CHALLENGE 25

Chapter 2
Responsibility of the Present Generation to Quickly Deal with Global Warming
－Challenge 25－

Section 1 Increasing Damage from Global Warming

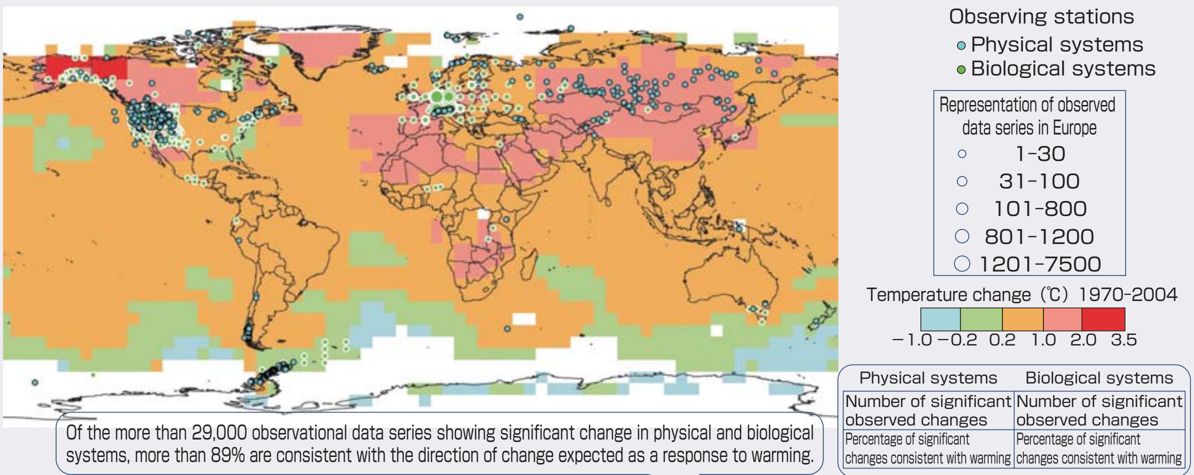
1 The Damage Currently Occurring

Efforts to accumulate scientific knowledge about global warming have been led by the Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to make a comprehensive assessment of anthropogenic climate change, its impacts, and adaptation to and mitigation of it from scientific, technical and socio-economic perspective. The Synthesis Report of the IPCC's Fourth Assessment Report: Climate Change 2007, its latest report, states in the Summary for Policymakers: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Figure 2-1-1).

Among events likely to be due to the effects of global warming are reduced snow and ice in polar regions and highlands, increases in wildfires and droughts, and an increase in intense tropical cyclone activity, etc. For example, annual average article sea ice extent has shrunk by 2.7 [2.1-3.3] % per decade, with larger decreases in summer of 7.4 [5.0-9.8] % (Numbers in square brackets indicate a 90% uncertainly interval around a best estimate).

We can observe the diminishing trend of sea ice in Figure 2-1-2. Figure 2-1-4 shows the satellite observation results of sea ice in the Arctic region in September 1979 and September 2007, indicating that the sea ice area dwindled to its smallest size on record in 2007. The IPCC Fourth Assessment Report noted that in some projections, "Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century."

Figure2-1-1 Correlation between Changes in Physical and Biological Systems*2 Observed Globally*1 and Warming



	Physical systems: Number of significant observed changes	Biological systems: Number of significant observed changes	Physical systems: Percentage consistent with warming	Biological systems: Percentage consistent with warming
North America	355	455	94%	92%
Latin America	53	5	98%	100%
Europe	119	28,115	94%	89%
Africa	5	2	100%	100%
Asia	106	8	96%	100%
Australia/New Zealand	6	0	100%	–
Polar regions	120	24	91%	100%
Terrestrial	764	28,586	94%	90%
Marine and freshwater	1	85	100%	99%
Global	765	28,671	94%	90%

"Polar regions" include also observed changes in marine and freshwater biological systems. "Marine and freshwater" includes observed changes at sites and large areas in oceans, small islands and continents. Locations of large-area marine changes are not shown on the map.

*1: Observation results were obtained from a subset of about 29,000 data series (from about 75 studies), selected from about 80,000 data series from 577 studies. These data series were selected by the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; and (3) showing a significant change in either direction.

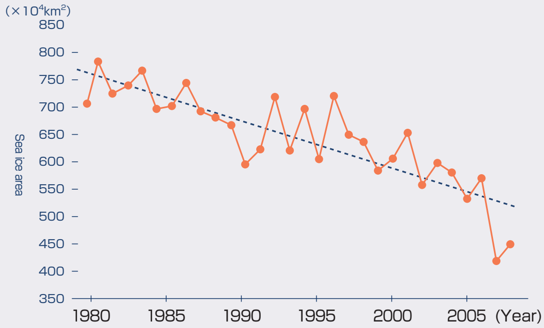
*2: Physical systems mean physical events related to ice, snow, frozen ground, hydrology and coastal areas, while biological systems mean events related to terrestrial, marine and freshwater living matter.

