Weather and Climate Drivers of Power Outages over the Continental U.S.

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CLIMATE X

Weather is the leading cause of U.S. power outages

Impacts

Power outages lead to security risks and deaths

Costs

U.S. weather-driven power outages cost 18-33 billion USD annually*

Future Resilience

Power infrastructure reaching the end of its lifespan

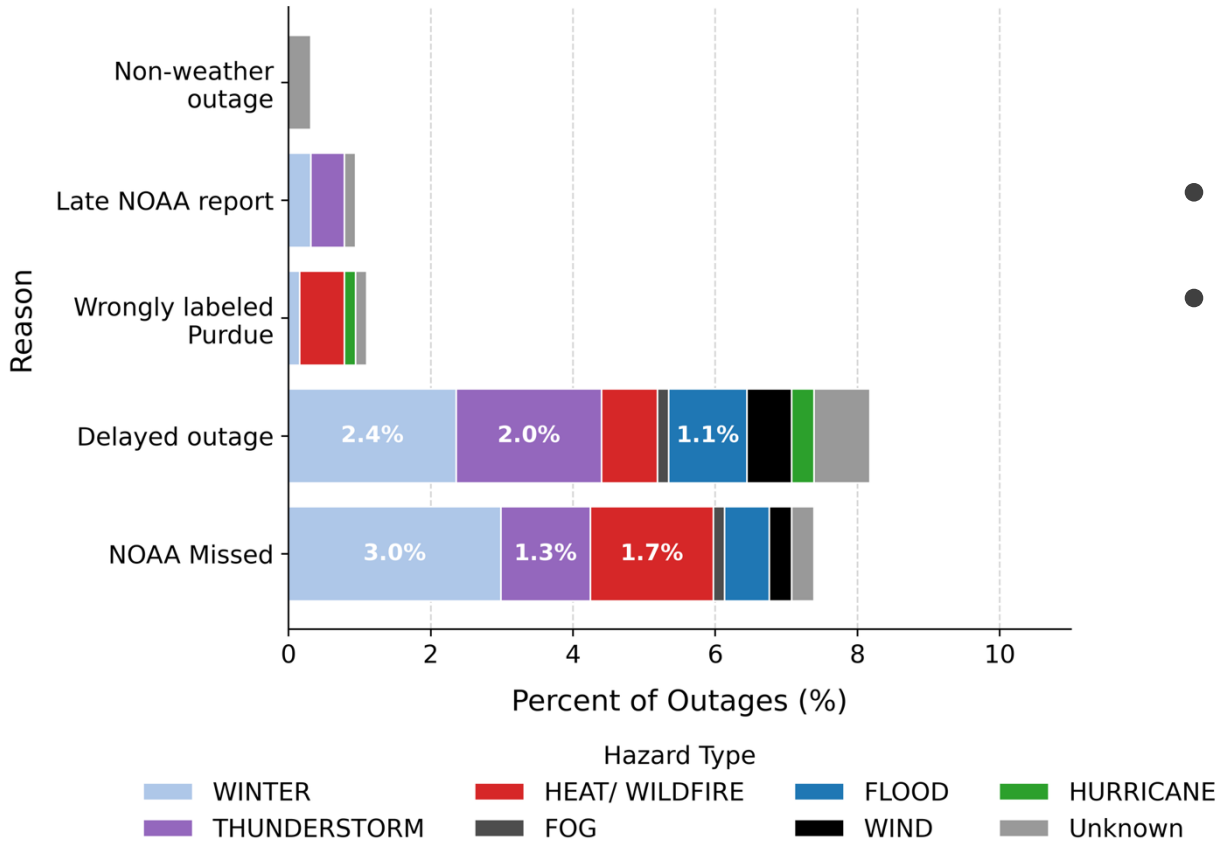
*Data from 2003-2012 (Executive Office of President, 2013)

