

Infrastructure Consequence Analyses and Climate Risks to Water, Agriculture and Energy

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Distinguished R&D

Infrastructure Consequence Effects Group



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interest*

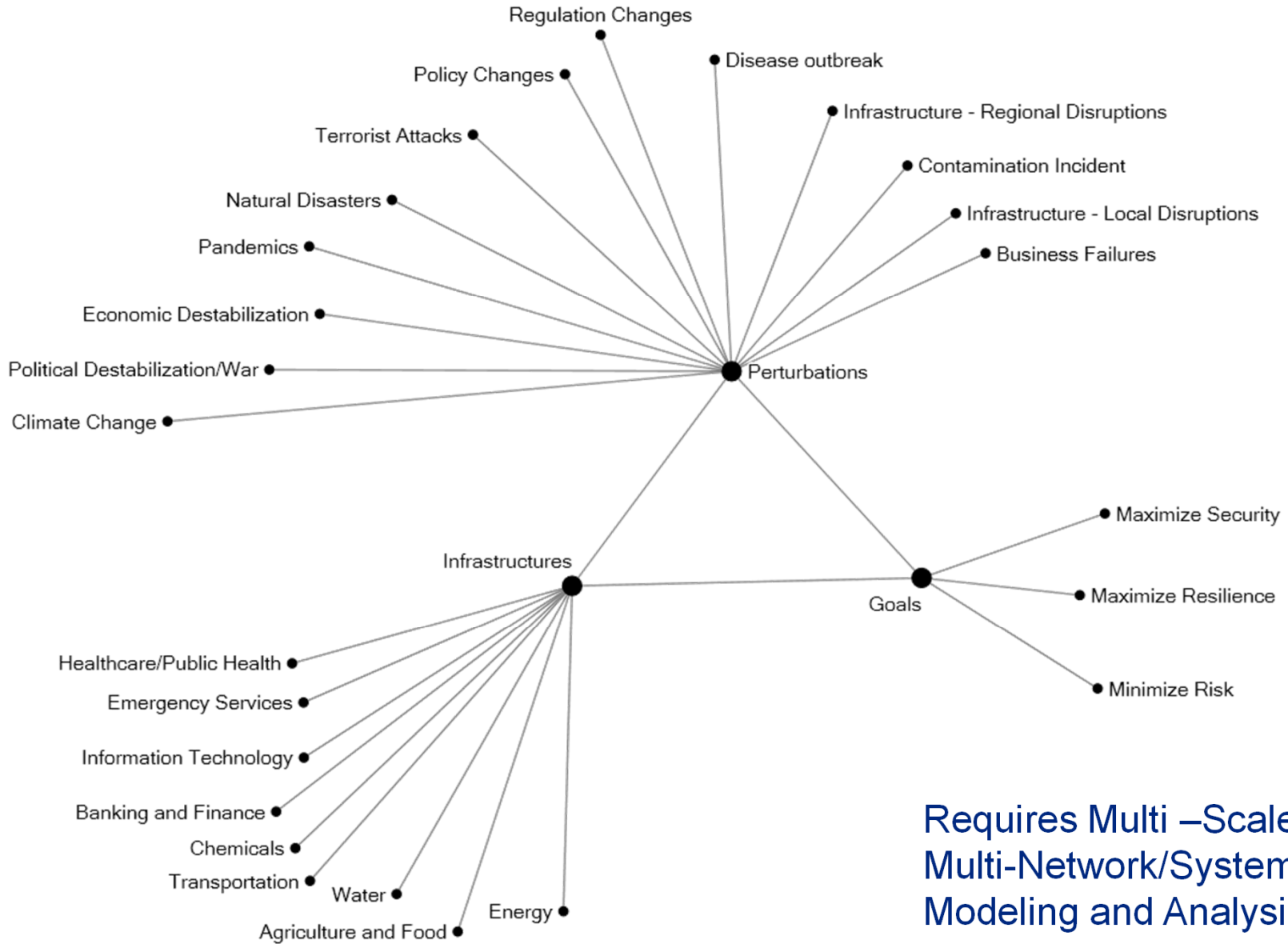


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The Infrastructure Space



Overarching Goal: Understand Risks and Engineer Solutions

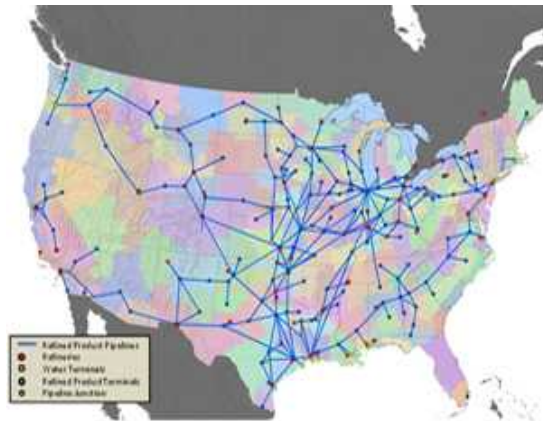
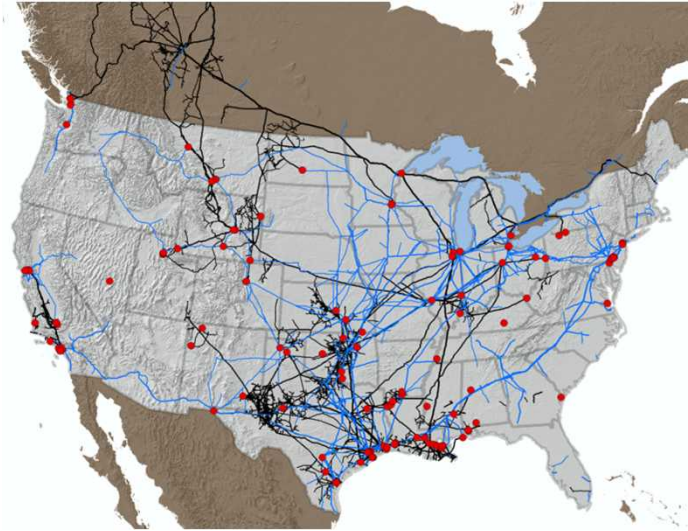


