



Strategic Responses to Climate Change



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**August 10, 2007
Albuquerque, NM**



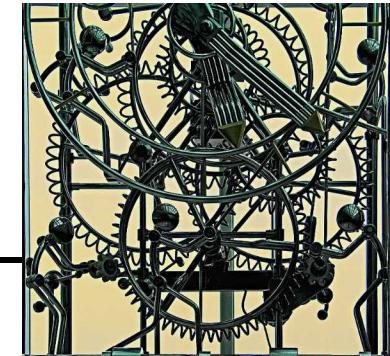
Sustainability is a Moving Target



- 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.



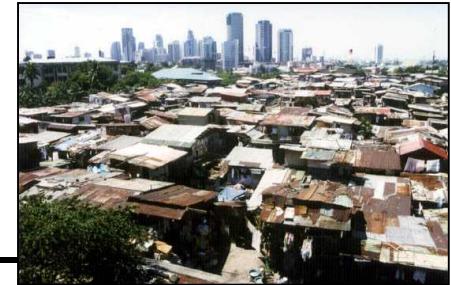
Changes to Survive Climate Change

- 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.

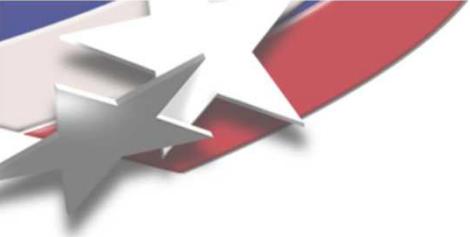




The Need for Applied Climate Models

- 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

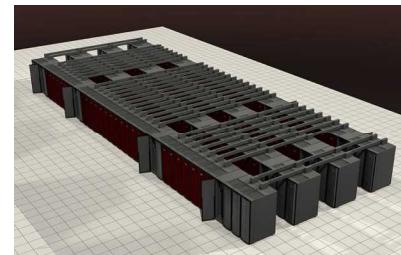
SWOT

- **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,





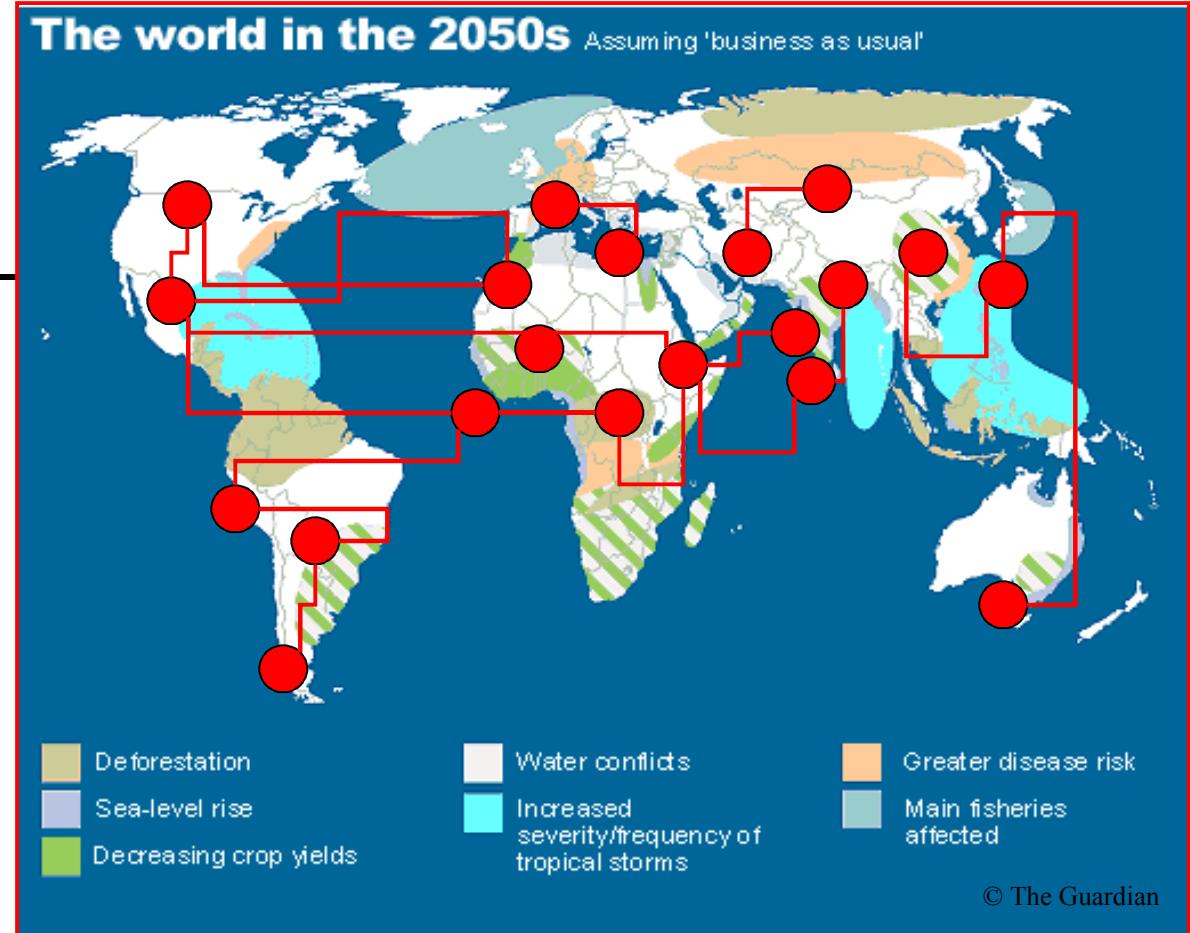
