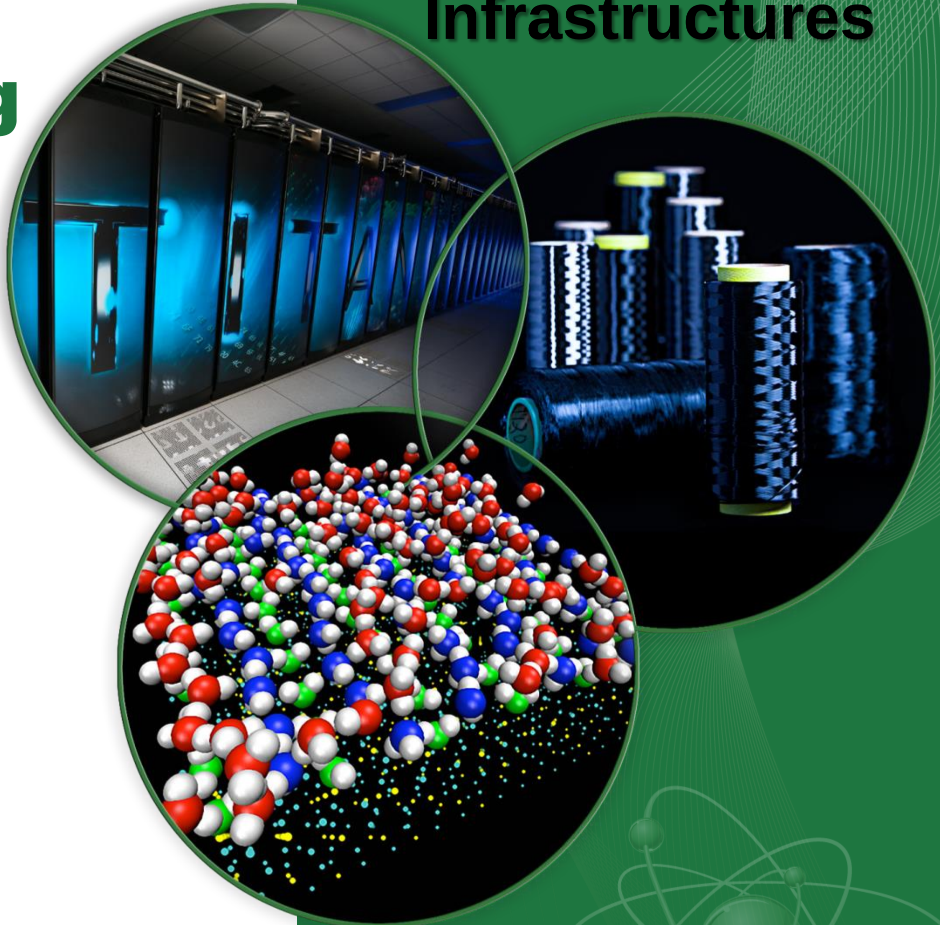
Critical Infrastructure Operational Resilience: Assessing Climate Impacts

Modeling Climate Impacts on Critical Infrastructures



Presented to the
Resilience Week 2014
1st National Symposium on
Critical Infrastructure Resilience

