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# Climate—Boundary Current Interactions: Stories from East and West

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*In collaboration with:*

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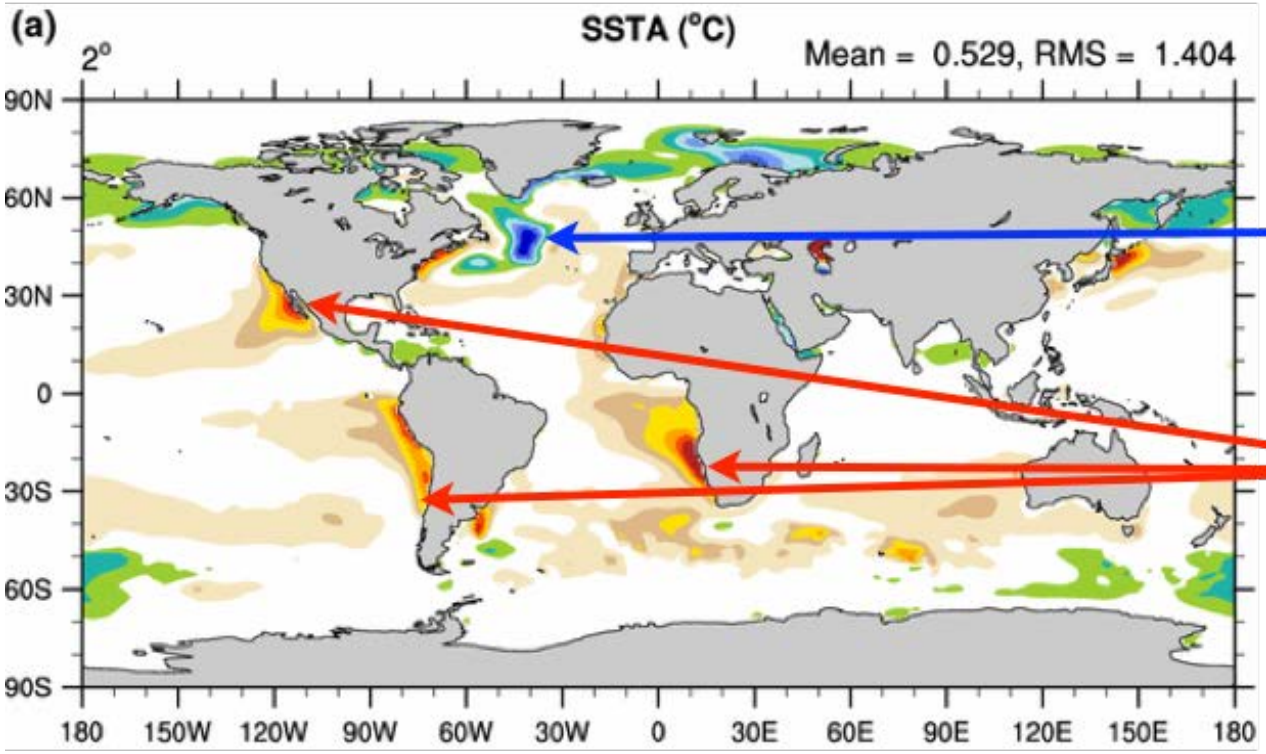
# Motivation: Climate model biases in coastal regions

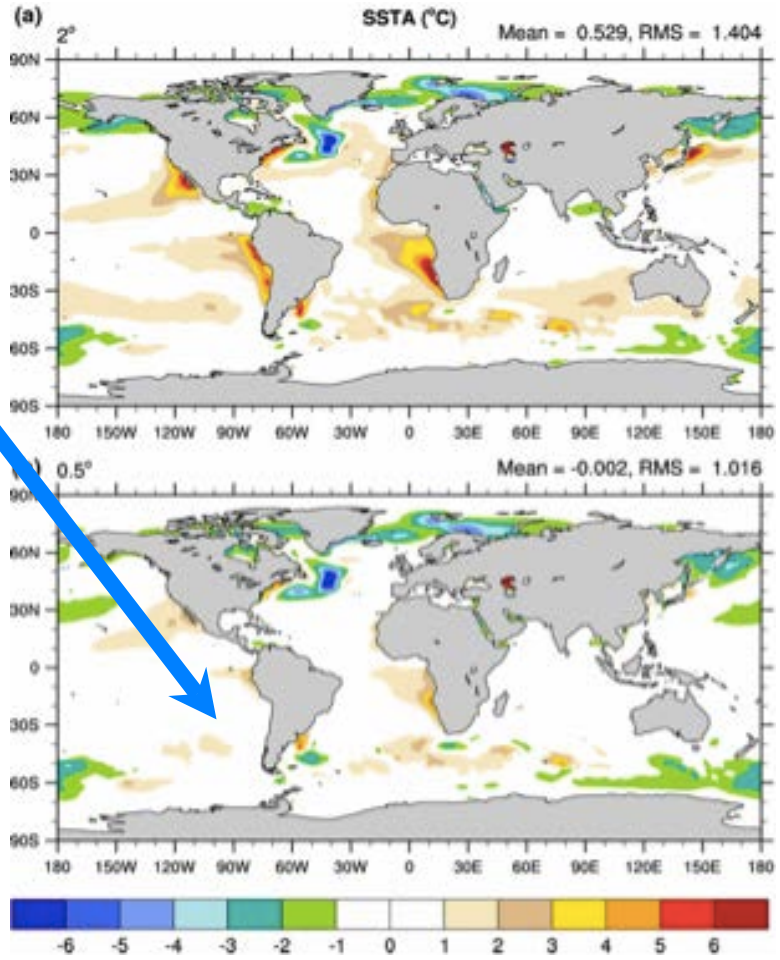


# Approaches to a solution

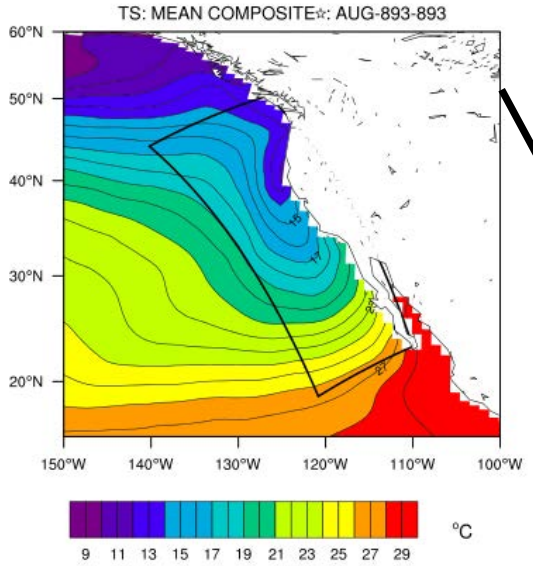
Higher resolution in the atmosphere--better upwelling favorable winds (Gent et al., 2010)

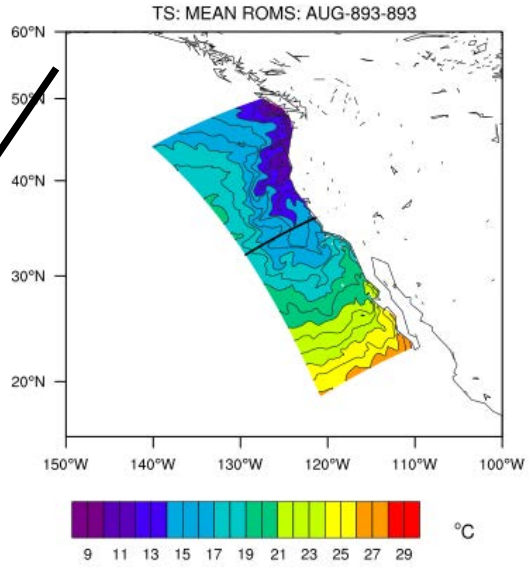
Improvements to boundary layer physics (Park and Bretherton, 2009)

