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Grid Operations, Decarbonization, Environmental and Energy Equity Platform
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Integration of Climate Forecasts in Bulk Power System Studies

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U.S. DEPARTMENT OF ENERGY
BATTELLE

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Assertions

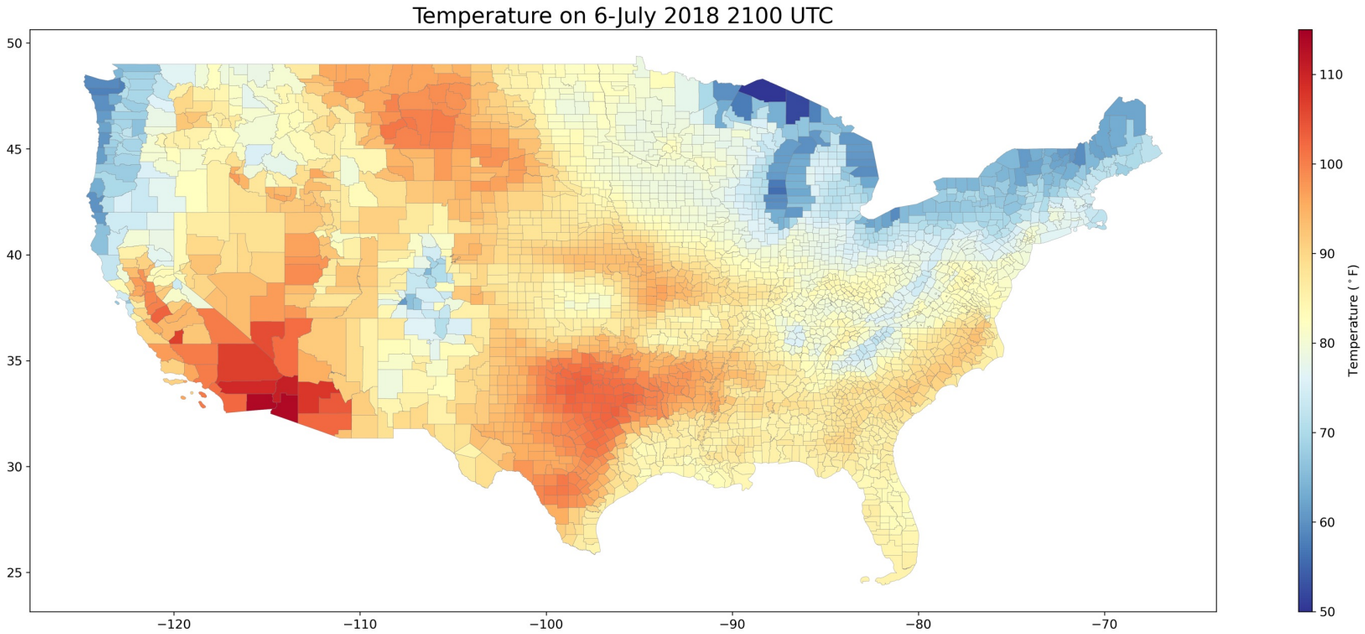
1. The existing grid is weather sensitive.
2. Weather characteristics (e.g., extremes) are changing rapidly.
3. The grid is also changing rapidly.
4. A high renewables grid will be even more weather sensitive.

LOS ANGELES | LOS ANGELES WEATHER

‘Unprecedented’ heat wave sets new records

Fire danger is high

By Elijah Chiland | Updated Jul 6, 2018, 5:43pm PDT | 30 comments



Thousands without power in Los Angeles after high demand due to heat wave

By Dakin Andone, CNN
Updated 8:19 PM EDT, Sat July 7, 2018

Records Broken as Heat Wave Bakes Southern California

• Edited By: Naqshib Nisar • Reuters • Last Updated: JULY 07, 2018, 12:56 IST

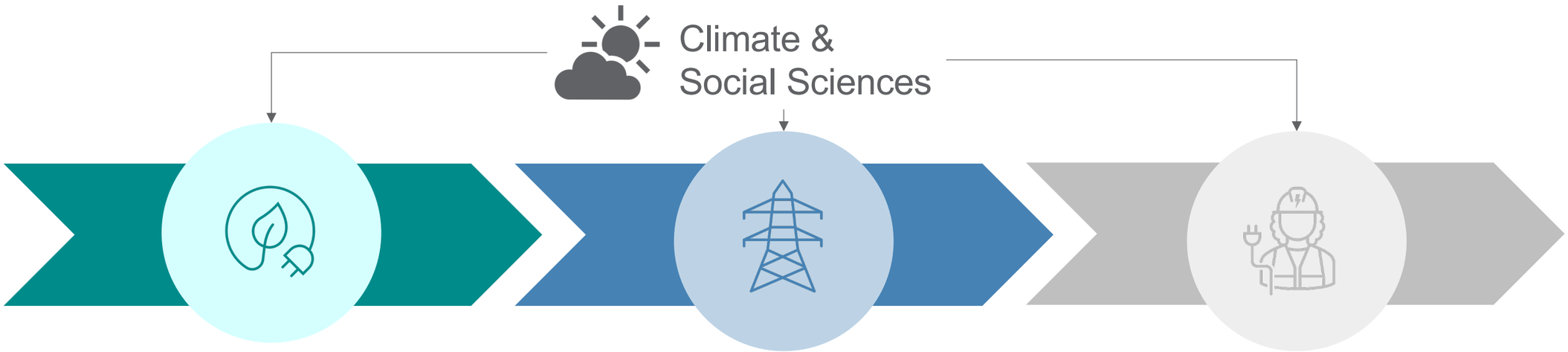
High temperatures will exceed 100 degrees Fahrenheit (37 Celsius) in Los Angeles and San Diego on Saturday, the National Weather Service said in a series of excessive heat warnings and advisories.

Key Messages

To assess the resilience and reliability of the bulk power system, it is critical to evaluate system performance:

1. With coincident load-wind-solar-hydro conditions;
2. Across a wide range of historical and projected weather conditions.

Consistent Integration of Climate Information Throughout the Long-Term Planning Process



Preferred Portfolio

Define the portfolio of scenarios that will guide long-term planning

Infrastructure Planning & Siting

Analyze resource adequacy under seasonal representative stress events

Operations Planning & Investment

Evaluate reliability, economic feasibility, and market incentives for least-cost, resilient operations

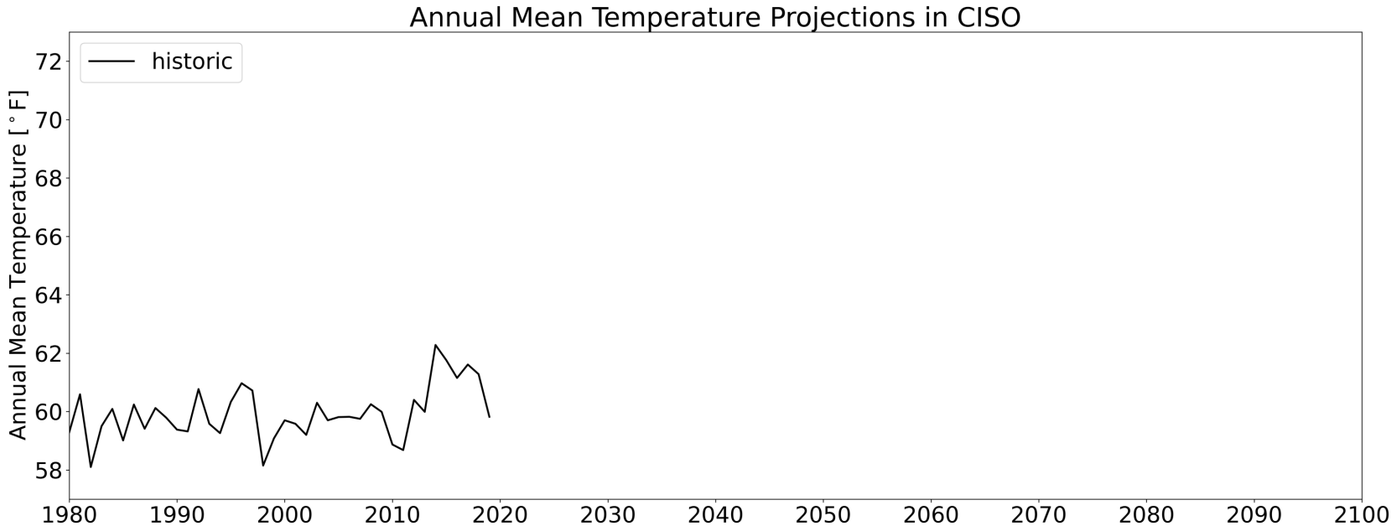
Datasets

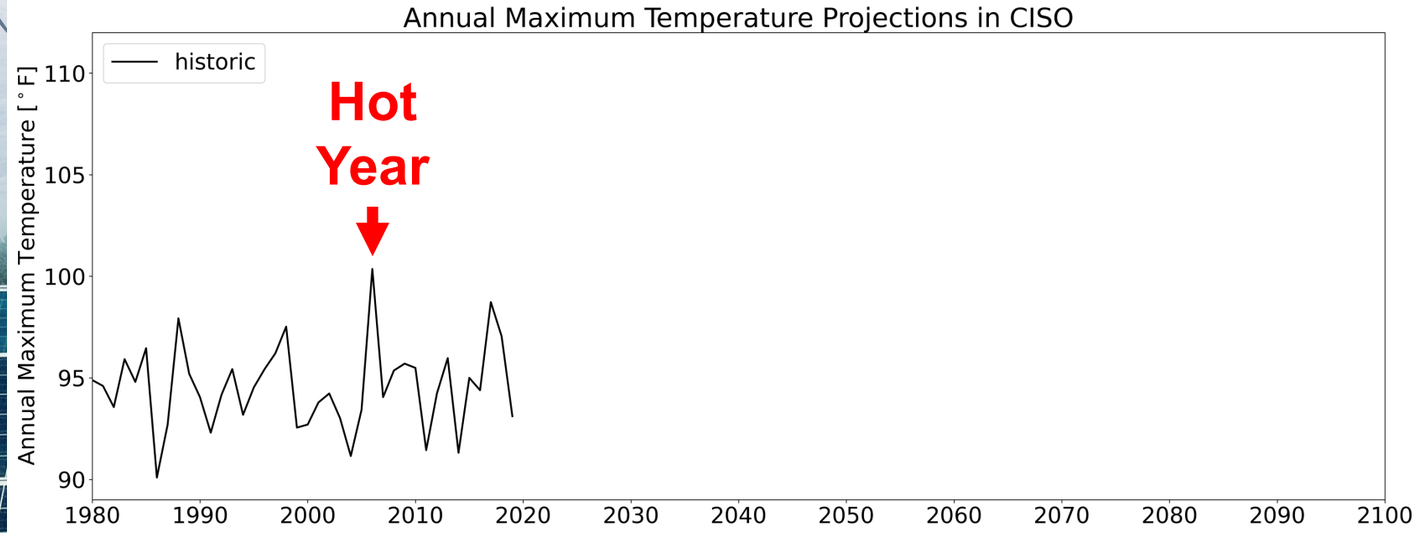
Climate scenarios, taxes and incentives, market structures, net-zero, technology innovation

