NPP Multi-Biome: NPP and Driver Data for Ecosystem Model-data Intercomparison, R2

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Revision date: August 29, 2013

Summary:

This data set represents a refined set of global net primary productivity (NPP) estimates and model driver data that are the results of the Ecosystem Model-Data Intercomparison (EMDI) workshop review and outlier analyses undertaken to assess the accuracy of global model forecasts of terrestrial carbon cycling. EMDI builds upon the accomplishments of the original worldwide synthesis of NPP measurements and associated model driver data prepared by the Global Primary Production Data Initiative (GPPDI) (Olson et al., 2001; 2012). The EMDI review and analyses produced NPP, climate, NDVI, land cover, vegetation, and soil data for a sub-set of GPPDI data: 81 Class A sites, 933 Class B sites, and 3,855 Class C 0.5 degree cell grids. Class A sites represent well-documented study sites that have complete above- and below-ground NPP measurements. Class B sites represent more numerous extensive sites with less documentation and site-specific information available. Class C cells represent estimates of NPP for 0.5 degree grid cells for which inventory, modeling, or remote-sensing tools were used to scale up the point measurements.

The data files are in comma-separated-value (.csv) format. There are 582 data files for Class A sites, 11 data files for Class B sites, and nine data files for Class C grid cells. This document and a companion file (Olson et al., 2001) describe the compilation of NPP estimates under the GPPDI and the EMDI review and outlier analyses that produced this refined set of NPP estimates and model driver data.

Revision Notes: This data set has been revised to correct previously reported NPP estimates for three OTTER Transect sites, U.S.A., in the Class A NPP data file. Please see the Data Set Revisions section of this document for detailed information.

Additional Documentation:

The Net Primary Productivity (NPP) data collection contains field measurements of biomass, estimated NPP, and climate data for terrestrial grassland, tropical forest, temperate forest, boreal forest, and tundra sites worldwide. Data were compiled from the published literature for intensively studied and well-documented individual field sites and from a number of previously compiled multi-site, multi-biome data sets of georeferenced NPP estimates. The principal compilation effort (Olson et al., 2001) was sponsored by the NASA Terrestrial Ecology Program. For more information, please visit the NPP web site at http://daac.ornl.gov/NPP/npp_home.html.

Data Citation:

Cite this data set as follows:

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1. Data Set Overview:

Project: Net Primary Productivity (NPP)

Understanding global-scale ecosystem responses to changing environmental conditions is important both as a scientific question and as the basis for making policy decisions. The confidence in regional ecosystem models depends on how well the field data used to develop the models represent the region of interest, how well the environmental model driving variables (e.g., vegetation type, climate, and soils associated with a site used to parameterize ecosystem models) represent the region of interest, and how well regional model predictions agree with observed data for the region. To assess the accuracy of global model forecasts of terrestrial carbon cycling, two Ecosystem Model-Data Intercomparison (EMDI) workshops were held (December 1999 and April 2001). The workshops included 11 biogeochemical, satellite-driven, detailed process, and dynamic vegetation global model types. The approach was to (1) run regional or global versions of the models for sites with NPP measurements (i.e., not fine-tuned for specific site conditions) that were assembled under the GPPDI process (Olson et al., 2001; 2012) and then (2) analyze the model-data differences.

Extensive worldwide NPP data were assembled under GPPDI along with model driver data, including vegetation, land cover, climate, and soils data, for use in the EMDI model-data intercomparison (Olson et al., 2012; Zheng et al., 2012). The NPP measurements were collected over a long time period by many investigators using a variety of methods. The minimum requirements for NPP data to be included were as follows:

• the use of one or more accepted methods to estimate above- or below-ground NPP;
• geographical location for the study site;
• definition of biome or vegetation type; and
• a citable reference to peer-reviewed publication, symposium, or workshop proceedings; book chapter; or technical memorandum.

The initial GPPDI data compilations are included in two ORNL DAAC mulit-biome NPP data sets: (1) NPP Multi-Biome: Global Primary Production Data Initiative Products, R2 (Olson et al., 2012), otherwise known as the GPPDI database; and (2) NPP Multi-Biome: Gridded Estimates for Selected Regions Worldwide, 1954-2001, R3 (Zheng et al., 2012), otherwise known as GPPDI-gridded. The GPPDI data were analyzed to extract a subset of NPP data suitable for the EMDI workshops. Model driver data (e.g., vegetation type, climate, and soils associated with a site used to parameterize ecosystem models) were compiled for the set of EMDI data and an extensive review of the combined NPP and driver data was conducted. The sequence of NPP activities culminating in the EMDI Workshops is summarized in Olson et al. (2001).

The results of the EMDI review and outlier analyses produced a refined set of NPP estimates and model driver data (i.e., this data set, known as the EMDI database). The EMDI process resulted in 81 Class A sites, 933 Class B sites, and 3,855 Class C 0.5 degree grid cells derived from the original GPPDI synthesis of NPP measurements and associated driver data. Class A sites represent well-documented study sites that have complete above- and below-ground NPP measurements. Class B sites represent more numerous “extensive” sites with less documentation and site-specific information available. Class C 0.5 degree grid cells represent estimates of NPP for which inventory, modeling, or remote-sensing tools were used to scale up the point measurements.

Comparing the NPP field measurements with an average NPP from the ensemble of model outputs provided a unique method to improve NPP data, model driver data, and model processes. Initial results showed general agreement between model predictions of NPP and field measurements of NPP but with obvious differences that indicated areas for potential data and model improvement.

2. Data Description:

The data files are in comma-separated-value (.csv) format. There are 582 data files for Class A sites, 11 data files for Class B sites, and 9 data files for Class C grid cells.

Spatial Coverage

Site: Global

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

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (m)
Global	-151.92	179.5	75.5	-49.75	17-3,114

Site Information

NPP estimates compiled under GPPDI (for 2,525 point sites and 5,164 0.5 degree grid cells) were reviewed and analyzed under the EMDI process to produce a refined set of NPP estimates and model driver data. The EMDI process resulted in 81 Class A sites, 933 Class B sites, and 3,855 Class C 0.5 degree grid cells derived from the original synthesis of NPP measurements and associated driver data. Class A sites represent well-documented study sites that have complete aboveground and below ground NPP measurements. Class B sites represent more numerous “extensive” sites with less documentation and site-specific information available. Class C cells represent estimates of NPP for 0.5 degree grid cells for which inventory,

modeling, or remote-sensing tools were used to scale up the point measurements.

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (m)
Class A (81 sites)	-148.25	152.45	66.37	-27.75	17 - 2,500
Class B (933 sites)	-151.92	179.5	75.5	-43.17	20 - 3,114 (0 - 4,655)
Class C (3,855 0.5 degree grid cells)	-122.25	152.75	63.75	-49.75	na

Notes: Reported elevations are given from the literature, along with elevations computed by TerrainBase Digital Elevation Model (DEM), where available, in parenthesis. na = not available.

Spatial Resolution

The NPP measurements are based on sampling of small field plots (m^2 to 1 ha). Gridded NPP data are half-degree latitude-longitude grid cells. The spatial resolution of model driver data are given in Tables 1, 2, 10, 11, 14, and 17.

Temporal Coverage

The overall temporal coverage for this data is 1901-1999. The point and gridded NPP measurements included herein cover the period from 1931 through 1996. This coverage does NOT include all years for all sites. EMDI Class A and B climate model driver data cover either 95 years (1901-1995) or 30 years (1961-1990) or both. Class C gridded climate model drivers cover the period 1930-1995. NDVI model driver data are 3-year means based on data from 1986, 1989, and 1990. Land cover model driver data are derived from the UMD 1-km Global Land Cover product circa 1992-1993. Soils model driver data cover the period from January 1970 to August 1996.

Temporal Resolution

Each individual point or gridded NPP measurement provides an annual NPP estimate. All NPP estimates are based on plant dry matter accumulation, expressed as gC/m^2/year (carbon content of dry matter weight). Climate model driver data are provided as monthly and/or annual means (temperature), amounts (precipitation), or percentages (cloud cover and sunshine).