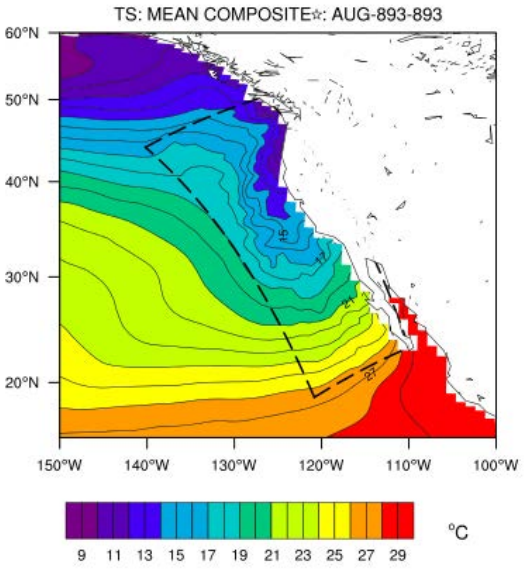
Improved resolution and physics in the ocean



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



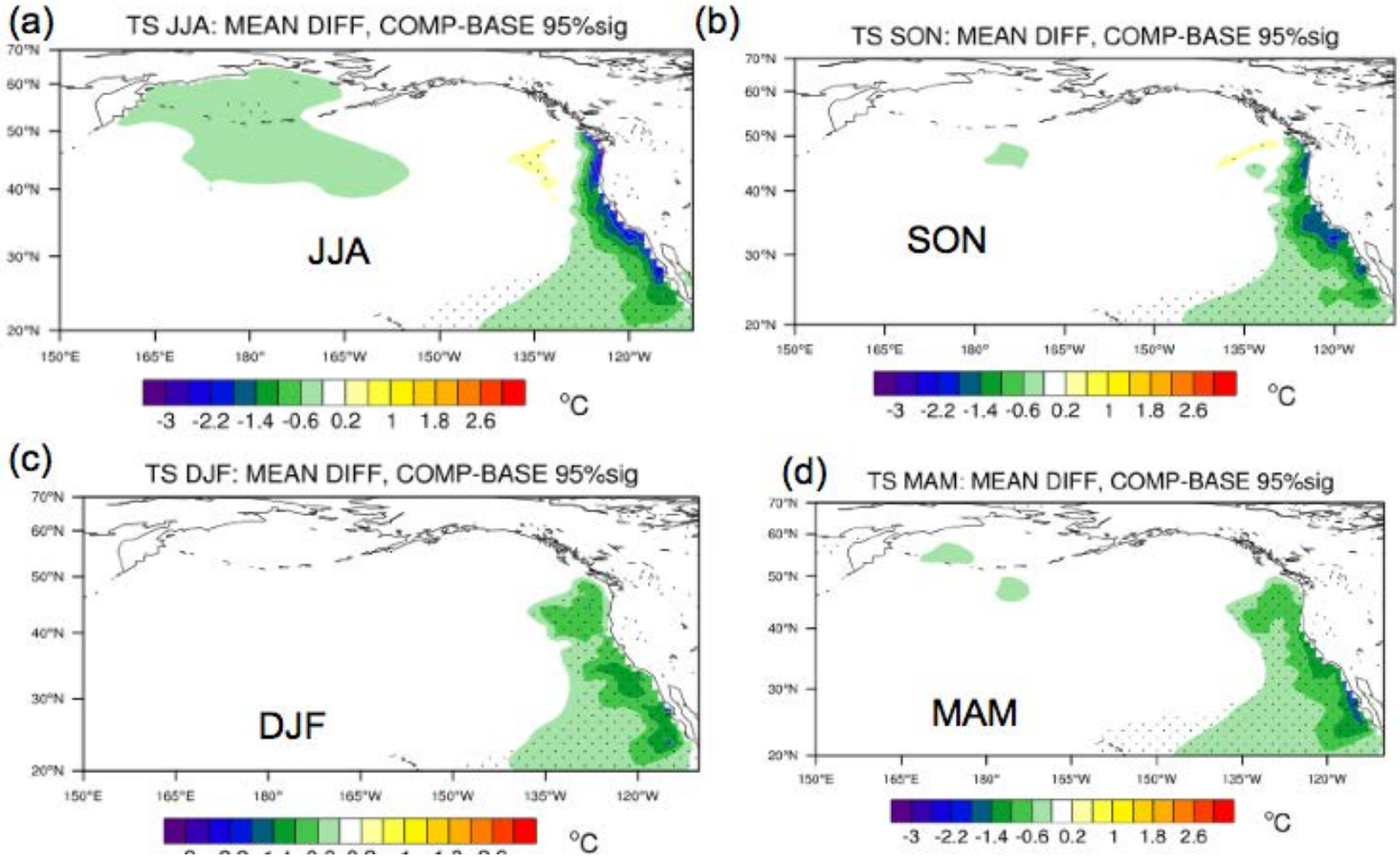



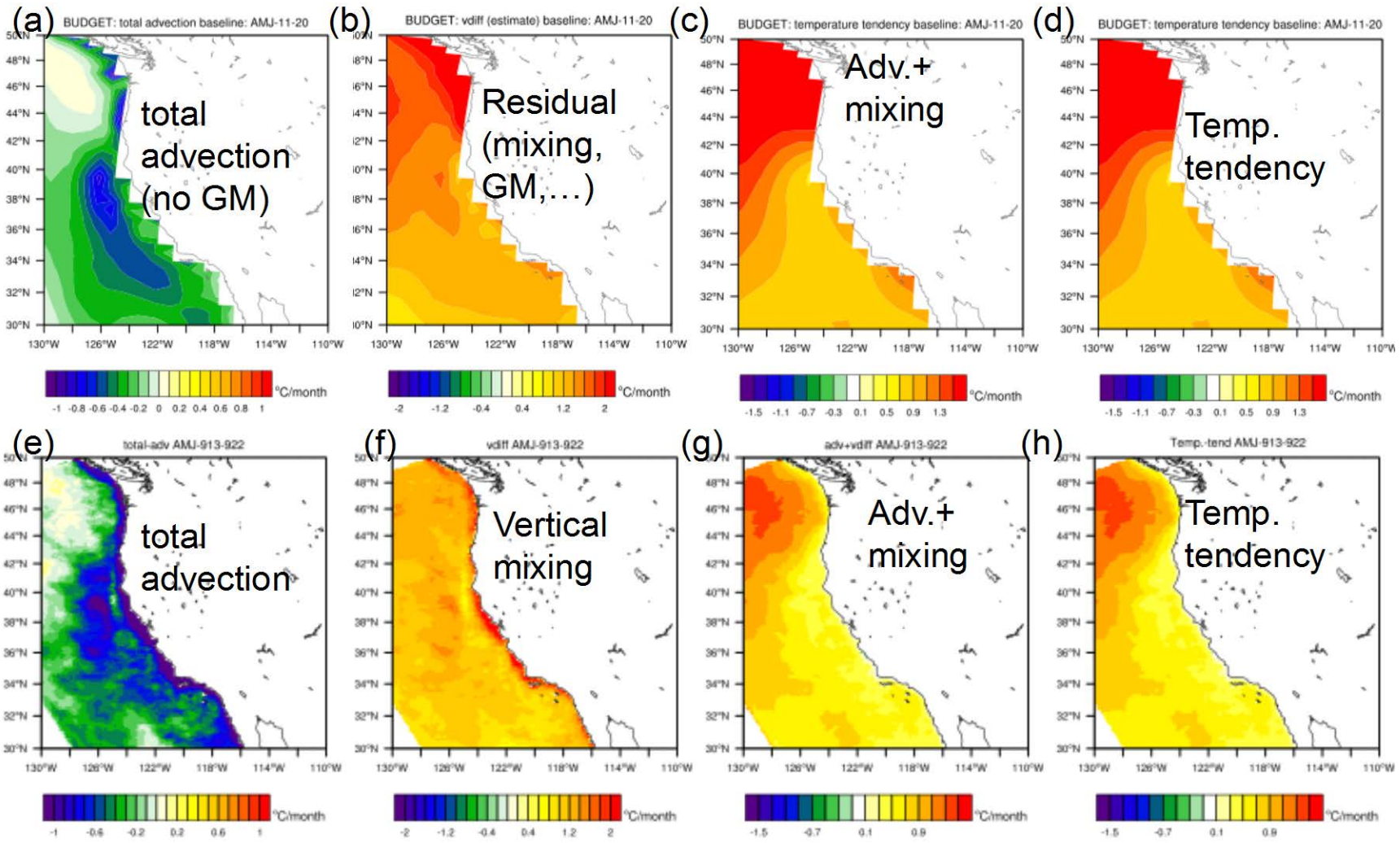
# Numerical experiment

- 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.