10, 20, and 30 year buildouts; wind, solar, load, and hydropower datasets; fuel prices

Electricity prices, technology-specific operations, transmission, storage, key performance

U.S. Climate Projection Dataset





- Historic data reproduces observed sequence of past events (1980–2019)
- Sequence is repeated twice in the future (2020–2059 and 2060–2099) with additional warming gradually applied
- 1/8 deg (~12 km) resolution, U.S., hourly
- 25 hourly and 250+ three-hourly variables
- Output is first spatially-averaged by county then population-weighted to create annual 8,760-hr meteorology time series for 54 BAs across the U.S.

Climate data was developed with DOE Sc funding and is publicly available:
https://data.msdlive.org/records/cnsy6-0y610

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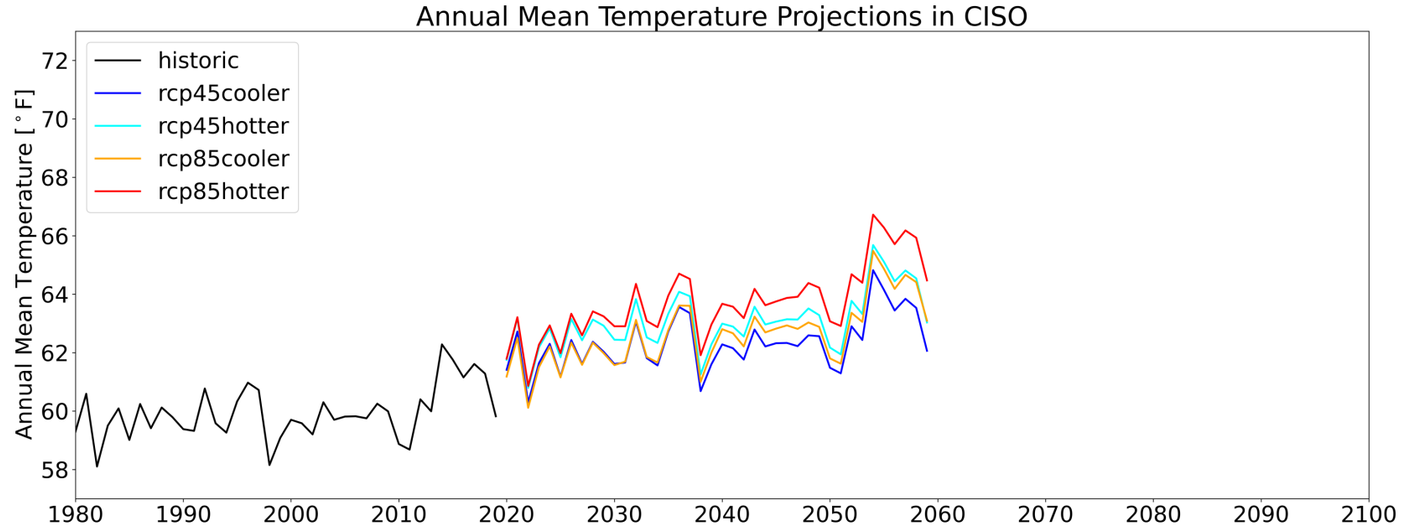

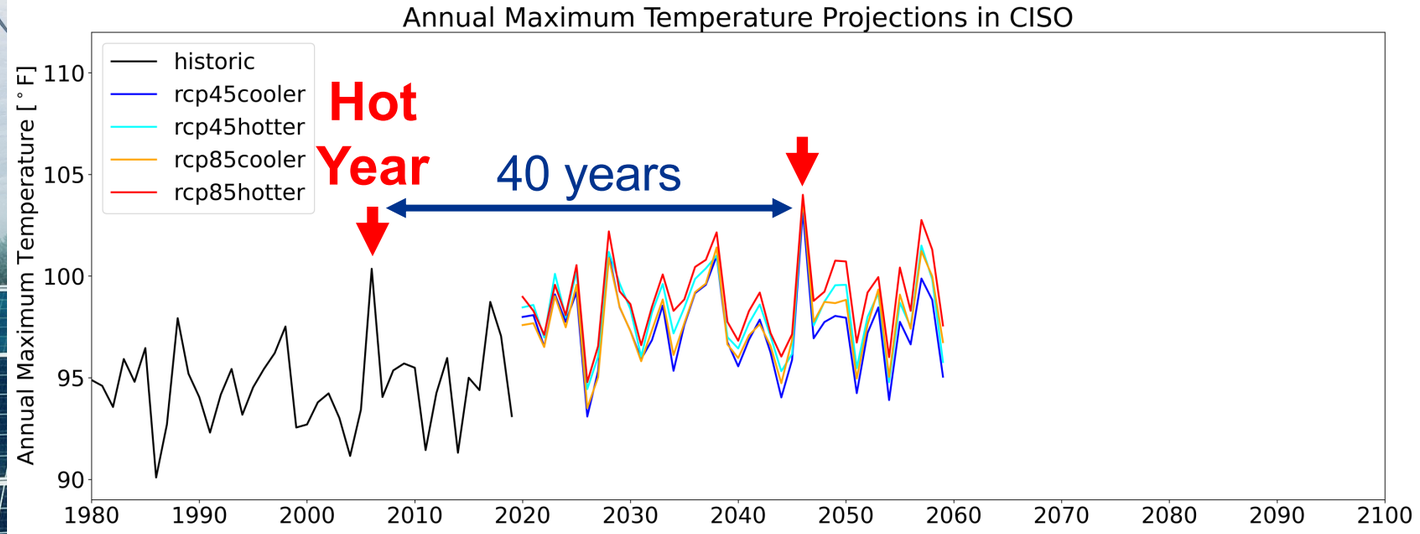

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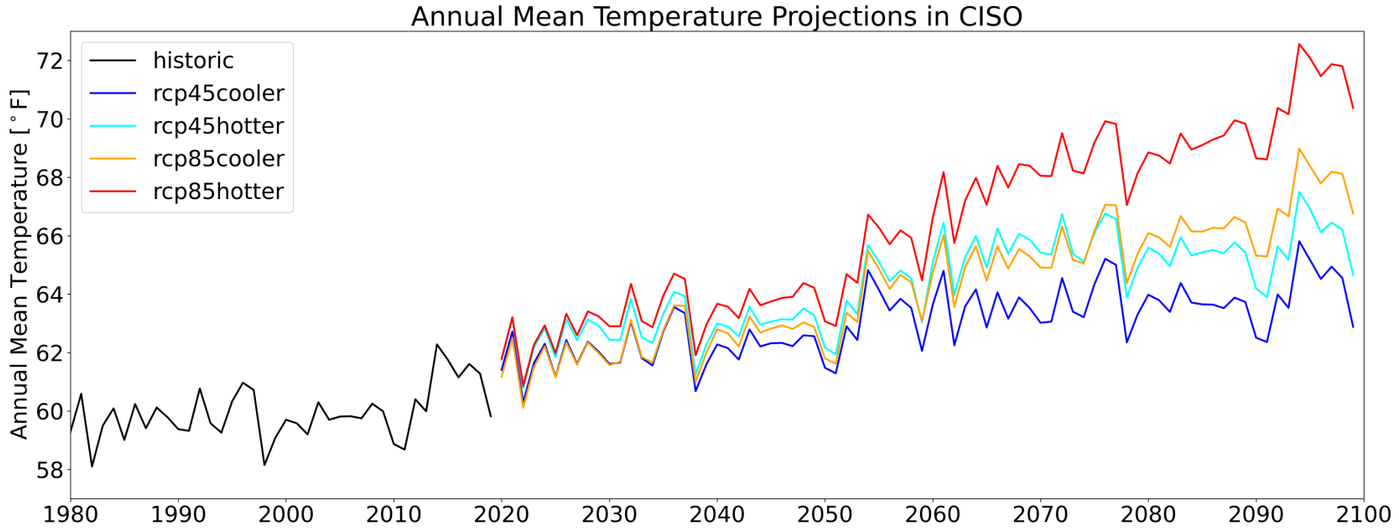

