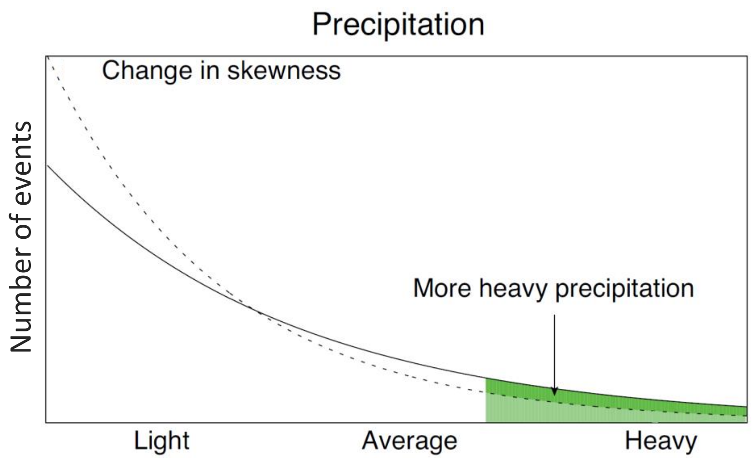
Impact of repeated dry-wet cycles on soil CO_2 efflux and extracellular enzyme activities in a beech forest

Sonja Leitner, Michael Zimmermann, Johannes Kobler, Christian Holtermann, Katharina M. Keiblinger, Sophie Zechmeister-Boltenstern

University of Natural Resources and Life Sciences
Institute of Soil Research
Vienna, Austria

Scientific background



- Increase in the frequency and intensity of heavy precipitation expected (*IPCC 2013*)
- Temperate zone → extended summer drought periods & stronger rainfall events → changed moisture regime
- Feedback effects between extreme events and changed emissions of climate-relevant gases (CO_2, CH_4, N_2O, NO_x) could intensify climate change

Scientific background

Impact of extreme events on soil processes:

Drought:

- reduced microbial activity → dormancy or mortality
- increased microbial C and N demand (cell walls, osmolytes)
- reduced emissions of CO_2 (water & substrate limitation)

Rewetting of dry soils :

- regrowth of microbial biomass
- rapid release of mineral N
- increased CO_2 emissions

} **"Birch effect"** *(Birch, Plant Soil 1958)*

Research questions

Q1: How do **soil temperature** and **soil moisture control** soil CO_2 efflux during repeated dry-wet cycles?

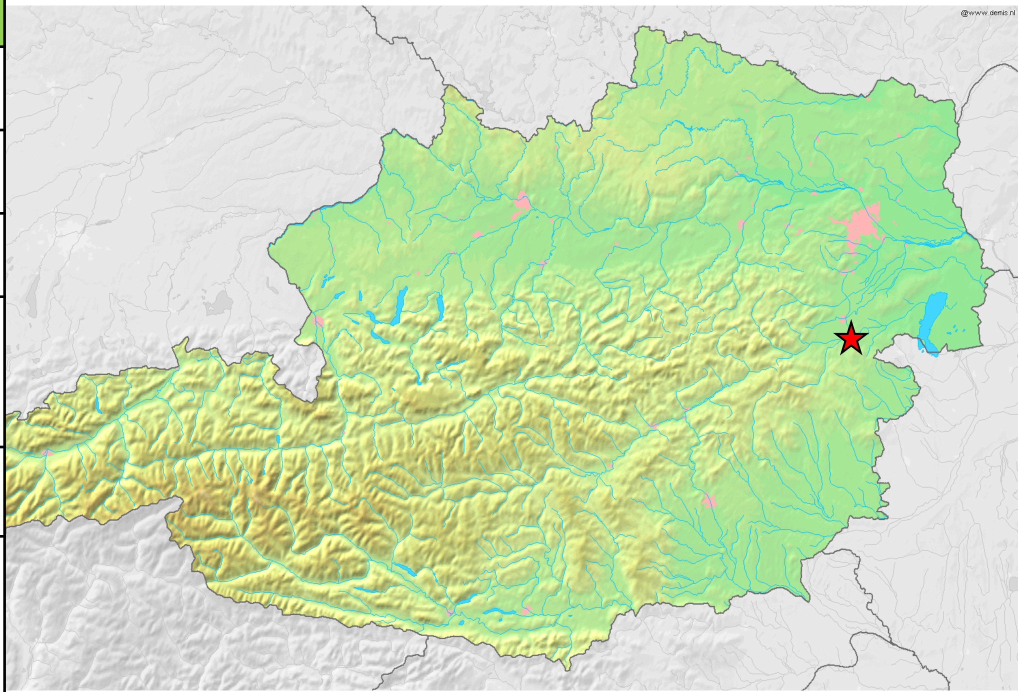
Q2: Will **total soil CO_2 efflux** decrease due to extended droughts or will repeated dry-wet cycles increase overall fluxes?

Q3: How do repeated dry-wet cycles affect **microbial extracellular enzymes**?

Experimental set-up

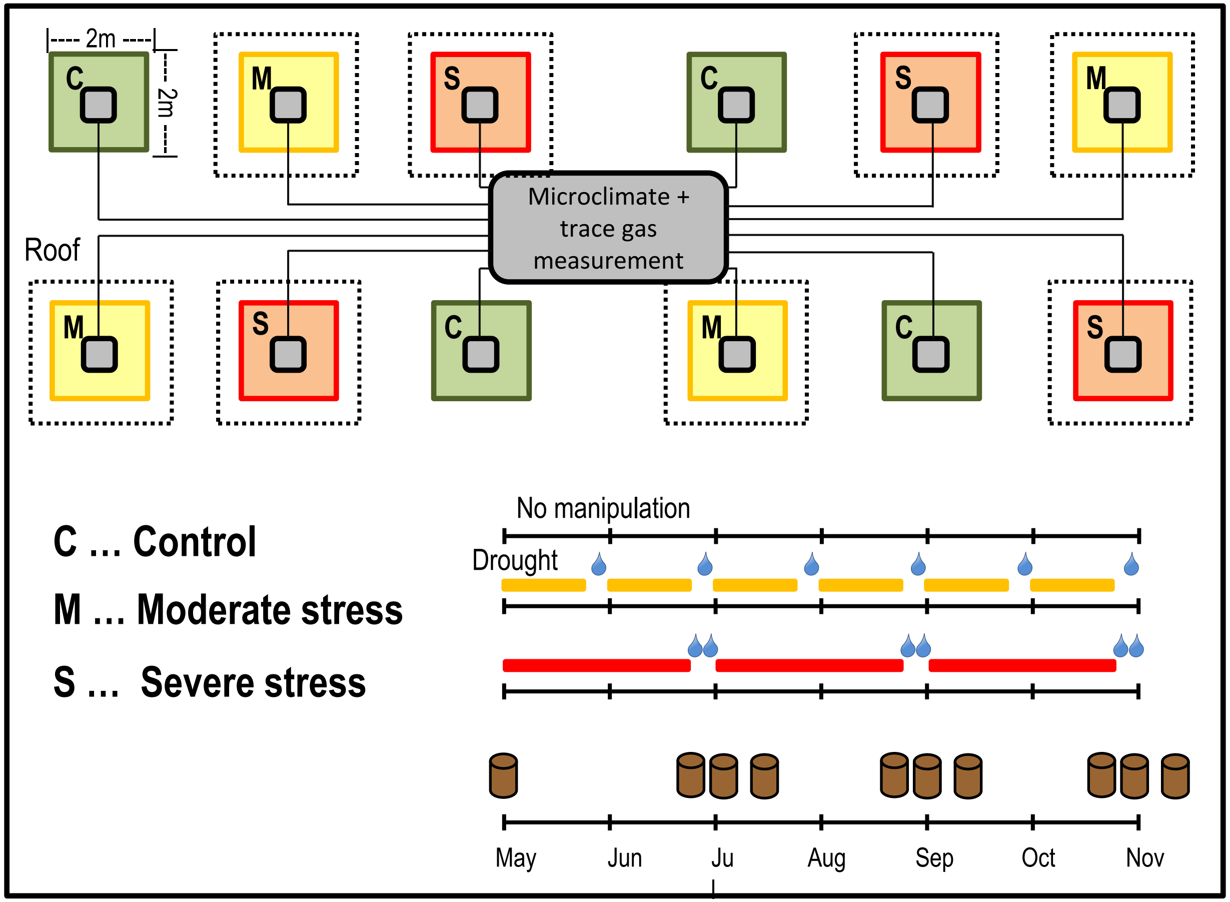
Field experiment in BOKU forest demonstration center („Lehrforst“), Rosalien mountains, Burgenland/Lower Austria

