Multi-scale modeling of boundary currents
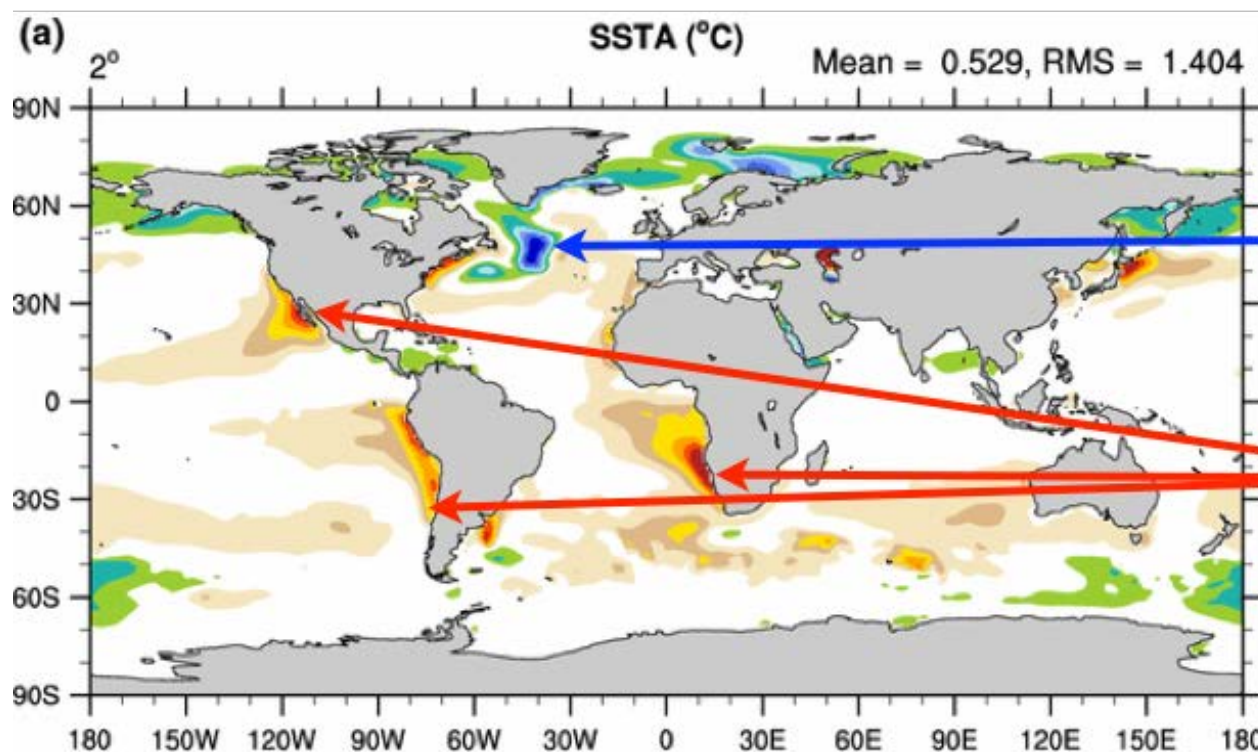
Enrique Curchitser

Department of Environmental Sciences

Institute of Marine and Coastal Sciences

In collaboration with:

Justin Small, Bill Large, Brian Kaufman, Kate Hedstrom, Mike Alexander, Raphael Dussin

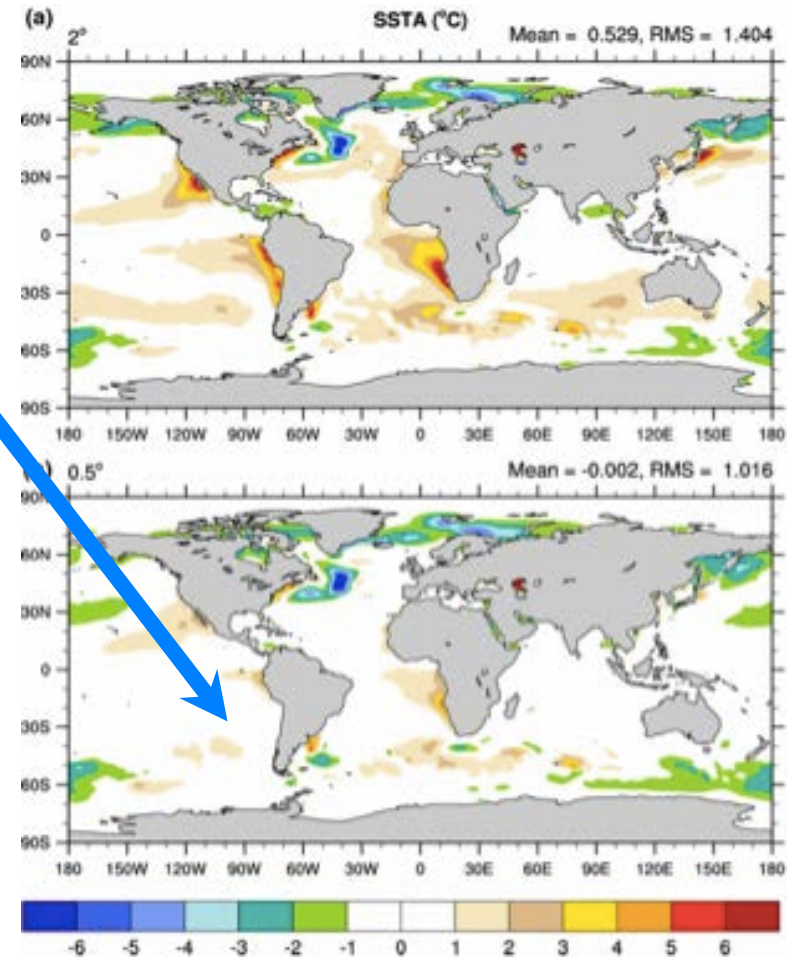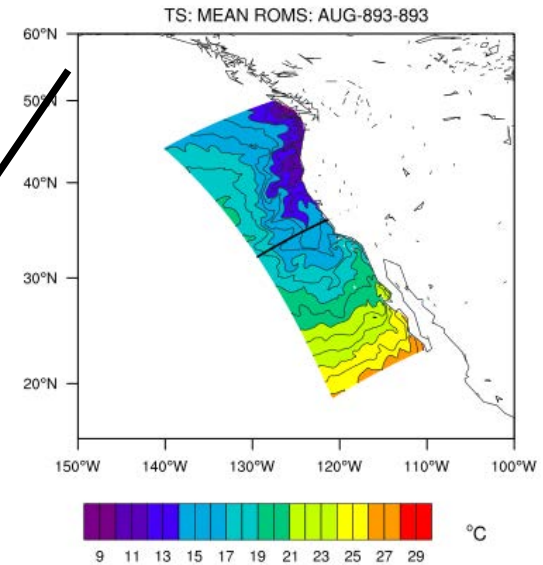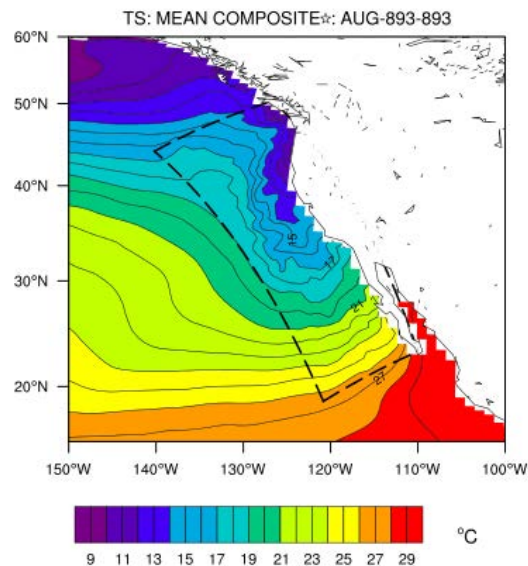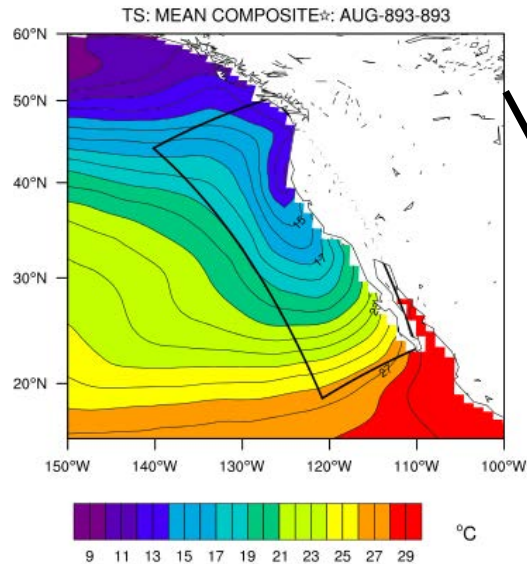# Motivation: Climate model biases in coastal regions

