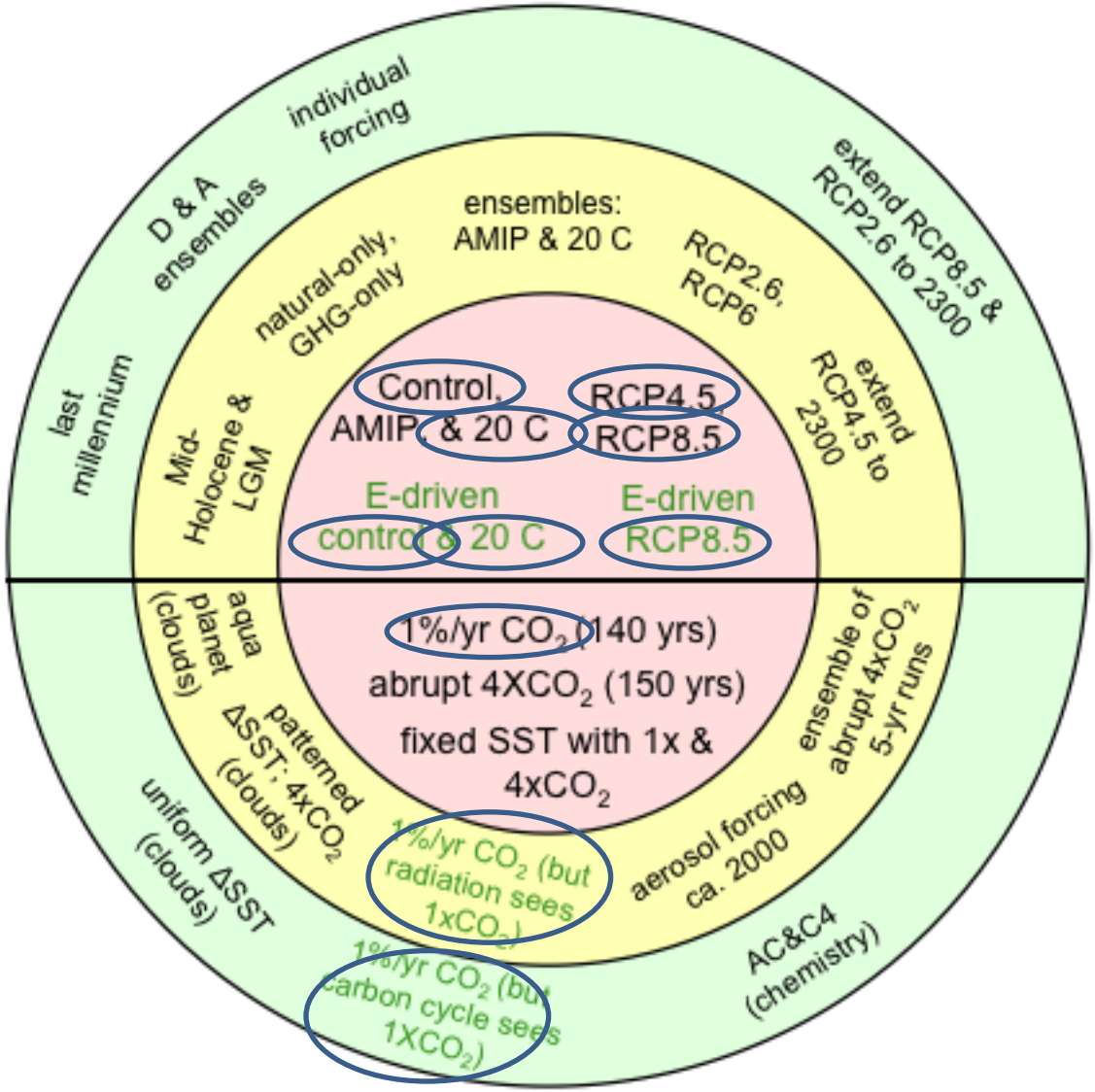
Update on BGCWG Activities

Keith Lindsay, BGCWG Co-chair
NCAR/NESL/CGD

NCAR is sponsored by the National Science Foundation

CESM1-(BGC) CMIP5 Experiments



Black: classical AOGCMs
Color: ESMs

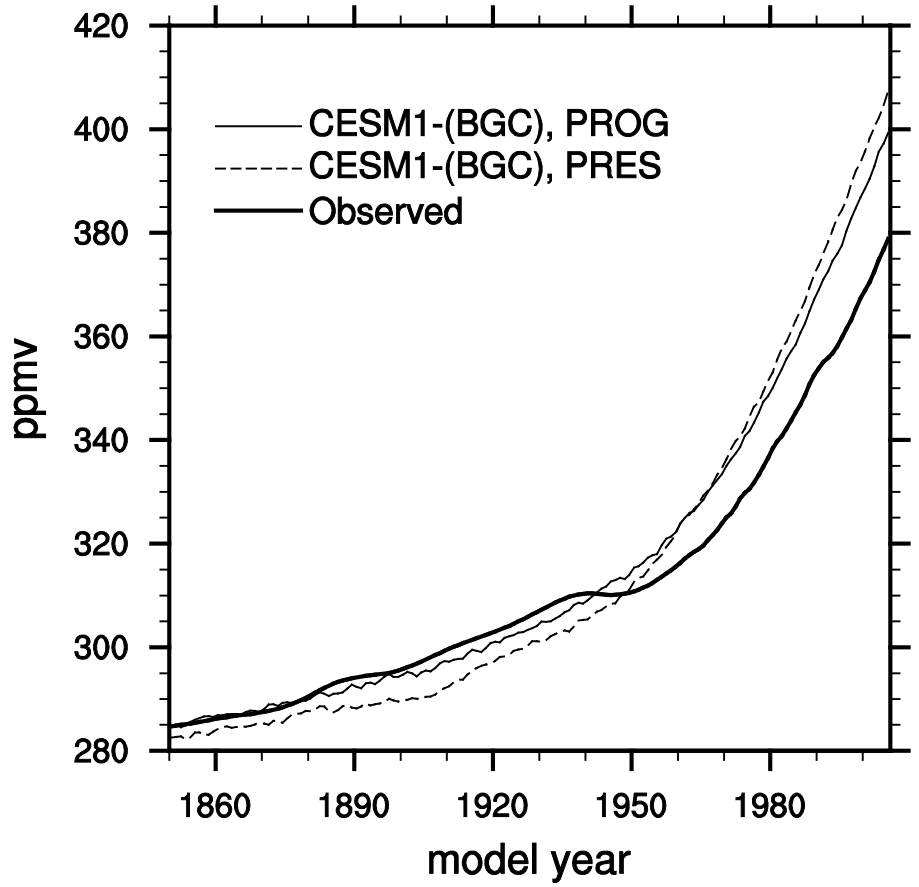
Experiments are forced by CO_2 concentration, unless specified as E-driven.

CESM CO_2 Options

- Constant
- Prescribed (Diagnostic)
- Prognostic

CO_2 option can be specified independently for BGC and radiation.

CO_2 in 20th Century Experiments



Modeled increase of CO_2 over 1850-2005 too large:

Observed: 94 ppmv

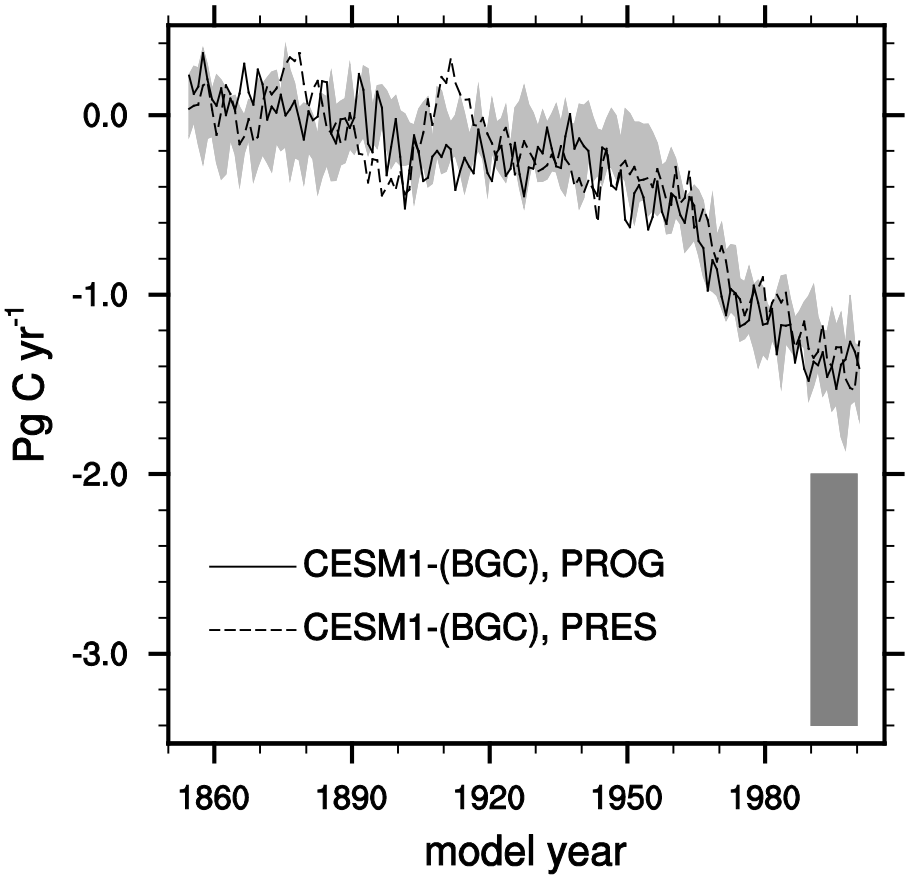
Diagnostic CO_2 tracer: 125 ppmv

Prognostic CO_2 tracer: 114 ppmv

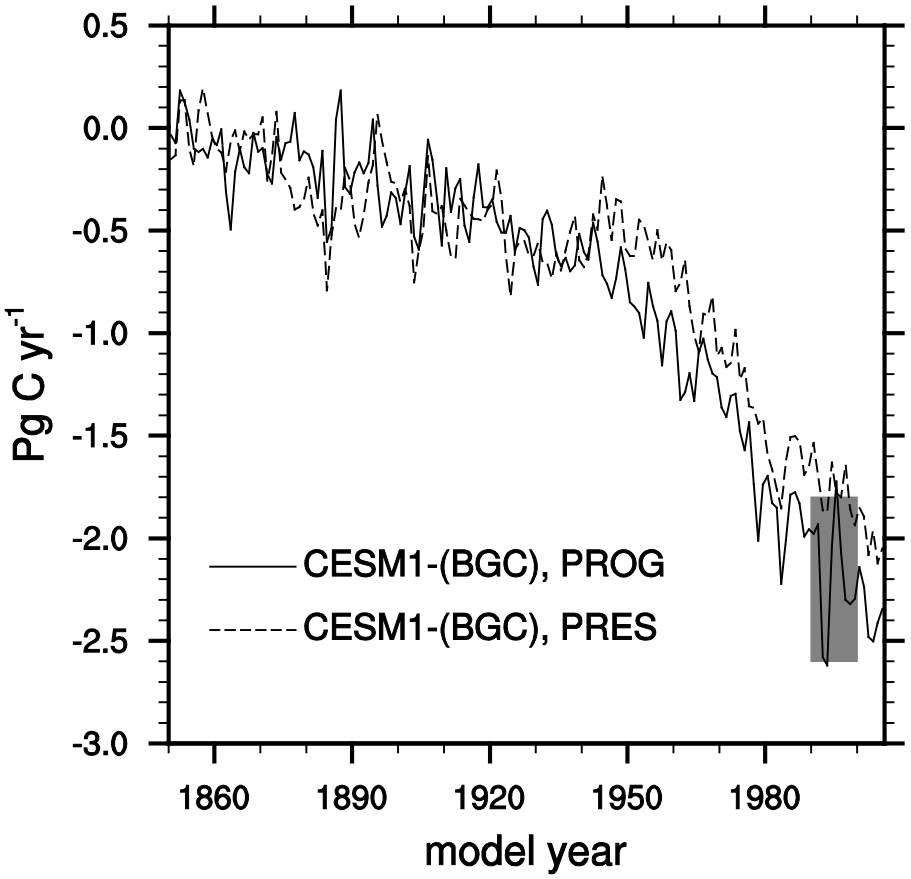
Lindsay et al., in prep

20th Century CO_2 Sinks from Atm

Land Residual Uptake



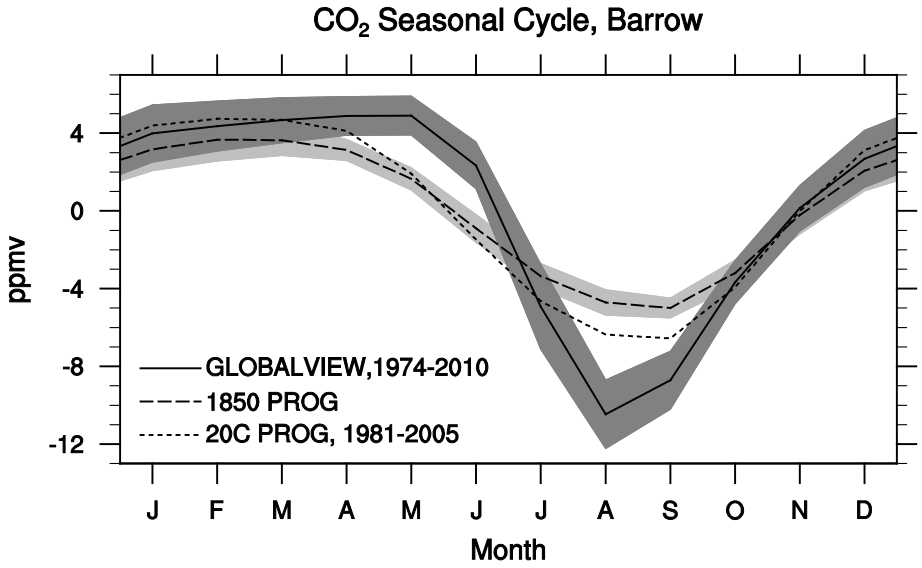
Ocean Uptake

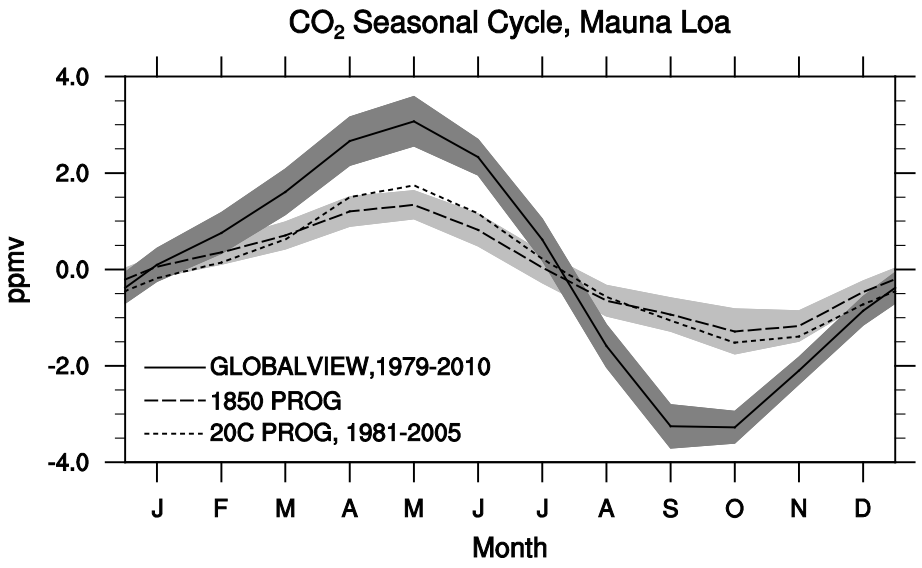


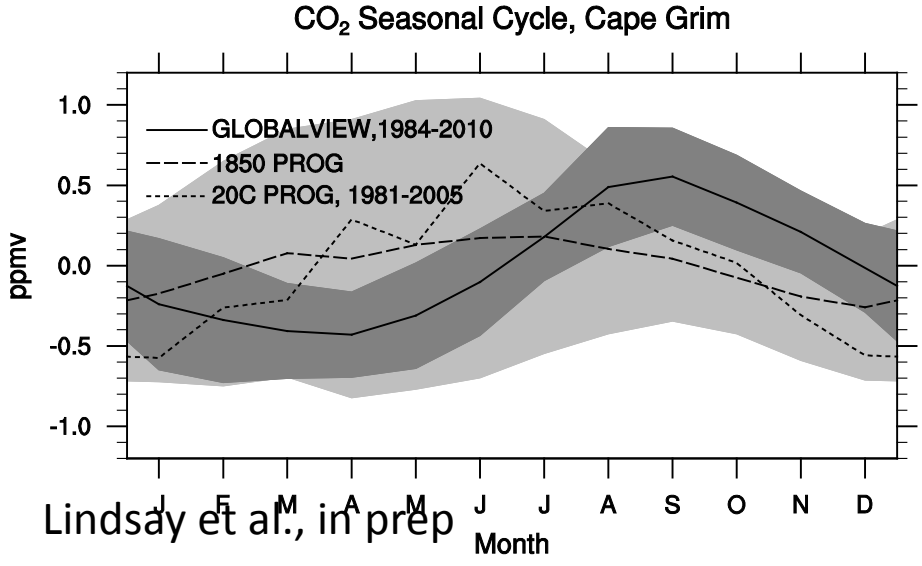
Lindsay et al., in prep

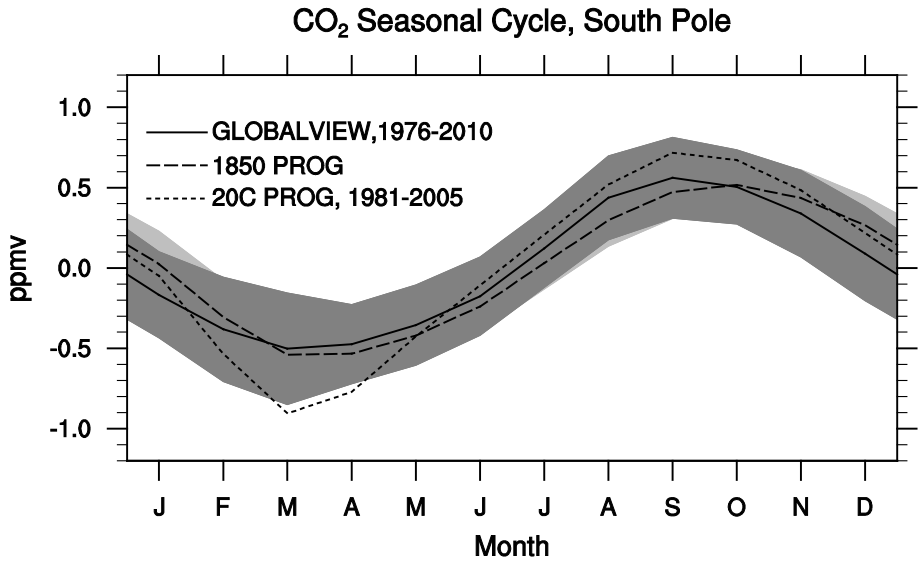
Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.

