State of the Community Climate System Model

Peter Gent

Chairman

CCSM Scientific Steering Committee

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 best to initialize 20th and 21st century 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 ?**

New parameterizations CAM 3.5 to CAM 4

- **Morrison & Gettelman cloud microphysics.**
- **New RRTMG radiation scheme; Iacono and Collins.**
- **New modal aerosol scheme from Ghan and Liu.**
- **University of Washington shallow convection and boundary layer scheme from Bretherton and Park.**

First coupled run with all these in CAM, plus updated ocean, land and sea-ice (track 5) done in late Jan. However, the simulation had problems (warm SSTs, thin Arctic ice, and very large aerosol indirect effect).

Atmosphere WG and SSC Meetings in March

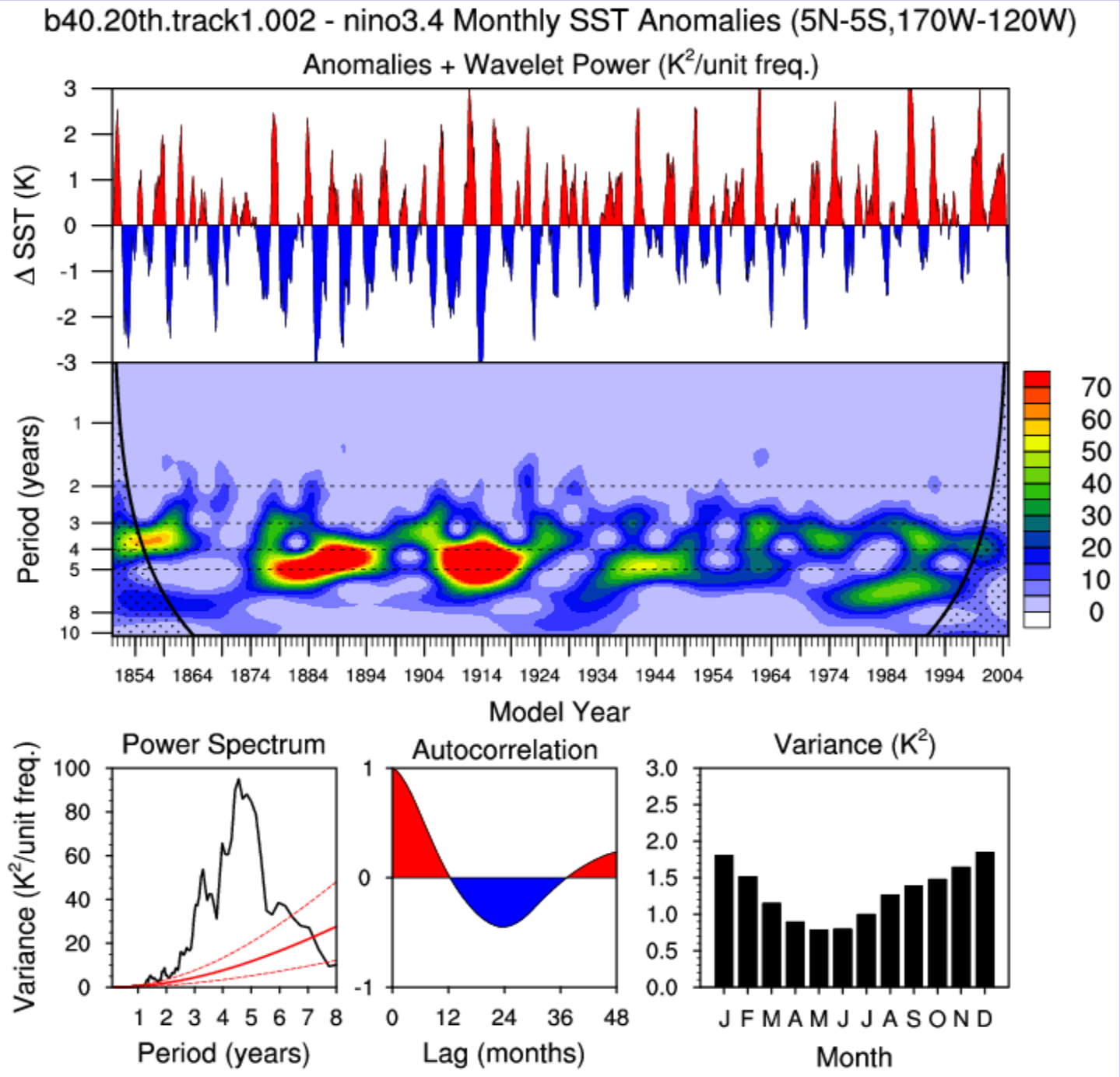
- **Atm WG decided that CAM 4 not ready to be used in carbon cycle 1850 Control and 20th Century runs.**
- **Safest option is to back off to CAM 3.5 (+), with the latest versions of the ocean, land and sea-ice (track 1).**
- **Downside is that it had been a prime goal for CCSM4 to include the indirect effect of aerosols; not in CCSM3.**
- **Upside is that it should be easier to get 1850 Control & 20th Century runs because tuning similar to CCSM3.**

What has been accomplished in the last three months?

