INDIA

INTRODUCTION

India ratified the Vienna Convention for the protection of ozone layer on June 19, 1991 and the Montreal Protocol on Substances that Deplete the Ozone Layer on September 17, 1992. The Copenhagen, Montreal and Beijing Amendments were also ratified on 3rd March 2003. The India Country Programme was prepared in 1993 chalking out a strategy to phase-out production and consumption of Ozone Depleting Substances (ODSs).

Atmospheric ozone monitoring started in India since 1928 when Dr. Royds made total ozone measurements in Kodaikanal with Dobson photoelectric ozone spectrograph as part of the first world-wide ozone measurements organized by Prof. G. M. B. Dobson. The first Dobson Spectrophotometer was acquired by India Meteorological Department (IMD) in 1940. The Indian ozone observational and research programme are as follows:

OBSERVATIONAL ACTIVITIES

Column measurements of ozone and other gases/variables relevant to ozone loss

Total ozone measurements are being carried out at 6 stations by the IMD. Present network of six Dobson and two Brewer spectrophotometers are stationed at Srinagar, New Delhi, Varanasi, Pune and Kodaikanal.

At all stations, routine measurements of total ozone are made (upto a maximum of six times per day) by trained personnel. Whenever, conditions permit, Umkehr observations are also made form these stations to compute the vertical distributions of ozone. Later, two Brewer Ozone Spectrophotometers were procured. One (#89) was installed at National Ozone Centre, IMD, New Delhi and other (#94) at Kodaikanal. It has an advantage over the Dobson Spectrophotometer because it is semiautomatic. Besides, it could also measure SO_2, NO_2 and UV-B.

Profile measurements of ozone and other gases/variables relevant to ozone loss

Vertical Ozone Distribution : The development of an Indian ozonesonde was taken up in 1963. The first successful sounding was carried out in September, 1964. The sondes were subsequently intercompared in WMOII03C. Further, comparisons were also held in West Germany in 1970 and 1980; in 1991 (Canada) and 1996 (Germany). Since early 1970, fortnightly soundings were attempted at New Delhi, Pune, Thiruvanathapuram, Dakshin Gangotri and Maitri (Antarctica). A large number of vertical profiles of ozone, water vapor and nitrogen dioxide have been obtained and average profiles for Delhi were derived. The data obtained by this method was compared with balloon, rockets and LIMS satellite data. The system has been successesfully operated during 13th, 14th and 16th Indian Antarctica Expedition and measured ozone height profiles in the Antarctica conditions both normal and ozone hole period. A similar high tech LHS with wide band (1GHz) acousto-optic spectrometers as back-end has also been developed and designed for operation at NPL, New Delhi sponsored by Indo-French Centre for Advanced Research.

The Laser Hetrodyn System (LHS) and mm wave radiometer : This system monitors the 10 micron ozone line in absorption mode against the Sun. The mm wave radiometer observes the 101 GHz ozone line in emission mode. This instrument has the advantage over LHS that it can be operated round the clock under all weather conditions as it does not require direct sun light. The line profiles in both the experiments are inverted to obtain the Ozone height distribution. The ozone height profiles over Delhi and Maitri have been generated for a limited period using these techniques. The laser heterodyne spectrometer due to its ultra high spectral resolution and quantum limited sensitivity, can resolve the individual spectral lines completely even Doppler broadened absorption lines in the upper stratosphere. In view of the above a major project has been undertaken to design, develop and set up the most sophisticated CO_2 laser heterodyne system to get on line profiles of various trace species in the atmosphere including ozone over Antarctica as well as at NPL, New Delhi. The system developed earlier has been modified by using wide band (1GHz) acousto-optic spectrometers for the first time to improve the height resolution, accuracy

and better spectral resolution. This is the first system of its kind on the global scale to use 1 GHz Acousto - optic spectrometer for laser heterodyne system to resolve the line completely with a very high spectral resolution and that is also in Antarctic environment. This HI-TECH system has been successfully set up and operated at Maitri, (70^0 46' S, 11^o 44' E) an Indian Antarctic station during 1993-94 and again during 1994-95 and ozone height profiles were obtained on cloud less clear days. The absorption line profiles obtain from Laser heterodyne system was used to retrieve the height profiles of ozone using inversion technique (an in house developed software to retrieve height profiles with inverse solution of radiative transfer equation).

Surface Ozone Measurements : During the 70s, the electrochemical surface ozone measurement system was successfully developed. The system is successfully operating at New Delhi, Pune, Kodaikanal, Thiruvanathapruam, Nagpur, Srinagar, Dakshin Gangotri and Maitri.

