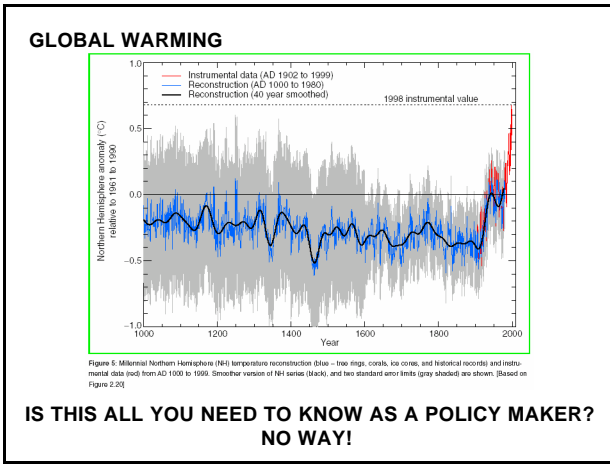


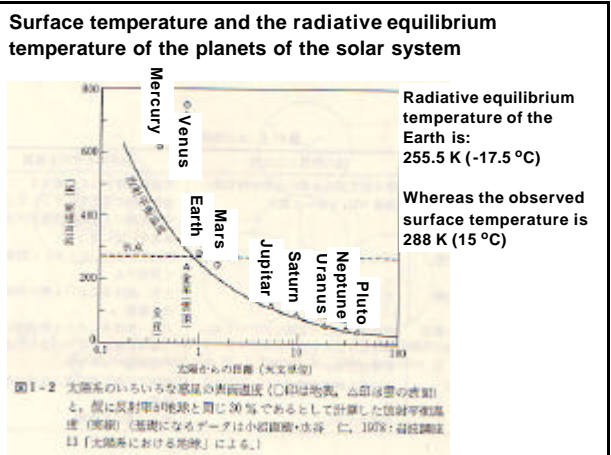
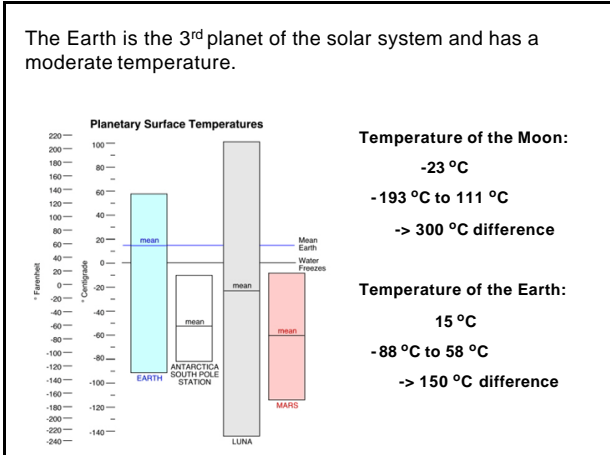
Overview of Global and Climate Change and related International Projects

Takuji Waseda
June 1, 2004

Global Environmental Policy

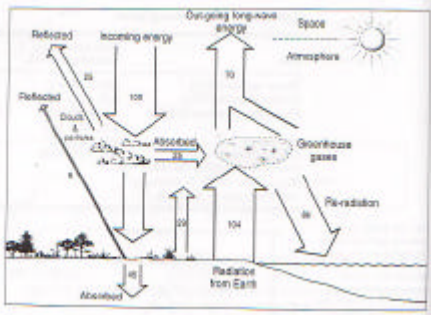


What is happening in the Earth?
What do we know about the planet that we live on?



Benefit of the Greenhouse Gases

Fig. 1.11. Global average pathways for energy in the atmosphere. A net total 180 w/m² comes from the Sun. (From Page 199)



Just like wearing a sweater ...
We **NEED** greenhouse gases to survive

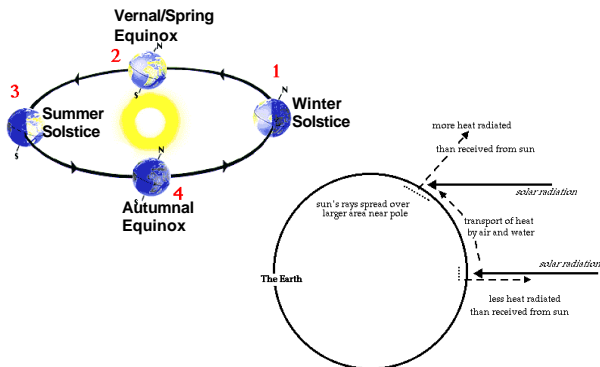
It is not just CO₂!

