Noble gas concentrations, N2/Ar and saturation anomalies (with associated CTD data) from the Labrador Sea in 2007, 2011, 2015, 2016 (N2:Ar Deep Tracer)

Website: https://www.bco-dmo.org/dataset/719989
Data Type: Cruise Results
Version:
Version Date: 2017-12-06

Project
» The Marine Dissolved N2/Ar Ratio, A Tracer for Deep Ocean Denitrification? (N2:Ar Deep Tracer)

Contributors	Affiliation	Role
Hamme, Roberta C.	University of Victoria (UVic)	Principal Investigator
Emerson, Steven R.	University of Washington (UW)	Co-Principal Investigator
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Coverage

Spatial Extent: **N**:60.4428 **E**:-48.542 **S**:55.4228 **W**:-56.5368
Temporal Extent: 2007-05-14 - 2016-05-14

Dataset Description

This data is provided free for educational and non-profit research purposes. Please cite the publication listed under Acquisition Description in any work that uses this database. If you would like to be apprised of any future corrections or updates to the data, send an e-mail to rhamme@uvic.ca. If you discover what you believe to be an error in the database, it is your responsibility to send an e-mail to rhamme@uvic.ca before using the data in a publication.

Both MatLab .mat databases and comma-delimited .csv text files are provided. These two formats contain identical information. The data from the paper is listed in order of collection (date). Different cruises can be identified by the cruise name or date.

Download the Matlab file: LabSea_Hammeetal2017-12-06

Methods & Sampling

Methodology is given in Hamme et al. (2017). Briefly, samples are collected through CO2-flushed tubing into ~180mL evacuated glass flasks until half full. Samples are weighed. The water is equilibrated with the headspace, then removed. Headspace gases are cryogenically purified to remove H2O and CO2 for N2/Ar samples or to

remove all gases except noble gases for the noble gas samples. An additional aliquot of 38Ar is added to the noble gas samples along with a balance gas of either N2 or He. Samples are analyzed on a MAT 252 or 253 isotope ratio mass spectrometer for the noble gas and UVic N2/Ar samples, and on a Delta XL for the N2/Ar samples run at UW. Samples are analyzed against standards of similar composition. Standard gases are calibrated relative to air with assumed dry mole fractions of 1.818e-5 for Ne, 9.34e-3 for Ar, 1.141e-6 for Kr, and 0.78084 for N2.

Related Reference:
These data were published in Figures 1, 2 and 4 of:
Hamme, R. C., Emerson, S. R., Severinghaus, J. P., Long, M. C., & Yashayaev, I. (2017). Using noble gas measurements to derive air-sea process information and predict physical gas saturations. Geophysical Research Letters, 44, 9901–9909. https://doi.org/10.1002/2017GL075123

Data Processing Description

All samples were collected in duplicate. Only data for which both duplicates were successfully analyzed and whose standard deviation was within three times the overall dataset pooled standard deviation are included in this dataset.

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- replaced commas and colons with semicolons

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Data Files

File
LabSea_gas.csv (Comma Separated Values (.csv), 31.95 KB) MD5:2e4dec38a861b2d5c2b4db3192fab82e Primary data file for dataset ID 719989

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Related Publications

Hamme, R. C., Emerson, S. R., Severinghaus, J. P., Long, M. C., & Yashayaev, I. (2017). Using Noble Gas Measurements to Derive Air-Sea Process Information and Predict Physical Gas Saturations. Geophysical Research Letters, 44(19), 9901–9909. doi:10.1002/2017gl075123 https://doi.org/10.1002/2017GL075123
Results

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Parameters

Parameter	Description	Units
latitude	The latitude of the station in degrees North.	decimal degrees
longitude	The longitude of the station in degrees East. Negative numbers indicate oW.	decimal degrees
event	number of the cast event that the water samples were drawn from.	unitless
niskin	number of the niskin that the water samples were drawn from.	unitless
year	year of sample collection	unitless
month	month of sample collection	unitless
day	day of sample collection	unitless

