Concentrations of He, Ne, Ar, Kr and Xe collected in copper tube samples in the SUSTAIN wind-wave tank in the summer of 2018

Website: https://www.bco-dmo.org/dataset/869304
Data Type: experimental
Version: 1
Version Date: 2022-02-03

Project
» Collaborative Research: RUI: Investigating Gas Exchange Processes using Noble Gases in a Controlled Environment (Gas Exchange at SUSTAIN)

Contributors	Affiliation	Role
Stanley, Rachel	Wellesley College	Principal Investigator
Haus, Brian	University of Miami Rosenstiel School of Marine and Atmospheric Science (UM-RSMAS)	Co-Principal Investigator
York, Amber D.	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Concentrations of He, Ne, Ar, Kr and Xe collected in copper tube samples in the SUSTAIN wind-wave tank in the summer of 2018. The results paper for these data was submitted to JGR-Oceans in December of 2021 and are in revision (Stanley et al., 2022).

Table of Contents

Coverage

Temporal Extent: 2018-07-10 - 2018-07-15

Methods & Sampling

Location: SUSTAIN wind-wave Tank, University of Miami

See Supplemental files "Experimental Conditions in SUSTAIN wind wave tank" which contain the same experiment numbers as this DiscreteNobleGasData dataset.

Methodology:

The noble gas concentrations (He, Ne, Ar, Kr and Xe) were measured at the Isotope Geochemistry facility at WHOI according to the method of Stanley et al. 2009 but with isotope dilution method for Kr and Xe, as in Jenkins et al. 2019. The copper tube samples were collected at the SUSTAIN tank at the start or end of each experiment and then shipped to WHOI for analysis. Full description of the sample collection and analysis is in

Stanley et al., “Gas Fluxes and Steady-State Saturation Anomalies at Very High Wind Speeds" Submitted to JGR-Oceans in Dec. 2021 (Stanley et al., 2022). Temperature was measured by an optode and salinity was interpolated from discrete samples collected by salinity and measured at the University of Miami.

Sampling and analytical procedures:

A full description of the sample collection and analysis is in Stanley et al., “Gas Fluxes and Steady State Saturation Anomalies at Very High Wind Speeds “ Submitted to JGR-Oceans in Dec. 2021. Here is the relevant paragraph about discrete noble gas measurements from that paper:

At the end of every experiment, and at the beginning of approximately half the experiments (the experiments conducted with U_10 = 20, 30, 40 and 50 m s-1 and the invasion/evasion experiments), samples for discrete noble gas analysis were collected in copper tubes (Jenkins et al., 2019; Loose et al., 2016). The samples were drawn from the tank through pre-soaked tygon tubing into 1 m of 5/8” diameter copper tubing, bubbles were removed by rapping, and at least 1 L of water was allowed to flow through the tube. Flow was temporarily stopped by clips and then the ends of the copper tube were cold-welded (Young and Lupton, 1983), producing two gas-tight samples of ~45 g each per time-point, though typically only one sample was analyzed. Samples were shipped to the Isotope Geochemistry Facility at WHOI where the gases were first extracted from the sealed copper tube into 30 mL aluminosilicate glass ampoules using an evacuated noble gas extraction line (Jenkins et al., 2019) and then analyzed for He, Ne, Ar, Kr and Xe on a quadrupole mass spectrometer by first being separated cryogenically and then using ion beam manometry spectrometry for He, Ne and Ar, and isotope dilution for Kr and Xe (given the smaller abundances of Kr and Xe, isotope dilution is required for better precision and accuracy) (Jenkins et al., 2019; Stanley et al., 2009a). Precison of the system, based on measurements of duplicate samples, is 0.1% for He, Ne, Ar, Kr and 0.2% for Xe.

Temperature was interpolated from in situ measurements of temperature made by an Anderra optode located next to the in situ pump that brought water to the copper tubes. Salinity measurements were made at the beginning and end of most experiments and then interpolated to the time of noble gas data collection to obtain an appropriate salinity. The salinity in the SUSTAIN tank changed slowly for the most part since typically it was a closed system and thus evaporation was the only cause for change. However, at certain points within the experiment, new water was added to the tank and at those times, salinity samples were also taken. Thus the salinity data is usually smoothly changing but with some jumps.

