State of the Community Climate System Model

Peter Gent

Chairman

CCSM Scientific Steering Committee

Scientific Priorities for CCSM4

- **Improve the tropical Pacific and ENSO simulations; reduce SST biases as much as possible.**
- **Include biogeochemistry and ocean ecosystem model for the carbon cycle.**
- **Include both the direct and indirect effects of aerosols.**
- **Include interactive vegetation and land use changes in the land component.**
- **Include an atmospheric chemistry component in CAM4.**
- **Include a land ice sheet component.**

Climate-carbon cycle feedback analysis

- Following Friedlingstein et al. 2006:

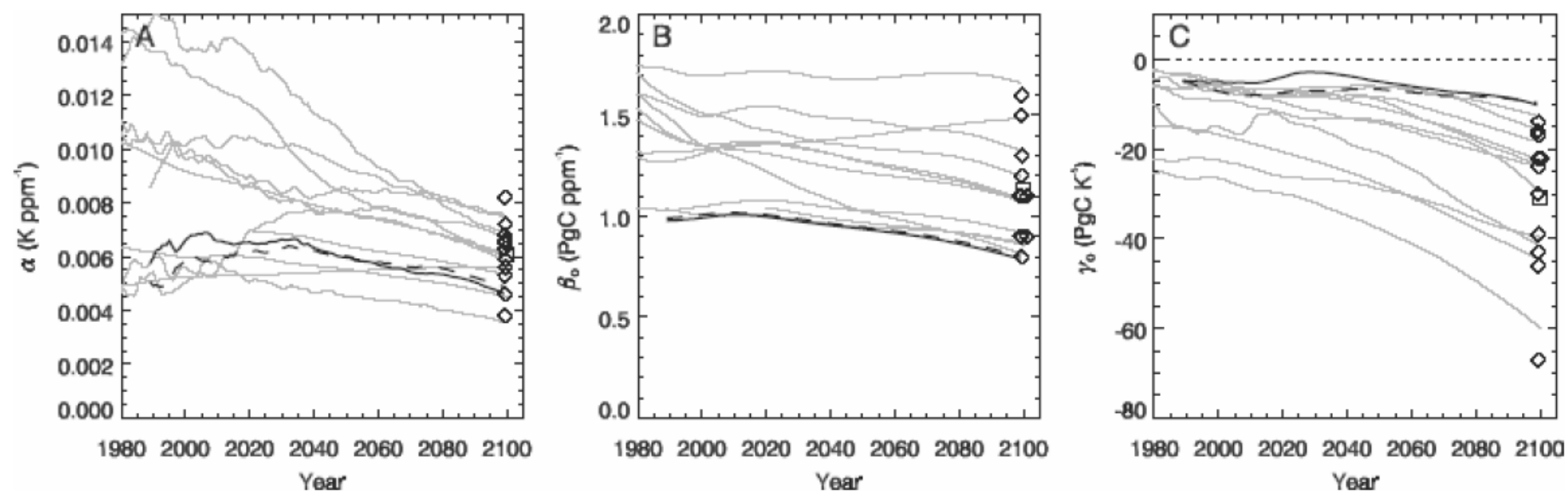
$$\text{Gain} \approx -\alpha \, (\gamma_L + \gamma_O) \, / \, (1 + \beta_L + \beta_O)$$