Background/Partners

- 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**

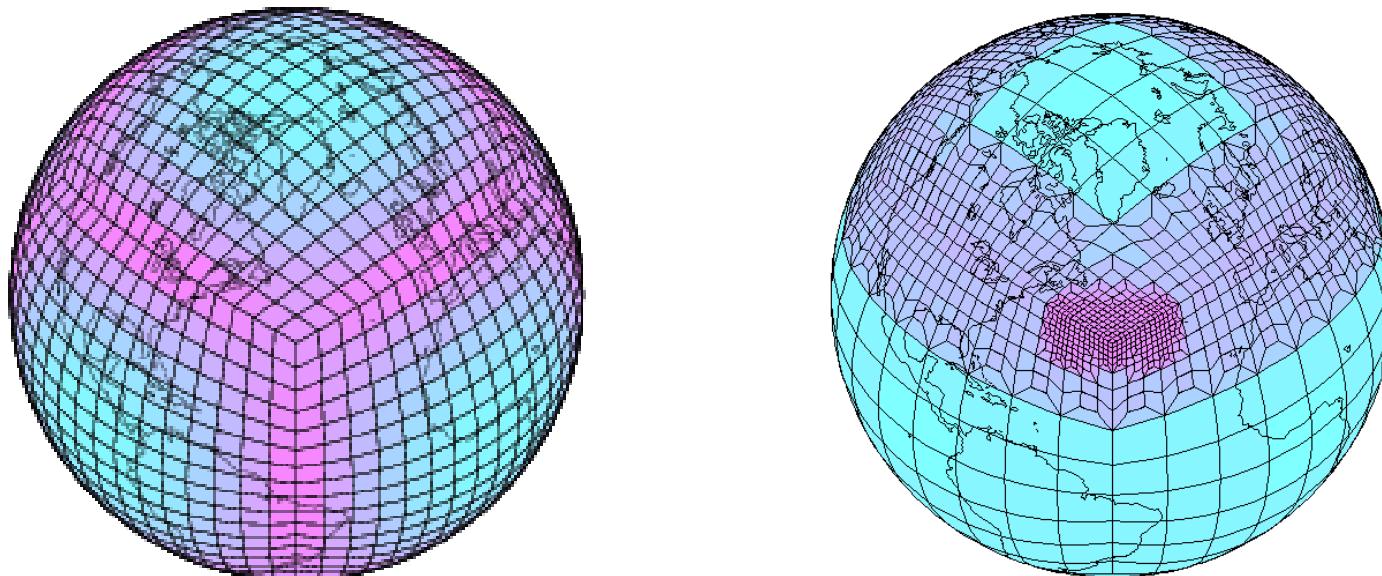


Climate change effects on international stability

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



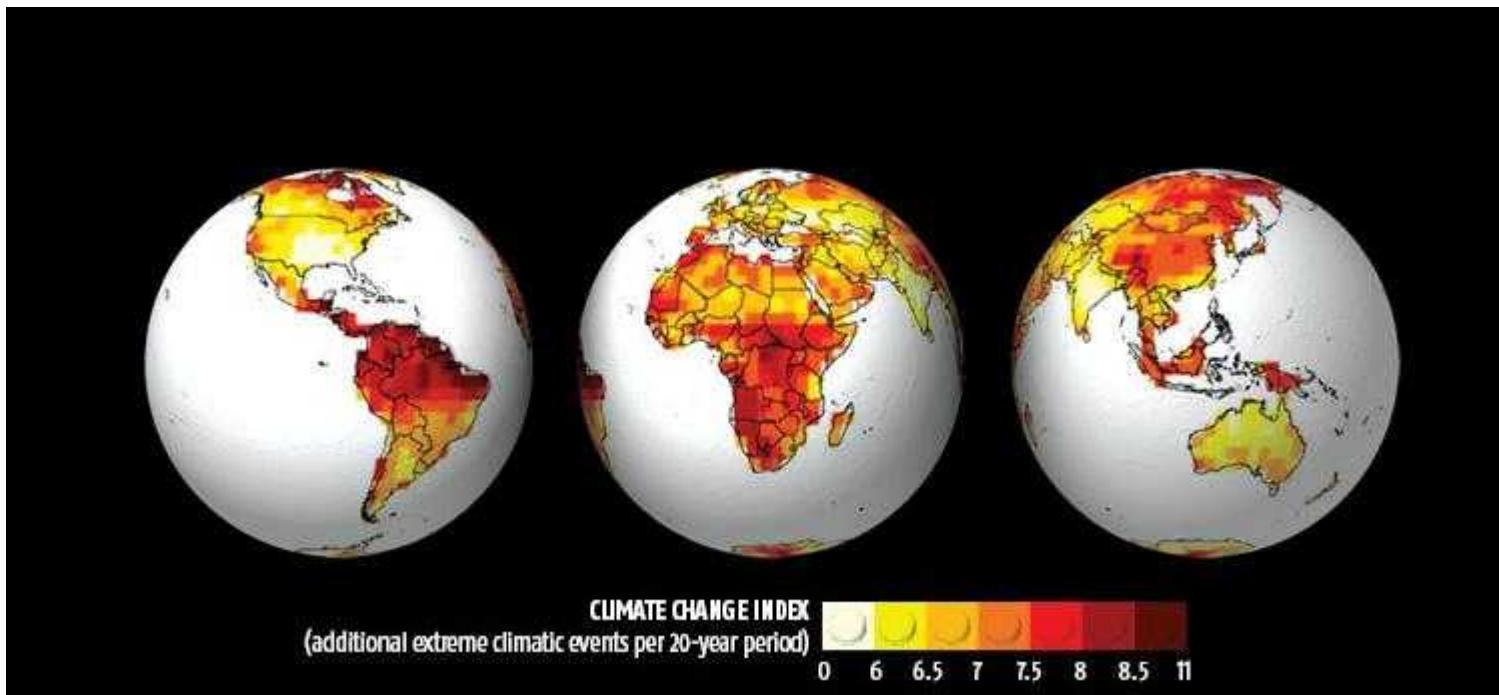
Climate-Societal Modeling can focus on local events causing global affects



