



# Strategic Responses to Climate Change



**George Backus, Project Manager  
Exploratory Simulation Technologies (SNL)**

**August 10, 2007  
Albuquerque, NM**



# **Sustainability is a Moving Target**

---

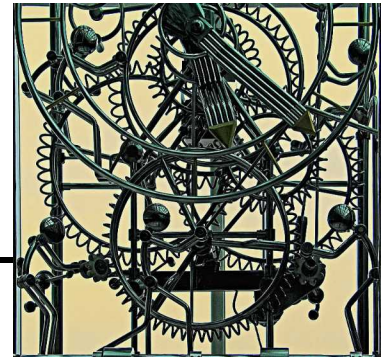


- **The classical conservation approach to sustainability as a long-term sustainable future, might not be the most critical perspective.**
- **Climate change events will likely unfold in ways that confound current mainstream expectations.**
- **Goal is to sustain the impacts of climate change and the subsequent structural changes in economies, societies, and population centers – and to not foreclose vital options for future generations.**



# From Obvious to Subtle

---



- **Migration – new/evolving population centers, even in industrialized world.**
- **New infrastructure required for commercial and societal activities.**
- **Response to disease vectors may lead to revamped (cultural/-institutional) demographics.**
- **Expansion of economic/political tensions due to Arctic accessibility and extreme weather elsewhere.**
- **Global security threatened by failed-nations, “re-colonization,” and neo-cold wars.**
- **Understanding land-use dynamics are critical to mitigating cascading weather and demographic phenomena.**
- **Multi-national companies are more significant than most nations to global progress. Supply chains will evolve, reconfigure, and determine economic progress.**



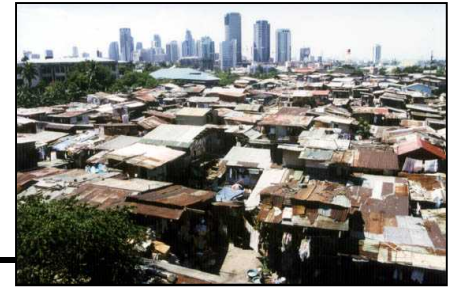
# Changes to Survive Climate Change

---

- **Characterize disruptive technologies that avoid perpetuating incompatible practices.**
- **Reserve capability of options (e.g. conservation), for contingencies and timing flexibility in the face on unexpected circumstances**
- **Establish keystone innovation requirements to meet critical, climate-induced challenges.**
- **For acceptance and implementation, analysis needs to focus on reducing the risk of technical and political solutions.**
- **Develop robust-execution methods to achieve desired outcome despite uncertainty.**



# Regional Impacts



- Regional climate change can vary greatly from the global averages with significant affect within the decade.
- The already occurring changes in extreme weather intensity are particularly troubling.
- The resilience of a region/country dramatically affects the ability to cope with the change.
- Recent data indicate that rapid or abrupt climate change may already be beginning.
- Non-linear affects can cause unpleasant surprises.



# Climate Change and Extreme Weather

---

- **Local crises lead to global problems. The local impact of climate-induced change, primarily in terms of extreme weather and land-use, could drive national and corporate decision making.**
- **Many countries and industries are seriously concerned about climate-change over the next decade, mostly in regard to increased extremes.**
- **Significant climate change has occurred over the last 50 years. It is accelerating – as are its impacts.**
- **Minor variations in climate dramatically affects land-use. Changes in land-use dramatically affect regional climate.**







# The Need for Applied Climate Models

---

- **Studying climate-change is no longer an academic pursuit.**
- **Positive feedback mechanisms may already have driven the earth-system beyond the tipping-point.**
- **Stakeholders and laws now require companies and governments to include the threats and opportunities of climate change in decision-making and disclosure.**
- **Any improved understanding of evolving near to mid-term extreme-weather will dramatically affect investment and infrastructure decisions.**
- **This task requires high-resolution climate/weather models integrated with compatible vegetation, socioeconomic, and industry/financial models**





# SNL efforts

---



- **Agent-Based Socio-Economic Simulation**
  - Extreme condition responses
  - Policy leverage points/stress-points
  - Regional and international Security/Law/Political dynamics
  - Market and technology evolution
  - International and national interdependencies
  - Region-dependent Value/Norm-based behaviors
- **New Technology Exploration/Development**
  - Assessment of technological options
  - Needs requirements/characterization
  - Applying advanced science and engineering to new situations
- **HPC climate-change simulation to allow detailed, coupling with above concerns.**



