Renewables in recent and future heat waves

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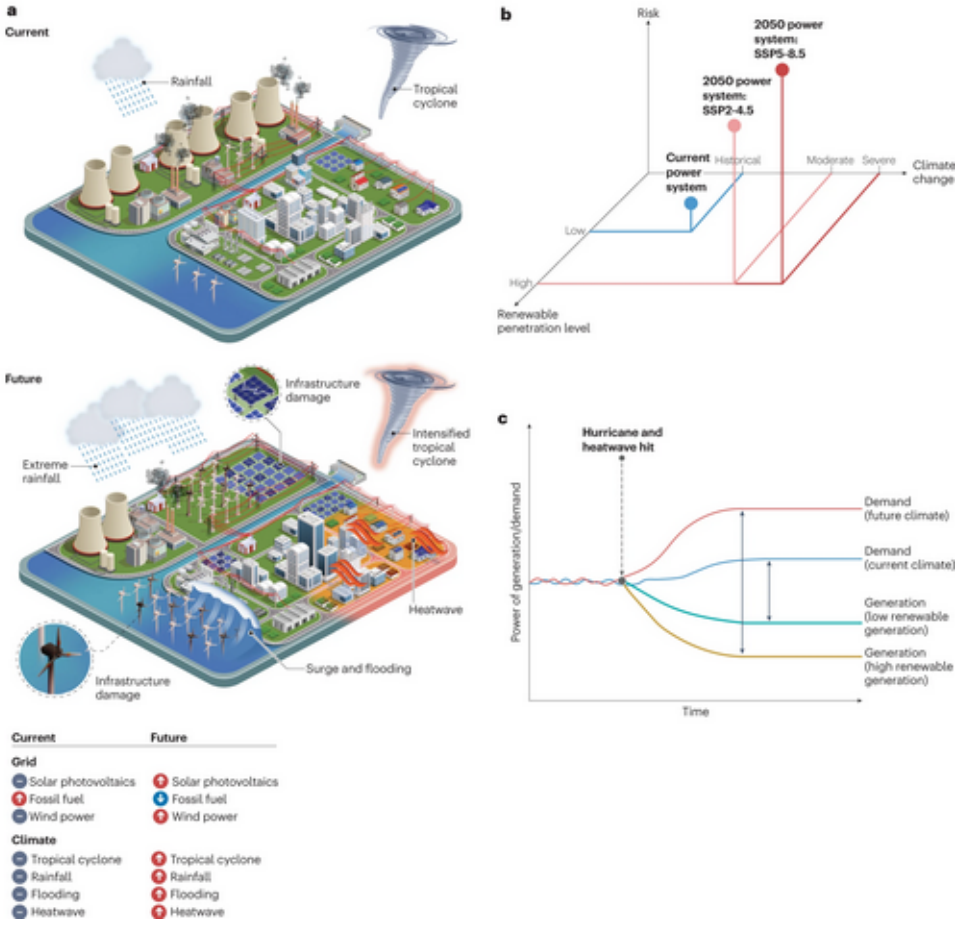
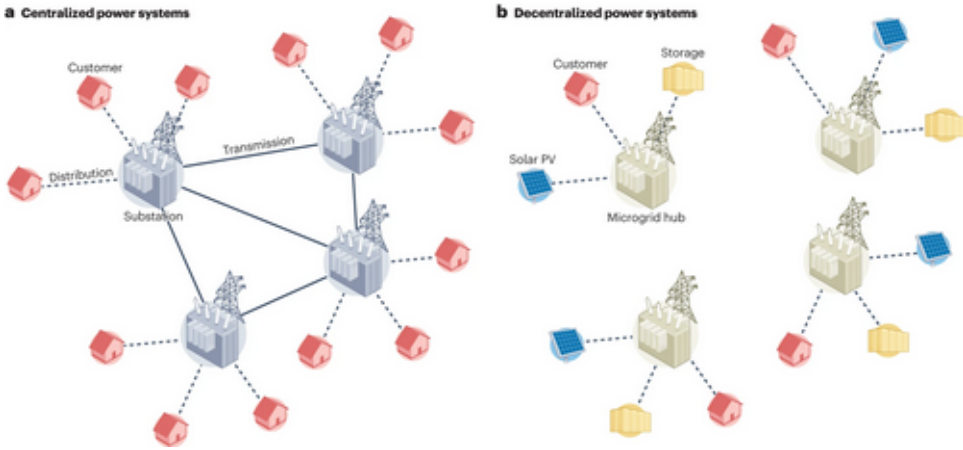
Motivation

