PalEON: Terrestrial Ecosystem Model Outputs for the Northeastern U.S., 0850-2010

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Summary

This dataset from the PalEON (Paleo-Ecological Observatory Network) Ecosystem Model Intercomparison Project (PEMIP) provides site-specific and regional outputs from terrestrial ecosystem model simulations in the Northeastern U.S. over the time period 0850-01-01 to 2010-12-31. For the regional scale modeling effort, five ecosystem models participated: ED2, LINKAGES, LPJ-GUESS, LPJ-WSL, and TRIFFID. Additional output for a larger ensemble is available for six individual sites with the following models: CLM-BGC, CLM-CN, ED2, ED2-landuse, JULES, TRIFFID, LINKAGES, LPJ-GUESS, LPJ-WSL, and SiBCASA. Output variables include key terrestrial ecosystem metrics, such as aboveground biomass, autotrophic respiration, evaporation, gross primary productivity, net ecosystem exchange, and net primary productivity (output variables differ by model). The PEMIP is a coordinated effort to develop a set of terrestrial ecosystem model simulations with the ability to evaluate high-resolution ecophysiological causes and consequences of forest responses to climatic variability and change over the past millennium.

This dataset contains 329 data files in netCDF-4 (*.nc) format and one companion file in PDF (*.pdf) format.

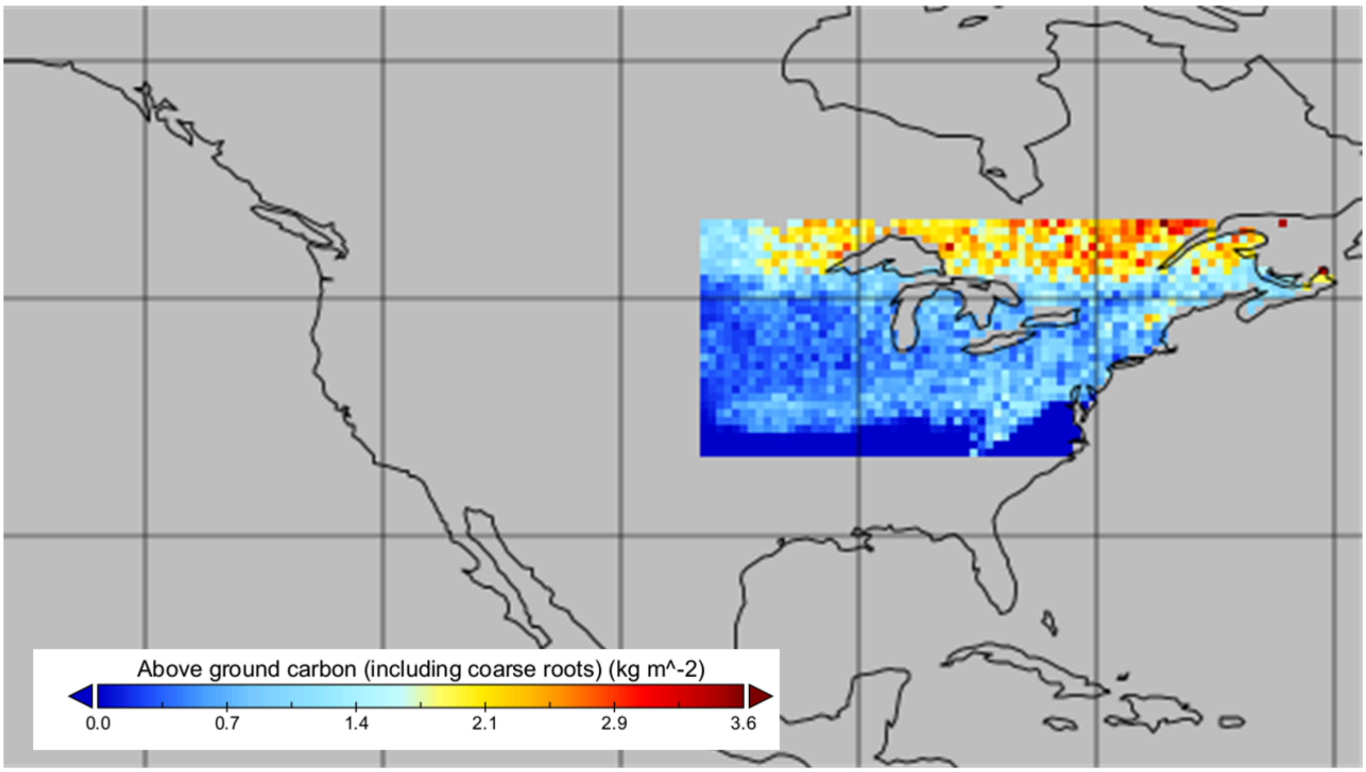

Figure 1. Aboveground biomass (including coarse roots) estimates in 2000 derived from the LPJ-GUESS model.