Data File Information

I. EMDI CLASS A DATA

Table 1. EMDI Class A data files

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS
EMDI_ClassA_Cover_UMD_81.csv	19920101-19931231	Proportion of each of the 14 UMD land cover types in a 9 x 9 patch of 1-km pixels around each of the 81 points and the associated land cover value for the centered1-km pixel and the 0.5 degree pixel
EMDI_ClassA_NDVI_81.csv	3-year monthly averages based on 1986, 1989, and 1990	Monthly average NDVI from 8-km pixels within a 25-km radius of the EMDI point
EMDI_ClassA_NPP_81_R2.csv	19310101-19960101	ANPP, BNPP, and TNPP data for each of the 81 Class A sites
EMDI_ClassA_PREC_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains monthly precipitation amount for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_PREC_PIK_81.csv	19610101-19901231	Monthly and annual 30-year mean precipitation amount for each of the 81 sites, derived from Leemans and Cramer (1991)
EMDI_ClassA_Site_81.csv	19310101-19960101	Summary data for each of the 81 sites. Data include site ID, location, elevation, country, annual average, minimum, and maximum temperature, and annual precipitation amount.
EMDI_ClassA_Soil_IGBP_81.csv	19700101-19960801	Soil characteristics for each of the 81 sites derived from the from the IGBP-DIS Soils Database
		Summary data for each of the 81 sites. Data include site ID, location, elevation, soil texture,

EMDI_ClassA_Summary_81.csv	19310101-19960101	annual average, minimum, and maximum temperature, annual precipitation amount, annual percentage of sunlight for daylight hours, dominant land cover type based on a 1 km grid cell centered on the site, and dominant land cover type based on 0.5 degree grid cell centered on the site.
EMDI_ClassA_SUN_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains monthly percentage of sunlight during daylight hours for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_SUN_PIK_81.csv	19610101-19901231	Monthly and annual 30-year mean percentage of sunlight during daylight hours for each of the 81 sites, derived from Leemans and Cramer (1991)
EMDI_ClassA_TAVE_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains monthly mean temperature for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_TAVE_PIK_81.csv	19610101-19901231	Monthly and annual mean temperature for each of the 81 sites, derived from Leemans and Cramer (1991)
EMDI_ClassA_TMAX_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains monthly maximum temperature for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_TMAX_PIK_81.csv	19610101-19901231	Monthly and annual maximum temperature for each of the 81 sites, derived from Leemans and Cramer (1991)
EMDI_ClassA_TMIN_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains monthly minimum temperature for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_TMIN_PIK_81.csv	19610101-19901231	Monthly and annual minimum temperature for each of the 81 sites, derived from Leemans and Cramer (1991)
EMDI_ClassA_TRANGE_1901-95.zip	19010101-19951231	Compressed (zip) file containing one .csv file for each of the 95 years in this series. Each file contains actual monthly diurnal temperature for each of the 81 sites, derived from New et al. (2000b).
EMDI_ClassA_Veg_81.csv	19310101-19960101	Summary vegetation data for each of the 81 sites. Data include site ID, location, biome, vegetation type, dominant species, and management regime.

Table 2. Column headings, parameter definitions, and units of measure for Class A site summary information data files

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassA_Site_81.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV_GIV	Elevation as given for the site	Meters
	ELEV_DEM	Elevation extracted from the global TerrainBase Digital Elevation Model (DEM) (5-min resolution)	
	COUNTRY	Country where site is located	Text
	TAVE_ANN	Annual average temperature, 1961-1990	degrees Celsius
	TMIN_ANN	Minimum annual temperature, 1961-1990	
	TMAX_ANN	Maximum annual temperature, 1961-1990	
	PREC_ANN	Annual total precipitation, 1961-1990	mm

EMDI_ClassA_Summary_81.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV	Elevation as given for the site	meters
	SAND	Sand content in top 30 cm	% w/w
	SILT	Silt content in top 30 cm	
	CLAY	Clay content in top 30 cm	
	TAVE	Annual average temperature, 1961-1990	degrees Celsius
	TMIN	Minimum annual temperature, 1961-1990	
	TMAX	Maximum annual temperature, 1961-1990	
	PREC	Annual total precipitation, 1961-1990	mm
	SUN	Annual mean percentage of sunlight during daylight hours, 1961-1990	%
	COVR1KM	Dominant UMD land cover type based on a 1 km grid cell centered on the site	Numerical code (0 through 13) defined in Table 4
	COVR50KM	Dominant UMD land cover type based on 0.5º grid cell centered on the site.	

Table 3. Column headings, parameter definitions, and units of measure for the Class A point NPP measurements (global sources)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassA_NPP_81_R2.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV_GIV	Elevation as given for the site	Meters
	ELEV_N	Number of elevation measurements for this site	Numeric
	SOURCE	Source of the NPP data name or code. Reference to person or organization that compiled the data or to another ORNL DAAC data set where the data came from.	Text
	BIOMENEW	Biome type, standardized to EDMI classes (see Table 24)	
	BIOME2	Aggregated biome type (see Table 24)	
	TAVE_N	Number of temperature measurements for this site	Numeric
	PREC_N	Number of precipitation measurements for this site	
	TEMP_ANN	Annual average temperature	degrees Celsius
	PREC_ANN	Annual total precipitation	mm
	ANPP_N	Number of published above-ground NPP measurements for this site	Numeric
	BNPP_N	Number of published below-ground NPP measurements for this site	
	TNPP_N	Number of published total NPP measurements for this site	
	MOD_N	Number of NPP estimates from models for this site	

	FLAG_N	Sum of all the flag values	
	ANPP_C	Above-ground NPP	gC/m^2/y
	BNPP_C	Below-ground NPP	
	TNPP_C	Total NPP	
	MODCA_AV	Average ensemble value from up to 11 EMDI models	
	FLAGS	Sum of all the flag values	Numeric

Table 4. Column headings, parameter definitions, and units of measure for the Class A point UMD land cover classification (Hansen et al., 2000b)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS	CODE FOR LAND USE CLASS
EMDI_ClassA_Cover_UMD_81.csv	SITE_ID	Site identification number based on unique lat/long	Numerical	
	LAT_DD	Latitude of NPP site (point)	Decimal degrees	
	LONG_DD	Longitude of NPP site (point)		
	WATER	Water	Numerical Code	0
	NEEDLE_E	Evergreen needleleaf forests		1
	BROAD_E	Evergreen broadleaf forests		2
	NEEDLE_D	Deciduous needleleaf forests		3
	BROAD_D	Deciduous broadleaf forests		4
	MIXED	Mixed forests		5
	WOODLAND	Woodlands		6
	WOODGRSS	Wooded grasslands/ shrubs		7
	SHRUB_CL	Closed bushlands or shrublands		8
	SHRUB_OP	Open shrublands		9
	GRASS	Grasses		10
	CROP	Croplands		11
	BARE	Bare ground		12
	URBAN	Urban and built-up		13
	COVR1KM	Dominant UMD land cover type based on a 1 km grid cell centered on the site	Numerical Code	0 through 13 (defined above)
	COVR50KM	Dominant UMD land cover type based on 0.5º grid cell centered on the site.		