Requires Multi-Scale and Multi-Network/System Data, Modeling and Analysis



Energy – Petroleum Fuels: Networks

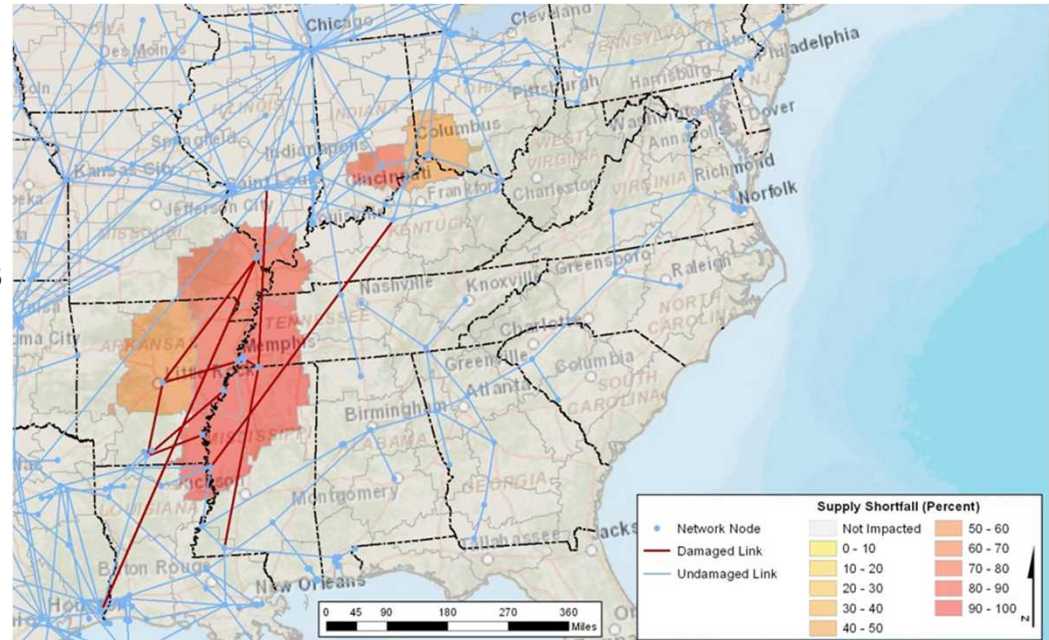
- Goals:
 - understanding risks of specific incidents (hurricanes, earthquakes, equipment failures)
 - identifying effective risk mitigations
- Approach:
 - incident and scenario-based analyses
 - national network model
- Developed for the National Infrastructure Simulation and Analysis Center (NISAC)



For references and contact information see:
<http://www.sandia.gov/nisac>

Example Scenario: Central U.S. Earthquake

- The New Madrid Seismic Zone (NMSZ) stretches along the Mississippi River Valley from southern Illinois to Memphis
- A cluster of very powerful earthquakes occurred during the winter of 1811–1812.
- The U.S. Geological Survey estimates a 7 to 10 percent chance of earthquakes with magnitudes equivalent to the 1811–1812 quakes occurring in any 50-year period *
- A similar cluster of earthquakes occurring today would cause extensive damage to oil and gas transmission pipelines



*(USGS, Center for Earthquake Research and Information Fact Sheet 2006-3125).

Global Chemical Supply Networks

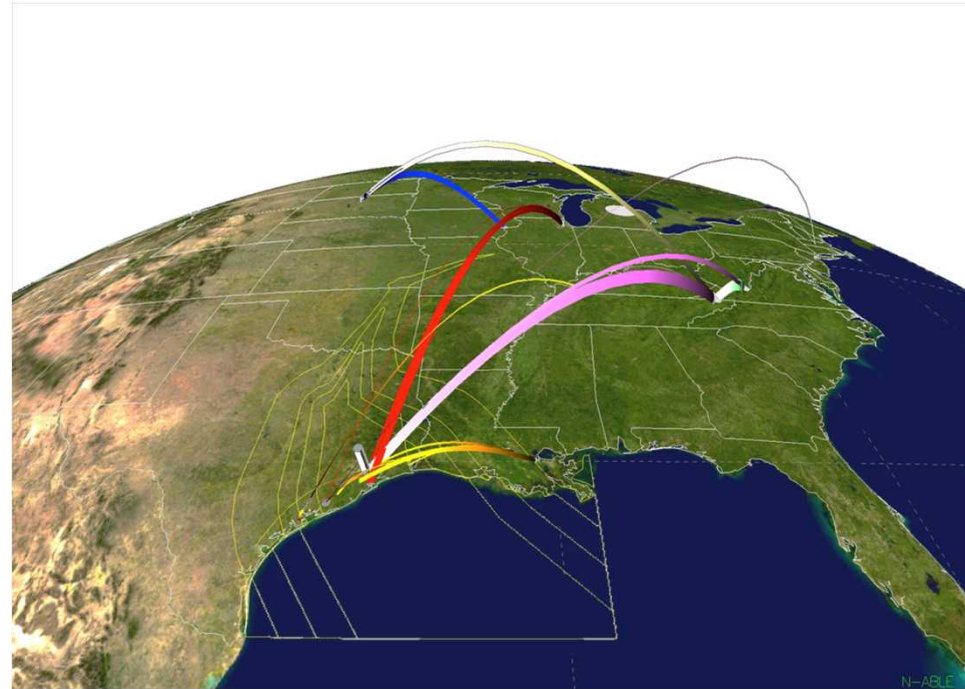
■ Goals:

- understanding risks of specific incidents (hurricanes, earthquakes, equipment failures)
- quantify resilience
- identify critical chemicals/processes

■ Approach:

- incident and scenario-based analyses
- entity-based network model (Exchange)
- agent-based economic model (NABLE)

