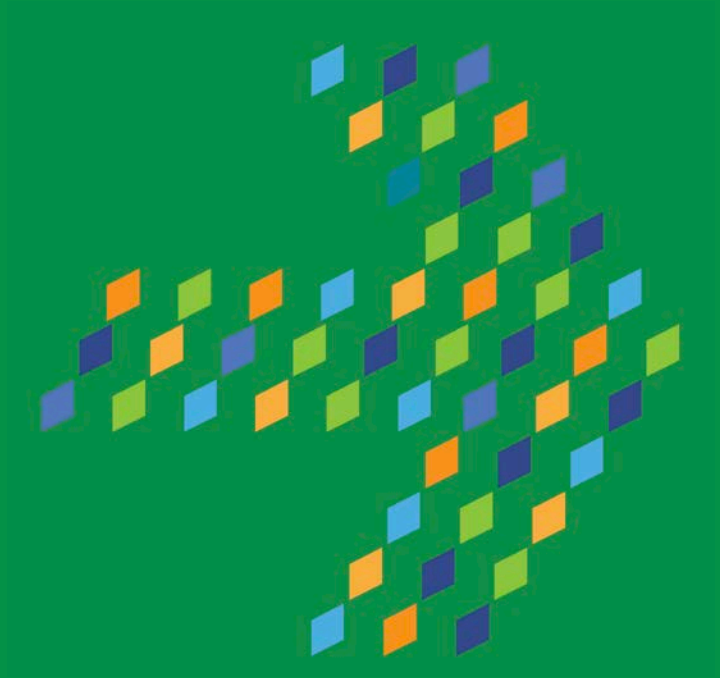


WELCOME

2024 JISEA Annual Meeting

Feb. 26–27, 2024

Session 3

NREL Transforming ENERGY | Colorado School of Mines | Colorado State University | Howard University Office of Research | Massachusetts Institute of Technology | Stanford University | University of Colorado Boulder

SESSION 3

Climate Adaptation and Clean Energy

Day Two: 9–11:50 a.m.

SESSION OVERVIEW

Hearing from two of many perspectives and reflecting on applicability to our current work (whether on adaptation or not); diving further into the topics identified as intersections.

GOALS / OUTCOMES

Co-developed write up of key areas related to research needs at the clean energy and climate adaptation intersection.

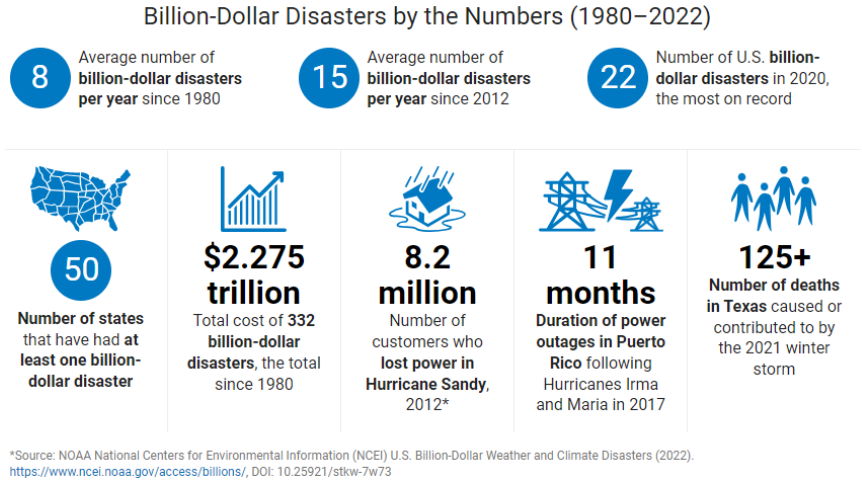
AGENDA

- Getting Here: Background
- Community Perspective
- Table Reflections
- Energy System Analysis Perspective
- Table Reflections
- Table Discussions: Diving in on Project Areas
- Closeout

Session Context: Building with, not ‘initiating’

How Did We Get Here

- Climate and Atmospheric Catalyzer
- 3 NREL interactive workshops
- Adaptation Catalyzer: Exploring Research Areas



Initial Questions

- What impact will deployment of renewable energy have on climate?
- How will climate change impact existing clean energy technology?
- What resources will be available?
- Will the clean energy infrastructure be located where people can use it?

https://www.nrel.gov/news/features/2022/more-than-one-pathway-to-energy-resilience.html

Session Context: Building with, not ‘initiating’

How Did We Get Here

- Climate and Atmospheric Catalyzer
- 3 NREL interactive workshops
- Adaptation Catalyzer: Exploring Research Areas

Observations

- Progress on acknowledging, but oversimplification of challenges of other sectors
- Slow build out of multi-disciplinary, multi-sector networks
- Extensive language, narrative, and framework differences

Session Context: Building with, not ‘initiating’

How Did We Get Here

- 3 NREL interactive workshops
- Catalyzer: Exploring Research Areas

Common Research Areas

- **Tech Design**: Human Centered Clean Energy Technology R&D in Adaptation Context
- **Training/Education Cross Sector Needs**
  - Technologists/Technology Developers to Understand Adaptation and Emerging Needs
  - Adaptation Practitioners on Energy Systems Structures and Needs
- **Understanding Energy Sector Specific Adaptation Needs**
  - Electricity Infrastructure
  - Fuels Infrastructure
  - Energy Supply Chain Infrastructure
  - Energy and other critical infrastructure sector interactions in adaptation context

When poll is active respond at **PollEv.com/nrelwebinars303**

What is not receiving as much investment as it needs?

