Recent results from NorESM CLM-FATES

Jessica Needham, CICERO, Oslo, Norway








The NorESM land team

Rosie Fisher

Kjetil Aas

Marit Sandstad

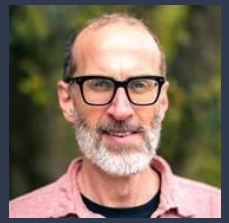
Matvey Debolskiy

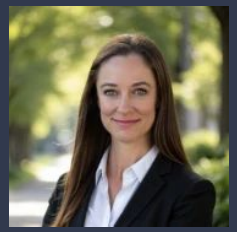
Jessica Needham

Mariana Vertenstein










The FATES team

Adrianna Foster

Sam Rabin

Gregory Lemieux

Ryan Knox

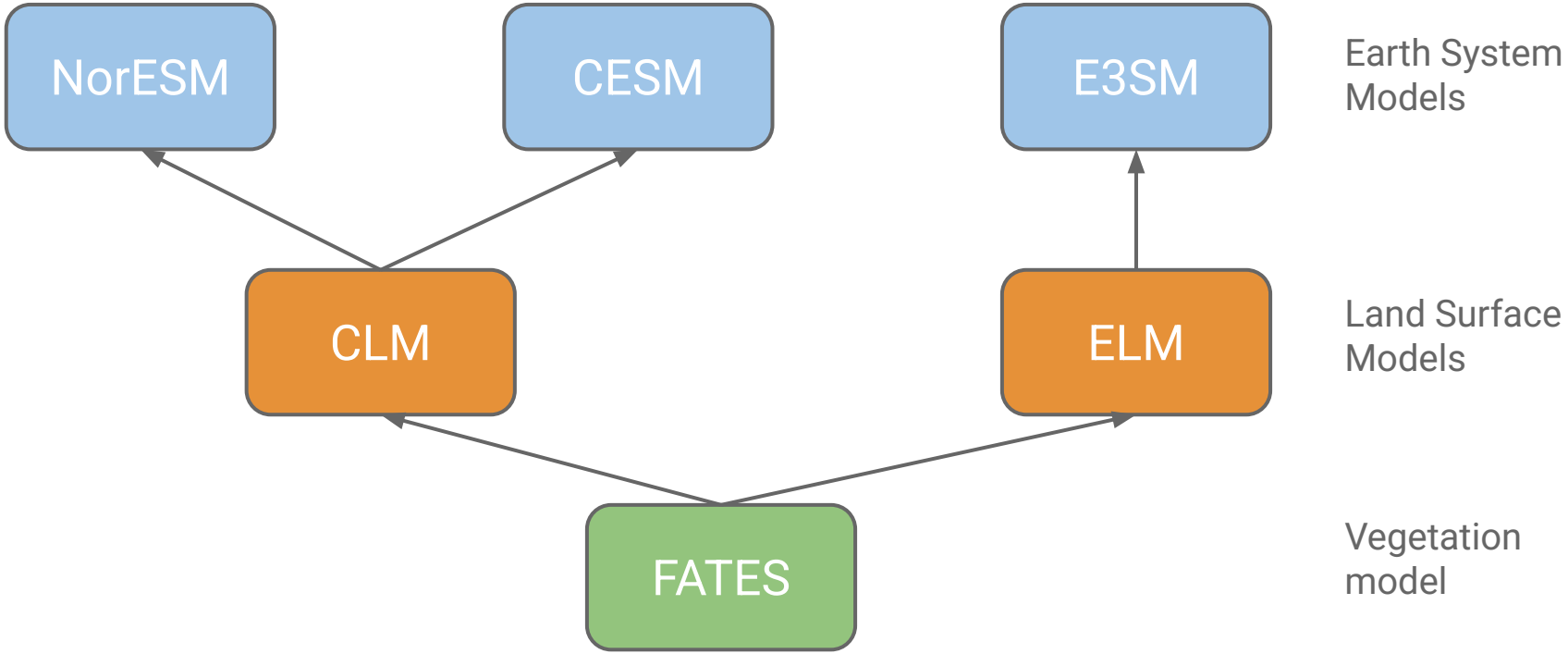
Charlie Koven

Marcos Longo

Jennifer Holm

Will Wieder

Many others



Model overview

A busy few years for FATES

- Land use implemented ~2024
- First TRENDY 2025
- WIEMIP 2026 (warming induced emissions model intercomparison project)
- First CMIP 2026

Today's talk

TRENDY

WIEMIP

Coupled model results

Future NorESM plans



TRENDY



Stephen Sitch, University of Exeter

CLM-FATES in TRENDY 2026

Kjetil Aas



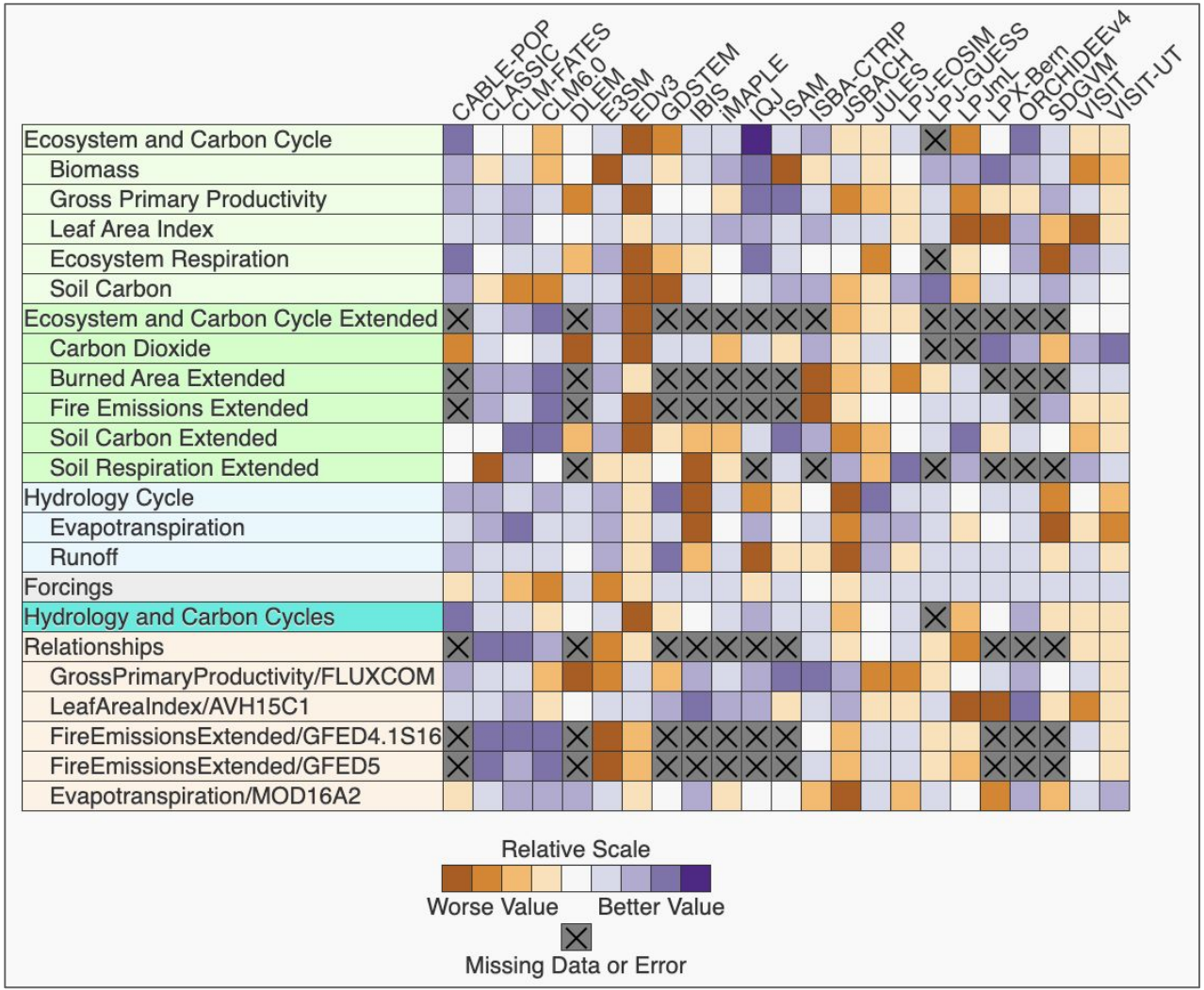
- Ensemble of land only models used in the Global Carbon Project
- Historical runs disentangling climate, CO_2, and land use impacts on the land carbon sink



FATES is the top/top 3 models for:

- GPP
- LAI
- evapotranspiration
- soil respiration
- fire emissions
- soil carbon turnover
- burned area v fire emissions

