

Package: PEPRMT (via r-universe)

May 21, 2026

Title Peatland Ecosystem Photosynthesis, Respiration and Methane
Transport model

Version 0.0.0.9100

Description PEPRMT-Tidal is a one-dimensional process-based model that predicts gross primary productivity, ecosystem respiration and methane exchange in tidal wetlands at the daily time step. This package contains functions for PEPRMT-Tidal, an updated version of the PEPRMT model. This model is described in detail in Oikawa et al. (2024).

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Encoding UTF-8

Roxygen list(markdown = TRUE)

RoxygenNote 7.3.3

Suggests knitr, rmarkdown, ggplot2

VignetteBuilder knitr

Imports dplyr

Depends R (>= 3.5)

LazyData true

URL <https://abbylewis.github.io/PEPRMT-Tidal/>

Repository <https://pecanproject.r-universe.dev>

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example_data	<i>Example data</i>
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Description

Data sourced from Oikawa et al. "A new coupled biogeochemical modeling approach provides accurate predictions of methane and carbon dioxide fluxes across diverse tidal wetlands." *Journal of Geophysical Research: Biogeosciences* 129.10 (2024): e2023JG007943. Eddy covariance data are from Ameriflux sites US-Srr, US-Edn, US-LA1, US-PLM, US-Stj See Ameriflux website for site location and information: <https://ameriflux.lbl.gov/sites/site-search/> All sites are North American tidal marshes

Usage

example_data

Format

example_data:

A data frame with 7,240 rows and 60 columns:

site Ameriflux site ID

Year Year

DOY_disc Discontinuous day of year (starts over at 1 at the beginning of each year)

DOY Day of year (continuously increases over time)

TA_C Air temperature (degrees C)

WTD_cm Water table depth (cm)

PAR_umol_m2_day Average Photosynthetically active radiation (umol m⁻² d⁻¹)

LAI Leaf Area Index (not used in this dataset so defaulted to NaN)

EVI daily Enhanced Vegetation Index from Landsat

FPAR FPAR flag for GPP module. Set to 0 if using EVI. Set to 1 if using LAI

LUE Light Use Efficiency. Computed by taking the average of daily measured GPP divided by daily average PAR for each site

Wetland_age_years Age of wetland in years

Salinity_daily_ave_ppt Daily average salinity (ppt)

NO3_mg_L Daily average NO₃ (mg/L)

SOM_MEM_gC_m3 Available soil organic matter (gC m⁻³) in the top 1 m of soil predicted by the Cohort Marsh Equilibrium (CMEM) model

CO2_gC_m2_day Measured Net Ecosystem Exchange (NEE) of CO₂ (gC-CO₂ m⁻² day⁻¹)

GPP_gC_m2_day Gross Primary Productivity (GPP) partitioned from NEE (gC-CO₂ m⁻² day⁻¹)

Reco_gC_m2_day Ecosystem Respiration (Reco) partitioned from NEE (gC-CO₂ m⁻² day⁻¹)

CH4_gC_m2_day Measured Net Ecosystem Exchange of CH₄ (gC-CH₄ m⁻² day⁻¹) ...

Source

Oikawa et al. 2024

PEPRMT_CH4

*Methane Exchange (CH4)***Description**

Methane production and transport module of the PEPRMT model (v1.0).

Usage

```

PEPRMT_CH4(
  data,
  wetland_type,
  Ea_SOM_CH4 = 14.9025078 + 67.1,
  kM_SOM_CH4 = 0.4644174 + 17,
  Ea_labile_CH4 = 16.7845002 + 71.1,
  kM_labile_CH4 = 0.4359649 + 23,
  Ea_oxi_CH4 = 15.8857612 + 75.4,
  kM_oxi_CH4 = 0.5120464 + 23,
  kI_S04 = 486.4106939,
  kI_NO3 = 0.1020278,
  k_plant_oxi = 0.35
)

