

Climate Models

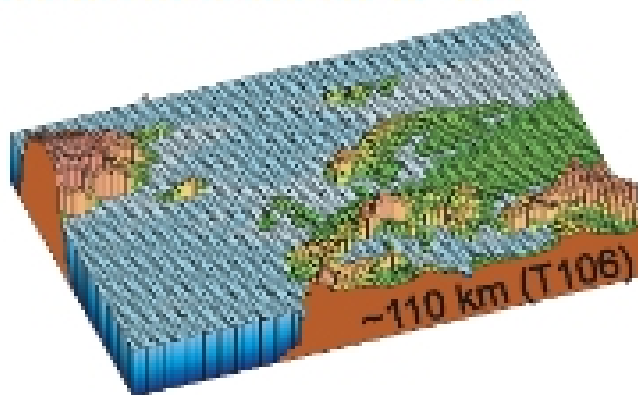
- What is a climate model?
- How long have they been around?
- How good are they?

Climate Models

- What is a climate model?
 - Mathematical representations of the atmosphere, ocean, sea ice and land surface
 - For each component, the model is based on the laws of physics and chemistry. For example,
 - the models conserve energy, mass, momentum. They obey the laws of physics (e.g., Fermi) and chemistry
 - Radiation (solar and terrestrial) is based on detailed theory (quantum mechanics).
 - Concentrations of some gases are prescribed because they change very very slowly (N₂, O₂, Ar, CFCs, etc)
 - Other gases are sometimes prescribed and sometimes calculated by the laws of chemistry and thermodynamics
 - The equations are hopelessly complicated to solve by pen and pencil ("analytically"), so we solve them numerically
 - The equations can't be solved at a molecular level, so the climate system is chopped up regular chunks

Climate Models

- The current size of a chunk of atmosphere, land, ocean or sea ice is about 150km x 150km



Climate Models

- The physical and chemical laws are solved in each of these chunks. Information in one chunk affects another because of motion
 - Wind (atmosphere)
 - Flow (ice, rivers, groundwater movement)
 - Currents (ocean)
- Motion, in turn, is due to pressure differences that result from temperature differences (recall week 2 lectures)
- These calculations require enormous computer resources

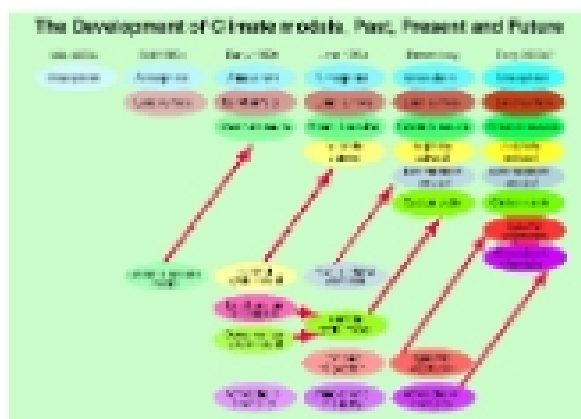
- Put stuff here

The vertical extent of a box is typically:

Atmosphere/Ocean: 80-500m Sea ice: 50cm Land: 10cm

Climate Models

- What is a climate model?
- How long have they been around?

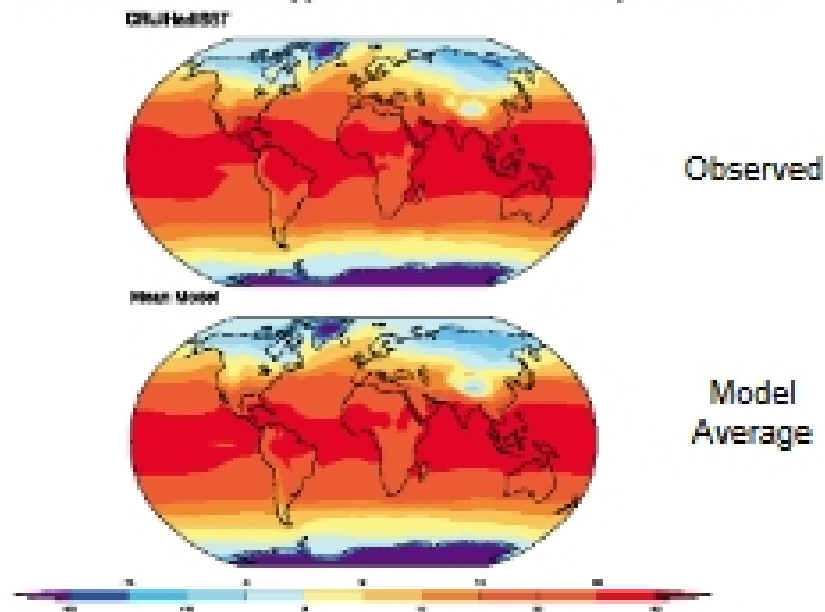


Climate Models are based on the laws of physics and chemistry, and used for ~40 years for various problems.