Outage data is fragmented, vague, and missing frequent small outage events

SCHEDULE 1 – TYPE OF EMERGENCY
Check all that apply

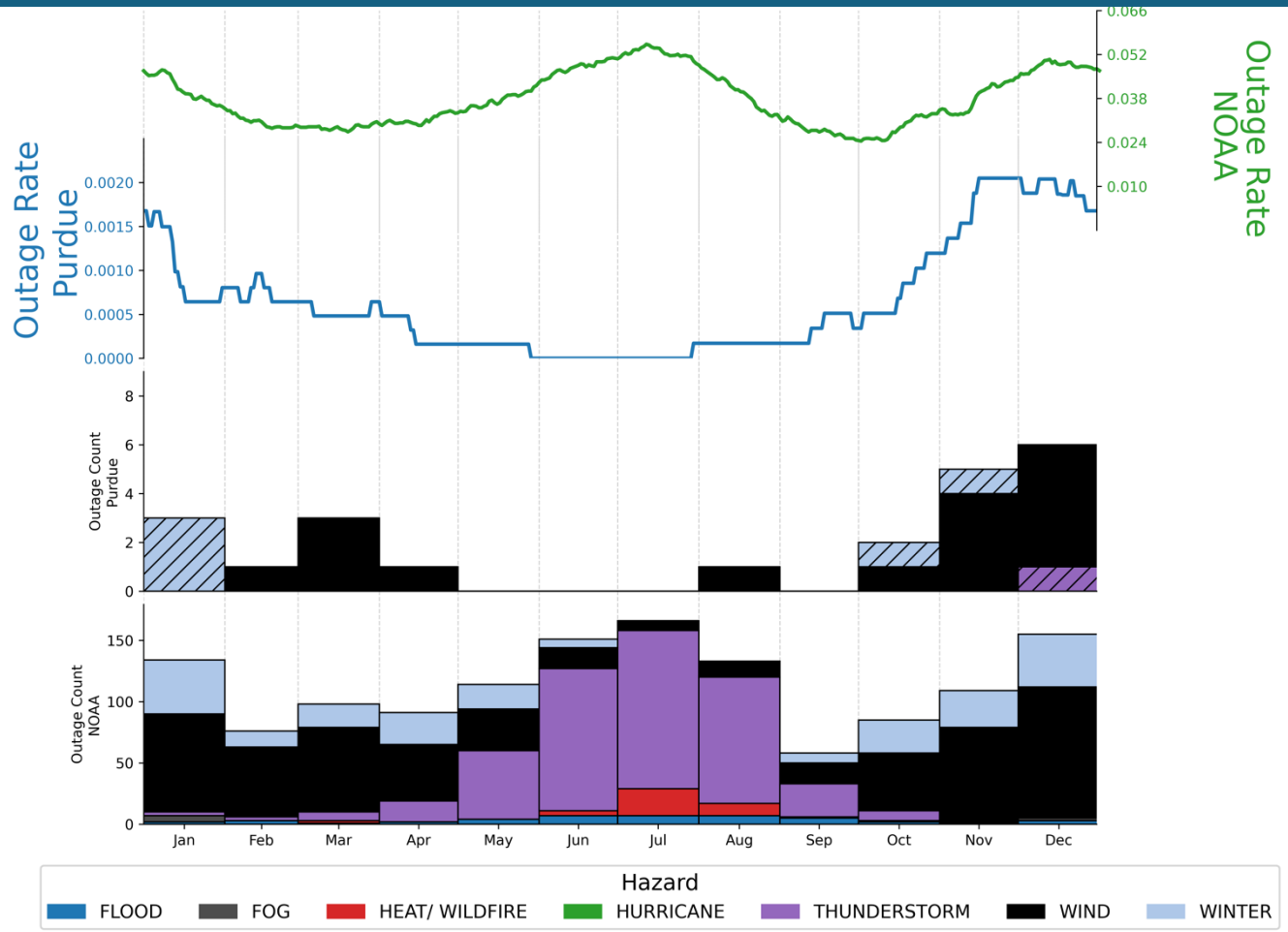
K. Cause	L. Impact	M. Action Taken
☐ Unknown	☐ None	☐ None
☐ Physical attack	☐ Control center loss, failure, or evacuation	☐ Shed Firm Load: Load shedding of 100 MW or more implemented under emergency operational policy (manually or automatically via UFLS or remedial action scheme)
☐ Ballistic	☐ Loss or degradation of control center monitoring or communication systems	☐ Public appeal to reduce the use of electricity for the purpose of maintaining the continuity of the electric power system
☐ Arson	☐ Damage or destruction of a facility	☐ Implemented a warning, alert, or contingency plan
☐ Explosive device	☐ Electrical system separation (islanding)	☐ Voltage reduction
☐ Other	☐ Complete operational failure or shutdown of the transmission and/or distribution system	☐ Shed Interruptible Load
☐ Threat of physical attack	☐ Major transmission system interruption (three or more BES elements)	☐ Repaired or restored
☐ Vandalism	☐ Major distribution system interruption	☐ Mitigation implemented
