Risk Assessment of Climate Systems for International Security

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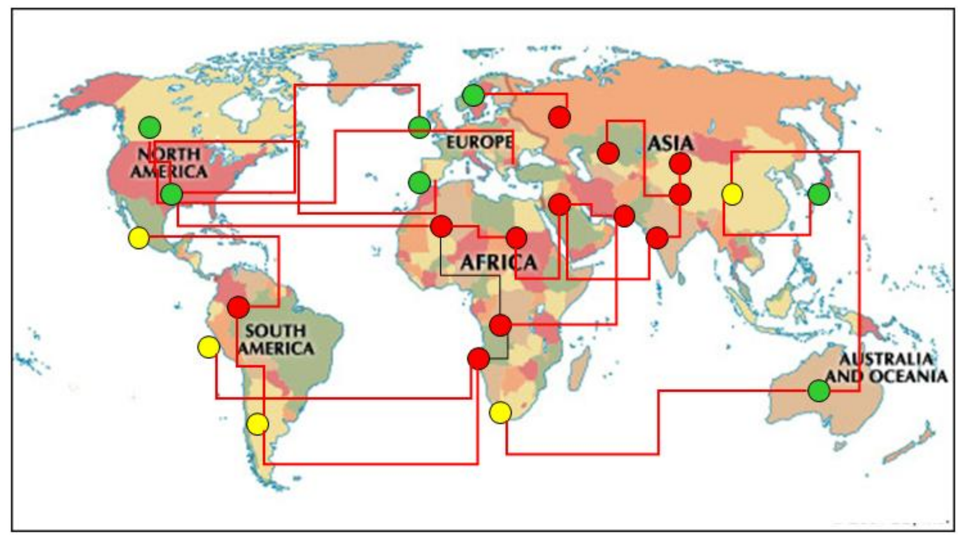
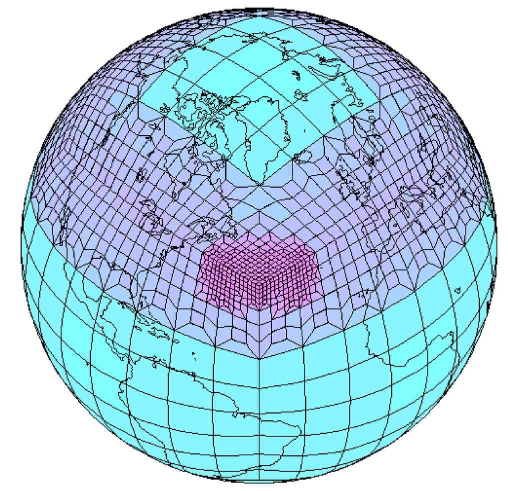
What we do: Find the keystone climate risks; find the minimalist activity to limit international destabilization threats.

The purpose of this work is to develop a globally applicable system to simulate evolving security dynamics and risk quantification related to climate change. The focus is on handling tail conditions more than "best estimates." Regional tensions can cause global problems. We simulate the intertwined economic, social, cultural, behavioral, and political dynamics within a region because economic and political decisions are largely based on perceptions and expectation formation. The ability to meet societal expectations often determine the perceived legitimacy of a government and subsequent threats to governmental stability.

