1. TITLE

1.1 Data Set Identification

ISLSCP II Carbon Dioxide Flux at Harvard Forest and Northern BOREAS Sites

1.2 Database and Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The files in this directory contain gap-filled flux data and associated meteorological data acquired from two flux tower sites from the FLUXNET global network: Harvard Forest (1992-1995) and the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA), Old Black Spruce (OBS) site (1994-1995).

There are 6*.zip files with this data set called **fluxnet_xx_YYYY.zip**, where xx is the site identifier (HV=Harvard Forest; NB=BOREAS NSA OBS), and YYYY is the four-digit year from 1992-1995.

When extrapolated, each *.zip file contains 20 files for flux data and 5 for associated meteorology data. The data files are named using the following naming convention:

fluxnet_xx_aa_bb_cc_YYYY_flx.csv	for fluxes
fluxnet_xx_cc_YYYY_met.csv	for meteorological data

where 'fluxnet' identifies this data set
'xx' is the site identification: HV=Harvard Forest; NB=BOREAS NSA OBS
'aa' refers to 3 basic data filling methods:
re = nonlinear regression
lu = look up tables
dc = mean daily courses
'bb' refers to the data pre-processing methods:
u0 = u* corrected

u1 = no correction applied
'cc' refers to the temporal resolution:
hh = half hourly
dd = daily
ww = weekly
mm = monthly
yy = yearly
'YYYY' is the 4-digit year code, e.g., "1994"

As an example, the file **fluxnet_NB_1994.zip**, when extrapolated, contains the 25 files described in Table 1 below for the BOREAS NSA OBS site for 1994. In Table 1, NEE is Net Ecosystem Exchange, u* is the friction velocity, LE is Latent Heat, H is Sensible Heat, PAR is Photosynthetically Active Radiation, VPD is Vapor Pressure Deficit, and Ta and Ts are the air and soil temperatures, respectively. Users should consult this document in its entirety for details on data processing methods.

Table 1. Examples of 25 file names contained in the Zipped data set for a site-year of flux data.

File Name	Gap Filling Method	U* Treatment	Time Step
fluxnet_NB_dc_u0_hh_1994.flx	Gap filling by mean daily courses of NEE, LE, H	data u* corrected	half-hourly
fluxnet_NB_dc_u0_dd_1994.flx	Gap filling by mean daily courses of NEE, LE, H	data u* corrected	daily
fluxnet_NB_dc_u0_ww_1994.flx	Gap filling by mean daily courses of NEE, LE, H	data u* corrected	weekly
fluxnet_NB_dc_u0_mm_1994.flx	Gap filling by mean daily courses of NEE, LE, H	data u* corrected	monthly
fluxnet_NB_dc_u0_yy_1994.flx	Gap filling by mean daily courses of NEE, LE, H	data u* corrected	yearly
fluxnet_NB_lu_u0_hh_1994.flx	Gap filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H)	NEE u* corrected	half-hourly
fluxnet_NB_lu_u0_dd_1994.flx	Gap filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H)	NEE u* corrected	daily
fluxnet_NB_lu_u0_ww_1994.flx	Gap filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H)	NEE u* corrected	weekly
fluxnet_NB_lu_u0_mm_1994.flx	Gap filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H)	NEE u* corrected	monthly
fluxnet_NB_lu_u0_yy_1994.flx	Gap filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H)	NEE u* corrected	yearly
fluxnet_NB_re_u0_hh_1994.flx	Gap filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime)	NEE u* corrected	half-hourly
fluxnet_NB_re_u0_dd_1994.flx	Gap filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime)	NEE u* corrected	daily
fluxnet_NB_re_u0_ww_1994.flx	Gap filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime)	NEE u* corrected	weekly
fluxnet_NB_re_u0_mm_1994.flx	Gap filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime)	NEE u* corrected	monthly

fluxnet_NB_re_u0_yy_1994.flx	Gap filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime)	NEE u* corrected	yearly
fluxnet_NB_re_u1_hh_1994.flx	Gap filling by regression corrected	NEE not u* corrected	half-hourly
fluxnet_NB_re_u1_dd_1994.flx	Gap filling by regression corrected	NEE not u* corrected	daily
fluxnet_NB_re_u1_ww_1994.flx	Gap filling by regression corrected	NEE not u* corrected	weekly
fluxnet_NB_re_u1_mm_1994.flx	Gap filling by regression corrected	NEE not u* corrected	monthly
fluxnet_NB_re_u1_yy_1994.flx	Gap filling by regression corrected	NEE not u* corrected	yearly
fluxnet_NB_hh_1994.met	Meteorological forcing parameters		half-hourly
fluxnet_NB_dd_1994.met	Meteorological forcing parameters		daily
fluxnet_NB_ww_1994.met	Meteorological forcing parameters		weekly
fluxnet_NB_mm_1994.met	Meteorological forcing parameters		monthly
fluxnet_NB_yy_1994.met	Meteorological forcing parameters		yearly

1.4 Revision Date of this Document

July 27, 2011

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Marconi Conference Gap-Filled Flux and Meteorology Data, 1992-2000.

