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Upper Air Observations in the 26th Indian Antarctic Expedition at Maitri

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ABSTRACT

India Meteorological Department (IMD) has been participating in all the Indian Antarctic Expeditions since the first expedition in 1981. During the year 2007, the upper air data at Maitri, were analyzed and the results are discussed here. Brewer spectrophotometer observations were taken for total Ozone, ultraviolet radiation (UVB), SO_2 and NO_2 whenever the sky conditions were favorable. Ozone sonde ascents were taken once a week and the ozone concentration and atmospheric temperature at all the level were also measured. Ozone depletion in the stratosphere, recovery and stratospheric warming are discussed. Radiometer sonde ascents were released fortnightly to study the net radiation balance, radiation flux in the upper atmosphere, the heat transfer in various layers, the temperature inversion in the lower levels of the Antarctic atmosphere and its role in causing blizzards. Global and diffused radiations were also measured. Hourly atmospheric turbidity aerosol observations were taken whenever sky conditions were favorable.

INTRODUCTION

In the present paper various upper air programmes undertaken during 26th IAE are presented. The observatory at Maitri is equipped with autographic instruments for continuous recording of diffused radiation, global radiation and surface ozone. Periodic balloon ascents are also taken to obtain vertical profile of upper air temperature, humidity and radiation fluxes. The meteorological station at Maitri is thus a well equipped weather observatory, capable of recording various observations

as well as watching and monitoring the weather systems which may approach and affect the station during the course of next few days.

OBJECTIVES

The Indian Meteorological Programme is an ongoing observational programme which is also making efforts in upgradation and modernization of instruments. The meteorological observatory at Maitri was allocated station index number (89514) by the World Meteorological Organisation (WMO) to facilitate international exchange of the observations recorded at the Indian station.

Ongoing Programme

The ongoing programme which is continued during the expedition include the following:

1. Study of vertical structure of the Antarctic atmosphere. Radiometer sonde and ozone sonde ascents were attempted during the period.
2. Study of atmospheric changes with reference to specific situations viz. eclipse, aurora etc.
3. Monitor the Radiation budget, Radiation flux in the upper atmosphere and heat transfer in various layers over Antarctica.
4. Measurement of surface ozone.
5. Investigate ozone depletion in the Antarctic spring season over this region.
6. Study the structure of the Antarctic troposphere, tropopause and stratosphere by taking balloon ascents at regular time intervals.
7. Maintenance of installed meteorological equipments.
8. Temperature inversion in the lower levels of the Antarctic atmosphere and its role in causing blizzards.
9. Thermal structure of the Antarctic atmosphere.
10. Study the Antarctic weather and its effect on lower latitudes.
11. Study the possible effect of Antarctic weather on weather systems affecting Indian sub-continent like the monsoon system.

Instruments Used

1. Ozone Generator.

2. The helical antenna was installed at the top structure of the building to receive signals from upper air soundings.
3. Audio-modulated Radio Sonde Ground Equipment for receiving signals from upper-air soundings (Ozone Sonde and Radio Meter Sonde).
4. Temperature sensor.
5. Wind direction and speed recorders.
6. Recorder for continuous monitoring of surface ozone.
7. Pyranometer and Sutron make data logger for continuous recording of Global and diffuse Solar Radiations.
8. Sunphotometer/Microtop to measure atmospheric turbidity (optical thickness).
9. Brewer spectrophotometer.
10. Pre amplifier to enhance the receiving power of the radio sonde ground equipment.
11. Different portable instruments for taking observations in the event of power failure.

Meteorological Data Collected

1. Autographic records of surface ozone.
2. Upper air radiation flux, temperature and humidity by Radio Meter Sonde.
3. Vertical ozone and temperature profiles by ozone Sonde.
4. Microtop sunphotometer observations.
5. Brewer observations.
6. AWS records of global and diffused solar radiations.

RESULTS AND DISCUSSION

Ozone Hole Studies

The Ozone hole occupies the region of polar vortex where the temperatures are below -80°C and the Polar Stratospheric Clouds (PSC) are observed. The ozone hole is confined to the lower stratosphere. Almost complete ozone depletion was observed over the altitude region 14.5-19.5 km. The ozone hole appears when sunlight illuminates the

vortex, and disappears soon after temperature rises beyond -80°C, destroying PSCs. Stratospheric ozone depletion generally begins in August. However, sharp decrease occurs during mid-September to mid-October period when the ozone concentration at the level of maximum reduces to almost zero. From November onwards the concentration starts increasing steadily and by the end of December or beginning of January, the ozone values reach the maximum. Stratospheric ozone depletion is strongly related to stratospheric temperature. Colder the winter stratosphere, greater is the depletion of ozone in the ensuing spring.