Human Centered Clean Energy Technology R&D in Adaptation Context

Training/Education for Technologists/Technology Developers to Understand Adaptation and Emerging Needs

Training/Education for Adaptation Practitioners on Energy Systems Structures and Needs

Understanding Adaptation Needs related to Electricity Infrastructure

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SPEAKERS

Ean Tafoya
GreenLatinos

Grant Buster
NREL Strategic Energy Analysis Center

SESSION 3

Climate Adaptation and Clean Energy

Day Two: 9–11:50 a.m.

TABLE TEAMS		
1	**Kaiya Murphy**	Partnership for Southern Equity
	Caitlin Henry	JISEA
2	**Jen Daw**	NREL
	Torie Gaylord	JISEA
3	**Grant Buster**	NREL
	Debbie Brodt-Giles	JISEA
4	**Peter Backlund**	CSU
	Nate Blair	NREL

TABLE TEAMS		
5	**Jibo Sanyal**	JISEA
	Fletcher Ouren	NREL
6	**Haley Clapper**	NREL
	Tess Stowers	JISEA
7	**Eliza Hotchkiss**	NREL
	Gunnar Tande	JISEA
8	**Quinn Parker**	Encolor
	Gail Mosey	NREL

SESSION 3

Climate Adaptation and Clean Energy

Day Two: 9–11:50 a.m.

Ean Tafoya

Colorado State Director
GreenLatinos

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Discussion #1 Reactions

Nobody has responded yet.

Hang tight! Responses are coming in.

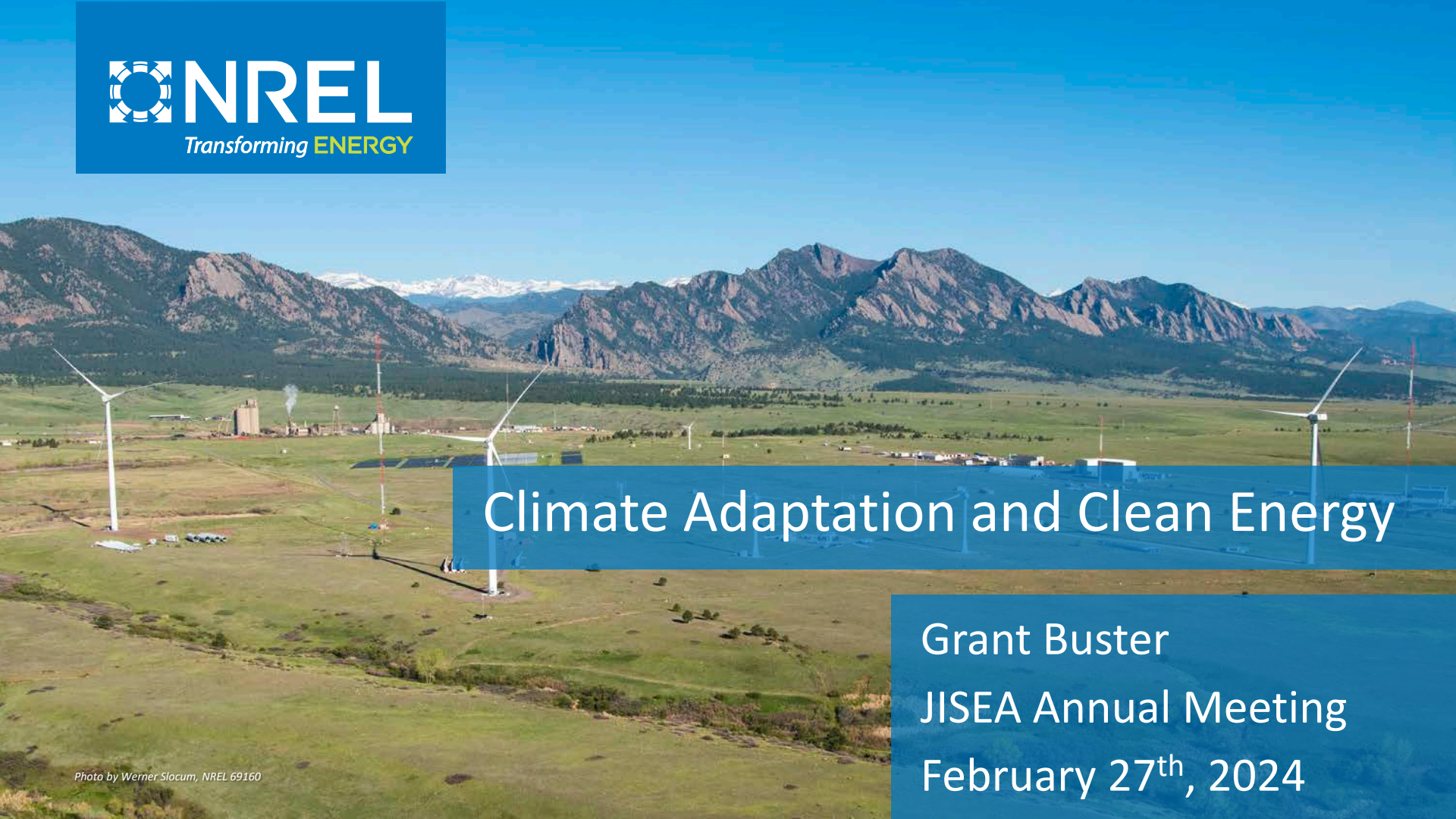
SESSION 3

Climate Adaptation and Clean Energy

Day Two: 9–11:50 a.m.

