LBA-ECO LC-07 Methane Releases from two Amazon HydroReservoirs, Brazil: 2000-2001

Get Data

Revision date: December 12, 2011

Summary:

This data set reports methane (CH_4) fluxes at the water–air interface and concentrations and isotopic signals of CH_4 in the bubbles stirred up from the sediment in Tucurui and Samuel reservoirs in 2000 and 2001. Tucurui (deep) reservoir is located near Belem city in the Tocantins-Araguaia basin in the eastern Amazon. Samuel (shallow) reservoir is situated near Porto Velho city in the Jamari River, a tributary of the Madeira River in the western Amazon. Field samples were collected between June 2000 and September 2001. There are two comma-delimited ASCII data files in this data set.

This study was carried out to identify differences in methane cycling between deep and shallow reservoirs (Lima, 2005). Isotopic and concentration analyses of methane in bubbles, dissolved in the water column, and emitted to the atmosphere demonstrate that water depth is critical regarding methane emissions from hydroreservoirs in the Amazon. Methanotrophic activities are greater in Tucurui (deep) while light isotopic methane is directly released from Samuel (shallow). Therefore, the methanotrophic layer of the deep reservoir is more efficient in oxidizing methane before reaching the atmosphere, since the quantity of methane in the sediments of the reservoirs were equivalent.

Figure 1. Gas flux chambers used in this study

Data Citation:

Cite this data set as follows:

Lima, I.B.T. 2011. LBA-ECO LC-07 Methane Releases from two Amazon HydroReservoirs, Brazil: 2000-2001. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi: 10.3334/ORNLDAAC/1047

Implementation of the LBA Data and Publication Policy by Data Users:

The LBA Data and Publication Policy [http://daac.ornl.gov/LBA/lba_data_policy.html] is in effect for a period of five (5) years from the date of archiving and should be followed by data users who have obtained LBA data sets from the ORNL DAAC. Users who download LBA data in the five years after data have been archived must contact the investigators who collected the data, per provisions 6 and 7 in the Policy.

This data set was archived in December of 2011. Users who download the data between December 2011 and November 2016 must comply with the LBA Data and Publication Policy.

Data users should use the Investigator contact information in this document to communicate with the data provider. Alternatively, the LBA Web Site [http://lbaeco-archive.ornl.gov/] in Brazil will have current contact information.

Data users should use the Data Set Citation and other applicable references provided in this document to acknowledge use of the data.

Table of Contents:

1. Data Set Overview:

Project: LBA (Large-Scale Biosphere-Atmosphere Experiment in the Amazon)

Activity: LBA-ECO

LBA Science Component: Land Use and Land Cover

Team ID: LC-07 (Melack / Novo)

The investigator was Lima, Ivan Bergier Tavares de. You may contact Lima, Dr. Ivan Bergier T. (for science) (ivan@cpap.embrapa.br) and Gastil-Buhl, M. (for data) (gastil@lifesci.ucsb.edu).

LBA Data Set Inventory ID: LC07_Reservoir_Methane_Emissions

This data set reports methane (CH_4) fluxes at the water–air interface and concentrations and isotopic signals of CH_4 in the bubbles stirred up from the sediment in Tucurui and Samuel reservoirs in 2000 and 2001. Tucurui (deep) reservoir is located near Belem city in the Tocantins-Araguaia basin in the eastern Amazon. Samuel (shallow) reservoir is situated near Porto Velho city in the Jamari River, a tributary of the Madeira River in the western Amazon. Field samples were collected between June 2000 and September 2001.

2. Data Characteristics:

This data set contains two comma-delimited ASCII data files.

File 1. **LC07_daily_hydroreservoir_methane_flux.csv**

This file provides average daily chamber CH_4 fluxes at the water–air interface in Tucurui and Samuel reservoirs in 2000 and 2001.

