



# Coupled Carbon Simulations with CESM-(BGC)

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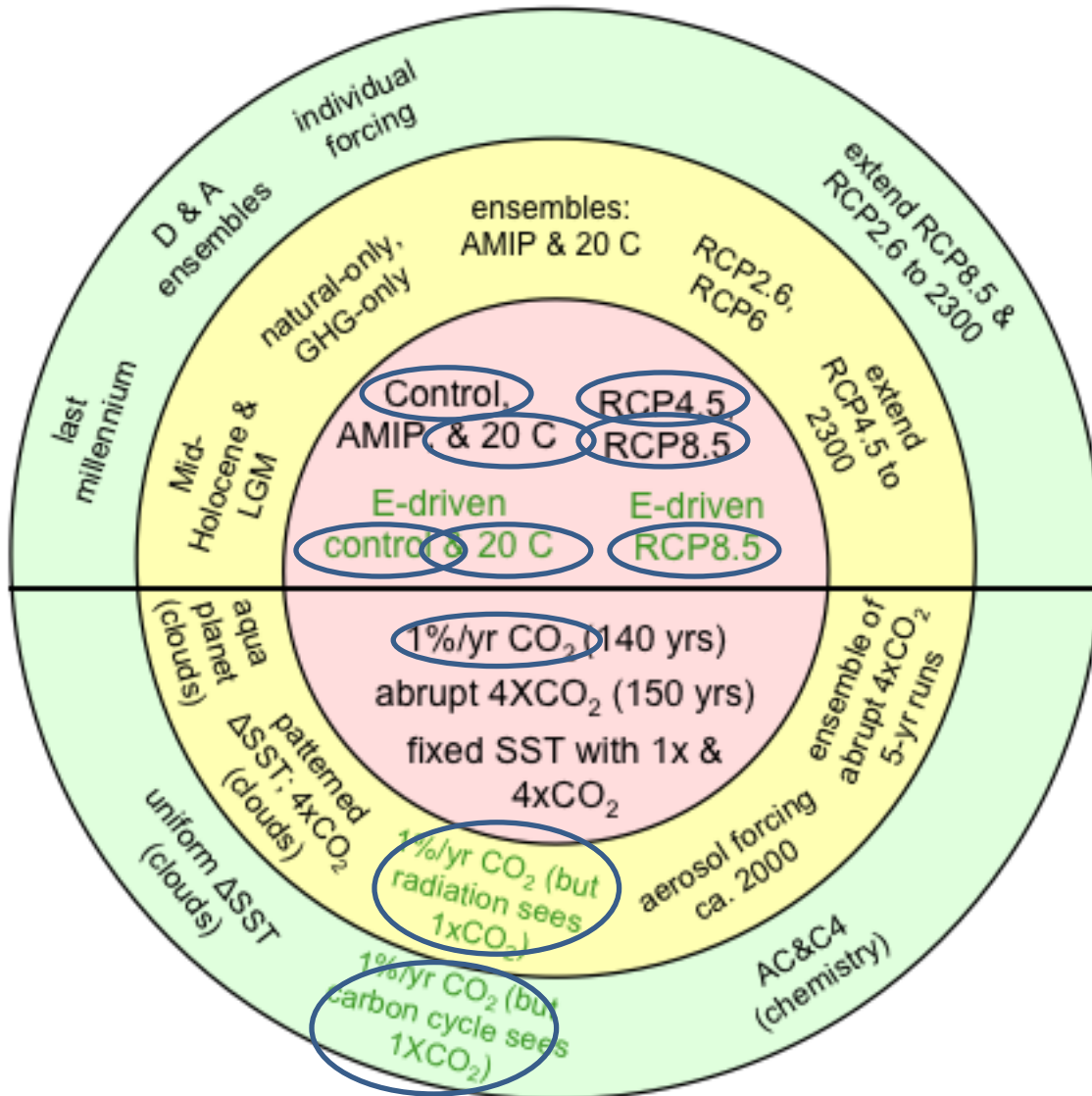
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D. Lawrence, M. Long , N. Mahowald,

K. Moore, J. Randerson, P. Thornton

NCAR is sponsored by the National Science Foundation

# CESM1-(BGC) CMIP5 Experiments



Black: classical AOGCMs  
Color: ESMs

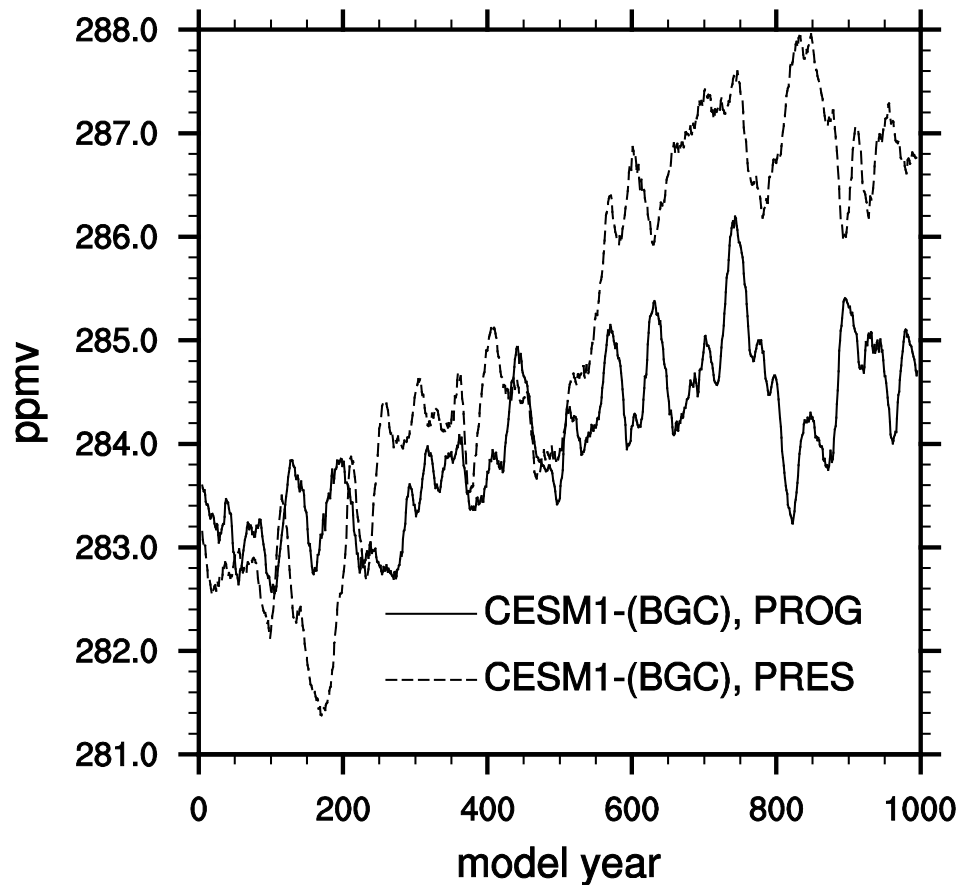
Experiments are forced by  $CO_2$  concentration, unless specified as E-driven.

## CESM $CO_2$ Options

- Constant
- Prescribed (Diagnostic)
- Prognostic

$CO_2$  option can be specified independently for BGC and radiation.

# Atmospheric CO<sub>2</sub> in 1850 Controls



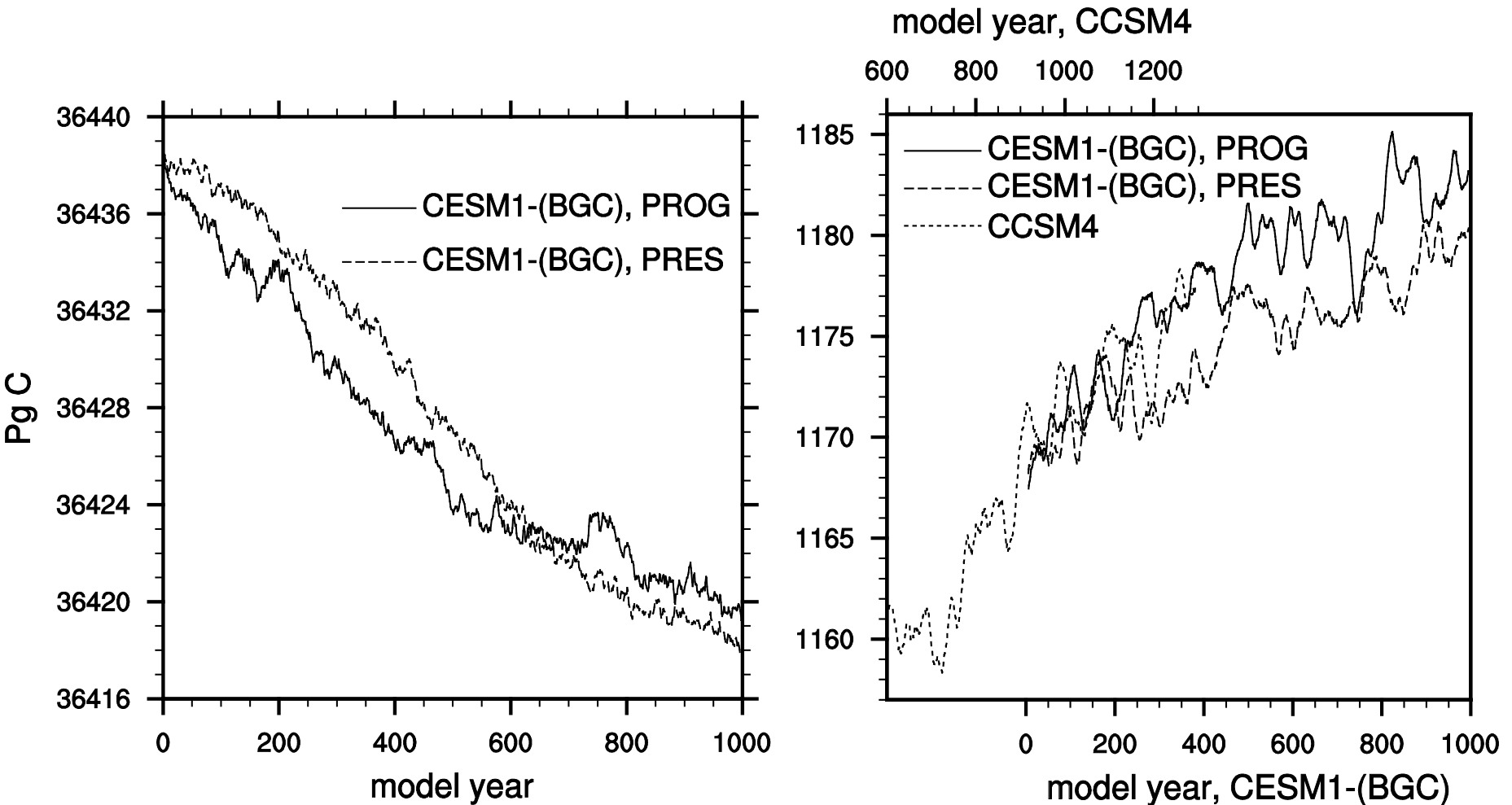
Land and Ocean BGC pools were spun up for  $O(1000)$  years with coupled model forcing.  
This is generally problematic.