Grant Buster

Researcher
NREL Strategic Energy Analysis Center



Climate Adaptation and Clean Energy

Grant Buster

JISEA Annual Meeting

February 27th, 2024

NREL Science Drives Innovation

Renewable Energy

- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation & Fuels

- Bioenergy
- Hydrogen and Fuel Cells
- Transportation and Mobility

Buildings and Industry

- Buildings
- Industrial Efficiency and Decarbonization
- Advanced Materials and Manufacturing
- State, Local, and Tribal Governments

Energy Systems Integration

- Energy Security and Resilience
- Grid Modernization
- Integrated Energy Solutions

Photo by Werner Slocum, NREL 66364

The NREL Model and Data Zoo

Simulate the evolution of the bulk power system through 2050

Calculate renewable energy generation and cost from weather inputs and land-use characteristics

Explore different local energy strategies and scenarios

Analyze the economic impacts of renewable energy development around the world

Explore global renewable energy potential

Optimize energy systems for buildings, campuses, communities, microgrids, and more

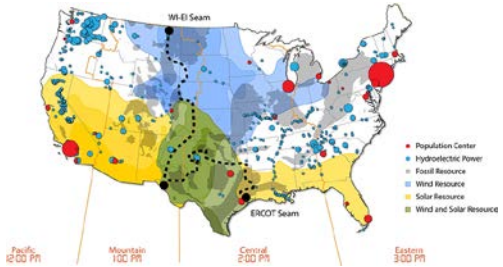
Build, solve, and analyze power system operations and dynamics models

Open access energy data resources

Simulate customer adoption of distributed energy resources

Renewable Energy Integration Studies: Envisioning the Future of Energy Systems

The NREL Seams Study



The North American Renewable Integration Study (NARIS)

LA100

The Los Angeles 100% Renewable Energy Study

PR100

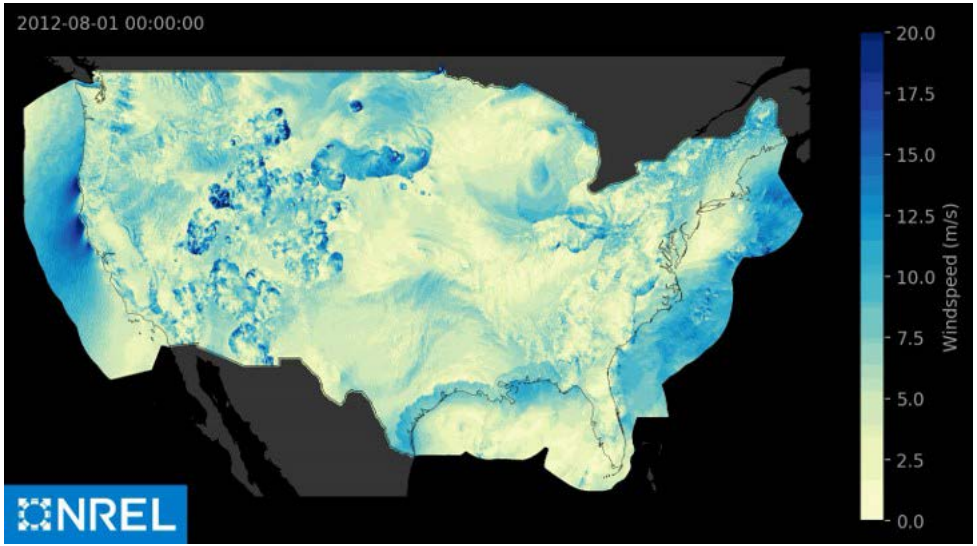
"The Evolving Role of Extreme Weather Events in the U.S. Power System with High Levels of Variable Renewable Energy"

U.S. DEPARTMENT OF ENERGY

Building a Better Grid

National Transmission Planning Study

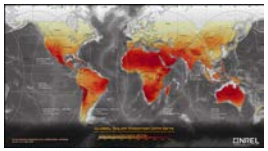
Historical Weather Data: NSRDB and WIND Toolkit

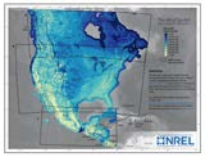


- The National Solar Radiation Database (NSRDB) is a satellite-derived irradiance dataset
- The Wind Integration National Dataset (WIND) Toolkit is produced using numerical weather prediction
- Focused on the accurate reproduction of historical weather conditions and wind and solar variability
- Limited temporal scope, no uncertainty quantification

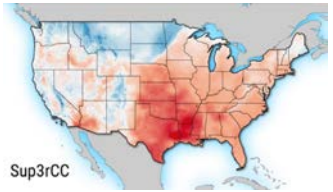
How is this data used?

Historical Weather Data (NSRDB, WTK)





Climate Change Data



Weather-to-Power Model

Power System Modeling

Capacity Expansion Model (CEM)

Production Cost Model (PCM)

