

Soil carbon-climate feedback during 21st century

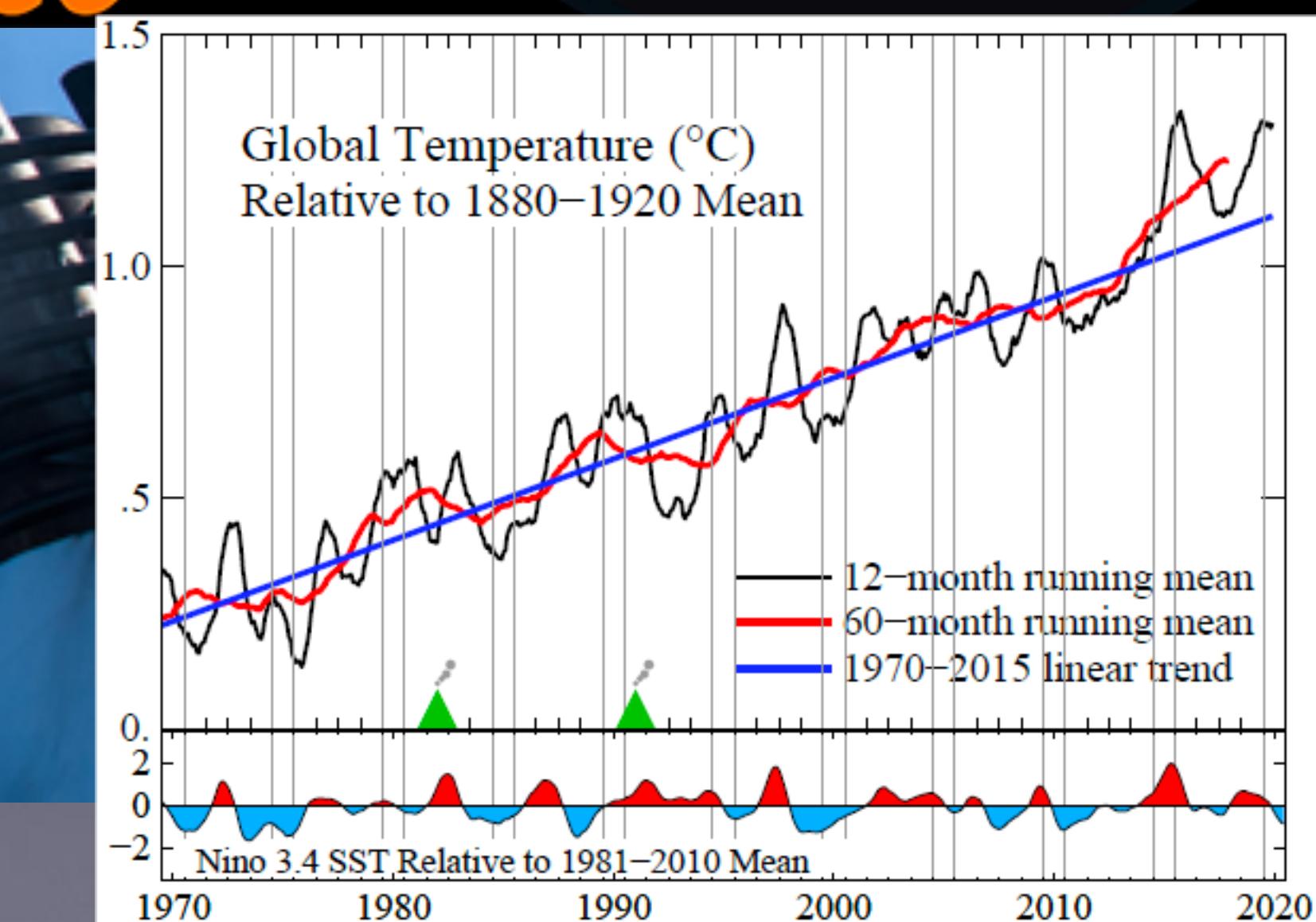
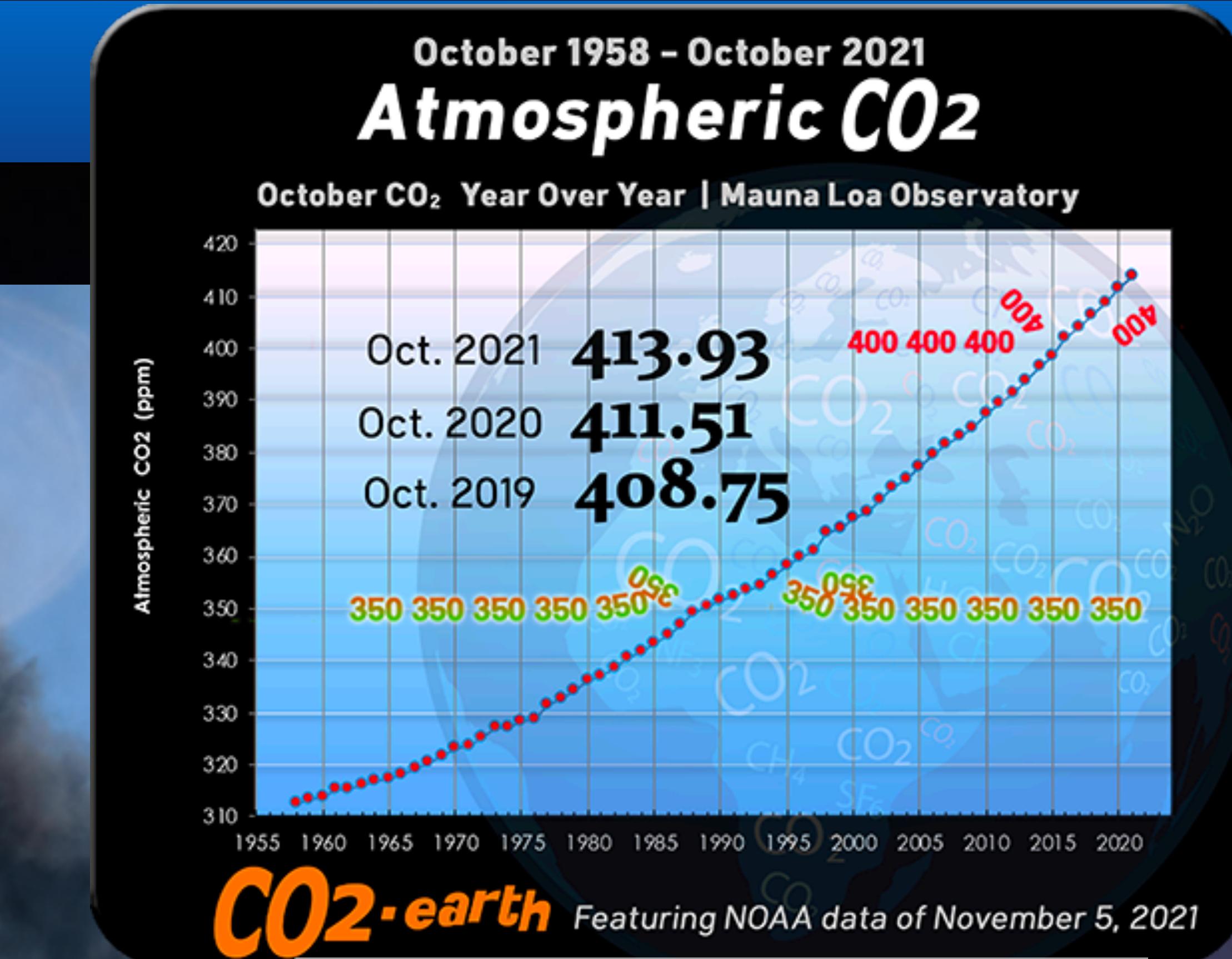
Zheng Shi^{1,2}, Forrest M. Hoffman¹, Min Xu¹, Umakant Mishra³, Steven D. Allison^{4,5}, James T. Randerson⁵

1. Computational Sciences & Engineering Division, Oak Ridge National Laboratory, United States
2. Institute of Environmental Genomics, University of Oklahoma
3. Computational Biology & Biophysics, Sandia National Laboratories, United States
4. Department of Ecology and Evolutionary Biology, University of California, Irvine
5. Department of Earth System Science, University of California, Irvine

CUT GHG emissions

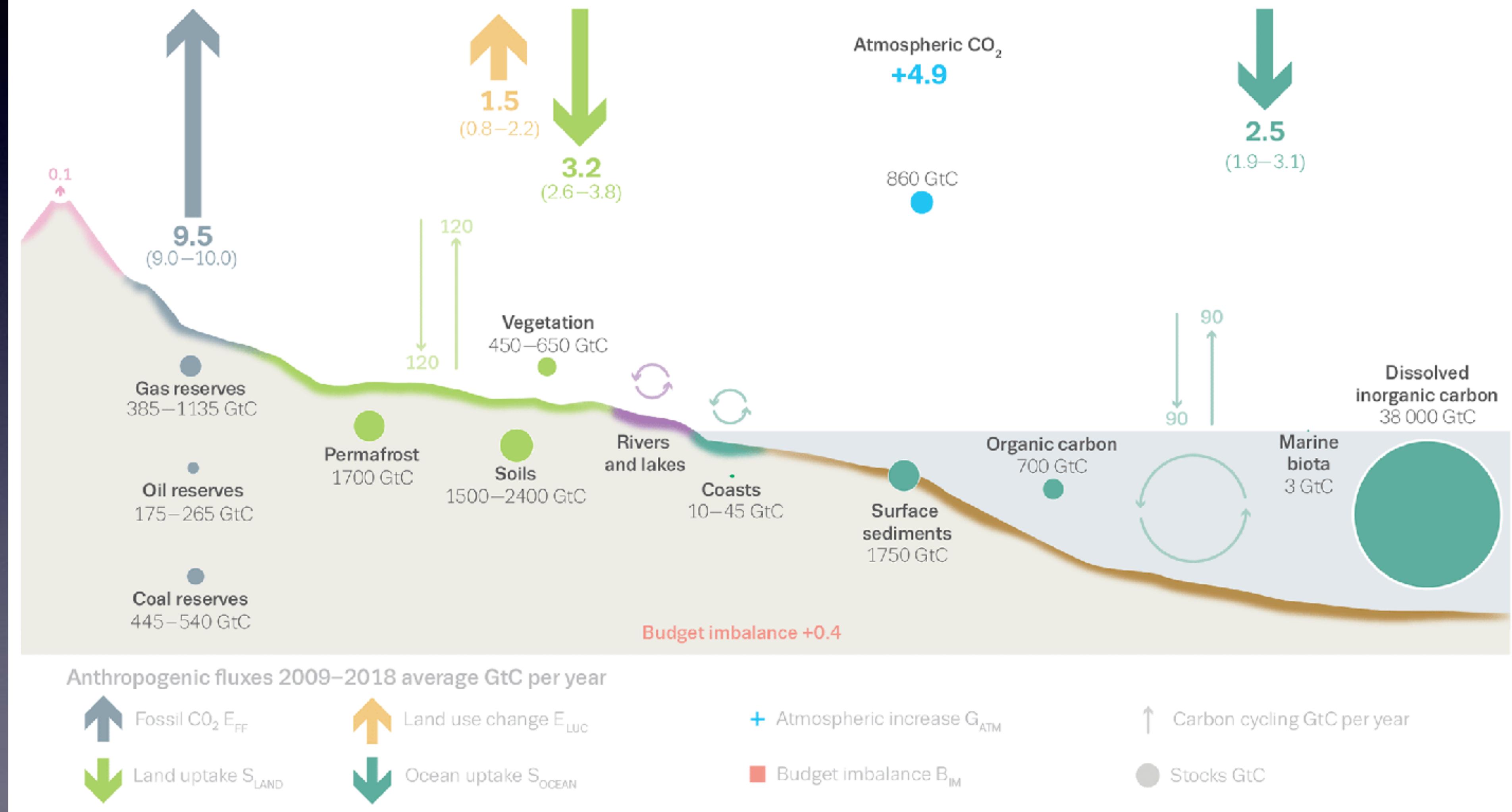


UN CLIMATE CHANGE CONFERENCE UK 2021



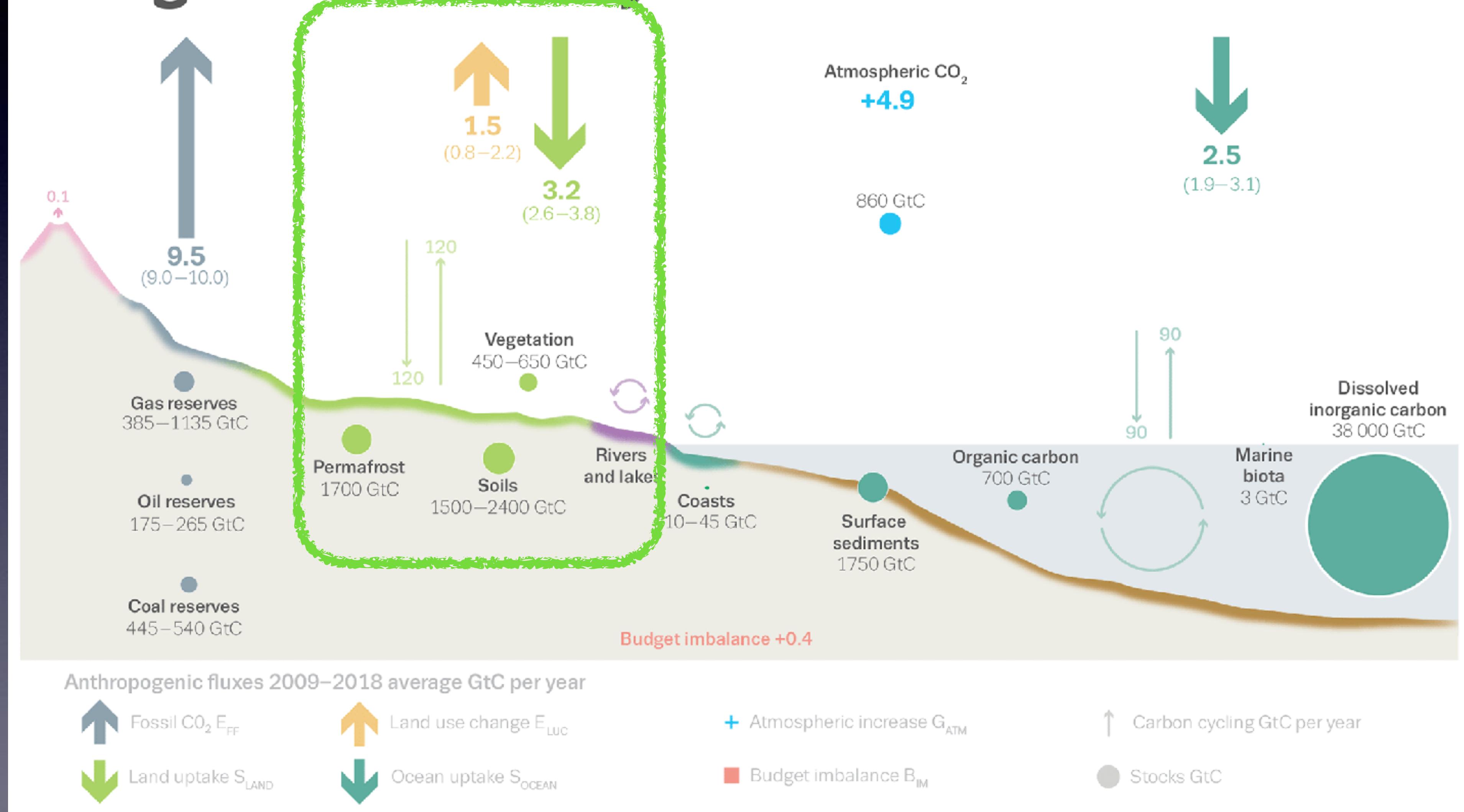
Carbon-Climate Feedback

The global carbon cycle



Carbon-Climate Feedback

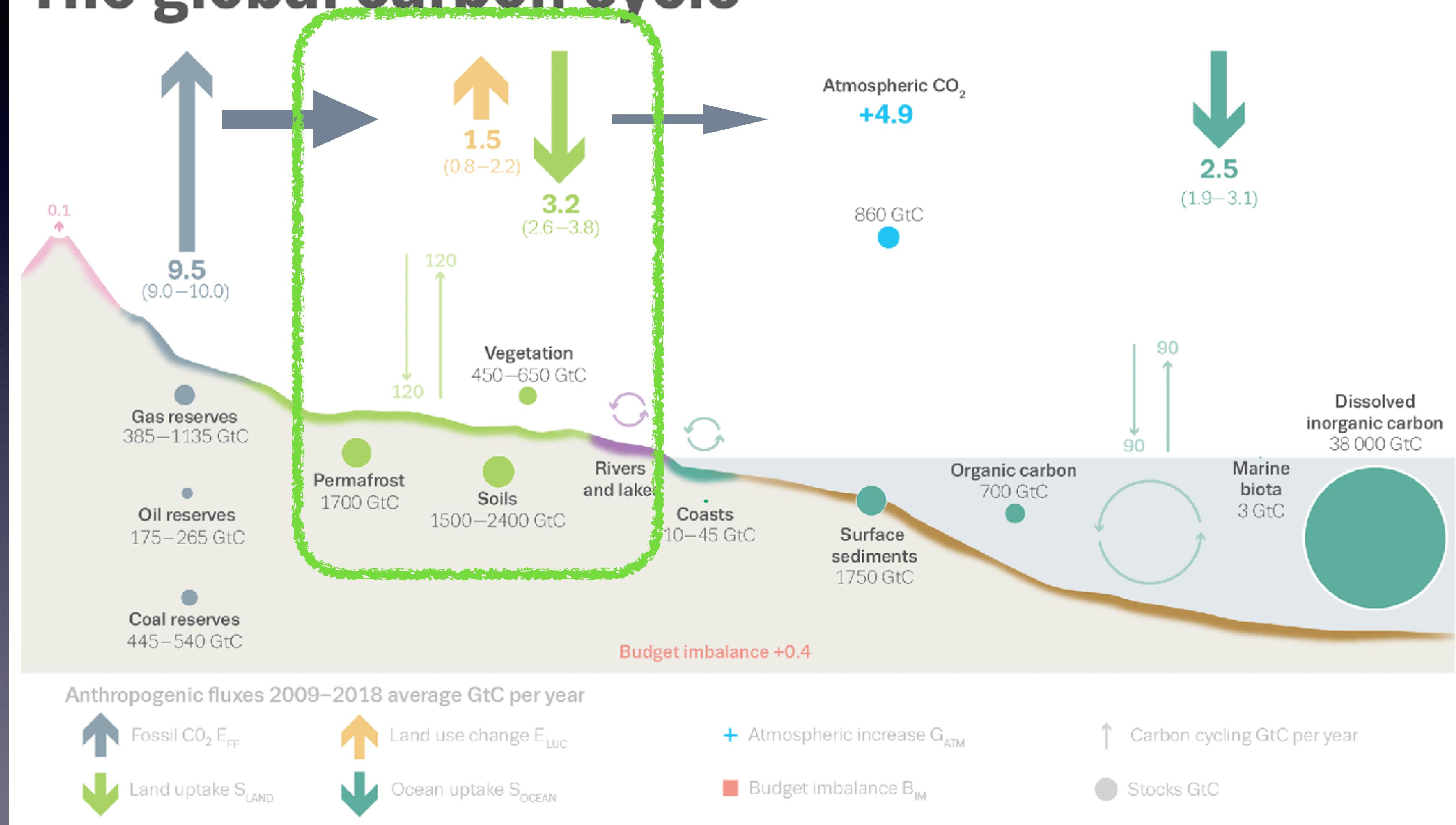
The global carbon cycle



Land uptake of emissions by 3.2 PgC
Stored in vegetation and soils
Ocean uptake of another 2.5 Pg C