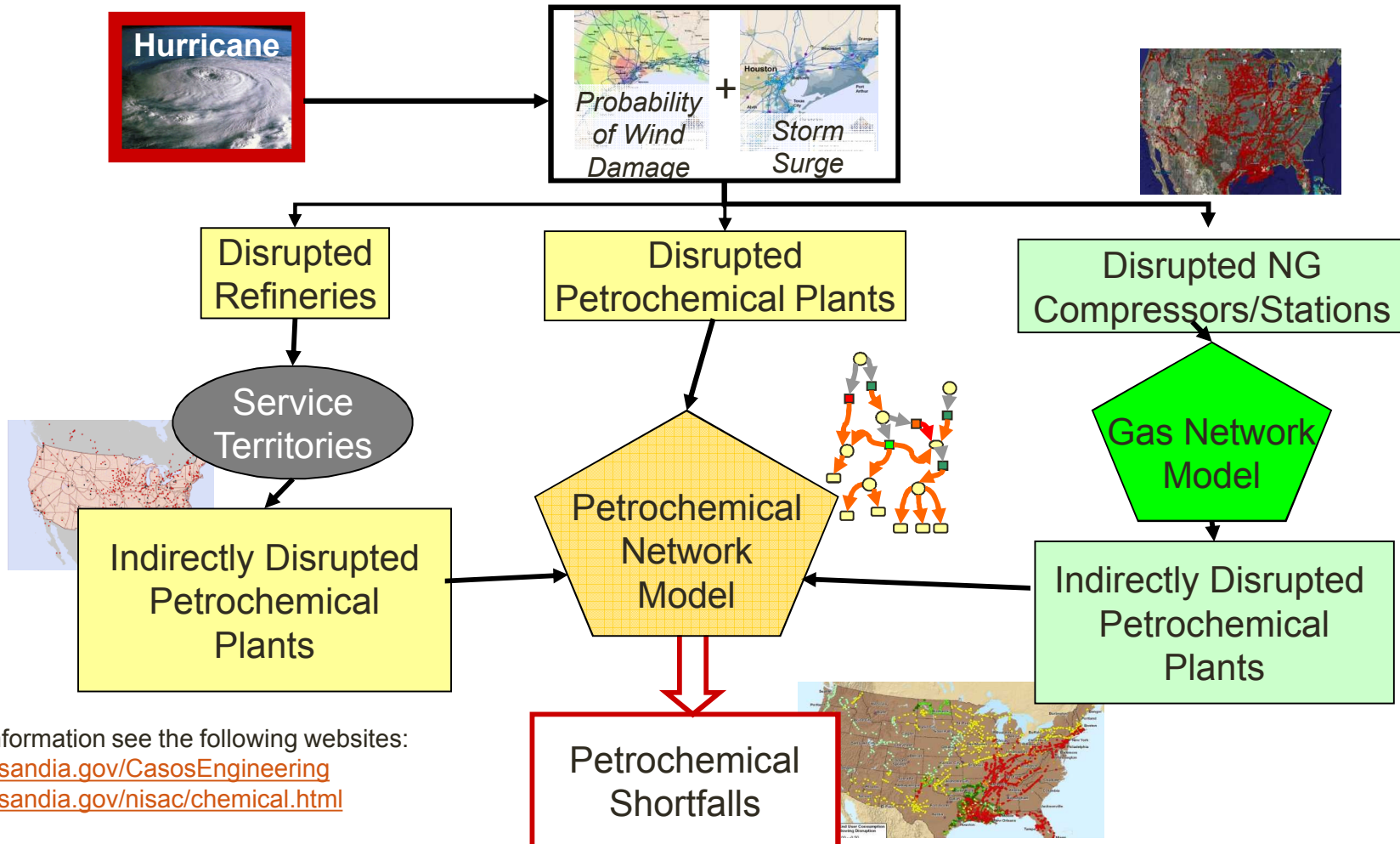
- Developed for the National Infrastructure Simulation and Analysis Center (NISAC)
(<http://www.sandia.gov/nisac/>)



N-ABLE

Chemical Supply Networks (with interdependencies)

Example – Hurricane Impacts on Petrochemical Supplies

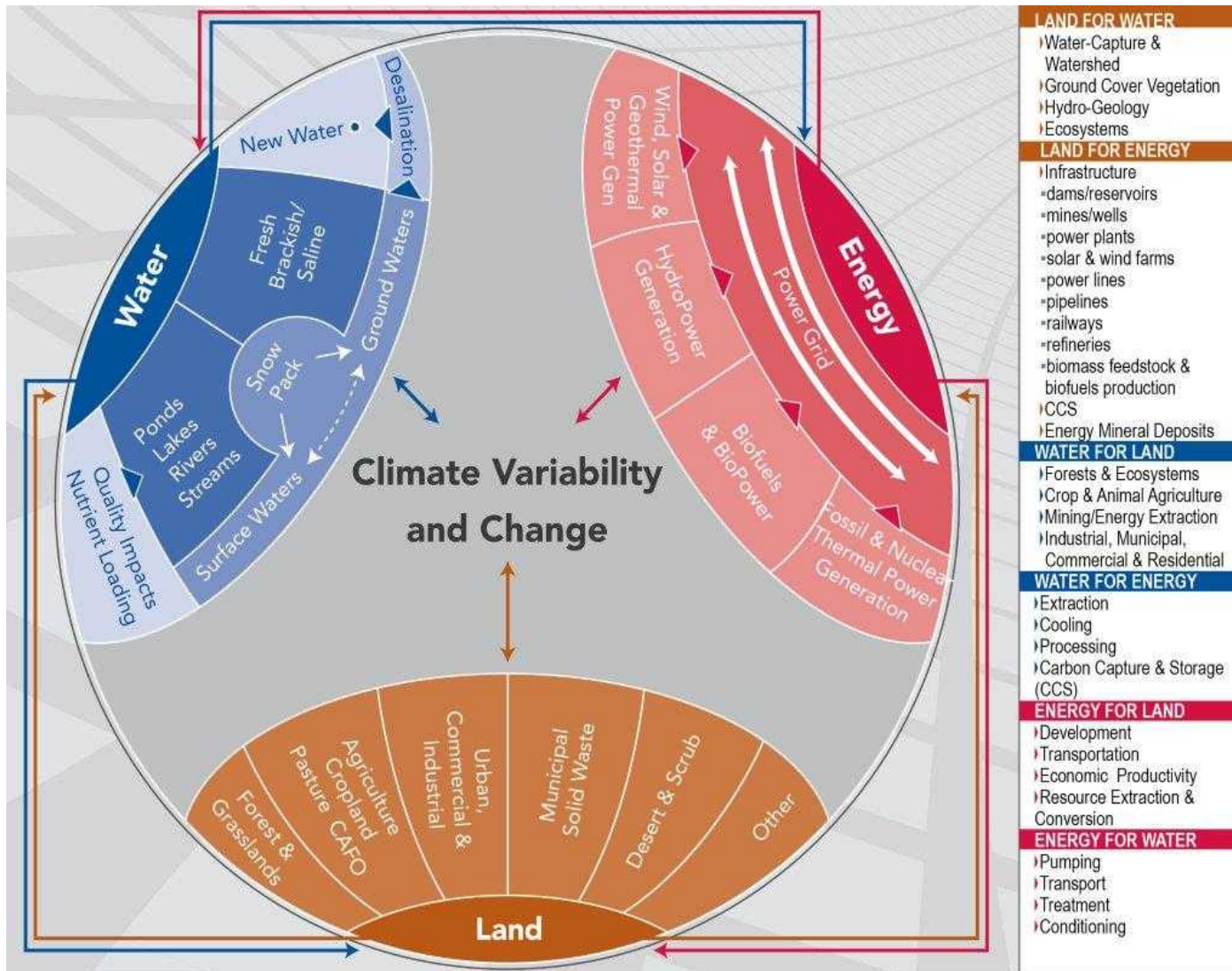


For more information see the following websites:

<http://www.sandia.gov/CasosEngineering>

<http://www.sandia.gov/nisac/chemical.html>

Climate Stresses and Infrastructure Planning



Energy/Water/ Land/..... Nexus

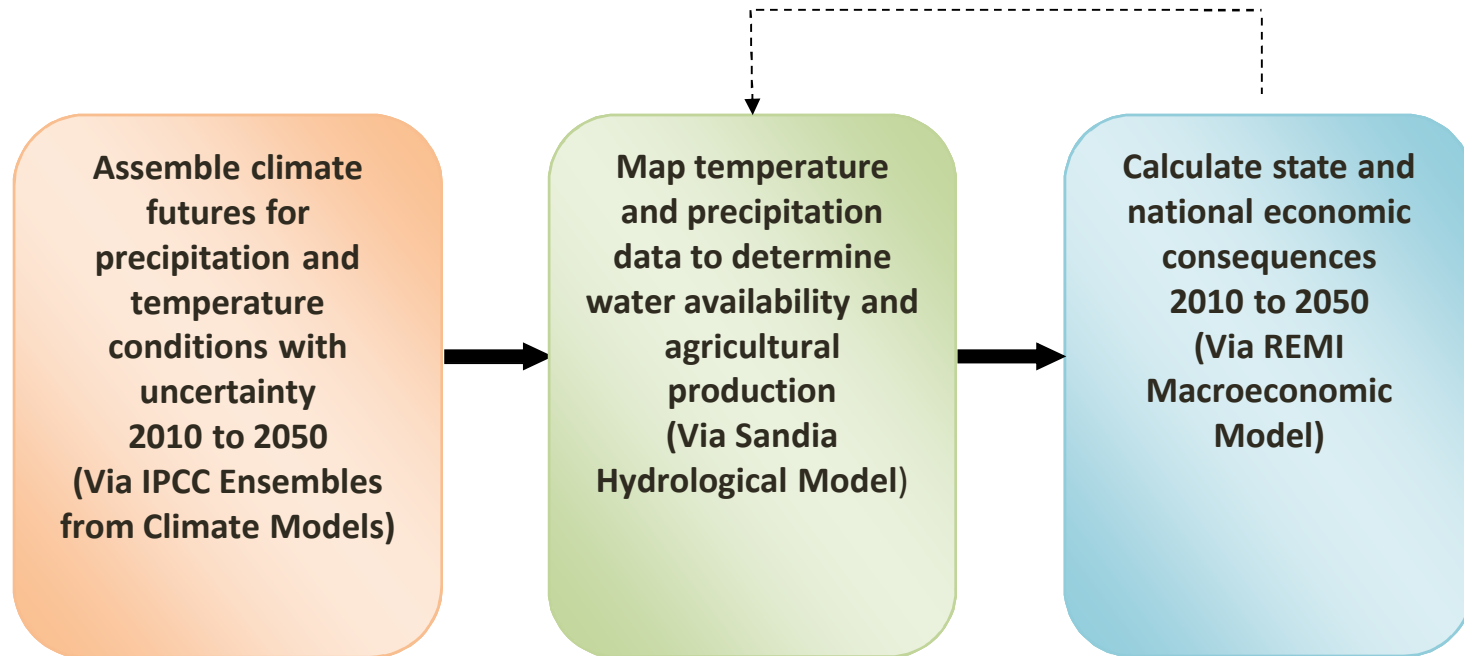
Competing Human Values



Environmental Health

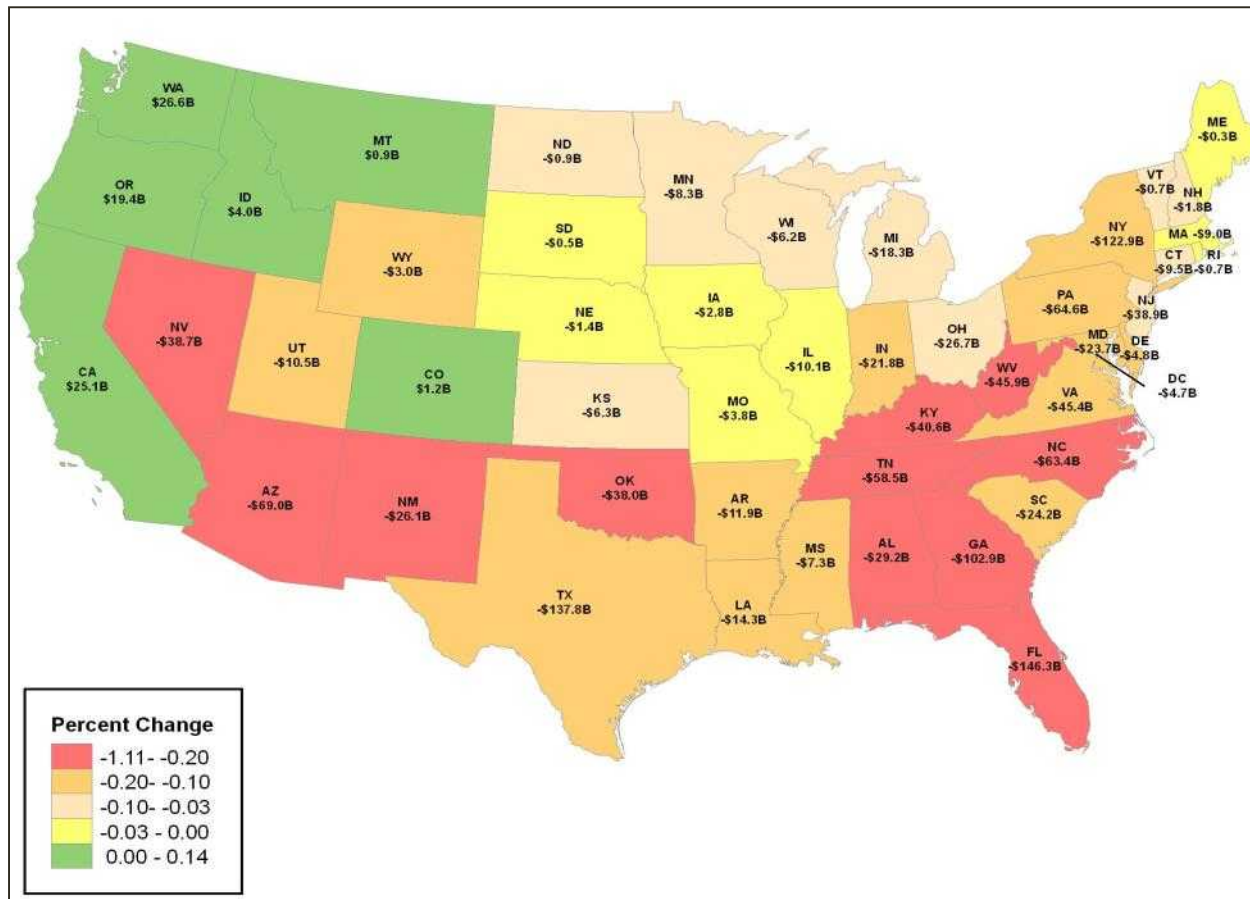
Growing Demand

Overview of the analysis process



From: Backus et al. (2010). Assessing the Near-Term Risk of Climate Uncertainty: Interdependencies among the U.S. States, SAND2010-2052

