INTEGRATED
MULTISECTOR
MULTISCALE
MODELING

MODELING INTERACTIONS AND FEEDBACKS ACROSS ENERGY, WATER, LAND, URBAN, AND ECONOMIC SYSTEMS TO EXPLORE CLIMATE VULNERABILITY AND RESILIENCE IN THE USA

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IM3 PHASE 2 EXPERIMENTAL DESIGN OVERVIEW

https://im3.pnnl.gov/, open science/open source

Experiment Group A

How will urban heat stress evolve with climate change; how effective are adaptations such as green roofs?

Experiment Group B

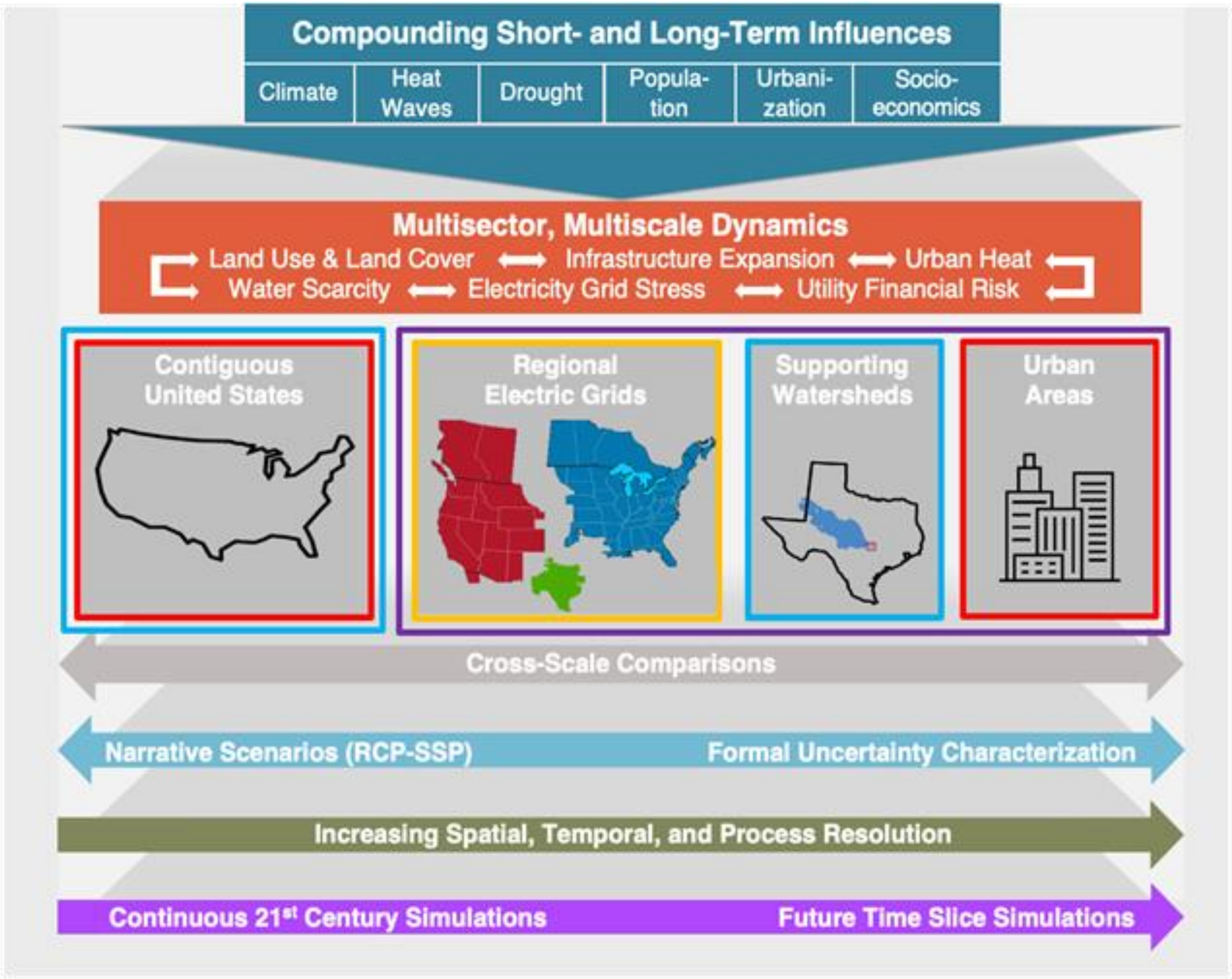
How will electricity infrastructure evolve under different energy system transitions and climate change and how will this affect grid stress?

