THAILAND

OBSERVATIONAL ACTIVITIES

Column measurements of ozone

Dobson No. 90 is mainly used for total ozone observations at Bangkok (13.67N, 100.62E). The latest inter-comparison was undertaken in March 2006 at Tsukuba, Japan. This inter-comparison was supported by JMA experts and WMO Scientific Advisory Group on ozone. Routine processing of total ozone is done using the Windobson software package, developed by Koji Miyagawa of JMA, and Dobson by Martin Stanek of CHMI.

Brewer spectrophotometers No.120 and 121 have been used as ground based measurements for total and profile ozone, SO2, NO2, Aerosol Optical Depth and UV spectra in Bangkok and Songkhla (7.2N, 100.6E) since 1997. Data analysis is done using O3Brewer and UVBrewer software.

Profile measurements of ozone

Ozone profiles have been retrieved regularly using Dobson and Brewer umkehr measurements. Data analysis is done using WOUDC software.

UV measurements

Spectral UV radiation measurements have been carried out with Brewer spectrophotometer in Bangkok and Songkhla since 1997. To enhance temporal resolution, a broadband UV radiometer will be installed at Bangkok in 2008.

Calibration activities

Dobson Inter-comparisons have been undertaken at Tsukuba in 1996 and 2006. Brewer spectrophotometers were maintained and calibrated by the International Ozone Service in 2000, 2004, and 2005 and 2008.

RESULTS FROM OBSERVATIONS AND ANALYSIS

The trend of long term ozone is updated as figures below;

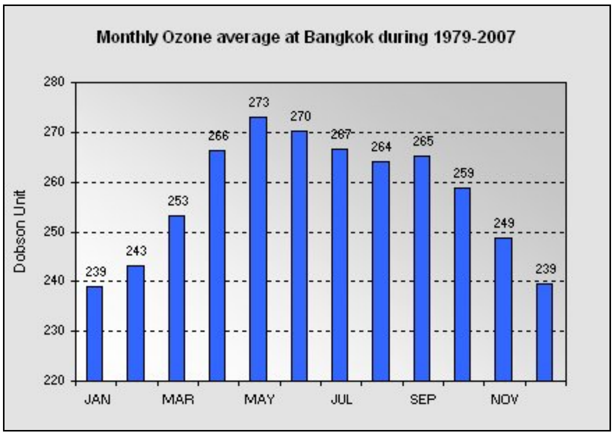


Fig. 1: Seasonal ozone trend

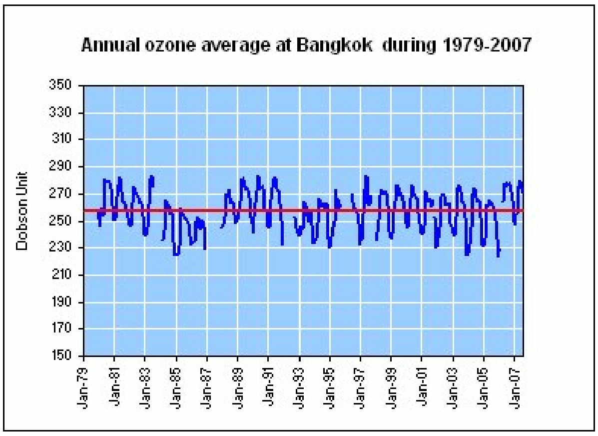
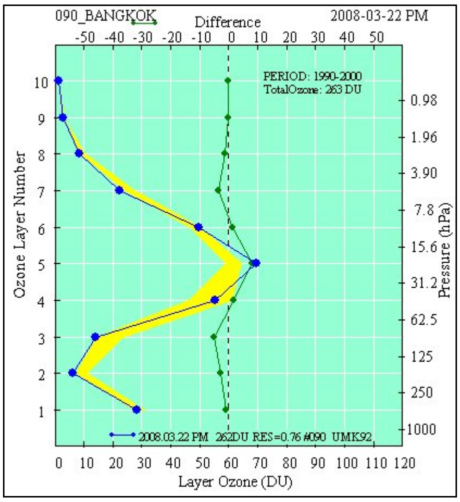


Fig. 2: Long-term trend of monthly average ozone



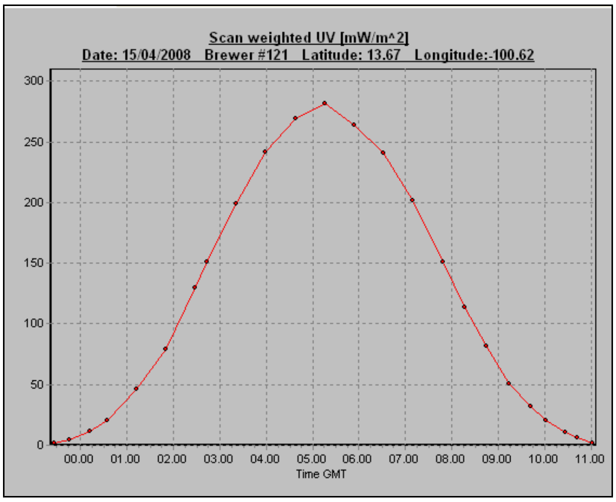


Fig. 3: Dobson Ozone profile, Mar 23 **Fig. 4: Erythemal UV, Bangkok, on April 15, 2008**

Ozone profiles obtained from Umkehr Dobson and Brewer measurements have been operated routinely and distributed to the public via internet.

UV index levels are normally extreme in mid-day over most of the country. UV indices usually range between 7 to 14.

THEORY, MODELLING, AND OTHER RESEARCH

Daily ozone and UV index modeling and forecasting is in use today. However, there is on-going research on the relationship between ozone and its effects on UV radiation, cloud cover and aerosol properties. This research is supported by the Joint Graduate School of Energy and Environment, with the goal of improving modeling.

DISSEMINATION OF RESULTS

Data reporting

Ozone and UV data is deposited regularly to the WMO World Ozone and Ultraviolet Data Centre in Toronto. Solar radiation data is deposited regularly to the WMO World Radiation Data Centre in St. Petersburg.

Information to the public

Ozone and UV radiation monitoring and forecasts are published via internet at http://ozone.tmd.go.th. An example forecast, from April 19, 2008, 12:00 is shown in Fig. 5.

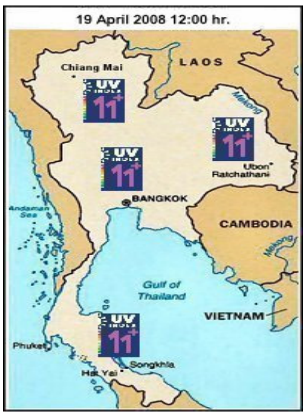


Fig. 5: A UV Index map.

Relevant scientific papers

Sudhibrabha S, Exell RHB, Sukawat D (2006) Ultraviolet Forecasting in Thailand, ScienceAsia Vol. 32 No 2, pp. 107-114.

Sudhibrabha S, Exell RHB, Sukawat D (2004) Ozone and UV Index Forecasting, Proceedings of the JGSEE and Kyoto University Joint International Conference on "Sustainable Energy and Environment (SEE)", 1-3 December 2004, Hua Hin, Thailand, pp.766-770.

Sudhibrabha S, Exell RHB, Sukawat D (2004) Preliminary Forecast of Ozone and UV over Thailand, Proceedings of the XX Quadrennial Ozone Symposium, 1-8 June 2004, Kos, Greece, pp. 1157-1158.

Vanichnukhroh P, Sukawat D, Sudhibrabha S (2004) Ozone Profile in the Climate of Thailand, Proceedings of the JGSEE and Kyoto University Joint International Conference on "Sustainable Energy and Environment (SEE)", 1-3 December 2004, Hua Hin, Thailand. pp. 763-765

PROJECTS AND COLLABORATION

As a member of the Vienna Convention and Montreal Protocol since July 7, 1989, the Thai government, through the Department of Industrial Works, has taken action to protect the ozone layer. The Thai government continues to phase out the use of Ozone Depletion Substances, and also continues to promote increased public awareness of the issue of ozone depletion.

Thai Meteorological Department has monitored and performed research on the ozone layer since 1979. It continues to extend its national radiation monitoring network, which will achieve nationwide coverage in 2008. As Bangkok is A GAW station it will have enhanced capabilities to monitor ozone, radiation, aerosol, and clouds.

FUTURE PLANS

Although Thailand is not a high-latitude country, the Thai government has encouraged and supported studies related to anthropogenic ozone depletion, natural variation in ozone concentration and its relation to climate change, and the forecasting of UV radiation. Thailand plans to improve its ozone monitoring capabilities by increasing the number of monitoring stations and by upgrading its instrumentation.

NEEDS AND RECOMMENDATIONS

Although sufficient support is available for Dobson spectrophotometer #90 from the experts at JMA and the WMO Scientific Advisory Group on Ozone, TMD has had some difficulties obtaining maintenance and calibration support for Brewer spectrophotometers #120 and #121. TMD would be able to better utilize its Brewer instruments if better support services for the Brewer spectrophotometer were available in Asia. Ultimately, TMD would like to develop the capability to maintain itself, and to calibrate its Brewer instruments using Dobson spectrophotometers at a standard reference site in Bangkok.

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TOGO

INTRODUCTION

Togo is worried about environmental problems, especially those concerning chemical substances. Thus government has signed many international conventions concerning the protection of health and the environment. About the protection of the ozone layer, it has adopted a number of regulations to help in the elimination process of ozone-depletion substances (ODS) and to substitute them with inoffensive substances. There have been many efforts in the information of the masses that use these substances. However research services in this domain have problems of absence of adequate scientific equipments to conduct follow up researches about the evolution of the atmospheric ozone layer. Our report gives an account of the activities conducted in Togo on the research projects which are being done or which will be done, what is needed the realize them adequately and recommendations in the fight against the impoverishment of the ozone layer.

RESEARCH ACTIVITIES

In **Togo** and at the University of Lomé precisely, research works on the throwing out of chemical substances in the environment are mainly done at the Faculty of Sciences by the laboratory **G T V D** (the waste management laboratory), the laboratory of atmospheric chemistry and the laboratory of water chemistry. These laboratories make environmental impact studies of the ecosystems and do physicochemical characterisations of the samplings.

But, since **Togo** does not have scientific equipments for the observation of the ozone, direct studies on the ozone are impossible. However, our country has a number of observation stations like the station of **Kouma- Konda** (in the south-west of **Togo**) but the activities of the observation station of **Kouma-Konda**, of the national service of meteorology are reduced to classical observations (temperature, pressure, raining) and are incapable of giving information about the evolution of the ozone layer. Though this station has been selected by the **G A W** programme to be rehabilitated for sub-regional needs, nothing has been done and it is still without evolution. Direct observations on the ozone are still impossible. Its rehabilitation is thus very necessary.

Without direct studies on the atmospheric ozone, the simulations initiated use information from the World Meteorological Organization and the National Oceanic Atmospheric Administration. Since the results obtained have not yet been validated, they have not been communicated to the centre for reference information.

Furthermore, since direct studies are impossible, and before we have simple means of observation of the ozone layer, the researches done in the domain of the ozone-depletion substances rather focus on the basic actions to take to reduce or eliminate or substitute these substances.

In this perspective, we have recently begun (**Prof Gnon BABA**) with the support of the University of Lomé, a research on the theme **« Evaluation des capacités techniques nationales d'observation et d'estimation des rejets de substances chimiques dans l'environnement, constitution d'une banque de données: Etudes préliminaires** » (Evaluation of the national technical capacities for the observation and estimation of the rejection of chemical substances in the environment, constitution of a data Bank: preliminary studies). This work, in fact constitutes a preliminary step for a vast programme that we are thinking of concerning the chemical substances which are thrown out in the nature everyday and which obviously have negative effects on the environment and public health, especially the **ODS**.

Furthermore, because of the interactions between the evolution phenomena of the ozone and those related to climate changing, our researches are also done on precursor gas. The laboratory **GTVD** is also currently conducting researches on substances often derived from burning or refuse incineration. In fact, household and hospital refuses are often burned in the open air because of the lack of incinerators and equipments of smoke neutralization. Researches are conducted then on the emission of direct gas such as CO_2, CH_4 and N_2O or indirect ones such as the carbon monoxide (CO), the volatile organic compounds and the nitrogen oxides (NOx) whose effects seem often neglected.

Among the various works, it is necessary to mention the development by Togo of its control plan for refrigerating fluids granting a number of workshops CFC recuperation and recycling equipments with the help of the UNDP and the UNEP.

The same way, campaigns are organized by the environment head office, to sensitize the people on the consequences of the impoverishment of the ozone layer and the UV increase in the atmosphere which have negative consequences on health and the environment. Training workshops are also organized and have helped refrigerating engineers, who are the main manipulators of the CFC, to acquire the appropriate techniques.

Finally apart from students' long essays relating to themes about the ozone, professors Ayité-Lô Nohende Ajavon and Gnon BABA from the university de Lomé have also contributed to the writing of the Review ***Scientific Assessment of Ozone Depletion:2006***

The research activities can produce expected results if the projects and perspectives have the appropriate support.

PERSPECTIVES, PROJECTS AND COLLABORATIONS

Perspectives and research projects

We are thinking of research projects and perspectives to bring an important contribution to the fight against the impoverishment of the ozone layer. They are:

- The follow up for the evolution of the atmospheric ozone layer.
- Research for new inoffensive substances.
- Rehabilitation of the **Kouma-Konda** station.
- Follow up for the process of reduction and elimination of the **ODS**.
- Research for cheap alternatives.
- Exploration of how to make synthesis of the atmospheric detergents.
- Recuperation, reduction and/or elimination of the **ODS** with simple instruments for research purposes.
- Inventory and identification of air pollutants in general.

COLLABORATIONS

The lack of adequate scientific services in the universities of Togo weakens their collaboration at the national level with other partners concerned with the **ODS** .We consider that only collaborations with international institutions like UNEP, the UNDP, WMO, the NEPAD, European Union, the NOAA, the Ozone Secretariat, can help in the research activities conducted in Togo in the fight against the impoverishment of the ozone layer.

NEEDS AND RECOMMENDATIONS

In order to realize the perspectives and projects enumerated above, a number of things are needed, some of which we are going to enumerate also as recommendations.

Needs

- Fully equipped and simple scientific services for the observation and the follow up for the evolution of the atmospheric ozone for research purposes.

- Small scientific equipments for the recuperation and the recycling of the **ODS** which involve research services.
- Financial supports to laboratories on the basis of the projects submitted for research activities.
- Collaborations with international institutions and developed countries.

Recommendations

- The Rehabilitation of the Koum-Konda station for the follow up of the evolution of the atmospheric ozone in the sub-region.
- Sustained attention to research services in developing countries.
- Material and Financial supports to research laboratories in developing countries.
- Creation in Africa, of a regional centre for researches on the interactions between the ozone and climate changing.
- Initiation of Sub-regional research projects involving scholars from many countries.
- Promotion of research services in developing countries because their works are always neglected.
- Creation of international and regional networks for exchanging information and experience on the SAO, and even the actions conducted in every country/region.
- Involvement of industrialists in the search for solutions related to SAO.
- More sensitizing for decision makes for more involvement in the research for solutions to environmental problems in general.

CONCLUSION

In Togo, like in other developing countries, despite the consciousness of government and scholars on the damages of the SAO , research actions about the protection of the ozone layer, are still slow even though they are fascinating .We have given in this report an account of the main research activities about the protection of the ozone layer. This kind of research needs specific investments. The researches we are planning will be successful only if they have the multiform assistance that we have also enumerated. If our recommendations are taken seriously, they can help advance the research on the SAO in a much sustained way.

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TURKEY

Turkish State Meteorological Service is responsible for observing ozone and UV radiation, also research activities have been carried out by Meteorology Service.

OBSERVATIONAL ACTIVITIES

Ozone measurement is made only in Ankara by two kinds of observations. Ozonsonde (ECC - Electrochemical Concentration Cell) and spectrophotometric methods with a Brewer Instrument are used by Turkish State Meteorological Service in Turkey.

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

Brewer Spectrophotometer
MK III instruments has been installed on the roof of main building of Turkish State Meteorological Service (TSMS) since November 2006 In order to measure total column ozone at Ankara Brewer (39° 97‘ N, -32° 86‘ E). Beeing the only Brewer in Turkey, it forms an integral part of the WMO ozone monitoring network (WMO, 1994).

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

Ozonsonde
Ozone measurements have been made by an ozonesonde instrument at Ankara, Turkey since early 1994 by the Turkish State Meteorological Service. Ankara is located at 32° 53' (E) Longitude and 39° 57' (N) Latitude with an altitude of 891 m. Ozone observations have been operated in every one or two weeks or sometimes a month since beginning. Total ozone column is detected with this operation. It is possible to find vertical ozone distribution, vertical ozone profile, in this way. Up to now, total 313 balloon have been launched and 282 daily total ozone column data have been obtained. The 31 observations could not be performed due to the different reasons such early exploding of the balloon.

UV measurements

Broadband measurements
The B band of the ultraviolet radiation has been measured with an UV-B recorder named Model 501 in two one location, Ankara (39° 97‘ N, -32° 86‘ E) and Antalya (located on southern coast of Turkey and at 54 m. Altitude, 30° 44' (E) Longitude and 36° 42' (N) Latitude).

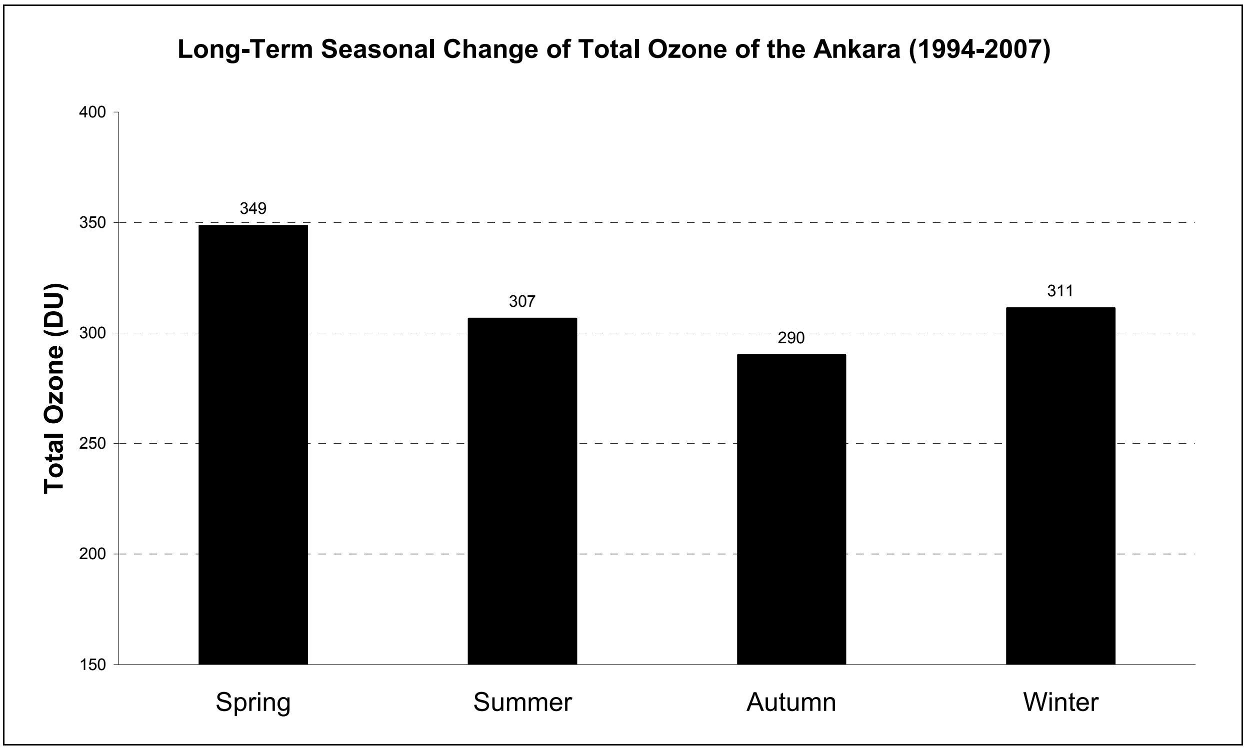
The UV-B observations were started on 3 January 1997 at Ankara, and on 21 May 1997 at Antalya. There is any problem on the UV-B time series of Ankara. However, time series of Antalya has some gaps and missing data. UV-Biometer of Antalya was over in 2003.

Additionally, UV-A and UV-B measurements from Brewer Spectrophotometer are observing by the TSMS.

Narrowband filter instruments
Additionally, TSMS going to assemble ten UVR1-B Global Spectral Radiometer to the east and interior of Turkey at the end of the 2008 year. These stations are in Silifke/Mersin, Mardin, Elazıg, Oltu/Erzurum, Aksaray, Kahramanmaras, Merzifon/Amasya, Sivas, Giresun and Van cities.