(K ppm^{-1}) α = transient climate sensitivity to CO_2

(PgC ppm^{-1}) β = (land or ocean) carbon storage sensitivity to CO_2

(PgC K^{-1}) γ = (land or ocean) carbon storage sensitivity to climate

Atmosphere and ocean components of climate-carbon cycle feedback

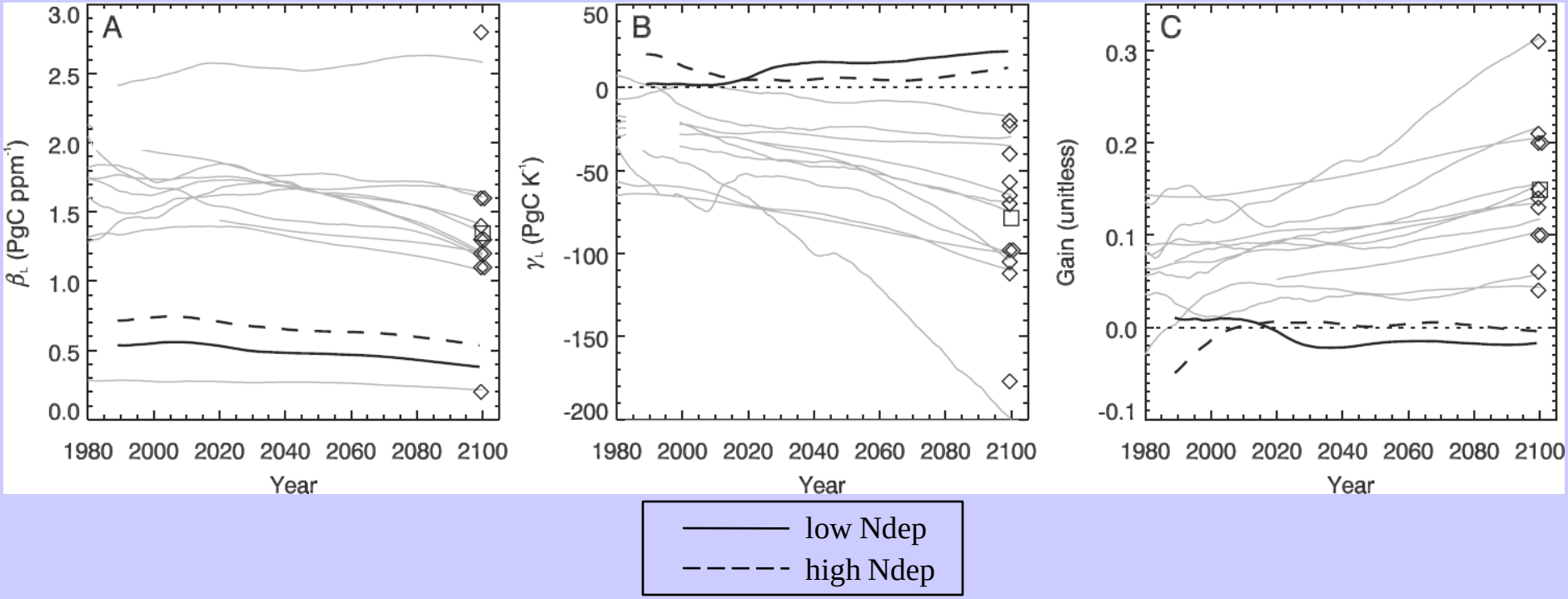


low Ndep
high Ndep

Lighter lines are other C4MIP models with just a carbon cycle

Thornton et al., in review

Land components of climate-carbon cycle feedback



- Effect of C-N coupling on gamma_land is to **reduce** atmospheric CO2 by about **130 ppm** by 2100, compared to previous model results

- Net climate-carbon cycle feedback gain (including ocean response) is nearly neutral or negative, compared to positive feedback for previous models.

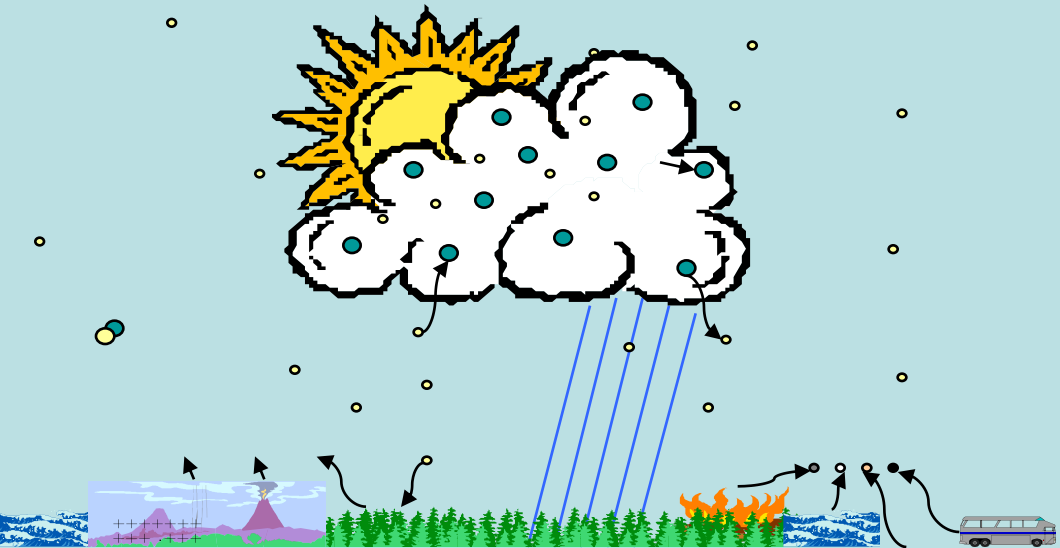
Aerosol Indirect Effects in CAM

Steve Ghan, Xiaohong Liu, Richard Easter: PNNL

Andrew Gettelman, Phil Rasch, Hugh Morrison, Jean-Francois Lamarque, Peter Hess, Natalie Mahowald, Francis Vitt: NCAR

Phillip Cameron-Smith, Cathy Chuang, Keith Grant: LLNL

Annica Ekman: Stockholm University



SciDAC
Scientific Discovery through Advanced Computing
Office of Science
U.S. DEPARTMENT OF ENERGY

Bulk model sensitivity tests

- Prognostic: online aerosol, NCAR emissions
- Prescribed: offline aerosol from prognostic aerosol history
- AEROCOM: online aerosol, AEROCOM emissions

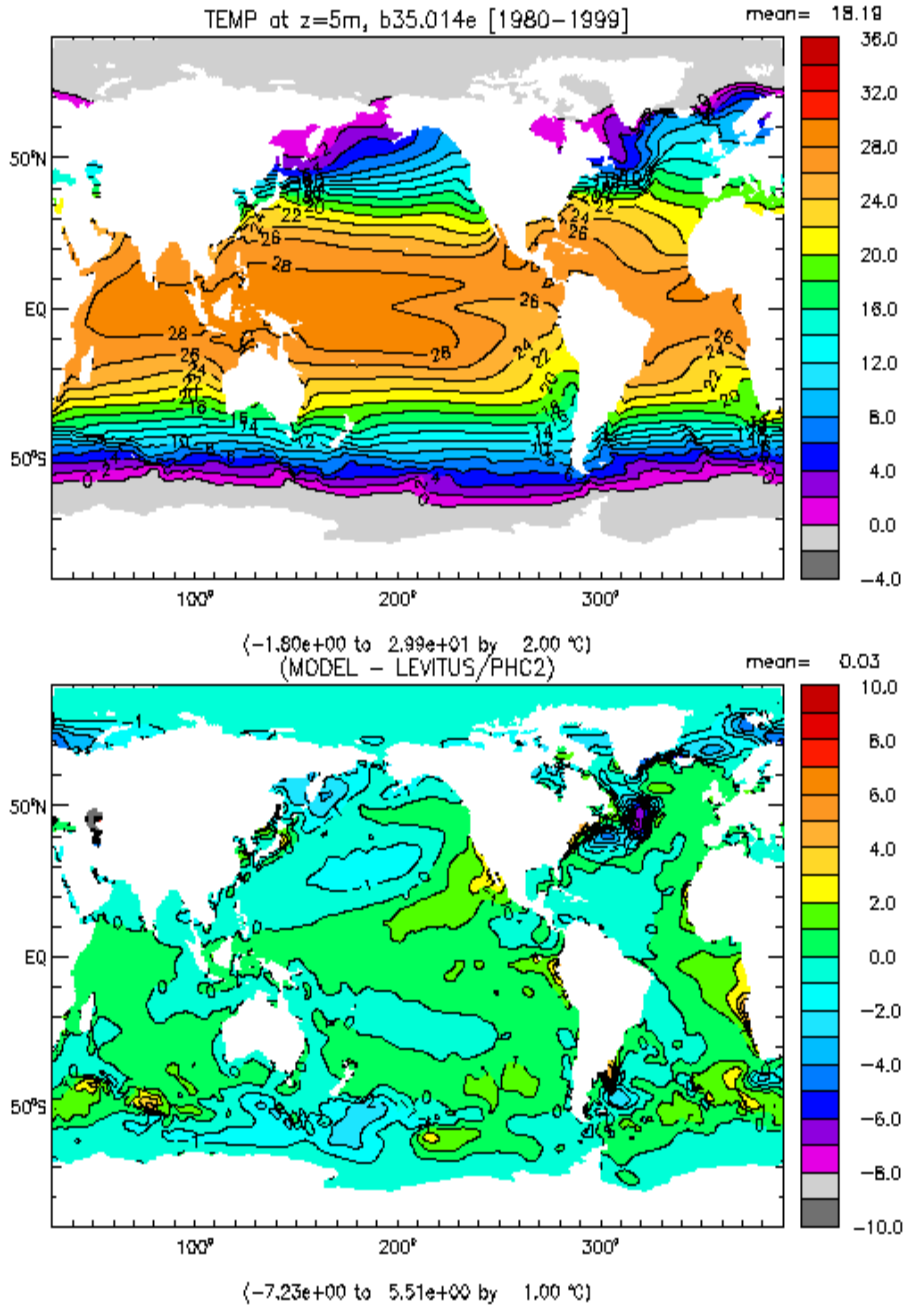
Experiment	ΔTOA (Wm^{-2})	ΔFdirect (Wm^{-2})	ΔFindirect (Wm^{-2})
Prognostic	-2.8	-0.73	-2.0
Prescribed	-3.0	-0.67	-2.3
Aerocom	-1.6	-0.49	-1.1