Table 5. Column headings, parameter definitions, and units of measure for the Class A point NDVI calculations (James and Kalluri, 1994)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
		Monthly NDVI mean -- average of	

EMDI_ClassA_NDVI_81.csv	JAN ... DEC	1986, 1987, and 1990	Index (0-1)
	JAN_N ... DEC_N	Monthly NDVI standard deviation	
	JAN_STD ... DEC_STD	NDVI number of years in mean (0-3)	

Table 6. Column headings, parameter definitions, and units of measure for the Class A model drivers climate information, 95-year climate series (1901-1995) (New et al., 2000b)

COMPRESSED FILE NAME	UNCOMPRESSED FILE NAMES (There is one file for each year, 1901-1995, with no missing years)	VARIABLE	DEFINITION (COLUMN HEADING)	UNITS
EMDI_ClassA_PREC_1901-95.zip	pre.81_1901.csv through pre.81_1995.csv	Precipitation	Monthly total precipitation amount, 1901-1995 (JAN ... DEC)	mm
EMDI_ClassA_TAVE_1901-95.zip	tmp.81_1901.csv through tmp.81_1995.csv	Average temperature	Monthly mean temperature, 1901-1995 (JAN ... DEC)	degrees Celsius
EMDI_ClassA_TMAX_1901-95.zip	tmx.81_1901.csv through tmx.81_1995.csv	Maximum temperature	Maximum monthly temperature, 1901-1995 (JAN ... DEC)	
EMDI_ClassA_TMIN_1901-95.zip	tmn.81_1901.csv through tmn.81_1995.csv	Minimum temperature	Minimum monthly temperature, 1901-1995 (JAN ... DEC)	
EMDI_ClassA_TRANGE_1901-95.zip	dtr.81_1901.csv through dtr.81_1995.csv	Actual diurnal temperature	Actual monthly diurnal temperature range, 1901-1995 (JAN ... DEC)	
EMDI_ClassA_SUN_1901-95.zip	sun.81_1901.csv through sun.81_1995.csv	Sunshine	Monthly mean percentage of sunlight during daylight hours, 1901-1995 (JAN ... DEC)	%

Table 7. Column headings, parameter definitions, and units of measure for the Class A model drivers climate information, 30-year climate series (1961-1990)(Leemans and Cramer, 1991, compiled by PIK)

FILE NAME	VARIABLE	DEFINITION (COLUMN HEADING)	UNITS
EMDI_ClassA_PREC_PIK_81.csv	Perception	Annual and monthly total precipitation amount, 1961-1990 (ANN; JAN ... DEC)	mm
EMDI_ClassA_TAVE_PIK_81.csv	Average temperature	Annual and monthly mean temperature, 1961-1990 (ANN; JAN ... DEC)	degrees Celsius
EMDI_ClassA_TMAX_PIK_81.csv	Maximum temperature	Maximum annual and monthly temperature, 1961-1990 (ANN; JAN ... DEC)	
EMDI_ClassA_TMIN_PIK_81.csv	Minimum temperature	Minimum annual and monthly temperature, 1961-1990 (ANN; JAN ... DEC)	
EMDI_ClassA_SUN_PIK_81.csv	Sunshine	Annual and monthly mean percentage of sunlight during daylight hours, 1961-1990 (ANN; JAN ... DEC)	%

Table 8. Column headings, parameter definitions, and units of measure for the Class A model drivers soil information (IGBP Soils Database)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	SAND	Sand content in top 30 cm	% w/w
	SILT	Silt content in top 30 cm	
	CLAY	Clay content in top 30 cm	
	SOILN30	Soil nitrogen in top 30 cm	

EMDI_ClassA_Soil_IGBP_81.csv	SOILN20	Soil nitrogen in top 20 cm	kg/m^2
	SOILN100	Soil nitrogen in top 100 cm	
	SOILC30	Soil carbon in top 30 cm	g/m^2
	SOILC20	Soil carbon in top 20 cm	
	SOILC100	Soil carbon in top 100 cm	
	PH	Soil pH (water) in top 30 cm	Units
	BD	Bulk density of top 30 cm	g/cm
	FC	Field capacity (water holding capacity) in top 30 cm	mm
	WP	Wilting point for top 30 cm	
	PAWC	Profile available water capacity	

Table 9. Column headings, parameter definitions, and units of measure for the Class A model drivers vegetation information (site-specific sources)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassA_Veg_81.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	BIOME	Biome type, standardized to EMDI classes (see Table 24)	Text
	VEG_TYPE	Vegetation type as given, somewhat standardized	
	SPECIES	Dominant species	
	MNGMT	Site management, if known	

II. EMDI CLASS B DATA

Table 10. EMDI Class B data files

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS
EMDI_ClassB_Cover_UMD_933.csv	19920101-19931231	Proportion of each of the 14 UMD land cover types in a 9 x 9 patch of 1-km pixels around each of the 933 points and the associated land cover value for the centered1-km pixel and the 0.5 degree pixel
EMDI_ClassB_NDVI_933.csv	3-year monthly averages based on 1986, 1989, and 1990	Monthly average NDVI from 8-km pixels within a 25-km radius of the EMDI point
EMDI_ClassB_NPP_933_v2.csv	19310101-19960101	ANPP, BNPP, and TNPP data for each of the 933 Class B sites
EMDI_ClassA_PREC_933.csv	19610101-19901231	Monthly and annual 30-year mean precipitation amount for each of the 933 sites, derived from Leemans and Cramer (1991)
EMDI_ClassB_Site_933.csv	19310101-19960101	Summary data for each of the 933 sites. Data include site ID, location, elevation, country, biome, vegetation type, dominant species, sub-biome, reference, and year of publication.
EMDI_ClassB_Soil_IGBP_933.csv	19700101-19960801	Soil characteristics for each of the 933 sites derived from the from the IGBP-DIS Soils Database
EMDI_ClassB_Summary_933.csv	19310101-19960101	Summary data for each of the 933 sites. Data include site ID, location, elevation, soil texture, annual average, minimum, and maximum temperature, annual precipitation amount, annual percentage of sunlight for daylight hours, dominant land cover type based on a 1 km grid

		cell centered on the site, and dominant land cover type based on 0.5º grid cell centered the on site.
EMDI_ClassB_SUN_933.csv	19610101-19901231	Monthly and annual 30-year mean percentage of sunlight during daylight hours for each of the 933 sites, derived from Leemans and Cramer (1991)
EMDI_ClassB_TAVE_933.csv	19610101-19901231	Monthly and annual 30-year mean temperature for each of the 933 sites, derived from Leemans and Cramer (1991)
EMDI_ClassB_TMAX_933.csv	19610101-19901231	Monthly and annual 30-year maximum temperature for each of the 933 sites, derived from Leemans and Cramer (1991)
EMDI_ClassB_TMIN_933.csv	19610101-19901231	Monthly and annual 30-year minimum temperature for each of the 933 sites, derived from Leemans and Cramer (1991)

Table 11. Column headings, parameter definitions, and units of measure for the Class B point UMD land cover classification (Hansen et al., 2000b)

ILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassB_Cover_UMD_933.csv	SITE_ID	Site identification number based on unique lat/long	Numerical
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	COVR1KM	Dominant UMD land cover type based on a 1 km grid cell centered on the site	Numerical Code (0 through 13 defined in Table 4)
	COVR50KM	Dominant UMD land cover type based on 0.5º grid cell centered on the site.	
	COVTYPES	Dominant UMD land cover frequencies based on 0.5º grid cell. This value equates to the number of unique land cover types (with a possible maximum of 14) in a 5 x 5 neighborhood patch of 0.5 degree cells around each site. It provides an indication of the homogeneity in land cover at the site.	

Table 12. Column headings, parameter definitions, and units of measure for the Class B point NDVI calculations (James and Kalluri, 1994)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassB_NDVI_933.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	JAN ... DEC	Monthly NDVI mean -- average of 1986, 1987, and 1990	Index (0-1)
	JAN_N ... DEC_N	NDVI number of years in mean (0-3)	Numeric
	JAN_STD ... DEC_STD	Monthly NDVI standard deviation	Index (0-1)

Table 13. Column headings, parameter definitions, and units of measure for the Class B point NPP measurements

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV	Elevation as given for the site	Meters
	ELEV_N	Number of elevation measurements for this site	Numeric
	SOURCE	Source of the NPP data name or code. Reference to person or organization that compiled the data or to another ORNL DAAC data set where the data came from.	Text

