EGYPT

OBSERVATIONAL ACTIVITIES

Column measurements of ozone

At Egypt, only Egyptian Meteorological Authority (EMA) is responsible for measurements of column ozone amount and operates the main total ozone-monitoring network. Long-term daily observations of total ozone have been performed at the regional ozone center of EMA at Cairo (30.08ºN, 31.28ºE) with the Dobson Spectrophotometer (D096) since 1967. Since 1984 second Dobson instrument (D069) has been maintained at Aswan (23.97ºN, 32.87ºE) to measure the amount of ozone over tropical area. At the late of 1998 Brewer Spectrophotometer mark II (B143) has been maintained at Matrouh (31.33ºN, 27.22ºE) to measure the total ozone and SO_2 over northwest coast area of Egypt. With the end of 1999 third Dobson Spectrophotometer (D059) has been maintained at Hurghada (27.28°N. 33.75ºE) to measure the amount of ozone over Red sea area.

Vertical Distribution of Ozone

Vertical distribution of ozone in the atmosphere is measured with Dobson and Brewer Spectrophotometers (Umkehr method) at Aswan, Matrouh and Hurghada. The N-values are stored in the ozone database at EMA and they are also deposited in the WOUDC, Toronto.

Surface ozone

EMA measure surface ozone outside urban regions, at Hurghada (27.28°N. 33.75ºE) which is an official WMO Global Atmospheric Watch (GAW) station. Also EMA measure surface ozone at Sidi Branni (31.37ºN, 25.53ºE). South Valley University (SVU) in cooperation EMA has been measured surface ozone at Qena (26.20ºN, 32.75ºE).

UV measurements

Broadband measurements

EMA take the measurements of broadband UV solar radiation using Eppley Ultraviolet Radiometer at Cairo and Aswan since 1989. Also EMA in cooperation with SVU have been measured the broadband UV radiation at Qena since 2000.

Narrowband filter instruments

EMA measured the biologically effective solar UV-B radiation by UVB-1 Pyranometer at Cairo, Aswan since 1998 and at Rafaah (31.22ºN, 34.20ºE) since 2000. The measurements of the global UV-B are performed with the Brewer single monochromator for different solar zenith angles at Matrouh. Also EMA in cooperation with SVU have been measured the UV-B radiation at Qena since 2000.

The present network of measurements of ozone and UV radiation at Egypt are shown in Table (1).

Table (1): Operational network of ozone and UV radiation at Egypt.

Type of observation	*Location*	*Org.*	*Instrument*	*Start*
Total Ozone Column	*Cairo*	*EMA*	*Dobson No. 096*	*1967*
	Aswan	*EMA*	*Dobson No. 069*	*1984*
	Matrouh	*EMA*	*Brewer No. 143*	*1998*
	Hurghada	*EMA*	*Dobson No. 059*	*2000*
Ozone Vertical Profile (Umkehr)	*Aswan*	*EMA*	*Dobson No. 069*	*1984*
	Matrouh	*EMA*	*Brewer No. 143*	*1998*
	Hurghada	*EMA*	*Dobson No. 059*	*2000*
UV Radiation	*Cairo*	*EMA*	*Eppley Radiometer*	*1989*
	Aswan	*EMA*	*Eppley Radiometer*	*1989*
	Qena	*SVU*	*Eppley Radiometer*	*2000*
UV-B Radiation	*Cairo*	*EMA*	*UVB-1 Pyranometer*	*1996*
	Aswan	*EMA*	*UVB-1 Pyranometer*	*1998*
	Matrouh	***EMA***	*Brewer No. 143*	*1998*
	Rafaah	*EMA*	*UVB-1 Pyranometer*	*2000*
	Qena	*SVU*	*UVB-1 Pyranometer*	*2000*

Calibration activities

Calibration of instruments

All Dobson instruments are regularly calibrated every 4 years towards world standard. EMA ozone scientists taking into consideration the maintenance and calibration of the Dobson instruments regularly

The WMO and EMA in close cooperation and assistance of the USA National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostics Laboratory (NOAA/CMDL) organized the International comparison of Dobson Spectrophotometers at Dahab, Egypt 23 February – 12 March, 2004. Further assistance was provided by the German Weather Service's European Dobson Regional Calibration Center (DWD-RDCC/E) and by the Czech Hydro-meteorological Institute's Solar and Ozone Observatory (SOO-HK). It was a campaign to maintain the network of Dobson ozone spectrophotometers operated in the Africa region (R1). Comparison Dobson spectrophotometers from Algeria (D011), Botswana (D015), Kenya (D018), Seychelles (D057), Egypt (D096, D069, D059), South Africa (D089) and Nigeria (Shimatzu 5703) towards the World Secondary Dobson Standard Instrument (WSSI) No. 65 from NOAA/CMDL's World Dobson Calibration Center (WDCC) Boulder, Co, USA, to determine the existing calibration level. European Regional Standard (D064) also participated for calibration verification. Sixteen specialists from five countries and the WMO Secretariat participated at the Intercomparison. This action is a fulfillment of WMO/GAW/QC requirements for monitoring of atmospheric total ozone.

Training of the Brewer operators

EMA in co-operation with WMO carries out a training programme for operators of ozone Arab countries. At 2004 EMA trained three operators from El Emirate country for installation, calibration and operation of Brewer spectrophotometer.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Variation and Trend of ozone

EMA studied the trend of ozone at Cairo, Aswan, Matrouh and Hurghada for different periods, shown in table (2). The highest values of negative trend were found through the period from January 1990 to December 1995 over Egyptian ozone stations especial over Cairo. While the highest values of positive trend was found after 1999. Figure (1) represents the monthly variation and trend of ozone at Cairo from October 1967 to December 2004 while Figure (2) represents the monthly variation and trend of ozone at Aswan from December 1984 to December 2004.

Table (2): Ozone trend at Egyptian ozone stations for different periods.

Period of Trend	Cairo	Aswan	Matrouh	Hurghada
01/1970 – 12/1980	0.0859			
01/1985 – 12/1990	0.0372	0.1343		
01/1985 – 12/1995	-0.0274	-0.0174		
01/1990 – 12/1995	-0.2201	-0.1273		
01/1990 – 12/2000	-0.0434	-0.0246		
01/1995 – 12/2000	-0.0006	0.092		
01/1999 – 12/2004	0.1216	0.1211	0.5844	
Beginning – 12/2004	0.0009	0.0066	0.6354	0.0301

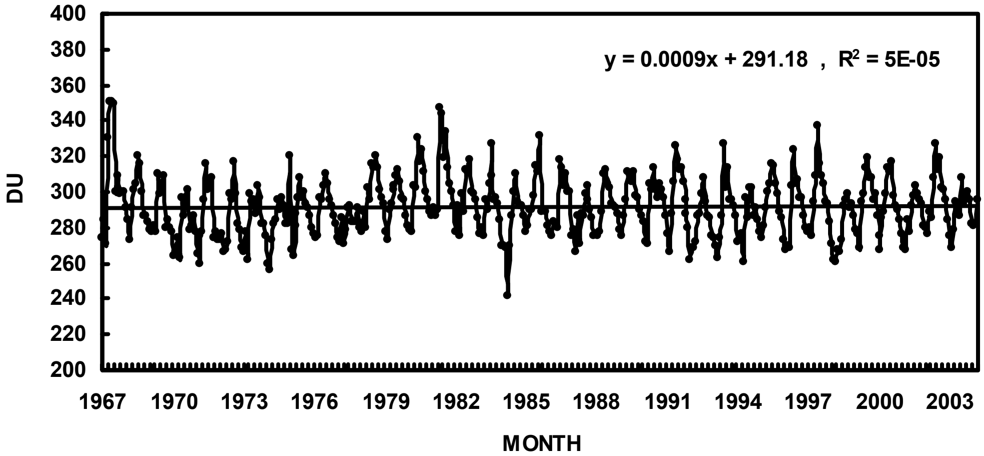

Figure (1): Monthly variation and trend of ozone at Cairo from Oct. 1967 to Dec. 2004.

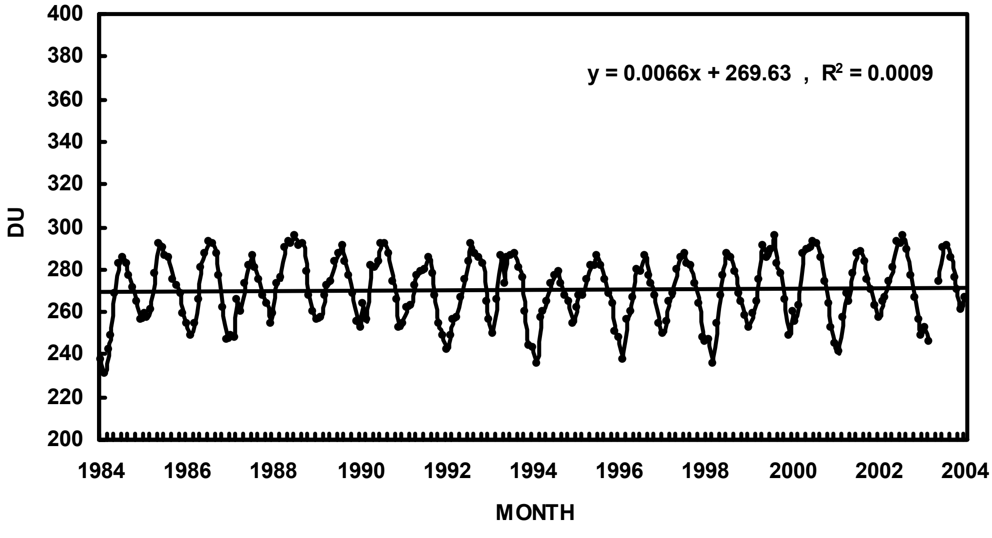

Figure (2): Monthly variation and trend of ozone at Aswan from Dec. 1984 to Dec. 2004.

Variation and Trend of ozone and UVB at Matrouh:

Figure (3) represent the monthly variations and trends of Ozone and UVB at Matrouh from November 1998 to December 2004. The Ozone amounts take the maximum value at spring while the UVB radiation takes the maximum value at summer. From the end of 1999 the trend of ozone amount increased while the trend of UVB radiation decreased.

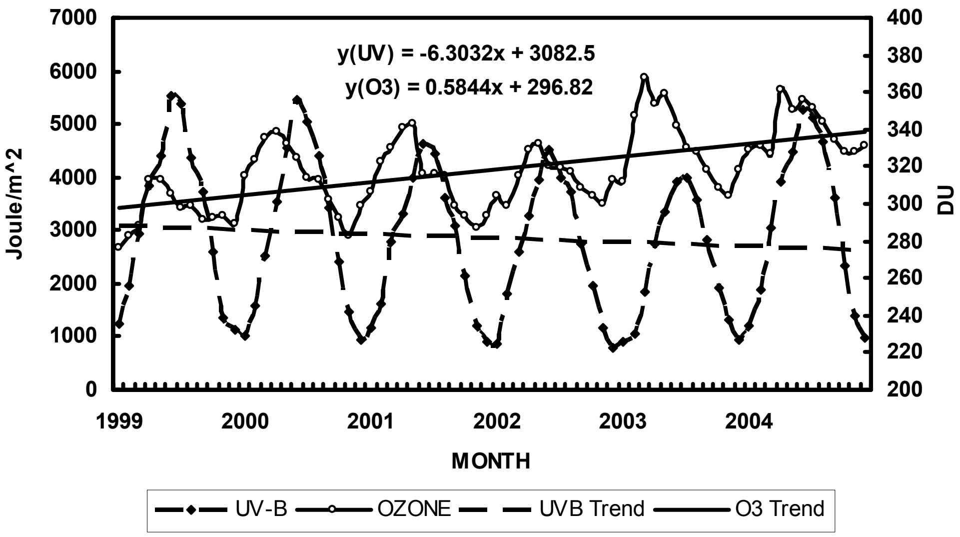

Figure (3): Monthly variations and trends of Ozone and UVB at Matrouh from 01/1999-12/2004.

THEORY, MODELLING AND OTHER RESEARCH

EMA study the analysis and forecast of UVB radiation over 4-sites at Egypt and compare with Erythemal of UVB measured by TOMS.

DISSEMINATION OF RESULTS

Data reporting

The ozone data collected from the network of Egyptian ozone stations by EMA at Cairo regional ozone center monthly. Data files of ozone are transmitted regularly with SO_2 to World Ozone Data Center (WOUDC) in Toronto, Canada.

Egyptian Environmental Agency Affairs (EEAA) monitoring Ozone Depleting Substances (ODS's) as CFCs, Halons, CC14, C2H3CL3, HCFCs, HBFCs, CH2BrCl and CH3Br. EEAA sent the annual data of ODS's to Ozone Secretariat of UNEP, Kenya and Multiliteral Fund (MLF), Canada.

Information to the public

Matrouh lie on the coast of NW Egypt and summer resort. The scans are used for calculation of actual values of UV Index (UVI) daily presented for the public during the seasons especially the summer season. UVI is a numerical risk scale and a way of describing the daily danger from solar UVB radiation. The EPA used the following classification of the UV exposure level based on the UV index (0-2 minimal, 3-4 low, 5-6 moderate, 7-9 high and >10 very high).UVB insulation displays a daytime variation with maximum at solar noon, figure (4) and variation with months take a maximum at summer months (figure 5c). UVB protection is critical during summer and especially so in the hours around solar noon. A person being out in the sun during midday hours more than ten minutes if you are without protection.

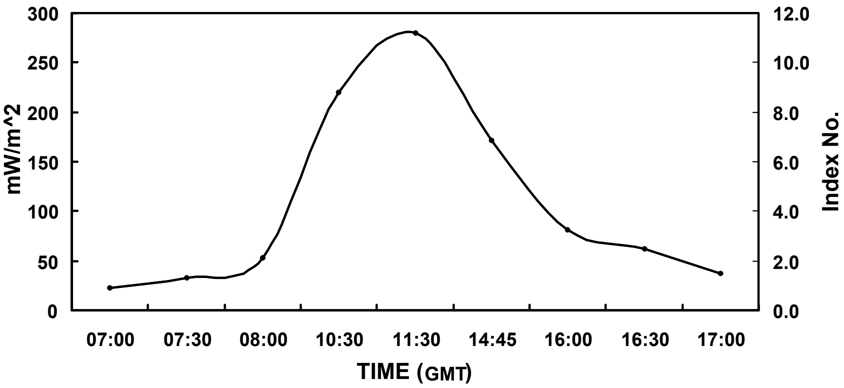

Figure (4): Diurnal variation of DUV and UVI on a clear summer day over Matrouh.

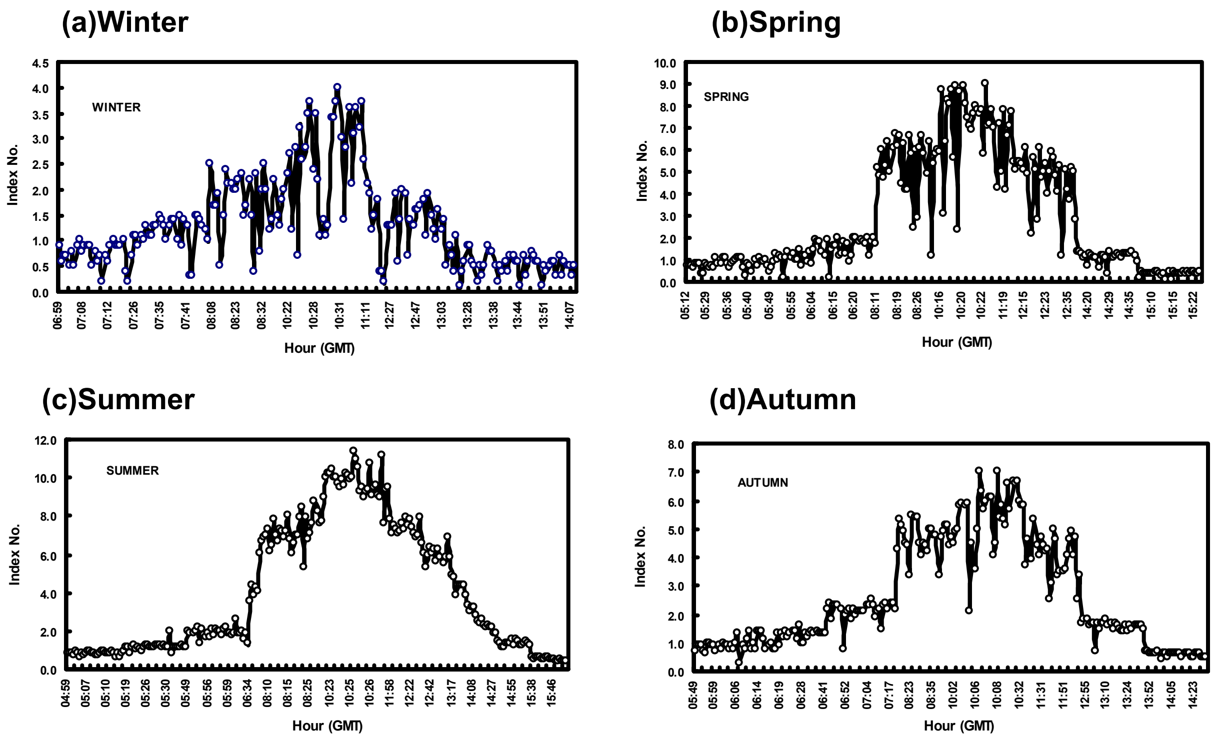

Figure (5): Diurnal variation of UV index over Matrouh at different seasons.

Relevant scientific papers

Through the last three years Scientists at EMA carry out a large number of papers have been published in various journals. Most recent ones are:

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. Geophysical Research, D(18), 8140-8152, 2002.

Sharobiem, W.M. and F.M. El-Hussainy: Sulfur dioxide observations and trends over Egypt. 7th Workshop on meteorological and sustainable development, 10-13 March 2002, Cairo, Egypt.

-El-Hussainy, F.M., W.M. Sharobiem: Atmospheric sulfur dioxide values and trend. Al-Azhar Bull. Science, Vol. 13, No. 1(June), 127-146, 2002.

Sharobiem, W.M.: Stratospheric ozone variations and trends over Egypt. 28th International conference for statistic computer science and its applications, 12-17 April 2003, Cairo, Egypt.

Hafez, Y.Y. and S.M. Robaa: Comparative studies of total ozone values over Cairo and Aswan, Egypt. J. Enfineering and Applied Science, vol. 50, No. 5, Oct. 2003, pp.861-874.

Sharobiem, W.M.: The good time to exposure to UVB irradiance at northwest coast of Egypt. Atmospheric Ozone. Proceeding of the Quadrennial Ozone Symposium, June 2004, Kos, Greece.

Sharobiem, W.M., A. S. Zakey and A. Y. El-Sayed (2004): Contribution of weather elements on surface ozone and sulfur dioxide at polluted area. 9th Workshop on meteorological and sustainable development, 28-29 April 2004, Cairo, Egypt.

Sharobiem, W.M.: Relation between Atmospheric Ozone and UVB radiation over Egypt. Meteorological Research Bulletin, EGYPT. Vol. 19. January 2005. pp. 100-113.

Sharobiem, W.M. (2005): Ozone and UV-B Measurements and Trend over Matrouh, Egypt. 9 th Biennial WMO/MSC Brewer Users Group Meeting. Delft, Netherlands, May 31 – June 3, 2005

PROJECTS AND COLLABORATION

EMA in cooperation with South Valley University (SVU) have been measured the broadband UV and UV-B radiation and other meteorological parameters.

National projects through the National Ozone Unit in EEAA to phasing out ODS's as phase out plane of CFC's and Methyl Bromide. Also projects of Halon Bank and Solvent project.

FUTURE PLANS

EMA co-operate with the Czech Hydro-meteorological Institute's Solar and Ozone Observatory (SOO-HK) for develop Dobson instruments at Cairo, Aswan and Hurghada. Where the data take by Semiautomatic Dobson Data Recorder.

The WMO and EMA in close cooperation and assistance of the International Ozone Services Inc., Toronto, Canada organized the Calibration of Brewer instrument at Matrouh next October 2005.

National phase out plan in EEAA for ODS's.

NEEDS AND RECOMMENDATIONS

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

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ESTONIA

INTRODUCTION

In Estonia, atmospheric total ozone and UV radiation monitoring began in 1994. The monitoring is carried out at the Tartu-Tõravere Meteorological Station (58^o.16'N, 26^o.28'E, 70 m a.s.l.) and the research work by the Department of Atmospheric Physics of the Tartu Observatory, located at the same site. The studies of atmospheric aerosols and atmospheric transmittance are also performed at the Institute of Environmental Physics of the University of Tartu. The Tartu Observatory has participated in the European Community EDUCE research project and is also taking part in the COST 726 activities.

INSTRUMENTS AND MONITORING

The Tartu-Tõravere Meteorological Station is the successor of the Meteorological Observatory of the Univeristy of Tartu, operating regularly since 1865. The first attempts to measure solar radiation at this station were made in the 1930s. Since January 1950, regular measurements have been performed outside the town and from 1965 the station has been at the present site. In 1999, the station was included in the Baseline Surface Radiation Network (BSRN).

At present the operating UV sensors are:

- Erythemally weighted: Scintec UV-SET (since 1998)
- YES UVB-1 (since 2005)
- PMA2200 used for calibration transforms (since 2003)
- UV-B narrowband (306 nm) Kipp&Zonen CUVB1 (since 2002)
- UV-A broadband UVSB2 (since 2002)

Direct sun total ozone measurements are made using a MICROTOPS-II instrument.

At two other stations - Tallinn-Harku (59^o24'N, 24^o36'E, 39 m a.s.l.) and Tiirikoja, (58^o51'N, 26^o57'E, 32 m a.s.l.) the narrowband UV-B sensors are installed and the Pärnu station (58^o23'N, 24^o30'E, 5 m a. s. l.) has a broadband UV-A sensor.

Taking into account the previous experience of the exploitation the minispectrometers a minispectrometer AvaSpec-256 produced by *Avantes* company was obtained by the Tartu Observatory and is suited for the field measurements by adding necessary auxiliary equipment.

Additionally, a teflon diffuser was made and studied for cosine response. A quartz fiber of 4 m length and 100 µm diameter connects the diffuser to the spectrometer. An UFS-5 glass optical filter was installed between the diffuser and fiber to reduce the scattered light inside the spectrometer and to guarantee the reliable recording of signal in the whole measured spectral region. For reliable recording of noise signals, the optical interface is automatically covered by a shutter before and after each measurement cycle.

The control of the sensitivity for the uniform recording of spectra is realized through the change of integrating time at the interval 1 to 60 s. In this way a maximum value of the signal approximately 16,000 arbitrary units is realized in each spectrum. For reducing the noise level the spectrometer is installed in a refrigerator and kept at the temperature of + 7^oC. Radiometric response of the system was established using the NIST (National Institute of Standards and Technology) traceable quartz FEL lamp.

The measurement process is fully computer-aided through a Linux programme. The control computer of the spectrometer is connected to the observatory web. Using the server it is possible to access any spectrum in a user-friendly form. It is also possible to track the measurements using any computer of the local web (http://sputnik.aai.ee) and also to have access to the archive of spectra.

UV CLIMATOLOGY

The Estonian total ozone climatology, based on TOMS and other available data, was published in 2002.

The first results of the proxy-based reconstruction of the erythemally weighted UV doses back to 1967 were published in 2002. These results were for the period from vernal equinox to the autumnal equinox, constituting about 90 % of the yearly dose. The sunshine duration was used as a cloud influence related proxy.

