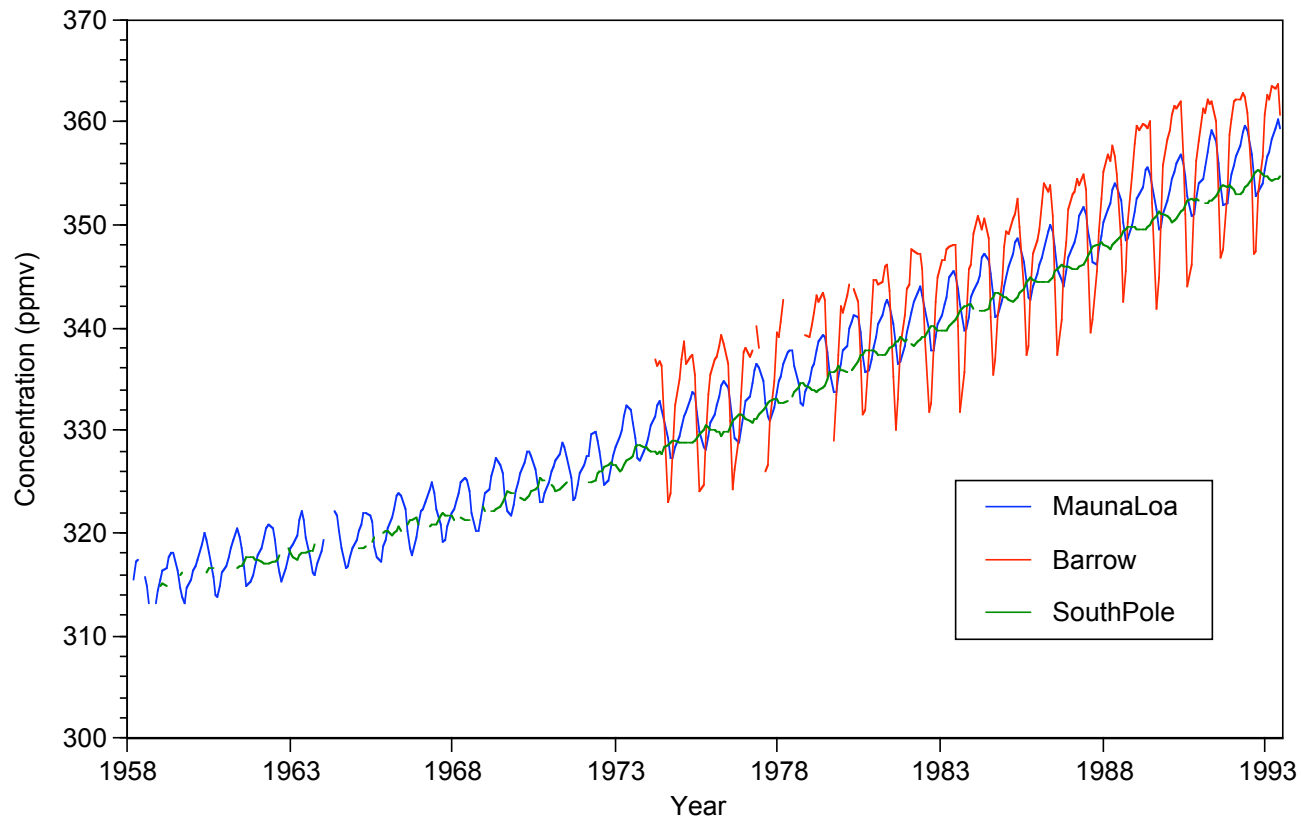


1. Earth Warming

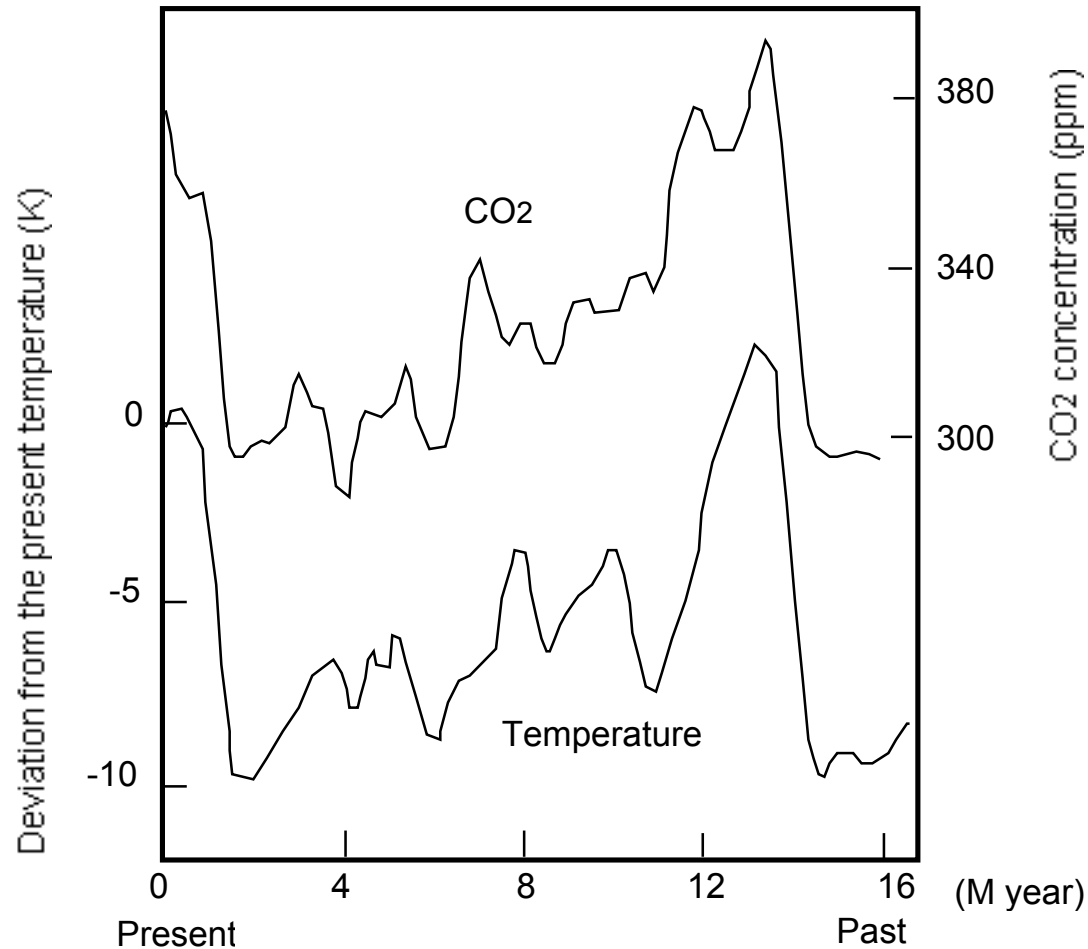
a. Atmospheric CO₂ concentration

In 1958 R.Keeling started the observation of the atmospheric CO₂ concentration at **MaunaLoa**, Hawaii, and found that the concentration is increasing apparently. This phenomenon was the beginning of the scientific and social movement on the earth warming problem.



