REPORT OF THE INTERNATIONAL WORKSHOPS ON OZONE OBSERVATIONS IN ASIA AND THE PACIFIC REGION (IWOAP, IWOAP-II)

Tokyo and Tsukuba, Japan

IWOAP 27 February - 26 March 1996
IWOAP-II 20 August - 18 September 1996

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Japan Meteorological Agency
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Prepared by the
WMO Quality Assurance/Science Activity Centres for RAlI and RAV

Co-sponsored by
Japan Meteorological Agency
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# TABLE OF CONTENTS

1. EXECUTIVE SUMMARY .................................................. 1
   1.1 Seminars ......................................................... 1
   1.2 Intercomparisons .................................................. 2

2. IWOAP ................................................................. 3
   2.1 Seminar on Ozone Observation .................................. 3
   2.2 Tsukuba Intercomparison ....................................... 10

3. IWOAP-II ............................................................... 12
   3.1 Seminar on Ozone Observation ................................ 12
   3.2 Tsukuba Intercomparison ....................................... 18

Annex A List of Participants of the IWOAP Seminar .................. 21
Annex B Programme of the IWOAP Seminar ............................... 25
Annex C Welcome Address at the IWOAP Seminar ...................... 27
Annex D Closing Address at the IWOAP Seminar ...................... 28
Annex E List of Participants of the Tsukuba Intercomparison in IWOAP . . 29
Annex F Individual Instrument Reports of the Tsukuba Intercomparison in IWOAP ........................................ 31
Annex G List of Participants of the IWOAP-II Seminar ................ 37
Annex H Programme of the IWOAP-II Seminar ........................... 41
Annex I Welcome Address at the IWOAP-II Seminar .................... 43
Annex J Closing Address at the IWOAP-II Seminar .................... 45
Annex K List of Participants of the Tsukuba Intercomparison in IWOAP-II ........................................ 46
Annex L Individual Instrument Reports of the Tsukuba Intercomparison in IWOAP-II ................................. 48
Annex M Format of the Country Reports of the IWOAP and IWOAP-II Seminars ........................................ 53
Annex N Definitions on the Ozone Instrument ........................... 54
1. EXECUTIVE SUMMARY

Two International Workshops on Ozone Observation in Asia and the Pacific Region were held from 27 February to 26 March 1996 (IWOAP) and from 20 August to 18 September 1996 (IWOAP-II) in Japan, under the co-sponsorship of the Japan Meteorological Agency (JMA), the Ministry of Transport of Japan (MOT) and the World Meteorological Organization (WMO).

The long-term quality controlled ozone data obtained within the framework of the WMO Global Atmosphere Watch (GAW) are essential for assessment of the state of the global ozone layer. The purpose of IWOAP and IWOAP-II is to determine the current status and to improve the quality of the ozone observations in Asia and the Pacific Region. The workshops were held as an activity of the Tokyo Quality Assurance/Science Activity Centre (QA/SAC) in GAW, which is responsible for maintaining consistent and known data quality in the region.

The workshops consisted of the seminars on ozone observation in Tokyo and the total ozone intercomparisons in Tsukuba. Altogether, eighteen experts from eight countries (excluding Japan) in the region and three experts from Germany, the United States of America and WMO participated in the seminars. Six Dobson instruments (China, India, Pakistan, Philippines, Republic of Korea and Thailand) and one Brewer instrument (Malaysia) were intercompared with the Regional Standard Instrument #116, at the Aerological Observatory, JMA, in Tsukuba.

1.1 Seminars

The purposes of the seminars were:

- to outline international activities regarding the observations of ozone,
- to exchange scientific and technical views and ideas on the observations of ozone,
- to discuss the future role of the national meteorological services (NMSs) in the region in the observations of ozone.

In conclusion:

- significant ozone reduction continues everywhere except in the equatorial region, and the intensity and size of the Antarctic ozone hole has reached record levels in the last three years;
- the Dobson observations continue to provide critically needed information on the global distribution of ozone and its trend.

The recommendations based on the seminars include:

- further development of monitoring ozone and timely archiving of the data in the WMO World Ozone and Ultraviolet Data Centre are essential for international activities regarding observations of ozone,
- regular calibration and international intercomparisons are essential for quality assured data which is indispensable for the global ozone assessments,
- WMO should strengthen training activities and initiate system audits ('expert visitations'),
- the QA/SAC in JMA should develop a system for reviewing the ozone data collected by each station in the region to identify and flag suspicious values.
1.2 Intercomparisons

The purposes of the intercomparisons were:

- the technical inspection and adjustment of the instruments,
- comparison of the Dobson/Brewer spectrophotometers with the Regional Standard Dobson Instrument #116, to determine the existing calibration level,
- determination of new calibration constants for each Dobson/Brewer spectrophotometer, as necessary,
- to provide instruction for operation of the Dobson/Brewer spectrophotometers at home stations, and share knowledge concerning the management of an ozone observation programme.

In conclusion:

- all participating instruments left the intercomparisons in proper condition and in correct operating order. Errors of the instruments at the initial and the final intercomparison are summarized in Table 1;
- the Dobson instruments were modified to accept an external drier unit. A simple version of the drier was prepared and given to the participants.

The recommendations based on the intercomparisons include:

- the total ozone data record should be reprocessed if the error of the instrument at the initial and the final intercomparison is large,
- WMO should standardize the electronic circuits with a simple, effective design using easily available components,
- some stations in the region should be visited by an expert from the WMO calibration centers to assist in and advise on the observing programme and to verify instrument operation,
- a three year intercomparison schedule should be continued.

JMA hopes that the workshops contribute to maintain and improve the quality of the ozone data in this region.

Table 1: Errors of the instruments at the initial and the final intercomparison

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Initial Intercomparison</th>
<th>Final Intercomparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manila, Philippines</td>
<td>+0.8% (1µs3)</td>
<td>+0.3% (1.15µs3.2)</td>
</tr>
<tr>
<td>Bangkok, Thailand</td>
<td>+5.0% (1µs3)</td>
<td>+0.1% (1.15µs2.5)</td>
</tr>
<tr>
<td>New Delhi, India</td>
<td>+0.0% (1µs3)</td>
<td>+0.1% (1.15µs3.2)</td>
</tr>
<tr>
<td>Yonsei University, Seoul, Korea</td>
<td>+3.6% (1µs3)</td>
<td>+0.1% (1.15µs2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.9% (2.5µs3.2)</td>
</tr>
<tr>
<td>Beijing, China</td>
<td>+1.6% (1µs3)</td>
<td>+0.3% (1.3µs3.5)</td>
</tr>
<tr>
<td>Quetta, Pakistan</td>
<td>-2.5% (1µs3)</td>
<td>+0.1% (1.3µs2.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+0.8% (2.5µs3.5)</td>
</tr>
<tr>
<td>Petaling Jaya, Malaysia</td>
<td></td>
<td>+1.3% (1.3µs3.5)</td>
</tr>
</tbody>
</table>
2. INTERNATIONAL WORKSHOP ON OZONE OBSERVATION IN ASIA AND THE PACIFIC REGION (IWOAP)

2.1 Seminar on Ozone Observation

2.1.1 Introduction

The Seminar on Ozone Observation during the International Workshop on Ozone Observation in Asia and the Pacific Region (IWOAP) was held from 4 to 6 March 1996 at the Headquarters of the Japan Meteorological Agency (JMA), Tokyo, Japan. A technical visit to the Tsukuba Intercomparison at the Aerological Observatory, JMA, was made from 7 to 8 March 1996.

The seminar was held as a part of the Cooperation for Climate Change Monitoring and Research Network in Asian and the Pacific Region (CLIMONET) and the International Technical Cooperation Project of the Ministry of Transport (MOT), organized jointly by MOT and JMA, and cosponsored by the World Meteorological Organization (WMO).

Participants of the seminar included eleven experts of the national meteorological services (NMSs) in Asia and the Pacific Region; WMO-Quality Assurance/Science Activity Centre (QA/SAC); the National Oceanic and Atmospheric Administration (NOAA), United States of America; Yonsei University, Republic of Korea; and relevant officers from MOT and JMA. The list of participants is shown in Annex A.

Atmospheric ozone plays an important role in absorbing the biologically damaging ultraviolet sunlight and in creating the temperature structure of the Earth's atmosphere. Downward trends in ozone continue to be observed over much of the globe, and the Antarctic ozone hole has continued to appear, its occurrences over the last several years having been particularly pronounced. These observations have accelerated the international efforts to protect the ozone layer and have led to the conclusion of the Vienna Convention in 1985, and the Montreal Protocol in 1987 and its Amendments. Since worldwide precise observations are necessary to assess the control measures, WMO has organized the Global Atmosphere Watch (GAW), which is a coordinated network of observing stations, associated facilities and infrastructure encompassing measurement and related scientific assessment activities. QA/SAC is responsible for maintaining consistent and known data quality in GAW.

IWOAP provided the first opportunity for experts in Asia and the Pacific Region to come together and have discussions on ozone observations and also the first intercomparison of Dobson spectrophotometers in this region with the instrument of JMA which was calibrated in the Intercomparison of Ozone Spectrophotometers held in Arosa, Switzerland, in 1995. This event was also the first commitment of the Tokyo QA/SAC operated by JMA to the establishment of a worldwide network of high quality observations.

The purposes of this seminar were:

1) to outline international activities regarding the observations of ozone,
2) to exchange scientific and technical views and ideas on the observations of ozone,
3) to discuss the future role of the NMSs in the region in the observations of ozone.

The programme of the seminar involved keynote speeches on international activities, country reports from five overseas participants and one expert of JMA, scientific lectures on observations, analysis and model study of ozone related phenomena, and a general discussion on the future role of the NMSs in the ozone observations. The programme of the seminar is shown in Annex B.
2.1.2 Opening of the Seminar

The seminar was opened at 10:00 a.m. on 4 March 1996 by Dr. Masaro Saiki, Senior Assistant for International Affairs, Planning Division, Administration Department, JMA. He invited Dr. Kozo Ninomiya, Director-General of JMA, to present an opening address.

On behalf of MOT and JMA, Dr. Ninomiya welcomed all the participants. He stressed the importance of observational facts when introducing measures to reduce adverse effects of environmental variations such as the depletion of the ozone layer.

Dr. Ninomiya hoped that the Tsukuba Intercomparison would contribute to maintain and improve the quality of the data from the Global Ozone Observing System (G04OS) promoted by WMO in the framework of its GAW and operated by the individual NMSs and other relevant institutes. Furthermore, he hoped that the seminar would provide a forum not only to exchange scientific and technical views and ideas on the observations of ozone, but also to reaffirm the importance of observations in various activities related to global environmental issues. Finally, he wished the overseas participants a pleasant stay in Japan. The full text of the opening address by Dr. Ninomiya is contained in Annex C.

2.1.3 Keynote Speeches

Dr. O. Uchino, JMA, chaired the first session on Keynote Speeches related to international activities.

Prof. V. A. Mohnen, WMO-QA/SAC for Europe and Africa, Germany, summarized the quality assurance in WMO/GAW. The scientific input to the debate on global climate change issues must derive from an 'adequate' knowledge base and data of 'known' quality. This can only be achieved through strict adherence to scientific principles of quality assurance. The three elements of quality assurance that must be appropriately implemented at all levels of the measurement/analysis/assessment hierarchy are: (1) data quality objectives (defined by accuracy, precision, completeness, representativeness, and comparability), (2) quality control (achieved through calibration, good laboratory practice, instrument/method intercomparison, training/education etc.) and (3) quality assessment (achieved through expert consultations, i.e. independent system and performance audits). QA/SACs have been established in GAW to design and execute all measures necessary to maintain consistent and high quality of data and to coordinate necessary training activities.

Mr. R. D. Evans, CIRES/NOAA, USA, described the total ozone observing programme using the Dobson spectrophotometer. The Dobson spectrophotometer has been used to study total ozone since its development in the 1920s. The observation of total ozone with this instrument is one of the longest geophysical measurement series in existence. Today, the instrument is an important part of a global effort to understand the role of stratospheric ozone in atmospheric chemistry, of biological and ecological effects of solar UV radiation, and of climate. The calibration process has linked most instruments to the World Standard Dobson Instrument DO83 in an effort to make the measurements from various instruments comparable. Consistency in measurement technique and data handling is equally important to this goal.

