Program for Monitoring and Process Study

Major Research Results

The Japan Meteorological Agency (JMA) monitored the annual average surface temperature in the 20th century at 17 observation sites where human impact on temperature changes resulting from urbanization is minimal (Fig. 4). The temperature changed within the lower levels in Japan until 1940; it turned sharply upward in the 1960s and 1990s, which is much higher than the global average rate of about 0.6°C. Mid-latitude countries like Japan are thought to be vulnerable to warming due to a decrease in the Sun's reflection caused by reduced snowfall in high-latitude continents.

The atmospheric concentration of greenhouse gases, such as carbon dioxide, methane, and aerosols, which impacts global warming, is steadily increasing as a result of human activities. Presently, Japan operates 15 regular monitoring stations among some 30 sites worldwide, including Minamitorishima (JMA), Hateruma Island (National Institute for Environmental Studies (NIES)), and Syowa Station (Institute of Polar Research and Tohoku University) (Fig. 5). All data show steady increases toward present, while monitoring data, except for Syowa Station which exhibits very small seasonal variations, reveal repeating similar seasonal changes.

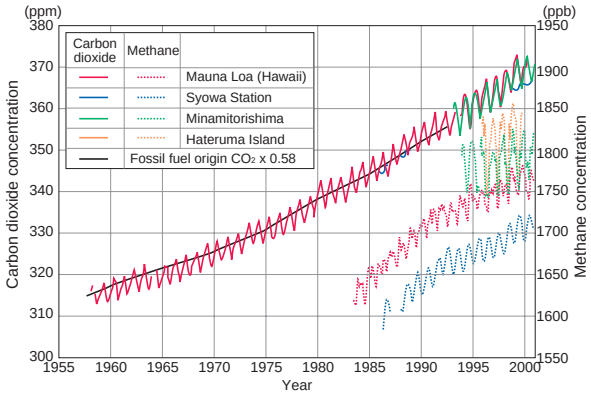

Fig. 5. Long-term carbon dioxide and methane monitoring data at Mauna Loa (National Oceanic and Atmospheric Administration (NOAA)), Syowa Station (National Institute of Polar Research and Tohoku University), Minamitorishima (JMA), and Hateruma Island (NIES) (from World Meteorological Organization (WMO) World Data Centre for Greenhouse Gases (WDCGG) database). Black line indicates the 58% value of accumulated carbon dioxide from fossil fuel combustion.

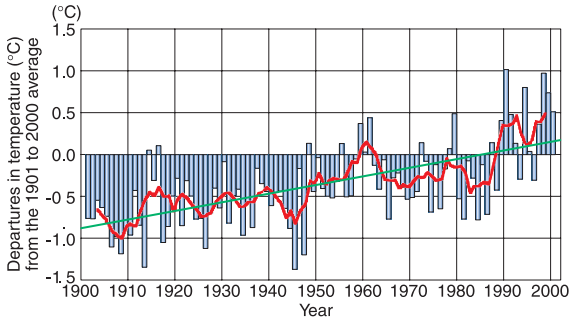

Fig. 4. Surface temperature variations in Japan from 1901 to 2000. Bar graph indicates departures of annual average temperature from the 1901 to 2000 average, and the red curve indicates 5-year running mean. Green curve indicates long-term trend.

Since the ocean absorbs about half of the total amount of carbon dioxide of anthropogenic origin after subtracting the amount accumulated in the atmosphere (3.3PgC), monitoring of spatial and seasonal variations of CO_2 flux in the ocean is quite important. To cover basin-scale monitoring of ΔPco_2 (difference of Pco_2 between atmosphere and surface of the ocean) with seasonal variations, ΔPco_2 in the sub-arctic Pacific waters was monitored from 1995 to 2001 by NIES using commercial vessels cruising a regular route and equipped with CO_2 measuring instruments (Fig. 6). The sub-arctic Pacific undergoes substantial seasonal variations, acting as a CO_2 sink for spring and summer but becoming a CO_2 source in winter.

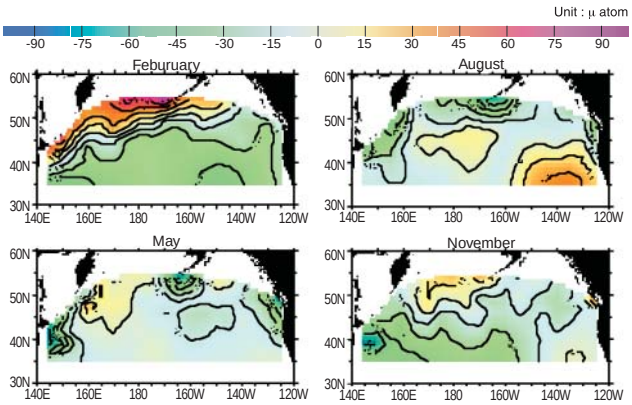

Fig. 6. Seasonal variation in air-sea ΔPco_2 distribution in the sub-arctic Pacific. It is obtained by a joint project of the National Institute for Environmental Studies and the Institute of Ocean Sciences, Canada, using a cargo ship "Skaugran" from 1995 to 1999.

Future Research Directions

To advance monitoring and research of global warming, collaborative observations and studies with several on-going international projects, including Global Climate Observing System (GCOS), Integrated Global Observation Strategy Partnership (IGOS-P) and Global Carbon Project (GCP), are required. In addition, Japan's geographical setting in the eastern end of the Eurasian Continent and facing the Pacific Ocean, provides a unique opportunity to contribute observation of global warming, through collaboration with Asian countries, including a huge area of Siberia, to expand land based observation sites, and with Pan-Pacific countries to expand ocean observation tracks and sites in the North and South Pacific Ocean, Southern Ocean, the Bering Sea, and the Polar Sea.

The following are highly recommended targets of global warming monitoring and required development of technologies for the next 10 years.

- ✔ Establishment of regionally distributed land-based monitoring stations in Siberia, China, and Southeast Asia to monitor integrated global-warming components such as greenhouse gases and aerosols, CO_2 flux, vegetation, and soil moisture.
- ✔ Intensive seasonal monitoring of surface ΔPco_2, chlorophyll a, and nutrients of the Pacific Ocean using research vessels and ships of opportunity, and the establishment of fixed time-series stations in the sub-arctic Pacific region for intensive monitoring of the carbon cycle and CO_2 flux in the upper ocean.
- ✔ Development of satellite sensors and other technology to monitor atmospheric CO_2 concentrations with an accuracy of 1ppm from the space.
- ✔ Aircraft and satellite observations of the interaction between physico-chemical characteristics of aerosols and cloud conditions in the atmosphere.