University of Exeter

TroPeaCC project (ERC)

Modelling the effects of water table dynamics on microbial methane emissions: focus on the tropics

j.bernard@exeter.ac.uk

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authors by alphabetic order

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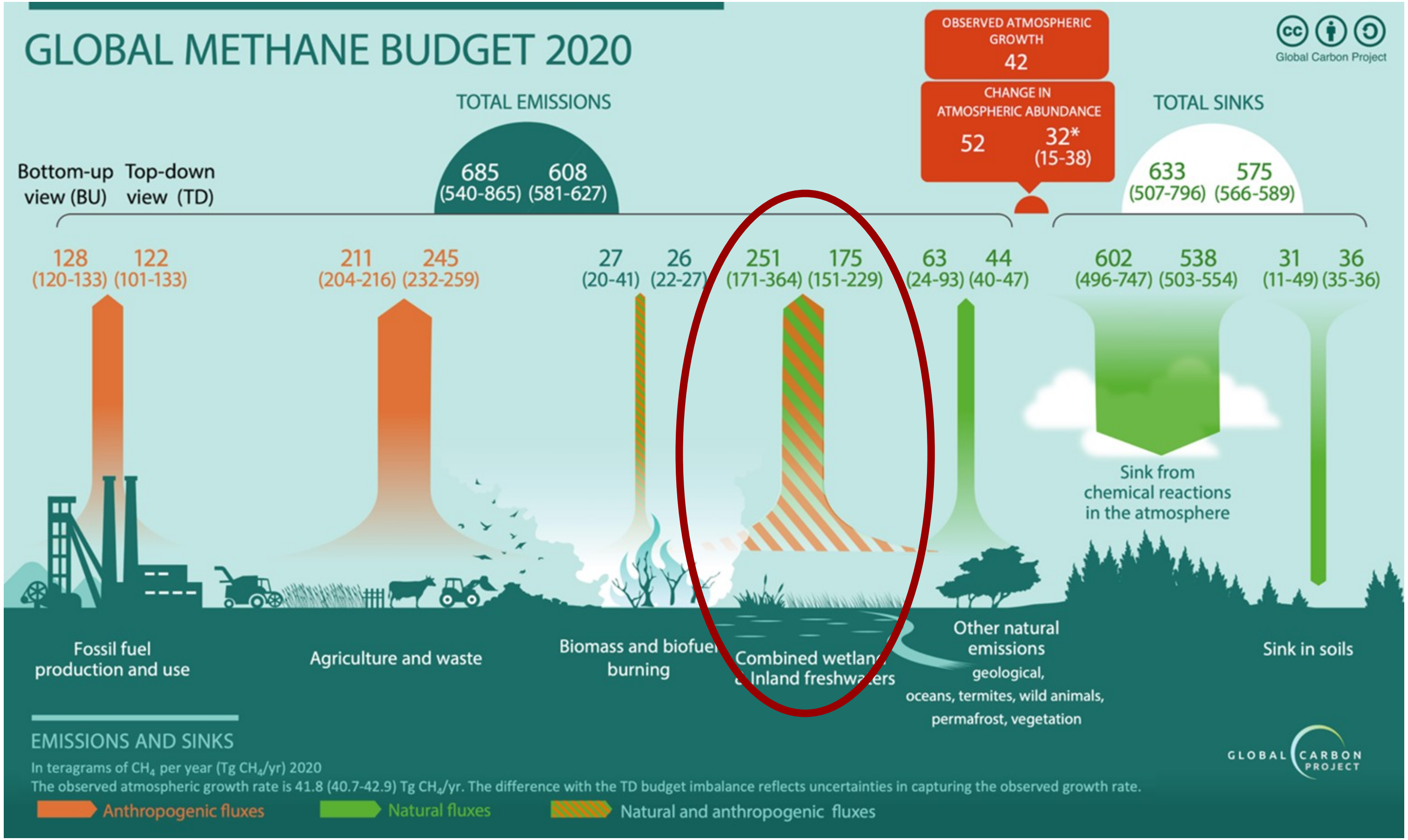
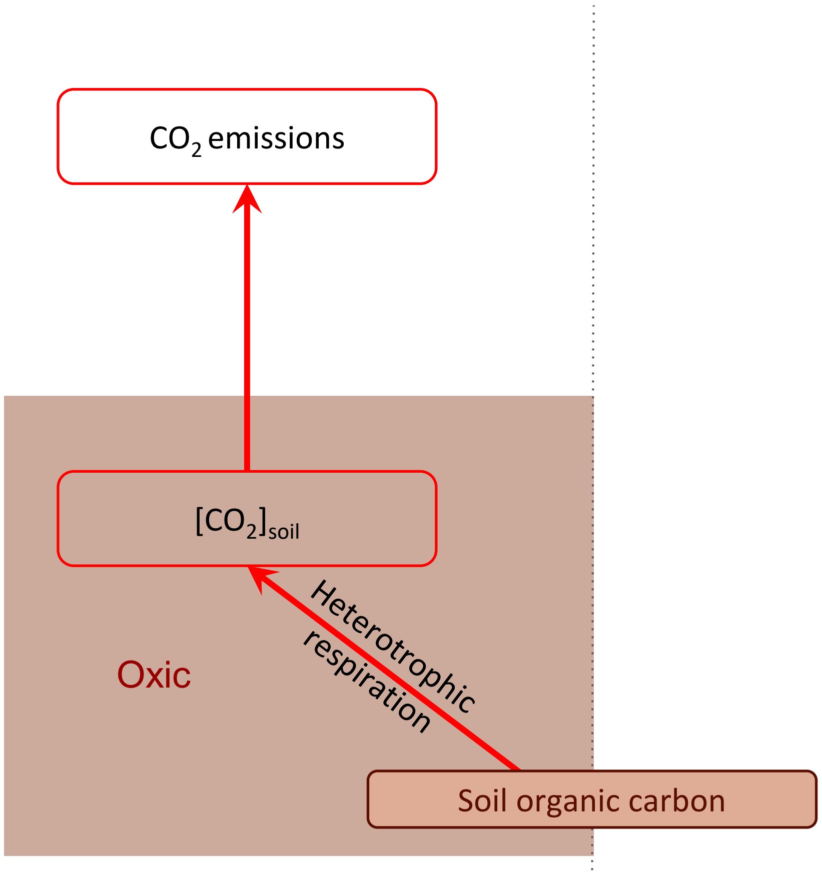


