Eighteenth Indian Expedition to Antarctica, Scientific Report, 2002
Department of Ocean Development Technical Publication No. 16.pp 59-80

Study of Ultraviolet Radiation in relation to the terrestrial ecosystem of Schirmacher Region of East Antarctica.

Khwairakpam Gajananda, Shambhu Nath, Risal Singh, Anubha Kaushik*, R S Tanwar and HN Dutta

Radio and Atmospheric Sciences Division, National Physical Laboratory, New Delhi-110 012.
* Department of Environmental Sciences & Engineering, Guru Jambheshwar University, Hisar

Abstract

UV-B radiation intensity data recorded at the Schirmacher Region of East Antarctica during the years February 1, 1998 to January 31, 2000, has been analyzed to study the intensity of UV-B radiation in relation to the terrestrial ecosystem of Schirmacher Region. The UV-B data has been recorded using a Biometer, measuring the intensity of UV-B radiation in terms of MED/hr (Minimum Erythemal Dose Per Hour). 1.0 MED/hr is defined as the amount of UV-B energy of 5.83 microwatts/cm^2 of irradiation, falling continuously for one hour. 1.0 MED/hr is the amount of energy with which if the average skin is exposed for one-hour irradiation, the skin will show minimal redness. Maximum amount of UV-B radiation during the whole years was recorded as 3.998 MED/hr on December 1, 1998 and 2.806 MED/hr on October 27, 1999, which exactly fall in the austral spring period of the years 1998 and 1999. The terrestrial ecosystem has been studied by taking the biotic and abiotic samples. The observation of UV-B radiation in relation to this terrestrial ecosystem and their possible effects are described according to the available literature.

Keywords: flora, fauna, terrestrial ecosystem, Schirmacher Oasis, invertebrates, prokaryote, eukaryotes, Katabatic, Erythema Action Spectrum, UV-Biometer, phytoplankton, zooplankton.

1. Introduction

In Antarctica, over the years, only the micro flora and fauna has evolved in this harsh climate (Li, et. al., 1993). Among the many factors responsible for limiting development of well developed flora and fauna is the UV-B radiation which damages the terrestrial ecosystem (Bornmanetal., 1991; Caldwell et al., 1986;

Hays et al., 1991; Pfundel et al., 1992; Strid et al., 1994; Teveni et al., 1993). At the same time, a number of studies have been carried out the world over to demonstrate the harmful effect of UV-B radiation on flora and fauna (Bornman et al., 1993; Caldwell, et al., 1994-1995; Environmental Studies Board, 1973; Harm, Walter, 1980; Johanson et al., 1995; Bjorn., 1997; Pang et al., 1991; Quaite et al., 1992a, 1992b; Rozema et al,, 1994; Runeckles et al., 1994; Tevini, 1993; SCOPE 1993). The studies of Bomman el al 1995; Gaugler et al., 1978; Gehrke et al., 1995; Li et al., 1993; Moorhead et al, 1994; Musil 1994; Negash et al., 1986; Quaite et al., (1992a-b); Setlow (1974); Teramura et al., 1994; Zepp et al., 1994; concluded that the effect of UV-B on the ecosystems are basically the damage to DNA, skin cancer, suppression of photosynthesis and growth, stomatal closure, effects on biogeochemical cycles, irradiation enhance mutation, affects on photochemical and reproductive system, effects on entomogenous nematodes, impact on litter quality and decomposition processes, changes on decomposition and soil organic matter dynamics etc. Murphy (1983) found that membranes are the targets of ultraviolet radiation.

Therefore, it is extremely important to measure UV-B radiation at any location, so as to understand the evolution and sustainability of the existing flora and fauna. The Oasis region on the periphery provide a better habitat, as these are snow free during local summer (Somme, 1985). However, the study of UV-B in relation to the existing micro flora and fauna is limited so far and is basically confined to the Antarctic Peninsula and Mc Murdo Sound areas (Karentz, D., 1991).

In the Schirmacher region of east Antarctica, only limited efforts have been made to understand the effect of some of the climatic factors on the ecosystem (Lokendra et.al., 1998), no effort has been made so far to study the effect of UV-B on the existing ecosystem. Keeping in view of the above fact, NPL's long-term UV-B monitoring program over the past 10 years is being tried to study the UV-B effects on ecosystem in this region. In this report, the data recorded during the period February I, 1998 to January 31, 2000 has been analyzed. At the same time, samples of soils, water, rocks and biological organisms, collected randomly from different sites of the Schirmacher Oasis (Fig.l) by the 18th ISEA member during the period, January to February 2000 were studied in the laboratory. Through personal observations and through the study of various samples of biological, soils, water, rocks etc., the microorganisms were identified. Food chain and the energy flow of the ecosystem are established. Further more, studies attempting to determine the ecosystem dynamics under the influences of the atmospheric phenomena like, biogeochemical cycles, ecological succession, population dynamics etc. are in progress.