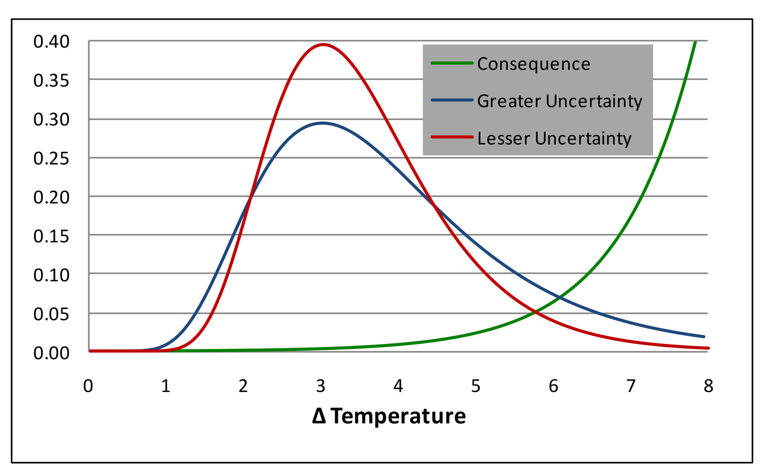


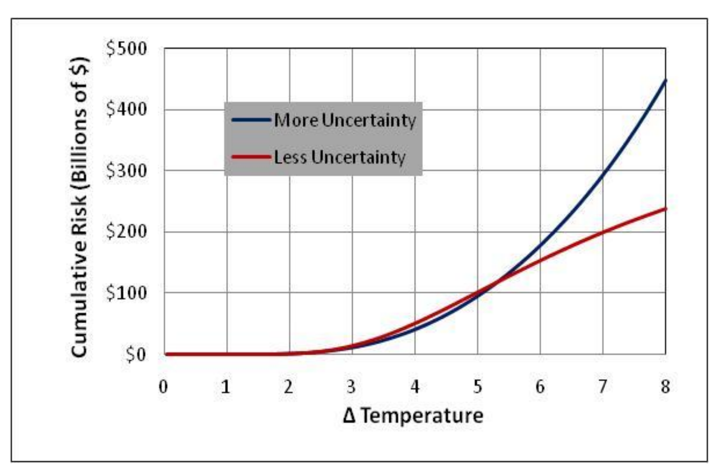


Combined uncertainty quantification from regionalized climate modeling and dynamic geopolitical simulation can illuminate potential conditions in the future that represent security concerns. Additional simulations can look for "fingerprints" that note measurable precursors falsifying or supporting the realization of security risks. Progressive hedging can determine the minimal preparedness that allows modification, as actual future conditions resolve present day uncertainty. Any proactive responses must avoid creating unintended consequences.

$$Risk = \int_T \int_P Consequence(t,p) \times e^{-r \times t} \times dp \times dt$$

p = probability; t = time; r = discount rate





Risk combines uncertainty with consequence. Because of the asymmetric costs/consequences, the more the uncertainty, the more the risk. Although these curves are illustrative of the concept, the actual analysis includes the specific impacts for each industry and country. Climate uncertainty is a tail heavy distribution. The "best estimate" contains little information. A small change in uncertainty produces a large change in risk. The risk is in the tail, not in the "best estimate."