Source: IPCC, Summary for Policymakers, Synthesis Report, Fourth Assessment Report: Climate Change 2007

A study on wildfires by the University of California, et al, and referenced by the IPCC Fourth Assesment Report found that since the 1970s, wildfires in the western United States increased in years when temperatures from spring to summer increased by about 2 degrees Celsius. Thus, large wildfires increased suddenly since the mid-1980s, and it has been reported that the frequency of wildfires is about four times and the forested area burned from 1987 to 2003 is 6.7 times the area from 1970 to 1986.

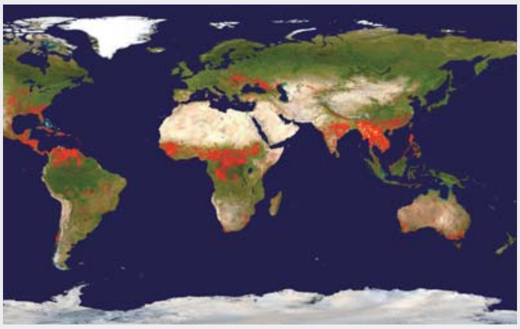
There are various causes of wildfires including temperature rises, which are due in part to global warming, droughts and precipitation patterns. Statistics of the U.S. National Aeronautics and Space Administration (NASA) show that up to about 500,000 square kilometers (=50 million hectares) of forests have been burned a year (Figure 2-1-5). It amounts to seven times the annual net reduction of the forest area of about 7.30 million hectares including increase of area by

Figure2-1-2 Change in Annual Minimum Extent of Arctic Sea Ice Over Time (1979-2008)



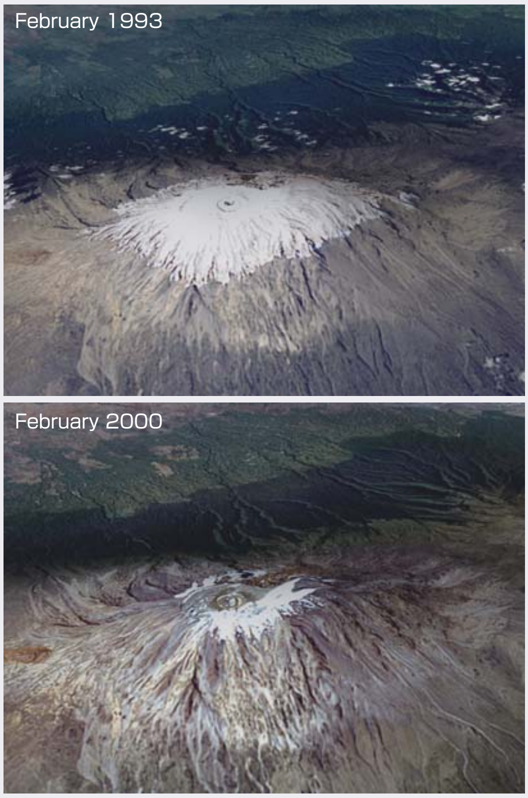
Note: The dotted line indicates the linear trend.
Source: The Japan Meteorological Agency website

Figure2-1-5 Fires in the World Detected by Satellite (MODIS) (March 22-31, 2010)



Source: Moderate Resolution Imaging Spectroradiometer (MODIS) Rapid Response System Global Fire Map (http://rapidfire.sci.gsfc.nasa.gov/firemaps/)

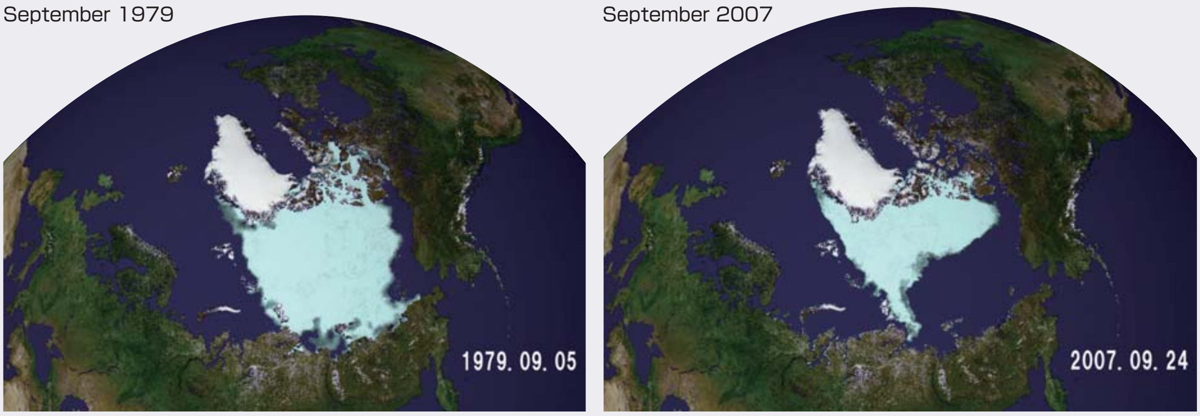
Figure2-1-3 Changes in Glaciers and Snow Cover on Kilimanjaro



Source: NASA (http://earthobservatory.nasa.gov/IOTD/view.php?id=3054)

