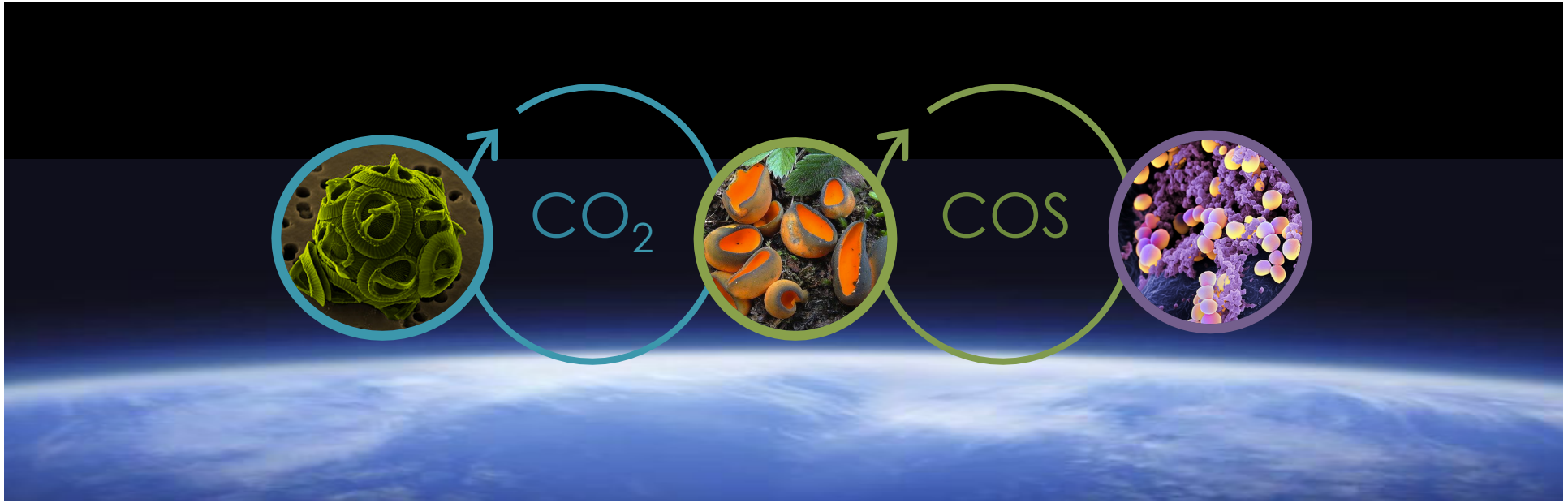
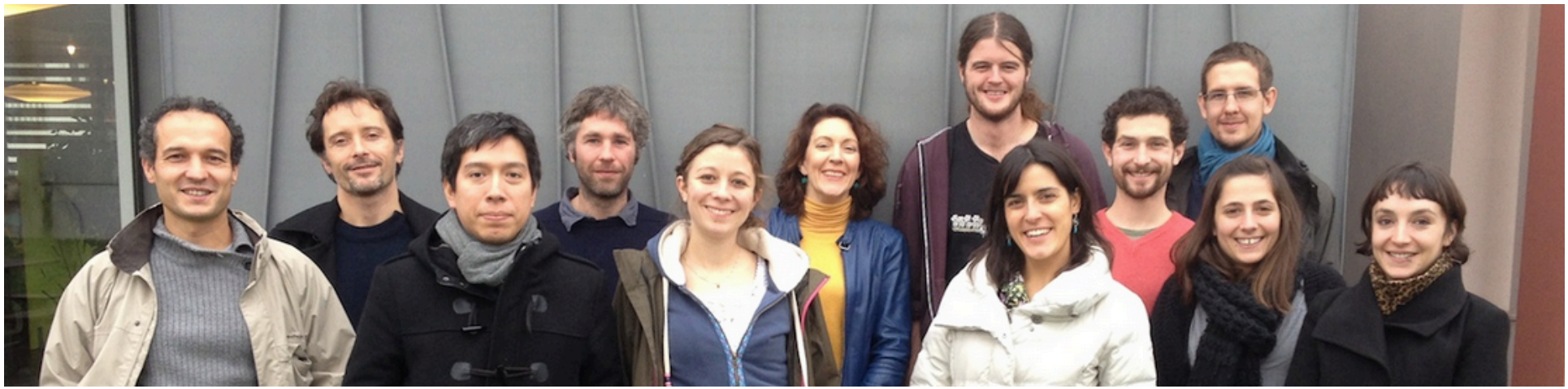
From enzyme to Earth function:

linking soil community function and composition to constrain the magnitude of the terrestrial CO_2 sink



Lisa Wingate

Acknowledgements



The ECOFUN team, INRA Bordeaux
The BIOCOM team, INRA Dijon
Laura Meredith University of Arizona

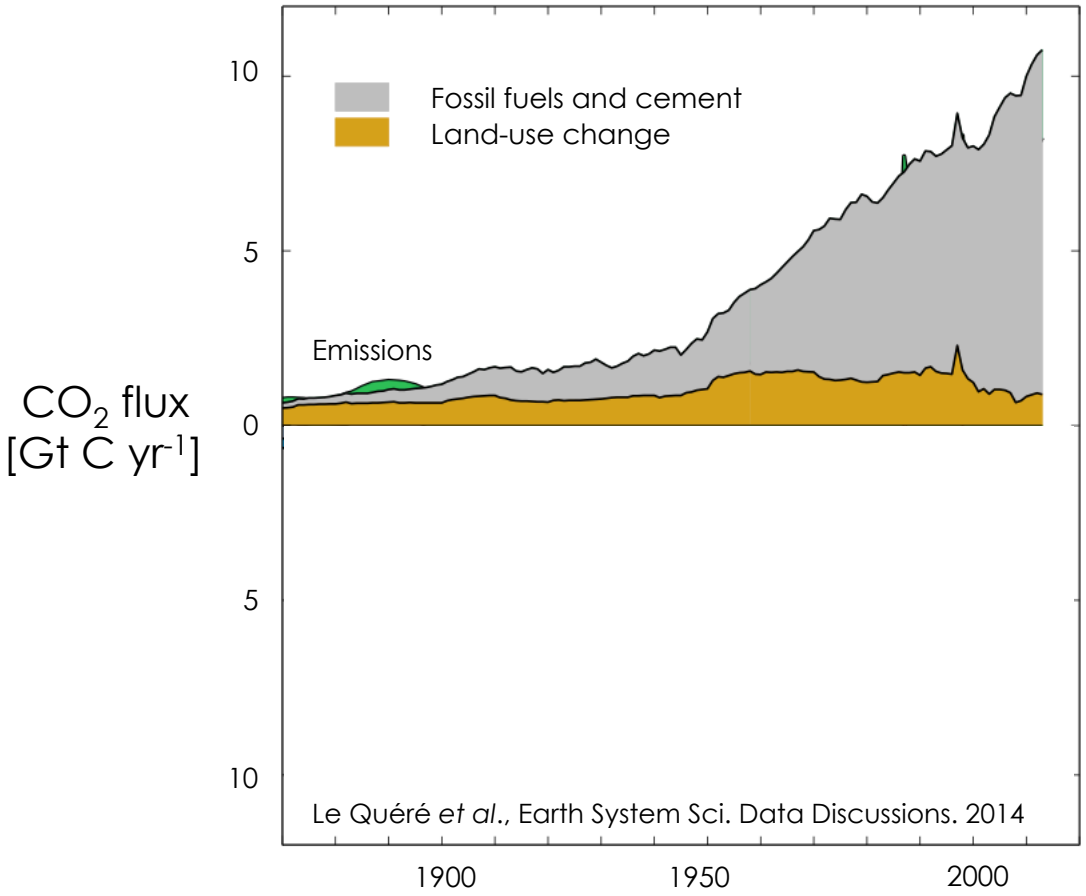
INRA SCIENCE & IMPACT

MARIE CURIE ACTIONS

erc European Research Council

Agence Nationale de la Recherche ANR

Strong inter-annual variability in the biospheric CO_2 sink



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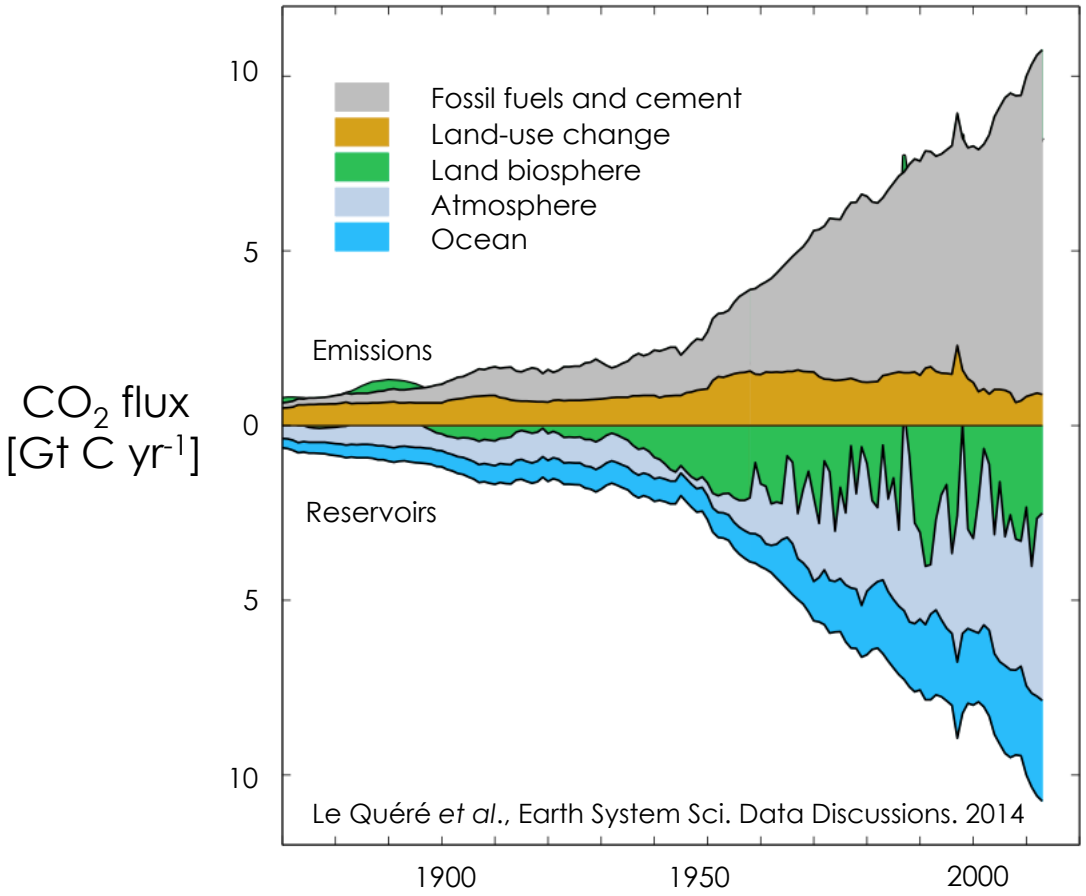
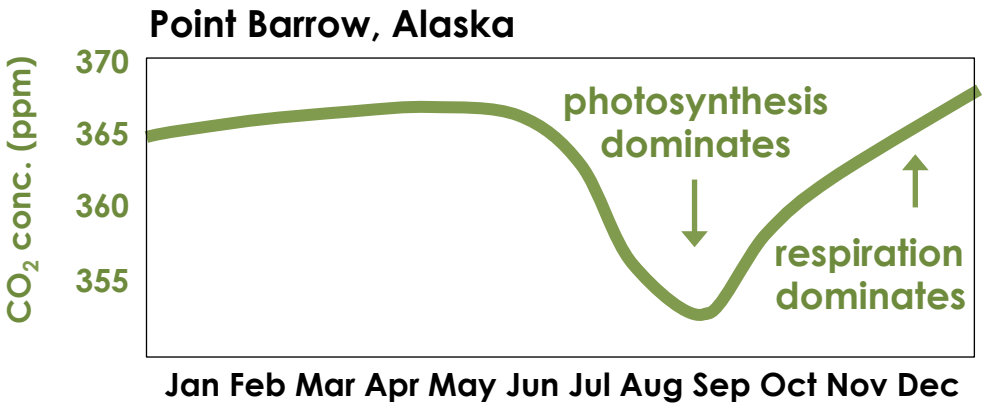
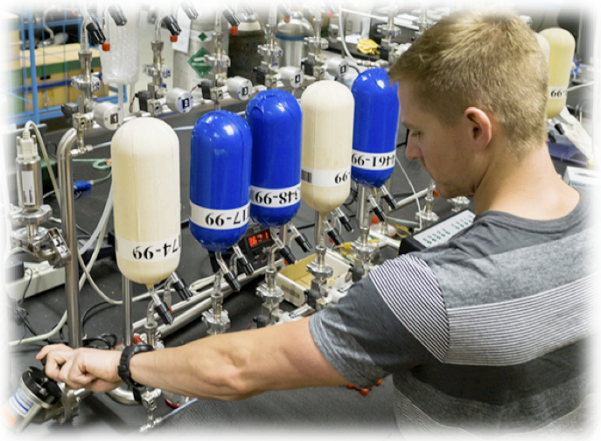