2.3 Contacts (For Data Production Information)

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2.4 Data Set Citation

Olson, R.J., D. Baldocchi, S. Holladay. 2011. ISLSCP II Carbon Dioxide Flux at Harvard Forest and Northern BOREAS Sites. In Hall, F.G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. 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/1029

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Falge, E., M. Aubinet, P. Bakwin, P. Berbigier, C. Bernhofer, A. Black, R. Ceulemans, A. Dolman, A. Goldstein, M. Goulden, A. Granier, D. Hollinger, P. Jarvis, N. Jensen, K. Pilegaard, G. Katul, P. Kyaw Tha Paw, B. Law, A. Lindroth, D. Loustau, Y. Mahli, R. Manson, P. Moncrieff, E. Moors, W. Munger, T. Meyers, W. Oechel, E. Schulze, H. Thorgeirsson, J. Tenhunen, R. Valentini, S. Verma, T. Vesala, and S. Wofsy. 2003. *Marconi Conference Gap-Filled Flux and Meteorology Data, 1992-2000.* Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/811

DATA USE POLICY - Kindly inform the appropriate Principal Investigators of how you are using site data and of any publication plans. If the Principal Investigators feel that they should be acknowledged or offered participation as authors, they will let you know and we assume that an agreement on such matters will be reached prior to publishing and/or use of the data for publication. If your work directly competes with the Principal Investigator's analysis they may ask that they have the opportunity to submit a manuscript before you submit the one that uses their data. In addition, when publishing, please acknowledge the agency that supported the research. The Principal Investigators for the Harvard Forest and Northern BOREAS sites are Drs. Steven Wofsy, Harvard University (scw@io.harvard.edu) and Michael Goulden, University of California-Irvine (mgoulden@uci.edu). Please contact the contacts listed in Section 2.3 BEFORE you contact the PIs with questions on data processing.

3. INTRODUCTION

3.1 Objective/Purpose

FLUXNET is a global network of micrometeorological tower sites that use eddy covariance methods to measure the exchanges of carbon dioxide (CO_2), water vapor, and energy between terrestrial ecosystem and atmosphere. Its goals are to understand the mechanisms controlling the flows of CO_2, water and energy to and from the terrestrial biosphere across the spectrum of time and space scales, and to provide ground information for validating estimates of net primary productivity, evaporation and energy absorption that are being generated by sensors such as those mounted on the NASA *Terra* and *Aqua* satellites.

At the time this data set was prepared, over 170 tower sites were operating on a long-term and continuous basis (see http://daac.ornl.gov/FLUXNET/fluxnet.html). Currently more than 500 tower sites are operating on a long-term and continuous basis. Researchers also collect data on site vegetation, soil, hydrologic, and meteorological characteristics at the tower sites. Gap-filled flux data and meteorological data for half-hourly, daily, weekly, monthly, and annual time intervals are typically provided for each site and year. Selected gap-filling methods were used on both u* corrected data and data that had not been corrected for u*. The data have been processed from data kindly provided by investigators of the AmeriFlux and EUROFLUX projects, and are subject to change. Users are urged to communicate with the contributing investigators and are reminded that data, when used for publication, are subject to FAIR USE rules (See Section 2.4).

Gap-filled flux data for two FLUXNET sites are provided in this International Satellite Land Surface Climatology Project (ISLSCP) Initiative II data collection as examples of the broader FLUXNET data archive available at the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). The Harvard Forest and BOREAS NSA (Old Black Spruce) sites were selected because they were the only ones in which measurements overlapped with the ISLSCP II period of 1986-1995. These two data sets are part of a larger data set of gap-filled flux data compiled as a result of the FLUXNET 2000 Synthesis Workshop, held at the Marconi Conference Center, Marshall, California, June 11-14, 2000 (Falge et al. 2003).

3.2 Summary of Parameters

Tower-based measurements of carbon dioxide (CO_2), water vapor, and energy fluxes are provided along with associated meteorological parameters (e.g. radiation, precipitation, temperature, etc.) for the two tower sites of Harvard Forest (1992-95) and BOREAS NSA, Old Black Spruce (1994-95). Data are provided at five temporal resolutions (half-hourly, daily, weekly, monthly and yearly) and for both day and night. Gap-filled flux data from four different filling methods are reported. Selected meteorological parameters were also gap-filled to support flux estimating methods. Note that the measured/estimated CO_2 fluxes and storage fluxes were summed into net ecosystem exchange (NEE), and ONLY NEE data are reported

3.3 Discussion

The flux community is interested in assessing the net uptake of carbon dioxide by the biosphere, not the flux across some arbitrary horizontal plane. When the thermal stratification of the atmosphere is stable or turbulent mixing is weak, material diffusing from leaves and the soil may not reach the reference height z_r in a time that is small compared to the averaging time T, thereby violating the assumption of steady state conditions and a constant flux layer. Under such conditions the storage term becomes non-zero, so it must be added to the eddy covariance measurement to represent the balance of material flowing into and out of the soil and vegetation. With respect to CO_2, the storage term is small over short crops and is an important quantity over taller forests. The storage term value is greatest around sunrise and sunset when there is a transition between respiration and photosynthesis and between the stable nocturnal boundary layer and daytime convective turbulence. Summed over 24 hours, the storage term is nil.