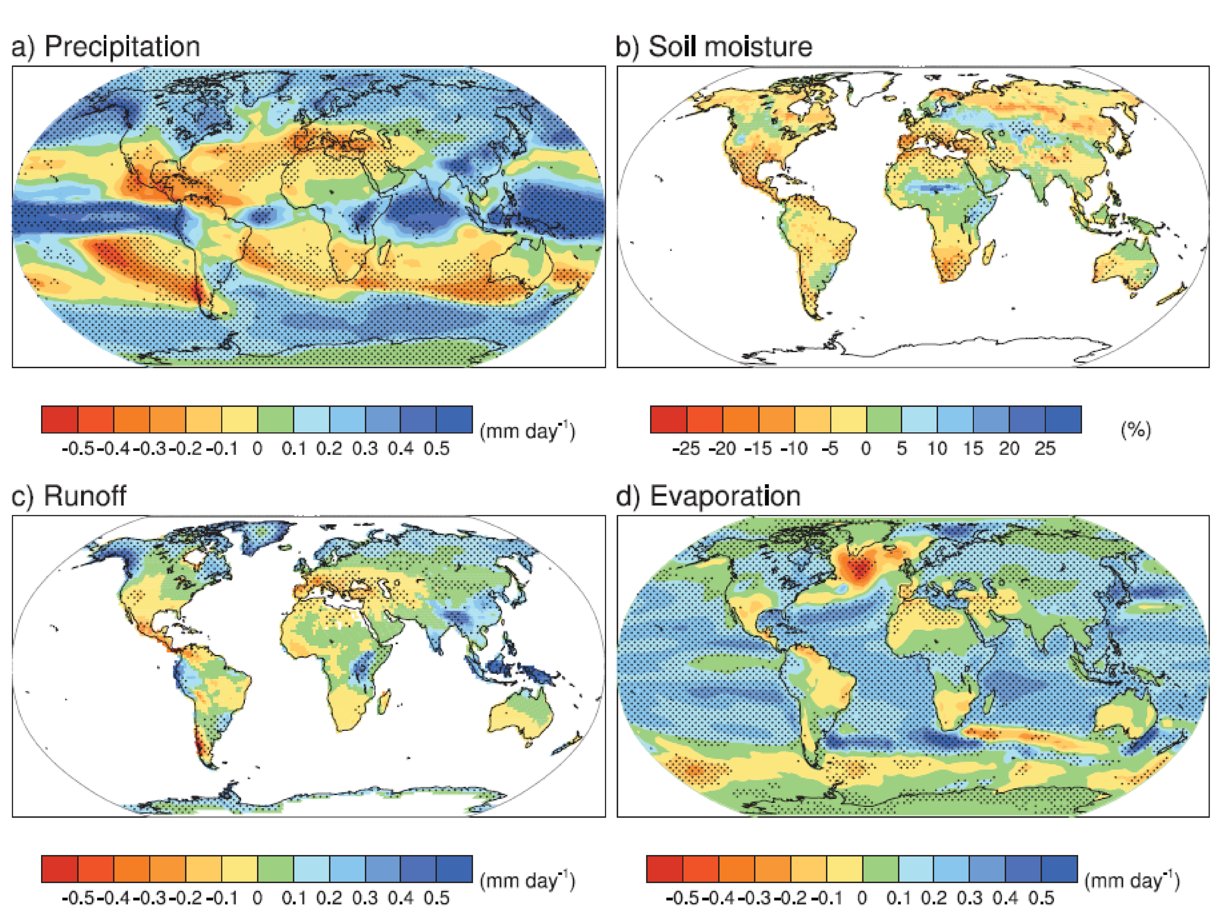
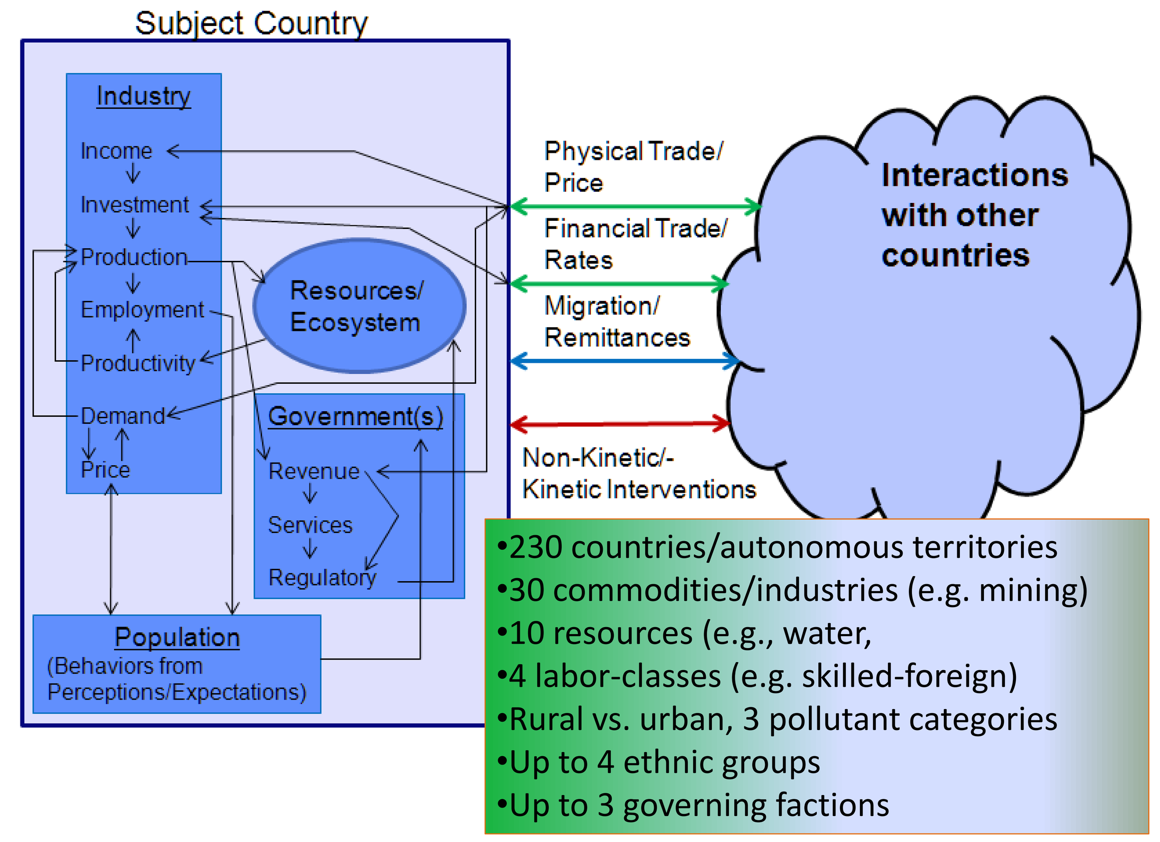
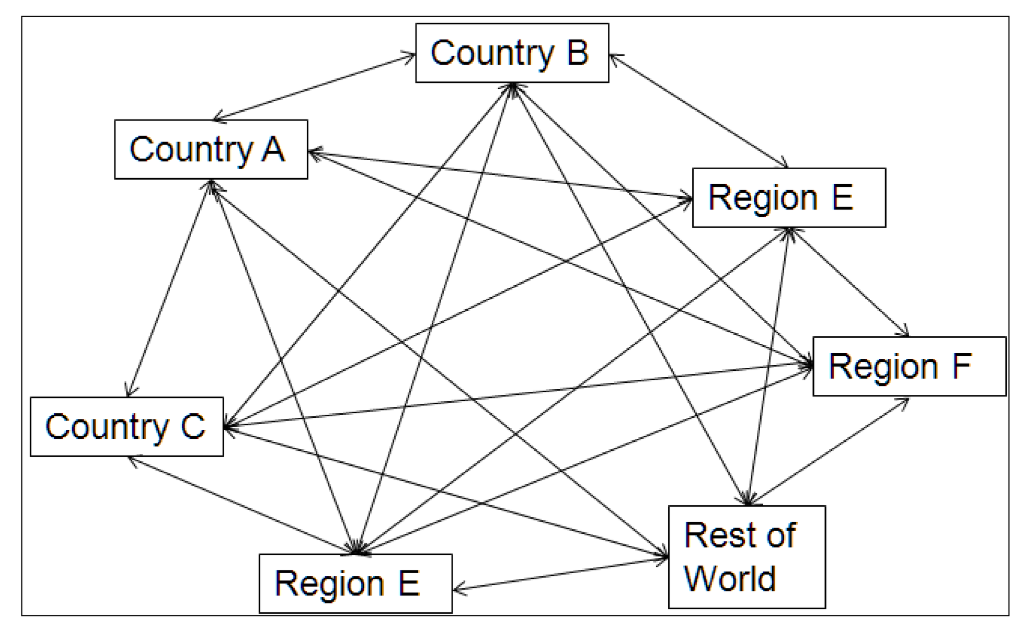


