Paleoclimate Simulations with CAM, SPCAM and CESM

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Goals

- Study Arctic cloud convective feedback mechanism with SPCAM

  1. Identify the minimum CO2 concentration which leads to the melting of winter sea ice and to the activation of the convective cloud feedback

  2. Identify the transient vs equilibrated response of the feedback during a transient simulation of increased CO2 concentration.

Goals (cont.)

3. Study the response of the SPCAM over the arctic and continental interiors to increased CO2 concentration under Eocene boundary conditions (Purdue simulations)

Completed Work

Standard CAM + slab ocean model followed by SPCAM + slab ocean model for:

- 16xPI CO2 concentration (~4480ppm)
- 4xPI CO2 concentration (start from prior CCSM experiment)

Slab Ocean Model (SOM)

1. Run model with fixed SSTs for a reasonable amount of time and compute Q-fluxes.
2. Also compute mixed-layer depth (in these simulations a constant mixed-layer depth of 50m was used for the entire globe)
3. Use the Q-fluxes to drive the SOM.

must do this separately for CAM and SPCAM!

Compute monthly mean net flux into the ocean from the control simulation:

$$F = FS - FL - LH - SH$$

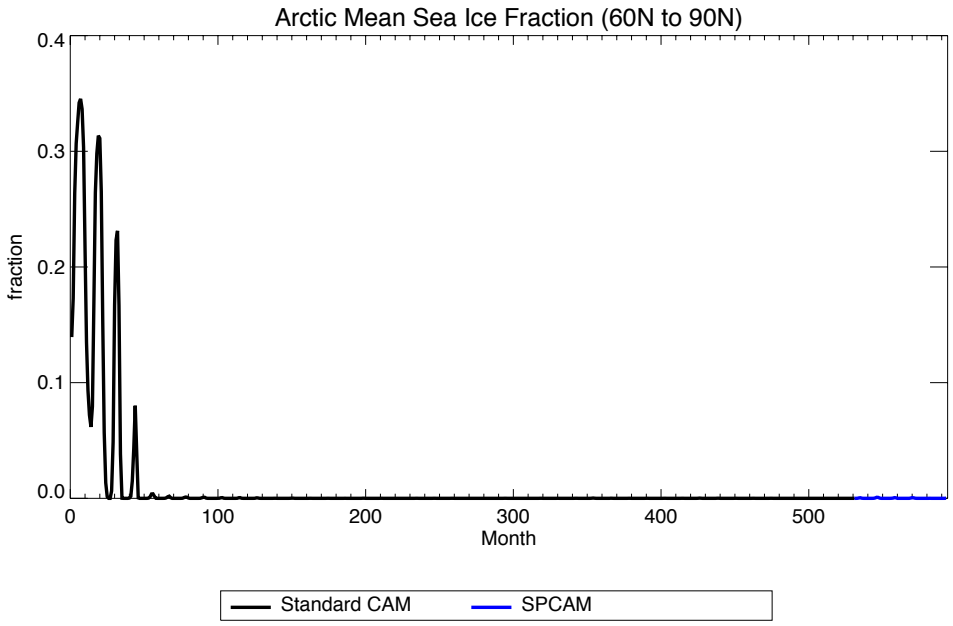
where FS = net shortwave flux

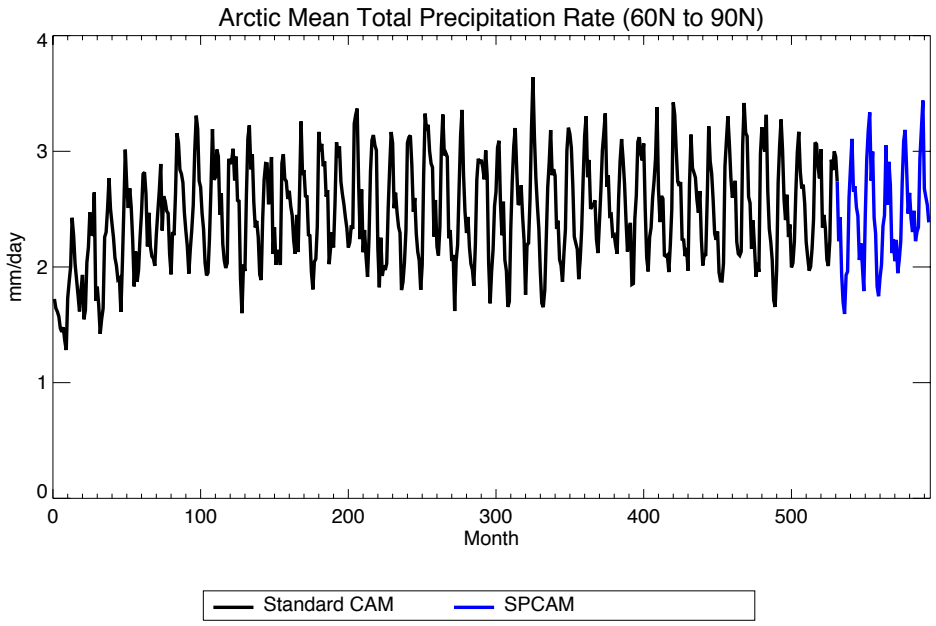
FL = net longwave flux

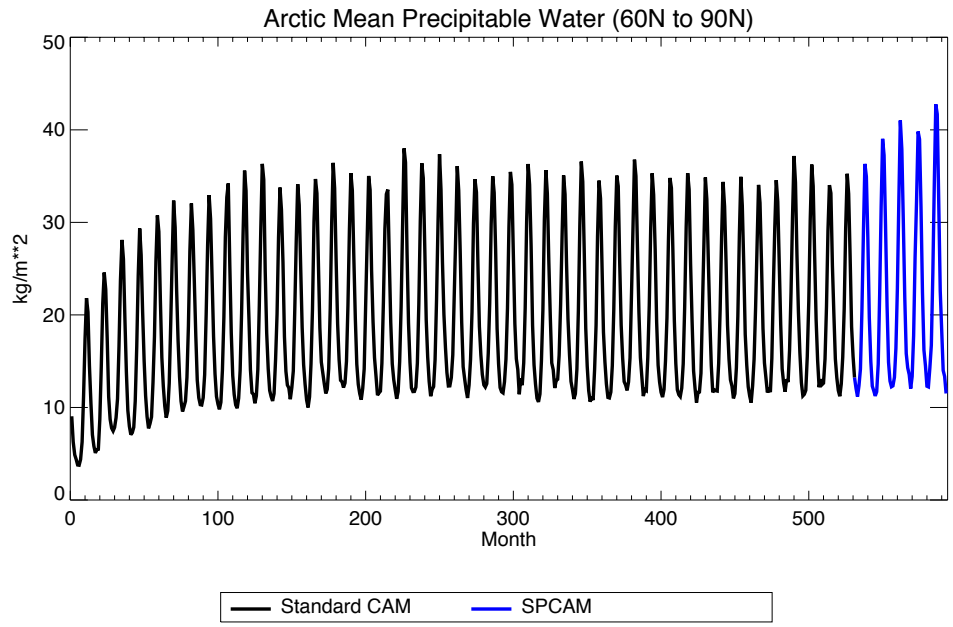
LH = latent heat flux

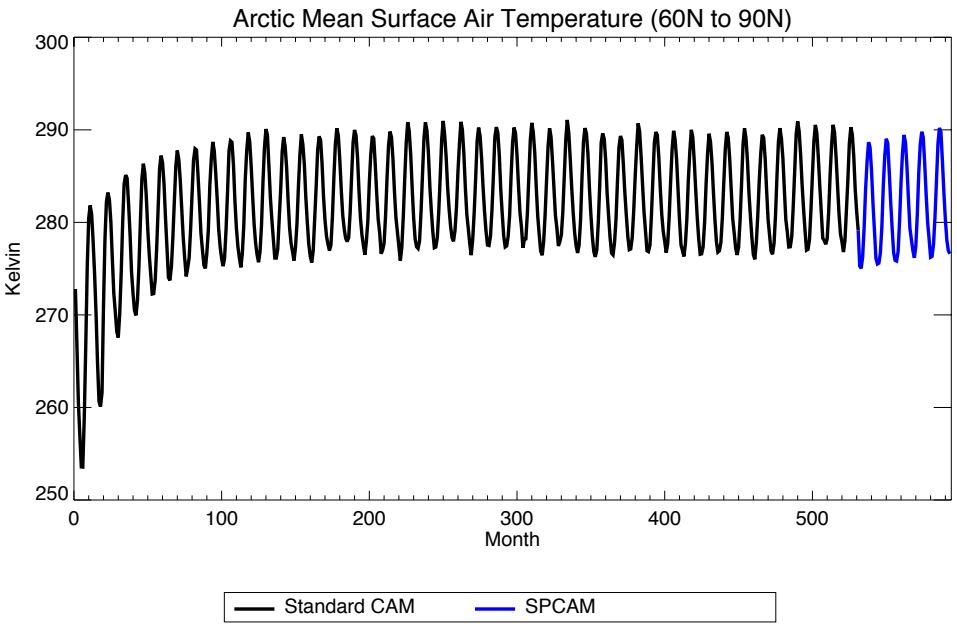
SH = sensible heat flux

16xPI CO2

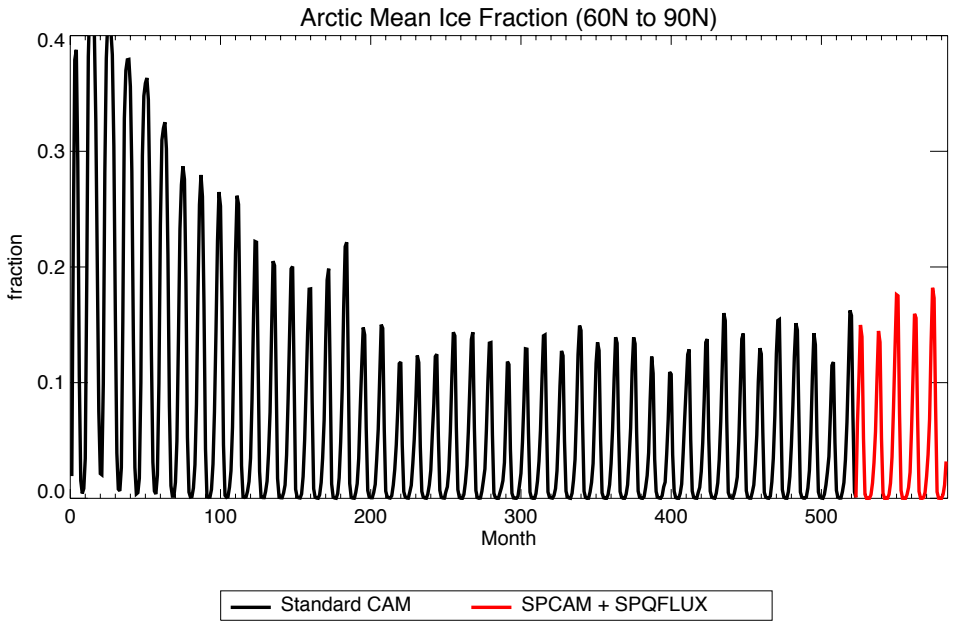

Arctic Mean Sea Ice Fraction (60N to 90N)
fraction
Month
Standard CAM
SPCAM

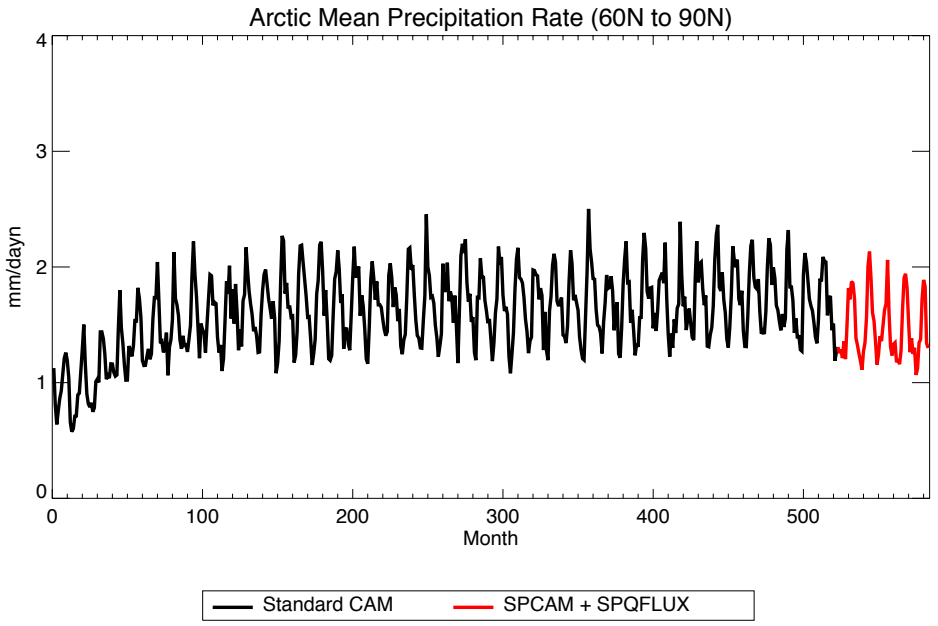

Arctic Mean Total Precipitation Rate (60N to 90N)
mm/day
Month
Standard CAM
SPCAM

