Power system vulnerability assessment under a changing climate

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Industry Relevance & Need

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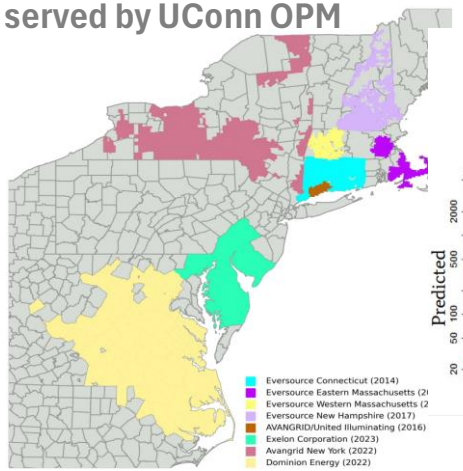
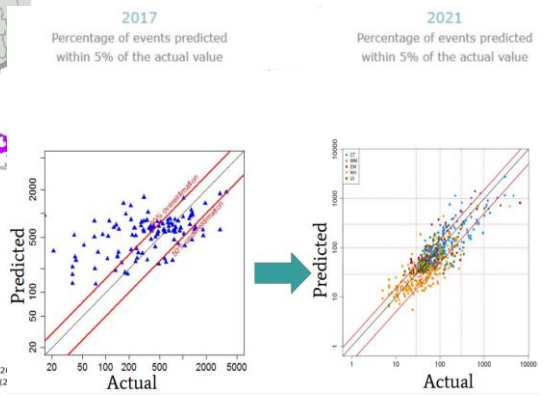
History

- Weather-related **power outages prediction models** (**OPM**) have been used to help pre-storm preparedness for utilities.
- The OPM performance keeps improving during the past decade.

The Expansion of Territories served by UConn OPM



OPM improvements



Challenge

The current OPM requires a comprehensive list of high-resolution input parameters that are typically derived from the regional meso-scale atmospheric models with a high computational cost.

- **For climate studies, there are difficulties to adopt the current OPM framework due to limited data at climate scale.**
- We need to develop new approaches that make use of the limited parameters from climate datasets and consider the uncertainties of long-term climate projections.
- The project results will provide important information on how future climate change may affect the electric distribution planning, operations, and infrastructure.

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Project Goals and Objectives

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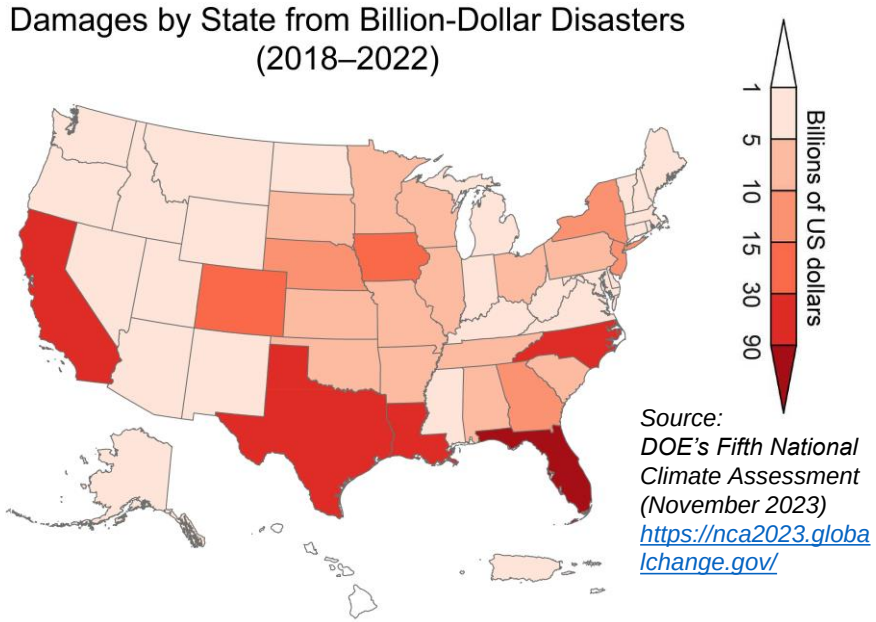

Source:
DOE's Fifth National Climate Assessment (November 2023)
https://nca2023.globalchange.gov/

The US now experiences, on average, a billion-dollar weather or climate disaster every three weeks.

