In-situ
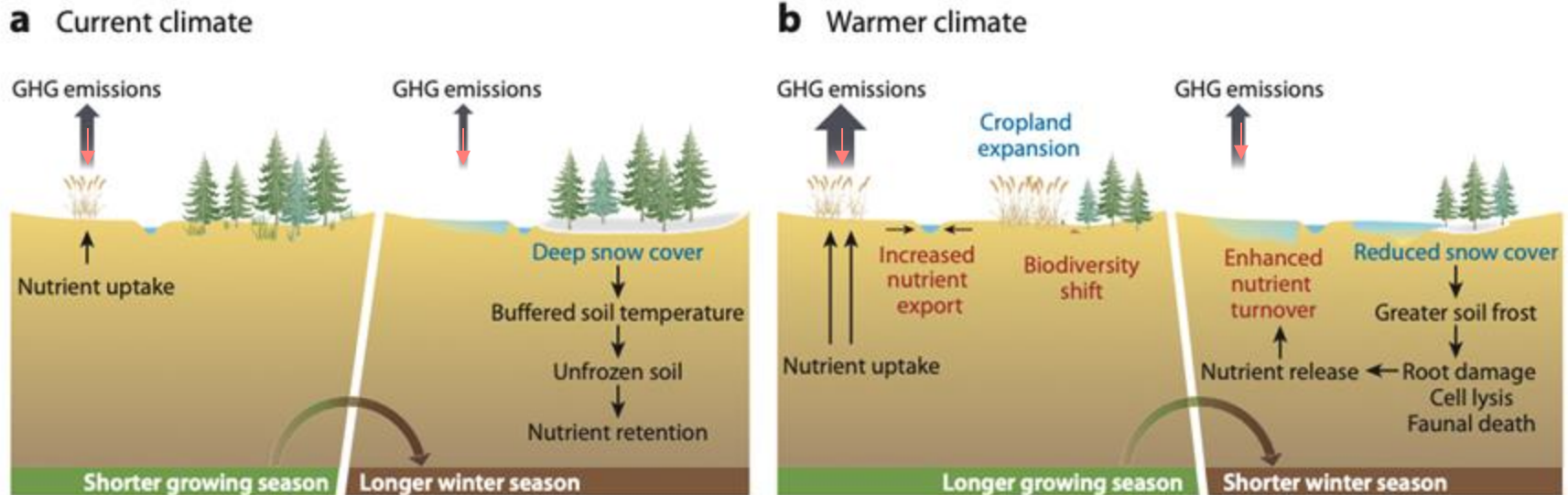# Soil Gas Fluxes

Haohua He, Grace Marsh

5 Dec. 2024

Soil Gas Exchange

Pi et al., *Annual Review of Environment and Resources*, 2021

Global warming with greenhouse gas (GHGs): CO_2, CH_4, N_2O
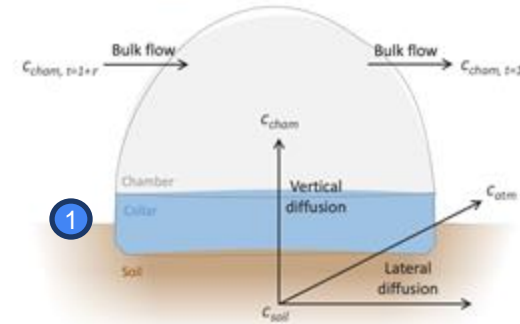
Soil ecosystem: Source or Sink? Drivers?