Track 1 Runs: 2º atm/land, 1º ocean/ice

- **Present day control; no C/N, lower ice albedos (032b): well balanced at TOA to <0.1W/m^2, run for 600 years.**
- **1850 Control run; no C/N, lower ice albedos; 160 yrs.**
- **20th Century run (1850-2005), branched yr 160 (002); Ts increase okay, Arctic Sept ice extent at 2000 small.**
- **1850 Control with C/N and little higher ice albedos; run for 100 years to branch 20th C, still continuing.**
- **Two 20th C runs (004 & 005); one without, one with, land use change in C/N. Ts similar, Arctic ice better.**

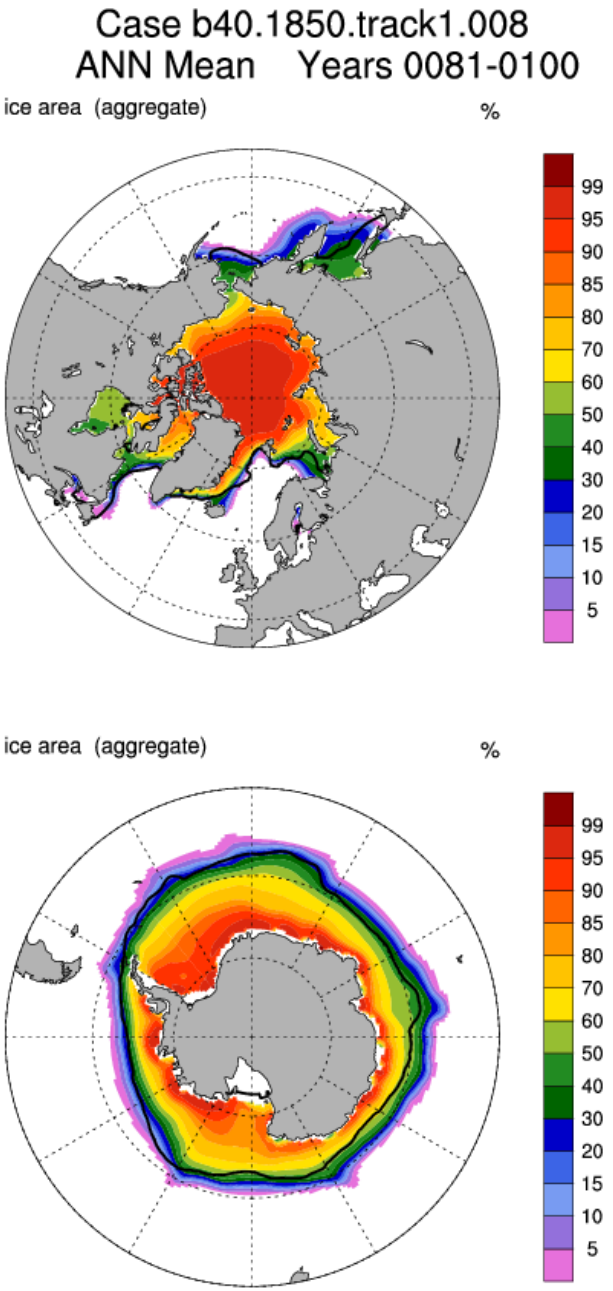
Nino 3.4 from first 20th C run.



