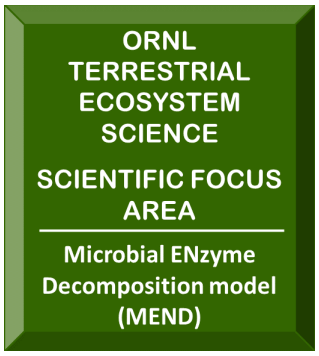
MOFLUX Intensified Soil Moisture Extremes Decrease Soil Organic Carbon Decomposition: Modeling Archive



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Summary:

This Modeling Archive is in support of a TES-SFA publication "Intensified Soil Moisture Extremes Decrease Soil Organic Carbon Decomposition: A Mechanistic Modeling Analysis" (Liang et al., 2021).

Here we provide model code, inputs, outputs and evaluation datasets for the Microbial ENzyme Decomposition (MEND) model for the Missouri Ozarks AmeriFlux eddy covariance measurement site (MOFLUX) near Ashland, Missouri USA. The MEND model was developed with explicit representation of microbial and enzyme pools to mechanistically simulate the role of microbial organisms and extracellular enzymes in soil organic carbon (SOC) decomposition.

Long-term SOC dynamics under intensified moisture extremes are studied using the MEND model that is parameterized with 11 years of measurements from the MOFLUX forest. The model explicitly represents microbial dormancy and resuscitation, different types of SOC-degrading enzymes, and how they vary with changes in soil moisture (Wang et al. 2015, 2019). A combination of two levels of frequency and severity of soil moisture, as well as a control with normal interannual variability, are used to simulate a range of moisture scenarios over 100 years.

The code of Microbial-ENzyme Decomposition (MEND) as well as the input and output data are included in the archive. A user's manual (MEND_Readme.pdf) is included with instructions for compiling and running the model to simulate soil organic carbon decomposition under various moisture scenarios.

Data and Documentation Access:

For public access to data from the US Department of Energy Terrestrial Ecosystem Science Scientific Focus Area (TES-SFA), please visit: https://tes-sfa.ornl.gov/

ORNL TES-SFA Data Policy: Archiving, Sharing, and Fair-Use

Related TES-SFA Publication:

A thorough description of the model and analyses is presented in the following publication:

Liang, J., Wang, G., Singh, S., Jagadamma, S., Gu, L., Schadt, C. W., Wood, J. D., Hanson, P. J., Mayes, M. A. 2021. Intensified Soil Moisture Extremes Decrease Soil Organic Carbon Decomposition: A Mechanistic Modeling Analysis. *Journal of Geophysical Research – Biogeosciences*

Related Datasets:

The MOFLUX site characteristic and data are available from the AmeriFlux web site (https://ameriflux.lbl.gov/).

Acknowledgements:

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Overview of Terrestrial Ecosystem Science Scientific Focus Area

The TES SFA supports research to understand and predict the interaction of Earth's terrestrial ecosystems and climate, and to assess vulnerability of terrestrial ecosystems to projected environmental change. The research focuses on how terrestrial ecosystems affect atmospheric CO_2 and other greenhouse gases (e.g., CH_4) and how the responsible ecosystem processes interact with climate and with anthropogenic forcing factors.

- Targeted experiments are conducted to quantify and predict ecosystem responses to warming and elevated CO_2 (eCO_2) and the feedbacks from ecosystems to the atmosphere and climate.
- Other process research aims to accurately quantify the exchange of CO_2, water vapor, and energy between the atmosphere and land ecosystems through processes such as

photosynthesis, evapotranspiration, net production, storage pools, and autotrophic and heterotrophic respiration.

- TES SFA research also includes efforts to provide comprehensive databases, above- and belowground, to benefit the analytical needs of Earth System Models.
- Understanding achieved by TES SFA tasks on the fundamental functions and interactions of vegetation, microbial community and soil is used to improve mechanistic representation of ecosystem processes within terrestrial biosphere models.

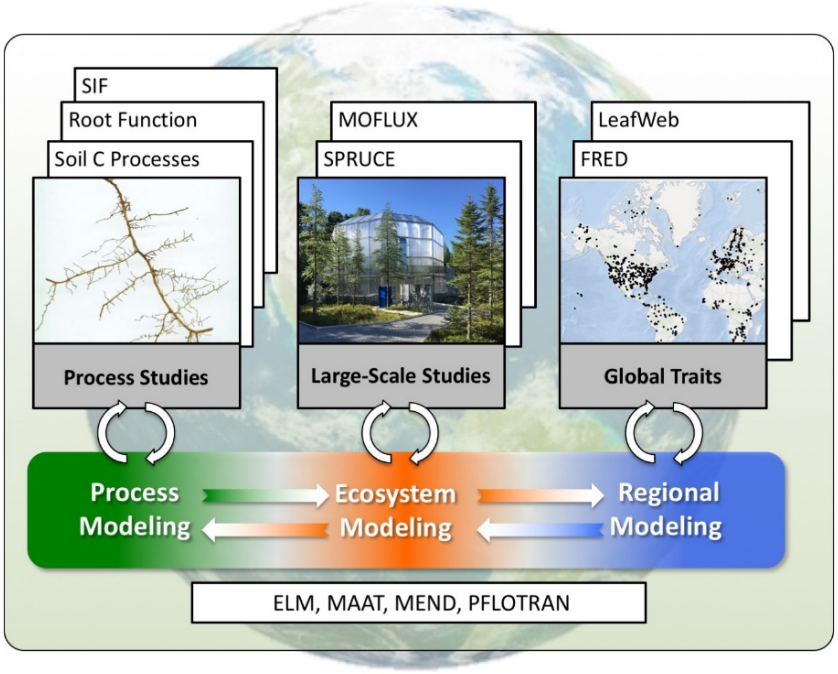

Diagram of the TES-SFA research philosophy and flow illustrating an iterative exchange between model projections, question or hypothesis development and the execution of observations and experiments to better understand impacts of multi-factor environmental changes on ecosystems.

