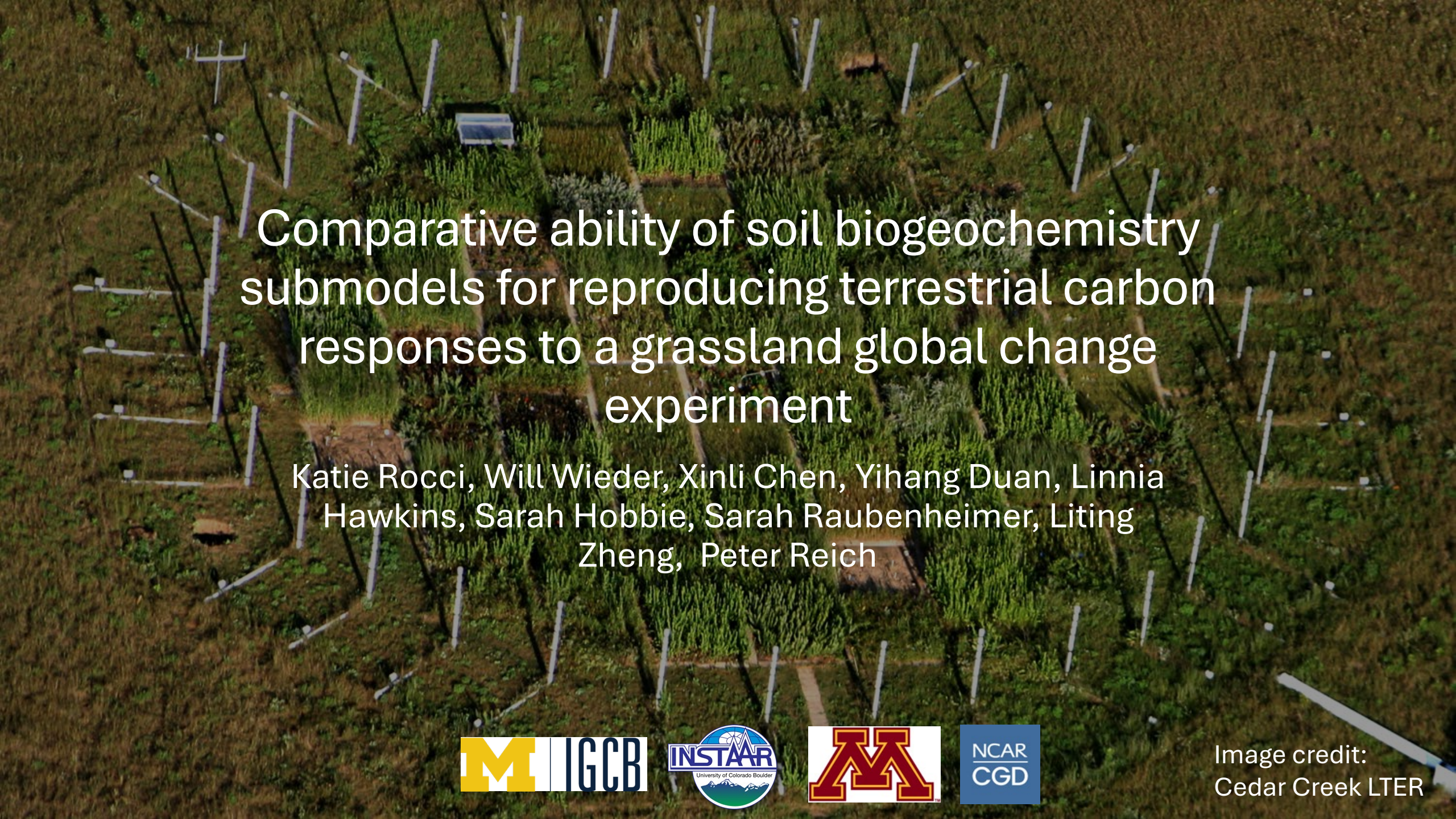


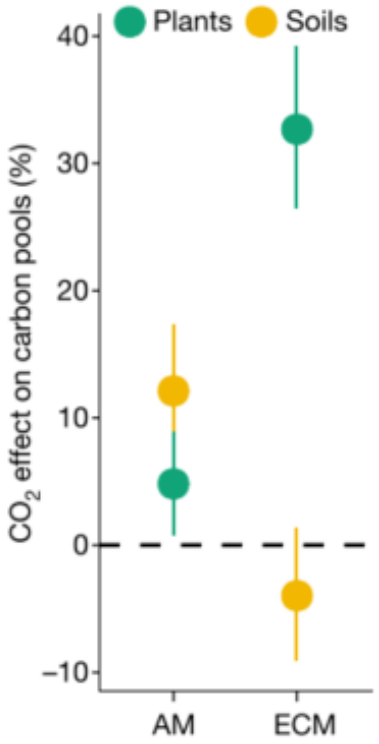
Comparative ability of soil biogeochemistry submodels for reproducing terrestrial carbon responses to a grassland global change experiment

Katie Rocci, Will Wieder, Xinli Chen, Yihang Duan, Linnia Hawkins, Sarah Hobbie, Sarah Raubenheimer, Liting Zheng, Peter Reich

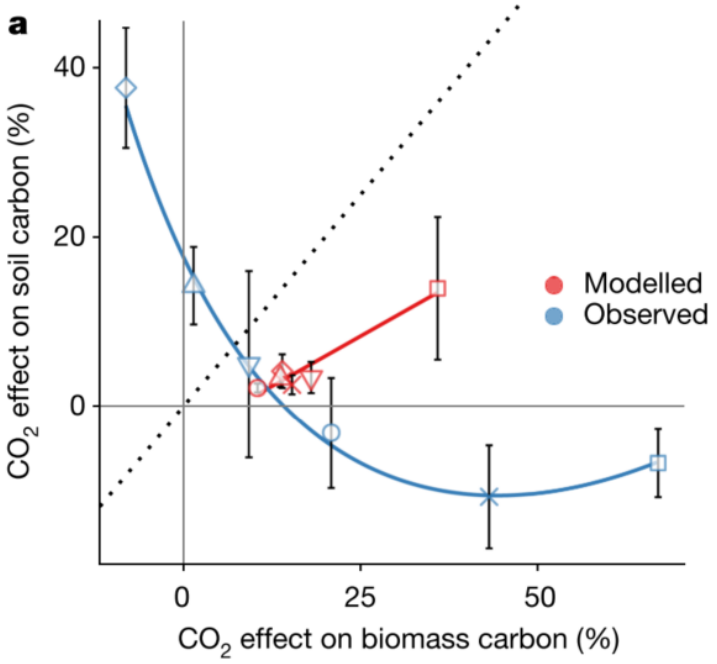
Image credit:
Cedar Creek LTER

Soil biogeochemical mechanisms are important for representing C cycle responses to climate change