There are other greenhouse gases and the largest contribution comes from water vapor

Table 1.2. The greenhouse gases

Gas	Basic absorption wavelengths (µm)	Contribution
Water vapour (H ₂ O)	2.66, 2.74, 6.27	55-70%
Carbon dioxide (CO ₂)	4.26, 7.52, 14.99	25%
Chlorofluorocarbons (CFCs)	9.52, 13.8, 15.4	11%
Methane (CH ₄)	3.43, 6.85, 7.27	5%
Nitrous oxide (N ₂ O)	4.50, 7.78, 16.98	2%
Ozone (O ₃), sulphur dioxide (SO ₂), other oxides of nitrogen, carbon monoxide (CO), etc.		<1% each

Why are the temperatures in the poles and the equator different?



Outgoing radiation vs Incoming radiation

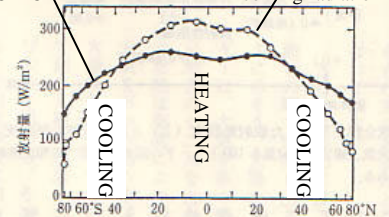
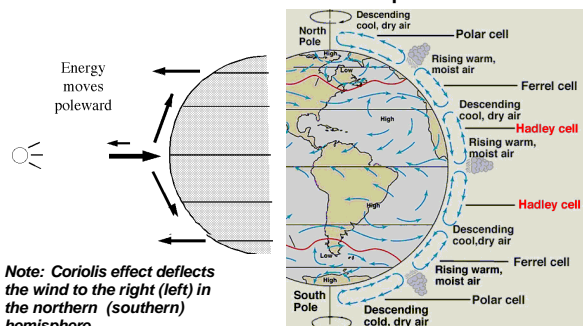


図 1-5 地球に太陽から入射する放射エネルギー (破線) と地球から外向きに出している放射エネルギー (実線) の緯度分布 (人工衛星観測による値) (T. H. Vonder Haar and V. E. Suomi, 1970: Science, 163, 667-669).
Zonal Average Radiation shown as a function of latitude (Meridional variation)

But the temperature on the Earth is relatively moderate.. why is this?

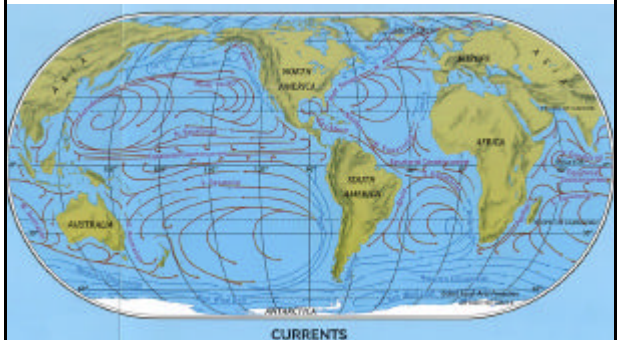
Wind and currents transport heat from the equator to the poles. That is why the Earth's temperature difference is small.

Atmospheric circulation

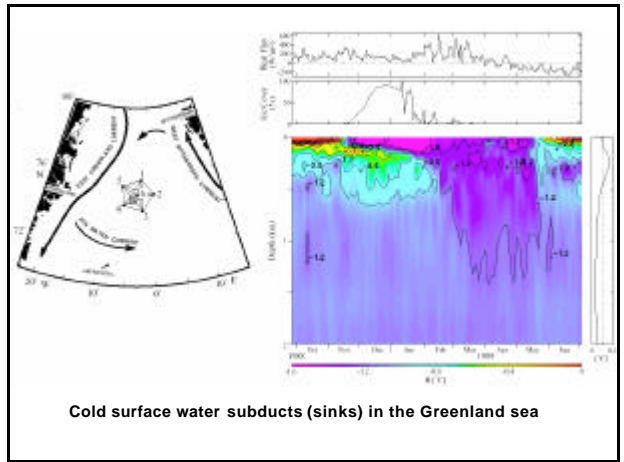
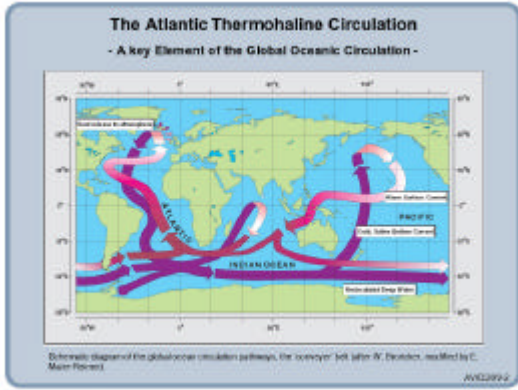