EMDI_ClassB_NPP_933_v2.csv	BIOMENEW	Biome type, standardized to EDMI classes (see Table 25)	
	TAVE_N	Number of temperature measurements for this site	Numeric
	PREC_N	Number of precipitation measurements for this site	
	TAVE	Annual average temperature	degrees Celsius
	PREC	Annual total precipitation	mm
	ANPP_N	Number of published above-ground NPP measurements for this site	Numeric
	BNPP_N	Number of published below-ground NPP measurements for this site	
	TNPP_N	Number of published total NPP measurements for this site	
	NPP_N	Number of estimated total NPP measurements for this site (estimated from ANPP or BNPP if no TNPP)	
	MOD_N	Number of NPP estimates from models for this site	
	AET_N	Number of models providing Actual Evapotranspiration (AET) for this site	
	FLAG_N	Sum of all the flag values	
	ANPP_C	Above-ground NPP	$gC/m^2/y$
	BNPP_C	Below-ground NPP	
	TNPP_C	Total NPP	
	MODCB_AV	Average ensemble value from up to 11 EMDI models	
	AETCB_AV	Average ensemble value for Actual Evapotranspiration from up to 5 EMDI models	mm/y
	FLAGS	Sum of all the flag values	Numeric
	TAVE_MAX	Maximum temperature for this site	degrees Celsius
	PREC_MAX	Maximum precipitation for this site	mm
	ELEV_MAX	Maximum elevation for this site	meters
	ANPP_MAX	Above-ground NPP – maximum of several published estimates	$gC/m^2/y$
	BNPP_MAX	Below-ground NPP – maximum of several published estimates	
	TNPP_MAX	Total NPP – maximum of several published estimates	
	NPP_MAX	NPP_EST – maximum of several estimates from ANPP or BNPP if no TNPP	
	MOD_MAX	Maximum model output of NPP	
	AET_MAX	Maximum model output of AET	mm/y
	FLAG_MAX	Maximum number of flags associated with a site	Numeric
	TAVE_MIN	Minimum temperature for this site	degrees Celsius
	PREC_MIN	Minimum precipitation for this site	mm
	ELEV_MIN	Minimum elevation for this site	meters
	ANPP_MIN	Above-ground NPP – minimum of several published estimates	$gC/m^2/y$
	BNPP_MIN	Below-ground NPP – minimum of several published estimates	
	TNPP_MIN	Total NPP – minimum of several published estimates	

	NPP_MIN	NPP_EST – minimum of several estimates from ANPP or BNPP if no TNPP	
	MOD_MIN	Minimum model output of NPP	
	AET_MIN	Minimum model output of AET	mm/y
	FLAG_MIN	Minimum number of flags associated with a site	Numeric

Table 14. Column headings, parameter definitions, and units of measure for Class B site summary information data files

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassB_Site_933.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV_GIV	Elevation as given for the site	Meters
	ELEV_DEM	Elevation extracted from the global TerrainBase Digital Elevation Model (DEM) (5-min resolution)	
	ELEV_G_N	Number of elevation measurements given for this site	Numeric
	ELEV_D_N	Number of elevation measurements extracted from the global TerrainBase Digital Elevation Model (DEM) (5-min resolution)	
	SITE_OLD	Reference to site ID in another ORNL DAAC data set. N/A = not applicable.	Numeric or Text
	SOURCE	Source of the NPP data name or code. Reference to person or organization that compiled the data or to another ORNL DAAC data set where the data came from.	Text
	COUNTRY	Country where site is located	
	BIOMENEW	Biome type, standardized to EDMI classes (see Table 25)	
	VEG_TYPE	Vegetation type as given, somewhat standardized	
	SPECIES	Dominant species	
	SUBBIOME	Sub Biome, e.g., conifer, deciduous	
	REFERENC	Published reference	
	YEAR_REF	Year of reference	YYYY
EMDI_ClassB_Summary_933.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	ELEV_GIV	Elevation as given for the site	Meters
	ELEV_DEM	Elevation extracted from the global TerrainBase Digital Elevation Model (DEM) (5-min resolution)	
	SAND	Sand content in top 30 cm	% w/w
	SILT	Silt content in top 30 cm	
	CLAY	Clay content in top 30 cm	
	TAVE	Annual average temperature, 1961-1990	degrees Celsius
	TMIN	Minimum annual temperature, 1961-1990	
	TMAX	Maximum annual temperature, 1961-1990	

	PREC	Annual total precipitation, 1961-1990	mm
	SUN	Annual mean percentage of sunlight for daylight hours, 1961-1990	%
	COVR1KM	Dominant UMD land cover type based on a 1 km grid cell centered on the site	Numerical code (0 through 13) defined in Table 4
	COVR50KM	Dominant UMD land cover type based on 0.5º grid cell centered on the site.	
	COVTYPES	Dominant UMD land cover frequencies based on 0.5º grid cell. This value equates to the number of unique land cover types (with a possible maximum of 14) in a 5 x 5 neighborhood patch of 0.5 degree cells around each site. It provides an indication of the homogeneity in land cover at the site.	
	SITE_NO	Unique site number	Numeric

Table 15. Column headings, parameter definitions, and units of measure for the Class B model drivers climate information, 30-year climate series (1961-1990)(Leemans and Cramer, 1991, compiled by PIK)

FILE NAME	VARIABLE	DEFINITION (COLUMN HEADING)	UNITS
EMDI_ClassB_PREC_933.csv	Precipitation	Annual and monthly total precipitation amount, 1961-1990 (ANN; JAN ... DEC)	mm
EMDI_ClassB_TAVE_933.csv	Average temperature	Annual and monthly mean temperature, 1961-1990 (ANN; JAN ... DEC)	degrees Celsius
EMDI_ClassB_TMAX_933.csv	Maximum temperature	Maximum annual and monthly temperature, 1961-1990 (ANN; JAN ... DEC)	
EMDI_ClassB_TMIN_933.csv	Minimum temperature	Minimum annual and monthly temperature, 1961-1990 (ANN; JAN ... DEC)	
EMDI_ClassB_SUN_933.csv	Sunshine	Annual and monthly mean percentage of sunlight during daylight hours, 1961-1990 (ANN; JAN ... DEC)	%

Table 16. Column headings, parameter definitions, and units of measure for the Class B model drivers soil information (IGBP Soils Database)

FILE NAME	COLUMN HEADING	DEFINITION	UNITS
EMDI_ClassB_Soil_IGBP_933.csv	SITE_ID	Site identification number based on unique lat/long	Numeric
	LAT_DD	Latitude of NPP site (point)	Decimal degrees
	LONG_DD	Longitude of NPP site (point)	
	SAND	Sand content in top 30 cm	% w/w
	SILT	Silt content in top 30 cm	
	CLAY	Clay content in top 30 cm	
	SOILN30	Soil nitrogen in top 30 cm	kg/m^2
	SOILN20	Soil nitrogen in top 20 cm	
	SOILN100	Soil nitrogen in top 100 cm	
	SOILC30	Soil carbon in top 30 cm	g/m^2
	SOILC20	Soil carbon in top 20 cm	
	SOILC100	Soil carbon in top 100 cm	
	PH	Soil pH (water) in top 30 cm	Units
	BD	Bulk density of top 30 cm	g/cm
	FC	Field capacity (water holding capacity) in top 30 cm	mm
	WP	Wilting point for top 30 cm	
	PAWC	Profile available water capacity	

III. EMDI CLASS C DATA

Table 17. EMDI Class C data files

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS
EMDI_ClassC_CLOUDS_1901-95.zip	19010101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual mean cloud cover (%) for each year in the 95-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)
EMDI_ClassC_Drivers.csv	19010101-19960101	Model driver data for 3,855 0.5 degree grid cells derived from global sources. Model drivers include cell ID; location; elevation; annual precipitation amount, average temperature, NDVI, and maximum/minimum temperatures; monthly average and maximum/minimum temperatures; monthly average and maximum/minimum precipitation amount; monthly NDVI; monthly and annual actual temperature range; predominant land cover class; soil texture (%); and biome classification.
EMDI_ClassC_IGBP_soils.csv	19700101-19960801	Soil characteristics for 3,855 0.5 degree grid cells derived from the IGBP-DIS Soils Database
EMDI_ClassC_NPP.csv	19310101-19960101	ANPP and TNPP estimates for 3,855 0.5 degree grid cells (global sources)
EMDI_ClassC_PREC_1901-95.zip	19010101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual precipitation amount for the 95-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)
EMDI_ClassC_TAVE_1901-95.zip	19010101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual average temperature for the 95-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)
EMDI_ClassC_TMAX_1930-95.zip	19300101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual maximum temperature for the 82-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)
EMDI_ClassC_TMIN_1930-95.zip	19300101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual minimum temperature for the 82-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)
EMDI_ClassC_TRANGE_1930-95.zip	19300101-19951231	Compressed (.zip) file containing one .csv file (48.5 MB) of monthly and annual actual temperature range for the 82-year series for 3,855 0.5 degree grid cells based on New et al. (1999, 2000b)

Table 18. Column headings, parameter definitions, and units of measure for the Class C 0.5 degree grid cell NPP measurements (global sources)