Mechanisms can change answers

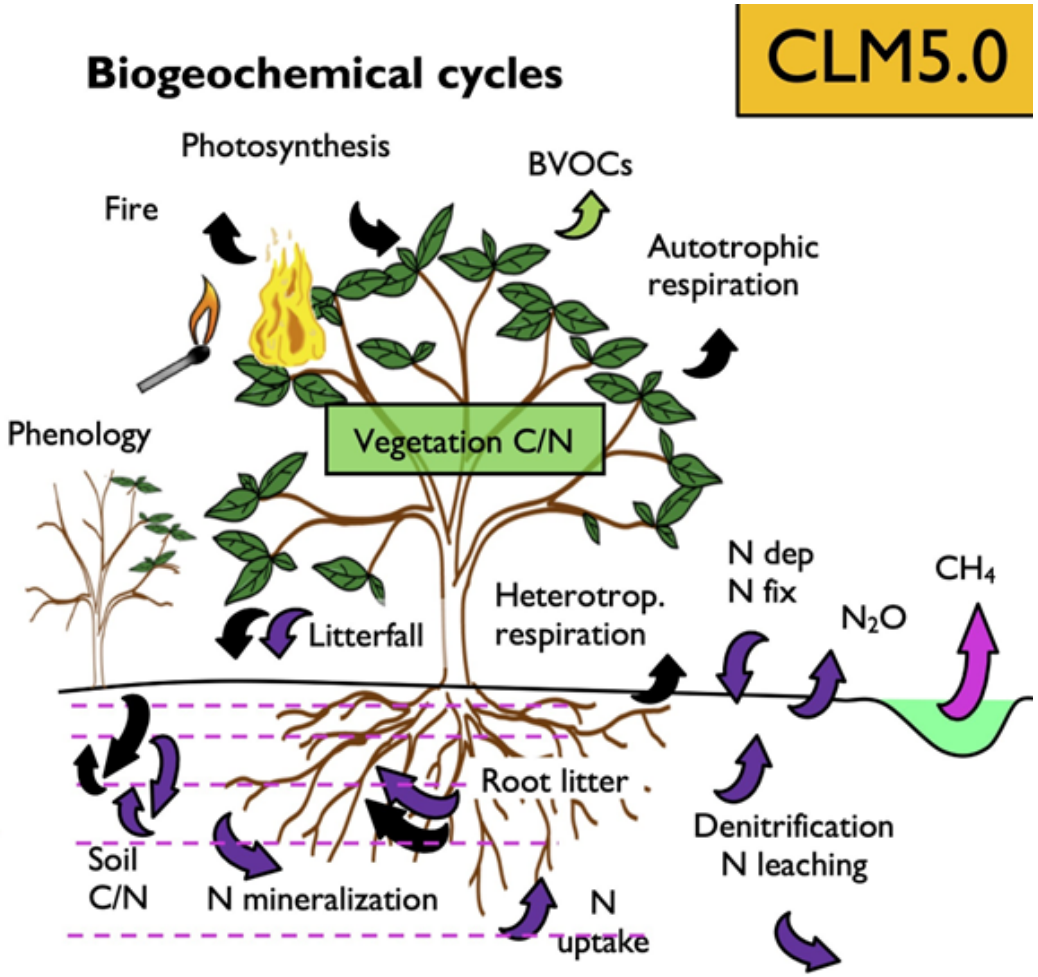


Mechanisms are underrepresented in models

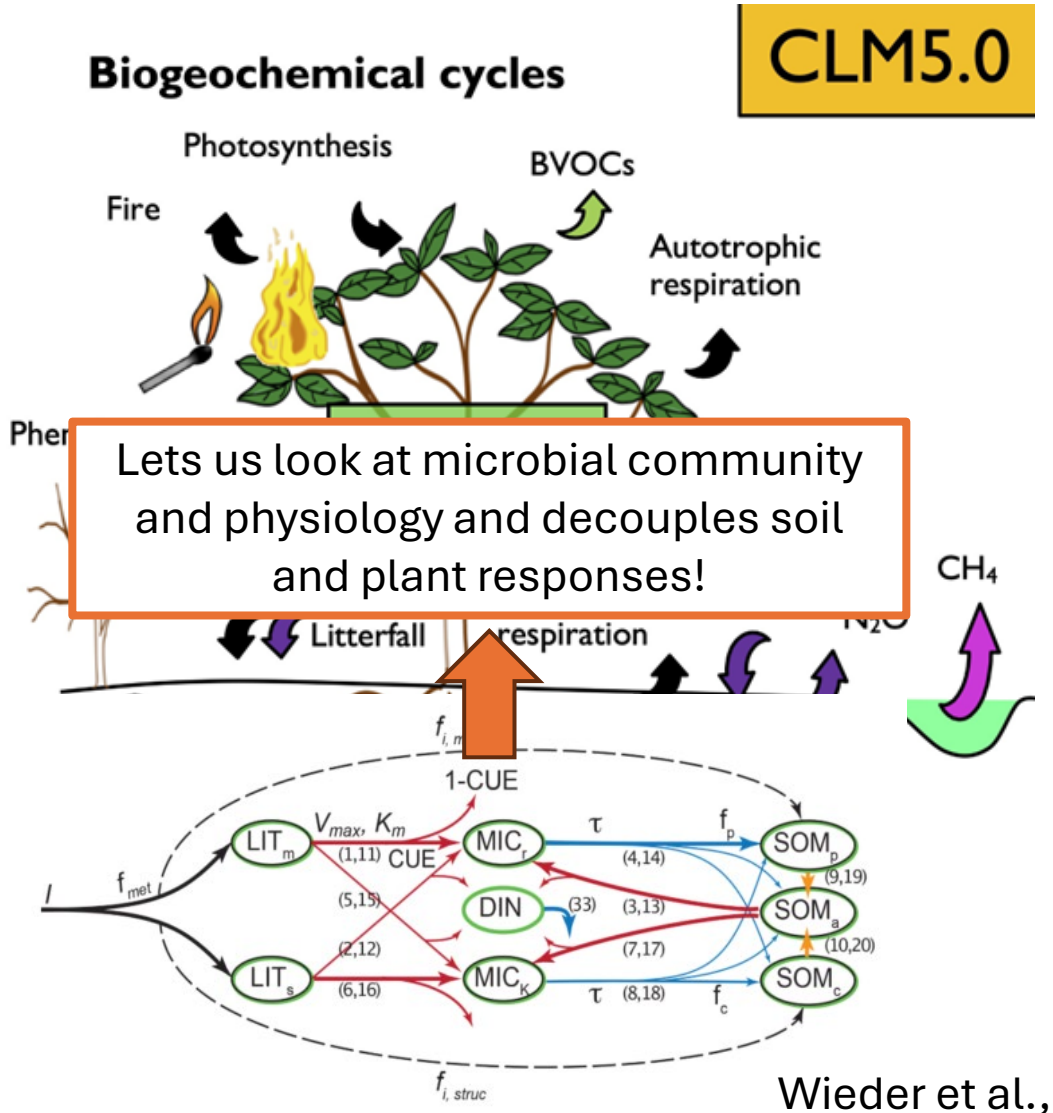


Terrer et al., 2021

We have the ability to assess soil BGC in CLM5



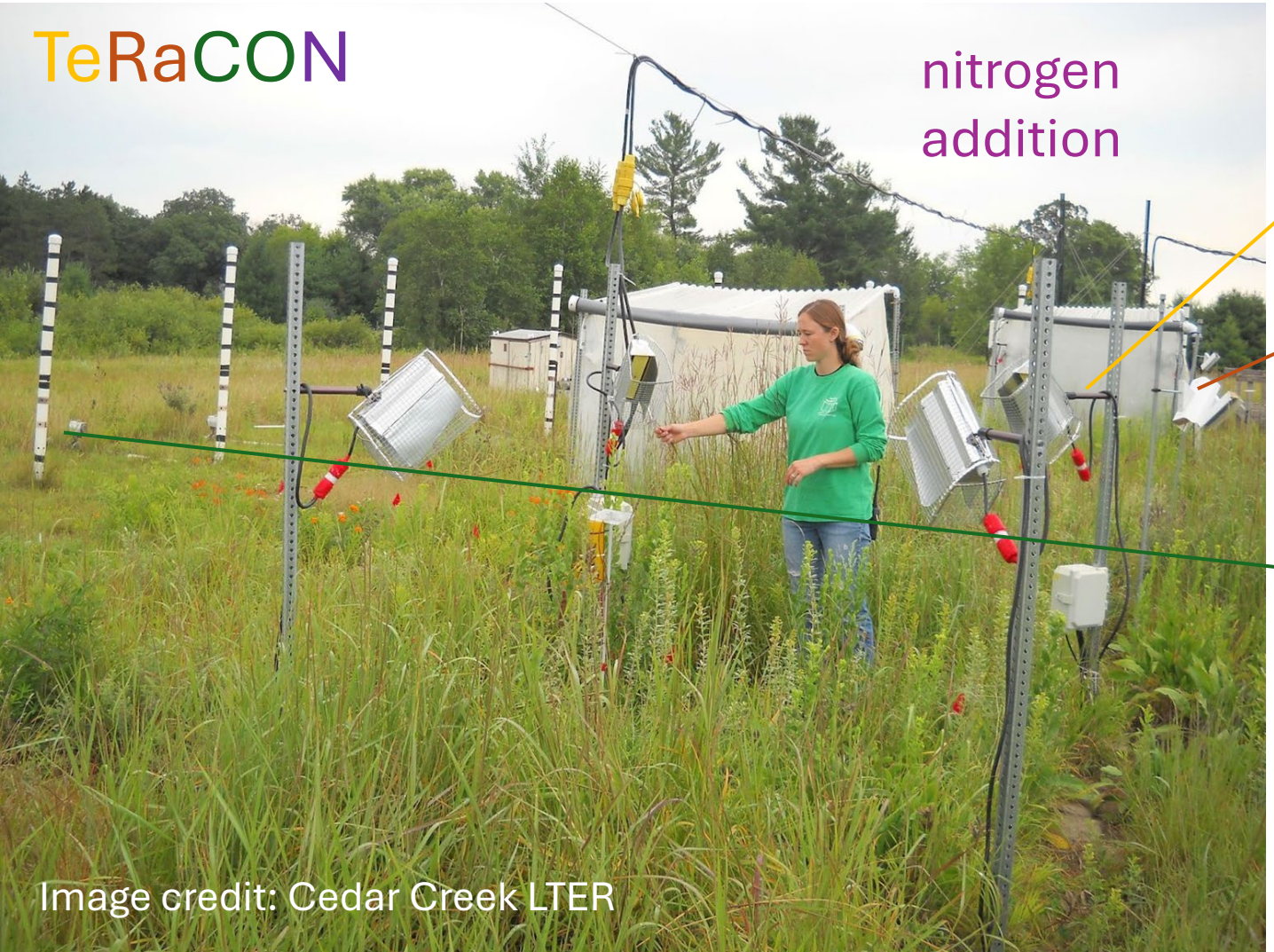