Note: Coriolis effect deflects the wind to the right (left) in the northern (southern) hemisphere

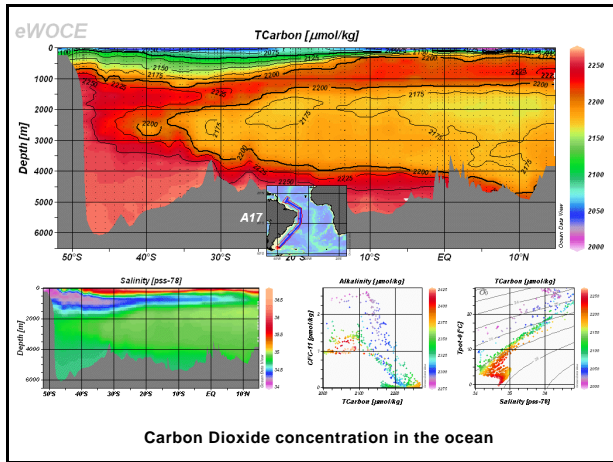
Wind Driven Ocean Currents



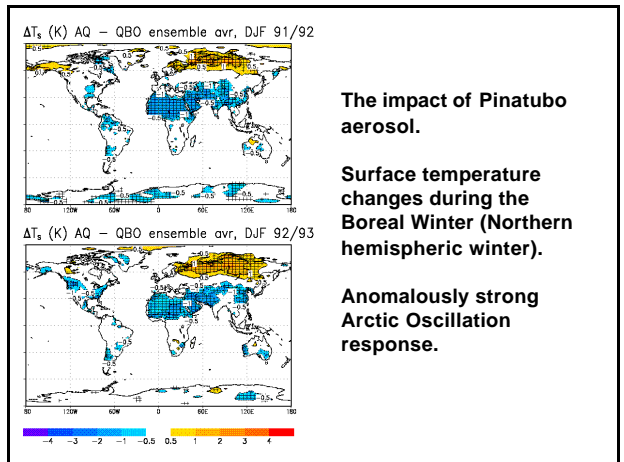
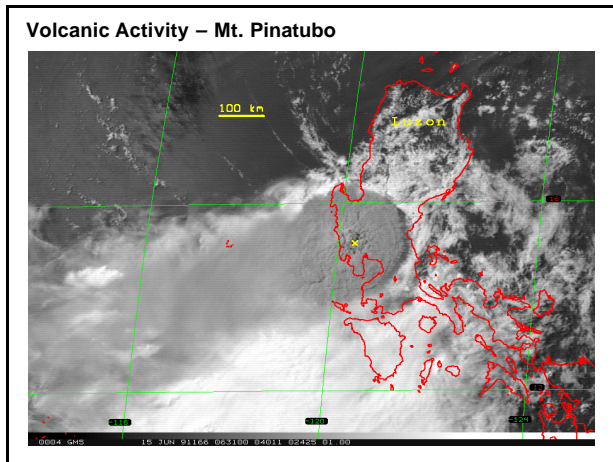
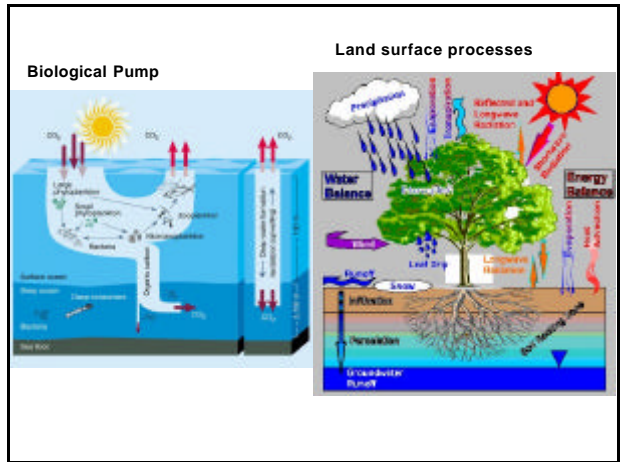
Circulation in the deep ocean – cooling in the polar region