CO_2 Seasonal Cycle





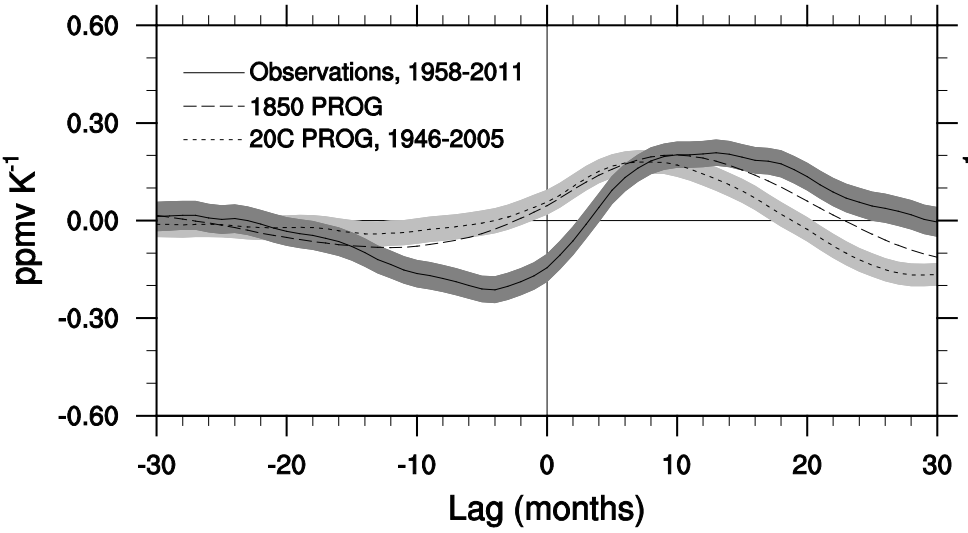




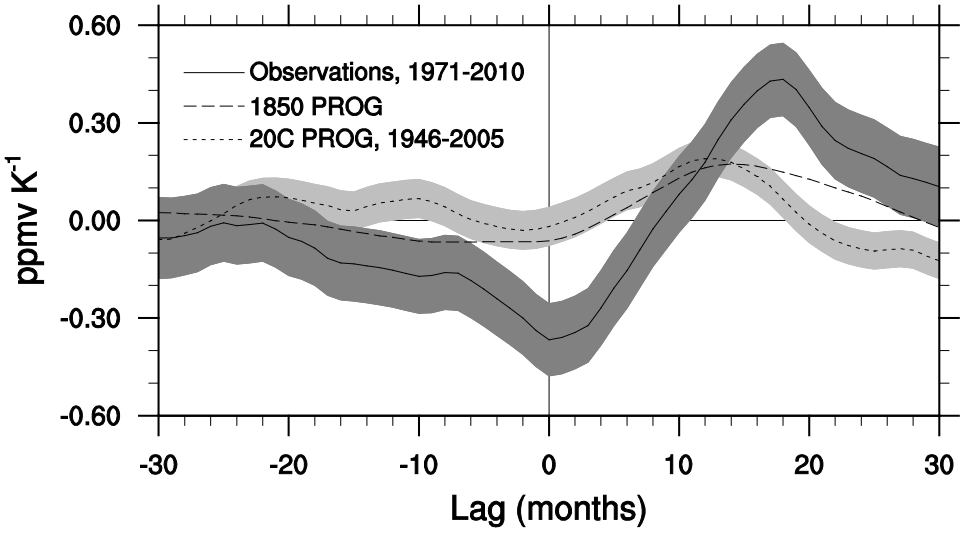
Lindsay et al., in prep

CO_2 Response to ENSO

Mauna Loa, Hawaii

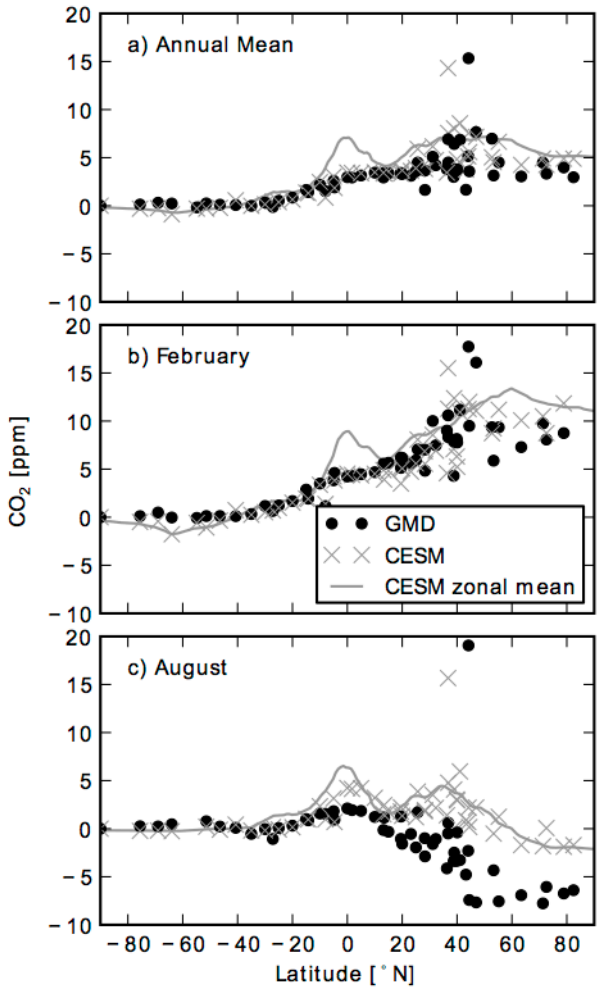


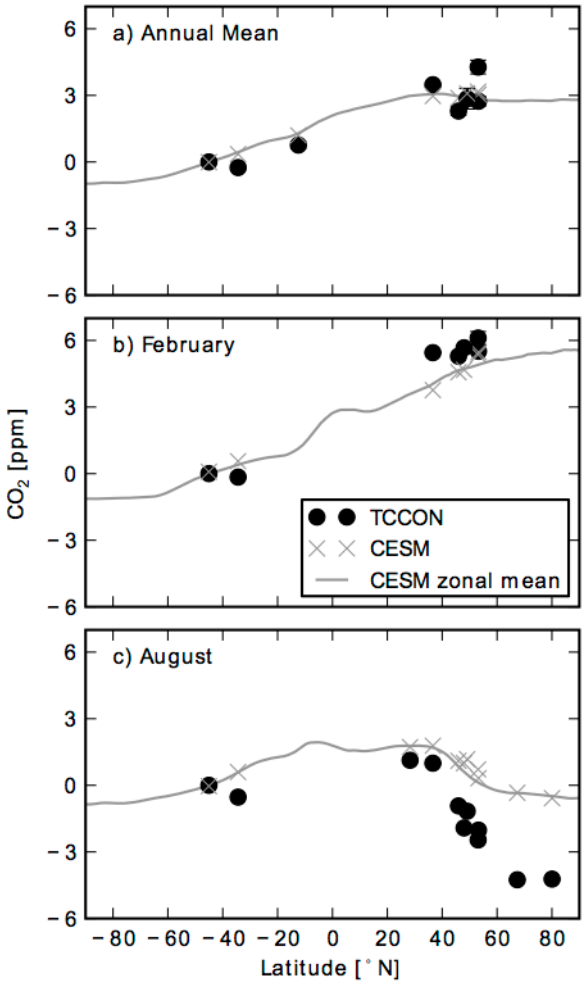
Point Barrow, Alaska



Lindsay et al., in prep

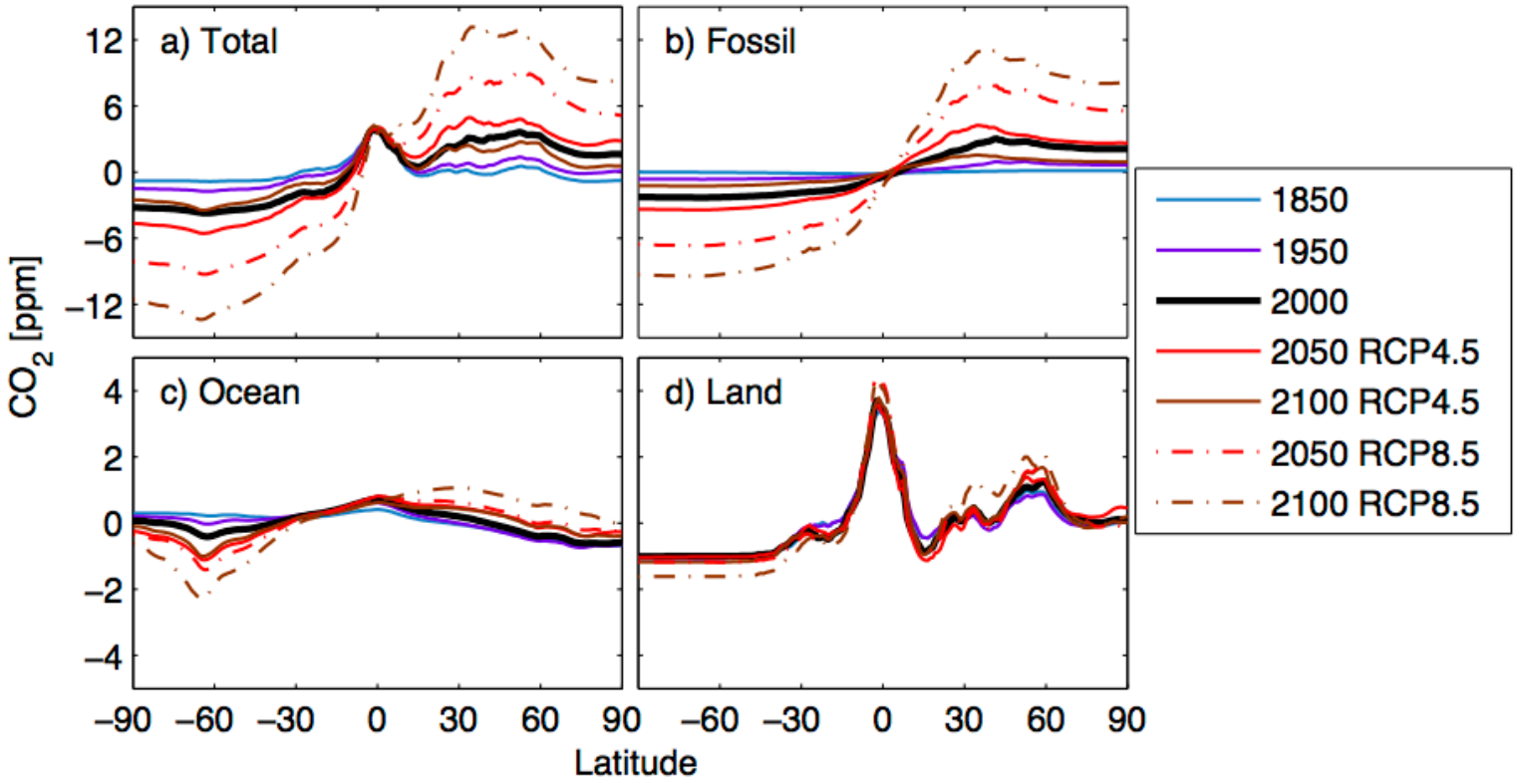
CO_2 Seasonal Cycle Surface & Column





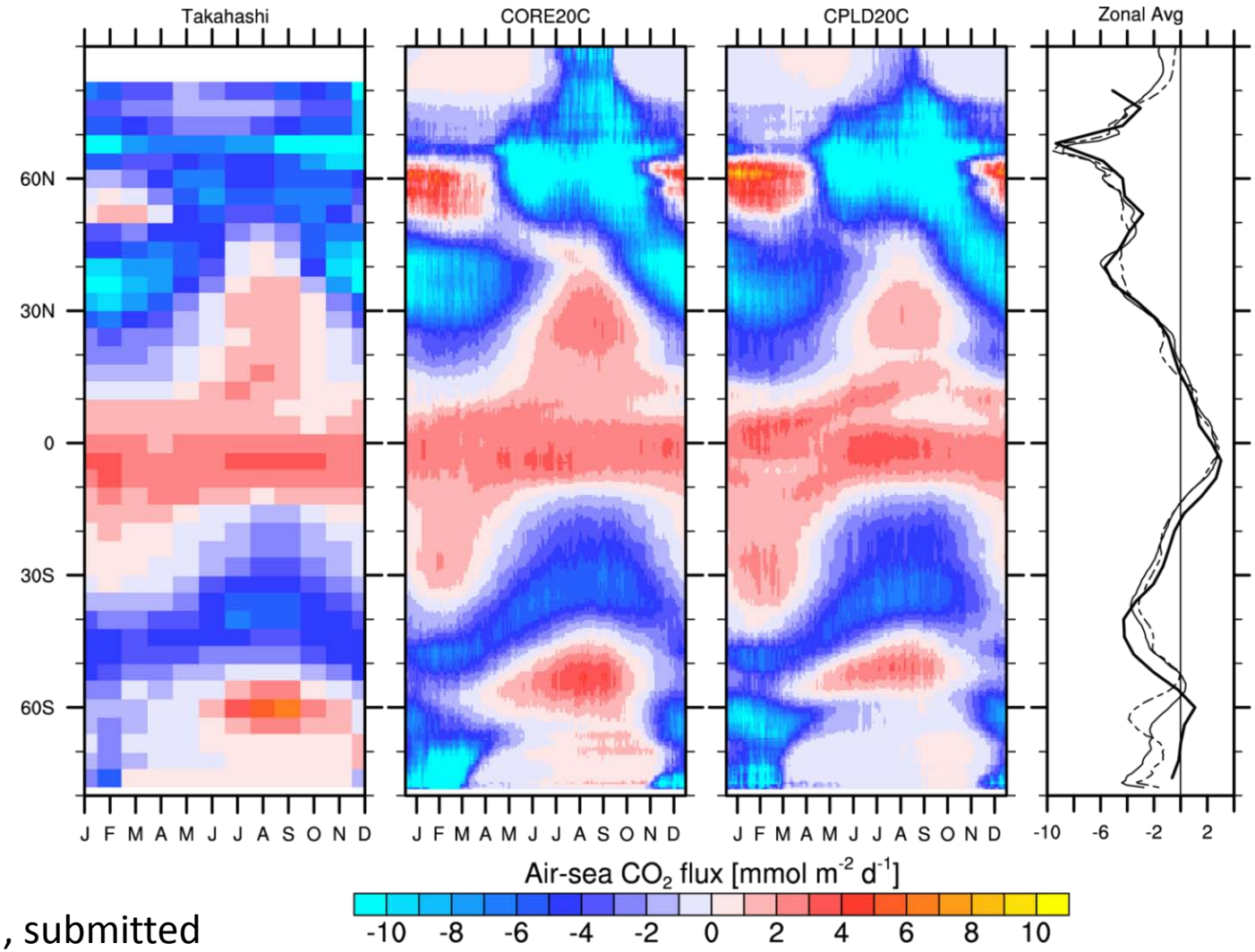
Keppel-Aleks et al., in prep

Evolution of CO_2 Meridional Gradient



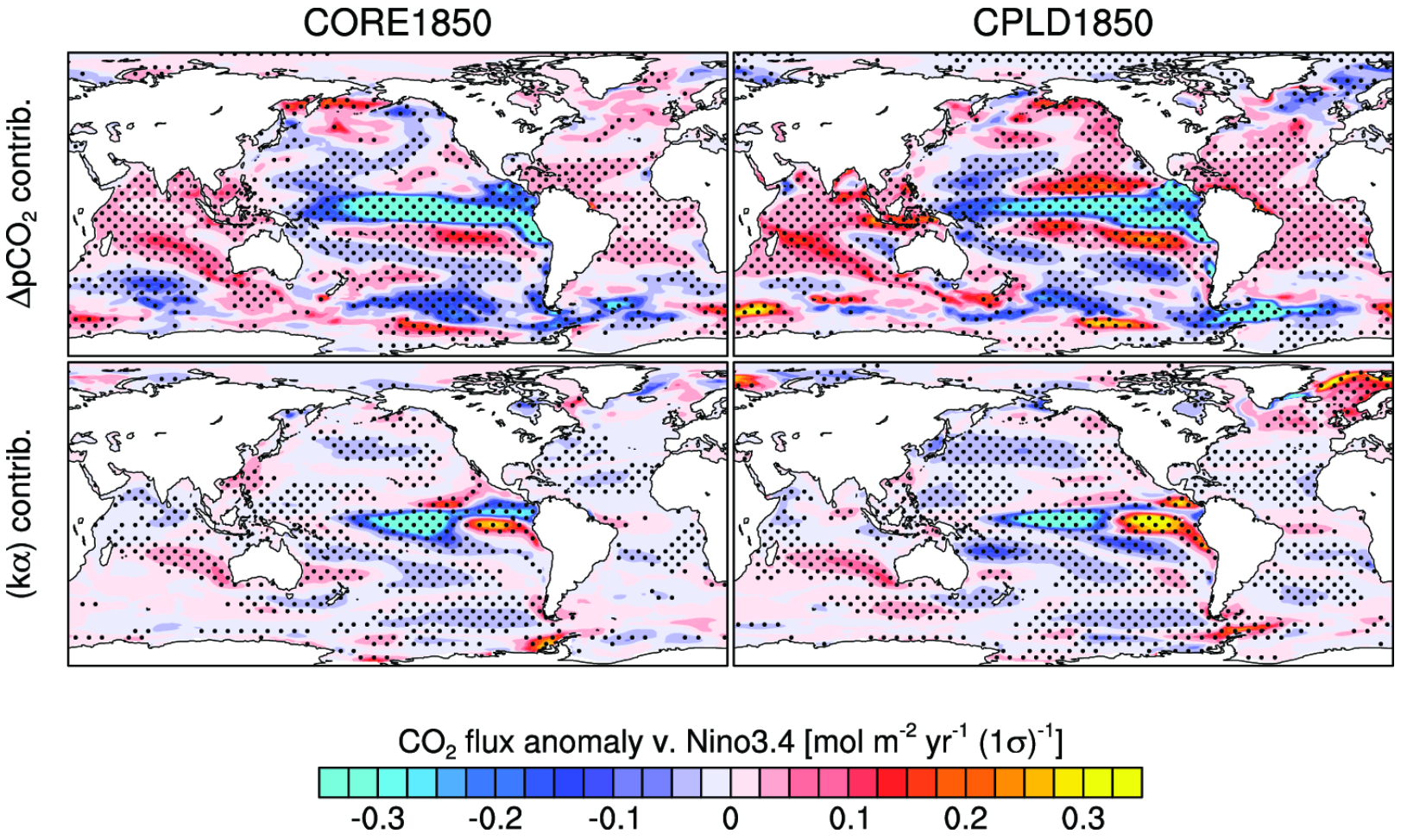
Keppel-Aleks et al., in prep

Sea-to-Air CO_2 Flux



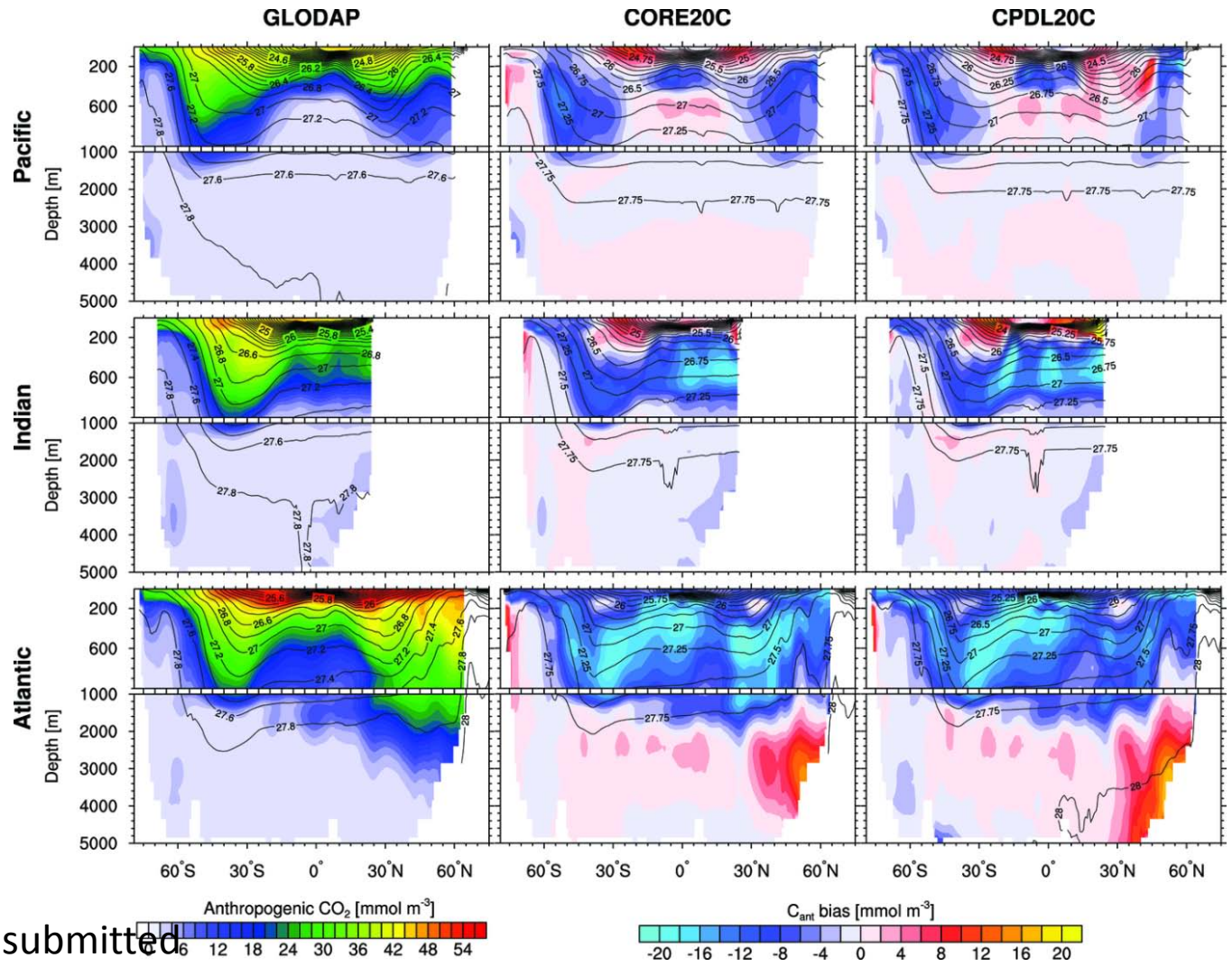
Long et al., submitted

Sea-to-Air CO_2 Flux Response to ENSO



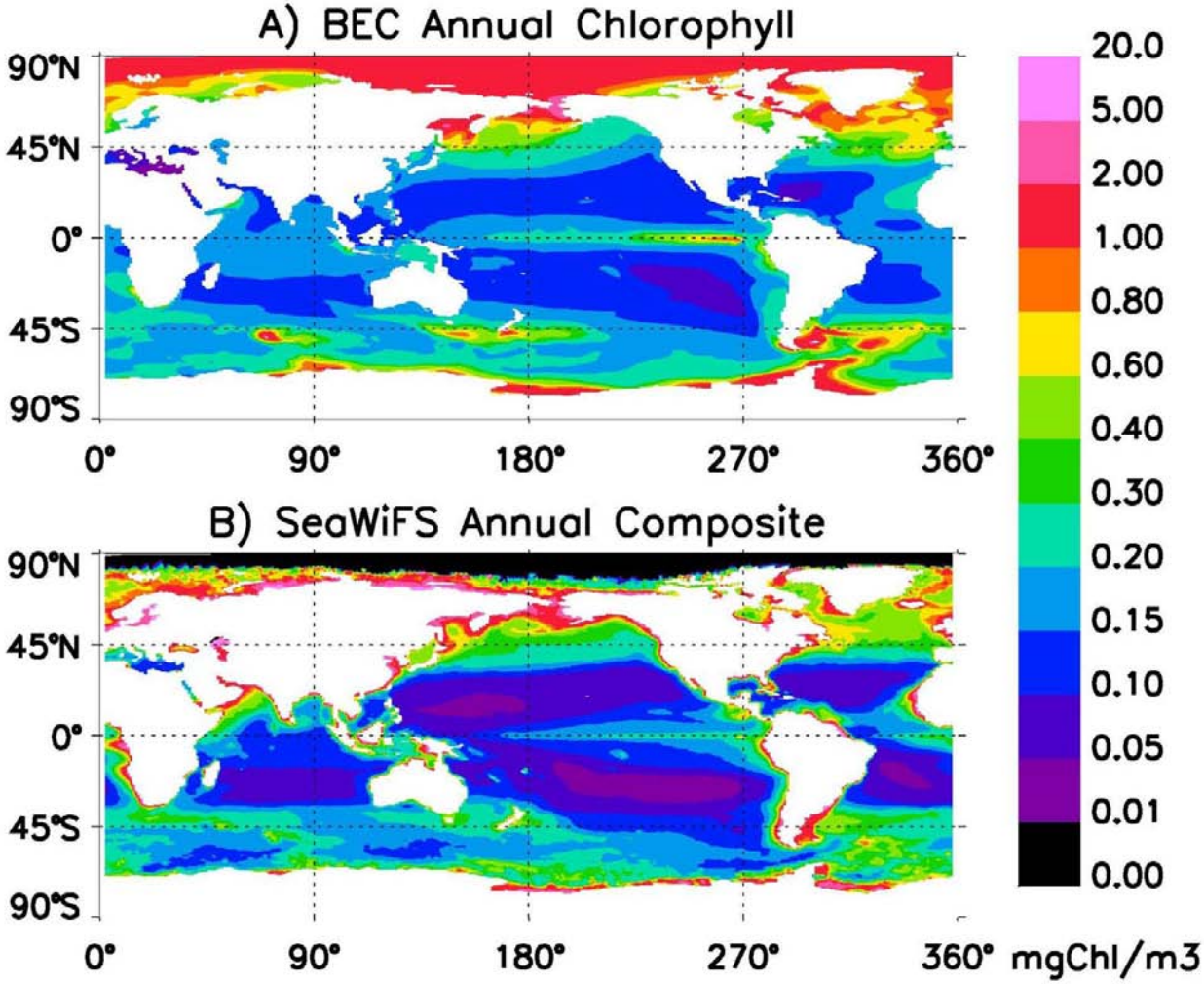
Long et al., submitted

Anthropogenic CO_2 vs GLODAP



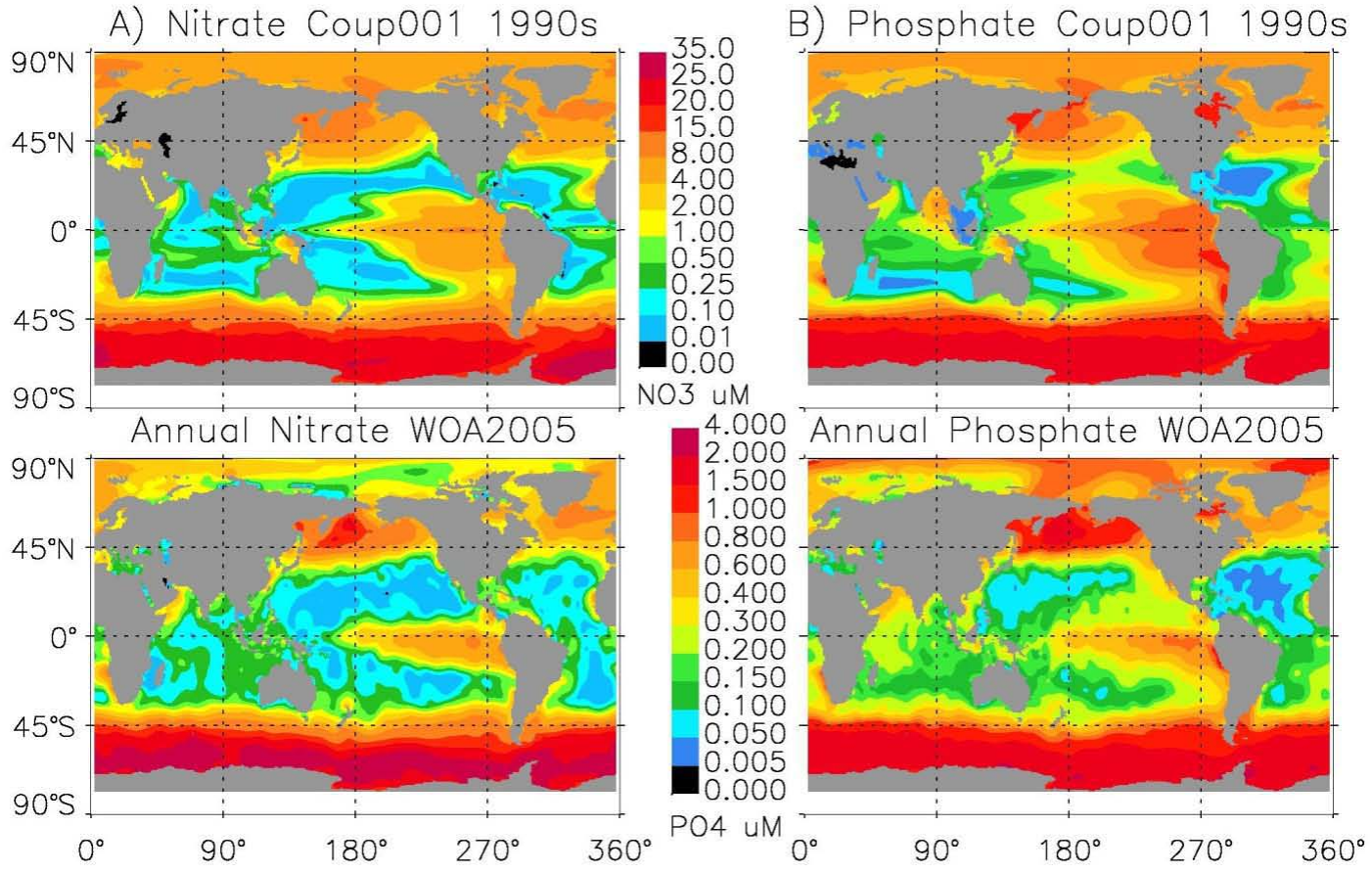
Long et al., submitted

Model Chl vs Satelitte Product



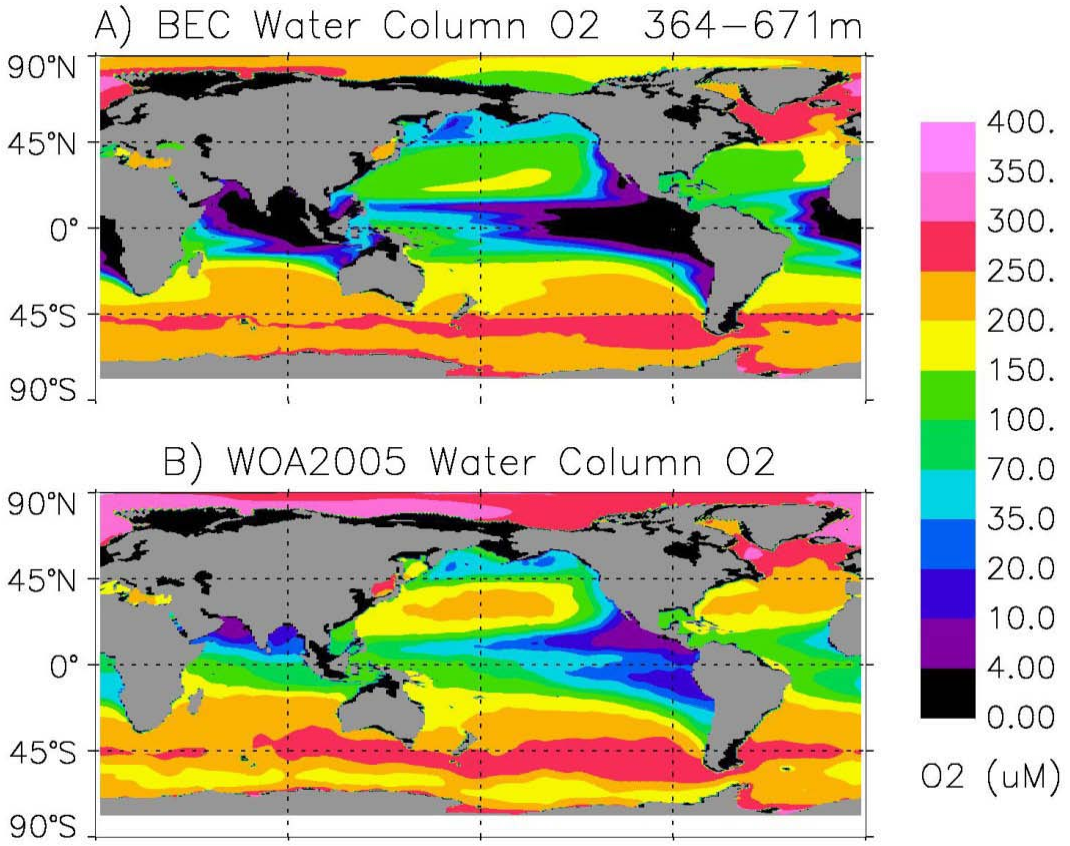
Moore et al., in prep

Model Surface Nutrient vs WOA



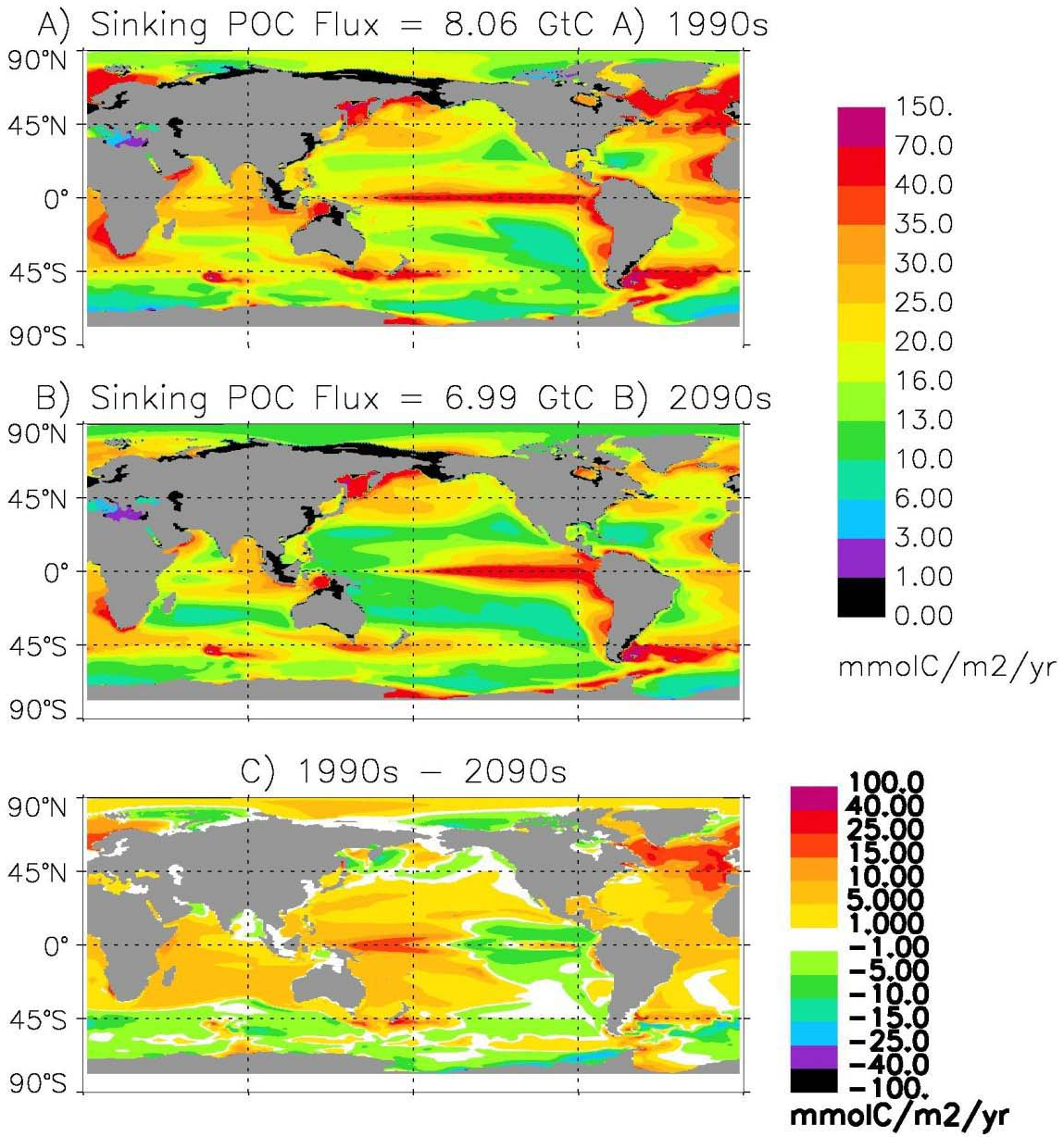
Moore et al., in prep

Subsurface O_2 vs WOA



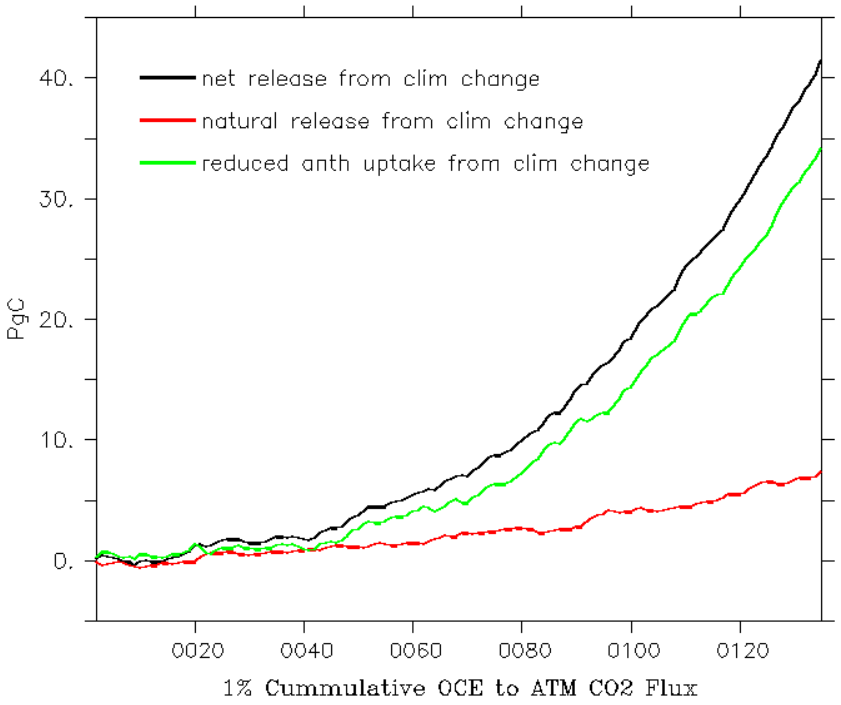
Moore et al., in prep

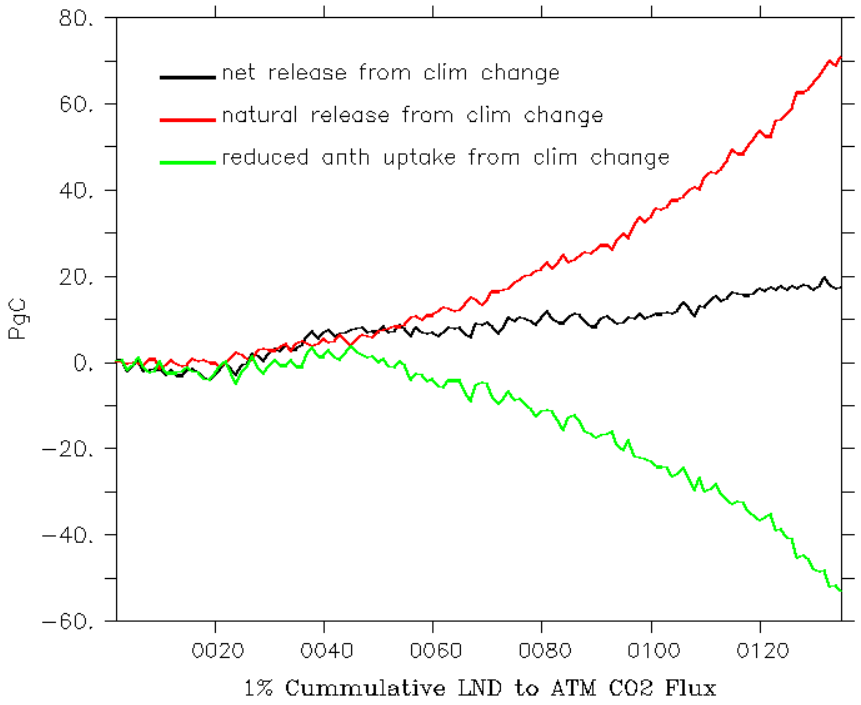
Projection of Change in 100m POC Flux in RCP8.5



Moore et al., in prep

Impact of Warming on CO_2 Fluxes in 1% CO_2 Ramping Experiments





Lindsay et al., in prep

Data Availability on ESG (2012-06-19)

Summary per CMIP5 table