```

Arguments

data	Data frame containing 18 required columns used as model inputs. See Details for expected column names.
wetland_type	Integer indicating wetland class: 1 = Freshwater peatland, 2 = Tidal wetland.
Ea_SOM_CH4	Activation energy for methane production from soil organic matter (kJ mol ⁻¹)
kM_SOM_CH4	Half-saturation constant for SOM methane production (g C m ⁻³ soil)
Ea_labile_CH4	Activation energy for methane production from labile carbon (kJ mol ⁻¹)
kM_labile_CH4	Half-saturation constant for labile methane production (g C m ⁻³ soil)
Ea_oxi_CH4	Activation energy for methane oxidation (kJ mol ⁻¹)
kM_oxi_CH4	Half-saturation constant for methane oxidation (g C m ⁻³ soil)
kI_S04	– Sulfate inhibition constant (mg L ⁻¹)
kI_NO3	– Nitrate inhibition constant (mg L ⁻¹)
k_plant_oxi	Fraction of CH ₄ oxidized during transport

Details

Runs the PEPRMT methane production and transport module for freshwater peatlands or tidal wetlands at a daily time step. Default parameter values were determined via MCMC Bayesian fitting (Oikawa et al. 2024).

The PEPRMT model was originally parameterized for restored freshwater wetlands in the Sacramento–San Joaquin River Delta, California, USA (Oikawa et al. 2017) and later updated for tidal wetlands with inhibition of methane production in response to salinity and nitrate (Oikawa et al. 2024).

Modules are intended to be run sequentially: PEPRMT_GPP, then PEPRMT_Reco, then PEPRMT_CH4.

All variables are expected at a daily time step.

All PEPRMT modules use the same input structure, although not all variables are used in every module.

Required data columns:

1. Continuous day of year
2. Discontinuous day of year
3. Year
4. Air temperature (°C)
5. Water table depth (cm)
6. PAR ($\mu\text{mol m}^{-2} \text{d}^{-1}$)
7. Leaf Area Index
8. Greenness Index
9. FPAR flag
10. Light Use Efficiency
11. Wetland age (years)
12. Salinity (ppt)
13. NO₃ (mg L^{-1})
14. Soil organic matter (g C m^{-3})
15. Site identifier
16. Modeled GPP ($\text{g C m}^{-2} \text{day}^{-1}$)
17. Modeled Reco ($\text{g C m}^{-2} \text{day}^{-1}$)
18. Net ecosystem exchange ($\text{g C m}^{-2} \text{day}^{-1}$)

Value

Updated dataframe containing:

CH4_mod total methane emitted ($\text{g C CH}_4 \text{ m}^{-2} \text{day}^{-1}$)

Plant_flux_net net methane flux via plant-mediated transport ($\text{g C CH}_4 \text{ m}^{-2} \text{day}^{-1}$)

Hydro_flux net diffusive methane flux from water to atmosphere ($\text{g C CH}_4 \text{ m}^{-2} \text{day}^{-1}$)

M1 methane pool produced from labile soil carbon ($\text{g C CH}_4 \text{ m}^{-3}$, top meter of soil and water)

M2 methane pool produced from soil organic carbon ($\text{g C CH}_4 \text{ m}^{-3}$, top meter of soil and water)

trans2 fraction of methane released via plant-mediated transport (unitless)

References

- Oikawa, P. Y., Jenerette, G. D., Knox, S. H., Sturtevant, C., Verfaillie, J., Dronova, I., Poindexter, C. M., Eichelmann, E., & Baldocchi, D. D. (2017). Evaluation of a hierarchy of models reveals importance of substrate limitation for predicting carbon dioxide and methane exchange in restored wetlands. *Journal of Geophysical Research: Biogeosciences*, 122(1), 145–167. <https://doi.org/10.1002/2016JG003438>
- Oikawa, P. Y., Sihi, D., Forbrich, I., Fluet-Chouinard, E., Najarro, M., Thomas, O., Shahan, J., Arias-Ortiz, A., Russell, S., Knox, S. H., McNicol, G., Wolfe, J., Windham-Myers, L., Stuart-Haentjens, E., Bridgham, S. D., Needelman, B., Vargas, R., Schäfer, K., Ward, E. J., Megonigal, P., & Holmquist, J. (2024). A New Coupled Biogeochemical Modeling Approach Provides Accurate Predictions of Methane and Carbon Dioxide Fluxes Across Diverse Tidal Wetlands. *Journal of Geophysical Research: Biogeosciences*, 129(10), e2023JG007943. <https://doi.org/10.1029/2023JG007943>

