Uncertainty for Climate Policy: Coupling Models Across Disciplines

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Outline for this Talk

- An Example: Propagating Uncertainty through Integrated Economic-Climate-Chemistry Models

- Limitations and Challenges to Quantitative Uncertainty Analysis

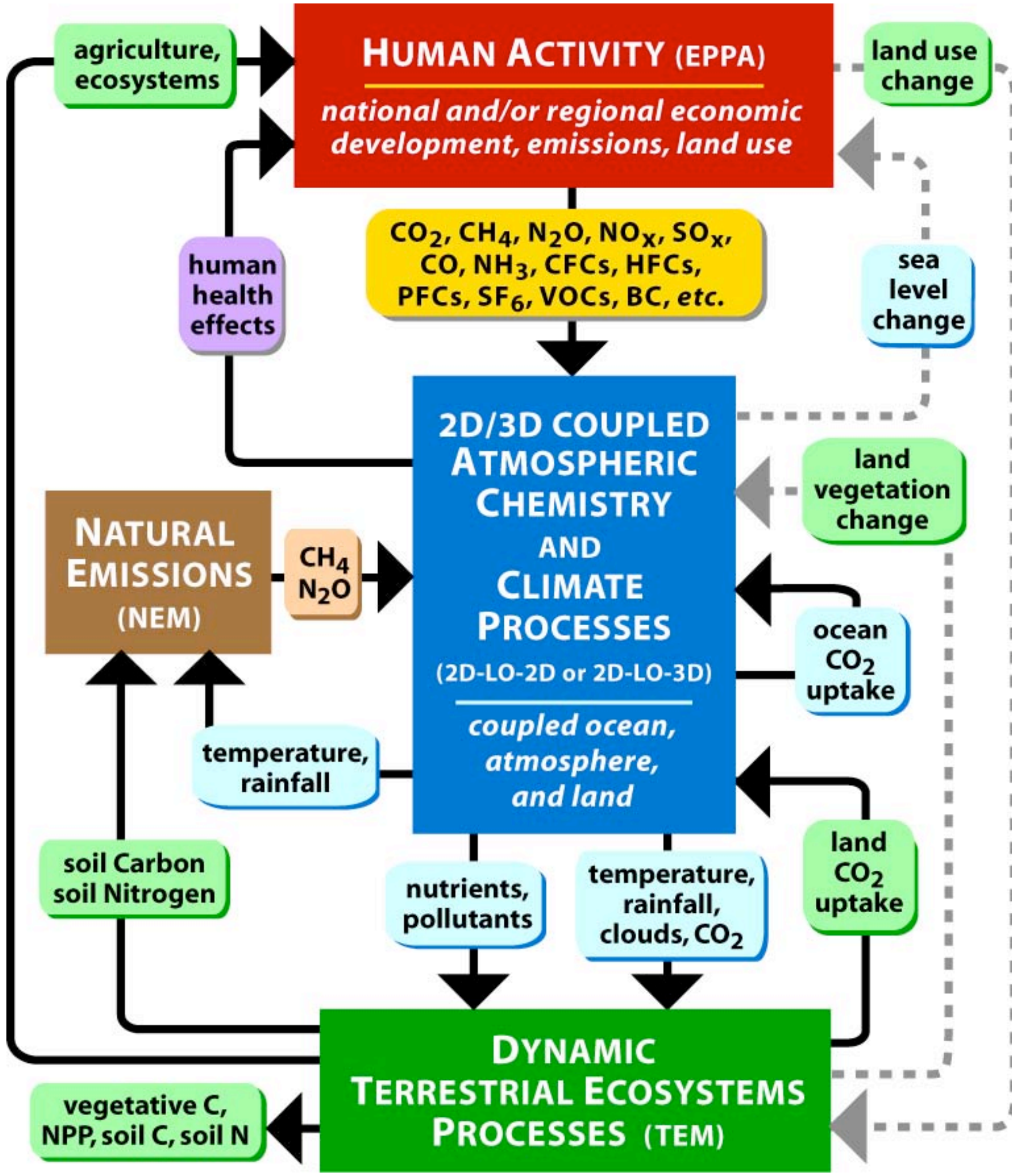
- Next Steps to Improve UA

Dilbert's Risky Decision

Model-Based
Parametric Uncertainty Analysis

- Knowns: assume functional model
- Unknowns: uncertain parameters are a *subset* of unknowns
- Unknowables: Need to be supplemented with other types of analysis

MIT Integrated Global System Model (IGSM)



Joint Program on the Science and Policy of Global Change

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Uncertainty Analysis of Climate Projections – Uncertain Parameters

- Economic & Technological Uncertainties
  - Labor Productivity Growth
  - Autonomous Energy Efficiency Improvement Rate
  - Emissions Factors for Industrial Pollutants
- Climate Uncertainties
  - Climate Sensitivity
  - Heat Uptake by Deep Ocean
  - Aerosol Forcing Strength

Uncertainty Analysis of Climate Projections – Outcomes

- What is the uncertainty (PDF) in:
  - Global Mean Temperature Change
  - Sea Level Rise

…As a result of:

- No Climate Policy
- One Possible Path of GHG Reductions

**How does the risk of "extreme" outcomes change?*

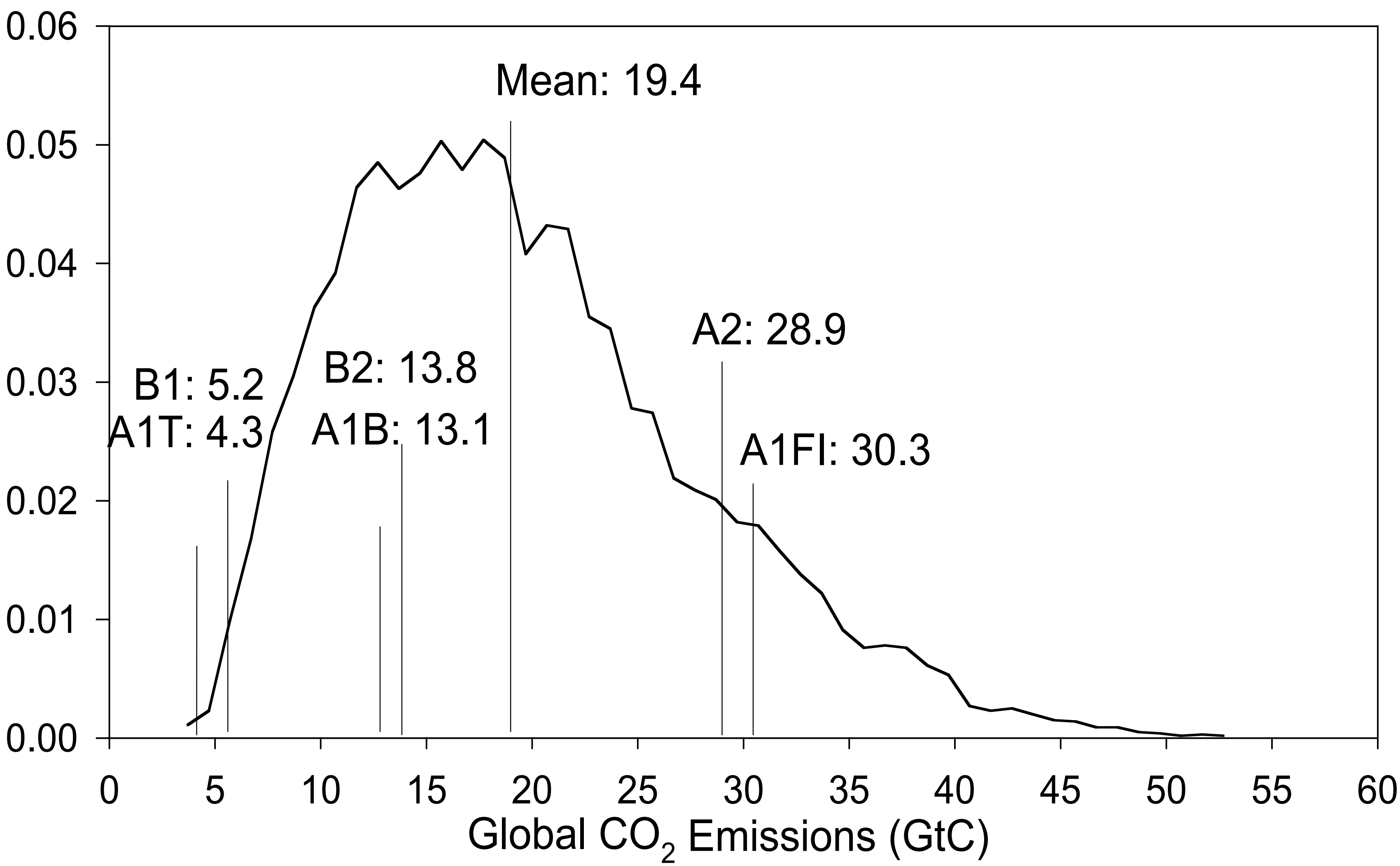
Sources for Parameter PDFs

- Economic Parameters
  - Literature, e.g., std err on regression coefficients
  - Expert Elicitation
- Climate Parameters
  - Constrained by Climate Detection work by Forest et al
  - Combined with Expert Judgments