Approaches to a solution

Higher resolution in the atmosphere--better upwelling favorable winds (Gent et al., 2010)

Improvements to boundary layer physics (Park and Bretherton, 2009)

Improved resolution and physics in ocean--better upwelling

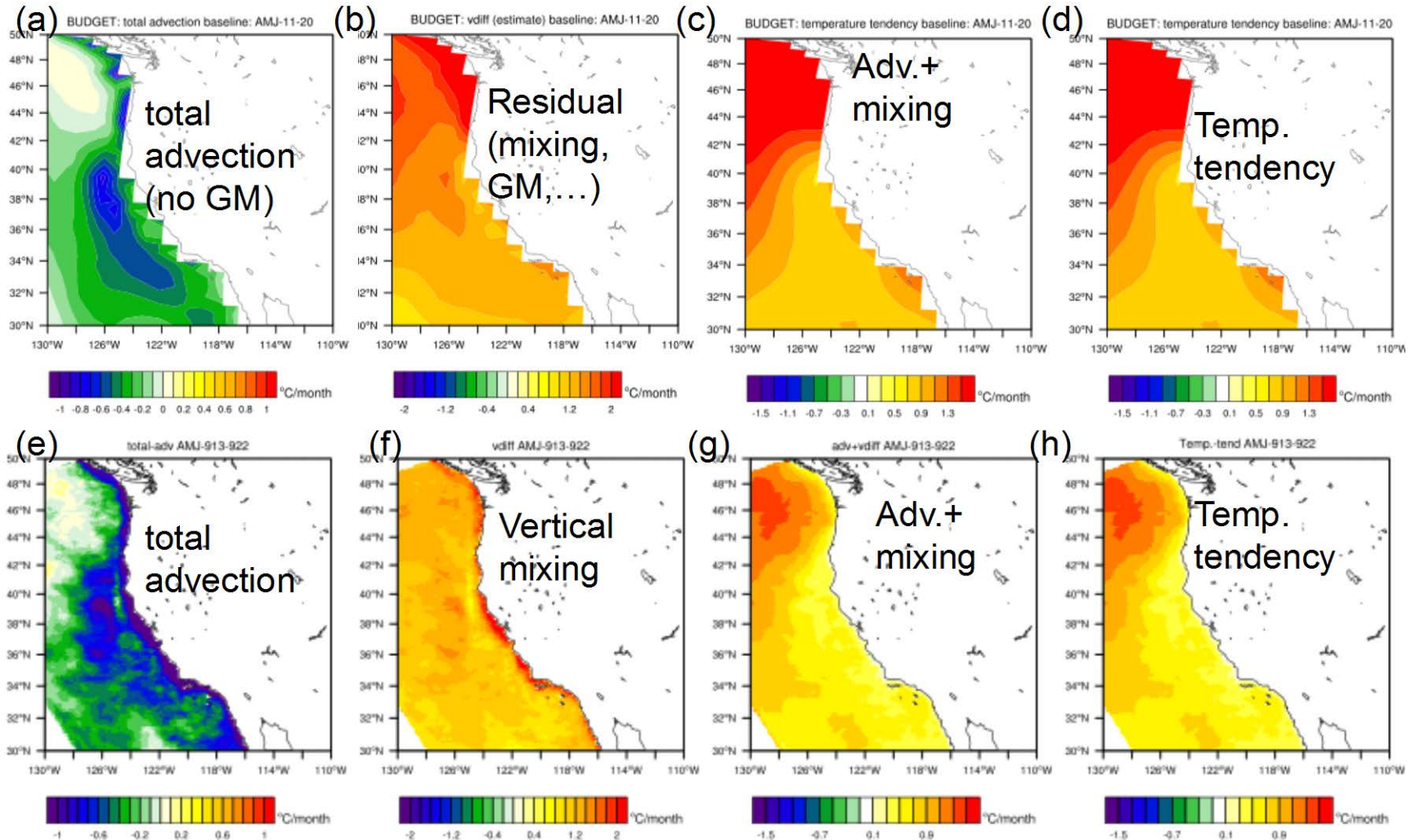# The method: Embedding a high-resolution ocean (ROMS) within NCAR-CESM

Numerical experiment

- Baseline: 150 year run of CCSM4, branched from 1870 control run.

- Composite: 150 year run of CCSM4-ROMS, same initial conditions.

- Ocean:
  - POP ~1-degree, 40 Z-levels
  - ROMS 7 km, 50 stretched sigma levels

- Atmosphere: CAM 4 1-degree

- Land: CLM 3

- Sea ice: CICE

- Analysis: 140 years of monthly means.