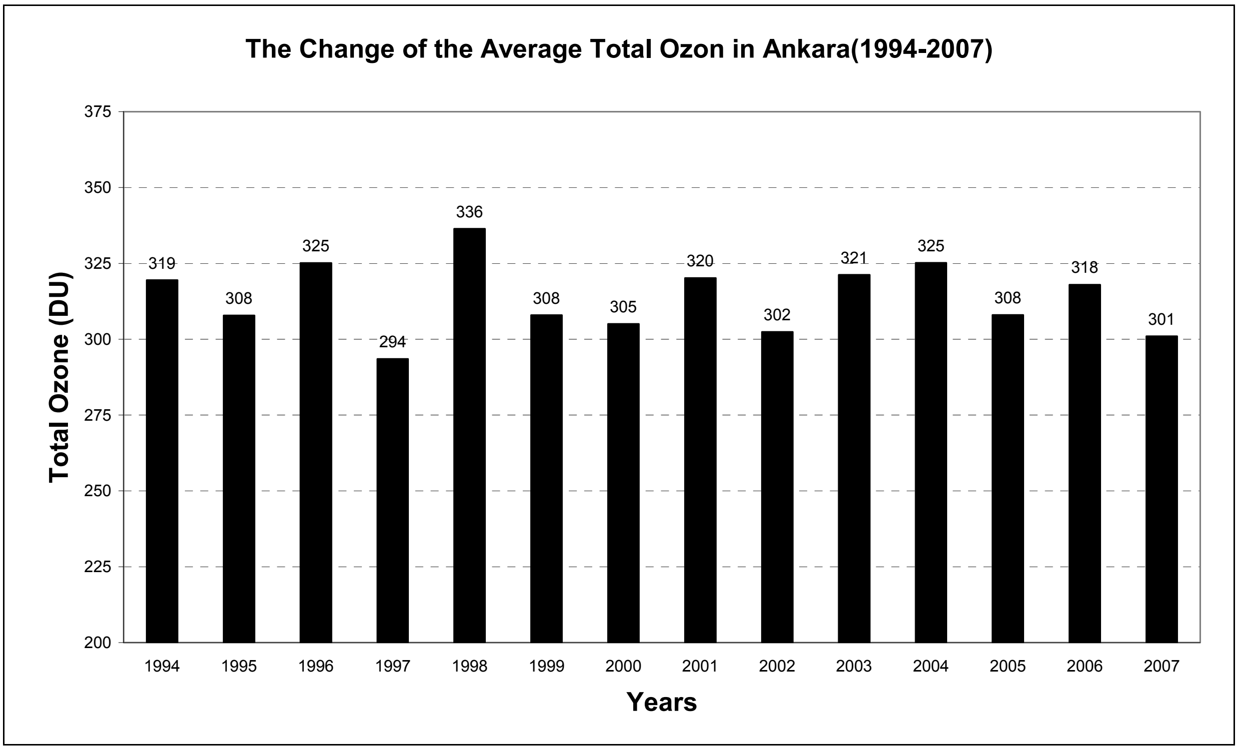
Calibration activities
Calibration of our Brewer spectrophotometer have been planned to carried out in this year. TSMS has the capacity about solar radiation but not instruments of ozone and UV radiation

RESULTS FROM OBSERVATIONS AND ANALYSIS

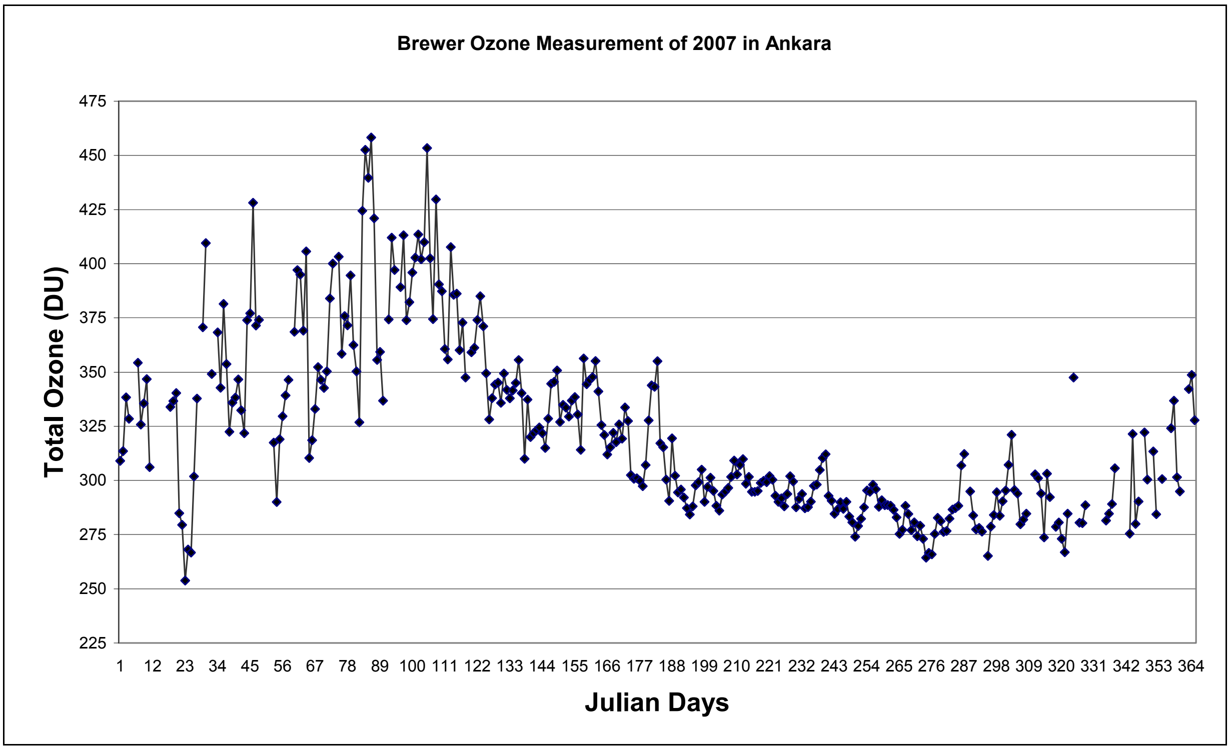


Graphic 1 : Seasonal Ozone Change in Ankara

The seasonal variability of ozone in Ankara, Turkey is characterized by a maximum in spring and a minimum in Autumn. The mean of the spring ozone is 349 DU, the mean of the autumn ozone is 290 DU between 1994 -2007 period.



In 1994-2007 period of ozonsonde measurements, the maximum mean of the period is in 1998 year as 336 DU and minimum mean of the period is in 1997 year as 291 DU.



Maximum brewer ozone data of Ankara is 458 DU in 86th Julian day and minimum of ozone data is 254 DU in 23rd Julian Day.

THEORY, MODELLING, AND OTHER RESEARCH

Turkish State Meteorological Service has been performing on an official project from TUBITAK (Turkish Scientific and Technical Research Council) tilted "Observation of the tropospheric and stratospheric ozone/UV-B changings over Turkey and analyses of the results".

A few academic personals from ITU (Istanbul Technical University) also includes in this Ozone Project under contract no: 105G032 .

Multi-Linear regression model was improved for Ankara by the staffs of this official (tubıtak) project. This study is the experimental model for Ankara. Multi correlation coefficients of the models differs between 0.775-0.876. It is greater than 0.80 in all months except from January. The standard error of the forecast is calculated between 7.28-23.26 DU. Standard error is smaller than 10 DU in July, August and September. Especially, the results in summer and spring seasons are more successful than winter season result.

Within this year has been started experimental UV-Index forecasting in Ankara by using Canadian Empirical Model. Confidence level of the model is under % 5, multiple-regression coefficient of the model is 0.98 and standard error of the model is 1.57 mW/m2.

DISSEMINATION OF RESULTS

Data reporting

The measured ozone data is sent to the `World Ozone and Ultraviolet Radiation Data Centre' (WOUDC) in order to be archived and published. The station number of Ankara is 348 in WOUDC. Clients could find both of the Ozonsonde and Brewer spectrophotometer data for Ankara in WOUDC.

Information to the public

There is a ozone and UV radiation web pages under the official meteorology web site. Its address is ***http://www.meteoroloji.gov.tr/2006/arastirma/arastirma-ozon-ozon.aspx***

This web page includes daily maximum UV Index table for all cities of Turkey (collaborated with DWD).

T.C. ÇEVRE ve ORMAN BAKANLIĞI
DEVLET METEOROLOJİ İŞLERİ GENEL MÜDÜRLÜĞÜ

Üç Günlük Ultraviyole İndeks ve Ozon Tahmini

HARİTA GÖRÜNÜMÜ | TABLO GÖRÜNÜMÜ

	28 Mart 2008, Cuma			29 Mart 2008, Cumartesi			30 Mart 2008, Pazar		
	Bulutlu Hava Günlük Maksimum UV İndeks	Açık Hava Günlük Maksimum UV İndeks	Toplam Ozon (DU)	Bulutlu Hava Günlük Maksimum UV İndeks	Açık Hava Günlük Maksimum UV İndeks	Toplam Ozon (DU)	Bulutlu Hava Günlük Maksimum UV İndeks	Açık Hava Günlük Maksimum UV İndeks	Toplam Ozon (DU)
ADANA	5.6	5.6	343	2.7	5.5	351	3.0	5.6	350
İncirlik Hvl.	5.6	5.6	343	2.7	5.5	351	3.0	5.6	350
Şakirpaşa Hvl.	5.6	5.6	343	2.7	5.5	351	3.0	5.6	350
ADIYAMAN	5.9	5.9	334	2.9	5.8	343	4.8	6.1	335
AFYONKARAHİSAR	5.8	6.0	342	3.2	6.1	337	6.2	6.2	337
AĞRI	5.8	6.6	311	3.0	6.0	341	3.4	6.9	308
AKSARAY	5.9	5.9	340	4.3	5.9	346	1.2	6.0	344
AMASYA	3.0	5.5	331	2.7	5.4	337	1.1	5.4	345
Merzifon Hvl.	3.0	5.6	330	2.8	5.5	336	1.1	5.5	344
ANKARA Keçiören	3.2	5.7	331	2.9	5.8	329	1.9	5.7	340
Akıncı Hvl.	4.8	5.7	334	4.0	5.9	329	5.8	5.8	339
Esenboğa Hvl.	3.2	5.7	331	2.9	5.9	329	1.9	5.7	340
Güvercinlik Hvl.	4.5	5.6	335	4.1	5.8	331	4.6	5.7	339
Etimesgut Hvl.	4.5	5.6	335	4.1	5.8	331	4.6	5.7	339
ANTALYA Hvl.	3.3	5.8	352	2.1	5.7	361	5.7	6.0	349
Alanya	4.1	5.8	352	2.8	5.6	364	6.0	6.0	349
Finike	3.0	6.0	354	2.7	5.0	367	6.2	6.2	352
ARDAHAN	5.0	6.5	316	3.4	6.0	340	3.4	6.7	314
ARTVİN	2.8	5.6	323	3.4	5.3	340	2.9	5.8	321

Daily Uv Index Forecasts for all cities in Turkey

Relevant scientific papers

C.Kahya, B.Aksoy, D.Demirhan, S.Topçu, S.İncecik, Y.Acar, M.Ekici and M.Özünlü ***'Ozone Variability over Ankara, Turkey'*** *European Geophysical Union'ın 15-20 April 2007*

Deniz D. Barı, Sema Topçu, Bülent Aksoy, Ceyhan Kahya, Selahattin İncecik, Yılmaz Acar, Mustafa Özünlü and Mithat Ekici ***"A Study of Daily Total Column Ozone Forecasting Based on TOMS Data and Meteorology"*** *'International Union of Geodesy and Geophysics' 02–13 July 2007*

B. Aksoy, S. İncecik, S.Topçu, D.D. Bari, C. Kahya, Y.Acar, M.Ozunlu ve M. Ekici ***'Total Ozone Over Ankara and Its Forecastıng Using Regression Models'***

Aksoy, B. ve Acar, Y. 2001. ***Ozon (O_3). Technical Report****, Turkish State Meteorological Service, Ankara, Türkiye.*

Aksoy, B. ve Ekici, M. 2001. ***Ultraviole Radiation, Technical Report****, Turkish State Meteorological Service,, Ankara, Türkiye.*

PROJECTS AND COLLABORATION

Turkish State Meteorological Service has been performing on an official project from TUBITAK tilted "Observation of the tropospheric and stratospheric ozone/UV-B changings over Turkey and analyses of the results". A few academic personals from ITU (Istanbul Technical University) also includes in this Ozone Project under contract no: 105G032.

In 2007, we have collaborated with the DWD about daily UV Index over Turkey. And now these informations are published to the public from our official web site. Additionally, we use the ozone data for Turkey from Eumetsat satellite and Ecmwf ozone forecast data. These data are used by TSMS Research Department for testing purpose in present. We are planning to apply to all region of Turkey in this year.

FUTURE PLANS

Planned studies for the period of 2008 - 2011 are as follows:

- To have more strong ozone and UV network in Turkey with three Spectrometers and UV network.
- To detect tropospheric ozone profile.
- To detect stratospheric ozone profile.

- To product daily ozone forecast routinely.
- To make UV index forecast routinely.
- To analyse time series of the ozone and the UV-B.
- To evaluate effects of the changes in the ozone and UV time series on the climate.
  To join meetings, congress and symposium about ozone and UV radiation.

NEEDS AND RECOMMENDATIONS

It is very important the support for annual calibrations and maintenance of the Brewer and UV sensors.

Educational activities and collaboration between ozone services are enhanced by the WMO, UNEP, WOUDC etc.

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TURKMENISTAN

Monitoring of atmospheric ozone
In Turkmenistan monitoring of atmospheric ozone is accomplished by a National Committee on Hydrometeorology at the Cabinet of Ministers of Turkmenistan (Turkmengidromet).
At present continue systematic daily observations of the total amount of the atmospheric ozone at three stations:

Ashgabat (37. 57^{o} N, 58.21^{o} E, 311.6 m, since 1926)
Repetek (38.34^{o} N, 63.11^{o} E, 185 m, since 1983)
Turkmenbashi (40.03^{o}N, 53.0^{o} E, 82.5 m, since 2002)

The measurements of total ozone amount are done by means of the ozonometer M-124, manufactured in Russia. The ozonometers physically became obsolete, already many years they were not calibrated. Spare and reserve ozonometers for replacement and control are absent. Nevertheless the carried out comparative analysis between the temporary changes in the total ozone amount, obtained using the ozonometers M-124 and by data of Central Aerological Observatory scientific report, gives satisfactory agreement.

Information
The daily averaged data of total ozone amount, obtained at three stations are sent by telegram to Moscow 736 OZONE. Monthly schedules O-3 not later than 3 days of the following month are sent to the Main Geophysical Observatory named Voeikov. Further all data are transferred to the coordinated international network by data exchange of the World Meteorological Organization (WMO).

All primary data are stored in the archive of Turkmengidromet on the paper carrier. As it is known, the paper becomes yellow at long storage, records grow dull and there is a danger of important information loss received for a long time. Therefore in the near future it is necessary to transfer all information on ozone in the electronic format.

Studies
It is known that the ozone actively absorbs UV - radiation of the Sun and hereby influences on temperature distribution in the stratosphere, consequently on climate. By-turn climate changes, leading changes of temperature and composition of the atmosphere can influence on condition of ozonosphere. Depletion of the ozone layer will increase hard spectrum of UV - radiation which promote initiation of sun burnings, eye diseases, allergic reactions and skin diseases including cancer. Therefore studying of change of the total content of atmospheric ozone appears as actual task of the present.

Studying of the total amount of atmospheric ozone is conducted by the Scientific and Technical Centre "Climate" of Turkmengidromet. The conducted investigation is directed toward the study of regional special features of the total ozone amount change and their time variations, and also determination of possible sources responsible for the ozone layer destruction.

Though obtained results of scientific analysis regarding influence of hard spectrum of UV - rays on condition of the ozonosphere in a phase of high solar activity, presently an opinion about role of anthropogenic factor becomes prevalent.

In the last years an increase of the quantity of industrial objects in Turkmenistan can lead to the growth of the role of anthropogenic factor.

Turkmenistan having ratified the Vienna Convention and the Montreal Protocol, and also London Amendment to the Montreal Protocol undertook the corresponding obligations on the problem solution of the Ozone depleting substances (ODS). Plan of actions is developed on decrease of pollutants emission in the atmosphere and on ODS phase-out.

22nd of January 2008 the Medzhlis (Parliament) of Turkmenistan has accepted a Decree about acceding to the Beijing, Montreal and Copenhagen Amendments of the Montreal Protocol on Substances that Deplete the Ozone Layer**.**

Problems and needs

The contemporary level of investigations requires the presence of new technical equipment, which will permit to carry out the regular control of the content of ozone both in the atmospheric surface layer and at the stratosphere heights.

This is dictated by the fact that decrease of the total ozone amount in the stratosphere leads to an increase of the intensity of UV - rays dangerous for the life, and its increase in the atmospheric surface layer adversely affects on human health and it leads to a drop in the productivity of agricultural crops (wheat, rice, potato and etc.).

For obtaining more reliable information about the total ozone amount it is necessary to enlarge a network of regular daily observations. Also necessary to more widely use the data, obtained from the satellites. This can be carried out with the aid of the acting stations equipping by the contemporary instruments and opening of new stations with the technical support of international organizations.

In Turkmengidromet also there is necessity in training of young specialists with purpose of effective usage of contemporary instruments for measuring the total amount of atmospheric ozone and ultraviolet radiation.

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UGANDA

OBSERVATIONAL ACTIVITIES

Currently, Uganda is not implementing any activities relating to monitoring the status of the ozone layer and UV radiation – particularly focusing on trends over the years. Nevertheless, this is a matter which Uganda desires to pursue, and initiate activities geared towards monitoring factors that important to both climate and the ozone layer. There is urgent need for equipment and funds to initiate such activities including setting up monitoring stations. Although no actual measurements have been initiated for measuring ground surface ozone, it is believed that some considerable level of ozone emission is high in the urban centres, especially Kampala City, where there is high volume of motor vehicle traffic and traffic jams. Of recent, since the year 2003 Uganda's Customs Authorities (Department) are clearing on average a total of 2,700 (two thousand seven hundred) imported vehicles per month; and out of which a significant proportion of these vehicles are reconditioned vehicles).

In addition, as part of the process of developing Air Quality Standards for Uganda, a number of measurements were carried out for carbon dioxide concentrations in different locations in and around Kampala City. According to the proposed Air Quality Standards for Uganda (currently awaiting approval), *the ambient air standard for ozone gas and carbon dioxide is 0.1ppm and 900ppm, respectively.* The last inventory for sources and sinks of greenhouse gases in Uganda was finalised in 1994, by the Meteorology Department under the then Ministry of Natural Resources. The inventory was sponsored by UNEP/GEF. Since then not much has been done to update the status of GHG emissions in the country, due mainly to lack of funds and equipment/technology.

Column measurements of ozone and other gases / variables relevant to ozone loss
(e.g. Dobson, Brewer, DOAS, FT-IR)

Such activities have not yet been carried out in Uganda.

Profile measurements of ozone and other gases/variables relevant to ozone loss
(e.g. ozonesondes, ozone lidar)

Due to lack of the appropriate equipment to capture and process ozone layer-related variables transmitted by the satellite in space above Uganda, such measurements have never been carried out consistently at national level.

UV measurements
There is no facility / provision for direct measurement of UV, hence, there are also no UV forecasts carried out in the country. Measurements of sunshine give an indirect indication of radiation exposures.

Calibration Activities
This is the responsibility of the Uganda's National Meteorological Centre at Entebbe. Despite the fact that some equipment was acquired by the Centre, calibrated and test-run during the 2005 period, not further activities have been carried out due to limited financial support to upgrade such activities since 2005.

RESULTS FROM OBSERVATIONS AND ANALYSIS
(e.g., trend analyses, UV doses (annual, monthly etc.), UV maps)

The main sources of CO_2 emissions are land use change and forestry, main sources of NO_x- and CH_4-emissions are agriculture and savanna burning. Relative contribution of anthropogenic gases to the greenhouse effect: CO_2: 75%; CH_4: 13%; and, NO_2: 12%. Uganda participates in the Global Climate Observing System with 30 observation stations (1990: 18 stations). Due to lack of funds, the stations are not operating at optimum level. There are no observation stations to participate in the Global Ozone Observing System.

THEORY, MODELLING, AND OTHER RESEARCH

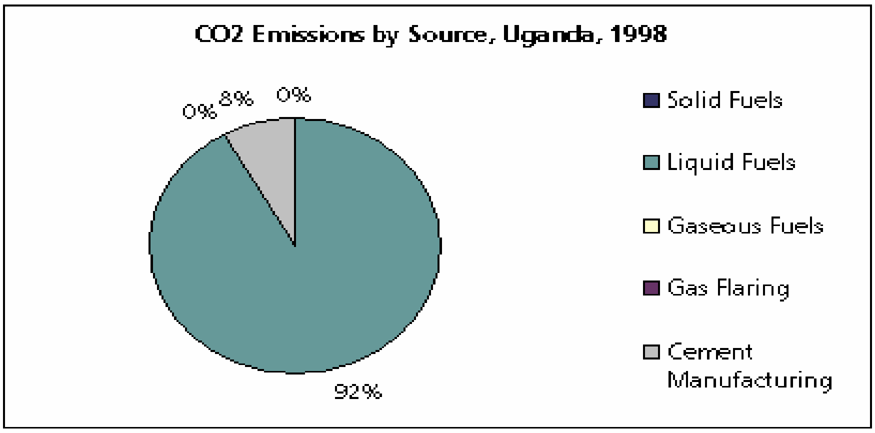
(e.g. 3-D CTM modelling, data assimilation, use of satellite data, UV effect studies)

Such activities have not yet been carried out in Uganda.