Citation

Rollinson, C., M. Dietze, B. Brooks, T. Hickler, Y. Liu, J.H. Matthes, J. Mclachlan, D.J.P. Moore, B. Poulter, T. Quaife, A.M. Raiho, K. Schaefer, and J. Steinkamp. 2026. PalEON: Terrestrial Ecosystem Model Outputs for the Northeastern U.S., 0850-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2509

Table of Contents

1. Dataset Overview

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Project: North American Carbon Program

The North American Carbon Program (NACP) is a multidisciplinary research program designed to improve understanding of North America's carbon sources, sinks, and stocks. The central objective is to measure and understand the sources and sinks of Carbon Dioxide (CO_2), Methane (CH_4), and Carbon Monoxide (CO) in North America and adjacent oceans. NACP is supported by a number of different federal agencies. NACP data holdings include atmospheric observations, remote sensing products, field measurements, inventories, and model outputs supporting carbon-cycle synthesis and inter-comparison.

Related Publications

Rollinson, C.R., A. Dawson, A. Raiho, J.W. Williams, M.C. Dietze, T. Hickler, S.T. Jackson, J. McLachlan, D.J.P. Moore, B. Poulter, T. Quaife, J. Steinkamp, and M. Trachsel. 2021. Forest responses to last-millennium hydroclimate variability are governed by spatial variations in ecosystem sensitivity. Ecology Letters 24:498-508. https://doi.org/10.1111/ele.13667

Rollinson, C.R., Y. Liu, A. Raiho, D.J.P. Moore, J. McLachlan, D.A. Bishop, A. Dye, J.H. Matthes, A. Hessl, T. Hickler, N. Pederson, B. Poulter, T. Quaife, K. Schaefer, J. Steinkamp, and M.C. Dietze. 2017. Emergent climate and CO_2 sensitivities of net primary productivity in ecosystem models do not agree with empirical data in temperate forests of eastern North America. Global Change Biology 23:2755-2767. https://doi.org/10.1111/gcb.13626

Related Datasets

Rollinson, C., M. Dietze, J.H. Mathes, J. Steinkamp, T. Hickler, B. Poulter, A.M. Raiho, J. Mclachlan, T. Quaife, Y. Liu, D.J.P. Moore, K. Schaefer, and B. Brooks. 2023. PalEON: Terrestrial Ecosystem Model Drivers for the Northeastern U.S., 0850-2010. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1779

- This dataset holds the model driver data used by the PalEON Ecosystem Model Intercomparison Project (PEMIP)

Ramankutty, N., J.A. Foley, F.G. Hall, G.J. Collatz, B.W. Meeson, S.O. Los, E.Brown De Colstoun, and D.R. Landis. 2010. ISLSCP II Potential Natural Vegetation Cover. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/961

Wei, Y., Shishi Liu, D.N. Huntzinger, A.M. Michalak, N. Viovy, W.M. Post, C.R. Schwalm, K. Schaefer, A.R. Jacobson, C. Lu, H. Tian, D.M. Ricciuto, R.B. Cook, J. Mao, and X. Shi. 2014. NACP MsTMIP: Global and North American Driver Data for Multi-Model Intercomparison. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1220

2. Data Characteristics

Spatial Coverage: north central and northeastern U.S.

Spatial Resolution: 0.5 degree and point resolution

Temporal Coverage: 0850-01-01 to 2010-12-31

Temporal Resolution: annual, monthly, daily, or 3-hour

Study Area: Latitude and longitude are given in decimal degrees.

