

Simulating the Strategic Adaptation to Climate Change

**The 8th International Workshop on Next Generation Climate Models for
Advanced High Performance Computing Facilities**

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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



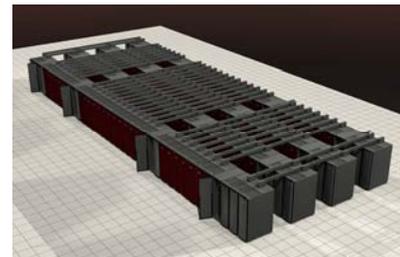
Ranking of World “Powers” (2004)

[Why worry about Companies?...]

• Rank	Country	Revenue (\$M)	•Rank	Country	Revenue (\$M)
• 1	United States	11,667,515	•30	Poland	241,833
• 2	Japan	4,623,398	•31	South Africa	212,777
• 3	Germany	2,714,418	•32	Greece	203,401
• 4	United Kingdom	2,140,898	•33	General Motors	193,517
• 5	France	2,002,582	•34	Finland	186,597
• 6	Italy	1,672,302	•35	Ireland	183,560
• 7	People's Republic of China	1,649,329	•36	DaimlerChrysler	176,688
• 8	Spain	991,442	•37	Toyota Motor	172,616
• 9	Canada	979,764	•38	Ford Motor	172,233
• 10	India	691,876	•39	Portugal	168,281
• 11	South Korea	679,674	•40	Thailand	163,491
• 12	Mexico	676,497	•41	Iran	162,709
• 13	Australia	631,256	•42	General Electric	152,866
• 14	Brazil	604,855	•43	Total	152,610
• 15	Russia	582,395	•44	Argentina	151,501
• 16	Netherlands	577,260	•45	ChevronTexaco	147,967
• 17	Switzerland	359,465	•46	ConocoPhillips	121,663
• 18	Belgium	349,830	•47	AXA	121,606
• 19	Sweden	346,404	•48	Allianz	118,937
• 20	Turkey	301,950	•49	Malaysia	117,776
• 21	Austria	290,109	•50	Israel	117,548
• 22	Wal-Mart Stores	287,989	•51	Volkswagen	110,649
• 23	BP	285,059	•52	Venezuela	109,322
• 24	Exxon Mobil	270,772	•53	Citigroup	108,276
• 25	Royal Dutch/Shell Group	268,690	•54	Czech Republic	107,047
• 26	Indonesia	257,641	•55	Singapore	106,818
• 27	Saudi Arabia	250,557	•56	ING Group	105,886
• 28	Norway	250,168	•57	Nippon Telegraph & Tele.	100,545
• 29	Denmark	243,043			

Strategic Adaptation to Climate Change (SACC)

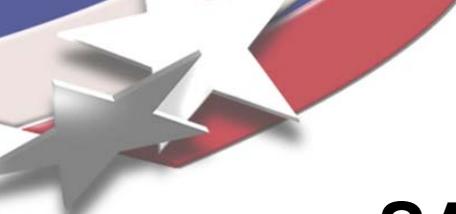
- **How will economies and societies adapt to inevitable climate change and its implications?**
 - **Analyses of neither human behaviors or climate can be predictive, but they can provide probabilistic assessment that allows risk-informed decisions for investment commitments spanning 60-year horizons.**
 - **Recent research indicates that ocean warming (SST) 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.**



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.**





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.**
- **Political and economic institutions operate in a crisis under the assumption of a return to “normal.”
Climate change will require an understanding of continuous change.**