- Statistics: T-test for means, F-test for variability.
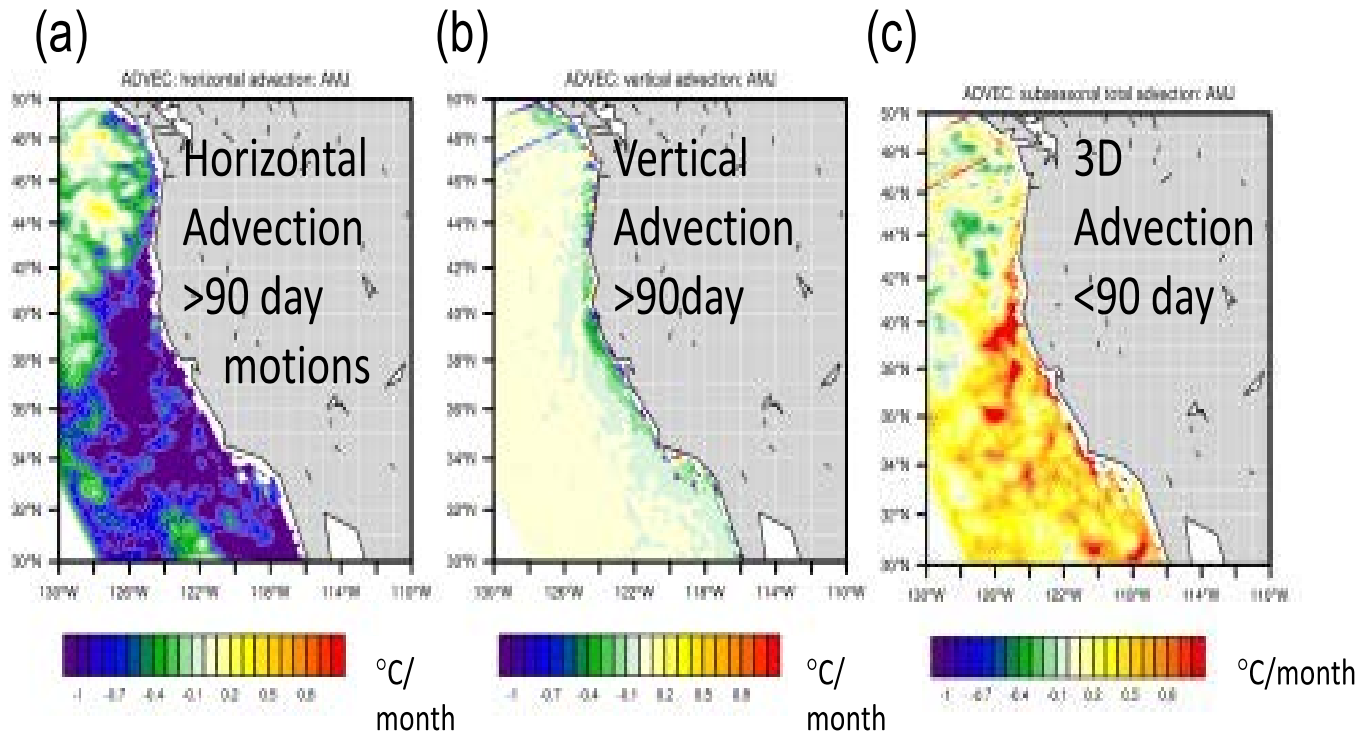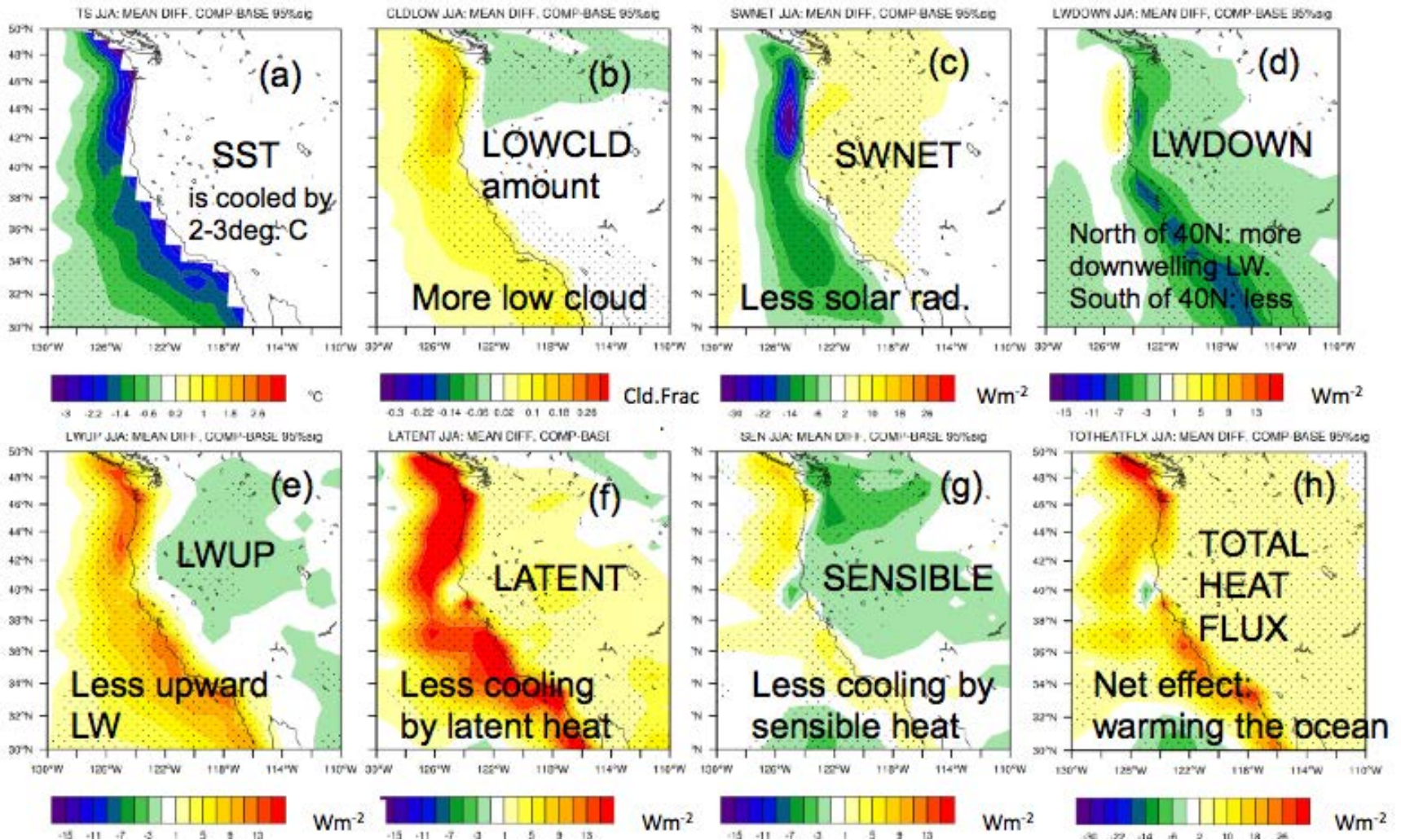
California Current: Local SST response
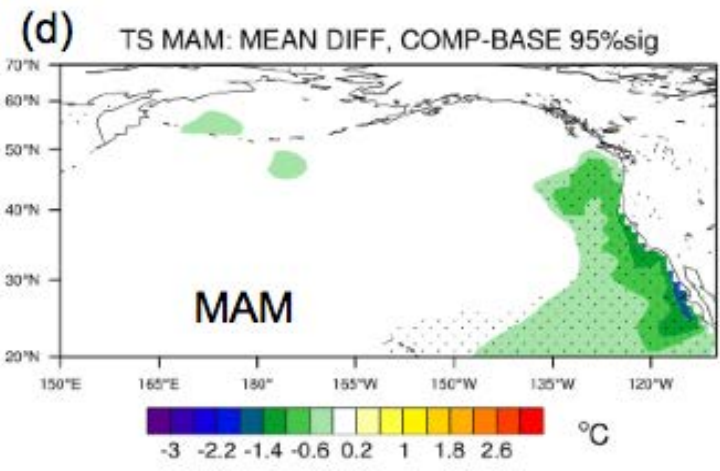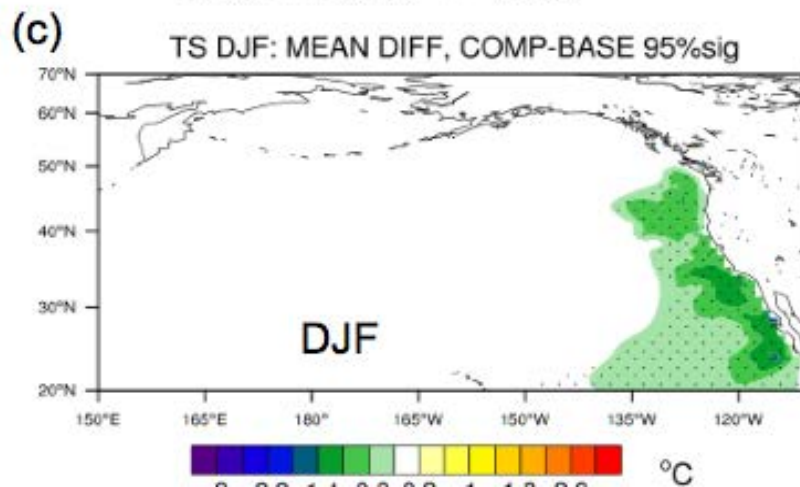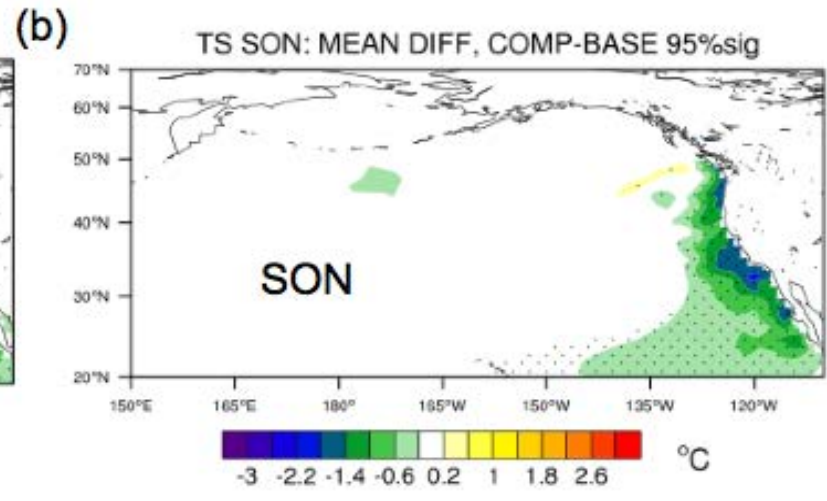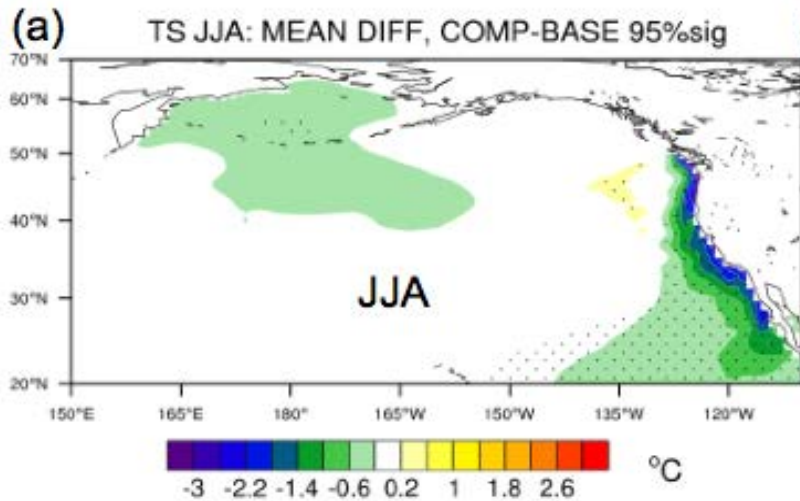
California Current: Heat budget