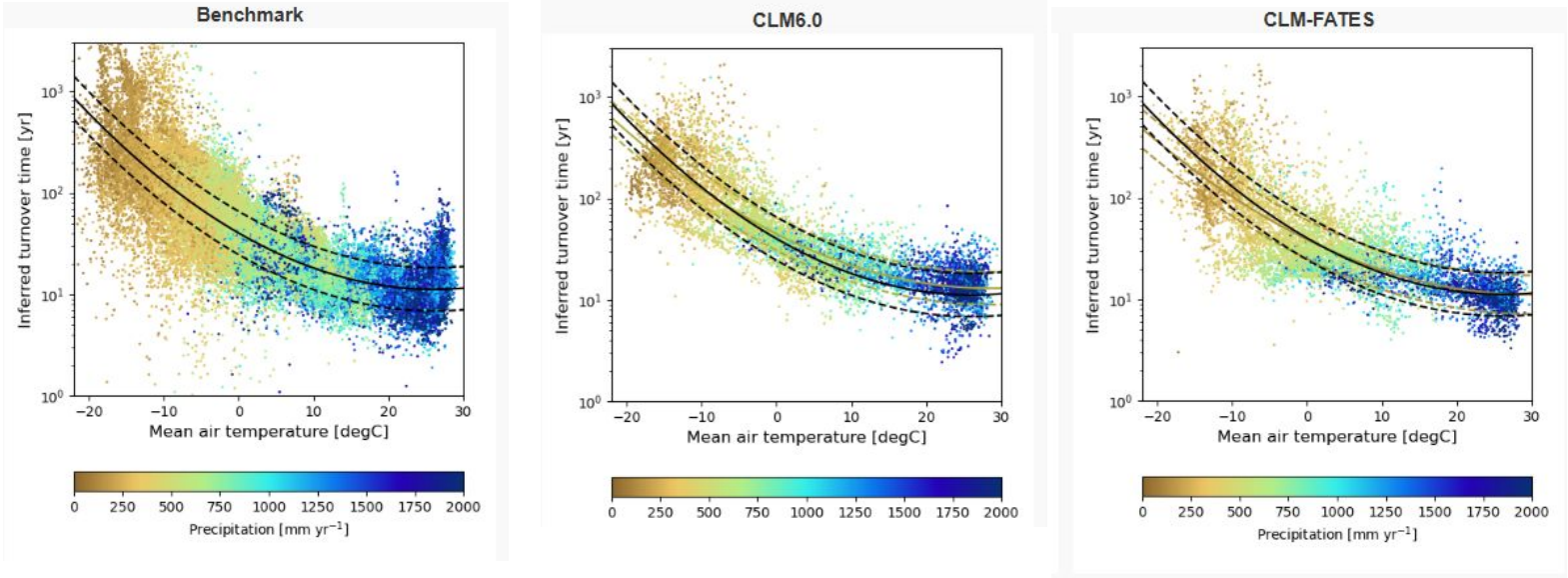
FATES is in the bottom 3 models for soil carbon



[ILAMB Analysis for TRENDYv15]

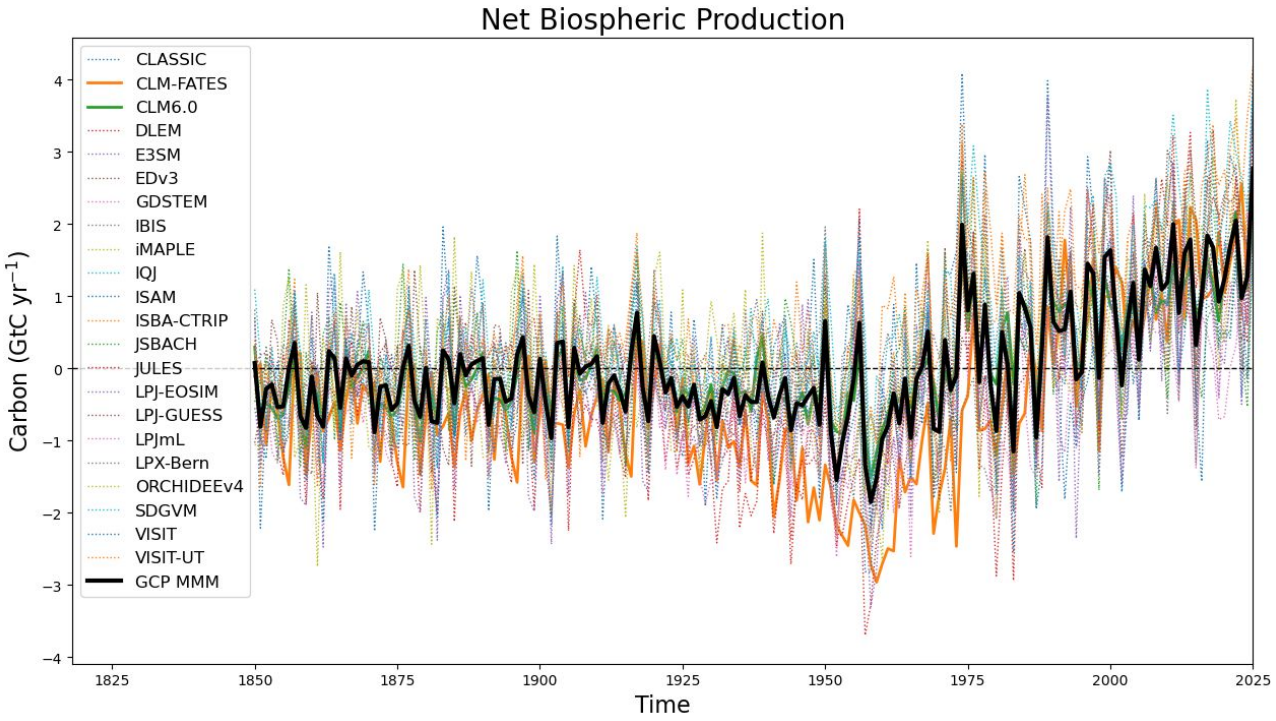
Friedlingstein,et al.: Global Carbon Budget 2026, Earth Syst. Sci. Data Discuss. [preprint], in review, 2026.

Inferred Soil turnover time (yr)



Air Temperature (Celsius)

TRENDY models predict a strong land carbon sink in the 21st C



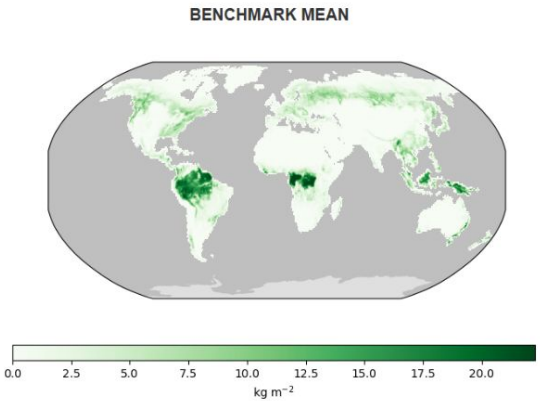
+ Land sink

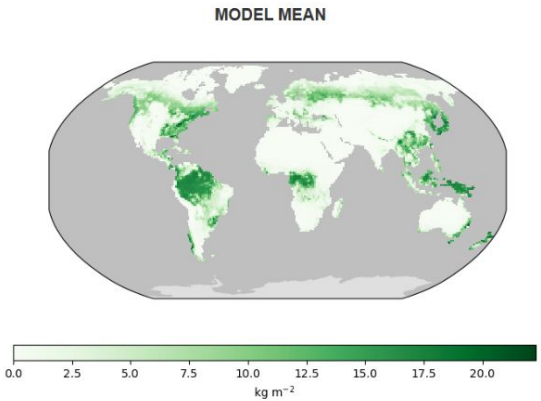
- Land source

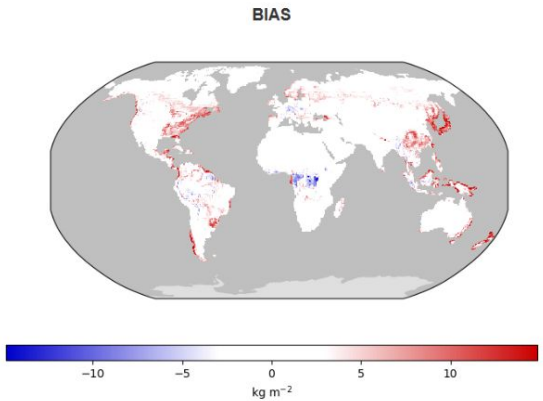
Global Carbon Project. (2026). Supplemental data of Global Carbon Budget 2026 (Version 0.1) [Data set]. Global Carbon Project. https://doi.org/10.18160/gcp-2026

(S3 - S4 + S0) + (S0 - S4 + δL)