Site	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
north central and northeastern U.S.	50	35	-60	-100

Data File Information

This dataset contains 329 data files in netCDF-4 (*.nc) format from 5 regional models and 10 site models. The files are named *paleon_<type>_<model>_<site>_<resolution>_<range>.nc*, where

- *<type>* is the spatial extent, either "site" or "region" (regional)
- *<model>* is the model used (see Table 1)
- *<site>* is the site abbreviation (see Table 2). This element is only present in the site files. An ‘S’ is appended to the beginning of the site code indicating sub-daily model outputs.
- *<resolution>* is the temporal resolution: "3hour", "annual", "daily", "monthly"
- *<range>* is the temporal coverage and YYYY represents a four-digit year.

Data File Details

- Generally, region files contain 30 rows and 80 columns, and site files are a single tile
- Missing values are defined in the ‘missing_value’ and/or ‘fill_value’ attribute.
- The coordinate reference system is longitude - latitude using the WGS 84 datum (EPSG:4326).

Table 1. Models included in PEMIP. Note the version ('v') in the abbreviation often references the modeling team's version/run rather than the published model version. See *Model_Description_Readmes.pdf* for additional details.

Model Name	Abbreviation used in Regional File Names	Abbreviation Used in Site File Names	Reference
Community Land Model (CLM) 4.5 with biogeochemistry (BGC)	N/A	CLM45BGC-v5-1	Oleson et al., 2013
CLM 4.5 with carbon, nitrogen, (CN), and biogeochemistry	N/A	CLM45CN-v3-1	Oleson et al., 2013
Ecosystem Demography Model (ED) version 2.1	ED2-v1	ED2-v7	Moorcroft et al., 2001; Medvigy et al., 2009
ED 2.1 Land Use (LU)	N/A	ED2-LU-v8	Moorcroft et al., 2001; Medvigy et al., 2009
JULES (Joint UK Land Environment Simulator)	N/A	JULES-STATIC	Best et al., 2011; Clark et al., 2011
JULES Top-down Representation of Interactive Foliage and Flora Including Dynamics (TRIFFID)	TRIFFID	JULES-TRIFFID-v1	Best et al., 2011; Clark et al., 2011
Linking Inherently Nonlinear K Among Gradients and EcoSystems (LINKAGES) version 1.3	LINKAGES	LINKAGES-v2-1	Post and Pastor, 2013
Lund–Potsdam–Jena – Wald, Schnee, Landschaft (LPJ-WSL)	LPJ-WSL-v1	LPJ-WSL-v6	Gerten et al., 2004; Sitch et al., 2003
Lund-Potsdam-Jena General Ecosystem Simulator (LPJ-GUESS) SVN revision 3826	LPJ-GUESS	LPJ-GUESS-v6	Gerten et al., 2004; Sitch et al., 2003; Smith et al., 2001; Smith et al., 2014
Simple Biosphere/Carnegie-Ames-Stanford Approach (SiBCASA)	N/A	SiBCASA-v1	Schaefer et al., 2008

Table 2. Site in the site-level model-intercomparison portion of PEMIP

Site Abbreviation	Site Name	PalEON Site	Latitude	Longitude
PHA	Harvard Forest	Highly Integrated Proxy Site (HIPS)	42.54	-72.18
PHO	Howland Forest	HIPS	45.25	-68.73
PUN	University of Notre Dame Environmental Research Center (UNDERC) – East	HIPS	46.22	-89.53
PBL	Billy's Lake	Intensive pollen sites (Pollen)	46.28	-94.58
PDL	Deming Lake	Pollen	47.17	-95.17
PMB	Minden Bog	Pollen	43.61	-82.83

Table 3. Data dictionary for all files

Variable	Units	Description
AGB	kgC m^{-2}	Total aboveground biomass
AutoResp	kgC m^{-2} s^{-1}	Autotrophic respiration rate
BA	m^2 ha^{-1}	Basal area by plant functional type (PFT)
CarbPools	kgC m^{-2}	Carbon in Each Model Carbon Pool
CO2	ppm	Carbon dioxide concentration in the air
CWDI	kgC m^{-2} $month^{-1}$	Coarse woody debris increment. Analogous to flux of woody material to the detrital pool resulting from mortality; corresponds to GWBI