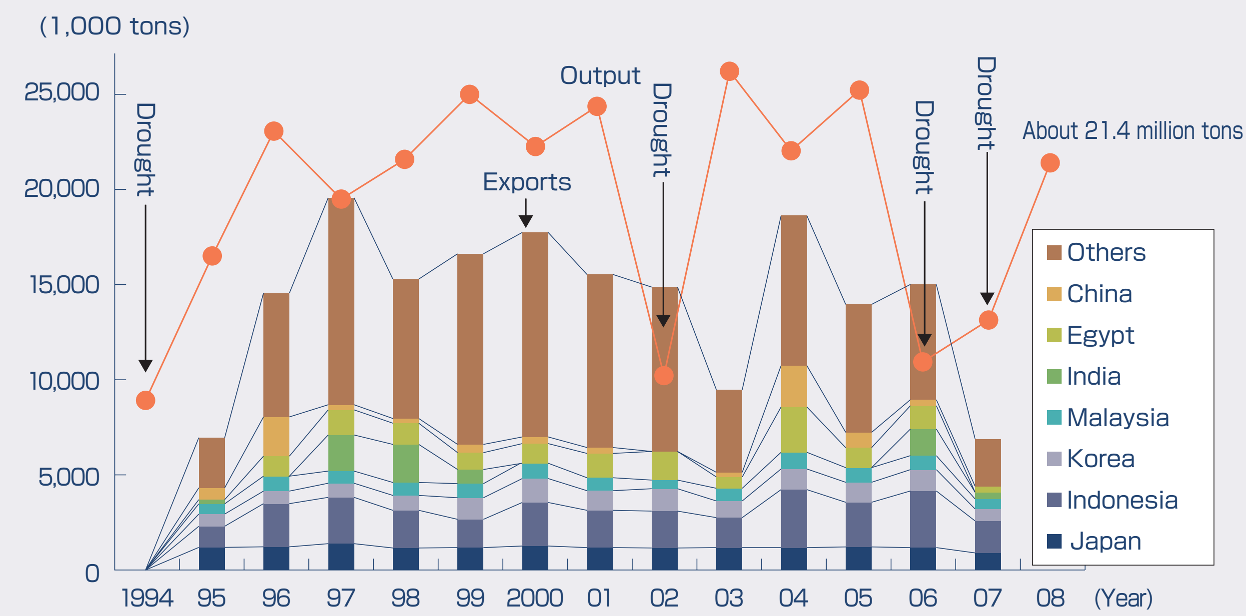
Figure2-1-4 Comparison of Satellite-Observed Arctic Sea Ice between September 1979 and September 2007 Lowest Levels in Satellite Observation Records

September 1979 September 2007



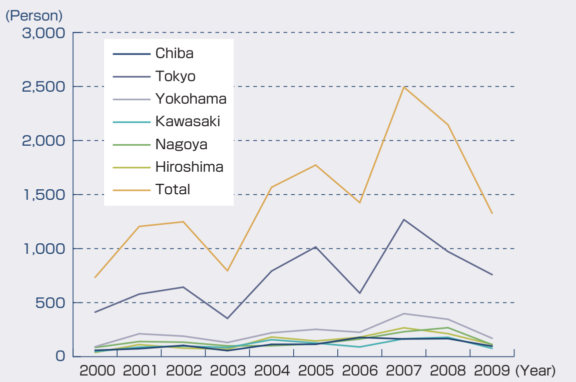
Note: The sea ice distribution was observed in 1979 by NASA' s Scanning Multichannel Microwave Radiometer (SMMR) and in 2007 by JAXA' s Advanced Microwave Scanning Radiometer for EOS (AMSR-E).
Source: Japan Aerospace Exploration Agency

Figure2-1-6 Wheat Output and Exports of Australia



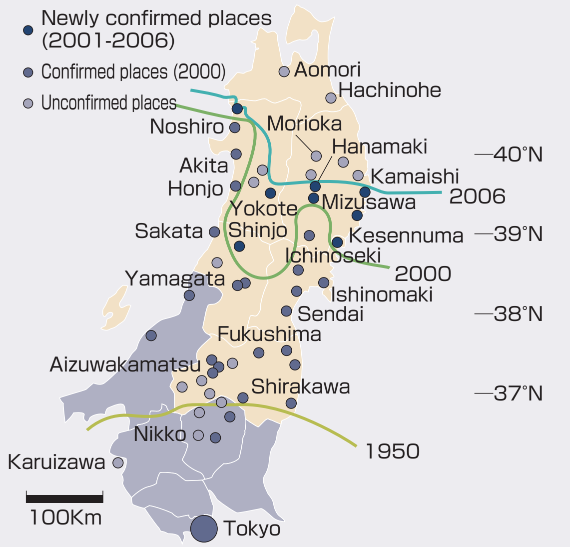
Source: Trade statistics of respective countries, U.S. Department of Agriculture, "Production, Supply and Distribution (PS&D) (2009.08)"

Figure2-1-7 Annual Trends of Heat Stroke Patients by Region



Source: National Institute for Environmental Studies (NIES)

Figure2-1-8 Shift in the Northern Limit of the Distribution of Tiger Mosquitoes



Source: Kobayashi, M., Komagata O., Nihei N., 2008: Global warming and vector-borne infectious diseases, J. Disast. Res, 3(2), 105-112. Fig.2