DISSEMINATION OF RESULTS

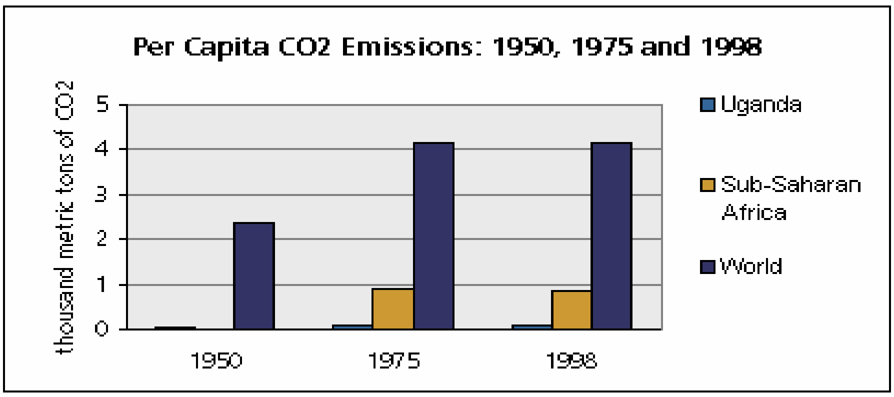
Available information/records, indicate that data/information relating to the climate or monitoring of the atmosphere, Uganda has been submitting data to different data centres. Although the list was not compiled during the preparation of this report, there are certain trends which serve the purpose of illustrating the status of efforts in Uganda to protect the atmosphere – regarding climate change and ozone protection.

Data reporting (e.g. submission of data to the WOUDC and other data centres)
There are available some historical trends as depicted in the figures below.

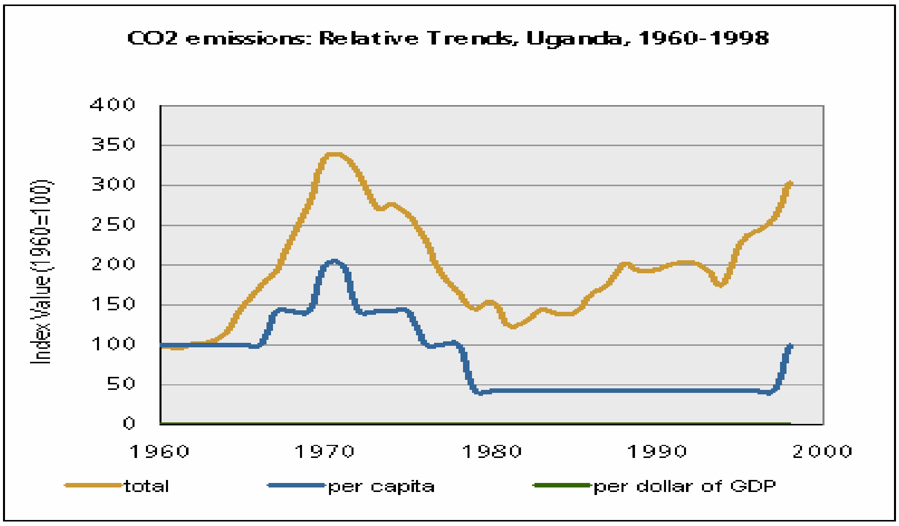


Source: World Resources Institute (WRI) (2006): Climate and Atmosphere, Country Profile – Uganda

In the WRI (2006) Report, it is indicated that by 1998 the percent change in total emission of carbon dioxide since 1990 was at 57%, compared to 10% an 8% for the rest of Africa and the world, respectively. Also the percent change *per capita* of total emissions since 1990 (as recorded in 1998) was at 133%, compared to –12% (minus 12%) and –2% (minus 2%) for the rest of Africa and the world, respectively.



Source: World Resources Institute (WRI) (2006): Climate and Atmosphere, Country Profile – Uganda



Source: World Resources Institute (WRI) (2006): Climate and Atmosphere, Country Profile – Uganda

Other historical data as provide by the Meteorology Department (Kampala, Uganda) in the 1995 status report, during the preparation of Uganda's profile on green house gas emissions and sinks, is as summarised below in ***Tables 1 and 2.***

Table 1: Carbon dioxide and Other Gases Emissions for Uganda

Source	Giga Grams (Kilo Tonnes)
(Fossil) Fuel Combustion	708.51
Biomass Burned for Energy	13,763.00
Industrial Processes	43.56
Land-use Change and Forestry	8,126.67
Total	**22,641.84**

Table 2: Carbon dioxide and Other Gases Emissions for Uganda

Source	CH_4 (Gg)	N_2O (Gg)	NO_X(Gg)	CO(Gg)	NMVOC(Gg)
(Fossil) Fuel Combustion	0.334	0.607	3.971	27.286	4.996
Biomass Burned for Energy	74.52	4.704	22.81	822.93	-
Industrial Processes	-	-	1173.54	-	0.935
Agriculture	1189.766	40.38	0.319	16867.05	-
Land-use Change / Forestry	1.971	0..14	-	17.243	-
Waste	4.526	-	-	-	-

Information to the public (e.g. UV forecasts)
Such activities have not yet been carried out in Uganda.

Relevant scientific papers
(Not accessed by the time of writing this report – constrained by time factor)

PROJECTS AND COLLABORATION

(e.g. national projects, international projects, other collaboration (nationally, internationally))

Uganda is one of the host countries for the implementation of the Clean Development Mechanism (CDM) Project, under the auspices of the World Bank, geared towards reducing emission of greenhouse gases. Its implementation was initiated in November, 2007, with selection of nine (regional) pilot urban centres – namely: Lira, Soroti, Mbale, Jinja, Kabale, Fort Portal and Mbarara Municipal Councils; and two Town Councils – Mukono and Kasese. Currently, the main activity being undertaken in each of the urban centres is the construction of structures for the Compositing Plant, and related infrastructure like access roads and water/electricity supply systems. The collaborating authorities for this Project are the local urban authorities (Town Councils and Municipal Councils).

Another related on-going venture is the West Nile Hydropower Project bordering the Democratic Republic of Congo and the Sudan. This Project falls within the broader rural electrification and development plans of the Government's Energy for Rural Transformation programme. The Project aims to take advantage of the dual benefits of the CDM – o promote sustainable development in rural Uganda by investing in socio-economic development and poverty alleviation, to reduce carbon dioxide emissions through renewable energy and to generate certified emissions reduction (CER). Hence, such a project reduces carbon dioxide emissions by replacing the inefficient diesel generators with hydropower, and by using reducing the use of kerosene used for lighting purposes. Emission reductions are estimated at 1.8 million tonnes over a period of 20 years (UNEP, 2003).

FUTURE PLANS (e.g. new stations, upcoming projects, instrument development)

Recognising the importance of ozone monitoring and noting that most tropospheric ozone is generated over the tropical atmospheric, Uganda has:

(a) A deliberate plan to acquire and establish its first upper air ozone monitoring station on either Mount Rwenzori in western part of the country (bordering the Democratic Republic of Congo) or Mount Elgon in the eastern region of the country bordering (Kenya). It is also important to monitor low level ozone generated in urban centres especially in the Kampala City. It is envisaged that Government of Uganda will spearhead these plans with the help of development partners.

(b) A plan to set up a measurement site for monitoring and forecasting UV radiation; however, the target date has not yet been set.

(c) Plans to train personnel to enhance professional competence in aspects of monitoring, data processing and research.

NEEDS AND RECOMMENDATIONS

In view of the proposed future plans, Uganda would appreciate support in the following areas:

(i) Financial assistance for acquisition of ozone and UV monitoring equipment.
(ii) Technical support for installation of the said equipment in (i) above.
(iii) Training for technical staff for maintenance, calibration and operation of the said equipment.
(iv) Support for scientific programmes in ozone and climate change.

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UNITED KINGDOM

OBSERVATIONAL ACTIVITIES

Column measurements of ozone and other gases/variables relevant to ozone loss
The UK Government's Department for Environment, Food and Rural Affairs (Defra) funds an on-going monitoring programme that records total values of stratospheric ozone at two UK locations. Measurements with a Dobson instrument are taken at the long-term Lerwick Observatory in the Shetland Islands (N of Scotland) and a Brewer spectrophotometer is used at the Reading site in Berkshire (S England). The latter site replaced the Camborne Observatory site in Cornwall at the end of 2003, where a Dobson instrument had been used for ozone measurements. The spectrophometers are used to record daily values, except when weather conditions prevent values from being recorded and during the winter at Lerwick when the sun is too low in the sky. Column ozone measurements which are made (but funded separately) at the University of Manchester (N England), using a Brewer instrument, are also made available for this monitoring programme. Days where the processed total ozone is below two standard deviations less than the long-term average mean for that month are designated as 'low ozone' events and are reported to the UK government immediately along with additional analysis.

The British Antarctic Survey (BAS), which is funded by the Natural Environment Research Council (NERC), runs a Dobson spectrophotometer at the Halley station and a SAOZ spectrometer at the Rothera station, in Antarctica. The BAS also supports the ozone monitoring programme run by the Ukrainian Antarctic Research Centre at Vernadsky station.

A SAOZ zenith sky visible spectrometer is operated at a site near Aberystwyth, Wales to measure mean values of total ozone (and nitrogen dioxide) both at sunrise and sunset on a daily basis.

Profile measurements of ozone and other gases/variables relevant to ozone loss
Defra has provided support for projects that monitor ozone-depleting substances by analysing ground-based measurements at Mace Head, County Galway (Ireland). High frequency, real time measurements of the principal halocarbons and radiatively active trace gases have been made at Mace Head since 1987, as part of the Global Atmospheric Gases Experiment (GAGE) there. For about 70% of the time the measurement station, which is situated on the Atlantic coast, monitors clean westerly air that has travelled across the North Atlantic Ocean. For about 30% of the time, Mace Head receives substantial regional scale pollution in air that has travelled from the industrial regions of Europe. The site is therefore uniquely situated to record trace gas concentrations associated with both the Northern Hemisphere background levels with the more polluted air arising from Europe.

Using the Mace Head data and a Lagrangian dispersion model NAME (Numerical Atmospheric dispersion Modelling Environment), driven by the output from the U.K. Met Office's Numerical Weather Prediction model, it is possible to estimate Northern Hemisphere baseline concentrations for each trace gas and their European and UK emission distributions. Analysis of the Mace Head data provides valuable information on quantifying Northern Hemisphere and European emissions of gases and identifying sources of and trends in ozone formation from different areas. This work will also involve a comparison of observed data with expected trends, and identify any new substances with ozone depleting or radiative forcing properties. The possible use and analysis of any data coming from other sites that could be of policy relevance is currently under consideration.

UV measurements

Broadband measurements
The solar UV index is measured at seven sites in the UK by the Radiation Protection Division of the Health Protection Agency. The Department of Health provides support for this UV monitoring work, which provides information for the Global Solar UV Index in association with WHO, WMO, UNEP and the International Commission on Non-Ionizing Radiation Protection.

Narrowband filter instruments
No instruments of this type are currently being used in the UK.

Spectroradiometers
Two UV monitoring sites are in operation, at a green-field site at Reading (funded by Defra) and a city site in Manchester. At Reading the Bentham DM150 UV spectroradiometer is calibrated on site and the site has been providing regular measurements since 1993. This instrument takes spectra from 290nm to 500nm at 0.5nm resolution every half-hour, between - 85deg < Zenith < +85deg. every day of the year. Periodic international comparisons with other UV spectroradiometers have provided consistently good results. The Manchester instrument provides five minute averages in each of five narrow wavebands (305, 313, 320, 340, 380nm). Apart from calibration periods, the latter instrument has been in continuous operation since 1997, and provides a southern site in the Nordic network of GUV radiometers.

Calibration activities
The Brewer instruments were calibrated in 2005 and 2007 at the Regional Brewer Calibration Centre-Europe (RBCC-E) inter-comparison exercises in El Arenosillo, Southern Spain. The current recommendation is to re-calibrate every two years.

The Dobson spectrophotometer inter-comparison took place at El Arenosillo in September 2007. This forms part of the World Meteorological Organisation's QA/QC programme to assure the quality of the measurements and to assess the performance of the instruments. All instruments are carefully maintained and checked monthly.

At the end of 2005, the BAS Dobson spectrophotometer was upgraded with modern electronics and recalibrated, at the European Centre at Hoenpeissenberg. BAS's old SAOZ spectrometer was replaced by a new one in 2007, which became the operational instrument in 2008 after a period of overlap.

RESULTS FROM OBSERVATIONS AND ANALYSIS

The long term monthly means and standard deviations for column ozone levels at both the Lerwick and Reading monitoring sites are shown in Figures 1 and 2.

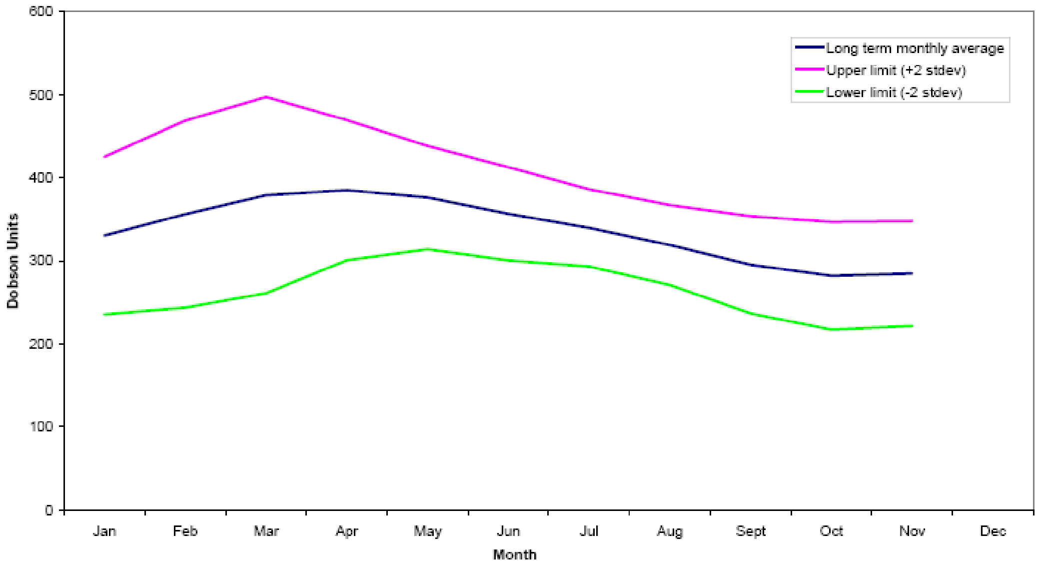

Figure 1: Ozone Climatology data, Lerwick, based on 1981-2007.

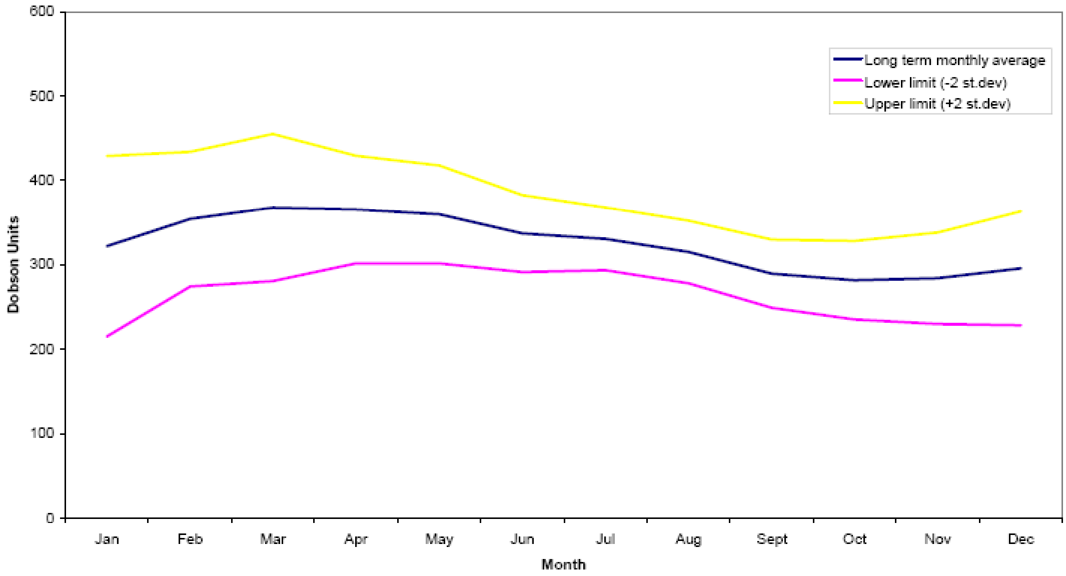

Figure 2: **Ozone Climatology data, Reading, based on 2003-2007.**

THEORY, MODELLING, AND OTHER RESEARCH

No activities to report.

DISSEMINATION OF RESULTS

Data reporting

The ozone monitoring data from Lerwick and Reading are processed daily by the local operators and then quality checked and disseminated. A number of checks are performed in order to ensure the integrity of these data, including comparison of daily results with OMI satellite measurements and the nearest ground-based measurements. Dissemination involves uploading a 'best daily average' to a dedicated web page (www.ozone-uv.co.uk) on the internet and issuing the results to the World Ozone and Ultra Violet Data Centre (WOUDC) Real-time Mapping Centre. Monthly data are submitted to the WOUDC for inclusion on their archive.

Data from the BAS Dobson and SAOZ spectrometer measurements are published in near real time on the BAS ozone web page (http://www.antarctica.ac.uk/met/jds/ozone/.
The Dobson measurements are also submitted to the WOUDC and WMO.

The UV measurement data from Manchester and Reading are submitted to the WOUDC.

Information to the public

Ozone monitoring results from the Lerwick and Reading sites are publicly available on the website (http://www.ozone-uv.co.uk/).

UV information and forecasts from the HPA broadband UV monitoring network are made available on the HPA and Meteorological Office websites. Data from the Reading monitoring site, converted into a simple UV index comparable with the HPA results, is also made available via the website (http://www.ozone-uv.co.uk/) in near real-time for public information.

Relevant scientific papers

Quarterly and annual reports are produced on the ozone and UV monitoring programme.

PROJECTS AND COLLABORATION

As part of the UK monitoring project, Defra funds some analysis of the ozone data collected at Reading and Lerwick. This research focuses on identifying low ozone events, and predicting how the frequency of low ozone events could alter as stratospheric levels change.

There are a number of NERC-funded ozone research projects that have either recently been completed or are currently ongoing. The Upper Troposphere/ Lower Stratosphere (UTLS) OZONE Programme, from 1999 to 2006, aimed to improve understanding of the causes of ozone change in the UTLS in the past, present and future. Ozone has been changing in this region of the atmosphere but the causes have been uncertain. A wide number of scientific research projects were funded, with topics ranging from transport of trace gases on annual and seasonal timescales, dynamical processes occurring on short-timescales, studies of chemical processes in the atmosphere and the laboratory and modelling studies of chemistry-climate interactions. This research has led to an improved understanding of chemical composition and structure in the UTLS region between 6 and 20km. Results from the Programme have shown, in particular, that interactions between dynamics (meteorology) and chemistry in the atmosphere play an important role in governing the distribution of ozone and other trace gases in the UTLS.

A 1-year NERC project, which ended in 2007, looked at understanding the climate response to stratospheric ozone depletion. The project, led by the University of East Anglia, identified particular processes involved in the tropospheric cooling response to ozone depletion over Antarctica. A 3-year research study, started in 2007 and also led by the University of East Anglia, is modelling climate change in the Southern Hemisphere, according to predictions of future ozone change.

NERC is funding a 5-year coordinated study, which started in 2007, on the influences of solar variability on atmospheric composition and climate. The SOLCLI consortium is led by Imperial College, with partners at the Universities of Cambridge, Leeds and Reading and the British Antarctic Survey and with collaborators in Germany, Japan, the USA and the UK Met Office. Study topics include: variability over the past 150 years in solar spectral irradiance; detection of solar signals throughout the lower and middle atmosphere; response of stratospheric composition, specifically ozone, to varying UV; mechanisms for stratosphere-troposphere dynamical coupling; and better representation of solar effects in climate models.
(see http://www.sp.ph.ic.ac.uk/~ssparrow/Solcli_web/solcli_home.htm).

The European Commission (EC) research programmes encourage collaborative projects involving research groups in different countries. The European Ozone Research Co-ordinating Unit (EORCU), based at the University of Cambridge, was set up in 1989 to coordinate stratospheric ozone research in Europe from both the national research programmes and the European Union research programme. There have been numerous joint projects between European scientists, the particular project described below is coordinated by a UK institution (University of Cambridge).

Stratospheric-Climate links with emphasis On the Upper Troposphere and lower stratosphere (SCOUT-O3) is a 5-year EC Integrated Project, ending in April 2009, which has 59 partner institutions and over 100 scientists involved from 19 countries. 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. These forecasts will be major European contributions to international assessments of ozone depletion and climate change prepared in support of policy such as the WMO-UNEP ozone assessments (Montreal Protocol) and the IPCC reports (Kyoto protocol). The forecasts will be built on models, which are being refined and improved in this study by exploitation of existing data for model testing and validation and by the provision of new data on fundamental processes. These forecasts will represent a considerable improvement on current predictions, being based on the significantly improved descriptions of the upper troposphere and stratosphere which the project will achieve. To meet these goals, SCOUT-O3 is split into 10 project objectives and eight activities (see http://www.ozone-sec.ch.cam.ac.uk/scout_o3/). Significant contributions from this project have already been made to the 2006 WMO-UNEP Ozone Assessment and to a number of initiatives organized within the international programme Stratospheric Processes And their Role in Climate (SPARC).

