Water column data from CTD casts along the East Siberian Arctic Shelf on R/V Oden during 2011 (ESAS Water Column Methane project)

Website: https://www.bco-dmo.org/dataset/660543
Data Type: Cruise Results
Version: 1
Version Date: 2016-10-04

Project
» The East Siberian Arctic Shelf as a Source of Atmospheric Methane: First Approach to Quantitative Assessment (ESAS Water Column Methane)

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Abstract
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Coverage

Spatial Extent: **N**:77.3829 **E**:178.9479 **S**:65.0835 **W**:125.0406
Temporal Extent: 2011-09-12 - 2011-10-07

Dataset Description

These data are from water column samples collected by CTD from the Lappet Sea, East Siberian Arctic Shelf in 2011.

Methods & Sampling

Acquisition methods are described in the following publication: Orcut, B. *et al. 2005*

Core sectioning, porewater collection and analysis

At each sampling site, sediment sub-samples were collected for porewater analyses and at selected depths for microbial rate assays (AOM, anaerobic oxidation of methane oxidation; methanogenesis (MOG) from

bicarbonate and acetate). Sediment was expelled from core liner using a hydraulic extruder under anoxic conditions. The depth intervals for extrusion varied. At each depth interval, a sub-sample was collected into a cut-off syringe for dissolved methane concentration quantification. Another 5 mL sub-sample was collected into pre-weighed and pre-combusted glass vial for determination of porosity (determined by the change in weight after drying at 80 degrees celsius to a constant weight). The remaining material was used for porewater extraction. Sample fixation and analyses for dissolved constituents followed the methods of Joye et al. (2010).

Microbial Activity Measurements

To determine AOM and MOG rates, 8 to 12 sub-samples (5 cm3) were collected from a core by manual insertion of a glass tube. For AOM, 100 uL of dissolved 14CH4 tracer (about 2,000,000 DPM as gas) was injected into each core. Samples were incubated for 36 to 48 hours at in situ temperature. Following incubation, samples were transferred to 20 mL glass vials containing 2 mL of 2M NaOH (which served to arrest biological activity and fix 14CO2 as 14C-HCO3-). Each vial was sealed with a teflon-lined screw cap, vortexed to mix the sample and base, and immediately frozen. Time zero samples were fixed immediately after radiotracer injection. The specific activity of the tracer substrate (14CH4) was determined by injecting 50 uL directly into scintillation cocktail (Scintiverse BD) followed by liquid scintillation counting. The accumulation of 14C product (14CO2) was determined by acid digestion following the method of Joye et al. (2010). The AOM rate was calculated using equation 1:

AOM Rate = [CH4] x alphaCH4 /t x (a-14CO2/a-14CH4) (Eq. 1)

Here, the AOM Rate is expressed as nmol CH4 oxidized per cm3 sediment per day (nmol cm-3 d-1), [CH4] is the methane concentration (uM), alphaCH4 is the isotope fractionation factor for AOM (1.06; (ALPERIN and REEBURGH, 1988)), t is the incubation time (d), a-14CO2 is the activity of the product pool, and a-14CH4 is the activity of the substrate pool. If methane concentration was not available, the turnover time of the 14CH4 tracer is presented.

Rates of bicarbonate-based-methanogenesis and acetoclastic methanogenesis were determined by incubating samples in gas-tight, closed-tube vessels without headspace, to prevent the loss of gaseous 14CH4 product during sample manipulation. These sample tubes were sealed using custom-designed plungers (black Hungate stoppers with the lip removed containing a plastic “tail” that was run through the stopper) were inserted at the base of the tube; the sediment was then pushed via the plunger to the top of the tube until a small amount protruded through the tube opening. A butyl rubber septa was then eased into the tube opening to displace sediment in contact with the atmosphere and close the tube, which was then sealed with a open-top screw cap. The rubber materials used in these assays were boiled in 1N NaOH for 1 hour, followed by several rinses in boiling milliQ, to leach potentially toxic substances.

A volume of radiotracer solution (100 uL of 14C-HCO3- tracer (~1 x 107 dpm in slightly alkaline milliQ water) or 1,2-14C-CH3COO- tracer (~5 x 107 dpm in slightly alkaline milliQ water)) was injected into each sample. Samples were incubated as described above and then 2 ml of 2N NaOH was injected through the top stopper into each sample to terminate biological activity (time zero samples were fixed prior to tracer injection). Samples were mixed to evenly distribute NaOH through the sample. Production of 14CH4 was quantified by stripping methane from the tubes with an air carrier, converting the 14CH4 to 14CO2 in a combustion furnace, and subsequent trapping of the 14CO2 in NaOH as carbonate (CRAGG et al., 1990; CRILL and MARTENS, 1986). Activity of 14CO2 was measured subsequently by liquid scintillation counting.