Site description	
Elevation	600 m asl
MAT	6.5° C
MAP	796 mm
Soil type	Dystric cambisol over granitic bedrock
Soil pH	3.8
Vegetation	European beech (*Fagus sylvatica*)



Experimental set-up

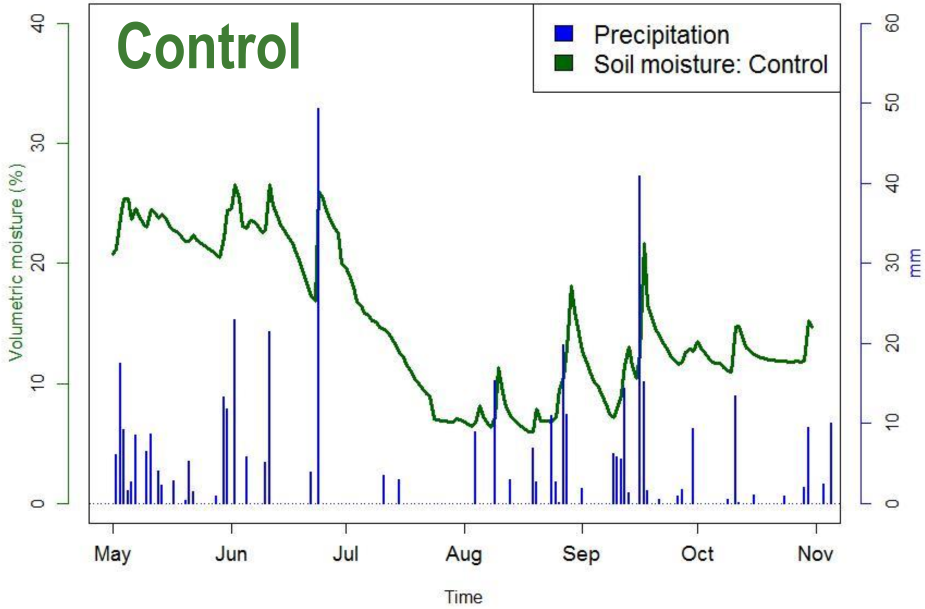
2 years of precipitation manipulation (2013-2014)



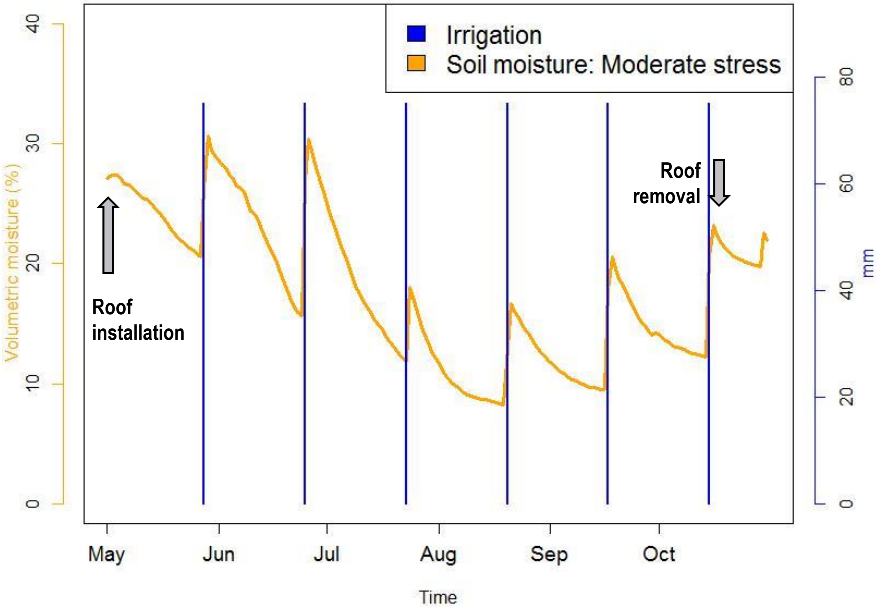
Measurements:

- CO_2, CH_4, N_2O, NO_x
- Soil nutrients (microdialysis)
  → Pia Minixhofer, Erich Inselsbacher
- Soil extracellular enzyme activites
- Microbial community composition
  (PLFA, metaproteomics) → Nermina Šaronjić
- Plot hydrology → Jan Bockholt
- Soil aggregate stability → Markus Schartner
- Soil hydrophobicity → Andreas Schwen
- Root activity → Boris Rewald

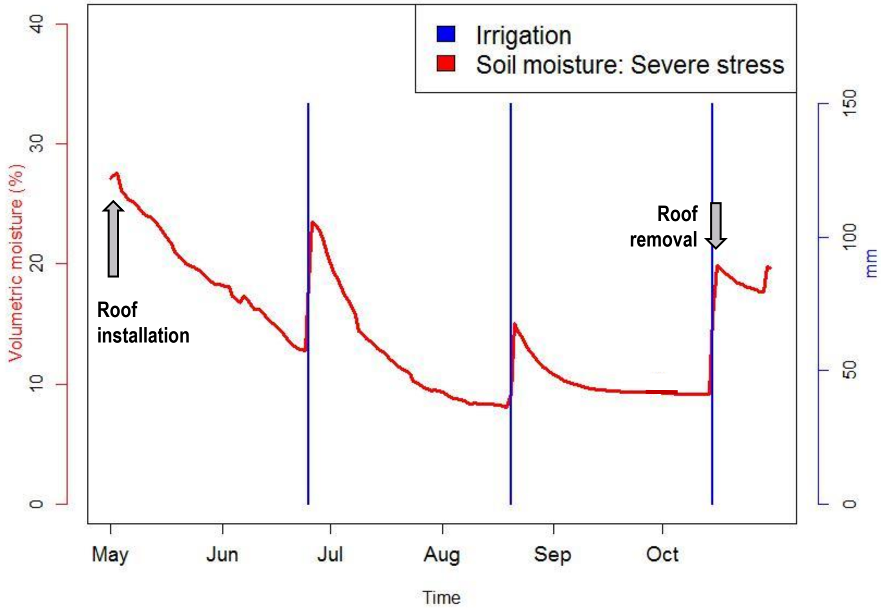
First-year results: Soil moisture & precipitation



