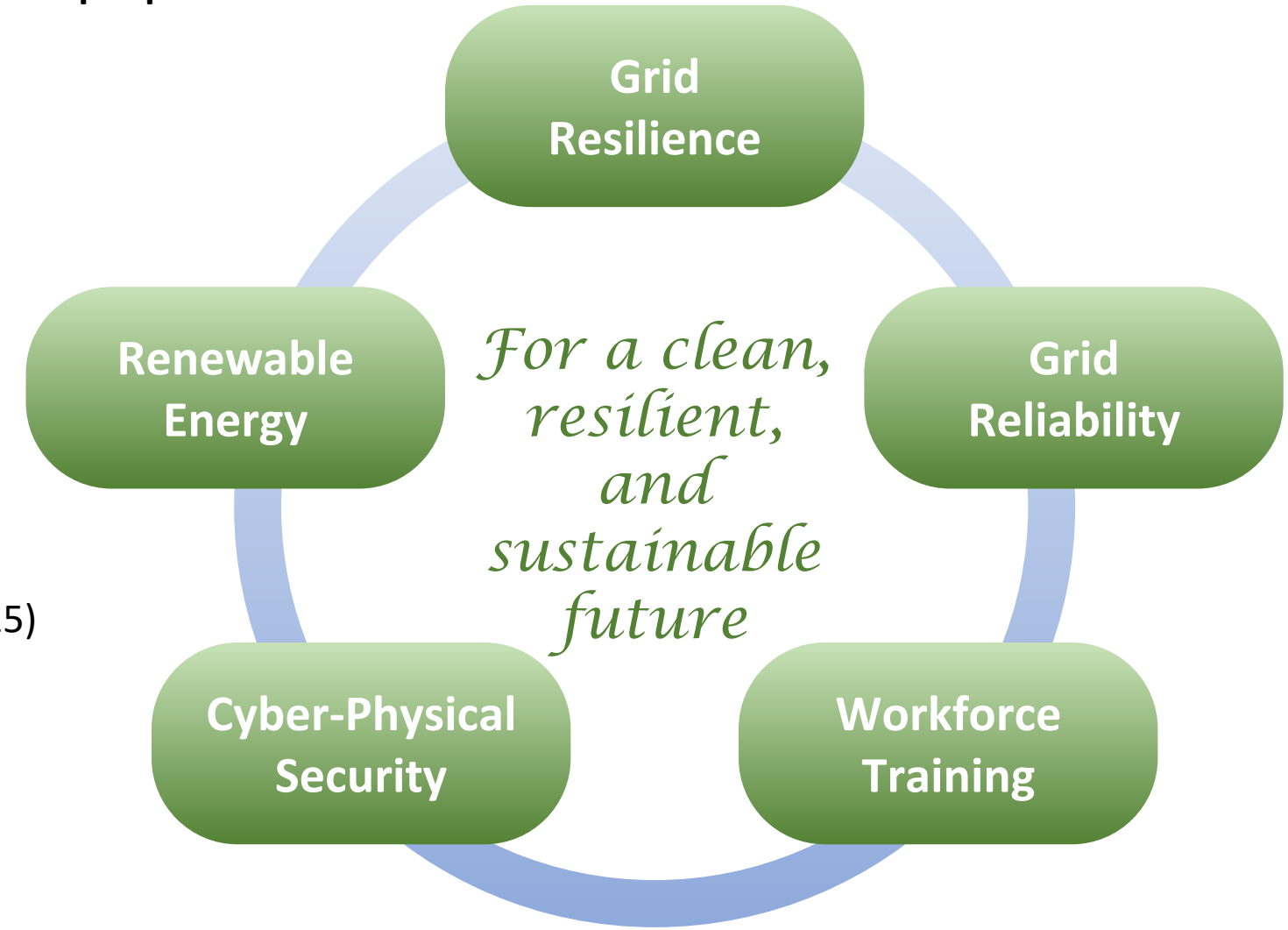
A partnership for the environment, the grid, and the people

The Eversource Energy Center is a utility-academia partnership which aims at advancing interdisciplinary research and technology for assuring reliable power during extreme weather and security events, and at solving sustainability challenges from local to global scale.



FUNDING:
$67M from industry and federal grants (2016-2025)

RESEARCH:
- 317 peer-reviewed papers
- 50 faculty
- 60 graduate students
- 7 patents

Our history: from Tropical Storm Irene to the North American OPM

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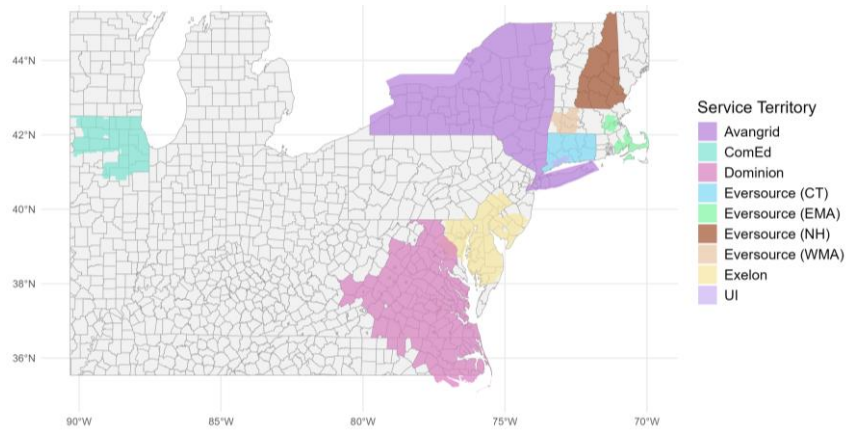