"CLM-Century"

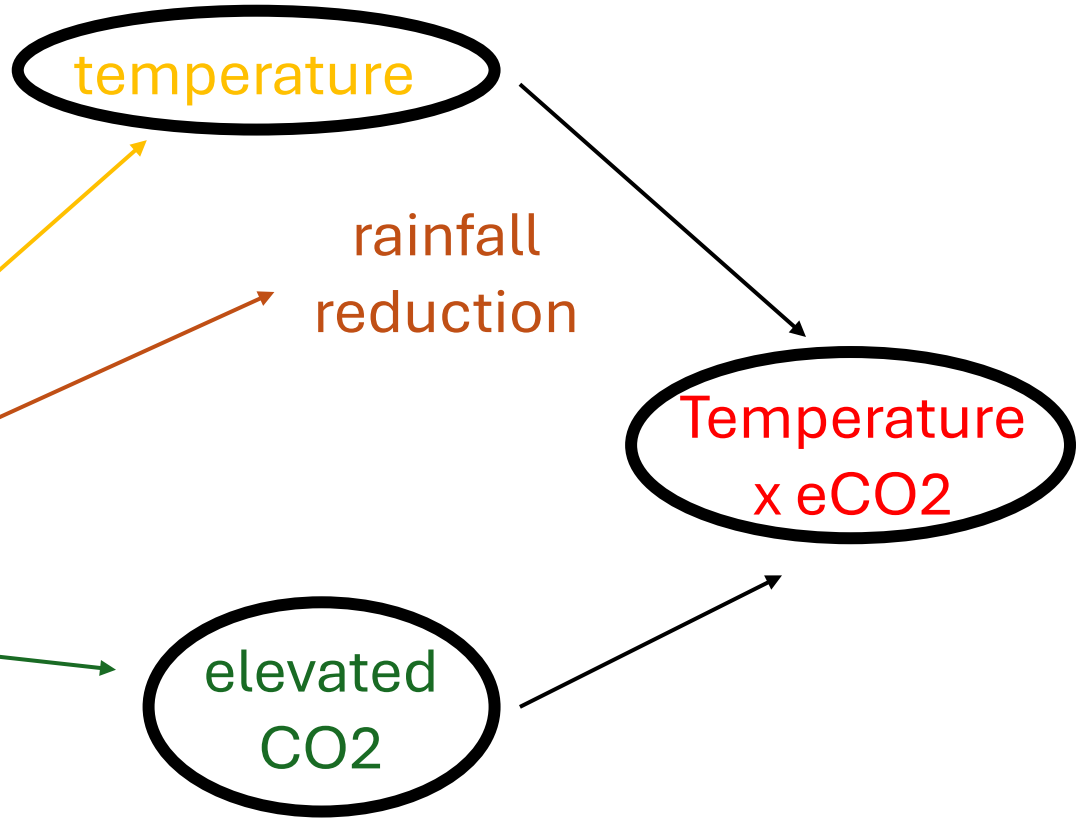


"CLM-MIMICS"

Wieder et al., 2015
Lawrence et al., 2019

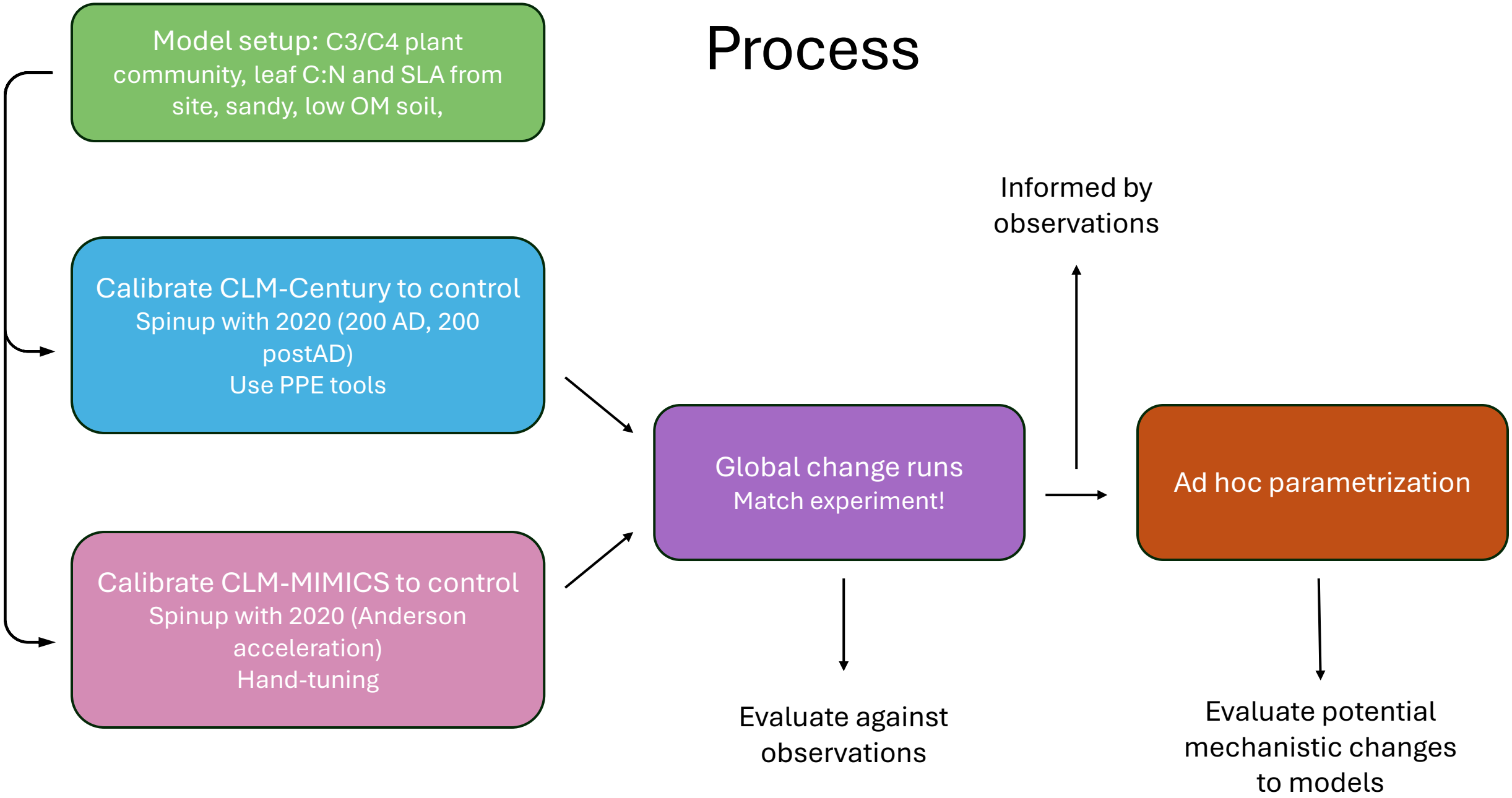
Global change experiments are one way to look at observational climate change reponses and their interactions