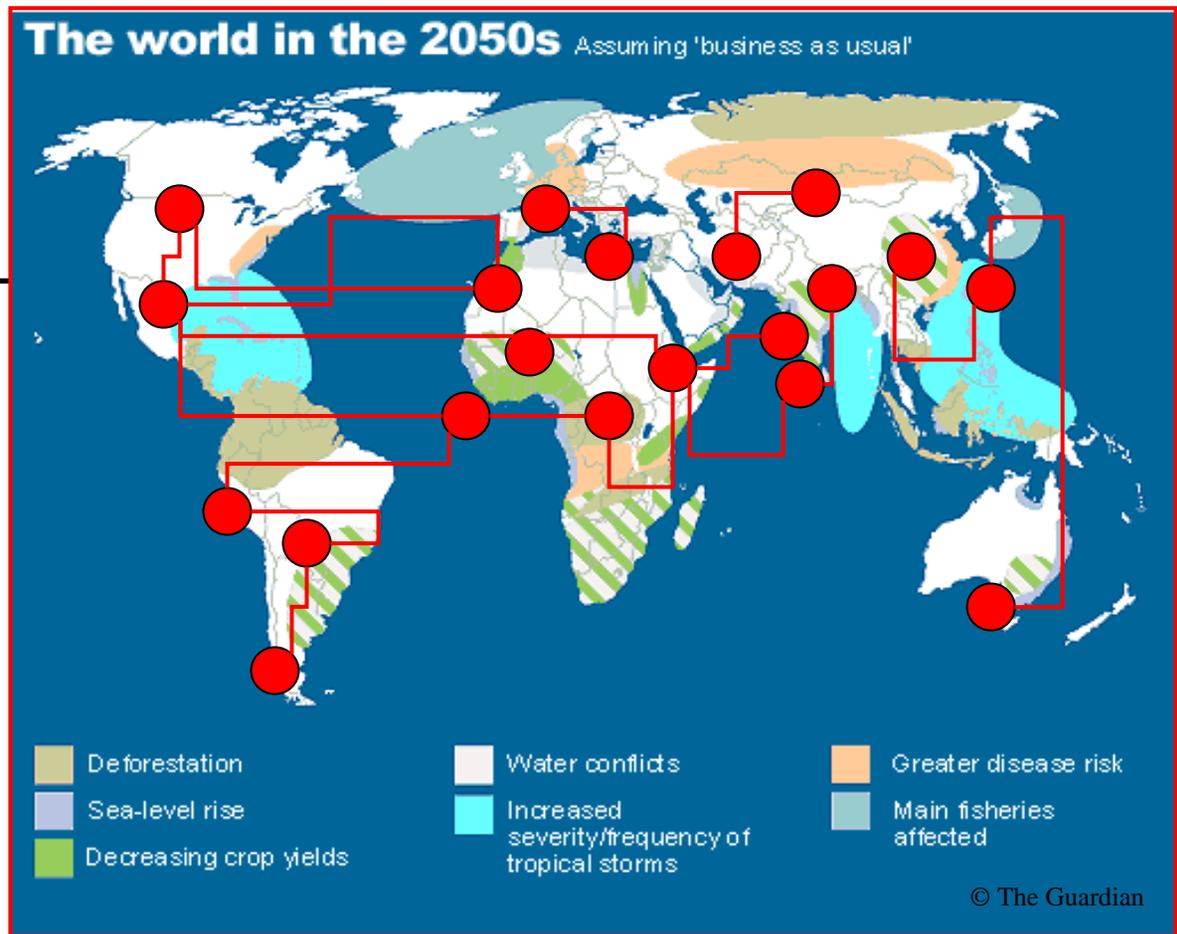
Geopolitical and Social Impacts of Global Climate Change

- 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.



Climate Change Adaptation

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

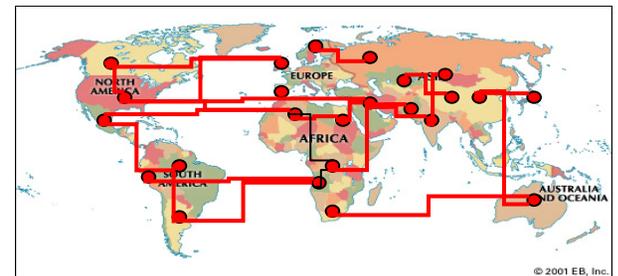
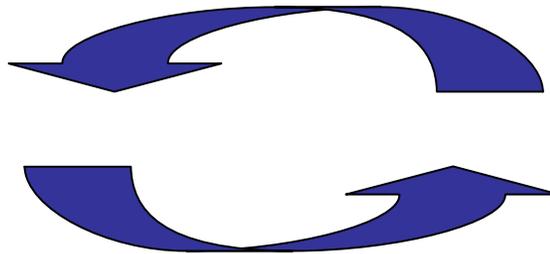
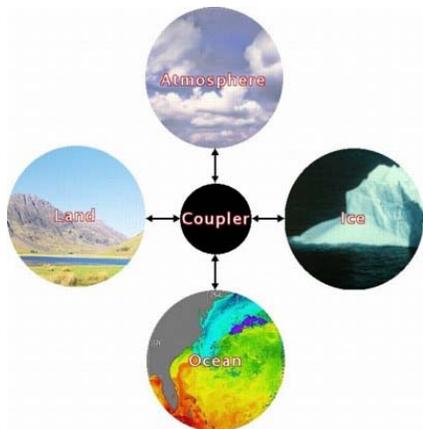


