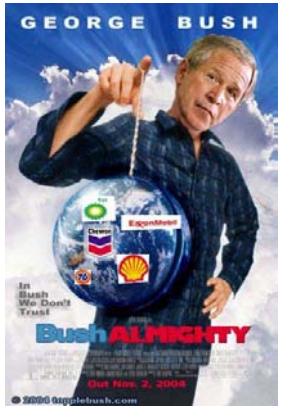


"We'll be working with our allies to reduce greenhouse gases. But I will not accept a plan that will harm our economy and hurt American workers."
-- U.S. President George W. Bush

TIME

When it Comes to Kyoto, the U.S. is the "Rogue Nation"

The rest of the world has decided to proceed with the Kyoto pact despite Washington's withdrawal. TIME.com's Tony Karon explains why that may be bad news for U.S. global leadership

http://www.time.com/time/world/article/0,8599,168701,00.html

Overview of Global and Climate Change and related International Projects

Takuji Waseda

May 17, 2005

Global Environmental Policy

GLOBAL WARMING

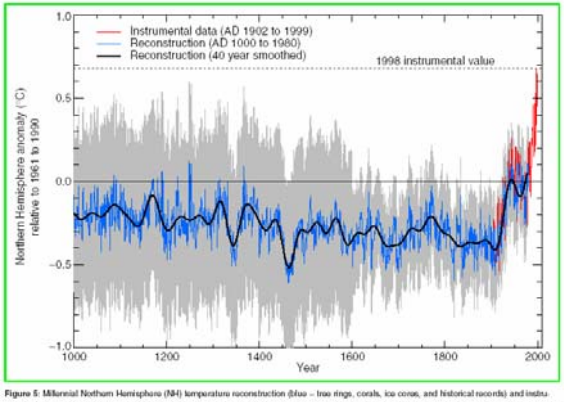
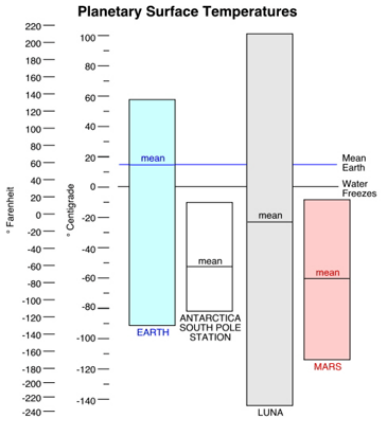


Figure 5: Millennial Northern Hemisphere (NH) temperature reconstruction (blue – tree rings, corals, ice cores, and historical records) and instrumental data (red) from AD 1000 to 1999. Smoother version of NH series (black), and two standard error limits (gray shaded) are shown. [Based on Figure 2.20]

IS THIS ALL YOU NEED TO KNOW AS A POLICY MAKER?
NO WAY!

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

The Earth is the 3rd planet of the solar system and has a moderate temperature.



Temperature of the Moon:

-23 °C

-193 °C to 111 °C

-> 300 °C difference

Temperature of the Earth:

15 °C

-88 °C to 58 °C

-> 150 °C difference

Surface temperature and the radiative equilibrium temperature of the planets of the solar system

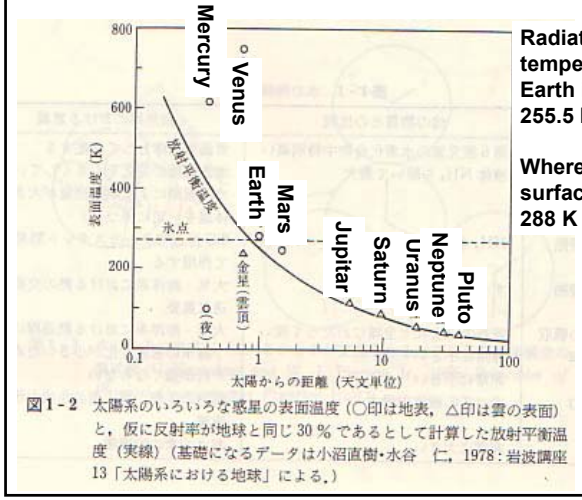


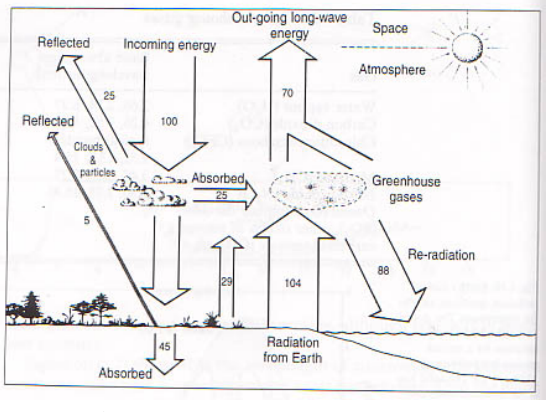
図1-2 太陽系のいろいろな惑星の表面温度（○印は地表，△印は雲の表面）と，仮に反射率が地球と同じ30％であるとして計算した放射平衡温度（実線）（基礎になるデータは小沼直樹・水谷 仁，1978：岩波講座13「太陽系における地球」による．）

Radiative equilibrium temperature of the Earth is:
255.5 K (-17.5 °C)

Whereas the observed surface temperature is 288 K (15 °C)

Benefit of the Greenhouse Gases

Fig. 1.11. Global average pathways for energy in the atmosphere. A notional 100 units comes from the Sun. [From Bigg, 1992a]



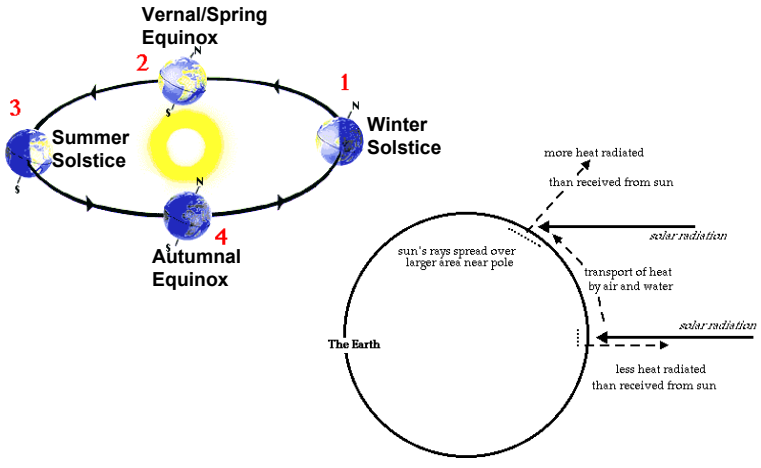
Just like wearing a sweater…
We *NEED* greenhouse gases to survive

It is not just CO_2!
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_2O)	2.66, 2.74, 6.27	55–70%
Carbon dioxide (CO_2)	4.26, 7.52, 14.99	25%
Chlorofluorocarbons (CFCs)	typical bonds: 9.52, 13.8, 15.4	11%
Methane (CH_4)	3.43, 6.85, 7.27	5%
Nitrous oxide (N_2O)	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?



