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Monitoring of ozone, water vapour etc during the voyage to Antarctica

S.L. JAIN AND O.P. TRIPATHI
Raido & Atmospheric Sciences Division National Physical Laboratory
New Delhi-110012, India.

Abstract

The monitoring of trace species such as water vapour, ozone etc. is of great significance for understanding the Physics, Chemistry and radiation budget of the atmosphere. The water vapour being highly variable constituent in the atmosphere with temperature, space and time, its measurement plays a great role in the study of many atmospheric processes, such as weather, climate, infrared astronomy, cloud physics communication, etc. A highly sophisticated and microprocessor based compact sun photometer consisting of five filter channels at 300, 305, 312, 940 and 1020 nm was used to measure water vapour and ozone in addition to various other parameters such as UV-B radiation, near IR radiation, aerosol optical depth etc. The measurements were made on the way from Goa, India (15°24' N, 73° 42'E) to Maitri, Antarctica (70 deg 46' S, 11 deg45' E)on Polar Bird (Norwegian ship) during December 1996- March 1997. It was found that water vapour decreased while total ozone increased as the ship moved towards the coldest, the windiest and the largest icy continent i.e. Antarctica. In the present communciation the salient features of the instrument and results obtained are discussed in detail.

1. Introduction

The monitoring of total ozone and green house gases like water vapour in the atmosphere plays an important role the understanding of global change. The reporting of catalytic depletion of ozone by CIO x and NO x by Johnston [1] in general and ozone hole over Antarctica during spring time by Farman [2] and Stolarski [3] in particular witnessed an unprecedented surge of interest in the monitoring of various trace species. Ozone is an important constituent in the stratosphere for the very existence of any living organism on this planet as it acts as a shield for us and protects us from the harmful UV-B radiation coming form the sun. Also ground based observations are mainly on land areas, there are occasional shipboard observations and are not part of the routine network. Also most of the measurements are in the Northern hemisphere, as a result of the distribution of observing stations, there is a potential for a strong geographic bias in the averaged total ozone amounts (zonal, hemispheric and global) as calculated for the observed station values. In view of the above, measurements of

UV-B/IR radiation at 300, 305, 312, 940 & 1020 nm using a micro processor based hand held compact system, have been made which in turn also provides ozone, water vapour and optical depth etc. The measurements were made on the way from Goa, India (15 deg 24' N, 73 deg 42' E) to Maitri, Antarctica (70 deg 6' S, 11 deg 45' E) on Polar Bird (Norwegian Ship) to study the latitudinal distribution or these parameters during December 1996- January 1997. The measurements were also made at Goa, Mauritius and Maitri. In the present communication the salient features of the instrument and results obtained are discussed in detail.

2. Experimental Set-up

A highly sophisticated and hand held microprocessor based sun photometer has been used to measure the solar radiation at 300, 305, 312, 940 and 1020 nm. The block diagram of the sun photometer is shown in Fig.l. The optical block is shaping the field of view of the instrument, filtering the incoming solar radiation, detecting it and facilitatting targeting at the sun. The electrical signals form the photodetectors are amplified, conveted to digital form and numerically processed in the signal processing block. The first three exceptionally narrow bandwidth filter channels are used to derive atmospheric total ozone while latter two channels are used for water vapour and aerosol optical depth. The field of view of the each optical channel is 2.5 deg. The system needs input parameters such a latitude, longitude and altitude of the place of observation which were obtained form GPS receiver of the ship. On board clock and calendar keeps track of the time necessary for astronomical calculations. A built-in barometer provides atmospheric pressure for the Rayleigh scattering correction and best of all, both raw data and calculated results from upto 800measurements are stored in an on-board non-volatile memory and can be both viewed on the instrument's LCD and transferred to a PC. All the data are arranged in a tabular form convenient for processing and interpretation. The instrument was used successfully at Goa, on board ship, Mauritius on the way to Antarctica and finally at Maitri. The system is presently being used to measure ozone etc. at Maitri, Antarctica and it well provide first hand information to us for "Ozone hole" phenonmenon. This is the first time that this type of measurements have been made during Indian Scientific Antarctica Expedition to study latitudinal distribution studies.

