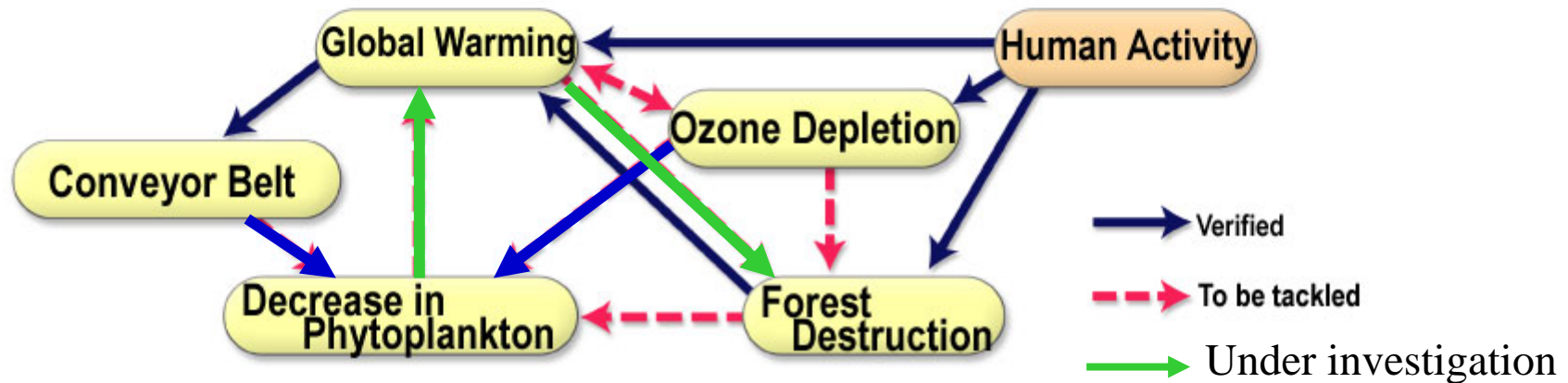
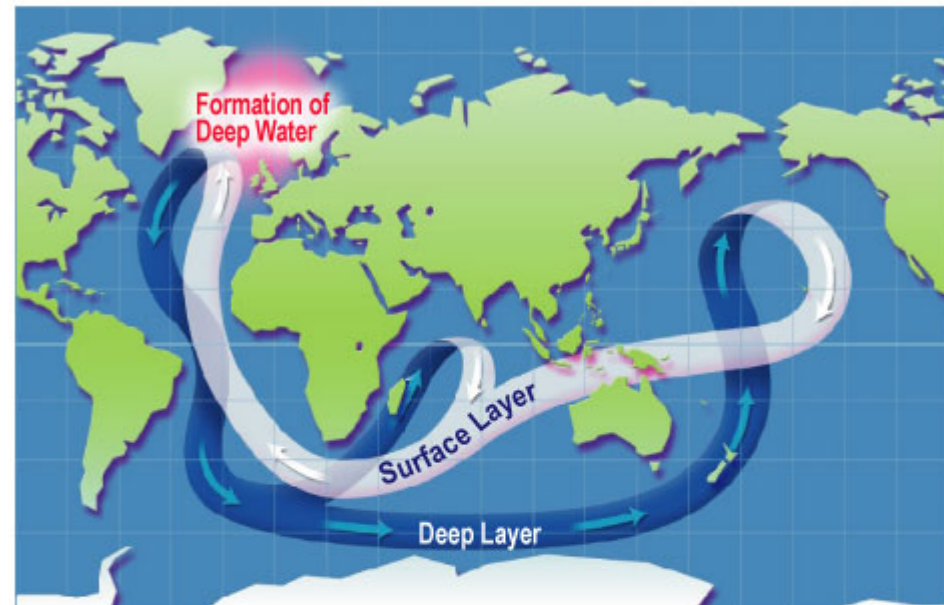
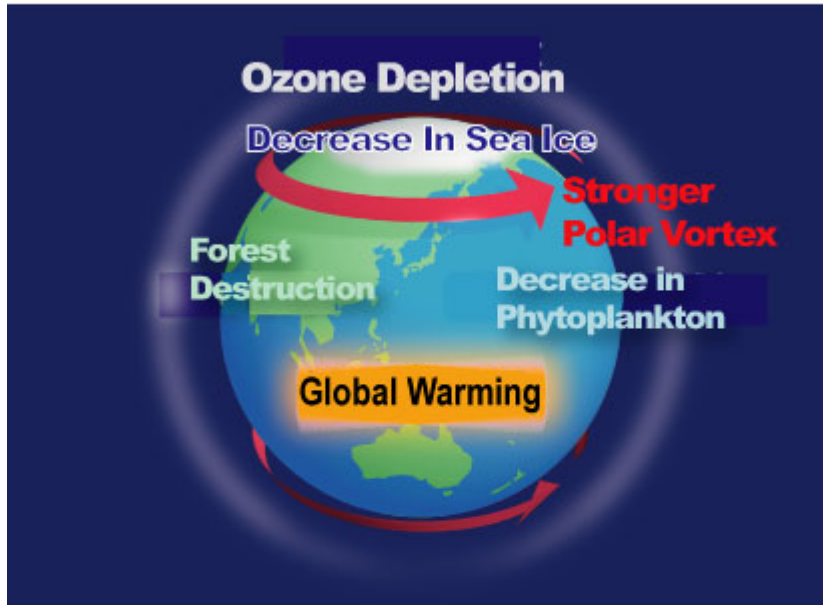


# Prediction and avoidance of an abrupt change in the bio-geosphere system

- Faculty of Environmental Earth Science
- Institute of Low Temperature Science
- **What is Abrupt Change?**
- A hundred year-scale change occurring as consequence of anthropogenic changes which bring a positive feedback between geosphere and biosphere, and destroy a self-recovery mechanism of the earth

