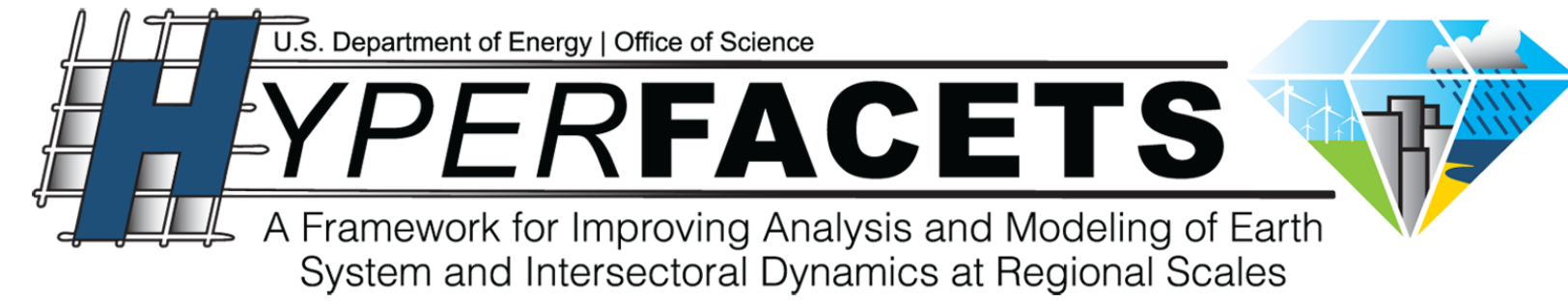


Assessing and Modeling the Compound Hazard of Freezing Rain and Wind Gusts

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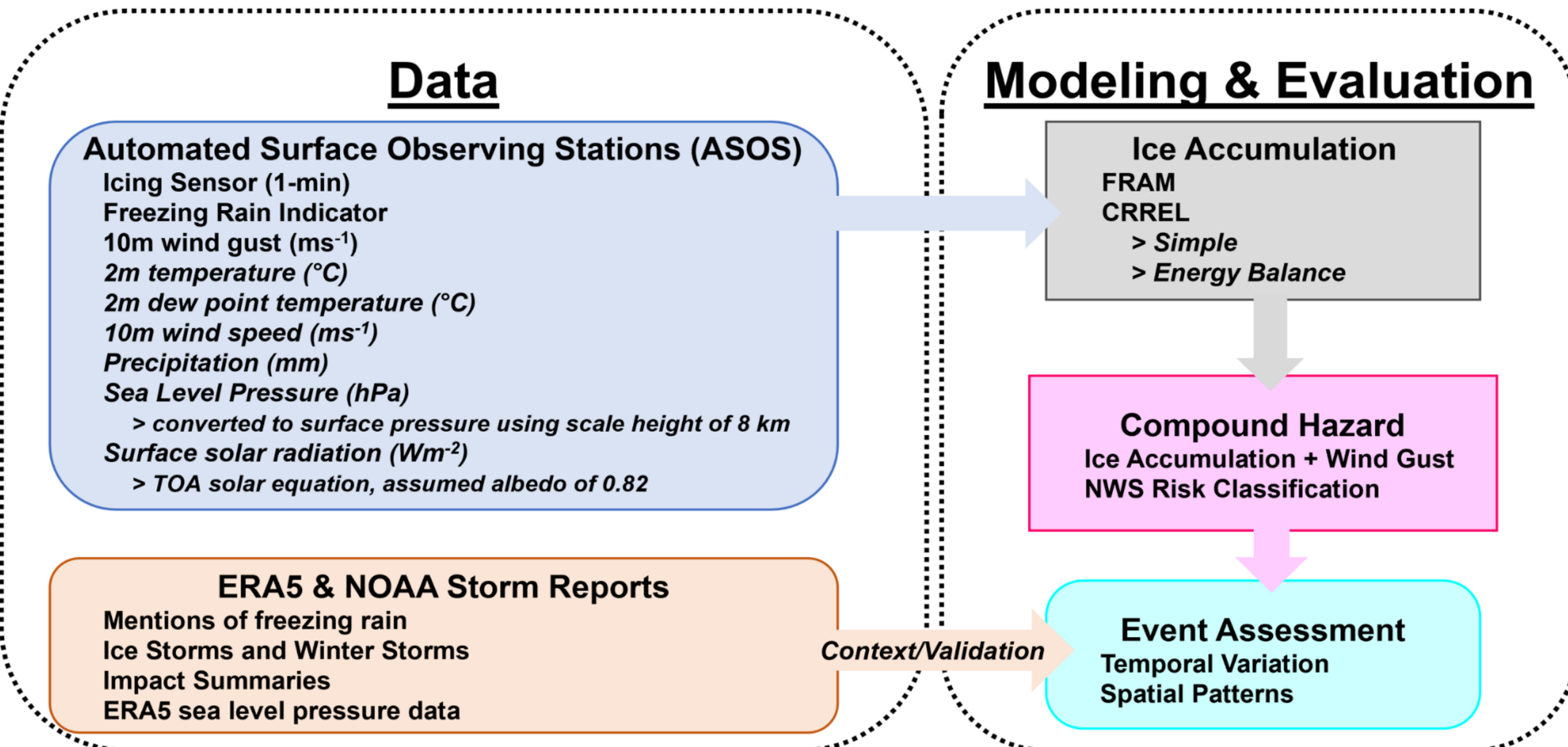
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Background & Methods