Initiated in tallgrass prairie in 2012

Process


Model setup: C3/C4 plant community, leaf C:N and SLA from site, sandy, low OM soil,
Calibrate CLM-Century to control
Spinup with 2020 (200 AD, 200 postAD)
Use PPE tools
Calibrate CLM-MIMICS to control
Spinup with 2020 (Anderson acceleration)
Hand-tuning
Global change runs
Match experiment!
Evaluate against observations
Informed by observations
Ad hoc parametrization
Evaluate potential mechanistic changes to models

Calibration to land C pools

=default

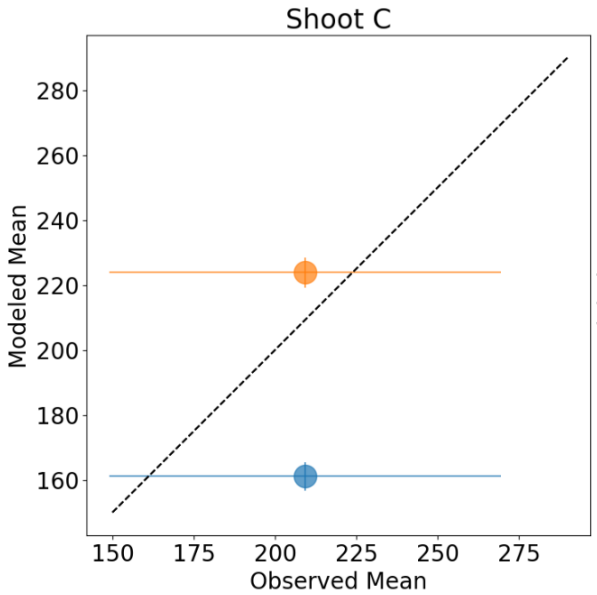
=calibrated

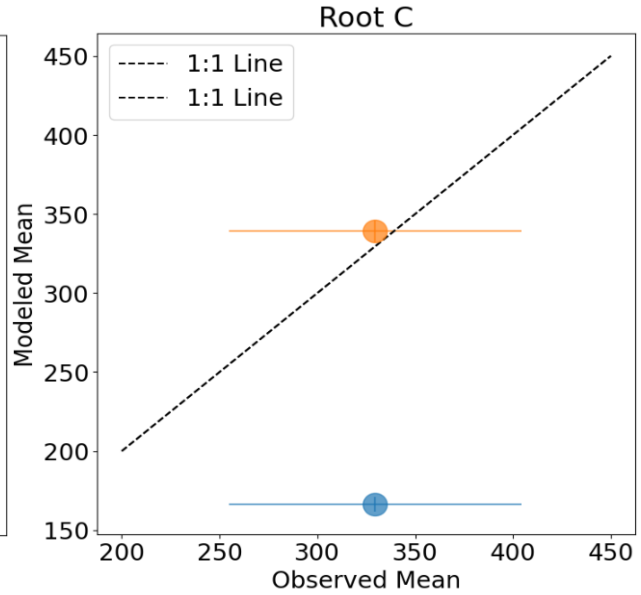
Same **plant parameters** and different *soil parameters*

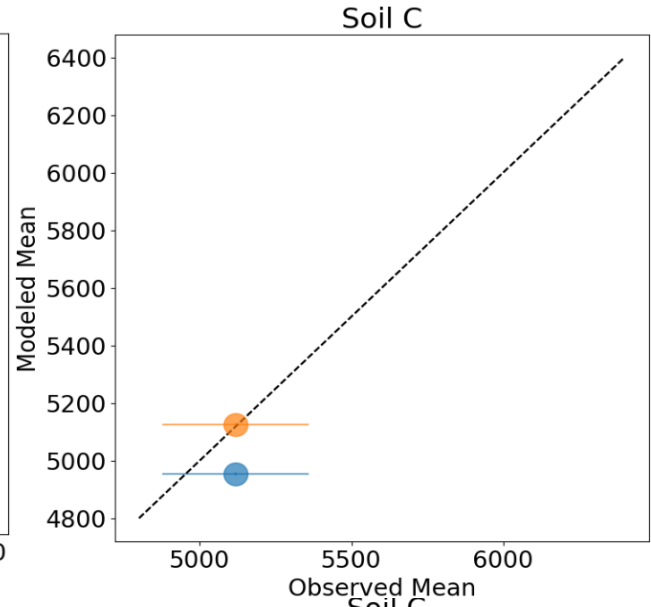
Higher C4 leaf longevity and N effect on Ps (vcad), plus higher jmaxb0, froot_leaf, and C available for N fixation

