Major inorganic ions in Primary Marine Aerosols (PMA) generated from seawater collected near the BATS station during R/V Atlantic Explorer cruises AE2113 (July 2021) and AE2303 (January 2023)

Website: https://www.bco-dmo.org/dataset/931318
Data Type: Cruise Results
Version: 1
Version Date: 2024-06-26

Project
» Collaborative Research: Seasonal Variability in refractory dissolved organic carbon fluxes associated with primary marine aerosol emitted from the oceans (Carbon Flux and Aerosol Emissions)

Programs
» United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)
» Ocean Carbon and Biogeochemistry (OCB)

Contributors	Affiliation	Role
Kieber, David J.	State University of New York College of Environmental Science and Forestry (SUNY ESF)	Principal Investigator
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Abstract
This dataset includes the concentrations of seven major inorganic ions determined in primary marine aerosol (PMA) samples collected from the Bermuda Atlantic Time-series Study (BATS) station during a summer cruise in 2021 and a winter cruise in 2023 aboard the R/V Atlantic Explorer. The major ions in PMA samples were collected using a high-capacity aerosol generator and the major ions were quantified using a Dionex dual channel model ICS 6000 high-performance ion chromatograph (ICS-6000 DP). This dataset was generated and prepared by Dr. Lei Xue under the supervision of Dr. David Kieber at the State University of New York, College of Environmental Science and Forestry. These data were used to determine the enrichment of major ions in PMA samples and to calculate the enrichment factors of protein/peptides and carbohydrates in PMA samples relative to bulk seawater and the associated seasonal variability. This work is part of a larger study to understand the seasonal variability in the fraction of refractory organic carbon in primary marine aerosol at the BATS station.

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Coverage

Location: Bermuda Atlantic TimeSeries Study (BATS) station
Spatial Extent: **N**:31.69 **E**:-64.156 **S**:31.652 **W**:-64.202
Temporal Extent: 2021-07-22 - 2023-01-28

Methods & Sampling

Bulk primary marine aerosol (PMA) samples for major inorganic ion analysis were produced from Sargasso seawater using a high-capacity marine aerosol generator (see Frossard et al. 2019 for detailed design of the PMA generator). In addition to bulk PMA samples, which contained particles of all sizes produced by the generator, a Micro-orifice Uniform Deposit Impactor (MOUDI) sampler was used once during each cruise to collect a dichotomous PMA sample with two particle size fractions; a submicron fraction with particles sizes ranging from <0.18 to 1 µm and a supermicron fraction with particles ranging from 1 to >10 µm in diameter. All PMA were produced by pumping near-surface seawater (ca. 5 m) continuously through the generator at a flow rate of 4 liters per minute and bubbling this seawater with air. The air was introduced through a venturi tube to generate a bubble spectrum approximating that generated from a breaking wave. Bulk PMA samples for major ions were collected on pre-combusted 47-mm diameter quartz fiber filters at the aerosol generator air sampling rate of 30 liters per minute and a sampling time of approximately 24 hours; a quarter of each PMA sample filter was stored in a Simport cryovial in a freezer for further analysis. Dichotomous samples were collected for 48 hours at a flow rate of 30 liters per minute; submicron particles were collected on a pre-combusted 37 mm diameter quartz filter, and supermicron particles were collected on a pre-combusted 47 mm diameter quartz filter.

A separate BCO-DMO dataset is available for the seawater samples that were collected on the two cruises for major ions. These samples (ca. 7 mL of unfiltered seawater) were collected into high-density polyethylene (HDPE) vials and stored frozen until analysis. (See "Related Dataset" section below for details).

To process the samples, 5 mL of high purity laboratory water (Milli-Q brand water) was added to each Simport vial containing a PMA sample filter followed by *?alternating steps of vortexing (5 min) and sonicating (5 min) three times. Each processed sample was filtered into another clean cryovial using a 0.22 µm acetate glucose syringe filter and a plastic syringe.?* Aliquots of the filtered samples were diluted in Milli-Q water for ion chromatographic analysis.