The EORCU is currently, or has recently been, involved in a number of other projects, including: the QUANTIFY Integrated Project and the ATTICA assessment project, both of which are concerned with emissions from different forms of traffic; and the CANDIDOZ project.

The Met Office Hadley Centre (MOHC), at Exeter, is working on the modelling of stratospheric and tropospheric ozone and their relationship to climate change, as part of its Defra and Ministry of Defence funded Integrated Climate Programme (ICP). The MOHC co-leads a work package on model validation and comparison for the EU SCOUT-O3 project and is represented on the coordinating/planning committees of two of the WCRP's SPARC modelling initiatives: CCMVal (Chemistry-Climate Model Validation) and DynVar (Modelling the Dynamics and Variability of the Stratosphere-Troposphere System). The MOHC group made major modelling and co-author contributions to the 2006 WMO/UNEP ozone assessment report. The MOHC is currently combining its stratospheric and tropospheric ozone models, in collaboration with the Universities of Cambridge and Leeds, to develop a whole atmosphere chemistry model UKCA (United Kingdom Chemistry and Aerosols). This will be combined with the MOHC's climate and ecosystem models to create a full Earth-System Model to predict the climate feedbacks involving ozone between climate, chemistry and ecosystems. This links in strongly with the NERC QUEST programme, its earth-system modelling (QUESM), the atmospheric chemistry component (QUAAC) and the land surface component (JULES).

FUTURE PLANS

Defra does not have any plans at present to provide direct government funding for any additional ozone, UV or ODS monitoring sites in the UK. The current basic levels of monitoring will, however, be continued.

Defra is keeping future research needs for policy development on stratospheric ozone under review.

NERC is continuing to provide some funding support for new research projects on ozone.

NEEDS AND RECOMMENDATIONS

There is a key need for further research on the interactions between stratospheric ozone and climate change. The capability of climate models to represent stratospheric (including stratospheric ozone) processes and interactions needs further development. More research is also required to understand the basic physical processes involved in ozone-climate links. The impacts of aviation on stratospheric chemistry and climate may also need further consideration.

Further work should be undertaken to clarify recent findings on the photolysis rate for dichlorine peroxide (Cl_2O_2), in view of its implications for the chemical model of ozone destruction.

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UNITED REPUBLIC OF TANZANIA

INTRODUCTION

The Light and Life in African Environments (LLAE) Project was conceived as a project aimed at studying the visible and ultra-violet solar radiation and its effects in the African equatorial regions, involving researchers from Norway, Gambia, Uganda and Tanzania. This would encompass measurements on land as well as in water on the coasts of the Atlantic and Indian Oceans, and Lake Victoria. The project lasted for only one phase, spanning the years 2002 to 2006. NUFU, the Norwegian funding agency, did not support it for the next phase, spanning the years 2007 to 2011, because it shifted its attention to other research areas. As a result, it became necessary to redefine the project on the Tanzanian side, and efforts have continued to seek funding but these have yet to materialize. In spite of this, data collection is still going on at the stations established at the Department of Physics of the University of Dar es Salaam, and on the slopes of Kilimanjaro Mountain. This report provides a short summary of the accomplishments of the project since its establishment, and future plans if funding is obtained.

GOALS AND OBJECTIVES

The goal of the project was to establish climatology of PAR and UV radiation as well as long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in the equatorial belt of Central Africa.

The attendant objectives were:

- To establish a network of PAR and UV surface-based measurement stations, including one station in Gambia, one in Kampala, one in Dar-es-Salaam and five in the Kilimanjaro area.
- To use the network of surface-based measurement stations to evaluate and validate studies of the ozone resolving sensors on ESA's Environmental Satellite (ENVISAT).
- To use the network of surface-based measurement stations and the satellite sensors to establish the climatology mentioned above.
- To carry out surface-based PAR and UV radiation measurements in Lake Victoria, and later in coastal waters in countries on the Eastern (Indian Ocean near Dar es Salaam) and the Western (Atlantic Ocean) coasts of Africa.
- To use the water-based instruments and satellite-based sensors to establish the floating water plant coverage, algae distribution, and primary production in the mentioned water bodies,
- To transfer the science and technology of monitoring environmental parameters and assessing national resources to the collaborating African institutions.

Following the requirement to address the interests of Tanzania in a more focused way, and foreseeing that it might only be possible to obtain funding for the research component on the Tanzania side, the project component in Tanzania has been revised to bear the title *Light and Life in Tanzanian Environments* (LLTE). Its goal is to establish the climatology of PAR and UV radiation, and long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in Tanzania. The attendant objectives are then:

- To extend the network of PAR and UV surface-based measurement stations over that already established at Dar-es-Salaam and Kilimanjaro.
- To extend the area of measurement using satellite-derived data with the ground measurements for validation.
- To use the network of surface-based measurement stations and the satellite sensors to establish the climatology mentioned above.
- To extend the surface-based measurements to include Lake Victoria and the Indian Ocean.
- To use the water-based instruments and satellite-based sensors to establish floating water

plant coverage, algae distribution, and primary production in the mentioned water bodies.

- To advance the already obtained science and technology of monitoring environmental parameters and assessing national resources.

Since the LLTE project is still taking shape, and noting that funds are still being sought to operationalize it, the activities reported in this report are those carried out under the LLAE project.

ORGANISATION AND OPERATION

The LLAE project was part of a much larger project titled ***Research in Basic Sciences at Makerere and Collaborating Universities to Promote Technological Development in Mathematics, Chemistry, Physics, and Biology*.** Most of the activities in this large project were based at Makerere University, with the LLAE sub-project involving collaborators from Norway, Uganda, Gambia and Tanzania. As such, the LLAE project was initiated from Uganda, and the Tanzanian involvement came in at a later stage. On the Tanzanian side, the project is based at the University of Dar es Salaam.

The main and crucial activities in the project include instrument calibration and data collection. The instrument in Dar es Salaam is calibrated each week, and it serves as a reference for the other instruments. Data is downloaded from the instruments in Kilimanjaro four (4) times a year, and that is when the instruments are calibrated. The calibration and downloading of data is done by a team of researchers, who have to visit all the stations in Kilimanjaro. In addition, a local technician takes care of the instruments in Kilimanjaro, especially cleaning to ensure that dust does not degrade the quality of the light going to the sensors within the instruments.

ACTIVITIES UNDERTAKEN AND THEIR ASSESSMENT

Establishing the Network

The initial objective of the project was to establish the network with six NILU-UV stations, one in Dar es Salaam and five in Kilimanjaro. Due to financial constraints, this number was reduced to four, with one instrument being installed in Dar es Salaam and three in Kilimanjaro. It was envisaged that the results from the four instruments could be evaluated to form the basis for the future architecture of the network.

Unfortunately, some factors have militated against the proper establishment of the network, especially in Kilimanjaro. First, although four instruments were installed initially, one of them failed to operate, and it was taken to the manufacturer for repairs. It has since been repaired and is awaiting installation. Secondly, after examination of the initial data from Kilimanjaro, it was discovered that the instruments needed to be mounted higher than originally planned. The parts for the two stations in Kilimanjaro were modified, and were installed in the July-September 2007 phase. The parts for the third station have already been fabricated, and are awaiting installation. Thirdly, the power supply in one of the instruments in Kilimanjaro operated erratically. This problem contributed to unreliable data, and it took quite some time to tackle. Currently, all stations are being monitored carefully to avoid the repetition of the anomaly. The latter two problems described above made it necessary to postpone the re-installation of the third station in Kilimanjaro. Its location is not easily accessed, and its installation must therefore be done very carefully to avoid recurrent mal-performance.

The achievement on the LLAE network is the experience that has been gained as far as establishing, managing and operating a network of measurement stations is concerned. This experience will therefore be very useful in the envisaged LLTE project and any similar work in future.

Data Collection and Analysis

Data has been collected from the instrument in Dar es Salaam since 2000 and analyzed. Data has also been collected from the instruments installed at Marangu and Horombo stations since 2003.

The achievements in data analysis are the reliable scientific results that have been obtained so far from the instrument installed in Dar es Salaam, which have also been compared with the ones from Serrekunda, Gambia and Kampala, Uganda. The results show that the atmosphere at Kampala has less ozone compared to that at either Dar es Salaam or Serrekunda because of the higher altitude of Kampala. The results also show that the satellite sensors over-estimate the erythemal UV falling on the earth's surface and also that clouds have a much reducing effect on the incoming UV radiation. These results seem to suggest that there will be less ozone in the atmosphere at Kilimanjaro than at Dar es Salaam because of the higher altitude of Kilimanjaro and the presence of less cloud. This, however, will be tested when reliable data from Kilimanjaro is obtained and analyzed. The results also seem to suggest that accurate results are best obtained by using ground-based measurements. The results further show that Dar es Salaam is slightly more affected by aerosols than Kampala because of the air-borne salt from the Indian Ocean, whereas Gambia is more affected (4 to 5 times) by aerosols than either Tanzania or Uganda because of the dust from the Sahara desert.

Some of the results mentioned above have appeared in several papers. While data collected at the Dar es Salaam station is very reliable, there have been a number of problems hindering the smooth collection of data in Kilimanjaro. First, as explained before, only two stations have been fully operational in Kilimanjaro. Therefore, data has never been collected from one of the stations. Secondly, the problem with the power supply in one of the stations as mentioned before made it impossible to obtain data that could be analyzed to draw good conclusions. Thirdly, all the instruments in this project exhibit some drift which lead to wrong interpretation of the data. Part of this problem has been tackled by instituting regular calibrations on the instruments, and these are synchronized to the times of collecting data. In addition to the frequent calibrations, software has been developed to correct for the drift. It is expected that the two measures will lead to reliable interpretation of the collected data. Fourthly, it has been quite a challenge for the researchers to reach the instrument at Gilman's Point, especially when the weather is not conducive. For this reason, part of the work in the LLTE project will be to design the electronics that will enable the remote collection of data from stations that are not easily accessible. Finally, the M.Sc. student in the project declined to proceed with the studies, and as a result, no reliable results could be obtained from his work.

The work that is going on now on data analysis is the preparation of a report to incorporate the data from Kilimanjaro. Due to the problems mentioned above, that data consists of portions when data was not collected and portions when the data collected was not reliable. The report is being prepared in collaboration with the counterpart researchers from Norway.

Training

Only one M.Sc. student was under training for this project, but explained above, that student already dropped from studies. Two technicians have been trained on the calibration and data collection procedures within the project.

The setback on the postgraduate training side was due to two factors. First, Tanzania was late in entering the LLAE project, which was a sub-project of the main project based at Makerere University, Uganda, and which had been running for more than 10 years. There was not much time therefore in recruiting postgraduate students. Secondly, the project was new, and prospective postgraduate students were precarious to join it.

Even though the first M.Sc. student in the project dropped out of studies, there is much research work for future postgraduate students in the project. Therefore, much emphasis will be put on attracting postgraduate students to the envisaged LLTE project.

Interaction with the Tanzania National Park Sector

The National Park Sector, that is TANAPA, TAWIRI and KINAPA has been very cooperative and helpful throughout the project. KINAPA specifically, has been very instrumental in offering whatever assistance was needed by the project personnel going up the Kilimanjaro throughout the instrument installation and data collection expeditions. It is hoped that this will continue in the envisaged LLTE project.

Following the work in Kilimanjaro, KINAPA had requested for 3 weather stations, but due to budget constraints only 3 temperature loggers were supplied. The expectation was to enable the purchase of the weather stations if NUFU had continued to support the project, but this was not possible. Since monitoring of the weather is very important all along the mountain climbing route in Kilimanjaro, efforts will be made to include the weather stations in the envisaged LLTE project. Also, an important aspect that can be added to the research within LLTE is climate change, which has become important with the possibility of the ice on Mountain Kilimanjaro disappearing. This is not only important ecologically, but also to the tourism industry.

Significance of the research to cancer research in Tanzania

The role of UV in cancer has been highlighted in many reports. Excess exposure to UV accelerates skin cancer. In efforts to find out more on this, a visit was made to the Ocean Road Cancer Institute (ORCI), in Tanzania. First, it was learned that increased skin cancer has been a problem of major concern to the institute. Second, it was learned that the most affected group in the population are albinos. The skin cancer and complications arising from them lead to a great reduction in the life span of albinos, to around 40 years. The second group so affected by this problem are children, especially young infants. Thirdly, there has been an increase in cases of skin cancer patients from among the general population, so far assumed least unaffected. Thus, while previously dark skinned people have been less affected by exposure to UV, there is an increase in the number of dark skinned people having skin cancer. Four, quite a number of tourists from Europe have sought treatment at the cancer institute after overexposure to sunlight, with some being hospitalized for days. The incidence of skin cancer is therefore a very important problem to the Ocean Road Cancer Institute.

The increased incidence of skin cancer and overexposure to UV as explained above led the institute to install instruments for measuring the amount of UV reaching the ground as far back as the 80's. Unfortunately, the instruments broke down, and attempts to have them repaired failed. Thereafter, no more attempts were made to re-start the measurements. It is envisaged that part of the ground-based data in the LLTE project will be of assistance to the institute.

FUTURE PLANS

Future progress in the research will be based on the goal of establishing the climatology of PAR and UV radiation, and long-term trends of total ozone abundance, cloudiness, PAR and UV radiation levels in Tanzania. Capitalising on the gained experience which will enable us chart out how we can proceed with the research, the intention is to establish LLTE as a successor to the LLAE project, and take on the challenge of making it sustainable. That, however, will need the involvement of all the relevant stakeholders.

Therefore, in addition to research on UV, PAR and ozone, the future project will focus on a number of issues:

a) Strengthening and expand the established network of measurement stations.
b) Extending its work to study life in Tanzanian water masses.
c) Including research on climate change, which will be of interest to the Kilimanjaro National Park.
d) Including research on the effects of UV on cancer, this will be of interest to cancer research in Tanzania.
e) Training more postgraduate students.
f) Increasing participation of other researchers and stakeholders.
g) Expanding the science and technology of monitoring environmental parameters.

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UNITED STATES OF AMERICA

OBSERVATIONAL ACTIVITIES

Column Measurements:
Ozone

US Satellites
Long-term dataset of total column ozone continues to be produced from the SBUV/2 instruments on the NOAA polar orbiting environmental satellites (NOAA-16, 17 & 18). One more instrument in this series remains to be launched around Feb. 2009. The SBUV record extends back to April, 1970 with a data gap between 1974 and 1978. The TOMS total ozone series started in October 1978 and ended in December 2006. All TOMS data have been reprocessed by applying an empirical correction based on the SBUV/2 record. Hence the SBUV total ozone record is considered the primary record for trend analysis. (NASA, NOAA)

Total ozone data from the Ozone Monitoring Instrument (OMI) on the EOS Aura satellite is available beginning October, 2004. Two independent algorithms are used to produce OMI total ozone data, one developed by NASA the other by KNMI, NL. Neither of the algorithms is fully compatible with the SBUV and TOMS total ozone (version 8) algorithms. Most of the differences occur over bright clouds and at large solar zenith angles. NASA plans to reprocess SBUV, TOMS and OMI data using a common (version 9) algorithm by the end of this year. (NASA)

Ozone Estimates from Infrared Sensors
NOAA produces estimates of total ozone by using information in the 9.7 micron channel of HIRS. The retrieval products are combined with SBUV/2 information to generate global maps of column ozone. See http://www.osdpd.noaa.gov/PSB/OZONE/TOAST/. (NOAA)

Dobson Network
Dobson total column ozone measurements in the U.S. are done through the NOAA/ESRL/GMD Cooperative Network at 16 locations, including 10 national sites in the continental U.S. and Hawaii. Five other sites are collaborative international programmes (South Pole, Perth, Lauder, Samoa, OHP). Data are used for satellite validation and determining ozone trends for the WMO/UNEP Ozone Assessments. NASA also supports Dobson measurements within the U.S. under the auspices of the Network for the Detection of Atmospheric Composition Change (NDACC). (NOAA/ESRL/GMD, NASA)

UVB Monitoring and Research Programme (UVMRP)
Direct-sun column ozone is retrieved by UV Multi-Filter Rotating Shadowband Radiometers (UV-MFRSRs) at 33 U.S. sites, 2 Canadian sites, and 1 New Zealand site within the U. S. Department of Agriculture (USDA) UV-B Monitoring and Research Programme (UVMRP). (USDA)

NOAA-EPA Ultraviolet Brewer (NEUBrew) Network
Brewer Mark IV UV spectrometers were deployed at six U.S. locations in the last half of 2006 with funding from the EPA and NOAA. Total column ozone and ozone profiles using the Umkehr technique are derived from these measurements http://esrl.noaa.gov/gmd/grad/neubrew/. (NOAA/ESRL/GMD, EPA)

Ozone-Relevant Gases and Variables

Ozone Monitoring Instrument (OMI) on the Aura Satellite
In addition to its primary focus on column ozone, OMI measures tropospheric columns of aerosols, nitrogen dioxide, and sulphur dioxide. (NASA)

GOME-2 Instrument on MetOp-A
NOAA is working to implement additional operational products from the GOME-2 Level 1 data. These include aerosols, nitrogen dioxide, and sulphur dioxide. (EuMetSat/NOAA)

Network for the Detection of Atmospheric Composition Change (NDACC)
This international ground-based remote-sensing network was formed to provide a consistent, standardized set of long-term measurements of atmospheric trace gases, particles, and physical parameters via a suite of globally distributed sites. While the NDACC maintains its original commitment to monitoring changes in the stratosphere, with an emphasis on the long-term evolution of the ozone layer its priorities have broadened considerably to encompass the detection of trends in overall atmospheric composition and understanding their impacts on the stratosphere and troposphere, establishing links between climate change and atmospheric composition, calibrating and validating space-based measurements of the atmosphere, supporting process-focused scientific field campaigns, and testing and improving theoretical models of the atmosphere. NDACC instruments that are particularly suited for column measurements include UV/Visible spectrometers for ozone, NO_2, BrO, and OClO; FTIR spectrometers for a wide variety of source and reservoir compounds; and Dobson and Brewer spectrometers for ozone. Additional information on the NDACC is available at http://www.ndacc.org. (NASA, NOAA/ESRL/GMD)

Profile Measurements:

Ozone

BUV Instrument Series (10 Instruments)
The SBUV/2 instruments on NOAA satellites continue to measure ozone vertical profiles in the upper stratosphere (1-30 hPa) with vertical resolution varying from 6 to 8 km. (This technique also provides accurate estimates of the partial column ozone between 30-700 hPa.) This data record extends back to April 1970, with a data gap between 1974 and 1978. Profile datasets are also being produced from the OMI instrument. OMI provides full daily coverage compared to SBUV which provides daily coverage in approximately two weeks. OMI profiles have similar information content as SBUV in the upper stratosphere (1-30hPa) but have higher vertical resolution (~10 km) at lower altitudes. The long-term ozone profile record from the SBUV/2 instrument series has been significantly affected by drifting orbits. Analysis of these effects is currently in progress. NASA plans to reprocess data from the entire BUV instrument series, including OMI, using a consistent algorithm (version 9) by the end of this year. Current and archived Version 8 ozone profile data are being used in the NOAA/NCEP Climate Forecast System Reanalysis and Reforecast, a successor of the NCEP/DOE Reanalysis 2. (NOAA/CPC, NASA)

Stratospheric Aerosol Measurement (SAM) and Stratospheric Aerosol and Gas Experiment (SAGE) Instrument Series (4 Instruments)
The SAM/SAGE series of instruments has provided the longest data set on the vertical profile of ozone in the stratosphere. Near-global coverage has been provided on a near-monthly basis for the periods 1979 to 1981 and 1984 to 2005. (NASA)

Aura Satellite Instruments
Ozone profiles from 0.5- 200 hPa with about 3 km vertical resolution have been produced by the Microwave Limb Sounder (MLS). The high resolution dynamic limb sounder (HIRDLS), which suffers from a partial obscuration of the field of view that occurred during launch, has recently reprocessed the ozone profile data. These data have 1 km or higher vertical resolution in the stratosphere. Two other instruments on Aura Tropospheric Emission Spectrometer (TES) and OMI produce lower vertical resolution ozone profiles but they measure lower into the troposphere than either HIRDLS or MLS. (NASA)

Balloonborne Measurements
NOAA routinely conducts ozonesonde measurements at nine locations (5 domestic, 4 international). NASA, in collaboration with NOAA and numerous international partners, supports the operations of the Southern Hemisphere Additional Ozonesonde (SHADOZ) network of ozonesonde launches from several locations in the tropics and southern subtropics. NASA also

flies ozonesondes and an ozone photometer as components of moderate-scale balloon campaigns that also utilize a submillimeter/millimeter-wave radiometer, an infrared spectrometer, and a far-infrared spectrometer. (NOAA/ESRL/GMD, NASA)