By
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ORNL is managed by UT-Battelle
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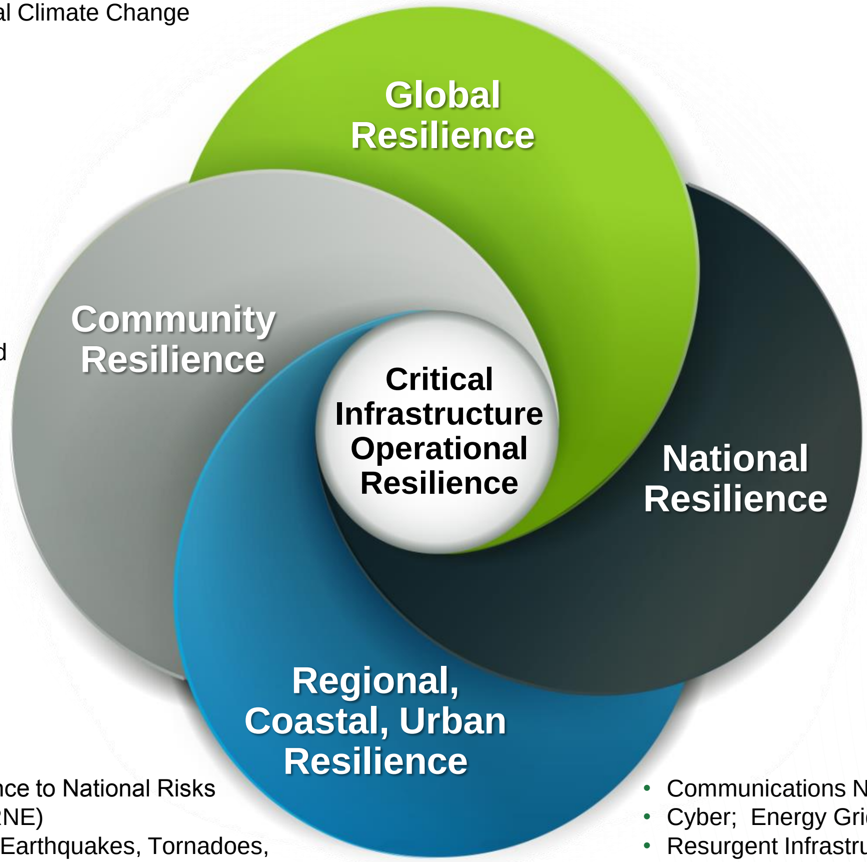
Motivation: Scale Matters in Improving Critical Infrastructure Operational Resilience

- International Threats
- International Interests
- Energy Resources
- Global Climate Change

- Global Health Pandemic
- Food Safety
- Scarcity of Natural Resources

- International Commerce
- Defense Operations
- Intelligence Operations



- Assess Community Resilience to Regional Risks
- Man-made Threats (CBRNE)
- Natural Threats (Floods, Earthquakes, Tornadoes, Hurricanes, Droughts, Wild Fires)
- Community Interests – Business Continuity
- Resurgence of Key Infrastructures
- Communications Network
- Cyber; Energy Grid
- Transportation Networks
- Local Emergency Operations

- Assess/Monitor National Resilience to Global Risks
- Man-made Threats (CBRNE)
- Natural Threats (Floods, Earthquakes, Tornadoes, Hurricanes, Droughts)
- Extreme Events
- National Interests
- Critical Infrastructures
- Aging Infrastructures
- Climate Change – Coastal Impacts
- Federal Emergency Operations
- Products: Policies, Standards; Guidelines; Tools; Federal Aide;

- Assess Region's Resilience to National Risks
- Man-made Threats (CBRNE)
- Natural Threats (Floods, Earthquakes, Tornadoes, Hurricanes, Droughts, Wild Fires)
- Extreme Events
- Regional Interests & Aging Infrastructures

- Communications Network
- Cyber; Energy Grid; Transportation Networks
- Resurgent Infrastructure
- Regional Emergency Operations
- Business Continuity

It appears critical infrastructure operational resilience is fundamental to developing resilience at all geographical scales. This is a complex and complicated concept. It appears to be a function of space, threats, and numerous other contributing factors. It may evolve around 4 principles: capacity; flexibility; tolerance; and cohesion. Alternatively, there is perhaps the need to understand how to apply five traditional components of resilience (robustness, redundancy, resourcefulness, response and recovery) to five subsystems of resilience (economic, environmental, governance, infrastructure, and social).

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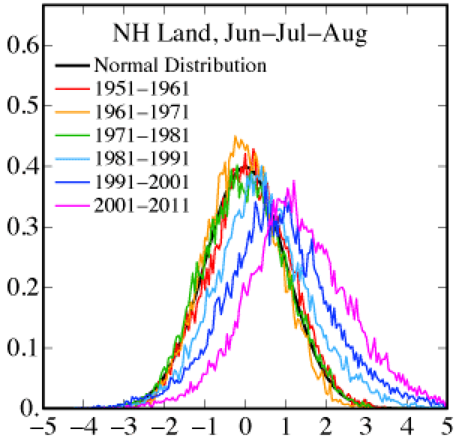
Discussion Overview

- Evidence of increased weather risk comes from observations as well as from physics and modeling
- More extreme weather events are happening, with increasing costs
- Infrastructure managers need to deal with increased probabilities and consequences of extreme weather events
- To deal with increased risk, we need to understand the magnitude of potential consequences and address them through resilience, hardening, adaptation and prevention.
- The Presidential Directive 21 (February 2013) makes the ability to model and project future exposures to extreme weather events and disruptions to critical infrastructure (CI) a national priority.