- The compound hazard posed by ice accumulation resulting from freezing rain (FZ) and subsequent wind gusts (G) poses significant risks to safety, energy transmission and infrastructure
- ASOS data over 2005-2022** are used to model hourly ice accumulation, which combined with in-situ wind gusts estimate compound (FZG) hazard via the **Sperry-Plitz Index**
- Major FZG events are contextualized using NOAA storm reports and sea level pressure patterns from ERA5
- Coburn, J., Barthelmie, R. J., Pryor, S. C. (2023): Quantifying the Compound Hazard of Freezing Rain and Wind Gusts Across CONUS. Submitted to Environmental Research Letters.

(a) Workflow

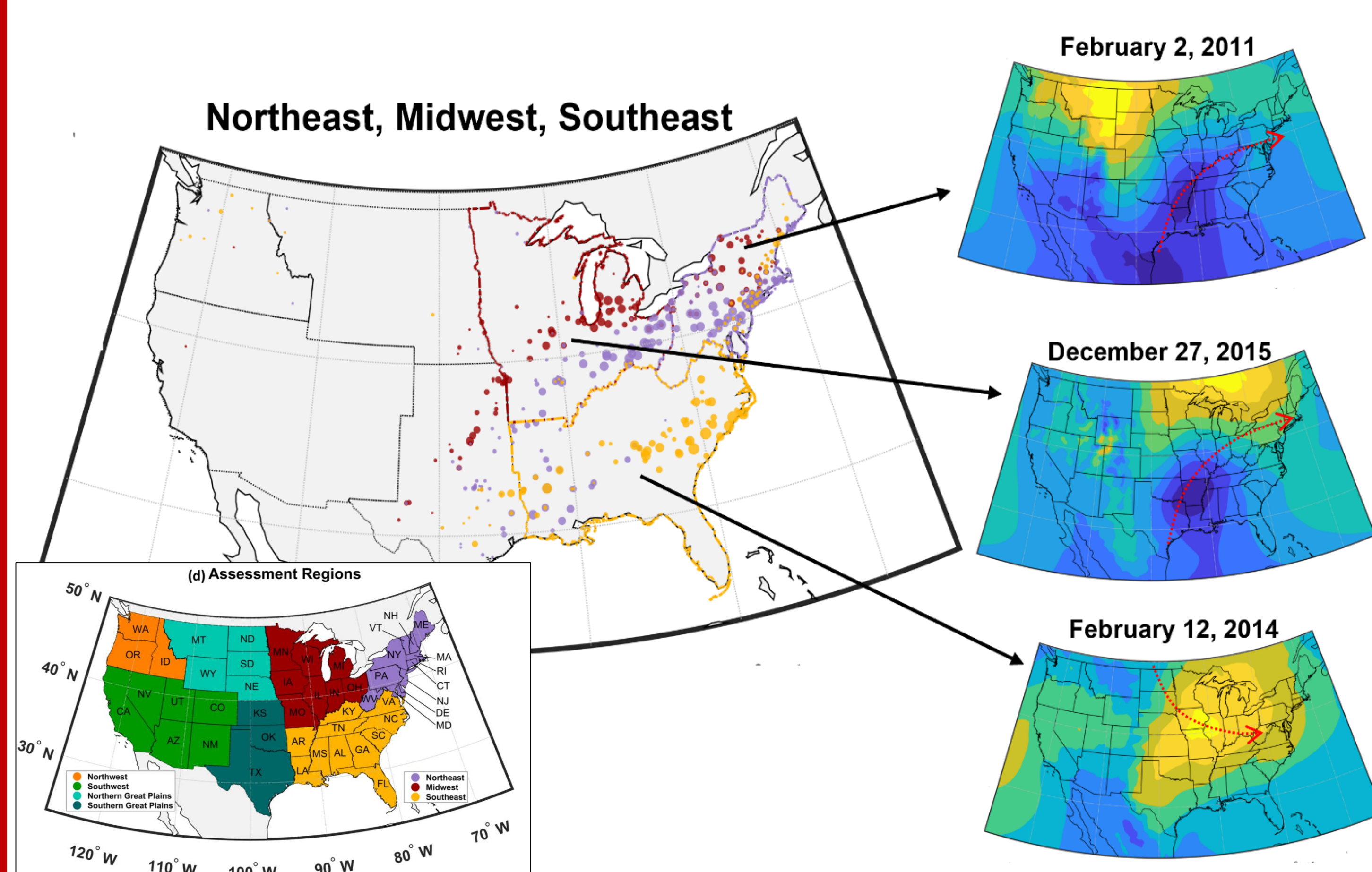
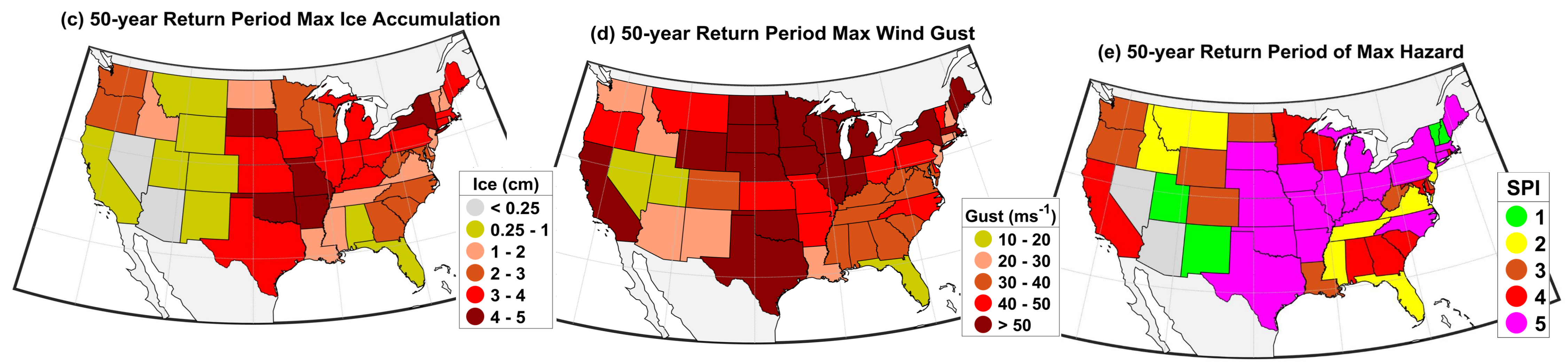