☐ Theft	☐ Uncontrolled loss of 200 MW or more of firm system loads for 15 minutes or more	☐ Other
☐ Suspicious activity	☐ Loss of electric service to more than 50,000 customers for 1 hour or more	☐ Additional Information/Comments
☐ Aircraft or Unmanned Aerial System (UAS)	☐ System-wide voltage reductions or 3 percent or more	
☐ Trespassing or non-destructive intrusion	☐ Voltage deviation on an individual facility of ≥10% for 15 minutes or more	
☐ Surveillance	☐ Inadequate electric resources to serve load	
☐ Other	☐ Generating capacity loss of 1,400 MW or more	
☐ Cyber event	☐ Generating capacity loss of 2,000 MW or more	
☐ Information Technology	☐ Complete loss of off-site power to a nuclear generating station	
☐ Operational Technology	☐ Loss of a total of 500 MW or more from inverter-based resource(s)	
☐ Fuel supply emergencies, interruption, or deficiency	☐ Other	
☐ Generator loss or failure not due to fuel supply interruption or deficiency or transmission failure	☐ Additional Information/Comments:	
☐ Transmission equipment failure (not including substation or switchyard)		
☐ Failure at high voltage substation or switchyard		
☐ Weather or natural disaster		
☐ Operator action(s)		
☐ Other		
☐ Additional Information/Comments:		

