Global Peatland Carbon Balance and Land Use Change CO2 Emissions Through the Holocene

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Data Set Version: V1

Summary

This data set provides a time series of global peatland carbon balance and carbon dioxide emissions from land use change throughout the Holocene (the past 11,000 yrs). Global peatland carbon balance was quantified using a) a continuous net carbon balance history throughout the Holocene derived from a data set of 64 dated peat cores, and b) global model simulations with the LPX-Bern model hindcasting the dynamics of past peatland distribution and carbon balance. CO2 emissions from land-use change are based on published scenarios for anthropogenic land use change (HYDE 3.1, HYDE 3.2, KK10) covering the last 10,000 years. This combination of model estimates with CO2 budget constraints narrows the range of past anthropogenic land use change emissions and their contribution to past carbon cycle changes.

There are 13 spatial data files in NetCDF (*.nc) format providing time series representations of peatland carbon balance and land use change emissions and four tabular data files in comma-separated (*.csv) file format containing the time series of global totals.

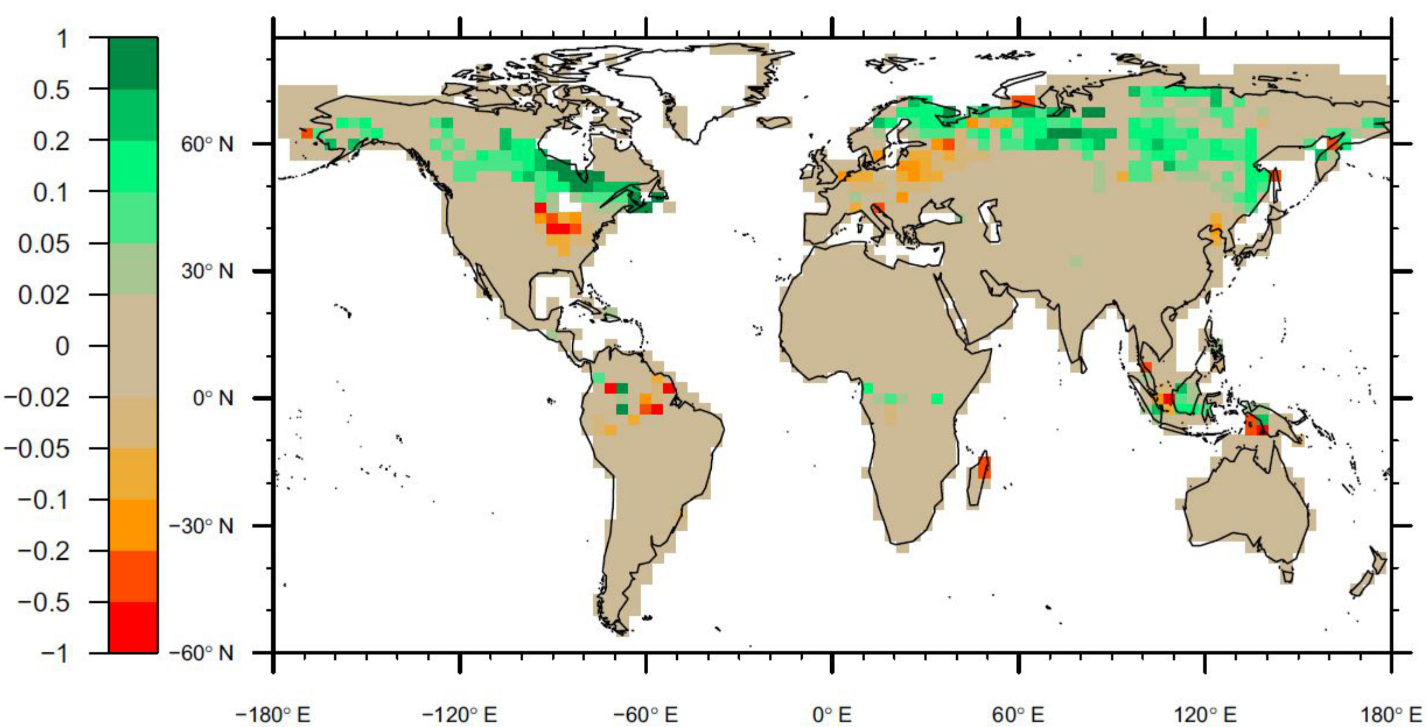

Figure 1: Change in the peatland area fraction between 13 kyBP and the present day, simulated by LPX under transiently changing environmental conditions, prescribed from CESM TraCE21k simulations. Note the irregular spacing of color levels. Negative values represent a larger peatland area

fraction at 13 kyBP than at present (from Stocker et al., 2017).