→ wetlands are responsible for about ⅓ of global methane emissions



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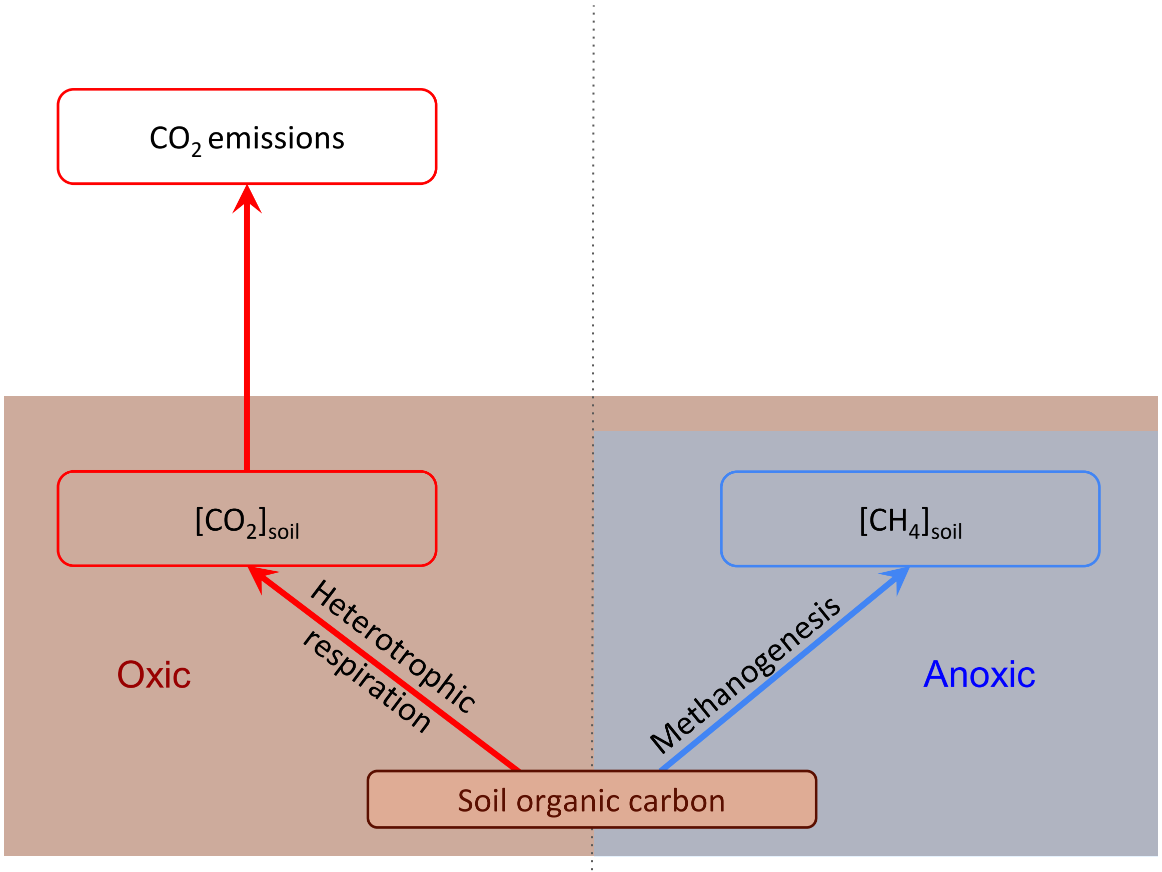