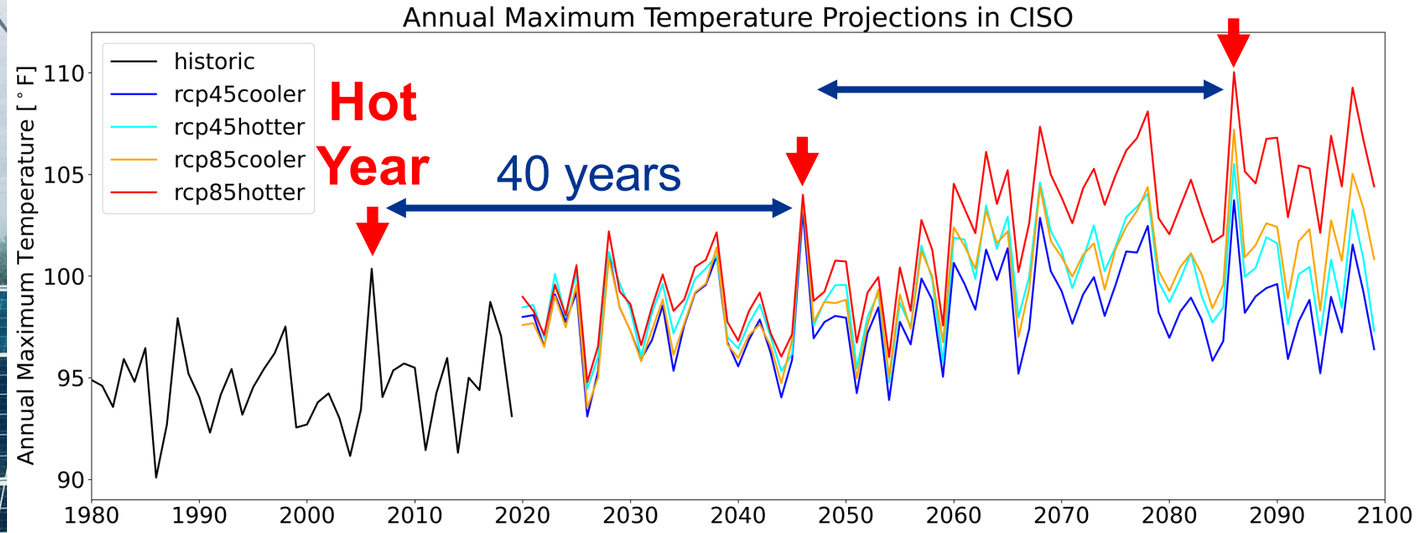

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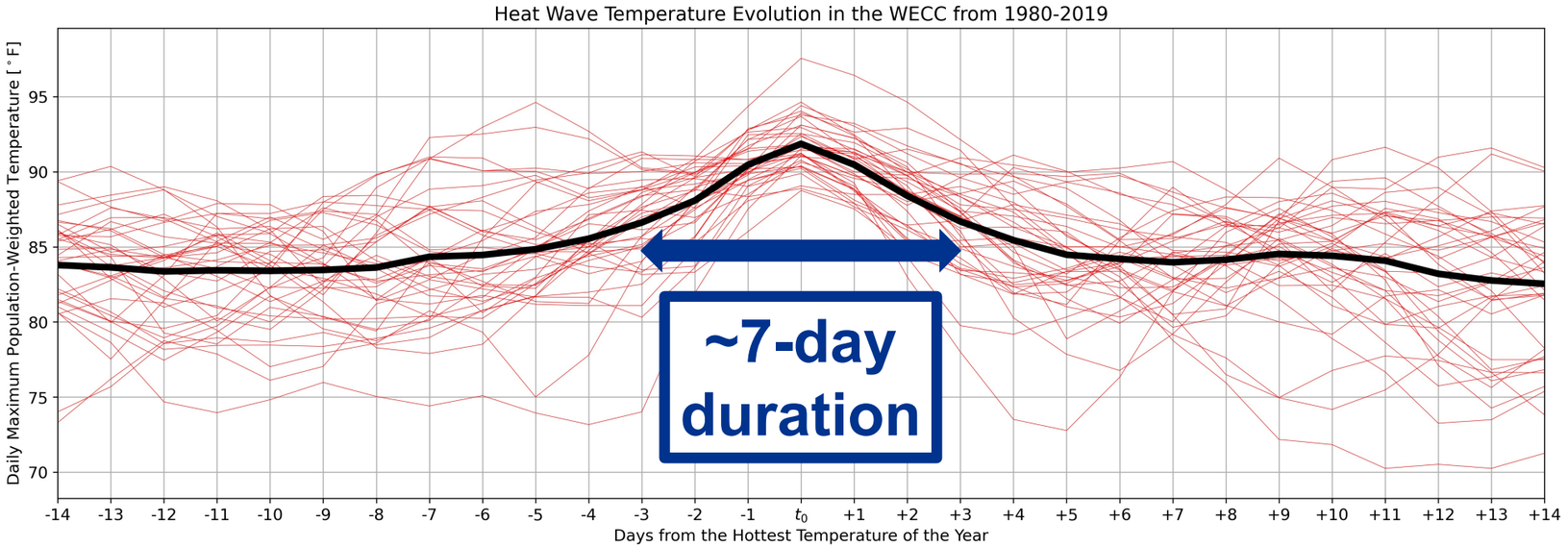
Designing Stress Tests Based on Heat Wave Dynamics



Typical heat waves last ~6-7 days and are, on average, symmetric about the maximum temperature day.

Designing Stress Tests Based on Heat Wave Dynamics

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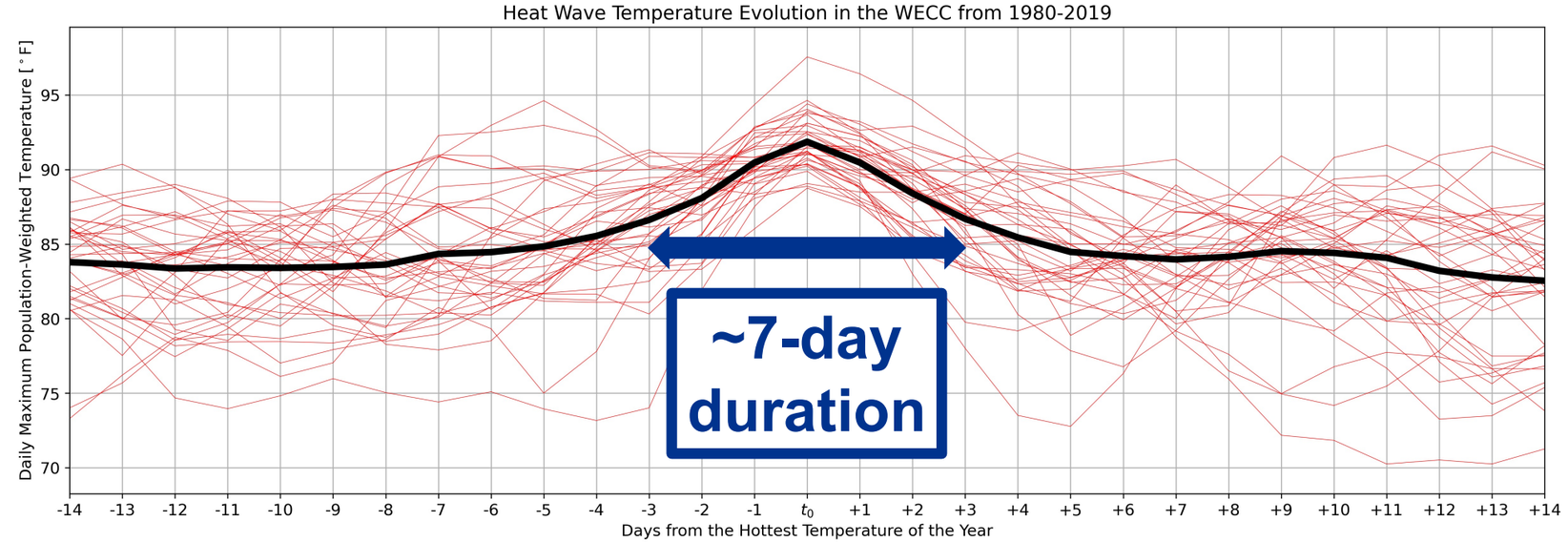
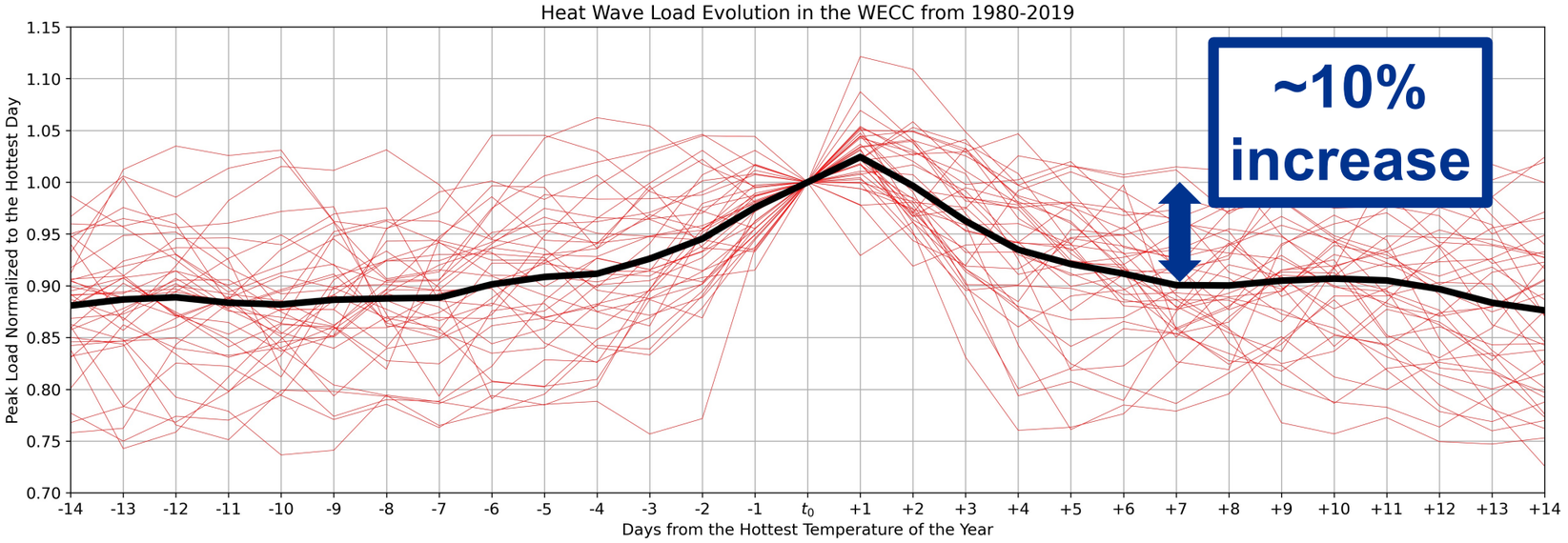
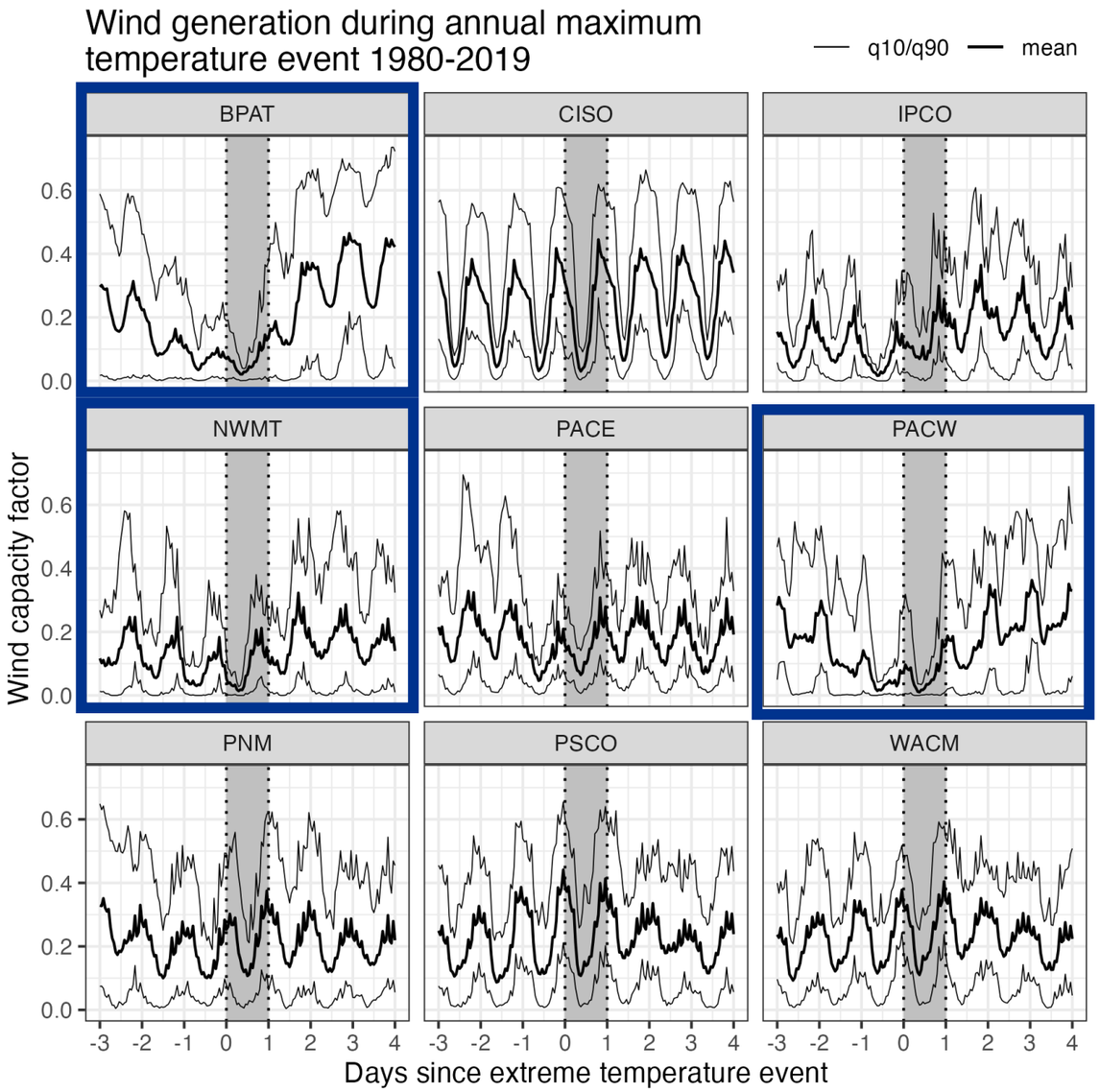




