Ocean aluminum cycle model output containing model-predicted aluminum distribution and 60 different estimates of dust deposition

Website: https://www.bco-dmo.org/dataset/922468
Data Type: model results
Version: 1
Version Date: 2024-03-15

Project
» Collaborative research: Combining models and observations to constrain the marine iron cycle (Fe Cycle Models and Observations)

Contributors	Affiliation	Role
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Abstract
Here present model output from a data-assimilating model of the ocean aluminum (Al) cycle. The model simulates inputs of Al from atmospheric dust, and internal cycling due to reversible scavenging and biological cycling, and assimilates data from the GEOTRACES archive. Full code and inputs for the model can be accessed at Zenodo (doi: 10.5281/zenodo.10139317). This file contains the aluminum model-predicted aluminum distribution from the fully-optimized model, as well as 60 different estimates of dust deposition from a range of model configurations to quantify uncertainty in this process. A code is provided to synthesize and plot these results in a figure summarizing the oceanic aluminum budget as in Xu and Weber 2021.

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Dataset Description

Data are presented in both the original Matlab data format (file "Xu_2021_model_output.mat") and a non-proprietary plain-text format "Xu_2021_model_output.zip" which contains a .txt file for each variable stored in Xu_2021_model_output.mat. See file descriptions for more information about the structure of these files.

Methods & Sampling

A model of the ocean aluminum (Al) cycle was developed in the MATLAB programming language, using the Ocean Circulation Inverse Model v2 to resolve physical transport. The model resolves deposition and dissolution of dust at the sea surface, and internal cycling of Al in the ocean by reversible scavenging, biological uptake, and sediment resuspension. The model is solved for the steady-state aluminum distribution, which is then compared to observations from the GEOTRACES Intermediate Data Product 2017, Version 2 (Schlitzer et al., 2018) to optimize uncertain parameters.

* IDP2017 data used: "Discrete Sample Data" (i.e. GEOTRACES_IDP2017_v2_Discrete_Sample_Data).

60 different configurations of the model are optimized, representing all combinations of 12 dust deposition fields and 5 configurations of the OCIM transport model. The model equations are described in Xu and Weber 2021 (https://doi.org/10.1029/2021GB007049) and full model code and inputs are available for download on Zenodo (doi: 10.5281/zenodo.10139317).

This dataset contains the main model results: the fully optimized model-predicted aluminum distribution, as well as estimates of Al supply to the surface ocean from dust deposition from the 60 model configurations described above.

Location:
Output from a global 3-dimensional model steady state model. Aluminum concentration is on a 3-dimensional grid, and dust deposition rates on a 2-dimensional grid. Grid information is found in the grid structure as follows:

grid.xt - Longitude
grid.yt - Latitude
grid.zt - Depth

Data Processing Description

The model was developed and run on the University of Rochester BlueHive computing cluster.

The model runs using custom code developed for this project and is available on the Zenodo repository (doi: 10.5281/zenodo.10139317).

BCO-DMO Processing Description

Data within Xu_2021_model_output.mat was loaded using Matlab online version r2023b. Each variable was exported as individual plain-text files and added as a non-propriety form of this dataset (see Data File "Xu_2021_model_output.zip"). Struct contents of grid and basin_masks which were added into subfolders "grid" and "basin_masks."

```
>> load("/MATLAB Drive/Xu_2021_model_output.mat")
>> whos
Name Size Bytes Class Attributes

Alconc 91x180x24 3144960 double
Aldep 91x180x60 7862400 double
basin_masks 1x1 524832 struct
cost 1x60 480 double
grid 1x1 3279200 struct
mod_names 1x60 7798 cell

>> writematrix(Alconc,'Xu_2021_model_output/Alconc.txt');
>> writematrix(Aldep,'Xu_2021_model_output/Aldep.txt');
>> writematrix(basin_masks.SOC,'Xu_2021_model_output/basin_masks/SOC.txt');
>> writematrix(basin_masks.ATL,'Xu_2021_model_output/basin_masks/ATL.txt');
>> writematrix(basin_masks.PAC,'Xu_2021_model_output/basin_masks/PAC.txt');
>> writematrix(basin_masks.IND,'Xu_2021_model_output/basin_masks/IND.txt');
>> writematrix(cost,'Xu_2021_model_output/cost.txt');
>> writematrix(grid.x,'Xu_2021_model_output/grid/x.txt');
>> writematrix(grid.y,'Xu_2021_model_output/grid/y.txt');
>> writematrix(grid.z,'Xu_2021_model_output/grid/z.txt');
>> writematrix(grid.AREA,'Xu_2021_model_output/grid/AREA.txt');
>> writematrix(grid.M3d,'Xu_2021_model_output/grid/M3d.txt');
>> writecell(mod_names,'Xu_2021_model_output/mod_names.txt');
```

