Pacific Northwest
NATIONAL LABORATORY

iHESD collaboration

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U.S. DEPARTMENT OF ENERGY BATTELLE

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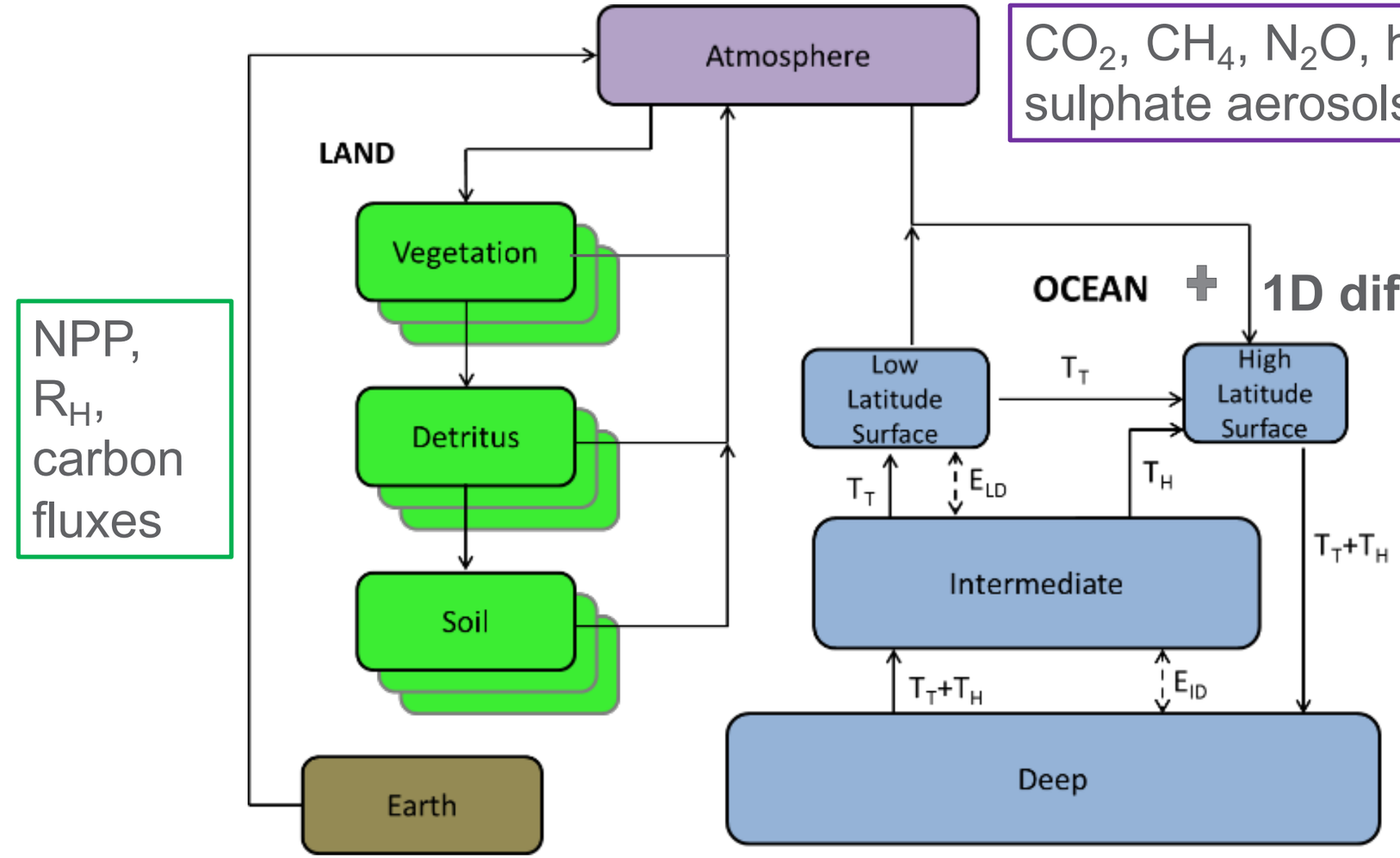
iHESD collaboration

