Aerosol and seawater beryllium-7 concentrations from the French GEOTRACES GS02 SWINGS cruise aboard R/V Marion-Dufresne (MD229) from January to March 2021

Website: https://www.bco-dmo.org/dataset/927568
Data Type: Cruise Results
Version: 1
Version Date: 2024-05-15

Project
» Collaborative Research: Quantifying the atmospheric flux of bio-active trace elements to the southwestern Indian Ocean (SWINGS Be-7)

Program
» U.S. GEOTRACES (U.S. GEOTRACES)

Contributors	Affiliation	Role
Stephens, Mark	Florida International University (FIU)	Principal Investigator
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Abstract
Beryllium-7, a cosmogenic radioactive isotope with a half-life of 53.3 days, is formed in the atmosphere, attaches to aerosol particles, and is deposited on the earth's surface through wet and dry processes. In this project, we measured Be-7 concentrations in aerosol particles and in seawater samples (depths < 200 meters) collected on the French GEOTRACES section GS02 SWINGS cruise aboard R/V Marion-Dufresne. The cruise originated at Réunion Island on 11 January 2021 and concluded at Réunion on 8 March 2021. Nineteen aerosol samples and seawater from eleven stations in the South Indian Ocean were collected. The dataset will be used to study the deposition of trace elements and isotopes (TEIs) and upper ocean mixing processes. Aerosol deposition is an important source of TE micronutrients to open ocean areas that are far removed from riverine sources. But, while the collection aerosol of samples for TEI analysis is straightforward, estimating the deposition flux also requires an appropriate deposition velocity (i.e. deposition flux is the product of the aerosol concentration and deposition velocity). Because Be-7 is supplied to the open ocean exclusively through aerosol deposition and it is removed through radioactive decay, the water column inventory and aerosol concentration of Be-7 can be used to derive the deposition velocity applicable to aerosol TEIs.

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Coverage

Location: Antarctic circumpolar current region of the South Indian Ocean
Spatial Extent: **N**:-25 **E**:81.912 **S**:-57.992 **W**:31.701
Temporal Extent: 2021-01-14 - 2021-03-04

Methods & Sampling

Seawater sampling: The procedures used on the GS02 SWINGS cruise were identical to those described for the GEOTRACES GP15 and GP16 cruises by Kadko et al. (2017, 2020), except that a Grundfos submersible centrifugal pump rather than a deck mounted pump was used to collect the seawater. Briefly, the submersible pump was attached to a 1.5-inch PVC hose and lowered to selected depths. 400 to 700 liters (L) of seawater were delivered to large plastic tanks in this manner. Beryllium-7 (Be-7) was then extracted by pumping the seawater through 200 grams (g) of iron impregnated acrylic fibers at a rate of ~10 liters per minute (Lai et al., 1988; Krishnaswami et al., 1972; Lee et al., 1991). A portable profiling CTD (model: Seabird SBE 19Plus) was attached to the end of the hose so that temperature, depth, and salinity could be recorded.

Aerosol sampling: Aerosol samples were collected according to protocols set forth in the GEOTRACES cookbook using a Tisch TE-5170V-BL high-volume aerosol sampler modified to collect 12 replicate samples on 47-millimeter (mm) diameter Whatman-41 (W-41) filters (Wallace et al, 1977; Baker et al., 2006). In order to minimize filter blanks, the W-41 filters were pre-cleaned inside a HEPA-filtered laminar flow hood using three cycles of leaching with 0.5M HCl (Optima) and then rinsing with ultra-high purity water (UHP water) according to trace element protocols (Morton et al., 2013; similar to Baker et al., 2006). Sector control, which was accomplished via a Campbell Scientific data logger, was set such that the sampler would only operate during winds of >0.5 meters per second (m/s) and from ± 60° of the ship's bow to avoid sampling air influenced by the ship's exhaust. Three replicate filters from each deployment, placed in PetriSlides, were sent to FIU for Be-7 analysis.