3 Results and Disussion

3, 1 Total Ozone

Ozone absorbs shorter wavelengths of ultraviolet radiation much more than longer wavelengths. This means that the amount of ozone between the observer and sun is proportional to the ratio of the suns ultra-violet radiation at the two wavelengths. This relationship has been used in the present work to derive total ozone column (the equivalent thickness of pure ozone layer at normal pressure) form the measurement at 3 wavelengths in the UV-region. Similarly as in the traditional Dobson instrument, the measurements at an additional 3^{rd} wavelength enables a correction for particulate scattering and stray light.

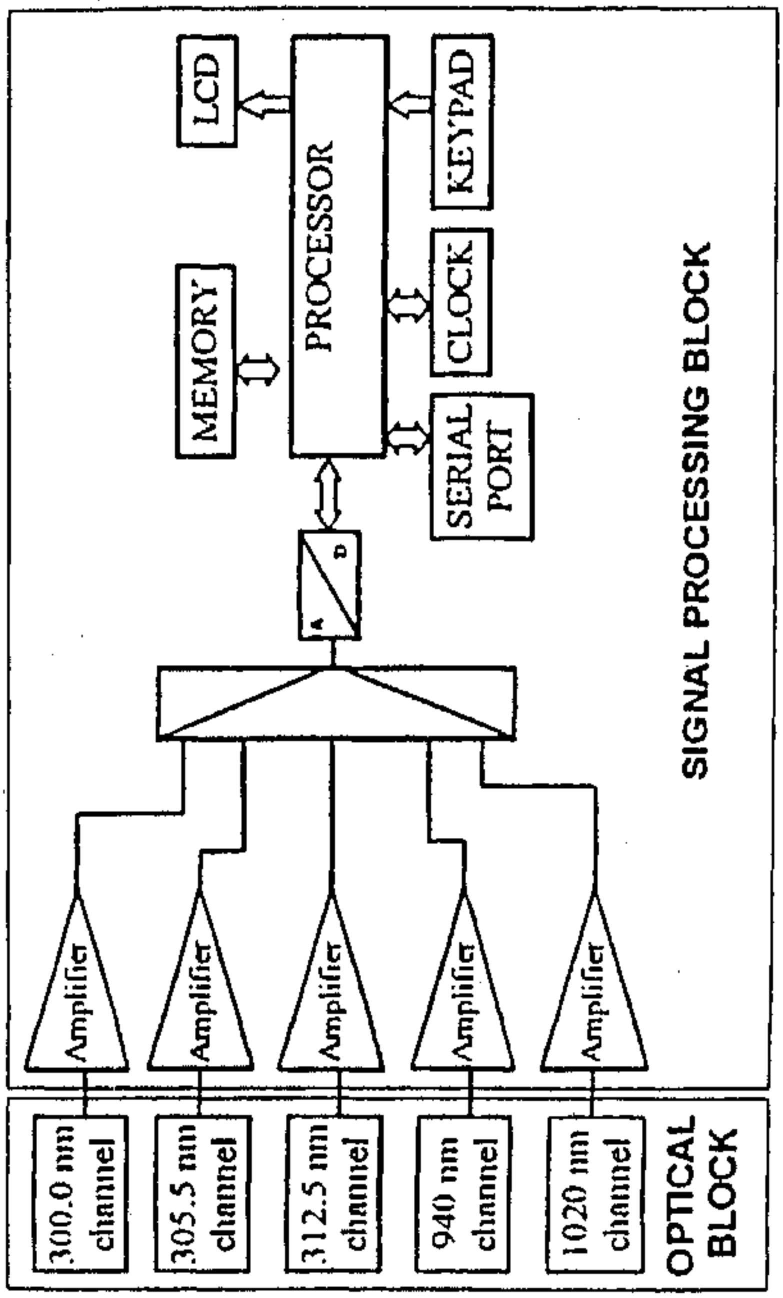

Fig. 1 : Block Diagram of Sunphotometer

The total ozone in the atmosphere was measured using sun photometer during voyage to Antarctica to study the latitudinal distribution of ozone form 15 deg N to 70 deg S. the variation of total ozone during local noon time with latitude is depicted in the Fig, 2. The ozone values are found to be higher at mid and high latitudes while are minimum at tropical latitudes. This is on expected lines and in agreement with other satellite and ground based measurements, Brewer and Wilson [4], Ramanathan [5]. In the absence of dynamics, the distribution of ozone would be determined by a balance between the chemical processes that create ozone and those that destroy it. On the chemical basis, ozone should be most abundant in the tropics, where the photo dissociation of O_2 by UV-B radiation is efficient. However due to the atmospheric dynamics picture is altogether different. The net production of ozone is being taken place at tropics while the net destruction at