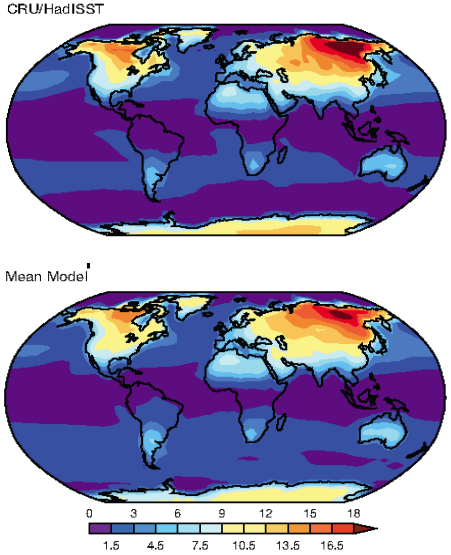
“Annual Cycle*” in Temperature

* Multiply by ~3 to get approximately the difference in July and January temperature



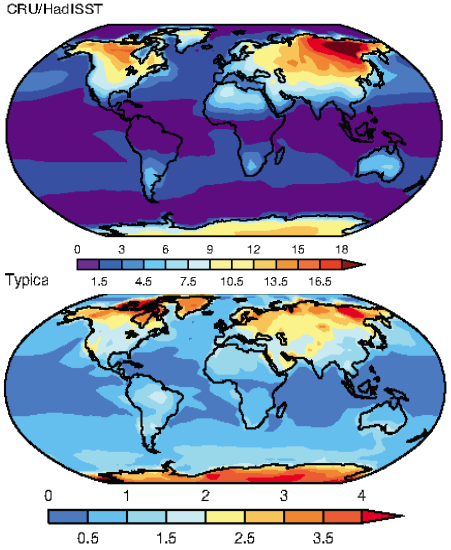
Observed

Model Average

IPCC 2007

“Annual Cycle*” in Temperature

* Multiply by ~3 to get approximately the difference in July and January temperature



Observed

Typical Model Error

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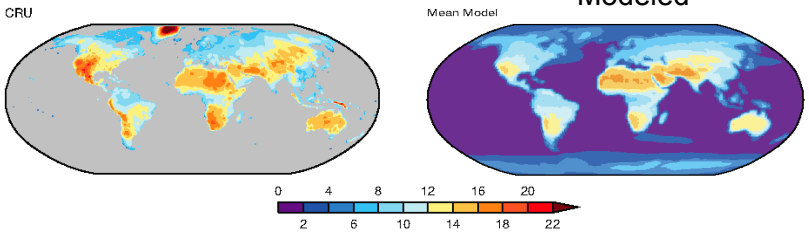
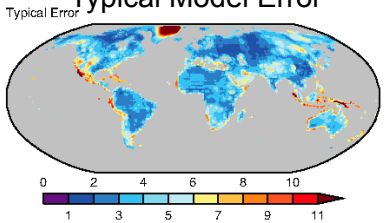
Diurnal (day-night) temperature range

Observed

Modeled



Typical Model Error



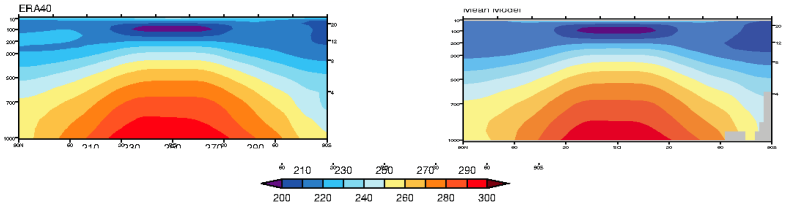
IPCC 2007 Fig. S8.3

Atmospheric Temperature

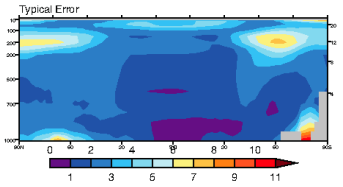
Zonal (east-west) average

Observed

Modeled



Typical Model Error

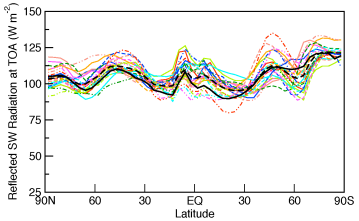


IPCC 2007

Top of the Atmosphere Radiation Flux

(averaged in the east-west direction)