Experiment Group C

How will land use and water availability evolve with climate change; what role can adaptive water management play (including financial instruments)?

Experiment Group D

How will future water scarcity and urban heat stress interact with climate change and energy system transitions to influence future grid stress?



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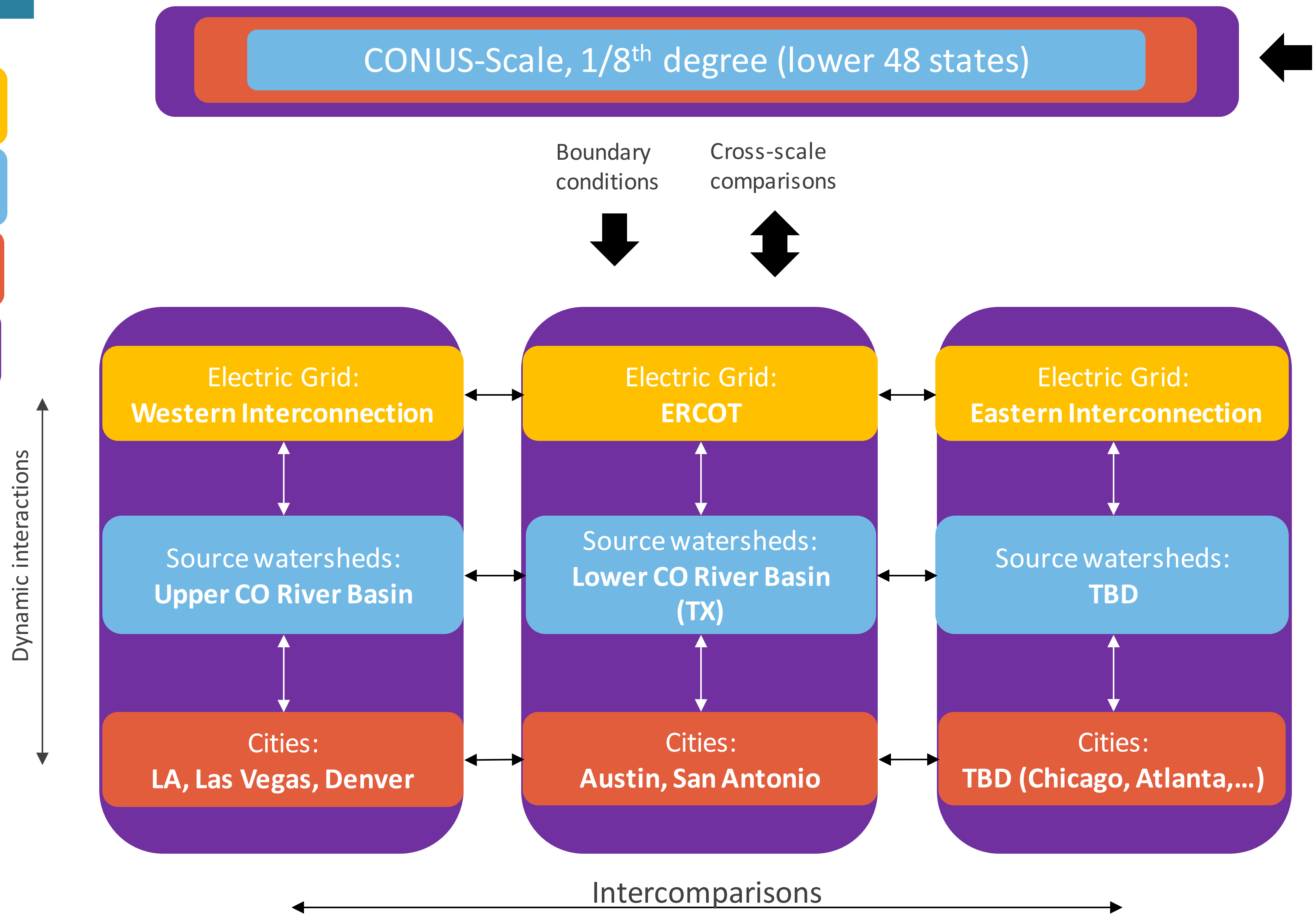
PHASE 2 NESTED DESIGN