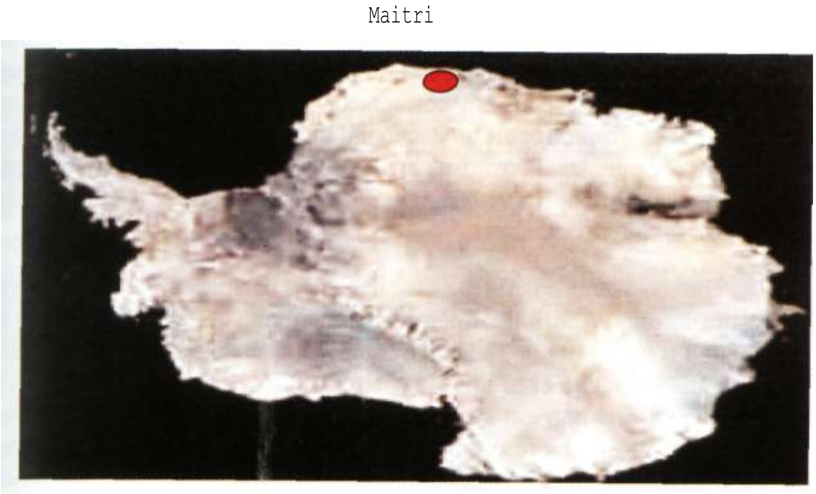

Fig.1. Map of Antarctica

2. Ecological Study of Schirmacher Oasis

The Schirmacher Oasis comprises one of the coldest and driest ecosystems on our planet. It gets less precipitation than the 'Thar Desert' and powerful winds scour the land. Despite this extreme environment, a variety of lives exist in the soils. streams, lakes, rocks, glacial and lake ices, melted water pools. Microorganisms, mosses, lichens and relatively few groups of invertebrates are present in this dry, rocky valley. Higher forms of life are virtually non-existent. The prokaryote dominates while a few varieties of eukaryotes prefer less stressful sites. The only higher life forms are bryophytes, rotifers, tardigrades. and nematodes. Vertebrate animals and vascular plants are lacking (except some migratory bird's species like skua, snow petrel etc., which migrate during the austral summer). The main factors limiting life are the sub-zero temperature, severe katabatic winds including blizzards, extremely low humidity, snowfall, availability of low liquid water and poor sun light even during summer months, high doses of UV radiation etc. Over thousands of years, this has resulted it to be one of the simplest ecosystems in the world, and very limited evolution of higher forms of lives. Therefore, species endemism are high in this region. In the presence of liquid water, solar energy drives photoautotrophic production that provides heterotrophic communities with carbon and energy supply. But in the present environmental problem of ozone depletion which was believed to have been reduced upto 50 percent in the concentration over Antarctica, a significant amount of harmful UV-B radiation are entering the atmosphere at a higher intensity.

The increase intensity of UV-B radiation could be detrimental for the terrestrial ecosystems in the Schirmacher Oasis. A ten percent reduction in the ozone, atmospheric level could result in a 1 percent increase in UV-B radiation (Nolan, 1997). This clearly shows that organisms, which are not accustomed to this level, will become detrimental and suppress the photoautotrophic production. If the primary producers are threatened, then the higher trophic level organisms will become dangerous and feel the negative effects of UV-B radiation. Therefore, UV-B radiation is now becoming an obvious limiting factor for living organisms.

The ecosystem is defined as the dynamics complex of plants, animals and microorganisms (biotic) with their non-living environment (abiotic) interacting as a functional unit (Odum, 1971). The biotic components of any ecosystem are linked as food chains and are interlocked to form complex food webs. Food webs perform the function of energy and nutrient cycles (Fig.2). The energy flows through ecosystem from sunlight and lost it by respiration (heat) of the communities members (Odum, 1971). Hence, ecosystems clearly follow the laws of thermodynamics. As described in Section 1, Schirmacher Oasis is a very simple ecosystem, no higher life forms exist, only lower forms of living organisms have survived here. The ecosystem is expressed in terms of both the structural and functional ways.

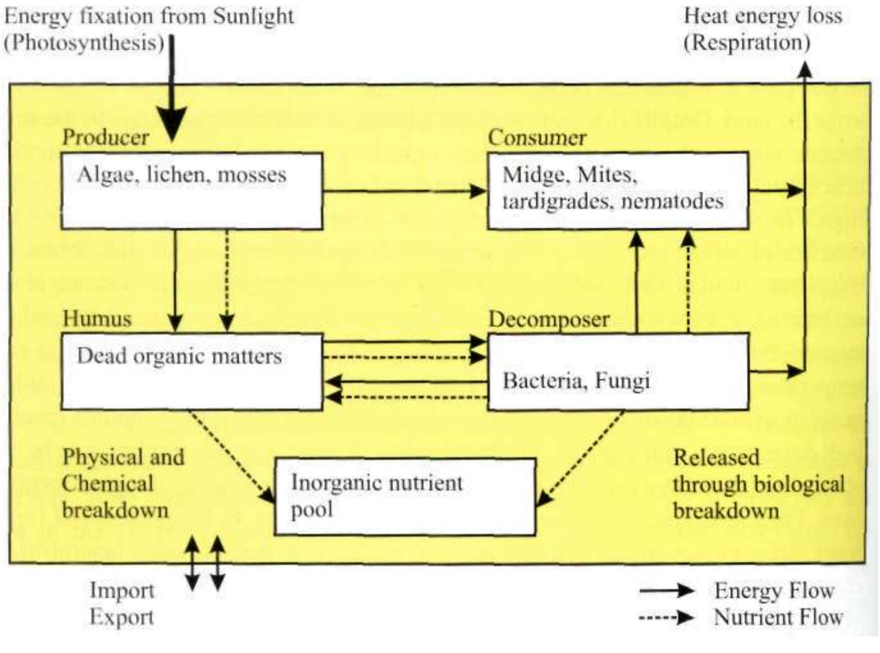

Fig.2. Simplified patterns of energy and nutrient exchange in the Schirmacher Oasis