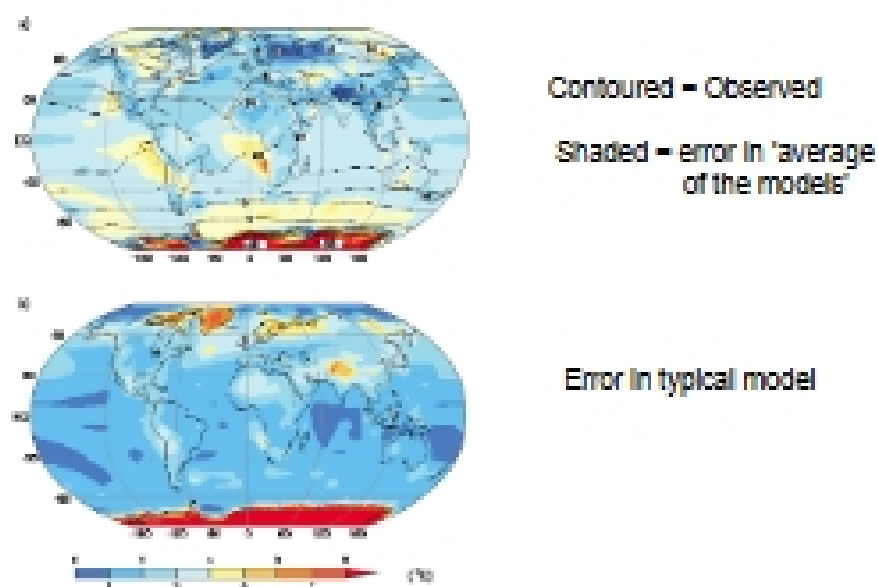
Climate Models

- What is a climate model?
- How long have they been around?
- How good are they?
 - Some examples from 14 of the 23 climate models used in the most recent IPCC report: Assessment Report #4 (AR4) in 2007.