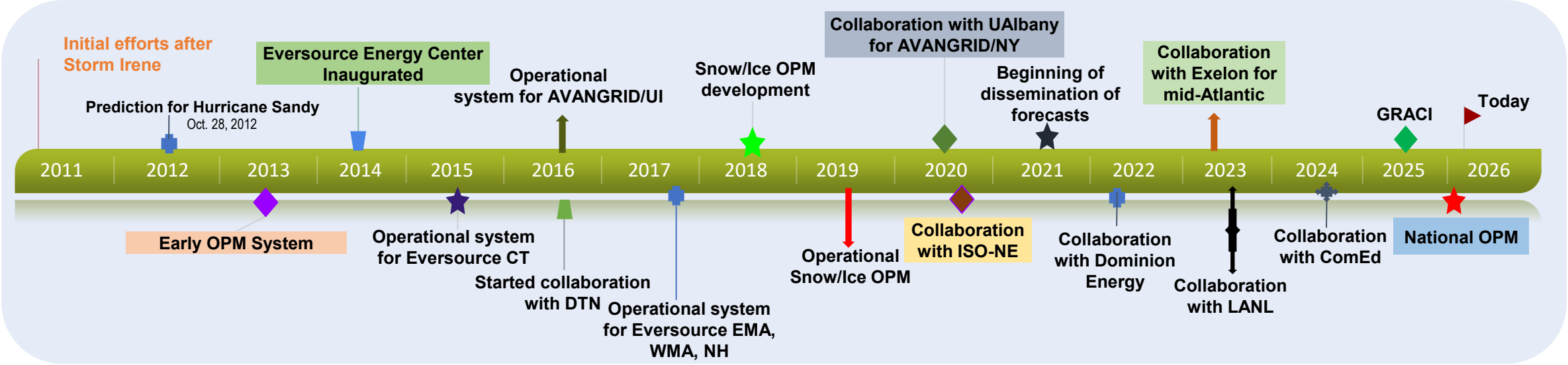

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Modeling storm preparedness, outage management and restoration

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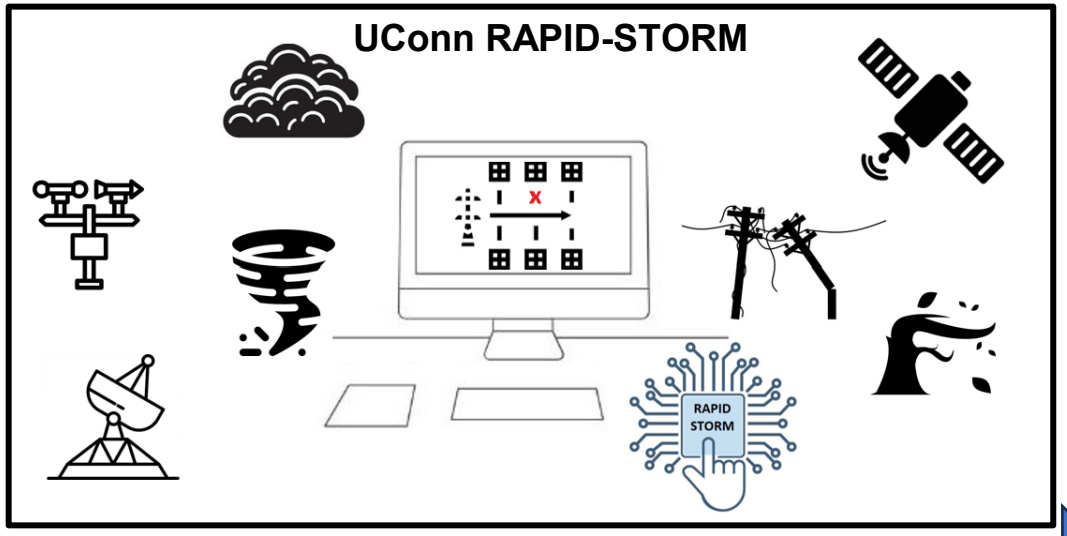
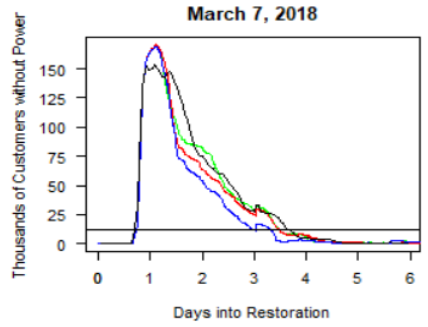
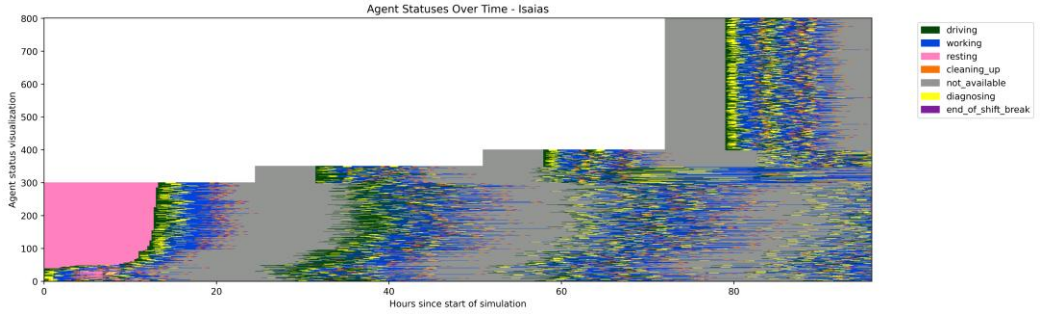
UConn OPM
OUTAGE PREDICTION MODEL