FLUXNET provides estimates of NEE for monthly and annual time periods from a variety of ecosystems. Data from eddy covariance are usually reported by half-hour with the objective to collect data 24 hours a day and 365 days a year. However, the average data coverage during a year is only 65% due to system failures or data rejection. Therefore, gap-filling procedures have been established for providing complete data sets (Falge et al. 2001a). Standardization of the procedure allows defensible fillings and the creation of comparable data sets, which form the basis for inter-site comparisons. The data are processed using the four methods (Table 2) developed by Falge et al. (2001a, b). In general, the "Look-up table" method, with the u* corrected NEE algorithm appears to be the most robust method for most sites. When using these secondary products (e.g. monthly and annual estimates, u* corrected values, gap filled data, etc.), users are strongly urged to be cautious. Uncertainties in these secondary products can be large due to a variety of factors. New algorithms are being developed continuously to generate robust secondary estimates. Users should check the FLUXNET web site for the latest information (http://daac.ornl.gov/FLUXNET/fluxnet.html).

Table 2. Gap-filling methods (Falge et al. 2001a,b).

Method	Gap Filling Method Description	File Name Component
MDC_corr	Filling by mean daily courses of NEE, LE, H; data u* corrected	_dc
Lookup_corr	Filling by look up tables for PAR-Ta (NEE), PAR-VPD (LE, H); NEE u* corrected	_lu_u0
Regr_corr	Filling by nonlinear regression (NEE only!) with Ts (nighttime), Ta sorted PAR (daytime); NEE u* corrected	_re_u0
Regr_notcorr	Filling as Regr_corrected, but NEE not u* corrected	_re_u1
Meteo	Meteorological forcing parameters	

4. THEORY OF ALGORITHM/MEASUREMENTS

Eddy covariance methods measure average vertical flux of mass (e.g. CO_2 or H_2O) or heat over a period of time. To measure average mass flux, sonic anemometers are used to measure the instantaneous vertical velocity of an air parcel and an infrared gas analyzer used to simultaneously measure the instantaneous concentration of CO_2 and H_2O in that parcel. The average vertical mass flux for a given time period is computed as the product of the instantaneous values of vertical velocity and gas concentration, integrated over that period (usually 15 to 30 minutes). To measure the instantaneous vertical velocity of an air parcel, a 3-D sonic anemometer is used. This instrument consists of three pairs of orthogonal ultrasonic transmit/receive transducers to measure the transit time of sound signals traveling between the transducer pairs. The wind speed along each transducer axis is determined from the difference in transit times. The infrared gas analyzer measures CO_2 and H_2O concentrations in the same parcel by detecting the absorption of infrared radiation by water vapor in the light path.

The eddy covariance method is used to measure trace gas fluxes between the biosphere and atmosphere. Vertical flux densities of CO_2 (FC), latent (LE) and sensible heat (H) between vegetation and the atmosphere are proportional to the mean covariance between vertical velocity (w') and the respective scalar (c') fluctuations (e.g., CO_2, water vapor, and temperature). Positive flux densities represent mass and energy transfer into the atmosphere and away from the surface and negative values denote the reverse. Ecologists use an opposite sign convention where the uptake of carbon by the biosphere is positive. Turbulent fluctuations were computed as the difference between instantaneous and mean scalar quantities.

5. EQUIPMENT

5.1 Instrument Description

Typical instrumentation at flux tower sites includes a three-dimensional sonic anemometer, to measure wind velocities and virtual temperature, and a fast responding sensor to measure CO_2 and water vapor. Scalar concentrations are measured with open and closed path infrared gas analyzers. Standardized data processing routines are used to compute flux covariances by the individual site investigators to produce flux estimates for either 30- or 60-minute intervals. Most researchers also deploy an array of other sensors to measure variables such as radiation (global, PAR, longwave), temperature (air and soil at different levels), humidity and soil moisture.

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

Agricultural scientists mount their sensors on small poles, while forest scientists use either walk-up scaffolding or low-profile radio towers. The height of the sensors depends on the height of the vegetation, the extent of fetch, the range of wind velocity and the frequency response of the instruments. To minimize tower interference on scaffold towers, investigators place their instruments on booms that point several meters up wind or at the tower of the tower. Spatial separation between anemometry and gas analyzers depend on whether one uses a closed or open path gas sensor. With the closed path systems, the intake is often near or within the volume of the sonic anemometers. A delay occurs as air flows through the tubing to the sensor, which is compensated with software during post-processing. Some investigators place their gas transducer on the tower in a constant environment box to minimize the lag time from the sample port and the sensor. Others draw air down long tubes to instruments housed in an air-conditioned hut below the tower. In either circumstance, flow rates are high (6 liter per minute) to insure turbulent flow and minimize the diffusive smearing of eddies. Open path gas sensors are typically placed within 0.5 m of a sonic anemometer, a distance that minimizes flow distortion and lag effects.

5.1.2 Mission Objectives

Goals of the flux community are to understand the mechanisms controlling the exchanges of CO_2, water vapor and energy across a spectrum of time and space scales. FLUXNET is a network of regional networks. Regional networks include AmeriFlux (South and North America), CarboEurope (Europe), Asia (AsiaFlux), Australia and New Zealand (OzFlux) as well as independent sites in southern Africa. The overarching objective of FLUXNET is to provide an infrastructure for the synthesis and analysis of long-term carbon, water and energy flux data that are being acquired worldwide by various regional flux networks. FLUXNET has several primary functions. First, it provides infrastructure for compiling, archiving and distributing carbon, water and energy flux measurement, meteorological, plant and soil data to the science community. Second, the project supports calibration and flux inter-comparison activities. This activity ensures that data from the regional networks are inter-comparable. And thirdly, FLUXNET supports the synthesis, discussion and communication of ideas and data by supporting project scientists, workshops and visiting scientists.