Dr. T. Ito, JMA, outlined the international approaches to climate change issues. The activities of communities involved in atmospheric observations are important because relevant scientific reviews on climate change issues and adequate policy making have in recent times been closely interrelated. The international approaches to the issues of global warming and ozone layer depletion are prominent examples. From these examples, it is clear that national and international policy making requires continuously updated assessment of scientific knowledge on the issues and that scientific knowledge should be produced based on the data from well-designed observation networks. The responsibility of the communities involved in atmospheric observation is to provide useful information based on high quality data for policy makers.
2.1.4 Country Reports

The six experts from Asia and the Pacific region were invited to present reports on ozone related activities in their NMSs based on the format for 'country reports' described in Annex M.

Mr. Chee Young Choi, Republic of Korea, chaired the first half of the session and Mr. R. D. Evans, NOAA, chaired the second half. Each presentation is summarized below.

PHILIPPINES: Ms. E. L. Juanillo, Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), presented facts about the Philippines which include its location, current population and meteorological characteristics. The organization, history and system of ozone layer monitoring were also highlighted in the report with an emphasis on the Dobson spectrophotometer being presently used by PAGASA. A discussion on data acquisition and an analysis of ozone observations as well as some primary results of data analysis, mercury lamp tests and standard lamp tests carried out were given. Finally, the methods of data management and analysis system at PAGASA were explained. Future work concerning the use of ozone data particularly related to human health, UV-B measurements using the Brewer spectrophotometer and problems on data management and instrument maintenance were outlined.

INDIA: Dr. V. S. Tiwari, India Meteorological Department (IMD), presented an overview of the organization, history and present system of ozone observations. At present, IMD has a network of five stations making total ozone and Umkehr observations with the help of Dobson spectrophotometers. Two Brewer spectrophotometers have also been added to the network since March 1994. New Delhi is the national ozone center for India and the regional ozone center for the Regional Association II (Asia) of WMO. The Dobson ozone spectrophotometer No.112 serves as the national standard and this instrument participated in the international intercomparison of Dobson spectrophotometers at Belsk (1974), Boulder (1977), Melbourne (1984) and Tsukuba (1996). Travelling standard lamp calibration checks during 1985-87 and 1992-93 were also carried out on all Dobson instruments of the Indian ozone network.

KOREA: Dr. Joon Kim, Yonsei University, Republic of Korea, provided a brief overview of the activities in relation to ozone observations and data analysis results. There are currently two ozone stations in the Republic of Korea. Ozone observation is carried out primarily by the two agencies: Global Environment Laboratory (GEL) at Yonsei University and Korea Meteorological Administration (KMA). The former is equipped with a Dobson spectrophotometer, and the latter with a Brewer spectrophotometer. At Yonsei University, ozone layer observations are made by members in the Atmospheric Ozone Research Division of GEL. Total ozone and vertical distribution have been measured since May 1984 and February 1986, respectively. Results of their analysis of total ozone and vertical distribution during the last 15 years were briefly discussed. Also, results of their calibration of the Dobson spectrophotometer were presented.

SINGAPORE: Ms. Tan Hui Sian, Meteorological Service Singapore (MSS), gave an overview of the climate, organization, ozone observation programme and data acquisition and analysis system. The Upper-air Observatory of MSS first made total ozone measurement over Singapore using a Dobson spectrophotometer in 1979. The history and progress of the ozone observation programme, which has been extended since then, were reported. Steps to monitor instrument performance and quality of observations were also reported.

THAILAND: Mr. Sarayut Rachupimol, Meteorological Department, Thailand, outlined the organization and ozone measurements. Total ozone observations with a Dobson spectrophotometer began in 1979, and additional measurements with a Brewer spectrophotometer will start in the middle of 1996. He provided the status of the Dobson and Brewer instruments and the ozone observations above Bangkok station during last 12 years. The important factors with regard to future developments were pointed out.
JAPAN: Mr. R. Kajihara, JMA, reported on the observation and analysis of the ozone layer by JMA. The observations and quality control of total ozone, ozone profile and ultraviolet radiation at Sapporo, Tsukuba, Kagoshima and Naha using Dobson and Brewer spectrophotometers as well as ozonesondes were explained. The management of the observations of the ozone layer in JMA is the responsibility of the Ozone Layer Monitoring Office (OLMO), JMA, in Tokyo. The OLMO analyzes the condition of the ozone layer using these data as well as data from global ground based and satellite observations. The results are reported monthly and important phenomena are announced in a timely manner.

2.1.5 Scientific Lecture

This session was chaired by Dr. V. S. Tiwari, India, Ms. E. L. Juanillo, Philippines; Ms. Tan Hui Sian, Singapore; and Dr. Joon Kim, Republic of Korea.

Ms. Tan Hui Sian, Meteorological Service Singapore, introduced the preliminary results of ozone observations in Singapore. No significant decrease in total ozone is evident over Singapore, or elsewhere in the tropics. Relevant observational data using a Dobson spectrophotometer were presented and discussed. A vertical profile representative of the ozone soundings begun recently was also presented. The profile is consistent with other ozone sondes observations near the equator, as well as with local Umkehr results. The calculated total ozone was also found to be close to the data obtained by direct sun observations using the Singapore Dobson spectrophotometer.

Mr. Chee Young Choi, Korea Meteorological Administration, presented a study of total ozone variations versus synoptic system. The temporal and spatial structure of the principal components which affect the distribution of total ozone as characterized. The main synoptic system characteristics accounting for the increase in total ozone were shown as a formation of trough and potential vorticity increase near the tropopause, i.e. the warm region in the lower stratosphere and the cold region in the middle troposphere. The results of principal component analyses of annual total ozone show that the spatial structure of the first eigenvector has a positive value which explains 75% of the total ozone variance in the North-eastern Asia region. The temporal structure of the first eigenvector has decreased during ten years, and this tendency has linearly correlated with the decrease in total ozone.

Mr. T. Sasaki, MRI, JMA, presented an overview of the numerical studies on ozone at MRI. A two-dimensional photochemical model developed at MRI is used to study the stratospheric ozone distribution and its change. The model includes heterogeneous chemistry which is now believed to be very important in the stratospheric chemistry. Calculated distributions of ozone and other minor constituents simulate well observed ones. With this model some numerical experiments were done. Results show that the model can simulate some of the recent ozone changes but that further studies are necessary.

In response to a question, Mr. Sasaki explained the merit of a two-dimensional model in comparison with a one-dimensional and a three-dimensional model. However, he also pointed out the necessity of developing a three-dimensional model to correctly assess the effects of longitudinal variation, especially in studying Arctic ozone change, where planetary wave contribution is strong.

Mr. T. Fujimoto, MRI, JMA, outlined principles and results of lidar measurements (Light Detection and Ranging). A lidar uses light (laser beam) for probing, while a radar (Radiowave Detection and Ranging) uses radio waves. The laser beams are monochromatic, highly coherent, and highly collimated. Using such advantages, the lidar can measure aerosols, haze, clouds, and atmospheric constituents (ozone and etc.) with high resolution in both space and time. Since 1988, an ozone lidar developed by MRI has been measuring ozone over Tsukuba. Observational results are in good agreement with the data obtained by SAGE II and ozonesondes. MRI will start to build a new lidar system which can measure the ozone concentration in an aerosol rich region, such as the troposphere or the lower stratosphere soon after a violent volcanic eruption.
In 1998, with the start of the International Tropospheric Ozone Year, WMO is hoping to coordinate tropospheric lidar instruments worldwide to observe tropospheric ozone. Mr. Fujimoto said that they would start preliminary experiments this year.

Dr. V. S. Tiwari, India Meteorological Department, presented a paper on ozone measurements and changes observed over the Indian region in recent years. Total ozone data from the Indian network do not indicate any systematic change except some periodicity. Vertical distribution of ozone in a different layer, however, shows that the atmospheric ozone in the lower troposphere over New Delhi indicates an increasing trend, but no such increasing trend is seen at Pune. In the lower stratosphere at New Delhi a slight decreasing trend is seen after 1985 but no such decrease is seen at Pune. Surface ozone measurements at New Delhi, Pune and Trivandrum do indicate that the concentration of ozone near the ground has steadily increased since the early 1980s, and New Delhi and Pune show a higher rate of increase compared to Trivandrum. This is attributed to an increase in anthropogenic gases and in situ production of ozone. The ozone measurements at Maitri (Antarctica) confirm that the ozone hole over Antarctica has increased in intensity and become wider in time and space.

Dr. S. Chubachi, MRI, JMA, gave the results of ozone observations over Antarctica obtained by the AD lunar and the CD solar Dobson in wintertimes and by the AD solar Dobson in summertimes as follows:

1) during the polar night period, the total ozone at Syowa shows no significant year-to-year trend or seasonal variation. The mean value in these months provides a base line for determining the springtime ozone decrease. Moreover, this result shows that the ozone depletion in the previous spring does not affect the wintertime total ozone at Syowa,

2) the mean total ozone in September relative to the mean total ozone during the polar night period varies linearly with that for August. This fact shows that the ozone destruction process is active in August and September. However, this relationship does not appear to continue through October because of the collapse of the polar vortex,

3) the magnitude of the springtime ozone depletion has increased from the 1980s to the 1990s,

4) analysis of the temperature at the 100 hPa level shows that final warming at Syowa has been delayed by 1.2 days per year. This suggests that the polar vortex is stabilized by the development of the Antarctic ozone hole.

Dr. Joon Kim, Yongsei University, Republic of Korea, described a study on measurement of ozone flux using the micrometeorological eddy correlation technique. This technique provides areally-integrated, in-situ measurement with minimal disturbance. The flux of an entity is computed by correlating the fluctuations in the vertical wind velocity with the fluctuations in the concentration of that entity. Instruments are required to have fast response time and high resolution. In this presentation, the theoretical background of the eddy correlation technique was reviewed. Also, the application of this micrometeorological technique to the flux measurement of trace gases such as ozone and methane was presented.

Mr. H. Shimura, Aerological Observatory, JMA, introduced the current status of the solar UV radiation measurements in the JMA network. The spectral UV measurement is important to monitor the possible increase in UV radiation in conjunction with the ozone layer destruction. JMA performs, therefore, UV spectral measurements at four stations in Japan, i.e. Sapporo, Tsukuba, Kagoshima and Naha, and at Syowa Station in Antarctica. In this presentation, the methods of observation, procedures of calibration and maintenance adopted by JMA as well as some results of UV observation at Tsukuba were introduced. It was also mentioned that the standardization of UV instruments should be established by the WMO as soon as possible.
Dr. M. Hirota, MRI, JMA, presented the observational results of mixing ratios of CCl₂F₂ and CCl₃F by MRI since 1979. Tropospheric samples were collected over Japan using small aircraft, and were analyzed for CCl₂F₂ and CCl₃F by a GCECD method. Mean volume mixing ratios in the troposphere were 453 ppt for CCl₂F₂ and 272 ppt for CCl₃F as of January 1990. Those of CCl₂F₂ and CCl₃F were increasing at almost constant rates, i.e., 16.2 ± 0.7 ppt/year for CCl₂F₂ and 10.3 ± 0.4 ppt/year for CCl₃F between 1979 and 1990. Global increasing rates are reported to be 16-20 ppt/year for CCl₂F₂ and 9-11 ppt/year for CCl₃F in the late 1970s to late 1980s. Those over Japan are in good agreement with these results. Since 1990, the growth rate of CCl₃F mixing ratio has slowed significantly, presumably in response to its reduced emission. It is said that the growth rate of CCl₂F₂ mixing ratio also has slowed.

Dr. O. Uchino, JMA, presented the state of the ozone layer in 1995 and of the ozone trend based on the ozone data observed by JMA and by satellite. A statistically significant negative trend of total ozone was detected at Sapporo. A nearly common tendency for tropospheric ozone to increase and for lower stratospheric ozone to decrease can be seen in the ozonesonde data obtained over Japan. Continued ozone depletion has been observed in the Antarctic stratosphere. The size of the 'ozone hole' was almost similar to that observed during the last three years and 1.6 times that of the Antarctic Continent. The global ozone trend was significantly negative except in the tropical region. Lastly, recent results of the UV-B radiation observed by JMA were presented.