PREPAREDNESS | STORM | RESTORATION

UConn ETR Model





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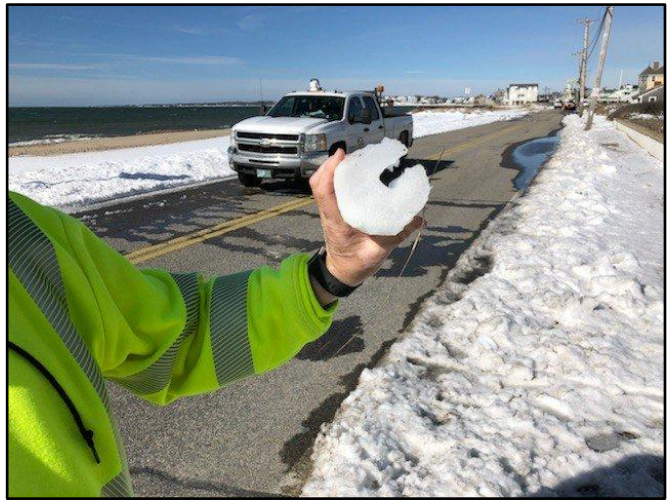
The need for power outage predictions

- Interactions between weather, vegetation and infrastructure are complex and non-linear.
- It is difficult for utility managers to estimate storm impacts to the electric grid based on weather information alone.

March 2nd, 2018 nor'easter in Massachusetts.



March 13th, 2018 nor'easter in Cape Cod.

- We developed an Outage Prediction Model (the UConn OPM) capable of predicting storm-related failures in the distribution network.
- Estimating future power outages allows utilities to allocate crews and distribute resources efficiently before upcoming storms.

The UConn OPM architecture

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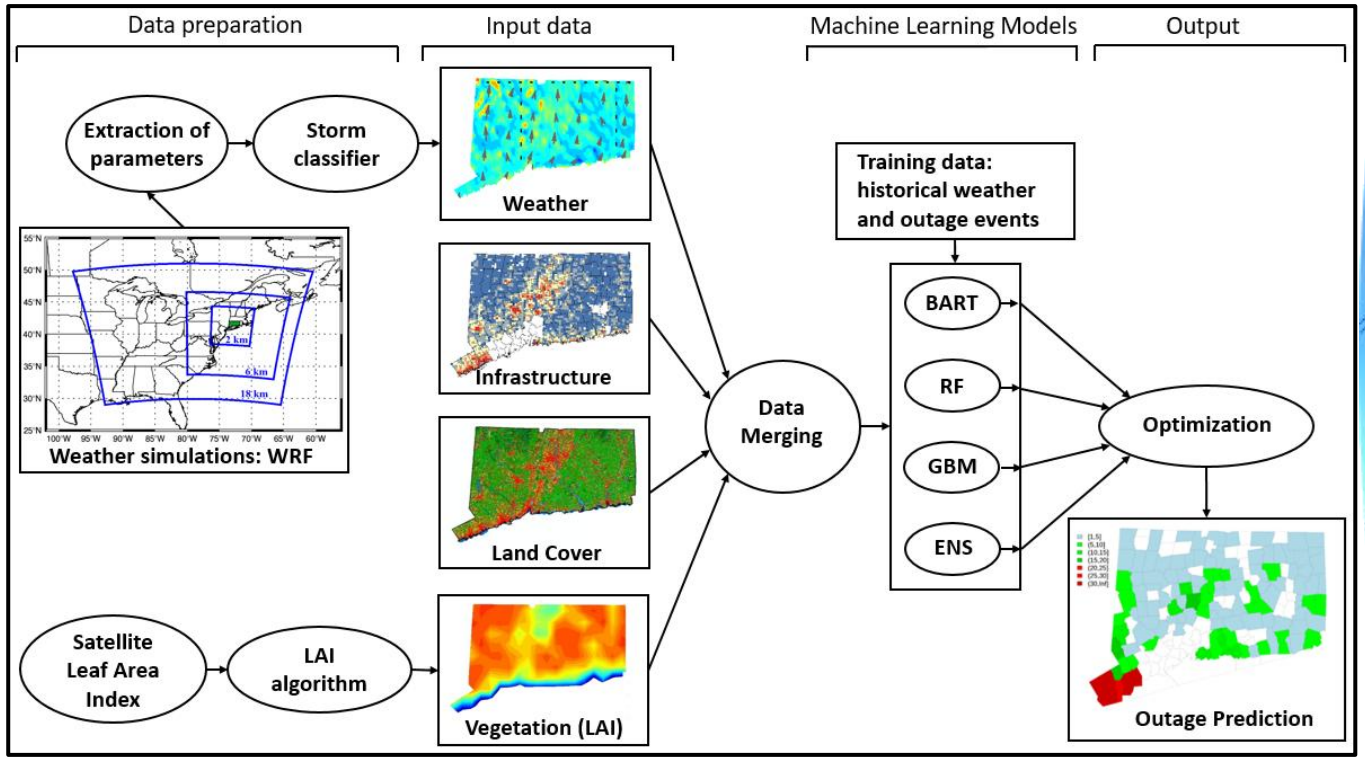
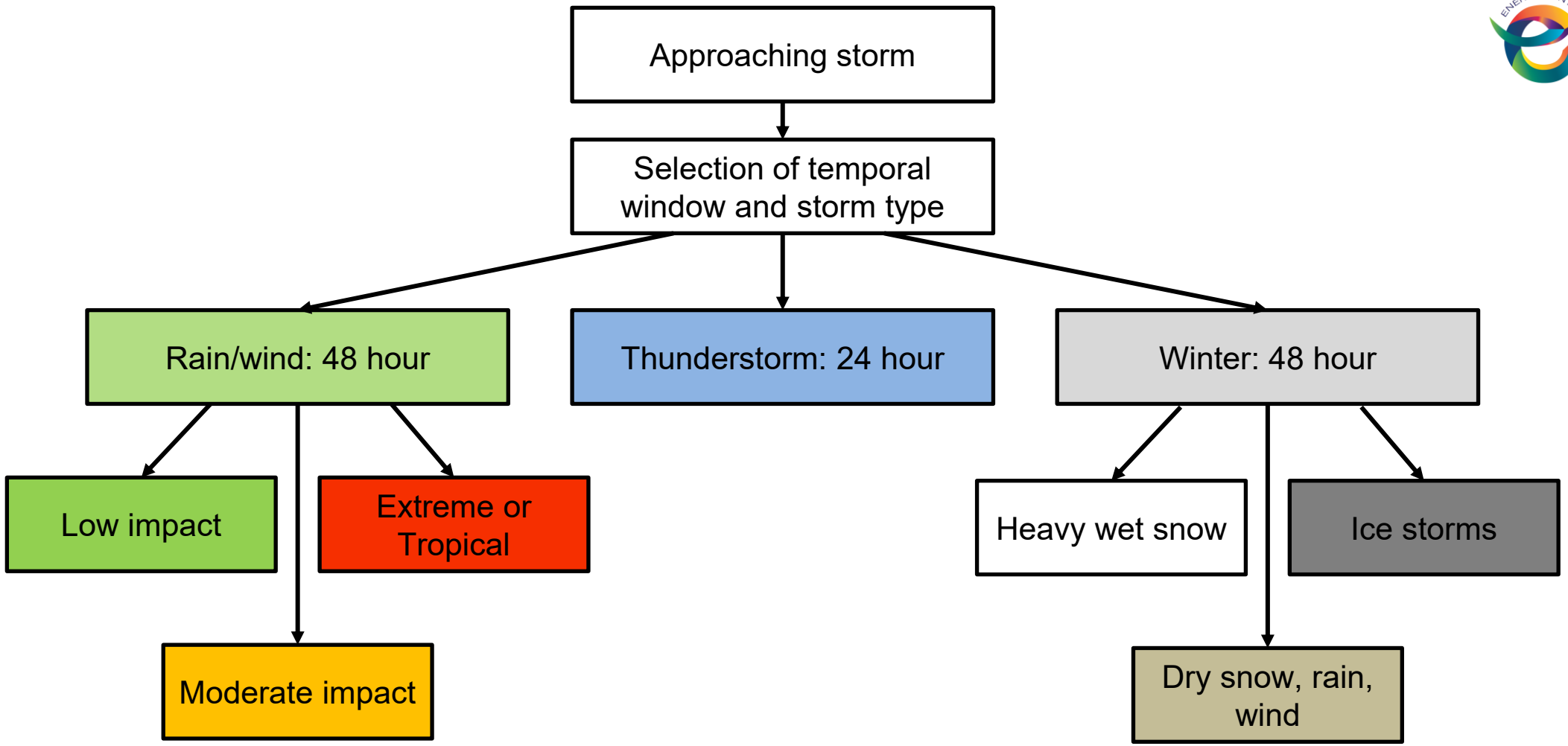
Key features:

- Used between 5 days and 6 hours in before storms.
- Weather forecasts simulated in-house at UConn.
- Trained with hundreds of historical events.
- Customized modules for:
  (i) rain/wind storms,
  (ii) thunderstorms,
  (iii) hurricanes,
  (iv) snow/ice storms



Adapted from: Cerrai et al., 2019a

The OPM Operational System



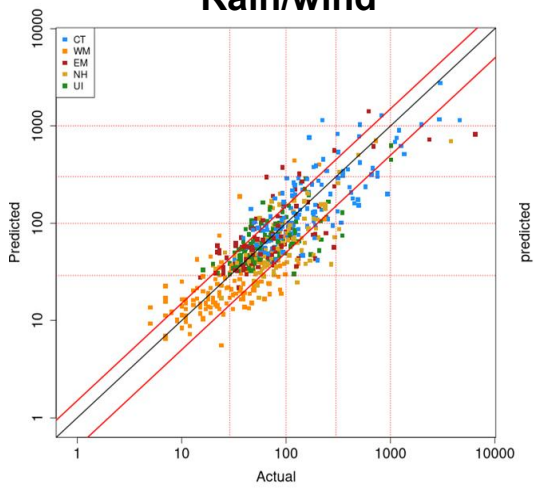
The OPM: historical storms validation

		Model			
		Rain-Wind	Thunderstorms	Winter	Extreme
Storms in Model Calibration	CT	151	125	55	44
	WMA	155	132	67	35
	EMA	103	55	32	13
	NH	115	71	73	15
	Total	524	383	227	107
Performance	Median error	38%	38%	67%	33%

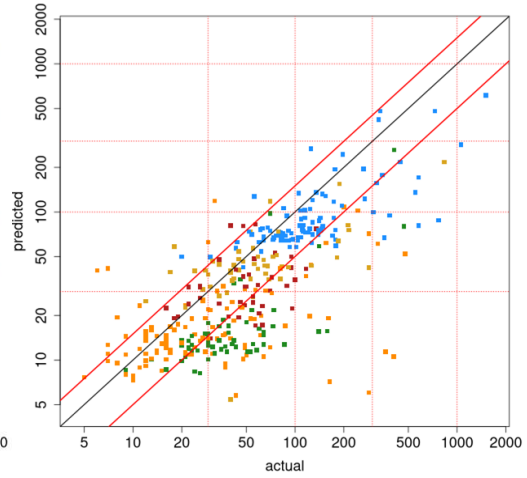
OPM by the numbers:

- 4 Eversource territories
- 4 models for each territory
- 1241 historical storms simulated for calibration
- Typical error of ~40%

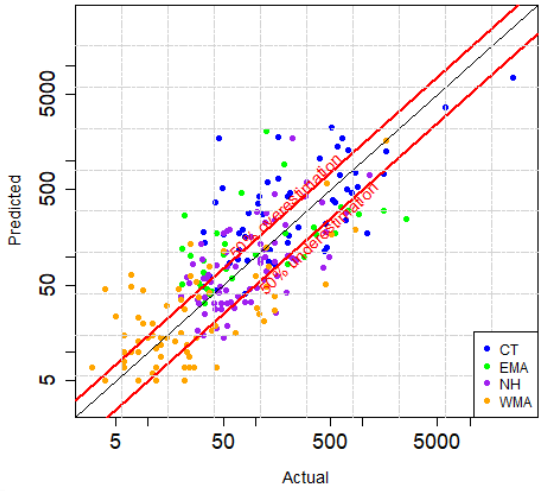
Rain/wind



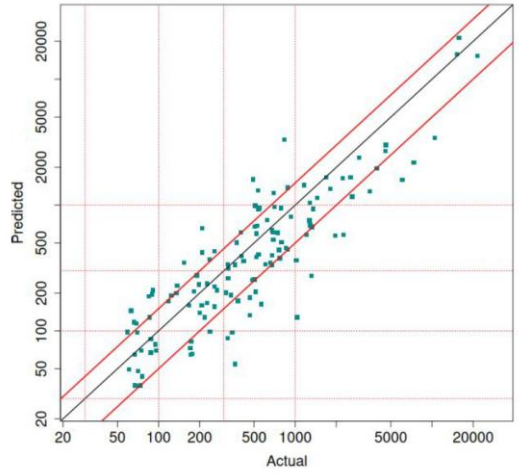
Thunderstorms



Winter Storms



Severe Events



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Current Operations for Eversource

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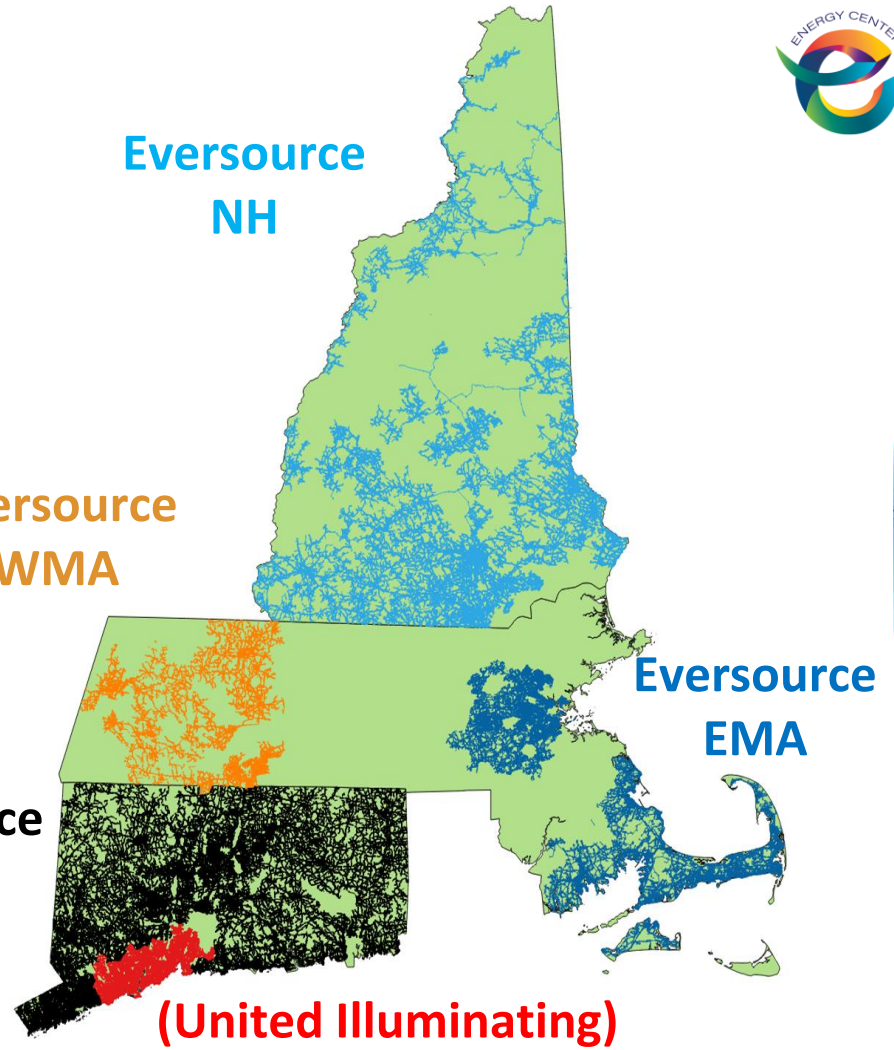
Year	Number of forecasted storms	Models* operational for all territories
2017	64	RW
2018	74	RW,T
2019	68	RW, T, SI
2020	66	RW, T, SI
2021	52	RW, T, SI, EX
2022	57	RW, T, SI, EX
2023	65	RW, T, SI, EX
2024	70	RW, T, SI, EX
2025	82	RW, T, SI, EX

* RW: Rain/wind; T: Thunderstorm, SI: Snow/ice, EX: Extreme

OPM operations by the numbers:

- 10 students (7 in outage modeling group,
- 3 in weather modeling group)
- 6 faculty, 1 postdoc
- Coordination with media and NWS before major storms