5.1.3 Key Variables

Carbon dioxide (CO_2), water vapor, and energy fluxes; meteorological and edaphic variables.

5.1.4 Principles of Operation

Application of the eddy covariance methods involves issues relating to site selection, instrument placement, sampling duration and frequency, calibration and post-processing. Ideally the field site should be flat, with an extensive fetch of uniform vegetation. In practice many of the Flux tower sites are on undulating or gently sloping terrain, as this is where native vegetation exists. Sites on extreme terrain, which may force flow separation and advection, are excluded. The degree of uniformity of the underlying vegetation varies across the network, too. Some sites consist of monospecific vegetation, others contain a mixture of species and a third grouping possesses different plant functional types in different wind quadrants. All sites have sufficient fetch to generate an internal boundary layer where fluxes are constant with height.

5.1.5 Instrument Measurement Geometry

Not applicable to this data set.

5.1.6 Manufacturer of Instrument

Instrumentation varies depending on specific flux tower sites. Contact site investigators for this information.

5.2 Calibration

Calibration frequencies of gas instruments vary from team to team. With closed path sensors, investigators are able to calibration frequently and automatically, such as hourly or once a day. Teams with open path sensors calibrate less frequently, e.g. every few weeks. However, a body of accumulating data indicates that calibration coefficients of contemporary instruments remain steady within that duration (+/- 5%). Scientists using open path sensors also compare their instrument responses to an independent measure of CO_2 concentration and humidity. Members of this network do not use a uniform standard for calibrating CO_2, yet. But many of us use CO_2 gas standards that are traceable to the standards at the Climate Monitoring and Diagnostics Laboratory of the National Oceanic and Atmospheric Administration, the standards of the global flask network.

5.2.1 Specifications

5.2.1.1 Tolerance

None given.

5.2.2 Frequency of Calibration

None given.

5.2.3 Other Calibration Information

None given.

6. PROCEDURE

6.1 Data Acquisition Methods

Typical instrumentation at flux tower sites includes a three-dimensional sonic anemometer, to measure wind velocities and virtual temperature, and a fast responding sensor to measure CO_2 and water vapor. Scalar concentration fluctuations are measured with open and closed path infrared gas analyzers. Research scientists perform initial data processing, quality assurance, and documentation of the hourly or half-hourly flux data based on the unique focus of each site. Regional networks acquire data from sites. At each step, data and metadata are reviewed, processed, and standardized in cooperation with the site PIs. These data are submitted to regional networks (e.g., AmeriFlux, CARBOEUROFLUX, etc.) that review data and metadata, convert to common formats and distribute to the user community through an FTP or Web server. Flux data typically flow from individual sites to regional networks to FLUXNET and eventually to a long-term data archive. FLUXNET compiles site characteristics, conducts quality assurance checks, generates value-added products, and provides access to the data.

6.2 Spatial Characteristics

6.2.1 Spatial Coverage

There are over 170 towers registered in FLUXNET associated with five active regional networks. Regional networks include AmeriFlux, CARBOEUROPE (combined EUROFLUX, MedeFlu, and other towers), AsiaFlux (expanded JapanNet and KoFlux (Korea)), OzNet (Australia and New Zealand) and CanadaFluxnet. The number of networks and sites is expanding. All major vegetation types of the world are represented by at least one tower although the representativeness is not uniform.

The Harvard Forest tower site is located in the state of Massachusetts, U.S.A at latitude 42 degrees 32' 15.92" N and longitude 72 degrees 10' 17.32" W. The BOREAS NSA OBS site is located near Thompson, Alberta, Canada at 55 degrees 52' 46.632" N latitude and 98 degrees 28' 50.916" W longitude. See http://fluxnet.ornl.gov/ for a list of all the sites currently included in the FLUXNET network. See Section 9.4 for a figure illustrating the location of the sites around the world.

6.2.2 Spatial Resolution

The spatial footprint of a flux tower depends on the height of the tower, local terrain, and local meteorology. Flux towers at typical forest sites sample approximately 1 km^2 of the surrounding landscape.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

Data for the Harvard Forest site in this ISLSCP II collection cover the period from 1992-1995 while the data for BOREAS NSA OBS cover the period from 1994-95. Note that additional gap-filled data are available at the ORNL DAAC for both these sites as well as many other additional sites to the year 2000. Additional site data are also available through the FLUXNET web site at the ORNL DAAC http://daac.ornl.gov/FLUXNET/fluxnet.html.

6.3.2 Temporal Resolution

Data are provided at five temporal resolutions of half-hourly, daily, weekly, monthly and yearly. Data are provided for both daytime and nighttime.

7. OBSERVATIONS

7.1 Field Notes

Field notes may be available from the principal investigators of individual flux tower sites.

8. DATA DESCRIPTION

8.1 Table Definition with Comments

Not applicable to this data set.