Cold surface water subsides (sinks) in the Greenland sea

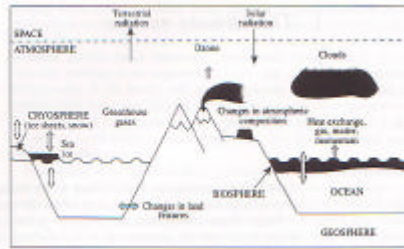


Carbon Dioxide concentration in the ocean



The earth temperature is maintained through subtle balances among *physical, chemical and biological* processes

Fig. 1.1 A schematic diagram of the climate system. [From Slegg 1972]



... and of course, human activities are a part of the system

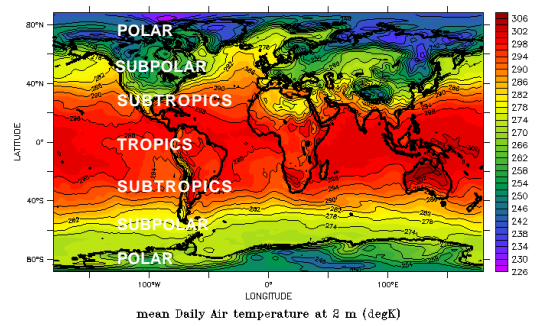
an-thro-po-gen-ic : resulting from the influence of human beings on nature

EARTH CLIMATE

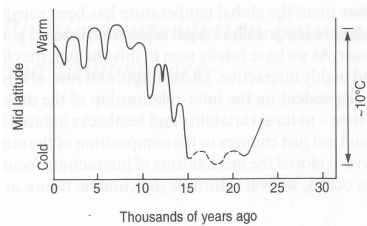
LAS 6.3.0/Ferret 5.60 -- NOAA/PMEL

TIME : 01-JAN-2002 00

DATA SET: AQMP_sat



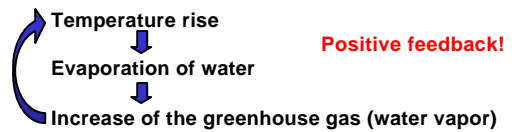
But the earth temperature in the past was not at all moderate...



So, what is the big deal about anthropogenic greenhouse gases?

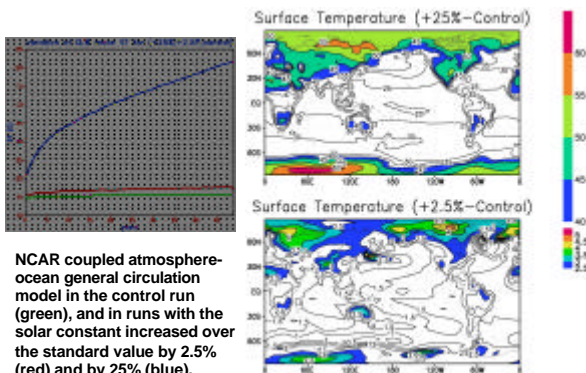
1. It is a climatic forcing that the Earth has never experienced
2. We do not know the consequence

**WORST SCENARIO
RUNAWAY GREENHOUSE EFFECT**



The earth would become like the Venus!

Simulated runaway greenhouse effect by changing the solar constant

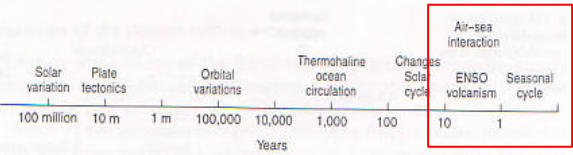


NCAR coupled atmosphere-ocean general circulation model in the control run (green), and in runs with the solar constant increased over the standard value by 2.5% (red) and by 25% (blue).

Runaway Greenhouse Effect may be an extreme case. To answer to the question of what are the impacts of the anthropogenic increase of the Greenhouse gases on the climate, we first need to understand the mechanism of how the climate system is maintained and what causes its change over time.