Tracers to constrain photosynthesis in C cycle models





Source data : NOAA CMDL

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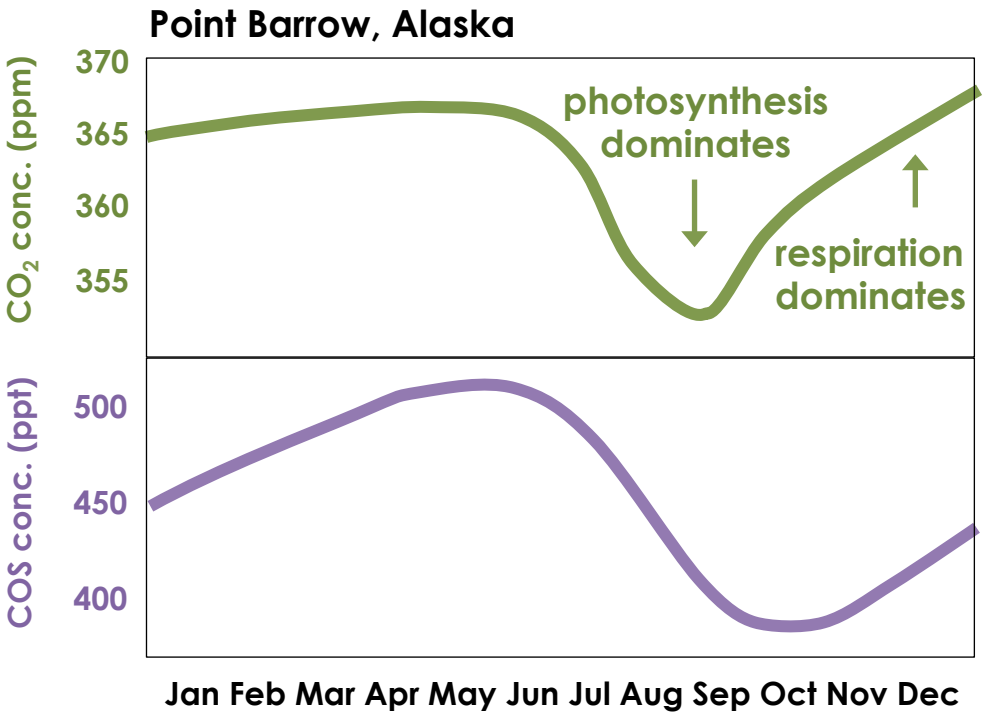
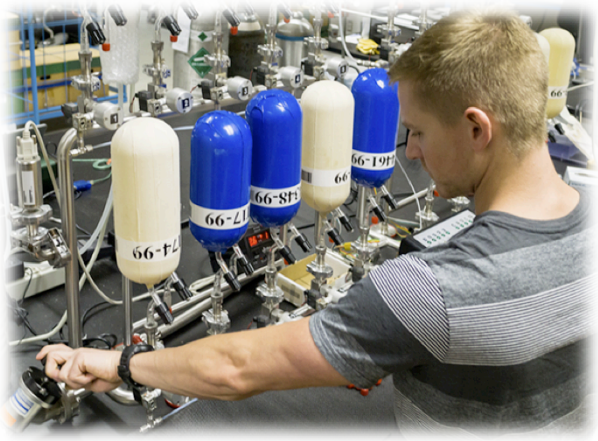
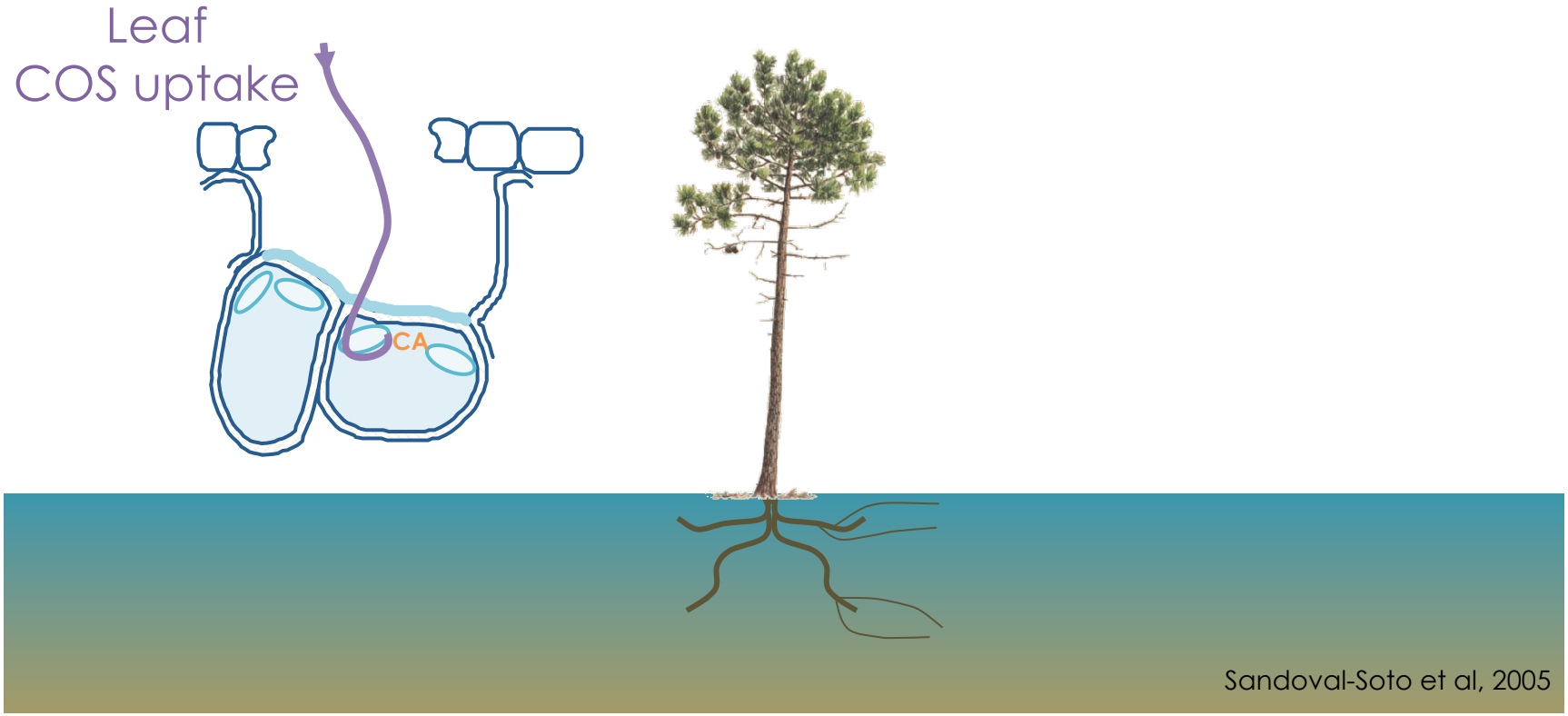




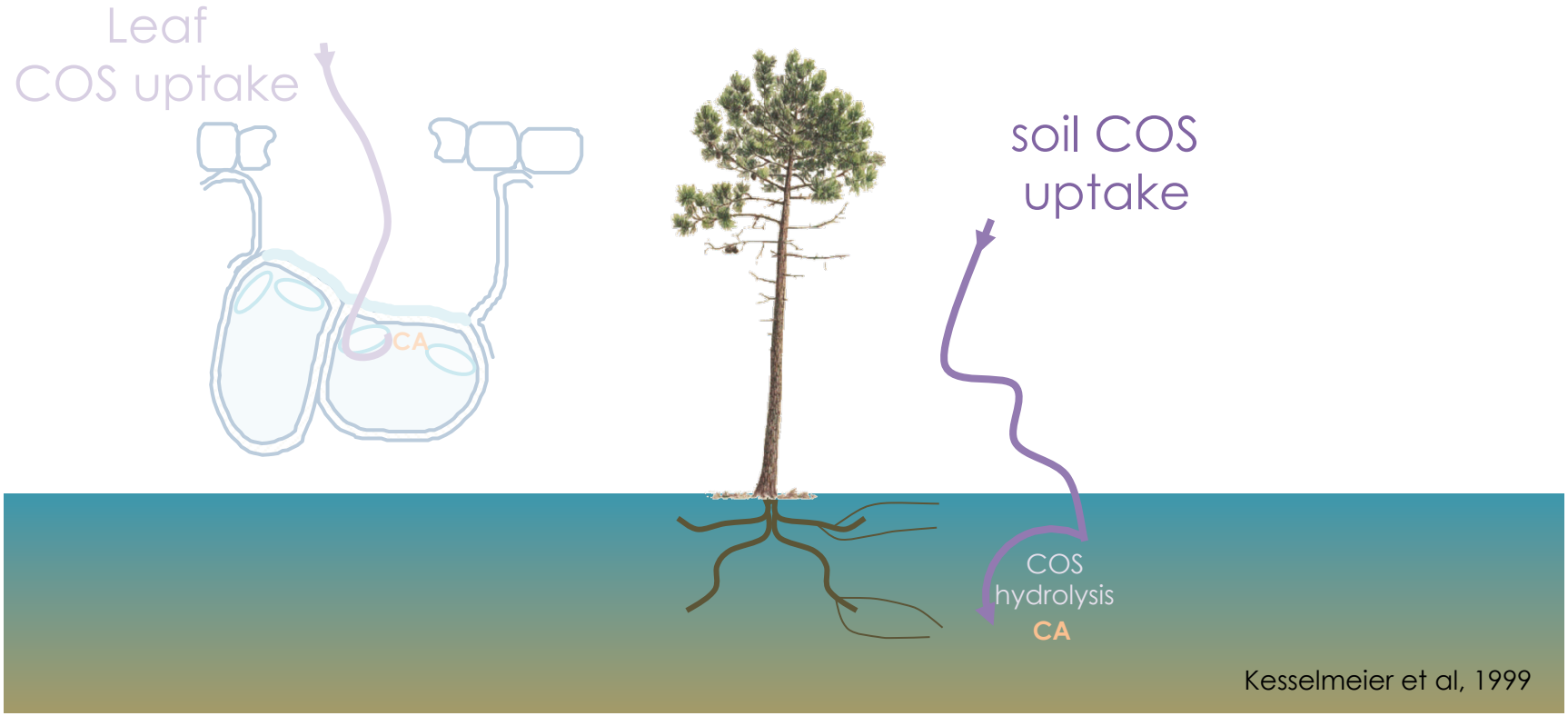
Source data : NOAA CMDL

COS hydrolysed in leaves by carbonic anhydrase



$$COS_{aq} + H_2O \xrightarrow{CA} CO_{2aq} + H_2S$$

COS hydrolysed in soils by carbonic anhydrase



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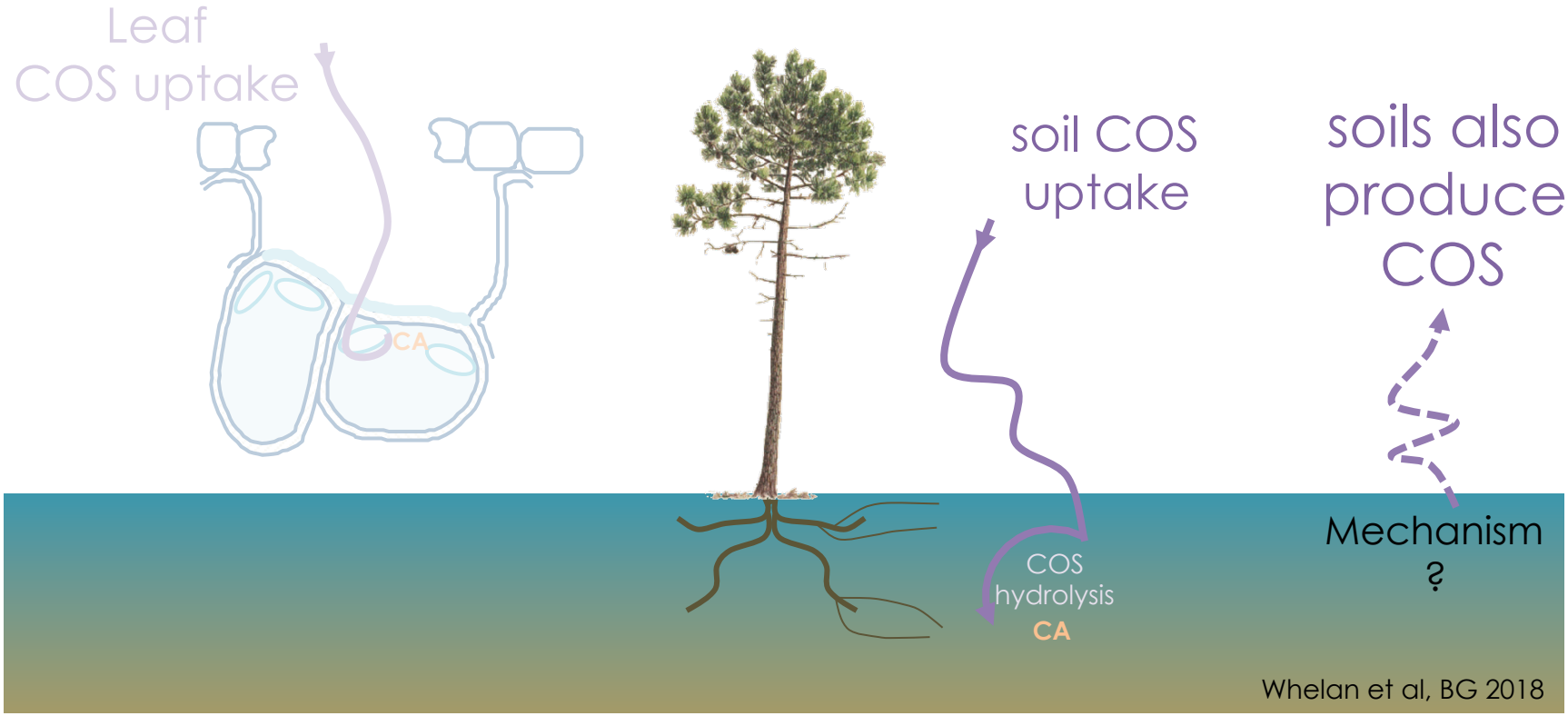
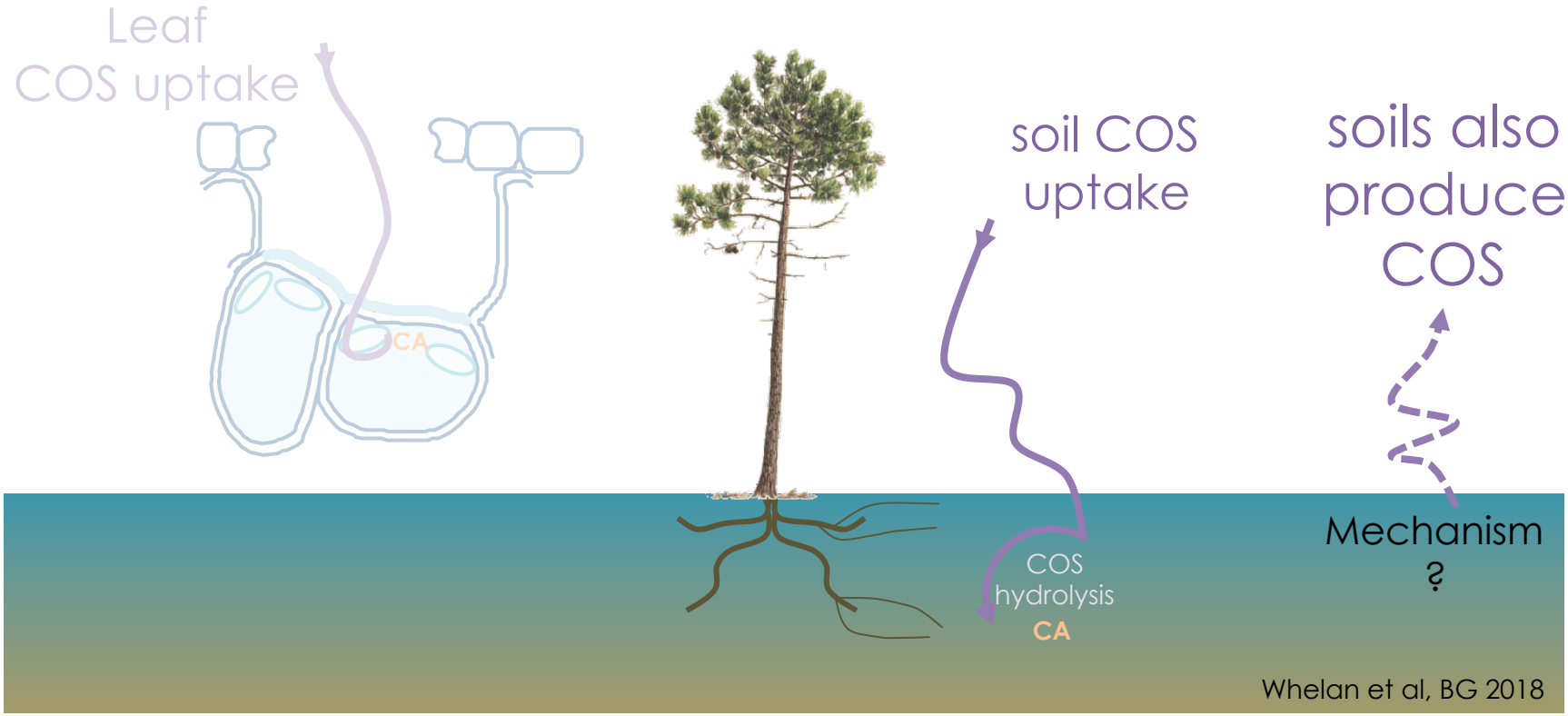
Possible abiotic and biotic production of COS in soils



