Short and long-term responses of soil CO_2 effluxes under drought

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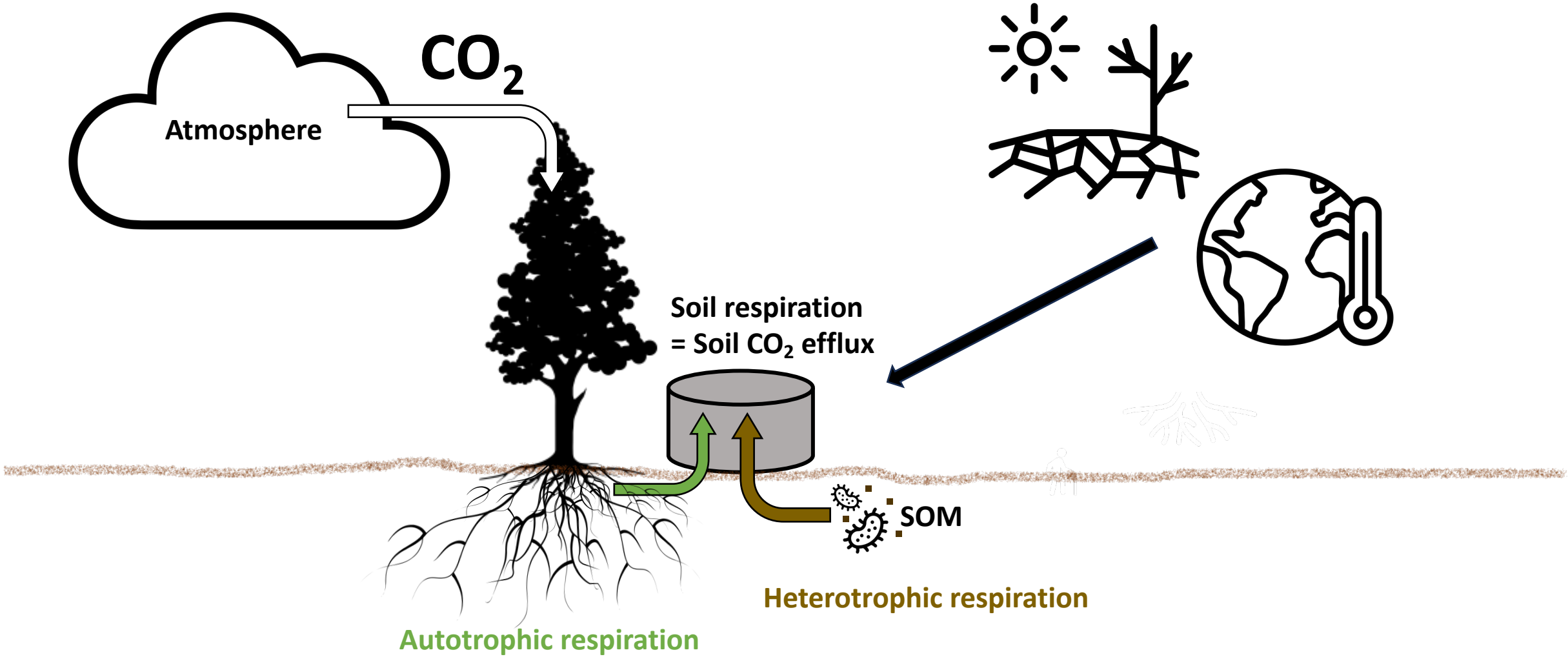
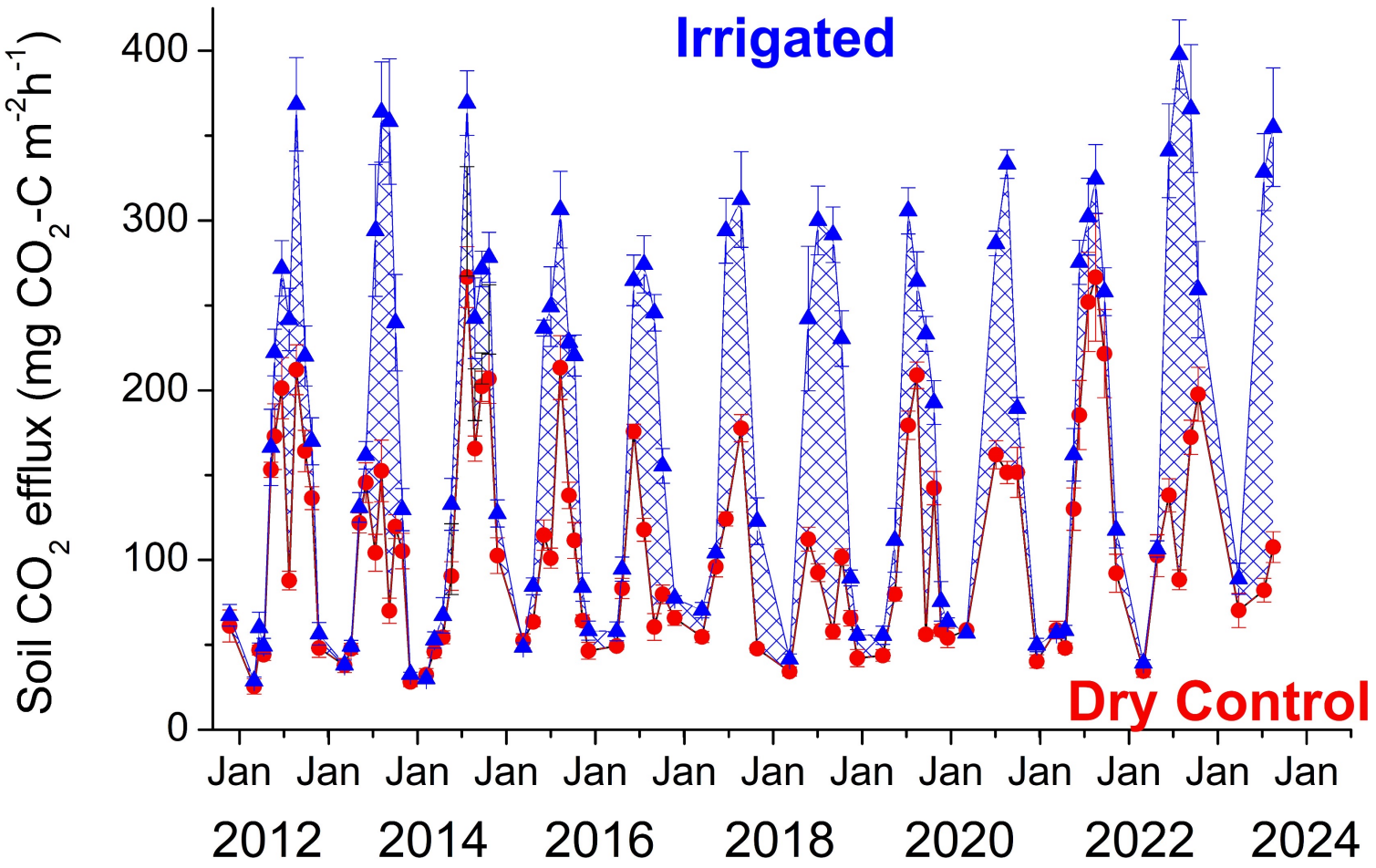
Pfynwald Workshop – 07.03.2024

RADIOCARBON INVENTORIES OF SWITZERLAND
An integrated approach to understand the changing carbon cycle