Heat waves increase peak loads by ~10% on average compared to the background peak loads.

Notable Suppression of Wind Generation During Heat Waves



BAs in the Pacific Northwest (e.g., BPAT, PACW, and NWMT) show notable suppression of wind generation during heat waves.

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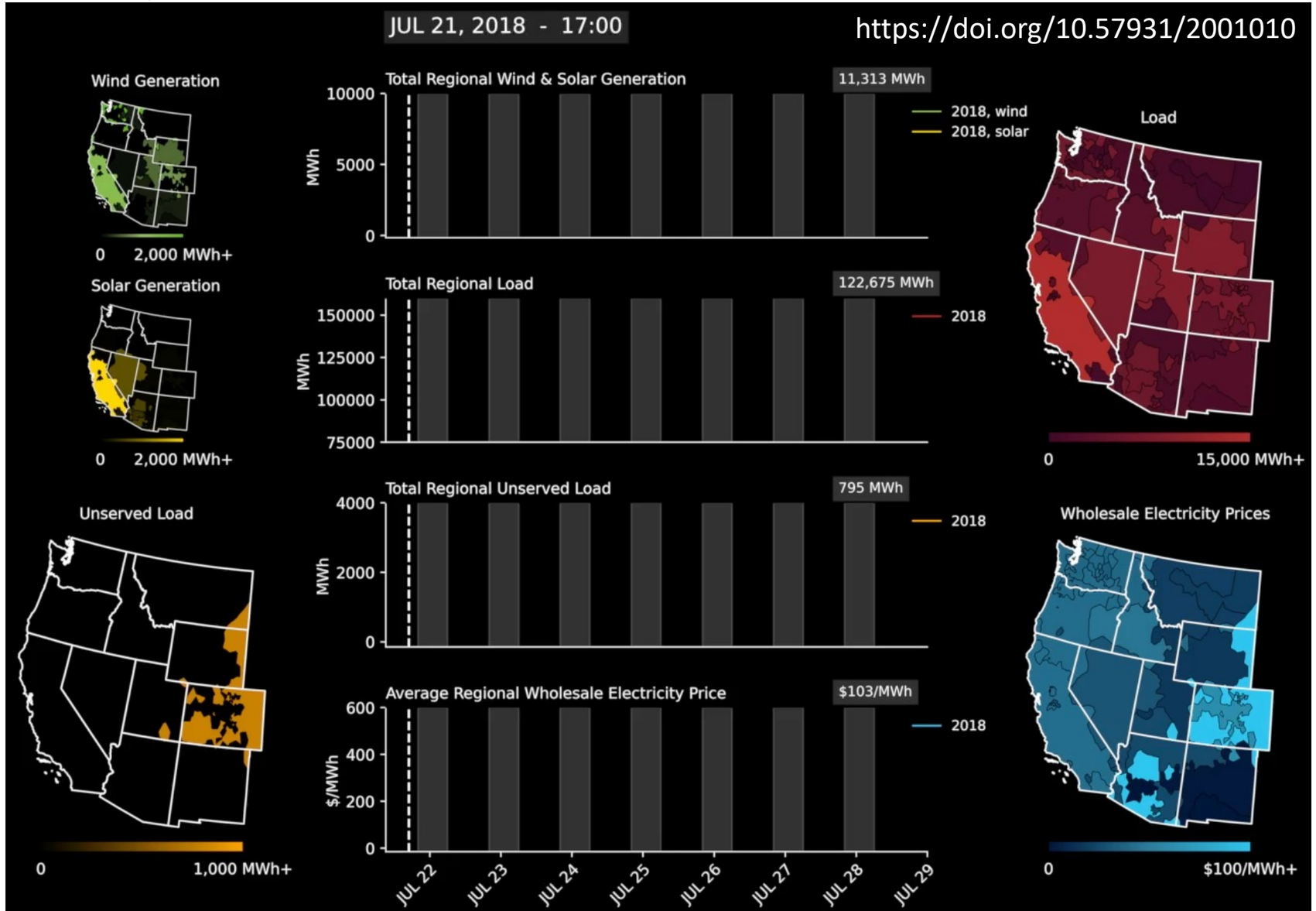
Exploring Historical Heat Wave Grid Stress



