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New and Export Productivity Regulation by Si and Fe in the Equatorial Pacific Ocean

Fei Chai
Principal Investigator; University of Maine, Orono, fchai@maine.edu

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Title:
New and Export Productivity Regulation by Si and Fe in the Equatorial Pacific Ocean

Project Participants

Senior Personnel

Name: Chai, Fei
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Jiang, Mingshun
Worked for more than 160 Hours: Yes
Contribution to Project:
Conducting 3D physical-biological model experiments.

Graduate Student

Name: Xu, Li
Worked for more than 160 Hours: Yes
Contribution to Project:
Testing 1D physical-biological model.

Name: Klein, Lawrence
Worked for more than 160 Hours: Yes
Contribution to Project:
Testing 1D physical-biological model.

Undergraduate Student

Research Experience for Undergraduates

Organizational Partners

Duke University Marine Laboratory
Richard Barber was supported by NSF to collaborate on this project.

University of Miami Rosenstiel School of Marine & Atmospheric Sci
Dr. T-H Peng was supported to collaborate on this project with contribution on the carbon modeling component.

San Francisco State University
Drs. Dugdale and Wilkerson were supported by NSF to collaborate on this project with contribution to silicate dynamics.

Other Collaborators or Contacts
Activities and Findings

Research and Education Activities:
This project incorporated the silicate pump hypothesis and Fe limitation into an ecosystem model to simulate CO2 fluxes in the equatorial Pacific. A first 1-D version of this model has been constructed and then embedded into a 3-D ocean circulation model for the equatorial Pacific. The 1-D model can be run and manipulated through a website with different parameters, and the 3-D model results can be accessed with the Live Access Server (LAS) (see Section 2 of the Project Description for details). The ecosystem model includes 2 types of phytoplankton (diatoms and picoplankton), 2 classes of zooplankton, Si and N detrital fractions, NO3, NH4, Si(OH)4 and total CO2. It functions as a chemostat-like system with the loss rates, provided largely from zooplankton grazing, controlling growth rates of the phytoplankton. It was capable of reproducing the low Si(OH)4, high NO3 and low chlorophyll conditions in the equatorial Pacific. A typical run initialized with Levitus nutrients reproduces closely the vertical nutrient structure (and other data) at 140?W obtained during JGOFS TT011 cruise.

We have coupled this ten-component biological model with a 3-D ocean circulation model based upon the Modular Ocean Model developed at Geophysical Fluid Dynamics Laboratory (GFDL) of NOAA with some modifications. The physical-biological model is forced with COADS (Comprehensive Oceanic and Atmospheric Data Set) monthly wind and heat flux. The initial conditions for NO3 and Si(OH)4 are from the processed NODC station data. Below the euphotic zone, sinking particulate organic matter is converted to inorganic nutrients by a regeneration processes, in which organic matter decays to ammonium, and then is nitrified to NO3. The flux of particulate material is specified using an empirical function. The Si(OH)4 regeneration is modeled through a similar approach but with a deeper regeneration depth profile. The biological model starts from year 1950 after the circulation model has integrated for 15 years.

04/01: ØModeling Carbon Cycle in the Pacific Ocean.Ø The Oceanography Society (TOS) 2001 Scientific Meeting, Miami, Florida.

12/00: ØModeling Carbon Cycle in the Pacific Ocean.Ø American Geophysical Union (AGU) Fall Meeting 2000, San Francisco, California.

11/00: 'Ecosystem and Carbon Cycle Modeling: Seasonal to Decadal Variability in the Pacific Ocean', School of Marine Sciences, University of Maine, Orono, Maine, USA.