FILE NAME	VARIABLE	DEFINITION	UNITS
EMDI_ClassC_NPP.csv	Lat	Latitude of 0.5º cell centroid	Decimal degrees
	Lon	Longitude of 0.5º cell centroid	
	ID	Cell identification number based on unique lat/long	Numeric
	GROUP	Model group assignment for testing data	Numeric (1 or 2)
	ANPP	Above-ground net primary productivity	$gC/m^2/y$
	ANPP_N	Number of records for ANPP	Numeric
	TNPP	Total net primary productivity	$gC/m^2/y$
	TNPP_N	Number of records for TNPP	Numeric
	BIOME2	Biome type, standardized to 14 EMDI classes (See Table 24)	Text

Table 19. Column headings, parameter definitions, and units of measure for the Class C 0.5 degree grid cell summary model drivers

FILE NAME	VARIABLE	DEFINITION	UNITS
EMDI_ClassC_Drivers.csv	LAT_DD	Latitude of 0.5 degree cell centroid	Decimal degrees
	LONG_DD	Longitude of 0.5 degree cell centroid	
	ID	Cell identification number based on unique lat/long	Numeric
	ELE	Elevation of 0.5 degree cell centroid based on 1 km Global Land One-km Base Elevation (GLOBE)	Meters
	ELE_STD	Standard deviation of elevation in a 0.5 degree cell based on 1-km data	
	ANU_PPT	Annual mean total precipitation in millimeters, 1961–1990	mm
	ANU_AVGT	Annual mean air temperature (ºC), 1961–1990	degrees Celsius
	ANU_MAXT	Annual maximum temperature (ºC), 1961–1990	
	ANU_MINT	Annual minimum temperature (ºC), 1961–1990	
	ANU_NDVI	Annual mean NDVI, August 1981-July 1994	Index (0-1)
	JAN_AVGT .. DEC_AVGT	Monthly mean air temperature (ºC), 1961–1990	degrees Celsius
	JAN_MAXT .. DEC_MAXT	Monthly maximum temperature (ºC), 1961–1990	
	JAN_MINT .. DEC_MINT	Monthly minimum temperature (ºC), 1961–1990	
	JAN_AVGP .. DEC_AVGP	Monthly mean total precipitation in millimeters, 1961–1990	mm
	JAN_MAXP .. DEC_MAXP	Monthly maximum total precipitation in millimeters, 1961–1990	
	JAN_MINP .. DEC_MINP	Monthly minimum total precipitation in millimeters, 1961–1990	
	JAN_NDVI .. DEC_NDVI	Monthly mean NDVI, August 1981-July 1994	Index
	JAN_DTRT .. DEC_DTRT	Monthly actual diurnal temperature range	degrees Celsius
	ANN_DTRT	Annual actual diurnal temperature range	
	LANDCOVE	Dominant UMD land cover type for 0.5 degree grid cell (Hansen et al., 2000b)	Numerical code (0 through 13) defined in Table 4
	SAND	Percentages of soil composition in sand	%
	SILT	Percentages of soil composition in silt	
	CLAY	Percentages of soil composition in clay	
	BIOME2	Biome types (see Table 26)	Text

Table 20. Column headings, parameter definitions, and units of measure for the Class C 0.5 degree grid cell model drivers climate information(New et al., 1999; 2000b, compiled by PIK)

COMPRESSED FILE NAME	UNCOMPRESSED FILE NAME	VARIABLE	DEFINITION	UNITS
EMDI_ClassC_CLOUDS_1901-95.zip	clds_c.csv	CLDS	Annual and monthly average cloud cover, 1901-1995 (ann_clds; jan_clds .. dec_clds)	%
EMDI_ClassC_PREC_1901-95.zip	prec_c.csv	PREC	Annual and monthly total precipitation amount, 1901-1995 (ann_prec; jan_prec .. dec_prec)	mm
EMDI_ClassC_TAVE_1901-95.zip	tave_c.csv	TAVE	Annual and monthly mean temperature, 1901-1995 (ann_tave; jan_tave .. dec_tave)	degrees Celsius
EMDI_ClassC_TMAX_1930-95.ZIP	tmax_c.csv	TMAX	Maximum annual and monthly temperature, 1930-1995 (ann_tmax; jan_tmax .. dec_tmax)	
EMDI_ClassC_TMIN_1930-95.ZIP	tmin_c.csv	TMIN	Minimum annual and monthly temperature, 1930-1995 (ann_tmin; jan_tmin .. dec_tmin)	
EMDI_ClassC_TRANGE_1930-95.ZIP	dtr_c.csv	DTR	Actual annual and monthly diurnal temperature range, 1930-1995 (ann_dtr; jan_dtr .. dec_dtr)	

Table 21. Column headings, parameter definitions, and units of measure for the Class C 0.5 degree grid cell model drivers soil information (IGBP Soils Database)

FILE NAME	VARIABLE	DEFINITION	UNITS
EMDI_ClassC_IGBP_soils.csv	LAT_DD	Latitude of 0.5 degree cell centroid	Decimal degrees
	LONG_DD	Longitude of 0.5 degree cell centroid	
	Source	IGBP Soils 0.5 degree unless otherwise stated	Text
	BIOME2	Biome types (see Table 26)	Text
	GROUP	Model group assignment for testing data	Numeric (1 or 2)
	Sand	Sand content in top 30 cm	% w/w
	Silt	Silt content in top 30 cm	
	Clay	Clay content in top 30 cm	
	WiltPont	Wilting point for top 30 cm	mm
	Fieldcap	Field capacity (water holding capacity) in top 30 cm	
	PAWC	Profile available water capacity	
	SoilC	Soil carbon in top 30 cm	g/m^2
	SoilC20	Soil carbon in top 20 cm	
	SoilC100	Soil carbon in top 100 cm	
	TotN2	Soil nitrogen in top 30 cm	kg/m^2
	TotN220	Soil nitrogen in top 20 cm	
	TotN2100	Soil nitrogen in top 100 cm	
	PHH20	Soil pH (water) in top 30 cm	Units
	Bulkdens	Bulk density of top 30 cm	g/cm

3. Data Application and Derivation:

The EMDI initiative was launched to assess the accuracy of global model forecasts of terrestrial carbon cycling, NPP in particular. The questions of interest were how well NPP field data used to develop the model forecasts represent the region of interest, how well the environmental model driving variables (e.g., vegetation type, climate, and soils associated with a site used to parameterize ecosystem models) represent the region of interest, and how well regional model predictions agree with observed data for the region. Under EMDI, extensive worldwide NPP data and model driver data, including vegetation, climate, and soils data, compiled under GPPDI (Olson et al, 2012) were reviewed and analyzed. Data that passed EMDI scrutiny were used to perform a model intercomparison exercise involving 11 regional and global ecosystem models (Table 23). Model-data differences were analyzed.

Comparing the NPP field measurements with an average NPP from the ensemble of model outputs provided a unique method to improve NPP data, model driver data, and model processes. Initial results showed general agreement between model predictions of NPP and field measurements of NPP but with obvious differences that indicated areas for potential data and model improvement.

4. Quality Assessment:

The ORNL DAAC collection of NPP data has undergone several levels of review or filtering. The activities associated with the GPPDI provided a literature review and data compilation that resulted in selecting Class A and B sites and Class C grid cells. The EMDI activity provided another level of review for all the data by examining relationships between NPP estimates and associated environmental controlling variables, such as temperature and precipitation. As a result of the EMDI review, flags were assigned to each NPP estimate and the EMDI investigators selected a subset of data for the model-data intercomparison based on the flags.

The data were reviewed at the EMDI I Workshop and a strategy was developed for additional “outlier analysis” to flag those NPP measurements that, in combination with their driver data and the NPP ensemble model values, appeared to be unrepresentative or represented conditions that the global ecosystem models did not consider (e.g., wetlands). The EMDI exercise also assigned consistent biome classes to all sites, standardized latitude and longitude to two decimal places, and assigned unique identifiers for locations (SITE_ID) and individual measurements (MEAS_ID) within classes for linking with model driver data and validation data.