General Description

Schirmacher Oasis is a typical desert oasis of Antarctica. It is situated about 70 km away from the Prince Astric Coast. The Oasis is basically 'moraine' formed by the east Antarctic glacier and is East to West tending low lying area. Schirmacher Oasis soils can be classified as dry polar desert soils, and their occurrence is limited to the deglaciated (ice-free) area. Organic compounds, such as 'humus' that links the biotic and abiotic component of the ecosystem is very poor in this region. It lies between the latitude 70°44'33"S to 70°44'30"S and longitude 11°22'40"E to 11°54'00"E. The size of the Oasis is about 32.5 sq. km. The oasis is a rocky terrain with low-lying hills (50 to 200m highs) interspersed randomly at various locations. Beneath few feet underground, permanent form of permafrost' exist making the soil compact and hard for plants to root. Small glacial lakes ranging in size from 0.02 to 1.5km^2 are also found in various locations.

Weather and Climate

The Oasis is buffeted by heavy winds. Winds as high as 250 km/h (116 knots) have been recorded. Katabatic (gravity driven) winds flow down slope from the interior towards the coast and, combined with the low temperatures, create dangerous wind-chill conditions and 'blizzards' (heavy storms with snow). Schirmacher region can be classified as a true cold desert; in the interior the average annual precipitation (expressed in terms of water) is less than 50 mm (2 inch). Raging blizzards often occur, picking up snow deposited in the interior towards the periphery. Heavy snowfall occurs when cyclonic storms over the surrounding seas push in relatively warm and moist air into the continent. This moist air freezes and is deposited as snow over the areas. The region has almost continuous daylight during the Southern Hemisphere's summer and darkness during the Southern Hemisphere's winter. Radiant energy, in the form of sunlight, is the ultimate and only significant sources of energy for any ecosystem (Kormondy, 1989).

Flora of Schirmacher Oasis

Plants compose most of the living mass in terrestrial ecosystems. The plants that survive in the Schirmacher oasis are restricted to the small ice-free areas. The vegetation is limited to mostly simple plants like algae, mosses (Fig. 3),

Fig. 3. Lichen and Mosses

liverworts, lichens and microscopic fungi. A few species of plants, such as plankton algae and mosses, live in the fresh water lakes. Short moss turf and cushion mosses are found most frequently in sandy and gravelly soils. Mosses are also found growing on the surface of the rocks (Fig.4). It is interesting to note that lichens are seen to grow even on rock surfaces, where availability of nutrients is low. This is due to the fact tint many of these rocks are porous, so as to retain little amount of water and the released acids by the lichens themselves, resulting in the formation of nutrients. At the same time, rock surfaces become much warmer under sunlight than the soil itself, helping favourable conditions for lichens to grow. Under the microscope it has been observed that the lichens penetrate the upper coat of the rock. Algae are also found under stones particularly light-colored quartz stones, where the microclimate is more favorable than in the surrounding sand or soil (Fig.5). This strategy enables them to scrape a humble living in this harsh environment.

Table 1. Plants of the Schumacher Oasis

Algae	Lichen	Mosses
1. Cyanophyceae i) Nostocales (Calothrix, Lyngbya, Nostoc, Oscillatoria, Phormidium, Schizithrix) ii. Chroococcales, (Aphanocapsa, Aphanothece, Gloeocapsa) 2. Chlorophyceae i) Clilorococcales (Chlorococcum) 3. Baccilariophyceae i. Pennales (Hantzschia, Pinnularia)	1. Acarospora *A. agwynnii* 2. Alectoria *A. minuscula* 3. Buellia *B. pallida* 4. Carbonea *C. capsulata* 5. Lecidea L cancariformis 6. Lecanora L. fuscobrumnea 7. Physcia P. caesia 8. Porpidia *P. species* 9. Rhizocarpon *R. flavum* *R. species* 10. Rinodina *R. species* 11. Umbilicaria *U. aprina* *U. decussata* 12. Xanthoria X. elegans	1. *Bryum argenteum*

Table No. 1 shows the flora of the Schirmacher Oasis. It is observed that lichen *Usnea* Sphacelata are the most abundant species, at times attaining height of some centimeters (Fig.3). The overall productivity of biomass in the Schirmacher Oasis is low i.e. only between 0.01 and 1 millimeter per year. But the life span of lichen is very long: an age of 200 years is common, the record is about 4500 years.