The rates of Bi-MOG and Ac-MOG rates were calculated using equations 2 and 3, respectively:

Bi-MOG Rate = [HCO3-] x alphaHCO3/t x (a-14CH4/a-H14CO3-) (Eq. 2)

Ac-MOG Rate = [CH3COO-] x alphaCH3COO-/t x (a-14CH4/a-14CH314COO-) (Eq. 3)

Both rates are expressed as nmol HCO3- or CH3COO-, respectively, reduced cm-3 d-1, alphaHCO3 and alphaCH3COO- are the isotope fractionation factors for MOG (assumed to be 1.06). [HCO3-] and [CH3COO-] are the pore water bicarbonate (mM) and acetate (uM) concentrations, respectively, t is incubation time (d), a-14CH4 is the activity of the product pool, and a-H14CO3 and a-14CH314COO are the activities of the substrate pools. If samples for substrate concentration determination were not available, the substrate turnover constant instead of the rate is presented.

For water column methane oxidation rate assays, triplicate 20 mL of live water (in addition to one 20 mL sample which was killed with ethanol (750 uL of pure EtOH) before tracer addition) were transferred from the CTD into serum vials. Samples were amended with 2 x 10^6 DPM of 3H-labeled-methane tracer and incubated for 24 to 72 hours (linearity of activity was tested and confirmed). After incubation, samples were fixed with

ethanol, as above, and a sub-sample to determine total sample activity (3H-methane + 3H-water) was collected. Next, the sample was purged with nitrogen to remove the 3H-methane tracer and a sub-sample was amended with scintillation fluid and counted on a shipboard scintillation counter to determine the activity of tracer in the product of 3H-methane oxidation, 3H-water. The methane oxidation rate was calculated as:

MOX Rate = [methane concentration in nM] x alphaCH4/t x (a-3H-H2O/a-3H-CH4-) (Eq. 3)

Data Processing Description

BCO-DMO Data Processing Notes:

- filled in blank cells with "nd"
- separated month and year into two columns
- converted lat/lons to decimal degrees
- replaced the code "MUC" with it's complete definition "multiple core"
- replaced the code "BDL" with it's complete definition "below defined level"

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Data Files

File
water_column_samples.csv (Comma Separated Values (.csv), 19.87 KB) MD5:8595246a5e95dbbf3a1ec0bda049b62e Primary data file for dataset ID 660543

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Related Publications

Orcutt, B., Boetius, A., Elvert, M., Samarkin, V., & Joye, S. B. (2005). Molecular biogeochemistry of sulfate reduction, methanogenesis and the anaerobic oxidation of methane at Gulf of Mexico cold seeps. Geochimica et Cosmochimica Acta, 69(17), 4267–4281. doi:10.1016/j.gca.2005.04.012
Methods

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Parameters

Parameter	Description	Units
station	Station where sampling occurred	unitless
date	Date of sampling; YYYY/mm/dd	unitless
lon	Longitude	decimal degrees
lat	Latitude	decimal degrees

depth_max	Max depth on site where sampling occurred	meters
depth_sample	Depth where sampling occurred	meters
temperature	Temperature where sampling occurred	celsius
pH	pH of water sample	pH
salinity	Salinity of water sample	practical salinity units (PSU)
Cl	Chlorine concentration	millimoles (mM)
SO4	Sulfate concentration	millimoles (mM)
DOC	Dissolved organic carbon concentration	micromoles (uM)
TDN	Total dissolved nitrogen concentration	micromoles (uM)
DON	Dissolved organic nitrogen concentration	micromoles (uM)
Nox	Mono-nitrogen oxide concentration	micromoles (uM)
NO2	Nitrite concentration	micromoles (uM)
NH4	Ammonium concentration	micromoles (uM)
TDP	Total dissolved phosphorus concetration	micromoles (uM)
DOP	Dissolved organic phosphorus concentration	micromoles (uM)
PO4	Phosphate concentration	micromoles (uM)
Si	Silicon concentation	micromoles (uM)
CH4	Methane concentration	micromoles (uM)
MOX	Methane oxidation rate	nanomole per liter per day (nmol/L/d)

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Instruments

Dataset-specific Instrument Name	CTD
Generic Instrument Name	CTD - profiler
Dataset-specific Description	Used to collect water column samples
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column. It permits scientists to observe the physical properties in real-time via a conducting cable, which is typically connected to a CTD to a deck unit and computer on a ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This term applies to profiling CTDs. For fixed CTDs, see https://www.bco-dmo.org/instrument/869934.