Dens	ha^{-1}	Stem Density by PFT
Estab	ha^{-1}	New individuals
Evap	$kg\ m^{-2}\ s^{-1}$	Total evaporation. Sum of evaporative sources minus transpiration
Fcomp	$kgC\ kgC^{-1}$	AGB fractional composition of each PFT within each grid cell.
Fire	$kgC\ m^{-2}\ s^{-1}$	Fire emissions
GPP	$kgC\ m^{-2}\ s^{-1}$	Gross primary productivity
GWBI	$kgC\ m^{-2}\ month^{-1}$	Gross woody biomass increment (analogous to tree-ring derived biomass)
HeteroResp	$kgC\ m^{-2}\ s^{-1}$	Heterotrophic respiration
LAI	$m^2\ m^{-2}$	Leaf area index
LW_albedo	1	Longwave albedo
lwdown	$W\ m^{-2}$	Incident longwave radiation averaged over the time step of the forcing data
LWnet	$W\ m^{-2}$	Net downward longwave radiation at surface
Mort	ha^{-1}	Mortality. Number of individuals lost through death.
NEE	$kgC\ m^{-2}\ s^{-1}$	Net ecosystem exchange
NPP	$kgC\ m^{-2}\ s^{-1}$	Net primary production of each PFT within each grid cell.
PFT	-	Name of each plant functional type (PFT) or species included in the model.
poolname	-	Names of each vegetation and soil carbon pool
precipf	$kg\ m^{-2}\ s^{-1}$	The per unit area and time precipitation representing the sum of convective rainfall stratiform rainfall and snowfall
psurf	Pa	Pressure at the surface
qair	$kg\ kg^{-1}$	Specific humidity measured at the lowest level of the atmosphere
Qh	$W\ m^{-2}$	Surface sensible heat flux for land tiles
Qle	$W\ m^{-2}$	Surface latent heat flux for land tiles
Qs	$kg\ m^{-2}\ s^{-1}$	Baseflow (lateral subsurface runoff)
Qsb	$kg\ m^{-2}\ s^{-1}$	Drainage and subsurface lateral flow
SnowDepth	$kg\ m^{-2}$	Snow depth (on ground)
SoilDepth	m	Depth to the bottom of each model-defined soil layer.
SoilMoist	$kg\ m^{-2}$	Soil water content in each model-defined soil layer.
SoilTemp	K	Soil temperature in each model-defined soil layer.
SW_albedo	1	Albedo (as used for net shortwave calculation)
swdown	$W\ m^{-2}$	Incident radiation in the shortwave part of the spectrum averaged over the time step of the forcing data
SWE	$kg\ m^{-2}$	Total water mass (ice plus liquid)
SWnet	$W\ m^{-2}$	Net Shortwave Radiation
tair	K	Nar surface air temperature (at 2 m)

time	Years/months/days since YYYY-MM-DD or seconds since YYYY-MM-DD HH:MM:SS	Timestep. The units are specifically defined in the ‘units’ variable attribute. Note: Some files have multiple time variables and dimensions such as ‘time.months’ and ‘time.years’
TotLivBiom	kgC m^{-2}	Total carbon content of living biomass (e.g. leaf +root+wood)
TotSoilCarb	kgC m^{-2}	Total soil and litter cabon content over the entire soil profile
Transp	kg m^{-2} s^{-1}	Transpiration of each PFT within each grid cell.
wind	m s^{-1}	Wind speed measured with a vertical coordinate in height of 10 m

Companion Files

This companion file *Model_Description_Readmes.pdf* contains text from readme files that modeling teams submitted holding metadata surrounding the individual modeling approaches.

3. Application and Derivation

Exposure to 21st-century climate change is expected to profoundly impact global forest composition, diversity, and structure, but the sensitivity of ecosystems to climate variability at multi-decadal to centennial time scales is poorly constrained by instrumental observations. Terrestrial ecosystem models used to forecast responses to climate change often have difficulty reproducing broad-scale and long-term responses to environmental variability, despite being well-grounded in empirical evidence and ecological theory. Moreover, there are several challenges that hinder the joint analysis and integration of terrestrial ecosystem models and palaeoecological data to better constrain modeled responses to climate variations at multi-decadal and longer timescales.

These data were used in the related publication by Rollinson et al. (2021), to establish the patterns of forest ecosystem and climate variability in the north-central and northeastern U.S. for the last millennium (850–1850 C.E.) and identify the mechanisms underpinning both forest ecosystem sensitivity and observed data-model discrepancies. A combination of data-model and model-model comparisons of palaeoclimatic and palaeoecological datasets was used (Figure 2). The results indicate that at centennial timescales, spatial patterns in the variability of forest composition and biomass are regulated by ecological factors such as ecotonal position and complexity rather than climate exposure as defined by the local magnitude of climate variability.

