Upper Ocean Box Model which solves for the time change of Dissolved Inorganic Carbon (DIC) in single upper ocean box

Website: https://www.bco-dmo.org/dataset/840371
Data Type: model results
Version: 1
Version Date: 2021-02-16

Project
» Collaborative Research: Uncertainty in Predictions of 21st Century Ocean Biogeochemical Change (ESM Uncertainty)

Program
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
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Abstract

The box model solves for the time change of Dissolved Inorganic Carbon (DIC) in single upper ocean box. The upper ocean box model is forced by observed atmospheric pCO2 and temperature. It calculates the pCO2 and air-sea CO2 flux.

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Coverage

Spatial Extent: **N**:90 **E**:180 **S**:-90 **W**:-180
Temporal Extent: 1960 - 2017

Acquisition Description

The upper ocean box model is forced by observed atmospheric pCO2 and temperature. It calculates the pCO2 and air-sea CO2 flux. The model runs 1960-2017 (Dec 2017) . If linear atmospheric boundary condition is selected, this is applied only 1980-2017. The output that is the focus of the plotting is 1980-2017. For complete documentation, including the equation being solved, see section 2.5 of McKinley et al. (2020).
The zip file McKinley2020_boxmodel.zip contains code and documentation for the Upper Ocean Box Model

along with information about how to make modifications to do sensitivity tests. See "Data Files" for access to McKinley2020_boxmodel.zip.

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Files included in the zip file McKinley2020_boxmodel.zip:

2 main files
Ocean_Atm_Carbon_Box_McKinley2020.m
plot_boxmodel_McKinley2020.m

3 helper routines
remove_fixed_trend.m
make_annual.m
calc_pCO2_McKinley2020.m

1 data file for atmospheric pCO2
adjusted_atmpco2_fromML_v3.mat

"README for Upper ocean diagnostic box model.rtf" (McKinley et al. 2020). Text reproduced below with additional information about data sources.

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In Matlab2017a.

Coding and documentation by Galen A. McKinley, Columbia University / Lamont Doherty Earth Observatory. mckinley@ldeo.columbia.edu

DESCRIPTION from "README for Upper ocean diagnostic box model.rtf"

In Ocean_Atm_Carbon_Box_McKinley2020.m
Atmospheric pCO2 boundary conditions are loaded, and the linear forcing, as a change from change from Jan 1980 to Dec 2017 is calculated.
The magnitude and duration of El Chichon and Mt Pinatubo volcano temperature anomalies are set and plotted.
The model equation is integrated, including carbon chemistry at each timestep.

In plot_boxmodel_McKinley2020.m, set key input variables:
  On lines 28-33, set model temperature, overturning, depth of box, piston velocity (kw), deep abiotic DIC concentration, Alkalinity.
  On line 37 set real or linear atmospheric pCO2 (do_linear_pco2 = 0, 1, respectively).
  On line 38, set volcano forcing of SST or not (vary_temp = 1, 0, respectively).

In plot_boxmodel_McKinley2020.m, set years to plot and to save on lines 44-45.

In plot_boxmodel_McKinley2020.m, line 50, set to save out *mat files (tosave=1), into an existing directory.

In plot_boxmodel_McKinley2020.m, plot results starting on line 90. Save results starting on line 164.

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PARAMETER INFORMATION

List variables hard coded in Ocean_Atm_Carbon_Box_McKinley2020.m
% A   % ocean Area
% rho   % density (kg/m3), default is 1027

% timestep   % choose 1/12 for monthly

Input variables for each run of Ocean_Atm_Carbon_Box_McKinley2020.m
do_linear_pco2atm=0; % if = 1, will replace NOAA ESRL global pCO2atm with linear change from 1980-2018
vary_temp=1; % if = 1, volcano imposed, mean T set by Temp; details in Ocean_Atm_Carbon_Box_McKinley2020.m
            % if = 0, TempC throughout
% TempC   % Temperature, set for box (C)
% nu_in   % rate of ocean overturning (m3/yr)
% dz   % Box depth (m)
% kw_in   % piston velocity, cm/hr input
% deepDIC   % deep ocean DIC
% ALK   % Alkalinity, global constant, mmol/m3

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pCO2_atm (uatm) is read in from file adjusted_atmpco2_fromML_v4.mat (Mean adjusted in years 1959-1979 to merge from Mauna Loa only prior to 1980 to global after. Water vapor correction has been applied using global SST to find uatm.)   Mauna Loa xCO2 data came from https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html from 1959-1979, and then ESRL global marine boundary layer https://www.esrl.noaa.gov/gmd/ccgg/mbl/data.php . From annual mean, we interpolate back to monthly to create a smoothly evolving timeseries that is deseasonalized. The slight adjutment is to bring the mean of Mauna Loa and the global MBL into agreement at the 1979-1980 transition.