high latitudes. To balance the budget, ozone is transported form region of high production in the equatorial middle and upper stratosphere, polewards and downwards to the lower stratosphere mainly by large scale atmospheric motions and then transferred to the upper troposphere in the middle and high latitudes and eventually destroyed in the lower troposphere or the surface of the earth. The measurement of latitudinal distribution of ozone on regular basis is therefore very important to understand the complex transport processes

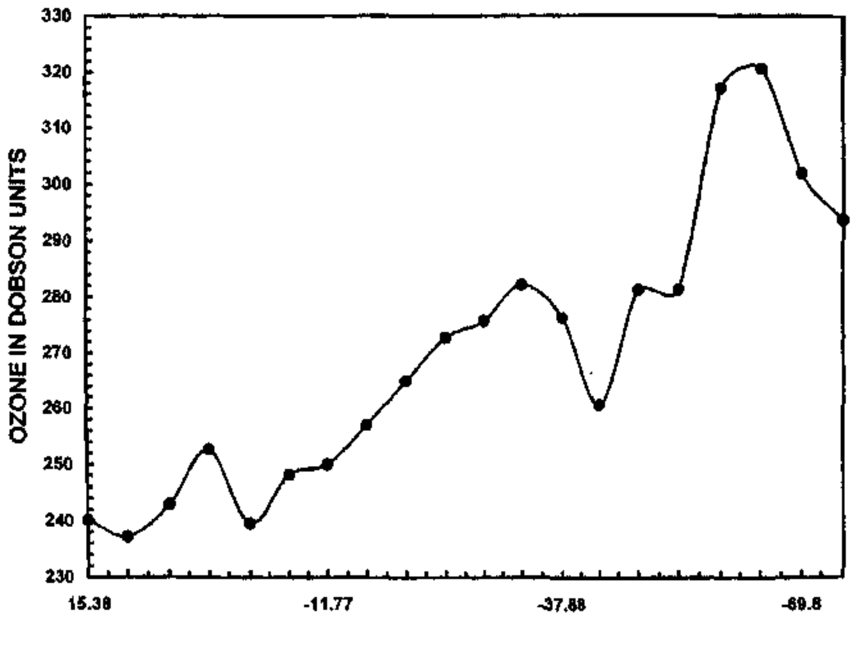

Fig. 2 Latitudinal Distribution of Total Ozone During Dec. 1996 - Jan. 1997

3.2 Water Vapour

The measurement of Water Vapour plays an important role in meteorology, climatology, infrared astronomy, cloud physics and communciation. Unlike other gases of the atmosphere, water vapour varies considerably with season, location, temperature and relative humidity. Also the latitudinal distribution of water vapour has hardly been studied due to scarcity of the data. Therefore efforts were made to monitor the water vapour on the way to Antarctica. The latitudinal distribution of Water Vapour measured during the 16^{th} Indian Scientific Antarctica Expedition from Goa to Maitri (Dec. 96 - Jan 97) is depicted in Fig. 3. The water vapour measurement is based on a pair of radiometric measurements in the IR band. The 940 nm filter (10 nm FW HM) is located in a strong water vapour absorption band while 1020 nm filter (10nm FW HM) is affected only by aerosol scattering. The water vapour was found to be maximum in tropical latitudes while it was minimum at polar latitudes. This is due to very cold and dry condition at polar latitudes.