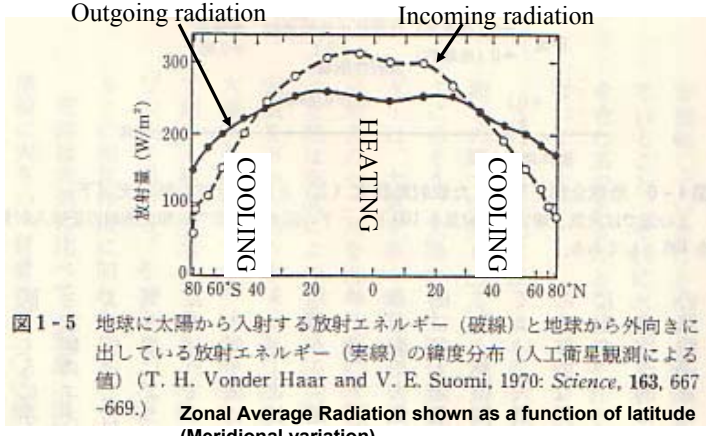


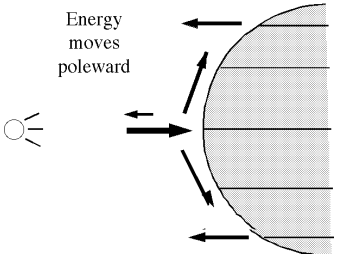
図 1 - 5 地球に太陽から入射する放射エネルギー（破線）と地球から外向きに出している放射エネルギー（実線）の緯度分布（人工衛星観測による値）（T. H. Vonder Haar and V. E. Suomi, 1970: *Science*, **163**, 667 -669.)

Zonal Average Radiation shown as a function of latitude (Meridional variation)

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

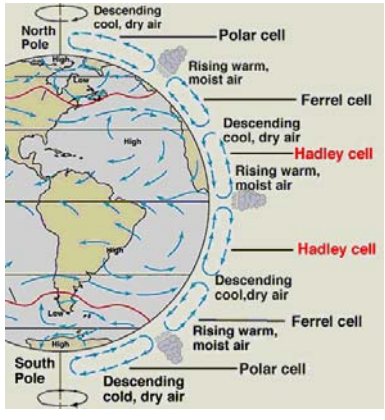
Wind and currents transport heat from the equator to the poles. That is why the Earth's temperature difference is small.

Energy moves poleward

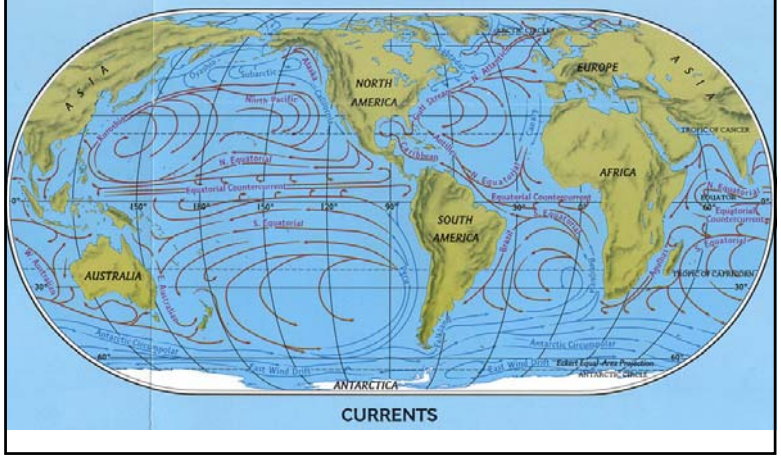


Note: Coriolis effect deflects the wind to the right (left) in the northern (southern) hemisphere