MOFLUX Site Description

The MOFLUX site is part of the long-term, high quality core sites of the AmeriFlux network. It is located in the University of Missouri's Baskett Wildlife Research and Education Area (BWREA, 38°44'39''N, 92°12'W), placed strategically within the geographically and ecologically distinct prairie-forest biome / precipitation transition in the central United States. MOFLUX operates a suite of meteorological, flux, ecological, physiological, and biometrical measurement systems that are either above or within the canopy, or on the forest floor, or in the soil. From its initiation in 2004, MOFLUX has played a key role in nearly all major Fluxnet and AmeriFlux network syntheses. The MOFLUX forest is the world's strongest isoprene source that has ever been measured (Potosnak et al. 2014). MOFLUX has been crucial to the reformulation

of the fundamental eddy covariance (EC) equation (Gu et al. 2012) and the development of novel EC theories (Gu et al. 2013). MOFLUX research has contributed to the improved understanding of photosynthetic carbon isotope discrimination (Gu and Sun 2014) and the importance of mesophyll diffusion for terrestrial carbon cycle (Sun et al. 2014).

Modeling Archive

This data set provides information needed to perform MEND simulations for the MOFLUX SOC decomposition using site-specific measurements. The model code, input data and model-generated output are provided. A user's manual (MEND_Readme.pdf) is included with instructions for compiling and running the model to simulate soil organic carbon decomposition under various moisture scenarios.

Data Characteristics:

Temporal Coverage and Resolution:

The model simulation is on an hourly time scale. Data for the calibration and validation are daily respiration from 2005 to 2012 and from 2013 to 2015, respectively. The scenario simulations cover 100 years with output on both daily and monthly time scale.

Spatial Coverage:

The MOFLUX site is located in the University of Missouri's Baskett Wildlife Research and Education Area.

Site boundaries: Latitude and longitude given in decimal degrees.

Site	Latitude	Longitude	Elevation (meters amsl)	Geodetic Datum	UTM Zone
Missouri Ozark Site (US-MOz)	38.7441	-92.2000	212	WGS84	15S

Modeling Archive Contents:

The modeling archive has been compiled into one compressed file: mend-moflux.zip

Model

The carbon-only version of the MEND model in simulating the MOFLUX soil carbon decomposition is archived. Here is the information of source code files and subroutines as well as major functions.

ID	F90 file	Notes	Major Functions & Subroutines
1	MEND_main	Main program	
2	MEND_IN	Control file	
3	MOD_MEND_TYPE	Data structure for MEND	
4	MOD_MEND	MEND model; Depends on ▪ MOD_MEND_TYPE ▪ MOD_USRFS	○ subMEND: MEND model ○ subMEND_PAR: MEND parameters modified by temperature, moisture, etc. ○ subMEND_RUN: run model continuously with multiple time-steps ○ subMEND_INI: model initialization ○ fMEND_OBJ: objective function for model evaluation & optimization ○ sINP_Read: read input, soil temp & moisture ○ sOUT_OPT_h: extract HOURLY outputs for response variables used for optimization ○ sOUT_OPT: convert HOURLY data (sOUT_OPT_h) to DAILY or MONTHLY data ○ subMEND_output: HOURLY outputs for all state variables & fluxes ○ sOUT_tscale: convert HOURLY outputs (subMEND_output) to DAILY, MONTHLY & YEARLY outputs ○ sOUT_ALL_tscale: convert HOURLY outputs (subMEND_output) to DAILY, MONTHLY & YEARLY outputs, called by sOUT_tscale
5	MOD_OPT_TYPE	Data structure for model optimization	
6	MOD_OPT	Optimization algorithm	Depends on ▪ MOD_OPT_TYPE ▪ MOD_MEND
7	MOD_STRING	String utility	
8	MOD_USRFS	User Functions and Subroutines	

The model dictionary:

Archive Content	File and \ Folders	Description
Source code	\ src	Folder contains the MEND code package.
Input data	\ userio\inp	Folder contains hourly soil temperature and water content, monthly litterfall rates, initial conditions, and heterotrophic respiration from 2005 to 2015.
Model output	\ userio\out	Folder contains daily and monthly simulation results.
Control file	MEND_namelist.nml	File for model configuration.
Model manual	MEND_Readme.pdf	File contains user guidance.

References:

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Wang G, Huang W, Mayes MA, Liu X, Zhang D, Zhang Q, Han T, Zhou G (2019) Soil moisture drives microbial controls on carbon decomposition in two subtropical forests. Soil Biology and Biochemistry 130, 185–194.

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Data Access:

For public access to ORNL TES SFA data please visit the TES SFA Web Site: https://tes-sfa.ornl.gov/home

Contact for Data Access Information: https://mnspruce.ornl.gov/contact