- Billion-dollar weather and climate disasters are events where damages/costs reach or exceed $1 billion, including adjustments for inflation.
- Between 2018 and 2022, 89 such events affected the US, including 4 droughts, 6 floods, 52 severe storms, 18 tropical cyclones, 5 wildfires, and 4 winter storm events.

Research questions

1. How to effectively and accurately quantify the occurrence and intensity of weather events and their changes based on long-time climate projections?
2. How to quantitatively assess the relationship between the return periods of weather events and the corresponding power outages?
3. How to locate power asset vulnerabilities under a changing climate and when will be the turning point for different regions?

Objectives

- Analyzing the relationship between power outages and weather events during the historical period.
- Establish a framework that can estimate the likelihood of outage occurrences in future periods (e.g. 2040-2060, 2080-2100) based on the ensemble future climate datasets.

Overall, we will provide valuable insights into the frequency and severity of power outages under future climate, enabling more effective resilience improvement investments and resource allocation.

Research Approach

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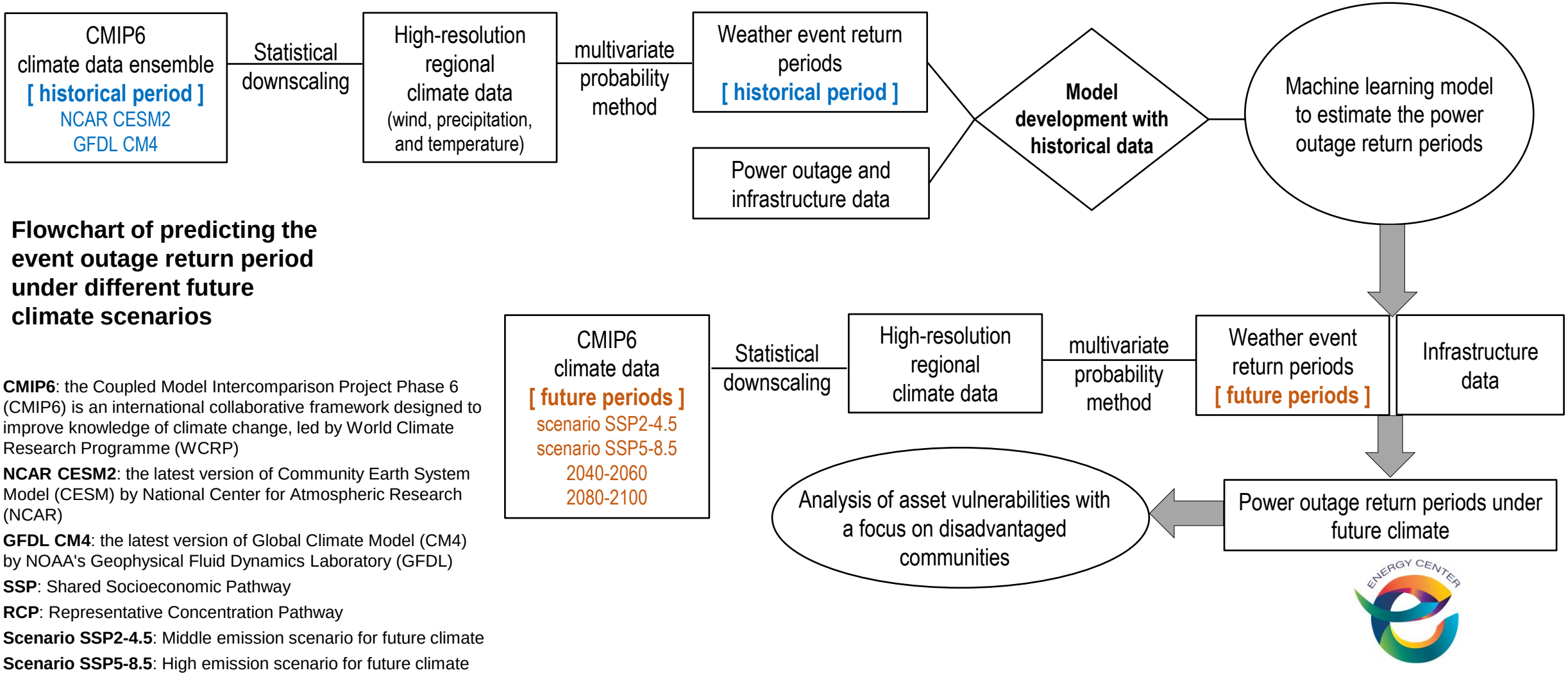

