Configuration and Operation of Marine Aerosol Generator Deployed on R/V Endeavor EN589 during Sept.- Oct. 2016

Website: https://www.bco-dmo.org/dataset/750862
Data Type: Cruise Results
Version: 1
Version Date: 2018-12-03

Project
» Collaborative Research: Coupled Ocean-Atmosphere Recycling of Refractory Dissolved Organic Carbon in Seawater (Refractory DOC Recycling)

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

Contributors	Affiliation	Role
Keene, William C.	University of Virginia (UVA)	Principal Investigator
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Abstract
This dataset describes the operating conditions for the high-capacity generator that produced primary marine aerosol from western North Atlantic seawater during cruise EN589 on RV/Endeavor during September and October 2016.

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Coverage

Spatial Extent: **N**:42 **E**:-67 **S**:35 **W**:-70
Temporal Extent: 2016-09-16 - 2016-10-14

Dataset Description

This dataset describes the operating conditions for the high-capacity generator that produced primary marine aerosol from western North Atlantic seawater during cruise EN589 on RV/Endeavor during September and October 2016.

Methods & Sampling

The marine aerosol generator was operated by William Keene (wck@virginia.edu) and John Maben. Please direct any related questions to William Keene.

Description and Operation of the Marine Aerosol Generator: Model primary marine aerosol (mPMA) was produced in a high-capacity generator fabricated from Pyrex and Teflon. See Keene et al. [2007] for a description and schematic of the original configuration of the device and Long et al. [2014] for an explanation of modifications implemented for deployment on ships at sea during the 2010 California Nexis (CalNex) campaign in the eastern North Pacific Ocean and the 2012 Western Atlantic Climate Study (WACS) in the western North Atlantic Ocean. During all previous deployments, bubble plumes were produced using sintered-glass frits and/or plunging seawater jets. During the Endeavor cruise, frits were replaced with force-air Venturis as described below.

Briefly, the 20-cm-diameter generator consisted of a 122-cm-deep seawater reservoir underlying a 97-cm-deep atmosphere. During most periods, fresh seawater drawn from approximately 5-m depth through the ship's clean seawater line flowed into the base of the seawater reservoir (typically at 4 L min-1) and drained evenly to exhaust over the top annular rim thereby continuously replacing the seawater surface and minimizing formation of standing bubble rafts. During two periods, feed seawater flowing through the generator was transferred from carboys containing seawater that had been collected at a depth of 2500 m, stored in 20 L Teflon lined carboys, and warmed to room temperature. Bubble plumes were generated by two mechanisms. (1) Ultra-pure air and seawater (drawn from the base of the generator's seawater reservoir) were pumped at adjustable rates of 1 to 5 L min-1 each through one of two force-air Venturi nozzles that were fabricated from Teflon and positioned at depths of 42 (shallow) and 72 cm (deep), respectively, below the air-seawater interface. (2) Bubble plumes were also produced by a seawater jet at flow rates of 1 to 3 L min-1 that impinged on the air-seawater interface. The jet nozzle was 0.32-cm ID and positioned at 50 cm above the interface.

mPMA was emitted to the headspace when bubbles rose to and burst at the air-seawater interface. Ultra-pure sweep air flowed through the headspace above the seawater reservoir at 70 L min-1. During most sampling periods, sweep air was hydrated to a relative humidity (RH) of ~80%. mPMA was sampled for chemical and physical characterization through isokinetic ports at the top of the generator.

The generator was blank tested by measuring mPMA number concentrations in the headspace at typical flow rates of bubble and sweep air but with no seawater in the reservoir. All blank tests yielded undetectable particle number concentrations (less than 2 cm-3) indicating that all particles measured during routine operation originated from seawater.

Bubble-plume void fractions were quantified over ranges of conditions by filling the generator, turning off the flow of feed seawater, incrementally increasing the flow of air through the Venturi, and measuring the volume of displaced water.

Refer to the elated papers below for additional details regarding the design and operation of the marine aerosol generator and associated analytical methods.