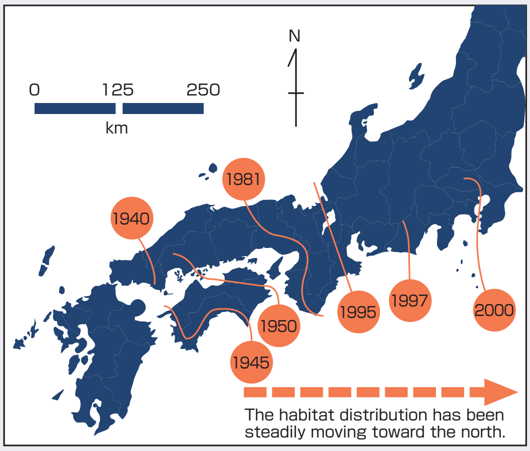
afforestation, restoration of vegitations and natural recovery of forests. Furthermore, the U.S. National Center for Atmospheric Research (NCAR) estimates that forest fires in the mainland United States and Alaska emitted about 290 million tons of carbon dioxide a year. According to the IPCC Fourth Assessment Report, annual global carbon dioxide emissions due to wildfires are estimated at 6.2 billion to 15.0 billion tons. In Australia, droughts have been occurring frequently since the turn of the century, causing large fluctuations in wheat crops (Figure 2-1-6).

In Japan, various events that are potentially attributable in part to the global warming have already been occurring, including an increase in heat stroke patients, expansion of distribution area of the Asian tiger mosquitoes that transmit dengue fever, etc., phenomena in which the distribution of living creatures shifts northward or to higher altitudes, and reduction in quality of rice and fruits.

Regarding heat stroke, there have been reports on increases in the number of patients, with many cities registering record numbers of heat stroke patients in 2007 (the number of people carried to medical institutions by ambulances) (Figure 2-1-7).

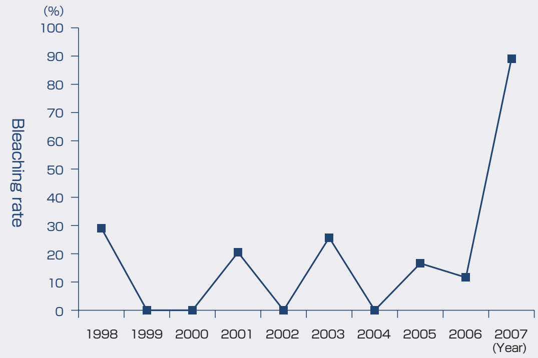
As one development that could affect human health, the expansion of mosquitoes that transmit infectious diseases has also been confirmed. The annual average temperature of about 11 degrees Centigrade is believed to be one of conditions for the habitat of tiger mosquitoes. In the 1950s, Tochigi Prefecture was the northern limit of the habitat distribution of tiger mosquitoes, but in the 2000s, the habitat distribution is confirmed to have expanded to the northern part of the Tohoku region (Figure 2-1-8).

Figure2-1-9 Shift to the North of the Habit Distribution of Great Mormons



Source: Masahiko Kitahara, "Expansion of the Range of Butterflies and Global Warming," 2008, Insects and Nature

Figure2-1-10 Coral Reef Bleaching Rate in Sekisei Lagoon



Note: The average for survey points with continuous data series (26 points)
Source: Ministry of the Environment

Figure2-1-11 Lower Quality of Rice due to Immature White Grains

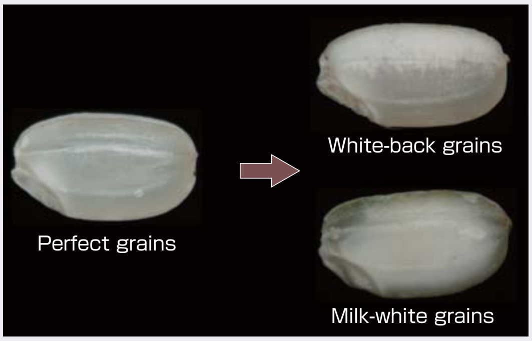


Photo: Satoshi Morita, Senior Researcher, National Agricultural Research Center for Kyushu Okinawa region (KONARC)

Figure2-1-12 Sunburn Mandarin Oranges

Photo: Citrus Breeding and Physiology Research Team, National Institute of Fruit Tree Science, National Agriculture and Food Research Organization (NARO)

As for the impacts on living organisms, there have been reports on the shift of the habitat distribution to the north or to higher altitudes. For example, the habitat distribution of great Mormons, which are said to need the average temperature of around 15 degrees Centigrade at the northern limit of the habitat, has been confirmed to move toward the north from the 1950s to the 2000s (Figure 2-1-9). The decline of alpine plant communities and bleaching of coral reefs have also been confirmed (Figure 2-1-10).

Looking further at the impacts on agricultural products, high temperatures are causing immature white grains (whitened brown rice) and body cracks (cracked brown rice) in rice and sunburned mandarin oranges (Figure 2-1-11, 2-1-12).