Field Measurements

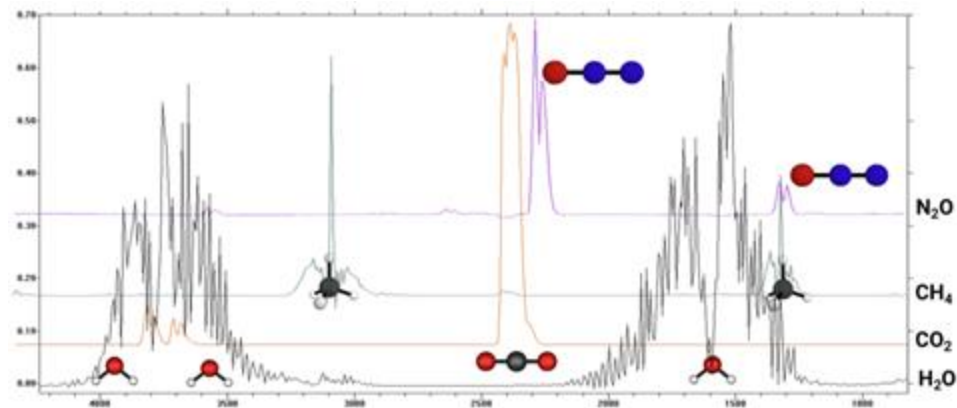- Soil site selection and collar placement
  - Prevent lateral gas diffusion
  - Minimise the effect of soil disruption

- Machine warming up

- Chamber installation and tubes connection
  - Make sure tightness
  - Check the Inlet and Outlet

- Measuring and recording !

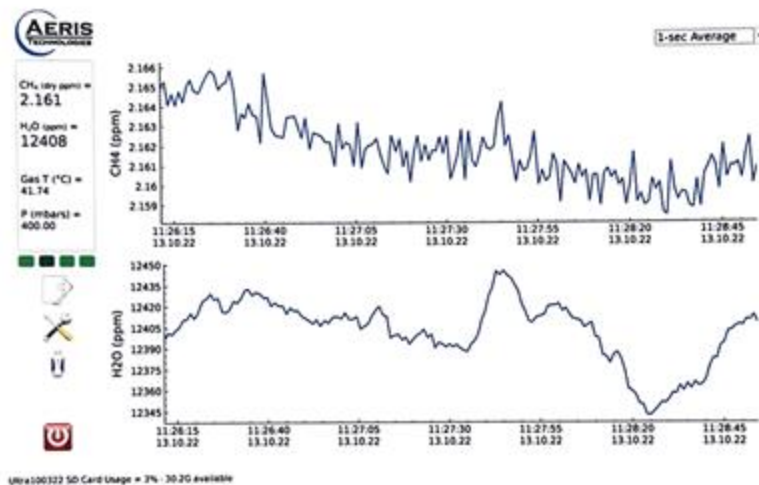Gas movement during a closed-transient chamber observation

Gas Analyser System

- An internal laser system detects absorption at specific wavelengths using mid infrared (MIR) spectroscopy.

- Gas concentration measurements (ppm) are calculated from this observed transmission spectra.

- Each analyser is designed for the detection of different gases, due to varying transmission spectra.

2.5 TIME SERIES SCREEN

Calculating Soil Gas Flux

- Soil gas flux was calculated from the initial and final gas concentrations measured in the field, in addition to temperature and gas volume.

- Flux formula

Total volume

$$flux = \left\{\frac{C2 - C1}{t2 - t1}\right\} \cdot \frac{v}{v_a \cdot \frac{T_2}{T_1}} \cdot \frac{1}{A} \quad (\mu mol\ m^{-2}s^{-1})$$

Slope of regression

Soil surface area

Molar volume of ideal gas at 273K = 22.4 x 10-3 m-3/mol

Standard temp (273K) / Air temp (K)

Calculating Gas Flux

Raw data extraction

Time (HH:MM:SS)
Concentration of CH_4, CO_2, N_2O (ppm)

Variables setup

Total air volume:
  collar_h + chamber + tubes + analyser (cm³)
Temperature: air_temp (℃) + 273.15 (K)
Surface area: collar_r

Gas flux (rate)

Time formatting: HH:MM:SS → s
Plot: y = ppm, x = s
Linear regression: slope = coef. (ppm s⁻¹)

Gas flux (std.)