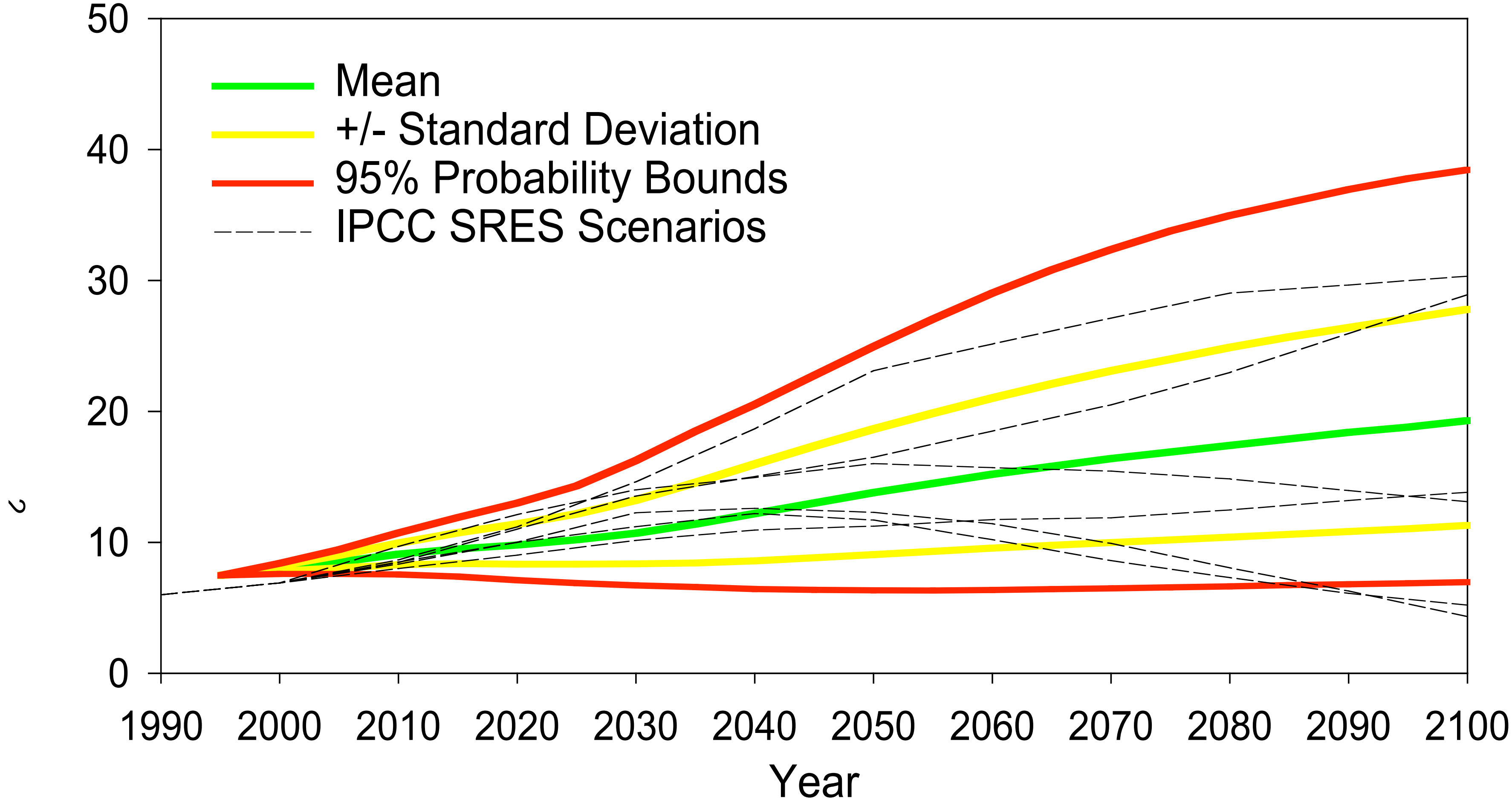
Uncertainty Propagation through IGSM

- Using Latin Hypercube Sampling, draw samples from all parameter PDFs, imposing correlation (n=250; n=1000)
- Propagate through EPPA to obtain emissions of all GHGs and other relevant substances
- Propagate through climate-chemistry model to obtain climate outcomes