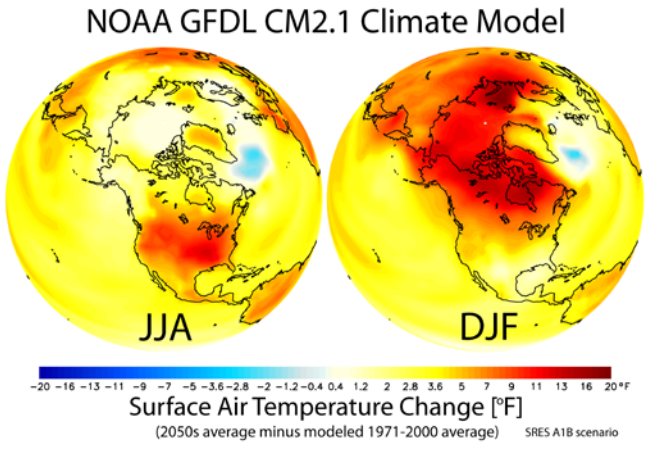
Transmission Models

Load Data

Results and Insights

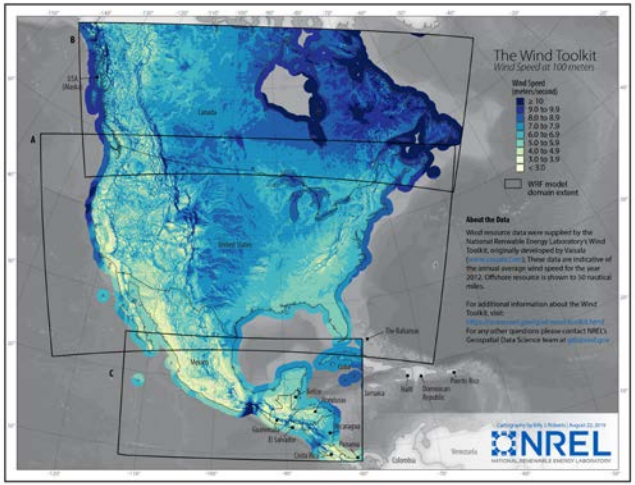
Integration of Climate Data: Mind the Gap

Global Climate Models (GCMs)



https://www.gfdl.noaa.gov/visualizations-climate-prediction/

Mesoscale NREL Datasets (WTK, NSRDB)



~100 km grid resolution
daily average data
2000-2100

How do we bridge this gap?

~2-4 km grid resolution
5 min-hourly data
Historical

Our solution needs to be flexible enough to enable researchers to study any climate model or climate change scenario and to stay current with new climate research.

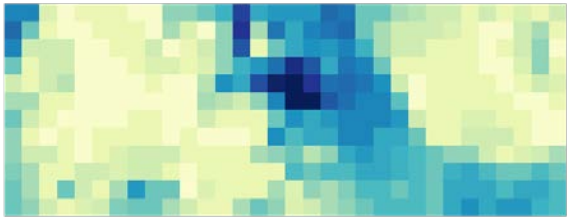
Super-Resolution for Renewable Energy Resource Data with Climate Change Impacts (Sup3rCC)

True High Res (WTK or NSRDB)

4km Hourly

Coarsen to create training data

Low Res (WTK, NSRDB, GCM)

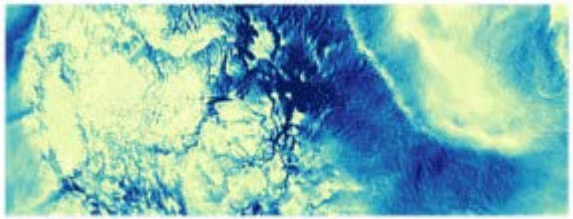


100km Daily

Discriminative Model

Generative Model

Synthetic High-Res Output



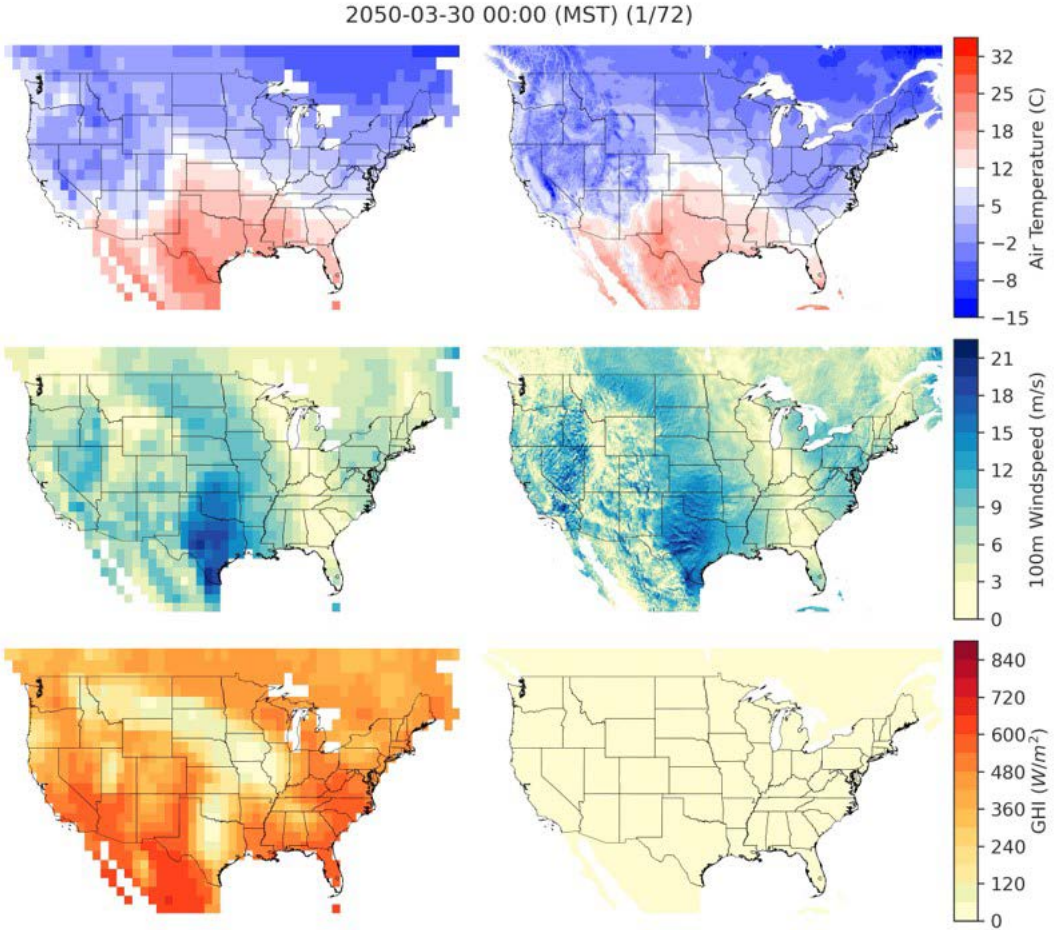
4km Hourly

Benefits of Downscaling with ML:

