1. The Goal of the Climate Change Measures

This part summarizes the discussion regarding how to make progress towards meeting the ultimate objective of the UNFCCC based on scientific knowledge.

1.1 Meeting the Ultimate Objective of the UNFCCC

The goal for the international community in addressing climate change is to meet the ultimate objective of the UNFCCC: "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (Article 2)

<The Goal of the Climate Change Measures >

○ The goal of measures to address climate change is stipulated in the UNFCCC, which now enters into force with the participation of most countries in the world, including the United States and many developing countries. Achieving the ultimate objective of the UNFCCC is the goal for the international community in coping with climate change.

○ The Convention states that its ultimate objective is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system," and that this level "should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner," (Article 2).

1.2 Stabilization of GHG Concentrations

Atmospheric concentrations of greenhouse gases (GHG) become stable when GHG emissions in the atmosphere reach equilibrium with the capacity of sinks in marine and terrestrial ecosystems. However, atmospheric GHG concentrations continue to rise because GHG emissions are exceeding the capacity of sinks.

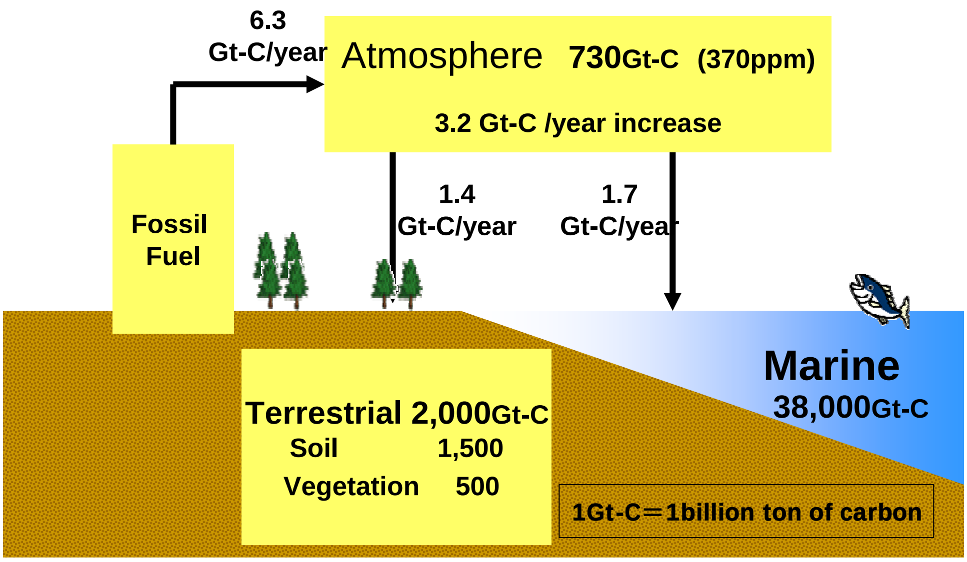
<Reaching an Equilibrium between GHG Emissions and Global Sink Capacity>

○ "Stabilization of greenhouse gas concentrations" as noted in the ultimate objective of the UNFCCC is defined as an equilibrium between global emissions of greenhouse gases (GHG) and the capacity of global sinks. Sources of atmospheric GHG emissions include both natural factors and human activities, while global sinks include marine ecosystems and terrestrial ecosystems such as forests.

<Anthropogenic GHG Emissions Greatly Exceed Global Sink Capacity>

○ At present, anthropogenic carbon dioxide (CO_2) emissions from fossil fuel combustion amount to 6.3 billion tons of carbon equivalent annually, twice as much as the annual capacity of sinks (3.1 billion tons). Thus about 3.2 billion tons of carbon are accumulating in the atmosphere every year (see Figure 1.1).