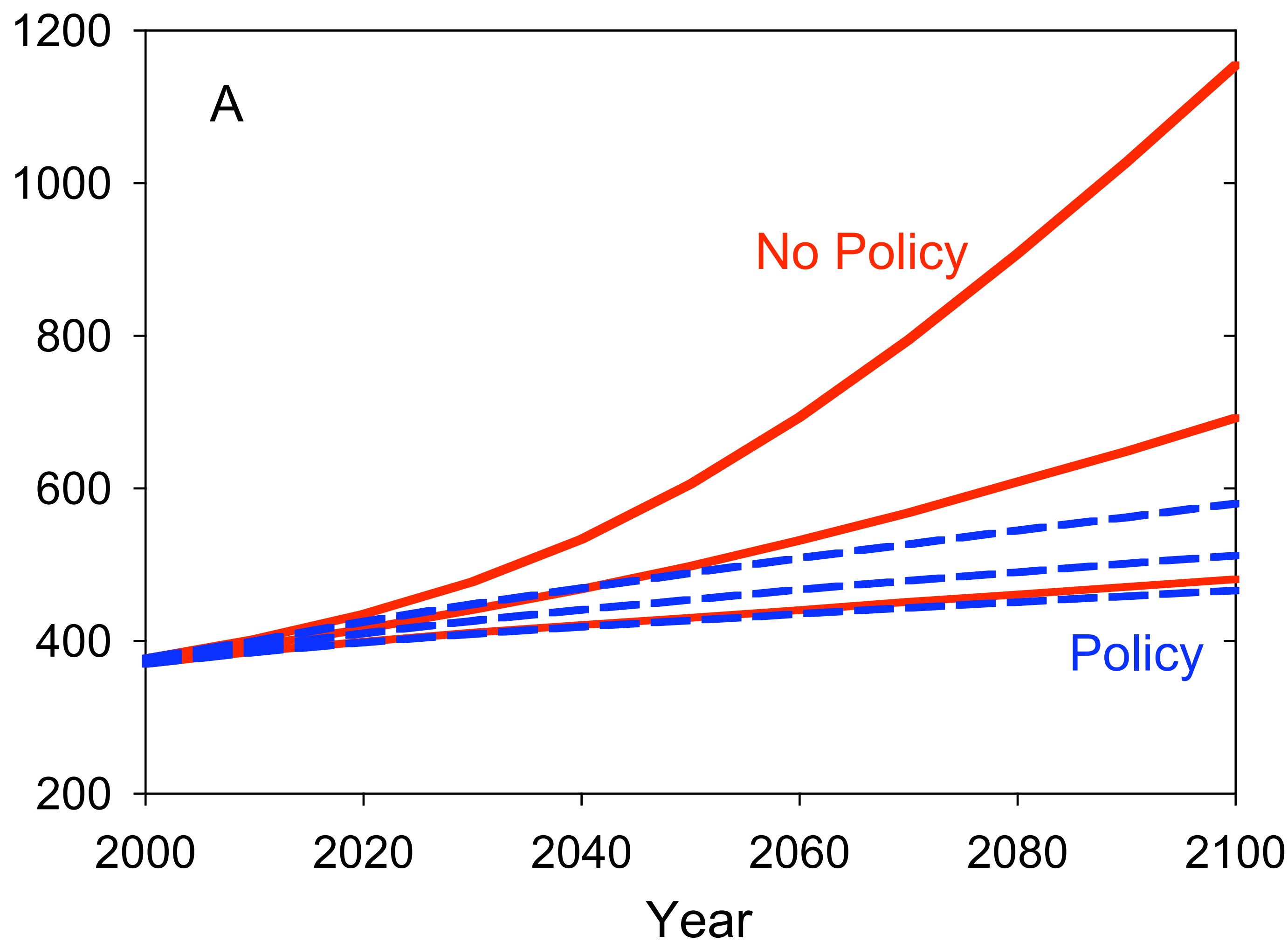
Global CO_2 Emissions in 2100



Global CO_2 Emissions

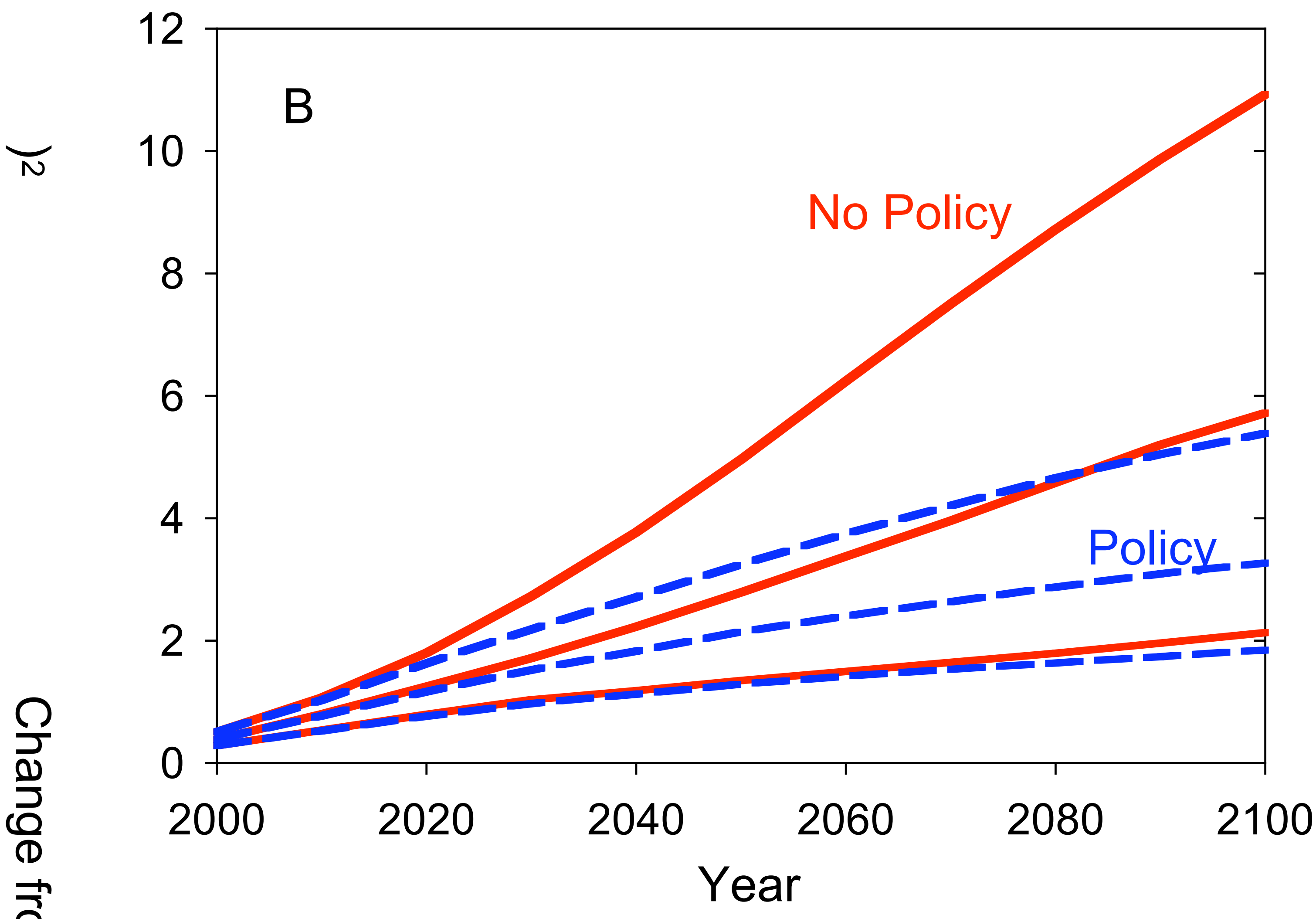


CO_2 Concentrations
Median and 95% Bounds