Model	# of runs	volumes (GB)	Amon	Lmon	LImon	Omon	OImon	day
CESM1-BGC	16	downloadable	2151.960	506.284	53.982	2578.238	413.138	1407.323
		total expected	2547.085	517.135	54.029	12651.009	411.650	1408.615
		percentage	84.5%	97.9%	99.9%	20.4%	100.4%	99.9%

Target is to have all model output on ESG by early July.

CESM Release Strategy

- Target 1-2 releases per year
  - Nov 1 and/or May 1
- Categories of Model Developments include
  - A. Software and infrastructure enhancements
  - B. New Capabilities, functionally vetted
  - C. New Capabilities, scientifically vetted
- Timelines of finalizing features included

- Personnel resources required?
- How to provide support of previous releases?

Ocean BGC Developments (list from Mar 2011)

- Functioning Diagnostics Package
- Fe/C stoichiometry, growth and grazing updates
- River Inputs of Nutrients
- Improved DOM cycling
- Coupling to a simple sediment model
- NH_3, N_2O surface emissions
- Ocean Acidification Feedbacks
- Enhancement of Calcifying Functional Groups
- Treatment of Sea-Ice Heterogeneity
  - PAR yes, sinking particles maybe
- Isotopes (C, O_2, N)
- Couple to Sea-Ice Algae
- Get Newton-Krylov fast spinup working at x1

Additional Ocean BGC Efforts

- More coordination with OMWG on efforts to reduce ocean model biases relevant to BGC
  - Target more BGC talks in OMWG Jan 2013 meeting
- Marine Methane Cycle

Land Model Efforts related to BGC (not under dev list would be shorter)

- Photosynthesis