To study the fluctuation of the ozone profile and investigate the ozone-hole during Antarctic Spring season, ozone sondes were released at Maitri. At the rate of one ascent per week, ozone sonde ascents were taken. The maximum ozone concentration varied from 15 km in winter to 35 km in summer. The highest ozone concentration over Antarctica is found around 20 to 22 km above ground as against the 27 to 28 km over tropics. The lowest ozone concentrations in the Antarctic atmosphere occur at about 7.5 km above ground as against 15 to 17 km over the tropics. The ozone depletion commenced in August and was reduced to less than half by the end of September. During November ozone concentration again built up. Figs.1-6 show the ozone profile during peak period (Apr-May), depletion period (August-November), and building up period (December) of 2007.

Ozone being one of the trace gases present in the atmosphere, continuous monitoring of surface ozone will give an opportunity to study the air chemistry of Antarctica. To measure this, fresh air was allowed to pass through the buffered potassium iodide solution kept in a specially designed glass bubbler at a fixed rate using a suction pump. While passing through the potassium iodide solution, the ozone in the air reacted with this solution and the corresponding output was recorded suitably. Further processing of data is still remaining for obtaining the results. Attempts are being made to improve its recording in future.

Upper-Air Temperature Profile

Indigenous Radio Sonde Ground Equipment (RSGE) operating on 401 MHZ was recording observations of upper air temperature profile. The station did not have indoor facility for filling the balloons with hydrogen gas. It was, therefore, not possible to arrange balloon ascents