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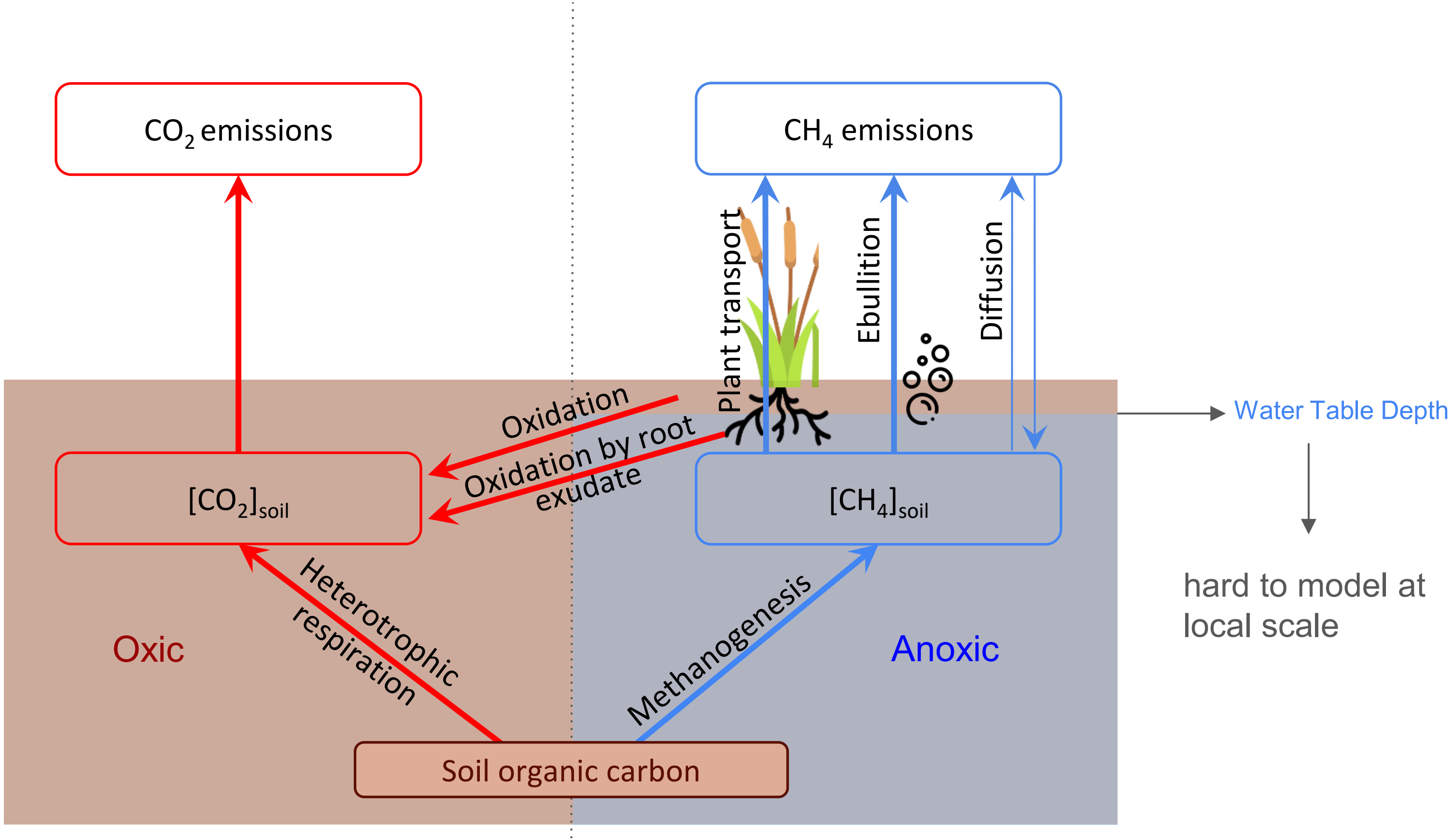

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Wetland methane emissions in JULES

Climate feedback from wetland methane emissions

N. Gedney
Hadley Centre, Met Office, Joint Centre for Hydro-Meteorological Research, Wallingford, UK

P. M. Cox
Hadley Centre, Met Office, Exeter, UK

C. Huntingford
Centre for Ecology and Hydrology, Wallingford, UK

The Sensitivity of Global Climate Model Simulations to the Representation of Soil Moisture Heterogeneity

N. Gedney and P. M. Cox
Hadley Centre, Met Office, Bracknell, Berkshire, United Kingdom

(Manuscript received 19 December 2002, in final form 18 June 2003)

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LETTER

Significant feedbacks of wetland methane release on climate change and the causes of their uncertainty

N Gedney[1,4], C Huntingford[2], E Comyn-Platt[2] and A Wiltshire[3]

[1] Met Office Hadley Centre, Joint Centre for Hydrometeorological Research, Maclean Building, Wallingford OX10 8BB, United Kingdom
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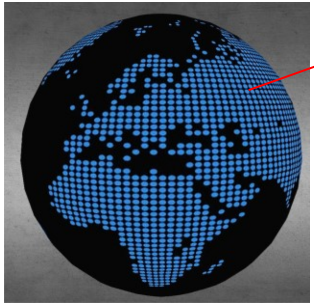
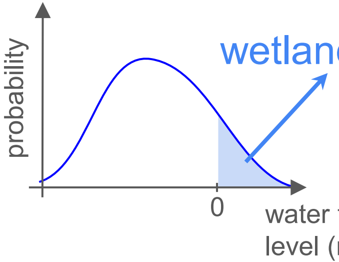


per pixel :



wetland fraction f_w

Soil organic carbon C

NPP

Soil temperature T

$$F_{CH_4} = f_w \sum_{layer=i} k C_i Q_{10}(T)^{(T-T_0)/10} e^{-\tau z_i}\, dz_i$$

→ in JULES, methane emissions are driven by wetland fraction, soil carbon, and temperature

JULES-microbe

Modeled Microbial Dynamics Explain the Apparent Temperature Sensitivity of Wetland Methane Emissions