Introduction: Soil respiration

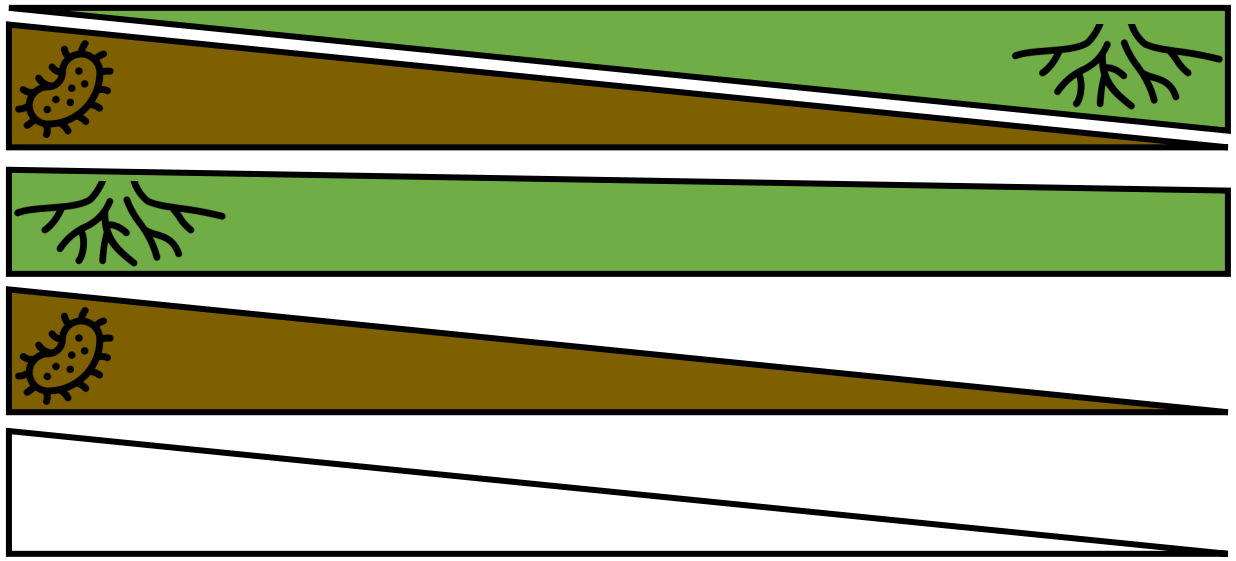


Pfynwald: Long-term pattern of soil CO_2 efflux



Soil respiration under drought

^{13}C and ^{14}C signatures of CO_2



Rel. source contribution of soil respiration

Root respiration

Microbial activity

Soil respiration rates

Moist

Drought

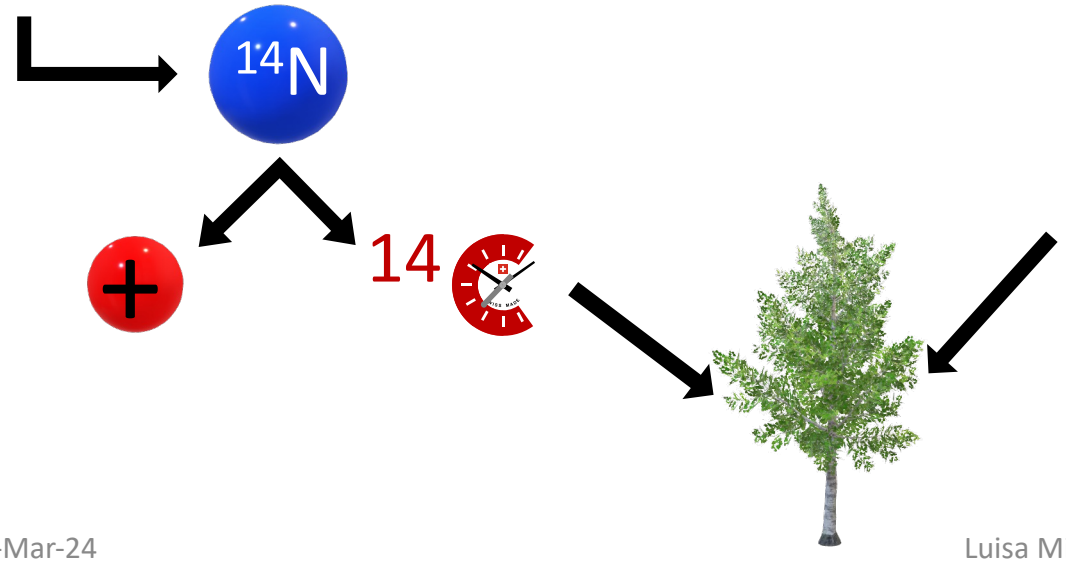
Introduction: Radiocarbon

Half-life:
~ 5700 years

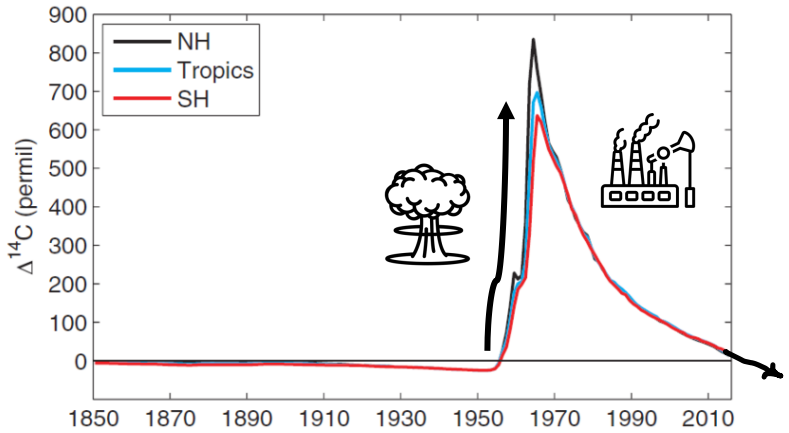
Age
Turnover times
Sources

Radiocarbon production and distribution

Naturally:
Cosmic radiation

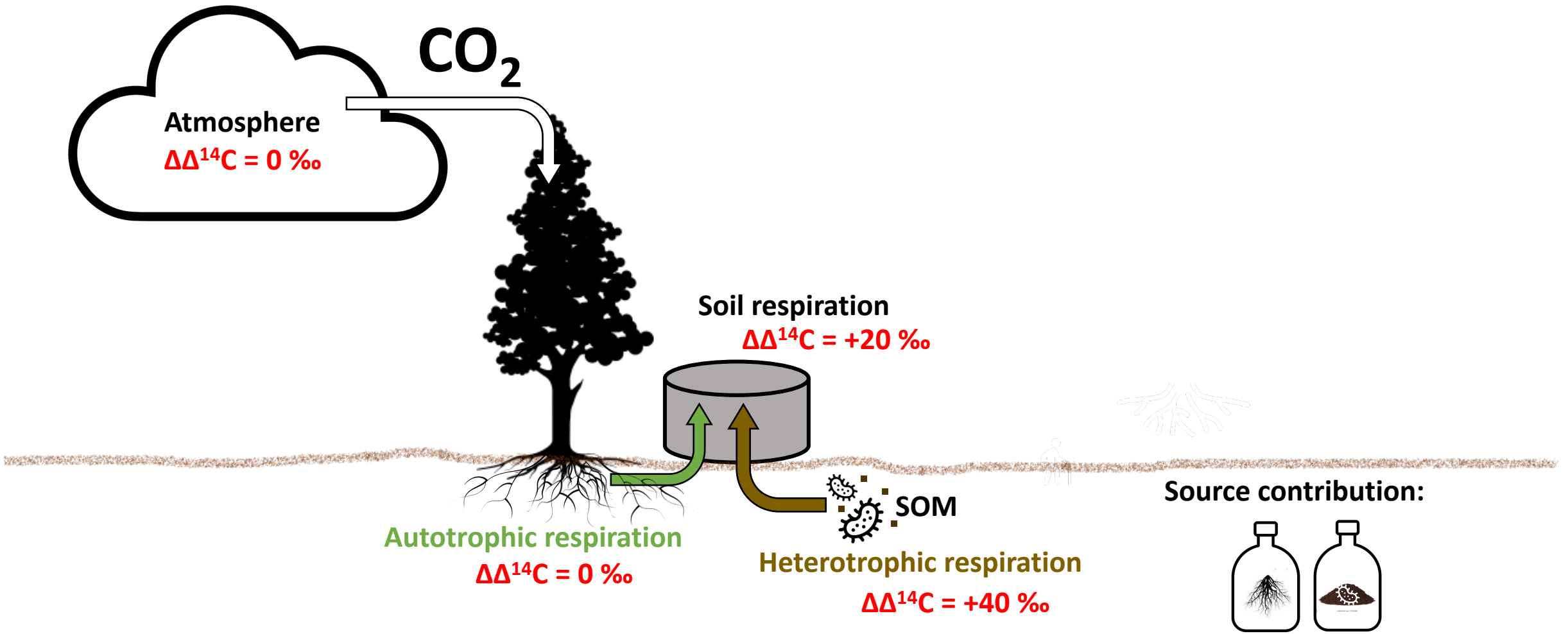


Artificially:
Nuclear bomb testing



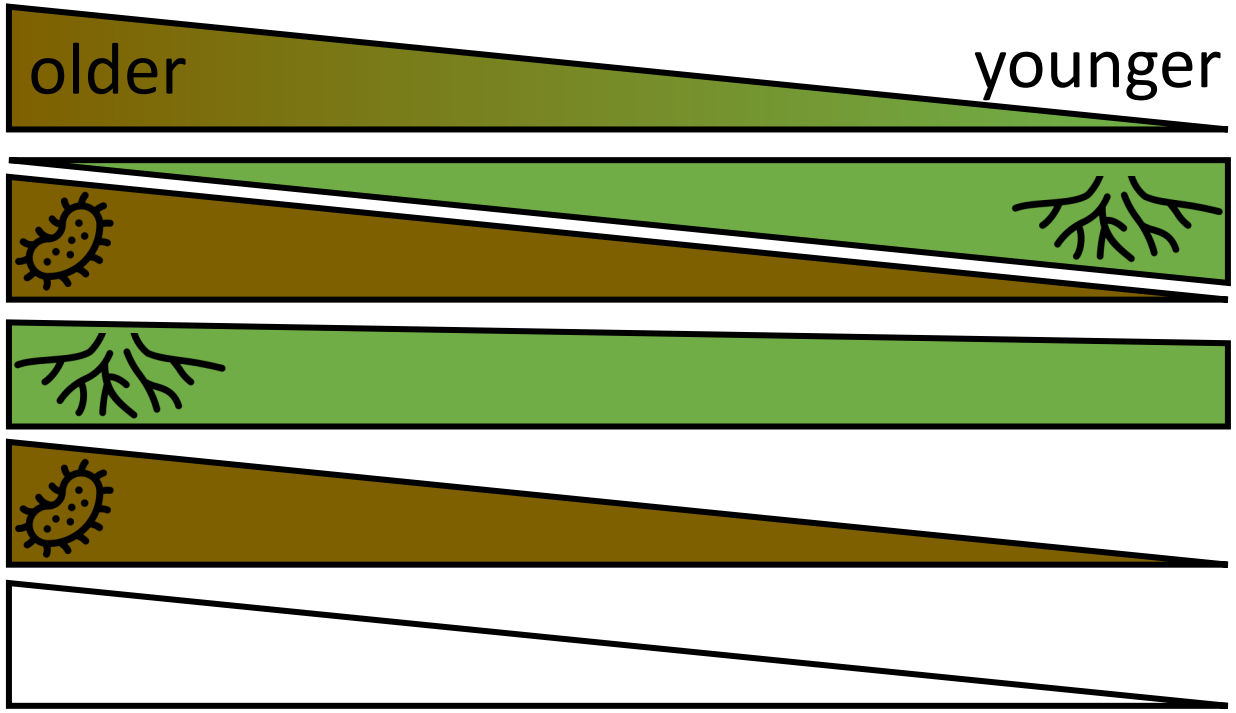
Graven et al. 2020

Introduction: Source contribution of soil respiration



values from Schuur et al. 2016

Hypotheses: Soil respiration under drought



$^{14}CO_2$ age of soil respiration

Rel. source contribution of soil respiration

Root respiration

Microbial activity

Soil respiration rates

Moist **Drought**

e.g. Borken et al. 2006

Motivation: Investigation of drought-related changes on the C cycle of forest ecosystems: short-term vs. long-term

Differences: Short vs. long-term drought ?

- ^{14}C age of soil-respired CO_2
- Source contribution:  vs. 

Seasonal variation in control and drought condition ?

