LES APPORTS DE LA GÉNOMIQUE À L'AGROÉCOLOGIE

MARDI 27 MARS 2018

AGROPOLIS INTERNATIONAL
MONTPELLIER

AGENCE NATIONALE DE LA RECHERCHE
ANR

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Chercheur INRA

Projet INCITE

Integrated response of plant, microbial and N Cycling InTEractions to precipitation patterns

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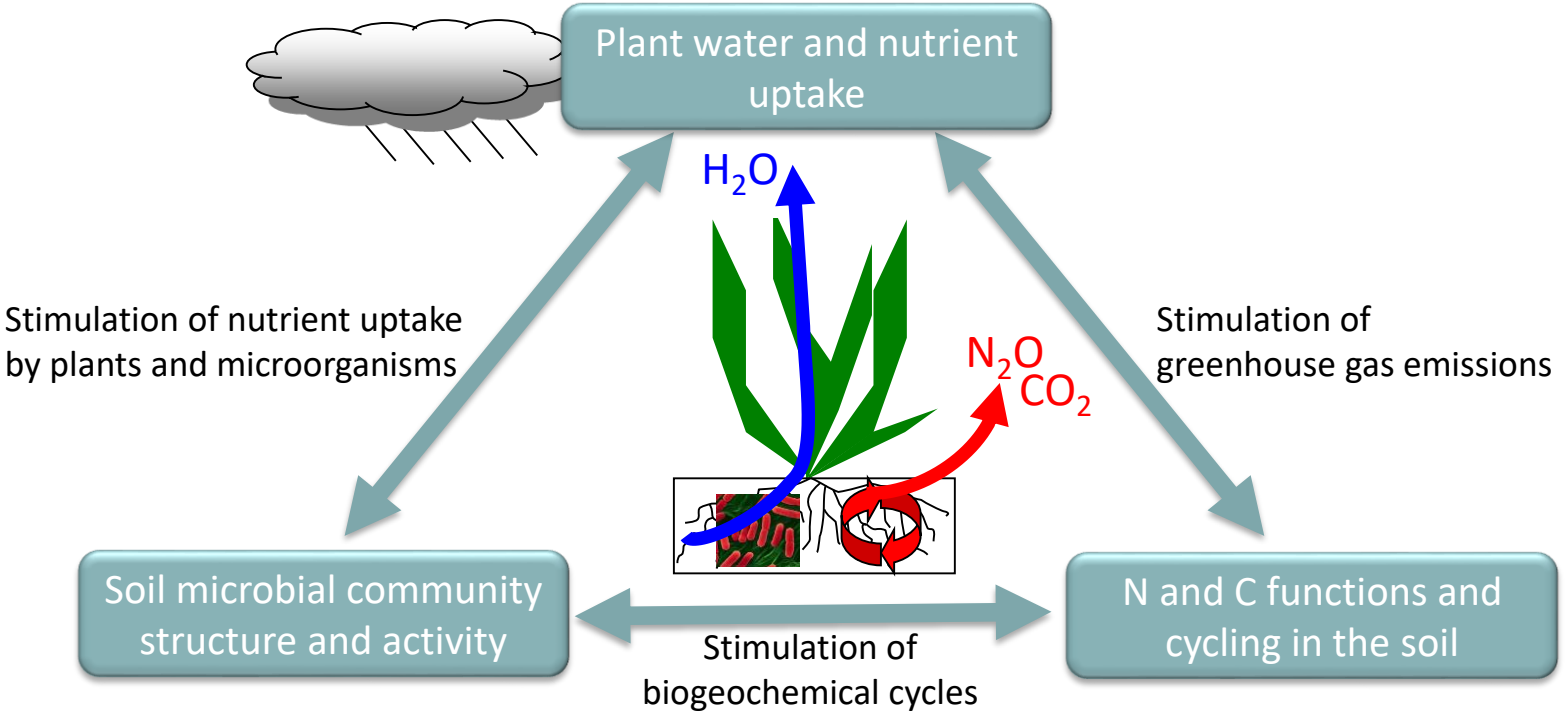
Context

Climate change predictions in Europe:

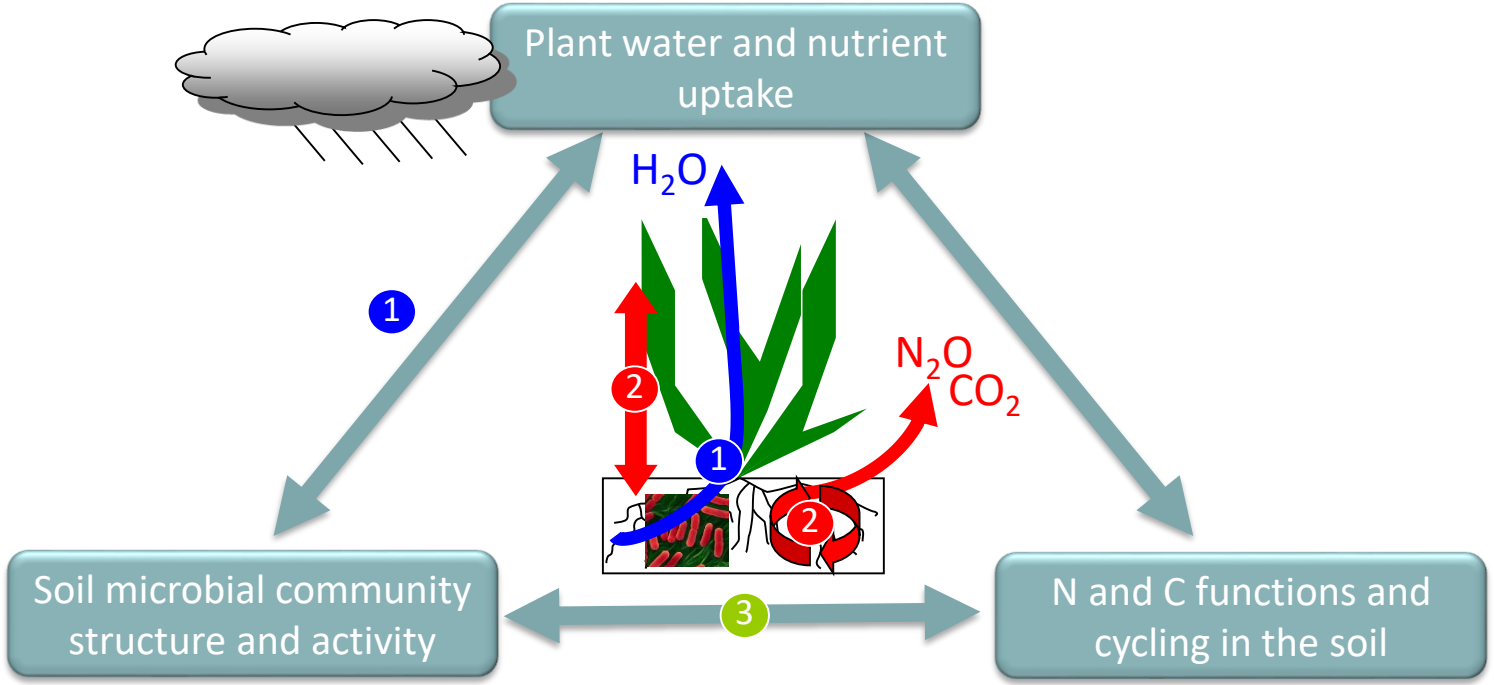
- less precipitation amounts
- more intense and less frequent rain events

Impacts three main aspects of plant-soil interactions, affecting productivity, C budgets and N losses



Objectives

1. Microbial activity, coupling with plant water uptake depth
2. Impacts on biogeochemical cycles, plant-microbe competition and synchronicity
3. Stability of microbial community vs. stability of biogeochemical functions