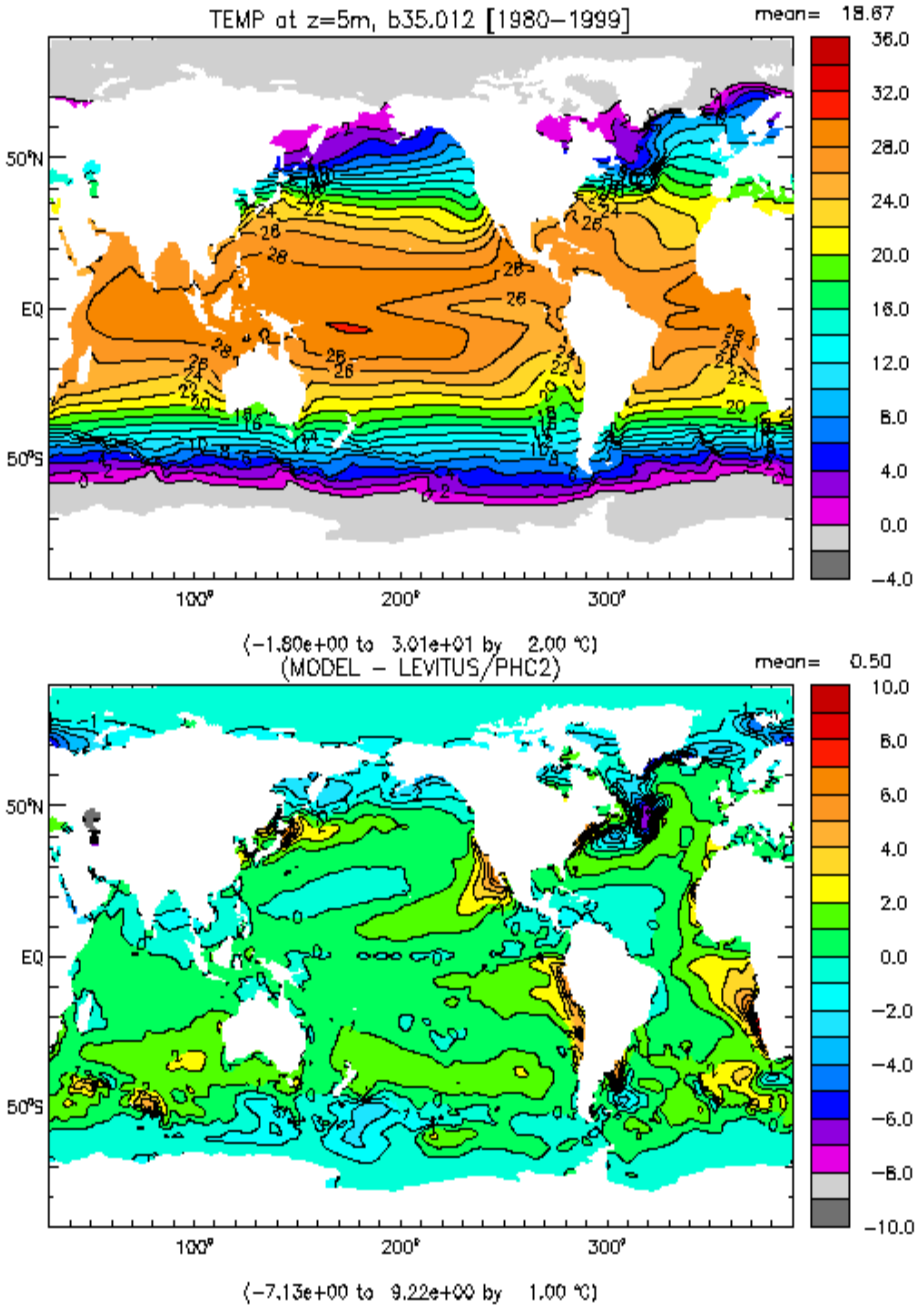
Trade-offs

- Bulk aerosol
  - is faster
  - is on the trunk
  - produces an acceptable indirect effect with AEROCOM emissions
- Modal aerosol
  - allows size distribution to vary in a realistic manner
  - treats aging to internal mixtures
  - produces a smaller indirect effect