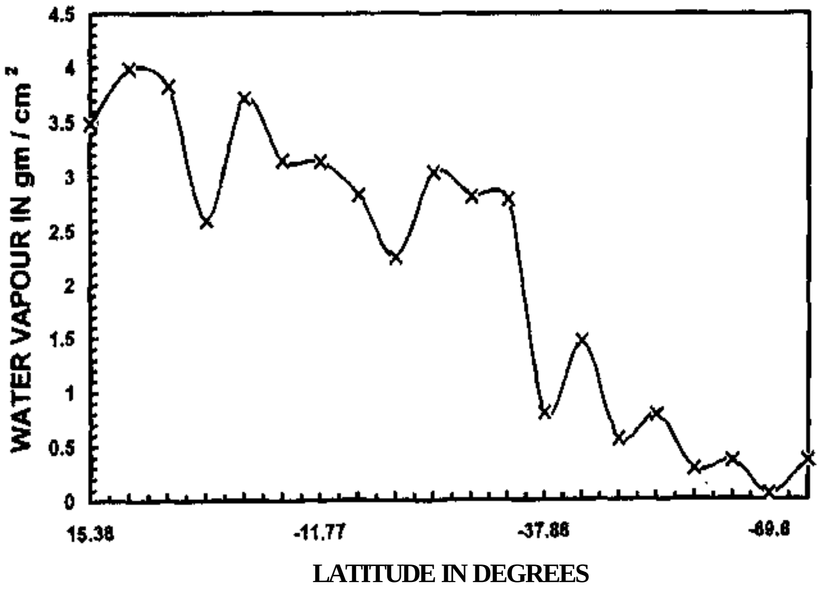

Fig.3 : Latitudinal Distribution of Water Vapour During Dec. 1996 - Jan. 1997

3.3 Optical Depth

The measurements of atmospheric aerosol play an important role in local, regional global meteorologhy e.g. visibility, air pollution, cloud formation and energy balance of radiation. Global atmospheric aerosols are experiencing long term variation due to both natural and human activities. Therefore the monitoring of aerosol characteristics including column optical depth, size distribution composition is necessary, The aerosol optical thickness at 1020 nm is calculated based on the extra-terrestrial radiation at that wavelength, corrected for the sun-earth distance and the ground level measurements of the radiation at 1020 nm during the 16th Indian Scientific Antarctica Expedition from Goa to Maitri (Dec. 96-97). The latitudinal distribution of the optical depth is shown in Fig.4. It is found that the data for the optical depth is not showing any trend with latitudes and are quite scattered. More observations are needed to draw any definite conclusion, The high values of optical thickness at high latitudes may be attributed to poor visibility during the time of observation.

