Coupled Carbon Simulations with CESM-(BGC)

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NCAR is sponsored by the National Science Foundation
CESM1-(BGC) CMIP5 Experiments

Black: classical AOGCMs
Color: ESMs

Experiments are forced by CO$_2$ concentration, unless specified as E-driven.

CESM CO$_2$ Options
- Constant
- Prescribed (Diagnostic)
- Prognostic

CO$_2$ option can be specified independently for BGC and radiation.
Atmospheric CO$_2$ in 1850 Controls

Land and Ocean BGC pools were spun up for O(1000) years with coupled model forcing. This is generally problematic.

Atmospheric CO$_2$ drifts by ~2 and ~4 ppmv over 1000 years in controls.

Surface flux negative feedback reduces drift in PROG control.

Drift is superposition of compensating drifts in land and ocean C inventories.
Ocean & Land Carbon Balance

[Graphs showing time series of carbon balance over model years for CESM1-(BGC), PROG, CESM1-(BGC), PRES, and CCSM4.]
T\textsubscript{air} & CO\textsubscript{2} in 20\textsuperscript{th} Century Experiments
20th Century CO₂ Sources to Atm

Fossil Fuels

Land Use Change

Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.
20th Century CO₂ Sinks from Atm

Land Residual Uptake

Ocean Uptake

Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.
CO$_2$ Seasonal Cycle
CO$_2$ Seasonal Cycle
12 stations from GLOBALVIEW

Wider variety of station locations

Hollow: 1850 PROG
Filled: 20C PROG

Amp>6
• Northern Hemisphere
• Large Land Contribution
• 20C reduces bias

Amp<2
• Southern Hemisphere
Power Spectra of Surface CO$_2$

![Graph of Power Spectra of Surface CO$_2$]
Power Spectra of Surface CO$_2$ Flux

Land-to-Air

Sea-to-Air

Variance (Pg C yr$^{-1}$)$^2$

Period (years)
Response to Niño 3.4 SST Anomalies

Land-to-Air CO$_2$ Flux

Regional Land-to-Air CO$_2$ Flux
Response to Niño 3.4 SST Anomalies

Surface Atmospheric CO$_2$

Sea-to-Air CO$_2$ Flux
What’s Next

• CMIP5 runs nearly complete
  – Control, 20\textsuperscript{th} C, RCPs, 1% CO\textsubscript{2} Ramp
  – Misc sensitivity experiments are ongoing
  – Imminent submission of 1\textsuperscript{st} CESM Journal of Climate Special Collection papers

• Public Release of Model Output

• Evaluate impact of model updates (CLM-CN, POP-BEC, CAM5) on CMIP results
CO₂ Seasonal Cycle Amplitude