- ^{14}C age of soil-respired CO_2
- Source contribution

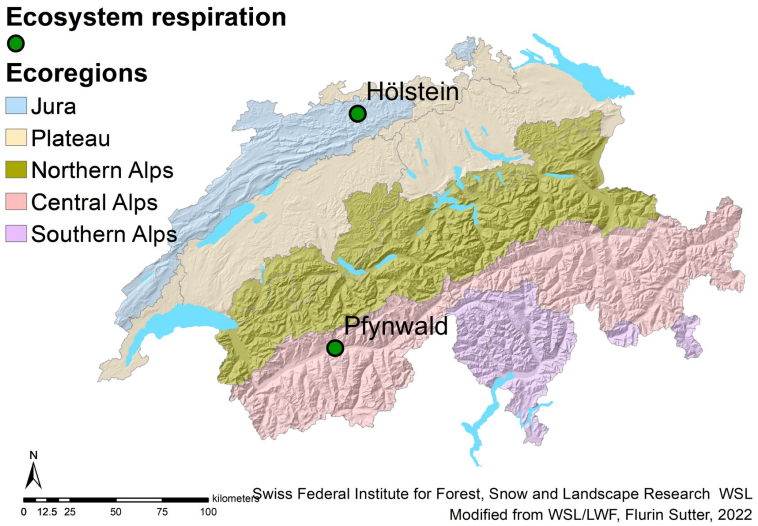
Study sites

Hölstein

MAT: 9.0 °C, **MAP:** 1009 mm

Veg: European beech, Norway spruce

Soil: Calcareous loamy sand



Pfynwald

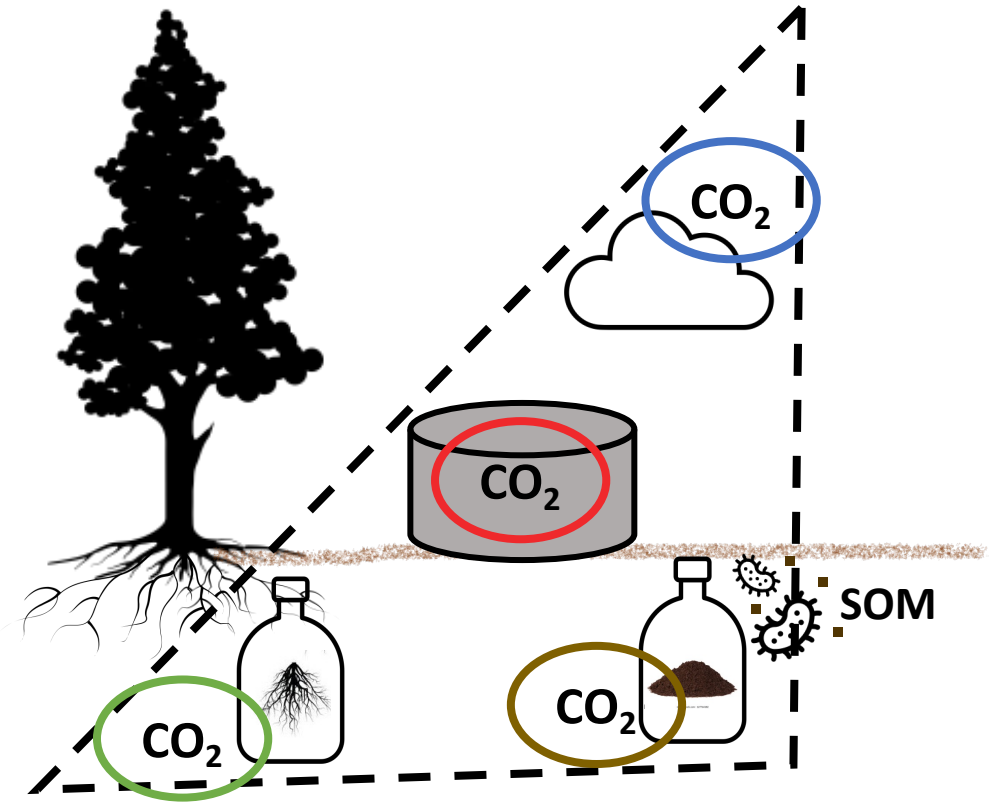
MAT: 9.2 °C, MAP: 518 mm

Veg: Scots pine

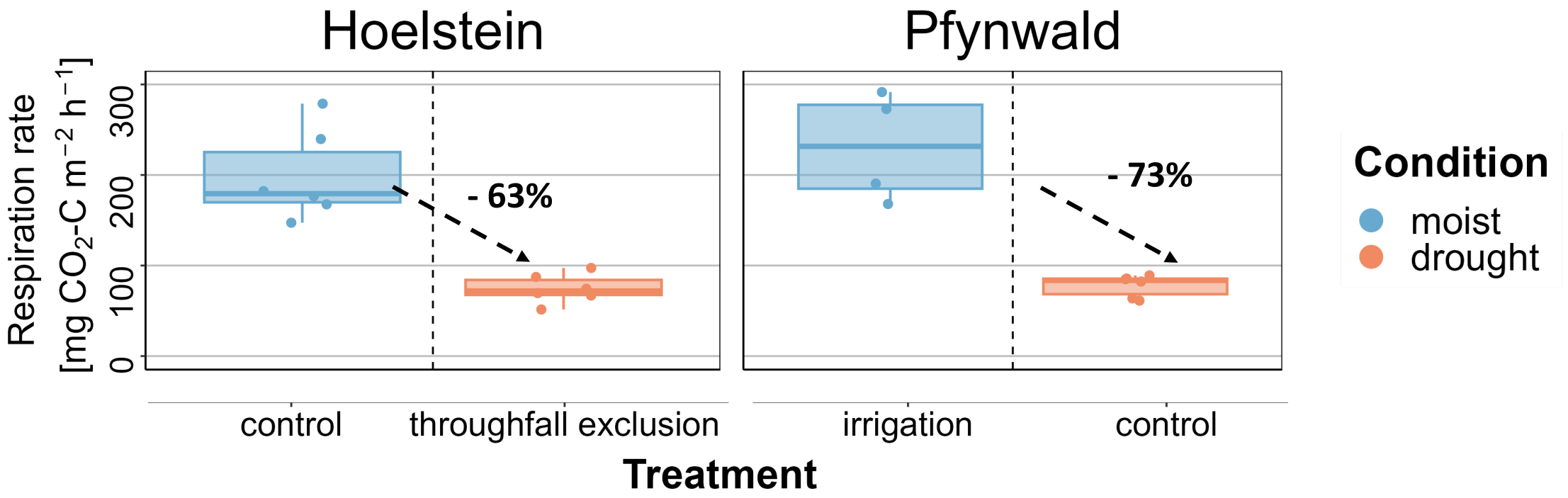
Soil: Shallow Pararendzina

Approach

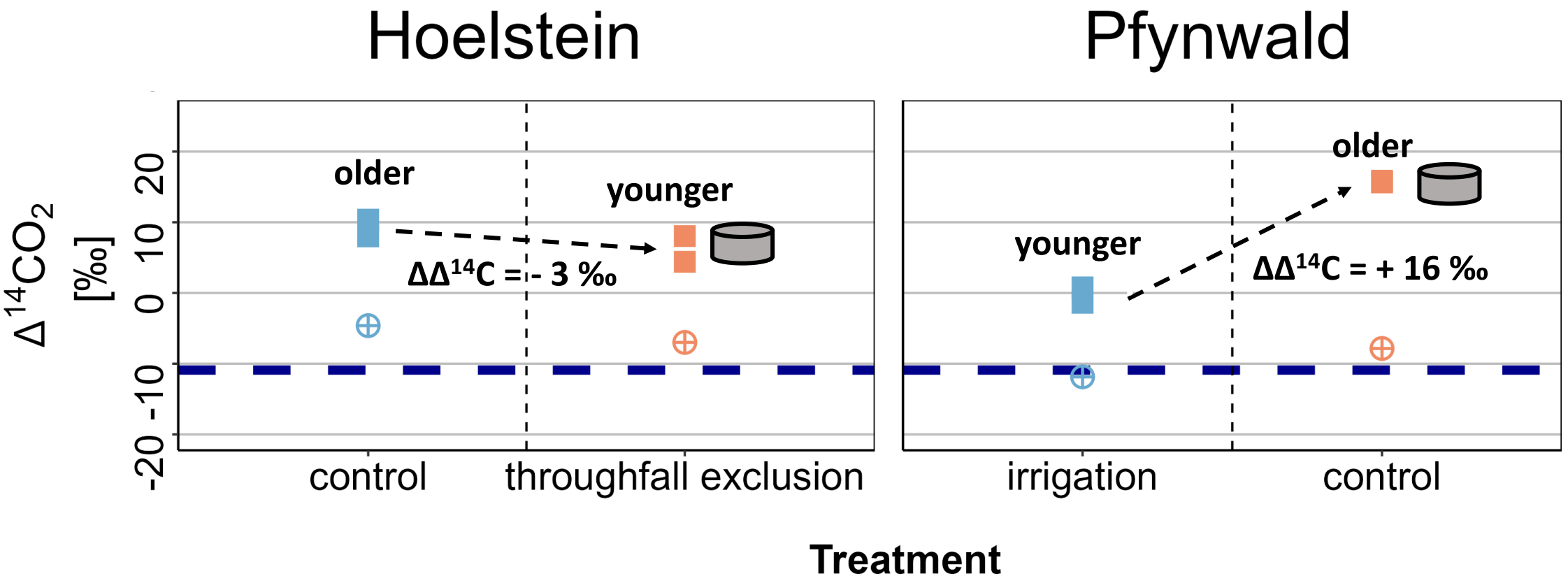
Hölstein control	Hölstein throughfall exclusion	Pfynwald irrigation	Pfynwald control