Carbon-Climate Feedback

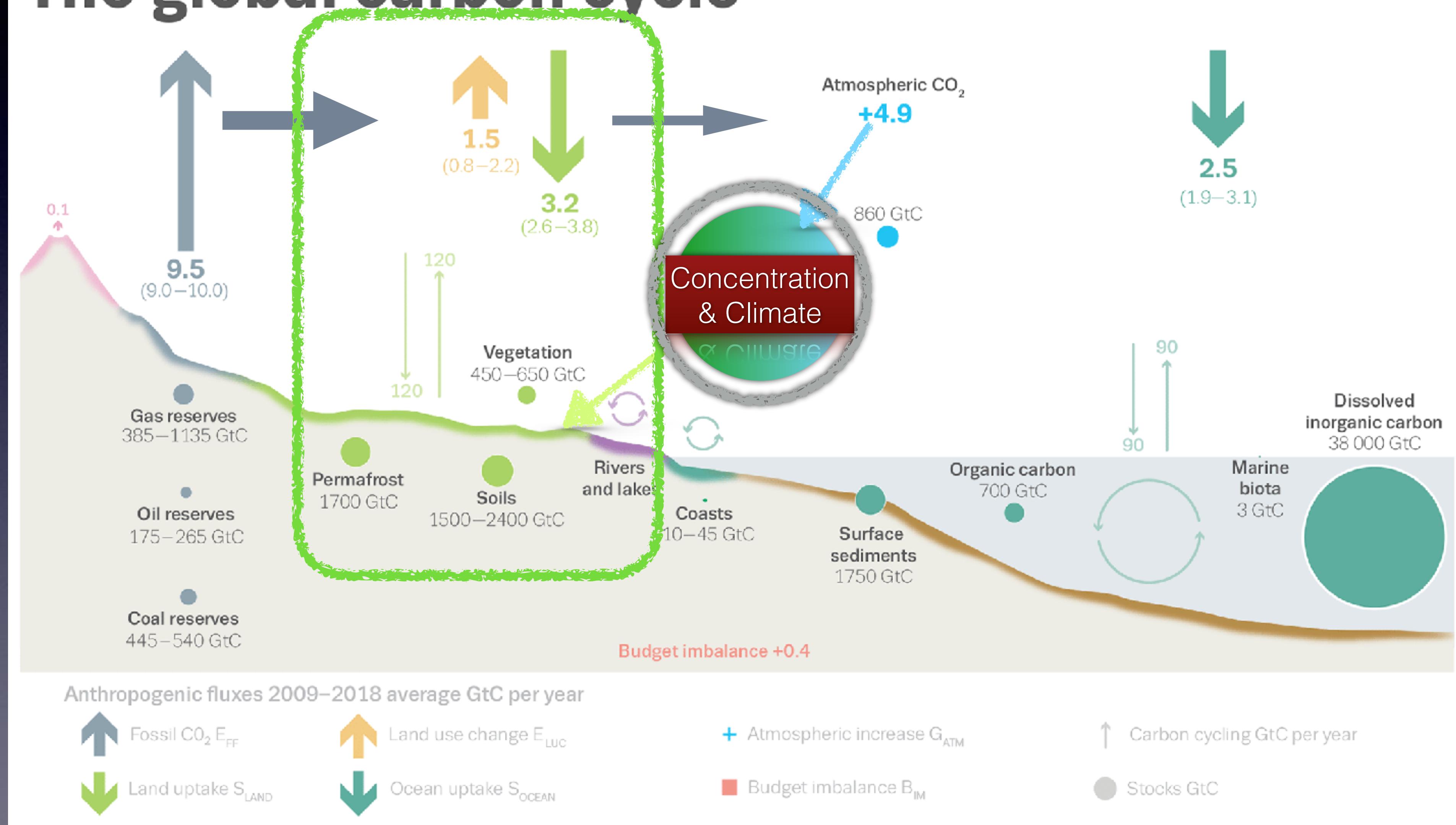
The global carbon cycle



Land uptake of emissions by 3.2 PgC
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Carbon-Concentration/Climate Feedback

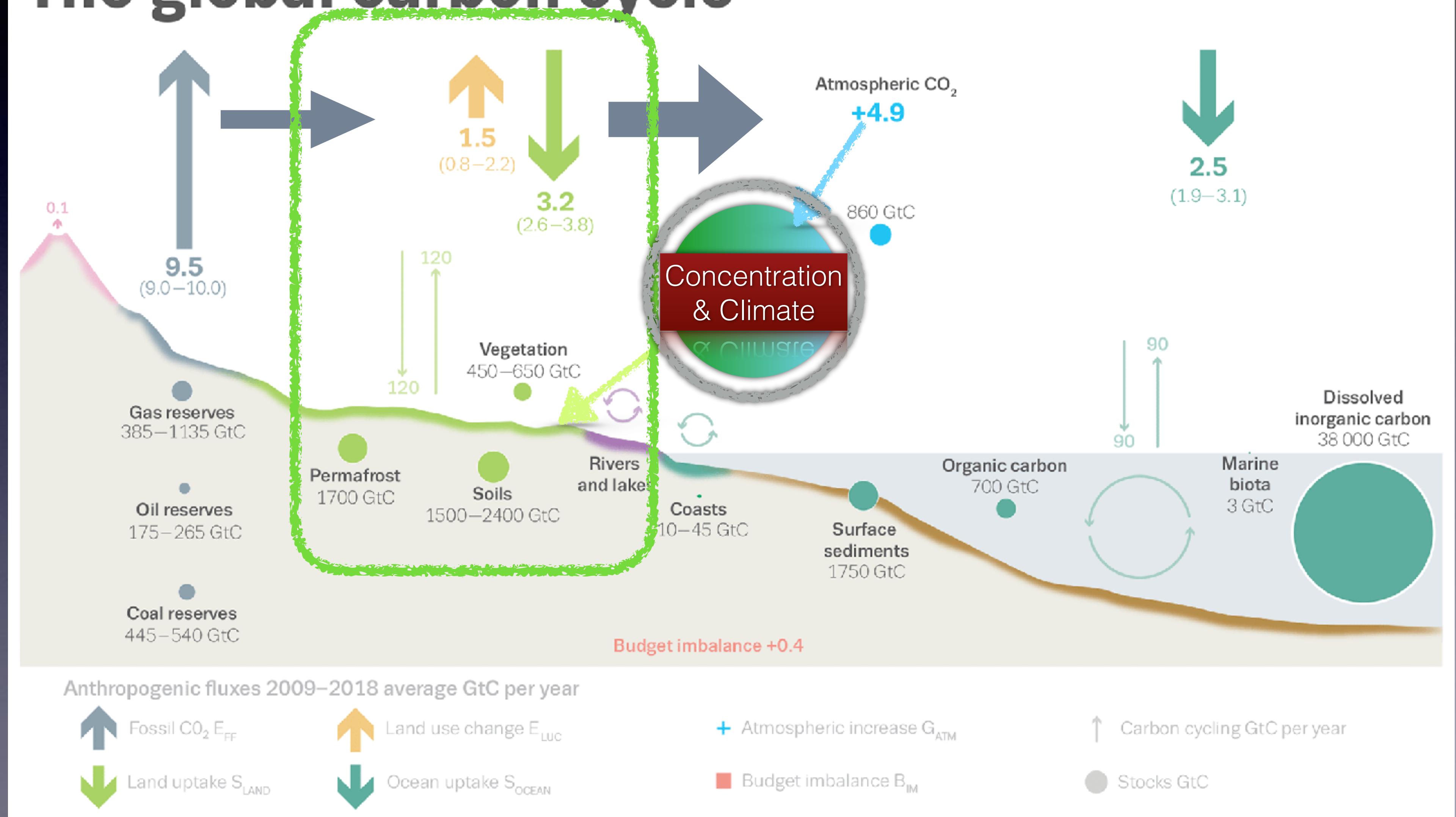
The global carbon cycle



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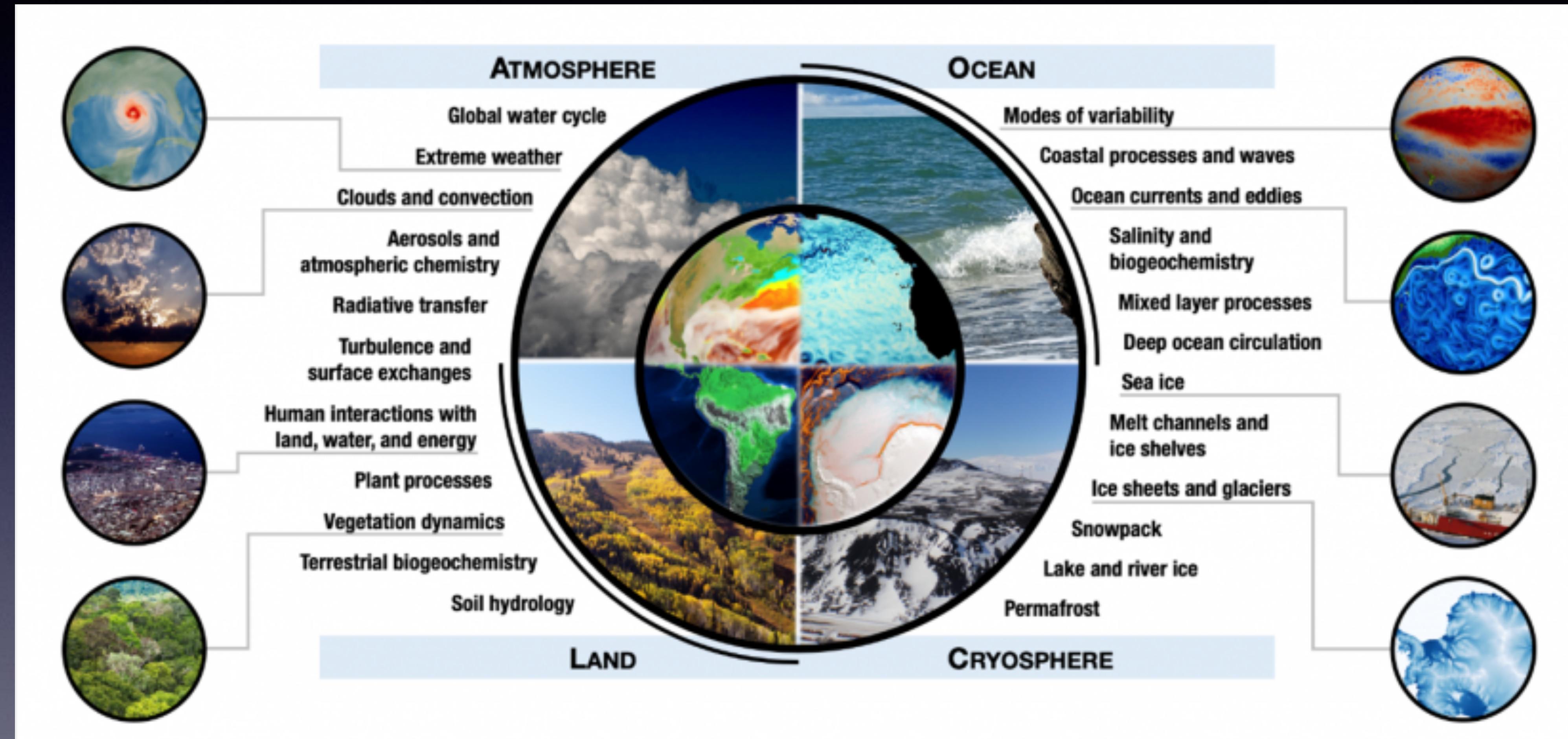
Carbon-Climate Feedback

The global carbon cycle



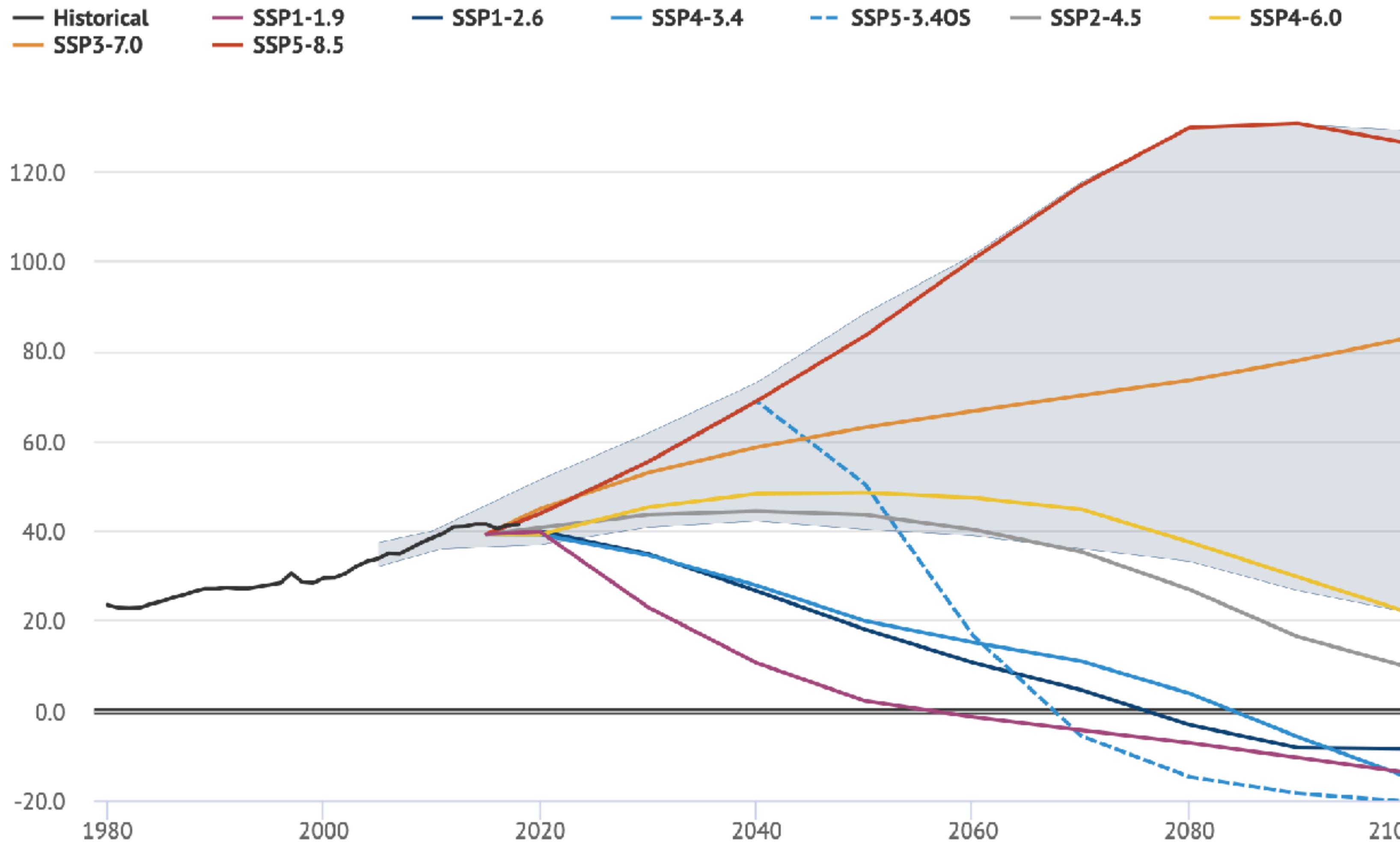
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Earth System Modeling