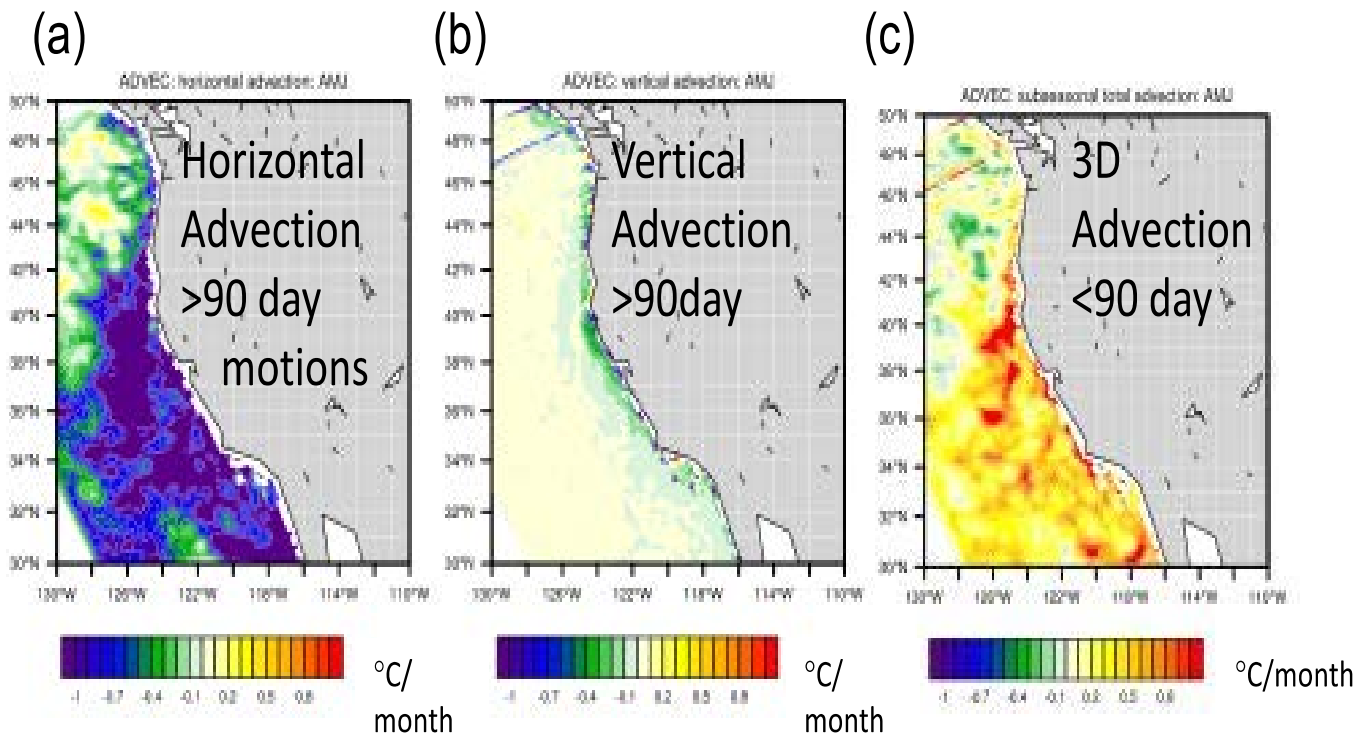
# California Current: Local SST response