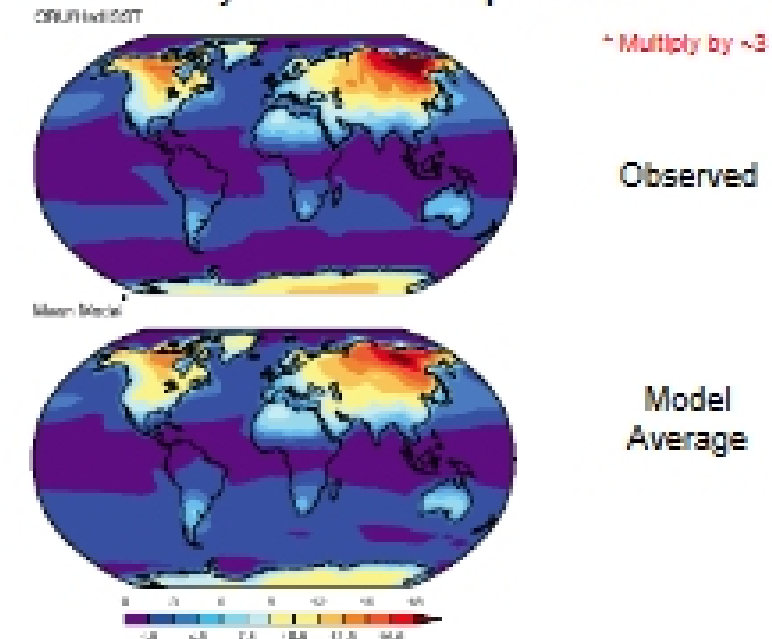
Annual Average Surface Temperature



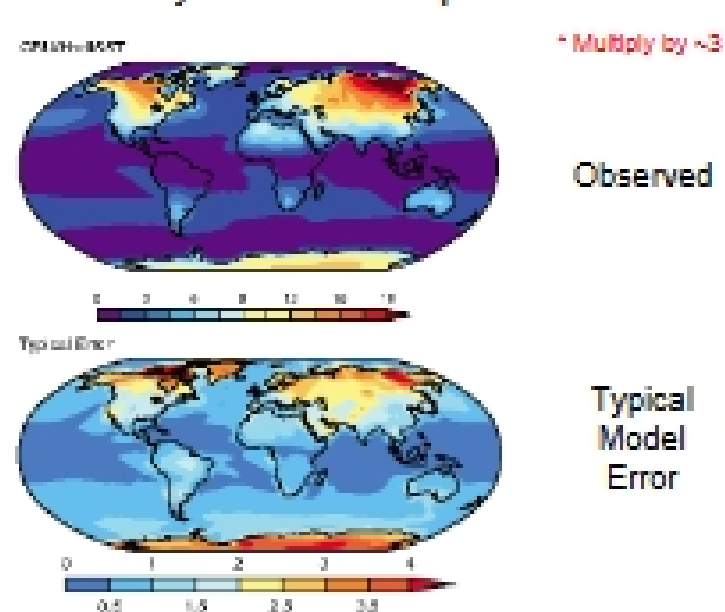
Annual Average Surface Temperature



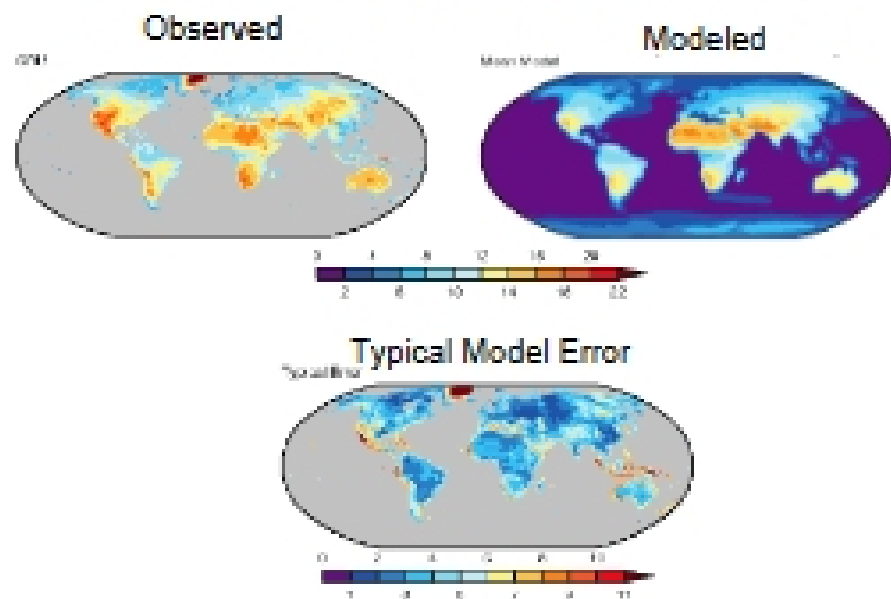
"Annual Cycle*" in Temperature



"Annual Cycle*" in Temperature

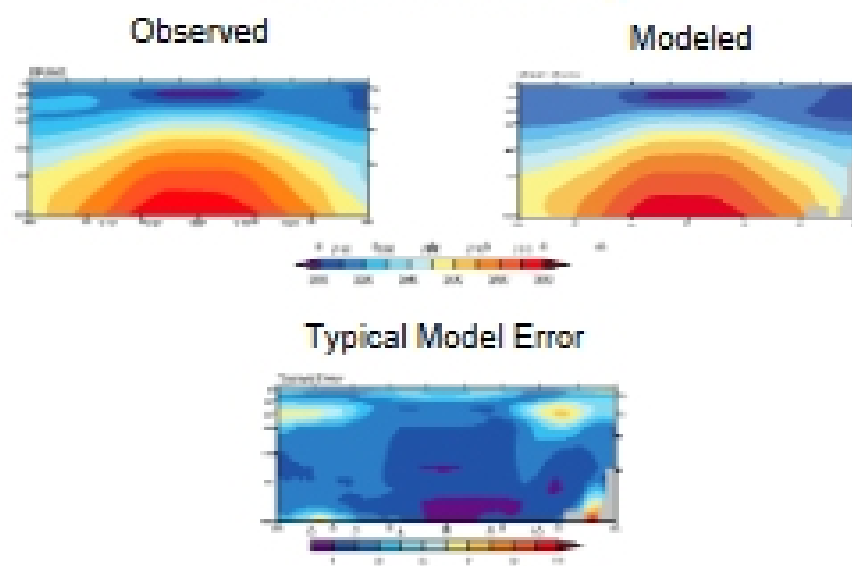