(b) Sperry-Plitz Index Table

SPI	Avg Ice Accumulation (cm)	Wind [Gust] (ms ⁻¹)	Damage/Impact/Risk Description
0	< 0.65	< 7.2 [10.5]	Minimal risk of damage to exposed utility systems, few outages.
1	0.25 - 0.65	7.2 - 11.2 [10.5 - 17.5]	Some isolated or localized utility interruptions possible, typically lasting less than a few hours. Roads and bridges may be slick or hazardous.
2	0.65 - 1.3	< 7.2 [10.5]	Scattered utility interruptions, typically lasting 12-24 hours. Roads and travel conditions may be extremely hazardous.
3	0.25 - 0.65	11.2 - 15.6 [17.5 - 24.5]	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Excessive tree limb damage. Outages lasting 1-5 days.
4	0.65 - 1.3	11.2 - 15.6 [17.5 - 24.5]	Prolonged and widespread utility interruptions with extensive damage to main distribution feeder lines and some high voltage transmission lines/structures. Outages lasting 5-10 days.
5	1.3 - 1.9	11.2 - 15.6 [17.5 - 24.5]	Catastrophic damage to entire exposed utility systems, including distribution and transmission networks. Outages could last weeks in some areas. Shelters needed.

A new atlas of the compound (FZG) hazard of freezing rain (FZ) and wind gusts (G) is produced for **CONUS** over **2005-2022** by applying an ice accumulation model to **ASOS** data,

Major FZG events produce widespread power outages over several hours to days and are typically associated with ‘Texas Hook’ midlatitude cyclones or cold fronts ahead of cold air outbreaks



Region	Mean Acc	Max Acc	Mean Gust	Max Gust	Max Hazard
Northeast	0.28	1.93	13.1	42.7	3
Midwest	0.32	3.02	15.3	29.3	4
Southeast	0.30	1.42	11.6	46.8	3

Storm Report Summary

Northeast

- 0.6-1.3 cm of ice on roads in Pennsylvania
- Scattered power outages lasting < 24 hours
- Building collapses due to ice/snow buildup
- Many road accidents/power outages in the Southern Great Plains & Midwest