Atmospheric CO<sub>2</sub> drifts by  $\sim 2$  and  $\sim 4$  ppmv over 1000 years in controls.

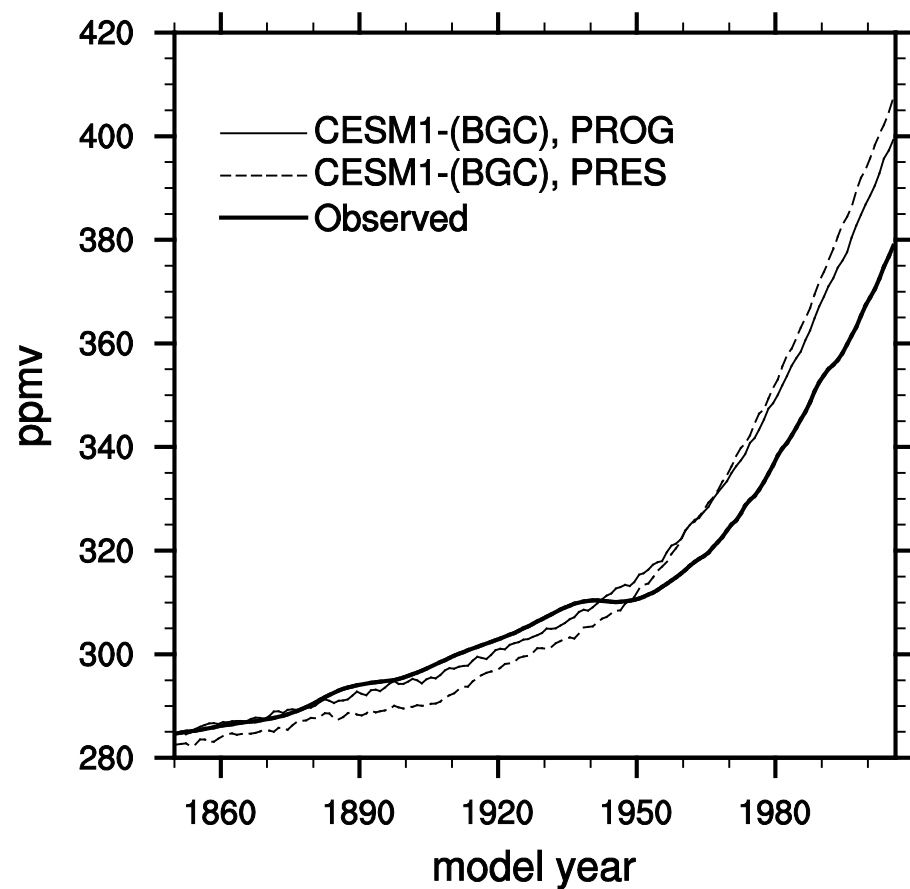
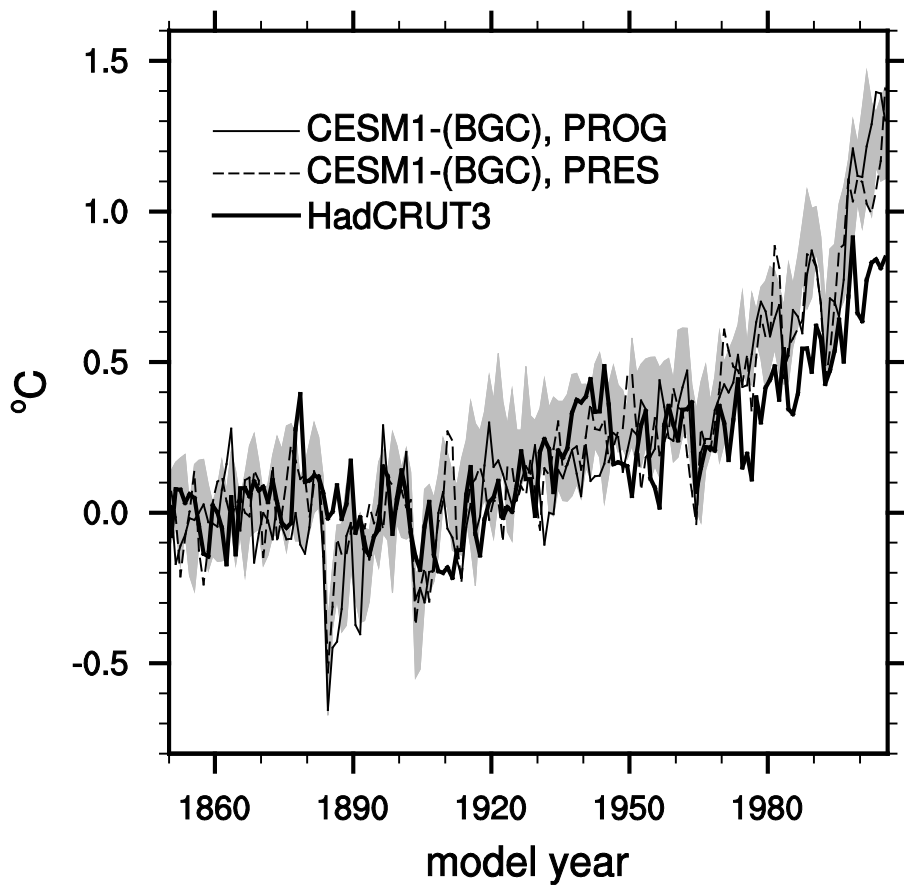
Surface flux negative feedback reduces drift in PROG control.