The specific issues that were addressed include:

• Biome class consistency – The review of biome assignments was prompted in part by the problems in using the satellite-derived land cover for each site (i.e., often this represented the dominant land cover for a 1 x 1 km area, not the cover for the 1 x 1 m to 1-hectare NPP measurement site).

• Managed sites – The EMDI modelers decided to flag and exclude likely heavily managed sites (e.g., cropland, plantations) and wetlands from the EMDI comparison.

• Multiple NPP values for a site – Some sites have several NPP values, often from several vegetation types, possibly as a result of reporting imprecise latitude/longitude coordinates or data from different studies at the same location. Some Class B sites have up to 35 observed NPP values at a site. Each site was assigned an EMDI biome class and the biome of every NPP measurement at the site was reviewed. Those NPP data that were inconsistent with the site biome were flagged. This resulted in 187 Class B measurements being dropped for the EMDI activity. A few Class C cells also had multiple NPP values where data had been compiled based upon different studies.

Olson et al. (2001) provide a detailed discussion of data quality issues, outlier analysis, and solutions used to compile the EMDI database.

Sources of Error

Approximately 50% of Class B measurement sites lacked a site-specific record of elevation. TerrainBase Digital Elevation Model (DEM), which has a 5-minute resolution (approximately 10 km at the equator), was used to generate elevation when missing. Because of the limited precision of both the site coordinates and the DEM algorithm, the latitude/longitude/elevation values may contain significant errors. Approximately 5% of the elevations based on the DEM had significantly negative elevations (>100 m below sea level), a likely indicator of compounded errors.

5. Data Acquisition Materials and Methods:

Extensive worldwide NPP data were assembled from the published literature, regression analysis, remote-sensing, and model simulations under GPPDI along with model driver data, including vegetation, climate, and soils data. Data contributors who compiled these data are listed in Table 22. EMDI was undertaken to review and subset the GPPDI data based on data quality analysis and criteria, perform an intercomparison of 11 regional or global versions of ecosystem models (Table 23) using the subsets, and analyze the model-field data differences. The sequence of EMDI activities that culminated in the preparation of the EMDI database is summarized in Olson et al. (2001).

Table 22. EMDI Data Contributors

Data	Contributor	Institution, Country
NPP	Jonathan Scurlock, Dick Olson, Keri Johnson	Oak Ridge National Laboratory, U.S.A.
	Steve Prince, Daolan Zheng	University of Maryland, U.S.A.
	Bill Parton, Steve Del Grossa	Colorado State University, U.S.A.
	Tom Gower, Drew Feldkirchner	University of Wisconsin-Madison, U.S.A.
	Jian Ni	University of Beijing, China
	Larry Tieszen	USGS EROS Data Center, U.S.A.
	Jennifer Jenkins	USDA Forest Service, U.S.A.
Elevation	Rob Braswell	University of New Hampshire, U.S.A.
Soil properties	Dick Olson, Keri Johnson	Oak Ridge National Laboratory, U.S.A.
Land cover	Steve Prince, Robb Wright	University of Maryland, U.S.A.
Monthly NDVI	Rob Braswell	University of New Hampshire, U.S.A.
Atmospheric CO2	Bob Cushman	ORNL Carbon Dioxide Information and Analysis Center, U.S.A.
30-year average monthly climate	Wolfgang Cramer, Stephen Sitch	Potsdam Institute for Climate Impact Research, Germany
Actual monthly climates		

Table 23. EMDI Modeling Groups

Model	Modelers	Institution, Country
AVIM	Jinjun Ji	Institute of Atmospheric Physics, China
BGC	Peter Thornton	University of Montana, USA
CARAIB	Bernard Nemry	University of Liege, Belgium
CENTURY	Bill Parton	Colorado State University, USA
GLO-PEM	Steve Prince, Daolan Zheng	University of Maryland, USA
GTEC	Mac Post, Tony King	Oak Ridge National Laboratory, USA
IBIS	Chris Kucharik, Jon Foley	University of Wisconsin, USA
LPJ	Stephen Sitch, Ben Smith	Potsdam Institute for Climate Impact Research, Germany
PNET	John Aber	University of New Hampshire, USA
STOMATE	Pierre Friedlingston, Laurent Kergoat	CNRS, France
VECODE	Victor Brovkin	Potsdam Institute for Climate Impact Research, Germany

Model Driver Data

Model driver data (e.g., vegetation type, climate, and soils associated with a site used to parameterize ecosystem models) were compiled from global databases specifically for the EMDI workshops. The information is consistent for all sites but may represent a value for a 5-km or 5-minute grid cell

within which a Class A or B site is located, thus the data may not necessarily reflect the conditions at the specific site of the NPP measurement. The same sources of driver data were used for the Class A and B data sets and an initial subset of Class C data; however, the driver data for the full set of Class C cells for EMDI II was taken from different sources than for EMDI I. See Olson et al. (2001) for details.

Elevation

For Class A and B sites, the site elevation from the published literature was used when available. However, approximately 25% of Class A and 50% of Class B measurement sites lacked a site-specific record of elevation. TerrainBase Digital Elevation Model (DEM), which has a 5-minute resolution (approximately 10 km at the equator), was used to generate elevation where missing. Because of the limited precision of both the site coordinates and the DEM algorithm, the latitude/longitude/elevation values may contain significant errors. Approximately 5% of the elevations based on the DEM had significantly negative elevations (>100 m below sea level), a likely indicator of compounded errors.

Elevations for Class C cells were based on an alternative 1-km DEM derived from the Global Land One-km Base Elevation (GLOBE) Project, a quality-controlled global DEM developed by the U.S. National Geophysical Data Center for International Geosphere-Biosphere Programme, Data and Information System (IGBP-DIS). Aggregation of the GLOBE DEM 1-km elevations to 0.5 degree cells resulted in only 0.2% of cells with significantly negative elevations. The GLOBE database was not available in 1999 when the Class A and B sites were assigned elevations.

Site and Grid Cell Biome Classification

Twenty-one (21) biome classes were defined to represent the NPP data and needs of the models. Sites were assigned to a biome based on initial biome class, sub-biome, species, vegetation type, and elevation. The 21 biome types were grouped into aggregated biome types based on similarity and the number of Class A and B sites to ensure there was enough data within each aggregated biome to conduct outlier detection. All of the biomes are represented in the GPPDI database. Heavily managed sites or sites typically not addressed by regional models, including crop, pasture, plantation, and wetland biome types, were assigned to a single “Managed” type and were excluded from the EMDI exercises.

Table 24. Biome Categories for EMDI Class A Sites

Biome Type (BIOMENEW)	Aggregated Biome Type (BIOME2)	Number of Sites
		Class A
Crops	Managed	N/A
Pasture		
Plantation		
Wetland		
Deciduous broad-leaf forest/boreal	DBL-DNL forest/boreal	8
Deciduous needle-leaf forest/boreal		
Deciduous broad-leaf forest/temperate	DBL forest/ temperate	
Deciduous broad-leaf forest/tropical	DBL forest/tropical	3
Desert	Desert	0
Evergreen broad-leaf forest/temperate	EBL forest/ temperate	0
Evergreen broad-leaf forest/tropical	EBL forest/tropical	17
Evergreen needle-leaf forest/boreal	ENL forest/boreal	15
Evergreen needle-leaf forest/temperate	ENL forest/temperate	6
Grassland/C3	Grassland	31
Grassland/C4 temperate		
Grassland/C4 tropical		
Mediterranean	Mediterranean	0
Mixed forest	Mixed forest	
Savanna/temperate	Savanna	
Savanna/tropical	Savanna	
Tundra	Tundra	
Total Records		81

Notes: N/A = Not applicable because biome category was excluded from EMDI.

