Eddy covariance proton and oxygen, DIC, TA flux data collected at Woods Hole Oceanographic Institution in 2014 (ECHOES project)

Website: https://www.bco-dmo.org/dataset/568429
Data Type: experimental
Version: 2015-09-23

Project
» Development of a Novel High-Resolution O2/H+ Eddy Correlation Technique to Study Carbon Cycling in the Coastal Ocean (ECHOES)

Contributors	Affiliation	Role
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Table of Contents

Dataset Description

This dataset includes benthic chamber fluxes in O2, H+, DIC and TA.

Related Reference:

Long MH, Charette MA, Martin WR, McCorkle DC. (2015) Oxygen metabolism and pH in coastal ecosystems: Eddy Covariance Hydrogen ion and Oxygen Exchange System (ECHOES). Limnology and Oceanography: Methods. DOI: 10.1002/lom3.10038

Related Datasets:

Datasonde in a light chamber
Datasonde in water column

Methods & Sampling

The ECHOES system consisted of an Acoustic Doppler Velocimeter (ADV, Nortek, USA) that was coupled to a FirestingO2-Mini fiber-optic O2 meter with a fluorescence-based fast-response (< 0.3 s) 430 µm tip diameter optode (Pyroscience, GE) and a fast-response (< 0.6 s) H+ Ion-Selective Field Effect Transistor and controller (ISFET; Microsens, CH) (Figure 2). The ADV had the capability to log both external signals (O2 and H+) and also provided output power to the sensors.

The H+ ISFET sensors were adapted to EC by using a flow-through design across the sensing surface of the ISFET sensor (Figure 2). The ISFET sensors are light-sensitive and must therefore be used in a dark environment. To prevent light interference, and to sample in the same measuring volume as the other sensors, a 40 mm long section of 19 gauge (0.69 mm ID) stainless steel tube was attached to the ISFET sensor to create a micro-flow cell for measuring pH. One side of the tubing was machined flat over a 5 mm length and epoxied over the sensing surface of the ISFET (Figure 2). A Mag-Drive gear pump (Micropump, USA) was used to pull fluid from the measuring volume to the sensor at a flow rate of 0.1 L min-1. The pump was located in a separate underwater housing with a dedicated constant-voltage battery source. The O2 optode and the H+ ISFET sensor were co-located just outside the ~ 2 cm3 measuring volume of the ADV, located 0.15 m below the ADV sensor head. The height of the ADV measuring volume above the sediment surface was 0.30 m.

The H+ ISFET sensor works in conjunction with a reference electrode. The reference electrodes were constructed from 8mm outside diameter alkali-resistant glass (Schott, GE) with a micro-porous glass frit tip (Princeton Applied Research, USA), filled with a saturated solution of potassium chloride, and fitted with a silver chloride coated silver wire. The reference and ISFET sensors were pre-conditioned in seawater overnight to reduce equilibration time in the field. An ISFET controller (Microsens, CH) operated the ISFET at a constant drain-source voltage and current relative to the source voltage provided by the reference electrode (see Martz et al. 2010) and had an analog output of approximately 55mV per pH unit. To better resolve the signal it was amplified 50 times using a custom signal amplifier with an adjustable voltage offset (Alligator Technologies, USA).

The O2 optodes were calibrated pre- and post-deployment using water-saturated air and saturated ascorbic acid solution (anoxic). A reference, or baseline, fluorescence signal was automatically subtracted from each O2 measurement by the Firesting O2 meter to remove any signal contributions due to ambient light variations. The fiber optic cable was securely fastened to the frame with tape throughout its length to prevent signal bias due to cable movement.

The ADV provided power for and logged the signal from both the H+ ISFET and the O2 optode at a frequency of 64 Hz. All instrumentation was mounted to a custom carbon-fiber frame with small-diameter legs (1 cm) to limit hydrodynamic interference. The lightweight construction allowed for ease of handling but each frame leg needed to be weighted and secured using anchors.

Data Processing Description

MATLAB code was developed to calculate the EC fluxes. Several data treatment procedures were tested; most of them were adapted from commonly used calculation procedures for terrestrial eddy covariance measurements (e.g. Baldocchi et al. 2003). The flux was determined over periods of 0.25 h. Data were averaged to 8Hz for flux calculations due to the ~ 10 Hz sample output refresh rate of the O_2 optode meter. The fluctuating components of the vertical velocity, O_2 and H^+ (Eq. 1), were determined by Reynolds decomposition with the means determined by a running average window of 5 minutes, which was identified to be the optimal time period for maintaining a constant flux signal while removing non-turbulent fluctuations (McGinnis et al. 2008).

Inherent in the high-frequency ADV velocity data were anomalous spikes that contaminated the EC signal. These velocity data spikes were replaced with interpolated data using existing MATLAB de-spiking procedures described by Goring and Nikora (2002) that resulted in the interpolation of <1 % of the vertical velocities used to calculate the flux. The ECHOES H^+ and O_2 signals were compared to the water column data sonde measurements to verify that the sensors had not malfunctioned by confirming that the real-time correlation between sensors and data sonde matched that of the overall correlation (i.e. the calibration curves). All signals were then examined manually to remove any further data spikes that were due to malfunction, fouling, or debris contacting the sensors. A GoPro camera (HERO2, GoPro, USA) on the ECHOES frame helped identify fouling of the sensors. Due to the difficulty of accurately leveling the instrument in the field, and the resulting potential to bias the vertical velocity measurements, a planar rotation was used based on the methods described by Lorke et al. (2013) that uses an average rotation angle for the different current directions.

