Impact of Horizontal Model Resolution on Air-Sea CO_2 Exchange in the California Current

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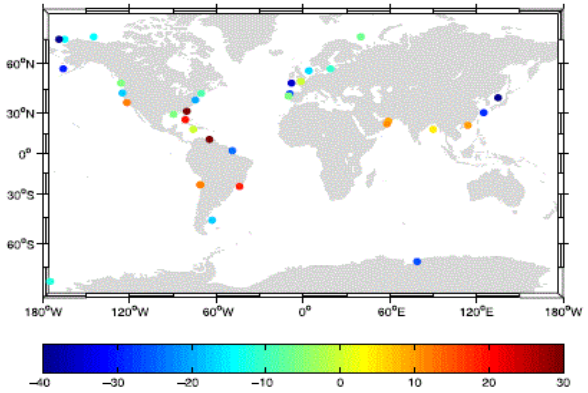
Motivation

Role of EBC regions in global carbon cycle

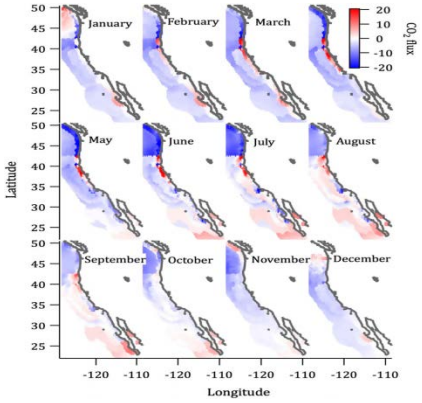
- Carbon exchange difficult to estimate from observations alone.
- Shelf outgassing compensated by primary production offshore.
- Substantial zonal and meridional gradients and variability.

Downscaling from climate to regional models

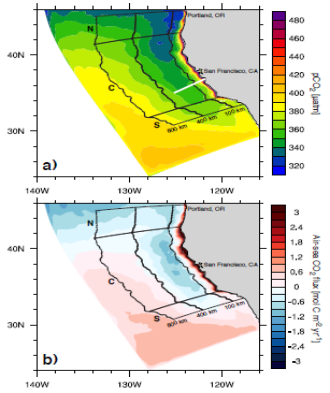
- Impact of horizontal resolution on air-sea CO_2 fluxes
- Implications for estimating net regional carbon budget.



-6 TgC/yr
Cai et al., 2006; Cai, 2011



-14 TgC/yr
Hales et al., 2012



-1 TgC/yr
Turi et al., 2013

Coupled Physical-Biogeochemical Model

Ocean Circulation Model

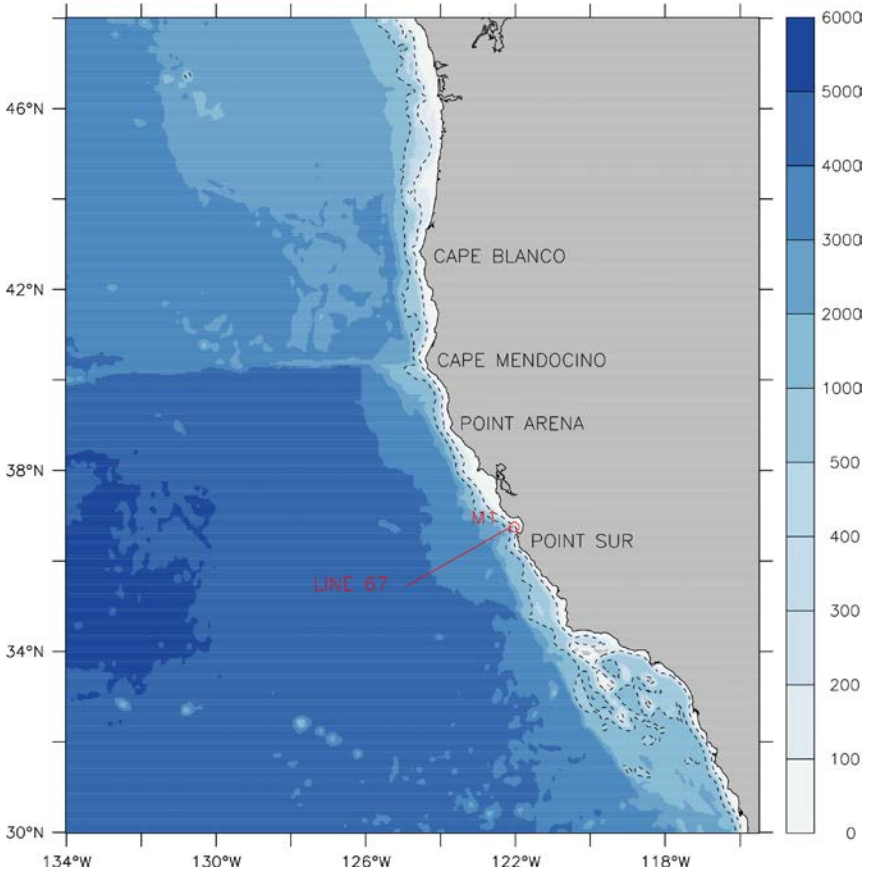
- ROMS
- Resolution: 1/3˚ , 1/10˚ , 1/30˚
- 42 vertical levels
- BC/IC: SODA, monthly
- Surface: COAMPS, daily