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

# Ocean & Land Carbon Balance

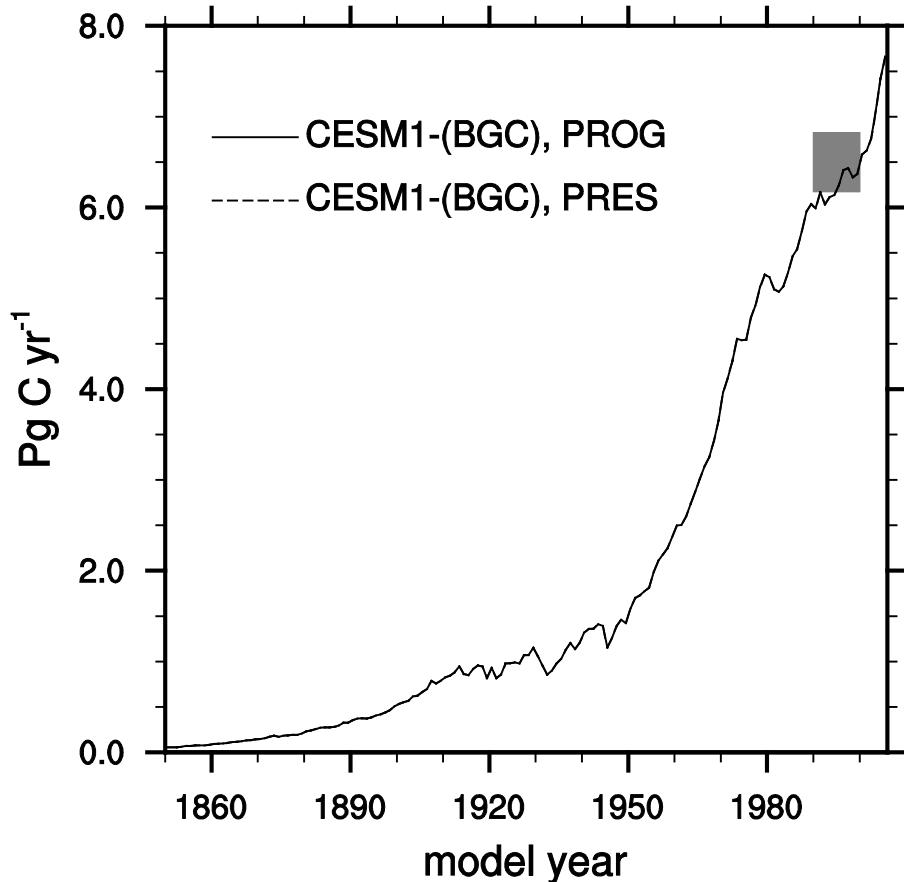


# T<sub>air</sub> & CO<sub>2</sub> in 20<sup>th</sup> Century Experiments

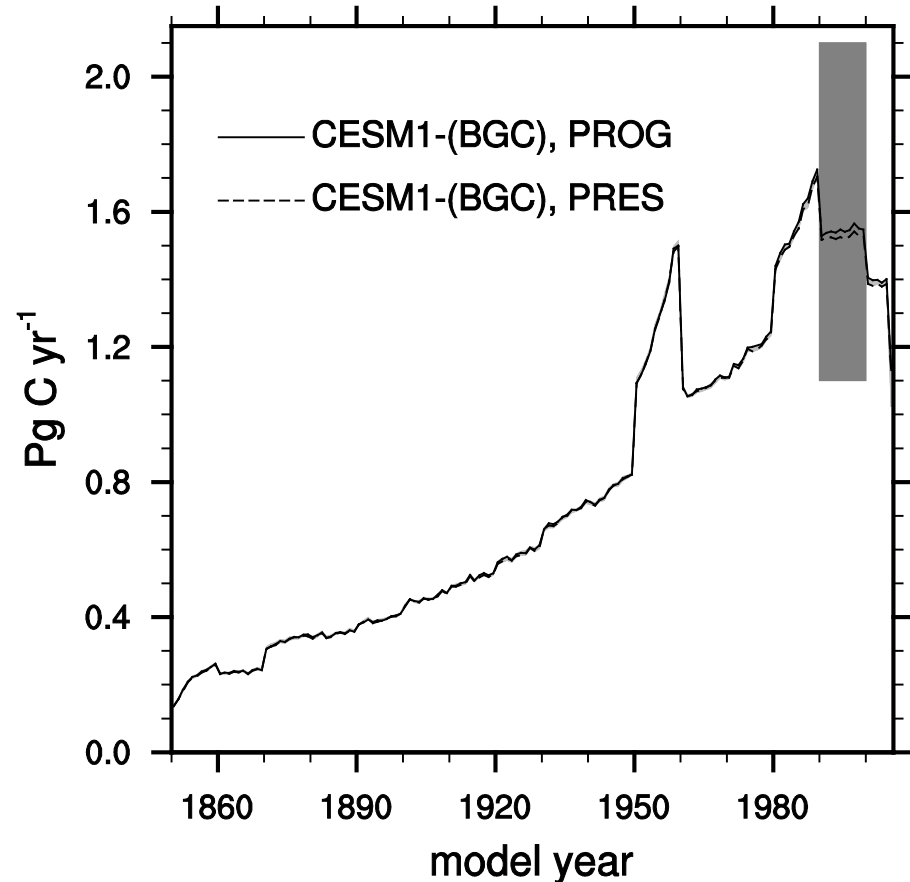


# 20<sup>th</sup> Century CO<sub>2</sub> Sources to Atm

## Fossil Fuels



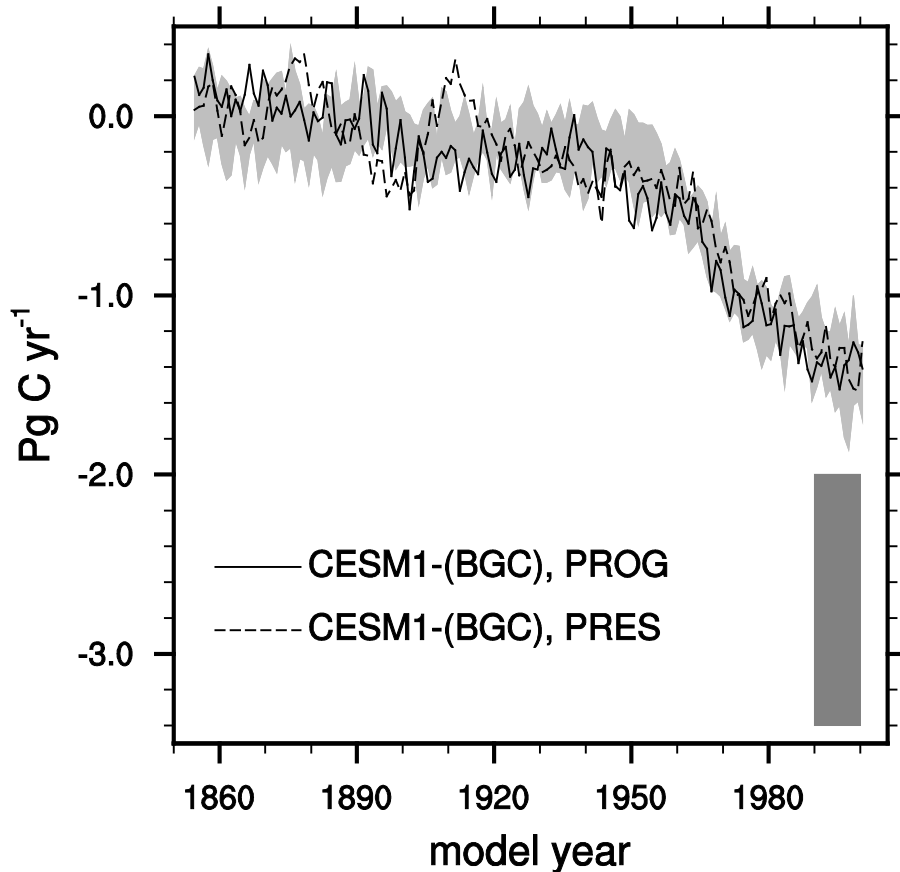
## Land Use Change



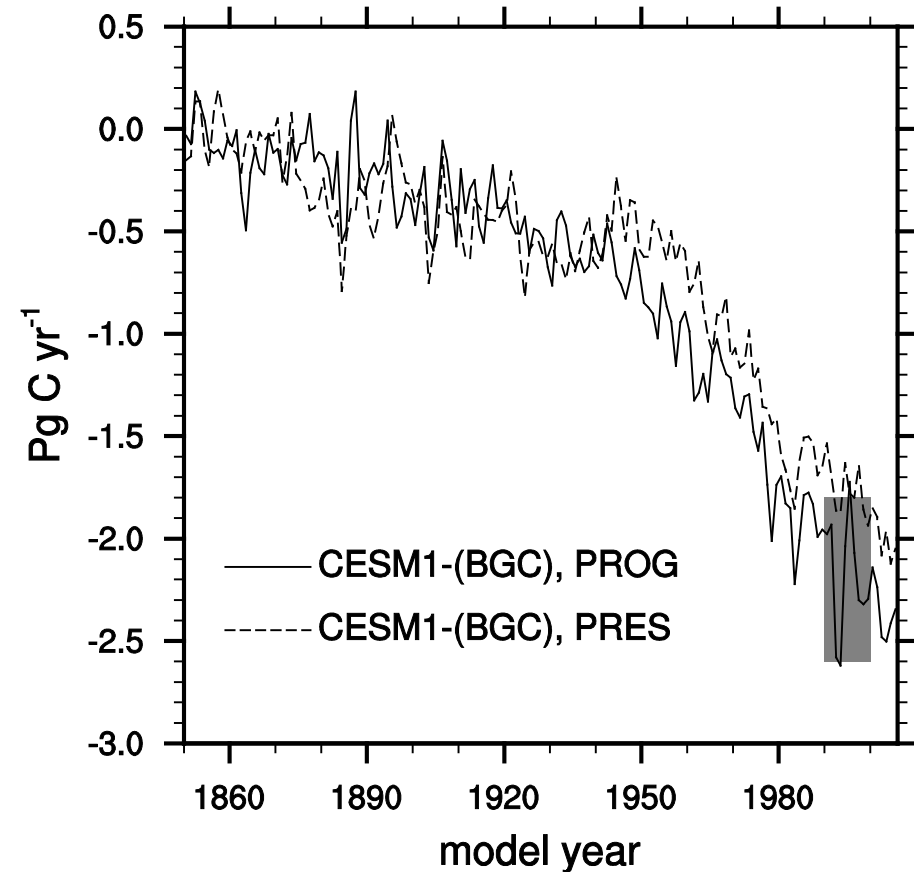
Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.

# 20<sup>th</sup> Century CO<sub>2</sub> Sinks from Atm

## Land Residual Uptake



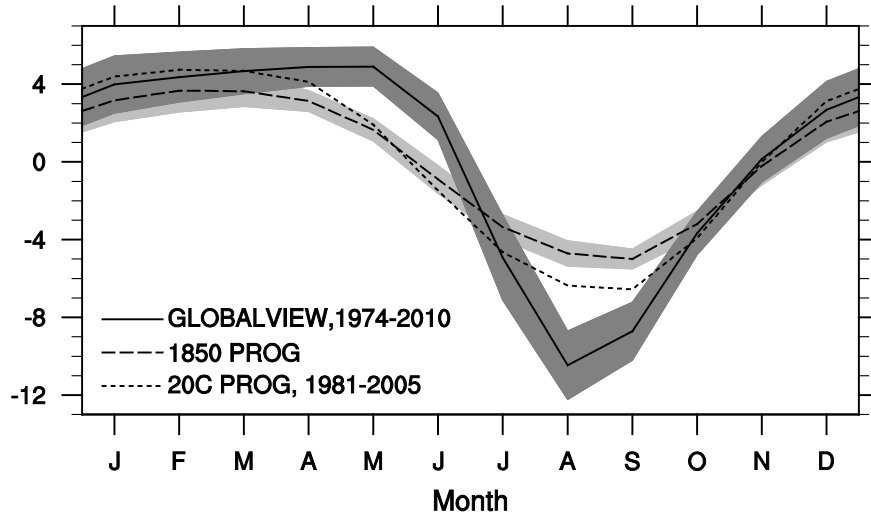
## Ocean Uptake



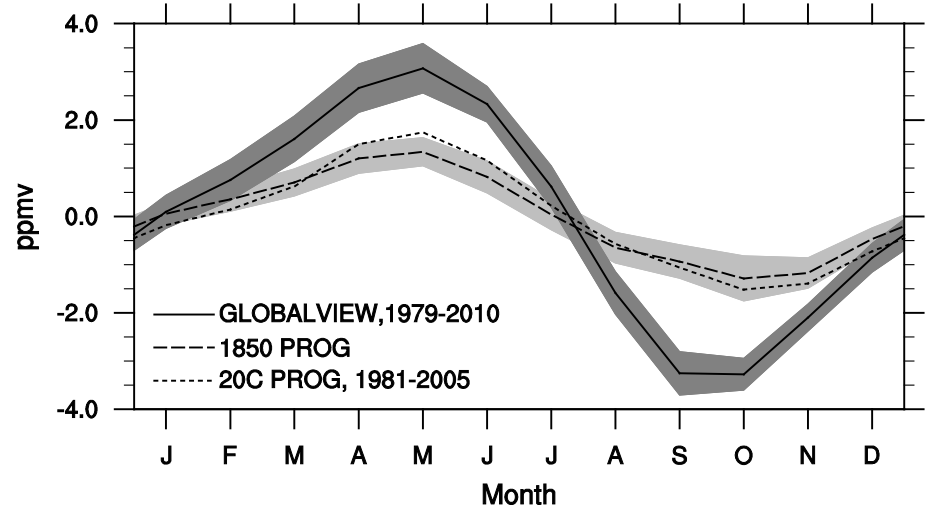
Gray bars are 1990s estimates from Canadell et al., PNAS, 2007.