Our Partnerships

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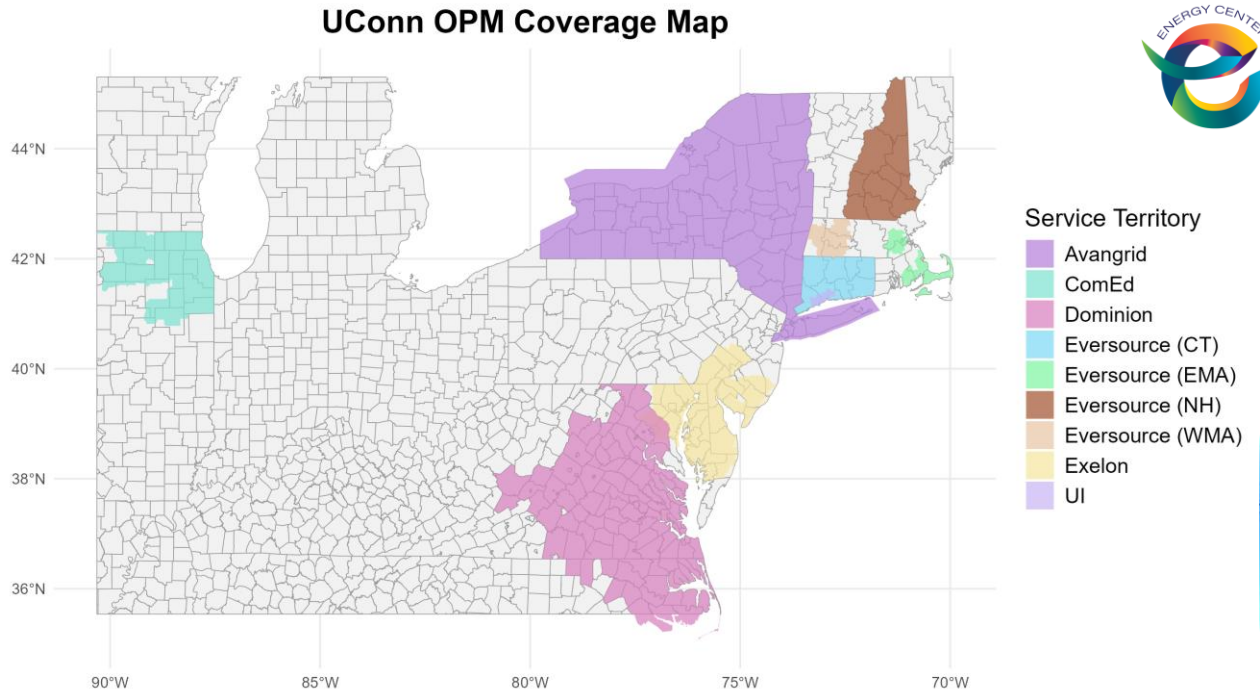
Our partner utilities serve:

- More than 20 million people
- Across 10 states
- Mostly in the Northeast US

Model performance:

- Over the past 10 years we have reduced the error by 10-fold, from above 300% to around 30%.
- Our most recent model developed for Exelon has an error below 20%.



Median Absolute Percentage Error		OPM type			
		Rain-Wind	Thunderstorms	Winter	Extreme
Electric Utility	Eversource	38%	38%	67%	33%
	Avangrid	32%	33%	42%	30%
	Dominion	24%	32%	62%	17%
	Exelon	24%	19%	48%	19%

Next operational milestone:
The North American Outage Prediction Project

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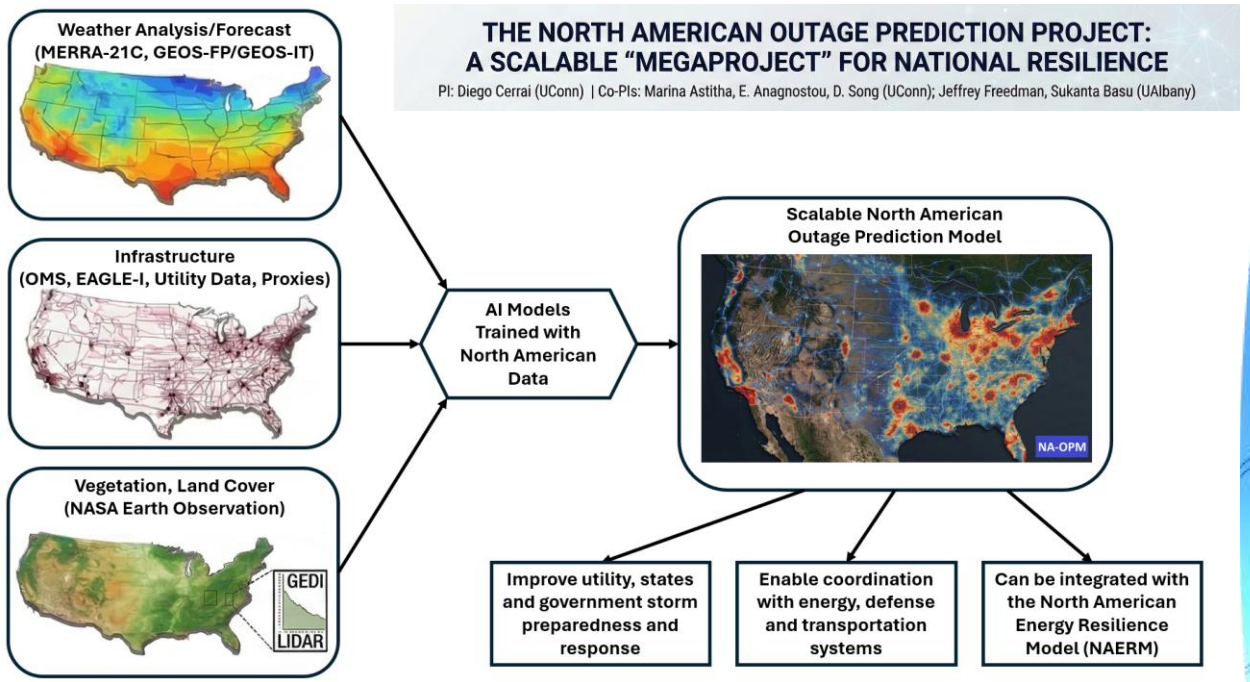
The NSF Center for Weather Innovation and Smart Energy and Resilience (WISER)