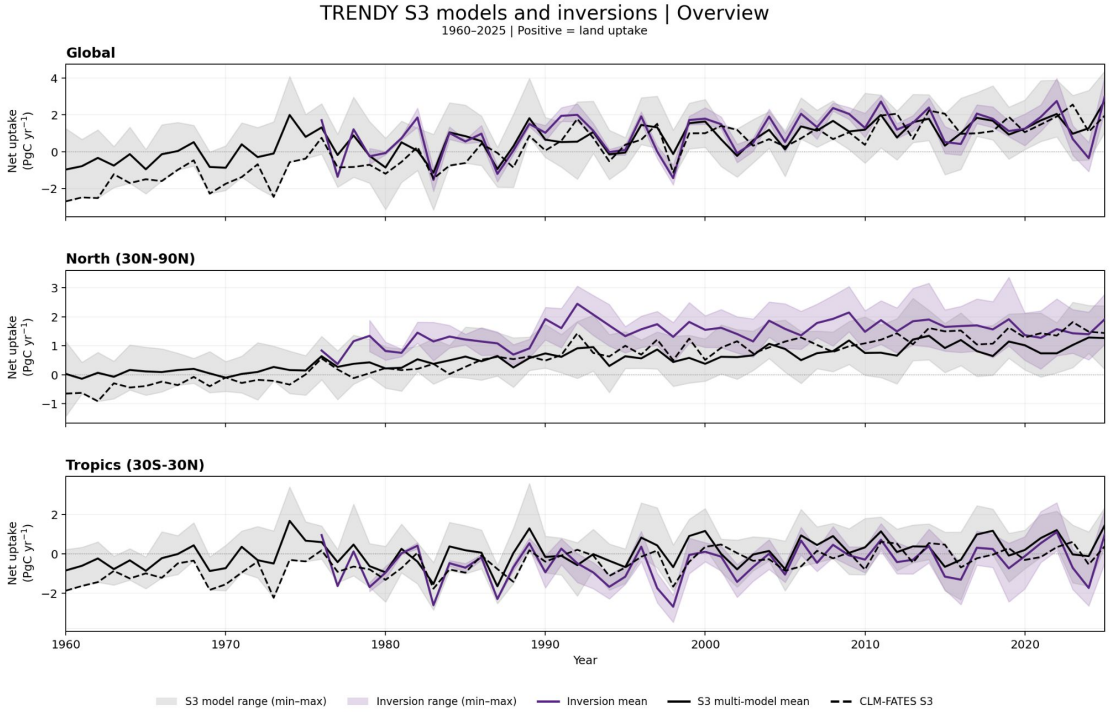
Vegetation Carbon
FATES v ESACCI (2014-2022)



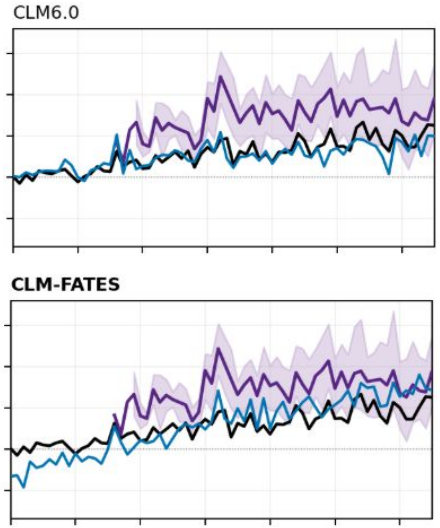




CO_2 fertilization in the northern hemisphere drives the land carbon sink in CLM-FATES (in line with inversions)

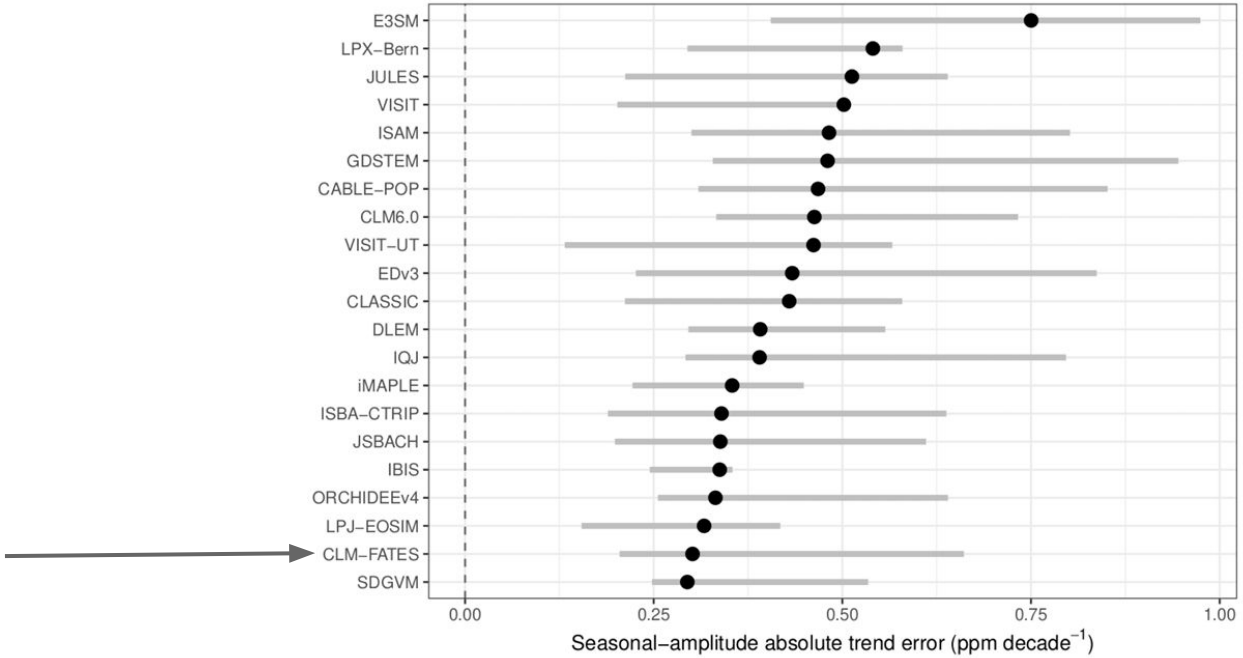


North - CLM6.0 and FATES



Figures credit Kjetil

CLM-FATES is good at modelling CO_2 seasonal amplitude



Friedlingstein,et al.: Global Carbon Budget 2026, Earth Syst. Sci. Data Discuss. [preprint], in review, 2026.

WIEMIP



Tom Colligan



Ben Poulter

SPARK
CLIMATE SOLUTIONS



Warming Induced Emissions MIP

Climate change is increasing greenhouse gas emissions from natural processes e.g. **permafrost thaw, wetland methane production, soil carbon loss, wildfires**

Implications for:

- Remaining carbon budget
- Warming stabilization
- Global tipping points
- Mitigation efforts







1% CO_2 simulations

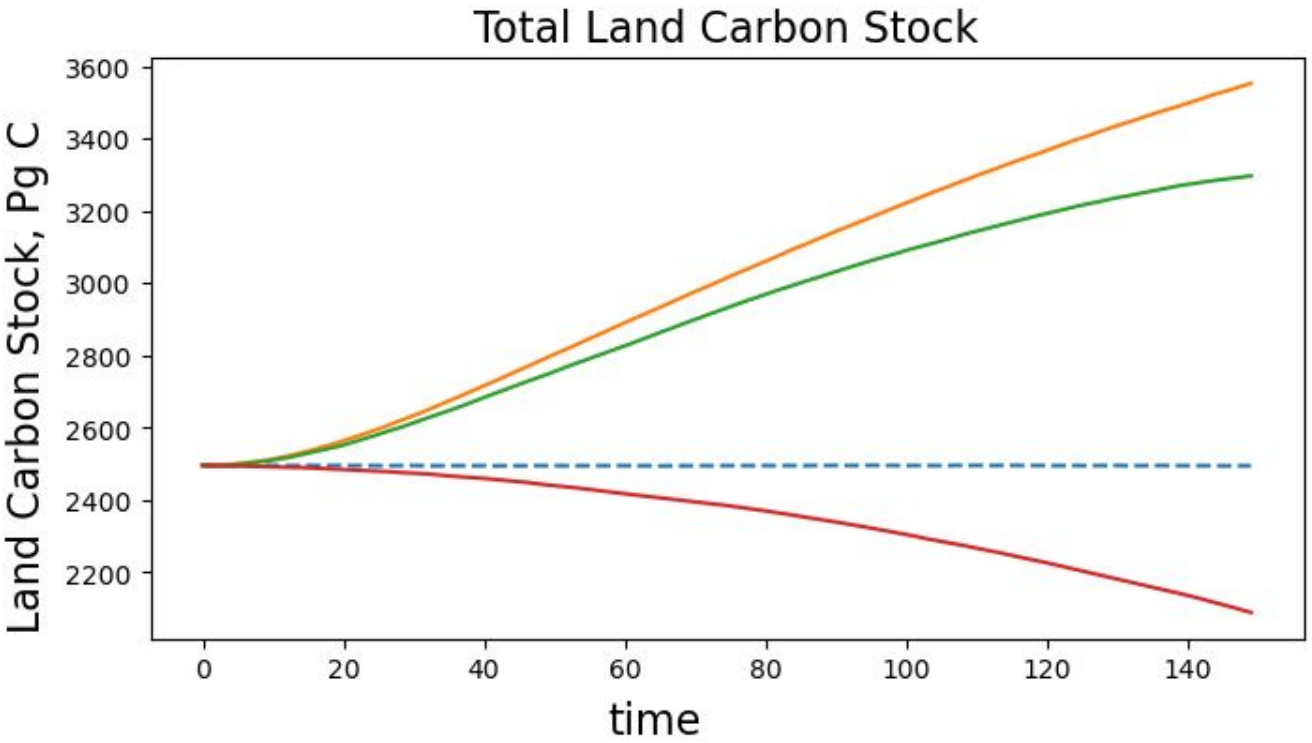
BGC - transient CO_2, constant climate

COU - transient CO_2, transient climate

CTRL - constant CO_2, constant climate

RAD - constant CO_2, transient climate

CLM-FATES has a large positive CO_2 response and a negative climate response in 1% CO_2 simulations



