Hydrothermal plume dispersion model outputs for the Endeavour Segment of the Juan de Fuca Ridge for the years 2016, 2021, and 2023

Website: https://www.bco-dmo.org/dataset/984984
Data Type: model results
Version: 1
Version Date: 2025-09-23

Project
» Collaborative Research: Hydrothermal Estuaries: What Sets the Hydrothermal Flux of Fe and Mn to the Oceans? (Hydrothermal Estuaries)

Contributors	Affiliation	Role
German, Christopher R.	Woods Hole Oceanographic Institution (WHOI)	Principal Investigator
Xu, Guangyu	University of Washington Applied Physics Laboratory (UW APL)	Principal Investigator
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset contains model output files from numerical simulations of hydrothermal plume dispersion at the Endeavour Segment of the Juan de Fuca Ridge, spanning two one-year periods in 2016 and 2021, as well as a 2.5-month period from mid-July to late September 2023. The simulations capture the complex interactions among seafloor hydrothermal discharge, deep-sea ocean currents, and mid-ocean ridge topography, and they illustrate the dispersion of hydrothermal plumes from the ridge segment into the surrounding ocean interior. Furthermore, the 2023 simulation was conducted in support of the research expedition AT50-15 to the Endeavour Segment in September 2023. Its outputs were used to guide at-sea autonomous underwater vehicle (AUV) surveys of hydrothermal plumes during the cruise. Following the expedition, the simulation was refined to improve its fidelity and the updated outputs were used to inform analysis of plume biogeochemistry. The model output files included in this repository are from the post-cruise refined simulation. All simulations were conducted using the Regional Ocean Modeling System (ROMS). The outputs, provided in NetCDF format, include three-dimensional fields of velocity, temperature, and salinity, along with additional model variables.

Table of Contents

Coverage

Location: The Endeavour Segment of the Juan de Fuca Ridge
Spatial Extent: **N**:48.9824 **E**:-127.5225 **S**:47.0157 **W**:-131.4892
Temporal Extent: 2016-01 - 2023-12

Methods & Sampling

The simulations were conducted using the Regional Ocean Modeling System (ROMS). The model outputs from the 2016 and 2021 simulations comprise daily averaged three-dimensional fields of velocity, temperature, salinity, along with other model variables. For the period of 2016-08-28 to 2016-12-11, the model outputs are averaged over 4-hour intervals. The data files from the 2023 simulation comprise both daily averaged and bihourly sampled model outputs.

Data Processing Description

This dataset contains model output and configuration files from the numerical simulations of hydrothermal plume dispersion at the Endeavour Segment of the Juan de Fuca Ridge, as presented in Xu and German (2023, 2024). These simulations were conducted using Version 4.1 of the Regional Ocean Modeling System (https://github.com/myroms).

See more about standard input and output at the ROMS Documentation Portal https://www.myroms.org/wiki and at https://github.com/myroms/roms/wiki (ROMS/TOMS Group, Shchepetkin and McWilliams (2005)).

Output is provided in NetCDF (.nc) format:
:format = "netCDF-3 64bit offset file" ;
:Conventions = "CF-1.4, SGRID-0.3" ;
:type = "ROMS/TOMS nonlinear model averages file" ;

Simulation model files are provided in this dataset as .zip packages (See "Data Files"). The folders named below are included in the .zip packages.

The folder **'Endeavour_2016/' i**ncludes the model files for the 2016 simulation period. The folder 'Endeavour_2021' contains model files for the 2021 simulation period. The folder 'Endeavour_cruise_2023' contains model files from a targeted simulation focused on the timeframe of the research expedition (R/V Atlantis AT50-15) to the Endeavour Segment in September 2023.

Within '**Endeavour_2016/'**, the subdirectory 'coarse_grid_no_tide' contains the model output and configuration files for the pilot coarse-resolution simulation (see Xu and German, 2023 for details). The subdirectory 'nest_fine2ultra' includes model files for the two-layer nested simulation with the full set of model forcings. Additional subdirectories contain variations of this simulation:

· 'nest_fine2ultra_no_tide': without tidal forcing
· 'nest_fine2ultra_no_tide_no_vent': without tidal forcing or hydrothermal venting
· 'nest_fine2ultra_no_vent': without hydrothermal venting

Within each subdirectory:

· 'build' includes the script (build_roms.sh) for compiling model source code;
· 'include' contains the user-modified source code files and runtime parameters files;
· 'input' includes the input files for model boundary conditions, initial conditions, and external forcing.