Legend

- Electricity Grid Stress Experiments
- Water Scarcity Experiments
- Urban Heat Stress Experiments
- Energy-Water-Land-Urban Dynamics Experiments



21st century scenarios covering a wide rage of climate and socioeconomic futures

City and region-specific "time slice" simulations of extreme events (i.e., heat waves, and drought) under climate change during 21st century

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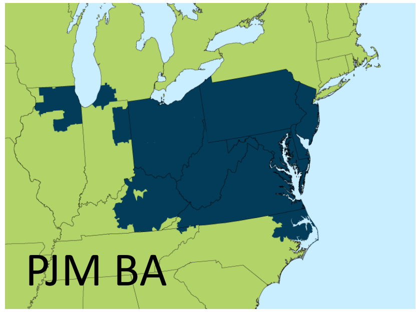
HIGH RESOLUTION CLIMATE FUTURES

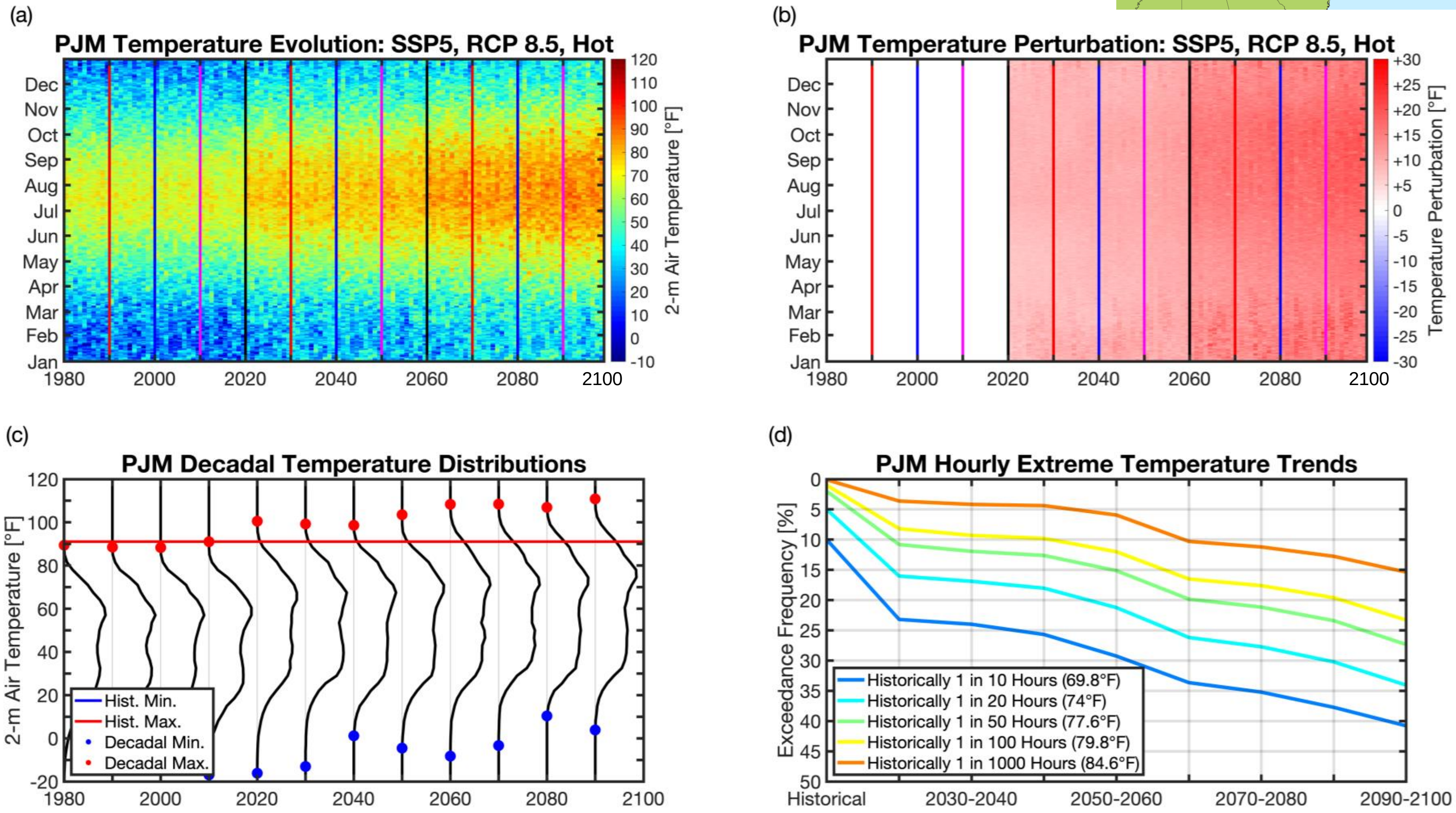


Thermodynamic global warming approach:

- CMIP6 GCMs averaged to produce 2 scenarios each for RCP8.5 and 4.5
- Dynamically-downscaled WRF simulations at 1/8th degree. ~20 hourly variables, CONUS, 1980-2100

Climate data preparation for electricity grid stress modeling:

- Hourly WRF output is first spatially-averaged by county in the CONUS
- County-level hourly values are then population-weighted (consistent with SSP) to create annual 8760-hr meteorology time series for each Balancing Authority (BA)



Burleyson et al. in prep

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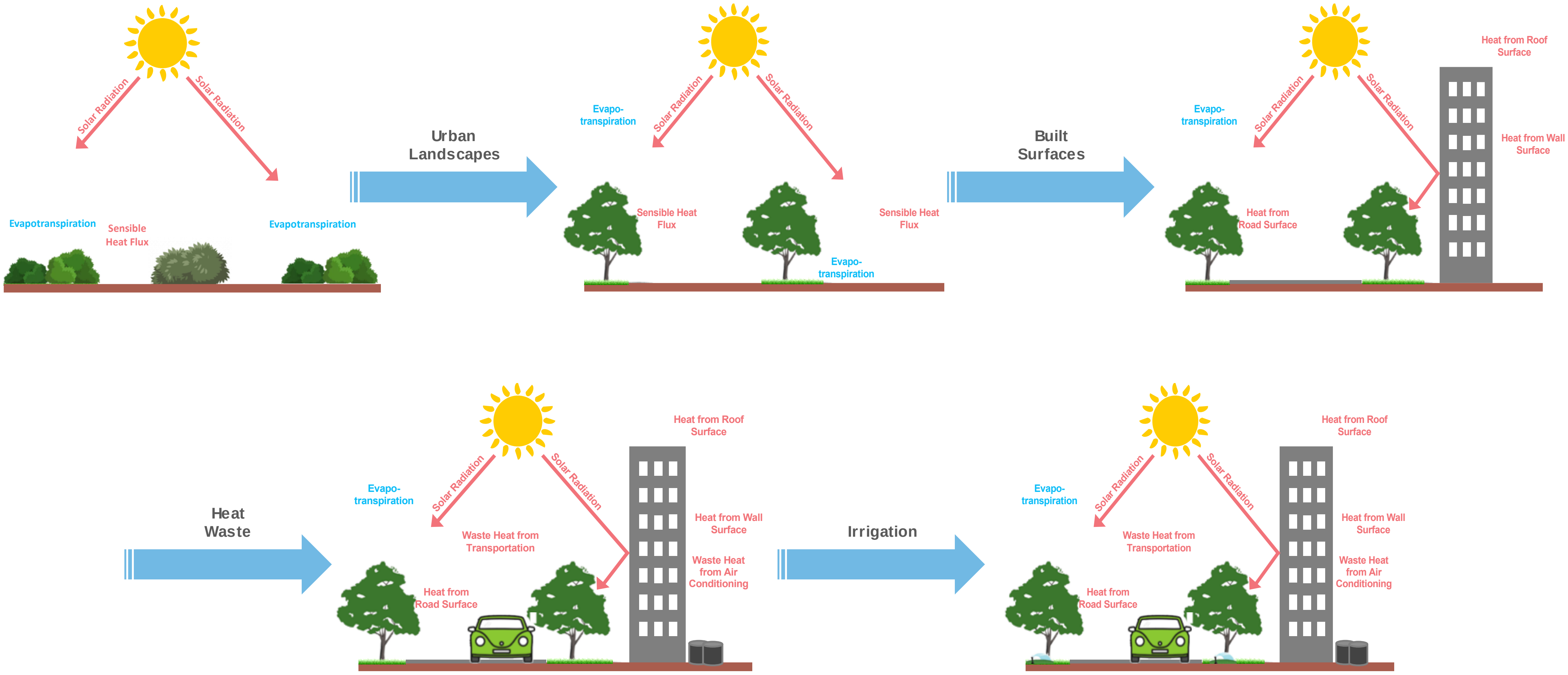
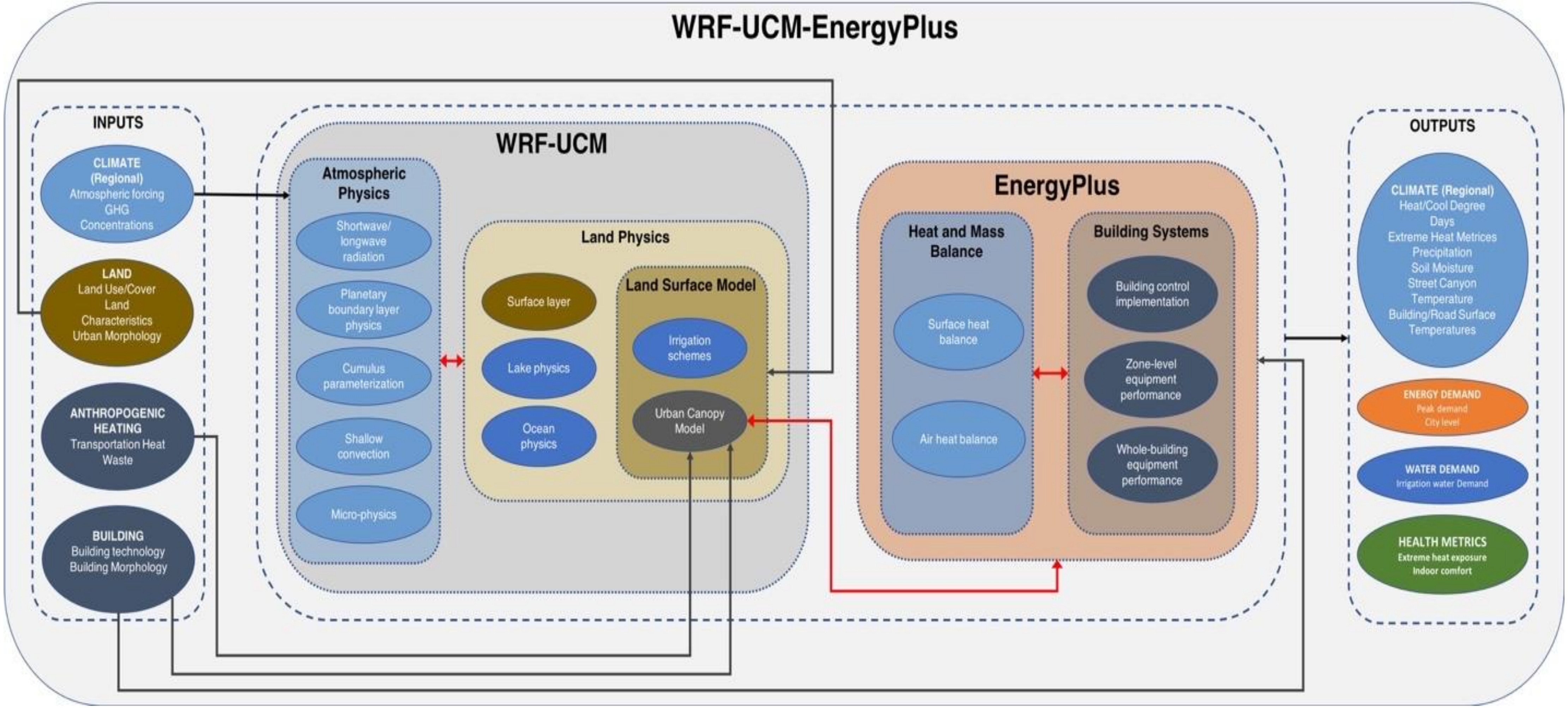
URBANIZATION EFFECTS: DECOMPOSITION OF URBAN HEAT ISLAND EFFECT