Column	Heading	Units/format	Description
1	Site	text	Name of reservoir: TUC = Tucurui (deep reservoir); SAM = Samuel (shallow reservoir)
2	Month	mm	Month(s) of sample collection
3	Year	yyyy	Year of sample collection
4	CH4_flux	mg/m2/d	Average chamber methane fluxes at the water-air interface in milligrams per square meter per day
Notes: Each field campaign accomplished four days of sampling by reservoir. Eight methane fluxes per day were obtained using two floating static chambers. By averaging two simultaneous chamber fluxes, up to four mean methane fluxes per day were estimated, gathering a maximum of 16 mean methane fluxes by reservoir for each of the three field campaigns. There are no missing values.			

Example Data Record:

```
Site,Month,Year,CH4_flux
TUC,6,2000,3.25
TUC,6,2000,4.31
TUC,6,2000,2.7
TUC,6,2000,2.64
...
SAM,9,2001,10.61
SAM,9,2001,4.38
SAM,9,2001,4.34
SAM,9,2001,18.93
```

File 2. **LC07_mean_hydroreservoir_methane_releases.csv**

This file provides average ± standard deviation of chamber CH_4 fluxes at the water–air interface and concentrations and isotopic signals of CH_4 in the bubbles stirred up from the sediment in Tucurui and Samuel reservoirs in 2000 and 2001.

Column	Heading	Units/format	Description
1	Site	text	Name of reservoir: TUC = Tucurui (deep reservoir); SAM = Samuel (shallow reservoir)
2	Month	mm	Month(s) of sample collection
3	Year	yyyy	Year of sample collection

4	CH4_flux	mg/m2/d	Average chamber methane fluxes at the water-air interface in milligrams per square meter per day
5	CH4_flux_SD	mg/m2/d	Standard deviation of methane fluxes (+/-) in milligrams per square meter per day
6	Samples_CH4_flux	numeric	Number of samples
7	Sediment_gas_bubble_conc	mM	Concentrations of methane in the bubbles stirred up from the sediment in the reservoirs, millimolar
8	Sediment_gas_bubble_conc_SD	mM	Standard deviation of sediment gas bubble concentration (+/-), millimolar
9	Samples_sediment_gas_bubble_conc	numeric	Number of samples
10	Sediment_gas_bubble_isotopic_signal	per mil (parts per thousand)	Isotopic signals of methane (d13 C-CH4) in the bubbles stirred up from the sediment in the reservoirs
11	Sediment_gas_bubble_isotopic_signal_SD	per mil (parts per thousand)	Standard deviation of isotopic signals of sediment gas bubble methane (+/-)
12	Samples_gas_bubble_isotopic_signal	numeric	Number of samples

Notes: Each field campaign accomplished four days of sampling by reservoir. Eight methane fluxes per day were obtained using two floating static chambers.
By averaging two simultaneous chamber fluxes, up to four mean methane fluxes per day were estimated, gathering a maximum of 16 mean methane fluxes by reservoir for each of the three field campaigns.
The number -999 denotes missing values.

Example Data Record:

```
Site,Month,Year,CH4_flux,CH4_flux_SD,Samples_CH4_flux,Sediment_gas_bubble_conc,
Sediment_gas_bubble_conc_SD,Samples_sediment_gas_bubble_conc,Sediment_gas_bubble_isotopic_signal,
Sediment_gas_bubble_isotopic_signal_SD,Samples_gas_bubble_isotopic_signal
TUC,6,2000,8.27,15.9,12,77.9,-999,1,-999,-999,-999
TUC,7,2001,33.5,33.1,10,745,2.48,2,-70.9,3.14,2
...
SAM,6,2001,129,141,15,574,70.4,2,-69.3,9.77,2
SAM,9,2001,48.1,64.8,11,68.3,-999,1,-999,-999,-999
```

Site boundaries:(All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Tucurui reservoir, in Eastern Para, north of Maraba (Tocantins)	-49.41667	-49.41667	-4.33333	-4.33333	World Geodetic System, 1984 (WGS-84)
Samuel reservoir near Porto Velho EMBRAPA (Rondonia)	-63.85355	-63.84105	-8.79095	-8.80345	World Geodetic System, 1984 (WGS-84)

Time period:

- The data set covers the period 2000/06/01 to 2001/09/30
- Temporal Resolution: Daily

Platform/Sensor/Parameters measured include:

- LABORATORY / GC-FID (GAS CHROMATOGRAPH/FLAME IONIZATION DETECTOR) / METHANE

3. Data Application and Derivation:

Recent studies have shown that methane emissions from hydroelectric reservoirs may comprise a considerable fraction of the anthropogenic atmospheric methane. Data from this study may contribute information on the role of hydroreservoirs in the Amazon region, where about 77% of the hydroelectric energy potential remains unexploited, in the framework of climate change and global warming.