# CO<sub>2</sub> Seasonal Cycle

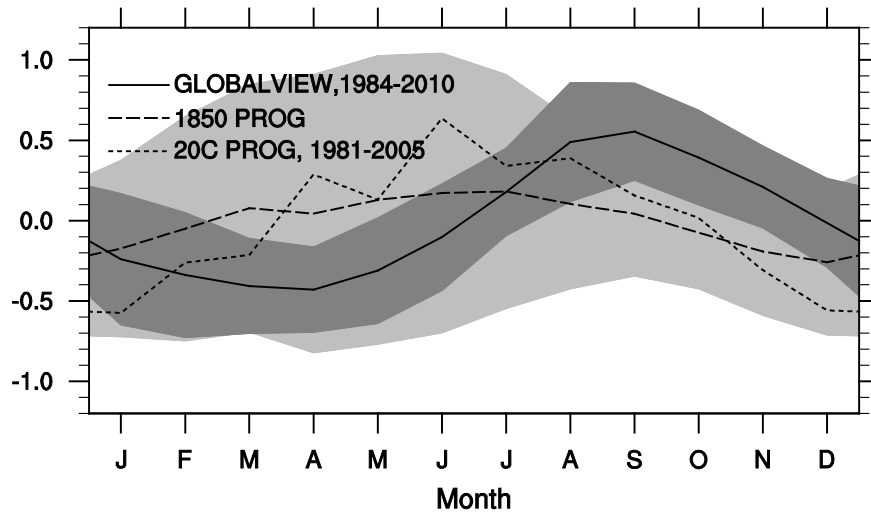
## CO<sub>2</sub> Seasonal Cycle, Barrow



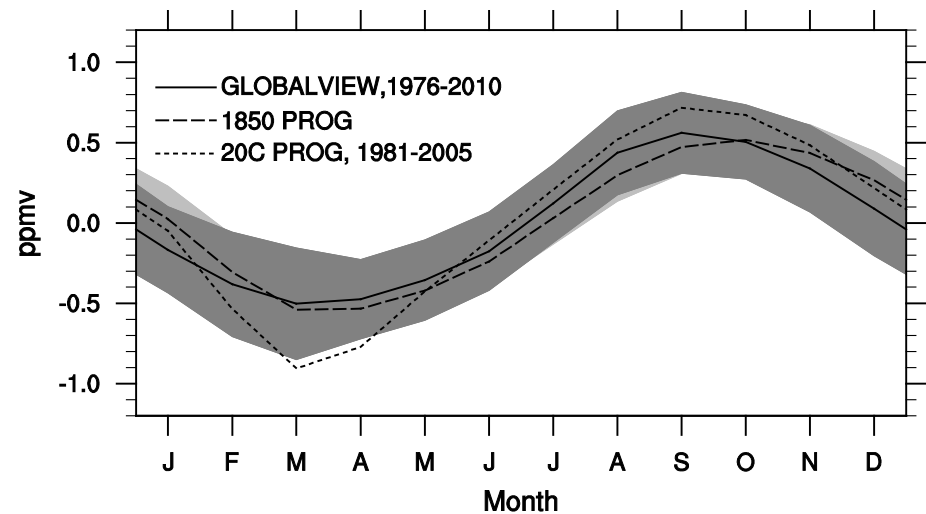
## CO<sub>2</sub> Seasonal Cycle, Mauna Loa



## CO<sub>2</sub> Seasonal Cycle, Cape Grim



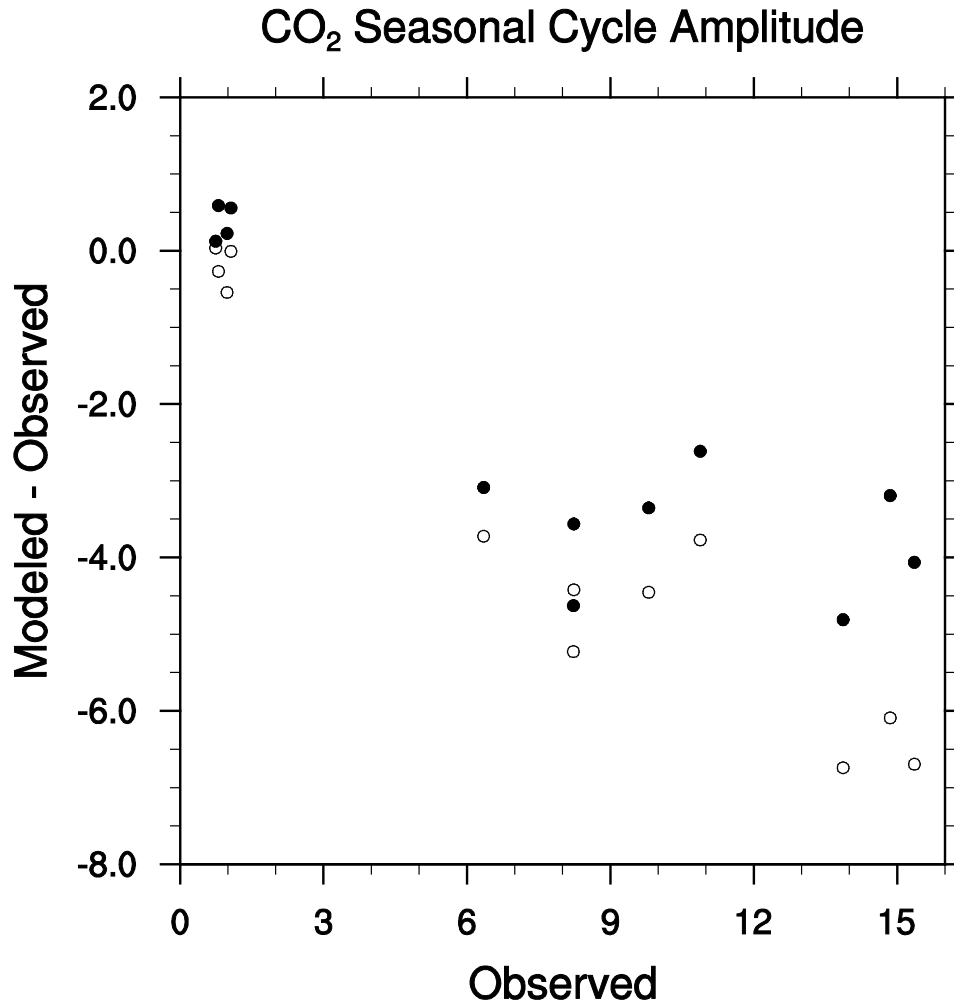
## CO<sub>2</sub> Seasonal Cycle, South Pole