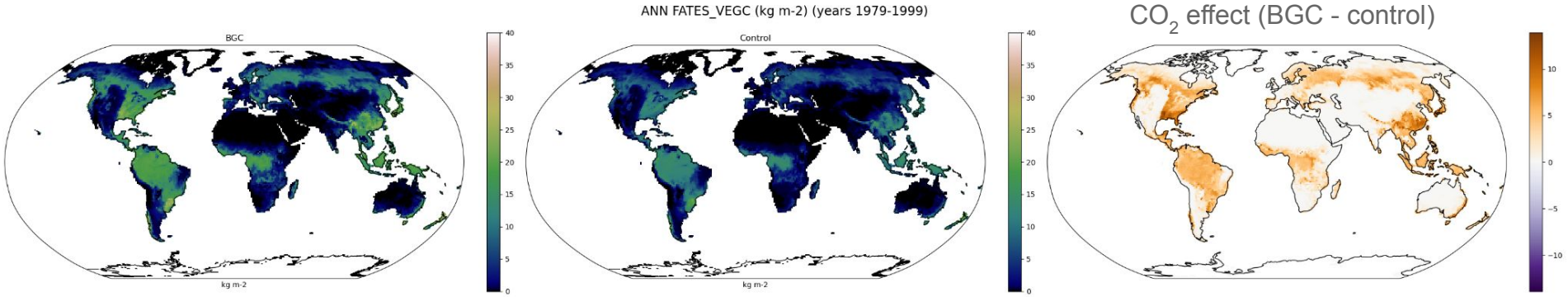
BGC - transient CO_2, constant climate

COU - transient CO_2, transient climate

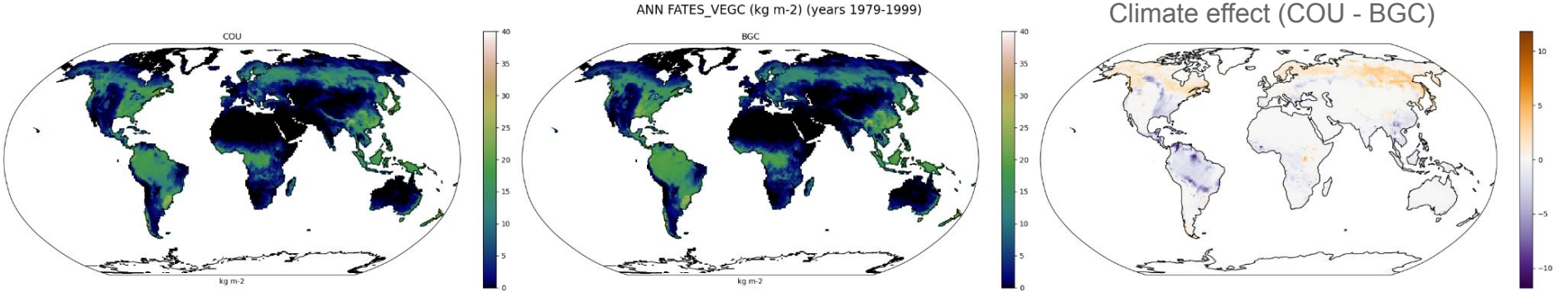
CTRL - constant CO_2, constant climate

RAD - constant CO_2, transient climate

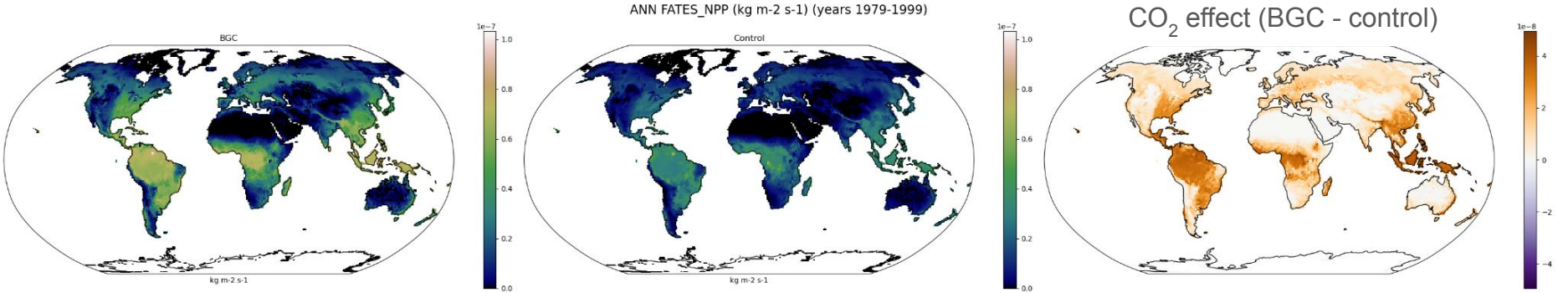
CO_2 increases vegetation carbon

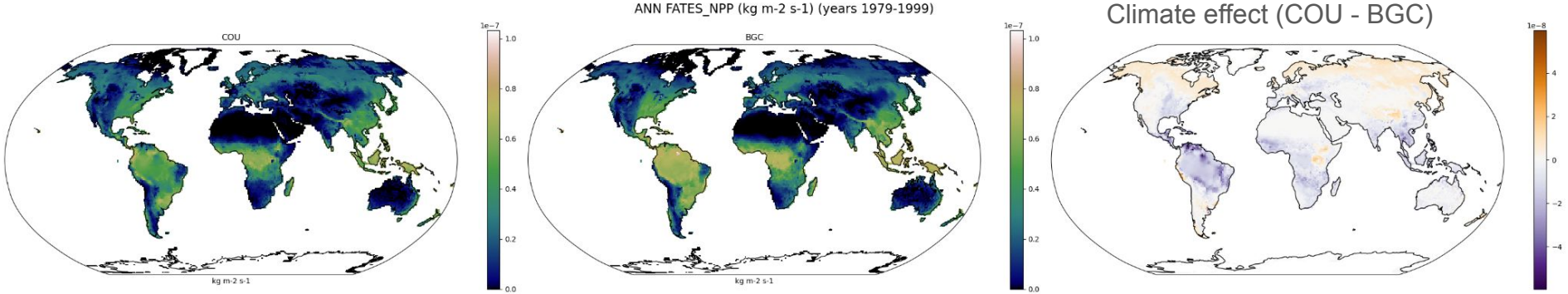


Climate increases vegetation C in the boreal zone, and decreases it in the tropics



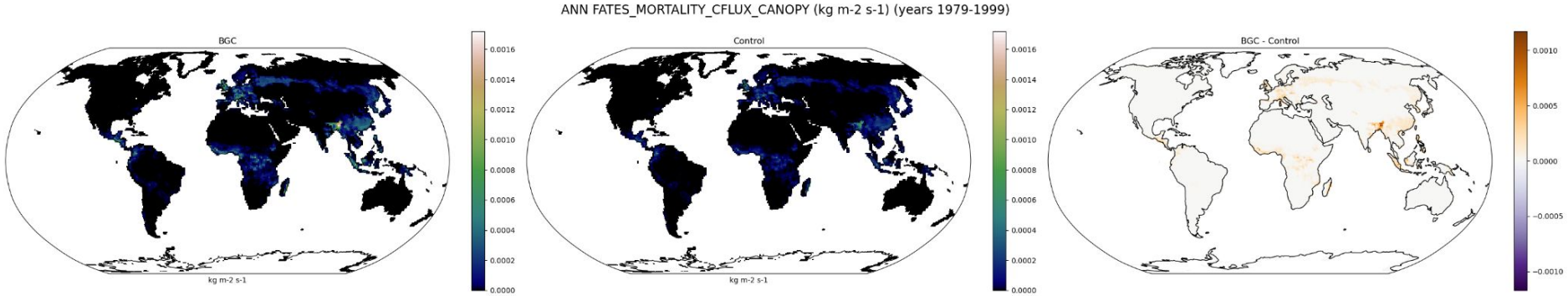
Beta and gamma primarily act on productivity



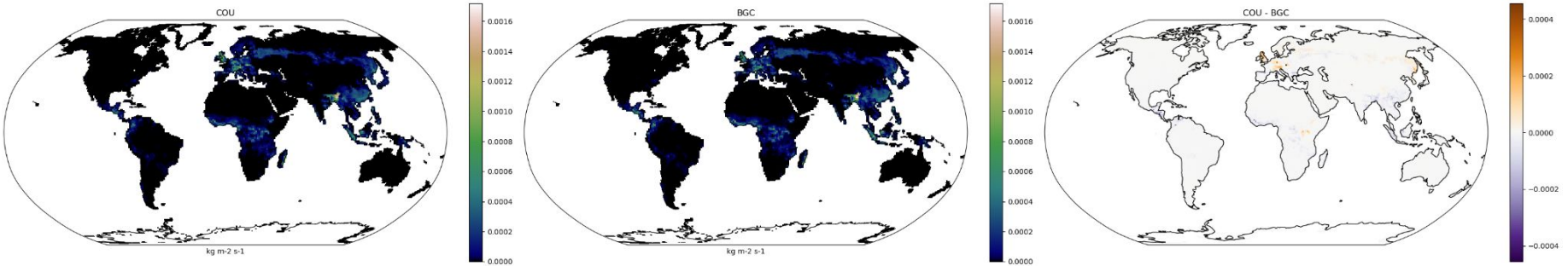


Beta and gamma have limited impact on mortality

CO_2 effect (BGC - control)



Climate effect (COU - BGC)



COU climate is not that stressful in the Amazon?