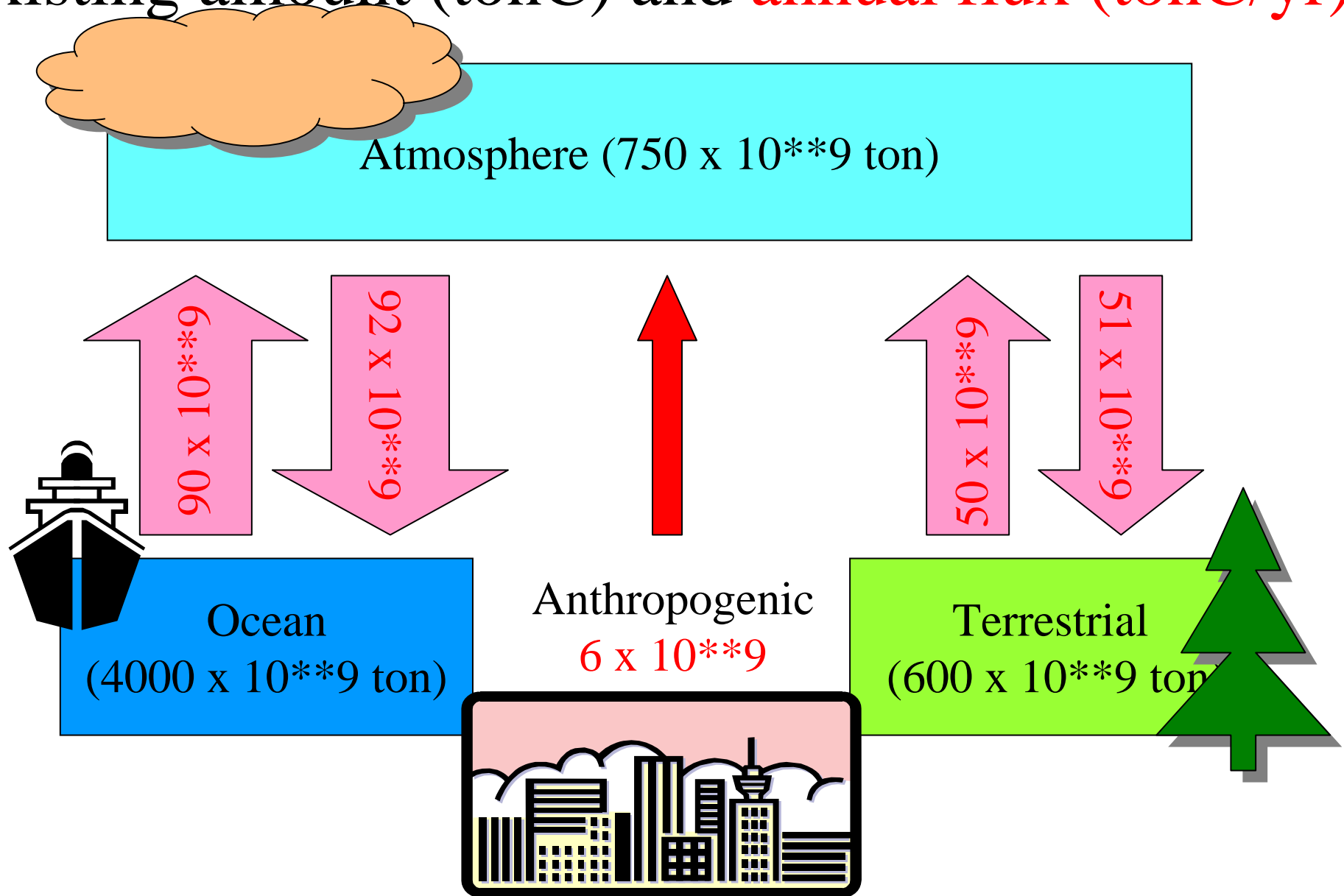
The topics that we focus on

## Clarify the mechanism of Abrupt Change

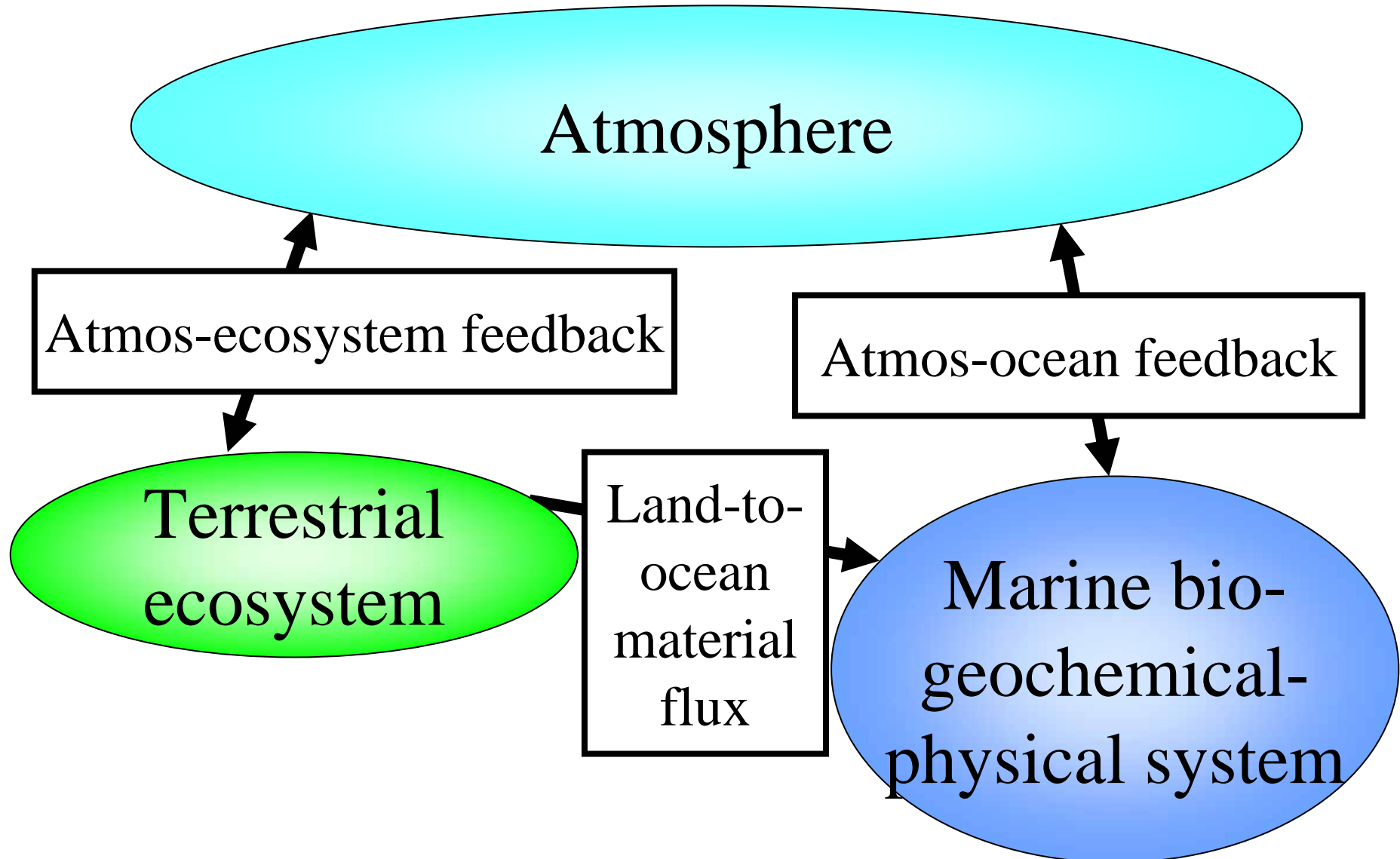


# Global Carbon (Dioxide) Cycle

existing amount (tonC) and **annual flux (tonC/yr)**



# Three topics in the program

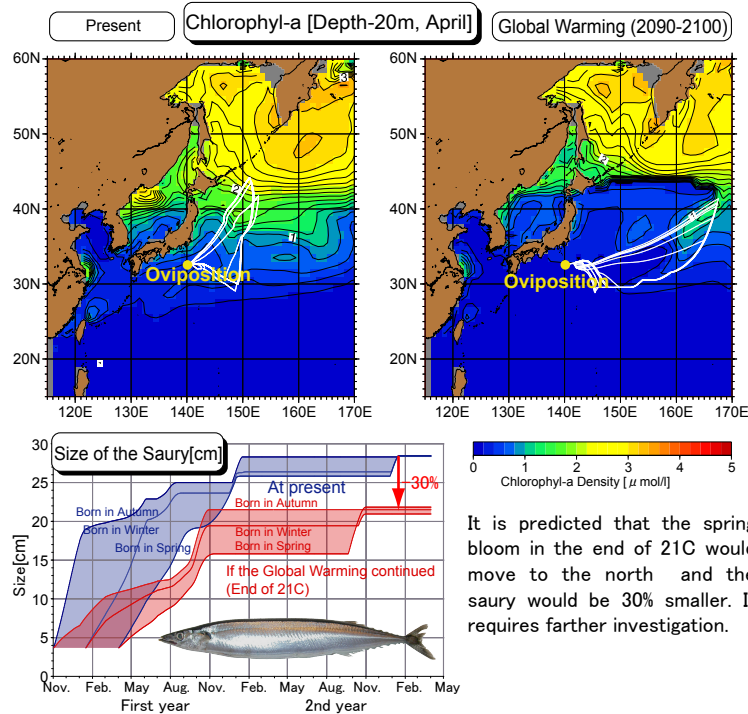