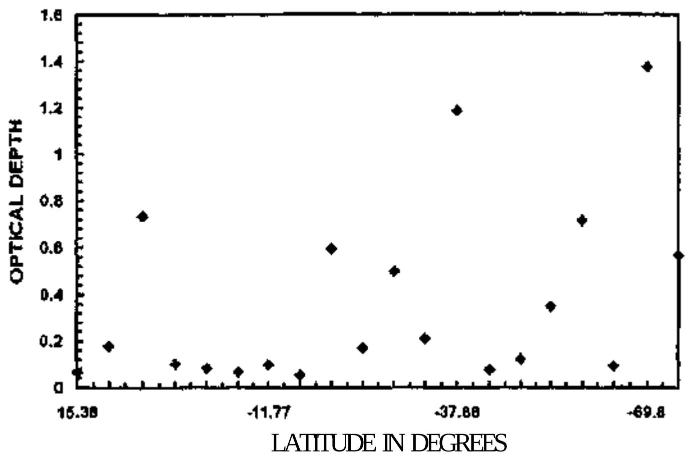

Fig. 4 : Latitudinal Distribution of Optical Depth During Dec. 1996 - Jan. 1997

3.4. Diurnal Variation

The measurements were also carried out for radiation at all the five wavelengths i.e. 300, 305, 312, 940 & 1020 nm to estimate water vapour and ozone at Goa, Mauritius and Maitri. The typical diurnal variations for all these parameters are shown in Figs. 5,6 and 7 for Goa, Mauritius and Maitri respectively. The total ozone has very little diurnal variation at all three locations, of course the vlaues are higher at Maitri. The water vapour is maximum around noontime. However, the water vapour is very low at Maitri compared to Goa and Mauritius. The radiation at 300, 305, 312, 940 & 1020 nm is found to be maximum around local noon. The sudden fall of radiation level at Mauritius around 0900 UT (Fig. 6) and at Maitri around 0800 UT (Fig. 7) is due to cloud cover at that time. There is a possibility of error in estimating ozone and water vapour due to cloud cover and one must always avoid to use data during cloudy conditions. The sunphotometer used for estimation of water vapour, ozone, optical depth etc. is quite handy and bieng used at Maitri on continous basis for hourly observations on all clear cloudless sunny days. The long-term data base will go a long way for trend analysis and global changes studies.

4. Acknowledgements

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5. **References**

1. Johnston H.S, "Reduction of stratospheric ozone by nitrogen oxide catalysts from supersonic transport exhaust', Sciences (U.S.A). 173 (1971) 517.
2. Farman J.C., Cardiner BG and shanklin JD 'Large losses of total ozone in Antarctica reveal seasonal CLOx/NOx interaction', Nature (GB), (1985) 207.
3. Stolarski R.S, A.J. Kruegar, M.R. Schoeberl; R.D. McPeters; P.A. Newman and J.C. Alpert, 'Nimbus -7 satellite measurements of the spring time Antarctic ozone decrease' Nature 322, 808-811 (1986).
4. Brewer AW & Wilson AW, QJR Meteorol Soc (GB), 94(1968)249.
5. Ramanathan K.R, Annals of the IGY (Pergamon Press, London) Vol. 32, 1964, P. 101.
6. S. Solomon, R.R. Garcia, F.S. Rowland, D.J. Wuebbles, Nature 321, 755 (1986)
7. M.B.McElroy,R.J.Salawich,S.C.Wofsy,Geophysres.Lett. 13, 1296(1986).