# CO<sub>2</sub> Seasonal Cycle

## 12 stations from GLOBALVIEW



Wider variety of station locations

Hollow: 1850 PROG

Filled: 20C PROG

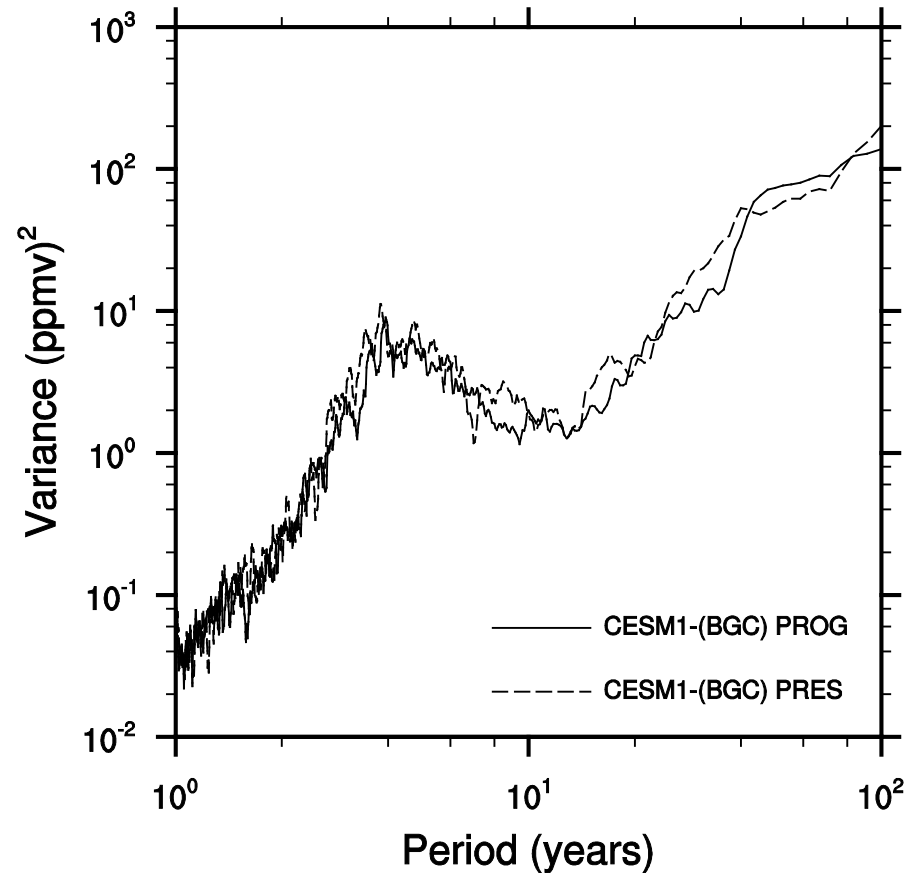
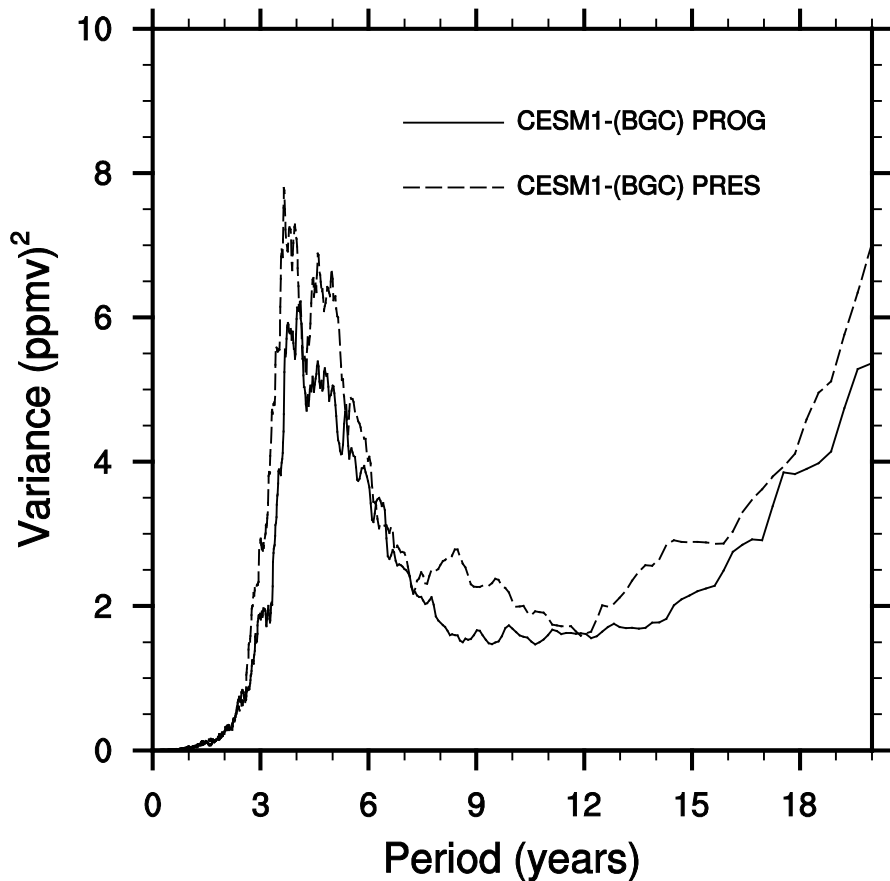
Amp > 6