Biogeochemical Model

- NEMURO (3N, 2P, 3Z, 3D)
- DIC, Alkalinity, Ca Carbonate (Hauri et al., 2013)
- OCMIP air-sea CO_2 exchange
- NEMURO BC/IC: WOA, monthly
- Carbon BC/IC: GLODAP, annual

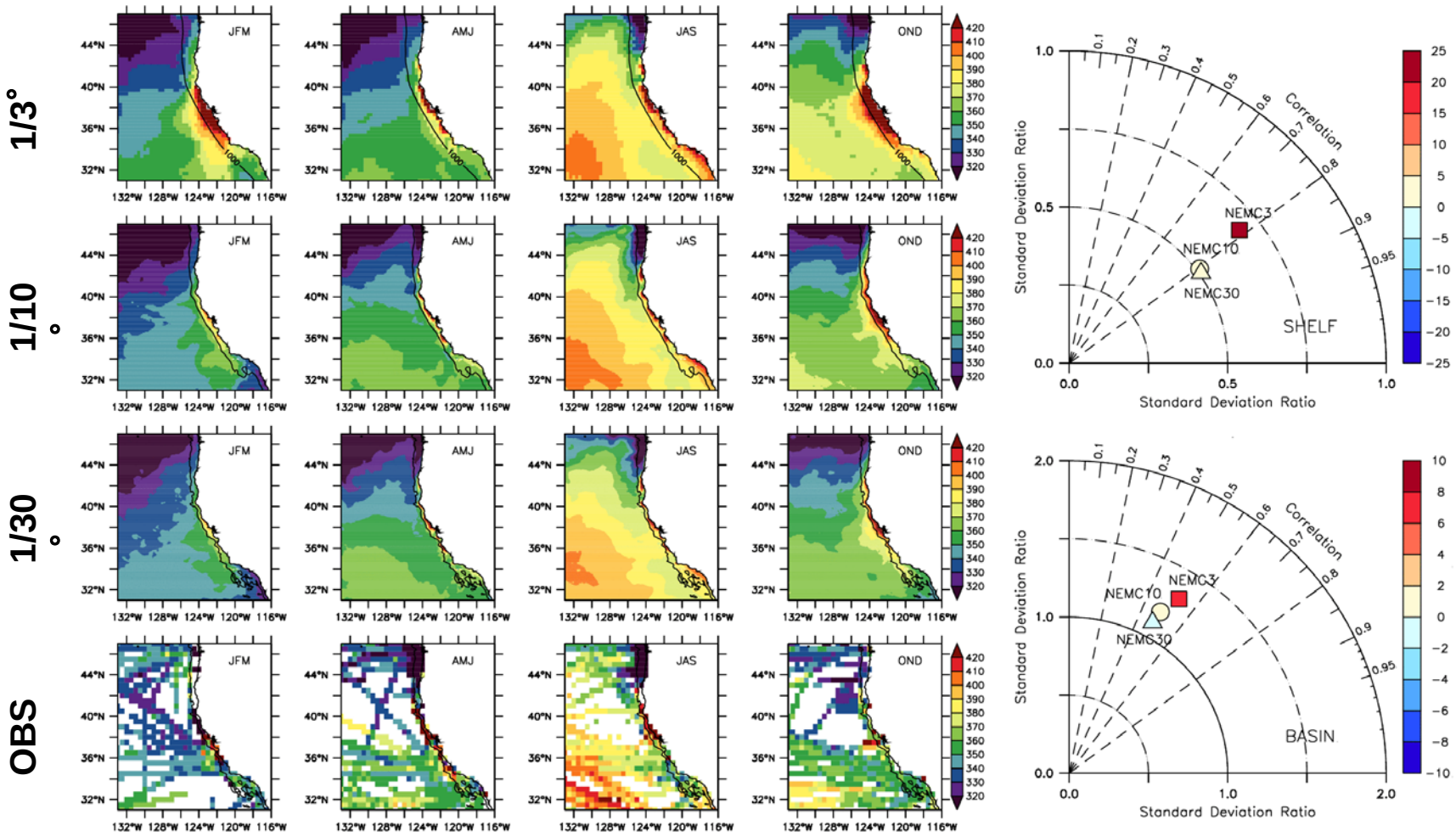
Run duration

- 7 years (1999-2005)