Integrated GDP risk by State

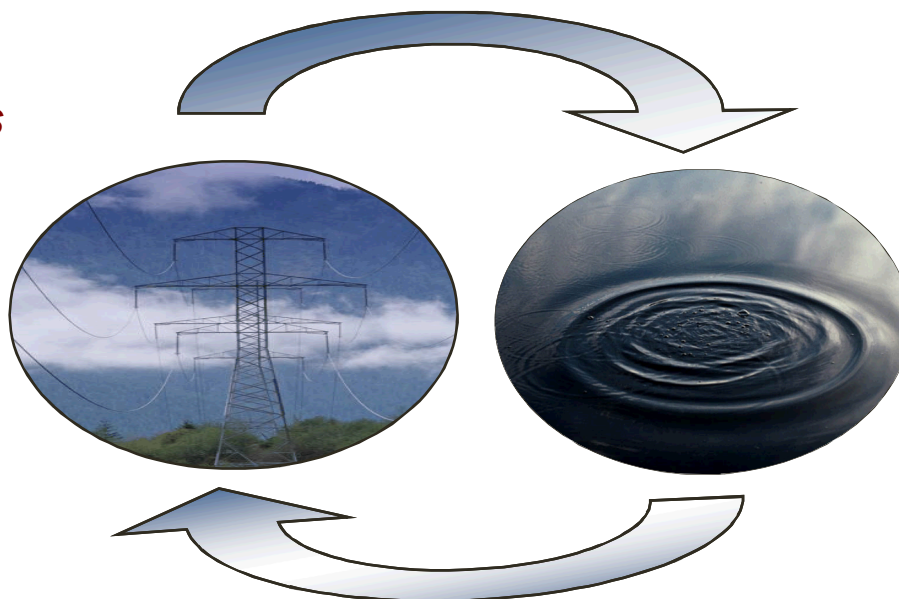


Backus (2010)

Climate Change: Prospects for Energy and Water Demand in the Southwest Region (WECC and ERCOT)

Energy and power production requires water

- ***Thermoelectric Cooling***
- ***Emission Control***
- ***Energy Minerals Extraction/Mining***
- ***Fuel Processing (fossil fuels, H₂, biofuels)***



Water production, processing, distribution, and end-use requires energy

Energy-Water Nexus

Electric Power Potential Impacts

- Higher temperatures increase the resistance of a conductor, which decreases the carrying capacity of the transmission line. Losses of 7% to 8% of peak are possible.
- Higher ambient temperatures reduce the peak-load capacity of banks of transformers. Could lose 1.6% to 2.7% capacity by the end of the century in California.
- Greater probability of wildfire damage and damage due to sea level rise

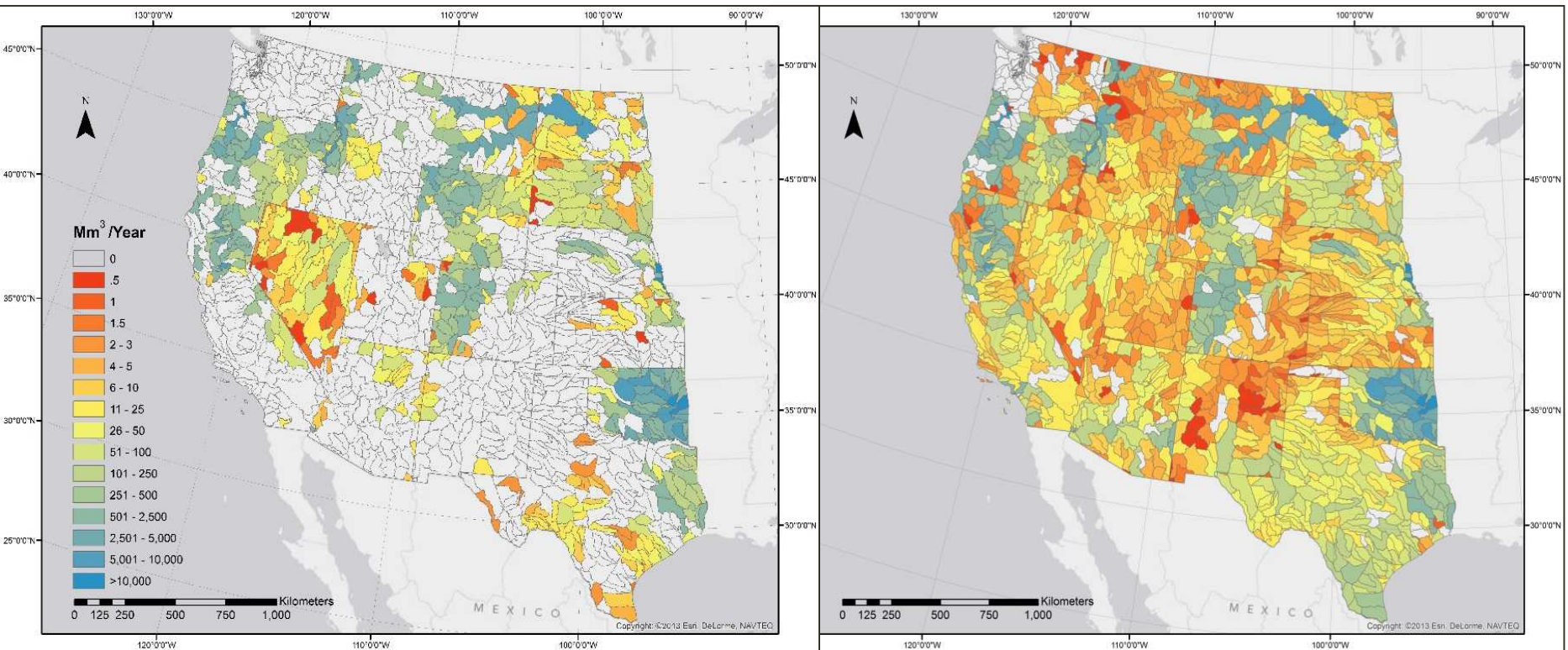


Water for Development

Water available for consumptive water based on projected changes in consumptive use 2010 to 2030