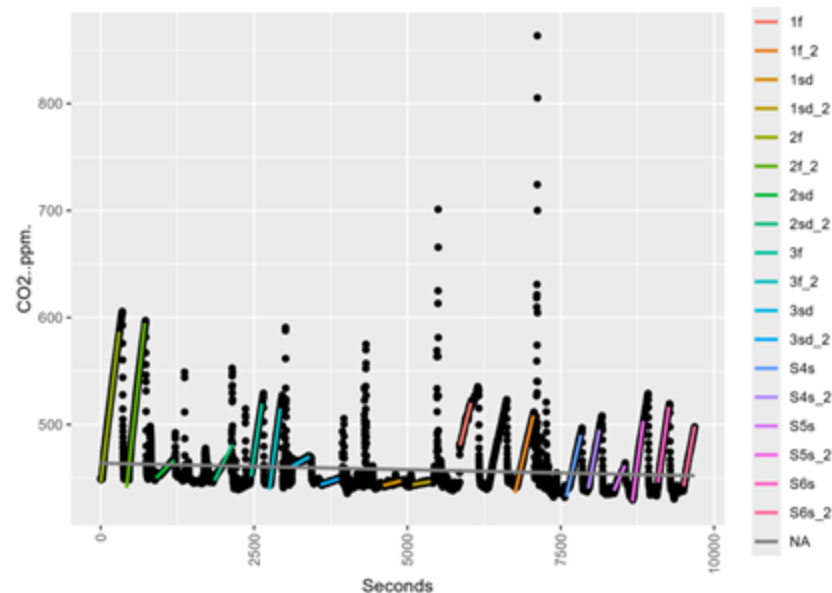Function: collar_h , air_temp, slope (µmol m⁻² s⁻¹)

Figure 1. CO_2 concentrations measured during gas flux analysis of forest soils (f), grassland (s) and sediment sites at the Sorge River, Lausanne.

Observed Methane Flux

- CH_4 flux from -2.128 to 0.065 nmol m^{-2} s^{-1}.

- Negative CH_4 flux from forest soil, indicating methanotrophy.

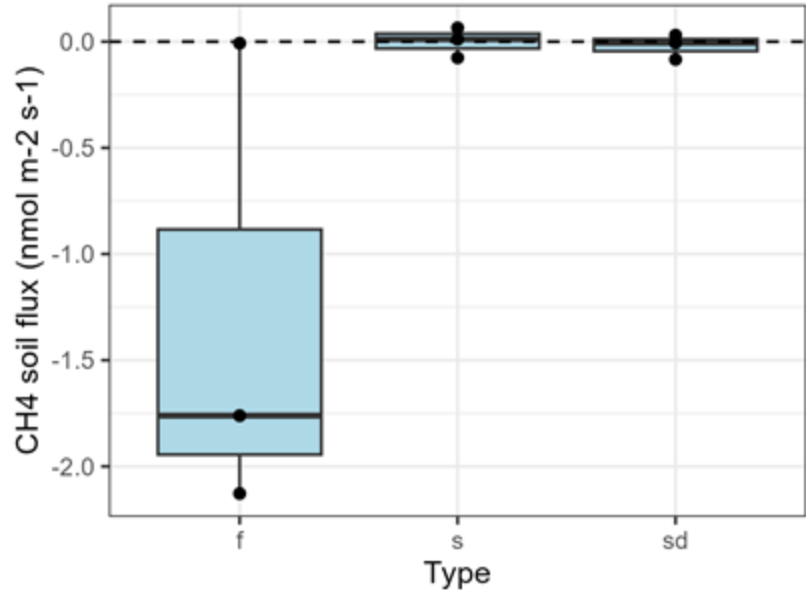- Relatively less CH_4 flux from sediment and grassland soils.

Figure 2. Methane flux at the Sorge River, Lausanne, from forest soils (f), grassland (s) and sediment sites.

Observed CO$_2$ Flux

- CO$_2$ soil flux from 0.113 to 4.861 µmol m^{-2} s^{-1}.

- Positive flux indicates CO$_2$ production from all soils, although to varying extent.