Sarah E. Chadburn[1], Tuula Aalto[2], Mika Aurela[2], Dennis Baldocchi[3], Christina Biasi[4], Julia Boike[5,6], Eleanor J. Burke[7], Edward Comyn-Platt[8], A. Johannes Dolman[9], Carolina Duran-Rojas[1], Yuanchao Fan[10,11], Thomas Friborg[12], Yao Gao[2], Nicola Gedney[13], Mathias Göckede[14], Garry D. Hayman[15], David Holl[16], Gustaf Hugelius[17], Lars Kutzbach[16], Hanna Lee[10], Annalea Lohila[2,18], Frans-Jan W. Parmentier[19,20], Torsten Sachs[21], Narasinha J. Shurpali[22], and Sebastian Westermann[19]

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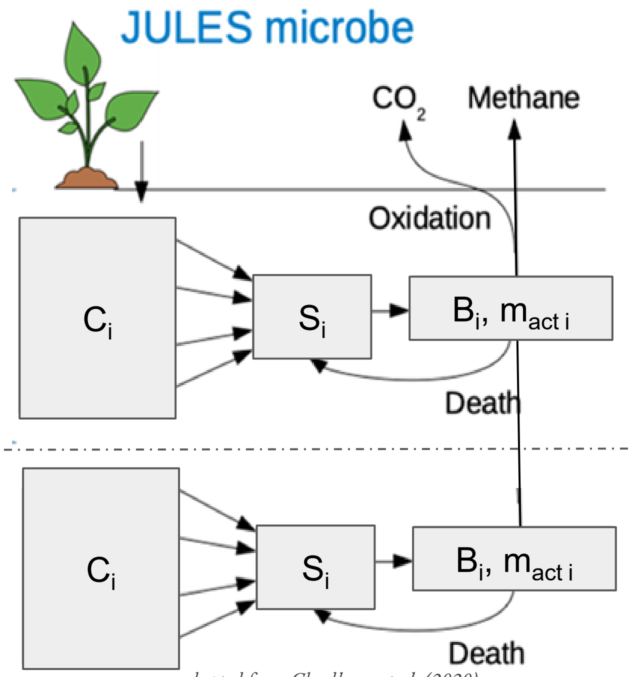

adapted from Chadburn et al. (2020)

C : soil Carbon *measured (site) or JULES*
S : soil substrate
B : methanogenic biomass
m_{act} : methanogenic activity

in each soil layer i :

$$\frac{dS}{dt} = C\ dissolution\ - \ methanogenesis\ - \ hetertrophic\ resp$$
$$= k_1 Q_1^{0.1\frac{T}{1-T/T_0}} C^{\frac{2}{3}} - k_2 Q_2^{0.1\frac{T}{1-T/T_0}} \phi B m_{act} - \xi\ S$$

$$\frac{dB}{dt} = \quad growth \quad - \quad death \quad - \quad maintenance\ resp$$
$$= (f k_2 \phi B m_{act} \ - \ k_d B m_{act} \ - \ \alpha k_2 B) Q_2^{0.1T/(1-T/T_0)}$$

$$\frac{d_{mact}}{dt} = \pm\ f\ k_2\ A_2\ m_{act} \quad \begin{array}{ll} + & \text{if growth} > \mu \\ - & \text{if not} \end{array}$$

$$F_{CH4} = f_w \sum_i F_{CH4,\,i}\ e^{-\tau z_i}\ dz_i = f_w \sum_i \frac{1}{2} k_2\ Q_2^{0.1\frac{T}{1-T/T_0}}\ \phi\ B\ m_{act}\ e^{-\tau z_i}\ dz_i$$

→ goal : to represent the **microbial community**; emissions are no longer directly proportional to soil carbon content.
Developed and tested at 6 boreal and 1 temperate sites

JULES-microbe

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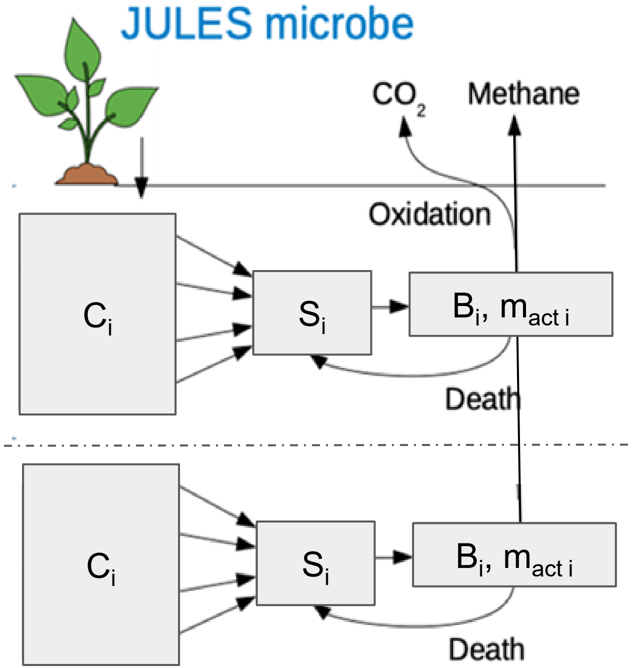

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\+ if growth>μ
\- if not

$$F_{CH4} = f_w \sum_i F_{CH4,\,i}\ e^{-\tau z_i}\ dz_i = f_w \sum_i \frac{1}{2} k_2\ Q_2^{0.1\frac{T}{1-T/T_0}}\ \phi\ B\ m_{act}\ e^{-\tau z_i}\ dz_i$$