2.1.6 General Discussion

Prof. V. A. Mohnen, WMO, chaired the final session of the seminar. Discussion was focused on the following subjects:

1) Quality Assurance/Quality Control
   - Calibration
   - Maintenance
   - standard operating procedures
   - Training
   - Data Correction
   - Observational Aspects
   - expert consultations (system and performance audit)

2) Joint activities of WMO with International Global Atmospheric Chemistry (IGAC)
   - Global Tropospheric Ozone Network (GLONET)
   - International Tropospheric Ozone Year (ITOY)
   - need for network/instrument expansion, ozone lidar
   - Atmospheric Chemistry Education (ACEED)

3) Observational Tools and Intercomparison
   - Dobson/Brewer
   - Ground based/satellite
   - Data harmonization
   - Ozone sondes (Jülich Ozone Sensor Intercomparison Experiment)

The future of ozone observations, based on the participants' discussion, is as follows. The Dobson observations continue to provide critically needed information on the global ozone distribution and the total ozone trend. The Dobson network has matured to a state where data of known quality are produced with a well-defined level of confidence. International 'agreements' exist on how to preserve the integrity of all instruments and how to maintain high levels of accuracy and precision.
To maintain consistent and high quality of data, four recommendations were made.

1) Maintain the three-year intercomparison of Dobson instruments.
2) Strengthen training activities and initiate system audits ('expert visitations').
3) Initiate standardization of Dobson electronics.
4) Re-publish standard operation procedures
   update of WMO report No.6, 'Operation Handbook-Ozone Observation with
   a Dobson Spectrophotometer'.

A discussion on the UV-B observations also took place. Many countries are now
implementing UV-B networks based on a variety of instruments, both narrow band (e.g. Brewer,
home build, etc.) and broad band (e.g. Robertson-Berger, Yankee, etc.). UV-B monitoring is
inherently difficult, and WMO is relying on the Scientific Steering Committee (SSC) for UV-B
headed by Dr. Paul Simon to recommend instrumentation and the quality control process.
International agreements on 'standard reference' and 'intercomparison' are urgently needed.
Although GAW has established the World Data Center for UV-B at the Atmospheric Environmental
Service, Canada, there are currently no networkwide quality assurance/quality control
procedures/guidelines in place. QA/SACs await guidance from SSC.

WMO-GAW has formed a strategic alliance on observations of tropospheric ozone with
IGAC-GLONET and agreed on three tasks that must initially be organized:

1) Emphasizes improvements in the quality of ozone profile measurements.
2) Identifies geographic regions where new stations are critically needed for achieving
   representative global coverage and develops a strategy for needed network
   expansion.
3) Encompasses initial planning for a worldwide ozone and related species intensive
   measurement programme in the 1998-1999 time frame to establish a global
   database for the verification of chemistry/transport models through the
   International Tropospheric Ozone Year (ITOY), a sub-project of GLONET.

To this end, four further modes of data gathering must be pursued:

1) Representative ozone sonde observations in the free troposphere using
   balloon-borne instruments (typically two to three launches per week).
2) In situ continuous measurements at surface stations that can distinguish
   tropospheric air from boundary layer air.
3) Ozone lidar remote sensing to obtain ozone profiles throughout the troposphere
   (continuous observations, weather permitting).
4) Occasional airborne measurements to simultaneously record ozone and all
   important precursor gases as well as other parameters relevant to ozone chemistry
   (for model evaluation and quality assurance/quality control).

2.1.7 Closing of the Seminar

On behalf of MOT and JMA, Mr. Yuco Takigawa, Director-General of the Observations
Department, JMA, expressed appreciation to all the participants for their contribution to the active
and informative discussion. The full text of his closing address is contained in Annex D.

The seminar closed at 16:10 p.m. on 6 March 1996.
2.2 Tsukuba Intercomparison

2.2.1 Purpose of the Intercomparison

The International Workshop on Ozone Observation in Asia and the Pacific Region (IWOAP) was held in February and March 1996. IWOAP was cosponsored by the Ministry of Transport (MOT), the Japan Meteorological Agency (JMA) and the World Meteorological Organization (WMO). The Workshop consisted of the intercomparison of Dobson Instruments with the Regional Standard Dobson Instrument #116 of JMA and the Seminar on Ozone Observation. Four experts from India, Korea, Thailand and the Philippines participated in the Intercomparison. The long-term quality controlled ozone data obtained within the framework of the WMO Global Atmosphere Watch (GAW) are essential to the assessment of the state of the global ozone layer. IWOAP was held as an activity of the Tokyo Quality Assurance/Science Activity Centre of GAW to contribute to the assessment and improvement of the quality of the ozone observations in Regional Association II (Asia) and V (South-West Pacific).

The main tasks were:

- the technical inspection and adjustment of the instruments,
- comparison of the Dobson spectrophotometers with the Regional Standard Dobson Instrument No. 116, to determine the existing calibration level,
- determination of new calibration constants for each Dobson spectrophotometer, as needed,
- provision of instruction for operation of the Dobson spectrophotometers at the home stations, and sharing of knowledge concerning the management of an ozone observation programme.

2.2.2 Operation

The Intercomparison of IWOAP was held at the Aerological Observatory (AOT) of JMA in Tsukuba from 27 February to 26 March 1996, under the management of the Ozone Layer Monitoring Office headed by Dr. Osamu Uchino. Its operation was guided by the scientific staff consisting of scientific director Robert Evans (NOAA/CIRES), technical director Toshinori Takao (JMA), and scientific assistant Koji Miyagawa (JMA). Logistics support and overall supervision were provided by Ryo-ichi Kajihara, Assistant to the Head of JMA Ozone Layer Monitoring Office. These four persons formed the Scientific Steering Committee for the Intercomparisons.

The Intercomparison was supported by the following staff of the Aerological Observatory:

Atsuko Hattori
Hidehiro Shimura
Takeo Ueno
Mahito Ito
Toshihiko Tamori
Yoshiyuki Terasaka

Director
Head of the Ozone and Radiation Section
Senior Researcher
Researcher
Researcher
Researcher

The following national Dobson spectrophotometers were adjusted and compared:

<table>
<thead>
<tr>
<th>No. of Dobson</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>D052</td>
<td>Philippines (Manila)</td>
</tr>
<tr>
<td>D090</td>
<td>Thailand (Bangkok)</td>
</tr>
<tr>
<td>D112</td>
<td>India (New Delhi)</td>
</tr>
<tr>
<td>D124</td>
<td>Republic of Korea (Yonsei University, Seoul)</td>
</tr>
</tbody>
</table>
The Intercomparison (IC) was performed and all work carried out according to a daily schedule taking into account the weather conditions and the technical state of the individual instruments. The technical facilities of the Aerological Observatory and special facilities from NOAA, Boulder, were utilized for the implementation of the IC.

The main steps specified below were generally accepted for each Dobson spectrophotometer:

- unpacking of the instrument, its check after the transport and installation at AOT,
- inspection of the technical condition of the spectrophotometer and its monitoring by means of the daily Standard and Mercury lamp tests,
- initial comparison against the Regional Standard to determine the existing calibration level,
- definition of the technical adjustments and special tests required (wedge calibrations, discharge lamp tests, cleaning and adjustment of the optics, refurbishing of the electronics etc.),
- final comparison against the Regional Standard,
- assessment of the results, determination of the new calibration constants (Reference R-N tables, Q-table and Reference Standard Lamp Readings),
- interview by the scientific director with the operator in charge on the results of his instrument intercomparison and other calibrations (meta data). At this point, copies of documentation related to the spectrophotometer calibration were given to the operator,
- packing of the instrument and other technical facilities for transport to its home station.

All repairs or adjustments performed and the results obtained for individual instruments are described in Annex F, and briefly given in Table 1. This information is saved in detail in the files kept by the operators and by the scientific director of the IC.

The IC was guided mainly by the scientific and technical directors during the operation, repair and adjustment of the instruments. Several days were used at the end of the IC period to instruct the operators in new techniques and computer programmes.

With regard to the goal of sharing the knowledge of the operation of the instrument, and the management of an observing programme, the individual participants were required to perform the necessary calibration procedures under the supervision of the scientific staff. For example, all wedge calibrations and discharge lamp tests were performed by the instrument's own operator.

2.2.3 Other Activities

All participants in the IC were also participants in the Seminar on Ozone Observation of IWOAP, held at the Headquarters of JMA in Tokyo on 4-6 March.

The updated version of the generalized software for processing of the Dobson total ozone observations, DOBSON 2.2, created at the Czech Hydrometeorological Institute’s Solar and Ozone Observatory at Hradec Kralove, was also presented and the participants were, on request, provided with the entire software package.

An afternoon Umkehr series was performed with the four intercomparison instruments, the standard instrument, and the observatory instrument. The difference between profiles calculated from the individual instrument measurements was less than four Dobson Units in any of the standard Umkehr layers. Most of the variation occurred in layers four and five.


2.2.4 Conclusions

All participating instruments left the intercomparison properly calibrated and in correct operating order. (See Annex F, Individual Instrument Results.)

The instruments were modified to accept an external drier unit. A simple version of the drier was prepared and given to the participants.

Many discussions on station operation and instrument maintenance were held among the participants.

2.2.5 Recommendations

A recommendation is made to WMO to standardize the electronic circuits with a simple, effective design using easily available components. To ensure the use of this design, WMO should provide the means of converting the various instruments to this circuit.

The stations at Manila and at Bangkok should be visited by an expert from the QA/SAC for the Regional Association II or V, to assist in and advise on the observing programme, and to verify the instrument operation. The representative from the Indian National Ozone Centre expressed a willingness to assist in this project. There are other possible stations and observing programmes in the regions that could benefit from such cooperative ventures.

The Scientific Steering Committee of the 1996 AOT intercomparison urges participants and/or their countries that the three-year schedule of the Region II and V Dobson spectrophotometer intercomparison, which is recommended by the WMO, be continued.

3. IWOAP-II

3.1 Seminar on Ozone Observation

3.1.1 Introduction

The Seminar on Ozone Observation during the Second International Workshop on Ozone Observation in Asia and the Pacific Region (IWOAP-II) was held from 27 to 29 August 1996 at the Headquarters of the Japan Meteorological Agency (JMA), Tokyo, Japan. A technical visit to the Tsukuba Intercomparison at the Aerological Observatory, JMA, was made on 30 August 1996.

The seminar was held as a part of the Cooperation for Climate Change Monitoring and Research Network in Asia and the Pacific Region (CLIMONET) and the International Technical Cooperation Project of the Ministry of Transport (MOT), organized jointly by MOT and JMA, and cosponsored by the World Meteorological Organization (WMO).

Participants of the seminar included twelve experts of the national Meteorological Services (NMSs) in Asia and the Pacific Region; WMO; University of Tokyo, Japan; Chinese Academy of Sciences, China; and relevant officers from MOT and JMA. The list of participants is shown in Annex G.

Atmospheric ozone plays an important role in absorbing the biologically damaging ultraviolet sunlight and in creating the temperature structure of the Earth’s atmosphere. Downward trends in ozone continue to be observed over much of the globe, and the Antarctic ozone hole has continued to appear, its occurrences over the last several years having been particularly pronounced. These observations have accelerated the international efforts to protect the ozone layer and have led to the conclusion of the Vienna Convention in 1985, and the Montreal Protocol in 1987 and its Amendments. Since worldwide precise observations are necessary to assess the control measures, WMO has organized the Global Atmosphere Watch
(GAW), which is a coordinated network of observing stations, associated facilities and infrastructure encompassing measurement and related scientific assessment activities. QA/SAC is responsible for maintaining consistent and known data quality in GAW.

IWOAP-II succeeded the first IWOAP, which was held in Tokyo and Tsukuba from 27 February to 26 March 1996. IWOAP had been the first opportunity for experts in Asia and the Pacific Region to come together and have discussions on ozone observations and also the first intercomparison of Dobson spectrophotometers in this region with the instrument of JMA, which was calibrated in the Intercomparison of Ozone Spectrophotometers held in Arosa, Switzerland, in 1995. This event had also been the first commitment of the Tokyo QA/SAC served by JMA to the establishment of a worldwide network of high quality observations. IWOAP-II was held for the countries in the region which were not able to participate in the first Workshop.

The purposes of this seminar were:

1) to outline international activities regarding the observations of ozone,
2) to exchange scientific and technical views and ideas on the observations of ozone,
3) to discuss the future role of the NMSs in the region in the direction of the observations of ozone.

