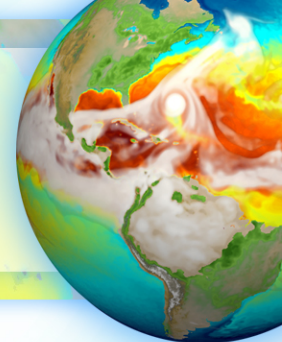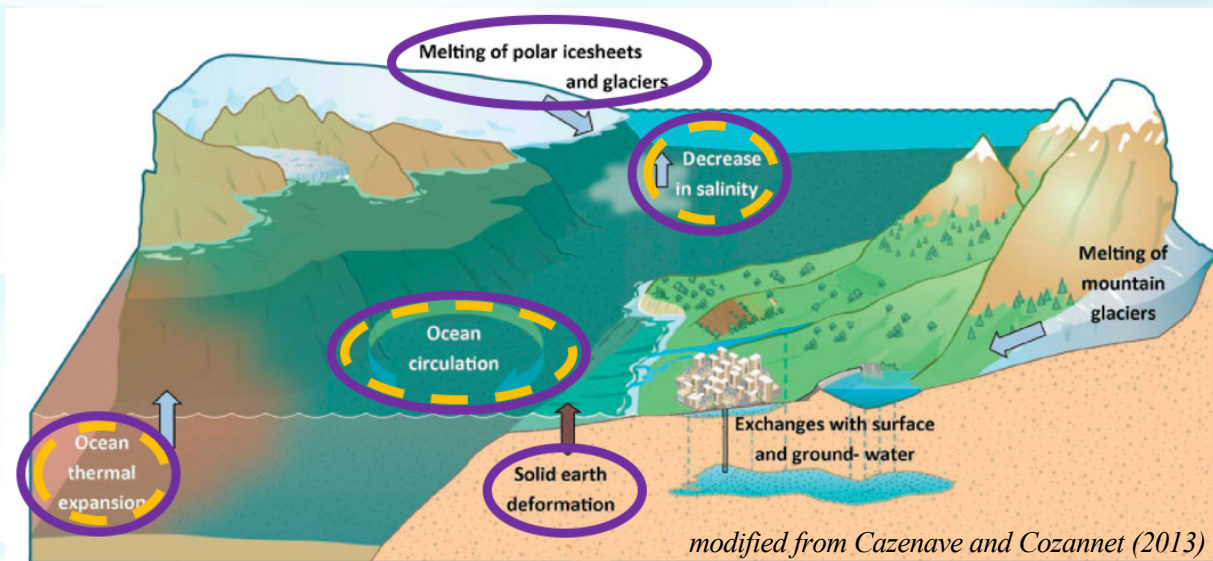# Creating a Sea-Level-Enabled E3SM:
A critical capability for predicting coastal impacts

Matt Hoffman
Los Alamos National Laboratory

DOE Early Career Research project

modified from Cazenave and Cozannet (2013)

E3SM Energy Exascale Earth System Model

U.S. DEPARTMENT OF ENERGY

Background

- Sea level does not change uniformly
  - Heat uptake and **thermal expansion** not uniform
  - Ocean circulation and wind forcing causes **dynamic sea level**
  - **Glacial Isostatic Adjustment (GIA)**
    - Change in shape of ocean basin
    - Change in Earth's gravitational field and rotation
  - Local, non-climatic effects
    - tectonics
    - fluid extraction
- Climate models do not directly model sea level