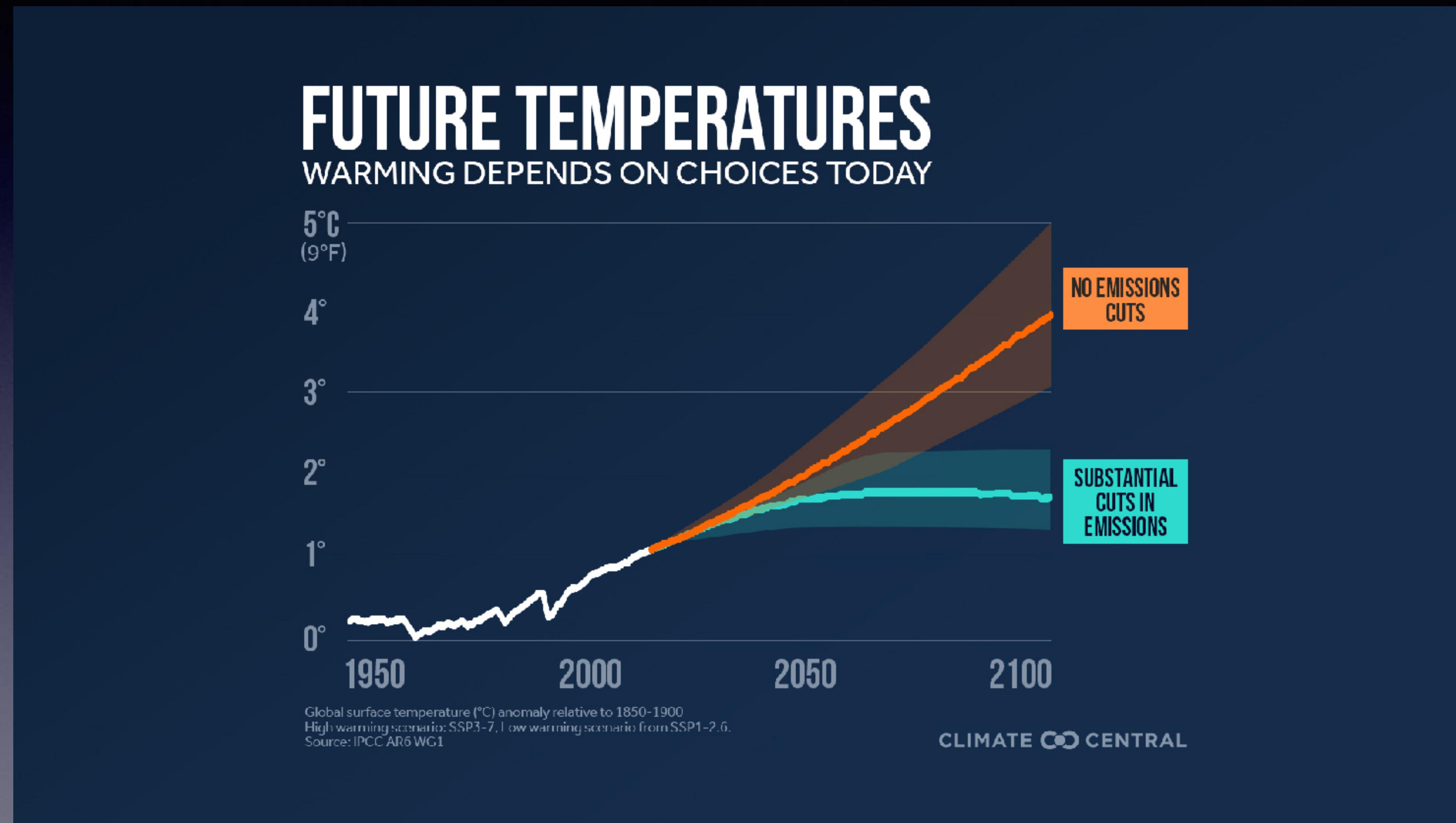
Shared socioeconomic pathways in CMIP6

CO₂ emissions in CMIP6 scenarios



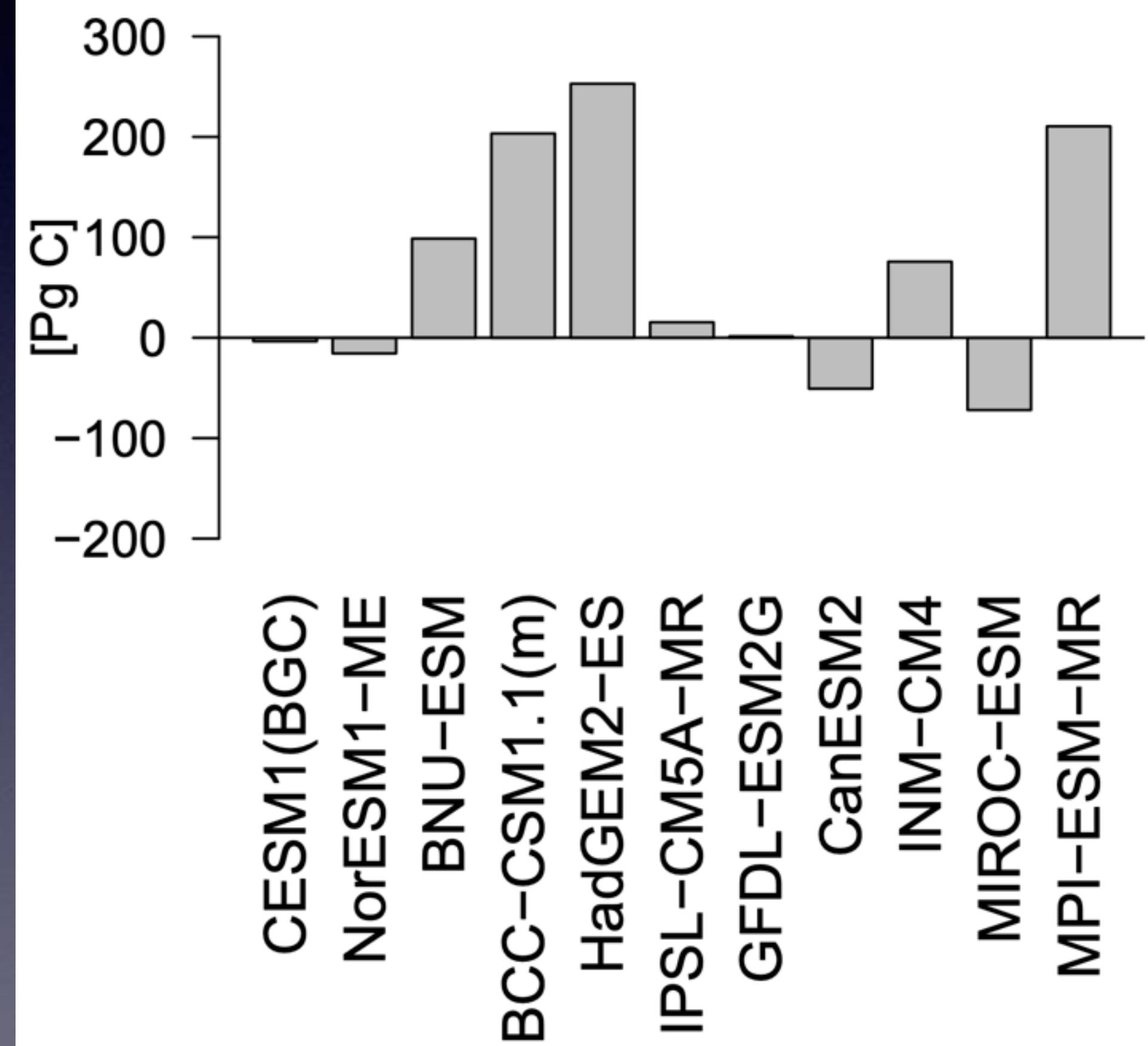
CMIP:
Coupled Model
Intercomparison
Project