- Potentially more carbon sources available in forest and grassland soil to support greater respiration/ decomposition.
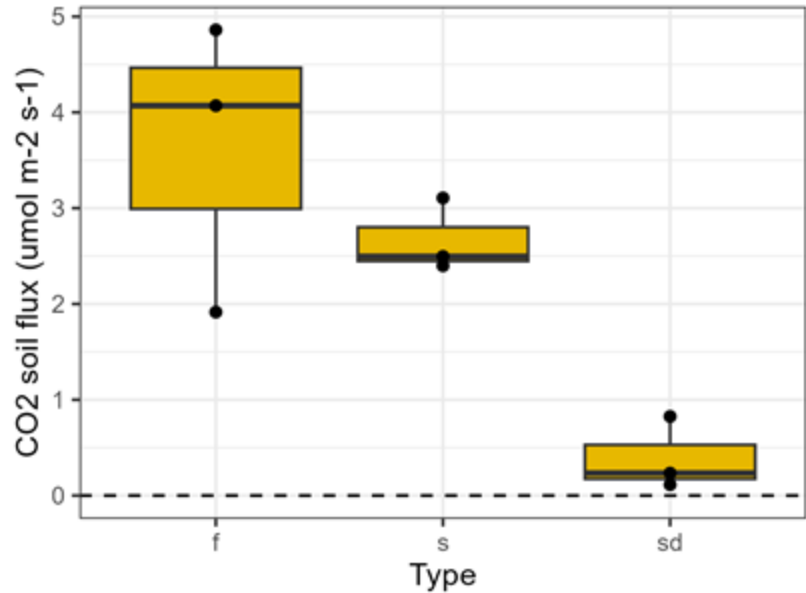

Figure 3. CO$_2$ flux at the Sorge River, Lausanne, from forest soils (f), grassland (s) and sediment sites.

Observed Nitrous Oxide Flux

- Minimal N$_2$O flux from 0.002 to 0.091 nmol m^{-2} s^{-1}.

- Positive nitrous oxide flux at all sites, with greatest production from grassland soils.

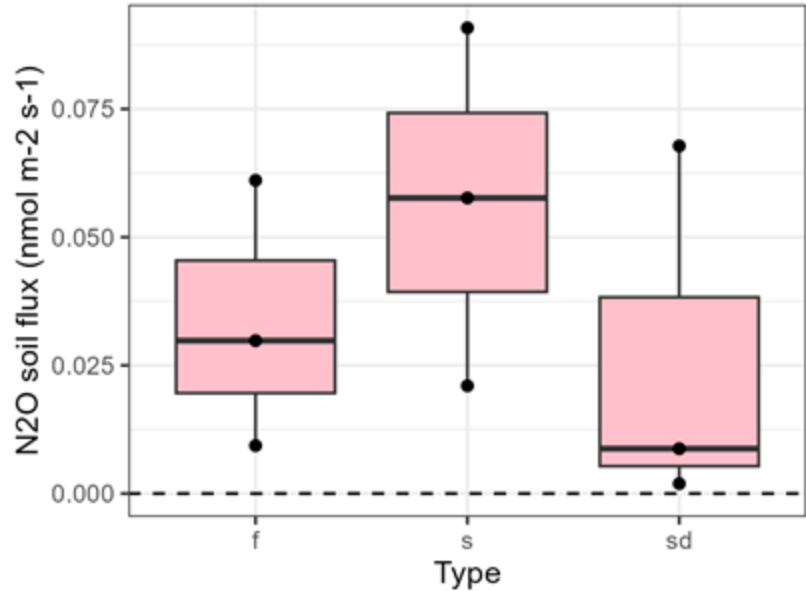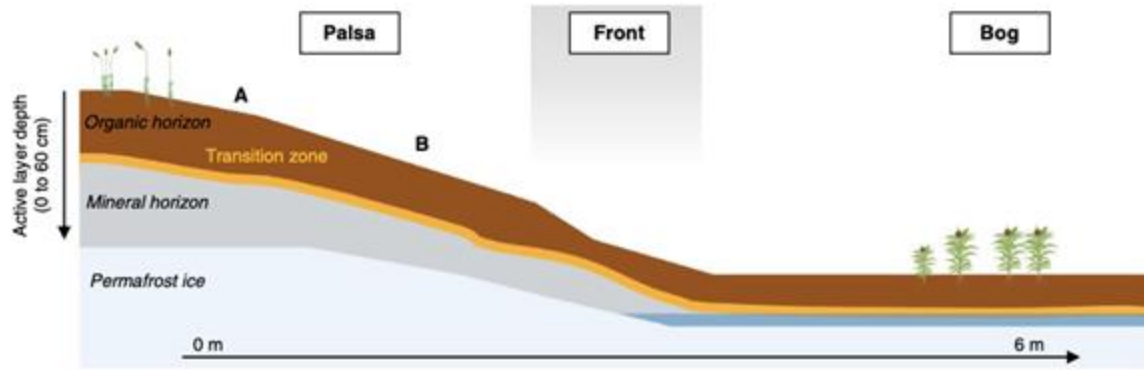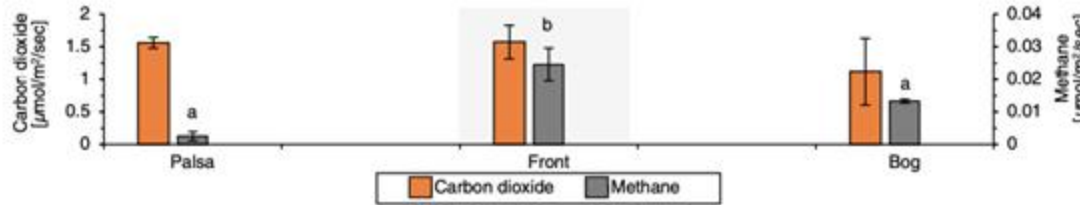- Potentially driven by more nitrogen sources from fertilisers.