Examples

```
# Example
# data(example_dataset)
# theta <- c(14.9025078, 0.4644174, 16.7845002, 0.4359649, 15.8857612,
# 0.5120464, 486.4106939, 0.1020278)
# out <- PEPRMT_CH4(theta, example_dataset, wetland_type = 2)
```

PEPRMT_GPP

Gross Primary Productivity (GPP)

Description

Gross Primary Productivity (GPP) module of the PEPRMT model (v1.0). Default values were determined via MCMC Bayesian fitting (Oikawa et al. 2023).

Usage

```
PEPRMT_GPP(
  data,
  a0 = 0.7479271,
  a1 = 1.0497113,
  Ha = 149.468171 + 30,
  Hd = 94.4532674 + 100,
  T_opt_GPP = 25 + 274.15
)
```

Arguments

- | | |
|------|---|
| data | Data frame containing 15 required columns used as model inputs. See Details for expected column structure. |
| a0 | Empirical intercept parameter for the fPAR scaling function (unitless). |
| a1 | Empirical slope parameter for the fPAR scaling function (unitless). |

Ha	Activation energy governing the temperature response of photosynthesis for general crop-type vegetation (kJ mol^{-1}). Controls the rate of increase in GPP with temperature below the thermal optimum.
Hd	Deactivation energy controlling the decline in photosynthesis above the thermal optimum (kJ mol^{-1}). Determines the rate of decrease in GPP at high temperatures.
T_opt_GPP	Temperature optimum for GPP

Details

Runs the PEPRMT gross primary productivity module for freshwater peatlands or tidal wetlands at a daily time step.

The PEPRMT model was originally parameterized for restored freshwater wetlands in the Sacramento–San Joaquin River Delta, California, USA (Oikawa et al. 2017) and later updated for tidal wetlands (Oikawa et al. 2023).

Modules are intended to be run sequentially: PEPRMT_GPP, then PEPRMT_Reco, then PEPRMT_CH4.

All variables are expected at a daily time step.

This model predicts GPP using a light use efficiency equation GPP can be predicted using leaf area index (LAI) or a greenness index from Phenocam data or remote sensing such as EVI or NDVI PEPRMT-Tidal applied in Oikawa et al. 2023 uses EVI from Landsat

Required data columns:

1. Continuous day of year
2. Discontinuous day of year
3. Year
4. Air temperature ($^{\circ}\text{C}$)
5. Water table depth (cm)
6. PAR ($\mu\text{mol m}^{-2} \text{d}^{-1}$)
7. Leaf Area Index
8. Greenness Index
9. FPAR flag
10. Light Use Efficiency
11. Wetland age (years)
12. Salinity (ppt)
13. NO_3 (mg L^{-1})
14. Soil organic matter (g C m^{-3})
15. Site identifier

Value

Updated dataframe containing:

GPP gross primary productivity ($\text{g C CO}_2 \text{ m}^{-2} \text{d}^{-1}$)

APAR absorbed photosynthetically active radiation ($\text{umol m}^{-2} \text{d}^{-1}$)