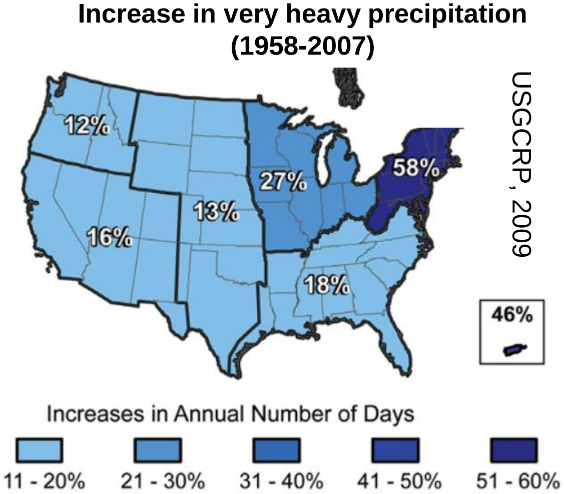
Observations

Extreme Heat

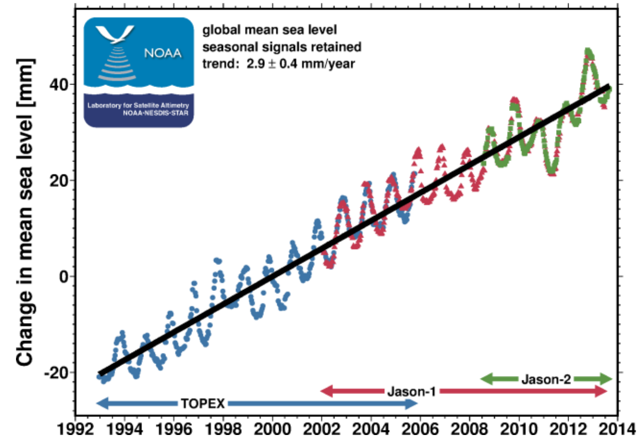


Hansen et al. (*PNAS*, 2012)

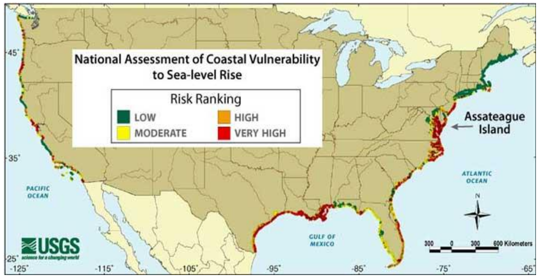
Heavy Precipitation



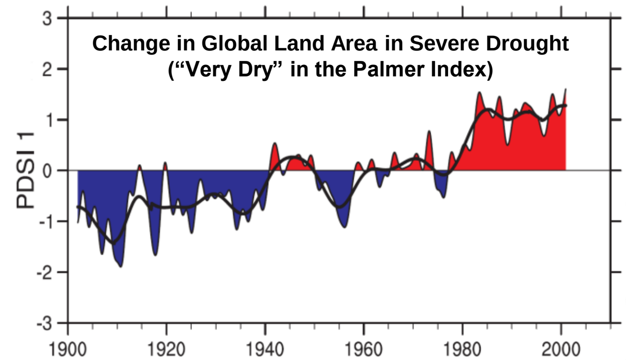
Sea Level Rise



Coastal Vulnerability

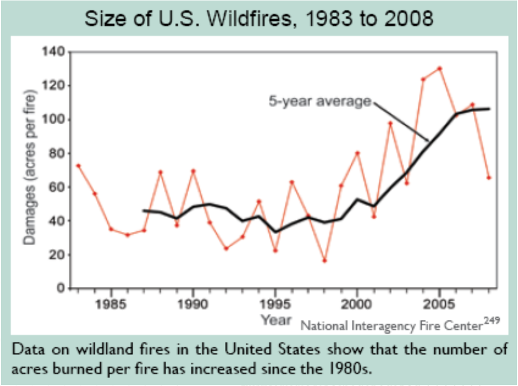


Increasing Drought



Dai, et al. (2004) *J. Hydromet.*

Wildfire Trend



ORNL's modeling/simulation programs are aimed at understanding impacts to critical infrastructures for all extreme events.