Model domain and bottom topography (m)

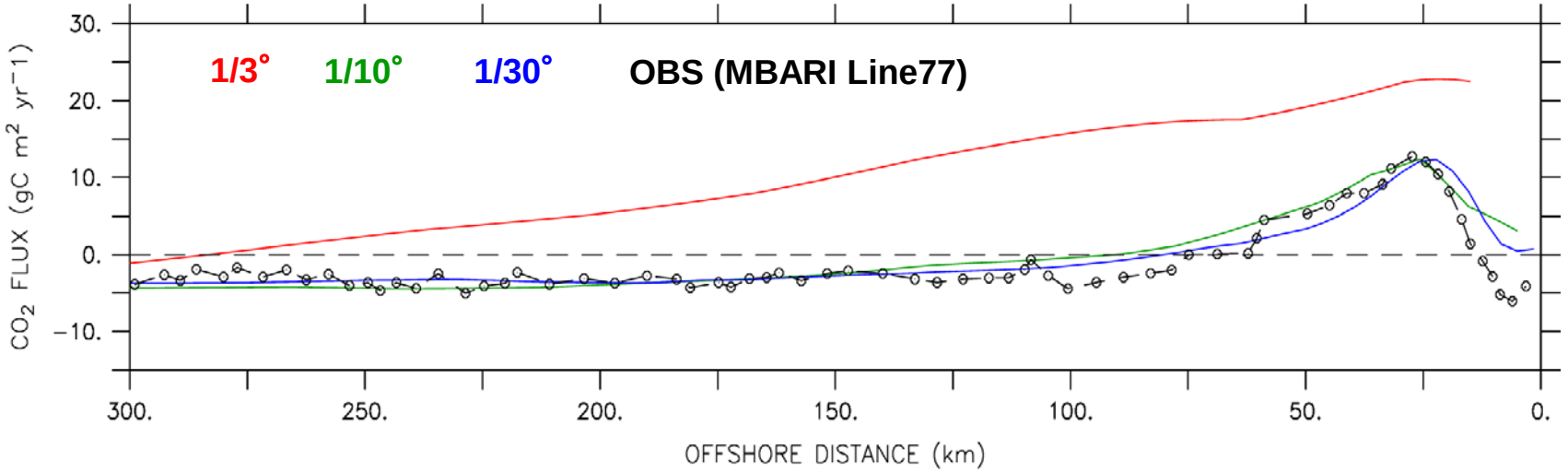
Model-Data Comparison: Seasonal Surface pCO2