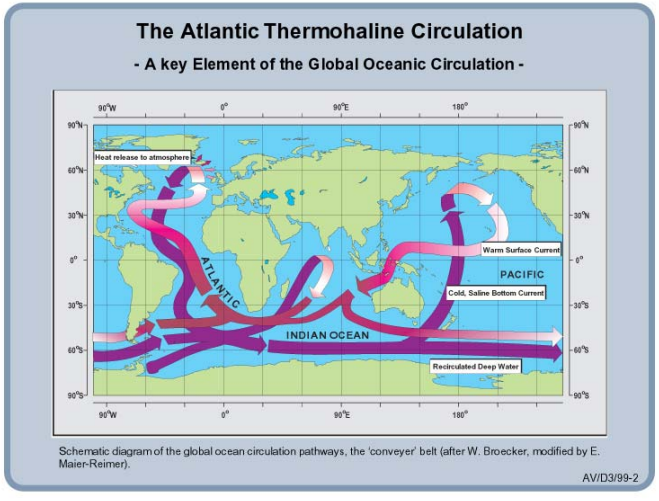
Atmospheric circulation

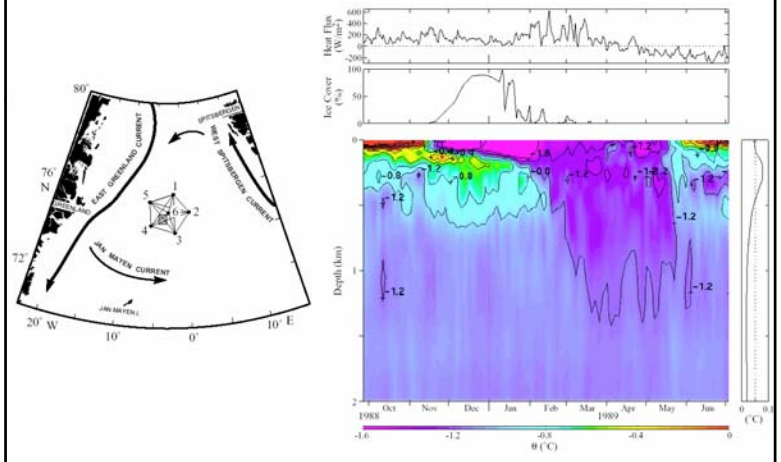


Wind Driven Ocean Currents

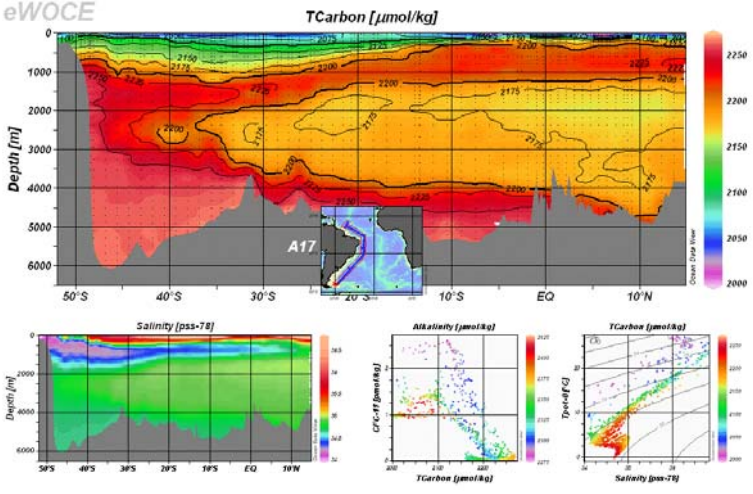


Circulation in the deep ocean – cooling in the polar region



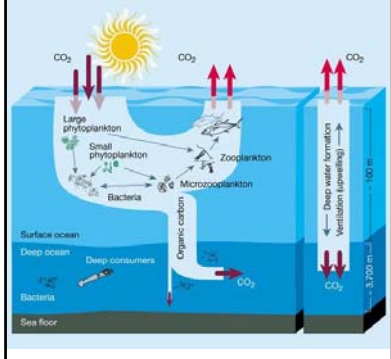


Cold surface water subducts (sinks) in the Greenland sea

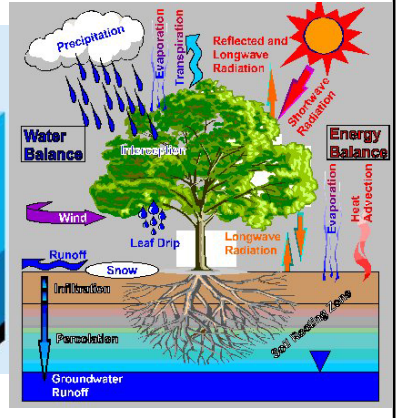


Carbon Dioxide concentration in the ocean

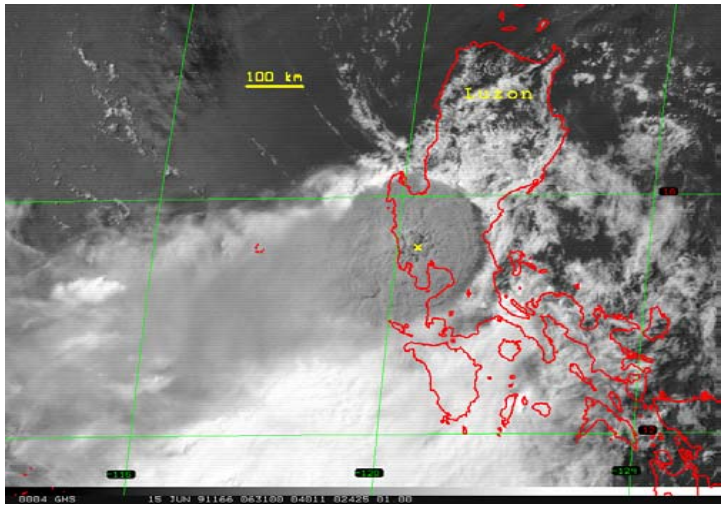
Biological Pump

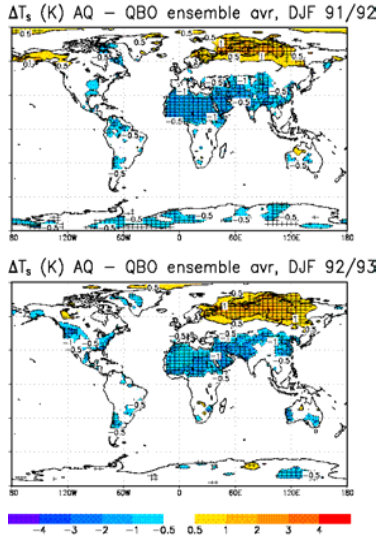


Land surface processes



Volcanic Activity – Mt. Pinatubo



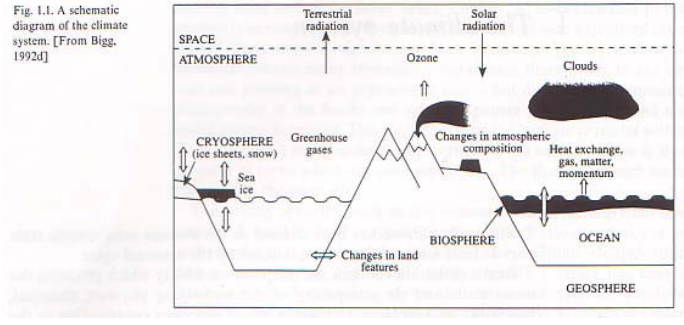


The impact of Pinatubo aerosol.

Surface temperature changes during the Boreal Winter (Northern hemispheric winter).

Anomalously strong Arctic Oscillation response.

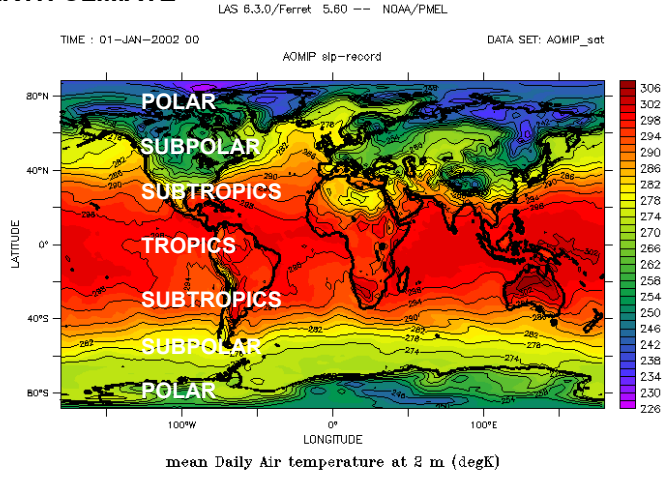
The earth temperature is maintained through subtle balances among *physical, chemical and biological* processes