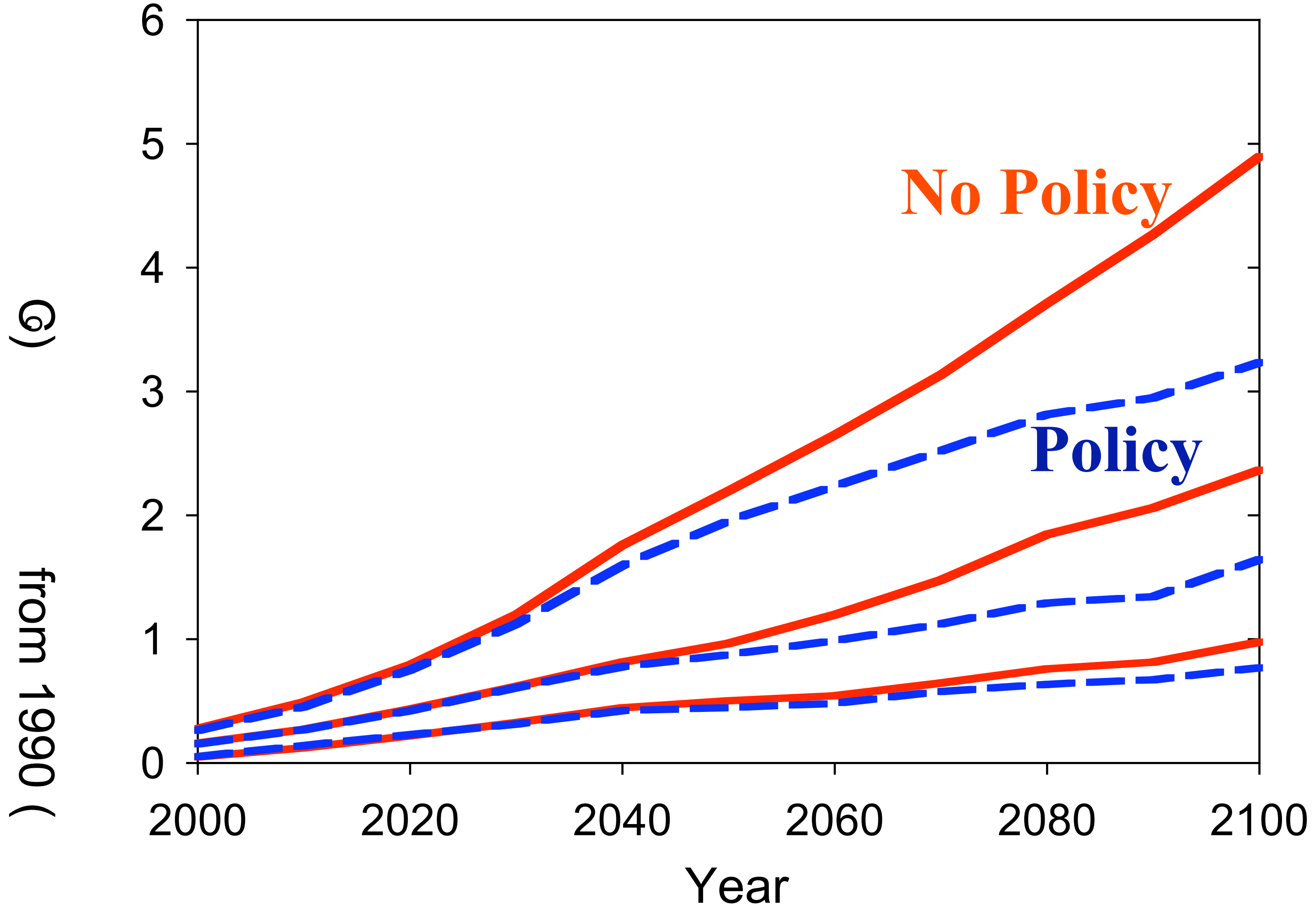
Total Radiative Forcing

Median and 95% Bounds

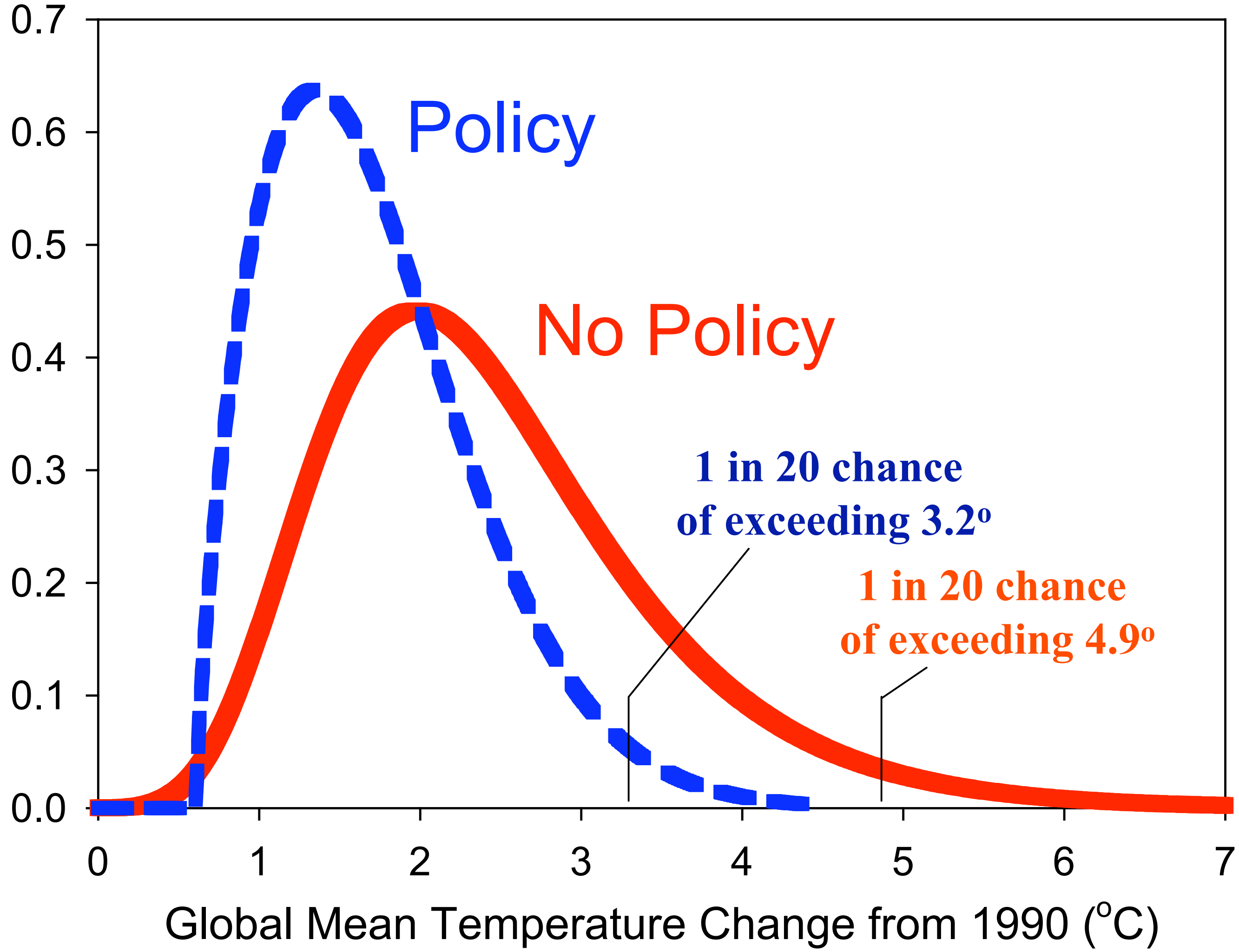


Global Mean Temperature Change

Median and 95% Bounds