SNL Adaptive Mesh Refinement and “Cubed Sphere” Simulation



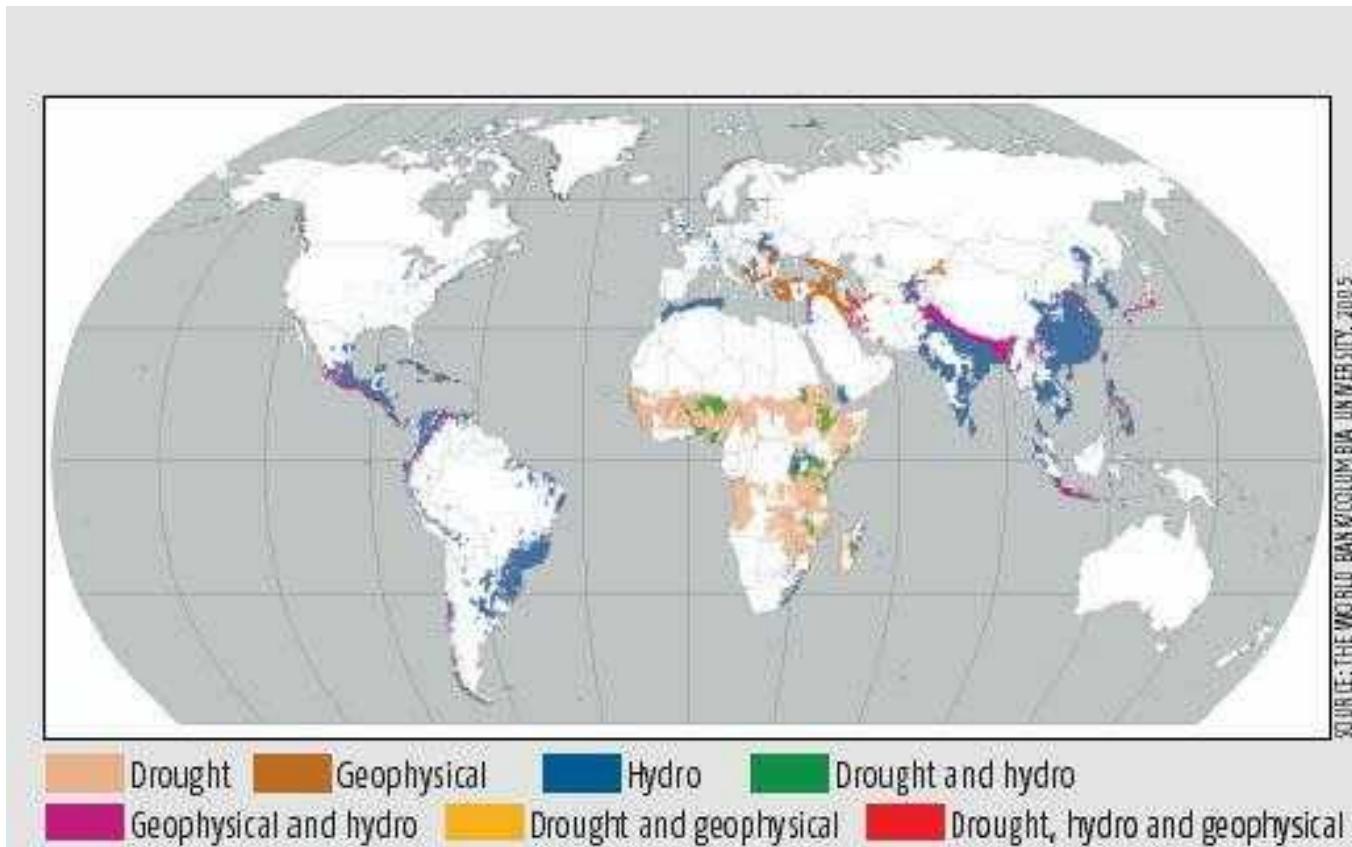
Climate change Index (Weighted to Norm)



The future conflict (red) hot spots.



The Future Challenges

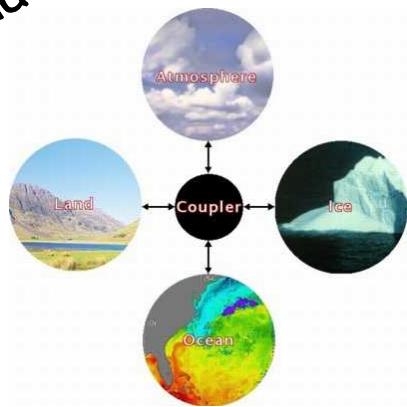




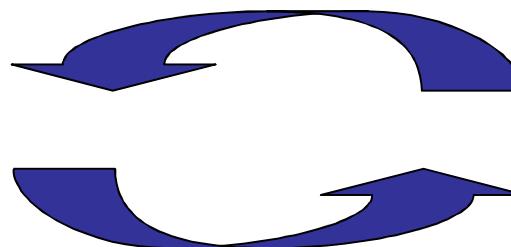
Conflict Analysis Using Agents

Climate and Environmental Scarcity

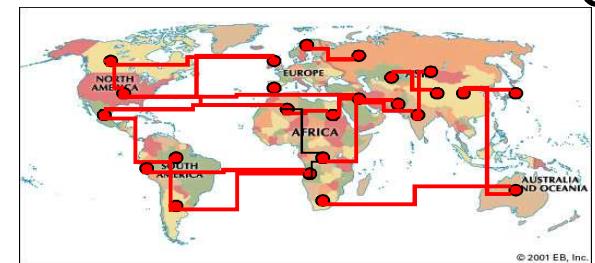
Climate model



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.