The programme of the seminar involved keynote speeches on international activities, country reports from four overseas participants and one expert of JMA, scientific lectures on observations and analysis of ozone related phenomena, and a general discussion on the future role of the NMSs in the ozone observations. The programme of the seminar is shown in Annex H.

3.1.2 Opening of the Seminar

The seminar was opened at 10:00 a.m. on 27 August 1996 by Dr. Masaro Saiki, Senior Assistant for International Affairs, Planning Division, Administration Department, JMA. He invited Mr. Toshiyuki Ono, Director-General of JMA, to present an opening address.

On behalf of MOT and JMA, Mr. Ono welcomed all the participants. He stressed the importance of observational facts when introducing measures to reduce adverse effects of environmental variations such as the depletion of the ozone layer.

Mr. Ono hoped that the Tsukuba Intercomparison would contribute to maintain and improve the quality of the data from the Global Ozone Observing System (GOS) promoted by WMO in the framework of its GAW and operated by the individual NMSs and other relevant institutes. Furthermore, he hoped that the seminar would provide a forum not only to exchange scientific and technical views and ideas on the observations of ozone, but also to reaffirm the importance of observations in various activities related to global environmental problems. Finally, he wished the overseas participants a pleasant stay in Japan. The full text of the opening address by Mr. Ono is contained in Annex I.

3.1.3 Keynote Speeches

Dr. O. Uchino, JMA, chaired the first session on Keynote Speeches related to international activities.

Dr. R. D. Bojkov, Special Advisor to the Secretary-General, WMO, gave an overview of the WMO-GAW programme. At present, nearly 60 Member countries are contributing to GAW, providing data proven to be essential for understanding the state and changes of the ozone layer. The size of the Antarctic ozone hole has reached record dimensions in the last three years and the continuing decrease in total ozone since the 1970s is statistically significant all year round everywhere except over the equatorial region. With the Montreal Protocol and its Amendments, peak global ozone losses are expected to occur during the next 10-15 years, when another 6-7%
of the ozone will be destroyed, before the rates of decrease in ozone level off and start to diminish. To provide authoritative information on the state of the ozone layer for policy-makers, GAW must be maintained and improved well into the next century.

Prof. T. Ogawa, University of Tokyo, Japan, presented a review on stratospheric chemistry. In addition to the gas-phase reactions involving hydrogen, nitrogen, chlorine and bromine species, heterogeneous reactions occurring on the surface of PSC (polar stratospheric clouds) particles and sulfate aerosols play an important role in the chemistry of the lower stratosphere. The chemical model calculation can be validated with observations of almost all chemical species incorporated in the reaction system, but there are a few discrepancies remaining between the model and the observations. Prof. Ogawa stated that public interest has been promoting the stratospheric ozone research, to improve our predictive capability on stratospheric ozone change. Quantitative understanding should be developed more on the chemical and dynamical processes controlling stratospheric ozone change. We need accurate and global observation data on atmospheric ozone and related species as well as meteorological parameters.

3.1.4 Country Reports

The five experts from Asia and the Pacific Region were invited to present reports on ozone related activities in their NMSs and organization based on the format for 'country reports' described in Annex M.

Mr. Guo Song, China, chaired the first half of the session and Mr. Teh Kim Poe, Malaysia, chaired the second half. Each presentation is summarized below.

MALAYSIA: Mr. Teh Kim Poe, Malaysian Meteorological Service, gave an overview of the ozone observation programme and data acquisition and analysis system. Malaysia is aware of the importance of ozone data in the equatorial region, and initiated an ozone programme with the aim to contribute to WMO-GAW. An assessment of ozone data taken from Malaysia has indicated that the total ozone in the equatorial region is relatively constant throughout the year, with only a slight seasonal variation coupled with a quasi-biennial oscillation (QBO). The vertical distribution of ozone has also been found to remain relatively constant all year round. In the case of UV-B daily irradiance, the values fluctuate around the mean value of 4000 mWm⁻², with a slight increase around the time of the equinoxes, i.e. during the months of February-March and September-October.

PAKISTAN: Mr. Muhammad Anees Siddiqi, Pakistan Meteorological Department, introduced technical information regarding the ozone layer monitoring station at Quetta, Pakistan. It contained the country meteorological characteristics, the organization, the history and system of ozone layer monitoring, and the data acquisition and analysis system. It included also the observation results as well as the mercury and standard lamp tests on the Dobson spectrophotometer at Quetta.

CHINA: Prof. Qiu Jinhuan, Chinese Academy of Sciences, outlined the organization and observing system of ozone monitoring in China. At present there are six ozone stations in China. Five among them are within the boundaries of China, and another is in Antarctica. Total ozone and Umkehr observations were made at all six stations, and UV-B observations are made only at the Zhong Shan and Mt. Waliguan stations. Data acquisition and analysis of ozone observation results as well as the data analysis system were mentioned. Problems on the data management and instrument maintenance are mainly: (1) some aged parts and their replacements and (2) calibration of the Brewer instruments.

THAILAND: Mr. Sarayut Rachupimol, Meteorological Department, Thailand, described an overview of the climate over Thailand, the organization and the ozone observation system. Thailand has made ozone observations in Bangkok with Dobson spectrophotometer #90 since 1980. Analysis of ozone data indicates that the total ozone over Bangkok fluctuates slightly around the mean of
253 DU with a lower value during the winter season (Nov.-Feb.) and a higher value during the summer season (Mar.-May) as well as during the rainy season (Jun.-Oct.). In order to have a better coverage for the ozone observation network in Thailand, two Brewer spectrophotometers (#120 and #121) were recently purchased and will soon be in operation.

**JAPAN**: Mr. R. Kajihara, JMA, reported on the observation and analysis of the ozone layer by JMA. The observations and quality control of total ozone, ozone profile and ultraviolet radiation at Sapporo, Tsukuba, Kagoshima and Naha using Dobson and Brewer spectrophotometers as well as ozonesondes were explained. The management of the observations of the ozone layer in JMA is the responsibility of the Ozone Layer Monitoring Office (OLMO), JMA, at Tokyo. The OLMO analyzes the condition of the ozone layer with these data as well as data from global ground based and satellite observations. The results are reported monthly and important phenomena are announced in a timely manner.

As the last speaker of this session, Prof. K. Kondratyev, Russia, introduced a paper on high latitude climate and remote sensing. He also reviewed a paper on global climate change and remote sensing.

### 3.1.5 Scientific Lecture

This session was chaired by Mr. Sahib Zad Khan, Pakistan; Prof. Qiu Jinhuan, China; and Mr. Sarayut Rachupimol, Thailand.

Mr. Guo Song, China Meteorological Administration, presented the observational results of atmospheric ozone from the Chinese Antarctic Zhongshan station. Since 1993, the Brewer spectrophotometer has been used to make continuous measurements of total column of O₃, NO₂, and SO₂ as well as of UV-B radiation. Through the Umkehr method they also obtained the ozone profiles and stratospheric NO₂ amounts. Through the measurements and analysis, they have found that the Antarctic ozone hole occurs each year from early August to early November over Zhongshan station. The decrease in total column amount during the ozone hole period caused an increase in UV-B irradiance. The NO₂ column amount, especially the stratospheric NO₂ amount, has a direct ratio to total column of ozone.

Mr. Teh Kim Poe, Malaysian Meteorological Service, described a study on hazy atmospheric conditions that occurred throughout Malaysia from August to October 1994 mainly due to forest fires in Sumatra and Kalimantan. During that period, surface visibility was occasionally reduced to 2 km or less. From the ozonesonde soundings, it was noticed that there was an increase in surface and tropospheric ozone during the hazy period. The increase was more pronounced at low levels where the haze particles were more abundant. Ozone at high levels acts as a shield against ultraviolet radiation, but near the surface it represents a serious health hazard due to its toxicity. Hence haze can have an adverse environmental effect on surface level air quality by contributing to surface level ozone production.

Dr. Y. Makino, MRI, JMA, gave the results of the airborne and ground-based FTIR (Fourier-transform infrared spectrometer) measurements over Japan (25-45° N), namely at Tsukuba (36°N) and at Eureka in the Canadian Arctic (80° N) especially concerning the HCl and HF total amount in the atmosphere. The latitudinal distributions of total HCl and HF over Japan showed good correlation with total ozone and were expressed as a cosine form concerning the latitude. The seasonal change of total HCl over Tsukuba showed the spring maximum and the minimum in late fall or winter. Since 1993, the stratospheric HCl has been destroyed or changed into activated ClOx about 50-60% of the expected amount in the beginning of the Arctic springtime.

Mr. Sarayut Rachupimol, Meteorological Department, Thailand, introduced the results of the Tsukuba Intercomparison during the first IWOAP for the Thailand Dobson instrument #90. It had used original calibration data with N-table from the 1 October 1987 Melbourne, Australia, intercomparison. After that the Dobson #90 was damaged and it became difficult to evaluate the
existing data set based on the initial intercomparison. The instrument was repaired and compared with the Japanese regional standard instrument at the Aerological Observatory, JMA, Tsukuba, Japan, from 27 February to 26 March, 1996. The difference between the two instruments was not significant.

Mr. Sahib Zad Khan, Pakistan Meteorological Department, described a study on ozone measurement and conditions over Pakistan. Data from Quetta (Pakistan), New Delhi (India), and Alma-Ata (Kazakhstan) formed the basis of this study. The first two stations lie in tropics and the third in mid-latitude. The mean monthly and annual data of all three stations were collected and linear regression equations were developed. Quetta and New Delhi are following the same trend, worked out for 1991, which is used in the regression analysis. The regression equations yielded exactly the same slopes (equal to 0.01748). The equation for Alma-Ata yielded a negative slope (equal to -3.367). These results suggested that two new stations be established in Pakistan, i.e. at Islamabad, in the northern part of Pakistan, and at Karachi, in the southern part.

Prof. Qiu Jinhuan, Chinese Academy of Sciences, presented a paper on variation trends of yearly mean and monthly mean total ozone amounts over Beijing (Xianghe) and Kunming during 1980-1994. The analysis is based on joint data of total ozone amounts measured by using a Dobson spectrophotometer and of aerosol optical depth measured by using a pyrheliometer. Annual decreasing rates of total ozone are 0.47% and 0.295% over the Beijing and Kunming areas during 1980-1994, respectively. Especially during 1991-1994 the decreasing rate was up to 2.428% over Beijing, and 0.907% over Kunming. Monthly mean total ozone was observed to have a decreasing trend during 1980-1994 for all months except for July over both the Beijing (Xianghe) and the Kunming areas.

Mr. T. Nagai, MRI, JMA, introduced the results on lidar observations of the polar stratospheric clouds (PSCs) over Eureka in the Canadian Arctic. To understand the ozone depletion in the Arctic, it is very important to clarify the properties of PSCs, since stratospheric ozone would be destroyed through the heterogeneous chemical reactions that occur on their surface in the polar spring. To obtain the properties of PSCs, lidar measurements have been done at Eureka (80° N, 86° W) in the Canadian Arctic since 1993. From these observations, the PSCs showed the dynamic and complex structure that could be thought to be a reflection of the dynamics of the polar night vortex in the Arctic stratosphere. The unusual PSCs were also observed in the high temperature range on January 1995. This suggests that a chemical composition of PSCs other than that of nitric acid trihydrate particles and/or ice must exist.

3.1.6 General Discussion

The discussion led by chairperson Dr. R. D. Bojkov, WMO, concentrated on the following issues and recommendations:

1) Current and future state of the ozone layer
2) Improving and augmenting of ozone measurement and research
3) Quality maintenance and re-evaluation of the ozone data and their analysis
4) UV-B instrumentation and data quality control
5) Strengthening of international collaboration and training

The reports by the participants confirmed that a significant ozone reduction which started in the early 1970s continues everywhere except in the equatorial region and that the intensity and size of the Antarctic ozone hole has reached record levels in the last three years. Unprecedented ozone deficiencies have been observed over middle and high latitudes of the Northern Hemisphere, with extreme values recorded over the Asian part of the region. Long-term (40 years) regular ozone monitoring coordinated by WMO plays an essential role in estimating the state of the ozone layer. An increase of the surface and tropospheric ozone, possibly related to emission of precursor gases by combustion and bush fires, has been reported. This is of importance especially in relation to the radiative effects of the ozone changes on global warming.
A more serious ozone depletion can be expected over the next two decades until stabilization in the chlorine loading of the stratosphere is achieved as a result of the implementation of the Montreal Protocol and its Amendments. All other things being equal, the ozone layer is expected to return to normal in the second half of the next century. It should be emphasized that the expected recovery of the ozone layer would have been impossible without the Montreal Protocol and its Amendments.