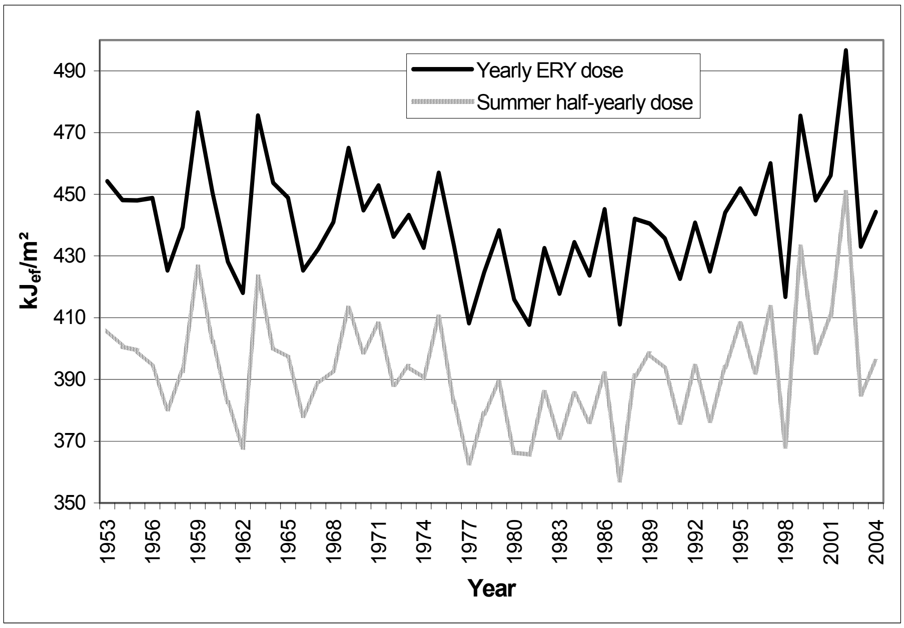

Figure 1: Reconstructed yearly and summer half-yearly erythemal doses at Tartu.

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Recently, the reconstruction of the erythemally weighted daily doses has been recalculated using the daily relative sum of broadband direct irradiance and the daily relative sum of broadband global irradiance as the cloudiness influence related proxies. The first proxy was used in the cases of significant contribution of sunshine during a day and the second on almost overcast days. The correction for deviation of total ozone from its climatic value was calculated when data were available.

It was assumed that in sunshine conditions the sum of broadband direct irradiance accounts for the deviation of atmospheric turbidity from the average. In the cold period of the year, statistical relationships were derived separately for snow and snow-free conditions.

The biases between measured and reconstructed daily doses in 52-58 % of cases around the year were within ± 10 % and in 82-84 % of cases within ± 20 %. In the summer half-year, these amounts were 58-65 % and 85-92 %, respectively. In most years the results for longer intervals did not differ significantly in case of climatic ozone and therefore no corrections were made for the daily deviations before 1979. The yearly and summer half-yearly doses (constituting on average 89 % of the yearly dose) in 1979-2004 agreed within ± 2 %, except the post volcanic years and a year of extremely fine weather (2002). The largest deviation 3.5 % was met in 2002.

In Figure 1, the yearly and summer half-yearly reconstructed doses for 1953-2004 are presented. One can see that the interval 1976-1993 regularly manifests values lower than the average. The amplitude of deviations from the average in the summer half-year is within 92-111 %. The range of variation of all proxy quantities is larger. For the sum of global irradiance, it is 89.7-114.4 %. For the sum of direct irradiance, it is 74.4-132.2 %, and for the sunshine duration 79.8-132.9 %. The spring period constitutues on average 42.9 % and the summer period 46.2 % of the yearly dose. The darkest 102 (roughly 100) days of the winter from November 1 to February 10 when the noon solar elevation remains below 15°, make up on average only 2.7 % of the yearly erythemal dose.

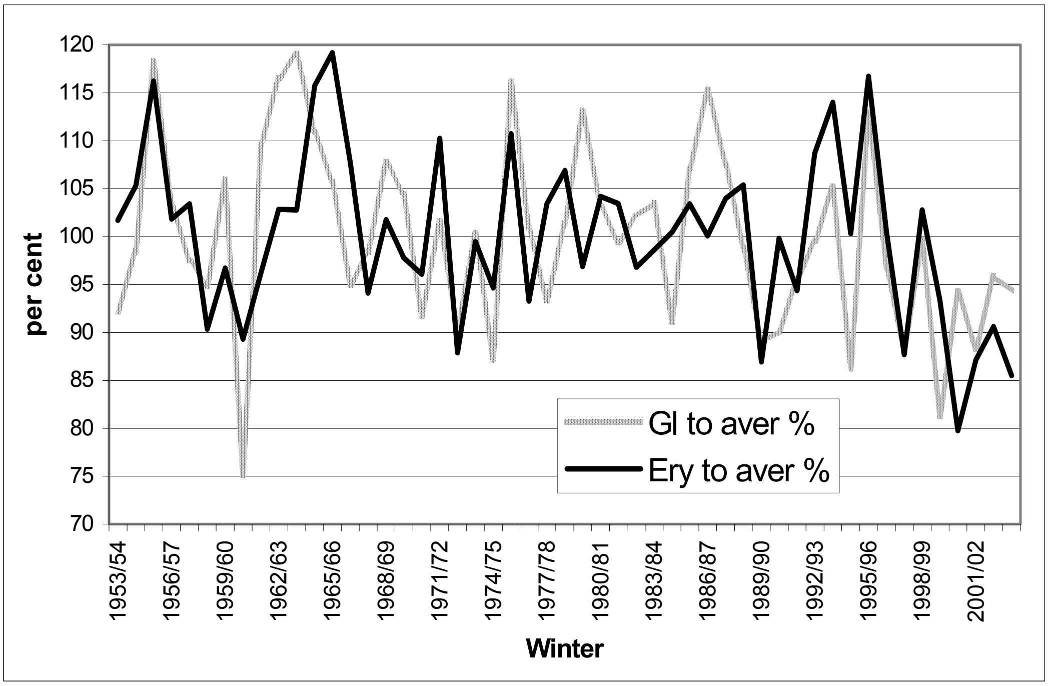

Figure 2: Reconstructed erythemal doses of 100 darkest days in winters 1953-2004.

The year-to-year variations of the erythemal dose as well as the sums of global broadband irradiance in the scale of percentage deviation from the average values are presented in Fig. 2. The variations of erythemal dose during that interval occurred in the range ± 20 %. The minimum values were met in cloudy winters with extended snow-free episodes. Since 2000, the midwinters have been darker than the average.

PUBLIC INFORMATION

In the summer period, when high UV levels occur, the Estonian Institute of Meteorology and Hydrology *warns people of the related risks using the radio, TV and other means of mass media.* Current value of the UV Index for each minute of a day is displayed on the Tartu Observatory *homepage* (http://www.sputnik.aai.ee)

The research results as well as the general ozone layer issues have also been introduced to the general public during the *public awareness campaigns* conducted in the frame of the UNEP funded Institutional Strengthening programme by the National Ozone Office (2001-2004). The presentations given by the specialists of the Tartu Observatory, the Estonian Institute of Meteorology and Hydrology and the Ozone Office in a special ozone tent lasted for approximately 40 minutes. Illustrative materials in Power Point as well as NASA images on the status of the ozone layer have been shown. During all events ozone leaflets, T-shirts and balloons were distributed among the participants and refrigerators were raffled. Although the campaigns primarily focused on raising public awareness, a positive side effect was that about 5 000 old refrigerators were collected during 3 years. For the future, the general public will continue to be informed of the UV levels and ozone issues. The Country ODS Phaseout Programme consisted of three additional projects: Recovery and Recycling (UNDP), Baltic Regional Halon Bank (UNDP) and Train the Trainers in Refrigeration (UNEP).The UN programmes gave strong momentum to ODS phaseout in Estonia and brought the country to new horizons. The results are clearly reflected in reduced usage of ozone depleting substances.

In Estonia, a biennial conference, Atmosphere*Human*UV-radiation, is also held regularly in each odd year. The results of current research are introduced and discussed.

Estonia has ratified the Vienna Convention, the Montreal Protocol and all its amendments and is following the decisions of the Parties. In addition, the EC legislation on ozone depleting substances, that goes in many areas beyond the requirements laid down in the Montreal Protocol, came in force on 1 May, 2004.

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EUROPEAN UNION

European Research on Stratospheric Ozone and UV Radiation

INTRODUCTION

Stratospheric research has been coordinated at European level since the late 1980s, building on a number of trans-national collaborative initiatives and EC projects supported by the research Framework Programmes (FPs) of the European Commission. The early European stratospheric research programmes (FP1-FP3, 1982-1994), focused on the investigation of potential severe Arctic ozone losses and increased UV radiation across 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. Large ozone losses over the Northern Hemisphere have indeed been observed in some winters in the early 1990s. This trend has continued in the early 2000s, coincide with a steady stratospheric cooling trend and new record low temperatures.

Research priorities within the 4th Framework Programme (FP4, 1994-1998) have shifted towards improving our understanding of the processes affecting stratospheric ozone over Northern Europe. The Third European Stratospheric Experiment on Ozone (THESEO 1998-2000) was a major component of this coordinated programme. At that time research focused on the mid-latitude lower stratosphere, the interaction with other layers of the atmosphere, the Arctic vortex, the tropics and sub-tropics.

Stratospheric research carried out under FP5 (1998-2002) was building on FP4 achievements with the emphasis to understand, quantify and predict stratospheric changes. This interdisciplinary research has been implemented through individual projects organised in research clusters addressing similar topics (details below).

The ongoing 6th Framework Programme (FP6, 2002-2006) is focusing on stratospheric climate interactions and on the impact of the transport modes on the upper troposphere/lower stratosphere (UTLS). Research is organised and implemented by 2 large Integrated Projects (IPs): SCOUT-O3 (Stratosphere-Climate links with emphasis On The UTLS) and QUANTIFY (Quantifying the Climate impact of Global and European Transport Systems), respectively.

Stratospheric research at European level was effectively co-ordinated by the EU Science Panel on Atmospheric Research and the European Ozone Research Coordination Unit (EORCU). The Science Panel has provided advice to the EC regarding future direction and priorities of atmospheric research for the currently running 6th Framework Programme (2002-2006) and to establish the coming 7th Framework Programme (beyond 2006). EORCU was responsible for the co-ordination of research clusters formed in the course of the 5th Framework Programme (see Table 1). EORCU also serves as the project office/co-ordination unit of the SCOUT-O3 IP funded under the 6th Framework Programme.

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 provides a large degree of coordination for a large number of European groups. The International Ozone Commission and the WCRP programme Stratospheric Processes And their Role in Climate (SPARC) should also be mentioned in this context.

Overall, European research has greatly benefited from the European research programmes which has provided an effective co-ordination mechanism and has helped European scientists to make major advances to the understanding of the stratospheric ozone and UVB issue. As a result, they have significantly contributed to international assessments and research experiments carried out in support of the Montreal and Kyoto Protocols.

Stratospheric Research under the 5th Framework Programme (1998-2002)

The scientific objectives of stratospheric research were addressed under ***Area 2.1.2 Stratospheric Ozone Depletion*** **in the work programme Global Change, Climate and Biodiversity, Key Action of the EC's Environment and Sustainable Development Programme:**

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."

During FP5 overall 32 research projects on stratospheric ozone and UV radiation were supported by the EC (see 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 were coordinated by the following five clusters:

1. Stratospheric ozone loss (SOLO)

The central objective was to quantify the ozone depletion in the northern and middle latitudes throughout the year. The research involved measurements made by balloons, aircraft, ground-based and satellite instruments which were used to understand the causes of chemical ozone loss under various atmospheric conditions. The analysis of THESEO data continued after contract extension. These studies helped 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 basic objective was to address persisting uncertainties concerning the upper tropospheric and lower stratospheric processes in the tropopause region related to aviation emissions. Research focused on the formation and evolution of contrails and particles and the ozone budget in the upper troposphere and lower stratosphere region. This work also included improved predictions and scenario calculations of aviation-induced future changes in climate. It has provided the aviation-aeronautics communities and decision-makers with options to mitigate climate impact from aircraft emissions.

3. Atmospheric UV radiation (ATUV)

The main objective was to study the evolution of the UV radiation at the earth's surface and in the atmosphere over the last ten years. Existing databases were extended and further developed to provide additional products, such as a European UV climatology using spectral UV irradiance measurements from 26 stations in Europe including actinic flux data suitable for use by a wide user community.

4. Ozone-climate interactions (OCLI)

The core objective was 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. This includes scenario calculations 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 was to coordinate atmospheric measurements at European level to provide data at regional and global scale for ozone and related species. GATO aimed also to help ensure that all field and satellite measurements made within the European programme are available for validation and for scientific analysis. The work in GATO involved in-situ and satellite measurements, including data from new campaigns. This research contributed significantly to international observational programmes.

The clusters have been effectively co-ordinated by EORCU and the Research Directorate General. Results have been disseminated by specially organised workshops on particular topics, through special sessions at conferences (e.g. EGS) and international meetings such as the Quadrennial Ozone Symposia and the SPARC Assemblies.

VINTERSOL campaigns

VINTERSOL (Validation of INTERnational Satellites and study of Ozone Loss) was a series of major European field campaigns addressing stratospheric ozone and the natural sources of NO_x. VINTERSOL ('Winter sun' in the Scandinavian languages) has taken place from late 2002 until early 2005. Like the previous European campaigns, VINTERSOL relied on joint support from national funding agencies and from the EC's Environment and Sustainable Development programme.

The following VINTERSOL campaigns have been carried out:

- 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
- balloon and aircraft studies in the tropics in early 2005.

Most of the research projects funded under FP5 already have or will finish by the end of 2005. Nevertheless, a number of measurement and modelling activities will run continuously yielding information on processes at longer time-scale in the stratosphere, partly supported by the FP6 IPs. For details please contact the EORCU web page http://www.ozone-sec.ch.cam.ac.uk/

Stratospheric Research under the 6th Framework Programme (2002-2006)

The scientific objectives of stratospheric research are addressed under topic ***I.5. Stratospheric Ozone and Climate Interactions*** **in the Work programme of the Thematic Sub-Priority 1.1.3 Global Change and Ecosystems**

1.5 Stratospheric Ozone and Climate Interactions

Research will focus on future stratospheric ozone levels affected by halogens, aerosols, water and greenhouse gas emissions and how physical, radiative and chemical changes in structure and circulation in the global stratosphere will be affected by climate change. UV radiation fluxes reaching the ground and the factors affecting their transfer in the atmosphere as well as the effects of surface pollution, aviation and natural factors on the upper troposphere and lower stratosphere will be studied in the context of ozone-climate interactions.

As a result of recent calls for proposals, 2 integrated research projects were selected focusing on ozone-climate interactions and UV radiation (SCOUT-O3), and on quantifying the impact of emissions from the transport sector on climate (QUANTIFY), respectively (see Table 2). SCOUT-O3 is a 5 years project which started May 1, 2004, supported by the EC with 15 Mill. €; QUANTIFY is a 5 years project which started March 1, 2005, supported by the EC with 8 Mill. €. Please note that the scientific ambition and financial support of these projects which adds up to 23 Mill. €, definitely exceeds that of individual FP5 research cluster.

In addition to the IPs, the Quadrennial Ozone Symposium 2004 (Kos, Greece, 1-8 June, 2004) has been supported through a Specific Support Action.

Core objectives of SCOUT-03

The aim of this project is to study and predict the evolution of the coupled chemistry/climate system with emphasis on reliable prediction of the future evolution of the ozone layer and surface UV. Forecasts will be build on refined and improved models by exploiting existing data for model testing and validation and by provision of new data on fundamental processes. In order to meet these goals, 10 project activities have been defined:

- Determination of air residence time (with major field campaign)
- The influence of clouds on the tropical UTLS (with major field campaign)
- Understanding the stratospheric water vapour trend and its consequences
- The stratospheric aerosol layer – role of TTL and possible changes
- Past UV changes, variability and trends
- Ozone variability and past changes at mid-latitudes
- Inter-annual variability in polar processes and likely changes in a changing atmosphere
- Improved understanding of the Brewer-Dobson and general stratospheric circulation
- Stratosphere/troposphere coupling – past and future
- Predictions of ozone recovery, effect on climate change on recovery and the impact of the ozone changes on surface UV

Campaigns

- Tropical aircraft campaign scheduled for November-December 2005, Darwin, Australia
- Tropical balloon campaigns planned for 2006/2007
- Age of air measurements planned for 2006
- UV-aerosol-cloud campaign, scheduled for spring/summer 2006 in Southern Europe

Core objectives of QUANTIFY

The main goal of QUANTIFY is to quantify the climate impact of global and European transport systems for the present situation and for several scenarios of future development. The climate impact of various transport modes (land transport, shipping, and aviation) will be assessed, including those of long-lived greenhouse gases like CO_2 and N_2O, and in particular the effects of emissions of ozone precursors and particles, as well as of contrails and ship tracks.

Several transport scenarios and potential mitigation options will be assessed on a sound common basis to identify the most effective combination of short and long-term measures as input for policy- and industrial decisions. The project aims to provide such guidance by focused field measurements, exploitation of existing data, a range of numerical models, and new policy-relevant metrics of climate change. The project will focus on the following activities:

- Establishment of transport Scenarios and emission inventories
- Regional dilution and processing (with emphasis on chemical conversion of ship emissions)
- Large –scale chemistry effects (impact of transport emissions on chemical composition for past and present day conditions)

- Long-term measurements of UTLS compounds
- Aviation, shipping and clouds (generation and modification of clouds by emissions of different traffic modes, with emphasis on cirrus clouds)
- Radiative forcing and climate change (contribution from different modes of transport)
- Development of improved metrics of climate change
- Synthesis of the results

Campaigns

- CIRCLE-1 aircraft campaign planned for 2007 (Most of the modelling work carried out in QUANTIFY is based on existing data records)

The 4th (and last) call of FP6, which has been launched in July 2005 offers additional opportunities for stratospheric research. Among the priorities listed under Area 6.3.VI *Operational forecasting and modelling* a topic on *European atmospheric observation systems* (indicative budget 7 Mill. €) is included. It is designed to reinforce ground-based atmospheric measurements complementary to satellites to strengthen the European component of co-ordinated international observation networks such as NDAC. This should provide a good opportunity for the European stratospheric research community to safeguard continues long term measurements.

European Assessment

The EC has published its second assessment on European research in the stratosphere in late 2001. 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 any ozone layer recovery could only become measurable around 2010 at the earliest.

The 4th FP6 call, launched in July 2005, includes under **Area IX** the following topic: **European assessment of the impact of transport on climate change and ozone depletion.** This assessment will, six years after the 1999 IPCC Special Report "Aviation and the Global Atmosphere", will provide an up-date of this report. The assessment will focus on atmospheric loading, impacts on climate change and stratospheric ozone depletion of gases and particulates from the air- and surface transport sectors, and will provide estimates of current and future trends based on FP5 project results. In case of successful application, first results are to be expected end of 2006.

Future activities

The complexity of the atmospheric processes, the scale of the scientific problems and the potential devastating impact on humans and the ecosystems caused by climate change, stratostospheric ozone depletion and UV radiation require real interdisciplinary research collaboration. This has already started under the 5th and 6th Framework Programme and most probably, will continue in the 7th Framework Programme. The Science Panel on Atmospheric Research in a recent report, entitled "Atmospheric Change and Earth Science AIRES III: Research challenges", points to the need to consolidate and strengthen these efforts to establish a solid scientific basis for developing policy options to protect the stratospheric ozone layer and the climate system. The report has identified a number of atmospheric research priorities within Earth System Science that will be most relevant for the future implementation of the 7th Framework Programme (2007-2013). In parallel, the proposal of the European Commission for the 7th Framework Programme under priority ***6. Environment (including climate change)*** is referencing the importance of changes in the atmospheric component of the Earth System in relation to international commitments such as the Montreal Protocol. Therefore it is likely that stratospheric research remains a EC research priority. The 7th Framework Programme is expected to be adopted by the European Council and the European Parliament in 2006.

Table 1 : Research projects and clusters in FP5.

Stratospheric Ozone Loss (SOLO) cluster

CIPA (*Comprehensive investigations of polar stratospheric aerosols)*

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

SAMMOA (*Spring-to-Autumn Measurements and Modelling 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)*

Two projects supported under Area 7.2 Development of generic Earth observation technologies **in the Global Change, Climate and Biodiversity, Key Action of the EC's Environment and Sustainable Development Programme:**

RAMAS *(Radiometer for Atmospheric Measurements At Summit)*
UFTIR *(Time series of Upper Free Troposphere observations from a European ground-based FTIR network)*

Table 2: Research projects in FP6.

Integrated Projects (IP)

SCOUT-O3 *(Stratosphere-Climate Links With Emphasis On The UTLS)*

QUANTIFY *(Quantifying the Climate impact of Global and European Transport Systems)*

Specific Support Action (SSA)

QOS2004 *(Quadrennial Ozone Symposium 2004)*

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FIJI

Summary

Ozone monitoring in Fiji is carried out only by the University of the South Pacific (USP) in collaboration with NASA/GSFC/NOAA/CMDL mainly under the SHADOZ (Southern Hemispheric Additional Ozonesondes) programme. Using ozonesondes, total column ozone (TCO), stratospheric ozone, tropospheric ozone and surface ozone profiles and amounts are being obtained since 1997. TCO, stratospheric and tropospheric ozone have shown a seasonal trend of spring maximum and fall minimum. Stratospheric ozone in particular has shown a slight decreasing trend (about 1%) since 1997-2003. Monitoring of ^{7}Be for certain time intervals has also been done to study stratosphere-to-troposphere exchange (STE) processes in the region. No proper long-term UV-B monitoring programme is in place for the country yet, though measurements using a broad-spectrum spectrophotometer have been going on for some time. Data however is also available, for about a year, from measurements done using a narrow band UVB-1 pyranometer.

Recent research at USP has focused on identifying ozone trends at a few South Pacific sites (Samoa, Tahiti and San Cristobal) including Fiji. Study has also been done to explain the trends and variations seen in ozone amounts at all levels (TCO, stratosphere, troposphere and surface) at each of these sites. Future research plans at USP mainly include setting up a proper continuous UV-B monitoring programme and improving the method of studying STE processes. A Dobson or a Brewer spectrophotometer is also planned to be introduced along with ozonesonde measurements.

INTRODUCTION

Fiji is located within the South Pacific region (18.1°S, 178.2°E). The only institution involved with scientific research and monitoring of ozone is the University of the South Pacific (USP) located in the capital city Suva in the main Island of Viti Levu. The ozone research at USP is carried out in collaboration with NASA/GSFC/NOAA/CMDL. The lead agencies at USP for this major project are the Department of Chemistry and the Pacific Centre for Environment and Sustainable Development (PACE-SD).

OBSERVATIONAL ACTIVITIES

Relevant observational activity in Fiji involves monitoring of vertical ozone profiles using electrochemical concentration cell (ECC) ozonesondes and periodic UV-B monitoring using broad and narrow band UV meters.

Profile Measurements of Ozone

Since 1997, vertical ozone profiles have been measured on a weekly basis, using a model 6A ECC ozonesondes. The vertical profile data from these measurements are being used to obtain the total column ozone and stratospheric ozone levels over Fiji since 1997.

UV-B Measurements

Currently there is no continuous UV-B monitoring programme in place for Fiji. Some measurements are being done by the Department of Physics and by the Fiji Meteorological Services using a broadband meter. However, with the absence of a proper validation method the accuracy of the data is questionable.