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Deployments

ESAS_Fall_2011

Website	https://www.bco-dmo.org/deployment/641549
Platform	shoreside East Siberian Arctic Shelf
Start Date	2011-09-01
End Date	2011-10-31
Description	Siberia Cruise Porewater Samples Collected Sept-Oct, 2011

ESAS_Spring_2011

Website	https://www.bco-dmo.org/deployment/641548
Platform	shoreside East Siberian Arctic Shelf
Start Date	2011-04-01
End Date	2011-05-31
Description	Spring 2011 Sediment/Permafrost Collection Type: Gravity core; Drill core Sampling Area: East Siberian Arctic Shelf

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Project Information

The East Siberian Arctic Shelf as a Source of Atmospheric Methane: First Approach to Quantitative Assessment (ESAS Water Column Methane)

Coverage: East Siberian Arctic Shelf

We propose to study methane (CH4) release over the East Siberian Arctic shelf (ESAS), the largest (~10% of the world ocean shelf area) and the shallowest shelf (mean depth <50 m) of the world ocean. Until recently, the ESAS was not considered a CH4 source due to subsea permafrost's impermeability, which completely isolated it from modern biogeochemical cycles. The ESAS stores the world's largest hydrocarbon stocks, mostly as shallow Arctic hydrates, and thus represents an enormous potential CH4 atmospheric source that could result from global warming-triggered permafrost degradation. Increased CH4 fluxes could occur as numerous weak seeps or strong bubble plumes over large areas. Due to the shallow nature of the ESAS, the majority of ESAS CH4 likely avoids oxidation and escapes to the atmosphere. To assess whether sudden, large-scale CH4 release occurs or is likely to occur in the future, we will investigate the migration pathway characteristics and identify the controlling factors of CH4 flux from the seabed, in the water column, and to the atmosphere.

Our central hypothesis is that seabed CH4 fluxes are significant year-round sources while atmospheric fluxes are only significant during ice-free periods. To understand both the temporal and spatial variability of CH4 fluxes, we will test the sub-hypotheses that ESAS emissions are strongly modulated by seasonal factors including water-column mixing and ice cover, while seabed CH4 emissions are much more weakly modulated (or not at all), and that the spatial distribution of emission correlates with the location of shallow and deep-water fault zones, and submerged thermokarst areas – primary geologic rather than biologic control. We will: 1) distinguish different CH4 sources 2) quantify the importance of microbial production and consumption of CH4 including seasonal variations vs. release of previously originated CH4 from seabed reservoirs; 3) evaluate contributions of different components (spatial, seasonal and transport components) to the annual CH4 flux; 4) investigate controlling factors and model CH4 release during critical periods such as storms, fall convection and ice-break up period and over critical area such as fault zones and thermokarst-affected areas; 5) use modeling to extend results to the entire ESAS and for climate change scenarios.

Water column hydrography and geochemical measurements will be conducted during a summer cruise and a winter expedition. To distinguish between individual CH4 sources we will measure stable carbon isotope ratios (δ13CCH4, δ13CDIC, δ13C-POC), D/H ratio of CH4 and water (δDCH4, δDH2O), CH4 radiocarbon age (Δ14C), and the abundance of non-CH4 hydrocarbons in water, air and sediment samples. To elucidate importance of microbial production (methanogenesis) we will estimate in situ production in particles; CH4 consumption (oxidation) will be measured in the water column and at the ice-water interface. To evaluate total flux, we will perform direct flux measurements (4 helicopter surveys) using eddy-correlation techniques to obtain integrative rates of CH4 flux and assess strength of the current CH4 source over two area. To assess contribution of ebullition, we will measure seafloor direct bubble flux over 6 control and 2 test sites on a nested range of sonar scales (3.5 kHz, largest), to multibeam sonar scanner (decameter), to turbine tents (meter), and a combination of bubble video imaging and bubble modeling (vent scale). To evaluate factors controlling CH4 fluxes, we will perform investigations of seabed permeability for gases using geophysics and 3He/4He ratio. Modeling will aim to develop a regional flux model.

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Funding

Funding Source	Award
NSF Division of Polar Programs (NSF PLR)	PLR-1023444

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