8.2 Type of Data

8.2.1 Parameter/ Variable Name	8.2.2 Parameter/ Variable Description	8.2.3 Data Range	8.2.4 Units of Measurement	8.2.5 Data Source
Half-Hourly Flux Data				
Day	Julian day	1-365 or 366	N/A	FLUXNET Harvard Forest and BOREAS NSA OBS Tower Sites
Hour	Decimal time of day (end of interval)	0.5-24	N/A	
NEE	Net ecosystem exchange (FC+storage+correction if applied)		μmol $m^{-2}s^{-1}$	
NEEx	Index value for a respective variable indicates the status of the reported half-hourly value: 0= Original Value 1=Missing in original 2=Rejected from original 3=Filled by value from secondary instrument 4=Last second removes by data provider	0-4	See 8.2.2	
LE	Latent heat		W m^{-2}	
LEx	See NEEx	0-4	See 8.2.2	
H	Sensible heat		W m^{-2}	
Hx	See NEEx	0-4	See 8.2.2	
Gs	Soil heat flux.	No Data = 9999	W m^{-2}	
Gsx	See NEEx	0-4	See 8.2.2	
Daily, Weekly, Monthly and Yearly Flux Data				
Date	Julian day for "dd" files, Week number for "ww", Month number for	1-365 or 366 for "dd"	N/A	FLUXNET Harvard

	"mm" files. Not included in "yy" files	files. 1-52 for "ww" files. 1-12 for "mm" files.		Forest and BOREAS NSA OBS Tower Sites
Interval	"tot", "day", and "night" refer to total daily, daytime only, or nighttime only estimates.	"tot", "day", or "night"	See 8.2.2	
NEE	Sum of net ecosystem exchange (FC + storage + correction if applied) for time period		gC m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
NEE_e	Error (+/-) introduced by filling for NEE		+/- gC m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
NEE_g	Percent gaps filled for period	0-100	%	
NEE_s	Standard deviation for NEE.		gC m^{-2} day^{-1}	
LE	Sum of latent heat for time period		MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
LE_e	Error (+/-) introduced by filling for LE		+/- MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
LE_g	Percent gaps filled for period	0-100	%	
LE_s	Standard deviation for LE.		MJ m^{-2} day^{-1}	
H	Sum of sensible heat for time period		MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
H_e	Error (+/-) introduced by filling for H		+/- MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
H_g	Percent gaps filled for period	0-100	%	
H_s	Standard deviation for H.		MJ m^{-2} day^{-1}	
G	Sum of soil heat flux for time period		MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
G_e	Error (+/-) introduced by filling for G ("zero" in this version)		+/- MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
G_g	Percent gaps filled for period	0-100	%	
G_s	Standard deviation for G.		MJ m^{-2} day^{-1}	
Half-Hourly Meteorological Data				
Day	Julian day (1-365 or 366)	1-365 or 366	N/A	FLUXNET Harvard Forest and BOREAS NSA OBS Tower Sites
Hour	Decimal time of day (end of interval)	0.5-24	N/A	
Rg	Global radiation		W m^{-2}	
Rgx	Index value for a respective variable indicates the status of the reported half-hourly value: 0= Original Value 1=Missing in original 2=Rejected from original 3=Filled by value from secondary instrument 4=Last second removes by data provider	0-4	See 8.2.2	

PAR	Photosynthetically active radiation		μmol $m^{-2}s^{-1}$	
PARx	See Rgx	0-4	See 8.2.2	
Ta	Air temperature (tower top)		°C	
Tax	See Rgx	0-4	See 8.2.2	
Ts	Soil temperature (5 cm depth)		°C	
Tsx	See Rgx	0-4	See 8.2.2	
RH	Relative humidity (tower top)		%	
RHx	See Rgx	0-4	See 8.2.2	
VPD	Vapor pressure deficit (tower top)		kPa	
VPDx	See Rgx	0-4	See 8.2.2	
Ca	CO_2 concentration in air (tower top)		ppm	
Cax	See Rgx	0-4	See 8.2.2	
Rn	Net radiation		W m^{-2}	
Rnx	See Rgx	0-4	See 8.2.2	
PPT	Precipitation		mm	
PPTx	See Rgx	0-4	See 8.2.2	
SWC	Soil water content in cm3 H2O cm-3 soil		cm^3 H_2O/cm^3 soil	
SWCx	See Rgx	0-4	See 8.2.2	
WS	Wind speed		m s^{-1}	
WSx	See Rgx	0-4	See 8.2.2	
Pa	Air pressure		kPa	
Pax	See Rgx	0-4	See 8.2.2	
u*	Friction velocity		m s^{-1}	
u*x	See Rgx	0-4	See 8.2.2	
Daily, Weekly, Monthly and Yearly Meteorological data				
Date	Julian day for “dd” files, Week number for “ww”, Month number for “mm” files. Not included in ”yy” files	1-365 or 366 for “dd” files. 1-52 for “ww” files. 1-12 for “mm” files.	N/A	FLUXNET Harvard Forest and BOREAS NSA OBS Tower Sites
Interval	"tot", "day", and "night" refer to total daily, daytime only, or nighttime only estimates.	“tot”, “day”, or “night”	See 8.2.2	
Rg	Sum of Global radiation for time period		MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
Rg_g	Percent gaps filled for period	0-100	%	
Rg_s	Standard Deviation for Rg		MJ m^{-2} day^{-1}	
PAR	Sum of Photosynthetic active radiation for time period		mol m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)	
PAR_g	Percent gaps filled for period	0-100	%	
PAR_s	Standard Deviation for PAR		mol m^{-2} day^{-1}	
Ta	Average Air temperature (tower top) of time period		°C	
Ta_g	Percent gaps filled for period	0-100	%	
Tami	Minimum Air temperature of time period		°C	
Tamx	Maximum Air temperature of time period		°C	
Ta_s	Standard Deviation for Ta		°C	