1. Computational efficiency (40x-200x faster than WRF)
2. Designed for renewables (wind, solar, temp, humidity)
3. Fully integrated into energy analysis software
4. Open-source: https://nrel.github.io/sup3r/

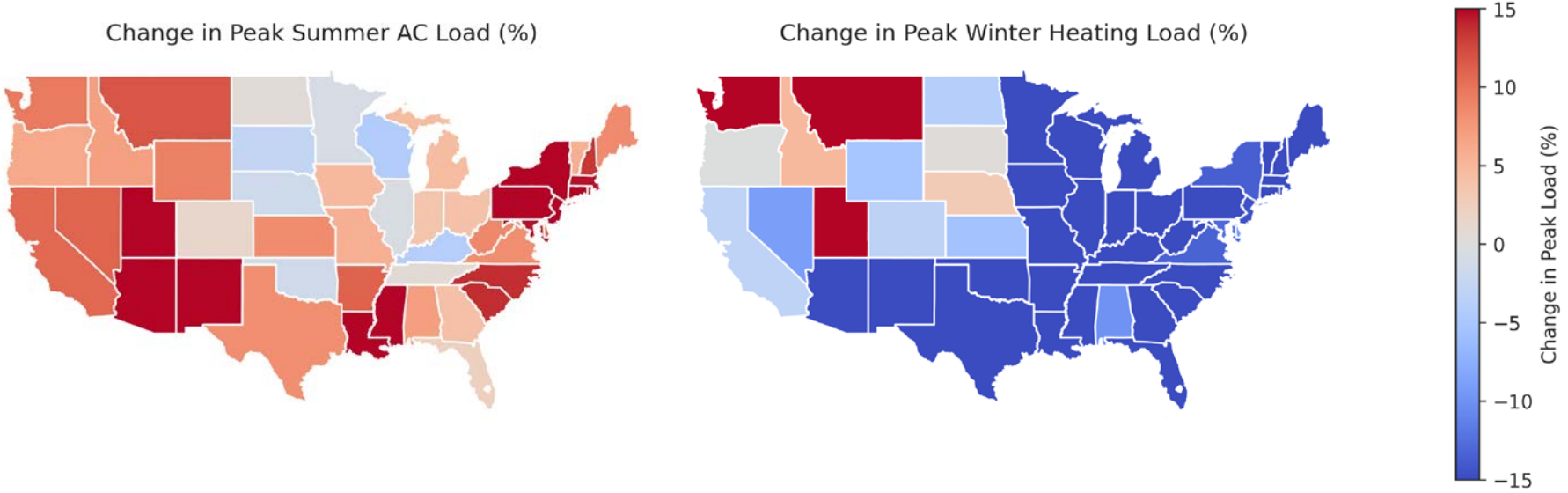
Sup3rCC

- The Sup3rCC 4km hourly outputs (right) add **high-resolution spatial features and temporal dynamics** conditioned on the low-res GCM input (left)
- Includes **wind speed, solar irradiance, temperature, and humidity**, all spatiotemporally coincident
- Initial data is available for two GCMs, SSP5-8.5, 2015-2059
- Data on NREL-HPC and OEDI:
  - /datasets/sup3rcc/
  - DOI 10.25984/1970814



Buster et al., "Super-Resolution for Renewable Energy Resource Data with Climate Change Impacts using Generative Machine Learning", in review at *Nature Energy* (2024).

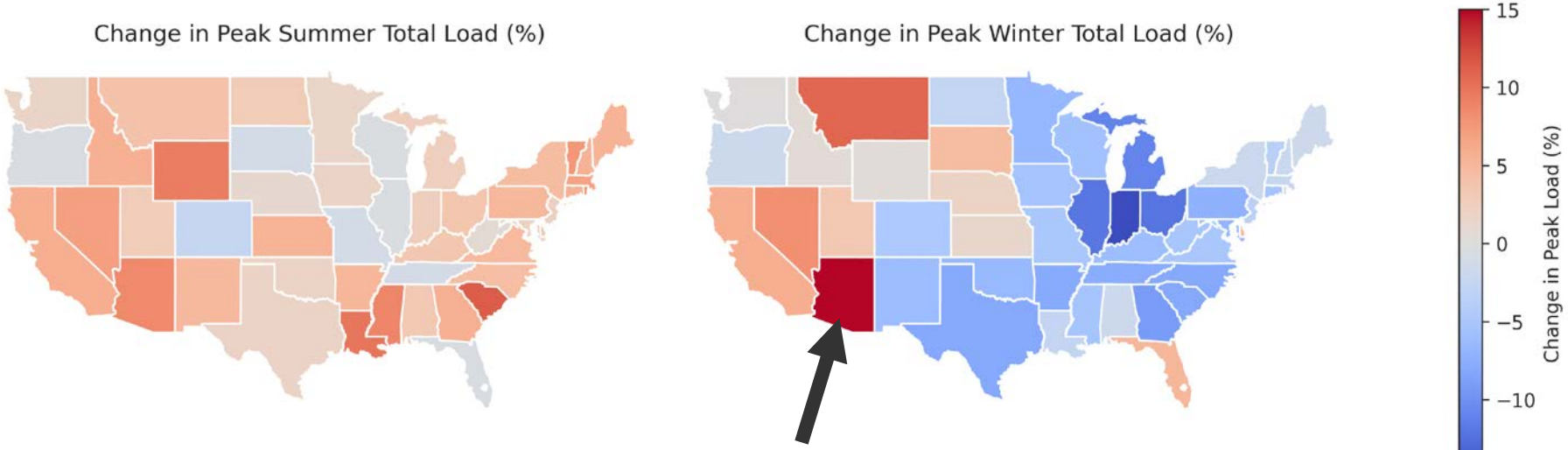
Impacts of Climate Change on Heat and Cooling Peak Energy Demand