A NEED FOR CLIMATE RESEARCH

TIME SCALES OF THE CHANGES

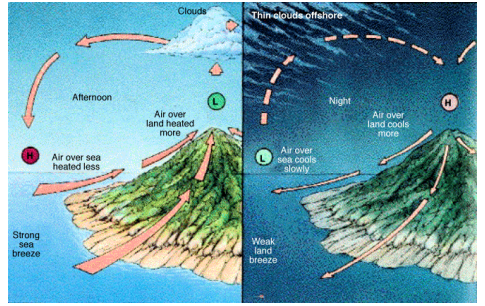


- Diurnal – day & night
- Intra-seasonal
- Annual cycle (Seasonal)
- Inter-annual
- Decadal
- Inter-decadal

SLOW PROCESSES ARE GOVERNED BY THE OCEAN DYNAMICS

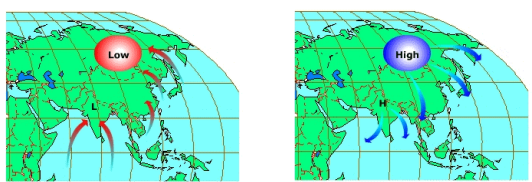
Oceanic Roles (AIR-SEA INTERACTION)

Land-sea temperature difference
•Sea breeze/Land breeze (diurnal)



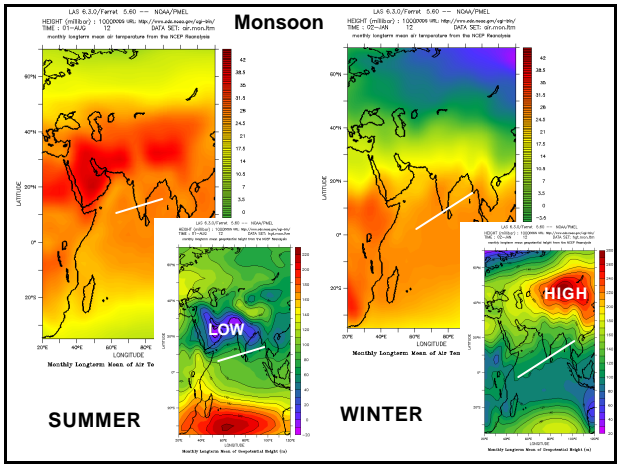
Land-sea temperature difference

•Monsoon (seasonal)



SUMMER

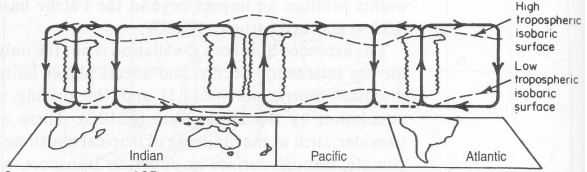
WINTER



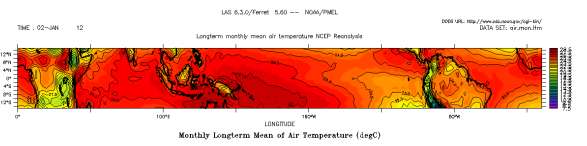
SUMMER

WINTER

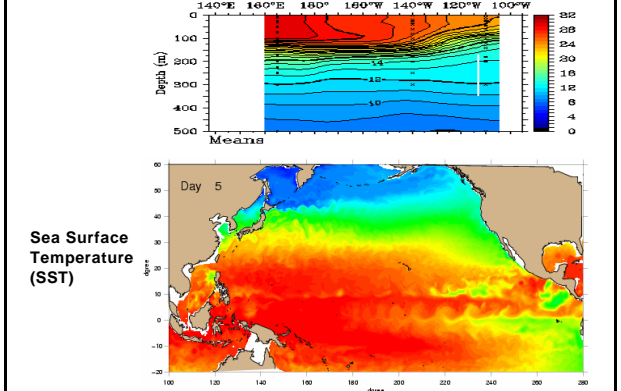
CONTRAST OF EAST-WEST SEA LEVEL TEMPERATURE