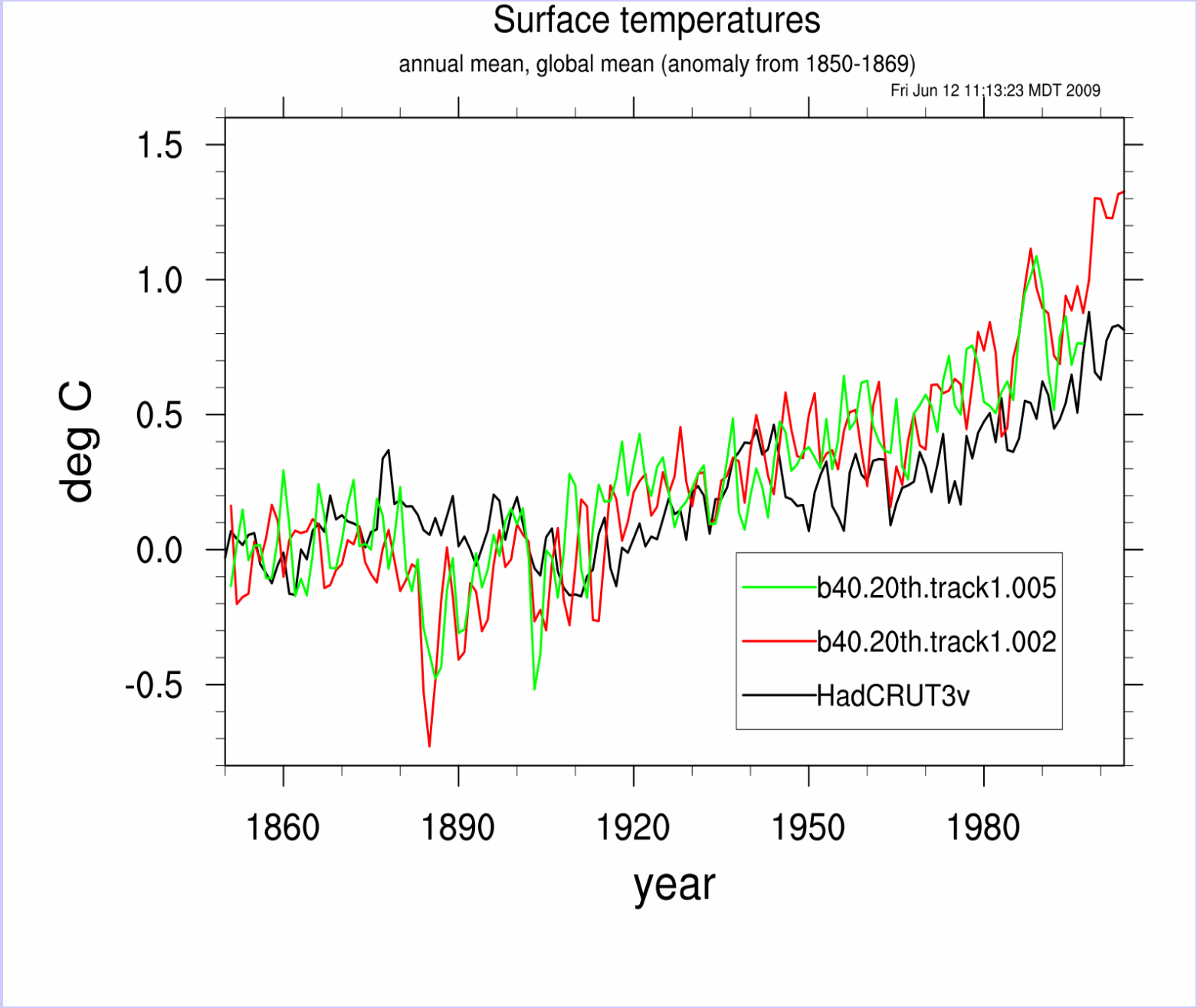
Sea Ice concentration in 2^{o} atm/land 1850 Control run.

Little too much in Pacific Arctic sector.