Figure 10.12. *Multi-model mean changes in (a) precipitation (mm day⁻¹), (b) soil moisture content (%), (c) runoff (mm day⁻¹) and (d) evaporation (mm day⁻¹). To indicate consistency in the sign of change, regions are stippled where at least 80% of models agree on the sign of the mean change. Changes are annual means for the SRES A1B scenario for the period 2080 to 2099 relative to 1980 to 1999. Soil moisture and runoff changes are shown at land points with valid data from at least 10 models. Details of the method and results for individual models can be found in the Supplementary Material for this chapter.* From: Meehl, G.A., e. al., 2007

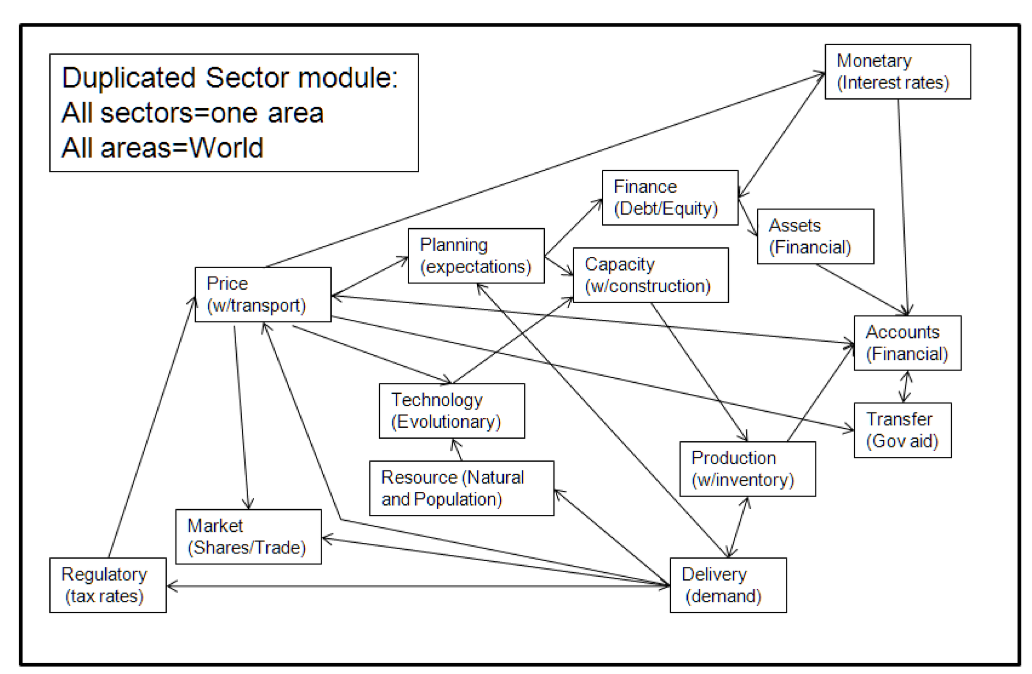
Much of the analyses focus on the impacts of water availability. Water availability directly affects economic infrastructure, and economy-wide impacts stem largely from infrastructure interdependencies.