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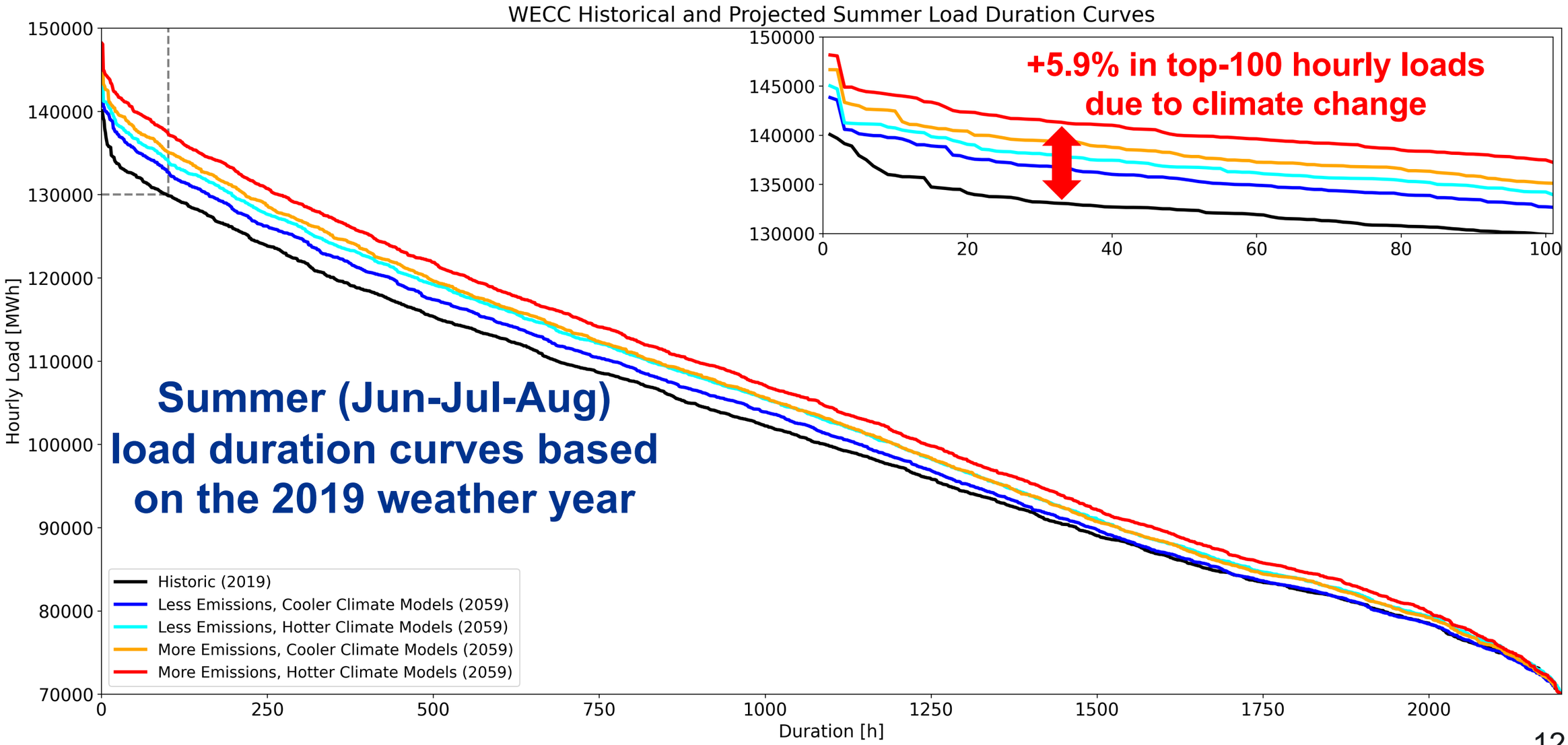
What About Future Heat Waves?



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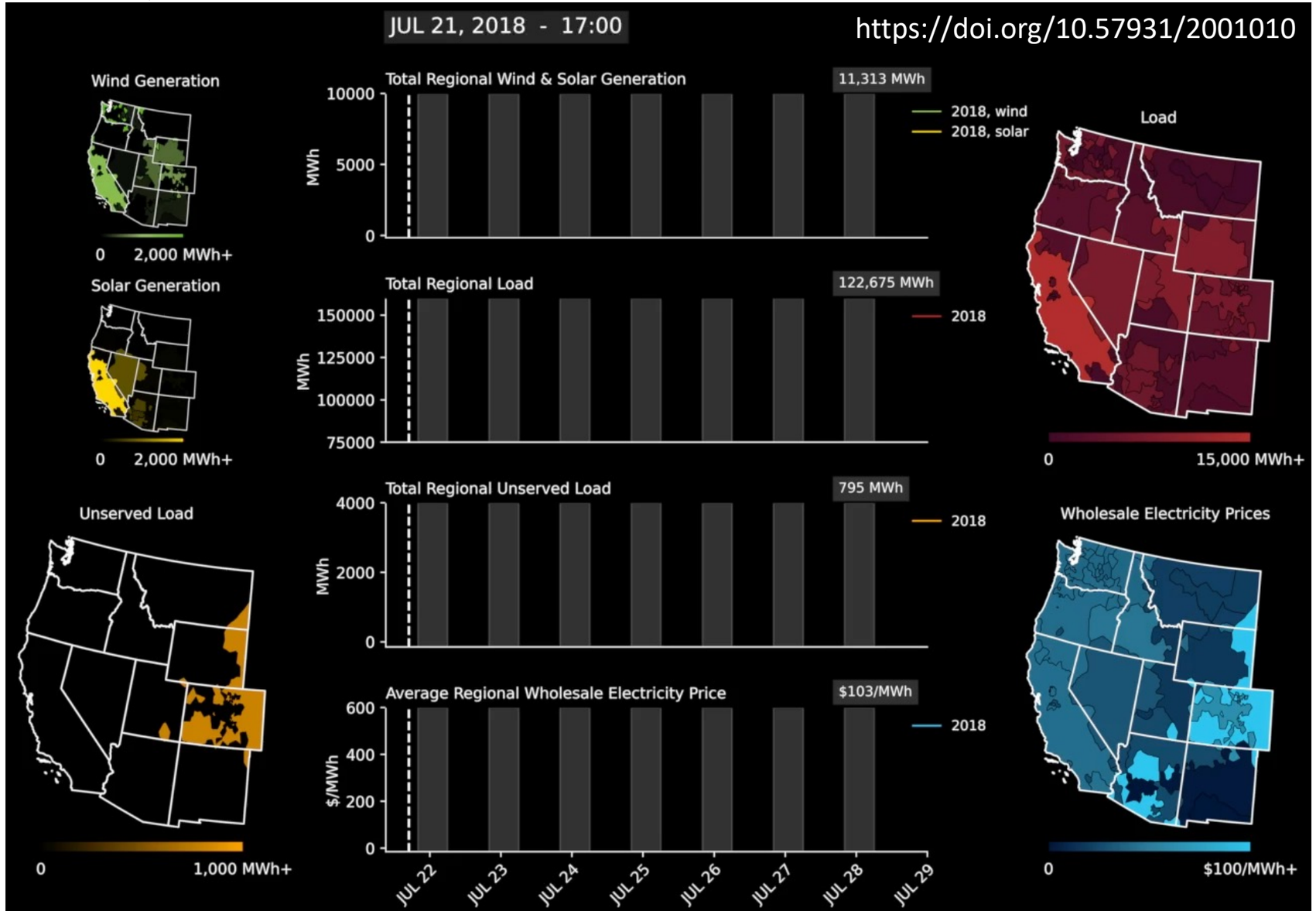
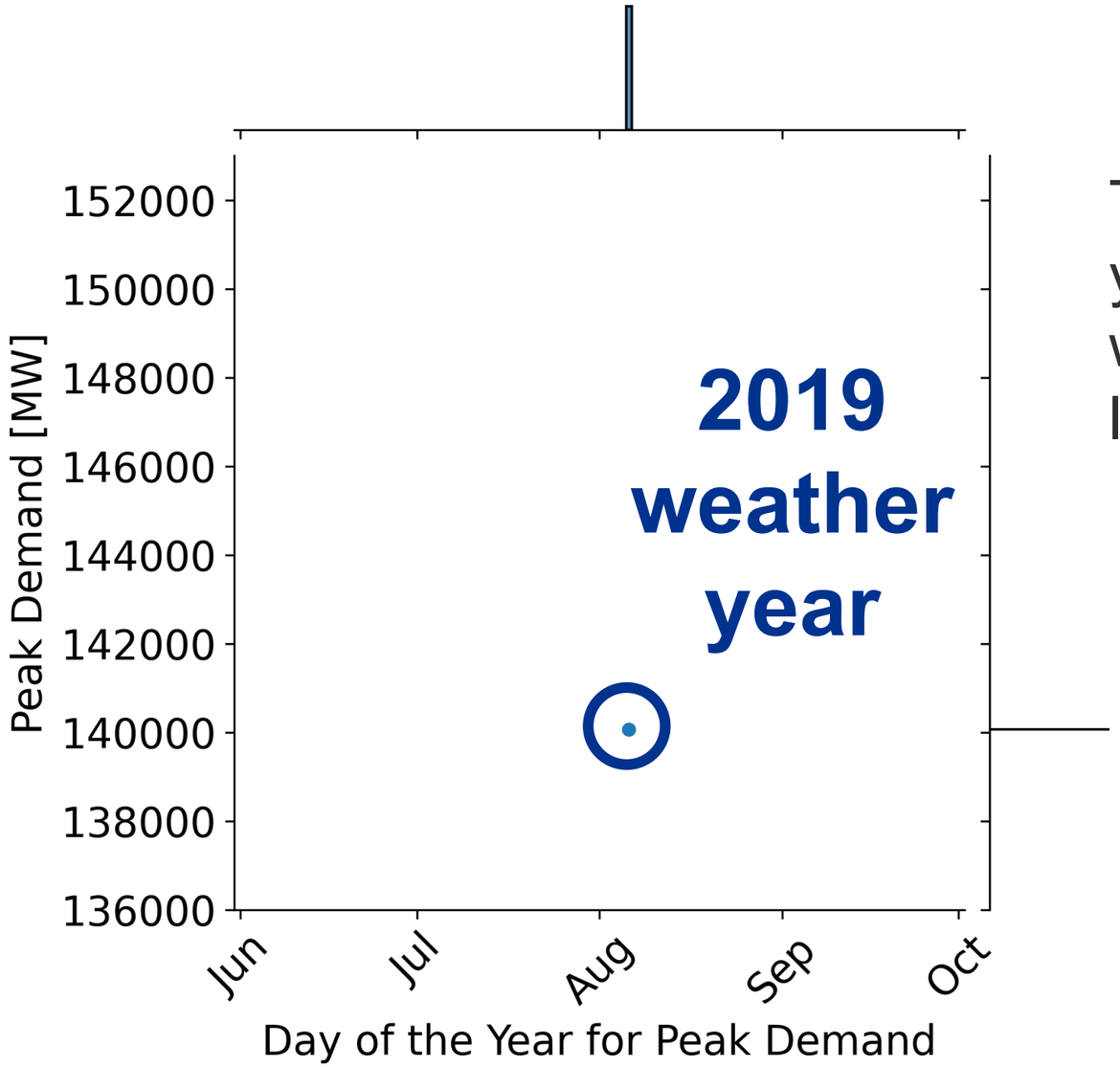
Exploring Future Heat Wave Grid Stress



