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# BASIN TCP Stable Isotope Composition of CO<sub>2</sub> in Terrestrial Ecosystems

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Revision date: February 10, 2010

### Summary:

This data set reports stable isotope ratio data of CO<sub>2</sub> (<sup>13</sup>C/<sup>12</sup>C and <sup>18</sup>O/<sup>16</sup>O) associated with photosynthetic and respiratory exchanges across the biosphere-atmosphere boundary. Measurements were made at selected AmeriFlux sites: Harvard Forest, Howland Forest, Rannells Flint Hills Prairie, Niwot Ridge Forest, and the Wind River Canopy Crane Site, which span the dominant ecosystem types of the United States. These data were collected periodically from 2001 through 2004 and are available as an ASCII comma separated file.

The goal of this Terrestrial Carbon Processes (TCP) project is to better capture isotopic effects of ecosystem-atmosphere interaction at diurnal, seasonal and interannual time scales by long-term monitoring <sup>13</sup>C of CO<sub>2</sub> exchange with the atmosphere at weekly intervals. Photosynthesis and respiration in terrestrial ecosystems have opposite effects on diurnal and seasonal patterns on atmospheric CO<sub>2</sub> concentration and isotope ratios. This isotopic variation contains information about the functioning of different terrestrial ecosystems.

Specifically, this research addresses the following fundamental questions to meet the need to have a stronger characterization of the isotopic composition of CO<sub>2</sub> in terrestrial biosphere-atmosphere exchange identified by the U.S. Carbon Cycle Science Plan (CCWG, 1999):

- Providing long-term observations of <sup>13</sup>C and <sup>18</sup>O of CO<sub>2</sub> in canopy boundary layer from diverse ecosystem types in the United States
- Dissecting <sup>13</sup>C of respiratory CO<sub>2</sub> fluxes into above- and belowground components
- Partitioning net ecosystem exchange (NEE) into assimilation and respiration components
- Modeling canopy CO<sub>2</sub> fluxes and isotopic discrimination

This TCP project contributes to The Biosphere - Atmosphere Stable Isotope Network (BASIN) (<http://basinisotopes.org>), an umbrella program aimed at improving our understanding of carbon and water cycle processes at the ecosystem, regional, and global scales. Data sharing and integration will allow for cross-site comparisons and provide an opportunity to assess any continental or global effects.

Additional information about AmeriFlux and the measurement sites can be obtained from the program web site at <http://ameriflux.lbl.gov/SitePages/Home.aspx>.

### Site Supplemental Information

A table of measurement sites cross referenced to FLUXNET sites and linked to the FLUXNET web site with supplemental information is included in Section 5.

Acknowledgement: The Terrestrial Carbon Processes (TCP) Program research performed by the Ehrlinger Lab at the University of Utah, James Ehrlinger, Director, was supported by the Office of Science (BER), U.S. Department of Energy, under Grant No. DE-FG03-00ER63012.

### Data Citation:

Cite this data set as follows:

Ehrlinger, J.R. and C.T. Lai. 2010. BASIN TCP Stable Isotope Composition of CO<sub>2</sub> in Terrestrial Ecosystems. 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/963](https://doi.org/10.3334/ORNLDAAC/963)

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### 1. Data Set Overview:

This data set reports stable isotope ratio data of CO<sub>2</sub> (13C/12C and 18O/16O) associated with photosynthetic and respiratory exchanges across the biosphere-atmosphere boundary. Measurements were made at selected AmeriFlux sites: Harvard Forest, Howland Forest, Rannells Flint Hills Prairie, Niwot Ridge Forest, and Wind River Canopy Crane Site, which span the dominant ecosystem types of the United States. These data were collected periodically from 2001 through 2004 and are available as an ASCII comma separated file.

### 2. Data Characteristics:

These data were collected periodically from 2001 through 2004 and are available as an ASCII comma separated file.