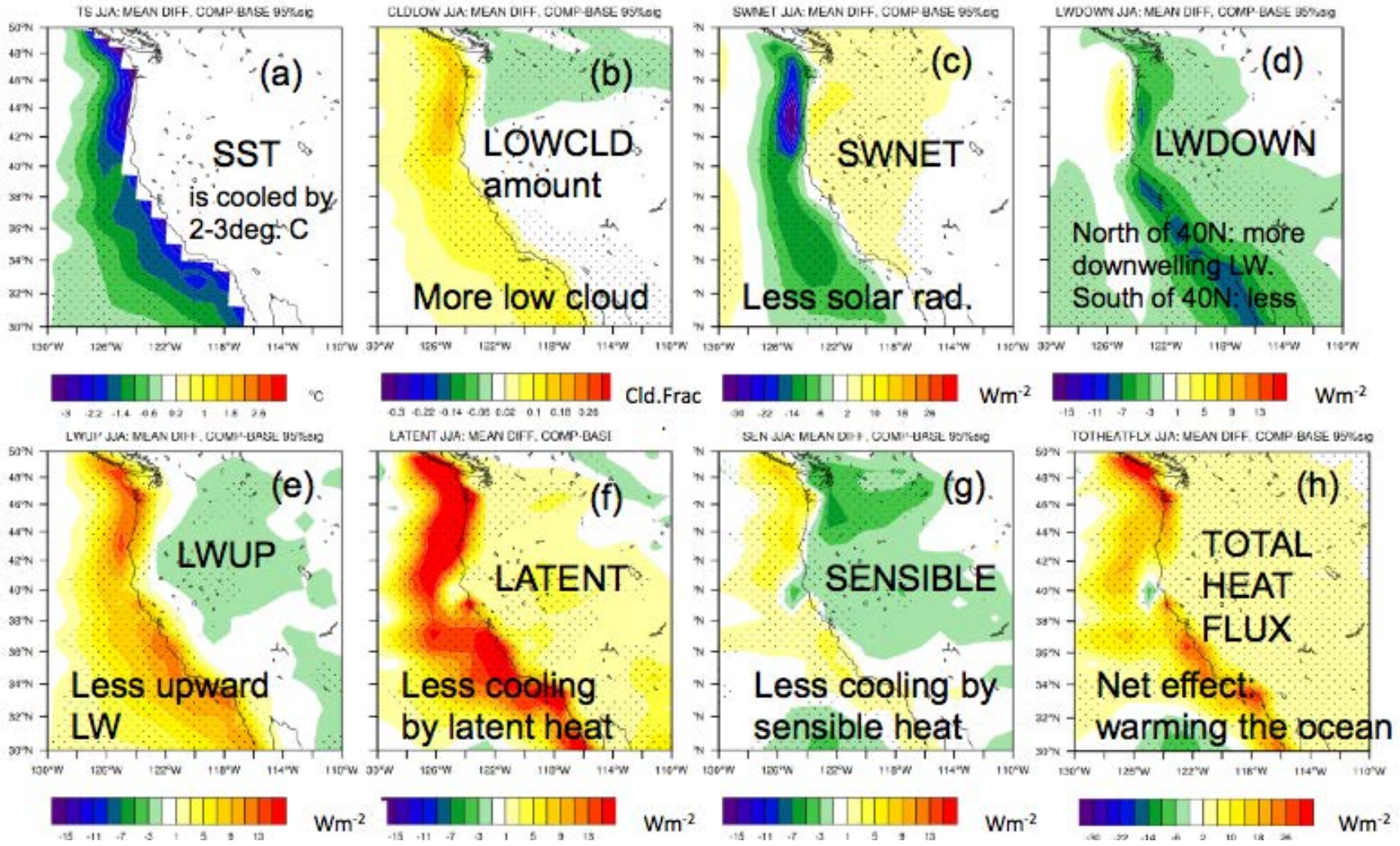
# California Current: Heat budget



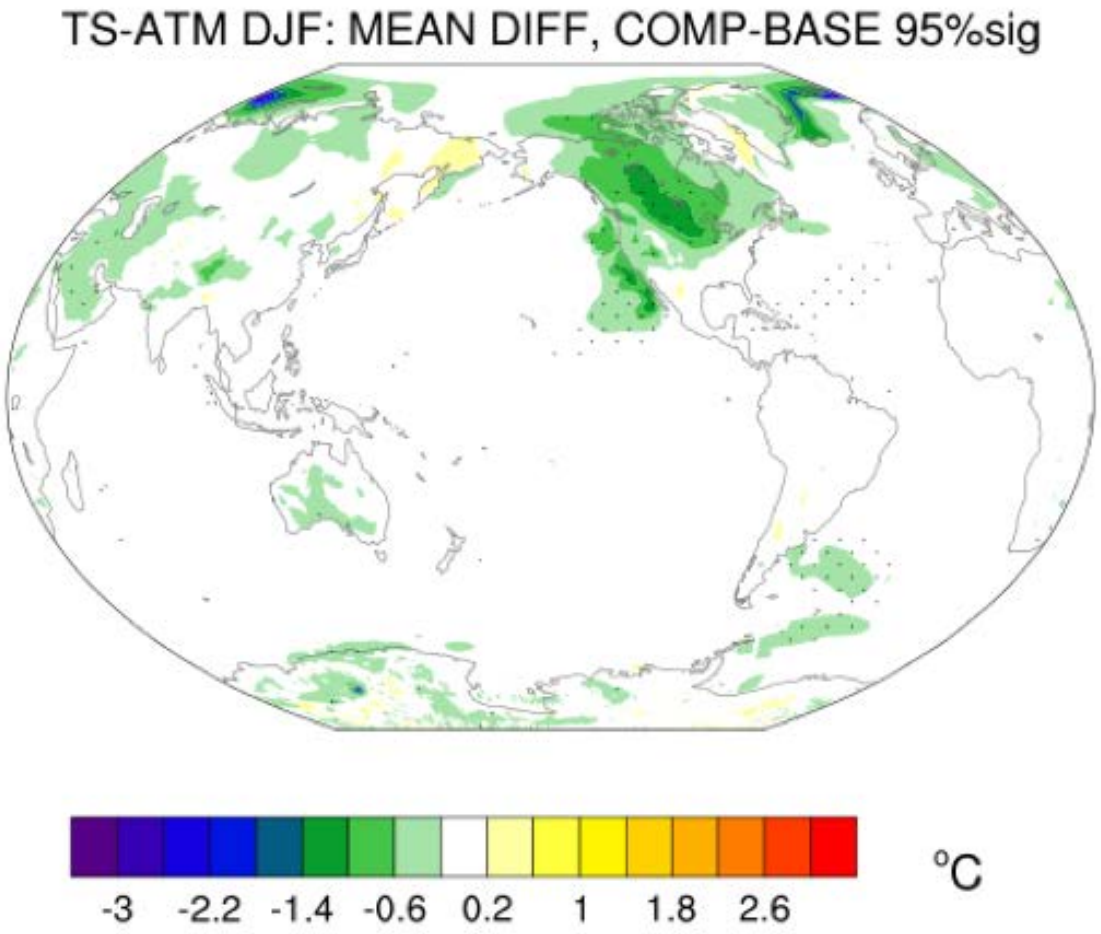
# Decomposition of advection term



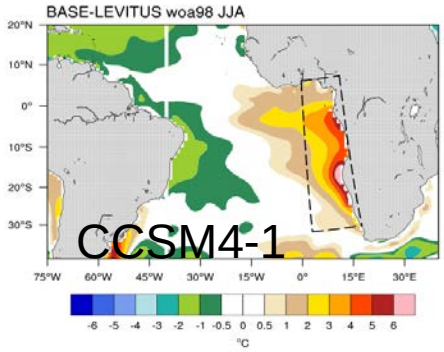
# California Current: Surface fluxes--the coupled response