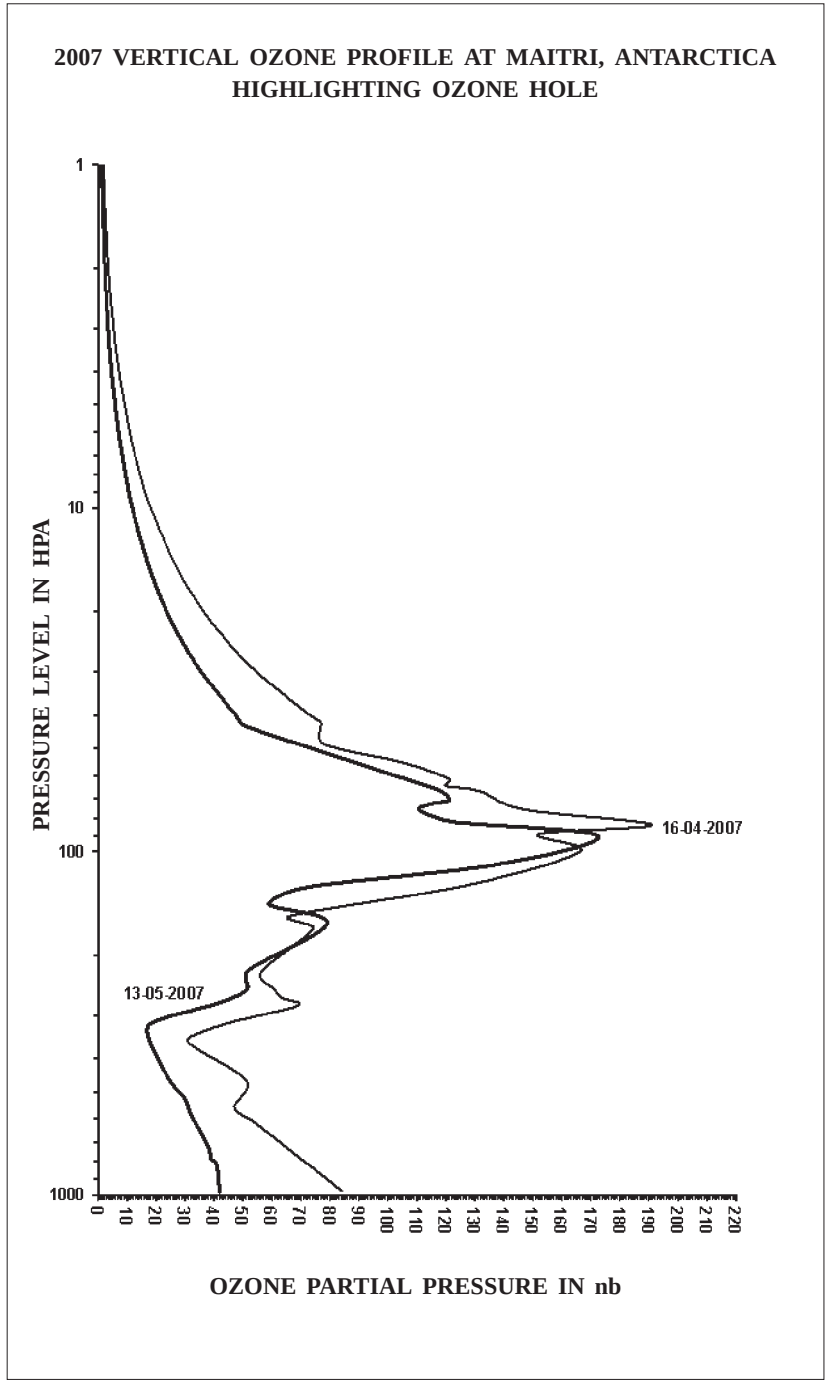

Fig. 1: Ozone profile at Maitri, Antarctica during peak period (April-May 2007)

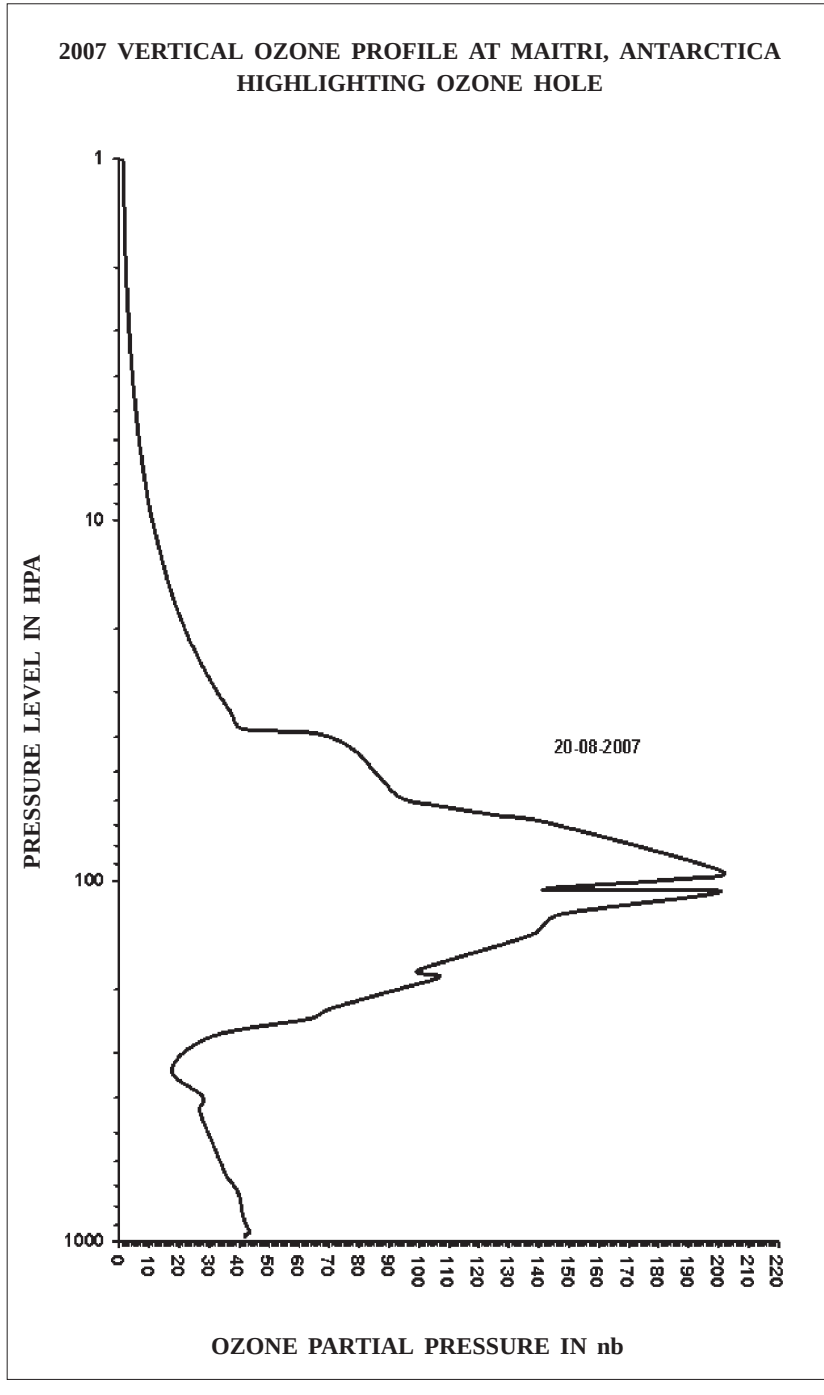

Fig. 2: Ozone profile at Maitri, Antarctica during depletion period (August 2007)