Data file description : TCP\_2001\_2004\_20091117.csv

Column Heading	Units or format	Description	Method
TCP_site	character	Sampling site name	
TCP_location	character	Sampling location within site	
Date_sampled	mm/dd/yyyy	Date sample collected	
Time_sampled	hh:mm	Time sample collected. Missing code = -9999.	
Time_zone	character	Local standard time zone	
TCP_Contact	character	Sampling and analysis information contact	
Sample_type	character	Sampled medium is air. When TCP_source = 2001-2004: daytime, nighttime, or tank air may be specified. When TCP_source= TCP_2004: only air is specified.	Sample_type = "tank air" indicates a calibration run and data values should not be combined with ambient samples.
Sample_ID	character	Data provider designation. Missing code = "Not provided"	
Flask_position	numeric	Sampling Strategies: Initial approach - Flask 1: control flask Flask 2-3: mid-afternoon samples from level 3 (top of the canopy) Flask 4-15: nighttime samples beginning an hour after sunset from level 1 and 2 (inside the canopy)  Beginning in July 2003, four flasks are collected in the mid-afternoon. See Lai et al. (2003; 2004) for more information on sampling strategy. Missing code = -999.	Flasks were collected by an automated sampling system (Schauer et al. 2003).
Height	meters	Sampling height in meters. Missing code = -999.	
CO2_air	ppm	CO2 concentration in flask sample.WMO scale. Missing code = -999.99	Measured with a bellow/IRGA system (Bowling et al. 2001).
del_13C_CO2	per mil	Isotopic ratio of <sup>13</sup> C/ <sup>12</sup> C in carbon dioxide. Pee Dee Belemnite (PDB) standard. Missing code = -999.99	Flasks were analyzed for isotope ratios at the Stable Isotope Ratio Facility for Environmental Research (SIRFER) at the University of Utah using a continuous-flow isotope ratio mass spectrometer system (Precon attached to a Delta S, San Jose , CA.)
del_13_standard	character	VPDB scale	

del_18O_CO2	per mil	Isotopic ratio of <sup>18</sup> O/ <sup>16</sup> O in carbon dioxide. Standard Mean Ocean Water (SMOW) standard. Missing code = -999.99	Flasks were analyzed for isotope ratios at the Stable Isotope Ratio Facility for Environmental Research (SIRFER) at the University of Utah using a continuous-flow isotope ratio mass spectrometer system (Precon attached to a Delta S, San Jose , CA.)
del_18O_std	character	VSMOW scale	
TCP_source	character	Marker for data provider source	
Orig_TCP_data_file	character	Original data file name as received from provider.	Numerous data files were combined by the Data Center into this single file and checked for consistency.
Notes	character	Supplemental sampling and analysis information	If the <b>Notes</b> value is "bad point" or "questionable" then related data values have been set to missing.
Ecosystem	character	Data provider designation	
Species	character	Data provider designation.	
Data_source1	character	Data provider information.	
Data_source2	character	Data provider information.	

**Example data records:**

```
TCP_site,TCP_location,Date_sampled,Time_sampled,Time_zone,TCP_Contact,Sample_type,Sample_ID,Flask_position,Height,
CO2_air,del_13C_CO2,del_13C_std,del_18O_CO2,del_18O_std,TCP_source,Orig_TCP_data_file,Notes,Ecosystem,Species,
Data_source1,Data_source2

character,character,mm/dd/yyyy, hh:mm,character,character,character,character,numeric,meters,
ppm,per mil,character,per mil,character,character,character,character,character,character,
character,character
...

Harvard Forest,EMS Annex Walk-Up Tower (130m SW of the EMS eddy flux tower),23/08/2001,20:52,EST,
"Chun Ta Lai, Jim Ehleringer",tank air,A131 (15),15,-999,396.00,-30.18,PDB,2.29,SMOW,2001-2004,
01_08_HV_auto_2.xls,,broadleaf forest,"Quercus velutina, Acer rubrum",DOE/TCP project - Stable Isotope Analyses at the Harvard Forest

Harvard Forest,EMS Annex Walk-Up Tower (130m SW of the EMS eddy flux tower),23/08/2001,15:24,EST,
"Chun Ta Lai, Jim Ehleringer",daytime air,5E (1),1,22.4,370.40,-8.19,PDB,40.62,SMOW,2001-2004,
01_08_HV_auto_2.xls,,broadleaf forest,"Quercus velutina, Acer rubrum",DOE/TCP project - Stable Isotope Analyses at the Harvard Forest
...

Wind River,Crane,10/09/2004,19:42,PST,"Chun Ta Lai, Jim Ehleringer",air,AAA4.5,5,0.5,
494.55,-12.83,PDB,39.06,SMOW,TCP_2004,040915_WR_auto_1.xls,,conifer forest,Pseudotsuga menziesii,
DOE/TCP project,

Wind River,Crane,10/09/2004,19:47,PST,"Chun Ta Lai, Jim Ehleringer",air,A20.6,6,30,
413.02,-10.21,PDB,40.43,SMOW,TCP_2004,040915_WR_auto_1.xls,,conifer forest,Pseudotsuga menziesii,
DOE/TCP project,

Please note that line breaks were added to improve readability and are not in the data file.
```