Dobson Umkehr
Profiles are obtained from six automated Dobson instruments using the Umkehr technique (Lauder, Perth, Hawaii, Boulder, OHP, Fairbanks). Through collaboration between NASA and NOAA, a new ozone-profile algorithm has been developed to process Dobson Umkehr data. This algorithm is similar to the SBUV V8 algorithm, and has been optimized for deriving trends. This algorithm has been used to process Brewer Umkehr data on a selective basis. However, due to lack of availability of the Brewer raw radiance data it has not been possible to reprocess the Dobson/Brewer Umkehr data using a consistent algorithm. (NOAA/ESRL/GMD, NASA)

Brewer Umkehr
Brewer Mark IV UV spectrometers were deployed at six U.S. locations in the last half of 2006 with funding from the EPA and NOAA. Total column ozone and ozone profiles using the Umkehr technique are derived from these measurements http://esrl.noaa.gov/gmd/grad/neubrew/. (NOAA/ESRL/GMD)

Network for the Detection of Atmospheric Composition Change (NDACC)
NDACC lidars (whose retrievals are limited primarily to the stratosphere) and microwave radiometers (whose retrievals are limited primarily to the stratosphere) are providing long-term ozone profile measurements. Ozonesondes routinely launched at many NDACC stations also provide ozone-profile data. In addition, several of the high-resolution FTIR spectrometers are beginning to yield ozone-profile information. (NASA, NOAA/ESRL/GMD)

NOAA-EPA Brewer Spectrophotometer UV and Ozone Network
The NOAA/EPA Brewer Spectrophotometer Network (NEUBrew) consists of six stations located in the western, central and eastern United States. Brewer MKIV instruments provide twice daily ozone vertical profiles based on Umkehr scans. Data is available online with a latency of one day. (EPA, NOAA)

Ozone-Relevant Gases and Variables

Stratospheric Aerosol Measurement (SAM) and Stratospheric Aerosol and Gas Experiment (SAGE) Instrument Series (4 Instruments)
The SAM/SAGE series of instruments has provided the longest data set on the vertical profile of aerosols in the stratosphere. Near-global coverage has been provided on a near-monthly basis for the periods 1979 to 1981 and 1984 to 2005. Water vapour profiles are also available. (NASA)

Aura Satellite Instruments
The four Aura instruments provide profile measurements of numerous atmospheric constituents and parameters in the stratosphere and troposphere. MLS is delivering profiles of temperature, H_2O, ClO, BrO, HCl, OH, HO_2, HNO_3, HCN, N_2O, and CO. HIRDLS is retrieving profiles of temperature, O_3, and HNO_3 at 1.2 km vertical resolution and will soon deliver profiles of H_2O, CH_4, N_2O, NO_2, CF_3Cl, CF_2Cl_2, and aerosols. TES is providing limited profile information for O3, CO, H2O, and HDO from its nadir viewing owing to it's high spectral resolution. (NASA)

Combined NASA Satellite Data
Past global space-based measurements of atmospheric composition (e.g., from SAGE, SBUV, UARS, and TOMS) are being extended via observations available from the Aura satellite and other A-Train satellites. These new measurements are providing an unprecedented global characterization of atmospheric composition and climate parameters. Efforts are underway to produce merged data sets connecting these recent measurements to past satellite observations of the atmosphere. (NASA)

Balloonborne Measurements
NOAA monitors upper tropospheric and stratospheric water vapour using cryogenic, chilled-mirror hygrometers that are flown with ozonesondes on a biweekly schedule in Boulder, CO, and at Lauder, New Zealand, in collaboration with NIWA. Water-vapour profiles also are obtained on a campaign basis in Indonesia, the Galapagos, and Hawaii. NASA supports the flights of several balloon instruments (primarily on a campaign basis) capable of providing profile information for numerous atmospheric constituents. (NOAA/ESRL/GMD, NASA)

Airborne Measurements
NASA-sponsored airborne campaigns, using both medium- and high-altitude aircraft, have been conducted with NOAA, NSF, and university partnerships, with a focus on satellite validation and scientific study of ozone and climate change. While designed more for process study than for trend determinations, the airborne measurements have provided a unique view of changes in atmospheric composition at various altitudes in response to source forcings. The most recent campaigns (Costa Rica AVE and TC4) have concentrated on the convection of source gases to the tropical upper troposphere and stratosphere with a goal of understanding the effects on stratospheric ozone. Currently, the international POLARCAT campaign with components from NASA, NOAA, DOE, and NSF are being executed looking at atmospheric processes in the Arctic troposphere. (NASA, NOAA, NSF)

New Aircraft Technologies: Unmanned Aircraft Systems (UAS)
NASA Dryden has obtained new resources in Unmanned Aircraft Systems including General Atomics Aeronautical Systems (GAAS) Altair (leased), Predator-B (IKHANA), and two Northrop Grumman Global Hawks. This new technology will permit longer duration flights (up to 36 hours), flights over hazardous areas for pilots, crew, and scientists (polar regions and remote oceans), and flights incorporating repetitive tasks (drop radiosondes, routine weather observations, and trace gas observations). NOAA sponsored the NOAA UAS Demonstration in 2005 and operated a two airborne channel gas chromatograph (UCATS- UAS Chromatograph for Atmospheric Trace Species) that measured greenhouse gases, stratospheric ozone depleting gases, and air quality gases. It included a small ozone ultraviolet absorption spectrometer. Two atmospheric instruments, ARGUS and UCATS with a water vapour instrument added, flew on the NASA UAS Fire Mission in 2006. In FY 2009, NASA will sponsor several flights including a few new atmospheric instruments for Aura Validation using one of its Global Hawks, a jet powered high altitude UAS (NASA and NOAA).

Network for the Detection of Atmospheric Composition Change (NDACC)
Several of the NDACC remote sensing instruments provide profile data for a variety of ozone- and climate-relevant gases and variables. These observations continue the long term trends for ozone, water vapour, CFCs, HCl, HF, CH_4, and N_2O. (NASA, NOAA, DoD/NRL)

Ground-Based In Situ Measurement Networks
Both NASA and NOAA support in situ sampling of ozone- and climate-related trace gases via networks of flask sampling and real time in situ measurements. These data provide the basis for determining global tropospheric trends and for computation of effective equivalent chlorine (EECl) in the atmosphere. The NASA Advanced Global Atmospheric Gases Experiment (AGAGE) network has the longest continuous observational record for such species, extending back almost three decades for some CFCs. New NASA and NOAA/ESRL/GMD instrumentation permits the monitoring of many of the CFC replacements, thereby enabling a tracking of such chemicals from their first appearance in the atmosphere. Measurement and standards intercomparisons between the AGAGE and NOAA/ESRL/GMD networks and with other international collaborators are leading to an improved long-term database for many ozone- and climate-related gases (NOAA/ESRL/GMD, NASA)

UV Irradiance Measurements:

Broadband Measurements

SURFRAD Network
Seven Surface Radiation Budget Network (SURFRAD) sites operate Yankee Environmental Systems, Inc. (YES) UVB-1 broadband radiometers. The ISIS network of solar measurements includes broadband Solar Light 501 UVB biometers at each of nine sites. Other instrumentation (located at the Table Mountain test facility near Boulder, Colorado) includes a triad of calibration-reference YES UVB-1 broadband radiometers, and two calibration reference Solar Light 501 UVB biometers. Several other broadband UV radiometers also are operated at the Table Mountain site. These include a Scintec UV radiometer, two types of Kipp & Zonen broadband UV radiometers, an EKO UV radiometer, and a Solar Light 501 UVA biometer. (NOAA/ESRL/GMD)

NOAA/ESRL/GMD *Network*
Supplemental measurements of UV-B using YES UVB-1 instruments continue at Boulder, Colorado and Mauna Loa, Hawaii, where high-resolution UV spectroradiometers also are operated and can be used to interpret accurately the broadband measurements. (NOAA/ESRL/GMD)

NEUBrew network
Each NEUBrew station has a Yankee UVB-1 broadband radiometer collocated with the Brewer spectroradiometer. The UVB-1 provides measurements of Erythemal daily dose. (EPA, NOAA)

USDA UV-B Monitoring and Research Programme (UVMRP)
Thirty-seven YES UVB-1 radiometers are fielded under this programme. (USDA)

Narrowband Filter Measurements

Central Ultraviolet Calibration Facility
Currently operating at the Table Mountain test facility in Colorado are a Biospherical Instruments GUV-511 UV radiometer, a Smithsonian 18-channel UV narrow-band radiometer, and two YES UV-MFRSRs. A YES UV-MFRSR is also deployed at the Central Ultraviolet Calibration Facility's High-Altitude Observatory at Niwot Ridge, Colorado. (NOAA/ESRL/GMD)

NOAA/ESRL/GMD Network
Narrowband radiometers (Biospherical Instruments, GUV, 305 nm, 313 nm, 320 nm, and 380 nm) are used at three sites in Alaska. These sites were established in 1998 and operated for about two years with initial funding, but have been operated in a minimal-maintenance mode since. One site was discontinued in 2003 when it was determined that the combination of on-site support and data communications problems were prohibitive. Initial and subsequent calibrations of the instruments have been performed by the manufacturer. Due to reductions in personnel and funding, since 2001 the instrument calibration schedules have been reduced and adequate quality control has not yet been applied to the data. The measurements were discontinued in 2006. (NOAA/ESRL/GMD)

USDA UVB Monitoring and Research Programme (UVMRP)
UV-MFRSRs deployed within this network measure total and diffuse horizontal and direct normal irradiance at nominal 300, 305, 311, 317, 325, 332, and 368 nm with a 2.0 nm bandpass. In addition, vis-MFRSRs are deployed with nominal 415, 500, 610, 665, 862 and 940 nm wavelengths with 10.0 nm bandpass. These 13 measurements are used to create a continuous synthetic spectra model which can then be convolved with specific weighting functions to meet researcher's needs. Access to the synthetic spectra is found on the UVMRP web site at: (http://uvb.nrel.colostate.edu/UVB/uvb_data_products.html) (USDA)

NEUBrew Network
Each NEUBrew station has a Yankee UV-MFRSR and visible MFRSR collocated with the Brewer spectrophotometer. (EPA, NOAA)

NSF UV Monitoring Network
Biospherical Instruments (BSI) GUV-511 moderate bandwidth multi-channel radiometers are deployed at five of the seven network sites (McMurdo and Palmer Station in Antarctica, San Diego California, Barrow Alaska, and Summit Greenland). A BSI GUV-514 radiometer is deployed at the South Pole. (NSF)

Spectroradiometer Measurements

Central Ultraviolet Calibration Facility
A high-precision UV spectroradiometer and a UV spectrograph are located at the Table Mountain Test Facility in Colorado under the auspices of this programme. (NOAA/ESRL/GMD)

Network for the Detection of Atmospheric Composition Change (NDACC)
State-of-the-art, high-resolution spectroradiometric UV observations are conducted as a part of the NDACC at several primary and complementary sites. In particular, U.S. collaboration with NIWA (New Zealand) enables such measurements at Mauna Loa, HI and Boulder, CO. The measurements at Mauna Loa were started in 1995, those in Boulder began in 1998, and they continue to the present. (NOAA/ESRL/GMD)

NSF UV Monitoring Network
BSI SUV-100 high-resolution scanning spectroradiometers are deployed at all seven network sites (McMurdo Station, Palmer Station, and South Pole Station in Antarctica; San Diego California; Barrow, Alaska; Summit, Greenland; and Ushuaia, Argentina). A BSI SUV-150B spectroradiometer is also deployed at Summit, Greenland. (NSF)

UV-Net Programme
Brewer Mark IV spectrometers that measure the spectrum between 290 and 325 nm are deployed at all 21 network sites located in 14 U.S. national parks and 7 urban areas around the U.S. (EPA)

NEUBrew Network
The NOAA/EPA Brewer Spectrophotometer Network (NEUBrew) consists of six stations located in the western, central and eastern United States. Brewer MKIV instruments provide UV irradiance over the range 286.5 nm to 363 nm with 0.5 nm resolution up to 20 times per day. Absolute spectral UV irradiance, instantaneous UV index, and daily erythemal dose time series are available online with a latency of one hour. http://esrl.noaa.gov/gmd/grad/neubrew/. (NOAA/ESRL/GMD, EPA)

Satellite-based Estimation
Surface UV radiation can be estimated using satellite-measured total column ozone and top-of-the-atmosphere radiance at a non-ozone absorbing UV wavelength as input to a radiative transfer code. Such methods have been applied to estimate both the spectral irradiance as well as UVB from the TOMS instrument series. Similar data are being produced by the Finnish Meteorological Institute (FMI) using OMI data. Since the cloud effects vary at very short spatial and temporal scales, the satellite derived UVB data are most useful for making estimates of monthly average UVB and spectral irradiance at ~100 km grid scales. An outstanding problem in the estimation of UVB from satellites is the strong UV absorption of most aerosols, most notably dust and secondary organics. An aerosol absorption correction is applied to the TOMS UVB record (but not to the OMI record) using TOMS-derived aerosol index (AI). Though AI can correct for elevated plumes of dust and smoke, it is not sensitive to aerosols near the surface. As a result the satellites can overestimate UVB by up to 30% in polluted areas. However, this error is largely localized to urban areas and shouldn't significantly affect regional averages. (NASA)

Calibration Activities:

Satellite BUV instruments
The UV instruments have very high susceptibility to degradation in the space environment with unpredictable variability from one instrument to another. In addition, some instruments have had non-linear detector response as well as hysteresis and spectral stray light problems. The

EP/TOMS instrument developed a complex cross-track dependent response after several years. NASA has for several decades supported the calibration of NOAA SBUV/2 instruments both before and after launch. The post launch activities include both hard calibration (by monitoring on-board calibration data and the solar irradiance), as well as soft calibration. Soft calibration techniques include analysis of spectral and spatial patterns in measured radiances to separate geophysical effects from instrumental effects. NASA flew the SSBUV instrument 8 times on the Space Shuttle to provide calibration of NOAA SBUV/2 instruments. Other satellite instruments such as SAGE, and currently the MLS instrument on Aura, are also providing useful calibration information. However, ground-based data have not been used for satellite calibration, except for the BUV instrument that operated on the Nimbus-4 satellite from 1970 to 1974. (NASA, NOAA)

Dobson Network
World Standard Dobson No. 83 is maintained at NOAA/ESRLGMD as part of the World Dobson Calibration Facility, and regularly participates in international intercomparisons of regional and national standards. (NOAA/ESRL/GMD)

Network for the Detection of Atmospheric Composition Change (NDACC)
Several operational protocols have been developed to insure that NDACC data is of the highest long-term quality as possible within the constraints of measurement technology and retrieval theory at the time the data are taken and analyzed. Validation is a continuing process through which instruments and their associated data analysis methods must be validated before they are accepted in the NDACC and must be continuously monitored throughout their use. Several mobile intercomparators within the various NDACC instrument types exist to assist in such validation. (NASA, NOAA/ESRL/GMD)

Ground-Based In Situ Measurement Networks
Both the NOAA/ESRL/GMD and NASA/AGAGE networks independently develop and maintain highly accurate and precise calibration scales at ppt and ppb levels for the major and minor long-lived ozone-depleting gases. In addition, both networks are developing reliable calibration scales for the short-lived halogen-containing gases that have been introduced as CFC replacements. (NOAA/ESRL/GMD, NASA)

Central Ultraviolet Calibration Facility
The Central Ultraviolet Calibration Facility (CUCF) is located in NOAA's David Skaggs Research Center in Boulder, Colorado. The CUCF calibrates more than 80 UV instruments per year for several U.S. Government agencies and other UV research concerns, both national and international. In addition to laboratory calibrations, the CUCF has developed a portable UV field calibration system that allows laboratory-grade calibrations to be made at spectroradiometer field sites. The CUCF also produces secondary standards of spectral irradiance that are directly traceable to NIST primary standards. The secondary standards can be calibrated for operation in either the vertical or horizontal orientation. (NOAA/ESRL/GMD)

USDA UVB Monitoring and Research Programme (UVMRP)
NOAA CUCF lamp calibrations performed in horizontal and vertical position using NIST traceable 1000-W halogen lamps are used to calibrate 51 USDA UV-MFRSRs and 52 UVB-1 broadbands. A U-1000 1.0-m double Jobin Yvon with 0.1-nm resolution and 10^{-10} out-of-band rejection is used as a reference spectroradiometer to transfer lamp calibration to a broadband triad. The UV-MFRSR radiometer spectral response and its angular response (critical for direct beam retrieval) are measured. The Langley calibration method is employed to provide additional absolute calibration of UV-MFRSRs and to track radiometric stability *in situ*. (USDA)

NEUBrew network
The NOAA/EPA Brewer spectrophotometer network (NEUBrew) consists of six stations located in the western, central, and eastern United States. Each Brewer Mark IV spectrophotometer is calibrated for absolute spectral UV irradiance at least one per calendar year. (EPA, NOAA)

RESULTS FROM OBSERVATIONS AND ANALYSIS

Ozone:

Merged Satellite Datasets

Since there are often biases between different satellite instruments it is necessary to create consistent long-term data sets by cross-calibration of different records when they overlap and by using ground-based data when they do not. Such data sets have been produced using TOMS and SBUV total column ozone and profile records. (NASA)

Total Column Ozone

Trends in total column ozone from 10 two-dimensional and 4 three-dimensional models and solar backscatter ultraviolet-2 (SBUV/2) satellite observations were compared for the period 1979-2003. Trends for the past (1979-2000), the recent 7 years (1996-2003), and the future (2000-2050) were compared. Future trends are expected to be positive and less than half the magnitude of the past downward trends. (NOAA/ESRL/CSD, NASA)

Ozone Depletion & Recovery

Statistical analysis of the merged SBUV profile ozone data set from 1979 to June 1997 shows the largest negative trends in the upper stratosphere at high latitudes (-8.5% per decade at 47.5˚S and -7.5 per decade at 47.5˚N), and less negative trends in the tropics and below 30 hPa (-2 to -4% per decade). These trends are in general agreement with previous profile trend estimates from satellite and ground-based records. The downward trend of ozone in the upper stratosphere has not continued beyond 1997, suggesting that decrease of chlorine observed in the upper stratosphere may be having a positive impact on ozone.

Total ozone levels have remained relatively constant over the last decade (1998-2007). Northern midlatitude ozone reached a minimum of 8% below 1979-1980 mean values in 1993 because of forcings from the Mt. Pinatubo eruption and the solar cycle minimum. From 1992-1998 total ozone levels recovered from the effects of the Mt. Pinatubo eruption to about 3% below the 1979-1980 values. In the years since, the northern midlatitude total ozone has been highly variable, but has increased on average, to about 1.5% below the 1979-1980 values. Southern midlatitude ozone decreased steadily until the late 1990s, and has been nearly constant since at 4.5 - 5% below 1979-1980 average values. There are no significant ozone trends over the tropics. (NASA, NOAA)

Antarctic Ozone Hole

Since approximately 1997, the underlying trend of Antarctic ozone (i.e., the trend after removal of the effect of natural variability in vortex temperatures) has been zero. This cessation of the downward trend in ozone is consistently seen at 60ºS to 70ºS in TOMS total ozone columns, SAGE/HALOE stratospheric columns, ozonesonde ozone columns at Syowa (69ºS), and Dobson total column measurements at 65ºS and 69ºS. The cessation of the downward trend is primarily a result of the saturation of the losses, and not due to decreasing levels of stratospheric chlorine. Antarctic ozone depletion is primarily controlled by inorganic chlorine and bromine levels (effective equivalent stratospheric chlorine, EESC), and secondarily controlled by Antarctic stratospheric temperatures. Fits of various ozone hole diagnostics to temperature and chlorine and bromine levels suggest that the ozone hole is very slowly improving. However, detection of this slow improvement is masked by the large natural variability of the Antarctic stratosphere. (NASA)

Ozone Maps

Daily maps of total ozone and monthly total ozone anomalies are being produced, as well as routine updates of the SBUV-2 total ozone change utilizing a statistical model that includes the 1979 to 1996 trend, the trend-change in 1996, plus ancillary variables of solar variation (f10.7), QBO, and AO/AAO. In addition, twice-yearly (Northern and Southern Hemisphere) winter summaries of selected indicators of stratospheric climate are generated. (NOAA/CPC)

Ozone-Related Gases and Variables:

Chlorine Activation

Substantial chlorine activation near the midlatitude tropopause was inferred from an analysis of airborne measurements of chlorine monoxide and ozone. The analysis suggests that a heterogeneous mechanism for the chlorine activation exists in volcanically quiescent periods and can impact ozone photochemistry in regions of the lowermost stratosphere. (NOAA/ESRL/CSD, NOAA/ESRL/GMD, NASA)

Rates of Chemical Reactions Important to Ozone Depletion
The rate of the reaction of hydroxyl radical (OH) with OClO has been studied. This rate affects the partitioning of chlorine into its active forms. The quantum yields for OH production in the photodissociation of nitric acid, a key reservoir species, were studied. (NOAA/ESRL/GMD)

Chemistry in Polar Stratospheric Clouds (PSCs)
High Altitude Balloon and Satellite Observations in the Polar Vortex
A January 2007 NASA balloon campaign from Kiruna, Sweden was conduction to validate of Aura observations in the polar vortex. A broad suite of Cl_y, NO_y, HO_x, and tracers measurements were made in PSCs detected by the HIRDLS and CALIPSO satellite instruments. These data are being analyzed to understand reactive radical partitioning in PSCs. (NASA)