UV-B was continuously measured for nearly one year, from July 2003 to July 2004 by the Department of Physics using a narrow band UVB-1 pyranometer with a spectral response in the 280-320 nm range. After July 2004, no measurements were done and now the pyranometer is being moved to the Fiji Meteorological Services (Nadi) where continuous monitoring is being planned to be carried out.

Calibration Activities

Since each ozonesonde is a new instrument, pre-launch procedures are designed to ensure valid data recording is done. The ozonesonde being used is a model 6A sonde provided by NOAA and it has taken part in sonde inter-comparison experiments such as stratospheric ozone inter-comparison (STOIC) in 1989 (Komhyr *et al*., 1995) and Julich ozonesonde inter-comparison experiment (JOSIE) in 1996 (Smit *et al*., 1996).

There is currently no proper calibration method in place for any UV-B monitoring done.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Stratospheric Ozone

Figure 1 shows the stratospheric ozone trend from 1997-2003 drawn from 0.25 km averaged ozone profiles. In the plot the whiskers represent the inner 90th percentile of the data, boxes the inner 50th percentile, the black bar the median, the red bar the mean and the black dots are the outliers in each (monthly) data set.

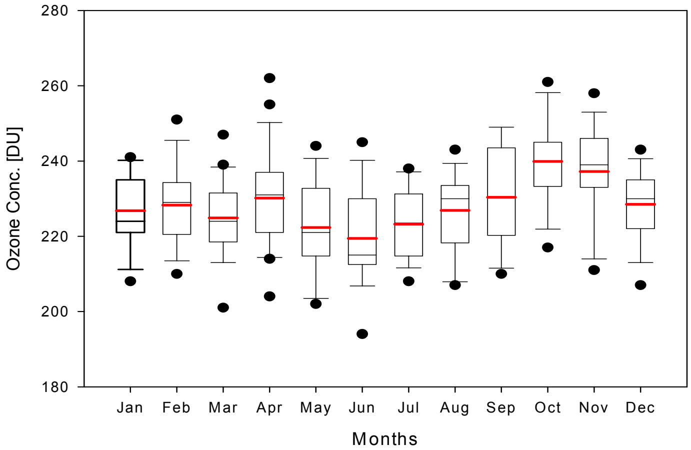

Figure 1: Stratospheric ozone trend for Fiji during 1997-2003.

The ozonesonde analysis has shown a seasonal cycle with high values during the spring months of September-November (SON) and low values during fall/winter months of May-July. The variability in ozone amounts appears to be highest during the SON months. These results are similar to those reported by Thompson *et al*. (2003).

Figure 2 shows the monthly averaged stratospheric ozone trend during 1997-2003. There appears to be a downward trend in stratospheric ozone over the 7-year period.

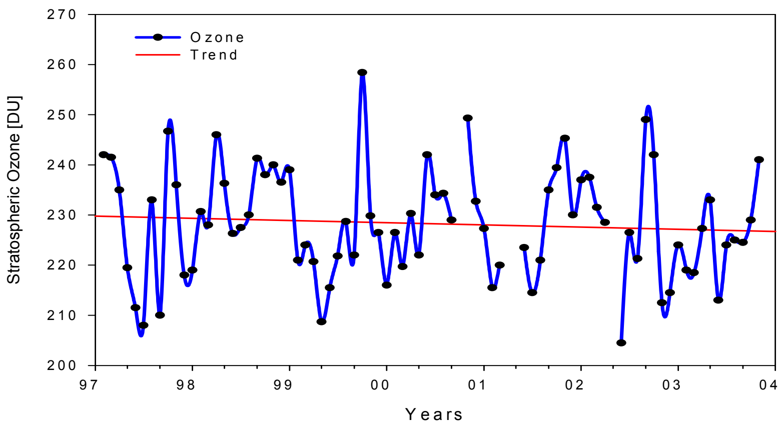

Figure.2: Monthly mean stratospheric ozone trend for Fiji during 1997-2003.

Total Column Ozone (TCO)

Figure 3 shows the TCO trend during 1997-2003 for Fiji, which reveals a seasonal trend and variability similar to that of stratospheric ozone.

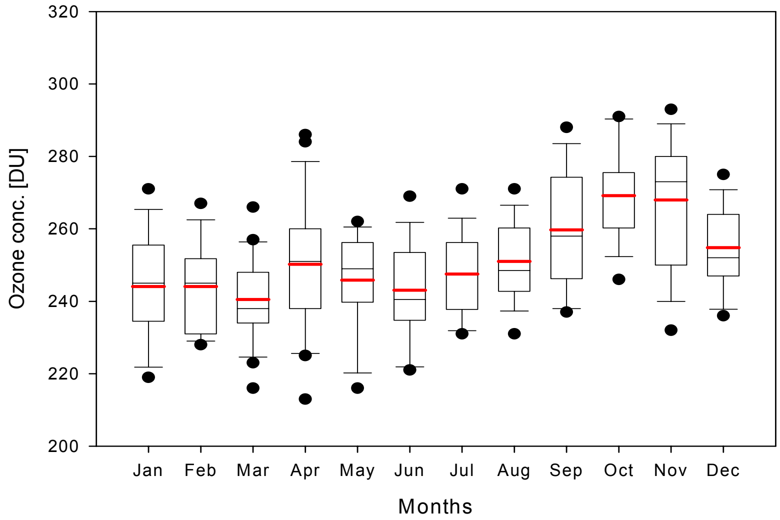

Figure 3: TCO trend for Fiji during 1997-2003.

Ultraviolet-B (UV-B) Radiation

The UV-B data obtained during the one year of monitoring from 2003 to 2004 by the UVB-1 pyranometer is given in Figure 4.

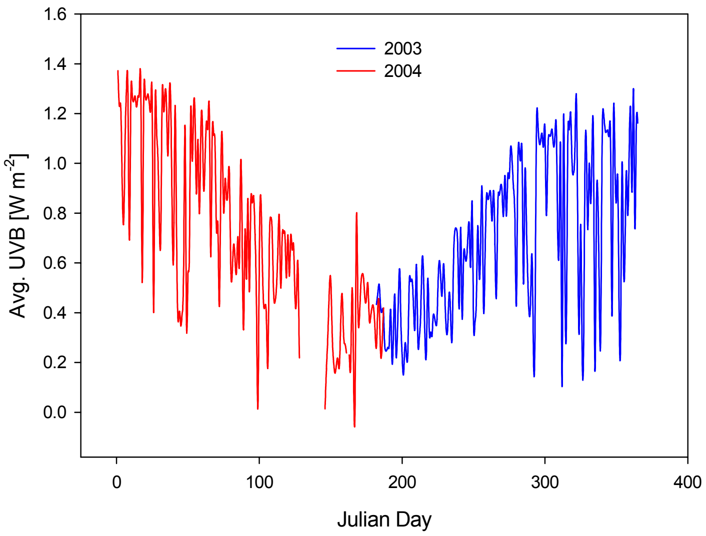

Figure 4: Daily average UV-B levels at Suva, Fiji, from July 2003 to July 2004.

OTHER RESEARCH

Other research relevant to the stratospheric ozone is the studying of the stratosphere-to-troposphere exchange processes.

Stratosphere-to-troposphere Exchange (STE)

One of the ways of studying the complex process of STE events is through tracer studies using cosmogenic radionuclides such as beryllium-7 (^{7}Be) (Dibb *et al*., 1992). Atmospheric aerosols at USP are collected using high-volume air samplers and the activity of ^{7}Be is determined using a high-resolution gamma-ray spectrometer with a hyper-pure germanium (HPGe) detector available at the Department of Physics at USP. The standard filters used for analysis are obtained from the Environmental Monitoring Laboratory (EML) in New York. Data of ^{7}Be measurements are available only from September 1999 to September 2000 and for part of 2003. Correlations with tropospheric ozone (Figures 5 and 6) suggest occurrence of STE events in the region. However, in view of the limited ^{7}Be data, conclusions cannot be definitive. Since ^{7}Be technique is time consuming, there is a need for a better method for determining any STE events in the region. In future studies we propose to attach a frost-point hygrometer to the ozonesonde for studying the STE processes.

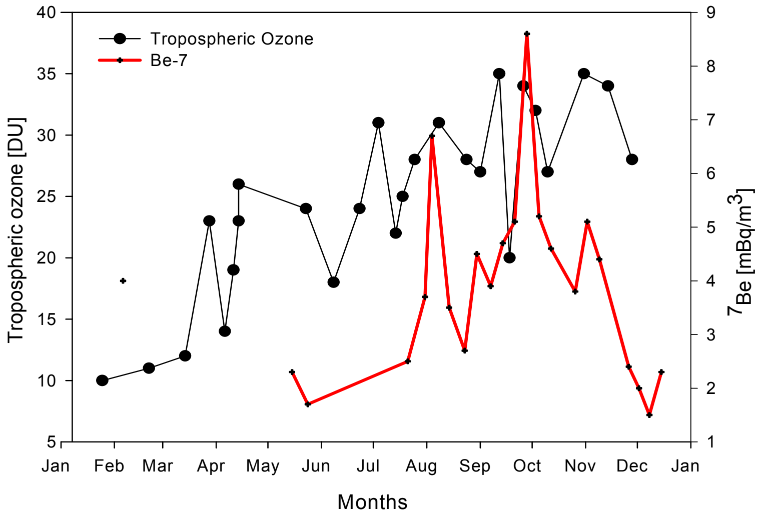

Figure 5: Correlation between ^{7}Be and Tropospheric ozone for Fiji, 2003.

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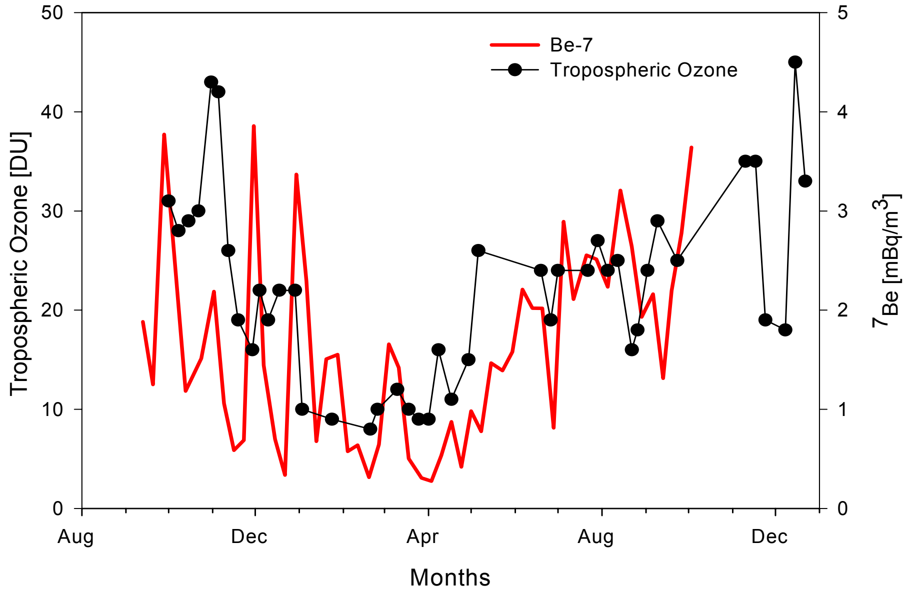

Figure 6: Correlation between ^{7}Be and Tropospheric ozone for Fiji, 1999-2000.

DISSEMINATION OF RESULTS

Data Reporting

The ozone profile data collected in Fiji is sent to NOAA in Boulder, Colorado. The data from there is then transferred to the SHADOZ (Southern Hemispheric Additional Ozonesondes) archives.

PROJECTS AND COLLABORATION

The major international collaboration is with NASA/GSFC/NOAA/CMDL. Under this collaborative effort ozone monitoring in Fiji began during the Pacific Exploratory Mission (PEM)-Tropics A mission of NASA in the spring of 1996. The phase B of this mission (PEM Tropics-B) was conducted in the fall of 1999. Since 1997, ozonesonde measurements are being done on a weekly basis as part of the SHADOZ (Southern Hemispheric Additional Ozonesondes) programme initiated by NASA/GSFC/ NOAA/CMDL. More information can be found in the SHADOZ web site http://croc.gsfc.nasa.gov/shadoz/.

This international collaboration was aimed at studying the atmospheric chemistry over the Pacific region (over two seasons) and to build ozone database for satellite validation, processing and modeling. Moreover, ozonesondes are currently also launched to coincide with the Aura satellite overpass.

At a national level collaborations with the ODS unit of The Department of Environment have provided a means of creating awareness of the ozone hole problems and use of ozone depleting substances such as CFCs.

Collaborations within the Departments (Chemistry, Physics and PACE-SD) of the University has also enabled completion of a number of projects especially, for Master of Science students (Chandra, 2004; Mani, 2004; Gopal, 2000). Recent research at USP has looked into:

- Comparative study of ozone trends at all levels (surface, troposphere and stratosphere) in Fiji, Samoa, Tahiti, San Cristobal (Galapagos) and the South Pole (Amundsen-Scott Station) during 1997-2003, using data collected by NOAA/CMDL.

- Identifying the relationship between tropospheric ozone variations in the South Pacific and biomass burning by using clustered and individual trajectory analysis.

- Investigating vertical mixing of air by relating tropospheric ozone anomaly with surface ^{7}Be levels in Fiji.

- Identifying widespread regional convection (SPCZ) as one of the important sources of variability in surface and tropospheric ozone.

- Investigating the influence of quasi-biennial oscillation and solar cycle on stratospheric ozone trends.

- Relating surface UV-B levels with stratospheric ozone variations.

FUTURE PLANS AND RECOMMENDATIONS

The following activities are planned for the future:

- Continue monitoring vertical ozone profiles under the SHADOZ programme.

- Study the STE processes more accurately by coupling a frost-point hygrometer with the ozonesonde launches, hence monitoring vertical water vapor profile regularly.

- Start a continuous UV-B monitoring programme and study the changes in the influx of surface UV-B radiation as a result of stratospheric ozone variations. It is planned to acquire a good narrow band UV-B pyranometer for the Department of Chemistry and also have a regular standardization and validation programme. For effective study of surface influx of UV-B, the atmospheric aerosol loading and cloud cover also needs to be determined. Hence, it is also planned to introduce a light detection and ranging (lidar) instrument and develop cloud characterization capacity at the university in conjunction with the Fiji Meteorological services. Accurate measurements of surface UV-B levels will also pave the way for the currently incomplete biological studies such as UV-B induced damage to plants, marine organisms, cases of skin cancer and cataracts.

- Introduce a Dobson or a Brewer spectrophotometer to enhance the capacity of ozone monitoring and research at USP.

Being a developing Island nation, funds and expertise are not readily available in Fiji to carry out the above activities effectively. Thus, completion of the above activities will depend heavily on funding from donor organizations.

ACKNOWLEDGEMENTS

The ozone project at USP is funded by NASA/GSFC and implemented through NOAA/CMDL under the SHADOZ programme. Sincere gratitude to Bryan Johnson of CMDL for ensuring timely shipment of supplies for regular ozone monitoring.

Data from measurements made under the SHADOZ programme can also be found in Thompson *et al*. (2003).

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FINLAND

OBSERVATIONAL ACTIVITIES

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

The discovery of the Antarctic "ozone hole" in the mid 1980s initiated several ozone monitoring activities also at northern high latitudes. In Finland ozone column monitoring has been carried out by the Finnish Meteorological Institute at Sodankylä (67.4N, 26.6E) since 1988 and at Jokioinen (60.5N, 23.3E) since 1994. At both stations an automated system based on Brewer spectrophotometer is continuously operated. At Sodankylä Arctic research centre (FMI-ARC) wintertime ozone columns are also monitored with a SAOZ spectrophotometer which is operated in cooperation with CNRS-Paris already since 1990. The SAOZ measurements also provide NO_2 and OClO column amounts. This instrument works at low solar zenith angles and is thus capable of measurements during the wintertime at high latitudes. Multiyear ozone measurements from both stations have shown large inter-annual variations, in addition significant ozone loss has been observed in the Arctic stratospheric vortex during several years since early 1990s.

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

Ozone soundings has been carried out since 1989 at Sodankylä where balloon ozone sensor measurements are carried out regularly throughout the year, while in Jokioinen these measurements are conducted during winter and spring when chemical ozone depletion is expected.

Another long-term initiative at FMI-ARC related to stratospheric ozone is the measurements of polar stratospheric cloud (PSC) properties. PSCs play an essential role in chemical chlorine activation and subsequent ozone depletion. PSCs are generally divided in two types based on their optical parameters, type II are large particles of primarily water ice, type I are typically smaller particles of nitric acid trihydrate or supercooled ternary solution droplets. At Sodankylä these stratospheric cloud particles have been observed during stratospheric campaigns since 1991/1992 by lidar and since 1994 by aerosol backscatter sondes.

At Sodankylä, since December 2002, stratospheric humidity is monitored in winter months using frost point mirror hygrometers from NOAA and/or alpha-lyman hygrometers developed at Central Aerological Observatory of RosHydromet. Already earlier, in January 1996 an Arctic dehydration event was recorded and investigated at Sodankylä using NOAA/CMDL hygrosondes. FMI has also hosted an international intercomparison campaign of lightweight hygrosondes in January-February 2004.

The national meteorological institutes in Finland (FMI) and Argentina (SMN) started a joint ozone research programme in 1987, including total ozone measurements over Marambio (64.1°S, 56.4W), Antarctica. In 1988 routine ozone soundings were started at Marambio. Recently FMI and SMN have started Aerosol optical depth and radionuclide measurements at Marambio.

UV measurements

Broadband measurements

FMI operates SL501 broadband instruments at six sites in Finland. These instruments provide on-line information on the erythemal irradiance that is published thru the internet along with the UV-Index forecast.

Narrowband filter instruments

FMI cooperates with Argentina and Spain on Antarctic ozone and UV. In 1999 the collaboration was extended to include UV radiation research. The established UV monitoring network consists of NILU-UV instruments in Marambio, Belgrano and Ushuaia. In Sodankylä a NILU-UV radiometer has been used to measure UV radiation of a reference field within a large field experiment of FUVIRC (Finnish Ultraviolet International Research Center).

Spectroradiometers

FMI has measured spectral UV irradiance with Brewer instruments in Jokioinen (Mark III since 1995) and Sodankylä (Mark II since 1990). Additionally, a new Bentham DM150 was recently acquired for campaign use.

Calibration activities

FMI has a dark room UV calibration facility both in Jokioinen and Sodankylä. FMI has participated several UV measurement comparison campaigns, there it has been established that the quality of Finnish Brewer measurements is excellent and steady. The Brewer instrument of Jokioinen served as one of the core instruments of the QUASUME project (Quality Assurance of Spectral Ultraviolet Measurements in Europe). FMI is also responsible for calibration of the Antarctic NILU-UV instruments and data quality assurance.

Satellite observations and instrument development

FMI has a strong participation in three satellite instruments that are targeted for monitoring ozone in the atmosphere (GOMOS/Envisat, OSIRIS/Odin, OMI/EOS-Aura). The GOMOS instrument onboard the ESA's Envisat satellite has been operating since spring 2002. Ozone profiles that cover the altitude range from upper troposphere to lower thermosphere during years 2002-2004 are already available. Due to the new measurement technique utilized by the GOMOS instrument the validation and the further development of the data processing algorithms of the GOMOS instrument has been intensive during the last years. Reprocessed data is expected at the end of 2005.

The OSIRIS instrument onboard the Swedish small satellite Odin has measured ozone profiles since 2001. The ozone profiles are processed also at FMI and during the last years the validation and optimization of the algorithms have taken place.

The Dutch-Finnish OMI instrument onboard the NASA's EOS-Aura satellite has measured total ozone columns since 2004. FMI is hosting the OMI UV irradiance processing and archiving facility and the validation of the ozone and UV products are ongoing. In addition, local maps of total ozone columns and UV irradiance covering Central and Northern Europe are processed at FMI. These Very Fast Delivery products exploit the Direct Broadcast antenna at Sodankylä, Northern Finland. Once validated, the total ozone and UV irradiance maps are planned to be available in the Internet (omivfd.fmi.fi) within half an hour after the overpass of the satellite.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Only Brewer UV measurements are considered to have a sufficient quality for assessment of long-term changes. The smaller the change is the longer time series is required for detection of it. A study on the Sodankylä UV time series 1990-2001 revealed no consistent trend during this 12 year period. An increase of UV levels were observed in early 1990s and then decrease towards the end of the period the largest values occurring in 1993 and after the cold winters of mid 1990s consistent with the ozone layer developments in the same period.

THEORY, MODELLING, AND OTHER RESEARCH

The modelling activities related to middle atmospheric ozone includes the use of a global 3D chemistry transport model of the stratosphere, a global stratospheric and mesospheric GCM and a model of the ionosphere. The modelling work includes both studies of long term trends of stratospheric ozone utilizing reanalyzed meteorological data (ERA-40) as well as process studies

(PSC, chlorine activation, ozone loss rates). Also trajectory modelling is utilized for studying the ozone and water vapour distribution in the UTLS region. The scientific use of satellite measurements is increasingly important and an assimilation system combining OSIRIS and GOMOS profile data with a CTM model has been developed. In addition, the impact of solar proton events on the stratosphere and mesosphere is studied. In this study the unique night time ozone profile measurements of the GOMOS instrument are used. GOMOS data is also used for studying turbulence in the stratosphere.

FMI has developed models for reconstruction of the past UV time series as well as for assessment of the future UV levels. These data are essential for assessment of the long-term changes in surface UV. FMI contributed to the Arctic Climate Impact Assessment (ACIA) with a shared lead authorship of the chapter on ozone and UV. FMI has participated in multidisciplinary research projects that aim at better understanding of the effects of increased UV exposures on human health, terrestrial and aquatic ecosystems, or materials.

FMI coordinates the research project UVEMA exploring the Effects of UV radiation on MAterials. The study focuses on rubber compounds, natural fibre composites and carbon fibres provided by the industrial partners of the project. A programme of long-term outdoor material testing is being set up at seven European sites, including Jokioinen Observatory and Arctic Research Centre at Sodankylä. Prevailing UV radiation and weather conditions are being monitored alongside with the programme at each station. Exposed material samples will be investigated in respect of various properties: colour, quality/coarseness of the surface and compression/flexural/tensile strength. As an outcome, more reliable estimates for the useful life-time of the materials are to be gained.

FMI Arctic Research Centre at Sodankylä hosts the experimental fields of FUVIRC-experiment (Finland UV International Research Centre) to study biological impacts of UV-B radiation to boreal plants at enhanced UV-radiation condition. There are two experimental sites representing typical landscape types of northern Fennoscandia, a boreal pine forest test field and peat land test field. Enhancement of the ambient UV-exposure can be regulated to desired values through extensive monitoring and control system. The field serves atmospheric chemistry, human health, and biological research initiatives by providing extensive UV monitoring data, guidance (i.e. calibration of instruments, maintenance of field test sites), and research facilities (i.e. laboratories, instruments, equipment and accommodation for visiting researchers).

DISSEMINATION OF RESULTS

Data reporting

FMI has participated in the Global Atmospheric Watch (GAW) programme since 1994. Within the programme, FMI maintains the Pallas-Sodankylä GAW station and conducts an extensive research programme related to atmospheric aerosols. Within this twin GAW station surface and boundary layer measurements are done in FMI clean air site of Pallas while upper air measurements, UV and Ozone monitoring takes place at Sodankylä. In upper air research Sodankylä functions as an auxiliary station in the global Network of Detection of Stratospheric Change.

