Second U.S. International Land Model Benchmarking (ILAMB) Workshop

Assessing feedbacks for the Coupled Climate–Carbon Cycle Model Intercomparison Project (C^4MIP)

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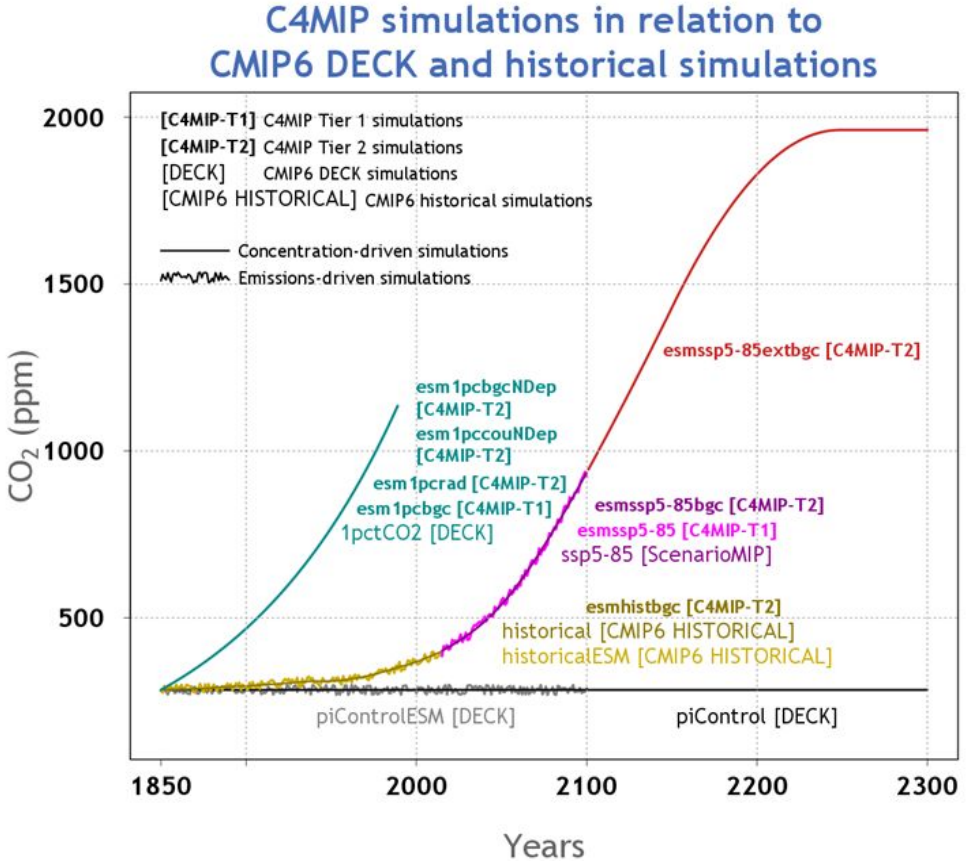
C^{4}MIP Experiments for CMIP6

The primary focus of the Coupled Climate–Carbon Cycle Model Intercomparison Project (C^{4}MIP) is to understand and quantify future century-scale changes in land and ocean carbon storage and fluxes. ESM simulations were devised to achieve this:

- idealized experiments to separate and quantify the sensitivity of land and ocean carbon cycle to changes in climate and atmospheric CO_2,
- historical experiments to evaluate model performance and investigate the potential for observational constraints on future projections,
- future scenario experiments to quantify future changes in carbon storage and hence the atmospheric CO_2 concentration and related climate change for given CO_2 emissions.

Experiments are designed to partner with CMIP6 Historical and DECK experiments.



C^{4}MIP Experiments for CMIP6

Category	Type of Scenario	Emission or Concentration Driven	Coupling Mode	Simulation Years	Short Name	Use by Other MIPS
Tier 1						
1% BGC	Idealized 1% per year CO_2 only, BGC mode	C-driven	CO_2 affects BGC	140	esm1pcbgc	OCMIP, LS3MIP
SSP5-8.5	SSP5-8.5 up to 2100	E-driven	Fully coupled	85	esmssp5-85	ScenarioMIP, LUMIP, OCMIP, LS3MIP
Tier 2						
1% RAD	Idealized 1% per year CO_2 only, RAD mode	C-driven	CO_2 affects RAD	140	esm1pcrad	OCMIP, LS3MIP
1% COU-Ndep	Idealized 1% per year CO_2 only, fully coupled, increasing N-deposition	C-driven	Fully coupled	140	esm1pccou-Ndep	OCMIP

C4MIP Experiments for CMIP6

Category	Type of Scenario	Emission or Concentration Driven	Coupling Mode	Simulation Years	Short Name	Use by Other MIPS
Tier 2 (continued)						
1% BGC-Ndep	Idealized 1% per year CO_2 only, BGC mode, increasing N-deposition	C-driven	CO_2 affects BGC	140	esm1pcbgc-Ndep	OCMIP
Hist/SSP5-8.5-BGC	Historical + SSP5-8.5 up to 2300, BGC mode	C-driven	CO_2 affects BGC	i. 155 ii. 085 iii. 200	esmhistbgc, esmssp5-85bgc, and esmssp5-85extbgc	ScenarioMIP, OCMIP, LS3MIP, DAMIP

C^{4}MIP Analysis Objectives

- Quantify and understand the carbon–climate feedback parameters (β_L, β_O, and γ_L, γ_O), which capture the modeled response of land and ocean biogeochemistry components to changes in atmospheric CO_2 and the associated changes in climate
- Evaluate models by comparing historical simulations with observation-based estimates of climatological states of carbon cycle variables, their variability and long-term trends
- Assess the future projections of components of the global carbon budget for difference scenarios

C^{4}MIP Evaluation Directions

- Historical “coupled” simulations can be assessed with the current suite of ILAMB and similar package benchmarks
- “Emergent constraint” benchmarks have potential to offer limits on estimates of future predictions
  - Cox et al. used interannual variability of atmospheric CO_2 and temperature to constrain γ_L
  - Hoffman et al. used the secular trend of atmospheric CO2 at Mauna Loa to contsrain the combination of β_L and β_O
- Long term extensions of “business as usual” scenarios (e.g., SSP5-8.5) from 1850 to 2300 will allow characterization of permafrost climate–carbon feedback because of new developments in soil process representations
- Investigate the influence of nutrient limitation (e.g., reducing the magnitude of β_L and γ_L?), disturbance (e.g., fires), and dynamic vegetation (e.g., Arctic greening) on climate–carbon feedbacks

C^4MIP Reference

- Jones, Chris D., Vivek Arora, Pierre Friedlingstein, Laurent Bopp, Victor Brovkin, John Dunne, Heather Graven, Forrest M. Hoffman, Tatiana Ilyina, Jasmin G. John, Martin Jung, Michio Kawamiya, Charles D. Koven, Julia Pongratz, Thomas Raddatz, James T. Randerson, and Sönke Zaehle (2016), The C4MIP experimental protocol for CMIP6, *Geosci. Model Dev. Discuss.*, doi:10.5194/gmd-2016-36.