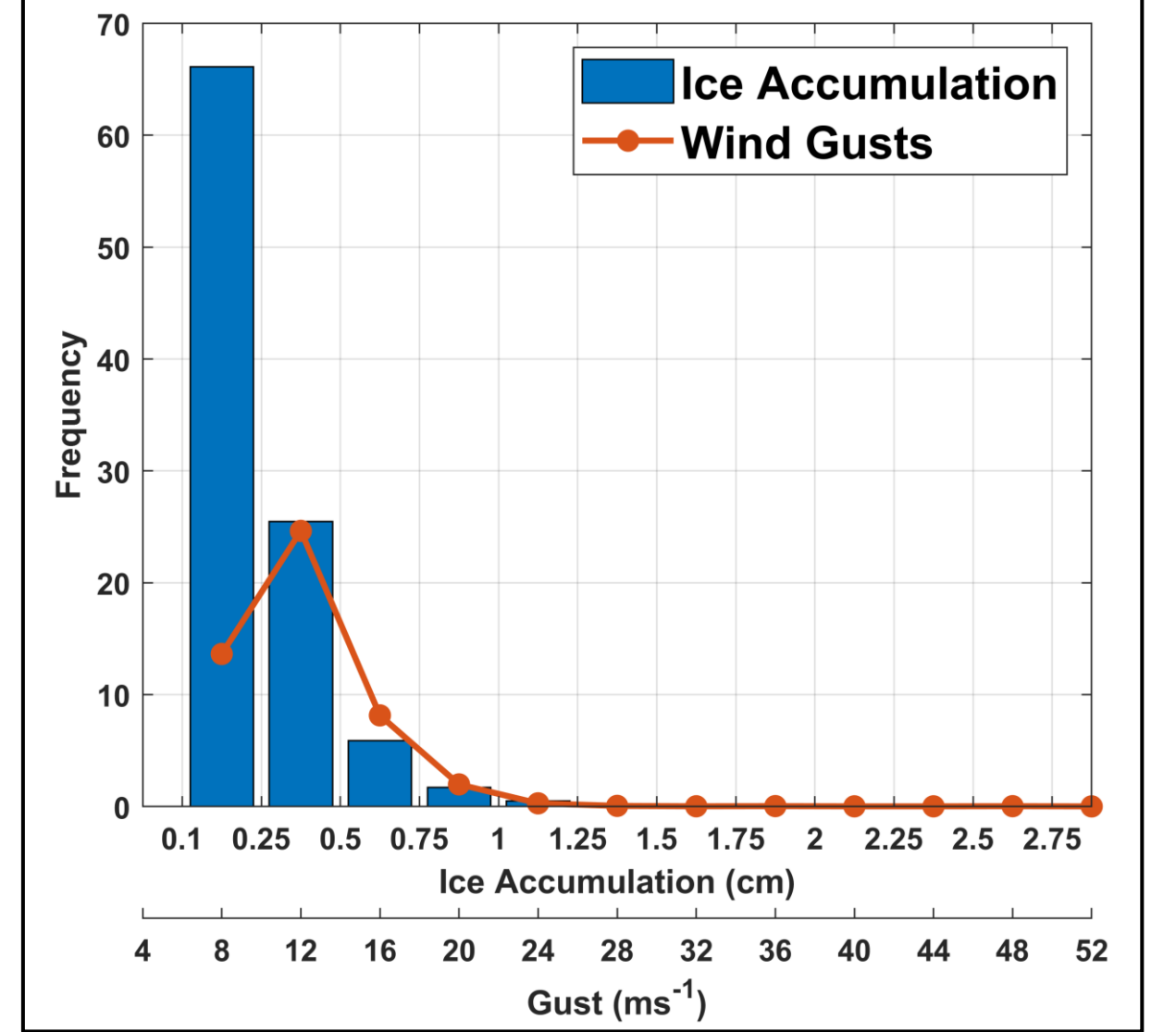
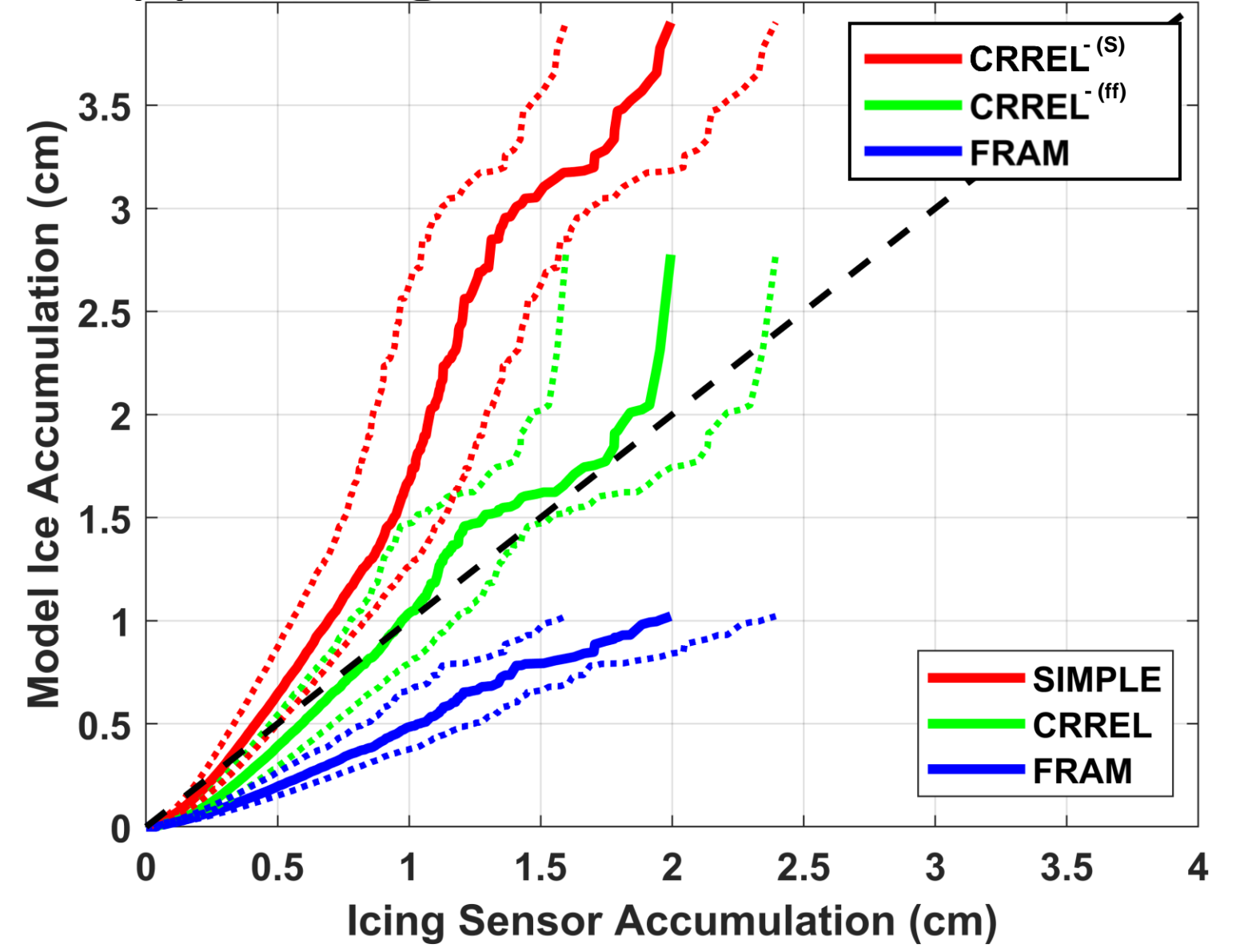
Midwest