Dry - Wet

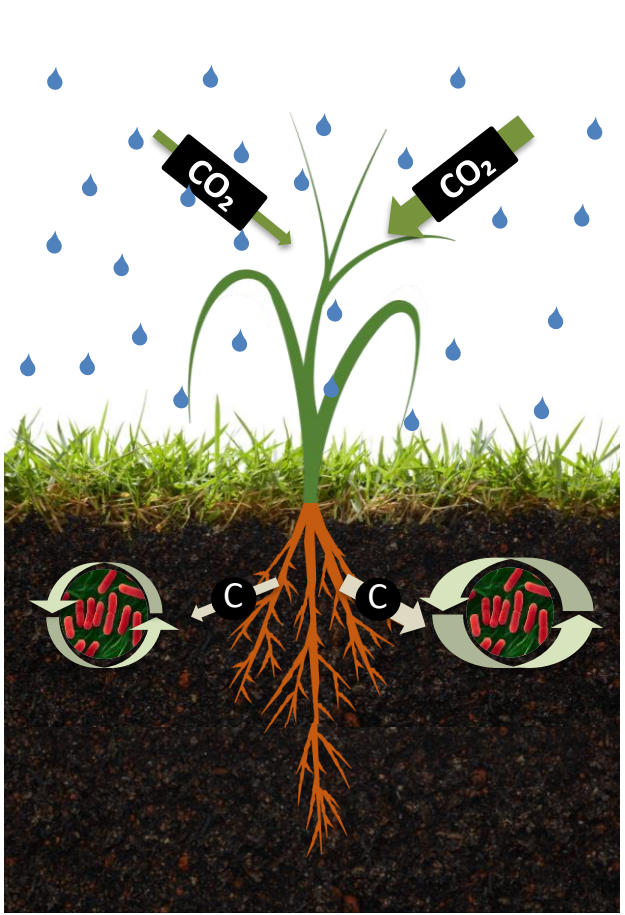
Drying

Soil matrix
↑ spatially disconnected
↑ aerobic
↓ osmotic potential

Soil microbes
↑ spatially isolated
↓ general activity
↑ survival strategies

Plant
↓ photosynthesis rate
↓? rhizodeposition

↓ plant-microbial coupling



Rewetting

Soil matrix
↑ spatially connected
↑ anaerobic
↑ osmotic potential

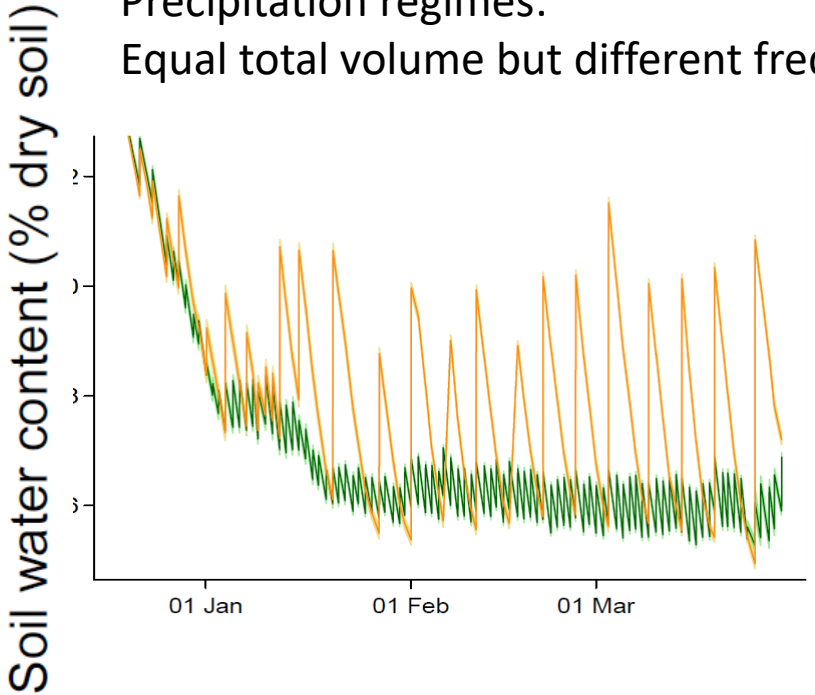
Soil microbes
↑ osmo-regulation
↑ motility
↑ burst of activity

Plant
↑ photosynthesis rate
↑? rhizodeposition

↑ plant-microbial coupling

1 Depth

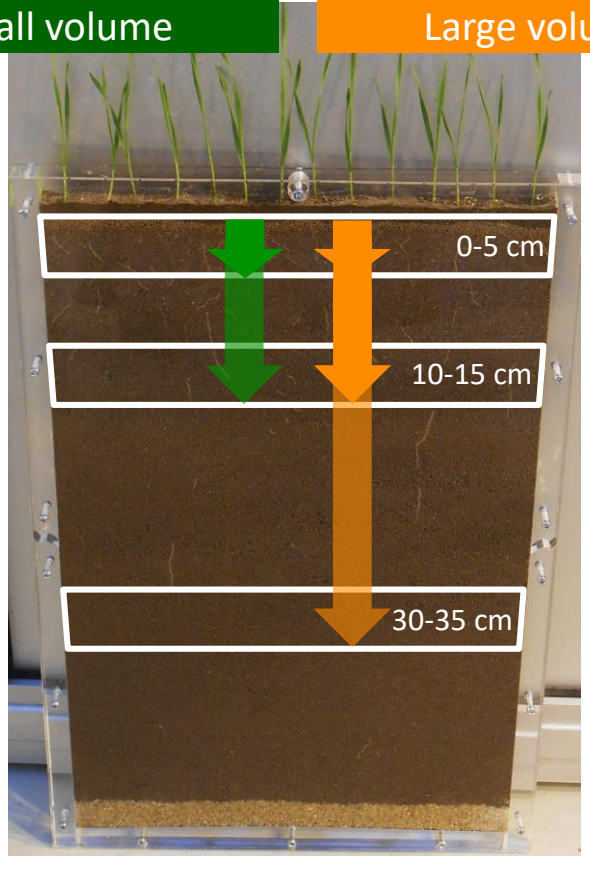
Precipitation regimes:
Equal total volume but different frequency