Data Processing Description

William Jenkins at the IGF converted the raw mass spectrometry data to concentrations of gases in the samples by comparing standards and samples.

BCO-DMO Data Manager Processing Notes:
* File DiscreteNobleGasData.txt imported into the BCO-DMO data system.
* Parameters (column names) renamed to comply with BCO-DMO naming conventions. See https://www.bco-dmo.org/page/bco-dmo-data-processing-conventions
* DateTime (UTC) column added in ISO 8601 format yyyy-mm-ddTHH:MMZ.
* Experimental conditions table attached as a supplemental file to this dataset.

[table of contents | back to top]

Data Files

File
discr_noble_gas.csv(Comma Separated Values (.csv), 4.56 KB) MD5:d4050bdf6c53c441124053a502b15957 Primary data file for dataset ID 869304

[table of contents | back to top]

Supplemental Files

File
Experimental Conditions in SUSTAIN wind wave tank filename: ExperimentalConditions.csv (Comma Separated Values (.csv), 1.55 KB) MD5:4de26b79183f48ba3396e86728ccbf1c Wind, wave and temperature conditions associated with each experiment in the SUSTAIN wind wave tank. Parameter (column) inforation (Name, Description, Units): ExptNumber, Number of experiment, used to cross ref to discrete noble gas table, none Start_date, date on which that set of experimental conditions started in format M/D/YYYY (GMT), none Start_time, time on which that set of experimental conditions started in format M/D/YYYY (GMT), none End_date, date on which that set of experimental conditions ended in format hh:mm (GMT), none End_time, time on which that set of experimental conditions ended in format hh:mm (GMT), none Wavetype, 0 denotes monochromatic waves, 1 denotes short crested JONSWAP, none WaterTemp, temperature of the water (nominal – actualy temperature fluctuated within 1 deg), deg C U10, wind speed, at 10 m above surface, that was produced for the experiment, m/s

[table of contents | back to top]

Related Publications

Jenkins, W. J., Lott, D. E., & Cahill, K. L. (2019). A determination of atmospheric helium, neon, argon, krypton, and xenon solubility concentrations in water and seawater. Marine Chemistry, 211(1), 94–107. doi:10.1016/j.marchem.2019.03.007
Methods

Stanley, R. H. R., Baschek, B., Lott, D. E., & Jenkins, W. J. (2009). A new automated method for measuring noble gases and their isotopic ratios in water samples. Geochemistry, Geophysics, Geosystems, 10(5), n/a–n/a. doi:10.1029/2009GC002429
Methods

Stanley, R. H. R., Kinjo, L., Smith, A. W., Aldrett, D., Alt, H., Kopp, E., Krevanko, C., Cahill, K., & Haus, B. K. (2022). Gas Fluxes and Steady State Saturation Anomalies at Very High Wind Speeds. Journal of Geophysical Research: Oceans, 127(10). Portico. https://doi.org/10.1029/2021jc018387
Results

[table of contents | back to top]

Related Datasets

IsRelatedTo

Stanley, R., Haus, B. (2022) **Concentrations of Ne, Ar, Kr and Xe as measured by the gas equilibrator mass spectrometer (GEMS) in the SUSTAIN wind-wave tank in the summer of 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-02-03 doi:10.26008/1912/bco-dmo.869295.1 [view at BCO-DMO]
Relationship Description: Datasets were collected concurrently during the same experiments and measure the same water.

[table of contents | back to top]

Parameters

Parameter	Description	Units
DateCollected	Date and time (UTC) sample was collected in format %d/%m/%Y %H:%M (e.g. 7/10/2018 15:45)	unitless
HeConc	Concentration of Helium in the water sample	micromoles per kilogram (umol/kg)
NeConc	Concentration of Neon in the water sample	micromoles per kilogram (umol/kg)
ArConc	Concentration of Argon in the water sample	micromoles per kilogram (umol/kg)
KrConc	Concentration of Krypton in the water sample	micromoles per kilogram (umol/kg)
XeConc	Concentration of Xenon in the water sample	micromoles per kilogram (umol/kg)
Temp	Water temperature	micromoles per kilogram (umol/kg)
Salinity	Water salinity (interpolated from discrete samples)	Practical Salinity Units (PSU)
ExptNumber	Experiment number, can be cross referenced with tank condition data (See Supplemental Files section) to learn about wind and wave conditions during that experiment	unitless
ISO_DateTime_UTC	Date and time (UTC) sample was collected in ISO 8601 format %Y-%m-%dT%H:%MZ (e.g. 2018-07-10T14:14Z)	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Andaerra Optode
Generic Instrument Name	Aanderaa Oxygen Optodes
Dataset-specific Description	Andaerra Optode for temperature
Generic Instrument Description	Aanderaa Oxygen Optodes are instrument for monitoring oxygen in the environment. For instrument information see the Aanderaa Oxygen Optodes Product Brochure.