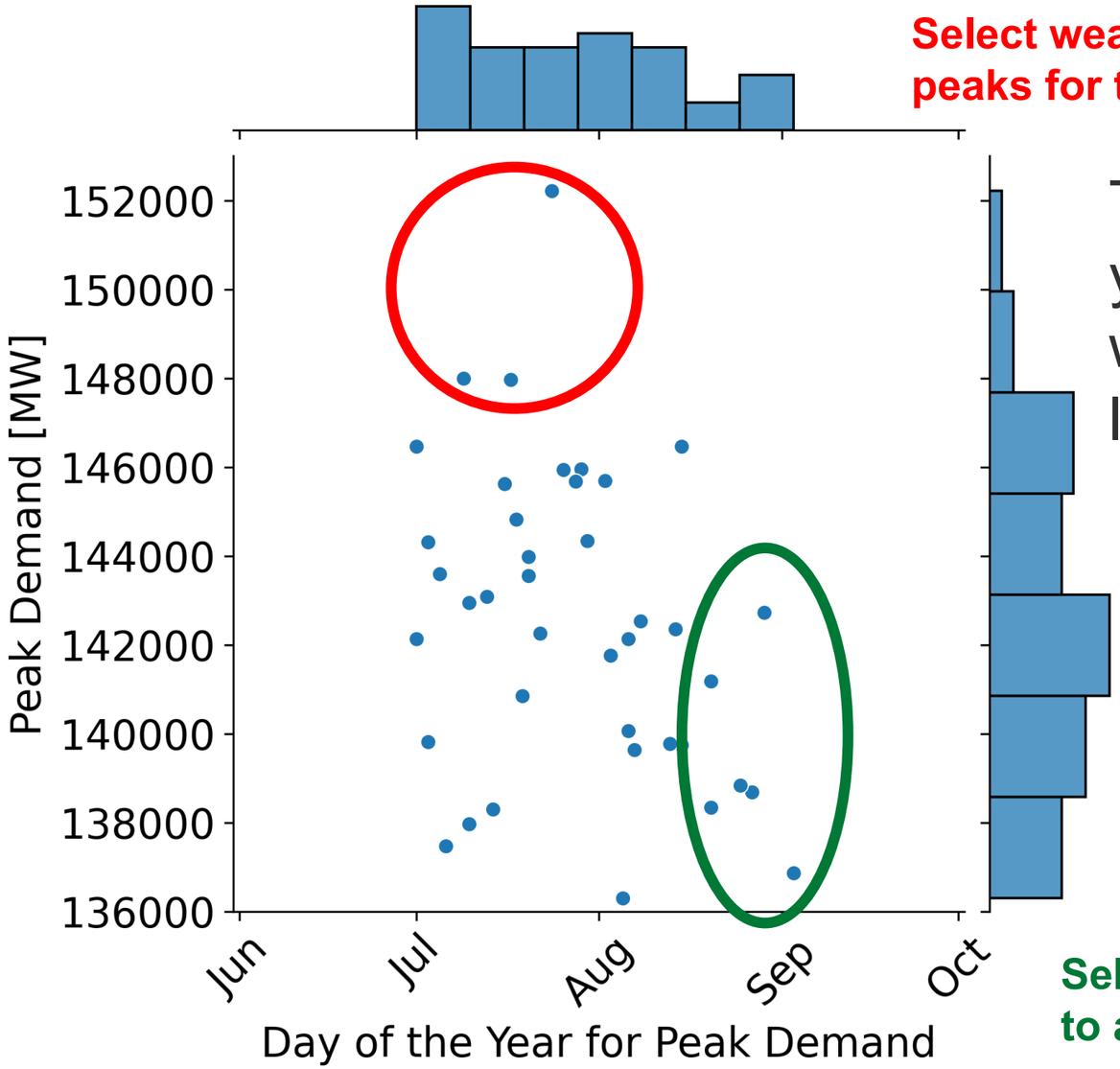
Simulating Multiple Weather Years to Explore Uncertainty



The prior example used a single weather year, but we can run many unique weather years through PNNL's wind, load, and solar models:

- All years have the same total annual energy consumption by design
- Absolute magnitude and timing of peak demand varies significantly depending on the weather each year

Simulating Multiple Weather Years to Explore Uncertainty



Select weather years with extreme peaks for testing resilience…

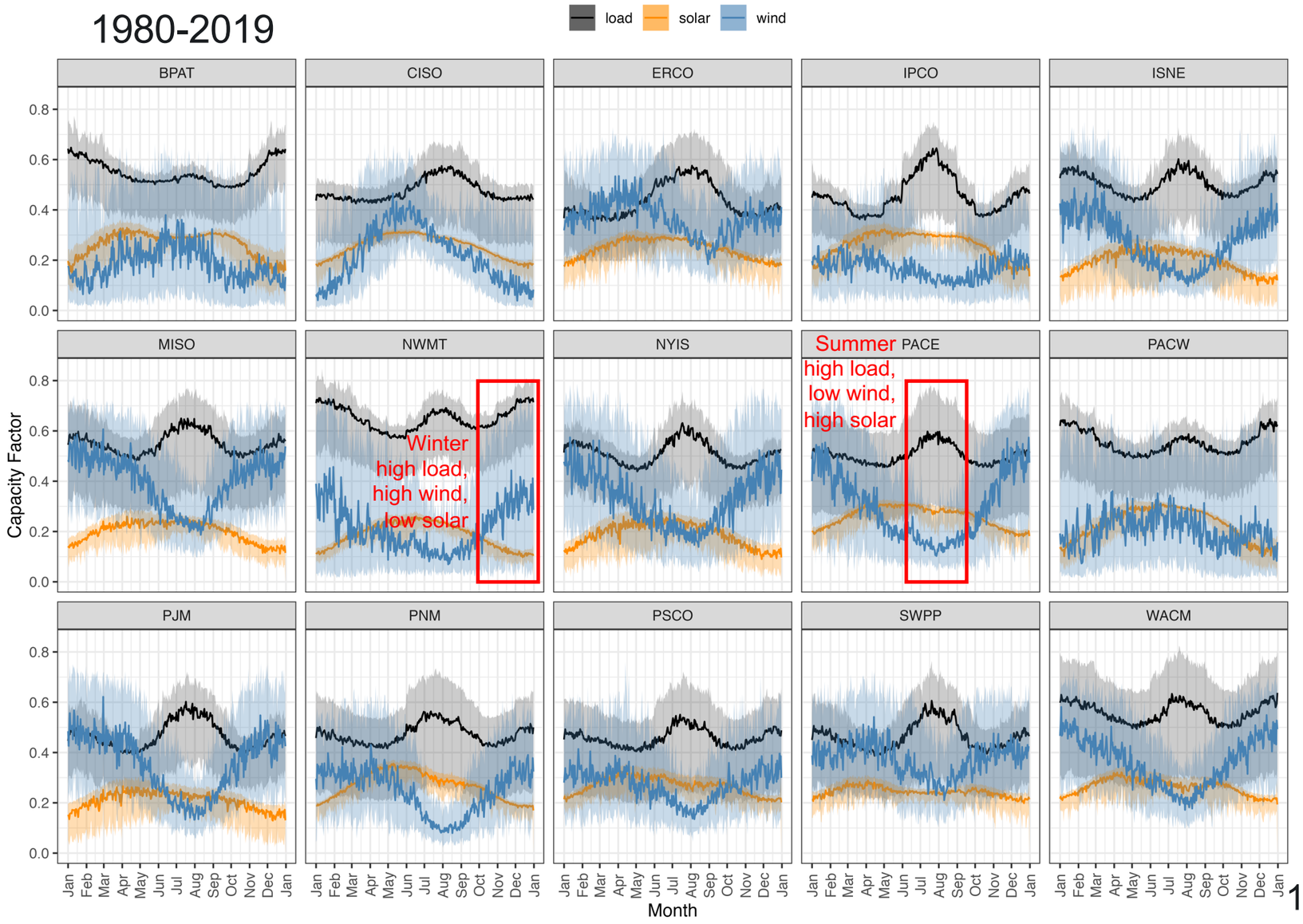
The prior example used a single weather year, but we can run many unique weather years through PNNL's wind, load, and solar models:

- All years have the same total annual energy consumption by design
- Absolute magnitude and timing of peak demand varies significantly depending on the weather each year

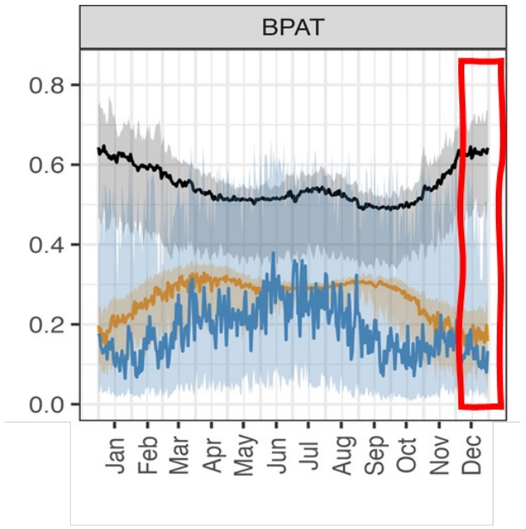
Select weather years with late season peaks to assess reliability with low hydro…

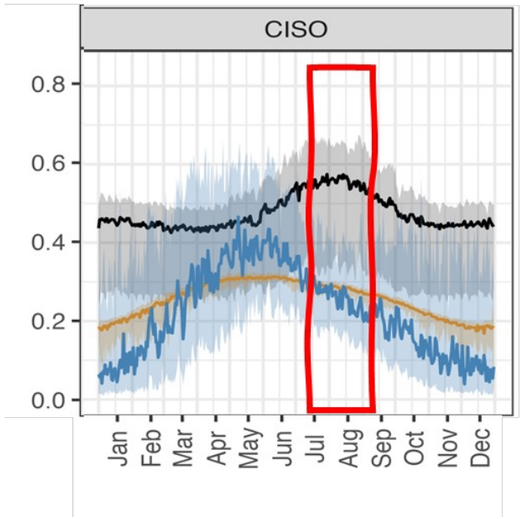
Wind Solar and Load Cycles Vary Depending on the Region and Season

At the seasonal time scale, there is often complementarity between wind and solar to address high load periods. For seasonal droughts, hydro, natural gas and transmission also need to be considered.