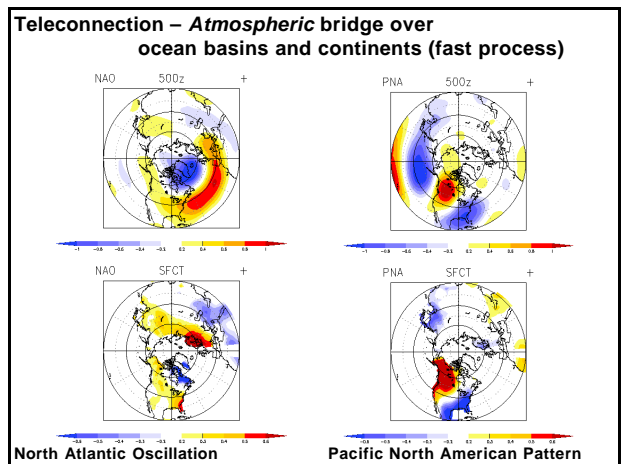
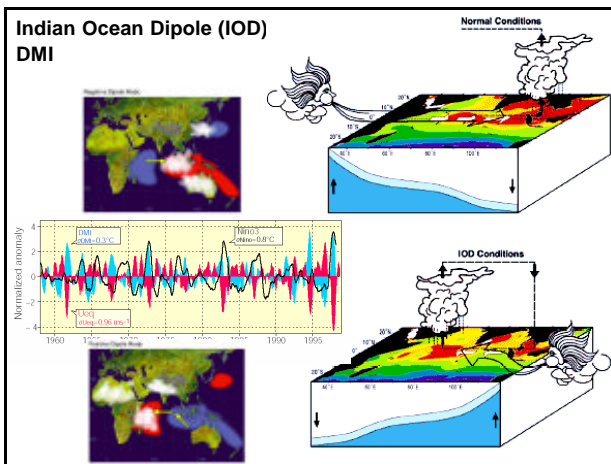
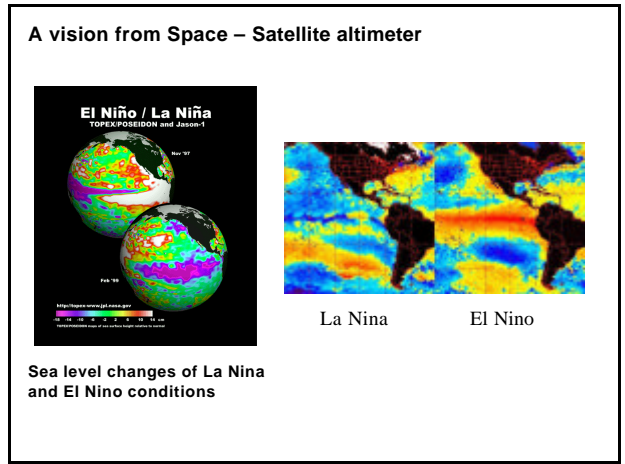
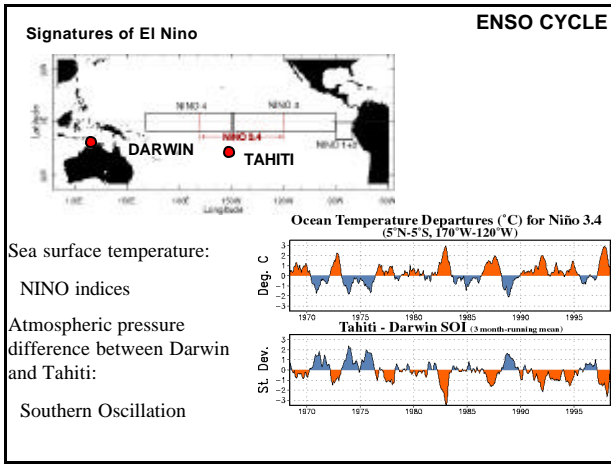
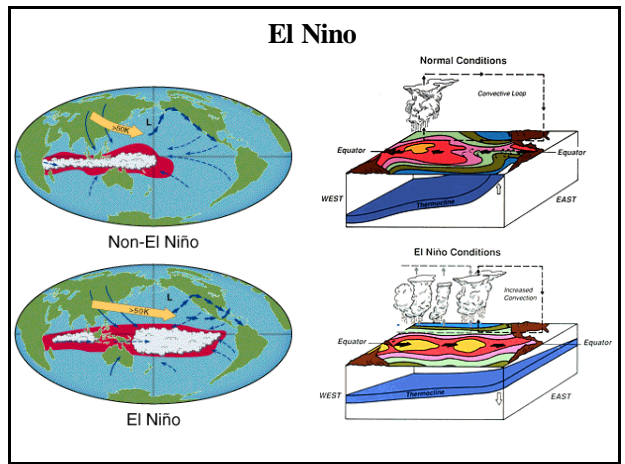
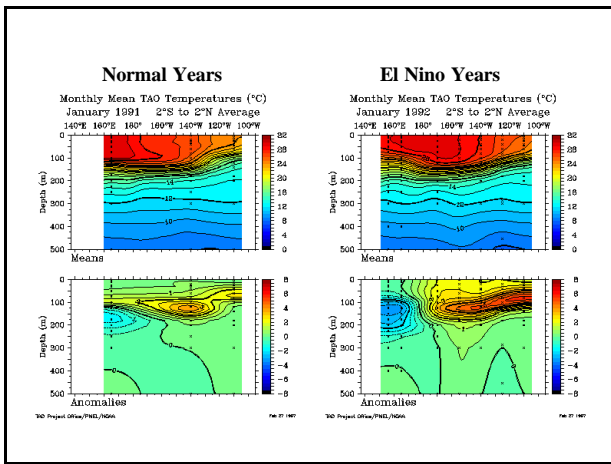
Walker circulation