Dataset-specific Instrument Name	Hiden PIC quadrupole
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	A mass spectrometric system using a Hiden PIC quadrupole (P/N PCI 1000 1.2HAL/3F 1301-9 PIC type 570309), equipped with an electron impact ion source, triple quadrupole mass filter, and a pulse counting secondary electron multiplier (SEM) for measurement of a suite of noble gases. This system was referred to informally as "MSThree" during the study.
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

[table of contents | back to top]

Project Information

Collaborative Research: RUI: Investigating Gas Exchange Processes using Noble Gases in a Controlled Environment (Gas Exchange at SUSTAIN)

Coverage: SUSTAIN wind-wave tank at University of Miami

NSF Abstract:

An exact description of gas exchange between the atmosphere and the ocean is not fully developed, yet it is a critical process for understanding climate change and ecosystem dynamics. This is particularly problematic when evaluating the important role of bubbles in air-sea gas exchange, especially in remote ocean locations where high winds and waves make direct measurements extremely difficult. This project seeks to provide needed fundamental, high wind/wave gas-exchange measurements by using a large, state-of-the-art, wind-wave tank. Here the PIs can apply their novel measurements of noble gases (neon, argon, krypton, and xenon) to calculate overall gas fluxes under precisely controlled conditions. This tank setting allows a systematic approach to define the physical and chemical parameters (temperature, salinity, pH, wind speed, turbulence, bubble size distribution, etc.) required to construct more accurate models without the great uncertainties inherent in making similar measurements from a ship in storm conditions. A significant outcome of this study, beyond improved understanding of air-sea gas exchange, could be greatly improved estimates of the critical ecological balance between photosynthesis and respiration. Current methods use carbon dioxide and oxygen dissolved in seawater as an indication of biological activity, but cannot distinguish between biological processes and atmospheric exchange, and estimates are especially inaccurate under high wind and wave conditions with strong bubble injection. This study will improve our ability to separate biological and physical processes in evaluation of dissolved gasses in seawater.

Also, this project will provide 15 female undergraduate students at Wellesley College with an exciting, on-site research experience using a state-of-the-art tank facility at the University of Miami, and results will be incorporated into general and advanced chemistry classes. The production of student-created, short format videos, and other public outreach activities will also be supported to disseminate information on the importance of marine gas exchange.

The study of gas exchange processes between the ocean and the atmosphere has been hindered by the lack of data required to define quantitative relationships that account for bubble processes under a variety of wind, wave, and temperature conditions. Current gas exchange models tend to be highly unreliable in their parameterization of bubble processes. In large part, this is due to the difficulty of making traditional measurements at sea in remote locations within well-defined conditions, especially with high winds and waves. By using the large SUSTAIN wind-wave tank (23 m x 6 m x 2 m), the researchers in this project plan to greatly advance our understanding of the effect of wind, wave, and temperature variability on gas transfer. The use of a recently developed, field-portable equilibrator mass spectrometer that allows nearly continuous measurements of noble gas ratios (Ne, Ar, Kr, and Xe) will result in these SUSTAIN tank experiments providing precisely characterized gas flux data under varying wind speeds from 10 to 40 m/s. In addition, an underwater shadowgraph system will image bubbles, allowing the researchers to quantify bubble size distributions, a key factor missing from bubble models. Current models use a greatly simplified, two size-class representation of bubbles; an approach that this research will re-evaluate in hopes of creating better parameterizations of the role of bubble size on gas flux, and consequently improved air-sea gas exchange models for oceanic and climatic applications.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1634467

[table of contents | back to top]