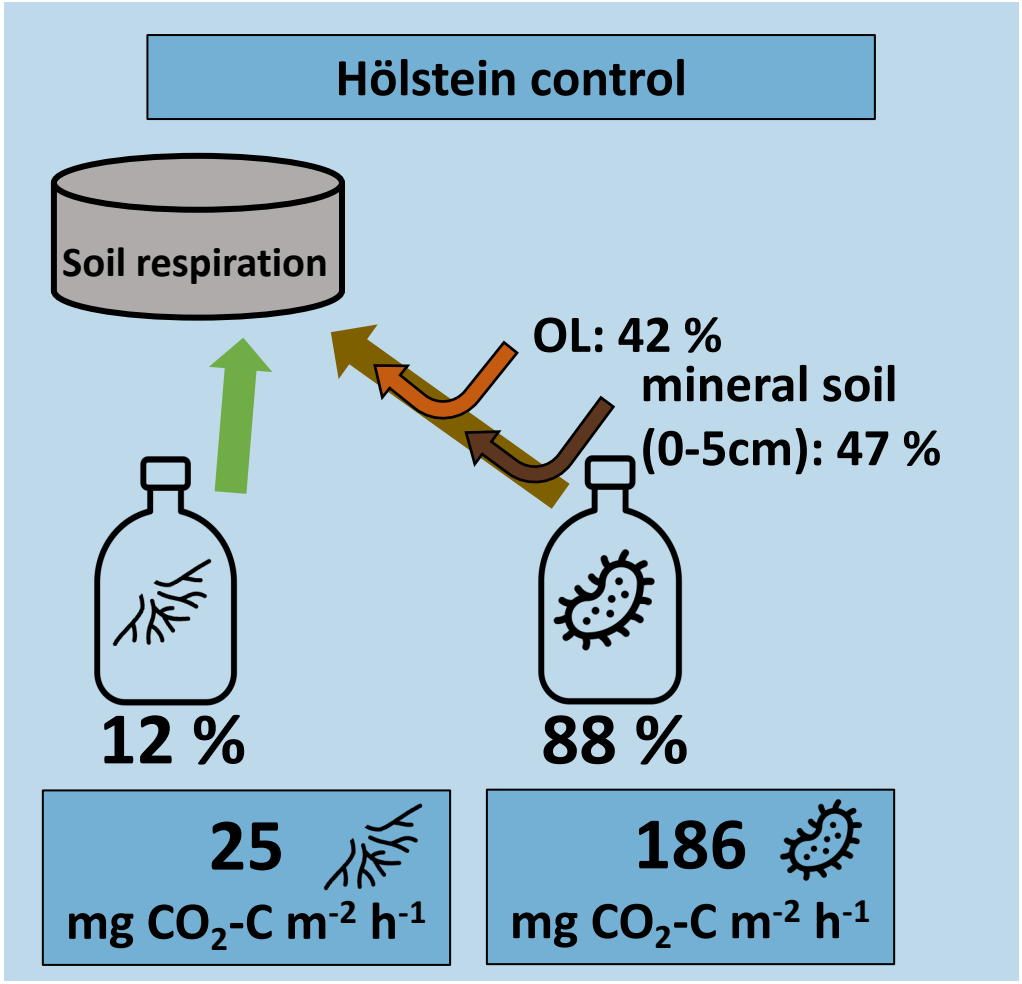
Soil respiration rates

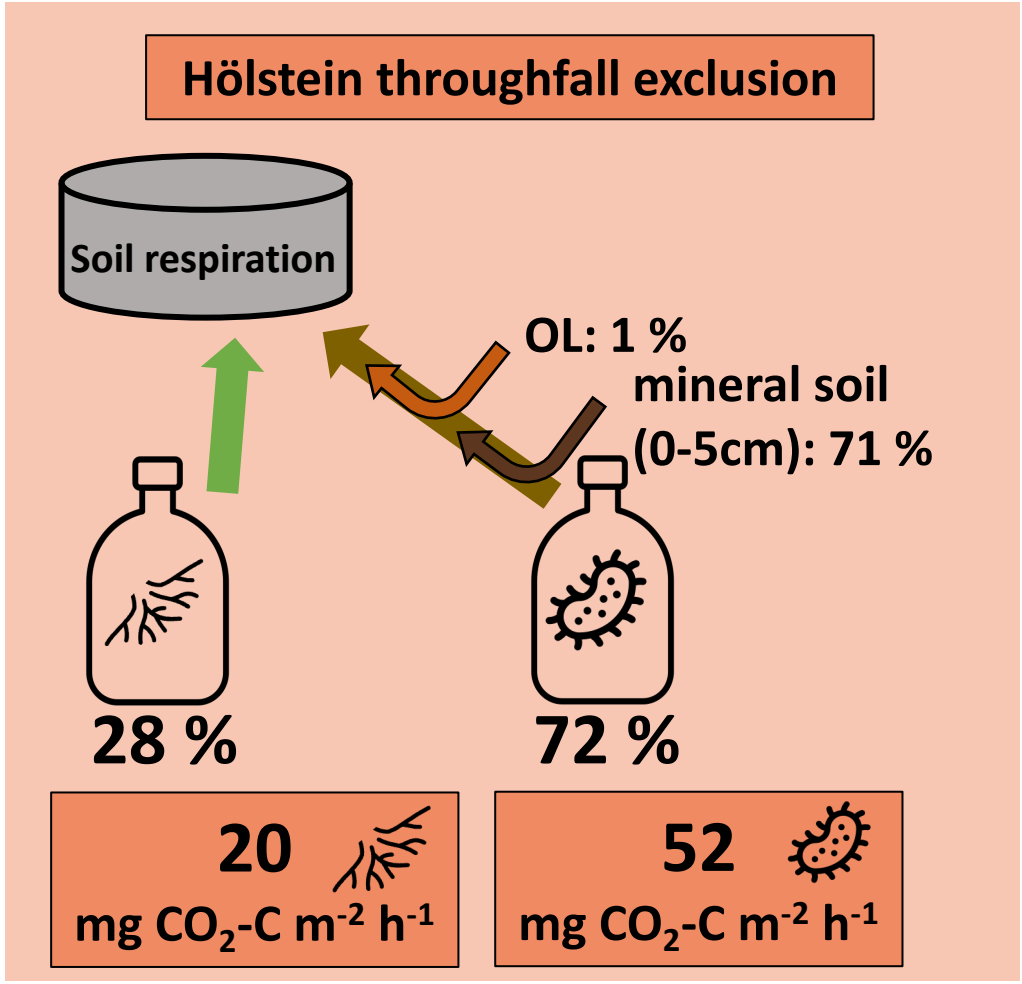


$^{14}CO_2$ of total soil respiration

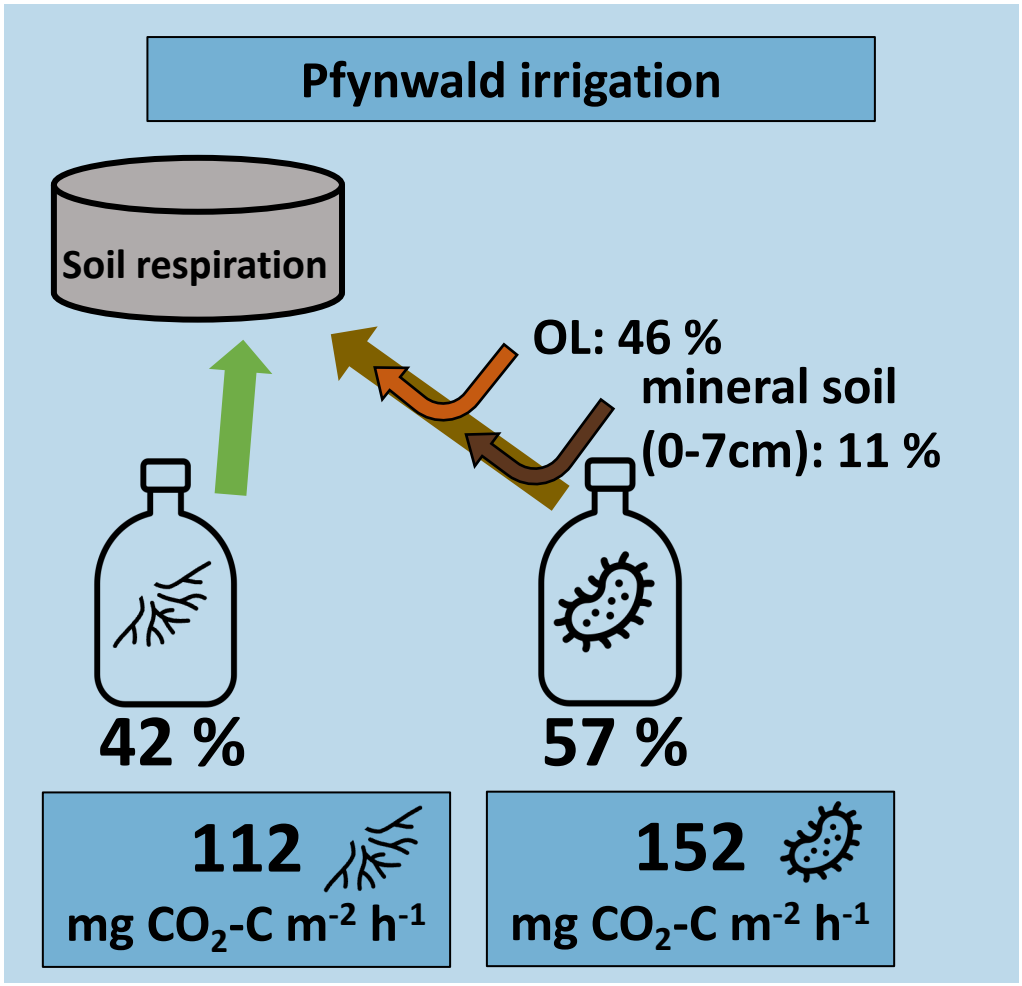


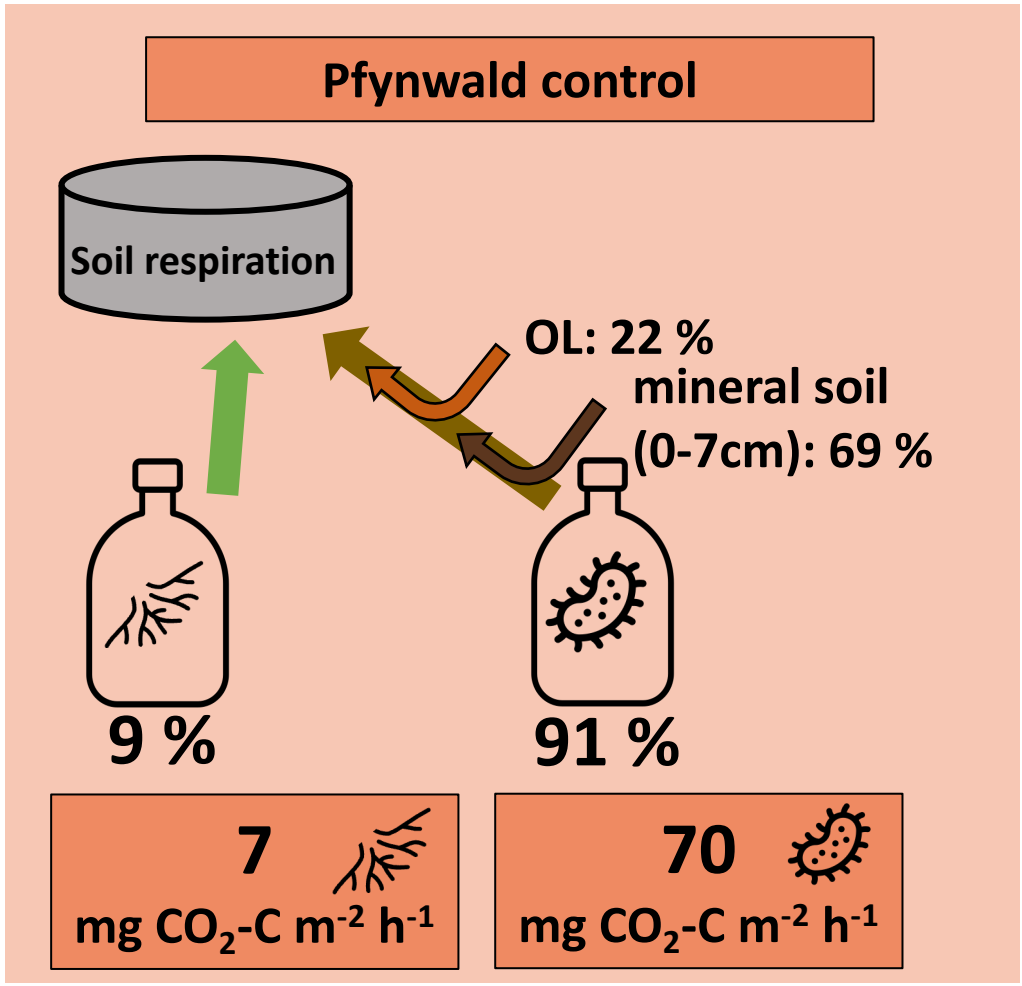
Short-term drought: Source contribution





Long-term drought: Source contribution

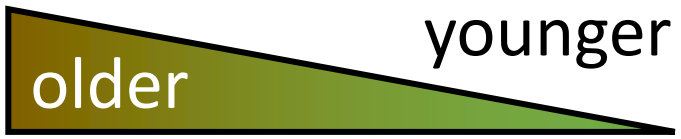




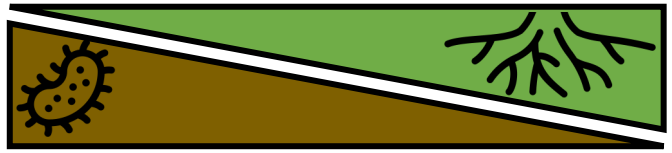
Short-term vs. long-term drought effects

Short-term drought effects

Long-term drought effects

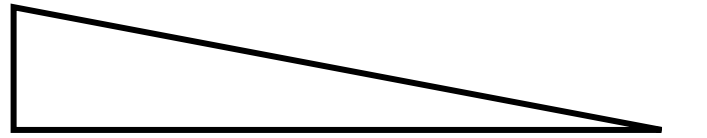


$^{14}CO_2$ age of soil respiration



Source contribution of soil respiration

Soil respiration rates

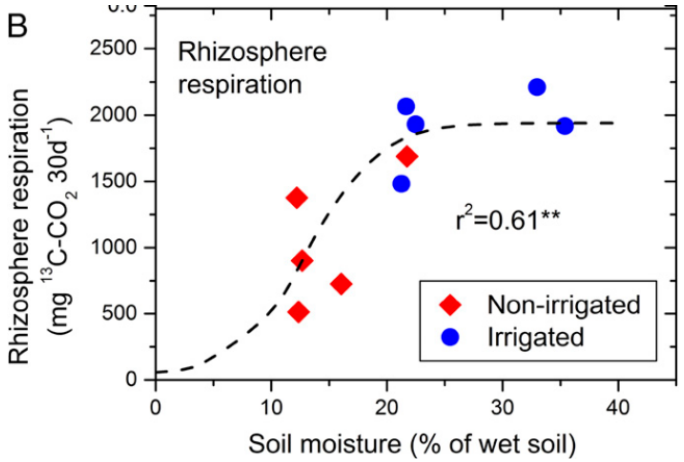


Long-term irrigation effects