Table 25. Biome Categories for EMDI Class B Sites

Biome Type	Aggregated Biome Type (BIOMENEW)	Number of Sites
		Class B
Crops	Managed	N/A
Pasture		
Plantation		
Wetland		

Deciduous broad-leaf forest/boreal	DBL forest/boreal	26
Deciduous needle-leaf forest/boreal	DNL forest/boreal	28
Deciduous broad-leaf forest/temperate	DBL forest/temperate	198
Deciduous broad-leaf forest/tropical	DBL forest/tropical	12
Desert	Desert	16
Evergreen broad-leaf forest/temperate	EBL forest/temperate	209
Evergreen broad-leaf forest/tropical	EBL forest/tropical	96
Evergreen needle-leaf forest/boreal	ENL forest/boreal	74
Evergreen needle-leaf forest/temperate	ENL forest/temperate	136
Grassland	Grassland/C3	36
	Grassland/C4 temperate	16
	Grassland/C4 tropical	21
Mediterranean	Mediterranean	9
Mixed forest	Mixed forest	39
Savanna	Savanna/temperate	1
	Savanna/tropical	6
Tundra	Tundra	10
Total Records		933

Notes: N/A = Not applicable because biome category was excluded from EMDI.

Biome type for Class C cells was based on information obtained from or reported by each individual study. If the biome was not available (e.g., in Senegal), an aggregated type based on the Hansen et al. (2000b) 1-km product was used. The biomes are listed in Table 26 along with the scheme that was used to consolidate the biomes into types consistent with the Class A and B aggregated biome types.

Table 26. Biome Categories for EMDI Class C Sites

Biome Type	Aggregated Biome Type (BIOME2)	Number of Sites
		Class C
Arid shrubland	Shrubland	576
Closed shrubland		
Open shrubland		
Boreal forest	forest/boreal	70
Boreal conifer-dominated	ENL forest/ boreal	82
Deciduous forest	DBL forest/ tropical	16
Evergreen forest	EBL forest/ tropical	1,195
Grass	Grassland	1,300
Grassland		
Savanna	Savanna	69
Subtropical forest	forest/ tropical	10
Temperate forest	forest/ temperate	312
Wooded grassland	Wooded grassland	92
Woodland	Forest	2
Xeric forest	Forrest/xeric	131
Total Records		3,855

Land Cover

Land cover was extracted from the University of Maryland's 1-km Global Land Cover product (Hansen et al., 2000b). Because of the limited spatial resolution of the database around coastlines (and especially islands), approximately 5% of the study sites were assigned a cover type of 0 (water). The land cover codes and respective land cover classes are shown in Table 4, with the abbreviations used in the data files.

- Class A sites - The proportion of each of the 14 land cover types in a 9 x 9 patch of 1-km pixels around each point is provided, as a measure of land cover homogeneity and the “representativeness” of the site. The associated land cover value for the centered 1-km pixel and the 0.5 degree pixel from the Hansen et al. (2000b) land cover data set is also given.
- Class B sites - The associated land cover type value for the original 1-km pixel and the 0.5 degree pixel from the Hansen et al. (2000b) land cover data set is provided. The number of unique land cover types (with a possible maximum of 14) in a 5 x 5 neighborhood patch of 0.5 degree

cells around each site provides an indication of the homogeneity in land cover at the site.
- Class C cells - The 0.5 degree land cover designation for Class C cells was developed from Hansen et al. (2000b) 1-km land cover product derived from satellite data. The accuracy of classification of land cover at 0.5 degree cell depends heavily on homogeneity in nature. This 0.5 degree cell land cover map has been available for more than a year or so without any change. Some inconsistencies between field observations and classified land cover types at 0.5 degree cell size are caused by differences in scales, methods, and other factors that are out of our control.

Climate

Long-term monthly climate averages (1931–1960) from the PIK database (Leemans and Cramer, 1991) and a 95-year monthly climate time series (1900–1995) based on the University of East Anglia climate database (New et al., 2000b; see also New et al. 1999 and 2000a) were used to compile climate data for Class A and B sites. The 95-year series was generated for the Class A sites only, while the 30-year means were generated for all of the Class A and B sites. Latitude, longitude, and elevation were used for interpolation; therefore, estimated climate depends on the accuracy of the site location. The approximate minimum and maximum temperatures were calculated from the average temperature by subtracting or adding one-half the diurnal temperature range. The annual mean was calculated as the mean of the 12 monthly means, while the annual minimum was calculated as the minimum of the 12 monthly minimums (not the mean minimum) and the annual maximum was calculated as the maximum of the 12 monthly maximums. The climate surfaces cover all of the land area north of 60° S and the nearby oceans. Some sites on isolated islands and in Antarctica do not have climate data. For Class C cells, climate variables are calculated by Daolan Zheng based on the data set of New et al. (1999, 2000a, b) for the period 1961–1990 and on the long-term monthly averages (1931–1960) from the PIK database (Leemans and Cramer, 1991) to keep the consistency with EMDI I climate data. Transient monthly climate for the 1901–1995 were extracted from New et al. (2000b) for the Class C cells, although the diurnal temperature range was only available for the years 1930–1995 so that minimum and maximum temperatures were limited to those years.

Soils

Soils data for EMDI sites were extracted from the IGBP Soils Database. The means of 14 distinct EMDI soil characteristics were calculated. Soils data were extracted at a 5-minute resolution for Class A and B sites and at a 0.5 degree resolution for Class C cell. See Olson et al. (2001) for details.

NDVI

NDVI data were extracted from the Pathfinder AVHRR [Advanced Very High Resolution Radiometer] Land (PAL) data set (James and Kalluri, 1994). PAL data are available as 10-day composites for August 1981 to August 1994 in global 8-km Goode's Homolosine (equal area) projection. Three-year monthly averages were calculated for Class A and B sites based on 1986, 1987, and 1990. A 13-year average was calculated for Class C grid cells.

The cloud mask that accompanies the PAL 10-day composites was applied, using the most conservative approach of masking all pixels that are flagged as “cloudy” or “mixed.” The NDVI data were recomposited to one month in order to minimize the effects of variable atmospheric conditions and viewing geometry.

To extract the time series, the EMDI latitude-longitude coordinates were converted into Goode's X-Y coordinates, then all of the 8-km NDVI pixels within a 25-km radius of the EMDI point were averaged (excluding cloudy and quality control-flagged pixels). Ice- and snow-covered land is generally identified as cloudy by the cloud retrieval algorithm so only vegetated/potentially vegetated pixels are included in the average. Persistent clouds and snow cover will often result in having no pixels associated with the site for some number of months. These missing data are assigned a value of -999. To represent site patterns for modeling, 3-year monthly averages were calculated for Class A and B sites based on 1986, 1987, and 1990. These are the only years that do not contain an instrument change over or a major pulse of volcanic aerosols. Coincidentally, the 3 years are fairly anomalous with respect to global climate: 1986 and 1987 were ENSO years and 1990 was the warmest year in the AVHRR record.

A 13-year average NDVI was provided for EMDI II Class C cells based on an analysis of the relationships between 3-year and 13-year NDVI values. The results of that analysis are briefly summarized in Appendix B of Olson et al. (2001).

Model Ensemble

The investigators reviewed the literature-derived, observed NPP data extensively prior to EMDI by looking at scatter plots and data outside of reasonable limits. The EMDI Workshop provided the initial model results to compare with the observed NPP data. An ensemble NPP value was calculated for each site as the average of the 11 Class A models (AVIM, BGC, CARAIB, CENTURY, GLO-PEM, GTEC, IBIS, LPJ, PNET, STOMATE, and VECODE) (Table 23) and 8 Class B models (AVIM, CARAIB, CENTURY, GLO-PEM, IBIS, PnET, STOMATE, and VECODE). An ensemble NPP value was calculated for each Class C cell as the average of the 4 models including AVIM, IBIS, PnET, and VECODE. If the model ensemble NPP value was based on less than 3 model outputs for Class A or B sites, or less than 2 outputs for Class C cells, then the model average for that site or cell was dropped. In addition, an ensemble AET (actual evapotranspiration) value was calculated based on the average of AET provided by five of the models for Class A (CARAIB, CENTURY, IBIS, PNET, GTEC), four of the models for Class B (CARAIB, CENTURY, IBIS, PNET), and two of the models for Class C (IBIS, PNET). If the model ensemble AET value was based on less than 3 model outputs for Class A or B sites or less than 2 for Class C cells, then the AET average for that site or cell was dropped.

Outlier Analysis

The investigators used the power of the statistical-empirical analysis to look for inconsistencies in NPP values for individual sites within the patterns formed by homogeneous groups (i.e., biomes). Often these inconsistencies were not apparent in a review of the literature associated with a specific study. The overall approach used at the EMDI 1 Workshop included seven tests to set outlier flags. These analyses are described in Olson et al. (2001).