MODELING URBAN MICROCLIMATE DYNAMICS



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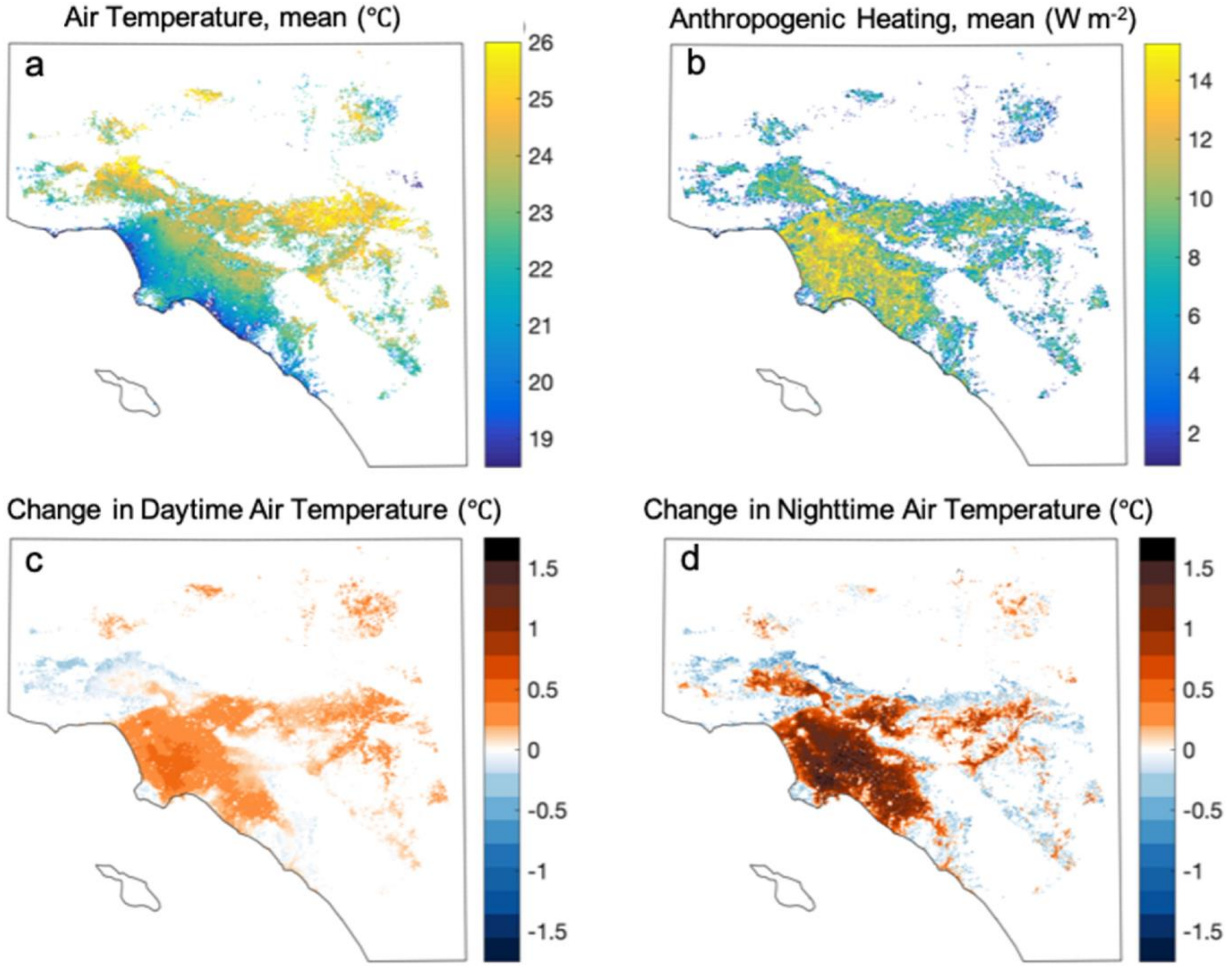
ANTHROPOGENIC HEAT EFFECTS ON URBAN HEAT ISLANDS IN LOS ANGELES

- WRF-UCM simulated air temperature maps, with and without incorporating EnergyPlus-simulated anthropogenic heating.
- Significant impact of anthropogenic heating on nighttime temperatures (d), particularly over industrial and commercial areas (average warming of 1.0 °C) and high-density residential areas (average warming of 0.5 °C). The impact on low-density residential areas, however, is negligible (average of 0.0 °C).
- Similar spatial patterns but with less intensity (average warming of <0.3 °C) are found for daytime air temperature changes, induced by anthropogenic heating (c).
- These results clearly show that anthropogenic heating from buildings contributes to the urban heat island effect in Los Angeles.