cruisename	The EXPO number is listed first, followed by a more colloquial cruise name, followed by the ship name, separated by semicolons. In Matlab file, formatted as cell array of strings.	unitless
press	Pressure	decibars
CTDtemp	in situ temperature measured by the CTD (AR7W cruises: finalized CTD data is an average of downcasts and upcasts within 10dbar of the pressure where the niskin bottle closed;GEOTRACES cruise: finalized CTD data from rosette bottle file) in oC on the ITS-90 Temperature Scale.	degrees Celsius
CTDsal	salinity measured by the CTD (AR7W cruises: finalized CTD data is an average of downcasts and upcasts within 10dbar of the pressure where the niskin bottle closed; GEOTRACES cruise: finalized CTD data from rosette bottle file); expressed on the PSS-78 scale.	unitless
Ne	Ne concentration in umol/kg determined by combining mass spectrometric Ne/Ar ratio measurements with absolute Ar concentrations by Ar isotope dilution with 38Ar. As discussed in the paper: the Ne method uses a helium balance gas but is otherwise similar to that of Hamme and Severinghaus (2007) "Trace gas disequilibria during deep-water formation" Deep Sea Research I: 54(6):939-950. Standard gases are calibrated relative to air with assumed dry mole fractions of 1.818e-5 for Ne.	micromol/kilogram
Ar	Ar concentration in umol/kg determined by Ar isotope dilution with 38Ar. As discussed in the paper, the 2007 measurements follow Hamme and Severinghaus (2007) "Trace gas disequilibria during deep-water formation" Deep Sea Research I: 54(6):939-950 while the later measurements use a similar method but with a helium balance gas. Standard gases are calibrated relative to air with assumed dry mole fractions of 9.34e-3 for Ar.	micromol/kilogram
Kr	Kr concentration in umol/kg determined by combining mass spectrometric Kr/Ar ratio measurements with absolute Ar concentrations by Ar isotope dilution with 38Ar. As discussed in the paper, the 2007 measurements follow Hamme and Severinghaus (2007) "Trace gas disequilibria during deep-water formation" Deep Sea Research I: 54(6):939-950; while the later measurements use a similar method but with a helium balance gas. Standard gases are calibrated relative to air with assumed dry mole fractions of 1.141e-6 for Kr.	micromol/kilogram
N2Ar	N2/Ar ratio determined by mass spectrometry with no units. Samples from 2007 were analyzed at Scripps Institution of Oceanography by purification with heated copper to remove oxygen following T. Kobashi; J.P. Severinghaus and K. Kawamura (2008) "Argon and nitrogen isotopes of trapped air in the GISP2 ice core during the Holocene epoch (0-11500 B.P.): Methodology and implications for gas loss processes" Geochim. Cosmochim. Acta 72 (19):4675-4686; doi:10.1016/j.gca.2008.07.006. Measurements from later years were analyzed at University of Victoria following Emerson et al. (1999) "Accurate measurement of O2, N2, and Ar gases in water and the solubility of N2" Marine Chemistry 64:337-347. Standard gases are calibrated relative to air with assumed dry mole fractions of 9.34e-3 for Ar and 0.78084 for N2.	unitless
N2Ar_UW	Same as for N2Ar but for data analyzed at University of Washington following a method that includes a 36Ar spike but otherwise follows Emerson et al. (1999) "Accurate measurement of O2, N2, and Ar gases in water and the solubility of N2" Marine Chemistry 64:337-347. Standard gases are calibrated relative to air with assumed dry mole fractions of 9.34e-3 for Ar and 0.78084 for N2.	unitless
depth	Depth	meters
ptmp	Potential temperature in oC and referenced to the surface.	degrees Celsius
sigma_theta	Potential density of the seawater expressed in sigma units and referenced to the surface.	kilograms per meter cubed - 1000
water_mass	Water mass for each sample identified using potential temperature and salinity data. 1 = LSW (Labrador Sea Water); 2 = IC (Irminger Current); 3 = ISW (Icelandic Slope Water); 4 = NEADW (NorthEast Atlantic Deep Water); 5 = DSOW (Denmark Strait Overflow Water); 6 = transitional water masses.	unitless

Nesat	Saturation anomaly of Ne in percent. 0% indicates that the Ne concentration is equal to that expected at equilibrium for the potential temperature and salinity of the water. ie. Nesat = (Ne/Neeq - 1) *100 The Ne saturation anomaly is calculated relative to the solubility curve of Hamme and Emerson (2004) "The solubility of neon, nitrogen, and argon in distilled water and seawater" Deep-Sea Research I: 51(11):1517-1528.	percent
Arsat	Saturation anomaly of Ar in percent. 0% indicates that the Ar concentration is equal to that expected at equilibrium for the potential temperature and salinity of the water. ie. Arsat = (Ar/Areq - 1) *100 The Ar saturation anomaly is calculated relative to the solubility curve of Hamme and Emerson (2004) "The solubility of neon, nitrogen, and argon in distilled water and seawater" Deep-Sea Research I: 51(11):1517-1528.	percent
Krsat	Saturation anomaly of Kr in percent. 0% indicates that the Kr concentration is equal to that expected at equilibrium for the potential temperature and salinity of the water. ie. Krsat = (Kr/Kreq - 1) *100 Kr saturation anomaly is calculated relative to the solubility curve of Weiss and Kyser (1978) "Solubility of Krypton in Water and Seawater" Journal of Chemical Thermodynamics 23(1):69-72.	percent
N2Arsat	Saturation anomaly of N2/Ar ratio in percent. N2/Ar ratio determined by mass spectrometry divided by the equilibrium ratio for the potential temperature and salinity of the water - 1 * 100; ie. N2Arsat = ((N2/Ar) / (N2eq/Areq) - 1) * 100. N2/Ar saturation anomaly is calculated relative to the solubility curves of Hamme and Emerson (2004) "The solubility of neon, nitrogen, and argon in distilled water and seawater" Deep-Sea Research I: 51(11):1517-1528.	percent
N2Arsat_UW	Same as for N2Arsat but for data analyzed at University of Washington.	percent