- WISER is a partnership between **UAlbany** and **UConn** with funding from NSF and industry members.
- Aims to provide **state-of-the-art weather and climate information** combined with leading edge industry-inspired R&D to empower the energy industry of the future.
- Since 2024, 26 projects have been funded. The OPM is the largest one.



https://wiser-iucrc.com/

PARTNERS: Pacific Gas and Electric Company; NEW YORK STATE OF OPPORTUNITY. NYSERDA; Hydro Québec; EVERSOURCE; nationalgrid; conEdison; People. Power. Possibilities. Central Hudson A FORTIS COMPANY; Avangrid A member of the Iberdrola Group; SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company; NEW YORK STATE NY Power Authority; NYSTAR Empire State Development Division of Science, Technology & Innovation

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Next steps in research:
Advancing our understanding of storm impact on infrastructure

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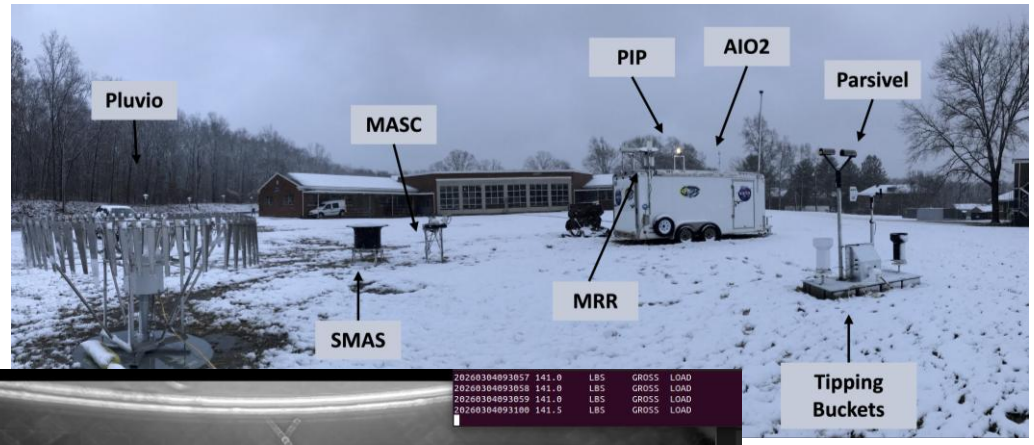
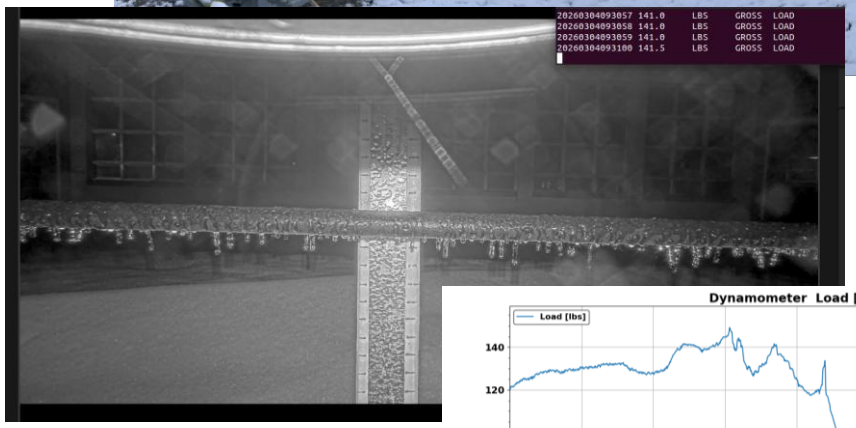
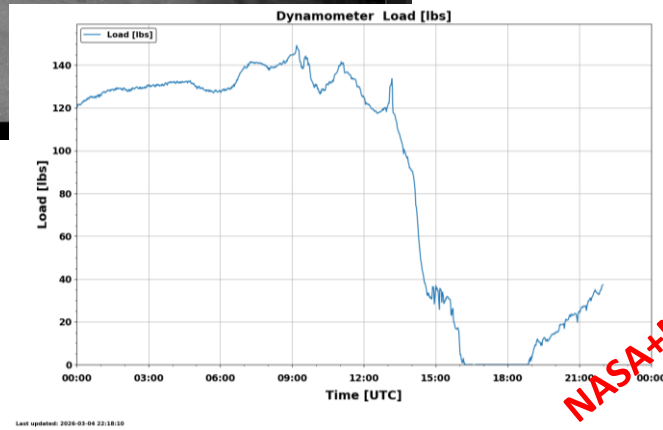
Since 2021, we have been working with NASA GPM GV to collect wintry precipitation data.

In 2026, we installed a power line to measure the tension force of the line under snow and ice accretion.

Goal is to develop a snow and ice accretion model to estimate icing on power lines from weather forecasts to improve OPM forecast accuracy.