Decomposition of advection term

(a) Horizontal Advection >90 day motions

(b) Vertical Advection >90day

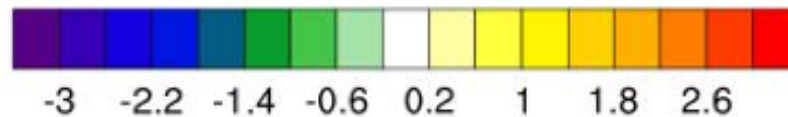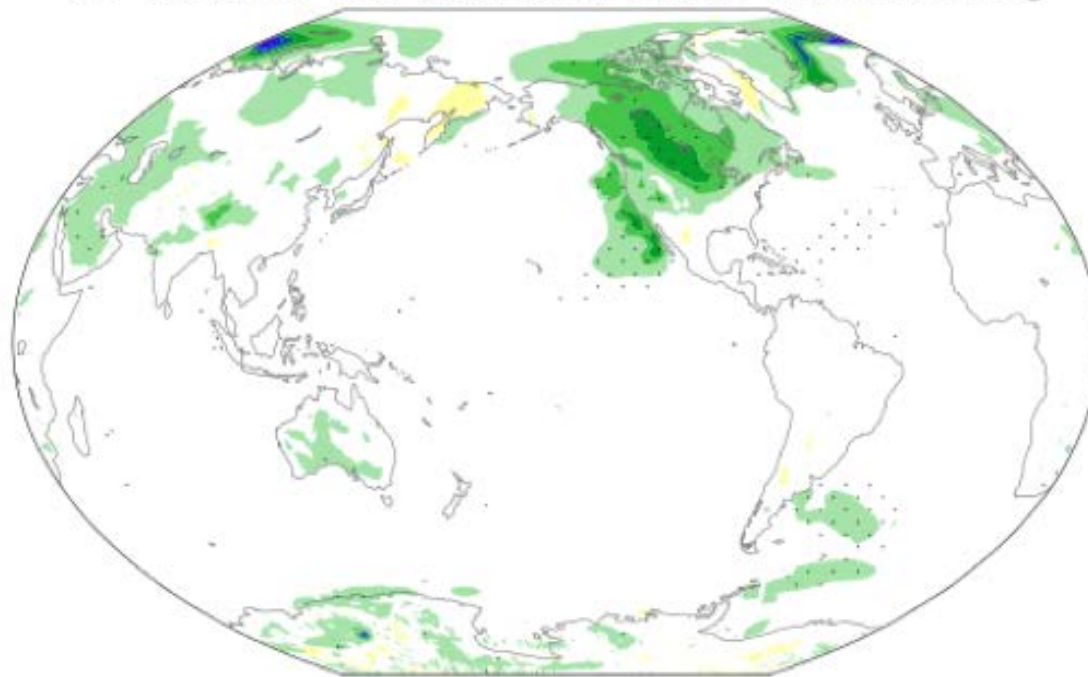(c) 3D Advection <90 day

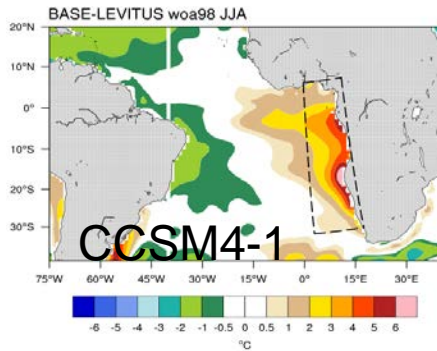# California Current: Surface fluxes--the coupled response