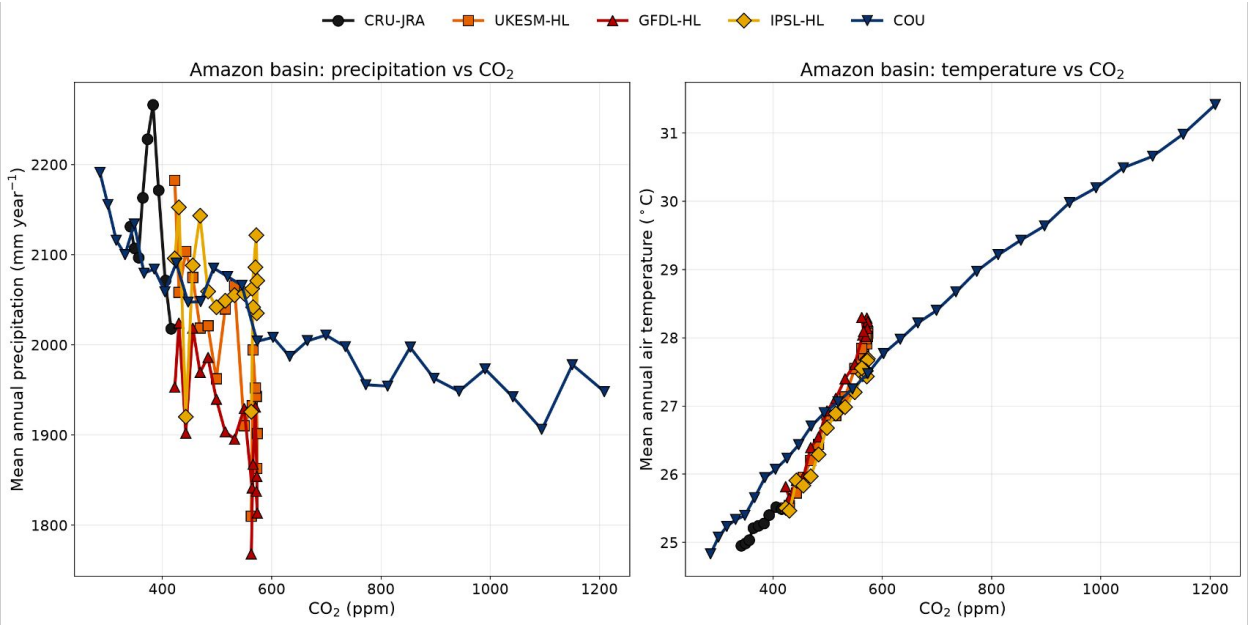
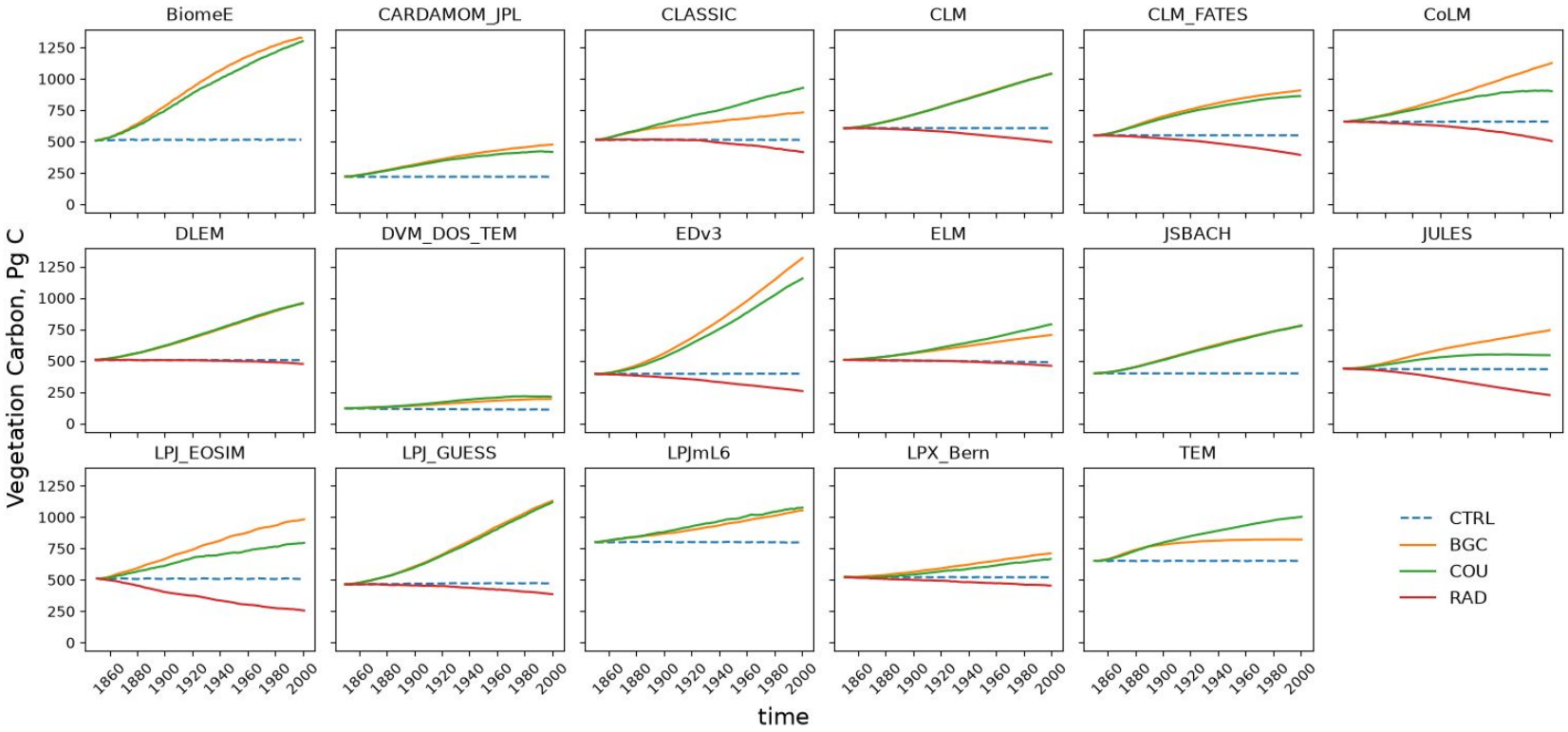
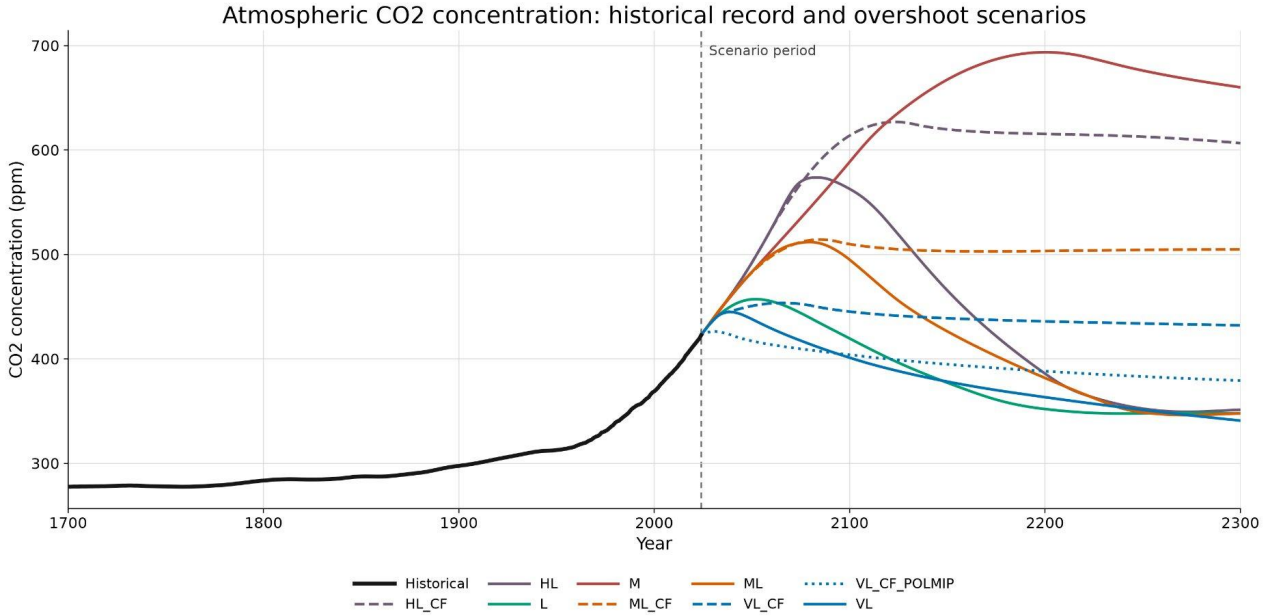