Seven major ionic species were analyzed using the method outlined in Keene et al. (2007). A Dionex dual channel model ICS 6000 high-performance ion chromatograph (ICS-6000 DP) was used to perform sample analysis. The anion channel was configured with Thermo Scientific Dionex guard (IonPac AG 18: 4 x 50 mm). The cation channel was configured **?with?** Dionex Guard (IonPac CG12 A: 4 x 50mm) and analytical (IonPacCG12A: 4 x 250mm) columns and a Thermo Scientific Dionex electrolytically regenerated suppressor (ADRS 600: 4mm). **The ion chromatograph was equipped with a Dionex AS-AP autosampler with the temperature set at 20°C, eluent generator cartridges (500 MSA, 500 KOH), ICS-6000 pumps, and Chromeleon 7 software.?**

Data Processing Description

Measurements from the ion chromatograph were compiled in Microsoft Excel along with the Marine Aerosol Generator collection metadata.

BCO-DMO Processing Description

- Imported data from source file "Major Ions in PMA for AE2113 and 2303 cruises 6.18.24.xlsx" into the BCO-DMO data system.
- Converted datetime columns to ISO8601 date format – from m/d/yyyy, H:M:S to %Y-%m-%dT%H:%M%SZ
- Converted longitude values to decimal degrees (where south and west directions are negative)
- Removed local time field
- Renamed fields to comply with BCO-DMO naming conventions

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Related Publications

Frossard, A. A., Long, M. S., Keene, W. C., Duplessis, P., Kinsey, J. D., Maben, J. R., Kieber, D. J., Chang, R. Y. -W., Beaupré, S. R., Cohen, R. C., Lu, X., Bisgrove, J., & Zhu, Y. (2019). Marine Aerosol Production via Detrainment of Bubble Plumes Generated in Natural Seawater With a Forced-Air Venturi. Journal of Geophysical Research: Atmospheres, 124(20), 10931–10950. Portico. https://doi.org/10.1029/2019jd030299
https://doi.org/10.1029/2019JD030299
Methods

Keene, W. C., Maring, H., Maben, J. R., Kieber, D. J., Pszenny, A. A. P., Dahl, E. E., … Sander, R. (2007). Chemical and physical characteristics of nascent aerosols produced by bursting bubbles at a model air-sea interface. Journal of Geophysical Research, 112(D21). doi:10.1029/2007jd008464
https://doi.org/10.1029/2007JD008464
Methods

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Related Datasets

IsRelatedTo

Kieber, D. J., Xue, L. (2024) **Major inorganic ions from seawater collected near the BATS station during R/V Atlantic Explorer cruises AE2113 (July 2021) and AE2303 (January 2023).** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-06-21 http://lod.bco-dmo.org/id/dataset/930111 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Cruise_ID	Cruise ID	unitless
Sample_Type	Bulk or dichotomous (supermicron or submicron) primary aerosol sample	unitless
ISO_DateTime_UTC_Start	Start date and time for the sampling of each aerosol sample	unitless
ISO_DateTime_UTC_Stop	Start date and time for the sampling of each aerosol sample	unitless
Latitude	Latitude of sample collection	decimal degrees
Longitude	Longitude of sample collection	decimal degrees
Chloride	Chloride, Cl-, concentration in seawater	Part per thousand (ppt)
Bromide	Bromide, Br-, concentration in seawater	Part per thousand (ppt)
Sulfate_Ion	Sulfate, SO42-, concentration in seawater	Part per thousand (ppt)
Sodium	Sodium, Na+, concentration in seawater	Part per thousand (ppt)
Potassium	Potassium, K+, concentration in seawater	Part per thousand (ppt)
Magnesium	Magnesium, Mg2+, concentration in seawater	Part per thousand (ppt)
Calcium	Calcium, Ca2+, concentration in seawater	Part per thousand (ppt)

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Instruments

Dataset-specific Instrument Name	Microorifice Uniform Deposit Impactor (MOUDI) sampler
Generic Instrument Name	Aerosol Sampler
Dataset-specific Description	A Microorifice Uniform Deposit Impactor (MOUDI) sampler was used once during each cruise to collect a dichotomous PMA sample with two particle size fractions; a submicron fraction with particles sizes ranging from 10 µm in diameter.
Generic Instrument Description	A device that collects a sample of aerosol (dry particles or liquid droplets) from the atmosphere.