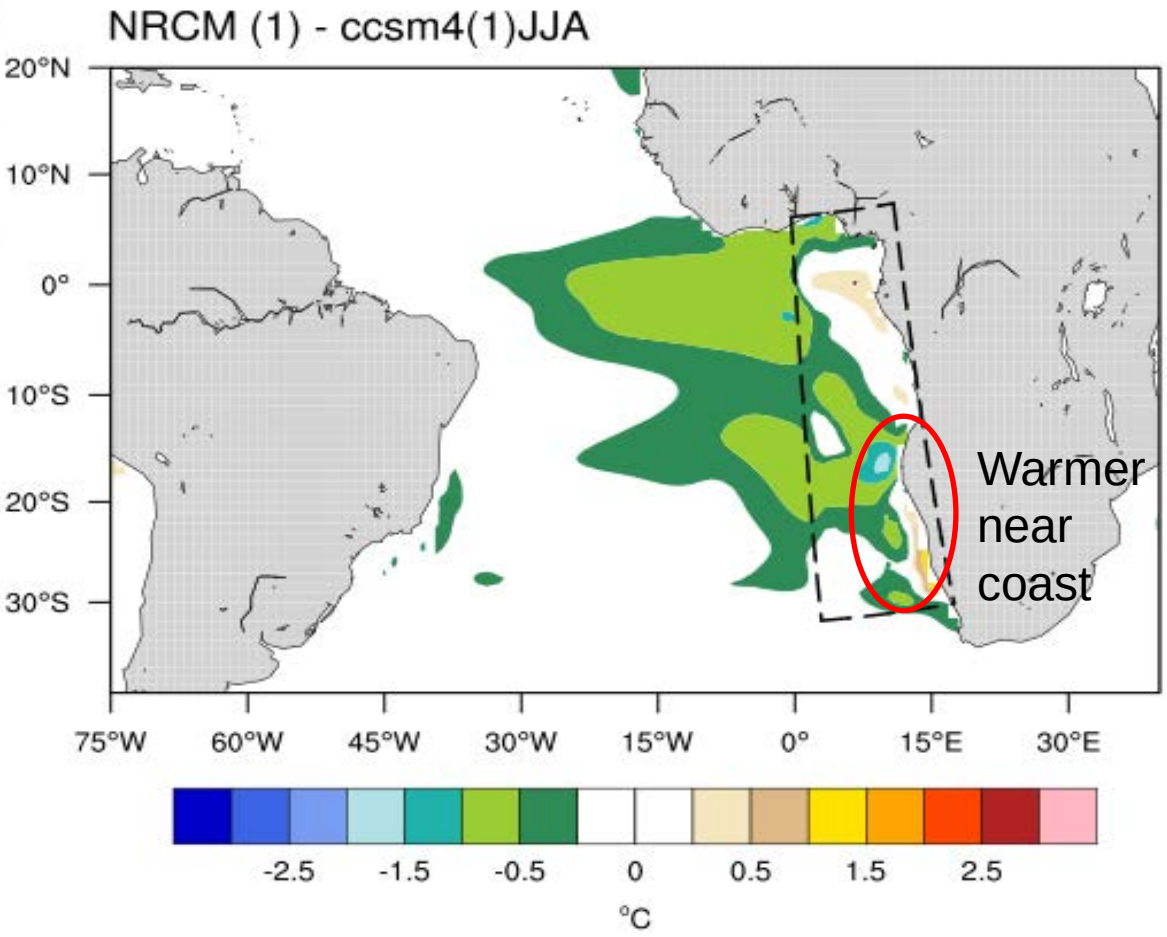
# Global response: Surface temperature



# Embedding a high-resolution ocean in the Benguela region

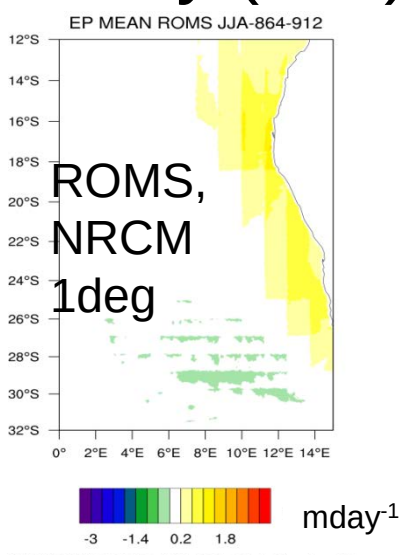



SST bias, CCSM4

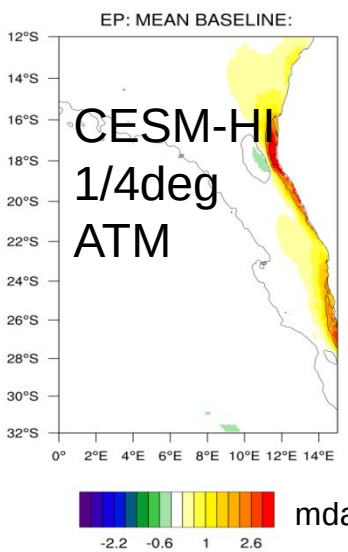



Nested RCM SST minus CCSM4 baseline, JJA

# Benguela: Ekman pumping (top) and Vertical Velocity (bot.), JJA averages




mday$^{-1}$

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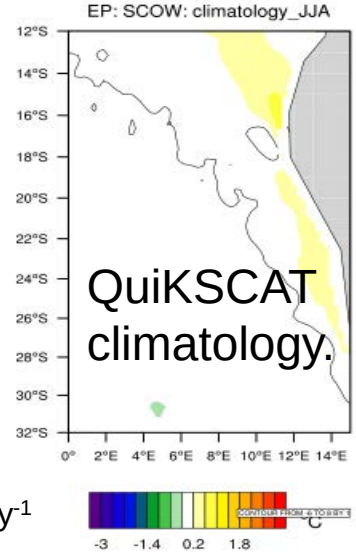