Global response: Surface temperature
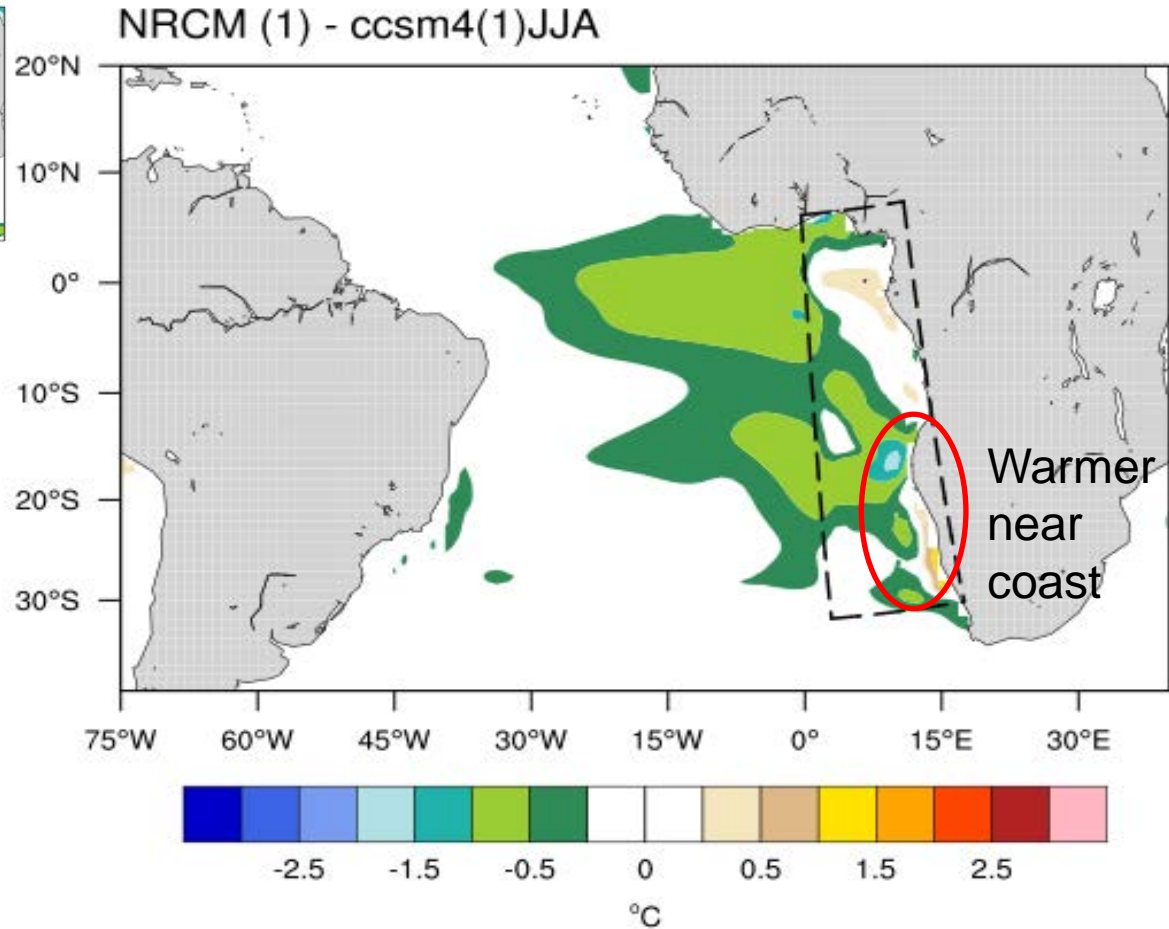

TS-ATM DJF: MEAN DIFF, COMP-BASE 95%sig

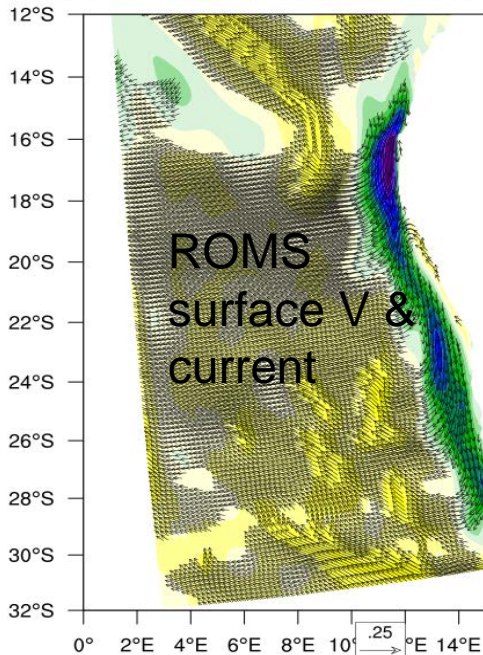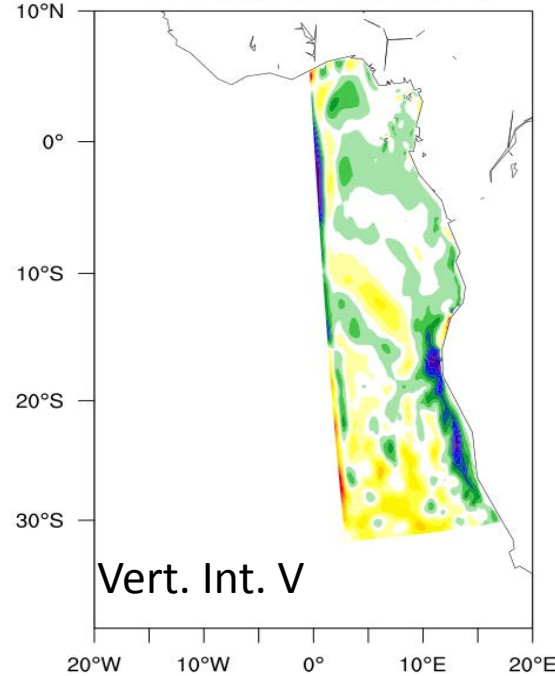# Embedding a high-resolution ocean in the Benguela region

CCSM4-1

SST bias,
CCSM4

Warmer
near
coast

Nested RCM SST minus CCSM4
baseline, JJA

Approximate Sverdrup balance
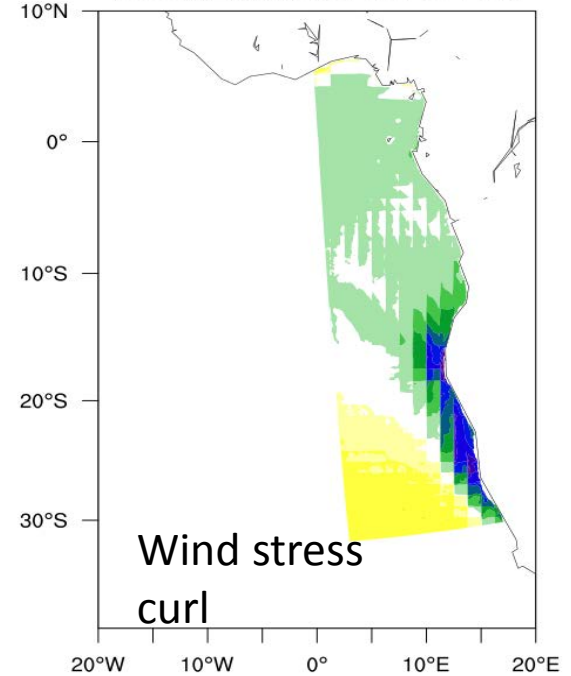
Benguela: Ekman pumping (top) and Vertical Velocity (bot.), JJA averages

ROMS, NRCM 1deg

CESM-HI 1/4deg ATM

QuiKSCAT climatology.
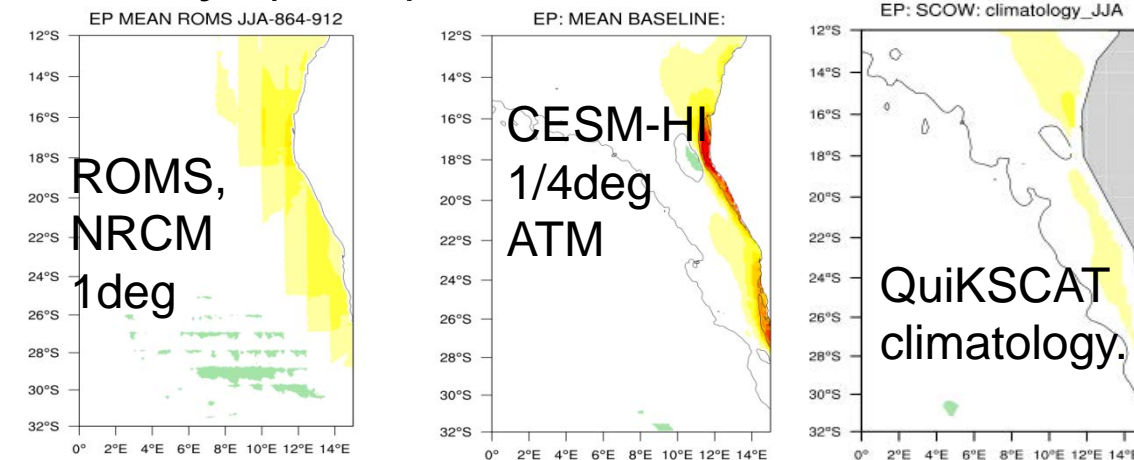
Risien and Chelton, 2008

