

LBA-ECO CD-06 Isotopic Composition of Carbon Fractions, Amazon Basin River Water

Summary:

This data set includes measurements of standard geochemical variables, dissolved CO₂, dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), fine particulate organic carbon (FPOC), and coarse particulate organic carbon (CPOC) in samples taken from 60 Amazonian river locations across the Amazon Basin from 1991 to 2003 (Mayorga et al., 2005). The ¹⁴C and ¹³C isotopic composition of DIC was measured on samples collected between 1991 and 2003. The ¹⁴C composition of organic carbon fractions was measured on samples collected from 1995 through 1996.

There are four comma-delimited data files with this data set. Note that site descriptions include a categorization of each site by topography according to the percentage of the drainage area above 1,000 m elevation (Mayorga et al., 2005). Only means of geochemical and carbon-fraction results are provided. Both individual ¹³C and ¹⁴C measurements and mean results are provided.

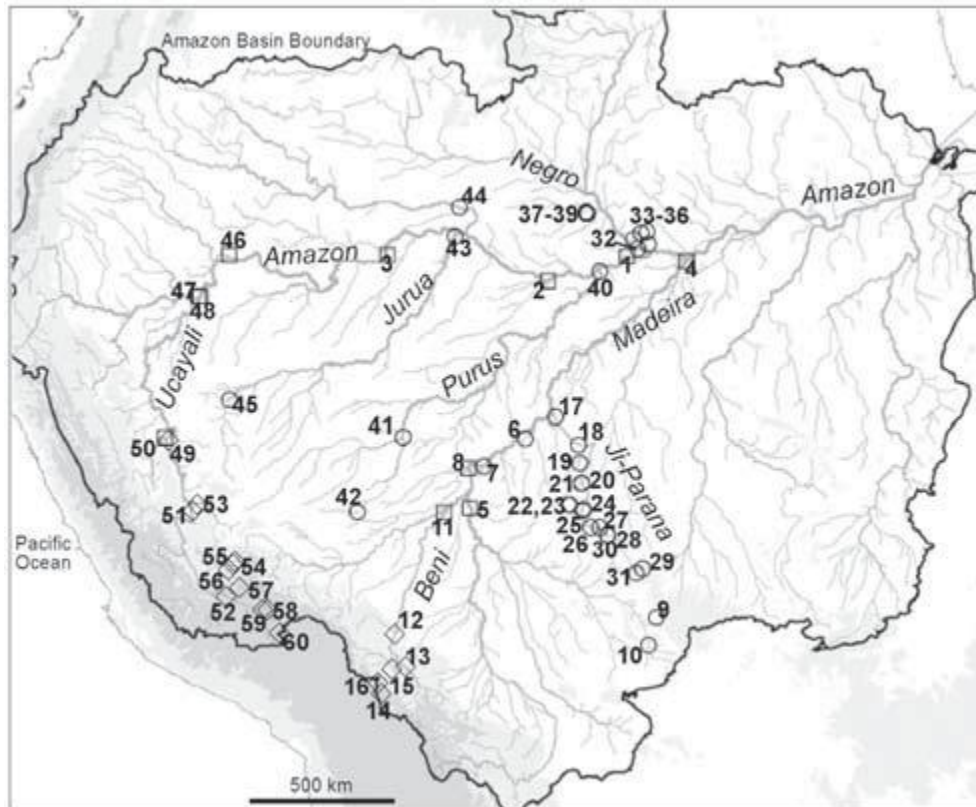


Figure 1. Amazon basin and river sites sampled for carbon isotopes. GTOPO30 elevation and a regional river network data set were used to categorize each site by topography according to the percentage of the drainage area above 1,000 m elevation: 16 mountain sites ($\geq 50\%$, with diamond markers); 11 mixed sites ($\geq 10\%$, with square markers), and 33 lowland sites ($\leq 10\%$, with circle markers). Mountain

sites are found only in the Andean Cordillera, while mixed sites are large rivers draining both mountain and lowland areas. Site numbers are displayed.