- 0.6-1 cm of ice reported across the region
- 15-22 mph wind gusts
- > 150k people lost power for 3-4 days from Illinois to Indiana
- Icing and up to 7 cm of sleet + snow result in downed trees
- Travel impacts from Texas to the Northeast

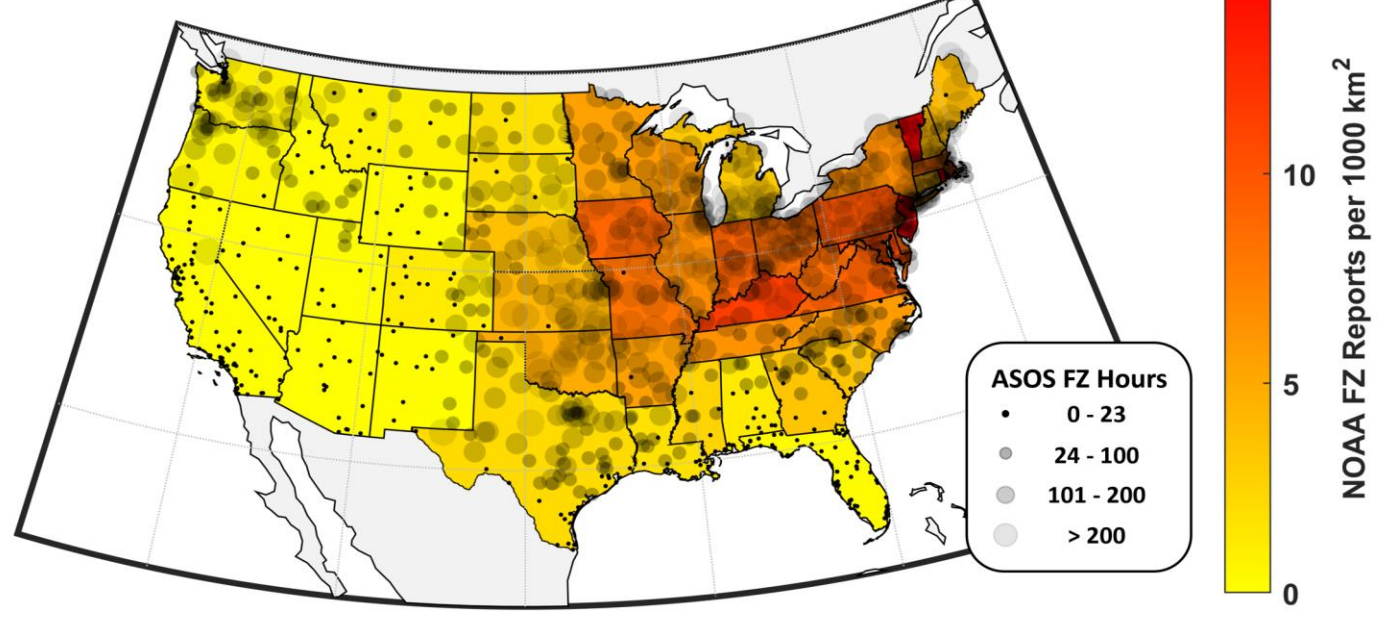
Southeast

- 0.6-1.3 cm of ice reported in Louisiana
- Scattered reports of > 2 cm of ice in Georgia & South Carolina
- Power outages to 10s of thousands over 2-3 days south of Atlanta
- Ice & snow effects on travel from Texas to Connecticut