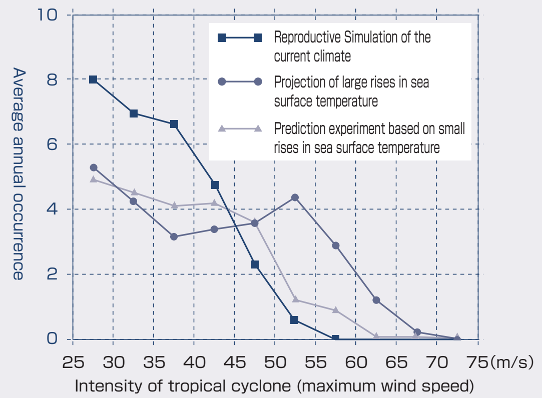
It is difficult to determine whether these events have been caused by global warming or by short-run, sporadic high temperatures. It is because that over the long term, the average temperature across Japan has risen about 1.1 degrees Centigrade in the past century, but in the short run, in 2004, the average temperature increased 1.00 degree Centigrade over the average year. It is believed that even when the above-mentioned events have been caused directly by short-term high temperatures, long-term global warming is also likely to have played a key role.

2 The Damage Expected in the Future

In recent years, studies on future projections of global warming have made strides and we are now able to envision what the earth will be like 50 years or 100 years later, though with a measure of uncertainty. In this subsection, we address the increase in powerful typhoons, the frequency of heavy rains, the rise in sea level and the increase or decrease in sweltering nights and frost days as symptoms of climate change, and the reduction in suitable habitats for beech forests and the expanding areas at risk of pine wilt as examples of the ill effects of global warming.

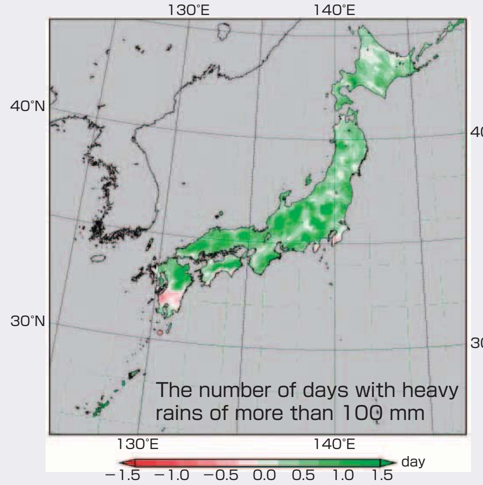
Regarding the future forecast of typhoons, the reproducibility of typhoons has improved with the use of the high-resolution atmospheric global climate model, and the reliability of change forecasts for typhoons has been enhanced. The use of this model indicates that while the total number of tropical cyclones generated in association with global warming will decline, the number of "extremely strong (the maximum wind speed of 44 m/s or more)" tropical cyclones will increase globally, accompanied by heavier rains (Figure 2-1-13). Forecasts of the frequency of heavy rains by the high-resolution regional climate model also show that comparison between two decades of the late 20th century and two decades in the late 21st century indicates that the number of days with heavy rains of more than 100 mm per day

Figure2-1-13 Frequency Distribution of the Average Number of Tropical Cyclones per Year by Intensity of Tropical Cyclones in Global Warming Simulations



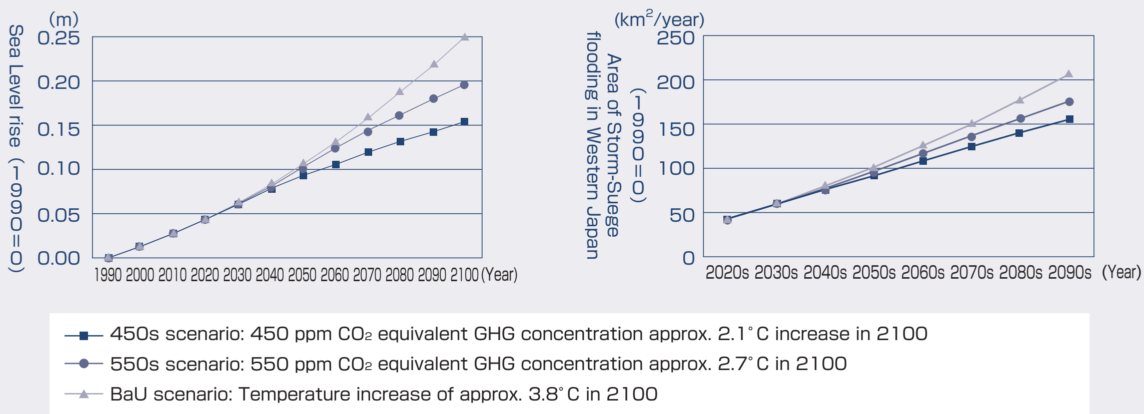
Note: Results of the simulations based on the observed sea surface temperature the simulations based on the projected sea surface temperature with small progress in warming (small increase in sea surface temperature) and the experiment based on the predicted sea surface temperature with greater progress in warming (large increase in sea surface temperature)
Source: Meteorological Research Institute, etc., 2007

Figure2-1-14 Projected Changes in Precipitation across Japan



Source: Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment, "Climate Change and Its Impacts in Japan" (October 2009)

Figure2-1-15 Global Sea Level Rise by Scenario and Area of Storm-Surge Flooding in Western Japan



Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

will increase in many regions, except for the southern part of the Kyushu region (Figure 2-1-14).