Figure credit Rosie Fisher

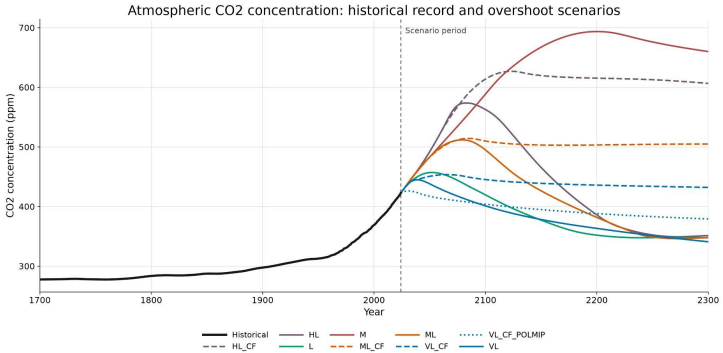
WIEMIP models show a range of responses to CO_2 and climate

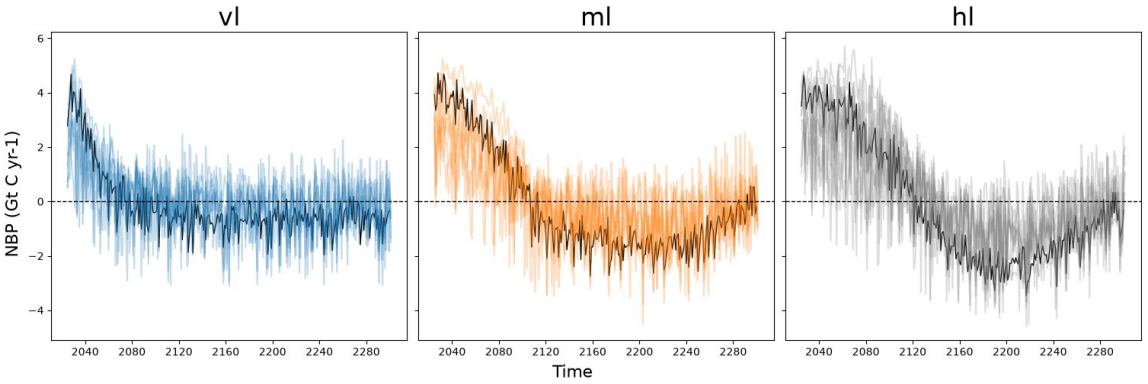


Overshoot scenarios

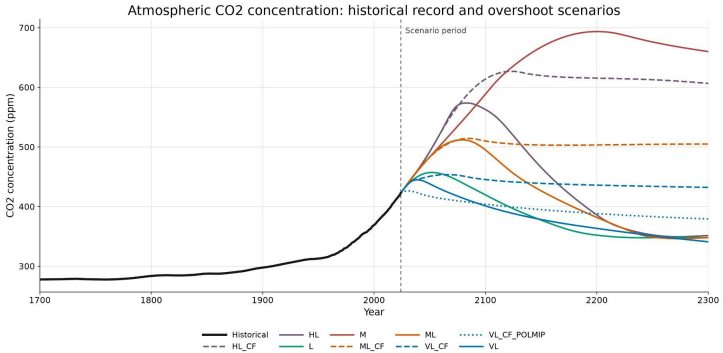


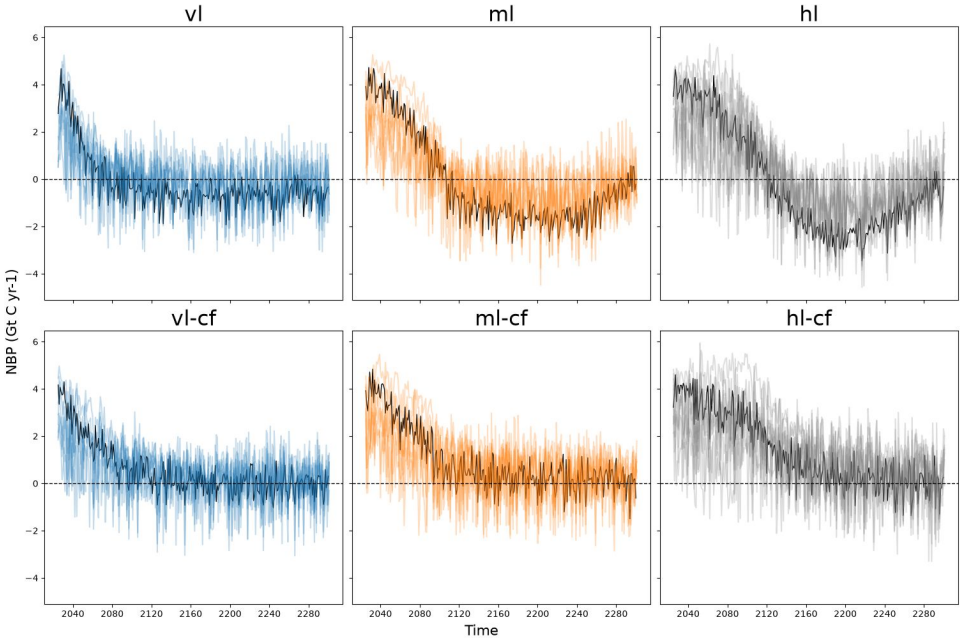
Overshoot scenarios – as atmospheric CO_2 declines the land becomes a carbon source



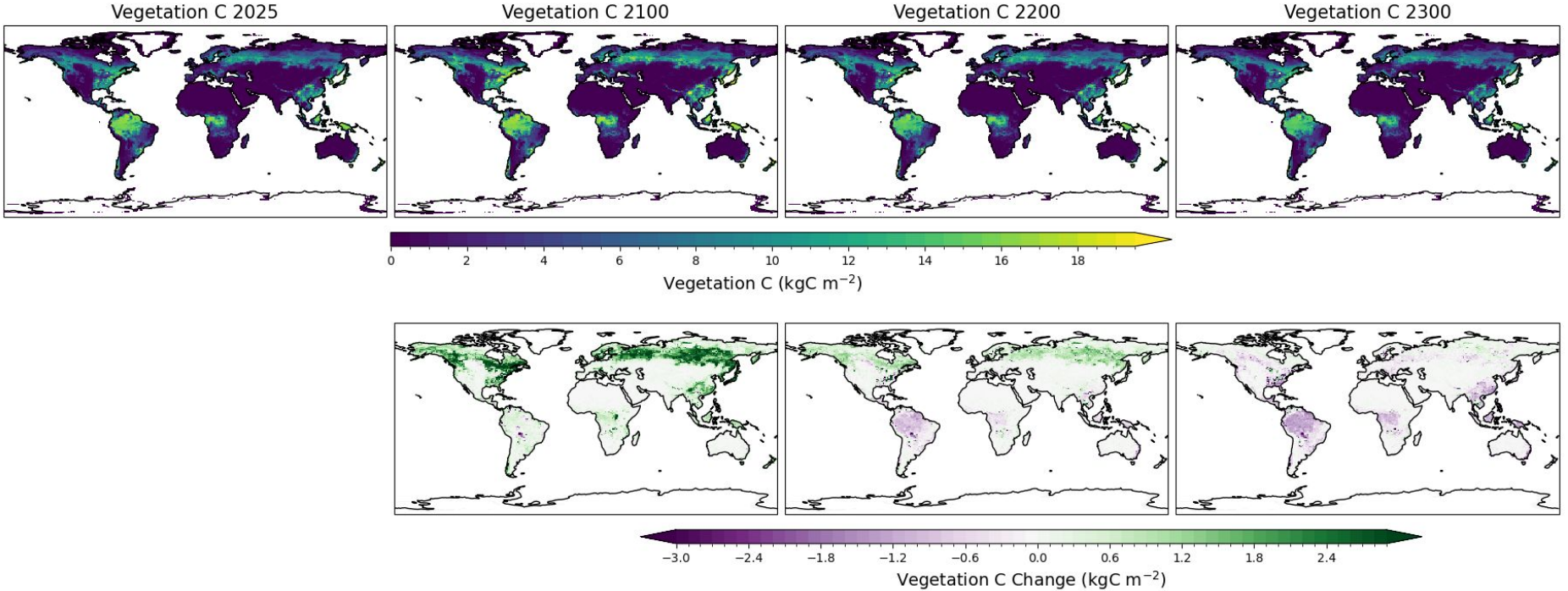


Overshoot scenarios – as atmospheric CO_2 declines the land becomes a carbon source