Standard model output is stored in NetCDF files named roms_avg_fine_xxxx.nc and roms_avg_ultra_xxxx.nc, corresponding to daily and 4-hour averaged outputs from the fine-resolution and ultra-fine-resolution grids of the nested simulation.

Station-sampled model output is included in NetCDF files named roms_sta_ultraxx.nc.

Model restart files, which are used to resume simulations from a saved state, are named roms_rst_finexx.nc and roms_rst_ultraxx.nc, corresponding to the fine-resolution and ultra-fine-resolution grids.

The file structure within **'Endeavour_2021/'** is identical, except that it does not include model files for the pilot coarse-resolution simulation.

The subdirectories within **'Endeavour_cruise_2023/'** are as follows:

· 'avg_files' includes two-day averaged model output in NetCDF files named roms_avg_ultra_xxxxx.nc.
· 'his_files' includes bihourly sampled model output in NetCDF files named roms_his_ultra_xxxxx.nc.
· 'model_files' includes input and configuration files organized into the subfolders 'build', 'include', and 'input', following the same structure as in 'Endeavour_2016' and 'Endeavour_2021.'

· ‘rst_files’ includes model restart NetCDF files named roms_rst_ultraxx.nc.
· ‘sta_files’ includes station-sampled model output in NetCDF files named roms_sta_ultraxx.nc.

References:

Xu G and German CR (2023) Dispersion of deep-sea hydrothermal plumes at the Endeavour Segment of the Juan de Fuca Ridge: a multiscale numerical study. Front. Mar. Sci. 10:1213470. doi:10.3389/fmars.2023.1213470.

Xu, G. and German, C.R., 2024, December. Modeling of Hydrothermal Plume Dispersion during Expedition AT50-15 at the Endeavour Segment of the Juan de Fuca Ridge. In AGU Fall Meeting Abstracts (Vol. 2024, No. 545, pp. OS41H-0545).

BCO-DMO Processing Description

Version 1
* File structure containing simulation folders with root folders Endeavour_2016/ and Endeavour_2021/ and Endeavour_cruise_2023/ were packaged into a zip file per simulation (See Data Files). Zip files were made with zip64 support to enable larger file sizes (made and tested using 7z).
* Supplemental file "file_inventory.csv" was constructed to catalog all files within the file hierarchy (catalogs what's in the .zip packages). And includes column archive_name to clarify which files are in which zip.
* Since run packages are large and may take significant time to download, examples of what are in .nc input and output files were added as supplemental files.

[table of contents | back to top]

Data Files

File
Endeavour_2016-coarse_grid_no_tide.zip (ZIP Archive (ZIP), 13.40 GB) MD5:6998def9a7ca7f2184ff301e6ecc66b3 Contains ROMS model configuration, input, and output files for the pilot coarse-resolution simulation without tidal forcing (coarse_grid_no_tide), representing the 2016 period. Includes configuration and input files (build, include, input), and daily averaged outputs (NetCDF) of model fields such as velocity, temperature, and salinity, along with other variables and parameters. See “Data Processing” section for more details.
Endeavour_2016-nest_fine2ultra-part1.zip (ZIP Archive (ZIP), 228.93 GB) MD5:6d9a77da69a00a3ce93db7bc4edb3d7e Part 1 of 3 for the two-layer nested fine-to-ultra-resolution simulation with full model forcings (nest_fine2ultra), covering 2016. Includes configuration and input files (build, include, input), and daily averaged NetCDF outputs from the fine grid, spanning from simulation start to August 28, 2016, and 4-hour averaged outputs from August 28 through the end of the simulation (roms_avg_fine_*).
Endeavour_2016-nest_fine2ultra-part2.zip (ZIP Archive (ZIP), 233.81 GB) MD5:10a1a3f4521cf21bd11bd4b457e5f699 Part 2 of 3 for the two-layer nested fine-to-ultra-resolution simulation with full model forcings (nest_fine2ultra), 2016. Includes daily and 4-hour averaged NetCDF outputs from the ultra-fine grid (roms_avg_ultra_*). See “Data Processing” section for more details.
Endeavour_2016-nest_fine2ultra-part3.zip (ZIP Archive (ZIP), 173.78 GB) MD5:d47e3def9a2dac838e75771da1aedcc2 Part 3 of 3 for the two-layer nested fine-to-ultra-resolution simulation with full model forcings (nest_fine2ultra), 2016. Includes daily and 4-hour averaged ultra-fine-grid outputs (roms_avg_ultra_*), station-sampled NetCDF files (roms_sta_*), and restart files for both grids (roms_rst_fine_*, roms_rst_ultra_*). See “Data Processing” section for more details.
Endeavour_2016-nest_fine2ultra_no_tide.zip (ZIP Archive (ZIP), 256.91 GB) MD5:d5b83307deb33fc4a4fee9b973b02e65 Contains files for the fine-to-ultra nested simulation without tidal forcing (nest_fine2ultra_no_tide), 2016. Includes daily averaged and station-sampled NetCDF outputs and model inputs/configuration. See “Data Processing” section for more details.