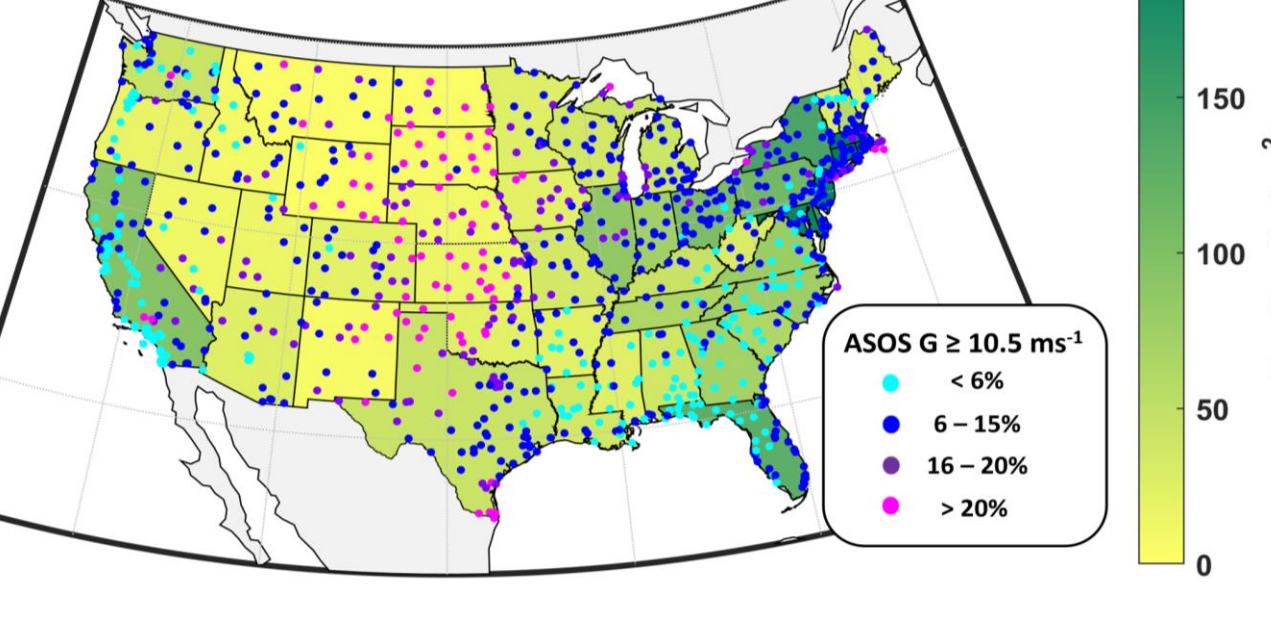
(a) Freezing Rain Event Ice Accumulation



