Model output of phytoplankton community composition variability as a function of intensity and duration of environmental disturbance at the Hawaii Ocean Time-series (HOT) location and nearby regions between 2003 and 2014

Website: https://www.bco-dmo.org/dataset/854787
Data Type: model results
Version: 1
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Project
» How does intensity and frequency of environmental variability affect phytoplankton growth? (Enviro variability and phytoplankton growth)
» OCE-RIG: The impact of submesoscale processes on oligotrophic carbon cycling and the sensitivity of this interaction to climatically driven changes (SHiP)

Contributors	Affiliation	Role
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Abstract
Model output of phytoplankton community composition variability as a function of intensity and duration of environmental disturbance at the Hawaii Ocean Time-series (HOT) location and nearby regions between 2003 and 2014. Model output was generated from numerical model simulations.

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Coverage

Spatial Extent: **N**:25.25 **E**:-155.5 **S**:20.25 **W**:-160.5
Temporal Extent: 2003 - 2014

Methods & Sampling

Location: Hawaii Ocean Time-series (HOT) and nearby regions (5deg x 5deg centered at HOT)

These data were generated from numerical model simulations.

See Supplemental File "Liu_and_Levine_modelDescription.pdf" for a methodology summary including a physical model description, ecological model description, model configuration and simulations, and Appendix A. "Key ecosystem parameters used in the model. Parameters optimized for the HOT site are denoted with asterisks."

Also, please refer to the associated publication Liu and Levine (2021) for additional details.

Data Processing Description

BCO-DMO data manager processing notes:
* Bundled .mat files and attached to this dataset landing page as Data Files
* Added model documentation as supplemental files.

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Data Files

File

File

Liu Levine PO model output (.mat files)

filename: Liu_Levine_PO_model_output.zip

(ZIP Archive (ZIP), 2.31 GB)
MD5:04cc97f90492a503416ee3de69217b2c

Model output files containing simulated biogeochemical parameters averaged over the entire model domain in MATLAB .mat format.

Each .mat file contains 12 years of model output from 2003 to 2014, and there are a total of 57 files corresponding to the 56 sensitivity heterogeneous mode experiments.

Reference:

Liu, X. and Levine, N. M., 2021. Ecosystem implications of fine-scale frontal disturbances in the oligotrophic ocean - an idealized modeling approach. Progress in Oceanography, https://doi.org/10.1016/j.pocean.2021.102519.

File names:

A suite of modeling experiments was conducted and a MATLAB file was generated for each of these experiments:

Example:

Rv120_`aa`Year_`bb`_`cc`_`dd`min_`ee`dflux_`ff`day.mat

where:

`aa` = total length of the simulation

`bb` = start year of the simulation

`cc` = end year of the simulation

`dd’ = time step for model evolution and numerical integration

`ee` = disturbance flux in meters per day

`ff` = disturbance duration in days

Key parameters:

In each file, simulated biogeochemical parameters averaged over the entire model domain are saved in a MATLAB data structure named “PATCH”:

DAY: time elapsed since the start of the simulation in days

SST: sea surface temperature in degree C

NO3: nitrate concentration in mmol per cubic meter

NH4: ammonium concentration in mmol per cubic meter

PHYTO_C: **phytoplankton carbon biomass concentration in mmol per cubic meter

GROWTH_C: **phytoplankton carbon biomass production in mmol per cubic meter per day

PHYTO_CHL: **phytoplankton chlorophyll concentration in mg per cubic meter

ZOO_C: zooplankton carbon biomass concentration in mmol per cubic meter

POC: particulate organic carbon concentration in mmol per cubic meter

DOC: dissolved organic carbon concentration in mmol per cubic meter

EXPORT_C: particulate organic carbon exported vertically out of the model domain

FLUX: vertical flux dissolved nitrogen from the deep boundary layer into the model domain

**: these phytoplankton related parameters were simulated for three functional/size groups: small phytoplankton (row 1), large phytoplankton (row 2), and diazotrophs (row 3).

File

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Supplemental Files

File
Liu and Levine model description filename: Liu_and_Levine_modelDescription.pdf (Portable Document Format (.pdf), 709.14 KB) MD5:1ff86a9d9986ae065596f92c992cd8d3

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Related Publications

Liu, X., & Levine, N. M. (2021). Ecosystem implications of fine-scale frontal disturbances in the oligotrophic ocean – An idealized modeling approach. Progress in Oceanography, 192, 102519. doi:10.1016/j.pocean.2021.102519
Results

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

How does intensity and frequency of environmental variability affect phytoplankton growth? (Enviro variability and phytoplankton growth)