Observations of Nitric Acid-Containing Particles
Airborne in-situ measurements revealed a new category of nitric acid-containing particles in the tropical lower stratosphere, most likely composed of nitric acid trihydrate. It is reasonable to expect that the tropical NAT particles and polar NAT particles nucleate via a similar process because of similar low temperatures; hence, the investigation of the tropical nucleation process is expected to further our understanding of particle nucleation in polar regions also. Observations of condensed-phase nitric acid in tropical subvisible cirrus clouds and in Arctic cirrus ice crystals have also been reported. (NOAA/ESRL/CSD, NOAA/ESRL/GMD, NASA)

Stratospheric Ozone - Climate Connection
Antarctic Ozone and Climate
Research has shown that the atmosphere's temperature structure is affected by decreases in stratospheric ozone. This has included the demonstration that the observed pattern of recent Antarctic surface temperature trends (cooling over the high plateau, accompanied by warming in the region of the Peninsula) is largely due to a change in Southern Hemisphere circulation that is related to the ozone hole.
(NOAA/ESRL/CSD)

Stratospheric Ozone and Climate Forcing
The indirect climate forcing associated with stratospheric ozone changes caused by 21st-century changes in the greenhouse gases carbon dioxide, methane, and nitrous oxide were computed using a two-dimensional radiative-chemical-dynamical model and radiative transfer models. For the various scenarios investigated, the range of future indirect radiative forcings from ozone were found to be small compared with the total direct radiative forcings of these greenhouse gases over the 2000-2100 time horizon. (NOAA/ESRL/CSD)

Ozone-Relevant Gases
Research has shown how the Montreal Protocol that protects Earth's ozone layer has also helped slow climate change. The double effect occurred because compounds that destroy the atmosphere's ozone layer also act as greenhouse gases. While protecting the ozone layer, the Montreal Protocol and its Amendments has also cut in half the amount of greenhouse warming caused by ozone-destroying chemicals that would have occurred by 2010 had these substances continued to build unabated in Earth's atmosphere. The amount of warming up to the year 2010 that was avoided is equivalent to 7-12 years of growth in radiative forcing by carbon from human activities. Earlier studies showed that continued growth in ozone-depleting substances would lead to significant warming of Earth's climate. The analysis quantifies the near-term climate benefits of controlling these substances. (NOAA/ESRL/CSD)

UV:

UV Trends

SURFRAD Network

A paper co-authored with Colorado State University (CSU) UVB researchers analyzing trends in solar UV irradiance at eight stations in the CSU-USDA network stations over the period 1995 to 2006 has been submitted for publication. Both positive and negative tendencies were detected ranging from –5% to +2% per decade. However, inter-annual variability was between 2 and 5%. (NOAA/ESRL/GMD)

USDA UVB Monitoring and Research Programme (UVMRP)

Analysis of nine years of broadband data indicates no statistically significant trend in UVB, though the author of this paper has recently begun to re-evaluate the results using more robust analysis methods. The difficulty in detecting the expected upward trend in UVB is due to calibration uncertainties, radiometric sensitivity drift, year-to-year variability due to changes in cloud cover, ozone, aerosols, albedo, etc. Improved quantification of these variables is essential for any trends analysis, and the UVMRP staff and researchers are, and have been, continuing the work to refine these parameters. (USDA)

A clear latitudinal gradient is seen in the data from North America, even though the range of selected latitudes (40°N to 47°N) is quite limited. At low altitudes, the peak values of erythemally weighted UV ($UV_{Ery)}$ increases by (2.5 ± 0.1)% per degree of latitude over the range of latitudes sampled. A clear altitudinal gradient is also evident. Near 41°N, the peak value of UV_{Ery} increases by ~15% as the altitude increases by ~1 km. This rate of increase is about three times larger than expected for a Rayleigh atmosphere. The increase is smaller for an altitude change from 1.5 km to 3.2 km, indicating that boundary layer extinctions are largest at altitudes below 1 km. (USDA)

UV Forecasts and Exposure

UV Forecasts and Alert System

NOAA/CPC is producing UV forecasts and has developed a UV Alert system with the EPA. The UV Index forecasts are on a gridded field covering the entire globe. Forecast fields are generated at one hour frequency out to five days. The UV Index forecasts include the effects of Earth-Sun distance, total ozone, solar zenith angle, surface albedo (inclusive of snow/ice), cloud attenuation, and climatological aerosol conditions. The gridded fields are freely available on the NCEP ftp site. The UV Alert system is designed to advise the public when UV levels are unusually high and represent an elevated risk to human health. The UV Alert system consists of a graphical map displaying the daily UV Alert areas, as well as additional information included in the EPA's UV Index ZIP Code look-up web page and via the EPA's AIRNow EnviroFlash e-mail notification system. The criteria for a UV Alert are that the noontime UV Index must be at least a 6 and must be 2 standard deviations above the daily climatology. (NOAA/CPC, EPA)

Effects of UVB Exposure

A major limitation in predicting the impacts of UVB irradiance on humans, plant leaves and flowers, and aquatic organisms is the difficulty in estimating exposure. An analysis of the spatial variability in the daily exposure to narrowband 300- and 368-nm and broadband 290- to 315-nm (UVB) solar radiation between 12 paired locations in the USDA UV-B Climatological Network over two summer growing seasons has been completed. The spatial correlation of the UVB, 300- and 368- nm daily exposures between locations was approximately 0.7 to 0.8 for spacing distances of 100 km. The 300-nm daily exposure was typically more highly correlated between locations than the 368-nm daily exposure. (USDA)

THEORY, MODELING, AND OTHER RESEARCH

Ozone:

Ozone-Layer Recovery Estimates

Equivalent effective stratospheric chlorine (EESC) is a convenient parameter to quantify the effects of halogens (chlorine and bromine) on ozone depletion in the stratosphere. EESC has been extensively used to evaluate future scenarios of ozone-depleting substances (ODSs) on the stratosphere. Research has led to a new formulation of EESC that provides revised estimates of ozone layer recovery. The work shows that ozone levels will recover to 1980 levels in the year 2041 in the midlatitudes, and 2067 over Antarctica, assuming adherence to international agreements that regulate the use of ODSs. The researchers assessed the uncertainties in the estimated recovery times. The midlatitude recovery of 2041 has a 95% confidence uncertainty from 2028 to 2049, while the 2067 Antarctic recovery has a 95% confidence *uncertainty from 2056 to 2078.* (NOAA/ESRL/CSD and NASA)

Antarctic and Arctic Ozone Loss
Contrasts between ozone depletion at the poles have been investigated in a recent study that used available long balloon-borne records and ground-based records that cover multiple decades. Antarctic ozone observations reveal widespread and massive local depletion in the heart of the ozone "hole" region near 18 km, frequently exceeding 90%. Although some ozone losses are apparent in the Arctic during particular years, the depth of the ozone losses in the Arctic are considerably smaller, and their occurrence is far less frequent. The observations demonstrate that the widespread and deep ozone depletion that characterizes the Antarctic ozone hole is a unique feature on the planet. (NOAA/ESRL/CSD)

SPARC Initiative on Halogen Chemistry and Polar Ozone Loss
NASA and NOAA scientists are working with international colleagues to examine the effects of new laboratory data on the photolysis rate of the ClO dimer (ClOOCl) on the quantification of polar ozone depletion. These efforts are coordinated under a new SPARC initiative on "The Role of Halogen Chemistry in Polar Ozone Loss", which will undertake a comprehensive review of existing and ongoing laboratory studies, atmospheric observations, and modeling activities. (NASA, NOAA)

Ozone Forecasts
Mechanisms to improve the ozone production and loss chemistry in the operational NCEP/Global Forecast System (GFS) have been implemented resulting in decreased ozone forecast errors at all latitudes. Aura/OMI near-real-time total ozone data will begin to be assimilated into the NCEP/GFS in the Fall of 2008. This will greatly enhance the horizontal ozone coverage previously provided just from the nadir SBUV-2 data. Additionally, tests using ozone profile information from near-real-time versions of the Aura/MLS and Aura/HIRDLS and total ozone data from MetOP/GOME-2 are being conducted. (NOAA/CPC)

Lower Stratospheric Halogen Chemistry
Observations of HOCl, HO_2, and ClO from multiple instruments on high altitude balloons, in conjunction with Aura MLS observations of ClO, suggest that the rate of the HO_2+ClO reaction is faster than the rate currently used in stratospheric photochemistry models. This reaction has a significant contribution to ozone loss in the lower stratosphere. (NASA)

Decadal Analyses and Simulations
Simulated fields of atmospheric constituents derived using NASA's Global Modeling Initiative (GMI) Chemical Transport Model (CTM) are being used in comparison with Aura data to evaluate the transport and photochemical processes in the upper troposphere and lower stratosphere. These simulations are being used along with trajectory calculations to interpret aircraft measurements of chlorofluorcarbons and to develop better estimates of their atmospheric lifetimes. In addition, 25-year time-slice simulations have been done in which specific years (in terms of halogen amounts) are repeated in order to get better mean distributions and estimates of variability for ozone and relevant chemical compounds. These simulations have been included in the Chemistry Climate Model Validation (CCMVal) exercise and were part of the 2006 WMO/UNEP Ozone Assessment. (NASA)

Ozone-Related Gases and Variables:
Environmental Properties of Atmospheric Gases
Chemistry of Potential ODS Replacements
Laboratory and theoretical work has provided information about the ozone-layer friendliness and climate friendliness of candidate replacements for ozone-depleting substances used for a variety of societal applications such as refrigeration, air conditioning, electronics manufacture, and fire protections. Early information about the suitability of a proposed substance is needed by industry before costly development investments are made. These results provide important input parameters for model calculations of the future vulnerability of the ozone layer, and are used together with industrial production-and-use information to analyze the growth of such chemicals in the atmosphere. (NOAA/ESRL/CSD)

UV
UV Instrumentation
The temperature dependence of the Brewer UV spectrometer has been studied in order to improve the quality of data for UV trends. (NOAA/ESRL/CMD)

UV Effects
The UVMRP supports research studying UVB effects on plants and ecosystems.
Numerous publications document the results of these on-going studies, and are listed on the programme's web site at (http://uvb.nrel.colostate.edu/UVB/uvb_publications.html). (USDA)

UV Model Comparisons
The UVMRP's modeling group, "The Center of Remote Sensing and Modeling for Agricultural Sustainability" has published preliminary results of their coupled climate-crop modeling system. Validation and system refinement is underway and has shown promising results. Cotton yields for the 14-state USA cotton belt over the 27 year span (1979-2005)agree to within +/-10% of the actual yields. This modeling effort is being expanded to evaluate precipitation, temperature and UV effects on the yields, with the ultimate goal of developing a system that will be capable of both achieving credible and quantitative assessments of key stress factors, and evaluating alternative cultural practices for sustainable agriculture production. (USDA)

DISSEMINATION OF RESULTS

Data Reporting:
Ozone
TOMS, SBUV and Aura data

In June 2004, a 2-DVD set containing the entire TOMS V8 data set was released. The data cover the period from November 1978 through August 2003. Similarly, a DVD containing SBUV V8 ozone profile data was released. Data are from Nimbus 7 (1978 to 1993), NOAA 9 (1985 to 1998), NOAA 11 (1988 to 2001) and NOAA 16 (2000 to 2003). In 2007 the entire Earth Probe TOMS data record (8/1996-12/2006) was reprocessed using a final correction for instrument degradation. Ozone data from Aura instruments (OMI, MLS, TES, and HIRDLS) are routinely distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC) at http://disc.sci.gsfc.nasa.gov/acdisc. Both level 2 (measured) data and level 3 (grid averaged) data are distributed in HDF format. OMI level 3 data are distributed in ASCII format via the TOMS web site (http://toms.gsfc.nasa.gov). (NASA)

NOAA plans to provide a four-year incremental supplement extending the SBUV(/2) Version 8 ozone profile data record through the end of 2007 by using retrievals from the SBUV/2 instruments on NOAA-16, -17 and -18 POES in the Summer of 2008. (NOAA)

Aura Validation Data Center (AVDC)
Preliminary and near real-time total ozone, ozonesondes, ozone profiles from LIDAR and microwave radiometers are archived from US Government Agencies and investigators worldwide. In addition, the AVDC (http://avdc.gsfc.nasa.gov/) also archives and distributes NASA and NOAA

total column, profile and tropospheric satellite data subsets. The collected preliminary ozone data are restricted to participants in Aura validation teams, ESA OMI announcement of opportunity participants, and international validation contributors, while the satellite data is freely available (http://avdc.gsfc.nasa.gov/Data/). (NASA)

Umkehr Data
Dobson Umkehr data processed using an SBUV-like algorithm are available at http://www.srrb.noaa.gov/research/umkehr/. (NOAA/ESRL/GMD, NASA)

World Ozone and Ultraviolet Radiation Data Center (WOUDC)
Total ozone, Umkehr, and ozonesonde data are reported to the WOUDC from U.S. Government agencies and institutions. Ozone data from sites that are part of the NDACC and the SHADOZ network are available from the programme web sites (http://www.ndacc.org/ and http://croc.gsfc.nasa.gov/shadoz/, respectively), and also are imported to WOUDC. (NOAA, NASA).

NEUBrew Data
UV spectra, total column ozone and Umkehr ozone profile data from the NOAA-EPA network are available at the web site http://esrl.noaa.gov/gmd/grad/neubrew/ (NOAA/ESRL/GMD, EPA)

Maps
All daily SBUV/2 total ozone hemispheric analyses generated from NOAA-16, NOAA-17, and NOAA-18 observations are available on the Climate Prediction Center's stratospheric web pages at http://www.cpc.ncep.noaa.gov/products/stratosphere/sbuv2to/. The raw data from the SBUV/2 are available from NESDIS. Additionally, the NCEP/GFS total ozone analysis and forecast fields out to five days are available at http://www.cpc.ncep.noaa.gov/products/stratosphere/strat_a_f/. (NOAA/CPC)
Daily maps from the Version 8 total ozone algorithm processing of GOME-2 data are available from NOAA Operations at http://www.osdpd.noaa.gov/PSB/OZONE/gome.html
(NOAA/CPC)

Assessments
NASA and NOAA scientists played key roles as reviewers and authors for various chapters in the 2006 WMO/UNEP Scientific Assessment of Ozone Depletion, mandated under the provisions of the Montreal Protocol. (NOAA, NASA)

2005 IPCC Special Report
The 2005 Special Report of the Intergovernmental Panel on Climate Change (IPCC) and the Technology and Economic Assessment Panel (TEAP) was published (*IPCC/TEAP Special Report on Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons). (NOAA, NASA, EPA, NIST, NSF)*

Stratospheric Winter Hemisphere Bulletins
Following each hemisphere's winter, an assessment of the stratospheric dynamics and chemistry are presented from a NOAA perspective. The southern hemisphere's winter bulletin focuses upon the ozone hole formation and longevity. Relevant thermal and dynamical attributions are presented. The northern hemisphere's winter bulletin will discuss ozone loss conditions and stratospheric warmings. http://www.cpc.ncep.noaa.gov/products/stratosphere/winter_bulletins/ (NOAA/CPC)

Ozone-Related Gases and Variables
Aura Data
Gas and Aerosol constituent data from Aura instruments (OMI, MLS, TES, and HIRDLS) are routinely distributed by the Goddard Earth Sciences (GES) Data and Information Services Center (DISC) at http://disc.sci.gsfc.nasa.gov/acdisc. Both level 2 (measured) data and level 3 (grid averaged) data are distributed in HDF format. OMI level 3 data are distributed in ASCII format via the TOMS web site (http://toms.gsfc.nasa.gov). (NASA)

Ozone-Depleting Substance Data
Long-term data from the NOAA/ESRL/GMD network are updated every six months on the website (http://www.esrl.noaa.gov/gmd/) and submitted annually to the World Data Centre and to the World Data Center for Atmospheric Trace Gases at the Carbon Dioxide Information Analysis Data Center (CDIAC). Data from field missions (firn-air studies, ocean flux studies), are posted shortly after mission completion. Data on very short-lived gases from ocean research cruises are posted for use on the NOAA/GMD website. (NOAA/ESRL/GMD)

Long-term data from the NASA/AGAGE network are reviewed on a semi-annual basis by the Science Team, and are archived every six months with Carbon Dioxide Information and Analysis Center (CDIAC) <http://cdiac.esd.ornl.gov/>. Data from the UCI flask sampling network are also archived at CDIAC. (NASA)

UV Data
SURFRAD Network Data
UV data from the SURFRAD Network are available on the NOAA/SRRB website (http://www.srrb.noaa.gov/). (NOAA/ESRL/GMD)

USDA UV-B Monitoring and Research Programme (UVMRP)
UV, visible and ancillary data from the UVMRP network is available next-day on the UVMRP website (http://uvb.nrel.colostate.edu/).

UVB-1 broadband data and UV-MFRSR data from this network are regularly submitted to the WOUDC. (USDA)

Information to the Public
Ozone
TOMS and OMI Data

Near-real-time ozone data from the OMI instrument on Aura is routinely distributed via the NASA web site (http://toms.gsfc.nasa.gov/). Data are usually available within 48 hours, though faster access can be arranged. The site provides online access to both TOMS (1978-2006) and OMI (2004-present) data. While used mostly by scientists, educators and students also use the site extensively. An Ozone Hole Watch web site, http://ozonewatch.gsfc.nasa.gov/ provides information for anyone interested in the Antarctic ozone hole. (NASA)

Merged TOMS/SBUV Total and Profile Ozone Data
Merged TOMS/SBUV total and profile ozone data sets are available on the Internet (http://hyperion.gsfc.nasa.gov/Data_services/merged/index.html). (NASA)

UV
Forecasts
Noontime UV forecasts are made available to the public via several formats. One is a text bulletin for 58 cities in the U.S. The other is a map displaying the UV Index forecast at each of the 58 cities' locations. These can be found at http://www.cpc.ncep.noaa.gov/products/stratosphere/uv_index/. Additionally, gridded fields of the noontime forecast for the U.S. and Alaska are made available via the NOAA/CPC and NOAA/NCEP ftp sites. UV Index forecast gridded fields covering the entire globe at one hour increments out to five days are available on the NCEP ftp site: ftp.ncep.noaa.gov/pub/data/nccf/com/hourly/prod. (NOAA/CPC)

Advisories
The primary UVR advisory in the United States is the UV Index, operated jointly by NOAA and EPA. Currently, the UV Index computer model processes total global ozone satellite measurements, a rough cloud correction factor, and elevation to predict daily UVR levels on the ground and the resulting danger to human health. This model assumes zero pollution levels. UV Index reports are available in local newspapers and on television weather reports. The EPA also issues a UV Alert when the UV Index is predicted to have a high sun-exposure level and is unusually intense for the time of year. UV Alert notices can be found at EPA's SunWise web site

(http://www.epa.gov/sunwise/uvindex.html), in local newspapers, and on television weather reports. (EPA)

Ozone-Depleting Gas Index

An ozone-depleting gas index (ODGI), based on Effective Equivalent Chlorine (EECl) measured globally in the NOAA/ESRL/GMD network, has been implemented. EECl and WMO/UNEP ozone-depleting gas scenarios are used to estimate the progress towards ozone recovery (ODGI = 100 on January 1, 1994 when EECl reached its maximum value and 0 at recovery). The results are updated annually and posted at http://www.esrl.noaa.gov/gmd/odgi. (NOAA/ESRL/GMD)

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PROJECTS AND COLLABORATION

NOAA/ESRL/GMD

The Dobson and ozonesonde measurements are included in the WMO Global Atmosphere Watch (GAW) and in the NDACC. Significant collaboration with federal agencies (NASA, DoE) and universities (University of Colorado, Harvard, Princeton, Humboldt State University, etc.) is maintained through both global monitoring and field missions. The CUCF is designated by a Memorandum of Understanding to be the national UV calibration facility by agreement among the following organizations: NOAA, USDA, EPA, NASA, National Institute of Standards and Technology (NIST), NSF, National Biological Service, and the Smithsonian Institution. The CUCF compared secondary standards of irradiance with the Joint Research Centre's European Union UV Calibration Centre's (ECUV) ultraviolet spectral irradiance scale in Ispra, Italy. The CUCF's irradiance scale is directly traceable to the NIST spectral irradiance scale, while the ECUV's irradiance scale is traceable to that of the German national standards laboratory, Physikalisch-Technische Bundesanstalt (PTB).

NOAA/CPC

Activities include participation in several initiatives of Stratospheric Processes and their Relation to Climate (SPARC), i.e., stratospheric temperatures, ozone, UV, climate change; collaboration with the EPA on the UV Index and the UV Alert system; collaboration with NASA in ozone monitoring, calibration of the SBUV/2 instruments, dynamical processes influencing ozone changes, and ozone assimilation; collaboration with the surface radiation monitoring efforts of NOAA/OAR and USDA-CSU for the validation of UV forecasts and NCEP/GFS surface radiation products, and the NDACC Data Host Facility.

NASA:

NASA collaborates extensively with several NOAA laboratories in all areas of ozone and UV research, including space-based, airborne, balloonborne, and groundbased measurements, as well as in various modeling and analysis activities. NASA often supports research activities within these laboratories, including support for NOAA groundbased measurements for satellite validation. The NDACC, which is championed by NASA and NOAA within the U.S., is a major contributor to WMO's Global Ozone Observing System (GO_3OS) within the frame of its Global Atmosphere Watch (GAW) Programme. NASA is closely collaborating with KNMI (Netherlands) and FMI (Finland) on processing data from the Aura OMI instrument. NASA is assisting NOAA in the implementation of the OMPS nadir and limb instruments on the NPOESS Preparatory Satellite (NPP) by developing the limb operational algorithms and by performing assessments of the nadir operational products.