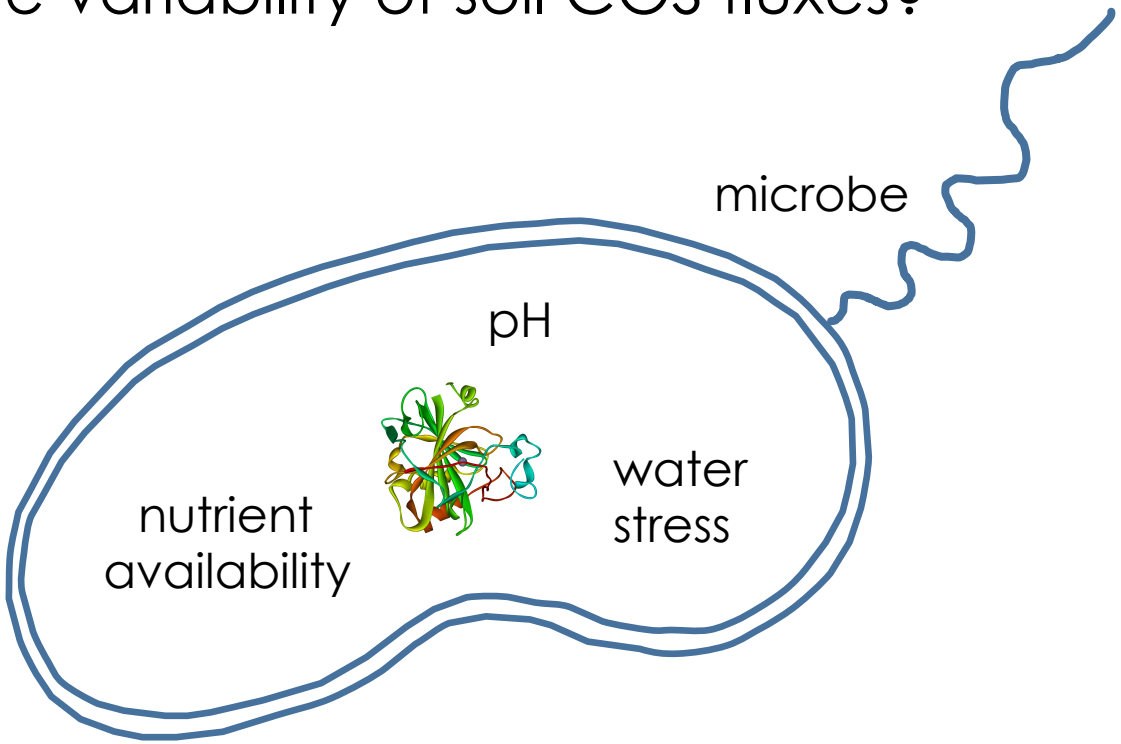
Possible abiotic and biotic production of COS in soils



What traits determine the soil-atmosphere flux of COS?

What regulates the variability of soil COS fluxes?

Is soil COS uptake regulated by **environmental traits?**



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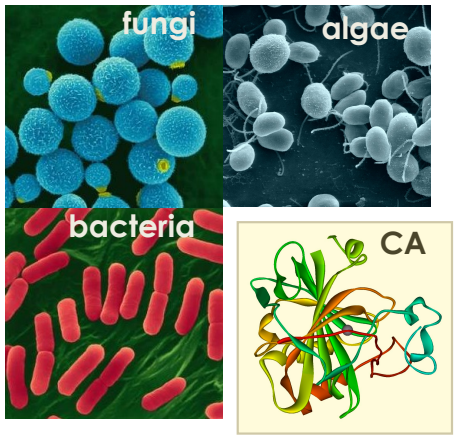
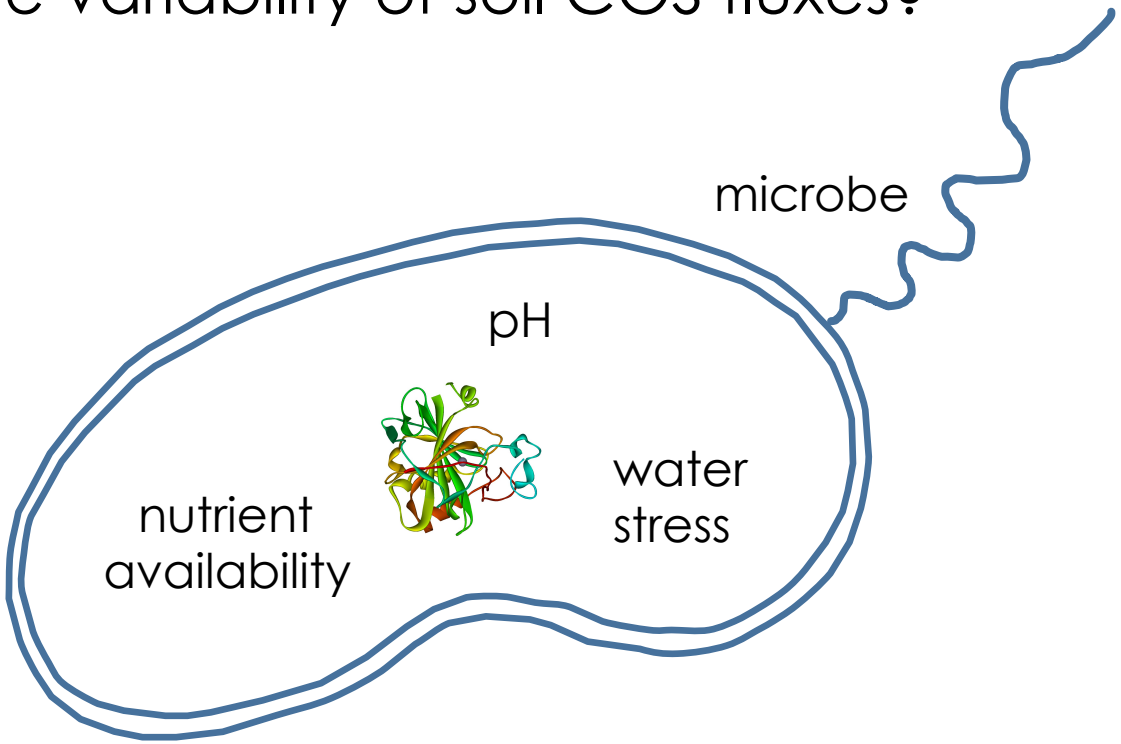


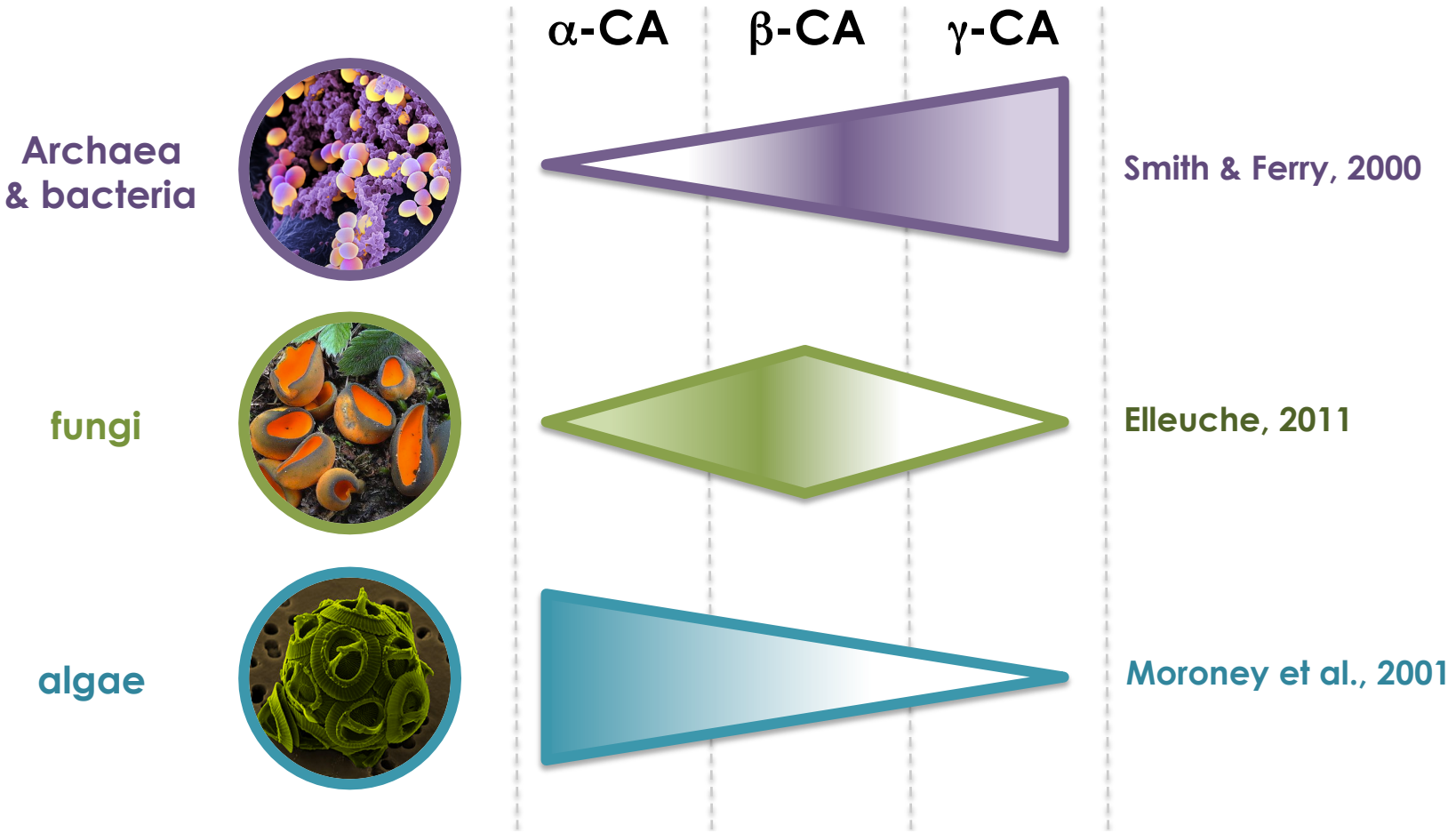


Is soil COS uptake linked to soil community traits: **size, composition or enzyme class?**

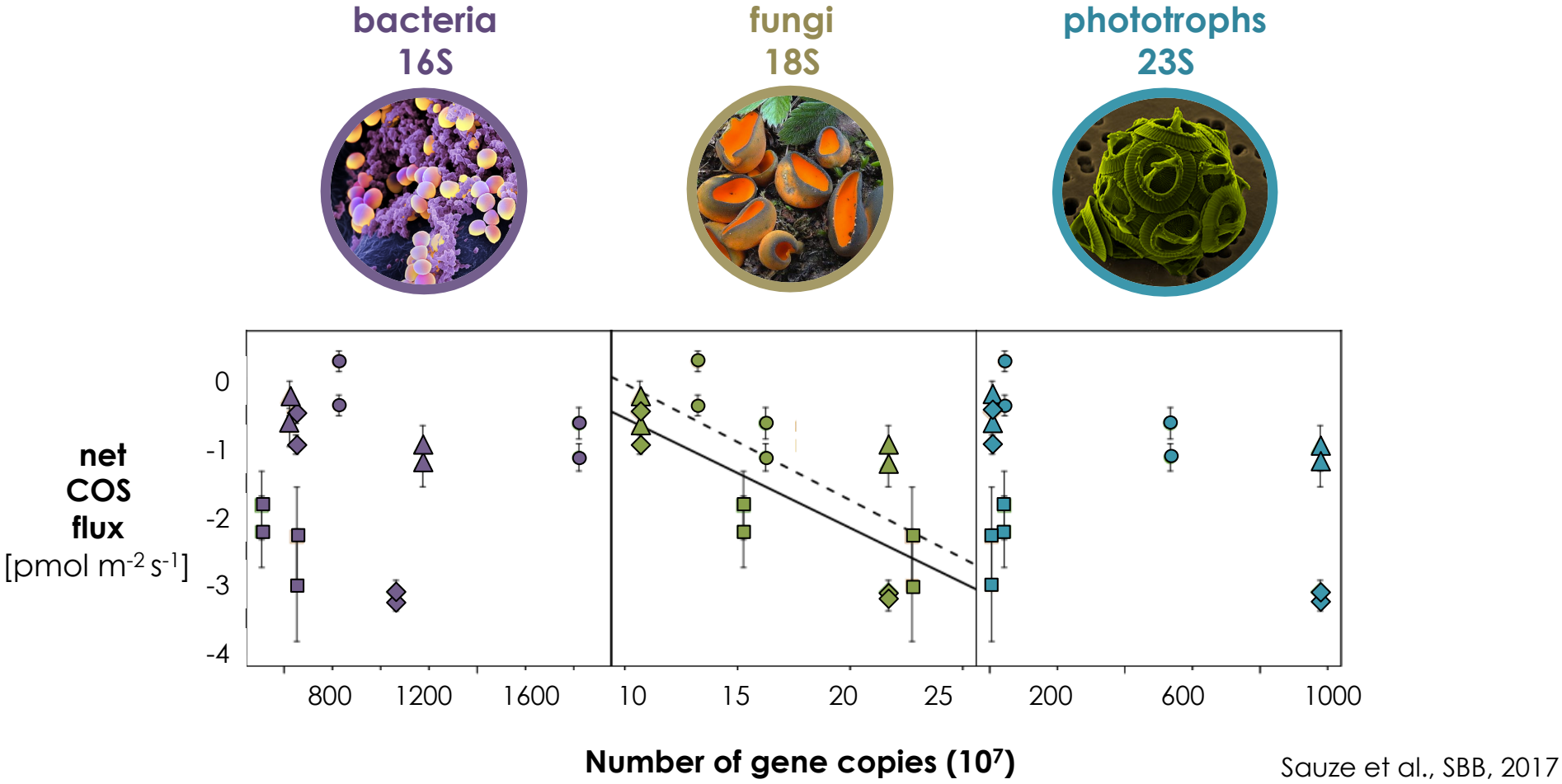
Carbonic anhydrase an extremely ancient enzyme

(Smith *et al.*, PNAS. 1999)