These research findings require further monitoring improvements, an understanding, of its physical meaning and application of the collected data. Even more accurate ozone monitoring is essential during the next 2-3 decades in order to detect any reduction in the rates of the ozone decline. More emphasis on analysis and deduction from the collected monitoring data is also needed.

Augmenting the ozone measurements is also needed especially in the tropics including a few places in the ocean area. Vertical ozone distribution measurements ( sondes as well as lidars and/or Umkehr) are essential for the understanding of the state of the ozone layer and its changes. It was noted that vertical ozone distribution measurements by sondes are practically nonexistent in the huge continental part of China and Russia and they are encouraged to begin individual and collective projects with other interested countries of the region to supplement this deficiency. Frequency of soundings in the equatorial belt should be once a week and 2-3 times weekly in the middle and higher latitudes. Operational use of ozone lidars would be very profitable and cost-beneficial and will provide important vertical ozone distribution information up to the layers of about 45 km.

Further development of monitoring and timely archiving in the WMO World Ozone and Ultraviolet Data Centre of measurements of total ozone including its vertical profiles as well as measurements of other trace species and aerosols are essential along with implementations of new observational capabilities both on the ground and in space (satellites).

The Dobson instruments continue to be the backbone of the Global Ozone Observing System (GOS) initiated in the 1950s and, since 1989, a major part of the WMO Global Atmospheric Watch (GAW). Their calibration is essential for quality assured data flow, which is indispensable for the international ozone assessments.

The high quality of the total ozone data can be assured if the instruments are regularly calibrated and international intercomparisons carried out every 2-3 years as recommended by the International Ozone Commission and endorsed by WMO Executive Council Decisions. In these activities the role of the Asian and Pacific quality control center maintained by JMA (Japanese QA/SAC) is indispensable as proven by the excellent arrangements of IWOAP-I and IWOAP-II in 1996.

There is need for more systematic analysis of the ozone data by the stations in order to avoid creeping in of erroneous data at very early stage. At some stations, re-evaluations of previous data as described in WMO Ozone Report #29 are also essential. This was done already by the JMA stations, and an exchange of the experience and relevant training would be very useful for the region.

The experience which JMA specialists have acquired over the years should be made available to other operators of Dobson as well as Brewer instruments. At first, written advice would be the minimum required. Next, JMA should establish a system for reviewing on a weekly, or at least on a monthly, basis the ozone data collected by each station of the region in order to identify and flag suspicious values and bring these to the attention (and question) of the stations. To facilitate these procedures, every ozone observing station should have e-mail access.
A discussion on the UV-B observations also took place. Many countries are now implementing UV-B networks based on a variety of instruments, both narrow band (e.g. Brewer, home build, etc.) and broad band (e.g. Robertson-Berger, Yankee, etc.). UV-B monitoring is inherently difficult, and recommendations regarding instrumentation and the quality control process are forthcoming. International agreements on 'standard reference' and 'intercomparison' are urgently needed. Although WMO has established the World Data Center for UV-B at the Atmospheric Environment Service, Canada, there are currently no networkwide quality assurance/quality control procedures/guidelines in place, but they are expected to be issued in the near future by WMO expert groups.

The participating countries expressed the urgent need for strengthening international collaboration and training of personnel involved in ozone monitoring and analysis and improving the scientific communications between the Members. In producing ozone data compatible in time and space a rigorous exchange of scientific and technical information is essential. Also, development of appropriate fully interactive radiative, chemical, and transport models is most desirable especially from the point of view of their application in the analysis and forecast of the ozone field over continental-scale regions.

3.1.7 Closing of the Seminar

On behalf of MOT and JMA, Mr. Michio Hitsuma, Director-General of the Observations Department, JMA, expressed sincere appreciation to all the participants for their contribution to the excellent presentations and productive discussion. The full text of his closing address is contained in Annex J.

The seminar closed at 12:30 p.m. on 29 August 1996.

3.2 Tsukuba Intercomparison

3.2.1 Purpose of the Intercomparison

The Second International Workshop on Ozone Observation in Asia and the Pacific Region (IWOAP-II) was held in August and September 1996. IWOAP-II was cosponsored by the Ministry of Transport (MOT), the Japan Meteorological Agency (JMA), and the World Meteorological Organization (WMO), same as the first IWOAP. IWOAP-II consisted of the intercomparison of Dobson and Brewer instruments with the Regional Standard Dobson Instrument #116 of JMA and the Seminar on Ozone Observation. Three experts from China, Malaysia and Pakistan participated in the Intercomparison. The long-term quality controlled ozone data obtained within the framework of the WMO Global Atmosphere Watch (GAW) are essential to the assessment of the state of the global ozone layer. IWOAP-II was held as an activity of the Tokyo Quality Assurance/Science Activity Centre of GAW to contribute to the assessment and improvement of the quality of the ozone observations in Regional Association II (Asia) and V (South-West-Pacific).

The main tasks were:

- the technical inspection and adjustment of the instruments,
- comparison of the Dobson/Brewer spectrophotometers with the Regional Standard Dobson Instrument No. 116, to determine the existing calibration level,
- determination of new calibration constants for each Dobson/Brewer spectrophotometer, as needed,
- provision of instruction for the operation of the Dobson/Brewer spectrophotometers at the home stations, and sharing of knowledge concerning the management of an ozone observation programme.
3.2.2 Operation

The Intercomparison of IWOAP-II was held at the Aerological Observatory (AOT) of JMA in Tsukuba from 20 August to 18 September 1996, under the management of the Ozone Layer Monitoring Office headed by Dr. Osamu Uchino. Its operation was guided by the scientific staff consisting of technical director Yasuo Hirose (JMA), Koji Miyagawa (JMA) and Mahito Ito (JMA). Logistics support and overall supervision were provided by Ryoichi Kajihara, Assistant to head of the Ozone Layer Monitoring Office, JMA. These four persons formed the Scientific Steering Committee for the Intercomparison. The Intercomparison was supported by the following staff of the Aerological Observatory:

Atsuko Hattori Director
Hidehiro Shimura Head of the Ozone and Radiation Section
Takeo Ueno Senior Researcher
Toshiyuki Noto Researcher
Toshihiko Tamori Researcher

The following national Dobson and Brewer spectrophotometers were adjusted and compared:

No. of Dobson Country
D075 China (Beijing)
D100 Pakistan (Quetta)

No. of Brewer Country
B090 Malaysia (Petaling Jaya)

The Intercomparison (IC) was performed and all work carried out according to a daily schedule taking into account the weather conditions and the technical state of the individual instruments. The technical facilities of the Aerological Observatory were utilized for the implementation of the IC.

The main steps specified below were generally accepted for each Dobson/Brewer spectrophotometer:

- unpacking of the instrument, its check after the transport and installation at AOT,
- inspection of the technical condition of the spectrophotometer and its monitoring by means of the daily standard lamp and mercury lamp tests,
- initial comparison against the Regional Standard to determine the existing calibration level,
- definition of the technical adjustments and special tests required (wedge calibrations, discharge lamp tests, temperature response test, cleaning and adjustment of the optics etc.),
- final comparison against the Regional Standard,
- assessment of the results, determination of the new calibration constants (Reference R-N tables, Q-table and Reference Standard Lamp Readings),
- interview by the technical directors with the operator in charge on the results of his instrument intercomparison and other calibrations (meta data). At this point, copies of documentation related to the spectrophotometer calibration were given to the operator,
- packing of the instrument and other technical facilities for transport to its home station.
All repairs or adjustments performed and the results obtained for individual instruments are described in Annex L and briefly given in Table 1. This information is saved in detail in the files kept by the operators and by the technical directors of the IC.

The IC was guided mainly by the technical directors during the operation, repair and adjustment of the instruments. Several days were used at the end of the IC period to instruct the operators in new techniques and computer programmes.

With regard to the goal of sharing the knowledge of the operation of the instrument, and the management of an observing programme, the individual participants were required to perform the necessary calibration procedures under the supervision of the scientific staff. For example, all wedge calibrations and discharge lamp tests were performed by the instrument’s own operator.

### 3.2.3 Other Activities

All participants in the IC were also participants in the Seminar on Ozone Observations of IWOAP-II, held at the Headquarters of JMA in Tokyo on 27-29 August 1996.

The updated version of the generalized software for processing of the Dobson total ozone observations, DOBSON 2.2, created at the Czech Hydrometeorological Institute’s Solar and Ozone Observatory at Hradec Kralove, was also presented and the participants were, on request, provided with the entire software package.

An afternoon Umkehr series was performed with the two intercomparison Dobson instruments, the standard instrument, and the observatory instrument on 12 September. The difference between profiles calculated from the individual instrument measurements was less than two Dobson Units in any of the standard Umkehr layers. Most of the variation occurred in layer six.

### 3.2.4 Conclusions

All participating instruments left the intercomparison properly calibrated. (See Annex L, Individual Instrument Results.)

The Dobson instruments were modified to accept an external drier unit. A simple version of the drier was prepared and given to the participants.

Many discussions on station operation and instrument maintenance were held among the participants.

### 3.2.5 Recommendations

A recommendation is made to WMO to standardize the electronic circuits with a simple, effective design using easily available components. To ensure the use of this design, WMO should provide the means of converting the various instruments to this circuit.

The station at Quetta should be visited by an expert from the QA/SAC for the Regional Association II or V, to assist in and advise on the observing programme, and to verify the instrument operation. There are other possible stations and observing programmes in the regions that could benefit from such cooperative ventures.

The Scientific Steering Committee of the 1996 AOT intercomparison urges participants and/or their countries that the three-year schedule of the Region II and V Dobson/Brewer spectrophotometer intercomparison, which is recommended by WMO, be continued.
LIST OF PARTICIPANTS OF THE IWOAP SEMINAR
Tokyo, 4 - 6 March 1996

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PROGRAMME OF THE IWOAP SEMINAR

Tokyo, 4 - 6 March 1996

Monday, 4 March

Opening of the Seminar
Chaired by Dr. Masaro Saiki
10:00-10:30 Opening Address
Dr. Kozo Ninomiya, Director-General, JMA

Session I International Activities
Chaired by Dr. Osamu Uchino

10:30-12:30 Keynote Speech
Quality Assurance in WMO-Global Atmospheric Watch (GAW)
Prof. Volker A. Mohnen
The Total Ozone Observing Programme Using the Dobson Ozone Spectrophotometer
Mr. Robert D. Evans
International Approach to Climate Change Issues
Dr. Tomoyuki Ito

Session II Country Reports
Chaired by Mr. Chee Young Choi

14:00-14:30 Philippines Country Report
Ms. Edna L. Juanillo
14:30-15:00 Indian Ozone Programme
Dr. Vidya Sagar Tiwari
Chaired by Mr. Robert D. Evans
15:30-16:00 Country Report on Ozone Observation in Korea
Dr. Joon Kim
16:00-16:30 Singapore Country Report on Ozone Observation
Ms. Tan Hui Sian
16:30-17:00 The Ozone Measurement in Thailand
Mr. Sarayut Rachupimol
17:00-17:30 Ozone Observing System in JMA
Mr. Ryoichi Kajihara

18:00- Reception

Tuesday, 5 March

Session III Scientific Lecture
Chaired by Dr. Vidya Sagar Tiwari

10:00-10:40 Preliminary Results of Singapore Ozone Observation
Ms. Tan Hui Sian
10:50-11:30  The Variations of Atmospheric Total Ozone in the North-eastern Asia
   Mr. Chee Young Choi
11:30-12:10  Two Dimensional Photochemical Model Study of Stratospheric Ozone Change
   Mr. Toru Sasaki
   Chaired by Ms. Edna L. Juanillo
14:00-14:40  Ozone Measurements by Lidar (Laser Radar)
   Mr. Toshifumi Fujimoto
14:40-15:20  Ozone Measurements and changes observed over India region in recent years
   Dr. Vidya Sagar Tiwari
   Chaired by Ms. Tan Hui Sian
15:40-16:20  Annual Variation of Total Ozone at Syowa Station Antarctica
   Dr. Shigeru Chubachi
16:20-17:00  Measurement of surface ozone flux using the micrometeorological techniques
   Dr. Joon Kim

Wednesday, 6 March
   Chaired by Dr. Joon Kim
10:00-10:40  UV-B Observation
   Mr. Hidehiro Shimura
10:50-11:30  Atmospheric Concentrations and Distributions of Chlorofluorocarbons over Japan since 1979
   Dr. Michio Hirota
11:30-12:10  Observations and Analysis of the Ozone Layer
   Dr. Osamu Uchino

Session IV  General Discussion
   Chaired by Prof. Volker A. Mohnen

14:00-15:30  General Discussion

Closing of the Seminar
   Chaired by Dr. Jun-ichi Shiino
15:30-16:00  Closing Address
   Mr. Yuso Takigawa, Director-General of the Observations Department, JMA

Thursday, 7 March

Technical Visit to Tsukuba Intercomparison

Friday, 8 March

Technical Visit to Tsukuba Intercomparison
WELCOME ADDRESS AT THE IWOAP SEMINAR

Director-General of the Japan Meteorological Agency
Dr. Kozo Ninomiya
4 March 1996

Good morning, distinguished participants, ladies and gentlemen.