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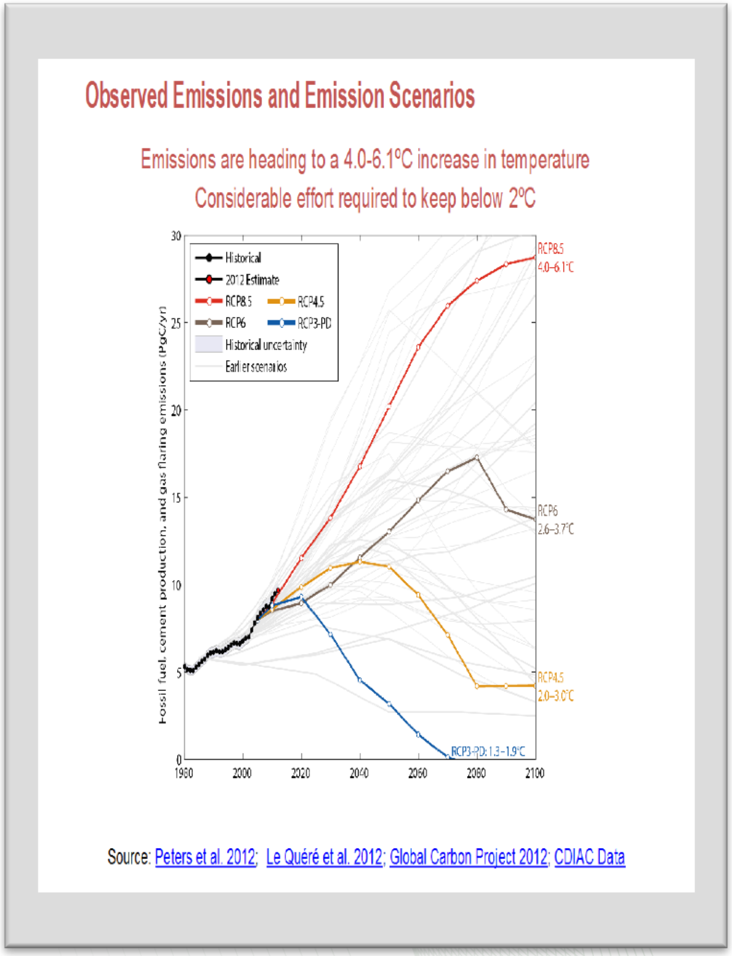
Climate Change and Extreme Weather

- Impacts of climate change are no longer hypothetical: they are being observed, and some of them are already becoming serious
- Greenhouse gas emissions are continuing to rise, making severe climate change more likely than moderate climate change
- Meanwhile, in 2011 and 2012 the US experienced an unusual series of climate-related extreme events: severe storms (e.g. Sandy), droughts, floods, winter tornados, wildfires – some continuing in 2013
- Improving the ability to project future exposures and disruptions for critical infrastructures has become a high national priority – especially exposures to extreme weather events



Grid Modeling and Analysis at ORNL

Assisting DOE in modernizing the electric grid; enhancing security and reliability of the energy infrastructure, and facilitating recovery from disruptions to energy supply.

• Accelerate advancement of new tools • Move toward predictive approaches • Integrate models and functions

Modeling and Simulation

Develop advanced models to be used in next generation of analysis tools for reliable and efficient operational control

Analysis

Provide expert analysis based on advanced models, data analytics, and high performance computing

Monitoring & Visualization

Develop platforms from large data sources that account for human factors

Data Management

Ensure data accuracy, integrity and trustworthiness at appropriate sampling rates based on efficient architecture for rapid authorization, integration, and retrieval