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Data Files

File
Al model output (Matlab format) filename: Xu_2021_model_output.mat (MATLAB Data (.mat), 6.18 MB) MD5:5862f464cb9fa5397eadb8b92da1b8c2 Model-predicted distribution and inputs of aluminum, with geographic grid information in Matlab format. This file contains: Alconc - concentration of aluminum in nM. Dimensions are latitude x longitude x depth Aldep - input of soluble aluminum to the surface ocean from dust deposition in mmol/m2/yr. Dimensions are latitude x longitude x 60 model configurations cost - a non-dimensional metric of the performance of each of the 60 model configurations, used for weighting. mod_names - a unique identifier for each of the 60 model configurations basin_masks - a structure that divides the ocean into Atlantic, Pacific, and Indian sectors, used by the plot_Al_budget.m code grid - a structure containing information about the geographical dimensions of the data. grid.xt, grid.yt and grid.zt are longitude (degrees E), latitude (degrees N) and depth (m) respectively, grid.AREA is area in m2. Variables within .mat file: Name Size Bytes Class Attributes Alconc 91x180x24 3144960 double Aldep 91x180x60 7862400 double basin_masks 1x1 524832 struct cost 1x60 480 double grid 1x1 3279200 struct mod_names 1x60 7798 cell basin_masks = struct with fields: SOC: [91x180 double] ATL: [91x180 double] PAC: [91x180 double] IND: [91x180 double] grid = struct with fields: x: [1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97 99 101 103 105 107 109 111 ...] (1x180 double) y: [-89.0110 -87.0330 -85.0549 -83.0769 -81.0989 -79.1209 -77.1429 -75.1648 -73.1868 -71.2088 -69.2308 -67.2527 -65.2747 -63.2967 -61.3187 -59.3407 -57.3626 -55.3846 -53.4066 ...] (1x91 double) z: [18.0676 54.7673 93.7255 137.2005 187.4509 246.7351 317.3115 401.4385 501.3747 619.3784 757.7082 918.6223 1.1044e+03 1.3172e+03 1.5595e+03 1.8333e+03 2.1410e+03 2.4849e+03 ...] (1x24 double) AREA: [91x180 double] M3d: [91x180x24 double]

File
Al model output (plain-text format) filename: Xu_2021_model_output.zip (ZIP Archive (ZIP), 6.52 MB) MD5:f31f142781c080bc0750b4ea25f1e4cb This is a non-proprietary format version of the model output in Matlab file "Xu_2021_model_output.mat." Struct contents of grid and basin_masks which were added into subfolders "grid" and "basin_masks." The missing data (null) identifier in these files is "NaN" which is the native Matlab missing data value. This file contains: Alconc - concentration of aluminum in nM. Dimensions are latitude x longitude x depth Aldep - input of soluble aluminum to the surface ocean from dust deposition in mmol/m2/yr. Dimensions are latitude x longitude x 60 model configurations cost - a non-dimensional metric of the performance of each of the 60 model configurations, used for weighting. mod_names - a unique identifier for each of the 60 model configurations basin_masks - a structure that divides the ocean into Atlantic, Pacific, and Indian sectors, used by the plot_Al_budget.m code grid - a structure containing information about the geographical dimensions of the data. grid.xt, grid.yt and grid.zt are longitude (degrees E), latitude (degrees N) and depth (m) respectively, grid.AREA is area in m2. .zip file contents: Alconc.txt - comma-delimited data matrix Aldep.txt - comma-delimited data matrix cost.txt - comma delimited list mod_names.txt - comma delimited list basin_masks/ATL.txt - comma-delimited data matrix basin_masks/IND.txt - comma-delimited data matrix basin_masks/PAC.txt - comma-delimited data matrix basin_masks/SOC.txt - comma-delimited data matrix grid/AREA.txt - comma-delimited data matrix grid/M3d.txt - comma-delimited data matrix grid/x.txt - comma-delimited data matrix grid/y.txt - comma-delimited data matrix grid/z.txt - comma-delimited data matrix

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Supplemental Files

File
Plotting code filename: plot_Al_budget.m (MATLAB Programming Script (.m), 3.48 KB) MD5:4abe0a4f2f6bdbd33f5dac76388b05d2 A model to synthesize and plot model output, to reproduce the ocean aluminum budget figure in Xu & Weber 2021. This matlab script loads file "Xu_2021_model_output.mat" and outputs file "weight_Aldep.mat." weight_Aldep.mat contains: Name Size Bytes Class Attributes weight_Aldep 91x180 131040 double