CLM-Century

Soil pool turnover

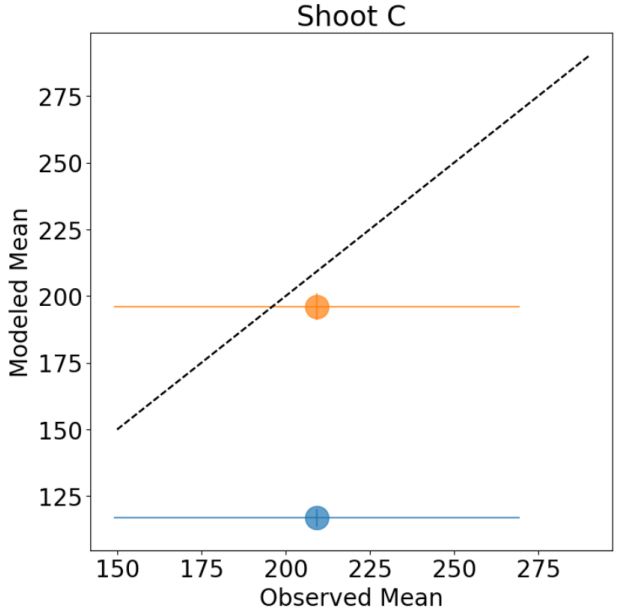


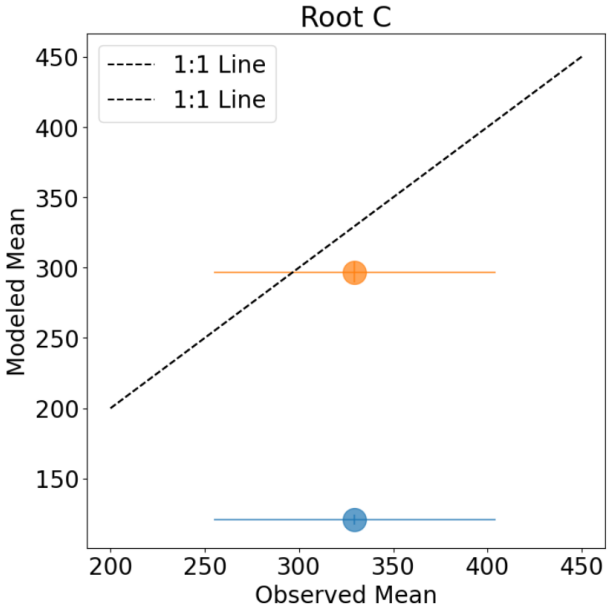


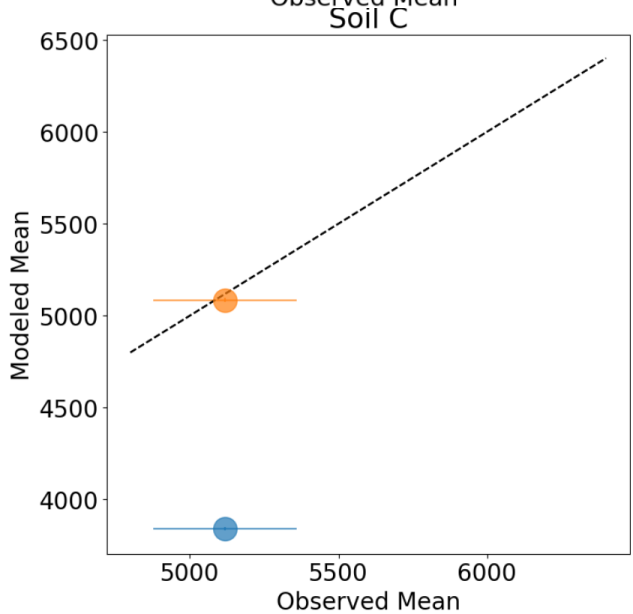


CLM-MIMICS

Microbial C:N, NUE, and turnover, decomposition/loss rate for litter and soils



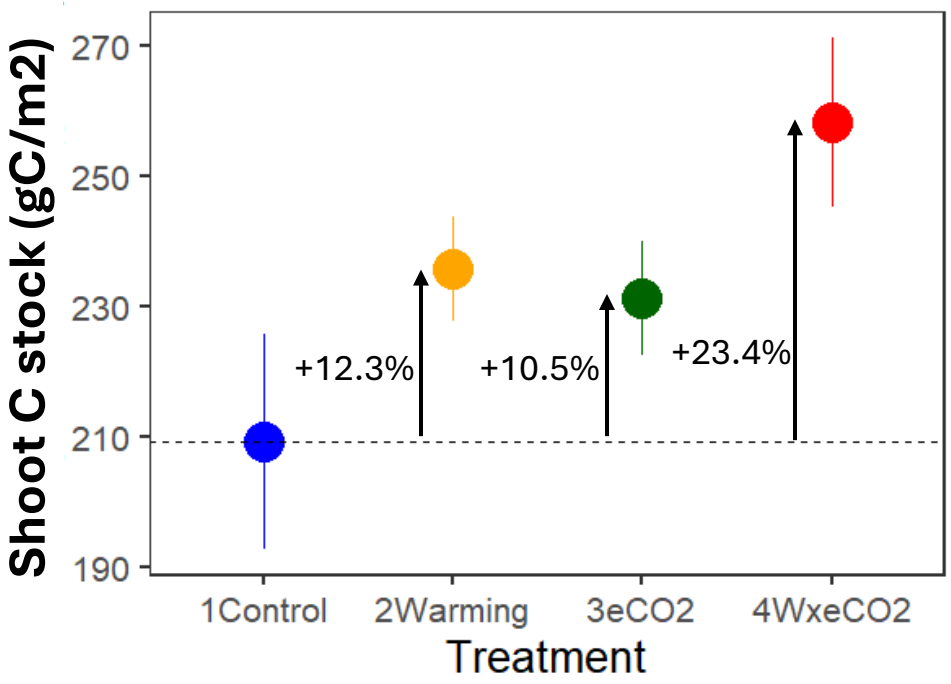




Global change effects

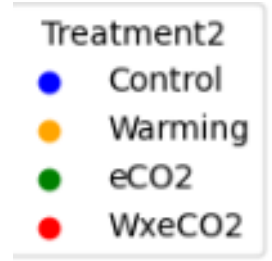
Average response of **shoot C** over 10 years