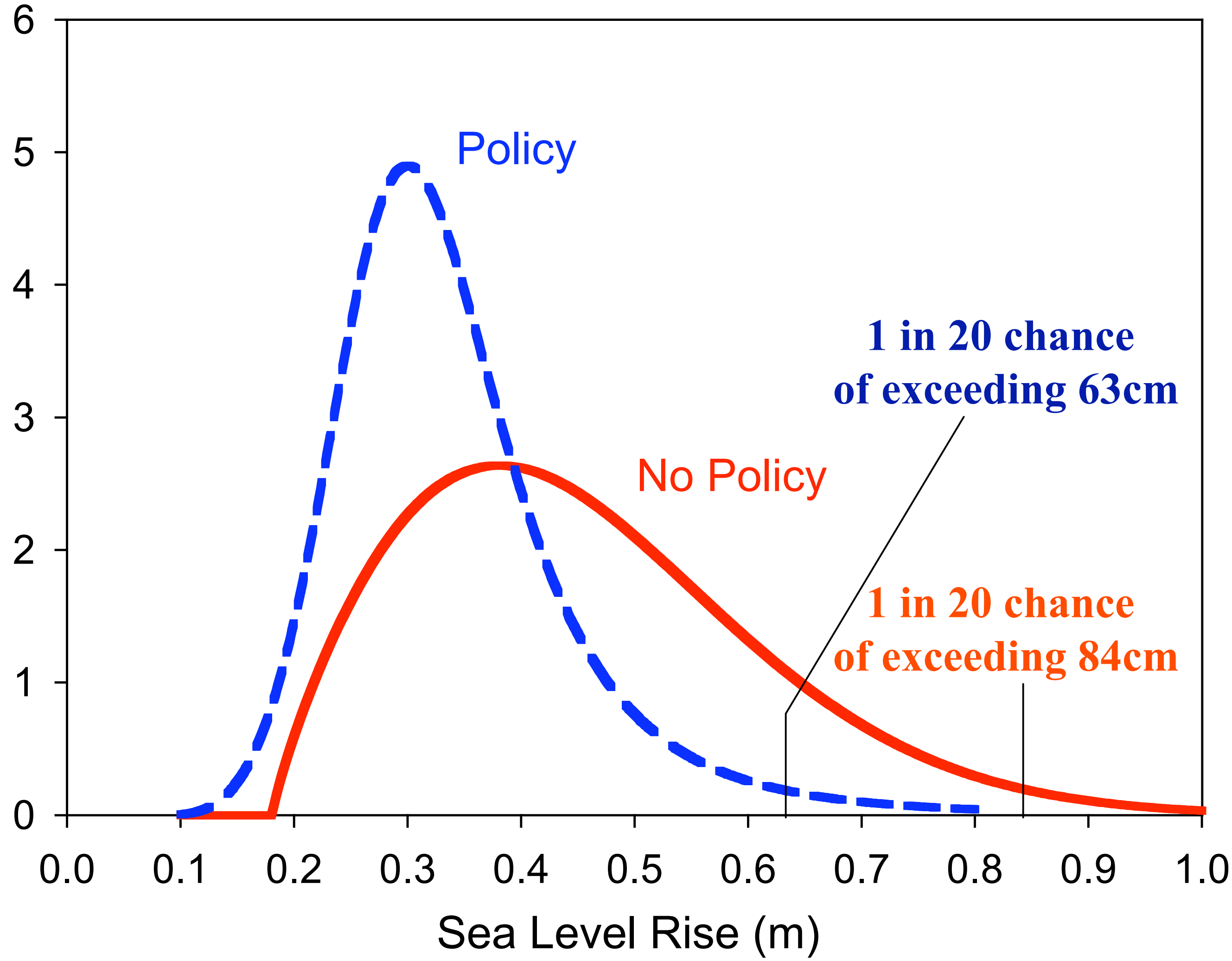


Global Mean Temperature Change by 2100



Sea Level Rise by 2100

(Thermal Expansion + Glacial Melt)



Analysis Does Not Stop There