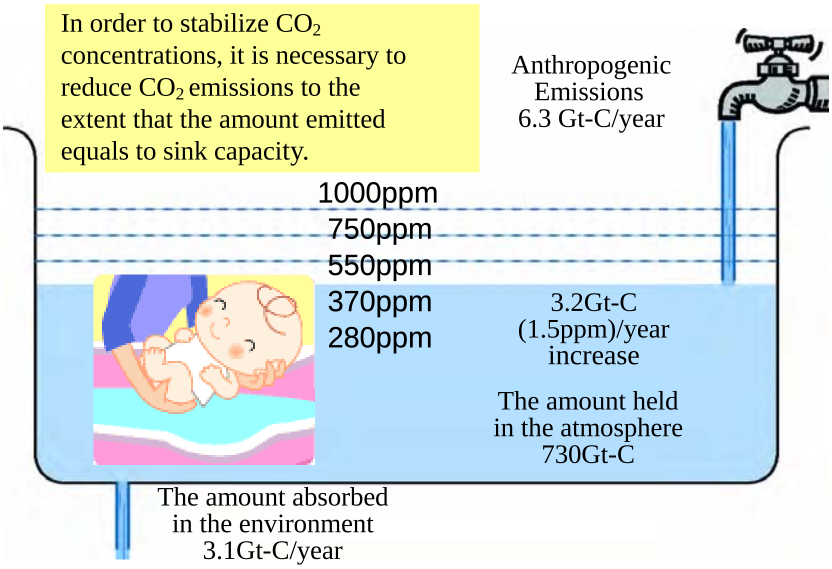
Figure 1.1 The Estimated Global Carbon Balance



Source: Adapted from the IPCC Third Assessment Report(2001)

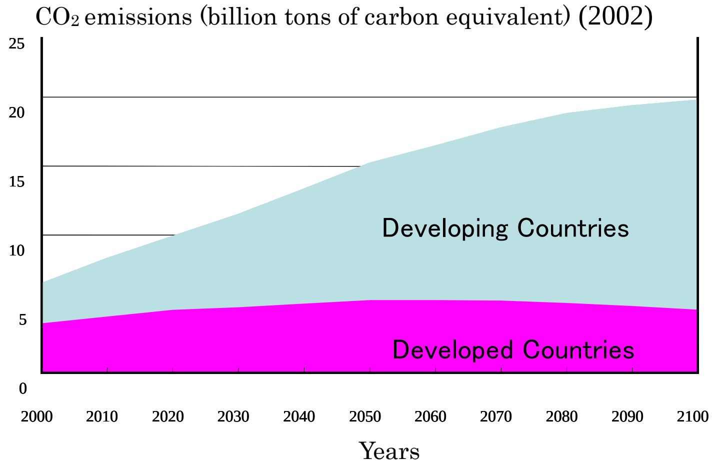
○ Due to past CO_2 accumulations, concentrations of atmospheric CO_2 rose from 280 parts per million (ppm) in 1750, prior to the Industrial Revolution, to 368 ppm in 2000. Figure 1.2 shows that, in order to stabilize atmospheric CO_2 concentrations by attaining an equilibrium between anthropogenic CO_2 emissions from fossil fuel combustion and the natural sink capacity, it is necessary to make the pace of emissions (the amount emitted per year) equal to the pace of absorption (the amount absorbed per year), which means achieving further reductions from our current emissions level.

Figure 1.2 Relationships among Emissions, Sink Capacity, and Atmospheric CO_2 Concentrations



○ However, it is estimated that CO_2 emissions will further increase from fossil fuel combustion. Figure 1.3 shows estimated global CO_2 emissions based on the IPCC B2 scenario (see Table 4.1). It indicates that future emissions from developing countries in particular will greatly increase, and that emissions from developing countries will be about 3 times the emissions from developed countries by 2100.