U.S. DEPARTMENT OF ENERGY

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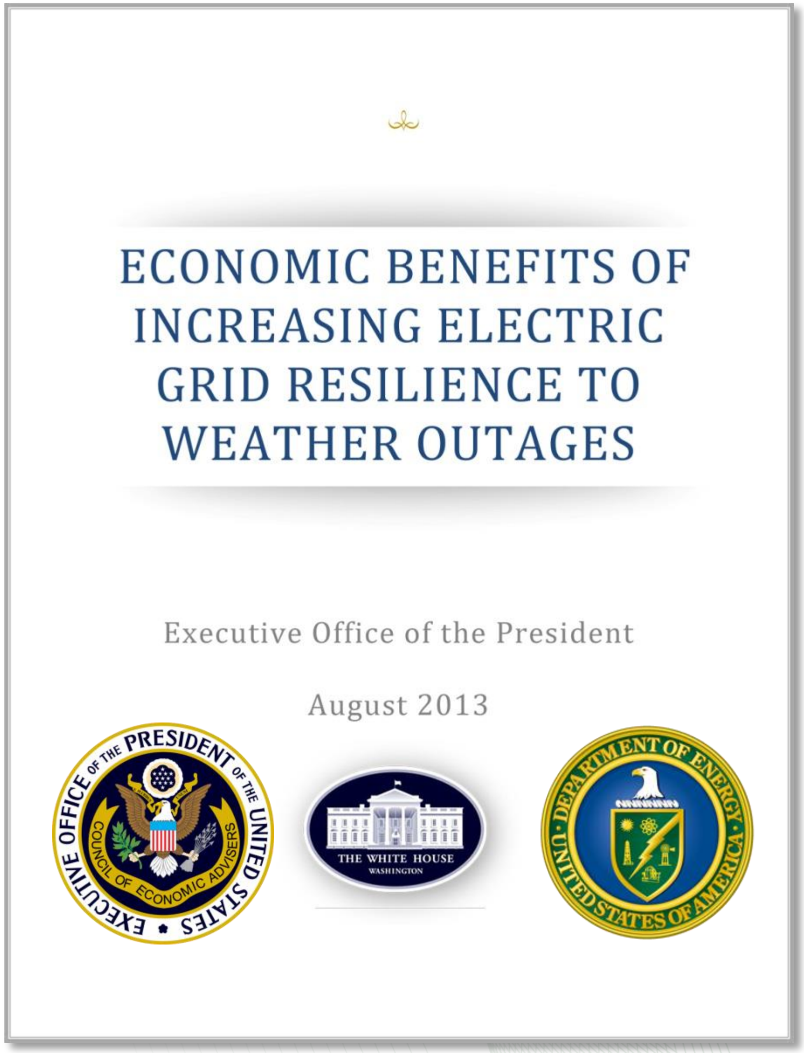
Achieving Critical Infrastructure Operational Resilience

- Priority 1: Manage risk
- Priority 2: Cost-effective strengthening
- Priority 3: Increase flexibility & robustness
- Priority 4: Increase visualization & situational awareness
- Priority 5: Advanced control capabilities
- Priority 6: Enhance availability of critical components


ECONOMIC BENEFITS OF INCREASING ELECTRIC GRID RESILIENCE TO WEATHER OUTAGES

Executive Office of the President

August 2013

Department of Homeland Security Extreme Weather Event Anticipation Tool

- Leverages ORNL’s critical infrastructure disruption models [VERDE/EARSS] for the electric power grid.
- Integrates capabilities from other toolsets and datasets to:
  - **Project extreme weather events**, based on the best available science, and produces: 1) maps of extreme event exposures organized by event type, location, and temporal interval of interest; and 2) assessments of the probability of the exposure.
  - **Simulate the effects/impacts of extreme weather events on critical infrastructures** and the effects of resilience enhancements which are based on science-based models developed over a decade in supporting emergency response operations.
  - **Assess alternatives for adaptive risk management** to assist planners in identifying the most effective mitigation and response strategies
  - **Support the analysis of interdependencies among several critical infrastructures**, including the key life-line sectors [energy (electric power grid, natural gas) , water, telecommunications, and transportation (ports, road, rail, air)], using DHS Infrastructure Interdependencies as the basis for analysis.
  - **Model impacted or at-risk populations, restoration, and damage area for multi-hazards** (including flood, wind, wildfire, earthquake, industrial incidents)