There is additional detail on the data processing to derive pCO2 from NOAA xCO2 in supplementary of McKinley, G. A., Fay, A. R., Eddebbar, Y. A., Gloege, L. and Lovenduski, N. S.: External Forcing Explains Recent Decadal Variability of the Ocean Carbon Sink, AGU Advances, 1(2), 1, doi:10.1029/2019AV000149, 2020.

adjusted_atmpco2_fromML_v3.mat contains variables:

adjusted_atmpco2_1959_2018	60x1	480	double
atm_pco2_wvcorr_global_AW	468x1	3744	double
atm_pco2_wvcorr_global_AW_annual	39x1	312	double
time_year	40x1	320	double

Output from Ocean_Atm_Carbon_Box_McKinley2020.m
[pco2_ocean,pco2atm,trend_pco2atm,flux,time,dt]

pco2_ocean % Global mean Ocean pCO2 (uatm)
pco2atm   % Global mean atmospheric pCO2 (uatm)
trend_pco2atm % atmospheric pCO2 trend for 1980 to 2017 (uatm/yr)
flux % air-sea CO2 flux (PgC/yr)
time % time of simulation
dt % timestep (fraction of year)

If plot_boxmodel_McKinley2020.m, these variables can be set there. Plotting of output is automated.
% TempC   % Temperature, set for box (C)
% NU_IN   % rate of ocean overturning (m3/yr)
% dz   % Box depth (m)
% kw_in   % piston velocity, cm/hr input
% deepDIC   % deep ocean DIC
% ALK   % Alkalinity, global constant, mmol/m3

Data Files

File	Version
Upper Ocean Box Model code and documentation filename: McKinley2020_boxmodel.zip (ZIP Archive (ZIP), 14.84 KB) MD5:9bbd562407156262834e26c04830c370 *This zip file contains the code for the Upper Ocean Box Model along with documentation.* *==* *Files included in the zip file:* *2 main files* *Ocean_Atm_Carbon_Box_McKinley2020.m* *plot_boxmodel_McKinley2020.m* *3 helper routines* *remove_fixed_trend.m* *make_annual.m* *calc_pCO2_McKinley2020.m* *1 data file for atmospheric pCO2* *adjusted_atmpco2_fromML_v3.mat* *"README for Upper ocean diagnostic box model.rtf" (McKinley et al. 2020).* *==* *See the "Acquisition Description" section for methodlogy and parameter information.*	original

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Related Publications

MathWorks (2017), MATLAB version R2017a (9.2) Documentation, The Mathworks, Inc. Retrieved November 13, 2020 from https://www.mathworks.com/help/releases/R2017a/index.html
Software

McKinley, G. (2020). Upper Open Carbon Box Model, McKinley et al. 2020, AGU Advances. figshare. https://doi.org/10.6084/M9.FIGSHARE.11983947.V1 https://doi.org/10.6084/m9.figshare.11983947.v1
Different Version

McKinley, G. A., Fay, A. R., Eddebbar, Y. A., Gloege, L., & Lovenduski, N. S. (2020). External Forcing Explains Recent Decadal Variability of the Ocean Carbon Sink. AGU Advances, 1(2). doi:10.1029/2019av000149 https://doi.org/10.1029/2019AV000149
Results

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Related Datasets

HasPart

Tans, P., Keeling, R. Trends in Atmospheric Carbon Dioxide. Available from https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html.

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Parameters

Parameters for this dataset have not yet been identified

Project Information

Collaborative Research: Uncertainty in Predictions of 21st Century Ocean Biogeochemical Change (ESM Uncertainty)

NSF Award Abstract:
The biogeochemistry of the oceans is undergoing large-scale changes due to anthropogenic climate change. Recent research suggests these changes are occurring significantly on regional scales, but due to model uncertainties, it is difficult to constrain the difference between anthropogenic and natural influences. In studying climate change and its effect on ocean biogeochemistry in the future, it is crucial to be able to distinguish between these influences; therefore, it is critical to identify and quantify the uncertainty in Earth System Models (ESMs). The researchers will use output from Community Earth System Model (CESM) and models participating in the Fifth Coupled Model Intercomparison Project (CMIP5) to isolate prediction uncertainty due to 1) internal variability, 2) model structure, and 3) emission scenario. This research will bridge an existing gap between Earth System Models and observational studies to assess how climate change will influence ocean biogeochemistry. Additionally, this project will support an early-career scientist and a graduate student, and the researchers are dedicated to mentoring undergraduate students through various programs at Colorado University - Boulder, National Center for Atmospheric Research, and the University of Wisconsin.

Earth System Model (ESM) simulations used to predict future changes in ocean biogeochemistry attributed to either natural or anthropogenic influences suffer from uncertainties, particularly on regional scales. This is problematic because, as the ocean continues to undergo large-scale change under the current climate, it is crucial to have an accurate predictor of the future and to be able to delineate between natural and anthropogenic forcing. This research aims to quantify the uncertainty on three levels: uncertainty due to internal variability, model structure, and emission scenario. Using output from the Community Earth System Model (CESM) and models in the Fifth Coupled Model Intercomparison Project (CMIP5), this study will evaluate the degree to which uncertainty has changed with newer models. Additionally, observations from global databased, satellites, and time-series sites will be used to compare models and assess the varying levels of skill in predicting the biogeochemistry of a region. The researchers also plan to break down the various components of the driving mechanisms behind prediction uncertainty, so that future models can begin to take these factors into account.

Program Information

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research

community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1558225
NSF Division of Ocean Sciences (NSF OCE)	OCE-1558258
NSF Division of Ocean Sciences (NSF OCE)	OCE-1818501