Pacific Ocean Interior – upwelling



Sea Surface Temperature (SST)

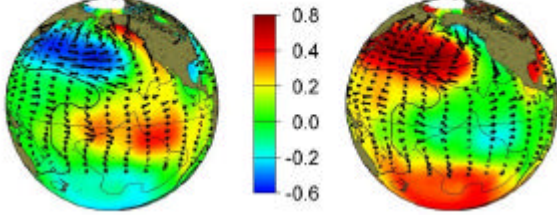


**Decadal Variability (slow process) : Oceanic Bridge
- Pacific Decadal Oscillation**

Pacific Decadal Oscillation

positive phase

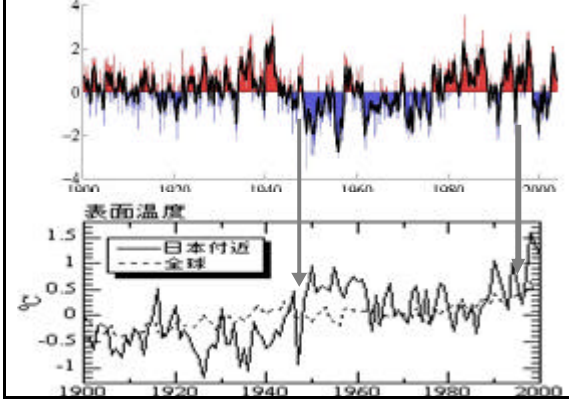
negative phase



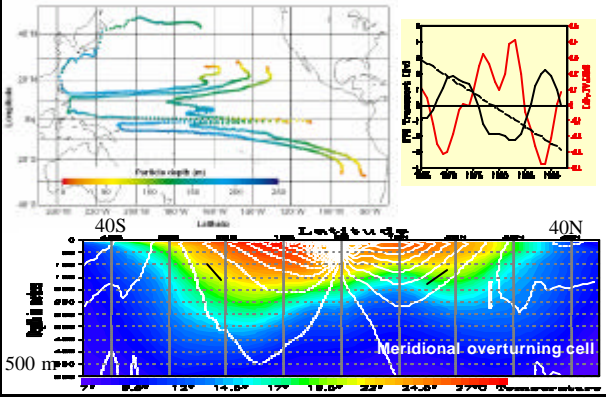
Color: SST; Contour: sea level pressure; Arrow: wind

Regime shift – associated with Pacific Decadal Oscillation

monthly values for the PDO index: January 1900–December 2003

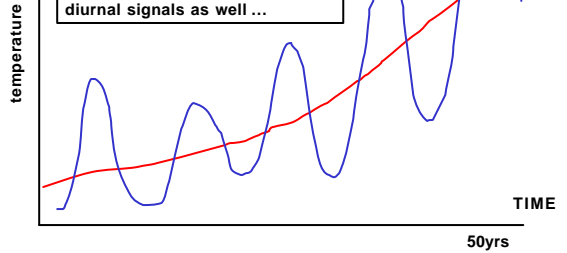


**Possible explanation for the decadal oscillation –
oceanic extra-tropics/tropics connection**

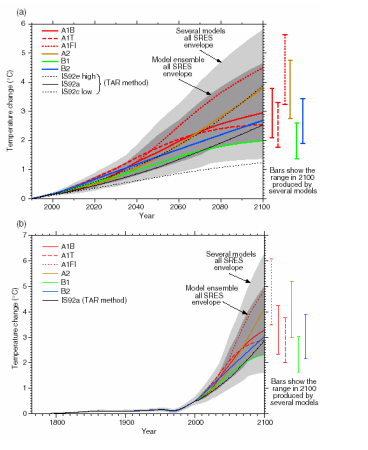


Variation in the future

GLOBAL CHANGE
DECADAL + INTERANNUAL
CHANGE
... and seasonal, intra-seasonal,
diurnal signals as well ...