Short-term Simulations/Forecasts

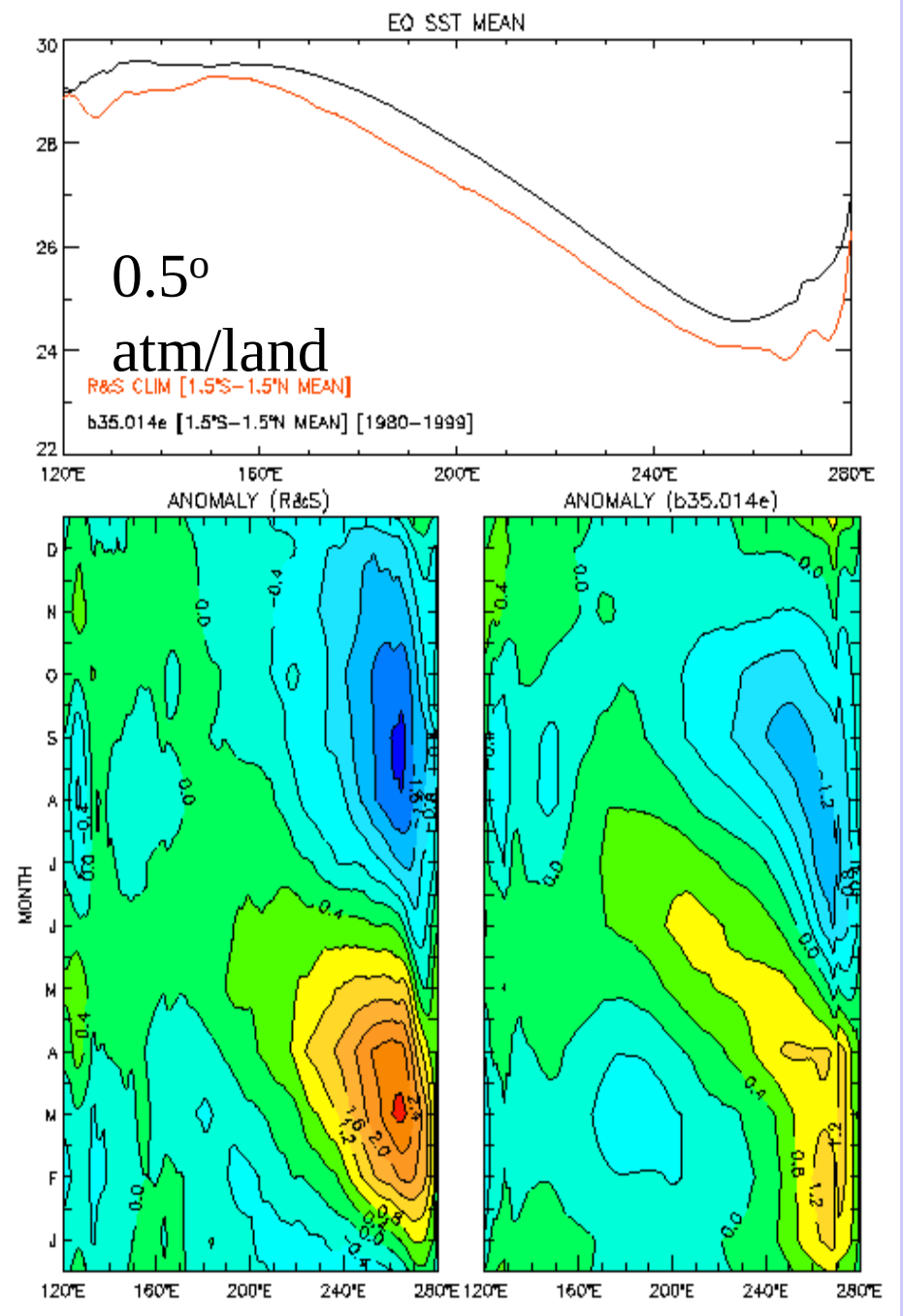
- **Use higher 0.5^{o} resolution atmosphere and land.**
- **Run from 1980 – 2000 using observed forcing, and then from 2000 – 2030 using the A1B scenario.**
- **Have just interpolated 1980 atmosphere and land ICs from 20th Century run using ~2^{o} resolution.**
- **Do need to initialize the ocean for these runs?**
- **Idea is to improve near-term projections over USA.**