FMI maintains the European UV Database (EUVDB). EUVDB is a regional WMO database containing some two million UV spectra. The UV spectra of the two Finnish Brewer instruments are submitted to EUVDB.

Regular ozone soundings have been performed at Marambio since 1988; the data has been used in scientific publications, and form a significant contribution to the WMO ozone bulletins (www.wmo.ch/web/arep/ozone.html).

Information to the public

FMI provides a 2-day forecast of the UV Index in Europe. The forecast, which is published in the internet, includes a contour map of the local solar noon maximum clear sky maximum UV Index. Additionally, local clear sky UVI forecast is provided for several sites in Finland and Europe. The Finnish broadband UVI measurements are also incorporated in the web page. FMI has actively participated in increasing the awareness of general public on the health effects of UV radiation. In addition, FMI contributed to the Arctic Climate Impact Assessment (ACIA) document with a shared lead authorship of the chapter on ozone and UV.

Ozone depletion has a large public interest due to related health (UV) and environmental issues, e.g. the unprecedented stratospheric conditions and severe ozone loss in the winter and spring 2004/2005 triggered a wide interest in the Finnish media. The major scientific results are published in international refereed journals and are also presented at relevant international conferences. Popularized information is distributed through press releases and interviews. Information about research activities as well as measurements and analysis results are also available through FMI web pages; Arctic and Antarctic research at FMI, www.fmi.fi/research_polar/polar.html, FMI-ARC observations and analyses, fmiarc.fmi.fi, Remote sensing projects and general Ozone and UV related information, www.fmi.fi/research_atmosphere/atmosphere.html.

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PROJECTS AND COLLABORATION

The major national funding organisations are the Academy of Finland and the National Technology Agency of Finland. The Antarctic research related to ozone and UV and the as well as the research of the impact of solar proton events on stratosphere and mesosphere is partly funded by the Academy of Finland. FMI collaborates with the University of Helsinki in atmospheric modelling and in developing data retrieval methods and assimilation technique for the GOMOS and OSIRIS instruments.

- FARPOCC (Finnish Antarctic Research Programme on Polar Climate Change, www.fmi.fi/research_polar/polar.html)
- MAIST (Middle atmospheric interactions with sun and troposphere)
- FUVIRC (Finnish Ultraviolet International Research Center, fuvirc.oulu.fi/index.htm)
- MUTUAL (Multiproxy Approach to Estimate Changes in UV Exposure in Arctic Lakes, www.helsinki.fi/bioscience/ecru/projects/mutual.htm)
- UVEMA (Effects of UV radiation on Materials, uvema.fmi.fi/)

FMI has participated in several EU funded Arctic and Antarctic research projects including tasks such as stratospheric modelling and measurement campaigns. The modelling activities include cooperation with the National Center for Atmospheric Research, USA and Max-Planck Institute, Hamburg. Sodankylä has participated in all major European stratospheric ozone campaigns. In 1999 and 2003 the Marambio activities formed an important part of the international stratospheric ozone research campaigns.

- QUASUME (Quality Assurance of Spectral Ultraviolet Measurements in Europe)
- RETRO (REanalysis of the TROpospheric chemical composition over the past 40 years, retro.enes.org/)
- CANDIDOZ (Chemical and Dynamical Influences on Decadal Ozone Change)
- SCOUT-O3 (Stratospheric-Climate Links with Emphasis on the Upper Troposphere and Lower Stratosphere, www.ozone-sec.ch.cam.ac.uk/)
- PROMOTE (PROtocol MOniToring for the GMES Service Element, www.gse-promote.org/)
- ACIA (Arctic Climate Impact Assessment, www.acia.uaf.edu/pages/scientific.html)
- COSMOS (Community Earth System Models, cosmos.enes.org)

FMI is hosting EUMETSAT Satellite Application Facility on Ozone Monitoring (O3M SAF, fmi.o3saf.fi). O3M SAF is one of the SAFs in EUMETSAT SAF network. SAFs are specialised development and processing centres within the EUMETSAT Application Ground Segment (www.eumetsat.int). O3M SAF is developed in co-operation with Koninklijk Nederlands Meteorologisch Instituut (KNMI), Deutsche Zentrum fur Luft- and Raumfarhrt (DLR), Deutscher Wetterdienst (DWD), Aristotle University of Thessaloniki (LAP), Hellenic National Meteorological Service (HNMS), Danish Meteorological Institute (DMI), Meteo-France (M-F) and Koninklijk Meteorologisch Instituut (KMI).

The purpose of the O3M SAF is to produce a set of near real-time and offline products and validation services. Near real-time products are GOME-2 total ozone and ozone profiles, HIRS total ozone and UV clear-sky fields. Offline products derived from GOME-2 data are total column amounts of ozone, NO2, BrO, ozone profiles, aerosol index and optical depth and UV fields including cloudiness and albedo. The ozone and UV data will be validated against ground-based observations of total ozone and UV as well as balloon borne, microwave and lidar observations of the vertical distribution of ozone. An important part of the O3M SAF activities has been related to scientific work to develop radiative transfer calculation methods and other algorithms used for satellite ozone and related data retrieval.

The Satellite Data Centre of FMI-ARC started in 2002. The activities include a processing facility for the GOMOS/Envisat ozone instrument. The FMI-ARC data centre also process part of the OSIRIS/Odin ozone data. Data reception from the EOS-Aura satellite is also going on for Very Fast Delivery products of the total ozone and UV irradiance maps, to be available within half an hour after the overpass of the satellite.

FUTURE PLANS

Although the basic processes related to stratospheric ozone are now fairly well understood, there remain important research topics related to ozone and UV, such as the effects of increased UV-irradiance on nature and details of the complex interaction between ozone depletion and the greenhouse effect. According to the present understanding the recovery of the ozone layer will take several decades, therefore it is desirable that the research activities will be continued and developed.

In the near future the vortex build-up period in the winter polar stratosphere and interaction between ozone variations and vortex dynamics will be studied. FMI will also take part in several activities organized during the International Polar Year 2007/2008. To continue the high resolution ozone profile measurements of OSIRIS and GOMOS instruments FMI has proposed OLIVIA (Occultation and limb viewing of the atmosphere) instrument to the ESA Earth Explorer programme in 2005.

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FRANCE

Ozone and UV radiation research in France is managed by the CNRS – Institut National des Sciences de l'Univers (INSU) under a dedicated Programme National de Chimie de l'Atmosphère (PNCA). Long term monitoring activities relevant to NDSC are coordinated by the Institut Pierre Simon Laplace (IPSL). Space and balloon components are managed by the Centre National d'Etudes Spatiales (CNES). Additional contributions are provided by the Institut Paul Emile Victor (IPEV), Météo-France, the Ministère de l'Ecologie et du Développement Durable, the Ministère de la Recherche, the Institut National de Recherche Agronomique (INRA) and a number of Universities. Many of the above programmes are also supported by the European Commission under the 5^{th} and 6^{th} Environmental Programmes.

The research include the long term monitoring of the stratosphere and UV-B in the frame of NDSC at a variety of sites, the study of ozone depletion related mechanisms in polar areas, at mid-altitude and in the tropics using balloon, aircraft and space borne instruments, most of them being operated in cooperation with other European and international institutes.

OBSERVATIONAL ACTIVITIES

Ground-based

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 locations in cooperation with local institutes: a lidar at Alomar in Norway and the SAOZ UV-Vis spectrometers 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, stratospheric 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 conducted previously at Bordeaux have been moved to Lanemezan.

In Antarctica, the instruments operating 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 closed in 2001, has bee replaced in 2005. An additional SAOZ is in operation since 1995 at the sub-Antarctic Island of Kerguelen. The installation of a SAOZ and a microwave radiometer are anticipated at the inland French-Italian station of Concordia expected to run year round after 2006.

At the tropical site of Reunion Island, the instruments operating are a temperature / aerosol lidar, stratospheric and 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 2006 together with a microwave radiometer for ozone and water vapour and a FTIR operated by the Belgium IASB-BIRA.

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, they are made publicly available after reprocessing through the NDSC archive centre.

Summary of Ground-based observations
Column measurements of ozone and other gases /variables relevant to ozone loss

SAOZ Ozone and NO2 at Scoresbysund (Greenland), Sodankyla (Finland), Salhekard (W. Siberia-, Zhigansk (E. Siberia), OHP (France), Bauru (brazil), Reunion Island, Kerguelen and Dumont d'Urville (Antarctica)
Dobson at OHP and Lanemezan (France)

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

Stratospheric Ozone lidar at OHP (France) and Dumont d'Urville (Antarctica)
Ozonesondes at OHP (France), Reunion Island and Dumont d'Urville
Stratospheric temperature lidar at at OHP (France), Reunion Island and Alomar (Norway)
Aerosol lidar at OHP (France), Reunion Island and Dumont d'Urville
Tropospheric ozone lidar at OHP (France) and Reunion Island

UV measurements

Broadband measurements at Dumont d'Urville (Antarctica)
Spectroradiometers at Villeneuve d'Asq and Briançon (France)

Calibration activities

NDSC intercomparison campaign of UV-Vis instruments in Norway, and ozone lidar intercomparison at OHP.

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;
- the analysis of the measurements of the SMR instrument (ozone, water vapour and ClO) on board the Swedish-Finnish-Canada-French ODIN satellite placed in orbit in 2001 and still operating;
- the exploitation of the data of the French initiated GOMOS instrument on board the ESA ENVISAT satellite in orbit since March 2002, and more generally a participation to that of the two other stratospheric chemistry instruments MIPAS and SCIAMACHY; and,
- a strong involvement in the validation of the measurements of GOME-ERS-2, ODIN and ENVISAT from ground based and dedicated balloon flights measurements in the Arctic, at Mid-latitude and in the tropics

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 2006. The derivation of ozone columns in the lower stratosphere from METEOSAT Second Generation and for METOP/HIRS is the specific contribution of Météo-France.

Aircraft

The two French research aircraft have been renewed for an ATR 42 and a Falcon 20, both anticipated starting operating in early 2006. France is also running since 1993 in cooperation with other European institutes and with support of the European Commission, the MOZAIC programme of in situ ozone, water vapour and NOy (since 2002) measurements on in-service commercial aircraft, from which tropospheric ozone climatology are derived at a number of airport worldwide.

Balloons

The French contribution to stratospheric balloon activities is twofold: CNES balloon 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 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; the 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.

Most recent balloon campaigns relevant to stratospheric dynamics and chemistry were:

- 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 studying ozone depletion;
- an ESA-CNES ENVISAT validation campaign of long duration MIR balloon flights in Bauru (22°S) in Brazil in February 2003;
- a European HIBISCUS campaign of 18 short and long duration circumnavigation balloon flights at the tropics in Brazil in January-March 2004 for studying the impact of deep convection on the stratosphere;
- an ESA-CNES ENVISAT validation campaing of 5 large balloon flights in Teresina, Northern Brazil in June-July 2005;
- a VORCORE project of 20 long duration constant level balloon currently held (September 2005) in Antarctica for studying the dynamics of stratospheric vortex.

Planned in the 2006 is a balloon / aircraft campaign in West Africa in the frame of the new European FP6 SCOUT-O3 project for studying the Stratospheric Chemistry-Climate relationship.

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 appropriate protocols, all

French space and field data relevant to the stratosphere are archived into a newly built national data base ETHER.

RESULTS FROM OBSERVATIONS AND ANALYSIS

A number of studies are being conducted based on the above observational data frequently in collaboration with foreign scientists and particularly European institutes within projects supported the European Commission. Among those studies, two are highlighted here as an illustration.

Figure 1 shows the results of the yearly evaluation of total ozone loss in the Arctic stratosphere since 1993 from the SAOZ ground based network illustrating the large inter-annual variability of the ozone destruction in relation with the meteorology of the vortex.

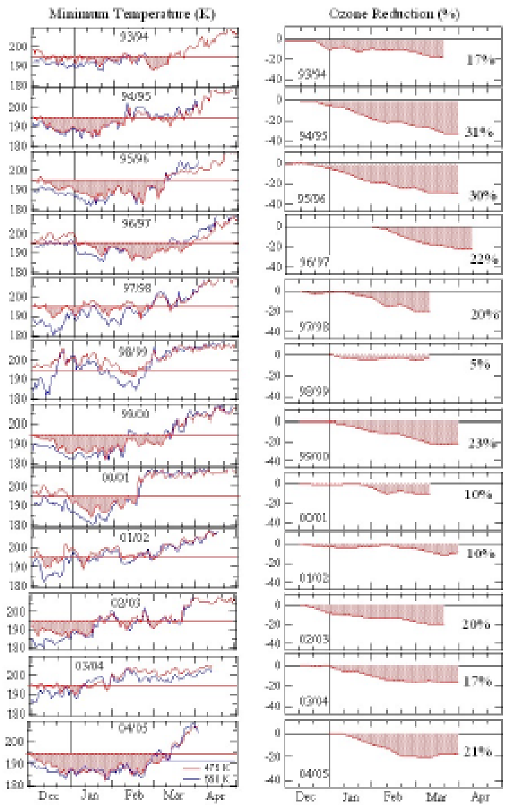

Figure 1: Estimation of amplitude of chemical stratospheric ozone reduction the Arctic during the winter season from the measurements of the SAOZ network. Left: minimum ECMWF temperature north of 60°N at 475 K and 550 K ; Right ozone chemical reduction after subtraction of the contribution of transport using a 3D CTM model. [Goutail et al., 2005].

Figure 2. shows a comparison of the 1985-2003 ozone concentration profiles trends above the Observatoire de Haute Provence evaluated from SAGE 2 and lidar observations. Although the exact figure depends a little on the period selected for the analysis, a consistent reduction of 4-7% / decade could be derived from both data sets in the upper stratosphere, and still of 1-3% at lower altitude.

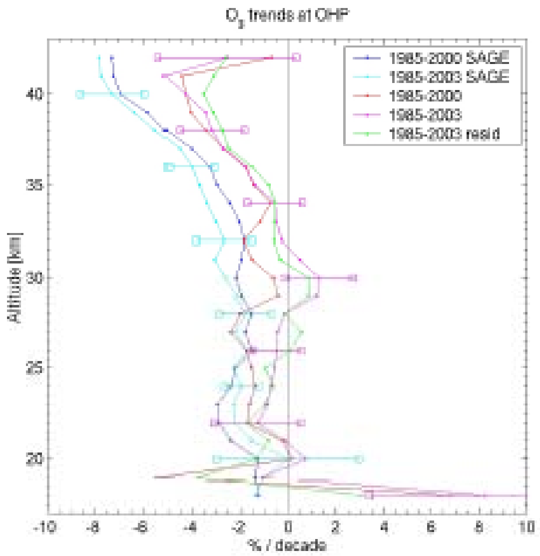

Figure 2: Stratospheric ozone reduction since 1985 above the OHP station in France derived from Lidar and SAGE II observations [Godin et al. 2005].

DISSEMINATION OF RESULTS

Data reporting

The SAOZ (ozone / NO_2) and ozonesondes data are made available in near real time to WMO, WOUDC and the ESA and EC data –bases at the Norwegian Institute for Air Research (NILU). All NDSC relevant data are deposited, after reprocessing, in the NDSC archive centre. In addition all French space and field data relevant to the stratosphere are archived into a national data base ETHER.

Relevant scientific papers

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FUTURE PLANS

NDSC ground-based observations will be continued at OHP, Reunion Island, Dumont d'Urville as well as at the SAOZ stations. The two new coming NDSC relevant projects are: (i) the beginning of the construction of the high altitude (2500 m asl) Maido station at Reunion Island planned to host a FTIR of the Belgium IASB, and a microwave radiometer of the Laboratoire d'Aerologie in Toulouse; (ii) the opening of the Concordia station inland Antarctica for its first wintering in 2005, where the installation of a SAOZ spectrometer is planned in 2006, followed later by an ozone/ water-vapour microwave radiometer.

The analysis, interpretation and modelling of most of French stratospheric ozone relevant ground-based, satellite, aircraft and balloon observational projects are part of the SCOUT-O3 FP6 project (2004-2009) supported by the European Commission and coordinated by the University of Cambridge (UK).

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GEORGIA

INTRODUCTION

In Georgia the examination of the atmospheric ozone (total ozone, ozone vertical distribution and surface ozone concentration) were started almost 50 years ago. Several decades were conducted only scientific studies of atmospheric ozone.

Later the Cabinet of Ministers of Republic of Georgia decided in Decision N711 of 8 November, 1995 that Georgia shall accede to "the 1985 Vienna Convention for the Protection of the Ozone Layer" and "the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer". On 21 March, 1996, Georgia acceded to these international documents and sufficiently these documents entered into force for Georgia on 19 June, 1996.

The National Country Programme for phasing out of ODSs was developed jointly with the scientific study programmes of ozone and approved in 1997 through assistance of United Nations Environment Programme and United Nations Development Programme and financial support of Multilateral fund so as to enable the country to implement obligations under the Montreal Protocol on the Substances that Deplete the Ozone Layer. The institutional framework was established to ensure the implementation of the Action Plan in the Country Programme. The National Ozone Unit the Ministry of Environment Protection and Natural Resources of Georgia is a coordinating body for the implementation of all activities under the Montreal Protocol.

OBSERVATIONAL ACTIVITIES

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

The regular observation of total ozone started at Abastumani Astrophysical Observatory of Academy of Sciences of Georgia (41° 45' N, 42° 50' E, 1600 m asl) in 1957. A second station was established in Tbilisi (41° 41' N, 44° 57' E, 450 m asl) by the Hydrometeorological Service of Georgia in 1964. Total ozone observation were also carried out at the observational post of the Institute of Geophysics of Academy of Sciences of Georgia in Telavi (41° 48' N, 45° 30' E, 600 m asl) from 1973 till 1987. All observations are carried with ozonemeters of M-124 type constructed in the Main Geophysical Observatory (MGO) in St. Petersburg (Russia).

Regrettably, both Tbilisi ozonemeters were broken in 2001. At present only Abastumani ozonemeter is under working conditions.

The regular measurements are conducted of surface ozone concentration with the use of the OMG-200 type ozonemeter since 1980 to the present in Tbilisi and Telavi.

Note

Using standard actinometrical observations for eight Georgian locations (Tbilisi,1928-1991; Telavi,Tsalka – 1457 m, Anaseuli – 158 m, Senaki – 40 m, Sukhumi – 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, actinometrical observations were stopped because the instruments were not tested.

The measurements were renewed of the Atmospheric Aerosol Optical Depth from 2003 in Tbilisi (Institute of Geography and Institute of Geophysics of Academy of Science of Georgia).

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

The vertical distribution of ozone in Georgia by optical method and with the electrochemical ozonesondes was carried out in 1973-1982. In recent years, such measurements are not conducted.

Note

The photometric measurements of twilight sky brightness in different narrow intervals of the visible spectrum have been carried out in Abastumani Astrophysical Observatory since 1940. Such measurements allow to determine aerosol loading in the stratosphere and mesosphere as a function of height.

UV measurements

Unfortunately, UV- measurements in Georgia are not conducted because of the absence of equipment.

Calibration activities

The calibration of the ozonemeters was made every two years in the MGO during the existence of the former Soviet Union. After 1990 due to financial difficulties the calibration of Abastumani ozonemeter was carried out only in 1994, the calibration of ozonemeter of the Institute of Geophysics did not calibration after 1988, the calibration of Tbilisi ozonemeter was carried in 1999. Therefore, at present the Abastumani ozonemeter dates of total ozone in Georgia are unreliable.

The calibration of actinometer was carried out in 2002 years through the financial support Institutional Straitening Project of UNEP and NOU of Georgia.

RESULTS FROM OBSERVATIONS AND ANALYSIS

In recent years is continued the study of long-term variations of atmospheric ozone (total and surface) and aerosol in Georgia and their connection with human health, photochemical smog in the atmosphere of Tbilisi and its influence on the people health, quasi-biennial variations of the stratosphere ozone and solar activity, the evaluation of the influence of lasting variations in the total ozone content on the changeability of the regime of biologically active ultraviolet solar radiation in Georgia, radioactively active small atmospheric admixtures climatic effects in Georgia, Interaction of the ozone and aerosol, etc. The enumeration of the published works is represented lower.

THEORY, MODELLING, AND OTHER RESEARCH

Calculation of the effect some radiatively active small atmospheric admixtures on the direct and diffuse solar radiation in Georgia have been carried out for the clear sky conditions. Estimation of the effect of the variations of water vapour, total ozone, aerosols in the atmosphere and underlying surface albedo on the short-wave solar radiation were given (see [14,19,22]).

DISSEMINATION OF RESULTS

Data reporting

The total ozone data of Tbilisi station (including 2000 year) are regularly (every day) sent to the Main Aerological Observatory near Moscow, where all analogous information received from the countries of the Commonwealth of Independent States is collected. Twice a year the daily total ozone values are sent to the Main Geophysical Observatory in St. Petersburg. These data after quality control in MGO are sent to the WMO World Ozone and UV Data Centre (WO3UDC) in Toronto.

The total ozone data of Abastumani station are kept in the Abastumani astrophysical observatory in the tables form. The total ozone data of Telavi and surface ozone concentration data of Tbilisi and Telavi are kept in the Institute of Geophysics in the tables form and computer data base form.

The Atmospheric Aerosol Optical Depth data are kept in Institute of Geography and Institute of Geophysics in the computer data base form.

The stratosphere and mesosphere aerosol data are kept in Abastumani astrophysical observatory in the tables and computer data base form.

Information to the public

The National Ozone Unit the Ministry of Environment Protection and Natural Resources of Georgia on regular bases (3 times per year) publishs UNEP OzonAction bulletin in the Russian language. The popular book “Twenty questions and answers about the ozone layer” was produced by NOU in Georgian language in 2005. Institute of geophysics through the press and television inform the population of Georgia about the ecological problems, connected with atmospheric ozone (not regularly)

Relevant scientific papers

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

Amiranashvili A., Amiranashvili V., Tavartkiladze K,Gabedava V. – Spatil-temporary characteristics of the aerosol pollution of the atmosphere in Georgia, Proc. 1st Int. Conf . on Ecology and Environmental Management in Caucasus, Tbilisi, Georgia, October 6-7, 2001, 57-58.

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Amiranashvili A., AmiranashviliV., Tavartkiladze K., Laulainen N. – Monitoring of aerosol pollution in Georgia, Transactions of the Institute of Hydrometeorology of Georgian Academy of Sciences, ISSN 1512-0902, vol. 108, 2002, 19-23, (in Georgian).

Amiranashvili A., Bregvadze A., Tavartkiladze K., Toroshelidze T., Kharchilava J., Melkonyan D., Krasovski A., Kolev S., Desyatkov G., Semionov V., Tarannikova R.- Monitoring of Total Ozone Content in Georgia. Prospects of International Cooperation on the Perfection of Operation of Ozonometer Stations Network and Organization of Surface UV Solar Radiation Measurements , Transactions of the Institute of Hydrometeorology of Georgian Academy of Sciences, ISSN 1512-0902, vol. 108, 2002, 45-51, (in Georgian).

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Amiranashvili A., AmiranashviliV., Tavartkiladze K . – Some characteristics of the aerosol pollution of the atmosphere in Eastern Georgia, Proc. 3th Int. Conf. "State and the conservation of air pond and water-mineral resources of health resort- recreational regions ", Kislovodsk, Russia, 21-24 April 2003 , 17-18, (in Russian).