Monthly atmospheric CO₂ concentrations

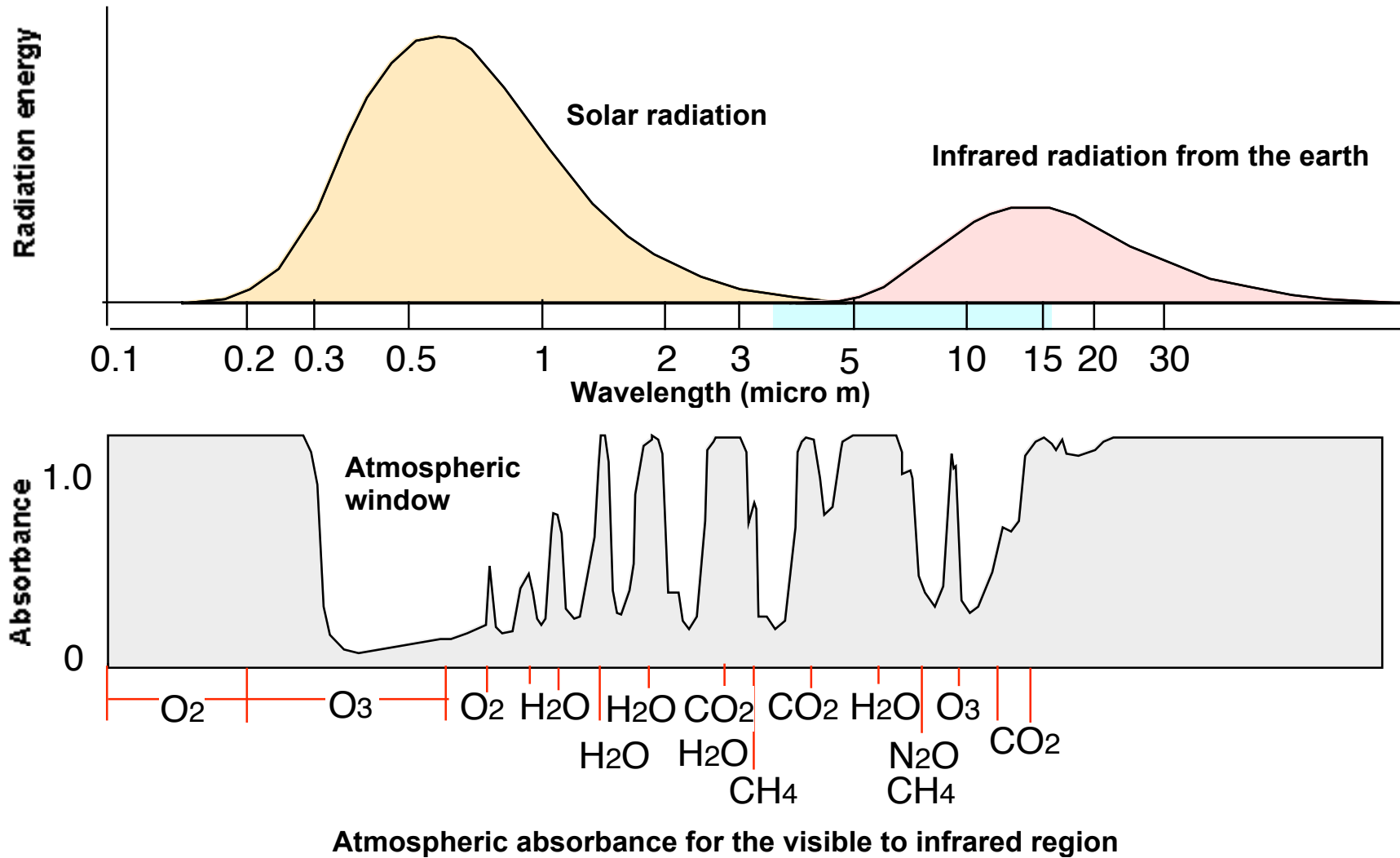
b. Relation between CO₂ concentration and the temperature



Variations of the temperature and CO₂ concentration obtained from the ice cap of the Antarctica

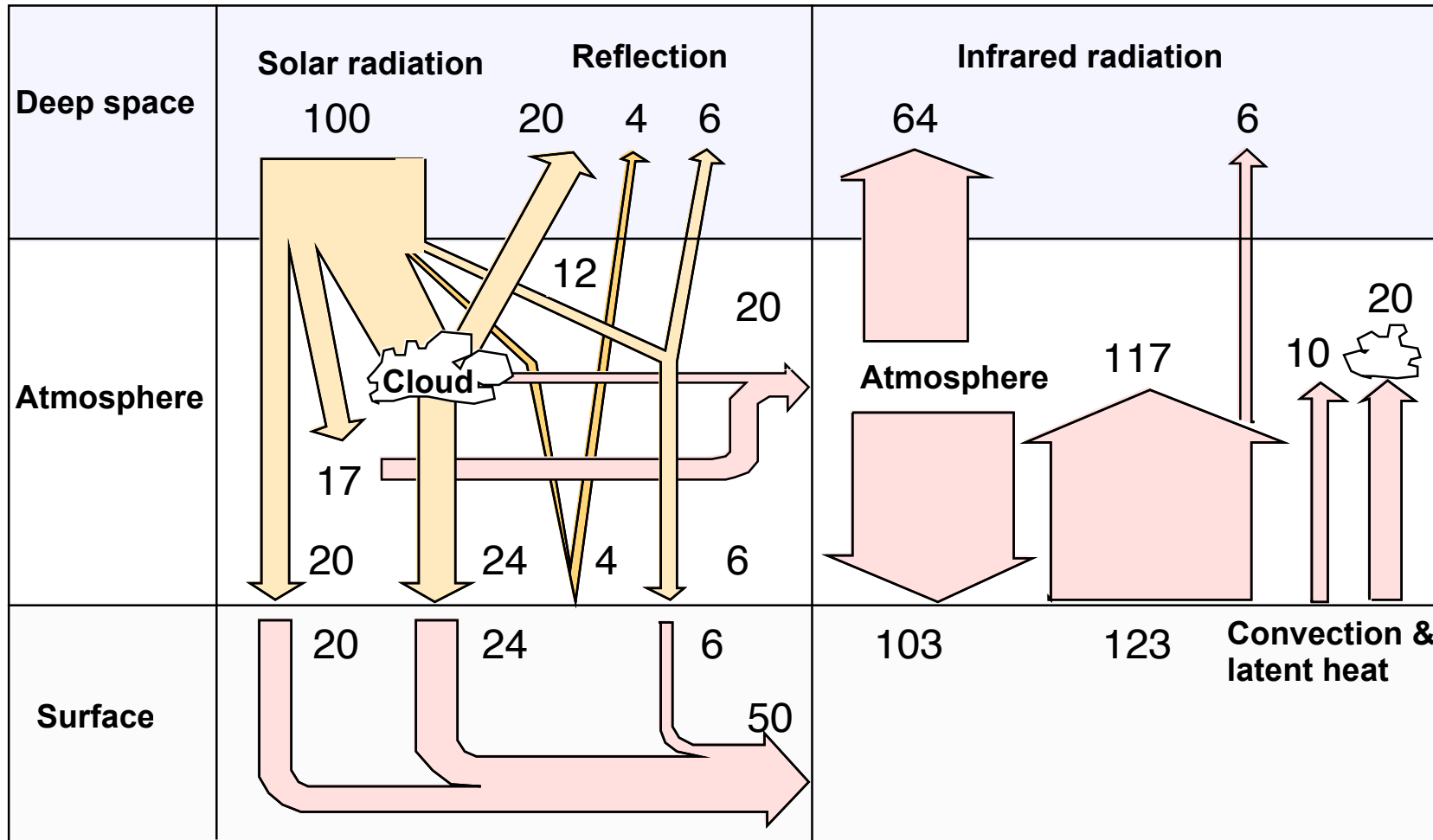
There is a **strong relation** between the **temperature** and the atmospheric **CO₂ concentration**, and there are two possibilities. One is the higher temperature introduces the increasing of CO₂ concentration, and the another is the increasing of CO₂ concentration introduces the higher temperature.