Diurnal (day-night) temperature range

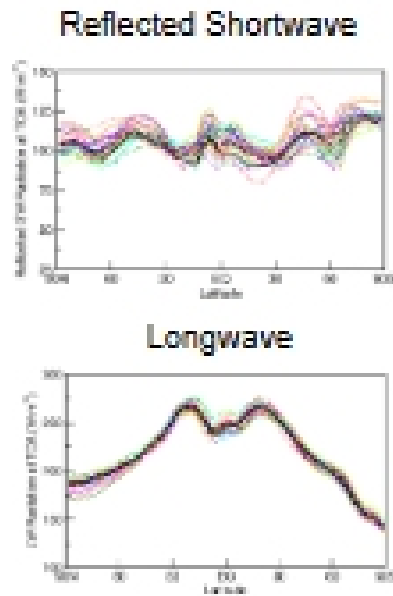


Atmospheric Temperature

Zonal (east-west) average



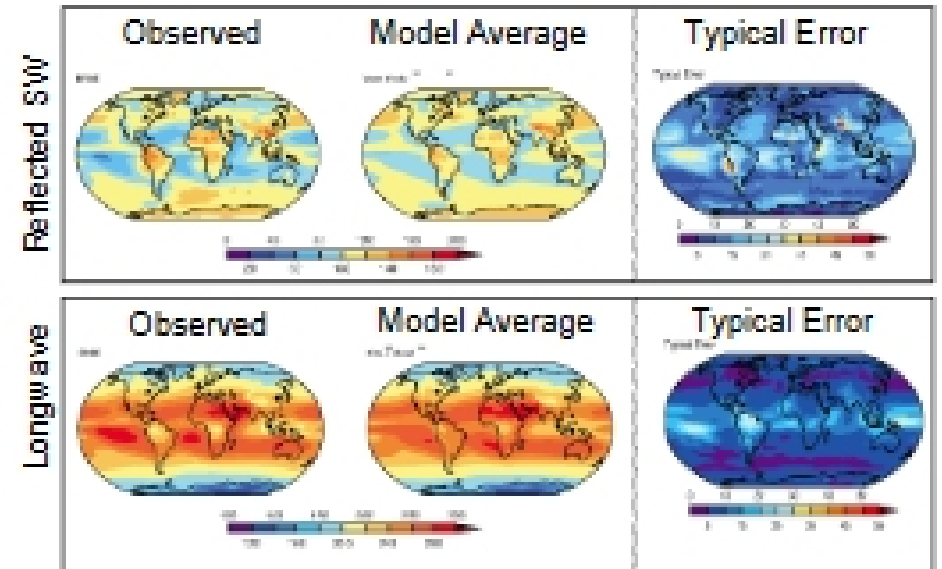
Top of the Atmosphere Radiation Flux



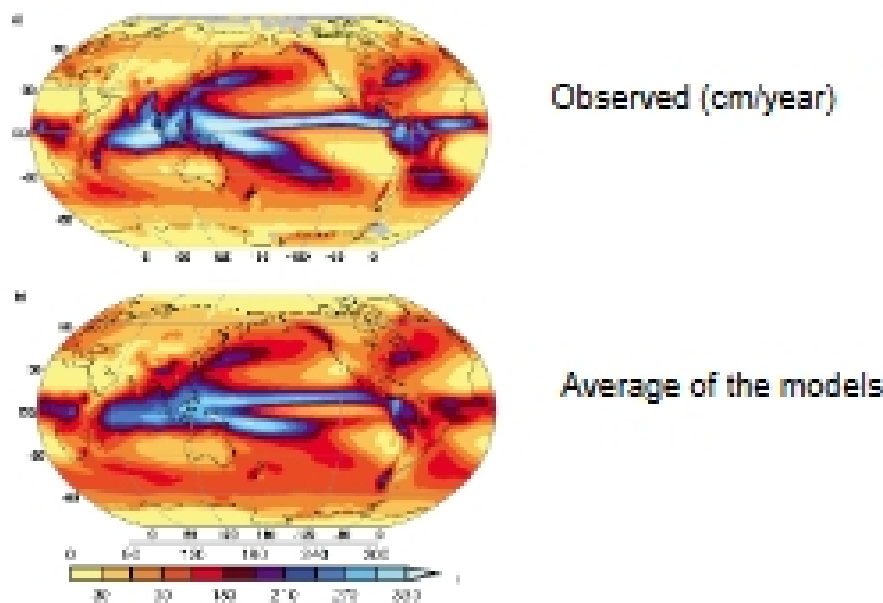
- One color line for each model
- Black dashed line for 'average of models'