# Global Warming

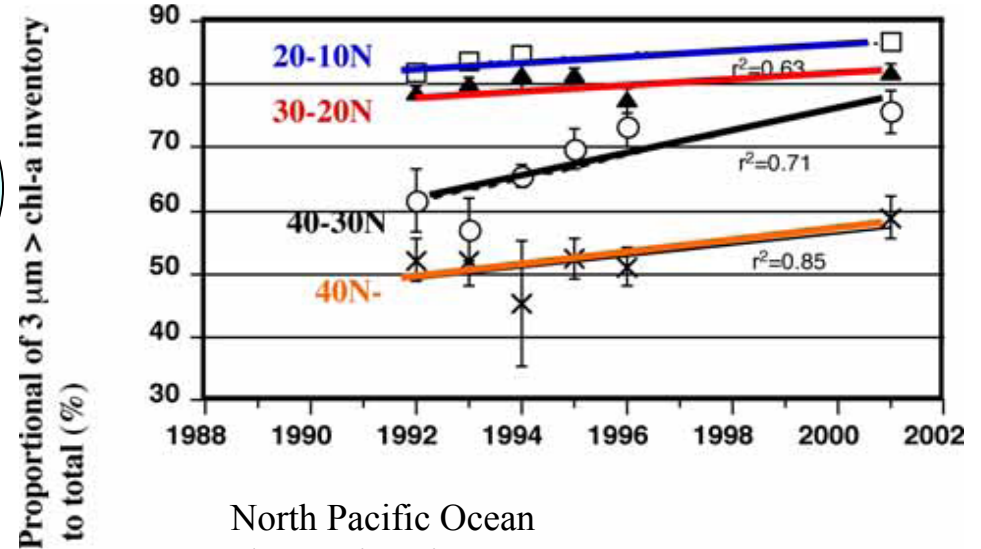
confirmed

**Phytoplankton  
reduction caused by  
global warming**

Northwest Pacific Ocean  
bio-geochemical-physical model



It is predicted that the spring bloom in the end of 21C would move to the north and the saury would be 30% smaller. It requires farther investigation.