c. Absorption of the infrared radiation from the earth



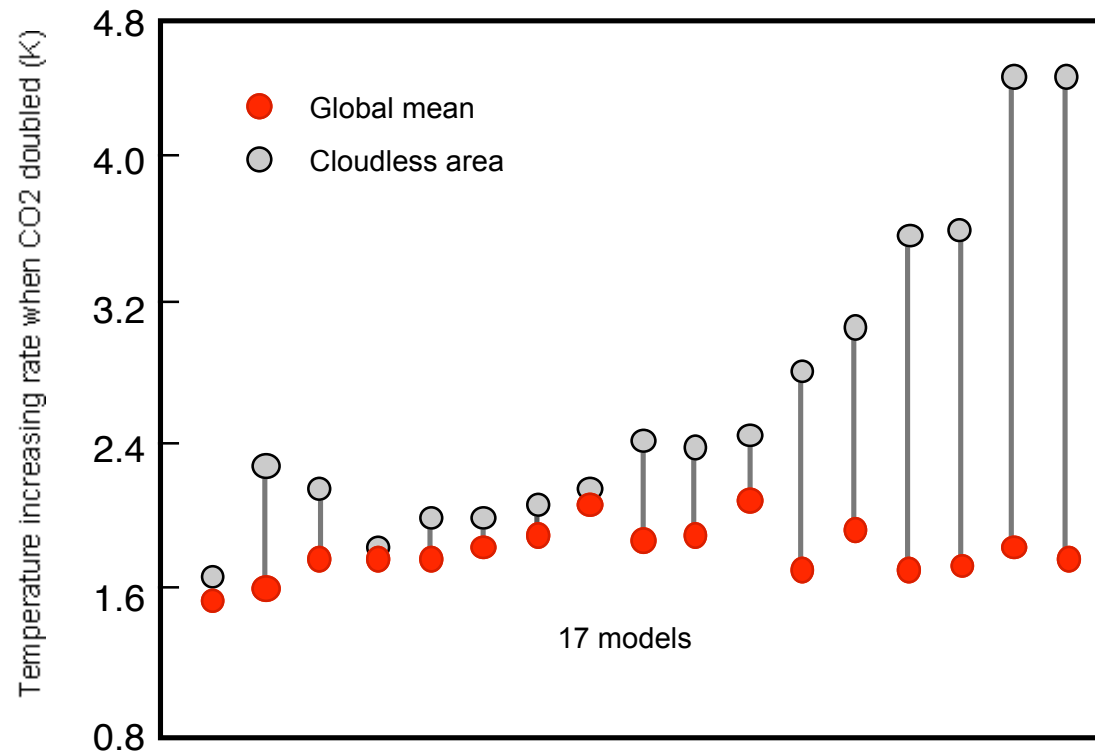
NOTE: Visible radiation ranges from violet (360 ~ 400 nm) to red (760 ~ 830 nm).