Analytical procedures: Samples were counted for Be-7 onshore using low background germanium gamma detectors at Florida International University (FIU). FIU's facilities include four HPGe detectors: three Ortec Coaxial GEM series detectors and one Canberra Broad Energy gamma detector. For aerosols, the three replicate 47 mm filters were stacked in a Petri dish for counting. For seawater, the fibers were dried and then ashed. The powder remaining after ashing was pressed into a 5.8-centimeter (cm) diameter pellet, and the pellet thickness was measured. The iron hydroxide pellet was placed in a Petri dish for gamma counting. Be-7 has a readily identifiable gamma peak at 478 kiloelectron volts (keV), and the spectra were evaluated using Maestro (Ortec) or Genie 2000 (Canberra) software.

The detectors were calibrated for each geometry by adding a commercially prepared mixed isotope solution of known gamma activities (Eckert & Ziegler Mixed Nuclide Solution 7500) to three W-41 filters (for aerosol samples) and pellets of various thicknesses (for seawater) to derive a calibration curve using peaks associated with following isotopes: Sn-113 @ 392 keV, Sr-85 @ 514 keV, Cs-137 @ 662 keV. The counting efficiencies of the four detectors ranges from 0.05686 to 0.11415 for Be-7 on aerosol filters. And for the seawater pellets from this cruise, the counting efficiencies ranged from 0.03480 to 0.08590.

Data Processing Description

Data Processing:
Be-7 has a readily identifiable gamma peak at 478 keV, and the spectra were evaluated using Maestro (Ortec) or Genie 2000 (Canberra) software.

Reported Be-7 activities were corrected to the time of sampling. The calculation is as follows:

$[\text{Be-7, dpm m-3}] = \{cpm \bullet ct \bullet \lambda \bullet \exp(\lambda \bullet d)\} / \{CE \bullet PE \bullet FE \bullet V \bullet [1-\exp(-\lambda \bullet ct)]\}$, where:

cpm = background corrected counts per minute for the region of interest (ROI);
ct = count time (days);
λ = the Be-7 radioactive decay constant (0.013 day-1);
CE = counting efficiency;
PE = photon emission probability (0.104 for Be-7);
FE – fiber extraction efficiency (92 ±3%);
V= volume (m-3);
d = time from sample collection to start of count (days)

The error (in counts) associated with each measurement is the statistical counting error (σ) and the uncertainty in the blank, $\sqrt{(\sigma 2 + \sigma b2)}$, multiplied by $\{ct \bullet \lambda \bullet \exp(\lambda \bullet d)\} / \{CE \bullet PE \bullet FE \bullet V \bullet [1-\exp(-\lambda \bullet ct)]\}$. The uncertainty of the extraction efficiency (3%) and the detector efficiency (2%) was in all cases smaller than the statistical counting error.

Quality Flags:
Quality flags were applied following the GEOTRACES policy (https://www.geotraces.org/geotraces-quality-flag-policy/), which recommends the SeaDataNet Scheme:
0 = no quality control;
1 = good value;
2 = probably good value;
3 = probably bad value;
4 = bad value;
5 = changed value;
6 = value below detection; (see attached Supplemental File for detection limits for Be-7 samples)
7 = value in excess;
8 = interpolated value;
9 = missing value;
A = value phenomenon uncertain.

Intercalibration and detection limits are provided in the attached Supplemental File "MD229_Intercal_and_Detection_Limits_Be7.pdf".

BCO-DMO Processing Description

- Imported original file "MD229_7Be_Data.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Created ISO 8601 date-time fields.
- Converted date columns to YYYY-MM-DD.
- Removed empty columns (Gear_ID, Rosette_Position).
- Saved the final file as "927568_v1_gs02_beryllium-7.csv".

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Data Files

File
927568_v1_gs02_beryllium-7.csv (Comma Separated Values (.csv), 7.49 KB) MD5:527dadb174392b214a7203a8a6ba547b Primary data file for dataset ID 927568, version 1

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Supplemental Files

File
Be-7 intercalibration and detection limits. filename: MD229_Intercal_and_Detection_Limits_Be7.pdf (Portable Document Format (.pdf), 194.14 KB) MD5:261c650c5704404eee07cce0033199f4 Supplemental file for dataset ID 927568, version 1. Intercalibration report and detection limits for Be-7 samples.

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Related Publications

Baker, A. R., French, M., & Linge, K. L. (2006). Trends in aerosol nutrient solubility along a west–east transect of the Saharan dust plume. Geophysical Research Letters, 33(7). doi:10.1029/2005gl024764 https://doi.org/10.1029/2005GL024764
Methods

Kadko, D. (2017). Upwelling and primary production during the U.S. GEOTRACES East Pacific Zonal Transect.