USDA:

USDA is actively collaborating with the NASA TOMS and AERONET groups on aerosol absorption using UV-MFRSR and Cimel instruments. USDA researchers participated in the NSF MIRAGE Mexico City air quality study in February/March 2006. Collaborations also exist with DoE for providing aerosol optical depths and column ozone data. Agency personnel participated in the Norwegian filter radiometer intercomparison held in Oslo in May 2005.

EPA:

The NOAA/EPA Brewer spectrophotometer network (NEUBrew) consists of six stations located in the western, central, and eastern United States. The NEUBrew network has deployed two Brewer Mark IV spectrophotometers to Brisbane, Australia. The data gathered from this location will be used for atmospheric research and human health effects studies.

FUTURE PLANS

Ozone:

Column Ozone from Dobson/ Brewer Zenith-Sky Measurements

The operational zenith-sky total ozone algorithm for Dobson and Brewer instruments is based on empirically derived tables. NASA has developed a TOMS-like algorithm to process these data, which has the potential to substantially improve data quality. There are plans to process all historical zenith-sky data using this algorithm. (NASA)

Ozone in Climate Forecast Models

NCEP has modified and extended its synoptic forecast model (GFS) to time scales of three weeks to nine months. Ozone forecasts as well as stratospheric temperatures and heights have significant errors in these forecasts. Experiments modifying the model's physics and structure will need to be conducted in order to improve these forecasts. (NOAA/CPC)

Ozone in the NCEP/Climate Forecast System Reanalysis

NCEP is replacing the NCEP/DOE Reanalysis 2 (R2) with the Climate Forecast System Reanalysis (CFSR). The CFSR improves upon the R2 in many ways. One is by using ozone profile information from the SBUV/2. The CFSR is being rerun from 1979 to present and will continue as the model for NCEP's Climate Data Assimilation System (CDAS). The CFSR should be the reanalysis of choice to study ozone-dynamics interactions. (NOAA/CPC)

Ozone-Relevant Gases/Variables:

OMPS and CrIS on NPP and NPOESS

The Ozone Mapping and Profiler Suite will become the operational US ozone monitoring instrument in the NPOESS period. The suite consists of two nadir detectors; one with coverage in the 310 to 380 nm range to provide daily global total column ozone maps, and the other with coverage from 250 to 310 nm to provide nadir ozone profiles to continue the SBUV(/2) record. The first OMPS will fly on the NASA NPOESS Preparatory Project Mission in 2010. The OMPS was design to include a third detector, the limb profiler, to provide high-vertical resolution ozone profiles. This instrument was de-manifested due to cost issues. It has been restored on NPP and options for future flights are under consideration. The Cross-track Infrared Sounder is a hyperspectral IR instrument with spectral coverage including the ozone lines around 9.7 microns. NOAA has implemented ozone retrieval algorithms with the AIRS instrument on EOS, and plans to use similar algorithms with the IASI on MetOp-A and the CrIS on NPP and NPOESS. (NOAA, NASA)

NEUBrew Network

The NOAA/EPA Brewer spectrophotometer network (NEUBrew) consists of six stations located in the western, central, and eastern United States. Future plans include the addition of UV-aerosol optical depths, tropospheric ozone estimates and total column abundance of NO2 and SO2 data products. (EPA)

UV:

UV Index Forecast

Aerosols and clouds are the greatest cause of UV Index forecast errors. NCEP and NESDIS are working together to improve the skill of forecasting aerosols. When model generated forecasts of Aerosol Optical Depth and Single Scattering Albedo become available they will be included in the UV Index forecast system. (NOAA/CPC)

NEEDS AND RECOMMENDATIONS

Ozone:

Column Ozone

Column ozone observations from ground stations and satellites provide the foundation for trend studies. Future levels of total ozone will be modulated by climate change effects. The current predictions of total ozone from state-of-the-art models suggest polar ozone recovery in the 2060-2070 period, and midlatitude recovery in the 2040-2050 period. It is a primary requirement to continue this data record and to enable retrieval improvements of the observations.

Column ozone data produced by satellite and ground-based instruments agree well in cloud-free conditions and at solar zenith angles less than 70º. However, the data quality of all measuring systems degrade under cloudy conditions and at large solar zenith angles, with differences of 10% or larger. Given the need for accurate ozone trends in the polar regions, it is important to improve the quality of ground-based data in these regions, and to focus future calibration and data intercomparison efforts accordingly. (NASA)

Profile Ozone

Ozone profile information has critical importance for both ozone recovery and climate change. The vertical structure of ozone (~ 1 km resolution) near the tropopause is crucial to calculating the radiative forcing of ozone on climate. Furthermore, polar ozone recovery should first manifest itself in the 20-24 km region of the polar stratosphere. Models of ozone suggest that the cooling of the stratosphere will accelerate ozone recovery in the upper stratosphere leading to a "super-recovery". Hence, observations of the vertical structure of ozone have a bearing on two key scientific issues: ozone recovery and climate change. (NASA)

There is a vast amount of unprocessed Brewer Umkehr data residing in the archives. A concerted effort should be made to process these data using a common Dobson/Brewer algorithm, which is necessary for trend studies. (NASA)

The only currently planned U.S. space-based ozone-monitoring instrument in the post-Aura era will be the NPOESS OMPS instrument, a limb scattering measurement with very little heritage. In order to provide a calibration source for OMPS so that the data will be of sufficient quality for scientific studies and trend analysis, consideration should be given to adding a simple solar occultation instrument to NPOESS. (NASA/NOAA/DOD)

NASA has two Earth Science Decadal Survey satellite missions recommended in the future. One (GEO-CAPE) is a geosynchronous orbit and designed to study North American air quality, but should also provide column ozone. The second (GACM) is described as a follow up to Aura with analogous instrumentation using more advanced technology. This will provide profiles for ozone and numerous trace gases in the stratosphere and troposphere. Neither project is planned to be launch until some time after 2017, leaving a large gap between Aura and the next mission. (NASA)

In order for ozone forecasts to improve in the NCEP/GFS, higher quality and greater numbers of ozone profiles need to be available for assimilation than what is available from the current nadir viewing SBUV/2. Ozone profiles from the Aura/MLS, HIRDLS and OMI are promising as they provide ozone profiles which are of greater resolution (MLS and HIRDLS) and of greater horizontal coverage (OMI). As these products are refined and made available in near-real-time, they will likely be assimilated into the NCEP/GFS.(NOAA/CPC)

Ozone-Relevant Gases and Variables:

Ozone- and Climate-Related Trace-Gas Measurements

There is a need to maintain and expand the existing *in situ* networks, both geographically and with improved instrumentation. Current workforce limitations prevent the development and propagation of gas standards on as rapid a schedule as required by these networks to keep up with the increasing number of new chemicals of scientific interest. In addition, expanded efforts are needed for data analysis as more and more chemicals are being measured. (NASA, NOAA)

Aerosol Absorption Optical Thickness (AAOT)

There are currently no operational ground-based instruments that provide AAOT in UV.
AAOT from the AERONET network is limited to wavelengths longer than 440 nm. NASA has improved a long-standing technique to derive AAOT in UV by combining measurements from

AERONET and UV Shadowband radiometers. Efforts to utilize this methodology for deriving AAOT in the UV should be implemented. (NASA)

Ozone- and Climate-Related Trace-Gas Measurements
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Field Campaigns
Aircraft, balloon, and ground-based measurement campaigns for satellite validation and science are expected to continue. These campaigns will provide important validation data for ozone and ozone- and climate-related trace gases and parameters for Aura and other satellite sensors. They also will address high-priority science questions associated with atmospheric ozone chemistry and transport. (NASA)

UV:

USDA UV-B Monitoring and Research Programme (UVMRP)
A new site was installed at the University of Houston, TX in August 2006, and the development of real-time data streams will be attempted within the network. New interagency collaborations will include participation in the NSF MIRAGE air-quality study in Mexico City (February/March 2006), and the generation of aerosol atmospheric corrections for a NASA/USGS invasive-species study. (UDSA)

Geographical Measurement Coverage
UV monitoring in the tropics is very limited. Relatively inexpensive broadband UV instruments could be set up easily at installations launching ozonesondes (e.g., SHADOZ) in the tropical region. Such efforts should be coordinated with the NDACC. In this way, UV at the surface under aerosols/pollution can be linked with the ozone profiles measured by the ozonesondes and ground-based profiling instruments. (NOAA/CPC)

Only seven of the EPA Brewers are currently deployed in or near densely populated areas. Satellite-derived UVR is less reliable for urban locations, because satellite instruments do not adequately characterize pollutants at ground level. Because of the deficiency of current urban UVR data, health researchers conducting local studies are sometimes making their own UVR measurements as needed, with instruments that are often not easily compared with those from any of the existing UVR networks. Thus, better ground-level measurements collected in locations close to air-quality monitors are required. Finally, many sites have data gaps and inconsistencies. Only a limited number of ground-based sites provide historically continuous UV records. More analyses of available data and improved calibration could fill gaps in coverage. (EPA)

Calibration and Validation
The WMO has requested that the CUCF become the WMO centre for UV calibrations.
However, funding for this within and outside NOAA has yet to be identified. Efforts to accomplish this are continuing. (NOAA/ESRL/GMD)

It is now well established that the ratio of UVB and UVA can be predicted accurately under clear conditions and to within a few percent in cloudy conditions wherever quality column ozone data exist. Absolute measurements of ozone amounts from satellites are accurate to 2% resulting in a 2% error in UV irradiance at 310 nm and an 8% error at 305 nm with larger errors at higher latitudes. UVA variability is known to correlate with variations in clouds, NO_2, and aerosols, some of which are also measured by satellites. Ground based intercomparisons studies are using long time averages to simulate the spatial footprint of satellites. Further studies are required to determine the effectiveness of this approach. (NASA)

Effects Research
Although the effects of UV exposure drive UV monitoring activities, only limited resources historically have been targeted towards UVB effects research. Expansion of UVMRP activities in this critical area is needed at a multi-agency level. (USDA)

Acronyms and Abbreviations

AAOT	aerosol absorption optical thickness
ACIA Arctic	Climate Impacts Assessment
AERONET	Aerosol Robotic Network
AGAGE	Advanced Global Atmospheric Gases Experiment
AIRS	Atmospheric Infrared Sounder
AO/AAO	Arctic/Antarctic oscillation
BSI	Biospherical Instruments
BUV	Backscatter Ultraviolet
CAFS CCD	Actinic Flux Spectroradiometer
CCD	charge-coupled device
CDIAC	Carbon Dioxide Information Analysis Data Center
CFC	chlorofluorocarbon
COADS	Comprehensive Ocean-Atmosphere Data Set
CPC	Climate Prediction Center (NOAA, U.S.)
CrIS	Cross-track Infrared Sounder
CSD	Chemical Sciences Division (formerly the Aeronomy Lab, NOAA, U.S.)
CSD	Chemical Sciences Division (NOAA,US)
CSU	Colorado State University (United States)
CTMs	chemical transport models
CUCF	Central Ultraviolet Calibration Facility
DAAC	Distributed Active Archive Center (NASA Langley, U.S.)
DISC	Data and Information Services Center (NASA Goddard, U.S.)
DoD	Department of Defense (United States)
DoE	Department of Energy (United States)
DOAS	Differential Optical Absorption Spectroscopy
ECD	electron capture detector
ECMWF	European Centre for Medium-Range Weather Forecasts (United Kingdom)
ECUV	European UV Calibration Center
EECl	effective equivalent chlorine
EESC	effective equivalent stratospheric chlorine
EOS	Earth Observing System
E EuMetSat	European Organization for the Exploitation of Meteorological Satellites
P	Earth Probe
EPA	Environmental Protection Agency (United States)
ESRL	Earth System Research Laboratory (NOAA, US)
FMI	Finnish Meteorological Institute (Finland)
FTIR	Fourier transform infrared
GAW	Global Atmosphere Watch
GC	Gas Chromatograph
GCM	general circulation model
GCMS	Gas Chromatography Mass Spectrometry
GES	Goddard Earth Sciences
GFS	Global Forecast System
GMAO	Global Modeling Assimilation Office (NASA Goddard, U.S.)
GMD	Global Monitoring Division (formerly CMDL – NOAA, U.S.)
GOES	Geostationary Operational Environmental Satellite
GO$_3$OS	Global Ozone Observing System (WMO)
GOME	Global Ozone Monitoring Experiment
GOMOS	Global Ozone Monitoring by Occultation of Stars
GSFC	Goddard Space Flight Center (NASA, U.S.)
HALOE	Halogen Occultation Experiment
HIRDLS	High-Resolution Dynamics Limb Sounder
HIRS	High-resolution Infrared Radiation Sounder

IHALACE	International Halocarbons in Air Comparison Experiment
IASI	Infrared Advanced Sounding Interferometer
JPL	Jet Propulsion Laboratory (United States)
KNMI	Koninklijk Nederlands Meteorologisch Institut (The Netherlands)
MetOp	Meteorological Operational Satellite
MFRSRs	Multi-Filter Rotating Shadowband Radiometers
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding
MIRAGE	Megacity Impacts on Regional and Global Environments
MLS	Microwave Limb Sounder
NASA	National Aeronautics and Space Administration (United States)
NAT	nitric acid trihydrate
NCAR	National Center for Atmospheric Research (United States)
NCEP	National Centers for Environmental Prediction (NOAA, U.S.)
NDACC	Network for the Detection of Atmospheric Composition Change
NDIR	non-dispersive infrared
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA, U.S.)
NIST	National Institute of Standards and Technology (United States)
NIWA	National Institute of Water and Atmospheric Research (New Zealand)
NOAA	National Oceanic and Atmospheric Administration (United States)
NOGAPS	Navy Operational Global Atmospheric Prediction System
NPOESS	National Polar-Orbiting Operational Environmental Satellite System
NPP NPOESS	Preparatory Satellite
NRL	Naval Research Laboratory (United States)
NSF	National Science Foundation (United States)
NWS	National Weather Service (NOAA, U.S.)
ODGI	ozone-depleting gas index
ODSs	ozone-depleting substances
OHP	Observatoire de Haute-Provence (France)
OMI	Ozone Monitoring Instrument
OMPS	Ozone Mapping and Profiler Suite (NPOESS)
OMS	Observations of the Middle Stratosphere
OSIRIS	Optical Spectrograph and Infrared Imaging System
PEM	Particle Environment Monitor
POAM	Polar Ozone and Aerosol Measurement
POES	Polar Orbiting Environmental Satellites
PSCs	polar stratospheric clouds
PTB	Physikalisch-Technische Bundesanstalt (Germany)
QBO	quasi-biennial oscillation
SAGE	Stratospheric Aerosol and Gas Experiment
SAM	Stratospheric Aerosol Measurement
SBUV	Solar Backscatter Ultraviolet
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography
SHADOZ	Southern Hemisphere Additional Ozonesonde (Network)
SOLSTICE	Solar Stellar Irradiance Comparison Experiment
SPARC	Stratospheric Processes and Their Role in Climate

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VIETNAM

INTRODUCTION

National Hydro – Meteorological Service of S.R. Vietnam (NHMS) has 3 ozone and UV-B observing stations. The observation is carried out since May 1992 in Hanoi station (21^{0}01'N, 105^{0}51'E). From 1994, Sapa station (22^{o}21'N, 103^{o}49'E) and Tan Son Hoa station (10^{o}47'N,106^{o}42'E in Ho Chi Minh City) also start observe. However, the observation in Tan Son Hoa station was stopped from April 2008 because of instrument's problem. All the management for the ozone and UV-B observation in NHMS is operated by the Aero – Meteorological Observatory (AMO).

Observational Activities

The Total amount of atmospheric ozone (TO3) and UV-B are measured by M124 filter instrument, manufactured in Russia. The TO3 is measured 7 times per day with the sun height is in between 20^o and 70^o. The UV-B is measured 11 times per days from 7h to 17h LT (within period of 1st May to 31st October), and 9 times per day from 8h to 16h LT (within period of 1st November to 30th April). From 2005 to 2008, AMO have sent all M124 for calibration in GGO (Petersburg, Russia) once, in 2006. Since the new filters of M124 were not available, so after the calibration few months, our M124 instruments could not give the data with high quality. Even though, all the 3 stations have to absorb TO3 and UV-B, following the National Guide for observation.

Results from observation and analysis

According to the Global Distribution of Total Ozone, measured by satellite, Vietnam is located in the region with the total amount of ozone is changed from 200DU to 300DU (1), minimum in winter and maximum in summer.

From 1/2006 to 12/2007, as indicated on the Table and Figure 1 the total ozone measured at Tan Son Hoa were changed in between 120DU to 240DU, lower than the result measured by satellite. The trend of TO3 was not similar in 2006 and 2007. It seems irregular in TO3 trend of year 2007 with rapid increase from the minimum in February to the maximum in May and June. Overall, TO3 in 2006 and 2007 was lower than the normal value.

At the same time the TO3 measured in Hanoi was slightly higher (table and figure 2). Also, it is very abnormal in trend of TO3 in 2007. In fact, the maximum appears in February instead of summer as usually.

The TO3 measured at Sapa arranged almost from 200 to 300DU along 2006 and 2007. But, the annual trend of TO3 in 2007 was not the same compared with the map of Global Distribution of TO3, measured by satellite. As shown on the figure, TO3 at Sapa decreased from January to December, except for February.

Table and Figure 1: Annual trend of TO3 measured at Tan Son Hoa.

Month	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007
1	251	234	216	211	142
2	247	243	205	216	120
3	249	261	199	224	121
4	254	263	185	219	227
5	257	267	184	225	239
6	243	266	183	228	240
7	248	269	n/a	227	233

8	260	263	n/a	226	228
9	273	260	n/a	226	229
10	267	256	n/a	201	221
11	238	229	n/a	187	208
12	241	225	n/a	144	197

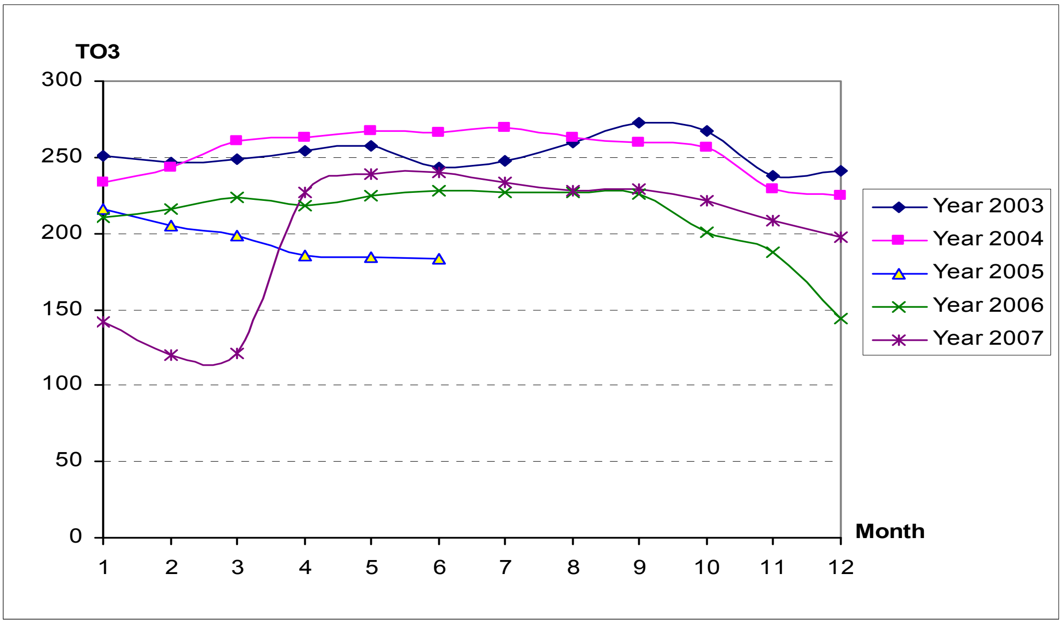
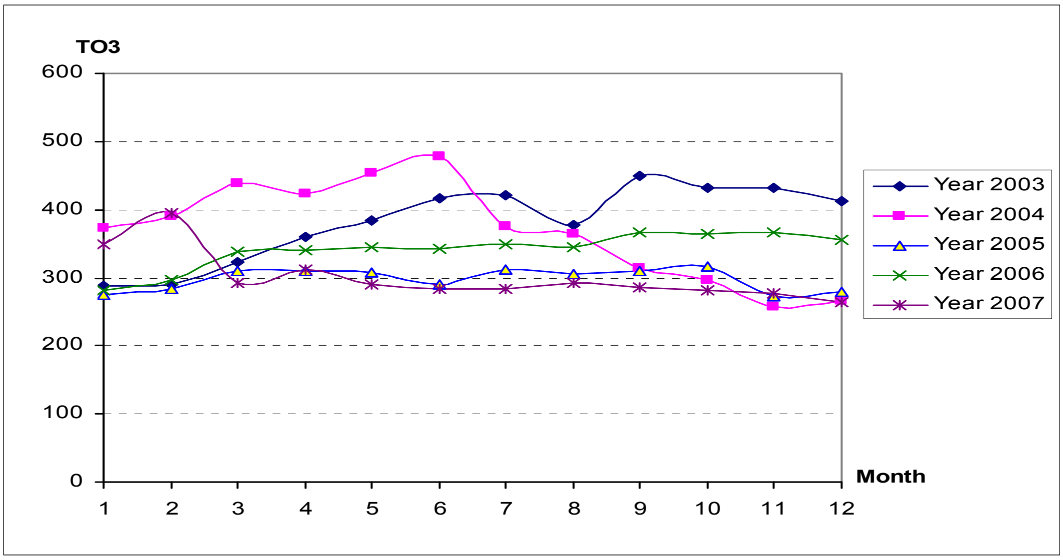


Table and Figure 2: Annual trend of TO3 measured at Hanoi.