- Multilayer Canopy
- Cold Region Hydrology
- Vertically Resolved Soil BGC
- Methane
- Spinup
- C Isotopes
- Crop Model Devs
- Separate above and below-ground litter
- Revised Fire Model
- Ecosystem Demography
- Riverine Nutrient Transport
- …

CSL Allocation on Yellowstone

- http://www.cesm.ucar.edu/management/CSL/

- BGCWG requested 13.32 million CPU hours
  - Experiments prioritized into 3 categories
    - A (60%), B(20%), C(20%)

- CESM awarded 80% of total request
- 85% of corresponding storage awarded

- New Experiment Database developed by CSEG will assist in management of experiments

Community Projects
39 million CPU hours total

- Large Ensemble Study
  - 40 member ensemble
  - 1950-2099, RCP8.5
  - CAM5, BGC
  - Need to generate Ocean BGC IC
  - 10 additional members with CESM1.5
- Last Millennium Ensemble Study
- High Resolution (Atm) Control Study

Development Experiments
5.54 million CPU Hours

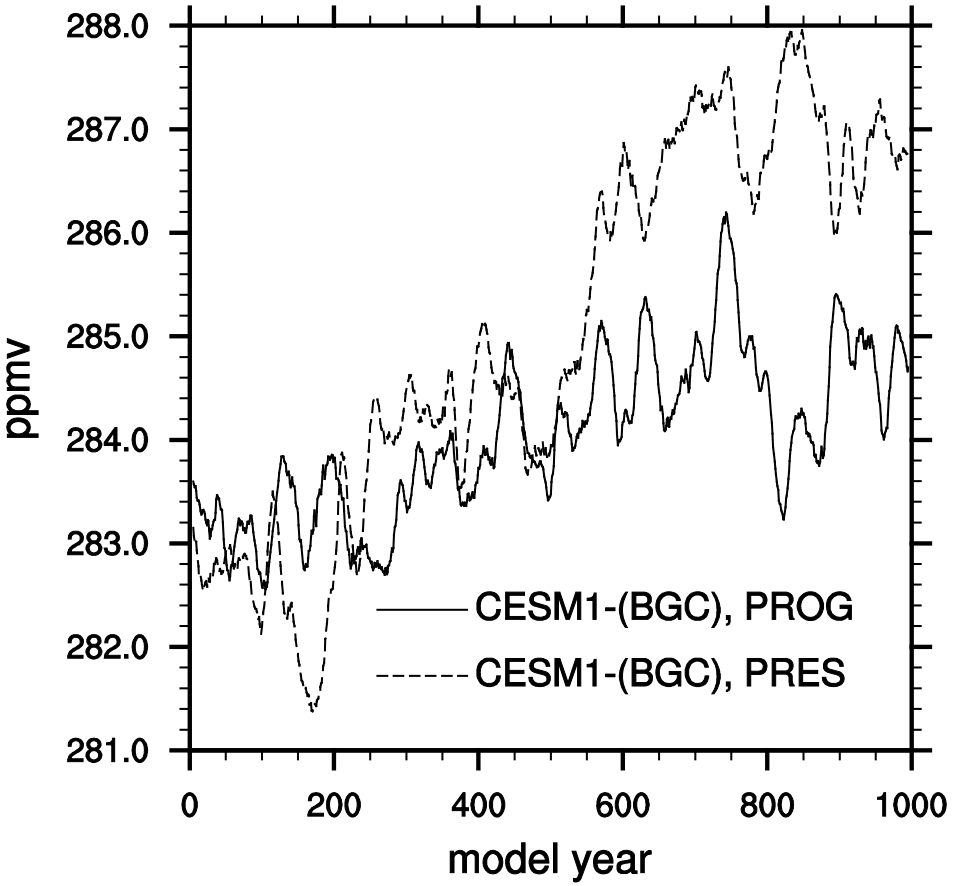
- Coupled Nitrogen Cycle
- Methane
- Ocean BGC Developments
- Ocean Acidification, Alkalinity Cycle
- Carbon Isotopes
- Ocean Spinup Development
- Ocean BGC with Resolved Eddies

Production Experiments
7.77 million CPU Hours

- Spinups with Model Updates
- New Coupled Controls
- New Coupled Transients
- RCP Extensions
- BGC in Past Epochs
- Coupled Nitrogen
- Additional Community Proposed

Questions
Comments
Discussion

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.