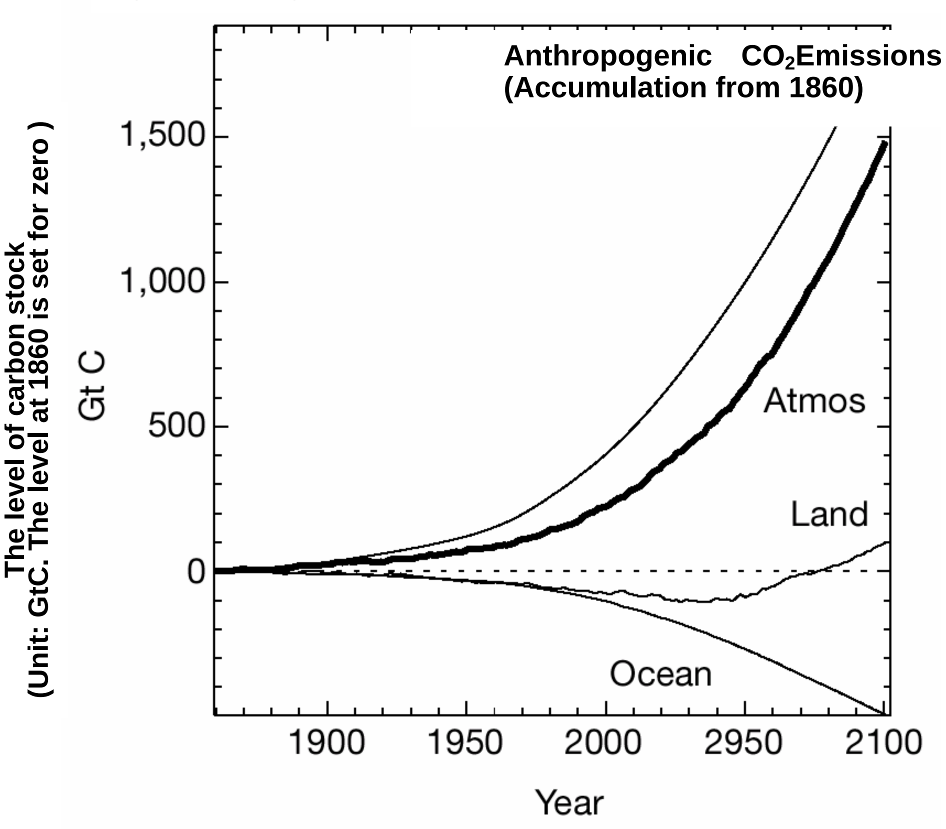
Figure 1.3 Prediction of future CO_2 emissions



Source: Kainuma, et al. (2002)
"Climate Policy Assessment"

○ The global capacity of sinks changes depending on the level of atmospheric CO_2 concentrations. In recent years, simulation research is being done to connect a dynamic vegetation model with climate models and take into account the feedback from changes in terrestrial surface carbon sink capacity to climate. In the long-run, it is projected that the temperature increase would stimulate respiration of plants and microorganisms in the soil, which then would reduce carbon sink capacity of the land. This would accelerate climate change, which would reduce the carbon sink capacity of the land to zero at around the year 2050, turning the land surface from a carbon sink into carbon source after that time (see Figure 1.4).

Figure 1.4 Changes in the Levels of Carbon Stock (Atmosphere, Land Surface, and Ocean)



Source: Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A. and Totterdell, I.J. (2000) Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model,Nature, 408, .

<Typical Case of Unsustainable Development>

○ We human beings are currently emitting twice as much CO_2 as can be absorbed given the global carbon sink capacity so atmospheric CO_2 concentrations are increasing. Some research estimates that anthropogenic CO_2 emissions will continue to rise for the next hundred years, while the global CO_2 sink capacity will decrease due to increased temperature. This would accelerate an increase of atmospheric CO_2 concentrations and further global warming, leading to elicitation of large-scale climate change. This is a typical case of unsustainable development.