Unappropriated Surface Water and Groundwater Sources Only

All Water Sources



For more information contact Vince Tidwell, Sandia National Laboratories and see

<http://www.sandia.gov/water/rdocs.html>

Basin-Scale Water Resource Planning

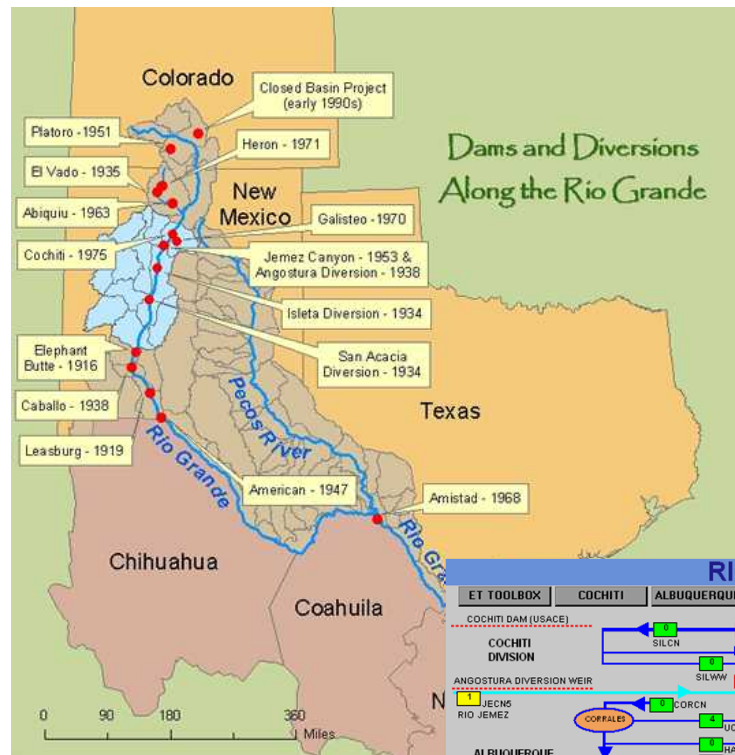
Goal:

- Understanding water supply and allocation risks

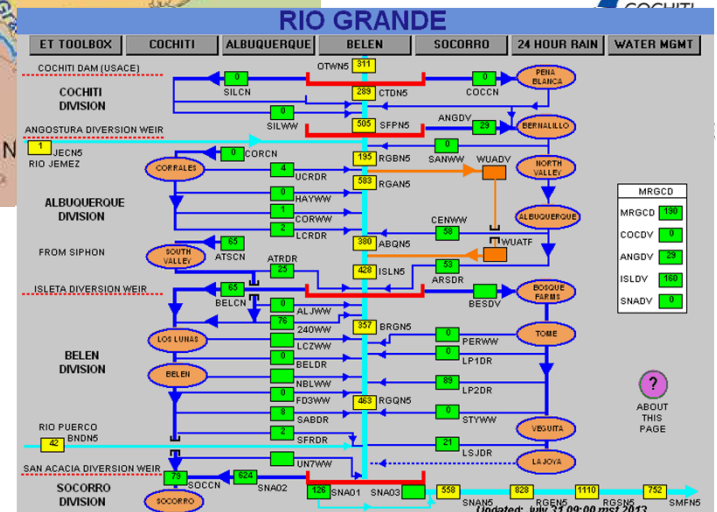
Approach:

- Scenario-based analyses
- Watershed system dynamics model
- Cooperative model building
- Workshops

Multiple funding sources



Albuquerque Bernalillo County Water Utility Authority
San Juan Chama Drinking Water Project