Different types of CA classes within microbial communities

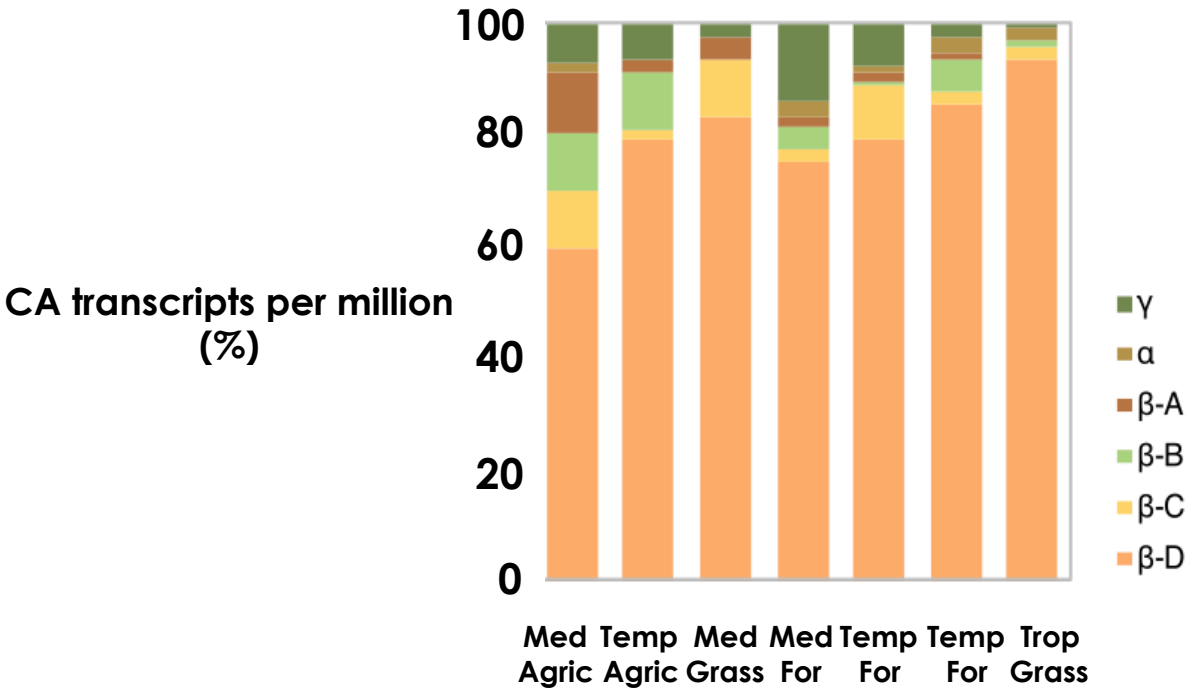


COS fluxes may be sensitive to community structure



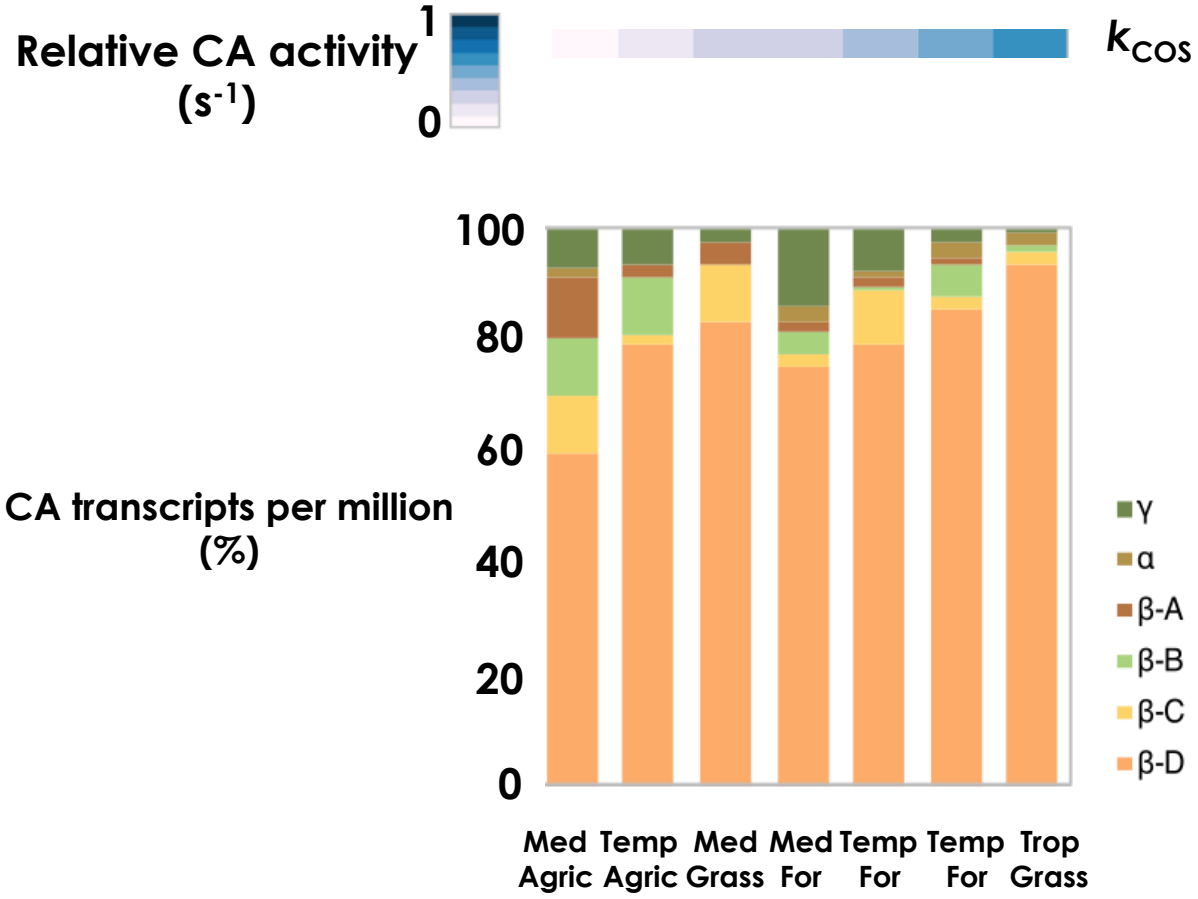
Sauze et al., SBB, 2017

Variations in soil CA classes between ecosystems



Meredith et al., ISME 2018

Variations in β-CA classes linked to COS uptake rate



Meredith et al., ISME 2018

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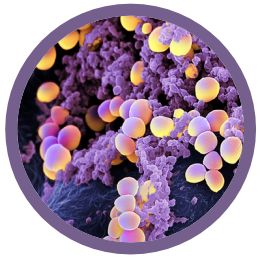
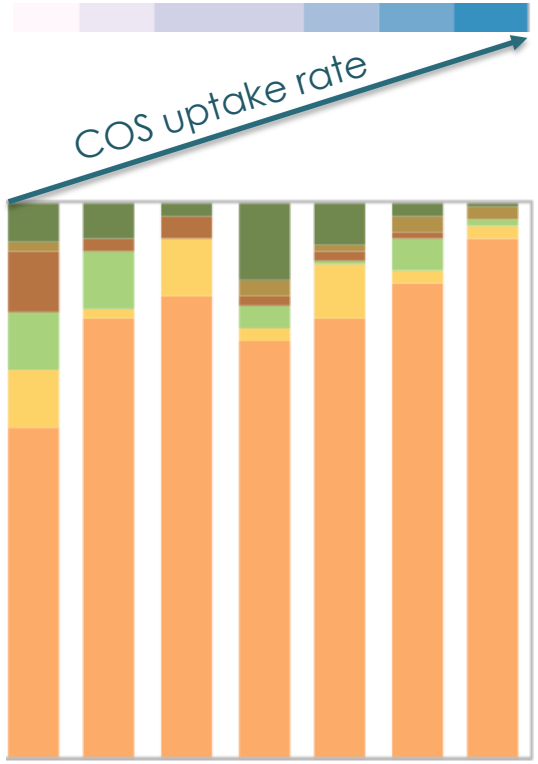
OTUs that **decrease** as COS uptake increases