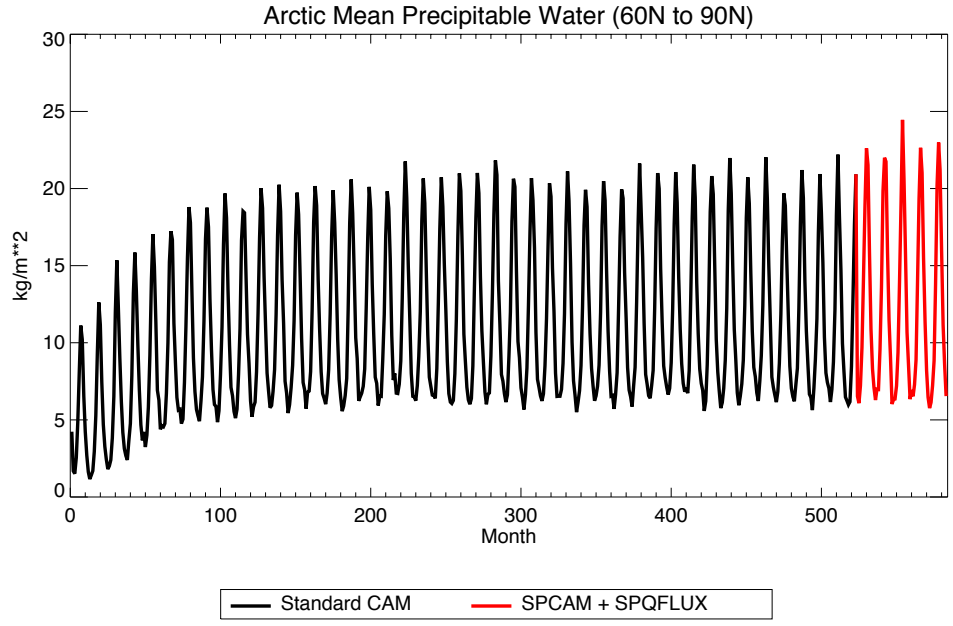

Arctic Mean Precipitable Water (60N to 90N)
kg/m**2
Month
Standard CAM
SPCAM

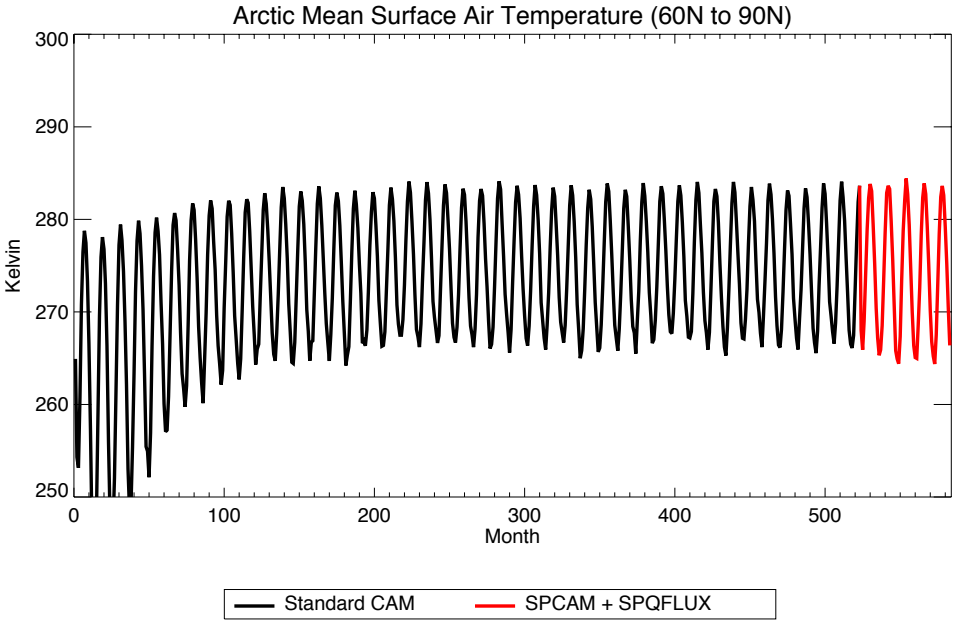

Arctic Mean Surface Air Temperature (60N to 90N)
Kelvin
Month
Standard CAM
SPCAM

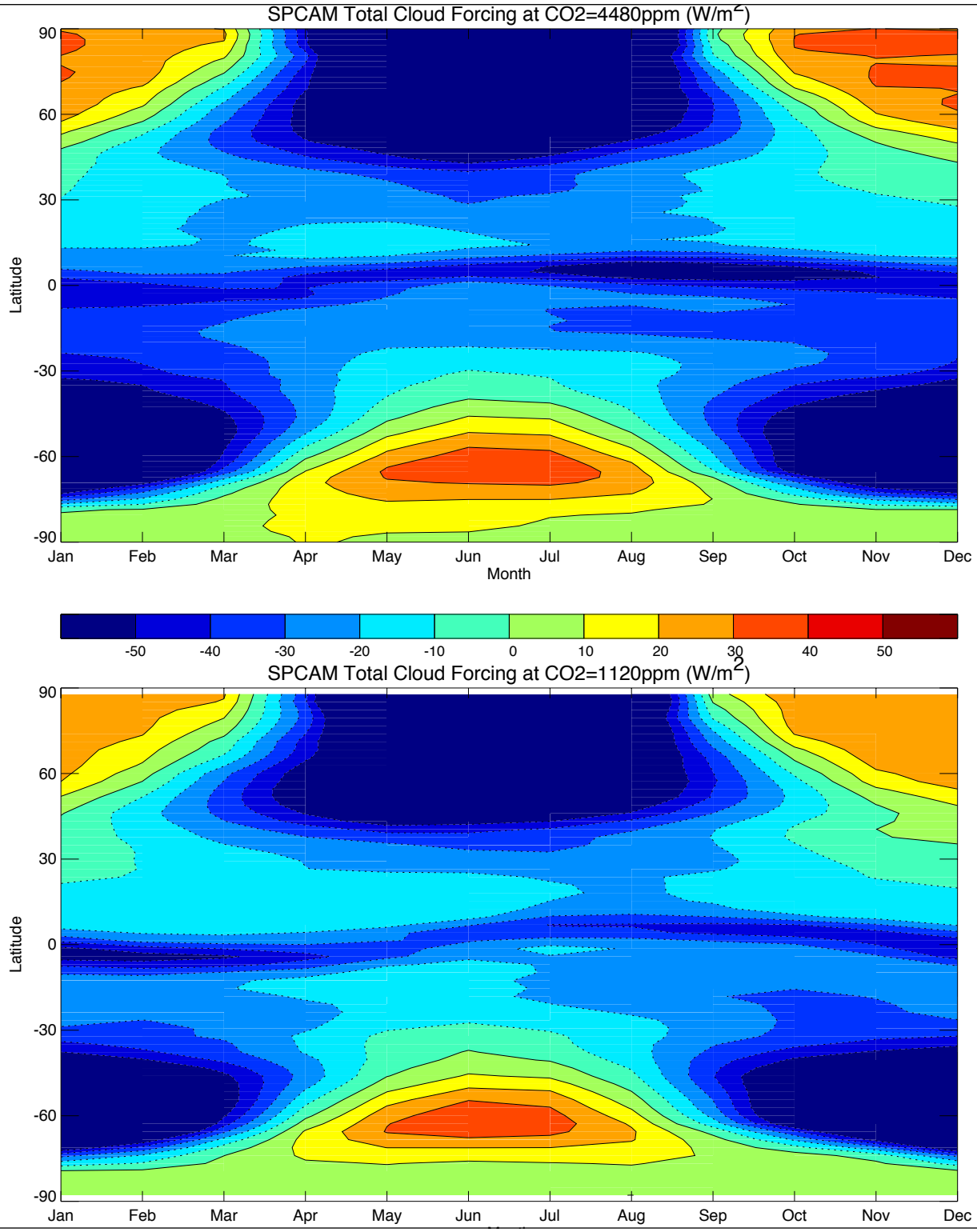
4xPI CO2


Arctic Mean Ice Fraction (60N to 90N)
fraction
Month
0.0
0.1
0.2
0.3
0.4
0
100
200
300
400
500
Standard CAM
SPCAM + SPQFLUX


Arctic Mean Precipitation Rate (60N to 90N)
mm/dayn
Month
0
1
2
3
4
0
100
200
300
400
500
Standard CAM
SPCAM + SPQFLUX


Arctic Mean Precipitable Water (60N to 90N)
kg/m**2
Month
0
5
10
15
20
25
30
0
100
200
300
400
500
Standard CAM
SPCAM + SPQFLUX


Arctic Mean Surface Air Temperature (60N to 90N)
Kelvin
Month
250
260
270
280
290
300
0
100
200
300
400
500
Standard CAM
SPCAM + SPQFLUX


SPCAM Total Cloud Forcing at CO2=4480ppm (W/m2)
90
60
30
0
-30
-60
-90
Latitude
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
-50
-40
-30
-20
-10
0
10
20
30
40
50
SPCAM Total Cloud Forcing at CO2=1120ppm (W/m2)
90
60
30
0
-30
-60
-90
Latitude
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Ongoing Work

Fully-coupled CESM simulation: B_1850_2000_CN

- 1850 to 2000 transient
- "CN" = active carbon-nitrogen model in CLM
- using CAM4 physics
- "f19_g16" grid setup: finite volume 2deg grid for atmos, 1deg displaced-pole ocean grid

Ongoing Work

step 1: spinup: 25 years starting from 1850 but holding all trace gases constant.