References

- Oikawa, P. Y., Jenerette, G. D., Knox, S. H., Sturtevant, C., Verfaillie, J., Dronova, I., Poindexter, C. M., Eichelmann, E., & Baldocchi, D. D. (2017). Evaluation of a hierarchy of models reveals importance of substrate limitation for predicting carbon dioxide and methane exchange in restored wetlands. *Journal of Geophysical Research: Biogeosciences*, 122(1), 145–167. <https://doi.org/10.1002/2016JG003438>
- Oikawa, P. Y., Sihi, D., Forbrich, I., Fluet-Chouinard, E., Najarro, M., Thomas, O., Shahan, J., Arias-Ortiz, A., Russell, S., Knox, S. H., McNicol, G., Wolfe, J., Windham-Myers, L., Stuart-Haentjens, E., Bridgham, S. D., Needelman, B., Vargas, R., Schäfer, K., Ward, E. J., Megonigal, P., & Holmquist, J. (2024). A New Coupled Biogeochemical Modeling Approach Provides Accurate Predictions of Methane and Carbon Dioxide Fluxes Across Diverse Tidal Wetlands. *Journal of Geophysical Research: Biogeosciences*, 129(10), e2023JG007943. <https://doi.org/10.1029/2023JG007943>

Examples

```
# Example
# data(example_dataset)
# out <- PEPRMT_GPP(theta, example_dataset, wetland_type = 2)
```

PEPRMT_Reco *Ecosystem Respiration (Reco)*

Description

Ecosystem respiration (Reco) module of the PEPRMT model (v1.0).

Usage

```
PEPRMT_Reco(
  data,
  wetland_type,
  Ea_SOM = 18.41329,
  kM_SOM = 1487.65701,
  Ea_labile = 11.65972,
  kM_labile = 61.29611
)
```

Arguments

- | | |
|--------------|--|
| data | Data frame containing 16 required columns used as model inputs. See Details for expected column structure. |
| wetland_type | Integer indicating wetland class: 1 = Freshwater peatland, 2 = Tidal wetland. |
| Ea_SOM | – Activation energy controlling the temperature sensitivity of decomposition from the soil organic matter (SOM) pool (kJ mol ⁻¹). |
| kM_SOM | – Half-saturation constant for microbial decomposition of the SOM pool (g C m ⁻³ soil). Determines substrate limitation strength for SOM respiration. |

Ea_labile	– Activation energy controlling the temperature sensitivity of decomposition from the labile carbon pool (kJ mol^{-1}).
kM_labile	– Half-saturation constant for microbial decomposition of the labile carbon pool (g C m^{-3} soil). Determines substrate limitation strength for labile respiration.

Details

Runs the PEPRMT ecosystem respiration module for freshwater peatlands or tidal wetlands at a daily time step.

The PEPRMT model was originally parameterized for restored freshwater wetlands in the Sacramento–San Joaquin River Delta, California, USA (Oikawa et al. 2017) and later updated for tidal wetlands (Oikawa et al. 2023).

Modules are intended to be run sequentially: PEPRMT_GPP, then PEPRMT_Reco, then PEPRMT_CH4.

All variables are expected at a daily time step.

Required data columns:

1. Continuous day of year
2. Discontinuous day of year
3. Year
4. Air temperature ($^{\circ}\text{C}$)
5. Water table depth (cm)
6. PAR ($\mu\text{mol m}^{-2} \text{d}^{-1}$)
7. Leaf Area Index
8. Greenness Index
9. FPAR flag
10. Light Use Efficiency
11. Wetland age (years)
12. Salinity (ppt)
13. NO_3 (mg L^{-1})
14. Soil organic matter (g C m^{-3})
15. Site identifier
16. Modeled GPP ($\text{g C m}^{-2} \text{day}^{-1}$)

Value

Updated dataframe containing:

Reco_mod Total ecosystem respiration ($\text{g C CO}_2 \text{m}^{-2} \text{day}^{-1}$)

NEE_mod Net ecosystem exchange of CO_2 ($\text{g C CO}_2 \text{m}^{-2} \text{day}^{-1}$)

S1 Labile soil carbon pool (g C m^{-3} , top meter of soil)

S2 Soil organic carbon pool (g C m^{-3} , top meter of soil)