d. Radiation balance of the earth



Balance of the radiation energy of the earth

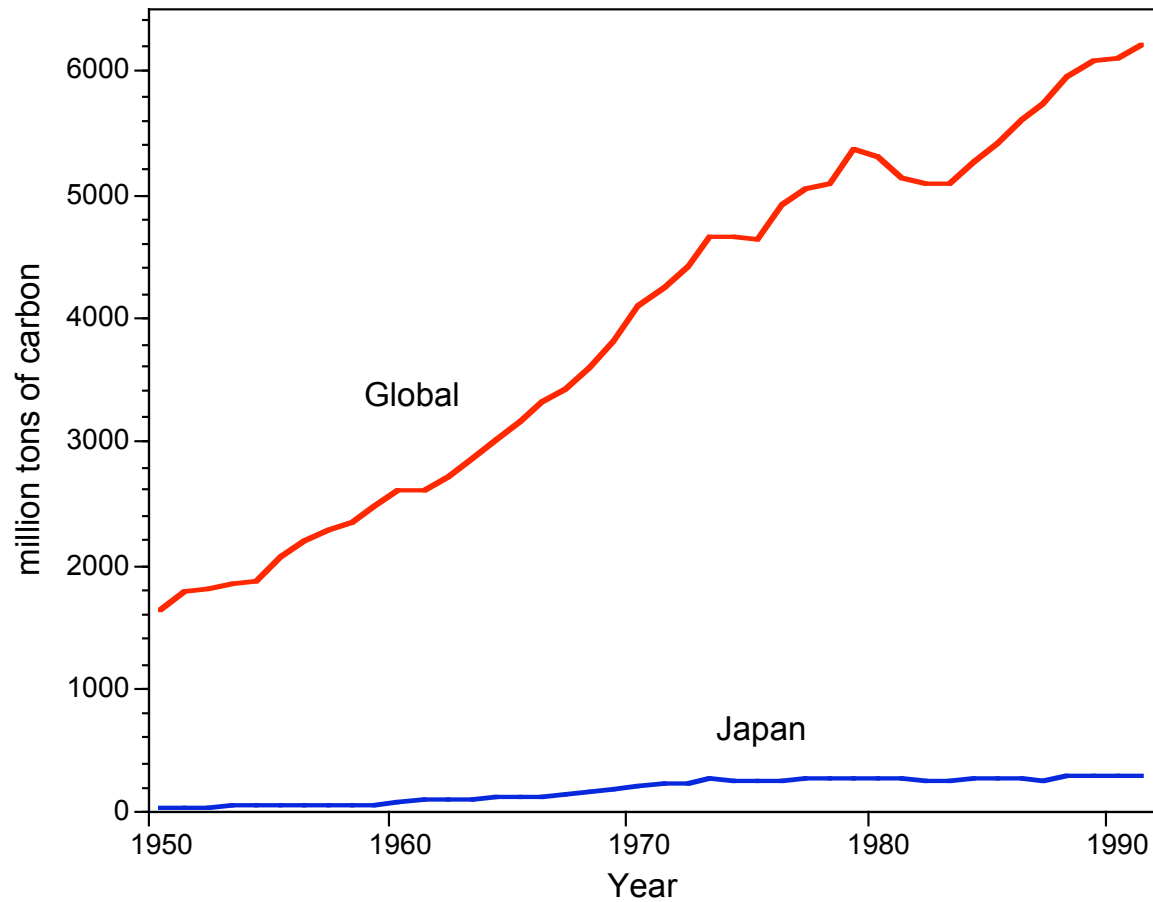
e. Model calculations for the CO₂ doubled case



The results of several models on the temperature increasing rate for the CO₂ doubled case

The estimation of the atmospheric condition when the concentration of CO₂ in the atmosphere is doubled of the present is given by the **global circulation model** (GCM), though, there are still uncertainties on the parametrization in the model calculation, such as cloud effect, aerosols effect, and so on. However, there are some uncertainties, all the models are forecasting the **earth warming** when the concentration of CO₂ increases.

f. CO2 emission



The main source of the CO₂ emissions is the **fossil fuel combustion**, coal and oil. The left figure shows the estimated carbon emission converted from the fuel consumption.

g. Global Warming Potential

Not only the CO₂ gas, other atmospheric constituents act as the greenhouse gases. To evaluate the earth warming problem, these greenhouse gases' effects are converted in the effect of CO₂ as the following table.