References at: <http://www.sandia.gov/water/rdocs.html>

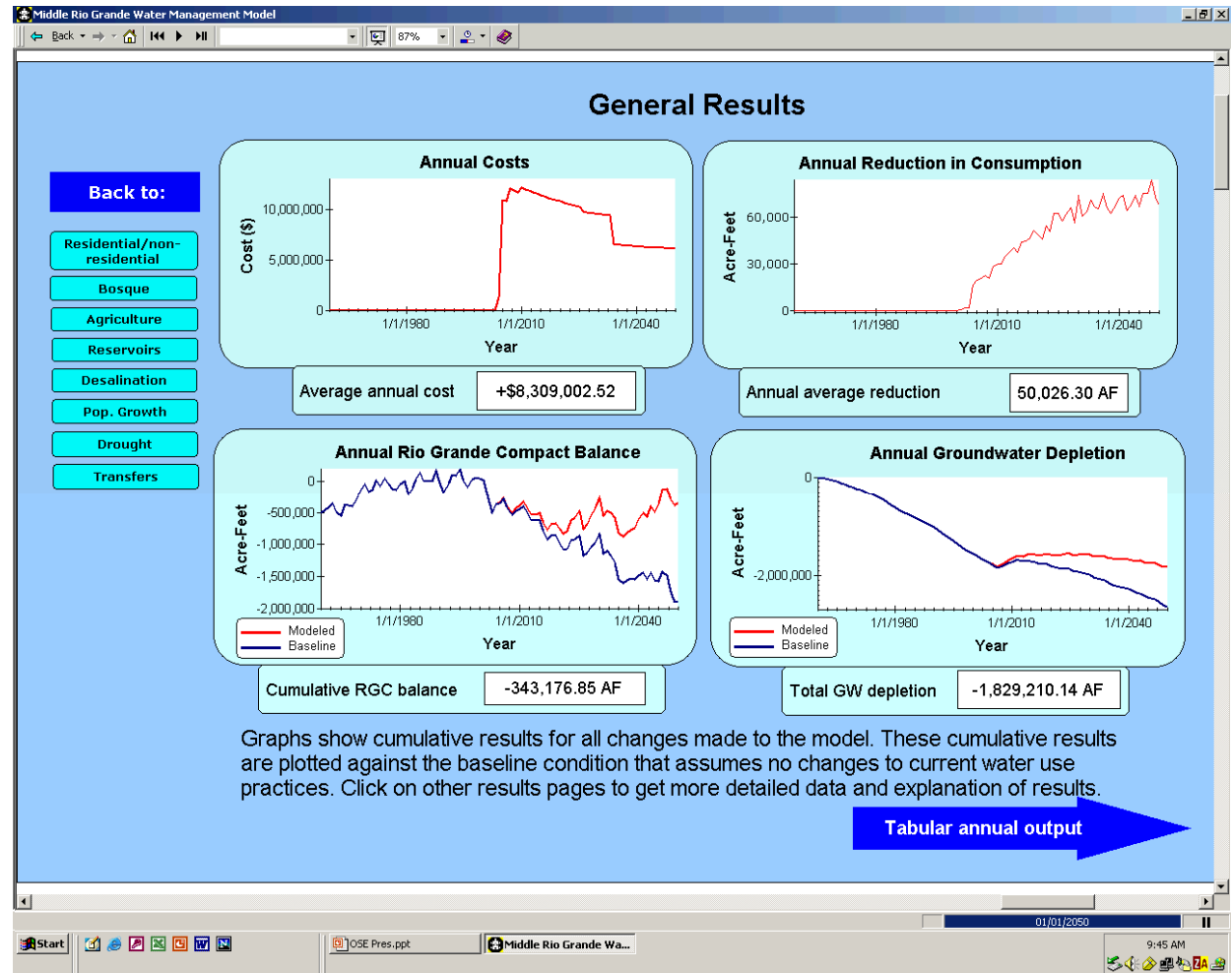
Model Development Process

- Cooperative Modeling Team including members from:
 - Each Water Assembly constituency group,
 - Middle Region Council of Governments (MRCOG), and
 - Utton Transboundary Resources Center, UNM
- Modeling team activities include:
 - Conceptualizing model components,
 - Identifying additional sources of expertise and data
 - Implementation in software
 - Model review and improvement
- Community engagement through:
 - Public forums,
 - Educational venues
 - Community events
 - Technical exchange

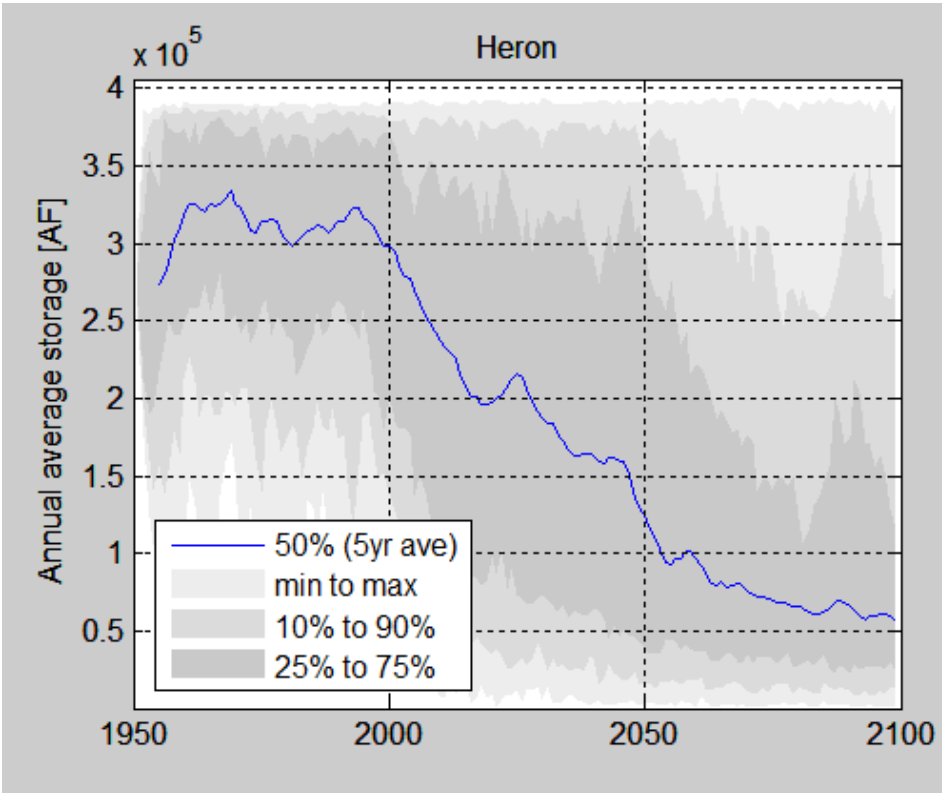
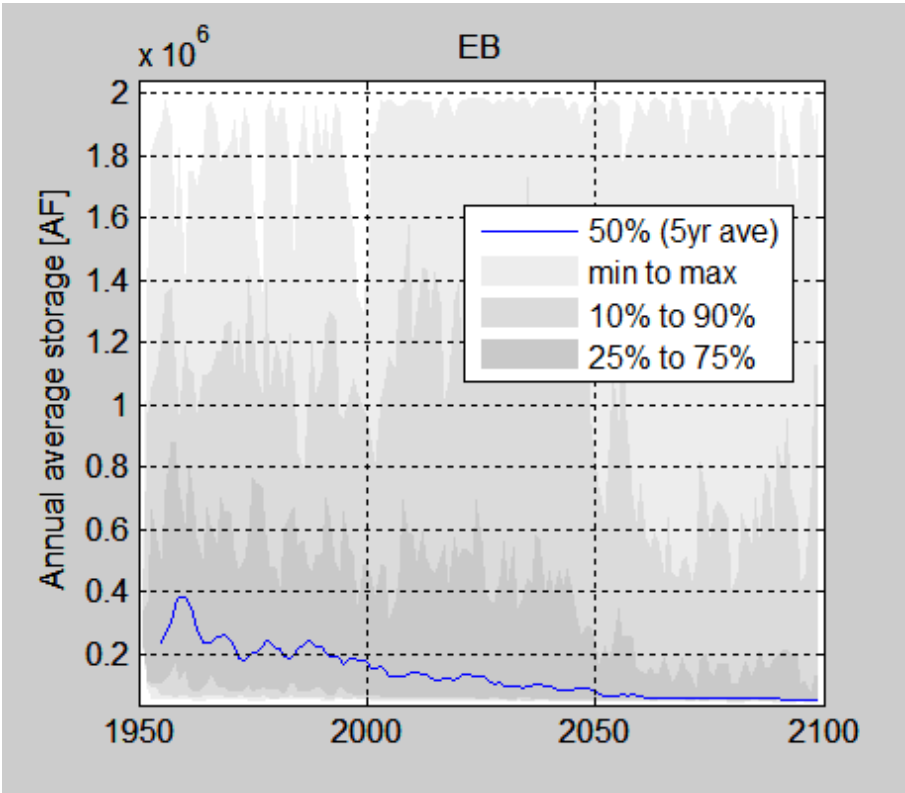


Visual/Interactive Environment for Analysis

- Broadly accessible
 - PC based
 - User friendly interfaces
 - Computations in seconds to minutes
- Provides interactive environment for scenario testing



Provides better understanding of the uncertainties and planning



Impacts to NM Reservoirs

<http://www.sandia.gov/water/rdocs.html>

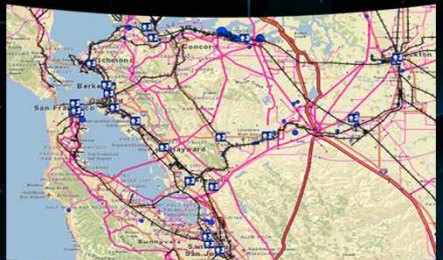
Roach et. al., 2013



PROVIDING TECHNICAL EXPERTISE TO
HELP CITIES
BETTER ADDRESS THE INCREASING SHOCKS AND STRESSES
OF THE 21ST CENTURY.



