NEW ZEALAND

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

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

Current and planned activities include:

1. Monitoring and measurements

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

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

c) *UVB radiation*: Since late 1990, surface spectral UV irradiance has been measured routinely at Lauder. Scans are made at 5 degree steps in solar zenith angle, and at 15 minute intervals over the midday period. The spectral resolution is ~1 nm, and data cover the range 290 to 450 nm in 0.2 nm steps. These spectra are complemented by a wide range of broadband

measurements and by all-sky images taken at 1 minute intervals to quantify the effect of cloud distribution and type on UV radiation. Similar spectral measurements have been undertaken in collaboration with NOAA/CMDL at Mauna Loa Observatory, Hawaii (since July 1995), and at Boulder Colorado (since July 1998) using weatherproof, temperature-controlled spectrometers. In addition, broadband instruments, which measure integrated UV with a response similar to human skin reddening (erythema), are operated by NIWA at Lauder, Leigh (36.3^{o}S, 174.8^{o}E) and Invercargill (46.4^{o} S, 168.3^{o} E). A complementary network of broadband monitors at population centres is operated by IRL. Because of mismatch between instrument sensitivity and erythemal response, corrections which depend on solar elevation and ozone need to be applied to all of these broadband instruments. Data from NIWA's broadband instruments and radiative transfer calculations are used to provide the public with information on UV radiation levels via the Internet. Data from the IRL network are disseminated to the public through telecom pagers held at radio stations.

2. Research and Modelling

a) *Ozone*: Global total column ozone measurements from Dobson spectrophotometers have been assimilated with satellite overpass measurements (4×TOMS and GOME) to form a global homogenized total column ozone time series. Trend analysis on this data base has been performed and the results are included in the 2002 WMO/UNEP ozone assessment and European ozone assessment documents.

b) *UV*: Surface spectral UV irradiance measurements made in New Zealand have been compared with northern hemisphere measurements. These comparisons show that the meridional gradient in surface UV is less in the southern hemisphere than in the northern hemisphere, possibly as a result of greater tropospheric pollution in the northern hemisphere. In support of the UV measurement programme, radiative transfer models have been developed at NIWA to predict surface UV spectral irradiance, to better understand factors affecting surface UV radiation, and for use with a semi-empirical algorithm to generate a history (since 1960) of surface UV irradiance at 73 sites around New Zealand. This UV Atlas project has resulted in the creation of a CD containing data from 1979 to 2001, including viewing software, which will be released to the New Zealand public at a UV workshop in Christchurch from 26 to 28 March 2002. Work is in progress to relate long term reductions in summertime ozone to increases in UV radiation in New Zealand

c) *Stratospheric trace gas processes*: NIWA has recently completed the first version of a Lagrangian chemical box model of stratospheric chemistry, with the collaboration of the University of Canterbury, JPL, and the University of Cambridge. This model is being used to interpret NIWA and other stratospheric data sets to better understand ozone depletion in the Antarctic and at mid-latitudes. Of particular interest is the effect of Antarctic ozone depletion on ozone levels over New Zealand. Studies currently underway include a comparison of modelled and measured O_3 depletion rates during ozone hole formation, and an investigation of the frequency and severity of outbreaks of polar vortex air over New Zealand.

3. Satellite validation

NIWA has been and will be involved in a range of satellite validation studies. Following the recent successful launch of ENVISAT, measurements made by NIWA will be used to validate the SCIAMACHY, GOMOS and MIPAS instruments. Ozone profile measurements at Lauder and column NO_2 measurements are now also being used to valdiation SAGE III measurements. Recent work has shown differences between Dobson spectrophotometer and TOMS total column ozone measurements, with a strong latitudinal dependence. Investigations into this phenomenon, with implications for the new TOMS version 8 retrieval algorithm, are continuing.

4. Other

A number of researchers from New Zealand are contributing to the 2002 WMO/UNEP ozone assessment document and the UNEP Environmental Effects of Ozone Depletion report.