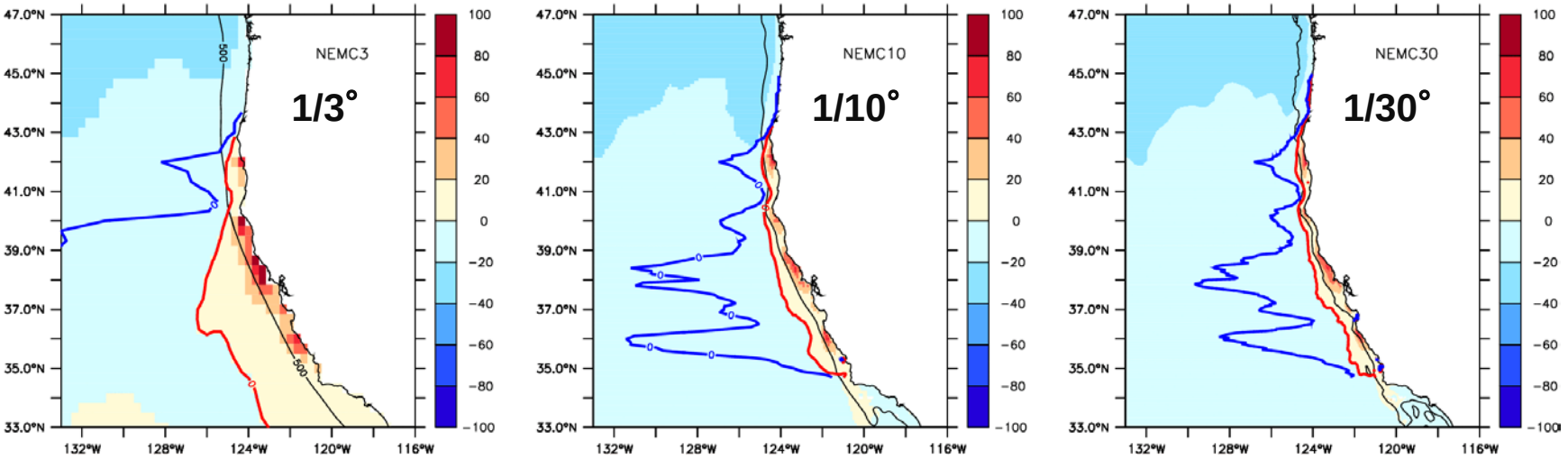


Significant bias reduction when increasing resolution from 1/3° to 1/10° .

Since CCS is ~neutral, important for correct sign of air-sea exchange.