Fig.4. Mosses

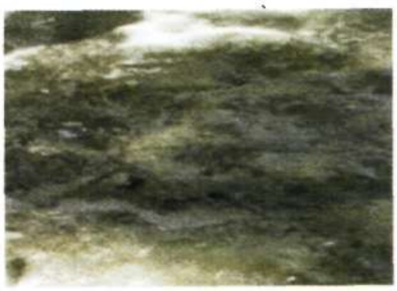
Fig.5. Algae

Fauna of the Schirmacher Oasis

No land vertebrates can survive in Antarctica's harsh conditions. Invertebrates, especially yeast's, protozoa, bacteria, mites (Fig.6), midges (Fig.7), tardigrade (Fig.8). nematodes etc., which can tolerate the lower temperatures, exist in the soil of this region but can b considered rare. Mites, which belong to the spider family, are the commonest land animals here and they make an ecological niche in this Oasis (Fig.6). They have been observed to live in the soil and vegetation. While tiny insects such as nematode worms, tardigrades. rotifers and mites have been observed in damper mosses and soils, most of the animal population is made up of microscopic protozoan (single-celled creatures). In this dry valley soil, nematodes species are at the top of the food chain, therefore, they are sometime called as "lions of the Antarctic dry valleys".

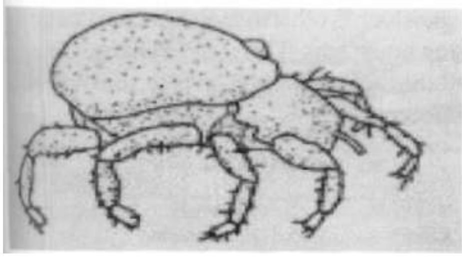
Fig.6. Mite

Many of Antarctica's invertebrates avoid freezing by super cooling, or keeping their body temperatures below their normal freezing point. About 4 species of birds (penguin, skua, snow petrel, storm petrel)

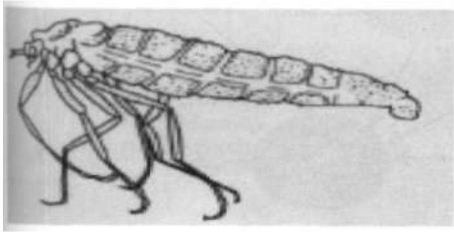
Fig.7. Midge

have been observed to migrate and breed during the summer in this oasis (Fig.9). These migratory birds are responsible for introducing lower forms of plants and animals. The ecological equivalents of the above flora and fauna are not reported to be found elsewhere in the mainland, therefore, they can be regarded as endemic species.

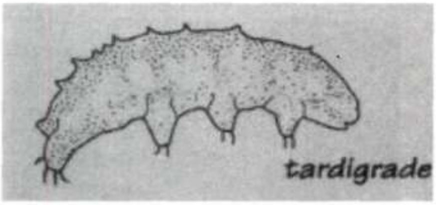

Fig.8. Tardigrade

Fig.9. Snow Petrel

Food webs

Food webs are the basic units of ecosystem, since all the energy and materials cycling take place around them. Living organisms, which perform all the dynamic functions with their non living environment inside and outside the food web makes the ecosystem flourish. The food webs of Schumacher Region can be represented as follows (Fig. 10). Although, Figure 10 shows a highly simplified food web of the Schirmacher Oasis, it can be regarded as more complex than this.

From Fig.2 and Fig. 10, it is shown, which is otherwise also known that the Sunlight is the prime driving force of all living organisms. Therefore, a change in the intensity of sunlight will be detrimental to all the living life forms. Hence, the study of various spectrums of the sunrays and their effect on

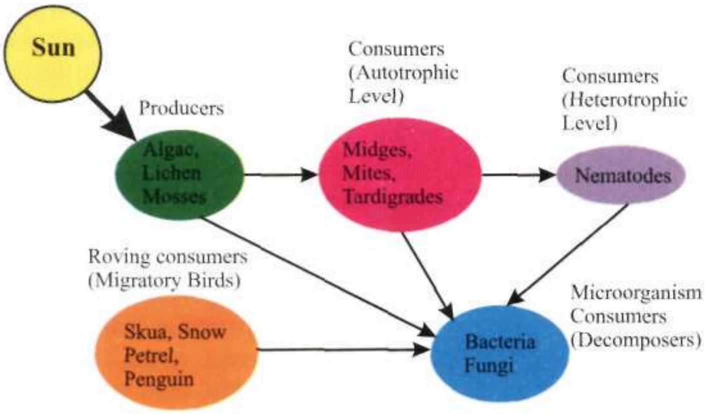

Fig. 10. Simplified Food Webs of the Terrestrial Ecosystem of Schirmacher Oasis

3. UV-B Measurement

The following instruments were used to monitor UV-B radiation at the wavelength between 280 nm to 340 nm during theyear February 1,1998 to January 31, 2000 at the Indian Antarctic Station, Maitri, located at the Schirmacher Region of East Antarctica.

1. UV-Biometer and
2. UV-Filter Photometer

In this report only UV-Biometer observations is discuss.