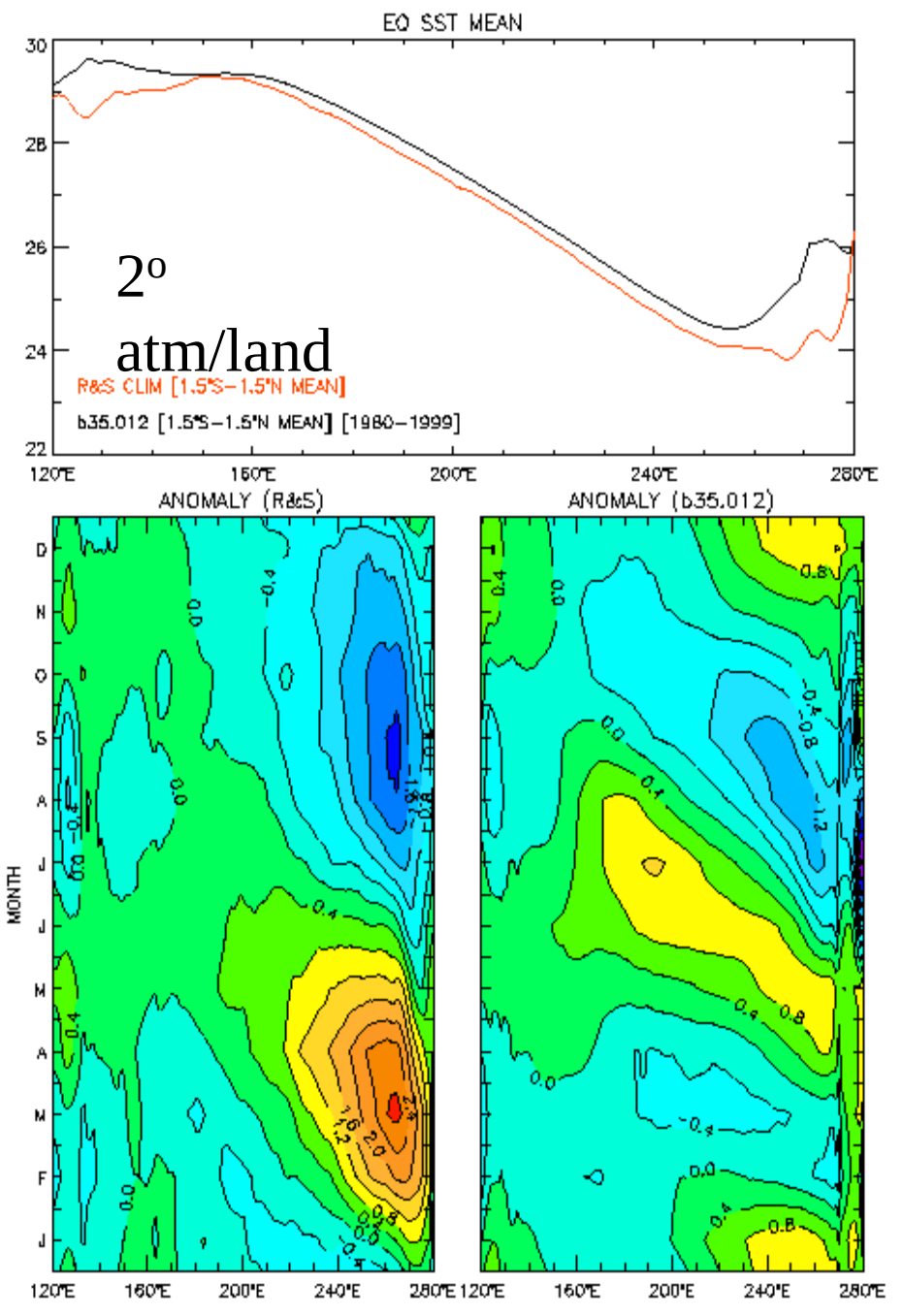


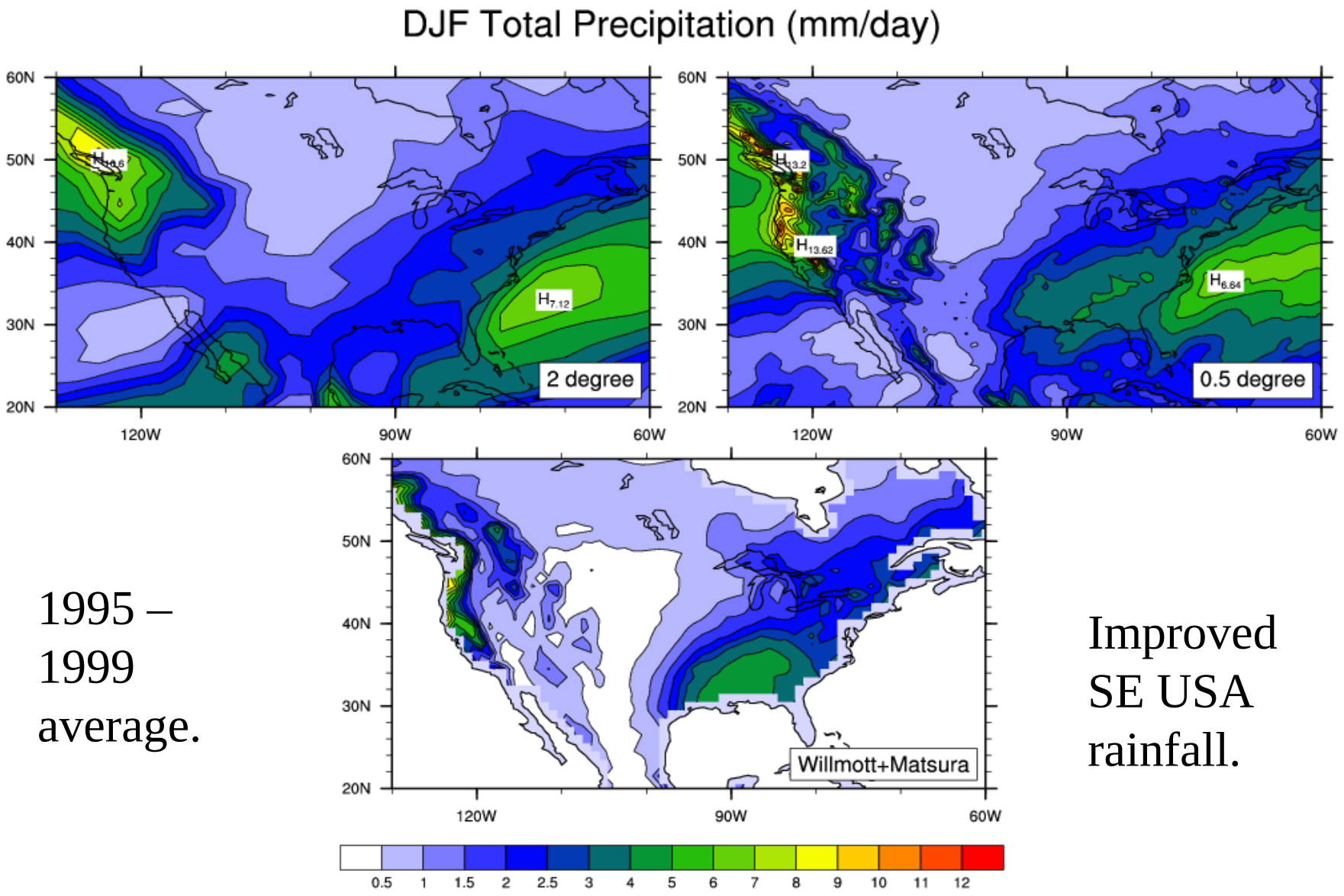


0.5° atmosphere/land

2°

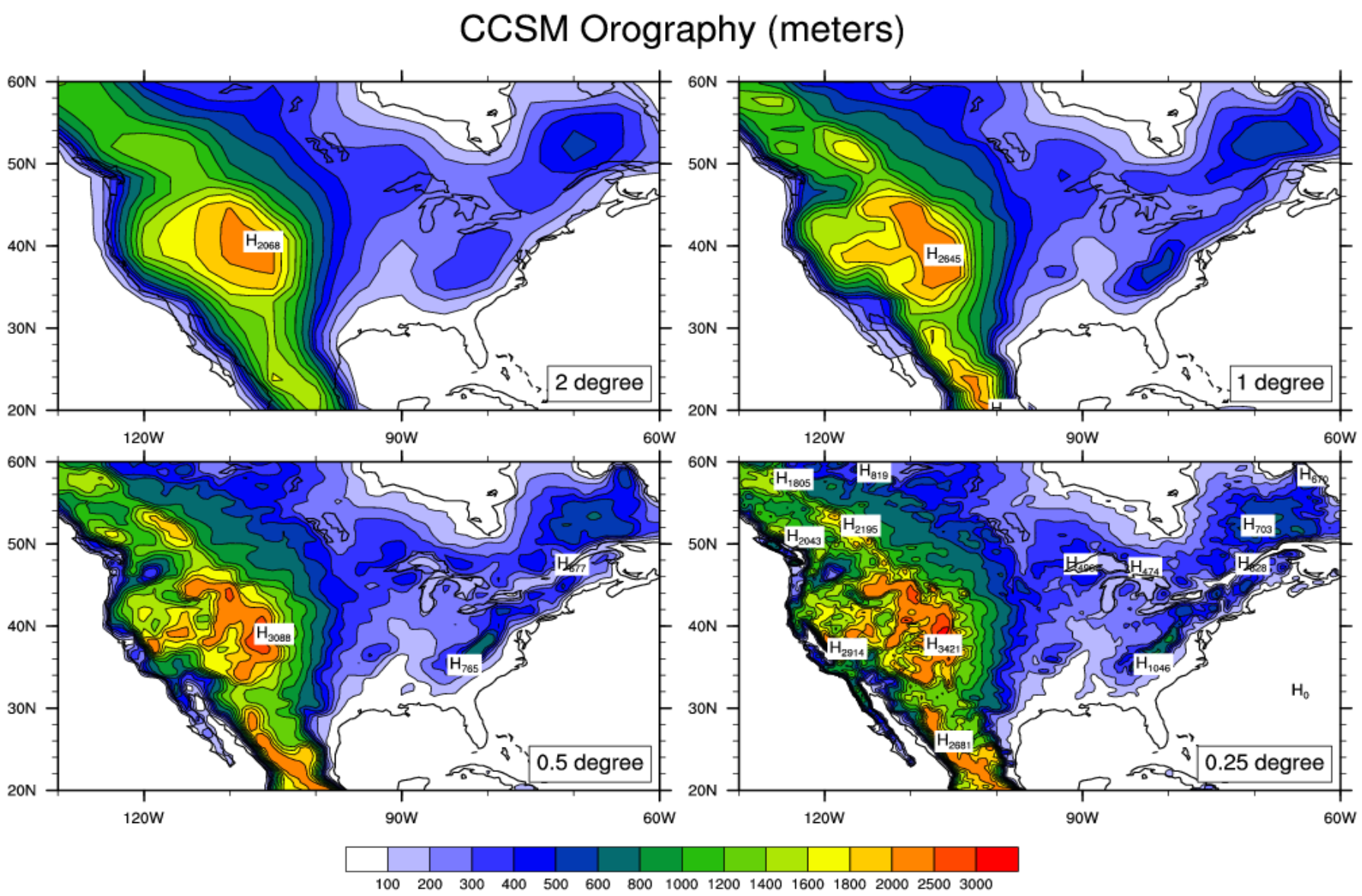

EQ SST MEAN
0.5º
atm/land
R&S CLIM [1.5°S–1.5°N MEAN]
b35.014e [1.5°S–1.5°N MEAN] [1980–1999]
ANOMALY (R&S)
ANOMALY (b35.014e)
MONTH
120°E
160°E
200°E
240°E
280°E


EQ SST MEAN
2º
atm/land
R&S CLIM [1.5°S–1.5°N MEAN]
b35.012 [1.5°S–1.5°N MEAN] [1980–1999]
ANOMALY (R&S)
ANOMALY (b35.012)
MONTH
120°E
160°E
200°E
240°E
280°E



1995 – 1999 average.

Improved SE USA rainfall.


CCSM Orography (meters)
60N
50N
40N
30N
20N
120W
90W
60W
H2068
2 degree
H2645
1 degree
H3088
H765
0.5 degree
H1805
H819
H2195
H2043
H703
H474
H3421
H2914
H1046
H2681
H0
0.25 degree
100 200 300 400 500 600 800 1000 1200 1400 1600 1800 2000 2500 3000

Unstable Greenland ice sheet?