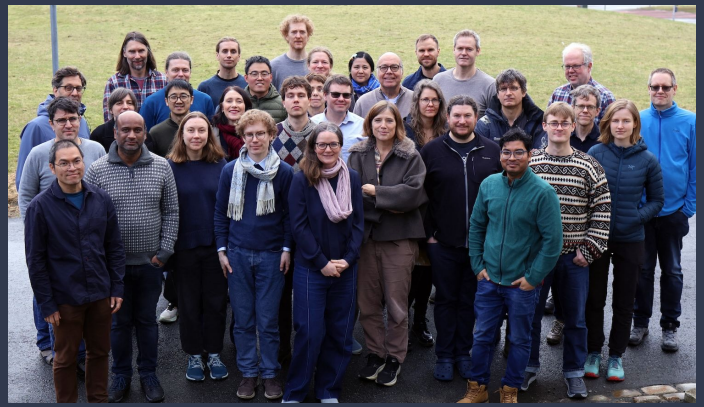




The tropics fail to recover by 2300 in the HL scenario

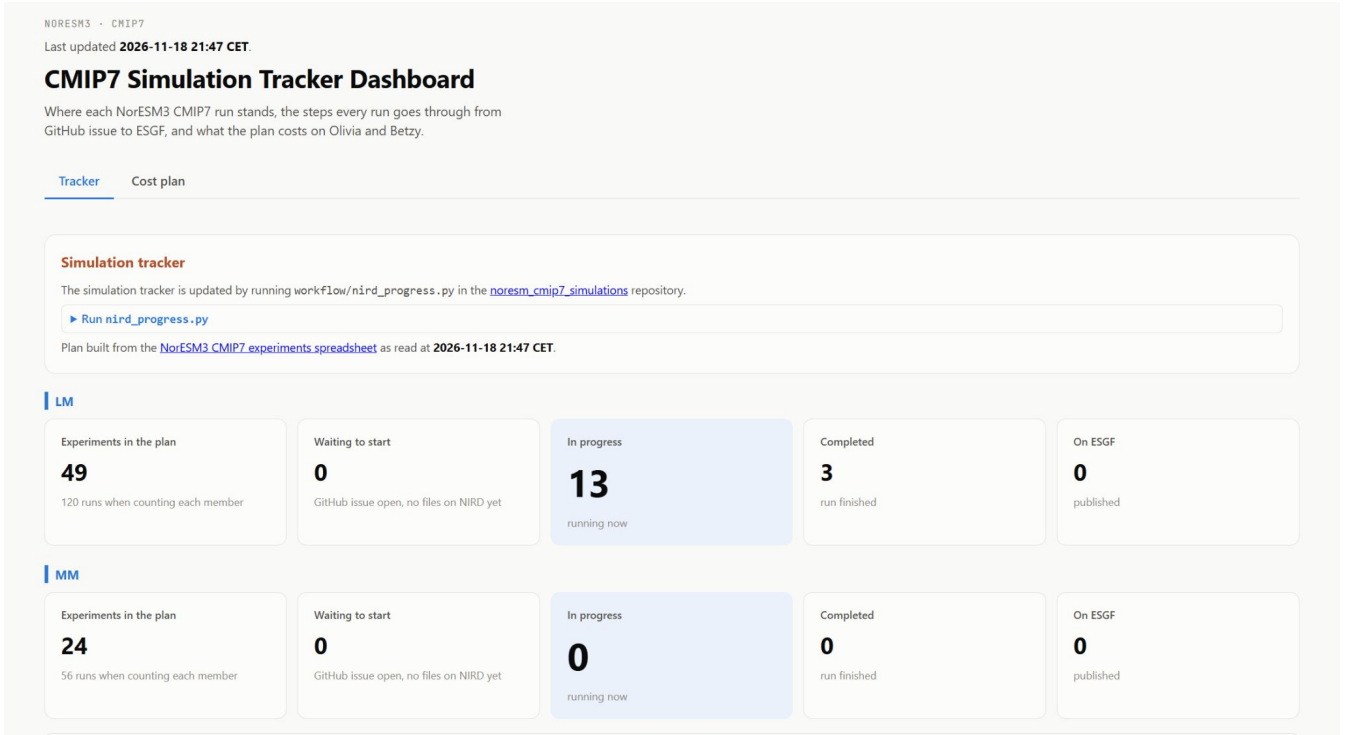


NorESM Coupled Model Results



The NorESM team

NorESM CMIP7 simulations are underway



NORESM3 · CMIP7

Last updated **2026-11-18 21:47 CET**.

CMIP7 Simulation Tracker Dashboard

Where each NorESM3 CMIP7 run stands, the steps every run goes through from GitHub issue to ESGF, and what the plan costs on Olivia and Betzy.

Tracker | Cost plan

Simulation tracker

The simulation tracker is updated by running `workflow/nird_progress.py` in the noresm_cmip7_simulations repository.

▶ Run `nird_progress.py`

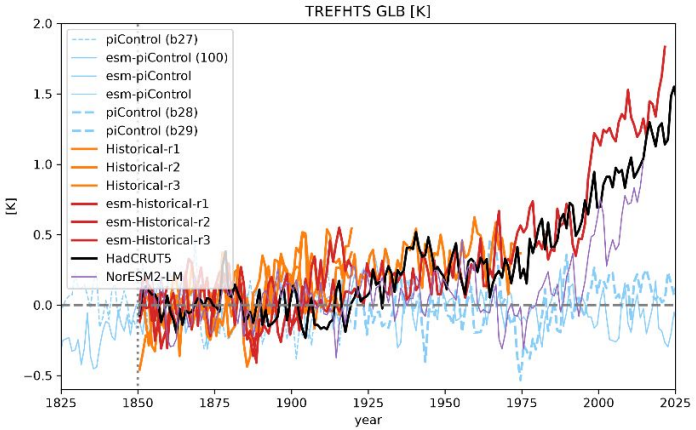
Plan built from the NorESM3 CMIP7 experiments spreadsheet as read at **2026-11-18 21:47 CET**.

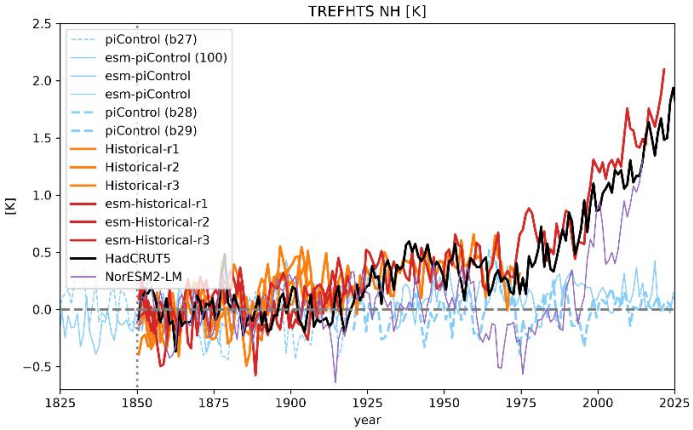
LM

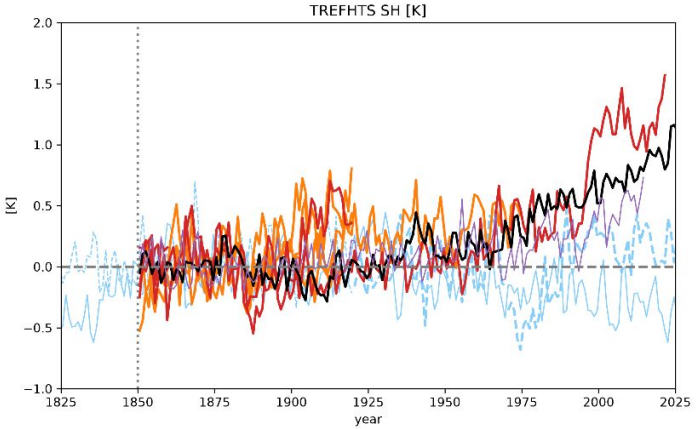
Experiments in the plan	Waiting to start	In progress	Completed	On ESGF
49	**0**	**13**	**3**	**0**
120 runs when counting each member	GitHub issue open, no files on NIRD yet	running now	run finished	published

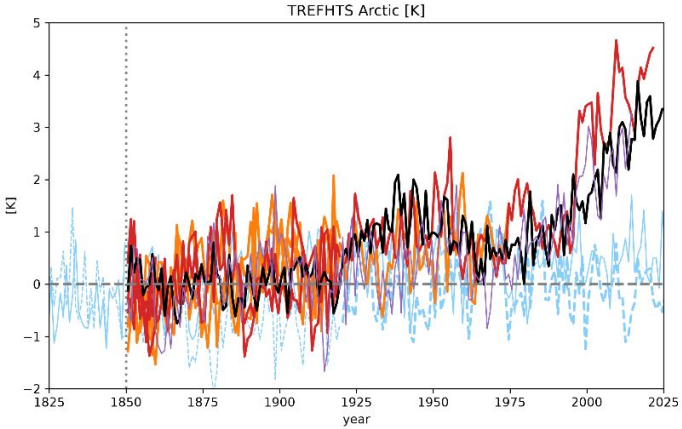
MM

Experiments in the plan	Waiting to start	In progress	Completed	On ESGF
24	**0**	**0**	**0**	**0**
56 runs when counting each member	GitHub issue open, no files on NIRD yet	running now	run finished	published

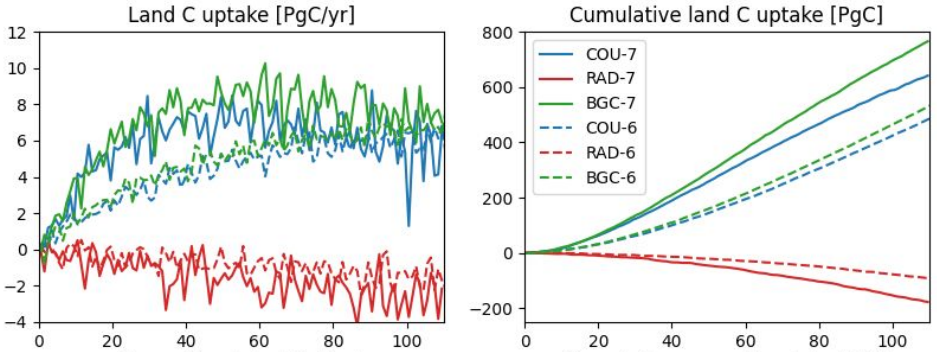

TREFHTS GLB [K]
piControl (b27)
esm-piControl (100)
esm-piControl
esm-piControl
piControl (b28)
piControl (b29)
Historical-r1
Historical-r2
Historical-r3
esm-historical-r1
esm-Historical-r2
esm-Historical-r3
HadCRUT5
NorESM2-LM
[K]
year