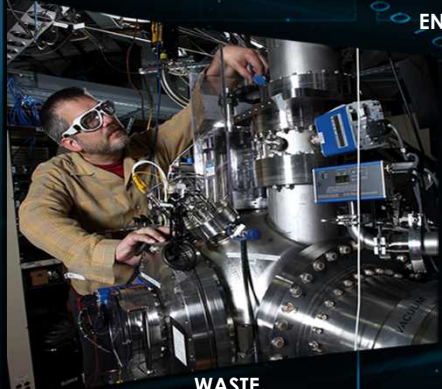
ENERGY



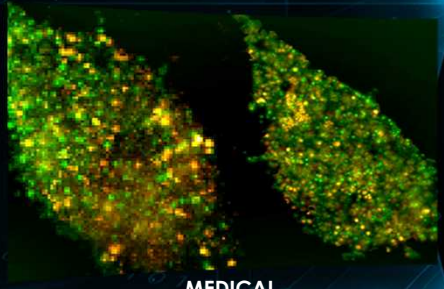
RISK ANALYSIS



WATER



WASTE



MEDICAL



TRANSPORTATION



FOOD



EMERGENCY
RESPONSE



ECONOMY



PSYCHOLOGICAL /
COGNITIVE EFFECTS

THE ROCKEFELLER FOUNDATION
100 RESILIENT CITIES
CENTENNIAL CHALLENGE

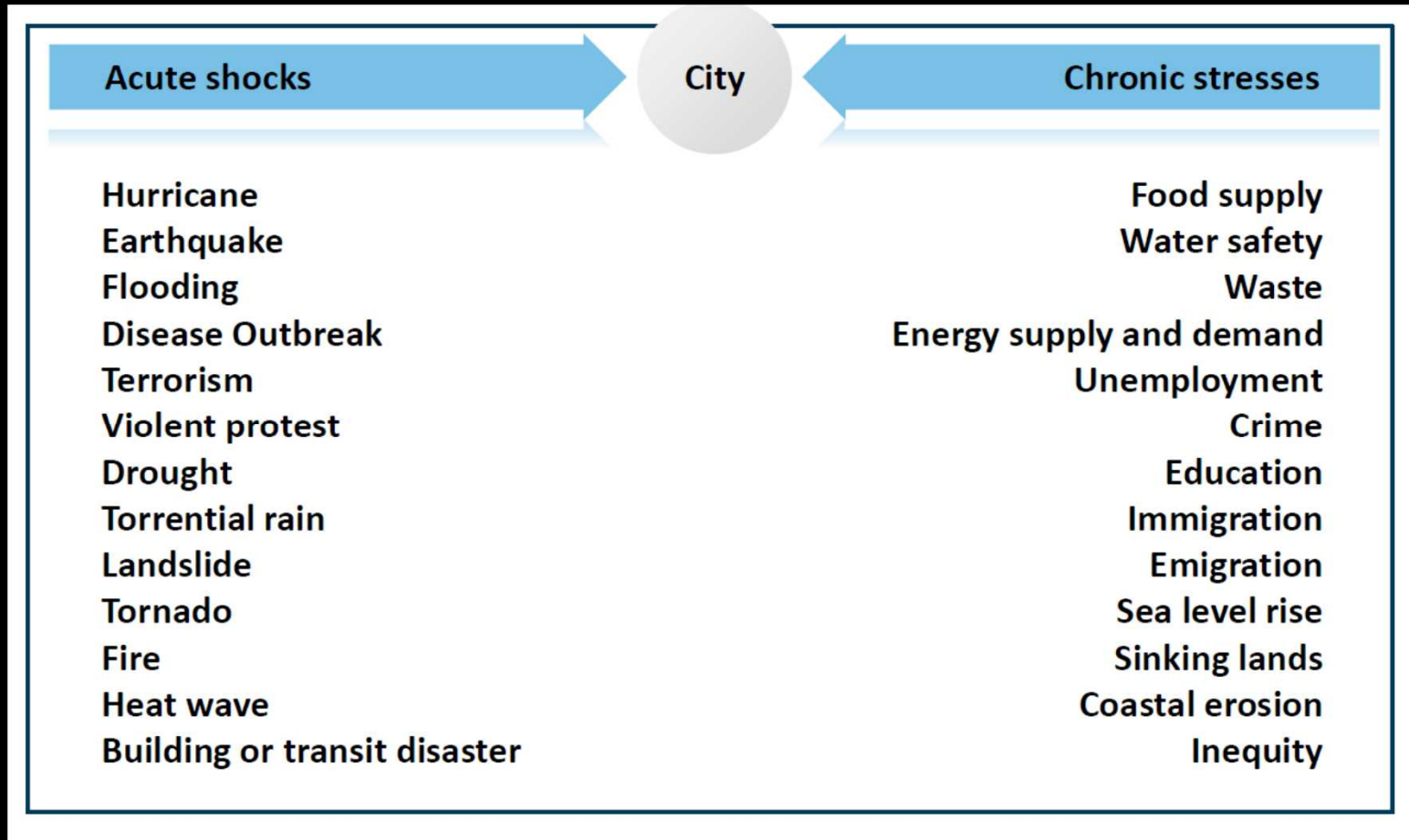




Image Courtesy of 100 Resilient Cities

Resiliency Concepts Combined With an Integrated Climate, Infrastructure and Economic View Is Needed to Plan Adaptation Strategies

- Many regions in the U.S. and Globally are likely to be negatively impacted by climate changes
- Multiple interdependencies and uncertainties can be daunting for planning
- An integrated system approach that accounts for global, national, regional and cross-sector interdependencies is a practical and cost-effective approach for understanding risks, enhancing resilience and improving adaptation strategies
- Working with local and regional stakeholders provides opportunity to test and improve our methods for national security applications and develop essential collaborations