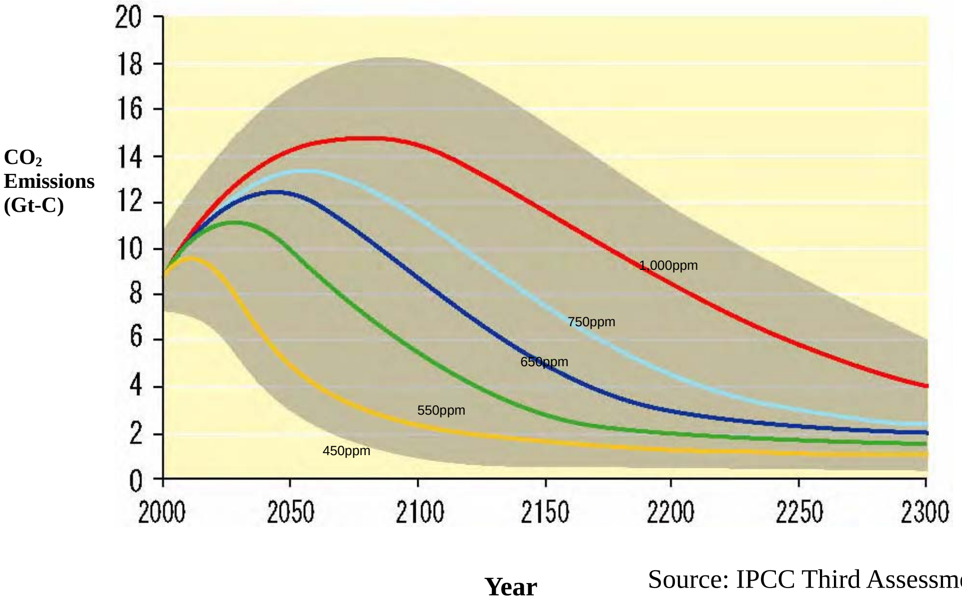
1.3 Stabilization Levels of GHG Concentrations

Various emission paths that lead to various stabilization levels of GHG concentrations can be described. It should be noted, however, that even after emissions have been reduced, CO_2 concentrations will not stabilize until 100 to 300 years later, and temperatures after several hundred years.

<Emissions Scenarios for Various Concentration Levels>

○ The level at which GHG concentrations stabilize depends on the cumulative amount of emissions up until stabilization is achieved. Various stabilization levels for CO_2 concentrations can be conceived, for example, at 450, 550, 650, 750, and even 1,000 ppm. The IPCC has provided a graph, as shown in the Figure 1.5, which illustrates the path of global CO_2 emissions corresponding to these concentration levels. The shaded part indicates uncertainty regarding the relationship between the amount of CO_2 emitted and the CO_2 concentration; specifically, uncertainty regarding CO_2 sink capacity of the land and ocean. Because there are greenhouse gases other than CO_2, concentrations, these gases also need to be taken into consideration with regard to the stabilization of GHG concentrations.

Figure 1.5 Changes in Global CO_2 Emissions Corresponding to Different Stabilization Levels



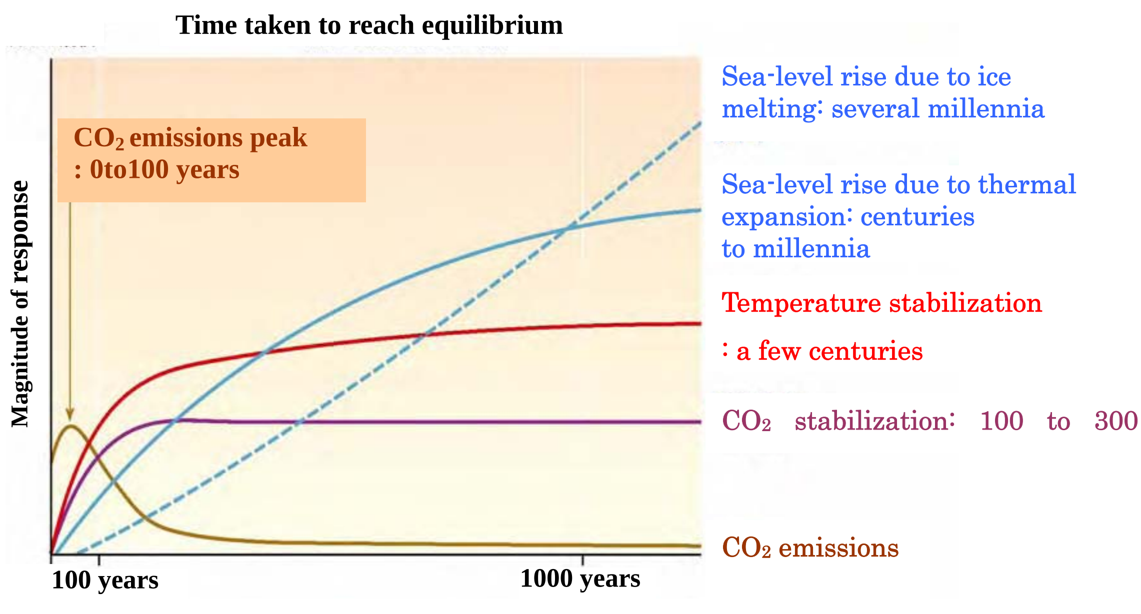
Source: IPCC Third Assessment Report (2001)