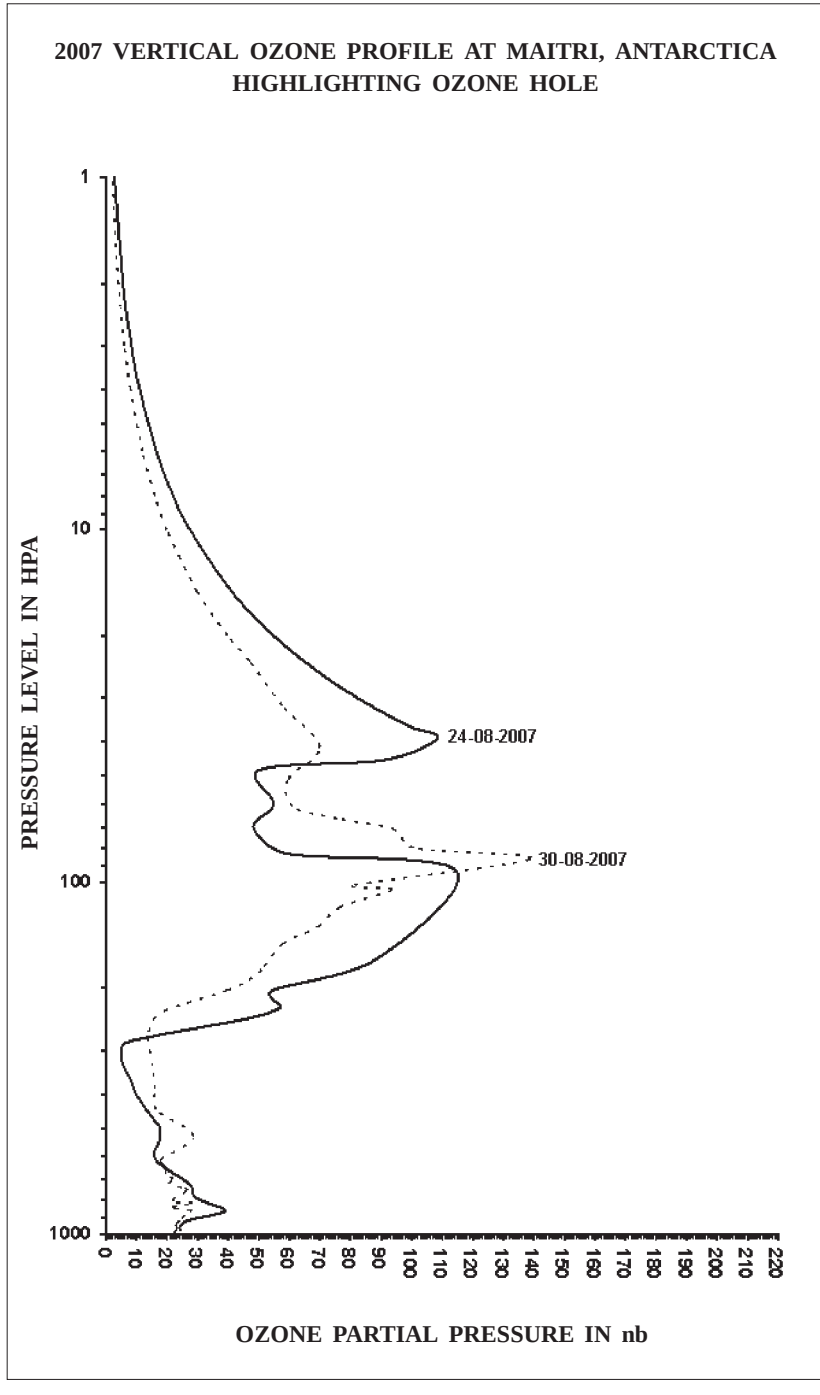

Fig. 3 : Ozone profile at Maitri, Antarctica during depletion period (August 2007)

