Sensitivity of Coastal Adaptation Costs and Decisions to Sea Level and Socioeconomic Uncertainties

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Introduction

- Sea-level rise and coastal flooding pose significant risks to coastal communities
- Efficacy of strategies to manage these risks depends on:
  - uncertainty in future emissions pathways
  - uncertainty in future socioeconomic change
  - uncertainty in geophysical factors (e.g., climate sensitivity)
- Greater model detail can constrain these uncertainties, but also introduces new uncertainties to represent additional processes
- So, we use Galveston, TX and New York City as case studies to ask:
  1. **As we increase model complexity, are we gaining information? Or are we awash in uncertainty?**
  2. **Which uncertain predictions & parameters most strongly influence coastal risk?**

Workflow

Sea-level projections using MimiBRICK[1]

Antarctic & Greenland ice sheets, thermal expansion, glaciers and ice caps, and land water storage contributions to local sea levels

Deep uncertainties

3 model configurations (BRICK, DOECLIM-BRICK, SNEASY-BRICK)
4 SSP-RCP pathways (SSP1-2.6, SSP2-4.5, SSP4-6.0, SSP5-8.5)

Calibration to observational data

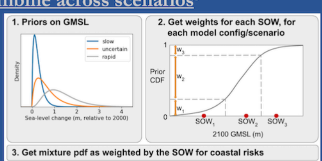
CO_2, temperature, ocean heat uptake, and sea level contributions

Local coastal impacts using MimiCIAM[2]

Mimi Coastal Impact and Adaptation Model to estimate net present value (NPV) of total adaptation costs from **protection** or **retreat**, and damages from **inundation, wetland loss,** and **flooding**

Combine across scenarios[3]

Subjective Bayesian priors on 2100 global mean sea level

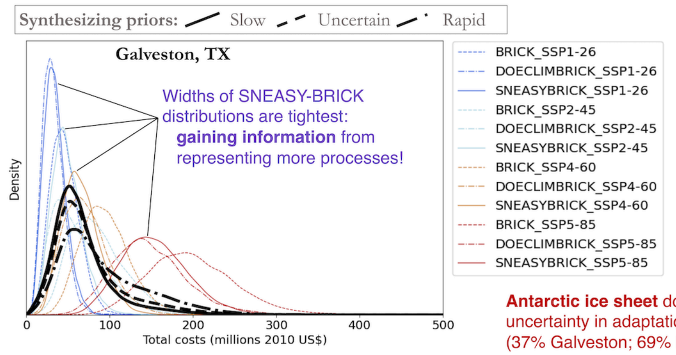


Global sensitivity analysis

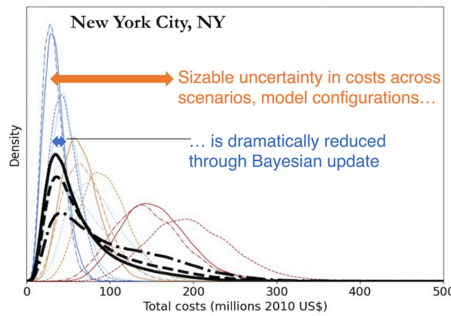
- Run model many times, varying uncertain parameters
- How much variance in NPV of total adaptation costs is attributable to each uncertainty?

Results

What are probabilistic estimates for NPV of adaptation costs?



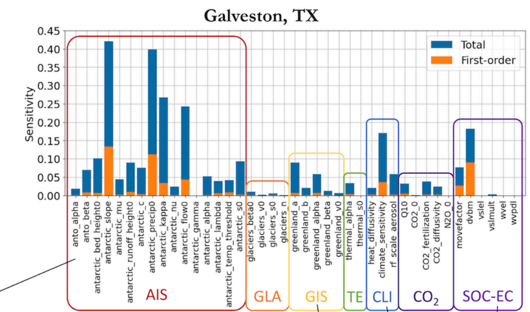
Widths of SNEASY-BRICK distributions are tightest: **gaining information** from representing more processes!



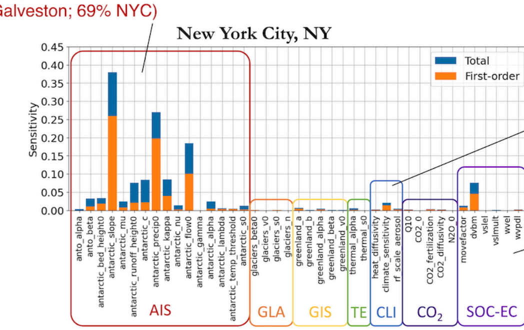
Sizable uncertainty in costs across scenarios, model configurations…

… is dramatically reduced through Bayesian update

What uncertain factors are adaptation costs most sensitive to?



Antarctic ice sheet dominates uncertainty in adaptation costs (37% Galveston; 69% NYC)



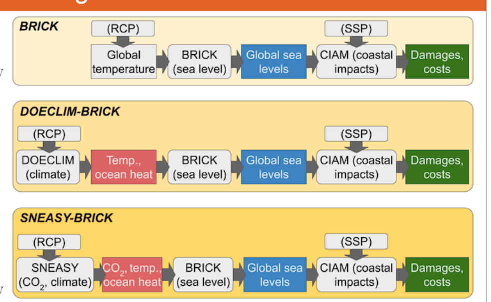
Greenland ice loss…

…driven by climatic factors (e.g., **climate sensitivity**)

Socioeconomic uncertainties (relocation costs and abandoned dryland value) are second-largest driver (12% Galveston; 5% NYC)

Model configurations

Lowest model complexity



Highest model complexity

Take-aways

- **Distributions tighten as model detail added – information gained!**
- **Predictions/parameters most strongly influencing coastal risk:**
  - Antarctic Ice Sheet - Socioeconomic (dryland value, relocation costs) - Climate sensitivity
- **Role of major ice sheets varies by proximity to site, gravitational effects**
- **In U.S. Gulf Coast site, CO_2, climatic, and temperature-driven factors important**
- This open source framework is readily incorporated into cost-benefit integrated assessment models to represent deeply uncertain sea-level impacts and adaptation responses in policy relevant metrics such as the social cost of carbon[4]
- **Model and analysis codes available from:**
  https://github.com/raddleverse

References

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2. Wong *et al.* 2022b, arxiv.org/abs/2211.16460 *(accepted, Earth's Future)*
3. Doss-Gollin & Keller 2022, doi: 10.1002/essoar.10511798.2
4. Rennert *et al.* 2022, doi: 10.1038/s41586-022-05224-9

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