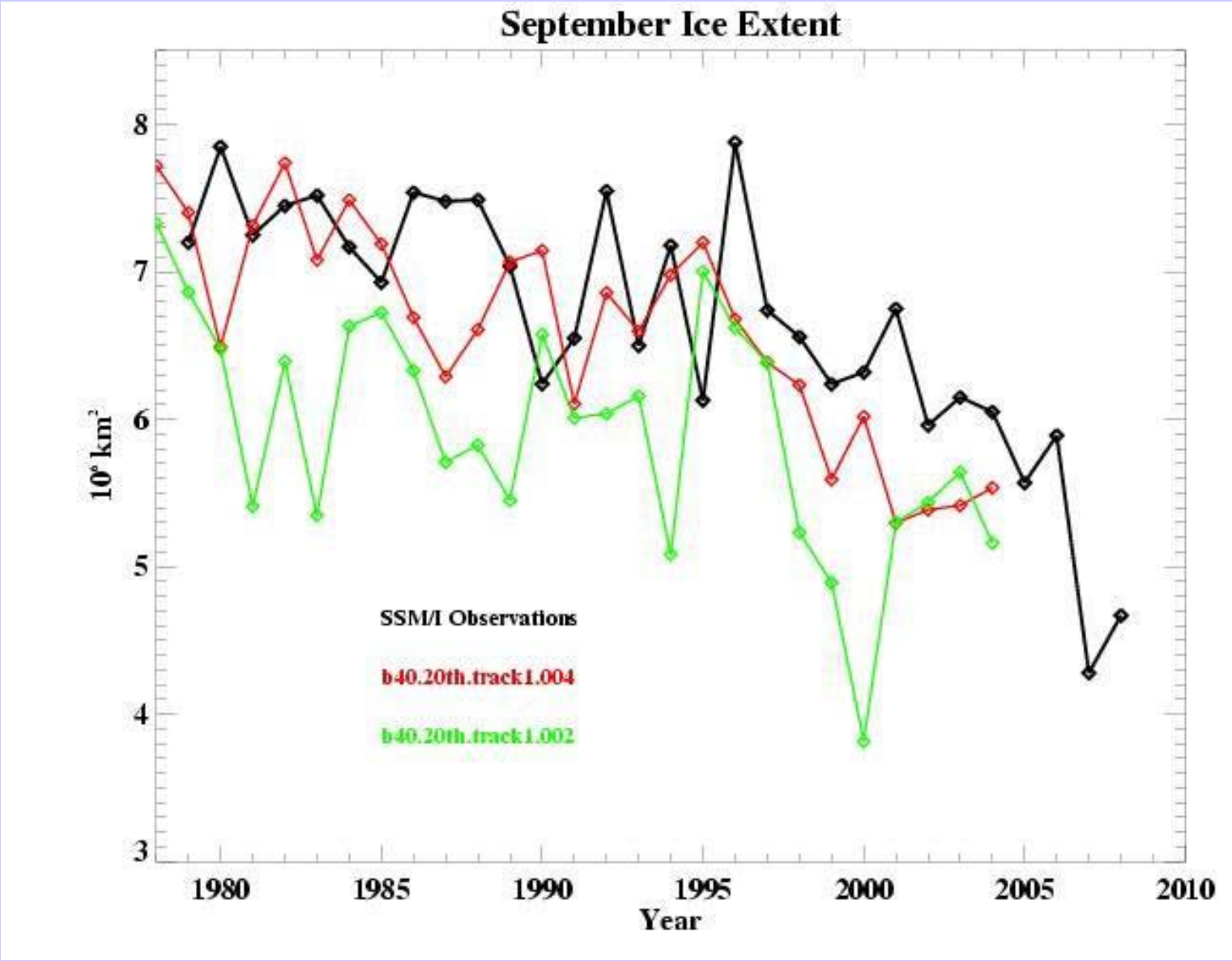
Much improved in Atlantic Antarctic sector compared to CCSM3.



Atm <Ts> change from 002 and 005 20C runs compared to obs.