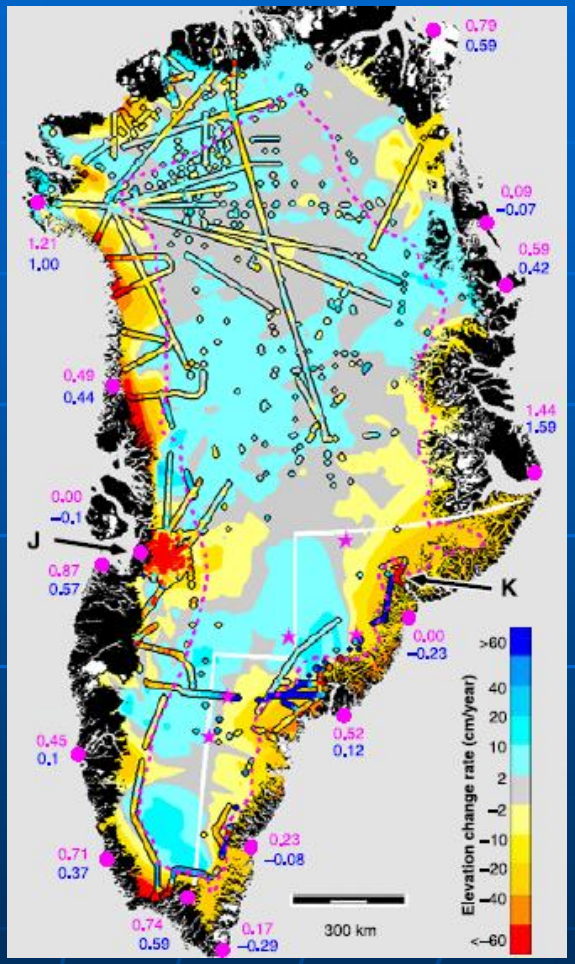
Surface melt on Greenland ice sheet descending into moulin, a vertical shaft carrying the water to base of ice sheet.

Source: Roger Braithwaite

Recent observations: Greenland

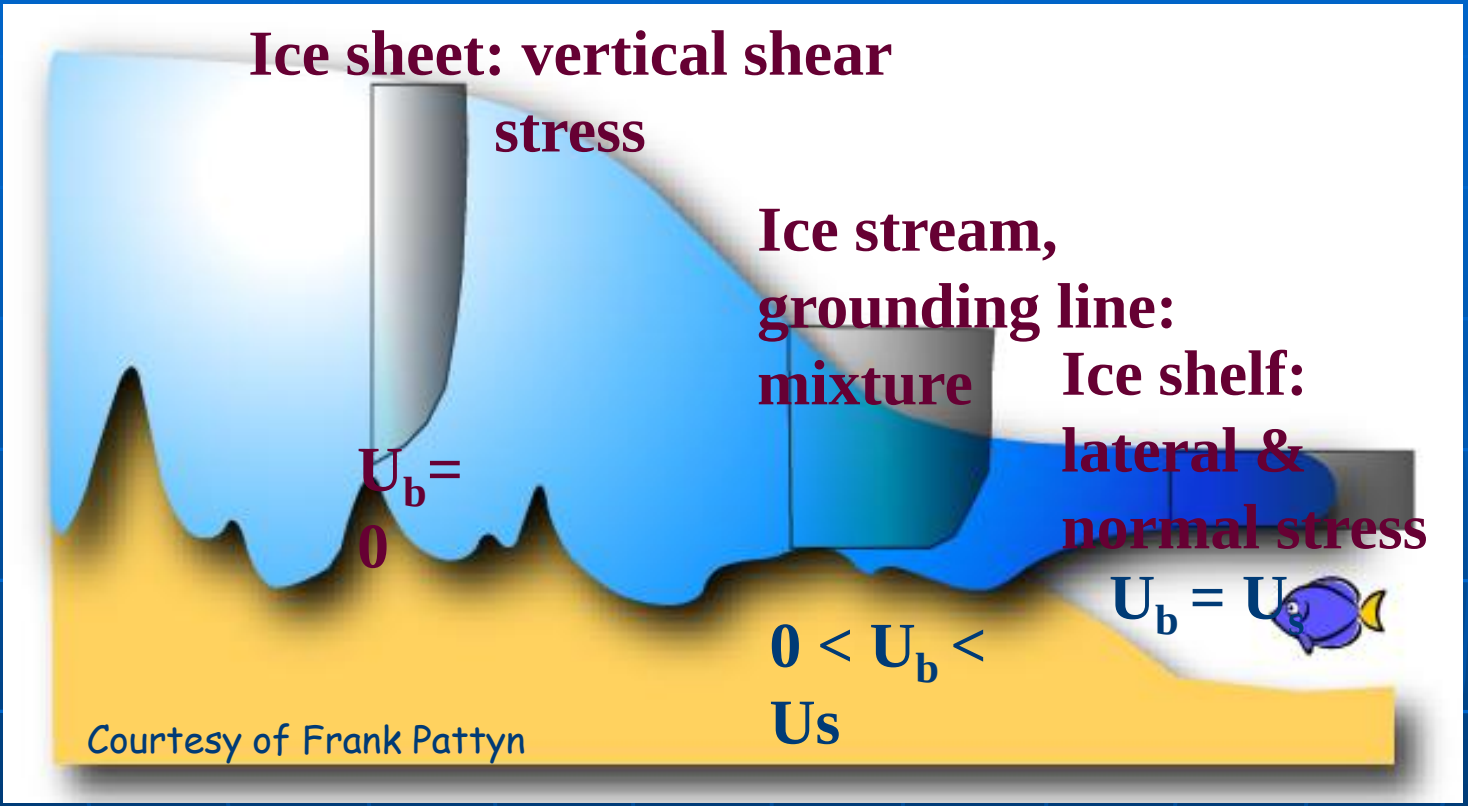
From Bill Lipscomb, LANL

- Laser altimetry shows rapid thinning near Greenland coast: ~0.20 mm/yr SLE
- Thinning is in part a dynamic response: possibly basal sliding due to increased drainage of surface meltwater.
- Ice observed to accelerate during summer melt season (Zwally et al., 2002)



Ice elevation change (Krabill et al., 2004)

Ice sheet dynamics



- Ice sheet interior: Gravity balanced by basal drag
- Ice shelves: No basal drag or vertical shear
- Transition regions: Need to solve complex 3D elliptic equations—still a research problem (e.g., Pattyn, 2003)