Widespread increases in summer peak AC load and decreases in winter heating load

this only compares historical load to mid-century weather for a single possible climate scenario

Impacts of Climate Change on All-Sector Peak Energy Demand



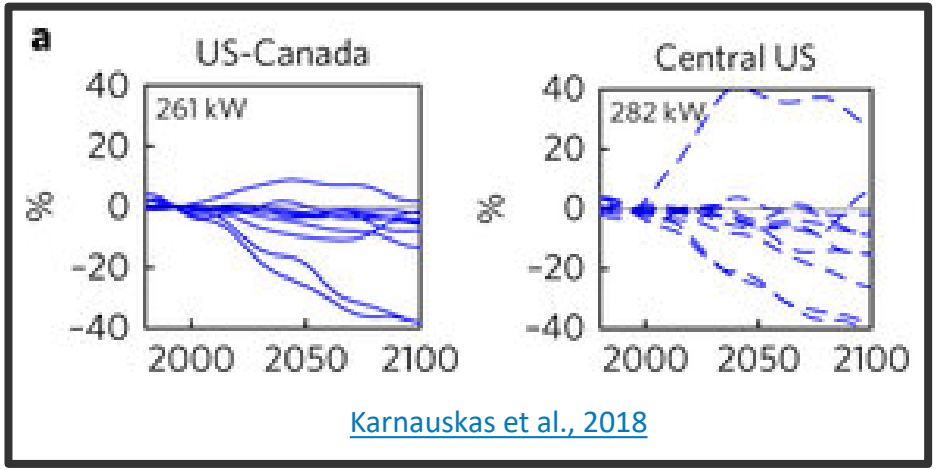
40% increase in peak winter load

Less pronounced changes for all-sector peak loads, but some dramatic local changes

this only compares historical load to mid-century weather for a single possible climate scenario