Further research may identify key climate variables responsible for similar seasonal and inter-annual variability of both methane production in the sediments and methane fluxes in the water–air interface.

4. Quality Assessment:

The Methane concentration average analytical error was ca. 3 - 5%. Analytical uncertainties in methane isotopic analyses were lower than 1 in per mil notation (0/00).

Floating static chamber measurements illustrated that methane emissions to the atmosphere from Amazon hydroreservoirs were particularly variable. A Kruskal–Wallis test, a nonparametric version of One-way ANOVA, showed that emissions were significantly different between the three field campaigns in both Tucurui ($p < 0.016$) and Samuel ($p < 0.006$). Maximum emissions took place in June–July 2001, and lower fluxes were observed in June–July 2000 and in September 2001.

Methane concentrations in sediment bubbles are equivalent to the quantities of methane released to the atmosphere (R = 0.99 and R = 0.97 for Tucurui and Samuel, respectively). In both reservoirs, bubble methane concentrations were ca. 600 mM in June–July 2001, one order of magnitude larger than concentrations observed in June–July 2000 and September 2001. Higher methane emissions occurred in June–July 2001, precisely when greater quantities of methane were present in the sediments of both reservoirs.

Methane isotope ratio in the sediment bubbles, dissolved in the water column, and emitted to the atmosphere at Tucurui and Samuel reservoirs were comparable to values typically verified in freshwater environments.

5. Data Acquisition Materials and Methods:

Study Sites

Tucurui reservoir is located near Belem city in the Tocantins-Araguaia basin in the eastern Amazon. The reservoir was formed in 1984 covering about 2,800 km^2 with an average depth of approximately 20 m. Samuel reservoir was formed in 1989 and is situated near Porto Velho city in the Jamari River, a tributary of the Madeira River in the western Amazon. It has about 60 km of barriers, which reduced about 80% of the potentially flooded area. As a result, Samuel reservoir has roughly 560 km^2 and mean depth around 6 m. Water residence time is close to 100 days, twice that determined for Tucurui.

Physical and chemical properties of the reservoirs are comparable. Water is typically clear with pH around 7.0 near the surface, and 6.0 to 6.5 in the hypolimnion. The concentration of organic carbon in both reservoirs is approximately 4.0 mg/l. In contrast, inorganic carbon is about 20 mg/l in Tucurui, double that determined in Samuel, due to the inorganic carbon inputs from Tocantins and Araguaia rivers.

Methane Fluxes

Static chamber fluxes were estimated during three field campaigns carried out in June–July 2000, in June–July 2001, and in September 2001. Methane fluxes were acquired relatively far from the shoreline of both Tucurui and Samuel reservoirs. Each field campaign accomplished four days of sampling by reservoir. It was obtained eight methane fluxes per day using two floating static chambers. By averaging two simultaneous chamber fluxes, four mean methane fluxes per day were estimated, gathering a maximum of 16 mean methane fluxes by reservoir for each of the three field campaigns. Each chamber has a headspace volume of 36,000 cm3 and an exchange area of 1,000 cm2. Both chambers were covered with reflective material to minimize the increase of inside temperature during deployments of 1 h. Samples were pumped every 15 min from 5-m length and 3-mm inner diameter nylon tubing with the aid of 60- ml plastic syringes adapted with luer-lock valves. Gas samples were then stored by needle injection in 15-ml pre-evacuated glass flasks sealed with butyl rubber stoppers for later concentration determination.

Methane concentration was determined with a flame ionization detector (FID) in a Shimadzu 17A gas chromatograph (GC). Around 1–3 ml of gas sample was injected in the GC system, composed of a system port at 150 degrees C, a 0.53-mm diameter and 30-m length Megabore column at 45 degrees C, and a FID at 200 degrees C. Average analytical error was ca. 3–5%.