UV-Biometer

Model 501 UV-Biometer consists of the detector (Fig. 11) designed for outdoor operation and the recorder that performs all control and data storage functions. The signal from the UV sensor is amplified and converted to frequency inside the detector and then transmitted to the recorder. The biometer has a characteristic similarity to that of phosphor-based Robertson-Berger meter. The sensor of the detector is a combination of absorption filters, phosphor and a GaAsP diode that together give a spectral response close to that of the Erythema Action Spectrum, (Fig. 11). It can indicate the effectiveness of the solar radiation for the induction of sunburn, phytoplankton mortality suppression of photosynthesis to minute plants, thymine dimers, skin elastosis etc. The main advantage of this instrument is me measurement to detect sun burning time, measurements for media and research organizations that provide public information about the effects of UV radiation

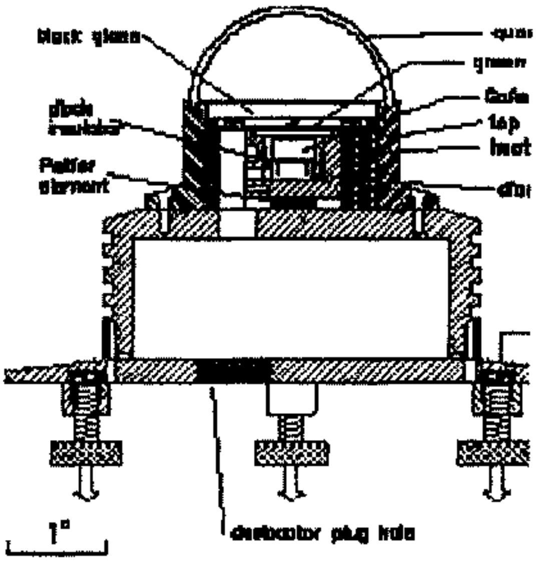

Fig. 11. UV-Biometer Detector

Specifications

Detectors (Fig. 11)

Spectral range: 290-340 mn, close to Erythema.

Measurement range: 0 to 10 MED/hr (Minimal Erytliemal Dose per Hour).

Angular response: within 5% from ideal cosine for incident angles.

Response time: 1 second

Temperature error: 0.2%^{0}C.

RAF: > 1 (Radiation Amplification Factor calculated for 30^0 solar zenith angle and 0.27 cm ozone column).

Operating temperature: -40 to +50°C ambient.

Environment: outdoors.

Recorder

Temperature range: 0 to +50C.

Environment: indoors, no water condensation.

Features

Output: digital (UV signal and sensor temperature).

Data acquisition: dedicated computerized data logger with liquid crystal display, keypad, serial communication port and parallel printer port; accommodates 2 detectors simultaneously; optional analog output.

Dose period: selectable from 1 minute to 1 hour.

Internal memory: stores up to six month of 1 hour dose integrals and sensor temperature from two detectors in a nonvolatile memory.

Data integrity: nonvolatile memory; internal rechargeable power backup for the recording circuitry;

automatic temperature compensation corrects data if ambient temperature exceeds specifications or AC power is lost.

Communication: compatible with any computer and modem equipped with an RS232 serial port; menu organized remote setup and data retrieval; user selectable baud rate from 300 to 9600 bps.

Power source: universal 90-250 VAC. 50-60 Hz or 12 VDC.

Principle

The solar light goes through the input filter that eliminates the visible component. Then the partially tillered light-containing whole of UV spectrum, excites the phosphor. The visible light emitted by phosphor is detected by GaAsP diode. The diode and the phosphor are encapsulated in the metal enclosure, which is thermostated, by the Peltier element. The current produced by GaAsP diode is amplified and converted to frequency inside the detector. The temperature of the detector is converted to frequency also. The frequency signal from detector is transmitted to the recorder.

The data is measured in units of MED/hr (5.83 microwatt/cm^2). One MED/hr would cause minimal redness of the average skin after one-hour irradiation (21 mj/cn^2). All functions of the instrument are defined by the software and can be modified according to specific user needs.

Handling and Maintenance

The detector was mounted on top of the Indian Antarctic Station, Maitri, building to get the maximum solar irradiance and to avoid obstruction by any materials. The quartz dome was regularly cleaned of dust and snow. The recorder was kept below in die hut, which was maintained at a constant temperature. The system was kept running round the clock during all the year round.

4. Results and Discussion

As the role of UV-B radiation plays mainly on the biotic components of the ecosystem, we emphasis our discussion mainly on the living organisms, There are six biological action Spectrum, they are Erythema action Spectrum, DNA to Protein Cross-links. DNA Breaks, Polychromatic action Spectrum for higher plants, Phytoplankton Photoinhibition and Typhimurium Killing. The RAF, which is the ratio of the change in effective energy in respect to the change in ozone thickness and a function of wavelength, is compared in Table 2. The table illustrates the fact that action spectrum with RAF close to that of UV-Biometer will follow the meter's reading (Morys and Berger, 1993). Therefore, in our study we take only the Erythema action Spectrum.

4.1 Results

The two years continues data recorded for local daily noontime values during February 1, 1998 to January 31, 2000 at the Schiirmacher Oasis, were compared, analyzed and plotted in Fig. 12 (a). The figure shows marked variations of the intensity of the radiation in all the seasons' i.e. summer and winter period including the austral spring. The data of the austral summer period of August 1998 to December 1998 are plotted in Fig 12(b) and from August 1999 to January 2000 in Fig. 12(c).