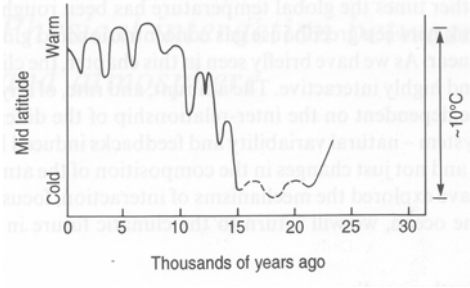
… and of course, human activities are a part of the system

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

EARTH CLIMATE



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**

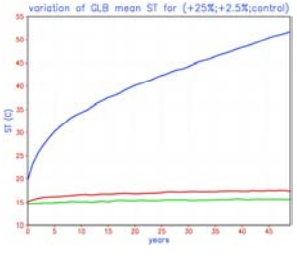
WORST SCENARIO
RUNAWAY GREENHOUSE EFFECT

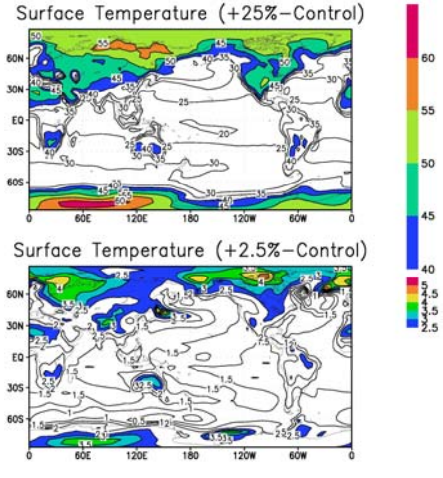
Temperature rise
↓
Evaporation of water
↓
Increase of the greenhouse gas (water vapor)

Positive feedback!

The earth would become like the Venus!

Simulated ranaway greenhouse effect by changing the solar constant



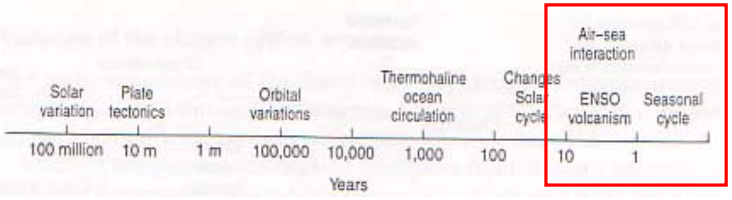


NCAR coupled atmosphere-ocean general circulation model in the control run (green), and in runs with the solar constant increased over the standard value by 2.5% (red) and by 25% (blue).

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

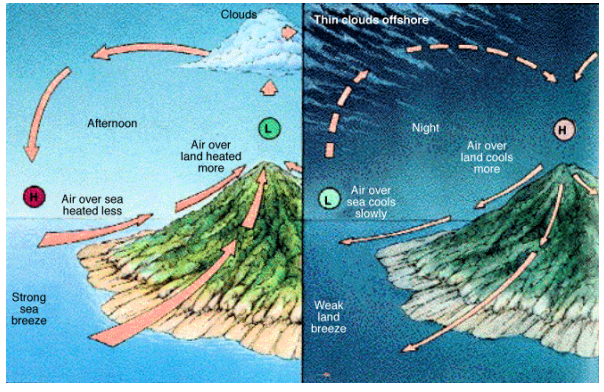


Diurnal – day & night
Intra-seasonal
Annual cycle (Seasonal)
Inter-annual
Decadal
Inter-decadal

SLOW PROCESSES ARE GOVERNED BY THE OCEAN DYNAMICS

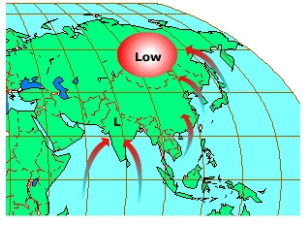
Oceanic Roles (AIR-SEA INTERACTION)

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

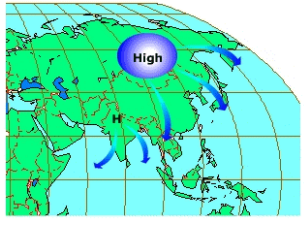


Land-sea temperature difference

•Monsoon (seasonal)

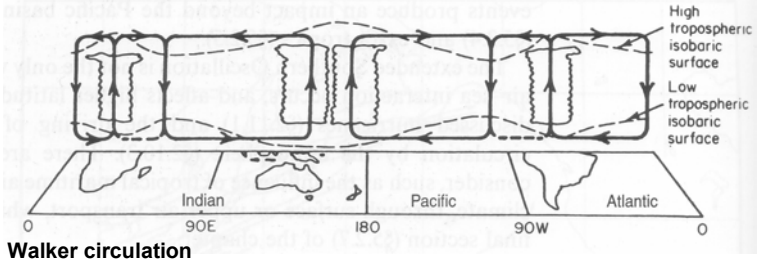


SUMMER

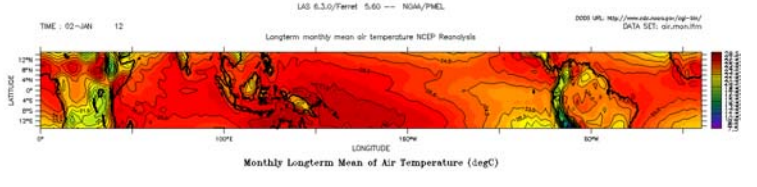


WINTER

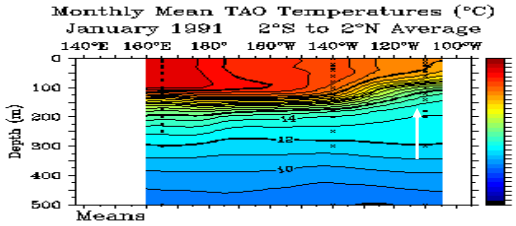
CONTRAST OF EAST-WEST SEA LEVEL TEMPERATURE