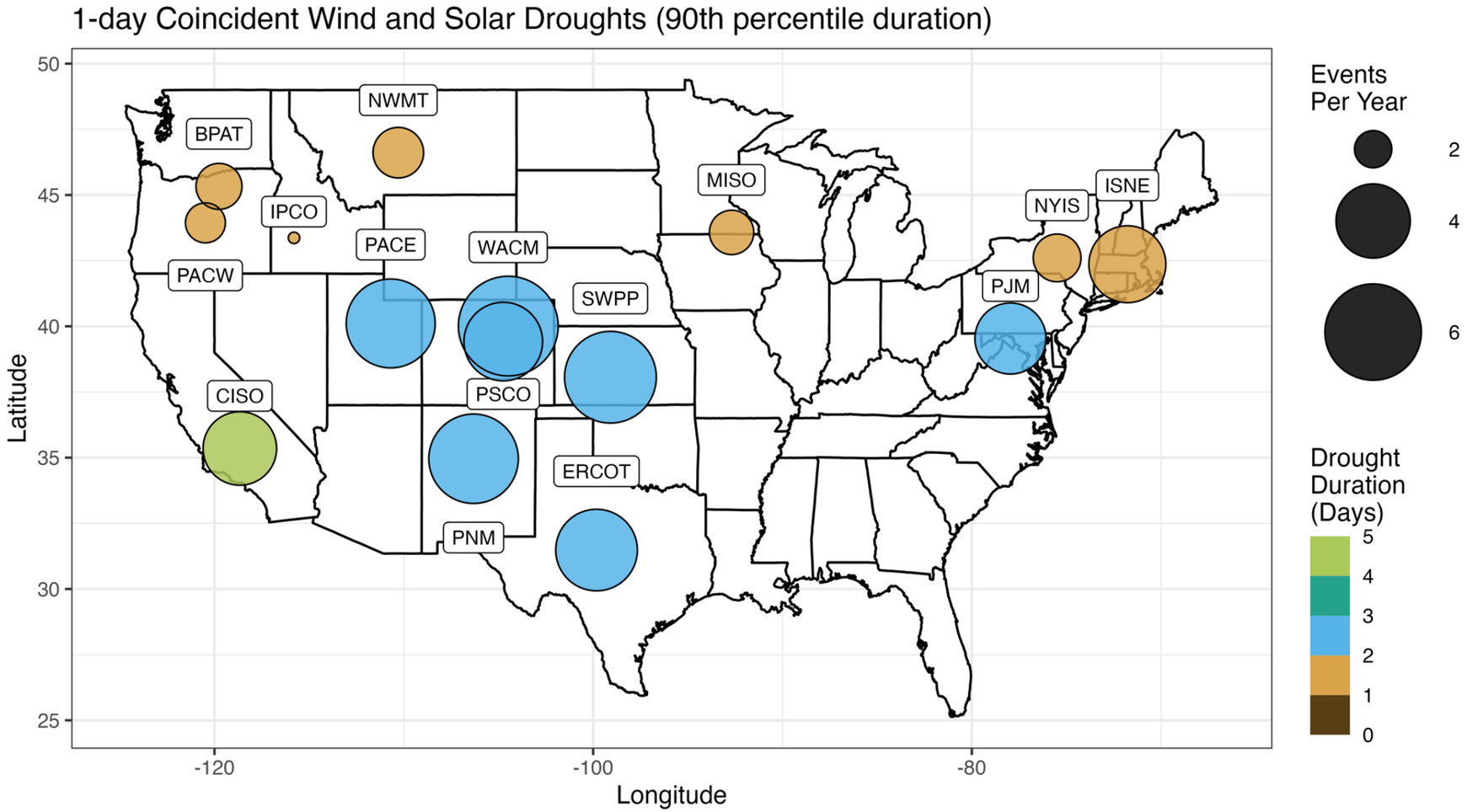


Coincident Datasets Help Identify Periods of Potential Stress



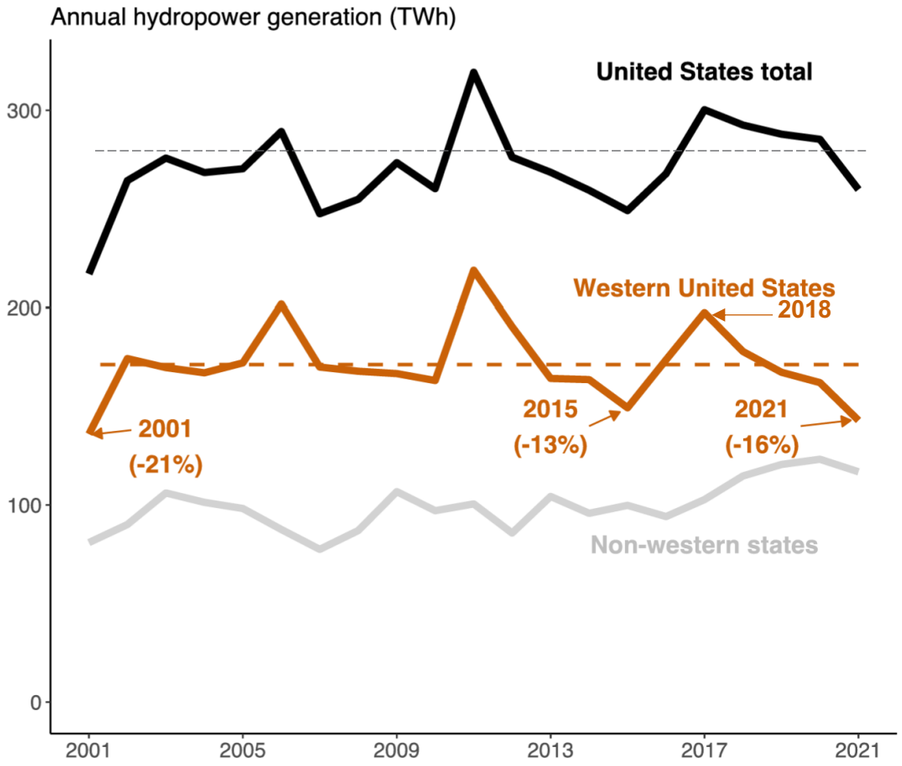


Bracken et al. (in revision)

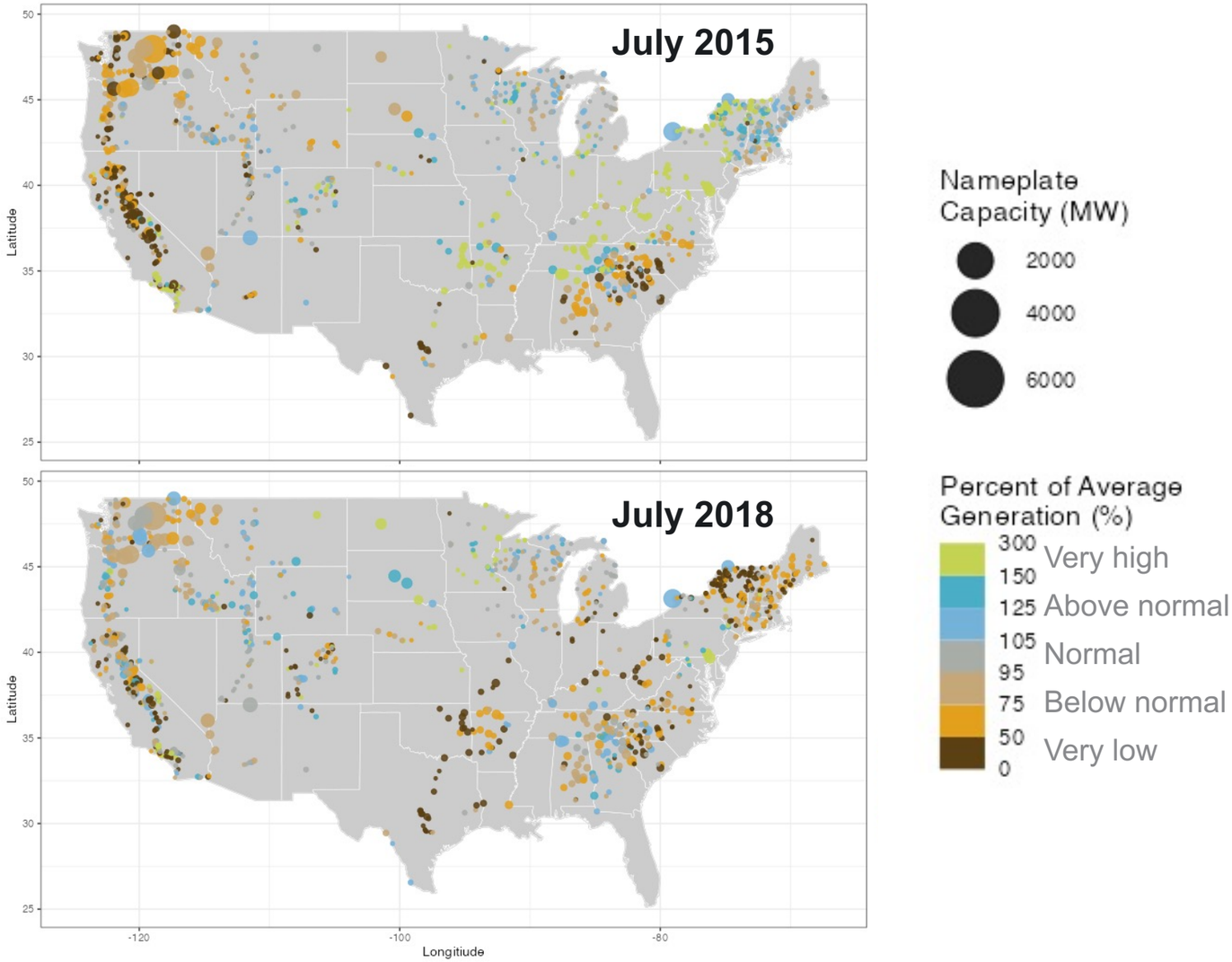


Energy droughts help understand storage and regional transmission needs and whether market mechanisms incentivize those operations.