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

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Geodetic Datum
Howland Forest (Main Tower), ME USA	-68.740278	-68.740278	45.2040700	45.2040700	World Geodetic System, 1984 (WGS-84)
Harvard Forest EMS Tower (HFR1), MA USA	-72.171478	-72.171478	42.5377556	42.5377556	World Geodetic System, 1984 (WGS-84)
Niwot Ridge (LTER NWT1), CO USA	-105.546403	-105.546403	40.0328778	40.0328778	World Geodetic System, 1984 (WGS-84)
Niwot Ridge (LTER NWT2), CO USA	-105.546944	-105.546944	40.0325000	40.0325000	World Geodetic System, 1984 (WGS-84)
Rannells Ranch (ungrazed), KS USA	-96.523000	-96.523000	39.1390000	39.1390000	World Geodetic System, 1984 (WGS-84)
Wind River Crane Site, WA USA	-121.9519111	-121.9519111	45.8204889	45.8204889	World Geodetic System, 1984 (WGS-84)

Time period:

- The data set covers the period 2001/06/05 to 2005/01/02.

### 3. Data Application and Derivation:

Stable isotope ratios of CO<sub>2</sub> are recognized as a key element in improving our interpretations of the carbon cycle at the ecosystem, regional, and global scales. The <sup>13</sup>C and <sup>18</sup>O analyses of CO<sub>2</sub> have been an element of the NOAA Cooperative Air Sampling Network - global flask network (<http://www.esrl.noaa.gov/gmd/ccgg/flask.html>) for over a decade, where these data are essential in partitioning fluxes within the global carbon cycle. The global flask network is an international effort which includes regular discrete samples from the 4 NOAA ESRL/GMD baseline observatories, cooperative fixed sites, and commercial ships. Air samples are collected approximately weekly from a globally distributed network of sites.

Stable isotope analyses are now becoming integrated into regional and ecosystem carbon cycle studies. In part this lag has been because terrestrial surfaces can have large diurnal, vertical, and seasonal impacts on CO<sub>2</sub> concentration and isotope ratios. Much of this variation is filtered out in a flask network that is largely focused at marine sampling sites. The U.S. Carbon Cycle Science Plan (1999) recognizes the need to expand atmospheric monitoring over terrestrial surfaces and the need to have a stronger characterization of the isotopic composition of CO<sub>2</sub> in terrestrial biosphere-atmosphere exchange. In that regard, the Terrestrial Carbon Processes (TCP) Program specifically identifies the need to "... obtain isotopic data that pinpoints source and seasonality of CO<sub>2</sub> fluxes". This project directly addresses the isotope ratio needs identified by both the U.S. Carbon Cycle Science Plan and the TCP Program.

### 4. Quality Assessment:

Measurement values flagged as questionable or bad by the data provider were set to missing, but the Note indicating a problem may remain. Quality assurance of the samples collected manually and by the automated sampling system are discussed in Schauer et al. (2003).

### 5. Data Acquisition Materials and Methods:

Flasks were collected by an automated sampling system (Schauer et al. 2003) for analyses of concentration, <sup>13</sup>C and <sup>18</sup>O ratios of carbon dioxide at AmeriFlux sites, including Wind River Canopy Crane Research Facility, Washington, Rannells Flint Hills Prairie, Kansas, Harvard Forest, Massachusetts, and Howland Forest, Maine.

- Two flasks are collected in the mid-afternoon (normally between 14:00 and 16:00) above the canopy, and 12 flasks are collected at 2 levels inside the canopy during nighttime, beginning an hour after sunset.
- Beginning in July 2003, four flasks are collected in the mid-afternoon. See Lai et al. (2003; 2004) for more information on sampling strategy.

Flasks were analyzed for isotope ratios at the Stable Isotope Ratio Facility for Environmental Research (SIRFER) at the University of Utah using a continuous-flow isotope ratio mass spectrometer system (Precon attached to a Delta S, San Jose, CA). Concentrations of carbon dioxide were measured with a bellow/IRGA system (Bowling et al. 2001). Beginning in April 2004, both concentration and isotope ratios were measured by an automated GC-IRMS system (Schauer et al. 2004).