# Key Technologies Will Control the Future

- Russia will have warmer temperatures and more rain, but require technology unique to the topology.
- Russia, Alaska, and Northern Canada will see rapidly expansive economic activity but ice and permafrost dynamics will require radical construction and design innovations.
- China and India will lose glacial water sources along with increasing migration and economic growth in extreme-weather prone areas. Conditions will require new infrastructure logic.
- Middle East and Canadian energy growth will challenge technical solutions for water, conversion, and transport.
- Movement of European & North American population centers will require the reinvention of infrastructure.
- Chinese demands on the global supply chains (South America/Africa) will revolutionize production-growth in marginal areas.



# Expanding Climate-Driven Markets

- **Assess evolving nation-state societal, political, supply-chain, and financial threats and opportunities.**
- **Model emerging market needs and the measures to exploit them.**
- **Analyze economic shifts, technological needs, and market viability.**
- **Recognition of radical changes in resource/ societal needs and availability.**
- **Determination of required characteristics of new (adaptation) technology**
- **Anticipate conditions to allow commercial responses with high pay-off and controllable risks.**



# **Looking at the Global Climate as a Business**

## **SWOT**

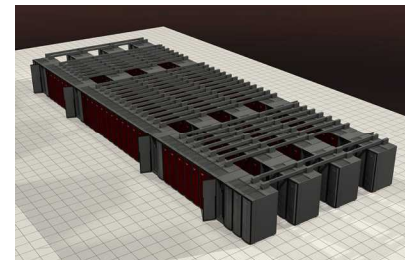
- **Strengths:** New market needs develop in concert with trade-induced growth.
- **Weaknesses:** Social and political tensions due to disproportional impacts of climate.
- **Opportunities:** Can provide the unique (disruptive) technologies needed to accommodate climate change.
- **Threats:** Investment in mitigation technologies cause financial market problems.



# Strategic Adaptation to Climate Change (SACC)

---

- How will economies and societies adapt to inevitable climate change and its implications?
  - Analyses of neither human behaviors or climate can be predictive, but they can provide probabilistic assessment that allows risk-informed decisions for investment commitments spanning 60-year horizons.
  - Recent research indicates that ocean warming causes both more intense and more frequent extreme weather, although controversy remains.
  - Other climate research indicates increased near-term drought, heat, or precipitation in specific regions.
- The SNL SACC effort works to use HPC for coupled agent-based socio-politico-economic modeling and earth-system level global modeling.





# SACC Purpose and Process

---



- **Provide regional and industry-specific climate impact information to industry and governments, delivering actionable research to enable decision-making.**
- **Help Industry and government institutions recognize, respond, and adapt to ever-changing climate change-induced dynamics.**
- **Determine and assess realizable and significant climate change events at various regional and inter-industry levels.**
- **Governments and companies want to consider “possible” risks and opportunities. They want a forward thinking picture.**
- **SACC focus is not on mitigation, but rather adaptation**
- **There is a critical need to translate applied research to industry and regional specifics; translate basic research to broader “potential” implications.**
- **We hope this approach enhances the access to both industry and government funding for climate research.**



# Research Program Rationale



- **Some industries may be the critical path to adequate national/global response.**
- **The vulnerability of some key industries may lead to cascading national/global impacts.**
- **Emergent dynamics could take government institutions by surprise and overwhelm them.**
- **Massive migration and international instability could strain US resources and capabilities.**
- **Climate change will require an understanding of continuous change in the form of disruptive technologies and unconventional solutions,**