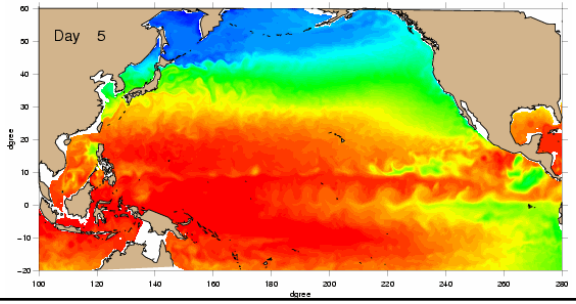
Walker circulation



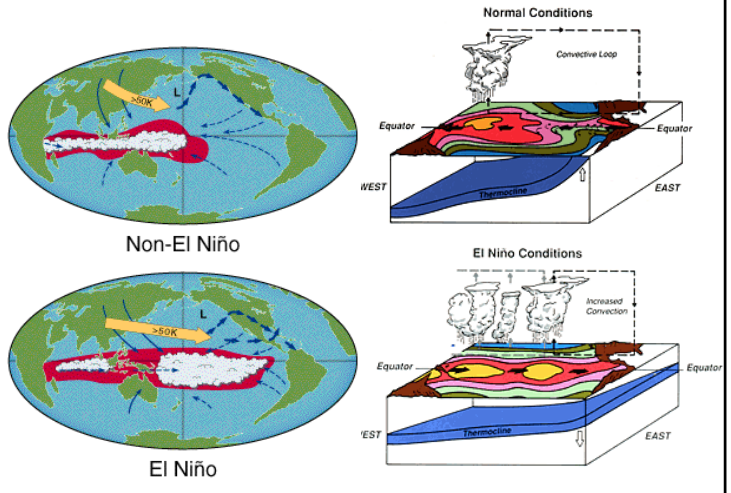
Pacific Ocean Interior – upwelling



Sea Surface Temperature (SST)

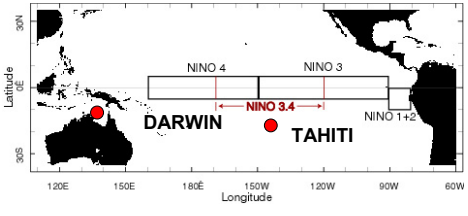


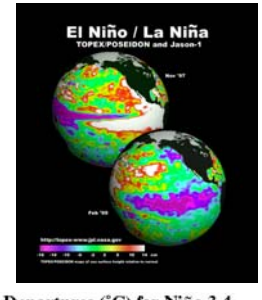
El Nino --- Air-Sea interaction



ENSO CYCLE

Signatures of El Nino and La Nina



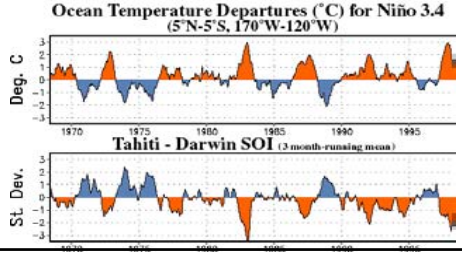


Sea surface temperature:

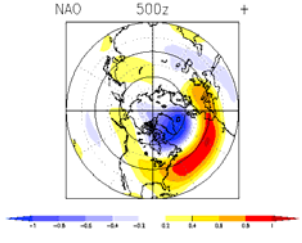
NINO indices

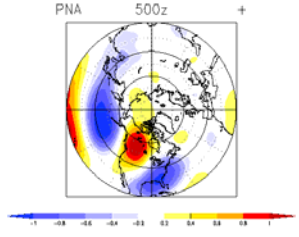
Atmospheric pressure difference between Darwin and Tahiti:

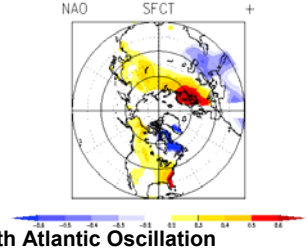
Southern Oscillation

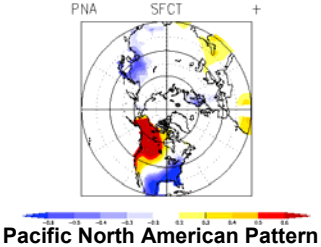


Teleconnection – *Atmospheric* bridge over ocean basins and continents (fast process)









North Atlantic Oscillation

Pacific North American Pattern

Teleconnection – *Atmospheric* bridge over ocean basins and continents (fast process)

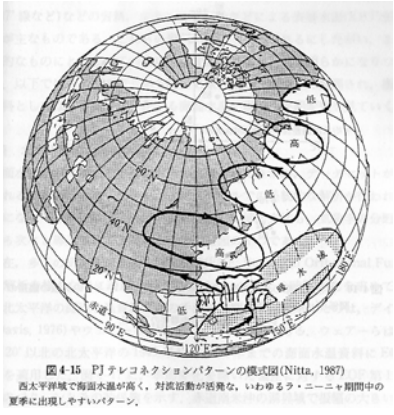


図 4-15　PJ テレコネクションパターンの模式図(Nitta, 1987)
西太平洋域で海面水温が高く，対流活動が活発な，いわゆるラ・ニーニャ期間中の夏季に出現しやすいパターン。

Enhanced convection in the western Pacific

↓

Anomalous low pressure

↓

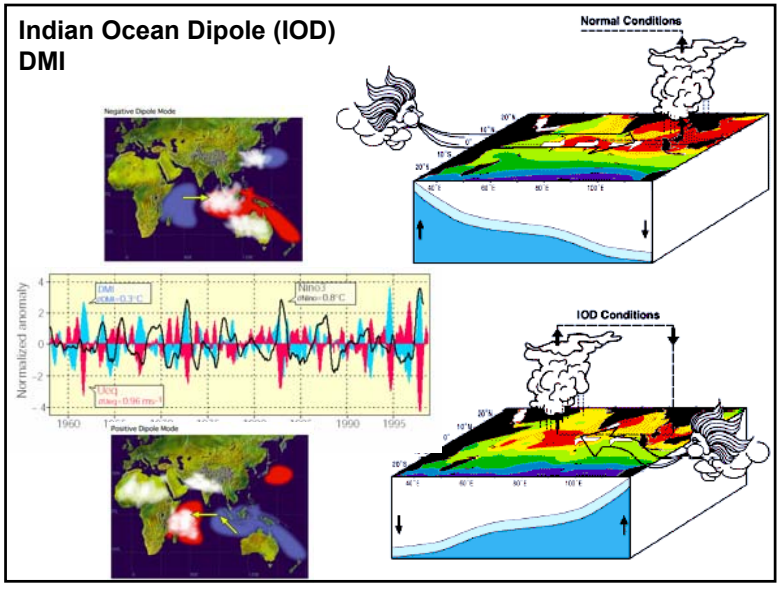
Transmission of Rossby wave

↓

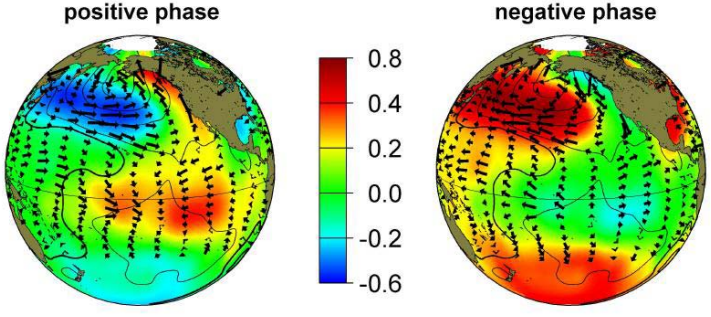
Anomalous high pressure over Japan
HOT and Dry Summer