Coverage: laboratory experiment

NSF Award Abstract:
Microscopic plants called phytoplankton are key members of global oceanic ecosystems, since their photosynthesis supports the majority of the marine food chain and produces about as much oxygen as land plants. Because of this, oceanographers have often carried out experiments examining how factors such as temperature and carbon dioxide levels may affect phytoplankton growth. Most previous experiments have used constant levels of temperature and carbon dioxide, but it is clear from looking at measurements from real ocean ecosystems that these two factors often vary greatly over timescales of days to weeks. Using field and laboratory experiments along with computer modeling, this project will test how the growth of several major groups of phytoplankton differs under constant conditions of temperature and carbon dioxide, compared to conditions in which these factors fluctuate in intensity and frequency. This research will give marine scientists a better picture of how phytoplankton may respond to a varying natural environment today and in the future, and therefore help us to understand how ocean food webs function to support critical living resources such as fisheries. The project will train graduate and undergraduate students and a postdoctoral researcher, and the lead scientists will be involved in an ocean science education program for largely minority high school students from a downtown Los Angeles school district.

The goal of this project is to use laboratory culture and natural community experiments to understand how realistically fluctuating temperature and pCO2 conditions may affect globally important phytoplankton groups in ways that differ from the artificial constant exposures used in previous work. Culture experiments will test how the intensity and frequency of short-term thermal and carbonate fluctuations affects the growth responses of diazotrophic and picoplanktonic cyanobacteria, coccolithophores, and diatoms under both current and projected future environmental conditions. These lab results will be supported and extended by parallel experiments using mixed natural assemblages from the California upwelling regime, allowing us to test these same questions using phytoplankton communities that experience large seasonal shifts between highly dynamic thermal and carbonate system conditions during the spring upwelling season, and relatively much more static conditions during fall stratification events. These results will be synthesized using a new generation of numerical models that employ novel approaches to incorporating realistic environmental variations to allow more accurate predictions of phytoplankton responses to a dynamic environment in today's marine ecosystems, and in the future changing ocean.

OCE-RIG: The impact of submesoscale processes on oligotrophic carbon cycling and the sensitivity of this interaction to climatically driven changes (SHiP)

NSF Award Abstract:
Overview: Anthropogenically induced warming has begun to change the global oceans and has the potential to alter the ocean carbon sink. Future changes in mixed layer depth and the delivery of nutrients into the surface ocean are hypothesized to be the primary processes that will impact primary production and carbon cycling in the ocean. Both of these processes are significantly impacted by submesoscale physical dynamics (1-10 km). However, current global climate models used to understand climate sensitivity do not resolve these important features, and so are missing a fundamental mechanism impacting ocean carbon cycling. In this project, the PI will develop a novel biogeochemical and ecosystem model that captures the impact of submesoscale processes on carbon cycling in a framework that is computationally tractable for large-scale simulations.

The Spatially Heterogeneous Dynamic Plankton (SHiP) model will represent a distribution of resource environments at the subgridscale and will include five phytoplankton functional groups, as well as light, nitrogen, and phosphorus limitation on phytoplankton growth. This research will focus on two oligotrophic sites, the Bermuda Atlantic Time-series Station (BATS) and the Hawaii Ocean Time-series (HOT). The SHiP model will be used to explore the impact of the observed submesoscale dynamics captured by the APEX/ISUS profiling nitrate floats on primary production, species dynamics, and carbon export flux. A suite of model simulations will also be conducted to investigate the sensitivity of carbon cycling at BATS and HOT to changes in the frequency and intensity of submesoscale front formation, such as might occur under future climate scenarios. Finally, the measurement-driven SHiP simulations will be compared against an idealized Regional Ocean Modeling System simulation that explicitly resolves submesoscale dynamics.

Intellectual Merit: Submesoscale processes have been shown to have a significant impact on ocean physics, however, the role that these processes play in carbon cycling remains unknown. This study will provide an observation-based analysis of the impact of submesoscale features on community composition and function in oligotrophic gyres and the sensitivity of this interaction to climatically driven changes. In addition, this work will validate a novel approach for mechanistically incorporating the impact of submesoscale dynamics into coarse-resolution models. This research will provide a computationally tractable framework for exploring the impact of changes in climate on global carbon cycling while including the impact of submesoscale processes.

Broader Impacts: The investigator and students associated with this project will collaborate with the Neighborhood Academic Initiative (NAI) at USC to develop an ocean sciences module including a field trip on an oceanographic research vessel. The NAI strives to improve high school graduation and college matriculation rates in the school district surrounding USC, which serves predominantly Latino/Hispanic and African-American communities. The module will also expose the students to oceanography, and help local high school teachers develop an ocean sciences lesson plan to incorporate into their curriculum.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1538525
NSF Ocean Sciences Research Initiation Grants (NSF OCE-RIG)	OCE-RIG-1323319

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