Fine root biomass

Brunner et al. 2019:

Fine root biomass ~80% higher in irrigation treatment



Joseph et al. 2023

Contribution of autotrophic respiration decreased in drought

Redistribution of C stocks

Guidi et al. 2022:

Reduced C transfer from organic layers to mineral soil in dry control treatment

Older SOC in dry control, because of reduced input of new C

Thank you!

Supervisors

Frank Hagedorn
Tim Eglinton

RICH 14
RADIOCARBON INVENTORIES OF SWITZERLAND
An integrated approach to understand the changing carbon cycle

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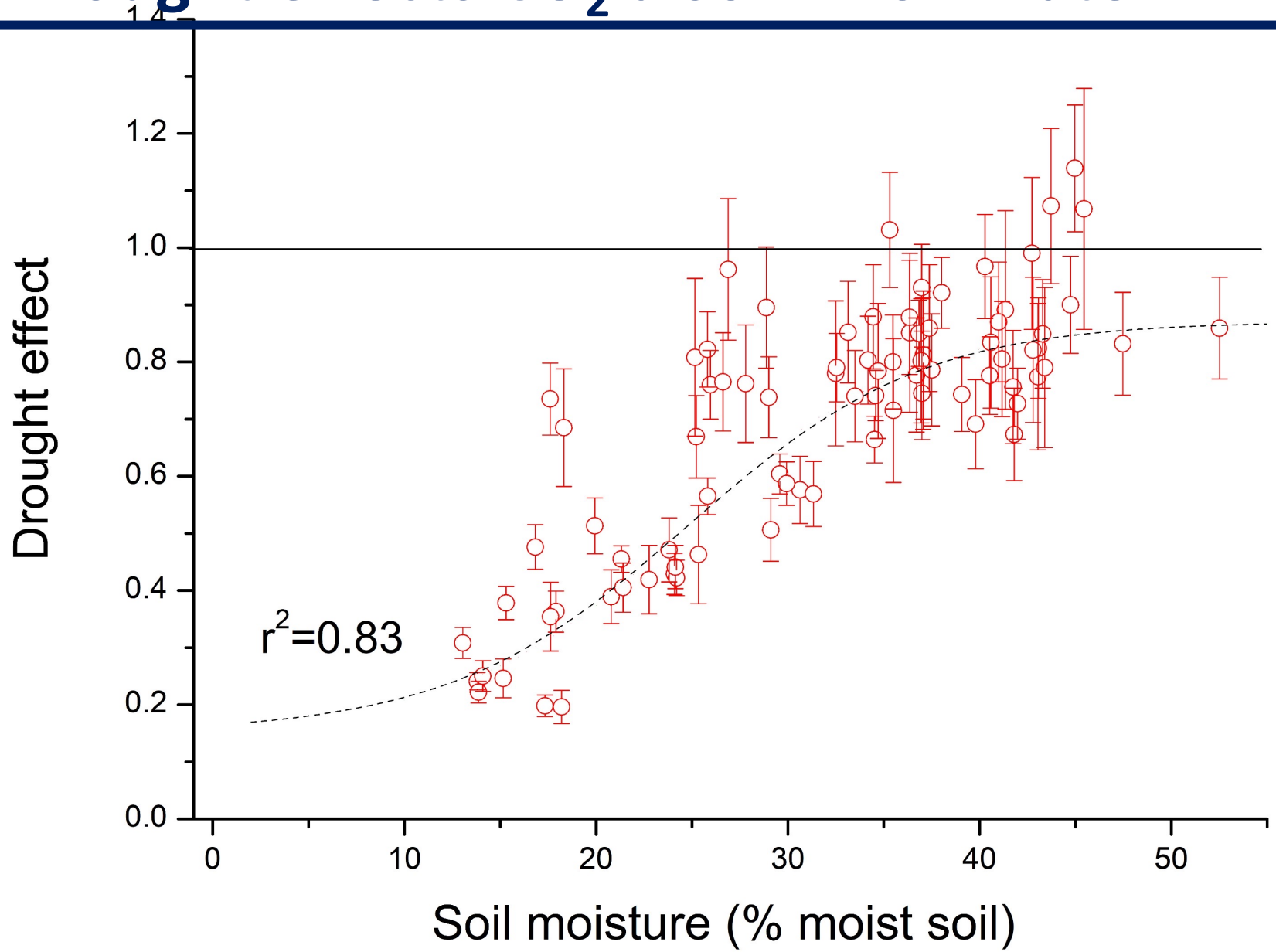
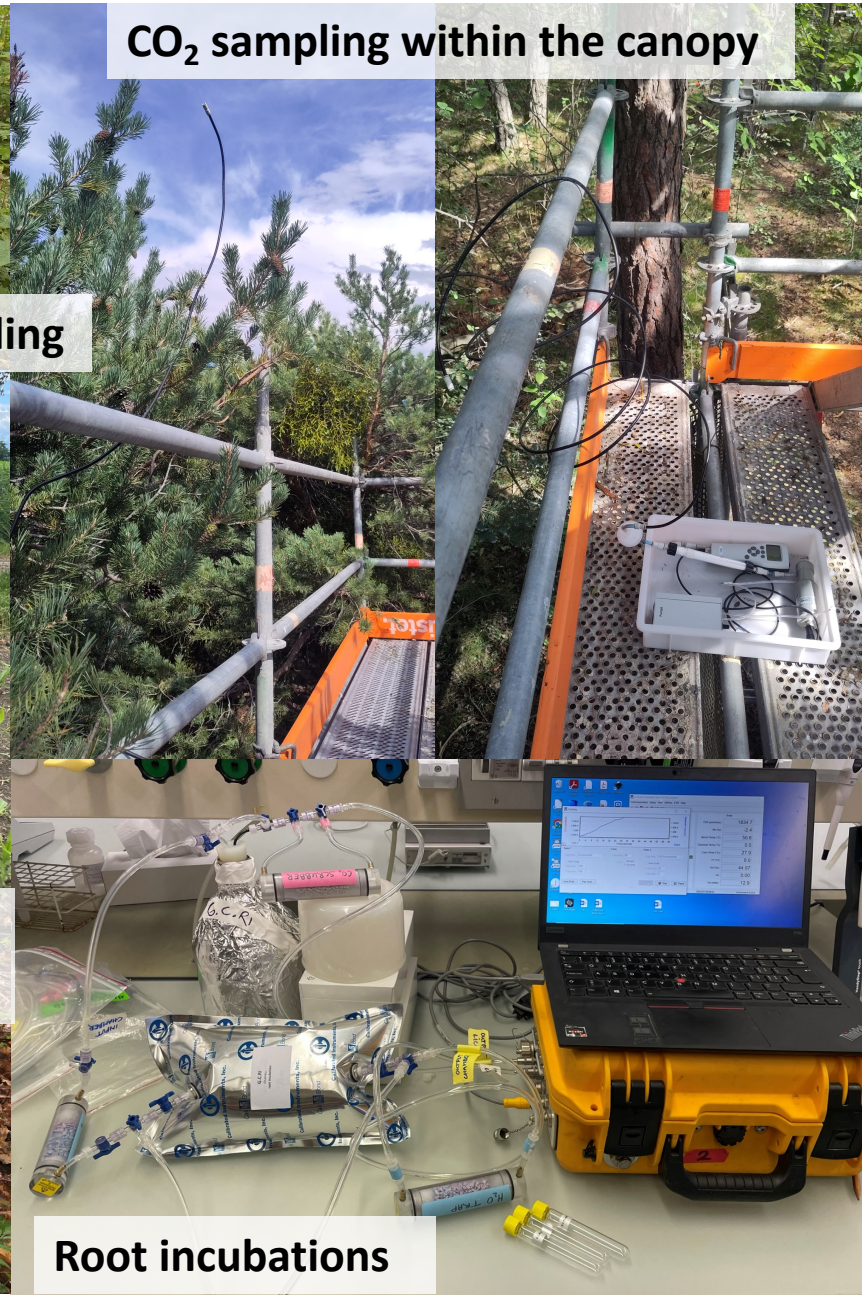
Katrin Di Bella Meusburger