Deltaproteobacteria
Cyanobacteria
Euryarchaeota

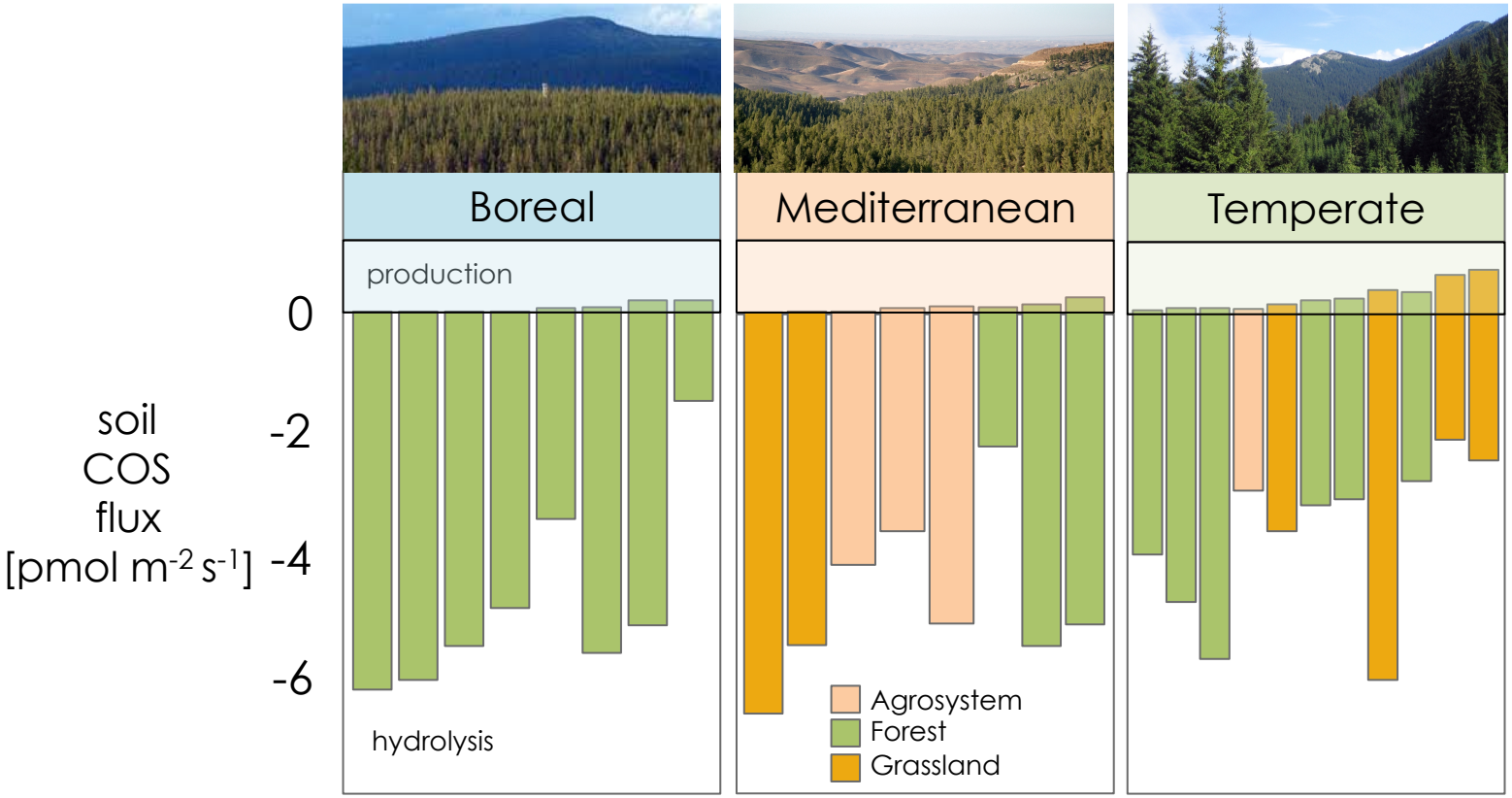


OTUs that **increase** as COS uptake increases

Ascomycota
Basidiomycota
Zygomycota
Alphaproteobacteria

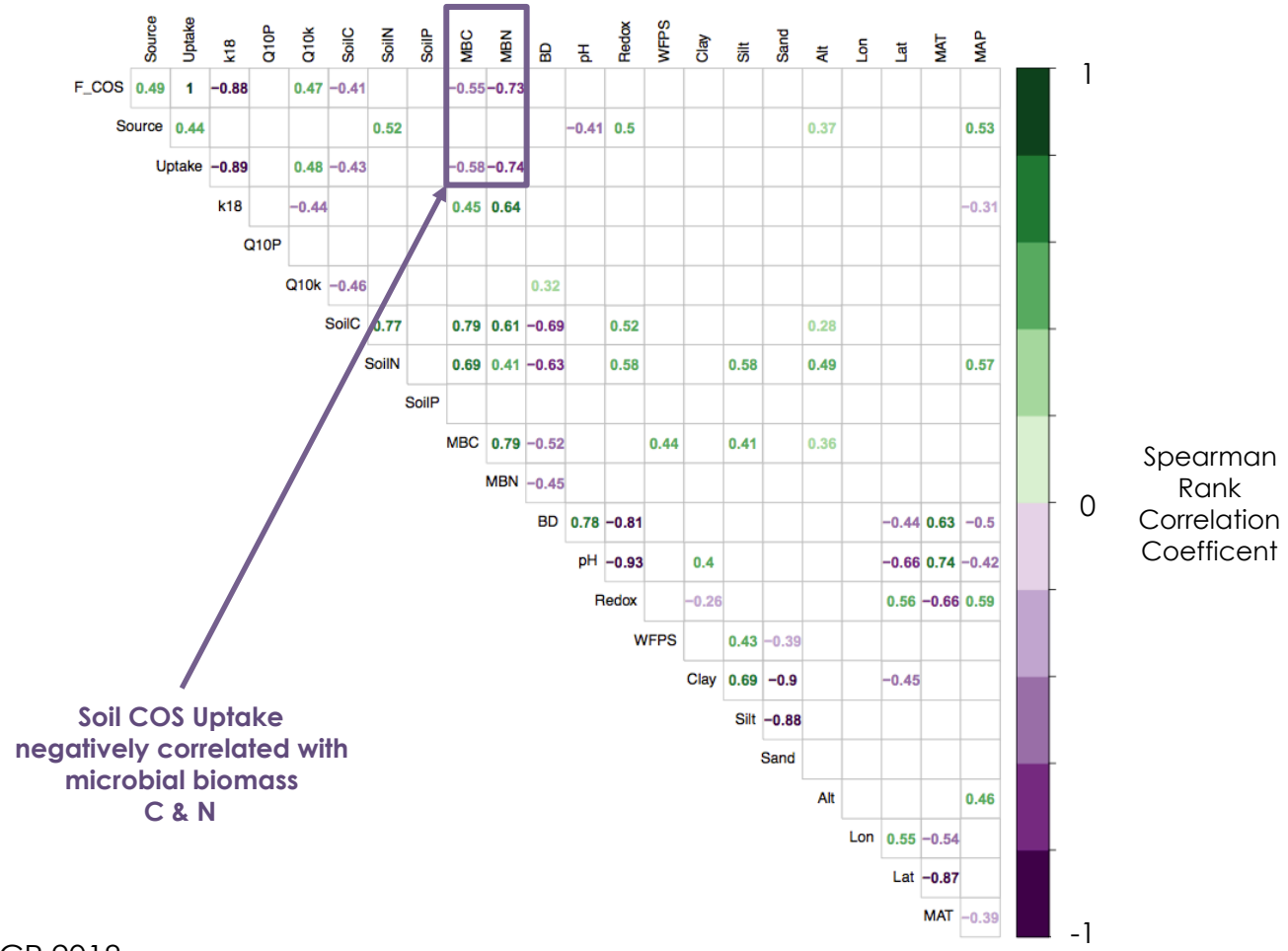
Meredith et al., ISME 2018

Variability of soil COS fluxes across Europe



Kaisermann et al., ACP 2018; Soil Systems 2018

Drivers of soil COS fluxes across Europe



Kaisermann et al., ACP 2018

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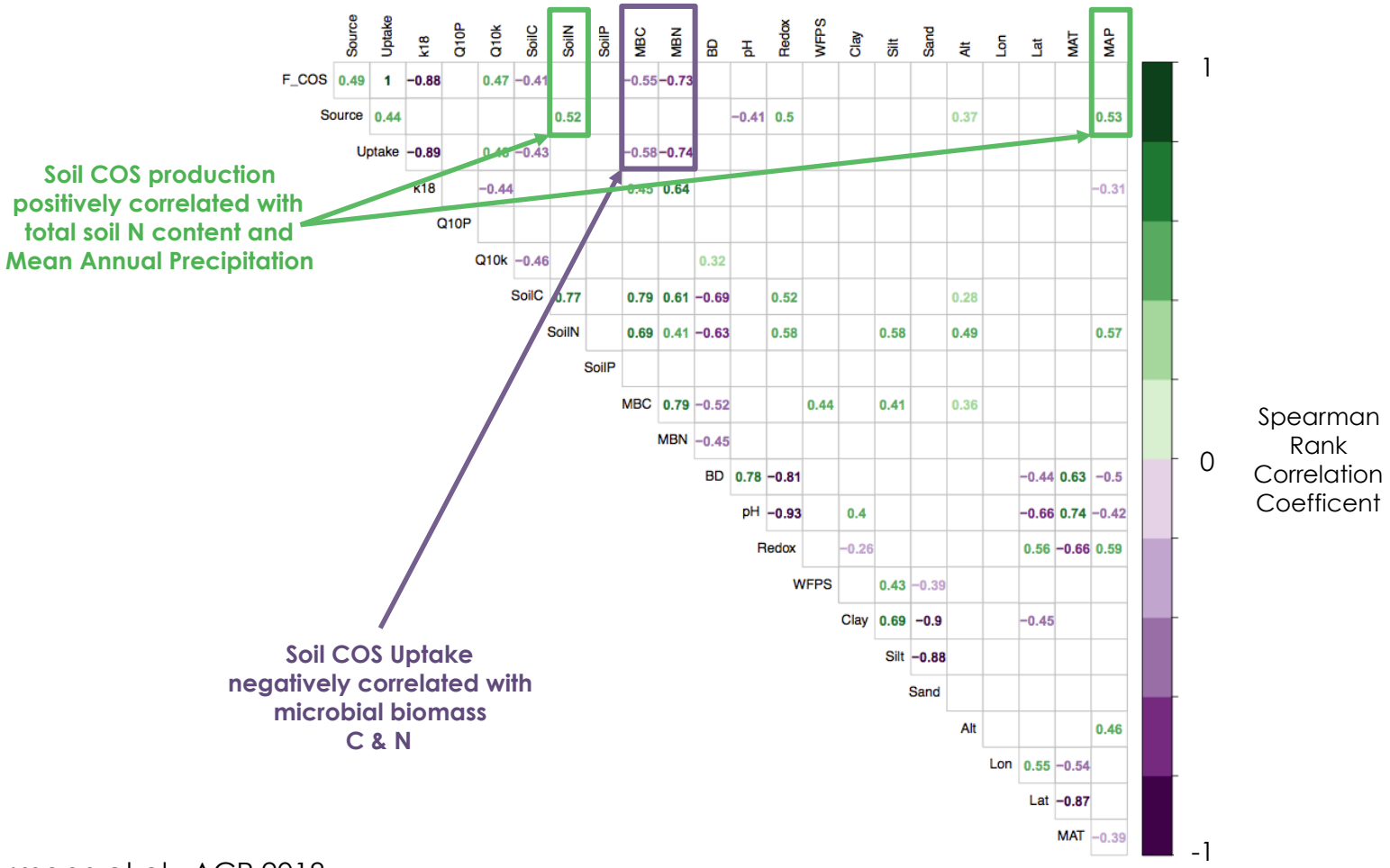
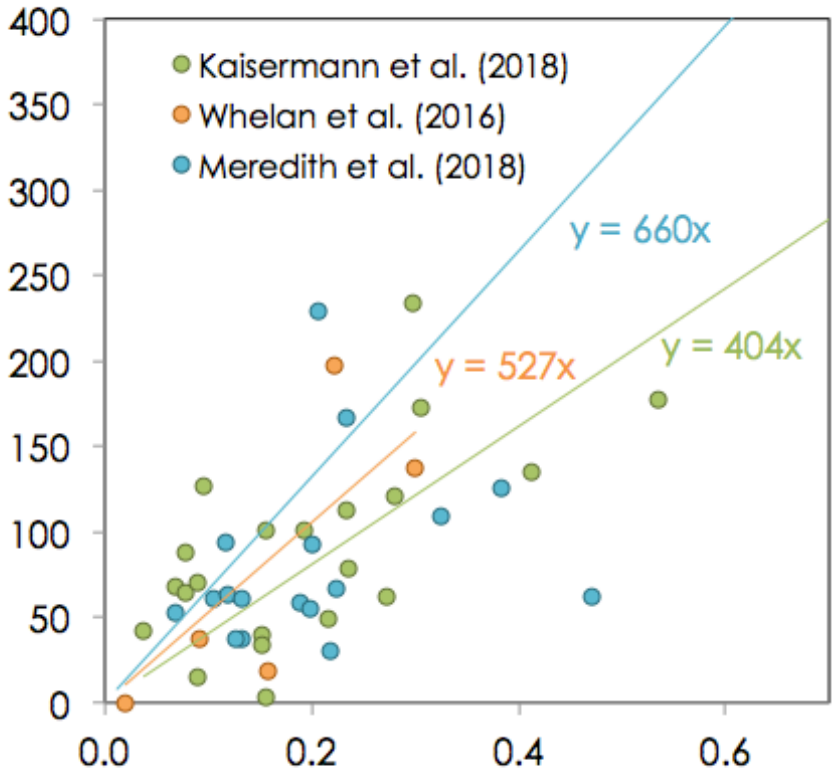


Kaisermann et al., ACP 2018

Potential to scale COS production with soil N content

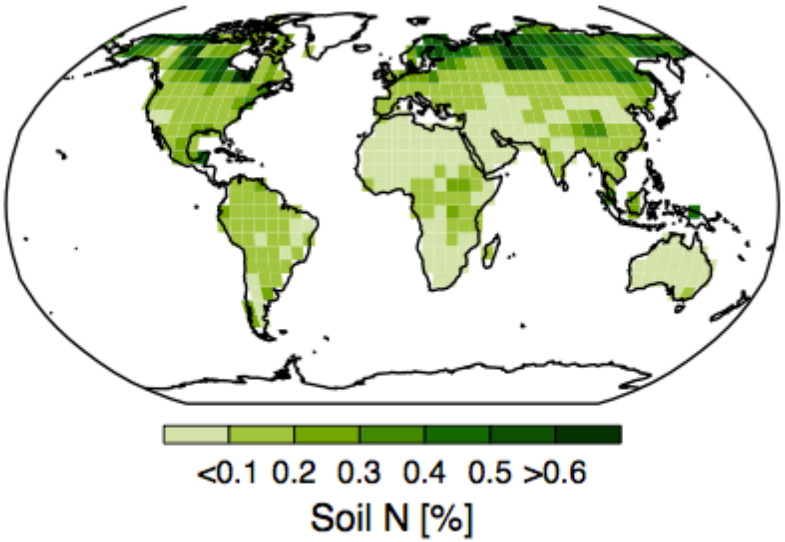
COS production @25°C (pmol Mg^{-1} s^{-1})



Total soil N content (%)

Wingate et al., in prep

Potential to scale COS production with soil N content



Wingate et al., in prep

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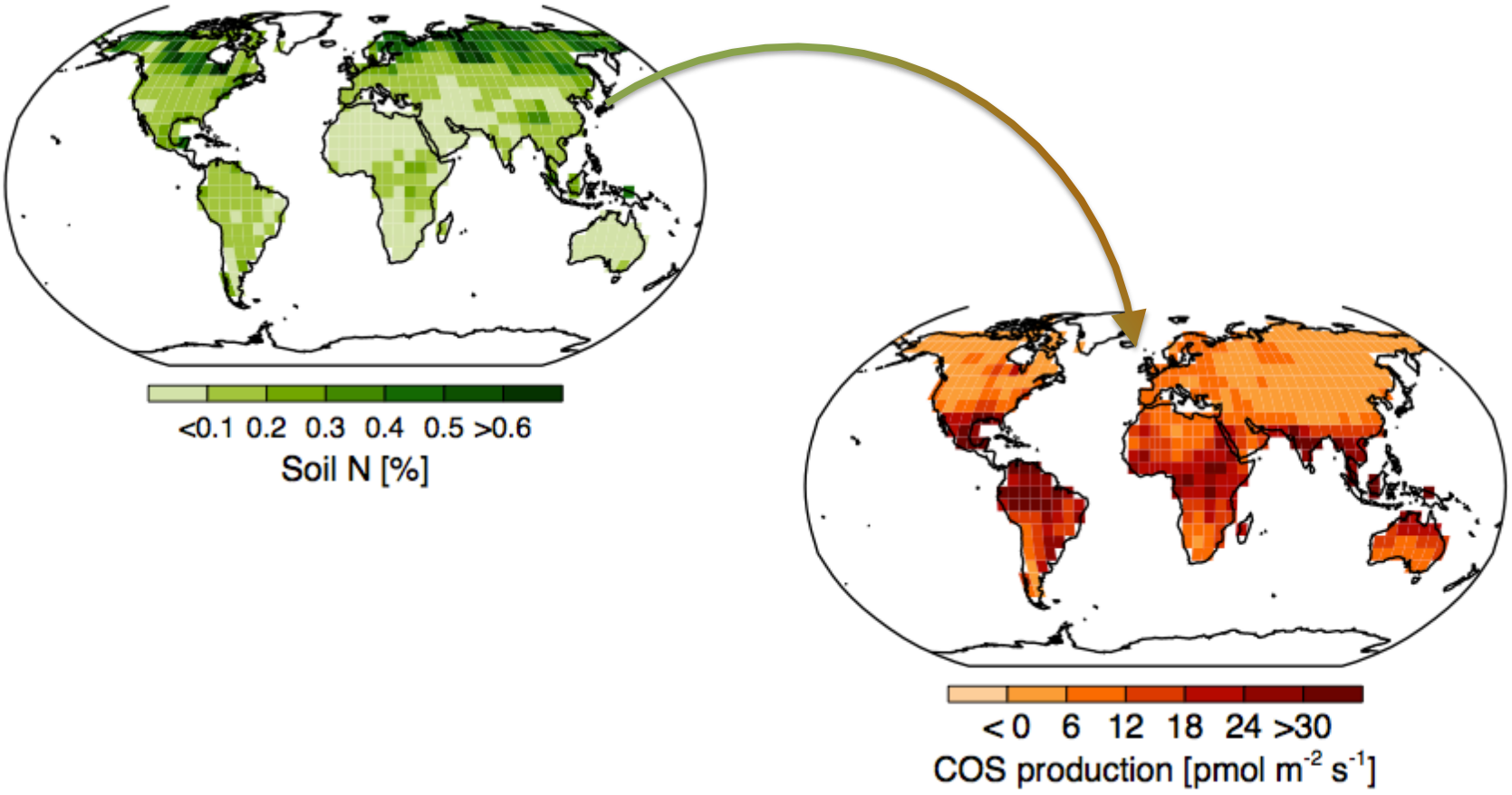
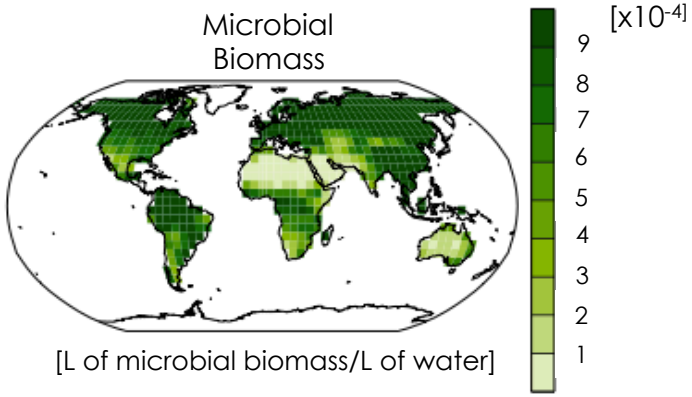


Wingate et al., in prep

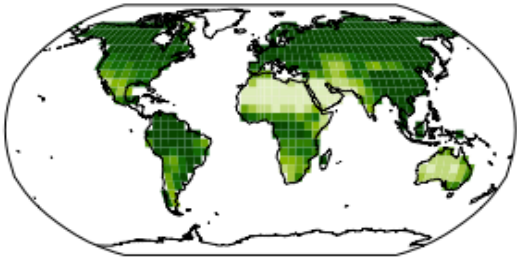
How will we scale soil COS uptake?



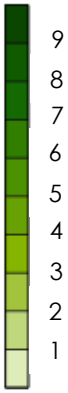
Wingate et al., in prep

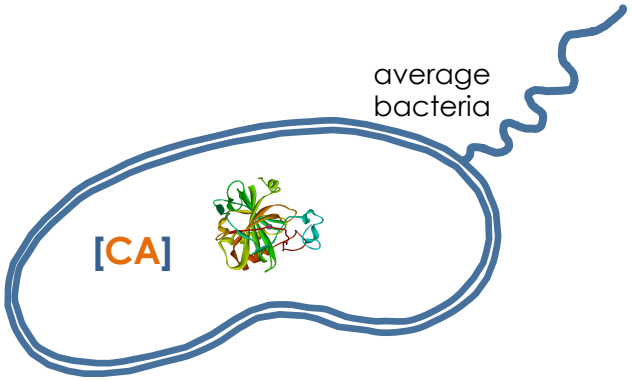
How will we scale soil COS uptake?

Microbial Biomass

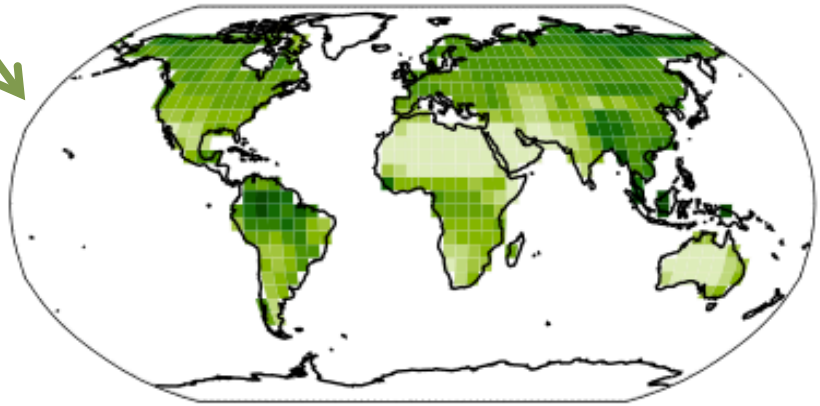


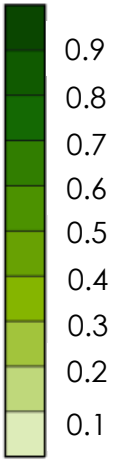
[L of microbial biomass/L of water]





Carbonic Anhydrase Concentration



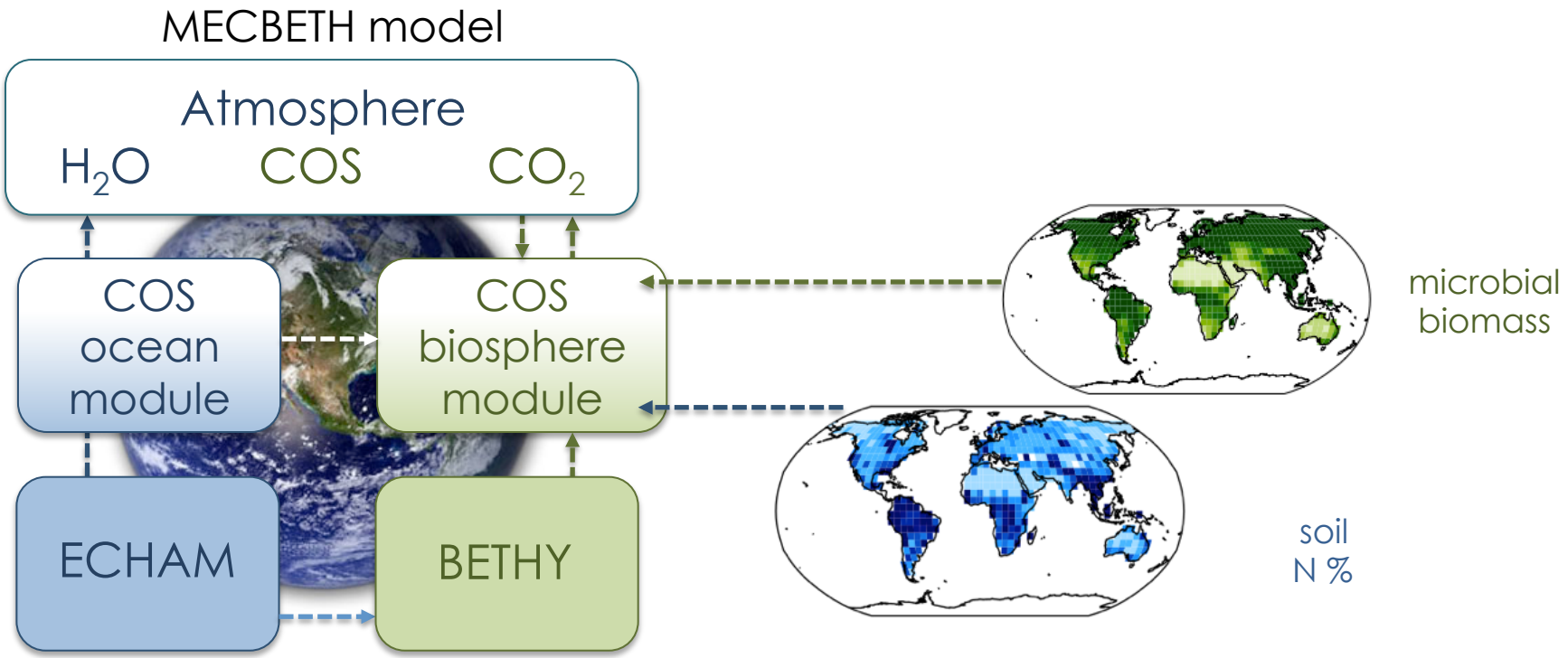


[µmol CA/L of soil]