Air-Sea Flux: Impact of Horizontal Model Resolution

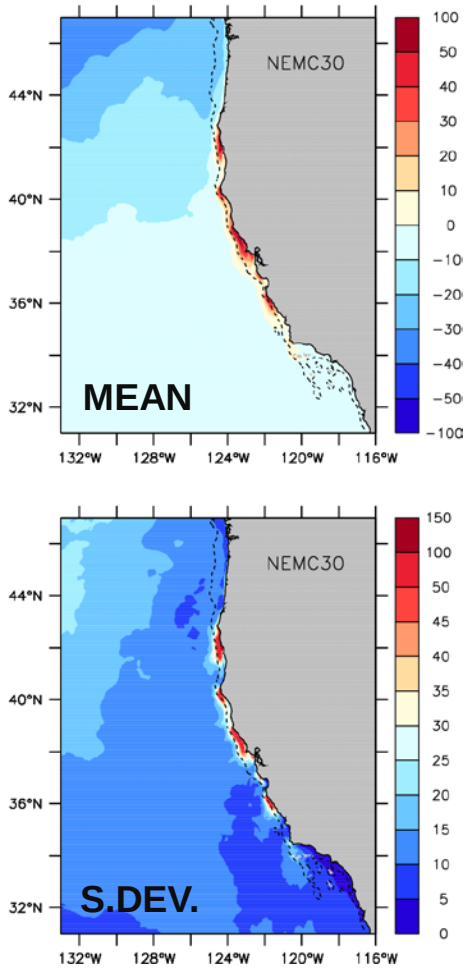


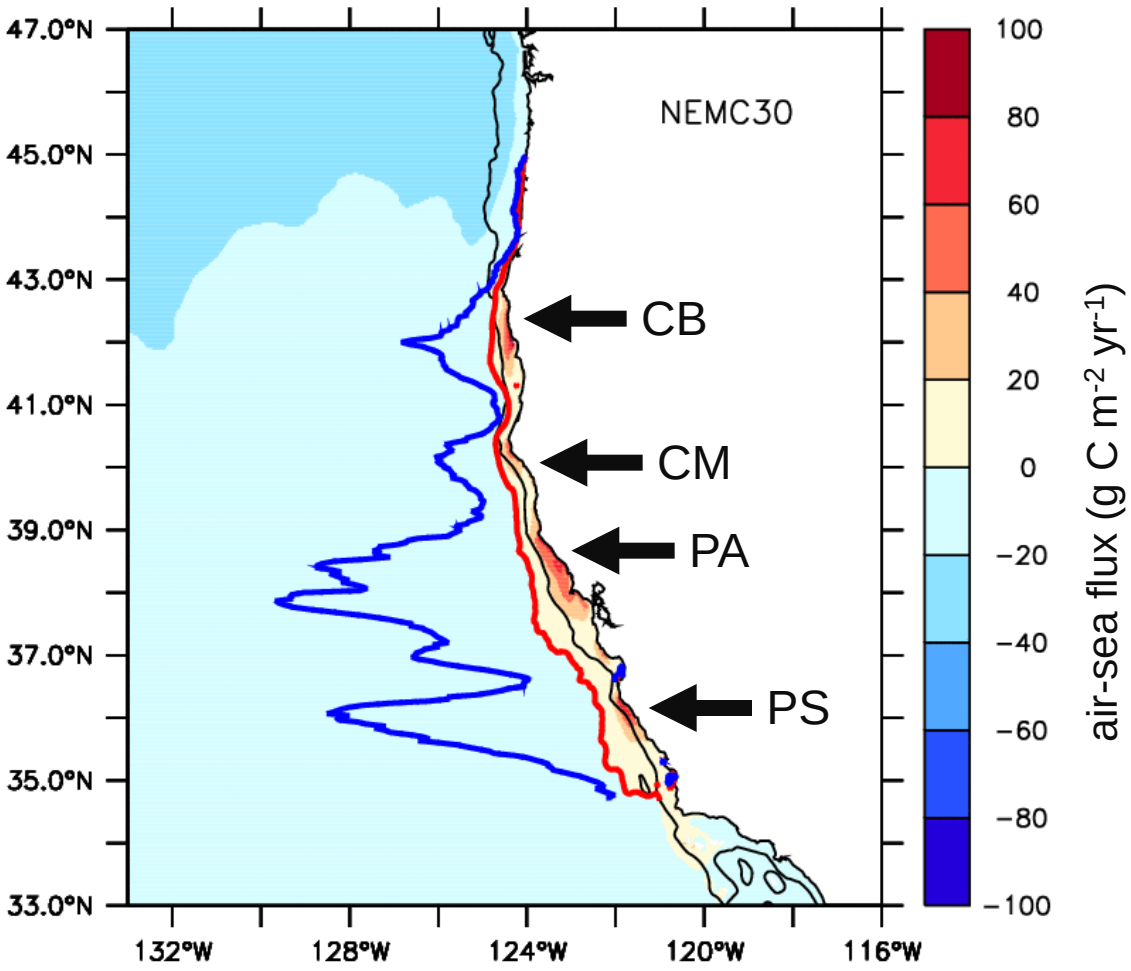


Red Line: Outgassing Region Blue Line: Equilibrium Region

1/3˚ solution grossly overestimates near-shore outgassing