# Background/Partners

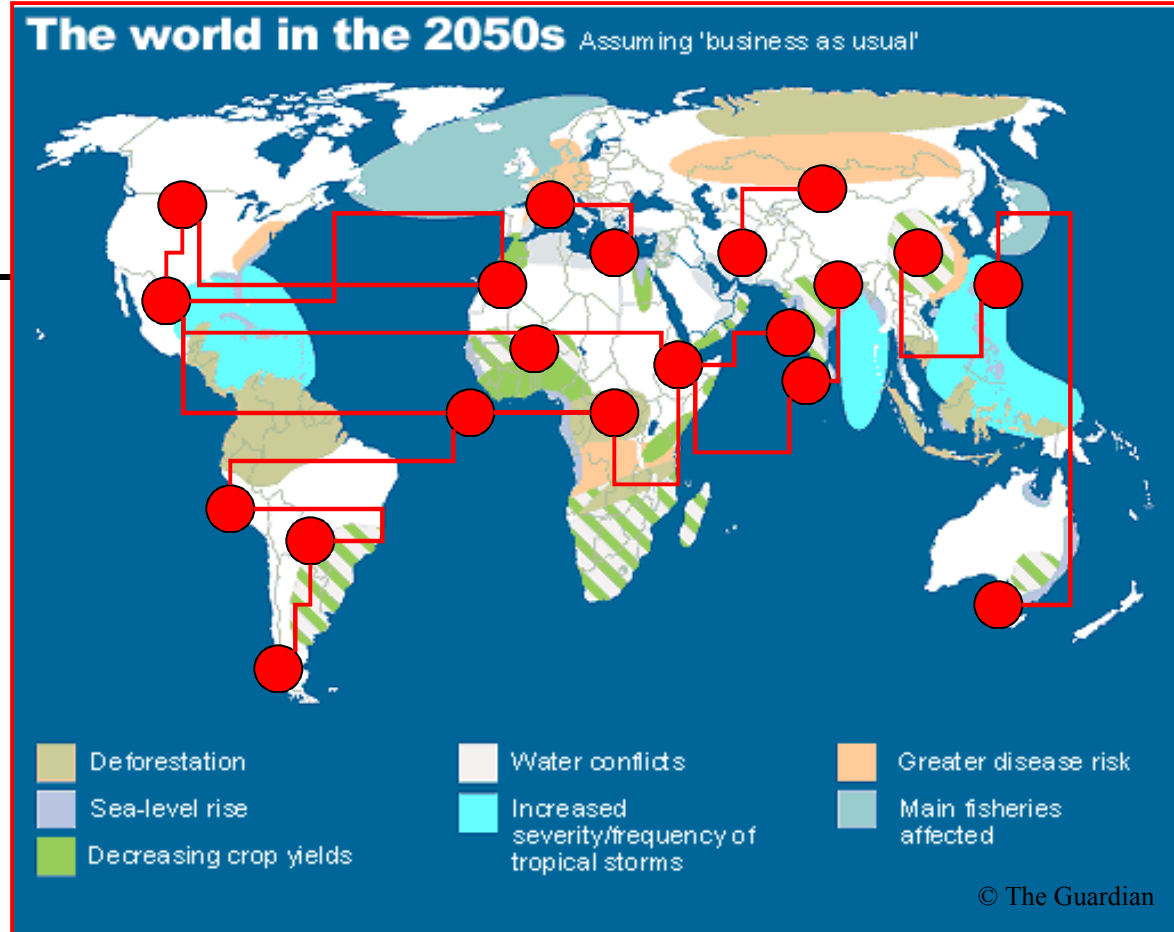


- Have partners for data and specialization (e.g. NCAR/ISSE, BP, Wall Street, Canada, European Union, PACOM, ARM, etc.).
- Some staff have 30 years of behavioral, societal, and economic analysis across many countries and policy domains.
- SNL has a world reputation for developing advanced, cost effective technologies to meet unique needs.
- Provide the self-consistent, integrated, comprehensive, and coherent information for risk-informed decisions.



# Climate Change Adaptation

**Agent-Based models linked to a climate model can indicate geopolitical and economic stresses caused by climatic change**