Ts	Average Soil temperature (5 cm depth) of time period		^oC
Ts_g	Percent gaps filled for period	0-100	%
Tsmi	Minimum Soil temperature of time period		^oC
Tsmx	Maximum Soil temperature of time period		^oC
Ts_s	Standard Deviation for Ts		^oC
RH	Average relative humidity (tower top) of time period		%
RH_g	Percent gaps filled for period	0-100	%
RHmi	Minimum relative humidity of time period		%
RHmx	Maximum relative humidity of time period		%
RH_s	Standard Deviation for RH		%
VPD	Average vapor pressure deficit (tower top) of time period		kPa
VPD_g	Percent gaps filled for period	0-100	%
VPDmi	Minimum vapor pressure deficit of time period		kPa
VPDmx	Maximum vapor pressure deficit of time period		kPa
VPD_s	Standard Deviation for VPD		kPa
Ca	Average CO_2 concentration in air (tower top) of time period		ppm
Ca_g	Percent gaps filled for period	0-100	%
Cami	Minimum CO_2 concentration in air of time period		ppm
Camx	Maximum CO_2 concentration in air of time period		ppm
Ca_s	Standard Deviation for Ca		ppm
Rn	Sum of Net radiation for time period		MJ m^{-2} day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)
Rn_g	Percent gaps filled for period	0-100	%
Rn_s	Standard Deviation for Rn		MJ m^{-2} day^{-1}
PPT	Sum of precipitation		mm day^{-1} (or $week^{-1}$ or $month^{-1}$ or $year^{-1}$)
PPT_g	Percent gaps filled for period	0-100	%
PPT_s	Standard Deviation for PPT		mm day^{-1}
SWC	Average Soil water content		cm^3 H_2O/cm^3 soil
SWC_g	Percent gaps filled for period	0-100	%
SWC_s	Standard Deviation for SWC		cm^3 H_2O/cm^3 soil
WS	Average wind speed		m s^{-1}
WS_g	Percent gaps filled for period	0-100	%
WS_s	Standard Deviation for WS		m s^{-1}
Pa	Average air pressure		kPa
Pa_g	Percent gaps filled for period	0-100	%
Pa_s	Standard Deviation for Pa		kPa
u*	Average Friction velocity		m s^{-1}
u*_g	Percent gaps filled for period	0-100	%
u*_s	Standard Deviation for u*		m s^{-1}

*****NOTES**: Units for the "tot" (daytime plus nighttime) are as given. Units for daytime and nighttime separately are per "time period", (i.e. the values added together give the "total"). Values for data ranges are not available at this revision

8.3 Sample Data Record

Sample records for the file **fluxnet_HV_dc_u0_yy_1992_flux.csv** are shown below:

```
Int. NEE NEE_e NEE_g NEE_s LE LE_e LE_g LE_s H H_e H_g H_s G G_e G_g G_s
-- gCm-2y-1 gCm-2y-1 % gCm-2d-1 MJm-2y-1 MJm-2y-1 % MJm-2d-1 MJm-2y-1 MJm-2y-
1 % MJm-2d-1 MJm-2y-1 MJm-2y-1 % MJm-2d-1
tot -179.3 11.3 36.1 2.6 1160.2 15.3 60.1 2.8 1091.1 17.8 31.9 3.1 -9999.0
0.0 100.0 0.0
day -546.4 8.7 38.0 2.8 1098.9 12.8 58.3 2.9 1358.5 8.7 33.6 2.8 -9999.0 0.0
100.0 0.0
night 367.1 2.6 34.2 0.5 61.3 2.5 61.8 0.2 -267.4 9.1 30.3 0.9 -9999.0 0.0
100.0 0.0
```

Sample records for the file **fluxnet_NB_hh_1995_met.csv** are shown below:

```
Day Hour Rg Rgx PAR PARx Ta Tax Ts Tsx RH RHx VPD VPDx Ca Cax Rn Rnx PPT PPTx
SWC SWCx WS WSx Pa Pax Ustar Ustarx
-- -- Wm-2 -- umolm-2s-1 -- degC -- degC -- % -- kPa -- ppm -- Wm-2 -- mm --
cm3cm-3 -- ms-1 -- kPa -- ms-1 --
1 0.50 0.00 3 0.00 3 -25.6 1 -9.80 1 -12.88 1 0.14 0 362.300 0 -20.0 1 0.000
1 -9999.000 1 3.012 1 -9999.00 1 0.27 1
1 1.00 0.00 3 0.00 3 -25.7 1 -9.79 1 -12.85 1 0.14 0 362.706 0 -19.3 1 0.000
1 -9999.000 1 3.000 1 -9999.00 1 0.32 1
1 1.50 0.00 3 0.00 3 -26.0 1 -9.80 1 -14.65 1 0.15 0 362.609 0 -15.5 1 0.000
1 -9999.000 1 3.116 1 -9999.00 1 0.27 1
```

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the ASCII, or text format. The files in this directory have a variable number of columns and rows, with all columns separated by a single space. Note that the number of columns in the half-hourly data is different than that for all the other data. Both numerical and text fields are included as described in Section 8.2. Each file contains two header lines, the first with the variable abbreviation and the second with the units of measurement. A value of –9999 denotes a missing numerical value. For each variable either sum or average/minimum/maximum, percent of gaps filled and standard deviation (S.D.) are provided. The S.D. is the standard deviation calculated from the respective daily sum or daily mean.

