WORLD METEOROLOGICAL ORGANIZATION

UNITED NATIONS ENVIRONMENT PROGRAMME

REPORT OF THE FIFTH MEETING OF THE OZONE RESEARCH MANAGERS OF THE PARTIES TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

(GENEVA, 25-27 MARCH 2002)

WMO Global Ozone Research and Monitoring Project

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TABLE OF CONTENTS

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THE FIFTH MEETING OF THE OZONE RESEARCH MANAGERS OF THE PARTIES TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

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1. OPENING OF THE MEETING

1.1 Mr Nelson Sabogal, Senior Scientific Affairs Officer, Ozone Secretariat, speaking on behalf of Dr Klaus Töpfer, Executive Director of the United Nations Environment Programme (UNEP), opened the meeting at 10:00 am on Monday 25 March and welcomed the participants (see Annex A). He recalled that the aim of the meeting was to review ongoing national and international research and monitoring programmes in order to ensure their proper co-ordination and implementation, and to identify gaps in these efforts that need to be addressed. To this end, the meeting would be expected to produce a report with recommendations for future ozone research, requirements to improve regional and global ozone monitoring, and ways to expand co-operation between developed and developing countries. These recommendations would be presented to the forthcoming Sixth meeting of the Conference of the Parties to the Vienna Convention to be held in conjunction with the Fourteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (Rome, 25 to 29 November, 2002).

1.2 Prof. Yan Hong, Assistant Secretary-General of WMO, welcomed participants on behalf of Prof. G. O. P. Obasi, Secretary-General of WMO who was unable to attend the meeting. He began by expressing pleasure at the continuous collaboration between WMO and UNEP in the organization of meetings of the Ozone Research Managers, as well as in ozone matters in general that stretches back into the 1970s. He recalled that the Vienna Convention calls for extensive cooperation between Parties on research and systematic observation, with emphasis on systematic measurements of the ozone layer, as well as in the promotion of training, taking into account the particular needs of developing countries and those countries with economies in transition.

1.3 Prof. Yan underlined the importance of the WMO Global Atmosphere Watch (GAW) Programme in providing essential data for the study of ozone depletion, and in forming a bridge between the advanced monitoring and research capabilities of developed countries on the one hand, and the expert help and financial assistance needed by developing countries on the other. Noting that the recovery of the ozone layer has yet to be observed despite falling levels of atmospheric chlorine, he stated that coordination between GAW, the Network for the Detection of Stratospheric Change (NDSC), and national and international agencies would continue to be a high priority for the coming decades. In conclusion, Prof. Yan emphasized that the challenges of protecting the environment for the generations to come could only be met though continuing international co-operative efforts, as exemplified by this meeting.

2. ADOPTION OF THE AGENDA

2.1 The agenda, as reproduced in Annex B, was adopted.

3. ELECTION OF THE CHAIRMAN

3.1 Dr Michael Kurylo (USA) was elected Chairman of the meeting by acclamation. He urged delegates to work towards producing practical recommendations, which would be presented to the Sixth meeting of the Conference of the Parties to the Vienna Convention. These recommendations should take into account progress made on the recommendations from previous Ozone Research Managers meetings, decision V/3 of the Fifth meeting of the Conference of the Parties to the Vienna Convention, and focus on those items of highest priority.

4. REVIEW OF THE REPORT OF THE FOURTH MEETING OF THE OZONE RESEARCH MANAGERS, HELD IN GENEVA, 28 TO 30 APRIL 1999 (WMO GLOBAL OZONE RESEARCH AND MONITORING PROJECT, REPORT NO. 45)

4.1 Mr Sabogal introduced the report of the Fourth Meeting of the Ozone Research Managers. The report had been discussed and endorsed at the Fifth meeting of the Conference of the Parties to the Vienna Convention (Beijing, 29 November to 3 December 1999), resulting in the adoption of decision V/3. This decision calls on all Parties:

(a) To continue to maintain instruments and develop the monitoring, calibration and archiving of measurements of stratospheric and tropospheric ozone, including measurements of vertical ozone profiles and of other trace species and aerosols that are essential and to pursue the development and implementation of new observational capabilities such as aircraft and satellite-based measurement, hand-in-hand with an accelerated programme for ground-bases instrument calibration;

(b) To expand the ground-based ozone stations, especially in the continental part of Asia (e.g. Siberia), as well as in the Caribbean and Central American region;

(c) To increase investigation and quantification of stratospheric and tropospheric processes through routine monitoring and experimental campaigns in order to understand current changes, and to further develop and implement predictions of stratospheric change, both for the short and long term;

(d) To continue giving high priority to research into the interactions between ozone and climate and into the impact of aircraft emissions on ozone;

(e) To request the World Meteorological Organization to continue to work towards improving the quality and compatibility of UV-B measurements and their archiving;

(f) To enhance substantially research on the effects of ultraviolet radiation (UV-B), and efforts to monitor such effects;

(g) To request the World Meteorological Organization and the United Nations Environment Programme to pursue ways of enhancing training and baseline monitoring of ozone and UV-B radiation and related research in developing countries, bearing in mind that these goals can only be accomplished with assistance from international funding organizations such as the Global Environment Facility and with the direct support of the Parties to the Convention to such programmes, through the appropriate mechanisms;

4.2 With regard to the implementation of decision V/3, Mr Sabogal highlighted the request to Parties to give high priority to research on the interactions between ozone and climate, and on the continuation of quality measurements of ozone, including vertical profiles, ultraviolet radiation, aerosols and trace species like CFCs, HCFCs and new substances. He also reported that, despite strenuous efforts, UNEP and WMO had been unable to secure funding from international funding organizations such as the Global Environment Facility (GEF), to finance training, monitoring and related research activities in developing countries, as requested by decision V/3.

4.3 Responding to Mr Sabogal's presentation, the Chairman warned of a growing sense among policy-makers that ozone depletion was becoming a solved problem, and that research on the issue should therefore be cut back. In this context, he called for a new focus on achievements to date and on the emerging research questions raised by those achievements, noting that the recovery of the ozone layer would be taking place at a time when the composition of the Earth's atmosphere will have been changed considerably by high concentration of greenhouse gases.

5. REPORT ON THE 2002 SCIENTIFIC ASSESSMENT, THE 2002 ENVIRONMENTAL EFFECTS ASSESSMENT AND ON ASPECTS OF ATMOSPHERIC OZONE SCIENCE AND RESEARCH BY THE CO-CHAIRS OF THE SCIENTIFIC AND ENVIRONMENTAL EFFECTS ASSESSMENT PANELS OF THE MONTREAL PROTOCOL

5.1 Dr Kurylo, on behalf of the Co-Chairs of the Scientific Assessment Panel of the Montreal Protocol, outlined the contents, structure and status of preparation of the 2002 Scientific Assessment of Ozone Depletion. The Assessment, expected to be available by the beginning of 2003, will include an executive summary, answers to frequently asked questions on ozone and contain chapters that specifically address issues raised by governments. These issues concern:

- Observed trends in controlled substances and consistency with reported production of Ozone Depleting Substances;
- Ozone-depleting impacts of new (short-lived) halogen-containing substances;
- Update on Methyl Bromide (sources, sinks, implications of new results for the ozone layer);
- Characterization of the known relations between ozone depletion and climate change (including feedbacks);
- Description and interpretation of observed changes in global and polar ozone and UV radiation (including future projections and expected impacts of climate change).

5.2 Prof. Jan C. van der Leun, Co-Chair of the Environmental Effects Assessment Panel of the Montreal Protocol, outlined the contents, structure and status of preparation of the 2002 Environmental Effects Assessment. In doing so, he highlighted that special attention would be given to the consequences of interactions between ozone depletion and climate change. One example of such interactions was that of skin cancer. Stratospheric cooling triggered by climate change was expected to delay recovery of the ozone layer, which could delay the peak of excess skin cancer cases by 10 years and increase that peak by 60%. Experimental work with mice also suggested more effective induction of cancer by UV-B at higher temperatures. These effects combined could mean ~100,000 extra skin cancer patients per year around the peak, although the incidence would decline with recovery of the ozone layer. Increased temperatures, however, could also impact on the baseline incidence of skin cancer, with excess cases rising as long as temperatures continued to increase. In conclusion, Prof. Jan der Leun called for priority to be given to research on environmental effects, especially given the interactions between ozone depletion and climate change.

6. CURRENT STATUS OF THE GLOBAL OZONE OBSERVING SYSTEM AND MONITORING OF UV-B RADIATION

6.1 Dr Michael Proffitt, Senior Scientific Officer, Atmospheric Research and Environment Department, WMO, provided an overview of the WMO Global Atmosphere Watch (GAW) Programme and its activities, noting that discussions at this meeting would help influence the direction of the Programme's work. GAW, he continued, constituted the primary global network of ozone monitoring stations, backed up by an infrastructure designed to maintain measurements of known quality and to make this date widely available to all users. He urged participants to continue submitting their ozone data to the World Ozone and Ultraviolet Data Centre in Toronto. Dr Proffitt reported that the current GAW network of Global and Regional Stations comprised about 300 sites. While some stations only measured a single parameter, others, particularly Global stations, had a full suite of observations measuring ozone, greenhouse gases, UV and other parameters. He introduced development within the new GAW Station Information System (GAWSIS) which, as its name implies, is being designed as an internet-based searchable database containing much information on each of the GAW stations. GAWSIS is expected to be operational soon. Concerning Dobson intercomparisons, Dr Proffitt highlighted the need for increased funding to avert deterioration of the calibration network, and in particular to enable continuing intercomparison of instruments in Latin America and Africa. Dr Proffitt reported that preliminary Standard Operating Procedures (SOPs) for the preparation of ECC ozonesondes had recently been developed and that a balloon campaign was planned for 2002/2003 to validate these.

6.2 Dr Proffitt also reported on the completion of WMO/GEF/United Nations Development Programme (UNDP) project in developing countries which saw the establishment of six new GAW Global Stations in developing countries. He also described a five-year proposal prepared by GAW in response to decision V/3, on Capacity Building for Detection of Stratospheric Ozone Recovery in Developing Countries. This proposal includes, among other elements, five new ozonesonde stations and associated development of scientific capacity in developing countries, along with two new regional centres for ground-based total ozone calibrations in Africa and South Americas. In conclusion, Dr Proffitt emphasised that the problem of ozone depletion was not yet over, and that availability of reliable measurements remained critically important.

7. COORDINATION

7.0.1 The meeting was informed of a number of programmes, other than WMO's GAW, that complement or are linked to the global effort to research and monitor atmospheric ozone. Brief reviews of these programmes are given below.

7.1 Network for the Detection of Stratospheric Change (NDSC)

7.1.1 Dr Kurylo, speaking as Co-Chairman of the NDSC, gave a brief synopsis of the goals, structure and work of the Network. He recalled that the NDSC consists of a set of high-quality, remote-sensing research stations, which measures ozone, key ozone-related species and parameters, and tracers of chemistry and of atmospheric motions. He emphasised that the NSDC is a major component of the international upper atmosphere research effort, contributing actively to GAW and enjoying broad international participation and endorsement. He drew the attention of delegates to further information on the NDSC available from a newly published brochure and the Network's internet site (http://ndsc.ws). In his presentation, Dr Kurylo highlighted the need for more stations in the southern hemisphere, along with the paucity of stations in the equatorial regions and efforts to expand measurement capability there. He underlined that a commitment to data quality lay at the heart of the NDSC, and that continuous monitoring was necessary to uphold this quality.

7.2 Intergovernmental Panel on Climate Change (IPCC)

7.2.1 Dr N. Sundararaman, Executive Secretary of the Intergovernmental Panel on Climate Change (IPCC), reported that the IPCC had recently completed its Third Assessment Report (TAR), which comprised four parts. Concerning the science of climate change, the TAR's key finding was that most of the temperature increase over the last 50 years was attributable to human activities. Regarding impacts, adaptation and vulnerability, the TAR found clear indications of how ecosystems were responding to temperature increase, for example, through early flowering. On the mitigation of climate change, the TAR advocated a basket of mitigation and adaptation options. Finally, the TAR's Synthesis Report presented its conclusions in the form of answers to nine questions posed by governments.

7.2.2 Dr Sundararaman noted that interlinkages between climate change and other environmental problems, although not new scientific questions, were now coming to the fore. The IPCC had already worked collaboratively with other bodies on interlinkage issues, and such collaboration was likely to increase. He reported on an emerging new initiative to bring together the IPCC and the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol to consider best practice guidelines on hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), an issue which would likely be taken up by the IPCC at its 19th plenary session in April 2002. He concluded by reporting that the IPCC would prepare a Fourth Assessment Report, although its timing was still uncertain.

7.3 Stratospheric Processes and their Role in Climate (SPARC)

7.3.1 Dr Pablo Canziani, speaking as a member of the SPARC Scientific Steering Group, gave an overview of SPARC's aims, structure, and present and future activities. He noted that the principal objective of SPARC was to help the stratospheric research community focus on issues of particular relevance to climate, and to advance understanding of how processes in the stratosphere influence climate. To this end, SPARC was working together with a range of international and national programmes.

7.3.2 Dr Canziani reported that SPARC initiatives were currently focussed on the following key themes: detection of stratospheric trends which indicate climate change or could affect climate; understanding stratospheric processes and their relation to climate; and modelling stratospheric processes and trends and their effects on climate. For further information, he drew attention to the SPARC Office (http://www.aero.jussieu.fr/~sparc/) and to the SPARC Data Centre, whose internet site gives access to a series of datasets (http://www.sparc.sunysb.edu). In conclusion, Dr Canziani emphasised the need for an integrated research focus on stratospheric climate change.

8. NATIONAL REPORTS ON ONGOING AND PLANNED OZONE RESEARCH AND MONITORING AND ON CALIBRATION AND ARCHIVING OF MEASUREMENTS

8.1 The meeting had before it 50 national reports submitted by Parties to the Vienna Convention, as well as a report from the European Union, on their ongoing and planned activities related to ozone research and monitoring, and calibration and archiving of measurements. These reports are reproduced in alphabetical order in Annex C to this report. Delegates from 48 Parties also presented oral summaries of their national reports to the meeting. An opportunity was provided for delegates to pose questions and comment on key issues raised by the national reports, as input to the recommendations developed under agenda item 10.

9. REPORT OF THE OZONE SECRETARIAT ON DEVELOPMENTS IN THE IMPLEMENTATION OF THE VIENNA CONVENTION AND THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

9.1 Mr Sabogal presented an overview of developments in the implementation of the Vienna Convention and the Montreal Protocol since the last meeting of the Ozone Research Managers. He reported that the Eleventh Meeting of the Parties to the Montreal Protocol (Beijing, China, 29 November to 3 December 1999) had agreed, among other things, on the replenishment of the Multilateral Fund for 2000-2002. He clarified that the mandate of the Multilateral Fund was to enable the phase out of ozone-depleting substances in developing countries, and not to fund research and monitoring activities. He further reported that the Beijing Amendment, adopted at the Eleventh Meeting of the Parties, had entered into force on 25 February 2002. He noted that the Beijing Declaration, adopted at that Meeting, had cautioned that recovery of the ozone layer had not yet been achieved.

9.2 The Twelfth Meeting of the Parties (Ouagadougou, Burkina Faso, 11 to 14 December 2000) had adopted a number of decisions, including a decision to facilitate the transition to CFC-free metered-dose inhalers and on the monitoring and prevention of illegal trade in ozone-depleting substances. He further noted that both the Ouagadougou and Colombo Declarations, adopted at the Twelfth and Thirteenth Meetings respectively, had mentioned that much work remains to be done to ensure the protection of the ozone layer.

9.3 Mr Sabogal reported that the most recent Thirteenth Meeting of the Parties (Colombo, Sri Lanka, 16 to 19 October 2001) had similarly adopted a number of decisions. These included, for example, procedures for assessing the ozone-depleting potential of new substances, a request to the Secretariat to compile precedents in other Conventions for adding new substances, and a request to Parties to urge industry and users to limit the use of n-propyl bromide (nPB). Pursuant to this latter decision, the TEAP will report annually on nPB use and emissions. Ten decisions were also taken to deal with non-compliance and the Secretariat was requested to prepare a report

on the monitoring of international trade and prevention of illegal trade in ODS, a particularly important problem.

9.4 With regard to the Fifth Meeting of the Conference of the Parties to the Vienna Convention (held together with the Eleventh Meeting of the Parties to the Montreal Protocol), Mr Sabogal recalled that he had reviewed the implementation of its decision V/3 under agenda item 4 (see above). In addition, the Fifth Meeting had, among other decisions, encouraged collaboration between the Assessment Panels of the Montreal Protocol and the IPCC, the Subsidiary Body for Scientific and Technological Advice under the United Nations Framework Convention on Climate Change, and the International Civil Aviation Organization. It had also acknowledged the important role played by the Scientific Assessment Panel in coordinating its report, and the contributions by WMO, national agencies and international organizations to the report's preparation.

9.5 In conclusion, Mr Sabogal reported that the Sixth meeting of the Conference of the Parties to the Vienna Convention would be held in conjunction with the Fourteenth Meeting of the Parties to the Montreal Protocol in Rome, Italy, from 25 to 29 November, 2002. He invited delegates to visit the Ozone Secretariat internet site for further information (http://www.unep.org/ozone).

10. ADOPTION OF RECOMMENDATIONS

10.0.1 On Wednesday, 27 March, delegates adopted the recommendations reproduced below, to be forwarded to the Sixth Conference of the Parties to the Vienna Convention. The recommendations were developed following extensive discussions on the basis of the national reports and presentations made at the meeting.

10.1 Introduction

10.1.1 Considerable progress has been made over the last decade in understanding the role of halogen chemistry in stratospheric ozone loss, particularly in the polar regions. Over the same time period, we have seen the effectiveness of the provisions of the Montreal Protocol and its Amendments in reducing the production and consumption of man-made, halogen-containing compounds, which is now yielding a gradual decline in the atmospheric halogen burden**.** Stabilization and recovery of the stratospheric ozone layer, however, has yet to be detected, and the problem of ozone depletion is still far from over. This implies prolonging the effects of increased UV radiation on human health and ecosystems. Hence, there is a strong need to maintain our current observational capabilities for tracking the decline of halogen concentrations and for detecting and tracking the stabilization and expected recovery of stratospheric ozone.

10.1.2 New scientific questions are also emerging. At the time of expected ozone recovery, the Earth's atmosphere will have been considerably altered by high concentrations of greenhouse gases, while there is growing recognition of a strong coupling between climate change, ozone production and loss, and accompanying changes in UV radiation at the ground. Such coupling places growing demands on long-term research and measurement needs, as well as those for delineating the various responses and effects among ozone, UV radiation at the ground and climate change.

10.1.3 The considerable advances achieved in scientific understanding have been used by some to suggest a lessening need for long-term observational systems. On the contrary, the new demands presented by climate interactions require the continuation, and even expansion, of systematic measurement capabilities, integrated with measurement activities conducted with increased temporal and spatial resolution.

10.1.4 The Fifth Meeting of the Ozone Research Managers, in recognition of the above issues, adopted the following recommendations. In doing so, they noted that international funding and cooperation will be required for their implementation, given that past recommendations have not received sufficient attention in the absence of such funding and cooperation. This has exacerbated problems associated with the maintenance of existing instruments and networks, and with the

implementation of new capabilities. The full implementation of the recommendations will require intensified capacity building in developing countries and countries with economies in transition (CEITs). Capacity building is in the interests of all Parties since a comprehensive understanding of ozone change, and the associated impacts, can only be obtained if global databases are available for research.

10.2 Systematic observations

Evaluation of the state of the ozone layer and an understanding of ground-level UV radiation require an integrated global observing system consisting of ground-based, satellite and in situ measurements. The continuity of these highly complementary measurements is crucial, since they are necessary to assess the onset of ozone layer recovery, to monitor its evolution and to track the associated changes in ground-level UV radiation.

- Provide financial support to maintain and expand well-calibrated ground-based measurement networks for column ozone (e.g. Brewer, Dobson, M-124, SAOZ). This includes the maintenance and preservation of ageing instruments, and the deployment of unused instruments in developing countries and CEITs, whenever possible. In addition, the application of new technologies, such as Microtops II, should be explored.

- Maintain and expand UV networks, including both spectrally resolved and broadband instruments. This will require identifying mechanisms to provide financial support for the expansion and establishment of calibration facilities, both on a regional and a global scale, as well as world calibration standards.

- Provide financial support to enhance long-term profiling of ozone and ozone- and climate-related trace gases in data-sparse areas, particularly in the tropics and mid-latitudes, and preferably at least once a week.

- Provide resources to continue and extend the long-term global column ozone trends record provided by space instruments. This requires the creation of a homogeneous data record from TOMS, SBUV, GOME and SCIAMACHY.

- Provide financial support to maintain both ground-based and space-borne measurement capabilities for climate- and ozone-related trace gases and atmospheric parameters. This includes ground-based networks, such as the NDSC and the WMO GAW Programme, and existing space instruments and platforms, such as SAGE II, UARS and GOME.

- Continue operations of unique high-latitude measurements and facilities, both in the Arctic and the Antarctic. Many have a severe need for reinvestment, which should not be made at the expense of related scientific activities.

- Continue and complete activities leading to the development of ozonesonde standard operating procedures, and extend such procedures to other ozone and UV instrument types.

- Provide financial support to conduct regularly scheduled intercomparisons of instruments and algorithms in order to maintain long-term data quality and integrity. In addition, the characterization of instrument-specific performance and capabilities is essential.

10.3 Data archiving

The archiving and accessibility of ozone and UV data are as important as the measurements themselves. WMO's World Ozone and Ultraviolet Data Centre (WOUDC), operated by the Meteorological Service of Canada in Toronto, is the primary repository of the world's ozone data. However, additional ozone measurement data are held at individual stations and national data

centre facilities. It is important that efforts are undertaken to transfer such information to the WOUDC as well as conducted re-evalulations of historical ozone and UV data.

- Report near-real-time data for column ozone, ozone profiles, ancillary ozone- and climate-related data, and UV radiation to the appropriate World Data Centres. This will require institutional, national and international funding commitments.

- Urge all data centres to develop procedures for the prompt submission of their ozone, UV and ancillary ozone- and climate-related data to the World Ozone and Ultraviolet Data Centre (WOUDC).

- Provide resources for the rapid dissemination of campaign data.

- Provide funding for archiving raw data from various observational networks, either at the local institution or at the WOUDC, as appropriate. It is understood that archiving raw data does not replace the archiving of final data products.

- Provide continued support for the re-evaluation of the historical ozone and UV data archives, in order to preserve and improve the long-term records.

10.4 Research needs

There are still a number of unanswered questions with respect to the expected recovery of ozone in the lower stratosphere. The most important are concerned with understanding cross-tropopause transport of water vapours, short-lived halogen species and ozone, the nucleation of denitrifying polar stratospheric clouds, and the effects of climate change on ozone depletion and recovery. Biological vulnerability to increased levels of UV radiation also requires much further research.

- Support epidemiological and experimental studies to check and specify the possibility of a marked increase in UV-induced skin cancer caused by rising temperature.

- Support studies on the consequences of interactions between ozone depletion and climate change on human health and ecosystems, including longer exposure to increased UV radiation due to a delayed recovery in the stratospheric ozone layer.

- Maintain the radiosonde network, and expand it into areas with inadequate coverage to support process studies. Provide funding to accommodate the reporting of higher-resolution radiosonde data to the World Data Centres. Encourage the recovery, reprocessing and archiving of historical radiosonde records.

- Support studies investigating the upper troposphere/lower stratosphere region and cross-tropopause transport, particularly as the latter applies to water vapour, short-lived halogen species and ozone.

- Support studies to quantify the chemical and dynamical components of polar and mid-latitude ozone loss.

- Support studies examining the effects of climate change on ozone depletion and recovery, as well as possible feedbacks.

- Support studies of aerosol microphysics as it applies to the nucleation of denitrifying polar stratospheric clouds, water vapour transport into the stratosphere, and the connection between aircraft contrails and cirrus formation.

- Support studies aimed at understanding the budgets of ozone- and climate-related trace gases. This includes studies of the effects of climate change on the sources, sinks and lifetimes of these gases.

10.5 Capacity building

Many of the world's ozone measuring stations are located in developing countries and CEITS. The instruments used (M-124 filter instruments, Dobson spectrophotometers, Brewer spectrophotometers, ozonesondes and UV meters) require sophisticated calibration and maintenance, much of which is unavailable without international resources. It is therefore vitally important that sufficient resources for spare parts, calibrations, advanced technical and scientific training is made available to maintain the current global network of observations.

- Provide resources for scientific and technical training, at and beyond the instrument-operation level, thereby allowing instrument operators and other scientific personnel in developing countries and CEITs to use their data, other available data and models, in both regional and international research areas.

- Support regional cooperation and encourage bilateral cooperation and collaboration among developed and developing countries and CEITs.

- Provide resources to establish systems for public dissemination of information about the effects of ozone and UV changes on human health and the environment. This dissemination, which includes education and outreach programmes, is especially important in developing countries and CEITs. Network facilities such as those of the UNEP Division of Trade, Industry and Economics (UNEP/DTIE), could be utilized for this purpose.

- Provide resources for the exchange of visits amongst personnel from monitoring stations in developed, CEITs and developing countries in order to ensure technology transfers and sustained measurement programmes.

- Provide resources to permit the participation of representatives from developing countries and CEITs in regional and international validation and intercomparison campaigns.

- Provide funding from the Parties directly, or via GAW, to developing countries and CEITs for capacity building, and for maintaining and modernizing operational support at GAW global, regional and associate stations.

11. OTHER MATTERS

11.1 No other matters were raised for discussion.

12. CLOSURE OF THE MEETING

12.1 Dr Kurylo, after thanking all participants for their attendance and hard work, declared the meeting closed at 17:15 on Wednesday, 27 March, 2002.

ANNEX A

WMO/UNEP FIFTH MEETING OF THE OZONE RESEARCH MANAGERS OF THE PARTIES TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

(GENEVA, 25-27 March 2002)

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ANNEX B

WMO/UNEP FIFTH MEETING OF THE OZONE RESEARCH MANAGERS OF THE PARTIES TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

(GENEVA, 25-27 March 2002)

AGENDA

1. OPENING OF THE MEETING

2. ADOPTION OF THE AGENDA

3. ELECTION OF THE CHAIRMAN

4. REVIEW OF THE REPORT OF THE FOURTH MEETING OF THE OZONE RESEARCH MANAGERS, HELD IN GENEVA, 28 TO 30 APRIL 1999 (WMO GLOBAL OZONE RESEARCH AND MONITORING PROJECT, REPORT NO. 45)

5. REPORT ON THE 2002 SCIENTIFIC ASSESSMENT, THE 2002 ENVIRONMENTAL EFFECTS ASSESSMENT AND ON ASPECTS OF ATMOSPHERIC OZONE SCIENCE AND RESEARCH BY THE CO-CHAIRS OF THE SCIENTIFIC AND ENVIRONMENTAL EFFECTS ASSESSMENT PANELS OF THE MONTREAL PROTOCOL

6. CURRENT STATUS OF THE GLOBAL OZONE OBSERVING SYSTEM AND MONITORING OF UV-B RADIATION

7. COORDINATION

7.1 Network for the Detection of Stratospheric Change (NDSC)
7.2 Intergovernmental Panel on Climate Change (IPCC)
7.3 Stratospheric Processes and their Role in Climate (SPARC)

8. NATIONAL REPORTS ON ONGOING AND PLANNED OZONE RESEARCH AND MONITORING AND ON CALIBRATION AND ARCHIVING OF MEASUREMENTS

9. REPORT OF THE OZONE SECRETARIAT ON DEVELOPMENTS IN THE IMPLEMENTATION OF THE VIENNA CONVENTION AND THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

10. ADOPTION OF RECOMMENDATIONS

10.1 Introduction
10.2 Systematic observations
10.3 Data archiving
10.4 Research needs
10.5 Capacity building

11. OTHER MATTERS

12. CLOSURE OF THE MEETING

ANNEX C

WMO/UNEP FIFTH MEETING OF THE OZONE RESEARCH MANAGERS OF THE PARTIES TO THE VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER

GENEVA, 25 - 27 MARCH 2002

Reports available to the meeting:

Argentina
Armenia
Belarus
Belguim
Bulgaria
Canada
Chile
Colombia
Costa Rica
Croatia
Cuba
Czech Republic
Denmark
Egpyt
Estonia
European Union
France
Georgia
Germany
India
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Netherlands
New Zealand
Panama
Peru
Poland
Romania
Seychelles
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Sweden
Switzerland
Thailand
Togo
Turkey
United Kingdom
United States of America
Uzbekistan
Viet Nam

ARGENTINA

1. INTRODUCTION

The involvement of Argentina in ozone/UV monitoring and research dates back to 1966, with the establishment of one of the first Dobson instruments in the South America. After the discovery of the Antarctic ozone hole in 1985, the activities in the field became important, now contributing with monitoring over an extended Southern latitude band and important research activities

The Argentine ozone/UV monitoring activities are as follows:

a) Total column ozone - using Dobson, Brewer, AFO and portable systems.
b) Vertical profiling of ozone, obtained with the Umkehr method, ozonesonde and LIDAR.
c) Surface ozone
d) UV spectrophotometers and integral UV

The Argentine research activities include the following topics:

a) Regional and global ozone and trace species trends, and variability using satellite and ground-based retrievals..
b) The role of ozone and the stratosphere in Climate Change
c) Interactions between the Antarctic ozone hole and mid-latitude processes in the stratosphere and troposphere.
d) Development and construction of ozone and related species measuring systems.
e) Chemistry of CFC replacements
f) UV forecasting and climatology.
h) UV-B impacts on terrestrial and marine ecosystems.

It must be pointed out that these activities are carried out thanks to the perseverance of Argentine technicians and scientists, given the limitations inherent to a developing country. The current economic situation has pushed this state of affairs to the limit, putting research and monitoring activities in jeopardy. International support is essential to continue with monitoring activities and to prevent the dismemberment of research teams.

2. MONITORING

Argentine monitoring activities cover a wide range of latitudes extending 22 to 55°S in the main territory and as far as 77°S in Antarctica. The specific instrument details and locations can be found in Annex I.

2.1 Total Ozone Monitoring Networks

The main total ozone monitoring network is operated by the Servicio Meteorologico Nacional (S.M.N.).

2.1.1. Dobson intruments

The S.M.N. is responsible for the Southern Cone Ozone Project (SCO3P-GAW), which includes a network of Dobson Spectrophotometers. Routine measurements of total ozone are made a number of times a day by trained personnel from all the above stations. Whenever sky conditions permit, Umkehr observations are also made at the Buenos Aires and Comodoro Rivadavia stations to compute the vertical distribution of ozone. The profiling at Comodoro Rivadavia is made occasionally only.

2.1.1.1 Standardization:

The SMN-SCO3P-GAW Dobson Network instruments were standardized with the World Standard in Dec. 1999

2.1.1.2 Publication of data

The total ozone data collected from the network are being regularly sent in WMO format to World Ozone Data Centre (WOUDC) Toronto, Canada. The Buenos Aires Umkehr profiles were sent to the WOUDC Toronto till February 2002. The total ozone data are also available daily in the S.M.N. Internet Page (http://www.meteofa.mil.ar) and are also included in the SCO3P Bulletin.

2.1.2 Total ozone – AFO

The SMN-SCO3P network also operates AFO Spectrophotometer to complete the latitudinal coverage of the network.

2.1.2.1 Standardization:

Buenos Aires is the National and Regional Ozone Calibration Centre for the AFO spectrophotometer and the Dobson Spectrophotometer N° 97 serves as National Standard.

2.1.2.2 Publication of data

The AFO's total ozone data are included daily in the S.M.N Internet Page (http://www.meteofa.mil.ar), are also included in the SCO3P Bulletin and are being regularly sent in WMO format to World Ozone Data Centre (WOUDC) Toronto, Canada.
Total ozone monitoring stations are also operated by the Instituto Antartico Argentino (IAA):

2.2 Vertical Distribution of Ozone

Routine ozone profiling activities are carried out at Base Marambio and.Belgrano II.
The system at Marambio is operated jointly with the Finnish Meteorological Institute. This is based on a co-operation agreement. Ozone soundings are performed twice monthly, from December through July, and twice weekly during the remaining months, coincident with the ozone hole events. The operations are currently suspended since a fire destroyed the hydrogen generator, as well as balloons, sondes and other supplies.The Centro de Ozono de Altura, at the Observatorio Central Buenos Aires is in charge of the ozonesonde operations at Marambio.
The system at Belgrano II is operated by the Instituto Antártico Argentino with support from Spain.

2.3 Surface Ozone

The SMN-SCO3P-GAW operates as well a network of surface O3 analysers.

2.3.1 Standardization

The Calibration Center for surface ozone network calibration is operated at the Observatorio Central Buenos Aires. The Instituto de Quimica del Medio Ambiente (INQUIMAE –University of Buenos Aires) is also carrying routine measurements in Buenos Aires.

2.3.2 Future Activities.

Characterization of the S.M.N.-SCO3P surface ozone data, and the relation with different synoptic situations.

2.4 UV-B Radiation

S.M.N.-SCO3P integrated UV network has an extensive coverage throughout the national territory.

2.4.1 Standardization

The integrated UV-B calibration center operates at Observatorio Central Buenos Aires. since April 1998. The instruments were characterized in September-October 1998. An in-situ calibration using a spectromete of the Institute of Medical Physics of the University of Innsbruck, Austria, was carried out between Nov. 1998 and Feb. 1999. A new calibration should be carried out during 2002,though it has been provisionally suspended until funding is obtained.

2.4.2. Publication of data

The data will be submitted to the Toronto WOUDC as soon as the data correction method, using the final calibration and intercomparison report, is implemented. The data will also be included in the SCO3p Bulletin.

2.4.3 Latitudinal UVR-PAR monitoring network

This network, funded and operated by the Consejo Nacional de Investigaciones Cientificas y Tecnicas (CONICET) uses GUV-511 broadband spectroradiometers to monitor UV radiation along the N-S axis of the Argentine territory. The network operates since September 1994. The instruments are calibrated each year with a reference radiometer, property of Biospherical Instruments Inc., San Diego, CA, USA. The data are being updated for most instruments on a real-time basis at the network database. The data can be found at: http://www.dna.uba.ar. This network is part of an almost complete South American network operating with GUV511 instruments operating all the way to the Is. of San Andres, Colombia, in the Caribbean.

2.4.4 CADIC.

A high resolution spectroradiometer SUV-100, operates in Ushuaia since November 1988. This instrument is the northernmost one in a cross-Antarctic network that is managed by the National Science Foundation (USAThe data is stored at CADIC and at Biospherical Instruments Inc. The data is available in CD-ROM, free of charge for all scientists that request it.

2.5 UV-Forecasting

Since the summer of 1995 the S.M.N provides a UV index (Intensidad Solar Ultravioleta – ISUV) daily forecast during summer for the Humid Pampas region and Uruguay. Since Jan. 2000 the forecast has been extended to all of the national territory. The ISUVn also provides maximum UV radiation expected at maximum solar intensity taking into account the forecast cloud cover. It includes the cloud cover in the calculation. The corresponding maps and radiation charts are available by INTERNET. Both forecast methods were developed jointly with the Instituto de Fisica Rosario –IFIR- and the Observatorio Astronomico de Rosario

2.6 Associated Stratospheric Trace Species.

A number of associated trace species are currently being monitored:

1) Aerosols

a) Aerosol LIDAR at CITEFA - Villa Martelli, Prov. of Buenos Aires, 34º35'S 58º29'W. This instrument, built locally in co-operation with France has been measuring aerosols since 1995. The data is stored at CITEFA

b) A J100 sunphotometer , on loan from NOAA, operates since March 1997 at the Universidad Nacional de la Patagonia Austral (UNPA), Rio Gallegos, Prov. of Santa Cruz (). The filters are locally calibrated and the data is stored at UNPA.

2.7 Intercomparison Requirements

All of the instruments described above, as well as those currently in the research stage described below, require periodic intercomparisons with world standard instruments abroad or following the recommende methodology for testing the equipment. Financial support is required to meet the high expenses of transportation of bulky equipments and travel of operators and experts.

3. RESEARCH

The SPARC Programme (WCRP) convened its 2nd Scientific Assembly in November 2000, in Mar del Plata, Argentina. This highly successful meeting, together with a special Associated Workshop on the impacts of UV radiation on terrestrial and aquatic ecosystems, signified an important boost for research activities in South America. Research activities have also resulted MSc and PhD thesis, some already completed. Some of the publications made in recent years are included below.

One of the most important results obtained was the study of the preferential positioning of the polar vortex/ozone hole, towards Southern South America and how it moves and stretches towards southern midlatitudes over the neighbouring oceans and the mainland in this sector of the hemisphere. A significant effort has been made in studies linking the variability of the ozone layer with meteorological processes and the Southern Hemisphere storm track. Climatological studies of stratospheric variables seem to indicate a change in the dynamics of the stratosphere between the ´80s and the ´90s. UV studies include the study of the response of local aquatic and terrestrial ecosystems in different parts of Argentina to enhanced UV levels. The period of UV continuous UV monitoring now spans a decade and UV climatology studies are now under way.
Despite some, albeit short-lived, improvements in the late ´90´s, the main difficulty has been the lack of adequate funding for research in all its aspects, including positions for young scientists. The important activities that have been nevertheless carried out in recent years include:

3.1 Ozone and Trace Species Observing Systems Development

1) Centro de Investigaciones Tecnologicas de las Fuerzas Armadas. CITEFA., Villa Martelli, Prov. of Buenos Aires.

Development of LIDAR systems to monitor atmospheric aerosols and stratospheric ozone. The DIAL ozone LIDAR began operations in 1998. The observations were compared with ozonesondes launched from Buenos Aires and with satellite profiles. Work is underway to upgrade the system and to install it in a movable container for campaign studies. Intensive working is underway to improve the retrieval algorithms. This activity is carried out in co-operation and with support from France. The aerosol lidar continues operations to study boundary layer and stratospheric aerosols, in order to carry out variability studies.

2) Instituto de Investigaciones sobre Medio Ambiente, Universidad de Mendoza, Prov. of Mendoza.

Development and construction passive microwave radiometers to monitor column water vapour and ClO. Campaigns have been carried out in the high Andes at Puente del Inca, Prov. of Mendoza. This activity is carried out in co-operation and with support from Germany.

3.2 Stratospheric Dynamics, Climatology and Chemistry.

1) Grupo de Atmosfera Media, Departamento de Ciencias de la Atmosfera, Universidad de Buenos Aires.

Climatology and dynamics of the stratosphere/troposphere system, using ground-based and satellite retrievals (TOMS, MSU, UARS, SAGE). The interactions between the Polar vortex/ozone hole and midlatitude stratospheric processes and ozone depletion are studied. Recent developments include the study of the interactions between tropospheric processes, ozone variability at mid-latitudes and polar vortex /ozone hole dynamics. This work includes vortex modelling activities and its interaction with tropospheric processes. In 2000 monitoring of column trace species (CO and CH4)begun in Peninsula Valdez for MOPPITT validation. These activities include interactions with research teams in Uruguay, in Europe, USA and Canada.

2) Centro de Investigaciones de la Atmósfera (CIMA - Universidad de Buenos Aires/CONICET)/Laboratorio de Ozono y UV-CADIC. Study of the interannual total ozone variability at high southern latitudes and the relationship with tropospheric synoptic activity. Study of cloud transmittance and the effects of clouds on UV radiation.

3) Laboratorio de Energia Solar, Universidad Nacional de San Luis, Prov. of San Luis.
Study of the ozone anomalies over the Andes and the high Altiplano, observed in the TOMS retrievals. An analysis of polar vortex dynamics and its midlatitude excursions was carried out, showing how the vortex edge can stretch over the Argentine and Chilean territory during those periods. Intercomparison of the TOMS retrievals with total ozone measured by the Dobson network in Argentina.

4) S.M.N.

Climatology of the ozone and the UVB in the country our data and satellite retrievals (TOMS, TOVS).

5) Departamento de Fisico-Quimica, Facultad de Ciencias Quimicas, Universidad Nacional de Cordoba, Prov. of Cordoba.

Chemistry of ozone depletion and CFC replacement substances, interacting with CITEFA in Argentina and the UK and Germany, abroad.

6) INIFTA, Universidad Nacional de La Plata (UNLP)

Study of reaction rates between ozone and various trace species. The activities are carried out in co-operation with Germany.

3.3 Ozone/UV Relationships.

The study of ozone/UV relationships is carried out in various institutions, using different sources of data, in particular comparing TOMS total ozone measurements with the behaviour of surface UV-B radiation. Such activities are carried out in particular by the scientists operating the UV-PAR latitudinal network, the S.M.N. the groups at the Instituto de Fisica de Rosario, Universidad Nacional de Rosario, Province of Santa Fe, CADIC and the Laboratorio de Energia Solar, Universidad Nacional de San Luis. The latter is also responsible for the collection of ozone and UV data measured by a set of portable radiometers built in a co-operative project between the Centro de Investigaciones Opticas (CIOP/UNLP) and Spain.

3.4 UV Climatology

The group operating the UV-PAR latitudinal network is carrying out a climatological study of UV-radiation over Argentina. The S.M.N is now also starting with the data from the SMN-SCO3P.

3.5 UV-B Impacts on Ecosystems.

The impacts of ecosystems both marine and terrestrial are carried out by a diversity of groups. The Estacion de Fotobiologia Playa Union, Province of Chubut and the Instituto Antartico Argentino carry out research on the effects of UV-B on phytoplankton and other marine species, including the use of underwater UV-profiling sensors. A biology group from the Universidad Nacional del Comahue, Province of Rio Negro, is studying the impacts of UV in the lake ecosystems of the Patagonian Andes. Researchers from the Facultad de Agronomia are involved in the study of the consequences of enhanced UV-B on the grasslands of Tierra del Fuego. These activities are made in co-operation with CADIC and the UV monitoring networks.

3.6 Publication

The results of the above activities are being published in national and international journals. The following list includes recent publications in international journals. A number of papers are now under review process.

-Canziani P.O., Compagnucci R.H.C., Bischoff S.A., Legnani W.E. A study of impacts of tropospheric synoptic processes on the genesis and evolution of extreme total ozone anomalies over Southern South America Submitted J. Geophys. Res., accepted Jan. 2002
-Compagnucci, R.H., M.A. Salles, P.O. Canziani, The spatial and temporal behaviour of the lower stratospheric temperature over the Southern Hemisphere: the MSU view. Part I: methodology and temporal behaviour. Int. J. Climatology, 21, 419-437, 2001
-Perez, A., Crino E., Aguirre de Carce I., Jacque F., Low Ozone events and three-dimesnional transport at midlatitudes of South America during springs of 1996 and 1997
-Salles, M.A., P.O. Canziani, R.H. Compagnucci, The spatial and temporal behaviour of the lower stratospheric temperature over the Southern Hemisphere: the MSU view. Part II: spatial behaviour. Int. J. Climatology,21, 439-454, 2001.
-Vigliarolo P.K., Vera C.S., Díaz S.B. Southern Hemisphere winter ozone fluctuations Quart. J. Roy. Met Soc., 127, 559-577, 2001.

3.7 Future Research Activities

The intent is to continue with the activities listed above. Nevertheless the present economic crisis does not ensure the continuation of present activities. The planning of future activities is not possible unless support is obtained from abroad.

4. TRAINING AND REFRESHING COURSES FOR OPERATORS AND SCIENTISTS

A number of national and regional training activities have continued to take place, both for operators of the various instruments included in the Argentine and regional networks, at the Observatorio Central Buenos Aires (S.M.N.), Pilar Obs (S.M.N.)., CADIC as well as scientists in the various interdisciplinary fields needed to understand the ozone/UV issues. The latter includes the preparation of Msc. and Phd. dissertations. A series of workshop/seminars have been held since 1998, organized jointly by the Departamento de Ciencias de la Atmosfera, Universidad de Buenos Aires (WMO Regional Training Center) with participation from NCAR, USA, and the University of Toronto, Canada. Financial support was provided by a grant from the InterAmerican Institute for Climate Change Research, for postgraduate students and young scientists from the MERCOSUR countries.

4.1 Requirements

Unless additional support is obtained the workshop/seminar activities will cease this year. Support is needed for the travel expenses of instrument operators that need to attend training programs abroad. This also is needed for the scientists attending training activities.

Annex I - Ozone and UV monitoring instruments operated by Argentina

1. Dobson network operated by S.M.N.

Station	Location	Since	Last calibration	Date of Last Submission
1. Buenos Aires	34°35'S-58°29'W	Jan. 1966	December 1999	Feb. 2002
2.Com. Rivadavia	45°47'S-67°30'W	Sep 1995	December 1999	Feb. 2002
3. Ushuaia – GAW	54°49'S-68°19'W	Sep. 1994	December 1999	Feb. 2002
4.Base Marambio	64°14'S-56°43'W	Sep. 1987	August 2001	Feb. 2002

2. AFO network operated by S.M.N.

Station	Location	Since	Instrument No Last Calibration	Date of Last Submission
2. Pilar	31°40'S-63°53'W	Oct. 1998	AFO 7- Sep. 1998	As above
3. San Julián	49°19'S-67°45'W	Oct 1998	AFO 5 - Set 1998	As above

3. The Instituto Antártico Argentino operates the following instruments

Station	Location	Instrument	Since	Last Known Calibration
Belgrano II	77°52'S 34°37'W	Brewer MKIV+ EVA*	January 1992 January 1995	Sept. 1997 -------
Marambio	64°14'S 56°37'W	EVA*	January 1994	January 1999
Ushuaia	54°48'S 68°19'W	Brewer MKIV** EVA***	September 1994 January 1994	January 1999

+ In co-operation with the CNR/IFA (Italy)
* Differential Absorption Visible Spectrometry instrument.Operated in co-operation with the Instituto de Tecnicas Aeroespaciales de España
** Operated in co-operation with the CNR/IFA (Italy) and Centro Austral de Investigaciones Cientificas (CADIC/Consejo Nacional de Investigaciones Cientificas y Tecnologicas)
*** Operated in co-operation with the Instituto de Tecnicas Aeroespaciales de España and CADIC/CONICET
The data is stored at the IAA and also submitted to the S.M.N.

4. Ozonesonde profiling

Station	Location	Since	Instrument No Last Calibration	Date of Last Submission
1 Marambio	64°14'S 56°43'W	September 1989	Vaisala ECC	Feb. 2002
2. Belgrano II	77°52'S 34°37'W	1999	Vaisala ECC	

5. Surface ozone network operated by S.M.N.

Station	Location	Altitude (m asl.)	Instrument Last Calibration	Since
La Quiaca Obs.	22°06'S 65°06W	3459	TEI 49 mod. 003 June 1997*	January 1996
Pilar Obs.	31º40'S 63º53'W	338	TEI 49 mod. 003 June 1997*	June 1995
San Julián	49º19'S 67º45'	62	TEI 49 mod. 003 June 1997*	October 1997
Ushuaia-GAW	54º48'S 68º19'W	7	TEI 49 mod. 003 June 1997*	October 1994

6. UV network operated by the S.M.N.

Station	Location	Altitude (m asl.)	Instrument Last Calibration	Since
La Quiaca Obs.	22°06'S 65°06W	3459	UV Pyranometer YES-UV-B1, Feb. 1999	January 1996
Pilar Obs.	31º40'S 63º53'W	338	UV Pyranometer YES-UV-B1, Dec. 1998	June 1995
			Solar Light UV-501, Dec. 1998	Feb. 1996
Planetario Rosario	32º55'S 60º47'	25	UV Pyranometer YES-UV-B1, Nov. 1998	November 1998
Mendoza	32º53'-68º51'	827	Solar Light UV-501, Mar. 1999	Mar 1999
Buenos Aires	34°35'S-58°29'W	25	Solar Light UV-501, Dec. 1998	September 1995
Comodoro Rivadavia	45°47'S-67°30'W	6	Solar Light UV-501, Feb. 1999	February 1997
San Julián	49º19'S 67º45'	62	UV Pyranometer YES-UV-B1, Feb. 1999	October 1997
Ushuaia GAW	54º48'S 68º19'W	7	Solar Light UV-501, Dec. 1998	April 1997
Marambio	64°14'S 56°43'W	198	Solar Light UV-501, Jan. 1999	May 1997

7. UV-B PAR National monitoring network with GUV-511 instruments.

Station	Location
Ushuaia	54º48'S 68º19'W
Trelew	43º14'S 65º19'W
Buenos Aires	34º35'S 58º29'W
Huaico Hondo	24º10'S 65º01'W

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ARMENIA

Results of activity

Total ozone measurements in Armenia are carried out at the local ozone-observing network since 1990.

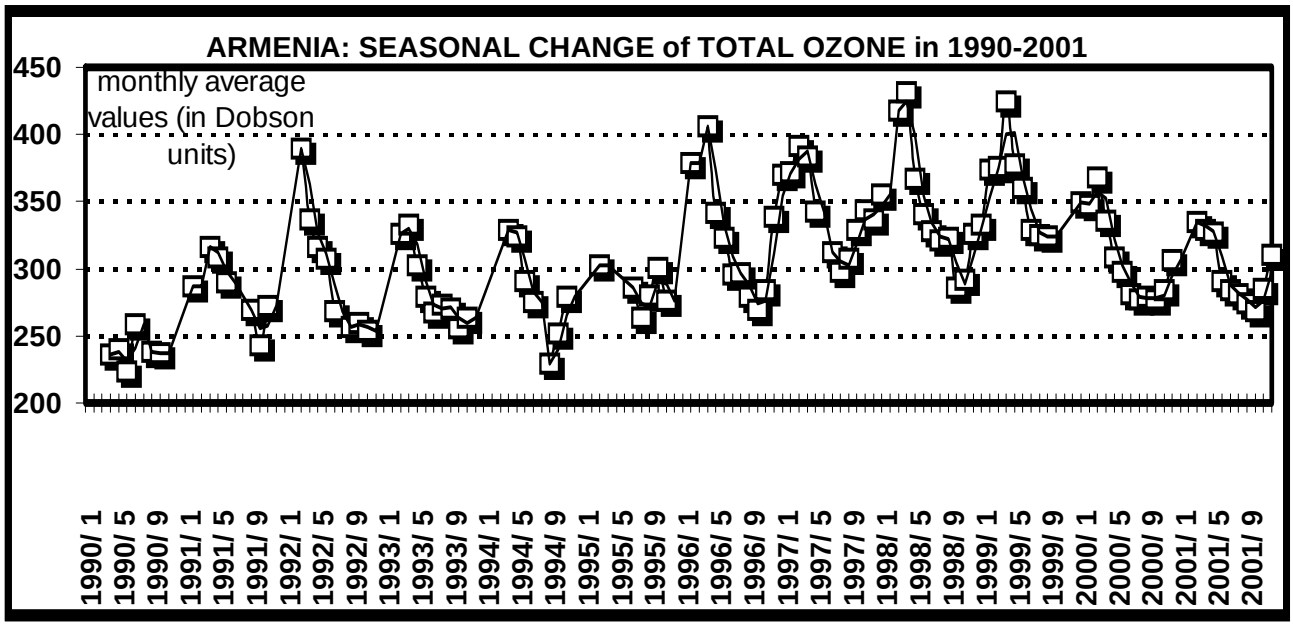

Table 1: Ozone Observing Network of Armenia.

Station	Location	Coordinate, altitude (m a.s.l.)	Instrument	Last calibration	Observations since
"YEREVAN"	Yerevan	40.1N, 44.3E; **1113**	M-124	2001	1990
"SEVAN"	Sevan	40.3N, 45.1E; **1927**	M-124	2001	***)**
"AMBERD"	Mt. Aragats	40.3N, 44.1E; **2070**	D-044	2000	2000
"ARAGATS"	Mt. Aragats	40.3N, 44.1E; **3227**	M-124	2001	***)**

***)** Reserve station.

Since 2000 with assistance of WMO, DWD (Germany) and SOOHK of CHMI (Czech Republic) on a southern slope of mountain Aragatc was organized the station WMO/GO3OS/ID#410 ("Amberd").

In addition to long-term measurements of total ozone on the station "Yerevan" were carried out also the short-term simultaneous ozone measurements on the stations "Sevan" and "Aragats". The results of these measurements were used to study average levels and dynamics of surface ozone and its vertical distribution in range of 1000-3000 m a.s.l.

The connection between changes of ozone layer and the morbidity of populations of Armenia by skin cancer is investigated.

Ongoing activity

The results of ozone monitoring on Dobson station "Amberd" are regularly submitted in monthly reports to WOUDC (Toronto, Canada). Data processing, management and transmission via WMO/GTS format are carried out by software developed at SOOHK. The processing and management of results of ozone monitoring on station "Yerevan" is carried out by software developed in Armenia.

The comparative analysis of total ozone monitoring at both stations "Yerevan" and "Amberd" is used for an estimation of vertical distribution of surface ozone and for debugging of the developed UV-radiation transfer model in view of typical for Armenia mountainous conditions.

On the basis of the information provided by the *Institute of Biological Physics and Biostatistics. University of Veterinary Medicine Vienna* (http://i115srv.vu-wien.ac.at/uv/uv-index/uvi_eue.txt) and according to the recommendations of COST-713 Action “UVB Forecasting” is daily calculated and published through mass media forecast for UV-indexes for mostly inhabited areas of Armenia.
The meanings of UV-indexes for Armenia are in-group of the highest for Europe.

Planned activities

The planned activities, alongside with continuation of the current activities, include also

- Organization of aerosol-monitoring on the stations of a local ozone observing network
- Organization of UV-monitoring on the stations of a local ozone observing network
  1) to study UV-climate of Armenia and
  2) to regularly submit to WOUDC UV-data on region of Southern Caucasus.
- Study specification of methodology COST-713 Action "UVB Forecasting" for application in the conditions of mountainous countries using the data of UV-monitoring and developed UV-radiation transfer model.

In realization of these plans we are ready also to the international cooperation in particular in questions connected to the use of equipment having appropriate class of accuracy.

In case of successful realization of this activity the results may be applied for the region of Southern Caucasus distinguished by its complex relief, as well for the general progress of UV-climatology science.

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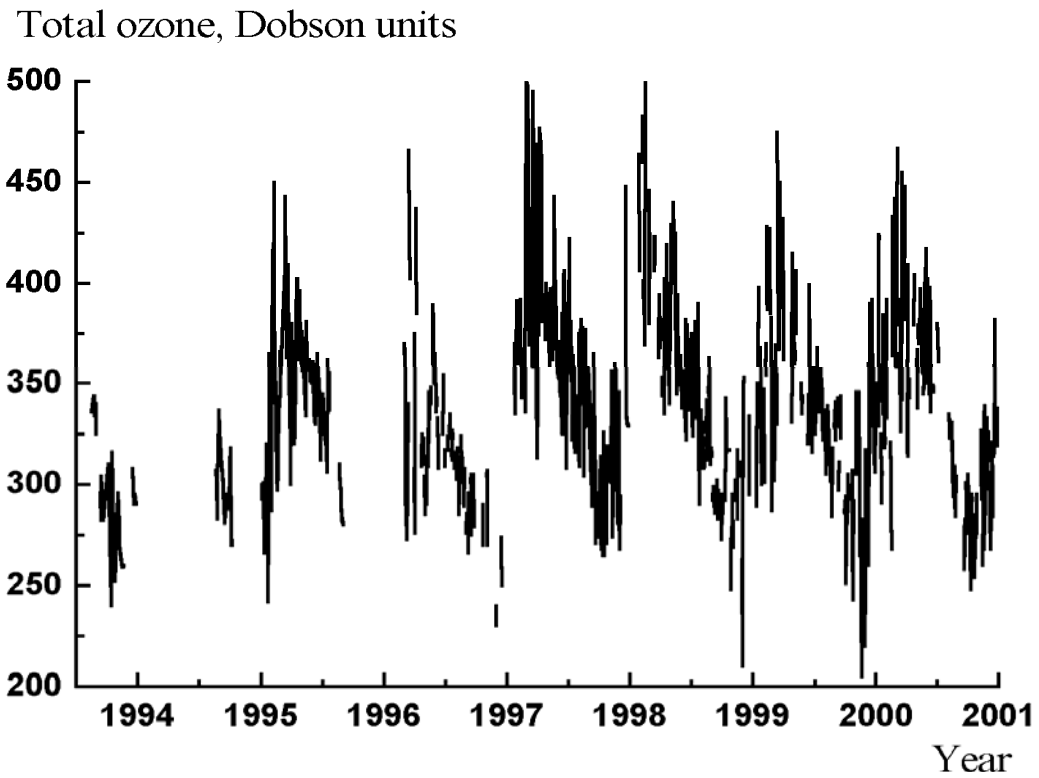
BELARUS

In recent years, institutions in Belarus have carried out a number of activities relating to ozone research and monitoring, in response to decisions taken by the Fifth Meeting of the Conference of the Parties to the Vienna Convention. The National Assembly adopted the Law of the Belarus Republic for Ozone Layer Protection. The National Environmental Monitoring System (NEMS), together with the Atmosphere Ozone Monitoring subsystem, was also established, and a plan for the development of the subsystem up to 2005 has been prepared. The government department responsible for atmospheric ozone research and monitoring is the Ministry of Natural Resources and Environmental Protection.

OZONE AND UV MONITORING

Total ozone measurements are carried out at a station located in Minsk at the National Ozone Monitoring Research & Educational Center (NOMREC), which is affiliated to Belarus State University. The Station coordinates are (53.833N, 27.469E). Its WO_3UDC identification number is 354. Experimental total ozone measurements started in 1995 with the universal solar ultraviolet spectrometer-ozonometer PION, constructed at Belarus State University. The device contains a small size double grating monochromator. In 1996, the PION was intercompared with a WMO regional standard (Dobson N 108 spectrometer) in St.-Petersburg (Russia). The last recalibration made in August 2001 showed high stability of the instrument parameters.
Regular Total Ozone Monitoring has been carried out in Minsk since March 1997. The data are submitted to the World (Canada) and CIS (Russia) data centers, as well as to the Belarus mass media. The results of total ozone measurements at the Minsk station are presented in Figure 1.

Fig. 1. Total ozone, Dobson units (N 354 station, Minsk).



Regular observations of horizontal ultraviolet irradiance in the spectral range 285-450 nm have been carried out with the portable UV spectroradiometer PION-UV (developed by NOMREC) since September 2001. The fully automated instrument PION-UV has a double holographic grating

monochromator with 0.8 nm resolution and a stray light reduction of $1*10^{-6}$ degrees, with a cosine for-optics system. It is a completely hermetic and temperature stabilized construction. The monthly monitoring of instrument parameters and calibration is carried out through a specially created testing procedure certified by the State Standard Agency, in accordance with WMO guidelines.
Regular Lidar vertical ozone profiles and aerosol monitoring was started at the Institute of Physics of the National Academy of Science (IPNAS) in 1999, in accordance with NEMS standards. Figure 2 shows the vertical distribution of ozone concentrations during 1999 – 2001.

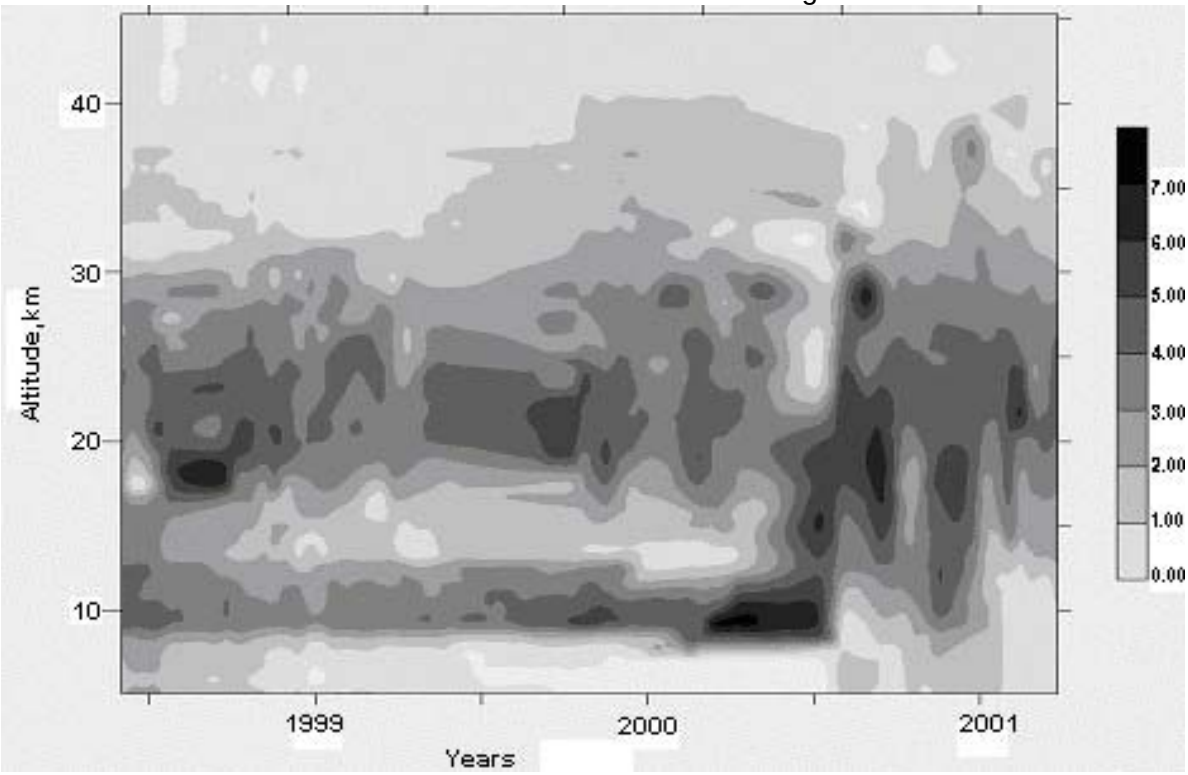


Fig. 2. Time dependence of ozone concentration structures during 1999 - 2001 above Minsk ($n_{oz} \cdot 10^{-12}[\mathbf{cm}^{-3}]$).

Planned activities

The Belarus Sanitary & Hygiene Research Institute (BSHRI), in cooperation with NOMREC, plans to start monitoring the effects of changed ultraviolet irradiation on human health next year.

In accordance with a decision taken at a regional NDSC meeting held in Moscow (October, 2001), nitrogen oxide NDSC standard measurements will be introduced in the region with the assistance of the Obukhov Atmosphere Physics Institute (Russia).
There are also plans to set up a meteorological base for a future surface ozone network, and to conduct surface ozone observations at the NOMREC station.

In 2003, NOMREC will start providing UV index forecasts, working with a public awareness company.

Ongoing and planned research activities

Improvements are being made to the total ozone and UV horizontal irradiance monitoring equipment, along with its maintenance. A self-calibration procedure for the control of total ozone equipment parameters and correction between intercomparisons is being developed. An Umkehr method for vertical ozone profile measurements will be implemented at the Minsk Ozone Station.
Software has been developed for automated mode measuring of solar UV spectral irradiance and daily doses of different biologic effects (erythema and DNA damage). The algorithm provides an optimal mode of measurement of observations under changing conditions throughout the whole day.

There are plans to analyse total ozone distribution and climatic phenomena intercorrelations over Europe, in particular, the impact of interseasonal ozone holes on the energy balance of the atmosphere.

NOMREC, in co-operation with BSHRI, has developed a methodology for the estimation of ultraviolet radiation sources. Work is also in progress to improve UV-index forecasting techniques.

IPNAS, in co-operation with the European EATLINET Lidar network, has carried out research into atmospheric aerosol transfer processes above the European region. The influence of dust from the Sahara desert, eruptions of the Etna volcano, forest fires in the USA and other natural and anthropogenic factors affecting atmospheric characteristics have been studied. In 2002, an experimental Lidar network for aerosol monitoring among the CIS countries is expected to begin operation. This activity will be carried out in close collaboration with EATLINET.

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BELGIUM

Introduction

The main research institutes that are currently involved in ozone/UV and ozone related observations and research include:

- the Royal Meteorological Institute (KMI-IRM)
- the Belgian Institute for Space Aeronomy (BIRA-IASB)
- the Université de Liège (ULg) - Institute of Astrophysics and Geophysics
- the Université Libre de Bruxelles (ULB)

The laboratory of Plant Ecology of the University of Antwerp has been involved in UV-B research from 1992 to 2000.

The Belgian Federal Office for Scientific, Technical and Cultural Affairs (DWTC-SSTC) is presently funding the ESAC II (Experimental Studies of Atmospheric Changes) project in the framework of the Federal Multi-annual Scientific Support Plan for a Sustainable Development Policy (2001-2005) partim Global Change, Ecosystems and Biodiversity.
This project represents a national effort to continue the existing Belgian contribution to the long-term surveillance of the Earth's atmosphere.
Its main objectives are the following:

- Extend and improve the important existing Belgian contribution in atmospheric research that was started in the 1950s, and that is internationally recognised.
- Investigate the composition of the atmosphere, to detect and understand its evolution, mainly through field observations. Special attention is being paid to the evolution of the ozone layer and chemical species and processes with an impact on climate changes; this research is specifically conducted within the frame of the European contribution to the Network for the Detection of Stratospheric Change (NDSC; for details, visit the home page http://www.ndsc.ws).
- Support the Belgian policies and decisions regarding the Amendments to the Montreal and Kyoto Protocols.

The ESAC project is co-ordinated by the Belgian Institute for Space Aeronomy and involves the Royal Meteorological Institute, the Institute of Astrophysics and Geophysics (ULg) and the Université Libre de Bruxelles (see http://www.oma.be/ESACII/Home.html).

Via the budget for "Impulse for research in the Belgian federal scientific institutes" some relevant projects at the BIRA/IASB are funded:

- Measurement, understanding and climatology of stratospheric aerosols
  Duration: 1/1/2000-31/12/2003
- Global distribution and variability of tropospheric and stratospheric nitrogen dioxide : enhancement and synergistic use of the multi-platform observing system
  Duration: 1/1/2001-31/12/2002
- Study of vertically resolved ground-based FTIR measurements at the Jungfraujoch for investigating dynamical and chemical processes at northern mid-latitude

Belgium participates in the optional ESA programmes that manage the ERS (European Remote Sensing) and ENVISAT (ENVIronmental SATellite) satellite missions. Concerning the study of the atmosphere, GOME (Global Ozone Monitoring Experiment) on ERS-2 and GOMOS (Global Ozone Monitoring by Occultation of Stars), MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) and SCHIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) on ENVISAT are the main atmospheric sounding instruments that measure trace gases and ozone in the atmosphere and detect their timely concentration changes.

Belgium further participates substantially in the PRODEX optional programme of ESA since 1988. PRODEX finances proposals addressing the development of new instruments for ESA satellites,

their calibration and validation, as well as their data processing including the development of algorithms, the implementation of specific applications and the general scientific data exploitation. Belgian relevant projects financed by this programme are: the Ozone validation campaigns in the context of the EUMETSAT SAF Ozone and Atmospheric Chemistry validation for the ERS and ENVISAT satellites (GOME exploitation, CINAMOM, ENVISAT-UV, SADE, ACHIWE,

Belgium is one of the four participating states in the optional Data User Programme (DUP) of ESA (1996-2003). Relevant Belgian DUP projects are: global aerosol mapping and ozone monitoring. After 2003, this programme will be integrated into the optional Earth Observation Envelope Programme (EOEP) of ESA, in which Belgium is involved since 1999.

Belgium also supports strongly the GMES (Global Monitoring for Environment and Security) initiative of the EC and ESA and participates actively in the 'GMES Services', which is part of the optional ESA Earth Watch programme.

The research institutes in Belgium: observation and research activities

The Royal Meteorological Institute (KMI-IRM)

Observations

- Daily monitoring of the total ozone amount using a Dobson spectrophotometer (Serial nr. 40) and an automated Brewer spectrophotometer (Serial nr. 16). Both direct sun (if possible) and zenith sky measurements are performed several times per day. A new Brewer double monochromator (Serial nr. 178) was installed in September 2001. All instruments are calibrated with respect to standard spectrophotometers. Their calibrations are kept completely independent, which allows mutual quality control of the data.
- Daily monitoring of UV-B radiation using the Brewer spectrophotometers. The calibration is checked on a regular basis by means of certified calibration lamps.
- Vertical ozone distribution measured three times per week by means of balloon soundings. Brewer-Mast ozone sondes were used up to March 1997, and ECC ozone sondes onwards. By applying appropriate correction procedures based on previous comparative studies and research, the mean difference between ozone profiles from both types of sondes was reduced to less than 3% at all altitudes.

Remarks: All routine observations (ozone and UV-B) are performed at Uccle (50°48'N, 4°21'E, 100 m asl) which is now accepted as an NDSC complementary site for ozone column and profile measurements. In the near future all measurements (including the historical data going back to 1969) will be archived in the Network's Data Host Facility at NOAA (Washington, DC).

Research

- Over the last years considerable effort was put in homogenising the long time series of total ozone amount and vertical ozone distribution at Uccle. Monitoring the quality of the observations is a permanent activity.
- Comparison of ozone profiles from ozone soundings at Uccle and profiles obtained from the SAGE II satellite instrument has confirmed the homogenisation consistency of the Uccle data sets.
- The trends of both total ozone amounts and vertical O_3 distributions are studied regularly. The relation between tropospheric ozone and meteorological parameters is currently under investigation.
- A UV Index forecasting procedure has been developed. During the summer months forecasted values of the UV Index are made available to the media in Belgium. An effort is being made to improve the understanding of the relation between measured and modelled UV intensities to derive optical depths in the UV from the Brewer observations.

Participation

- In the Belgian ESAC-II project.
- In ongoing international projects dealing with tropospheric ozone:
  TOR-2 (Tropospheric Ozone Research) in the framework of EUROTRAC-2;
- In programmes for validation of ozone data from satellite instruments:
  - Geophysical validation campaign of GOME aboard ERS-2;
  - Validation of ozone measurements from SCIAMACHY, MIPAS and GOMOS aboard Envisat;
  - Ozone SAF (Satellite Application Facility) of EUMETSAT.

(d) Representation in international organisations

- EUMETSAT
- O_3 SAF
- COST 713 on UV-B forecast (terminated in 2001)
- ASOPOS (Assessment of Operating Procedures for Ozone Sondes), in co-operation with WMO/GAW
- NDSC
- Brewer and Dobson ad hoc committees of WMO/GAW

University of Liège (ULg)

(a) Observations

- Infrared solar observations performed regularly at the International Scientific Station of the Jungfraujoch (ISSJ, Swiss Alps, 3580 m asl) which became part of the northern mid-latitude "Primary NDSC Station" in 1989.

- Time period of observations: limited historic data in 1950-51, then increasing number of routine observations since 1976; after mid-1980s, monitoring of over 20 species, with some fifteen of direct relevance to the Vienna (1985) and the Climate (1992) Conventions.

- Type of instruments: initially grating spectrometers then wide-band, very high spectral resolution Fourier transform Infra-Red (FTIR) instruments allowing to study multiple species, simultaneously; geophysical parameters consist in total- and partial column abundances above the site.