To what extent can NOAA storm reports be used to produce a robust outage record?

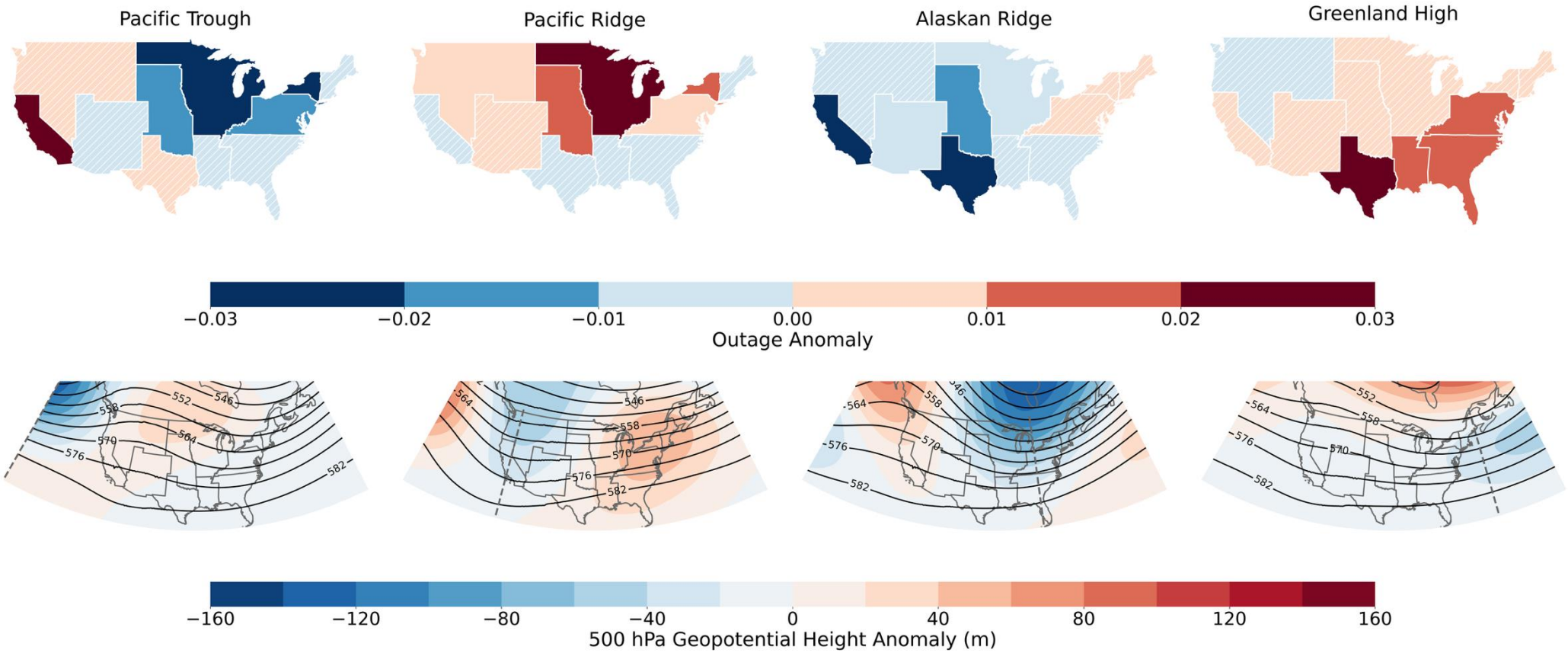


- 636 large outages (Purdue)
- 23,347 total outages (NOAA)

Which weather phenomena are the primary drivers of large- and small- scale power outages?

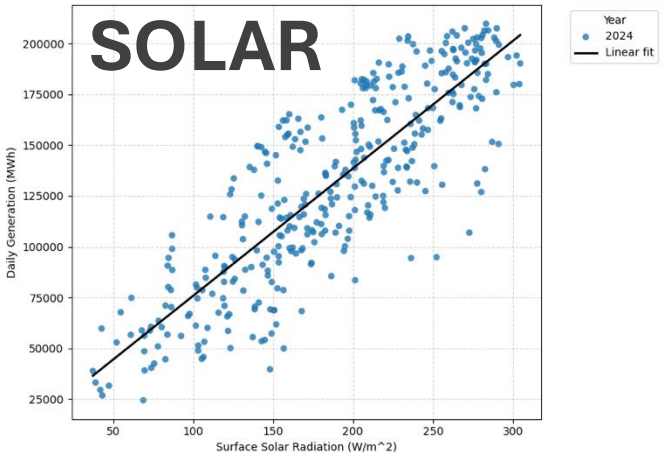


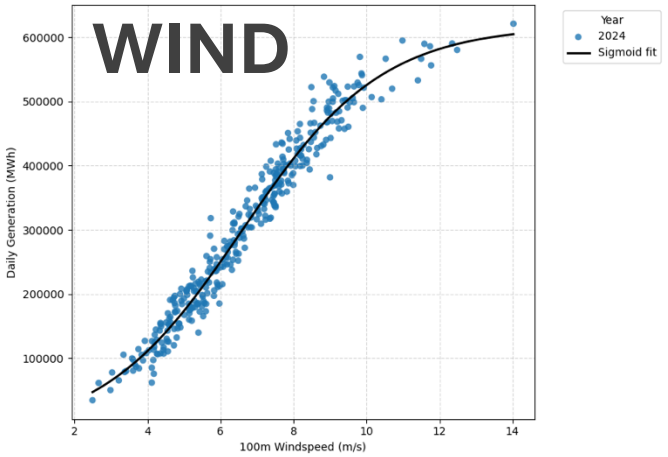
What is the relationship between power outages and large-scale weather patterns?