Moderate stress

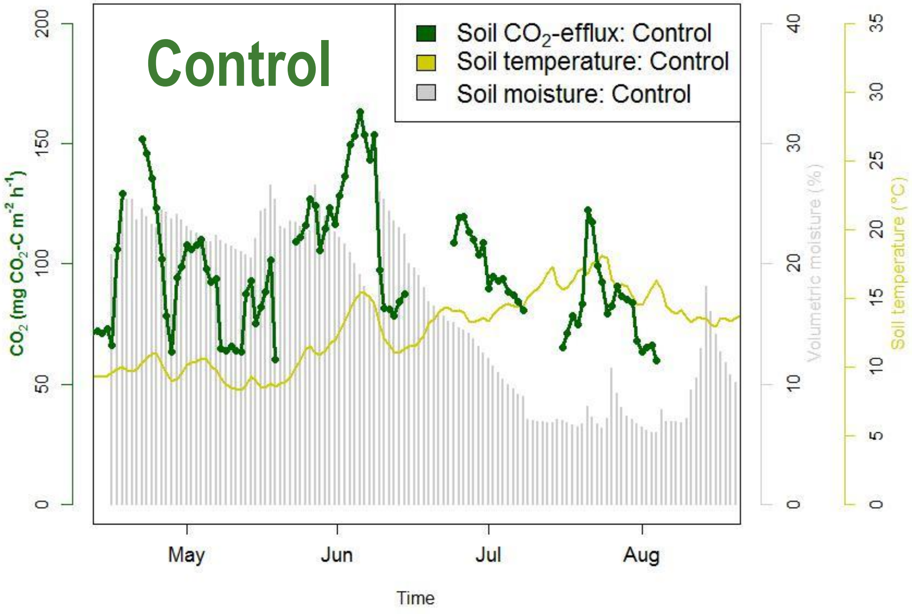


Severe stress

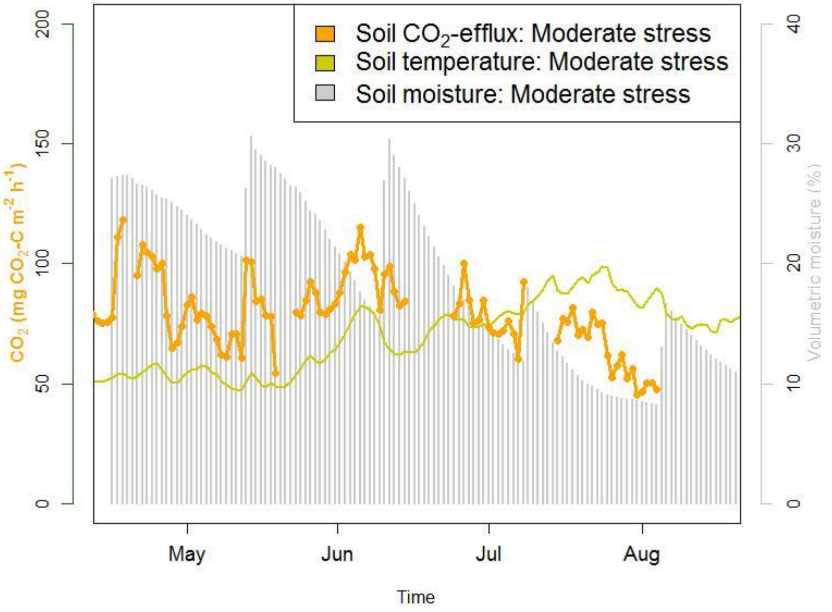


First-year results: Soil CO_2 efflux

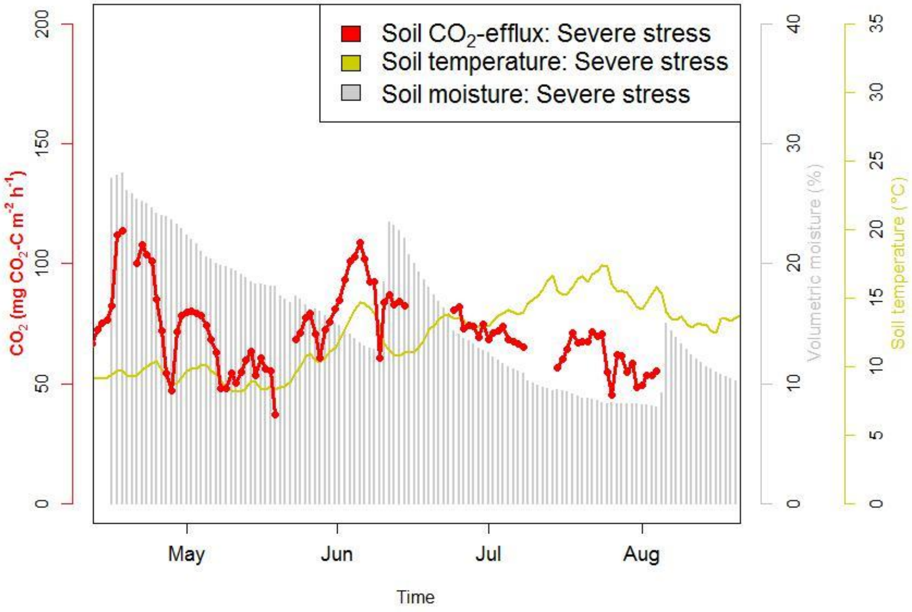
Q1: How do soil temperature and soil moisture control soil CO_2 emissions during repeated dry-wet cycles?