Vahmani et al. 2022; https://doi.org/10.1016/j.buildenv.2022.108841

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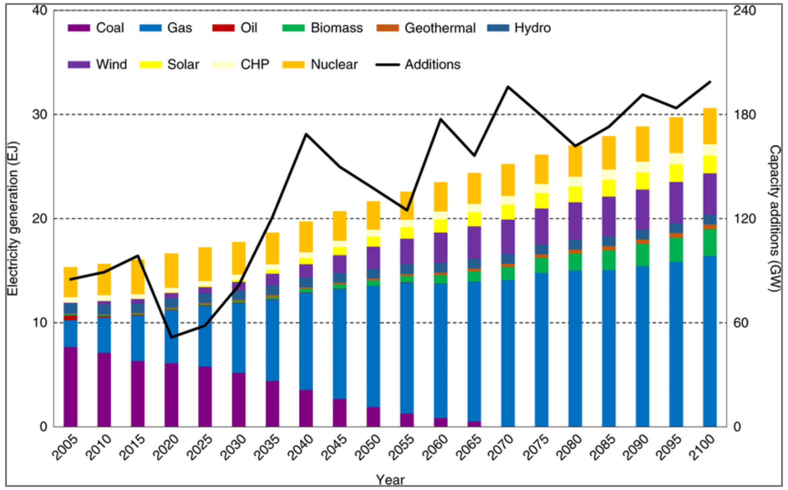
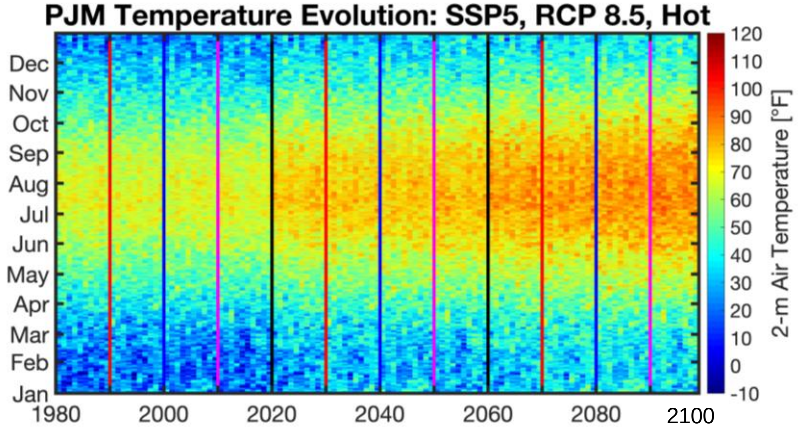
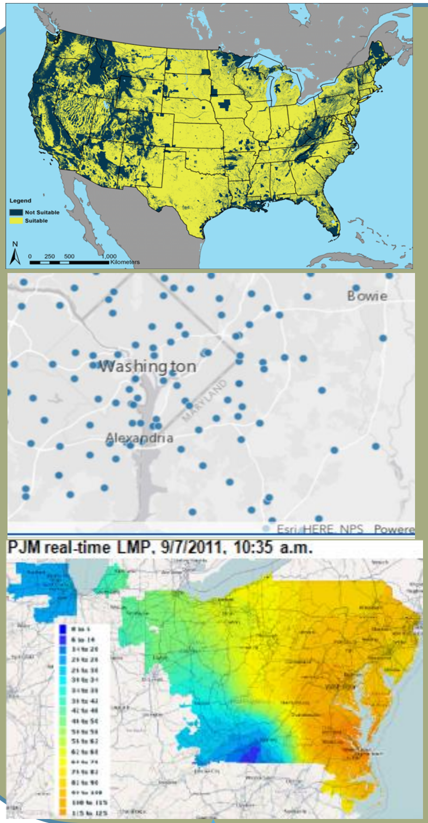
MODELING ENERGY SYSTEM TRANSITIONS AND ELECTRICITY GRID STRESS UNDER CLIMATE CHANGE

IM3

State- or regional-scale capacity expansion (e.g., from GCAM-USA)







GIS-based, dynamic, tech-specific siting suitability

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Location-based interconnection costs (substations; gas pipelines)

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Net locational economic value (LMPs; generation costs)