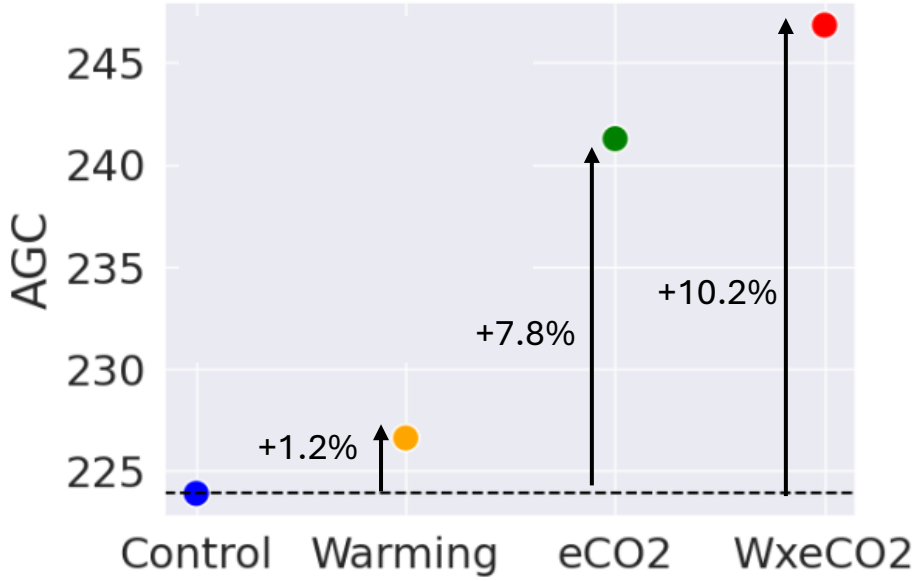
Observations

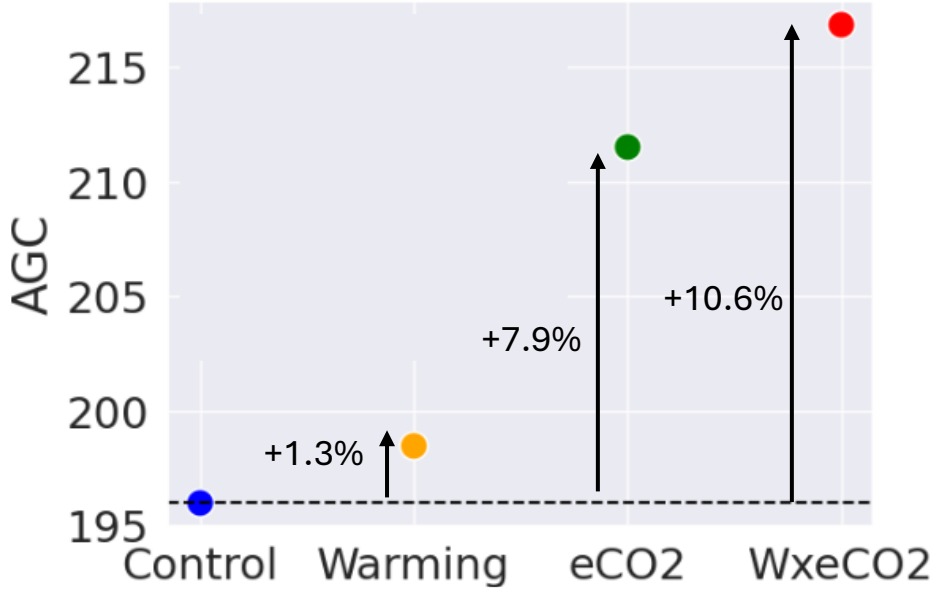


Century

MIMICS



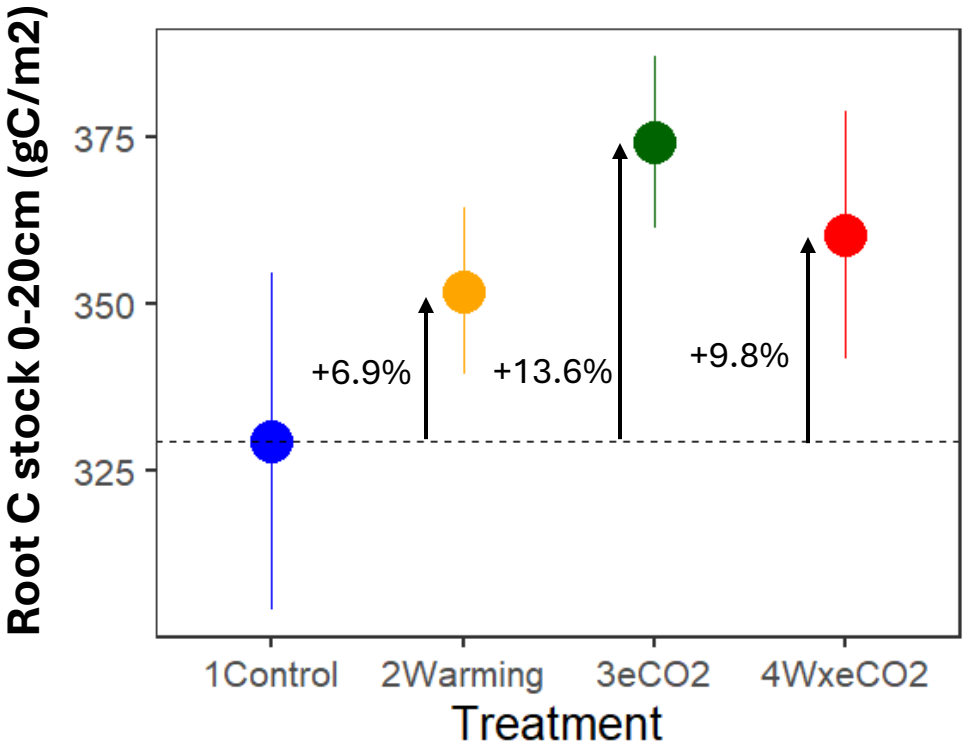




Global change effects

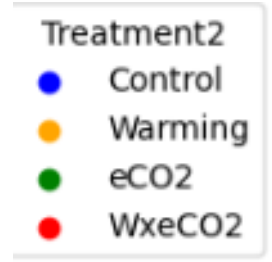
Average response of **root C** over 10 years