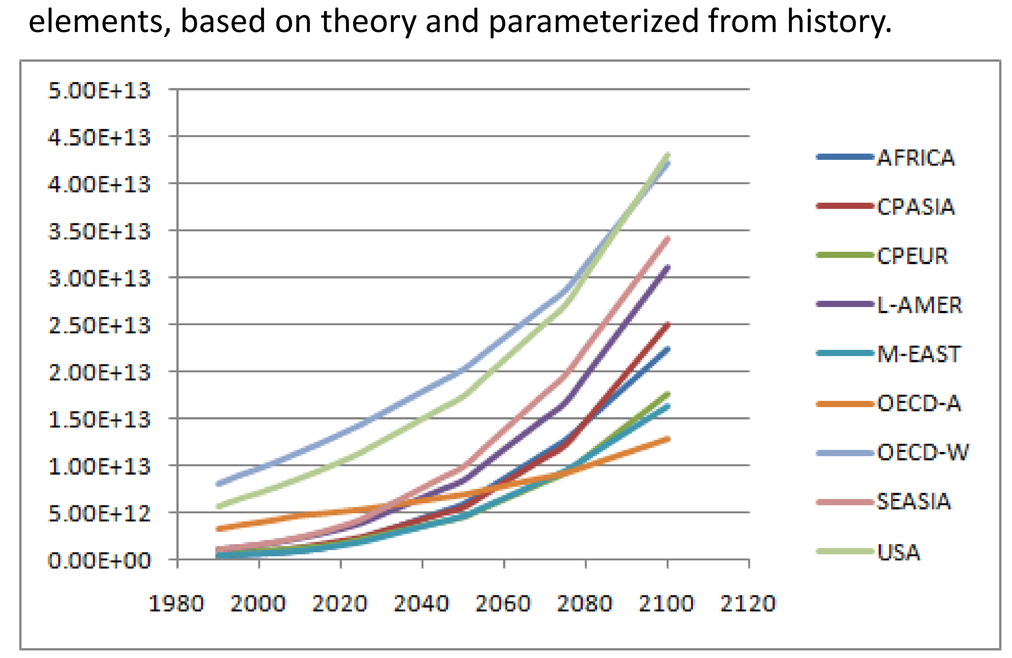
Each country is composed of interacting sectors that interact with other countries. Multiple internal and external entities can affect nation-state stability both militarily and economically. Impacts on infrastructure and supply-chains appear to dominate subsequent dynamics.