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

Amp < 2

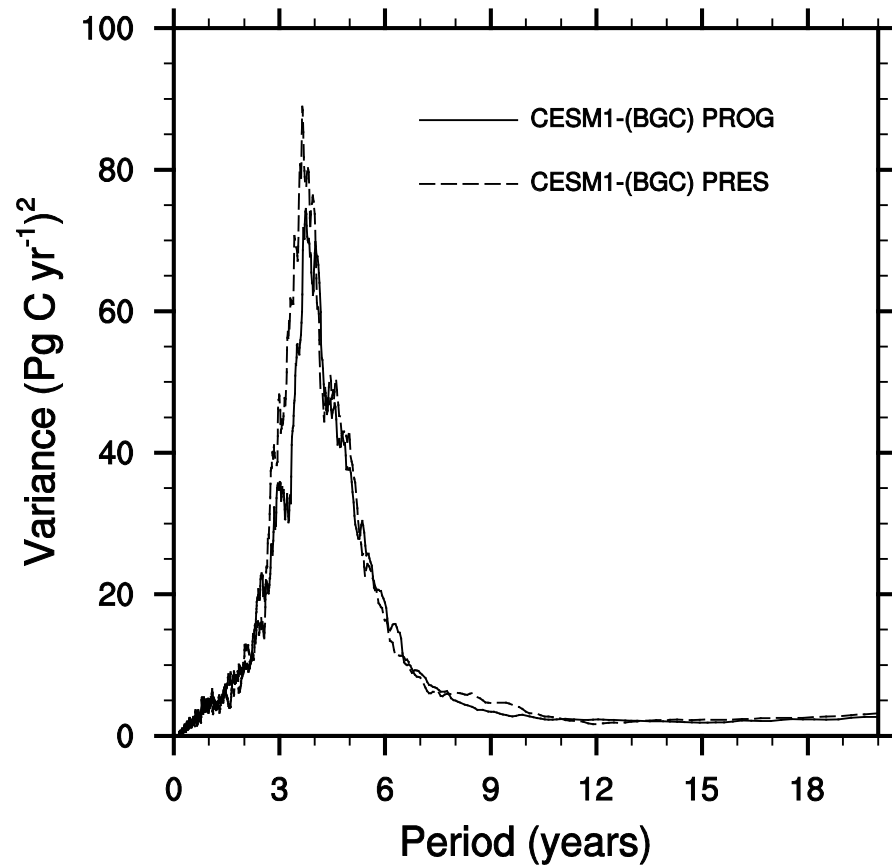
- Southern Hemisphere

# Power Spectra of Surface CO<sub>2</sub>

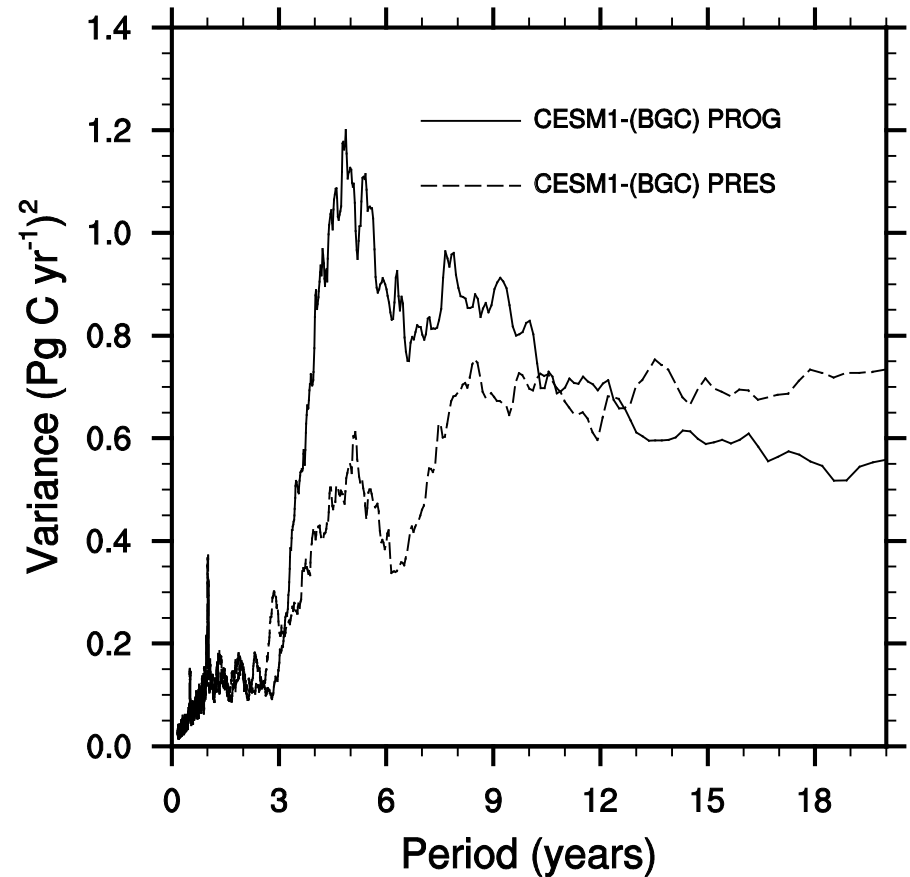


# Power Spectra of Surface CO<sub>2</sub> Flux

## Land-to-Air

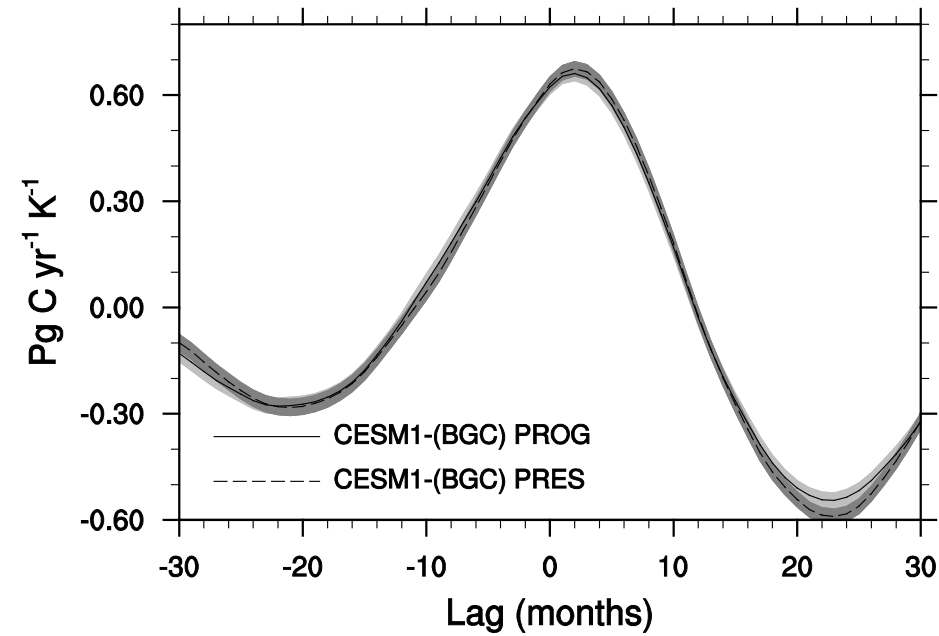


## Sea-to-Air

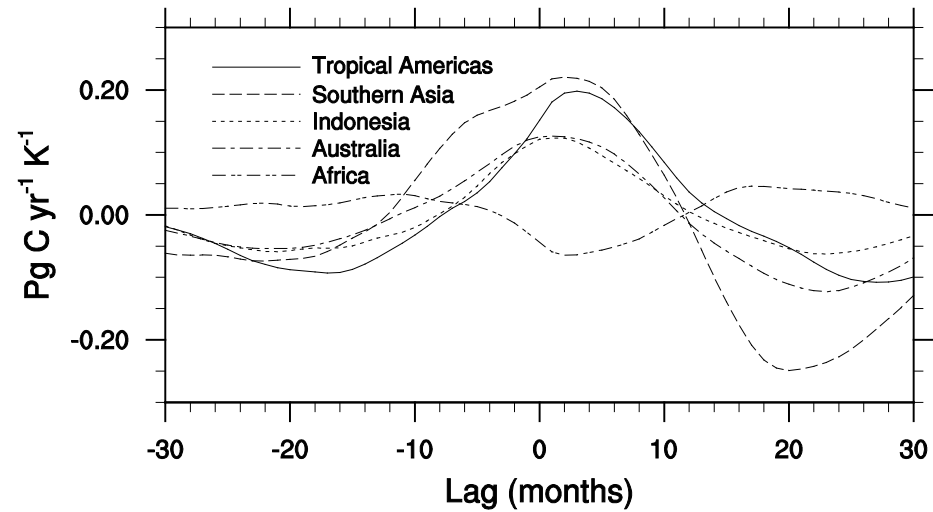


# Response to Niño 3.4 SST Anomalies

## Land-to-Air CO<sub>2</sub> Flux

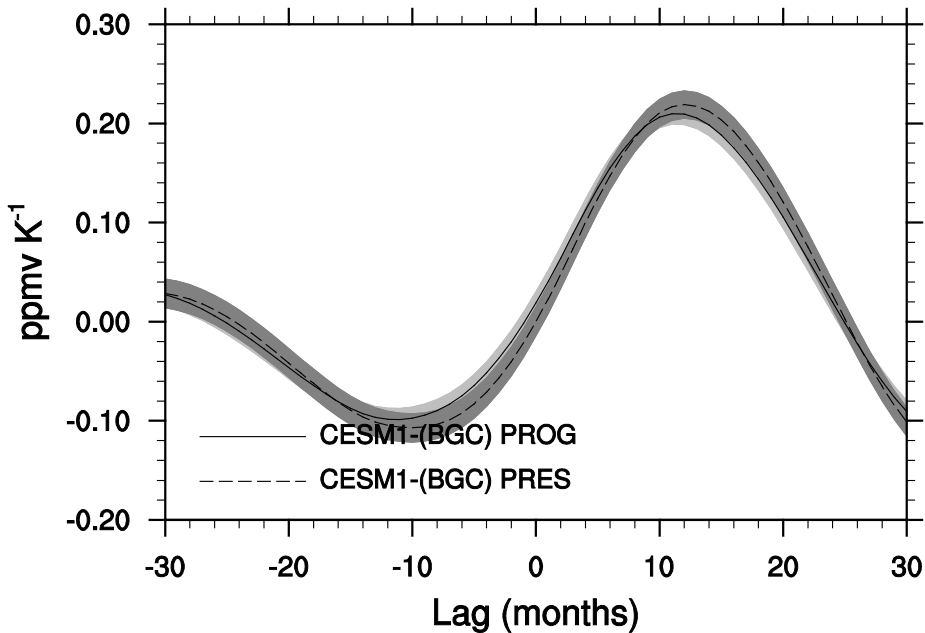


## Regional Land-to-Air CO<sub>2</sub> Flux

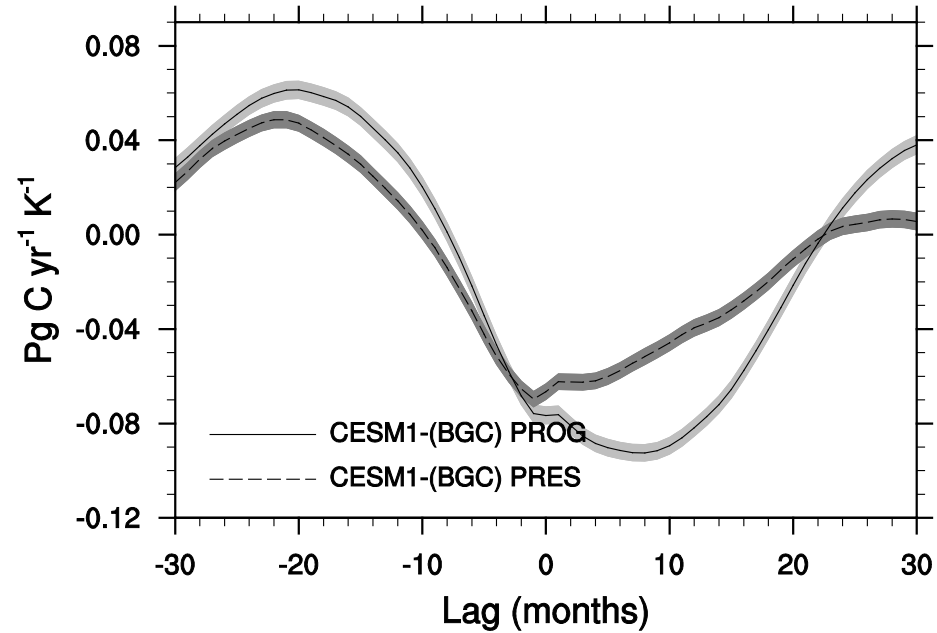


# Response to Niño 3.4 SST Anomalies

## Surface Atmospheric CO<sub>2</sub>



## Sea-to-Air CO<sub>2</sub> Flux

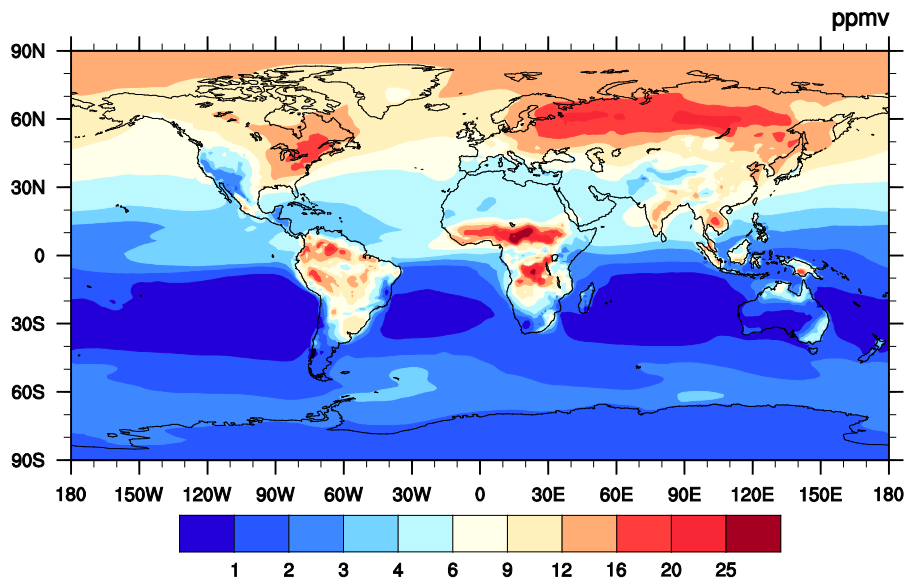


# What's Next

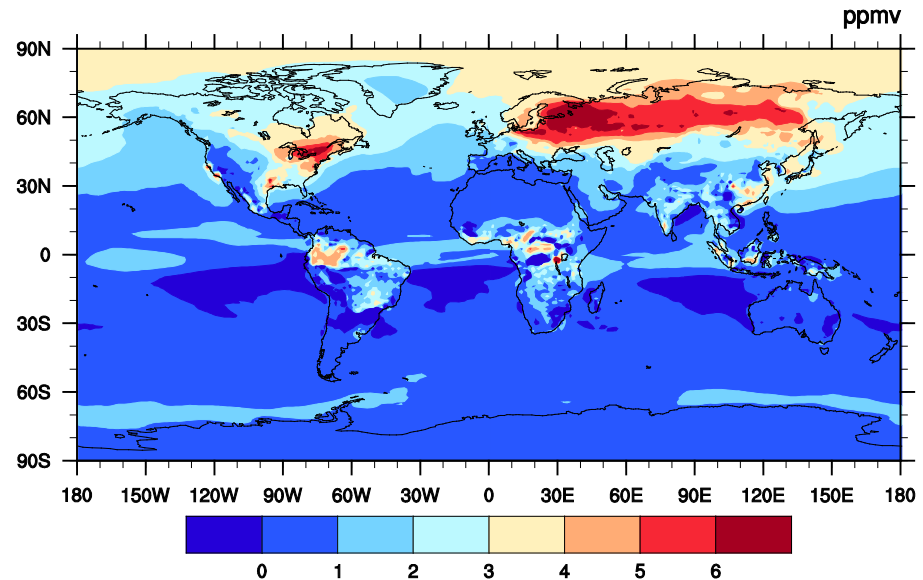
- CMIP5 runs nearly complete
  - Control, 20<sup>th</sup> C, RCPs, 1% CO<sub>2</sub> Ramp
  - Misc sensitivity experiments are ongoing
  - Imminent submission of 1<sup>st</sup> CESM Journal of Climate Special Collection papers
- Public Release of Model Output
- Evaluate impact of model updates (CLM-CN, POP-BEC, CAM5) on CMIP results