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Related Publications

DeVries, T., & Holzer, M. (2019). Radiocarbon and Helium Isotope Constraints on Deep Ocean Ventilation and Mantle-3He Sources. Journal of Geophysical Research: Oceans, 124(5), 3036–3057. Portico. https://doi.org/10.1029/2018jc014716 https://doi.org/10.1029/2018JC014716
Methods

Xu, H., & Weber, T. (2021). Ocean Dust Deposition Rates Constrained in a Data-Assimilation Model of the Marine Aluminum Cycle. Global Biogeochemical Cycles, 35(9). Portico. https://doi.org/10.1029/2021gb007049 https://doi.org/10.1029/2021GB007049
Results

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Related Datasets

Software

Xu, H., &; Weber, T. (2023). *Ocean aluminum cycle model*. Zenodo. https://doi.org/10.5281/ZENODO.10139317 https://doi.org/10.5281/zenodo.10139317

IsDerivedFrom

Schlitzer, R., Anderson, R. F., Dodas, E. M., Lohan, M., Geibert, W., Tagliabue, A., … Landing, W. M. (2018). The GEOTRACES Intermediate Data Product 2017, version 2, Chemical Geology, 493, 210–223. doi:10.1016/j.chemgeo.2018.05.040

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Collaborative research: Combining models and observations to constrain the marine iron cycle (Fe Cycle Models and Observations)

NSF Award Abstract:
Tiny marine organisms called phytoplankton play a critical role in Earth's climate, by absorbing carbon dioxide from the atmosphere. In order to grow, these phytoplankton require nutrients that are dissolved in seawater. One of the rarest and most important of these nutrients is iron. Even though it is a critical life-sustaining nutrient, oceanographers still do not know much about how iron gets into the ocean, or how it is removed from seawater. In the past few years, scientists have made many thousands of measurements of the amount of dissolved iron in seawater, in environments ranging from the deep sea, to the Arctic, to the tropical oceans. They found that the amount of iron in seawater varies dramatically from place to place. Can this data tell us about how iron gets into the ocean, and how it is ultimately removed? Yes. In this project, scientists working on making measurements of iron in seawater will come together with scientists who are working on computer models of iron inputs and removal in the ocean. The goal is to work together to create a program that allows our computer models to "learn" from the data, much like an Artificial Intelligence program. This program will develop a "best estimate" of where and how much iron is coming into the ocean, how long it stays in the ocean, and ultimately how it gets removed. This will lead to a better understanding of how climate change will impact the delivery of iron to the ocean, and how phytoplankton will respond to climate change. With better climate models, society can make more informed decisions about how to respond to climate change. The study will also benefit a future generation of scientists, by training graduate students in a unique collaboration between scientists making seawater measurements, and those using computer models to interpret those measurements. Finally, the project aims to increase the participation of minority and low-income students in STEM (Science, Technology, Engineering, and Mathematics) research, through targeted outreach programs.

Iron (Fe) is an important micronutrient for marine phytoplankton that limits primary productivity over much of the ocean; however, the major fluxes in the marine Fe cycle remain poorly quantified. Ocean models that attempt to synthesize our understanding of Fe biogeochemistry predict widely different Fe inputs to the ocean, and are often unable to capture first-order features of the Fe distribution. The proposed work aims to resolve these problems using data assimilation (inverse) methods to "teach" the widely used Biogeochemical Elemental Cycling (BEC) model how to better represent Fe sources, sinks, and cycling processes. This will be achieved by implementing BEC in the efficient Ocean Circulation Inverse Model and expanding it to simulate the cycling of additional tracers that constrain unique aspects of the Fe cycle, including aluminum, thorium, helium and Fe isotopes. In this framework, the inverse model can rapidly explore alternative representations of Fe-cycling processes, guided by new high-quality observations made possible in large part by the GEOTRACES program. The work will be the most concerted effort to date to synthesize these rich datasets into a realistic and mechanistic model of the marine Fe cycle. In addition, it will lead to a stronger consensus on the magnitude of fluxes in the marine Fe budget, and their relative importance in controlling Fe limitation of marine ecosystems, which are areas of active debate. It will guide future observational efforts, by identifying factors that are still poorly constrained, or regions of the ocean where new data will dramatically reduce remaining uncertainties and allow new robust predictions of Fe cycling under future climate change scenarios to be made, ultimately improving climate change predictions. A broader impact of this work on the scientific community will be the development of a fast, portable, and flexible global model of trace element cycling, designed to allow non-modelers to test hypotheses and visualize the effects of different processes on trace metal distributions. The research will also support the training of graduate students, and outreach to low-income and minority students in local school districts.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1658042

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