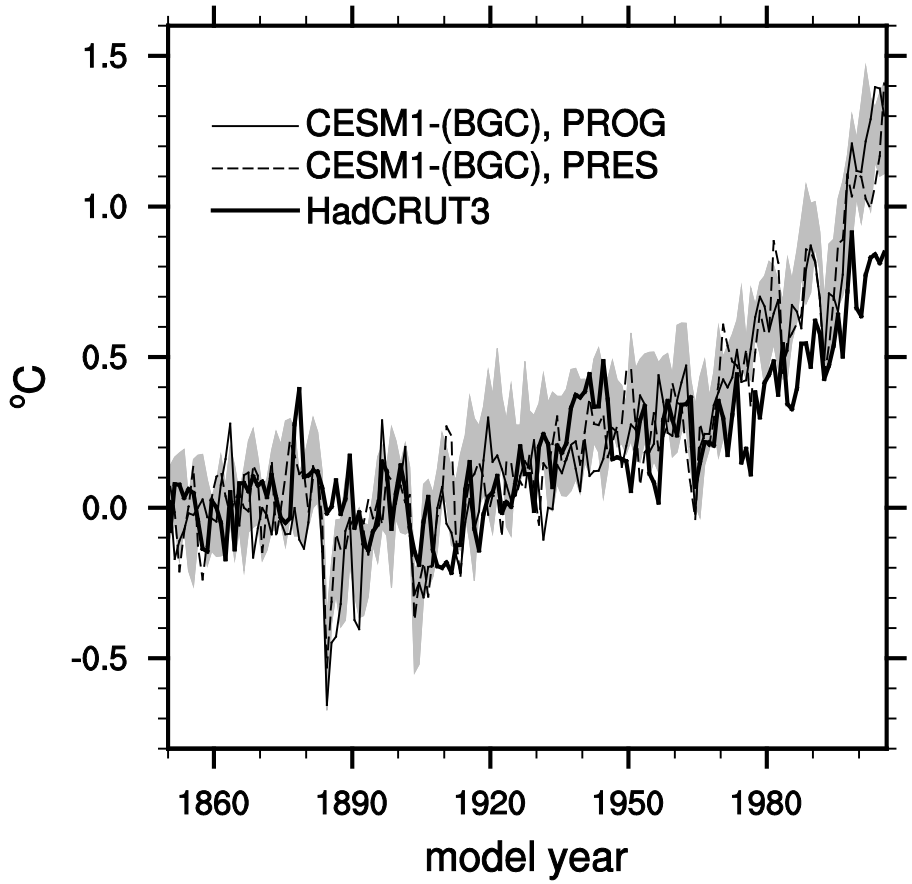
Atmospheric CO_2 drifts by ~2 and ~4 ppmv over 1000 years in controls.

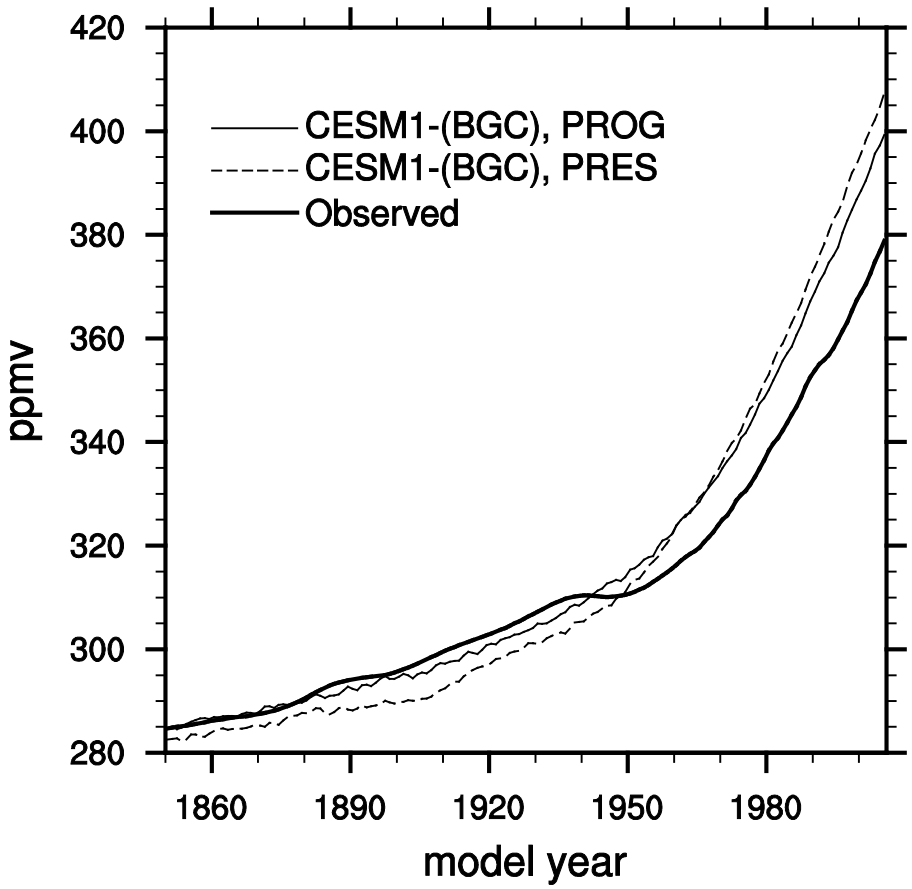
Surface flux negative feedback reduces drift in PROG control.

Drift is superposition of compensating drifts in land and ocean C inventories.

Lindsay et al., in prep

T_{air} & CO_2 in 20th Century Experiments

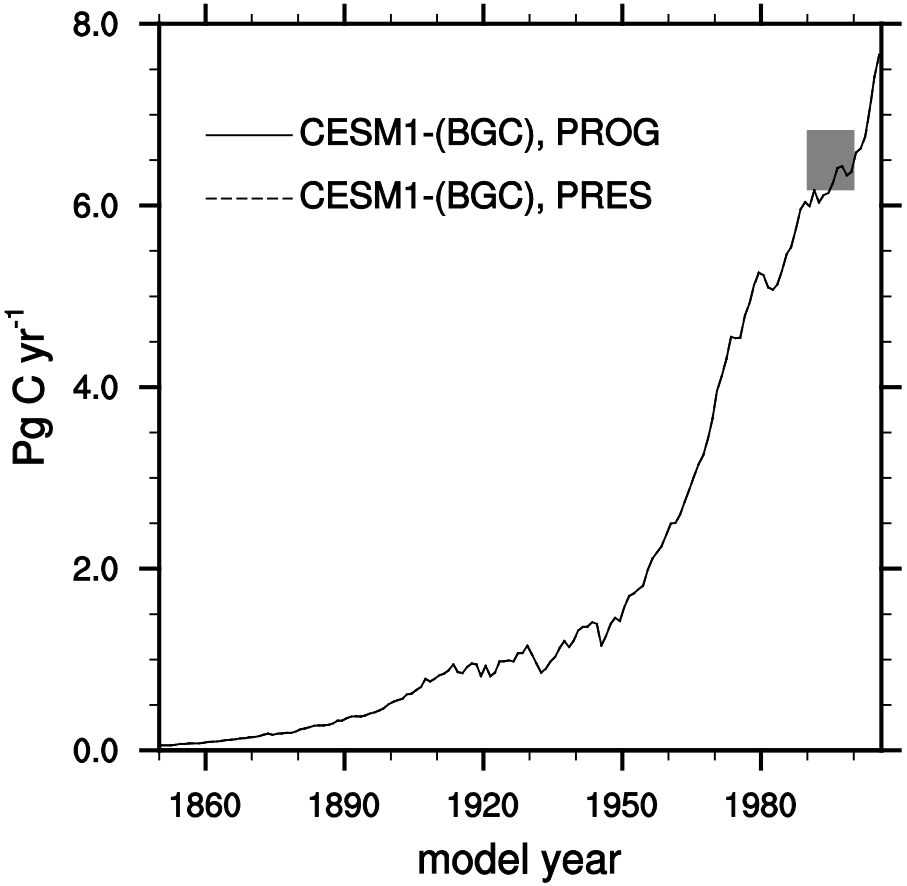




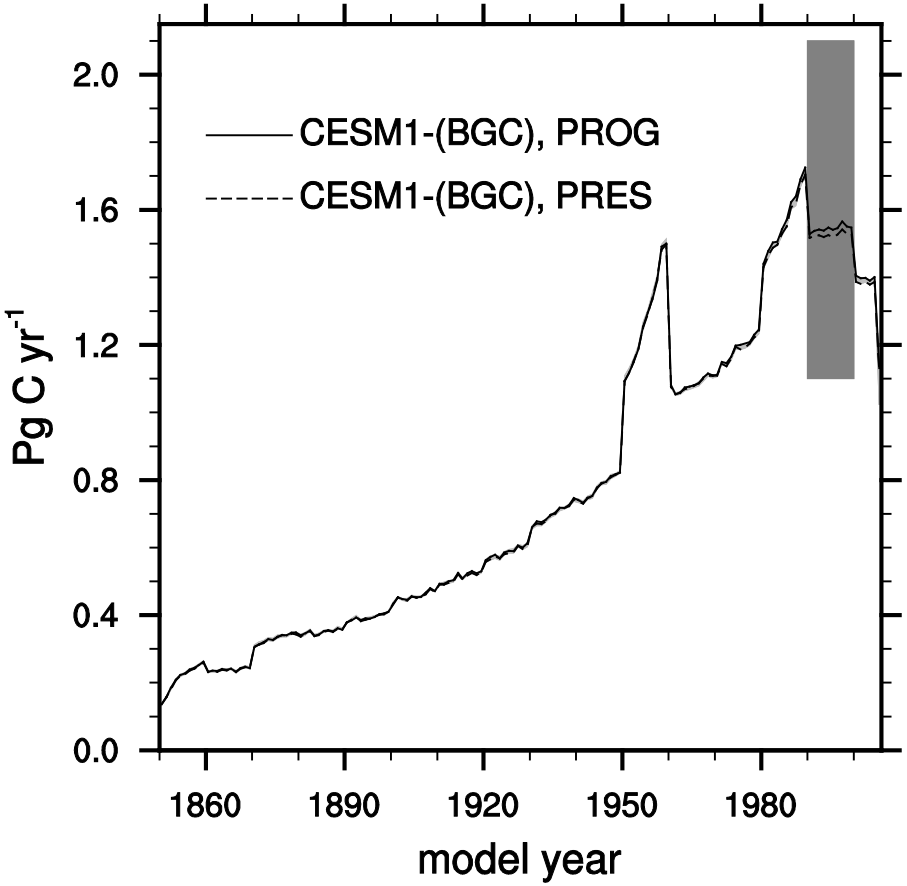
Lindsay et al., in prep

20th Century CO_2 Sources to Atm

Fossil Fuels



Land Use Change

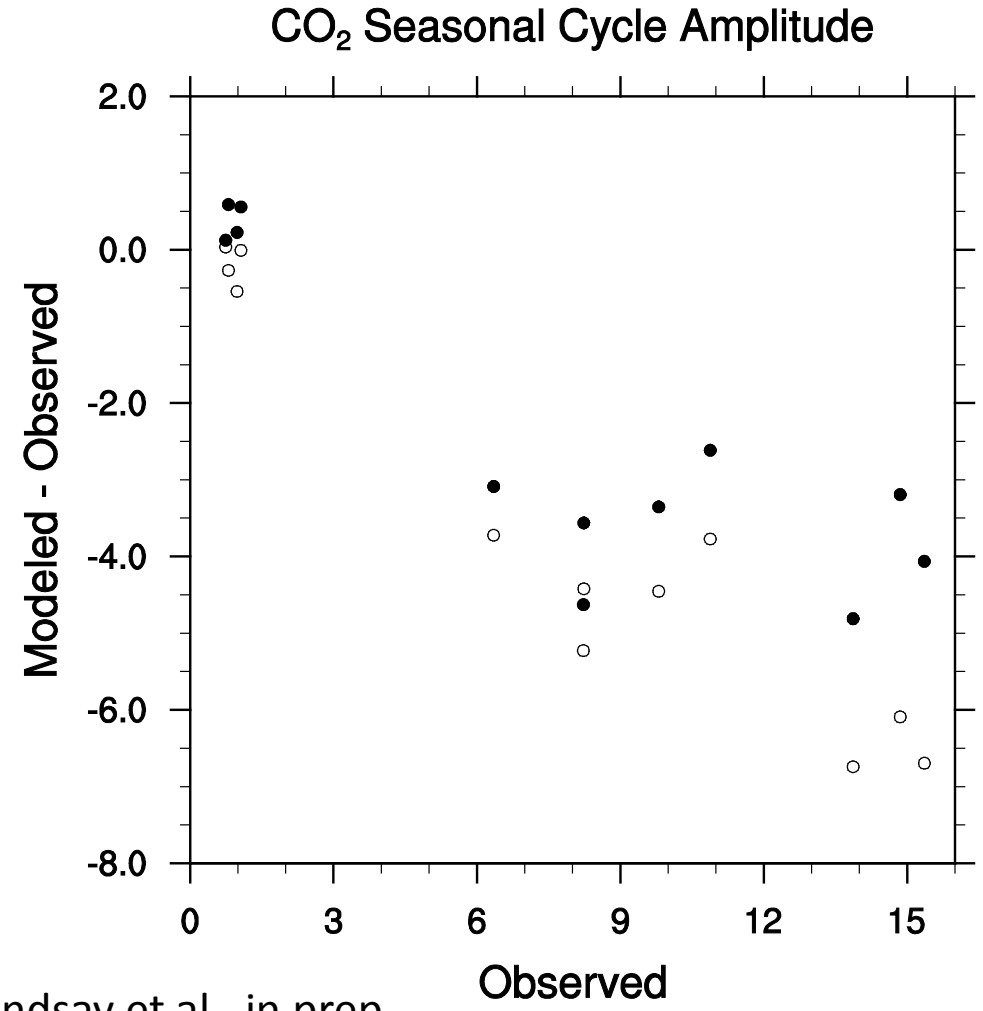


Lindsay et al., in prep

Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.