ROMS, NRCM 1deg

CESM-HI
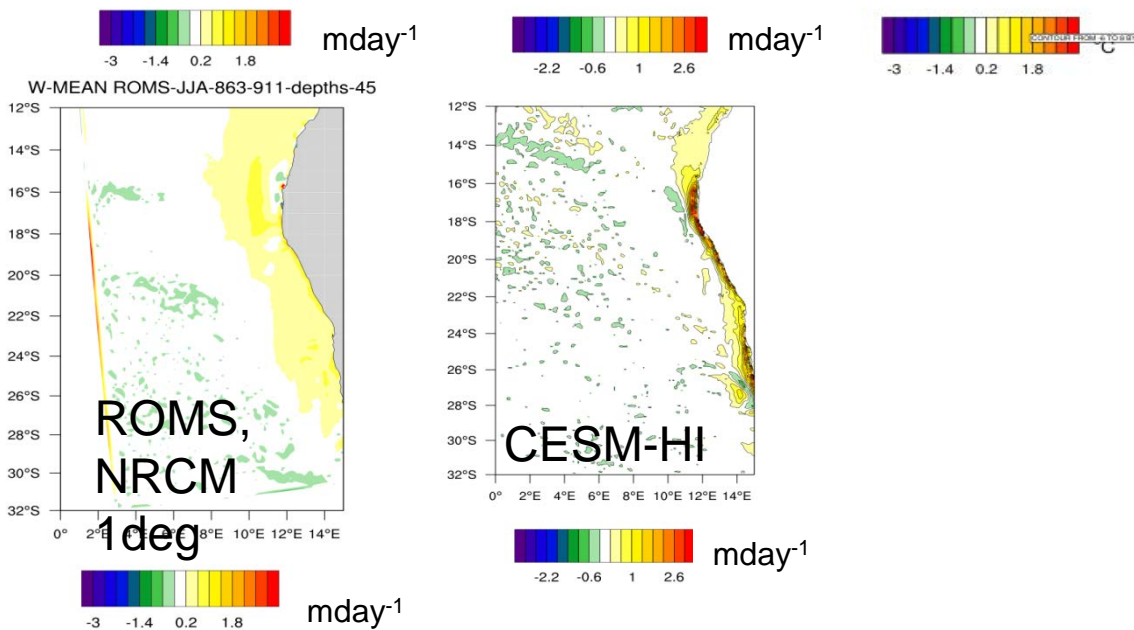
Western boundary currents: Northwest Atlantic--SSH