Citation

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Table of Contents

1. Data Set Overview

This dataset provides time series of global peatland carbon balance and carbon dioxide emissions from land use change throughout the Holocene (the past 11,000 yrs), as published in Stocker et al., 2017. The global peatland carbon balance was quantified using a) a continuous net carbon balance history throughout the Holocene derived from a data set of 64 dated peat cores (extended from Yu et al., 2010, and Loisel et al., 2014), and b) global model simulations with the LPX-Bern model hindcasting the dynamics of past peatland distribution and carbon balance (based on Stocker et al., 2014). CO_2 emissions from land-use change are based on published scenarios for anthropogenic land use change (HYDE 3.1, HYDE 3.2, KK10) covering the last 10,000 years. Provided are CSV files for time series for global totals and NetCDF files for global spatial fields (only for model-based peat C balance and CO_2 emissions from land use change), both covering the Holocene until present.

Related Publication:

Stocker, B.D., Z. Yu, C. Massa, and F. Joos. 2017. Holocene peatland and ice-core data constraints on the timing and magnitude of CO2 emissions from past land use. *Proceedings of the National Academy of Sciences*, 114: 1492-1497. http://doi.org/10.1073/pnas.1613889114

2. Data Characteristics

Spatial Coverage: Global

Spatial Resolution: 3.75 x 2.5 degree; Tabular data values represent global summary statistics

Temporal Coverage: the Holocene (last 11,000 yr)

Temporal Resolution: Decadal

Study Area (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Global peatlands	-180	180	90	-90

Data File Information

This data set contains all time series data for the peatland carbon balance and land use change emissions as published in Stocker et al., 2017. The spatial data are provided in 13 files in NetCDF (*.nc; version 3) format and the time series are summarized in four comma-separated (*.csv) tabular data files.

<u>Spatial Data Files</u>

The file names and descriptions for the NetCDF data files are listed in Table 1. The variable names, their units, and descriptions for each of the NetCDF data files are listed in Tables 2-4. Each spatial data file is given at 3.75- x 2.5-degree spatial resolution and 10-yr temporal resolution. NetCDF files prefixed with *luarea_** (6 files) contain global spatial representation of land use area and files prefixed with *fluc_** (6 files) contain land use carbon emissions corresponding to different land use scenarios (HYDE 3.1, HYDE 3.2, KK10, and variants; see Section 5).

Table 1. Spatial data file names and descriptions

Data File Name	Description	Temporal Coverage
peatland_area_carbon_13kaBP-2000CE.nc	Simulated (LPX-DYPTOP model) peatland area fraction (unitless) and soil C stocks in peatland soils [g C m-2]. See file metadata.	-11000 to 1990
luarea_<scenario>.nc	Land use area. Provides data for grid cell area fraction covered by land unit *i* as used in LPX simulations for Holocene land use change. See file metadata.	-10000 to 2001
fluc_<scenario>.nc	CO2 emissions due to anthropogenic land use change per 10 year period [g C m-2 (10yr)-1]. See file metadata.	-10000 to 2001

Table 2. Variable names, units, and descriptions for land use spatial data files; e.g. *luarea_<scenario>.nc*

Variable Name	Units	Description
LATITUDE	degrees_north	Latitude of center of grid cell
LONGITUDE	degrees_east	Longitude of center of grid cell
luarea	x/1	Grid cell area fraction covered by land covers 1 through 5
TIME	year CE	The middle year CE of the decade represented by the data
Z	land unit	1 = primary, 2 = secondary, 3 = cropland, 4 = pasture, 5 = built up

Table 3. Variable names, units, and descriptions for land use carbon emissions spatial data files; e.g. *fluc_<scenario>.nc*

Variable Name	Units	Description
LATITUDE	degrees_north	Latitude of center of grid cell
LONGITUDE	degrees_east	Longitude of center of grid cell
fLUC	gC m-2 (10 yr)-1	CO2 emissions due to anthropogenic land use change
TIME	year CE	The middle year CE of the decade represented by the data

Table 4. Variable names, units, and descriptions for peatland area fraction and soil carbon stocks spatial data file: *peatland_area_carbon_13kaBP-2000CE.nc*

Variable Name	Units	Description
LATITUDE	degrees_north	Latitude of center of grid cell
LONGITUDE	degrees_east	Longitude of center of grid cell
TIME	year CE	The middle year CE of the decade represented by the data
cpeat	gC m-2	Peat soil carbon
fpeat	x/1	Grid cell area fraction covered by peatland

Tabular Data Files

All time series data for the peatland carbon balance and land use change emissions as published in Stocker et al. (2017) are provided as CSV files covering the Holocene (last 11,000 yr) until 1950 CE. They contain global summary statistics of the data provided in the NetCDF files.