Data Citation:

Cite this data set as follows:

Mayorga, E., A.K. Aufdenkampe, C.A. Masiello, A.V. Krusche, A.I. Hedges, P.D. Quay, J.E. Richey, and T.A. Brown. 2012. LBA-ECO CD-06 Isotopic Composition of Carbon Fractions, Amazon Basin River Water. Data set. Available on-line [<http://daac.ornl.gov>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. <http://dx.doi.org/10.3334/ORNLDAAC/1120>

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This data set was archived in September of 2012. Users who download the data between September 2012 and August 2017 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 website [<http://lba.inpa.gov.br/lba/>] 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.

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1. Data Set Overview:

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

Activity: LBA-ECO

LBA Science Component: Carbon Dynamics

Team ID: CD-06 (Richey / Victoria)

The investigators were Richey, Jeffrey E.; Victoria, Reynaldo Luiz; Souza, Reginaldo; Aalto, Rolf Erhart; Abdo, Mara Silvia Aguiar; Alin, Simone Rebecca; Aufdenkampe, Anthony K.; Ballester, Maria Victoria Ramos; Barbosa, Roosevelt Passos ; Bernardes, Marcelo Correa; Bezerra de Barros Lima, Roberta; Bolson, Marcos Alexandre; Bolson, Marcos Alexandre; Bonelle, Nilton ; Brito, David Silva; Cabianchi, Giovana; Cogo, Michelle Cristine; da Silva, Luis Vilmar Souza; Dalmagro, Higo Jose; de Oliveira, Carolina Barisson Marques; Deus, Fabiano Alves de Devol, Allan H.; do Nascimento, Clive Reis; Ellis, Erin Elizabeth; Ferro, Jaderson Coradi; Filho, Walter Jorge do Nascimento; Frickmann, Fernando Cruz; Gamero Guandique, Manuel Enrique; Gomes, Beatriz M; Gomes, Viviane ; Gouveia Neto, Sergio Candido; Hanada, Lais de Carvalho; Holtgrieve, Gordon William; Kelly Batalha Silva, Roberta; Krusche, Alex; Kurzatkowski, Dariusz; Lacerda, Francisco A. Siebra; Leite, Nei; Logsdon, Miles Grant; Macedo, Gelson de; Marcondes, Renata ; Marilheuz, Campos Paro; McGeoch, Lauren ; Melo, Emanuele Gurgel de Freitas; Mendes, Francisco de Assis; Moreira, Marcelo Zacharias; Munhoz, Kelli; Neu, Vania ; Ometto, Jean Pierre; Pimentel, Tania Pena; Priante Filho, Nicolau; Rabelo, Claudenir Silva; Rasera, Maria de Fatima Fernandes Lamy; Remington, Sonya Marie; Rodda, Sarah; Ruiz Mateus, Neuza Maria; Salimon, Cleber; Santiago, Alailson Venceslau; Santos, Arnaldo Marcilio dos; Silva, Cleoni Virginio da; Silva, Jonismar; Silva, Simao Correa da; Sousa, Eliete ; Souzapetro, Petronio Lopes de; Toledo, Andre Marcondes Andrade; Tumang, Cristiane Azevedo; Umetsu, Cristiane Akemi; Victoria, Daniel de Castro; Xavier, Farley de Oliveira and Mayorga, Emilio. You may contact Mayorga, Emilio (emiliomayorga@gmail.com).

LBA Data Set Inventory ID: CD06_C_Isotopes

This data set includes measurements of standard geochemical variables, dissolved CO₂, dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), fine particulate organic carbon (FPOC), and coarse particulate organic carbon (CPOC) in samples taken from 60 Amazonian river locations across the Amazon Basin from 1991 to 2003 (Mayorga et al., 2005). The ¹⁴C and ¹³C isotopic composition of DIC was measured on samples collected between 1991 and 2003. The ¹⁴C composition of organic carbon fractions was measured on samples collected from 1995 through 1996.