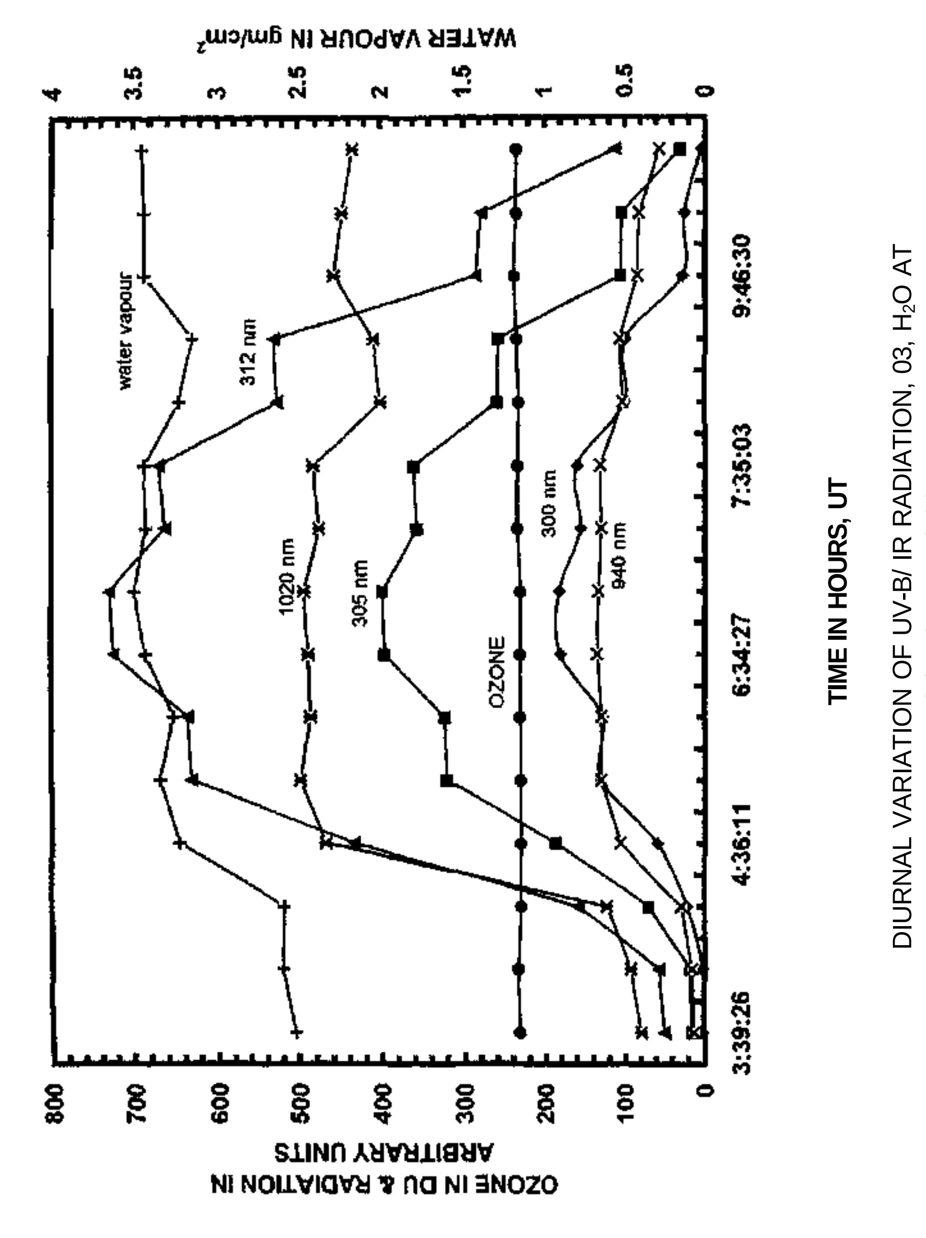

Fig. 5 : Diurnal Variation of UV-B/R Radiation, o3, H2o at Goa on 11.12.96

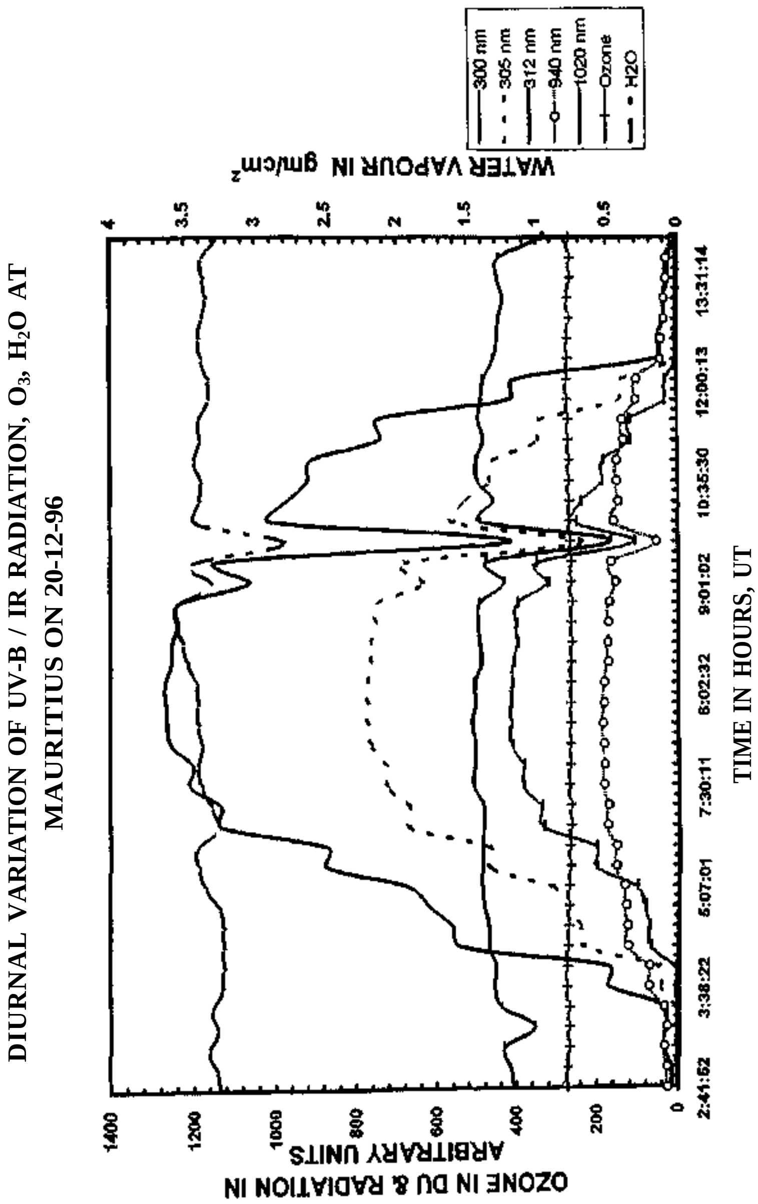

Fig. 6 : Diurnal Variation of