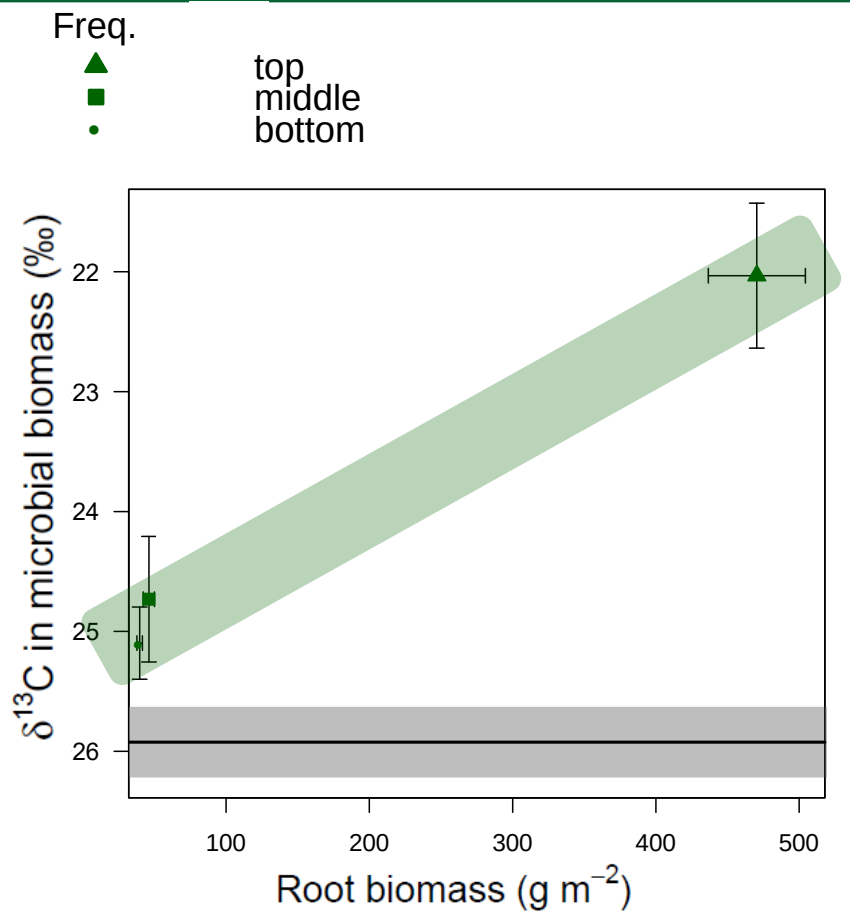
Engelhardt et al. (2018) The ISME Journal

Frequent
Small volume

Infrequent
Large volume



1 Depth



Frequent treatment:

↑ live root biomass

↓

↑ available C

↓

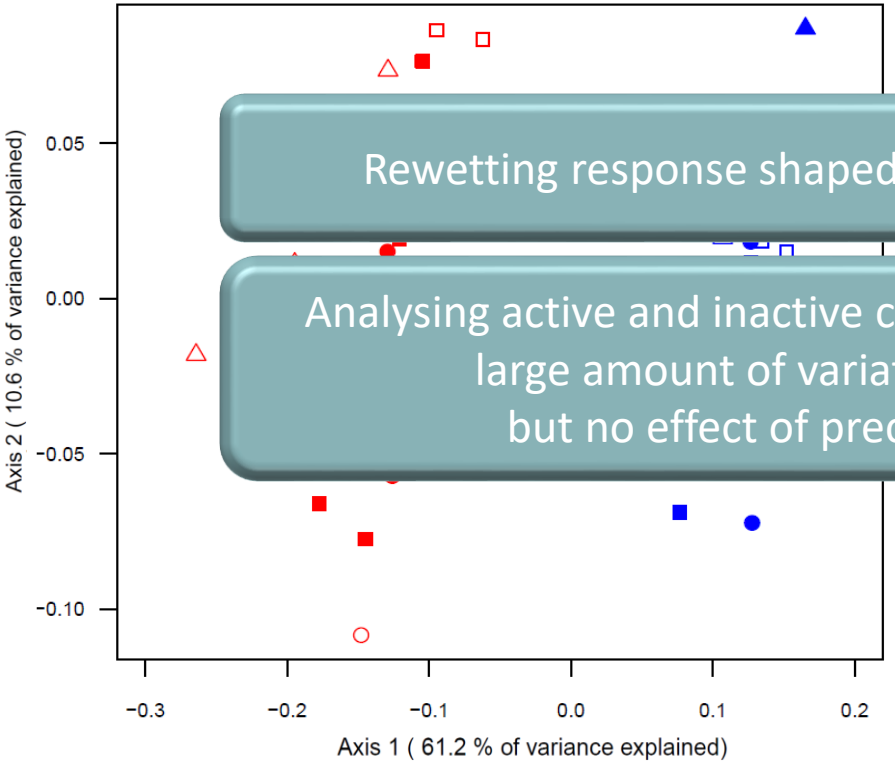
↑ ^{13}C immobilization

Infrequent treatment:

Loss of plant-microbial coupling in top soil layer

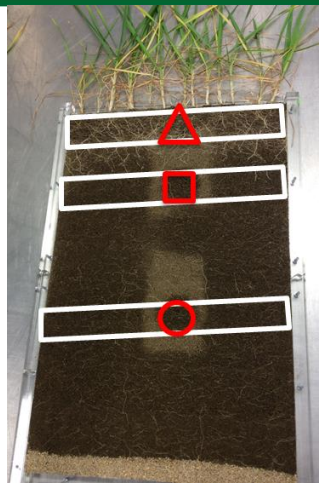
Precipitation regime legacy effect on C flux from plant to microbes