#### Site with Supplemental Information

TCP site names cross referenced to FLUXNET site names and linked to FLUXNET web site with supplemental information.

TCP Site	TCP Location	FLUX_site_name	IGBP_class	Latitude	Longitude	Elev	State	FLUX_network	FLUX_site_link
Wind River	Crane	Wind River Crane Site	Evergreen needleleaf forest	45.8204889	-121.95191	355	WA	AmeriFlux	<a href="http://www.fluxnet.ornl.gov/site/1103">http://www.fluxnet.ornl.gov/site/1103</a>
Wind River	Young Stand		Evergreen needleleaf forest				WA		
Niwot Ridge	East	Niwot Ridge Forest-Colorado (LTER NWT1)	Evergreen needleleaf forest	40.0328778	-105.5464	-999	CO	AmeriFlux	<a href="http://www.fluxnet.ornl.gov/site/997">http://www.fluxnet.ornl.gov/site/997</a>
Niwot Ridge	West	Niwot Ridge Forest (2)-Colorado (LTER NWT2)	Evergreen needleleaf forest	40.0325	-105.54694	-999	CO	Unaffiliated	<a href="http://www.fluxnet.ornl.gov/site/998">http://www.fluxnet.ornl.gov/site/998</a>
Rannells Flint Hills Prairie	Ungrazed Site	Rannells Ranch (ungrazed)	Grasslands	39.13900	-96.52300	-999	KS	Unaffiliated	<a href="http://www.fluxnet.ornl.gov/site/920">http://www.fluxnet.ornl.gov/site/920</a>
Howland Forest	Main Tower	Howland Forest Main Tower	Mixed forest	45.20407	-68.740278	60	ME	AmeriFlux	<a href="http://www.fluxnet.ornl.gov/site/890">http://www.fluxnet.ornl.gov/site/890</a>
Harvard Forest	EMS Annex Walk-Up Tower EMS (130m SW of the eddy flux	Harvard Forest EMS Tower (HFR1)	Mixed forest	42.5377556	-72.171478	340	MA	AmeriFlux	<a href="http://www.fluxnet.ornl.gov/site/886">http://www.fluxnet.ornl.gov/site/886</a>

tower)

## 6. Data Access:

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) [<http://daac.ornl.gov>].

### Data Archive Center:

#### Contact for Data Center Access Information:

E-mail: [uso@daac.ornl.gov](mailto:uso@daac.ornl.gov)

Telephone: +1 (865) 241-3952

## 7. References:

Bowling DR, Cook CS, Ehleringer JR (2001) Technique to measure CO2 mixing ratio in small flasks with a bellows/IRGA system. *Agricultural and Forest Meteorology*, 109, 61-65. doi:[10.1016/S0168-1923\(01\)00252-0](https://doi.org/10.1016/S0168-1923(01)00252-0)

CCWG, 1999. A U.S. Carbon Cycle Science Plan. Sarmiento, J.L. and S.C. Wofsy (eds.). Carbon and Climate Working Group, University Corporation for Atmospheric Research, Washington, DC, USA, 69 pp.

Lai CT, Schauer AJ, Owensby C, Ham JM, and Ehleringer JR (2003) Isotopic Air Sampling in a Tallgrass Prairie to Partition Net Ecosystem CO2 Exchange, *Journal of Geophysical Research*, 108, D18(4566), doi:[10.1029/2002JD003369](https://doi.org/10.1029/2002JD003369).

Lai C-T, Ehleringer JR, Tans PP, Wofsy SC, Urbanski SP, Hollinger DY (2004) Estimating photosynthetic 13C discrimination in terrestrial CO2 exchange from canopy to regional scales, *Global Biogeochemical Cycles*, 18, GB1041, doi:[10.1029/2003GB002148](https://doi.org/10.1029/2003GB002148).

Schauer AJ, Lai C-T, Bowling DR, and Ehleringer JR (2003) An automated sampler for collection of atmospheric trace gas samples for stable isotope analyses. *Agricultural and Forest Meteorology*, 118, 113-124. doi:[10.1016/S0168-1923\(03\)00065-0](https://doi.org/10.1016/S0168-1923(03)00065-0)

Schauer AJ, Cook C, Lott M, Ehleringer JR (2004) An automated system for stable isotope and concentration analyses of CO2 from small atmospheric samples, submitted to *Rapid Communications in Mass Spectrometry*.



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