- Collaboration between
  - Corinne Hartin (PNNL/JGCRI)
  - Ryan Sriver and Ben Vega-Westhoff (UIUC)
  - Klaus Keller (PSU)
  - Tony Wong (CU)
- SFA iHESD proposal had 2 tasks written in well suited for outside collaboration
  - Better representation of ocean heat uptake within Hector
  - Probabilistic temperature projections within Hector

iHESD collaboration

- Collaboration started with the iHESD SFA in 2016
  - ~100k/year
- Funding from PNNL to UIUC to PSU
  - Graduate student support
  - Summer salary support
  - Post-doc support
- The following year due to changes in the budget we discontinued the portion of funding to PSU.

Overview of Hector – a simple climate model



CO_2, CH_4, N_2O, halocarbons, BC, OC, sulphate aerosols, strat H_2O, trop O_3

NPP, R_H, carbon fluxes

pH, $CaCO_3$ saturations, carbon fluxes, heat uptake

Hartin et al., 2015 – GMD
Hartin et al., 2016 – BGS

www.github.com/JGCRI/hector

Workflow

- Step 1 – Incorporate DOECLIM model into Hector
  - 1-D diffusive ocean – C++
- Step 2 – Couple BRICK to Hector
  - Sea-level model – Fortran and R
- Step 3 – Bayesian calibration of Hector-BRICK
- Step 4 - Paper 1 - Impacts of observational constraints related to sea level on estimates of climate sensitivity (Vega-Westhoff et al., 2019 – Earth's Future)
  - https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018EF001082
- Step 5 – Paper 2 - What is the role of climate sensitivity in extreme sea-level rise scenarios?

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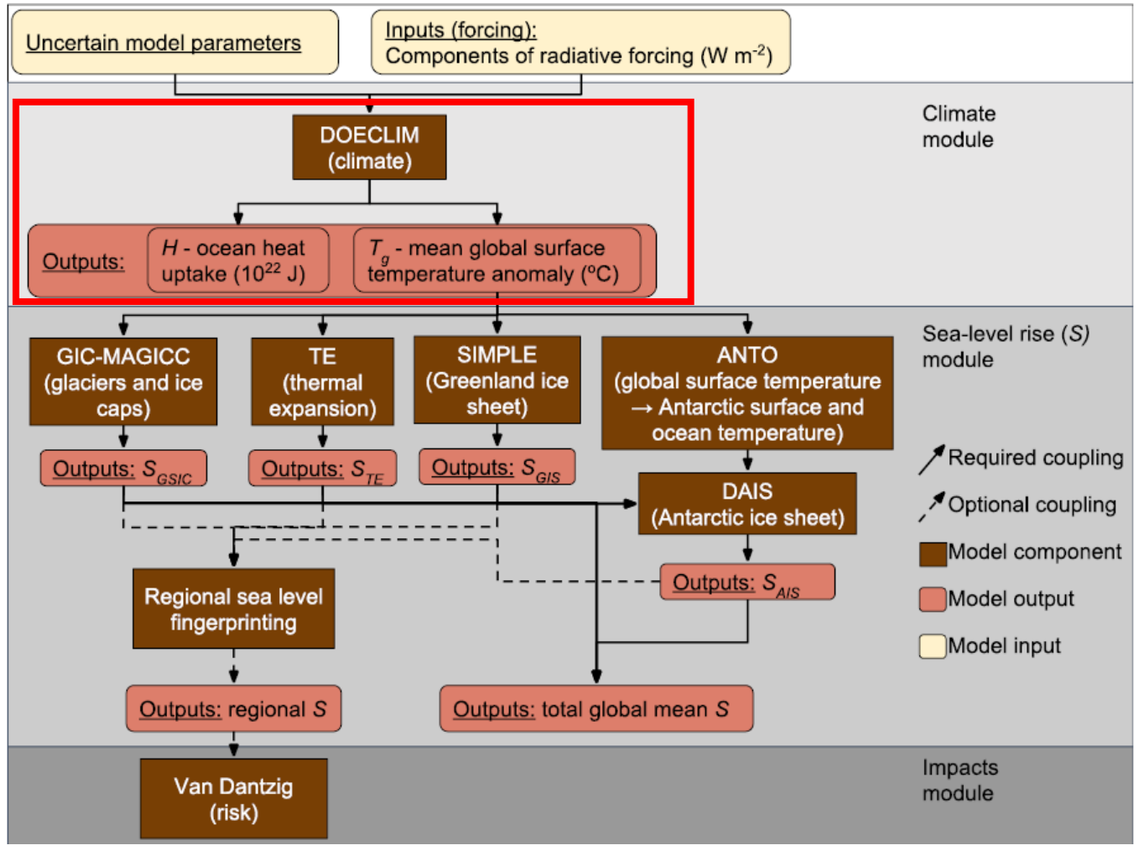
Overview of DOECLIM and BRICK