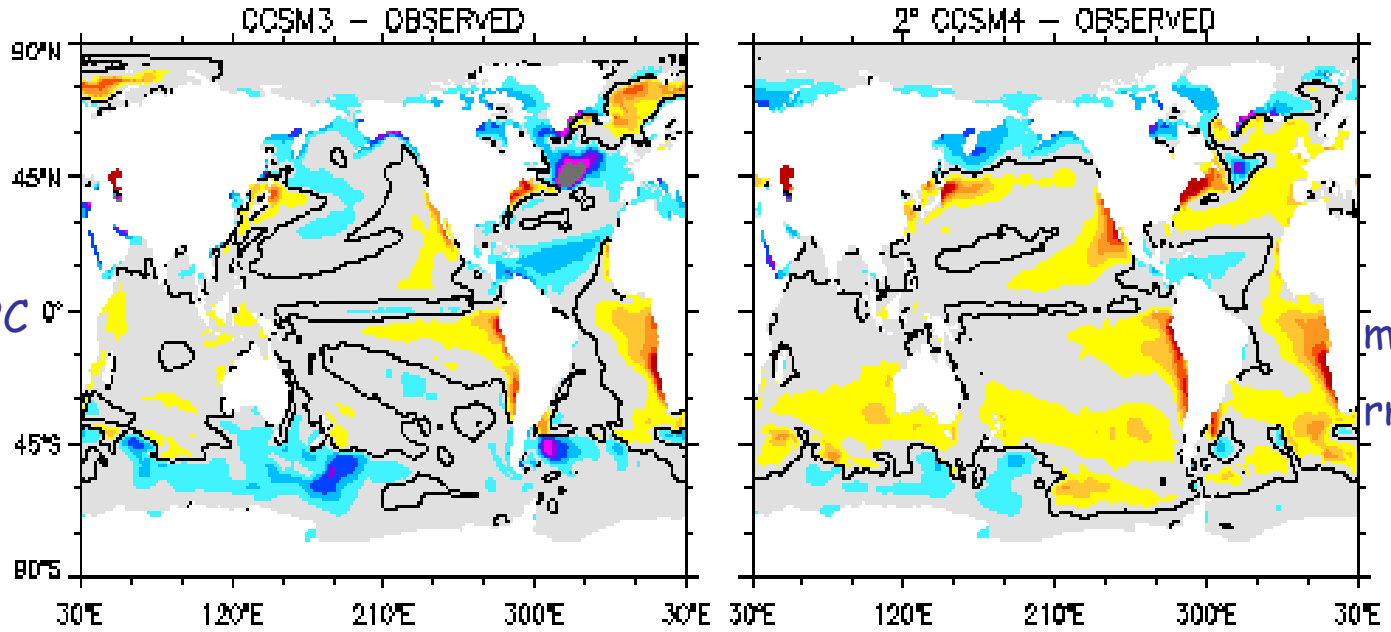
September Arctic sea ice extent from 002 and 004 20C runs compared to satellite obs.