Dataset-specific Instrument Name	
Generic Instrument Name	Centrifuge
Dataset-specific Description	To process the samples, 5 mL of high purity laboratory water (Milli-Q brand water) was added to each Simport vial containing a PMA sample filter followed by alternating steps of vortexing (5 min) and sonicating (5 min) three times.
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	Dionex dual channel model ICS 6000 high-performance ion chromatograph (ICS-6000 DP)
Generic Instrument Name	Ion Chromatograph
Dataset-specific Description	The major ions in each seawater sample were quantified using a Dionex dual channel model ICS 6000 high-performance ion chromatograph (ICS-6000 DP). The anion channel was configured with Thermo Scientific Dionex guard (IonPac AG 18: 4 x 50 mm). The cation channel was configured Dionex Guard (IonPac CG12 A: 4 x 50mm) and analytical (IonPacCG12A: 4 x 250mm) columns and a Thermo Scientific Dionex electrolytically regenerated suppressor (ADRS 600: 4mm). The ion chromatograph was equipped with a Dionex AS-AP autosampler with temperature set at 20 oC. Eluent generator cartridges: 500 MSA, 500 KOH. ICS-6000 pumps. Software: Chromeleon 7.
Generic Instrument Description	Ion chromatography is a form of liquid chromatography that measures concentrations of ionic species by separating them based on their interaction with a resin. Ionic species separate differently depending on species type and size. Ion chromatographs are able to measure concentrations of major anions, such as fluoride, chloride, nitrate, nitrite, and sulfate, as well as major cations such as lithium, sodium, ammonium, potassium, calcium, and magnesium in the parts-per-billion (ppb) range. (from http://serc.carleton.edu/microbelife/research_methods/biogeochemical/ic....)

Dataset-specific Instrument Name	Dionex AS-AP autosampler
Generic Instrument Name	Laboratory Autosampler
Dataset-specific Description	The ion chromatograph was equipped with a Dionex AS-AP autosampler with temperature set at 20 °C.
Generic Instrument Description	Laboratory apparatus that automatically introduces one or more samples with a predetermined volume or mass into an analytical instrument.

Dataset-specific Instrument Name	High-capacity marine aerosol generator
Generic Instrument Name	Marine Aerosol Generator
Dataset-specific Description	Bulk primary marine aerosol (PMA) samples for major inorganic ion analysis were produced from Sargasso seawater using a high-capacity marine aerosol generator (see Frossard et al. 2019 for detailed design of the PMA generator).
Generic Instrument Description	A high-capacity marine aerosol generator deployed at sea, using near-surface seawater and purified air to create a lab-based approximation of ocean-atmosphere aerosol systems. Example device described here: Frossard, A. A., Long, M. S., Keene, W. C., Duplessis, P., Kinsey, J. D., Maben, J. R., Kieber, D. J., Chang, R. Y. -W., Beaupré, S. R., Cohen, R. C., Lu, X., Bisgrove, J., & Zhu, Y. (2019). Marine Aerosol Production via Detrainment of Bubble Plumes Generated in Natural Seawater With a Forced-Air Venturi. Journal of Geophysical Research: Atmospheres, 124(20), 10931–10950. Portico. https://doi.org/10.1029/2019JD030299

Dataset-specific Instrument Name	Sonicator
Generic Instrument Name	ultrasonic cell disrupter (sonicator)
Dataset-specific Description	To process the samples, 5 mL of high purity laboratory water (Milli-Q brand water) was added to each Simport vial containing a PMA sample filter followed by alternating steps of vortexing (5 min) and sonicating (5 min) three times.
Generic Instrument Description	Instrument that applies sound energy to agitate particles in a sample.

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Deployments

AE2113

Website	https://www.bco-dmo.org/deployment/860681
Platform	R/V Atlantic Explorer
Start Date	2021-07-22
End Date	2021-08-01

AE2303

Website	https://www.bco-dmo.org/deployment/929877
Platform	R/V Atlantic Explorer
Report	https://www.rvdata.us/search/cruise/AE2303
Start Date	2023-01-18
End Date	2023-01-28

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Project Information

Collaborative Research: Seasonal Variability in refractory dissolved organic carbon fluxes associated with primary marine aerosol emitted from the oceans (Carbon Flux and Aerosol Emissions)

Coverage: Bermuda Atlantic Time-series Study (BATS) station

NSF Award Abstract:

Collaborative Research: Seasonal variability in refractory dissolved organic carbon fluxes associated with primary marine aerosol emitted from the oceans