1 Depth



Rewetting response shaped bacterial communities

Analysing active and inactive community independently:
large amount of variation due to depth
but no effect of precipitation legacy



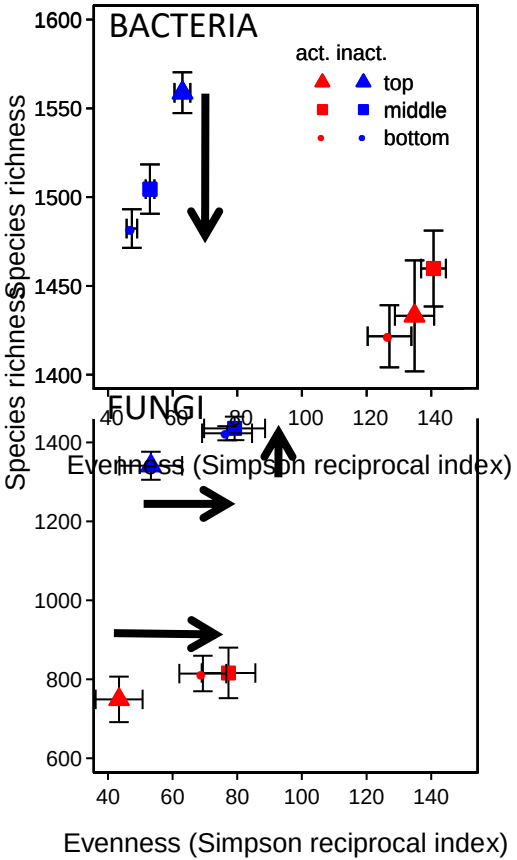
	Active	Inactive
Depth	12	20
Precipitation legacy	ns	ns
Depth x Precip. leg.	ns	ns

1 Depth

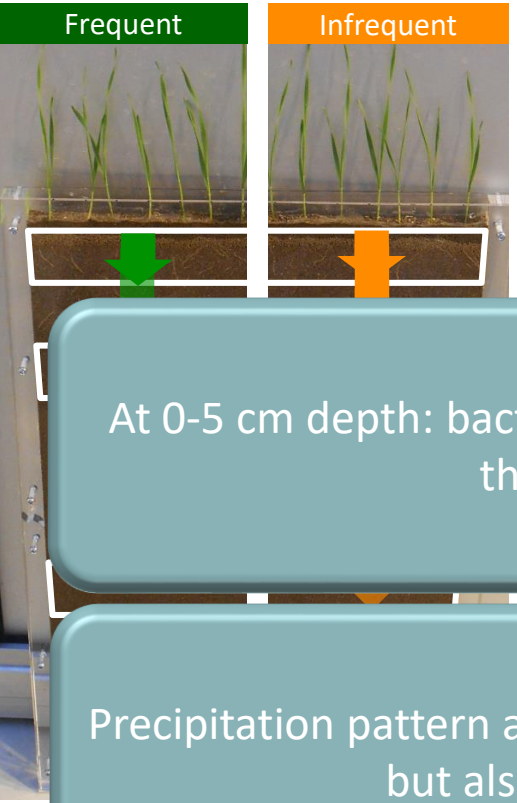
Overall: No significant effect of precipitation history on bacterial or fungal diversity, but depth response

Across different environmental conditions of the soil profile, the diversity of active bacteria is unchanged and they are phylogenetically clustered

Across precipitation treatments:



1 Depth

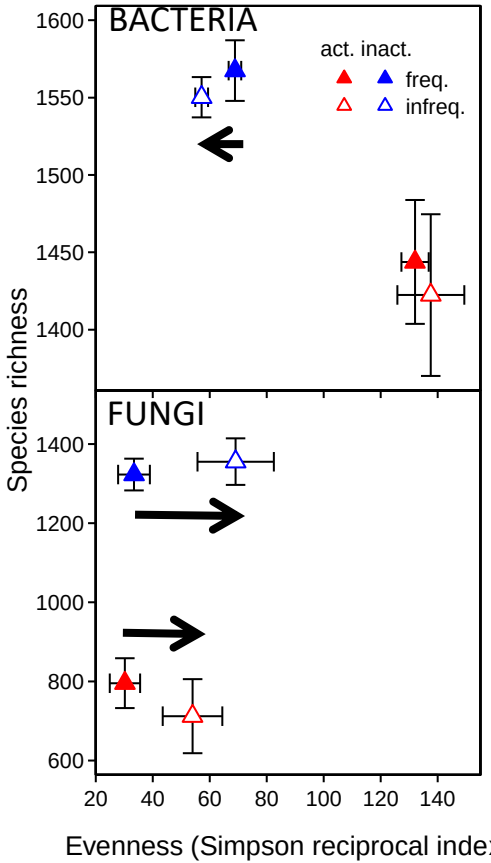


Top 0-5cm depth: significant precipitation regime effects on microbial diversity

At 0-5 cm depth: bacterial seed bank reflects legacy more than active players.