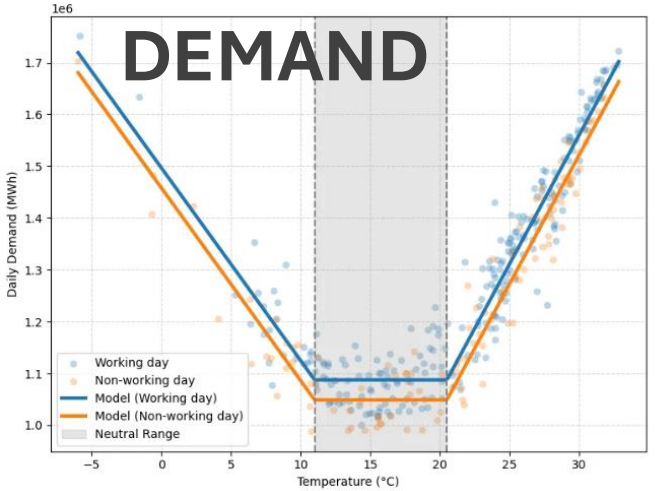


Future Work

What are the high-risk days over U.S. and how do these vary by regime?



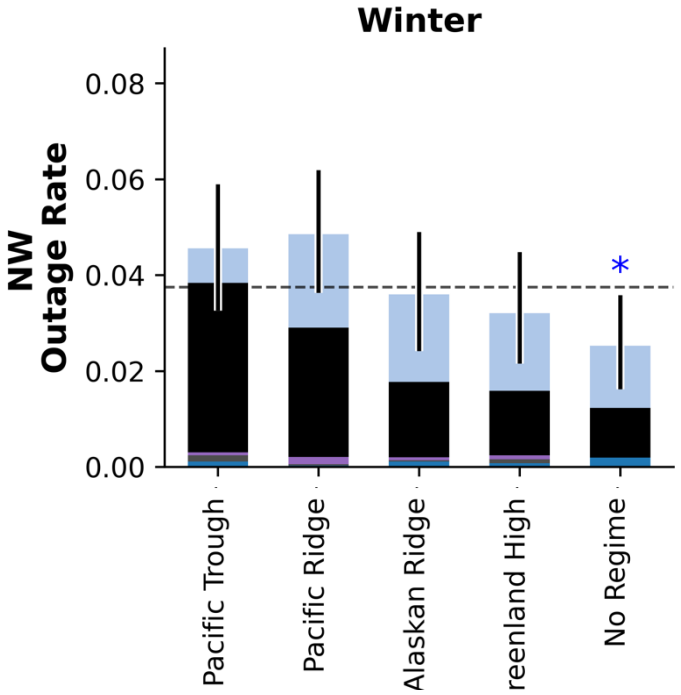


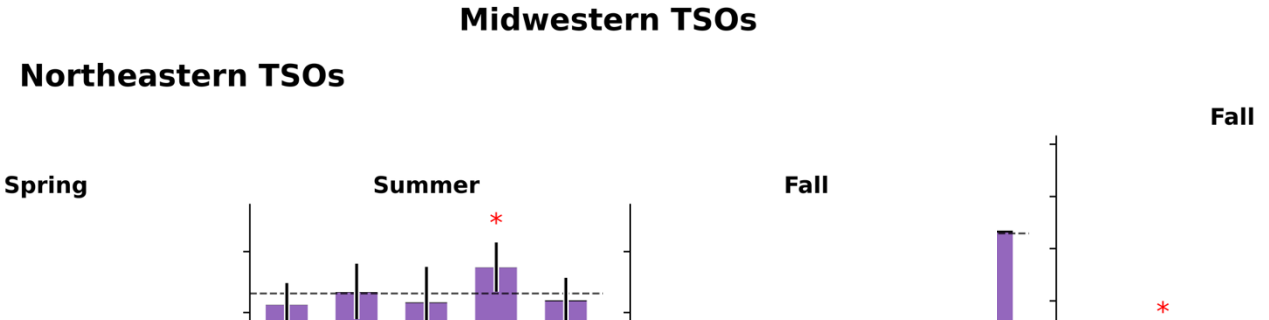


QUESTIONS

Problem

How will specific weather events, which have historically caused large-scale transmission outages, evolve under different climate scenarios?





To what extent can NOAA storm reports be used to produce a robust outage dataset?