Figure 4. Nitrous oxide flux at the Sorge River, Lausanne, from forest soils (f), grassland (s) and sediment sites.

Microbial iron cycling during palsa hillslope collapse promotes greenhouse gas emissions before complete permafrost thaw

a Carbon dioxide and methane emissions along the palsa hillslope into bog

✓ **Field CO$_2$&CH$_4$ fluxes**

Carbon dioxide and methane emissions along the palsa hillslope with highest emissions at the collapsing front

✓ **Microbial analyses**

Carbon-Iron-cycling, and Methane-cycling microorganisms are increasing in relative 16S rRNA (gene) abundance along the palsa hillslope

Patzner et al., *Nature Communications Earth & Environment*, 2022

Microbial iron cycling during palsa hillslope collapse promotes greenhouse gas emissions before complete permafrost thaw

a Iron-cycling microorganisms along the palsa hillslope
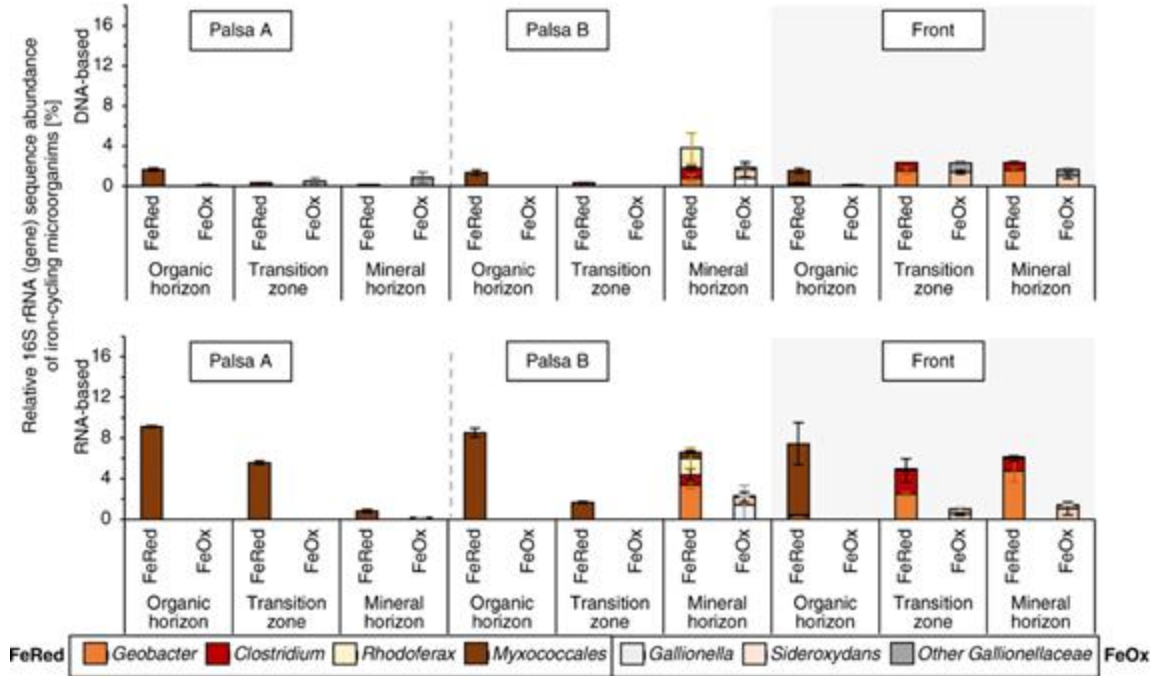
✓ **Field CO$_2$&CH$_4$ fluxes**

Carbon dioxide and methane emissions along the palsa hillslope with highest emissions at the collapsing front