- Coupled DOECLIM to Hector – Diffusion Ocean Energy balance CLImate Model
  - 1-D diffusive heat ocean
    - ✓ parameters – diffusivity, radiative forcing, and aerosol scaling
    - ✓ “fast” and “slow” response – mixed layer and deep ocean
- BRICK - Building blocks for Relevant Ice and Climate Knowledge
    - ✓ Glaciers and ice caps
    - ✓ Thermal expansion
    - ✓ Greenland ice sheet
    - ✓ Antarctic ice sheet
    - ✓ Regional fingerprinting



Wong et al., 2017 - GMD

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How does parametric uncertainty influence the tails of global sea-level rise?

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ILLINOIS PennState PNNL

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 temperature and 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.*
- Ongoing sea-level rise work addresses climate scenarios leading to extreme outcomes and regional variability.

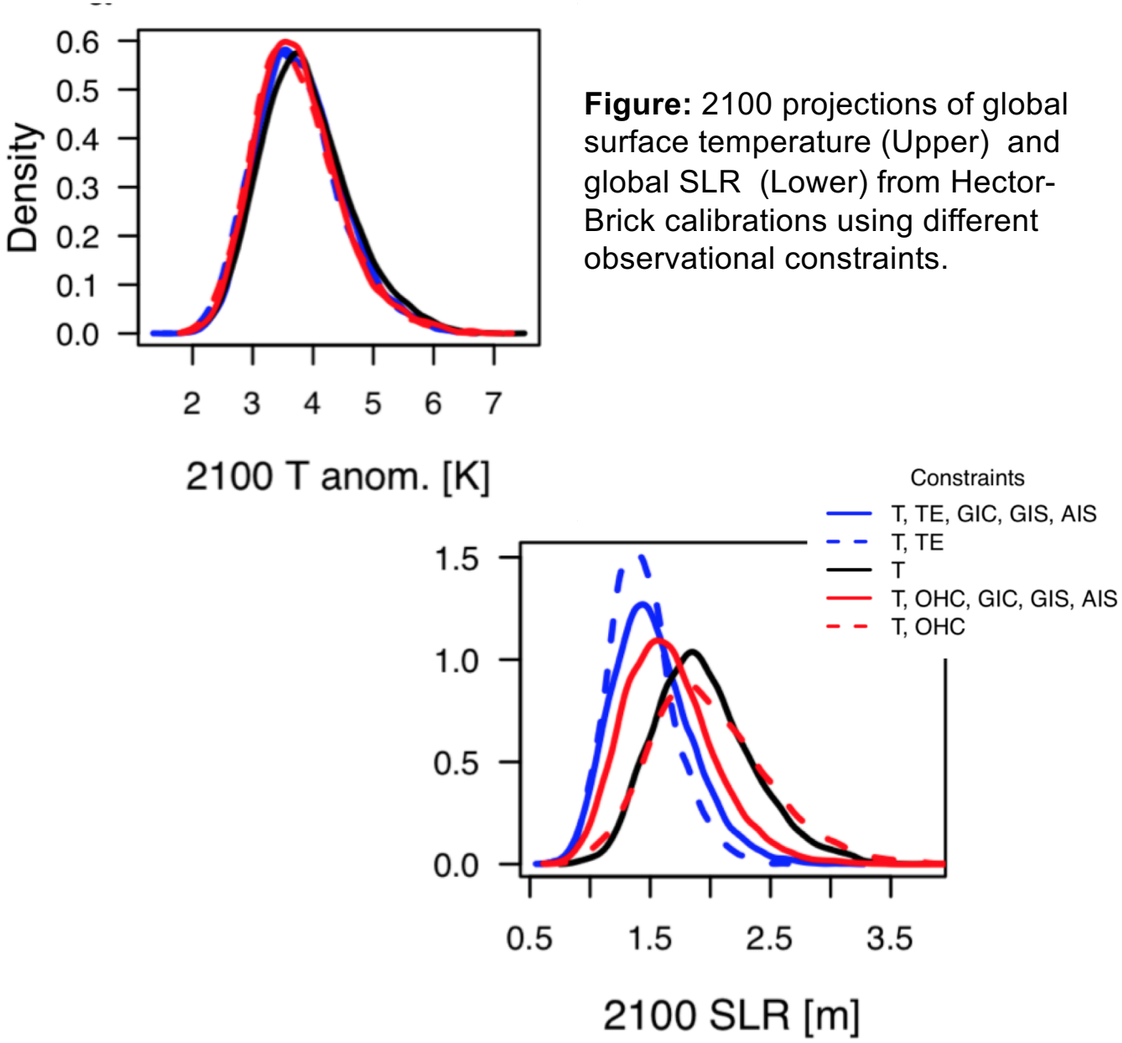

Figure: 2100 projections of global surface temperature (Upper) and global SLR (Lower) from Hector-Brick calibrations using different observational constraints.

Vega-Westhoff, B, RL Sriver, CA Hartin, TE Wong, and K Keller. "Impacts of Observational Constraints Related to Sea Level on Estimates of Climate Sensitivity." Earth's Future (2019) https://doi.org/10.1029/2018EF001082

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What is the relationship between climate sensitivity and extreme sea-level rise?

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Objective

Investigate sensitivity of global-to-regional sea level rise (SLR) to uncertainty in equilibrium climate sensitivity (ECS) using Hector-BRICK

Approach

- Analyze temperature and sea-level response in Hector-Brick with high/low ECS scenarios and different RCPs (**Figure 1**)
- Results based on Bayesian calibration utilizing multiple atmosphere/ocean observational constraints.
- Focus on extreme SLR outcomes (above 90th percentile) at global to regional scales using fingerprint technique (**Figure 2**)

Impact

- *Both high and low climate sensitivity scenarios yield wide ranges in SLR, highlighting the effect of deep uncertainties on SLR projections on global and regional scales.*