Air-Sea Flux: Outgassing and Equilibirum Regions at 1/30˚

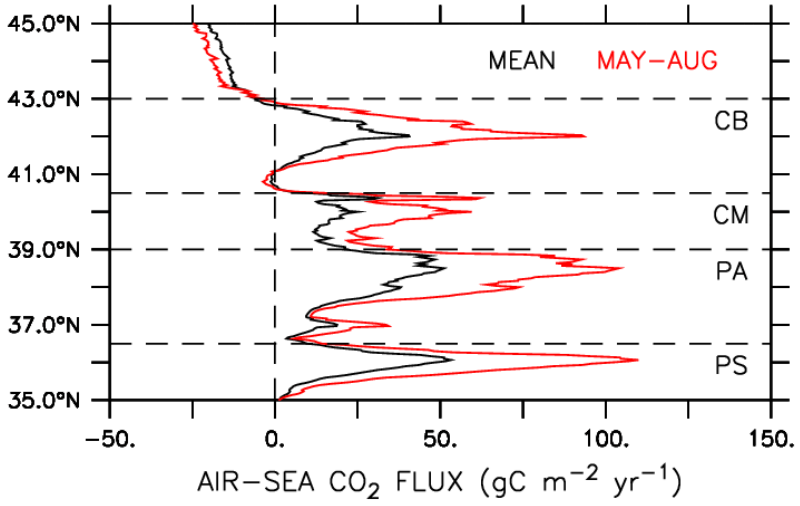


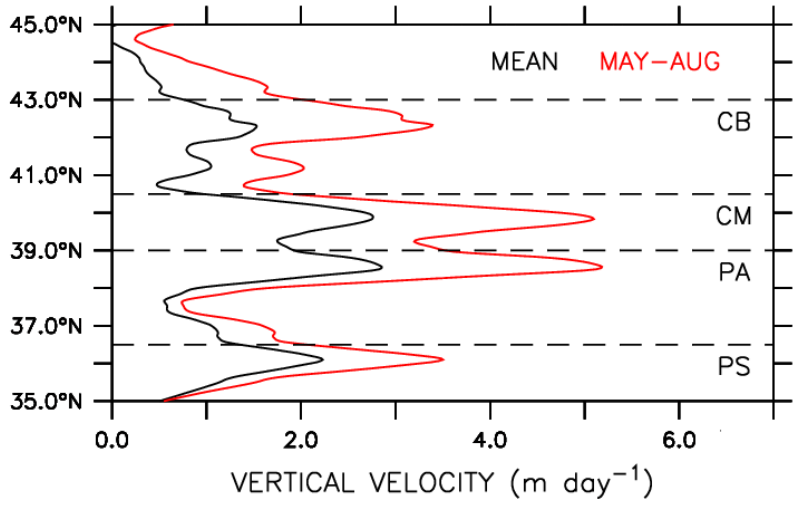


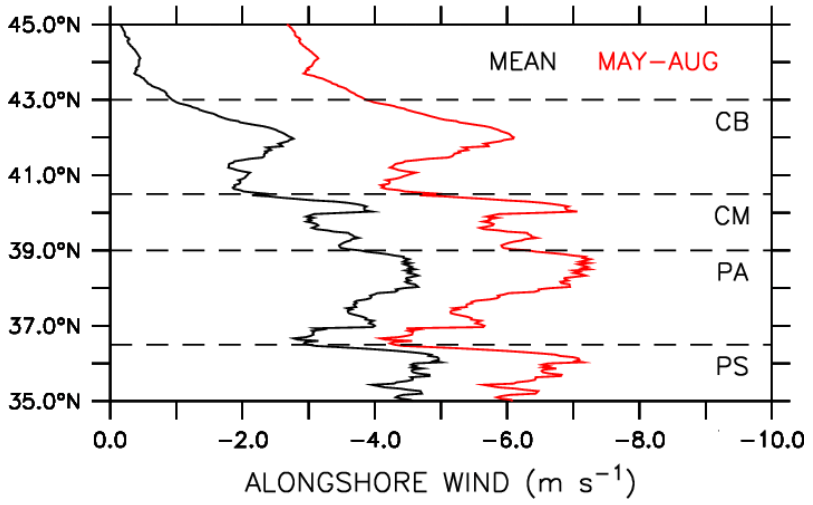
Red Line: Outgassing Region Blue Line: Equilibrium Region