North Pacific Ocean  
observations in 1990's

under investigation

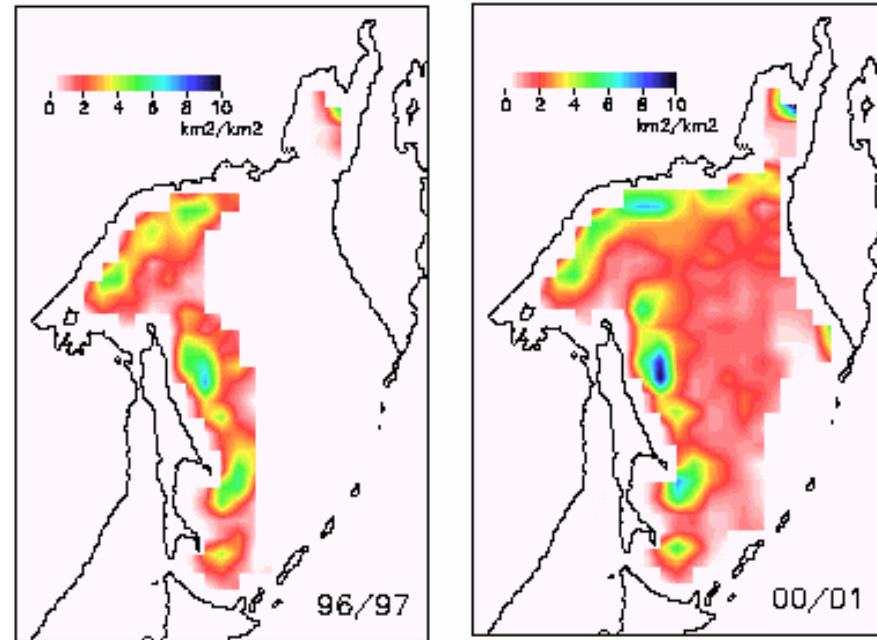
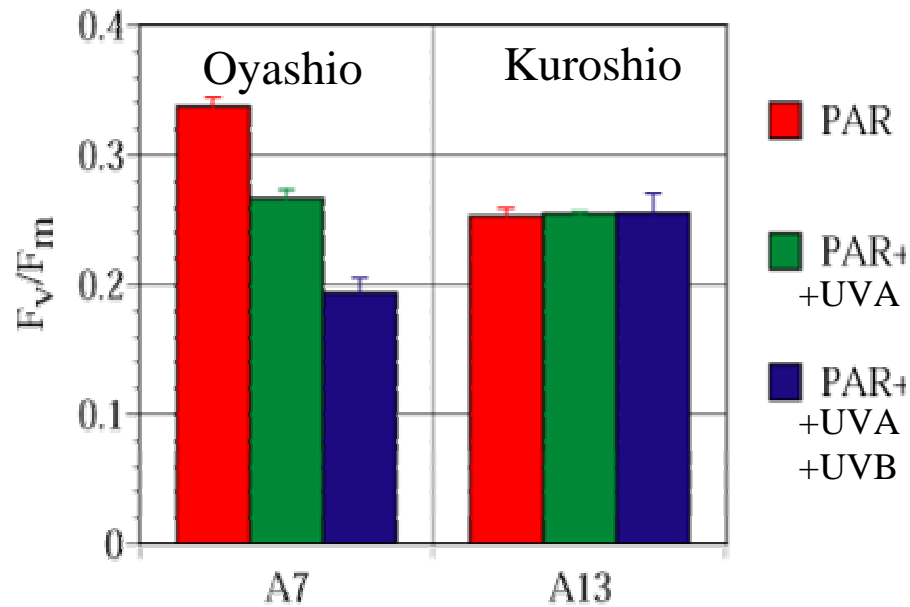
**Plankton species  
change reduces alkalinity  
and CO<sub>2</sub> is emitted**

# Ozone depletion-UVB

# Polar ocean influences

Phytoplankton in Oyashio damaged by UVB  
How is bacteria?

Photosynthesis efficiency reduced by UVB

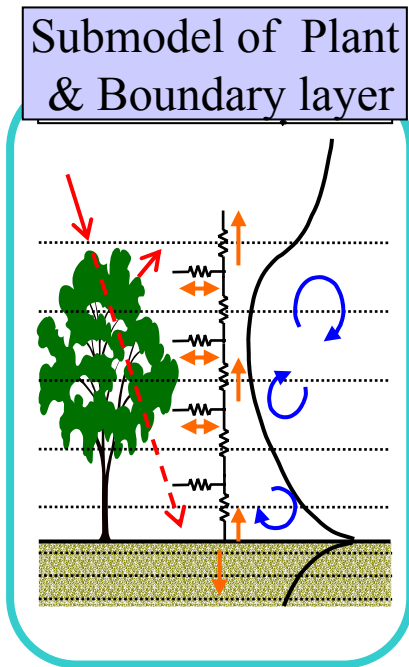


Ice formation observed in satellite images

Ice forms in Okhotsk inducing dense water interannual variation

# Ecosystem-climate

Coupled model of atmosphere and terrestrial ecosystem

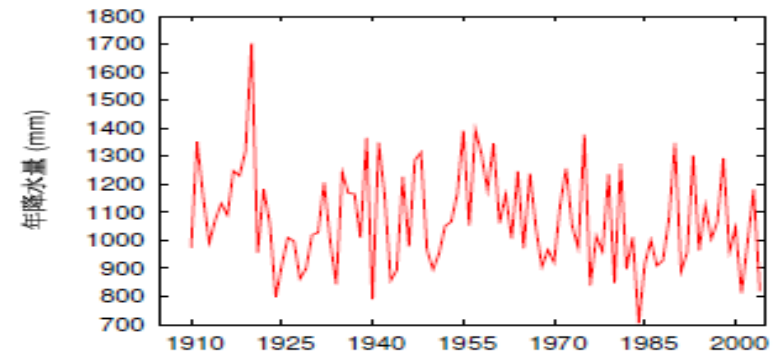
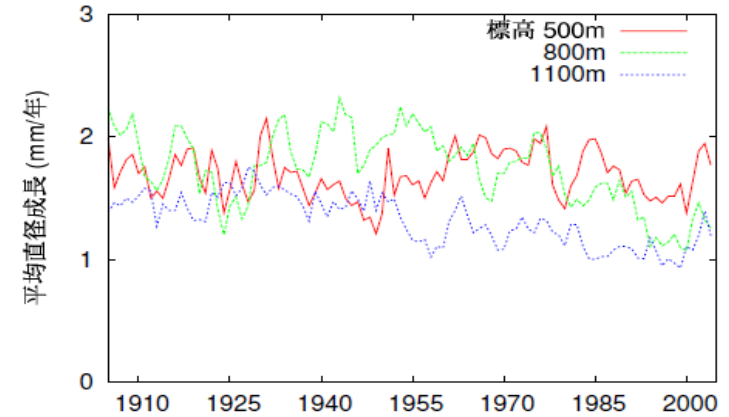
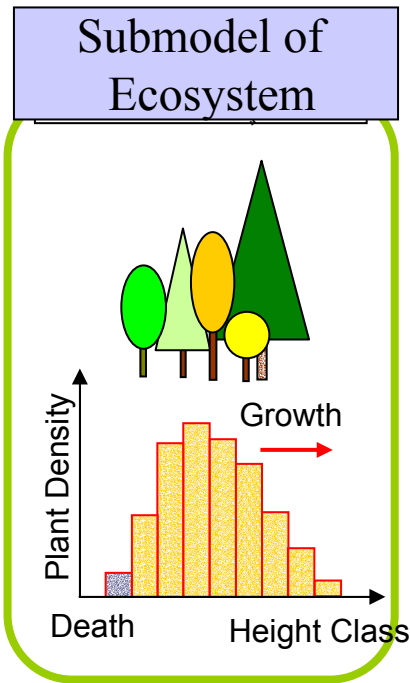