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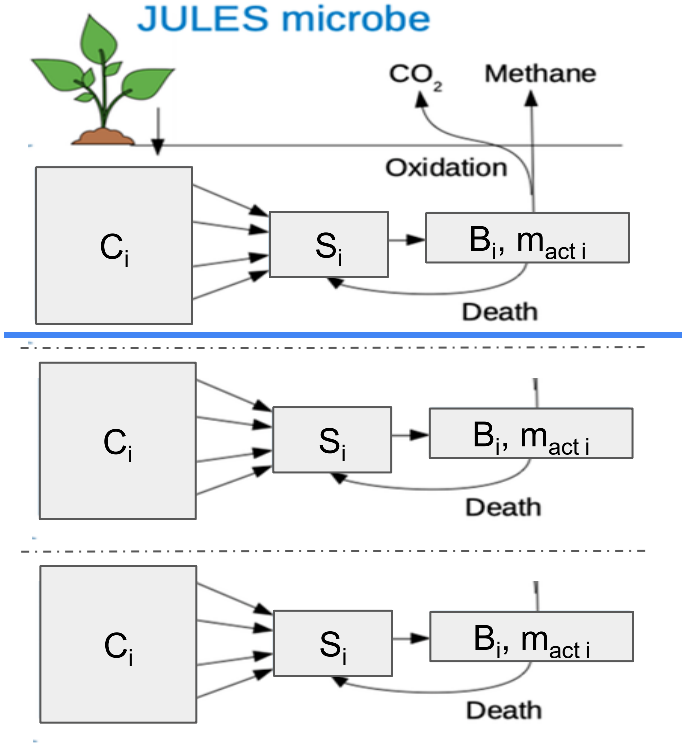
JULES-microbeWT



Water Table

Modeled Microbial Dynamics Explain the Apparent Temperature Sensitivity of Wetland Methane Emissions

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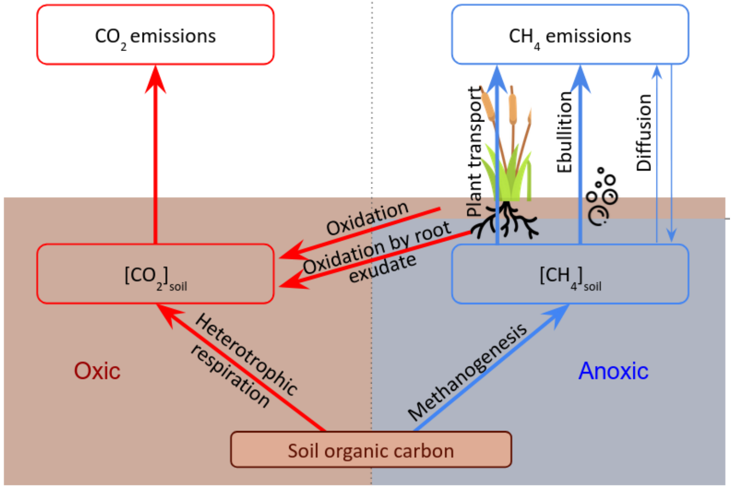
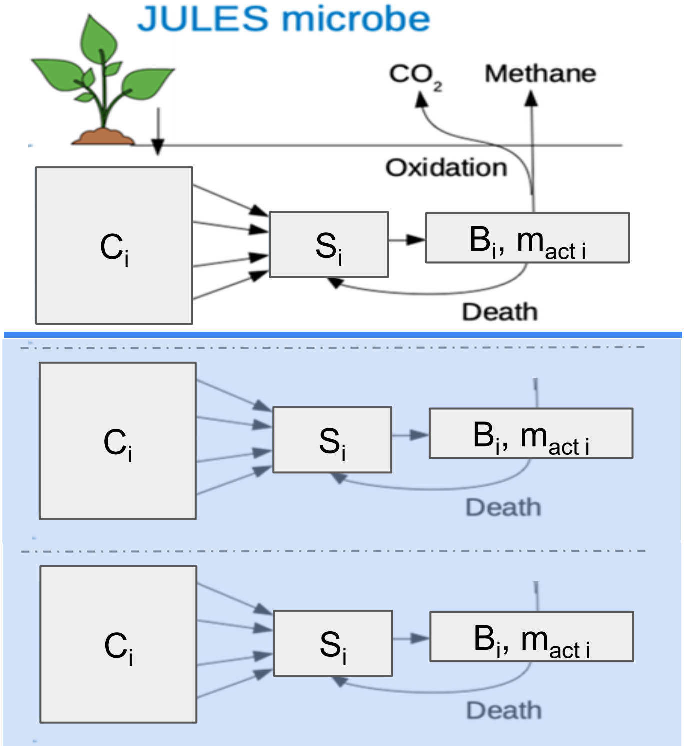
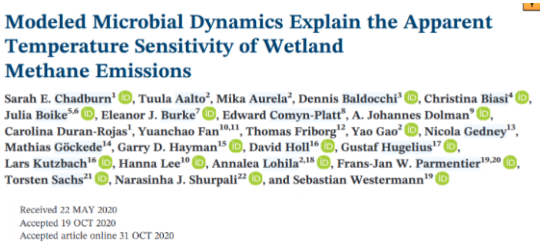