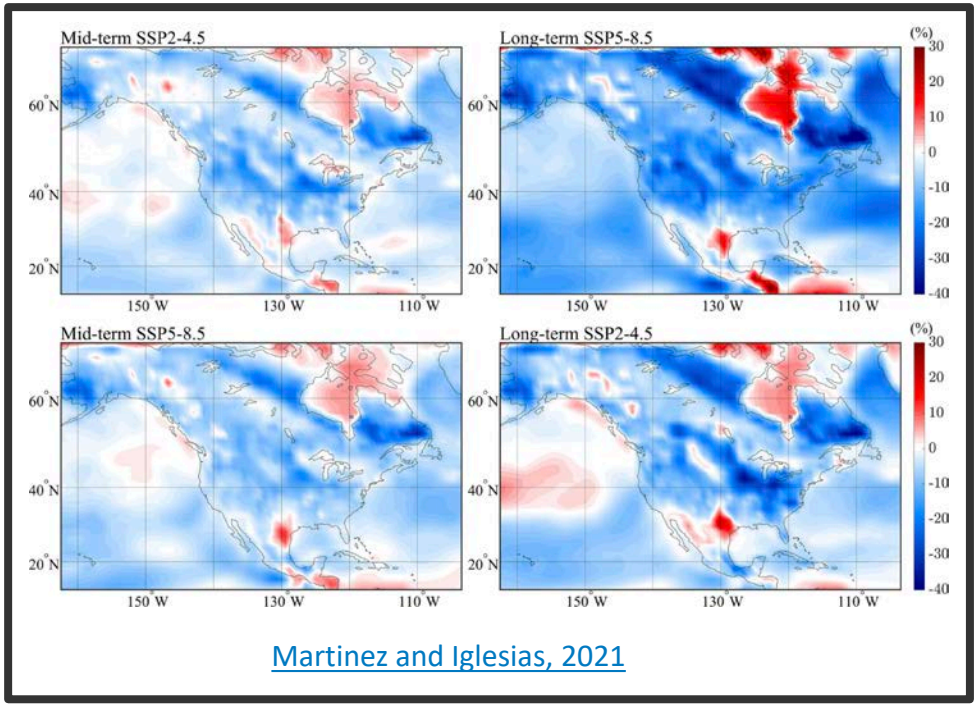
Projected Changes in Wind Resources

CMIP5 Changes in Wind Resource



Karnauskas et al., 2018

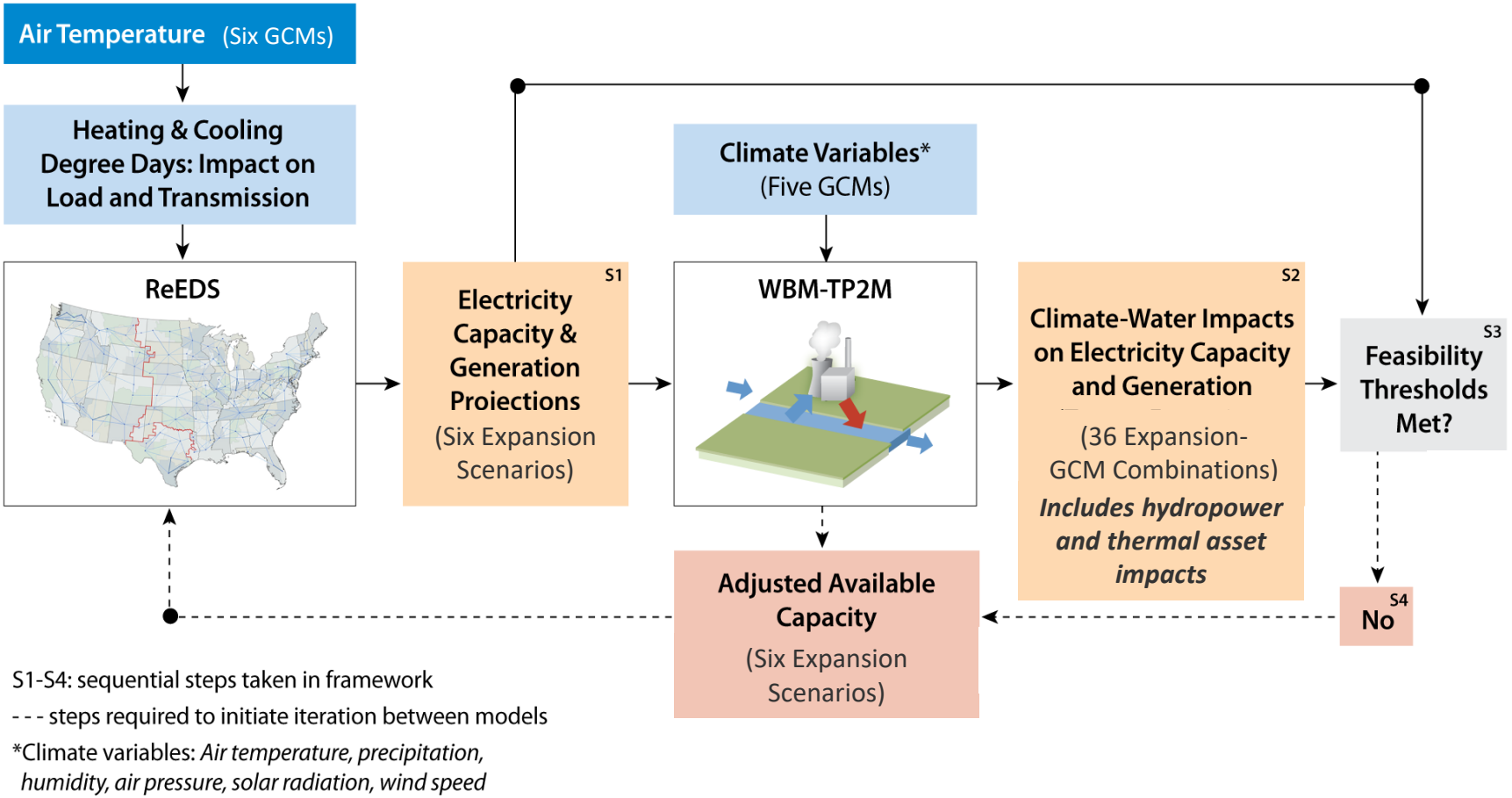
CMIP6 Changes in Wind Resource



Martinez and Iglesias, 2021

- Growing consensus on **decreased wind resource** in the U.S. by mid-century
- Could be attributed to arctic amplification and **weaker latitudinal temperature gradients**

Iterative Data and Modeling Exchange Platform can show long-term climate impacts



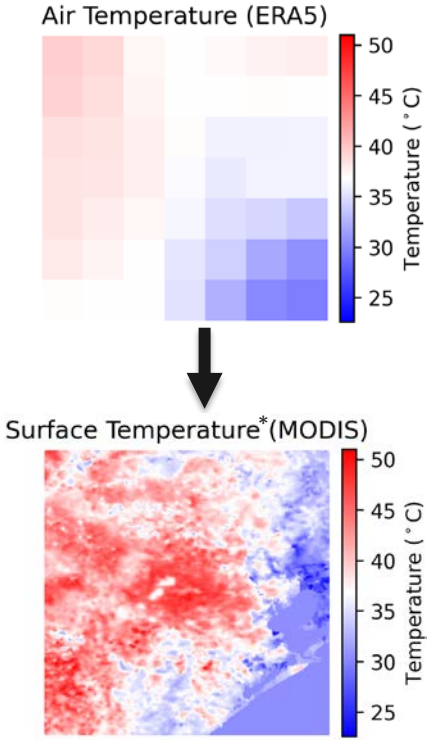
Adapted from Miara, A., Cohen, S., Macknick, J.E., Vörösmarty, C.J., Corsi, F., Sun, Y., Tidwell, V.C., Newmark, R., Fekete, B., Climate-Water Adaptation for Future US Electricity Infrastructure. Environmental Science and Technology, 2019.

PACES: Power Planning for Alignment of Climate and Energy Systems

- Downscaling climate projections for power system analysis with multiple methods
  - Generative Machine Learning (Sup3rCC)
  - Numerical Weather Prediction (WRF)
- Exploration of planning strategies under climate change uncertainty
  - Decision making with deep uncertainty (DMDU)
  - Stochastic capacity expansion
- Application to utilities
  - Tennessee Valley Authority
  - Southern Company