- Archiving: series of NDSC-relevant molecules (e.g., HCl, $ClONO_2$, HF, COF_2, HNO_3, NO_2, NO, O_3, CFC-12, HCFC-22) measured from 1989 to present, archived at the NOAA Data Host Facility and at NILU (Norway); pre-1989 data to be archived as time permits, but available upon request; specific databases archived at NILU in support of European campaigns such as ESMOS, SESAME and THESEO, and for validating the GOME satellite experiment

(b) Research

- Through its participation in the reanalysis of quasi-global observations by the American shuttle-based FTIR instrument ATMOS (Atmospheric Trace MOlecule Sperctroscopy), members of ULg have contributed to the automatic retrieval of some 30 atmospheric constituents between about 70 and 5 km altitude, thus demonstrating the possibility to sound both the stratosphere and the free troposphere from space (for details, visit http://remus.jpl.nasa.gov/atmosversion3/atmosversion3.html.

- Participation to the Belgian ESAC–1 and -2 projects. The main objective is to contribute inputs in support of the Montreal and Kyoto Protocols, thus contributing to sustainable development policies.

- Participation in EC projects: COSE, SOGE, THESEO-2000+, also in the EUROTRAC-2/TROPOSAT subproject.

- Contributions to ESA-co-ordinated calibration/validation projects in support of the ENVISAT mission.

- Participation in the definition of the Canadian ACE space mission and the European IASI/EUMETSAT experiment, and preparation to support their validation.

(c) International involvements

- Scientific contributions to international assessments issued regularly by the WMO and by the EC.
- Representations in the EC-Ozone Panel, the SAG of ENVISAT-MIPAS, the NDSC-GAW, the IOC.

Belgian Institute for Space Aeronomy (BIRA-IASB)

(b) Observations

(a1) Ground based observations

- Monitoring of O_3 and interacting species (halogens, NO_y, BrO, HCFC, CFC,…) for budget and long-term trend studies: continued since eighties
- Monitoring of UV-B
- Campaign measurements for related process studies, e.g., in the frame of THESEO, SESAME, EASOE (EC)
- Some focus on tropospheric O_3 in LS/UT and free troposphere - inversion methods for ground-based data to derive information about vertical distributions of atmospheric species, in particular distinct tropospheric and stratospheric abundances (O_3 sondes at Uccle/Ukkel, see RMI section 2.1; differential campaign in Jungfraujoch area in summer 1998; long-path measurements at ULB campus)
- Observatories and instruments involved:
  - Jungfraujoch: FTIR and SAOZ instruments. SAOZ measures O_3 and NO_2 columns in the UV-Vis spectral range, since 1990. The time series of FTIR data starts in the early eighties (see ULg section 2.2)
  - Uccle/Ukkel (see section 2.1 for Dobson, Brewer and O_3 sondes): UV-B instruments (spectral UV-B measurements), since 1993
  - Harestua, Norway, 60°N, 11°E: UV-VIS DOAS instruments, since 1994 (O_3, NO_2, OClO, BrO)
  - Observatoire de Haute Provence (OHP), France, 44°N, 8°E: UV-VIS DOAS instrument (O_3, NO_2, BrO columns), since summer 1998. The UV-VIS DOAS instrument has been upgraded with an off-axis capability in 2000 and since then provides also tropospheric abundances of O_3, NO_2, BrO, and H_2CO.
  - Ile de la Réunion (22°S, 55°E) : UV-Vis DOAS off-axis instrument (O_3, NO_2, BrO, H_2CO columns and tropospheric abundances), starting in summer 2002.
  - Mobile Fourier-transform instrument for campaign measurements; the first one will be held in Ile de la Réunion (22°S, 55°E), in Sept-Oct. 2002

Remarks: All sites are NDSC-affiliated. Data concerning the chemical species are submitted to NADIR/NILU and NDSC/NOAA databases; UV-B data are in the SUVDAMA (EC) database.

(a2) Balloon measurements

- Stratospheric balloon measurements of species relevant to the O_3 issue, in particular HNO_3 vertical profiles between 15 and 35 km, possibly $ClONO_2$ and HCl in the future. The technique used is chemical ionisation mass spectrometry.

Research

(b1) Satellite experiments, in particular GOME/ERS-2 (current) and ENVISAT

- Validation and maturation of level 2 products, including O_3, NO_2, BrO, and aerosol, based on ground-network correlative observations
- Development of climatologies of some stratospheric species like NO_2, …
- Scientific studies concerning O_3 related dynamical and chemical processes are ongoing, in preparation of the exploitation of the ENVISAT data
- Chemical 4D variational data assimilation, in particular of O_3 (see also modelling)
- Extra-terrestrial solar UV irradiance calibration, UV proxies, and mapping of UV at the surface, UV-index mapping
- Analysis of stratospheric aerosol data: characterisation, climatology, etc., based on exploitation of ORA/EURECA radiometer and SAGE II data; in future, extension towards ENVISAT data
    - Spectral inversion of satellite data (BrO from GOME, aerosol from ORA and GOMOS (prototype algorithm)).

(b2) Modelling studies

- Complete 3D modelling of the stratosphere, including transport, chemistry, aerosol micro-physics and a heterogeneous chemistry module
- Chemical 4D variational data assimilation, in particular of O_3
- 1D box model for process studies, and for interpretation of UV-Vis DOAS observations
- Studies based on 3D model IMAGES for the troposphere and UT/LS boundary region
- Development of inverse tropospheric modelling methods, to identify emissions

(b3) Laboratory measurements (in co-operation with ULB; see section 2.4)

- Spectroscopic studies in support of remote sensing experiments (optical spectroscopy, ion chemistry for mass spectrometry applications,…)
- Spectroscopic studies in support of investigations concerning global warming issue
- Radiometric calibration for UV monitoring instruments

(c) Representation in international organisations

- WMO: UV-SAG (GAW)
- SPARC/WCRP
- NDSC (GAW/WMO)
- SAG of GOME and GOME-2, GOMOS, SCIAMACHY, OMI
- O_3 Panel (EC), Vintersol Core Group (EORCU)
- ESA council
- Member of the Science Team of the Canadian ACE/SciSAT mission

(d) Participation

- to International assessment studies: the EC Scientific Assessment ‘European research in the stratosphere 1996-2000, Advances in our understanding of the ozone layer during THESEO’, EUR19867, 2001
- in many EC projects; ongoing projects are: QUILT, UFTIR (+ co-ordination), MAPSCORE
- in TROPOSAT, subproject of EUROTRAC-2
- in the project ‘ Chemistry and climate related studies using the IASI remote sensor’ for preparing the scientific research aspects of the IASI mission onboard METOP-1 (launch nominally 2005).

Universite Libre de Bruxelles (ULB)

(a) Observations

- Infrared and UV-Visible solar observations performed at the Brussels (ULB campus) site.
- Campaign solar observations facilities are being installed on Ile de la Réunion

Type of instrument: very high spectral resolution Fourier transform spectrometer operating in the IR, Vis and UV regions, allowing to study multiple species simultaneously and yielding total- and partial column abundances above the sites.

(b) Research

- Laboratory spectroscopic studies in support of remote sensing experiments (absorption cross-sections and absolute intensities).
- Laboratory spectroscopic studies in support of global warming issues.

(c) Participation

- in the Belgian ESAC (Experimental Studies of Atmospheric Changes), the main objective of which is to contribute inputs in support of the Montreal and Kyoto Protocols (collaboration with IASB, IRM and ULg)
- in the ACE (Atmospheric Chemistry Experiment) project of the Canadian SCISAT-1 satellite mission and co-ordination of the Belgian contributions.
- in the IASI project of the European EUMETSAT mission on board the future METOP satellite

The Laboratory of Plant Ecology of the University of Antwerp

(a) Observations

During the past years regular, but not continuous measurements of UV-B were made at the University (Wilrijk/Antwerpen) using an Optronic OL754 spectro-radiometer, last calibrated in 1998. Due to technical problems with these measurements, they have not been included in any data-network. The measurements have been discontinued and it is as yet unclear whether they will resume.

(b) Research

The laboratory of Plant Ecology of the University of Antwerp has been involved in UV-B research from 1992 to 2000. The main objectives were to describe and model the impact of increased UV-B levels on the growth, physiology and productivity of crop plants. During the first years bean and rye were studied both in growth chambers using artificial light and in greenhouses of different UV-transmitting Plexiglas. In these studies differences of 10-20% in UV-B were used. Since 1997 the attention focused on grassland species. The sensitivity of 6 economically important grass species has been screened in a greenhouse study. The results indicate huge differences between the species. Some are seriously damaged by ambient UV-B doses while others are positively affected by these same doses. Both total growth and plant morphology are influenced by UV-B, but not always at the same time indicating the existence of a photo-morphological response to UV-B. In 1999-2000 the interactive effects of different UV-B levels with enhanced CO_2 were studied. Ambient UV-B increased the positive effect of CO_2 on growth of different grass species and of white clover. Furthermore the effects of UV-B on competitive interactions between grass and white clover were investigated. The results showed that current UV-B levels have only photomorphogenic effects on both species, but the resulting changes in biomass allocation can nonetheless influence competitiveness and thus result in reduced growth of some species.

Original key results

The evolution of Ozone at Uccle

Over Uccle the total ozone content has decreased by 1.2 +/- 0.6 % per decade during the period August 1971 - December 2001. This negative trend is mainly due to decreasing ozone concentrations in the stratosphere during the winter/spring period, as observed from the results of the ozone soundings since 1969. The troposphere shows an increase in ozone concentrations**.**

Jungfraujoch long-term observations

- Since 1986, monitoring of the vertical column abundances of HCl and $ClONO_2$, which are the main **inorganic Cl_y reservoirs** in the stratosphere; their sum shows that the rate of increase of Cl_y has progressively slowed down during the mid-1990s, and has stabilised since about 1997, in response to the production regulations on O_3-depleting substances outlined in the Montreal Protocol and its Amendments and Adjustments. Ongoing measurements should provide indications regarding a statistically significant rate of decrease of Cl_y following this stabilisation.
- Monitoring of the evolution of anthropogenic **chlorine-bearing source gases** such as CFC-12 and HCFC-22 demonstrates the efficiency of the amended Montreal Protocol upon regulated versus unregulated ozone-depleting compounds.
- The **O_3 column** monitoring above ISSJ from 1984 to 2001 shows an average decrease of (-0.25 ± 0.12) % per year; the large uncertainty results from the strong perturbation that resulted from the Mt. Pinatubo eruption in 1991 and affected the stratospheric ozone layer during 3 to 5 years.
- The vertical column monitoring of the most abundant **NO_y compounds** (HNO_3, NO_2, NO, $ClONO_2$) shows no statistically significant change in their total stratospheric loading. However, NO_2 reveals a statistically significant rate of increase of (0.6 ± 0.2)%/yr which is commensurate with similar studies at southern mid-latitudes.
- The continued, although slowing rise of the **inorganic fluorine concentration** HF + COF_2) in the stratosphere, contrary to the decrease of chlorine. At present, the observed rate of change is in poor agreement with model predictions and correlative observations.
- Determination, from the mid-1980s to present, of the rates of increase of the major **radiatively active gases** that are to be regulated by the Kyoto Protocol: CO_2 (mean 0.41%±0.01% / year), CH_4 (slowing down from 0.74%/year in 1987 to 0.1%/year in 2000), N_2O (mean 0.30%/year), SF_6 (slowing down from 14%/year in 1987 to 5%/year in 2000).
- **Tropopause heights** appear to have risen during the eighties, and lowered in the nineties. This may correlate with changes in the radiative balance in the atmosphere. The tropopause changes may also explain observed differences in the rates of change of N_2O concentrations at sea-level versus total column trends; they may also correlate with the slowing in the nineties of the negative total ozone trend that was observed in the eighties. Has a recovery of ozone been observed after 1994 ? The question whether this signature is due to inter-annual variability or to a steady trend will be answered by extending the times series in the future.

UV spectral irradiance measurements at Uccle

Having acquired now about 11 years of UV spectral irradiance data, a UV climatology has been developed. The key factors that influence the UV dose at ground level are the occurrence of clouds and the amount of ozone: their impact has been studied. Because of the large variability of these factors, the available time series of UV data appears to be too short to detect a possible UV trend in a reliable way.
An operational **UV index forecasting procedure** has been developed and implemented: UV Index forecasts are now disseminated daily to the public in the late spring and summer months.

Laboratory data

The molecules for which new or more accurate spectroscopic data (absorption cross-sections, line positions and intensities) have been obtained are: O_2 and its collision complexes O_2-X with X=N_2, Ar, or O_2 itself), NO_2 and its dimer N_2O_4, H_2O and its isotopomers HOD and D_2O, C_2H_2, OCS, HOCl, and HCFC-22 and HFC-152a.

Progress in instruments, data analysis and interpretation

New climatological models have been developed for particular purposes, e.g., for O_3, based on the Uccle soundings and local tropopause altitudes, for NO_2, based on the synergy between satellite and ground-based data and models, and for HF, HCl and CH_4, based on HALOE satellite data.

The development and quality assessment of the GOME BrO product

The development of a correlative data base for ENVISAT

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BULGARIA

1. Ozone monitoring

Total ozone

One of the goal, outlined in the Recommendations of the fourth meeting of the Ozone Research Managers is the systematic measurements, which provide the basis for understanding the ozone regime, its trends and validation the effects of the measures requested by the Montreal Protocol.

In Bulgaria, the first total ozone measurements were initiated to the early 1960s, under the supervision of Prof. Dr R.D. Bojkov. Germany carried them out using Dobson spectrophotometers #64 provided for about 5 years. After a few years interruption Russian filter ozonometers started to be used in the Bulgarian National Institute of Meteorology and Hydrology. In 1998 with the financial support from WMO two Russian ozonometers M-124 were renovated and calibrated at Main Geophysical Observatory - St. Petersburg. The measurements at only one station (NIMH-Sofia) could be maintained.

The comparison between the monthly variations of the total ozone over Sofia for 2000 and 2001 is presented at Fig.1.

The monthly variations of the total ozone over Sofia for 2000, compared with those ones over Potsdam and Rome are presented at Fig.2.

All data are being sent every month to the WMO World Ozone and UV Data Center operated by the Canadian AES in Toronto.

Vertical Ozone Distribution

In the period 1983-1992, balloon ozone soundings were released once a week at the NIMH-Sofia. For that purpose were used ozonesondes OSE - manufactured in the former German Democratic Republic. The activities were interrupted largely due to financial difficulties resulting from transition to market economy. From May 2001 a Vaisala DigiCORA III - a PC based radiosounding system for measuring pressure, temperature and humidity has replaced the Russian radiosounding system. The present financial status doesn't allow us to expand the measurements of the ozone vertical profiles with the above-mentioned Vaisala system, because of the expensive additional equipment (ozone sensors, special balloons, etc.).

UV-radiation Monitoring

At the present moment we do not have a modern spectral UV-radiation monitoring. Such kind of regular measurements are very desirable to be developed in our country, but again there is a shortage of funds.

Figure 1

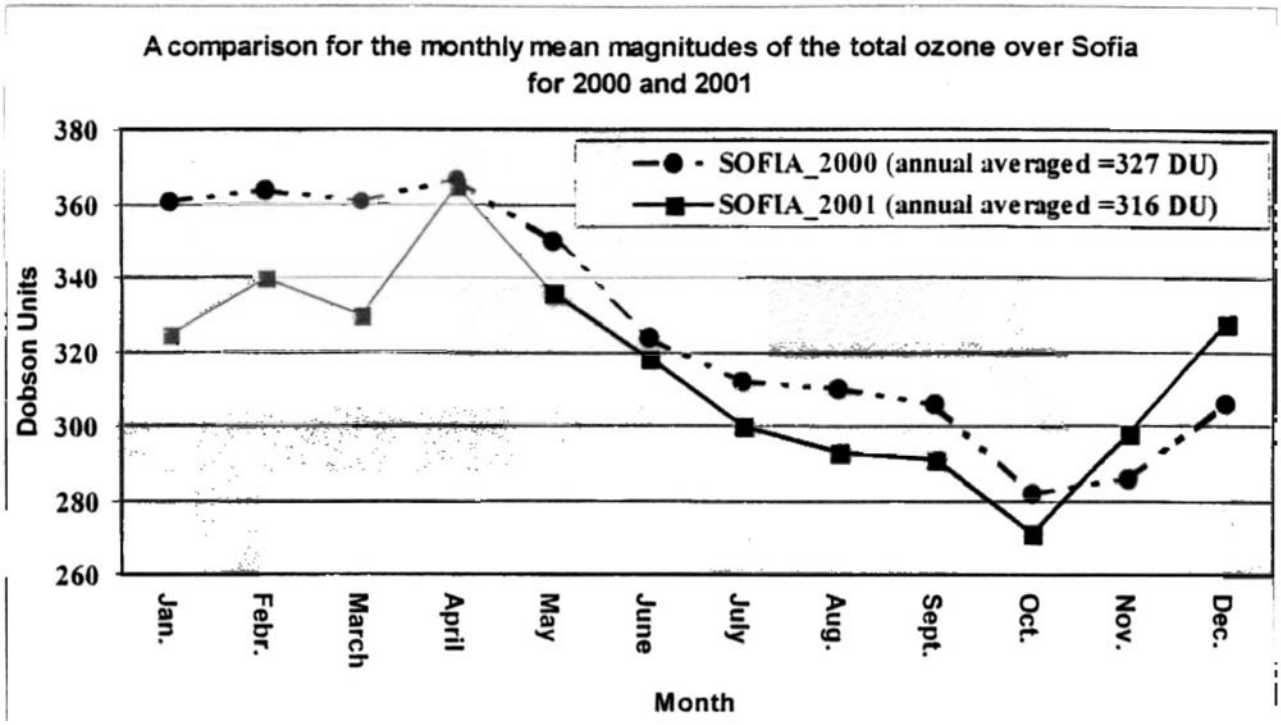
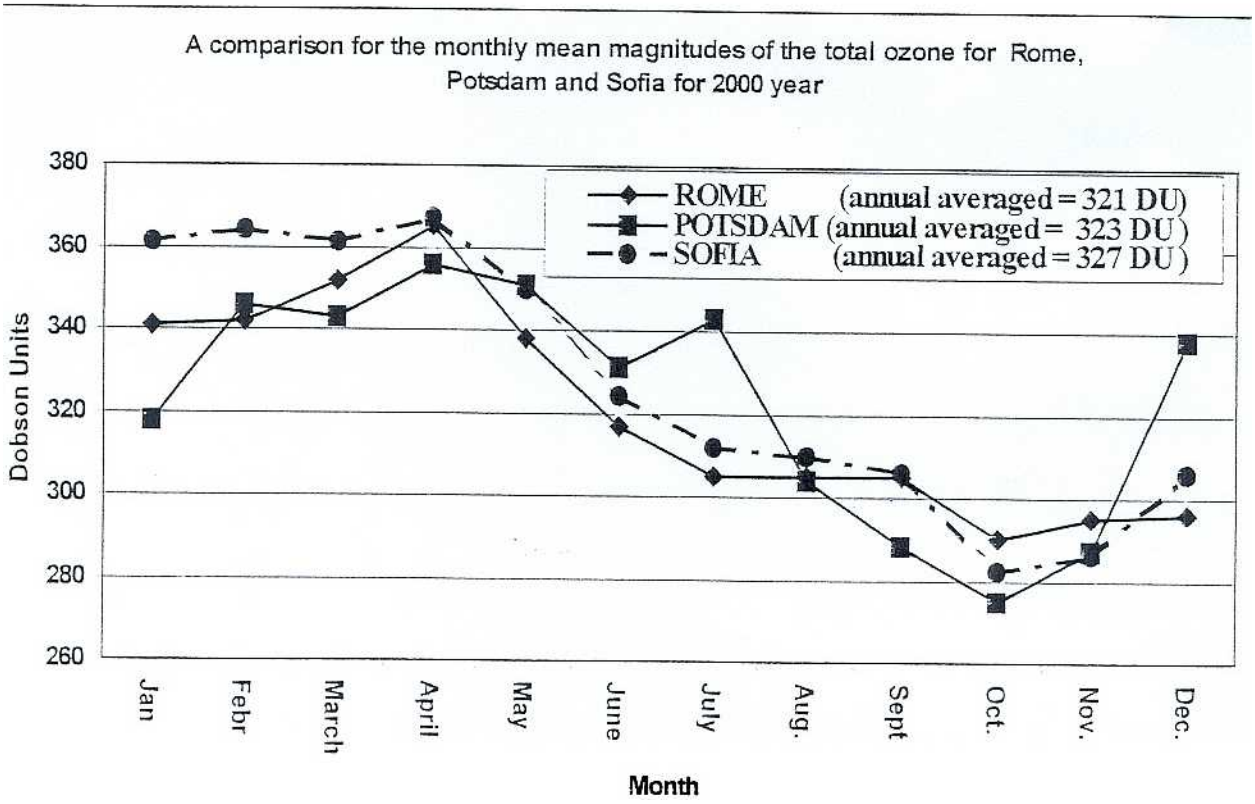


Figure 2



CANADA

The government department in Canada with the responsibility for atmospheric ozone research is the Meteorological Service of Canada (MSC). Its ozone and UV monitoring program is based on twelve sites where Brewer spectrophotometers are operated; ozone sondes are flown at least weekly from six of these sites. The Brewer instruments are programmed to make total ozone measurements on the sun and/or moon and on the zenith sky. The Brewers also make Umkehr measurements of the ozone vertical profile and spectral scans of the horizontal UV irradiance. Near-real time total ozone data is used with the Canadian Weather Prediction model to generate public forecasts of the UV-index; real time UV scan data are used for public information and validation of the UV forecasts. The raw data from the Brewers are processed in the Brewer Data Management Centre, which is also used to process data from several Brewer instruments operated in other countries. The Canadian sonde data as well as ozone and UV data from the Brewers are archived and made available to all users through the World Ozone and UV Radiation Data Centre(WOUDC).

Toronto is the WMO/GAW Brewer Ozone Calibration Centre. The reference is a group of three Brewers that are characterized regularly and taken approximately every two years to a high altitude station (Mauna Loa) in order to track their extra-terrestrial readings; except for these trips they remain in Toronto. Most Brewer calibrations are done on site by bringing another Brewer to the site and making simultaneous measurements there. The other Brewer should be one of three 'Travelling Standards' that are compared at least twice per year against the reference group in the Toronto. Besides maintaining the reference and travelling instruments and a Dobson spectrophotometer, the Calibration Centre continues work on ozone metrology such as the relationships between ozone measurements made at different wavelengths and with different viewing geometries from the ground or space and the effects of temperature on ozone measurements. A double as well as a single Brewer is operated permanently by the MSC at the NDSC Mauna Loa station.

The MSC operates the WOUDC on behalf of the WMO. The availability of all types of data from the WOUDC and their value depends to a considerable extent on the prompt submission of data from those agencies throughout the world that make ozone and UV measurements. It is a pleasure to report that these data submissions have become highly satisfactory. There are minor exceptions such as the lack of some ozone sonde data sets and spectral UV data from some countries in Europe. However, the current volume of spectrally- resolved UV data in the WOUDC is approximately 340 station-years, which may be more than 75% of what could be made available. During the past three years the WOUDC has moved towards making products that assist the originators and users of UV and ozone data with quality control. The center now accepts ozone and UV data in near real time and posts current maps of column ozone obtained from current ground-based and satellite instruments. Daily hemispheric and global maps are available for all periods during the past forty years. Also various forecasts maps of ozone (at present KNMI, NCEP and MSC) are posted on the site.

The Stratospheric Ozone Observatory at Eureka (80°N), established in 1992, is a contribution from Canada to the Network for the Detection of Stratospheric Change(NDSC). The measurement program there is the result of extensive international collaboration, especially between the government agencies of Japan, Canada and Ontario. The instruments include Raman and Rayleigh lidars for measurement of ozone, water vapour, density and aerosols, FTIR spectrometers both for atmospheric thermal emission and for solar and lunar occultation, and various UV/Vis spectrometers including modified Brewer spectrometers. The operations at the Eureka observatory will be curtailed during the summer of 2002. The Lidars and FTIR spectrometer will however be kept serviceable in the building for 2 years so that their operation can be resumed if alternative funding for the site can be found. The column ozone asnd UV measurements will be continued from the Eureka base camp and Eureka will continue as one of the six Canadian ozone sonde stations. There is a complementary NDSC site for lidar ozone measurements at York University in Toronto. Another arctic location where ozone is measured is

the Canadian GAW station at Alert. This has the highest latitude, 82.50°N, of all sites where concentrations of halocarbons are monitored.

The Canadian Space Agency contributes to ozone research by funding satellite projects such as MOPITT, the OSIRIS instrument on the Swedish Odin satellite and the Atmospheric Chemistry Experiment (ACE). These are led by scientists from Canadian Universities, respectively of Toronto, Saskatchewan and Waterloo. The Canadian numerical weather prediction model is being modified to assimilate the tropospheric carbon monoxide data from MOPITT. Odin was launched in March 2001 and the OSIRIS spectrometer has been producing limb radiance spectra since it was commissioned in August 2001. Preliminary retrieved data on ozone and NO2 vertical profiles have been developed. These have exceptionally high vertical and spatial resolution. ACE, which is the most recently commissioned, will make occultation measurements with an infrared Fourier transform spectrometer (FTIR) and with a spectrometer operating in the UV/visible wavelength range. It is scheduled to fly early in 2003. The data will include concentrations of at least ten trace gases as well as characteristics of polar stratospheric clouds. The science team of ACE reflects collaboration with teams in Belgium, France and the USA.

The Canadian Middle Atmosphere Model (CMAM) has been developed by the collaboratively by scientists from most of the universities mentioned in this summary, coordinated at the University of Toronto, and by MSC. It is a T47L65 climate model with interactive dynamics, chemistry and radiation extending to an altitude of 95km. It is currently being run with the same 3-DVAR as used in the Canadian NWP to assimilate meteorological data up to 30 km. Current goals are to develop univariate and then multivariate assimilation of profile ozone data, possibly from OSIRIS.

Canada supports the Global Ozone Observing System through specific initiatives such as the Seventh Biennial WMO Meeting of Experts on the Brewer Spectrophotometer Operation and Calibration in to be held in Toronto in September 2002. During the past 3 years the MSC and Health Canada have developed a special program to educate children in care with regard to UV exposure. It is called the “Children’s UV-Index Sun Awareness Program and was initially directed to primary school children but now includes high schools as well. Part of the program is WEB based and involves the students making and reporting measurements.

Addresses:

World Ozone and UV Data Centre	www.msc-smc.ec.gc.ca/woudc/
Maps and real time measurements	http://exp-studies.tor.ec.gc.ca
Childrens UV-Index Sun Awareness Program	www.msc-smc.ec.gc.ca/uvindex

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CHILE

In Chile, several different scientific groups are engaged in the investigation of ozone depletion and ultraviolet radiation. The majority are studying changes in incident UV using several types of instruments, mostly broad band. Table 1 lists the instruments used to measure ultraviolet radiation, column ozone, ozone concentration with altitude. All these instruments are associated to scientific groups belonging to universities.

Table 1.- UV and ozone measuring instruments in Chile

Station	University	Geo. Coord.	Instruments	Period of observations
Arica	Atacama	18S;70W	Solar Light 501	1998 -
Antofagasta	Santiago	23S;70W	Solar Light 501	2000 -
Santiago	Santiago	33S;70W	Solar Light 501	1999 -
	De Chile		GUV 511	1995 -
Valparaíso	Federico Santa María	33S;71W	Solar Light 501	
Valdivia	Austral	39S;73W	GUV 511	1995 -
			SUV 100	1997 -
Punta Arenas	Magallanes	53S;71W	Brewer MkIV 068	1992-2000
			GUV 511	1993 -
		51S;72W 53S;72W 53S;70W 55S;68 W	Solar Light 501 (4) [1] Puerto Natales [2] Punta Arenas [3] Puerto Porvenir [4] Puerto Williams	1997 -
			Ozonesondes	Campaigns in spring time 1995-1996-1997-2001
			Brewer MkIII 180	2002 -

The GUV 511 instruments in the various stations are calibrated annually with a standard instrument sent from the factory and are part of the project Latin American, “Enhanced ultraviolet-B radiation in natural ecosystems as an added perturbation due to ozone depletion”. This project is directed by Maria Vernet (Scripps Institution of Oceanography, La Jolla, California) and financed by the Inter American Institute for Global Research, (IAI), The database of the GUV instruments are stored and maintained by each group, also exists an archive of all data from all stations.

Both the Brewer and the SUV spectroradiometers possess self calibration mechanisms which are constantly checked and updated by the respective scientific group. Additionally, the Brewer is calibrated monthly with an external lamps to verify the stability of the measurements. The instruments Solar Light of the group of the University of Magallanes are calibrated once per year with the instrument Brewer.

Results of Studies at Punta Arenas Chile (Lat. 53S, Long. 70W).

The Brewer instrument No. 068 was operational at Punta Arenas from May 1992 until November 2000 thanks to a cooperative agreement between INPE, Brazil (Brazilian National Institute for Space Research) and UMAG,Chile (University of Magallanes). The Figure 1 shows the variation of the ozone column measured by Brewer from 1992 until 2000. Part [a] reefers to the daily averages (red line refers to the running average, n=30). The horizontal line marks the rim of the threshold of

the “Antarctic Ozone Hole” (AOH), and is defined as ozone values less than, or equal to, 220 DU. Part b. of Figure 1 is the monthly mean which shows an ozone depletion of 3.2% per decade, a rate which is in accord with the latest results published in WMO-98 (Rep. 44) for latitudes similar to Punta Arenas.

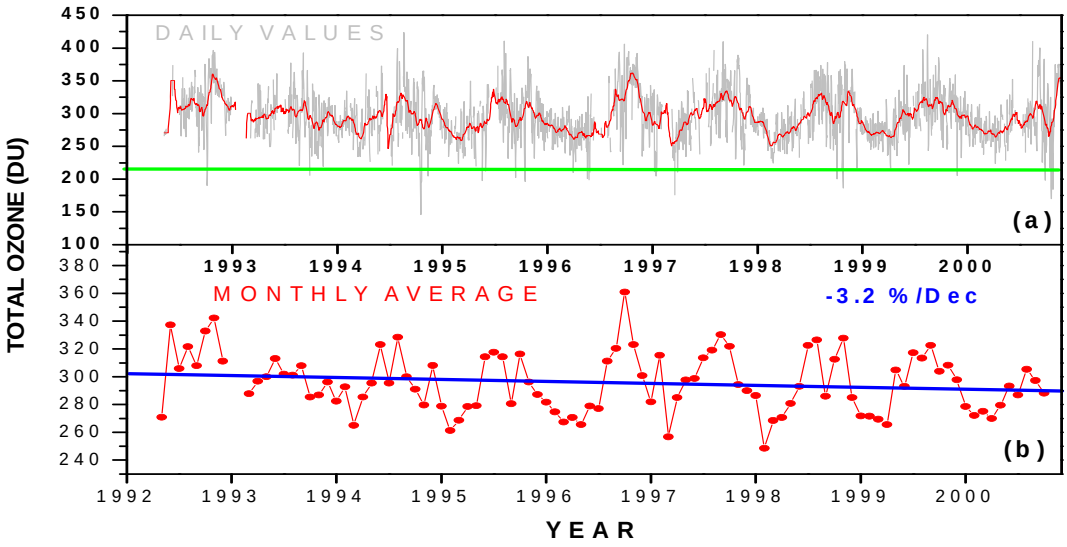

Fig.1 .- Daily and monthly mean values of total column ozone over Punta Arenas Chile 1992-2000 obtained with Brewer spectroradiometer (No 068).

For the past decade or more, the Antarctic Ozone Hole has passed over Punta Arenas with varying intensity for varying periods of time. Table 2 shows several examples of these ozone depletion events measured with the Brewer instrument at Punta Arenas. In the construction of Table 2, an “event” was defined as ozone values less than, or very close to, 220 DU. The largest depletions occurred on 17 October, 1994, with 145.8 DU, on 22 October 1998, with 186.2 and recently on 12 October, 2000, with 170 DU. During the period 1992-2000 there were other instances of ozone depletion which did not reach the threshold of 220 DU, but were, nevertheless, important, considering historical values of column ozone for Punta Arenas. For example, Table 3 shows a series of ozone depletion events for the year 2000. In this case a climatological reference mean was calculated from TOMS overpass data from 1978-1987 and an ozone depletion event was defined as a depletion of 20% compared to the climatological mean, which for August is 321.4±35.8, for September, 324.6±45.7 and October 336.0±45.7. During the year 2000, seven significant ozone depletion events were measured which comprised 17 days. For Punta Arenas, the year 2000 was a particularly active year for the Antarctic Ozone Hole.

Table 2. Ozone depletion events over Punta Arenas, Chile period 1992-2000

Events	Year	O3 Low DU	Date (dd-mm)	Duration Days
1	1992	190.3	05-10	3
2	1993	205.9	27-09	1
3	1994	145.8	17-10	6
4	1995	202.1	10-09	1
5	1995	196.5	13-10	3
6	1996	221.6	18-09	1
7	1997	221.5	11-11	1
8	1998	200.3	30-09	2
9	1998	186.2	22-10	3

10	1999	206.1	21-11	1
11	1999	233.2	05-12	1
12	2000	225.6	10-09	1
13	2000	198.4	21-09	3
14	2000	218.0	07-10	2
15	2000	170.0	12-10	4
16	2000	181.1	18-10	3

Table 3.- Low ozone events to Punta Arenas, Chile year 2000.

Events	Date	Ozone (DU)	Decrease %
1	Aug. 22	243.9	24.1
	Aug. 23	243.2	24.3
2	Sept. 11	225.6	30.5
3	Sept. 19	223.1	31.2
	Sept. 20	222.7	31.3
	Sept. 21	198.4	38.9
4	Sept. 24	240.9	25.8
	Sept. 25	252.7	22.1
5	Oct. 6	233.4	30.5
	Oct. 7	218.0	35.1
6	Oct. 11	188.4	43.9
	Oct. 12	170.0	49.4
	Oct. 13	212.4	36.8
	Oct. 14	208.0	38.0
7	Oct. 16	225.0	33.0
	Oct. 17	237.0	29.5
	Oct. 18	180.0	46.4

In order to compare the present with historic ozone levels, in figure 2 we compare the mean monthly climatological values for Punta Arenas from TOMS overpass data for the period 1978-87, represented with the hatched area (average, plus and minus one standard desviation), a period considered “normal”, that is, without the influence of the Antarctic Ozone Hole.

Figure 2 shows the monthly means obtained by the Brewer instrument from the daily means for [a] the period 1992-2000 and [b] the year 2000. It can be seen from this figure that the average values of each month within the period 1992-2000 are less than the climatological mean, especially for the months of September, October and November. It is also important to note that the values between November and April are lower than the climatological mean. This observation is being studied in greater detail. For the year 2000, the average monthly means are considerably lower than the climatological average, which would seem to indicate a pronounced deterioration in the ozone layer over latitudes similar to Punta Arenas.

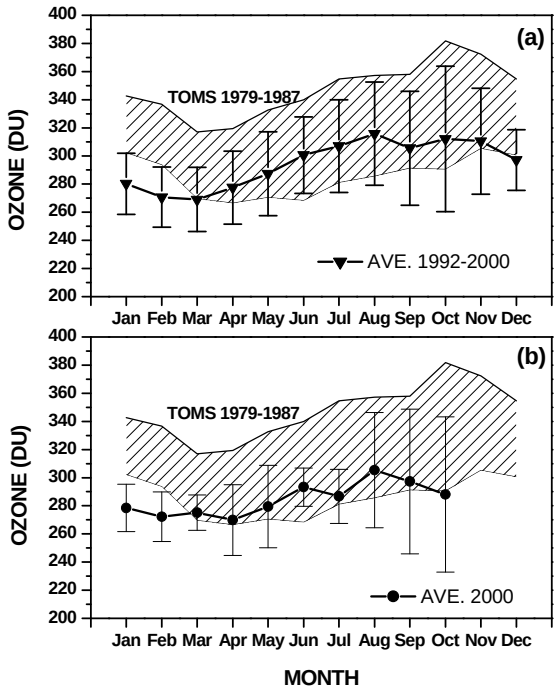

Fig. 2.- Ozone monthly averages for 1992-2000 [a] and 2000 [b], for Punta Arenas. The hatched area represents the monthly climatological averages derived from TOMS data, (average, plus and minus one standard deviation) shown for reference.

Figure 3 shows the average monthly values of Damaging Ultraviolet Radiation (DUV; UVA and UVB). These measurements are taken daily at solar noon. The observed increase is 12.5% per decade.

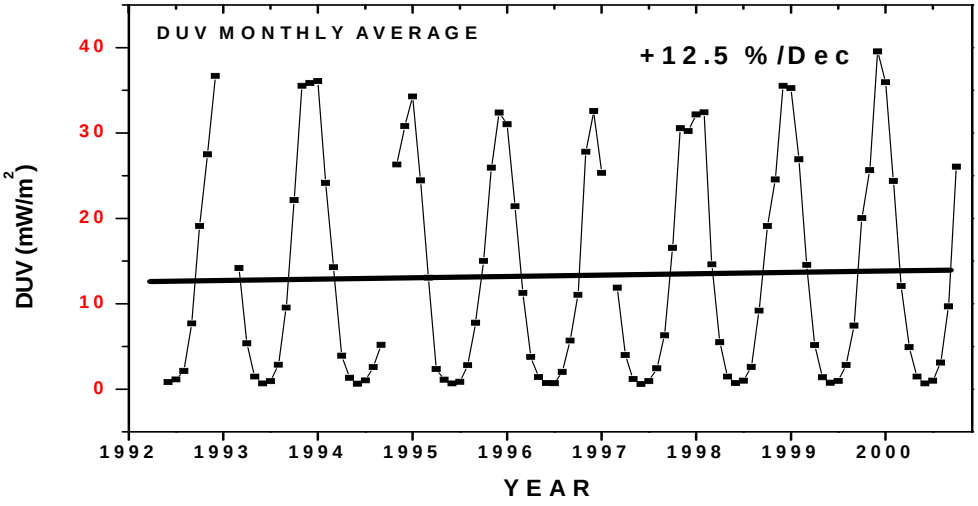

Fig. 3.- Average monthly of ultraviolet radiation (DUV) for Punta Arenas 1992-2000.

The field campaigns of ozone sonde launchings at Punta Arenas have clarified that the greatest stratospheric ozone destruction takes place between 12 and 30 km. (Kirchhoff, V.W.J.H.; Casiccia, C.; Zamorano, F.; Y. Sahai; Valderrama, V. Observations of the 1995 ozone hole over Punta Arenas, Chile, J. Geophys. Res., vol. 102, no D13:16109-16120, July 20, 1997.)

Current Activities

- Complete the installation of a newly purchased Brewer MK-III, No 180, in Punta Arenas. This will allow the continuation of the data set initiated by the Brewer 068 in 1992. The new, instrument will be operated by “The Laboratory for Monitoring Ozone and Ultraviolet Radiation” of the University of Magallanes which will perform all calibrations, archive and analysis of the measurements. This Brewer will contribute greatly to the study of the evolution of the Antarctic Ozone Hole and other atmospheric phenomena over the “Southern Cone” of South America and the Southern Hemisphere.

- The network of broadband GUV instruments will continue in operation until at least 2005, funded by the IAI. All instruments will be calibrated annually.

- Plans are underway to initiate an extensive network of instruments to measure UV

Plans for the Future

We would like to carry out the following activities but funds are needed.

- Construct a network of instruments to measure ozone and ultraviolet radiation along the total length of Chile using the country’s unique geographical features and scientific installations, with two or three additional Brewer Spectroradiometers in the northern and central regions.

- Implement a long term program of continuous balloon sonde measurements to establish a profile of stratospheric ozone concentrations over Punta Arenas.

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COLOMBIA

1. UV MEASUREMENTS

Each station has UV Biospherical Spectroradiometrers GUV 511, available with multi-channel filter which provides information on region of the spectrum 290-700 nm, for UV-B, UV-A and Photosyntetically Active Radiation (PAR) wavelengths. The instruments measure in fractions of seconds for each region of measurement and integrate them in intervals of a minute. The data is available since 1998 for each one of the following stations and parameters:

Station	*Latitude*	*Longitude*	*Height*
Riohacha	11° 32′ N	72° 56′ W	4 m
Santa Fe Bogotá	04° 42′ N	74° 09′ W	2546 m
Pasto	01° 11′ N	77° 18′ W	2580 m
Leticia	04° 33′ SUR	69° 23′ W	84 m
San Andrés Isla	12° 35′ N	81° 42′ W	2 m

Parameters:
UV-B 305 nm
UV-B 320 nm
UV-A 340 nm
UV-A 380 nm
Photosyntetically Active Radiation PAR
Integrated UV-B 290-320 nm
Integrated UB-A 320-380 nm

2. OZONE MEASUREMENTS

In Colombia, regular measurements for ozone vertical profiles have been since November of 1998 in ELDORADO-Bogota meteorological station with ozonesondes. Measurements of total ozone are derived from the integrated ozone obtained to ozonosondes and satellite information or derived data from the UV radiation.

2.1 Ozonesonde

The ozonesonde corresponds to the electrochemical concentration cells category (ECC) produced by Vaisala and called ozonesonda OR. On this ozonesonda the sensor is comprised of ozone, the interface of the sensor of ozone and the radiosonde. The ozone sensor unit is a Model 6A ECC

- Ozone vertical profile

The monitoring program is the next:
Frequency: monthly
Day: the last Thursday of the month
Hour: 12:00 local hour
Station: ELDORADO-Bogotá
Parameters: Pressure, Ozone, Height, Temperature, Relative Humidity, Virtual temperature, Dew Point, L Rate and Ascensional Rate.

- Total column ozone

The monitoring program is the next:
Frequency: monthly

Day: the last Thursday of the month
Hour: 12:00 local hour
Station: ELDORADO-Bogotá
Parameters: Integrated Ozone, Residual Ozone and Total Ozone.

2.2 Total ozone

In absence of spectral photometer, the total ozone measurements are obtained by means of two methods: data derived from UV measurements and satellite-based measurements.

- Total ozone derived uv measurements

Station: Bogotá, Leticia, Riohacha, Gaviotas y San Andrés
Monitoring Program: Hourly
Methods of measurement: Total ozone based on the measurement of UV at 305 and 320 manometers.
Physical Model: Lambert-Beer

- satellite-based measurements

With the information TOMS/SBUV satellite instruments of the NASA, has been possible to obtain daily information of total ozone for grid points in Colombia for spatial grid 1°X1.25° latitude/longitude, since November of 1978.

3. INVESTIGATION

3.1. UV index

Based on the UV spectral range of 305-340 nm measured, UV index were determined to express the degree of danger to the solar exposition around the noon.

3.2. Models to calculate total ozone based on UV measurements

In absence of spectral photometer to measure total ozone concentration in the atmosphere, the physical-mathematical model of Lamber-Beer Law and tropical multilineal relationships applied to atmosphere of the McClatchey model, are used.

3.3. Models to calculate the aerosol quantity in the atmosphere upon Bogota

Model to obtain the aerosol quantity in the atmosphere as a measured of global solar radiation received by an horizontal surface for clear days, is based on the model suggested by Angstrom known as “turbidity coefficient β” which calculate suspended aerosols in the atmospheric column.

3.4. Ozone variability and trends on Colombia

Studies of the ozone variability and trends based on satellite data set. The atmospheric variations are classified in four categories: a) short time, related to the diurnal variations, variations in the ultraviolet radiation, dynamic variations and weather systems; b) seasonal or annual cycle; c) interannual related to the Quasi Biennial Oscillation (QBO) and El Niño-Southern Oscillation (ENSO) cycle and d) decadal, dependent of the 11-year solar cycle.

FUTURE ACTIVITIES

4.1 Monitoring

To carry out campaigns of measurements of the vertical profile of the ozone in other Colombian zones.

4.2 Investigation

The investigations will be oriented to develop a model of forecast national UV index and to improve the knowledge of the stratospheric processes and the roll on the climate change.

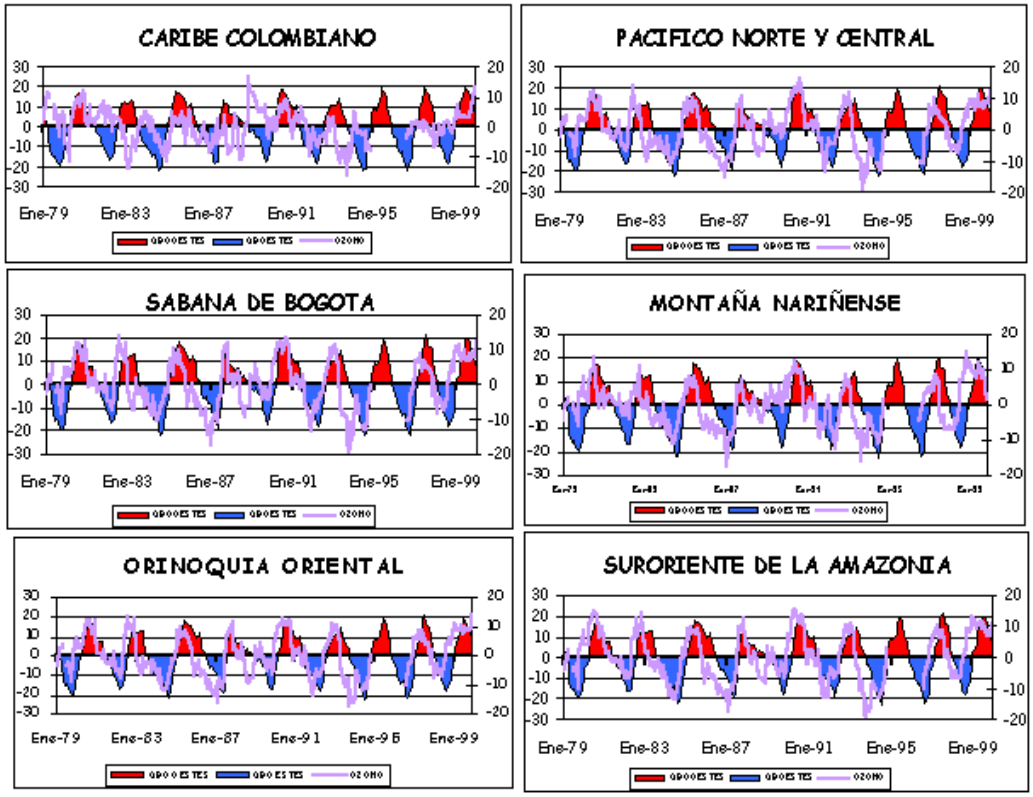

Fig. 1. Interannual variation of total column ozone of the mean regions of Colombia, obtained from satellite measurements with Total Ozone Mapping Spectrometer (/TOMS NASA) and zonal wind anomalies at 30 hPa.

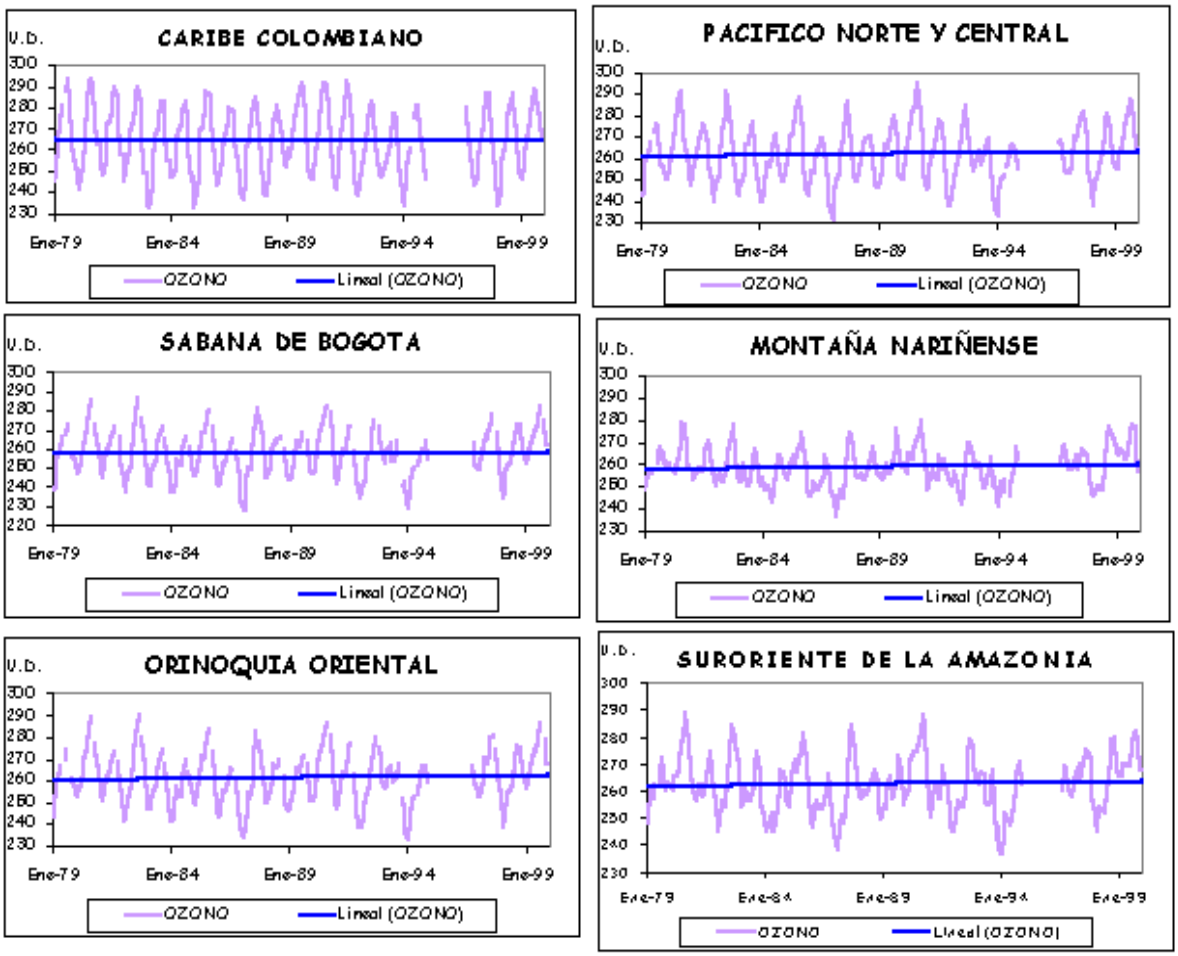

Fig. 2 Trend of the total column ozone in the mean regions of Colombia, obtained from satellite measurements with Total Ozone Mapping Spectrometer (/TOMS NASA.).

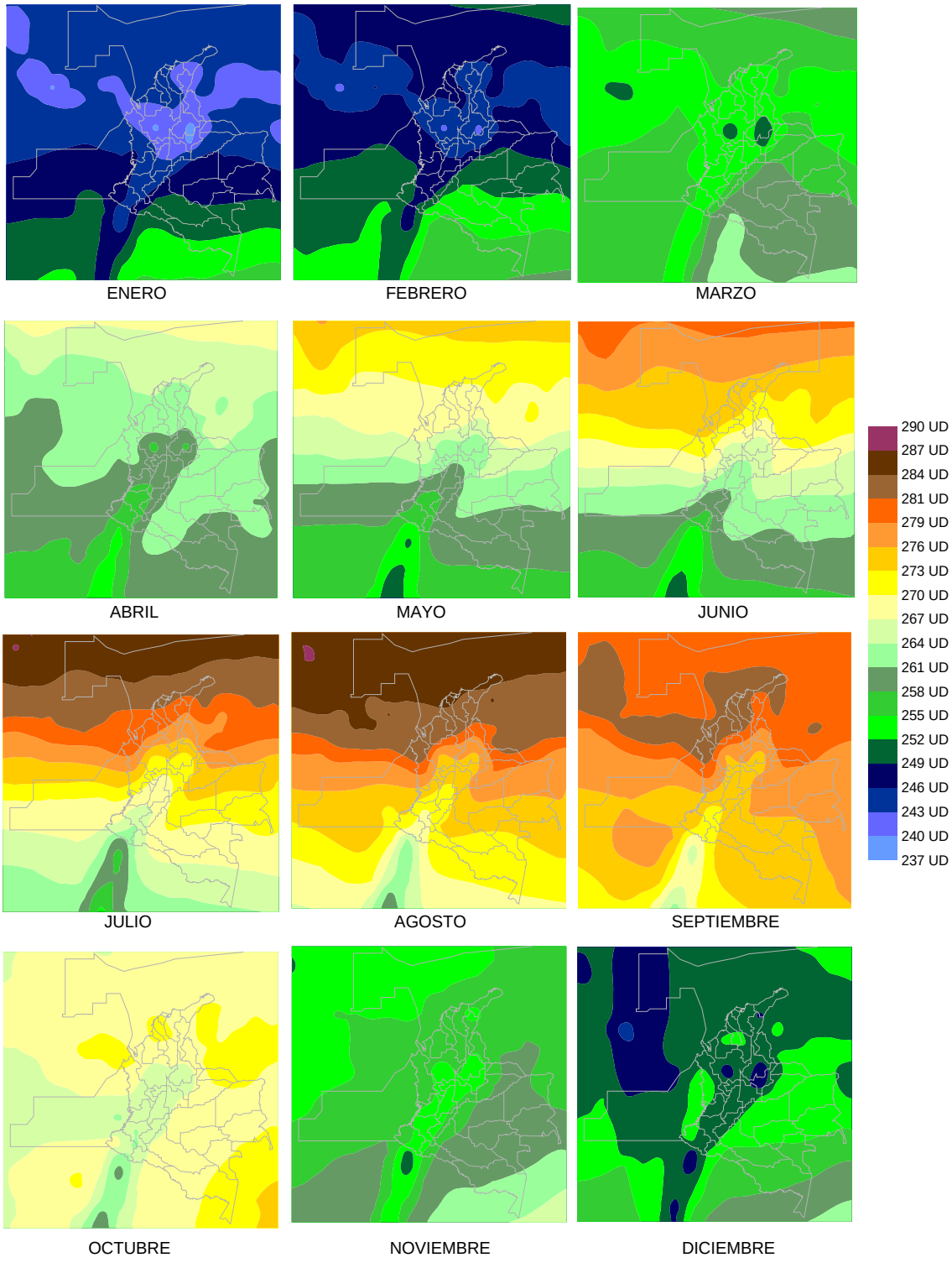

Fig. 3. Seasonal variation of the total column ozone in Colombia, obtained from satellite measurements with Total Ozone Mapping Spectrometer (/TOMS NASA).

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COSTA RICA

The research activities on UV-B radiation are limited to the Meteorology department of University of Costa Rica and the Physics department of the National University. Besides, the Costa Rican Meteorological Institute has in operation a solar radiation monitoring network consisting of 60 silicon radiometers that registers Global radiation. At University of Costa Rica, the Physics department has registers total Ultraviolet Radiation (A+B), and UV-B for the last 5 years. In regards to Stratospheric Ozone, no direct measurements have been done in Costa Rica. Nevertheless in the future, the country has the willing of measuring it.

The Physics Department of National University, has issued several papers through Geophysics Magazine from the Pan-American Institute of Geography and History:

- Annual Variation of the Ultraviolet Global Solar Radiation in Costa Rica
- Experimental Measurements of the Ultraviolet Radiation B in Costa Rica
- Measurements of Spectral components of the Radiation UV-to and UV-B.
- Variation of the Ultraviolet Global Solar Radiation with the Geographical altitude.

- Short measuring campaigns of Radiation global and Ultraviolet-B, they have been carried out in the following locations:
    - · Heredia (10º02´ N, 84º09W, 1,050 mts)
    - · Volcán Irazú (9º59´ N, 83º50W 3,400 mts),
    - · Mounts Green of Siquirres (10º06´ N, 83º26W 34 mts),
    - · Limón (10º00´ N, 83º02W 5 mts)
    - · San Pablo of Turrubares (9º50´ N, 89º19W, 375 mts),
    - · Santa Cruz of Guanacaste (10º16´ N, 85º35W, 54 mts).

- **Date of measuring campaign:**
    - February 1991 to March 1993
    - June 1995 to May 1996
    - January 1996 onwards (At University of Costa Rica)

- **Used equipment:**
    - Global Solar radiation (.295 um up to 2,8 um), Eppley precision black and white, I model 8-48
    - UV Solar radiation solar (.295 um up to .385um) Eppley of precision UV, model TUVR.

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CROATIA

Introduction

UV-B monitoring and research activities in Croatia are conducted by Meteorological and Hydrological Service of Croatia (MHSC) and Geophysical Institute of the University of Zagreb.
Continuous tropospheric ozone measurements are conducted by Meteorological and Hydrological Service of Croatia (MHSC), Rudjer Boskovic Institute of Physics and Chemistry (RBI), Zagreb and Institute of Medical Research and Occupational Medicine (IMI).
Generally, there is continuous cooperation and exchange of information between institutes and research groups. Scientific and research activities are supported by the Ministry of Science and Technology and Ministry of Environment and Spatial Planning.
Total column ozone concentrations are not measured since these measurements are highly resource demanding. Hence, there is no plan in the near future to start these measurements. Data neded for the analysis and research are inferred from web sites that provide free access to satelite data and ground level based stratospheric ozone observations.

Ground based UV-B measurements

Meteorological and Hydrological Service of Croatia and Geophysical Institute carry out continuous measurements of UV-B. At present there are three operational sites – one in Zagreb (GI) operating since mid 1998 (UV-Biometer) and two (UVB Pyranometers) along the Northern part of Croatian Adriatic coast line operating since 1997 and 1999 (MHSC).

Table 1. Currently operating UVB stations in Croatia

Station	Latitude	Longitude	Hight a.s.l. (m)	Operate since	Instruaments
Opatija	45° 20’	14° 19’	5	1997	Kipp&Z., at 306 nm
Umag	45° 27’	13° 32’	10	1999	Kipp&Z., at 306 nm
Zagreb	45° 50’	16° 01’	158	1998	Solar Light

The new UV-B monitoring network is under development and will be established within a national meteorological monitoring network by the end of 2002 (Table 2). Spatial site distribution is given at Figure 1.

Table 2. New Croatian UV-B monitoring network

Station	Latitude (N)		Longitude (E)		Measurements
	deg.	min.	deg.	min.	
Bilogora	**45**	**53**	**17**	**12**	**UVA, UVB**
Zagreb	**45**	**49**	**15**	**59**	**global, direct, diffuse, UVA, UVB**
Parg	**45**	**36**	**14**	**38**	**UVA, UVB**
Pula	**43**	**30**	**17**	**8**	**UVB**
Zadar	**44**	**8**	**15**	**13**	**global, diffuse, UVA, UVB**
Hvar	**43**	**10**	**16**	**27**	**UVB**
Dubrovnik	**42**	**39**	**18**	**5**	**UVB**

Research

The main goal for conducting continuous measurements of UV-B in Croatia is to establish, evaluate and describe the processes that control UV-B levels and develop predictive capability for a short time range. At present, UV-B index forecasting for public for the summer period is under development.
In addition, measurements should encourage and support the analysis and investigation of the effects of UV-B radiation on the terrestrial and aquatic ecosystems as well as human health.

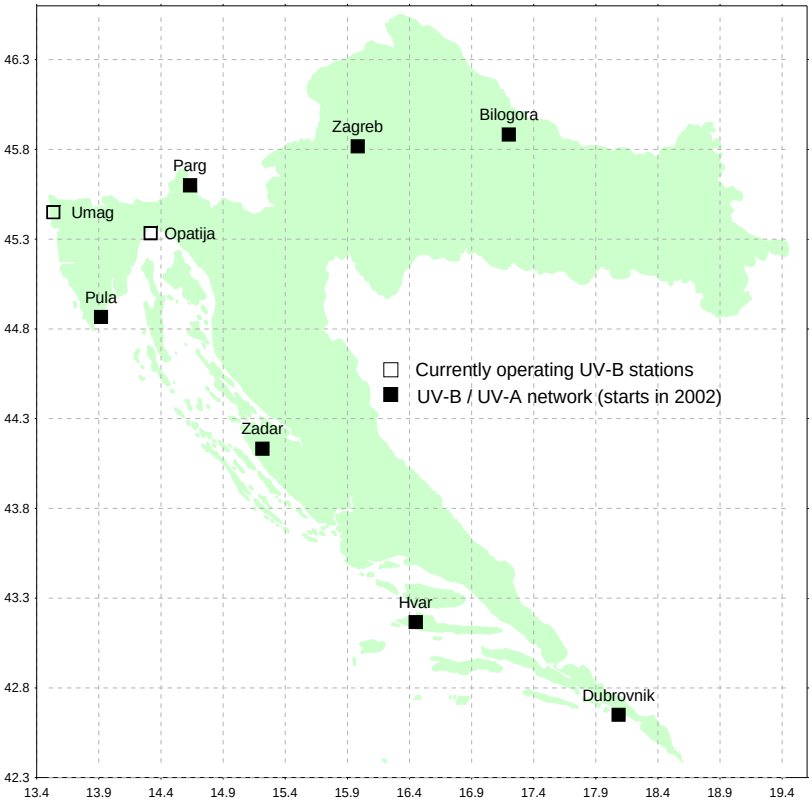

Figure 1. Spatial distribution of UV-B monitoring sites in Croatia

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CUBA

Introduction

The Institute of Meteorology of the Ministry of Science, Technology and Environment of Cuba is the institution responsible for the activities directed to the study of the behavior of the Ozone Layer and ultraviolet Solar Radiation.

The investigations are specifically carried out through the investigation projects:
"Study of the behavior of the Ozone Layer on Cuba" and "Climatology of the ultraviolet solar radiation. Valuation of its potential effects upon health", all in the frame of the National Research Program "Global Changes and the Evolution of the Cuban Environment" that the Agency for the Environment of the Ministry develops.

Program of measurements of the total amount of atmospheric ozone and ultraviolet solar radiation (UV-B)

Measurements of total amount of atmospheric ozone began to be carried out in a regular way in Cuba by mid 1981, using for these purposes filter ozonometers type M-83 and M-124 of Soviet origin. The program of measurements continues until the present, with intervals without measurements during 1984 and from December 1992 until November 1998, due to the lack of ozonometers in the required technical condition. This monitoring program, from 1985 on, was framed as the investigation topic; "Study of the variations of the total amount of atmospheric ozone in the presence of tropical hurricanes", in the Cuban-Soviet collaboration program for the study of the tropical atmosphere and hurricanes, what allowed, in first place, to establish a regular regime of measurements of the ozone layer in our territory, and the development of investigations about the variability of the atmospheric ozone in the presence of tropical hurricanes for our region. The results of this investigations were materialized with the presentation of contributions to the International Symposia on Tropical Meteorology, that were held in Havana (April, 1987) and Obninsk (1991) and the publication of several papers (Gushchin et al, 1987), (Gushchin. G.P, Peláez. J.C et al, 1991).

The program of surveillance of the Ozone Layer continues until present without interruptions and ozonometers M-124 #297 and 192 were calibrated last time in August 1999 at the Main Geophysical Observatory of Russia in Saint Petersburg thanks to the support granted by the WMO.

The program of measurements of the total amount of ozone and ultraviolet solar radiation (UV-B) is in charge of the group of Solar Radiation of the Center of Physics of the Atmosphere of the Institute of Meteorology and is carried out at the station of Havana (23° 10′ N, 82° 21′ W, 50 m) - site of the Institute of Meteorology of Cuba.

The measurements of the total amount of ozone are carried out in manual way and rather through the measurement of direct solar radiation. The processing of measurements is carried out on a PC where they are coded and stored in magnetic support together with the parameters of the meteorological situation corresponding to the day of the measurements. Specialists of the Institute of Meteorology of Cuba developed the data processing and storage computer programs in 1987.

The program of surveillance of the ultraviolet radiation had its beginnings in a program of measurements that was carried out in the station of Havana (23° 10′ N, 82° 21′ W, 50 m) from 1984 to 1985 with the use of a filters instrument developed at the Main Meteorological Observatory in Postdam. Starting on January 30 2002 a program of measurements of the solar ultraviolet erythemal radiation has begun as part of the project "Study of the behavior of the Ozone Layer on Cuba" in collaboration with the Observatory of Solar Radiation of the Institute of Geophysics of the

Autonomous University of Mexico, the instrument used is a Biometer 501 #2853 manufactured by the firm Solar Light.

Together with the measurements of the total amount of ozone and ultraviolet solar radiation the Group of Solar Radiation of the Center of Physics of the Atmosphere of the Institute of Meteorology of Cuba is in charge of a research program for the solar radiation and other related magnitudes in the country. Next we relate the complete program of measurements carried out in the station Havana.

Measurements regime:

1. Direct Irradiance (S)
2. Diffuse Irradiance (D)
3. Global Irradiance (Q)
4. Short wave reflected Irradiance (Rc)
5. Global erythemal ultraviolet Irradiance (UV-B)
6. Photosyntetically Active Radiation (PAR)
7. Net balance of radiation (B)
8. Total content of Atmospheric Ozone (CTO)
9. Sunshine
10. Atmospheric turbidity and optical thickness of the aerosols
11. Temperature of the ground (Ts)
12. Condition of the active surface
13. Cloudiness and condition of the sky

Installed instruments

1. Yanishevski type Actinometer, model M-3
2. Linke Feussner Actinometer, model Kipp and Zonen
3. Yanishevski type Piranometer, model M-80-M
4. EKO type spectral Piranometer, model SBP-801
5. KIPP and ZONEN type Piranometer, model CM-5
6. PAR Piranometer, developed at the INSMET
7. BIOMETER 501 A #2853. –Solar Light
8. Yanishevski type Balanzometer, model M-10
9. EKO type Pirgeometer, model CN-11
10. Sontag type Difusometer (Germany)
11. M-124 type Ozonometer (Russia)
12. EKO data logger, model MP-110

The sampling period for the fluxes of solar irradiance – for all the components, included UVB- is 2 minutes and they are automatically stored into a PC.

Main lines of research

The main lines of investigation embraced in the project “Study of the behavior of the Ozone Layer in Cuba” are directed to the investigation of possible variations of the total amount of ozone in the presence of tropical hurricanes for our region. Equally it is objective of the project to characterize the behavior of the total content of ozone in our region.

With regard to the characterization of regime of ultraviolet solar radiation and in the specific case of the ultraviolet solar radiation of erythemal effect, it is necessary to point out that due to the location of the Havana station (urban type), the program of measurements is directed to the study of the behavior of this component of the radiation flux only for the City of Havana. A no less important

objective of the project is the forecast of the index of UV radiation in several locations of the country that require of this type of information for its socioeconomic importance.

From the instrumental point of view work is in progress in the development of algorithms that allow to use the information of the 3rd filter of the M-124 ozonometers together with filters I and II in the calculation of the optical thickness of the atmospheric aerosols (AOT) in the ultraviolet region of the spectrum.

The project “Climatology of the ultraviolet solar radiation. Valuation of the potential effects upon health” contemplates to evaluate the regime of solar radiation on the national territory and it is specifically directed to the study of the impact of ultraviolet solar radiation upon human health. This project is developed with the participation of specialists in oncology, dermatology, ophthalmology and immunology of several institutions of the Ministry of Public Health of Cuba.

With regard to the V/3 Decision of the Fifth Meeting of the Conference of the Parties of the Vienna Convention for the Protection of the Ozone Layer (Beijing, 29 Nov-3 Dec., 1999), we can inform that Cuba – as is pointed out in all the previously exposed work - continues its measurements program for the Surveillance of the Ozone Layer, and it incorporated since January 30 2002 the monitoring of ultraviolet solar radiation. The project “Climatology of the ultraviolet solar radiation. Valuation of the potential effects upon health” closely links the investigations on the regime of ultraviolet solar radiation with the possible impacts on health and specialists of different medical institutions of the country participate in it, with the objective of being able to apply the results of the investigation in the people's well-being and the security.

The Institute of Meteorology of the Ministry of Sciences, Technology and Environment has specialists qualified enough to be able to extend and to enrich the program of investigations and surveillance of the Ozone Layer and the Ultraviolet Solar Radiation to the region of the Caribbean and Central America. We express by this means our readiness to help in the formation of specialists and the establishment of new stations in this region of the Caribbean and Central America, through international funding institutions as could be GEF (global Environment Facility) that guarantee the financing for the acquisition of instruments and necessary means.

In order to maintain our programs of measurements we also request some financial aid that allow us to be able to calibrate our ozonometers and sensors of ultraviolet solar radiation. This year (2002) we expect to calibrate our ozonometers in the Geophysical Observatory of Saint Petersburg through the assistance of the WMO.

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CZECH REPUBLIC

According to recommendations of the Fourth Meeting of the Ozone Research Managers of the Parties to the Vienna Convention. Geneva 1999 summarized in its Report, mainly in the Decision V/3, the following activities on monitoring and research of atmospheric ozone are being carried out and planned in the Czech Republic.

1. MONITORING

Monitoring of the atmospheric ozone and related parameters (e.g. UV solar radiation) are performed at specialized observatories of the Czech Hydrometeorological Institute (CHMI) as a contribution of CHMI to the Global Atmosphere Watch Program (GAW) of the World Meteorological Organization (WMO). The following monitoring programs have been implemented in CHMI.

Total Ozone

Long-term daily observations of total ozone have been performed at the Solar and Ozone Observatory of CHMI in Hradec Kralove (SOO-HK) with the Dobson spectrophotometer D074 since 1962 and with the Brewer spectrophotometer B098 since 1994. Both instruments are regularly calibrated every 2-4 years towards world and regional standards. Since 1999 D074 has been maintained as a secondary reference instrument for the RA-VI region. Total ozone measurements are stored in the ozone database at SOO-HK and are regularly submitted in monthly reports to the World Ozone and UV Data Center of WMO (WOUDC), Toronto and to several cooperating stations in Europe. More information is available at:
http://www.chmi.cz/meteo/ozon/hk-e.html

Vertical profiles of ozone

Vertical distribution of ozone in the atmosphere is measured with the balloon-borne ozone sondes at the Aerological Observatory (AOPH) of CHMI in Praha. Since 1992 the ECC sondes have been launched three times per a week in January - April. The vertical profiles measured and processed with the Vaisala DigiCora facility are submitted in the real time to the Regional Ozone Sonding Center at NILU, Norway. The final results are stored in the ozone database of CHMI and they are also deposited in the WOUDC, Toronto.

UV-B Solar Radiation

Spectroradiometric measurements of the global UV-B solar radiation are performed with the Brewer single monochromator B098 for different Solar Zenith Angles (SZAs) at SOO-HK every day since 1994. The scans are stored in the UV data base at SOO-HK and are used for calculation of actual values of the UV-Index daily presented for the public by mass media during the summer season. Doses of the erythemally weighted UV-B radiation are measured also with broad-band UV-Biometers at SOOHK and GAW Observatory Kosetice since 1995. All the instruments are regularly calibrated and UV data are checked by a QA system before they are deposited in the data base and submitted to partners institutions.

2. RECENT AND ONGOING RESEARCH PROJECTS

The following ozone and UV research projects were carried out in the recent years or are being performed in CR at the present.