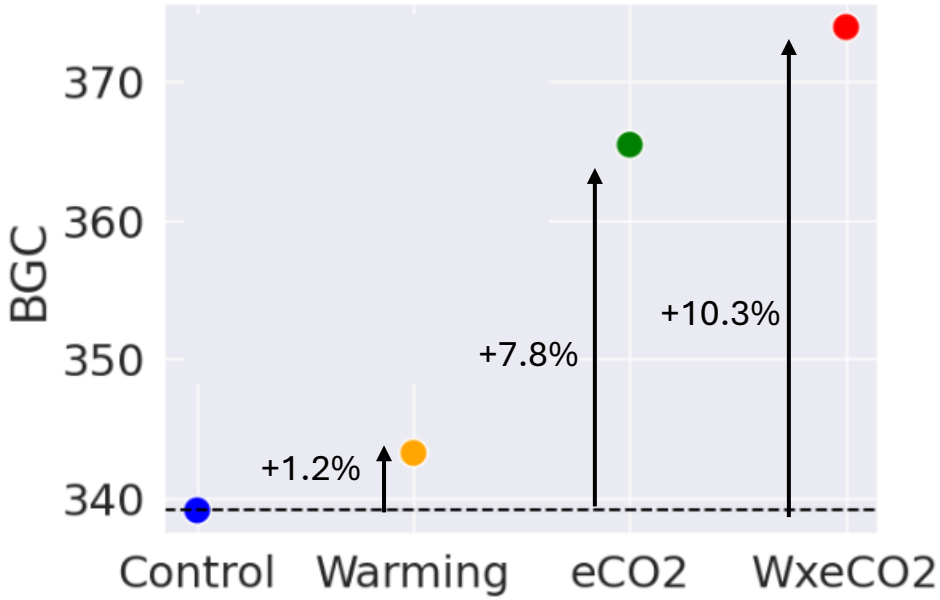
Observations

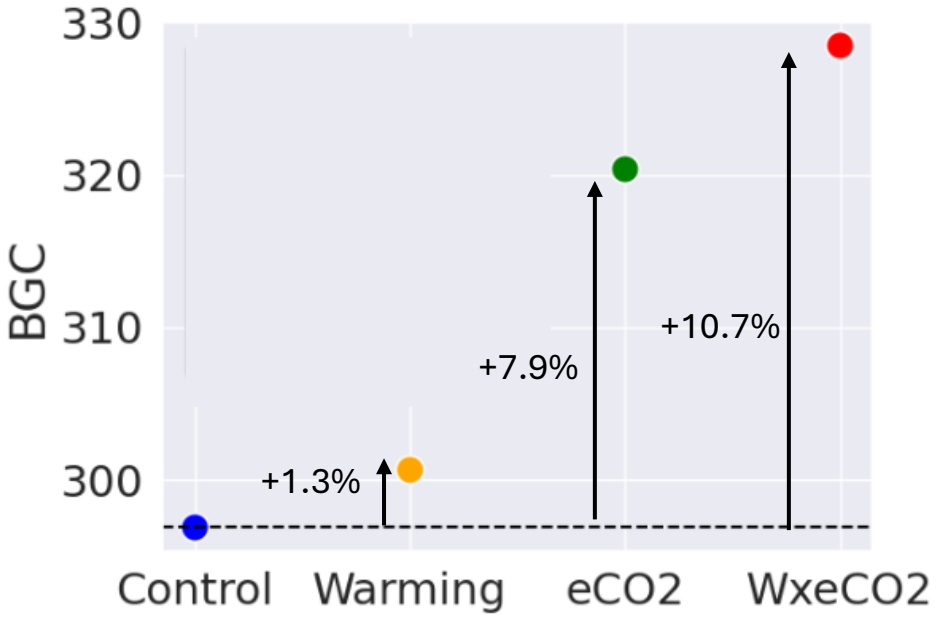


Century

MIMICS



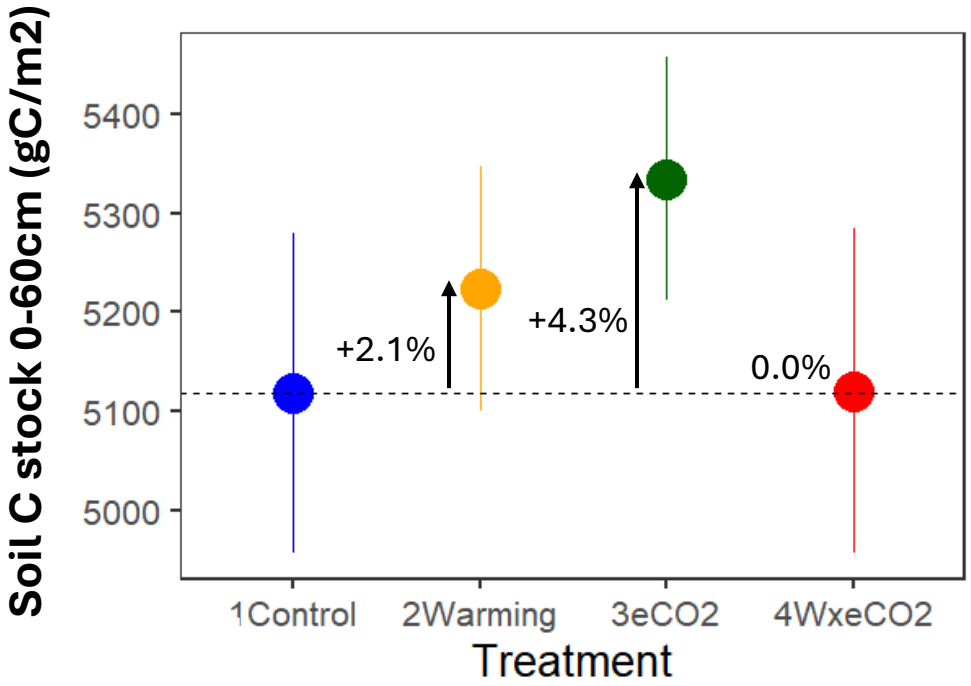




Global change effects

Average response of **soil C** over 10 years

Observations



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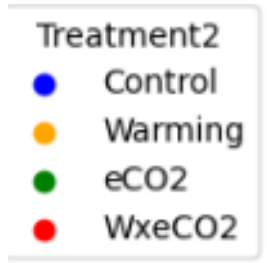

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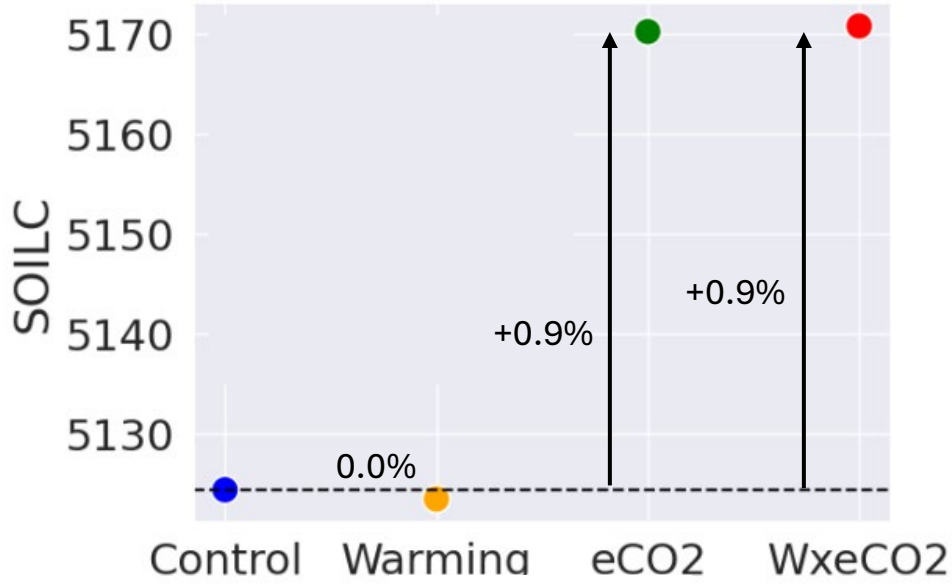

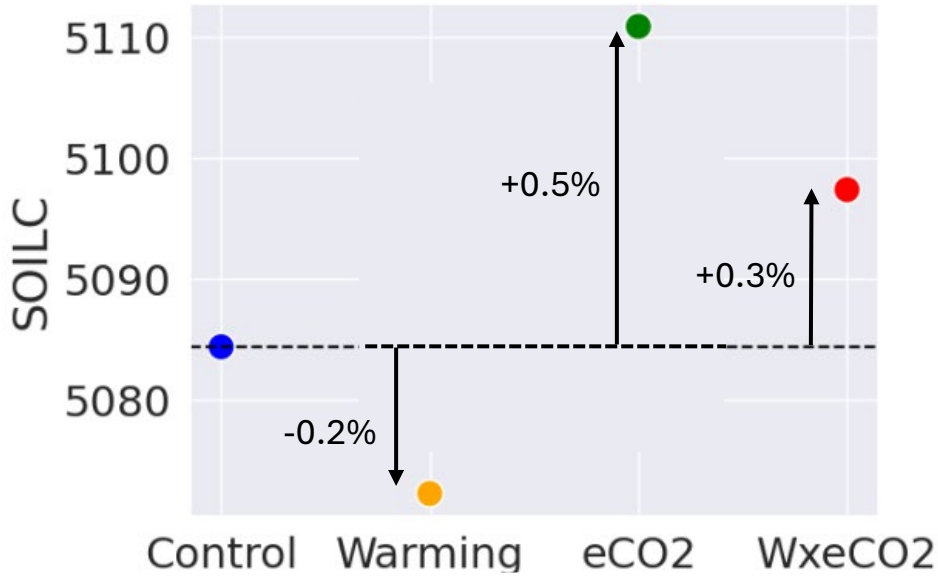

Takeaways from model-observation comparison

1. Weaker model responses than observed responses

2. Observations have more positive responses to warming

3. Observations have more interactive responses than models

Ad hoc parameter changes: what mechanisms are we missing?

Ecological driver	Brief explanation	Parameter change	Model applied to	GC applied to	Inspired by
Allocation change	Less root biomass needed to acquire N with warming	Lower froot:leaf under warming and combined	Both	Warming, combo	Site data
Lower cost of AM N acquisition	More N availability might promote plant mechanisms to uptake N	Lower akc_active and akn_active	Both	Warming, combo	Site data = higher TBCA might mean more C to AM (or to root exudates but not in models) *higher N uptake under warming: Zhang et al., 2025
Higher litter decomp	Warmer temp means more energy for microbes to decompose or shift to higher quality plant material	C: higher litter taus (turnover) M: higher litter vmods, lower ko to balance	Both	Warming	Higher N mineralization under warming but also higher soil C (suggesting litter and not soil decomp)
Higher microbial turnover	Warmer temp means faster reactions and turnover as well	Higher tau (turnover) values	MIMICS	Warming	Several articles: Li et al., 2019; Zhou et al., 2024; Wang et al., 2022; Hagerty wet al., 2014; Wang et al., 2020
Changes in microbial CUE	Decreases due to water stress or depletion of available OM or increase with N availability	Higher or lower MGE	MIMICS	Warming	Zhang et al., 2022

Ad hoc parameter changes: what mechanisms are we missing?