MINoSGI



Photo synthesis

Growth and death



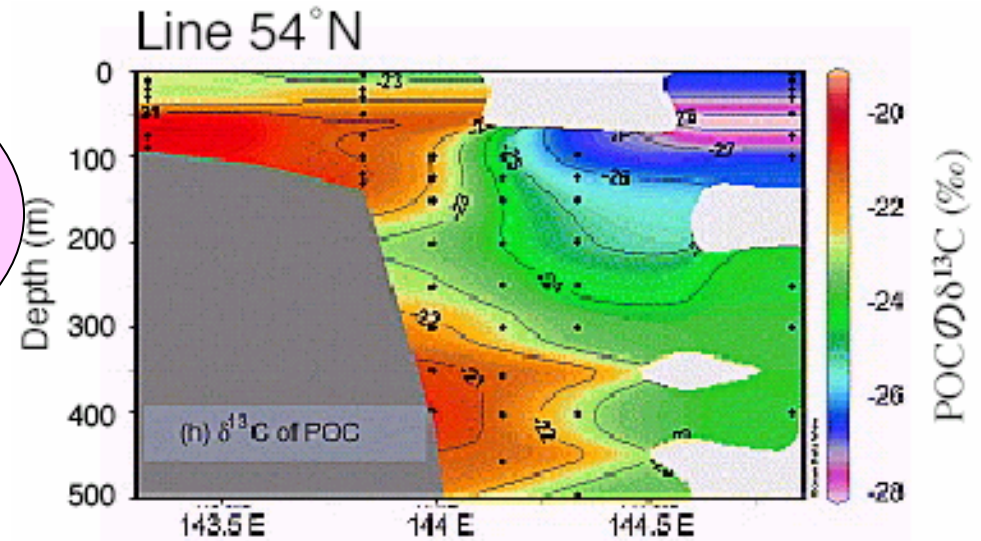
Growth rate vs. precipitation  
Lower growth under less precipitation above 800m

Plant grows more rapidly under warming Hydrology cycle?

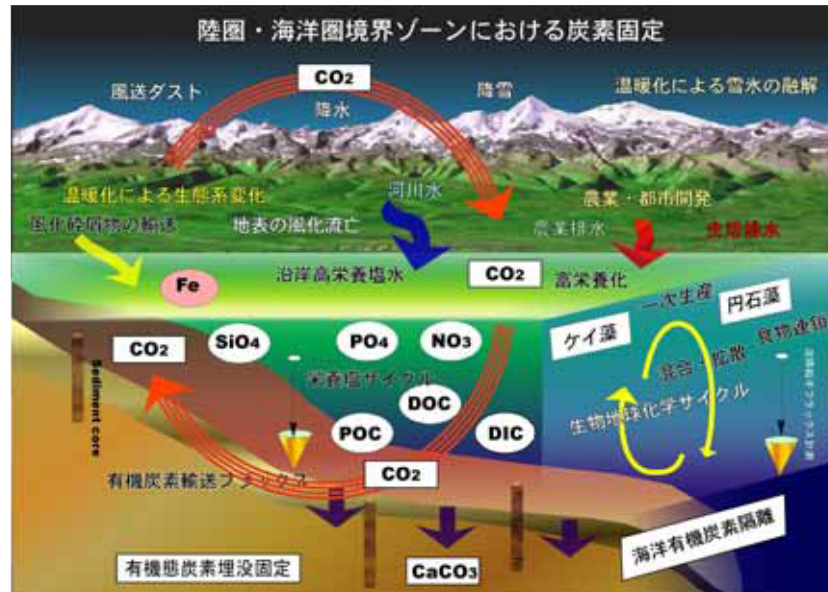
# Terrestrial material flowing to ocean

Terrestrial material enhances marine productivity?

Tokachi river to Oyashio



Amur river to Okhotsk Sea



Dense water formation under ice growth on continental shelf



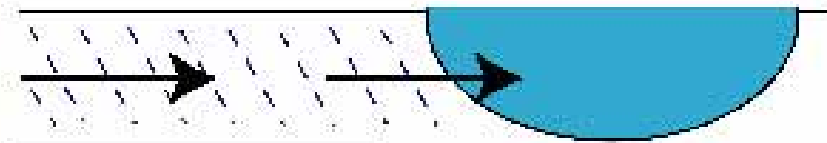
# From Amur River Basin to Okhotsk Sea



Forest in upper reach and Wetland in lower reach. In Chinese territory, wetland has been converted farmland

Iron promotes marine productivity

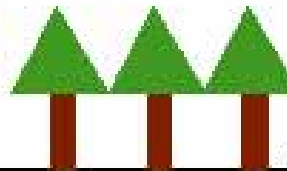
## Wetland



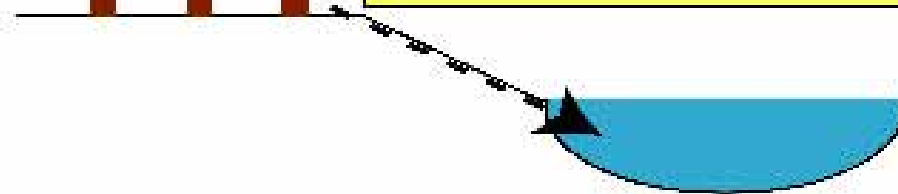
Iron is dissolved in anoxic ground water ( $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$ )

Most of discharged iron is oxidized ( $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$ ) and precipitates on river floor.

## Forest



Part of iron ( $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ) forms complex with humic substance, which does not precipitates.



# Proposal of avoidance method

- ④ Method to avoid an abrupt change (based upon the bio-geosphere system mechanisms)