2. Data Characteristics:

Data are provided in four ASCII comma-delimited files:

File #1: Sample_site_descriptions.csv

File #2: Geochemical_property_means.csv

File #3: C_fraction_delta_values_ind_samples.csv

File #4: Mean_C_fraction_delta_values.csv

File #1: Sample_site_descriptions.csv

Column	Heading	Units/format	Description
1	Site_category		Sites are categorized based on proportion of their drainage area at elevations greater than 1,000 m
2	River		Name of the river sampled

3	Site_name		Name given to the sampling location. A few sites represent aggregated data from distinct sites in relative proximity.
4	Latitude	decimal degrees	Sampling location: latitude in decimal degrees (s)
5	Longitude	decimal degrees	Sampling location: longitude in decimal degrees (w)
6	Area	km2	Site drainage area in square kilometers
7	Elev_site	m	Elevation at the sampling site in meters
8	Elev_basin_mean	m	Mean elevation of the site drainage area in meters
9	Elev_1000	%	Percent of the site drainage area with elevation greater than 1,000 m

Example data records:

```

Site_category,River,Site_name,Latitude,Longitude,Area,Elev_site,Elev_basin_mean,Elev_1000
Lowland,Candeias,Candeias,-8.766,-63.708,"13,200",77,179,0.2
Lowland,Azul,Azul,-9.627,-64.942,"4,030",103,184,0
Lowland,Novo,Novo,-14.172,-59.742,150,295,314,0
...
Lowland,Comemoracao,COM-2,-11.667,-61.188,"6,740",199,372,0
Lowland,Comemoracao,COM-1,-12.718,-60.173,160,594,598,0
Lowland,Pimenta Bueno,PB-2,-11.703,-61.192,"8,650",197,321,0
...
Mountain,Salcca,Salcca,-14.102,-71.422,"3,190",3792,4743,100
Mountain,Vilcanota,Tinta,-14.166,-71.402,"1,610",3571,4239,100
Mountain,Lago Langui-Layo,Langui,-14.437,-71.292,470,3877,4276,100

```

File #2: Geochemical_property_means.csv

Column	Heading	Units/format	Description
1	Site_category		Sites are categorized based on proportion of the site drainage area at elevations greater than 1,000 m
2	River		Name of the river
3	Site_name		Name given to the sampling location
4	Site_ID		Each sampling site was assigned a unique numeric site ID
5	Temperature	degrees C	Mean water temperature reported in degrees Celsius
6	pH		Mean river water pH
7	Alkalinity	ueq per L	Mean river water alkalinity either measured by Gran titration or estimated from temperature, DIC and pH; reported in microequivalents per liter (ueq per L)
8	FSS	mg per L	Concentration of fine suspended sediments reported in milligrams per liter of water
9	Perc_FPOC	%wt	Percent of fine suspended sediments composed of FPOC calculated as column 8 divided by column 13 and reported in percent
10	CO2	ppm	Mean river water CO2 concentrations were either measured directly by headspace equilibration or estimated from temperature, pressure, pH, DIC, and alkalinity and reported in parts per million (ppm)
11	DIC	umol per L	Concentration of DIC reported in micromoles per liter (umol per L)

12	DOC	mg C per L	Concentration of DOC reported in milligrams C per liter (mg per L)
13	FPOC	mg C per L	Concentration of dissolved FPOC reported in milligrams C per liter (mg per L)
14	CPOC	mg C per L	Concentration of dissolved CPOC reported in milligramsC per liter (mg per L)
Missing data are represented by -9999			
Mean geochemical properties were based on samples analyzed for carbon isotopes			