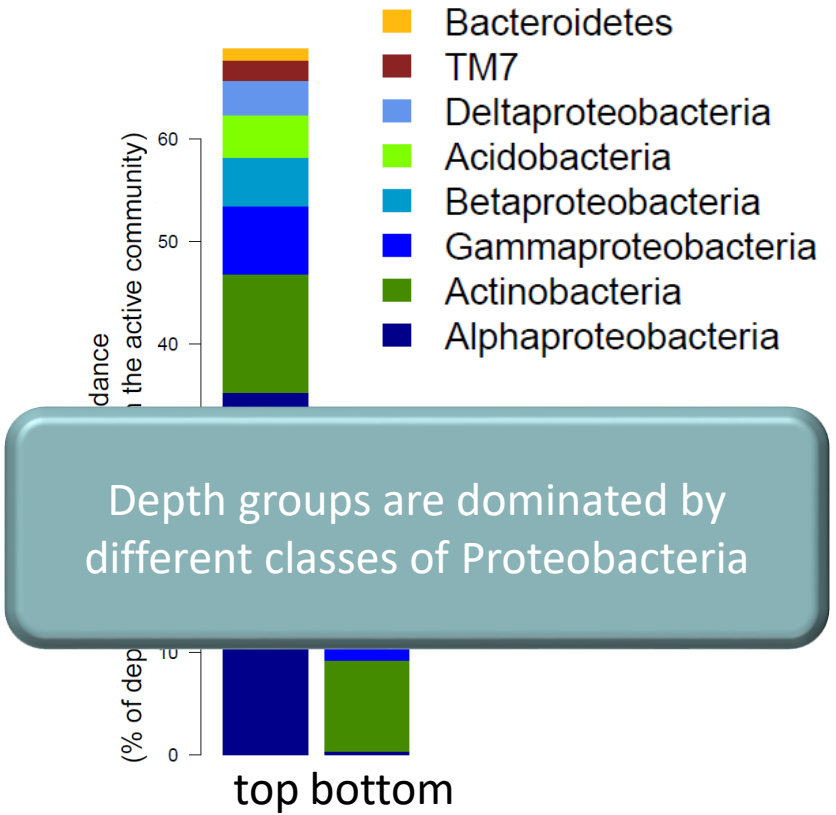
Precipitation pattern affected not only fungal:bacterial ratio but also their relative activity

In top soil:



1 Depth

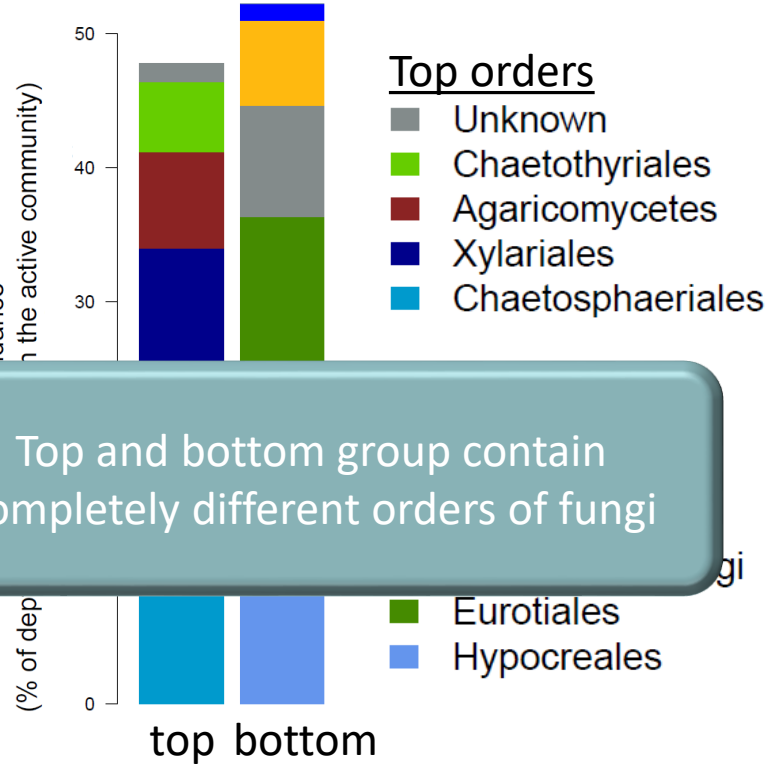
BACTERIA



Depth groups are dominated by different classes of Proteobacteria

FUNGI

dominated by phylum Ascomycota



Top and bottom group contain completely different orders of fungi

2 Nutrients and time

biomass
photosynthesis rate

N uptake

Under less frequent precipitation

Under high N inputs

N_2O

NH_4^+ (under freq water)