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Carbon-Iron-cycling, and Methane-cycling microorganisms are increasing in relative 16S rRNA (gene) abundance along the palsa hillslope

Patzner et al., *Nature Communications Earth & Environment*, 2022

Thanks for listening!

Questions?

Gas Emissions from Soil Incubation Experiments

Soil CO_2 or CH_4 emission rate (CER, mg C kg^{-1} soil h^{-1}):

$$CER = \frac{(C_t - C_0) \times V \times T \times M \times 10^{-3}}{m \times T_r \times t \times 22.4}$$

C_t: concentration (ppm) of CO_2 in the bottle at a specific sampling time;

C_0: initial concentration (ppm) of ambient CO_2 prior to gas sampling;

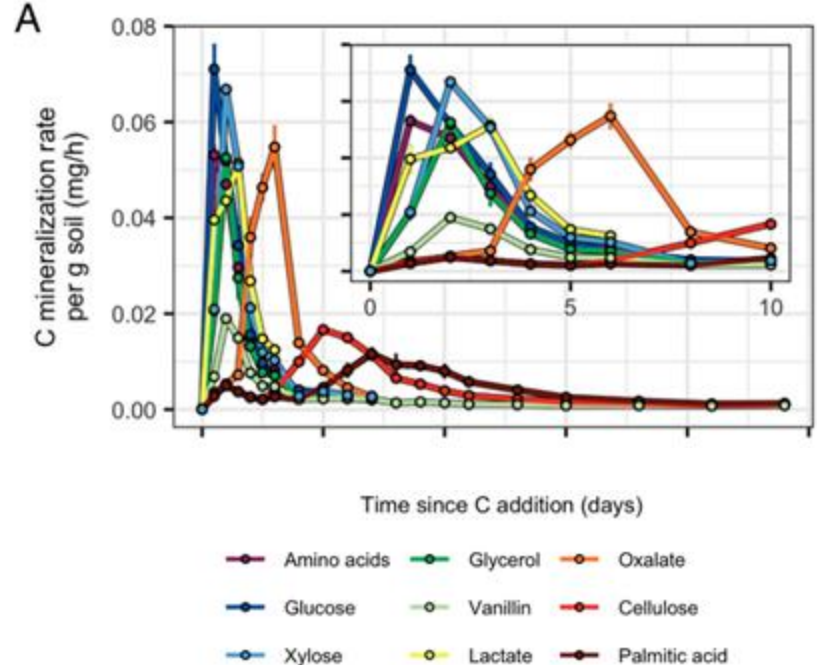V : volume of the incubation bottle (m^3);

T : standard temperature (273.15 K);

M : molecular weight of C (12 g mol^{-1});

m : dry weight of the soil sample (kg);

T_r : temperature at gas sampling (298.15 K);

t : duration of gas sampling (h);

22.4 (L mol^{-1}): the molar volume of an ideal gas at 1 atm and 273.15 K.