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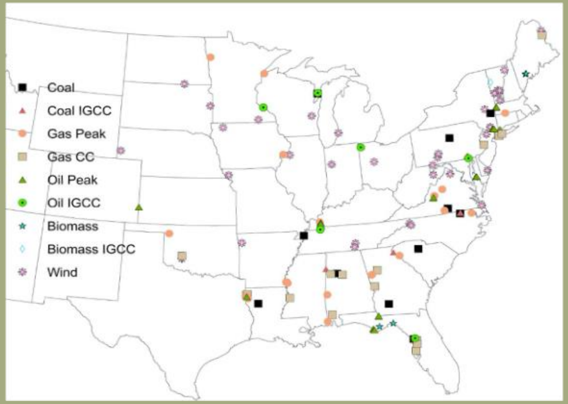
Capacity Expansion Regional Feasibility (CERF) model

Individual power plant siting at 1 km^2 resolution



https://github.com/IMMM-SFA/cerf

Electricity Demand Model (TELL) (hourly, for each BA)

Grid Operations (GO) Model (hourly, UC/ED)

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THANK YOU!

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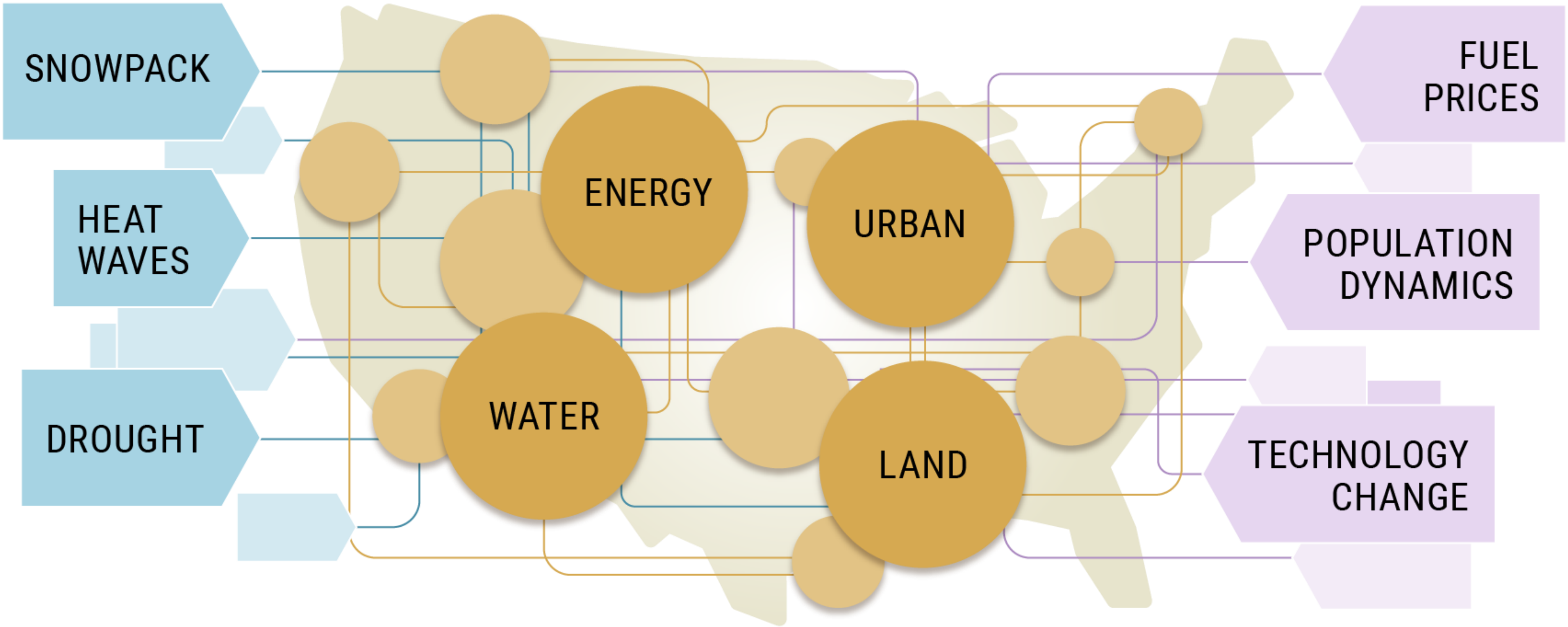

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