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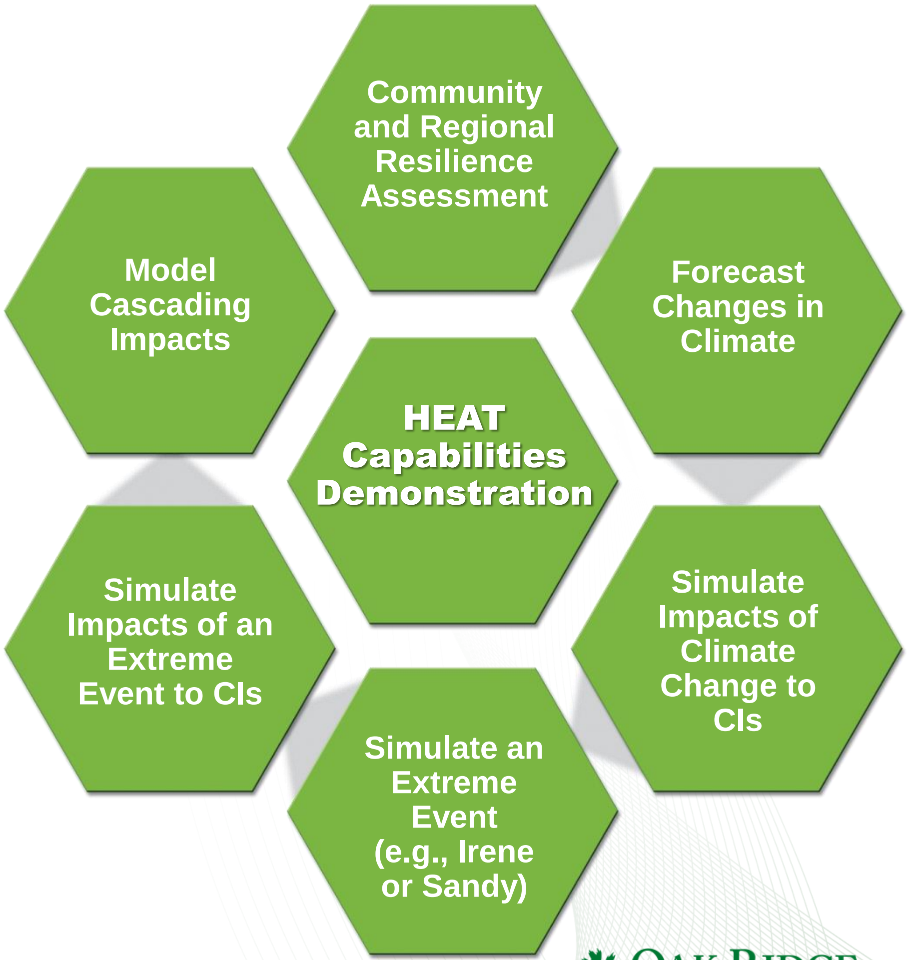
Department of **H**omeland Security **E**xtreme Weather Event **A**nticipation **T**ool

- HEAT can be used to support community and regional resilience assessments.
- It is currently being used to support the DHS Regional Resilience Assessment Program (RRAP) to study climate threats and impacts for Portland, Maine.