Data Processing Description

BCO-DMO Processing:
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- re-formatted date from d-Mon-yy to yyyy-mm-dd
- replaced blank cells with nd (no data)

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Data Files

File
aerosol_generator.csv (Comma Separated Values (.csv), 19.44 KB) MD5:b966b3fc5c945f0f6252ed5f87a6367b Primary data file for dataset ID 750862

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Related Publications

Keene, W. C., Long, M. S., Reid, J. S., Frossard, A. A., Kieber, D. J., Maben, J. R., … Bates, T. S. (2017). Factors That Modulate Properties of Primary Marine Aerosol Generated From Ambient Seawater on Ships at Sea. Journal of Geophysical Research: Atmospheres, 122(21), 11,961–11,990. doi:10.1002/2017jd026872
https://doi.org/10.1002/2017JD026872
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

Kieber, D. J., Keene, W. C., Frossard, A. A., Long, M. S., Maben, J. R., Russell, L. M., … Bates, T. S. (2016). Coupled ocean-atmosphere loss of marine refractory dissolved organic carbon. Geophysical Research Letters, 43(6), 2765–2772. doi:10.1002/2016gl068273 https://doi.org/10.1002/2016GL068273
Methods

Long, M. S., Keene, W. C., Kieber, D. J., Frossard, A. A., Russell, L. M., Maben, J. R., … Bates, T. S. (2014). Light-enhanced primary marine aerosol production from biologically productive seawater. Geophysical Research Letters, 41(7), 2661–2670. doi:10.1002/2014gl059436 https://doi.org/10.1002/2014GL059436
Methods

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Parameters

Parameter	Description	Units
ID_Number	Sequential ID number indicting an individual period during which performance and/or mPMA properties were characterized with the generator operated in the same configuration.	unitless
Sample_Type	Type of measurement and/or sample: T (Performance test) = Physical characterization only; S = Physical characterization + seawater grab sample for chemical characterization; CI = Physical characterization + cascade impactor sample or blank for analysis of major ions and organic carbon (OC); B = Physical characterization + bulk sample or blank for analysis of major ions and OC or for photochemical manipulation experiments	unitless
Start_Date_local	For T period: start date for the first 5-minute measurement interval for the sizing instruments (scanning mobility particle sizer and aerodynamic particle sizer) or measurement date for water displacement characterization. Other periods (S, CI, B): Start date for mPMA sample or date for mPMA blank or seawater grab sample. Formatted as yyyy-mm-dd.	unitless
Start_Time_local	For T period: start time (Atlantic Daylight Time - ADT) for the first 5-minute measurement interval for the sizing instruments (scanning mobility particle sizer and aerodynamic particle sizer) or measurement time for water displacement characterization. Other periods (S, CI, B): Start time for mPMA sample or time for mPMA blank or seawater grab sample. Note: Times for many void fraction measurements were not recorded.	unitless
End_Date_local	For T period: stop datefor the last 5-minute measurement interval for the sizing instruments. Other periods: Stop date for mPMA sample. Formatted as yyyy-mm-dd.	unitless
End_time_local	For T period: stop time (Atlantic Daylight Time - ADT) for the last 5-minute measurement interval for the sizing instruments. Other periods: Stop time for mPMA sample.	unitless
water_depth_type	Depth from which feed seawater was drawn: NS = near-surface (~5 m); NADW = North Atlantic deep water (~2500 m). The 2500 m seawater was transferred from a CTD to 20 L HDPE Teflon-lined carboys, warmed to room temperature, and pneumatically transferred from the carboys to the generator.	unitless
Generator_Seawater_flowrate	Flow rate of feed seawater into base of generator	liters/minute
Jet_Flowrate	Flow rate of seawater though jet	liters/minute
Sweep_Bubble_Air_rate	Total flow rate of air through generator (sweep + bubble air)	liters/minute
plumes_Venturi	Plumes produced by shallow (S) or deep (D) Venturi. Note: Immediately preceding the final two observation periods, seawater flow into the generator was turned off and the seawater level in the reservoir was lowered to approximately 4 cm above the top of the shallow Venturi (designated as S*).	unitless
Venturi_Air_flowrate	Flow rate of bubble air through Venturi	liters/minute
Venturi_Seawater_flowrate	Flow rate of seawater through Venturi	liters/minute
Rel_Humidity	Average RH of air in generator’s head space (%)	unitless

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Instruments

Dataset-specific Instrument Name	Teledyne Hastings mass flowmeters and Vasala model HMP 233 probe and meter.
Generic Instrument Name	Flow Meter
Dataset-specific Description	Airflow rates were regulated with needle valves and quantified with Teledyne Hastings mass flowmeters. Seawater flow rates were measured at the exhaust. RH and temperature were measured continuously at the outlet with a Vasala model HMP 233 probe and meter.
Generic Instrument Description	General term for a sensor that quantifies the rate at which fluids (e.g. water or air) pass through sensor packages, instruments, or sampling devices. A flow meter may be mechanical, optical, electromagnetic, etc.