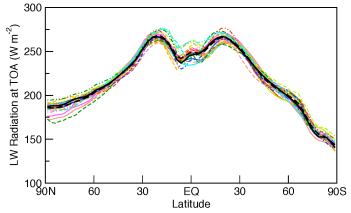
Reflected Solar



- One color line for each model
- Black dashed line for 'average of models'

- Error

Emitted Radiation



typically 10-15 W/m^2 (10% in reflected shortwave and 5% in emitted outgoing longwave radiation)

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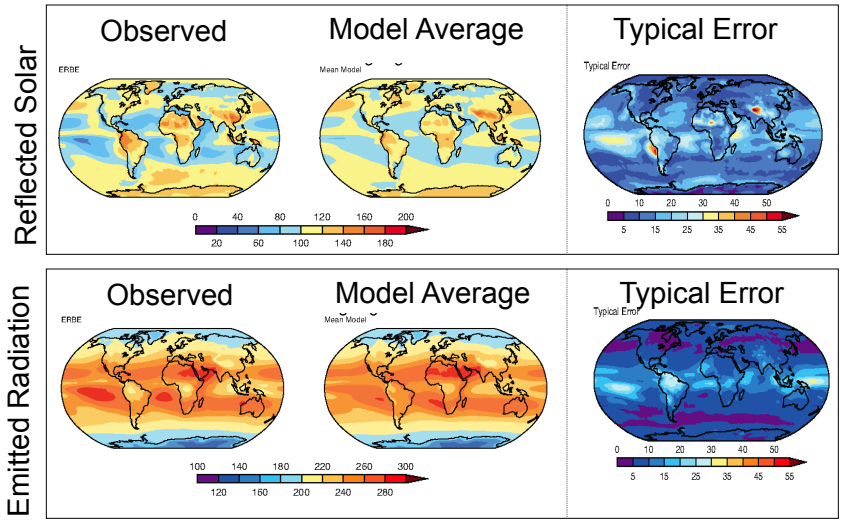
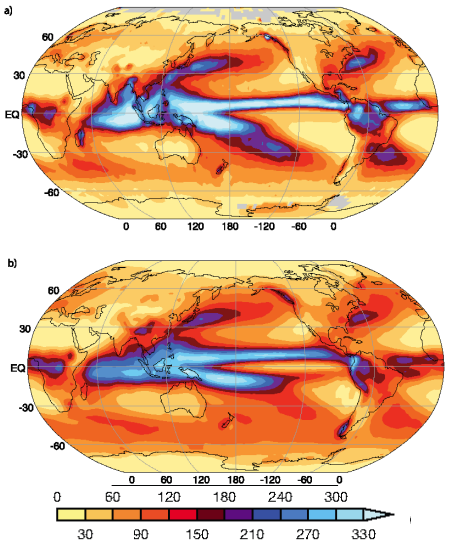
Top of the Atmosphere Radiative Flux



IPCC 2007

Annual Average Precipitation



Observed (cm/year)