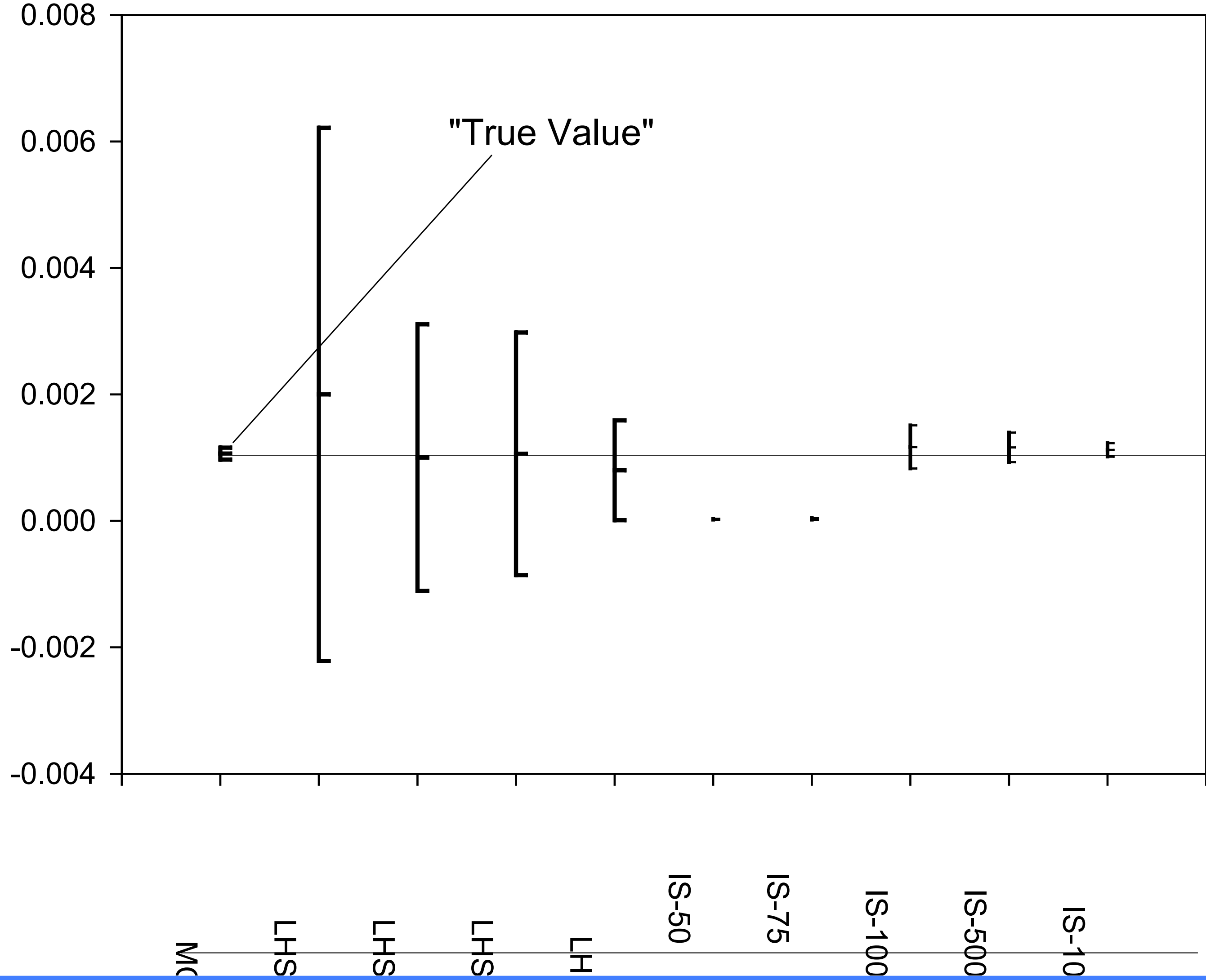
- Need uncertainty in abatement costs
- Need sequential decision of time with learning (adaptive strategies)
- Interactions among strategic actors