8.5 Related Data Sets

Falge, E., et al. 2005. FLUXNET Marconi Conference Gap-Filled Flux and Meteorology Data, 1992-2000. 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/811

ISLSCP II project information and other data sets can be obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC), http://daac.ornl.gov/ISLSCP_II/islscpii.shtml.

Additional data can be downloaded from FLUXNET or regional networks:

FLUXNET - http://daac.ornl.gov/FLUXNET/fluxnet.html
AmeriFlux - http://public.ornl.gov/ameriflux/Participants/Sites/Map/index.cfm
CarboEuroFlux - http://www.bgc-jena.mpg.de/public/carboeur/
AsiaFlux – http://asiaflux.net
OzFlux – http://www.ozflux.org.au/
CanadaFluxnet – http://www.fluxnet-canada.ca/home.php

9. DATA MANIPULATIONS

9.1 Formulas

The data manipulations performed at each site are generally documented in open literature publications. The FLUXNET web site has over 3600 literature citations, most linked to specific sites that can provide information on processing the flux data.

9.1.1 Derivation Techniques/Algorithms

See Falge et al. (2001 a,b) for a description of the data filling techniques.

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

See Falge et al. (2001 a,b).

9.2.2 Processing Changes

None given.

9.2.3 Additional Processing by the ISLSCP II Staff

The original data submitted to the ISLSCP II staff had 9 spaces between each data column, and a blank line between each row. The data files were reprocessed to use a single space as the column delimiter and the blank lines were removed. The data files were then renamed to the current naming scheme (see Section 1.3).

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None given.

9.4 Graphs and Plots

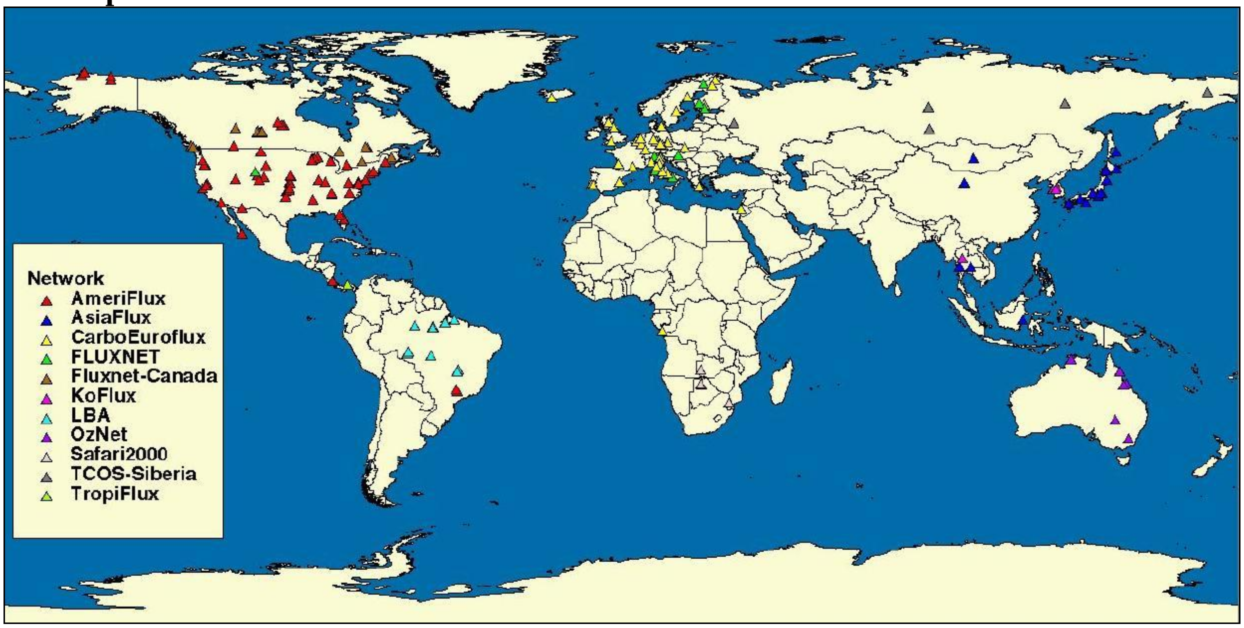

Figure 1. Location of current FLUXNET tower sites in 2005.

10. ERRORS

10.1 Sources of Error

Gaps in the data record are attributed to system or sensor breakdown, periods when instruments are off-scale, when the wind is blowing through a tower, when spikes occur in the raw data, if the vertical angle of attack by the wind vector is too severe and when data are missing because of calibration and maintenance. Other sources of missing data arise from farming operations and other management activities (e.g., prescribed burn of grasslands). Rejection criteria applied to the data vary among the flux tower groups. Data might be rejected, when stationarity tests or integral turbulence characteristics fail, when precipitation limits the performance of open path sensors, during sensor calibration, or when spikes occur in instrument readings. Other criteria used to reject data include applications of biological or physical constraints (lack of energy balance closure; and a meandering flux-footprint source area. If the wind is coming from a non-preferred direction as may occur over mixed stands, a certain portion of the data will need to be screened. In addition, rejection probability for some sites is higher during nighttime because of calm wind conditions. The average data coverage during a year is between 65 % and 75% due to system failures or data rejection.

10.2 Quality Assessment

The data processing strategy is that the 1/2-hour or hourly flux and micrometeorology data are compiled, processed, and reviewed by sites prior to being submitted to regional networks to be maintained and distributed. FLUXNET acquires copies of the processed data from regional networks and occasionally directly from individual flux towers. FLUXNET processes the data to produce a more standardized gap-filled, aggregated flux data for a set 13-15 flux parameters that were selected by the flux community.