On behalf of the Japan Meteorological Agency, I am delighted to welcome all of you to the International Workshop on Ozone Observation in Asia and the Pacific Region.

First of all, I would like to express my sincere appreciation to the Ministry of Transport of Japan for their cooperation in the organization of this workshop. My thanks also go to the World Meteorological Organization, which endorses and co-sponsors the workshop and has enabled several important participants to come here.

In 1974, Prof. Rowland and Dr. Molina, who was awarded the Nobel prize for Chemistry last year, indicated the potential threat of human-produced CFCs to the ozone layer. After eight years, in 1982, Dr. Chubachi of Japan found that the ozone observation data at the Japanese Antarctic Station showed remarkably small amount of ozone than in the past. Within a few years this reduction in the ozone in Antarctica became known to the world as 'Ozone Hole'. The world-wide observations, since then had shown that the ozone layer was being depleted widely. These observational evidences accelerated substantially the international efforts to protect the ozone layer and led to the conclusion of the Convention on the Protection of the Ozone Layer known as the Vienna Convention in 1985 and of the Protocol on Substances that Deplete the Ozone Layer, or the Montreal Protocol in 1987. This clearly shows the importance of the observational facts in the arrangement of measures to reduce adverse effects of environmental variations such as depletion of the ozone layer. Those observational facts are only obtained by continuous efforts by the meteorological community.

The International Workshop on Ozone Observation in Asia and the Pacific Region is the first opportunity for experts in Asia and the Pacific Region to come together and have discussions on ozone observations and is also the first intercomparison of Dobson spectrophotometers in the Region with the instrument of JMA which was calibrated in the Intercomparison of Ozone Spectrophotometers held in Arosa, Switzerland, last year. This event is indeed the first commitment of the Tokyo Quality Assurance/Science Activity Centre operated by the Japan Meteorological Agency to the establishment of a world-wide network of high quality observations.

I hope that the Tsukuba Intercomparison will contribute to maintain and improve the quality of the data from the Global Ozone Observation System promoted by the World Meteorological Organization in the framework of its Global Atmosphere Watch and operated by the individual national Meteorological Services and other relevant institutes. Furthermore, I hope that the Seminar on Ozone Observation of this week will provide an excellent forum not only to exchange scientific and technical views and ideas on the observations of the ozone, but also to reaffirm the importance of observations in various activities related to the global environmental problems.

Finally, I hope that all of you will find the Seminar fruitful and I do wish all of you a pleasant stay in Japan.

Thank you.
ANNEX D

CLOSING ADDRESS AT THE IWOAP SEMINAR

Director-General of the Observations Department
Japan Meteorological Agency
Mr. Yuso Takigawa
6 March 1996

Good afternoon, ladies and gentlemen.

In closing the Seminar on Ozone Observation, I would like to express our sincere appreciation to all the speakers and other participants for their excellent contributions to the active and informative discussions.

Over the years, continued concern and increased scientific information led to the growing international acceptance of the need to take actions to protect the ozone layer. In view of these international actions, global production and emission of the major ozone depleting substance (ODS) has decreased rapidly. Now it is our responsibility to confirm the impact of such actions, including resultant reduction of the ozone depleting substance on the ozone concentration itself in the atmosphere for identification of further required actions.

As Professor Mohnen emphasized in his keynote speech on Monday, in order to make the policy makers listen to us, first, we need to know how precisely we can measure the ozone. Then we need to attach such quality information to the ozone observation data that we make available to them as the scientific basis to be considered in their decision making process.

I am sure that this Seminar and the whole International Workshop on Ozone Observation in Asia and the Pacific Region contributes to enhance our consciousness of the importance of the quality of the ozone observations and to improve the quality of the ozone data.

Finally, I hope that your remaining stay in Japan will be pleasant. It may sound too early, especially for those who stay in Tsukuba for the whole intercomparison, but taking this opportunity, I also would like to wish all of you a safe journey back to your respective countries.

Thank you very much.
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Tsukuba, 27 February - 26 March 1996

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INDIVIDUAL INSTRUMENT REPORTS OF THE
TSUKUBA INTERCOMPARISON IN IWOAP

Instrument D052
Instrument D090
Instrument D112
Instrument D124
Instrument D052
Manila, Philippines

Original Calibration Data:


Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)
12 March 1996

d_Na: -0.53   d_Nc: +0.54   d_Nd: +0.05   d_Nad: -0.6

The d_Nad value implies an average +0.8% error in the calculated ozone value, mu = 1 to 3
Total Ozone = 300 Dobson Units.

Comment: Lamp correction to Nad is 4.7 N-unit -- about 7%. The results were highly mu dependent at mu > 2.2 on AD, but results at low mu (high sun) were usable.

Work Performed:
- The instrument arrived not operational. Before a usable intercomparison was possible, the Photomultiplier (PMT) circuit had to be repaired, the amplifier and it's power supply were replaced, and the shutter motor starting capacitor was replaced.
- The instrument was dirty, inside and out. It was cleaned on the outside and polished by the operator.
- The optics were in very poor condition.
- The cobalt filter before the PMT was badly corroded, and was replaced.
- The optical wedges were deteriorated, and were replaced.
- The mirror surfaces were dirty, and corroded, and were replaced.
- The optics (mirrors) were adjusted for correct instrument symmetry.
- The rubber gaskets were replaced, and the interior cleaned.
- A wedge calibration was attempted with the instrument before cleaning, but the results were not usable.
- After cleaning, and the repair of the optics, a wedge calibration was performed, dated 15 March 1996.
- Discharge lamp series was performed on 16 March 1996, and a new Q-table developed. The new table was not significantly different from the old ones.
- Symmetry was checked after optical repair, and found to be within tolerance.
- Modifications were made to an existing hole in the instrument for an external drier unit.

Final intercomparison: 16 March 1996 and 18 March 1996. New N-tables and Reference Standard Lamp values for lamps 52Q8, 52Q9, UQ1 and UQ7 were defined.

Highest Difference against the standard for ADDSGQP observations in mu range 1.15 to 3.2 was 0.3% in total ozone.

Note: The instrument was operated at high sun on the 16 March 1996, and then at low sun on 18 March 1996, to verify the calibration. The N-adjustments to the G-table for the calibration were taken from 16 March 1996.
Recommendations/Comments:
- Data taken before 12 March 1996 should be correct at low mu values, when the instrument was operated correctly and was functional. Lamp tests from the station are very erratic. The lamp test history should be studied to identify the periods of instrument malfunction, and the data reprocessed after this evaluation. The station has been supplied with a computer programme capable of reprocessing. This station has taken only one observation set per day, in the morning.
- The condition of the instrument indicated that it had been subject to high humidity, heat, dirt, and possible insect contamination. After the return to the station, the instrument should be kept in a more suitable place, with the interior kept dry with silica gel. The station should make observations in accordance with instructions in WMO Report No. 6, and process the data with the WMO supplied computer programme. If there is any obvious problem with the data, such as large differences between morning and afternoon results, the station should contact WMO for assistance.
- The station should keep all calibration materials -- N-tables, Q-tables, instrument calibration history, lamp test records -- as well as the data record in a safe central location.
- This instrument is almost a new instrument. The relationship between the direct sun and zenith observations is likely to change. Care should be taken to make a continuing series of direct sun and zenith observations close in time.
- This station should be monitored for proper operation, and instrument care.

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Instrument D090

Bangkok, Thailand

Original Calibration Data:
N-tables from 1 October 1987 Melbourne, Australia, intercomparison.
Reference Standard Lamp Values for lamps 90Q2.
Lamp test results used in data processing at home station.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)
2 March 1996

Due to Instrument damage and repair, initial intercomparison results do not correlate with station data. The results on the Nad wavelengths were 5% too high.

Work Performed:
- Instrument arrived with a damaged wedge assembly. Some repair had been attempted at the station, with the result that the wedge characteristics had changed from the calibration before the damage. The wedge bands were replaced, and a new R-dial limit pin installed.
- Wedge calibration was performed after the repair, but before cleaning. The resultant G-table was applied to the intercomparison of 02 March 1996. There was no improvement in the results.
- Cobalt filter was found to be corroded, and was replaced.
- Interior cleaned, and gaskets replaced.
- Optics cleaned of dust.
- A discharge lamp test series was performed, and a new Q-setting table determined, dated 12 March 1996.
- Optical symmetry checked and was found to out of limits. Left side mirror position was reset. Symmetry rechecked after final intercomparison, and found to be out of limits by a small amount. This apparently had not effect on the intercomparison results.
- Some minor repairs were made to the shutter motor assembly.
- Modifications were made to an existing hole in the instrument for an external drier unit.

Final intercomparison: 16 March 1996.
- New N-tables and Reference Standard Lamp values were defined for instrument lamps plus new 90Q4, UQ1 and UQ7.
  Highest Difference against the standard for ADDSGQP observations in mu range 1.15 to 2.5 was 0.1% in total ozone.

Recommendations/Comments:
- The damage to the instrument made it difficult to evaluate the existing data set based on the initial intercomparison. If the ozone data after the return of the instrument are significantly lower than before the damage, then it may be assumed that the initial intercomparison was correct. In this case, techniques in WMO Report No. 29 can be used to reprocess the existing data set, using the software provided to the operator.
- The instrument showed some evidence of being exposed to high heat and humidity. The operator indicated that the instrument is now being kept in an air conditioned facility.
- The operator was provided with data reduction software and given some instructions as to its use. It is recommended that the station be monitored for the proper use of the software, and operation of the instrument.

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Instrument D112
New Delhi, India

**Original Calibration Data:**

N-tables from intercomparison.
Reference Standard Lamp Values for lamp 112Q1.
Lamp test results used in data processing at home station.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)
2 March 1996

\[ \text{d}_{Na}:-2.0 \quad \text{d}_{Nc}:-2.2 \quad \text{d}_{Nd}:-2.0 \quad \text{d}_{Nad}:0.0 \]

The d_{Nad} value implies an average +0.0% error in the calculated ozone value, \( \mu = 1 \) to 3
Total Ozone = 300 Dobson Units.

**Work Performed:**
- A wedge calibration was performed, and the resultant G-table applied to the data of 2 March 1996, without any improvement.
- A discharge lamp series was performed, the resultant Q-table was not significantly different from the existing table.
- Interior cleaned, and gaskets replaced.
- Optics cleaned of dust.
- Shutter motor gear train repaired.
- Optical symmetry checked and found to be out of limits. Optics were adjusted for proper symmetry.
- A discharge lamp test series was performed, and a new Q-setting table determined and dated. The resultant Q-table is approximately 1.0 Q-unit low at the value for 15 degrees Celsius.
- Wedge calibration was performed 15 March 1996.
- Modifications were made to an existing hole in the instrument for an external drier unit.

**Final intercomparison:** 16 March 1996.
New N-tables and Reference Standard Lamp values were defined for instrument lamps plus new instrument lamp 112Q0, and UQ1 and UQ7.