<The Time Lag between Atmospheric GHG Emissions and Stabilization of GHG Concentrations and Impacts>

○ GHG concentrations will not immediately stabilize even if GHG emissions reach equilibrium with global sink capacity. There is a time lag. There will be an additional time lag between stabilization of GHG concentrations and stabilization of temperature and sea level. It is necessary to take into account the time lag when thinking of the levels at which the concentration of atmospheric GHG is stabilized.

○ The figure 1.6 illustrates the time lags attending CO_2 emissions, stabilization of CO_2 concentrations, stabilization of temperature, and sea-level rise. Even if global CO_2 emissions are successfully reduced during the next 100 years, CO_2 concentrations will only stabilize after the lapse of an additional 100 to 300 years, temperature after several hundred years, and sea-level rise due to thermal expansion after several hundred to several thousand years.

Figure 1.6 Relationships among CO_2 Emissions, CO_2 Concentrations, Temperature, and Sea Level Rise



Source: IPCC Third Assessment Report (2001)

1.4 Impacts of Climate Change

- The IPCC Third Assessment Report concludes that most of the warming observed over the last 50 years is attributable to human activities.
- The impacts of climate change have already begun to appear around the world, including Japan. The IPCC Report shows that the risks associated with climate change will increase with higher temperatures and that if temperatures rise about two degrees Celsius over the next 100 years, the distribution of negative impacts will begin to extend to most regions of the world.
- The level of impacts will vary depending on the country or region. The risk of adverse effects will increase as the rate and scale of temperature changes increase.
- In recent years, extreme weather events are occurring frequently around the world. There is a concern that climate change could result in more frequent and more severe extreme weather events, with increasing damage.

<Significance of Sharing Scientific Background Knowledge>

○ Precise and impartial scientific background knowledge is required in order to address climate change. Also, in promoting measures to cope with climate change, it is also important to ensure that this scientific background knowledge is shared at both the local and global levels.

○ It is especially important to share scientific background knowledge about causal links between anthropogenic GHG emissions and impacts on human and ecosystems due to temperature rise and climate change, and about the levels of these impacts. When such knowledge becomes available, the issue of acceptable levels of impacts becomes more a matter of policy, than of science, and should be regarded as a matter for decisions to be made by human society.

<Observed Phenomena and Impacts of Climate Change >

○ Impacts of climate change have already appeared. Regarding their causes, the IPCC Third Assessment Report concludes that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

○ Temperature increases have been observed in various parts of the world. Over the 20^{th} century, the average global temperature rose by 0.6±0.2 degrees Celsius, and it is likely that the 1990s was the warmest decade of the millennium. The IPCC Report summarizes the changes that have already been observed (see Table 1.1).

Table 1.1 Changes Observed in Recent Years

Indicator	**Observed changes**
Global mean surface temperature	Increased by 0.6 over the 20th century
Global mean sea level	Increased by 10-20centimaters over the 20th century
Hot days/heat index	Increased (likely)
Cold/frost days	Decreased for nearly all land areas
Heavy precipitation events	Increased at mid-and high northern latitude (likely)
Drought	Increased frequency in some regions
Glaciers	Widespread retreat
Snow cover	Decreased in area by 10% (since the1960s)
Weather-related economic losses	Ten-fold increase (over the last 40years)

Source: IPCC Third Assessment Report (2001)

○ Phenomena that seem to be impacts of climate change have also been observed in Japan, such as the following:

- *Prunus yedoensis* (cherry trees) now start blossoming [on average] five days earlier than they did 50 years ago.
- The distribution of alpine plants has decreased and the distribution of forested area has increased in Hokkaido, the northernmost island of Japan.
- Inland distribution of broad-leaved evergreen trees such as *Quercus myrsinifolia* (Japanese white oak) has increased.
- The distribution areas of butterflies, moths, dragonflies, and cicadas have moved north as they disappear from the southern limits of distribution.
- *Papilio Memnon* (a butterfly), whose northern limit of distribution used to be the islands of Kyushu and Shikoku, were first observed in Mie Prefecture on Honshu Island in the 1990s.
- *Cyrtophora moluccensis* (a tent spider) that were formerly observed only in western Japan in the 1970s appeared in Tokyo and vicinity in the 1980s.
- *Anser albifrons* (white-fronted goose) extended its wintering sites to Hokkaido.
- Tropical fish species have appeared in Osaka Bay.

Source: "Global Warming and Japan – Estimated Effects on Nature and People" (Harasawa and Nishioka, eds. 2003)

<Estimated Future Impacts of Climate Change>

○ Various possible adverse effects are predicted in the future (see Table 1.2).

Table-1.2 Various Projected Impacts of Climate Change

Subject	Projected Impacts
Global mean surface temperature	Increased by 1.4-5.8°C from 1990 to 2100
Global mean sea level	Increased by 9-88cm from 1990 to 2100
Impacts on weather events	Increase of flood and drought
Impacts on human health	Increase of heat stress and infectious diseases such as malaria
Impacts on ecosystem	Extinction of some animal and plant species, migration of ecosystem
Impacts on agriculture	Decrease of grain harvest at many regions, temporary increases in some regions
Impacts on water resources	Change in supply and demand balance, adverse effects on water quality
Impacts on market	Large economic loss especially in developing countries which rely on primary products

Source: IPCC Third Assessment Report (2001)

○ Possible adverse effects are predicted in Japan. For example,

- if the sea level rises one-meter, more than 90 percent of the beaches in Japan will disappear. Also tidal wetlands where migratory birds feed will disappear.
- Increased temperature may lead to fluctuations in rainfall, affecting watersheds
- The potential malaria distribution area may expand to include western Japan.
- Increased incidence of heat stroke due to heat waves.

Source: Harasawa and Nishioka, eds. 2003

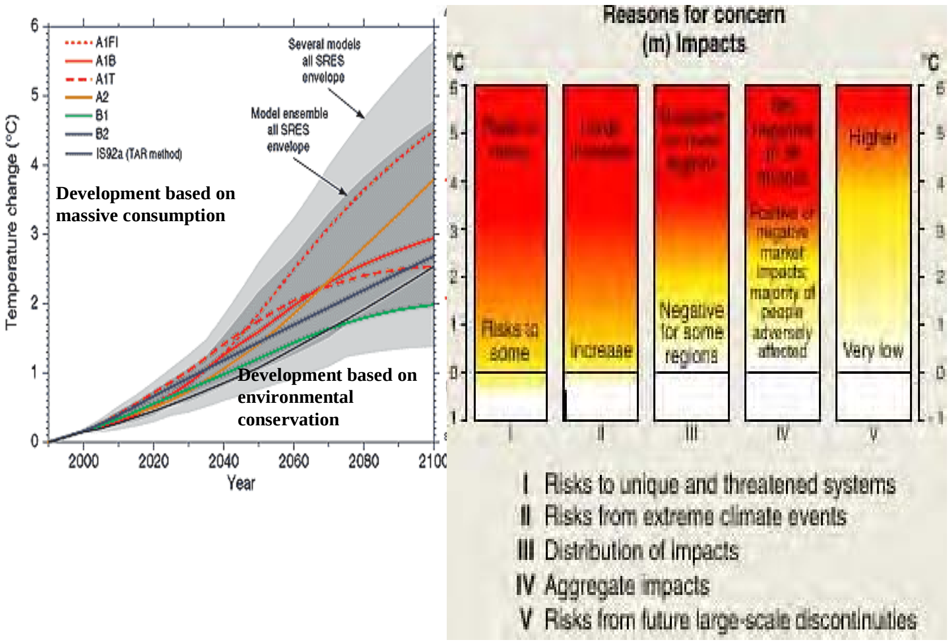
<The Relationship between Temperature Rise and Impact Risks>

○ The IPCC Third Assessment Report looks at the degree of the temperature increase and its effects on the level of the risks by using five indicators on each of its future socio-economic development scenario (see Figure 1.7). This two-part figure shows that a small increase in temperature may cause positive impacts in some regions. However, the more the temperature rises, the greater will the risks of climate change become. For instance, if the global mean temperature rises more than 2℃ in the next 100 years, the probability of the adverse effects cause by climate change becomes higher.