→ but in reality, emissions can occur if WT is below the surface, e.g. -10cm

JULES-microbeWT





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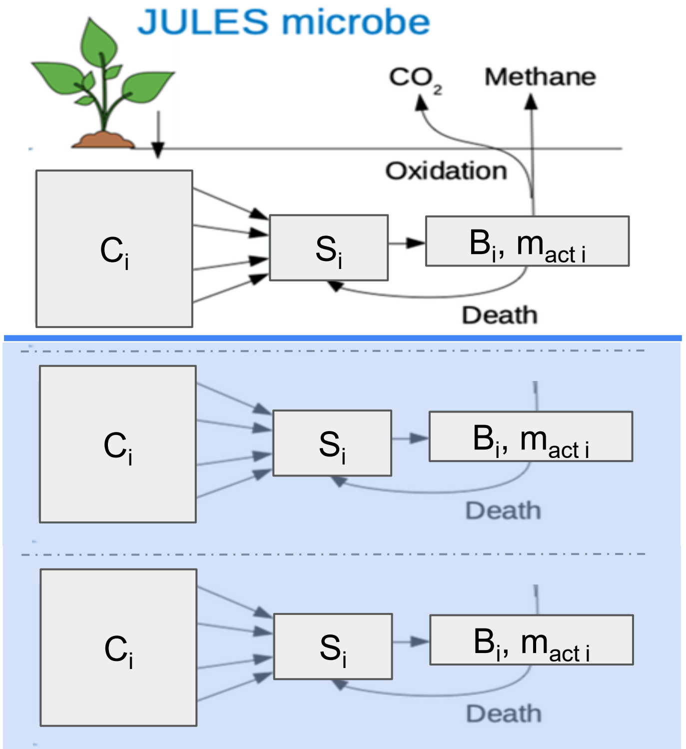
dry layer → substrate, microbial biomass, microbial activity
no methane emission

Water Table

wet layers → substrate, microbial biomass, microbial activity ↗
methane emission

→ goal : to represent the influence of the water table (WT)

JULES-microbeWT



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dry layer → substrate, microbial biomass, microbial activity
no methane emissions

Water Table

wet layers → substrate, microbial biomass, microbial activity
methane emissions

→ goal : to represent the influence of the water table (WT)

→ problem : only calibrated with **1 site**, which is a **temperate** and **managed** site (and probably degraded)

JULES-microbeWT developments

I. Local python version of JULES-microbeWT

I. Site data gathering and multisite calibration

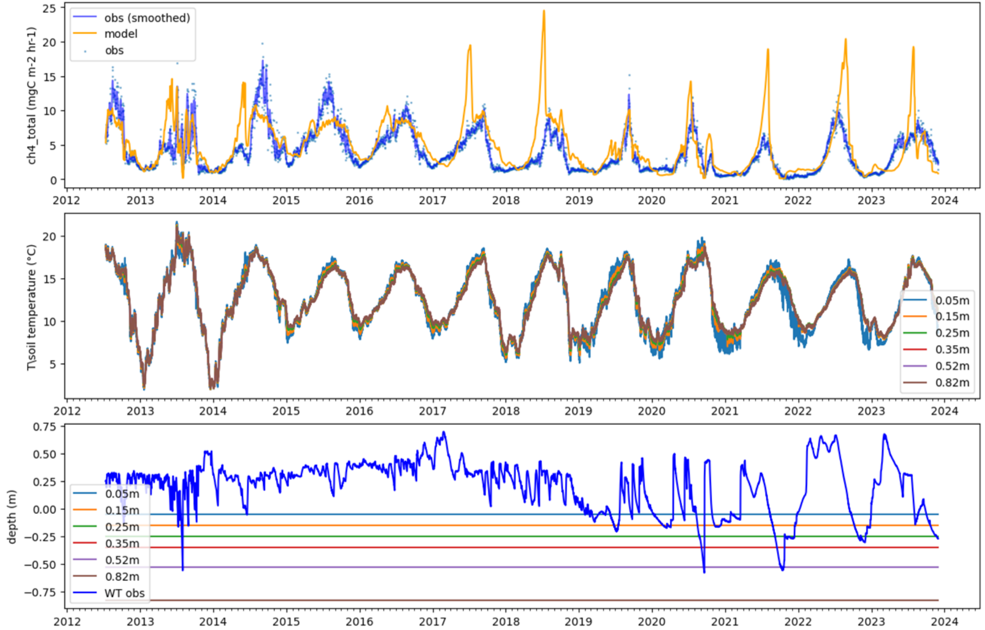
I. Global JULES runs

I. local python version of JULES-microbeWT

in collab. with Janice Liu (see her poster tomorrow)