Basic idea: enhance mechanisms in the natural ecosystem-geochemical cycles

Example

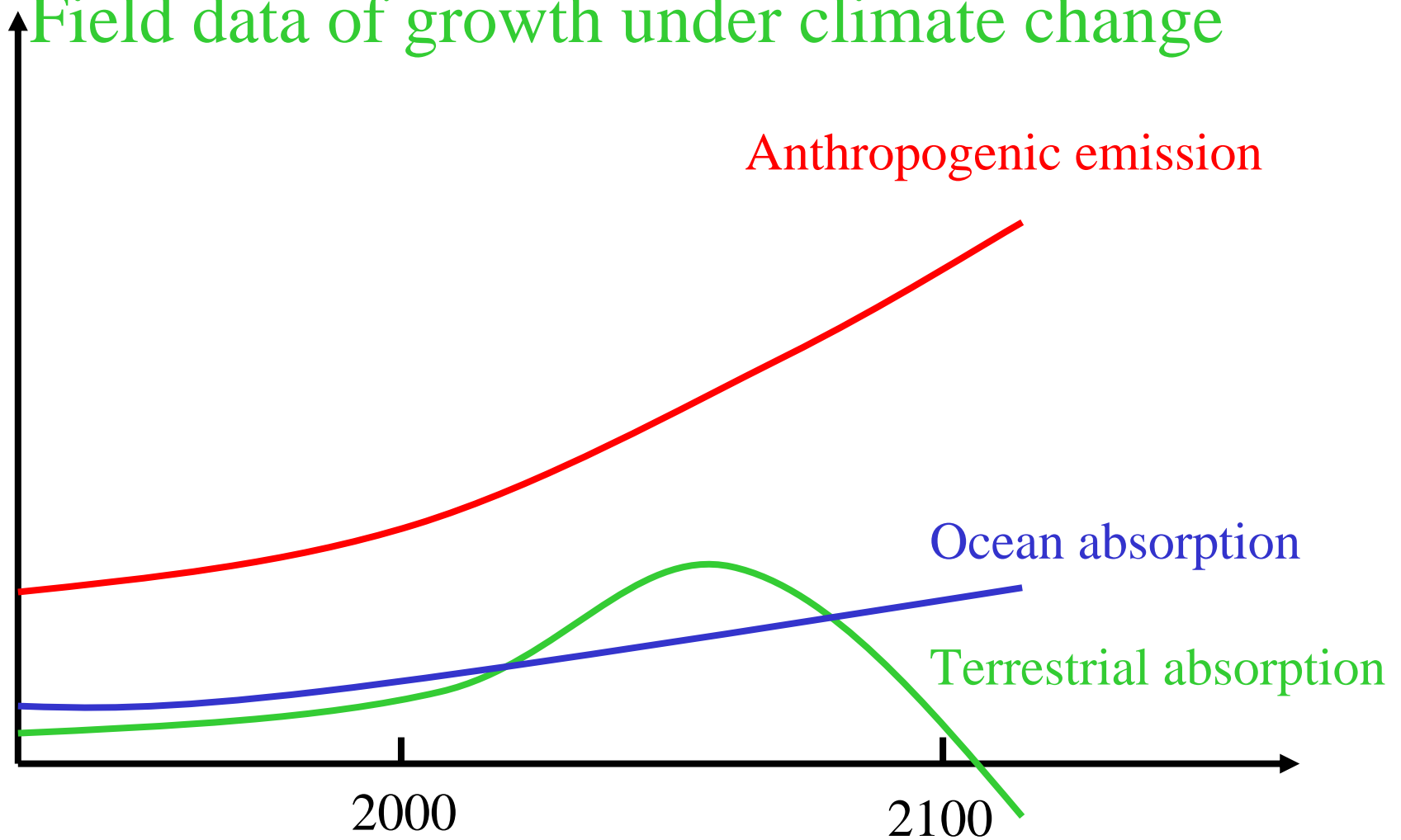
- CO<sub>2</sub> absorption by enhancing productivity  
Ex. enhance productivity on the shelf  
ejected to deep ocean

**Optimize biodiversity and carbon fixation**

# Carbon emission and absorption rates

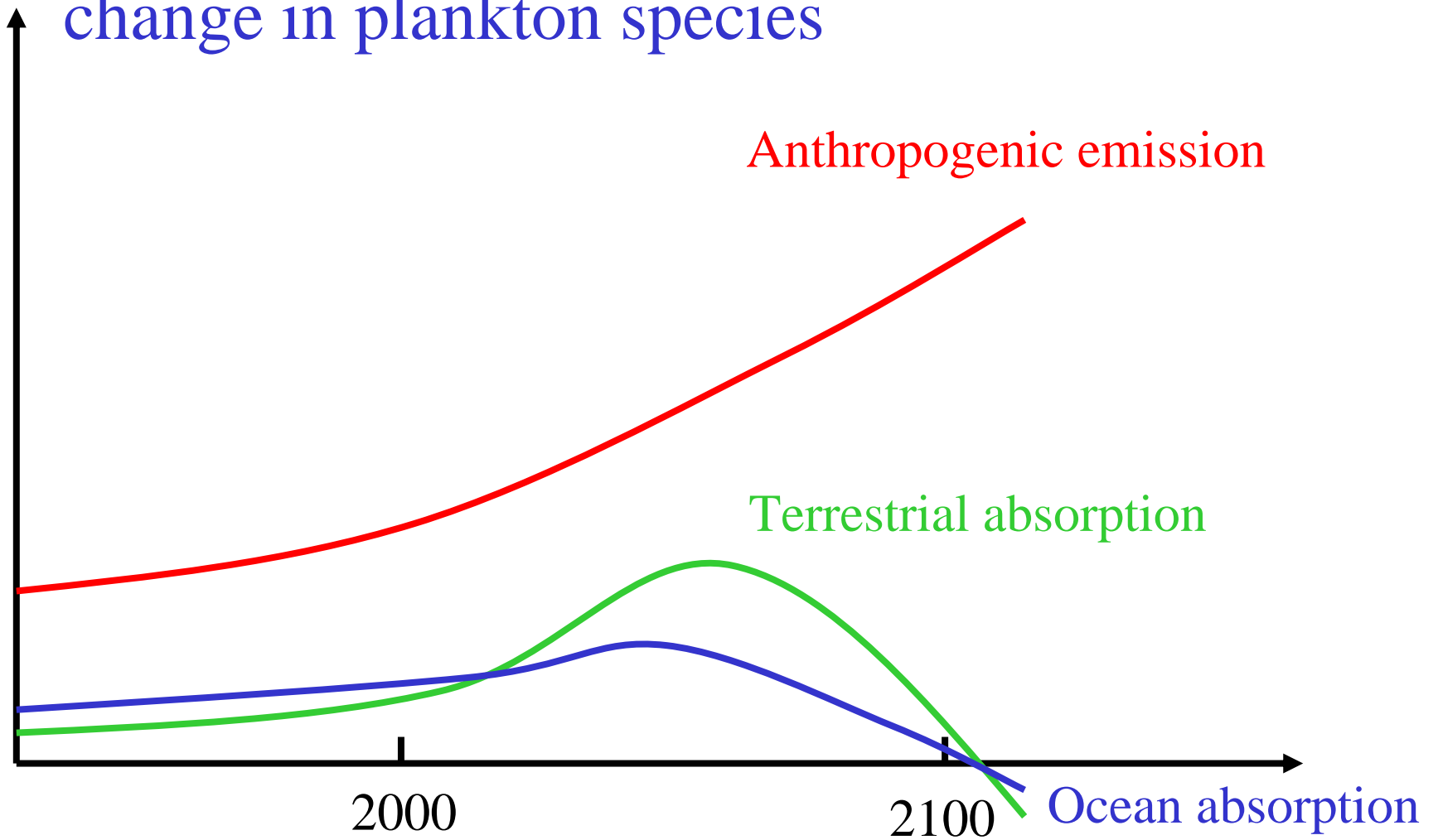
Sensitivity of terrestrial ecosystem is crucial