Global Biogeochemical Cycles. doi:10.1002/2016gb005554 https://doi.org/10.1002/2016GB005554
Methods

Kadko, D., Landing, W. M., & Buck, C. S. (2020). Quantifying Atmospheric Trace Element Deposition Over the Ocean on a Global Scale With Satellite Rainfall Products. Geophysical Research Letters, 47(7). Portico. https://doi.org/10.1029/2019gl086357 https://doi.org/10.1029/2019GL086357
Methods

Krishnaswami, S., Lal, D., Somayajulu, B. L. K., Dixon, F. S., Stonecipher, S. A., & Craig, H. (1972). Silicon, radium, thorium, and lead in seawater: In-situ extraction by synthetic fibre. Earth and Planetary Science Letters, 16(1), 84–90. doi:10.1016/0012-821x(72)90240-3
Methods

Lai, D., Chung, Y., Platt, T., & Lee, T. (1988). Twin cosmogenic radiotracer studies of phosphorus recycling and chemical fluxes in the upper ocean. Limnology and Oceanography, 33(6part2), 1559–1567. doi:10.4319/lo.1988.33.6part2.1559
Methods

Lee, T., Barg, E., & Lal, D. (1991). Studies of vertical mixing in the Southern California Bight with cosmogenic radionuclides 32P and 7Be. Limnology and Oceanography, 36(5), 1044–1052. doi:10.4319/lo.1991.36.5.1044
Methods

Morton, P. L., Landing, W. M., Hsu, S.-C., Milne, A., Aguilar-Islas, A. M., Baker, A. R., … Zamora, L. M. (2013). Methods for the sampling and analysis of marine aerosols: results from the 2008 GEOTRACES aerosol intercalibration experiment. Limnology and Oceanography: Methods, 11(2), 62–78. doi:10.4319/lom.2013.11.62
Methods

Wallace, G. T., Fletcher, I. S., & Duce, R. A. (1977). Filter washing, a simple means of reducing blank values and variability in trace metal environmental samples. Journal of Environmental Science and Health . Part A: Environmental Science and Engineering, 12(9), 493–506. doi:10.1080/10934527709374775
Methods

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Parameters

Parameter	Description	Units
Station_ID	Station ID number (blank values = no station number for aerosol sampler deployments)	unitless
Event_ID	Event ID	unitless
Start_Date_UTC	Sample collection start date	unitless
Start_Time_UTC	Sample collection start time (UTC)	unitless
Start_ISO_DateTime_UTC	Sample collection start date and time (UTC) in ISO 8601 format	unitless
End_Date_UTC	Sample collection end date (for aerosol sampler deployments)	unitless

End_Time_UTC	Sample collection end time (for aerosol sampler deployments) (UTC)	unitless
End_ISO_DateTime_UTC	Sample collection send date and time (UTC) in ISO 8601 format (for aerosol sampler deployments)	unitless
Start_Latitude	Latitude at start of sample collection	decimal degrees
Start_Longitude	Longitude at start of sample collection	decimal degrees
End_Latitude	Latitude at end of sample collection (for aerosol sampler deployments)	decimal degrees
End_Longitude	Longitude at end of sample collection (for aerosol sampler deployments)	decimal degrees
Sample_ID	GEOTRACES sample ID number	unitless
Sample_Depth	Depth of seawater sample	meters (m)
Be_7_D_CONC_PUMP_ggelbm	Seawater beryllium-7 activity concentration	microBecquerel per kilogram (uBq/kg)
SD1_Be_7_D_CONC_PUMP_ggelbm	One standard deviation for Be_7_D_CONC_PUMP_ggelbm	microBecquerel per kilogram (uBq/kg)
Flag_Be_7_D_CONC_PUMP_ggelbm	Quality flag for Be_7_D_CONC_PUMP_ggelbm. SeaDatNet flag scheme.	unitless
Be_7_A_T_CONC_HIVOL_0nfmzr	Aerosol beryllium-7 activity concentration	milliBecquerel per cubic meter (mBq/m^3)
SD1_Be_7_A_T_CONC_HIVOL_0nfmzr	One standard deviation for Be_7_A_T_CONC_HIVOL_0nfmzr	milliBecquerel per cubic meter (mBq/m^3)
Flag_Be_7_A_T_CONC_HIVOL_0nfmzr	Quality flag for Be_7_A_T_CONC_HIVOL_0nfmzr. SeaDataNet flag scheme.	unitless

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Instruments

Dataset-specific Instrument Name	Tisch TE-5170V-BL high volume aerosol sampler
Generic Instrument Name	Aerosol Sampler
Generic Instrument Description	A device that collects a sample of aerosol (dry particles or liquid droplets) from the atmosphere.