- Resilience of the electric grid, amid increasing demand, is a growing concern
- 2023 saw the largest-ever number of billion-dollar weather disasters (NOAA)
  - Southern / Midwestern summer drought and heat wave was the nation’s costliest and most deadly
  - Record hot in Texas (and globally)
- Climate can stress the electric grid, and also affects renewable energy

Resilience of renewable power systems under climate risks

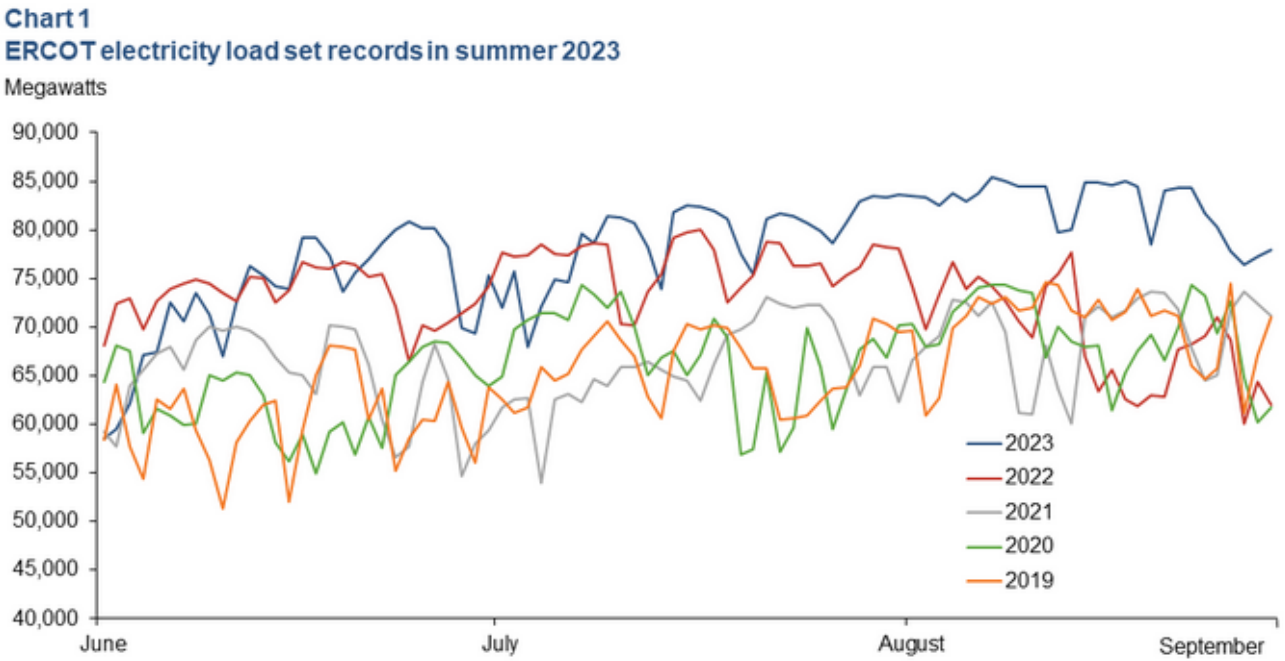




Xu et al. 2024

The experience of Texas

Chart 1
ERCOT electricity load set records in summer 2023

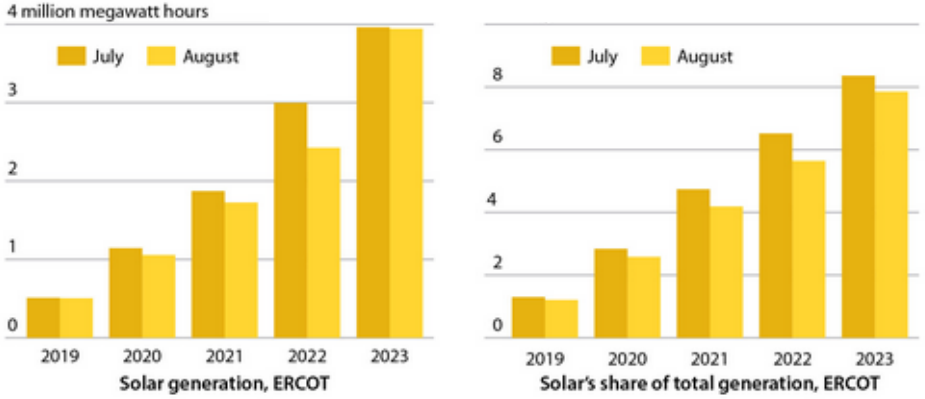


Dallas Fed: Record-breaking Texas summer heat tests the grid, ERCOT operations

Solar Generation in Texas

Solar generation in ERCOT, the r
growth. Shown here are figures

NOTE: Figures are observed daily peak hourly load, normalized to the first Sunday of June.
SOURCE: Electric Reliability Council of Texas.

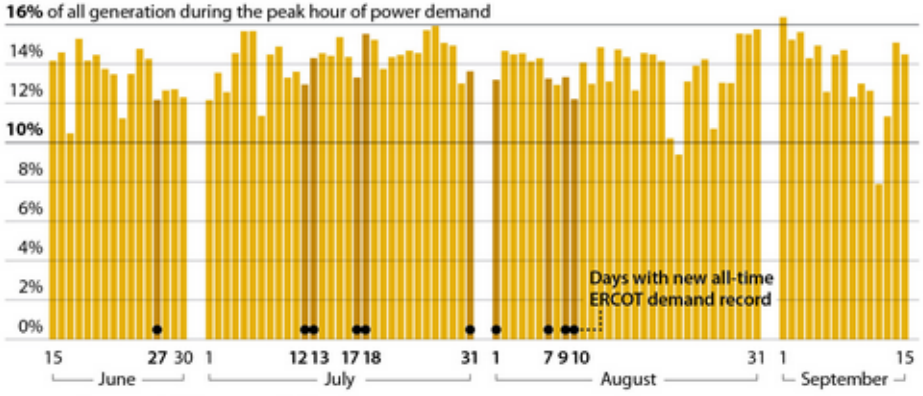


Source: Electric Reliability Council of Texas IEEFA

Federal Reserve Bank of Dallas

Texas Solar Generation During Peak Electricity Demand Hour

Utility-scale solar consistently provided between 10% and 16% of the electricity needed in ERCOT during the critical peak hour on 91 out of 93 days between June 15 and September 15.