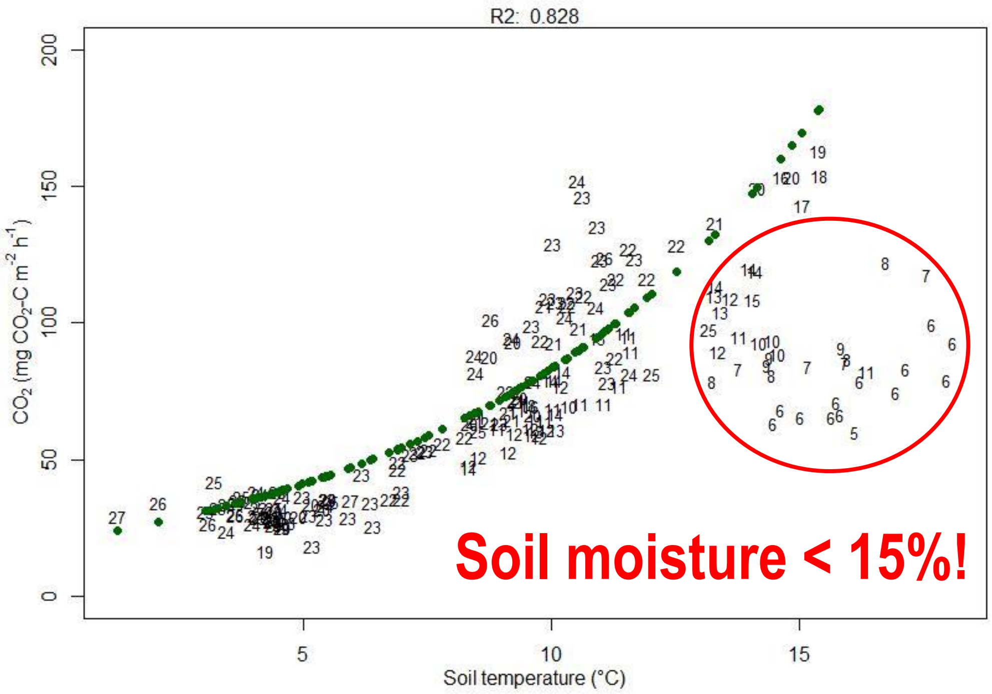
Moderate stress

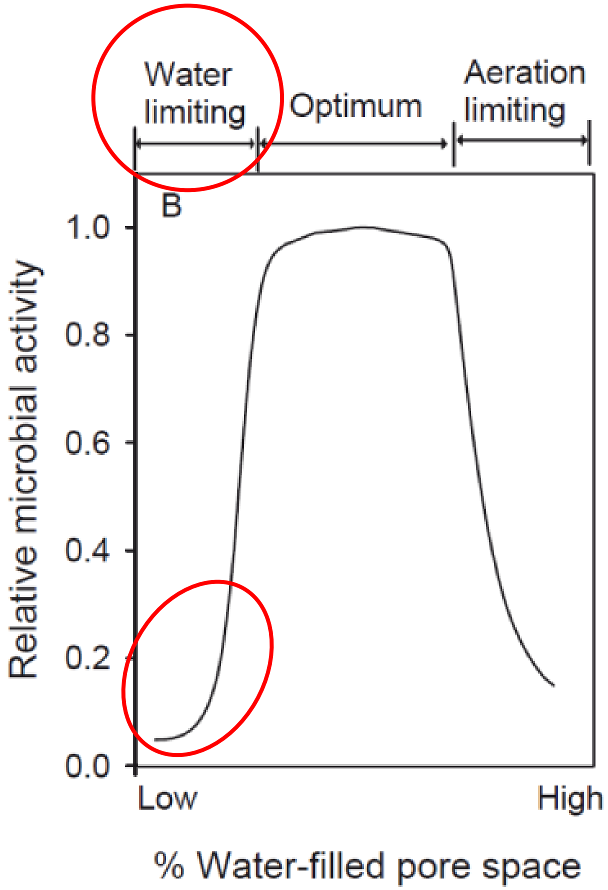


Severe stress

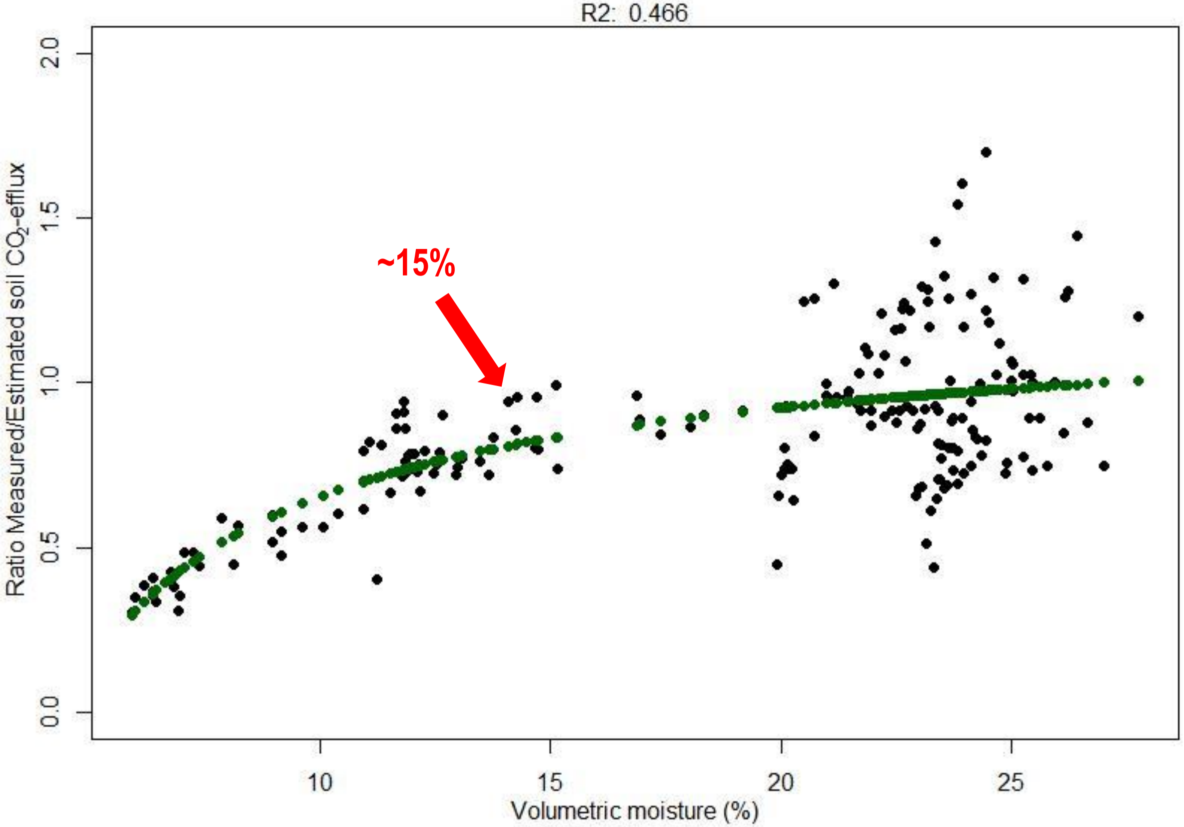


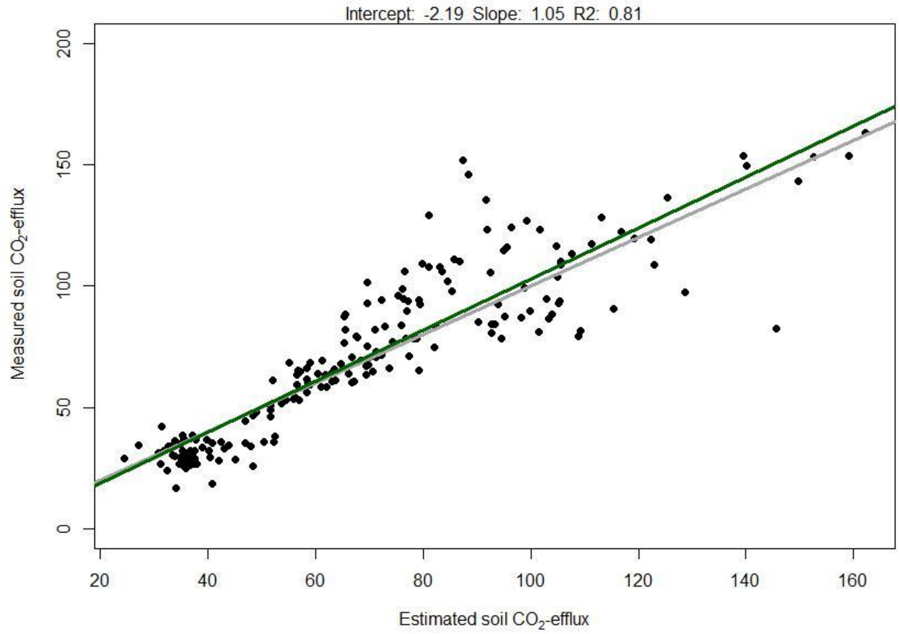
CO_2 and soil temperature „Control“ dataset