Global Warming Potential per unit weight (IPCC)

greenhouse gas	contribution for the warming in 1980s (%)	GWP	life time (year)	sources
carbon dioxide (CO ₂)	55	1	50 ~ 200	fossil fuel, forest destruction
methane (CH ₄)	15	10	10	swamp
dinitrogen monoxide (N ₂ O)	6	100	150	manure, microbe activity
chlorofluorocarbon flon-11 (CFCl ₃) flon-12 (CF ₂ Cl ₂)	17	10,000	65 130	industrial products
other chlorofluorocarbon	7	10,000	-	industrial products

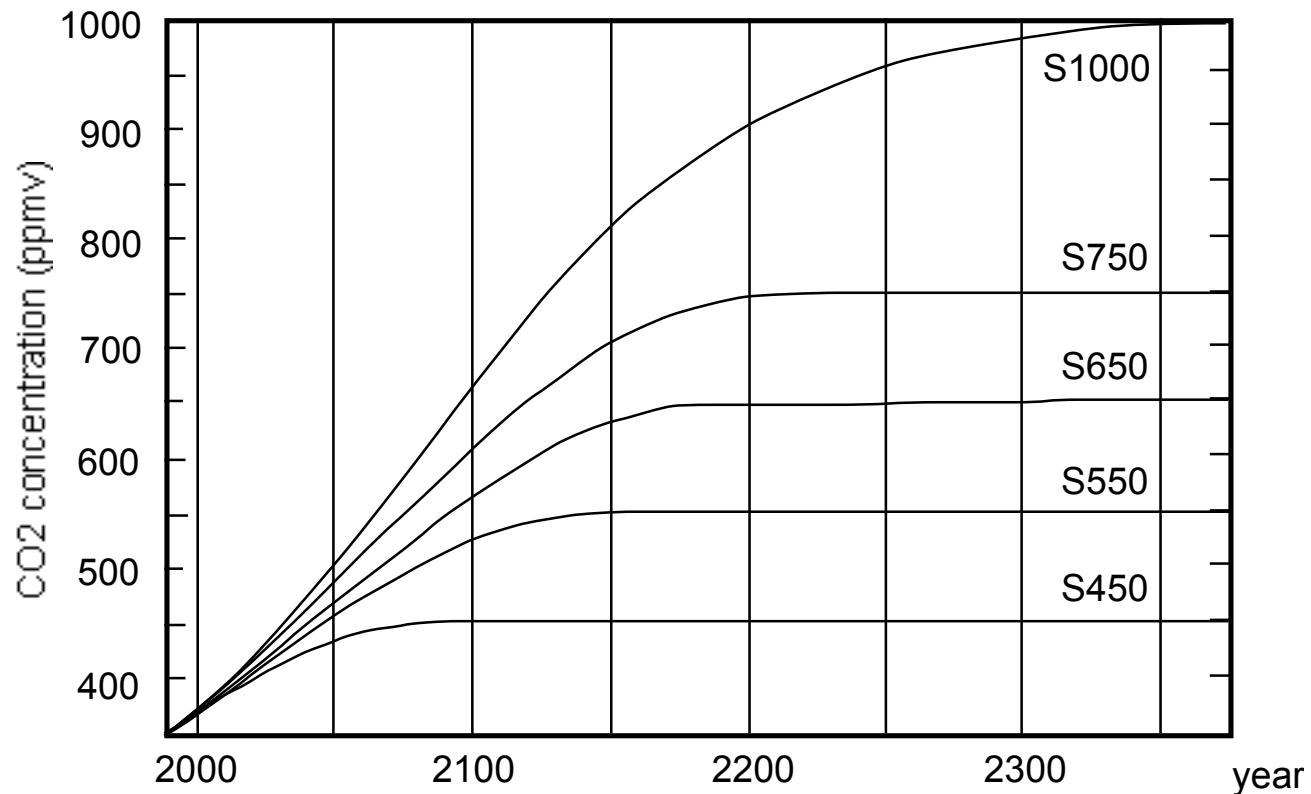
GWP is estimated the integrated radiation energy of the gas normalized by the CO₂ in define time scale.