UV-B/R Radiation, o3, H2o at Mauritius on 20.12.96.

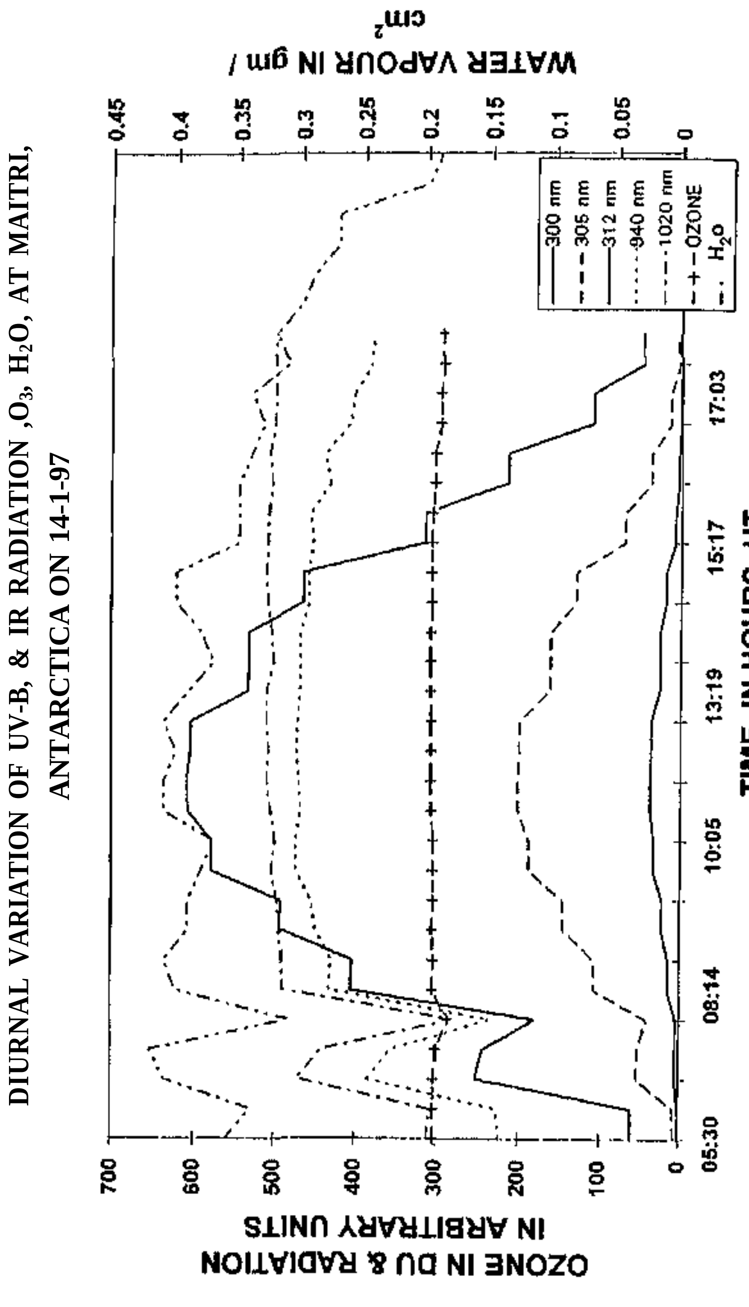

Fig 7. : Diurnal variation of UV-B/IR Radiation, o3, H_2o at Maitri, Antarctica on 14.1.1997.