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

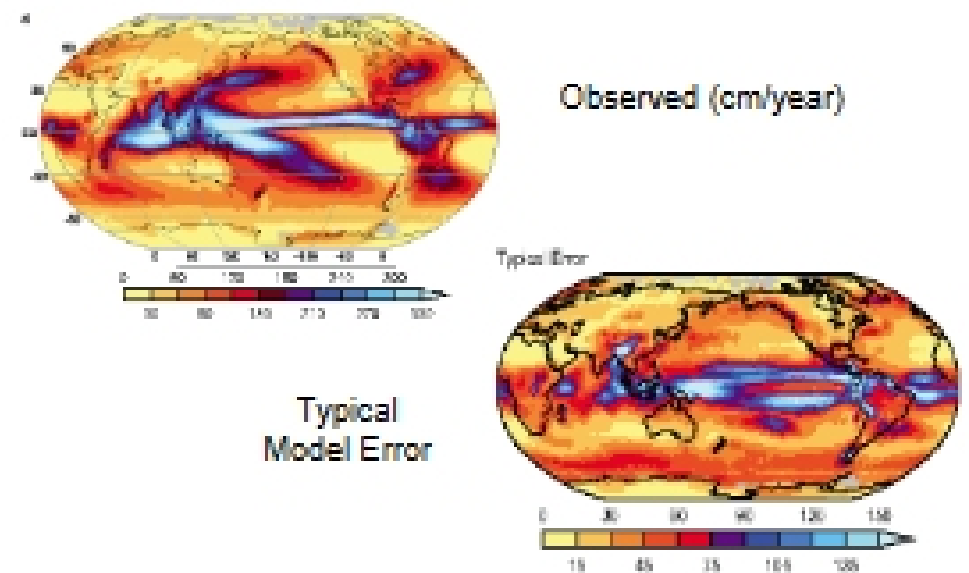
Top of the Atmosphere Radiative Flux



Annual Average Precipitation

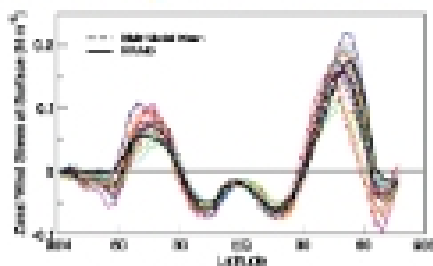


Annual Average Precipitation

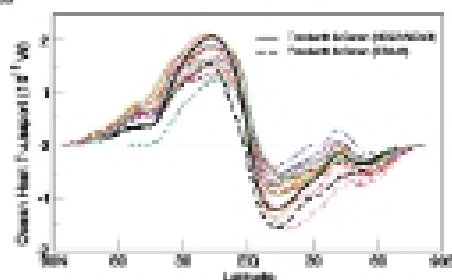


Surface Wind Stress and Ocean Heat Transport

Zonal Average Surface Wind Stress

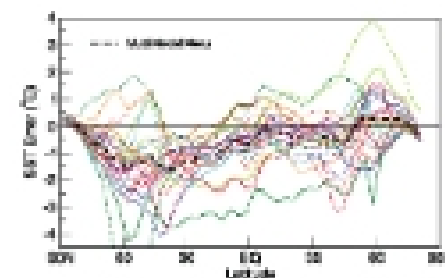
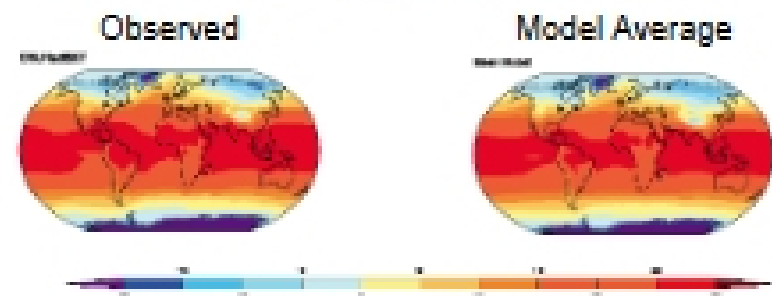


Northward Ocean Heat Transport



One color line for each model

Annual Average Ocean Temperature



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