Drought effects CO_2 also in non water limiting conditions

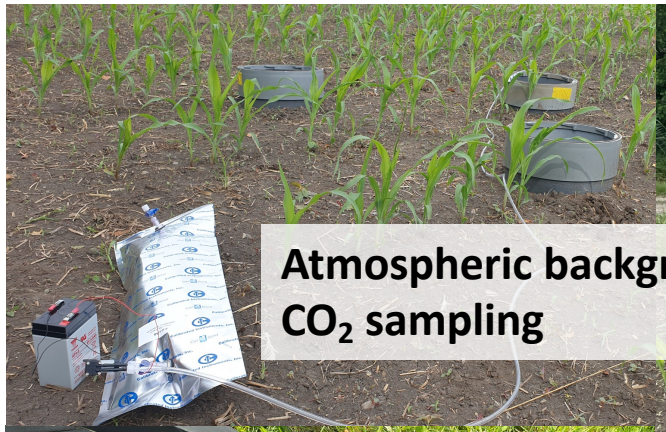


Sampling campaign

Soil-respired CO_2 sampling

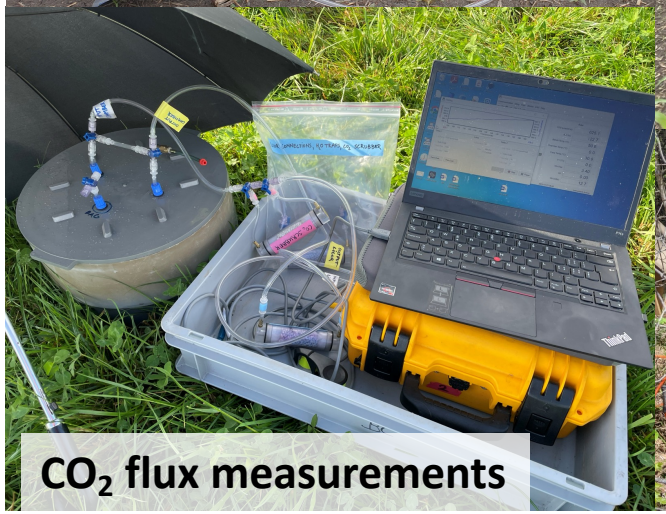


CO_2 sampling within the canopy



Atmospheric background CO_2 sampling

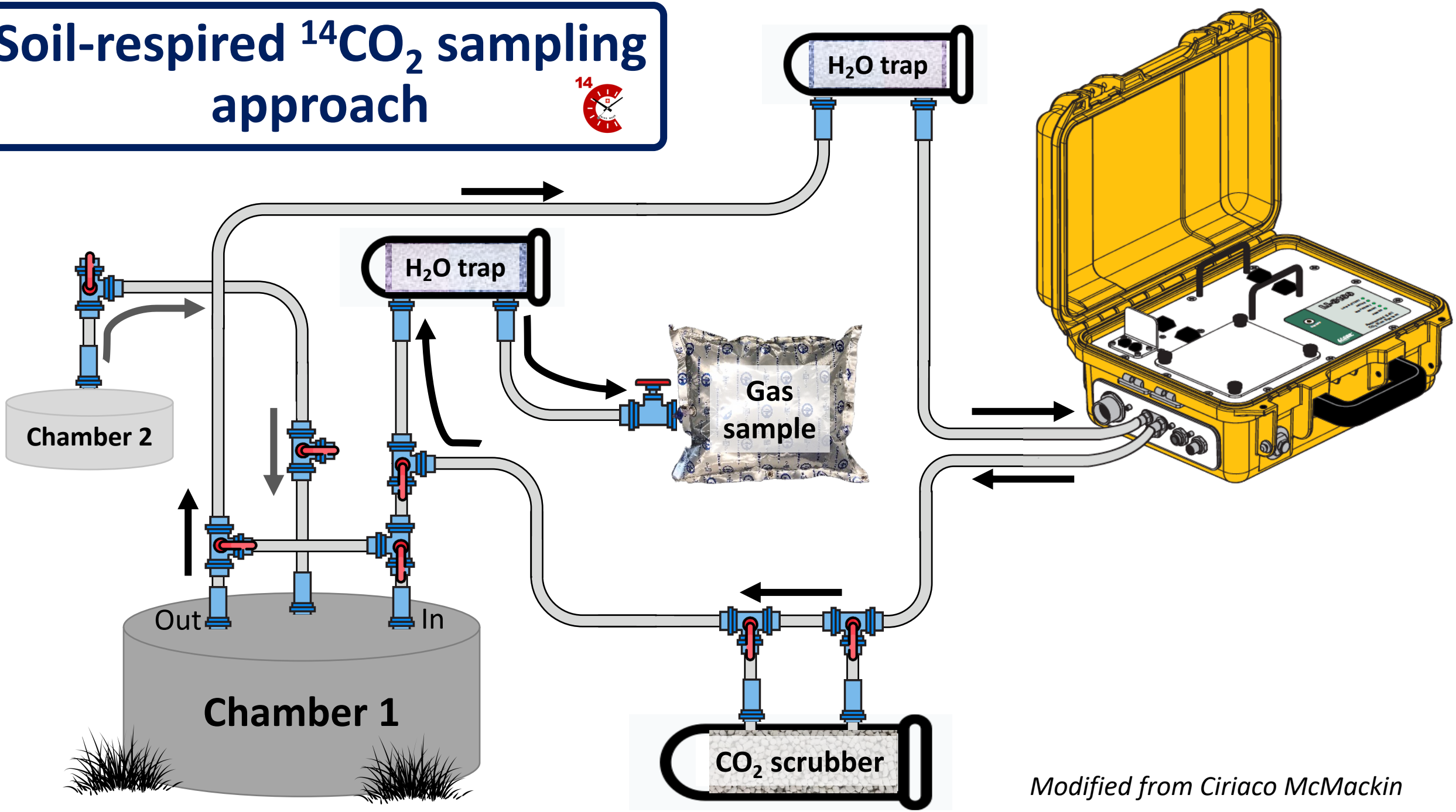
Continuous high temporal resolution CO_2 flux measurements