(a) Freezing Rain: 2005 - 2022



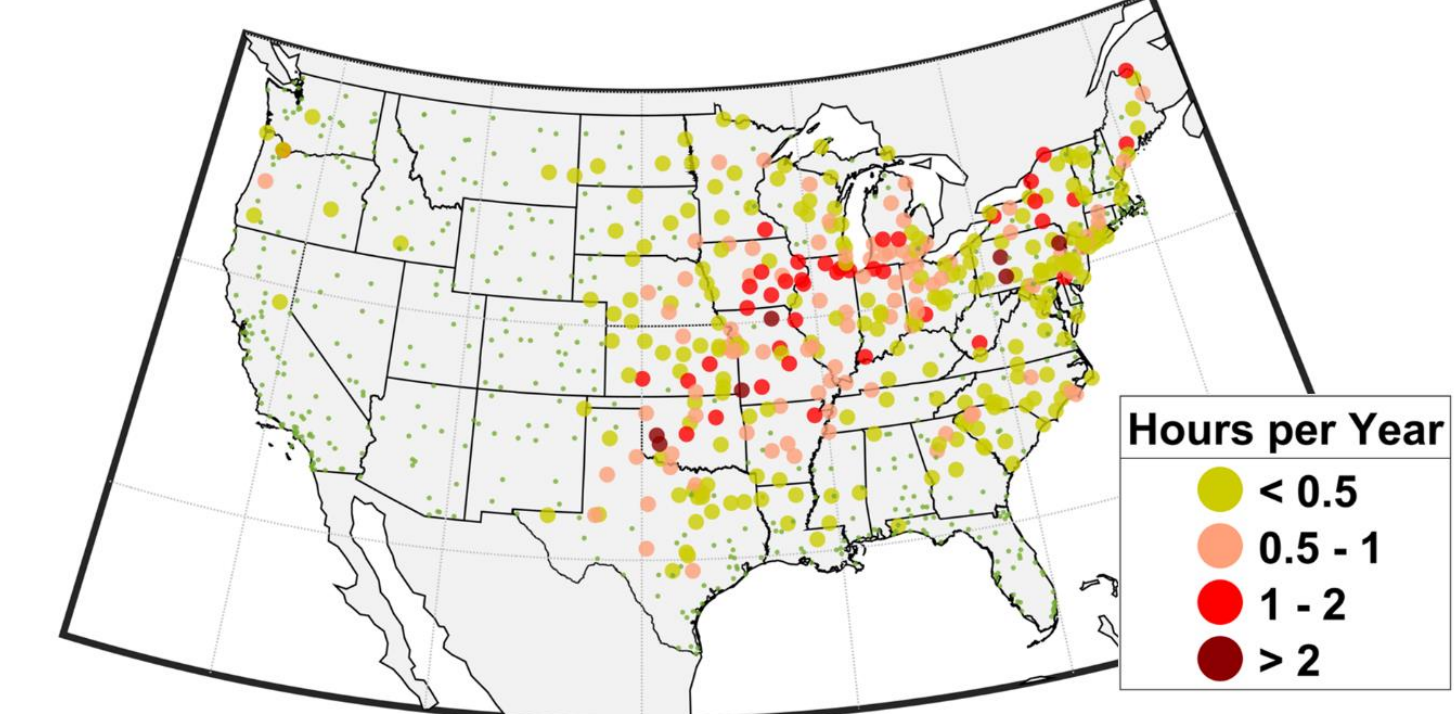
(b) Gusts and Population Density



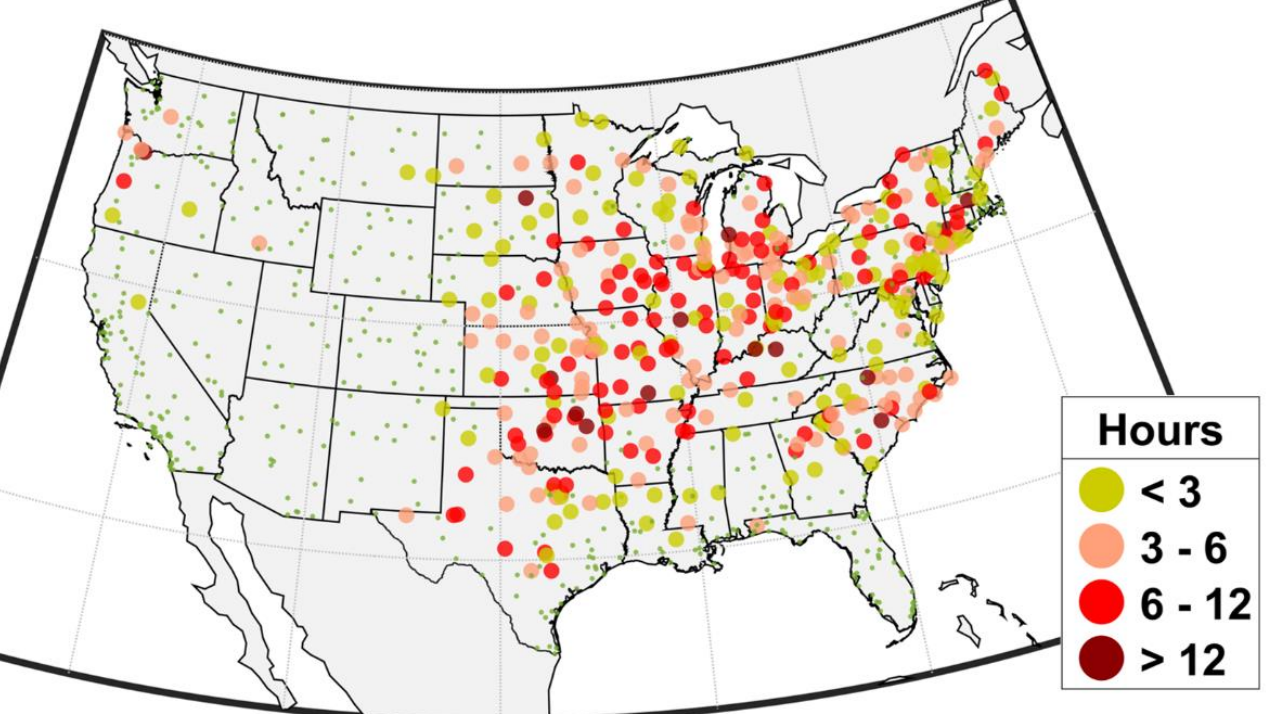
Discussion

- The Cold Regions Research and Engineering Lab (CRREL) ice accumulation model (including energy balance terms) produces best fit to sensor-estimated values
- Potential outcomes suggested by SPI broadly fits impacts summarized by storm reports, though with high spatial heterogeneity
- Most freezing rain events do not produce high enough accumulations to result in significant damage, though major events are common enough to occur 1-2 times per year
- Highest impact events resulted in power outages which lasted several days to a couple of weeks