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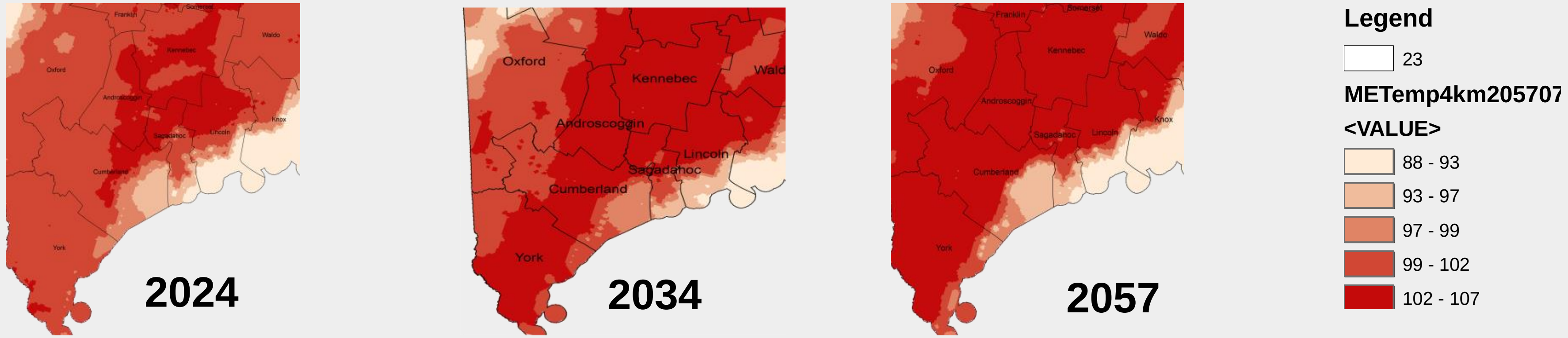
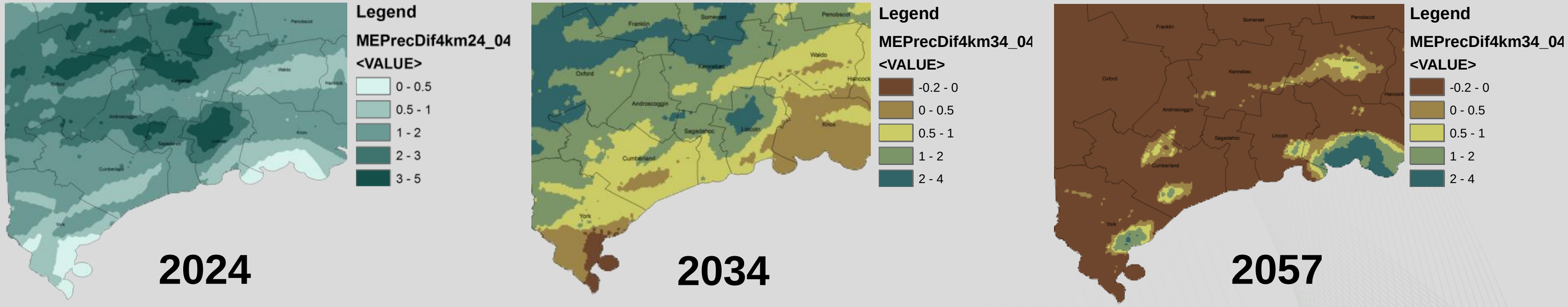
Climate Demonstration: Higher summer temperatures projected for areas of Portland.



Climate Demonstration: Less precipitation projected for Portland.



Our modeling/simulation shows that the climate is getting hotter and drier in the area where Portland draws its main water supply.

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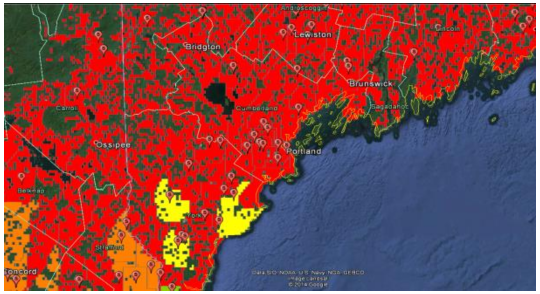
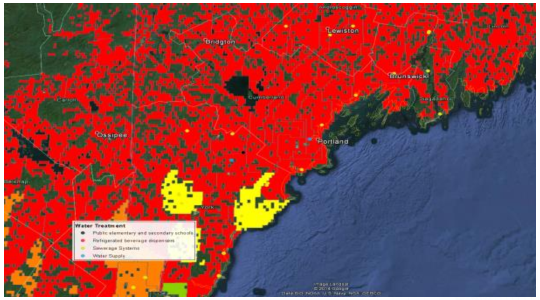
Extreme Event Demonstration (Model and Simulate Hurricane Irene in Portland, ME)

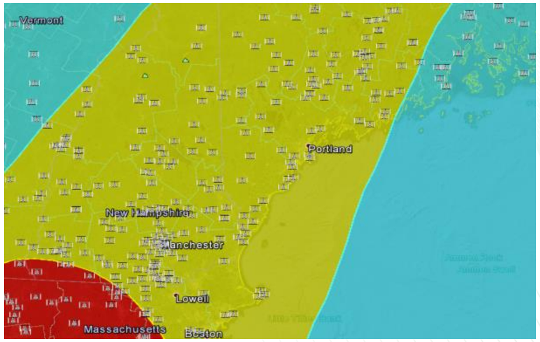
- By overlaying one km resolution extreme event power and communication outage forecasts with other critical infrastructure sectors, one can model both direct and indirect infrastructure cascades through multiple sectors.
- Our results may aid planners in better understanding:
  - Diverse consequences and cascading impacts of an extreme event
  - Areas which are more or less vulnerable
  - Restoration time for neighborhoods
  - Strategies for response operations