ORNL DAAC

Wingate et al., in prep

Plan for predicting COS fluxes at the global scale



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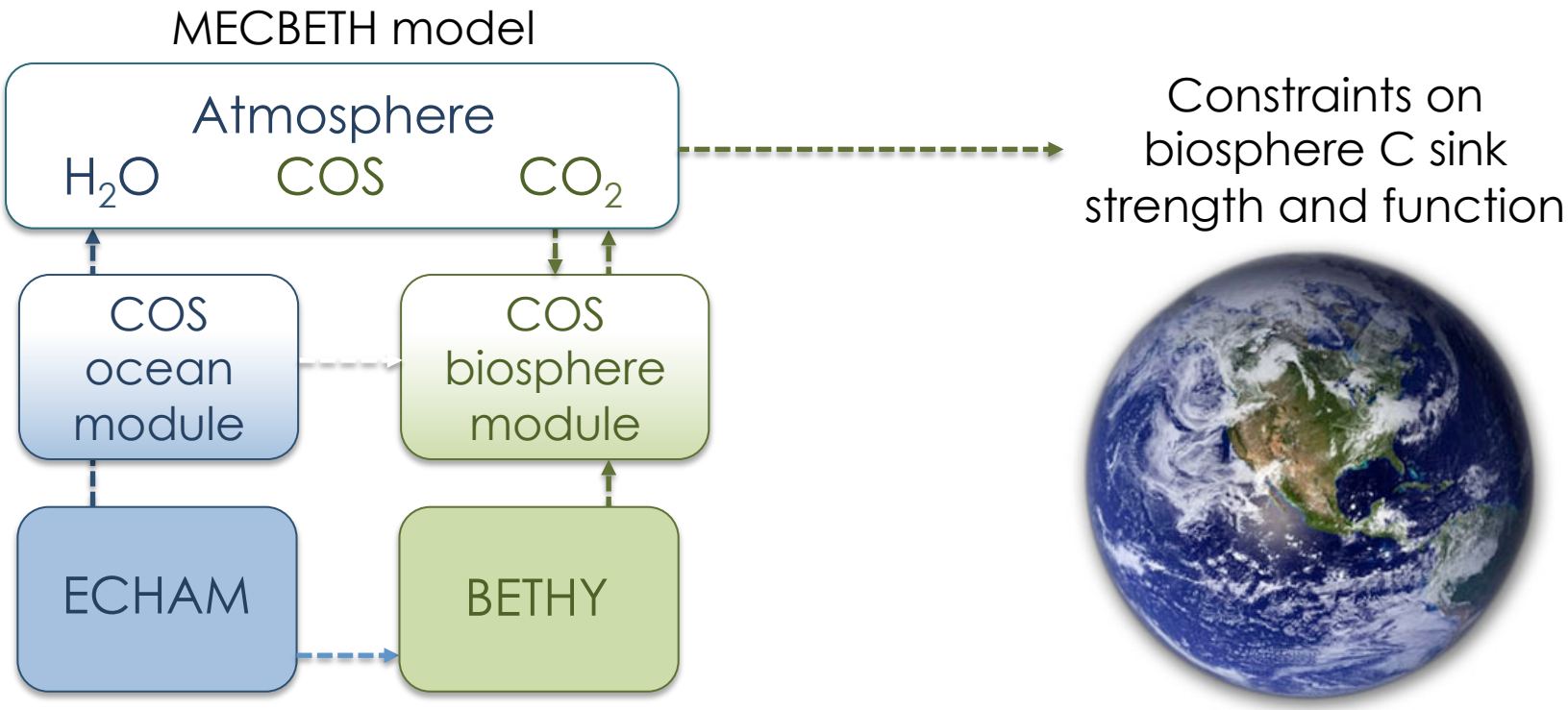
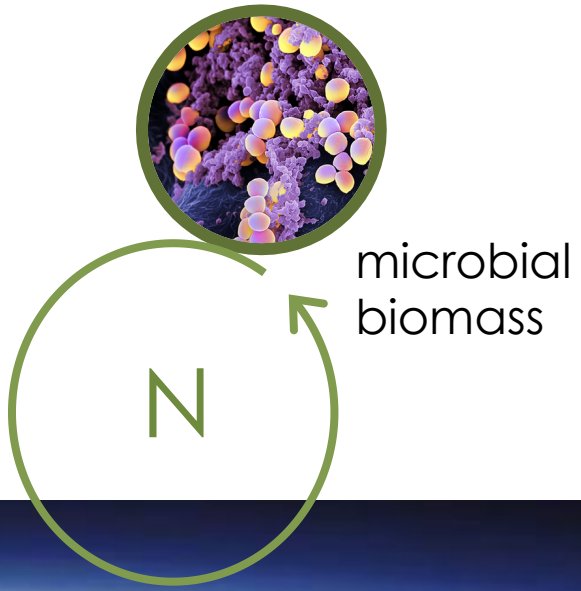


Conclusions



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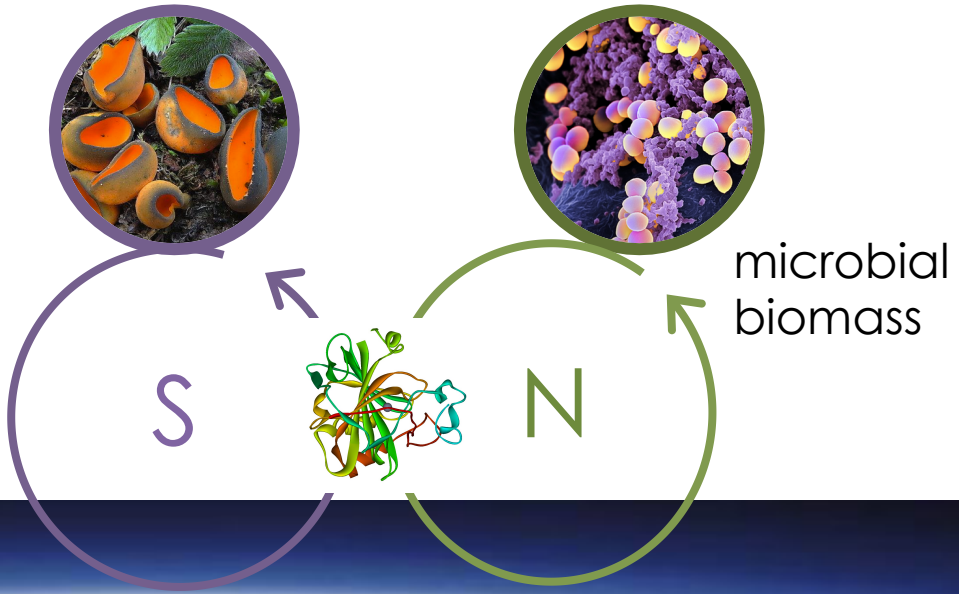
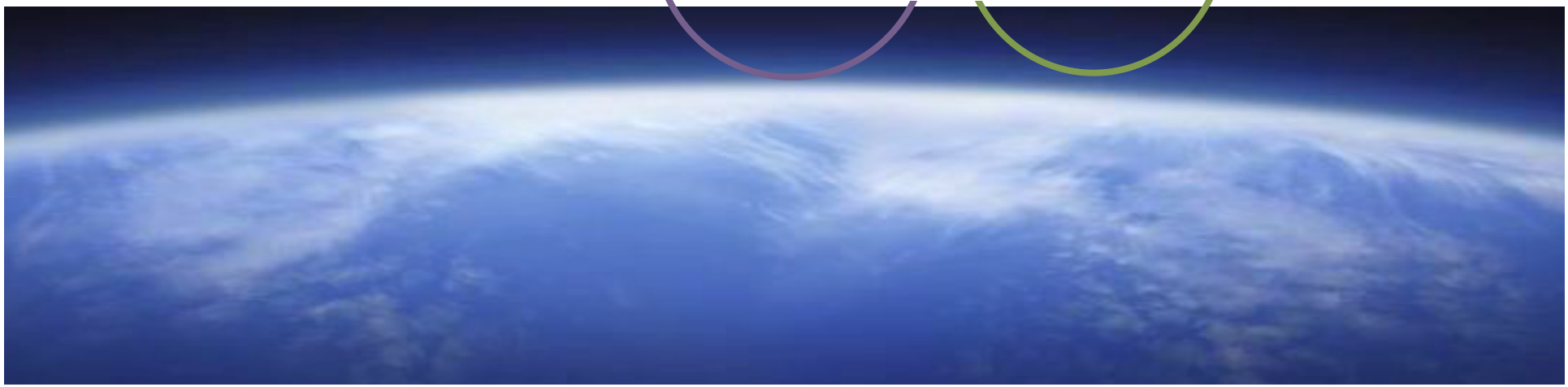
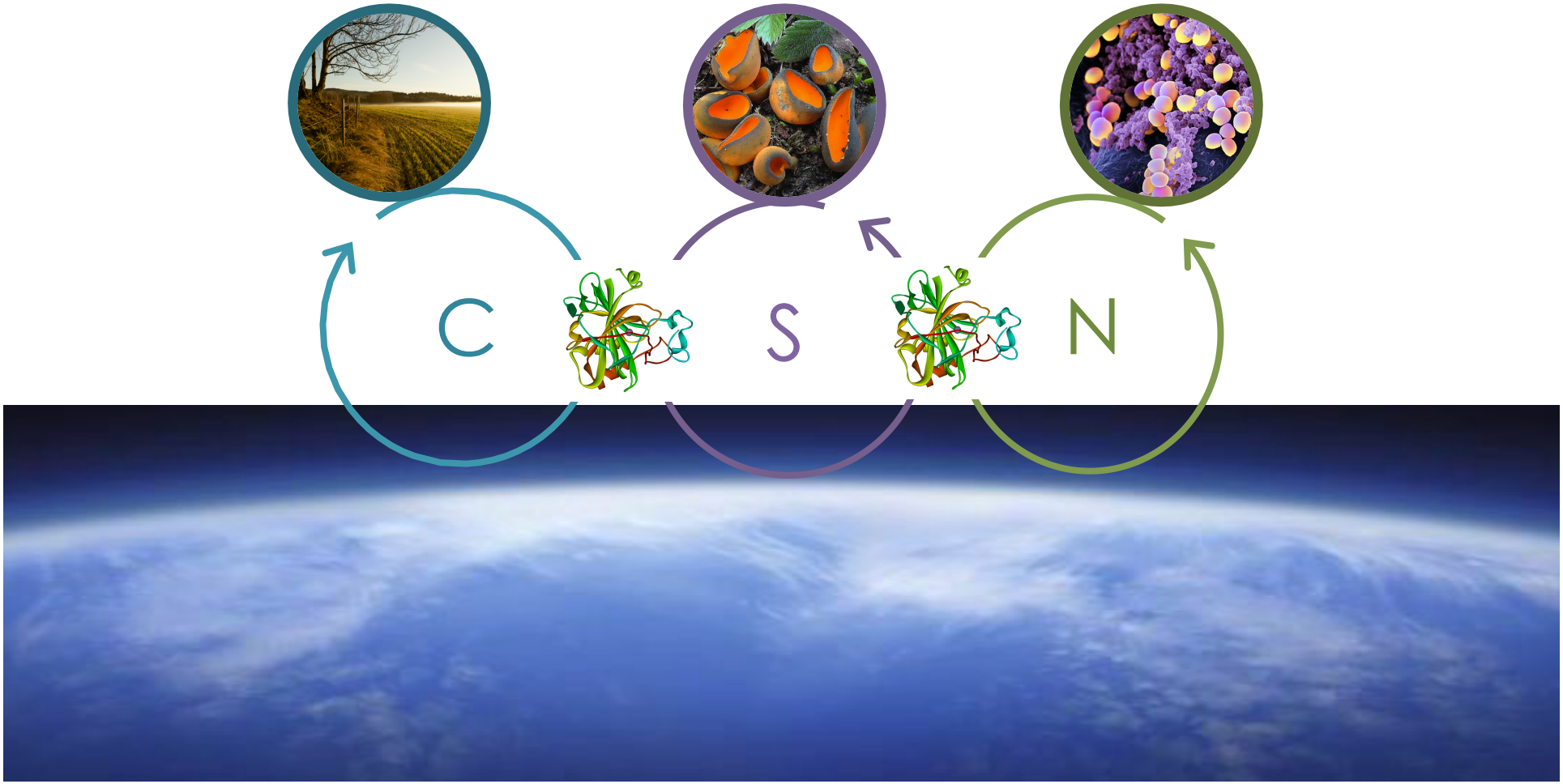
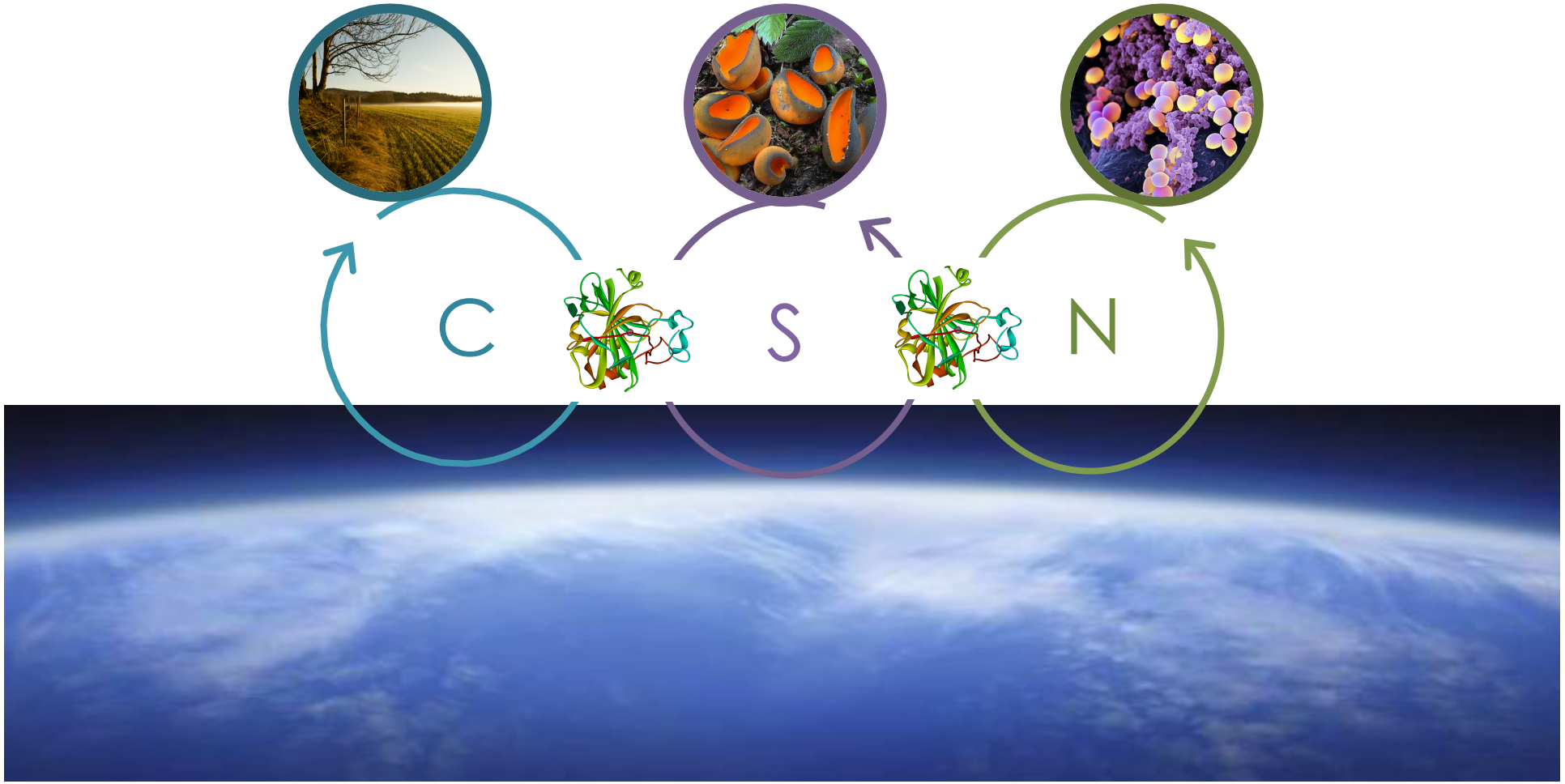