References

- Oikawa, P. Y., Jenerette, G. D., Knox, S. H., Sturtevant, C., Verfaillie, J., Dronova, I., Poindexter, C. M., Eichelmann, E., & Baldocchi, D. D. (2017). Evaluation of a hierarchy of models reveals importance of substrate limitation for predicting carbon dioxide and methane exchange in restored wetlands. *Journal of Geophysical Research: Biogeosciences*, 122(1), 145–167. <https://doi.org/10.1002/2016JG003438>
- Oikawa, P. Y., Sihi, D., Forbrich, I., Fluet-Chouinard, E., Najarro, M., Thomas, O., Shahan, J., Arias-Ortiz, A., Russell, S., Knox, S. H., McNicol, G., Wolfe, J., Windham-Myers, L., Stuart-Haentjens, E., Bridgham, S. D., Needelman, B., Vargas, R., Schäfer, K., Ward, E. J., Megonigal, P., & Holmquist, J. (2024). A New Coupled Biogeochemical Modeling Approach Provides Accurate Predictions of Methane and Carbon Dioxide Fluxes Across Diverse Tidal Wetlands. *Journal of Geophysical Research: Biogeosciences*, 129(10), e2023JG007943. <https://doi.org/10.1029/2023JG007943>

Examples

```
# Example
# data(example_dataset)
# theta <- c(18.4, 1487.6, 11.6, 61.3)
# out <- PEPRMT_Reco(theta, example_dataset, wetland_type = 2)
```

run_PEPRMT

run_PEPRMT

Description

Wrapper function to run all steps of the PEPRMT model (v1.0).

Usage

```
run_PEPRMT(
  data,
  wetland_type,
  a0 = 0.7479271,
  a1 = 1.0497113,
  Ha = 149.468171 + 30,
  Hd = 94.4532674 + 100,
  T_opt_GPP = 25 + 274.15,
  Ea_SOM = 18.41329,
  kM_SOM = 1487.65701,
  Ea_labile = 11.65972,
  kM_labile = 61.29611,
  Ea_SOM_CH4 = 14.9025078 + 67.1,
  kM_SOM_CH4 = 0.4644174 + 17,
  Ea_labile_CH4 = 16.7845002 + 71.1,
  kM_labile_CH4 = 0.4359649 + 23,
  Ea_oxi_CH4 = 15.8857612 + 75.4,
  kM_oxi_CH4 = 0.5120464 + 23,
  kI_S04 = 486.4106939,
```

```

    kI_NO3 = 0.1020278,
    k_plant_oxi = 0.35
)

```

Arguments

data	Data frame containing 15 required columns used as model inputs. See Details for expected column structure.
wetland_type	Integer indicating wetland class: 1 = Freshwater peatland, 2 = Tidal wetland.
a0	Empirical intercept parameter for the fPAR scaling function (unitless). Used in GPP module.
a1	Empirical slope parameter for the fPAR scaling function (unitless). Used in GPP module.
Ha	Activation energy governing the temperature response of photosynthesis for general crop-type vegetation (kJ mol^{-1}). Controls the rate of increase in GPP with temperature below the thermal optimum. Used in GPP module.
Hd	Deactivation energy controlling the decline in photosynthesis above the thermal optimum (kJ mol^{-1}). Determines the rate of decrease in GPP at high temperatures. Used in GPP module.
T_opt_GPP	Temperature optimum for GPP. Used in GPP module.
Ea_SOM	– Activation energy controlling the temperature sensitivity of decomposition from the soil organic matter (SOM) pool (kJ mol^{-1}). Used in Reco module.
kM_SOM	– Half-saturation constant for microbial decomposition of the SOM pool (g C m^{-3} soil). Determines substrate limitation strength for SOM respiration. Used in Reco module.
Ea_labile	Activation energy controlling the temperature sensitivity of decomposition from the labile carbon pool (kJ mol^{-1}). Used in Reco module.
kM_labile	Half-saturation constant for microbial decomposition of the labile carbon pool (g C m^{-3} soil). Determines substrate limitation strength for labile respiration. Used in Reco module.
Ea_SOM_CH4	Activation energy for methane production from soil organic matter (kJ mol^{-1}). Used in CH4 module.
kM_SOM_CH4	Half-saturation constant for SOM methane production (g C m^{-3} soil). Used in CH4 module.
Ea_labile_CH4	Activation energy for methane production from labile carbon (kJ mol^{-1}). Used in CH4 module.
kM_labile_CH4	Half-saturation constant for labile methane production (g C m^{-3} soil). Used in CH4 module.
Ea_oxi_CH4	Activation energy for methane oxidation (kJ mol^{-1}). Used in CH4 module.
kM_oxi_CH4	Half-saturation constant for methane oxidation (g C m^{-3} soil). Used in CH4 module.
kI_S04	Sulfate inhibition constant (mg L^{-1}). Used in CH4 module.
kI_NO3	Nitrate inhibition constant (mg L^{-1}). Used in CH4 module.
k_plant_oxi	Fraction of CH4 oxidized during transport. Used in CH4 module.