Source: Electric Reliability Council of Texas IEEFA

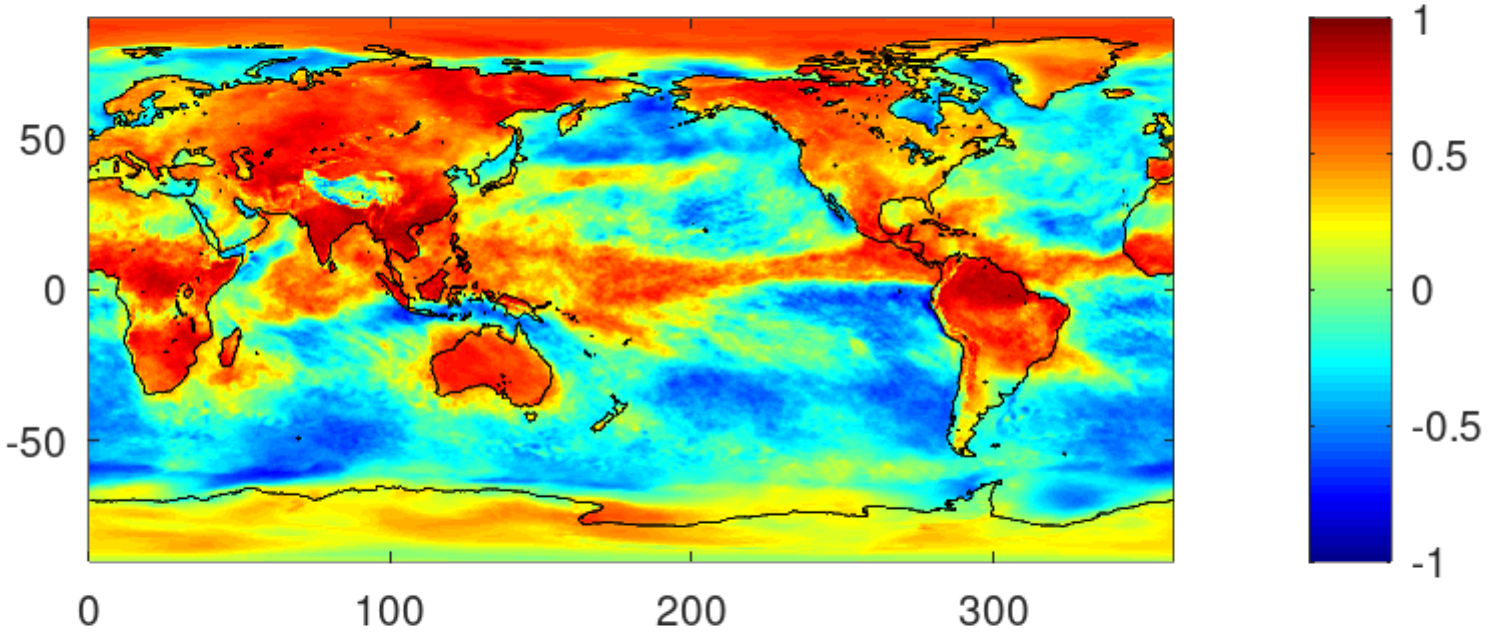
Plus: Considerable wind in evenings
Battery storage capacity ramping up

IEEFA:
Solar delivers for the Texas grid: Reliable output at peak demand

How does this work across geographies?

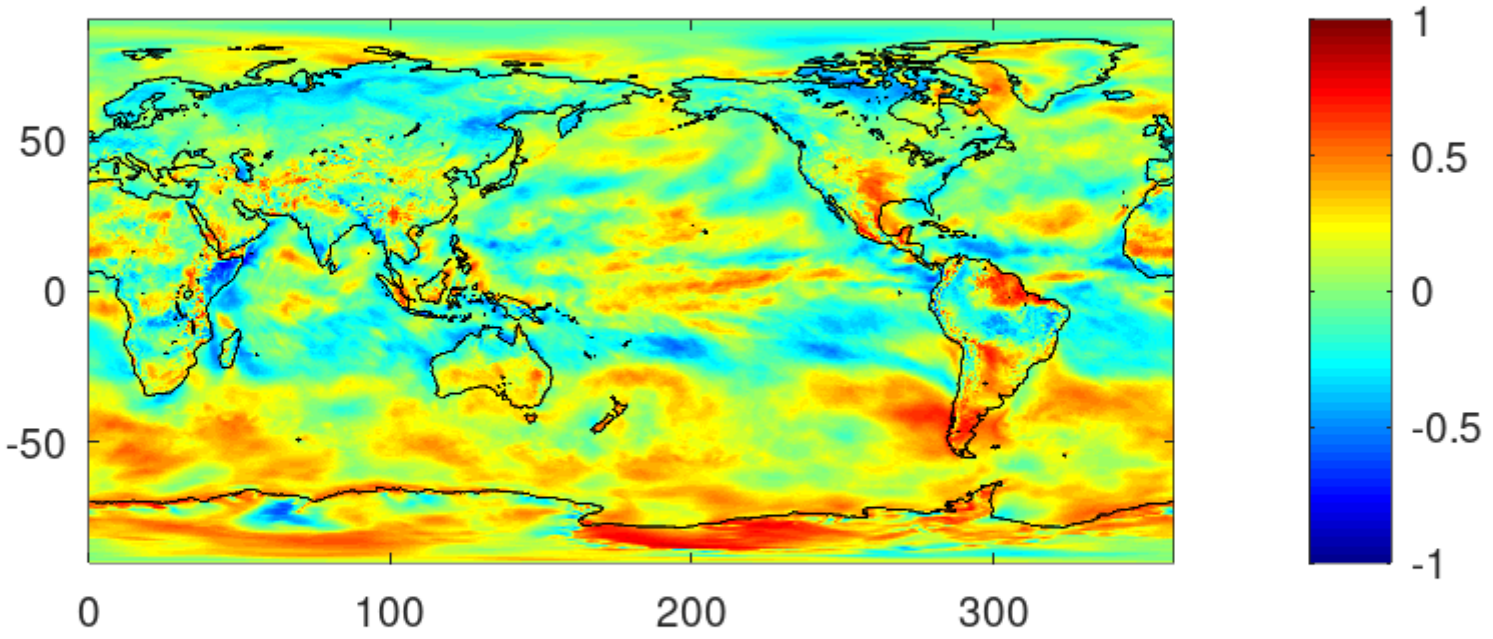
- Using daily summer 2023 data from EIA, the correlation between electricity demand and solar generation was 0.56 in Texas, but 0.17 in NY and 0.00 in CA
- Need to understand the behavior of solar power, as well as wind, during the hottest days
- I mapped the correlation between daily temperature, solar radiation, and wind for June-September 2023 using ERA5