Fig. 12 (a) shows that the UV-B radiation intensity for local noontime over Schirmacher region has a seasonal and annual variation. As the UV-B intensity depends on column ozone content, solar zenith angle and weather conditions in Antarctica like aerosol free environment. The recorded UV-B intensity follows the solar zenith angle for average sky conditions and average ozone content value. The average intensity has been observed to be high even during the month of January, when ozone values recovered from ozone hole process. However, there is a large day-to-day variability due to changes in the weather condition. On account of this weather condition the maximum UV-B radiation (3.998 MED/hr) was recorded on December 1, during the year 1998 a day outside the ozone hole period and (2.806 MED/hr) was recorded on October 27, 1999, which falls almost in the middle of austral spring (maximum period of O_3 depletion) period. The UV-B recorded on the average during the year 1999 was lower than the year 1998, this is again due to the fact that during November 1999, 2 days of snowfall, 6 days of overcast sky and a foggy day was recorded. On December 1999, 10 days of snowfall and 9 days of overcast sky prevail (Table 3). Therefore, almost all the value of UV-B radiation during spring of 1999 was low. But during January 2000, the weather improved thus the value of UV-B also increases gradually. As mentioned earlier, the threshold limit of UV-B radiation is at 1 MED/hr, almost all the values of October, November, December and January, 2000 plotted on Fig. 12 (b) and (c) exceed this limit. The average UV-B intensities during January-February periods are higher for the year 1999 compared to the year 1998. The variation is mainly due to weather conditions. Similarly, the average UV-B intensities during the period of November and December are higher for the year of 1998 than that of the year 1999. This is also mainly due to weather condition.

It is extremely important to note that only during the sunny periods, biological system generates its metabolic activities, productivity etc., but the presence of high doses of UV-B restricts many of these activities resulting in the situation where two mutually counteracting factors are operating.

During April to September, the MED/hr values are low Fig. 12 (a). This is due to the fact that solar zenith angles are low, day light duration is shorter than the night times. Moreover, maximum number ofblizzards (12 times) with very high wind speed (116 knots) and heavy snowfall has been recorded during these two months.

One interesting feature has been observed during the month of December 1999. in which the MED/hr values were observed to be low. This is because of heavy snowfalls for about 10 days, overcast sky and a blizzard (December 20, 1999), which were observed in this month. Only the first week and the last week of the month show slightly greater than 1 MED/hr of radiation. Since Fig. 12a, Fig. 12b and Fig. 12c shows higher erythema action spectra per hour of more than 1 MED/hr for several hours a day and continues similarly for many more days, long-term exposure for 7-8 hrs per day on a clear day will have large effects on the flora and fauna of ecosystem. Therefore, our study indicates that due to high MED/hr value within a short period of time, the possibility of the effects of harmful UV-B radiation on the living organisms of the terrestrial ecosystem of Schirmarcher Oasis might be significant. Perhaps the low values of UV-B associated with the overcast sky condition during summer might be the most favourable period for various activities

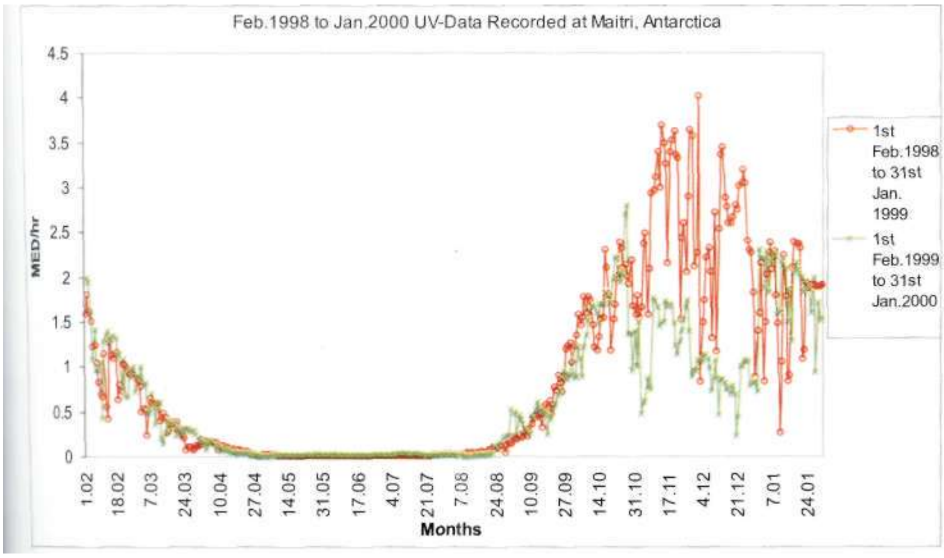

Fig.12 a. Graph showing the maximum daily values during the noontime for the period 1st February 1998 to 31st January 2000 obsreved Over Maitri, Antarctica.

of microorganisms making an interesting point to study the Antarctic flora and fauna under high UV-B environment combined with continuos overcast sky. Basically, it may be required to have a study of the microorganisms and their behaviors during prolonged low UV-B values during the austral summer and compare this with the data during prolonged exposure of high UV-B over the Schinnacher region.