CO_2 Seasonal Cycle

12 stations from GLOBALVIEW



Lindsay et al., in prep

Wider variety of station locations

Hollow: 1850 PROG
Filled: 20C PROG

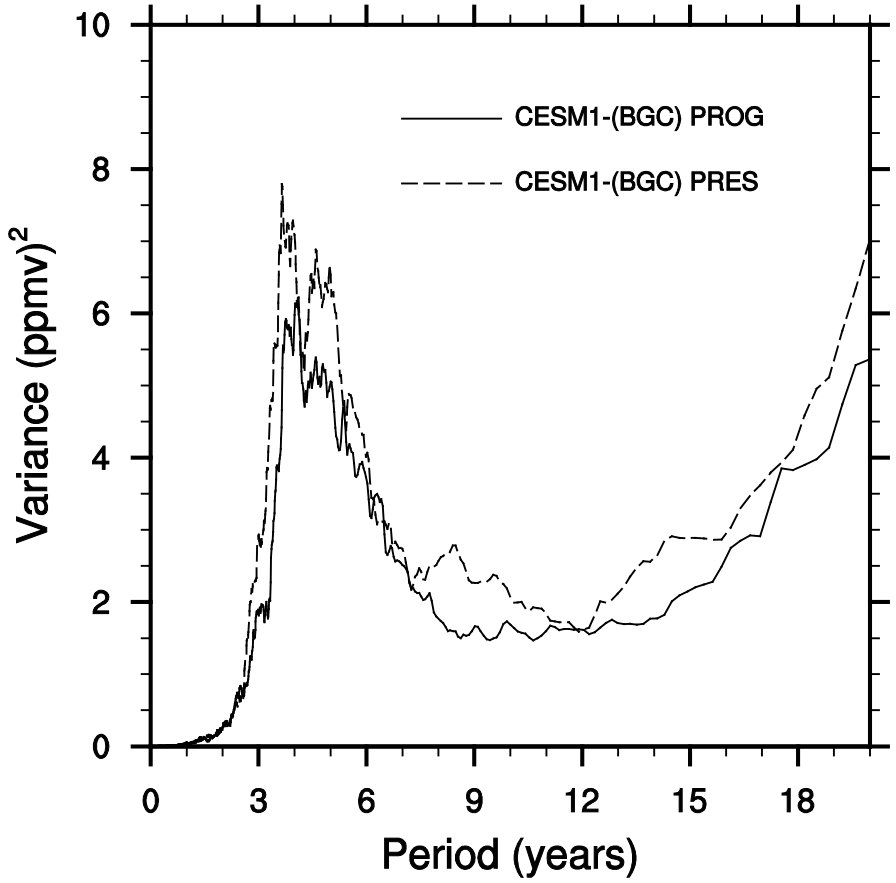
Amp>6

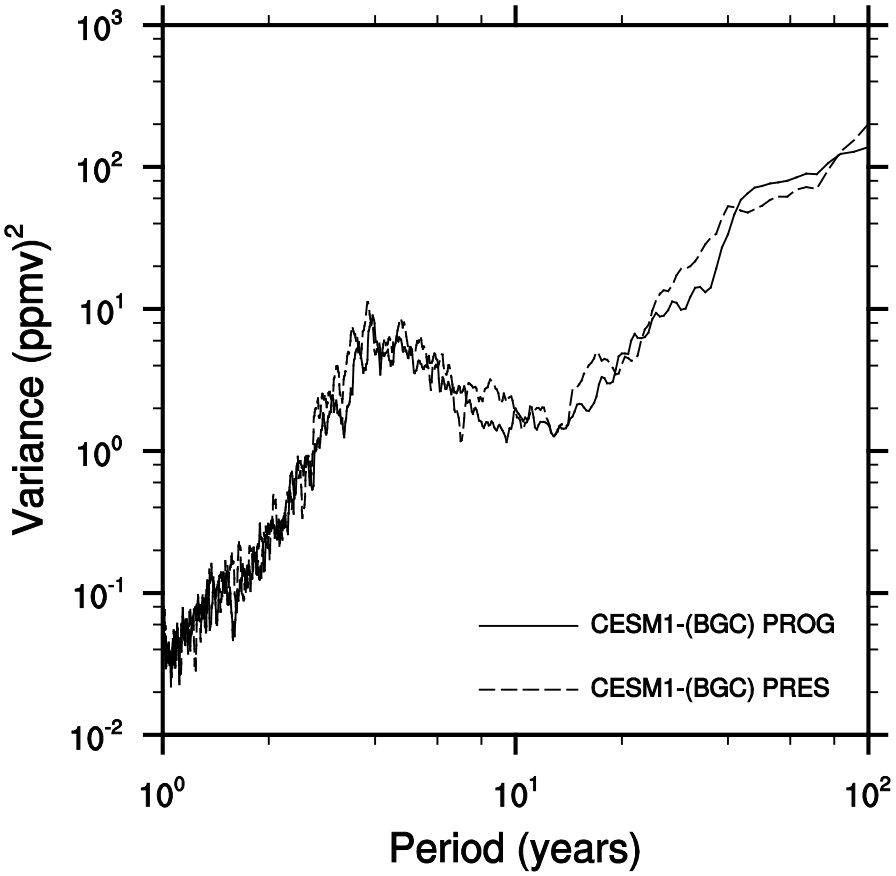
- Northern Hemisphere
- Large Land Contribution
- 20C reduces bias