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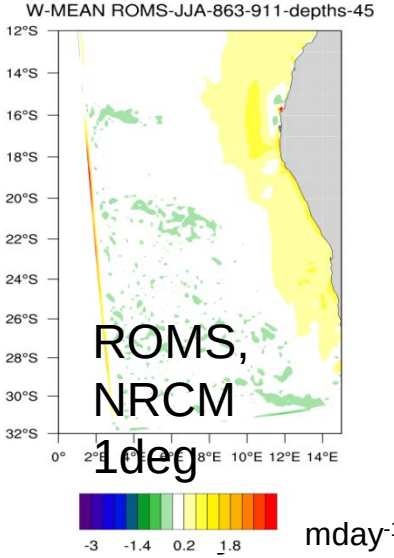
Risien and Chelton, 2008

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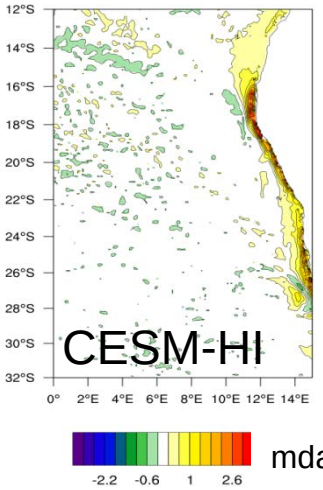


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# Alternative wind interpolations

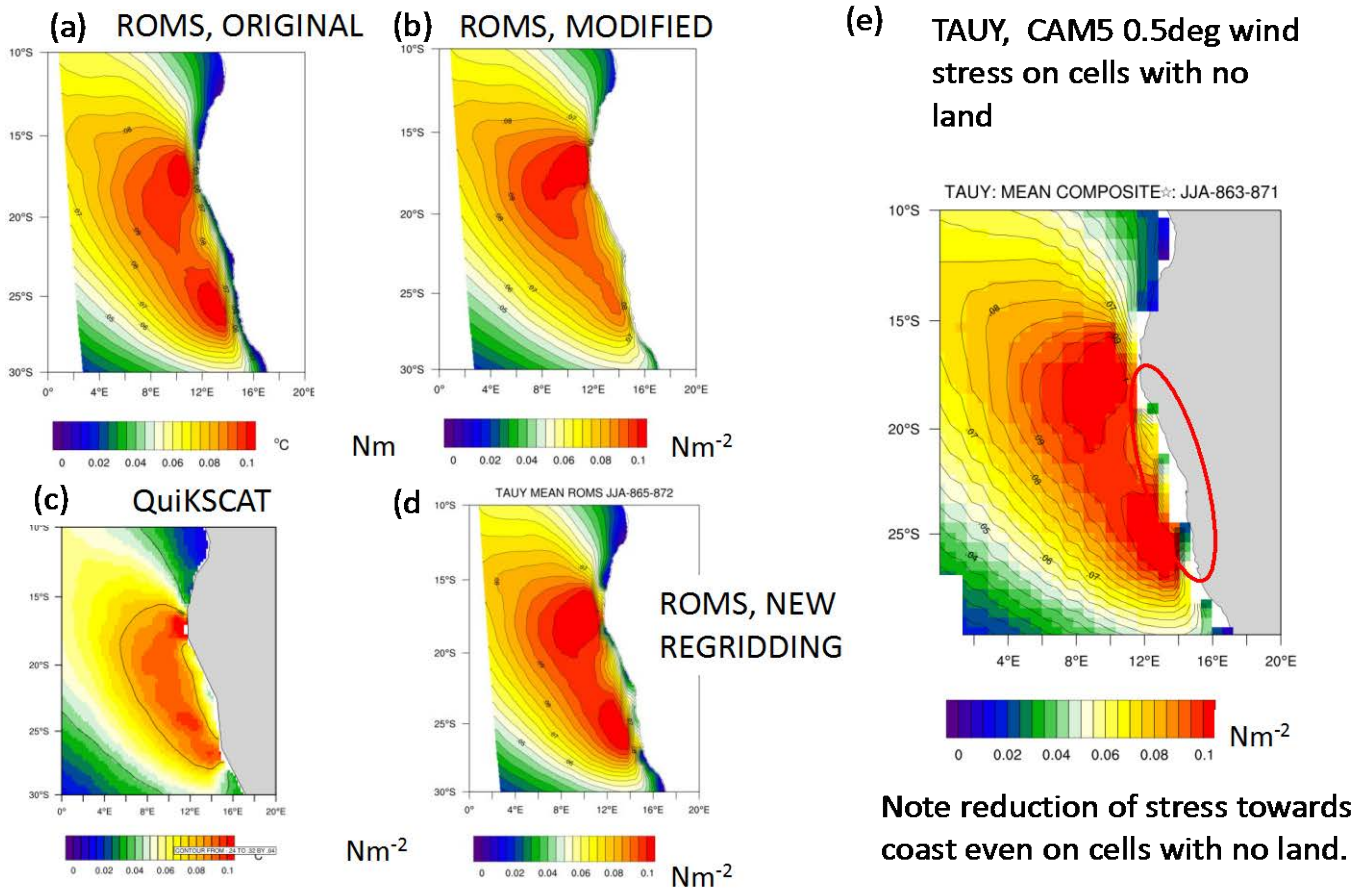
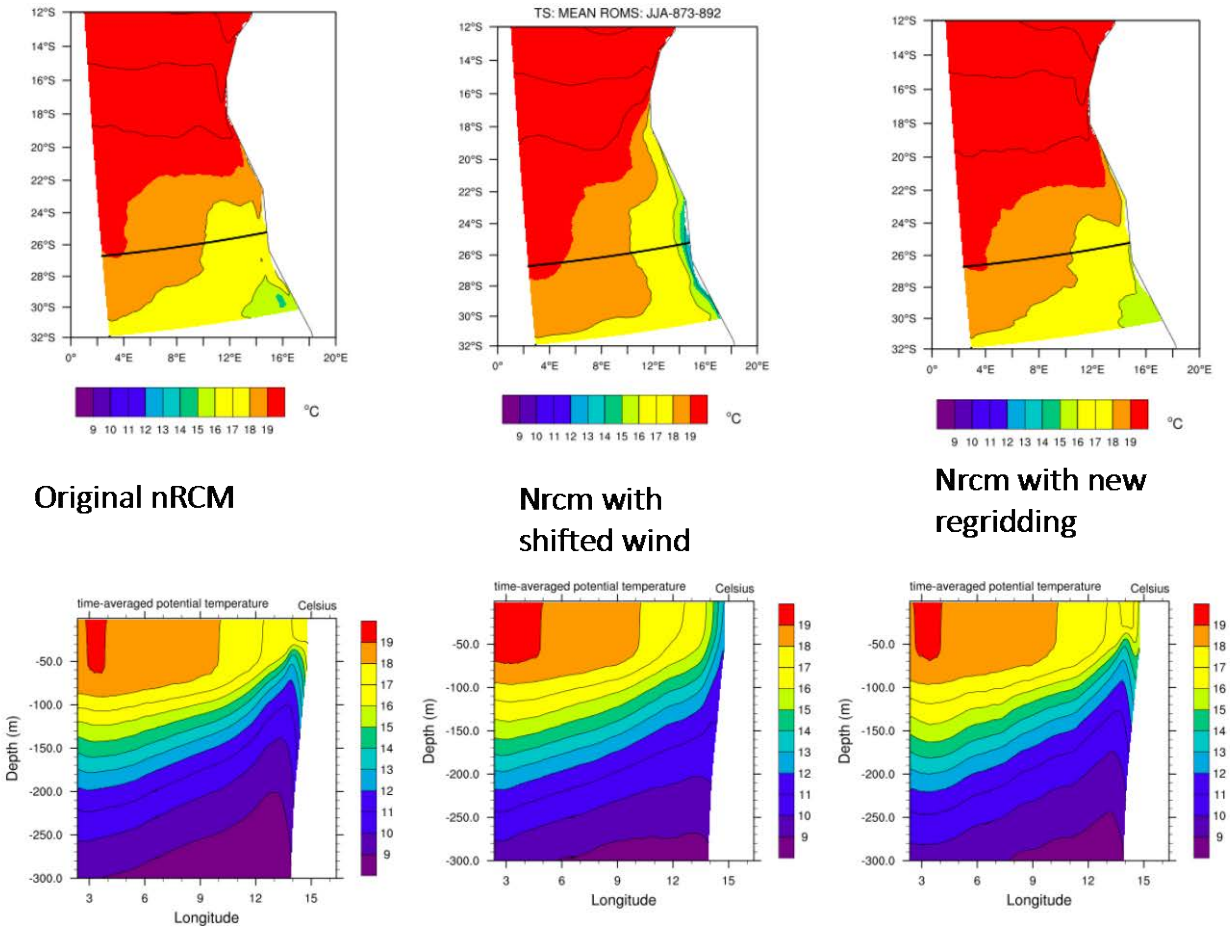