Field data of growth under climate change



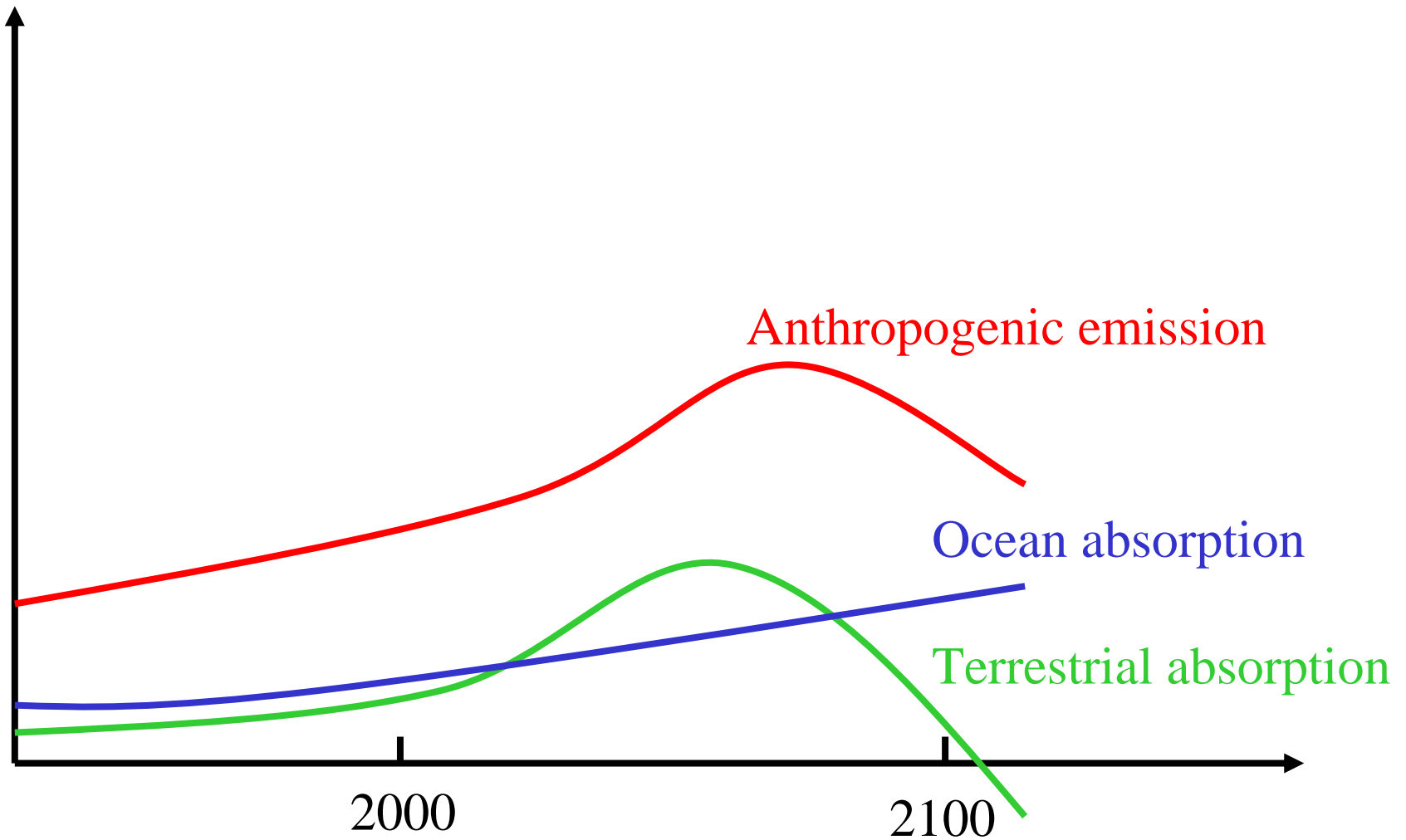
# Carbon emission and absorption rates

Weakening of global ocean conveyor belt,  
change in plankton species



# Carbon emission and absorption rates

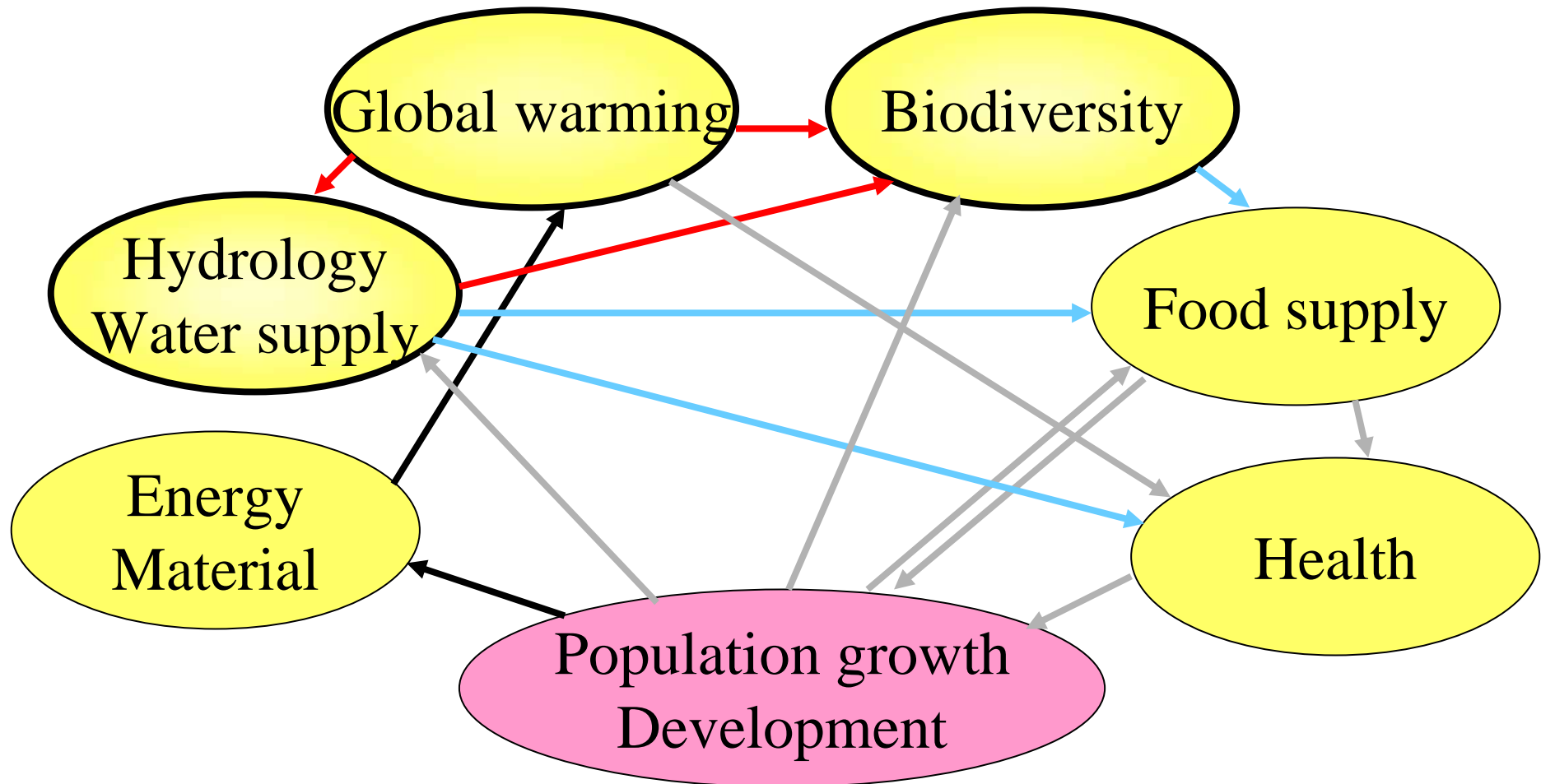
Life style change and technology improvement