NOTE: **IPCC** is the acronym of Intergovernmental Panel on Climate Change

h. Stabilization of the CO₂ - atmospheric concentration

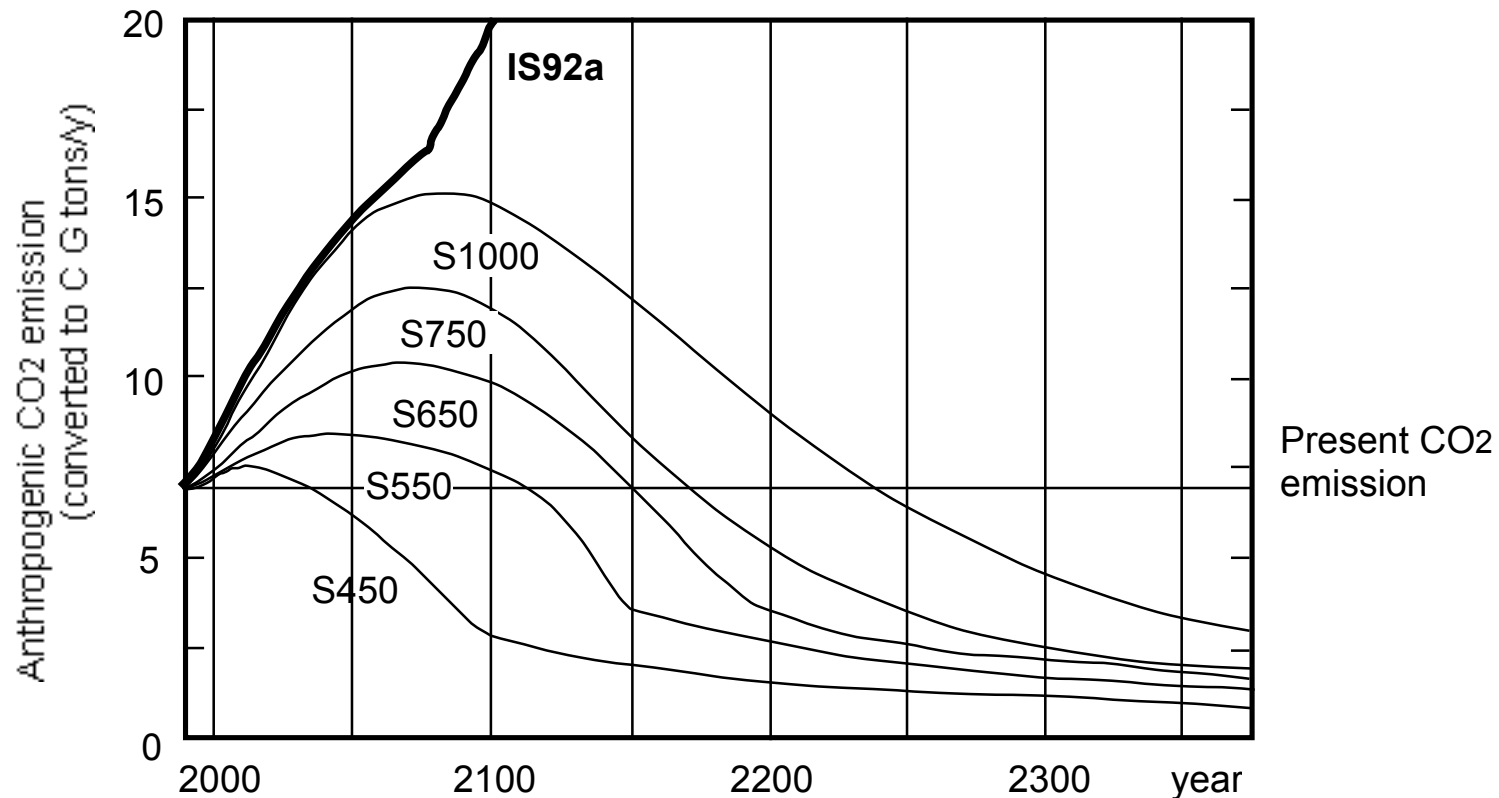
The lower figure shows the CO₂ concentration changes following the scenarios defined by IPCC working group 1. In the figure, for example, S450 is the scenario which stabilize the CO₂ concentration to 450 ppmv.

To stabilize the CO₂ concentration following each scenario, CO₂ emission must be limited as shown in the next figure.



i. Stabilization of the CO₂ - emission

To stabilize the CO₂ concentration, we must follow the limitation on the CO₂ emission. It says, for example on the S550 scenario, we must limit the CO₂ emission to the level of year 2000 in 2100, and must **reduce** the emission to **50 % of year 2000 in 2150**. However, IPCC expected that the CO₂ emission will rapidly increase when we adopt no counter measures for the reduction (IS92a scenario).



2. Kyoto mechanism to reduce GHG concentrations

a. reduction mechanism and reduction target

- Clean Development Mechanism (CDM);
- Joint Implementation (JI)
- International Emissions Trading (IET)

Those mechanisms are derived from "Article 12 of the Kyoto Protocol"

- to assist non-Annex 1 countries in achieving sustainable development;
- to contribute to the ultimate goal of the convention i.e., stabilization of GHG concentrations in the atmosphere; and
- to help Annex 1 countries comply with their emission reduction commitments.