<Regional Differences in Impact Occurrence >

○ The levels of impacts are not the same around the world, but vary according to country or region. Levels of damage to humans and ecosystems also vary according to levels of preparedness to these impacts. Impacts are thought to be particularly serious in developing countries in tropical and subtropical zones, due to geographical factors that make them vulnerable to climate change impacts as well as their inability to sufficiently prepare for such impacts.

Figure 1.7 Relationship between Temperature Rise and its Impacts and Risks

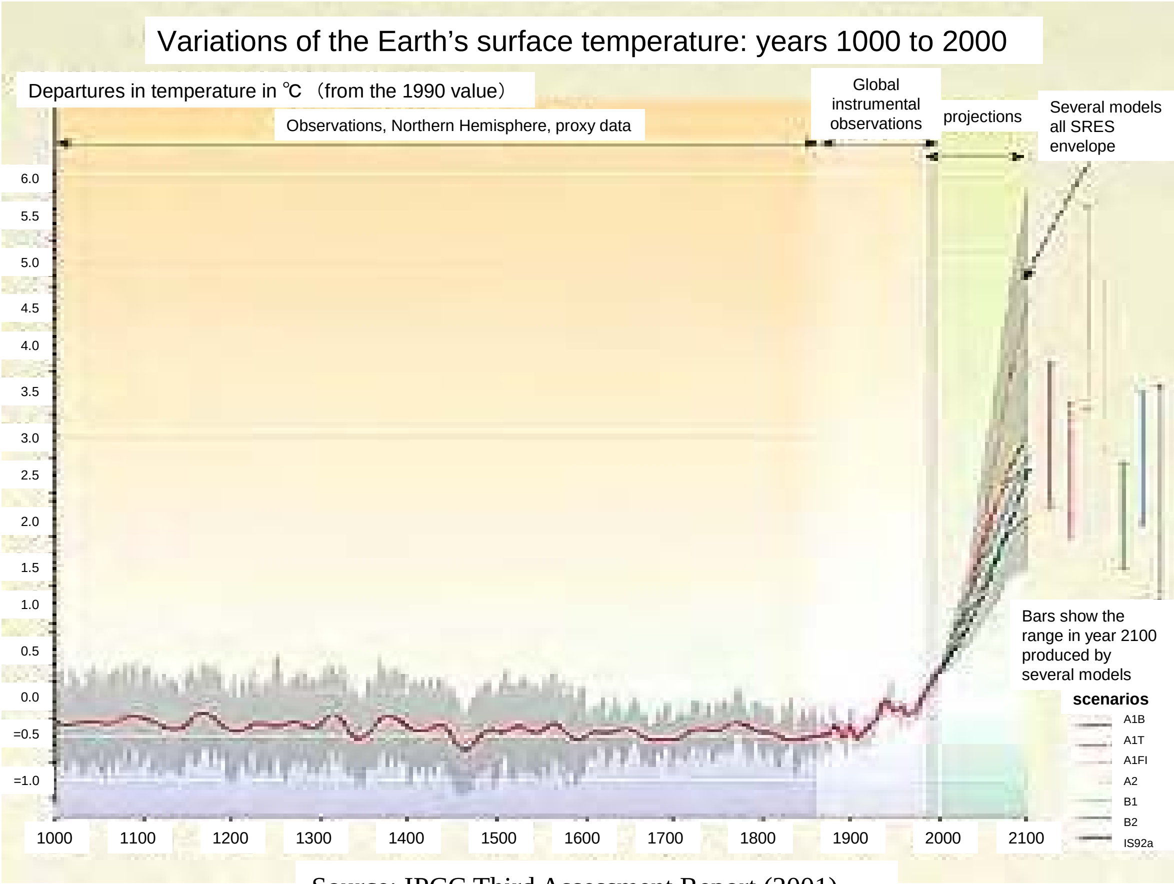


Source: IPCC Third Assessment Report (2001)

<Rate of Change and Impact Levels>

○ In addition to the level of temperature change, the rate of change is also important in considering impacts on ecosystems and on agriculture. According to the temperature rise predicted by models, although there are some variations depending on the models and scenarios used, it is clear that every model predicts a drastic temperature rise compared to that of the last 1000 years (see Figure 1.8).