File
Endeavour_2016-nest_fine2ultra_no_tide_no_vent.zip (ZIP Archive (ZIP), 232.25 GB) MD5:871422cca63b94d8156979f1edc11949 Includes daily averaged and station-sampled NetCDF outputs and model inputs/configuration for the fine-to-ultra nested simulation without tidal forcing and without hydrothermal venting (nest_fine2ultra_no_tide_no_vent), 2016. See “Data Processing” section for more details.
Endeavour_2016-nest_fine2ultra_no_vent-part1.zip (ZIP Archive (ZIP), 232.17 GB) MD5:b29576d6539c6e9ba3c0833c4f465ef9 Part 1 of 3 for the nested fine-to-ultra simulation without hydrothermal venting (nest_fine2ultra_no_vent), 2016. Includes configuration and input files (build, include, input) and daily averaged NetCDF outputs from the fine grid, spanning from simulation start to August 28, 2016, and 4-hour averaged outputs from August 28 through the end of the simulation (roms_avg_fine_*).
Endeavour_2016-nest_fine2ultra_no_vent-part2.zip (ZIP Archive (ZIP), 234.76 GB) MD5:50b377cef8f480526e49957b68ef721c Part 2 of 3 for the nested fine-to-ultra simulation without hydrothermal venting (nest_fine2ultra_no_vent), 2016. Includes daily and 4-hour averaged NetCDF outputs from the ultra-fine grid (roms_avg_ultra_*). See “Data Processing” section for more details.
Endeavour_2016-nest_fine2ultra_no_vent-part3.zip (ZIP Archive (ZIP), 117.26 GB) MD5:4a8f64920acd71587e30c612516b67d6 Part 3 of 3 for the nested fine-to-ultra simulation without hydrothermal venting (nest_fine2ultra_no_vent), 2016. Includes daily and 4-hour averaged ultra-fine-grid outputs (roms_avg_ultra_*), station-sampled NetCDF files (roms_sta_*), and restart files for both grids (roms_rst_fine_*, roms_rst_ultra_*). See “Data Processing” section for more details.
Endeavour_2021-nest_fine2ultra.zip (ZIP Archive (ZIP), 180.94 GB) MD5:aea98ecdba2959a8ba475db57a4d6e0a Complete model configuration, input, and NetCDF output files for the 2021 nested fine-to-ultra simulation with full model forcings (nest_fine2ultra). Structure mirrors the 2016 nested run with full model forcing except that all model outputs are daily averaged. See “Data Processing” section for more details.
Endeavour_cruise_2023-part1.zip (ZIP Archive (ZIP), 204.75 GB) MD5:bef522fbb0e07e94e192b9a75389ef12 Part 1 of 4 for the 2023 cruise simulation (Endeavour_cruise_2023). Includes two-day averaged outputs (avg_files) and bihourly outputs (his_files). See “Data Processing” section for more details.
Endeavour_cruise_2023-part2.zip (ZIP Archive (ZIP), 222.90 GB) MD5:0352949503689a52a6086d34b324b6b8 Part 2 of 4 for the 2023 cruise simulation (Endeavour_cruise_2023). Includes bihourly sampled outputs (his_files). See “Data Processing” section for more details.
Endeavour_cruise_2023-part3.zip (ZIP Archive (ZIP), 223.08 GB) MD5:6686d47f9cdec50eb6234a5a5fb15222 Part 3 of 4 for the 2023 cruise simulation (Endeavour_cruise_2023). Includes bihourly sampled outputs (his_files). See “Data Processing” section for more details.
Endeavour_cruise_2023-part4.zip (ZIP Archive (ZIP), 150.28 GB) MD5:ac4d0f3ec23582fb6400686f5c88c876 Part 4 of 4 for the 2023 cruise simulation (Endeavour_cruise_2023). Includes bihourly outputs (his_files), configuration and inputs (model_files/build, model_files/include, model_files/input), station-sampled files (sta_files), and restart files (rst_files). See “Data Processing” section for more details.