Track 1 Runs: 1º atm/land, 1º ocean/ice

- **A spanner was thrown into the works about 3 weeks ago when a short run was done with 1º atm/land.**
- **The improvement in the SSTs in upwelling regions was as large as going to 0.5º atm/land in CCSM 3.5.**
- **Now have a 1850 Control that has gone 100 years, and a 20th Century run is going on Jaguar this week.**
- **The 1850 <SST> is less than late 20th Century obs.**
- **Decision this morning to use this version for IPCC AR5 long carbon cycle runs, but need more computer time.**

SST DIFFERENCES FROM OBSERVATIONS

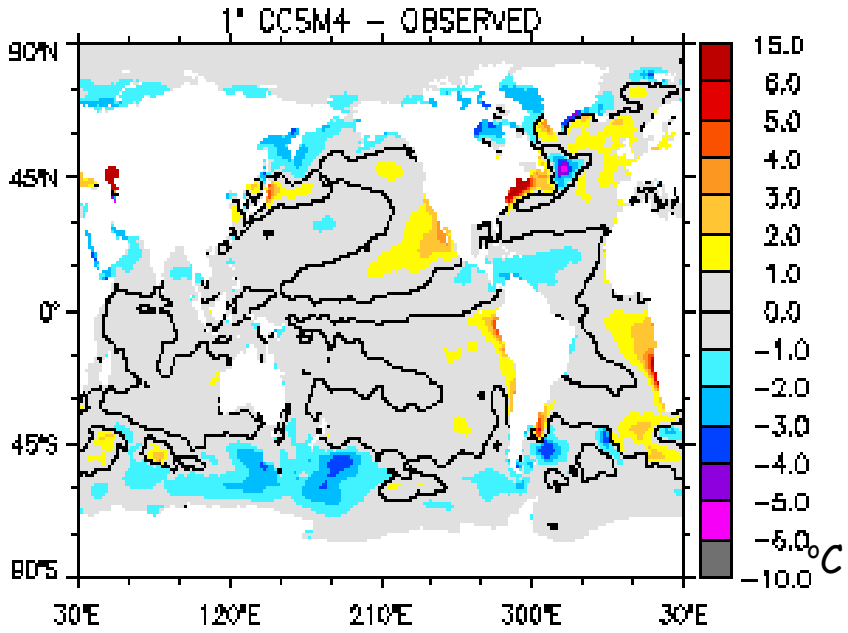


mean= -0.06°C

rms= 1.29°C

mean= 0.63°C

rms= 1.44°C

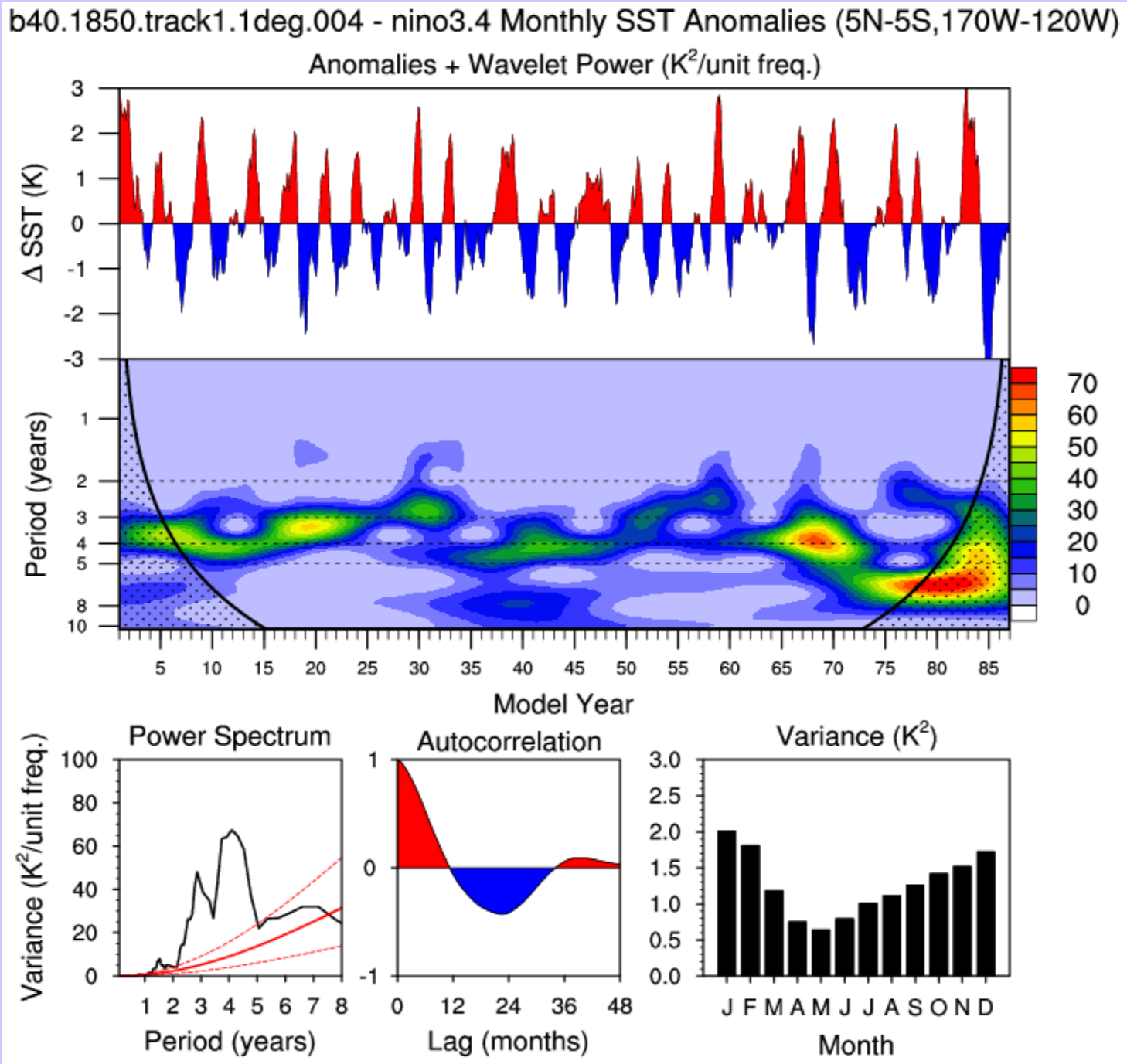


mean= -0.01°C

rms= 1.07°C

Obs: Levitus et al. (1998),
Steele et al. (2001)