Surface ozone is being measured over New Delhi, an urban site, a region of intensive anthropogenic activity since 1997. Temporal variation studies on surface ozone at NPL, New Delhi during July, 1997 to December, 2007 shows that in all year's winter and monsoon months attains low values of ozone than the critical value (NAAQS – 1 Hour average -120 ppbv). Where as during summer and post monsoon months ozone values attains critical value, which alarming poor air quality in these seasons.

Measurement of Minor Constituents : In addition to surface ozone, monitoring of NOx, CO, CH_4, NMHC, aerosols and meteorological parameters has also been carried out at the same site on a continuing basis to help in interpreting surface ozone variations. The Differential Absorption Lidar (DIAL) facility is also being used from time to time to monitor surface ozone, water vapour, ethylene and ammonia.

UV measurements

Broadband measurements

Measurements of UVB started in India around 1980 by independent scientists around India. Since its inception, the care of these instruments has changed hands several times and future funding is in jeopardy. The instruments were banded into a more formal network under the Indian Middle Atmospheric Programme (IMAP) in 1982-83. The IMAP program ended in 1989 and funding has continued for all stations except Jodhpur since then under ISRO-UGC. The six instruments originally included Jodhpur, Pune, Visakhapatnam, Mysore, New Delhi and Trivandum. The instruments are filter based instruments which measure four wavelength bands with 10 nm FWHM. The center wavelengths are roughly 280, 300 and 310 nm. For the moment, Dr. S. C. Chakravarty of the Space Science Office, ISRO and B. H. Subharay are keeping the program running.

Regular measurement of UV-B radiation by filter photometer were started in 1979 at National Physical Laboratory, New Delhi. At present under Indian Middle Atmospheric Programme (IMAP) a chain of 7 stations have been established for routine measurement of global UV-B radiation at 280, 290, 300 and 310nm.

UV-Biometer : The measurement of Minimum Erythermal dose in the UV-B range started at Delhi in 1995 January and is continuing.

Narrowband filter instruments

India started using Narrowband filter instruments for measurement of radiation from July 1957 at 21 principal and 22 ordinary stations where continuous recording of global and defused solar radiances and bright hours of sunshine are measured. UV-A, UV-B and UV-Total measurement has also been introduced at all the stations to study the impact of climate on human health, agriculture productivity, ozone depletion etc.

Spectoradiaometers

The spectral measurements in the UV-B range at ½ nm interval started in 1989 and is continuing. The UV network is likely to expand and coordinate with international programme.

Calibration activities
The network instruments are calibrated against the National Standard at regular intervals. The National Standard is in turn, inter-compared against World standard in WMO organized International Intercomparisons. India participated in such comparisons held at Belsk (1974), Boulder (1977), Melbourne (1984) and Japan (1996). IMD, New Delhi is the National Ozone Centre for India and the Regional Ozone Centre for the Regional Association-II (Asia) of the World Meteorological Organization (WMO).

UV measuring instruments have been calibrated by using monochromators and wherever possible by using brewer spectrophotometer.

RESULTS FROM OBSERVATIONS AND ANALYSIS

The major findings are as follows : -

1) Though the latitudinal variation of trends for Dobson and satellite data are similar for Dobson data over India gives small positive trend at the subtropical and equatorial regions, which is a significant finding. Extension of trend analysis using neural network over the period 1991-2001 has been done to predict ozone over Delhi.

The Stratospheric Ozone profiles obtained from Jharia from north India are found more lower then those lines to south. The low stratospheric Ozone according to study may be because of O_2, CO, CH_4 etc on regular basis at Maitri. Two years continuous observation of CO_2 hourly average concentration revealed that average yearly value of 368.43 ppm in 2002 and 369.72 ppm in 2003 indicating anthe coal fires containing gases such as methane, oxides of sulphur and carbon.

NPL has established a semi -automatic gas chromatograph for monitoring green house gases such as C increase of 1.3 ppm. This corresponds to growth rate of 0.35% per year.

2) Analysis of long term total ozone data from the Indian stations have not shown any trend.

THEORY, MODELLING, AND OTHER RESEARCH

Impact studies of UV rays on plants, animals and human beings were conducted in Jawaharlal Nehru University, Banaras Hindu University etc. which were published in national and international journals. Central Radiation Laboratory, Pune has also been conducting radiation studies at 45 stations. India also maintains one weather monitoring station at Maitri, Antarctica with a facility for measurements of global and diffuse solar radiation using pyranometers and of optical depth using a sunphotometer.