[table of contents | back to top]

Supplemental Files

File	
example_End2021_input_Endeavour_wind_era_2021.txt	(Plain Text, 1.78 KB) MD5:17aec1bd991ab4cb95523a4cd93eea04
NetCDF header information from one example input file "Endeavour_2021/nest_fine2ultra/input/Endeavour_wind_era_2021.nc" obtained with command "ncdump -h" which includes global attributes, variable names, data types, dimensions, and attributes (:long_name, :units, etc).	
example_End2021_roms_avg_fine_0182.txt	(Plain Text, 19.02 KB) MD5:b188663bafc8386554f39fd2f8fa8d5a
NetCDF header information from one example output file "Endeavour_2021/nest_fine2ultra/roms_avg_fine_0182.nc" obtained with command "ncdump -h" which includes global attributes, variable names, data types, dimensions, and attributes (:standard_name, :long_name, :units, etc).	
file_inventory.csv	(Comma Separated Values (.csv), 1.14 MB) MD5:650018a29a830e0ef474167722bed996
A file inventory table that catalogs all the files within all .zip packages in this dataset. Columns: relative_filepath, The relative path from the first root folder in the zip package to the filename (e.g. "Endeavour_2016/nest_fine2ultra/input/Endeavour_grid_fine_rotate3_ini_roms.nc") filename, the filename (e.g. "Endeavour_grid_fine_rotate3_ini_roms.nc") filesize_bytes, The filesyze in bytes md5sum, A checksum (md5sum) which can be used to verify the integrity of the file after transfers. archive_name, Name of the zip package in this dataset that contains the file.	

[table of contents | back to top]

Related Publications

Shchepetkin, A. F., & McWilliams, J. C. (2005). The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. Ocean Modelling, 9(4), 347–404. https://doi.org/10.1016/j.ocemod.2004.08.002
Software

Xu, G. and German, C.R., 2024, December. Modeling of Hydrothermal Plume Dispersion during Expedition AT50-15 at the Endeavour Segment of the Juan de Fuca Ridge. In AGU Fall Meeting Abstracts (Vol. 2024, No. 545, pp. OS41H-0545). https://ui.adsabs.harvard.edu/abs/2024AGUFMOS41H0545X/
Results

Xu, G., & German, C. R. (2023). Dispersion of deep-sea hydrothermal plumes at the Endeavour Segment of the Juan de Fuca Ridge: a multiscale numerical study. Frontiers in Marine Science, 10. https://doi.org/10.3389/fmars.2023.1213470
Results

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Project Information

Collaborative Research: Hydrothermal Estuaries: What Sets the Hydrothermal Flux of Fe and Mn to the Oceans? (Hydrothermal Estuaries)

Coverage: Juan de Fuca Ridge

NSF Award Abstract:

NSF Award Abstract:
Like volcanoes on land, the mid-ocean ridges that cross the ocean floor are not continuously erupting; however, the magmatic heat present just beneath the surface can continue to drive hot springs, just like the ones found within the crater of the "super volcano" at Yellowstone. In our recent work, we have shown that the chemicals released into the oceans from seafloor hot-springs can be dispersed all across the oceans. Now our interest has focused in on one element in particular, iron. This is one of the most abundant elements in every planetary body in the Universe yet it is vanishingly rare in Earth's oceans today. Set against that, it is essential to just about every form of life on Earth from the simplest and most ancient strains of microbes to the most complex animals including humans. In Earth's oceans, the lack of this "essential micro-nutrient" has been found to limit how much life can flourish near both the south and north poles in the Pacific Ocean in the sunlit surface ocean even though the supply of sunlight and other major nutrients (phosphorous, nitrogen) should be more than adequate. Our newest research suggests that iron released from hydrothermal plumes (where the concentrations coming from vents are more than 1 million times higher than normal ocean water) could play a major role. Despite undergoing massive dilution as hydrothermal solutions leave the vents and traverse thousands of kilometers through the oceans, we believe that at least some of the iron released from deep sea hot springs can survive this journey and make a significant impact on how much live exists in Earth's polar oceans and how much CO2 it draws down from the atmosphere. To investigate that idea, this project will study the fate of iron released from a hydrothermal vent over a length scale that hasn't been studied before - from the first 1km through the ocean out to 100km away from the vent-site. This will fill a gap in our knowledge between what happens right at a vent-site (as studied by research submarines) and what happens to ocean chemistry all across Earth's entire ocean basins (as studied by a huge international research project called GEOTRACES). Our work will use a 3D computational model to predict where the plume of material from a vent in the Northeast Pacific Ocean should escape to after it is erupted from some vents at a volcanic system called the Juan de Fuca Ridge. We will then use an advanced autonomous free-swimming robot to search out in the predicted plume area, first to test the accuracy of our predicted model and, second, to collect samples from the hydrothermal plume from where it first forms to as far out as we can follow it. The samples we collect will include both filtered seawater and the particulate material (whether mineralogical or microbiological) that we can extract from the filters. Together, this will allow us to track the fate of the iron and other key physical and geochemical tracers down-plume away from the vents, to work out where it ends up (in the water and in the sediments) and also how fast those processes happen. The work we do will also help plan how to conduct similar robotics-based exploration on future space missions beyond Earth where it has been hypothesized that seafloor events also exist (e.g. Saturn's moon Enceladus) and where, if we are really lucky, we may find that life is hosted based on the energy from seafloor volcanoes, just as happens here on Earth. We have a resident artist embedded in our program who has already begun experimenting with the use of air-flow and sound in her sculptures to help communicate the complex nature of these plumes. She will join our cruise, and work with our team post-cruise to design and hopefully build a sculpture that that could potentially result in a large and long-term outdoor installation.

The international GEOTRACES program has revealed that iron (Fe) is released ubiquitously from submarine ridges to the deep ocean. Results from US GEOTRACES section GP16 showed that both dissolved and particulate (colloidal) Fe may persist so far as to be able to influence primary productivity in High-Nutrient/Low-Chlorophyll (HNLC) regions of the Southern Ocean. As a complement to these sectional studies, we propose a detailed process study to elucidate the mechanisms by which hydrothermally sourced Fe can persist across the oceans at the scale that GEOTRACES has revealed. Specifically, while the "persistent" Fe in a hydrothermal plume appears to behave quasi-conservatively from 100km to 4000km across the SE Pacific Ocean, it is also known that the majority of the Fe present at the Southern EPR on that US GEOTRACES GP16 cruise did not persist over the 100km separation between that station and the next deep ocean station beyond the ridge crest. To fill that gap, this project will conduct a coupled modelling and field study to investigate the fate of hydrothermally sourced Fe at ranges of 0-1, 1-10 and 10-100km down-plume away from a well established vent-source. To begin, we will use the detailed micro-bathymetry and the long-term current meter data available from the Main Endeavour Segment of the Juan de Fuca Ridge to implement a recently developed 3D theoretical plume dispersion model that can predict both the detailed 3D dispersion trajectory and the rate of flow within the hydrothermal plume away from two long-studied and well characterized Main Endeavour Field (MEF) vents. At sea, we will use that predictive model to guide Sentry autonomous underwater vehicle (AUV) surveys that will follow the plume "down-wind" and "across-plume" to compile a 3D survey using in-situ sensors [optical, redox, conductivity, temperature, depth (CTD)] that will allow us to (1) confirm (and better constrain) the predictive model, and to (2) map out the shape and trajectory of the plume to provide context for discrete water column samples that we will collect - both from the AUV and from a trace metal clean CTD-rosette. Sampling from the AUV will use the latest generation of SUPR samplers designed for the CLIO trace-metal-clean water sampler. This will suffice for samples of dissolved, colloidal and particulate trace metals and collection of filtered material for grain-by-grain mineralogical and biogeochemical analyses. That sampling program will be backed up by larger volume sampling down-plume using a CTD-rosette to augment our AUV-based program with helium isotope analyses (to track extents of physical plume dilution at increasing distances downwind and across plume) and for complementary ligand and organic compound analyses to investigate the role that organic complexation might play in protecting reduced species of Fe [and manganese (Mn), too] against oxidative precipitation and removal from the oceanic water column. Post cruise, our combination of biogeochemical measurements and improved 3D physical modelling will not only be able to provide new insights into the processes that control the fluxes of Fe and Mn to the oceans from hydrothermal venting but also the length scales over which those processes take effect. Finally, because our 3D theoretical model includes velocities, we also anticipate being able to deduce the rates at which these processes occur.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851007
NSF Division of Ocean Sciences (NSF OCE)	OCE-1851199

[table of contents | back to top]