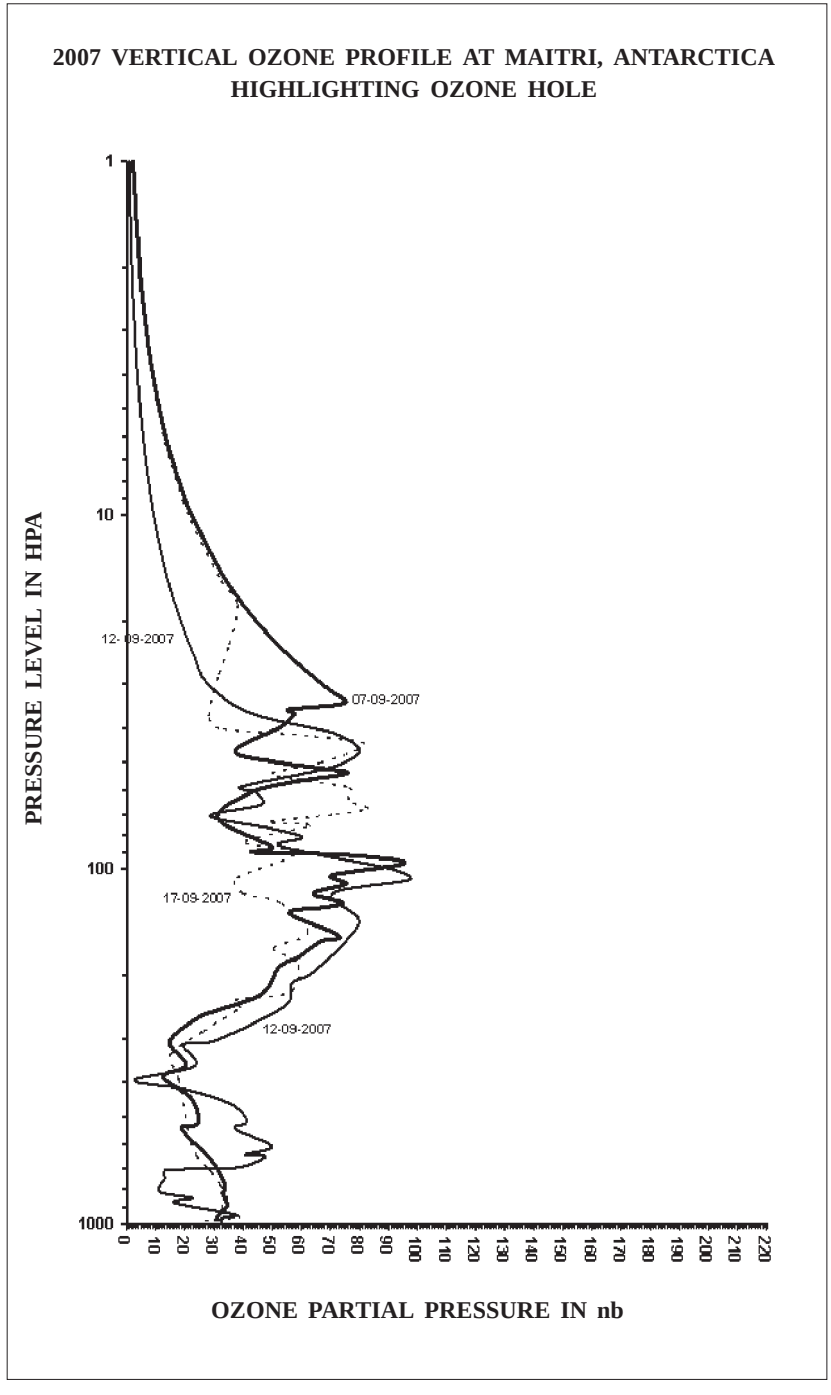

Fig. 4: Ozone profile at Maitri, Antarctica during depletion period (September 2007)