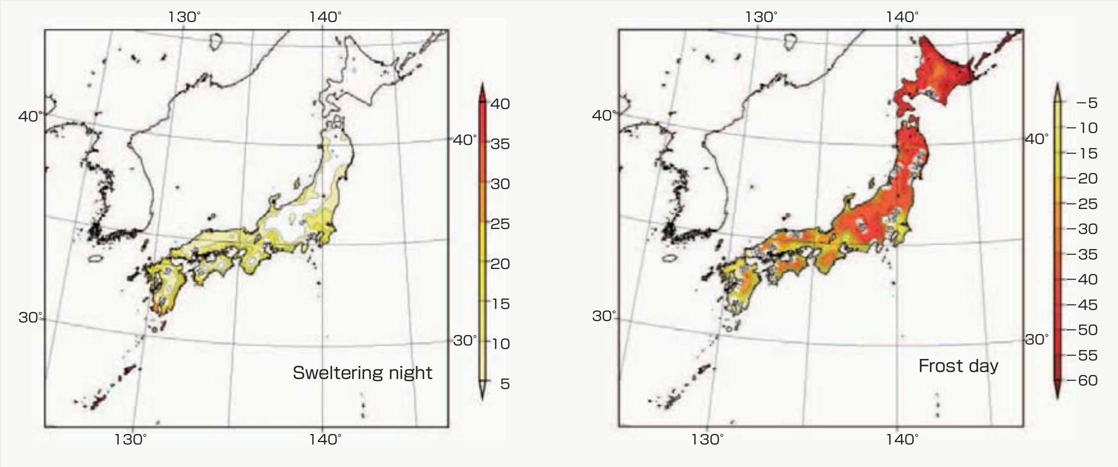
According to "Comprehensive Assessment of Climate Change Impacts to Determine the Dangerous Level of Global Warming and Appropriate Stabilization Target of Atmospheric GHG Concentration" (hereafter referred to as "Project for Comprehensive Projection of Climate Change Impacts"), a strategic research and development area project financed by the Global Environment Research Fund of the Ministry of the Environment, the global average sea level is projected to rise by about 25 cm by 2100 if no action is taken to cope with global warming. Projections of the flooded area caused by storm surges in Western Japan under the same scenario point to an annual increase of about 200 km^2 by the end of the 21st century, indicating that areas with relatively low levels of coastal waterproof barriers are at risk of being flooded (Figure 2-1-15).

We are already beginning to feel in our bones an increase in sweltering nights and a decrease in frost days. According to the Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change, "Climate Change and Its Impacts in Japan" – which was compiled in October 2009 by the Ministry of Education, Culture, Sports, Science and Technology, the Japan Meteorological Agency and the Ministry of the Environment – the number of frost days (with the intraday lowest temperature of less than 0 degree Centigrade) 100 years from now is projected to drop particularly sharply in the mountain areas of Honshu, Tohoku and Hokkaido, while the number of sweltering nights (with the intraday lowest temperature of 25 degrees Centigrade or higher) is expected to sharply increase in the Kanto region and south of the Kinki region (Figure 2-1-16).

These temperature changes have a big impact on vegetation, etc. According to studies under the Project for Comprehensive Projection of Climate Change Impacts, if no action is taken, suitable habitats for beech forest are projected to decline by nearly 70% by the end of the 21st century, and about 50% of the pine distribution areas that were not at risk of pine wilt at the end of the 20th century are expected to newly become areas at risk of pine wilt (Figure 2-1-17).

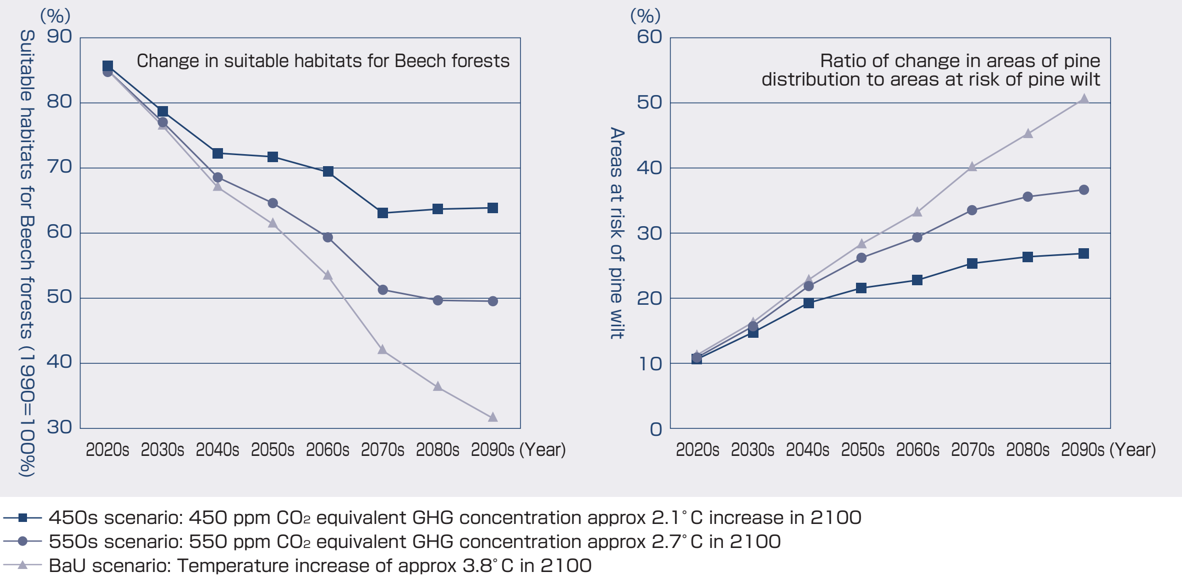
Meanwhile, other countries are also making various projections about future impacts of global warming. Many