Dataset-specific Instrument Name	Seabird SBE 19Plus
Generic Instrument Name	CTD Sea-Bird SBE SEACAT 19plus
Generic Instrument Description	Self contained self powered CTD profiler. Measures conductivity, temperature and pressure in both profiling (samples at 4 scans/sec) and moored (sample rates of once every 5 seconds to once every 9 hours) mode. Available in plastic or titanium housing with depth ranges of 600m and 7000m respectively. Minature submersible pump provides water to conductivity cell.

Dataset-specific Instrument Name	Campbell Scientific data logger
Generic Instrument Name	Data Logger
Generic Instrument Description	Electronic devices that record data over time or in relation to location either with a built-in instrument or sensor or via external instruments and sensors.

Dataset-specific Instrument Name	low background germanium gamma detectors
Generic Instrument Name	Germanium detector
Dataset-specific Description	FIU's facilities include four HPGe detectors: three Ortec Coaxial GEM series detectors and one Canberra Broad Energy gamma detector. The detectors were calibrated for the each geometry by adding a commercially prepared mixed isotope solution of known gamma activities (Eckert & Ziegler Mixed Nuclide Solution 7500) to three W-41 filters (for aerosol samples) and pellets of various thicknesses (for seawater) to derive a calibration curve using peaks associated with following isotopes: Sn-113 @ 392 keV, Sr-85 @ 514 keV, Cs-137 @ 662 keV. The counting efficiencies of the four detectors ranges from 0.05686 to 0.11415 for Be-7 on aerosol filters. And for the seawater pellets from this cruise, the counting efficiencies ranged from 0.03480 to 0.08590.
Generic Instrument Description	Germanium detectors are semiconductor diodes having a p-i-n structure in which the intrinsic (i) region is sensitive to ionizing radiation, particularly x rays and gamma rays. Under reverse bias, an electric field extends across the intrinsic or depleted region. When photons interact with the material within the depleted volume of a detector, charge carriers (holes and electrons) are produced and are swept by the electric field to the p and n electrodes. This charge, which is in proportion to the energy deposited in the detector by the incoming photon, is converted into a voltage pulse by an integral charge sensitive preamplifier. Germanium detectors are mostly used for gamma spectroscopy in nuclear physics, as well as x-ray spectroscopy.

Dataset-specific Instrument Name	Grundfos submersible centrifugal pump
Generic Instrument Name	Pump
Dataset-specific Description	Grundfos SP2A-48 pump with Grundfos submersible motor (2.2 KW, 400 V)
Generic Instrument Description	A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps

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Deployments

MD229

Website	https://www.bco-dmo.org/deployment/927581
Platform	R/V Marion-Dufresne
Start Date	2021-01-11
End Date	2021-03-08
Description	French GEOTRACES section GS02 SWINGS Cruise on R/V Marion-Dufresne (cruise ID MD229). For more information, see the following: https://swings.geotraces.org/en/homepage-english/ The French GEOTRACES SWINGS GS02 cruise started from La Réunion island (France) on January 13th, 2021 and ended at the same place on March 8th, 2021. During 54 days, many stations have been sampled with various pieces of equipment on board the Marion Dufresne II research vessel in order to elucidate trace element sources, transformations, and sinks in key areas of the Indian sector of the Southern Ocean contributing to the global effort of the GEOTRACES programme.