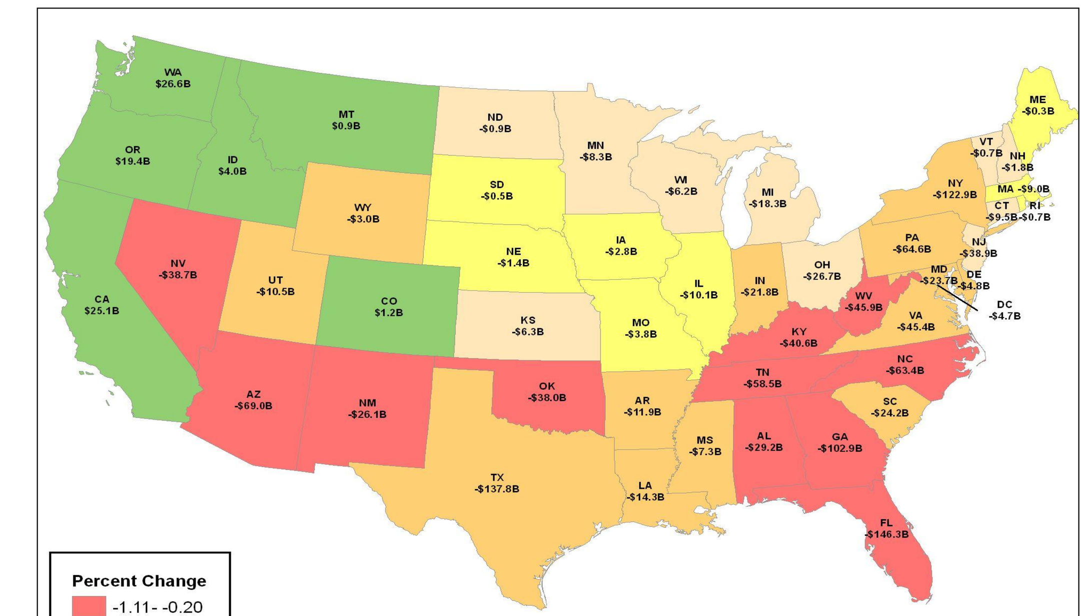
The modeling system can automatically reconfigure and parameterize its level of aggregation for a focus on regional interactions.



Each sector is composed of interacting behavioral and physical elements, based on theory and parameterized from history.

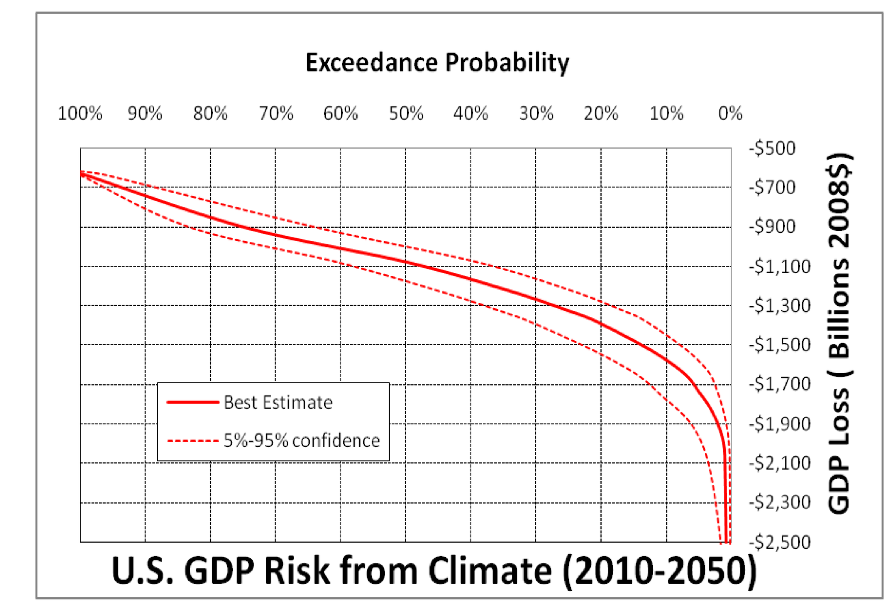


The model is calibrated to a referent future (e.g. IPCC Scenarios). Uncertainly quantification determines risk and differential impacts.