Table 5. Tabular data file names and descriptions

Data File Name	Description	Temporal Coverage
dcpeat_lpx_stocker17pnas.csv	Annual peatland net ecosystem productivity (NEP) and total global peatland carbon storage (TOTC) simulated by LPX. NEP represents the net CO2 exchange between the biosphere and the atmosphere over active peatlands only. TOTC represents the total global amount of carbon stored in active peatlands as simulated by LPX. Cumulative NEP is not identical to TOTC due to simulated spatial shifts in peatland extent and decaying peat carbon not accounted for in	-11000 to 1990

	NEP.	
dcpeat_yml_stocker17pnas.csv	Decadal peatland net carbon balance, derived following the methodology of Yu et al. (2010), using data from 64 peat cores from Loisel et al. (2014) as described in Stocker et al. (2017). Summary statistics are based on a set of 1000 individual Monte Carlo simulations. Values are given at a decadal time step and are representative of annual values within the decade starting in 'year'-5 and ending in 'year'+4.	-10050 to 1950
dcpeat_cum_yml_stocker17pnas.csv	Cumulative peatland net carbon balance, derived following the methodology of Yu et al. (2010), using data from 64 peat cores from Loisel et al. (2014) as described in Stocker et al. (2017). Summary statistics are based on a set of 1000 individual Monte Carlo simulations. Values are given at a decadal time step and are representative of annual values at the end of the decade.	-10050 to 1950
luc_co2_emissions_stocker17pnas.csv	Annual and annual cumulative CO2 emissions from anthropogenic land use change simulated using the LPX model in a D1 setup (Pongratz et al., 2014) under constant preindustrial environmental boundary conditions and following six different land use change scenarios (HYDE 3.1, HYDE 3.1 upper, HYDE 3.2, HYDE 3.2 upper, KK10, and KK10D)	-10000 to 2001

The column names, their units, and descriptions for each of the CSV data files are listed in Tables 6-9.

Table 6. *dcpeat_lpx_stocker17pnas.csv*

Column Name	Units	Description
year	year_CE	year CE
nep	PgC yr-1	Net ecosystem productivity summed over all peatland areas globally
totc	PgC	Total global carbon storage in peatlands

Table 7. *dcpeat_yml_stocker17pnas.csv*

Column Name	Units	Description
age	years	years before present (1950 CE)
year	year	year CE
mean	PgC yr-1	Peatland net carbon balance; mean of 1,000 Monte Carlo simulations
median	PgC yr-1	Peatland net carbon balance; median of 1,000 Monte Carlo simulations
sd	PgC yr-1	Peatland net carbon balance; standard deviation of 1,000 Monte Carlo simulations
q10	PgC yr-1	Peatland net carbon balance; 10%-quantile of 1,000 Monte Carlo simulations
q90	PgC yr-1	Peatland net carbon balance; 90%-quantile of 1,000 Monte Carlo simulations

Table 8. *dcpeat_cum_yml_stocker17pnas.csv*

Column Name	Units	Description
age	years	years before present (1950 CE)
year	year	year CE
mean	PgC	Peatland net carbon balance; mean of 1,000 Monte Carlo simulations
median	PgC	Peatland net carbon balance; median of 1,000 Monte Carlo simulations
sd	PgC	Peatland net carbon balance; standard deviation of 1,000 Monte Carlo simulations
q10	PgC	Peatland net carbon balance; 10%-quantile of 1,000 Monte Carlo simulations
q90	PgC	Peatland net carbon balance; 90%-quantile of 1,000 Monte Carlo simulations