step 2: 1% per year increase CO2 ==> 3xPI

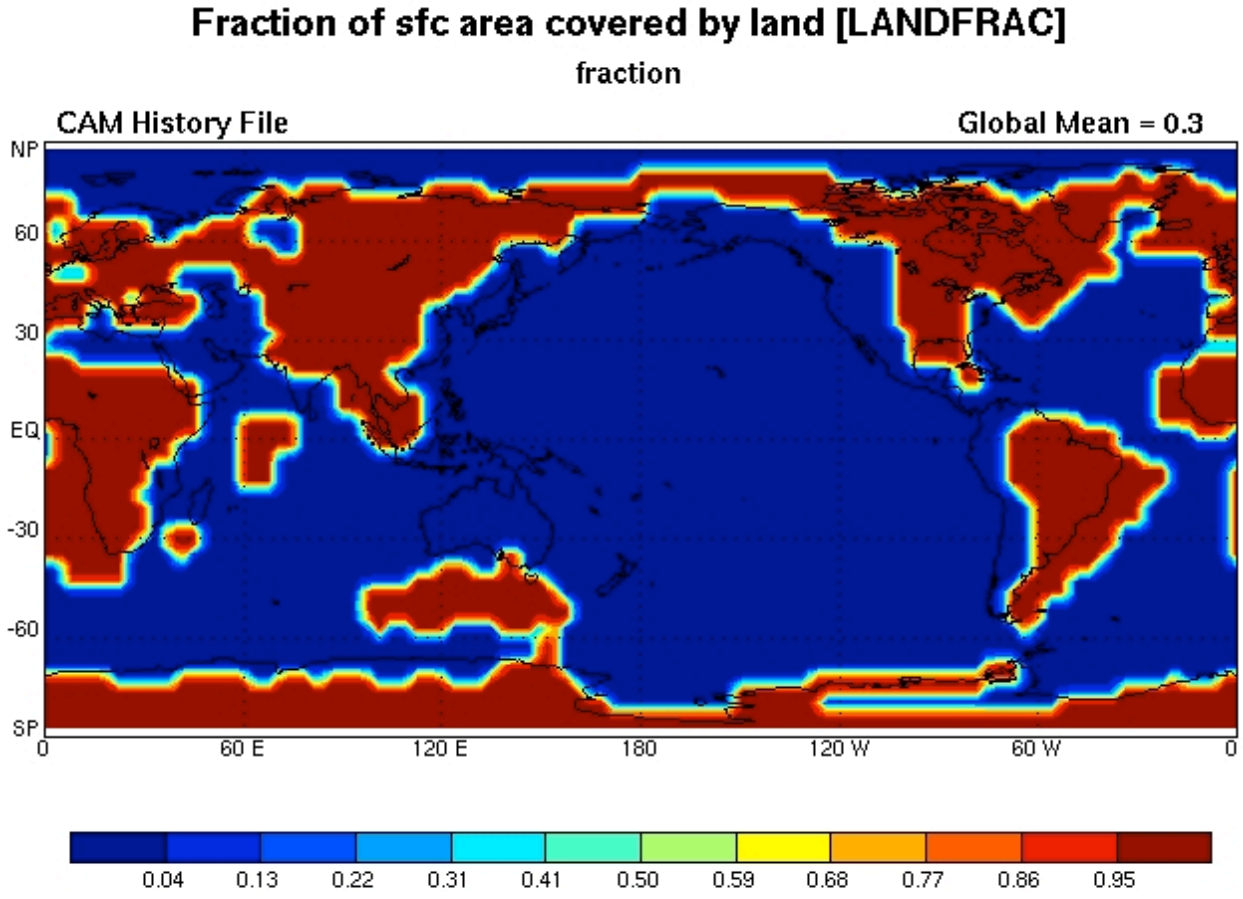
step 3: run two SPCAM simulations initialized from this run at:

- when Arctic sea ice has decreased by 50%
- at end of this fully-coupled simulation

CESM is a whole different animal than CCSM3.

- Good: canned cases, optimized for many popular supercomputers (bluefire, franklin, etc.)
- More steps, tougher to tweak the details

Eocene Land Fraction



Previous CCSM Simulation: The World Without Sun

- How long after you turn the sun off before the oceans freeze over (at the surface)
- www.nickdavisproductions.com