Figure2-1-16 Changes in the Annual Number of Days above 25℃ and Frost Days across Japan (Unit: Day)



Note 1: Difference between the 20-year average from 2081-2100 and the 20-year average to the 1981-2000
2: Projection results under the A2 scenario based on a regional model with a holizontal resolution of 20 km (RCM20)
3: Calculation results are based on a single model under a single scenario. Results may vary if a different model or scenario is used.
Source: Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment, "Climate Change and Its Impacts in Japan" (October 2009)

Figure2-1-17 Global Warming Impacts on Japan (Change in Suitable Habitats for Beech Forests and Ratio of Change in Areas of Pine Distribution to Areas at Risk of Pine Wilt)



Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

of impacts of global warming are related to "water," such as increased risk of flooding and a decline in water supply, and the damage from water-related impacts is likely to increase sharply as global warming progresses. Climate change poses particularly large threats to developing regions. Many developing regions have had warm climates from the beginning, and are vulnerable to major changes in precipitation patterns. Economies of developing countries often depend on agriculture that is particularly vulnerable to climate change, and this presents a major risk factor. Lastly, because of poverty, many developing countries often find it difficult to take measures to cope with climate change on their own.

In Table 2-1-1, we summarize examples of impacts of climate change projected for Africa, Asia, Latin America and small islands in the IPCC Fourth Assessment Report.

3 Necessary Countermeasures

As discussed above, the damage presumably caused by global warming is already beginning to occur as a reality, making it necessary to take adaptation measures (measures to mitigate the adverse impacts by adjusting appropriate responses of nature and the human community to climate change and associated rises in

Table2-1-1 Examples of Projected Impacts by Region

Africa	・By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. ・In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. ・Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP). ・By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenario.
Asia	・By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. ・Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. ・Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. ・Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.
Latin America	・By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. ・There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. ・Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase. ・Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.
Small islands	・Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. ・Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. ・By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. ・With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

Source: Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry, Japan Meteorological Agency, "Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, Summary for Policymakers" (translated by the Ministry of the Environment)

Table2-1-2 Climate Scenarios and Impacts by Stabilization Level (Nationwide Values)

Climate Scenario/Impact Field		Unit	2030s			2050s			2090s		
			450s	550s	BaU	450s	550s	BaU	450s	550s	BaU
	Change in average temperature (1990=0℃)	℃	0.9	0.9	1.0	1.3	1.6	1.7	1.6	2.3	3.2
	Change in annual mean precipitation (1990=100%)	%	100	101	101	105	106	107	107	110	113
	Sea level rise (1990=0m)	m	0.06	0.07	0.07	0.10	0.11	0.12	0.15	0.19	0.24
Floods	Flooded area	1000km²	0.2	0.2	0.2	0.6	0.7	0.7	0.5	0.6	0.8
	Food damage cost potential	Trillion yen/year	1.3	1.3	1.3	4.4	4.7	4.9	5.1	6.1	8.3
Landslide disasters	Probability of slope failure	%	3	3	3	3	4	4	4	5	6
	Slope failure damage cost potential	Trillion yen/year	0.60	0.60	0.60	0.49	0.52	0.58	0.65	0.77	0.94
Beech forest (Japanese beech)	Suitable habitats for Beech forest	%	79	77	77	72	65	61	64	50	32
	Cost of damage due to loss of suitable habitats for Beech forest	100 million yen/year	778	829	851	1034	1273	1381	1325	1811	2324
Pine wilt	Areas at risk of pine wilt	%	15	16	16	22	26	28	27	37	51
Rice	Rice yield	t/ha	4.9	5.0	5.0	4.9	5.0	5.1	4.8	4.9	5.1
Sand beaches	Area of sand beach loss	%	13	13	13	19	21	23	29	37	47
	Cost of damage due to loss of sand beaches	100 million yen/year	116	118	121	176	192	208	273	338	430
Storm surges	Population affected by storm-surge flooding (western Japan)	10,000 people/year	12	12	12	19	20	21	32	37	44
	Population affected by storm-surge flooding (Japan's three major bays)	10,000 people/event	11	11	11	17	17	17	30	32	35
	Area of storm-surge flooding (western Japan)	km²/year	60	60	61	92	97	102	155	176	207
	Area of storm-surge flooding (Japan's three major bays)	km²/year	24	24	24	37	38	39	63	67	72
	Cost of damage due to storm-surge flooding (western Japan)	Trillion yen/year	2.0	2.0	2.0	3.1	3.3	3.5	5.4	6.2	7.4
	Cost of damage due to storm-surge flooding (Japan's three major bays)	Trillion yen/year	0.2	0.2	0.2	0.3	0.4	0.4	1.8	2.0	2.3
Heat stress	Heat stress mortality risk	—	1.5	1.6	1.6	1.8	2.1	2.2	2.1	2.8	3.7
	Cost of damage due to heat stress (heat stroke)	100 million yen/year	243	265	274	373	480	529	501	775	1192

Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

temperatures and the sea level).