Century

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MIMICS

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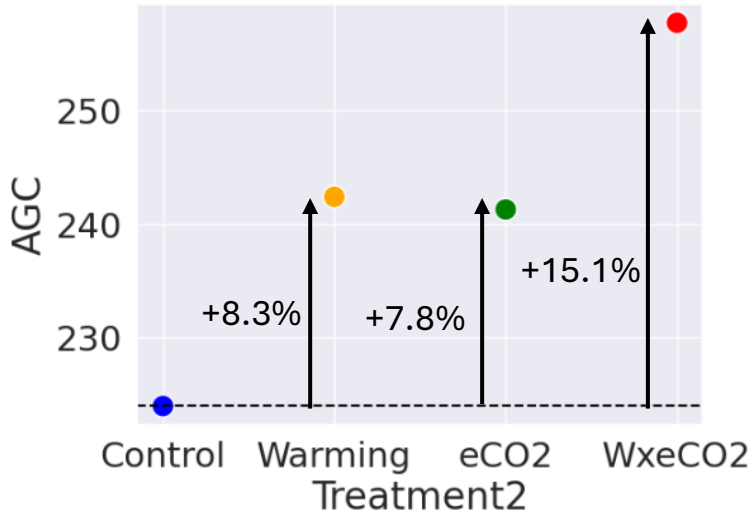
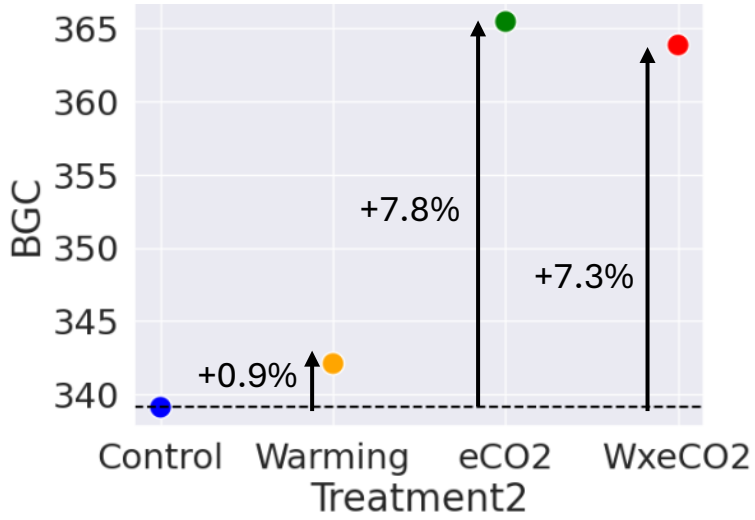
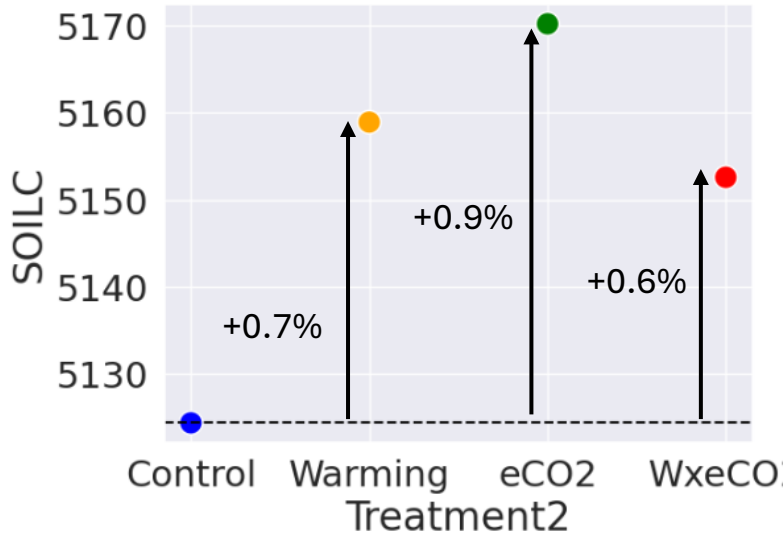
Ad hoc parametrization responses

Century







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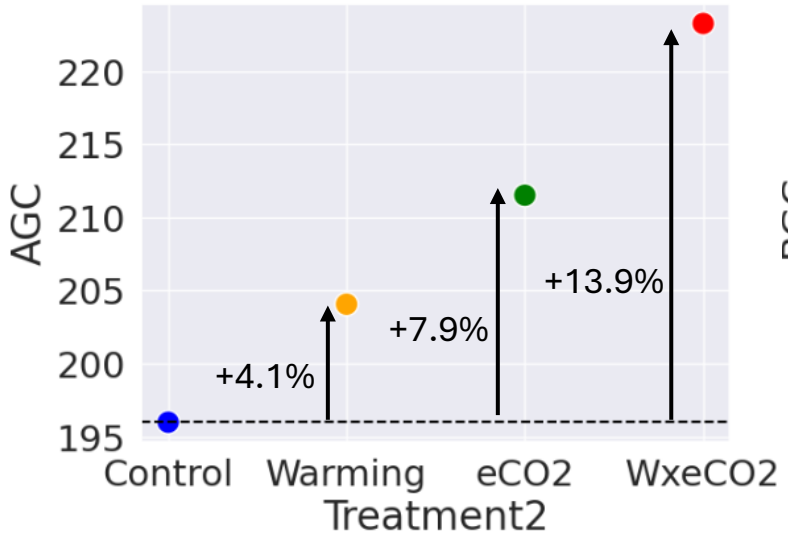
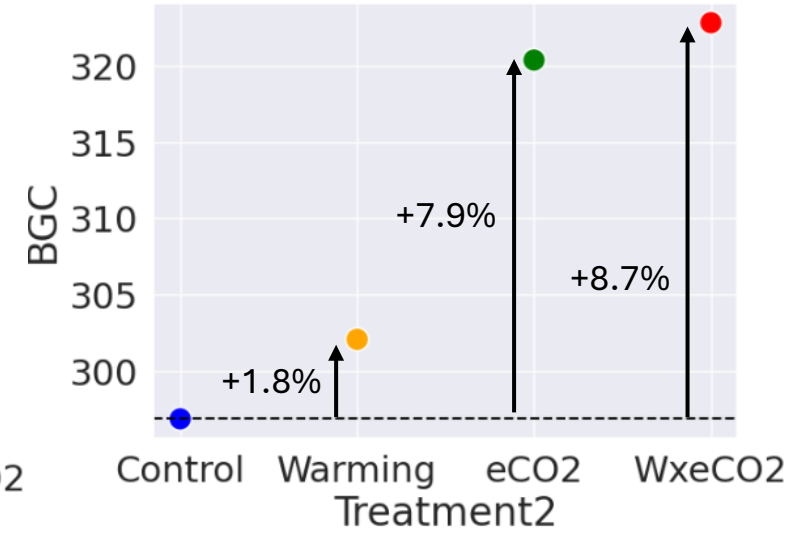
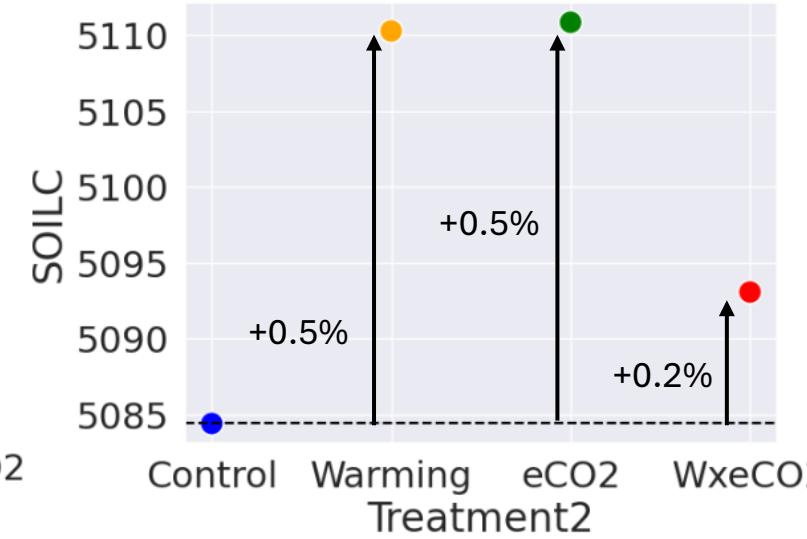
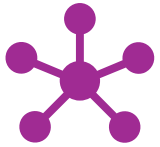






Takeaways

Thanks for listening!



Presuming models can provide insight about combined global changes may not be a safe assumption when interactions occur

Representation of microbes in soil models does not necessarily confer unique C pool responses to global change

However, representation of microbes in soil models does allow for investigation of new soil BGC mechanisms