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 CO₂ 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: $1/3^\circ$, $1/10^\circ$, $1/30^\circ$
- 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 $\text{CO}_2$ exchange
- NEMURO BC/IC: WOA, monthly
- Carbon BC/IC: GLODAP, annual

Run duration
- 7 years (1999-2005)
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

1/3°  1/10°  1/30°  OBS (MBARI Line77)

1/3° solution grossly overestimates near-shore outgassing
Air-Sea Flux: Outgassing and Equilibrium 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
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 CO2 sink of ~6.0 TgC/yr
Net sink contribution: 20% SoCCS and 80% NoCCS
Summary

Role of EBC regions in global carbon cycle
- CO₂ outgassing on the shelf and absorption offshore.
- At 600km offshore, CCS is net CO₂ 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