Flowchart of predicting the event outage return period under different future climate scenarios

- **CMIP6**: the Coupled Model Intercomparison Project Phase 6 (CMIP6) is an international collaborative framework designed to improve knowledge of climate change, led by World Climate Research Programme (WCRP)
- **NCAR CESM2**: the latest version of Community Earth System Model (CESM) by National Center for Atmospheric Research (NCAR)
- **GFDL CM4**: the latest version of Global Climate Model (CM4) by NOAA's Geophysical Fluid Dynamics Laboratory (GFDL)
- **SSP**: Shared Socioeconomic Pathway
- **RCP**: Representative Concentration Pathway
- **Scenario SSP2-4.5**: Middle emission scenario for future climate
- **Scenario SSP5-8.5**: High emission scenario for future climate

Outcomes and Deliverables

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Deliverables

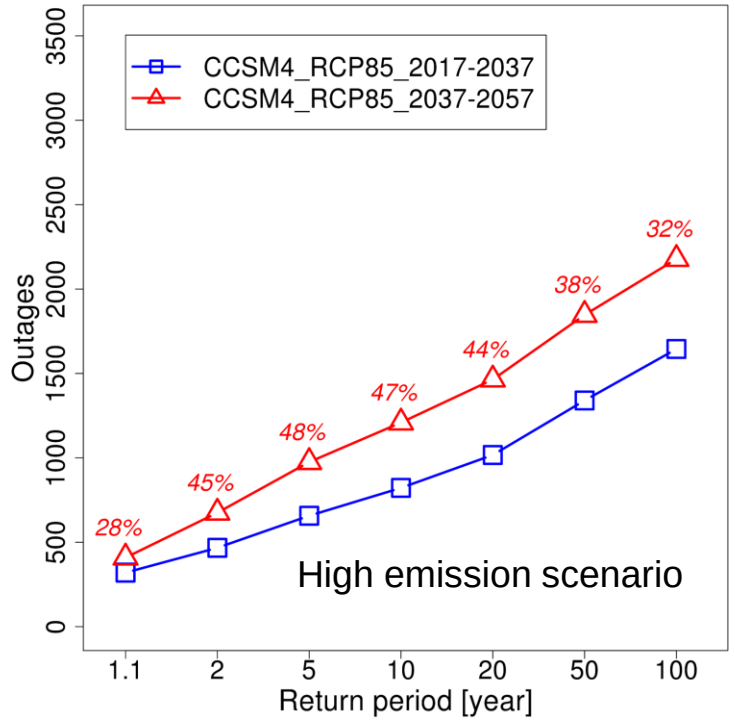
1. Downscaled ensemble climate datasets over historical and future periods under scenarios SSP2-4.5 and SSP5-8.5

2. Return period estimates for weather events, as gridded products or at circuit/substation level in CT territory.

3. Machine learning model that provides return period estimates for the number of power outages, derived based on the historical weather data and power assets information.

4. Report on the evolving trends of power outage return periods under future climate projections.

Preliminary results based on CMIP5 product



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