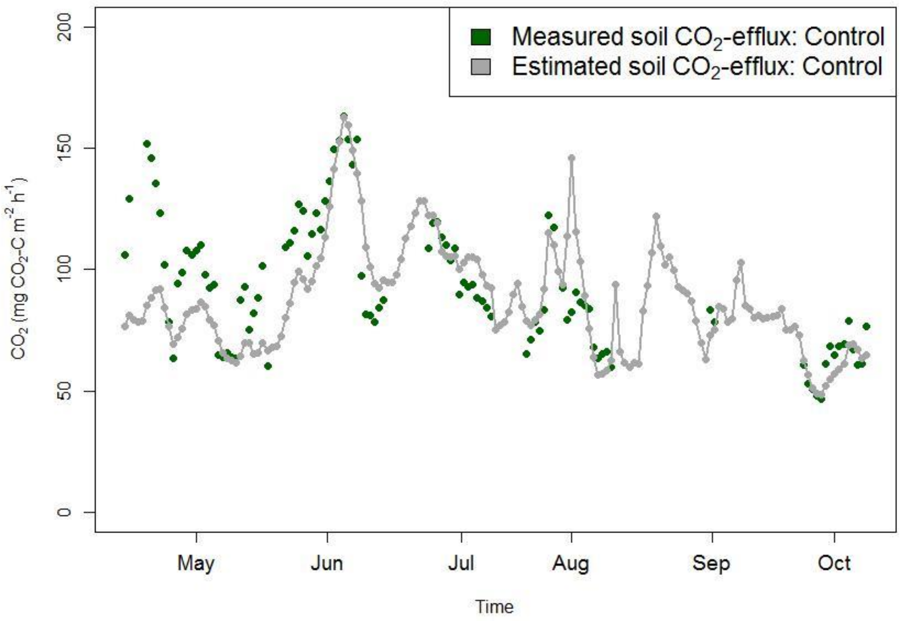


CO_2 and soil moisture „Control“ dataset





Model (T, moisture) to predict CO_2 – „Control" dataset



Q1 ✓

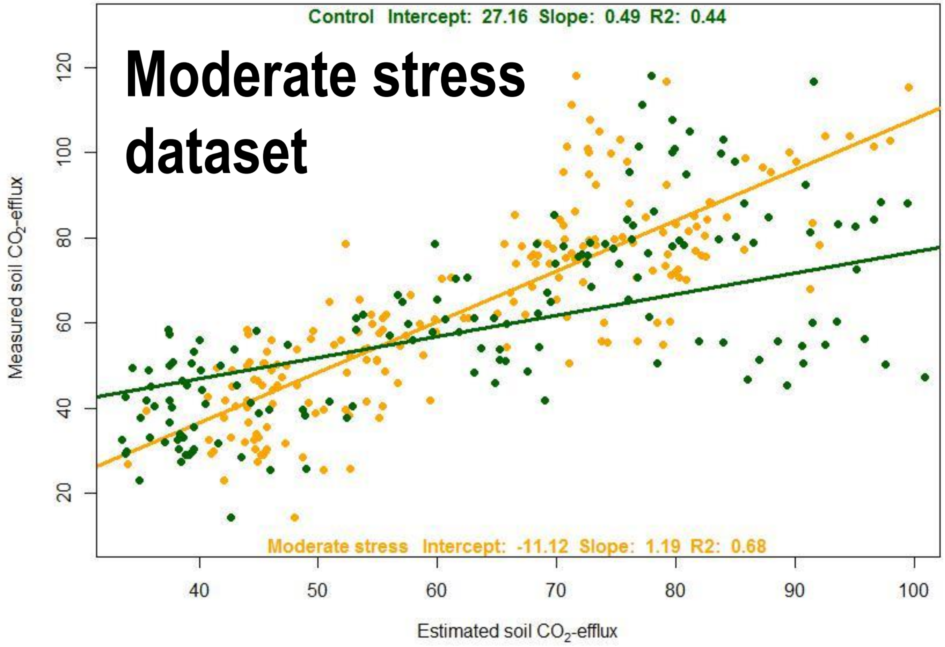
Q2: Will **total soil CO_2 efflux** decrease due to extended droughts or will repeated dry-wet cycles increase overall fluxes?

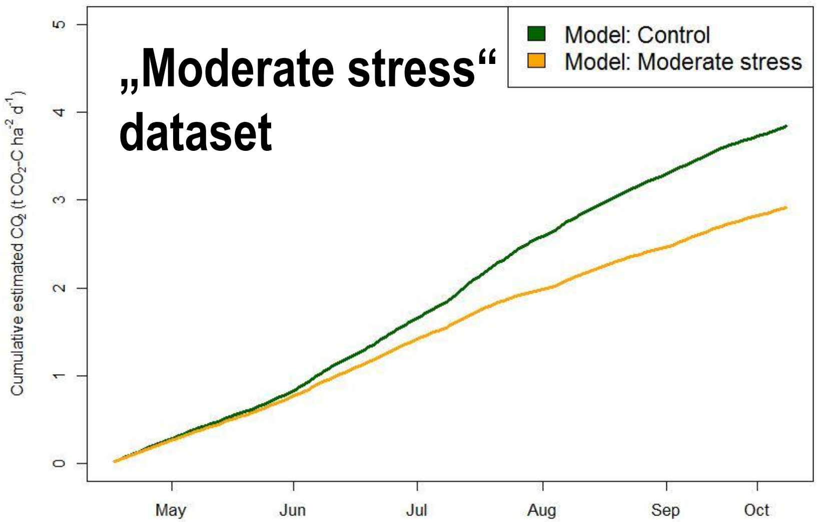
✓ 1. Fit a model (T, moisture) to dataset of „control“ plots

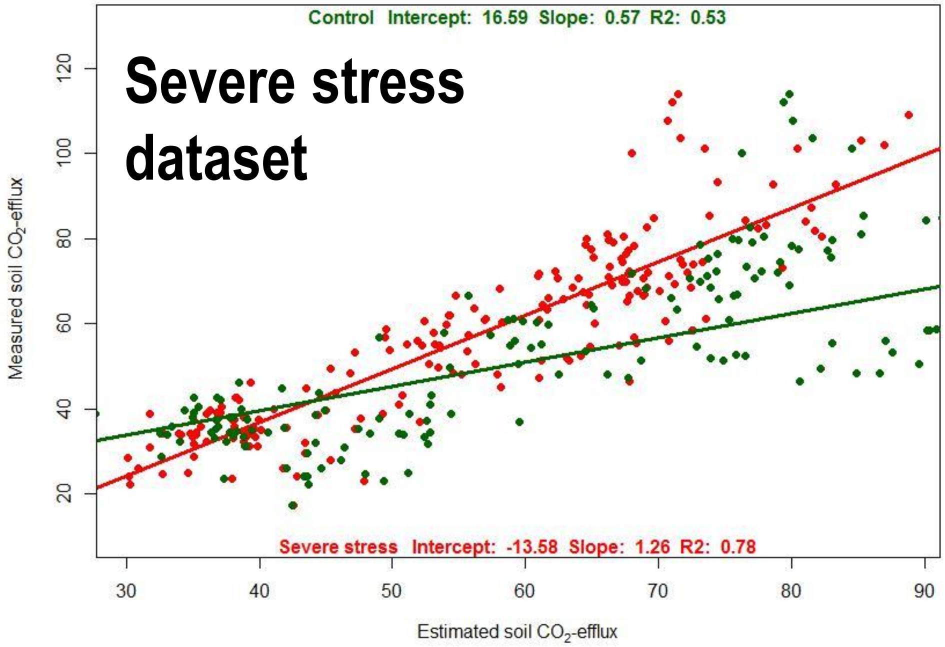
2. Apply „control-plot model“ on datasets of „moderate stress“ and „severe stress“

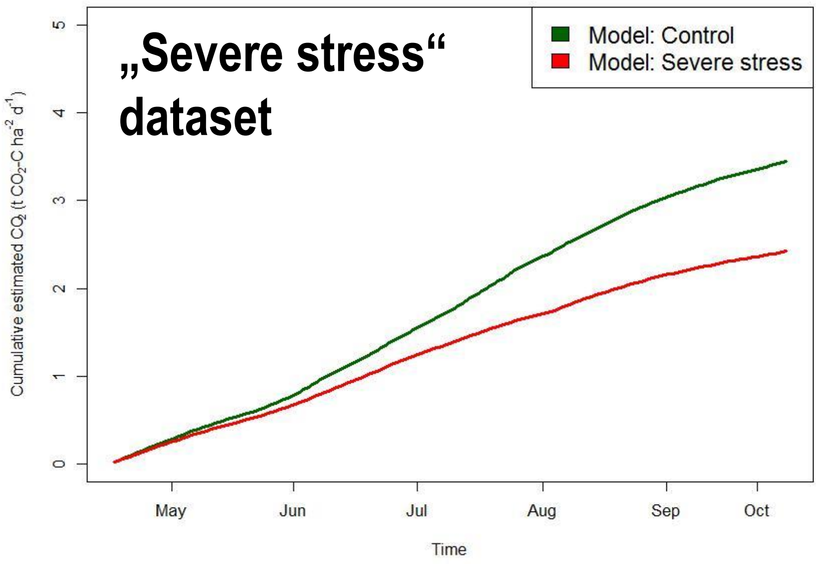
3. Parameterize models for datasets of „moderate stress“ and „severe stress“ treatments
→ explanatory power?