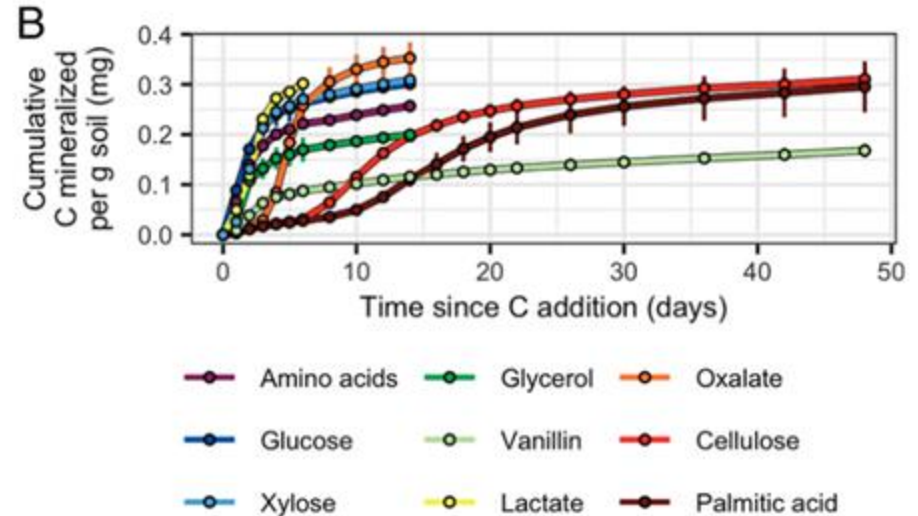Barnett et al., Proc Natl Acad Sci U S A, 2021

Gas Emissions from Soil Incubation Experiments

Cumulative soil CO_2 or CH_4 emission (CCE, mg C kg^{-1} soil) during the incubation:

$$CCE = \sum_{i=1}^{n} (CER_i \times \Delta D_i)$$

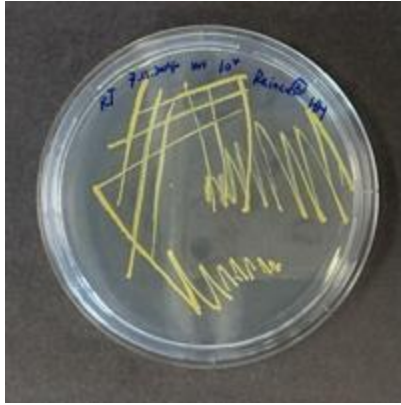CER_i : soil CO_2 emission rate (mg C kg^{-1} soil h^{-1}) at a specific sampling time-plot;

ΔD_i : interval time optimized between sampling time-plots

Barnett et al., Proc Natl Acad Sci U S A, 2021

Thanks for listening!

Questions?

Isolated Microorganism from Water of Site4

Morphology

Size:

	moderate
Shape:	circular
Elevation:	umbonate
Margin:	smooth
Surface:	glistening
Color:	yellow
Opacity:	opaque

Smell:

Gram staining

Gram-positive (G$^+$)
Cocci in irregular clusters

Antibiotics test

Toxicity on Colony2:
TET30 > CIP5 > KMN30
> VAN30

Isolated Microorganism from Water of Site4

Micrococcus luteus
Kocuria rosea

✓ **Carbon utilization test**

Purple color: microbial metabolic activity
Water control & carbon source: mixotrophic organisms ?

✓ **Catalase test**

Slight formation of bubbles: breakdown of H_2O_2

✓ **Enzymatic definition**

~~Not reliable for gram-positive bacteria ?~~