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Instruments

Dataset-specific Instrument Name	Thermo Finnigan MAT253
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Thermo Finnigan MAT252
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Thermo Finnigan Delta XL
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

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Deployments

18HU20070510

Website	https://www.bco-dmo.org/deployment/719851
Platform	CCGS Hudson
Report	https://datadocs.bco-dmo.org/d3/data_docs/N2Ar_Deep_Tracer/cruise_rpt_ar07w_18HU20070510do.pdf
Start Date	2007-05-10
End Date	2007-05-27
Description	WOCE Line AR7W cruise

18HU20110506

Website	https://www.bco-dmo.org/deployment/719854
Platform	CCGS Hudson
Report	https://datadocs.bco-dmo.org/d3/data_docs/N2Ar_Deep_Tracer/cruise_rpt_ar07w_18HU20110506do.txt
Start Date	2011-05-06
End Date	2011-05-28
Description	WOCE Line AR7W cruise

18DL20150710

Website	https://www.bco-dmo.org/deployment/719857
Platform	CCGS Amundsen
Report	https://datadocs.bco-dmo.org/d3/data_docs/N2Ar_Deep_Tracer/geotraces_canadian_cruise_report_gn02_gn03_and_figs.pdf
Start Date	2015-07-10
End Date	2015-08-20
Description	A GEOTRACES cruise in the Canadian Arctic

18HU20150504

Website	https://www.bco-dmo.org/deployment/720001
Platform	CCGS Hudson
Start Date	2015-05-04
End Date	2015-05-24

18HU20160430

Website	https://www.bco-dmo.org/deployment/719999
Platform	CCGS Hudson
Start Date	2016-04-30
End Date	2016-05-24

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Project Information

The Marine Dissolved N2/Ar Ratio, A Tracer for Deep Ocean Denitrification? (N2:Ar Deep Tracer)

Coverage: Global oceans

The role of nitrate in the ocean carbon cycle and its relatively short residence time make it crucial to understand the marine nitrogen cycle; however, there is currently insufficient experimental evidence to accurately determine present day fluxes. Denitrification and nitrogen fixation are the main sink and source for dissolved inorganic nitrogen in the sea.

In this study a research team at the University of Washington will collaborate with colleagues at the University of Victoria to study changes in the N2/Ar ratio in seawater caused by denitrification. Previous research has demonstrated the utility of this tracer in the oxygen minimum zones of the Pacific and Indian Ocean, but they will investigate observed changes in the "background" distribution of the ratio. The investigators already have unpublished data that indicate the N2/Ar ratio increases by about 0.5 % from the Atlantic to Pacific Oceans in waters below 1000 meters. If this increase is assumed to be caused by denitrification in deep ocean sediments it amounts to roughly 80 Tg/yr of denitrification. This is a significant portion of estimated global denitrification (between 200 and 400 Tg/yr) and within the range of the largely untested predictions of deep-ocean sediment denitrification using global sediment diagenesis models. Presently it is not possible to unequivocally attribute the observed deep water column N2/Ar increase to denitrification because it could also be caused by deep-water formation processes in the Antarctic.

The investigators will separate the fraction of the N2/Ar ratio increase due to the physical processes of atmosphere or ice-water interaction from that due to denitrification by measuring other noble gas ratios (primarily Ne/Ar and Kr/Ar) that change only in response to ocean surface cooling and bubble processes. They will measure deep water-column profiles of N2/Ar, Ne/Ar and Kr/Ar in strategically-located sites where there are ships of opportunity: the Labrador Sea, the North Atlantic at the Bermuda time-series site, the Drake Passage, the Indian Ocean south of Madagascar, the subtropical North Pacific at the Hawaii Ocean time-series site, and the subarctic North Pacific at Station P. Preliminary measurements of all of the gas ratios have been made, and extensive testing has been done to identify sources of contamination in the sampling methods. This proposal involves a two-laboratory collaboration to make it possible to sample a large number of ocean sites, minimize atmospheric contamination by rapid sample analysis, and create maximum accuracy through laboratory intercalibration.

Broader Impacts: This project will promote international ocean science collaboration between the U.S.and Canada. It will support the research of an assistant professor to apply analytical methods that she has helped develop to an important problem in oceanography. A PhD candidate at the University of Washington will be trained in the area of chemical oceanography using analytical methods of gas ratio and isotope ratio mass spectrometry.

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Funding

Funding Source	Award
National Sciences and Engineering Research Council of Canada (NSERC)	328290-2006
NSF Division of Ocean Sciences (NSF OCE)	OCE-1029299
National Sciences and Engineering Research Council of Canada (NSERC)	329290-2012
National Sciences and Engineering Research Council of Canada (NSERC)	433848-2012
National Sciences and Engineering Research Council of Canada (NSERC)	433898-2012

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