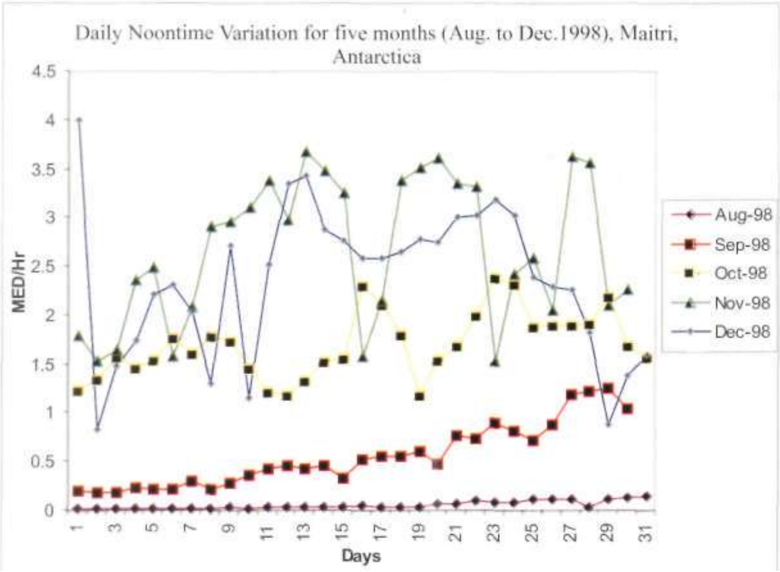

Fig.1Zb. Graph showing the daily value during the noontime for five months at Maitri, Antarctica.

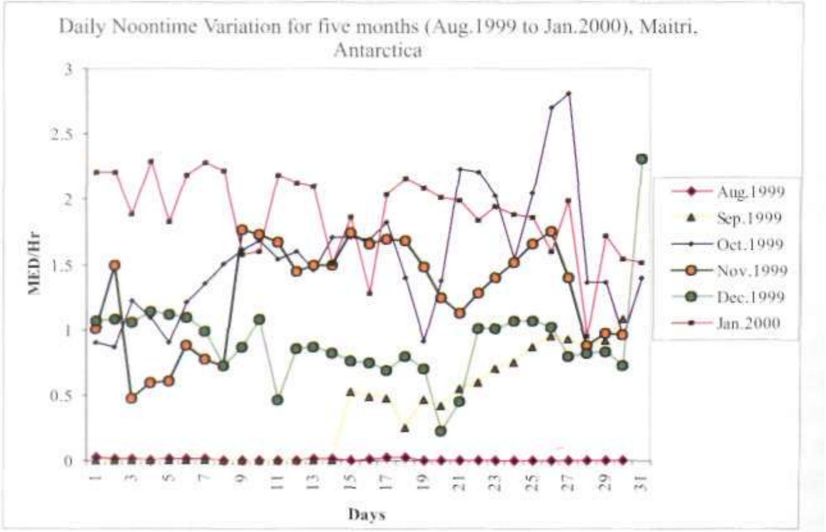

Fig. 12c. Graph showing the daily value during the noontime for six months at Maitri, Antarctica.

4.2. Discussion

The modern classification of UV radiation into 3 bands: UV-C (100-280 nm), UV-B (280-320 nm) and UV-A (320-400 nm) were accepted at the Congress of Comite Internationale de Lumiere in 1932. It was first proposed by Saidman, based on the differences of the biologic effectiveness in these bands. Since then, many studies have been performed to determine the action spectra for biological objects other than human skin (Morys and Berger, 1993). Plants and organisms need UV-A part of the ultraviolet radiation for photosynthesis, and humans need it to convert vitamin D, an increased level could be detrimental for ecosystems. In our own human community dermatologists have seen an increase in skin cancer and cataracts (Hader, 1997).

Since the first reports of potential stratospheric ozone reduction over 26 years ago (Johnslon, I971; Crutzen, 1972), UV-B (280-315 mn) effects on higher plants have been the subject of considerable research. Hausser and Valine (1921) described the experiment that allowed for the measurement of the wavelength dependency of erythema, action spectra, (Urbach and Gange, 1986). The biological weighting functions used for this purpose often relate with action spectra. Action spectra assumed to be relevant for plants indicate that the shorter UV-B wavelengths are the most important. However, the relative importance of shorter Vs longer UV-B wavelengths, varies considerably. Depending on these slopes, the Radiation Amplifications Factors (RAF) vary enormously. Action spectra that do not decrease sharply with increasing wavelength result in small RAF values, thus, the evaluation of weighting functions (and therefore action spectra) becomes a critical parameter (M.M. Caldwell et al. 1994). There is evidence that action spectra for many plant functions are steep in nature indicating that ozone reduction translates into large increases in effective solar UV-B (Caldwell, 1971; Setlow 1974). Some more recent spectra developed specifically for evaluating the ozone reduction problem show flatter slopes (and therefore lower RAF values) than the earlier work (Caldwell et al., 1986; Steinmueller, 1986; Quaite et al., 1992). Still, these spectra are sufficiently steep so that ozone reduction must be taken quite seriously. Biological weighting functions also are needed to relate solar UV to UV from artificial sources used in experiments (WMO/UNEP, 1994).

In terrestrial and aquatic ecosystems, the affect of UV-B radiation on trophic levels is dangerously effective. Our primary producers such as prokaryotic green plants, phytoplankton and zooplankton will be affected. Under this circumstance, higher trophic level organisms such as nematodes, tardigrades, arthropods (insects), birds, mammals, agricultural products, bacteria and humans will feel the negative effects of UV-B radiation. From the base of the food chain to the top of all organisms on this planet will be affected by the increase in ultraviolet light. According to Karentz (1991). the potential threat to the Antarctic terrestrial ecosystem, which is associated with the enhanced UV-B radiation and the ozone hole must be considered especially to terrestrial habitats which may thaw during the UV-B peak to the ozone minimum. In the light of above arguments, the present effort of relating the UV-B intensities with the Schirmacher ecosystem was undertaken.