Highest Difference against the standard for ADDSGOP observations in \( \mu \) range 1.15 to 3.2 was 0.1% in total ozone

**Recommendations/Comments:**
- The existing data set from the instrument is correct, based on the initial intercomparison.
- This instrument is used to calibrate other Dobson instruments. The past intercomparisons should be inspected for correct procedures. If differences are found, the intercomparisons should be reprocessed, and the change in the data set due to the new calibration must be evaluated.
Instrument D124

Yonsei University, Seoul, Korea

Original Calibration Data:


Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.) 2 March 1996

d_Na: -0.7   d_Nc: +0.8   d_Nd: +1.83   d_Nad: -2.5

The d_Nad value implies an average +3.6% error in the calculated ozone value, mu = 1 to 3
Total Ozone = 300 Dobson Units.

Work Performed:
- The instrument had been dropped in June, 1995, resulting in a bent shaft connecting the R-dial to the optical wedge assembly. The shaft was straightened (not perfectly) after the initial intercomparison, and wedge calibration.
- An initial wedge calibration was performed and the results applied to the 02 March 1996 data. The results were not improved.
- A discharge lamp series was also performed before any changes were made to the instrument. The resultant Q-setting table was not significantly different from the existing table.
- Interior cleaned, and gaskets replaced.
- Optics cleaned of dust.
- Optical symmetry checked and found to be out of limits, and the left side mirror was reset.
- A discharge lamp test series was performed, and a new Q-setting table determined, dated 13 March 1996. This Q-setting table was again not significantly different from the original table.
- Another wedge calibration was performed on 14 March 1996, and the G-table used in the final intercomparison.
- Modifications were made to an existing hole in the instrument for an external drier unit.

Final Intercomparison: 16 March 1996.
- New N-tables and Reference Standard Lamp values defined for instrument lamps plus UQ1 and UQ7.

Highest Difference against the standard for ADDSGQP observations in mu range 1.15 to 2.5 was 0.1% in total ozone, -0.9% in the range 2.5 to 3.2.

Recommendations/Comments:
- Casual inspection of the lamp test history does not show a change after the instrument was dropped. The results of the initial intercomparison indicate that the ozone values from the instrument are 3 to 4% too high. A check of the wedge calibration was made by performing a wedge calibration and applying the results to the initial calibration. This resulted in no improvement over the simple adjustment on the original N-table, and to observations in the normal operating range on the instrument. A recommendation is made to investigate the data record for a step change of 3-4% after June 1995. If no change is found, then the existing record should be reprocessed with a linear calibration drift correction. If a change is found, then the data record from June 1995 should be reprocessed with the changes to the N-table from the initial intercomparison.
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Tokyo, 27 - 29 August 1996

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PROGRAMME OF THE IWOAP-II SEMINAR

Tokyo, 27 - 29 August 1996

Tuesday, 27 August

Opening of the Seminar
Chaired by Dr. Masaro Saiki
10:00-10:30 Opening Address
Mr. Toshiyuki Ono, Director-General, JMA

Session I  International Activities
Chaired by Dr. Osamu Uchino
10:30-12:30 Keynote Speech
WMO Global ozone observing system (GO3OS) and Ozone Depletion
Dr. Rumen D. Bojkov
Current status and perspectives of ozone research
Prof. Toshihiro Ogawa

Session II  Country Reports
Chaired by Mr. Guo Song
14:00-14:30 Ozone Layer and UV-B Measurement in Equatorial Region, Malaysia Country Report
Dr. Teh Kim Poe
14:30-15:00 Pakistan Country Report
Mr. Muhammad Anees Siddiqi
Chaired by Mr. Teh Kim Poe
15:30-16:00 The Report on Ozone Observation in China
Prof. Qiu Jinhuang
16:00-16:30 Thailand Country Report
Mr. Sarayut Rachupimol
16:30-16:50 Ozone Observing System and Analysis of the Ozone Layer in Japan
Mr. Ryoichi Kajihara
16:50-17:00 High Latitude Climate and Remote Sensing, Global Change and Remote Sensing
Prof. Kirill Kondratyev

18:00- Reception

Wednesday, 28 August

Session III  Scientific Lecture
Chaired by Mr. Sahib Zad Khan
10:00-10:40 The Measurement of Atmospheric Ozone and its Profile, NO2 and UV-B Radiation in Chinese Zhongshan Station During Antarctic Ozone Hole
Mr. Guo Song
10:50-11:30 Increase of surface ozone during the 1994 haze episode in the Malaysia region
Mr. Teh Kim Poe
11:30-12:10 FTIR measurements of HCl and HF on board aircraft and on the ground
Dr. Yukio Makino
Chaired by Prof. Qiu Jinhuang
14:00-14:40 The result of the Tsukuba Intercomparison in the IWOAP for the Thailand Dobson Instrument #90
   Mr. Sarayut Rachupimol

14:40-15:20 Perspectives on ozone measurements and its condition over Pakistan
   Mr. Sahib Zad Khan
   Chaired by Mr. Sarayut Rachupimol

15:40-16:20 Variation Trends of Total Ozone over Beijing (Xianghe) and Kunming Areas during 1980-1994
   Prof. Qiu Jinhuai

16:20-17:00 Lidar Observations of the polar stratospheric clouds over Eureka in Canadian Arctic
   Mr. Tomohiro Nagai

Thursday, 29 August

Session IV General Discussion and Closing
   Chaired by Dr. Rumen D. Bojkov

10:00-12:00 General Discussion on Ozone Observation

Closing of the Seminar

   Chaired by Dr. Takayo Matsuo

12:00-12:30 Closing Address

   Dr. Michio Hitsuma, Director-General of the Observations Department, JMA

14:00-15:30 Tour of JMA

Friday, 30 August

   Technical Visit to Tsukuba Intercomparison
WELCOME ADDRESS AT THE IWOAP-II SEMINAR

Director-General of the Japan Meteorological Agency
Mr. Toshiyuki Ono
27 August 1996

Good morning, distinguished participants, ladies and gentlemen.

On behalf of the Japan Meteorological Agency, I am delighted to welcome all of you to the Second International Workshop on Ozone Observation in Asia and the Pacific Region.

First of all, I would like to express my sincere appreciation to the Ministry of Transport of Japan for their cooperation in the organization of this Workshop. My thanks also go to the World Meteorological Organization, which endorses the Workshop and sent Dr. Rumen Bojkov, Special Advisor to the Secretary-General of WMO for Ozone and Global Environment Issues, for a keynote speech in this morning. Dr. Bojkov received the United Nations Global Ozone Award for his outstanding contribution to the protection of the ozone layer at the tenth anniversary of the Vienna Convention in December 1995.

Since Prof. Rowland and Dr. Molina indicated the potential threat of human-produced CFCs to the ozone layer in 1974, the abundances of the chlorofluorocarbons (CFCs), methyl chloroform, and halons in the atmosphere have been observed and monitored at global ground-based sites. In 1982, Dr. Chubachi of Japan found that the ozone observation data at the Japanese Antarctic Station showed remarkably small amount of ozone than in the past. Within a few years this reduction in the ozone in Antarctica became known to the world as 'Ozone Hole'. The antarctic 'Ozone Hole' of 1992 and 1993 were the most severe on record. The world-wide ozone observations revealed that the ozone layer was being depleted widely.

These observational evidences accelerated substantially the international efforts to protect the ozone layer and led to the conclusion of the Convention on the Protection of the Ozone Layer known as the Vienna Convention in 1985 and of the Protocol on Substances that Deplete the Ozone Layer, or the Montreal Protocol in 1987. The Montreal Protocol and its Amendments and Adjustments are reducing the impact of human-produced halocarbons on the ozone layer and should eventually eliminate the ozone depletion.

This clearly shows the importance of the observational facts in the arrangement of measures to reduce adverse effects of environmental variations such as depletion of the ozone layer. Those observational facts are only obtained by continuous efforts by meteorological community.

The purpose of the Workshop is to grasp the current status and to improve the quality of the ozone observations in Asia and the Pacific Region. The Workshop consists of the Seminar on Ozone Observation and the Tsukuba Intercomparison, and is to succeed the first International Workshop on Ozone Observation in Asia and the Pacific Region, which was held in Tokyo and Tsukuba from 27 February to 26 March this year. It was the first opportunity for experts in the Region to come together and have discussions on ozone observations and also the first intercomparison of Dobson spectrophotometers in the Region with the instrument of JMA which was calibrated in the Intercomparison of Ozone Spectrophotometers held in Arosa, Switzerland last year. This Workshop is held for the countries in the Region which were not able to participate in the first Workshop.
I hope that the Tsukuba Intercomparison will contribute to maintain and improve the quality of the data from the Global Ozone Observation System promoted by WMO in the framework of its Global Atmosphere Watch and operated by the individual national Meteorological Services and other relevant institutes. Furthermore, I hope that Seminar on Ozone Observation of this week will provide an excellent forum not only to exchange scientific and technical views and ideas on the observations of the ozone, but also to reaffirm the importance of observations in various activities related to the global environmental problems.

Finally, I hope that all of you will find the Seminar fruitful and I do wish all of you a pleasant stay in Japan.

Thank you.
GOOD morning, Ladies and Gentlemen.

In closing the Seminar on Ozone Observation of the Second International Workshop on Ozone Observation in Asia and the Pacific Region, on behalf of the Japan Meteorological Agency, I would like to express our sincere appreciation to all the participants for their excellent presentations, and productive discussions.

As we noted in the Seminar, scientific information based on ozone observations led to the agreement of the Montreal Protocol and its Amendments to stop the production of ozone depleting chemicals quickly for protection of ozone layer. The recent observations demonstrated that the increase in concentration of ozone depleting chemicals in the troposphere has slowed down presumably by the implementation of the Montreal Protocol and its Amendment.

It is our responsibility to monitor ozone and the related chemicals in the atmosphere and to provide scientific information which helps policy makers to take further required action for supporting global environment. The information should be more reliable and of high quality for more confident decision making.

In the Seminar, we had common views that much more effort is needed to make our observation and data more reliable.

I am convinced that this Seminar and the related activities here contribute to the enhancement of the quality of ozone observation and the data and demonstrated the willingness and ability of JMA to guide and assist the ozone activities in Asia and the Pacific Region.

I hope we have close and continuous relationship on ozone observation among WMO, countries in Asia and the Pacific Region, and JMA to support and develop the GAW Programme.

Finally, I would like you to have a pleasant stay here and a safe trip back to your countries.

Thank you very much.
LIST OF PARTICIPANTS OF THE TSUKUBA INTERCOMPARISON IN IWOAP-II

Tsukuba, 20 August - 18 September 1996

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INDIVIDUAL INSTRUMENT REPORTS OF THE
TSUKUBA INTERCOMPARISON IN IWOAP-II

Instrument D075
Instrument D100
Instrument B090
**Original Calibration Data:**

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)
22 August 1996

\[ d_{Na} = -0.72 \quad d_{Nc} = -0.92 \quad d_{Nd} = +2.00 \quad d_{Nad} = -1.12 \]

The \( d_{Nad} \) value implies an average +1.6% error in the calculated ozone value, \( \mu = 1 \) to 3
Total Ozone = 300 Dobson Units.

**Work Performed:**
- A wedge calibration was performed, and the resultant Q-table applied to the data of 24 August 1996.
- A discharge lamp series was performed. The resultant Q-table was not significantly different from the existing table.
- Optics cleaned of dust.
- Optical symmetry checked, and found to be within limits.
- Discharge lamp test series was performed, and a new Q-setting table determined on 30 August 1996. The resultant Q-table is not significantly different from the former Q-table.
- Wedge calibration was performed on 3 September 1996.
- The motor of the rotating shutter was checked and adjusted.
- The test of temperature coefficient of the instrument was performed in the range from 0 deg to +40 deg.
- Standard lamp 75W was corroded and replaced with a new one, which was labeled as 75Q2.
- Modifications were made to an existing hole in the instrument for an external drier unit.
- The rubber gaskets were replaced, and the interior cleaned.
- The collimating lens of the sun director was removed.
- The switch of the power supply was replaced.

**Final intercomparison:** 12 September 1996.
New N-tables and Reference Standard Lamp values for lamps 75Q1, 75Q2 and 116J1 were defined.

Highest Difference against the standard for ADDSGQP observations in \( \mu \) range 1.3 to 3.5 was 0.3% in total ozone.

**Recommendations/Comments:**
- Use new N-tables and reference standard lamp values for data taken after 13 September 1996.
- This instrument is used to calibrate other Dobson/Brewer instruments in the home country.
- The rotating shutter motor should be replaced with a new one when requested.
- The updated version of the generalized software for processing of the Dobson total ozone observations, DOBSON 2.2, created at the Czech Hydrometeorological Institute’s Solar and Ozone Observatory at Hradec Kralove, was also presented and the participants were, on request, provided with the entire software package.