Model comparison

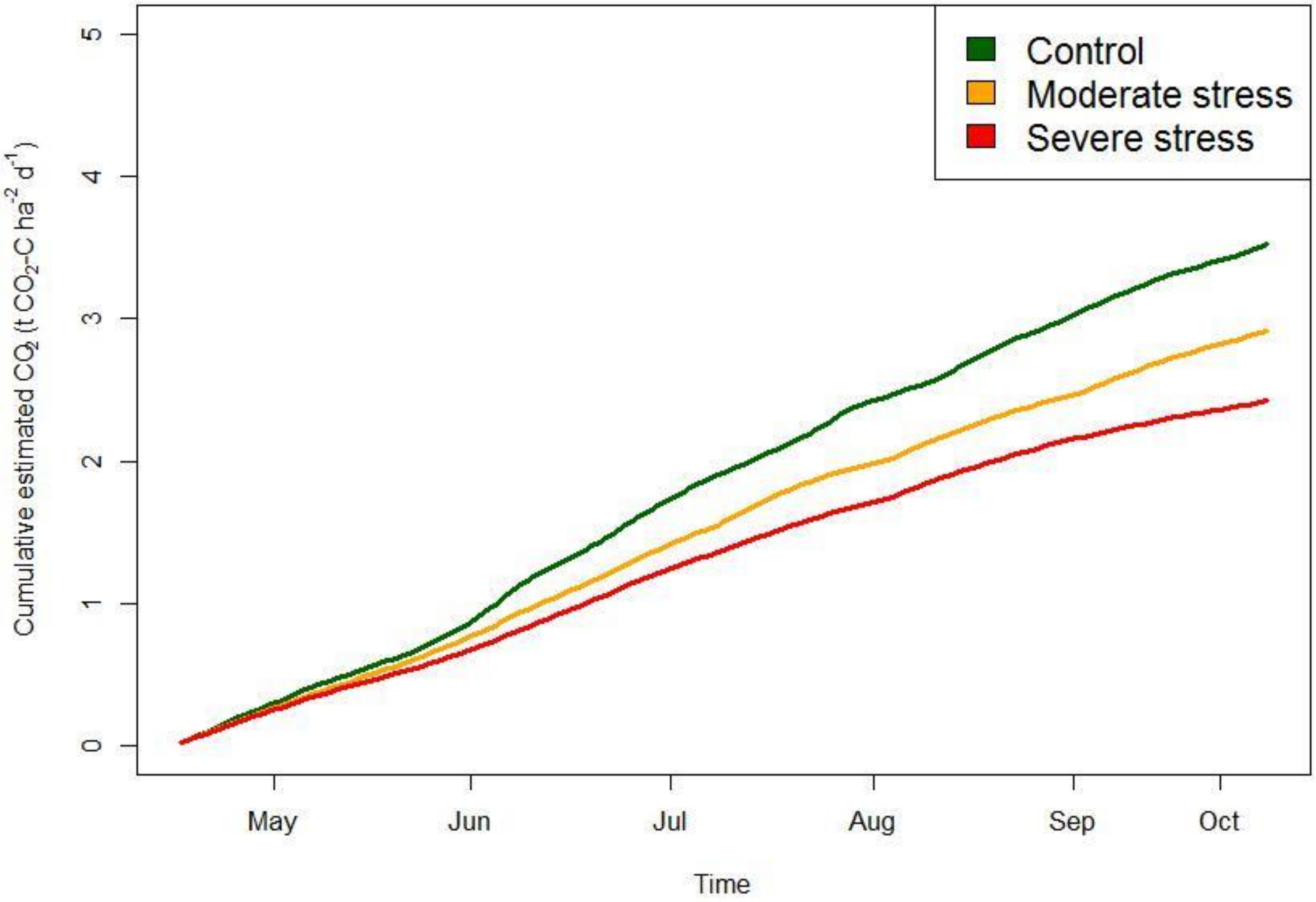






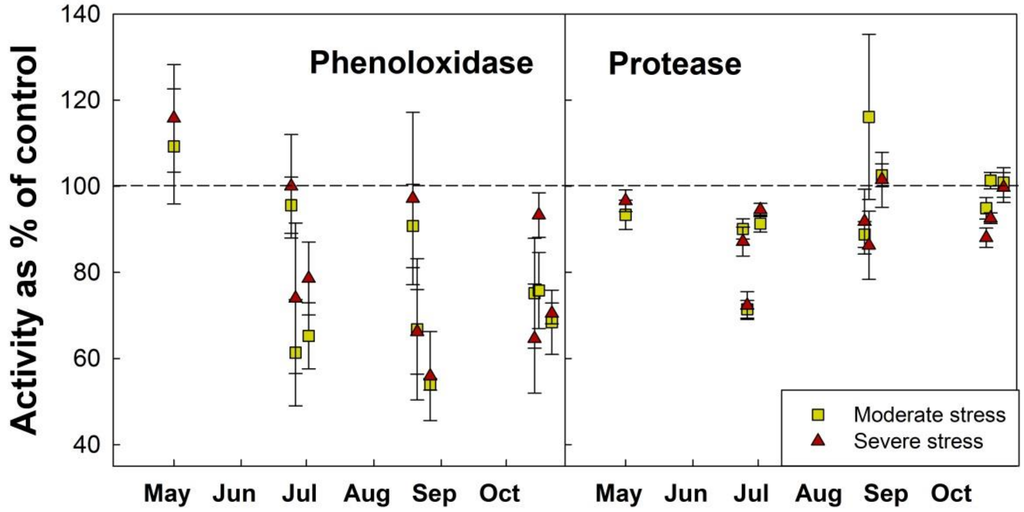


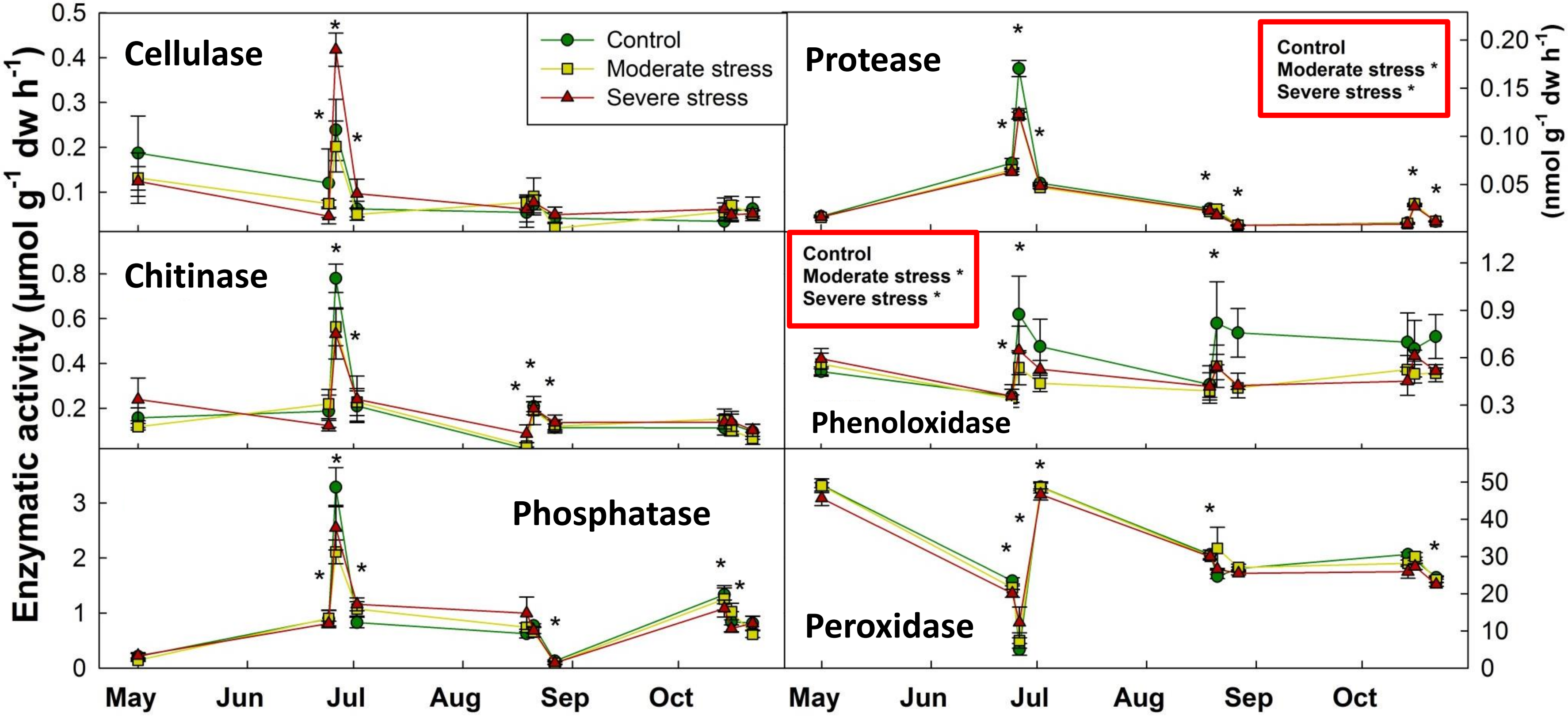
Cumulative soil CO_2 efflux



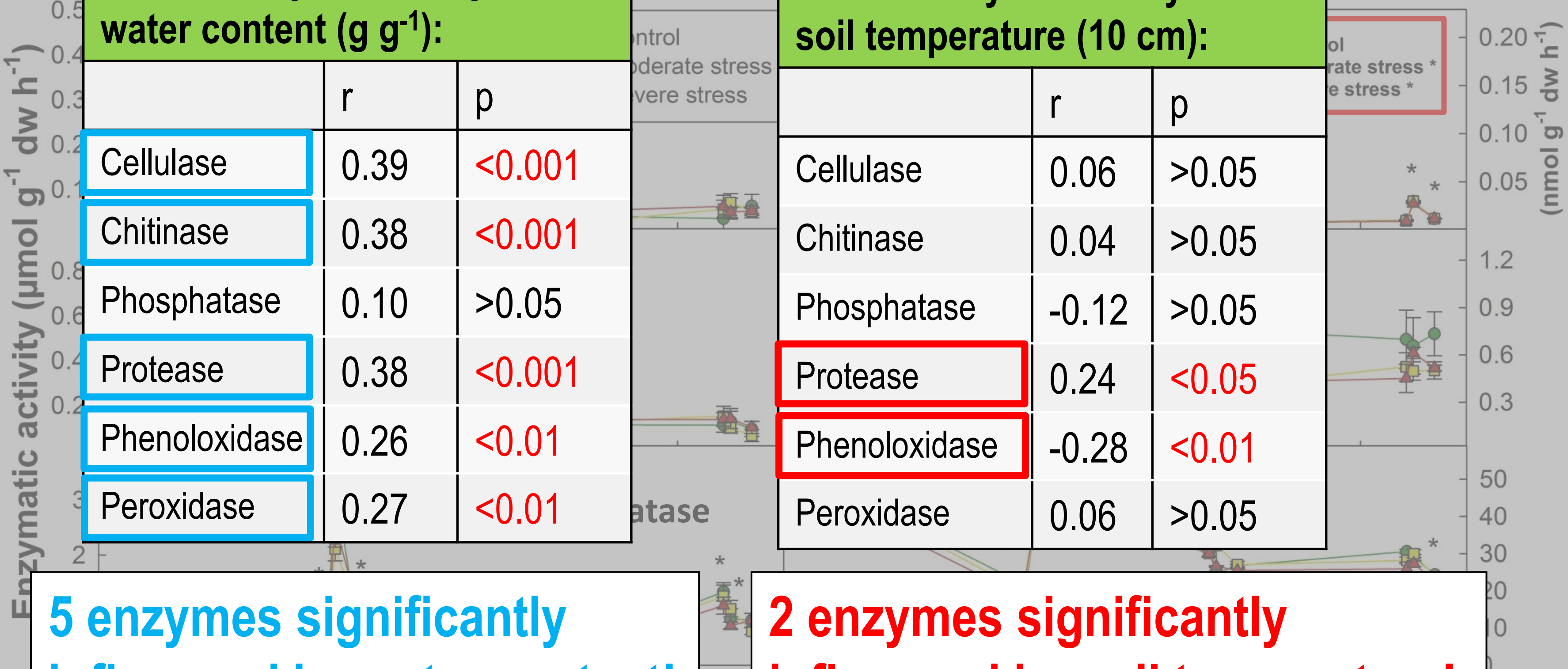
Q2 ✓

First-year results: extracellular enzyme activities





First-year results: extracellular enzyme activities



Spearman rank correlation between enyme activity and water content ($g\ g^{-1}$):