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PANAMA

1. Introduction

In Panama, higher levels of global radiation as well as UVB radiation are registered, compared to countries with higher latitude, because of its climate and geographical position. For this reason, a continuous monitoring of local UVB radiation and ozone column becomes a very relevant task. The incidence of various types of skin cancer (basal cell carcinomas, squamous cell carcinomas and melanomas) has increased locally and worldwide. In addition to the effects on human health, it is remarkable that UVB radiation damages crops, interferes with the mechanism of photosynthesis, strikes the population of phytoplanktom and also of other organisms.

With the aim of facing this problem in our country, the Laboratory of Atmospheric Physics was created at the University of Panama, within the Vice Rectory of Research and Post graduated Studies. Subsequently, a research project was initiated through which a characterization has been performed of the levels of UVB radiation and total ozone column in Panama City. In addition to the levels of UVB radiation and total ozone column, other parameters also monitored are global radiation, photosynthetically active radiation (PAR) and different atmospheric parameters such as cloud cover, rain, ambient temperature, atmospheric pressure, precipitable water, aerosol optic thickness and relative humidity. At the initial stage of the project, the measurements have been performed only in Panama city.

In this first stage of the research project carried out by the Laboratory of Atmospheric Physics, one monitoring site, located at the main Campus of the University of Panama, was used for the measurements. In this site, two wide band radiometers, model 501 UV-Biometer, were installed, as well as two model PSP pyranometers, one PAR radiometer, two ozone layer meters, model Microtops II and one meteorological station, along with the respective data acquisition equipment (data loggers). This first stage started in July, 1997.

In the second stage of the project, a national monitoring network will be established composed by five measurement sites, located at the cities of David, Santiago, Penonomé and Chitré, along with the measurement site already located in Panama City. These measurement stations will continuously monitor UVB radiation, PAR radiation and other meteorological parameters. For this reason, each one will have UVB wide band radiometers, PAR radiometers and meteorological stations installed. In this way, it will be possible to characterize the levels of irradiance, as well as UVB, global and PAR irradiation corresponding to the different climatic zones within our country. Based on the data obtained from these sites, it will be possible to elaborate mathematical models, valid for the entire national geography, to correlate UVB, global and PAR irradiance and irradiation with other atmospheric parameters. This stage of the project was, already, initiated in 2001, with the installation of one meteorological station and one 501 UV-Biometer at the Enrique Malek Airport, in David City, located at about 500 km west from Panama City.

2. Instruments and Methods

In the following lines, the instrumentation used at the Laboratory of Physics of the Atmosphere in relation with the research project, will be briefly described:

- Three UVB wide band radiometers, model 501-Biometer, from Solar Light Co., along with data acquisition systems (data loggers).
- Eppley pyranometers for the measurement of global solar radiation.
- Kipp and Zonen pyranometers for the measurement of global radiation.
- Ozone meters, model Microtops II, from Solar Light Co.
- Ambient temperature and relative humidity sensor.
- GPS unit, model Garmin 38
- 5 1/2 digit Digital Multimeter, model Instek.

- PMA 2132 sensors, from Solar Light Co, for the measurement of photon flux in the 400 – 700 nm range, along with the PMA 2100, matched data acquisition system, also from Solar Light Co.
- Geonica automatic meteorological station, located at the University of Panama, Main Campus, Panama City.
- Campbell Scientific Inc. automatic meteorological station, located at the Enrique Malek Airport, David City.
- Computers and statistics software for data processing.
- Dedicated software to allow daily information on UVB radiation to be presented to the general public via Internet.

The data collected by the radiometers is stored every five minutes for subsequent processing using Sigma Plot software. From the processed data, mean hour irradiance, total daily dose, UV indexes (UVI) and daily mean irradiance curves are obtained.