4. Quality Assessment

No quality assessment is available for this dataset.

5. Data Acquisition, Materials, and Methods

This dataset includes site and regional model outputs that have a consistent spatial extent, resolution, and coordinate reference system. The environmental and meteorological drivers used to derive these outputs are available in Rollinson et al. (2023). Details about the drivers and outputs are available in Rollinson et al. (2021).

The PalEON (**Pal**eo-**E**cological **O**bservatory **N**etwork) Ecosystem Model Intercomparison Project (PEMIP) is an interdisciplinary team of paleoecologists, ecological statisticians, and ecosystem modelers from across a number of institutions began in the early 1990s to provide an efficient mechanism for coordinating palaeoclimate modeling activities (Braconnot et al., 2021). The goal of the PEMIP is to reconstruct forest composition, fire regime, and climate in forests across the northeastern U.S. and Alaska over the past 2,000 years and use the results to drive and validate terrestrial ecosystem models (Figure 2).

Ten models across six sites (i.e., site extent models) were included in PEMIP to serve as a baseline for the regional extent models. There were five models at the regional extent covering north-central and northeastern U.S. Outputs were standardized to adhere to a common naming convention following ALMA standard names (https://web.lmd.jussieu.fr/~polcher/ALMA/convention_output_3.html) and NetCDF (*.nc) file structure. Specific details on each model are contained in the companion file.

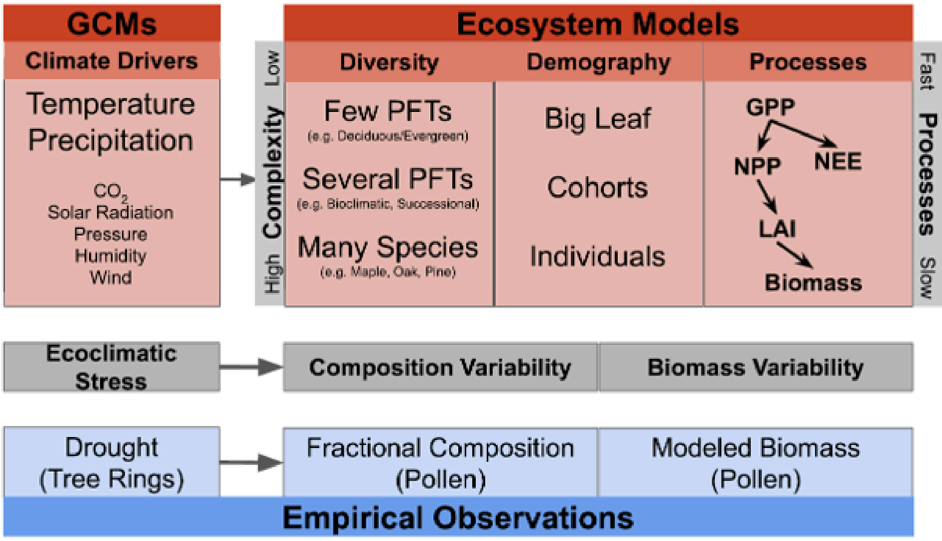

Figure 2. Overview of the unified conceptual framework (grey boxes) for parallel analysis of empirical data (blue boxes) and model output (red boxes) described in the study by Rollinson et al. (2021). For ecosystem models, the latent climatic and ecosystem processes are described for unobservable palaeoecological data and differences among models in complexity. Complexity is organized into three categories: 1) diversity, ranging from a few plant functional types (PFTs) to many species; 2) demography, ranging from "big leaf" models with no explicit treatment of forest demography to models with individual trees and 3) ecophysiological processes. Changes in forest biomass emerge from latent ecophysiological processes including gross primary productivity (GPP), net primary productivity (NPP), net ecosystem exchange (NEE), and leaf area index (LAI). Ecophysiological processes are controlled by the model representation of higher-level vegetation processes. Latent model drivers, processes, and states (red boxes) result in estimates of forest composition and biomass that can be compared to palaeoecological data products (blue boxes). Models vary in complexity due to design philosophy and trade-offs between model complexity and computational speed.

6. Data Access

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

PalEON: Terrestrial Ecosystem Model Outputs for the Northeastern U.S., 0850-2010

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
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