→ draft of a bug-free* offline python version of the model *hopefully

US-Tw1 = temperate managed site



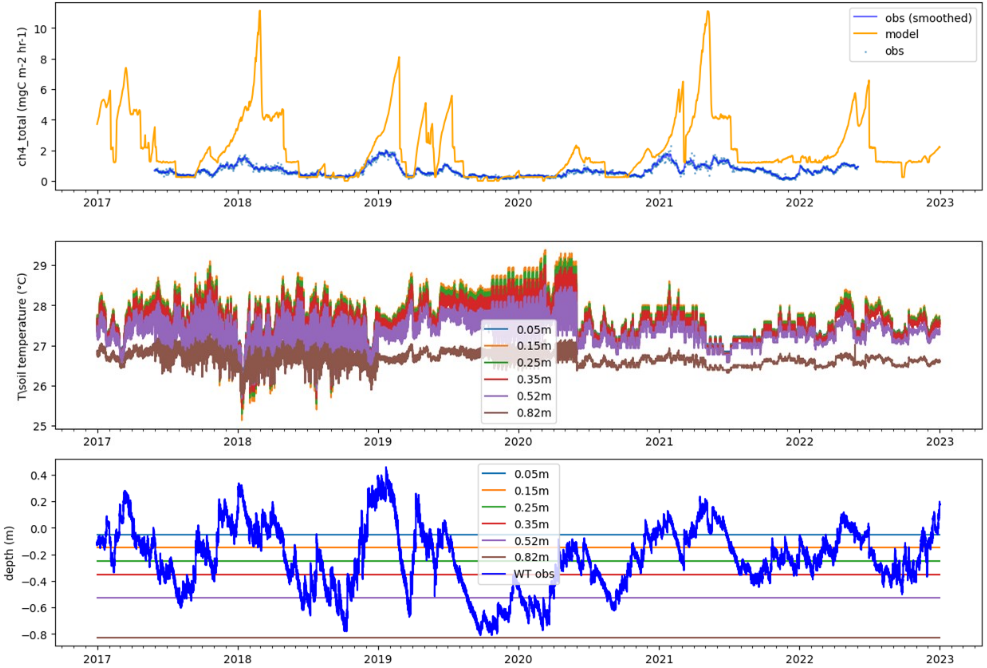
→ captures parts of the variability (complex model, lots of parameters), parameter tuning could be improved

I. local python version of JULES-microbeWT

in collab. with Janice Liu (see her poster tomorrow)

→ draft of a bug-free* offline python version of the model *hopefully

ID-Kam = tropical pristine site



→ needs parameter calibration at global scale

II. Site data gathering, especially in the tropics

→ There are lots of parameters to calibrate => more sites are needed.

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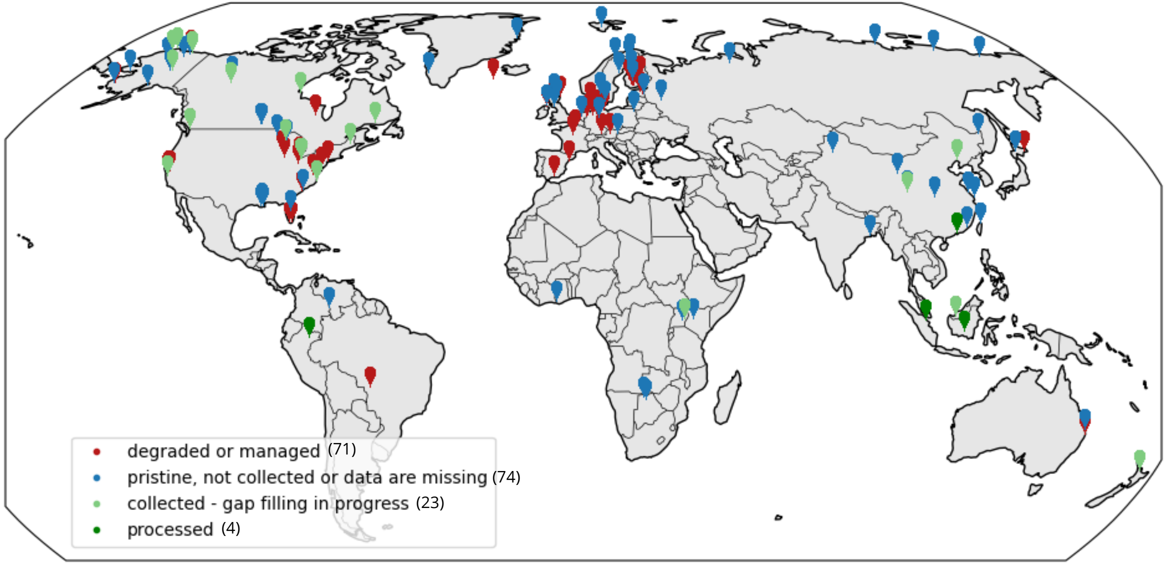
→ There are lots of parameters to calibrate => more sites are needed.
→ Data gathering of tropical sites began by J. Ramirez.
→ Since the development of the model in 2020, new data - a few new sites in the tropics (including TroPeaCC sites!).
→ Work in progress: listing and gathering data, plus gap filling using machine learning (ML) and meteorological reanalysis (ERA5).

variables needed:

- FCH4 (½ hourly)
- Water Table (½ hourly)
- Temperature (½ hourly)
- soil carbon profile