# CO<sub>2</sub> Seasonal Cycle Amplitude

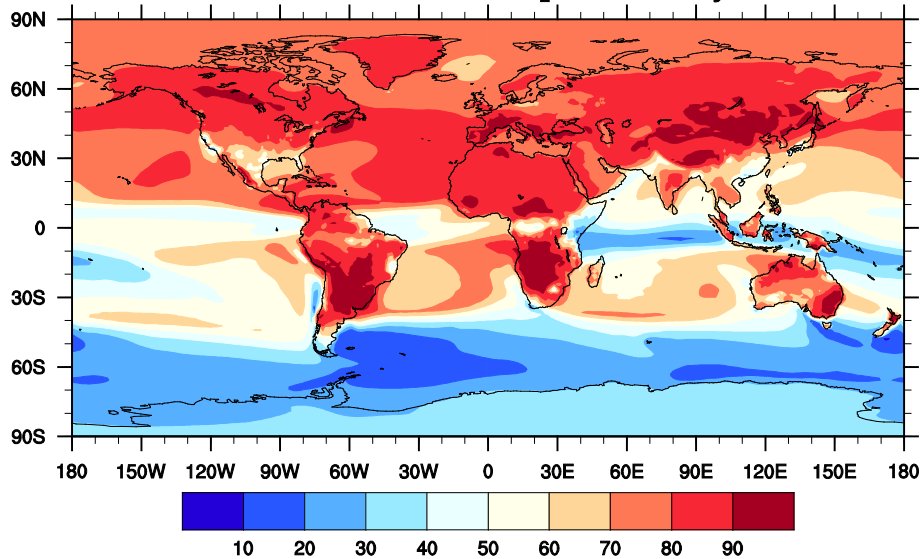
CO<sub>2</sub> Seasonal Cycle, 20C Amplitude



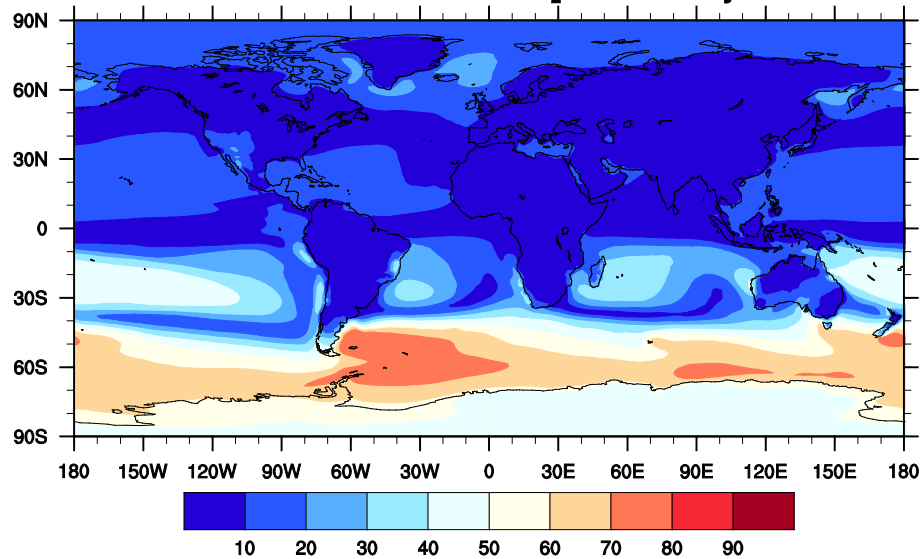
CO<sub>2</sub> Seasonal Cycle, 20C Amplitude - 1850 Amplitude



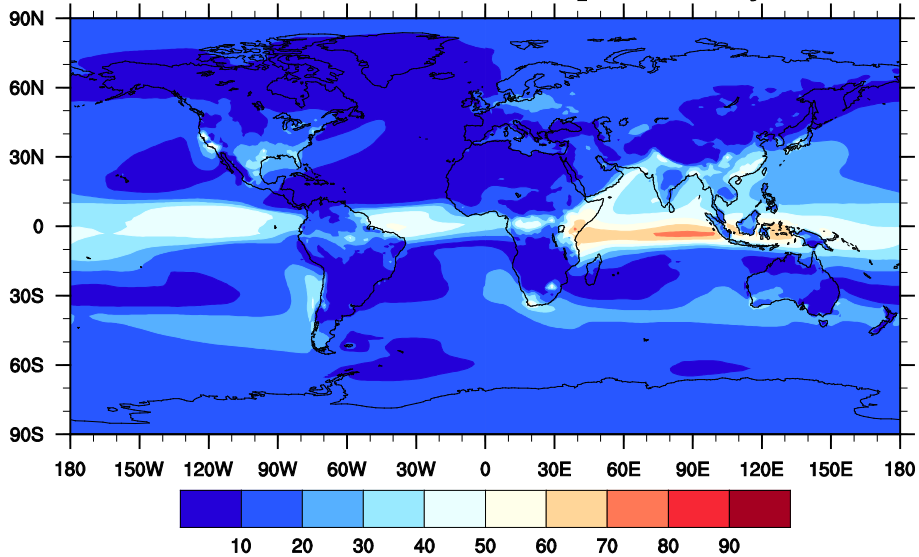
### Land Contribution to CO<sub>2</sub> Seasonal Cycle



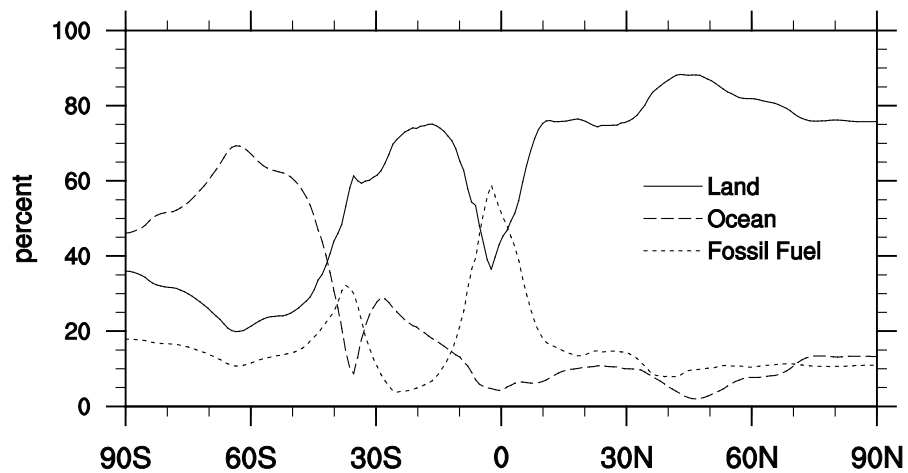
### Ocean Contribution to CO<sub>2</sub> Seasonal Cycle