* * * * *
Instrument D100
Quetta, Pakistan

Original Calibration Data:
N-tables and Reference Standard Lamp values from the 1 June 1988, Melbourne, Australia Intercomparison, apparently from Lamp Tests.
Reference Standard Lamps 100.1, 100.2, 100.3, 100.4, and 100.5.

Initial Calibration Results (Adjustments based on the results of Standard Lamp tests included.)
2 September 1996

\[
\begin{align*}
d_{Na} & : +2.21 \quad d_{Nc} : +0.66 \quad d_{Nd} : +0.47 \quad d_{Nad} : +1.74
\end{align*}
\]

The \( d_{Nad} \) value implies an average -2.5% error in the calculated ozone value, \( \mu = 1 \) to 3
Total Ozone = 300 Dobson Units.

Comment: Lamp correction to Nad is 0.6 N-unit -- about 0.9%.

Work Performed:
- The existing Q-setting table was adjusted considering the altitude difference between Quetta and Tsukuba. Minus 0.8 deg was added to the existing Q-setting table based on the result of mercury lamp test at AOT.
- The optics were in poor condition.
- The shutter motor stopped after a few hours of operation.
- The motor of the rotating shutter was checked and adjusted.
- The optical wedges were dirty, and were cleaned.
- The mirror surfaces were dirty, and were carefully cleaned with ethyl ether and cotton wool.
- The bolt of the L1 mirror was repaired.
- The optics (mirrors) adjusted for correct instrument symmetry.
- The rubber gaskets were replaced, and the interior cleaned.
- A wedge calibration was performed before cleaning.
- After cleaning the optics, a wedge calibration was performed on 11 September 1996.
- Discharge lamp test series was performed, and a new Q-setting table determined on 7 September 1996, including temperature correction for +15 deg to +40 deg.
- The collimating lens of the sun director was removed.
- The switch of the power supply was replaced.
- Modifications were made to an existing hole in the instrument for an external drier unit.

Final intercomparison: 8 September 1996.
- New N-tables and Reference Standard Lamp values for lamps 100Q1, 100Q2, 100Q3 and 116J1 were defined.
  
  Highest Difference against the standard for ADDSGQP observations in \( \mu \) range 1.3 to 2.5 was 0.1%, and in \( \mu \) range 2.5 to 3.5 it was 0.8% in total ozone.

Recommendations/Comments:
- Data taken before 1 September 1996 should be corrected, when the instrument was operated correctly and was functional.
- The power supply for the standard lamp was very unstable and should be replaced.
- The instrument showed some evidence of being exposed to high heat and humidity. The instrument should be kept in a dry and clean room as far as possible.
- Use new N-tables and reference standard lamp values for data taken after 17 September 1996.
- This instrument is used to calibrate other Dobson instruments in the home country.
- The rotating shutter motor should be replaced with a new one when requested.
- The updated version of the generalized software for processing of the Dobson total ozone observations, DOBSON 2.2, created at the Czech Hydrometeorological Institute's Solar and Ozone Observatory at Hradec Kralove, was also presented and the participants were, on request, provided with the entire software package.
- The quantity of data should be increased by making observations of the zenith sky and the afternoon sky.
Instrument B090
Petaling Jaya, Malaysia

Work Performed:
- Comparisons were made against the Regional Standard Dobson No.116; it was done on 22 August, 31 August, 2 September, 8 September, 11 September and 12 September.
- The ozone ETC value was corrected on the basis of the results of comparison under good condition dated 8 September and 11 September. The old ETC value of 2804 was changed to the new value of 3216. The ozone absorption coefficient was not changed.
- The wavelength shift was adjusted on the basis of the result of Cl-test using a mercury lamp. The zero value of the micrometer was adjusted from the old value of 2669 to a new value of 3465.
- The best position of the micrometer for ozone observations was checked occasionally and shows good results.
- The zero position of the zenith prism was adjusted to exact position on the basis of the result of the TU-test using an external lamp.
- The zero position of filter #2 was adjusted to exact position by correcting the software.
- The gears for filters #1 and #2 were changed.
- Interior cleaned, and gaskets replaced for the top cover.
- The gears of micrometer and azimuth tracker were cleaned.
- The responsivity for UV measurement was checked using NIST lamp calibration procedure.
- Intercomparison of UV measurement was performed against JMA national standard.

Result of the comparison:
Highest Difference against the Regional Standard Dobson No.116 in mu range 1.3 to 3.5 was 1.3% in total ozone.

Recommendations/Comments:
- Management of software and the constant files should be maintained as it is.
- Regular monitoring of the responsivity, voltage check at the test terminals and the discrepancy should be checked and documented.
- Cleaning of gear of azimuth tracker should be done periodically.
- Silicagel should be checked and replaced periodically.

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FORMAT OF THE COUNTRY REPORTS OF THE IWOAP AND IWOAP-II SEMINARS

1. Introduction

2. Country Meteorological Characteristics

3. Organization, History and System on Ozone Layer Monitoring
   3.1 Organization
   3.2 History
   3.3 Observing system

4. Data Acquisition and Analysis
   4.1 Result of observation with the Dobson spectrophotometer
   4.2 Condition of mercury lamp test, standard lamp test and two lamp test
   4.3 Data management
   4.4 Data analysis system

5. Problem on the Data Management and Instrument Maintenance
DEFINITIONS OF THE OZONE INSTRUMENTS

A, C and D Wavelength Pairs: The Dobson instrument measures the difference between the intensity of selected wavelengths in the range of 3000 to 3400 Ångstroms. Certain pairs were chosen to measure ozone. These are called the A, C and D pairs. There was a B, but it is rarely used due to interference by other atmospheric absorbers.

Intercomparison: Series of simultaneous measurements made by several Dobson instruments, one of which is a standard. Usually, the time period is chosen so the measurements are made over a wide range of \( \mu \).

Standard Lamp Test: A measurement of the \( N \)-value of a specific Quartz-Halogen (normally) bulb for the standard wavelength pairs. These bulbs are usually specific to an instrument. The result is used as a measure of the drift of the instrument's specific ETC.

Q-setting Table: The table used to set the instrument's wavelength controls to a wavelength pair. The setting is dependent on instrument temperature. The controls are rotatable quartz plates, hence the name Q-setting.

Discharge Lamp Test Series: A series of measurements on various spectral lines from discharge lamps to calibrate the instrument's wavelength controls.

Mercury Test: A test to determine the correctness of the Q-setting table with respect to a single spectral line of mercury. Normally performed routinely to verify the optical alignment of the primary (right hand side) optics to the slit S2.

Symmetry Test: A series of tests on two spectral lines of mercury to verify the spectral dispersion, and the right to left side alignment of the optics.

Wedge Calibration: The procedure used to determine the density of the optical wedge used in the instrument.

\( \mu(\mu) \): Normalized optical path length through the atmosphere of radiation at the wavelengths used by the Dobson instrument. Calculated from the solar zenith angle, \( \mu \) ranges from 1.0 (sun overhead) to greater than 12.0 (sun on the horizon).

G-table: Table relating the position of the optical wedge, defined by degrees of arc on the R-dial, to relative attenuation. G-tables are defined for each A, C, and D wavelength pair by the Wedge Calibration.

N-table: A G-table converted by the addition of the instrument's extra-terrestrial constant (ETC) to all the entries. The ETC can be determined by lamps with a known \( N \)-value, direct intercomparison with a standard Dobson instrument, or by a Langley plot method.

ETC-value: Extraterrestrial instrument constant value of Brewer spectrophotometer.

Cl-test: Lamp scan on slit 1 for scanning either the internal mercury or standard lamps.

NIST: National Institute of Standard and Technology (USA).

TU-test: Test UVB alignment using an external quartz-halogen lamp over the UVB-dome.
7. Fourth Analysis on Reference Precipitation Samples by the Participating World Meteorological Organization Laboratories by Robert L. Lampe and John C. Puzak, December 1981*
8. Review of the Chemical Composition of Precipitation as Measured by the WMO BAPMoN by Prof. Dr. Hans-Walter Georgii, February 1982
11. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at May 1982
12. Report on the Mount Kenya Baseline Station Feasibility Study edited by Dr. Russell C. Schnell
14. Effects of Sulphur Compounds and Other Pollutants on Visibility by Dr. R.F. Pueschel, April 1983
15. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1981, May 1983
17. General Consideration and Examples of Data Evaluation and Quality Assurance Procedures Applicable to BAPMoN Precipitation Chemistry Observations by Dr. Charles Hakkari, July 1983

19. Forecasting of Air Pollution with Emphasis on Research in the USSR by M.E. Berlyand, August 1983

20. Extended Abstracts of Papers to be Presented at the WMO Technical Conference on Observation and Measurement of Atmospheric Contaminants (TECOMAC), Vienna, 17-21 October 1983


23. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1982. November 1984


26. Sulphur and Nitrogen in Precipitation: An Attempt to Use BAPMoN and Other Data to Show Regional and Global Distribution by Dr. C.C. Wallén. April 1986


29. Recommendations on Sunphotometer Measurements in BAPMoN Based on the Experience of a Dust Transport Study in Africa by Dr. Guillaume A. d'Almeida. September 1985


35. Provisional Daily Atmospheric CO₂ Concentrations as Measured at BAPMoN Sites for the Year 1983. December 1985


43. Recent progress in sunphotometry (determination of the aerosol optical depth). November 1986


46. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1984. December 1986


50. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1985. December 1987


53. WMO Meeting of Experts on Strategy for the Monitoring of Suspended Particulate Matter in BAPMoN - Reports and papers presented at the meeting, Xiamen, China, 13-17 October 1986. October 1988

55. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at 31 December 1987


58. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the years 1986 and 1987


62. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the year 1988


64. Report of the consultation to consider desirable locations and observational practices for BAPMoN stations of global importance, Bermuda Research Station, 27-30 November 1989


68. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data For 1989, Volume I: Atmospheric Aerosol Optical Depth

69. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1989

72. Integrated Background Monitoring of Environmental Pollution in Mid-Latitude Eurasia by Yu.A. Izrael and F.Ya. Rovinsky, USSR
73. Report of the Experts Meeting on Global Aerosol Data System (GADS), Hampton, Virginia, 11-12 September 1990
75. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1990
76. The International Global Aerosol Programme (IGAP) Plan: Overview
77. Report of the WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, Lake Arrowhead, California, 14-19 October 1990
78. Global Atmospheric Background Monitoring for Selected Environmental Parameters BAPMoN Data for 1990, Volume I: Atmospheric Aerosol Optical Depth
83. Report on the Global Precipitation Chemistry Programme of BAPMoN
84. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at GAW-BAPMoN sites for the year 1991
85. Chemical Analysis of Precipitation for GAW: Laboratory Analytical Methods and Sample Collection Standards by Dr. Jaroslav Santoch
89. 4th International Conference on CO₂ (Carqueiranne, France, 13-17 September 1993)
91. Extended Abstracts of Papers Presented at the WMO Region VI Conference on the Measurement and Modelling of Atmospheric Composition Changes Including Pollution Transport, Sofia, 4-8 October 1993


94. Report on the Measurements of Atmospheric Turbidity in BAPMoN


96. Global Atmospheric Background Monitoring for Selected Environmental Parameters WMO GAW Data for 1993, Volume I: Atmospheric Aerosol Optical Depth

97. Quality Assurance Project Plan (QAP)P for Continuous Ground Based Ozone Measurements


99. Status of the WMO Global Atmosphere Watch Programme as at 31 December 1993


101. Report of the WMO Workshop on the Measurement of Atmospheric Optical Depth and Turbidity, Silver Spring, USA, 6-10 December 1993, (edited by Bruce Hicks)


103. Report of the Meeting of Experts on the WMO World Data Centres, Toronto, Canada, 17-18 February 1995, (prepared by Edward Hare)

104. Report of the Fourth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the First Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE, Garmisch-Partenkirchen, Germany, 13-17 March 1995

105. Report of the Fourth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Garmisch, Germany, 6-11 March 1995)


110. Report of the WMO-NOAA Expert Meeting on GAW Data Acquisition and Archiving (Asheville, NC, USA, 4-8 November 1995)


113. The Strategic Plan of the Global Atmosphere Watch (GAW)


116. GAW Guide