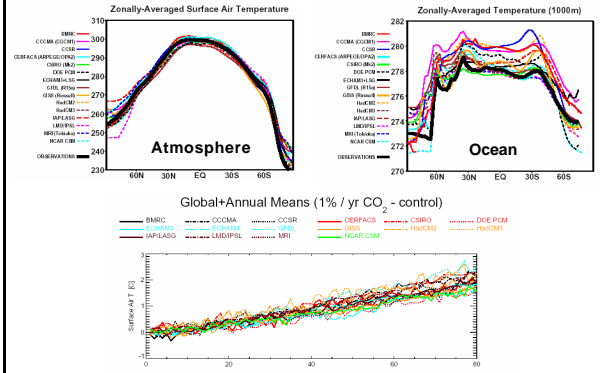
**PREDICTION –
coupled atmosphere-
ocean(land-ice) model**



CMIP

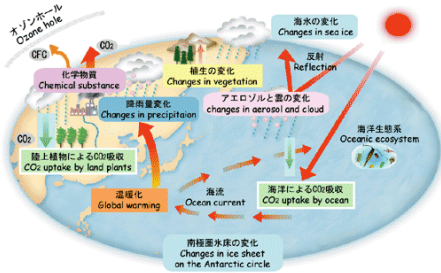
Coupled Model Intercomparison Project

35 Models from worldwide

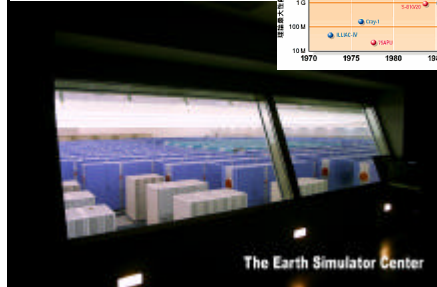
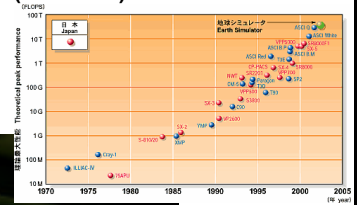


TOWARDS THE CONSTRUCTION OF AN IMPROVED COUPLED MODEL

Japanese project at the Frontier Research System for Global Change (JAMSTEC)



THE EARTH SIMULATOR (JAMSTEC)



5 times faster
than the existing
fastest computer

SUMMARY

The constituents of the earth system are: atmospheric, oceanic, land, ice, biological, chemical and geological processes.

We have reviewed mainly the atmosphere-ocean coupled processes.

The numerical prediction models show variations that are quite large but the reasons are not well understood.

Worldwide, there is an ongoing coupled model inter-comparison project.

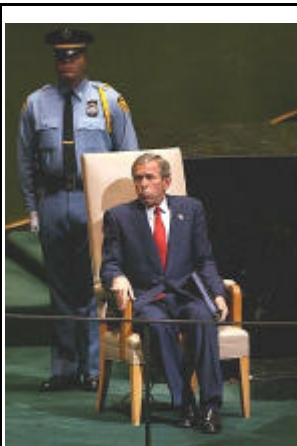
Japan has now started its own project to lead the climate research using the Earth Simulator.

Homework:

Select from below:

- 1) Given the uncertainties in the current Global Change prediction models, justify the need for further climate research from a view point of an environmental policy decision maker.
- 2) Given the uncertainties in the current Global Change prediction models, disprove the need for climate research from a view point of an environmental policy decision maker.

Suggested reading: IPCC third assessment report – Climate change 2001: The scientific basis (TS or full report) @ <http://www.ipcc.ch/>



Q: "Does the President believe that, given the amount of energy Americans consume per capita, how much it exceeds any other citizen in any other country in the world, does the President believe we need to correct our lifestyles to address the energy problem?"

A(Ari Fleischer): "That's a big no. The President believes that it's an American way of life, and that it should be the goal of policy makers to protect the American way of life. The American way of life is a blessed one. And we have a bounty of resources in this country."