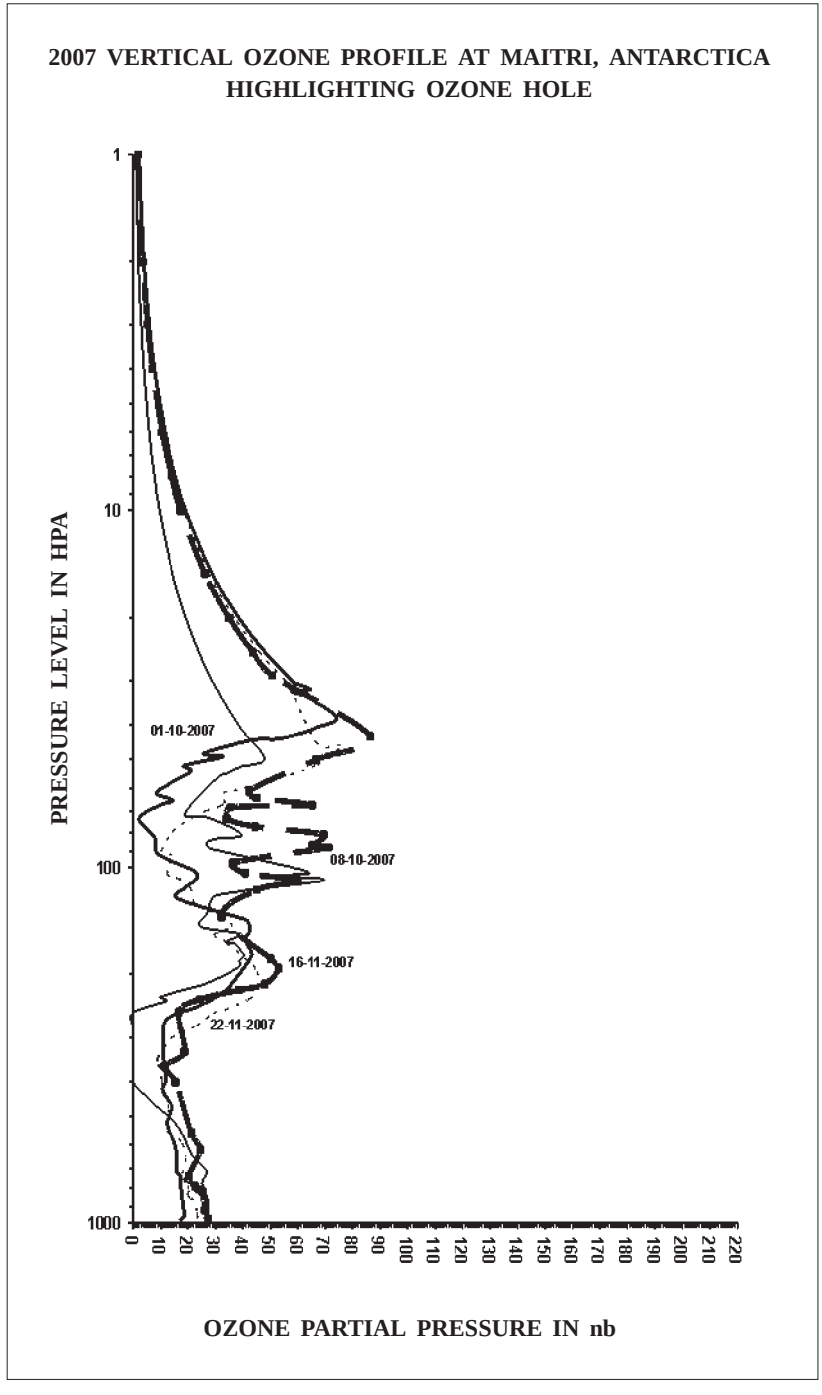

Fig. 5: Ozone profile at Maitri, Antarctica during depletion period (October-November 2007)