Figure 1.8 Prediction of Drastic Temperature Change



Source: IPCC Third Assessment Report (2001)

<Extreme Weather Events and Climate Change Impacts>

○ According to the IPCC Third Assessment Report, climate change will not only have medium and long-term impacts, but may also cause increased frequency and intensity of extreme weather events.

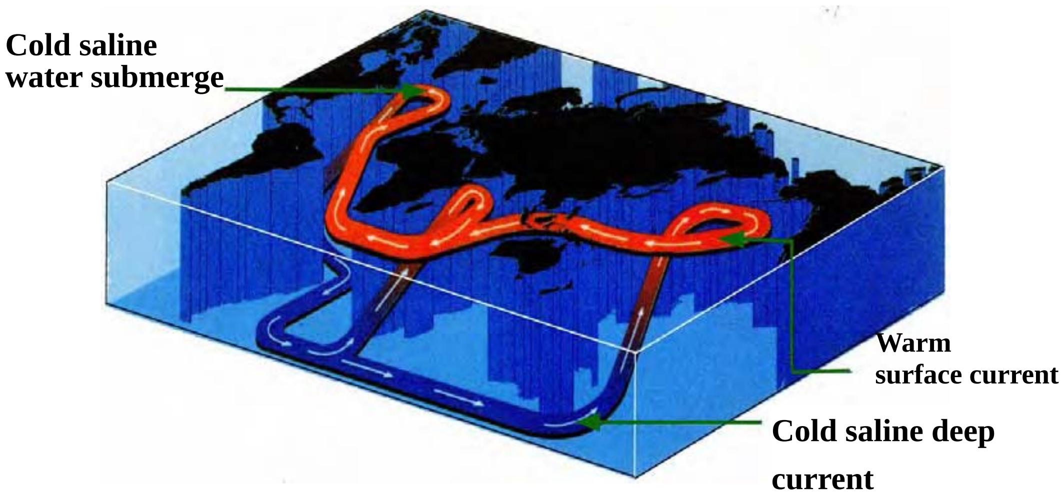
○ In particular, much concern has been expressed recently that the frequent extreme weather events now happening around the world, such as drought and abnormally high temperatures, might be part of climate change. It is necessary to compile and analyze observation data that may have a bearing on future extreme weather events around the world in order to enhance scientific knowledge of climate change impacts.

○ Scientific study on the impacts of climate change has so far focused on predictions of average global impacts. It is expected, however, that extreme weather events that are unpredictable using conventional methods based on past weather data will frequently occur as impacts of climate change in various parts of the world. It is therefore necessary from now on to undertake further studies of the occurrence of the extreme weather events that are accompanying climate change and their regional impacts, in addition to the global impacts of climate change.

<Probability of Catastrophic Events>

○ While catastrophic events are estimated to be unlikely during the 21st century, there is some concern regarding the following possibilities: rapid climate change due to rapid emissions of GHG being held in the marine and terrestrial biosphere; significant rise of sea level due to melting of the Antarctic and Greenland ice sheets (4-6 meter rise in case of irreversible collapse of the Western Antarctic Ice Sheet); and a colder Europe due to the collapse of the global ocean circulation system. For example, the ocean circulation system circulates every 2000 years, maintaining climate with its vast heat capacity. Figure 1.9 shows the possibility of Europe becoming colder due to changes in the speed and direction of the Gulf Stream (a warm current) triggered by climate change.

Figure 1.9 Example of Catastrophic Event Caused by Extreme climate change (Collapse of the oceanic circulation system)



○ Although catastrophic events are estimated to be unlikely during the 21st century, rapid climate change could increase the probability of such events occurring.