Hydropower Datasets Are Available for Input Into Power System Models



Interannual variations in hydropower generation are expected and need to be considered in power system studies.



July hydropower generation by power plant. Hydropower datasets include weekly potential generation and flexibility.

Sharing Data and Models

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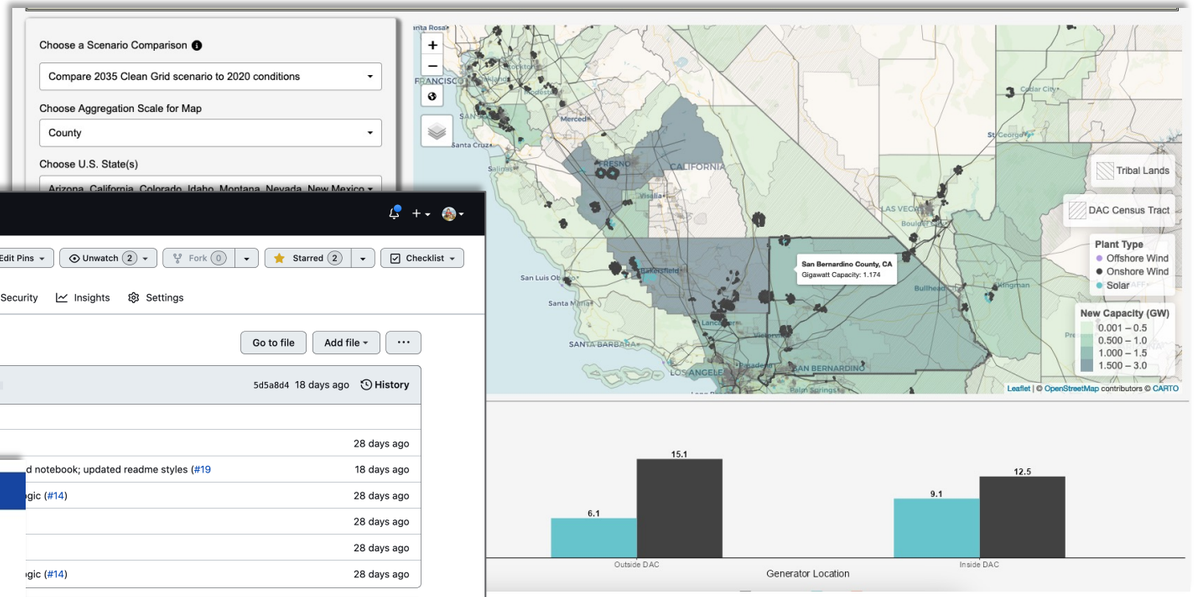
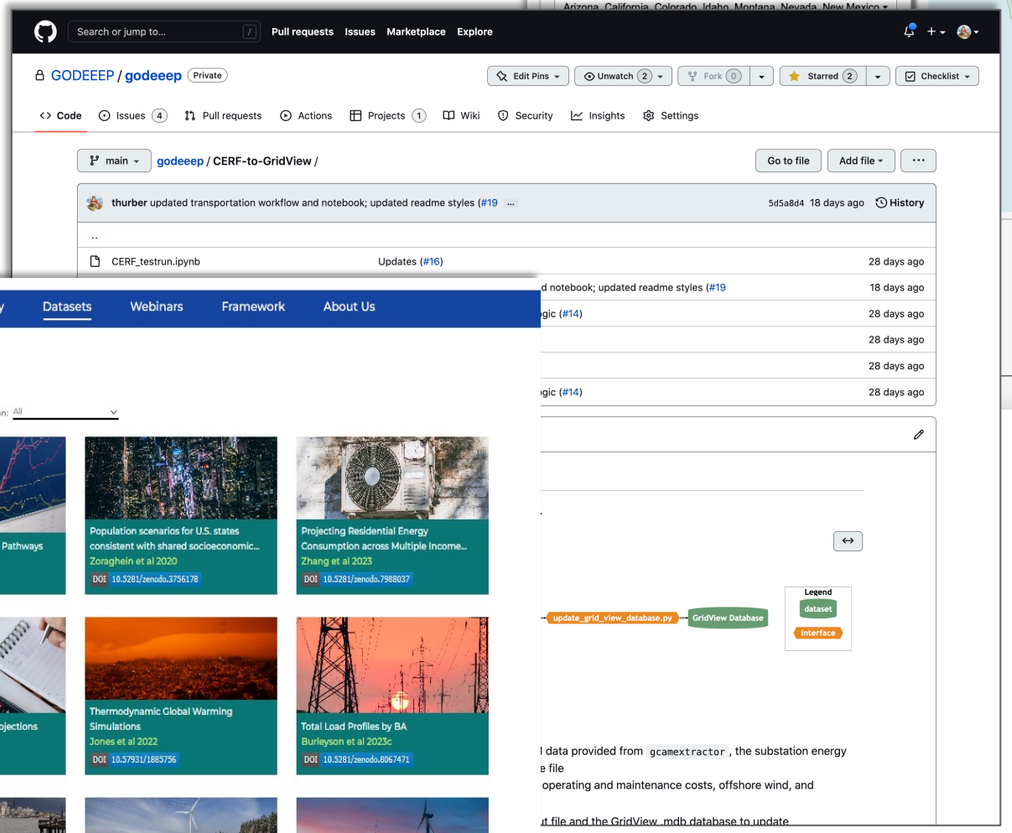
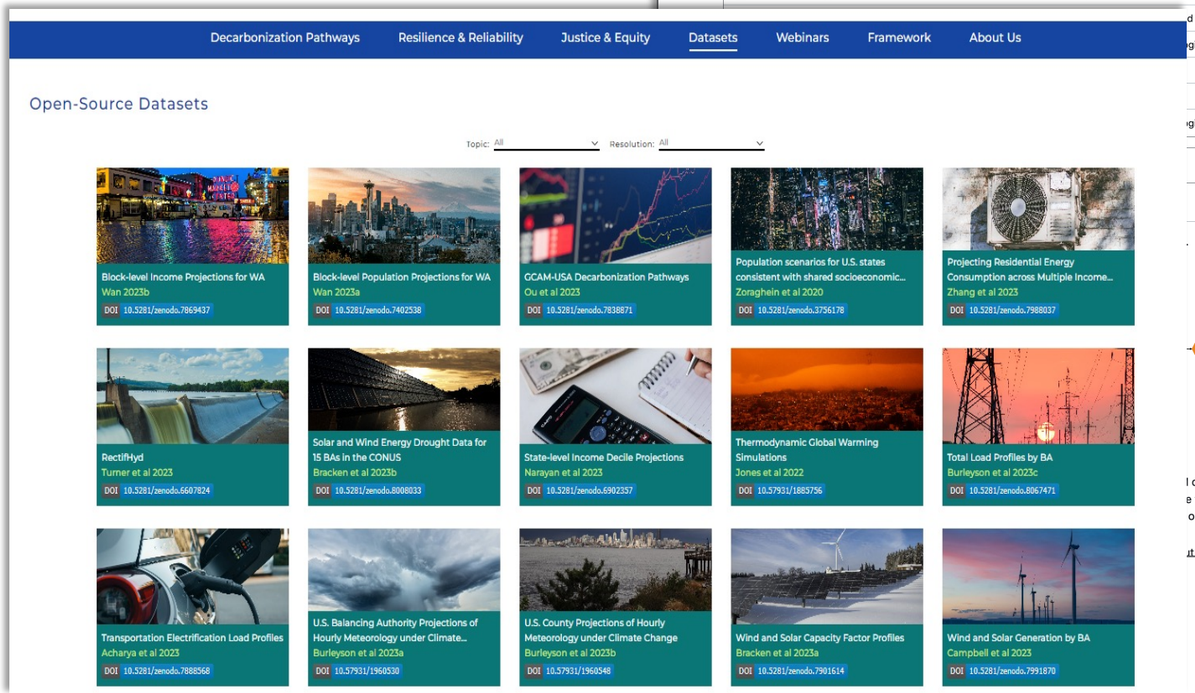
Open-source, vetted datasets are available in multiple formats in support of targeted questions by industry.







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Key Messages and Results

- To assess the resilience and reliability of the bulk power system, it is critical to evaluate system performance with coincident load-wind-solar-hydro conditions and across a wide range of historical and projected weather conditions.
- We are translating scientific understanding into actionable power-system relevant data and insights for use in long-term planning.
- The conditions that stressed your system in the past may not be the ones that stress your system in the future.
- Innovations:
  - Spatially- and temporally-coincident load, wind, and solar data
  - Capture consistent and realistic impacts on electricity supply and demand for use in stress testing projected infrastructure
  - Quantitative characterization of wind and solar droughts