Current SSC Members and Terms

Dave Bader, PCMDI	CCPP Chief Scientist
Gordon Bonan, NCAR	7/31/2009
Chris Bretherton, U Washington	12/31/2008
Bill Collins, LBNL	12/31/2009
Scott Doney, WHOI	6/30/2010
Peter Gent, NCAR	6/30/2008
Steve Ghan, PNNL	12/31/2009
Jeff Kiehl, NCAR	6/30/2010
Bill Large, NCAR	CGD Director
Phil Rasch, NCAR	12/31/08
Steve Vavrus, U Wisconsin	6/30/2010
Mariana Vertenstein, NCAR	12/31/2008

CoChairs of Working Groups

Rotating off :=

Land WG: Steve Running, Univ of Montana

Ocean WG: Bill Large, NCAR

Software Engineering WG: Cecelia DeLuca, NCAR

Thanks for your terms as Cochairs

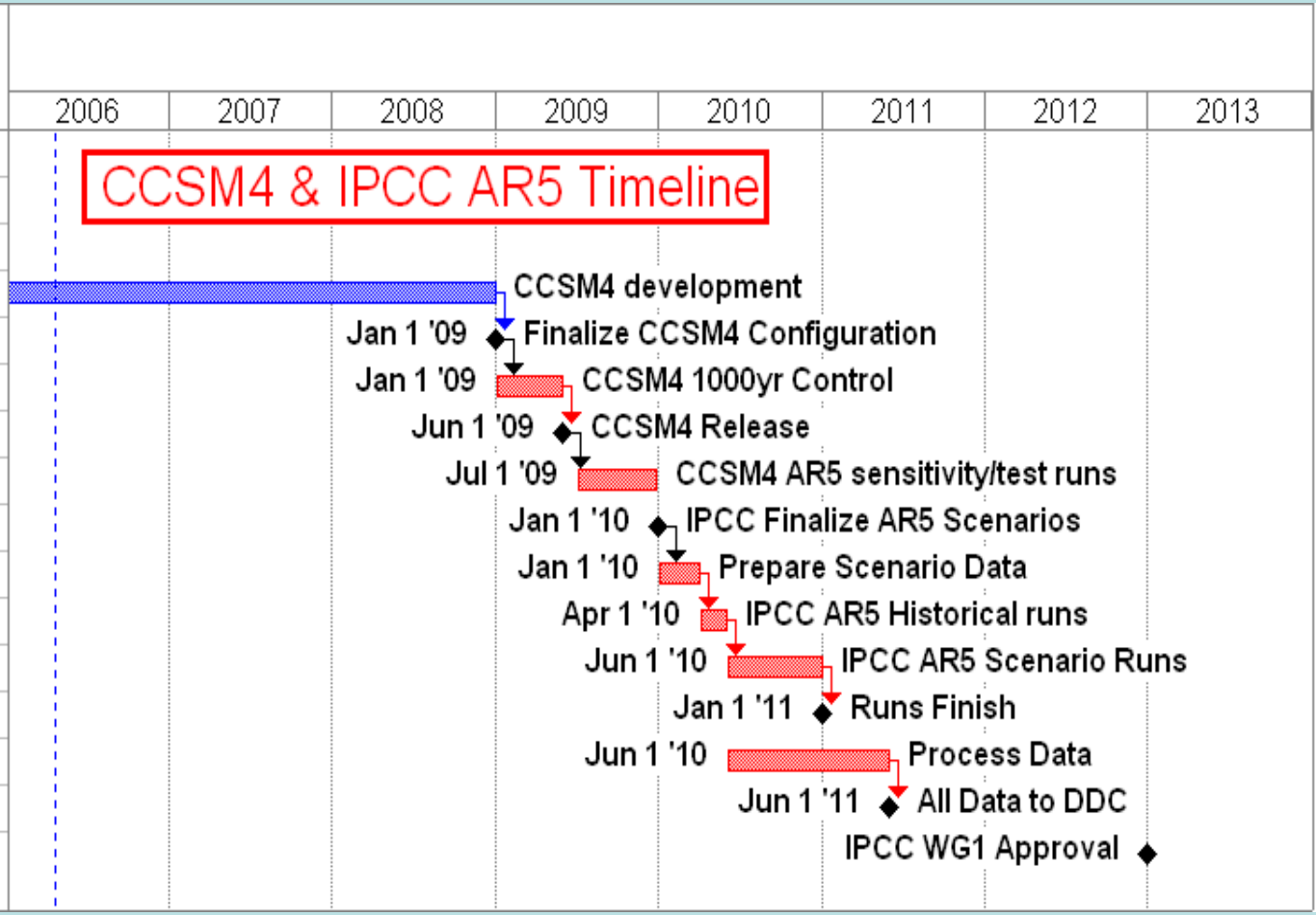
Starting terms :=

Land WG:

Ocean WG: Gokhan Danabasoglu, NCAR

Implementation Plan for CCSM 4

ID	Task Name
1	
2	
3	
4	CCSM4 development
5	Finalize CCSM4 Configuration
6	CCSM4 1000yr Control
7	CCSM4 Release
8	CCSM4 AR5 sensitivity/test runs
9	IPCC Finalize AR5 Scenarios
10	Prepare Scenario Data
11	IPCC AR5 Historical runs
12	IPCC AR5 Scenario Runs
13	Runs Finish
14	Process Data
15	All Data to DDC
16	IPCC WG1 Approval



CCSM 4 needs to be ready by the end of 2008 for AR5 in early 2013.

What needs to be done in the next year ?

- **The individual components of CCSM4 need to be finalized: the deadline is September 30.**
- **Then CCSM4 needs to be finalized; usually takes a few months, and 1870 control and 20th century runs made. Need high-res and low-res versions as well.**
- **Need to determine how to initialize future scenario runs for the carbon cycle, especially the ocean.**
- **Need to get much more experience with short-term simulations – do we have the correct format, what difference does initializing the ocean make, etc ?**