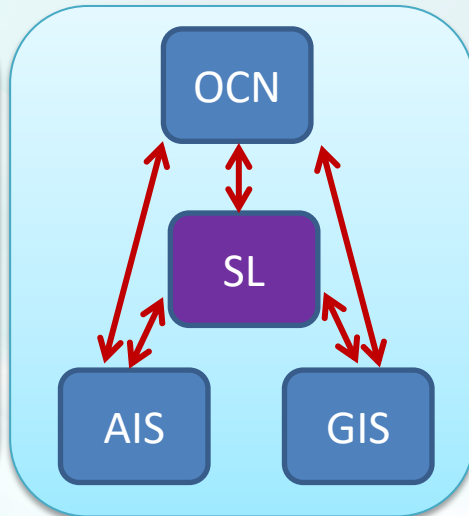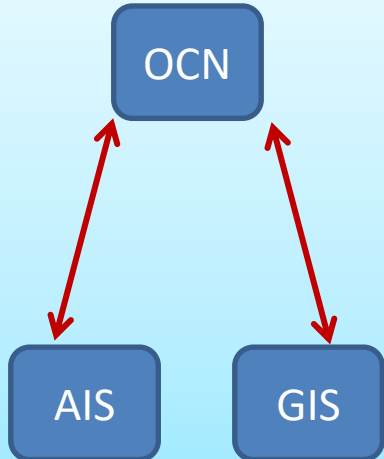

Slangen, et al. (2014)
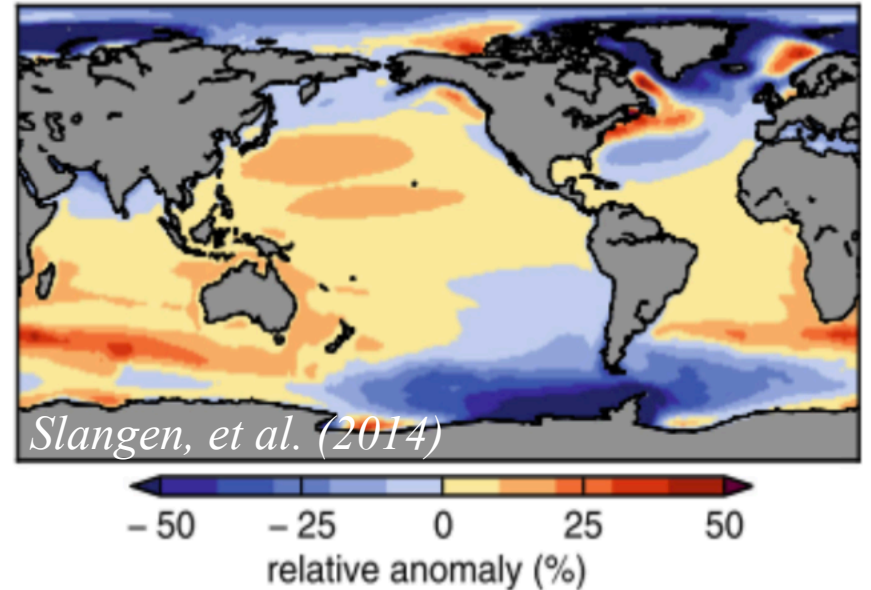
Projected RSL anomaly at 2100 relative to GMSL

Model Development

Develop a Sea-Level-Enabled E3SM by:

- Adding a Sea Level Equation/GIA model component to E3SM

- Adding regional sea level representation to ocean model

- Adding regional sea level representation to ice sheet model

Model Development

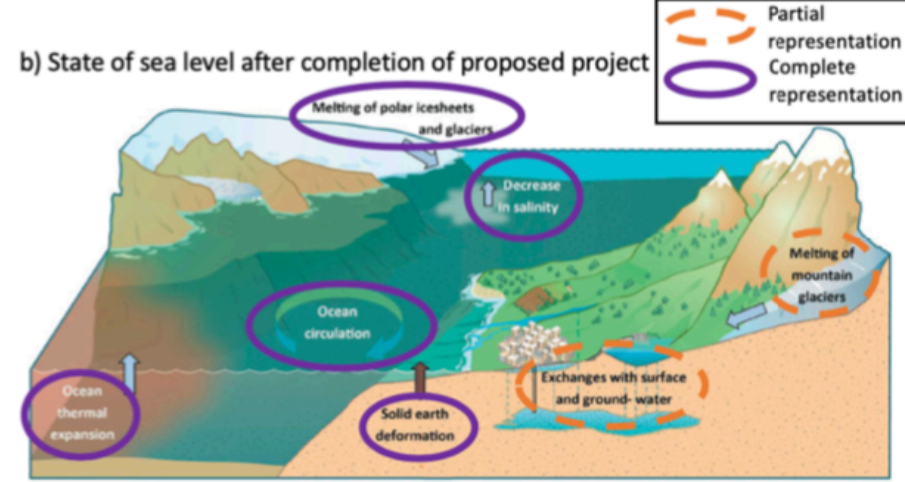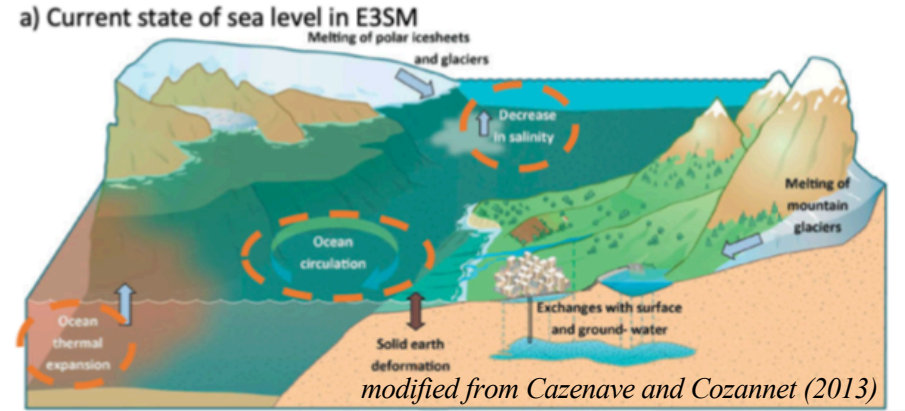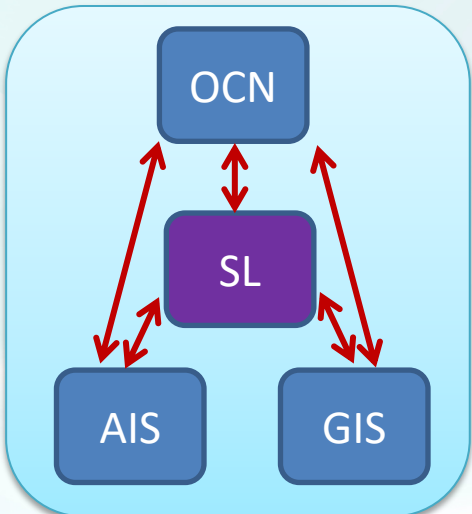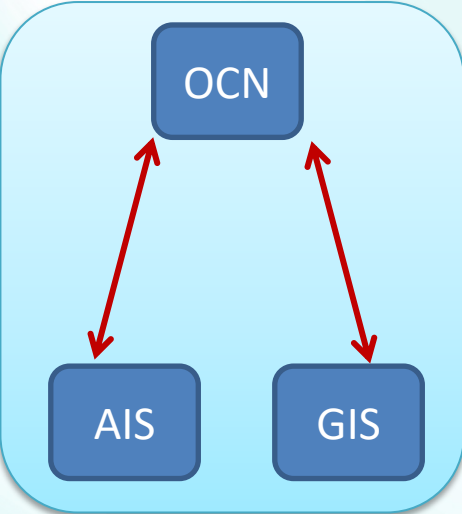Develop a Sea-Level-Enabled E3SM by:

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a) Current state of sea level in E3SM

modified from Cazenave and Cozannet (2013)

b) State of sea level after completion of proposed project

Science Objectives

- Improve on existing sea level projections that linearly add independently estimated contributions

$$RSL(x) = F_{AIS}(x)AIS + F_{GIS}(x)GIS + F_{GIC}(x)GIC + F_{LW}(x)LW + GIA_{LGM}(x) + T(x) + DSL(x) + L(x)$$

- Quantify sea-level/Earth-system feedbacks, including in Antarctic Ice Sheet evolution

- Model how future sea level changes affect offshore storm surge along U.S. coast

Sweet et al. (2017)
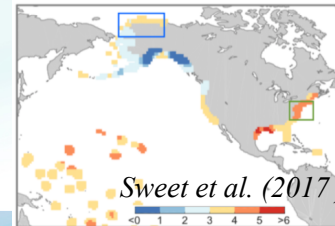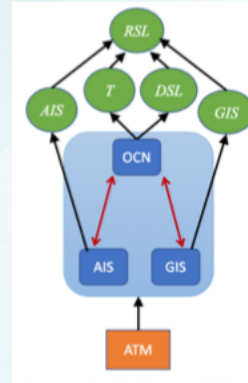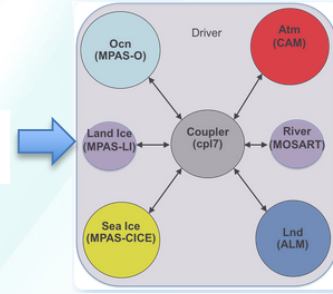
Project Status

- Task 1: developing offline regional sea level projections using existing E3SM ocean + ice sheet output

- Hiring 2 postdocs with GIA/Sea Level Equation expertise (planned start Spring 2021)

- Coordination with E3SM Cryo & WC Campaigns, ProSPect, ICoM, InteRFACE projects

- Unfunded collaborations:
  - University of Michigan
  - Harvard University
  - McGill University
  - NASA Goddard

Summary

- Goal: E3SM first climate model with regional sea level representation

- Development targeted for E3SM Phase 3-4
    - Scheduled to be complete 2023-24

A Fort Lauderdale street during high spring tides

Source: Bob Gremillion, January 2017
via https://domesticpreparedness.com/preparedness/three-storms-demonstrate-five-forms-of-flooding/
and Richard Alley