Power outages projected from Hurricane Irene analog storm



Power outages overlaid with water sector treatment plants



Potential wind damage areas overlaid with communications sector cell towers

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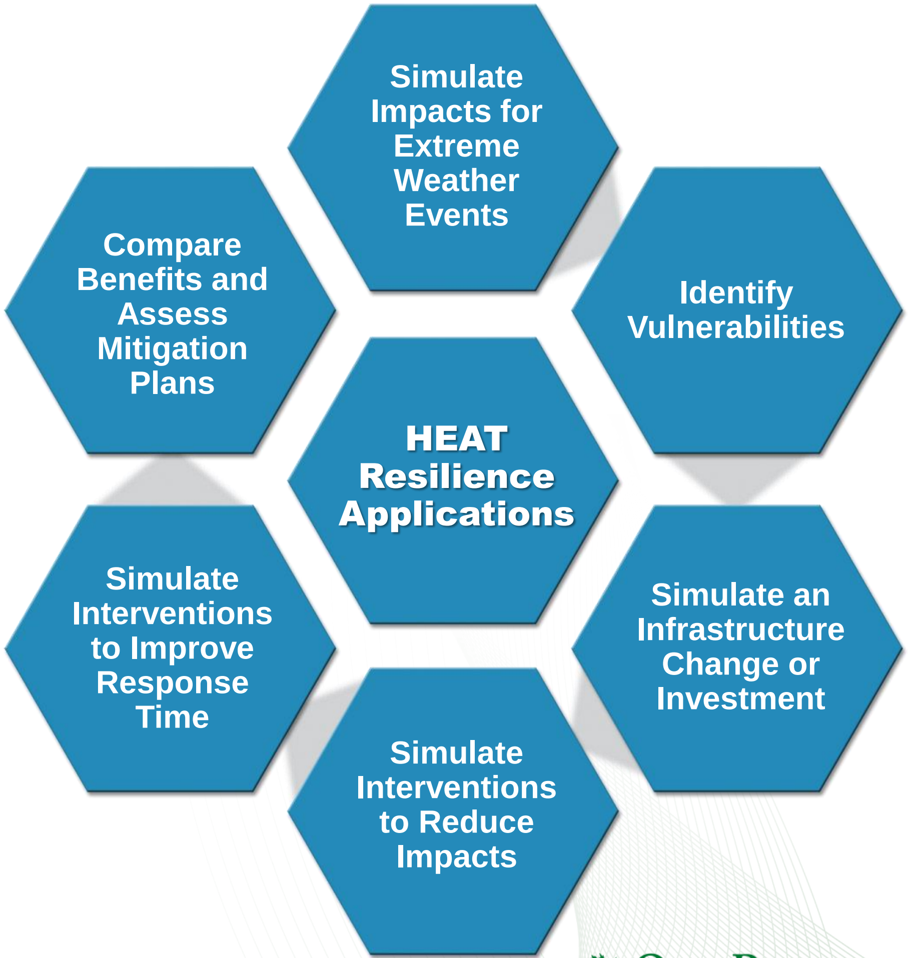
- HEAT supports a framework for studying critical infrastructure security and resilience.
- The tool can be used to:
  - Project exposures.
  - Simulate impacts.
  - Examine adaptation, mitigation and response strategies.



Summary

- By understanding extreme weather trends and future risks, we can act to reduce vulnerabilities and increase critical infrastructure operational resilience
- At ORNL, we are focusing on resiliency modeling/simulation across several key areas including:
  - Risk management tools
  - Increasing flexibility through controls and microgrid operation
  - Providing situational awareness to federal and local governments along with industry
  - Developing tools to aid decision-makers in identifying and reducing vulnerabilities and enhancing response capacities.
- Acknowledgments:
  - Department of Homeland Security
  - Argonne National Laboratory – Infrastructure Assurance Center
  - Melissa Allen and Linda Sylvester (Doctoral Students)
- Thank you!

Questions