DISSEMINATION OF RESULTS

Results of the studies are disseminated through electronic media/website of respective institutions and query services.

Data reporting
The total ozone data and Umkehr data (vertical profile of Ozone) are being regularly sent in WMO format to the World Ozone Data Centre (W03DC) Canada, and are being regularly published by the Centre.

Information to the public
The information on ozone concentration and other constituents are placed in the website of India Meteorological Department.

Relevant scientific papers

Nandita D Ganguly, Department of Physics, St.Xavier's College, Ahmedabad. "Low level of stratospheric ozone near the Jharia coal field in India".

Dr. B. C. Arya, Scientist-F Radio and Atomspheric Sciences Division,"Report on NPL's activities related to Ozone and other trace gases.

Beig G. Saraf N and Peshin S. K. "*Latitudinal Gradient in long trends in Tropospheric ozone over Tropical India*". Proceedings Quadrennial Ozone Symposium (1-8 June, 2004).

Namita Kundu, Peshin S. K., Sachchidannand Singh and Meera Jain "*Variation of ozone Chemopause and Tropopause height difference with tropospheric temperature*". Proceedings Quadrennial Ozone Symposium (1-8 June, 2004).

Kulandaivelu E and Peshin S. K. "*Measurement of total Ozone, D-UV radiation, Sulphur dioxide and Nitorgen dioxide with Brewer Ozone Spectrophotometer at Maitri, Antarctica-2000*". Mausam, 54, 2(April 2003).

Peshin S. K., Panda N. C., Dewhare J. N. and Perov S. P. "*Comparison of Indian ozonesonde and Umkehr profiles at New Delhi 1989-1997*", Mausam, 54, 2(July 2003) 679-682.

"*UV-B flux increase during Coronal Mass Ejection*" by Saumitra Mukherjee and Anita Mukherjee, Jawaharlal Nehru University, New Delhi; 4th (Virtual) Thermospheric/Lonospheric Geospheric Research (TIGER) Symposium.

"*Possible Biological Effects by UV-radiation Newly Detected from Internally Administered Radioisotopes*" by M. A. Padmanabha Rao, 114, Charak Sadan, Vikaspuri, New Delhi, India

"*Modernization of Radiation Network*" by R. D. Vashishha & M. K. Gupta of India Meteorological Department, Pune, India

"Air quality monitoring in Chennai, India in the summer of 2005" by Mr. M. Pulikesi etal.

"Low level of stratospheric ozone near the Jaharia coal field in India" by Ms. Nandita D Ganguly.

PROJECTS AND COLLABORATION

Ministry of Science and Technology, under its atmospheric programme, is developing projects for monitoring of ozone and minor constituents including various greenhouse molecules such as Carbon Dioxide (CO2), Methane (CH4), Nitrus Oxide (NOx).

Indian Middle Atmospheric Programme (IMAP), operating since 1982, has provided an umbrella for integrating all Indian efforts on ozone research. Rocket Programmes in collaboration with ex-USSR were stepped up during this period with payloads from Physical Research Laboratory, Ahmedabad and the National Physical Laboratory, Delhi. These, along with balloon and ground based measurements, have well characterized the ozonesphere over India.

Indo-Russian collaborative programme on variations in ozone and aerosol content in tropics/extratropical troposphere and stratosphere are being studied.

A collaborative programme with Ultraviolet International Research Center, Finland has been launched to monitor the UV radiations.

FUTURE PLANS

a) Continuous monitoring of ozone profile over the country.
b) Study on atmospheric chemistry in relation to ozone layer depletion and climate change.
c) To participate in the international intercomparisons of Dobson Spectrophotometer, Brewer Spectrophotometer and Ozonesonde.
d) To develop biological system to monitor UV-B.
e) To continue research on impact of UV-B on human health and eco-systems.
f) To develop climatic models to predict the climatic change over India.

NEEDS AND RECOMMENDATIONS

- In accordance with the decision of the Meeting of Parties to the Vienna Convention, present activities need to be continued to monitor ozone concentration and UV radiations.
- Research activities relating to impact of UV radiations on life and its supporting system need to be conducted.
- The Ozone Research Managers meeting may recommend to the Meeting of Parties for taking decisions to request Parties to provide adequate support to continue the present activities and to carry out future plans.
- Developed countries may consider to have bilateral assistance programme with developing countries to strengthen ozone and UV-monitoring and research system.
- UNEP networking system may also include ozone and UV monitoring activities in their agenda.

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