Example data records:

```

Site_category,River,Site_name,Site_ID,Temperature,pH,Alkalinity,FSS,Perc_FPOC,CO2,DIC,DOC,FPOC,CPOC
Lowland,Candeias,Candeias,6,25.4,5.92,98,19.1,7.13,7,640,362,1.65,1.36,0.13
Lowland,Azul,Azul,7,25.1,5.94,77,14.7,9.91,5,723,275,0.69,1.46,-9999
Lowland,Novo,Novo,9,24.7,6.41,98,15.6,9.42,"2,476",184,0.68,1.47,0.93
...
Lowland, Ji-Parana, JIP-1, 27, 29.3, 7.15, 131, 14.8, -9999, 643, 150, 2.43, -9999, -9999
Lowland, Comemoracao, COM-2, 28, 25.2, 6.25, 39, 20.7, 9.6, "1,346", 85, 2.49, 1.12, 0.18
Lowland, Comemoracao, COM-1, 29, 23.6, 5.32, 3, 15, 1.96, "1,872", 70, 1.6, 0.53, -9999
...
Mountain, Salcca, Salcca, 58, 15.1, 7.55, "2,060", 289.5, 1.15, "3,872", "2,259", 1.32, 3.33, 6.63
Mountain, Vilcanota, Tinta, 59, 18.7, 7.69, "3,320", 4.5, 16.16, "4,103", "3,252", 2.63, 0.72, 0.01
Mountain, Lago Langui-Layo, Langui, 60, 11.9, 8.46, "1,900", 1.5, 30.27, 400, "1,821", 1.9, 0.45, -9999

```

File #3: C_fraction_delta_values_ind_samples.csv

Column	Heading	Units/format	Description
1	Site_category		Sites are categorized based on proportion of the site drainage area at elevations greater than 1,000 m
2	Site_ID		Each sampling site was assigned a unique numeric site ID
3	Date	YYYYMMDD	Sample date (YYYYMMDD)
4	C_fraction		Carbon fraction analyzed: DIC= dissolved inorganic carbon; CO2= carbon dioxide; DOC= dissolved organic carbon; FPOC= fine particulate organic carbon; CPOC= coarse particulate organic carbon: analyses for CO2 fraction were calculated; all others were measured directly
5	Delta_14C	per mil	Isotopic ratio of 14C to 12C: Delta (capital greek Delta) 14C data are reported as $[(^{14}\text{C}/^{12}\text{C} \text{ ratio of the sample} / 0.95 \text{ times the } ^{14}\text{C}/^{12}\text{C} \text{ of the Oxalic Acid I standard, decay corrected to 1950}) - 1] * 1000$ (as defined in Stuiver and Polach, 1977). A mass-dependent 13C correction has been applied
6	delta_13C	per mil	Isotopic ratio of 13C to 12C: delta (lowercase greek delta) 13C data are reported as $[(^{13}\text{C}/^{12}\text{C} \text{ ratio of the sample} / \text{the } ^{13}\text{C}/^{12}\text{C} \text{ of the PeeDee Belemnite standard}) - 1] * 1000$, or the deviation in parts per thousand of the 13C/12C ratio of the standard from the 13C/12C of the PDB standard
Missing data are represented by -9999			

Example data records:

```

Site_category,Site_ID,Date,C_fraction,Delta_14C,delta_13C
Lowland,6,19960702,DIC,-9999,-19.3
Lowland,6,19960702,CO2,100,-20.6
...
Lowland,41,19960623,DIC,-9999,-13.8,
Lowland,41,19960623,CO2,72,-21.1
Lowland,41,19960623,DOC,175,-29.3
...
Mountain,59,19961023,CPOC,-353,-26.4
Mountain,60,19961024,DIC,-9999,-2
Mountain,60,19961024,CO2,-109,-11.3

```

File #4: Mean_C_fraction_delta_values.csv

Column	Heading	Units/format	Description
1	Site_category		Sites are categorized based on proportion of their drainage area at elevations greater than 1,000 m
2	Carbon_fraction		Identification of the carbon fraction (CO2= carbon dioxide; DIC= dissolved inorganic carbon; DOC= dissolved organic carbon; FPOC= fine particulate organic carbon and CPOC= coarse particulate organic carbon)
3	N_samples		Number of samples included in the calculation of the mean value
4	Delta_14C	per mil	Mean Delta 14C value for this carbon fraction and site category combination reported in parts per mil
5	Std_dev_D14C	per mil	Standard deviation of the mean Delta 14C value
6	delta_13C	per mil	Mean delta 13C value for this carbon fraction and site category combination reported in parts per mil
7	Std_dev_d13C	per mil	Standard deviation of the mean delta 13C value
missing data are represented by -9999			