The oceans hold a massive quantity of organic carbon that is greater than all terrestrial organic carbon biomass combined. Nearly all marine organic carbon is dissolved. On average, it is thousands of years old, chemically stable, and carried throughout the entire ocean several times before complete removal. However, little is known about the processes that produce and remove this old carbon, referred to as refractory dissolved organic carbon (RDOC). One potential removal pathway involves RDOC adhering onto the surfaces of rising bubbles produced by breaking waves. The bubbles ultimately burst at the sea surface, ejecting tiny particles (primary marine aerosol, “PMA”) that carry the RDOC into the atmosphere. Most of this PMA organic carbon is associated with the smallest particles (less than 1 µm diameter) that drift in the atmosphere for several days to weeks. During this time, RDOC in these particles can be degraded photochemically (by sunlight), partially transported landward, and/or returned to the sea. When this RDOC is converted to inorganic carbon (e.g., carbon dioxide) or degraded to more reactive constituents in the atmosphere, it is effectively removed from the marine RDOC reservoir. Based on preliminary results, the annual rate at which RDOC is removed from the ocean by this process is similar to all other known RDOC losses (interactions with particles, biological degradation, and hydrothermal circulation), except for photochemical degradation in seawater. Building on this prior research, this project will identify seasonal changes in the removal of RDOC from the oceans through this process during three research cruises to the northwestern Atlantic Ocean. Results from this project will provide important findings about the coupled ocean-atmosphere loss of RDOC and improve understanding of the role of RDOC in the global carbon cycle and Earth's climate. The research will involve two early career faculty, and will provide training for undergraduate, graduate, and postdoctoral researchers.

Radiocarbon (C-14) measurements indicate that RDOC comprises 19 to 40 % of the organic carbon associated with PMA produced by bursting bubbles at the sea surface. Injection of RDOC into the atmosphere in association with PMA is a potentially important process that removes as much as 2 to 20 Tg RDOC yr-1 from the oceans. This project will measure seasonal variations in the PMA-mediated emission of marine RDOC to the atmosphere by quantifying: (1) the fraction of RDOC in PMA OC and (2) its relationship to the abundance of biologically produced labile and semi-labile dissolved organic matter in near surface seawater. These relationships will be evaluated at the Bermuda Atlantic Time-series Station during three research cruises (one in July, two in January). During the cruises, the investigators will measure: (1) the natural abundance C-14 values for PMA and its organic source materials in seawater; (2) the dynamic and equilibrium surface tension and physical properties of seawater, including bubble size distributions; (3) concentrations of major ions, organic carbon, carbohydrates, peptides and proteins, and surfactants in PMA; and (4) chromophoric dissolved organic matter (CDOM) and the concentrations of dissolved organic carbon, chlorophyll a, major ions, carbohydrates, peptides and proteins, and surfactants in near-surface seawater and in the sea-surface microlayer. Based on these chemical measurements and physical properties, this study will reveal the magnitude and potential controls on RDOC inputs into the atmosphere as a component of PMA.

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

United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Website: http://www.us-solas.org/

Coverage: Global

The Surface Ocean Lower Atmosphere Study (SOLAS) program is designed to enable researchers from different disciplines to interact and investigate the multitude of processes and interactions between the coupled ocean and atmosphere.

Oceanographers and atmospheric scientists are working together to improve understanding of the fate, transport, and feedbacks of climate relevant compounds, and also weather and hazards that are affected by processes at the surface ocean.

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Physical, chemical, and biological research near the ocean-atmosphere interface must be performed in synergy to extend our current knowledge to adequately understand and forecast changes on short and long time frames and over local and global spatial scales.

The findings obtained from SOLAS are used to improve knowledge at process scale that will lead to better quantification of fluxes of climate relevant compounds such as CO2, sulfur and nitrogen compounds, hydrocarbons and halocarbons, as well as dust, energy and momentum. This activity facilitates a fundamental understanding to assist the societal needs for climate change, environmental health, weather prediction, and national security.

The US SOLAS program is a component of the International SOLAS program where collaborations are forged with investigators around the world to examine SOLAS issues ubiquitous to the world's oceans and atmosphere.

Â» International SOLAS Web site

Science Implementation Strategy Reports

US-SOLAS (4 MB PDF file)
Other SOLAS reports are available for download from the US SOLAS Web site

Ocean Carbon and Biogeochemistry (OCB)

Website: http://us-ocb.org/

Coverage: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and

with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2023104

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