Kharchilava J., Amiranashvili A., Chikhladze V.– Some results of studies of the surface ozone concentration in Ruispiri and Tbilisi in 2002 year, Proc. 3th Int. Conf. "State and the conservation of air pond and water-mineral resources of health resort- recreational regions ", Kislovodsk, Russia, 21-24 April 2003 , 37-38, (in Russian).

Amiranashvili A., AmiranashviliV., Gogua R., Matiashvili T., Nodia A., Kharchilava J., Khunjua A., Chikhladze V., Tavartkiladze K., Gabedava V. - The estimation of the risk of some meteorological- geophysical factors for the health of people under the conditions of Eastern Georgia (based on the example to Tbilisi), Proc. 3th Int. Conf. "State and the conservation of air pond and water-mineral resources of health resort- recreational regions ", Kislovodsk, Russia, 21-24 April 2003 , 74-76, (in Russian).

Amiranashvili A., AmiranashviliV., Kharchilava J., Tavartkiladze K., Toroshelidze T., Gabedava V. - The evaluation of the influence of lasting variations in the total ozone content on the changeability of the regime of biologically active ultraviolet solar radiation in Georgia , Proc. 3th Int. Conf. "State and the conservation of air pond and water-mineral resources of health resort- recreational regions ", Kislovodsk, Russia, 21-24 April 2003 , 76-77, (in Russian).

Amiranashvili A. , Amiranashvili V. , Tavartkiladze K. - Effect of the variability of some radiatively active small atmospheric admixtures (RASAA) on short-wave solar radiation fluxes, IUGG 2003 Abstract, , Sapporo, Japan, June 30-July 11, 2003, MI02a/30P/D-017.

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Kirkitadze D. – Some results of studies of the aerosol pollution of the atmosphere in Tbilisi, Transactions of Institute of Geophysics of Georgian Academy of Sciences, ISSN 1512-1135, vol. LVIII , 2003, 177-181, (in Russian).

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Amiranashvili A.G., Amiranashvili V.A., Tavartkiladze K.A.- Influence of cloudiness and aerosol pollution trends on the total solar radiation in some non industrial regions of Georgia , Proc. 14thInternational Conference on Clouds and Precipitation , Bologna , Italy ,18-23 July2004.

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Amiranashvili A.G., Amiranashvili V.A., Kirkitadze D.D, Tavartkiladze K.A. - Some results of investigation of variations of the atmospheric aerosol optical depth in Tbilisi , Proc. 16th International Conference on Nucleation&Atmospheric Aerosols, Kyoto, Japan, 26-30 July 2004, 416-419.

Amiranashvili A.G., Chikhladze V.A., Kharchilava J.F, Buachidze N.S., Intskirveli L.N. -Variations of the weight concentrations of dust, nitrogen oxides, sulphur dioxide and ozone in the surface air in Tbilisi in 1981-2003 , Proc. 16th International Conference on Nucleation&Atmospheric Aerosols, Kyoto, Japan, 26-30 July 2004, 678-681.

Amiranashvili A.G., Amiranashvili V.A., Gzirishvili T.G., Kharchilava J.F., Tavartkiladze K.A. – Modern Climate Change in Georgia. Radiatively Active Small Atmospheric Admixtures, Transactions of Institute of Geophysics of Georgian Academy of Sciences, ISSN 1512-1135, Monograph, vol. LIX , 2005, 1-128.

PROJECTS AND COLLABORATION

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;
- Interaction of the stratospheric and tropospheric 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

- Installation of equipment for monitoring 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.
- The organization of regular information campaign for the population of Georgia via the mass media on dangerous levels of surface ozone, solar UV-radiation and prophylaxis measures for mitigation of their negative effect.

NEEDS AND RECOMMENDATION

- There is an urgent need for financial assistance intended for the reparation of two ozone instruments M-124 and calibration of four ozone instruments M-124;
- There is an urgent need to purchase one or two more modern total ozone instrument and two or three UV-B solar radiation instruments;
- There is no funds available for periodic calibration of standard actinometrical instruments;
- A standard Dobson or Brewer spectrophotometers and more modern surface ozone instruments are essential to have In the future.

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GERMANY

In accordance with Decision VCV/3: Recommendations of the fifth meeting of the Ozone Research Managers to the Parties of the Vienna Convention at Geneva in 2002, the following significant research and monitoring activities have been carried out since 2002 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 centers (MPI, DLR, FZ-Karlsruhe, 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 and federal level. Surface ozone will not be discussed further in this report.

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

Institute	Location	Field	Keywords
Deutscher Wetterdienst, www.dwd.de/en/FundE	Hohenpeissenberg, Lindenberg	MT, R, QA/QC	Regional Ozone Center, 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 O_3-Sonde, JOSIE, ClaMS
MPI f. Meteorologie (DKRZ), www.dkrz.de/	Hamburg	R, MD	ECHAM
DLR, DLR/DFD, www.dlr.de/ www.wdc.dlr.de/index.html	Oberpfaffenhofen	R, MD, MT, QA/QC	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.atmosphere.mpg.de/enid/2_html	Mainz	R, MD	ECHAM/CHEM
Uni Heidelberg, www.uphys.uni-heidelberg.de/	Heidelberg	R, QA/QC	DOAS
IMK, Forschungszentrum und Universität Karlsruhe www-imk.physik.uni-karlsruhe.de/	Karlsruhe, Garmisch-Partenkirchen (IfU)	R, D, MD, MT, QA/QC	FTIR, MIPAS, ENVISAT,
Uni München (LMU)	München	R, MD	UV, STAR
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 programme 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 38 years for ozone measurements up to 30 km altitude (balloon-sonde and Dobson-spectrometers) and 18 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. Both institutes provide the public with UV-information including daily forecasts of the UV-index (see below).

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) and temporary onboard of RV POLARSTERN. The Neumayer meteorological observatory is designed as a radiation and climate monitoring station and an air chemistry observatory. In the next years a new station (Neumayer III) will replace Neumayer II to continue the long-term observations. This includes measurements of surface radiation as part of a global observation network to detect long-term changes in the Earth's radiation budget and their impacts on climate (BSRN). Since 1992 vertical ozone balloon soundings are part of the regular observations. These measurements continue the sounding record from the former station Georg Forster, beginning in 1985.

The full suite of NDSC measurements are routinely performed at the primary station Koldewey. This includes ozone-soundings by ECC-sondes, Lidar, microwave, DOAS, FTIR and UV-spectrometers. In addition, the same radiation measurements as at Neumayer-Station are performed as part of the BSRN.

IMK (Forschungszentrum and University of Karlsruhe) contributes with ground based remote sensing observations by FTIR- and mm- spectrometers and LIDAR instruments within the NDSC and WMO-GAW networks to trend assessments. With a new tropical mm-spectrometer station in Merida, Venezuela, 4700 m asl, FZK-sites cover tropical, sub-tropical, mid- and polar latitudes. Within the NDSC, FTIR spectrometers are operated by IMK at Kiruna (North of Sweden) and at Izaña on Tenerife Island and a primary NDSC station at the Zugspitze. Several ozone- and climate-related species are measured with this technique since about 10 years. The stratospheric aerosol content is monitored since 1976 with a LIDAR which is part of the NDSC at the Garmisch site.

Two major satellite instruments onboard the European ENVISAT satellite, MIPAS and SCIAMACHY, are initialized and supported by groups at IUP/IFE, University of Bremen, and IMK, Karlsruhe. DLR/DFD is routinely retrieving and processing the data from a number of satellite instruments, among them GOME, SCIAMACHY, and MIPAS. In order to improve the utilization of data, the World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT) was established.

The primary focus of WDC-RSAT is the provision of data which are primarily gathered from satellite based sensors. Higher level data and information products are also generated from the data through assimilation into numerical models of the atmosphere and of its interaction with the biosphere.

WDC-RSAT grew out of the Atmos Users Center (AUC) of the German Remote Sensing Data Center which was established to provide the European atmospheric satellite data user community with direct and easy access to measurements and derived data products from a wide range of sensors.

In addition to providing sensor data and analysis products of the atmosphere, WDC-RSAT offers various services such as the assistance of scientific field campaign planning by e.g.

analyzing the overall atmospheric state. Additionally offered is a service contributing to validation of atmospheric measurements through application, for example, of a 3D trajectory model such that satellite data can be better matched with correlative measurements.

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

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

RESEARCH AND DEVELOPMENT

The German Ministry of Education and Science (BMBF) has been funding a number of ozone and UV-research programmes. These programmes were conducted in close cooperation with partners from Europe and abroad, and include laboratory studies, modeling and the evaluation of existing data. They substantially improve the understanding of the ozone layer, especially at northern high and mid-latitudes. The AFO 2000 Programme, in particular the KODYACS project has investigated the links between long-term ozone depletion and climate change. KODYACS combined substantial modeling efforts (ECHAM/CHEM) with analysis of existing long-term measurements.

Apart from ongoing ozone related research activities, DLR-IPA is involved in two major EU-funded projects: DLR-IPA is coordinator and one of the main contributors for the international TROCCINOX project. TROCCINOX is aimed at improving the knowledge about trace gases (including water vapor) and particles (ice crystal and aerosols) in the upper troposphere and lower stratosphere in connection with tropical deep convection as well as large scale upwelling motions. A major focus is on production of NO_x by lightning (LNO_x) in tropical thunderstorms. In two major international campaigns (January to March 2004, and January to March 2005), several aircraft, including Brazilian Bandeirante, DLR-Falcon and Russian high-altitude Geophysica were deployed over Brazil, and on transfer flights across the Atlantic.

DLR-IPA and the Atmospheric Chemistry Department of the Max Planck Institute for Chemistry in Mainz are partners in the SCOUT-O3 project. SCOUT-O3's aim is to provide predictions about the evolution of the coupled chemistry/climate system, with emphasis on ozone change in the lower stratosphere and the associated UV and climate impact. In cooperation with FU-Berlin, DLR-IPA is leading SCOUT-O3 activity 1, which will generate ozone, climate and UV predictions with various state-of-the-art models. DLR-IPA is also involved in the major international SCOUT-O3 tropical thunderstorm campaign, November/December 2005 in Darwin (Australia), and in measurement and modeling activities for surface UV. 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 and operates a number of relevant systems at the KOLDEWEY Arctic station in cooperation with AWI. The building of a new tropical station (Merida, Venezuela, 4700 m asl) in cooperation with FZ Karlsruhe and AWI is in progress. 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 IMK (Forschungszentrum and University of Karlsruhe) measurements of ozone and ozone relevant species have been performed for many years by ground-based and airborne observations. Since the successful launch of the ENVISAT satellite, the retrieval of MIPAS-ENVISAT data beyond ESA standard products with the KOPRA-RCP processor developed at IMK provides data sets on a global scale of NO, NO2, N2O5, HNO4, ClONO2, ClO, many other chlorine species, atmospheric tracers, other atmospheric parameters like photolysis rates and cloud particle properties (PSC, SVC). Main results are a detailed analysis of mixing effects during the Antarctic vortex split period in 2002, a global picture of PSC occurrence in the Antarctic, and the chemical effects of the strong solar storm events in fall 2003 and Arctic winter 2003/2004, showing ozone loss of 30% in about 50 km altitude. Balloon-borne observations allowed further analysis of the composition of PSC particles, ground based studies analyzed ozone loss in several winters. A new container with many new instruments has been developed for measurements on board a passenger aircraft Airbus A340-600 of Deutsche Lufthansa AG to measure regularly the distribution of ozone and other trace gases in the tropopause region.

The Lidar observation at Garmisch shows that the stratospheric aerosol load has relaxed after the eruption of Mt. Pinatubo. Current background levels are comparable to that observed in the seventies. Possible contributions from air traffic can therefore be excluded. Around 1995/1996 the Zugspitze and Jungfraujoch solar FTIR observations of total HCl and ClONO2 have monitored the Cl_y-turnover as a response to the Montréal protocol.

At Forschungszentrum Jülich various research activities related to stratospheric ozone are carried out including in-situ and remote observations and model simulations. In-situ observations of stratospheric water vapor and halogen oxides (ClO, Cl2O2, BrO) are made from aircraft and balloon platforms. Remote observations of various chemical species from aircraft (M55-Geophysica) are performed with the IR spectrometer CRISTA-NF. 3-dimensional simulations with respect to chemical ozone loss and the ozone budget are performed with the Lagrangian CTM CLaMS. Also different methods for diagnosing chemical ozone loss from available observations have been developed and are applied.

Under the coordination of Forschungszentrum Jülich (FZJ) the European IAGOS (Integration of Routine Aircraft Measurements into a Global Observing System) project (http://www.fz-juelich.de/icg/icg-ii/iagos/) started in the beginning of 2005 with the preparation of a distributed infrastructure for observations of atmospheric composition (e.g. ozone) on the global scale from commercial in-service aircraft. Commercial aircraft are complementary to satellite, balloon borne and ground based observations and can constitute an important component in a future integrated global observation system to watch the atmosphere for global or regional changes in the frame of the WMO/IGACO-(Integrated Global Atmospheric Chemistry Observations) theme. The IAGOS-initiative goes beyond the European MOZAIC (Measurement of Ozone by Airbus In-Service Aircraft) project (http://www.aero.obs-mip.fr/mozaic/), where five Airbus A340 long range passenger aircraft are equipped with automated instrumentation to measure comprehensive climatologies of the large scale distribution of ozone between surface and 12 km altitude since 1994. FZJ has been involved in MOZAIC from very beginning (coordination by CNRS in France). In total, more than 25,000 long-haul flights have been accomplished between 1994 and 2004 for O3 measurements, yielding more than 100,000 hours of data from the tropopause region and 40,000 tropospheric profiles over many cities.

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.

MATCH campaigns, coordinated by AWI and funded by the EU and national institutes have been carried out for more than ten successful years, most recently in the cold winter 2004/2005. These campaigns have been instrumental for our current understanding of the chemical ozone loss in the Arctic.

The Atmospheric Chemistry Department of the Max Planck Institute for Chemistry in Mainz has a research focus on ozone and the role of radicals in photo-oxidation mechanisms which play a central role in the self-cleansing capacity of the atmosphere. Computer models are developed to simulate the interactions of chemical and meteorological processes, and investigate the influences of atmospheric composition changes on climate.

The UV-group at the University of Munich investigates different influences on surface UV including modeling and detailed measurements.

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. In this scope, several JOSIE (Juelich Ozone Sonde Intercomparison Experiment: http://www.fz-juelich.de/icg/icg-ii/josie) sonde simulation experiments have been conducted in the laboratory to evaluate the performance of ozone sondes. In April 2004 the WMO/BESOS (Balloon Experiment on Standards for Ozone Sondes) field campaign at the University of Wyoming at Laramie, USA, was held to test the reliability of JOSIE-results in the real atmosphere. The results of JOSIE and BESOS clearly demonstrate that caution has to be exercised in making instrumental changes or in preparing/operating procedures with regard to the sonde performance and hence the interpretation of ozone trends. Under the auspices of WMO/GAW the Assessment of Standard Operating Procedures for Ozone Sondes (ASOPOS) has been initiated and a panel meeting of experts in Jülich (September 2004) critically evaluated operating procedures and is preparing a detailed document with recommendations for standardization of sonde operation.

The Regional Dobson Calibration Center for WMO RA VI Europe (RDCC-E) at the Meteorological Observatory Hohenpeissenberg (MOHp) has been responsible for second level calibration and maintenance of more than 30 operational Dobson spectrometers in Europe since 1999. The close cooperation between MOHp and the Solar and Ozone Observatory at Hradec Kralove (SOO-HK, Czech Republic) guarantees excellent calibrations, training of operators, supply of the community with hard- and software. In the past 6 years 12 intercomparisons were performed with altogether 39 spectrometers from 18 countries. 9 Dobsons were completely refurbished electronically, among them 3 instruments being operated by the British Antarctic Survey at stations at the South Pole and one from Nairobi/Kenya.

The regional standard Dobson No. 064 was calibrated twice towards the primary standards (2002 at Boulder, USA, 2004 at Dahab, Egypt). During the last mentioned campaign DICE near the Red Sea the RDCC-E assisted in the organization and realization of the calibration service for the African network in WMO RA I together with the World Dobson Calibration Center (NOOA, Boulder - USA). In 2005 the staff of the RDCC-A from South Africa visited MOHp to get a training course in Dobson maintenance service.

GAWTEC, the Training and Education Center of the GAW Programme, has been established in July 2001. From the beginning, it was funded by the Bavarian State and supported by WMO. Since 2004, the German Federal Environmental Agency provides significant financial contributions to GAWTEC, which is also a co-operating partner of the German Quality Assurance/Science Activity Center. GAWTEC organizes training courses twice a year for personnel from GAW stations worldwide. It is based at the UFS Schneefernerhaus on the Zugspitze mountain. Experts from UBA, IMK at Garmisch, DWD at Hohenpeissenberg and additional invited experts hold training courses in measurement techniques of GAW-relevant parameters including ozone. Special emphasis is put on quality control, data handling and interpretation. Funding for GAWTEC will be provided at least until the end of 2006.

At the Ground Truthing Facility in Garmisch (IFU/IMK) dedicated validation studies have been performed for the instrument SCIAMACHY onboard ENVISAT by ground-based FTIR observation. Thereby significant deviations between the FTIR NO2 column amounts and the ESA SCIAMACHY results have been identified.

By IMK observations from the ground based stations in Kiruna and Tenerife have been used for validation of the SCIAMACHY and MIPAS observations on ENVISAT, and the Japanese satellite instrument ILAS-2. For the validation of MIPAS and SCIAMACHY on ENVISAT, balloon borne campaigns with a MIPAS FTIR instrument at several sites and several flights with MIPAS on the Geophysica aircraft have been performed.

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INDIA

INTRODUCTION

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

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

OBSERVATIONAL ACTIVITIES

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

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

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

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

Vertical Ozone Distribution : The development of an Indian ozonesonde was taken up in 1963. The first successful sounding was carried out in September, 1964. The sondes were subsequently intercompared in WMOII03C. Further, comparisons were also held in West Germany in 1970 and 1980; in 1991 (Canada) and 1996 (Germany). Since early 1970, fortnightly soundings were attempted at New Delhi, Pune, Thiruvanathapuram, Dakshin Gangotri and Maitri (Antarctica).

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.

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.

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

UV measurements

Broadband measurements

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

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

Narrowband filter instruments

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

Spectoradiaometers

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

Calibration activities

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

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

RESULTS FROM OBSERVATIONS AND ANALYSIS

The major findings are as follows : -

a) Analysis of long term total ozone data from the Indian stations have not shown any trend.
b) From the equator to about 20^{o}N, the tropospheric ozone concentration remains practically same throughout the year.
c) Significant changes noticed in the vertically distribution of ozone associated with passing weather systems occur at New Delhi during the non-monsoon months.
d) Depletion of ozone over Antarctica is observed confirming occurrence of the Antarctic Ozone hole. The ozone hole phenomenon has also been observed over the Indian Antarctic station at Maitri (70^{o}S, 11^{o}E) where IMD monitors ozone amount throughout the year.

THEORY, MODELLING, AND OTHER RESEARCH

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

DISSEMINATION OF RESULTS

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

Data reporting

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

Information to the public

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

Relevant scientific papers

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

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

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

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

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

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

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

PROJECTS AND COLLABORATION

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

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

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

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

FUTURE PLANS

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

NEEDS AND RECOMMENDATIONS

In accordance with the decision of the Meeting of Parties to the Vienna Convention, present activities need to be continued to monitor ozone concentration and UV radiations.

Research activities relating to impact of UV radiations on life and its supporting system need to be conducted.

The Ozone Research Managers meeting may recommend to the Meeting of Parties for taking decisions to request Parties to provide adequate support to continue the present activities and to carry out future plans.

Developed countries may consider to have bilateral assistance programme with developing countries to strengthen ozone and UV-monitoring and research system.

UNEP networking system may also include ozone and UV monitoring activities in their agenda.

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IRAN

INTRODUCTION

The meteorological organization and geophysics institute of the University of Tehran are conducting UV-B and ozone monitoring and research activities in Iran.

Generally, there is continuous cooperation and exchange of information between these centers and other research groups, such as the universities and related research institutes.

Data collection stations operating under the supervision of the above centers are listed below:

Table 1: Currently operating UV and ozone stations in I.R. Iran.

Station Name	Synop Station	Upper Atmosphere Station	Surface Ozone	Vertical Ozone	Total Ozone	Lat.	Long.	Height (m)
Geophysics	Yes	No	Yes	No	Yes	$35^0$44'N	$51^0$33'E	1419
Firoozkooh	Yes	No	Yes	No	No	$35^0$43'N	$52^0$34'E	2986
Esphalan	Yes	Yes	Yes	Yes	Yes	$32^0$47'N	$51^0$72'E	1550

EXISTING ACTIVITIES

Total Ozone Measurement

Esphahan ozone station is identified with an international 336 codes. Total ozone is being measured using Dobson system since January 2000.

Since April 2000, Brewer ozonometric equipment was installed and has been operating at Esphahan station.

This system measures total ozone in vertical column in an area of $1cm^2$ by attracting solar and sky radiation. In addition, the system measures UV-B, SO_2, and NO_2.

Geophysics institute station: since 2000, total ozone is measured using Dobson system 30 minutes (from 8am to 7pm) and the result is compared with the satellite data. The data recorded at the above stations is regularity being reported to the WODC (World Ozone Data Center) and are available through the center's web pages.

Vertical Ozone Measurement

Vertical ozone is being measured using ozonesonde, radiosonde and Balloon twice a month. The vertical ozone data recorded in the stratosphere layer (about 30Km from earth) is transmitted to the ground stations for further processing. The vertical distribution of ozone is calculated by digicora system. That combines data received from both the ozonesond (ECC/6A) and the radiosond and results in final distribution patters of ozone.

Surface Ozone Measurement

In IRAN surface ozone outside urban area is being measured at Firooz-kooh which is an official WMO Global Atmospheric Watch (GAW). Meteorological organization also measure surface ozone in cooperation with geophysics institute of the University of Tehran in Tehran and Esphahan stations.

Upper Atmosphere Research

Esphahan station identified by an OIFM code and measures on a daily basis the upper atmospheric conditions between 11 to 12 GMT every day. This measurement includes vertical pressure, temperature, humidity, wind speed and direction.

In order to study the Upper atmosphere, radiosonde (RS80) and hydrogen balloon (Totex 600gr) are used for data collection. Data recorded by these instruments then is transmitted to the global telecommunication system using a switching system.

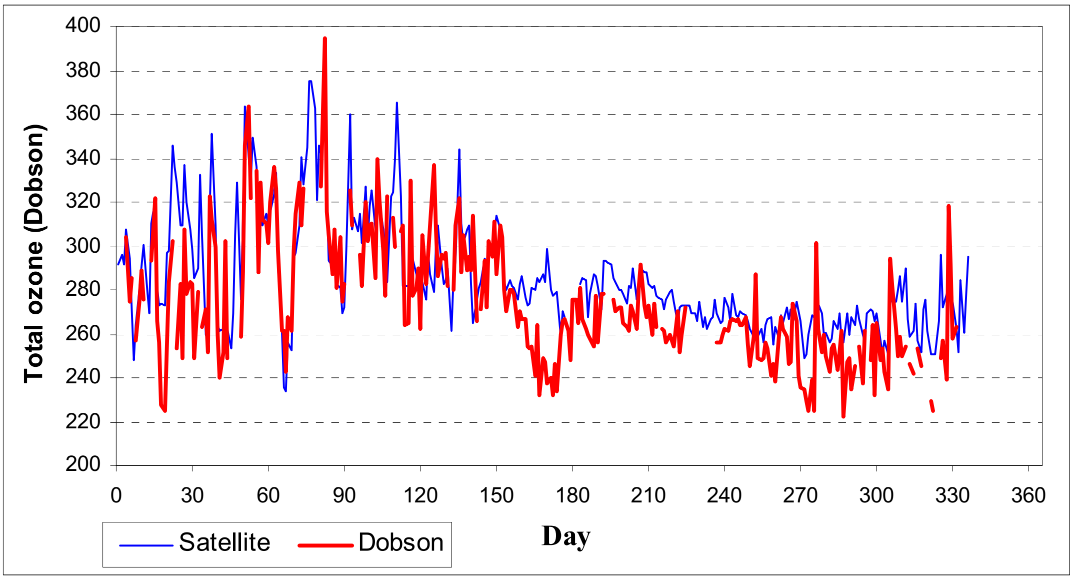

Figure 1: Comparison between Dobson data and satellite data for 2004.