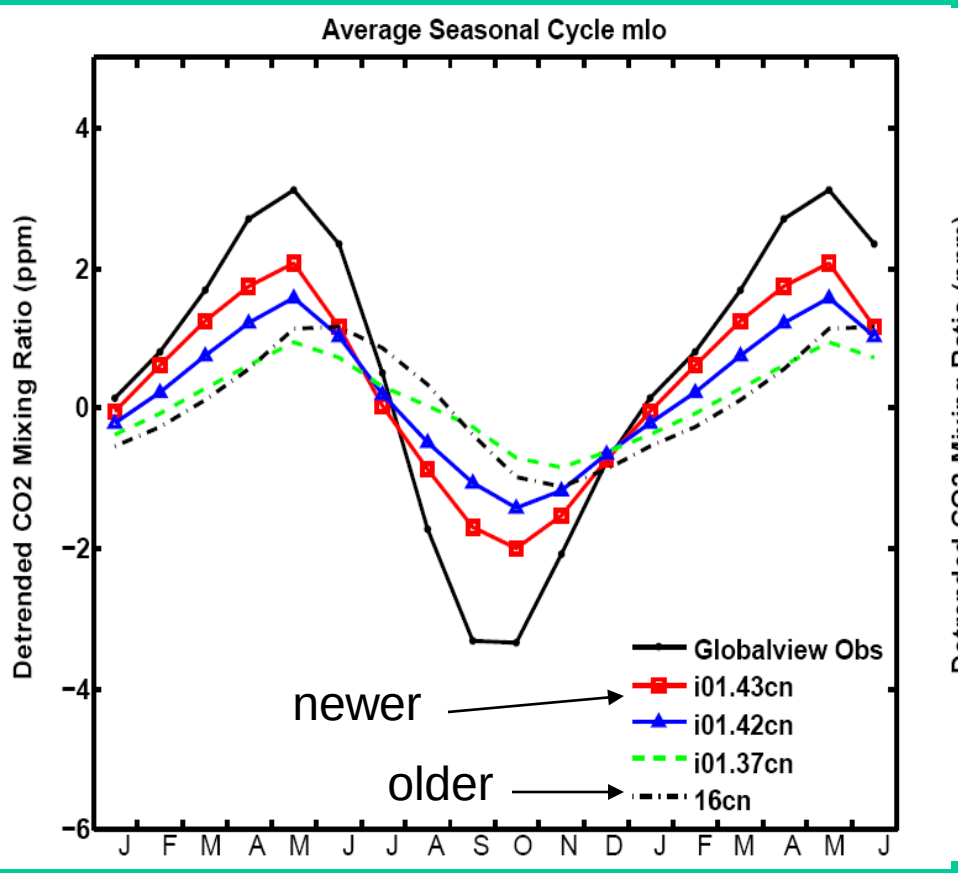
Nino 3.4 time series in 1º 1850 Control run.



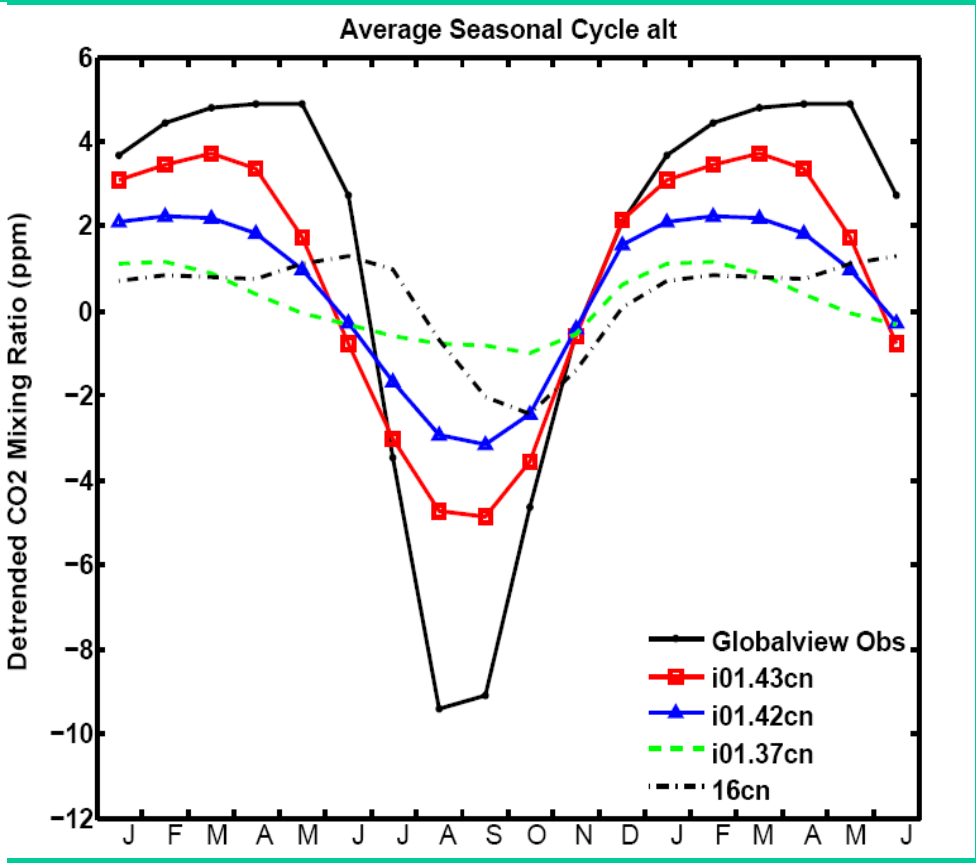
Carbon Cycle Land and Ocean Components

- **Thornton C-N model is the land component. Last year was shown to have problems with Arctic annual cycle of carbon uptake, but this has been much improved.**
- **The Moore, Doney, Lindsay ecosystem model is the ocean component; further improvements this year.**
- **Both components need spun up ICs for 1850, which need atmospheric forcing from 1850 Control run.**
- **Keith Lindsay has been working on a Newton-Krylov method to speed up finding the ocean ICs. This is working okay in 3º ocean; now starting in 1º ocean.**