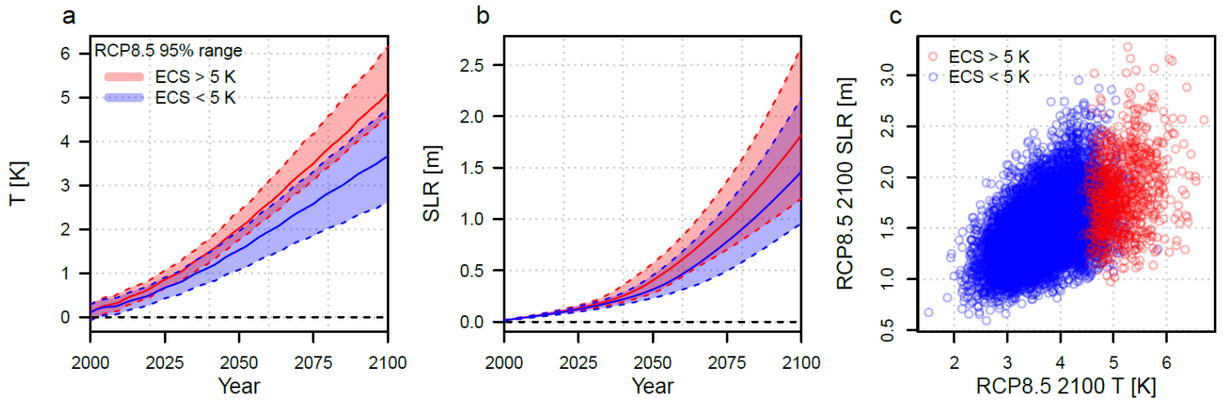

Figure 1: Global temp (left) and SLR (center) projections for high/low ECS scenarios; 2100 scatter plot (right)

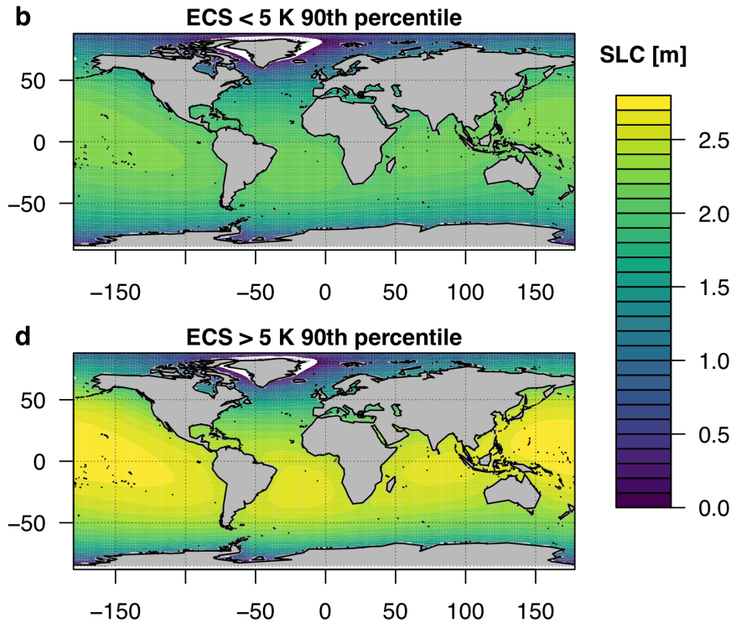

Figure 2: 90th percentile global SLR 2100 projections for low and high ECS scenarios

Vega Westhoff, B., Sriver, R. L., Hartin, C. A., Wong, T. E., and Keller, K. (In Preparation), What is the role of climate sensitivity in extreme sea-level rise scenarios?, Geophysical Research Letters

What were the success~~/challenges~~ in terms of communication, data sharing, data analysis, writing of manuscript, etc.?

- Awesome new model with new capabilities.
- Open in terms of discussion and priorities of the project and priorities of DOE.
  - Periodic check-ins. Small and large groups.
  - Random phone calls along the way.
  - Worked in google docs for the publication writing

Lessons learned along the way: insights to inform future collaborative work between MSD groups

- Need to keep in mind the iHESD deliverables as well as the needs of the researchers involved
  - Balance between model development, research, and papers
    - ✓ E.g., early career scientists need publications
- It was a little slow going early on with a steep learning curve in terms of:
  - 1) learning Hector,
  - 2) learning the statistics, and
  - 3) linking it all together (computing).
  - *However, all the work has led to a pretty 'slick' version of Hector-BRICK with a lot of capabilities in uncertainty quantification and coastal extremes.*
- Re-evaluate along the way and change scope or direction
- Recommend collaborations with people you enjoying working with, you can be honest with, can brainstorm with, and learn from.

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Thank you