Development and Implementation of Technologies for the European Ozone Calibration Center

A research project supported by the Grant Agency of CR carried out at SOO-HK in 2001-2003. The main goals of the project are investigation of calibration histories of Czech ozone spectrophotometers, development and construction of technical facilities and software tools for participation of SOO-HK in tasks of the Regional Dobson Calibration Center of the RA-VI (Europe) – see the section International co-operations.

THESEO and MATCH Projects

Research projects on investigation of stratospheric dynamics and their impacts in ozone changes over Arctic and sub-Arctic regions. The campaign are supported by EC and by many national institutions. CHMI takes part in these campaigns mainly by a real-time submission of vertical ozone profiles measured at the AOPH, Prague.

COST-713 Action - UVB Forecasting

An international project organized by the European Commission (EC) in 1996-2001 under the Cooperation in Science and Technology Program. The main outputs were development and implementation of technologies for forecasting of the UV-Index in participating 12 European countries including CR and its presentation to the public. Also a system for real-time ftp exchange of the UVB observations among COST-713 participants has been created and tested. More information on the COST-713 project can be found at: http://159.213.57.69/uvweb/index.html

3. FUTURE PROJECTS

In coming years Czech specialists plan to take part in several ozone and UV research projects established under the 5th Framework Programme of EC. These are:

CANDIDOZ – Chemical and Dynamical Influences on Decadal Ozone Change

The project starts in April 2002. CHMI together with the Department of Atmospheric Physics of the Czech Academy of Sciences will participate as members of the Consortium. Relation between total ozone observations performed with different techniques, long-term consistency of the data base at SOO-HK and estimation of trends of total ozone in Central Europe are the main tasks of the Czech team in the project.

EDUCE – European Database for UV Radiation Climatology and Evaluation

This research project started in 2000 and it continues in previous works carried out under the project SUVDAMA focussed mainly on creation of a European spectroradiometric UV data base. Specialists from SOO-HK are going to join the EDUCE project based on invitation of the research team in June 2002. Deposition of UV measurements and reconstruction of historical changes of the UVB radiation in the territory of CR during last 40 years are the main tasks of the Czech participants in the project.

4. INTERNATIONAL CO-OPERATIONS

WMO-GAW Ozone Programme

For a long time observatories of CHMI take part in the ozone part of the WMO/GAW Programme. These activities which are planned to be continued in the future cover mainly the following scopes:

- Calibration of instruments

Specialists from SOO-HK take part as invited experts in realization of WMO sponsored intercomparisons of ozone spectrophotometers. This includes also repairs and adjustments of the Dobson instruments

- Creation of software tools

Special software products have been developed at SOO-HK and provided to GAW stations for processing and telecommunication transfer of total ozone observations.

- Co-ordination of GAW ozone stations

Experts from SOO-HK contribute in maintenance and co-ordination of the Dobson part of the global GAW ozone network. This includes mainly activities of the Dobson Ad-Hoc Committee and maintenance of the Dobson Web Pages located created at SOO-HK and located at the server of CHMI: http://www.chmi.cz/meteo/ozon/dobsonweb/welcome.htm

- Training of the Dobson operators

CHMI in co-operation with WMO carries out a training program for operators of ozone spectrophotometers from stations located in developing countries. The training courses include also implementation of new software tools created at SOO-HK and donated by CHMI to the GAW programme. 32 Dobson operators and managers of 21 ozone stations (se the figure below) were trained by experts of CHMI either at SOO-HK or at missions in the period 1996-2001. More information can be found at:
http://www.chmi.cz/meteo/ozon/dobsonweb/training.htm

The Regional Dobson Calibration Center of RA-VI

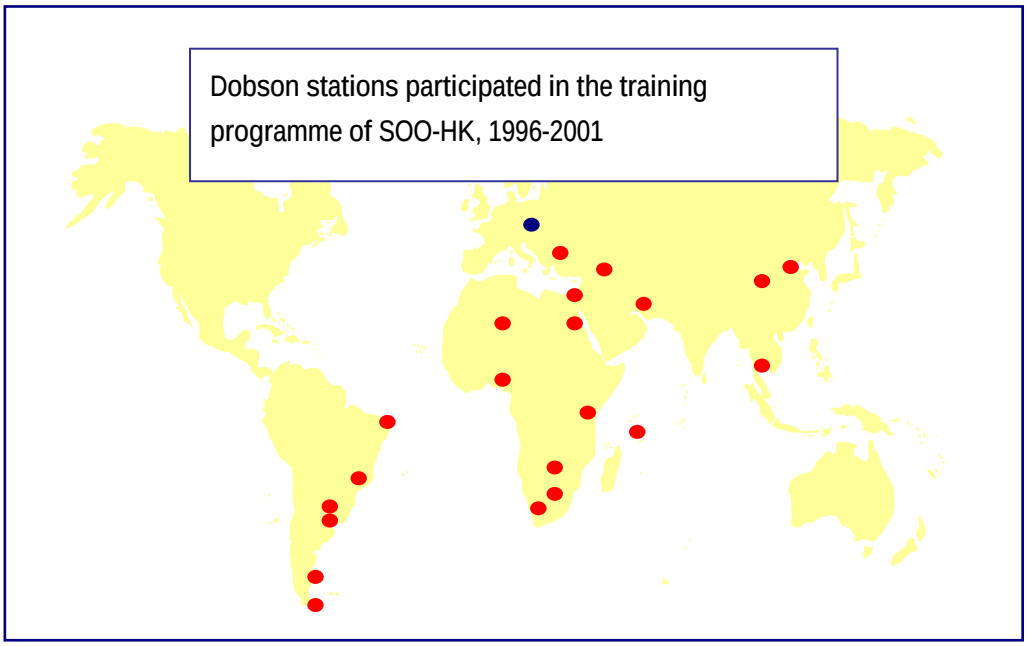
A cooperation of SOO-HK with the Regional Dobson Calibration Center of RA-VI (RDCC Europe) located at the Meteorological Observatory of the German Meteorological Service at Hohenpeissenberg (MOHP) successfully continues. Regular calibration campaigns held every year at MOHP play a key role in the maintenance of the ground-based network for monitoring of the ozone layer in Europe. Czech specialists contribute to RDCC campaigns mainly by technical assistance in adjustments and repairs of calibrated instruments and in training of operators for new stations.

The SCIAMACHY Validation project

Observatories of CHMI have been invited to contribute to the SCIAMACHY Validation project implemented by the European Satellite Agency (ESA) in 2002. Total ozone observations and vertical profiles of ozone measured at SOO-HK and AOPH will be provided for operational validation of ozone observations performed with the SCIAMACHY satellite system launched by ESA

WOUDC Ozone Mapping Center

Since 2000 SOO-HK submits every day near-real time total ozone data measured in Hradec Kralove to the MSC/WOUDC Mapping Center in Toronto. Thee observations contribute as input data for creation of daily maps of geographical distribution of total ozone (thickness of the ozone layer) over the Northern Hemisphere.


Dobson stations participated in the training programme of SOO-HK, 1996-2001

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DENMARK

Stratospheric ozone monitoring

Daily observations of total ozone are performed by the Danish Meteorological Institute (DMI) in Denmark and Greenland:

Station	Location	Instrument	Start of observations
Copenhagen	56°N, 12°E	Brewer Mark IV	May 1992
Sondre Stromfjord (Kangerlussuaq)	67°N, 51°W	Brewer Mark II	September 1990
Thule Air Base (Pituffik)	77°, 69°W	SAOZ 1024 diode array	September 1990

On non-regular basis, total ozone has also been measured from Qaanaaq (78°N, 69°W), using the DMI Dobson #92 instrument since early 2000.

Weekly ozone soundings have been performed using balloonborne EEC sensors from Scoresbysund (Illoqqortoormiut, 71°N, 22°W) since January 1993. Ozone soundings have also been performed on campaign basis from Thule Air Base each winter since January 1992 and occasionally from Copenhagen.

The measurements are reported to databases under Network for the Detection of Stratospheric Change (NDSC) and World Ozone and UV-radiation Data Center under the WMO-programme Global Atmosphere Watch.

Thule and Sondre Stromfjord are primary Arctic stations within the Network for the Detection of Stratospheric Change. In addition to the DMI instrumentation, aerosol lidars are operated at these stations by the University of Rome (Italy) and SRI International (USA), respectively, together with an FTIR spectrometer at Thule, operated by National Center for Atmospheric Research (USA). DMI also collaborates with Service d'Aeronimie du CNRS (France) for daily total ozone measurements by a SAOZ instrument at Scoresbysund.

Ozone research

DMI has participated in all major European/US Arctic ozone research campaigns throughout the 1990'es such as ESSOE, SESAME, THESEO, and THESEO-2000/SOLVE. In addition, DMI has participated in numerous research project, funded by the European Commission and Danish research agencies. The ozone research at DMI relates to transport studies of stratospheric ozone, including dilution effects at mid-latitudes from Arctic ozone depletion, studies of polar stratospheric clouds by microphysical simulations and balloon-borne experiments from Greenland and Northern Scandinavia, modelling studies of mountain lee waves, and ozone and UV trend assessments. Climate modelling, relating to the influence of ozone on the stratospheric circulation and climate, is also performed at DMI.

Ultraviolet radiation

Daily measurements of the surface UV-B radiation are performed by DMI at Thule, using a high resolution spectroradiometer, since summer 1994.

At the Botanical Institute, University of Copenhagen, effects of enhanced UV-B radiation on terrestrial ecosystems have been studied during the 90's starting with arctic heath ecosystems, but in the last years the studies have concentrated on the effects on forest trees (beech and oak).

Effects of UV-B radiation on marine phytoplankton in the Greenlandic waters have recently been studied in a cooperation between DMI, DHI - Water and Environment and ASIAQ in Nuuk, Greenland.

The DMI participates in EUMETSAT's Satellite Application Facility on Ozone Monitoring, aiming at the development of operational UV-index products, based on satellite measurements of the ozone layer. UV-B index forecasts, based on Danish total ozone measurements, were initiated at DMI in summer 1992. This public service runs every summer season, made public on the Internet and in several media.

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EGYPT

1- INTRODUCTION

The involvement of Egypt in ozone monitoring and research dates to 1967 with the establishment of Dobson spectrophotometer No. 96 in Cairo.

The Egyptian Meteorological Authority (EMA*) monitoring activities is as follows:*
-Total column ozone using Dobson and Brewer instruments.
-Vertical profiling of ozone obtained with the Umkehr method.
-Surface ozone measurements
-The broadband UV and UV-B radiation measurements

Scientists at the Research Department in EMA research activities include the following topics:
- Ozone distribution, variation and its trend.
- Effect of ozone on the climate variability.
- Principle components affect on the distribution of ozone and UV-radiation.
- UV observation, analysis and forecast.
- Surface ozone and SO_2 observations.

2. MONITORING AND MEASUREMENTS:

2.1 Stratospheric ozone

At Egypt, only EMA is responsible for measurements of column ozone amount and operates the main total ozone-monitoring network. EMA at 1967 started to measure ozone by Dobson spectrophotometer No. 96 at Cairo. At 1973 Cairo became Regional Ozone Center (ROC) with Dobson No. 96 for ozone stations at North Africa and Middle East. Ozone amount measured over tropical area by Dobson Spectrophotometer No. 69 at Aswan (Upper Egypt) since 1984. The Brewer Spectrophotometer Mark II No. 143 operated EMA at Mrsa Mtrouh station (north coast of Egypt) is also used to monitor ozone, SO_2 and UV-B radiation since November 1998. One new ozone station at Hurghada (27.28°N) has been established during the past three years in Egypt. Total amount of ozone over Hurghada (GAW station) will be measured by Dobson spectrophotometer No. 59 from November 2000. The present EMA network of ozone measurements consist of the following:

	Aswan	Hurghada	Cairo	M. Mtrouh
WMO No.	62414	62464	62371	62306
WOUDC ID.	245	409	152	376
Latitude	23.97°N	27.28°N	30.08°N	31.33°N
Longitude	32.78°E	33.75°E	31.28°E	27.22°E
Height (meter)	193	007	037	035
Instrument	Dobson # 069	Dobson # 059	Dobson # 096	Brewer # 143
Started at	December 1984	November 2000	October 1967	November 1998
Last Calibration	1999 – Swiss	2000 – Germany	2001– Germany	NEED

Table (1): The Egyptian Ozone Stations.

Routine measurements of total ozone are made a number of times per day (at different air masses) by trained personnel at all the above stations. Whenever sky conditions permit, Umkehr observations are also made to compute the vertical distribution of ozone. Scientists of ozone from EMA taking into consideration the maintenance and calibration of the Dobson instruments

regularly. The ozone data collected from the network at ROC. Data files of ozone are transmitted regularly with SO_2 to World Ozone and Ultraviolet Data Center (WO_3UDC) in Toronto, Canada.
EMA cooperate with Thessaloniki University in Greece and WMO in the WMO-GO_3OS Ozone Mapping Center. The program includes the exchange in near- real time total ozone data for preparation of the daily ozone maps of the Northern Hemisphere.

Trend of ozone total amount increased through the last three years over all ozone stations at Egypt, as fig. (4). Before this period, the trend of ozone decreased but not significant (figures (2,3)). Fig. (1) show the monthly variation of total amount of ozone over Egypt with a maximum value at spring over Cairo and Mutrouh and at summer over Aswan.

2.2 Surface ozone

In Egypt surface ozone measurements outside urban regions, at Hurghada which is an official WMO Global Atmospheric Watch (GAW) station and at Sidi Branni (31.37ºN, 25.53ºE). EMA also measured surface ozone in cooperation with the Egyptian Environmental Information System (EEIS) at 14 locations in Greater Cairo, which is polluted, and urban city. This project is to establish a sustainable standard quality of environment over Greater Cairo.

South Valley University with EMA started to measure surface ozone at Qena (26.20ºN, 32.75ºE) from April 2000.

2.3 UV radiation

Early in 1989, EMA have been operating an overall UV monitoring network for measurements, on a continuous basis, of the solar UV radiation. Eppley Ultraviolet Radiometer (Photometer) is used routinely for measurements of sun and sky broadband UV radiation at Cairo and Aswan.

EMA take the measurements of biologically effective solar UV-B radiation using UVB-1 pyranometer at Cairo, Aswan and Rafaah and using Brewer Mark II at Mersa Mtrouh. EMA in cooperation with South Valley University have been measured the broadband UV and UV-B radiation at Qena from April 2000. The present network of UV and VU-B radiation measurements shown in table (2) as the following:

	Aswan	Qena	Cairo	Rafaah	M. Mtrouh
WMO No.	62414	62403	62371	62335	62306
Latitude	23.97°N	26.20ºN	30.08°N	31.22ºN	376
Longitude	32.78°E	32.75ºE	31.28°E	34.20ºE	31.33°N
Height (m)	193.0	095.9	037.0	073.3	27.22°E
UV Instrument	Eppley Radiometer	Eppley Radiometer	Eppley Radiometer		
UV-B Instrument	UVB-1 pyranometer	UVB-1 pyranometer	UVB-1 pyranometer	UVB-1 pyranometer	Brewer Mark II
Started at	08/1989 (UV) 09/1998(UVB)	04/2000 (UV) 04/2000(UVB)	03/1989 (UV) 05/1996(UVB)	06/2000(UVB)	11/1998(UVB)

Table (2): The Egyptian UV and UV-B radiation Stations.

3. PROPOSALS AND NEEDS:

-We are in great need for scientific advice to elaborate a research program in ozone and climate change model.
-We will appreciate assistance to start measurements of vertical ozone distribution by ozonesonde especially, at Aswan station (tropical area).
-We needs technical and financial assistance for the regular calibration of Brewer with the travelling standard.

4. RESEARCH ACTIVITY:

I-*In cooperation between EMA and Meteorological Department, faculty of science, Cairo University carries out in ozone field the following Thesis:*

- Studies on Ozone Layer in relation to Climate.
- Ozone Layer in relation to Atmospheric Dynamics and Photochemistry.
- Some Characteristics of Ozone Changes related to Tropopause Fold during Mediterranean Cyclogensis.
- Variation of Mean Zonal Winds relating to the Ozone Hole.
- Physical and Chemical Characteristic of Air Pollution over Egypt.
- UV Index Analysis and Forecast.

II-*Through the last three years Scientists at EMA carry out the following researches:*

- Abdel Basst, H. and A. Gahein (2000) : Diagnostic study on the relation between ozone and potential vorticity. Quadrennial Ozone Symposium, pp.305, August 2000, Sapporo, Japan.
- EL-Asrag, A. M., A. S. Zaki and W. M. Sharobiem (1999): Statistical analyses of global ozone by EOF and long-term change of aerosols. Long-term Changes and Trends in the Atmosphere, 16-19 Feb.1999, Pune, India.
- El-Hussainy, F.M., W.M. Sharobiem and D.M. Ahmed (2001) : Surface ozone observations over Egypt. Meteorological and Sustainable Development Conference, 2-4 April 2001, Cairo, Egypt.
- Gahein, A. and H. Abdel Basst (2000) : On relation betweeen ozone and cyclogensis : case study. Quadrennial Ozone Symposium, pp.395, August 2000, Sapporo, Japan.
- Kourtidis, C. Zerefos, S.Rapsomanikis, V.Simeonov, D.Balis, E.Kosmidis, P.E.Perros, D.Melas, A.Thompson, J.Witte, B.Calpini, B. Rappenglueck, I.Isaksen, W.M. Sharobiem, A.Papayannis, P.Fabian, N.Mihalopoulos, H.Gimm and R. Drakou: Regional levels of ozone in the troposphere over Eastern Mediterranean. J.Geophys. Res.-Atmospheres (under press).
- Korany, M. H., W. M. Sharobiem and A. A. Gahein (2001) : Spectral ultraviolet radiation measurements over Matrouh. Meteorological and Sustainable Development Conference, 2-4 April, 2001, Cairo, Egypt.
- Shakour, A. A. and A. S. Zaki (1999) : The relation between sulfur dioxide and sulfate in Cairo atmosphere. Central European Journal of Occupational and Environmental Medicines, vol. 4, 2, pp82.
- Sharobiem, W.M. and A. Gahein(2000): Comparison between Dobson, Brewer and TOMS total ozone measurements at Cairo and Aswan. Meteorological and Sustainable Development Conference, 2-4 February 2001, Cairo, Egypt.
- Sharobiem, W.M. and M.H. Korany (2000): Eclipse and the change of ozone and radiation components. Meteorological and Sustainable Development Conference, 2-4 February 2001, Cairo, Egypt.
- Sharobiem, W.M. and A.M. El-Asrag (2000) : Principle components affect on the distribution of ozone and UV-radiation over Egypt. Quadrennial Ozone Symposium,pp.639, August 2000, Sapporo, Japan.
- Sharobiem, W.M. (2000): Principle components of the distribution of ozone and UV-radiation over Egypt. 6th biennial Brewer workshop, August 2000, Tokyo, Japan.
- Zaki, A.S. and W.M. Sharobiem (1999): Long-term change of ozone and UV over Egypt. Non-CO2 gases, 8-10 September 1999, Noordwijkerhout, the Netherlands.

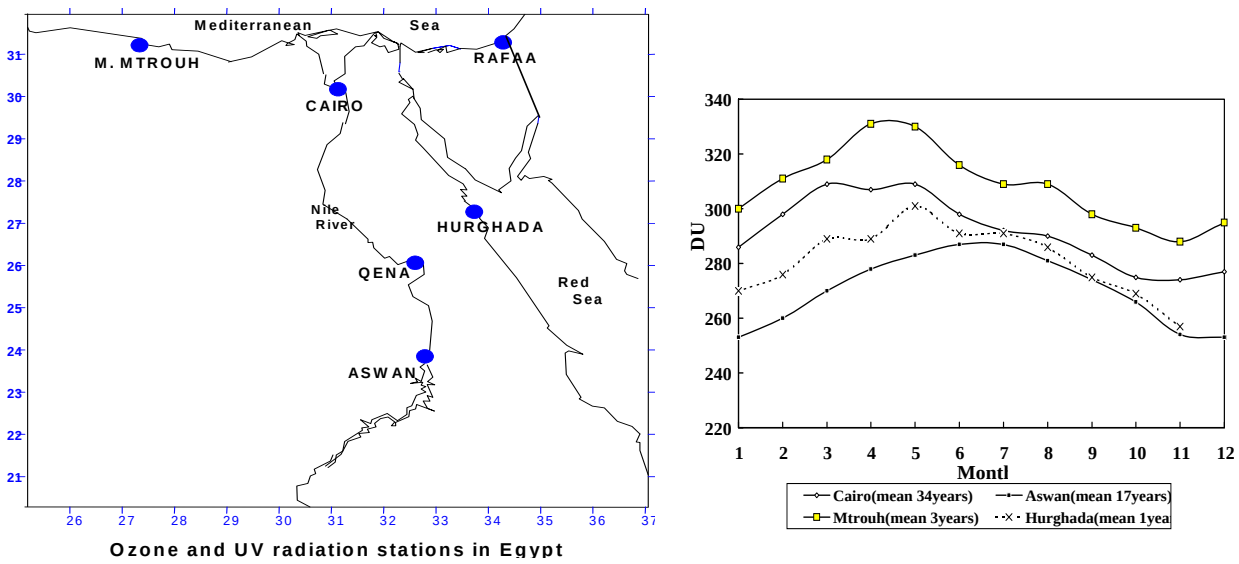


Fig.(1): Monthly variation of total ozone amount over Egypt

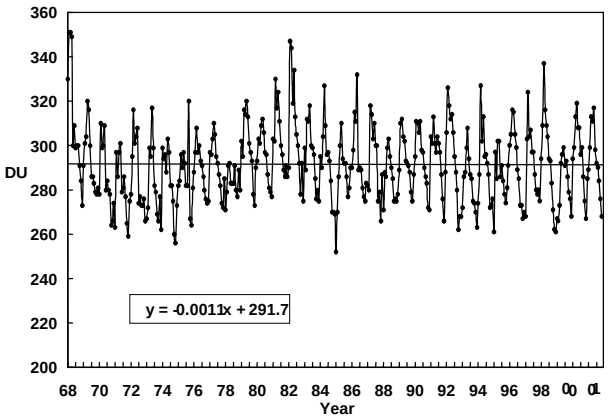


Fig.(2):Variation and trend of total ozone at Cairo from Jan. 1968 to Dec. 2001.

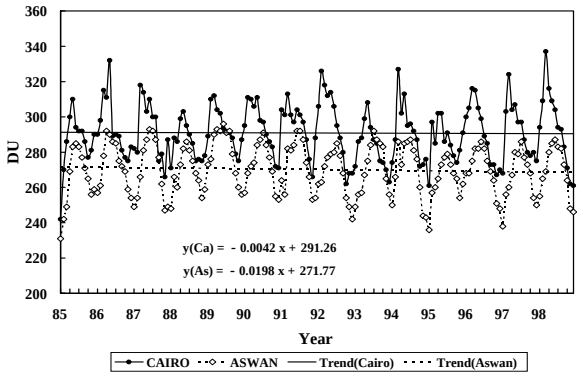


Fig.(3):Variation and trend of total ozone amount at Cairo and Aswan from 1985 to Dec.2001.

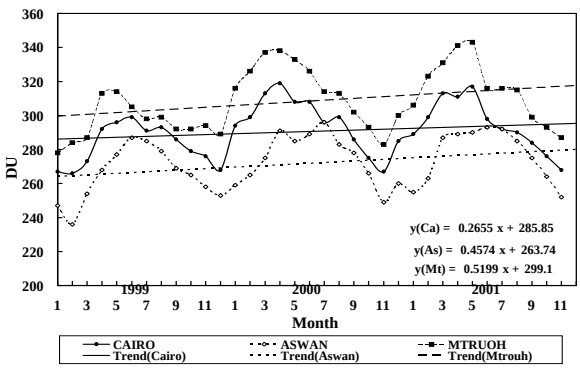


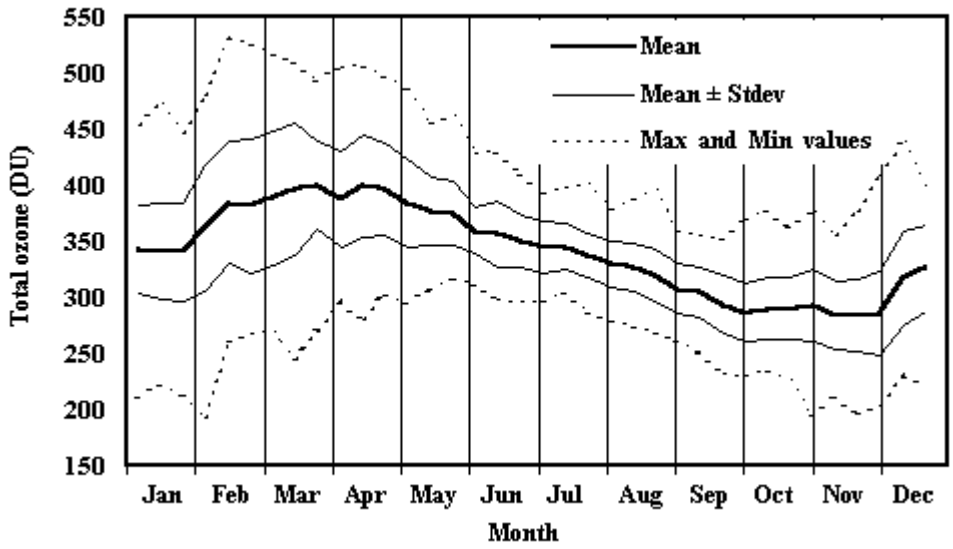
Fig.(4):Variation and trend of total ozone amount Over Egypt from Jan. 1999 to Dec.2001.

ESTONIA

Regular direct sun total ozone measurements in Estonia (at Tõravere, 58.3^{o} N, 26.5^{o} E, 70 m above sea level) have been carried out since January 1994, using the laboratory spectrometer SDL-1 supplied with a mirror system and Dobson retrieval algorithm. The site is the Tartu/Tõravere Baseline Surface Radiation Network (BSRN) meteorological station. Direct sun measurements of total ozone have been possible during about one third of days since March to October and available in few cases in winter months. For climatological studies the total ozone data from the Nimbus–7 Total Ozone Mapping Spectrometer TOMS (1979-1993) and other TOMS (http://jwocky.gsfc.nasa.gov/) were used. Since July 1996 the available Earth Probe TOMS data have been regularly compared with ground level measurement data obtained at Tõravere. The best agreement appeared in 1999 when the mean ratio of 124 compared values TOMS/Tõravere was 0.998 with the standard deviation 0.031.

A mean annual cycle of total ozone over Estonia in 1979–2000, composed using the averaged over ten-day values, is presented in Fig. 1 as well as the standard deviation limits and the ten-day extreme values. The years subjected to strong stochastic forcing by El Chichon (1983) and Mt. Pinatubo (1992 and 1993) volcanic aerosol were excluded. Due to the gap in the used data set the year 1995 and partly 1996 have also been excluded. Post-volcanic low values of total ozone are systematically met from January to September. No volcanic influence was noticed during late autumn total ozone minimum.

Fig. 1. Total ozone mean annual cycle.

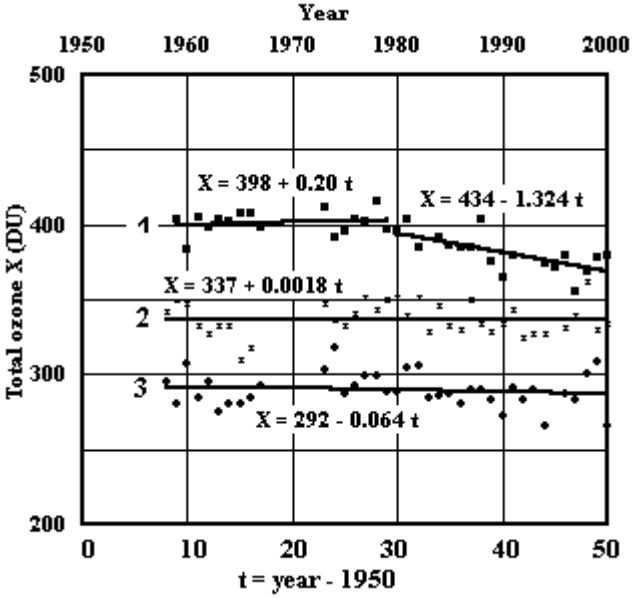


To detect the seasonal trends for longer time interval the published monthly mean data of 1957-1967 and the interpolated monthly mean values from Riga and St. Petersburg stations data in 1973-1978 were included (htpp://www.tor.cc.gc.ca/woudc). The results presented in Fig. 2 manifest no systematic trend in summer months June to August as well as in the late autumn minimum (October-November). The highest variability of total ozone occurs in winter/spring (February to April) when the poleward transport of ozone peaks and the synoptic frequency variations as well as the QBO related year-to-year differences are the strongest. The downward trend in winter/spring total ozone began since about 1980. The estimated trend before 1980 was not statistically significant.

In 1980-2000 it was -3.0±2.6 % per decade. Since 1987 low ozone events have been recorded in late April or early May in 1987, 1990, 1993, 1995 and 1997. The deepest ones exceeding 2σ (standard deviation) below mean were recorded in 1993 and 1997 (both 295 DU) and close to that (307 DU) in 1990 and 1995. On the average the daily total ozone value exceeds ±σ in 116 days

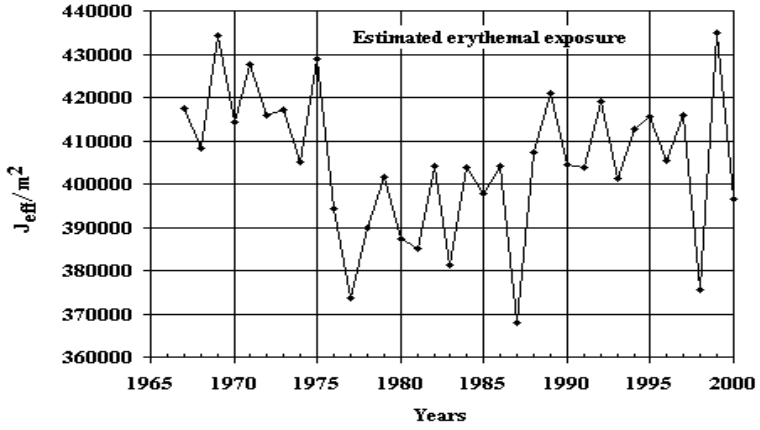
per year (58 below and 58 above). In post-volcanic years 1992 and 1983 the numbers of low ozone days were 114 and 92 containing relatively high contribution in summer months. Since 1986 large numbers of low ozone days tend to occur more often. The number 97 in 1997 even exceeded the value of post-volcanic 1983 and the number 85 in 2000 occurred close to it.

Fig.2. Total ozone trends in Estonia
1 – Feb-Apr; 2 – June-Aug; 3 – Oct-Nov.



Regular measurements of the erythemal UV irradiance at the same site have been performed since January 1, 1998. Since February 2002 the narrow-band UV-B measurements are regularly performed at effective wavelength 306 nm. The mean features of the erythemal UV have been studied and the summer half-year (since spring equinox to autumn equinox) erythemal doses for past years 1967-2001 estimated using the sunshine duration and cloudiness data. The results are presented in Fig. 3.

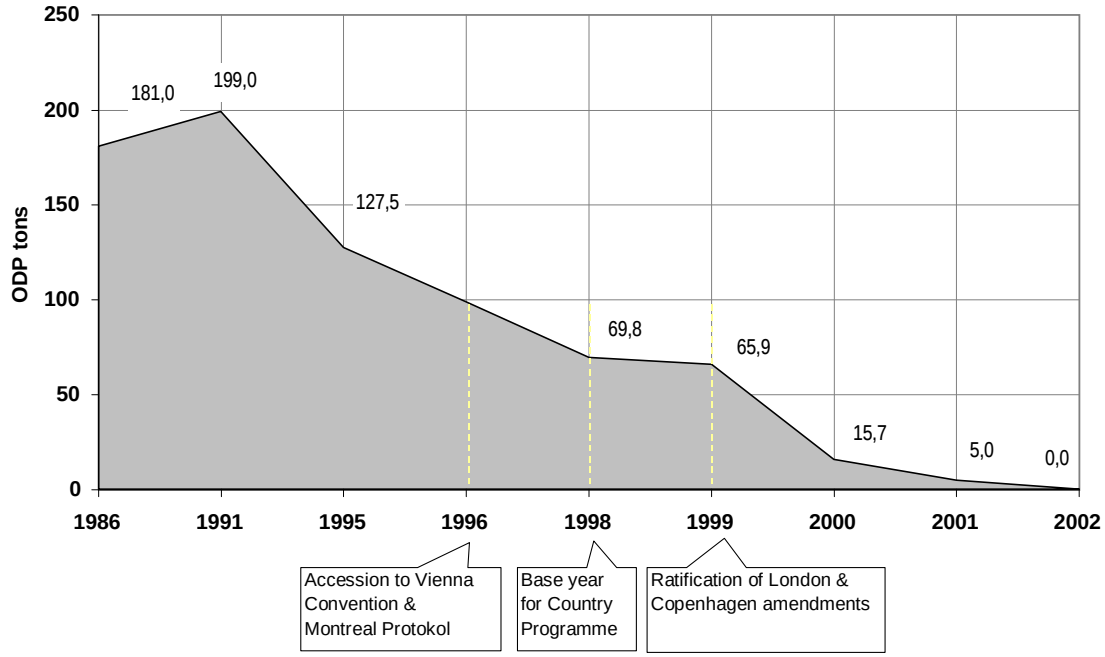
Fig. 3. Estimated summer half-year erythemal exposure in Estonia (58.3^0N, 25.5^0E, 70 m asl).



Estonia acceded to the Vienna Convention for the Protection of the Ozone Layer and the Montreal Protocol on Substances that Deplete the Ozone Layer on October 17, 1996 and ratified the London (1990) and Copenhagen (1992) amendments on April 12, 1999. The Montreal amendments have been submitted to the Parliament for ratification. The ratification of Peking amendments is scheduled in 2002. Estonia has never produced any type of ozone depleting substances and the per capita CFCs consumption has dropped in 1998 under 0.05 kg.

All legal acts concerning ozone depleting substances are based on The Ambient Air Protection Act (1998 Estonia does not produce any substances regulated by the Montreal Protocol. The total consumption of ODS in Annexes A and B in the base year of 1998, was 69.8 ODP tonnes. Implementation of passed legal acts has resulted in a steady decline in consumed CFCs (see Figure 4).

Fig. 4. Consumption of Annex 1 Group 1 substances and projections up to year 2002



Import of all ozone depleting substances from countries not acceded to the Montreal Protocol was prohibited from May 1999. The import of virgin CFCs was prohibited from 1 January 2002. The system for licensing the import and export of virgin, used, recycled and reclaimed controlled substances in Annexes A, B, C and E was established and implemented in 1999. Due to the measures taken by the Estonian Government the import of ODS dropped from 407 tons in 1997 to zero tons in 2002. Estonia does not produce products containing CFCs and import of such products was prohibited from May 1999.

The Estonian Government allows continued use of CFC in installed equipment and domestic refrigerators as long as these refrigerants are available on the market. The use of CFCs for solvent application is officially finished, however, some companies still have CFCs in stock. In cooperation with local authorities, waste handers and companies involved in the recovery and recycling project efforts have been made to set up a system for collection of used refrigeration equipment covering the whole Estonia.

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EUROPEAN UNION

European research on stratospheric ozone and UV radiation after THESEO

Introduction

Stratospheric research has been coordinated at a European level since the late 1980s, building on a number of trans-national collaborative initiatives and EC projects developed during the 1980s. Prior to 1996, a major emphasis of the European stratospheric research programme had been the investigation of the possibility of severe Arctic ozone losses and increased UV radiation throughout Europe and the populated northern mid-latitudes. Results from a series of national and international programmes including the European Arctic Stratospheric Ozone Experiment (EASOE, 1991-92) and the Second European Stratospheric Arctic and Mid-latitude Experiment (SESAME, 1994-95) concluded that the winter polar stratosphere over northern Europe was primed for severe ozone losses and that large losses had occurred in some winters in the early 1990s. The emphasis since 1996 has shifted to improving our understanding of the processes affecting ozone over Europe. The Third European Stratospheric Experiment on Ozone (THESEO 1998-2000) has been a major element of this coordinated programme. The principal aim of THESEO was to improve understanding of processes controlling ozone loss over populated areas. Accordingly, the research was focussed on the mid-latitude lower stratosphere, the linkage to other layers of the atmosphere, the Arctic vortex, the tropics and sub-tropics. During the 1999/2000 winter, a close cooperation was achieved with the USA sponsored SOLVE (SAGE III Ozone Loss and Validation Experiment).

The mechanism which has been used to effect coordination in Europe has consisted of the EC Research DG, national agencies, the EU Science Panel on Stratospheric Ozone and the European Ozone Research Coordination Unit (EORCU). The Science Panel, consisting of experts on stratospheric ozone, has provided advice to the EC regarding the implementation and possible future directions of the research in this area. EORCU works closely with the EC Research DG and the Science Panel, and liaises with EC project coordinators, other scientists and with national programmes. Effective links are maintained with existing international observational programmes such as the Network for the Detection of Stratospheric Change (NDSC) and the Global Atmosphere Watch programme of the World Meteorological Organisation (WMO-GAW) which already provide a large degree of coordination for the large number of European groups who participate, with groups such as the International Ozone Commission and the WCRP programme Stratospheric Processes And their Role in Climate (SPARC) and with the research programmes in other countries.

The additional benefits of having a research programme coordinated at the European level have helped European scientists to make major advances to the understanding of the stratospheric ozone and UVB issue and to contribute significantly in international assessments and research experiments carried out in support of the Montreal and Kyoto Protocols.

Research clusters

The stratospheric issues are currently addressed within the work programme for Area 2.1.2 Stratospheric Ozone Depletion in the Global Change, Climate and Biodiversity Key Action of the EC's Environment and Sustainable Development Programme (part of the 5th Framework Programme 1998-2002):

2.1.2 Stratospheric ozone depletion, in support of the Montreal Protocol.

The target is the quantification and prediction of ozone depletion in the stratosphere and the increase of UV-radiation levels at the Earth's surface. This focuses on the quantification of anthropogenic and natural emissions of ozone depleting substances and their transformations; reduction of the uncertainties in stratospheric-tropospheric exchange processes and the impacts of aircraft emissions; quantification of ozone loss in the stratosphere over Europe and the linkages

with the polar, tropical regions and the upper troposphere; understanding of stratospheric cooling and its links to tropospheric global warming, and better quantification of its impacts; accurate determination of the atmospheric UV radiation field and its changes in the European region."

As a result of call for proposals, during the last years in this area, 30 research projects are currently supported by the EC on stratospheric ozone and UV radiation (Table 1). They include the CRUSOE concerted actions entitled “Coordination of Research into Understanding of Stratospheric Ozone over Europe” which supports EORCU. These projects together with national activities are coordinated in the following five clusters:

1. Stratospheric ozone loss (SOLO)

   The main objective is to quantify the ozone depletion in the northern and middle latitudes throughout the year. The research involves measurements made by balloons, aircraft, ground-based and satellite instruments which are used to understand the causes of chemical ozone loss under various atmospheric conditions. The analysis of THESEO data continues to take place during and after extensions of these projects. These studies help to improve our understanding of the long term trends observed over polar and mid-latitudes.

2. Coordination of Research for the Study of Aircraft impact on the Environment (CORSAIRE)

   The main objective is to address persisting uncertainties concerning the upper tropospheric and lower stratospheric processes in the tropopause region where the aviation emissions occur. The main areas of research are the formation and evolution of contrails and particles and the ozone budget in the upper troposphere and lower stratosphere region. This work includes improved predictions of aviation-induced future changes in climate and providing the aviation and aeronautics communities and decision-makers with options to reduce future changes in climate impact from aircraft emissions.

3. Atmospheric UV radiation (ATUV)

   The main objective is to study the evolution of the UV radiation at the earth's surface and in the atmosphere over the last ten years or so. The existing databases are developed to provide additional products, in particular a European UV climatology using spectral UV irradiance measurements from 26 stations in Europe and a database of actinic flux suitable for use by a wide user community.

4. Ozone-climate interactions (OCLI)

   The main objective is to study the physical and chemical impacts on climate in the past caused by variations in stratospheric ozone and to study to what extend these variations can be explained by natural and/or anthropogenic forcing. The cluster simulates also future temperature, ozone radiative forcing and UV radiation amounts for various scenarios of future greenhouse gas emissions and halogen concentrations in order to investigate the impact of the Montreal and Kyoto Protocols.

5. Global atmospheric observations (GATO)

   The main objective is the coordination of scientists involved in making atmospheric measurements to provide broad European and global coverage of ozone and related species. This research is an important contribution by Europe to the international observational programmes. The work in GATO involves the use of data from ground based, balloon, aircraft and satellite measurements, including data from new campaigns. GATO aims also to help ensure that all field and satellite measurements made within the European programme are available for validation and for scientific analysis.

Each cluster have a liaison group whose purpose is to ensure coordination within the cluster, e.g. establishing scientific links between projects and planning workshops or other meetings. The cluster liaison groups are made up of project coordinators, Science Panel members, EORCU, and the Research DG.

An important way of achieving good links between the projects is through the use of workshops and meetings to discuss and present results. A range of gatherings can be used for this ranging from specially organised workshops on particular topics, to the use of special sessions at conferences (e.g. EGS) through to larger meetings such as the Quadrennial Ozone Symposia and the SPARC Assemblies. It should be noted that the Sixth European Symposium on Stratospheric Ozone will be organised in September 2-6, 2002 at Göteborg, Sweden.

VINTERSOL campaign

VINTERSOL (Validation of INTERnational Satellites and study of Ozone Loss) is a major European field campaign studying stratospheric ozone. VINTERSOL ('Winter sun' in the Scandinavian languages) will take place from late 2002 until mid 2004. It is the latest major European field campaign to study ozone loss. Like the previous European campaigns, VINTERSOL relies jointly on support from national funding agencies and from the EC's Environment and Sustainable Development programme.
An important new dimension for VINTERSOL is the involvement of several European satellite instruments. Measurements from the ERS-2 GOME satellite instrument (operational since 1995) and from the POAM III instrument on the SPOT IV satellite (operational since 1998) will continue to be used. In addition, measurements from the ODIN satellite (launched in February 2001) and ESA's new ENVISAT satellite will be validated and, in time, analysed. VINTERSOL is thus being mounted in conjunction with the validation campaign for ENVISAT satellite, and it will significantly extend the scope and duration of the validation activities, so enhancing the quality of the measurements made by these satellite instruments. The increasing international dimension to earth observation studies is also evident, as there will be cooperation with the validation campaigns for the NASA SAGE III instrument (SOLVE-2) and the NASDA ILAS satellite.

There are four main phases to VINTERSOL in which detailed studies of atmospheric processes will be made:

- a small balloon campaign in the tropics in late 2002;
- intensive Arctic ozone loss studies in the 2002/03 winter/spring;
- ozone loss studies in the Antarctic winter and spring 2003; and
- balloon and aircraft studies in the tropics in early 2004.

In addition, a number of measurement and modelling projects will run continuously through this period yielding information on the longer time-scale processes in the stratosphere. The VINTERSOL planning document can be made available through the EORCU web page (www.ozone-sec.ch.cam.ac.uk/).

European Assessment

The EC published in late 2001 its second assessment on European research in the stratosphere. It took almost two years and over 100 scientists to prepare this assessment which is based on European research efforts during the last few decades and the analysis of 40 years of atmospheric data. It provides a thorough review of the progress of the European research programme on stratospheric ozone, UV radiation and aircraft impact on the atmosphere during 1996-2000, including THESEO. The results of the assessment endorse the position of the EU concerning the international agreements on ozone depletion (Montreal Protocol) and climate change (Kyoto Protocol), as well as the International Civil Aviation Organisation's regulation of the impact of aviation emissions. The assessment concludes among others that the occurrence of ozone mini-

holes over Europe increases and any ozone layer recovery could only become measurable around 2010 at the earliest.

Future activities

Possible future directions of atmospheric research including stratospheric ozone and UV radiation, were described by the European scientific community in a recent document entitled "A global strategy for atmospheric interdisciplinary research in the European Research Area (AIRES in ERA)". The report identifies the environmental issues and scientific areas for atmospheric research that will be most relevant for the future implementation of the ERA and the 6th Framework Programme 2002-2006. In parallel, the European Commission proposal for the 6th Framework Programme under its priority on Sustainable Development, Global Change and Ecosystems does include stratospheric ozone research in relation to the Montreal Protocol. The 6th Framework Programme is expected to be adopted by the European Council and the European Parliament later iin 2002.

Table 1 : Research projects and clusters

Stratospheric Ozone Loss (SOLO) cluster

CIPA (*Comprehensive investigations of polar stratospheric aerosols)*

THESEO 2000 – EUROSOLVE (*Improved understanding of stratospheric ozone loss by measurements and modeling contributing to THESEO and SOLVE)*

SAMMOA (*Spring-to-Autumn Measurements and Modeling of Ozone and Active species)*

TOPOZ III *(Towards the Prediction of Stratospheric Ozone III: The Partitioning of the NOy Components)*

QUOBI *(Quantitative Understanding of Ozone losses by Bipolar Investigations)*

EUPLEX *(European Polar Stratospheric Cloud and Lee Wave Experiment)*

Atmospheric UV radiation (ATUV) cluster

ADMIRA (*Actinic flux determination from measurements of irradiance)*

EDUCE (*European database for Ultraviolet Radiation Climatology and Evaluation)*

INSPECTRO *(Influence of clouds on the spectral actinic flux in the lower troposphere)*

Ozone-Climate Interactions (OCLI) cluster

SOLICE (*Solar influences on climate and the environment)*

DETECT (*Detection of changing radiative forcing over the recent decades)*

EUROSPICE (*European project on stratospheric processes and their impact on climate and the environment)*

PARTS (*Particles in the upper troposphere and lower stratosphere and their role in the climate system)*

CANDIDOZ *(Chemical and Dynamical Influences on Decadal Ozone Change)*

Global Atmospheric Observations (GATO) cluster

AMIL2DA *(Advanced MIPAS-Level-2 Data Analysis)*

GOA (*GOME Assimilated and Validated Ozone and Nitrogen Dioxide Fields for Scientific Users and for Model Validation)*

MAPSCORE (*Mapping of Polar Stratospheric Clouds and Ozone levels relevant to the Region of Europe*)

QUILT (*Quantification and Interpretation of Long-Term UV-Visible Observations of the Stratosphere)*

SOGE (*System for Observation of Greenhouse Gases in Europe)*

Coordination of Research for the Study of Aircraft impact on the Environment (CORSAIRE) cluster

MOZAIC-III (*Measurement of Ozone, Water vapour, Carbon monoxide and Nitrogen oxides by Airbus in-service aircraft (MOZAIC-III) - O_3 and H_20 budgets in the UT/LS)*

TRADEOFF (*Aircraft emissions: Contribution of different climate components to changes in radiative forcing-tradeoff to reduce atmospheric impact)*

INCA (*Interhemispheric differences in cirrus properties from anthropogenic emissions*

STACCATO (*Influence of Stratosphere-Troposphere Exchange in a Changing Climate on Atmospheric Transport and Oxidation Capacity)*

UTOPIHAN-ACT(*Upper tropospheric ozone : processes involving HOx and NOx. The impact of aviation and convectively transported pollutants in the tropopause region)*

CARIBIC 3 (*Civil aircraft for regular investigation of the atmosphere based on an instrument container)*

HIBISCUS (*Impact of tropical convection on the upper troposphere and lower stratosphere at global scale)*

SCENIC (*Scenario of aircraft emissions and impact studies on chemistry and climate)*

TROCCINOX (*Tropical convection, cirrus and nitrogen oxides experiment)*

Concerted actions

CRUSOE (*Coordination of Research into and Understanding of Stratospheric Ozone over Europe*

CRUSOE II *(Coordination of Research into Understanding of Stratospheric Ozone over Europe II)*

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Additional information on this European stratospheric research: http://www.ozone-sec.ch.cam.ac.uk/

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FRANCE

Ozone and UV radiation research in France is primarily managed by the CNRS – Institut National des Sciences de l'Univers (INSU) under a dedicated Programme National de Chimie de l'Atmosphère (PNCA), while the space component is managed by the Centre National d'Etudes Spatiales (CNES). Additional contributions are provided by the Institut Polaire (IFRTP), Météo-France, the Ministère of Environnement, the Ministère de la Recherche, the Institut National de Recherche Agronomique (INRA) and a number of Universities. Ozone research is also largely supported by the Direction Générale Recherche of the European Commission under the 5th Environmental Programme.

The research include the long term monitoring of the stratosphere and UV-B at a variety of ground-based stations and the study of ozone depletion mechanisms from space borne instruments, balloons and aircraft field campaigns, most of them in cooperation with other European and international institutes.

1. Ground-based Ozone and UVB Monitoring

France is running two primary stations of the international Network for Detection of Stratospheric Change (NDSC) at the Observatoire de Haute Provence (OHP) and the Antarctic station of Dumont d'Urville (DDU), a complementary site at Reunion Island in the Indian Ocean and a number of instruments at other international locations in cooperation with local institutes: Alomar in Norway and the SAOZ UV-Vis spectrometers network associated to NDSC at Scoresbysund (Greenland), Sodankyla (Finland), Salekhard and Zhigansk (Federation of Russia), Bauru (Brazil), Tarawa (Republic of Kiribati) and Kerguelen Island.

The list of instruments at OHP includes a series of lidar for stratospheric temperature, aerosol, wind and ozone, and tropospheric ozone and water vapour, a SAOZ UV-Vis spectrometer, a BrO UV spectrometer of IASB-BIRA in Belgium, an automated Dobson from NOAA, weekly ozonesondes and a spectral UV-B monitor at the nearby Alpine station of Briancon. Additional Dobson measurements are conducted at Bordeaux. The micro-wave ClO measurements at Plateau de Bure have been closed in 1999 after the reduction of activity of the station after an accident.

In Antarctica, the instruments run since 1988 are a PSC / aerosol lidar in cooperation with the Italian CNR, a SAOZ, a UV-B monitor and ozonesondes at Dumont d'Urville. The ozone lidar has been closed in 2001 but the measurements should resume in 2004. An additional SAOZ is in operation since 1995 at the sub-Antarctic Island of Kerguelen. The installation of a SAOZ and a microwave radiometer is anticipated at the inland French-Italian station of Concordia expected to run year round after February 2004.

At the tropical site of Reunion Island, the instruments permanently running are a temperature / aerosol lidar, a stratospheric and a tropospheric ozone lidars, a SAOZ and weekly ozone sondes. A high altitude station is under construction at Maïdo at 2500 m asl for hosting all previous instruments after 2003 together with a FTIR operated by the Belgium IASB-BIRA, as well as a microwave radiometer for ozone and water vapour.

France is also responsible for the temperature lidar measurements at the Norwegian-German lidar station of ALOMAR in Norway.

While part of the data (SAOZ ozone / NO_2 and ozonesondes) are made available in near real time to WMO and to the European data base at the Norwegian Institute for Air Research (NILU) for research programmes and satellite validation, all are made available to the international community after reprocessing through the NDSC archive center.

2. Satellites

Relevant to stratospheric ozone research, a variety of space activities have been carried out in France under the auspices of CNES:

- the scientific exploitation of the data of the Polar Ozone and Aerosol Monitoring (POAM) instruments of the Naval Research Laboratory in the United States placed on board the French CNES satellites (POAM II on SPOT III in 1994 and POAM III on SPOT IV in 1998), from which ozone destruction rates in the Arctic have been derived;
- a contribution to the exploitation of the measurements of the Japanese NASDA ILAS instrument flown on ADEOS in 1997;
- the starting analysis of the measurements of the SMR instrument (ozone, water vapour and ClO) on board the Swedish-Finnish-Canado-French ODIN satellite placed in orbit in 2001;
- the preparation of the data processing of the French proposed GOMOS instrument on board the ESA ENVISAT satellite in orbit since early March 2002, and more generally the contribution of a number of French scientists to the preparation of the two other stratospheric chemistry instruments MIPAS and SCIAMACHY; and,
- a strong involvement in the validation of the measurements of POAM, GOME-ERS-2, ILAS and ODIN from ground based and dedicated balloon flights measurements in the Arctic and at Mid-latitude.

Now planned in 2002-2003 for the validation of ENVISAT, the US SAGE III-METEOR and the Japanese ILAS-ADEOS II, are several balloon campaigns in France, Sweden and Brazil.

Finally, Météo-France is contributing to the preparation of EUMETSAT's Ozone Monitoring Satellite Application Facilities hosted by the Finnish Meteorological Institute. This facility will deliver ozone and minor constituents products derived from the GOME-2 and HIRS instruments on board METOP, the European meteorological polar platform to be launched in 2005. The derivation of ozone columns in the lower stratosphere from METEOSAT Second Generation and for METOP/HIRS is the specific contribution of Météo-France.

3. Aircraft

Two research aircraft operated by INSU have been used for stratospheric investigations: the ARAT Fokker aircraft carrying the LEANDRE lidar for studying Polar Stratospheric Clouds in the Arctic and a Mystère 20 equipped with the ALTO ozone lidar for studying horizontal transport across the vortex edge as well as the sub-tropical barrier. Both aircraft are to be replaced in 2003 by an ATR 42 and a newer Mystere 20 respectively.

France is also running since 1994 and in cooperation with other European institutes, the MOZAIC programme of in situ ozone, water vapour and NOy (in 2002) measurements on in-service commercial aircraft, from which tropospheric ozone climatology are derived at a number of airport worldwide. http://www.aero.obs-mip.fr/mozaic/access.html

4. Balloons

The French contribution to balloon activities is twofold: CNES balloon manufacturing and operations in France, Sweden and Brazil for a number of European and international scientists, and development of scientific instruments designed for ozone related research at French laboratories.

The balloons used during the past several years include large open stratospheric balloons carrying heavy (500-600 kg) payloads for few hours (20 flights/year), small flexible and cheaper balloons which could be flown more frequently particularly in the Arctic in the winter for studying fast chemical changes (20 flights/year) and long duration balloons of two types: Infra-Red Montgolfier carrying 60 kg at 25 km flown for few weeks in the Arctic or in the tropics, and constant level super-pressure balloons carrying 20 kg at 19 km for few weeks.

Stratospheric chemistry instruments developed in France include:

- a large FTIR (LPMA) for measuring profiles of long lived, reservoir and radical species;
- a tuneable diode laser system (SPIRALE) for the in-situ measurement of NOx and NOy species;
- a star occultation UV-Visible spectrometer (AMON) for the night-time measurement of O3, NO2, NO3 and OClO; and several light weight instruments flown more frequently on small balloons together with other European instruments at a variety of sites:
- the SAOZ UV-visible spectrometer for O_3, NO_2, BrO and OClO by solar occultation;
- its SALOMON moon occultation version;
- the SDLA diode laser for in-situ CH_4, CO_2 and water vapour; and,
- the Rumba meteorological payload for long duration balloons.

5. Scientific programmes

Asides from the NDSC long-term involvement, most of activities are carried out under cooperative programmes supported by the European Commission in conjunction with ESA and European national agencies:

- the THESEO European Ozone Arctic campaigns in 1998 and 1999 and the follow-up Europeo-American THESEO-SOLVE during the winter of 2000 during which all above aircraft and balloon experiments have been flown several times for studying NOx, chlorine and bromine chemistry, polar stratospheric clouds and denitrification of the vortex, meteorology and finally ozone loss, and,
- balloon flights for the validation of ILAS in 1997, POAM in 1999 and 2000, and ODIN in 2001.

Planned in the near future are:

- a European VINTERSOL campaign in the Arctic during the winter of 2002/2003 for the validation of ENVISAT, SAGE III and ILAS II as well as ozone depletion scientific objectives;
- short and long duration circumnavigation balloon flights at the tropics within a new HIBISCUS European project for investigating the impact of deep convection on the stratosphere in 2002 and 2004;
- a VORCORE long duration constant level balloon project for studying the dynamics of Antarctic vortex in 2003.

6. Data interpretation, exchange and archival

Though the data are analysed through many cross-exchanges with international scientists and particularly Europeans within cooperative projects, France institutes have developed a full set of models ranging from Lagrangian, 3-D chemical transport (CTM), contour advection, meso-scale and assimilation models. While the experimental data as well the results of modelling relevant to European projects are archived into the NILU data base available through an appropriate protocol, all French space and field data relevant to the stratosphere are archived into a newly built national data base ETHER.

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GEORGIA

Routine Program

Monitoring of total ozone (TO), surface ozone (SO) and stratospheric aerosol (SA) is being conducted in Georgia by the following organizations:

1. Hydrometeorological Service of Georgia (HS).
2. Abastumani Astrophysical Observatory of Academy of Science of Georgia (AAO).
3. M.Nodia Institute of Geophysics of Academy of Science of Georgia (IG).

All organizations take part in monitoring and research activities using the following instruments:

Name of the station	Organization	Instrument	Since (year)	Last calibration	Parameter
Tbilisi (41°41'N,44°57'E,450 m asl)	HS	M-124	1964	1997	TO, Both Instruments were broken in 2001
Abastumani (41°45'N,42°50'E,1600 m asl)	AAO	M-124	1957	1994	TO
Abastumani (41°45'N,42°50'E,1600 m asl)	AAO	Twilight sounding method	1940	Permanent	SA
Tbilisi (41°41'N,44°57'E,450 m asl)	IG	OMG-200	1980	Permanent	SO
Telavi (41°48'N,45°30'E,600 m asl)	IG	OMG-200	1980	Permanent	SO

The total ozone data of Tbilisi station are regularly (every day) sent to the Main Aerological Observatory near Moscow, where all analogous information received from the countries of the Commonwealth of Independet States is collected. Twice a year the daily total ozone values are sent to the Main Geophysical Observatory in St. Peterburg. These data after quality control in MGO are sent to the WMO World Ozone and UV Data Centre (WO3UDC) in Toronto.

Note

1**.** The photometric measurements of twilight sky brightness in different narrow intervals of the visible spectrum have been carried out in Abastumani Astrophysical Observatory, South Caucasus since 1940. The method is described in Rozenberg (1966). Such measurements allow to determine aerosol loading in the stratosphere and mesosphere as a function of height. The database covers periods of high aerosol loading in the stratosphere after strong volcanic eruptions such as Fuego, St. Helens, El Chichon and Pinatubo. Prominent mesospheric aerosol enhancements caused by intensive meteor showers, such as Leonids, have also been registered.
A significant improvement of the measurements may be achieved by using a spectrometer based on CCD linear detector instead of the photometer equipped with a photomultiplier and interference filters which is currently in use. An access to databases of lidar and satellite measurements of atmospheric aerosol loading would be also very useful.
Rozenberg, G.V.: 1966, *Twilight.* Plenum Press, New York, 1-380.

2. Using standard actinometrical observations for eight Georgian locations (Tbilisi,1928-1991;Telavi,Tsalka – 1457 m, Anaseuli – 158 m, Senaki – 40 m, Sokhumi – 116 m,-in the mid. 1950 – 1991; Jwari Pass – 2396 m, 1973 – 1985;Kazbegi – 3656 m,1955-1964), the Atmospheric Aerosol Optical Depth was established (Institute of Geography and Institute of Geophysics of

Academy of Science of Georgia). In 1991 actinomertical observations were stopped because the instruments were not tested.

Research Programme:

-Time variations of the total ozone and the surface ozone in several regions of Georgia and their dependence on the atmospheric processes;
-Trends and decline of the total ozone;
-Increasing of surface ozone in Georgia and conditions for appearance of photochemical smog;
-Effect of ozone on local climate;
-Ozone, aerosols and ecosystem;
-Total ozone and solar activity;
-Vertical aerosol distribution in the stratosphere and middle atmosphere by the twilight sounding method;
-Effect of ozone and atmospheric aerosol on the direct and diffuse solar radiation including ultraviolet radiation.

Future Plans:

-Monitor regularly total ozone, ozone vertical distribution, surface ozone, tropospheric and stratospheric aerosols, atmospheric aerosol optical depth;
-To continue research programme;
-Laboratory modelling interaction ozone with small atmospheric admixtures (aerosols, gases);
-Laboratory modelling interaction UV radiation with ozone, cloudiness, aerosols and gases.

Publication of Results:

The results of the research works are published in the form of one monograph and in more than one hundred various articles. The most recent ones are:

J.Kharchilava, K.Tavartkiladze, M.Lokapishvili,V.Amiranashvili – On the total ozone variation in Georgia, Journ. of Georgian Geophys. Soc.,Iss.(B),Atmosphere,Ocean and Cosmic Rays, vol.2, 1997, pp.39-49.
J.Kharchilava, K.Tavartkiladze, M.Lokapishvili,V.Amiranashvili-The variability and distribution of the total atmospheric ozone in Georgia, Bull. of the Georgian Acad. of Sci.,157,No 1,1998, pp.53-55.
I.Mateshvili,G.Mateshvili.N.Mateshvili – Measurement of the vertical aerosol distribution in the middle atmosphere by the twilight sounding method, Journ. of Aerosol. Sci.,Pergamon,vol.29, No 10,1998, pp.1189-1198.
O.Benashvili,J.Lominadze,T.Toroshelidze – Investigation of the stratosphere ozone long-term trend in day-time and twilight, Bull. of the Georgian Acad. of Sci.,160,No 3,1999, pp.468-470
A.Amiranashvili,V.Amiranashvili,K.Tavartkiladze – Dynamics of the aerosol pollution of the armosphere in Georgia in 1956-1990, Journ. of Aerosol. Sci.,Pergamon,vol.30, Suppl. 1,1999, pp.s667-s668.
I.Martin,T.Toroshelidze,W.Alves,M.Mello,A.Gusev,G.Pugacheva –Solar cycle and global long term variations of stratospheric ozone, Adv.Space Res.,Pergamon,vol.24,No 5,1999,pp.665-669.
J.Kharchilava, K.Tavartkiladze – The peculiarities of the vertical distribution of ozone in Georgia, Bull. of the Georgian Acad. of Sci.,162,No 1,2000, pp.77-79
O.Lomaya,K.Mchedlishvili,G.Chkhaidze,J.Kharchilava,Z.Khvedelidze –Investigation of the ozone relationship with some meteorological factors, Bull. of the Georgian Acad. of Sci.,162,No 2,2000, pp.259-261.
A.Amiranashvili,V.Amiranashvili,T.Gzirishvili,G.Gunia,L.Intskirveli,J.Kharchilava –Variations of the weight concentrations of dust,nitrogen oxides,sulphur dioxide and ozone in the surface air in Tbilisi, Proc. 15th Int. conf. on nucleation and atmospheric aerosols,Rolla,Missouri,6-1 August 2000, pp.793-795.
A.Amiranashvili,V.Amiranashvili,K.Tavartkiladze – Aerosol pollution of the atmosphere and its influence on the direct solar radiation in some regions of Georgia, Proc. 15th Int. conf. on nucleation and atmospheric aerosols,Rolla,Missouri,6-1 August 2000, pp.605-607.

Need of Support:

-We need urgently financial support by WMO for the reparation of two ozone instruments M-124 and calibration of four ozone instruments M-124;
-We need financial support by WMO to purchase two or three UV-B solar radiation instruments;
-Financial support for periodic calibration of standard actinometrical instruments;
-In the future it is necessary to have a standard Dobson or Brewer spectrophotometers and more modern surface ozone instruments.

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GERMANY

In accordance with Decision VCV/3: Recommendations of the fourth meeting of the Ozone Research Managers to the Parties of the Vienna Convention at Geneva in 1999, the following significant research and monitoring activities have been carried out since 1999 in Germany.

Ozone-monitoring and related research in Germany is distributed over numerous institutions. Usually, there is no distinct separation between research and development, monitoring and quality control. In general, research is carried out at university institutes or at research centres (MPI, DLR, FZ-Jülich). Regular long-term monitoring of ozone outside the planetary boundary layer is provided by DWD and AWI, UV-monitoring by BfS, UBA and DWD. Surface ozone is monitored by authorities at the national (UBA), state and local level. Surface ozone will not be discussed further in the report.

Table 1. Overview of institutes involved in ozone/UV research (R), development (D), modelling (MD), monitoring (MT), quality assessment /quality control (QA/QC)

Institute	**Location**	**Field**	**Keywords**
Deutscher Wetterdienst, www.dwd.de/research/	Hohenpeissenberg, Lindenberg	MT, R, QA/QC	Regional Ozone Centre, DCC, NDSC, GAW
Alfred Wegener Institut für Polar u. Meeresforschung, www.awi-potsdam.de/ www.awi-bremerhaven.de/	Potsdam, Bremerhaven	R, MT, D	Neumayer, Ny Ålesund, MATCH
Forschungszentrum Jülich, www.fz-juelich.de/	Jülich	R, QA/QC, MD	Calibration C. O_3-Sonde, JOSIE CLAMS
MPI f. Meteorologie (DKRZ), www.dkrz.de/	Hamburg	R, MD	ECHAM
DLR, DLR/DFD, www.dlr.de/	Oberpfaffenhofen	R, MD, MT	GOME, ECHAM, Air-Traffic
IAP Kühlungsborn, www.iap-kborn.de/	Kühlungsborn	R, D, MT	Middle Atmosphere, Alomar,
Bundesamt f. Strahlenschutz (BfS) www.bfs.de/	Salzgitter	MT	UV
Umweltbundesamt, www.umweltbundesamt.de/	Berlin	MT,	Air quality
Uni Bremen, IUP, IFE, www-iup.physik.uni-bremen.de/index.html	Bremen	R, D	GOME, SCIAMACHY, MICROWAVE
Uni Köln, Inst f. Meteorologie, www.uni-koeln.de/math-nat-fak/geomet/	Köln	R, MD	EURAD,
FU Berlin, Inst. f. Meteorologie , strat-www.met.fu-berlin.de/	Berlin	R, MT	Stratosphere
Uni Frankfurt, Inst. f. Meteorologie, www.rz.uni-frankfurt.de/IMGF/meteor/klima/	Frankfurt	R, MT	CFC's
Uni Mainz, MPI f. Chemie , www.mpch-mainz.mpg.de/	Mainz	R, MD	ECHAM/CHEM
Uni Heidelberg, www.uphys.uni-heidelberg.de/	Heidelberg	R, QA/QC	DOAS
Uni Karlsruhe, IMK www-imk.physik.uni-karlsruhe.de/	Karlsruhe, Garmisch (IFU)	R, MD	MIPAS, FTIR, KASIMA
Uni München (LMU),	München	R, MD	UV, STAR
Uni München (TU), www.forst.tu-muenchen.de/EXT/LST/METEO/	Freising-Weihenstephan	R	
Uni Hannover, Inst. f. Meteorologie www.muk..uni-hannover.de	Hannover	R	UV

Monitoring

Germany's Meteorological Service (DWD) is running a very intense measurement program at the Observatories Hohenpeissenberg and Lindenberg, monitoring the ozone vertical distribution and total ozone columns on a regular and long-term basis (Table 2). Special efforts are put into high quality and long-term consistency. The time series cover 35 years for ozone measurements up to 30 km altitude (balloon-sonde and Dobson-spectrometers) and 15 years for upper stratospheric LIDAR observations. Data are regularly submitted to the data centers at Toronto, Thessaloniki, NILU, and NDSC. In addition to the observational UV-network of the BfS (Table 2), DWD continues to measure UV-B radiation for research and development purposes (see below). Both institutes provide the public with UV-information including daily forecasts of the UV-index.

The Alfred Wegener Institute for Polar and Marine Research (AWI) is very active in atmospheric research. It operates two fully equipped polar stations in the Arctic (Ny-Ålesund/Koldewey - NDSC primary station), and Antarctic (Neumayer). The Neumayer meteorological observatory is designed as a radiation and climate monitoring station and an air chemistry observatory as well. Measurements of radiation are carried out on a large scale as part of a global observation network to detect long-term changes in the Earth's radiation budget and their impacts on climate. Since 1992 vertical ozone balloon soundings belong to the regular observations.
At Koldewey station, routine ozone and UV measurements are taken by ECC-sondes, Lidar, microwave, DOAS, FTIR and UV-spectrometers. Many of these measurements are run in close cooperation with IUP/Uni Bremen.

DLR/DFD is routinely retrieving and processing the data from a number of satellites to investigate the atmosphere and surface of the earth. Especially the processing, distribution and archiving of the GOME and in future the SCIAMACHY data is a substantial task of DLR/DFD. A variety of GOME ozone and UV products is made available via the Atmospheric User Centre (AUC) on the Internet (http://auc.dfd.dlr.de/GOME/index.html).

Type of observation	Location	Org.	Instrument	Type	Start
Total Ozone Column	Hohenpeissenberg	DWD	Dobson	No. 104, No. 064	1967
	Hohenpeissenberg	DWD	Brewer	No. 010	1983
	Hohenpeissenberg	DWD	Microtops	No. 3128, No. 3785	1996
	Lindenberg	DWD	Brewer	No. 078	1992
	Potsdam	DWD	Dobson	No. 071	1964
	Potsdam	DWD	Brewer	No. 030	1987
	Potsdam	DWD	Brewer	No. 118	1996
Calibration	Hohenpeissenberg	DWD	Dobson	No. 064	1999
Ozone Vertical Profile	Hohenpeissenberg	DWD	Ozonesonde	Brewer-Mast	1967
	Hohenpeissenberg	DWD	LIDAR (Stratosphere)	DIAL	1987
	Lindenberg	DWD	Ozonesonde	ECC (since 1992)	1974
	Ny Ålesund (Spitzbergen)	AWI	Ozonesonde	ECC	1990
	Ny Ålesund (Spitzbergen)	AWI	LIDAR	DIAL	1991
	Neumayer (Antarctica)	AWI	Ozonesonde	ECC	1992
	Garmisch	FZK	LIDAR (Troposphere)	DIAL	1988
Calibration	Jülich	FZ	Ozonesonde		
UV	Garmisch	FZK	Bentham DTM 300		1994
	Hohenpeissenberg	DWD	Brewer MK II	No. 010	1991
	Lindenberg	DWD	Brewer MK IV	No. 078	1991
	Potsdam	DWD	Brewer MK II	No. 030	1993
	Potsdam	DWD	Brewer MK III	No. 118	1996
	Potsdam	DWD	Bentham DM 150		2000
	Potsdam	DWD	Spectro 320D		2002
	Dortmund	BAuA	Bentham DM150		
	Kulmbach	LfU	Bentham DM150		
	München	BfS	Bentham DM150		1993
	Langen	BfS	Bentham DM150		1993
	Schauinsland	BfS	Bentham DM150		1993
	Sylt	CAU	Bentham DM 300		1995
	Zingst	BfS	Bentham DM150		1993
	Zugspitze	FZK	Bentham DTM 300		1995

Table 2. Operational network for long-term measurements of ozone and UV

Research and Development

129 research projects were funded in the German Ozone Research Programme by the German Ministry of Education and Science (BMBF). This programme started in 1989 and has ended in 1999. Many field campaigns, e.g. POLECAT, POLSTAR, CHORUS, laboratory studies, modelling and the evaluation of existing data, were conducted in close cooperation with partners from Europe and abroad. This very successful programme substantially improved the understanding of the ozone layer, especially at northern high and mid-latitudes. Some continuation of that programme is being funded by the BMBF in the more widespread AFO 2000 Programme. In particular the KODYACS project is investigating the links between long-term ozone depletion and climate change. KODYACS combines substantial modelling efforts (ECHAM/CHEM) with analysis of existing long-term measurements.