Table 9. *luc_co2_emissions_stocker17pnas.csv*

Column Names	Units	Description
year	year	year CE
hyde31	PgC yr-1	CO2 emissions under Hyde31 land use scenario (Goldewijk 2001)
hyde32	PgC yr-1	CO2 emissions under Hyde32 land use scenario (Goldewijk 2016)
hyde31u	PgC yr-1	CO2 emissions under Hyde31 upper land use scenario (Goldewijk 2001)
hyde32u	PgC yr-1	CO2 emissions under Hyde32 upper land use scenario (Goldewijk 2016)
kk10	PgC yr-1	Annual CO2 emissions under kk10 land use scenario (Kaplan et al., 2011)
kk10d	PgC yr-1	Annual CO2 emissions under kk10d land use scenario (Stocker et al., 2017; SI Text)
hyde31_cum	PgC	Cumulative CO2 emissions under Hyde31 land use scenario (Goldewijk 2001)
hyde32_cum	PgC	Cumulative CO2 emissions under Hyde32 land use scenario (Goldewijk 2016)
hyde31u_cum	PgC	Cumulative CO2 emissions under Hyde31 upper land use scenario (Goldewijk 2001)
hyde32u_cum	PgC	Cumulative CO2 emissions under Hyde32 upper land use scenario (Goldewijk 2016)
kk10_cum	PgC	Cumulative CO2 emissions under kk10 land use scenario (Kaplan et al., 2011)
kk10d_cum	PgC	Cumulative CO2 emissions under kk10d land use scenario (Stocker et al., 2017; SI Text)

3. Application and Derivation

This data set presents observation- and model-based reconstructions of past peatland carbon and land-use CO2 emission estimates based on published land use scenarios.

4. Quality Assessment

Uncertainty estimates are included for the peatland carbon balance (YML) time series data. The data were assessed using a set of 1000 Monte Carlo simulations that account for uncertainty in peat core measurements and uncertainty in parameters used to derive the global peatland carbon balance for multiple core measurements.

5. Data Acquisition, Materials, and Methods

This data set is the product of combined observation- and model-based estimates for the global peatland carbon balance with published reconstructions of terrestrial carbon stock changes during the Holocene and the last millennium.

Global peatland carbon balance

The carbon balance of global peatlands was derived using an observation-based reconstruction (Yu 2011) and global modeling (Archer et al., 2009). The reconstructions were based on carbon accumulation records from an updated data set of 64 peat cores from northern peatlands from Loisel et al. (2014), using the same methodology as Yu (2011) to calculate net carbon balance through time (YML; *dcpeat_yml_stocker17pnas.csv, dcpeat_cum_yml_stocker17pnas.csv)*. Uncertainty of global peatland carbon balance was obtained from a set of 1,000 Monte Carlo simulations, generated by varying input parameters used for the reconstruction within an assumed Gaussian distribution.

The global peatland simulations were done using version 1.2 of the LPX-Bern dynamic global vegetation model (LPX; *dcpeat_lpx_stocker17pnas.csv; peatland_area_carbon_13kaBP-2000CE.nc*) that includes the DYPTOP module (Dynamical Peatland Model Based on TOPMODEL) to simulate peat and wetland extent (Stocker et al., 2014). Simulations were initialized and started under last-glacial maximum conditions (22 kyBP) and account for transient peatland dynamics until the present in response to varying CO_2 and climate, prescribed from TraCE21ka simulations (Loisel et al., 2014) with the Community Earth System Model and changing land-sea-ice distribution (Peltier 2004). Data were evaluated only for the period after 13 kyBP.

Land use change emissions

CO_2 emissions from anthropogenic land use change were also simulated using LPX-Bern, accounting for gross land use transitions arising from shifting cultivation and wood harvesting. This is the same global vegetation model as used to quantify model-derived global peatland carbon balance, but applied for an independent set of simulations where no anthropogenic peatland drainage was considered. CO_2 was fixed at 287 ppm and climate was held constant. Only land use was varied. CO_2 emissions were quantified as the difference in the net land-atmosphere CO_2 exchange flux from a simulation including land use change and a control simulation without land use change. Past land use change scenarios were based on published data sets: HYDE 3.1 (Goldewijk 2001; *luarea_hyde31.nc, luarea_hyde31u.nc*), HYDE 3.2 (Goldewijk 2016; *luarea_hyde32.nc, luarea_hyde32u.nc*), KK10 (Kaplan et al., 2011; *luarea_kk10.nc*), and KK10D (Stocker et al., 2017; *luarea_kk10d.nc*). Shifting cultivation was simulated in time-varying regions with permanent agriculture, following Olofsson and Hickler (2008). Wood harvest was prescribed based on maps for harvested area (Hurtt et al., 2006) for the period

1960-2000 CE and were back projected following total cropland area per continent specifically for each land-use scenario (*luc_co2_emissions_stocker17pnas.csv; fluc_hyde31.nc, fluc_hyde31u.nc, fluc_hyde32.nc, fluc_hyde32u.nc, fluc_kk10.nc, fluc_kk10d.nc*).

6. Data Access

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

Global Peatland Carbon Balance and Land Use Change CO2 Emissions Through the Holocene

Contact for Data Center Access Information:

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