Temperature change with/without emission cut

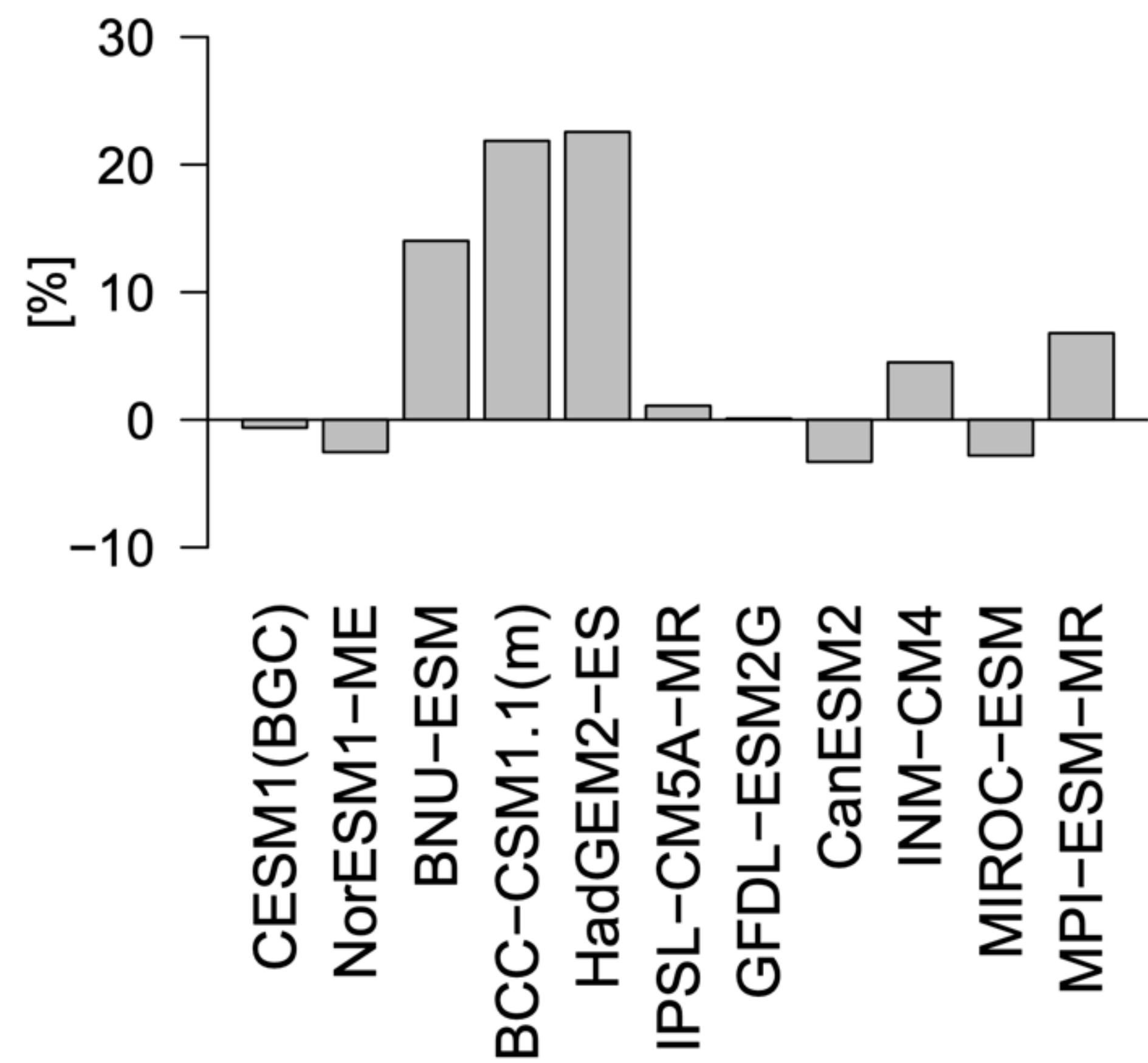


Soil carbon response to climate change in CMIP5

21st century absolute change



21st century relative change



72 Pg C loss to a gain of
253 Pg C

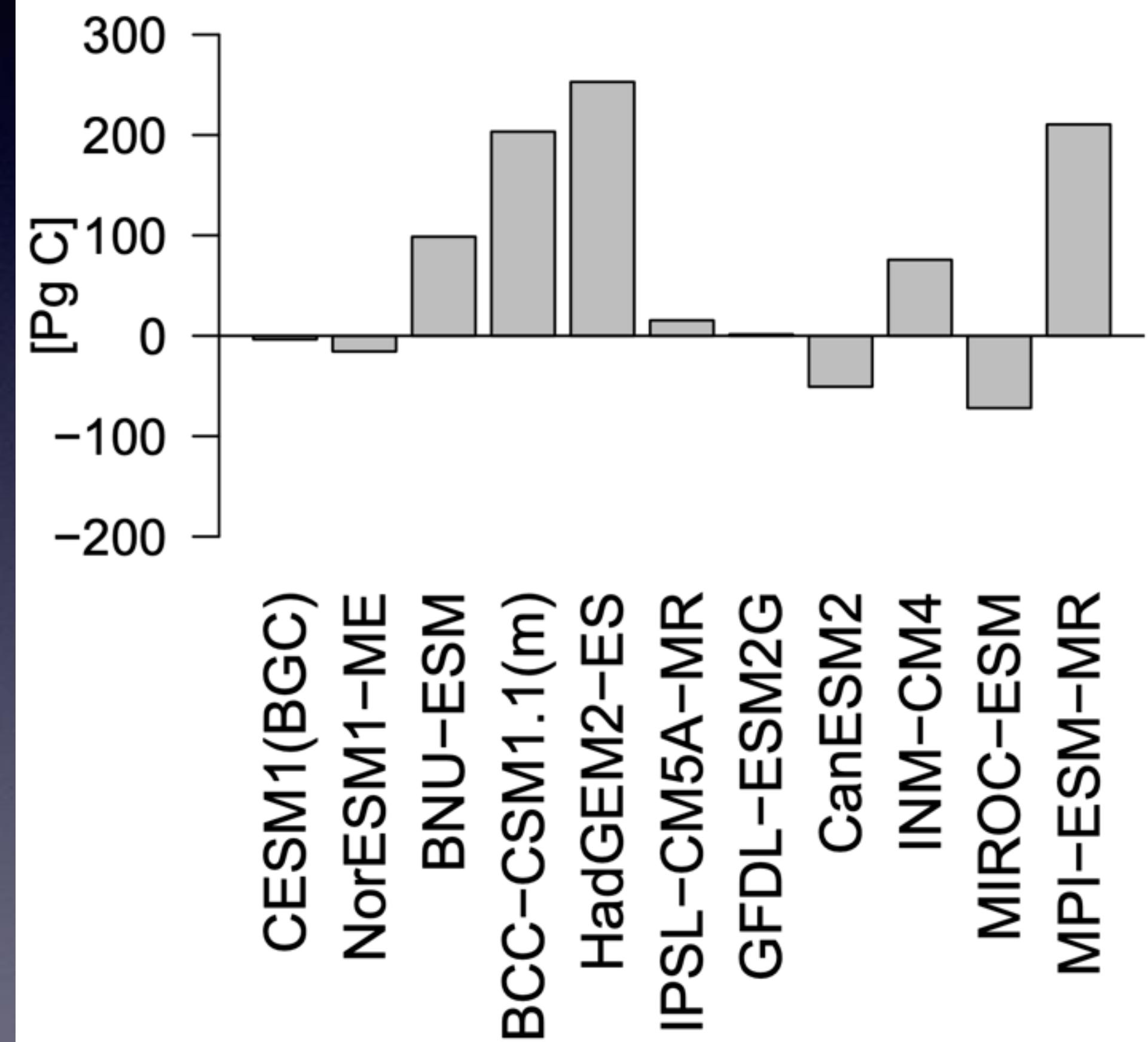
A multi-model mean gain
of 65 Pg C

Large absolute changes
mirror relative changes

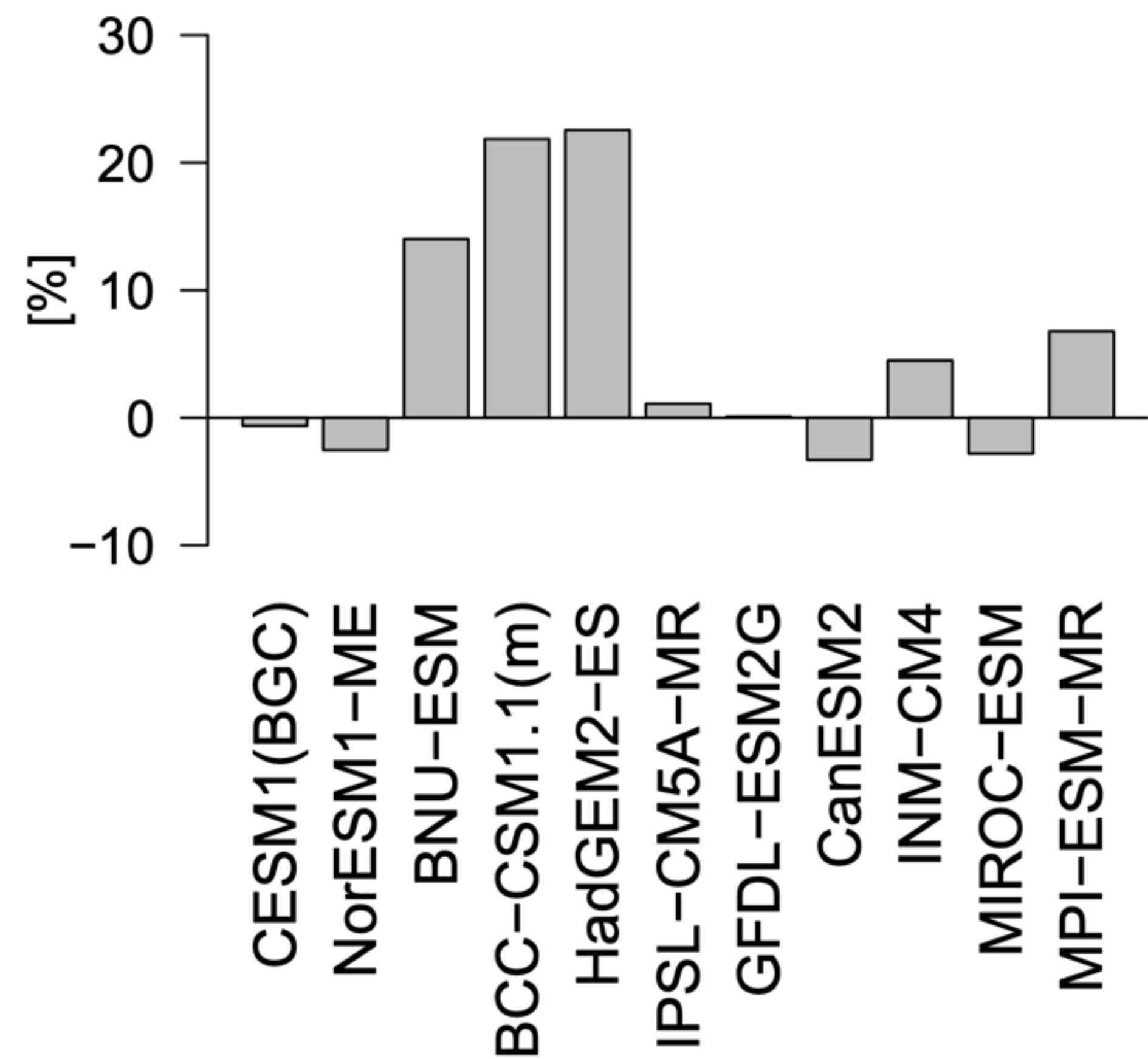
Todd-Brown et al. 2014

Soil carbon response to climate change in CMIP5

21st century absolute change



21st century relative change



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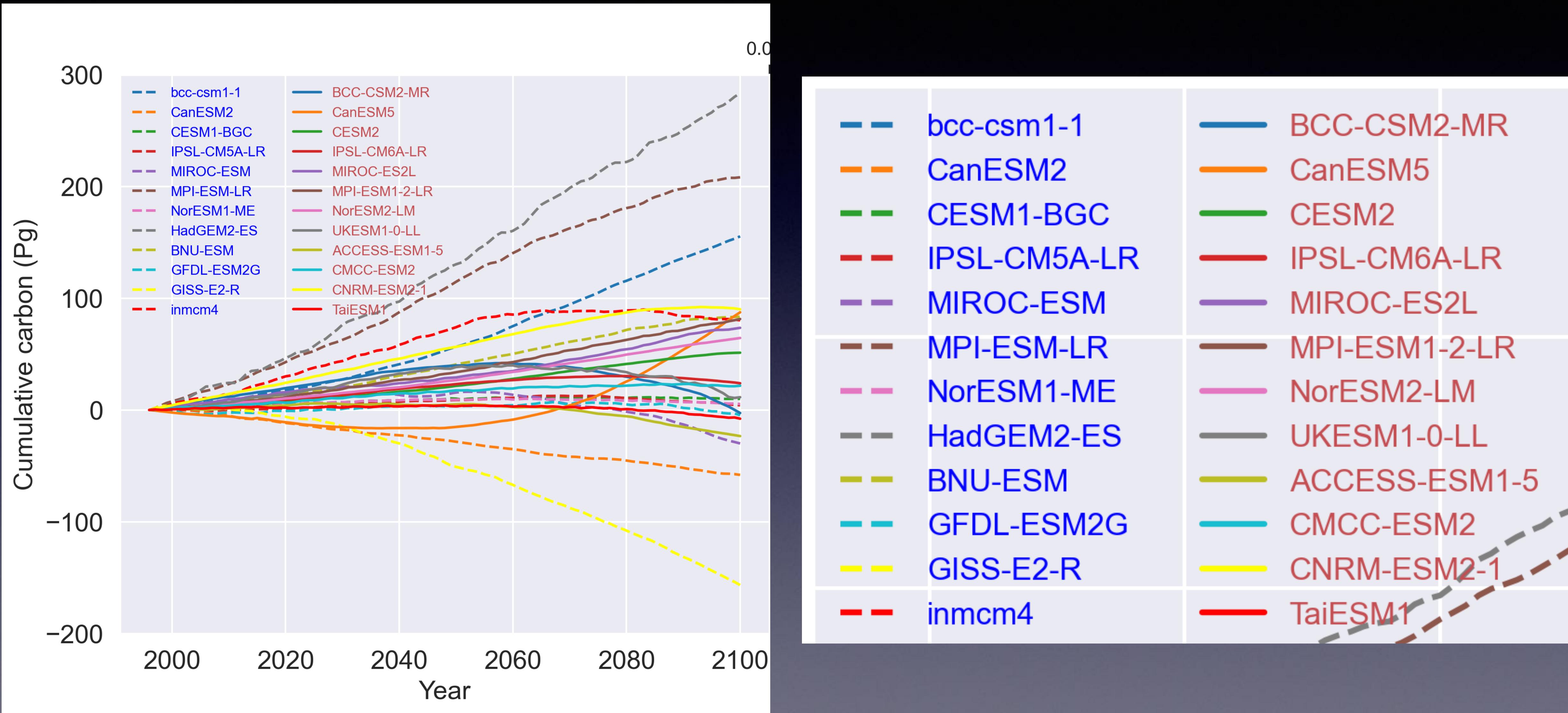
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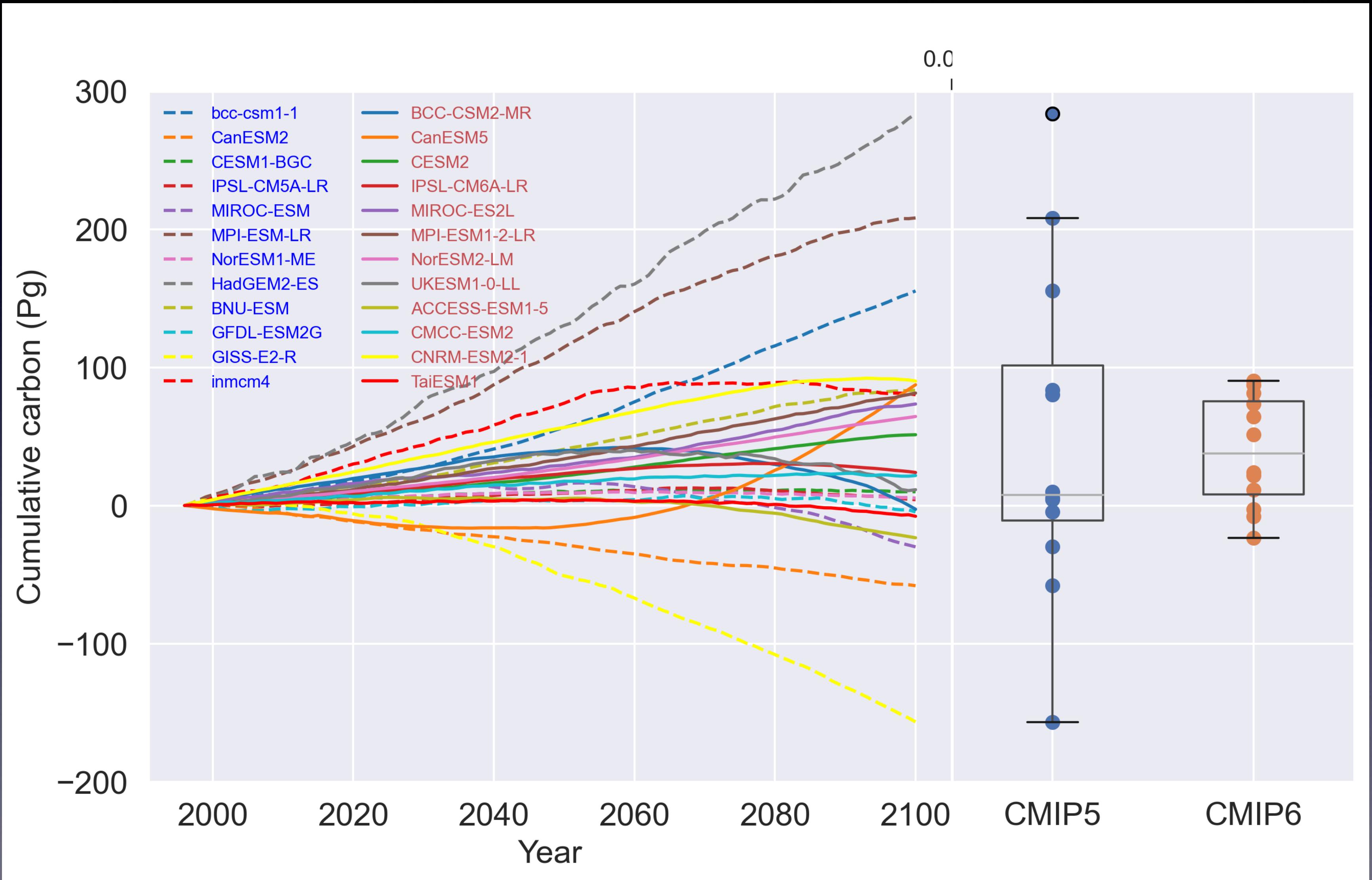
CMIP6?
Drivers?
Uncertainty from models
and inputs?
Data-constraint?

Todd-Brown et al. 2014

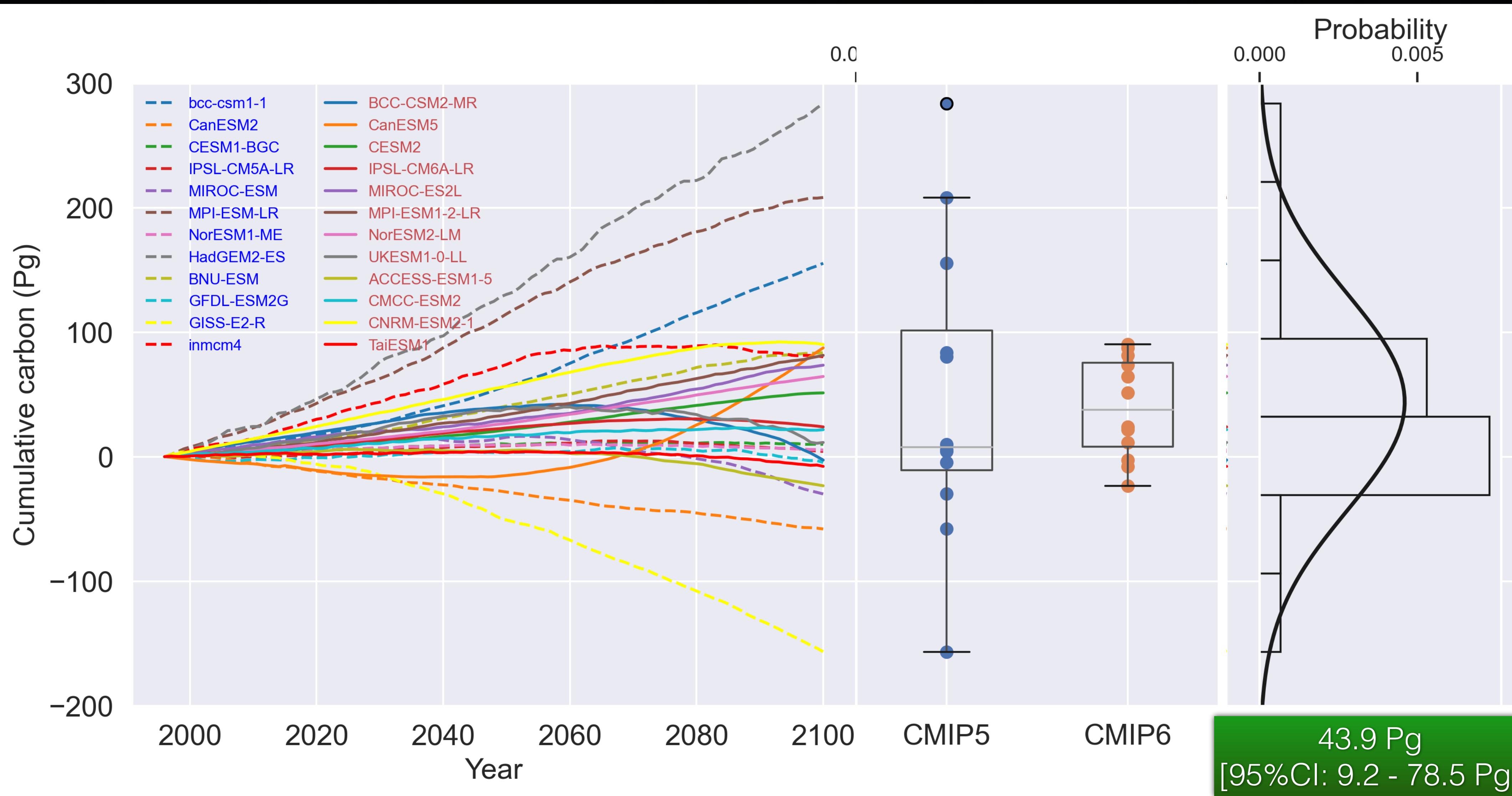
Divergent soil carbon change in CMIP5&6 models



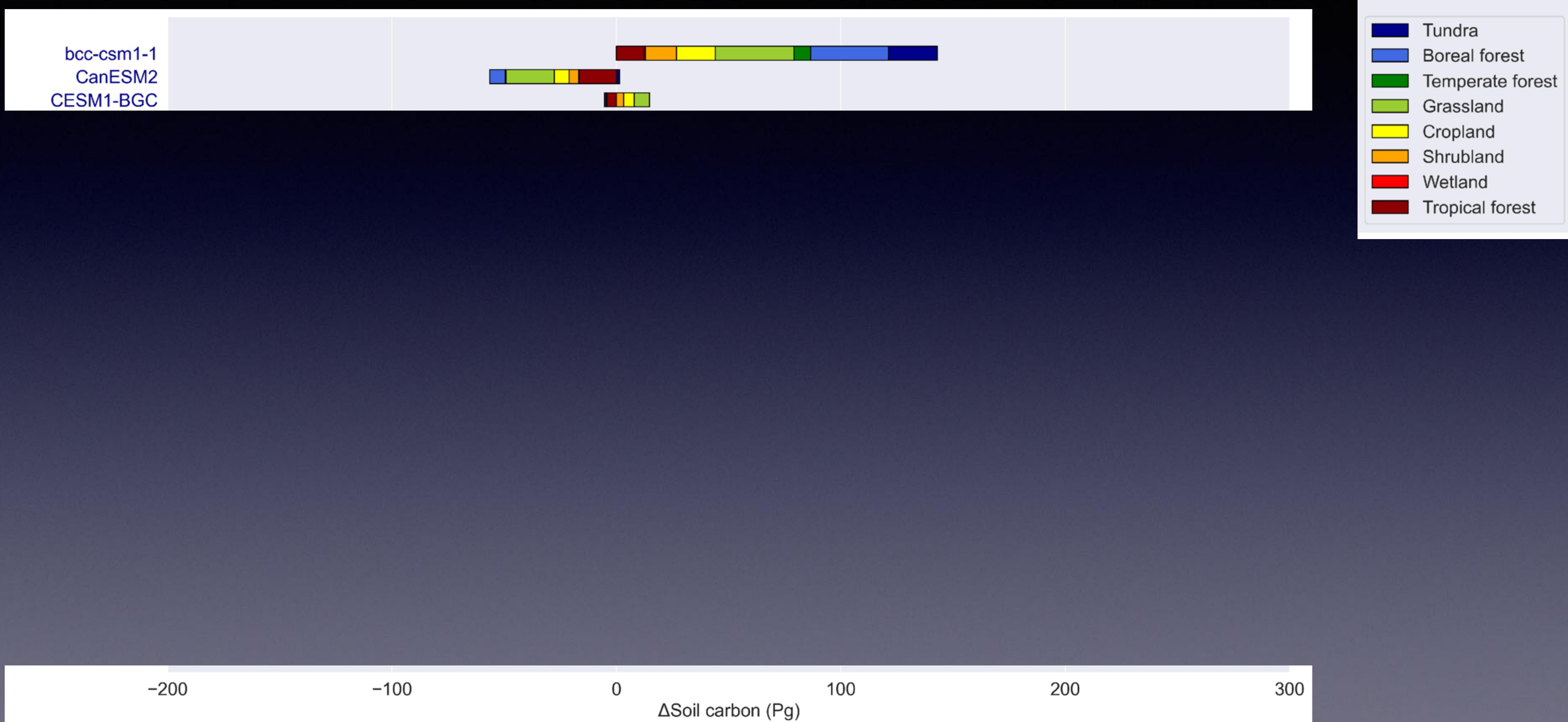
Soil carbon response to climate change in CMIP6