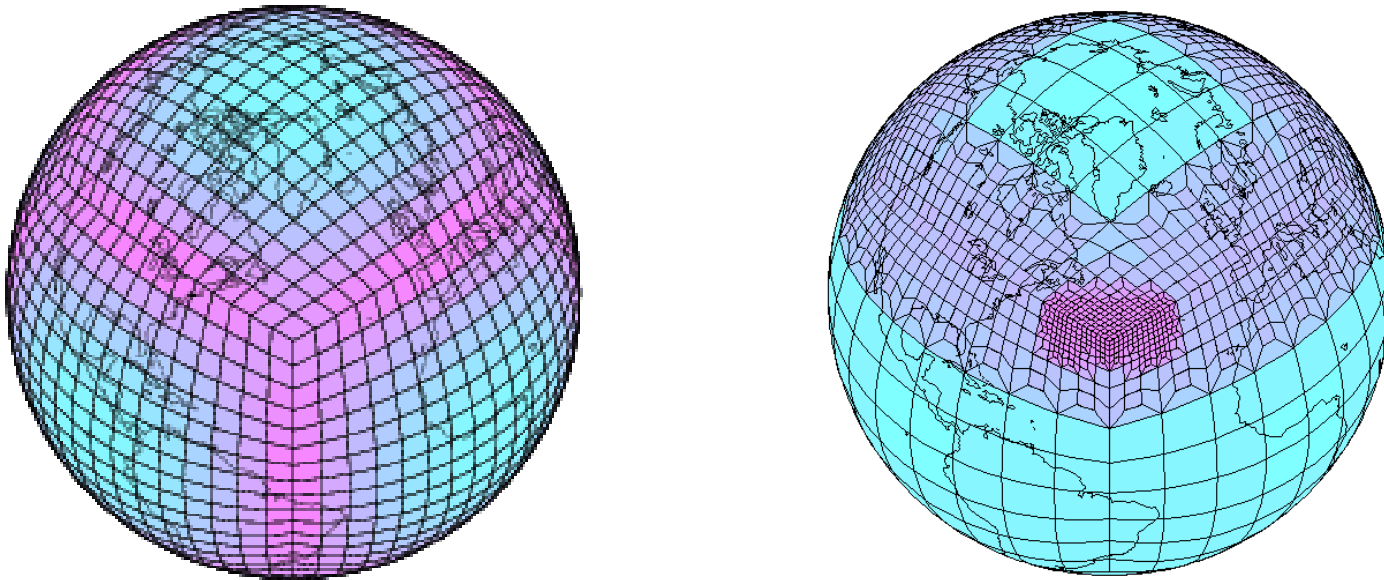


## Climate change effects on international stability

- **Competition for scarce resources.**
- **Migration and border disputes.**
- **Water shortages and distribution.**
- **Severe weather events and natural disasters.**
- **Early warning forecast of conflict.**

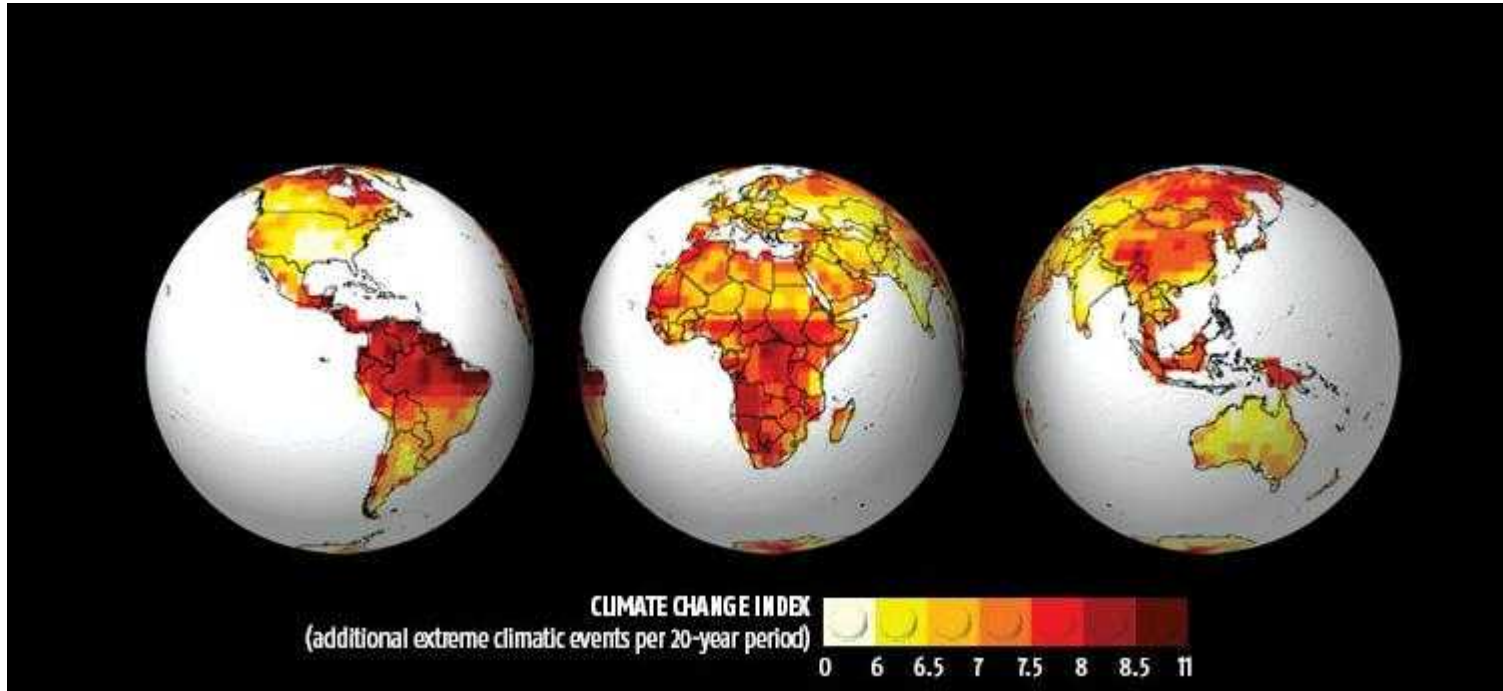
# Climate-Societal Modeling can focus on local events causing global affects