	r	p
Cellulase	0.39	<0.001
Chitinase	0.38	<0.001
Phosphatase	0.10	>0.05
Protease	0.38	<0.001
Phenoloxidase	0.26	<0.01
Peroxidase	0.27	<0.01

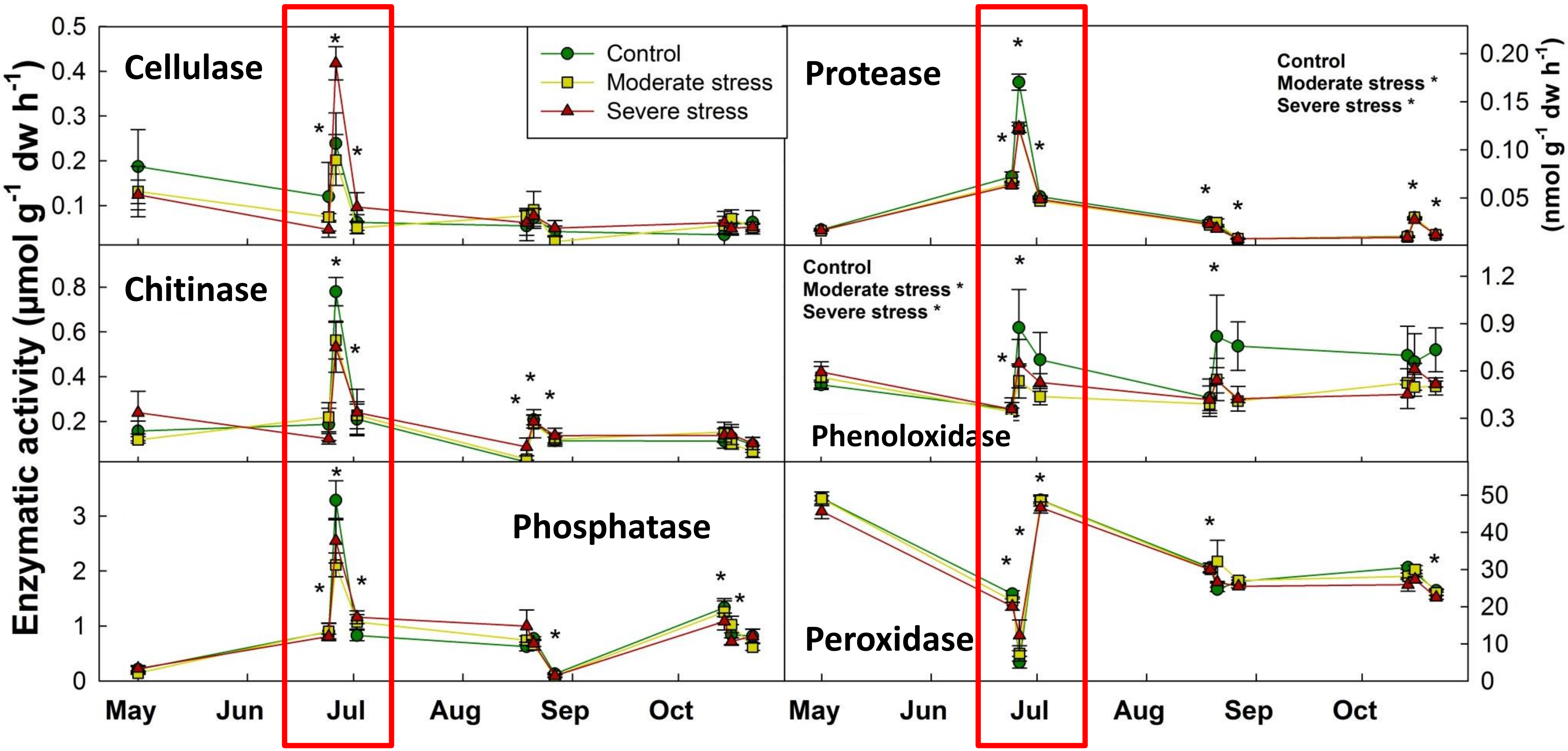
Spearman rank correlation between enyme activity and soil temperature (10 cm):

	r	p
Cellulase	0.06	>0.05
Chitinase	0.04	>0.05
Phosphatase	-0.12	>0.05
Protease	0.24	<0.05
Phenoloxidase	-0.28	<0.01
Peroxidase	0.06	>0.05