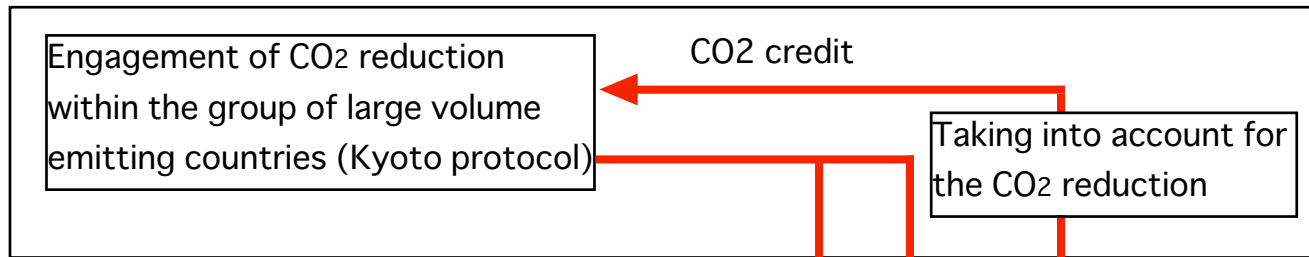
NOTE 1: The Kyoto Protocol (adopted at COP 3 in Kyoto on 11 December 1997) commits Annex I Parties to individual, legally-binding targets to limit or reduce their greenhouse gas emissions, adding up to a total cut of at least 5% from 1990 levels in the "commitment period" 2008-2012. The individual targets for Annex I Parties are listed in the Protocol's Annex B (table right), and range from a -8% cut for the EU's 15 member states and several other countries, to a +10%

NOTE 2: The targets cover emissions of the six main greenhouse gases, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆).

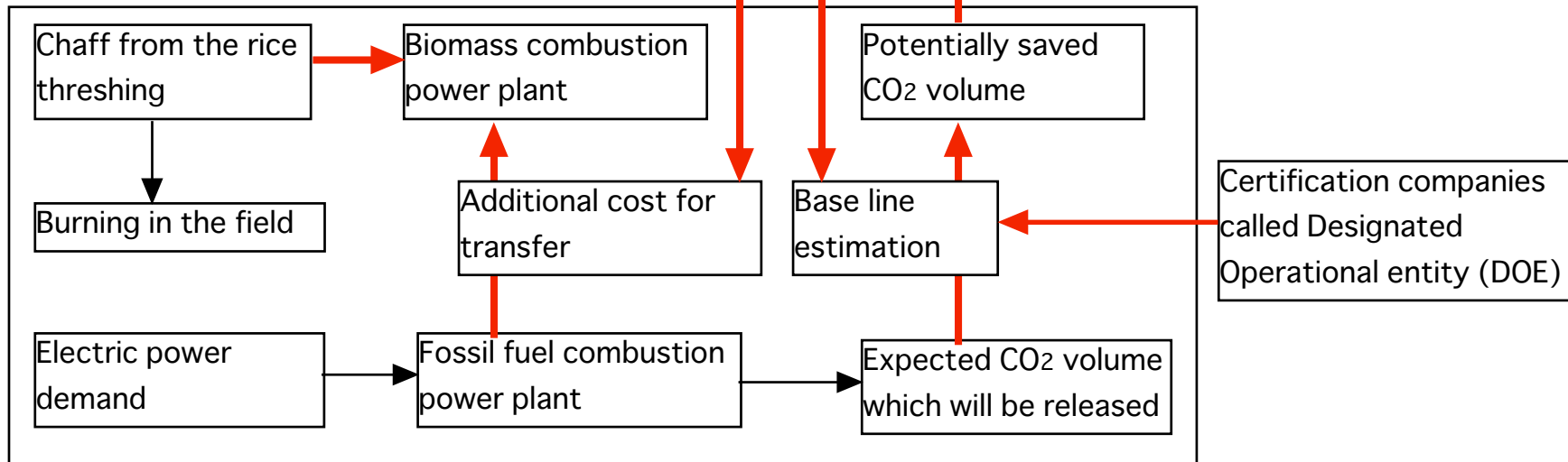
Country	Target
EU-15, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
US	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	0
Norway	+1%
Australia	+8%
Iceland	+10%

b. CDM case study

Japan



Thailand



A possible CDM application business using rice chaff combustion power plant