IUP-Uni Bremen is one of the leading institutes in the scientific design of the GOME and the SCIAMACHY instruments. Algorithms for retrieving trace gas amounts from the instruments' raw data are developed in cooperation with German Remote Sensing Data Center (DFD) , the Smithsonian Astrophysical Observatory (Harvard, Cambridge/MD, USA), the University of Heidelberg (Germany), the Koninklijk Nederlands Meteorologisch Instituut (KNMI, The Netherlands), and other institutes from the GOME Science Advisory Group.

IUP-Uni Bremen substantially contributes to the NDSC. They operate the KOLDEWEY Arctic station in cooperation with AWI. They are building a new tropical station (Merida, Venezuela, 4700 m asl) in cooperation with FZ Karlsruhe. They are also contributing to another arctic station on the Greenland ice-shelf (at 3200 m asl) in cooperation with DPC, Kopenhagen, Uni Bordeaux, Uni Leeds and NSF USA (EU-Project).

At Forschungszentrum Karlsruhe/IMK measurements of ozone and ozone relevant species have been performed for many years by ground-based and airborne observations. The measurements are combined with process studies and 3D chemical transport modelling. These efforts led to the detection of severe denitrification over the Arctic and the specification of chlorine and nitrogen species in Arctic winters over the last decade. In cooperation with MPI Mainz they identified a critical sensitivity of the arctic vortex and the ozone loss to greenhouse gas forcing, which leads to delayed recovery of the ozone layer arising from enlarged PSC and denitrification probability.

Long-term measurements of stratospheric CFC12 have been conducted by the University of Frankfurt and FZ Jülich. Since 1978 they have studied the evolution of this important source gas by regular balloon soundings.

By the winter 2000/01 the MATCH campaign, coordinated by AWI and funded by the EU and national institutes ended after ten successful years. One of the main findings of MATCH is that under certain conditions the ozone loss rates measured in-situ inside the Arctic polar vortex are up to a factor of two larger than we can currently explain. Follow up studies have raised significant concerns about the completeness of our current understanding of the chemical ozone loss in the Arctic (see Future Activities).

QA/QC/Validation

Activities towards improving the quality of balloon-ozone-soundings were continued at the World Calibration Center for Ozone Sondes (WCCOS) at FZ Jülich. JOSIE 1996 showed the critical importance of sonde preparation procedures. Since, WCCOS has been instrumental in the international effort to achieve Standard Operating Procedures (SOPs), that would guarantee a uniformly high standard of ozone soundings world-wide. The second international ozone sonde intercomparison experiment (JOSIE-2000) conducted in September 2000 is an important milestone on this path towards SOPs. Pre-experiments sponsored by the WMO, prior to JOSIE-2000, were performed in 1998 and 1999. A meeting of experts in Geneva from May, 1-3, 2001 critically examined JOSIE 2000 and evaluated the entire series of JOSIE experiments.

The Regional Dobson Calibration Center (RDCC) for WMO RA VI at the Meteorological Observatory Hohenpeissenberg (MOHp) became operational in 1999. The first intercomparison was carried out with two regional standards, D064 (Germany) and D074 (Czech Republic), and the world standard D065 (Boulder, USA). RDCC is responsible for calibration and second level maintenance of more than 30 Dobson spectrometers operational in Europe and the Middle East. The close cooperation between MOHp and the Solar and Ozone Observatory at Hradec Kralove (SOO-HK, Czech Republic) guarantees excellent calibrations. 4 intercomparisons were performed in 2000 and 2001 with altogether 13 spectrometers from 10 countries. One of these instruments (D044, formerly University of Cologne) was completely refurbished and given to the Armenian Hydrometeorological Service as a loan.

In June 2002 a calibration of the regional standard instrument Dobson No. 064 by the primary ("World") standards D 065/D 083 is planned at the World Dobson Laboratory at NOAA in Boulder (USA). A regular calibration with three operational Dobsons and the second regional standard D 074 (from Czech Republic), will be held at MOHp afterwards.

Since July 2001 GAWTEC, the GAW Training and Education Centre of the GAW Programme has been established with funds from the Bavarian State and support from WMO. It is a cooperating partner of the German Quality Assurance/Scientific Activity Centre and organizes training courses twice a year for personnel from GAW stations worldwide. GAWTEC is based at the UFS Schneefernerhaus at the Zugspitze mountain. Experts from UBA, DWD and IFU at Garmisch and additional invited experts are giving training courses in measurement techniques of GAW-relevant parameters including ozone. Special emphasis is put on quality control, data handling and interpretation.

Within the EU-Projects STREAMER (cooperation with DLR/DFD) and EUMETSAT Ozone-SAF Hohenpeissenberg did a very thorough validation of (pre-operational) ozone profiles derived from GOME data. Validation will be continued in the Ozone-SAF. A SCIAMACHY validation group was set up at University of Heidelberg.

Future Activities

A novel Fourier transform infrared spectrometer (MIPAS=Michelson Interferometer for Passive Atmospheric Sounding) has been developed at Forschungszentrum Karlsruhe/IMK for the measurement of atmospheric trace constituents. One of these instruments will supplement the SCIAMACHY instrument onboard ESA's ENVISAT satellite. The atmosphere at the Earth's limb will be observed over an altitude range of 5 to 150 km with a vertical resolution of 3 km. By means of horizontal (limb) sounding of infrared emissions MIPAS can measure profiles of over 20 trace gases globally day and night. Global coverage will be obtained in 3 days. After ENVISAT's launch in spring 2002, there will be data sets available at the ATMOS User Center (DLR/DFD/AUC, see above).

DWD is intensively preparing to take over the assigned task of European Centre for UV-forecasting. Within the EU-Project "Small Scale Structure Early Warning and Monitoring in Atmospheric Ozone and Related Exposure to UV-B Radiation (STREAMER)" DWD has developed an operational system for dynamical forecasts of 3D ozone fields, driven by DWD's global GME numerical weather forecast model. Feeding the predicted ozone, cloud, moisture, etc. fields into the "STAR" radiative transfer model from LMU Munich, DWD is producing highly resolved UV forecasts on a daily basis. Following the recommendations of COST action 713, DWD has offered this service to WMO.

12 new EU projects have recently been approved to investigate emerging issues on ozone, UV radiation and aviation impacts during the next 2-3 years. In 10 of these 12 projects a large number of german research institutes are active partners or coordinate the project. The MATCH Campaign will be continued in Antarctica from 2003 onward, coordinating ozone-soundings from 8 stations on the continent.

Since spring 2002 DLR/DFD hosts the World Data Center for Remote Sensing of the Atmosphere for the International Council of Scientific Unions (ICSU).

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INDIA

1. INTRODUCTION

India ratified the Vienna Convention for the protection of ozone layer on June 19, 1991 and the Montreal Protocol on Substances that Deplete the Ozone Layer on September 17, 1992. The India Country Programme was prepared in 1993 chalking out a strategy to phaseout production and consumption of Ozone Depleting Substances (ODS).

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

2. TOTAL OZONE OBSERVATIONS:

Total ozone measurements are being carried out at 6 stations by Indian Meteorological Department (IMD). Present network of six Dobson and two Brewer spectrophotometers are stationed at Sringagar, New Delhi, Varanasi, Pune and Kodaikanal.

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

2.1 Standardisation

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

2.2 Publication of data

The total ozone data and Umkehr data (vertical profile of Ozone) are being regularly sent in WMO format to the World Ozone Data Centre (WO3DC) Canada, and are being regularly published by the Centre.

3. CURRENT TOTAL OZONE RESEARCH

3.1 Long term trend of Tropopause over the Indian region

Radiosonde observations were taken during the past 32 years at New Delhi (28^0N, 77^0E) and 26 years at Thiruvananathpuram (8^0N, 76^0E) and has been analyzed to examine the long-term trend of tropopause height (TPH) and tropopause temperature (TPT) at these two stations. From the result, it appears that TPH was increasing and TPT was decreasing over the years. The trend of change was not same throughout the period of study. Considering the whole period of data we find that the increase of TPH was in the range of +0.57 to +1.13 % decade and the decrease of

TPT was in the range of –0.53 to –0.94 % decade. Qualitatively this was explainable with the decreasing trend of ozone in the stratosphere. Results of analysis shows that long-term change in the tropopause characteristics is taking place over the India region. This change is not unidirectional throughout the period of study.

3.2 Ozone concentrations over India

Ozone observations were taken during the past several years by Dobson Spectorphotometers at Delhi, Varanasi, Pune and Kodaikanal have been analyzed to examine its long-term trend over Indian stations. An increasing trend of total ozone over the yeas has been noticed at all the places, except at Varanasi, where a decreasing trend has been found. The cause of these trends could be attributed, partly, to the trends of ozone in the troposphere. The results also indicate that there are certain changes in ozone levels at the Indian stations. These changes are less apparent in the long-term trend analysis of total ozone data, as the increase in tropospheric ozone has a compensating effect to the decrease in ozone at stratospheric levels.

4. VERTICAL OZONE DISTRIBUTION

The development of an Indian ozonesonde was taken up in 1963. The first successful sounding was carried out in September, 1964. The sondes were subsequently intercompared in WMO/IO_3C comparison held in West Germany in 1970 and 1980; in 1991 (Canada) and 1996(Germany). Since early 1970 fortnightly soundings are attempted at New Delhi, Pune, Thiruvanathapuram, Dakshin Gangotri and Maitri (Antarctica).

4.1 Current vertical Ozone Distribution Research:

4.1.1 Vertical distribution of ozone over the Indian Ocean (15^0 N-20^0S) during Second Field Phase INDOEX-1999.

The vertical distribution of ozone over the Indian Ocean was measured during the second field phase (FFP) of Indian Ocean experiment from 15^0N to 20^0S in February/March 1999. A pocket of low ozone (~10 ppbv) was observed near the surface in addition to high ozone concentration observed at 8-12 km within the region of 5-15^0S during both INDOEX FFP-98 and INDOEX IFP-99. However, the north-south gradient in ozone concentration and the layered structure at 5-8 km as observed in INDOEX FEP-98 are not prominent during INDOEX IFP-99.

East-west cross-section of ozone concentration in the troposphere along 20^0S and 15^0N may be characterized as the background value of pristine and continental air on the northern and southern side of the equator, respectively. Through back trajectory analysis indicates that flow of air masses is mostly form the Indian subcontinent as well as south-east Asian region, it is difficult to distinguish the degree of relative contribution of continental flow to ozone concentration over the Indian Ocean. The comparison between marine and continental ozone profiles suggests that the northern side of the Inter Tropical Convergence Zone (ITCZ) resembles the continental profiles as observed over the Indian subcontinent and African region, rather than east Asian region.

5. ALLIED PROGRAMME

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

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

5.1 The Laser Hetrodyn System (LHS) and mm wave radiometer:

This system monitors the 10 micron ozone line in absorption mode against the Sun. The mm wave radiometer observes the 101 GHz ozone line in emission mode. This instrument has the advantage over LHS that it can be operated round the clock under all weather conditions as it does not require direct sun light. The line profiles in both the experiments are inverted to obtain the Ozone height distribution. The ozone height profiles over Delhi and Maitri have been generated for a limited period using these techniques.

6. SURFACE OZONE MEASUREMENTS

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

7. UV-B MEASUREMENTS

Regular measurement of UV-B radiation by filter photometer were started in 1979 at Physical Research Laboratory, New Delhi. At present under Indian Middle Atmospheric Programme (IMAP) a chain of 7 stations have been established for routine measurement of global UV-B radiation at 280, 290, 300 and 310nm using narrow band interference filters at Shillong (IMD), Jodhpur (IMD), Pune University, Waltair Andhra University, Mysore University and Trivandrum (CESS).

7.1 UV- Biometer

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

7.2 UV Spectroradiometer

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

8. INDIAN OZONE PROGRAMME OVER ANTARCTICA

Considering the importance of ozone measurements over Antarctica, an International Ozone Campaign had been organized during 1987. India participated in campaign and had set up observational facilities at Dakshin Gangotri (DG) (70^0.75 S, 11^0.75E) during the summer and winter expeditions of 1987. The programme started with UV-B radiation measurements and later on more sophisticated instrument like Laser Hetrodyne System (LHS) and Millimeter Wave radiometer were introduced. Regular ozone soundings from Maitri (Antarctica) (70^0 46'S, 11^0 45'E) are carried out with the Indian electrochemical ozone sonde.

The spectral measurement of UV-B started in 1987 and is continuing. Minimum Ecothermal dose measurement also started in 1993 to study the effect of vertical ozone profile. The National Physical Laboratory has established a millimeter-ground base instrument at Maitri, Antarctica for continuous ozone observation during the year under all weather condition.

9. MEASUREMENT OF MINOR CONSTITUENTS

Various greenhouse molecules such as Carbon Dioxide (CO_2), Methane (CH_4), Nitrus Oxide (NO_x) have also been measured regularly at National Physical Laboratory, New Delhi, Physical Research Laboratory, Ahmedabad and Banaras Hindu University, Varanasi.

10. FUTURE PLANS:

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

11. REFERENCE

A large number of papers have been published in various journals. Most recent ones are:

- Recent changes observed in column ozone concentrations over India, MAUSAM, 51, 1 (January 2000), 69-74.
- Long-term Trend of Tropopause over New Delhi and Thiruvananthapuram, GEOPHYSICAL RESEARCH LETTERS, VOL. 27, NO. 15, PAGES 2181-2184, AUGUST 1, 2000.
- Further evidence of total ozone variation during the solar eclipse of 1995, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 106, NO. D3, PAGES 3213-3218, FEBRUARY 16, 2001.
- Observations of vertical distribution of tropospheric ozone over Indian Ocean and its comparison with continental profiles during INDOEX FEP-1998 and IFP-1999, CURRENT SCIENCE (SUPPLEMENT), VOL.80, 10 APRIL, 2001

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IRAN

Introduction:

The first experience in this field was done with a Dobson Ozonometric equipment in Institute of Geophysics (Tehran University) about 20 years ago.
After some times of its usage, with assistance of Meterological Organization of Iran and cooperation of WMO, this instrument was sent to the United States and Canada for repairing and changing of some parts and then was calibrated. Then with the assistance of Canada , it was installed in Ozonometric Center of Esfahan (in middle of Iran region, 32 52 N, 51 71 E) and it was used for about 2 years. After that, it is was transferred to Institute of Geophysics, Tehran University.

Current Situation:

Then Brewer Ozonomentric equipment was brought from Canada and was installed and has been in operation in Esfahan for the past 2 Years.
This equipment not only measures total Ozone automatically but also measures total NO_2 and CO and amount of UV-B rays.
Vertical ozonesonde was installed at Mehrabad station which is able to plot ozone profile of atmospheric layers. After being operated, it was transferred to Ozonometric Center of Esfahan. The Vertical Ozonsonde is working on the basis of electrochemical pile technology. Every other week, Ozonesonde instrument with Radiosonde is sent to the atmosphere and the relevant data has been sent to Ozonometric Center of Canada for more analysis.

The Firooz-Kooh station (north region of Iran near Damavand mountain, 35 43N, 52 34 E) was selected by WMO as a GAW station assistance budgets, equipment for a GAW station for regional usage several places, with the help of WMO experts, the Amin-abad hills were chosen as a suitable place for establishing a new station .

The equipment used in this station is :

1- Ozone analyzer instrument for measuring surface ozone. It is under operation but since the computer link is not working properly , it is measured manually every hour by an observer. These measurements are in terms of PPB units and is done on atmospheric background conditions and not on urban conditions .This equipment should be checked and adjusted with the assistance of WMO experts. The calibration can be done in its original place every 2 years. This unit should be calibrated as soon as possible because calibration has not been done for the past 2 years.
2- Wet and dry deposition equipment is employed for analyzing rainwater . The parameters that can be measured are PH. conductivity coefficient , *cations* and anions . But unfortunately the rainwater analysis has not yet been done in this station . This is because the deposition operations are so delicate that some more equipment are needed to be installed .
3- Black carbon measuring equipment is employed for gathering black carbons by using special filters through pumping.
4- Aerosol sampler is employed for gathering atmospheric suspended particles (aerosols) by using special filters.
5- Sun photometer is used for measuring turbidity of sky and has not been operated yet .
6- Synoptic station

Requirements:

1. There is a need for installing equipment for an upper atmospheric station.
2. Installation of green house equipment would be helpful to enable us to measure green house effects.

Future Plans and Activities:

- Recognizing the vitality of research and observation of UV and ozone fluctuations, and country's obligation to the Vienna Convention,
- Taking into account the recommendations of fourth meeting of Ozone Research Managers, the following activities are planned for the future:

1. Establishing working groups to conduct the following activities within the relevant governmental and non-governmental organizations. The working groups are responsible to identify the needs, adopting the research framework to define projects on the following issues:

    - Regular UV monitoring, forecasting, and public information services;
    - Research on Environmental impacts of UV increase due to the ozone depletion in different parts of Country covering effects of UV radiation on
        One. human and animal health,
        Two. terrestrial and aquatic ecosystems,
        Three. biogeochemical cycle,
        Four. air quality,
        Five. materials

    - Adopt a programme on systematic measurement of ground-based and satellite-based ozone amount;

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ITALY

INTRODUCTION

Italy is active in many areas of stratospheric research, including atmospheric processes, monitoring of Ozone and UV levels, modeling of Ozone and related species. Research is performed by university departments and Italian Research Council's (CNR) groups. Research activities are supported principally by the Italian government, Italian Space Agency (ASI), European Space Agency (ESA) and European Union.

Following the **Decision V/3** (recommendations of the fourth meeting of the Ozone Research Managers taken by the Fifth Meeting of the Conference Parties to the Vienna Convention for the Protection of the Ozone Layer), Italian research groups are particularly active in:

- monitoring and archiving of measurements of tropospheric and stratospheric ozone and other trace species and aerosols;
- developing and implementing new observational capabilities such as aircraft-based measurements;
- investigating and quantifying stratospheric and tropospheric processes through routine monitoring and experimental campaigns;
- studying the interaction between ozone and climate and the impact of aircraft emission on ozone.

RESEARCH ACTIVITIES

The main directions of ozone research in Italy can be summarized as follows:

- ***Ozone monitoring***. A series of stations is taking routine measurements on ozone, UV radiation and chemical compounds.

- ***Ozone related studies (observations and process study)***. This is being carried out mainly through coordinated activity in the fields (campaign) in different part of the world. Italy has been an active part in developing and operating a new airborne platform for stratospheric measurements.

- ***Modeling activity*** in connection to the development of the algorithms for the use of satellite data. This activity also include Chemical and Transport Modeling of the stratosphere and trajectory modeling to interpret the field data and assessment studies carried out with a class of models.

1. Ozone monitoring

Routine daily measurements of column ozone are carried out at the stations of Vigna di Valle (42.1 N, 12.2 E), Sestola (44.2 N, 10.8 E), Brindisi (40.6 N, 17.9 E) and Messina (38.2 N, 15.5 E) by Servizio Meteorologico of Aeronautica Militare, by means of three Dobson and four Brewer spectrophotometers. Data from these stations are regularly sent to the WMO3UDC in Toronto.

Routine measurements are also carried out at Ispra (45.8 N, 8.6 E) and Rome (41.9 N, 12.5 E) using a Brewer spectrometers managed by University of Rome “La Sapienza”.

Ozone sounding and Dobson readings at S. Pietro Capofiume station (44.6 N, 11.6 E -WODC station 297) were performed on a weekly base from 1991 to 1997, and after that during short time campaigns in the frame of EU project (such as Match or Votalp) and for key studies. Also, in conjunction with campaigns, ozone soundings are taken at university of L'Aquila (12E, 43N).

ENEA (National Agency for the Environement and the Energy) operates a station for climate observation on the Lampedusa Island (35.5 N, 12.5 E), where it performs routine observations of ozone and UV using a Brewer spectrometer. Stratospheric aerosols are being monitored from the lidar site of Brasimone in central Italy

Regular measurements of column and tropospheric ozone as well as of selected greenhouse gases are performed at the GAW observatory of Mt. Cimone (northern Apennines, 2150 m) maintained by the Aereonautica Militare.

ISAC/CNR coordinates daily measurements of total ozone and nitrogen dioxide, performed by means of a Differential Optical Absorption Spectrometer (DOAS), at the following stations: M.te Cimone (since 1994), Terra Nova Bay-Antarctica (since 1995) and Stara Zagora-Bulgaria (since 1999).

Other monitoring activities are carried out by ISAC/CNR using brewer instruments installed seasonally in Ushuaia (Argentina, 54°S) and steadily in Antarctica at Scott and Belgrano stations.

A daily bulletin on the UV-B radiation exposure times is disseminated to the public since the summer 1995 by ENEA, in a collaboration with Ministero per l'Ambiente, following methods used by the Atmospheric Environment Service of Canada, and University of Thessaloniki (Greece).

2. Ozone observations and process studies

Many research groups are involved in programs addressed to the study of stratospheric ozone and related problems.

- Observations

At present lidar instruments from Italian institutions or within international collaborations are operational at some stations which participate in the Network for Detection of Stratospheric Changes, NDSC, i.e. at Thule (76.5 N, 68.8W, Greenland, University of Rome "La Sapienza"), Lauder (New Zealand, IFAC/CNR), Dumont d'Urville and McMurdo (Antarctica, IFAC/CNR and ISAC/CNR). From these stations lidar observations of stratospheric aerosol, temperature and ozone are carried out. In particular, the formation, evolution and climatology of Polar Stratospheric Clouds, and their influence on the ozone depletion process, are studied in the high latitude regions during the winter and spring seasons.

Aerosol depolarization, multi-wavelength backscattering and, occasionally, ozone profiles are measured at Rome and Florence. Measurements of aerosol and temperature profiles are carried out from Frascati: the long term behavior of the thermal structure of stratosphere and mesosphere and the propagation of gravity waves are among the main arguments of study. The evolution of the temperature profile and of the gravity waves is studied at Brasimone with a Rayleigh and Na resonance scattering lidar.

An high resolution Fourier transform spectrometers for atmospheric emission measurements in the far-infrared spectral range has been developed by ISAC/CNR and deployed on board of stratospheric aircraft and balloons to perform limb sounding observations of minor atmospheric constituents involved in the ozone chemistry. The IBEX instrument (Infrared Balloon Experiment) was flown from the NSBF (National Scientific Balloon Facilities) bases in Texas and New Mexico and from the Italian base of Milo, Sicily.

- **APE project**

Since 1996 the Airborne Platform for Earth observation (APE) project is being carried out. APE is an international scientific project, which involves also CNR, ENEA, the Italian Antarctic Program and the Universities of L'Aquila and Rome, in a cooperation with Russian institutes (Central Aerological Observatory, CAO).

This project is addressed to the study of the chemistry-physics of the stratosphere by means of instruments installed on a high-altitude aircraft, the M-55 Geophysika (Fig. 1). This aircraft is able to reach 21 km of altitude with a 1500 kg payload. Many of the instruments onboard the M-55 are developed in Italy. The payload includes: (1) a pressurized elastic backscatter Lidar (Air-Borne Lidar Experiment, ABLE) operated by the University of Rome; (2) a Fourier Transform spectrometer (Spectroscopy of the Atmosphere with Far-IR Emission-Airborne, SAFIRE-A) operated by IFAC/CNR (Fig. 2); (3) a DOAS spectrometer (GASCOD) operated by ISAC/CNR; (4) a multi-wavelength backscatter instrument (air-borne MAS) operated also by ISAC/CNR; (5) a chemiluminescent ozone sensor (FOZAN) operated by ISAC/CNR in collaboration with CAO. Various APE field campaigns have been performed in the past: in the Arctic (APE-POLECAT campaign, Rovaniemi, Finland, winter 1996/97), in the tropics (APE-THESEO, campaign, Seichelles, spring 1999) and in the Antarctic region (APE-GAIA campaign, Ushuaia, Argentina, autumn 1999). The M-55 will operate during the 2002-2004 period in the following projects: EUPLEX (European Polar Stratospheric Cloud and Lee Wave Experiment), TROCCINOX (Tropical Convection, Cirrus, and Nitrogen Oxides Experiment) and for the ENVISAT Satellite Validation Mid-lat. and Arctic Campaign. Responsibility for data interpretation and modeling support to all past APE missions has been mostly of the University of L'Aquila.

- ENVISAT validation

Various Italian scientist groups from CNR and University departments will participate to the geophysical validation of the data from the ENVISAT Earth observing satellite. Validation activities are devoted principally to the MIPAS, GOMOS and SCIAMACHY instruments on board the ENVISAT, and will be performed by means of instrumental measurements, theoretical modeling and data assimilation.

FIG. 1: The M55-Geophysika stratospheric aircraft

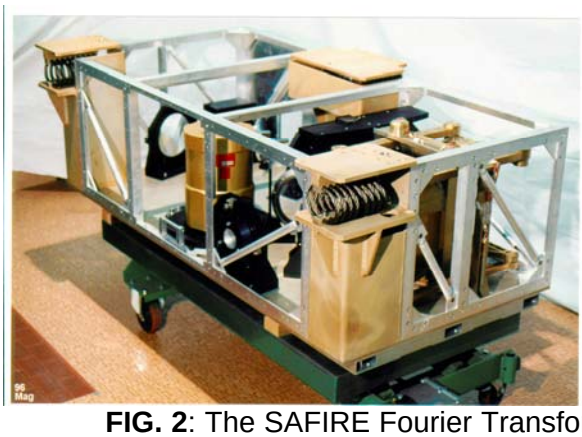

FIG. 2: The SAFIRE Fourier Transform Spectrometer

3. Modeling

In the IFAC/CNR Institute in Florence observational techniques, instruments and methods of analysis are developed for studying the Earth atmosphere. Since 1995, in the frame of an ESA study involving a large international consortium of scientists, IFAC has developed the algorithm for the near real time Level 2 analysis of MIPAS measurements performed on board the ENVISAT platform. In parallel, IFAC is participating in the AMILD2DA CEE project, involving many international groups working on MIPAS data analysis, and devoted to MIPAS data analysis itself and comparison of the obtained profiles with the products of the other atmospheric instruments on ENVISAT.

University of L'Aquila has contributed to the ozone assessment of WMO/UNEP, by using photochemical modeling based on IPCC scenarios, with the main purposes of studying aviation and stratospheric aerosol effects on ozone. University of L'Aquila participates, in the framework of

the TOPOZ-II projects, to an extensive validation of 3D Chemical and Transport Models (CTM) which uses data from the MOZAIC campaign and ozonesondes. A General Circulation Model (GCM) coupled with a chemical code, is also used to study the upper troposphere an lower stratosphere (UTLS) region, with particular regard to climatic feedback due to aerosol and ozone distribution changing (Fig. 4).

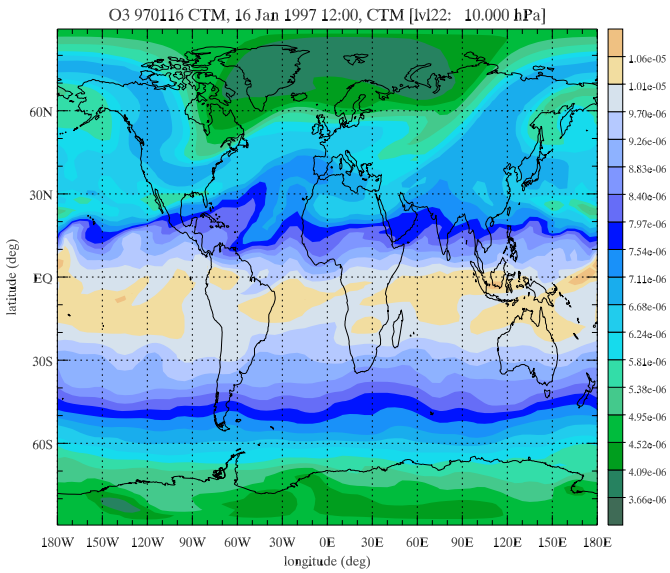

FIG. 3: Example of stratospheric O_3 field assimilated in a 3D Chemical Transport Model from satellite (MLS/UARS) data, for winter 1997.

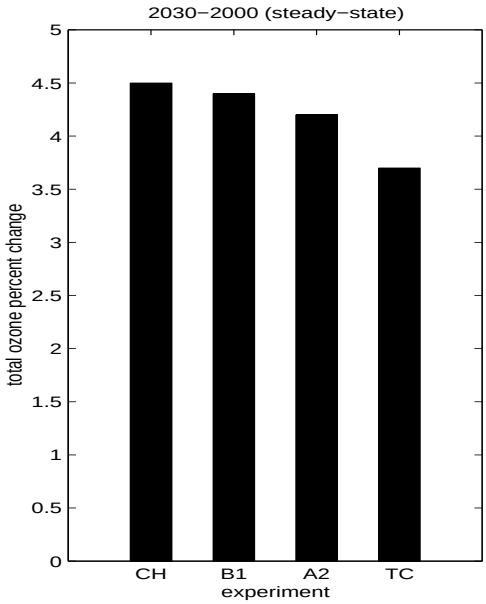

FIG. 4: Example of calculated O_3 % changes under different WMO / IPCC scenarios.

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JAPAN

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

1. Monitoring

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

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

1.2. Lidar and microwave monitoring of the ozone layer

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

1.3. Monitoring of related chemical constituents

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

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

1.4. UV-B monitoring

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

2. Research

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

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

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

(b) *Satellite observations*

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

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

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

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

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

(d) *Modeling and experimental studies*

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

2.2. Research on the environmental effects of ozone depletion

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

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

(b) *UV-B effects on ecosystems*

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

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KENYA

Ozone research and monitoring activities in Kenya are the country's effort to compliment the international systematic atmospheric observations in support of the spirit of the Vienna Convention. Kenya is committed to provide, in line with the objectives of GAW-GO_3OS, long-term records of ozone and other species that are essential for determining the variability of these species and their impacts on life and climate. Notably, the goal is the continued monitoring of tropospheric and stratospheric ozone and the assessment of its variations that are relevant to the wellbeing of the environment.

Ozone research and monitoring activities in Kenya are undertaken at three locations closely related to Kenyaa Meteorological Department. Profiles of Ozone are taken weekly at Kenya Meteorological Department, while continuous measurements of surface ozone and daily column ozone are measured at the Mount Kenya GAW station and the University of Nairobi respectively. This information is exclusive of other related activities that may be going on in the country, such as San Marco, Malindi, Kenya. This site is associated with the military and information concerning the facility is not open to the public.

Nairobi Ozonesonde Station:

Location: Kenya Meteorological Department (1^0 $18^/$ South, 36^0 $45^/$ East, Elevation 1795m)

Period of Observation_ - since May 1996

Instrument - EN-SCI ECC Ozonesonde

- Frequency of operation is weekly

- Performance and system audit done in January, 2000 and February 2002.

- Standard Operating Procedures referenced to Manufacturer and Julich Ozonesonde Intercomparison Experiment (JOSIE), 1998,1999, and 2000.

- QA and Twinning partner is Meteoswiss Aerological station Payerne.

Exchange of data:

Nairobi ozone profile data is available at WOUDC in Toronto via Payerne. The same data is available at SHADOZ (Southern Hemisphere Additional Ozonesondes) website. SHADOZ is a NASA Project whose goal is to address the ozone data gaps in the southern Hemisphere.

Nairobi vertical ozone data has been requested and sent to local and foreign Universities. A recent paper on tropical ozone data including Nairobi is going to appear in the January edition of the Journal of Geophysical Research (JGR). Similar data was presented in the Ozone Symposium, Sapporo, 2000.

UV-B Monitoring

Instrument - Broad-band Pyranometer. This instrument has never yielded any good data at all and needs to be replaced. The problems relate to the acquisition and processing software as well as the calibration.

- Exchange of data: Not yet started.

Dobson Spectrophotometer

Location- Department of Meteorology, University of Nairobi (1^0 $16^/$ S 36^0 $48^/$, E, elevation 1710m)

Period of observations- since 1984

Calibration- Inter-comparison with Brewer in 1992
- Alignment corrected in October 1998
- Intercomparison in South Africa, March/April 2000.

Dobson is used to compare and normalize the Nairobi ozone profiles.

Data exchange - Every 4 months. Latest data available at WOUDC, Toronto, Canada, is June 2001.

The operations and management of this instrument is by the University.

The Dobson is currently out of service. Some spares for the instrument electronics are lacking. A recent retrenchment of University staff also adversely affected the smooth operations of the Dobson. It is not possible now to guarantee the previous levels of operation. That is another reason why data gaps may start appearing in future.

Mount Kenya Global Atmosphere Watch Station

Tropical, continental, high altitude (3680m) monitoring station.
Auxiliary data of meteorological parameters and precursor gases are measured. These are essential for the better understanding of ozone changes, both in the troposphere and stratosphere. Other monitoring programmes are surface ozone, aerosols (black carbon), solar radiation, carbon monoxide (CO), and precipitation chemistry.

The station started operations in December 1999. But there are many data gaps in the records due to frequent long periods without power at the station.

Calibration of surface ozone instrument – February 2002
Installation of CO Analyzer (TECO 48S) – February 2002

Data Exchange: There is no data at the World Data Centres. Exchange will start as soon as a continuous data record is achieved. A limited initial data set has been exchanged through expert visits. Similar data has also been used locally by scientists and universities.

On Going Research

This is related to the distribution of atmospheric ozone
as a climate variable and the increase in UV radiation that may result from the decrease in atmospheric ozone abundance.

1. Characterization of air-masses reaching the Mount Kenya GAW station.
2. Regional build-up of equatorial high altitude ozone.
3. Vertical distribution of ozone in continental equatorial atmosphere.
4. Relative Humidity in the vicinity of the tropopause.
5. Seasonal and annual variation in total ozone (column and integrated).
6. Trends in tropospheric and stratospheric ozone over equatorial Africa.

Future Activities

- Monitoring of GHGs – Flask sampling at GAW station in cooperation with NOAA, CMDL.
- Continuous CO monitoring
- Possibility of the Nairobi ozone station being in the global network of the NDSC (Network for Detection of Stratospheric Change) following the commissioning of the SCHIAMACHY project in Nairobi in March 2002.

Recommendations

- Provide support to the measurement programmes in order to guarantee smooth measurements activities.
- Enhance capacity building in the developing countries to ensure professional competence in data handling.
- Expand the UV measuring network where there is none. Kenya needs a UV instrument along side the Dobson and the ozone profiles.
- Acknowledgement of, and offers of co-authorship to, data providers should be encouraged in order to promote self-confidence and appreciation of their efforts.

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KUWAIT

I . INTRODUCTION

The State of Kuwait is situated at the north- eastern part of the Arabian Peninsular bounded by Iraq from the north and west, Saudi Arabia from the West and South and the Arabian Gulf from the east .

It has a surface area of 18000 sq Km extended between 28° 30´ and 30º 05´ north latitude and between 46º 33´ and 48º 36´ east longitude .The climate in Kuwait is harsh as it goes up to 60º C in summer and it reaches as low as –3º C in Winter.

The Environment Public Authority (EPA) in Kuwait is the focal point to follow up all the environmental treaties and conventions that the country is a party to

Air & Noise Pollution Monitoring Department on another hand is responsible for monitoring and investigating atmospheric pollution and related issues .

II. HISTORY:

1970 : After Stockholm Declaration – Occupational Health and Hygiene Unit Was established within MOH.

1980 : Environment Protection Council (EPC).

1982 : Protection Department (EPD) was established..

1986 : A- Air Pollution Monitoring Stations were established.

B- First informal Ozone committee was established.

1987 : UV measurements started in Mansooria Fixed Station

1989-1990 : Studies on effects of Solar Radiation ,UVB on health.

1990 : Iraqi Invasion

1992-1993 : Reestablishment of Ozone Committee -EPC
b-Amiri Decree 135/1992-Ratification Vienna Convention & Montreal Protocol.

1994 1- Reclassification of Kuwait as an Article 5 Country.
2- Ratification of London & Copenhagen Amendments.

3- UVA, UVB Solar Continuous monitoring .

1995-1996 : : Establishment Of EPA .

2000 : UVA, UVB continuous Monitors in Shuwaik

III. AIR POLLUTION MONITORING STATIONS :

In 1984 Environment Protection Council (EPA today) established 3 fixed Stations . Now there are six air pollution monitoring stations around the country (as shown in the Map) . The main Pollutants measured in these stations are :

1- SO2, H2S 2- NO, NO2
3- THC- CH4, N-CH4 4- O3
5- CO 6- CO_2
7- NH_3 8- SPM

The stations also are equipped with metrological sensors such as Temperature- Wind Direction & wind Speed – Relative Humidity-Atmospheric Pressure –Solar Radiation and UV.

The Table below shows the location of each station with the main pollutant monitored .

	Station	Longitude	Latitude	Pollutants ppb	UV W/m^2	Uva W/m^2	Uvb W/m^2	Solar W/m^2
1	**Mansooria**	48° 00	29° 22′ 30	**Sox- Nox-O3- CO -THC-SPM**	**Yes**	**Yes**	**Yes**	**Yes**
2	**Rabia**	47° 56′	29° 18′	**Sox- Nox,O3- Co -THC- SPM**	–	–	–	–
3	**Reqqa**	48° 6′	29° 7′30	**Sox- Nox,O3- Co -THC, NH3- SPM**	–	–	–	–
4	**Jahra**	47 40′	29 20′	**Sox- Nox,O3- Co CO2- THC,SPM**	–	–	–	
5	**Um Al –Haiman**	48° 8′	28° 58′	**Sox- Nox,O3- Co CO2- THC,NH3- SPM**	–	–	–	
6	**Um Al Aish**	47° 45′	29° 50′	**Sox- Nox,O3- Co THC**	–	–	–	
7	**Shuwaik**	47° 56′	29° 20′	**So2-SPM**	–	**Yes**	**Yes**	–

IV. UV MONITORS :

Ultra Violet radiation is the part of electromagnetic spectrum that has wavelength between 200 and 400 nm . In biomedical literature this is divided into the UVA, UVB, UVC bands .
UVA:400-320nm
UVB: 320-285nm
UVC : 285-200nm.

Although UV represents 3% of all total radiations of the Sun , and what reaches the earth is UVA & UVB no UVC , UVB still has great effects on life on our planet Earth. UV monitoring in Kuwait started in 1987, Two ways of monitoring were used:

1- **Spot Monitoring .**
2- **Continuous Monitoring .**

1. On Spot UV Monitoring

The Air pollution department In Shuwaik Industrial Area used Portable sensors such as (IL—442{400-320nm}) & (Mutzhas Meter- {380-320 nm}) were used to measure **UVA**. The **UVB** was measured by (Polysulfone Films). Technicians used to take the devices out in an open area , focus it to the sun and try to get the best reading. This was carried out during noon from 11:30 to 12 o'clock daily and was very hard to carry out during summer days under the burning sun. Now this method is no more in use as continuous monitoring devices were installed.

2. Continuous Monitoring

During 1987 (EP-Lab-UV detector (290-386) continuous monitors were fixed in Mansooria Ambient Air Quality Monitoring Station for monitoring UVA-UVB as total. However, in 1994 (SKU 420-{ 380-315nm} for UVA) and (SKU 430 { 315-280} for UVB) were installed instead of the old measurements are expressed in W/m^2 .

As for Shuwaik Industrial area, during June 2001 another monitor for UVA- UVB was installed –(UV- Biometer 501) . UVB is measured by (MED/HR) where 1 MED/HR = $5.83*10^{-6}$ (W / Cm^2).

MED: Minimum Erythemea Dose per hour.

The (UV-Biometer) can indicate the effectiveness of solar radiation for the induction of sun burn, phytoplankton mortality and can be used for global monitoring especially in conjunction with information about ozone thickness ,cloud cover and air Pollution .

UV and Solar being measured at Shuwaik industrial Area

V. SOLAR RADIATION :

Four out of six stations have solar radiation Monitors. All the monitors are working on continuous bases.

VI. TROPOSPHERIC OZONE :

Kuwait started to monitor tropospheric ozone since 1984. No column Ozone or stratospheric ozone has been monitored till date.
Ozone concentrations in Kuwait at its maximm during (10 –17 o'clock) in summer seasons specially June were incidents of concentrations above the hourly standards (1 hr = 80 ppb) are likely to occur.

The figures shows the concentration of Tropospheric Ozone is the during June ,Solar radiation and UV, UVB

VII. STUDIES & RESEARCHES ON UV EFFECTS :

Ministry of Health has researches on the effect of UV on Human health .Some of these researches are:

1- Solar Middle Ultra Violet Radiation In Kuwait
2- Spectro radiometric Assessment of The Solar UV-B And it's Biological Effectiveness In Kuwait . These researches were done by M .Kollias and A- Baqer.

These researches were carried out by Kuwait University and Ministry of Health and funded by EPC.

VIII. RECOMMENDATION:

1- UNEP should consider organizing regional Ozone Officer meetings on the issues of Vienna Convention in the same way as applied Meeting to Montreal Protocol .

2- Kuwait needs technical assistance from UNEP,WMO in the following areas :

i- Selection and installation of stratospheric Ozone Monitors.
ii- Analyses of existing data in order to evaluate and prepare a UV Index for Kuwait.
iii- Encourage , support on going researches & studies on effects of UVB, Tropospheric, Stratospheric Ozone on human and environment in the Gulf Co-operation Countries (GCC).

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KYRGYZ REPUBLIC

Introduction

During long time the Kyrgyzstan carries out investigations on ozone and concerned problems in the Central Asian region in two directions:

- a complex monitoring of ozone and main greenhouse gases at the station “Issyk-Kul” located on a coast of the high-mountain Issyk-Kul Lake (42.6°N, 77°E, 1640 m a.s.l.);
- a monitoring of tropospheric and stratospheric aerosol at the Lidar station “Teplokljuchenka” located in a southeast part of the Issyk-Kul Lake (42.5°N, 78.4°E, 2200 m a.s.l.).

These stations are located in the mountains of the Northern Tien Shan, have the very favorable conditions for investigations of the above-mentioned problems due to a high transparency of an atmosphere, a lot of sunny days in a year, and also because of absence of sources of anthropogenic pollution. They are unique in the central part of the Eurasian continent.
Investigations of ozone layer and stratospheric aerosol changes and their influence on regional climate change are carried out at these stations.

1. MONITORING

At present, a complex monitoring of total ozone and atmosphere parameters that may influence an ozone layer state are carried out in Kyrgyzstan.

1.1. The ozone&GHG station “Issyk-Kul”

Investigations of atmospheric ozone in Kyrgyzstan were begun at the Kyrgyz State National University in 1978. Different variants of spectral multiwave methods of measurement of the total content of ozone and stratospheric nitrogen dioxide were developed. For realization of these methods the devices were made, and the scientific station "Issyk Kul" was created.

The regular measurements of the total ozone content are carried out at the station since June 1979 (manager V.Semyonov). During the next years the monitoring of a content of a stratospheric nitrogen dioxide (NO_2), an integrated content of carbon oxide (CO_2), water vapor (H_2O) in an atmosphere, and a spectral transparency of an atmosphere in a visible spectrum range of a solar radiation with an estimation of effective parameters of tropospheric aerosol was organized at this station.

For validation of ozone measurements in various years, a comparison of the measurements by the ozonometer at the station with measurements by the national etalon device of Russia (Dobson spectrophotometer #107) and with the data of measurements by the satellite device TOMS was carried out.

Since January 2000, a monitoring of intensity of solar UV radiation at the Earth’s surface in 5 bands of a solar spectrum in width of 2 nm being centralized on wave lengths 305.5; 312.5; 320.0; 340.0 and 380 nm was carried out by the device MICROTOPS II. The device registers radiation of a solar disk plus scattered radiation within a solid angle of 2.5 degrees.

1.2. The Lidar station “Teplokljuchenka”

A monitoring of tropospheric and stratospheric aerosol by the multiwave lidar is carried out since April 1988 at the Lidar station “Teplokljuchenka” (manager B.Chen).

The lidar can work in two modes:

- Simultaneous registration of intensity of backscattered radiation at three laser wavelengths (355, 532 and 1064 nm) and Raman backscattering by atmospheric nitrogen (387 nm) in analog or photon counting modes of operation;

- Registration of two perpendicular polarization components of backscattered signal at 532 nm wavelength by using of Vollastone prism as a polarizer.

2. RESEARCH

2.1. The ozone&GHG station “Issyk-Kul”

Mean monthly total ozone contents (**X**) in an atmosphere over the central part of Eurasia for period of 1979-2001 are presented in Fig.1. A determination error for **X** is less than ±0.5%. The figure also presents the smoothed total ozone content (thick curve) and the linear trend (straight line). During the whole observation period the mean annual ozone content in an atmosphere decreased to about 10.5% (34 DU) with an average rate -(0.41±0.03)% per year.

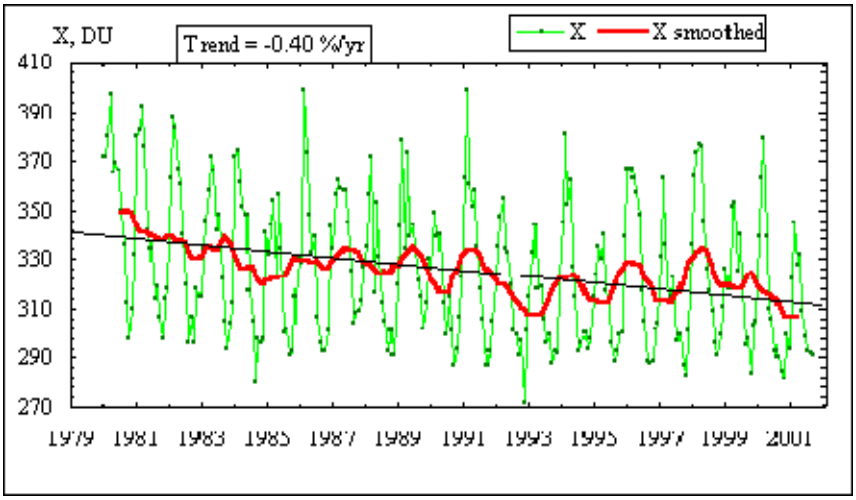

Fig.1. Total ozone content (X) in an atmosphere of the Northern Tien Shan.

During the whole measurement period the almost regular quasibiennial oscillations of smoothed **X** content with the amplitude of 15 DU were observed. The disturbance of these oscillations regularity took place in the periods of 1980-1983 and 1991-1992.

In different time intervals the real trend of interannual ozone change may significantly differ from the linear trend for all period of observations. After a short period (1993-1998) of restoration of ozone layer with the mean rate 0.6% per year, a further ozone layer depletion with the rate –1.5% per year took place during the following period.

The parameters of daily (fast), interdiurnal, seasonal and long-term fluctuations of an ozone layer and stratospheric aerosol above the Northern Tien Shan were determined. It is established that a probable reason of daily (fast) fluctuations are the internal gravitational waves generated by instability of jet flows in troposphere. Interdiurnal changes are connected to displacement of air mass, reorganization of vertical streams in jet flows, and to planetary waves.

It is seen from Fig.1 that during some time periods, along with usual seasonal total ozone variations, considerable "gaps" - negative anomalies of different duration (from several days to several months) - were observed at the station. In their essence these anomalies are regional, local "microholes" in ozone layer similar and equal in size to the anomalies observed over Europe in 1980s.

The parameters of abnormal deviations of ozone and NO_2 were determined (see Fig.2). These anomalies appear in a phase or in an anti-phase depending on the shape and displacement of the northern circumpolar vortex.

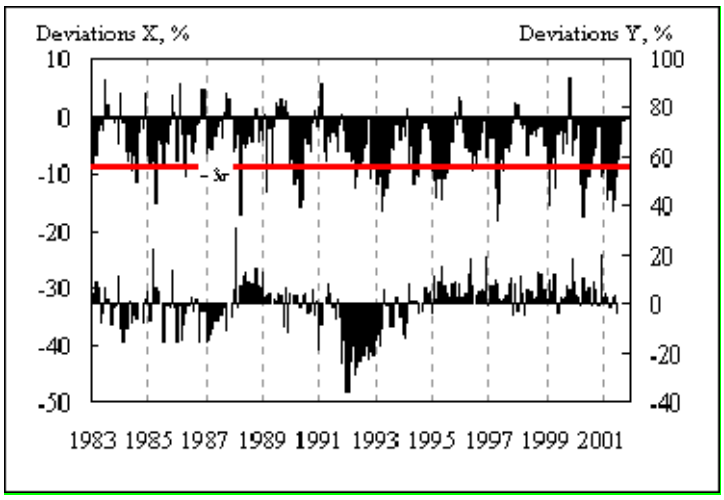

Fig.2. Deviations of total ozone (upper panel) and nitrogen dioxide (lower panel) from a monthly mean at the Issyk-Kul station.

The investigation of influence of solar activity on an ozone layer above the mountain region of the Central Asia was carried out.

2.2 The Lidar station "Teplokljuchenka"

The regularities of transformation of an aerosol layer in a stratosphere and its changes in a result of the natural and man-caused accidents, influence of stratospheric aerosol on a radiating and thermal regime of the region were investigated. The model estimations of climatic consequences of natural and anthropogenic changes of a stratospheric aerosol layer were carried out.

The investigations of influence of sulfuric acid stratospheric aerosol on the general content of ozone were carried out, and preliminary results were obtained.

A comparison of dynamics of the reverse aerosol dispersion coefficient $F_{\pi\alpha}$ change in the layer 15-30 km with a change of total ozone content shows a presence of the relation between them (see Fig.3). In which connection, this relation is negative as a whole for the analysis period (1988-2000),

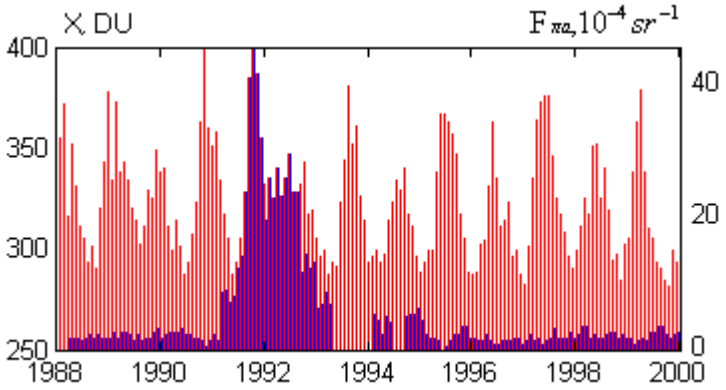

Fig.3. Variation of total ozone content (X) and reverse aerosol dispersion coefficient ($F_{\pi\alpha}$) in the layer 15-30 km.

while it is positive, vice versa, during the periods of atmosphere distortion by natural disasters (convulsion of nature, oil fire, nuclear explosion and others). A presence of such relation cannot be explained by mechanisms of photochemical interaction of ozone with sulfuric acid stratospheric aerosol. Evidently, another physical-chemical mechanism of influence of stratospheric aerosol on ozone layer exists.

3. APPLICATIONS

The results of measurements of ozone obtained at the station “Issyk-Kul” are regularly transmitted to the WMO World Ozone and UV radiation Data Centre (Canada) where it is registered by the number 347.

4. PUBLICATIONS

The results of investigations are being published in national and international journals and proceedings.

5. PLANNED RESEARCH ACTIVITIES

In account of the Decision V/3. Recommendations of the fourth meeting of the Ozone Research Managers, the priority at the above mentioned stations in Kyrgyzstan for the nearest future will be given to investigations of interaction between ozone and climate, between stratospheric aerosol and climate, and influence of sulfuric acid stratospheric aerosol on ozone.
To realize these tasks, it is necessary to carry out:

5.1. Control of ozone layer and solar UV radiation in a mountain region of the Northern Tien Shan:

- to continue monitoring of ozone, NO_2, CO_2, H_2O and parameters of an atmosphere aerosol at the station “Issyk-Kul”. To provide measurements of the ozone vertical profile using the Umkehr technique.
- to establish the ozone lidar for carrying out of probe of a vertical ozone stratification and investigations on influence of stratospheric aerosol on ozone;
- to establish the devices for measurement of other greenhouse gases (CH_4, N_2O), tracer gases (SO_2, CO), total and scattered solar UV radiation at the Earth’s surface.

5.2. Investigations:

- on the basis of the results of measurements of ozone, greenhouse gases and stratospheric aerosol, to carry out investigations of influence of these gases on a climate in the Central Asian region;
- to develop a statistical model of ozone change over a mountain region of the Central Asia for medium-term forecast of ozone layer state;
- to investigate an influence of ozone layer depletion on intensity of solar UV radiation at the Earth’s surface in the region of the Issyk-Kul Lake;
- to take part in the international project on validation of measurements of O_3, NO_2, CO_2, H_2O, N_2O, CH_4, CO and parameters of aerosol by the device SCIAMACHY established on the satellite ENVISAT.

6. NEED OF SUPPORT

For solution of above mentioned tasks, improvement and expansion of the base monitoring of ozone and stratospheric aerosol in the Central Asian region, Kyrgyzstan as a developing country needs a financial support from international organizations.

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LITHUANIA

Observational network

The Lithuanian Hydrometeorological Service (LHMS) follows the standard programme of observations of the World Meteorological Organization recommendable for hydrometeorological services. The state of ozone layer is monitored at the Kaunas meteorological station (Index No. 312). Total ozone measurements have been carried out with the M -124 filter ozonometer since 1 January 1993. The Kaunas station is located close to the center of Lithuania.

The ultraviolet solar radiation measurements have been carried out in Kaunas and Palanga (by the Baltic Sea) since 2000. Mean and maximum daily radiation is monitored using the UV-Biometers type 501 A, version 3 (in Kaunas – UV-A and UV-B, in Palanga – UV-B).

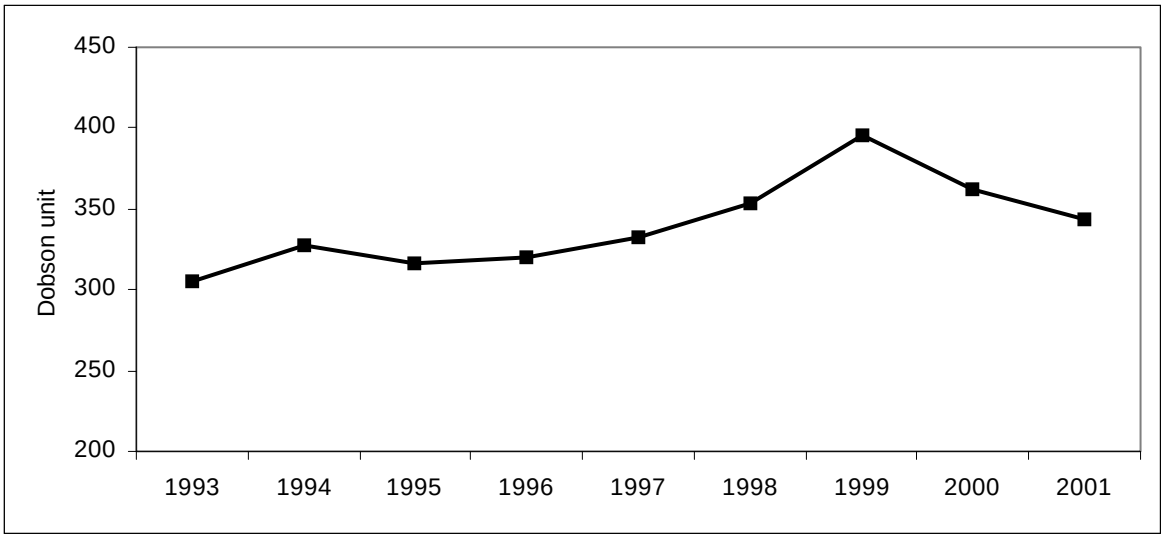
Instrument calibration

The M -124 filter ozonometer is calibrated every two years at the Remote Sensing Scientific Research Centre of the Main Geophysical Observatory in St Petersburg, Russia.

The UV-Biometers were calibrated by the LHMS Meteorological Laboratory in 1999. Local standard meters should be re-calibrated using a higher-class standard instrument in 2002.

Data analysis

All observational data are stored and processed. Because of comparatively short series of observations, they are insufficient for a comprehensive study. Last year the LHMS Division of Climatology and Methodology completed a study titled “Ozone In the World and In Lithuania” (lead researcher Dr Audronė Galvonaitė), however, due to rather limited amount of observational data (less than 10 years), its conclusions might be considered as preliminary.



Total ozone column over Kaunas, 1993 – 2001

Last year the LHMS Division of Meteorology started to originate the UV Index forecasts on a trial basis. It also monitors the state of ozone in Lithuania and carries out analyses of its quantitative changes. In case of significant ozone layer depletion, the division originates warnings communicated through the mass media.

International cooperation

The ozone measurement data are sent on a regular basis to the World Ozone and Ultraviolet Data Centre in Toronto, Canada.

The Italian – Lithuanian Counterpart Fund supported the establishment of UV monitoring network in Lithuania. Polish Institute of Meteorology and Water Management has assisted LHMS in application of the UV Index forecasting model.

Future

Observations of the ozone layer and UV radiation will be continued. However, our current ozone meters are not the very precise ones. Our ozone and ultraviolet measurements data would be much better quality provided we could obtain a Brewer Spectrophotometer. It is a modern and highly precise instrument (pricing about USD200,000), used worldwide since 1980-ties. Besides the direct measurements, it can be used as a standard meter for calibration of the UV-Biometers. Its purchase and installation will form a good basis for the further acquisition of the ozone and ultraviolet information and its scientific and practical applications.

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MALAWI

1.0 INTRODUCTION

Malawi developed the Environmental Management Act as a follow-up to the Vienna Convention and the Montreal Protocol for the protection of the ozone layer. One of the recommendations under the Montreal Protocol on the protection of the ozone layer is the phasing out of all non-essential and non-critical uses of ozone layer depleting substances, which include methyl bromide, fluorines, chlorofluorocarbons (CFC) and halogens.

Various types of research have been initiated to develop mechanisms of protecting and monitoring the ozone layer, and determining the effects of ultra violet light due to the depletion of the ozone layer. Ozone layer and ultra violet light research and monitoring activities in Malawi have been done indirectly with emphasis on adaptive research on management of ozone layer depleting substances, developing strategies to phase out all the ozone layer depleting substances and development of alternatives to these undesirable substances.

Malawi has been using about 132 metric tones of Methyl Bromide of which 21 tonnes were being used for commercial storage of grain by the Agricultural Development and Marketing Corporation (ADMARC) while 111 tonnes were used in the tobacco industry for raising tobacco seedlings. ADMARC with the help of the British government undertook research on alternatives to Methyl Bromide and came up with a fumigant called Phosphine which is environmentally friendly and does not affect the ozone layer adversely. The Cooperation is now using Phosphine only for grain storage. The task now is to phase out the remaining 111 tonnes of Methyl Bromide in the tobacco industry which makes significant contribution to the ozone layer depletion.

The Agricultural Research and Extension Trust (ARET) in Malawi is currently investigating into the efficacy of the various chemicals and systems as alternatives to Methyl Bromide use in the tobacco industry. These include the Floating tray system, Basamid (granular), Metham Sodium, Telon II, EDB and Burning maize stalks over the soil to sterilize soils for tobacco nurseries.
This research will contribute to the protection of the ozone layer and avoid ultraviolet radiation reaching the earth. The highlights of the on-going research on ozone layer and the planned research activities are outlined in the following sections

2.0 ON-GOING RESEARCH ON OZONE LAYER

2.1 Soil-less Culture : Floating Tray System

The technology was borrowed from Zimbabwe and the Republic of South Africa (RSA). The floating tray system uses a polystyrene tray, pine bark as the medium for growth and water in a pond for irrigation and nutrition of the plants. It is a soil-less medium and no chemicals are used to sterilize the pine bark medium. Therefore, the medium does not require fumigation thereby doing away with the use of ozone layer depleting substances.

Malawi started with 1.5 ha area of nursery in year 2001/2002 using the floating trays and will expand to 6.5 ha during the second year i.e. year 2002/2003. Observations made indicate that the system will enable growers use less nursery area i.e. 1 pond of 22.5m by 1.05m/ha instead of 3 beds/ha of 30 m^2 each; a permanent nursery site can be used because there is no need for rotation, and the system has reduced labour requirement because one person instead of three can manage over 50 beds or ponds. However, the limiting factor is the initial cost of the trays, the need to use pelleted seed, lack of equipment to pelletize the seed, and the small-size seedlings which may be difficult to use during dry planting. However the technology is promising and may enable Malawi effectively stop the use of ozone layer depleting substances.

2.2 Chemical Soil Sterilization System : Basamid (Granular), Metham Sodium or Herbifume (Liquid Formulation) and Telon II

The two compounds Basamid and Metham Sodium have the same active ingredient (Methylisothiocynate) the difference being that one is in granular form while the other one is in liquid form. These two chemicals have been evaluated for their effectiveness in controlling weeds and nematodes. Both chemicals turn into Methylisothiocynate (MITC) gas upon reacting with water in the soil and it is the MITC gas that kills weeds, soilborne pathogens and nematodes.

Observations from the research results show that Basamid is very effective in killing weeds and nematodes while Metham Sodium has shown inconsistent results over seasons in the control of nematodes and weeds (Table I). Research efforts are being made to improve the application procedures of Metham Sodium to enhance its effectiveness.

The major disadvantage of the two chemicals is that the treatment period and procedures take almost a month before sowing which is 10 days more than methyl bromide treatment.

TABLE 1: EFFECTS OF SOIL FUMIGANTS ON WEED AND NEMATODE CONTROL IN HEAVY AND LIGHT SOILS DURING SOIL

STERILIZATION IN THE NURSERY

TREATMENT	WEED POPULATION		NEMATODE POPULATION				NEMATODE INFECTION	
			INITIAL		FINAL		(ROOT GALL SCORES)	
	HEAVY SOIL	LIGHT SOIL	HEAVY	LIGHT	HEAVY	LIGHT	HEAVY SOIL	LIGHT SOIL
Burning	16.3	4.5	73	95	487	593	6.5	4.9
Methyl Bromide	1.9	1.3	51	78	0	0	0	0
Metham Sodium	4.2	8.3	52	85	331	477	5.1	4.8
Basamid	2.0	1.3	43	75	145	105	3.0	1.2
Telon II	145.5	6.8	45	74	0	0	0	0.1

Combination of Metham Sodium and Telon II

In an effort to improve the efficacy of Methum Sodium in the control of both nematodes and weeds another chemical called Telon II was tried in combination with Metham Sodium. It has been observed that a combination of Telon II and Metham Sodium is very effective in controlling weeds and nematodes (Table 2). However, it has been noted that Telon II is highly effective in controlling nematodes but not weeds. Additional experiments on the use of Telon II alone for controlling nematodes in the nursery have shown Telon II to be highly effective for nematode control (Refer to Table I).

TABLE 2: SYNEGETIC EFFECTS OF METHAM SODIUM AND TELON II ON THE CONTROL OF NEMATODES AND WEEDS IN A TOBACCO NURSERY

TREATMENT	WEED COUNT		ROOT (GAP) GALL SCORES	
	FIRST	FINAL	FIRST	FINAL
30ml MS and 21ml Teleon II	6	2.3	0	0.2
60ml MS and 21ml Teleon II	7	3	0	0.5
30ml MS and 28ml Teleon II	11	4.7	0	0
60ml MS and 21ml Teleon II	4.7	4.3	0	0

2.3 Physical Soil Sterilization System : Burning Maize Stalks over the Soil

Most smallholder farmers in Malawi do not use chemicals to sterilize soil in their nursery beds due to poverty but burn maize stalks on top of the nursery bed and the heat generated kills the weeds and nematodes. The farmers heap maize stalks 0.3 – 1.0 metre high on the nursery beds and burn them.

The method is very effective in controlling weed seeds, adult nematodes and eggs if applied correctly i.e. by pre-watering the beds to allow weeds to germinate and nematode eggs to hatch before burning the maize stalks which will generate heat to kill them. However due to scarcity of grass and maize stalks not many farmers are able to sterilize their beds effectively and most of them are turning to the use of chemicals. This is the right time to prepare them for the use of ozone layer friendly chemicals.

3.0 PLANNED OZONE LAYER RESEARCH

Malawi has both smallholder farmers with limited resources and skills and Estate farmers who have relatively adequate resources and good skills. It is therefore important to compare the effectiveness and feasibility of the various chemical and non-chemical methods of sterilizing tobacco nursery bed soils under both conditions. Two experiments have been proposed to be implemented during the next two to three years i.e. 2002/2005. The parameters to be monitored and measured are as follows:- a) weed control, b) nematode control, c) soil borne disease control, d) seedling vigour and uniformity and plant size at transplanting, e) cost of production for each method used, f) practicability and feasibility under both smallholder farmer and commercial farmer conditions.

Project 1: The effectiveness of the various chemical and non-chemical methods in the sterilization of nursery bed soils for raising tobacco seedlings as an alternative to Methyl bromide.

a) Objective: To identify a chemical which is as effective as Methyl bromide in the sterilization of nursery seed bed soils for raising tobacco seedlings.

b) Proposed Treatments

- Methyl bromide (control)
- Basamid (granular formulation)
- Metham Sodium (liquid formulation)
- Telon II

- New chemical (x)
- New chemical (y)
- Grass burning on nursery beds
- Grass burning with pre-watering treatment

Project 2: To determine the effectiveness of the various sterile growth media and container systems in raising tobacco seedlings in the nursery as an alternative to the use of Methyl bromide.

a) Objective: To raise seedlings in soil-less media to avoid fumigation procedures for sterilization of tobacco nursery seed beds aimed at controlling weeds, soil borne diseases and insect pests.

b) Proposed Treatments:

i) Main plot: container systems

- Floating tray system
- Dry tray system
- Controlled concrete trenches
- Open nursery beds in a plastic tunnel

ii) Sub-plot: Growth Medium

- Pine bark (imported)
- Pine bark (local)
- Rice husks
- Groundnut shells
- River sand
- Mixture of sand/rice husks (50/50)
- Mixture of sand/saw dust (50/50)
- Mixture of sand/local pine bark (50/50)
- Mixture of sand and groundnut shells (50/50)

4.0 CONCLUSION

Very good effort has been made to look for an alternative to Methyl bromide in the fumigation of nursery soils for raising tobacco seedlings. Basamid has to-date shown that it is a good alternative to Methyl bromide. However, some farmers are experiencing problems in implementing the procedures of application accurately and they follow short cuts resulting in inconsistent results. Initiatives have been undertaken to fine-tune the technology to make it farmer friendly. The floating tray technology has been accepted by limited number of farmers because it was introduced late and we had problems in getting the pinebark on time for the season. Furthermore the technology has high cost of investment initially and requires skills in its management. ARET is also trying its best to conduct adaptive research to fine-tune the technology and simplify the procedures. These two technologies, Basamid and the floating tray system, have the greatest potential to replace the use of the ozone layer depleting chemical substance, Methyl bromide. There is therefore good hope that in five years time Malawi will be ready to stop using Methyl bromide.

***

MOROCCO

Introduction

Casablanca is the biggest city in Morocco. It's located at 7,7° West and 33,6° North. Its climate is soft.

Casablanca is a city which has evolved very quickly, its automobile park represents almost 50% of the national park and its industry represents 60% of the whole national industrial activity. The number of inhabitants in Casablanca is now about 4 millions. But each day, there is many cars and trucks which enter to Casablanca and many individuals who come to the city, from other small cities, for their work. This situation, with others, made of Casablanca a locality very polluted. Obviously, this pollution can affect the measurement accuracy.

Casablanca is also a coastal city and breeze is a mechanism which attenuate the pollution concentration in the city.

In Casablanca, the Ozone measurement began on 1969. Until now, three instruments have been used for that purpose: Dobson (1969-1989); Brewer MKII (1989-1993); Brewer MKIII (2000-…). Unfortunately, all over this period, no calibration test has been done.

Measurements

Dobson period (1969-1989);
With this instrument, measurements have been done during the zenith period, once per day. But, during the week-ends and days off and days with an important cloud cover, measurements didn't have been done.

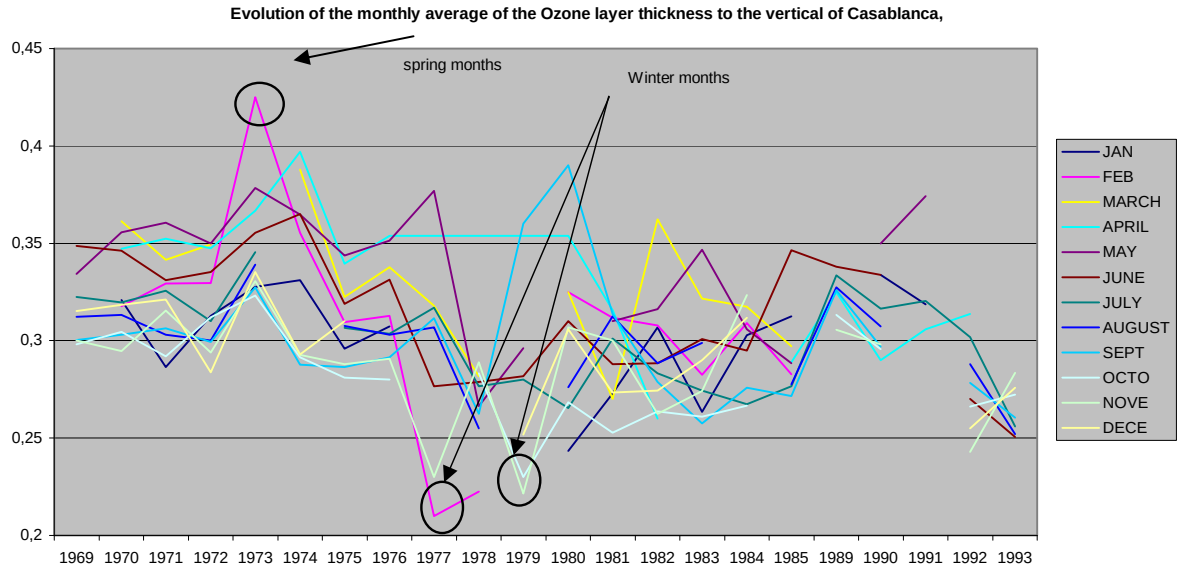
Brewer MKII period (1989-1993);
During this period, measurements have been performed during two hours (12-14 o'clock), because the instrument is automatic. Probably measurements are more accurate at least if the instrument is well calibrated. The measurements have been performed as above.

Brewer MKIII period (2001-…);
This period began on late 2000. The instrument measures the SO_2 concentration and the UV radiation also. The measurements are continuous and it's an easy to use instrument. Obviously it keeps the same limitations as its ancestor.