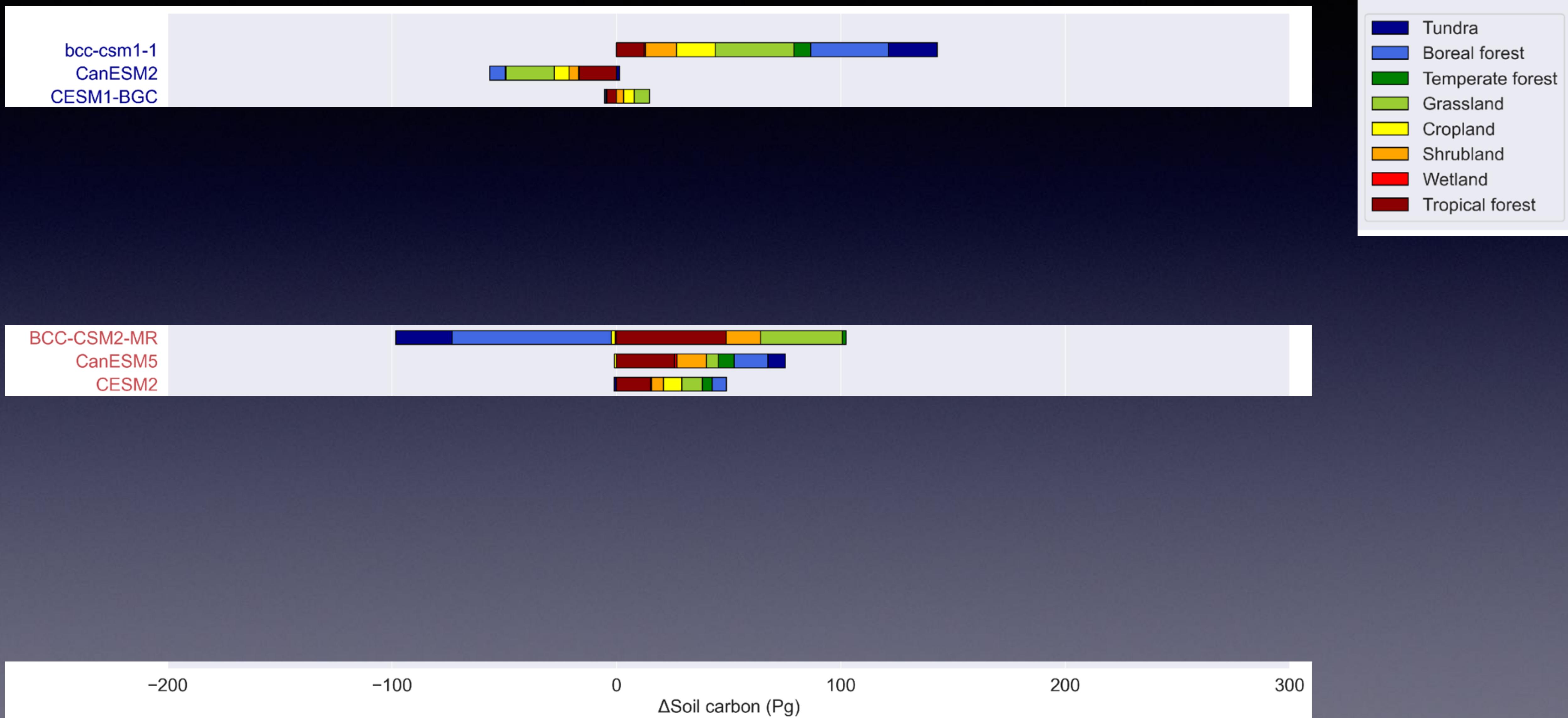
Mean soil carbon gain in CMIPs



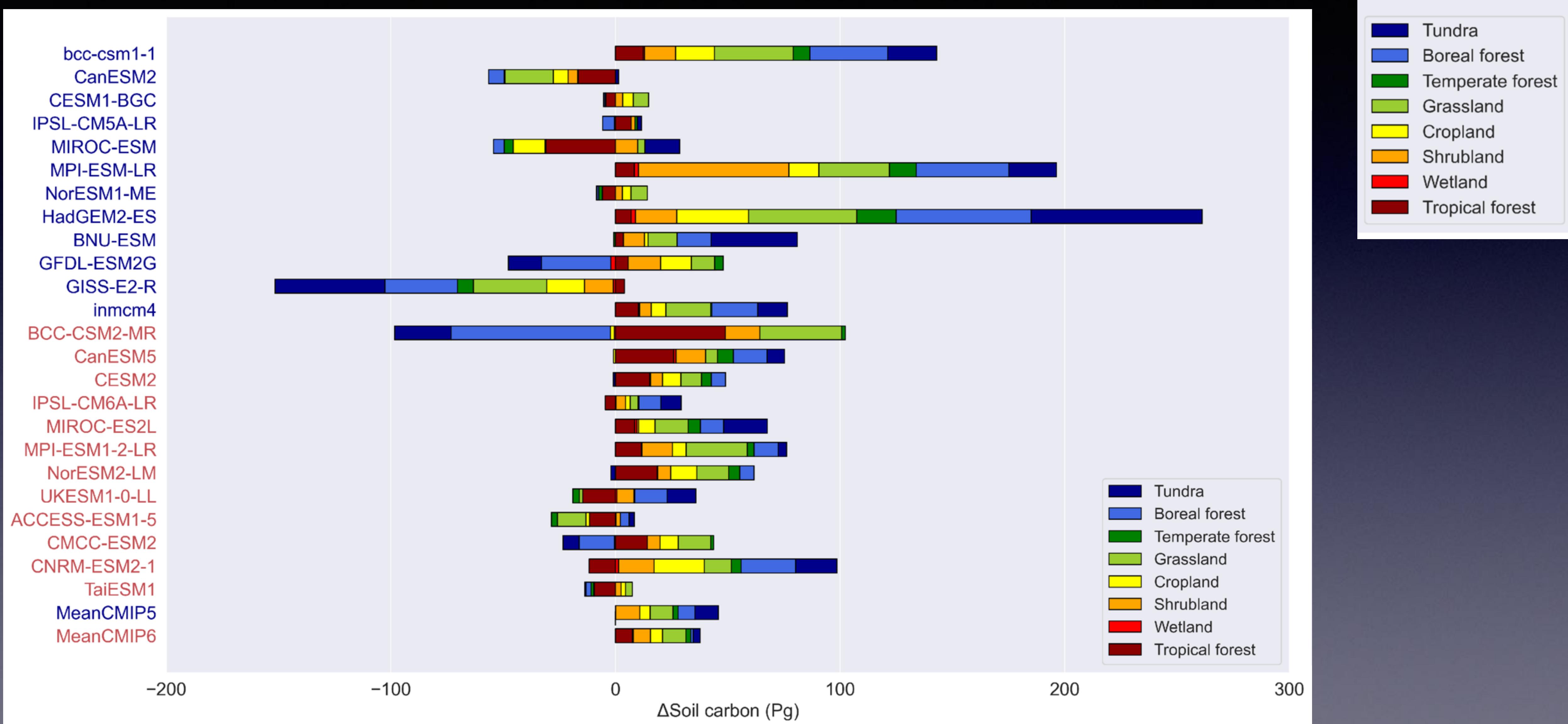
Divergent response on biome levels



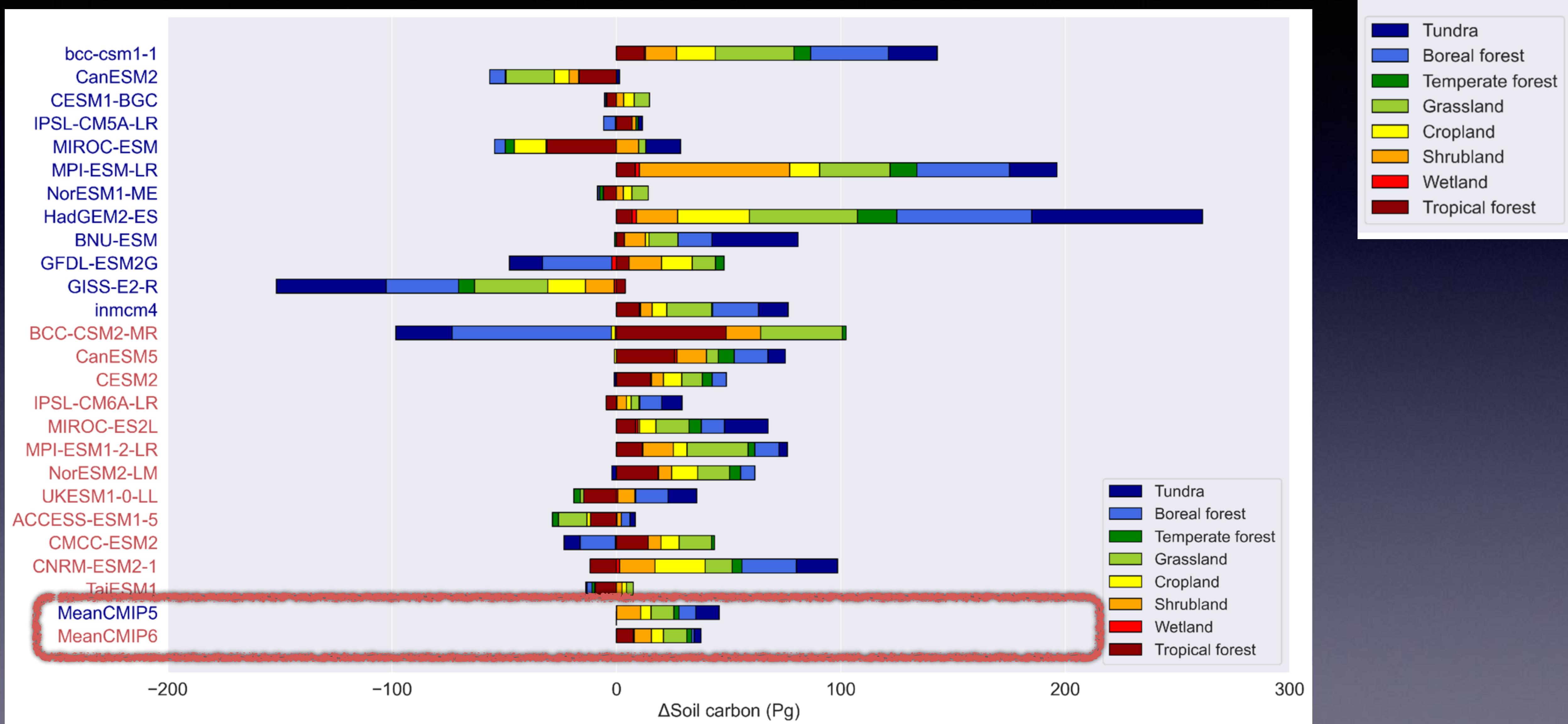
Divergent response on biome levels



Divergent response on biome levels



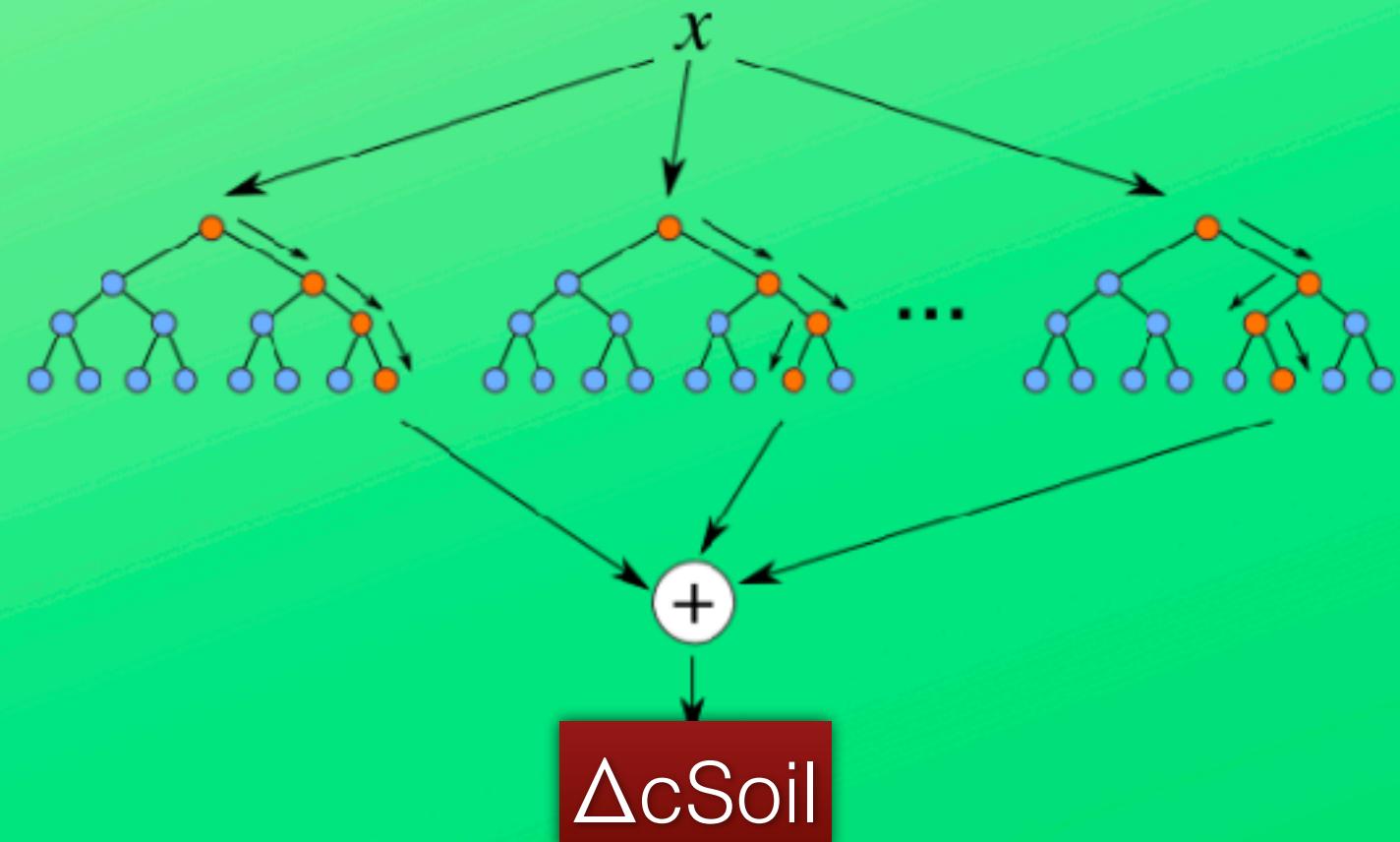
Divergent response on biome levels



Soil carbon change is highly predictable

NPP
 ΔNPP
cSoil
Ta
 ΔTa
P
 ΔP
 τ
 $\Delta \tau$

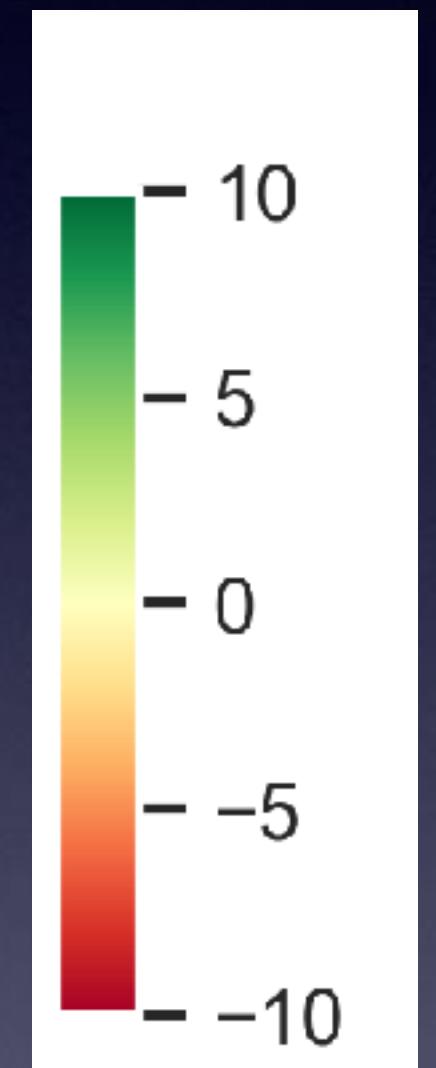