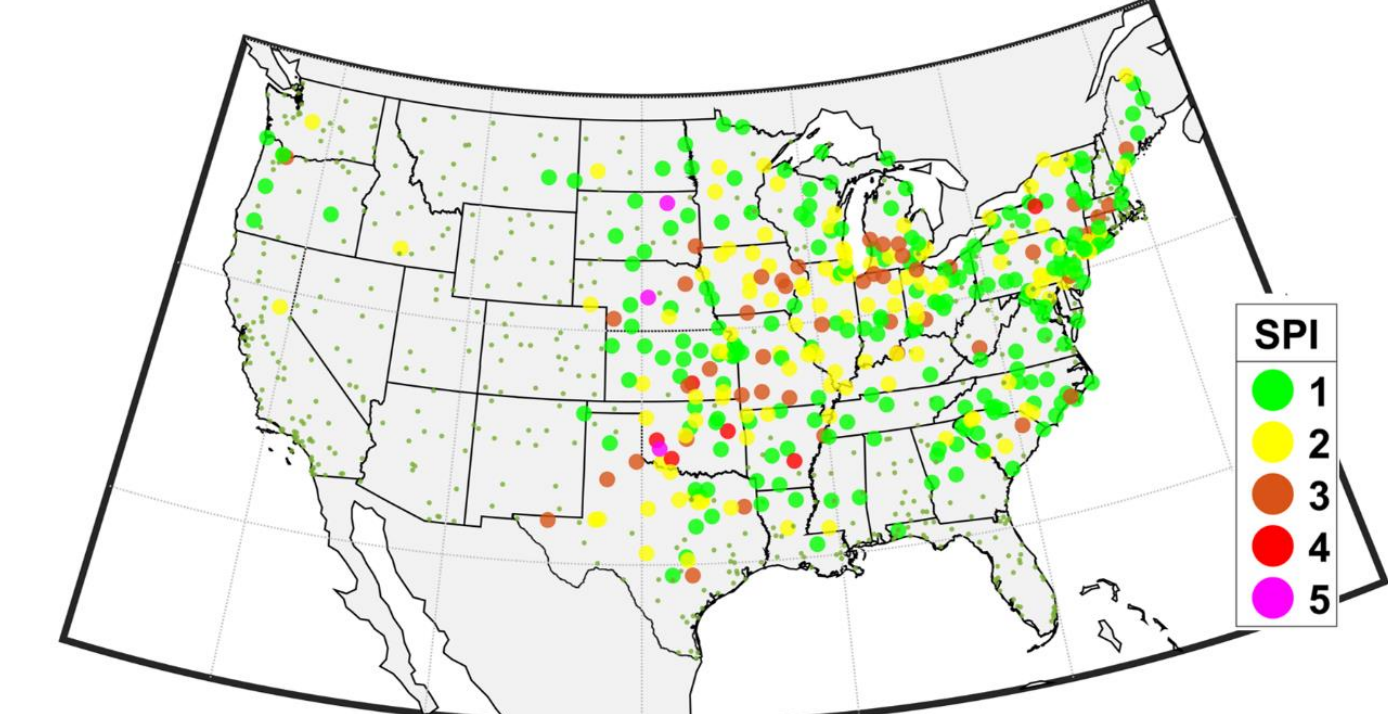
(a) Hazard Frequency



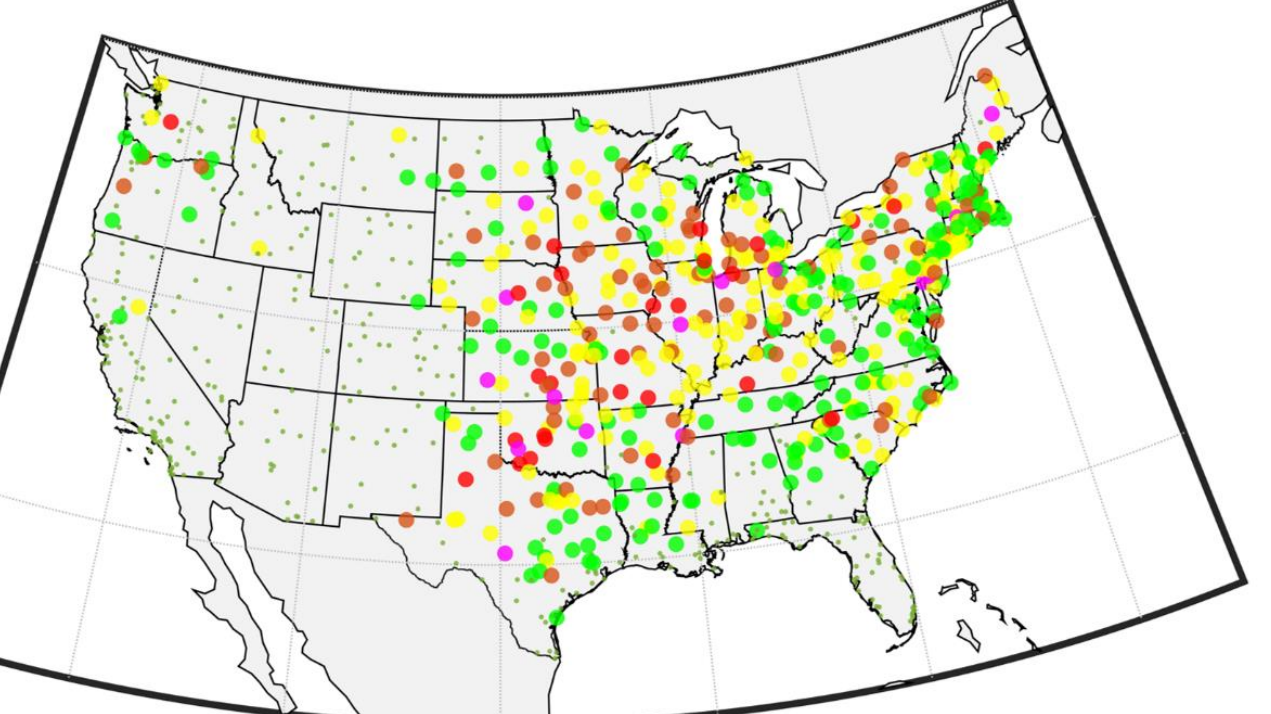
(b) Maximum Hazard Length



(c) Maximum CRREL (ff) Hazard Event



(d) Maximum CRREL (S) Hazard Event



Future Work

- Use FZG atlas produced here as the target for prediction modeling using statistical and machine learning approaches
- Use modeling to extend FZG record and assess climatological variability and trends