nitrification

amoA (archaea)
potential nitrification

NO_3^-

denitrification

nirK, nirS, nosZ1, nosZ2
potential denitrification

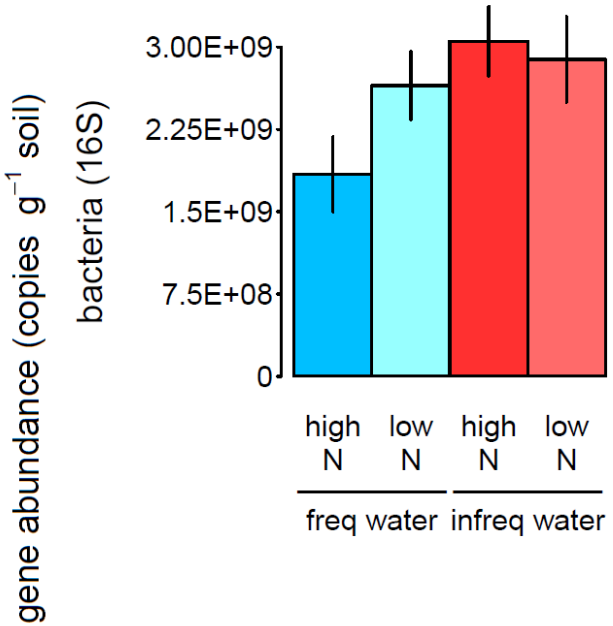
Microbial biomass N

Alternating wetter and drier conditions stimulated nitrification-denitrification sequences

N input increased plant N uptake through increased microbial turnover

Engelhardt et al. unpubl. data

② Nutrients and time



Infrequent precipitation decreased fungal:bacterial ratio

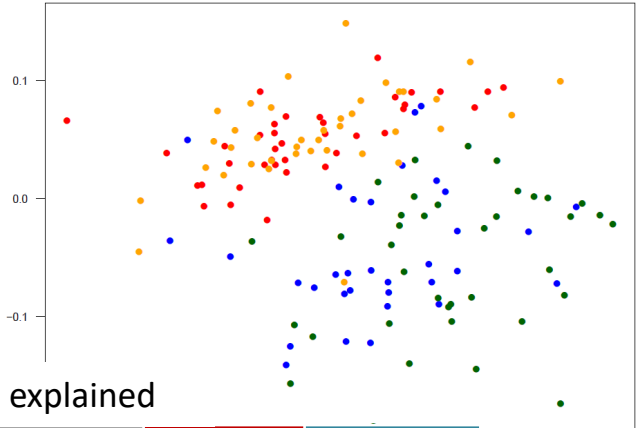
Potential consequences on soil food web stability, as well as soil C sequestration, and N retention

2 Nutrients and time

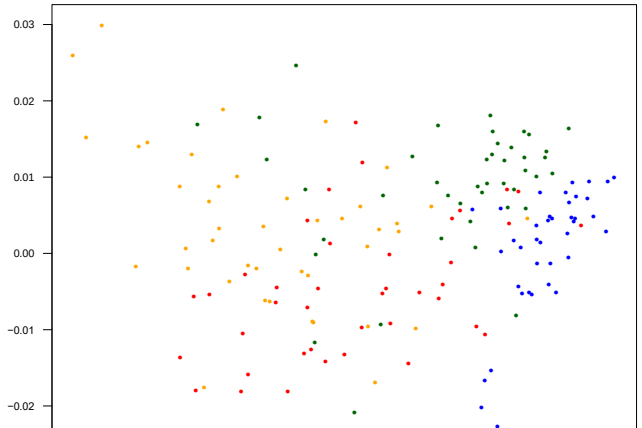
During 29 hours after rewetting:

- Frequent water, high N
- Frequent water, low N
- Infrequent water, high N
- Infrequent water, low N