---



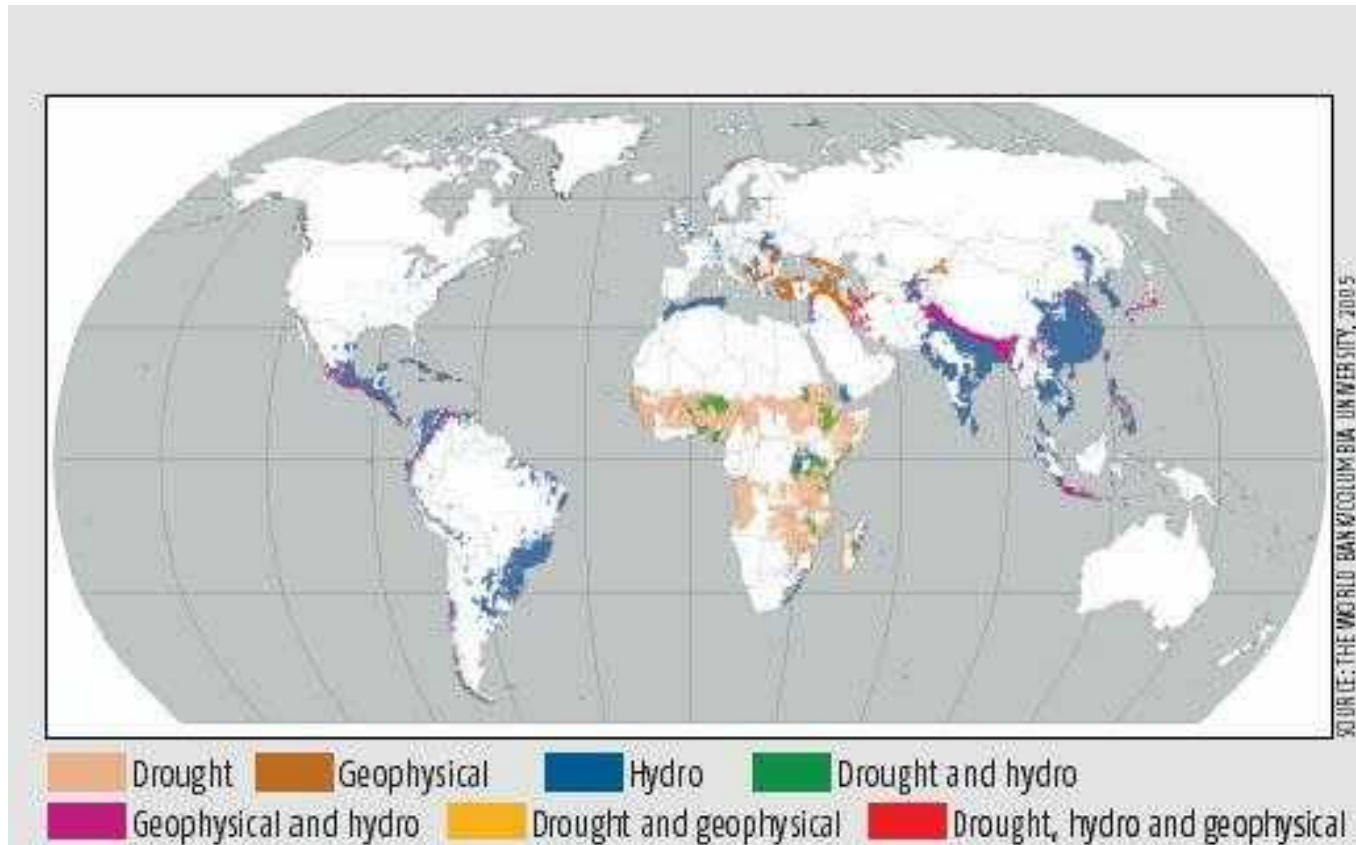
SNL Adaptive Mesh Refinement and “Cubed Sphere” Simulation