Average of the models

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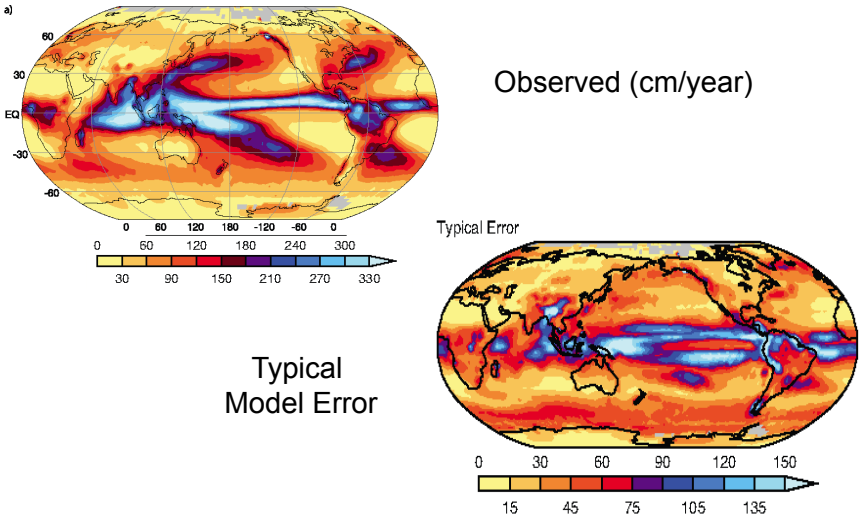
Annual Average Precipitation



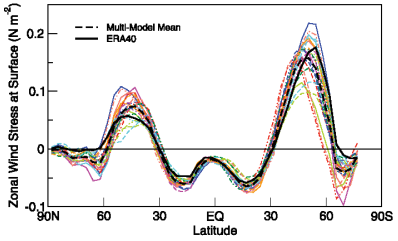
Observed (cm/year)

Typical Model Error

IPCC 2007

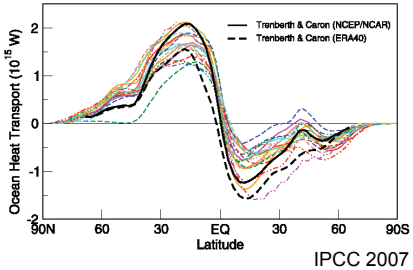
Surface Wind Stress and Ocean Heat Transport

Zonal Average Surface Wind Stress



One color line for each model

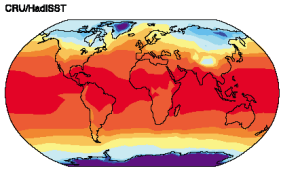
Northward Ocean Heat Transport



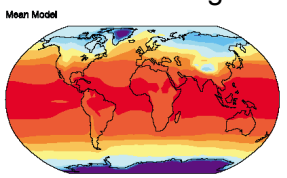
IPCC 2007

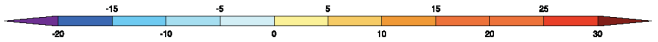
Annual Average Surface Temperature

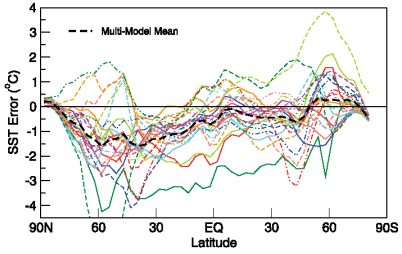
Observed



Model Average







Error in zonal (east-west) averaged annual *sea* surface temperature

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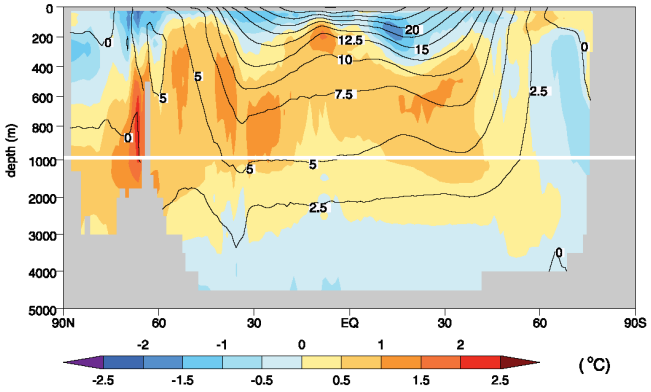
Vertical Distribution of Ocean Temperature



Contours = observed temperature
Color = error in the 'average of the models'