Atmospheric pattern during the summer of La Nina period

Indian Ocean Dipole (IOD)
DMI

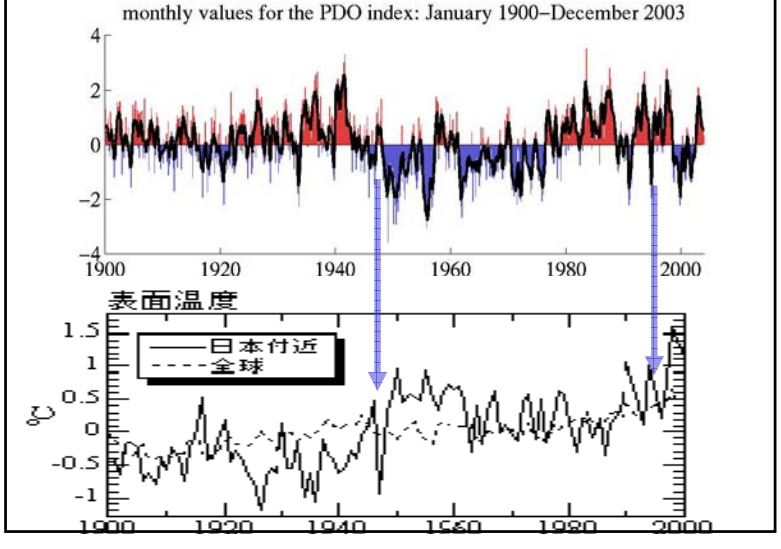


Decadal Variability (slow process) : *Oceanic Bridge*
- Pacific Decadal Oscillation

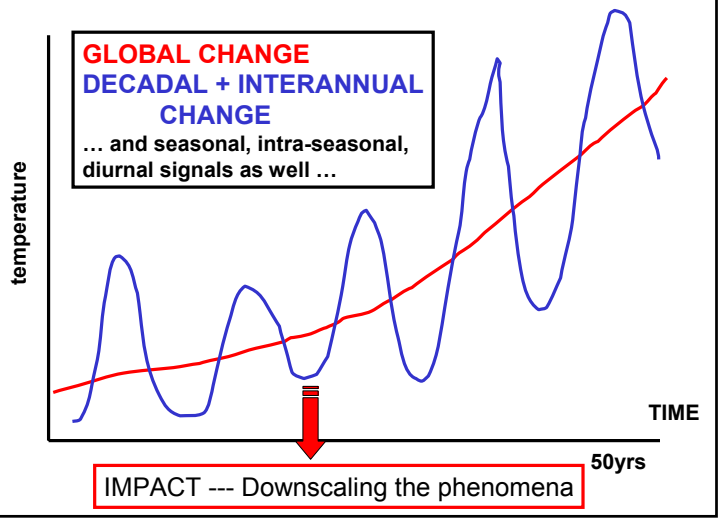


Color: SST; Contour: sea level pressure; Arrow: wind

Regime shift – associated with Pacific Decadal Oscillation



Variation in the future



IPCC Emission Scenarios

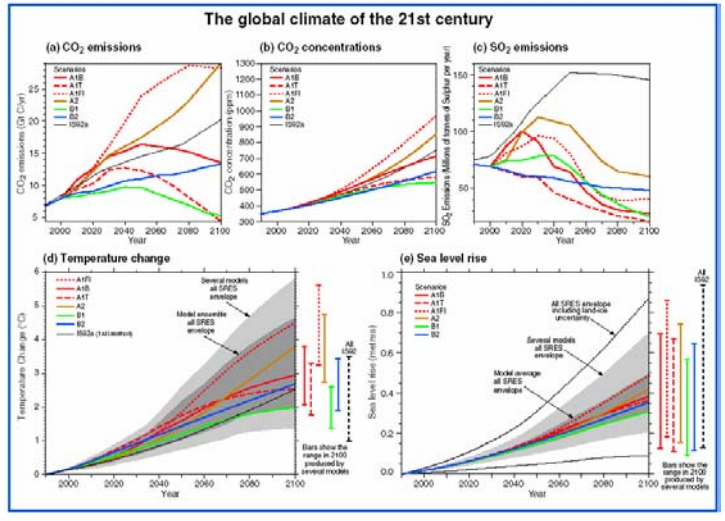
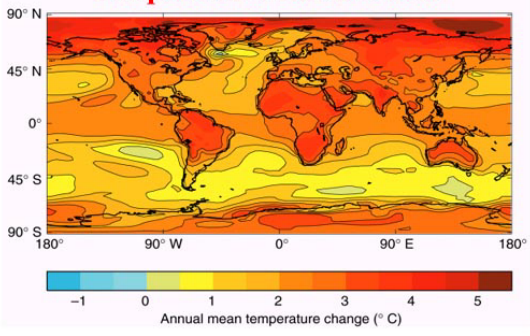


Figure 5: The global climate of the 21st century will depend on natural changes and the response of the climate system to human activities.

Impacts of global warming http://www.ipcc.ch/press/sp-cop6.htm

Figure 11: Projected Changes in Annual Temperatures for the 2050s

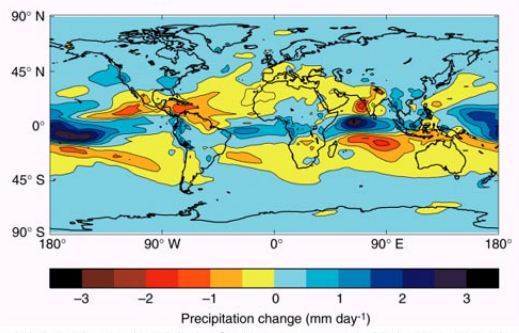


The projected change in annual temperatures for the 2050s compared with the present day, when the climate model is driven with an increase in greenhouse gas concentrations equivalent to about a 1% increase per year in CO_2.