CO_2 flux measurements

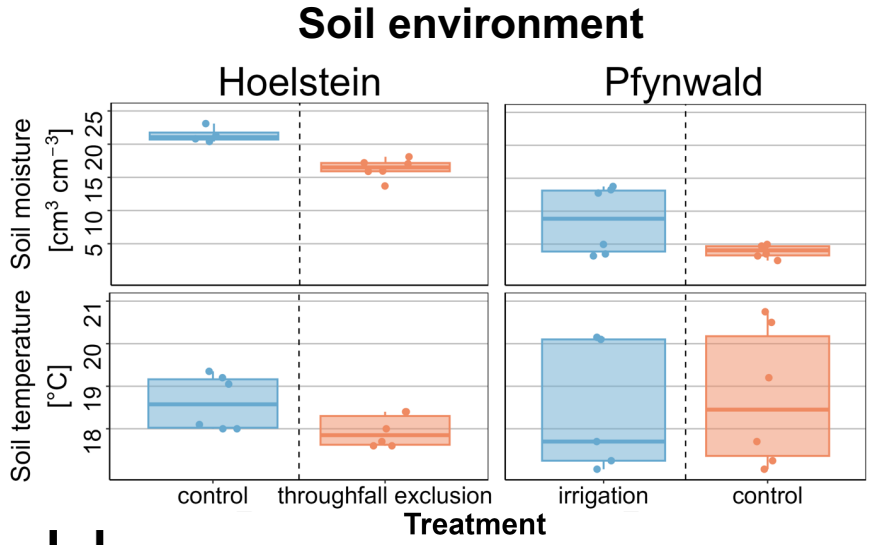
Root incubations

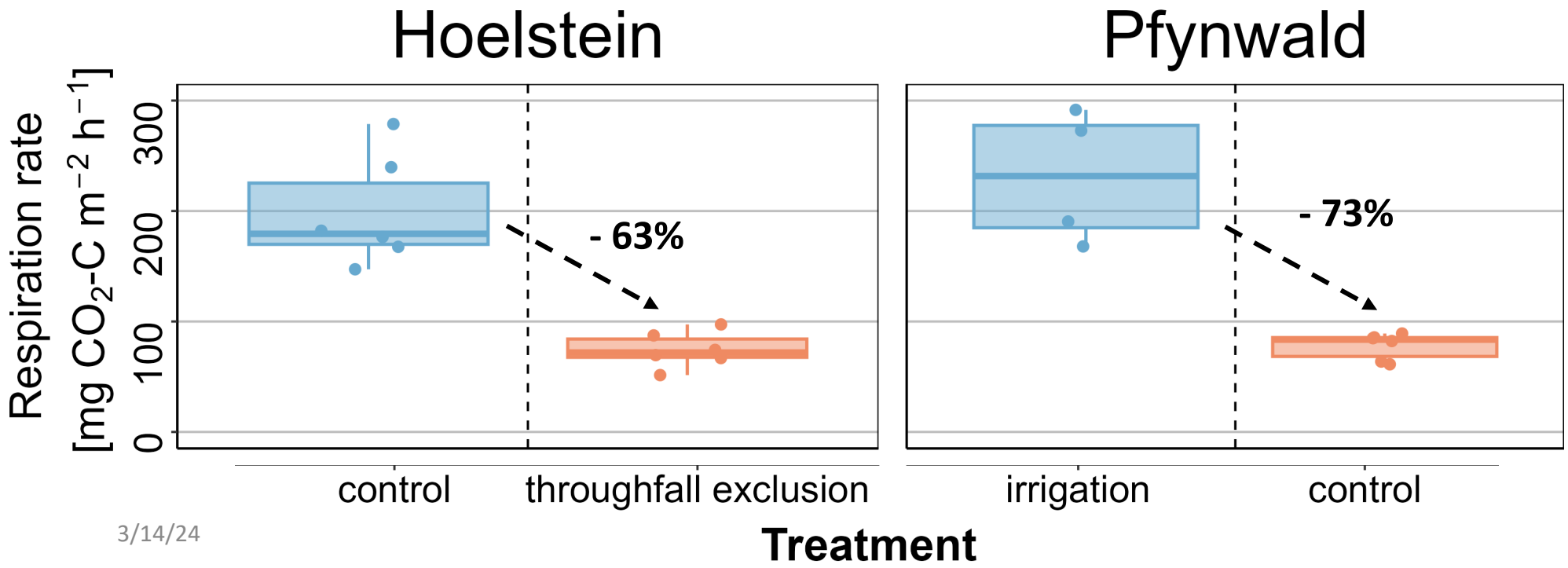
Soil-respired $^{14}CO_2$ sampling approach