Missing data and data quality

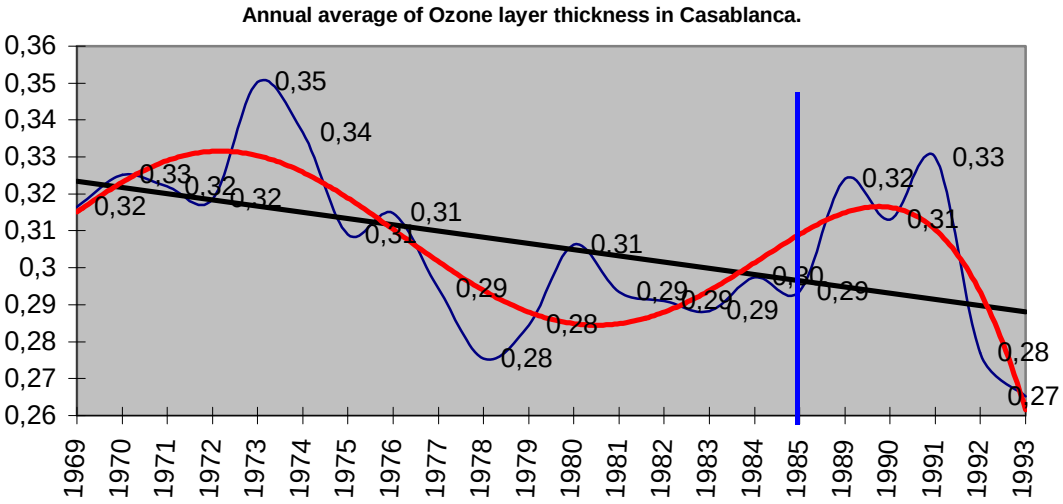
The missing data reflect the instruments availability and, in the sense explained above, the operating mode; These lacks are numerous in Casablanca during the winter season. There is many months indeed where no data has been recorded.

Data quality reflects the instrument calibration. In this respect, some data are abnormally low or abnormally high. As examples, data for February 1977 and October and November 1979 ozone layer thickness reached, respectively, 210, 221 and 230 DU, and during February 1973 it reached 425. Web distributed maps, show that, during these periods, data are almost normal; Thus, unless these data represent a local phenomenon which had not been observed by satellite and other terrestrial observing systems, it can be considered as, at least, suspect.



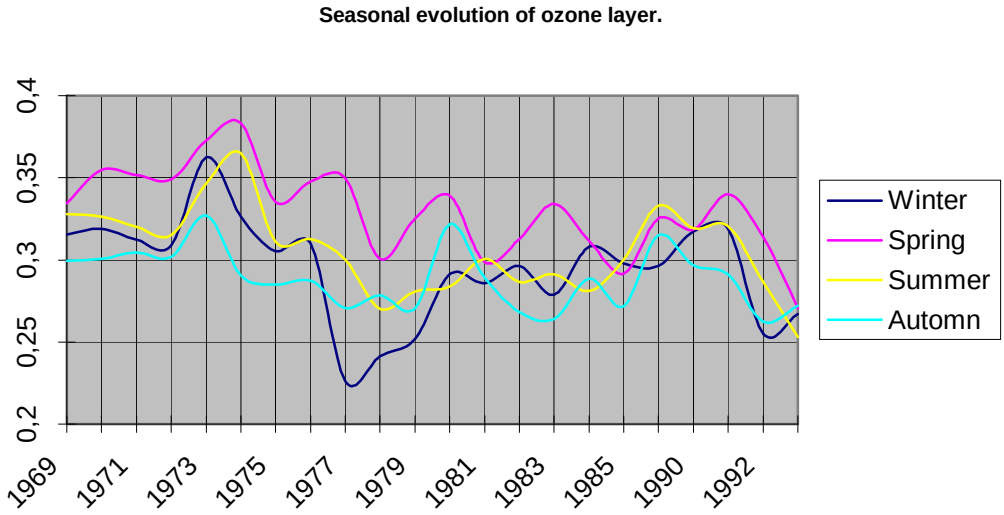
Evolution of the annual ozone layer to the vertical of Casablanca.

Annual Ozone layer thickness to the vertical of Casablanca, has two characteristics; The first is its general decay and the other is its bimodal shape. These two characteristics are made evident by the two trends put in the figure below. The other things that one has to mention are the years with missing data (1986-1988) and years with brewer instrument (1989-1983) which are separated from the other with the blue vertical bar in the figure below.



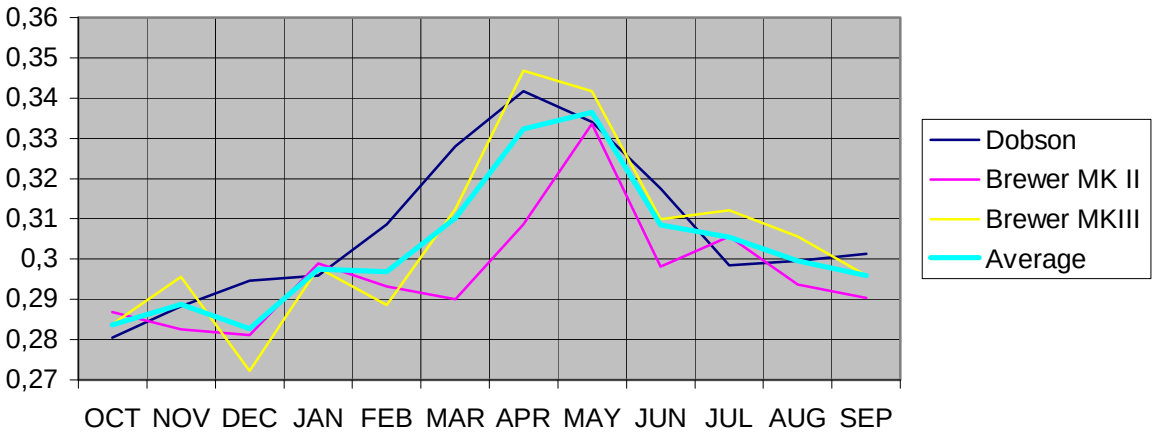
Seasonal evolution of ozone layer to the vertical of Casablanca

In general, Spring is the season where ozone is at the highest level and autumn is the season where it is at its lowest level. There is, however, some years where winter is the lowest level; These years coincide with the years mentioned above as years with some suspect data in winter months. The bimodal shape is visible also in these curves.



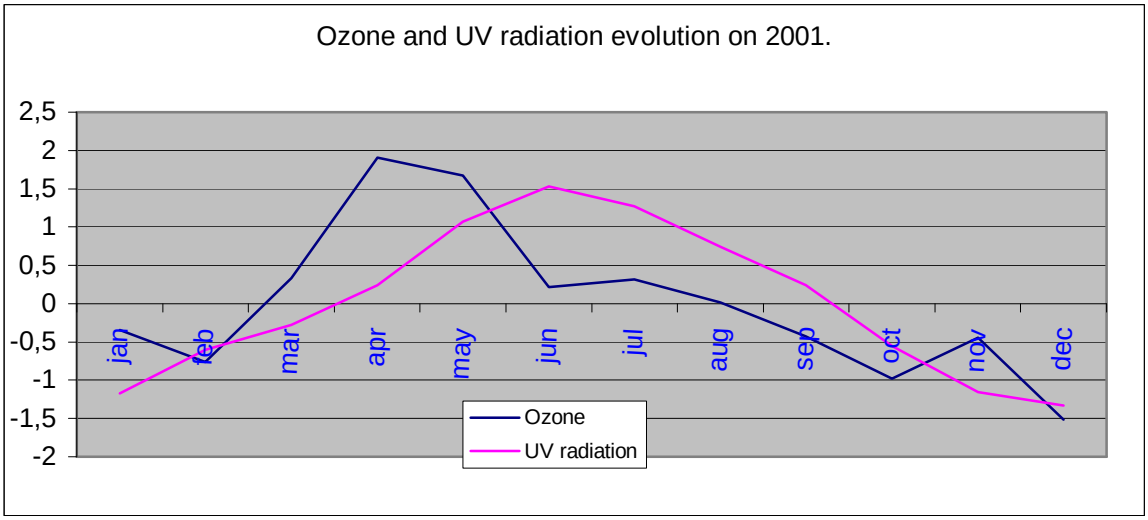
Annual rhythm of the monthly evolution of the ozone layer to the vertical of Casablanca.

The annual rhythm, month by month, shown in the figure below, shows that there is an increase in the ozone layer between October and May and a decrease between May and September.



UV radiations

The Brewer MK III measures also the UV radiations; The figure below, presents the monthly evolution of ozone and the UV radiation during the year 2001. The UV radiation's curve is similar to direct radiation, i.e., it increases during the summer and decreases during the winter. What is curious is the positive correlation between ozone and UV radiation.



Conclusion

As a conclusion, there is a long period of record of ozone in Casablanca. These records have some suspect data, but when monthly or annual averages are considered, the data show some consistent shapes with other localities. The decrease observed is also consistent with decreases observed elsewhere.

In the research center there is many trial-studies to evaluate the impact of weather parameters on health, but we never tried to use ozone layer thickness as a predictor because records aren't continuous or don't coincide with clinical data.

Other activities related to Ozone.

Each year, since the creation of the annual anniversary of the ozone layer, the Moroccan meteorological Service participate to the radio programs in order to promote the public awareness of the environmental effects of the emissions of controlled substances and other substances that deplete the ozone layer.

Other activities related to the industrial sector will be also presented.

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MYANMAR

Abstract

This report describes the activities for the protection of ozone layer and the future plan for ozone monitoring as a part of the global ozone monitoring network. The author also tries to get the correlation of the skin cancer and eye disease of cataract with the ozone depletion.

1. Introduction

Ozone layer absorbs much of the biologically damaging ultraviolet radiation emitted by the sun. As a consequence, the world ecosystems have evolved over hundreds of years in ultraviolet conditions controlled by this layer of ozone.

The total amount of ozone at any hemisphere of the earth varies daily but is generally lowest over equatorial region and highest at mid-northern latitudes, such as the area around Hudson's Bay and eastern Siberia. A significant decline was observed over both polar region, especially during the cold stratospheric winter/spring periods. There is no statistically significant trend in the equatorial belt (10°N-10°S) and between 10° and 35°N (WMO,1998). Figure (1) shows the percentage depletion in total atmospheric ozone between 1979 and 1997 from 60°N to 60°S. Figure (2) shows the overall ozone decline. The annual cycle of global ozone for two periods (1964-1980 and 1984-1997) are plotted in figure(3).

The exhaust gases from a fleet of supersonic aircraft flying in the lower stratosphere could adversely impact stratospheric ozone and a class of inert chemical known as chlorofluorocarbons (CFCs) used in refrigerators, air conditioning systems and airsprays, transported to the atmosphere by convective air currents, released free chlorine under the action of sunlight could destroy ozone. Measurement and special stratospheric campaigns during 1986 and 1987 confirmed that CFCs were playing a major role in ozone destruction.

Additional scientific evidence emerged on just how destructive both chlorine and bromine could be to stratospheric ozone, and this was confirmed by observations from WMO ozone network.

2. Geographical Feature of the Union of Myanmar

Myanmar is situated between latitude 9° 58' N to the south, and 28° 31' N to the north, 92° 10' E to the west and 101° 11' E to the east.

Myanmar has the largest area among the nations of the southeast Asian peninsula with an area of about 680,000 square kilometers. It is sharing common borders with China in the north and northeast, with Laos in the east, with Thailand in the southeast, and India and Bangladesh in the west. Myanmar has a population of about 50 million.

3. Radiation and Ozone Measuring Instrument

In 1992 the USSR had sent six sets of ozone measuring instrument and one thousand ozone sounding balloons to Myanmar under the WMO/VCP project of OB/7/1/1. Although Myanmar received those black and white coloured balloons, very unfortunately all six sets of radiation and ozone measuring instrument were supposedly lost at one of the Asian seaport on 1 January, 1992 and Myanmar lost the opportunity for monitoring the vertical profile of ozone and for better understanding of global atmosphere. Since that time Myanmar has planned to monitor the ozone layer at different locations throughout the country.

4. Activities for Protection of the Ozone Layer

Myanmar has signed many important International Agreements and Conventions including the Vienna Convention and the Montreal Protocol of Protection of the Ozone Layer.

Another activity is the formulation of a country program to phase out Ozone Depleting Substance (ODS). The formulation of the country program was initiated in 1997 with UNDP assistance. It is being carried out by the National Commission for Environmental Affairs acting as lead agency and supported by a country program work team formed within the Agency. An intensive survey was conducted by the work team at the government departments, private entrepreneurs, workshops and individuals who are connected with the use of Ozone Depleting Substance.

The following points are presented to provide an overview of the ODS situation in Myanmar.

- In Myanmar, the main ODS consuming sector is the refrigeration and the air conditioning systems.
- CFC 12 is the largest consumed controlled substance in Myanmar and its consumption is steadily increasing from 1994 to 1996.
- Consumption of CFC 11 started in 1996 and is consumed in central air conditioning equipment and cold storage facilities installed during the year.
- No ODSs are produced in the country.
- The scientists and researchers are aware of ozone depletion, interconnection of ozone depletion and climate change. They also report these information and preventive measures to the policy makers.
- The educational public awareness dissemination concerning ozone depletion, causes and the dangerous threat of stratospheric ozone depletion for climate and society and reduction of ozone depletion are being carried out by using different kinds of media.

5. Patients of skin cancer and eye disease

There are three hospitals established especially for cancer treatment. These are Yangon general hospital, Mandalay general hospital and Tounggyi Sao San Htun hospital.
Only the number of patients suffering from skin canncerand eye disease who took treatment at the general hospitals (at Yangon and Mandalay) and eye, ear, nose and throat hospitals (at Yangon and Mandalay) are collected. Among those diseases the possible disease of cancer due to ozone depletion and the number of those patients are sorted as shown in Tables 1 and 2.

The commonest cancer at Yangon General Hospital from the year 1993 to 1999 are shown in tables 3, 4, 5. The number of patients of eye disease “cataract” which is caused by the ozone depletion is sorted out from collected eye diseases and it is shown in table 6. Actually these data do not represent the country’s total because the number of patients who have taken medical treatment at private and cooperative clinics and hospitals, indigenous hospitals and indigenous medicine practitioners are not included.

6. Future Plan for Monitoring Ozone layer

The global average of ozone distribution and the locations of the WMO ground-base ozone network are shown in Figure 4. This figure shows that the ozone measuring stations are less and inadequate in the tropical region. If WMO provides the ozone measuring instruments to install Myanmar, which lies in the tropics, and the northern Myanmar situates at the boundary of sub-tropics, it will fulfill the requirement of more measuring ozone stations in the tropics. Myanmar has arranged proposed locations for installation of ozone measuring instruments at existing six different meteorological stations throughout the country when the opportunity for receiving ozone measuring instruments comes. These proposed locations are shown in figure 5.

7. Concluding Remark

Although the number of patients suffering from skin cancer and eye disease are increasing in the year 2001 compared with those of the earlier years the correlation between the number of those patients and ozone depletion is not significant.
This may be due to the following reasons:

1. Myanmar lies in the tropics in which no downward trend in ozone has been observed in equatorial belt (10°N-10°S) and between 10° and 35°N.
2. The number of patients of skin cancer and eye disease collected here does not represent the country's total number of patients.

Monitoring of ozone layer and the expanded activities to protect the ozone layer are inevitable task in Myanmar.

Acknowledgement

The author is grateful to Dr. San Hla Thaw, Acting Director General, Department of Meteorology and Hydrology for his keen interest, encouragement and suggestions for this report. The author is also thankful to the authorities of Yangon and Mandalay general hospital, eye hospital (Yangon), nose and throat hospital (Mandalay) for providing the required data.

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Oncology Department
Mandalay General Hospital

Serial No.	Year	Disease		
		Skin	Malignment Malaenoma	Basal Cell Carcinoma
1	1964	13	-	-
2	1965	23	-	-
3	1966	18	-	-
4	1967	15	-	-
5	1968	23	-	-
6	1969	21	1	-
7	1970	23	-	-
8	1971	25	1	-
9	1972	21	-	-
10	1973	20	1	-
11	1974	21	-	-
12	1975	15	-	-
13	1976	9	-	-
14	1977	11	-	-
15	1978	7	-	-
16	1996	9	5	-
17	1997	11	5	-
18	1998	24	4	2
19	1999	23	6	-
20	2000	22	2	15
21	2001	*	*	*

* Data not including.
Table (1). Number of cancer patient at Mandalay General Hospital.

Radiotheraphy Department
Yangon General Hospital

Serial No.	Year	Disease			
		Skin	Malignment Malaenoma	Malaenoma	Basal Cell Carcinoma
1	2000	2	1	10	2
2	2001	12	5	2	4
3	2002 (up to 15-2-2002)	4	1	2	1

Table (2). Number of cancer patient at Yangon General Hospital.

Table 3. TEN **COMMONEST** CANCERS FOR ALL PATIENTS (1993-99)

NO. OF CASES					
ICD	**TYPE OF CANCER**	**MALE**	**FEMALE**	**TOTAL**	**PERCENT**
180	CA CERVIX	0	2947	2947	16.99%
174	CA BREAST	0	2787	2787	16.07%
162	CA LUNG	1712	897	2609	15.04%
161	CA LARYNX	758	223	981	5.66%
150	CA OESOPHAGUS	453	205	658	3~9%
202	NHL	350	257	607	3.50%
147	CAPNS	356	155	511	2.95%
151	CA STOMACH	210	167	377	2.17%
173	SKIN OTHER THAN MELANOMA	193	161	354	2.04%
141	CA TONGUE	210	122	332	1.91%
	ALL CANCERS	**7159**	**10187**	**17346**	

Table 4. TEN COMMONEST MALE CANCERS **(1993-99)**

ICD	**TYPE OF CANCER**	**NO. OF CASES**	**PERCENT**
162	CA LUNG	1712	23.91%
161	CA LARYNX	758	10.59%
150	CA OESOPHAGUS	453	6.33%
147	CA PNS	356	4.97%
202	NHL	350	4.89%
187	CA PENIS	295	4.12%
141	CA TONGUE	210	2.93%
151	CA STOMACH	210	2.93%
173	SKIN OTHER THAN MELANOMA	193	2.70%
196	SECONDARY AND UNSPECIFIED L/N	173	2.42%
	ALL MALE CANCERS	7159	

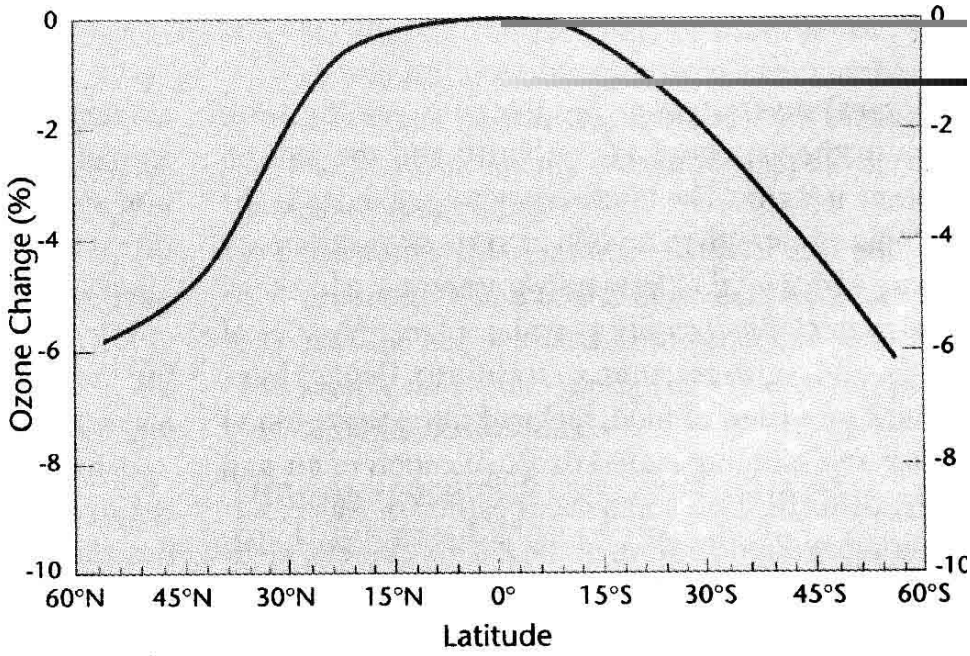
Table 5. TEN **COMMONEST FEMALE CANCERS (1993-99)**

ICD	**TYPE Of CANCER**	**NO. OF CASES**	**PERCENT**
180	CA CERVIX	2947	28.83%
174	CA BREAST	2787	27.36%
162	CALUNG	897	8.81%
202	NHL	257	2.52%
161	CALARVNX	221	2.11%
150	CAOESOPHAGUS	205	2.01%
183	CA OVARY	203	1.99%
182	CAUTERINESOQY	184	1.81%
151	CA STOMACH	167.	114%
173	SKIN OTHER THAN MELANOMA	161	1.58%
	ALL FEMALE CANCERS	10187	

Serial No.	Year	Hospital	
		Yangon Eye Hospital	Mandalay Eye, Ear, Nose and Throat Hospital
1.	1991	3582	*
2.	1992	3342	*
3.	1993	3483	*
4.	1994	3459	*
5.	1995	3661	*
6.	1996	3967	*
7.	1997	3741	874
8.	1998	3289	798
9.	1999	2655	806
10.	2000	3021	792
11.	2001	4094	1167

* Data not collected.

Table (6). Numbers of patient of eye disease “cataract” who take treatment at the government hospital.



Fi— *North-to-south ozone depletion, 1979-1997*

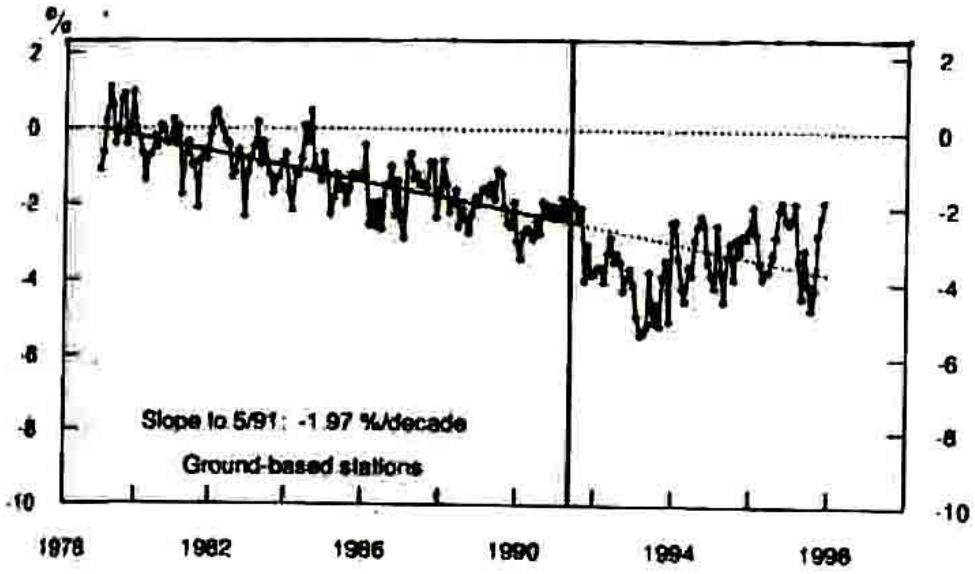


Figure 2— Deviations in total ozone (expressed in per cent of baseline monthly mean), area-weighted over 60°S–60°N from ground-based stations averaged in 5° latitude zones. A seasonal trend model, including solar and Quasi-Biennial Oscillation effects, was fitted to ozone over the period January 1979 to May 1991. The bold vertical line is the time of the Mt. Pinatubo eruption in May 1991.

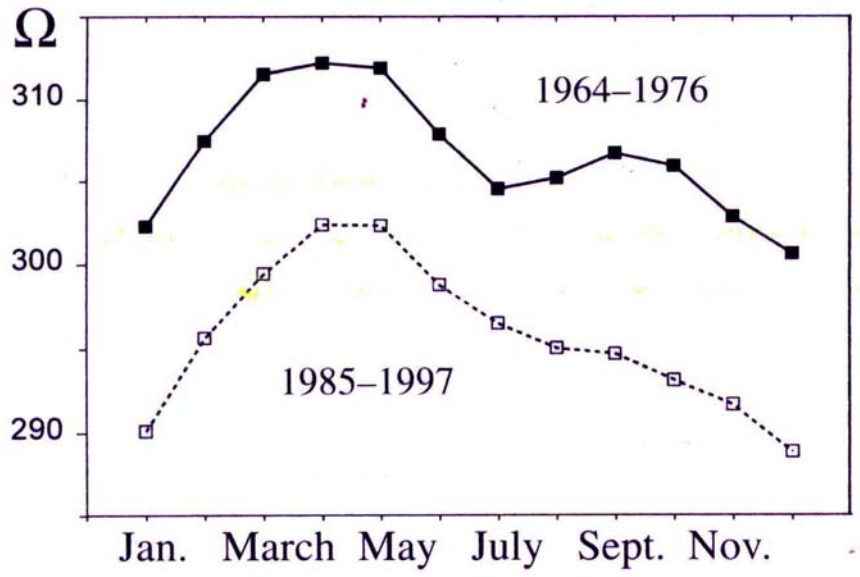


Figure 3— Global ozone average (area-weighted) for two periods as function of season (*Updated from Bojkov and Fioletov,* JGR, *1995*}

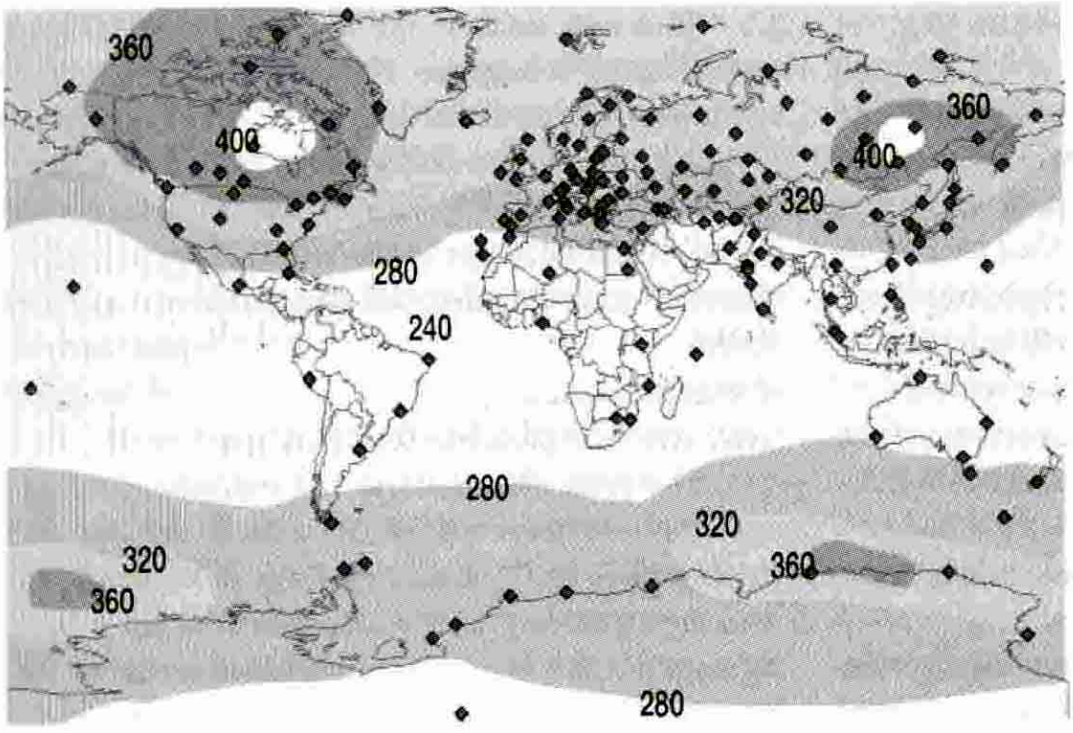


Figure 4— Average total ozone disstriubtion: location of WMO ground-based ozone network

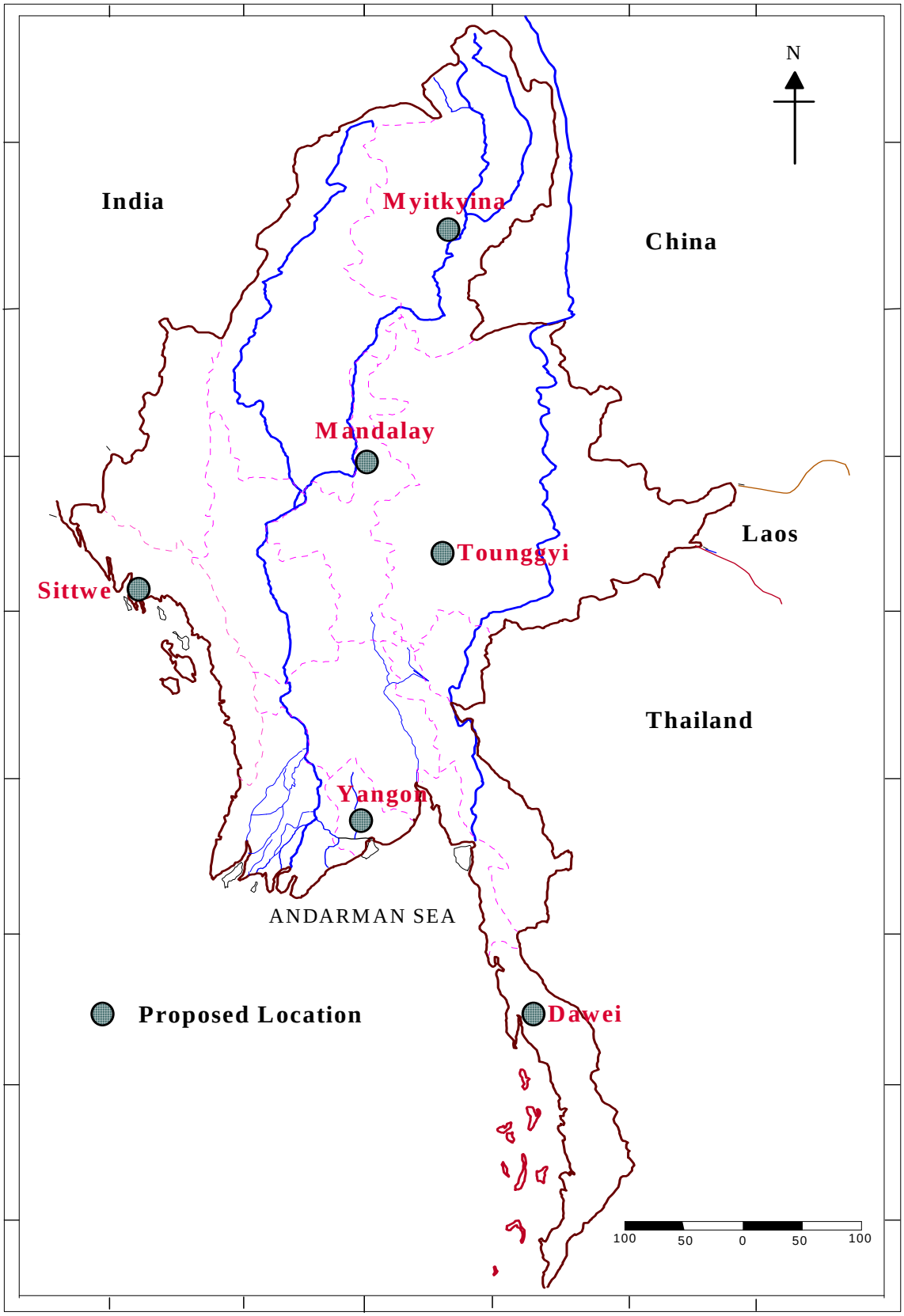


Figure 5. Proposed location for installation of radiation and ozone measuring instrument

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NETHERLANDS

The contribution of the Netherlands to ozone monitoring and research are summarized in this report, for the Royal Netherlands Meteorological Institute (KNMI), the National Institute for Public Health and the Environment (RIVM), and the Institute for Marine and Atmospheric Research, Utrecht University (IMAU).

Royal Netherlands Meteorological Institute (KNMI):

Observations at KNMI in De Bilt, Netherlands, (52.10N, 5.18E).
Brewer MKIII Spectrophotometer:

- total ozone, continuous observations since 1994.
- Data deposited at WO3UDC.
- Near-real-time data "WMO Ozone Mapping Centre" and WO3UDC

Research and applications

- validation of ozonesonde and satellite observations
- radiative transfer model studies
- UV exposure estimations by RIVM

Brewer MKIII Spectrophotometer (continued)

- UV scans, about once per hour since 1994.
- Data deposited at EDUCE database

Research and applications:

- Calibration of UV-index forecasts
- Radiative transfer model studies

Ozonesondes

- profiles of ozone temperature, humidity and wind, typically up to ~30 km.
- Approx. weekly balloon releases since 1992.
- Intensified releases during MATCH campaigns.
- Extra releases during GOME (ERS-2) overpasses.
- Data deposited at WO3UDC.
- Data deposited near-real-time at NILU database.

Research and applications:

- stratosphere/troposphere exchange
- validation of satellite observations
- development of GOME ozone profile retrieval.

Observations at the Suriname Meteorological Service (MDS) in Parmaribo, Suriname, (5.81N, 55.21W).
Brewer MKIII Spectrophotometer:

- Continuous total ozone and UV scans, plus Umkehr at dusk and dawn: since April 1999.
- Data deposited at NDSC, WO3UDC databases

Research and applications

- Validation of ozonesonde and satellite observations
- Radiative transfer model studies
- Calibration of UV-index forecasts

Ozonesondes:

- Profiles of ozone, temperature, humidity and wind, weekly balloon releases since September 1999.
- Data deposited at SHADOZ (Southern Hemisphere Additional Ozone Sondes) and NDSC databases

Research and applications:

- Atmospheric transport, dynamics and chemistry in the Tropics
- Stratosphere/troposphere and interhemispheric exchange
- Validation of satellite observations (GOME and SCIAMACHY)

- Development of GOME total ozone and ozone profile retrieval.
- Algorithm development for global UV index forecasts based on GOME total ozone

Retrieval, analyses and validation of satellite observations:

- GOME total ozone, ozone profile, and NO_2 column retrieval, since 1997.
- SCIAMACHY profile retrieval, from 2002.
- GOME UV Index forecasts, from 2001
- SCIAMACHY validation, preparation and carry out, since 1997.

Preparation of future satellite missions:

- Participate in designing future ESA atmospheric chemistry missions: TROC, Geo TROPE, and ACECHEM.
- Scientific lead for the Dutch-Finnish Ozone Monitoring Instrument (OMI) on board EOS AURA (PI-institute)
- Preparation for GOME-2 (Ozone SAF)

Modelling:

Chemistry-transport modeling:

- Tropospheric ozone budget.
- Effects of aviation
- Aerosols
- Lightning and surface NOx
- Stratospheric ozone
- Methane

Dynamics:

- Stratosphere/troposphere coupling (also for 2 x CO_2).
- Inter-hemispheric exchange
- Effects of gravity waves on STE and vortex permeability
- AO: Arctic Oscillation

Validation:

- Aircraft measurements of composition, e.g. Caribic project
- Ozone soundings in De Bilt and Paramaribo

Assimilation of ground-based and satellite observations:

- EU project GOA: data assimilation of GOME ozone and GOME NO_2.
- GOME total ozone and ozone profile assimilation in 3-D chemistry transport model (ESA Data User Programme). Near real-time ozone fields and ozone + global UV Index forecasts are continuously generated and can be obtained at the web-site: http\\:www.knmi.nl/neonet/atmo_chem./gome/fd
- Preparations for the assimilation of SCIAMACHY products: ozone, methane, aerosols, NO_2, and others
- Participation in ENVISAT validation

Contribution to Assessment reports:

- European Research in the Stratosphere 1996-2000
- IPCC Assessment – Third Assessment Report (TAR)
- WMO/UNEP Ozone Assessment Report 2002

National Institute for Public Health and the Environment (RIVM)

Operation of a stratospheric lidar for ozone, temperature and aerosol profiling at NDSC Primary Station Lauder, New Zealand:

- Ozone profiles 8 - 45 km
- Temperature profiles 8 - 65 km
- Aerosol backscatter coefficient profiles 8 - 30 km

- Between 50 -100 measurement nights per year
- Time series starts December 1994, NDSC database.

Operation of a tropospheric lidar for ozone and aerosol profiling at TOR station Bilthoven, the Netherlands:
- Ozone profiles 1 - 8 km
- Aerosol backscatter coefficient profiles 1 - 8 km
- Between 50 -100 days per year with observations
- Time series starts December 1994, TOR database.

UV-monitoring with high spectral resolution in Bilthoven, the Netherlands:
- Year-round UV monitoring with high spectral resolution
- UV-maps of Europe using satellite and groundbased measurements, including cloud effects
- Extensive validation activities of these maps by comparing satellite fields with groundbased observations
- Setting up of a European UV database (SUVDAMA project)

Participation in satellite validation programs:
- GOME ozone profiles (active member of ESA validation working group)
- ENVISAT validation program: Sciamachy, Gomos and Mipas.
- EOS Aura/OMI

Contribution to assessment reports:
- UNEP/WMO Scientific assessment of Ozone Depletion
- European Environmental Agency assessment reports

Institute for Marine and Atmospheric Research, Utrecht University (IMAU)

Observations by aircraft (twinjet), in collaboration with European groups:
Ozone and precursors:
- Ozone, hydrogen peroxide
- NO_y gases, CO, hydrocarbons
- Aldehydes, ketones, organic acids, alcohols
- Actinic fluxes

Air mass tracers:
- Methane, nitrous oxide
- Water vapor, CFC's
- Carbon dioxide

Aerosols:
- Small particles and ion-molecule clusters
- Aerosol size distributions
- Aerosol chemical composition

Research topics:
- Oxidation processes in upper troposphere/lower stratosphere
- Stratosphere-troposphere exchange
- Ozone chemistry in the tropical troposphere
- Aerosol microphysical processes

Atmospheric chemistry and climate modelling:
Chemistry transport modelling:
- Tropospheric ozone budget
- Oxidation efficiency of the atmosphere
- Ozone chemistry in the lower stratosphere
- Heterogeneous processes
- Biosphere-atmosphere interactions

Chemistry climate modelling:

- Stratosphere-troposphere exchange
- Aerosol dynamics and composition
- Ozone, methane and aerosol radiative forcing and responses

Model validation:

- Aircraft measurements
- Balloon ozone soundings
- Satellite observations (e.g., GOME, HALOE)

Contribution to assessment reports:

- WCRP – model intercomparisons
- WMO/UNEP Ozone Assessment 2002
- European Assessment on the Impact of Aircraft on the Atmosphere

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NEW ZEALAND

Ozone and UV monitoring and research in New Zealand is funded primarily from the Public Good Science and Technology (PGS&T) fund administered by the Foundation for Research Science and Technology (FRST). Research funding also comes from commercial activities such as providing research products and instrument development. Most ozone and UV work is undertaken at the Lauder and Wellington sites of the National Institute of Water and Atmospheric Research (NIWA), a Crown Research Institute (CRI). The site at Lauder is the southern hemisphere mid-latitude charter site for the Network for Detection of Stratospheric Change (NDSC).

The Physics and Astronomy Department at the University of Canterbury in Christchurch also contributes to this research; and several other CRIs have programs to monitor changes in biologically damaging UV radiation (e.g., Industrial Research, LandCare, AgResearch). Some of these programmes are in collaboration with NIWA scientists.

Current and planned activities include:

1. Monitoring and measurements

a) *Ozone*: Ozone measurements were made using a Dobson spectrophotometer (no. 17) located at Invercargill (46.4^{o} S, 168.3^{o} E) from 3 July 1970 to 30 September 1987. The instrument was then re-located to Arrival Heights in the Antarctic (77.8^{o} S, 166.7^{o} E), another NDSC site, where it has been operated since. Another Dobson spectrophotometer (no. 72) has been operated at NIWA Lauder (45.0^{o}S, 169.7^{o}E, alt 370m) since the beginning of 1987 in collaboration with NOAA. These instruments are also used for Umkehr observations to estimate the vertical profile of ozone in the stratosphere. In addition to these instruments, UV-visible spectrometers at Arrival Heights, Macquarie Island (54.5^{o}S, 159.0^{o}E), Lauder, Mauna Loa (19.5^{o}N, 155.6^{o}W, alt 3400m), Tarawa (1.5^{o}N, 173^{o}E), and Kiruna (67.8^{o}N, 21.1^{o}E) measure total column ozone. Vertical ozone profiles over Lauder are measured by ozonesondes (weekly since August 1986, to ~33 km), a microwave radiometer (~ daily since November 1992, 20-70 km), and a UV DIAL system in cooperation with RIVM, The Netherlands (during cloudless nights since November 1994, 8-50 km). All of these data are regularly submitted to the NDSC database. A Dobson intercomparison campaign was conducted at Lauder in November and December 2001 and included vertical ozone profile measurements from ozonesondes, lidars and microwave radiometers. Following the OPAL intercomparison in 1996, a second intercomparison of vertical ozone profiles from ozonesondes, the microwave radiometer, the RIVM lidar, and the NASA/GSFC lidar will take place in April 2002 (the OPAL II campaign).

b) *Other atmospheric constituents related to ozone depletion:* Measurements of key stratospheric trace gases involved in ozone depletion are made by NIWA using a range of ground-based and balloon-borne instruments from Arrival Heights, Macquarie Island, Lauder and Kiruna. High resolution Fourier transform infrared (FTIR) interferometers at Lauder and Arrival Heights are used to determine column amounts of O_3, HCl, HNO_3, CH_4, N_2O, HF, COF_2, CO, C_2H_6, $ClONO_2$, CFC-11, CFC-12, NO_2, OCS, and CO_2. For some of these species, 2 to 4 vertical layer amounts are retrieved from the FTIR spectra as well. A new high resolution FTIR instrument has recently been purchased for operation at Lauder. A microwave spectrometer is operated near Arrival Heights for monitoring the ClO vertical profile. UV-visible spectrometers measure slant column NO_2 over Kiruna, Japan, Hawaii, Tarawa, Lauder, Macquarie Island and Arrival Heights, BrO over Kiruna, Lauder and Arrival Heights, and OClO over Kiruna and Arrival Heights. Aerosol profiles are also measured by lidar. A microwave spectrometer at Lauder makes clear sky measurements of the profile of H_2O in the upper stratosphere and mesosphere.

c) *UVB radiation*: Since late 1990, surface spectral UV irradiance has been measured routinely at Lauder. Scans are made at 5 degree steps in solar zenith angle, and at 15 minute intervals over the midday period. The spectral resolution is ~1 nm, and data cover the range 290 to 450 nm in 0.2 nm steps. These spectra are complemented by a wide range of broadband

measurements and by all-sky images taken at 1 minute intervals to quantify the effect of cloud distribution and type on UV radiation. Similar spectral measurements have been undertaken in collaboration with NOAA/CMDL at Mauna Loa Observatory, Hawaii (since July 1995), and at Boulder Colorado (since July 1998) using weatherproof, temperature-controlled spectrometers. In addition, broadband instruments, which measure integrated UV with a response similar to human skin reddening (erythema), are operated by NIWA at Lauder, Leigh (36.3^{o}S, 174.8^{o}E) and Invercargill (46.4^{o} S, 168.3^{o} E). A complementary network of broadband monitors at population centres is operated by IRL. Because of mismatch between instrument sensitivity and erythemal response, corrections which depend on solar elevation and ozone need to be applied to all of these broadband instruments. Data from NIWA's broadband instruments and radiative transfer calculations are used to provide the public with information on UV radiation levels via the Internet. Data from the IRL network are disseminated to the public through telecom pagers held at radio stations.

2. Research and Modelling

a) *Ozone*: Global total column ozone measurements from Dobson spectrophotometers have been assimilated with satellite overpass measurements (4×TOMS and GOME) to form a global homogenized total column ozone time series. Trend analysis on this data base has been performed and the results are included in the 2002 WMO/UNEP ozone assessment and European ozone assessment documents.

b) *UV*: Surface spectral UV irradiance measurements made in New Zealand have been compared with northern hemisphere measurements. These comparisons show that the meridional gradient in surface UV is less in the southern hemisphere than in the northern hemisphere, possibly as a result of greater tropospheric pollution in the northern hemisphere. In support of the UV measurement programme, radiative transfer models have been developed at NIWA to predict surface UV spectral irradiance, to better understand factors affecting surface UV radiation, and for use with a semi-empirical algorithm to generate a history (since 1960) of surface UV irradiance at 73 sites around New Zealand. This UV Atlas project has resulted in the creation of a CD containing data from 1979 to 2001, including viewing software, which will be released to the New Zealand public at a UV workshop in Christchurch from 26 to 28 March 2002. Work is in progress to relate long term reductions in summertime ozone to increases in UV radiation in New Zealand

c) *Stratospheric trace gas processes*: NIWA has recently completed the first version of a Lagrangian chemical box model of stratospheric chemistry, with the collaboration of the University of Canterbury, JPL, and the University of Cambridge. This model is being used to interpret NIWA and other stratospheric data sets to better understand ozone depletion in the Antarctic and at mid-latitudes. Of particular interest is the effect of Antarctic ozone depletion on ozone levels over New Zealand. Studies currently underway include a comparison of modelled and measured O_3 depletion rates during ozone hole formation, and an investigation of the frequency and severity of outbreaks of polar vortex air over New Zealand.

3. Satellite validation

NIWA has been and will be involved in a range of satellite validation studies. Following the recent successful launch of ENVISAT, measurements made by NIWA will be used to validate the SCIAMACHY, GOMOS and MIPAS instruments. Ozone profile measurements at Lauder and column NO_2 measurements are now also being used to valdiation SAGE III measurements. Recent work has shown differences between Dobson spectrophotometer and TOMS total column ozone measurements, with a strong latitudinal dependence. Investigations into this phenomenon, with implications for the new TOMS version 8 retrieval algorithm, are continuing.

4. Other

A number of researchers from New Zealand are contributing to the 2002 WMO/UNEP ozone assessment document and the UNEP Environmental Effects of Ozone Depletion report.

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PANAMA

1. Introduction

In Panama, higher levels of global radiation as well as UVB radiation are registered, compared to countries with higher latitude, because of its climate and geographical position. For this reason, a continuous monitoring of local UVB radiation and ozone column becomes a very relevant task. The incidence of various types of skin cancer (basal cell carcinomas, squamous cell carcinomas and melanomas) has increased locally and worldwide. In addition to the effects on human health, it is remarkable that UVB radiation damages crops, interferes with the mechanism of photosynthesis, strikes the population of phytoplanktom and also of other organisms.

With the aim of facing this problem in our country, the Laboratory of Atmospheric Physics was created at the University of Panama, within the Vice Rectory of Research and Post graduated Studies. Subsequently, a research project was initiated through which a characterization has been performed of the levels of UVB radiation and total ozone column in Panama City. In addition to the levels of UVB radiation and total ozone column, other parameters also monitored are global radiation, photosynthetically active radiation (PAR) and different atmospheric parameters such as cloud cover, rain, ambient temperature, atmospheric pressure, precipitable water, aerosol optic thickness and relative humidity. At the initial stage of the project, the measurements have been performed only in Panama city.

In this first stage of the research project carried out by the Laboratory of Atmospheric Physics, one monitoring site, located at the main Campus of the University of Panama, was used for the measurements. In this site, two wide band radiometers, model 501 UV-Biometer, were installed, as well as two model PSP pyranometers, one PAR radiometer, two ozone layer meters, model Microtops II and one meteorological station, along with the respective data acquisition equipment (data loggers). This first stage started in July, 1997.

In the second stage of the project, a national monitoring network will be established composed by five measurement sites, located at the cities of David, Santiago, Penonomé and Chitré, along with the measurement site already located in Panama City. These measurement stations will continuously monitor UVB radiation, PAR radiation and other meteorological parameters. For this reason, each one will have UVB wide band radiometers, PAR radiometers and meteorological stations installed. In this way, it will be possible to characterize the levels of irradiance, as well as UVB, global and PAR irradiation corresponding to the different climatic zones within our country. Based on the data obtained from these sites, it will be possible to elaborate mathematical models, valid for the entire national geography, to correlate UVB, global and PAR irradiance and irradiation with other atmospheric parameters. This stage of the project was, already, initiated in 2001, with the installation of one meteorological station and one 501 UV-Biometer at the Enrique Malek Airport, in David City, located at about 500 km west from Panama City.

2. Instruments and Methods

In the following lines, the instrumentation used at the Laboratory of Physics of the Atmosphere in relation with the research project, will be briefly described:

- Three UVB wide band radiometers, model 501-Biometer, from Solar Light Co., along with data acquisition systems (data loggers).
- Eppley pyranometers for the measurement of global solar radiation.
- Kipp and Zonen pyranometers for the measurement of global radiation.
- Ozone meters, model Microtops II, from Solar Light Co.
- Ambient temperature and relative humidity sensor.
- GPS unit, model Garmin 38
- 5 1/2 digit Digital Multimeter, model Instek.

- PMA 2132 sensors, from Solar Light Co, for the measurement of photon flux in the 400 – 700 nm range, along with the PMA 2100, matched data acquisition system, also from Solar Light Co.
- Geonica automatic meteorological station, located at the University of Panama, Main Campus, Panama City.
- Campbell Scientific Inc. automatic meteorological station, located at the Enrique Malek Airport, David City.
- Computers and statistics software for data processing.
- Dedicated software to allow daily information on UVB radiation to be presented to the general public via Internet.

The data collected by the radiometers is stored every five minutes for subsequent processing using Sigma Plot software. From the processed data, mean hour irradiance, total daily dose, UV indexes (UVI) and daily mean irradiance curves are obtained.

3. Calibration

All radiometers and other sensors are calibrated each year. Calibrations have been performed by Solar Light Co and by the Solar Radiation Observatory, at the UNAM, Mexico.

4. Experimental Results

- During local noon, the maximum mean irradiance corresponding to a clear day is near **5,3 MED/h**,
- The maximum mean irradiance during the dry season in the years 1998, 1999, 2000 and 2001 were **3,27, 3,34, 3,75** and **3,82 MED/h**, respectively.During the **76,7 %** of the days in the dry season, UVB indexes with health risk were observed.
- During the **52 %** of the days in the rainy season, UVB indexes with health risk were observed. The UVB irradiance, as well as the irradiation or dose, shows a similar behavior, with a main maximum during the dry season and a secondary maximum in September, during the rainy season. During the months of June and July, the UVB radiation levels are significantly attenuated. During the months of June and July, the mean accumulated cloudiness reach its maximum value. The UVB mean monthly dose showed a statistically significant increase during the years of 2000 and 2001. The monthly mean accumulated cloudiness showed a statistically significant decrease during the years of 2000 and 2001.
- For the condition of clear sky, the highest irradiation or doses are registered between 10:00 hour and 14:00 hour.
- The average total ozone column is **248 DU**. The minimum value **(220 DU**) is registered during the months of December, January and February. The maximum value (**300 DU**) is registered during the month of August. Nevertheless, these values lie within the variability margin correspondent to the Panama City latitude.
- The total ozone column shows an oscillatory variation which is described by a harmonic mathematical function. The total ozone column shows positive and negative anomalies of the order of 2% which may be associated with the quasi biannual oscillation .

Empirical Model

Another goal reached by the Laboratory of Physics of the Atmosphere is the development of an empirical model to correlate the UVB irradiance for hours within local noon with the following parameters: Ozone column, cloudiness fraction and day of the year. For this purpose, September the 15^{th} of 1998 has been taken as a reference. Normalized irradiance data vs ozone column for clear days as well as normalized dose data vs cloudiness fraction corresponding to clear days were analyzed. From this analysis the following equation was found:

$$I = 4{,}66\{1 + 0{,}033\cos\theta_n\}[1 - 0{,}68c]e^{-0{,}0183(OZ-248)}\cos(\delta - \varphi)$$

Where θ_n is the daily angle, **c** is the cloudiness fraction, **OZ** is the value of the ozone column, δ is the solar declination and φ is the latitude.

Future Projections in the Research Line

1. To establish a nationwide network for the measurement of UV radiation and other atmospheric parameters
2. To establish a Regional Radiometric network.
3. To establish a national radiometric data base.
4. To create a continuous information system to alert the community concerning high UV indexes (IUV).
5. To monitor the UVB radiation levels in some of the sites of the Panama Canal hydrographic watershed.
6. To study the possible effects of the increasing levels of UVB radiation on some of the amphibious species in the Panama Canal Hydrographic watershed.
7. To study the possible correlation between the increment in skin cancer cases in the Republic of Panama and the levels of UVB radiation registered.
8. To implement the I Latin American Congress on UV and Ozone at Panama City. This event is scheduled for July 15 to 19, 2002.

Achievements

1. Organization of Seminars and Lectures, oriented to general public, concerning effects of UVB on human health, with the collaboration of National Cancer Association.
2. Organization of a Seminar Workshop on UVB and Ozone, within the II Central American and Caribbean Congress of Physics.
3. Diffusion of information about UV Indexes, oriented to general public.

Figure 1 shows the curves of mean monthly irradiance vs local hour for the dry seasons corresponding to 1998, 1999, 2000 and 2001.

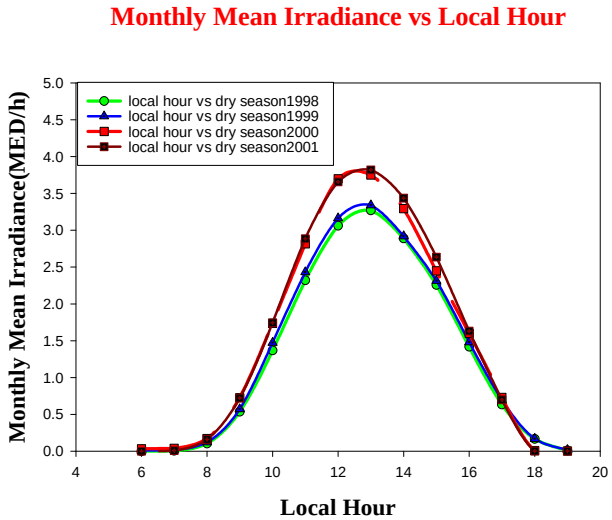

Figure N° 1

Figure N° 2 shows a contour map of the Maximum mean Monthly Irradiance vs Local hour for the entire year, years 1998 to 2001.

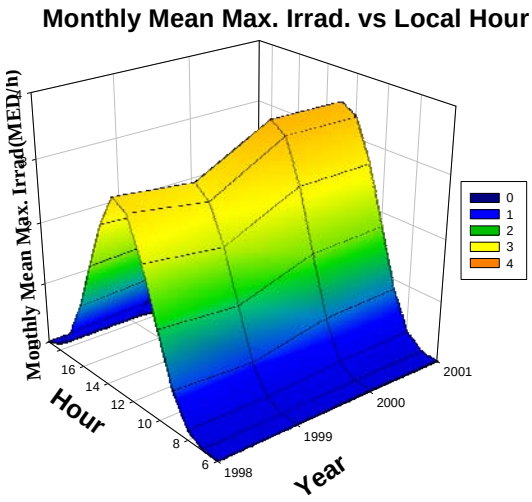

Figure N° 2

Figure N° 3 shows the curve of mean monthly irradiance vs time correspondent to the years 1997 to 2001.

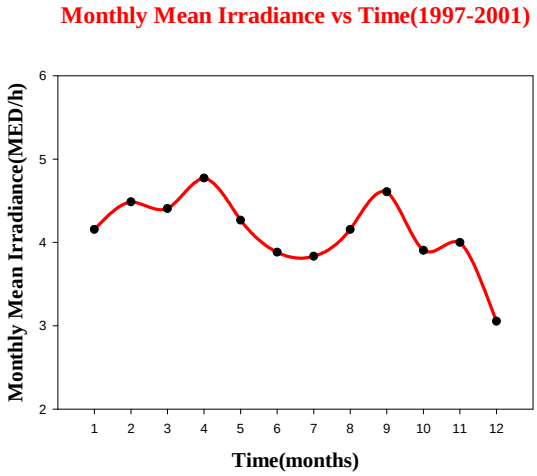

Figure N° 3

Figure N° 4 shows the curve of mean monthly irradiation or dose vs time for the years 1997 to 2001.

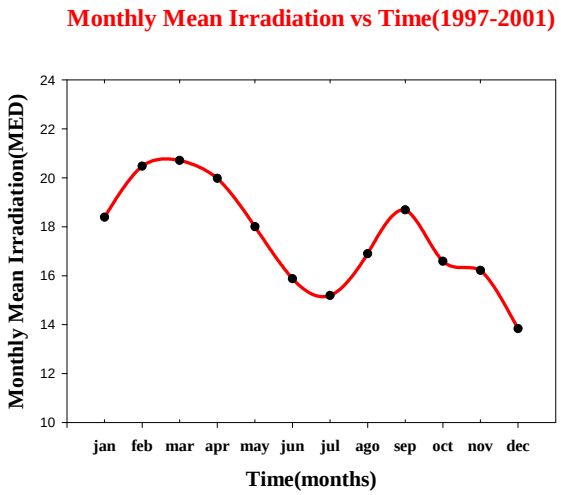

Figure N° 4

Figure N° 5 shows the behavior of the ozone column in Panama City, from February 1998 to December 2000. The fitting equation for this curve is:

$$OZONO = 248 + 30sen\left\{\frac{2\pi[d_n + 257]}{365}\right\}$$

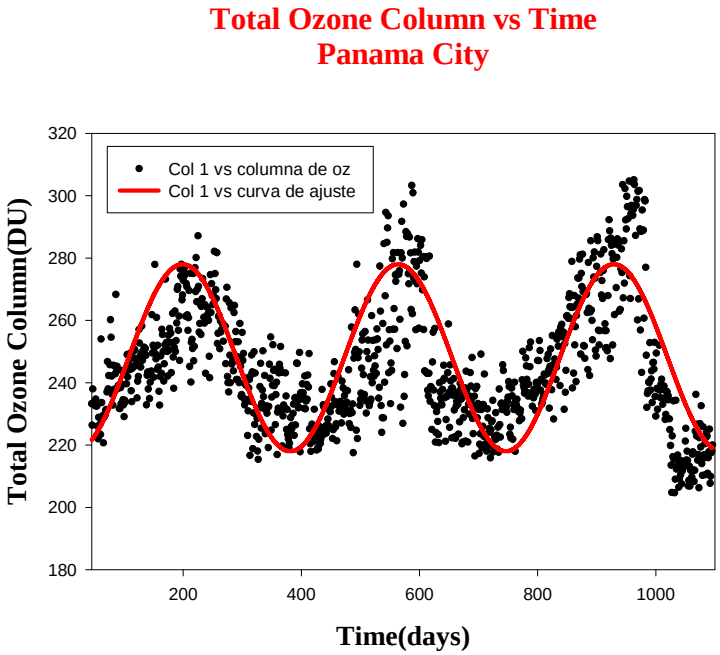

Figure N° 5

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PERU

I. PROGRESS IN THE IMPLEMENTATION OF THE PERU´S COUNTRY PROGRAM

1.1 Date of approval of the Country Program

XVII Meeting of Executive Committee of the Multilateral Fund of Montreal Protocol, July 1995, Montreal, Canada.

1.2 Name of the National Focus Point for the Country Program Implementation

Technical Office of the Ozone-Peru, which is part of the Ministry of Industry, tourism, integration and International Commercial Business- MITINCI.

1.3 Executive Agency for the Country Program Implementation

United Nations Environment Program-UNEP

1.4 Progressive elimination plan of ozone-depleting substances-ODS *(T.M. of potential ozone-depleting substances)*

Substances	*1993*	*1994*	*1995 1998*	*1999 2002*	*2003 2006*	*2007 2010*
CFC Group I	280	322	227	122	61	0
Halon Group II	0	0	0	0	0	0
CCL4 Group II	15	17	13	7	0	0
MCF Group 3	3	4	3	2	1	0

1.5 Total Consumption of Ozone-depleting substances in 1993, 1995 and 1999

In 1993, reference year for Peru´s Country Program elaboration, the consumption of ozone-depleting substances was 326,69 M.T.. In 1995, year in which it was approved, the consumption reached 650,58 T.M.. In 1999 the consumption was 318,551 T.M..

1.6 Annual per capita consumption in 1999 (Kg).

In 1999, the annual per capita consumption was 0,01263 Kg/year.

1.7 Approved and used funds for 1999-2000 Country Program activities (US$)

Twenty five projects were approved and funded during 1999-2000. This projects implementation was carried out during the project “Preparatory assistence”, with the UNEP support.

1.8 Financial support for projects (US$):

a) Projects of Industrial technologic transformation

Sector	Empresa	Situación del proyecto
Foams (CFC 12)	PAMOLSA	Concluded
Industrial refrigeration	INDUSTRIAS ALFA S.A.	Concluded
Industrial refrigeration	COLDEX S.A.	Concluded
Industrial refrigeration	INDUSTRIAS SELVA S.A.	Concluded
Industrial refrigeration	INDUSTRIAS REUNIDAS S.A.	Closed
Industrial refrigeration	ANDINA INDUSTRIAL S.A.	Desisted
Industrial refrigeration	INDUSTRIAS LENCHE S.A.	In implementation
Commercial refrigeration	MASTER SERVICE S.A.	Concluded
Commercial refrigeration	COPEMACO S.A.	Concluded
Commercial refrigeration	COLFRIO S.A.	Concluded
Commercial refrigeration	FORMETAL S.A.	Closed
Solvents	FABER CASTELL S.A.	Concluded
Solvents	CARBOLAN S.A.	Concluded
Solvents	PAPELES INDUSTRIALES S.A.	Concluded

b) Project of recovery and recycling on refrigerant substances

c) Project Good practices on refrigeration Sector

d) Project Poliestireno Foams

e) Demonstative Project of Methyl bromide.

f) Project Plan of management of refrigerants

II. MONITORING OF OZONE AND ULTRAVIOLET-B RADIATION

2.1 Introduction

Peru, through Meteorological and Hydrological National Service-SENAMHI have started again the Ozone monitoring which was carried out by Geophysical Institute of Peru-IGP between 1964 to 1991 in Huancayo (3350 masl). At the present, it is carrying out in the Marcapomacocha station, which was sited by the GAW at 4530 masl, in the western region of the country, getting total Ozone data with a Dobson Spectrophotometer, property of the USA.

The data of this station becomes very important because it covers the western tropical region of South America.

Besides since 1999 we count on with data of UV-B radiation for Lima and Arequipa, the two most important cities of the country.

2.2 Activities

a) Participation at Intercomparison meeting of Dobson Spectrophotometer and UV-radiometers, carried out in Buenos Aires, 1999.

b) The total ozone data collected in the Maracapomacocha station are regularly sent to World Ozone Data Center since February 2000. Some figures are added.

c) Participation at Intercomparison meeting of Pyranometers and UV-radiometers, carried out in Mexico, 2001.

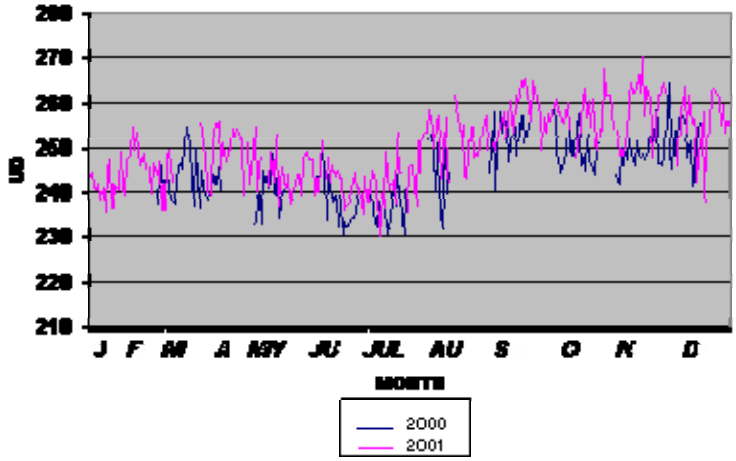
d) Monitoring of UV-B radiation in Lima and Arequipa (since 1999). Some figures are added.

2.3 Projections

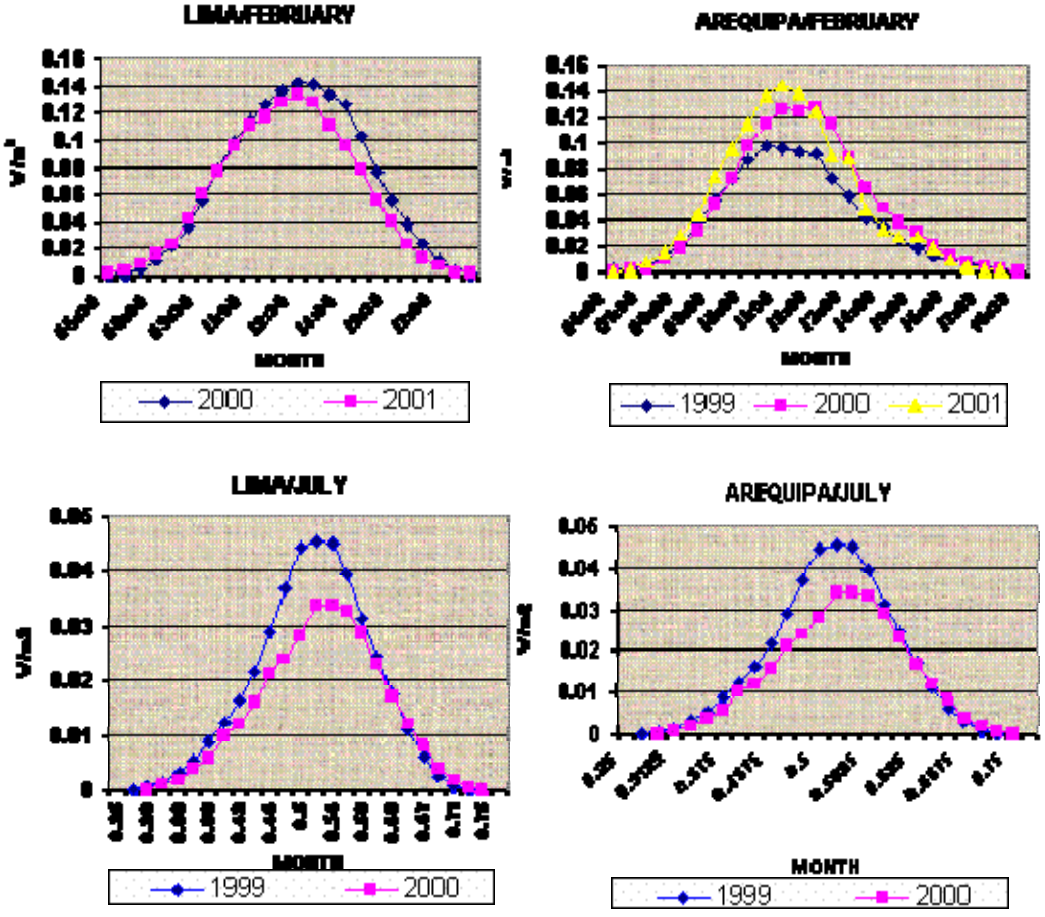
a) Acquisition of another UV-B radiometer to be installed in the Marcapomacocha station.

b) Deal with internacional cooperation organizations donations of complementary equipments to monitoring acid precipitation, aerosols, dioxide of carbon, tropospheric ozone and turbidity in Marcapomacocha station.

OZONE TEMPORAL VARIATION IN MARCAPOMACOCHA STATION (4530 masl) 2000 - 2001



HOURLY VARIATION IN LIMA AND AREQUIPA CITIES



POLAND

The ozone and UV-B monitoring and research activities, carried on in two INSTITUTES, are supported by: GENERAL INSPECTORATE OF ENVIRONMENT PROTECTION; NATIONAL FUND FOR ENVIRONMENTAL PROTECTION AND WATER MANAGEMENT; MINISTRY OF THE ENVIRONMENT.

INSTITUTE OF METEOROLOGY AND WATER MANAGEMENT

Monitoring

- The ozone soundings are performed at Legionowo (52.40N, 20.97E) upper-air station since 1979. Up to May 1993 the OSE ozone sensor with the METEORIT/MARZ radiosounding system was used. Since June 1993 the ECC ozone sensor with OMEGA (since 1997 LORAN) DigiCora/RS80 radiosounding system is in use. The ozone soundings are launched regularly on each Wednesday. The data are submitted to the WMO Ozone Data Centre regularly on monthly schedule.
- The Legionowo ozone profiles were used in the validation procedures of ozone profiles derived from satellite projects: GOME, POAM III, ILAS.
- Since 1993, on the base of the NOAA/TOVS satellite data, total ozone maps over Poland and surroundings are operationally performed at a satellite receiving station in Krakow.
- In July 1993 broadband UV Biometers model SL 501 vers. 3, have been installed at three stations in Poland: Leba (54.75N, 17.53E), *Baltic Coast,* Legionowo (52.40N, 20.97E), *Centre of Poland,* and in *Tatra Mountains:* Kasprowy Wierch 1989m (49.32N, 19.98E), operated until 1996, in 1995 a Biometer was installed at Zakopane 857m (49.30N, 19,97E).
- In 2000 two NILU-UV spectral filter instruments were installed at Legionowo, measuring the UV-B, UV-A, total ozone and optical depth.
- Surface ozone measurements with Monitor Labs. ML9810 started in 1995 at 3 stations: Leba (54.75N, 17.53E) *Baltic Coast*, Jarczew (51.81N, 21.98E) *Centre of Poland*, Sniezka (50.73N, 15.73E) *Sudety Mountains*.

Research

- Ozone and UV research activities are carried on in the Centre of Aerology in Legionowo in co-operation with the Satellite Research Department in Krakow.
- The Centre of Aerology participated since 1994 in the European Stratospheric ozone campaigns: SESAME, THESEO and O3-LOSS in the Match programme (evaluation of ozone chemical destruction in Polar Vortex). At Legionowo, during the winter/spring months, ozone soundings are performed more frequently, two or three times weekly, according to expected ozone deficiencies over Poland. The results are submitted operationally to the Data Base at NILU (Norway).
- The ozone research studies focus continuously on the long term changes (trends) in ozone profile in connection with the temperature profile changes and on the case studies of dramatic stratospheric ozone deficiencies, observed with growing frequency during the last years in winter/spring months. These cases are connected either with the excursions of Polar Vortex into the midlatitudes, either with European ozone "mini-holes". The dynamical background of appearance of these cases over Poland has been studied.
- During the last years, the ozone and UV research activities were directed mainly on UV forecasting. For that reason, several studies have been performed on: short term day to day changes of total ozone; the relation of total ozone to atmospheric characteristics (tropopause, geopotential heights, etc.); validation of total ozone derived from NOAA/TOVS satellite with dobson total ozone; elaboration of a method of one-day total ozone forecast; radiative transfer modelling and adaptation of libRadtran model to local conditions; sensitivity of UVR on ozone profile, clouds and albedo.
- In the years 1996-2000 IMWM participated in the UVRAPPF EC project and in the COST-713 Action - *UV forecasting*.

- On the base of these research experiences a method of UV Index forecast for Poland has been worked out and implemented operationally.

Public information

- Since 1999 the UV Index forecast for Poland is available from May to August on www.imgw.pl. One of the key tasks of COST-713 Action - *UV forecasting* was the development of efficient methods for dissemination of the UV Index forecasts and for warning the public against the possible detrimental health effects. A booklet "UV Index for the Public" has been prepared (with polish participation) and published in 2000 (EC publications). In 2001 a polish version of the booklet, "Indeks UV a człowiek", has been prepared and published by the IMWM, sponsored by the INSPECTION OF ENVIRONMENT PROTECTION.