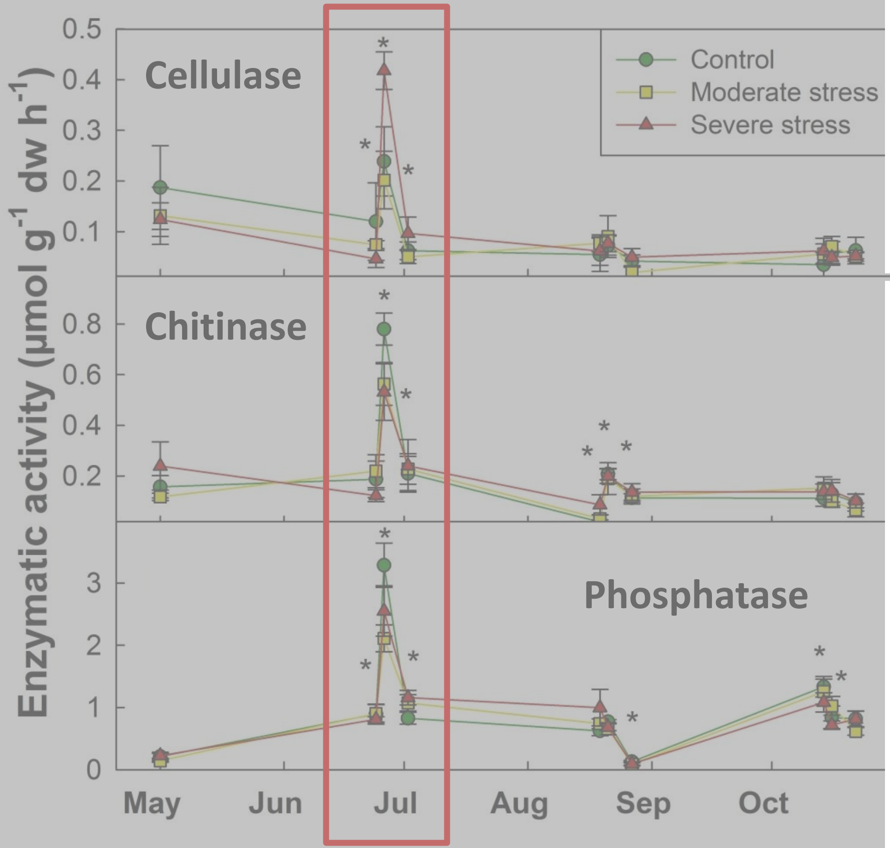
5 enzymes significantly influenced by water content!

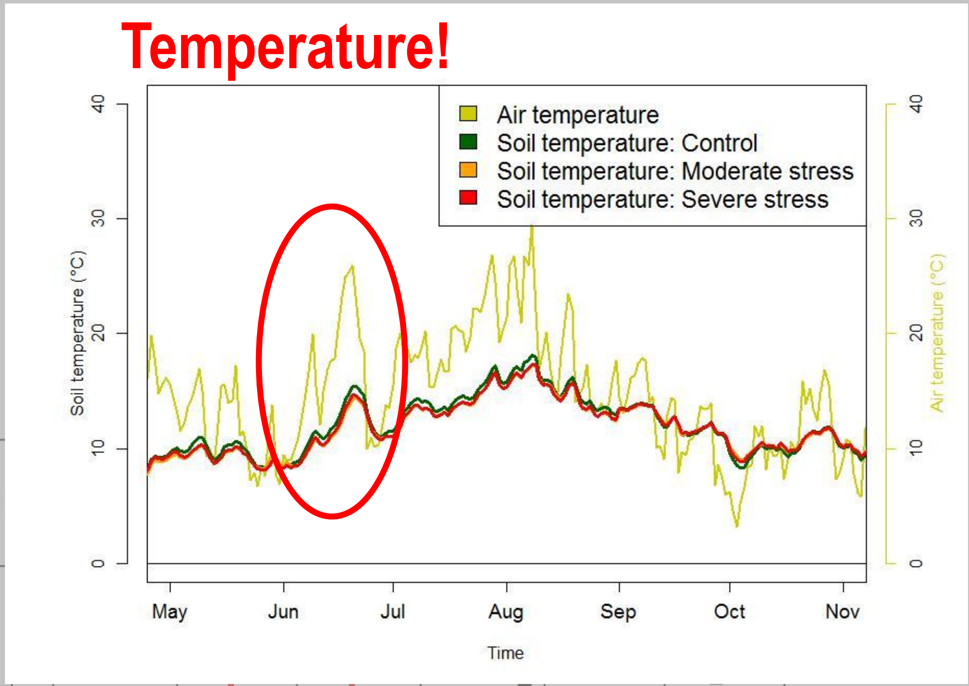
2 enzymes significantly influenced by soil temperature!

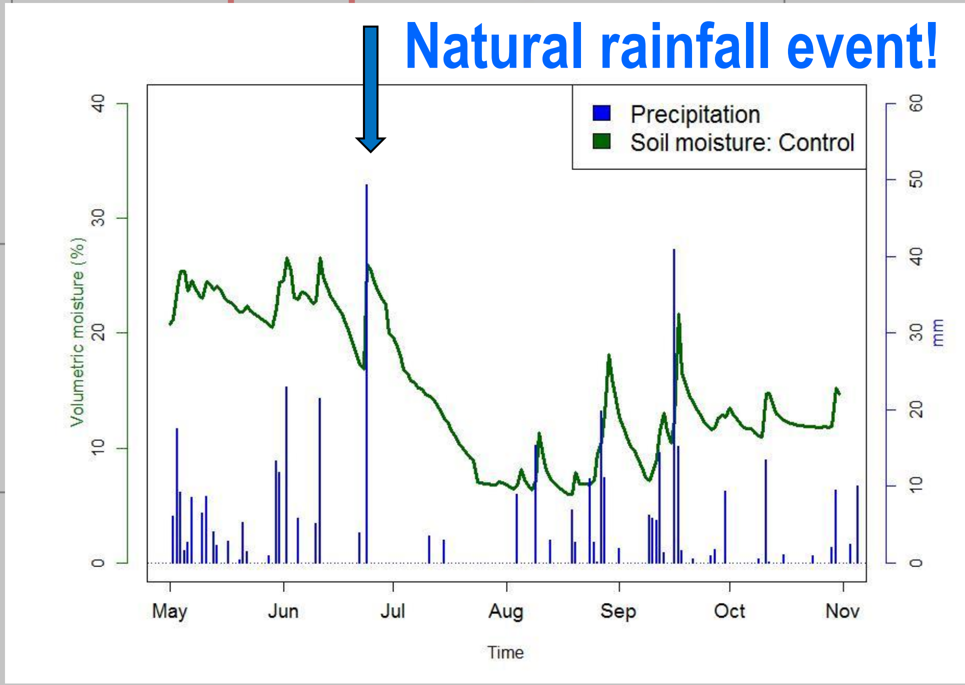
First-year results: extracellular enzyme activities



First-year results: extracellular enzyme activities







Conclusions – soil CO_2 efflux

- Good prediction of soil CO_2 effluxes with model (temperature, moisture)
- Relationship between CO_2 effluxes and T and moisture changes due to precipitation manipulation
- Cumulative CO_2: Extended droughts & heavy rainfalls lead to decreased overall soil CO_2 effluxes

Conclusions – Soil extracellular enzymes

- Soil water content and temperature influence extracellular enzyme activites
- Protease and phenoloxidase are reduced by repeated dry-wet cycles → suppressed decomposition of protein and recalcitrant substances → lower N-demand?
- Dry and warm conditions in spring followed by rewetting stimulate microbial enzyme production


Thanks for your attention! ☺
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