3. Calibration

All radiometers and other sensors are calibrated each year. Calibrations have been performed by Solar Light Co and by the Solar Radiation Observatory, at the UNAM, Mexico.

4. Experimental Results

- During local noon, the maximum mean irradiance corresponding to a clear day is near **5,3 MED/h**,
- The maximum mean irradiance during the dry season in the years 1998, 1999, 2000 and 2001 were **3,27, 3,34, 3,75** and **3,82 MED/h**, respectively.During the **76,7 %** of the days in the dry season, UVB indexes with health risk were observed.
- During the **52 %** of the days in the rainy season, UVB indexes with health risk were observed. The UVB irradiance, as well as the irradiation or dose, shows a similar behavior, with a main maximum during the dry season and a secondary maximum in September, during the rainy season. During the months of June and July, the UVB radiation levels are significantly attenuated. During the months of June and July, the mean accumulated cloudiness reach its maximum value. The UVB mean monthly dose showed a statistically significant increase during the years of 2000 and 2001. The monthly mean accumulated cloudiness showed a statistically significant decrease during the years of 2000 and 2001.
- For the condition of clear sky, the highest irradiation or doses are registered between 10:00 hour and 14:00 hour.
- The average total ozone column is **248 DU**. The minimum value **(220 DU**) is registered during the months of December, January and February. The maximum value (**300 DU**) is registered during the month of August. Nevertheless, these values lie within the variability margin correspondent to the Panama City latitude.
- The total ozone column shows an oscillatory variation which is described by a harmonic mathematical function. The total ozone column shows positive and negative anomalies of the order of 2% which may be associated with the quasi biannual oscillation .

Empirical Model

Another goal reached by the Laboratory of Physics of the Atmosphere is the development of an empirical model to correlate the UVB irradiance for hours within local noon with the following parameters: Ozone column, cloudiness fraction and day of the year. For this purpose, September the 15^{th} of 1998 has been taken as a reference. Normalized irradiance data vs ozone column for clear days as well as normalized dose data vs cloudiness fraction corresponding to clear days were analyzed. From this analysis the following equation was found:

$$I = 4{,}66\{1 + 0{,}033\cos\theta_n\}[1 - 0{,}68c]e^{-0{,}0183(OZ-248)}\cos(\delta - \varphi)$$

Where θ_n is the daily angle, **c** is the cloudiness fraction, **OZ** is the value of the ozone column, δ is the solar declination and φ is the latitude.

Future Projections in the Research Line

1. To establish a nationwide network for the measurement of UV radiation and other atmospheric parameters
2. To establish a Regional Radiometric network.
3. To establish a national radiometric data base.
4. To create a continuous information system to alert the community concerning high UV indexes (IUV).
5. To monitor the UVB radiation levels in some of the sites of the Panama Canal hydrographic watershed.
6. To study the possible effects of the increasing levels of UVB radiation on some of the amphibious species in the Panama Canal Hydrographic watershed.
7. To study the possible correlation between the increment in skin cancer cases in the Republic of Panama and the levels of UVB radiation registered.
8. To implement the I Latin American Congress on UV and Ozone at Panama City. This event is scheduled for July 15 to 19, 2002.

Achievements

1. Organization of Seminars and Lectures, oriented to general public, concerning effects of UVB on human health, with the collaboration of National Cancer Association.
2. Organization of a Seminar Workshop on UVB and Ozone, within the II Central American and Caribbean Congress of Physics.
3. Diffusion of information about UV Indexes, oriented to general public.

Figure 1 shows the curves of mean monthly irradiance vs local hour for the dry seasons corresponding to 1998, 1999, 2000 and 2001.