POLISH ACADEMY OF SCIENCES - INSTITUTE OF GEOPHYSICS

Monitoring

- Measurements are carried out at the Belsk Observatory (51° 50' N. 20° 47'E).
- Since 1963 total ozone measurements and Umkehr series have been performed by means of the Dobson spectrophotometer. In 1991 Brewer spectrophotometer was installed. Total ozone and Umkehr profile series have been re-evaluated in 1983 and 1987 respectively.
- The Dobson and Brewer spectrophotometers are regularly calibrated. The recent calibration of the Dobson instrument took place in 2001 at Hohenpeissenberg, and Brewer instrument was calibrated against Brewer#17 maintained by International Ozone Corporation in 2001.
- The ozone data are regularly submitted to the WMO Data Centre in Toronto. The mean daily values of total ozone are also submitted operationally to the Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece, and to the World Ozone and UV Data Centre in Toronto.
- Systematic measurements of ground level ultraviolet solar radiation (UV-B) with the Robertson-Berger meter have been carried out since 1975. In 1992 UV Biometer SL501A was installed. Spectral distribution of UV radiation has also been monitored with the co-located Brewer spectrophotometer.
- The surface ozone measurements with Monitor Labs, ML8810 meter started in 1991, and since 1992 NOx measurements have been performed with Monitor Labs, (ML8841) meter.

Research

- The ozone research activities mainly focus on statistical analyses (trends) on local and global scale, and methodology of ozone measurements. The changes in the ozone layer over middle altitudes are examined in connection with changes in the dynamic factors characterising the atmospheric circulation in the troposphere, the lowermost stratosphere, and the stratospheric overworld. The study is focused on the role played by the dynamical factors in ozone variability, because natural dynamical processes in the Earth's atmosphere can perturb the recovery of the ozone layer.
- Factors influencing the UV radiation (ozone content, aerosol, cloudiness) are studied, with particular emphasis on the response of UV radiation to forcing factors, at various time scales.
- The Belsk UV data series is the longest time series of UV measurements in Europe and similarly to ozone series is a subject of intensive study. In the studies of the UV-B variability advanced statistical methods such as wavelet decomposition and multivariate adaptive regression spline are used.

Future plans of ozone and UV activities in Poland

- Continuation of the monitoring of ozone and UV.
- Participation in the EDUCE EC project (IMWM and IG PAS).
- Participation in the COST 723 Action - The Role of the Upper Troposphere in Global Change (IMWM).
- Participation in the validation of ozone and temperature profiles in the SCIAMACHY project (IMWM).

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ROMANIA

In Romania, the scientific research concerning the ozone layer protection proves scientifically and technically the policies and strategies established by the Ministry of Waters and Environmental Protection and fulfills the obligations imposed on Romania as a signatory party to the international conventions on the ozone layer protection.

Romanian legislation framework regarding the ozone layer protection

- The Montreal Protocol on substances depleting the ozone layer (ODS)
- The Vienna Convention on the ozone layer protection
- The Amendment adopted in London
- The Amendment to the Montreal Protocol
- The National Committee for the ozone layer protection with the technical secretariat for the ozone layer protection.

Human activities cause a significant change in the atmospheric concentrations of several gas (CH_4, N_2O and CFCs) sources. This change and its impact on the ozone layer should be studied together and not separately. The issue of climate change covers both the influence of CO_2 on climate and the influence of other minor atmospheric compounds. The changes in the atmospheric concentrations of the ozone and H_2O, CH_4, N_2O, CFCs lead to a change in the thermic structure of the atmosphere. The increase and variations of the tropospheric ozone influence the climate and the way to estimate the total ozone.

The research directions and themes are carried on either within some national programmes of the ozone layer investigation and monitoring or within some sectorial programmes at the level of research institutes.

The technical Secretariat for the ozone layer protection harmonizes the national programmes with the sectoral ones.

At present, the depletion of the stratospheric ozone affects the global atmospheric by increasing the UV-B radiation at ground level. In Romania, the study of this phenomenon is one of the most important research objectives.

As a conceptual approach, the research goals have been selected both from the sphere of the activities for ODS alternatives and from the studies on the effects of the ozone layer depletion on terrestrial and aquatic ecosystems, on human and animal health as well as on climate system.

In Romania, there are numerous design and research-development units that deal with the ozone layer protection: The National Institute of Meteorology and Hydrology, The National Research and Development Institute for Environmental Protection - Bucharest, the Research Institute for Silviculture, the Research Institute for Sea Waters, research units from various fields of activity: human health, animal health, construction materials, refrigerating equipment.

Titles of research projects, directions of research and studies

- Studies and researches on the introduction of the chemical and technological alternatives for the decreasing of ODS emissions, in expanded and isolating materials (foam sector).

- Studies and researches for the use of the ecological agents in compressors for the re-equipment of the old refrigerating units and of the ecological agents mixtures used as ODS alternatives in different refrigerating units for food industry (refrigerating sector).

- Studies to replace CFCs with dimethyl ether in refrigerating equipment and to reduce the percent of CTC in mixtures from solvent field

- Studies and research concerning the implementation of chemical substituents and alternative technologies to reduce the emissions of ODS in the field of insulating and foam materials of constructions

- Studies and research concerning the use of ecological agents in the units of compressor-condenser with hermetic compressors for re-equipment of trade refrigeration

- Study on the impact of the National Programme for ODS removal on the production of refrigerating equipment

- Research concerning the possible use of some mixtures of ecological agents as substituents of ODS in different types of refrigerating devices

- Examples for the effects of the ozone layer change

- Study on the UV-B influence upon forest vegetation

- The effects of the ozone layer change upon the biodiversity and bioproductivity of the ecological systems from the ecotone

- The influence caused by the increase of the solar radiant intensity (especially UV-B) upon humans and animals: some skin and eye diseases

- Studies concerning the impact caused by the change of solar radiant intensity, especially UV-B, upon animal health

- Studies concerning the influence of UV-B radiation upon the productivity of aquatic ecosystems

- Biochemical processes in polluted marine waters influenced by solar radiation

- Continuous monitoring of the ozone amount

- Creation of a data base meeting the requirements of the world center for the ozone data collection from Canada

- Total ozone climatology and corelation with meteological parameters
- Defining the ozone parameters in prognosis models

A few results obtained

The period from July, 1, 1999 to July, 1, 2000 was the year of the CFC consumption freeze at national level and the beginning of a new stage in phasing-out these substances in accordance with the obligations imposed on our country as a signatory party to the international treaties already mentioned.
With a consumption of 350 t CFC, Romania complied with the production and consumption limits established in the protocol .

Romania has registered progress as regards the implementation of the legal conditions for ozone by developing the required legislative and institutional framework.

Our country has established the control of the trade in ODS and some restrictions on the use of halogenated hydrocarbons.

The implementation of the transfer of 'clean technologies' has led to the reduction of ODS.

In 2000, the downtrend in total ozone continued; its value was 9.41% of the multiannual monthly means.

The mean monthly deviations of the total ozone in 2000 as compared to those in the previous 5 years are all negative. That proves the downtrend which is also intensified by the high negative values in summer.

Because the ozone concentration depends greatly on the atmospheric transport at high level, there may occur incidentally high ozone concentrations that bring about positive deviations. The relevant example is the evolution of the total ozone in 1998 considered as a normal year.

These phenomena occur at regional scale and should not be considered as a proof of the ozone layer restoration.

In 2000 the UV-B values are comparable to those in winter and spring, 1999. However , starting from the end of May and up to August, inclusively, the daily mean values of the sunny days are 1-2% bigger and the maximal values of June and July are 5-6% bigger than the corresponding values of 1999. This increase is caused mainly by the low content of water vapours in the entire atmosphere.

A climatological profile of the ozone was determined in the latitude of the Bucharest station.

Bucharest station belongs to the world monitoring network for ozone and is an important point in the south - eastern part of Europe.

The influence of the UV-B radiation on forest vegetation leads to the:

- reduction and perturbation of the seed germination of the resinous and deciduous species
- decrease of the emergence percentage (10-20%) at the seeds of resinous and deciduous species
- decrease of the strength to grow high and thick (as diameter) of the seedling coming from exposed/irradiated seeds
- morphological and structural changes in the foliage of the seedling coming from exposed/irradiated seeds
- it has been ascertained the fact that the UV-B radiation had the smallest values in April and September and the highest in June and July.

For the marine ecosystems

- in the N-V of the Black Sea the UV-B radiation gets to the soil and surface water on days when cloudiness is zero between 11 in the morning and 2 in the afternoon and its intensity is relatively maximal at a wavelength of 310-311 nm
- the high UV-B radiation had a destructive effect on some marine organisms and a stimulating effect on some plant organisms
- the protective effect exerted by seawater on marine ecosystems against increased solar radiation

The creation of a national monitoring network for tropospheric ozone was proposed under the form of a project in 1998.

The creation of the national project for tropospheric ozone might be the last stage of a research project carried out between 1994-1998.

The operational mode of the network: data collecting, analysis and processing as well as the information flux will be carried out in compliance with the AQC criteria.

This last stage was not achieved because of the lack of money.

The assessment of the results obtained from the research concerning the ozone layer protection has made possible the identification of the following needs:

- to better co-relate the national research programmes with the sectorial ones.
- to continue the activity of monitoring the ozone and related parameters
- to broaden knowledge on:
  - « long and short term evolution of the ozone layer and the interactions between climate change and the change in the ozone layer;
  - « the interactions between the processes from the troposphere and those from the stratosphere;
  - « the response/reaction of the aquatic and terrestrial ecosystems considered as unit and number as well as the response of some organisms or populations;
  - «the ways to evaluate the UV-B effects on forest vegetation.

- the identification of the new posibilities of the international cooperation in the field
- the identification of the new financial sources for national research projects

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SEYCHELLES

1.0 BACKGROUND

Seychelles is an archipelago of 115 islands in western Indian Ocean mainly between latitudes 3 degrees and 10 degrees south and longitudes 51 degrees and 57 degrees east. Consists of Mahe group of 41 steeply mountainous granitic islands, and outlying coralline group of flat coral islands. The three neighboring islands of Aldabra, Farquhar, and Desroches, which were dependencies of the Seychelles until 1965 and belonged to the British Indian Ocean Territory after that time, were returned to Seychelles control in 1976. The main island of Seychelles, Mahe is 144 square kilometres is very close to the equator positioned at 04.40°South and 55.31°East and is one of the only islands in the Indian Ocean within the Equatorial Belt, which was found ideal to set up a monitoring ozone station within that area.

With the commissioning of the Meteorological Services Station at the Seychelles International Airport on the island of Mahe in 1971, the Meteorological Services section fell under the Ministry of Tourism and Civil Aviation. Emphasis was more on aeronautical meteorology rather than public weather service and global atmospheric monitoring.

In 1976 it was found necessary to set up an upper wind and temperature station due to lack of upper air data within the tropics, hence the opening of the Rawinsonde station within the southeast area of the Seychelles International Airport. It was almost immediately thereafter that a station for taking ozone data was set up by the British Met. Office under the able leadership of Mr. Mike Long worth and Mr. Colin Brookes. Seychellois staff of the Meteorological Services was trained to operate the ground equipment – the Dobson Spectrophotometer and the compilation of ozone readings was done twice a day.

While the total ozone data was taken by the Meteorological Services staff there was a separate sub-unit dealing with ozone matters (Montreal Protocol) in the Ministry of Environment.

In March 1999 a change in Government Policy made it possible for the Meteorological Services Section to be moved to the Ministry of Environment under the Division of Policy, Planning and Services to become the Seychelles National Meteorological Services which culminated in the development of more interest and better coordination of the ozone issues.

2.0 TRAINING

In March 1999 Dr. Bojkov of W.M.O. in collaboration with Dr. Karel Vanicek of the Solar and Ozone Observatory of the Hydro-meteorological Institute offered the Seychelles Meteorological Services the Dodson Software Package. Some members of the Seychelles Meteorological staff were trained to analyse the Raw Ozone Data and the results were sent directly to Toronto.

Every four years with the financial help of W.M.O. and the Republic of South Africa the ground instrument “The Dobson 57” is sent to the South African Bureau of Standards in Pretoria for general calibration done by the American Technicians from N.A.S.A.

In March 2000 we participated at the Dobson Spectrophotometer Intercomparison meeting in Pretoria, South Africa. We also went for the Dobson Spectrophotometer Operators and ozone data collation and management training in May 2000 at the Czech Hydro meteorological Institute in cooperation with WMO.

In 2001 Seychelles was represented at various seminars and workshops on ozone related matters in Zambia, Montreal and Namibia.

With the knowledge acquired the management found it necessary in January 2002 to set up an ozone unit within the National Meteorological Service of the Division of Policy Planning and Services of the Ministry of Environment.

3.0 RESEARCH

Global studies in ozone have shown that the amount of ozone in an atmospheric column in the tropics is very small as compared to polar region and mid-latitudes. Due to that reason the amount of solar radiation with harmful Ultra-Violet radiation rays received in Mahe, Seychelles is very large. Even a small change of the amount of ozone in the atmosphere will adversely affect Seychelles. And this is why steps are being taken to properly monitor the ozone content in that parts of the World, hence contribute in protecting the ozone layer.

Even though readings of the total ozone started way back in 1976, due to a lack of trained research staff, ozone raw data was sent to British Meteorological Office to be analysed and sent to the World Ozone and Ultraviolet Radiation Data Centre. Unfortunately no feedback was made available to us, and at the present the ozone readings in our possession date back to the year 1994 till presently.

Even though much has been done on finding alternatives to Ozone Depleting Substances, studies of the available ozone readings are very limited. The studies at the moment are geared towards the following-

1. Ozone fluctuations over the years, and
2. Seasonal total ozone variations – namely variations between the South-East Monsoons and the North-West Monsoons.

To date no substantial conclusions have been achieved, but from the following table the mean monthly ozone between the years 1994 to 2001 plotted month by month illustrates the distribution of total ozone within this region.

YEAR	*MONTHS (ozone unit-DU)*											
Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1994	244	246	248	248	250	250	259	273	265	260	260	265
1995	257	256	262	269	263	259	255	250	253	258	253	247
1996	245	238	246	249	248	241	246	256	279	281	274	267
1997	262	261	272	276	271	267	266	268	270	259	250	239
1998	230	232	242	242	248	251	256	256	263	271	267	258
1999	258	257	254	276	271	257	269	265	265	259	255	245
2000	233	245	255	265	266	262	256	253	250	255	253	

Figure 1

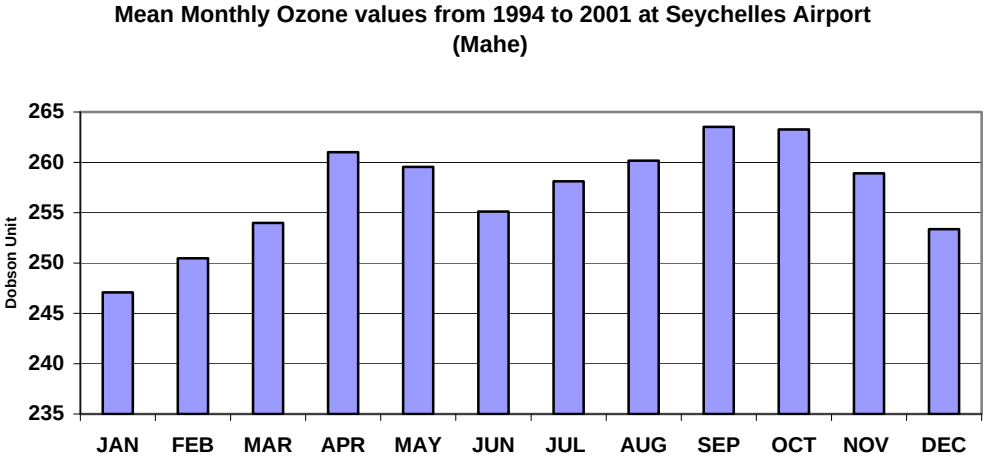

Figure 2

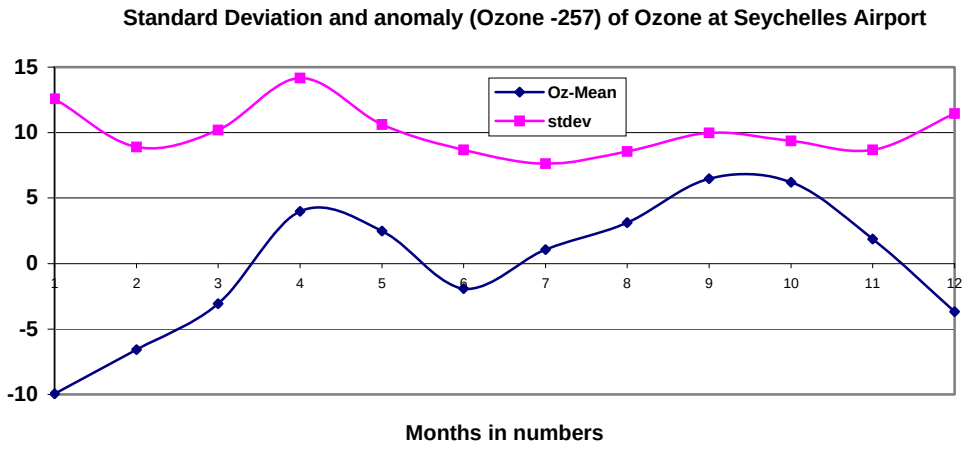

Figure 3

As figures 1, 2 and 3 illustrate, there is scope for a lot more research to be done on the available data to account for low readings during some months between 1994 and the year 2000 and there is evidence of a lack of correlation during some months of the same period. Therefore attempts will be made to investigate the causes of high and low concentrations of ozone by correlation analysis with meteorological factors and other pollutants.

4.0 RESEACH PLANS AND PROGRAMMES

Since our Research work is still in its early stages, coupled with the lack of proper training, our ozone unit would appreciate any assistance available in the following areas:

(i) Training and exchange of ideas with more experienced members of the international community in order to upgrade the capabilities of our local staff and equipment.
(ii) Further training for the technical and operation personnel in the maintenance of instruments.
(iii) Investigating the causes of high and low concentrations of ozone by correlation analysis with meteorological factors and other pollutants.

5. 0 CONCLUSION

At present our Dobson Spectrophotometer is not functioning properly and only test readings are taken occasionally. Since last year the readings have been too low to be of useful value. We will appreciate if WMO continues with regular checks of Dobson Spectrophotometer for gross calibration errors and helps us to make our Dobson Spectrophotometer operational.

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SLOVAKIA

1. INTRODUCTION

Atmospheric ozone and UV-B monitoring and research is mostly carried out by the Slovak Hydrometeorological Institute (SHMI) and the Geophysical Institute of the Slovak Academy of Sciences (GISAS). Several other institutions perform special surface ozone measurements and carry out a research associated with adverse ozone effects on environment.

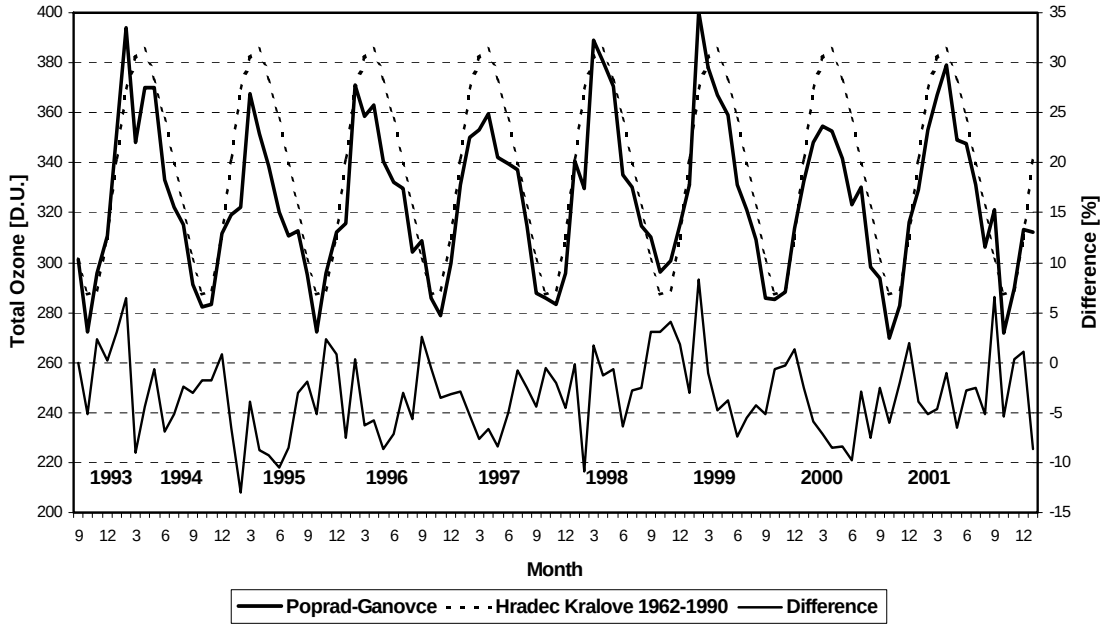
2. MONITORING AND MEASUREMENTS

Total Ozone

Total ozone measurements have been performed by the Centre of Aerology and Ozone Measurements (CAOM) of SHMI since August 1993. The Global Ozone Observing System (GOOS) station No. 331 is situated at Poprad-Ganovce (49.03N, 20.32E, 706 m altitude). The Brewer ozone spectrophotometer MKIV No.097 is used for routine measurements of total ozone and UV-B solar radiation. By proper weather conditions the mornings Umkehr vertical ozone profiles are taken.

The Brewer No.097 is regularly calibrated against World Travelling Standard Brewer No.017 every two years. Since the last Meeting of the Ozone Research Managers that instrument has taken part in two international inter-comparisons and calibrations (Poprad-Ganovce 1999, Budapest 2001).
The Brewer data are stored in the ozone database of SHMI and daily averages are submitted to the World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto every month. The raw Brewer data including Umkehr and UV-B data for period 1993-2001 were also submitted to the WOUDC in order to archive, process and check them by Brewer Data Management System (BDMS) of the Atmospheric Environment Service (AES) Canada.
Since winter 1993 the station participate in WMO GAW Northern Hemisphere Ozone Mapping

Fig. 1 Total Ozone at Poprad-Ganovce Station Measured with Brewer #097 (September 1993 - January 2002)

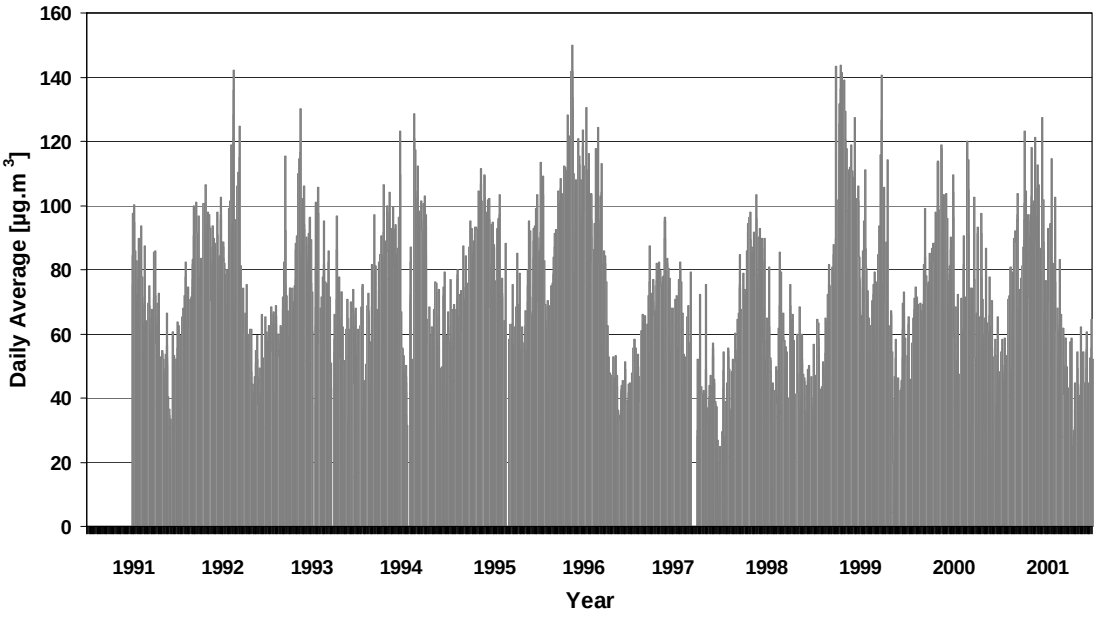


Experiment by daily submitting of total ozone data to Ozone Mapping Centre, Thessaloniki, Greece. The daily data are also submitted to WOUDC.

Ground Level Ozone

The measurement of ground level ozone concentrations in Slovakia started in 1991 within the monitoring network of the Slovak Hydrometeorological Institute. The number of monitoring stations has been gradually extended. At present the network consists of 18 stations. The stations Stara Lesna (49.15N, 20.29E, 808 m altitude, in operation since 1991), Starina (49.04N, 20.26E, 345 m altitude, in operation since 1994) and Chopok (48.94N, 19.59E, 2008 m altitude, in operation since 1994) are a part of the Environment Monitoring and Evaluation Programme (EMEP) network. Ozone analyzers of the Thermoenvironment (TEI) and the MLU companies have been used in most of the stations. In 1994, the secondary national ozone standard was installed in the Slovak Hydrometeorological Institute and regular audits by portable calibrator started to be carried out in the stations. The secondary standard of the SHMI is regularly compared with the primary ozone standard of the Czech Hydrometeorological Institute.

Fig. 2 Ground Level Ozone at EMEP station Stara Lesna 1991-2001



A project focused on protection of nature in the Tatras National Park (TANAP) is solved jointly by the TANAP office and the Polish Academy of Sciences (PAS). There are three other ground level ozone analyzers, operated upon principle of UV radiation absorption in Slovak part of the High Tatras. They are situated at 1100, 1778 and 2633 m altitudes and together with SHMI stations Stara Lesna and Poprad-Ganovce provide proper data for the vertical tropospheric ozone profile research. In period May-October about 25 passive Ogawa type sensors are exposed and two weekly evaluated in the High Tatras in a frame of that monitoring and research.

Monitoring and research of the tropospheric ozone vertical profile is also carried out at the Forest Research Institute (FRI). Three ML ozone analyzers are distributed at 480, 850 and 1360 m altitudes in Polana massif (central part of Slovakia).

Solar UV-B Radiation

Spectral measurements of the solar UV-B radiation (in the region 290-325 nm at 0.5 nm increments) have been performed with the Brewer spectrophotometer at Poprad-Ganovce since August 1993. Observations are scheduled at regular time intervals.

The other instruments are broadband ones. At present the SHMI UV-B network consists of three SOLAR Light 501 UV Biometers (Kosice, 48.70N, 21.27E, 230 m altitude, since 1997, Bratislava 48.17N, 17.12E, 287 m altitude, since 1998, Poprad-Ganovce, since 1999).

The CAOM maintains the 501 UV Biometer designed as the national reference instrument. That instrument was compared with the Czech reference UV Biometer during the Brewer calibration campaign in Budapest with very good result. Two network instruments were calibrated towards the reference one in autumn 2001. The third is planned to be calibrated in spring 2002.
Regular yearly comparison and calibration of all SHMI and GISAS UV network instruments against the reference one will start this year. A recalculation of UV data sets is planned to be done after each calibration.

GISAS measures the global ultraviolet radiation with Eppley UV-radiometer, model TUVR for the wavelength range 290-385 nm at Stara Lesna. This instrument was recalibrated at the Czech National Radiation Centre Hradec Kralove according to the laboratory standard NBS with quartz-halogen lamp EPI-1755 1000 W. In September 2001 YES UV Biometer was installed at Skalnate Pleso (49.20N, 20.23E, 1778 m altitude). The instrument was calibrated towards the SHMI reference UV Biometer during the campaign at Poprad-Ganovce in autumn 2001.
Next 501 UV Biometer, bought already by GISAS will be installed at higher altitude in the High Tatras soon.

3. RESEARCH

Ozone and other Atmospheric Parameters Relations

As the upper-air and total ozone station is at the same place there are good conditions to investigate dependence of the total ozone on other atmospheric parameters at CAOM Poprad-Ganovce. The long term temperature course at selected levels was compared with total ozone. The negative total ozone trend significantly correlates with both positive temperature trend in the troposphere and negative temperature trend in the lower stratosphere. A precise investigation of the Poprad-Ganovce upper-air data 1961-2000 to use it for climate studies is about to finish.

Total Ozone and UV Index Forecast

In spring 2000 Slovak Hydrometeorological Institute started providing the UV Index forecast for the public using a regression model. Regional regression coefficients are calculated from 1993-1999 Poprad-Ganovce total ozone, DUV and upper-air data. The heights of standard pressure levels necessary for the total ozone prediction are forecasted by the numerical model ALADIN. The UV Index forecast and other information on total ozone and solar radiation are available on www.shmu.sk/ozon. The forecast is a result of collaboration between Slovak Hydrometeorological Institute and Slovak Academy of Sciences. The regression model is regularly checked and still improved.

Ground Level Ozone

Vertical gradient of the tropospheric ozone concentration has been studied at the FRI. International project focused on influence of the ground level ozone increase upon plants and animals is carried out by PAS and TANAP office in the High Tatras mountains. At SHMI ground level ozone trends, critical levels AOT40, AOT60 and other parameters of ambient air quality are evaluated and analyzed.

Annual Report on Ozone

The analyze of total ozone, surface ozone and solar UV radiation is regularly included in the annual publication: "Air Pollution in the Slovak Republic.

International Projects

SHMI participate in international ozone and UV projects mainly by regular submitting of the good quality ozone and UV-B data to the WOUDC. It is also prepared to take part in regional programs coordinated by WMO, EC and other relevant institutions.

4. APPLICATIONS

Public Information

The report on present state of ozone layer and intensity of solar damaging UV radiation (Erythema effect) for sunny day is sent to Slovak Press Agency twice a day. It is regularly utilized by television, broadcast and newspapers.

CAOM Poprad-Ganovce also has been preparing short report on the total ozone amount and recommended maximal sunburn time. This report is propagated by mobile telephone service.
SHMI prepared regular total column ozone and UV Index (March-September) forecast. It is propagated by SHMI Web site.

Ministry of Environment and SHMI gradually equip big cities with electronic billboards. Both total and surface ozone data are included into presented information.
In 2001 Czech Hydrometeorological Institute licensed the modification and translation of the publication UV Index for the Public into Slovak language. The brochure was published in November 2001.

Public Warning

In association with the protection of human health and vegetation the set of ambient air quality standards for surface ozone concentrations according to the EU Directive 92/72 EEC has been adopted since 1996:

Ambient air quality standards	**O_3 concentration [$\mu g.m^{-3}$]**	**Average within the time interval**
for human health protection	110	8 h
for protection of vegetation	200/65	1 h / 24 h
for information to the public	180	1 h
for warning to the public	360	1 h

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SLOVENIA

Introduction

Under Article 3 (Research and systematic observation) of the Vienna Convention for the Protection of the Ozone Layer, the Parties have to initiate or co-operate in research and scientific assessment on protection of the ozone layer and adverse impacts on human health and environment. Annex I to the Convention contains a detailed list of the mayor scientific issues.

Every three years, the Ozone Research managers from all the Parties to the Convention meet to review the latest scientific findings on the state of the ozone layer and its reports are circulated to all Parties. The last meeting of the Ozone Research managers was organised in 1999.

Effects on human health and other biological effects of the ozone layer

An important tool for research on skin cancer is the cancer registry. Cancer Registry of Slovenia has been collecting and processing the data on cancer patients in Slovenia since 1950. This data base enables the running of national population-based registry on the incidence, prevalence and survival of cancer patients in Slovenia. The total number of all cases of cancer is still increasing. But the incidence of skin and malignant melanoma and few other cancers is increasing steeply in both sexes. Research data shows that skin cancer is prevailing. Several research projects were carried out. Some more detailed studies were performed on survival on malignant melanoma under EUROCARE project *Monitoring Cancer Patients' Survival in Europe* (Mrs.Vera Pompe-Kirn - national co-ordinator for Slovenia). More information can be found on http://www.onko-i.si/Ang/ResearchProjcts.html.

The research on biological effects of UV-B radiation was conducted on the National Institute of Biology. The majority of work was done in the framework of the EC project *The role of UV-B radiation on aquatic and terrestrial ecosystems: an experimental and functional analysis of the evolution of protective and adaptive mechanisms in plants, Environment and Climate - PL 970637* from 1998-2001 (Mrs. Alenka Gaberščik - co-ordinator for Slovenia). The project was made in the co-operation with Lund University (Sweden), University of Erlangen (Germany) and Vrie University Amsterdam (the Netherlands). The Slovenian part of the project was estimated to 100.000 EUR. The research work is continuing in the framework of Ph.D. and Master thesis. The research includes long-term effects on growth parameters, some metabolic processes and biochemical properties of different plant species. For the purpose of the project UV-B, UV-A and photosyntheticaly active radiation has been monitored since 1999 using dosimeter ELDONET (European Light DOsimeter NETwork).

Research into the physics of the atmosphere

No basic research was done in Slovenia in this field. There was some international co-operation in view of implementation. In 1999 the model for UV index forecast developed in DWD – Deutcher Wetterdienst in Offenbach, Germany was tested in Slovenia by Hydrometeorological Institute. The model with grid mash of 7 km x 7 km is covering Slovenia as well. Starting with 15 April 2000 the daily forecasts of UV index became available for public.

Systematic observations

Slovenia plays an active role in the Global Atmosphere Watch (GAW), the principal world program for air monitoring, coordinated by the World Meteorological Organization (WMO). Two Slovenian regional monitoring stations, Krvavec (1730 m a. s. l.) and Iskrba (550 m a. s. l.), contribute data to the GAW monitoring network. Within the framework of the GAW program, being of predominantly research nature, the chemical composition of the atmosphere was monitored and trends were recorded. Since the inclusion into the GAW program the following activities in connection with the ozone monitoring have been performed:

- Measurements of surface ozone
- Introduction of methods to ensure the quality of measurements

- Maintaining the traceability of the Slovenian reference standard for measurements of ground – level ozone to the primary standard
- Preparation for expanding the monitoring program to other components (meteorological parameters, CO, UV etc.).

The state institution responsible for monitoring is the Office for Monitoring inside the Environmental Agency of the Republic of Slovenia, http://www.arso.gov.si/. For ozone measurements, the Office for Monitoring is performing regular annual calibrations of its reference calibrator (Thermo Environmental Instruments, Model 49C-PS) against the regional GAW standard (NIST UV-Photometer SRP#17) at the Czech Hydrometeorological Institute (CHMI) in Prague, which is traceable to the primary GAW designated standard in Switzerland.

Alternative substances and technologies

In December 1997 the Decree on Handling Substances Depleting the Ozone Layer was adopted by the Government of Slovenia. The decree covers all ozone depleting substances and is written in accordance with the EU regulation No. 3093/94. It requires immediate phase out of CFC-s, halons, 1,1,1-trichloroethane, tetrachloromethane and HBFC, and it limits the use of HCFC and metilbromide. The phase out was successful and there was no need for additional research on alternative substances after 1999. The substitution of substances in existing systems, CFC-s in cooling and air-conditioning devices remained unsolved. In mid 2001 the Gorenje Company started the 50.000 EUR project to solve the problem. The project will be completed by the end of 2002.

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SOUTH AFRICA

1. INTRODUCTION

The South African Weather Service (SAWS), formerly known as the South African Weather Bureau, now an agency of the Government Department of Environmental Affairs and Tourism, is the focal point of ozone monitoring and research activities in South Africa.

The ozone monitoring and research activities are conducted within the context of the World Meteorological Organizations (WMO) Global Atmosphere Watch (GAW) program. The Global Atmosphere Watch component of the South African Weather Service (SAWS), as part of its Public Good Service, are conducting certain specialized atmosphere monitoring and research services for the Department of Environmental and Tourism Affairs (DEAT), in order for the Department to fulfill its national, regional and international obligations. The Department has the responsibility for implementing the Montreal Protocol and facilitates the coordination role with industry. South Africa is dealing effectively with its commitments under the Protocol.

The depletion of the stratospheric ozone layer, increases in troposphere ozone, higher levels of acidity in rain, rising carbon dioxide and methane concentrations, and changes in the radiative balance of the earth-atmosphere energy system - all reflects the increasing influence of human activity on the global atmosphere, the life-support system of planet Earth. Environmental issues and policy matters have to play a pivotal role in meeting the developing needs and challenges of the people in a new democratic South African Society. Clauses in protecting and respecting the environment in a sustainable context, is embedded in the South African Constitution.

The Global Atmosphere Watch program entails research and sustained systematic monitoring of atmosphere parameters, which in the event of human interferences on the atmosphere could result in harmful effects to mankind. The monitoring program of our GAW Station Cape Point and the regional GO_3OS stations Irene, and Springbok includes ozone measurements (total column, vertical profile and near the surface), other greenhouse gases (CO_2, CFCs, CH_4, N_2O, water vapor), solar radiation, UV-B, reactive gas species (SO_2, NO_x, CO), chemical composition of rain and atmospheric particles, radionuclides and the normal suite of meteorological parameters. The Baseline Surface Radiation Network (BSRN) station, situated at De Aar also has been running successfully since its establishment in 1999. To ensure the required quality of data, a strict process in cooperation with many world data centers ensures a data integrity assurance/quality control plan for GAW world- wide, which has been recently developed.

Worldwide it is proven that sustained systematic observation only survives under the auspice and responsibility of a Government. More and more of these specialized environmental monitoring activities are shifted towards the responsibilities of National Meteorological Services. This is

undoubtedly a core service resulting from international agreements undertaken by government of the Republic of South Africa.

2. OZONE MEASUREMENTS

The first South African ozone measurements were made during 1964 until 1972 with Dobson #089 operating from Pretoria. Reinstating South Africa's commitment to the Vienna Convention, the Weather Service now operates two Dobson ozone spectrophotometers, #089 at Irene near Pretoria (25.9 S, 28.2 E) since 1989, and #132 at Springbok (29.7 S, 17.9 E) since 1995. Both these instruments have been regularly calibrated with reference to the world standard.

A WMO/GAW International Comparison of Dobson Spectrophotometers (SAWB2000IC) was organized by the World Meteorological Organization and the South African Weather Service in close cooperation with the USA National Oceanic and Atmosphere Administration's Climate monitoring and Diagnostics Laboratory (NOAA/CMDL). This first Africa, WMO Region-I Intercomparison event was conducted in Pretoria from 18 March – 10 April 2000. In addition the Czech Hydrometeorological institute contributed by providing an expert to assist with the further training of Dobson operators. In conjunction a workshop was held where ozone experts presented several contributions related to monitoring total ozone and functions of the global ozone network. Dobson's from Tamanrasset – Algeria, Nairobi – Kenya, Victoria Airport - Seychelles, Boulder – USA, Irene and Springbok - South Africa, and Maun - Botswana participated.

The South African Dobson observation program includes daily total ozone measurements (mostly high quality direct sun observations), and weekday Umkehr observations during sunrise. On average 500 total ozone readings per month are collected, and weather permitting between 10 and 15 Umkehr measurements. Final Umkehr results are hampered by the inadequate knowledge that exists within our institution and collaboration partners are seeked for assistance.

Since November 1998, the Weather Service has been fortunate to reinstate its ECC RSG80-15GE Ozonesonde sounding program, which operated during the period 1990 until 1993. Weekly ozonesonde soundings are conducted. This data is shared with the Southern Hemisphere ADditional OZonesondes (SHADOZ) program from NASA, USA, which also is submitted to WOUDC. Since 2000, the Irene ozonesonde station was officially accepted into the SHADOZ network.

3. ULTRAVIOLET- B RADIATION

Since January 1994 the Weather Service has maintained a routine program for monitoring erythemally weighted UV-B radiation at Cape Town (34.0S, 18.6E), Durban (30.0S, 31.0E) and Pretoria (25.7S, 28.2E), De Aar (30.7S, 24.0E) and Port Elizabeth (33.9S, 25.5E). The equipment used in this network is the Solar Light Model 501 Robertson-Berger UV-Biometer. The program was motivated by and in collaboration with the School of Pharmacy at the Medical University of Southern Africa (MEDUNSA), near Pretoria.

Since December 2001, the UV-Biometers are directly linked on the Services wide area network, and available in real-time on the SAWS WWW-site. UV-B forecasts are also issued for the Cape Town, Durban and Pretoria-Johannesburg metropolitan areas since 1 December 1997. The main purpose of the UV-Biometer network is to make the public aware of the hazards of excessive exposure to biologically active UV-B radiation, and it contributes to the schools awareness programs for education. Regular enquiries from scholars are dealt with to satisfy their need to acquire more ozone and ultraviolet radiation knowledge.

Two UV-B narrow-band (~306nm) Kipp & Zonen sensors are located at the two Dobson sites to investigate possible trend correlation between ultraviolet radiation and total ozone.

4. GLOBAL ATMOSPHERE WATCH – CAPE POINT

Since 1 April 1997, the Weather Bureau has taken over the Cape Point Global Atmosphere Watch (GAW) station at Cape Point (34.3S, 18.5E) from Council for Science and Industrial Research (CSIR). The Cape Point station is managed by the Weather Service and assisted by a scientific research partner, namely the Fraunhofer Institute for Atmospheric Environmental Research (IFU) in Garmisch, Germany.

Measurements include a wide range of parameters namely: - surface O_3, gases which lead to stratospheric ozone depletion such as: $CFCl_3$, CCl_2F_2, $CC_{l2}F\text{-}CClF_2$, CH_3CCl_3, CCl_4 and N_2O, ozone precursor gases in the troposphere such as CO, CO_2, UV-A and UV-B radiation, Be, Pb^{210} as some tracers of stratospheric air entering the troposphere, and various other meteorological parameters. Radon measurements to assists with the classifications of air masses arriving at Cape Point have been successfully established over the lat three years. The regular scientific audit from EMPA, Switzerland, continues to reveal very successfully surface ozone calibrations at the Laboratory.

5. OTHER NATIONAL AND INTERNATIONAL INVOLVEMENT

Ozone and related research are conducted sporadically within the country, mostly at a few Academic institutions such as the University of Natal, Cape Town and Zululand. Research interest of the effects of ultraviolet radiation amongst the medical and environmental sectors has also become more pronounced.

During the **S**outhern **A**frican **F**ire **A**tmosphere **R**esearch **I**nitiative SAFARI 2000, and with SHADOZ cooperation, the frequency of ozone soundings was increased at Irene - South Africa, Lusaka - Zambia and Nairobi - Kenya to take part in the investigations of atmospheric pollutants, and the characteristics thereof over the southern African continent. SAFARI 2000 is an international regional science initiative being developed for Southern Africa to explore, study and address linkages between land-atmosphere processes and the relationship of biogenic, pyrogenic or anthropogenic emissions, and the consequences of deposition on the functioning of the bio-geophysical and biogeochemical systems of southern Africa. Troposphere ozone is becoming an important monitoring and research topic to address and understand the pollution impacts of the region.

South Africa is also a member of the established WMO-Ad Hoc Committee on Dobson Operations, and is also represented as a current member of the International Ozone Commission (IO3C).

6. FUTURE PLANS

In collaboration with various research institutes we still would like to utilize general circulation models for ozone and UV-B predictions. This will increase our understanding and ability to render a more efficient public service. The Weather Service is continuing with efforts to ensure real-time data availability on the SAWS WWW- site at http://www.weathersa.co.za

The installation of a Dobson Spectrophotometer #15 at Maun, Botswana is still unfortunately being delayed due to inadequate infrastructure.

During December 2001, the SAWS GAW program, in collaboration with Norwegian donor funding has established a surface ozone monitoring station at the South African National Antarctic Base (SANAE at 72S, 3W). We would like to extend our Antarctic GAW activities within the next few years, and partnerships with international role-players such as the Alfred Wegner Institute (AWI) for Polar and Marine Research from Germany, and members connected to the German, Neumayer Antarctic base is underway. Future plans also include the establishment of ozone monitoring

stations at Gough (40S, 10W) and Marion (47S, 37E) islands where permanent South African weather offices are located.

During the 2002 World Summit on Sustainable Development Conference, which is being hosted by South Africa from 26 August – 4 September 2002, one of the official side events earmarked is the 25th anniversary celebration of the Cape Point Global Atmosphere Watch Station. Also celebrating " World Ozone Day –16 September " on this occasion, the opportunity arises to emphasize the crucial role of GAW monitoring and research processes being undertaken for sustainable development. The South African Weather Service on this front is also committed to collaboration in our region to enhance future ozone monitoring and related GAW research activities. With this new drive we draw inspiration from the **Ne**w **P**artnership for **A**frica's **D**evelopment (NEPAD) plan.

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SPAIN

1. Ongoing activities

Continuous ozone, UV radiation and related atmospheric compounds monitoring and research is mainly conducted by the Instituto Nacional de Meteorología (INM) and the Instituto Nacional de Técnica Aeroespacial (INTA). The Departments of Physics and Meteorology of several Spanish universities do research on ozone and UV. Most of the national actions are financed by the National R+D Plan of the Ministry of Science and Technology.

1.1 Monitoring and QC/QA systems

The longest total ozone record in Spain (since 1980) has been obtained with the Dobson spectrophotometer #120 installed at "El Arenosillo" station (Huelva) and operated by INTA. This instrument has been used in a number of intercomparisons at Davos and is in operation at present. The latest calibration was held at Arosa Dobson intercomparisons in August 1999. Data are submitted to the World Ozone and Ultraviolet Radiation Data Centre (WOUDC-AES, Canada) every 6 months.

1.1.1. Brewer spectrophotometer national network

INM operates a national Brewer spectrophotometer network (Figure 1 and Table 1), partially financed by the National R+D Plan of the Ministry of Science and Technology. The Brewer at the “El Arenosillo” station, financed by the Andalusian Regional Government, is managed by INTA. This network provides total ozone and spectral UV that is real-time monitored through the INM’s intranet. The information is stored and validated in a centralized database.

Total ozone daily means are submitted daily to the WMO Northern Hemisphere Daily Ozone Mapping Centre run by the Laboratory of Atmospheric Physics at the Aristotle University of Thessaloniki (Greece) and to the WOUDC.

Figure 1; National UV broadband radiometer and spectrophotometer network

Evaluated and refined total ozone data from Madrid, Murcia and Izaña stations are periodically submitted to the WOUDC database.

The Brewers (#033 and #157) at the Izaña Observatory have been intercompared with the international traveling reference Brewer#17 every year since 1991. Other Brewers of the network are intercompared and calibrated every two years. Last two intercomparisons were held at the El Arenosillo station in September 1999 and September 2001.

Since November 1999 the Brewer network has performed a common measurement schedule (ozone and spectral UV) on a daily basis. This information is stored in the centralized INM database. Spectral UV Quality Control (QC) consists of 50W lamp tests at each station performed every 2 weeks. Spectral UV Quality Assurance (QA) is carried out every year using a portable 1000W lamp calibration system designed by Int'l Ozone Services Inc. (IOS, Canada). Primary standard lamps (NIST traceable) are located at the optical lab of the Izaña Observatory. Before and after the national calibration trip 1000W secondary standard lamps are calibrated against the primary ones.

Station	Location	Instrument	Institution	Since	Last calibration
A Coruña	43ºN 8ºW	Brewer MK-IV #151	INM	Oct 1998	September 2001
Zaragoza	42ºN 1ºW	Brewer MK-IV #166	INM	Nov 1998 (#033) Nov 1999 (#166)	September 2001
Madrid	40ºN 4ºW	Brewer MK-IV #70	INM	1988 (#033) May 1992 (#070)	September 2001
Murcia	38ºN 1ºW	Brewer MK-IV #117	INM	May 1995	September 2001
El Arenosillo	37ºN 6.44ºW	Brewer MK-III #150	INTA	June 1997	September 2001
Izaña	28ºN 16ºW 2400 m a.s.l.	Brewer MK-III #157	INM	May 1992 (#033) July 1998 (#157)	September 2001
Santa Cruz Tenerife	28ºN 16ºW Sea level	Brewer MK-II #033	INM	Oct 2000	September 2001

Table 1; National Brewer Spectrophotometer network

1.1.2 The UV broadband radiometer network

A national UVB broadband network of 16 Yes-pyranometers (Figure 1), managed by INM, has been fully operational since July 1999. This network was financed by the National R+D Plan of the Ministry of Science and Technology.

Data from each station is submitted daily to the INM's central database and the UV index (UVI) is disseminated by Internet: http://www.inm.es/web/infmet/tobsr/ulvio/PRIMERA.html

A primary reference UV pyranometer, located at the Izaña Observatory, and a secondary portable reference UV pyranometer are kept just for the broadband UV network tests. The primary reference instrument participated in a broadband UV detector intercomparison organised by the LAP (Laboratory of Atmospheric Physics) of the Aristotle University of Thessaloniki (Greece) in September 1999. This intercomparison, carried out within the scope of the COST 713 action on "UV-B forecasting", hosted a total of 33 UV broadband detectors from 14 countries.

Comparisons of these pyranometers with double Brewer and Bentham spectroradiometers have been performed at the Izaña Observatory and at the El Arenosillo station. Results show that spectral response calibration facilities must be established. The design of this system is scheduled for 2002 and its implementation for 2003.

1.1.3. The UVIFAN network

The group of photobiology and algae biotechnology of the Ecology Department at Malaga University manages the "UVIFAN" UV network, based on broadband Eldonet (European Light Dosimeter Network) radiometers, in the Andalusia region. This network has been financed by the EC FEDER 1FD97-0824 Project. Detailed information of this network can be found at http://uvifan.scai.uma.es/

1.1.4. The Ozone/UV Antarctic network

In the framework of several projects financed in previous convocations of the National R+D Plan of the Ministry of Science and Technology, three UV-VIS spectrometers (EVA) designed and developed at INTA to measure column NO2 and O3 were installed at the permanent Argentinian bases of Belgrano (77º 52' S 34º37' W), Marambio (64º 14' S 56º37' W) and Ushuaia (54º 48' S 68º19' W), respectively, in 1994. The selected stations are scientifically interesting for the study of polar atmosphere as the southernmost, which is Belgrano, is mostly located inside the vortex, Marambio on the edge, and Ushuaia right outside the vortex. Three multi-channel narrow-band radiometers (NILU-UV) were installed by INM in the same stations in 1999, thanks to the existent agreements of scientific collaboration between INTA, INM, Dirección Nacional del Antártico (DNA/IAA) and Centro Austral de Investigaciones Científicas (CADIC, Argentina). The NILU instruments measure global radiation at five UV channels and PAR. A radiative transfer model is used to calculate the total ozone content, cloud transmittance and the biologically effective UV doses. Both complementary instruments are part of the Spanish Antarctic network that is now coordinated in the framework of the joint INTA-INM's "MAR" (Measurement of Antarctic Radiance for monitoring the ozone layer) Project (REN2000-0245-C02-01) financed by the National R+D Plan.

The Finnish Meteorological Institute (FMI) is in charge of the NILU radiometers' quality assurance system performing intercomparisons twice a year with a traveling reference NILU.
The main objective of this network is to provide both long term and near real-time observations of column O_3 and NO_2, and UV radiation in order to characterize the polar vortex.
A description of the network, including instruments and stations, as well as the results of this network can be found at http://www.izana.go.to/mar

1.1.5. The Global Atmospheric Watch (GAW) Program at the Izaña Observatory

The Izaña Global Atmospheric Watch (GAW) station, operated by INM, is located at 28º18'N, 16º29'W, 2360 m a.s.l. on the island of Tenerife (The Canary Islands, Spain). The GAW program concerning the ozone and related compounds consists of the following:

- Continuous total ozone monitoring since May 1991, including two Umkehr profiles per day (since January 1992) is performed using Brewer spectrophotometers (see Table 1).
- UV scans every 20 minutes are obtained from the Brewer spectrophotometers since May 1991.
- A double spectroradiometer Bentham DM-150, installed in March 1999, provides global and diffused UV radiation scans every 15 minutes. This is the national UV reference instrument.
- The ECC ozonesonde program was initiated in November 1992. The ozonesoundings are launched from Santa Cruz de Tenerife station (36 m.a.s.l.), at a distance of 28 Km. from the Izaña Observatory, on a weekly basis. During intensive campaigns more than twenty sondes per month are launched.
- Meteorological soundings (PTU) have been launched twice per day (at 00 and 12 GMT) since 1958.
- A UV-VIS (DOAS) spectrometer instrument (EVA) from INTA for measuring total column NO2 and O3 has been operating at Izana Observatory since 1993.
- Optical depth (368, 500 and 778 nm) has been measured at Izaña using a PMOD/World Radiation Center (WRC, Davos) sunphotometer since January 1994. Since

June 2001 a Multifilter Precision Radiometer designed at the WRC has been operating at the Izaña Observatory.

1.1.6. The Network for the Detection of Stratospheric Change (NDSC) Program at the Izaña Observatory

Since 2000/2001 the Izaña Observatory has participated in the NDSC network as a complementary station in the following four programs:

- Total ozone with a double Brewer spectrophotometer managed by INM.
- ECC ozonesonde program operated by INM.
- UV-VIS: A photodiode array Spectrograph from INTA has been running at Izaña since December 1998. This instrument is able to measure total columns of O3 , NO2 and H2O. Retrievals of Iodine monoxide (IO) are being explored to detect whether or not this radical is in measurable magnitudes in the atmosphere outside of the boundary layer. A new UV photodiode array spectrograph from INTA was installed at the Izaña Observatory in November 2001 to expand the capabilities of the previous ones to BrO. Bromine has 50 times more Ozone Depletion Potential (ODP) than Chlorine and its concentration in the atmosphere is still increasing due to Methyl Bromide (CH3Br) and Halon emissions.
- FTIR: since February 1999 a ground-based FTIR (Fourier Transform InfraRed) spectrometer (Bruker IFS 120 M) is operated at the Izaña Observatory by the Institut für Meteorologie und Klimaforschung (IMK) (Forschungszentrum Karlsruhe, Germany). Besides zenith column amounts (ZCA) of trace gases such as O3, H2O, HDO, N2O, CH4, HF, HCl, ClONO2, NO, NO2, and HNO3, profiles of gases with narrow absorption lines such as O3, NO, HCl and HF can be retrieved.

1.1.7. INTA's station at Keflavik (Iceland)

A long-term ozonesounding program between INTA and IMO (Icelandic Meteorological Office) is running at the subArctic station of Keflavik (Iceland, 64ºN, 22ºW). Activities devoted to monitoring the ozone layer in the region of influence of the stratospheric polar vortex started in 1991 within the First Coordinated European Experiment for Ozone depletion Studies (EASOE). Since then and to date ozonesondes have been launched during winter through a number of European projects (SESAME, OSDOC, THESEO) and will continue in the near future (QUOBI).

1.1.8. Long-term ozonesondes station at Belgrano Base (Antarctica)

A long-term ozonesounding program between INTA and DNA/IAA (Argentina) has been running at the Belgrano station (Argentina, 78ºS, 35ºW) since 1999. Since then and to date ozonesondes have been launched through a number of Spanish (MAR and "Caracterización del vórtice Antártico y transporte meridional a partir de observaciones remotas de trazadores estratosféricos") and European projects (QUOBI).

1.1.9. Intensive campaigns

INTA and INM have participated in previous years, and participate nowadays, through the mentioned ozonesounding stations, at Keflavik, Madrid and Tenerife in the Match Experiment coordinated by the AWI (Alfred Wegener Institute, Germany). This experiment is being carried out in connection with the European projects (EASOE, SESAME (OSDOC), THESEO (O3-LOSS), EUROSOLVE). Sondes are both European and nationally financed.

Two national UV and visible spectroradiometer intercomparisons were held at the El Arenosillo station (INTA) in September 1999 and September 2001, respectively. Solar measurements and lamp calibrations were performed.

INOVO INterhemispheric OClO Polar VOrtex Variability. An intensive campaign to test the new high-resolution spectrograph and carry out measurements of OClO and study the impact of high

reflective surface (snowy surface) on the species retrieved during the winter of 2001 at the polar observatory of Sodankyla, Finland. The instrument will be installed at Marambio Base, Antarctica next austral summer. The campaign has been financed by the European Commission through the LAPBIAT infrastructure facility.

1.1.10. Other monitoring programs and activities

Episodic UV spectra are obtained by the Universities of Barcelona (Bentham DM-300), Valencia (Optronics and LICOR), Valladolid (LICOR) and la Laguna (Bentham and Optronics). Most of the measurements are used in investigations concerning the relationship between aerosol optical depth and spectral UV radiation.

INM has run a regular ozonesonde program in the Madrid-Barajas station on a weekly basis since March 1992.

INTA operates an ozonesounding facility at the El Arenosillo station with sporadic launches. Intensive campaigns, most of them financed by European projects, are frequently carried out at the El Arenosillo station.

The Department of the Fundamental Physics of La Laguna University, in collaboration with INM, operates a double Bentham DM-150 spectroradiometer at the Izaña Observatory headquarters (sea level) in Tenerife. A comparison of the UV and visible spectra obtained from this spectroradiometer with those obtained from a similar Bentham DM150 installed at the Izaña Observatory (2400 m a.s.l.) will be used to study the connection between UV radiation and radiative properties of the atmospheric aerosols and clouds.
INTA is collaborating with the Institute of Aerospace Medicine from DLR on solar UV dosimetry by biological sensors (biofilms @). The collaboration covers the measurement campaigns at different locations in Spanish and German territory and the improvement of data analysis (image treatments, unattended exposure devices, etc).

Departments of several universities are carrying out observations and studies regarding solar UV radiation and related atmospheric components. A summary of the activities performed by the Spanish universities is as follows:

- The Department of Optics and Applied Physics of Valladolid University is working on aerosol optical depth (AOD) characterization, including the UV range.
- The Department of Astronomy and Meteorology at Barcelona University has been taking sporadic measurements of UV and visible spectrum for the last nine years using a LI-COR 1800 spectroradiometer and now with a Bentham DM300 spectroradiometer. This group has also measured AOD. Work has also been done on simulation modeling using different radiative transfer codes.
- The Department of Thermodynamics at Valencia University is working on the aerosol observations and validating different radiative transfer codes.
- The Department of Applied Thermodynamics at Valencia Polytechnic University has been carrying out continuous measurements of UV with an Eppley radiometer since 1995.
- The Department of Fundamental and Experimental Physics at La Laguna University is working on aerosol characterization and its relationship with spectral UV radiation.
- The Atmospheric Physics Group at Granada University is working on solar radiation, remote sensing and aerosol characterization.
- The Department of Agriculture and Food at La Rioja University has been studying the effects of UV-B radiation on mountain aquatic bryophytes in their natural surroundings and has evaluated their use as bio-indicators.

1.2. UVI forecasting

In accordance with the COST-713 action (“UV-B prediction”) of the European Commission a H+24 forecasting model of UVI for Spain has been implemented by INM. This model has a resolution of

5'x5' on a geographical domain bounded by 45ºN/15ºW and 25ºN/5ºE. The ozone prediction is based on a regression model, and the UVA-GOA radiative model from Valladolid University is used for UVI calculation.

The daily maximum forecasted UVI, as well as the daily variation of UVI under clear skies for each province capital of Spain are reported by internet:
http://www.inm.es/web/infmet/predi/ulvip.html

1.3. UVI public divulging

As part of the activities performed by Spain in the framework of the COST 713 Action "UVB forecasting", a "UV-Index for the Public" booklet (in Spanish) has been adapted and expanded with some examples for the Canary Islands region by INM. A printed version of this booklet has been published in collaboration with the Dermatology Department at La Laguna University Hospital of Tenerife (HUC) and the pharmaceutical associations of the Canary Islands. The booklet can be seen as a web page at: http://www.izana.go.to/uvi

1.4. Satellite activities

INTA and INM participate in the STREAMER project coordinated by the DLR, Germany. It is a European project from the Earth Observation Program devoted to forecasting ozone and UV-B in the European sector using the GOME/ESA instrument (and SCIAMACHI/ESA in ENVISAT in the future) and meteorological forecasting. The output will be level – 3 products (maps) 24h forecasting of both ozone and UV-B on Internet, available to the public.

1.5. Ozone and UV research

INM and INTA have actively participated in recent years in European projects related to ozone and UV research, which have recently finished or are still in progress. They are as follows:

- REVUE (Reconstruction of Vertical Ozone Distribution from Umkehr Estimates), ENV4-CT95-0161)
- TRACAS (TRAnsport of Chemical species Across Subtropical tropopause) ENV4-CT97-0546.
- STREAMER (Small Scale Structure Early Warning and Monitoring in Atmospheric Ozone and Related Exposure to UV-B Radiation), ENV4-CT98-0756.
- QUILT (Quantification and Interpretation of Long Term UV-Visible Observations of the stratosphere) EVK2-CT2000-0059. Devoted to improvements of Spectroscopic data products (NO2, O3, BrO, OClO, IO), Revision of the data sets, Modeling and interpretation, etc.
- QUOBI (Quantitative Understanding of Ozone Losses by Bipolar Investigations) EVK2-CT-2001-00129 (2002-2004): The main objective of the project is to test our quantitative understanding of the chemical mechanisms that destroy ozone in wintertime Arctic stratosphere and springtime Antarctic and to improve the representation of these processes in chemical models of the atmosphere.

INM, INTA and the Universities of Barcelona, Valencia, Valladolid and La Laguna participate in two large coordinated ozone&UV-related projects financed by the National R+D Plan of the Ministry of Science and Technology:

- "Measurement and Modeling for the space-time distribution of the ultraviolet solar irradiance in Spain" (CLI97-0345-C05).
- DEPRUVISE (Determination and forecasting of solar ultraviolet Radiation in Spain: influence of ozone, aerosol particles and cloudiness).

2. Future activities

2.1. Monitoring and QC/QA systems

A new UV photodiode array spectrograph from INTA will be installed in October 2002 in Marambio (Antarctica). It will retrieve zenith column amounts of BrO, OClO).

Cosine response calibration facilities for Brewer and UV broadband radiometers will be implemented at the Izaña Observatory during 2002.

The "Veleta 2002" field campaign will be held in July 2002, in the framework of the DEPRUVISE project, financed by the National R+D Plan of the Ministry of Science and Technology. This field campaign has been designed to obtain experimental data of elevation effects on solar ultraviolet irradiance. For this purpose different radiometers and spectroradiometers will be installed on both slopes of the Sierra Nevada Massif. The stations will cover from sea level to 3400 m a. s.l. on the top of the Veleta Peak. This information will be used to evaluate the aerosol radiative forcing on the solar UV irradiance. Several groups from the Universities of Granada, Barcelona, Valencia, Valladolid, Malaga and La Laguna, and the INTA and INM will participate in the field campaign.
A national UV-instrument intercomparison will be held at the Izaña Observatory (INM) in the summer of 2003.

Aerosol optical depth (AOD) will be obtained by INM from the Brewer spectrophotometer network using the direct sun measurements. This information will be used as input in the national UVI forecasting model.

INM (Izaña Observatory) will perform the QA/QC of the UVIFAN network in order to achieve an homogenization of public information provided by both, UVIFAN and the national UV radiometer network (INM).

INM and Instituto de Meteorologia (IM) of Portugal will routinely exchange data and information from their respective Brewer and UV broadband networks.

2.2. UVI forecasting

The UVI forecasting model will be improved by incorporating as predictors forecasted temperature at 150 hPa, 100 hPa and 70 hPa from the ECMWF in the regression ozone model. A parameterized cloud modification factor will also be included using the cloud forecasts provided by the ECMWF. Validation of forecasted ozone and UVI will be validated using the Brewer and the UV broadband national networks. UVI forecasting will be provided to H+48.

2.3. UVI public divulging

During 2002 an intensive campaign to divulge the UVI to the public is planned by the INM in collaboration with the Spanish Cancer Society, and main national TV, radio and newspaper media.

2.4. Satellite activities

A micropulse aerosol lidar (INTA) and ground-based ozone total column measurements by high quality NDSC (INM and INTA) will be used at the Izaña Observatory facilities during heavy Saharan dust storm events during the summer 2002 to find out whether or not the retrieval of satellite operating in backscattering mode such as TOMS and GOME is severely affected by interferences from the absorbent characteristics of mineral aerosols.

2.5. Ozone and UV research

STREAMER–II. INTA participates in a proposal submitted to the European GMES (Global Monitoring the Environment and Security) Programme devoted to the elaboration of H+24 UV and ozone forecasted maps above Europe and research associated to the ozone layer. The new project will focus on operational aspects regarding data management (GIS, Web, etc), climatology of ozone related species and Streamer events on a global scale based on European satellites and 3D modeling. Validation exercises will also be performed to ensure the data and model quality.
NDSC – Double blind intercomparison of OClO measurements. Within the framework of the QUILT project, a NDSC intercomparison will take place in the winter of 2002/2003 at the polar facility of Andoya, Norway, (68ºN). INTA will participate with its instrument. The purpose is to harmonize results and identify possible causes of discrepancy between instruments. Eleven European Institutes involved in QUILT will participate in this campaign. Unofficial comparison of BrO will be carried out as well.

The effects of clouds and the cloud-sea on the spectral UV radiation will be investigated by INM and La Laguna University at the Izaña GAW observatory using radiative models (DISORT/UVSPEC) and in-situ observations made with double spectrophotometers Brewer and Bentham at sea level and 2400 m a.s.l., respectively.

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SRI LANKA

Sri Lanka is an island situated in the tropics, at the Southern tip of the Indian sub-continent. The Ozone Layer is naturally thin over the tropics, without much seasonal change and as such UV-B reaching the earth surface in our region is expected to be high. As such, UV-B measurements at ground level are necessary, especially in the tropics, not only during a particular season but also throughout the year.

It was accepted at various meetings; Ozone Research Managers Meetings, Meeting of Parties to the Vienna Convention and Montreal Protocol, ODS Officers Network Meeting that monitoring stations of UV-B and total column Ozone need to be increased in the tropics. There are still data sparse regions, and, being at the Southern tip of a large continent with a vast ocean to the South, extending to the South Pole, Sri Lanka is ideally situated to set up a fully pledged monitoring station.

Sri Lanka has taken some steps and still is in the process of obtaining instruments to set up a few stations to measure UV-B. Although it is not related to the ozone layer, Sri Lanka maintains records of Ozone concentrations in Colombo City in relation to air pollution.

The Department of Meteorology, Sri Lanka has purchased two single channel light sensors from UK manufacturers. This Pyranometer contains a UV-B sensor, which records continuously. The Meteorology Department installed these two instruments at Higurakgoda, Central Part of the country, and at Ratmalana close to Colombo about one year ago. Unfortunately the instrument at Ratmalana is out of order though some data is available from the Higurakgoda station. Data will be analyzed in the future and it is noticed that there are values in the range of 1.9 Wm^{-2}.

In the mean time the Physics Dept. of the University of Colombo is making arrangements to set up an instrument for research work at the Department.

Sri Lanka is in need of assistance to set up a network of stations for recording and research. With such an observing network it will be possible to supply ground truth data to supplement satellite measured global coverage.

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SWEDEN

Ground based monitoring of UV

Broadband and spectral UV-monitoring has been done in Sweden at a number of sites by SMHI (Swedish Meteorological and Hydrological Institute). A selection of data sets is freely available at http://www.smhi.se. Measurements are still recorded, at two sites in Sweden, in Norrköping by SMHI and in Stockholm by SSI (Swedish Radiation Protection Institute). SSI has plans to start monitoring also at other sites.

At both institutes UV-spectroradiometers has been calibrated using absolute irradiance calibrated 1000 W halogen lamps giving a trace to NIST. The instruments have also participated in several international intercomparison campaigns; Norrköping (1991), NOGIC93, NOGIC96, SUSPEN (1997) and NOGIC2000. Last year several institutes in Europe have tested a system using a travelling lamp. J. Gröbner, at the Joint Research Center, EC, Ispra, took this initiative.

Broadband meters from SMHI and SSI have also been intercompared at campaigns; NOGIC93, NOGIC96, STUK/WMO (1995), LAP/COST/WMO-99 and NOGIC2000.

Because of the lack of an international adopted reference and calibration procedure for UV-measurements comparisons are very valuable.

Swedish activity: SMHI and SSI.

UV-index forecasting for public information

The distribution of the daily UV-index forecasts from SMHI started in 1993 at the end of June and lasted to the end of the summer. In 1994 the distribution started in spring as a weekend forecast at the end of each week. This forecast was valid for clear skies and for the optimal slope (the sloping surface receiving the maximum radiation). During the summer season the daily forecast produced included the effect of clouds.

At a WMO-meeting in July 1994 it was agreed that the UV-information to the public should be harmonised. The meeting agreed on a minimum set of criteria that the UV-information should be based on. Starting in spring 1995 the Swedish UV-index was changed according to these recommendations. One large change was the introduction of the new action spectrum (from ACGIH-NOISH to the CIE-erythemal action spectrum recommended by WMO, WHO and ICNIRP. For the public the most apparent change was seen in the new scale range. This was a shift from 0-100 to roughly 0-16.

In 1996 the UV-index forecast was introduced on the World Wide Web (http://www.smhi.se) as a Table for 15 regions in Sweden and three resorts. Next year, 1997, the graphical layout was improved and since then the daily course of the UV-index is presented for a number of climatological similar regions in Swedish. During the first winters there was no forecasting of UV-index done. The season started in late March and stopped at the end of August. Now, it is in operation all the year around. There is also some additional text presenting the some specific features of interest regarding UV-radiation in general.

Swedish activity: SMHI and SSI.

Modelling UV-radiation

A system, STRÅNG, for modelling radiation parameters has been developed at SMHI, with additional funding from the Swedish Environmental Protection Agency and the Swedish Radiation Protection Institute (SSI). There are older systems in operation for different applications, time and spatial scales. The main object of the new system is to produce field data in *near real time* with

hourly resolution. At the moment the following variables are considered: global irradiance, CIE-weighted UV (Figure 1), photosynthetic active irradiance, direct solar irradiance and sunshine duration.

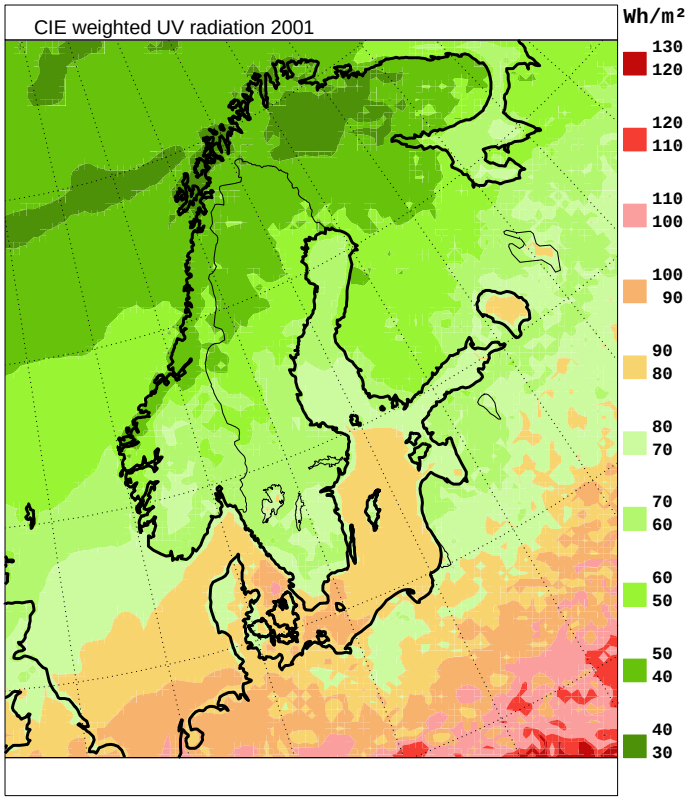

Figure 1. CIE-weighted UV-radiation for 2001 from STRÅNG.