NASA+NSF CAREER funding

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Other OPM applications: modeling grid resilience

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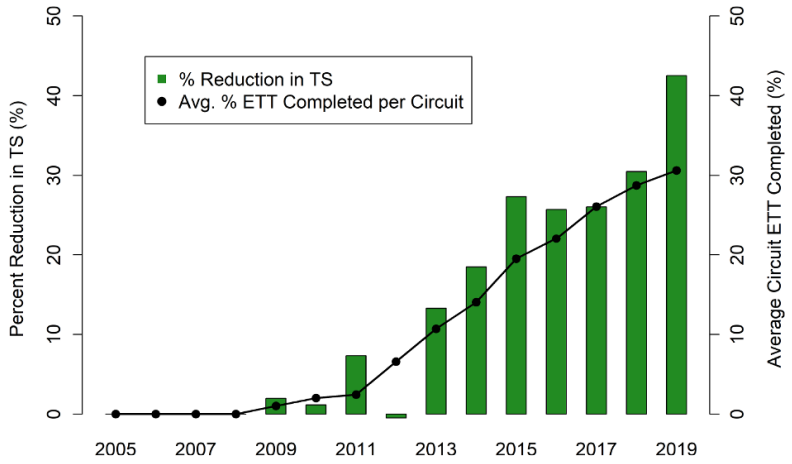
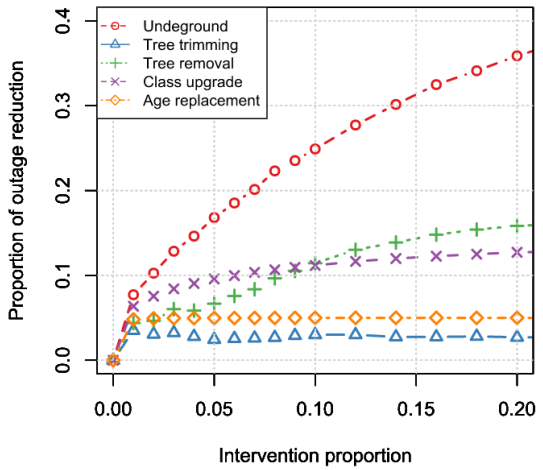
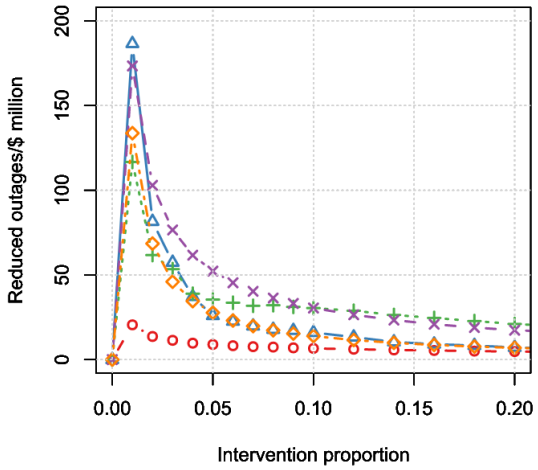
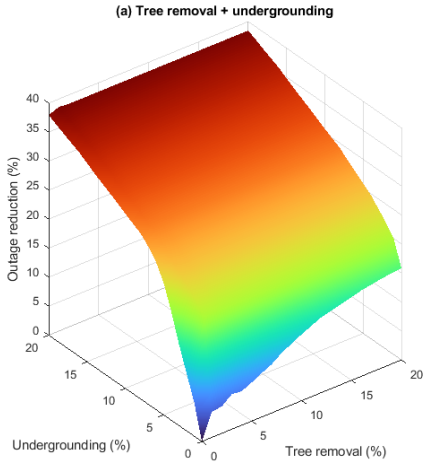
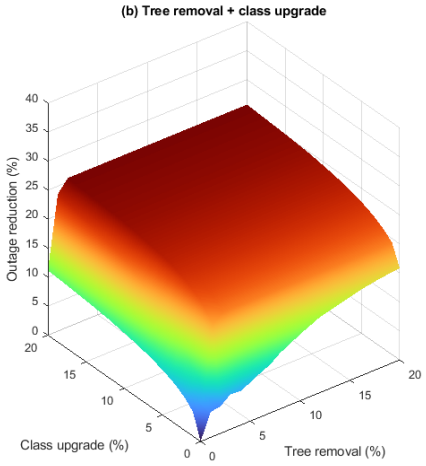
- The OPM also allows to evaluate the effectiveness or the ROI future resilience improvements.
- Or relate the decrease of power outages to the amount of tree trimming performed, or to different combinations of resilience improvement activities.











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More information: Research and Training

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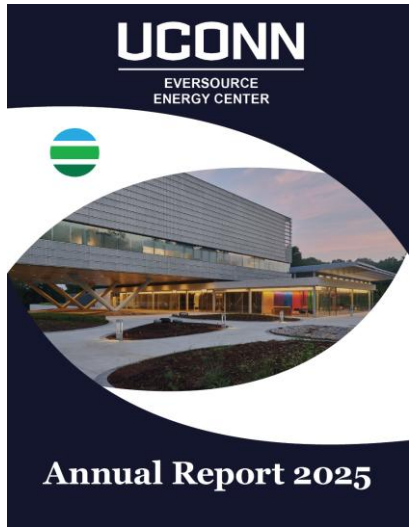

POWER GRID MODERNIZATION CERTIFICATE

UCONN COLLEGE OF ENGINEERING

UConn Power Grid Modernization Certificate

- Program is designed to take 2 years, 1 class per semester
- Certificate includes 4 core courses

Communication Systems for Smart Grids	Predictive Analytics for Scientists and Engineers	Microgrids	Distribution Management Systems

This fully online program with synchronous and asynchronous coursework, offered by the **UConn Eversource Energy Center**, is designed to give utility engineers the talents needed to adapt to new technologies and deal with the challenges of managing the increasing complexity of the grid.

Please feel free to email me at:
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