10.2.1 Data Validation by Source
None given.

10.2.2 Confidence Level/Accuracy Judgment
None given.

10.2.3 Measurement Error for Parameters and Variables
None given.

10.2.4 Additional Quality Assessment Applied
None given.

11. NOTES

11.1 Known Problems with the Data
It is the intent of the micrometeorological community to collect eddy covariance data 24 hours a day and 365 days a year. However, missing data in the archived records is a common feature. The average data coverage during a year is between 65 % and 75% due to system failures or data rejection. Tests show that this observed level of data acceptance provides a statistically robust and over-sampled estimate of the ensemble mean. So the filling of missing data does not provide a significant source of bias error.

11.2 Usage Guidance
Check the FLUXNET Web site http://daac.ornl.gov/FLUXNET/fluxnet.html for data set updates and guidance.

DATA USE POLICY - Kindly inform the appropriate Principal Investigators of how you are using site data and of any publication plans. If the Principal Investigators feel that they should be acknowledged or offered participation as authors, they will let you know and we assume that an agreement on such matters will be reached prior to publishing and/or use of the data for publication. If your work directly competes with the Principal Investigator's analysis they may ask that they have the opportunity to submit a manuscript before you submit the one that uses their data. In addition, when publishing, please acknowledge the agency that supported the research. The Principal Investigators for the Harvard Forest and Northern BOREAS sites are Drs. Steven Wofsy, Harvard University and Michael Goulden, University of California-Irvine. Please contact the contacts listed in Section 2.3 BEFORE you contact the PIs with questions on data processing.

11.3 Other Relevant Information
Available from the FLUXNET Web site http://daac.ornl.gov/FLUXNET/fluxnet.html.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

Falge, E., M. Aubinet, P. Bakwin, P. Berbigier, C. Bernhofer, A. Black, R. Ceulemans, A. Dolman, A. Goldstein, M. Goulden, A. Granier, D. Hollinger, P. Jarvis, N. Jensen, K. Pilegaard, G. Katul, P. Kyaw Tha Paw, B. Law, A. Lindroth, D. Loustau, Y. Mahli, R. Manson, P. Moncrieff, E. Moors, W. Munger, T. Meyers, W. Oechel, E. Schulze, H. Thorgeirsson, J. Tenhunen, R. Valentini, S. Verma, T. Vesala, and S. Wofsy. 2003. *Marconi Conference Gap-Filled Flux and Meteorology Data, 1992-2000.* 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/811

12.2 Journal Articles and Study Reports

Falge, E., D. Baldocchi, R.J. Olson, P. Anthoni, M. Aubinet, C. Bernhofer, G. Burba, R. Ceulemans, R. Clement, H. Dolman, A. Granier, P. Gross, T. Grünwald, D. Hollinger, N.-O. Jensen, G. Katul, P. Keronen, A. Kowalski, C. Ta Lai, B. E. Law, T. Meyers, J. Moncrieff, E. Moors, J. W. Munger, K. Pilegaard, Ü. Rannik, C. Rebmann, A. Suyker, J. Tenhunen, K. Tu, S. Verma, T. Vesala, K. Wilson, S. Wofsy. 2001a. Gap Filling Strategies for Defensible Annual Sums of Net Ecosystem Exchange. *Agr For Meteorol*. 107: 43-69

Falge, E., D. Baldocchi, R.J. Olson, P. Anthoni, M. Aubinet, C. Bernhofer, G. Burba, R. Ceulemans, R. Clement, H. Dolman, A. Granier, P. Gross, T. Grünwald, D. Hollinger, N.-O. Jensen, G. Katul, P. Keronen, A. Kowalski, C. Ta Lai, B. E. Law, T. Meyers, J. Moncrieff, E. Moors, J. W. Munger, K. Pilegaard, Ü. Rannik, C. Rebmann, A. Suyker, J. Tenhunen, K. Tu, S. Verma, T. Vesala, K. Wilson, S. Wofsy. 2001b. Gap Filling Strategies for Longterm Energy Flux Data Sets. *Agr For Meteorol.* 107:71-77.

13. DATA ACCESS

13.1 Contacts for Archive/Data Access Information

The ISLSCP Initiative II data are available are archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at http://daac.ornl.gov.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

BOREAS	BOReal Ecosystem-Atmosphere Study
DAAC	Distributed Active Archive Center
FC	Net Ecosystem CO_2 flux
GSFC	Goddard Space Flight Center (NASA)
H	Sensible Heat Flux
ISLSCP	International Satellite Land Surface Climatology Project
LE	Latent Heat Flux
NASA	National Aeronautics and Space Administration
NEE	Net Ecosystem Exchange
NSA	Northern Study Area (BOREAS)
OBS	Old Black Spruce (BOREAS NSA)
ORNL	Oak Ridge National Laboratory
PAR	Photosynthetically Active Radiation
PPFD	Photosynthetic Photon Flux Density
RGS	Short-wave global radiation
RH	Ambient relative humidity
SC	CO_2 Canopy Storage
SD	Standard Deviation
Ta	Ambient air temperature
Tau	Momentum flux
Ts	Soil temperature
VPD	Vapor Pressure Deficit
WD	Wind Direction
WS	Wind Speed