The benthic chamber fluxes were calculated from the change in O_2, H^+, DIC and TA concentrations in the chambers through time, using the known volume and sediment surface area of the chamber. Corrections for the removal of water for DIC and TA samples were included to account for the influx of ambient water, utilizing the measured water column conditions.

BCO-DMO Processing:

- added conventional header with dataset name, PI name, version date, reference information
- renamed parameters to BCO-DMO standard
- reformatted date
- combined multiple tables and sorted all by time

[table of contents | back to top]

Data Files

File
flux_data.csv (Comma Separated Values (.csv), 2.79 KB) MD5:1d5b9bbdb5154cfd7ac62ef13eafdbc8 Primary data file for dataset ID 568429

[table of contents | back to top]

Parameters

Parameter	Description	Units
hour	Hour of day: mid-time for each flux analysis period. 14.00 = 2:00 pm	decimal time
O2_flux_chamber	Chamber oxygen Flux	mmol oxygen m-2 h-1
pH_flux_chamber	Chamber pH Flux	mmol H+ m-2 h-1
Eddy_covar_pH_flux	Eddy covariance pH flux	mmol H+ m-2 h-1
Eddy_covar_O2_flux	Eddy covariance Oxygen flux	mmol oxygen m-2 h-1
DIC	Dissolved inorganic carbon	umol L-1
DIC_stdev	standard deviation	umol L-1
TALK	Total alkalinity	umol L-1
TALK_stdev	standard deviation	umol L-1

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	ADV
Generic Instrument Name	Acoustic Doppler Velocimeter
Dataset-specific Description	Acoustic Doppler Velocimeter
Generic Instrument Description	ADV is the acronym for acoustic doppler velocimeter. The ADV is a remote-sensing, three-dimensional velocity sensor. Its operation is based on the Doppler shift effect. The sensor can be deployed either as a moored instrument or attached to a still structure near the seabed. Reference: G. Voulgaris and J. H. Trowbridge, 1998. Evaluation of the Acoustic Doppler Velocimeter (ADV) for Turbulence Measurements. J. Atmos. Oceanic Technol., 15, 272–289. doi: http://dx.doi.org/10.1175/1520-0426(1998)0152.0.CO;2

Dataset-specific Instrument Name	Oxygen Optode
Generic Instrument Name	Optode
Dataset-specific Description	FirestingO2-Mini fiber-optic O2 meter with a fluorescence-based fast-response (< 0.3 s) 430 um tip diameter optode (Pyroscience, GE)
Generic Instrument Description	An optode or optrode is an optical sensor device that optically measures a specific substance usually with the aid of a chemical transducer.

Dataset-specific Instrument Name	ISFET
Generic Instrument Name	pH Sensor
Dataset-specific Description	Fast-response (< 0.6 s) H1 Ion-Selective Field Effect Transistor (ISFET) and controller (Microsens, CH)
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	multi-sensor data sonde
Generic Instrument Name	Water Quality Multiprobe
Dataset-specific Description	Multi-sensor data sonde (MS5; Hydrolab)
Generic Instrument Description	An instrument which measures multiple water quality parameters based on the sensor configuration.

[table of contents | back to top]

Deployments

Waquoit_Long

Website	https://www.bco-dmo.org/deployment/563651
Platform	WHOI
Start Date	2014-06-25
Description	Measurements of the exchange of oxygen and hydrogen ions across the sediment-water interface.

[table of contents | back to top]

Project Information

Development of a Novel High-Resolution O2/H+ Eddy Correlation Technique to Study Carbon Cycling in the Coastal Ocean (ECHOES)

Coverage: Waquoit Bay, Massachusetts, USA

An aquatic eddy covariance (EC) system was developed to measure the exchange of oxygen (O_2) and hydrogen ions (H^+) across the sediment-water interface. The system employs O_2 optodes and a newly developed micro-flow cell H^+ ion selective field effect transistor; these sensors displayed sufficient precision and rapid enough response times to measure concentration changes associated with turbulent exchange. Discrete samples of total alkalinity and dissolved inorganic carbon (DIC) were used to determine the background carbonate chemistry of the water column and relate the O_2 and H^+ fluxes to benthic processes. The ECHOES system was deployed in a eutrophic estuary (Waquoit Bay, Massachusetts, USA), and revealed that the benthos was a sink for acidity during the day and a source of acidity during the night, with H^+ and O_2 fluxes of ± 0.0001 and ± 10 mmol m^{-2} h^{-1}, respectively. H^+ and O_2 fluxes were also determined using benthic flux chambers, for comparison with the EC rates. Chamber fluxes determined in 0.25 h intervals co-varied with EC fluxes but were ~4 times lower in magnitude. This difference was likely due to suppressed porewater advection in the chambers and changes in the chemistry of the enclosed chamber overlying water. The individual H^+ and O_2 fluxes were highly correlated in each data set (EC and chambers), and both methods yielded H^+ fluxes that could not be explained by O_2 metabolism alone. The ECHOES system provides a new tool for determining the influence of benthic biogeochemical cycling on coastal ocean acidification and carbon cycling.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1361514

[table of contents | back to top]