10/00: 'Modeling Carbon Cycle in the Pacific Ocean', North Pacific CO2 Data Synthesis Symposium, Tsukuba, Japan.
Findings:
Between 5oS-5oN, 90oW-180o, the estimated sea-to-air CO2 flux of 4.3 mol/m2/yr from the model is consistent with the observed results (1.0 to 4.5 mol/m2/yr). When source Si(OH)4 concentrations are increased in the model diatoms increase, the picoplankton population and NO3 consumption decrease, resulting in a maximum surface TCO2 and increased CO2 flux to the atmosphere at intermediate source Si(OH)4 concentrations. The 1-D model considers the role of Fe implicitly through the parameters that determine the growth rate of diatoms, and Fe enrichment experiments conducted using the model matched the ecological behaviors observed during IronEx-2. Another result of the study was to evaluate the sources of Si(OH)4 to the equatorial upwelling current which were found to be asymmetrical, with less Si(OH)4 (only 30% of the total supply) entering from the south Pacific compared to the north. These results, suggest a coupling between Southern Ocean productivity, equatorial productivity, and the efflux of CO2 to the atmosphere from the equatorial upwelling system.

For the three-dimensional modeling, overall, the model captures the essential interannual variability shown by Barber and Chavez, (1983), Murray et al. (1994) and Feely et al (1997) and ENSO effects on phytoplankton dynamics. The total phytoplankton biomass decreases during all five El Niño events (1972-73, 1975-76, 1982-83, 1986-87, 1991-92), not just near the surface but also throughout the water column. The strongest reduction of the phytoplankton biomass occurred during the 1982-83 El Niño, followed by 1972-73 El Niño. The highest biomass was in 1987-88 and 1974, the La Niña periods. The phytoplankton biomass decreases due to the combination of Si(OH)4 supply to the euphotic zone (decrease both in upwelling
and deepening of the nutricline) and decrease in Si(OH)4 concentration during the El Niño events, which results in reduction of diatom growth.

These results are summarized in 3 lengthy manuscripts in press in Deep Sea Research and several other related publications.

**Training and Development:**

Two graduate students (Li XU and Lawrence KLEIN) have been involved in the 1D model development. Based upon their modeling activities and experiences, both of them are working on their MS thesis, which should be done within the next year.

Dr. Mingshun JIANG, a postdoc at the University of Maine, has been involved in the 3D modeling. Jiang had learned how to run the MOM code combined with the 10-component ecosystem model on supercomputers. He is now working with the ocean modeling group as a research associate. He is working on a couple of manuscripts based upon the results from this project.

**Outreach Activities:**

The 1-D model has been implemented on the website, which allows 'non-modelers' be able to run the 1D model interactively. This is very useful for people who do not know any computer language. We have put the 3D model results online, which can be accessed with the Live Access Server (LAS). These activities enhance a broader participation in understanding ocean ecosystem modeling.

**Journal Publications**


**Books or Other One-time Publications**


Editor(s): R.B. Hanson, H.W. Ducklow, & J.G. Field (Editors)

Collection: The Changing Ocean Carbon Cycle: A midterm synthesis of the Joint Global Ocean Flux Study,

Editor(s): C-T Arthur Chen
Collection: Marine Environment: the Past, Present and Future
Bibliography: p.240-255

Collection: Proceedings of the 2nd International Symposium 'CO2 In The Ocean
Bibliography: 183-189

Web/Internet Site

URL(s):
http://athena.umeoce.maine.edu/1deco-new/1deco.htm
http://rocky.umeoce.maine.edu/las-public/

Description:

Other Specific Products

Contributions within Discipline:
Predictive understanding of how iron, silicate and nitrate affect carbon partitioning in the equatorial Pacific. How the marine ecosystem and carbon cycle response to the physical forcing on interannual and decadal time scale.

Contributions to Other Disciplines:
The ecosystem model developed from this project has been incorporated into other coastal physical models, such Gulf of Maine and Monterey Bay.

Contributions to Human Resource Development:
Research activities has helped to train graduate students and postdoc to learn about ecosstems modeling and using supercomputers in ocean modeling.

Contributions to Resources for Research and Education:
Our interactive 1D modeling website and 3D model results online have been linked with US JGOFS website.

Contributions Beyond Science and Engineering:
none

Categories for which nothing is reported:

Any Product