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Deployments

EN589

Website	https://www.bco-dmo.org/deployment/710271
Platform	R/V Endeavor
Report	http://dmoserv3.bco-dmo.org/data_docs/Refractory_DOC_Recycling/EN589_Post_Cruise_Report_10.20.16.pdf
Start Date	2016-09-16
End Date	2016-10-15
Description	The main purpose of this cruise was to study the organic matter put into the atmosphere as particles (also called aerosols) that are generated from bursting bubbles at the sea surface. To do this, the investigators deployed an aerosol generator to reproduce a model surface ocean using the ship's clean flow-through seawater system. The ship occupied four hydrographic stations: two biologically productive stations and two stations in the Sargasso Sea. To support the aerosol generator work, over fifty CTD casts were conducted to collect seawater and to characterize the physical, chemical, and biological properties of the water column. Cruise description excerpted from EN589 post-cruise report: EN589_Post_Cruise_Report_10.20.16.pdf. Related documents: EN589_Cruise_Plan.pdf

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Project Information

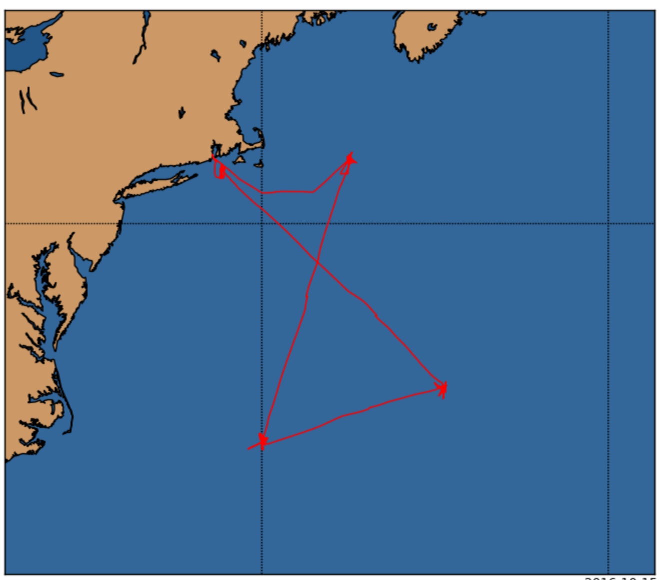
Collaborative Research: Coupled Ocean-Atmosphere Recycling of Refractory Dissolved Organic Carbon in Seawater (Refractory DOC Recycling)

Coverage: Northwest Atlantic Ocean

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 and more than 95% is refractory, and cycled through the oceans several times before complete removal. Refractory dissolved organic carbon (RDOC) concentrations are uniform with depth in the water column and represent the "background" carbon present throughout the oceans. However, very little is known regarding RDOC production and removal processes. One potential removal pathway is through adsorption of RDOC onto surfaces of rising bubbles produced by breaking waves and ejection via bubble bursting into the atmosphere. Building on prior research, the investigators will evaluate the importance of ocean- atmosphere processing in recycling marine RDOC during a research cruise in the northwestern Atlantic Ocean. Results of the research will provide important insights regarding the coupled ocean-atmosphere loss of RDOC, thereby improving understanding of and ability to predict the role of RDOC in oceanic and atmospheric biogeochemistry, the global carbon cycle, and Earth's climate. The research will involve three early career faculty, and will provide training for undergraduate and graduate researchers.

Recent results based on a limited set of observations indicate that the organic matter (OM) associated with primary marine aerosol (PMA) produced by bursting bubbles from breaking waves at the sea surface is comprised partly to wholly of RDOC rather than OM of recent biological origin as has been widely assumed. The injection of RDOC into the atmosphere in association with PMA and its subsequent photochemical oxidation is a potentially important and hitherto unrecognized sink for RDOC in the oceans of sufficient magnitude to close the marine carbon budget and help resolve a long-standing conundrum regarding removal mechanisms for marine RDOC. This project will involve a shipboard investigation and modeling study to (1) quantify the relative contributions of marine refractory dissolved organic carbon (RDOC) to primary marine aerosol organic matter (PMA OM) produced from near-surface seawater in biologically productive and oligotrophic regions and from North Atlantic Deep Water, and to (2) determine the importance of atmospheric photochemical processing as a recycling pathway for RDOC. To test these hypotheses, a high-capacity aerosol generator will be deployed at four hydrographic stations in the NW Atlantic Ocean to characterize (1) the natural abundance of 14C in PMA and in surface and deep seawater; (2) the surface tension and physical properties of bubble plumes; (3) size-resolved production fluxes, chemical composition, organic carbon enrichments, spectral absorbance, and photochemical evolution of PMA; and (4) the carbon content, optical properties, and physical properties of seawater. The importance of RDOC recycling via PMA production and photochemical evolution will be interpreted with model calculations.

EN589 Cruise Track



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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

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536608
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536605
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536674
NSF Division of Ocean Sciences (NSF OCE)	OCE-1536597

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