NPP Measurement Data -- The Results of the EMDI Review Process

The measurements of NPP were categorized as either Class A, representing intensively studied or well-documented study sites; Class B, representing more numerous “extensive” sites with less documentation and site-specific information available, or Class C, representing regional collections of 0.5 degree latitude-longitude grid cells.

- EMDI Class A Data. One hundred and fifty (150) unique GPPDI Class A sites that represent grassland, tropical forest, temperate forest and

boreal forest sites had complete NPP measurements (above- and below-ground components) and relatively complete documentation. Following EMDI review of the site data, 69 sites were eliminated because:

- 13 sites lacked driver data because of limited spatial resolution in global coverages (e.g., sites near coastal areas, islands, etc.);
- 22 sites lacked below-ground NPP (BNPP);
- 28 sites because Olson et al. (2001) were unable to acquire NPP estimates within the EMDI schedule; and
- 6 sites were eliminated in the outlier analysis.

The resulting EMDI Class A NPP data set contains 81 NPP data records.

Most of the NPP estimates provided in the literature were in units (g) of dry biomass (organic matter) per square meter per year. These values were converted to carbon units (e.g., $gC/m^2/y$) using a mass fraction of 0.5 for woody components and 0.45 for grass and foliage components (Raich et al., 1991). If investigators were unable to determine whether the biomass was predominantly wood or foliage, a ratio of 0.475 g C per 1 g biomass was used.

- EMDI Class B Data. Of the 2,363 GPPDI Class B sites, 933 unique sites passed the outlier analysis under EMDI. These sites represent grassland, tropical forest, temperate forest, boreal forest, tundra, savanna, crops, and plantations sites that have at a minimum above-ground net primary productivity (ANPP) measurements, a site location, and documentation (e.g., a literature citation).

For those sites lacking a value for total net primary productivity (TNPP), TNPP (NPP_EST) was estimated from ANPP or BNPP by calculating biome-specific ratios from sites that had both ANPP and BNPP measurements. These ratios were calculated based on the biome classification reviewed at the EMDI I workshop and using data with outliers excluded. The ratios of ANPP to BNPP differ by biome. Based on the EMDI analysis, a ratio of 0.5 BNPP:TNPP for grasslands, deserts, and tundra and a ratio of 0.22 BNPP:TNPP for forests was used (see Appendix C in Olson et al., 2001).

- EMDI Class C Grid Cell Data. NPP and driver data for EMDI Class C cells were compiled and reviewed as described in Olson et al. (2001). Drivers includes elevation, biome, monthly climate (mean, min, and max temperature and total precipitation), NDVI, and soil texture (fraction of sand, silt, and clay). Of the 5,164 NPP estimates for 0.5º grid cells in the GPPDI database, a sub-set of 3,855 unique cells was available for EMDI model-data intercomparison.

Missing components to provide estimates of TNPP were calculated as described above for Class B sites. In addition, a variety of methods were used to derive the 0.5º grid-cell estimates. Table 27 and Olson et al. (2001) summarize methods used by each study. Principal methods used for estimation of 0.5º cell NPP data include

• stratification of grid cells and area weighting of field NPP observations in each stratum;
• aggregation of finer scale (plot or stand level) spatial inventory data;
• local modeling of NPP using key environmental variables, for which maps are available; and
• direct correlation of ground measurements with remotely sensed vegetation indices.

See Olson et al. (2001) and data sources for details.

Table 27. Sources and information about EMDI Class C grid cell NPP

Cell ID range	Location	NPP estimation method	0.5 degree cell scaling method	Source
1000s	Great Plains, USA	Rangeland inventory	Aggregated to 0.5 degree cells based on 1-km cells derived from soil maps	Tieszen et al. (1997)
2000s	Yellowstone, USA	Measurements of DBH increment (540 plots) within uniform stands	Multiple regression – cover type, topography, soils for each stand type	Hansen et al. (2000a)
3000s	N/A	N/A	N/A	N/A
4000s	Australia	Measurements of grassland biomass increment	GRASP pasture production model based on rainfall	Day et al. (1997)
5000s	Minnesota, USA	Forest inventory (2,711 plots)	Mean of plots for given forest type, then areal weighted	Goetz and Prince (1996)
6000s	Mid-Atlantic and Maine, USA	Forest inventory (2,640 plots)	Weighted mean of plots in cells	Jenkins et al. (2001)
7000s	Russia, SE and NE USA	Forest inventory	Mean of stands for different type (in Russia) or means of counties (in U.S.A.), areal weighted or resampled	Gower et al. (2001); Krankina et al. (2001)
8000s	Great Plains, USA	Rangeland inventory	Means by Major Land Resource Areas (MLRA) associated with 0.5º cells within MLRAs	Sala et al. (1988)
9000s	Mid-West, USA	Crop inventory and growth model	Means by county extrapolated to 0.5º	Prince et al. (2001)
10000s	Pacific Northwest, USA	Literature giving estimates by stand age	Association of NPP with high resolution map of stand age	Turner et al. (2000)
11000-12000s	Great Plains, USA.	Rangeland inventory	Empirical relationship with precipitation used	Gill et al. (2002)
13000s	Eastern forests, USA	Forest inventory by county	Association of 0.5º cells within counties	Brown et al. (1999)
14000-			Least-squares statistical model based on climate, soils,	

17000s	Australia	Literature	and vegetation	Barrett (2002)
18000s	Finland and Sweden	5-year set of forest measurements (660 plots) with allometric equations	Calibrated TM/AVHRR imagery with field data, aggregate to 0.5º cells	Zheng et al. (2003; 2004)
19000s	Senegal	11-year set of measurements for major cover types	Calibrated AVHRR Model with field data	Diallo et al. (1991)
20000-21000s	South America	Calibrated model based on literature values	TEM model simulations for 0.5º cells	Raich et al. (1991)
22000s	China	Forest inventory (>1,000 plots)	Mean NPP for 33 forest classes, extrapolated to region at 6-km, aggregated to 0.5º cells	Jiang et al. (1999)

Notes: N/A = Not applicable because not included.

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:

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Additional Sources of Information:

Please see Olson et al. (2001) for additional data sources and references.

8. Data Set Revisions:

Revision Summary:

The EMDI data file for Class A sites [**EMDI_ClassA_NPP_81_R1.csv**] has been revised to correct previously reported net primary production (NPP) values for three OTTER U.S.A. transect sites.

Data File Changes:

The EMDI data file for Class A sites [**EMDI_ClassA_NPP_81_R1.csv**] has been revised to correct previously reported above-ground, below-ground, and total NPP values for Waring's Woods and Scio (unfertilized) and above-ground and total NPP values for Juniper/Sisters OTTER transect sites to agree with values reported in Runyon et al. (1994). EMDI data for these OTTER sites in **EMDI_ClassA_NPP_81_R2.csv** are now correct.

In the table below, **Uncorrected** refers to file **EMDI_ClassA_NPP_81_R1.csv,** and **Corrected** refers to file **EMDI_ClassA_NPP_81_R2.csv**

Site Identification	Parameter Field	Uncorrected	Corrected
	ANPP 2	556	551

	(gC/m /yr)		
GPPDI Class A 94 (ott Waring's Woods)	BNPP ($gC/m^2/yr$)	219	181
	TNPP ($gC/m^2/yr$)	774	732
GPPDI Class A 95 (ott Scio, unfertilized)	ANPP ($gC/m^2/yr$)	551	831
	BNPP ($gC/m^2/yr$)	181	238
	TNPP ($gC/m^2/yr$)	732	1,069
GPPDI Class A 91 (ott Juniper/Sisters)	ANPP ($gC/m^2/yr$)	67	57
	TNPP ($gC/m^2/yr$)	152	143

Data User Action: If you downloaded this data set from the ORNL DAAC on-line archive before August 29, 2013, you should download it again from the ORNL DAAC.

Revision History:

Original Citation

Olson, R. J., J. M. O. Scurlock, S. D. Prince, D. L. Zheng, and K. R. Johnson (eds.). 2001. NPP Multi-Biome: NPP and Driver Data for Ecosystem Model-Data Intercomparison. Data set. Available on-line [http://daac.ornl.gov] from the Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.