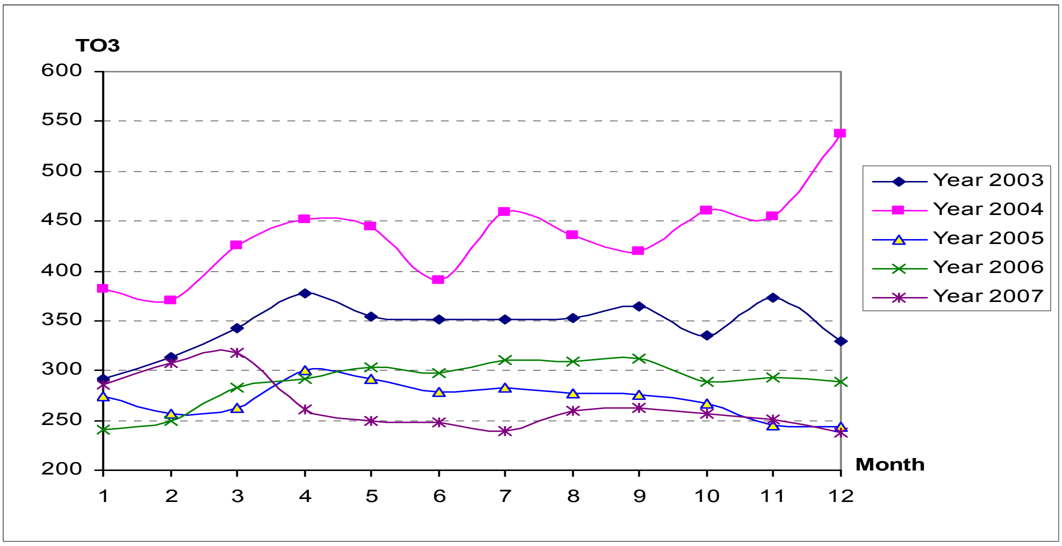
Month	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007
1	288	373	274	281	350
2	290	390	284	296	394
3	322	439	310	338	292
4	360	424	310	340	312
5	385	454	308	344	291
6	417	478	291	342	283
7	422	376	311	349	284
8	377	365	305	344	292
9	450	314	310	365	285
10	431	297	316	365	281
11	431	257	273	367	276
12	412	267	280	356	265



Month

Table and Figure 3: Annual trend of TO3 measured at Sapa.

Month	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007
1	291	382	274	241	286
2	313	370	257	250	308
3	342	425	263	283	318
4	377	452	301	292	261
5	354	444	292	303	250
6	352	390	279	298	248
7	352	459	283	311	239
8	353	436	277	309	259
9	365	419	276	312	262
10	335	460	267	289	256
11	373	454	246	294	251
12	330	538	243	288	238



So, last two years 2006 and 2007 the TO3 data measured in Vietnam has not been qualified, especially in 2007, due the fault M124 and we have no budget for calibrating the equipments in Russia every year. Since the ozone data was not qualified, the UV-B would not qualify too. So the UV-B data would not be reported here.

Future Plan
Since the filters of M124 will not be produced NHMS plan to replace the new equipment for ozone and UV-B observation and to continue the international collaboration in this field.

In planning from now to the 2010, the total ozone and ultraviolet radiation network will be improved and replaced by new equipment. The equipment that we want to equip is Brewer spectrometer. However, our difficulty is limited finance. After this workshop, we hope to get the help from WMO on this Brewer equipment and document to serve for activity of total ozone and ultraviolet radiation in Vietnam.

Needs and recommendations
1. NHMS needs the financial support to replace the equipment for measuring the TO3 and UV-B to meet the requirement of the quality of data.
2. NHMS's personnel's need the scientific and technical training and more international collaboration.
3. NHMS needs the financial support for exchange of visits amongst personnel from the monitoring stations of NHMS and other countries for improve our personnel's operational skill and knowledge.
4. NHMS hope to receive the support to carry out the ozonesounding in Hanoi at least once a week since we conduct the radiosounding twice a day by the DigiCORA-RS sonde, manufactured by Vaisala Co., Finland.

Finally, I would like to thank to WMO/UNEP give me opportunity to attend this meeting and give the national report on ozone and UV-B monitoring activities in S.R. Vietnam and NHMS would expect more international support in this field.

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ZAMBIA

INTRODUCTION

Although Zambia places the management of the environment and natural resources as one of its priority areas, projects related to the direct monitoring of ozone in the stratosphere none existent. Through the Environmental Council of Zambia (ECZ), the country runs programmes to manage, monitor and protect the environment and natural resources including effects that could result from the modification of the ozone layer from the stratospheric air pollution.

Zambia is classified under Article 5, Paragraph 1 of the Montreal Protocol (MP) since its consumption per capita of Annex A, Group 1 chemicals is less than 0.3kg ODP per year. The country has no manufacturing facilities for any substances controlled under the Montreal Protocol. The total demand for Annex A, Group1 and Annex B Group I, II, III chemicals is met through imports.

Zambia's uses controlled substances in the servicing of refrigerators, freezers and mobile air conditioners. The refrigeration sector in Zambia can be broken down into sub-sectors according to the levels of consumption as shown in Table 1.

Table 1: Consumption of ODS in the refrigeration sector in Zambia.

Refrigeration Sector	Percent
Commercial and Industrial Refrigeration	73.5
Domestic Refrigeration	24.5
Mobile A/C Units	2.0
Total	**100**

Status of Ratification

Zambia made an accession to the Vienna Convention for the Protection of the Ozone Layer and the MP for the phase-out of the Substances that Deplete the Ozone Layer on 24th January, 1990. It ratified the London Amendment on 15th April, 1992 and Government is in the process to ratify the Copenhagen, Beijing and Montreal amendments.

THE COUNTRY PROGRAMME

Zambia has received technical and financial support through The United Nations Environment Programme (UNEP) as an implementing agency of the MP. The Country Programme was approved at the 8th Meeting of the Executive Committee in 1992 for funding by the Multilateral Fund. The country programme was derived from the ODS consumption data that was collected in 1991. The consumption pattern showed more than 90% of ozone depleting substances associated with the use of chlorofluorocarbons (CFCs) based refrigerants used in cooling systems such as refrigerators and air conditioners. Since then, several measures were initiated to meet the MP requirements of the 50% cut in consumption by 2005 and the 85% cut by 2007, leading to 100% phase-out by 2010.

Consumption Trends of ODS in Zambia

In the Refrigeration Sector, CFC -12 is the most widely used. During the past 12 years, the overall consumption of CFCs in Zambia was as follows:

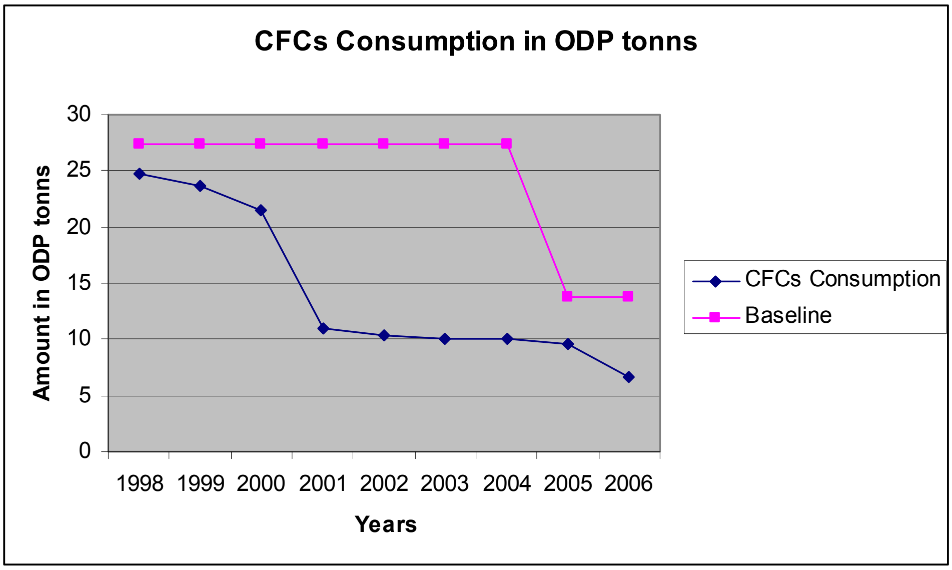

Figure 1: Trend of CFC-12 Consumption in tonnes

Zambia met its phase-out target in 2005 and seems well positioned to meet the 2007 and 2010 overall CFC phase-out targets set by the MP. To reduce the CFC refrigerant on imports, the government has chosen retrofit of equipment where possible and use the recovery and recycling systems as a principle strategy to achieve CFC phase-out.

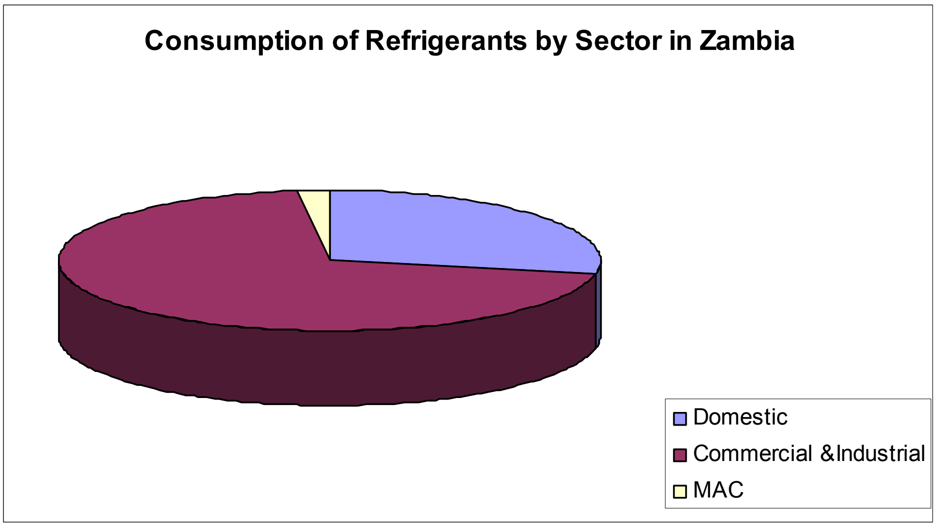

Figure 2: Refrigeration Sectors in Zambia.

Domestic refrigeration sectors

The importation of domestic refrigerators and air conditioners is increasing, however since 2002 all new imported fridges, freezers and air conditioners are CFC free containing R134a or the transitional refrigerant R22. The new equipment represents 25% of actual number of fridges and freezers. About 24.5% of the imported refrigerants are used for servicing of domestic refrigeration equipments.

Industrial and Commercial Sectors

These sub-sectors include those which use systems of refrigeration for food storage such as abattoirs, the fishing industry, breweries/beverages industry, supermarkets, hospitals and the hotel industry. They represent the largest sector in the cooling industry and have been using about 73.5% of imported refrigerants. The use of recovered CFCs is common compared to other sectors.

Mobile Air Conditioners (MACs) Sector
The number of vehicles in circulation in Zambia has increased by more that 100% from 25000 in 1998 to 50000 in 2005 according to statistics from government. In compiling refrigerant use statistics for this sub-sector it has been assumed that the percentage of cars equipped with MAC has increased. This sector uses about 2% of imported refrigerants. However, all vehicles imported after 1998 have their MAC equipment using HFC134a. This is due to the rising improved skills of MACs servicing sector by the manufacturers of vehicles.

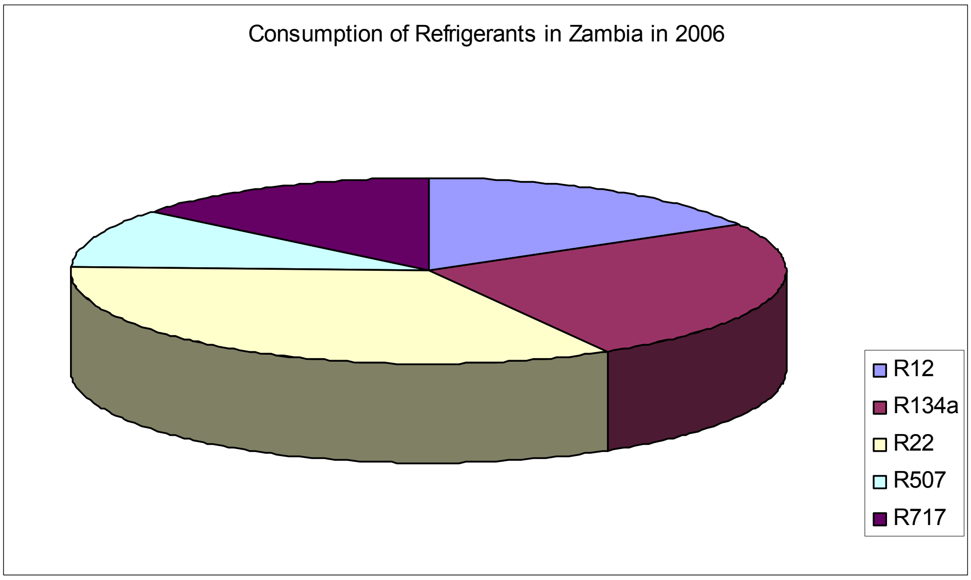

Figure 3: Consumption of Refrigerants in Zambia

The Trend in the Consumption of Refrigerants in Zambia
The consumption of CFC in Zambia seems to be decreasing. This is due to the enforcement measures being applied. Most of the enterprises involved in the sale of display coolers, fridges or freezers are changing to ozone friendly substances and products. The table below shows some of the trends in CFC in relation to alternative substances.

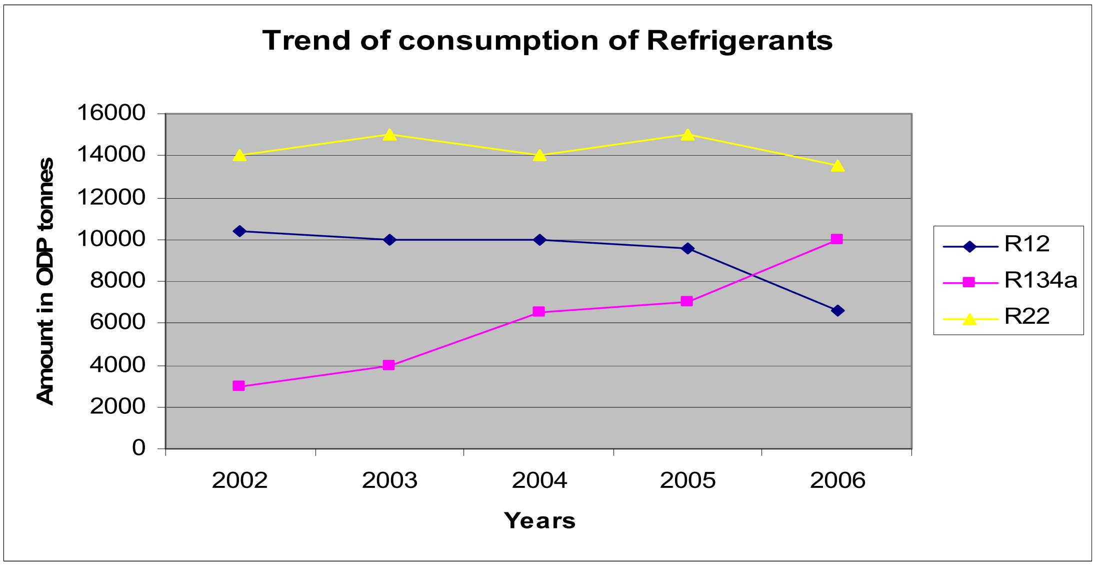

Figure 4: Consumption Trends of R22, R12 and R134a in Zambia in tones.

DISSEMINATION OF INFORMATION ON OZONE IN ZAMBIA

Submission of consumption data to Ozone Secretariat

Zambia is constantly conducting surveys to collect data to determine and monitor its consumption level of Ozone Depleting Substances (ODS). Surveys are conducted to determine the current consumption of ODS and the need to update data on the consumption of ODS in Zambia. This data is analysed in conjunction with the Central Statistics and submitted to the Ozone Secretariat.

Information on ozone issues to the public

The Ozone Unit under the Institutional Strengthening programme being assisted by UNEP has been in effect since 1994. The NOU has raised awareness on ozone related issues among refrigerant workshop managers, service managers, suppliers and distributors of ODS through workshops, print and electronic media, car stickers (1000), posters (5,000) and brochures (10,000) to assist the general public in understanding the protection of the ozone layer.

Awareness activities are also being carried on traders, encouraging them to import ozone friendly equipment using alternative refrigerants to ODS. The NOU has also been coordinating programmes under the RMP on training and legislation development. One of the main achievement of the NOU was the adoption by Government of the Statutory Instrument No. 27 of 2001 on the ODS control Regulations in Zambia.

RELEVANT SCIENTIFIC PAPERS

Scientific papers related to ozone levels are rare due to lack of projects designed to monitor ozone in the stratosphere directly.

However, the University of Zambia is currently in the process of doing this and also there are some studies being done on Climate Change.

PROJECTS AND COLLABORATION

National Projects

The country has received support through several projects under the Multilateral Fund for the implementation of the Montreal Protocol as follows: (1) Country Programme Preparation; (2) Institutional Strengthening; (3) Refrigeration Management Plan and Update; (4) Recovery and Recycling programme; (5) TPMP Preparation.

International Projects

The country has received support through several international consultants on the capacity building of the stakeholders in the ozone protection projects under the Multilateral Fund for the implementation of the Montreal Protocol as follows: (1) Training of Trainers in Refrigeration Management, (2) Training of Trainers for Customs Officers, (3), Training of the legal Consultants on ODS Regulations and Provision of equipment to higher leaning and Vocational Training Institutions.

Other collaboration

At the sub-regional level, Zambia is a member of SADC (Southern African Development Cooperation) and member of COMESA (Common Market of Eastern and Southern Africa) and is in cooperation with other states in the harmonisation of the ODS Control Regulations within the region. This prescribes a tight measure of control which aims at preventing trans-boundary movements of ODS between member states.

Currently, a regional project on ozone impacts to crops – a biomonitoring initiative for southern Africa is underway[1]. The project under the Air Pollution Information Network for Africa (APINA) to investigate whether ozone damage to crops and other plants is likely to occur in selected Southern African countries. Biomonitoring experiments, using white clover clones (*Trifolium repens* cv.

Regal, NC-S (ozone-sensitive) and NC-R (ozone-resistant)), have been successfully piloted in South Africa, and was implemented in Zimbabwe, Zambia(based at the University of Zambia), Tanzania and Mozambique in the 2007 growing season.

Besides being the first regional biomonitoring initiative in southern Africa, the project will serve as an interface between policy-makers and air pollution scientists involved in APINA. In addition to highlighting the potential consequences of air pollution, the network will also foster regional collaboration in addressing the issue.

FUTURE PLANS

Higher learning institutions such as the University of Zambia are keen to participate in research programmes such as direct monitoring of ozone using specialized and state of the art instrumental techniques. The starting point is the regional project on ozone impacts to crops, although currently ozone measurements are done in Sweden after trapping the ozone with passive samplers. The meteorological Department is also positioned to undertake projects related to ground ozone monitoring.

NEEDS AND RECOMMENDATIONS:

It is recommended that there should be funding to assist the lower ODS consuming countries in:

- Acquiring the necessary equipment for the data gathering.
- Training of the data collection assistance.
- Capacity building of stakeholders institutions data management.
- The technical measures to sustain the data gathering.

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ANNEXES

Annex 1. Summary of CFC 12 Consumption

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	**Base**
CFC	24.7	23.6	21.5	11.0	10.4	10.0	10.0	9.53	6.60	**27.4**

Source: Ozone Secretariat

Annex 2. Consumption of Refrigerants by Sector

Sector	Type of Refrigerant	Quantity (Kgs)	% of R12 by Sector
Domestic Refrigeration and Air Conditioning	R-12	1584	24.5%
	R-134a	2400	
	R-22	3240	
Commercial & Industrial Refrigeration	R-12	4752	73.5%
	R-134a	7200	
	R-507	4080	
	R-22	9720	
	R-717	5450	
Mobile air Conditioning	R-12	123	2%
	R-134a	200	
	R-22	270	Mainly for Cleaning

Annex 3. Trends in the CFC-12 and HFC-134a Consumption in tones

	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
CFC-12	23600	21500	11000	10400	10000	10000	9530	6600
HFC-134a	0	1500	2600	3000	4000	6500	7000	10000
HCFC-22	14300	18000	9000	14000	15000	14000	15000	13500

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