Reduced complexity climate models are useful tools for quantifying decision-relevant uncertainties, given their flexibility, computational efficiency, and suitability for large-ensemble frameworks necessary for statistical estimation using resampling techniques (e.g., Markov chain Monte Carlo—MCMC). Here we document a new version of the simple, open-source, global climate model Hector, coupled with a one-dimensional diffusive heat and energy balance model (Diffusion Ocean Energy balance CLIMate model; DOECLIM) and a sea-level change module (Building blocks for Relevant Ice and Climate Knowledge; BRICK) that also represents contributions from thermal expansion, glaciers and ice caps, and polar ice sheets. We apply a Bayesian calibration approach to quantify model uncertainties surrounding 39 model parameters with prescribed radiative forcing, using observational information from global surface temperature, ocean heat uptake, and sea-level change. Results provide important constraints on probabilistic projections of global, regional, and local sea-level rise. Ongoing work includes combining probabilistic results with historical tide gauge records to analyze changes in flood risk at the local scale.

Hector is an open source simple global carbon-climate model that simulates global climate change given emissions and radiative forcings from greenhouse emission data and accounting for carbon cycling, radiative forcings from greenhouse gases, aerosols, and pollutants (Hartin et al., 2015).

New sea-level rise component - BRICK

- New global sea-level rise (SLR) component using BRICK (Building blocks for Relevant Ice and Climate Knowledge; Wong et al., 2017), including SLR contributions from:
  - Thermal expansion (TE)
  - Antarctic Ice Sheet (AIS)
  - Greenland Ice Sheet (GIS)
  - Glaciers and small ice caps (GIC)

Calibration using Adaptive MCMC

We adapt a Bayesian calibration tool from BRICK to perform probabilistic assessment:

- Include 39 parameters from sea-level and energy balance components
- Observational constraints include global surface temperature, ocean heat content, and sea-level rise
- Incorporates mechanistically-motivated prior ranges and employs Gelman-Rubin diagnostics to assess convergence.
- Initial Hector calibrations include 4 MCMC chains of 1 million runs

Probabilistic version available at: https://github.com/bvegawest/hector/tree/dev_slr

Objective

Apply new Hector-Brick model to analyze parametric uncertainties surrounding extreme global sea-level rise projections

Approach

- Performed a Bayesian model calibration (adaptive MCMC) to estimate 39 model parameters with prescribed RCP8.5 radiative forcing
- Analyzed probabilistic projections of global sea-level rise for different combinations of observational constraints from the atmosphere, ocean, and land ice

Impact

- Different combinations of observational constraints can yield similar temperature but drastically different SLR projections, particularly for extreme scenarios.
- Next Steps: Analyze effects of different forcing scenarios from CMIP5 and CMIP6 on extreme SLR.