The most important variable input fields for computing the UV are cloud parameters and the total ozone. The latter is retrieved from satellite data, when available, and the cloud data is available at relatively high resolution in an operational system Mesan (Mesoscale analysis), that is operated at SMHI. It compiles information from a number of sources including satellite and ground based stations. The Mesan set the practical limits of both the spatial (22km) and the temporal resolution (hourly). The core radiation model implemented into the system is SMARTS2 developed by Gueymard (1995). It covers the full solar spectrum.

Swedish activity: SMHI, Swedish Environmental Protection Agency and SSI.

Ground based monitoring of total ozone

Daily monitoring is done at two sites in Sweden. The instruments Brewer and Dobson ozone spectrophotometers are regularly calibrated approximately at three years interval according to WMO-recommendations. Data are sent to the World Ozone and Ultraviolet radiation Data Centre (WOUDC) at MSC in Toronto, Canada, every month. Preliminary data are also sent to MSC (WOUDC) and to the WMO Ozone Mapping Centre, Thessaloniki, Greece for the production of near real-time maps. All total ozone data are available at WOUDC and at the web-site of SMHI (www.smhi.se). Beside of monitoring, efforts are mainly directed on quality assurance and on improving the observations at low solar elevations (focused sun observations), which is a challenge at high latitudes.

Swedish activity: SMHI on behalf of Swedish Environmental Protection Agency.

Ozone data from the ODIN-satellite

The Swedish Odin satellite was launched 20 February 2001. The Swedish Space Corporation, on behalf of the Swedish National Space Board and the space agencies of Canada, Finland and France, developed the satellite. It combines two scientific disciplines on a single platform astronomy and aeronomy. Briefly observations will be used for studies of star formation/early solar system and for studies of the atmosphere with the aim of better understanding the physics and chemistry controlling the distribution of ozone and other gases.

For this task Odin not only uses the sub-mm radiometer but also an Optical Spectrograph and InfraRed Imaging System, OSIRIS. The two instruments complement each other with the distribution of some gases being more accurately determined by one or other of the instruments. For aeronomy the spacecraft follows the Earth limb - scanning the atmosphere up and down from 15 to 120 km at a rate of up to 40 scans per orbit. Measurements are made from 82 S to 82 N.

Unique capabilities for the radiometer are measurements of ClO in the stratosphere and water vapour to altitudes over 90 km in the mesosphere as well as night and daytime measurements of ozone, nitric acid and dinitrous oxide. The OSIRIS instrument provides high precision measurements of ozone and nitrogen dioxide under sunlit conditions and should also provide measurements of OClO and BrO under suitable conditions.

During the northern hemisphere summer months noctilucent clouds have been observed at 82 km altitude and simultaneous measurement of the water vapour concentration as the same altitudes made. When fully analysed these observations should allow us to determine the budget and conditions required for the formation of these particles. Although plagued by a progressive problem with maintaining pointing, a problem now solved, the first observations of the Antarctic ozone hole were made by the OSIRIS instrument (Figure 2).

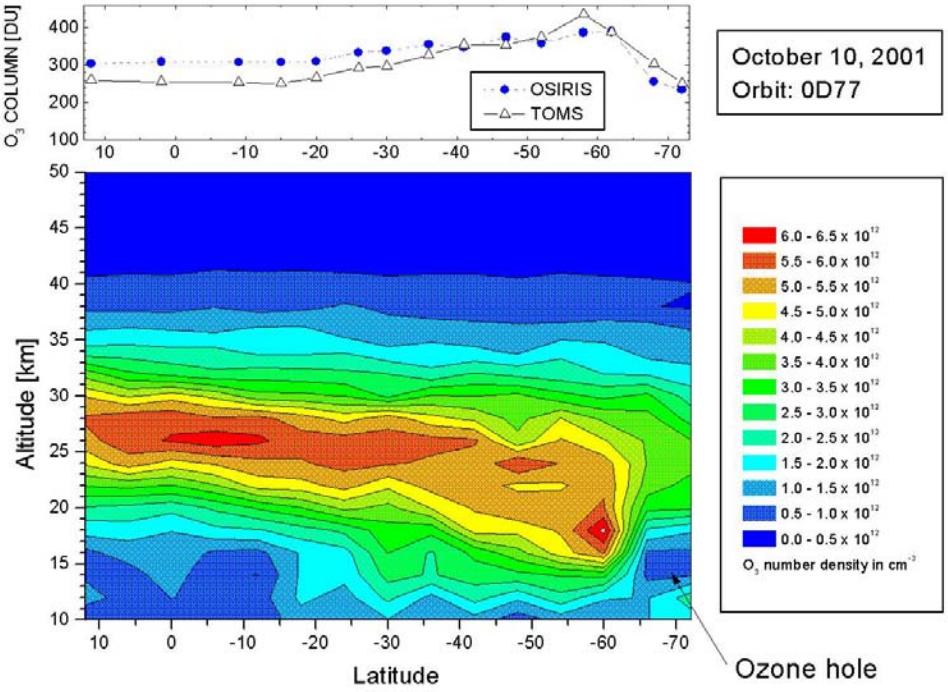

Figure 2. Example of ozone data from the OSIRIS instrument on ODIN satellite.

Swedish activity: Chalmers University of Technology and Department of Meteorology at Stockholm University on behalf of the Swedish Space Corporation

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SWITZERLAND

Switzerland has a long tradition of ozone study which started in the twenties in Arosa. A practically uninterrupted monitoring of total ozone was initiated at that time. Later on, other monitoring programs were developed in particular the balloon ozone sounding at Payerne (1968), the radiation network CHARM (1995) and the aerosols monitoring at Jungfraujoch (1995). The monitoring activities are under the responsability of MeteoSwiss, while a large part of the research activities are seeded in the Universities and research laboratories.

The Swiss contribution to the GAW (Global Atmosphere Watch) has conducted to the development of two WMO calibration centres.

In 1995, Switzerland has contributed to the build up of the ozone sounding station of Nairobi, Kenya. There is a continuing support to this station as technical assistance (regular visit) and operators training and schooling. The data quality control and transmission to the SHADOZ project data base are assured in collaboration with MeteoSwiss.

Monitoring activities

The monitoring activities under the MeteoSwiss responsibility cover three aspects: **ozone**, **radiation** and **aerosols**.

Operational ozone measurements:

Ozone is a well developed monitoring activity in Switzerland. The Payerne and Arosa stations are well know for their long record of ozone measurements.

- Total Ozone:
  - Total ozone measured at Arosa with two semi-automated Dobson spectrophotometers (D101 & D062) and three automatic Brewer instruments B040 & B072 (Mark II) and B156 (Mark III).
- Ozone profiles:
  - Balloon soundings at the Payerne aerological station using a Brewer-Mast O_3-sonde,
  - Umkehr profiles from automated Dobson (D051) and Brewer (B040) instruments at Arosa,
  - Micro-wave radiometer at Bern.

Operational aerosols measurements:

The aerosol part of the monitoring is based on the measurements conducted at the Jungfraujoch station. Several instruments have been operated since 1995 (a 3-wavelength nephelometer (450, 550 and 750 nm), an aethalometer, a condensation particle counter and an epiphaniometer) by the Paul Scherrer Institute (PSI) in collaboration with MeteoSwiss.

Operational radiation measurements:

The **Swiss Atmospheric Radiation Monitoring** programme (CHARM) is another task of MeteoSwiss. It consists of 4 stations spread over an altitude range of 366 to 3587 m a.s.l which was build up between 1995 and 2001. The monitoring programme is coordinated with the ozone activities and includes:

- The direct, diffuse and global components of the broad-band erythema UV-ERY radiation (Solar Light UV-Biometers),
- Spectral direct irradiance measurements with Precision Filter Radiometers (PFR) at selected wavelengths in the range 305 nm to 1024 nm.

At Arosa, spectral scans of global UVB measurements using the Brewer instruments are regularly measured since 1988. Direct sun UVB scan will be included this year in the data acquisition programme.

Research and development activities associated with the monitoring

Some of such activities linked to the monitoring activities are listed hereafter:

- Development and improvement of the calibration methods for radiation monitoring instruments in collaboration with the World Optical Depth Research and CalibrationCentre at Davos.
- Study of the influence of atmospheric (ozone, cloud cover, aerosol optical depth, water vapour) and geographical parameters (altitude, albedo) on the UV-B variability.
- Improvement of the Brewer-Mast ozonesonde operational procedure and tests of the ECC O_3-sonde. In particular, it is planned to switch to ECC ozonesonde at Payerne in 2002.

Academic activities with an ozone component

The Institute for Atmospheric and Climate of the Swiss Federal Institute of Technology, Zurich, has different projects related to ozone. In particular, the different ozone series from Payerne and Arosa have been extensively studied. Recently, the following projects have been completed:

- Re-evaluation, homogenisation and trend calculations of the ozone time series: total ozone since 1926, Umkehr series since 1957 and balloon soundings since 1968.
- Ozone and Nitrogen Oxides have been measured along Air Routes with measurements on a Jumbo jet.
- An UV-Index forecast has been developed and related research have been performed on the characteristics of the UV-ERY radiation within the COST 713 Action on UVB forecasting. Presently, MeteoSwiss is forecasting the UV-index during summer.

At the University of Berne, the Institute for Applied Physics has a recognised expertise in the development of passive microwave radiometers. In particular, the following instruments have been developed recently:

- A new microwave receiver for ozone profiling has been developed and it is now in a pre-operational phase. It will be installed at MeteoSwiss in Payerne for monitoring purpose later on this year.
- A microwave radiometer for ozone profiling of the former generation is installed at the University of Bern since 1994 and it belongs to the primary NDSC station Jungfraujoch.
- A new radiometer for the detection of ClO has been installed at Junfraujoch. It has been built within the EC-project EMCOR and is presently operational there.
- Tools have been developed for the study of aerosol, columnar ozone and water vapour based on narrow-band spectral measurements in the UV and visible range from the CHARM measurements

The Swiss Federal Institute of Technology, Lausanne, is running an ozone LIDAR instrument but with a range limited to troposphere profiling. A laboratory for the study of heterogeneous chemistry of ozone related components is also active in this institute.

Besides the operational monitoring activities, the PSI participates to campaign of intensive measurements with additional equipment at Jungfraujoch. In 2000, the CLACE (Clouds and Aerosol Characterisation Experiment) campaign has been successfully conducted in the February-March period to characterise the free troposphere as well as occasionally the convective boundary layer developed by local convection.

Calibration centres

The WMO has attributed the role of calibration centres to two swiss institutes: ground based ozone instruments calibration centre (WCC) at Swiss Federal Laboratories for Materials (EMPA) and the World Optical Depth Research and Calibration Centre (WORCC) at Davos.

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THAILAND

1. Monitoring

The total ozone and UV radiation monitoring are carrying out at Thailand Meteorological Department (TMD) that there are the Global Ozone Observing System stations of WMO-Global Atmospheric Watch programme. The measurements performed by the Atmospheric Ozone, Solar Radiation and Turbidity Observations Subdivision at Bangkok and Southern Meteorological Centre at Songkhla.

Stations	Locations	Ozone Measurements	UV measurements
Bangkok (No. 216)	13.67 N, 100.62 E	-Dobson Spectrophotometer No.090 -Brewer Spectrophotometer No.121	- Brewer Spectrophotometer No.121
Songkhla (No. 345)	7.20 N, 100.60 E	-Brewer Spectrophotometer No.120	- Brewer Spectrophotometer No.120

Total ozone measurements made by using:

- Dobson spectrophotometer No. 090 since 1979. The latest inter-comparison was in Tsukuba, Japan 1996. The monthly test results are currently still stable.

- Brewer spectrophotometer No. 120 is used since 1997 and re-installed after replacing of some parts in 2001.

- Brewer spectrophotometer No.121 is used since 1996 and calibrated in 2000 with the traveling Brewer No 017. (By the International Ozone Service Company, Canada)

For the important process of data calculating and analysis, it is very appreciated using some worth software as DOBSON/DOBSTOOL for Dobson data also the O3BREWER and UVBREWER by the Solar and Ozone Observatory, Czech Hydrometeorological Institute's development, which are really useful for the ozone communities.

UV Radiation

Both UVA and UVB are measured with Brewer spectrophotometer in range of 286.5-363 nm for the main purpose of research and public awareness in meteorology programme.

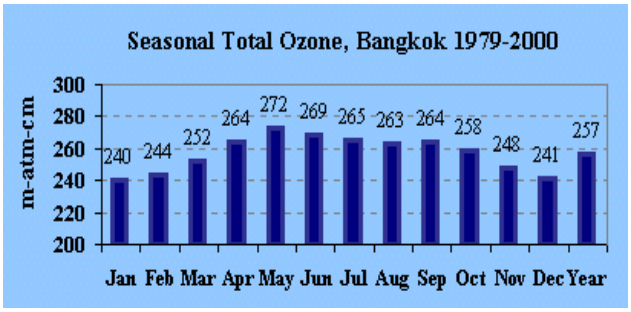
Ozone and UV Radiation data

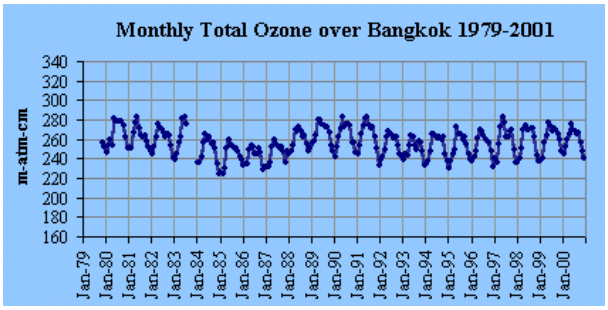
Both Dobson and Brewer data were reported regularly to World Ozone and UV Radiation Data Centre in Toronto that will be finally checked and Quality Assurance.

2. Research

Research on ozone in tropics countries may not used directly to the study of UV increasing but is very important for many aspects of its effects and modeling especially on solar UV radiation that is very high in this region. Also there is requirement to measure simultaneously with other atmospheric parameters like aerosol and other gases (i.e.SO2, NOx). As the limit of groundbase measurement we have been used the satellite data from NASA's Earth Probe TOMS that are very valuable.

We will see the behavior of long term ozone variation from the measurements, by seasonal and small changing by annually from the examples below.

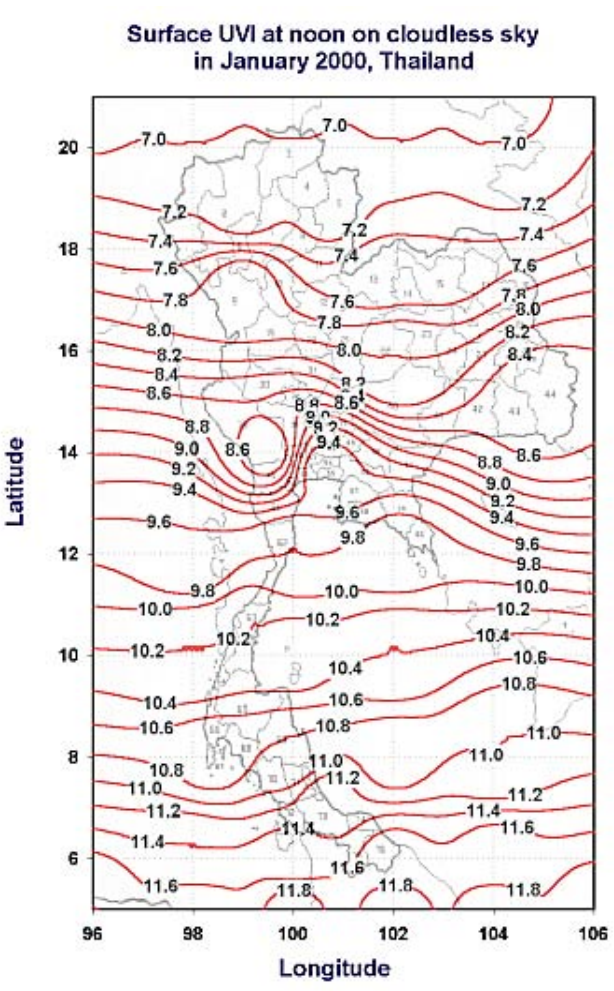


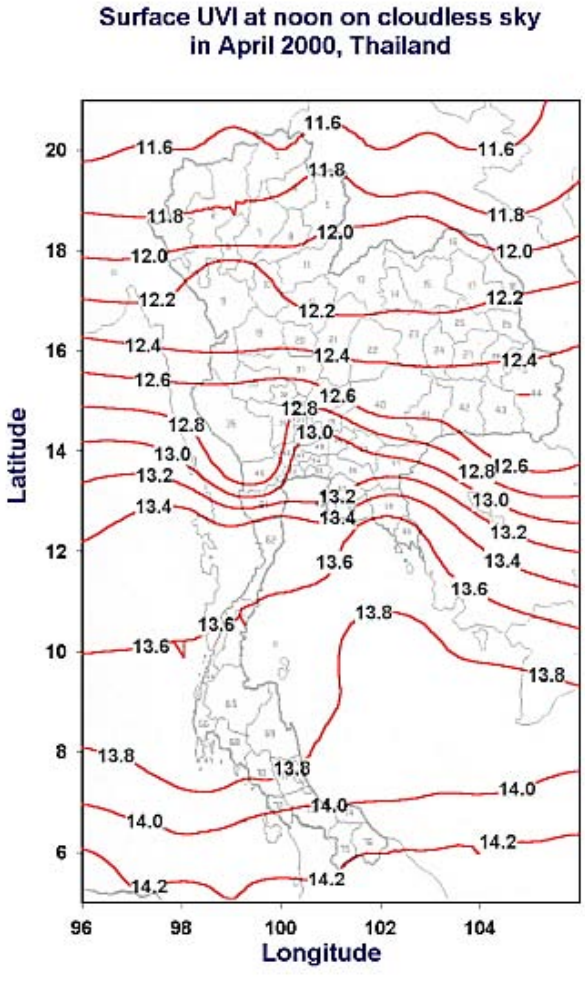


UV Radiation

UV index forecasting were initiated by TMD and presented as a daily public service at the website httt://www.tmd.go.th/ozone/uv index.htm, mainly in summer season for 4 parts of Thailand.

UV index calculation is operated under the STAR model (credit to Dr.Harry Schwander and others) by using total ozone data from groundbase measurements and TOMS's data for the other sites of the country; aerosol optical depth at 550 nm is also needed. The study shows that UV index levels are high – to very high at noon on clear sky throughout a year the examples are shown as follow.





Mostly of public information related to ozone and UV radiation are distributed in form of publications, radio programme and Internet.

Ozone and UV radiation as well as its effects to Thai people's health and environments are interested and still involving to many national researches in several medical and education institutes.

3. Planned Activities

Although the UV effects on human skin of mostly people in tropics are not most sensitive against solar UV Radiation but actually there is increasing number of cataract and skin cancer patients and more concerning about UV radiation and health effects. Therefore, we will have more activities in many aspects. The plans are including to:

- Improve the quality of instruments and data by calibration and performing in more standard maintenance for Brewer Spectrophotometer
- Improve the procedure of UV index forecasting by research on atmospheric aerosol and ozone forecasting over Thailand (at least in main parts)
- Set up more site of UV monitoring to ensure the quality of UV researches.

4. Recommendation

There are some difficulties of Brewer maintenance in humid country and in the domestic processes to a calibration. Some problems could not be solved directly by the right person at the right problems. To avoid the unqualified local company to handle the instruments, they require WMO's support and directly managing as government-to-government method. Including the possibility in case of the Brewer workshop could extend a period of training on Brewer maintenance and technical analyses.

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TOGO

1. INTRODUCTION

Togo is a country of West Africa, located on the coast of the Gulf of Guinea, between 6 th° and 11th of Northern latitude and 0° and 2° longitude. It is limited to the West by Ghana, in the East by the Republic of Benin, in North by Burkina Faso and the South by the Atlantic Ocean. Togo has a surface of 56.600 km2 and a total population estimated at four (4) millions inhabitants.

It is a country of mountains which take it in scarf in the shape of a chain of the South - West in the North-East and plains. Three large basins divide the togolese territory: the basin of Oti with its affluents in the North which covers 26.700 km2, either 47,3 % of the country ; the basin of Mono in one –third of the central of the East with 21.330 km2 or 37,5 % and the coastal basin of 8.000 km2 or 14,3 %.

The climate of Togo is of tropical type soudanian in North with one dry season and a rainy season, and guinean type in the South characterized by two seasons of rain which alternate with two dry seasons.

The temperature varies between 18° and 33°; precipitations lie between 800 and 1650 mm a year.

The primary, secondary and tertiary sectors contributed respectively in 1999 for approximately 41,0 %, 21,1 % and 37,9 % with the GDP.

The poverty which touched 30 % of the population towards the end of 1980 quickly increased and reaches today 70 %.

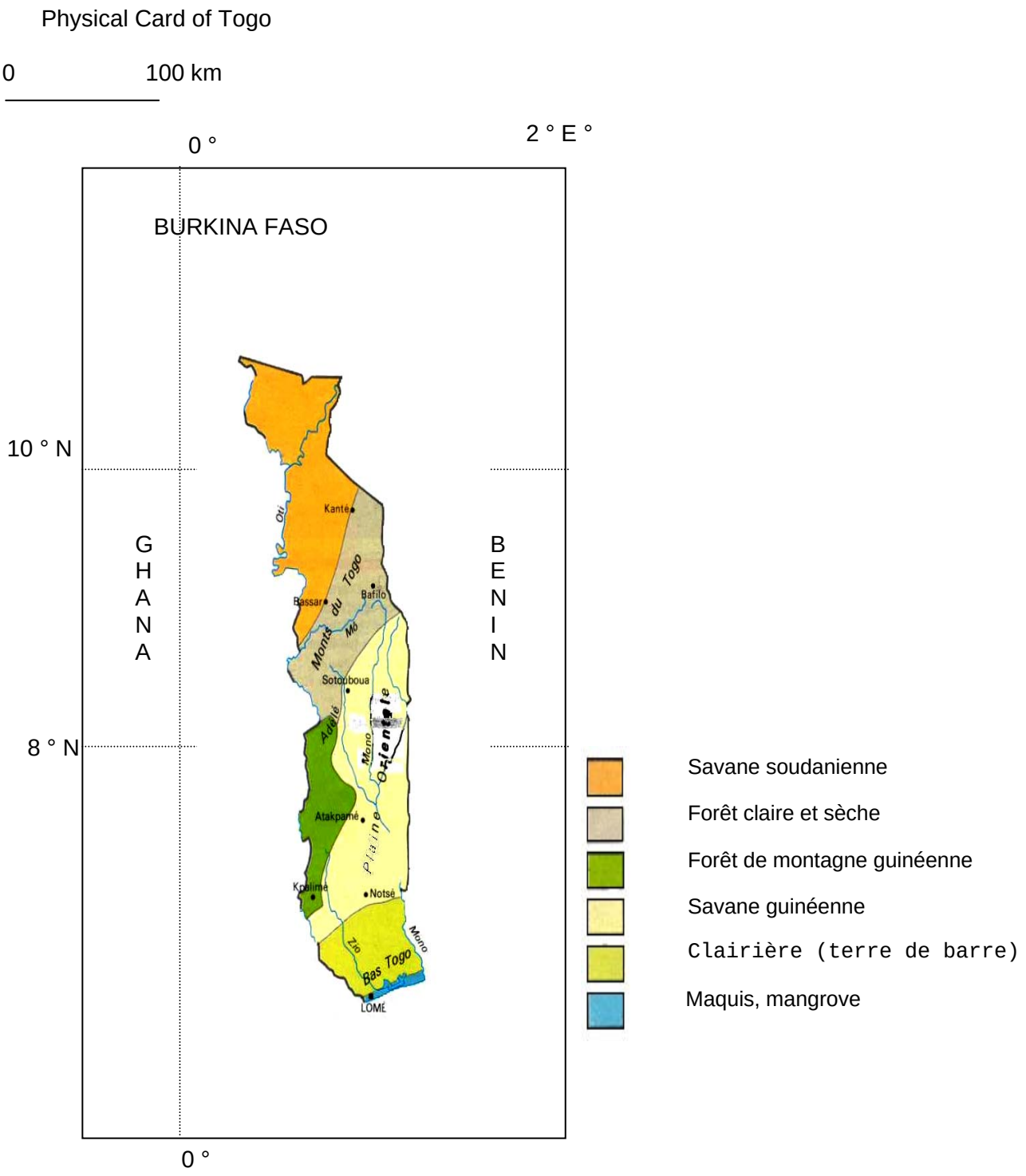
2. STATE OF SEARCH ON OZONE

According to our investigation, it revealed that it does not exist in Togo neither measurements and follow-up nor on ozone or the ultraviolet ones. The faculty of science of University of Lomé (Département de Chimie Atmosphérique), does not have laboratory in this direction. In the same way, the Persons in charge of the National Service of the weather affirm to have installed a station in Kouma-Konda (South-Western of the country), but which is provided only for traditional statement concerning rainfall, direction and intensity of the wind, the temperature and atmospheric pressure

However, within the framework of the setting of the UN Convention on the Climatic Changes, IPCC Methodology allowed to know the precursors of ozone in stratosphere. That is the carbonmonoxide (CO), the oxidesnitrogen (Nox) and the organic compounds nonmethane birds (COVNM).

The year 1995, is the basic year in Togo for gases inventory purpose of greenhouses and precursors of ozone.

Physical Card of Togo



3. INVENTORY OF THE PRECURSORS OF OZONE

Emission of carbon monoxide (CO)

The CO emissions are the second source of GES in absolute value, without taking into account the values of potentials of total various gases, for a total of 716,59 Gg. These emissions come from three great activities sectors which are Energy 350,68 Gg (49 %), Agriculture 240,26 Gg (33,5 %) and Affectation of the Grounds and Forestry 125,65 Gg (17,5 %) cf fg

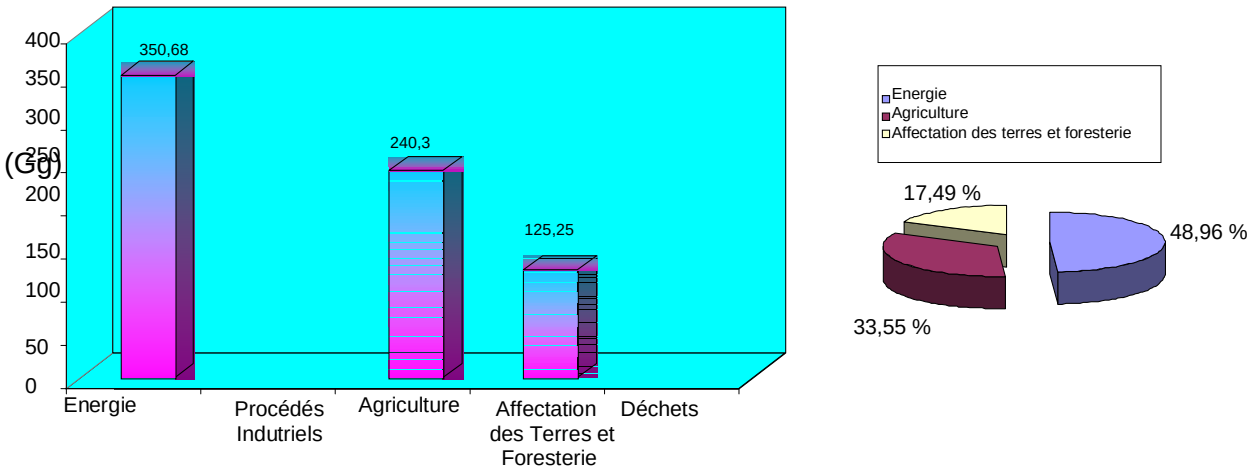


Figure 1: Emissions de CO en 1995, par secteur et en pourcentage.

Emission of oxydenitrogen (NOx)

The total emissions of N0x in Togo come in 5th position for an estimate from 18,94 Gg, value rather low which does not take account of national realities. The sectors of Energy, Agriculture and affectation of the Grounds and Forestry are the most significant sources with respectively 10,44 Gg; 4,92 Gg and 3,58 Gg cf fig 2.

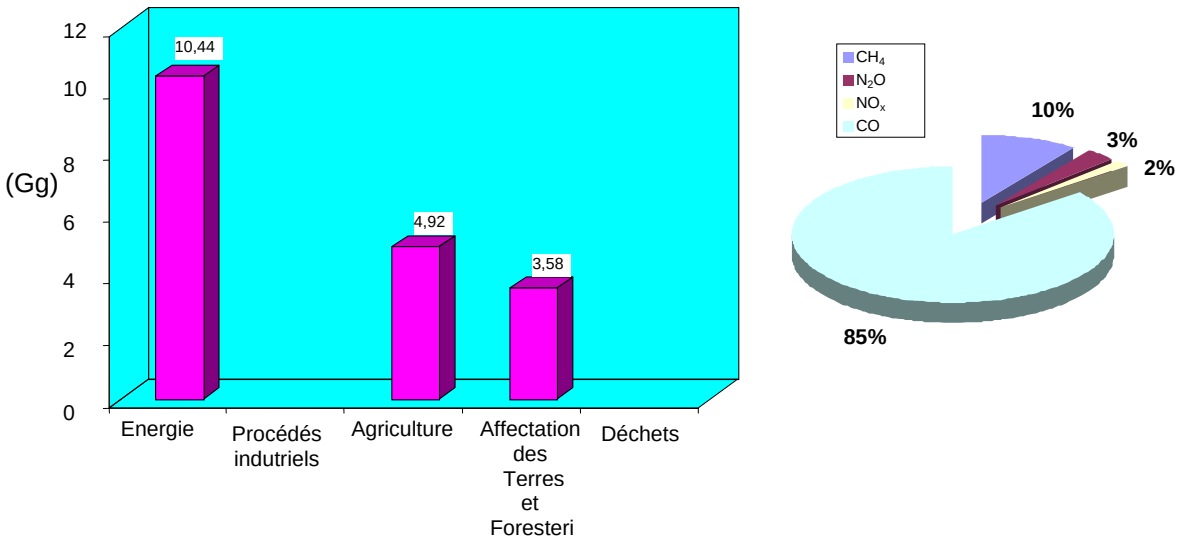


Figure 2 : Emission des oxydes d'azote en 1995

Emission of organic compounds nonmethane birds (COVNM)

The principal contributions on the whole of the nonmethane emissions of organic compounds volatile (COVNM) come mainly from the Energy sector with 32,35 Gg and 6,94 Gg for under sectors Residence-Craft industry and Transport respectively the share of the processes Industrial are only of 0,24 Gg. Lack of data on the solvent has not allowed to estimate emissions of this sector which should largely exceed those of the sector energy. (cf fig 3),

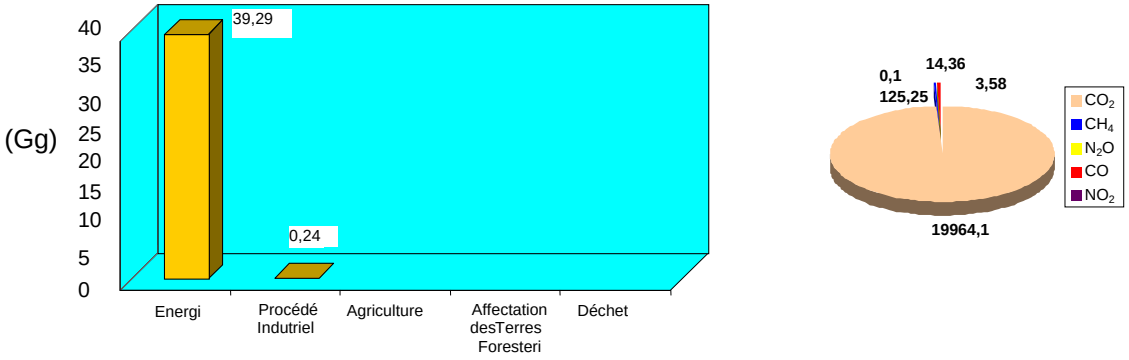


Figure 3 : Emissions de COVNM en 1995.

4. IMPACT OF THESE GASES ON THE LOCAL CLIMATE

The precursors of ozone being gases for purpose of greenhouse, it is obvious that the contribute to the warming of the local or regional climate, which can cause the reduction of rainfall and increase dry seasons.

5. CONCLUSION

It is essential for the Government to set up a national unit of search on ozone and to reinforce the capacity of measurement and of follow-up of station of Kouma-Konda and to create other stations which must be necessary fit out with some suitable tools.

Creation a powerful laboratory for atmospheric studies purpose is more imperative than any requirement as the same as a high level training program, which can offer to the future researchers required competences. The success of this program and the search lies in a technical and financial support to the Togolease Government by the World Meteorology Organisation (WMO), the Francophony and other tradtional financial Backers of Togo.

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TURKEY

Ozone Observations

Ozone measurements have been made by an ozonesonde instrument at Ankara, Turkey since early 1994 by the Turkish State Meteorological Service. Ankara is located at 32° 53' (E) Longitude and 39° 57' (N) Latitude with an altitude of 891 m. Ankara is capital of Turkey and situated in the mid-northern part of the Central Anatolia Region. Ozone observations have been operated in every one or two weeks or sometimes a month since beginning. Therefore, daily measurements are not available. Total ozone column is detected with this operation. It is possible to find vertical ozone distribution, vertical ozone profile, in this way. Up to now, total 171 balloon have been launched and 154 daily total ozone column data have been obtained. The 15 observations could not be performed due to the different reasons such early exploding of the balloon.

The measured ozon data is sent to the 'World Ozone and Ultraviolet Radiation Data Centre' (WOUDC) in order to be archived and published. The station number of Ankara is 358 in WOUDC.

The quality of the ozone data obtained from ozonsonde instrument has been evaluated taking into account the Total Ozone Mapping Spectrometer (TOMS) data obtained aboard the Earth Probe Satellite. A preliminery comparison study was made by using the Ankara's data and the TOMS' data. Total 86 TOMS' ozone data for Ankara location was obtained from the NASA Goddard Space Centre, and a correlation was found between the TOMS and the Ankara's ozonsonde data. The rather, high correlation coefficient of 0.89 was detected in this study. This result is statistically significant and shows that there is a good agreement between these data set. At the same study, relative errors of the ozonsonde data were computed based on the TOMS data is reliable. The mean relative error was found as 2.4 percent. All results showed that ozone measurements in Turkey are reliable.

The ozone time series of Ankara was also analysed statistically and looked for trend at the evaluation studies of the Turkey's ozone data. Any significant trend was detected, no clear decrease or increase. The extreme values in ozone time series were found as 243 DU and 389 DU. The mean total ozone column was computed as 313 DU. This values were very close to the values of documents of WMO and UNEP (The changing ozone layer, Rumen D. Bojkov,1995).

On the other hand, we have some doubt for our ozonsonde instrument. So, ozonsonde includes 2 part, transmitter and ozonsonde. Before every observation it is necessary to calibrate ozonsonde part of instrument with an ozonizer/test unit. However, maintenance of the current ozonizer/test unit has never been done since beginning.

Ozone Forecast

Turkish State Meteorological Service (TSMS) has given its attention to the ozone forecast for the last one year. Some ozone forecasting models have been evaluated in the Research Department of TSMS. It has been decided to use a statistical regression model originally given by Long et al.(Bull. Am. Met. Soc. Vol.77, 1996). This model uses geopotential height and temperature together for standard pressure levels (500, 100 and 50 hPa) in forecasting total ozone column. Firstly data set including daily ozone, upper atmospheric radiosonde data covering 500 and 100 hPa geopotential heights and 50 hPa temperature measurements obtained. TOMS ozone data was used in that study because of daily ozone data is not available in TSMS. Therefore, estimated ozone data have been obtained only for the period of January 2000 – March 2001.

Estimated and measured ozone data for each day have been compared. It has been found that this model can estimate total ozone column with an about 9 percent relative error. Although estimated data series exhibit an agreement with measured data, some discernible deviations are detected. It has been computed that the 11 percent of estimated data showed excess deviations. All results show that model could be used to forecast total ozone column.

Although model has not been used yet routinely by TSMS, preparations for estimating daily ozone value has been lasting.

UV-B Observations

The B band of the ultraviolet radiation has been measured with an UV-B recorder named Model 501 in two location, Ankara and Antalya (located on southern coast of Turkey and at 54 m. Altitude, 30° 44' (E) Longitude and 36° 42' (N) Latitude).

The UV-B observations were started on 3 January 1997 at Ankara, and on 21 May 1997 at Antalya. There is any problem on the UV-B time series of Ankara. However, time series of Antalya has some gaps and missing data. While Ankara station has 1742 daily data, Antalya station has only 1049 daily data. UV-B data have never been evaluated climatologically and statistically because of the very short time series.

Planned studies for the period of 2002 – 2006 are as follows:

- To have more strong ozone and UV-B network in Turkey with one Brewer Spectrometer and four UV-B recorder;
- To detect tropospheric ozone profile;
- To detect stratospheric ozone profile;
- To product daily ozone forecast routinely;
- To make UV index forecast routinely;
- To analyse time series of the ozone and the UV-B;
- To evaluate effects of the changes in the ozone and UV-B time series on the climate.

Note: Turkey has no recommendations on the report of the 4ORM due to fact that the documents do not exist in its archive.

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UNITED KINGDOM

In accordance with decision VCV/3 part (a) of the Fifth Meeting of the Conference of the Parties to the Vienna Convention, the UK has continued to maintain instruments and develop monitoring, calibration and archiving of stratospheric and tropospheric ozone, and other associated trace species and aerosols. Part (c) of VCV/3 states that investigation and quantification of stratospheric and tropospheric processes through routine monitoring and experimental campaigns should be increased in order to understand current changes and to further develop and implement predictions of stratospheric change both for the short term and long term. The UK has also supported a number of projects that fulfil this objective. Details of current monitoring and investigation of stratospheric and tropospheric processes follow.

1. Monitoring stratospheric ozone

1.1 DEFRA funds an on-going monitoring programme that records total ozone values at two UK locations: Lerwick in the Shetlands, and Camborne in Cornwall. 3 UK Dobson spectrophometers are used to record daily values, although weather conditions sometimes prevent values from being recorded and Lerwick shuts down for a short period each winter when the sun is too low. Daily values are sent to WOUDC (World Ozone and UV Data Centre) at the end of each month, and to the WMO GAW ozone-mapping centre at Thessaloniki.

1.2 One of the spectrophotometers was re-calibrated in 1999 (at Camborne), and the other two were re-calibrated in 2000 (against a world-class instrument at Hohenpeissenberg, Germany). All three are carefully maintained and checked monthly. A number of checks are performed in order to ensure the integrity of the data, including comparison of daily results with satellite measurements, and the nearest ground-based measurements. The values are compared to those obtained at European stations at similar latitudes, and there is good agreement between Camborne and the Belgian station at Uccle, and between Lerwick and Oslo.

1.3 The Natural Environment Research Council (NERC) also supports column ozone monitoring at Aberystwyth. This has been performed for the last nine years. Further details on this can be obtained from: http://users.aber.ac.uk/ozone/ .

2. Stratospheric ozone research

2.1 DEFRA funds a research project that analyses the ozone data collected at Camborne and Lerwick. This research concentrates on identifying low ozone events, and predicting how the frequency of low ozone events could alter as stratospheric levels change.

2.2 In accordance with decision VCV/3 part (d), which states that a high priority should be given to research into interactions between ozone and climate, DEFRA has also supported research at the University of Cambridge and the Met Office into current and future stratospheric ozone depletion and the implications of climate change. This research has used 20-year simulations with a coupled stratospheric chemistry-climate model to compare modelled and observed trends and to predict ozone trends for the period 2000-2019. This project is part of the wider research carried out by the Met Office stratospheric processes group, which aims to assess the impact of changes in greenhouse gases and halogen loadings on stratospheric ozone and temperature, and to provide future predictions of these quantities. Funding for this group is also provided by NERC and CEC.

2.3 The Met Office is one of the partners in the EuroSPICE project (Stratospheric Processes and their impacts on Climate and the Environment). (Other partners are: CNRS-SA, France, CNRS_LMD, France, Finnish Met. Inst., Finland, Free University of Berlin, Germany, University of Reading, UK, University of Buenos Aires, Argentina.) The specific aim of the EuroSPICE project is to update the observed stratospheric trends in ozone, surface UV and temperature and simulate those trends using climate models with/without coupled chemistry. The simulations will then be used to predict the behaviour of these quantities over the period 2000-2019, determine the likely cause of past stratospheric trends and develop understanding of the impact of stratospheric change.

2.4 The European Ozone Research Co-ordinating Unit (EORCU), which is based at the University of Cambridge, co-ordinated the extension of the Third European Stratospheric Experiment on Ozone (THESEO) into the winter of 1999/2000 in conjunction with the Sage III Ozone Loss and Validation Experiment (SOLVE) led by NASA. This was the largest ever field experiment into polar ozone loss.

2.5 The Natural Environment Research Council (NERC) has funded the Upper Troposphere/ Lower Stratosphere OZONE Programme which commenced in 1999 and will continue for 7 years to 2006. The main aim is to improve understanding of the causes of ozone change in the upper troposphere and lower stratosphere in the past, present and future. This is a region where ozone has been changing but the causes still remain uncertain. To date, 40 scientific research projects have been funded which cover a wide variety of research topics. These range from transport of trace gases on annual and seasonal timescales, dynamical processes occurring on short-timescales, studies of chemical processes in the atmosphere and the laboratory and modelling studies of chemistry-climate interactions. Results from the Programme have shown, in particular, that interactions between dynamics (meteorology) and chemistry in the atmosphere play an important role in governing the distribution of ozone and other trace gases in the upper troposphere and lower stratosphere.

3. Tropospheric ozone monitoring and research

3.1 Ground-level ozone is recorded hourly at 73 automatic recording stations (52 urban and 19 rural) across the UK. Data collection is managed by DEFRA, and the department has also commissioned research to model the formation of ozone and provide forecast tools. Research into the impacts of changing tropospheric ozone levels on vegetation has also been funded by DEFRA.

3.2 Tropospheric ozone modelling is carried out at the Met Office as part of the Climate Prediction Programme funded by DEFRA. Prediction of future climate requires predictions of radiatively-active trace gases such as ozone, and a coupled climate-chemistry model has been developed to fulfill these requirements. Recent research with this model uses multi-decadal simulations to investigate the role of climate change as a feedback process for tropospheric chemistry. This feedback has been found to be extremely important and results in lower predictions of ozone and methane concentrations. The simulations do not yet include the indirect effects of climate change on tropospheric chemistry through changes to the biospheric emissions, and work has started with coupled ecosystem models in order to investigate this process.

4. Monitoring ozone-depleting substances

4.1 DEFRA has provided support for projects that monitor ozone-depleting substances by analysing ground-based measurements at Mace Head (Ireland) and Weybourne. Aircraft data obtained with the support of the EU funded CARIBIC programme has also been analysed. The measurements have shown that UK emissions of CFCs are declining steadily and emissions of bromine-containing species are stable.

4.2 The aircraft data has enabled identification of two new ozone-depleting substances present in the atmosphere, n-propyl bromide (NPB) and hexachlorobutadiene (HCBD). Samples of European plumes have been monitored to ascertain the level of success achieved by the Montreal Protocol in reducing emissions of ozone depleting substances. The data has also shown that there may be issues with non-compliance as there is a positive correlation between some controlled and replacement species.

4.3 DEFRA has funded a new project that will build on this work by continuing to measure emissions of halocarbons and identify new ozone-depleting substances. Part of this project will also involve identification of additional data sources for comparison purposes. The bulk of the monitoring for this project will take place at Mace Head on the coast of Ireland. The location of this station is advantageous; the instruments are able to monitor background levels of trace gases when winds are westerly and have travelled over the Atlantic, and can monitor levels in polluted European air when winds are easterly.

5. Monitoring and research into effects of increased UV-B radiation

Decision VCV/3 part (f) stated that research into the effects of UV-B radiation and efforts to monitor such effects should be increased. DEFRA and the Department of Health (DoH) have funded monitoring contracts and research into the effects of UV-B.

5.1 A DEFRA funded contract makes spectral measurements of solar shortwave UN radiation at the surface to produce a UV climatology which allows detection of long-term trends that may arise as a result of stratospheric ozone depletion.

5.2 Two UV monitoring sites are in operation – there is a green-field site at Reading, and a city site in Manchester. The Reading site spectroradiometer is calibrated on site and has been providing regular measurements since 1992. It provides hourly spectrums between sunrise and sunset in the 280-500nm range. Periodic international comparisons with other UV spectroradiometers have provided consistently good results. The Manchester instrument provides five minute averages in each of five narrow wavebands (305, 313, 320, 340, 380nm). It is calibrated annually on site and in 2000 it was calibrated to the Norwegian standard instrument. Apart from calibration periods, the instrument has been in continuous operation since 1997, and provides a southern site in the Nordic network of GUV radiometers.

5.3 DEFRA also funded an assessment of the impacts of ozone depletion on aquatic ecosystems. The project concentrated on three aquatic life forms: marine animals, plant life and fish. Increased UVB was shown to have a detrimental effect on all three groups.

5.4 The Department of Health provides support for UV monitoring performed by the National Radiological Protection Board (NRPB). The NRPB Solar Radiation Monitoring Project at NRPB provides information for the Global Solar UV Index in association with WHO, WMO, UNEP and the International Commission on Non-Ionizing Radiation Protection.

6. Key results and future directions

6.1 Significant UK contributions to research have been made in a number of areas:

- Interaction of chemistry, dynamics and radiation in the upper troposphere and lower stratosphere
- Role of dynamical and chemical influences on past ozone trends

- Modelling future changes in stratospheric ozone in response to the anticipated reduction in halogen loading and the effects of climate change
- Estimating the importance of climate feedback on future tropospheric ozone predictions.
- Understanding the microphysics and photochemistry of ozone loss in polar regions
- Understanding the impact of aviation on the atmosphere
- Use of satellite data with models and data assimilation to understand stratospheric ozone

6.2 The main thrust of future work is toward understanding the interaction between the stratosphere and climate change, and to work out what the effects will be on stratospheric ozone and UV radiation. Issues include the impact of CH4 and N2O emissions on ozone recovery (thought to offset halocarbon reductions quite significantly); the effect of changing dynamics on polar ozone depletion particularly in the Arctic (through lower temperatures and changed vortex stability); the impact of changing dynamics on mid-latitude ozone; understanding the causes and implications of currently unexplained long-tern increase in stratospheric water vapour; and, given their importance in climate change, investigating what the future tropical influence on the stratosphere (where there is currently no significant ozone trend) might be.

7. Commitment to future monitoring and research

7.1 At this stage DEFRA has not specified the areas that will receive direct government funding in the future. However, given the high priority of VCV/3 part (d), some research into stratospheric interactions and climate will be included in the contract funded by DEFRA at the Met Office. Monitoring of a comprehensive range of ODSs will be funded, for at least the next three years, in line with VCV/3 part (a). The current basic level of ozone monitoring will be maintained but any expansion of the monitoring activities will depend on budgetary constraints.

7.2 NERC are planning to support future ozone research and monitoring through their UTLS (Upper Troposphere Lower Stratosphere) and COSMAS (Core Strategic Measurements for Atmospheric Science) programmes, which run until 2003 and 2005 respectively. The focus of COSMAS will be determined by the infrastructure and knowledge base requirements by upcoming NERC, UK, EU and international programmes (such as UTLS and EU ozone experiments). A joint UTLS-COSMAS meeting will be held in July to identify the priorities for the two programmes. More information on these programmes can be found on the following web-sites:

www.utls.nerc.ac.uk and www.nerc.ac.uk/funding/thematics/cosmas/ .

8. Further information

8.1 Details of DEFRA funded research, including the full reports for scientific contracts, can be accessed from the DEFRA website at www.defra.gov.uk. by following the llinks to the environment pages.

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UNITED STATES OF AMERICA

1.0 INTRODUCTION AND OVERVIEW

This section describes the contributions of the United States of America to international efforts in atmospheric chemical / dynamical and UV radiation monitoring and research relevant to global changes in atmospheric ozone and its relationship to changes in climate. These research and observational activities provide a set of predictive tools and capabilities that deliver sound scientific information for use by policy and economic decision makers as they consider various options for mitigating or adapting to global change. An attempt has been made to construct a reasonably comprehensive description of the activities supported by the various US Government Agencies that have research programs in these areas, utilizing their FY2002 reports to the US Global Change Research Program (USGCRP) as well as more recent inputs provided specifically for this report. Nevertheless, it is possible that some Agency contributions are not reflected herein.

Relevant atmospheric chemical and UV radiation research within the United States is principally managed under the auspices of the National Aeronautics and Space Administration (NASA), the Department of Commerce (DoC) (primarily the National Oceanic and Atmospheric Administration (NOAA) but also the National Institute of Standards and Technology (NIST)), the National Science Foundation (NSF), the Department of Energy (DoE), the Environmental Protection Agency (EPA), the Department of Health and Human Services / National Institutes of Health (HHS/NIH), the United States Department of Agriculture (USDA), the Department of Defense (DoD), and the Smithsonian Institution (SI). The following is an integrated overview of the central themes and approaches found within these institutional programs:

- Global observations of atmospheric change, including
  - Ground-based flask collection and in-situ measurements of ozone- and climate-related trace gases at a set of globally distributed stations;
  - Ground-based measurements of upper tropospheric and stratospheric parameters, particles, and chemically active compounds using remote sensing instruments;
  - Space-based, balloon-borne, and airborne measurements of ozone and chemicals and parameters related to stratospheric and tropospheric ozone chemistry.

- Elucidation of the processes that cause regional and global atmospheric changes, including
  - Laboratory studies of key atmospheric trace chemical species to determine the kinetic, photochemical, thermodynamic, and spectroscopic properties that are required as inputs to computational models; and
  - Focused airborne/balloon-borne/surface-based field campaigns (integrated with satellite-based measurements) that are designed to probe selected regions of the atmosphere to characterize the controlling chemical and related dynamical processes.

- Development of a predictive capability that includes diagnostic and prognostic models, which incorporate the chemical and dynamical understanding gained, to test the scientific theories, to reveal deficiencies in understanding, and to predict future atmospheric chemical behavior as a result of natural and/or anthropogenic forcings.

- Linkages of atmospheric chemical changes to other environmental changes such as ecological and human health, including
  - Monitoring the exposure of ecosystems to ultraviolet radiation;
  - Characterizing potential human health risks associated with substances that are planned to replace compounds having known risks to the environment, and development of suitable alternatives for those substances; and
  - Measuring and modeling atmospheric species (e.g., sulfur dioxide/sulfate, nitrogen oxides/nitrate) involved in global tropospheric chemistry, particulate formation, and acid deposition.

- Evaluation and assessment of scientific findings and integrating them for use by decision makers, including
  - State-of-science assessments of the ozone layer and climate system, as they relate to atmospheric trace gases and associated human impacts.

The following sections provide a more detailed synopsis of how these research responsibilities are distributed amongst the various US Government Agencies.

2.0 NASA

2.1 *Goals and Objectives*

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. Within this framework, NASA has mapped out a research strategy for the next decade to address questions in the logical scientific progression of variability, forcing, response, consequences, and prediction respectively:

- How is the global Earth system changing?
- What are the primary causes of change in the Earth system?
- How does the Earth system respond to natural and human-induced changes?
- What are the consequences of changes in the Earth system for human civilization?
- How well can we predict future changes to the Earth system?

Under each of the above five categories are more detailed questions that reflect the ESE thematic research areas. Thus, NASA's component of the US program in atmospheric chemistry research lies within the ESE research theme of Atmospheric Chemistry, Aerosols, and Solar Radiation and is designed to address the following more specific questions:

- How is stratospheric ozone changing, as the abundances of ozone-destroying chemicals decrease and those of new substitutes increase?
- What trends in atmospheric constituents and solar radiation are driving global climate?
- How do stratospheric trace constituents respond to changes in climate and atmospheric composition?
- What are the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality?
- How well can future atmospheric chemical impacts on ozone and climate be predicted?

Research activities formulated around these questions are designed to increase our understanding of the distribution of ozone and other chemically and radiatively active species in the global troposphere and stratosphere in the context of an atmosphere undergoing both chemical and climatic change from both human-induced and natural processes. Elements of the NASA program are (a) global measurement of trace constituent and aerosol distributions with space-based platforms, (b) focused process-oriented field campaigns utilizing space-, aircraft-, balloon-, and ground-based instruments, (c) long-term measurements of key trace tropospheric and stratospheric constituents with ground-based instruments, (d) computational models for simulating the recent past and long-term future of atmospheric chemical composition, (e) development of new technologies for atmospheric chemistry measurements, (f) laboratory investigations of fundamental kinetic, photochemical, thermodynamic, and spectroscopic processes, and (g) support for national and international assessments and intercomparison activities.

2.2 *Contributing Elements*

2.2.1 Earth Observing System (EOS) and other Space Flight Programs - This element involves the development of new space-based remote sensing instrumentation and associated flight platforms, ground and data systems, algorithms, and data processing. The largest part of this is associated with the EOS Aura mission, a four-instrument mission currently planned for launch in early 2004. The instruments comprising this mission are as follows.

- The High Resolution Dynamics Limb Sounder (HIRDLS) will use infrared emission to measure ozone, water vapor, temperature, and a broad range of trace constituents, including long-lived source gases and most of the important nitrogen-containing species (N_2O, NO_2, HNO_3, N_2O_5, and ClONO2) in the upper troposphere and stratosphere. The long duration and high vertical resolution of HIRDLS measurements will make a unique contribution to knowledge of stratospheric constituents and the transport of trace gases between different regions of the stratosphere and troposphere. HIRDLS is a joint development of the US and United Kingdom.
- The Microwave Limb Sounder (MLS) uses emission in the microwave spectrum to observe the distribution of ozone, water vapor, long-lived tracers like N_2O, halogen compounds and the OH radical. Simultaneous measurements of ClO and HCl will also made. These observations will allow a critical test of current understanding of the partitioning of chlorine between reservoir species. Sulfur dioxide measurements will enable studying the decay of stratospheric SO_2 injected by occasional volcanic eruptions.
- The Tropospheric Emission Spectrometer (TES) will conduct an exploratory survey of tropospheric trace constituents and corresponding chemical processes. The high spectral resolution (~0.025 cm^{-1}) of TES will allow vertically resolved measurements of ozone and other trace constituents, including the important nitrogen oxide family that plays a major role in ozone production in the lower atmosphere. Key tropospheric molecules measured by TES also include carbon monoxide and water vapor. TES will operate in both a nadir- and limb-viewing mode, and is pointable so that interesting regions can be observed more than once per day.
- The Ozone Monitoring Instrument (OMI), supplied by the Netherlands, will measure total column amounts of ozone as well as yield information on ozone profiles. The OMI column ozone record will build on the measurement record obtained from the Total Ozone Mapping Spectrometer (TOMS) and the European Global Ozone Monitoring Experiment (GOME) and will provide similar information with higher spatial resolution. OMI will also measure total column amounts of several other trace gases, notably NO_2.

The EOS flight program also includes the Measurement of Pollution in the Troposphere (MOPITT) instrument aboard the EOS-Terra platform launched in December 1999 and the third Stratospheric Aerosol and Gas Experiment (SAGE III) instrument launched in December 2001. The US space measurements program is closely interconnected with that of our foreign partners - for example, the first SAGE III was launched aboard a Russian Meteor-3M spacecraft, while Canadian and Dutch instruments are being flown aboard EOS-Terra and EOS Aura respectively (with important British contributions to another Aura instrument). NASA supported scientists are involved in algorithm development and data analysis for GOME and there are plans to provide support to US scientists for the analysis of ENVISAT data.

2.2.2 Total Ozone and Aerosol Mapping - Total ozone data have come principally from the series of Total Ozone Mapping Spectrometer (TOMS) flights on NASA spacecraft or cooperative flight missions of opportunity, and Solar Backscatter Ultraviolet (SBUV) measurements on the NOAA polar-orbiting operational environmental satellite series. Both are based on solar ultraviolet backscatter measurements to determine ozone amounts. TOMS is a cross-track scanning instrument that provides daily global mapping of total column ozone with long-term accuracy of the order of 1% per decade. SBUV is a nadir-viewing instrument that provides total column and partial ozone profile data along the sunlit portion of the sub-satellite track, i.e., typically 16 orbits per day.

The TOMS program also provides unique information on the distribution of aerosol and particulate matter in the troposphere, including UV-absorbing particles (mineral dust, volcanic ash, smoke particles from fires and biomass burning) and sulfate aerosol. TOMS aerosol data are of particular

interest because they currently constitute the only source of information on large-scale aerosol loading of the atmosphere over land areas.

TOMS instruments were flown on Nimbus 7, Meteor-3, ADEOS, and currently on Earth Probe platforms since 1997. A launch failure of the QuikTOMS instrument occurred in September 2001, placing the continuity of the column ozone record from TOMS instruments in jeopardy. Space-based measurements by other agencies will, thus, be important in filling any ozone observation gap. The European space agency GOME instrument has been operating since 1995 and the successor instrument SCIAMACHY on the European ENVISAT mission is expected to provide more comprehensive data, beginning in 2002. NASA investigators are playing a significant role in the exploitation of GOME data and the development of retrieval algorithms for both GOME and SCIAMACHY. This type of cooperative effort is expected to be pursued in the future, as data from these instruments will be required for the continuity of the column ozone record until the launch of OMI on EOS-Aura.

Additional SBUV/2 instruments are still planned for launch on the NOAA Polar-orbiting Operational Environmental Satellite series. In the long term, the US National Polar Orbiting Environmental Satellite System (NPOESS) will deploy an Ozone Mapping and Profiling Suite (OMPS) that encompasses the capabilities of TOMS and will maintain backscatter UV measurement of total ozone and stratospheric profiles indefinitely in the future. Likewise, an ozone-profiling sensor (GOME-2) is planned on the European METOP operational polar-orbiting environmental satellite series.

2.2.3 Ozone, Aerosol and Polar Stratospheric Cloud Profiles - The principal source of high resolution stratospheric ozone and aerosol profile data has been the Stratospheric Aerosol and Gas Experiment (SAGE) program, based on the principle of occultation of solar radiation by the limb of the atmosphere. The main limitation of SAGE data is spatial coverage, since solar occultations occur only in two latitudes bands for a given orbit. The SAGE data have been very important in determining long-term trends in ozone vertical profile, especially in the lower stratosphere and SAGE data analysis and science studies continue to be a research priority – in particular, comparison of SAGE ozone profile data with UARS observations. NASA also supports the systematic analysis of high latitude solar occultation data acquired by the Polar Ozone Aerosol Monitor (POAM) instruments on the French SPOT earth observation satellite series (in polar orbit).

Two flight models of an improved instrument SAGE III have been fabricated for deployment on a Russian Meteor-3M spacecraft launched in December of 2001 (sun-synchronous polar orbit) and possibly on the International Space Station in 2007 (51.5° inclination orbit). The nature of solar occultation instruments in polar sun-synchronous orbits restricts observations to high latitudes, although the lunar occultations will help to “fill in” the tropics and mid-latitudes. An third SAGE III instrument is available for another flight opportunity should one arise. It is the intention that this program merge with the NASA systematic measurement program (see below).

Stellar occultation is a promising technique for ozone profiling, as it provides many more occultation opportunities than either solar or lunar occultations and enables greatly expanded spatial coverage. In addition, the small size of stellar sources simplifies the retrieval process. This approach has been successfully demonstrated with the UVISI instrument on the DoD MSX mission, with NASA support for data analysis. The Global Ozone Monitoring by Occultation of Stars (GOMOS) instrument on the European ENVISAT mission (to be launched in early 2002) will also make use of the stellar occultation technique.

2.2.4 Mission Operations and Data Analysis - This element involves spacecraft operation, data transfer and processing, and scientific verification and analysis for presently operating satellites making trace constituent and aerosol measurements of the global atmosphere. Currently, these include the Earth Probe/Total Ozone Mapping Spectrometer (EP/TOMS) and Earth Radiation Budget Satellite/Stratospheric Aerosol and Gas Experiment (ERBS/SAGE II) instruments, as well as the Upper Atmosphere Research Satellite (UARS). Support is also provided to help maintain

the accuracy of the long-term record of measurements from the Solar Backscatter Ultraviolet (SBUV/2) instruments flown by the National Oceanic and Atmospheric Administration.

2.2.5 Research and Analysis Programs

Upper Atmosphere Research Program (UARP) – This program uses a combination of laboratory measurements, long-term globally distributed ground-based measurements, process-oriented airborne- and balloon-borne campaigns, and process models to study the distribution of ozone, aerosols, and other atmospheric trace constituents in the global stratosphere and upper troposphere. Laboratory measurements emphasize those of fundamental stratospheric and tropospheric molecular processes (kinetics, photochemistry, thermochemistry) and properties (molecular spectroscopy relevant to remote and *in situ* sensing). Ground-based measurements emphasize accurate long-term knowledge of distributions of stratospheric trace constituents whose concentrations are expected to vary with time, as well as their tropospheric precursors. Process-oriented field campaigns range from studies of high latitude chemistry to transport processes connecting the tropics and mid-latitudes. Balloon-borne missions support both comprehensive studies of atmospheric trace constituent profiles above altitudes reachable by aircraft and validation of satellite measurements. New instrumentation is developed for airborne use, especially to increase the set of constituents amenable to *in situ* measurement.

Tropospheric Chemistry Program (TCP) – This program emphasizes the use of airborne platforms to study the impact of human activity (e.g. fossil fuel combustion, biomass burning) on the composition of the super-regional to global-scale troposphere. Process-oriented field campaigns are carried out with comprehensively instrumented aircraft for these studies. In recent years these have been located in the Pacific Ocean region, including both the western and tropical Pacific, an emphasis that is planned to continue in concert with Atlantic studies. The Pacific region, in particular, is expected to be impacted heavily by the growing industrial activity and growing transportation needs of Asia, but it is still a relatively clean air part of the world. Studies there provide an valuable baseline for studies of the chemistry/climate connection. The Pacific Ocean region is also an excellent laboratory for studies of fundamental tropospheric photochemistry. Process modeling studies and the development of smaller, lighter instrumentation for the airborne measurement are also important elements of the program.

Atmospheric Chemistry Modeling and Analysis Program (ACMAP) – This program uses a combination of data analysis and computational modeling approaches to study the distribution of trace constituents and aerosols in the global atmosphere and the way in which material is transported between different regions of the atmosphere. Both space- and aircraft-based measurements are extensively studied to improve our understanding of chemical and transport processes, as well as the spatial and temporal variability (both short and long term) of atmospheric trace constituents. Computational models are used to simulate both the evolution of the atmosphere in recent times for comparison with observational data and in the future to allow for projections of future changes based on assumed chemical and climatic forcing, as well as to explore the linkages between atmospheric chemical and climate change.

Earth Observing System Interdisciplinary Science Program (EOS/IDS) - This element of the NASA program involves the uses a variety of computational models to study the linkages between atmospheric chemistry and climate change, including the development of computational models that can address the feedback effects between the processes associated with these two issues. Models that can simulate the distribution of radiatively important tropospheric ozone and tropospheric aerosols are the major part of this research element.

Technology Development Program - The implementation of this relatively new focus on technology development for both space- and airborne-based instrumentation continues. This will accelerate the incorporation of new technology into atmospheric chemistry measuring instruments, and may even facilitate the development of whole new observational approaches. The investments made in this program will significantly improve the chances that new technology can be successfully proposed for future space-based missions.

2.3 *Selected Highlights*

- Investigations of the altitude dependence of ozone trends via detailed studies of the altitude dependence of ozone loss have continued using ground-, balloon-, and space-based observations. Results from these studies of the loss rates of ozone in the upper stratosphere, are consistent with computational models. Ozone profile trends studies will continue with data from the SAGE III satellite instrument launched in December 2001. The continuity of NASA's column ozone trends studies was set back by the launch failure of the QuikTOMS instrument in September 2001 and the degradation of the optics of the EP-TOMS instrument. NASA scientists are calibrating the latest EP-TOMS data using SBUV-2 retrievals. They are also playing a significant role in the exploitation of GOME column ozone data and the development of retrieval algorithms for both GOME and SCIAMACHY. This type of cooperative effort is expected to be pursued in the future, as data from these instruments will be required for the continuity of the column ozone record until the launch of OMI on EOS-Aura.

- Based on SAGE I and SAGE II observations, stratospheric sulfate aerosol levels in 2002 are significantly less than those observed in the 1970's, which had been considered the baseline for non-volcanic aerosol levels. In most regions, aerosol levels in 2002 are more than 20% less than those observed in 1979. However, at altitudes near the tropopause, levels are nearly the same in the two periods. This suggests that anthropogenic effects on stratospheric aerosol levels are minimal.

- NASA supported data analysis has succeeded in measuring the tropospheric pollutants and ozone precursors nitrogen dioxide (NO_2) and formaldehyde (HCHO) from space, using the European Space Agency's Global Ozone Monitoring Experiment (GOME) instrument. The NO_2 measurements included global determinations that distinguish between the stratospheric background concentrations and the tropospheric amounts from activities such as biomass burning and industrial activity. Formaldehyde measurements include the burden over North America and the initial studies to relate the measured concentrations to sources of biogenic volatile organic compounds (VOCs).

- NASA and NOAA satellite observations show that the Antarctic ozone thinning in 2001 Austral spring began earlier than usual, exceeded 26 Million km^2, and broke up in the first two weeks of December. The measurements were obtained this past year between mid-August and early October using the Total Ozone Mapping Spectrometer (TOMS) instrument aboard NASA's Earth Probe (TOMS-EP) satellite and the Solar Backscatter Ultraviolet Instrument (SBUV) aboard the NOAA-14 satellite. Data from the satellites show that 2001 ozone depletion reached a an extremely large and persistent ozone hole that exceeded a size of 10.3 million square miles (26.6 million square kilometers) on Sept. 17, 2001. The ozone hole exceeded 25 million km2 for 20 days during the Austral spring of 2001. The ozone level fell to 99 Dobson units on Sept. 26, 2001. These extremely low values are comparable to those observed during the 1990's.

- Unusually low levels of ozone over the Arctic were measured during March 1997 and 2000 by satellite-based monitoring instruments operated by NASA and the National Oceanic and Atmospheric Administration (NOAA). During the winter of 1999-2000, the NASA sponsored SAGE III Ozone Loss and Validation Experiment (SOLVE) was jointly conducted with the European Commission sponsored Third European Stratospheric Experiment on Ozone 2000 (THESEO 2000). This joint measurement campaign employed satellite, aircraft, and ground-based instruments to measure Arctic stratospheric ozone losses, and the factors that control those losses. During the period from mid-January to mid-March, a 60% loss of ozone was observed in a layer near 20 km. This large loss has been tied to halogen catalytic loss processes with direct measurements of chlorine and bromine species. The cold temperatures of that year enhanced the activation of chlorine via the heterogeneous chemistry that occurs on the surfaces of polar stratospheric cloud particles. Recent years, such as the winter of 2000-2001, have been relatively warmer, slowing the ozone loss process. This large interannual variability confounds the direct attribution of ozone loss, and makes difficult the separation of

ozone loss resulting from chemistry and dynamics. Further, the impact of climate change on stratospheric ozone remains a paramount challenge.

- UARP continues to support the operation of the Advanced Global Atmospheric Gases Experiment (AGAGE) network, which aims to further our understanding of a number of important global chemical and climatic phenomena by (1) optimally determining from observations, the rate of emission and/or chemical destruction (i.e., lifetime) of the anthropogenic chemicals that contribute most of the reactive chlorine and bromine released into the stratosphere; (2) accurately documenting the global distributions and temporal behavior of the biogenic/anthropogenic gases N_2O, CH_4, CO, H_2, CH_3Cl, CH_3Br, and $CHCl_3$; (3) optimally determining the average concentrations and trends of OH radicals in the troposphere by calculating the rate of destruction of atmospheric CH_3CCl_3 and other hydrohalocarbons from continuous measurements of their concentrations together with industrial estimates of their emissions; (4) optimally determining, using CH_4 and N_2O data (and theoretical estimates of their rates of destruction), the global magnitude and distribution by semi-hemisphere or region of the surface sources of CH_4 and N_2O; and (5) providing an accurate data base on the rates of accumulation of trace gases over the globe which can be used to test the synoptic-, regional-, and global-scale circulation predicted by three dimensional models and/or to determine characteristics of the sources of these gases near the stations. The continuation of this effort is crucial in order to monitor the chlorine loading of the atmosphere in response to the Montreal Protocol on Substances That Deplete the Ozone Layer (and its Amendments and Adjustments) as well as provide information for climate change studies. These measurements show a decreasing burden of regulated ozone destroying chemicals, and increasing abundances of substitute compounds less destructive to ozone, in the lower atmosphere. As a component of the AGAGE network, *in situ* gas chromatograph-mass spectrometer measurements of a wide range of chlorofluorocarbon replacements and other halocarbons have been initiated at one Northern Hemisphere site (Mace Head, Ireland) and one Southern Hemisphere site (Cape Grim, Tasmania) and this capability will soon be extended to other sites.

- The continued implementation of the international ground-based remote-sensing measurement Network for the Detection of Stratospheric Change (NDSC), championed in the US by NASA and the National Oceanic and Atmospheric Administration (NOAA), remains a high priority. The NDSC was formed to provide a consistent, standardized set of long-term measurements of atmospheric trace gases, particles, and physical parameters via a suite of globally distributed sites. The NDSC is based on a set of high quality, remote-sensing research stations for observing and understanding the physical and chemical state of the stratosphere and for assessing the impact of changes in the stratosphere on the underlying troposphere and on global climate. The measurement priorities include ozone, key parameters such as temperature and aerosols that affect the ozone layer, and tracers of chemistry and of atmospheric motion. The NDSC consists of five Primary Stations (all but one being comprised of multiple sites) so designated because their geographical characteristics and operational infrastructure facilitate measurements with nearly a complete suite of primary NDSC instruments (lidars for ozone, temperature, and aerosols; UV/Visible spectrometers for ozone, NO_2 and OClO; UV spectrometers for ground-level UVB radiation; microwave radiometers for ozone, ClO, and water vapor; FTIR spectrometers for a wide variety of source and reservoir compounds; Dobson and Brewer spectrometers for ozone, and balloon sondes for ozone and aerosols). Additional measurements are conducted at more than 40 Complementary NDSC Sites, at each of which only a subset of the primary NDSC measurements are conducted. Future expansion in low latitude regions of the globe is high NDSC priority whose degree of implementation will depend on funding availability.