Temperature vs. insolation



Most land areas, including southern and interior US: strong positive correlation
Most ocean areas (outside monsoon region): negative correlation
Southwest, Northeast, Midwest US: weak positive correlation

Temperature vs. wind

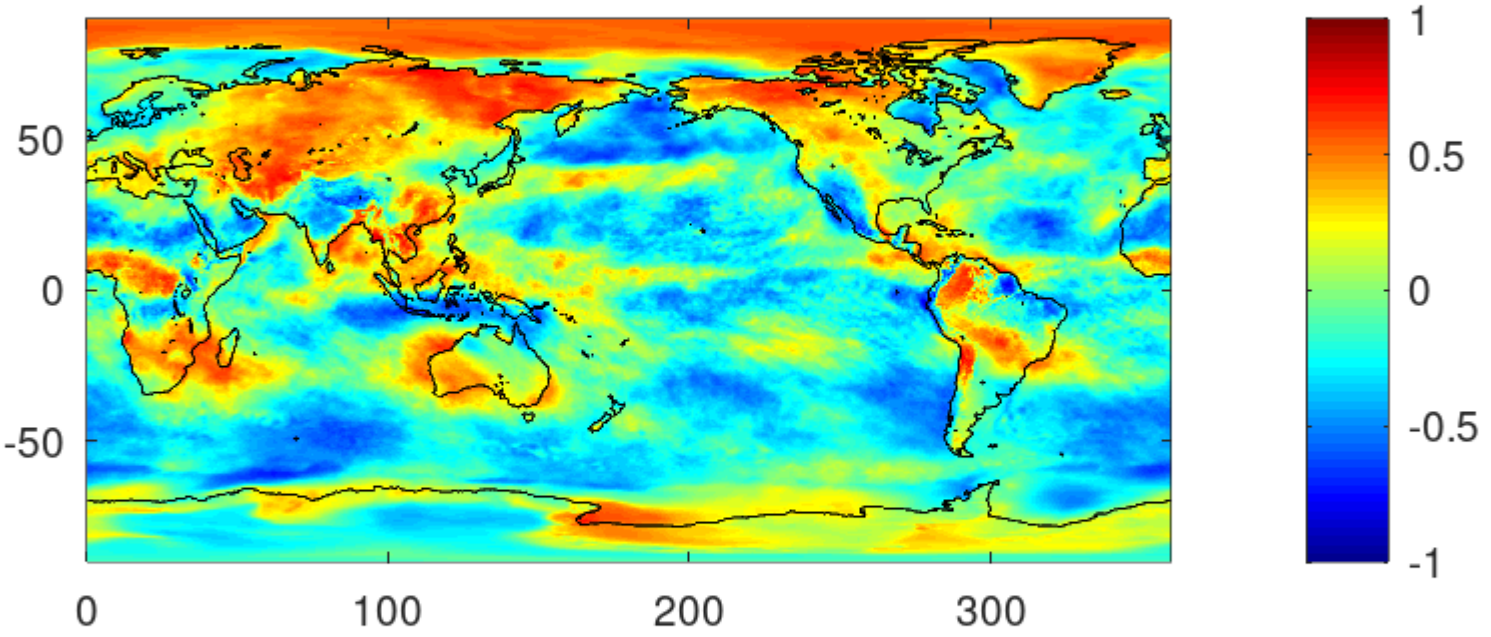


Texas and Southern Plains: strong positive correlation
Eastern US: negative correlation
Western US: near-zero correlation

What about humid heat?

