Modeling Impacts of Mesoscale Eddies on Biogeochemical Processes in South China Sea and Gulf of Alaska

Prof. Fei CHAI (柴扉)
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- Eddies and biological responses in the SCS
- Eddy transporting iron in Gulf of Alaska
- Iron fertilization with a Haida eddy - August 2012
Regional Ocean Model System (ROMS) 1/8 deg. (~12km) (1991 to 2013)

Carbon, Silicate, Nitrogen Ecosystem Model (CoSiNE)  
(Chai et al., 2002, 2003, 2007, 2009; Fujii and Chai, 2007; Liu and Chai, 2009; Xiu and Chai, 2011, 2014; Palacz et al., 2011; Guo, Chai et al., 2014)
Okubo-Weiss parameter

\[ W = s_n^2 + s_s^2 - \omega^2 \]

\[ s_n = \frac{\partial u}{\partial x} - \frac{\partial v}{\partial y}, \quad s_s = \frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}, \quad \omega = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \]

1st guess: \( W < -0.2 \sigma_W \)

Geometric center

Mean SLA and distances to the center

Search the area limited by the maximum distance for points where SLA greater/less than the mean SLA

Only those eddies with life span > 30 days, radius > 45 km, water depth > 1000m
Eddies in the South China Sea

Numbers: 27-38/yr (33); Area: 10% of the total area

Xiu, Chai et al., JGR, 2010
Impact of Cyclonic and Anti-Cyclonic on N, P, Z

Xiu and Chai, JGR, 2011
Annual Mean Integrated New Production in the SCS, 1993-2007

- Cyclonoic (1.8)
- Anti-Cyclonoic (0.9)
- Mean (1.4)
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Modeled Eddies Occurrence

Red Area: 15-20%

Satellite Derived Eddies Occurrence

Xiu, Chai et al., DSR, 2012
A total of 26 westward moving Haida eddies (16 years), 280 days averaged life span

Xiu, Palacz, Chai et al, GRL, 2011
Averaged Vertical Velocity (m/day) (only positive)

- Eddy Box (0.96)
- Reference Box (0.53)
- OSP (0.05)
Dissolved Fe Concentration along the Cross Section
June 2007, a three-month old Haida eddy

Particulate Fe concentrations are ~ 3 x higher

Roy and Wells, 2011
Dissolved Iron Supplies to Upper Ocean (100m) (umol m$^{-2}$ day $^{-1}$)

Xiu, Palacz, Chai, et al., GRL, 2011

Langmann et al., JGR, 2010

Palacz et al., DSR II, 2011
Chlorophyll Anomaly

2008

July

Volcanic ash induced

Aug.

Chlorophyll Anomaly

Artificial iron fertilization

Sept.

Oct.

-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
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- Eddy characteristics in SCS and GoA (ROMS and Satellite) numbers (33 vs. 7), duration (60 vs. 280 days), 2/year
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- Eddy characteristics in SCS and GoA (ROMS and Satellite) numbers (33 vs. 7), duration (60 vs. 280 days), 2/year long-lived in GoA, locations & tracks, interannual variability
- Nutrients and phytoplankton respond to eddies
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- Cyclonic eddies enhance transporting nutrients & production
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- Nutrients and phytoplankton respond to eddies depth issue, history of eddy, different phytoplankton groups
- Cyclonic eddies enhance transporting nutrients & production 30% higher inside cyclonic eddies (1.8 vs. 1.4 mmol/m²/day)
- GoA anticyclonic eddies phytoplankton biomass elevated, decadal trend, iron profiles supplying iron (umol/m²/day): 1 (eddy) vs. 0.03 (dust)
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Mesoscale (10-100km) and Sub-mesoscale (1-10km) physical processes are important in regulating nutrient transport and biological productivity, and iron works