Estimating Extreme Probabilities

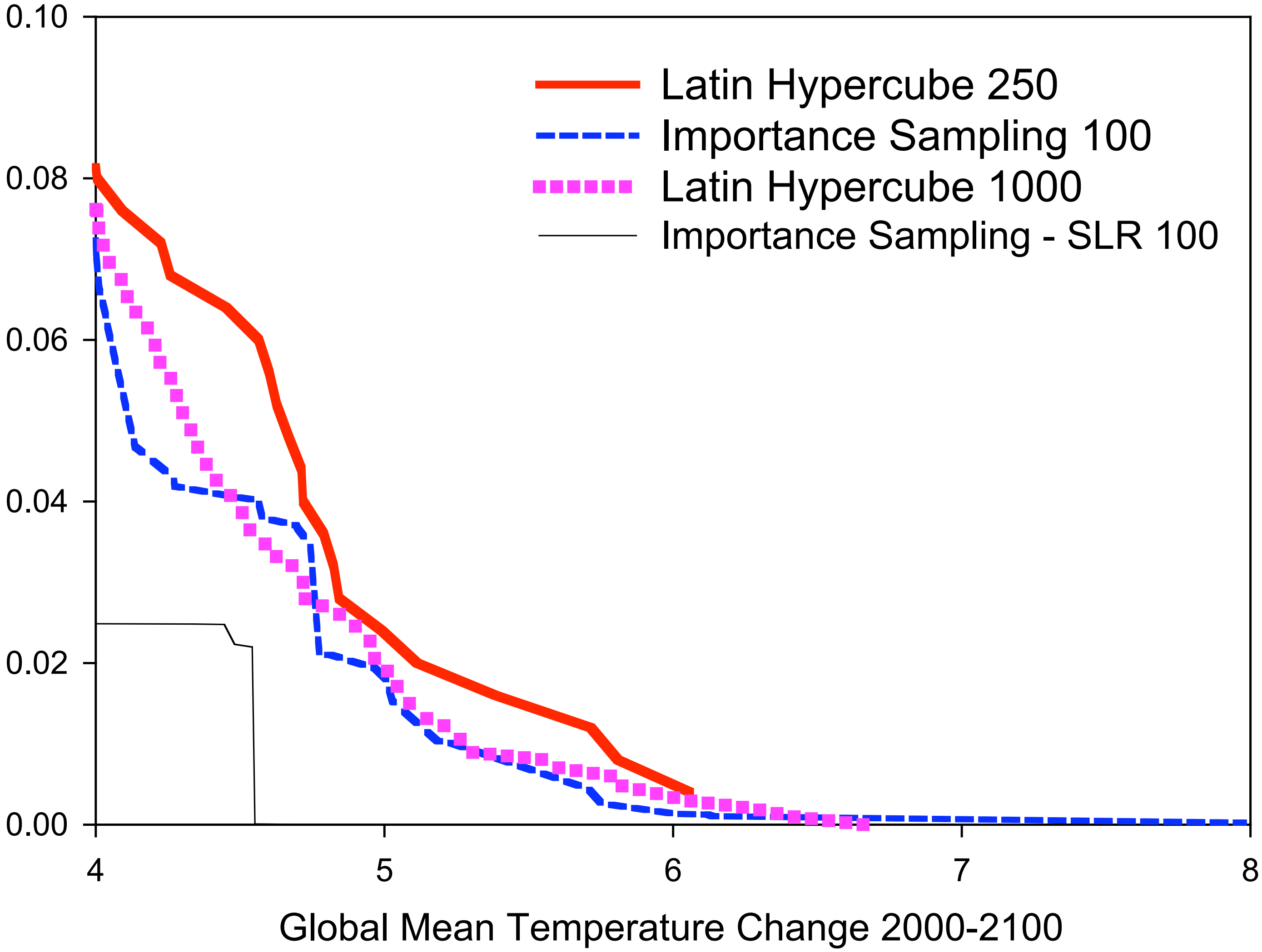
- Requires *many* simulations to estimate tails

- Alternative technique: Importance Sampling
  - "Distort" parameter PDFs to sample disproportionately from extreme outcome range
  - Re-Weight resulting outcomes by true likelihood
  - Requires orders of magnitude fewer runs to get accurate estimate and minimal variance

Estimation of Probability of an Extreme Outcome: LHS vs IS



LHS vs. IS: Extreme Temperature Change from MIT Model



Challenges to Uncertainty Analysis

- Empirical Challenges
  - Past behavior does not fully determine the future
  - Sparse data
  - Expert judgments required – cognitive biases

- Methodological Challenges
  - Combining experts
  - Model uncertainty

Challenges to Uncertainty Analysis (II)

- Institutional Challenges
  - How to structure formal assessment processes?
  - Focus on consensus
  - Expert judgments in a political context
  - Appropriate venue for uncertainty analysis?
- Philosophical Challenges
  - Frequentist vs. Bayesian
  - Differing views on future social development

Possible Next Steps to Improve UA

- Constructing PDFs for socio-econ. parameters:
  - Using historical data to *inform*
- Multiple Experts
  - assessments across wider range, intercomparisons?
- More focus on impacts (beyond ΔT)?
- More links between standard scenarios and probabilistic information?
- Other ideas?

Calvin's View on Risky Decisions