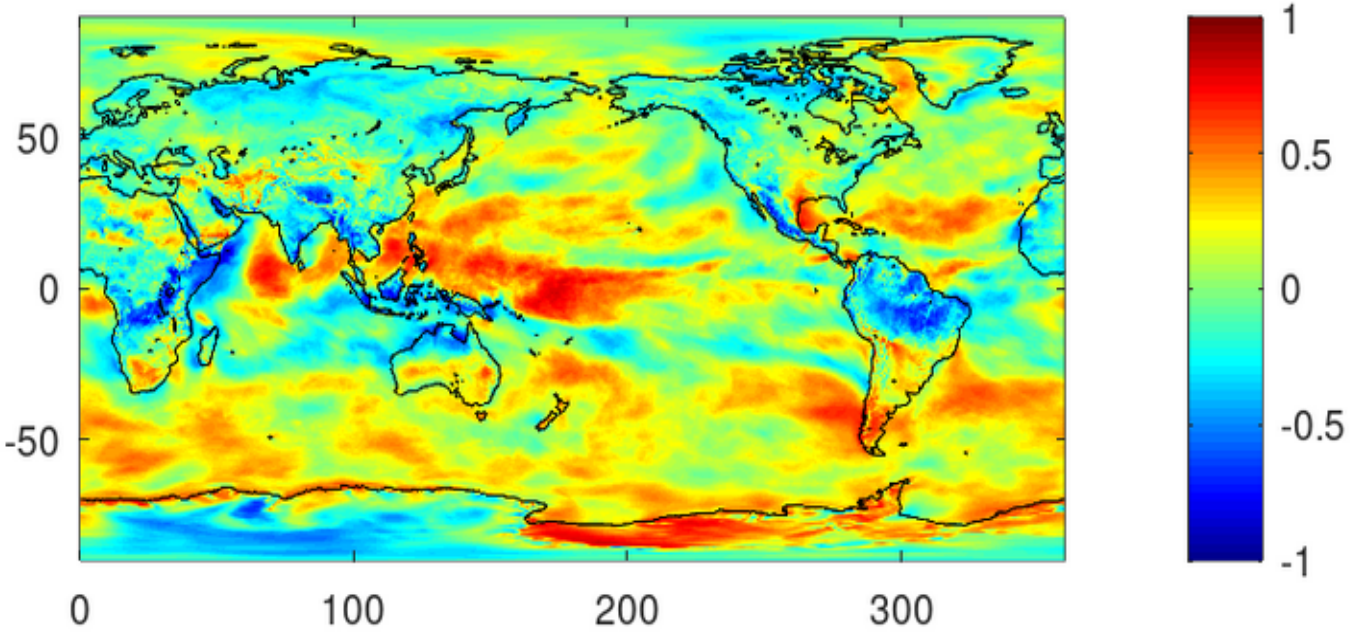
- Demand for cooling increases with humidity as well as temperature
- We might worry that humid hot days tend to be cloudy, with less available sunlight
- I looked at correlations with solar and wind of wet-bulb temperature (WBT) as a measure of humidity

WBT vs. insolation



Less positive correlation than with temperature
Still fairly positive in many land areas, including the Great Plains and southeast Asia

WBT vs. wind



Correlation is negative for many land areas
Still strongly positive for Texas and the Caribbean

Tentative conclusions

- Solar and also wind tend to be abundant during hot summer days, improving grid resilience
  - This varies geographically and also depending on how important humidity is
- Meteorological regimes associated with demand peaks and other grid stressors can be studied in more detail
- One stressor may be large-scale wildfires, associated with heat waves but also potentially suppressing insolation and wind, which we also saw in the past year

Thanks!

- I’d love to hear your ideas for taking this research area further
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