More specifically, such measures include construction of breakwater and embankment to prevent storm surge damage in water-related disasters and coastal areas, construction of temporary impounding facilities to mitigate flood damage due to localized heavy rains, securing of refuges for animals and plants that lose their habitats due to global warming in natural ecosystems, early detection and prevention of the perishing and loss of forests, and development of agricultural crops with high temperature resistance in the food field.

"The Stern Review: The Economics of Climate Change," a report on the result of studies conducted under the direction of the British Minister of Finance, notes that if no action is taken to cope with global warming, in other words, business as usual (BaU), that would "reduce welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20%." The Stern Review also estimates the annual costs of stabilization of greenhouse gas (GHG) concentration in the atmosphere at 500-550ppm CO2e to be around 1% of gross domestic product (GDP) by 2050, a level lower than the intensity of measures assumed for Japan's mid-term goals.

Figure 2-1-2 shows the results of studies on the costs of domestic damage due to the impacts of global warming estimated under the Ministry of the Environment's Project for Comprehensive Projection of Climate Change Impacts. The impacts and damage are estimated to decrease considerably if GHG emissions are reduced through mitigation measures. If additional measures are not taken (BaU), however, up to ¥8.3 trillion in flood damage, ¥0.94 trillion in landslide disasters, ¥232.4 billion in cost of damage due to loss of suitable habitats for beech forest, ¥43.0 billion in cost of damage due to loss of sand beaches, ¥7.4 trillion in cost of damage due

Column　We Answer Your Questions about Global Warming

Some erroneous descriptions have given rise to the recent controversy over the credibility of the IPCC Fourth Assessment Report (AR4).

However, these errors concern only a small portion of the AR4 that runs about 1,000 pages and the credibility of the AR4's scientific basis regarding global warming remains intact. Following the recent controversy, the IPCC has commissioned the InterAcademy Council (IAC) to conduct an independent review of the processes and procedures of the IPCC in preparing its reports. The IAC review results will be discussed at this year's IPCC Plenary Session and reflected in the IPCC Fifth Assessment Report (to be released in 2013-2014).

In this column, we explain about questions you might have regarding global warming based on scientific knowledge offered in the IPCC AR4 and other documents.

(1) Is there sufficient evidence that anthropogenic greenhouse gases are the major cause of global warming?

Not only anthropogenic factors such as greenhouse gas emissions but also natural factors including solar activity and aerosols discharged by volcanic eruptions cause changes in the global mean temperature, and a combination of various factors leads to temperature rises or decreases. Around the mid-20th century, there were periods when the global mean temperature stayed flat despite higher atmospheric concentrations of greenhouse gases due to other offsetting factors. The IPCC AR4 noted that based on the results of climatic simulations for 1906-2005, rapid global warming observed in the recent several decades cannot be reproduced without considering anthropogenic increases in greenhouse gas emissions.

(2) The biggest greenhouse effect comes from water vapor. So, isn't it true that a small increase in carbon dioxide emissions has little impact on the environment?

It is true that water vapor has the biggest greenhouse effect (about 60%), but carbon dioxide also plays an important role by contributing about 30% of the greenhouse effect. The amount of water vapor in the atmosphere is determined by exchanges (evaporation and precipitation) between the atmosphere and oceans/land surface. Thus, the amount of water vapor does not increase or decrease significantly due to human activities. Water vapor is believed to grow in amount in the atmosphere if temperatures rise which increasingly accelerates global warming, but much more contributory to temperature rises are carbon dioxide emissions by human activities. In other words, due heed certainly needs to be given to water vapor in that water vapor currently is a factor for the greenhouse effect and has potential to amplify global warming in the future. In order to contain the progression of global warming, however, it is more effective to curb emissions of carbon dioxide and other greenhouse gases.

(3) Isn't it true that the major cause of global warming is animated solar activity, etc. and not the increase in greenhouse gas concentrations?

As noted in (1), not only the increase in greenhouse gas concentrations but also animated solar activity (an increase in radiant energy from the sun) and other factors cause to alter the global mean temperature. However, the latest observation data on the number of sunspots, a good indicator of solar activity, shows that sunspots have stayed almost flat or tended to decrease since the mid-20th century, indicating little possibility of solar activity becoming more vigorous. Cosmic rays (electric atomic nuclei drifting in outer space) that reach the earth's atmosphere are said to form clouds, and there is a theory that cosmic rays decrease when solar activity becomes vigorous and a resultant reduction in the amount of clouds causes temperatures to rise. At present, however, there is no established correlation between cosmic rays and the amount of clouds and the physical mechanism involved has not been elucidated. After assessing scientific discussions concerning natural factors such as solar activity and cosmic rays, the IPCC AR4 has concluded that the increase in global average temperatures in the latter half of the 20th century is very likely due to the increase in anthropogenic greenhouse gas concentrations.

to storm-surge flooding (Western Japan), and ¥119.2 billion in cost of damage due to heat stress (heat stroke) mortality, respectively, is estimated each year in the 2090s.

Section 2　Economic Effects of Measures to Cope with Global Warming

Measures to cope with global warming are believed to have both positive and negative effects on the economy. As specific positive effects on the economy, considerable new business opportunities are conceivable in a diverse range of industries and services. The market for low-carbon energy products is one of fields with considerable potential going forward. Japan must strive to take advantage of these business opportunities.

Measures to deal with climate change may also help eliminate existing inefficiencies. At the corporate level,