Fig. 9. a, b, c) Meridional component of wind stress in JJA. a) in ROMS part of NRCM (0.5deg CAM). B) corresponding field from Nrcm- MOD, C) from QuikSCAT. d) from ROMS with new regridding.e) on CAM grid points with no land

# Alternative wind interpolations



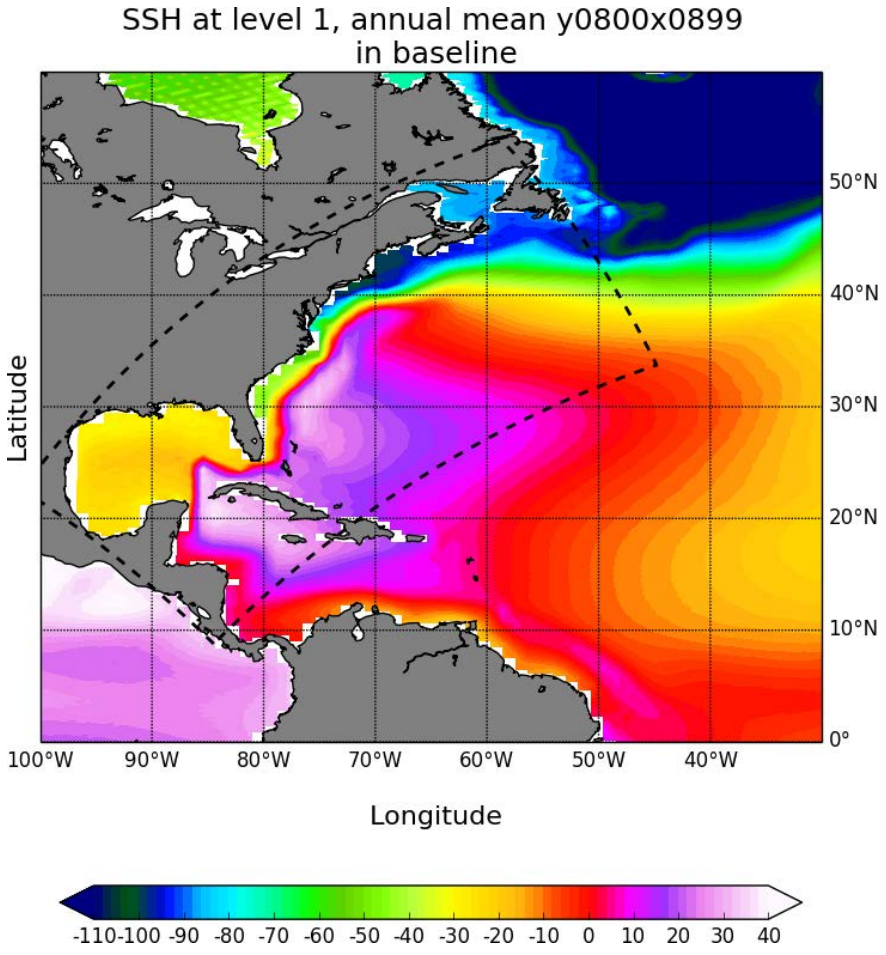

Original nRCM

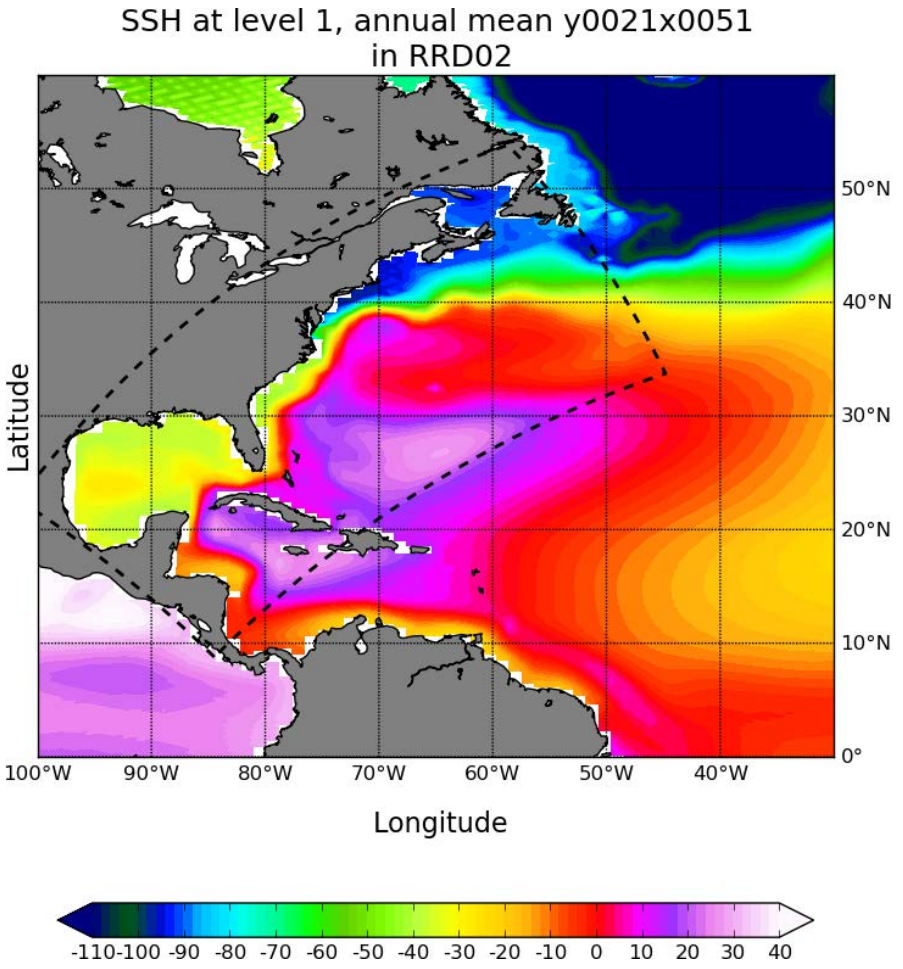
Nrcm with shifted wind

Nrcm with new regridding

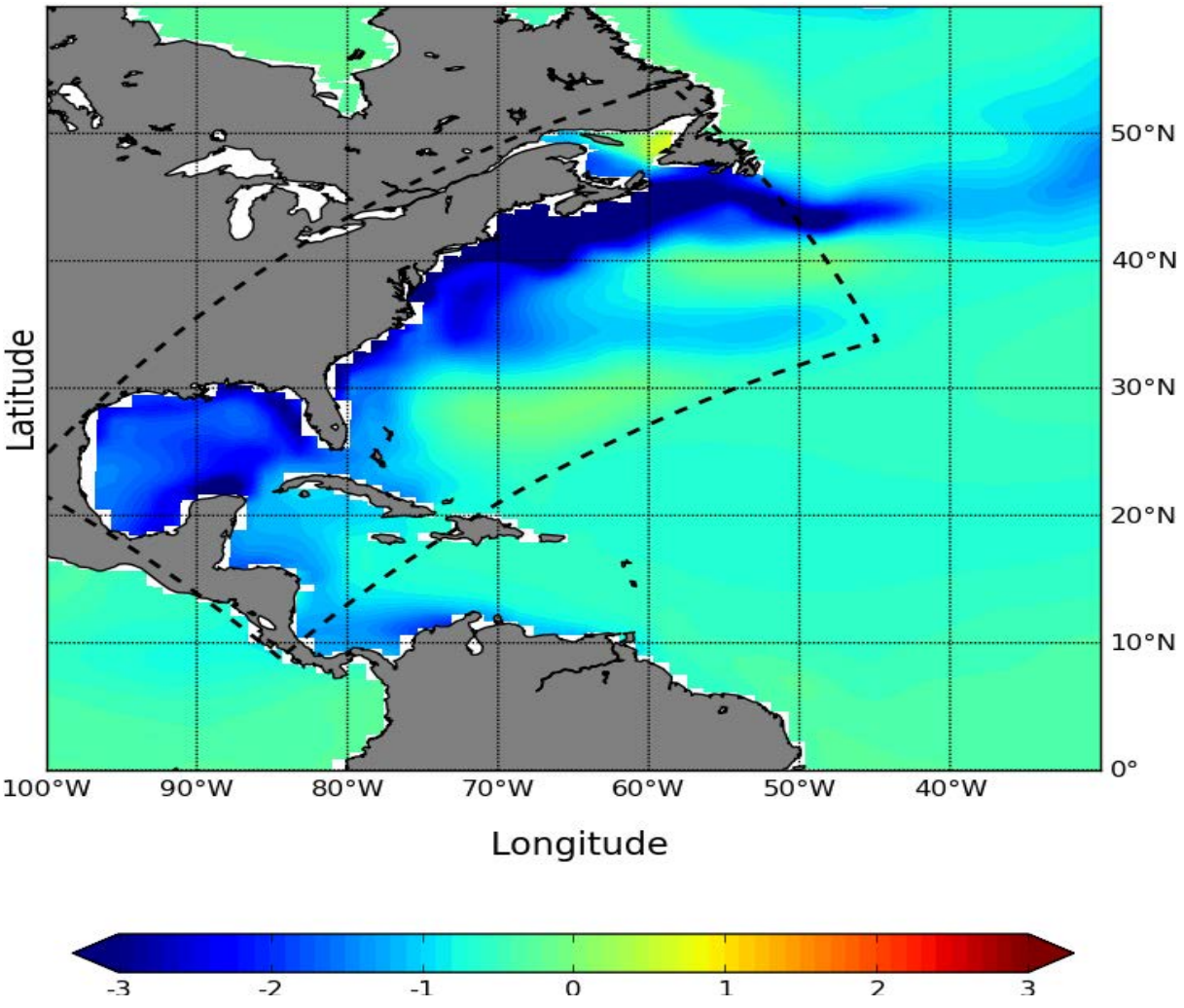
Vertical sections of potential temperature along lines shown in top panels.