Details

Runs all PEPRMT functions and returns an output dataframe with modeled GPP, Reco, and CH₄

The PEPRMT model was originally parameterized for restored freshwater wetlands in the Sacramento–San Joaquin River Delta, California, USA (Oikawa et al. 2017) and later updated for tidal wetlands with inhibition of methane production in response to salinity and nitrate (Oikawa et al. 2024).

Modules are run sequentially: PEPRMT_GPP, then PEPRMT_Reco, then PEPRMT_CH₄.

All variables are expected at a daily time step.

All PEPRMT modules use the same input structure, although not all variables are used in every module.

Required data columns (order does not matter):

1. DOY: Continuous day of year
2. DOY_disc: Discontinuous day of year
3. Year
4. TA_C: Air temperature (°C)
5. WTD_cm: Water table depth (cm)
6. PAR_umol_m2_day: PAR ($\mu\text{mol m}^{-2} \text{d}^{-1}$)
7. LAI: Leaf Area Index
8. EVI: Greenness Index
9. FPAR: FPAR flag
10. LUE: Light Use Efficiency
11. Wetland_age_years: Wetland age (years)
12. Salinity_daily_ave_ppt: Salinity (ppt)
13. NO₃_mg_L: NO₃ (mg L^{-1})
14. SOM_MEM_gC_m3: Soil organic matter (g C m^{-3})
15. site: Site identifier

Value

Updated dataframe containing:

GPP gross primary productivity ($\text{g C CO}_2 \text{ m}^{-2} \text{ day}^{-1}$)

APAR absorbed photosynthetically active radiation ($\text{umol m}^{-2} \text{ d}^{-1}$)

Reco_full Total ecosystem respiration ($\text{g C CO}_2 \text{ m}^{-2} \text{ day}^{-1}$)

NEE_mod Net ecosystem exchange of CO₂ ($\text{g C CO}_2 \text{ m}^{-2} \text{ day}^{-1}$)

S1 Labile soil carbon pool (g C m^{-3} , top meter of soil)

S2 Soil organic carbon pool (g C m^{-3} , top meter of soil)

pulse_emission_total total methane emitted ($\text{g C CH}_4 \text{ m}^{-2} \text{ day}^{-1}$)

Plant_flux_net net methane flux via plant-mediated transport ($\text{g C CH}_4 \text{ m}^{-2} \text{ day}^{-1}$)

- Hydro_flux** net diffusive methane flux from water to atmosphere (g C CH₄ m⁻² day⁻¹)
- M1** methane pool produced from labile soil carbon (g C CH₄ m⁻³, top meter of soil and water)
- M2** methane pool produced from soil organic carbon (g C CH₄ m⁻³, top meter of soil and water)
- trans2** fraction of methane released via plant-mediated transport (unitless)

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