JAPAN

In Japan, Ministry of the Environment (ME) and the Japan Meteorological Agency (JMA) play principal roles in monitoring atmospheric ozone and constituents related to the depletion of the ozone layer and in promoting, coordinating, and implementing research on the ozone layer and the environmental effects of increased surface UV-B. The Global Environment Research Fund (GERF) was begun by the ME in 1990 to promote coordination and cooperation among national institutes and universities involved in research on global environmental issues, including ozone depletion, by providing financial assistance to these organizations. The ME also supports a program to monitor global environmental changes on a long-term basis at the Center for Global Environmental Research (CGER) of the National Institute for Environmental Studies (NIES). The Annual Report on the state of the ozone layer, surface UV-B radiation, and atmospheric concentrations of ozone-depleting substances is published by the ME. The Ozone Layer Monitoring Office of JMA coordinates observations, monitoring, and data processing of atmospheric ozone and surface UV-B radiation. These data are reported to the World Ozone and Ultraviolet Data Center (WOUDC) of the World Meteorological Organization (WMO) in Canada. At the same time, intensive data analyses are performed, and the results are published as the "Annual Report of Ozone Layer Monitoring" by JMA. The details of the above-mentioned ongoing and planned monitoring and research activities are as follows.

1. Monitoring

1.1. System for the global ozone observation in the framework of the Global Atmosphere Watch (GAW) of WMO

JMA carries out total column ozone and Umkehr measurements with Dobson spectrophotometers and determining vertical ozone distribution with ozone sondes at four sites in Japan (Sapporo, Tsukuba, Kagoshima, and Naha) and at Syowa Station, a site in the Antarctica. JMA also began total column ozone and Umkehr measurements with a Brewer spectrophotometer at Minamitorishima in 1994. Since the First and Second International Workshop on Ozone Observation in Asia and the Pacific Region (IWOAP and IWOAP-II) in 1996, JMA has been evaluating the ozone data in cooperation with other participating countries. JMA began the operation of the Quality Assurance/Science Activity Center (QA/SAC) in Tokyo and the Regional Dobson Calibration Center in Tsukuba in accordance with the GAW strategic plan 2001–2007 to contribute to the assessment and improvement of the quality of ozone observations in the Regional Associations II (Asia) and V (South-West Pacific) of WMO.

1.2. Lidar and microwave monitoring of the ozone layer

Since October 1990, CGER of NIES has been measuring the vertical profiles of the stratospheric ozone above Tsukuba (where NIES is located) with laser radar (lidar), which is accepted as one of the complementary measurements of the Network for the Detection of Stratospheric Change (NDSC). The lidar data are sent to the NDSC archiving facilities. NIES also began measurements of vertical profiles of ozone with microwave (millimeterwave) radiometers in September 1995 at Tsukuba and in March 1999 at Rikubetsu. Ozone measurements with the radiometers are incorporated into the CGER monitoring program.

1.3. Monitoring of related chemical constituents

The ME observes CFCs, CCl_4, CH_3CCl_3, hallons, HCFCs, HFC and CH_3Br. at remote sites (Wakkanai and Nemuro) and at an urban site (Kawasaki). CGER of NIES observes surface ozone, CFCs, CCl_4, CH_3CCl_3, CO_2, CH_4, N_2O, NO_x, Rn, and aerosols at remote sites (Hateruma and Ochiishi). JMA observes surface ozone, CFCs, CCl_4, CH_3CCl_3, CO_2, N_2O, CH_4, and CO at Ryori (one of the WMO/GAW Regional Stations) and surface ozone, CO_2, CH_4, and CO at Minamitorishima (one of the WMO/GAW Global Stations) and Yonagunijima (one of the WMO/GAW Regional Stations). JMA also observes CFCs, CO_2, N_2O, and CH_4 in both the

atmosphere and seawater of the western Pacific on board the research vessel *Ryofu Maru*. JMA began the operation of QA/SAC of CO_2 and CH_4 and the Calibration Center of CH_4 in Asia and the South-West Pacific in accordance with the GAW strategic plan, in order to contribute to the assessment and improvement of the quality of CH_4 and CO_2 measurements.

1.4. UV-B monitoring

JMA observes surface UV-B radiation with Brewer spectrophotometers at Sapporo, Tsukuba, Kagoshima, and Naha in Japan and at Syowa Station in Antarctica. These data are reported to WOUDC. CGER of NIES monitors surface UV-A and UV-B radiation with broadband radiometers at 20 observation sites in Japan.