Example results: improved seasonal cycle; (sequence of four modifications with progressive improvement)



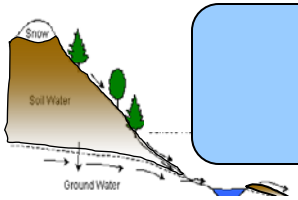
Mauna Loa



Alert

Sea Ice Model Update

- Community Ice CodE (CICE) 4.0 Base Code, (maintained by Elizabeth Hunke at LANL).
- Delta-Eddington Radiative Transfer in sea ice and snow (Briegleb and Light).
- Melt Pond Parameterization (Bailey and Holland).
- Arbitrary Number of Tracers (for example – age, melt ponds, aerosols).
- Aerosol cycling and deposition on sea ice/snow.



LMWG progress towards CLM4

- **Soil hydrology**
  - since CLM3.5, numerous updates and tuning
  - improved soil moisture variability, surface fluxes, soil moisture stress, partitioning of ET into its components
- **Snow model**
  - snow density dependent snow cover fraction parameterization
  - SNICAR: snow age, vertically resolved heating in snowpack, aerosol deposition
- **Urban model**
  - impact on climate is very small, represent heat island
  - heating/AC/wasteheat flux: +0.03 to 0.05 W/m^2 over land
- **Ice stream in River Transport Model**
  - excess snowcap water to ice stream; reduces CCSM imbalance by ~0.4 W/m^2
- **Revised surface dataset and grass optical properties**
  - reduced albedo biases
- **Reference height: distance between ref height and ATM$_{bot}$ same for all tiles**
- **Permafrost**
  - organic soil; deeper soil column (~50 m, 15 soil levels)

Ocean Initialization for Decadal Forecasts

- **Have used 2 datasets: hindcast using the CCSM ocean component, and the GFDL ocean reanalysis product.**
- **Have tried 2 methods: a) initialize ocean and run, b) strongly restore to hindcast over 5-10 yrs, then run.**
- **In all cases, the N Atlantic MOC returned to near its coupled run value in 4-5 years. Have not found any evidence to strongly favor hindcast or GFDL data.**
- **The present day CCSM 4 run has much reduced MOC variability than CCSM 3. So, how important is it to initialize the MOC? Need to initialize the global upper ocean heat content correctly. Discussion on Thursday.**

Status of CCSM to do the IPCC AR5 Runs

- **Physical model for carbon AR5 runs is now ready.**
- **Need land C/N and ocean ecosystem ICs for 1850; not done, but substantial progress has been made.**
- **Want to use track 5 at 0.5º atm/land for AR5 decadal predictions; model version still needs to be finalized.**
- **Need to make final decision how to initialize the ocean.**
- **Plans to do carbon runs on CSL time at NCAR, decadal runs on DOE machines, mostly Jaguar at Oak Ridge.**

IPCC AR5 Runs – Other CCSM Components

- **There are a few paleo runs included in the AR5 suite.**
- **Some runs will include interactive chemistry: fast version in carbon runs (Cameron-Smith, Prather), and fuller version in decadal forecasts (Lamarque).**
- **A few of the carbon cycle runs will use WACCM as atm component; is it needed to get correct ozone in SH?**
- **Some of the carbon cycle 21st Century runs will include the first version of the land ice component. How will ice melt from Greenland affect the MOC and sea level?**
- **Will soon be a COMMUNITY EARTH SYSTEM MODEL.**

CCSM Personnel Changes

- **Jim Hurrell will take over as chairman of SSC on July 1st.**

- **Have new WGs: WACCM; Cochairs Dan Marsh (NCAR) and Aaron Ridley (U Michigan): Land Ice; Cochairs Bill Lipscomb (LANL) and Jesse Johnson (U Montana).**

- **Some long serving WG Cochairs will rotate off: Leo Donner (GFDL, atm), and Steve Jayne (WHOI, ocean).**

- **There is a new "Science Plan 2009-2015" on web site, written by the SSC with input from some WG Cochairs.**

Colorado Governor Ritter's Mansion, February 17, 2009
CCSM won the Co-Labs award for "Impact in Climate Science"

Colorado Governor's Mansion

February 17, 2009.