SSH at level 1, annual mean y0800x0899 in baseline
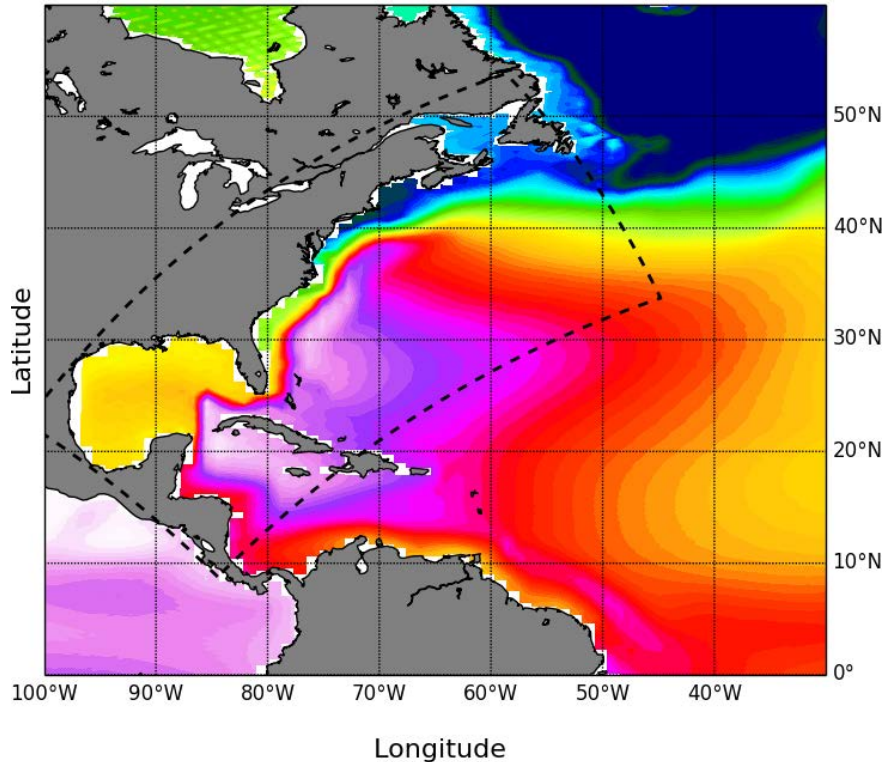
SSH at level 1, annual mean y0021x0051 in RRD02
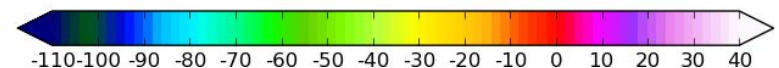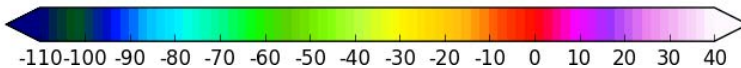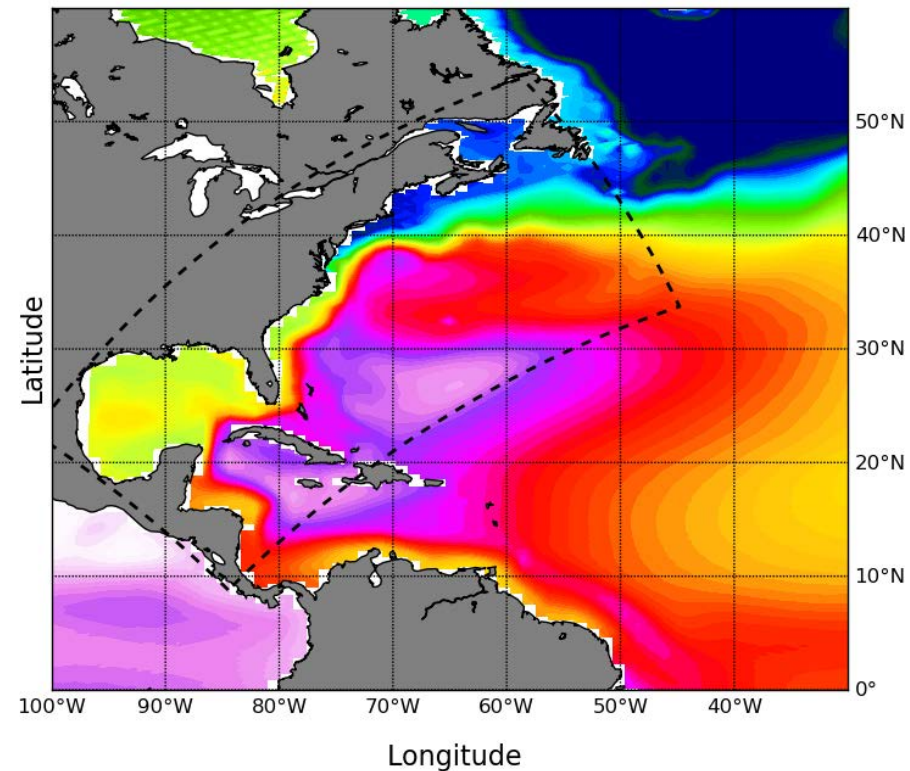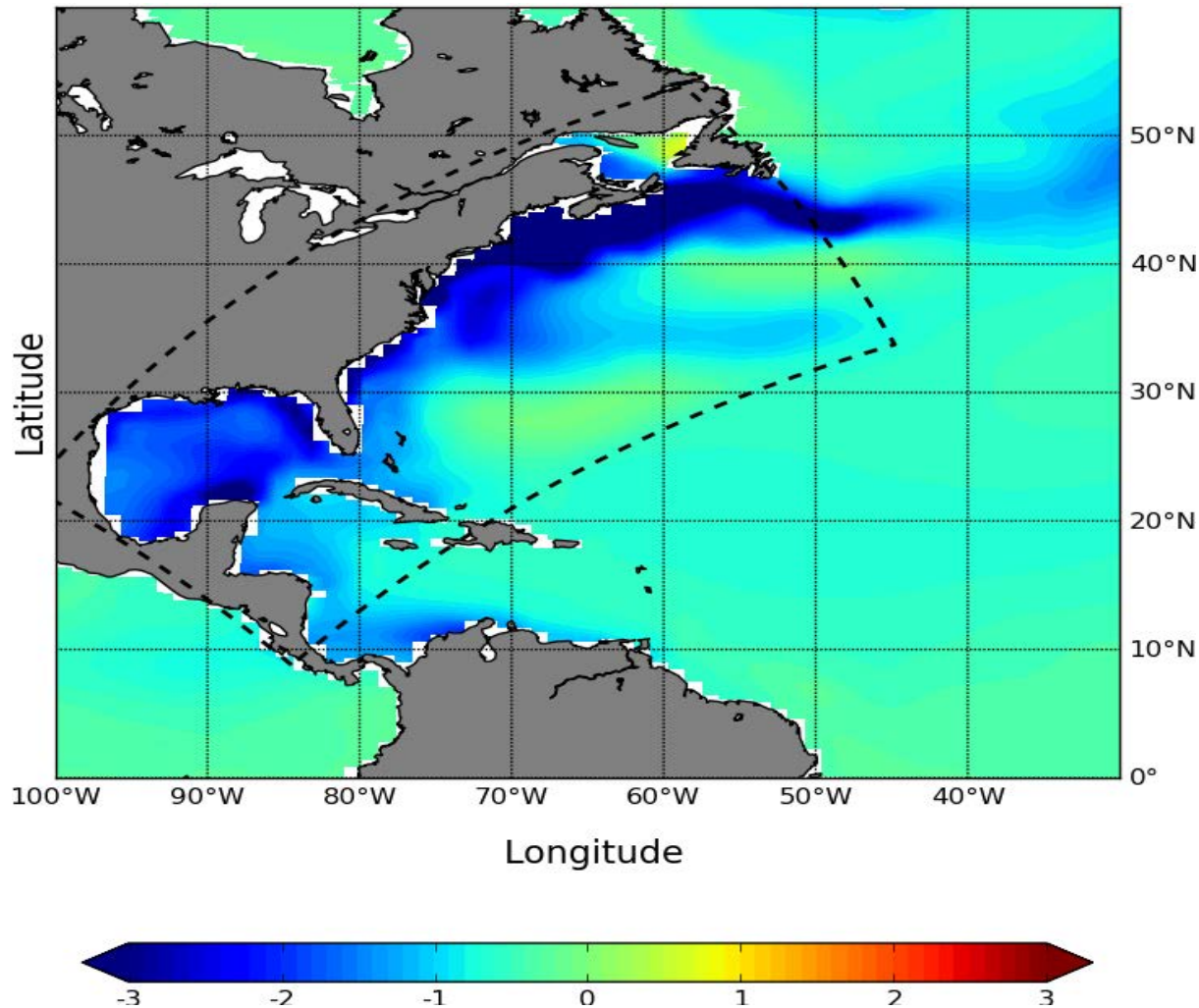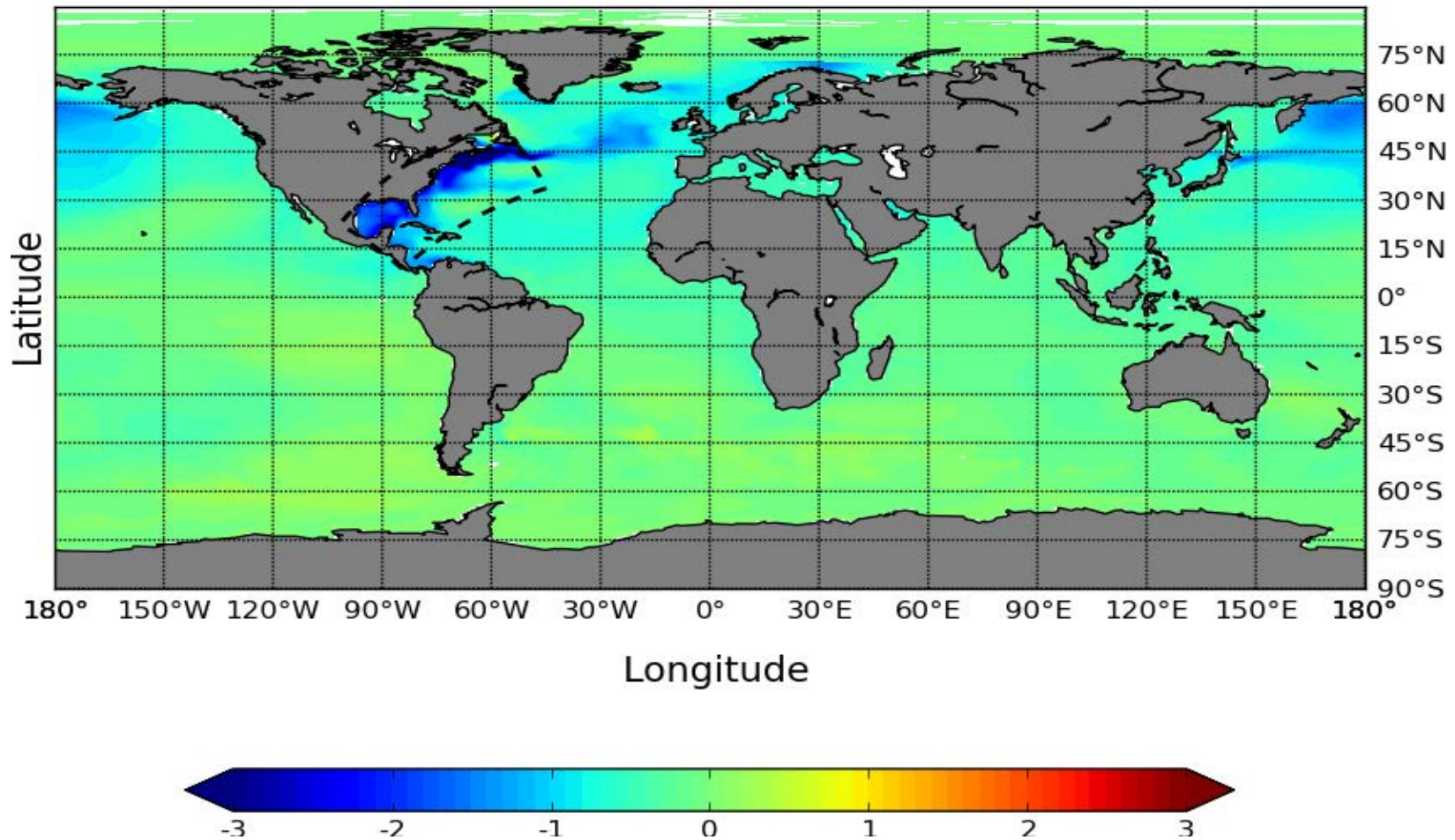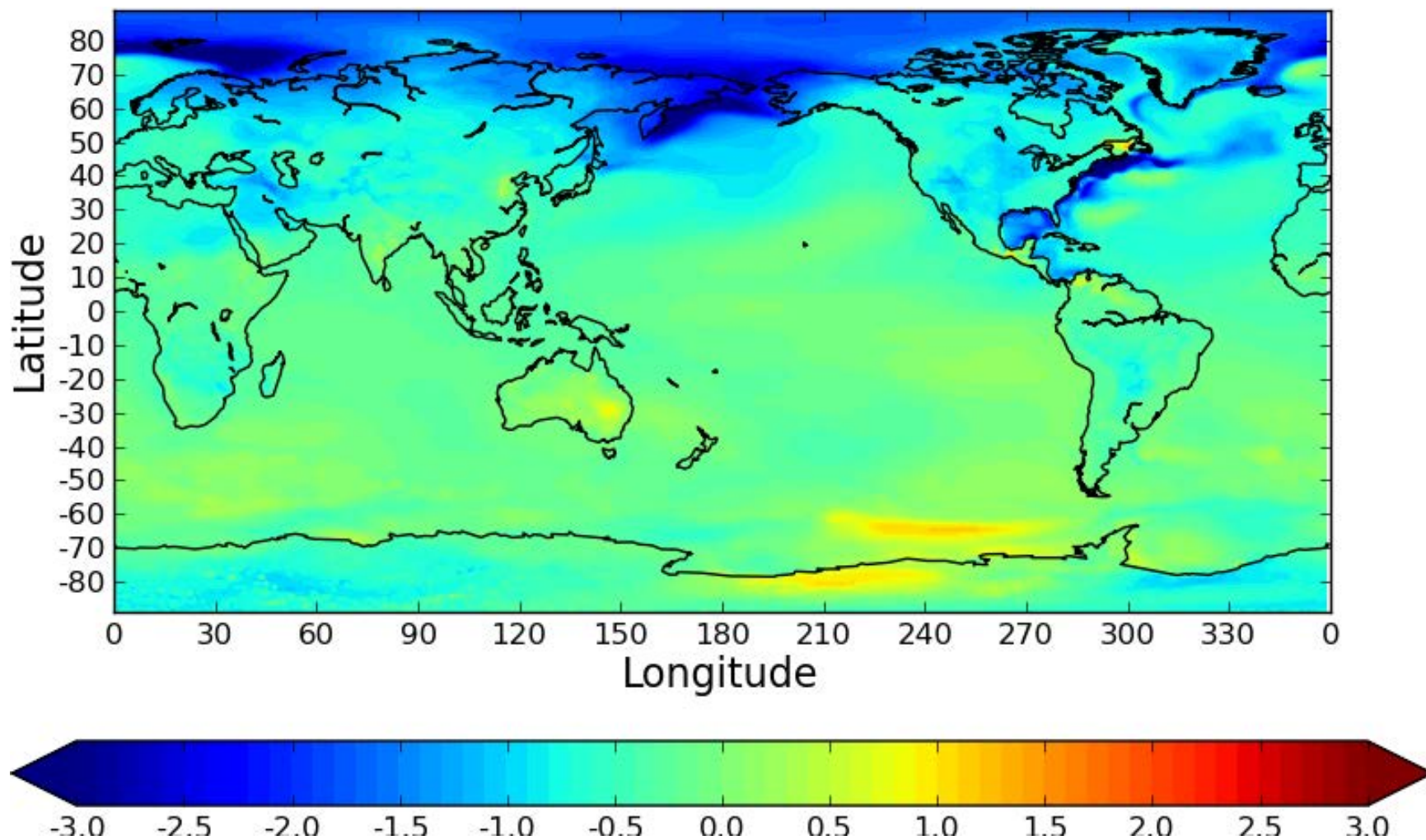
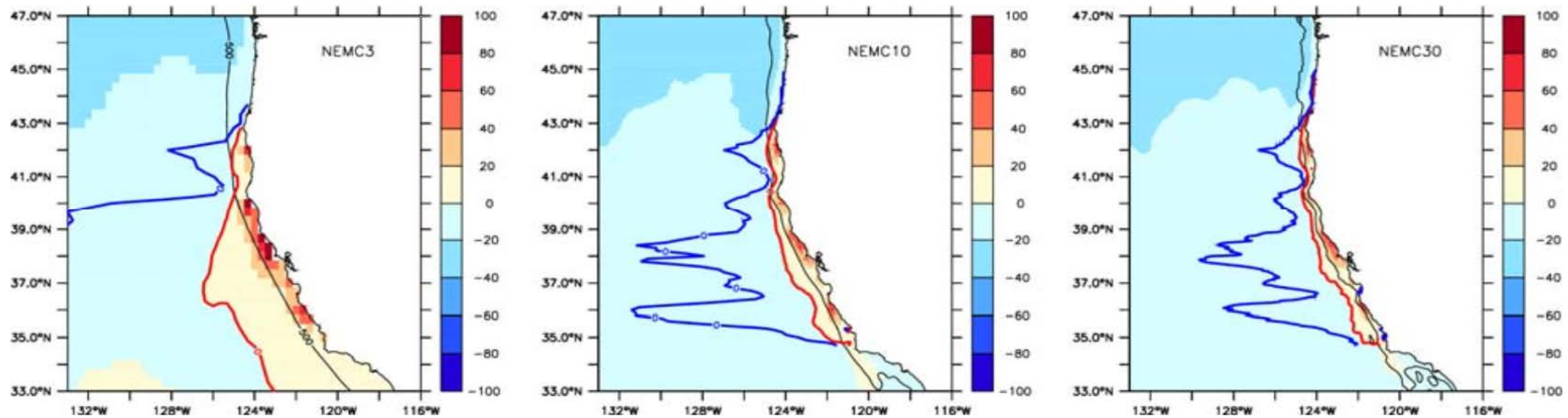# Western boundary currents: Northwest Atlantic Composite-Baseline SST difference

Western boundary currents: Northwest Atlantic Composite-Baseline SST difference

Northwest Atlantic: Global surface temperature

To Conclude…back to CCS. Biogeochemical considerations: It's both the atmosphere and ocean resolutions!

Global Biogeochemical Cycles

Air-sea CO_2 fluxes in the California Current: Impacts of model resolution and coastal topography

Jerome Fiechter[1], Enrique N. Curchitser[2], Christopher A. Edwards[3], Fei Chai[4], Nicole L. Goebel[3], and Francisco P. Chavez[5]

[1]Institute of Marine Sciences, University of California, Santa Cruz, California, USA, [2]Institute of Marine and Coastal Sciences, State University of N. J. Rutgers, New Brunswick, New Jersey, USA, [3]Ocean Sciences Department, University of California, Santa Cruz, California, USA, [4]School of Marine SciencesUniversity of Maine, Orono, Maine, USA, [5]Monterey Bay Aquarium Research Institute, Moss Landing, California, USA