2. Research

2.1. Research on measurement of the ozone layer and the processes of ozone depletion

(a) *Research related to the Network for Detection of Stratospheric Change (NDSC)*

NIES and the Solar-Terrestrial Environment Laboratory (STEL) of Nagoya University have established stations with NDSC instruments, including lidars, millimeterwave radiometers, and Fourier transform infrared spectrometers (FTIR). Some of the activities conducted by these organizations have been incorporated into the NDSC complementary measurements in Japan, and they offer especially valuable data to NDSC related to their geographical locations. The Meteorological Research Institute (MRI) of JMA, the Communications Research Laboratory (CRL), and some universities are measuring O_3, HCl, HF, and other stratospheric constituents with NDSC instruments at NDSC primary stations such as Eureka (Canadian Arctic), Lauder (New Zealand), and other mid-latitude and tropical sites in cooperation with foreign research organizations.

(b) *Satellite observations*

The ME developed satellite-borne instruments to observe profiles of ozone and other atmospheric species related to ozone chemistry. The Improved Limb Atmospheric Spectrometer (ILAS) was put into space on board the Advanced Earth Observing Satellite (ADEOS), which was launched in August 1996 by the National Space Development Agency of Japan and which made continuous measurements over high-latitude regions until June 1997, when ADEOS stopped its operation due to an accident. Data obtained with the ILAS instrument have been processed and analyzed at NIES and have also been distributed to science communities for further research.

Development and tests for the ILAS-II instrument has been completed. The ILAS-II will be launched with ADEOS-II into almost the same orbit as ADEOS in November 2002 to continue the ozone-layer measurements. An ILAS-II follow-on instrument, SOFIS (Solar-Occultation FTS for Inclined-orbit Satellite), is being developed to measure greenhouse gas distributions as well as the ozone layer. Its launch is projected for about 2008.

(c) *Studies on atmospheric processes of ozone depletion*

NIES and Nagoya University participated in two European ozone projects, SESAME and THESEO. They contributed to balloon observations of stratospheric trace species (ozone, aerosols, and water vapor) over Eastern Siberia from a station at Yakutsk in cooperation with the Central Aerological Observatory of Russia. They carried out campaign experiments in Kiruna (Sweden), Alaska, Antarctica, Yakutsk, and Japan to validate the ADEOS/ILAS and RIS (Retroreflector in Space) observations, and to understand ozone depletion in the Arctic region and its effects on the ozone layer in mid-latitude regions. NIES, MRI, CRL, and university groups have been observing ozone and minor stratospheric constituents to understand the variability of the ozone layer over Japan. The ME supports these activities through GERF. MRI has measured ozone, aerosols, and

other species relevant to stratospheric ozone depletion using lidars and FTIR to understand the stratospheric processes over the Canadian Arctic with support from the Ministry of Education, Culture, Sport, Science and Technology of Japan.

(d) *Modeling and experimental studies*

A chemical-radiative-dynamical coupled general circulation model (CCSR/NIES AGCM) has been developed by the Center for Climate System Research (CCSR), the University of Tokyo, and NIES to investigate the response of future ozone to volcanic eruptions and changes in halogen loading and greenhouse gases. NIES has also developed a three-dimensional chemical transport model (CTM) in which the temperature and wind velocity data are assimilated into the calculated fields in CCSR/NIES AGCM by using a nudging method. The CTM is being used to simulate the variability of ozone in the stratosphere. MRI has also developed a three-dimensional CTM and is currently working on improving it. Chemical kinetics and photochemical data on both gas-phase and heterogeneous reactions are being measured by NIES, the National Institute of Advanced Industrial Science and Technology, and university groups to evaluate chemical processes in the stratosphere.

2.2. Research on the environmental effects of ozone depletion

(a) *UV-B effects on human health*

The effects of the increase of ultraviolet radiation on human health are being studied under GERF. Some of these studies include an exposure assessment of UV radiation, a molecular epidemiological study of UV exposure on skin cancer, and an epidemiological study on ocular diseases due to increased UV radiation and UV-B-mediated immuno-suppression resulting in an increase in viral infections (NIES, National Cancer Center Research Institute, National Institute of Health, National Institute of Industrial Health, Kobe University, Osaka City University, Kagoshima University).

(b) *UV-B effects on ecosystems*

The effects of enhanced UV-B radiation on terrestrial plants and marine plankton are being studied by projects with support from GERF. Some of these studies focus on the effects of enhanced UV-B on the production of vegetables (Chugoku National Agricultural Experiment Station), the susceptibility of marine plankton to UV-B radiation (Hokkaido National Fisheries Institute), and the effects of enhanced UV-B on forest vegetation (Forestry and Forest Products Research Institute) and the plant genome (NIES).

***