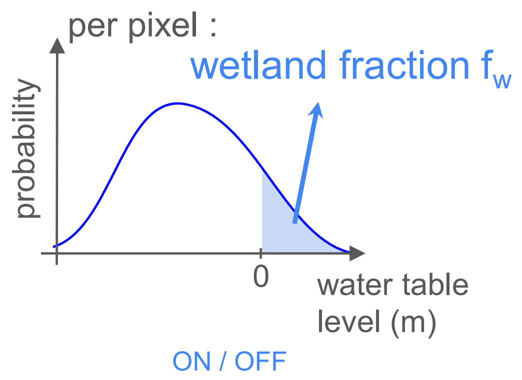


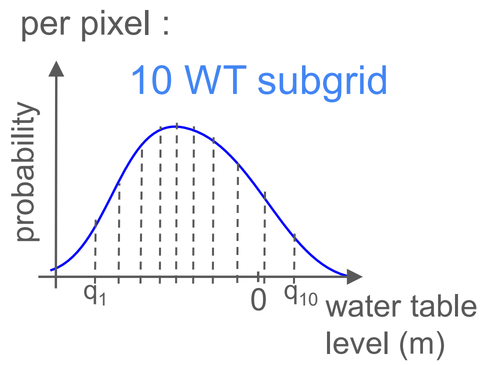
Eddy Covariance towers with methane measurements in wetland sites

→ in situ data process in progress, goal : multisite calibration

III. Implementation in FORTRAN JULES

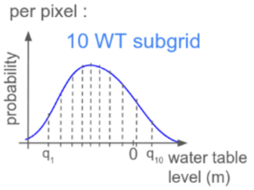
→ Part of this has already been implemented in the global FORTRAN JULES by S. Chadburn in 2020.





→ run the model on the 10 subgrid

III. Implementation in FORTRAN JULES



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→ merge with trunk vn7.8

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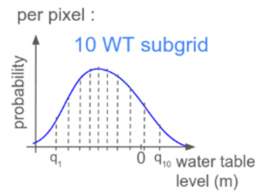

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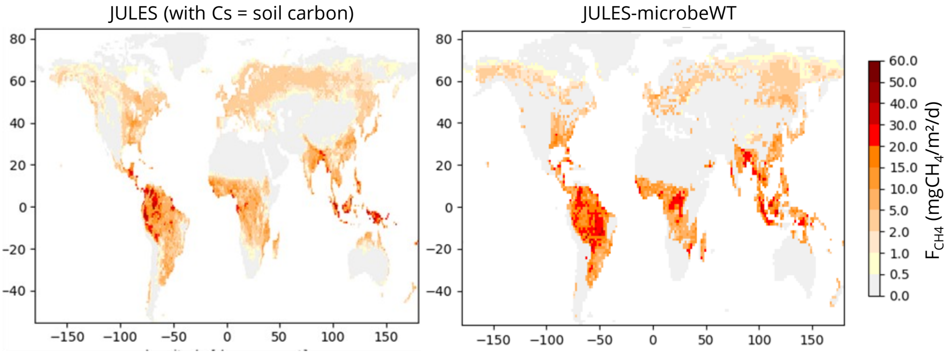
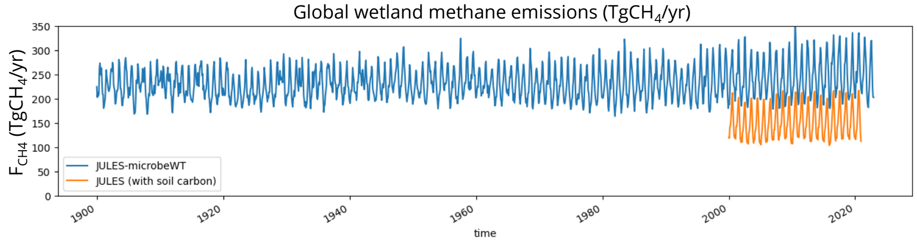




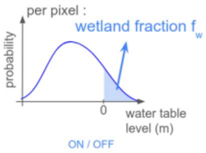
→ still some inconsistency

- too much inundation
  → tries to use more realistic soil properties ancillaries, led to bug with negative nitrogen in soils
- bug with water table management? seems to be defined twice at different location in the code?

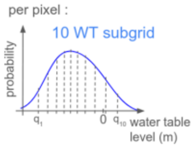
→ limitation : this approach doesn't account for river flooding, one important way of wetland formation

IV. perspectives

→ global runs to compare WT consideration effect vs wetland fraction consideration



vs



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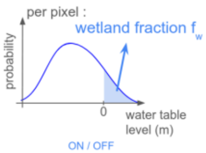

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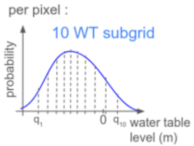
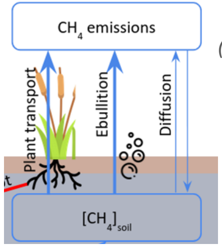


→ adding processes :

- refine rewetting (now, on/off)
- transport through plants



if water table above root depth, then bypass oxidation

(following same logical as Gedney et al. 2019 developments for wetland fraction)

IV. perspectives

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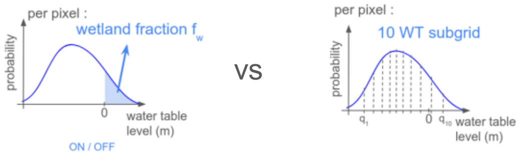

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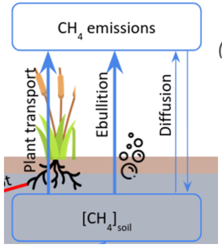

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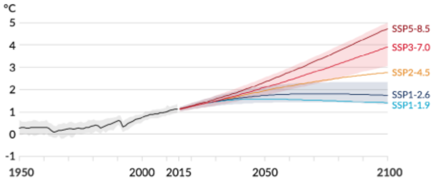
→ global runs

- analyse past emissions estimates
- projections : estimate future emissions under different scenarios



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