### Fossil Fuel Contribution to CO<sub>2</sub> Seasonal Cycle

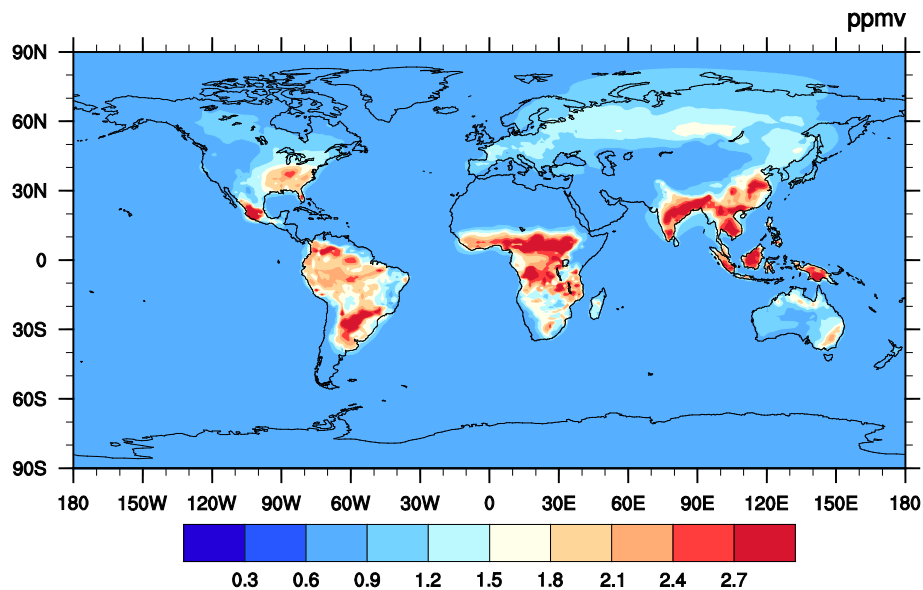


### Contribution to CO<sub>2</sub> Zonal Mean Seasonal Cycle

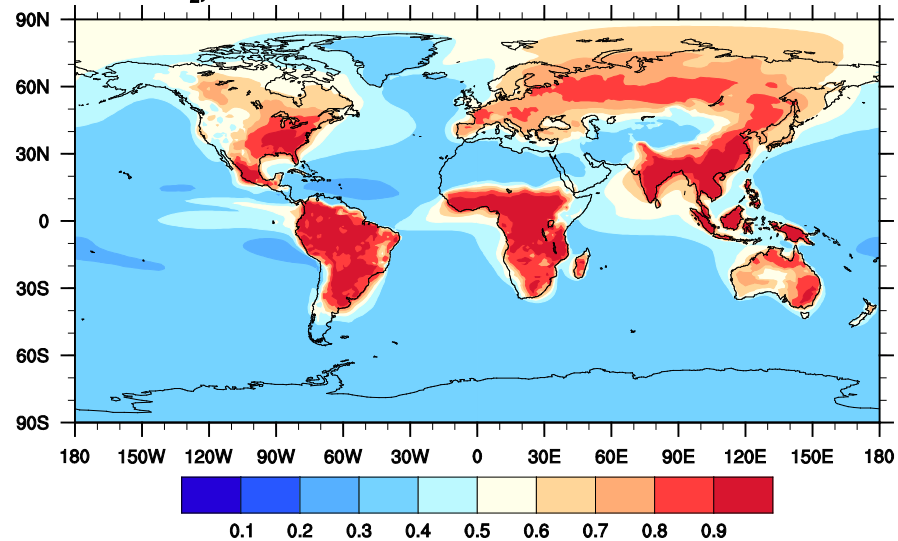




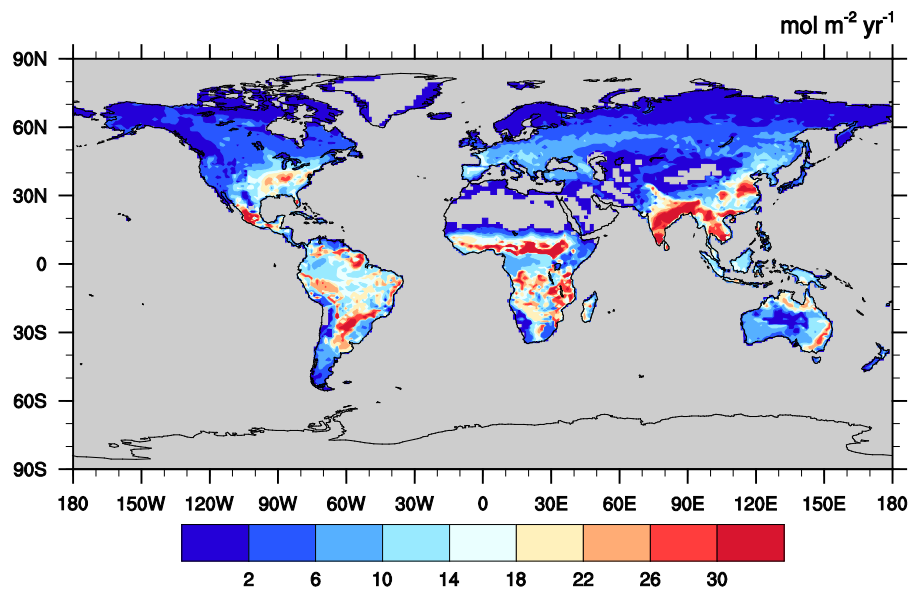
### Surface CO<sub>2</sub> Interannual RMS



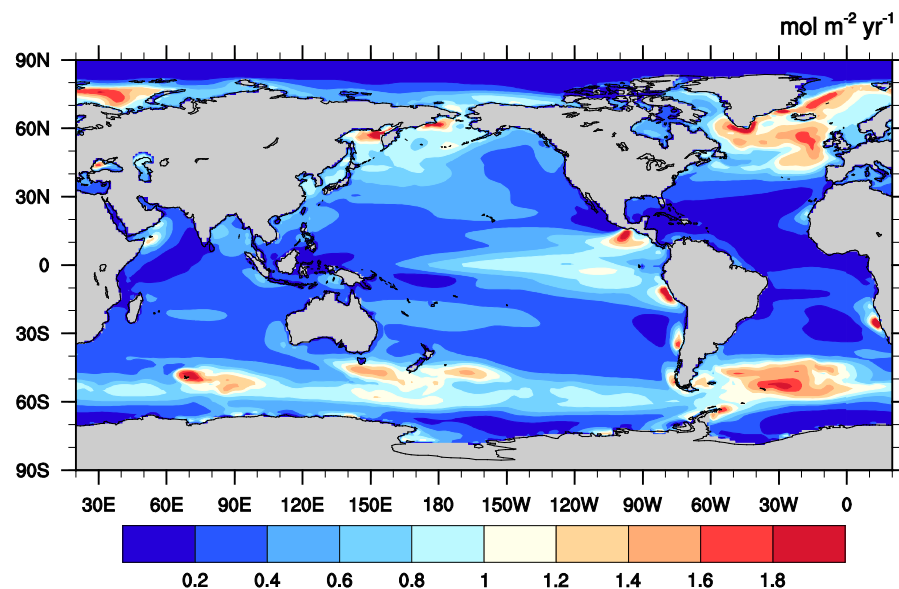
### Surface CO<sub>2</sub>, Fraction of Interannual Variance in Sub-decadal Band



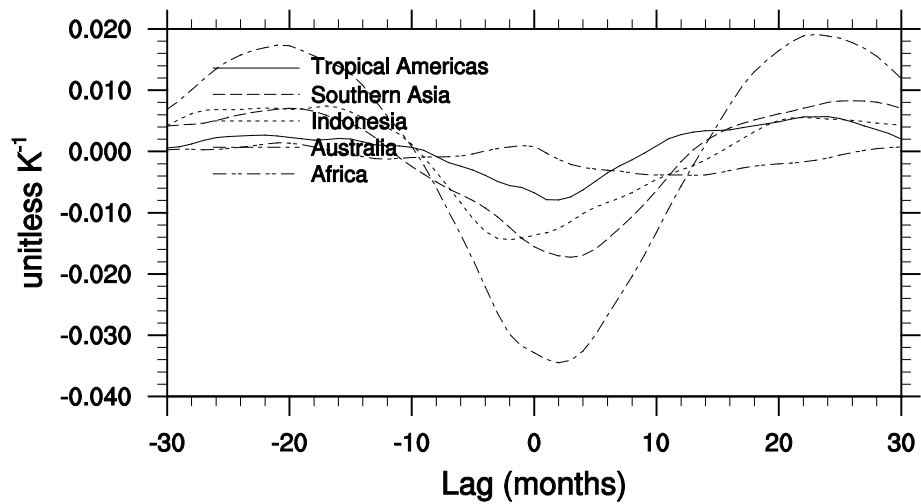
### Land-to-Air CO<sub>2</sub> Flux Interannual RMS



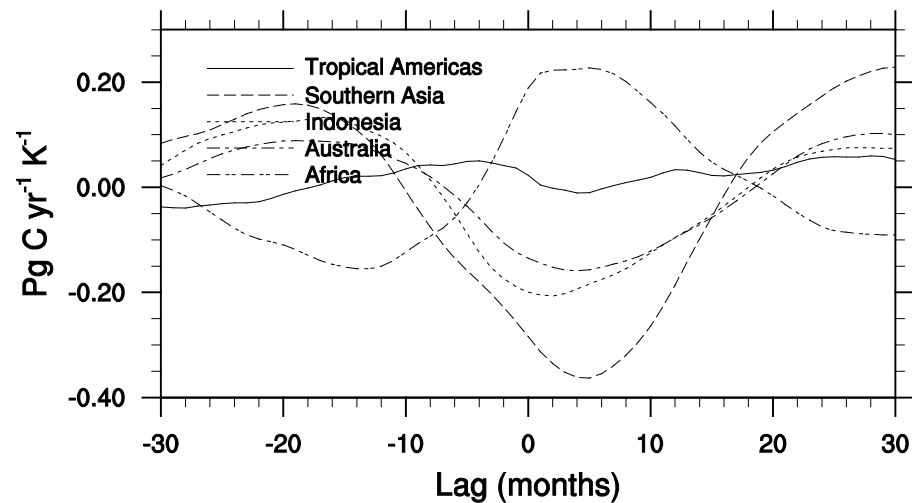
### Sea-to-Air CO<sub>2</sub> Flux Interannual RMS



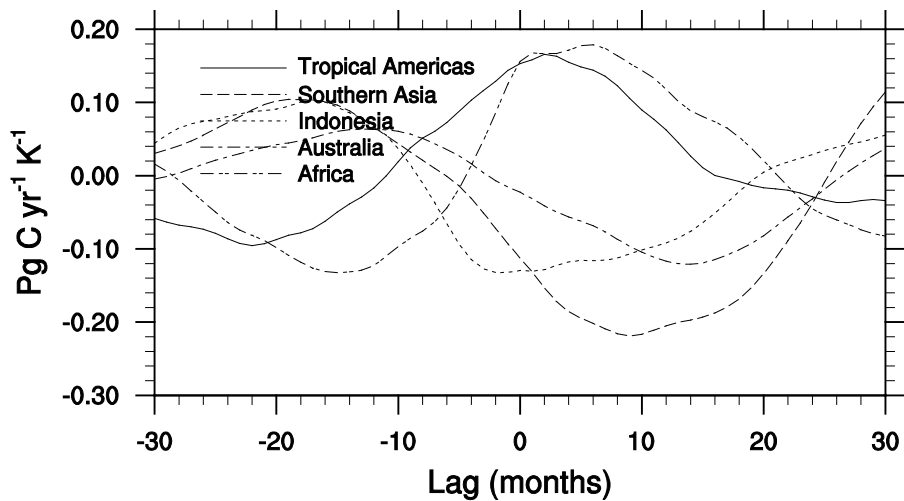
### BTRAN



### GPP



### ER



### AR