BACTERIA



FUNGI



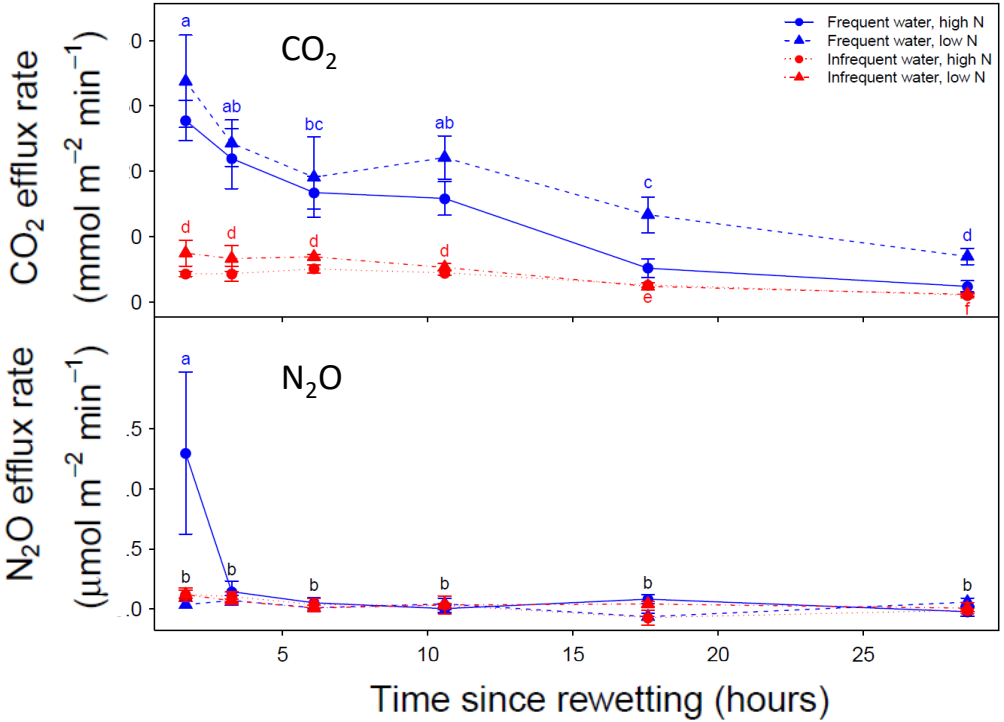
% variance explained

	Bacteria	Fungi
Precipitation legacy	18	36
N legacy	35	10
Time after rewetting	ns	ns
Precip. leg. x Time	ns	ns

Stability of the microbial community structure over time, after the large immediate response to rewetting

② Nutrients and time

Soil greenhouse gas emissions upon rewetting

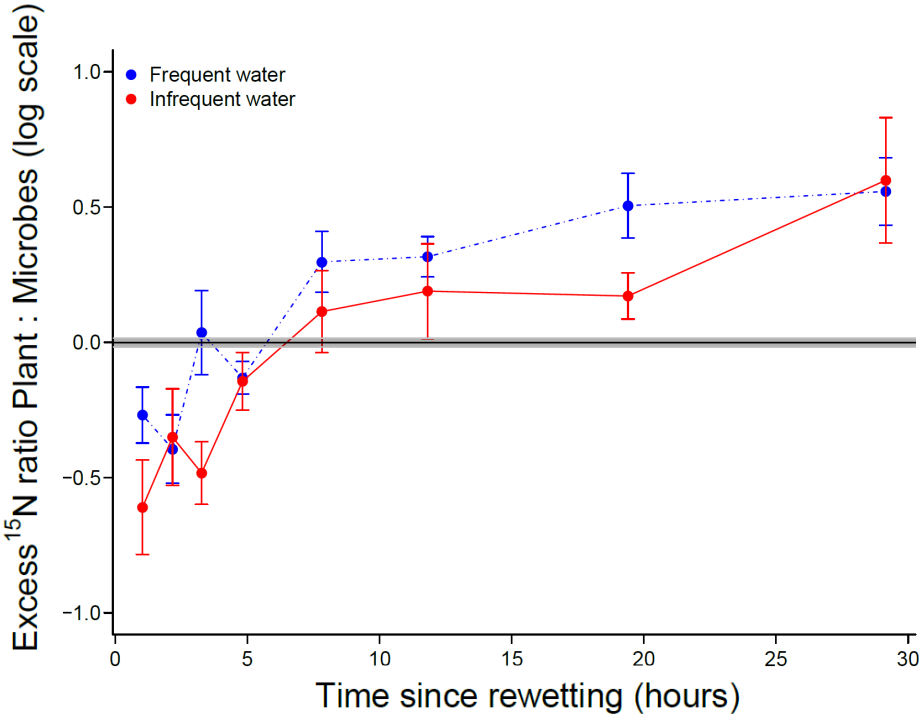


Frequent precipitation pattern enhances soil CO_2 emissions upon rewetting

Contrasts with soil-only studies: contribution of root respiration

2 Nutrients and time

Plant-microbial competition for soil inorganic N



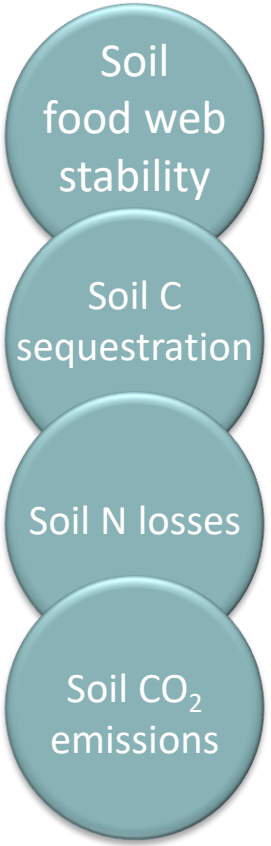
Frequent precipitation pattern enhances plant competitiveness for N after rewetting

Impact

- Depth shapes structure of soil microbial community more than precipitation legacy
- Top soil is where precipitation history matters:
  - > shift in fungal vs bacterial dominance
  - > loss of plant microbial coupling under infrequent precipitation
- N cycling is stimulated by dry-wet amplitude
- Soil CO_2 emissions upon rewetting are related to both root respiration and soil microbial activity

Next challenge: predictability

Ecosystem property at stake:



Thanks

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