Methane fluxes were calculated by (phi) = $(\Delta c/\Delta t) \cdot (V/A)$, where $\Delta c/\Delta t$ is the rate of methane concentration change into the chambers. All fluxes (phi) < 0 were discarded of the analysis, since, in terms of energy conservation, $\Delta c/\Delta t < 0$ may represent physically improbable fluxes. Methane bubbles eventually intercepted some time series. When bubbles interfered in the beginning of the deployment, the disturbance created a negative rate, due to mixing within the chamber and thus dilution of the bubbles close to the atmospheric methane concentration. For those cases, methane fluxes were also discarded.

Methane Concentration in Sediment Gas Bubbles and Water

Methane bubbles were sampled in the three field campaigns by stirring up the sediments. Arising bubbles were collected with an entirely submerged 25-cm diameter inverted plastic funnel. The open narrow end of the funnel was sealed with a rubber stopper of 3-cm diameter. With a needle, bubble gas samples were pumped into a 60-ml plastic syringe adapted with a luer-lock valve and thereafter injected in pre-evacuated 15-ml glass flasks sealed with butyl rubber stoppers for later FIDGC analysis. In June–July 2001 gas samples were collected for dissolved methane analysis in the epi, meta and hypolimnion of both reservoirs. Using a headspace equilibrium technique presented by McAullife (1971), a 60-ml plastic syringe adapted with a luer-lock valve containing 30 ml of water sample and 30 ml of pure nitrogen was vigorously shaken during 2 min, transferring the dissolved phase to the nitrogen headspace. The headspace was then injected with a needle in pre-evacuated 15-ml glass flasks sealed with butyl rubber stoppers for later FID-GC analysis.

Methane Isotopic Analysis

After the FID-GC analysis, the remaining gas contained in the 15-ml glass flasks acquired in June–July 2001 from the emitted CH_4 (chambers), CH_4 in the water column and CH_4 in the sediment bubbles was employed for $\delta^{13}C–CH_4$ analysis in a PreCon system Finnigan Mat) in line with a mass spectrometer Finnigan Delta-Plus (Merritt and Hayes, 1995). Isotopic analysis of methane consisted of trapping CO_2 from samples in liquid nitrogen, and then of the oxidation of methane at 1,000 degrees C. The carbon isotopic ratio of the oxidized methane ($\delta^{13}C–CO_2$) was then determined and expressed by $\delta^{13}C = [(R_a/R_p) - 1]1{,}000$ in per mil notation (%), where *R* denotes the $^{13}C/^{12}C$ ratio for the sample *a* and for the standard *p* (Pee Dee Belemnite, PDB). Analytical uncertainties were lower than 1%.

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive Center:

Contact for Data Center Access Information:
E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

7. References:

Lima I.B.T. 2005. Blogeochemical distinction of methane releases from two Amazon hydroreservoirs. Chemosphere, 59: 1697-1702.

Related Publications

Ramos, F.M., I.B.T. Lima, R.R. Rosa, E.A. Mazzi,. J.C. Carvalho, M.F.F.L. Rasera, J.P.H.B. Ometto, A.T. Assireu, and J.L. Stech. 2006. Extreme event dynamics in methane ebullition fluxes from tropical reservoirs. Geophysical Research Letters, 33(21); L21404.

Bambace, L.A.W., F.M. Ramos, I.B.T. Lima, and R.R. Rosa. 2007. Emissions from tropical hydroelectric dams. Energy, 32(6): 1038-1046.

Lima I.B.T., F.M. Ramos, L.A.W. Bambace, and R.R. Rosa. 2008. Methane emissions from large dams as renewable energy resources: A developing nation perspective. Mitigation and Adaptation Strategies for Global Change, 13(2): 193-206.

McAullife, C. 1971. GC determination of solutes by multiple phase equilibration. Chem. Technol. 1(1): 46–51.

Merritt, D.A., and J.M. Hayes. 1995. Carbon isotopic analysis of atmospheric methane by isotope ratio-monitoring gas chromatography–mass spectrometry. J. Geophys. Res. 100: 1317–1326.