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Measurement of column ozone, water vapour over Indian Ocean

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The study of various minor constituents in the atmosphere plays an important role in the understanding of physics, chemistry, dynamics and radiation budget of the atmosphere. These trace species have temporal as well as spatial variation and therefore the knowledge of latitudinal distribution of these species is of great significance. Keeping this in view 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 column ozone, water vapour in addition to various other parameters such as UV-B radiation, near IR radiation, aerosol optical depth etc. The measurements were made from Goa, India (15° 24′ N, 73° 42′ E) to Maitri, Antarctica (70° 46′ S, 11° 45′ E) over Indian Ocean during 16th Indian Scientific Expedition to Antarctica (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.

[**Key words:** Column ozone, water vapour, aerosol optical depth, sun photometer, Maitri, Antarctica, Indian Ocean]

1 Introduction

The monitoring of total ozone and green house gases like water vapour etc is of great significance as they play an important role in the understanding of physics, chemistry, dynamics and radiation budget of the atmosphere. 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 and protects the biosphere from the harmful UV-B radiation coming from the sun and is the only gas that absorbs solar radiation at the ultraviolet end of the spectrum strongly which in turn plays an important role in controlling the temperature structure of the stratosphere. It was reported that depletion of the ozone layer by anthropogenic halocarbons introduces a negative radiative forcing[1]. Most of the ozone is created over the tropics and transported to higher latitudes by the general circulation of the stratosphere. The Brewer–Dobson circulation transports ozone out of its tropical source region into the polar region.

The reporting of catalytic depletion of ozone[2] by ClO_x and NO_x in general and ozone hole over Antarctica during spring time[3, 4] in particular witnessed an unprecedented surge of interest in the monitoring of various trace species in the atmosphere. 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 and 1020 mm using a microprocessor based hand held MICROTOP-II, have been made which in turn also provides ozone, water vapour and optical depth etc. The measurements were made on the way during the voyage to Antarctica over Indian Ocean from Goa, India (15° 24′ N, 73° 42′ E) to Maitri, Antarctica (70° 46′ S, 11° 45′ E) on *Polar Bird* (Norwegian Ship) to study the latitudinal distribution of these parameters while participating in the 16th Indian Scientific Expedition to Antarctica (December 1996-March 1997). The study area map is depicted in Fig. 1.

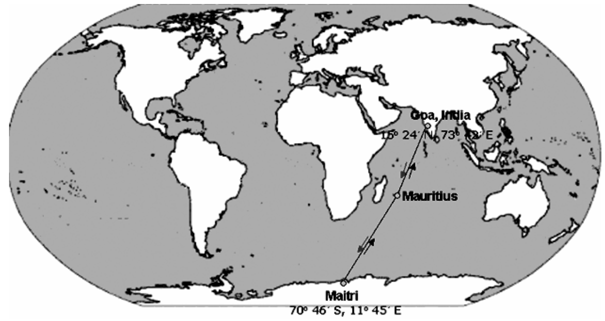

Fig. 1—Study area map-ship route from Goa, India via Mauritius to Maitri, Antarctica and back

2 Experimental Setup

A hand held microprocessor based sun photometer (MICROTOP-II, Solar Light Company, USA) has been used to measure the solar radiation at 300, 305, 312, 940 and 1020 nm. The instrument consists of 5 optical collimators, accurately aligned to aim in the direction of sun, with a full field of view of 2.5°. Each channel is fitted with a narrow band interference filter and photodiode suitable for the particular wavelength of interest. A sun target and a pointing assembly is permanently attached to the optical block and laser aligned to assure good alignment with optical channels when the image of the sun is centered at the cross hairs of the sun target then all optical channels are looking directly at the solar disk. A small amount of the circumsolar radiation is also captured but it makes little a contribution to the signal. The radiation captured by the collimators and then filtered falls on photodiodes producing an electrical current proportional to the radiant power intercepted by the photodiodes. These signals are amplified and converted to digital form in a high-resolution A/D converter. The signal from the photodiodes is processed in series but with 20 conversions per second the result can be treated as if the photodiodes were read simultaneously.

The sun photometer used in the present case is slightly different from the conventional wheel filter type where the individual filters are rotated with the help of wheel and filtered signal is detected by the common detector and electronics. In the present case all the five filters are exposed to solar radiation simultaneously and the signal is detected using separate detectors and electronics for each channel. The first three exceptionally narrow bandwidth (2.5 nm FWHM, Full Width At Half Maximum) filter channels are used to derive atmospheric total ozone while later two channels having bandwidth of 10 nm FWHM are used for water vapour and aerosol optical depth. The system needs input parameters such as latitude, longitude and altitude of the place of observation which were obtained from Global Positioning System (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 up to 800 fields are stored in an on-board non volatile memory and can be viewed on the instrument's LCD screen and transferred to a PC using a suitable software. All the data are arranged in a tabular form convenient for processing and interpretation. The instrument was used successfully at Goa, on board ship over Indian Ocean on the way to Antarctica and finally at Maitri for the study of "Ozone hole" phenomenon[5, 6]. This is the first time that this type of measurements have been made during Indian Scientific Antarctica Expedition to study latitudinal distribution studies. The hourly observations were taken on all clear sunny days throughout the journey from Dec. 12, 1996 to Jan. 4, 1997.

In order to achieve the best performance the MICROTOP II is able to perform in series of rapid measurements of all the channels within one measurement scan. Processing a series of measurements allows for reduction of the error associated with sun targeting and reduction of measurement noise. The measurements are taken at a rate of 20 samples/second (one sample contains reading from all five channels) and one scan is completed in 10 to 11 seconds. Input amplification stages were optimized to have lowest noise level. The bandwidth of all the amplifiers was reduced to a minimum (10 Hz) and kept equal for all channels. Each measurement cycle comprises multiple measurements of all channels that are processed numerically in order to lower the noise level and improve overall accuracy.

3 Results and Discussion

3.1 Total column 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 sun's ultraviolet 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) from the measurements at 3 wavelengths in the UV-B region. Similarly, as in the traditional Dobson instrument, the measurements at an additional 3rd wavelength enables a correction for particulate scattering and stray light.

The total column ozone in the atmosphere was measured over Indian Ocean using sun-photometer during voyage to Antarctica to study the latitudinal distribution of ozone from 15° N to 70° S. The variation of total column ozone during local noon time with latitude is depicted in the Fig. 2. The total column ozone values are found to be higher at mid and high latitudes while are minimum at tropical