# Climate change Index (Weighted to Norm)



The future conflict (red) hot spots.

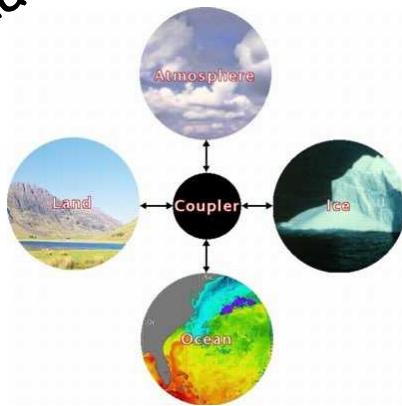
# The Future Challenges



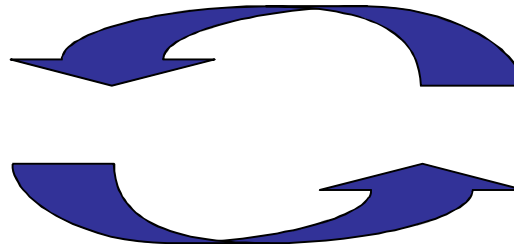
# Conflict Analysis Using Agents

## *Climate and Environmental Scarcity*

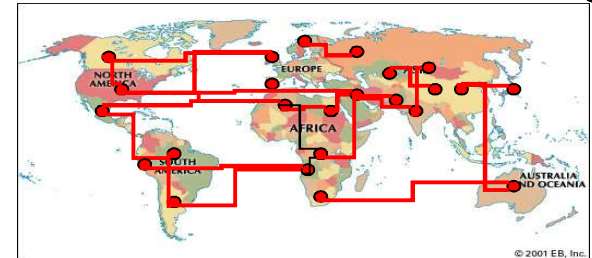
Climate model



*Social/Political/Economic feedback*



Conflict model



*Climatological feedback*

To achieve the level of detail needed for local/regional simulations that account for dynamic network structures:

**Climate Models, Nation/State Agent models and GeoPolitical models** can be combined on our massively parallel computational platforms to enable bi-directional feedbacks.



# Geopolitical and Social Impacts of Global Climate Change

- Climate change is not uniformly distributed. There will be winners and losers.
- Mass migrations of populations from the bottom tier of losers will create international tensions.
- Extended growing seasons and new shipping lanes will benefit some nations.
- Chronic drought, sea-level rise, and ecological deterioration will create economic hardship for other nations.
- Perceived “free-riders” will suffer international scorn.
- International alliances will shift.





# Analytical Convergence

- **Atmospheric and Climate Studies, Security Studies, Market Studies, Economic Assessments**
- **Agent Based, System Dynamic, International Macroeconomic, Socioeconomic, And Climatological Simulation.**
- **Technology development, assessment, manufacturability, and commercial handoff.**
- **Uncertainty Evaluation with Optimization**
- **Verification & Validation /Confidence Assessment/Falsifiability**
- **Consequence Evaluation and Unintended Consequence Avoidance**
- **Unrecognized Emergent Behaviors**





# Summary



- Regional climate change can vary greatly from the global averages with significant affect within the coming decades.
- These time frames are consistent with government and industry investment/technology decisions.
- The indicated changes in extreme weather are particularly troubling.
- Non-linear affects can cause unpleasant surprises.
- High-resolution climate modeling has a new responsibility.