The Met Office. Hadley Centre for Climate Prediction and Research.

Impacts of global warming http://www.ipcc.ch/press/sp-cop6.htm

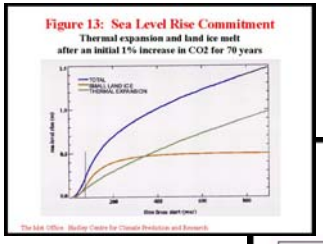
Figure 12: Projected Changes in Annual Precipitation for the 2050s

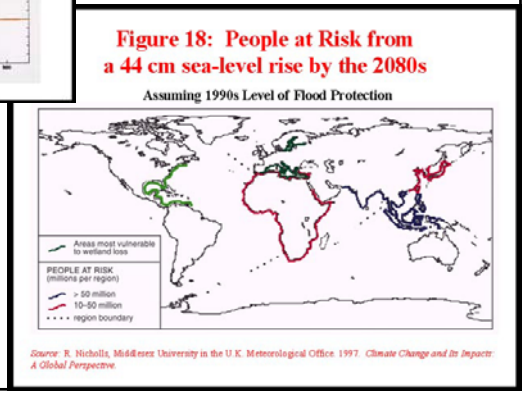


The projected change in annual precipitation for the 2050s compared with the present day, when the climate model is driven with an increase in greenhouse gas concentrations equivalent to about a 1% increase per year in CO_2.

The Met Office - Hadley Centre for Climate Prediction and Research.

Impacts of global warming http://www.ipcc.ch/press/sp-cop6.htm





Impacts of global warming http://www.ipcc.ch/press/sp-cop6.htm

Figure 17: Vector (insect)-borne Diseases

Disease	Vector	Population at risk (millions)	Present distribution	Likelihood of altered distribution with warming
Malaria	mosquito	2,100	(sub)tropics	✓✓
Schistosomiasis	water snail	600	(sub)tropics	✓✓
Filariasis	mosquito	900	(sub)tropics	✓
Onchocerciasis (river blindness)	black fly	90	Africa/Latin America	✓
African trypanosomiasis (sleeping sickness)	tsetse fly	50	tropical Africa	✓
Dengue	mosquito	unavailable	tropics	✓✓
Yellow fever	mosquito	unavailable	tropical South America & Africa	✓

Likely ✓
Very likely ✓✓

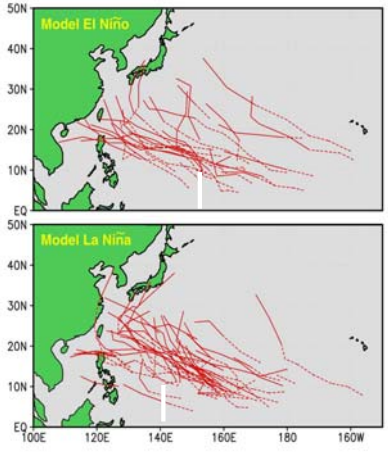
Source: Modified WHO, as cited in Stone (1995).

Assessing the local impacts - Typhoon

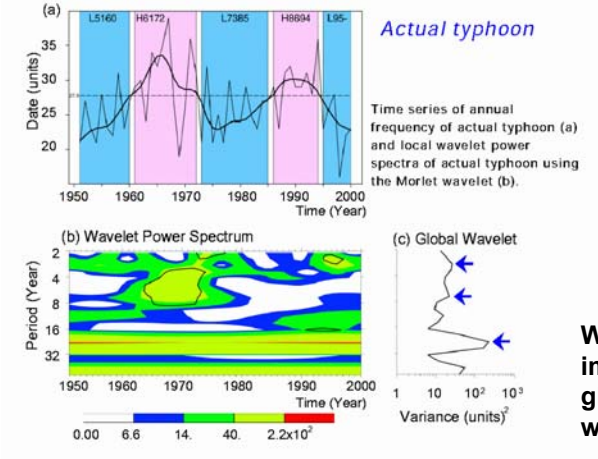
Shift of typhoon genesis location due to ENSO

During El nino
-- shift towards the east

During La nina
-- shift towards the west

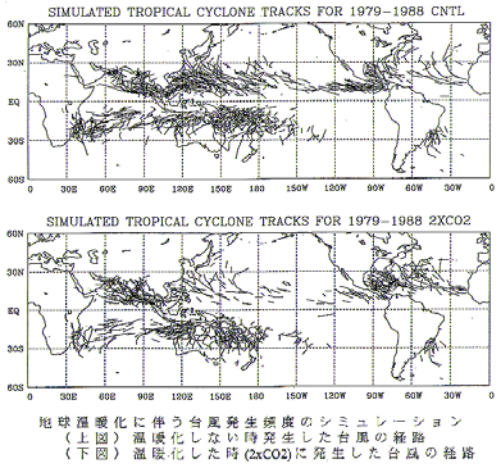


Assessing the local impacts – Typhoon variations at different time scales



What is the impact of global warming?

Assessing the local impacts – Typhoon Impact of global warming

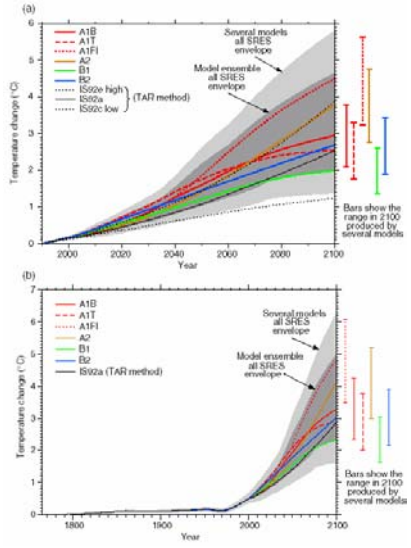


地球温暖化に伴う台風発生頻度のシミュレーション
（上図）温暖化しない時発生した台風の経路
（下図）温暖化した時(2xCO2)に発生した台風の経路

The number reduces but are predicted to be stronger

…recall Y2004, strong typhoon due to high SST East of Philippines

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



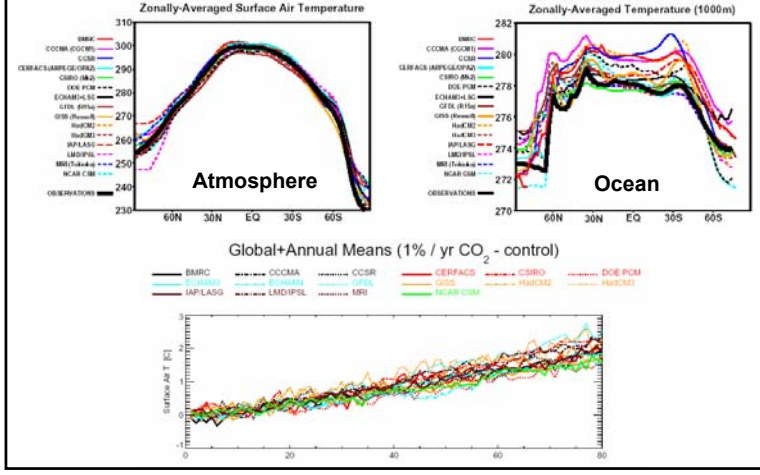
Uncertainties of temperature rise from various numerical models

What causes such variability?