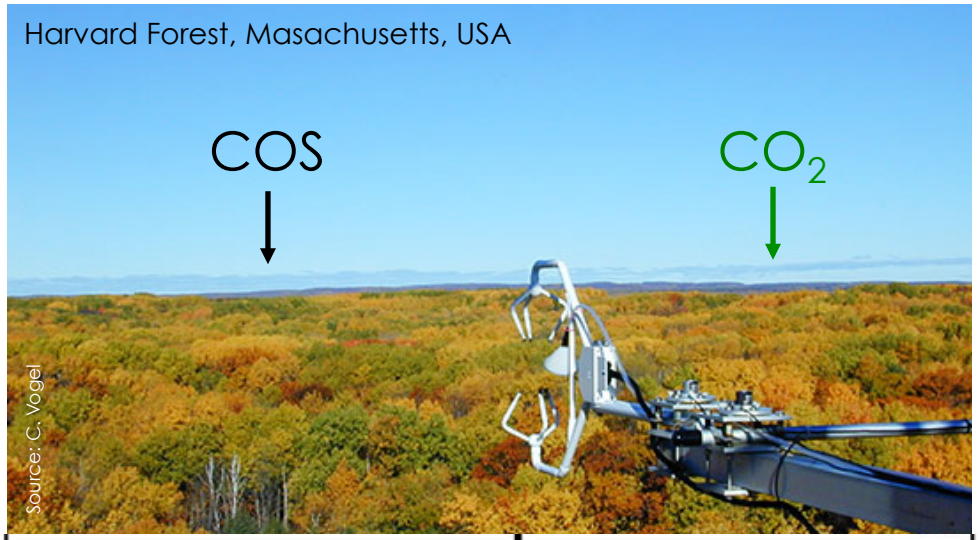
Conclusions



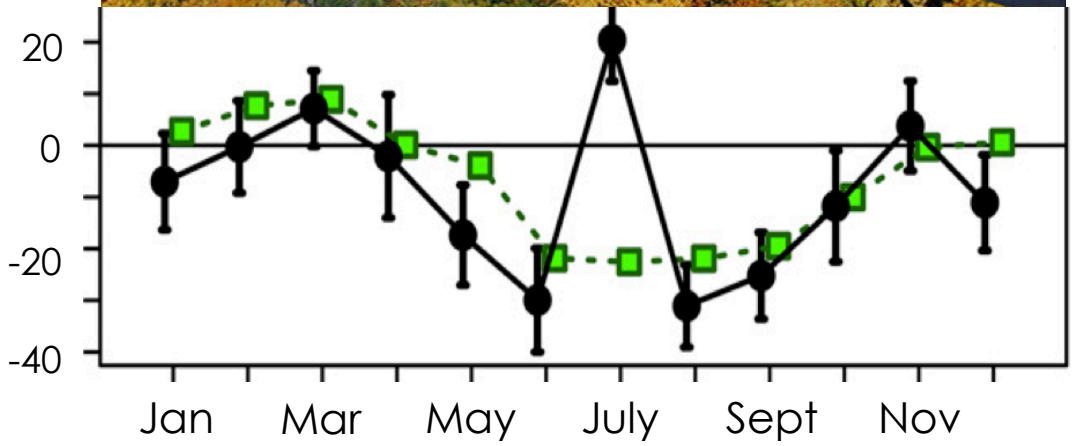
Thank you for your attention



COS uptake tracks CO_2 uptake during the day



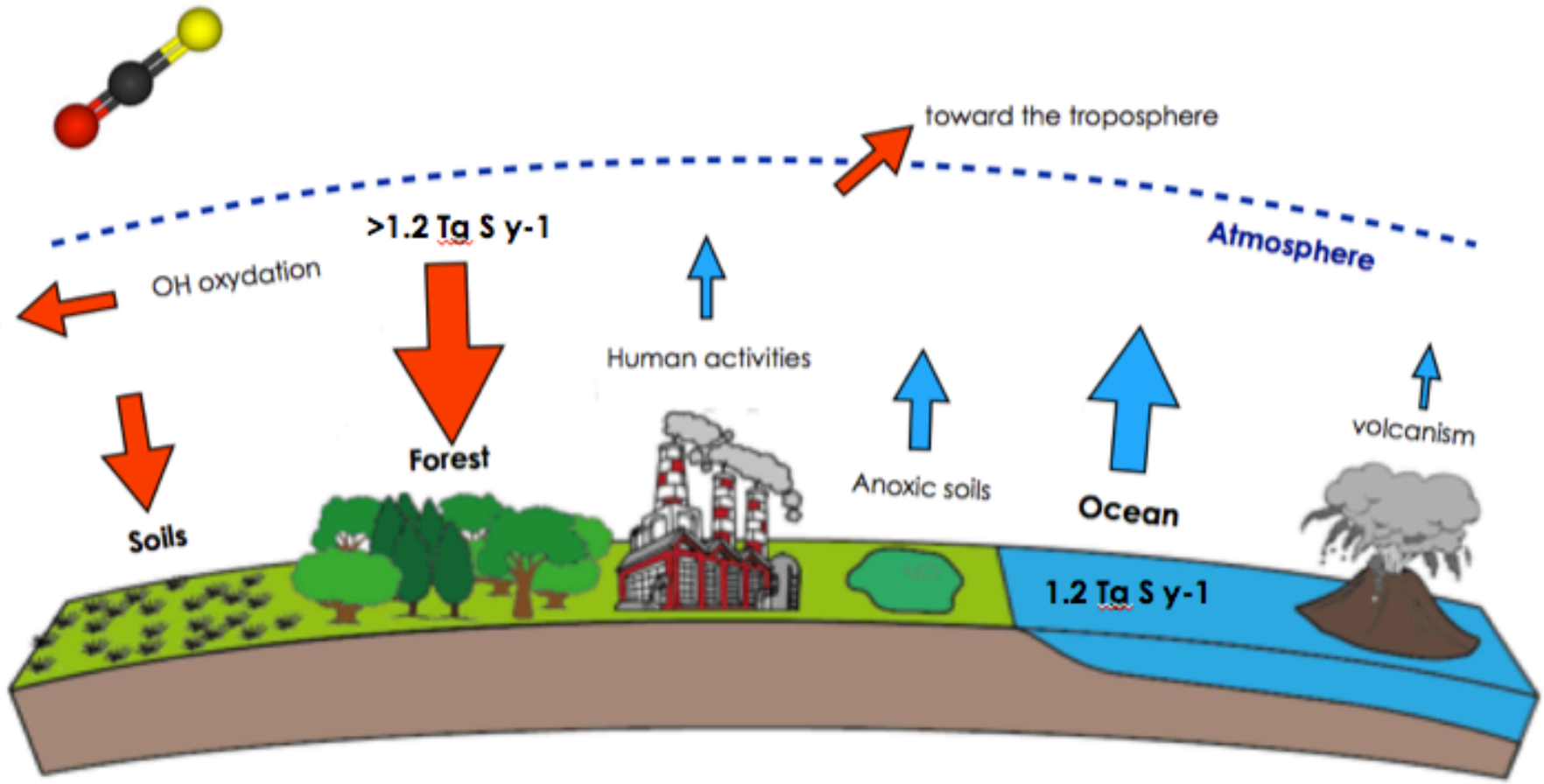
COS
mean daytime Fluxes
[pmol m^{-2} s^{-1}]



CO_2
mean daytime Fluxes
[μmol m^{-2} s^{-1}]

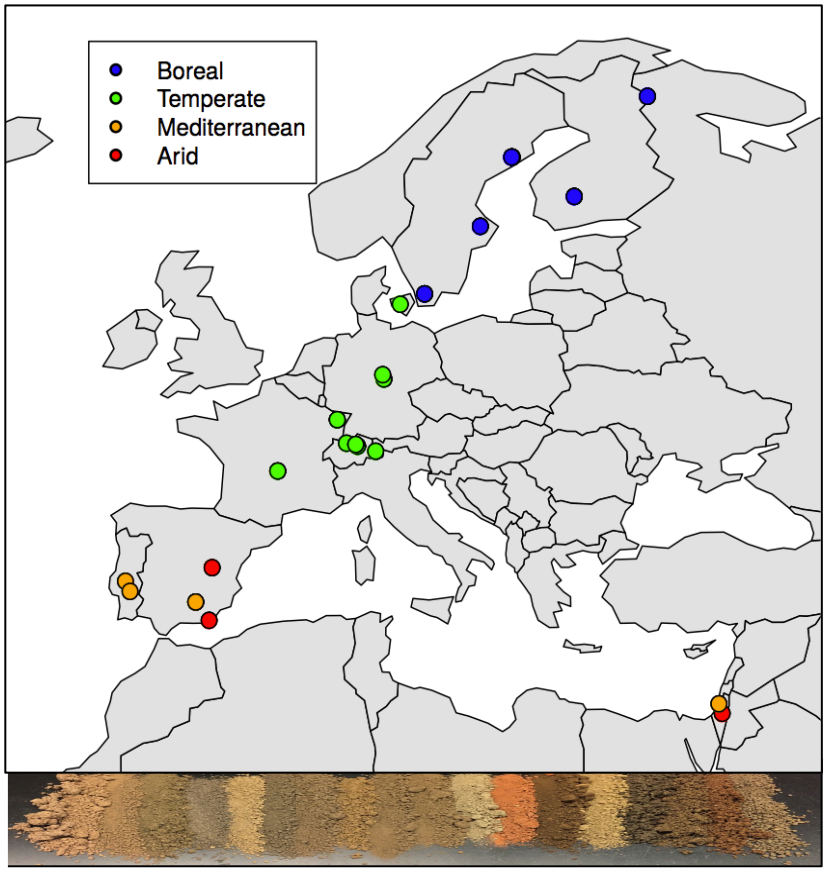
Commane et al., PNAS, 2015

Global COS cycle



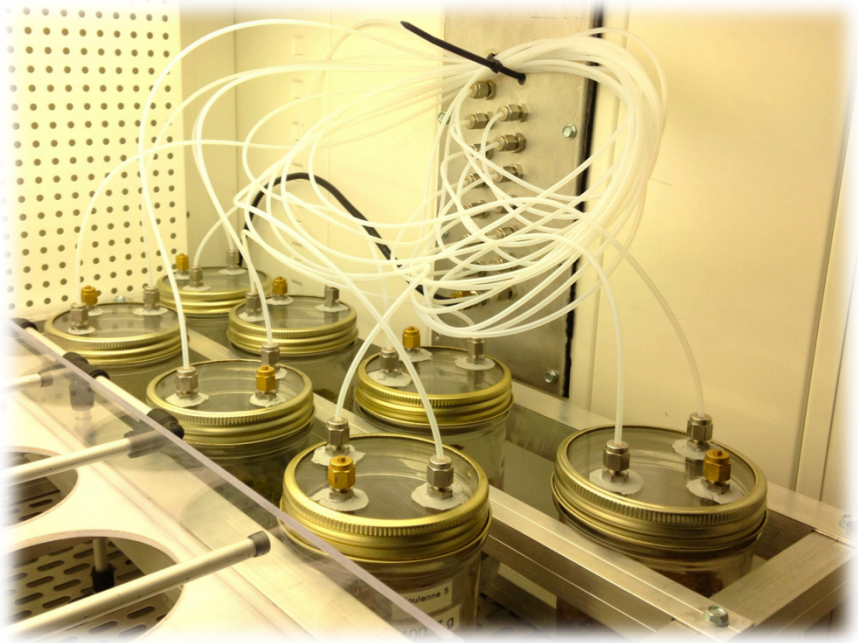
Whelan et al., Biogeosciences, 2018

Variability of soil COS fluxes across Europe



Kaisermann et al., ACP 2018; Soil Systems 2018

Measuring variability of soil COS fluxes and CA activity



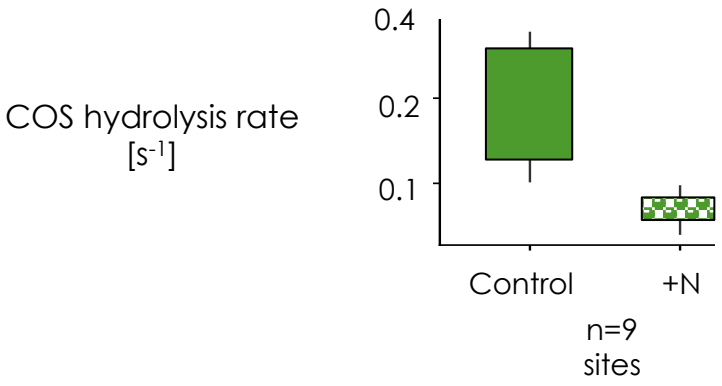
gée et al., BG 2016; Gimeno et al., New Phy 2017; Sauze *et al*. SBB 2017; Kaisermann et al., ACP 2018; Meredith et al., 2018