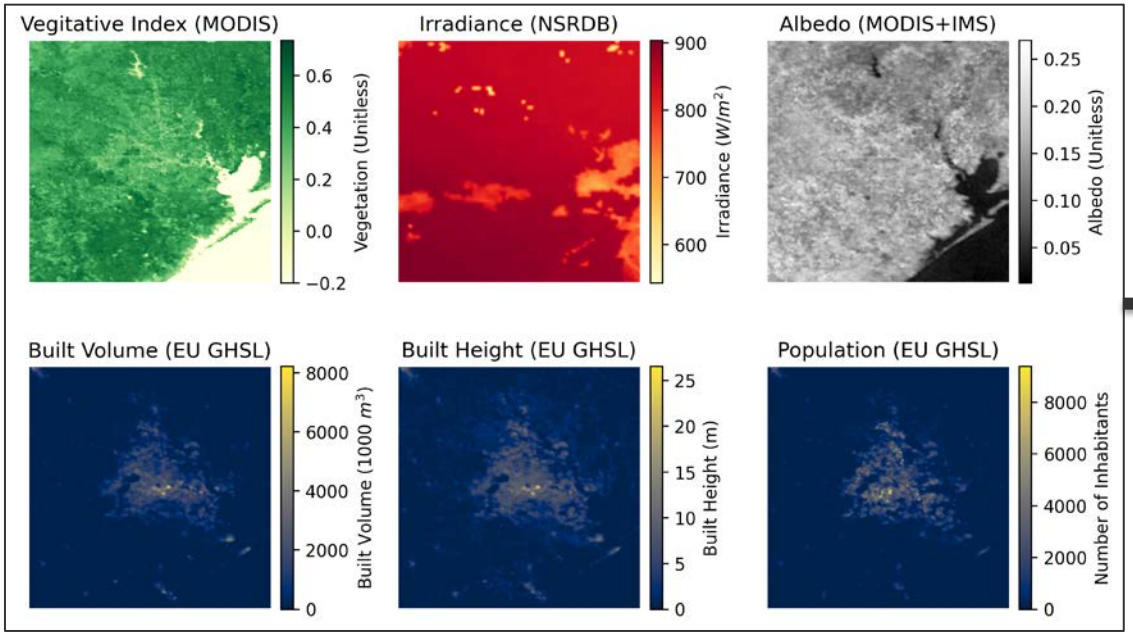
Beyond Power Systems: Urban Heat Islands

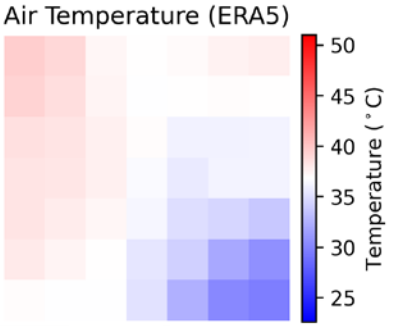
- Urban heat island (UHI) dynamics is an important input to community resilience
- Direct driver of risk to grid infrastructure, energy demand, and human health
- UHI data with hourly timeseries and climate change impacts is rare or non-existent
- Super-resolution methods can be used for more than renewable energy resource modeling!

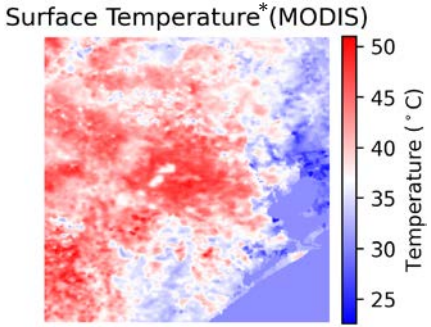


*Surface temperature is not as impactful to human health as air temperature, but can be used to characterize spatial variability in urban heat islands

Beyond Power Systems: Urban Heat Islands







- We are sourcing high-resolution urban features to build accuracy into the generative process

*Surface temperature is not as impactful to human health as air temperature, but can be used to characterize spatial variability in urban heat islands

Gaps!

Hurricanes

How does climate change affect hurricanes? How can we simulate hurricanes for power system impacts?

Wildfires

How does climate change affect wildfires? How can we simulate wildfires for power system impacts?

Migration

How might climate change drive human migration? How does this stress energy infrastructure and energy demand?

What Else?

Are we overlooking climate risks to the energy sector? Are we neglecting key climate phenomena?

Colleagues Contributing to Climate Change Data and Climate Impacts Analysis

Brandon Benton

Paul Pinchuk

Stuart Cohen

Ariel Miara

Andrew Glaws

Ryan King


NREL
Transforming ENERGY
Questions and Discussion
Photo by Werner Slocum, NREL 69160

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Discussion #2 Reactions

Nobody has responded yet.

Hang tight! Responses are coming in.

Table Topic Discussions

1. Human Centered Clean Energy Technology R&D in Adaptation Context.
2. Training/Education for Technologists/Technology Developers to Understand Adaptation and Emerging Needs
3. Training/Education for Adaptation Practitioners on Energy Systems Structures and Needs.
4. Understanding Adaptation Needs related to Electricity Infrastructure
5. Understanding Adaptation Needs related to Fuels Infrastructure.
6. Understanding Adaptation Needs related to Energy Supply Chain Infrastructure.
7. Understanding Energy and other critical infrastructure sector interactions in adaptation context
8. Wildcard – What is missing?

SESSION 3

Climate Adaptation and Clean Energy

Day Two: 9–11:50 a.m.

TABLE TEAMS		
1	**Kaiya Murphy**	Partnership for Southern Equity
	Caitlin Henry	JISEA
2	**Jen Daw**	NREL
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8	**Quinn Parker**	Encolor
	Gail Mosey	NREL

Thank you!

We invite you to the virtual JAM24 synthesis meeting on April 8, 2024, 11:30 a.m.–1 p.m. MT.

Join us via Microsoft Teams by visiting
bit.ly/JAM24-synthesis

NREL/PR-6A50-89107

www.jisea.org

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JISEA Joint Institute for Strategic Energy Analysis

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