Equilibrium distance indicates local strengthening in outgassing

CCS Outgassing and Coastal Topography

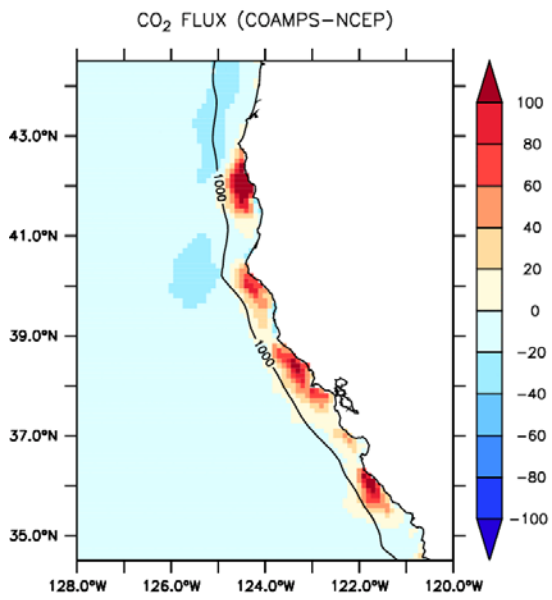


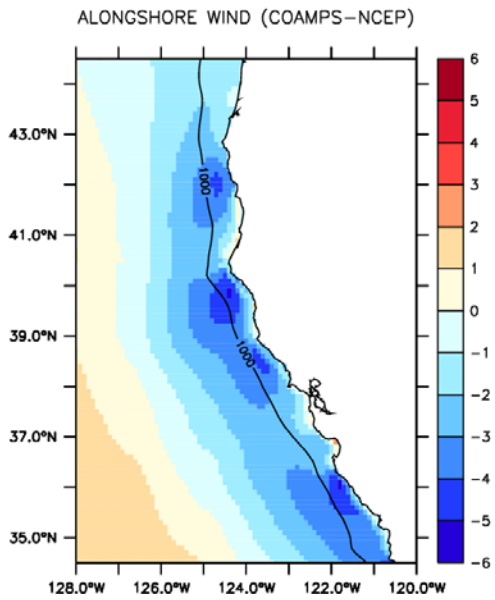


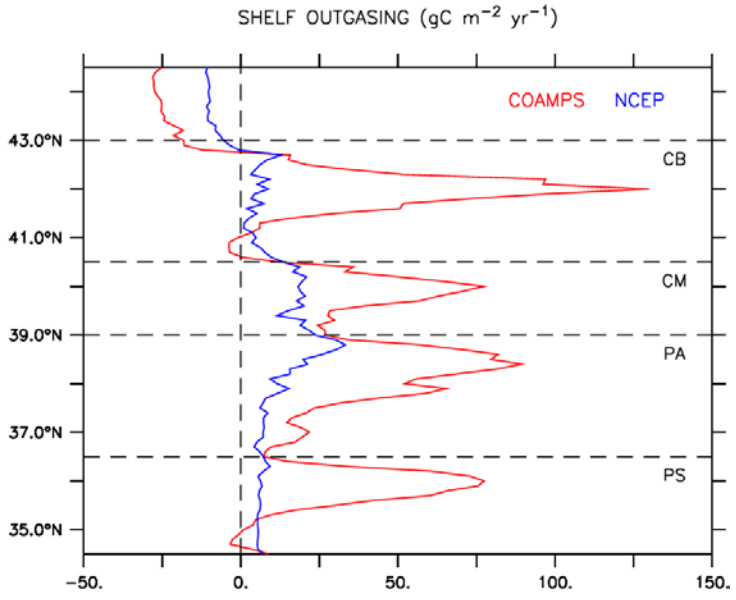


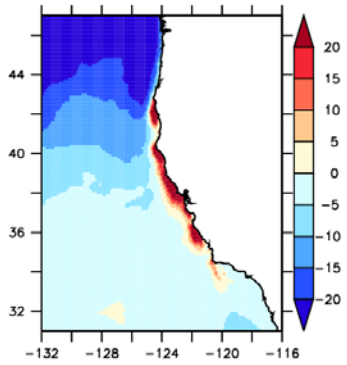
Outgassing enhancement equatorward of topographic features associated with intensification of upwelling-favorable winds