Example data records:

```

Site_category,Carbon_fraction,Num_samples,Delta_14C,Std_dev_D14C,delta_13C,Std_dev_d13C
Mountain,CO2,14,-240,233,-9999,-9999
Mixed,CO2,11,-14,99,-9999,-9999
Lowland,CO2,43,89,44,-9999,-9999
Carbonate-free lowland,CO2,38,98,20,-9999,-9999
Mountain,DIC,14,-9999,-9999,-4.9,2.7
Mixed,DIC,11,-9999,-9999,-14.2,2.9
Lowland,DIC,43,-9999,-9999,-17,5.9
Carbonate-free lowland,DIC,38,-9999,-9999,-17.1,6.2
Mountain,DOC,6,94,176,26,3
Mixed,DOC,9,196,59,-29,0.6
Lowland,DOC,15,177,64,-29,0.9
Carbonate-free lowland,DOC,11,175,67,-29.1,0.7

```

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

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Rondonia, Brazil Amazon Basin (Amazon Basin)	-74.572	-58.798	-1.817	-16.472	World Geodetic System, 1984 (WGS-84)

Time period

- The data set covers the period 1991/08/12 - 2003/01/26
- Temporal Resolution: samples were collected at irregular intervals over multiple campaigns

Platform/Sensor/Parameters measured include:

- LABORATORY / MASS SPECTROMETER / CARBON
- FIELD INVESTIGATION / IRGA (INFRARED GAS ANALYZER) / CARBON DIOXIDE
- LABORATORY / CHN ANALYZER / DISSOLVED SOLIDS
- LABORATORY / WEIGHING BALANCE / ORGANIC MATTER

3. Data Application and Derivation:

Isotopic calculation of CO₂ gas in equilibrium with DIC

DIC is composed of dissolved carbonate species (H₂CO₃(aq), HCO₃(aq), and CO₃(aq)) in temperature- and pH-dependent equilibrium with one another. Isotopic fractionation occurs during conversion from one species to another (Clark and Fritz 1997) and dissolution of CO₂ gas; CO₂ gas is hereafter referred to as simply CO₂. $\delta^{13}\text{C}$ of CO₂ gas in equilibrium with DIC is calculated from measured $\delta^{13}\text{C}$ -DIC and pH, and from temperature-dependent isotopic equilibrium fractionations between CO₂ and DIC species (Clark and Fritz 1997, Zhang et al., 1995).

pH can vary dramatically in a large basin and is largely a function of weathering lithologies. $\Delta^{14}\text{C}$ is defined to be insensitive to mass-dependent fractionation (Stuiver and Polach, 1977); as a result $\Delta^{14}\text{C}$ -CO₂ equals $\Delta^{14}\text{C}$ -DIC. Although a focus on isotopes of CO₂ instead of DIC is unconventional, it yields more straightforward assessments of the impact of respiration and air-water gas exchange on DIC across geochemically diverse rivers.

4. Quality Assessment:

Absolute $\Delta^{14}\text{C}$ and $\delta^{13}\text{C}$ analysis errors (1 sigma) are typically less than 6 per mil and less than 0.2 per mil, respectively.

Radiocarbon trends in atmospheric CO₂. Measurements from Schauinsland Station, Germany, were used to characterize atmospheric $\Delta^{14}\text{C}$ -CO₂ from 1991 to 2003 (Levin and Hesshaimer 2000, Levin and Kromer 2004). The uncharacterized effect of seasonal and short-term atmospheric variability is minimized by comparing river $\Delta^{14}\text{C}$ only against time-weighted annual means (Levin and Kromer 2004). A constant plus 8 per mil offset was added to Schauinsland annual means to account for a 5 per mil depletion from regional fossil-fuel emissions at Schauinsland relative to the well-mixed, mid-latitude European troposphere (Jungfraujoch site, Levin and Kromer 2004), and approximately 3 per mil further depletion at the midlatitude troposphere relative to tropical South America (Levin and Hesshaimer 2000, Randerson et al., 2002). Atmospheric $\Delta^{14}\text{C}$ CO₂ composition within the Amazon basin is unknown, but seasonal and regional variability may be as large as 10 per mil (Randerston et al., 2002). Riverine

Delta 14C values within 5 per mil of our estimated atmospheric annual average for the sampling year probably represent carbon turnover times of one year or less. Mid-1990s tropospheric CO₂ can be characterized by a partial pressure (pCO₂) of 370 ppm and delta 13C composition of 28 per mil (Clark and Fritz 1997, Levin and Hesshaimer 2000, Randerson et al., 2002).