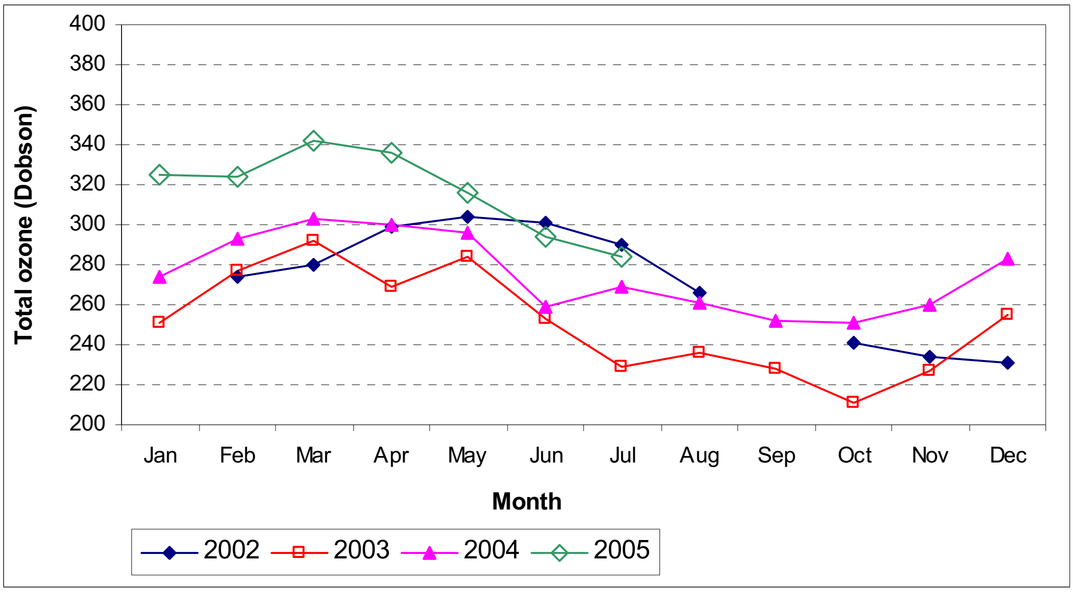

Figure 2: Monthly variations of total ozone for the years 2002 to 2005.

UV-B Measurement

UV-B is being measured at Esphahan station. UV is measured at spectral of 320 - 330 nm including UV-B.

Publication of Data

Total and vertical ozone data in WMO format are being regularly reported to the World Ozone Data Center in Canada (WODC). The data recorded by the stations are also being archived at the related centers.

Calibration

Data recorded by the stations is regularly checked for their validation and consistency. In the case of data inconsistency the equipment are sent to the WMO for calibration. Currently monitoring equipment at Geophysics and Esphahan stations are calibrated and properly are in operation.

However, the Firooz-kooh stations equipment are damaged and have not been in use for about 5 months.

Research Studies

Study of relation between ozone and humidity
Investigation of ozone pollution in the earth (2003)
Effects of meteorological parameters on the ozone pollution
Measurement of ozone layer changes using Dobson and Brewer photo spectrometer data.

Future Plans and Activities

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

REQUIREMENTS

Calibration surface ozone instrument at Firooz-kooh station.
Provide and install equipment for upper atmospheric stations.
Provision of additional filters for the instruments at Esphahan station for upper atmospheric measurement

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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. Most of the research is performed by Universities and Italian Research Council's (CNR) groups, but also by other institutions (i.e., ISPRA, ENEA, Air Force Meteorological Service). In the last years, these research activities have been supported by the Italian Government, Italian Space Agency (ASI), European Space Agency (ESA) and European Union.

Following the recommendations of the fifth meeting of the Ozone Research Managers, in 2003-2005, the ozone-related research has covered the traditional monitoring and archiving of measurements of tropospheric and stratospheric ozone, of other trace species and aerosols; but there was also a strong impulse to the development and implementation of new observational capabilities such as aircraft-based measurements (i.e. APE, Airborne Platform for Earth observation). Moreover, more attention has given to study the interaction between ozone and climate. The modeling activities covered the development of the algorithms for assimilating satellite data in a class of models, as well as, the full chemical and transport parameterization, and trajectory modeling, the latter has been mainly used to interpret the field data.

OBSERVATIONAL ACTIVITIES

Profile measurements of ozone

Old database

Balloon ozone soundings were performed at S. Pietro Capofiume (44.6N, 11.6E) on a weekly base from 1991 to 1997, and after that during short time campaigns. A similar activity was performed at University of L'Aquila (43.3N 13.3E) but the soundings were quite sparse on time base, from 1994 to 2002. Concerning older database, at University of L'Aquila, DIAL (Differential Absorption Lidar) ozone measurements have been also taken almost continuously from 1991 to 1996, more sparse from 1997 to 1999.

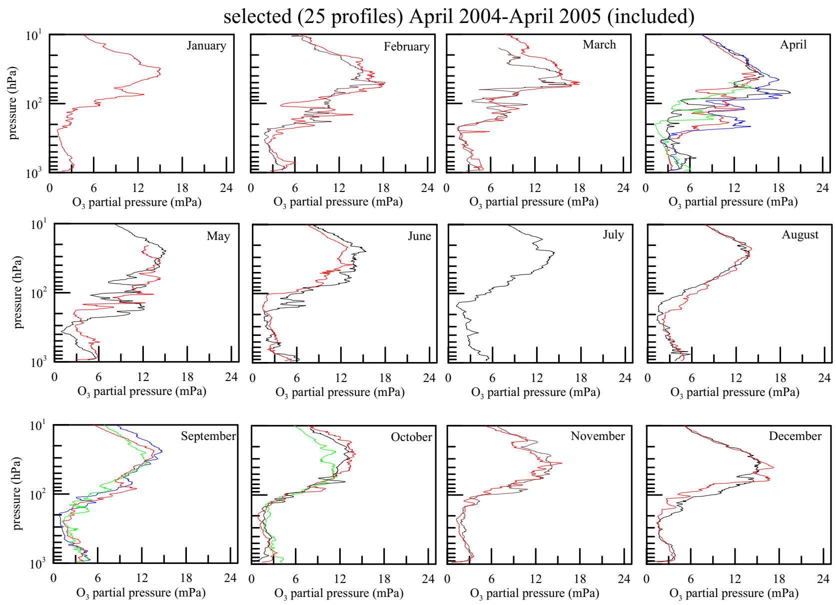

Figure 1: University of L'Aquila/CETEMPS balloon ozone soundings: ozone partial pressure vs. atmospheric pressure, in the period April 2004-April 2005. The data taken in different days are grouped per month.

Recent ozone profile monitoring

According to the commitments included in a convention between University of L'Aquila/CETEMPS (Center of Excellence for the integration of remote sensing techniques and modeling for the forecast of severe weather) and Italian Government/Ministry of Environment, from 2003, balloon ozone soundings are performed (at least 2 per months) at L'Aquila. The latter constitute the more recent and extended database of ozone profiles (see Figure 1 and Figure 2).

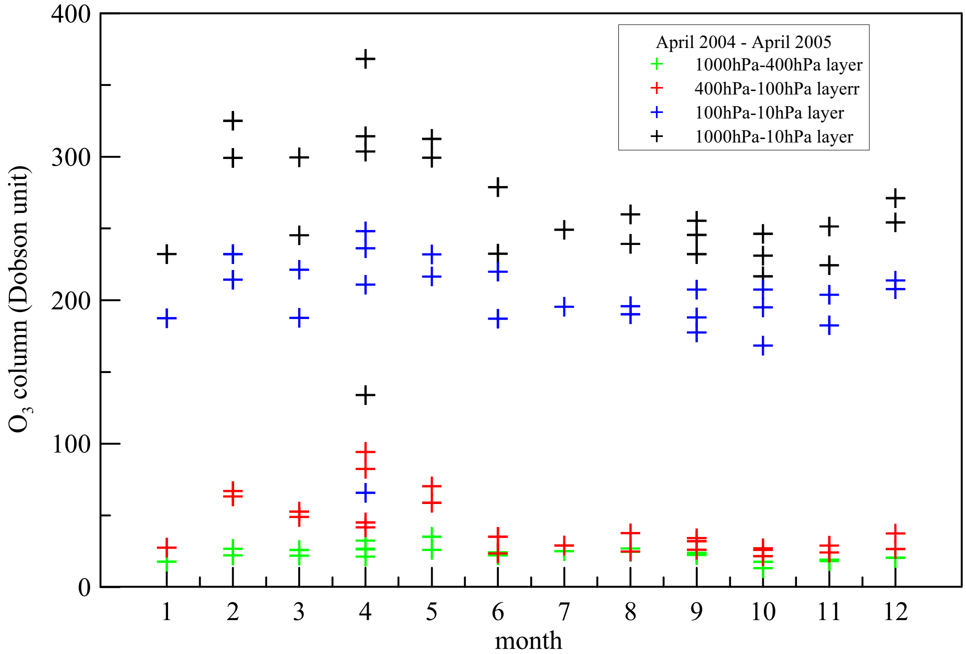

Figure 2: Ozone columnar densities (Dobson unit) at different height levels, as derived from the ozone profiles in Figure 1.

These data allows to figure out a good representation of the climatological behaviour of the stratospheric ozone in a geographical region centred over Italy. The ozone profile data analysis is in progress: the weather and dynamical patterns on continental scale should be considered for each observation to discriminate among the different processes affecting the evolution of the stratospheric and tropospheric ozone content.

UV and ozone column measurements

Currently, there are more than 10 UV/total ozone monitoring instruments (Brewers, pyranometers, spectrophotometers, see Table 1). The operating agencies are ISPRA, ENEA, Italian Meteorogical Service, CNR, and several universities.

Table 1: Some of the Italian UV/total ozone monitoring instruments (Brewers, pyranometers, spectrophotometers).

Instruments	Location
17 Brewer Mark IV	Modena
21 RB-501	Bolzano
22 Brewer Mark IV	Ispra
24 Bentham DM 150	Ispra
78 Brewer Mark IV	Rome

304 Brewer Mark IV	Vigna di Valle
305 Brewer Mark IV	Brindisi
306 Brewer Mark IV	Messina
Brewer Mark III	Lampedusa
UVB/UVA Pyranometer (YES)	Ispra
UVB/UVA Pyranometer (YES)	L'Aquila
UVB Pyranometer (YES)	Rome

Data from most of the stations are regularly sent to the central and coordinated database (e.g. WOUDC). These activities, still continuing, have been described in details in the previous report (WMO Global Ozone Research and Monitoring Project, Italian national report, Report no. 46, 2002).

In November 2003, within the cited convention between University of L'Aquila/CETEMPS and Italian Government/Ministry of Environment, two pyrometers (Yankee Environmental Systems) for UV-A and UV-B continuous monitoring were installed at L'Aquila, to be used in conjunction with the balloon ozone soundings. The UV data, as well as the ozone profiles, constitute the base for the compilation of the Italian Government annual report on ozone and UV status.

RESULTS FROM OBSERVATIONS AND ANALYSIS

The analysis of time ozone and UV components of the Italian stations (and others) have been investigated in order to single out any effective ozone trend together with the role of ozone fluctuations due to weather patterns. Many research groups adopted filtering techniques and an advanced statistical methodologies to be applied to the Dobson ozone long time series. Sensitivity studies are performed using models for the UV spectral and integrated irradiance. Most of the research groups involved in these studies have acquired enough experience so far: the main results indicate that, in spite of the unavoidable uncertainties in the input parameters (ozone, aerosol, surface albedo, pressure, temperature, relative humidity, cloud cover), measured and computed clear sky irradiances are in reasonable agreement..

THEORY, MODELING, AND OTHER RESEARCH

The modeling studies of different Italian institutions (Universities, CNR, ISPRA, etc.) concern the development and the test of 3D-atmospheric chemistry transport models with high spatial resolution, and also ozone/UV-related radiation transport modeling. At the moment, the main purpose is to understand the interplay of ozone, aerosols and greenhouse gases for a better assessment of climate effect of ozone in comparisons with that of non-reactive greenhouse gases.

The radiative forcing from ozone changes and from ozone depleting substances is significant. For this reasons the connections between ozone depletion and climate changes are strong and more complex that those simply related to CFC-control international protocols. In particular, the ozone distribution in the future will depend on the emission and impact of other greenhouse gases and not just those that deplete ozone. Scientific assessment of ozone depletion in the future can be meaningful only by coupling chemical and climate processes in numerical global models. This is the reason for including long time dependent simulations from chemistry-climate coupled models in the more recent IPCC (IPCC, 2005, Special report on ozone and climate. Issues related to HFCs and PCFs) and WMO assessments. The University of L'Aquila Atmospheric modeling research group has taken part in these efforts and it is participating in the international assessment campaign (CCMVal, Eyring et al., Overview of planned coupled chemistry-climate simulations to support upcoming ozone and climate assessments, SPARC newsletter, 25, July 2005), as well as in other projects (e.g. SCOUT-O3 - EC) for the climate-chemistry numerical simulations activity.

Other activities concern the assimilation of data in global models and air mass trajectory modelling: an assimilation code has been developed into a stratospheric 3D Chemical Transport Model, and it is used for the assimilation of ozone data from ENVISAT instruments, as a support of the ENVISAT Calibration/Validation campaign. In this framework, Lagrangian trajectory modelling have been also used to analyze field and satellite data and as a support to the middle latitude and arctic APE airborne missions. Other studies, based on statistical analyses and climatological models outputs, have investigated the climatic impact of the observed antarctic ozone changes onto stratosphere and troposphere, using as input total column ozone trends.

A joint project devoted to the study of the dynamical/climatic behaviour of the antarctic ozone hole and its impact on middle latitudes, is ongoing since 2003 under the Italy/Argentina bilateral scientific programme.

DISSEMINATION OF RESULTS

Data reporting

One of the deliverable product of the Convention between University of L'Aquila/CETEMPS and Italian Government/Ministry of Environment is an annual report on the status of the ozone layer; it is mainly focused on the Italian geographical region, and should also enlighten evidences of general trends, which can have social and political consequences.

Information to the public

The activities related to the monitoring of the ozone and UV have made possible to build up the solar UV geographic patterns in Italy. The daily dose in the range 290–325nm is computed at sites where a thorough and homogeneous climatology is available. In addition, several institutions made public the estimations of the UV index. Most of them make also use, in standard radiative transfer models, of the Global Forecast System (NCEP/NOOA) for the evaluation of the ozone column and cloud coverage over several Italian sites (resolution 1x1 degrees). Some of the estimations also include the surface albedo and the terrain characteristics, others can also account for the local pollutants concentrations.

The maps of solar UV patterns for Italy meets the study requirements in the field of skin and eye epidemiology, as well as, in other investigations dealing with the impact of UV on the biosphere.

PROJECTS AND COLLABORATION

Main EU ozone-related projects (active in 2002-2005) with Italian co-partnership:
Trade-off between climate and air pollution policies, JRC research ref.2212
ENSEMBLES, IP, ref. 505539
SCOUT-O3, IP, ref. 55390

FUTURE PLANS

The traditional UV data and the ozone profile long term monitoring will constitute, in the near future, a solid database for improving the studies of the ozone-related atmospheric processes.

In addition, it is expected that with new satellite data (i.e., ENVISAT) and the growing interaction with the numerical weather forecasting community valuable advantage will be take by new and existing research facilities, also in the issues concerning the ozone-climate interactions.

Most of the information and results reported in this document has been taken from public documents and scientific papers.

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JAPAN

In Japan, the Ministry of the Environment (MOE) and the Japan Meteorological Agency (JMA) play principal roles in monitoring atmospheric ozone, atmospheric constituents related to the depletion of the ozone layer, and surface UV-A and UV-B ultraviolet radiation. The MOE has been promoting coordination and cooperation among national institutes and universities through the Global Environment Research Fund (GERF) since 1990. The MOE also supports a programme 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 Ozone Layer Monitoring Office of the JMA coordinates observations, monitoring, and data processing of atmospheric ozone and surface UV-B radiation.

OBSERVATIONAL ACTIVITIES

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

The JMA carries out total column ozone and Umkehr measurements with Dobson spectrophotometers at three sites in Japan (Sapporo, Tsukuba, and Naha) and at Syowa Station, a site in Antarctica. Most of these measurements were initiated during the International Geophysical Year (1957–8). The JMA also began total column ozone and Umkehr measurements with a Brewer spectrophotometer at Minamitorishima (Global Atmosphere Watch, GAW, Global Station, a remote isolated island in the western North Pacific) in 1994.

The MOE observes concentrations of halocarbons (CFCs, CCl_4, CH_3CCl_3, halons, HCFCs, and CH_3Br) and HFCs at remote sites (around Wakkanai and Nemuro) and at an urban site (Kawasaki). The CGER of NIES observes halocarbons (CFCs, CCl_4, CH_3CCl_3, and HCFCs), HFCs, surface ozone, CO_2, CH_4, N_2O, NO_x, H_2, the O_2/N_2 ratio, and aerosols at remote sites (Hateruma and Ochiishi).

The JMA observes surface concentrations of ozone depleting substances (CFCs, CCl_4, and CH_3CCl_3) and other constituents (surface ozone, CO_2, N_2O, CH_4, and CO) at Ryori (GAW Regional Station in northern Japan). Concentrations of surface ozone, CO_2, CH_4, and CO are also observed at Minamitorishima and Yonagunijima (GAW Regional Station in the Ryukyu Islands). The 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*.

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

Ground-based and sonde measurements

Since October 1990, the CGER of NIES has been measuring the vertical profiles of the stratospheric ozone over Tsukuba (where NIES is located) with an ozone laser radar (ozone lidar), which is accepted as a complementary measurement by the Network for the Detection of Stratospheric Change (NDSC). Recently, the lidar data were reprocessed using a newly developed algorithm (version 2). The lidar ozone profiles were assessed by comparison with the JMA ozone sonde data and Stratospheric Aerosol and Gas Experiment II (SAGE II) ozone profiles, and were registered in the NDSC database. The CGER began measurements of vertical profiles of ozone with millimeter-wave radiometers in September 1995 at Tsukuba and in March 1999 at Rikubetsu.
The JMA carries out observation of the vertical ozone distribution by KC (KI solution and carbon electrode) ozone sonde at three sites in Japan (Sapporo, Tsukuba, and Naha) and at Syowa Station, Antarctica. The KC ozone sonde is an electrochemical-type ozone sonde that has been used in Japan since it was developed by the JMA in the 1960’s. Observations are conducted once a week.

Satellite measurements

The Improved Limb Atmospheric Spectrometer (ILAS) and its successor ILAS-II were developed by the MOE to observe profiles of ozone and other atmospheric species related to ozone layer depletion in high-latitude regions. The ILAS was flown on the Advanced Earth Observing Satellite (ADEOS) from August 1996 to June 1997. The ILAS-II was put into space on board the ADEOS-II in December 2002 and made measurements from January to October in 2003. Data obtained with the ILAS instrument have been processed and analyzed at NIES and the version 5.2 data, which include O_3, HNO_3, H_2O, N_2O, CH_4, and aerosol extinction coefficients, have already been distributed to the scientific community for further research. The version 6.1 data, which include $ClONO_2$ and CFC-12 in addition to the version 5.2 species, are to be released in 2005. Data obtained with the ILAS-II instrument have been processed with the version 1.4 retrieval algorithm and are to be released to the public in 2005.

UV measurements

Broadband measurements

The CGER has been monitoring surface UV-A and UV-B radiation using broadband radiometers at 21 observation sites in Japan since 2000.

Spectroradiometers

The JMA observes surface UV-B radiation with Brewer spectrophotometers at Sapporo, Tsukuba, and Naha in Japan and at Syowa Station in Antarctica. The observations were started in 1990–1.

Calibration activities

The JMA began operation of the Quality Assurance/Science Activity Centre (QA/SAC) in Tokyo and the Regional Dobson Calibration Centre (RDCC) in Tsukuba in accordance with the GAW strategic plan 2001–7 to contribute to the assessment and improvement of the quality of ozone observations in Regional Associations II (Asia) and V (South-West Pacific) of the World Meteorological Organization (WMO). The Regional Standard Dobson instrument (D116) is calibrated against the World Standard instrument (D083) every three years. Recent intercomparison with the World Standard occurred in 2004 at NOAA/CMDL in Boulder, Colorado, USA. The Dobson instruments used for observation at domestic sites are calibrated against the Regional Standard every three years. As an activity of the RDCC, the JMA held two campaigns of Dobson Intercomparison, one in 2003 (at Tsukuba with participation from China) and the other in 2004 (at Seoul for Korea). As an activity of the QA/SAC, the JMA dispatched an expert to the Philippines to adjust the Dobson instrument and to instruct the operators in Manila.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Continuous observation of vertical ozone profiles with a millimeter-wave radiometer in Tsukuba demonstrates that semiannual variations between 56 and 76 km are present and that the phase of the semiannual variation inverts suddenly at around 68 km.
Trend analyses were done for total ozone at three sites (Sapporo, Tsukuba, and Naha) eliminating the variation component of solar activity and quasi-biennial oscillation (QBO). The results show that total ozone has decreased over the last 20 to 30 years except at Naha, which is located on a lower latitude. Trends for vertical profiles were examined by using Umkehr and ozone sonde measurements. At all sites in Japan, ozone decreases are seen in two ranges, i.e., at about 20 and 40 km altitudes.

Because spectral UV measurements by the JMA have been recorded for fewer than 15 years, the general UV trend is uncertain. However, an apparent negative relation between UV intensity and total ozone amount was found in the data collected under clear sky conditions. It was also found that UV intensity varies depending on the weather conditions. Using the statistical relation between sunshine duration and precipitation and fine resolution weather data, an estimated UV intensity map (for every cell in a 20-km horizontal grid) was made and published for reference by the public.

THEORY, MODELLING, AND OTHER RESEARCH

A chemical climate model (CCSR/NIES CCM) based on a spectral atmospheric general circulation model (CCSR/NIES AGCM) was developed by the Centre for Climate System Research (CCSR), the University of Tokyo, and NIES and used for estimating the future development of the stratospheric ozone layer. A new version of CCSR/NIES CCM with T42 horizontal resolution has been developed that includes bromine chemistry. NIES has also developed a three-dimensional chemical transport model (CTM) in which 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.

The Meteorological Research Institute (MRI) of the JMA has developed a stratospheric CTM that can be run in interactive or non-interactive mode between chemistry and radiation. MRI-CTM is now operationally integrated at the JMA to produce assimilated ozone distributions by incorporating total ozone data from Total Ozone Mapping Spectrometer (TOMS) and several-day forecasts. The calculated ozone distributions are used to monitor ozone variation and for the UV forecast service. MRI-CTM is also used for research for making future predictions of the ozone layer.