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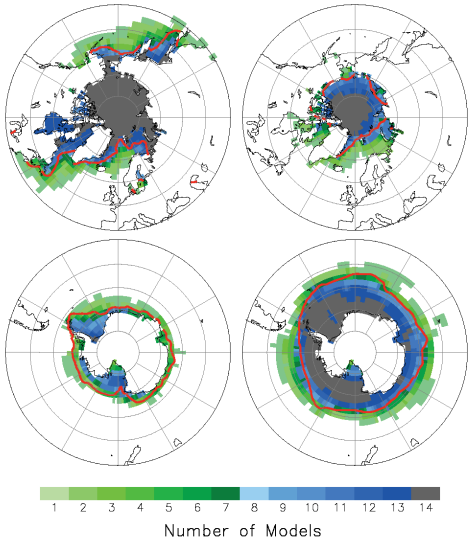
Sea Ice Extent



- Red line demarks the position of the 15% sea ice coverage at the end of winter from observations
- Color is the number of models that have at least 15% sea ice coverage

Baseline for observations 1980-1999

Grid size for calculating sea ice coverage is 2.5 x 2.5 latitude-longitude

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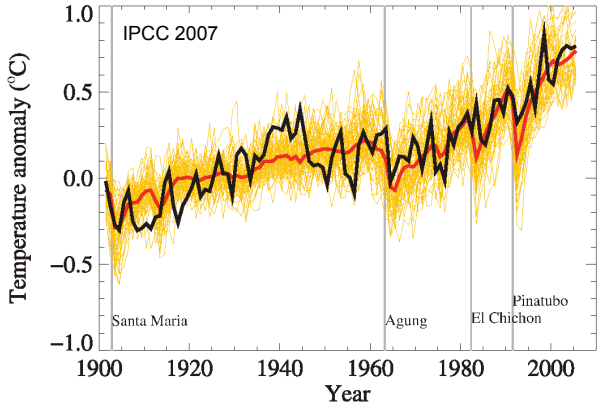
Natural Variability

- The models simulate accurately the weather on 200km scales
- The models simulate accurately the natural patterns of variability in the atmosphere on 200-1000km scales
  - North Atlantic Oscillation, the eastern Atlantic pattern, the Pacific North American pattern, the Western Pacific pattern, etc
- The models do very poorly the El Nino/Southern Oscillation (ENSO) phenomenon
- The models do poorly in places where topography changes markedly on scales that are smaller than the atmospheric grid (e.g., Puget Sound)
  - In these cases, useful information can be obtained by 'downscaling' (mainly for temperature; precipitation in only some cases)

More test of the Models

- They have been used to simulate climates of the past and evaluated against the paleo (proxy) data
  - The Early Holocene: 6000 and 8500 years before present (yr BP), when the Sahara was green
  - The Last Glacial Maximum: 23,000 yr BP, the maximum extent of the most recent glacial period
    - Used to evaluate the relative contributions of changes in insolation, land ice (albedo) and carbon dioxide (180ppm vs 280ppm pre-industrial) to the climate changes.
  - The Eocene: 65 million yr BP, when the earth was ice free and much warmer than today (by ~10-15ºC) and CO_2 levels were 2-4 times more than today.
    - Note the AR4 models used to do this systematically underestimate the warming of the Eocene
- They have been used to simulate the climate of the 20th Century

Simulating the Global Average Temperature over the 20th Century



Each yellow line is one simulation.

Red line = average of all 58 simulations

Black line = observed

Simulations include natural (solar and volcanic) and human (carbon dioxide, etc) forcing

14 models were used in this figure with a total of 58 simulations

Climate Models: Summary

- Based on the laws of physics and chemistry
- They do some things very well
  - Temperature (in general, they do better on larger space & time scales
    - Diurnal: good
    - Weekly and longer time scale (100km to continental scales): very good
    - Global scale: excellent
  - Storm tracks in the midlatitudes
- Some things ok
  - Natural variability in the midlatitudes (especially winter)
  - Snow
- And some things not so well
  - Precipitation
    - Midlatitudes: good
    - Tropics: poor to fair