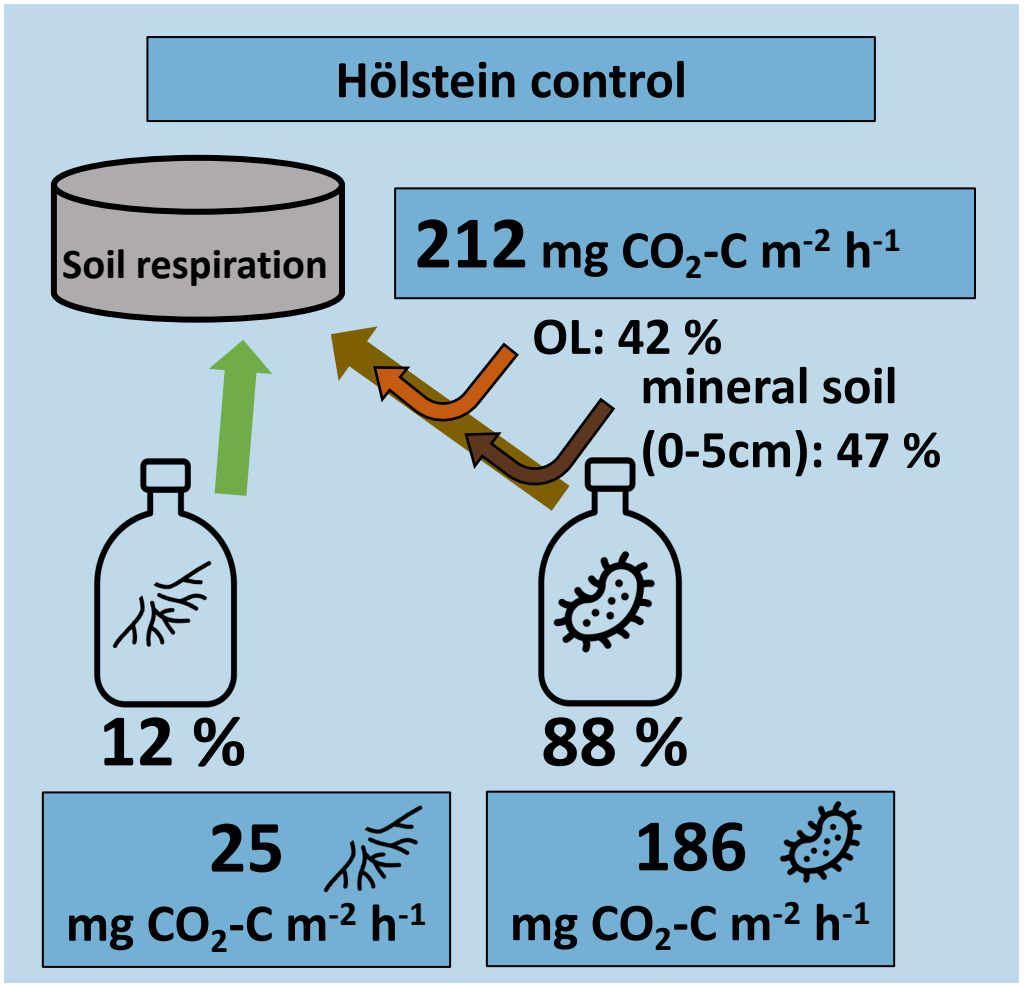
Modified from Ciriaco McMackin

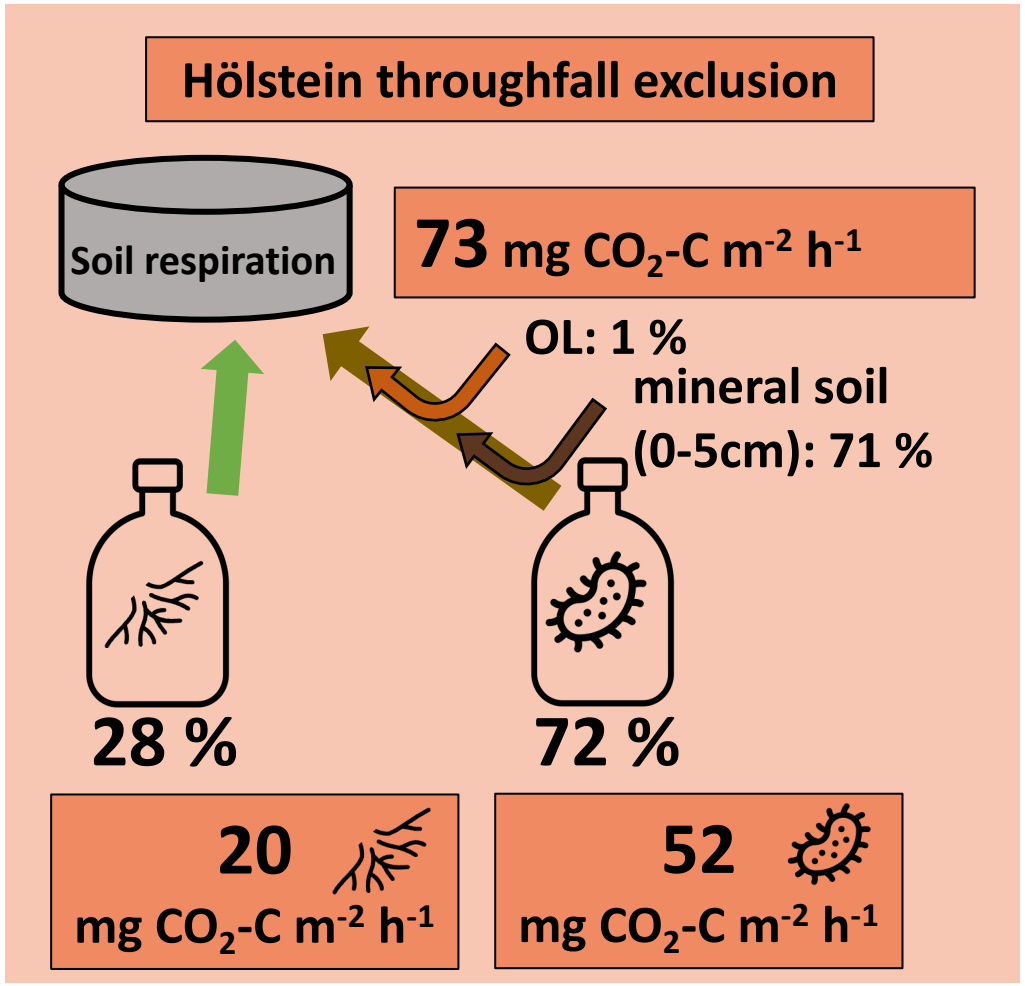
Soil respiration rates



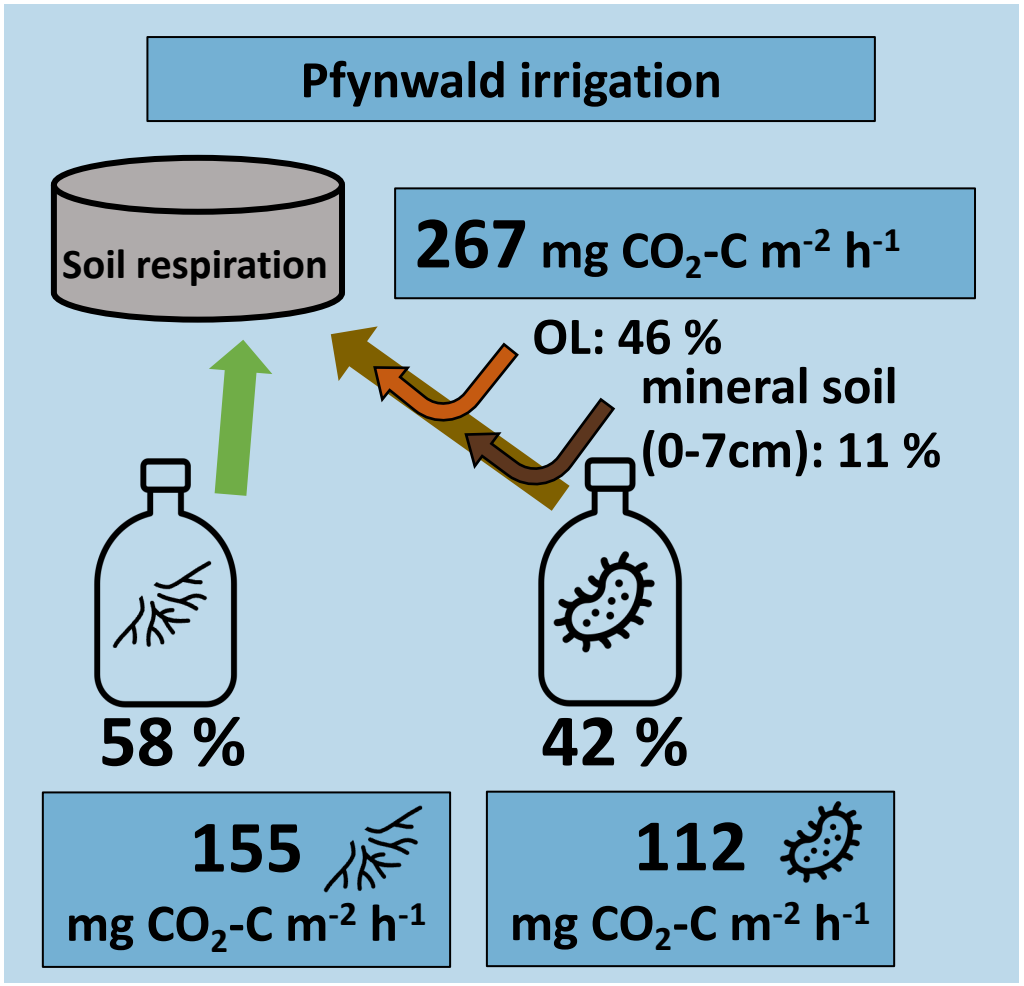


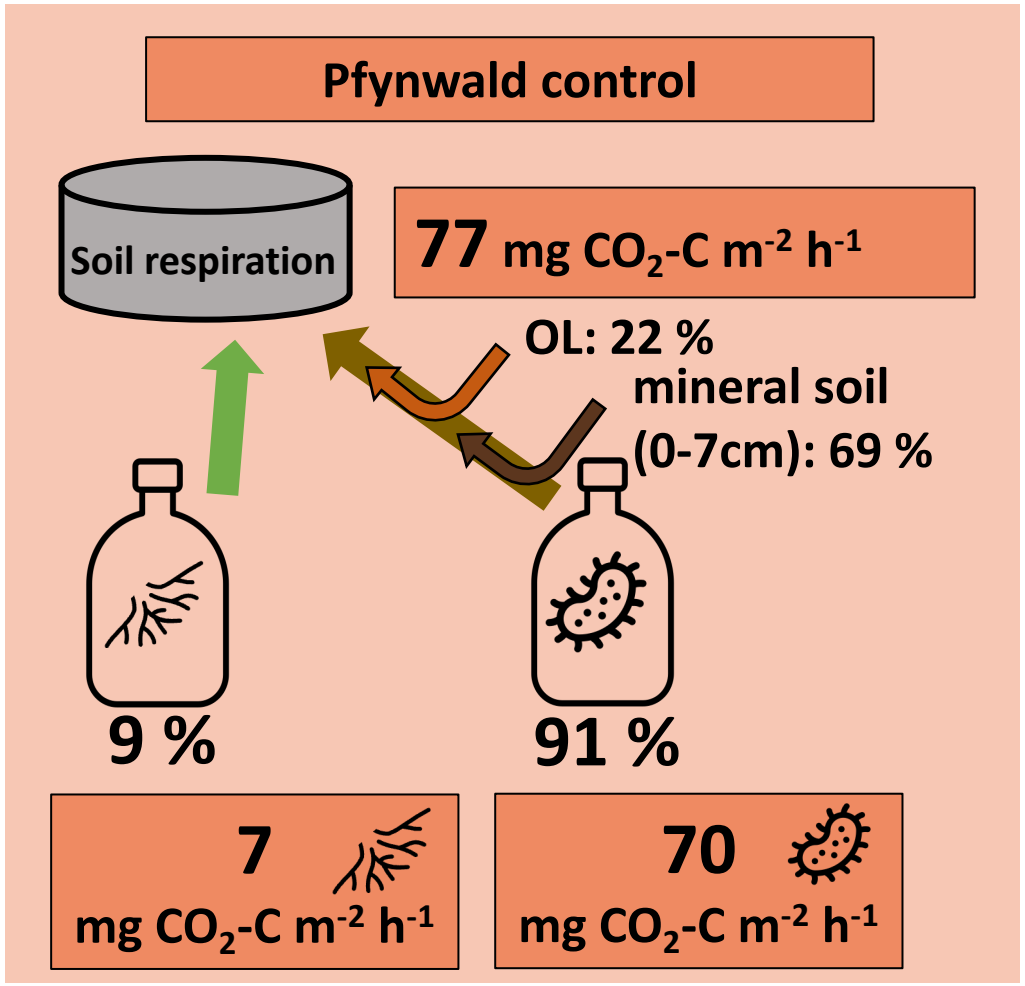
Short-term drought: Source contribution





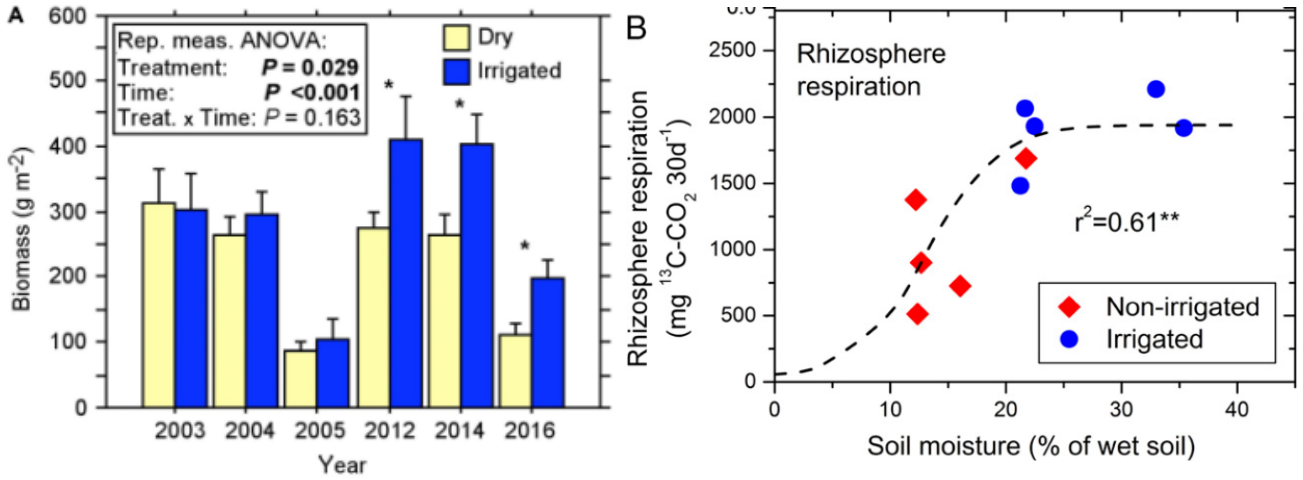
Long-term drought: Source contribution





Long-term irrigation effects

Fine root biomass

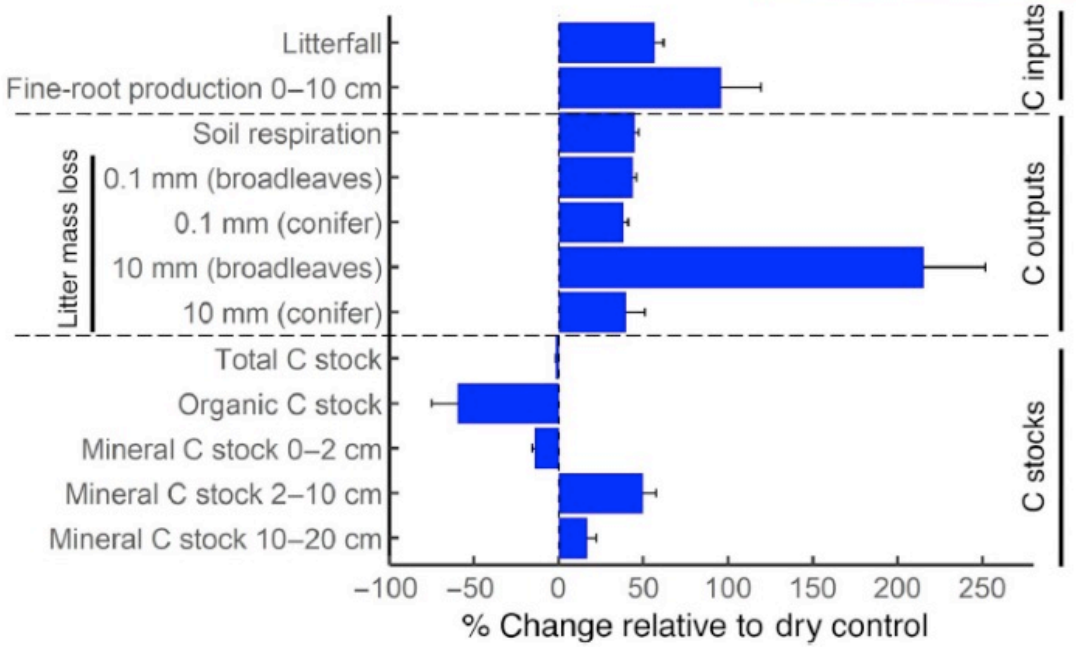


Brunner et al. 2019

Contribution of autotrophic respiration increased with irrigation

Redistribution of C stocks

Guidi et al. 2022



Older SOC in dry control, because of reduced input of new C

Limitations / Concerns

- Irrigation treatment vs. drought treatment?
- Single time point measurements, lack of replicates
- Differences very little → almost in area of measurement error
- Different soil types, other factors, that would affect the different signatures? E.g. carbonate soil, carbonate in sediment that is in irrigation water, etc.