Amp<2

- Southern Hemisphere

Power Spectra of Surface CO_2

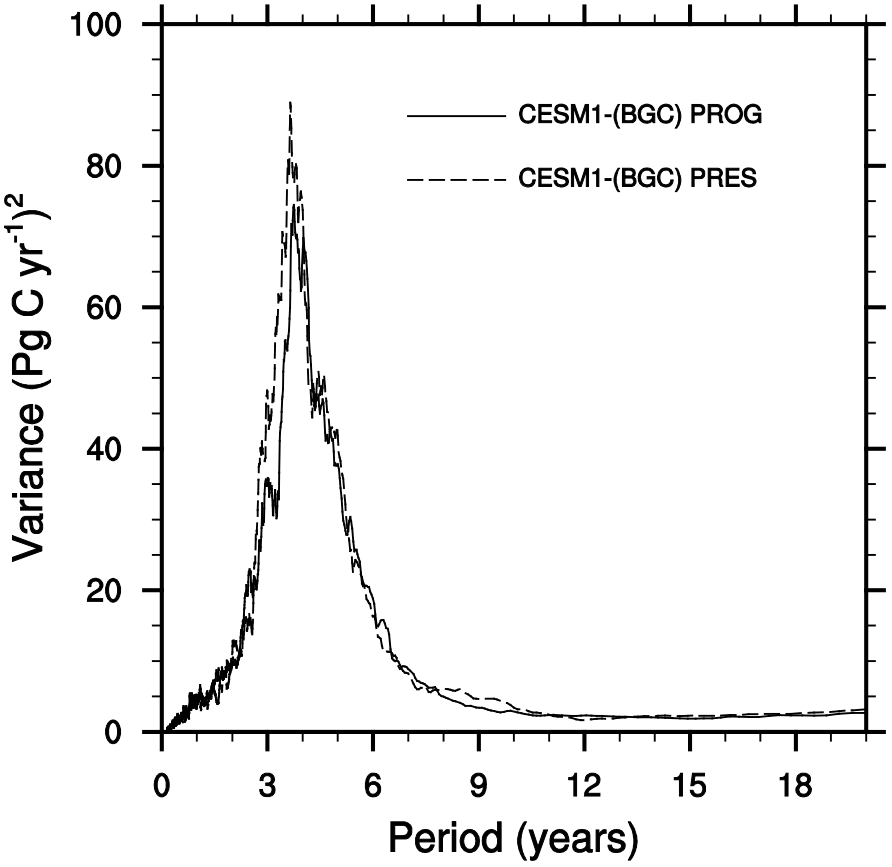




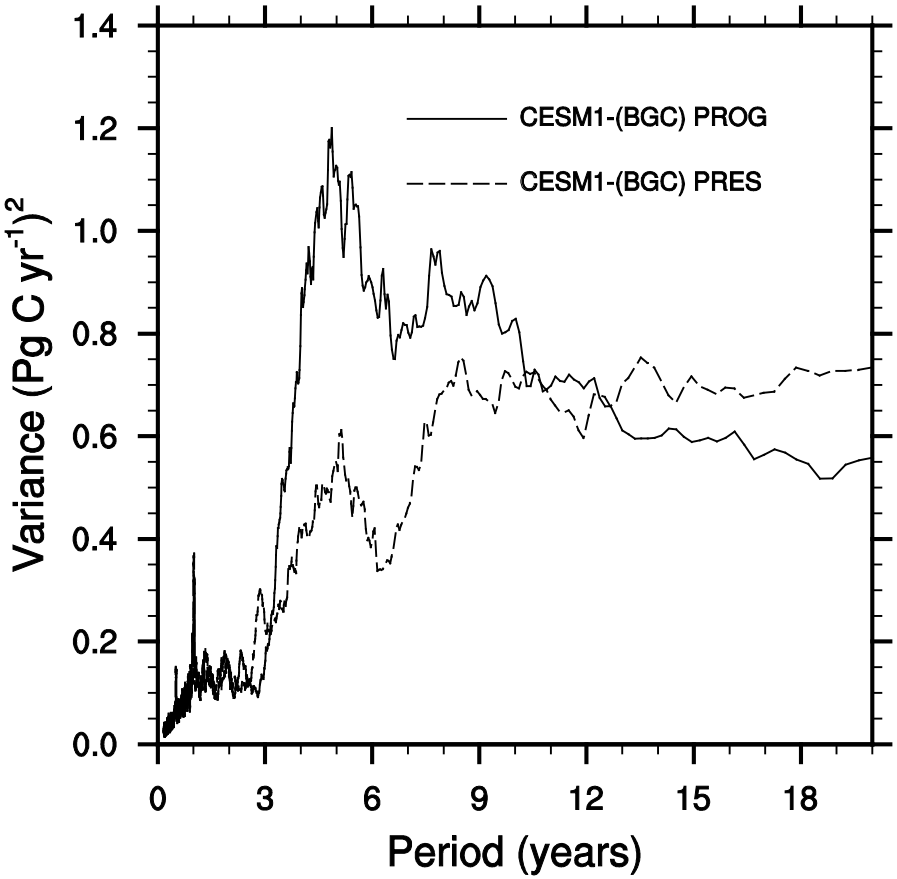
Lindsay et al., in prep

Power Spectra of Surface CO_2 Flux

Land-to-Air



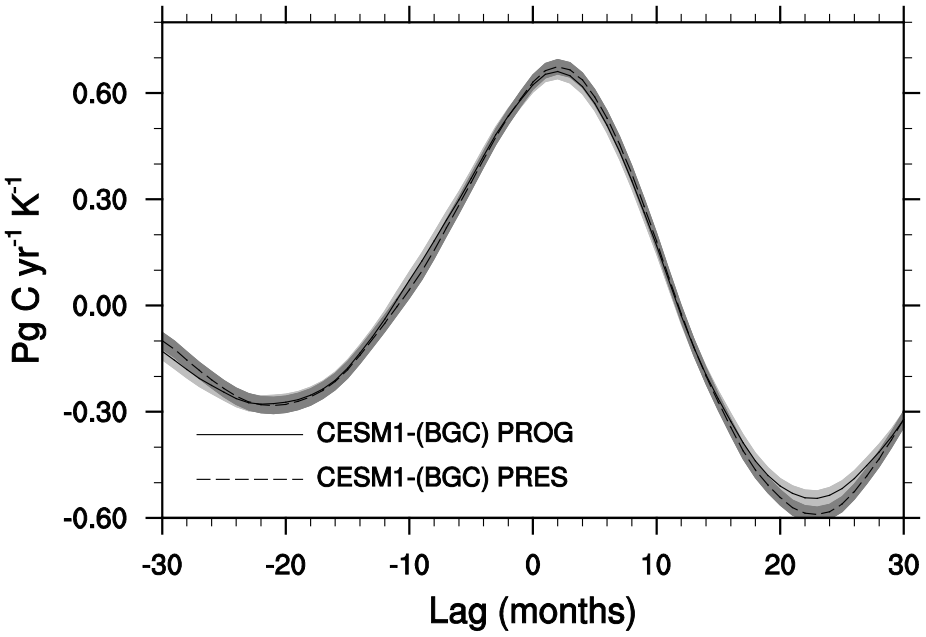
Sea-to-Air



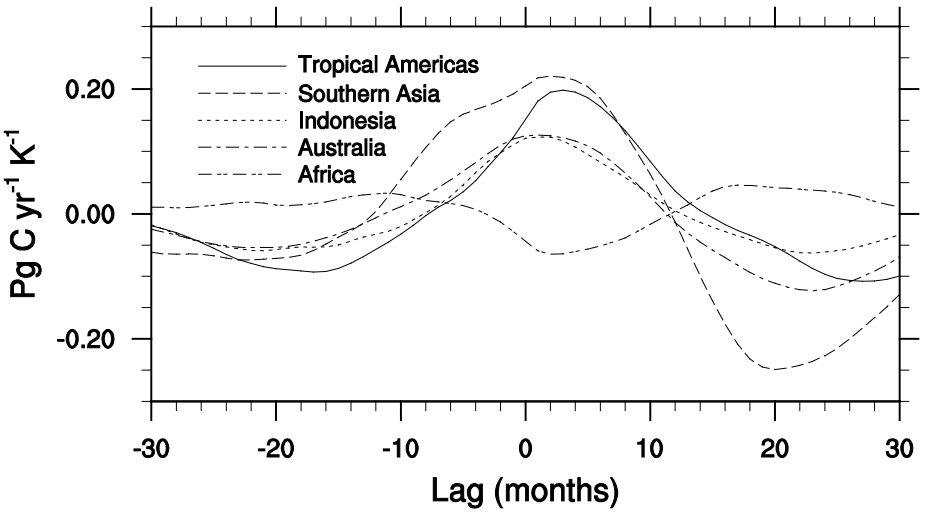
Lindsay et al., in prep

Response to Niño 3.4 SST Anomalies

Land-to-Air CO_2 Flux



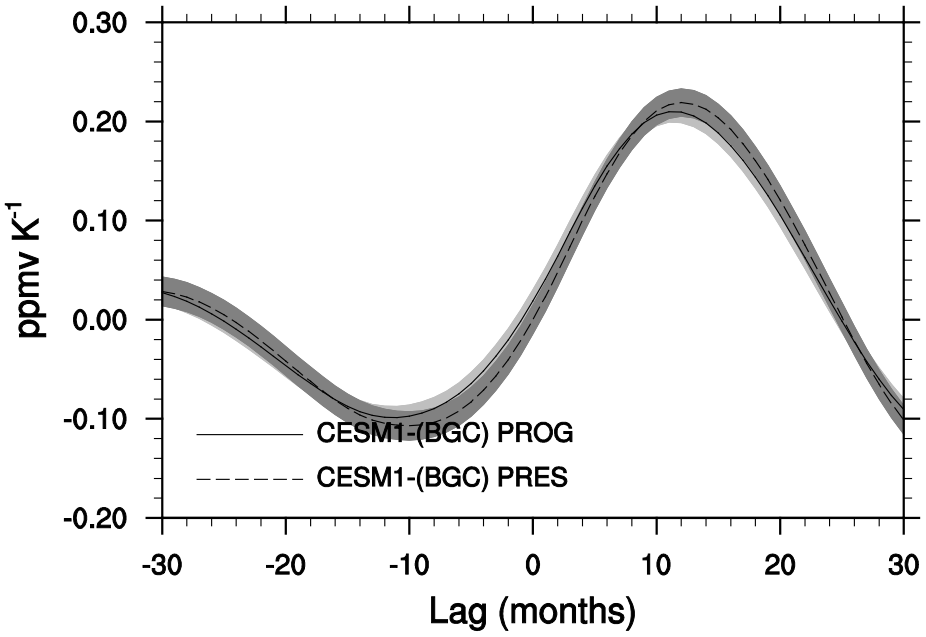
Regional Land-to-Air CO_2 Flux



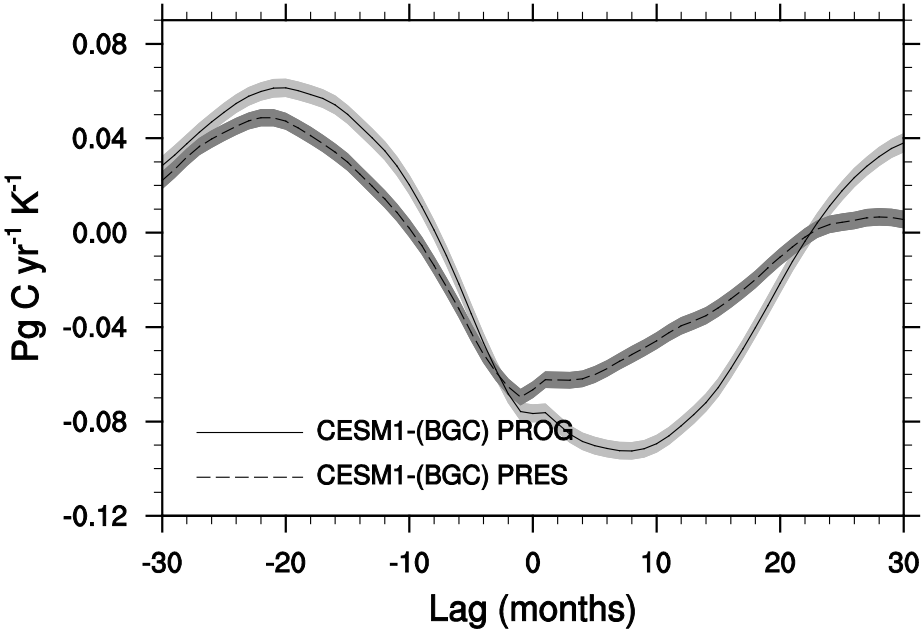
Lindsay et al., in prep

Response to Niño 3.4 SST Anomalies

Surface Atmospheric CO_2



Sea-to-Air CO_2 Flux



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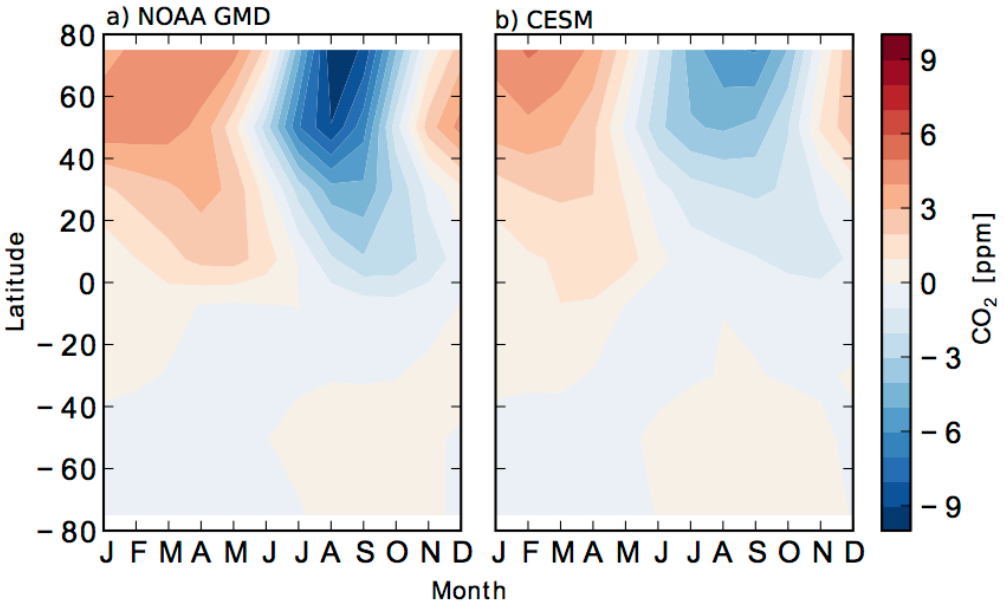
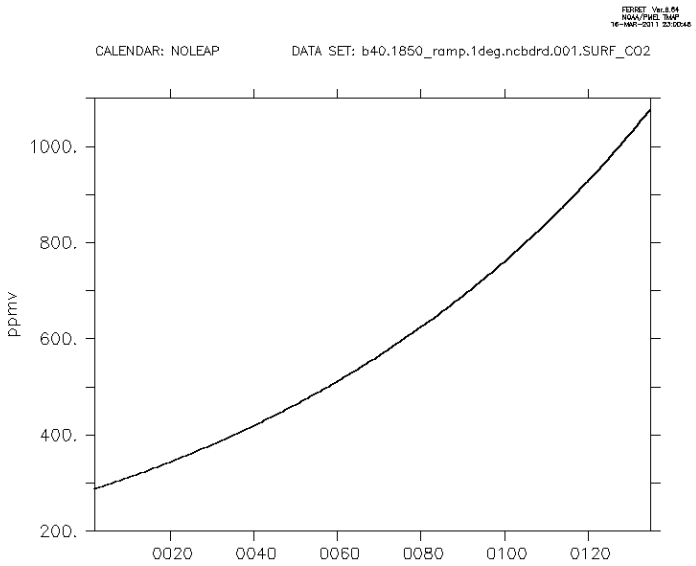
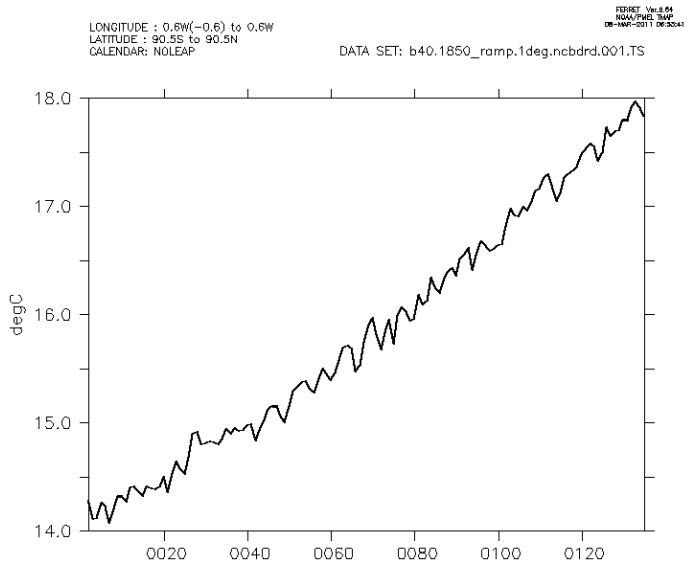
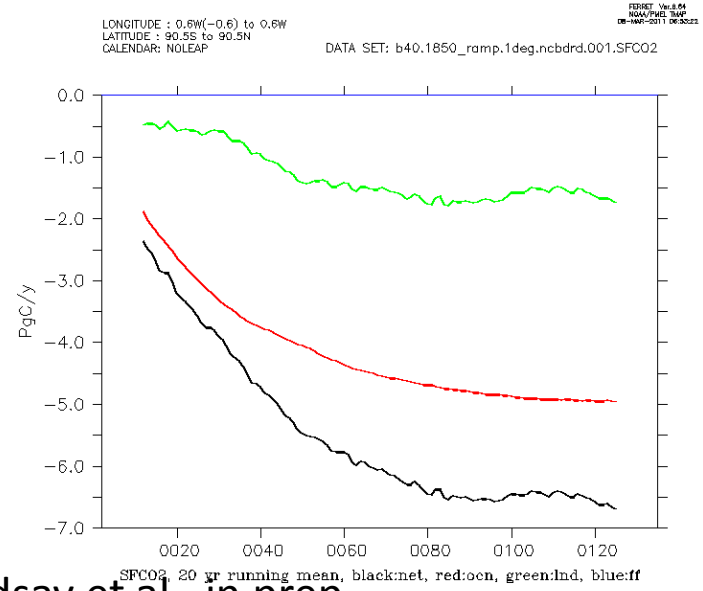


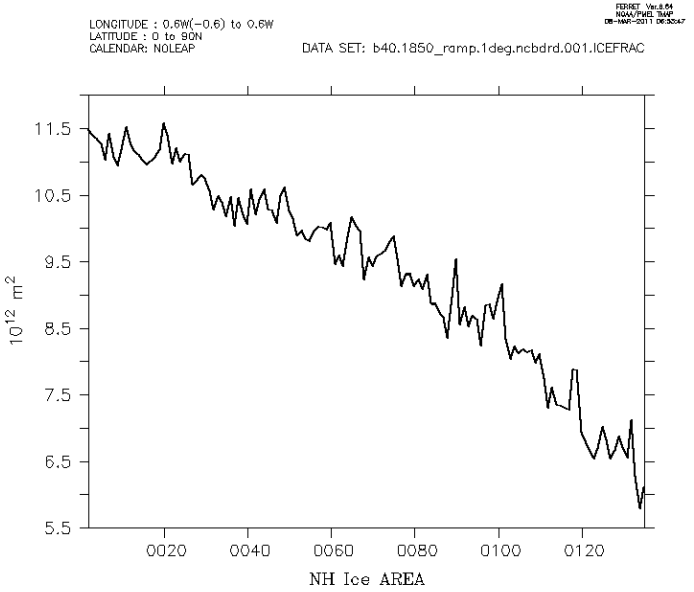
Keppel-Aleks et al., in prep

1% CO_2, Prescribed CO_2









Lindsay et al., in prep