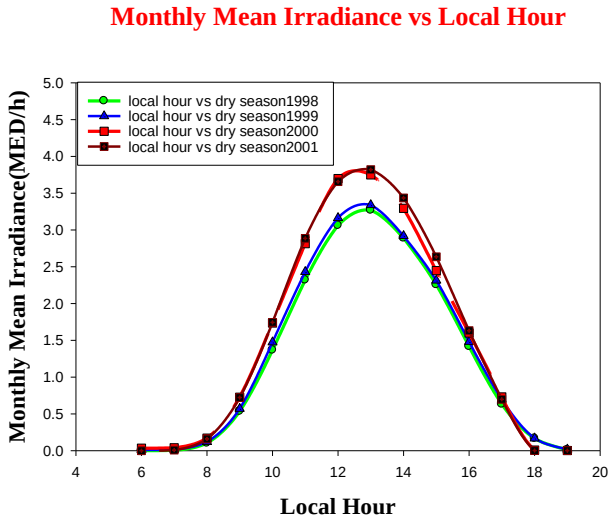

Figure N° 1

Figure N° 2 shows a contour map of the Maximum mean Monthly Irradiance vs Local hour for the entire year, years 1998 to 2001.

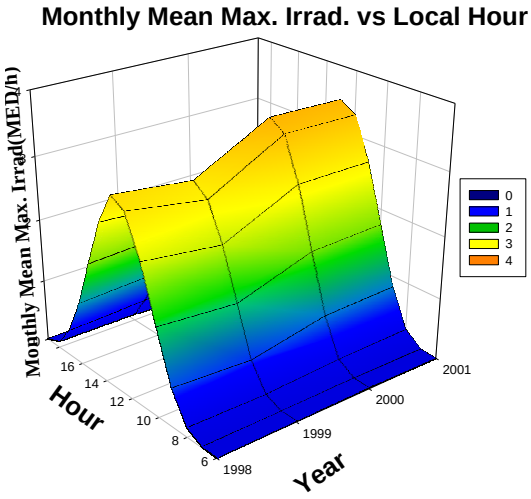

Figure N° 2

Figure N° 3 shows the curve of mean monthly irradiance vs time correspondent to the years 1997 to 2001.

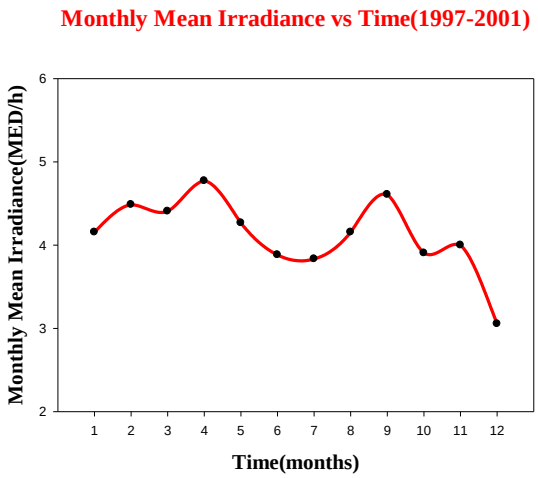

Figure N° 3

Figure N° 4 shows the curve of mean monthly irradiation or dose vs time for the years 1997 to 2001.

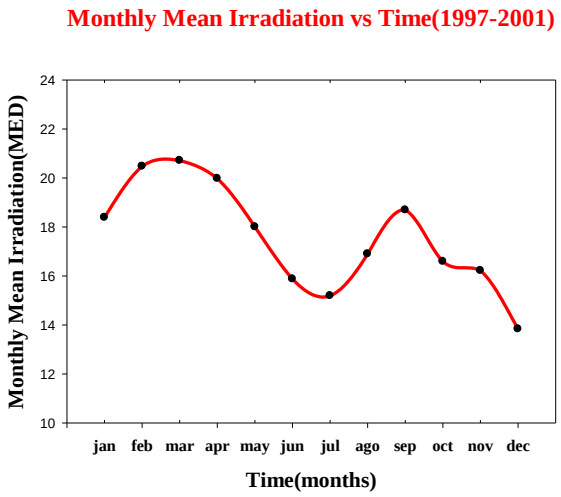

Figure N° 4

Figure N° 5 shows the behavior of the ozone column in Panama City, from February 1998 to December 2000. The fitting equation for this curve is:

$$OZONO = 248 + 30sen\left\{\frac{2\pi[d_n + 257]}{365}\right\}$$

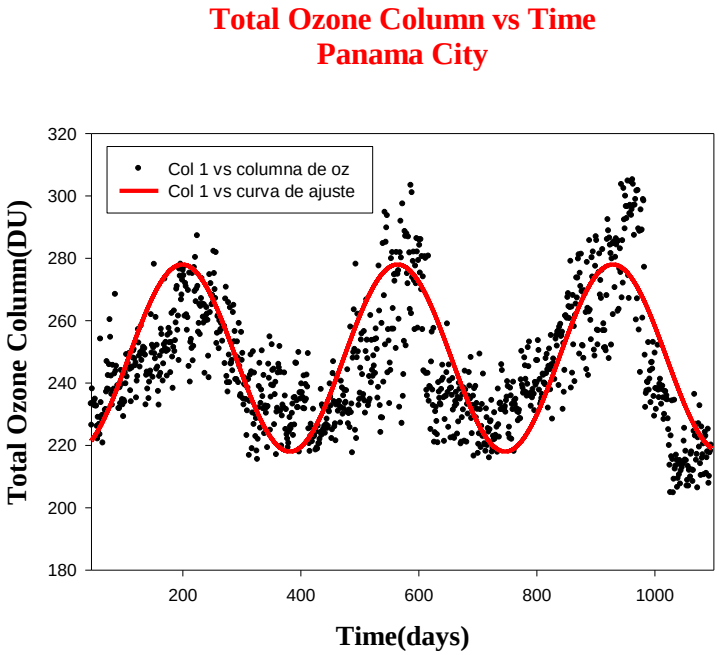

Figure N° 5

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PERU

I. PROGRESS IN THE IMPLEMENTATION OF THE PERU´S COUNTRY PROGRAM

1.1 Date of approval of the Country Program

XVII Meeting of Executive Committee of the Multilateral Fund of Montreal Protocol, July 1995, Montreal, Canada.

1.2 Name of the National Focus Point for the Country Program Implementation

Technical Office of the Ozone-Peru, which is part of the Ministry of Industry, tourism, integration and International Commercial Business- MITINCI.

1.3 Executive Agency for the Country Program Implementation

United Nations Environment Program-UNEP

1.4 Progressive elimination plan of ozone-depleting substances-ODS *(T.M. of potential ozone-depleting substances)*

Substances	*1993*	*1994*	*1995 1998*	*1999 2002*	*2003 2006*	*2007 2010*
CFC Group I	280	322	227	122	61	0
Halon Group II	0	0	0	0	0	0
CCL4 Group II	15	17	13	7	0	0
MCF Group 3	3	4	3	2	1	0

1.5 Total Consumption of Ozone-depleting substances in 1993, 1995 and 1999

In 1993, reference year for Peru´s Country Program elaboration, the consumption of ozone-depleting substances was 326,69 M.T.. In 1995, year in which it was approved, the consumption reached 650,58 T.M.. In 1999 the consumption was 318,551 T.M..

1.6 Annual per capita consumption in 1999 (Kg).

In 1999, the annual per capita consumption was 0,01263 Kg/year.

1.7 Approved and used funds for 1999-2000 Country Program activities (US$)

Twenty five projects were approved and funded during 1999-2000. This projects implementation was carried out during the project “Preparatory assistence”, with the UNEP support.