Impact of Surface Atmospheric Forcing on Air-Sea Flux

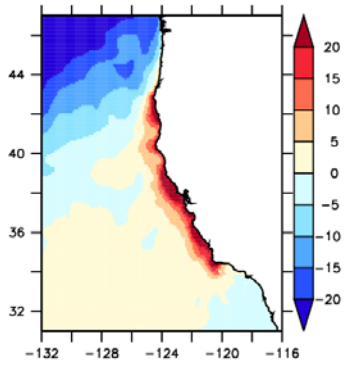




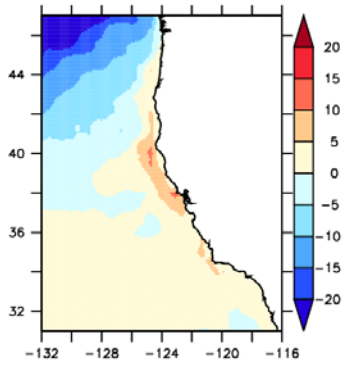




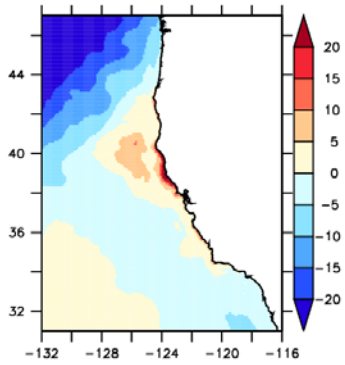
COAMPS



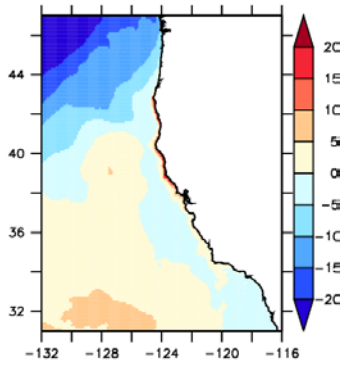
CCMP



MERRA

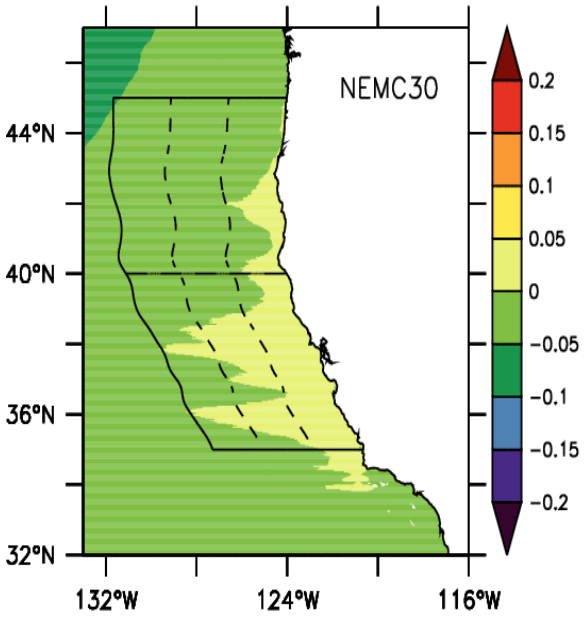


CORE2



NCEP

Net Air-Sea Carbon Exchange in CCS

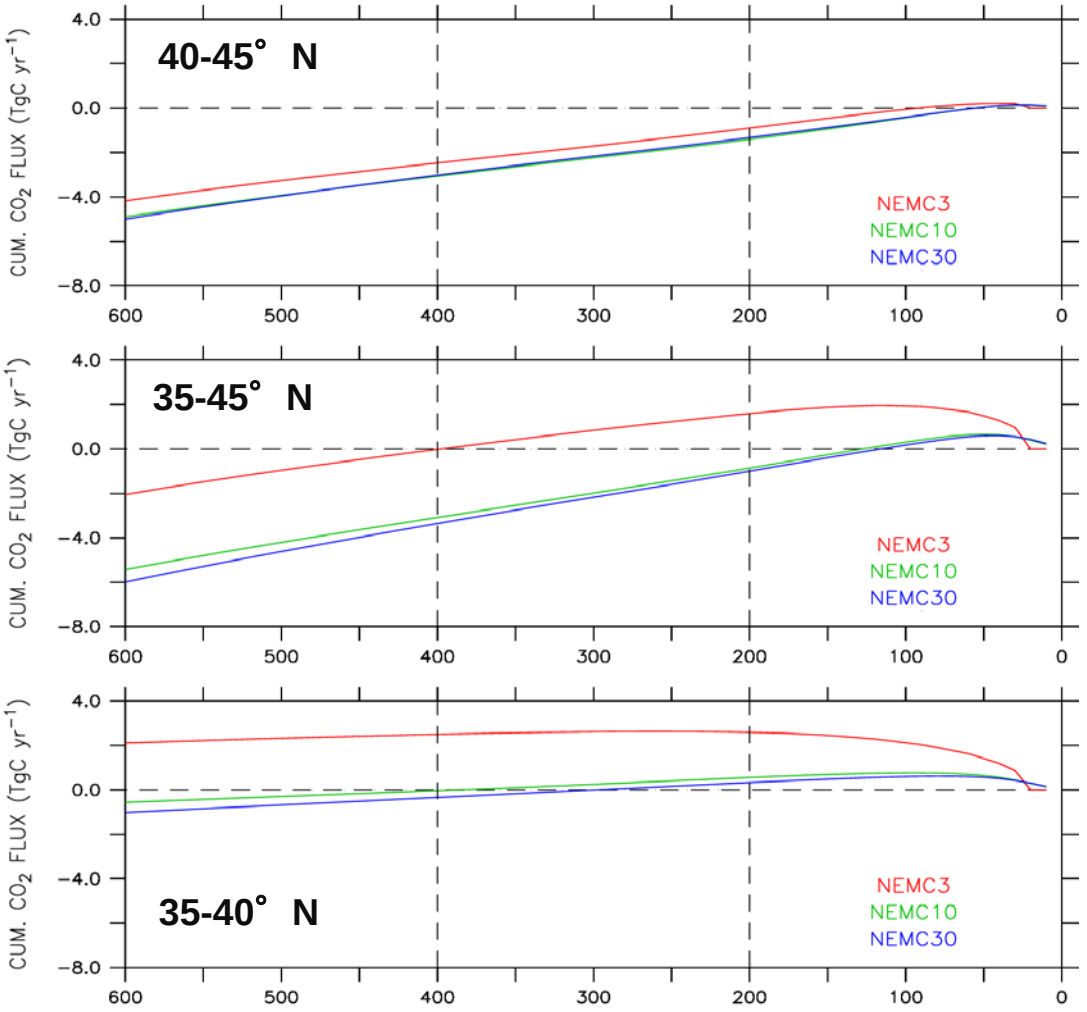


For 35-45° N out to 600 km

1/3° : ~2.0 TgC/yr

1/10° : ~5.4 TgC/yr

1/30° : ~6.0 TgC/yr



At 600km offshore, CCS is net CO_2 sink of ~6.0 TgC/yr

Net sink contribution: 20% SoCCS and 80% NoCCS

Summary

Role of EBC regions in global carbon cycle

- CO_2 outgassing on the shelf and absorption offshore.
- At 600km offshore, CCS is net CO_2 sink of 6.0 TgC/yr.
- Net sink contribution: 20% SoCCS and 80% NoCCS.
- Net carbon exchange at 1/10° is 10% larger than at 1/30°.

Downscaling from climate to regional models

- 1/3° vs. 1/10°: mesoscale eddy activity (Gruber et al., 2011).
- 1/10° vs. 1/30°: shelf slope accuracy (Estrade et al., 2010).
- Enhanced localized outgassing equatorward of capes.
- Wind forcing resolution important to resolve expansion fans.

Fiechter et al., Global Biogeochemical Cycles, 2014