CMIP

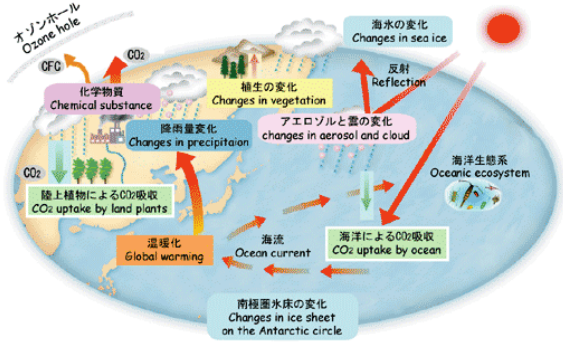
Coupled Model Intercomparison Project

35 Models from worldwide

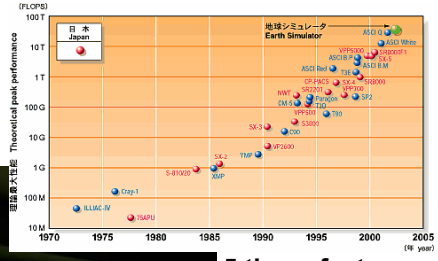


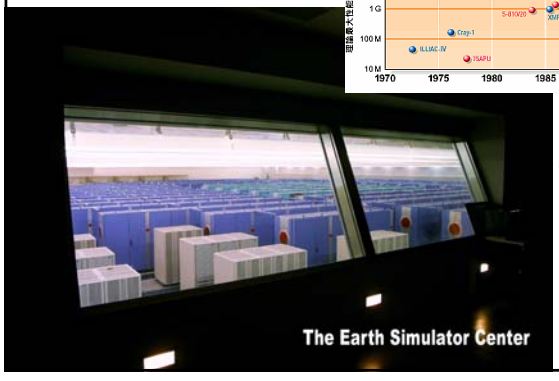
TOWARDS THE CONSTRUCTION OF AN IMPROVED COUPLED MODEL

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



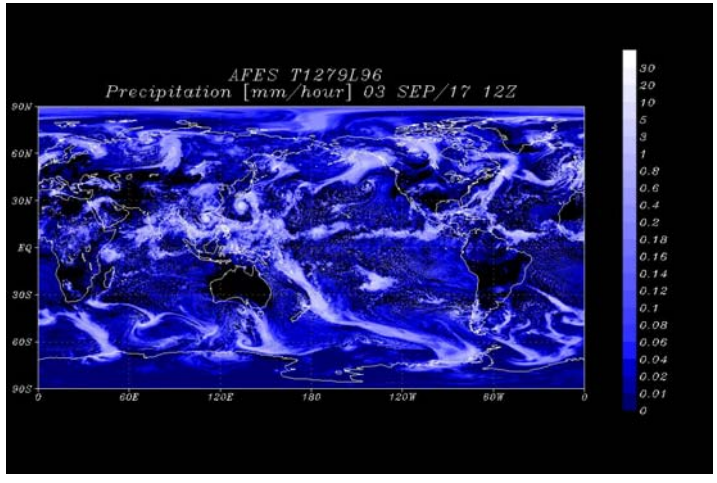
THE EARTH SIMULATOR (JAMSTEC)



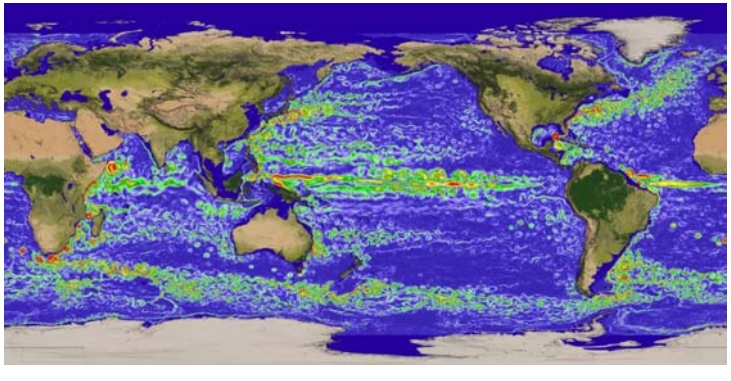


5 times faster than the existing fastest computer

Earth Simulator – atmospheric model

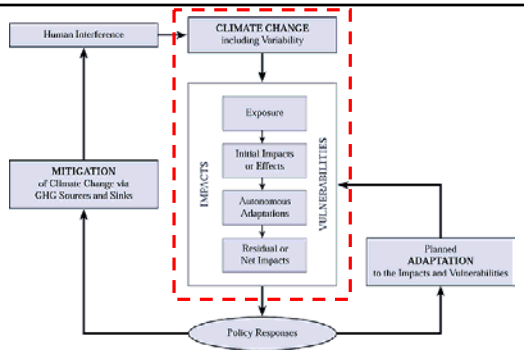


Earth Simulator – ocean model



SUMMARY

1. **The constituents of the earth system are: atmospheric, oceanic, land, ice, biological, chemical and geological processes**
2. **Climate change results from the interaction among different processes, naturally**
3. **The global warming due to anthropogenic GHG alters the natural variations of the earth climate**
4. **To assess the impacts of that, there is a worldwide modeling effort under IPCC emission scenario**
5. **Prediction skill has improved but more work is needed**
6. **Impacts of global warming requires further research**



Homework:

Do some research on possible impacts of climate change related to the global warming and discuss the vulnerabilities of our society e.g. increase of diseases in South Asia, increasing storm damages in the Pacific Islands, extreme events (droughts, heavy rainfalls, high/low temperature etc.)

Suggested reading:

IPCC third assessment report Climate change 2001:
The scientific basis and/or Impacts, Adaptation and Vulnerability
(TS or full report) @ http://www.ipcc.ch/