Lab experiments to explore the role of Nitrogen

9 European soils fertilised
5 different Boreal sites
4 different Temperate sites

Kaisermann *et al.*, Soil Systems 2018

Lab experiments confirm nitrogen is a strong regulator



Kaisermann *et al.*, Soil Systems 2018

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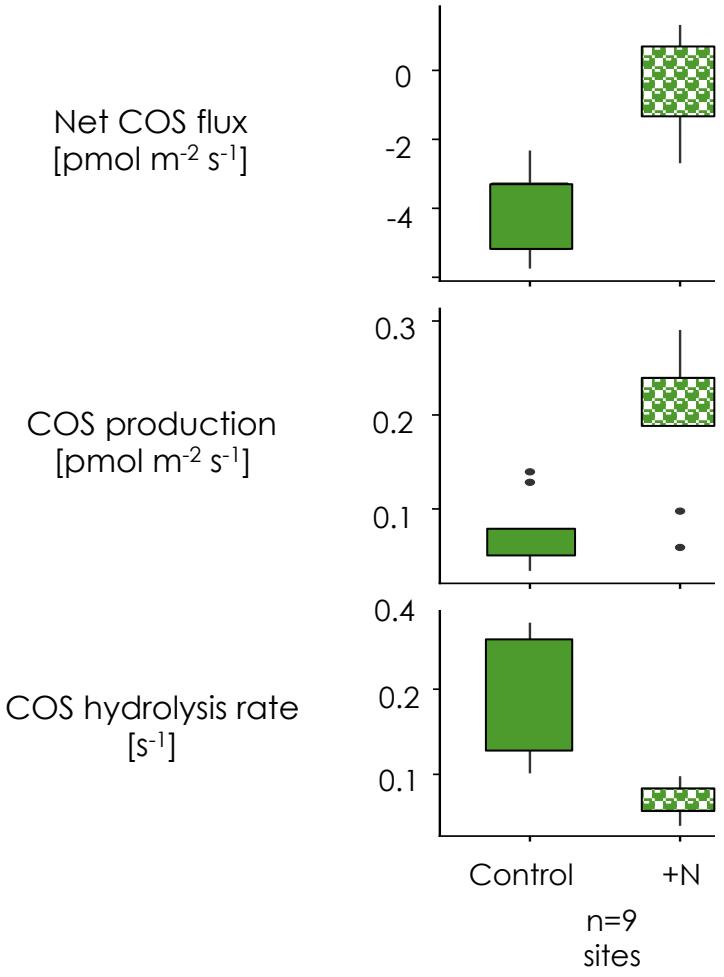
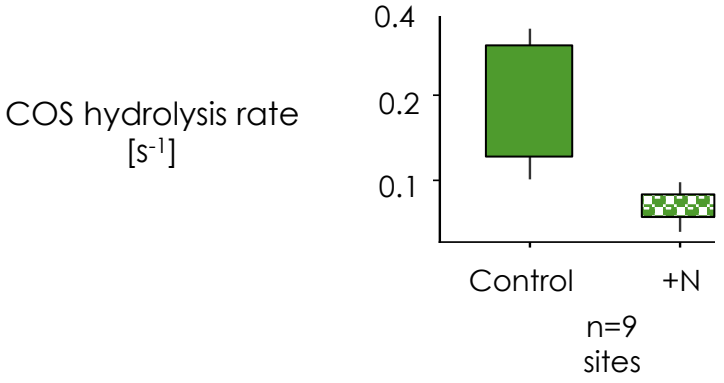
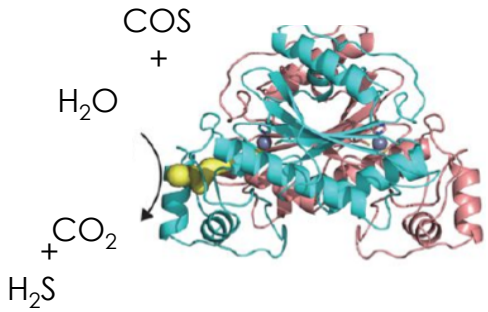


Kaisermann *et al.*, Soil Systems 2018

Carbonic anhydrase is inhibited by nitrate





Kaisermann *et al.*, Soil Systems 2018

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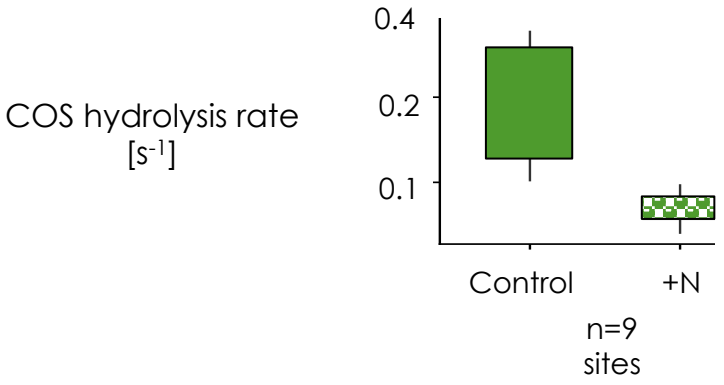
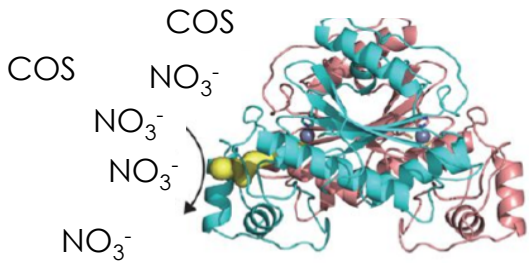
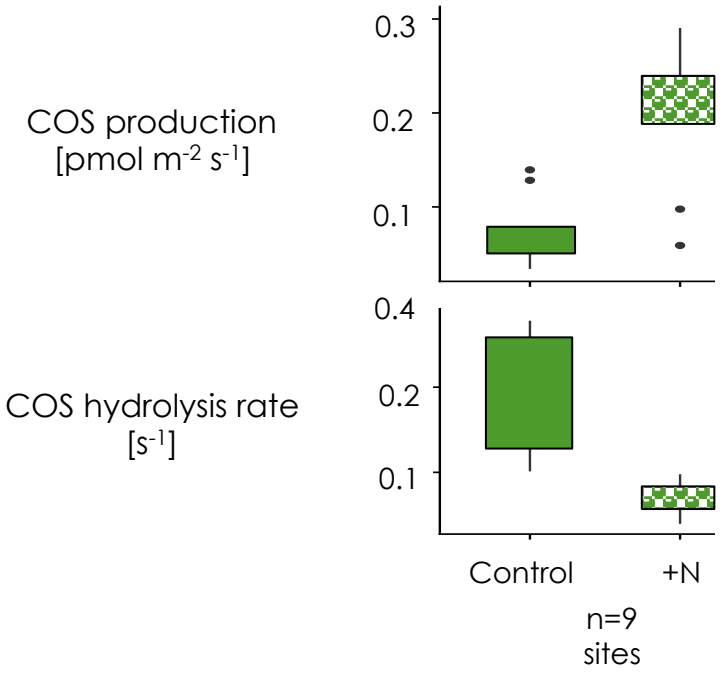


Carbonic anhydrase inhibition

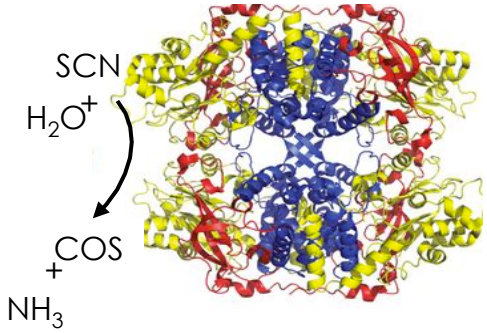


Kaisermann *et al.*, Soil Systems 2018

Thiocyanate hydrolysis releases COS



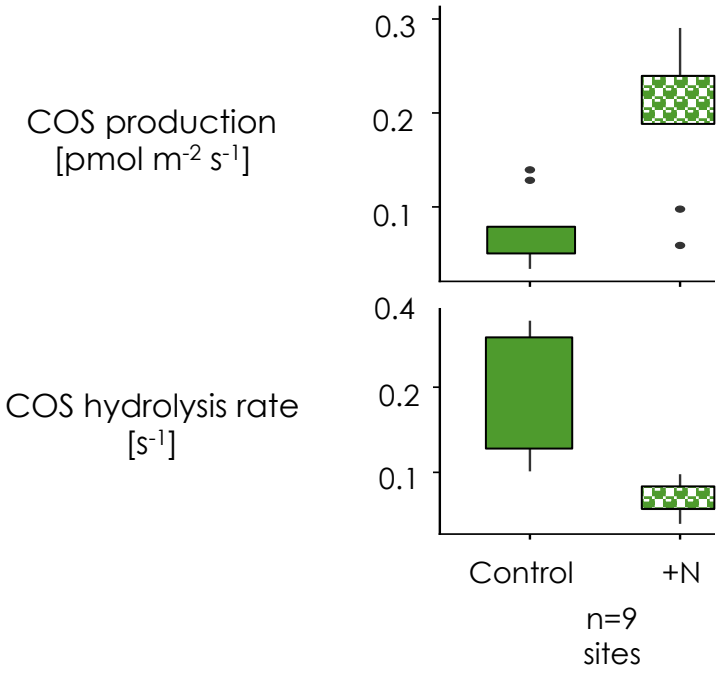
Thiocyanate hydrolase



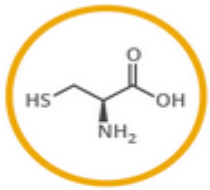
not clear if SCN content increases with N content

Meredith *et al.*, Soil Systems 2018

Link to the amount of COS precursors?

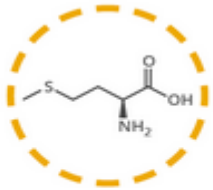


non-essential



Cysteine
cys

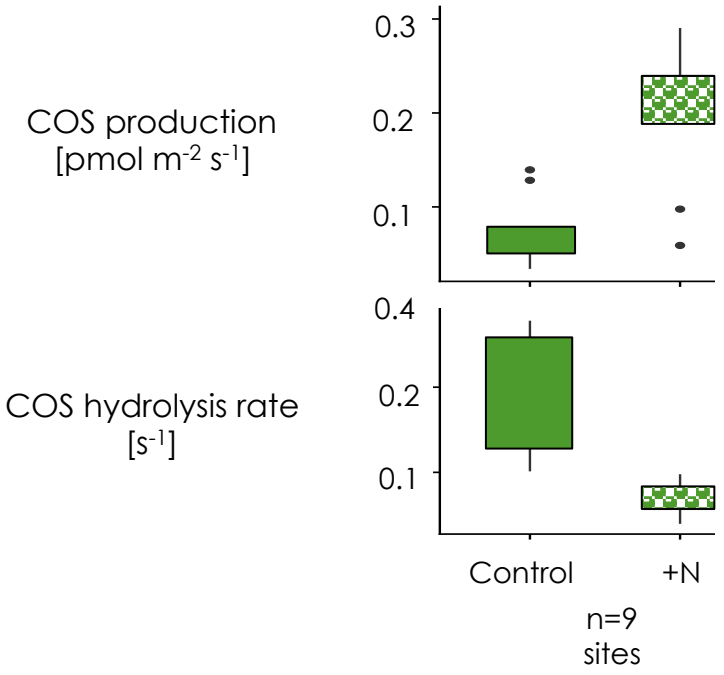
essential



Methionine
met

Meredith *et al.*, Soil Systems 2018

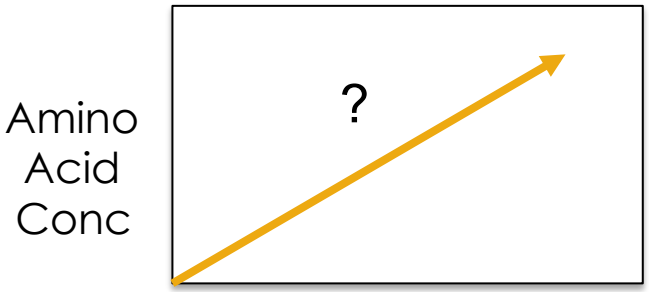
Link to the amount of COS precursors?



non-essential essential

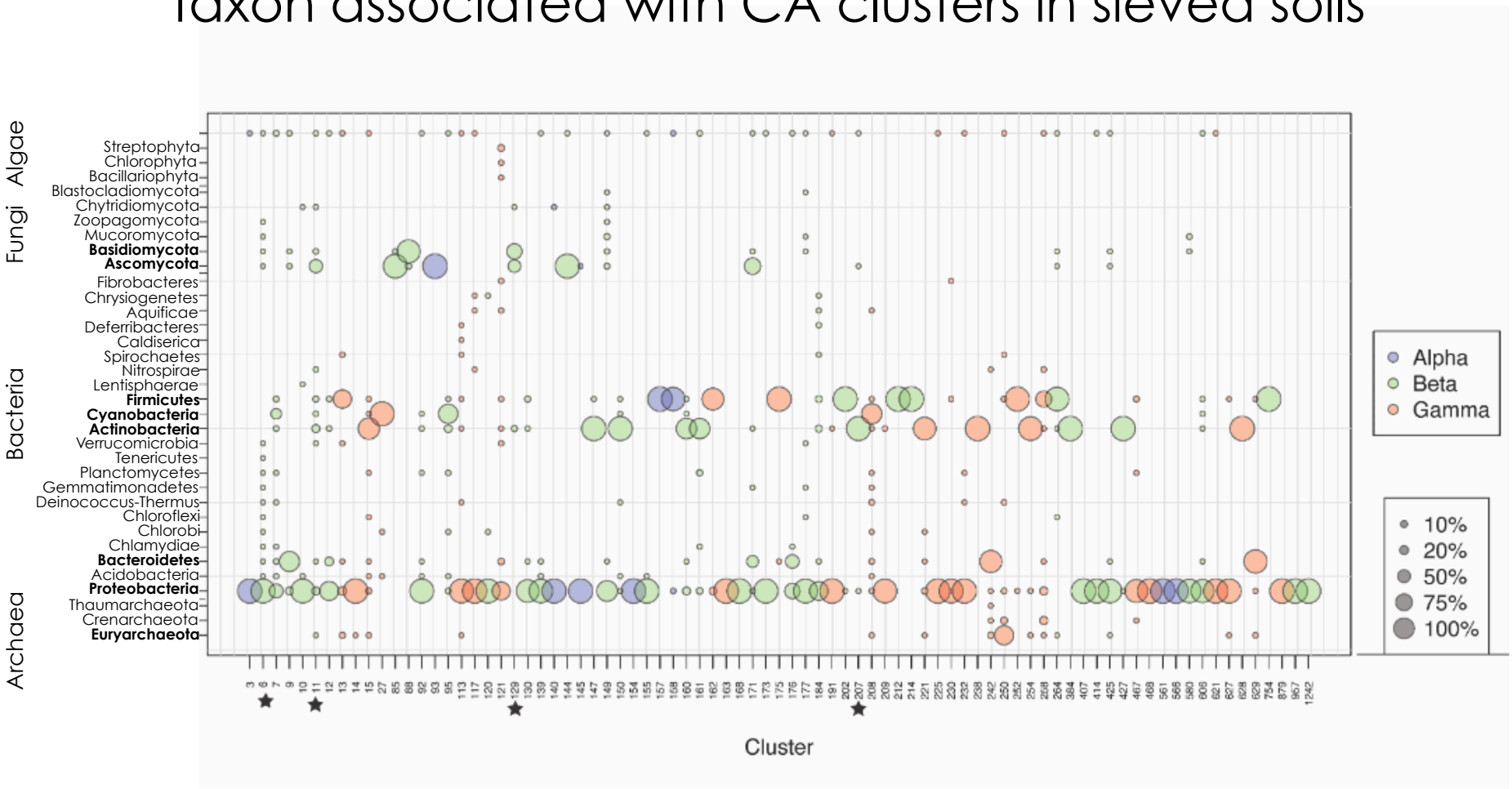
Cysteine
cys

Methionine
met



Meredith *et al.*, Soil Systems 2018

Taxon associated with CA clusters in sieved soils



Meredith et al., ISME 2018