# Western boundary currents: Northwest Atlantic--SSH



# Western boundary currents: Northwest Atlantic Composite-Baseline SST difference



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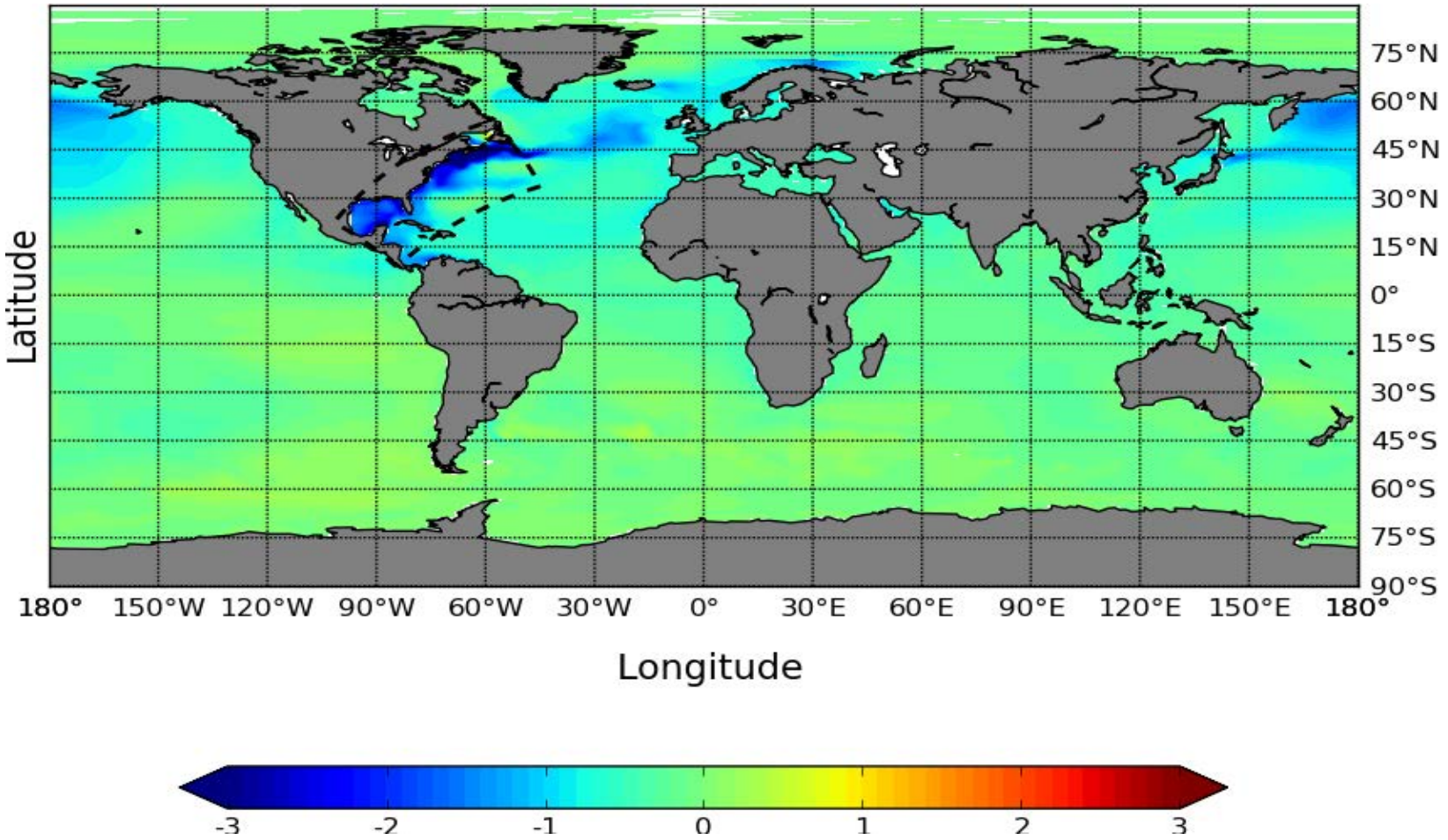
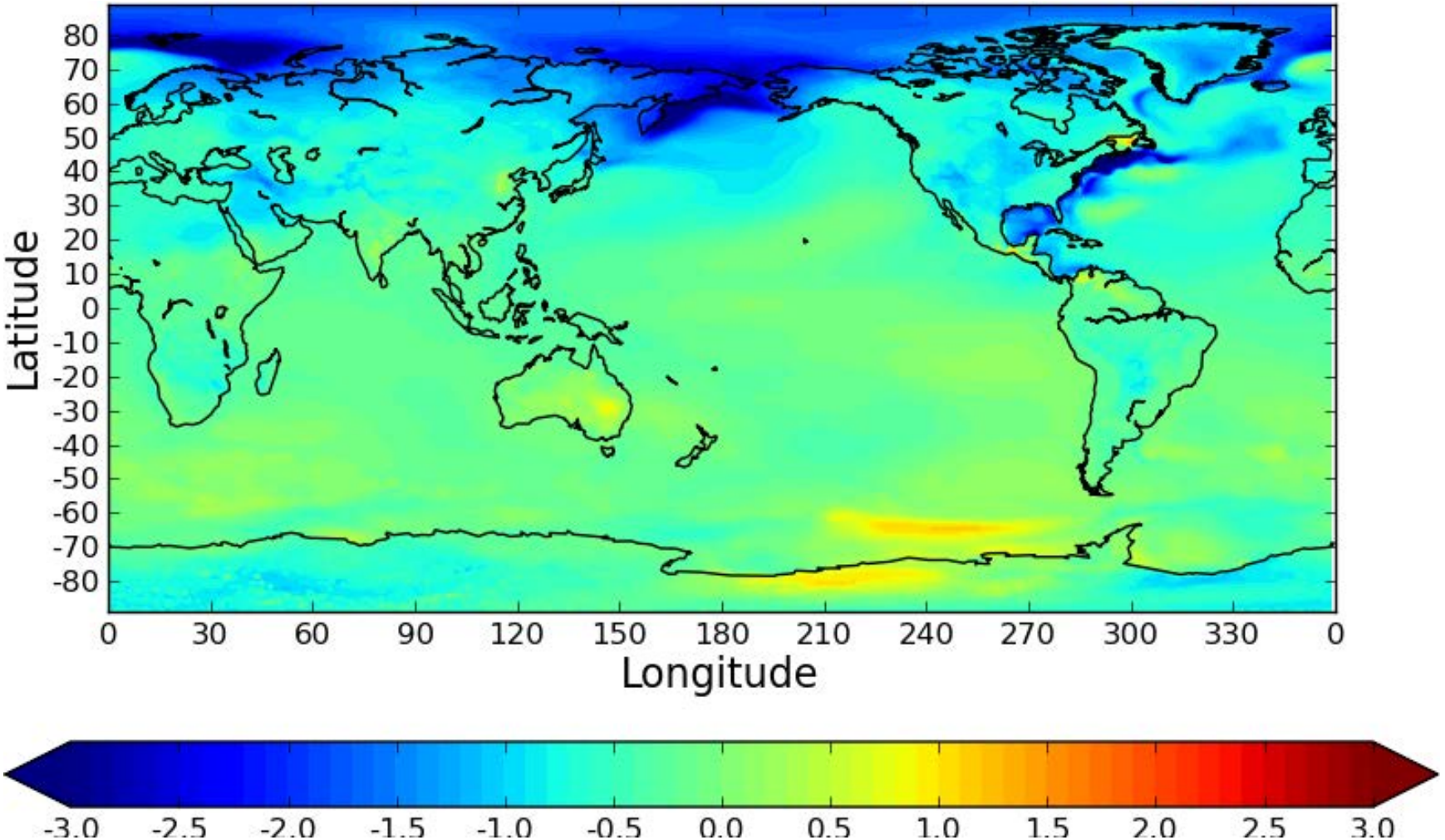


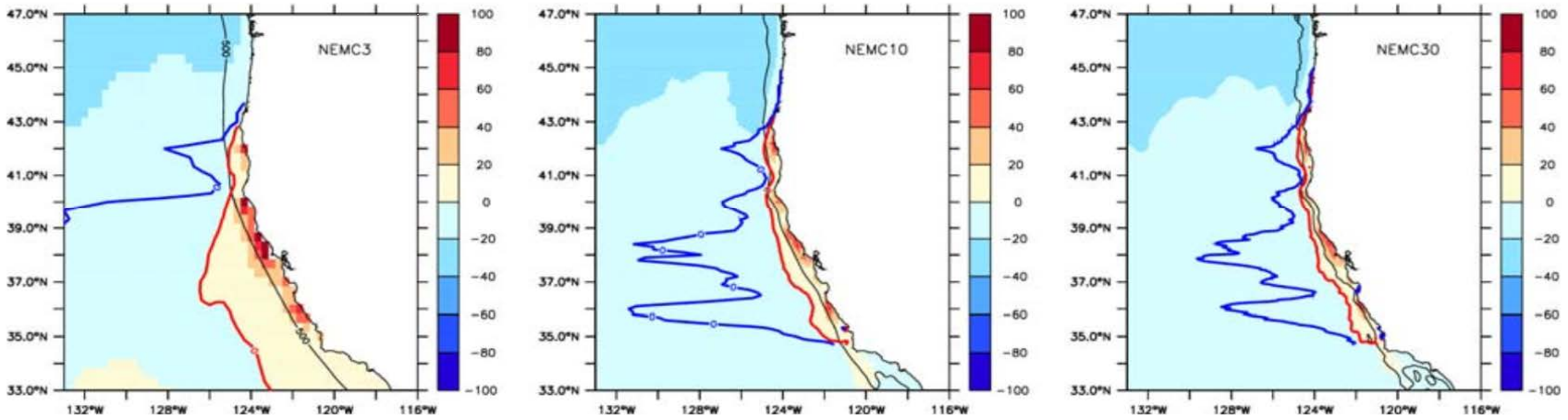
# Northwest Atlantic: Global surface temperature



# Summary

- We can address some of the GCM biases in coastal regions by embedding a high-resolution ocean model.
- In the CCS, the coupled response is to dampen the upwelling signal of cold SSTs.
- Different mechanisms are in balance in different regions. Ocean high-resolution by itself (or atmospheric resolution) will not address all the biases.
- There is both a local and a large-scale response to the perturbations introduced through the coastal regions.

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




**Global Biogeochemical Cycles**

**RESEARCH ARTICLE**
10.1002/2013GB004683

**Key Points:**
- Outgassing intensification linked to coastal topographic features
- Near-shore outgassing balanced by offshore absorption
- Carbon fluxes most sensitive to horizontal resolution for 35-40N

## 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]**

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