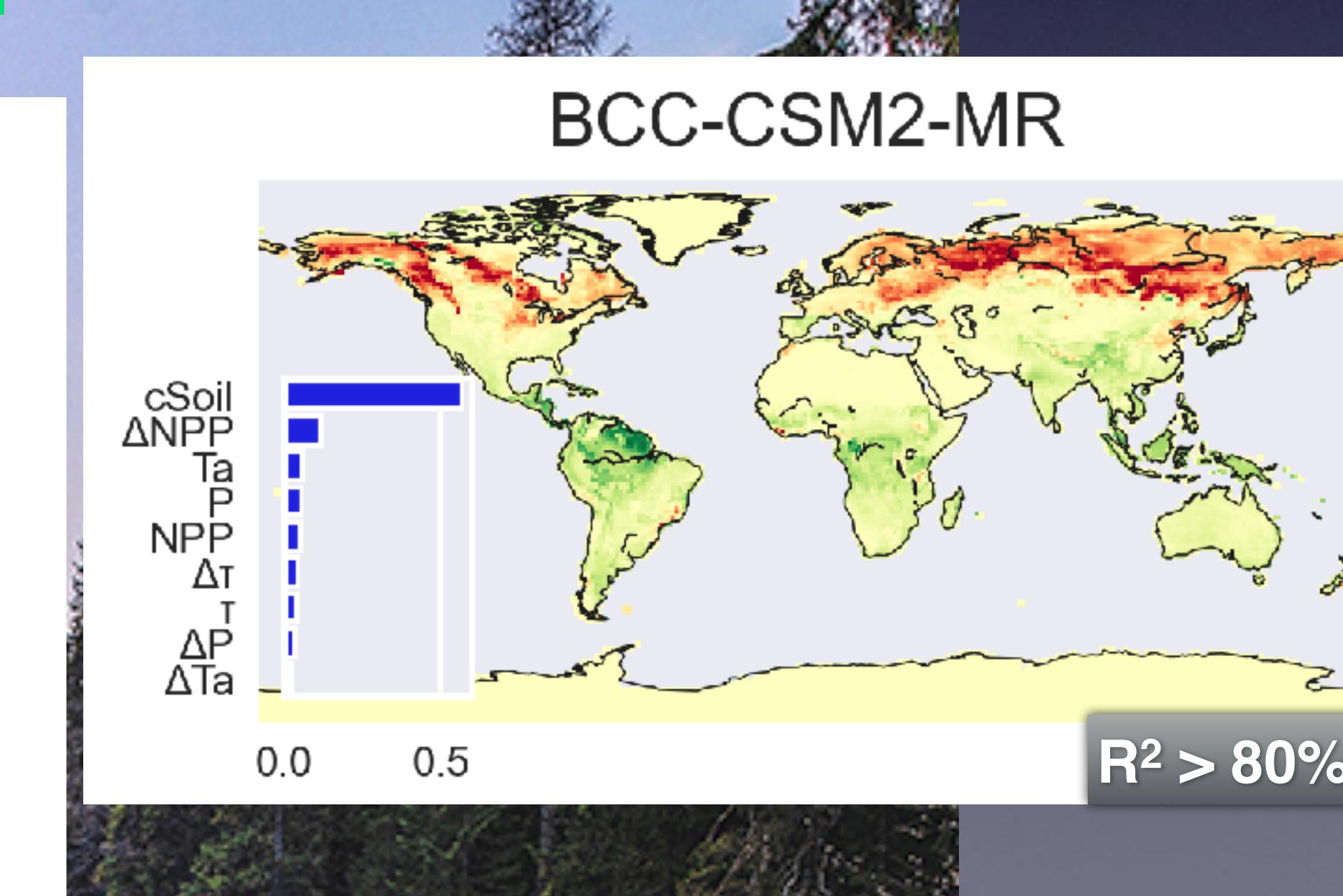
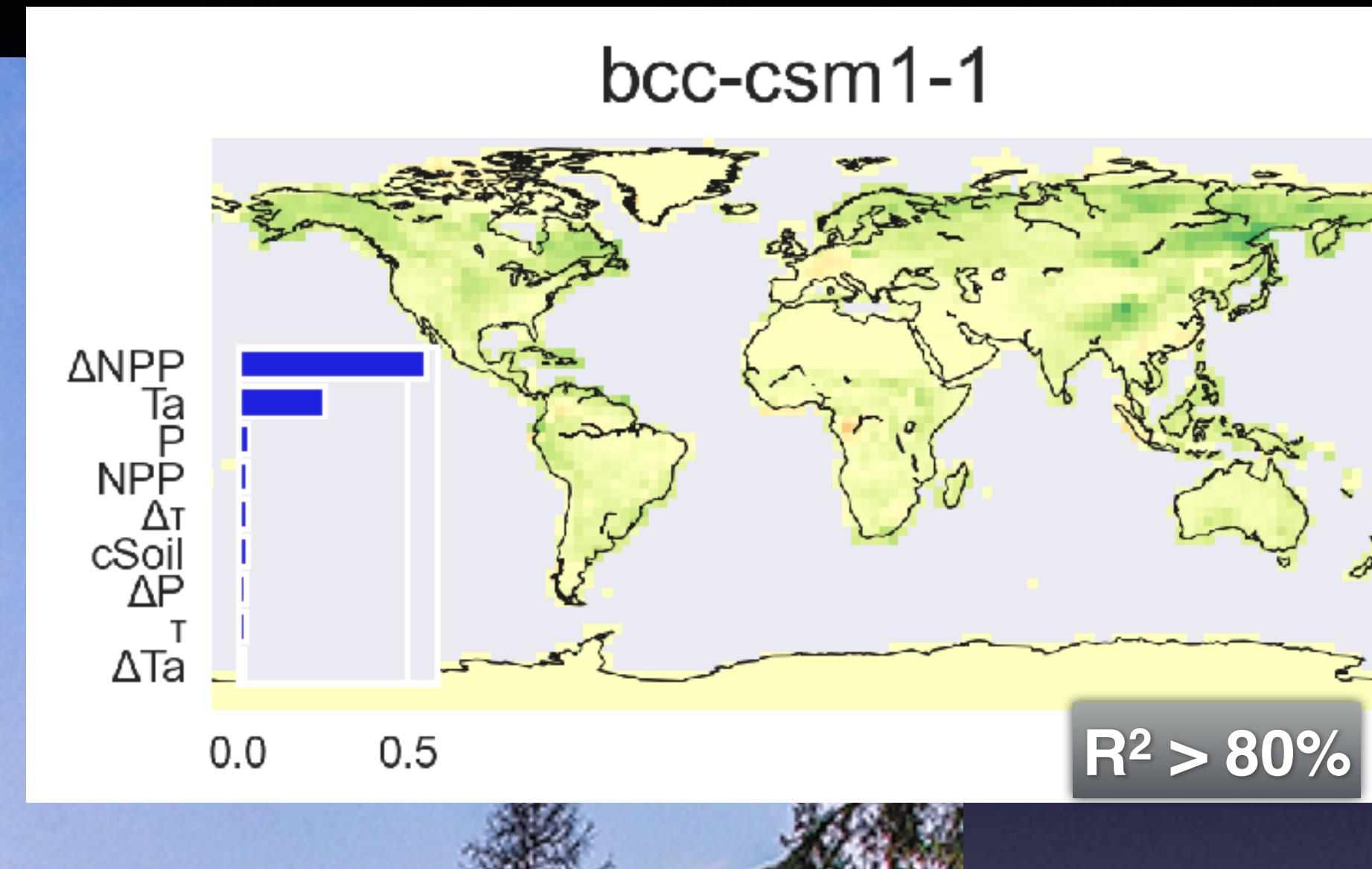
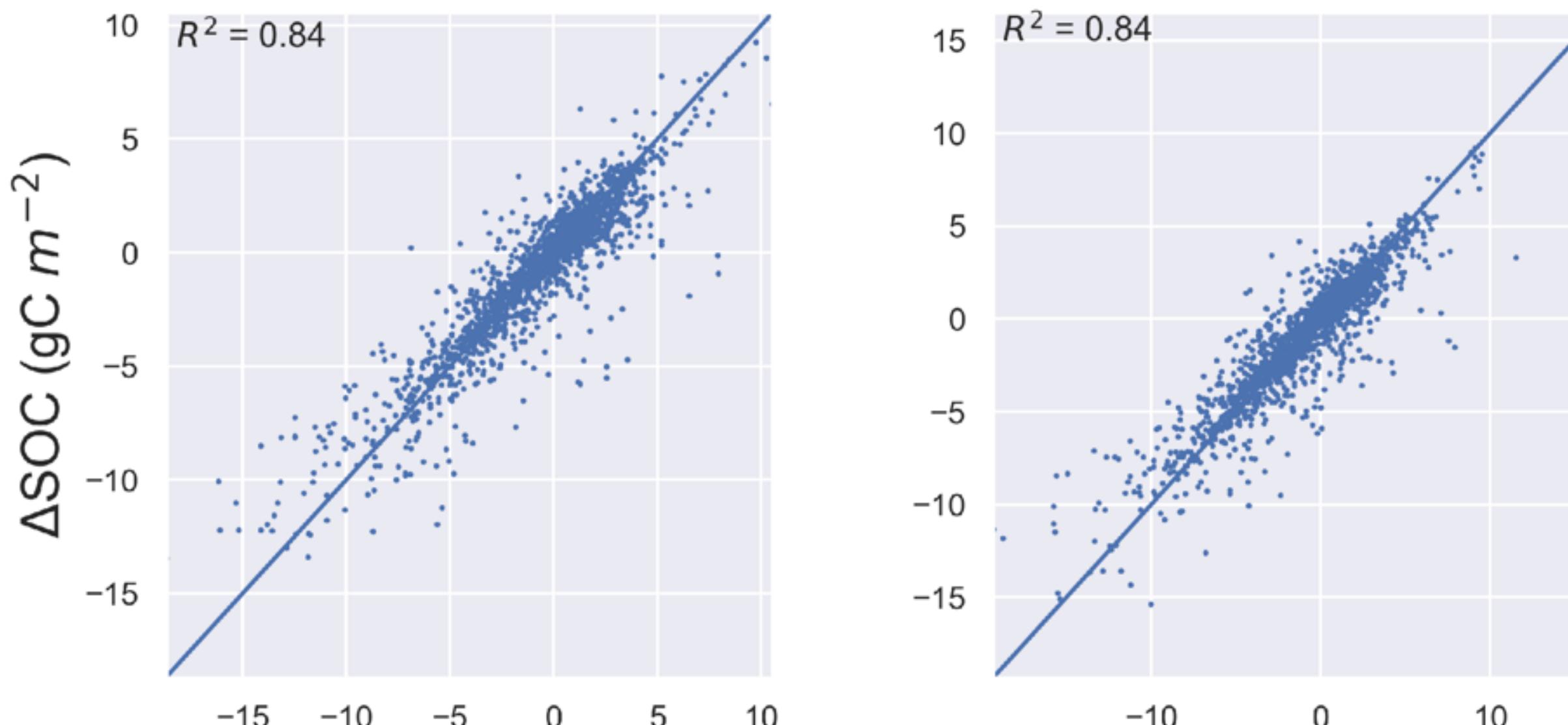
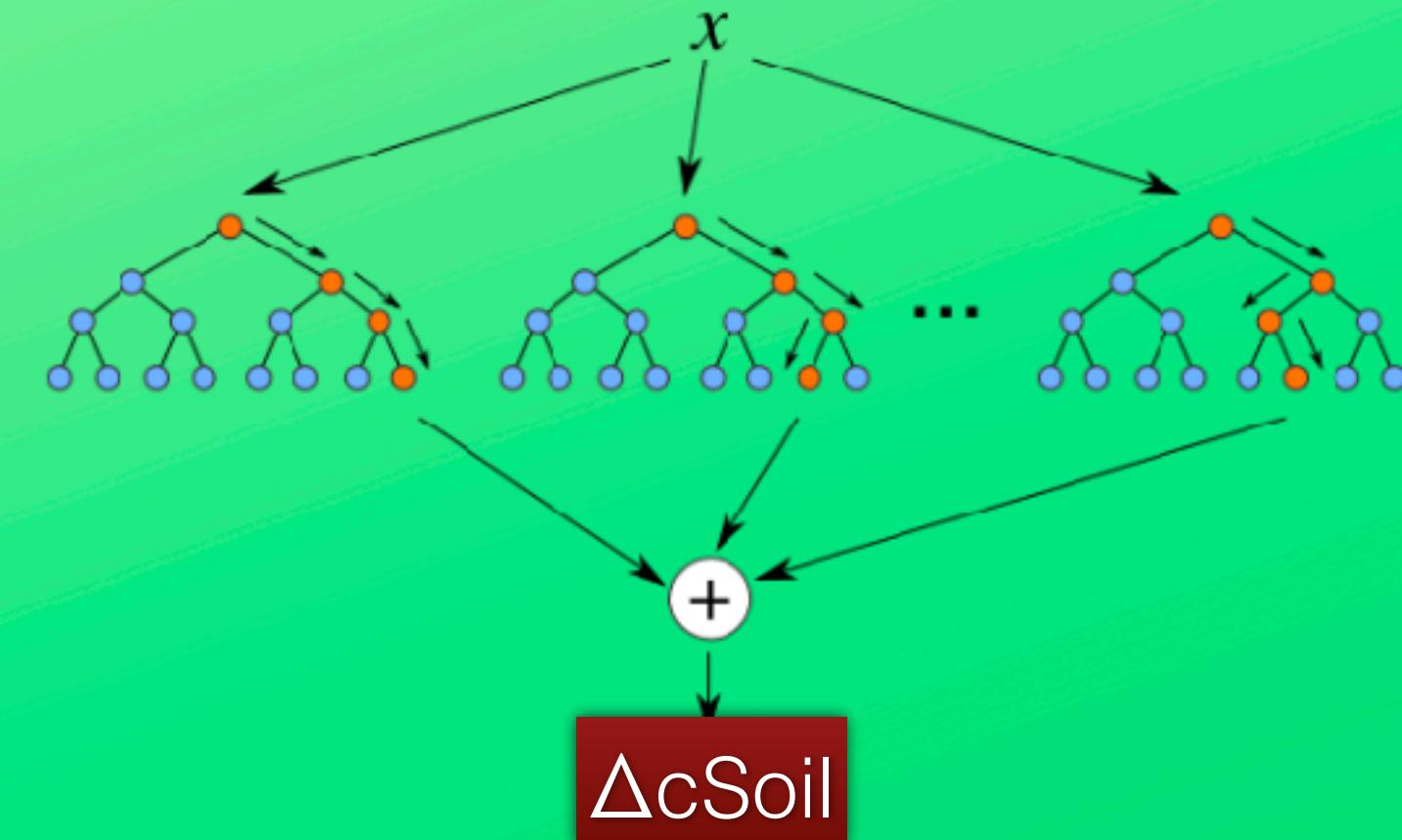
Random Forest Regression



Highly predictable of soil carbon change

NPP
 ΔNPP
cSoil
Ta
 ΔTa
P
 ΔP
 τ
 $\Delta \tau$

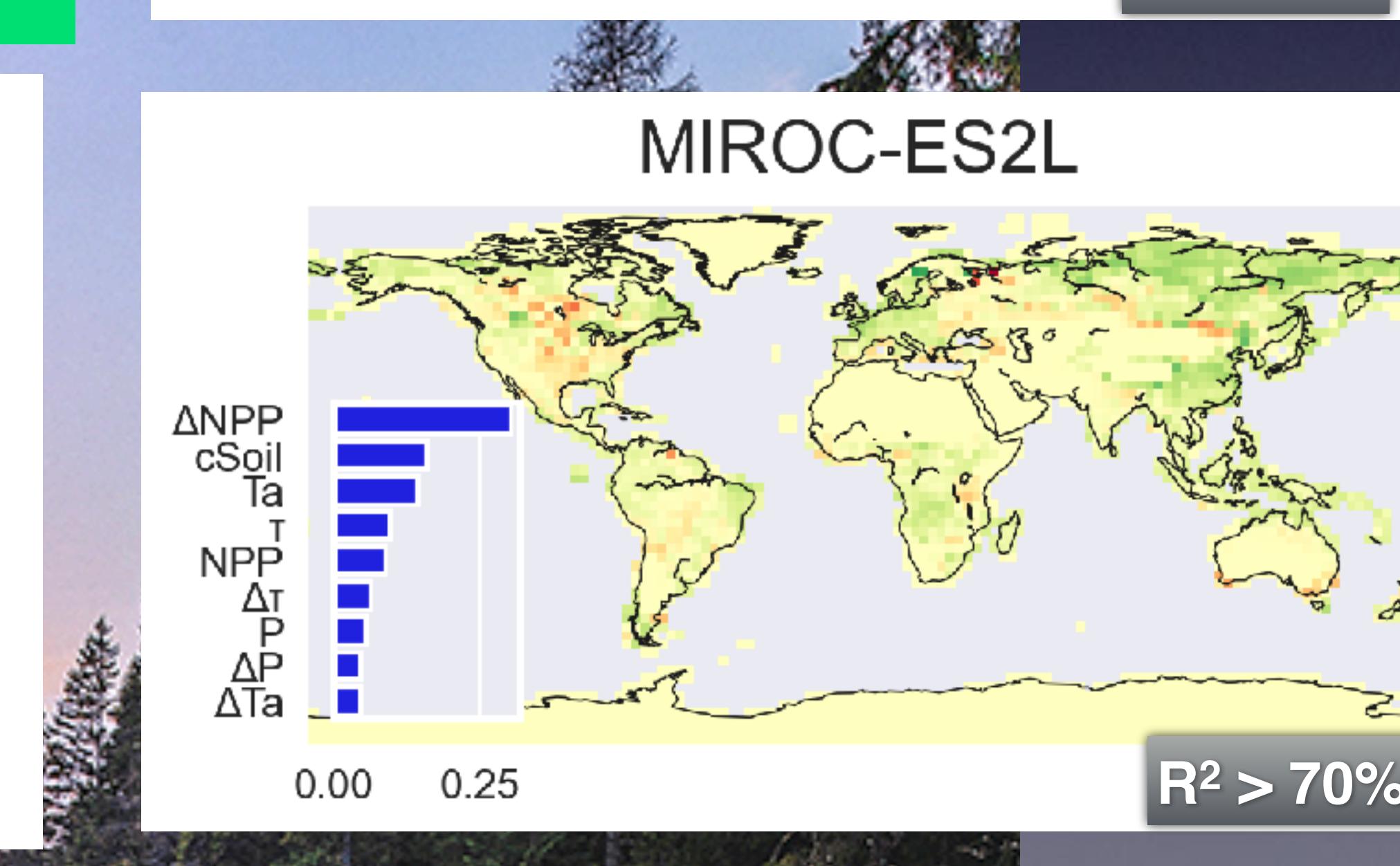
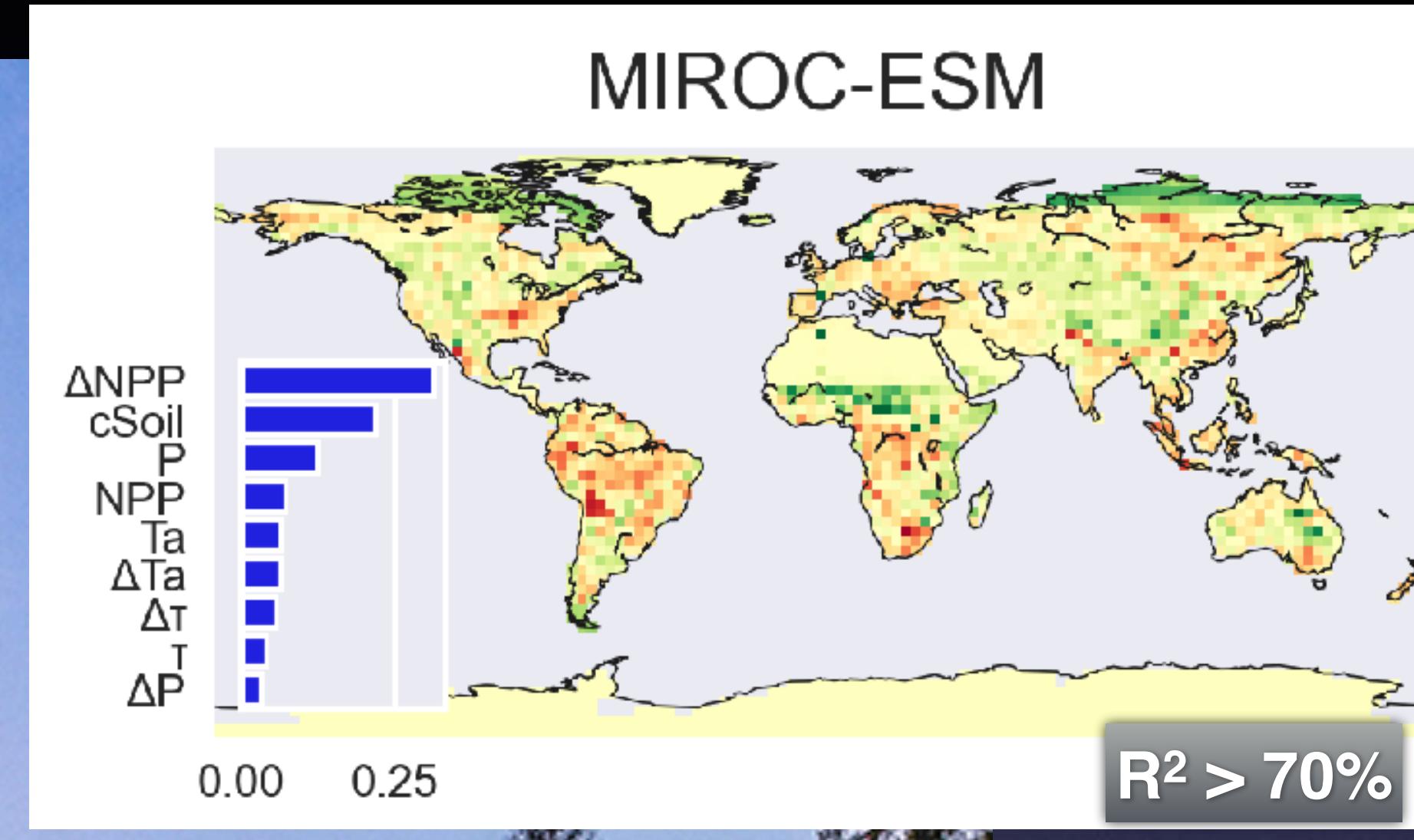
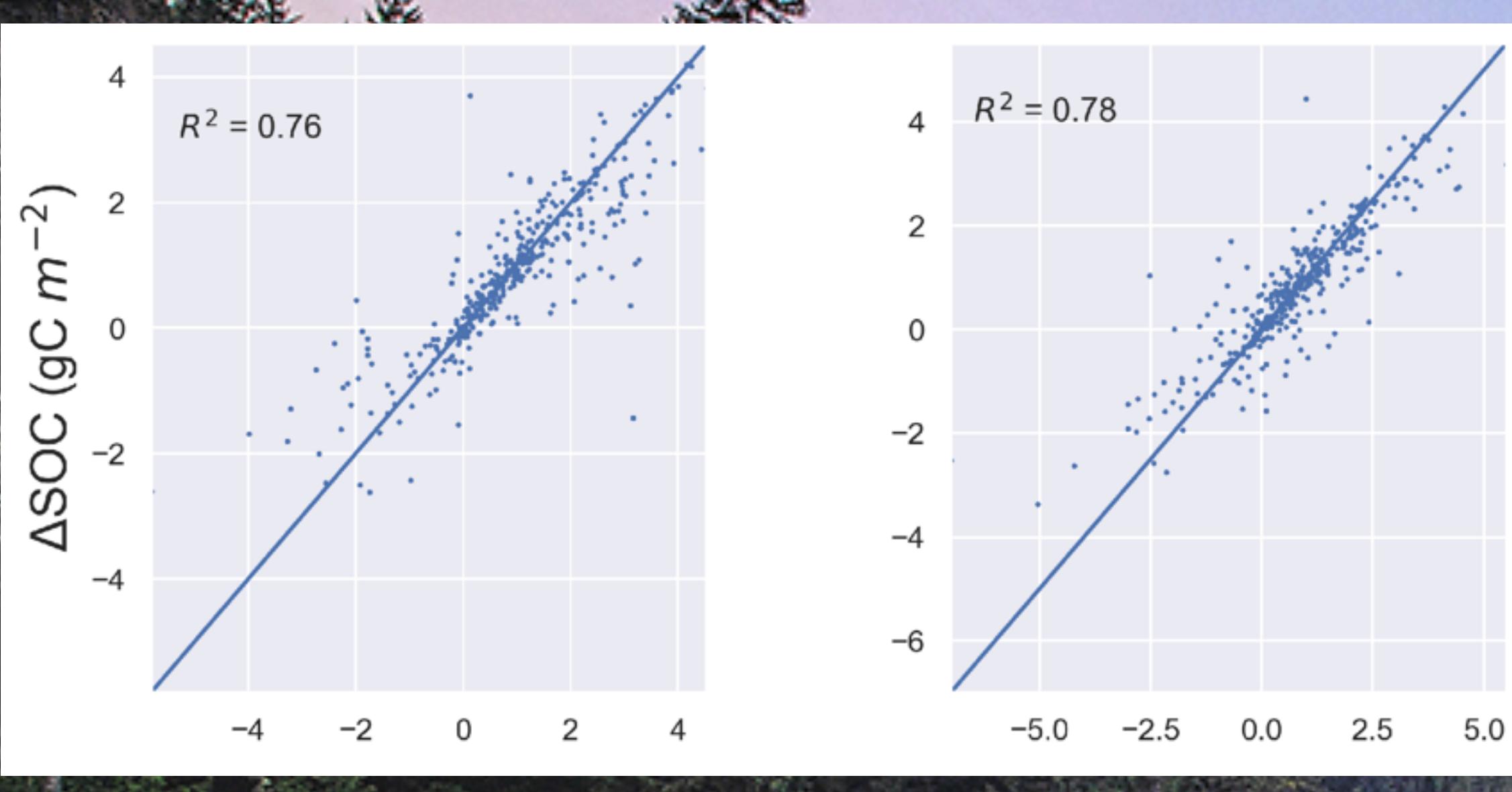
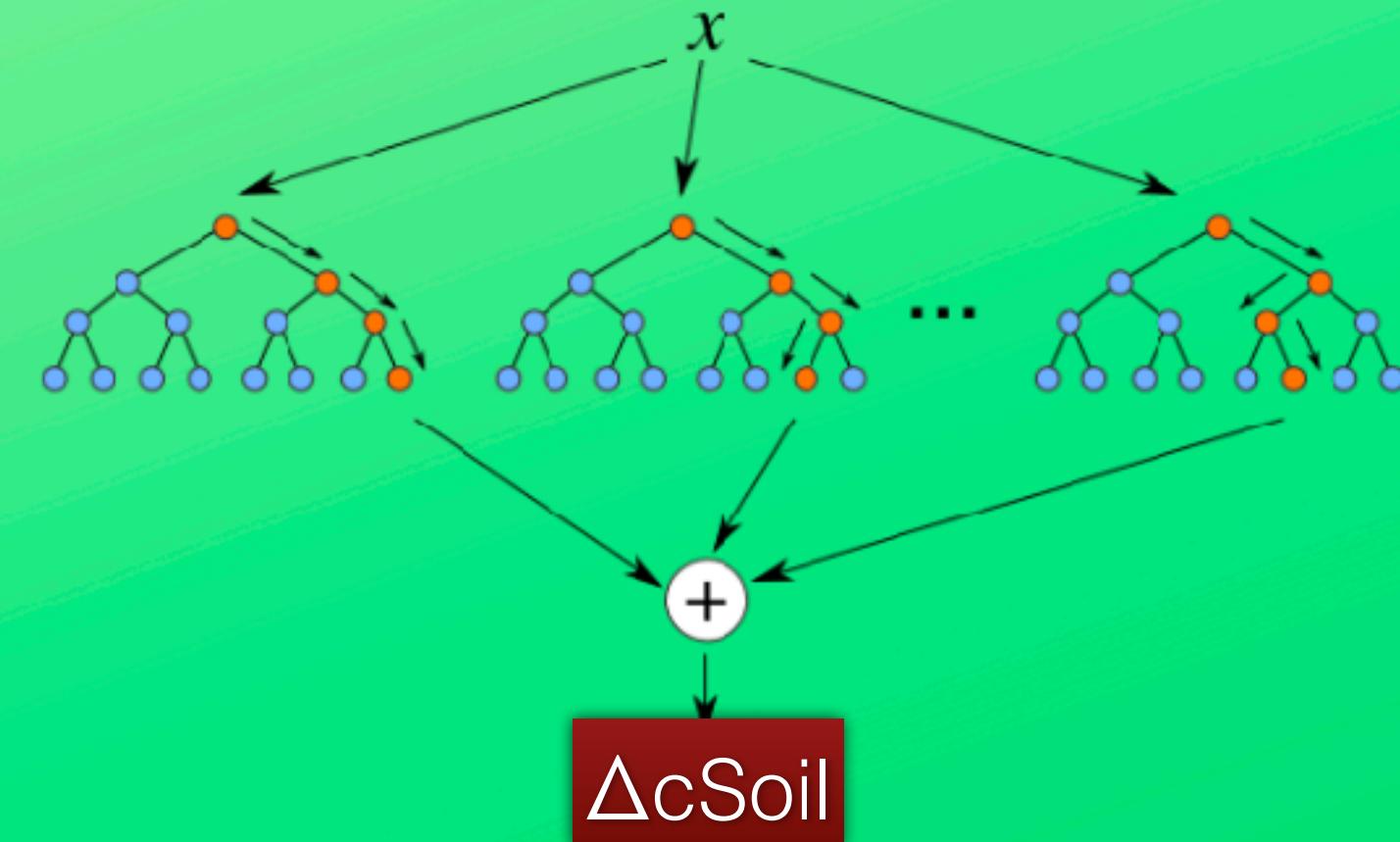
Random Forest Regression