Climate change effects on international stability

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

The need for the comprehensive picture: International Security

Social/Political/Economic feedback



Climatological feedback

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

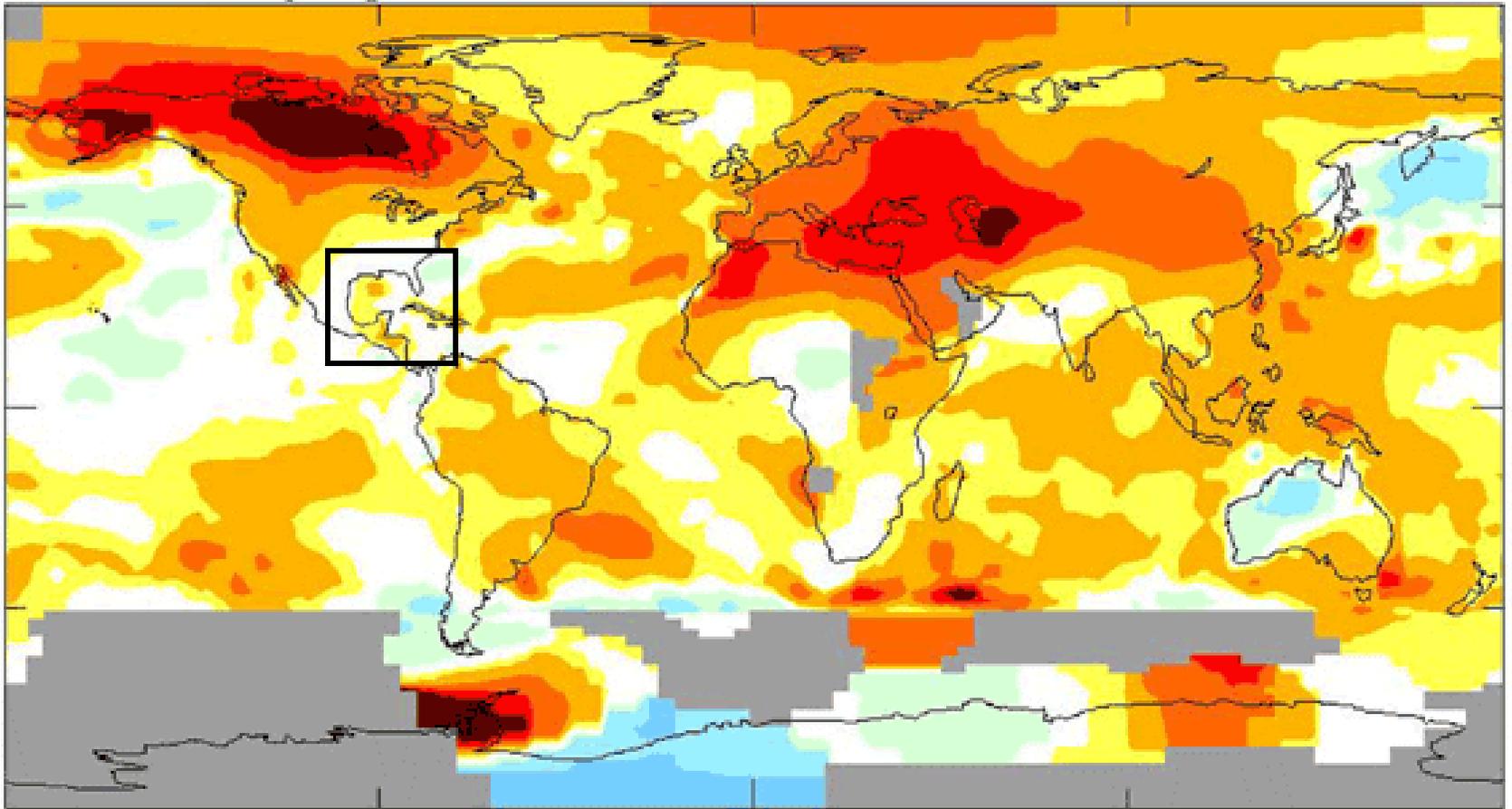
Climate Models, Nation/State Agent models and GeoPolitical models can be combined on our massively parallel computational platforms to enable bi-directional feedbacks.

Analysis Characterization

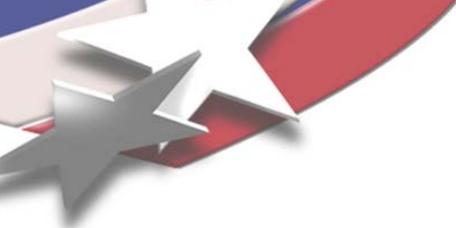
- **Want to know risk ,not hopes; dynamics, not statics.**
- **Need to robustly focus on unprecedented actions, changes, and events.**
- **Causal Dynamics**
 - **Time Delays and Feedback Dynamics**
 - **Psychology, Statistics, Engineering, Economics**
 - **Simulates actual as opposed to assumed responses**
 - **Focus on what we don't know to ensure desired outcome.**
- **New robust “social science” methods have become available.**
 - **Bounded Rationality (Herbert Simon, 1978)**
 - **Qualitative Choice (Daniel McFadden, 2000)**
 - **Imperfect Information (Joseph Stiglitz, 2001)**
 - **Risk Asymmetry (Daniel Kahneman, 2002)**
 - **Stock and Flow Cointegration (Clive Granger, 2003)**
 - **Agent-Based Modeling/Conflict Gaming (Thomas Schelling, 2005)**



Can we Resolve (Quantify) the Uncertainty of Change?



Can we improve on-the-ground decision-making and reduce the stress (and impacts) of adaptation?



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 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.**