5. Data Acquisition Materials and Methods:

Site description:

Each sampling site in the Amazonian river system was categorized by topography (refer to Gesch et al., 1999 and Mayorga, E., Logsdon, M. G., et al., 2005) according to the percentage of the drainage area above 1,000 m elevation:

- mountain, greater than or equal to 50% (16 sites)
- mixed, greater than or equal to 10% (11 sites)
- lowland, less than 10% (33 sites)

Mountain sites are found only in the Andean Cordillera, while mixed sites are large rivers draining both mountain and lowland areas.

Sample collection and analysis:

Samples analyzed for 14C DIC were collected between 1991 and 2003, whereas organic-carbon 14C samples are from 1995 through 1996 (Mayorga et al., 2005). All samples were preserved with mercuric chloride immediately after collection at mid-depth from the deepest section of the channel. DIC samples were prepared as described in Quay et al. (1992) and stored in tightly capped glass bottles for up to 24 months; in the lab, the top half of the bottle was drawn into a vacuum line (eliminating particles) and stripped of CO₂ after acidification (Quay et al., 1992).

CPOC (63 to 2,000 µm) was isolated either by sieving or with a plankton net, FPOC (0.1 to 63 µm) by tangential flow microfiltration, and DOC (1,000 atomic mass units to 0.1 µm) by tangential flow ultrafiltration (Hedges et al., 2000). Final concentration and drying were achieved by centrifugal evaporation or freeze drying, and the dried powder was stored in the dark at ambient temperature for up to 6 years (Hedges et al., 2000). Organic samples were combusted as in Quay et al., 1992.

Cryogenically purified CO₂ from organic carbon and DIC was analyzed for stable isotope and radiocarbon by dual-inlet isotope ratio mass spectrometry and accelerator mass spectrometry (AMS) (Vogel et al. 1987), respectively; more than 90 percent of 14C analyses were carried out at the Lawrence Livermore National Laboratory Center for Accelerator Mass Spectrometry, and the rest at the University of Arizona Accelerator Mass Spectrometry Laboratory.

CO₂ extracted from DIC was stored in sealed glass ampoules for up to 8 years. 13C is reported in delta 13C notation versus the PDB standard (Clark and Fritz 1997). Radiocarbon values are reported as age-corrected Delta 14C adjusted for sample delta 13C (Stuiver and Polach 1977); carbon is defined as modern when it originates after 1890 (Stuiver and Polach 1977).

Isotopes for all carbon fractions were not always analyzed at each site. Additional analyses include pH, major ions, alkalinity, and total carbon fraction concentrations. Major ions were quantified by ion chromatography. Alkalinity was measured by Gran titration, or estimated from temperature, pH and DIC when not measured. CO₂ concentrations were either measured directly by headspace equilibration or estimated from temperature, pressure, pH, DIC, and alkalinity.

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:

- Clark, I. & Fritz, P. 1997. Environmental Isotopes in Hydrogeology (Lewis Publishers, Boca Raton).
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- Zhang, J., Quay, P. D. & Wilbur, D. O. 1995. Carbon isotope fractionation during gas-water exchange and dissolution of CO_2 . *Geochim. Cosmochim. Acta* 59, 107-114.

Related Publications

- Mayorga, E., A.K. Aufdenkampe, Masiello, C.A., Krusche, A.V., Hedges, A.I., Quay P.D., Richey, J.E. and T.A. Brown. 2005. Young organic matter as a source of carbon dioxide outgassing from Amazonian rivers. *Nature* 436: 538-541. doi:10.1038/nature03880