# Beyond Kyoto Protocol

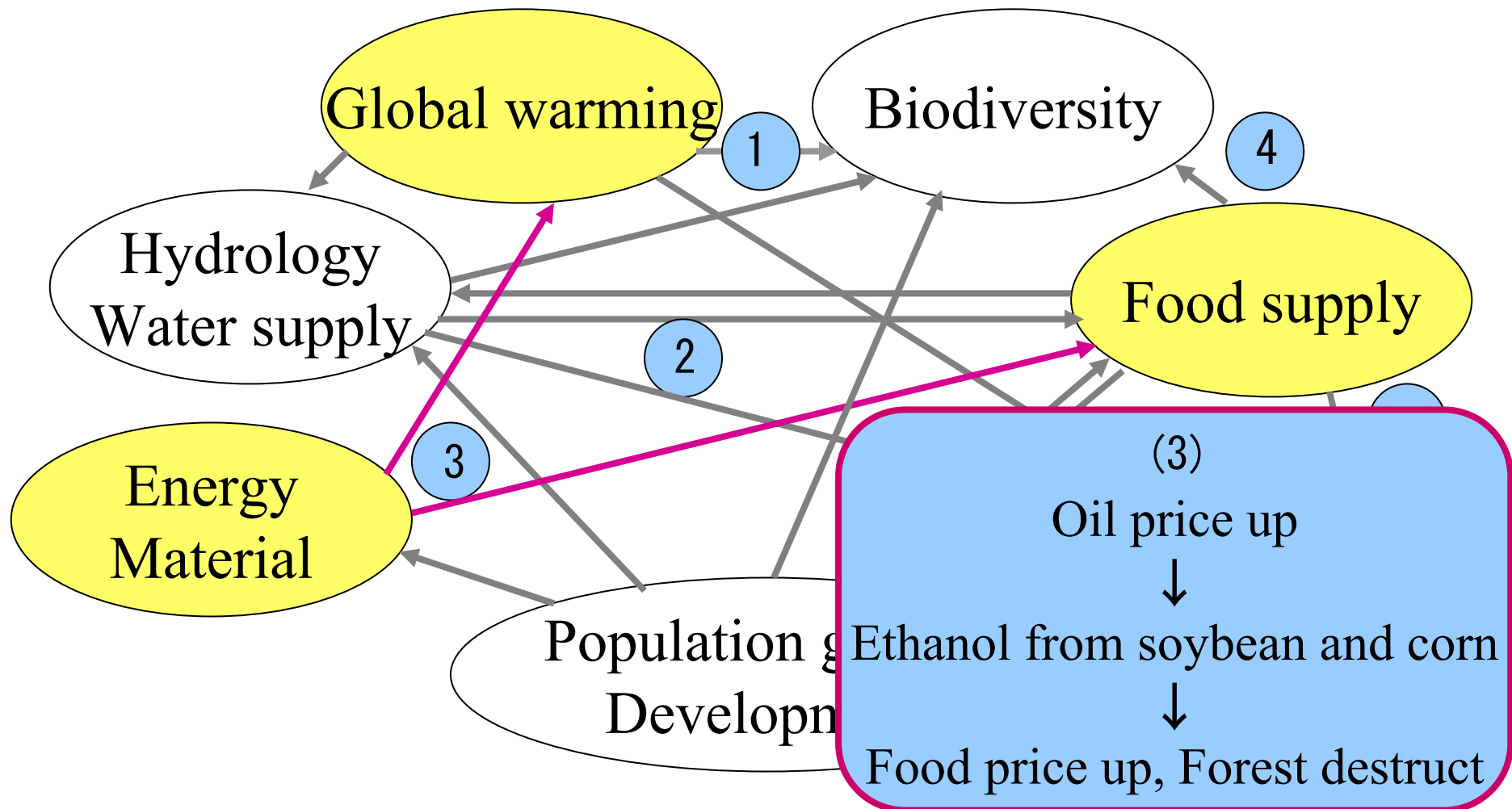
- What will come in 2050-2100?
- The global population has increased by a factor of 2.4 in last 50 years, and will increase.
- Some of the under-developing countries will become developed countries in 50 years, and emit a large amount of carbon dioxide.
- Global warming will change the pattern of rain.
- Biodiversity is reduced and food supply is limited.
- Human health is damaged.
- How can we solve this problem?

# Feedback with problems **Beyond Kyoto Protocol**



Once each problem gets worse, it worsens the others.  
Can we solve all problems together?

# Feedback with problems **Beyond Kyoto Protocol**



However, we try to solve one problem,  
but often make others worse.