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Project Information

Collaborative Research: Quantifying the atmospheric flux of bio-active trace elements to the southwestern Indian Ocean (SWINGS Be-7)

Coverage: Southwest Indian Ocean

NSF Award Abstract:
Marine phytoplankton (microscopic photosynthetic algae) produce about half of the oxygen we breath and remove billions of tons of carbon dioxide from the atmosphere each year. This primary productivity plays a central role in controlling atmospheric carbon dioxide (pCO2) levels and the global climate. Yet, phytoplankton productivity is limited by lack of iron (an essential trace element) in about 40% of the global ocean. While phytoplankton productivity helps remove carbon dioxide from the atmosphere, it also removes iron and other essential trace elements (like manganese, cobalt, copper, and zinc) from the upper ocean. One critical issue is, "What are the sources for these essential trace elements that are needed to replace those removed by phytoplankton to keep the annual productivity cycles going?" This is especially important in the waters of the Southern Ocean around Antarctica, where ocean circulation brings deep water to the surface; water that is enriched in nutrients like nitrate and phosphate but depleted in essential trace elements. The main source for

iron in the open ocean is from desert dust deposition. In this project, scientists will collect aerosols (fine particles in the air) and rain samples over the Southern Ocean to measure how much iron (and the other essential trace elements) is depositing to surface waters. Other scientists will be measuring how fast phytoplankton are growing, and together we will learn how the input of trace elements from dust helps to remove carbon dioxide from the atmosphere. This information can then be used to help predict the future of Earth's climate. The scientists will communicate results of their study to the public via open house events at their respective campuses, as well as through online forums. One undergraduate student from Florida International University, a leading minority serving university, would be supported and trained as part of this project.

The project will measure the aerosol fractional solubility and atmospheric deposition of bio-essential trace elements as part of a multidisciplinary project studying trace element sources, transformations and sinks in the Indian Ocean sector of the Southern Ocean. The research cruise track will cross the currents and oceanographic fronts that are major pathways of the general circulation in the region where we expect to find multiple possible aerosol sources, and where aerosol Fe deposition and rainfall rates are predicted to range over 1-2 orders of magnitude. Aerosol samples (bulk and size-fractionated) will be collected on a daily basis and event-based rain samples to be analyzed for total and soluble major and trace elements including nitrate, phosphate, silicate, chloride, sulfate, Na, Mg, Al, V, Mn, Fe, Co, Ni, Cu, Zn, and Cd. In addition, scientists will analyze the water-soluble organic compounds in aerosols, focusing on compounds such as oxalate and methane-sulfonic acid (MSA) that enhance aerosol trace element solubility. Scientists will use Be-7 concentrations in aerosols and the upper water column to calculate aerosol bulk deposition velocities and test whether the relationship between rainfall rate and bulk deposition velocity that we have previously published can be applied on a more global basis. Further, scientists will use the trace element concentration data along with air-mass back trajectory analysis to apportion the aerosols between anthropogenic and natural sources, and study how aerosol sources affect the fractional solubility. Aerosol and rain subsamples will be provided to collaborators on the cruise for the analysis of additional important parameters.

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.

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Program Information

U.S. GEOTRACES (U.S. GEOTRACES)

Website: http://www.geotraces.org/

Coverage: Global

GEOTRACES is a SCOR sponsored program; and funding for program infrastructure development is provided by the U.S. National Science Foundation.

GEOTRACES gained momentum following a special symposium, S02: Biogeochemical cycling of trace elements and isotopes in the ocean and applications to constrain contemporary marine processes (GEOSECS II), at a 2003 Goldschmidt meeting convened in Japan. The GEOSECS II acronym referred to the Geochemical Ocean Section Studies To determine full water column distributions of selected trace elements and isotopes, including their concentration, chemical speciation, and physical form, along a sufficient number of sections in each ocean basin to establish the principal relationships between these distributions and with more traditional hydrographic parameters;

* To evaluate the sources, sinks, and internal cycling of these species and thereby characterize more completely the physical, chemical and biological processes regulating their distributions, and the sensitivity of these processes to global change; and

* To understand the processes that control the concentrations of geochemical species used for proxies of the past environment, both in the water column and in the substrates that reflect the water column.

GEOTRACES will be global in scope, consisting of ocean sections complemented by regional process studies. Sections and process studies will combine fieldwork, laboratory experiments and modelling. Beyond realizing the scientific objectives identified above, a natural outcome of this work will be to build a community of marine scientists who understand the processes regulating trace element cycles sufficiently well to exploit this knowledge reliably in future interdisciplinary studies.

Expand "Projects" below for information about and data resulting from individual US GEOTRACES research projects.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2147723

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