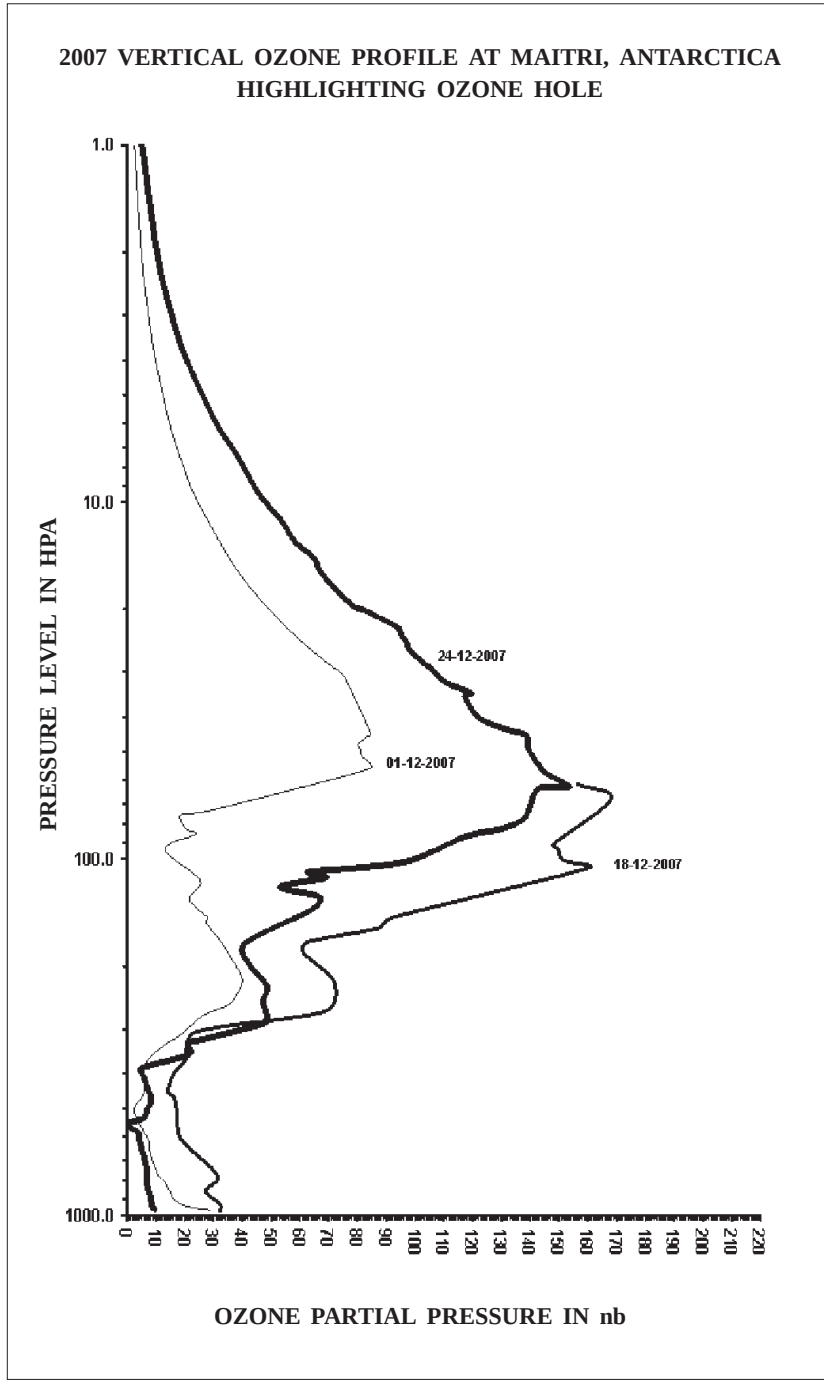

Fig. 6: Ozone profile at Maitri, Antarctica during building up period (December 2007)

during the windy weather. Feasibility of daily balloon launching will be possible from Maitri only with the help of balloon launching shelter like the same in the nearby Russian Station Novo. The tropopause height varies from 8 to 11 km and temperature varies between -45° to -60°C. More frequent ascents for longer period will be necessary for a meaningful analysis of the upper atmosphere. Temperature curves for different levels were drawn and are shown in Fig. 7.

Radiometer-sonde, were also taken for monitoring air temperature, pressure, humidity and radiation of the upper atmosphere. In spite of the lack of proper facilities for launching balloons, all efforts were taken to maintain upper air observations. Few ascents could go beyond 50 mb levels. It can be seen that as season changed from summer to winter not much change was observed in middle troposphere as compared to lower and upper tropospheric levels. A computer programme was developed specially for its computation. The stratosphere was found to be cooling gradually as the winter advanced. During winter, the stratospheric temperature reached -70°C. But the warming was found to be very quick. Sudden warming by 10 to 15°C in stratosphere was noticed in October. However, the lapse rate in stratosphere was found very less especially in winter.

Global Solar Radiation

Global and diffused solar radiations were continuously recorded over the Antarctica using two separate thermo electric pyranometers installed. The main cause for the higher value in January is the longer hours of sunshine and the higher zenith angle of the sun.

APT Pictures and Weather Fax Charts

Cloud pictures from polar orbiting NOAA satellites and weather fax charts from Pretoria, South Africa were received during the Expedition. The APT pictures, fax charts and barographic records of the corresponding period were correlated to understand the weather systems, and issue forecasts to different convoys and for determining the frequency of cyclonic storms approaching the Maitri station. The facsimile equipments on board the ship and Maitri were of great help in monitoring the weather charts transmitted from Pretoria. These weather charts were of great help in anticipating the weather conditions over the oceans and Maitri. The facsimile weather charts received from Pretoria were clear and received regularly covering the Maitri station area.