TREFHTS NH [K]
piControl (b27)
esm-piControl (100)
esm-piControl
esm-piControl
piControl (b28)
piControl (b29)
Historical-r1
Historical-r2
Historical-r3
esm-historical-r1
esm-Historical-r2
esm-Historical-r3
HadCRUT5
NorESM2-LM
[K]
year

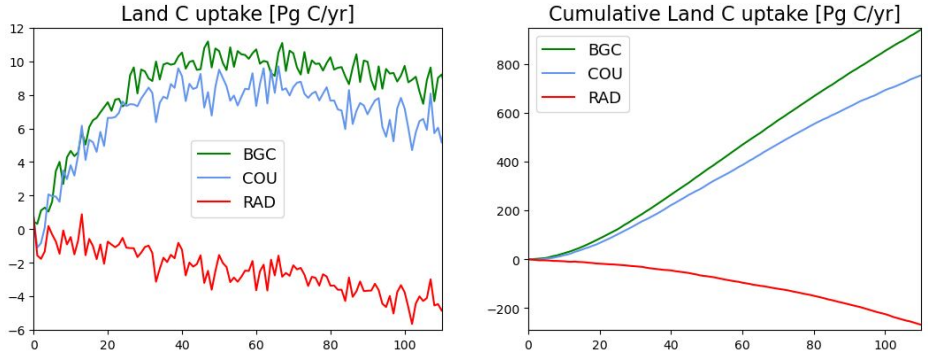

TREFHTS SH [K]
[K]
year


TREFHTS Arctic [K]
[K]
year

The land is slightly less sensitive to climate and CO_2 in the coupled simulation

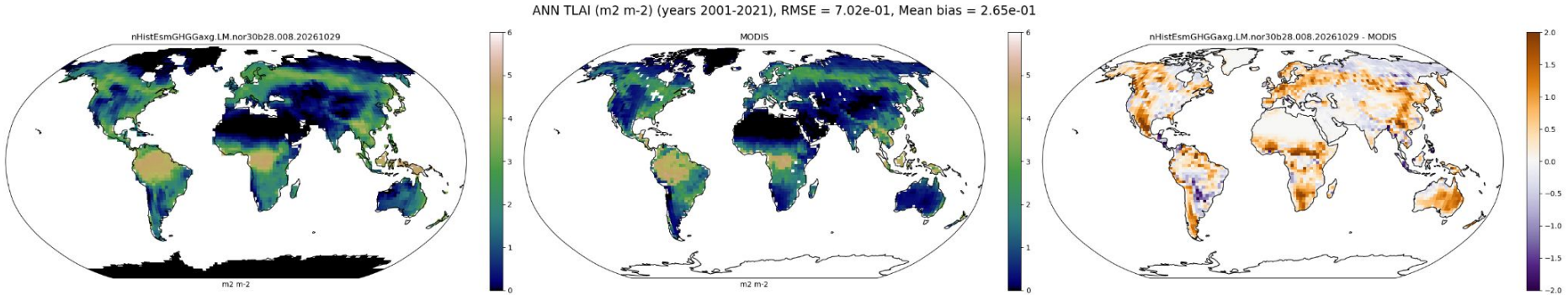


Coupled simulation

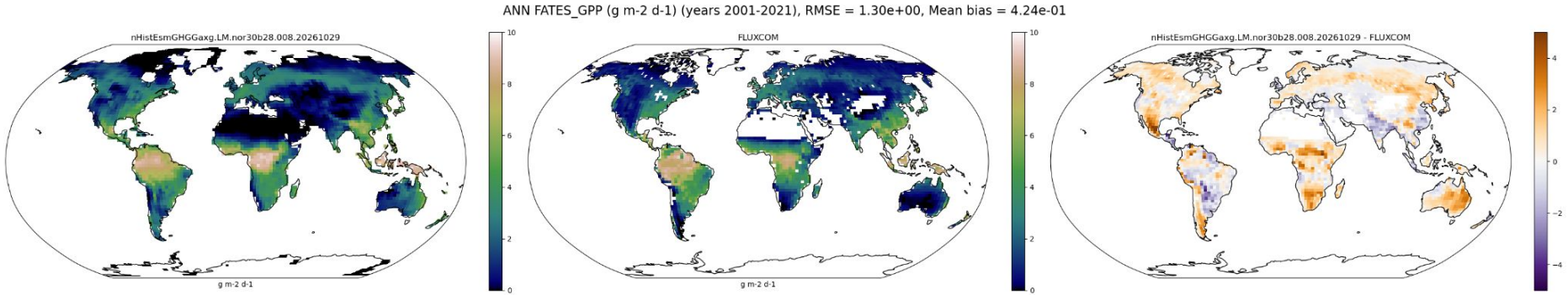


Land only simulation

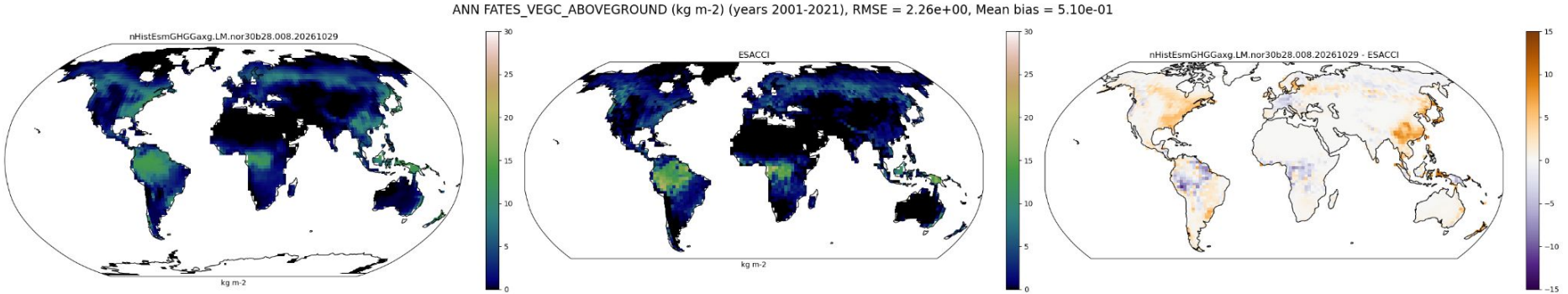
Emissions driven coupled historical simulation: Leaf area index



Emissions driven coupled historical simulation: Gross primary productivity



Emissions driven coupled historical simulation: Vegetation carbon



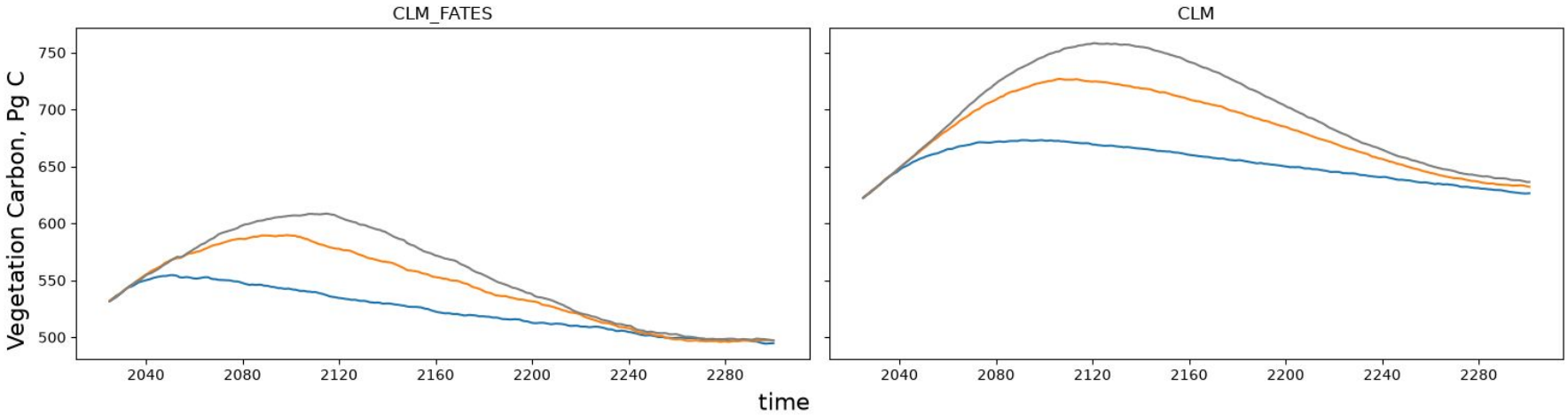
Future FATES plans



Future plans

- Crops
- Nitrogen calibration
- Dynamic vegetation calibration
- BECCS (bioenergy carbon capture and storage)
- FATES MIMICS+ coupling

Thank you


CLM_FATES
CLM
Vegetation Carbon, Pg C
750
700
650
600
550
500
2040
2080
2120
2160
2200
2240
2280
time

ANN FATES_MORTALITY_CFLUX_USTORY (kg m-2 s-1) (years 1979-1999)