- The NASA-sponsored SAGE III Ozone Loss and Validation Experiment (SOLVE) and the Third European Stratospheric Experiment on Ozone (THESEO 2000), collaborated to form the largest field campaign yet mounted to study Arctic ozone loss. This international campaign involved more than 500 scientists from over 20 countries. These scientists made measurements across the high and mid-latitudes of the northern hemisphere to study (a) the processes leading to ozone loss in the Arctic vortex and (b) the effect on ozone amounts over

northern mid-latitudes. The campaign included satellites, research balloons, 6 aircraft, ground stations, and scores of ozone-sondes. Campaign activities were principally conducted in 3 intensive measurement phases centered on early December 1999, late January 2000, and early March 2000. Observations made during the campaign showed that temperatures were below normal in the polar lower stratosphere over the course of the 1999-2000 winter. Because of these low temperatures, extensive polar stratospheric clouds (PSCs) formed across the Arctic. Large particles containing nitric acid trihydrate were observed for the first time, showing that denitrification can occur without the formation of ice particles. Heterogeneous chemical reactions on the surfaces of the PSC particles produced high levels of reactive chlorine within the polar vortex by early January. This reactive chlorine catalytically destroyed about 60% of the ozone in a layer near 20 km between late-January and mid-March 2000, with good agreement being found between a number of empirical and modeling studies. The measurements made during SOLVE-THESEO 2000 have improved our understanding of key photochemical parameters and the evolution of ozone-destroying forms of chlorine. SOLVE also had the objective of conducting direct SAGE III intercomparison activities. While these were not accomplished because of a prolonged delay in the launch of the satellite instrument, SOLVE data are being used in conjunction with measurements from several other satellite instruments for validation studies.

- Laboratory studies in spectroscopy, thermodynamics, chemical kinetics, and photochemistry are fundamental to UARP's maintaining the expertise required for interpreting atmospheric measurements and for performing theoretical simulations of the atmosphere (such as the investigation of heterogeneous processes that occur on polar stratospheric cloud particles and sulfate aerosols, photochemical processes that govern the partitioning of active and reservoir species, and atmospheric degradation mechanisms for CFC replacement compounds). Important kinetic and photochemical results from UARP investigations and similar studies conducted nationally and internationally are periodically evaluated and summarized by a panel of scientists organized by NASA's UARP. The reports of this NASA Panel for Data Evaluation, distributed as a NASA Jet Propulsion Laboratory publication, contains entries for more than 700 chemical processes and serves as the standard data set for atmospheric assessment models. A similar assessment process is being formulated for spectroscopic data.

- The Transport and Chemical Evolution Over the Pacific (TRACE-P) field experiment was conducted in March/April 2001, had as it's major objectives to (1) determine the chemical composition of the Asian outflow over the western Pacific in spring in order to understand and quantify the export of chemically and radiatively important gases and aerosols, and their precursors, from the Asian continent and (2) determine the chemical evolution of the Asian outflow over the western Pacific in spring and to understand the ensemble of processes that control the evolution. TRACE-P data is currently undergoing detailed review and analysis.

- Operations of the Southern Hemisphere Additional Ozonesonde (SHADOZ) network continues with additional ozonesondes launched from several locations in the tropics and southern subtropics. This program is developing the first ever climatology of upper tropospheric ozone in the tropical region. Most previous efforts to measure ozone in this region have typically been focused on either the Atlantic or the Pacific but not both. This network is done in collaboration with numerous international partners.

3.0 DOC

3.1 NOAA

3.1.1 Goals and Objectives

NOAA's global change efforts are designed to provide a predictive understanding of the climate system and its modes of variability, and to advance the application of this information in climate-sensitive sectors through a suite of process research, observations and modeling, and application and assessment activities. Specifically, NOAA's research program includes ongoing efforts in

operational in situ and satellite observations with an emphasis on oceanic and atmospheric dynamics, circulation, and chemistry; understanding and predicting ocean-land-atmosphere interactions, the global water cycle, and the role of global transfers of carbon dioxide among the atmosphere, ocean and terrestrial biosphere in climate change; improvements in climate modeling, prediction, and information management capabilities; the projection and assessment of variability across multiple timescales; the study of the relationship between the natural climate system and society and the development of methodologies for applying climate information to problems of social and economic consequences; and archiving, management, and dissemination of data and information useful for global change research.

3.1.2 Contributing Elements

Atmospheric Composition – Research activities under this element include:

- Characterizing the "ozone-friendliness" of substitutes for ozone-depleting gases, developing methods for the detection of the recovery of the ozone layer, and characterizing the regional variance of tropospheric ozone and its role in the heat budget.
- Quantifying the trends and sources/sinks of long-lived greenhouse gases, and characterizing the fundamental processes that control the shorter-lived radiative species.
- Advancing efforts to reduce uncertainties in the understanding of direct radiative forcing by tropospheric aerosols through an integrated program focused on targeted in situ measurements of aerosols integrated with model analyses.

To accomplish the above, NOAA employs global monitoring, process-oriented laboratory and field studies, and theoretical modeling to improve predictive understanding of the atmospheric trace gases that influence the earth's chemical and radiative balance, with emphases on stratospheric ozone depletion and greenhouse warming.

Climate Variability and Change – Studies under this element are aimed at

- Increasing understanding of the role in climate variability, and the predictability, of the El Niño-Southern Oscillation, the North Atlantic (or Arctic) Oscillation, Tropical Atlantic Variability, the Pacific Decadal Oscillation, and the Pan-American monsoons.
- Continuing the advancement of the sustained global ocean observing system to support Climate Variability and Predictability (CLIVAR) research, operational and experimental climate forecasting, and the major scientific assessments.
- Advancing the improvement of models and modeling systems for climate prediction at all timescales and the ability to provide regional-scale forecasts and predicted probabilities of extreme weather events.
- Advancing detailed studies of past climate variability on seasonal to centennial time scales using century to millennia-long paleoenvironmental proxy records in order to improve the current understanding of seasonal to decadal variability.
- Developing and applying advanced statistical techniques to detect climate change signals and attribute these to specific causes.

Global Carbon Cycle – This research element focuses on

- Advancing efforts to produce more accurate projections of future atmospheric CO_2 concentrations by better parameterization of transfers of CO_2 between ocean, atmosphere, and terrestrial biosphere, and development of dynamic, coupled carbon cycle models.
- Initiating observations and modeling necessary to quantify the magnitude and variability of the Northern Hemisphere terrestrial sink, with an initial focus on large-scale observations over the North American continent and adjacent ocean basins.
- Continuing to document the inventory of carbon in the ocean as it accumulates, and characterize how that inventory might be affected by changes in ocean circulation in the future.

3.1.3 Specific Laboratory Contributions

3.1.3.1 Aeronomy Laboratory

SOLVE Field Mission - scientists in two NOAA Laboratories, the Aeronomy Laboratory and the Climate Monitoring and Diagnostics Laboratory, participated in a NASA-sponsored experiment to study Arctic springtime ozone loss. The field campaigns of the SAGE III Ozone Loss and Validation Experiment (SOLVE) were conducted from November 1999 to March of 2000, and included several flights of the NASA ER-2 high-altitude research aircraft and the NASA DC-8 medium altitude flying laboratory. Onboard the ER-2 were NOAA instruments that measured ozone, reactive nitrogen compounds, water vapor, and tracer species such as halocarbons and nitrous oxide. The Observations of the Middle Stratosphere (OMS) balloon gondola was also deployed and carried NOAA instruments to measure vertical profiles of trace gases and meteorological parameters. Scientists from NOAA, NASA, academia, and other agencies participated in the experiment. Significant findings from the study were:

- In one of the Arctic stratosphere's coldest winters on record, scientists, during February and March of 2000, measured ozone losses as great as 50 percent at about 60,000 feet altitude in the ozone layer. *Payoff:* The findings may be an indication that future cold winters in the Arctic could prolong the depletion of ozone by manmade chlorine compounds, despite the fact that chlorine is now diminishing in the atmosphere in response to international agreements.
- An unusual class of large PSC particles was observed for the first time, using a NOAA instrument that measures reactive nitrogen compounds in the atmosphere. *Payoff:* The newly discovered class of particles has given scientists a better understanding of the processes that "set the stage" for chlorine-caused ozone depletion in the stratosphere above the Arctic, and will enable scientists to make better predictions of ozone loss in the Northern Hemisphere in the future.

International Ozone-Layer Assessment - NOAA scientists are playing prominent roles in the 2002 international scientific assessment of the ozone layer, in preparation during 2001-2002. The document, World Meteorological Organization/United Nations Environment Programme Scientific Assessment of Ozone Depletion: 2002, will be completed in December 2002 in accordance with the Montreal Protocol on Substances that Deplete the Ozone Layer and available in printed form in spring 2003. Hundreds of scientists worldwide are contributing to the planning, preparation, reviewing, and publication of this document. NOAA scientists are participating as Co-chair, chapter lead authors, chapter authors, chapter contributors, reviewers, and coordinating editor. Payoff: The assessment will give "state-of-scientific-understanding" information regarding the Earth's ozone layer.

Laboratory Studies of Reactions Important To the Stratospheric Ozone Layer - The NOAA Aeronomy Laboratory conducts laboratory studies to elucidate the reaction rates and product pathways of reactions that are important to the stratospheric ozone layer. In 2000/2001, for example, research showed that a degradation product of methyl chloroform was, itself, a chlorine-containing compound (phosgene) that can still transport some chlorine to the stratosphere. This study demonstrates the importance of a complete study of the chemical degradation of an ozone-depleting substance in the troposphere. The Aeronomy Lab's research includes studies that help identify the "ozone-friendliness" of new industry-proposed substitutes for ozone-depleting compounds. A recent emphasis is the study of new proposed compounds that are relatively short-lived in the atmosphere, but which might (through either the initial compound or its degradation products) deliver reactive halogens to the stratosphere. *Payoff:* The complete "chemical picture" is information that is valuable to have in advance of the costly investments that are involved in gearing up to produce and market a new compound.

Advancing the Understanding of Ozone Changes In the Stratosphere - NOAA Aeronomy Laboratory scientists and their colleagues have completed analyses of the data series from ozone stations in Europe, correlating the ozone observations with the North Atlantic Oscillation over the time period since the 1960s. A significant part of the variance in the ozone records is explained by the phase of the NAO. During the NAO "positive" phase, deep intrusions of naturally low-ozone air from the upper tropical troposphere into the mid-latitude lower stratosphere may be an important

process in the observed ozone changes. *Payoff:* The combination of long-term dynamical changes and chemical processes will provide a better understanding of the observed ozone behavior and hence a better predictive capability of the future ozone layer.

NOAA researchers and their colleagues have studied the trends, radiation, and chemistry of a key player in stratospheric ozone-layer processes: water vapor. The trends of water vapor over the past half century have been newly characterized in an international study conducted under the auspices of SPARC. Further, a comprehensive study has examined the effects of observed trends of stratospheric water vapor on both ozone depletion and temperature. The work has shown that water vapor trends have likely made significant contributions to the decline in mid-latitude ozone observed over the past twenty years, and that they played a substantial role in the cooling of the stratosphere. *Payoff:* The efforts help to quantify the role of a key player in the stratosphere, thus advancing understanding of the factors contributing to the observed ozone trends.

Measuring the Chemical Composition Of Individual Atmospheric Particles - This NOAA research elucidated the role of atmospheric particles in sequestering reactive halogen atoms (fluorine, chlorine, bromine, iodine) in the critical tropopause boundary region at the interface of Earth's troposphere and stratosphere. If tightly bound in particles, the halogen atoms are effectively removed from chemical reaction cycles that influence stratospheric ozone depletion processes. Scientists at the Aeronomy Laboratory carried out state-of-the-art airborne measurements of aerosol particles in the hard-to-access tropopause region, characterizing the chemical composition of individual particles in real time. The measurements were made by use of a highly sophisticated instrument developed at the Aeronomy Laboratory, the Particle Analysis by Laser Mass Spectrometry (PALMS) instrument. Particles are sampled into the PALMS instrument during flight and characterized "on the fly", that is, without requiring that samples be collected or stored. The instrument was flown aboard a NASA WB-57F research aircraft during field missions in 1998, 1999, and 2000. Latitudinal transects were completed, and data were also gathered in the exhaust plumes of a rocket and the space shuttle. The resulting powerful dataset has thousands of individual particle mass spectra and contains the most detailed information to date on aerosol chemical composition near the tropopause. *Payoff:* The research has contributed to a better understanding of the role of aerosols in the depletion of ozone in the stratosphere, which will ultimately contribute to an improvement in the predictive capability of models of stratospheric ozone.

3.1.3.2 Climate Monitoring and Diagnostics Laboratory

Ozone Monitoring -

- Dobson Cooperative Observing Network: This consists of16 stations around the world measuring total column ozone with 15 to 40 year records - 9 in continental North America, 2 in Pacific island locations (Hawaii and American Samoa), 1 in South America (Peru),1 in New Zealand (Lauder),1 in Australia (Perth),1 in Europe (France), and1 in Antarctica (South Pole). There are 6 stations measuring ozone vertical profiles using the Umkehr method (Alaska, France, Colorado, Hawaii, Australia, and New Zealand).

- Ozonesonde Network: There are 8 stations making ozone vertical profile measurements (0 – 35 km). Three of these have been operating for15 or more years (Colorado, Hawaii, and South Pole), while the remaining 5 have 3-10 years of data (California, Alabama, Galapagos, Samoa, and Fiji).

- Surface Ozone Network: There are 4 long-term sites (25+ years) and 4 shorter record sites.

Water Vapor Profiles at Boulder, Colorado - Monthly profiles have been obtained from 1980 to present covering the altitude range 5 - 28 km.

Measurements of Ozone Depleting Source Gases (N_2O, Halocarbons, Halons, Halogen Solvents, SF_6) – This network consists of 8 stations equipped with in situ instruments and 14

stations that employ flask sampling
Greenhouse Gases (CO_2, CH_4, N_2O, SF_6, CO) – These measurements are obtained at 6 stations using in situ instruments, and at 47 stations and on 1 ship using flask sampling techniques.

Radiation Measurements – There are 15 stations at which solar and thermal radiation are recorded and 5 stations recording UV radiation.

3.1.3.3 Air Resources Laboratory

Quality is an ongoing and critical concern in any attempt to monitor and explore changes in ozone and UV, and is the major focus of NOAA's Air Resources Laboratory Surface Radiation Research Branch. Understanding the biological effects of UV radiation and determining whether the Montreal Protocol and its amendments are successful depend on measurements that are as accurate as possible. NOAA's Air Resources Laboratory personnel invest substantial effort to attain and ensure high quality UV measurements, and are internationally recognized as the world's leaders in this area. This focus on quality is emphasized by both the Central UV Calibration Facility, which characterizes and calibrates several types of UV instruments used in monitoring network worldwide, and by the Surface Radiation Budget Network (SURFRAD), providing accurate, consistent measurements at sites across the U.S.

UVB monitoring by NOAA's Surface Radiation Budget Network - Broadband erythemal UVB measurements are made by the Surface Radiation Budget Network (SURFRAD), established in 1993 by NOAA's Air Resources Laboratory through the support of NOAA's Office of Global Programs. The network was designed to measure the surface radiation budget, and also provides information on surface erythemal UVB amounts and basic meteorological parameters. Monochromatic solar data, which can be used to recover aerosol loading, have also been archived since operational monitoring began. Currently, six stations are operating in climatologically diverse regions of the United States and are located in regions where the landform and ground cover are nearly homogeneous over an extended region. This homogeneity allows point measurements from the stations to be representative of a larger area for satellite validation work. The SURFRAD stations are located in northeastern Montana (since March 1, 1995), central Illinois (since Jan. 1, 1995), northwestern Mississippi (since January 1, 1995), Boulder, CO (since August 1, 1995), the Nevada Test Site northwest of Las Vegas (since March 16, 1998), and near Penn State in central Pennsylvania (since June 29, 1998). SURFRAD and the Department of Energy ARM/SGP site in Kansas and Oklahoma (which also began in 1995) are the first long-term surface radiation budget networks to exist in the United States.

All SURFRAD instruments are exchanged annually with freshly calibrated units; their calibrations are all traceable to recognized world standards. Daily files of three-minute averaged data from each station are quality controlled and distributed in near real time via anonymous FTP and the world wide web (http://www.srrb.noaa.gov). To further support satellite and model validation activities, an imaging system that records the hemispheric sky and computes the cloud fraction once each minute has been deployed at each station. To bolster the network's utility to radiative transfer research, rawinsonde-type soundings are interpolated to the SURFRAD site locations for 0000 and 1200 UTC each day. Assurances are made that the interpolated soundings are hydrostatically consistent.

SURFRAD data are submitted regularly to the BSRN archive in Zurich, Switzerland. Observations from SURFRAD have been used for validating hydrologic, weather prediction, and climate models, and for satellite determinations of surface UVB and solar irradiance. For example, data from several UV instruments over a three-year period at the Mississippi station were used to demonstrate an 18% bias in TOMS-based clear-sky surface UVB estimates (DeLuisi et al., 2002). Work is continuing to determine the cause of the bias, and whether the method is useful for evaluating UV instrument performance.

The Central UV Calibration Facility (CUCF) - The Central UV Calibration Facility (CUCF) was set up in the mid-1990s to meet the needs of the U.S. Interagency UV Monitoring Program. The internationally recognized facility, located in the Surface Radiation Research Branch of NOAA's Air Resources Laboratory, has developed instrumentation and other laboratory assets worth an estimated $2.5-3.0 million. The WMO recently designated it as the UV calibration facility of North and South America. The CUCF's services, research, and responsibilities continue to grow as the importance of UV science is being increasingly recognized by scientific organizations worldwide. The facility has hosted four spectroradiometer intercomparisons and has provided calibration and installation assistance to foreign countries, including Argentina, Greece, Italy, and New Zealand. Dr. Kathleen Lantz, one of the facility's staff members, serves on a WMO panel for UV instrumentation and has made significant contributions concerning UV measurement technology and calibration.

Assessing Signs of Recovery in Total Column and Vertical Ozone Distributions - With the Montreal Protocol in place, we are currently looking forward to slow, gradual recovery of the ozone layer over coming decades. One critical question for research planning, policy and communication with the public is, "How long will it take until we can see an improvement in the ozone layer?" We have made some of the first steps toward addressing that question using data from the Total Ozone Mapping Spectrometer (TOMS) and predictions from NASA's Goddard Space Flight Center two-dimensional chemical model. These data were used to estimate the length of time needed to detect the expected recovery of the ozone layer (Weatherhead et al., 2000). Because of the variability and autocorrelation associated with the total column ozone data, between 15 and 45 years will be needed to detect recovery in most regions of the world. This recovery is likely to be most readily detected in the Southern Hemisphere near New Zealand, southern Africa, and southern South America. Work is in progress to explore signs of recovery in ozone profile data from the Solar Backscattering UV (SBUV) series of instruments and from the Umkehr record.

Different processes dominate ozone depletion at different altitudes of the atmosphere. Vertical ozone profile measurements therefore play an important role in identifying the influences of these processes, and in detecting signs of recovery. The historical Dobson Umkehr record began in 1956 and provides retrievals of the vertical ozone profile. Improvements to the Umkehr ozone profile retrieval algorithm have been developed and are now being implemented. One of the changes in the algorithm (Petropavlovskikh et al.) eliminates the bias due to total ozone trends, which is known to affect the existing Umkehr ozone profile record. The updated algorithm is able to simulate observations more accurately and provides data output that is easier to analyze. The updated retrievals are being compared with ozonesonde, lidar, and other highly resolved vertical profile data and can provide high quality information for identifying signs of ozone recovery at altitudes where decreases in ozone-depleting substances would influence the first signs of a turn-around. For instance, the earliest signs of recovery may be expected to occur at around 40 km altitude where CFC chemistry is the prevailing factor in ozone destruction. Questions about the effect of human activities on chemical ozone destruction and recovery will likely be most easily answered by examining ozone variability at the 40-km altitude. The Umkehr measurements have very solid information about ozone variability, and loss and recovery rates at this level. The long historical record can also provide additional information for separating the dynamic and chemical mechanisms of depletion, and can help the community better understand climate change effects.

Analysis of UV Network Data - Scientists in NOAA's Air Resources Laboratory have worked on quality assurance and data analysis issues using Brewer Mark IV observations from the Environmental Protection Agency/University of Georgia's UV monitoring network. The network is operated collaboratively with the National Park Service and includes instruments at 14 national parks and in 7 urban areas. Weatherhead et al. (2001) have completed work to characterize the temperature dependence of the Brewer Mark IVs, which are used for ground-based UV and ozone monitoring worldwide. Additional work is in progress to explore latitudinal and seasonal relationships between noontime UV dose rate and daily-integrated UV amounts. Improved understanding of UV levels, changes, and effects requires good estimates from satellite, well-maintained ground-based monitoring, and robust models. Only by combining and utilizing all three of these elements can the links between UV and biological effects be understood.

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3.2 *NIST*

3.2.1 Goals and Objectives

NIST activities pertinent to stratospheric ozone chemistry and ground level UV radiation are in the areas of (1) laboratory and computational studies of the kinetics, thermodynamics, photochemistry, and spectroscopy of ozone-related and climate-related trace gases, (2) data evaluation activities aimed at providing a reliable kinetic and photochemical database for use in atmospheric modeling, (3) participation in international ozone assessment activities as reviewers and authors, and (4) research to provide for more accurate measurements ground-level changes in damaging ultraviolet radiation.

3.2.2 Contributing Elements

Laboratory and Computational Studies - NIST researchers conduct laboratory studies that emphasize photochemical and kinetic measurements contributing to the general understanding of the chemistry of the stratosphere and upper troposphere, with a specific emphasis on stratospheric ozone. In particular, these laboratory experimental activities focus on measurements of the gas-phase rate constants for the reactions of hydroxyl radicals with anthropogenic and naturally occurring ozone-related and climate-related trace gases. These include partially halogenated hydrocarbons, other species under consideration as replacements for the fully halogenated chlorofluorocarbons (CFCs), and other naturally occurring or anthropogenically produced compounds important in determining the chemical and/or radiative balance of the Earth's atmosphere. The results of these determinations are used together with measurements of ultraviolet absorption cross-sections (also measured in the NIST laboratories) to estimate the atmospheric (tropospheric) lifetimes of such compounds. These atmospheric lifetimes are critical modeling input parameters for the estimation of Ozone Depletion Potentials (ODPs) and Greenhouse Warming Potentials (GWPs) upon which decisions are made regarding the

environmental acceptability of such chemicals. These photochemical kinetic studies emphasize areas of moderate uncertainty and sensitivity identified by the NASA Data Panel as well as through interactive discussions with the international atmospheric experimental and modeling communities and members of the technical communities interested in environmentally same industrial chemicals and fire suppressants. In addition, infrared band strengths are measured for selected chemicals to provide estimates of their GWPs. A program of ab initio rate constant calculations augments the experimental program by providing reactivity and lifetime estimates beyond those that are derived from the experimental kinetic data base for OH reactions. In addition to developing and applying computational methods for calculating the chemical and physical properties of selected species and systems, this activity is aimed at establishing the accuracy and reliability of computational methods and developing resources to provide guidance to non-experts on methods, reliability, and resource requirements for such computations.

Data Evaluation - NIST maintains a Chemical Kinetics Database that includes essentially all reported kinetics results for thermal gas-phase chemical reactions. The database is designed to be searched for kinetics data based on the specific reactants involved, for reactions resulting in specified products, for all the reactions of a particular species, or for various combinations of these. In addition, the bibliography can be searched by author name or combination of names. The database contains in excess of 38,000 separate reaction records for over 11,700 distinct reactant pairs. These data have been abstracted from over 12,000 papers with literature coverage through early 2000. NIST researchers also serve as members of NASA's Panel for Data Evaluation. This Panel meets up to twice yearly to prepare published evaluations of photochemical, thermodynamic, and kinetic data for use in atmospheric modeling. These reports have been issued as both NASA Reference Publications and as publications of the Jet Propulsion Laboratory (via both printed and electronic media).

Ozone Assessment Activities - NIST scientists played prominent roles as authors and reviewers for various chapters in the 1998 scientific and technology assessments conducted under the auspices of WMO and UNEP for the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. Similar participation exists for the current WMO/UNEP assessments in preparation during 2001-2002 and targeted for completion in December 2002.

UV Standards and Calibration Research - NIST scientists engage in activities to specify, standardize and categorize UV instruments (spectral, narrow band, and broadband) in order to provide for more accurate measurements of ground-level changes in damaging ultraviolet radiation from the sun. Such measurements are crucial in assessing effects of ozone depletion in the upper atmosphere on human health, agriculture, fisheries and materials such as concrete, plastics and paints. In partnership with NOAA NIST maintains an intercomparison and research site at Table Mt., CO. The goal of such research to help the various UV monitoring agencies achieve high levels of accuracy in UV measurements so that readings from different networks in different locales will be reliable in calculating global trends. Continuous calibration will be needed to ensure the long-term data quality. To do this, routine intercomparison of spectral instruments will be an integral part of each network's operations. As a non-regulatory agency of the Commerce Department's Technology Administration, NIST promotes U.S. economic growth by working with industry to develop and apply technology, measurements and standards.

4.0 NSF

4.1 *Goals and Objectives*

NSF programs address global change issues through investments in challenging ideas, creative people, and effective tools. In particular, NSF global change research programs support research and related activities to advance the fundamental understanding of dynamic physical, biological, and human systems and the interactions among them. The programs encourage interdisciplinary activities with particular focus on Earth system processes and the consequences of change. NSF programs facilitate data acquisition and information management activities necessary for

fundamental research on global change, and promote the enhancement of models designed to improve our understanding of Earth system processes and interactions and to develop advanced analytic methods to facilitate basic research. NSF also supports fundamental research on the general processes used by organizations to identify and evaluate policies for mitigation, adaptation, and other responses to the challenge of varying environmental conditions

4.2 *Contributing Elements*

NSF will continue to invest in collaborative international programs such as the World Climate Research Programme, the International Geosphere-Biosphere Programme, and the International Human Dimensions Programme. A major focus on atmospheric composition and chemistry will continue through programs in tropospheric chemistry. Studies of atmospheric transport of aerosols will provide insights into how aerosols affect the radiative and cloud nucleating properties of the atmosphere, and ultimately the climate. In concert with its agency partners, NSF will continue its emphasis on climate variability and change. This is a major activity for the Agency and consists of support for observational campaigns and numerous analytical and modeling activities, as well as paleoclimate studies.

Specific activities in the area of stratospheric chemistry include:

- Balloon-borne measurements of ozone and aerosol profiles: Antarctica, SH and NH mid-latitudes; ClO and BrO in mid-latitude cirrus and Arctic PSCs
- Instrument development and participation in airborne stratospheric measurement campaigns
- Ground-based measurements of OH column abundance
- Sample analysis, laboratory and theoretical studies aimed at an improved understanding of the isotopic composition of major stratospheric constituents
- Laboratory and theoretical spectroscopy studies of trace gases relevant to the stratosphere
- Laboratory and *ab initio* modeling studies of gas phase reactions and heterogeneous processes on surfaces representing polar stratospheric cloud particles
- Development and application of chemical transport models describing stratospheric chemistry, near-tropopause transport, and chemistry/climate interactions
- Studies of the budget of halogenated hydrocarbons and fate of CFC-substitute compounds

In the area of ground-based UV monitoring, NSF has an active program within the polar regions. Pertinent details of this activity include the following:

- Established in 1987: sites at McMurdo, Palmer and South Pole (Antarctica), Ushuaia (Argentina) Barrow (AK), San Diego (CA). Site to be established at Summit Greenland
- Instrument: SUV-100 scanning spectroradiometer (Biospherical Instruments)
- Data Products: Full-resolution spectra from 280-600 nm, measured quarter hourly
- Databases with spectral integrals and biologically weighted irradiance for various action spectra and with spectral measurements at selected wavelengths
- Databases with daily doses
- Preliminary data available weekly via the website <www.biospherical.com/nsf>
- Final data available on CD-ROM or via website

5.0 DOE

5.1 *Goals and Objectives*

Research supported by DoE's Office of Biological and Environmental Research (BER) addresses the effects of energy production and use on the global Earth system, primarily through studies of climate response. It includes research in climate modeling, atmospheric chemistry and transport, atmospheric properties and processes affecting the Earth's radiation balance, and sources and sinks of energy-related greenhouse gases (primarily CO_2). It also includes research on the

consequences of atmospheric and climatic changes on ecological systems and resources, critical data needs for the detection and attribution of climate change, and tools and methods needed to conduct scientific assessments of climate change, and education and training of scientists and researchers in global change.

5.2 *Contributing Elements*

5.2.1 Atmospheric Chemistry and Carbon Cycle - DoE will continue the support of field, laboratory, and modeling studies to improve our understanding of the atmospheric processes associated with transport, transformation, and dispersion of energy-related emissions and their effects on air quality and climate, including studies of oxidants, aerosols, and the heterogeneous chemistry of these materials. It will also include studies of the dispersion of energy-related materials through the lower troposphere to help understand the fundamental processes that control vertical transport for stable and transition boundary layers and how pollutants move through these layers in the lower atmosphere.

Research in both terrestrial and marine environments will be continued to improve understanding of the global carbon cycle. DoE will continue field CO_2 enrichment experiments (FACE), observations of net CO_2 exchange between the atmosphere and biosphere (AmeriFlux), and dynamic modeling of the carbon cycle and its relationship to climate influences. This research will focus on biophysical controls, biogeochemical mechanisms and climate-related feedbacks of terrestrial carbon cycling. Data from experiments and tested carbon cycle models will be used for predictions of future atmospheric CO_2 change and for estimating quantity and longevity of carbon sequestration by terrestrial ecosystems. Support for experiments and AmeriFlux measurements continues to be a high priority. DoE also will continue to fund the development and application of new molecular biological probes to carbon and nitrogen cycles in near shore marine environments. A field experiment combining a range of new probes with biogeochemical rate measurements and satellite imagery will be planned for a well-characterized near-shore site.

5.2.2 Climate and Hydrology - DoE will continue the development of advanced diagnostics and an on-line diagnostic library to evaluate the ability of climate models to simulate and predict climate variability and change. To better connect observational and modeling research programs, DoE will implement a parameterization test bed that will facilitate the development and implementation of improved physics modules into climate models. Additionally, extensive effort will be directed toward advancing the computational, numerical, and software engineering aspect of climate models as part of the Scientific Discovery through Advanced Computing Program in DoE's Office of Science.

Using data collected at the Atmospheric Radiation Measurement (ARM) Cloud and Radiation Testbed sites, DoE's ARM Program will continue measurement and modeling efforts to improve the radiative flux calculations and associated heating rates in climate models.

5.2.3 Related Research - DoE plays a major role in carbon sequestration research to slow the increase in atmospheric concentrations of energy-related greenhouse gases, especially carbon dioxide, and their emissions to the atmosphere. The research builds on but is not part of the USGCRP. It focuses on developing the understanding needed both to enhance the net carbon sequestration of excess CO_2 from the atmosphere in terrestrial and ocean systems and to assess the potential environmental consequences and ancillary benefits. DoE (in collaboration with NSF) will support an iron-fertilization experiment in the Southern Ocean, the largest high nutrient-low chlorophyll region in the world's oceans, focusing on quantifying the amount of carbon that is exported to the deep ocean - a prerequisite for carbon sequestration.

6.0 EPA

6.1 *Goals and Objectives*

EPA's Global Change Research Program is an assessment-oriented program with primary emphasis on understanding the potential consequences of climate variability and change on human health, ecosystems, and socioeconomic systems in the United States. This entails: (1) improving the scientific basis for evaluating effects of global change in the context of other stressors and human dimensions (as humans are catalysts of and respond to global change); (2) conducting assessments of the risks and opportunities presented by global change; and (3) assessing adaptation options to improve society's ability to respond effectively to the risks and opportunities presented by global change as they emerge.

6.2 Contributing Elements

Few studies have investigated the effect of global change on air quality. Given EPA's legal mandates with respect to air pollution and substantial capability and expertise in modeling air quality and evaluating integrated response actions, examining the effects of global change on air quality is a logical focus of the Global Program. Assessments are planned that will examine the potential consequences of global change on tropospheric ozone and particulate matter. The air quality assessments will provide input to related human health assessments.

7.0 DHHS / NIH

7.1 *Goals and Objectives*

Three NIH institutes support research on the health effects of UV and near-UV radiation. Their principal objectives include an increased understanding of the effects of UV and near-UV radiation exposure on target organs (e.g., eyes, skin, immune system) and of the molecular changes that lead to these effects, and the development of strategies to prevent the initiation or promotion of disease before it is clinically defined. In addition, the National Institute of Environmental Health Sciences (NIEHS) supports research on the health effects of CFC replacement chemicals, including studies on the metabolism and toxicity of HCFCs and halogenated hydrocarbons.

7.2 *Contributing Elements*

The NIEHS program supports grants and intramural projects that investigate the effects of UV exposure on the immune system, aging process, sensitive tissues such as the retina and skin, and methods to reduce these harmful effects. Other projects involve the comparison of mutagenic potential in bacteria of UV and near-UV radiation at levels found in natural sunlight and at levels anticipated with a 15 percent depletion of stratospheric ozone. Several projects supported by NIEHS are investigating molecular changes in DNA that lead to aberrations and mutations in human tissue, rodents, fruit flies, and bacteria, and the variety of ways these organisms repair damage to DNA resulting from UV exposure.

The National Eye Institute (NEI) supports studies on the impacts of UV radiation on the eye (retinal damage as well as corneal capacity). A major initiative is underway to determine how and why eye cataract develops and to search for ways to prevent or slow the progression of cataract, an age-related eye disease that affects 17-20 million people globally. This project is investigating the role of UVB radiation, which has been implicated as a specific risk factor in cataract development. Another important area of research is the understanding of certain detoxification systems in the eye and how they combat damage from UVB radiation. The goal of this effort is to identify drugs that might have therapeutic or preventative applications.

The National Cancer Institute (NCI) is supporting a wide range of studies to characterize the etiology, biology, immunology, and pathology of a variety of changes in the skin (morphological

effects that might precede skin cancer), including photoaging, non-melanoma skin cancers, and melanoma caused by exposure to UV radiation. Other research is exploring UV-induced immunosuppression, which is critical to the development of UV-induced skin tumors, and the cellular and molecular basis for the genetic predisposition to UVB-induced skin cancer in people with Basal Cell Nevus Syndrome.

The National Institute of Arthritis and Muscoloskeletal and Skin Diseases (NIAMS) supports basic and clinical research on the effect of UVA and UVB radiation on skin.

8.0 USDA

8.1 *Goals and Objectives*

USDA-sponsored research focuses on understanding terrestrial systems and the effects of global change (including water balance, atmospheric deposition, vegetative quality, and UV-B radiation) on food, fiber, and forestry production in agricultural, forest, and range ecosystems, examining the role of managed and unmanaged terrestrial systems in the global carbon cycle, and assessing how agricultural and forestry activities can contribute to a reduction in greenhouse gas concentrations.

8.2 *Contributing Elements*

As part of the collaborative interagency Carbon Cycle Science Program, USDA conducts research on how land management practices affect the net carbon balance and develop methods to assist farmers, ranchers, and forest landowners in increasing carbon sequestration and better managing other greenhouse gas emissions. USDA will continue to quantify carbon sources and sinks from land management activities, including fluxes for all U.S. forest and agricultural lands and other land uses. The implications of changes in water quality and availability on agricultural and forestland productivity will be assessed. USDA research will examine the economic implications of alternative greenhouse gas offset strategies. In addition, USDA will continue to assess how resilient managed agricultural, rangeland, and forest ecosystems are to climate change and what adaptation strategies will be needed to adjust to a changing climate.

The Agricultural Research Service (ARS) will focus on four broad research areas: 1) studies of the carbon cycle and carbon storage, emphasizing identification and quantification of the current and potential roles of agriculture in the global carbon cycle with sufficient accuracy to inform policy and aid producers in making decisions that are both economically and environmentally sound; 2) managing non-carbon dioxide trace gases, such as methane and nitrous oxide, which are produced by certain processes in some crop and animal production systems; 3) determining the impacts of increased atmospheric carbon dioxide, rising temperatures, and altered water availability on crops and their interactions with other biological components of agricultural ecosystems; and 4) characterizing and measuring changes in weather and the water cycles at local and regional scales, and determining how to manage agricultural production systems facing such changes.

The Economic Research Service (ERS) will continue to focus on two broad research areas: 1) the long-run impacts of the accumulation of greenhouse gases on agriculture, including effects resulting from changes in temperature and precipitation, and from carbon dioxide fertilization; and 2) the economic implications of alternative net greenhouse gas emission reduction and carbon sequestration options for U.S. agriculture.

The Cooperative State Research, Education, and Extension Service (CSREES) will continue to support the USDA UV-B Monitoring Network. Information from this research network is combined with satellite-based measurements to provide an accurate climatological UV-B irradiance database. This database documents long-term trends and supports research and assessment of the potential for damage to ecosystems. Global change research in CSREES's National Research Initiative (NRI) Competitive Grants Program and formula-funded programs aims to increase

understanding of the possible impacts of global environmental change on the sustainability of agriculture and forestry.

8.2.1 UVB Monitoring and Research Program

Langley Calibrations - Accurate calibration of UV ground-based radiometers is crucial in identifying trends in UV radiation, developing UV climatologies, and quantifying the amount of short-wave radiation absorbed by clouds and aerosols. The Langley method of calibrating UV multi-filter shadow-band radiometers (UV-MFRSR) is explored by Slusser et al. (2000). This method has several advantages over the traditional standard lamp calibrations: radiometer signal level is optimal during the Langley event, the Sun is a free, universally available and very constant source (to within <0.5% between 300 nm and 400 nm over the 11-year solar cycle) and nearly continual automated field calibrations can be made for each Langley event. Difficulties arise as a result of changing ozone optical depth during the Langley event and the breakdown of the Beer-Lambert law over the finite filter band-pass since optical depth changes rapidly with wavelength. The Langley calibration of the radiometers depends critically upon the spectral characterization of each channel and on the wavelength and absolute calibration of the extraterrestrial spectrum used.

Results of Langley calibrations made over a period from January 1 through September 30, 1998 for two UV-MFRSRs at Mauna Loa HI (3.4 km elevation) were compared to calibrations made at CUCF using two National Institute of Standards and Technology (NIST) traceable lamps. The objectives of this study were to compare Langley calibration factors with those from standard lamps and to compare field-of-view effects. The two radiometers were run simultaneously: one on a Sun tracker with a collimated full field of view of about 2.0 degrees and the other in the conventional shadow-band configuration. After 2 months the positions of the radiometers were switched. After another 2 months the radiometers were left in place but the field-of-view for the tracker radiometer was narrowed to 1.5 degrees. Both radiometers were calibrated May 15, 1998 at the CUCF with two secondary 1000-W lamps. The spectral response functions of the channels were measured at the CUCF on October 15, 1998. Over a 9-month period the ratio of Langley to lamp calibration factors for the 7 channels from 300 nm to 368 nm using the shadow-band configuration ranged from 0.948 to 1.025. The estimated uncertainty in the Langley calibrations ranged from ±5.5 % at 300 nm to ±2.4% at 368 nm. For all channels calibrated with CUCF lamps the estimated uncertainty was ±1.6%. Thus for each channel of the two radiometers the agreement between the two methods was within the combined uncertainties of the two methods. Differences between the Langley and lamp calibration factors were much larger at shorter wavelengths using the Langley tracker results, probably due to changing ozone during the Langley event.

Aerosol Properties - Aerosols are suspended atmospheric particles in the solid or liquid phase excluding cloud droplets or precipitation. These particles are of critical importance to the hydrological cycle because they provide condensation sites upon which cloud droplets form in slightly supersaturated air. In addition aerosols scatter and absorb solar radiation, changing the amount of UV reaching the earth's surface as well as modifying the heating of the atmosphere. The USDA UV-B Monitoring Network has the capability to report optical depths, a measure of the total aerosol loading, at 30 sites across the continental U.S. Each of the sites of the UV-B Monitoring Network is equipped with both a UV-MFRSR and a Visible-MFRSR which by measuring the direct beam return the total optical depths on clear days at a total of 13 wavelengths from 300 nm to 940 nm. This constitutes the largest U.S. network of ground-based aerosol optical depths and thus provides atmospheric scientists with a unique data set with which to constrain their models that quantify precipitation processes, aerosol and cloud formation, and global warming.

The Southern California Ozone Study (SCOS97) involved a whole suite of chemical, optical, and meteorological measurements taken in an effort to understand the causes of urban tropospheric pollution in the Los Angeles basin. Two USDA UV-MFRSRs were loaned to the experiment to determine UV irradiances, as well as total and aerosol optical depths (Vuilleumeir et al. 2001). One was placed atop Mt. Wilson and the other in urban Riverside. It was determined that the total optical depths are a necessary input into air quality pollution models.

Ozone Retrievals - Column ozone has been retrieved by Slusser et al. (1999) under all sky conditions at Table Mountain, Colorado (40.177N, 105.276W) from global irradiances of the UV-MFRSR 332 nm and 305 nm channels (2 nm FWHM) using lookup tables generated from a multiple scattering radiative transfer code suitable for solar zenith angles up to 90 degrees. For five months in 1996-97 the mean ratio of column ozone retrieved by the UV-MFRSR divided by that retrieved by the collocated Brewer was 1.024 and for the UV-MFRSR divided by those from a nearby Dobson was 1.025. The accuracy of the retrieval becomes unreliable at large SZA > 75 degrees as the detection limit of the 305 nm channel is reached and due to overall angular response errors.

Direct Sun column ozone has been retrieved under all sky conditions in Mauna Loa HI and the Canadian sites of Bratt's Lake and Toronto (Gao et al., 2000). The mean ratio of column ozone retrieved by the UV-MFRSR divided by that retrieved by the collocated Dobson was 0.969 in Mauna Loa between Julian date 150 and 270 in 1999. Comparisons were also made with Brewers in Canada. The ratio of column ozone retrieved by the UV-MFRSR divided by that of a Brewer was 1.022 in Toronto between Julian date 120 and 240 in 1999, and 1.001 in Regina between Julian date 160 and 250. The UV-MFRSR advantages of relatively low cost, unattended operation, automated calibration stability checks using Langley plots, and minimal maintenance make it a unique instrument for column ozone measurement.

Synthetic Spectra - Plant, animal, and materials effects researchers often want to multiply their particular action spectrum by the spectra measured to estimate damage due to UV. Because of this a study was initiated to use a model to "fill in the pieces" from the 7 channel UV radiometer measurements and construct the entire spectrum. We retrieved a number of synthetic spectra from the 7 channel UV-MFRSR data and made comparisons of these spectra with spectral measured from collocated spectrometers at Boulder CO (Gao et al., 2002). Erythemal doses are generally within ±5% for all SZA < 75 degrees. The study was presented at the Society of Photo-Optical Instrumentation Engineers UV Meeting in San Diego in July 2001.

Radiometric Stability - Bigelow and Slusser (2000) evaluate the stability of the Ion-Assisted-Deposition (IAD) filters used in both prototype and production models of the UV-MFRSR. Based upon an initial examination of a few prototype and production instruments it appeared that there was an approximate 1% per year decline in each instruments' I_o values due to filter instability. The IAD filters are much more stable than the filters in VIS-MFRSRs as reported by Bigelow et al. (1998).

Comparisons of UV-MFRSRs with TOMS and Radiative Transfer Model - Slusser et al. (2002) compared irradiances from a UV-MFRSR with those from a radiative transfer model (TUV) (Madronich, 1993) and NASA TOMS retrievals. Sensitivity tests of the modeled ratio of direct to diffuse irradiances for different aerosol absorption were made for Big Bend of Texas. Clear sky retrievals at New Mexico and Oklahoma generally agreed to within ±4% of the TUV model and the satellite retrievals.

Spectrometer Research Network - Six high-resolution U-1000 1.0 m double spectrometers have been developed by Dr. Lee Harrison of SUNY Albany (Harrison et al., 2002). The first has been completed and installed at the NIST / NOAA research site at Table Mountain CO. This instrument has been operating since December 1998 and the performance has been good although there has been a steady decline in responsivity. The instrument resolution (0.1 nm), out-of-band rejection (10^{-10}), wavelength accuracy and repeatability (±0.02 nm), and cosine response exceed the specifications of any spectrometer in the world. Unlike the Brewer, the instrument is tightly temperature controlled, making it extremely reliable for periods of time directly following a calibration. Data from the instrument are being used to calibrate the triad of UVB-1 broadbands, which in turn are used to calibrate the 44 UVB-1 broadbands (Lantz et al., 1998). The second instrument was installed at the DoE Central Plains ARM CART site near Billings, Oklahoma in September 1999. Currently only the Table Mountain CO instrument has been calibrated. Three automated portable calibrators have been completed and during 2002 will be cycled through the three sites to establish calibration. NASA has expressed interest in the data to validate their

retrievals, in particular at wavelengths shorter than 305 nm. NASA is also interested in the magnitude of Raman scattering, which can be studied with U-1000 due to its very fine resolution.

Long Term UVB Broadband Time Series - Frederick et al. (2000) analyzed a four-year time series at 10 USDA sites to determine the influence of solar zenith angle, column ozone, and clouds on seasonal and year-to-year variability in UV irradiances. One conclusion is that variations in cloud cover contribute more than variations in column ozone in the observed year-to-year changes in UV irradiances. The UVMRP collected the broadband monthly sums for all of its 31 sites. These sums show a maximum yearly total at New Mexico and a minimum at Maine.

Other Cooperative Research - Funding was secured from NOAA for a full climatological site at Poker Flat, Alaska. This new site will be an integral part of NOAA's effort to study the effects of ozone and aerosols on Arctic UV It was installed in September 2000. This is the first use of a UV-MFRSR in the Arctic. A new site was installed in September in Starkville, MS. Data from the site in MS will be used in collaboration with the research of Dr. K. R. Reddy of Mississippi State University who is studying UV effects on cotton. This data will also be used by Remote Sensing Technology Center at MSU to provide accurate information to support Precision Farming.

Details of Monitoring Activities - All 2000 and 2001 7 channel UV-MFRSR data (Bigelow et al., 1998) is archived at the WOUDC. The instruments are calibrated at the NOAA Central UV Calibration Facility in Boulder, CO. Data for most sites extends back to January 1, 1999.

List of USDA UVB Climate Sites

Site	Lat.	Long.	Elev.	Town	State
AK02	65.119	147.430	510	Fairbanks	Alaska
AZ02	36.058	112.183	2073	Flagstaff	Arizona
CA02	38.529	121.761	18	Davis	California
CA22	32.806	115.444	-18	Holtville	California
CO02	40.792	104.755	1641	Nunn	Colorado
CO12	40.450	106.734	3220	Steamboat Sp.	Colorado
CO99	40.177	105.276	1524	Longmont	Colorado
FL02	25.383	80.683	0	Homestead	Florida
GA02	33.175	84.407	270	Griffin	Georgia
HI02	19.539	155.578	3397	Hilo	Hawaii
IL02	40.045	88.368	213	Bondville	Illinois
IN02	40.475	86.992	216	W. Lafayette	Indiana
LA02	30.358	91.166	7	Baton Rouge	Louisiana
MD02	38.916	76.149	7	Queenstown	Maryland
MD12	39.015	76.950	34	Beltsville	Maryland
ME12	46.681	68.038	144	Presque Isle	Maine
MI02	45.555	84.666	238	Pellston	Michigan
MN02	47.181	93.533	390	Grand Rapids	Minnesota
MS02	33.469	88.782	85	Starkville	Mississippi
MT02	48.310	105.100	634	Poplar	Montana
NE02	41.133	96.483	353	Mead	Nebraska
NM02	32.617	106.742	1317	Las Cruces	New Mexico
NY02	42.876	77.029	218	Geneva	New York
NZ02	-45.038	-169.684	370	Alexandra	New Zealand
OK02	36.617	97.500	317	Billings	Oklahoma
ON02	43.780	79.470	198	Toronto	Ontario
SK02	50.197	104.700	580	Regina	Saskatchewan
TX02	29.133	103.517	670	Panther Jnct.	Texas
UT02	41.666	111.900	1368	Logan	Utah
VT02	44.533	72.856	408	Burlington	Vermont
WA02	46.750	117.183	804	Pullman	Washington
WI02	44.708	89.766	381	Dancy	Wisconsin

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9.0 DOD

9.1 *Goals and Objectives*

The Department of Defense does not support dedicated Global Change Research, but continues a history of participation in the USGCRP through sponsored research that concurrently satisfies National Security requirements and stated Goals of the USGCRP.

9.2 *Contributing Elements*

9.2.1 Atmospheric Composition - The Naval Research Laboratory's (NRL's) Special Sensor Ultraviolet Limb Imager, presently awaiting a launch vehicle, will provide long-term baseline data for investigations of global change in the upper atmosphere. Analysis and prediction of world-wide aerosol concentrations, including desert dust, biomass smoke, marine and anthropogenic aerosols, and a radiative transfer algorithm yielding atmospheric transmission coefficients is generated by the Navy Aerosol Analysis and Prediction System (NAAPS).

Other DoD research associated with the US atmospheric chemistry focuses on space and ground-based measurements of ozone, aerosols, water vapor and other trace species. DoD investments in new and novel sensors include the third generation Polar Ozone and Aerosol Measurement (POAM III) sensor system aboard the French SPOT satellite, which is providing high-resolution stratospheric ozone measurements to complement data from NOAA and NASA satellite sensors (TOMS/SBUV). A Ballistic Missile Defense Organization satellite instrument, the Ultraviolet and Visible Imager and Spectrographic Imager (UVISI) aboard the MSX satellite, with NASA support for data analysis has been used to obtain atmospheric ozone profiles using stellar occultation. This is a promising new technique for ozone profiling, as it provides many more occultation opportunities than either solar or lunar occultations and enables greatly expanded spatial coverage. The Naval Research Laboratory is responsible for operation of ground-based microwave instruments at a number of NDSC stations.

The US Defense department is a partner with NASA and NOAA in the US National Polar Orbiting Environmental Satellite System (NPOESS), which will deploy an Ozone Mapping and Profiling Suite (OMPS) that encompasses the capabilities of TOMS and will maintain backscatter UV measurement of total ozone and stratospheric profiles indefinitely in the future.

9.2.2 The POAM Measurement Program - The POAM measurement program was originally supported by the Ballistic Missile Defense Organization with the objective of characterizing atmospheric propagation at laser wavelengths over the poles, for laser weapon and surveillance system applications. Emphasis on stratospheric ozone was added by NRL. POAM is an example of a DoD duel use program, having relevance to the military and also to basic science. POAM is currently supported by NRL and NASA (through the Data Buy Program).

Unique Valuable Measurements: POAM II was in operation from October 1993 – November 1996, and POAM III from March 1998 – present. During the large majority of this time (the only exception being November 1996 - May 1997 when ILAS I was in operation) POAM has been the only operational instrument providing measurements of ozone and related constituents in the polar regions on a continuous basis and has supplied the only satellite-based PSC climatology.

Ozone Depletion: POAM was an important contributor to the SOLVE/THESEO-2000 campaign, providing measurements to the SOLVE data base within 24 hours of acquisition. In addition, the POAM team provided a proxy global ozone product (from potential vorticity / ozone correlations) on a daily basis to provide overhead ozone for computation of J values in photochemical model calculations. POAM has now monitored the formation and dissipation of the ozone hole in unprecedented detail for 8 years and has also provided the first detailed satellite measurements of the dehydration of the Antarctic stratosphere, which is critical phenomenon for ozone hole formation and also plays a role in the middle atmospheric water vapor budget.

UT/LS Processes: POAM measurements and subsequent analysis have provided the first evidence that tropospheric smoke generated in forest fires can reach the lower stratosphere. The mechanism for this cross tropospheric transport appears to be intense thunderstorm activity generated by a combination of severe mesoscale / synoptic scale meteorological forcing and the intense heat generated by the fires. The extent and ramifications, regarding perturbations in the radiation field, of this aerosol source are under investigation. The climatological impact may be significant. Both the POAM ozone and water vapor measurements have now been pushed into the upper troposphere. Validation efforts show that the UT/LS ozone and water vapor products are clearly of sufficient quality for scientific research. These measurements have been used to diagnose the roles of horizontal, isentropic transport from the low latitude upper troposphere and diabatic descent from the mid-stratosphere in establishing the distribution of ozone and water vapor in the high latitude lowermost stratosphere.

Mesosphere / Stratosphere Coupling: On two occasions POAM observed enhanced NO_2 in the lower stratosphere, which has been traced to enhanced NO_x from the mesosphere and lower thermosphere that descended into the vortex during polar night. The effect of the enhanced NO_x on ozone loss in the mid-stratosphere has also been documented (resulting in localized ozone reductions of up to 40%). POAM has provided the first measurements and climatology of polar mesospheric clouds (PMCs) in extinction. The advantage of making these measurements in extinction is that this simple geometry allows properties of the PMC particle size distribution to be readily deduced. For example, the determination that the upper limit to the PMC modal particle radii is about 70 nm is consistent with SME particle size inferences. The POAM PMC climatology has been compared with that obtained 10 years earlier by the SME satellite. A significant increase in the cloud brightness between SME and POAM has been found. The increased cloud brightness may be an indicator of global change resulting from increased water vapor and decreased temperatures in the middle atmosphere.

10.0 SI

10.1 *Goals and Objectives*

Within the Smithsonian Institution, global change research is conducted at the Smithsonian Astrophysical Observatory (SAO), the National Air and Space Museum, the Smithsonian Environmental Research Center (SERC), National Museum of Natural History, Smithsonian Tropical Research Institute (STRI), and National Zoological Park. Research is organized around themes of atmospheric processes, ecosystem dynamics, observing natural and anthropogenic environmental change on daily to decadal time scales, and defining longer-term climate proxies present in the historical artifacts and records of the museums as well as in the geologic record at field sites. The Smithsonian Institution program strives to improve knowledge of the natural processes involved in global climate change, provide a long-term repository of climate-relevant research materials for present and future studies, and to bring this knowledge to various audiences, ranging from scholarly to lay public. The unique contribution of the Smithsonian Institution is a long-term perspective, e.g., undertaking investigations that may require extended study before producing useful results and conducting observations on sufficiently long (e.g., decadal) timescales to resolve human-caused modification of natural variability.

10.2 Contributing Elements

10.2.1 Atmospheric Composition - Researchers at SAO study stratospheric trace species that play an important role in ozone photochemical cycles using balloons, airplanes, and satellites. Solar activity and irradiance are being studied to understand better the climatic effects of solar variability. At SERC, measurements will be made of spectral UV-B in Maryland (>25-year record), Florida, Arizona, and other sites in the United States. These data will be disseminated electronically to meet the needs for assessing the biological and chemical impact of varying UV exposure.

10.2.2 UV Radiation Monitoring - The Smithsonian Institution is a participant in the US Interagency Ultraviolet Radiation Monitoring Network, with the overall goals of defining short- and long-term variation in spectral UV-B; studying the variation of UV-B over latitudinal gradients as well as the effects of clouds and other factors, such as aerosols, on UV-B. The program also supports SERC's program of UV-B effects research, which is conducted by SERC's Photobiology/Solar Research Laboratory (SRL). A priority in the SRL research program has been the development of an instrument that provides sufficient spectral resolution for evaluation of wavelength-dependent UV-B responses, yet is less complicated and easier to operate than the available high-resolution scanning instruments. A basic objective is to design simple and rugged instruments that are serviceable for continuous monitoring under a wide range of temperature and weather conditions. To this end, SRL has designed, built, calibrated and operated multi-filter spectral UV-B radiometers. Measurements have been made continuously in the Washington, DC metro region since the mid-1970's, at present time the series is 25+ years in length, which is unrivaled for spectral measurements (Figure 1 shows map of instrument location and a picture of the tower at SERC where the instrument is mounted). The current instrument design (SR18) incorporates 18, 2 nm bandwidth filters, with center wavelengths at nominal 2-nm intervals between 290 and 324 nm. Spectra are recorded through rotation of a filter wheel, 14 times per minute. Instrument measurements of solar radiation have been extensively validated in a series of intercomparisons with grating based instruments conducted by NOAA. In the last several years, SR18 operation has been expanded to eight sites as part of ongoing collaboration with NIST and USDA. Site locations include SERC, USDA Beltsville, Atlas-Miami, Purdue University, University of Nebraska, Forest Products Laboratory in Madison, WI, Table Mountain in Boulder, CO, and Atlas-Phoenix. SERC/SRL is responsible for maintenance, calibration and data analysis to insure high data quality. This network provides data on incident solar UV spectral irradiance as needed for evaluating effects of varying UV-B on marine ecosystems (SERC), agricultural products (USDA) and materials coatings (NIST).

10.2.3 Changes in Ecosystems - Several SI programs examine biological responses to global change. At SERC, research is being conducted on the responses of global ecosystems to increasing CO_2, exotic species introductions, and solar UV. At STRI, research is being conducted on the effects of climate change (including CO_2 increase) on tropical ecosystems.

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UZBEKISTAN

Ozone layer monitoring

In Uzbekistan ozone layer monitoring is performed by the Administration of Environmental Pollution Monitoring (UMZ) of the Main Administration on Hydrometeorology (Glavgidromet). At present time systematic daily observations of total stratospheric ozone continue at two stations:

Tashkent (41.2º N, 69.2º E, 478 m altitude asl, since 1989)
Termez (37.1º N, 67.2º E, 311 m altitude asl, since 1989)

Unique stations as Kumbel and Abramov Glacier stopped in 1999 ozone measurements because of the equipment disrepair and lack of financing for its reconstruction.

Total ozone measurements are made by ground techniques using filter ozonometer M-124, manufactured in Russia. In spite of the ozonometer has not been calibrated for many years (due to financial problems), according to the report of the Central Aerological Observatory (CAO) (Dolgoprudny, the suburbs of Moscow) stratospheric ozone data from the Tashkent station are in good agreement with satellite data.

Systematic measurements of tropospheric ozone and other trace gases (CO_2, CO, NO_2) are made in all big cities. Samples are taken twice a day - in the morning and in the midday beginning from April through October. Tropospheric ozone is defined using photometry method based on ozone drive of iodine when its absorption by potassium iodine solution. Evolved iodine is defined by spectrophotometric measurement of light absorption by iodine ions when the wavelength is 352 nm. Annual concentration of surface ozone in Tashkent exceeds Maximum Permissible Concentration (MPC) by 1.3-3 times what corresponds to 39-69 mkg/m^3. Daily averaged MPC amounts to 30 mkg/m3. The most ozone amount is registered in Bekabad town (2-3 MPC), what is caused by high atmospheric air pollution level. Yearly increase in surface ozone concentrations is observed from May through September, in October ozone content a little decrease. The data obtained are published in yearly reviews of atmosphere pollution. Data of high ozone concentrations are submitted to the Bodies of Goskompriroda according to exchange information scheme adopted in the Republic.

Information

Daily averaged data of total ozone content from the Tashkent station are sent to the Voeikov Main Geophysical Observatory (MGO) (St-Petersburg, Russia) one time a month where they are generalized and then transmitted to the WMO World Ozone Centre in Toronto (Canada). The last transmission of the information was on January 2002.

Total ozone observation data from the Tashkent station are transmitted to CAO (Dolgoprudny, suburbs of Moscow) for the inclusion of this information into the agreed international framework of the data exchange.

During winter season (December-March) similar information is three times a week being transferred to the WMO Ozone Mapping Centre in Tessalonoki University (Greece).
The information from the Termez station is used for research.

The whole primary data are stored in the archive of Glavgidromet of the Republic of Uzbekistan.

Studies

Research and experimental studies related to the investigation of ozone layer state in Uzbekistan are carried out in Central Asian Research Hydrometeorological Institute (SANIGMI) in the Laboratory of Ozonometry and Ionosphere Studies.

Investigations are aimed at study of regional peculiarities of total ozone amount variations, tendencies to change and assessment of time characteristics of ozone change over the Uzbekistan' territory.

The variations of monthly averaged values of total ozone amount over Tashkent and Termez are presented in the figures 1 and 2. This information was obtained during the period 1979-1993. These figures were constructed on the base of the NIMBUS-7 satellite data during the period 1979-1993 and ground based observations during the period 1989-2001, that is, there was period when satellite and ground based observations were conducted simultaneously. There is a good agreement in these data. In both figures the trend is shown which has been revealed using standard function of trend construction on the base of 4 Degree Polynom in EXCEL. One can see that during the last years (since 1997) the trend has changed the sign. Long-term decrease in ozone layer density over Uzbekistan stopped and opposite process has begun. As ozone-depleting substances discharges into the atmosphere have not reduced during the last years the total ozone trend change can not be explained only by change of anthropogenic factors influence. Very likely in nature there are more powerful processes, influence of which has not been taken into consideration. Obviously, long-term global variation of ozone layer density takes place or the reason is the highest solar activity at the end of millenium.

The investigations of spectral composition of time variation of total ozone amount have begun in order to assess particular physical parameters and global macro processes of non-anthropogenic character (meteorological conditions, 26 month variations of stratospheric winds, notation of the Earth Pole, solar activity variation cycles, for example, 100 years cycle, maximum of which falls at 2000 and other climate phenomena), which influence ozone layer formation over the North Hemisphere, that is, the investigations aimed at sharing and quantitative evaluating the portion of anthropogenic and non-anthropogenic components in ozone layer formation over the North Hemisphere.

In the frameworks of aerosol program in SANIGMI the investigations of atmospheric aerosol in surface layer are being conducted. Physic-chemical and disperse aerosol composition, processes and distance of aerosol transfer from different emissions sources as natural as anthropogenic with usage of ground observations and mathematical models are studied. Aerosol influence on the atmosphere transparency is being assessed.

In Uzbekistan the National Program to Stop the Use of Ozone-Depleting Substances (ODS) was developed and adopted by the Government in 2000. The Strategy and Plan of Actions on step-by-step stopping ozone-depleting substances usage were provided in this Program.

Problems and needs

The current level of investigations implies availability of modern instruments and equipment. However due to financial problems equipment available does not meet current requirements. Filter ozonometers M-124 used at the ozone monitoring stations are obsolete ones. The last calibration of all instruments was done in 1993. Presently it is impossible to calibrate filter ozonometer in Tashkent because we have no a reference Dobson or Brewer spectrophotometer.

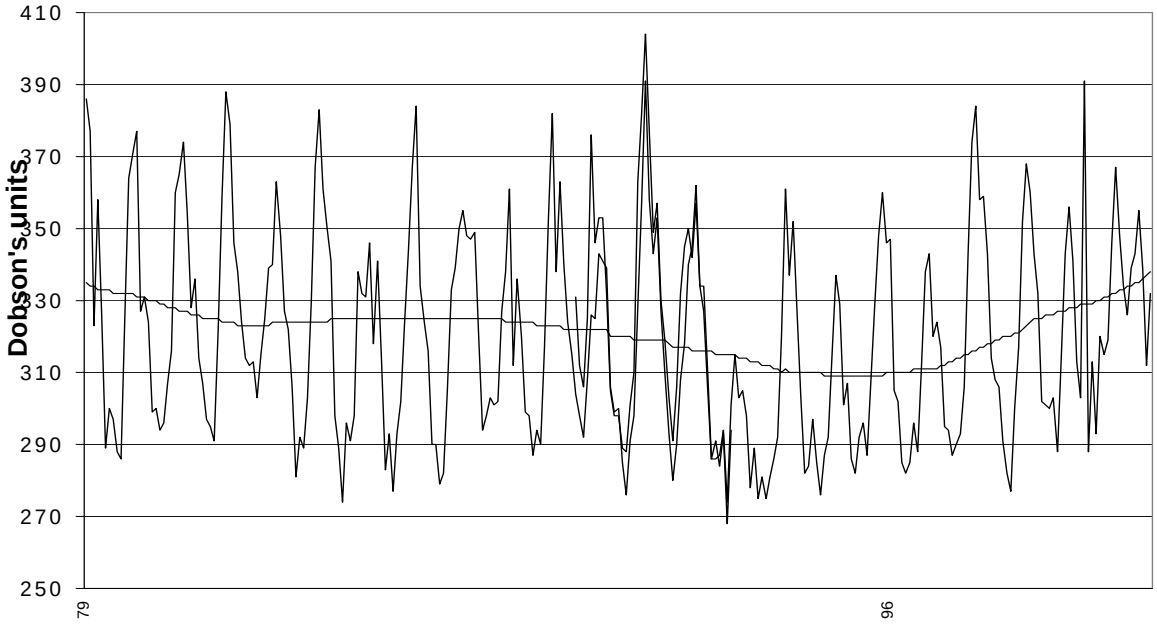
In order to obtain more comprehensive and reliable information on total ozone amount it is necessary to extend the network of regular daily observations. It can be realized under proper equipping stations with modern instruments and under financial support of the international organizations.

Unfortunately in the absence of instruments we could not begin monitoring of ultra-violet (UV-B) solar radiation alongside with total ozone amount measurements and experimental estimation of the decrease of the agricultural crops yield caused by the increase in solar UV-B radiation. To study spatial distribution and monitoring of total ozone amount over Uzbekistan can be used satellite data.

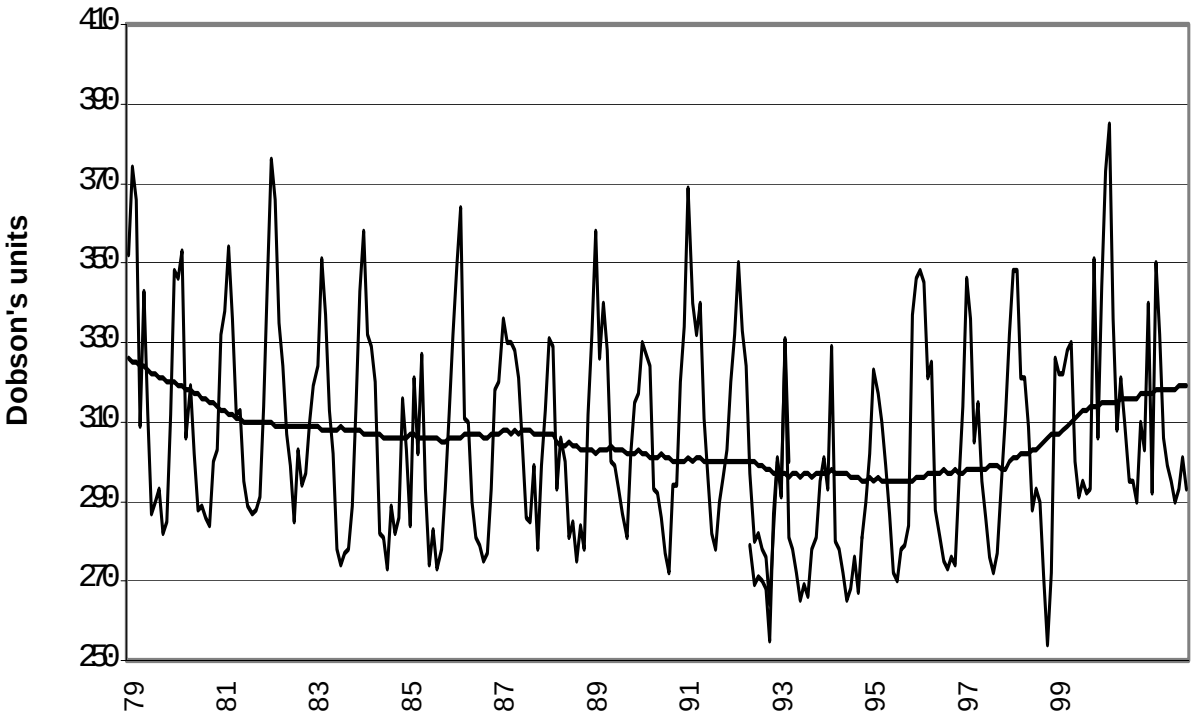
In Glavgidromet since January 2001 the station for receiving digital satellite data from satellites of the NOAA type has been operated. It has been obtained as humanitarian help of USAID. However we can not use total ozone amount data for lack of the TOVS software for decoding ozone data flow and funds for programs acquisition.

There is an urgent necessity in training for young specialists with purpose of learning modern instrumentation for measurement of ozone and UV-B radiation, halocarbon traces, learning new mathematical models, combining atmospheric chemistry and climate and also forecasting ozone layer behavior.

Long-term variations of ozone above Tashkent during 1979-2001 years



Long-term variations of ozone above Termez during 1979-2001 years



VIET NAM

Background

Vietnam has became a member of WMO since 1976 and ratifyed Vienna Convention on the Ozone Layer Protection, the Montreal Protocol on substances that deplete the ozone layer and both its London and Copenhagen amendments in 1994.

According to the Environment Law issued by the National Assembly in 1993, Vietnam commits fully comply with all the obligations of a member of International organizations or of a Party to signed international treaties.

In accordance with above principles, The Vietnam Government has assigned Hydrometeorological Service (HMS) - The Government Agency to prepare and implement the Country Programme for Implementation of Montreal Protocol in Vietnam. HMS has established the Vietnam National Ozone Unit (Ozone Office) as National Focal Point for implementation of MP.

Ongoing activities on ozone observation and research

Ozone observation

Ozone observation network in Vietnam consists of 3 stations: Hanoi, established in 1992; Sapa and Tansonhoa, established in 1994. Hanoi and Sapa stations located in the north and Tansonhoa located in the South of the Country. These stations are equipped by ozone spectrometers M124 made in Russia and carries out the 9 obs/day measurements of total ozone and UV radiation.
The spectrometers M 124 are calibrated every two years in Russia.

Among the 3 above stations, Hanoi ozone station is the one of the global ozone-observing network under the number of 330. The ozone data gathered in this station is transferred to the global data center every 2 months and published in the World Ozone Data.

During last 3 years, 2 training courses for the observation technicians of the ozone stations have been conjointly organized by the National Ozone Unit and Airological Observatory of HMS. The courses had been aimed at the ozone layer protection and implementation of Montreal Protocol issues and improvement of measurement skills of the technicians.

Ozone researches

Most of scientific and technology researches in Vietnam are funded and managed by the Government, including Ozone ones.

There are only two organizations undertaking the ozone researches in Vietnam. One biggest is the Airological Observatory (AO) under HMS and other is Hanoi University.

The objectives of the ozone researches carried out by above agencies aim at the scientific assessment of distribution and changes of stratosphere ozone in order to identify and understand current status of the ozone layer under the Country.

Planned activities

For the next 2002 - 2005 years, The following activities on the ozone monitoring and research have been planned:

1. Fully Comply with control measures under the Montreal Protocol, phase out 50% CFC consumption in 2005.
2. Strengthen and improve the ozone observations in the 3 stations;

3. Provide equipment and train technicians of the 3 ozone stations in using and application of software for data processing and transmitting;
4. Enhance the funding from the Government for the ozone researches;
5. Present in cooperation with Ministry of Education and Training the Ozone award for an excellent ozone/ozone layer protection research among students.

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