1.8 Financial support for projects (US$):

a) Projects of Industrial technologic transformation

Sector	Empresa	Situación del proyecto
Foams (CFC 12)	PAMOLSA	Concluded
Industrial refrigeration	INDUSTRIAS ALFA S.A.	Concluded
Industrial refrigeration	COLDEX S.A.	Concluded
Industrial refrigeration	INDUSTRIAS SELVA S.A.	Concluded
Industrial refrigeration	INDUSTRIAS REUNIDAS S.A.	Closed
Industrial refrigeration	ANDINA INDUSTRIAL S.A.	Desisted
Industrial refrigeration	INDUSTRIAS LENCHE S.A.	In implementation
Commercial refrigeration	MASTER SERVICE S.A.	Concluded
Commercial refrigeration	COPEMACO S.A.	Concluded
Commercial refrigeration	COLFRIO S.A.	Concluded
Commercial refrigeration	FORMETAL S.A.	Closed
Solvents	FABER CASTELL S.A.	Concluded
Solvents	CARBOLAN S.A.	Concluded
Solvents	PAPELES INDUSTRIALES S.A.	Concluded

b) Project of recovery and recycling on refrigerant substances

c) Project Good practices on refrigeration Sector

d) Project Poliestireno Foams

e) Demonstative Project of Methyl bromide.

f) Project Plan of management of refrigerants

II. MONITORING OF OZONE AND ULTRAVIOLET-B RADIATION

2.1 Introduction

Peru, through Meteorological and Hydrological National Service-SENAMHI have started again the Ozone monitoring which was carried out by Geophysical Institute of Peru-IGP between 1964 to 1991 in Huancayo (3350 masl). At the present, it is carrying out in the Marcapomacocha station, which was sited by the GAW at 4530 masl, in the western region of the country, getting total Ozone data with a Dobson Spectrophotometer, property of the USA.

The data of this station becomes very important because it covers the western tropical region of South America.

Besides since 1999 we count on with data of UV-B radiation for Lima and Arequipa, the two most important cities of the country.

2.2 Activities

a) Participation at Intercomparison meeting of Dobson Spectrophotometer and UV-radiometers, carried out in Buenos Aires, 1999.

b) The total ozone data collected in the Maracapomacocha station are regularly sent to World Ozone Data Center since February 2000. Some figures are added.

c) Participation at Intercomparison meeting of Pyranometers and UV-radiometers, carried out in Mexico, 2001.

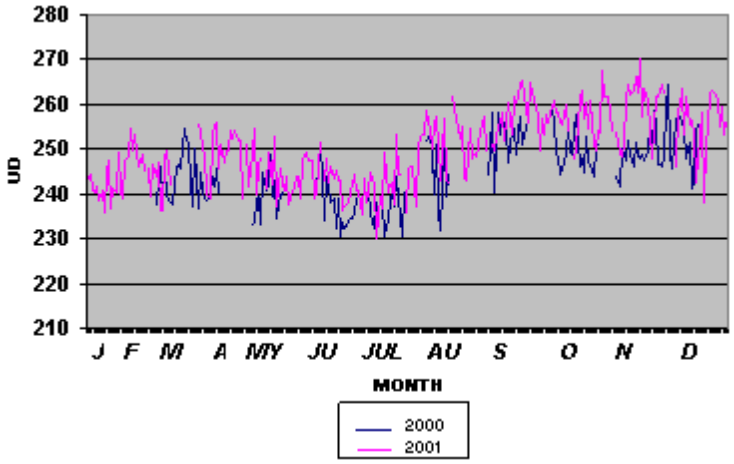
d) Monitoring of UV-B radiation in Lima and Arequipa (since 1999). Some figures are added.

2.3 Projections

a) Acquisition of another UV-B radiometer to be installed in the Marcapomacocha station.

b) Deal with internacional cooperation organizations donations of complementary equipments to monitoring acid precipitation, aerosols, dioxide of carbon, tropospheric ozone and turbidity in Marcapomacocha station.

OZONE TEMPORAL VARIATION IN MARCAPOMACOCHA STATION (4530 masl) 2000 - 2001



HOURLY VARIATION IN LIMA AND AREQUIPA CITIES