The MRI, the National Institute of Information and Communications Technology (NICT), and some universities have measured 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.

The MRI has measured ozone, aerosols, and other species relevant to stratospheric ozone depletion using lidars and Fourier transform infrared (FTIR) spectrometers to understand the stratospheric processes over the Canadian Arctic, and it made analytical studies of ozone depletion in the Northern Hemisphere.

In spite of the short observation periods of ILAS (November 1996–June 1997) and ILAS-II (January–October 2003), their data have been used extensively to evaluate quantitatively the extent of the polar ozone destruction, for example, the determination of chemical ozone loss rates in the polar regions. Their data have also been used to elucidate the detailed chemical and physical processes related to ozone layer depletion, for example, polar stratospheric cloud (PSC) formation and denitrification mechanisms in the polar regions.

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

The effects of enhanced UV-B radiation on terrestrial plants are being studied by NIES. NIES developed a novel method of detecting plant UV-B stresses. This method is based on the detection of mRNA expression changes by cDNA macroarray analysis.

DISSEMINATION OF RESULTS

Data reporting

NIES and the Solar-Terrestrial Environment Laboratory (STEL) of Nagoya University have established stations with NDSC instruments including lidars, millimeter-wave radiometers, and FTIR spectrometers. Some of the activities conducted by these organizations have been incorporated into the NDSC complementary measurements in Japan. The reanalyzed NIES ozone lidar data were recently registered in the NDSC database, and the NIES millimeter-wave ozone data at Rikubetsu are ready for registration in the NDSC.

Observation data acquired by the JMA are submitted monthly to the World Ozone and UV Data Centre (WOUDC) in Toronto. Provisional total ozone data are also posted daily on Character Form for the Representation and Exchange of Data (CREX) of the WMO global telecommunication system (GTS), and used accordingly in the WMO Ozone Mapping Centre in Thessaloniki. In the Antarctic winter and spring seasons, total ozone and ozone sonde data acquired at the Japanese Antarctic station, Syowa, are submitted weekly to the WMO Secretariat for the preparation of Antarctic Ozone Bulletins.

Information to the public

The Annual Report on the state of the ozone layer, surface UV-B radiation, and atmospheric concentrations of ozone-depleting substances is published for the public by the MOE. Data on total ozone, ozone sonde, and UV-B measurements acquired by the JMA are summarized monthly and published for the media and the public through a website. The Annual Report of Ozone Layer Monitoring, which includes detailed trend analyses of ozone over Japan and the globe, is also published for the government and the public by the JMA. Based on UV-B observation results and newly developed ozone forecast techniques, the JMA started a UV forecast service (hourly UV-index map) through a website for the public in 2005. This service not only provides forecast information, but an analytical UV map and quasi-real-time UV observation results are posted hourly on the website.

Relevant scientific papers

The MOE supports research on global environmental changes, including ozone layer depletion, through the GERF and their results are published in the Annual Summary Reports.

PROJECTS AND COLLABORATION

Through the GERF, the MOE supports the projects “Research on explanation of long-term trend and prediction of future change of ozone layer” and “A study on elucidating mechanisms of polar ozone depletion using satellite measurement data”.

The Aerological Observatory of the JMA has developed an automated Dobson measuring system. This system reduces the operator’s burden and improves the data quality. Some foreign organizations are interested in introducing this automated Dobson system. The JMA is ready to provide technical support, and plans for collaboration with various organizations are now in preparation.

FUTURE PLANS

The NIES millimeter-wave radiometers, which have been used for the continuous measurement of the vertical profile of ozone over Japan, have been improved to extend the altitude range of the observation. It is planned to measure continuously the vertical profiles of ozone from the lower stratosphere to the mesosphere as an NDSC activity.

The calibration of Dobson instruments from all over the world to the World Standard is essential to precisely monitor global ozone change. However, most Dobson instruments in Asian countries, except in China, Korea, and Japan, have not been calibrated since 1996. The JMA is now planning to hold a Dobson Intercomparison with the participation of four countries in the spring of 2006.

The observation of ozone, water vapour, and other species will be performed near the tropical tropopause to understand the role of the tropical transition layer. Developing and improving the numerical models, CCM and CTM, will continue, which will enable better prediction of future changes of the ozone layer and better understanding of the mechanisms of the chemistry–climate interaction.

Studies using ILAS and ILAS-II data will be continued to better understand the mechanisms of polar ozone destruction.

NEEDS AND RECOMMENDATIONS

To evaluate the changing state of the ozone layer and ground-level UV radiation, including detection of ozone layer recovery, systematic observations with the cooperation of international monitoring networks, such as the NDSC and the WMO GAW Programme, should be continued.
To detect recovery of the ozone layer, a fine and high-quality ozone-monitoring network is required. However, some regions do not have a well-functioning systematic calibration system. Each government that conducts ozone observation should recognize the importance of periodic Dobson Intercomparisons that ensure high-quality ozone data, and promote activities relevant to the detection of ozone recovery.

To more precisely predict future changes in the ozone layer, numerical models need to be improved; especially desirable is integration between stratospheric and climate models. The interactions between climate change and ozone layer depletion and changes in the ozone layer in the post-CFC period due to the emissions of CH_4, H_2, and N_2O need to be assessed. Chemical and dynamical processes including the formation of PSCs and denitrification mechanisms, cross-tropopause transport, and the ozone budget near the tropopause region need to be studied.

The effects of increased UV radiation on human health and ecosystems need to be studied, especially the effects of possible longer exposure to increased UV radiation under rising temperature conditions.

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KRYGYZSTAN

Influence of Stratospheric Aerosol on General Contents of Atmospheric Ozone over Central Asia

INTRODUCTION

At present conclusive evidences of the aerosol influence on variability of ozone exist, in particular, on observations of ozone contents after powerful volcanic eruptions (Krekov M.M., Zvenigorodskiy S.G., 1990). Herewith the intercoupling between ozone and aerosol, as indicated in (Ivlev L.S., Chelibanov V.P., 2001), it is enough complex and ambiguous. Four types of interdependences are given here: 1) ozone present in atmosphere enhances generating of aerosol particles, 2) aerosol particles, in particular, dust ones, promote ozone molecules destruction, 3) the processes take place in atmosphere, which ozone simultaneously change the contents of the aerosols and ozone and 4) the aerosols influence on ozone contents in atmosphere through radiation processes.

The issue of dependencies between aerosol content and ozone has become particularly sharp in connection with a problem of the ozone holes. Thus, it is worth to note that this problem is far from ambiguous solution. So, repeatedly observed considerable reductions of the ozone contents in the layers, polluted by aerosol, can be called both by direct decay of the ozone molecule on the dust particles, and by other processes (Ivlev L.S., Chelibanov V.P., 2001).

The volcanic eruptions can influence on general contents of ozone (GCO) in atmosphere moreover mechanisms of this influence can be the most different. For instance, in nonvulcanic periods to account of presence in atmosphere dioxide sulphurs SO_2 (the sulphureous gas) can occur the accumulation of ozone under photooxidation SO_2 by oxygen of the air (Ivlev L.S., Sirota V.G., Khvorostovsky S.N., 1990) may intervene.

Below we shall examine some mechanisms of the accumulation and exhaustions of the stratospheric ozone under influence of sulphuric-acid aerosol under different conditions of the atmosphere.

METHODOLOGY

In Central Asia region measurements of vertical structure of concentration and optical characteristics of stratosphere and troposphere aerosol have been conducted since 1988 at the Lidar Station Teplokluchenka (Kyrgyz Republic) by means lidar method. The high mountain Lidar Station Teplokluchenka (LST) is located on a height over 2000 m above sea level southeast of a high mountain lake Issyk-Kul in Central Tien-Shan (42.5^0 N, 78.4^0 E).

The main questions of methodology multiwavelength lidar sensing of the atmospheric aerosol, processing backscattering signal and receptions optical and microphysical characteristics of the aerosol in (Chen et al., 2002; Chen et al., 2004) are stated.

In Figure 1 monitoring data of aerosol backscattering coefficient for 1988-2001 are given. For more than 20 years the monitoring of O_3, CO_2, H_2O, NO_2 and spectral transparency of the atmosphere (STA) in the central part of Euro-Asian continent is made only at the Issyk-Kul station (42,6^0 N, 77^0 E, 1650 m a.s.l.) located at the bank of Issyk-Kul Lake in the mountains of northern Tien-Shan (Kashin, et al., 2000; Semyonov, et al., 2000).

The measurements of total ozone column (**X**) are performed with the help of a spectrophotometric scanning set (SPS).

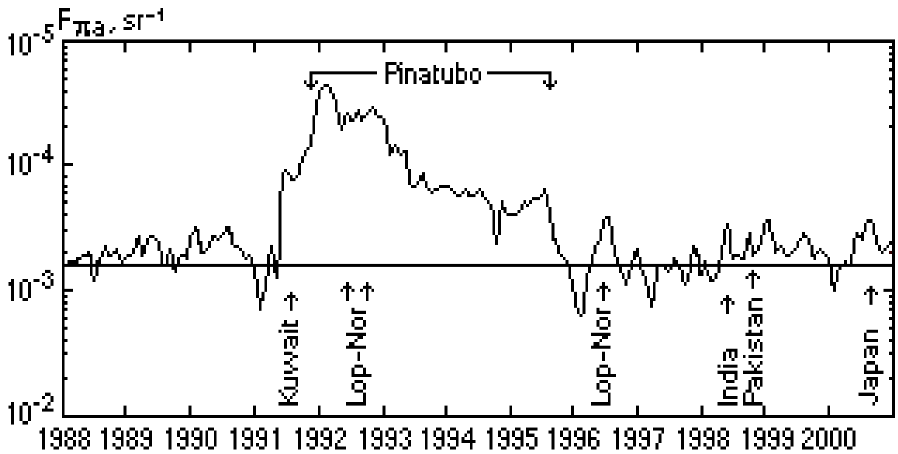

Figure 1: Monitoring data of integral backscattering coefficient in the height range 15-30 km.

Mean monthly **X** values in the atmosphere over the central part of Eurasia for 1979 – 2001 in Figure 2 are given (Toktomyshev and Semenov**,** 2001).

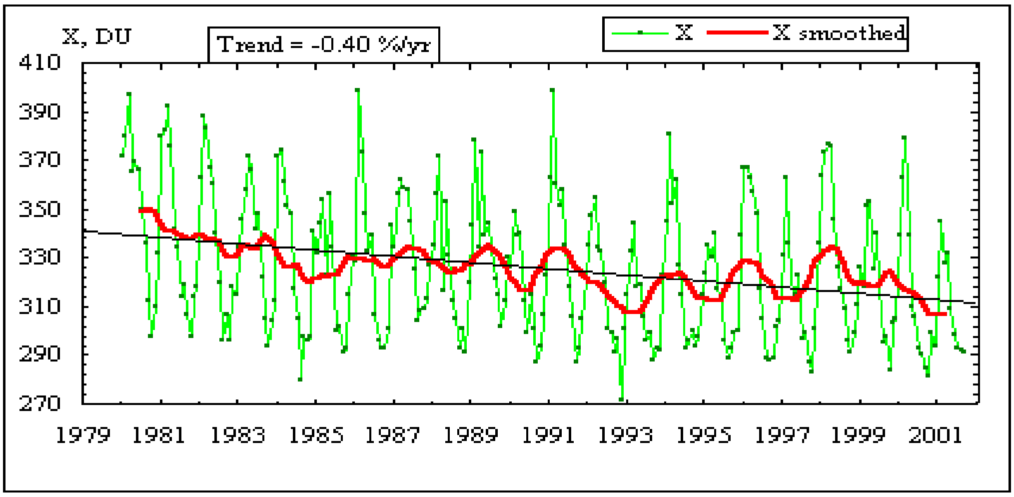

Figure 2: Total ozone content (X) in an atmosphere of the Northern Tien Shan.

THE BACKGROUND PERIOD

The set up in (Chen and Lelevkin, 2000) heights of the location of the backscattering ratio maximum R_{max} over the Central Asian region (the average height of 18.25 km, 17.62 in cool and 19.0 km in warm half-year) indicate that maximum of concentrations of the background stratospheric aerosol (SA) is mainly formed in the stratosphere itself during a year regardless of a season. Consequently, in the background periods the sulphurous gas SO_2 arrival from the troposphere is not a direct source of the aerosol formation. Carbonilsulphide, photodissociated with the sulphureous gas forming in the lower stratosphere, seems to play the main role in the background SA shaping.

The results of the experiment show (Chen and Lelevkin, 2000), that prior to the Volcano Pinatubo eruption in the background period the area of 24–29 km is marked out with local minimums in the correlations function where the main mass of the background aerosol is concentrated. This happens at the height of the ozone concentration maximum (24–27 km), not in the field of Junge aerosol layer, that allows to expect that the ozone accumulation takes place here, i.e. O_3 generation under photooxidation of SO_2 by the air oxygen (Ivlev L.S., Sirota V.G., Khvorostovsky S.N., 1990): ${}^3SO_2({}^3B_1) + O_2 \rightarrow SO_3 + O({}^3P)$.

In winter (December) in stratosphere of moderate latitudes prevails a zonal (western) circulation. In January and February the circulation in stratosphere is unstable, the meridianal transference prevails against the zonal one (Stolypina, 1981). It is because the circumpolar cyclonic whirlwind shifts to the south and the Pacific maximum – to the north, and both of them become immobile. Increase in height of SA maximum location and in maximum optical thickness is observed (Chen and Lelevkin, 2000).

VOLCANIC SULFUR DIOXIDE AND OZONE

Pinatubo volcano eruption (Philippines), June 15-16, 1991 was one of the most powerful in this century. As a result of the eruption a huge amount of substance in a gaseous and aerosol phase was thrown out in atmosphere. Evaluations, carried out because of satellite observations have shown, that the mass of a thrown out sulfur dioxide makes approximately 20 million tons (Bluth G.J.S. et al., 1992); that has rendered a powerful influence to radiating processes in atmosphere as well as to transformation of ozone layer. Oxidation of sulphureous gas leads to formation of fine dispersion sylph-acid aerosol.

In Figure 1 it is visible, that the concentration of SA arises sharply during 3 months, reaching its maximum value in January 1992 and than it decreases up to May. Increase of an optical thickness in an initial phase is explained by that to poor absorbed sylph-acid aerosol the diameter of particles dispersion increases fast.

The condition of the SA and its parameters variations had greatly influenced both the radiative processes and the ozone layer transformation.

In summer the SA transformation at altitudes lower than 20 km is caused by western air masses transference. In the higher stratosphere at eastern circulation the conditions promoting aerosol's transference from tropical latitudes into moderate zones of the northern hemisphere are absent. In summer the meridianal circulation in stratosphere weakens practically up to zero (Stolypina, 1981). The aerosol appeared at the heights more than 20 km was registered in the late October of 1991 at establishing western circulation of a moderate zone of stratosphere. For all of this, the summer stratospheric anti-cyclone was destructed and new favorable conditions for aerosol transference from tropical zone into the moderate ones of the northern hemisphere in upper stratosphere appeared. During this period one observed an increased SA maximum (Chen and Lelevkin, 2000).

From June 1992 to January 1993 the SA grew in tens time in comparison with the background ones before the volcano eruption (Chen and Lelevkin, 2000). Then, the concentration of AS had gradually come back to the level of 1988-1989. It was connected to that that at volcanic eruptions of the explosive type not only sulfate particles of different sizes appeared in stratosphere, but great amount of the sulfur dioxide (Turko et al., 1983) too. The thickness of the SA increased after coming of sulfur dioxide in stratosphere due to its consequent oxidation up to sulfuric acid vapors which were condensed together with a water vapor on the already available in stratosphere particles, or form new particles by homogenous nucleation from a gas phase. In our case study these processes evidently continued up to the end of 1992 – beginning of 1993.

The outcomes of measurements have shown (Chen and Lelevkin, 2000), that major masses of volcanic aerosol in the first period after the volcano eruption are located in layers of 16-18 and 23-25 km. During the next period after the particles' sedimentation the formation of the aerosol from sulfur dioxide in a layer of maximum stratospheric ozone concentration of 26-28 km occurs.

Therefore, the reduction of total ozone occurs (see Fig. 3), which seems to be used up in the photooxidation reaction SO_2 (Ivlev L.S., Sirota V.G., Khvorostovsky S.N., 1990): ${}^3SO_2({}^3B_1) + O_3 \rightarrow SO_3 + O_2$. Since June 1992 till February 1993 a sharp deceleration of the aerosol concentration depletion is observed. In the result of this reaction the stratospheric aerosol has been formed during this period: $SO_3 + H_2O \rightarrow H_2SO_4$. During the period of March-August 1993 the SA concentration diminished nearly by two times and total ozone sharply proliferated (Fig. 3) as a result of ozone generation under SO_2 photooxidation by the air oxygen: ${}^3SO_2({}^3B_1) + O_2 \rightarrow SO_3 + O({}^3P)$ (Okabe, 1981).

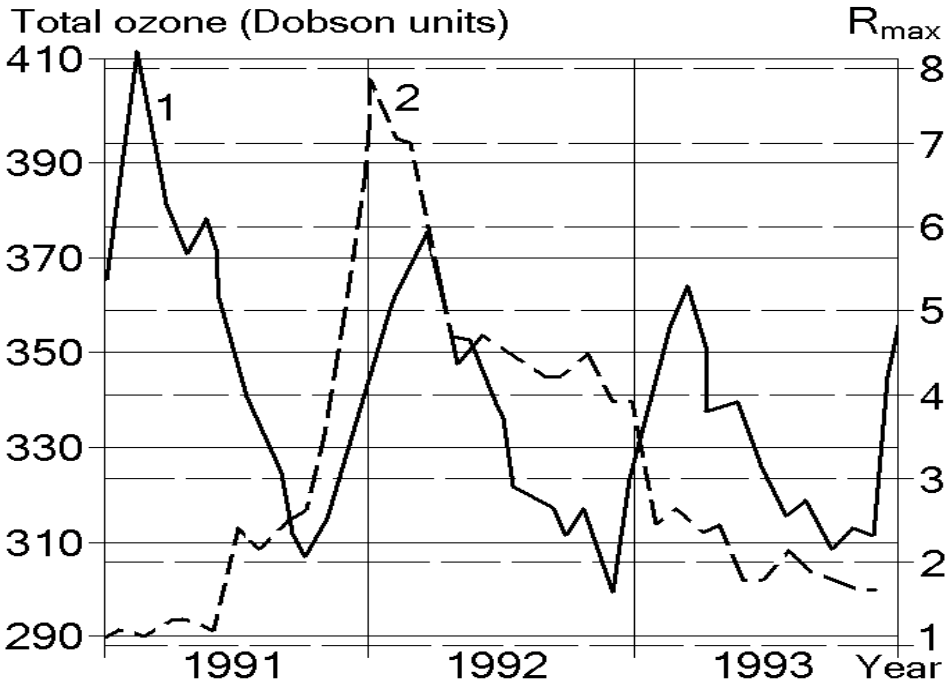

Figure 3: Joint distribution of R_{max} and total ozone (1 – total ozone, 2 – R_{max}).

EMPIRICAL LINKS BETWEEN THE SA AND GENERAL CONCENTRATION OF OZONE

The analysis of empirical links between the SA and general concentration of ozone (GCO) has shown that during all operating period of the volcano Pinatubo eruption the coefficient of the linear correlation between SA and GCO appeared equal to r=0.87±0.07, when the reliability of the linear correlation was P=0.99.

During the background period before the volcano eruption the SA was formed in stratosphere due to photo-oxidation of stratospheric SO_2, and a coefficient of correlation between the SA and GSO was negative (r=-0.46±0.17 with P=0.95). When the products of the volcano eruption came in our latitudes at a stage of forming the SA from SO_2 (from June 1993 to February 1993) the O_3 was absorbed in a sulfate aerosol, and the concentration of O_3 reduced. Thus the negative correlation between SA and GCO increased in comparison with the background period: r=-0.76±0.12, P=0.99.

During the ozone generation at photo-oxidation of the sulfur dioxide by oxygen of the air, occurred from March 1993 to August 1993, the coefficient of correlation became positive again: r=0.88±0.07, P=0.99.

CONCLUSION

Thereby, the process of SA relaxation after the volcanic eruptions is accompanied by its double impact influencing the stratospheric ozone content: by reducing general concentration of ozone at reaction of SO_2 photo-oxidation, and by increasing GCO as a result of the ozone generation at SO_2 photo-oxidation by oxygen of the air. Hence, alongside with the given reasons (Toktomyshev and Semenov, 2001) of the appeared over Central Asia of so-called “local ozone holes" (ozone concentration reduction), there are other mechanisms of the ozone reduction, set out above, connected with the ozone absorption by the stratospheric sulfate aerosol and connected with sulfur dioxide photo-oxidation, being during the background period in stratosphere.

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LITHUANIA

Network

Lithuanian Hydrometeorological Service under the Ministry of Environment (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 (WMO Index 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 centre of Lithuania.

Ultraviolet solar radiation measurements have been carried out at 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 last calibration was carried out in 2004.

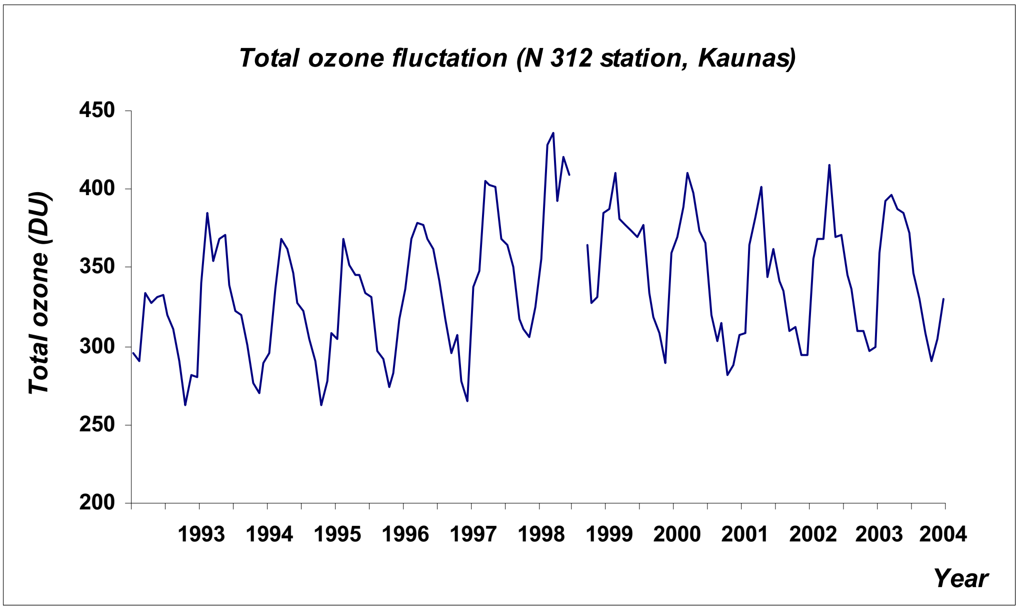
The UV-Biometers have been calibrated by the LHMS Metrological Laboratory in 2005. Local standard meters were re-calibrated with a higher-class standard instrument in 2002 and should be re-calibrated again in 2006.