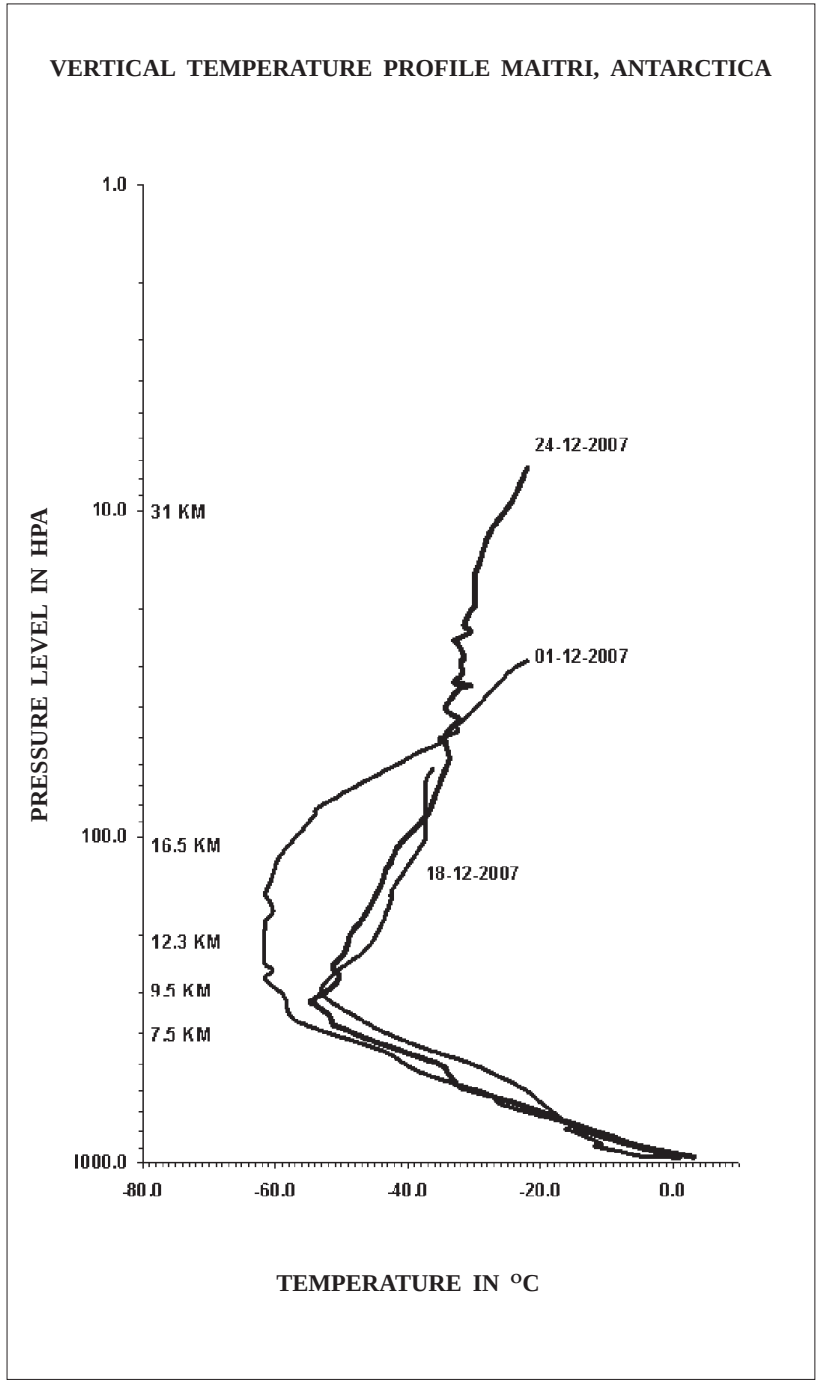

Fig. 7: Temperature profile at Maitri, Antarctica during December 2007

Data Access

The meteorological data of Maitri will be available at the office of Additional Director General of Meteorology (Research), India Meteorological Department, Shivajinagar, Pune – 411 005.

Recommendations

The electronic components are generally nearing their working limits in winter and hence military specifications of the components are a must. The sensors and the instruments will have to be periodically checked and serviced to avoid an uninterrupted data acquisition. It is advisable to construct a balloon launching hut for safe operations. The existing meteorological facility at the permanent station may be strengthened by providing additional equipment for upper air study. The team at the permanent station should consist of an experienced weather forecaster and a specialist in meteorological instruments. One summer member (from instruments background) should visit the station and ensure the working condition of all the instruments.

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