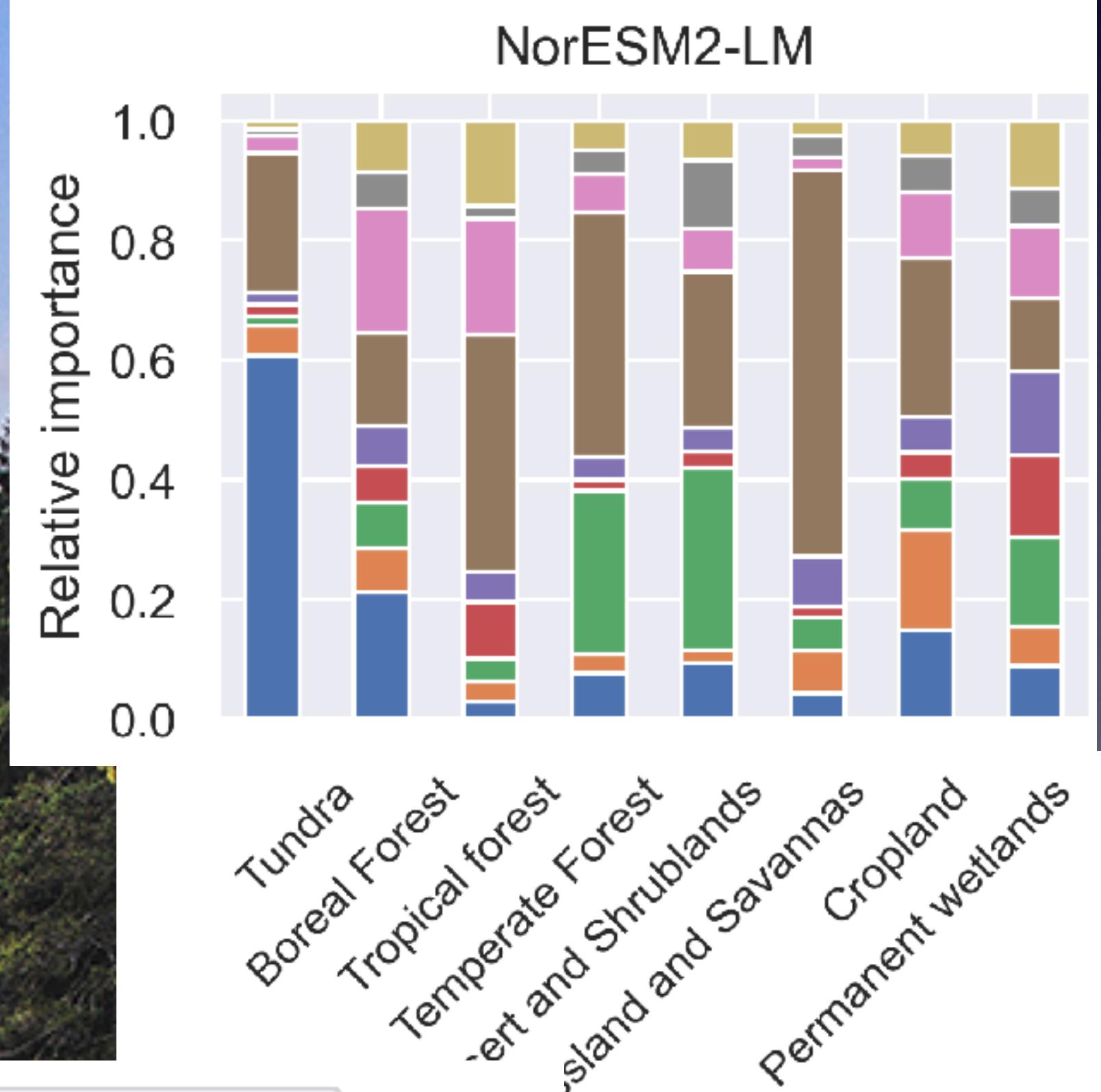
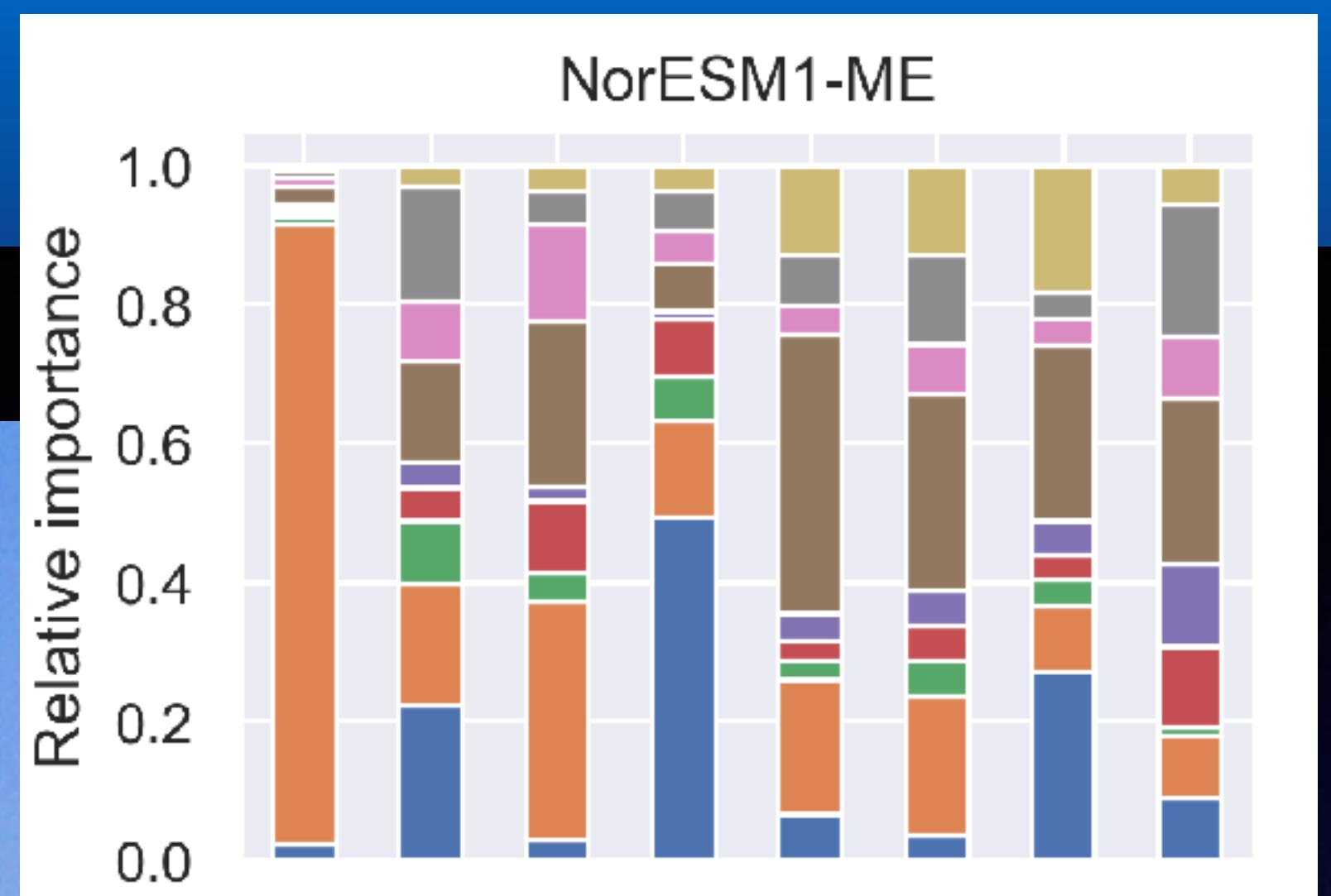
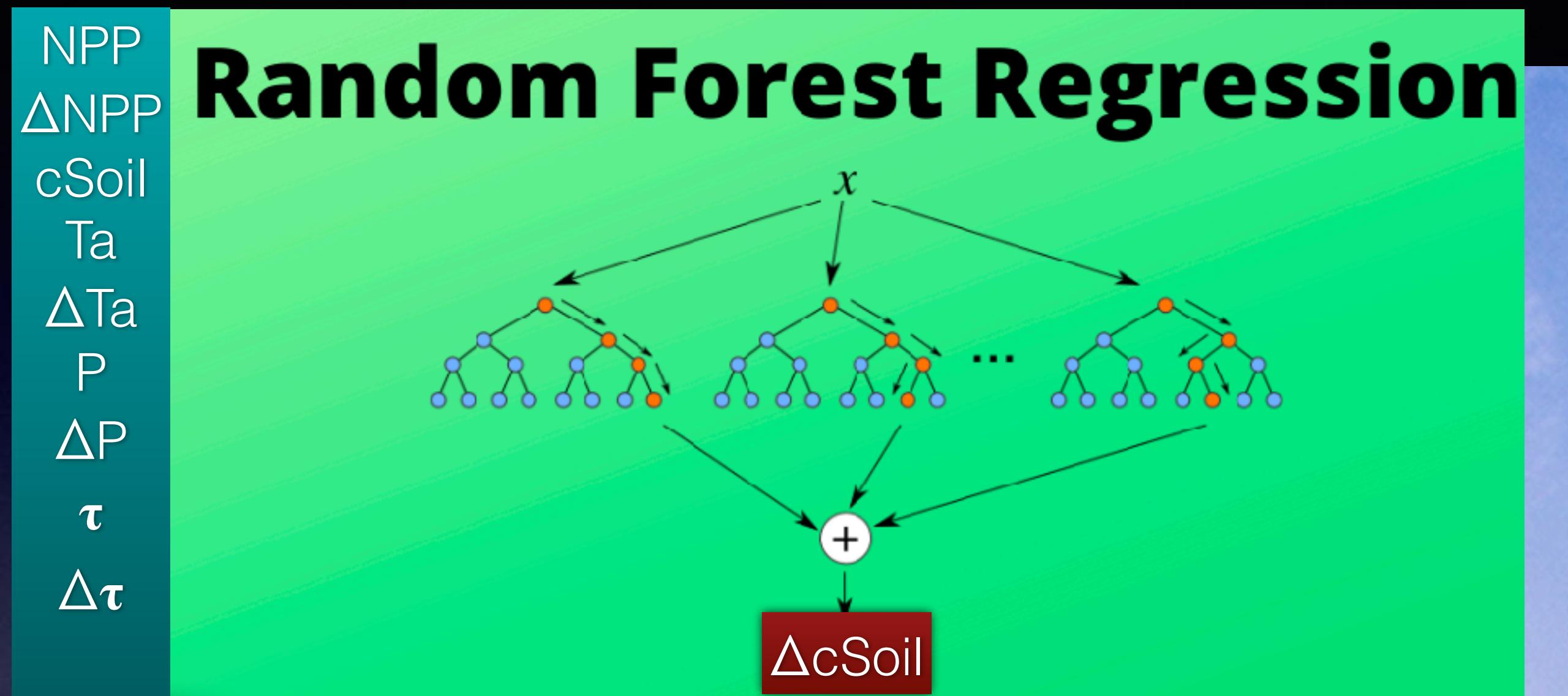
Highly predictable of soil carbon change