Results from observations and data analysis

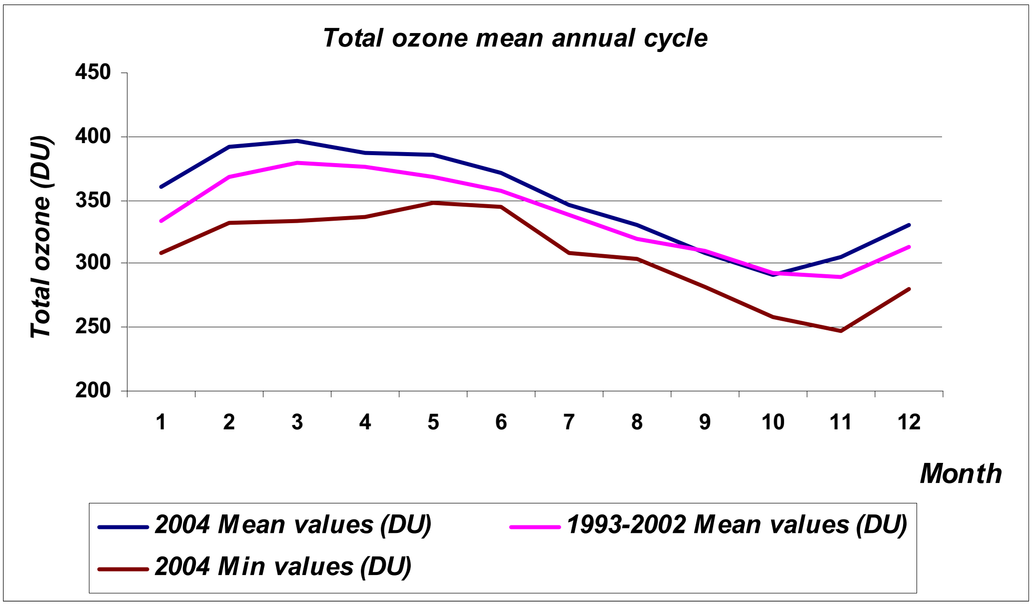
All observational data are stored and processed on a regular basis. Due to comparatively short series of observations, they are considered insufficient for a comprehensive study. In 2001, the LHMS Climatology and Methodology Division (lead researcher – Dr Audronė Galvonaitė) completed a study titled “Ozone In the World and In Lithuania”. In 2003, the LHMS Meteorology Division carried out the ozone data analysis resulting in establishment of the mean total ozone values for the period of 1993 – 2002 that have since been used to assess the ozone layer depletion over Lithuania. It is also used in monitoring the ozone column and assessment of its quantitative changes. In case of significant ozone layer depletion, the LHMS Meteorology Division originates warnings disseminated through the mass media and over the Internet.

Since 2001, the LHMS Meteorology Division has been originating the UV index forecasts (UVI) for annual periods of May – August. These forecasts are disseminated through the mass media and Internet. In case of significant ozone layer depletion, the Division originates warnings communicated through the mass media and Internet.

Since 2002, the total ozone values and their change as well as the ultraviolet solar radiation intensity figures are published in the State of the Environment annual reports issued by the Ministry of Environment of the Republic of Lithuania.



In 2004, the total amount of atmospheric ozone fluctuated quite significantly. As in previous years, its minimum value (about 300 DU) was observed in autumn, and the maximum (about 400 DU) – by the end of winter and in spring. In 2004, the absolute minimum amount of atmospheric ozone (247 DU) was measured in November, while its absolute maximum (497 DU) – in March. Mean annual amount of the total ozone was 351 DU. Comparing with 2003 measurements; the total amount of atmospheric ozone remained practically the same.



International cooperation

The ozone measurement data are sent on a regular basis to the World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto, Canada. Since 2004, also the UVB measurement data from the Kaunas station have been sent to WOUDC.

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

Future

Observations of the ozone layer and the UV radiation will be continued. Though our current ozone meters are of good quality, however, we would like to increase the precision of measurements provided we could obtain a Brewer Spectrophotometer. It is a modern and highly precise instrument 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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MALAYSIA

OBSERVATIONAL ACTIVITIES

The International Conference on Tropical Ozone and Atmospheric Change held in Penang, Malaysia in February 1991 underscore the lack of atmospheric ozone measurements and research in the equatorial region. Realizing the importance of developing countries in the tropics to play a more important role in the global initiatives to achieve a better understanding of the atmospheric changes and the effects on the environment linked to ozone changes, Malaysia has initiated its active involvement in the World Meteorological Organization (WMO) Global Ozone Observing System (GO_3OS) with the launching of its ozone monitoring programme in October 1992.

The ozone monitoring programme involves monitoring of ozone concentrations at the surface, the vertical distribution of ozone up to the stratosphere and total column ozone in the atmosphere.

Column Measurement of Ozone

Total column ozone measurements in Malaysia began in 1992 using the Sci Tec Inc. Brewer Ozone Spectrophotometer Mark II, instrument number 090 at the Petaling Jaya Station, Petaling Jaya Meteorological Station (Lat. 03 deg.06' N, Long. 101 deg. 39' E, elevation 45.7m above MSL). This is the only regular long term total column ozone monitoring site in Malaysia.

Ultraviolet Measurements

Daily ultraviolet radiation measurements are also made using the same Brewer Spectrophotometer mentioned above.

Ozone Profile Measurements

Ozone profile measurements are conducted at the Kuala Lumpur International Airport, Sepang Meteorological Station (Lat. 2 deg. 43' N, Long. 101 deg. 42' E, elevation 16.3m above MSL) using the Vaisala Digicora system. Sounding are made twice a month during the times when the AURA satellite passes the station. Overpass times are made available by the SHADOZ (Southern Hemisphere ADditional OZonesondes) project.

Surface Ozone

Hourly surface ozone concentration is measured continuously using the Thermo Environment Instruments Inc. C49 Ozone Analyzer at the Cameron Highlands Meteorological Station (Lat. 04 deg. 28' N, Long. 101 deg. 22' E, elevation 1545.0m above MSL). Prior to that, surface ozone measurements were made using the Monitor Lab ML 9811 Ozone Analyzer from the year 1997 to 2002.

Calibration Activities

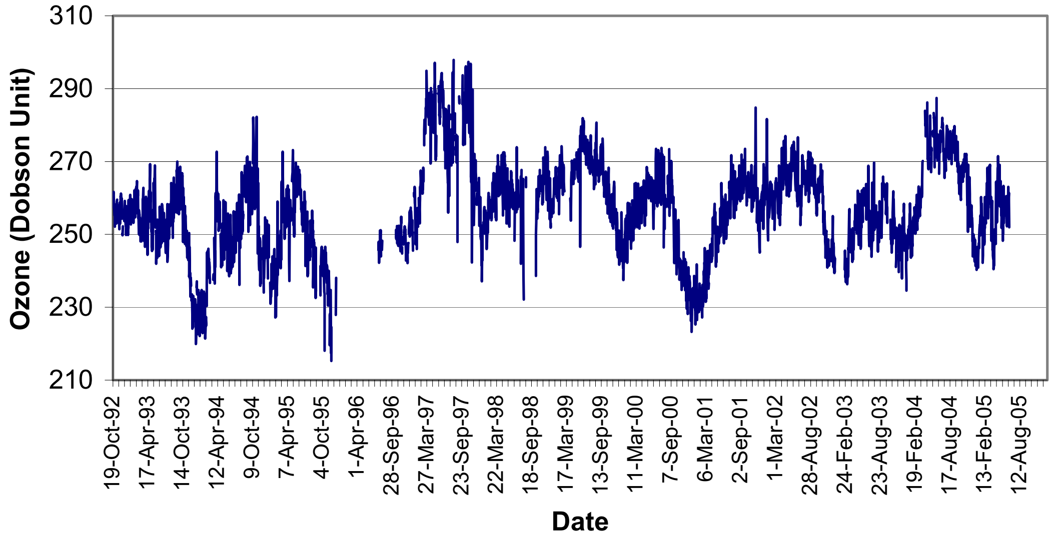
The Brewer Spectrophotometer is calibrated by International Ozone Services of Canada. The calibration is performed every two years. Quality assurance and quality control procedures are strictly adhere to during ozone sounding and surface ozone measurements.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Total Column Ozone

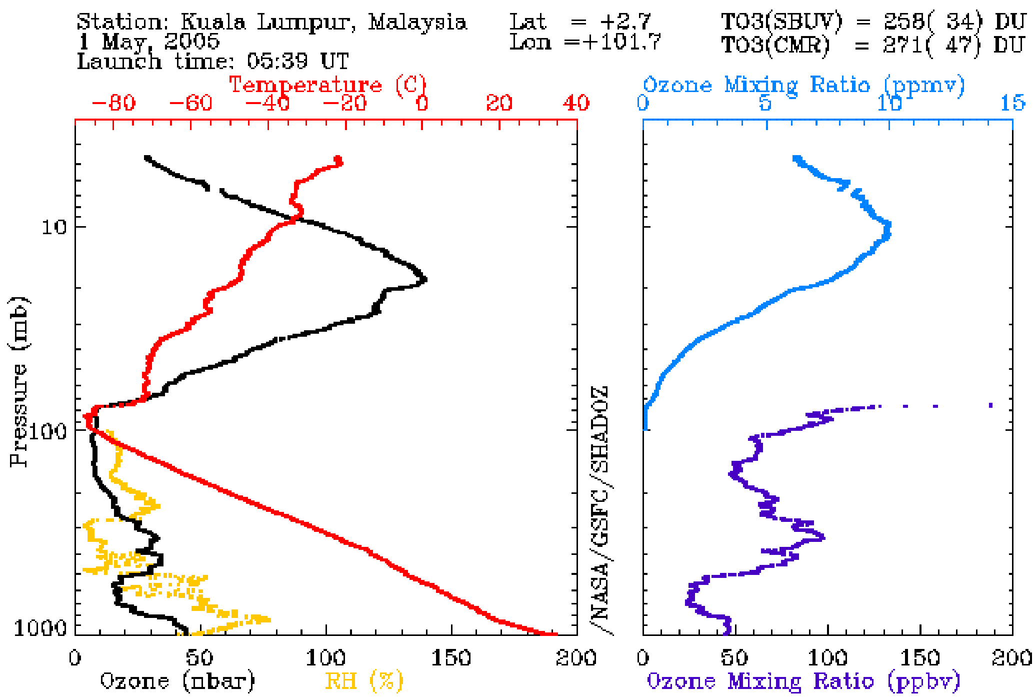
The time series of total column ozone measurements since 1992 is shown in Figure 1.

Figure 1: Total Column Ozone 1992-2005
Petaling Jaya



Ozone Profile Measurements

The figure below shows the latest vertical ozone profile made available on the SHADOZ website.



RESEARCH ACTIVITIES

Asian Ozone Pollution in Eurasian Perspective

This project concerns spatial distribution and temporal variability of ozone, an important atmospheric constituent in the troposphere, which is an effective greenhouse gas and a toxic substance for human health and vegetation. It aims to get a perspective of surface ozone in Asia and to discuss how it is affected by human activity by clarifying both intra- and inter-continental long-range transport over the Eurasian continent.

The project compiles observational data of surface ozone at remote and rural sites as well as selected urban sites data in Asia. The integrated dataset will illustrates the overview of ozone pollution in Asia, and will be used to evaluate the contribution of emissions of ozone precursors in various parts of Asia as well as those from Europe and North America by using the "tagged" method of the global chemical-transport. International workshops are organized for the discussion of data compilation/ analysis and for proposing policy strategy how to reduce ozone pollution in Asia.

DISSEMINATION OF RESULTS

Data Reporting

Total column ozone data and vertical ozone profile data are reported every six months to the WMO Global Atmosphere Watch World Ozone and Ultraviolet Radiation Data Centre in Canada.

Information to the Public

Vertical ozone profile data is made available after every launch on the SHADOZ website for the scientific community.

Daily solar UV index is posted on the Malaysian Meteorological Department's website as a service to the public.

Annual air quality reports containing data and information on ozone monitoring is published annually.

Information on ozone and ozone issues are discussed and posted on the Malaysian Meteorological Department website.

Relevant Scientific Papers

Tropospheric ozone climatology over Peninsular Malaysia from 1992 to 1999, Journal of Geophysical Research, Vol. 107, NO. D15, 10.1029/2001JD000993, 2002. Authors: S Yonemura, H Tsuruta, S Kawashima, S Sudo (NIAS) Leong C P, Lim S F, Zubaidi (MMS)

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PROJECTS AND COLLABORATION

Southern Hemisphere Additional OzoneSondes (SHADOZ)

SHADOZ (Southern Hemisphere ADditional OZonesondes) project is designed to remedy data discrepancy of a number of stations that are operating in the southern hemisphere tropics and subtropics which has differing frequency and reporting procedures. SHADOZ achieve its aims by coordinating launches, supplying additional sondes in some cases, and by providing a central archive location. Data will be collected in a timely manner and will be available through this website to the SHADOZ and TOMS Science Teams, as well as to the scientific community as a whole.

Currently, twelve active sites are participating in SHADOZ. The sites are at Ascension Island; American Samoa; Fiji; Irene, South Africa; Java, Indonesia; Malindi and Nairobi, Kenya; Natal, Brazil; Paramaribo, Surinam; La Réunion, France; San Cristóbal, Galapagos; and Kuala Lumpur, Malaysia.

FUTURE PLANS

Air Quality Modelling

The Malaysian Meteorological Department (MMD) in its 5-year Development Plan beginning in 2006 plans to introduce air quality forecasting as one of its product and service. Among the parameters that will determine air quality will be surface ozone concentrations in ambient air.

Monitoring

The MMD is planning to measure surface ozone concentrations at the Danum Valley GAW Station to detect changes in ozone levels during the dry biomass burning season in the island of Borneo.

Research

A proposal to study the oxidant and particle photochemical processes above a South-East Asian tropical rain forest prepared by the Lancaster University, United Kingdom is being evaluated by funding agencies. This joint project involves a number of parties including the MMD.

NEEDS AND RECOMMENDATIONS

Capacity building and exchange programmes and twinning projects in quality assurance and quality control is needed to improve data quality and accuracy.

Increase in the frequency of ozonesonde launch from once a fortnight to once a week. The SHADOZ project is expected to provide this support.

Total column ozone and UV measurements to cover the island of Borneo. An additional Brewer spectrophotometer installed in the state of Sabah will provide these data over Borneo.

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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 weekends 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-…);

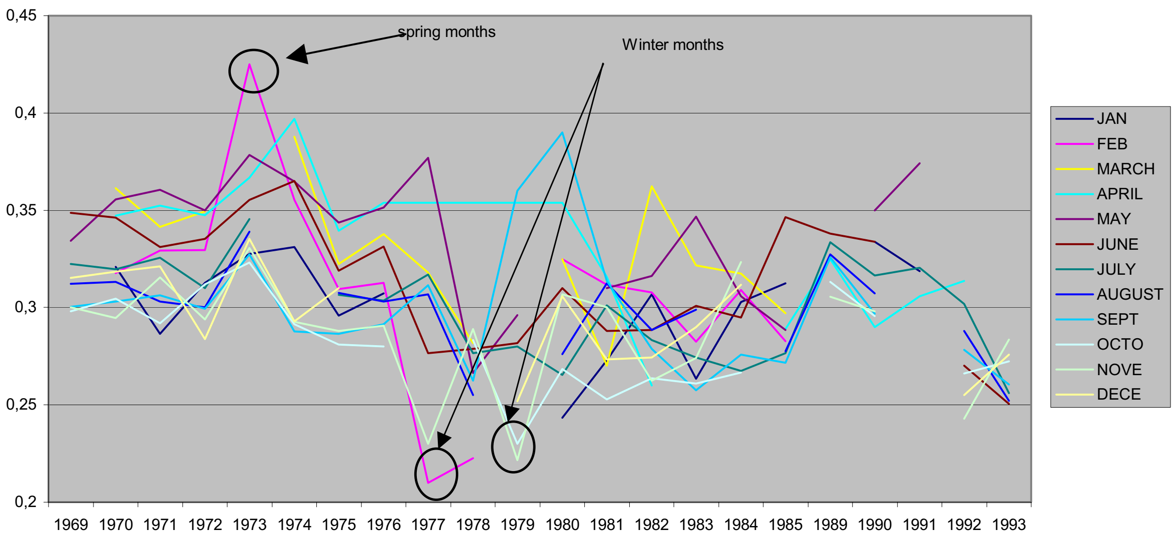
This period began on late 2000. The instrument measures the SO_2 concentration and the UV radiation also. The measurements are continuous and it's an easy to use instrument. Obviously it keeps the same limitations as its ancestor.

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.

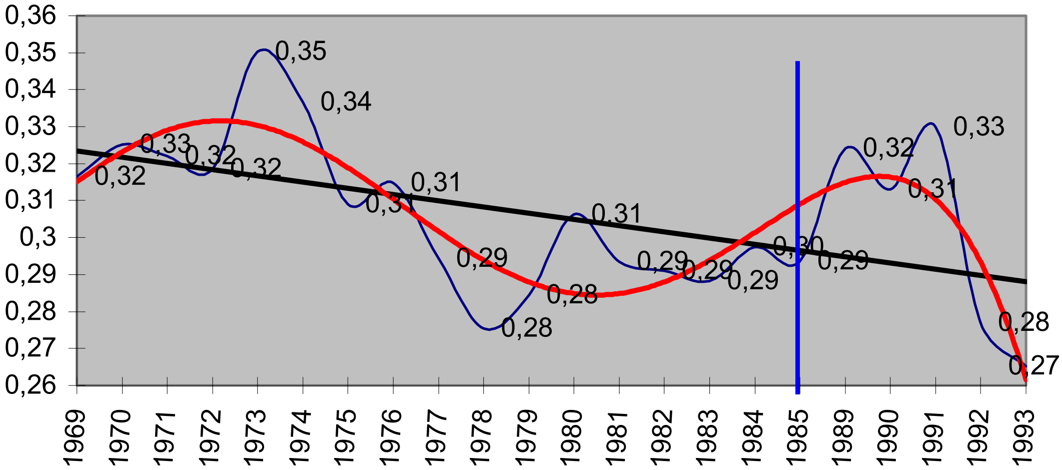
Evolution of the monthly average of the Ozone layer thickness to the vertical of Casablanca,



Evolution of the Annual Ozone Layer to the Vertical of Casablanca

The 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.

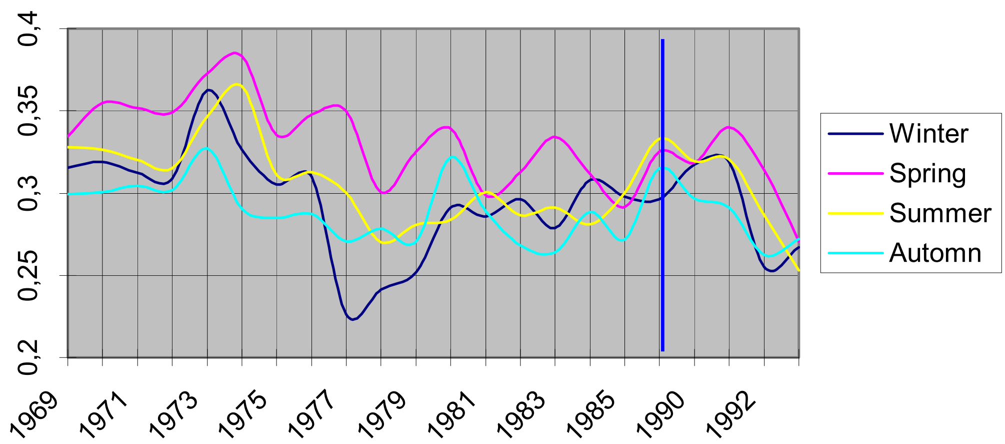
Annual average of Ozone layer thickness in Casablanca.



Seasonal Evolution of Ozone Layer to the Vertical of Casablanca

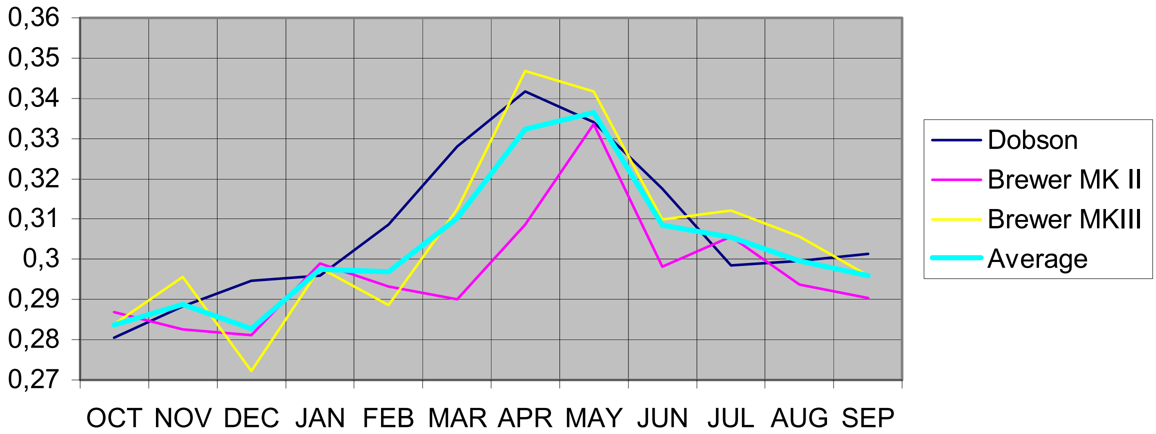
In general, Spring is the season where ozone is at the highest level and autumn is the season where it is at its lowest level. There is, however, some years where winter is the lowest level. These years coincide with the years mentioned above as years with some suspect data in winter months. The bimodal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

Seasonal evolution of ozone layer.



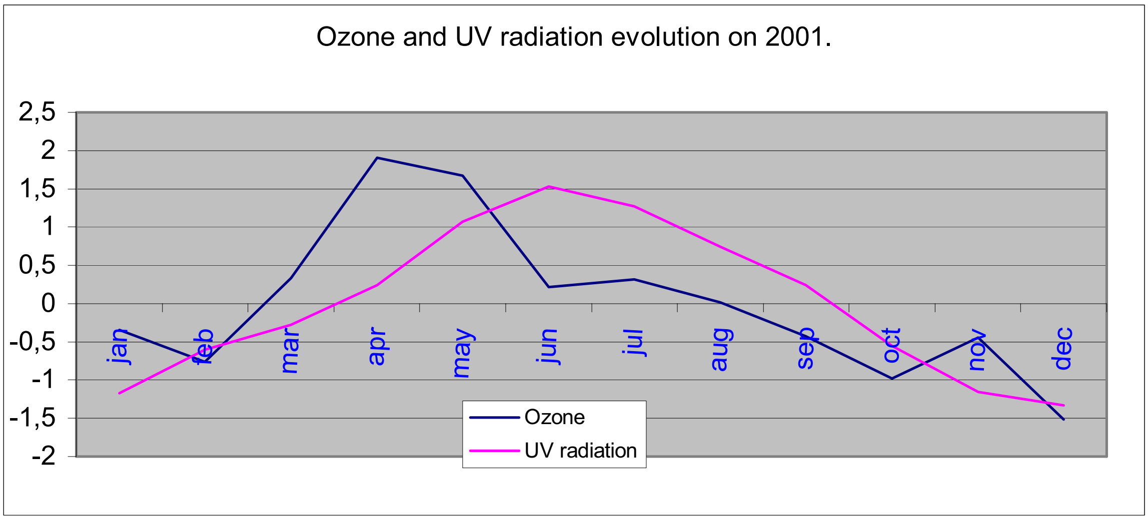
Annual Rhythm of the Monthly Evolution of the Ozone Layer to the Vertical of Casablanca

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 the ozone and the 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 programmes 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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