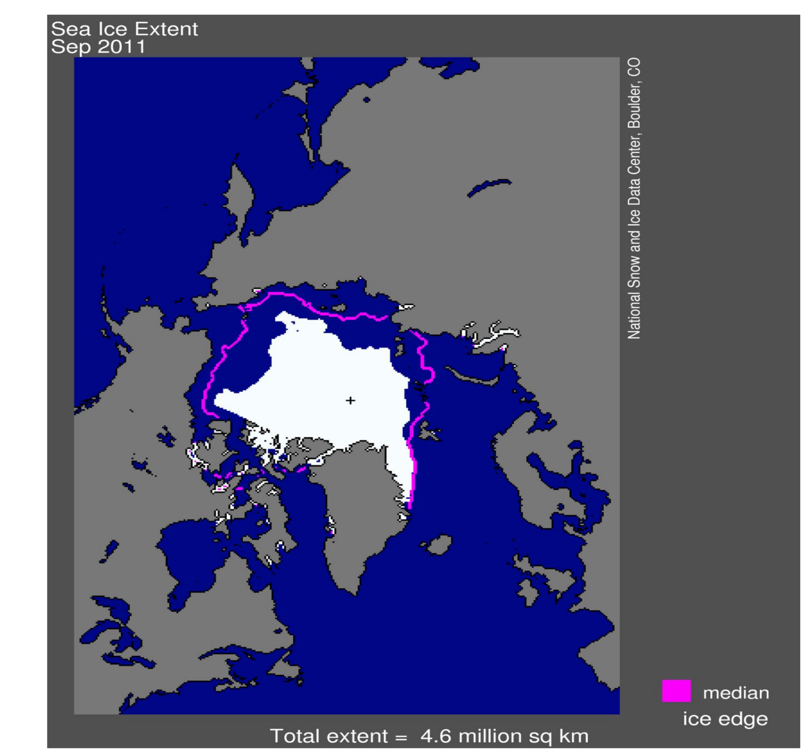


GDP Risk By State, 2010 to 2050, w/o Cost Discounting

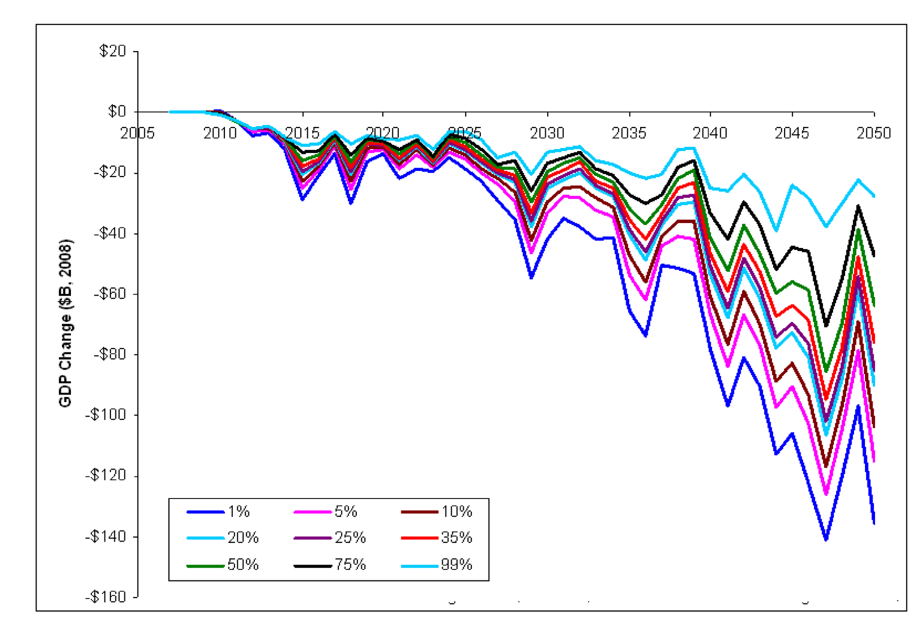
To demonstrate a risk assessment methodology*, we simulated the interacting impacts among the interacting, continental U.S. states, detailing 70 economic sectors, including business and population migration, from 2010 to 2050 over the full range of volatile-climate-change exceedance-probabilities to assess risk. We only considered economic risk from water availability, assuming no policy interventions.



U.S. Risk by exceedance probability. The risk is largely on the right side of the median. Due to the "fat tail" of the risk distribution, the "mean" is not a useful reference point.



The changing conditions in the Arctic represent a situation with potential security implications. The perceptions of an economically assessable Arctic determine the security dynamics of the Arctic more than the realized climate change.



Volatility brings the future transiently into the present. In this example, the 50% exceedance-probability impact for 2049 is comparable to that of 2035 and 2028. Both earlier dates would have impacts greater than that of a "mean-value" trend line.

PCMM	Level 1	Level 2	Level 3	Level 4
Quality	Exploratory	Design Support	Qualitative Support	Qualified
Units Module Capability	Least Complete			Most Complete
Units Module Capability	Most Risk			Least Risk
Units Module Capability	Least Evidence			Most Evidence

How do you measure validation progress using **P**redictive **C**apability **M**aturity **M**odel (PCMM)? Start with maximum entropy and work to right of the PCMM table, improving the model until entropy no longer declines. In this situation, calibration and parameterization stabilize; new data/structures no longer changes moments of uncertainty distribution. (McNamara et. al., 2008)

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