NPP
 ΔNPP
cSoil
Ta
 ΔTa
P
 ΔP
 τ
 $\Delta \tau$

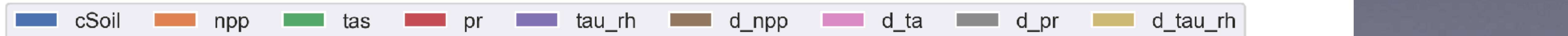
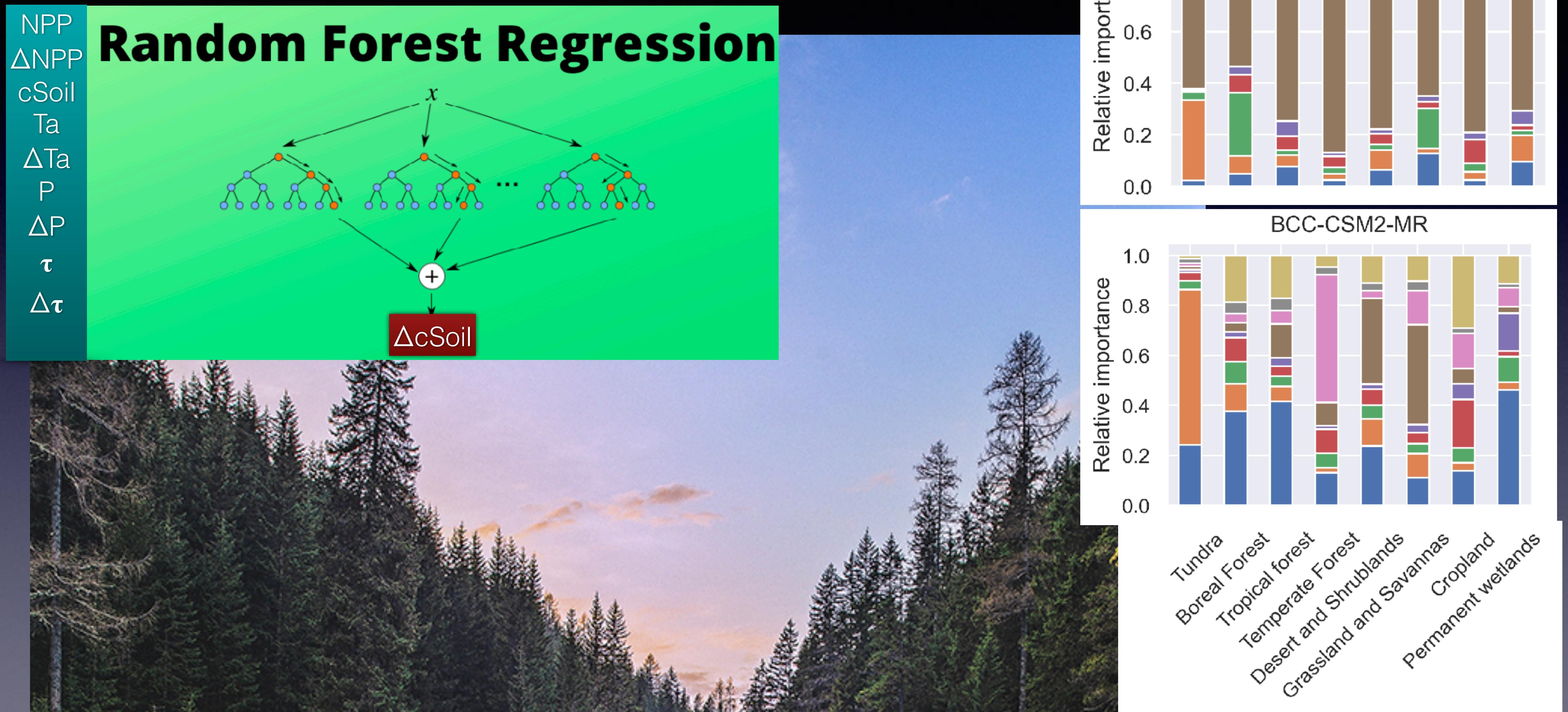
Random Forest Regression



Biome-level feature importance



Biome-level feature importance

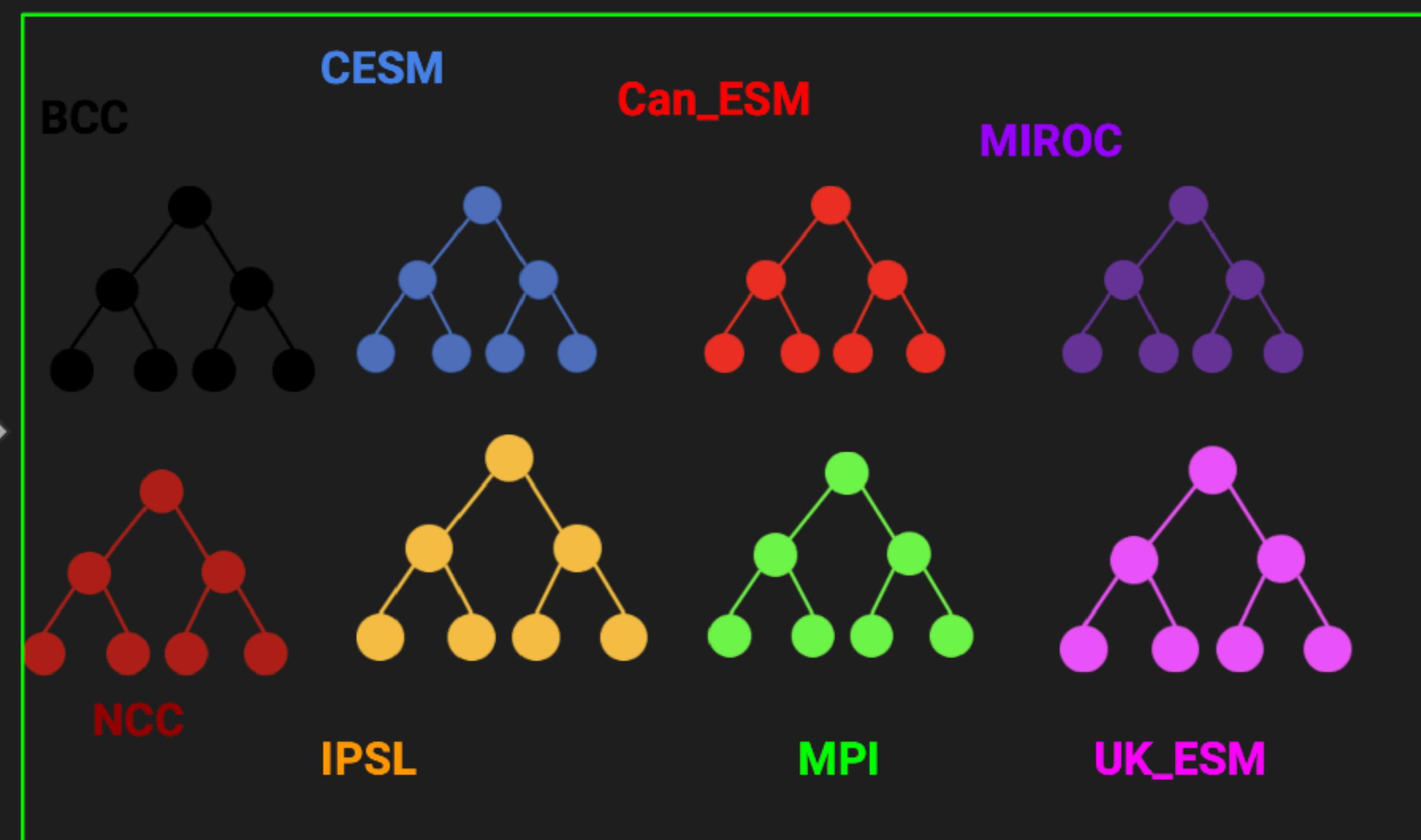


Uncertainty partitioning using random forest

Inputs:

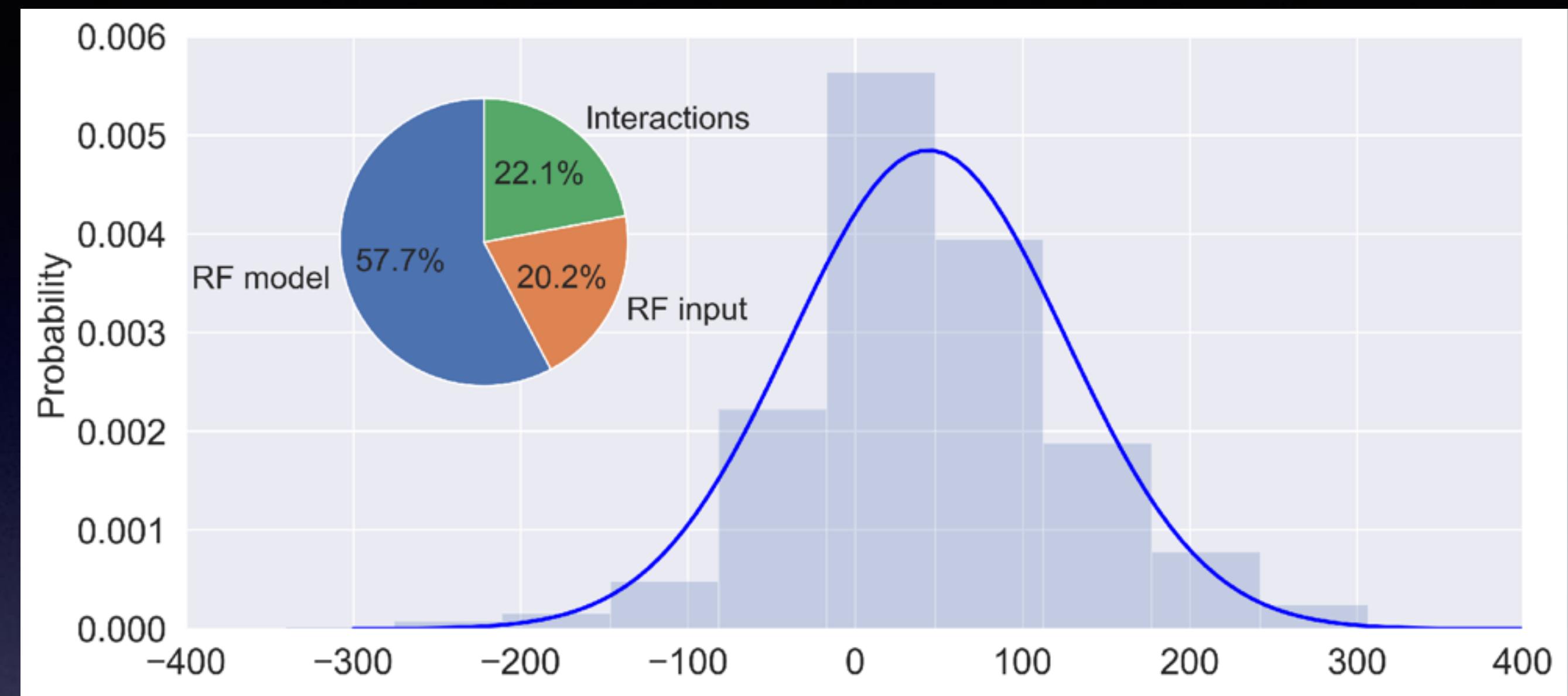
- Temperature
- Precipitation
- NPP
- τ
- Soil carbon
- Δ Temperature
- Δ Precipitation
- Δ NPP
- $\Delta\tau$

Trained RF model ensembles

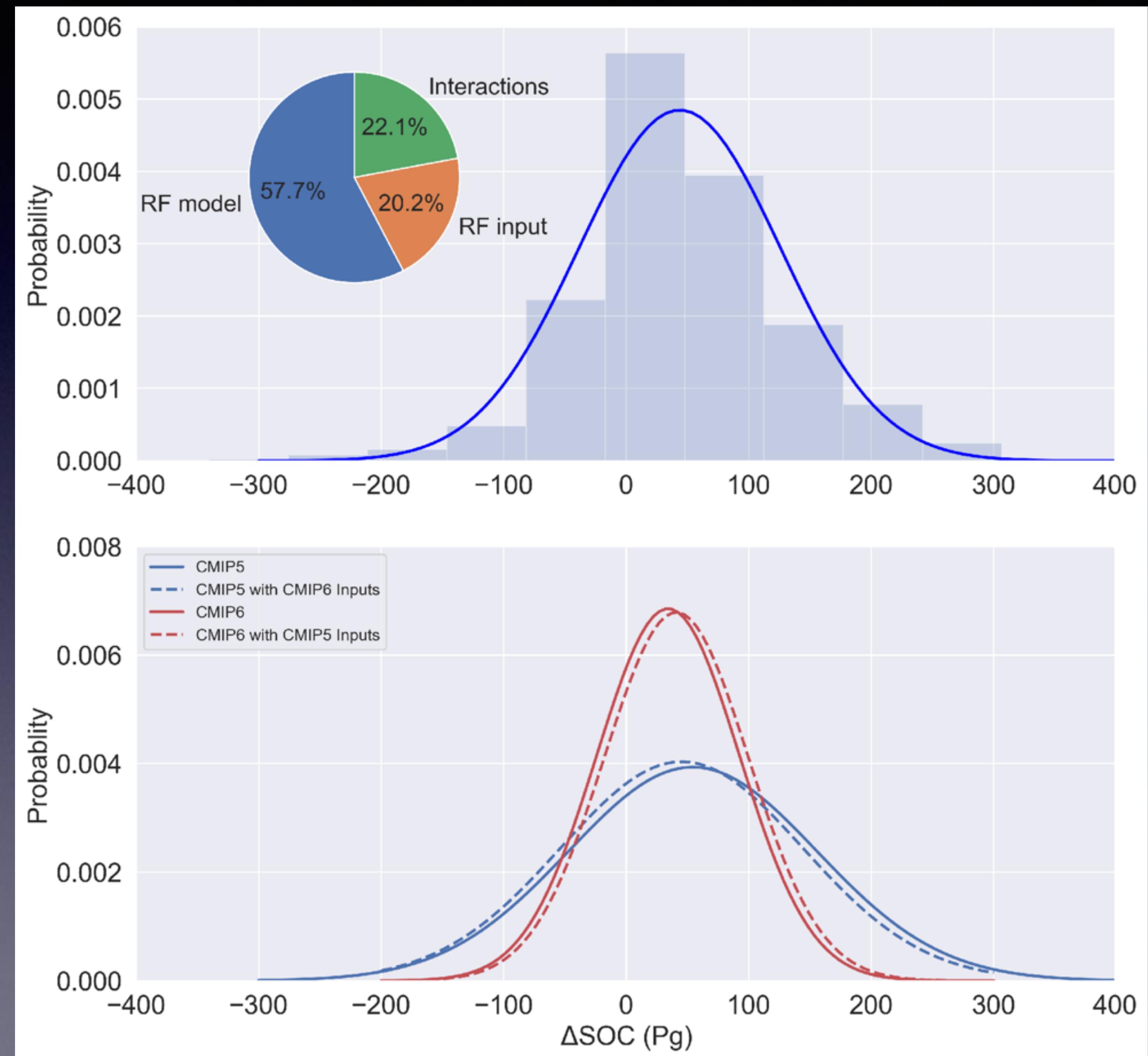


Δ Soil C
 Δ Soil C

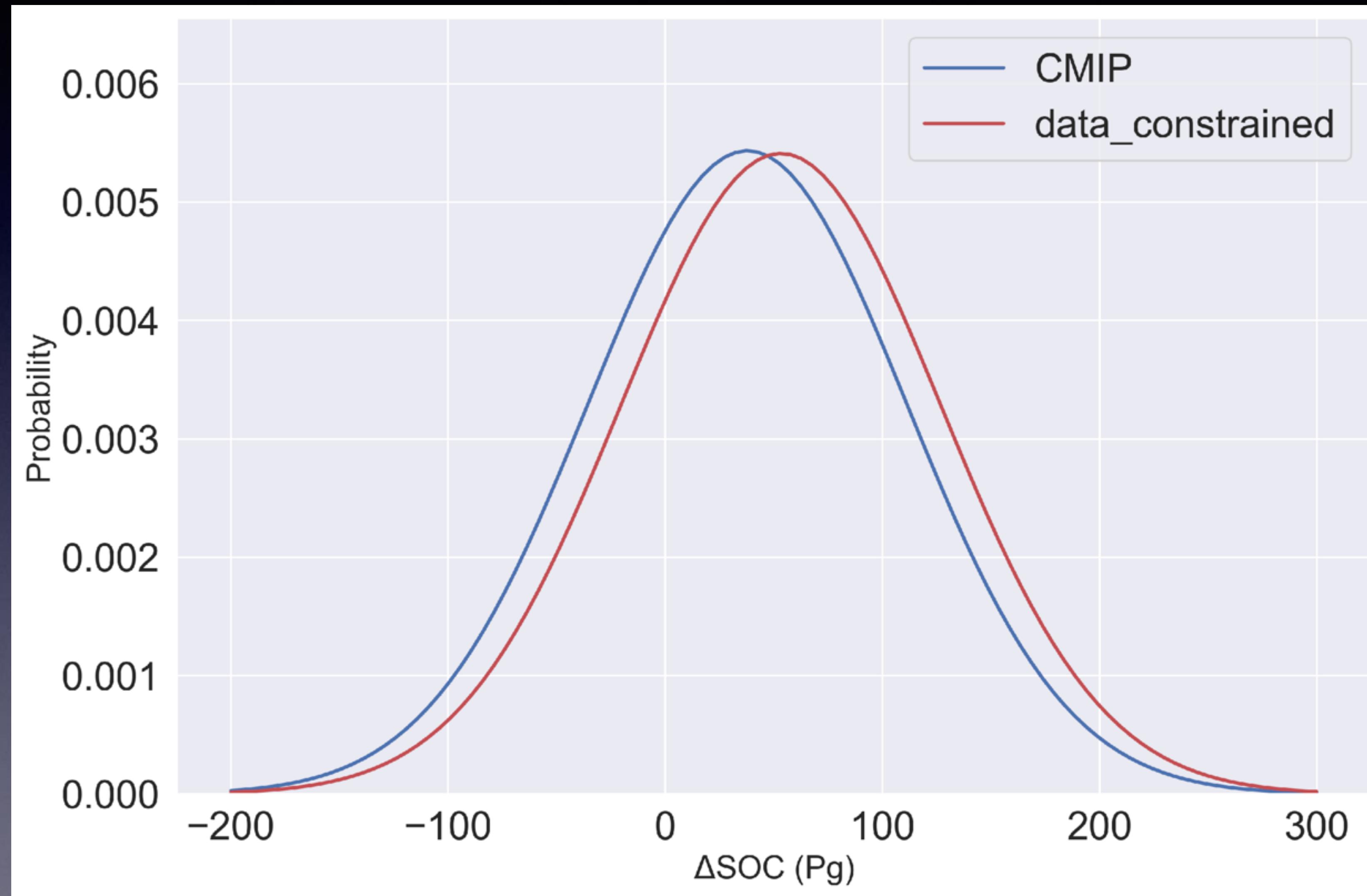
Model structure explains most uncertainty



Model structure explains most uncertainty



Data-constrained soil carbon change



Soil carbon
Temperature
Precipitation
NPP
 τ

Conclusions

1. Earth system models predict a mean carbon gain during the 21st century
2. However, large variation exists among models and across biomes.
3. CMIP6 models predict less variation than CMIP5 models
4. Predictors for soil carbon change vary among models and across biomes
5. Model structure may explain more variation than inputs