It has been established by various studies that there are three main targets for the destructive action of UV-B radiation in the plant cell: The 'genetic system' (DNA, both damage and gene regulation [Pang and Hays, 1991]), the 'photosynthetic system', and 'membrane lipids' (Bjom, 1996). In animals and birds, the damage are mainly of immunosuppression, disability to cope up with the habitat, eye damages, skin cancer, susceptible to wear of feathers, susceptible to eggs, stunting of growth, high mutation rates etc. (Bjom, 1996). These aspects are the future targets of the present studies on the samples collected from the Schirmacher region during the 18th Indian Scientific Expedition to Antarctica.

5. Conclusion

Our preliminary studies suggest that the ecosystem of Schirmacher Oasis must have grown with some control of high UV-B doses. Therefore, a comprehensive long-term program involving the study of ecosystem under both prolonged low UV-B conditions and high UV-B conditions should be drawn, so as to understand the relationship and scientific mechanisms through which the ecosystem of Schirmacher region has survived. Also, we should be in a position to predict long-term measurements that would be required for understanding the signatures of global warming.

6. Acknowledgement

One of the authors (Kh.G) is grateful to NPL, New Delhi and DOD for proving an opportunity to participate as a winter member in the 18th Indian Scientific Expedition to Antarctica. The authors are indebted to Director, NPL, Head, RASD, and NPL Antarctic cell for training and useful discussion. Finally, thanks are due to IMD team at Antarctica, which provided data on display at Maitri and to many of teammates for supporting the experiments running in this harsh polar environment.

7. References

1. Bjorn Lars Olof., Effects of Ozone depletion and increased UV-B on terrestrial ecosystems. 1996, Overseas Publishers Association (OPA), Amsterdam B. V Published in The Netherlands Gordon and Breach Science Publishers, 1997,

2. Bornman, J.F., and Vogelmann, T.C. Effect of UV-B radiation on leaf optical properties measured with fiber optics. J Vol., 42: 547-554. 1991.

3. Bomman J.F. and A. H. Teramnra, "Effects of ultraviolet-B radiation on terrestrial plants", In: (Plenum Press, New York., 1993) (A. R.Young, L. O.Bjorn, J.Moan and W.Nultsch eds.) Environmental UVphotobiology pp. 427471(1993).

4. Bomman J.F. and C.Sundby-Emanuelsson, "Response of plants to UV-B radiation: some biochemical and physiological effects", In: (N.Smirnoff, ed.) Environment and Plant Metabolism (BIOS Scientific publishers, Ltd., Oxford, 1995), pp. 245-262.

5. Caldwell, M.M., Solar ultraviolet radiation and the growth and development of higher plants, pp. 131-177 in Photophysiology. Volume 6, A.C., Giese (eds.), Academic Press, New York, 1971.

6. Caldwell, M.M., L.B. Camp, C.W. Warner, and S.D. Flint, Action spectra and their key role in assessing biological consequences of solar UV-B radiation change, pp. 87-111 in Stratospheric ozone reduction, solar ultraviolet radiation and plant life, R C , Worrest and MM Caldwell (eds.), Springer, Berlin, 1986.

7. Caldwell C.R, "Modification of the cellular heat sensitivity of cucumber by growth under supplemental ultraviolet-B radiation", Plant Physiol., 104,395-399 (1994).

8. Caldwell M.M. (USA), A.H. Teramnra (USA), M. Tevini (FRG), J.F. Bomman (Sweden), L.O. BjOm (Sweden), and G. Kulandaivelu (India). Effects of increased solar ultraviolet radiation on terrestrial plants, WMO/UNEP Environmental Effects of Ozone Depletion: 1994 Assessment, Chapter 3

9. Cmtzen,P.J., SSTs—a threat to the earth's ozone shield, Ambio 1:41-51,1972.

10. Environmental Studies Board. Ad hoc Panel on the Biological Impacts of Increased Intensities of Solar Ultraviolet Radiation. National Academy of Sciences and National Academy of Engineering. Washington, D.C. 1973.

11. Gaugler R. and G. M.Bousch, "EFecls of ultraviolet radiation and sunlight on the enlomogenous nematode, Neoaplectana carpocasae". J. Inverebr Pathol., 32, 291-2% (1978).

12. Gehrke C, H.Johanson, T. V.Callaghan, D.Chadwick and C. H.Robinson 'The impact of enhanced ultraviolet-B radiation on litter quality and decomposition processes in Vaccinium leaves from the Subarctic" Oikos., 72,213-222 (1993)

13. Hader, P. Donet. "Stratospheric Ozone Depletion and Increase in Ultraviolel Radiation." The Effects of Ozone Depletion on Aquatic Ecosystems Ed Hader, P. Donet. Austin, Texas: R.G. Landes Company, 1997. l.

14. Hader, P. Donet and Worrest, C. Robert. "Consequences of the Effects of Increased Solar Ultraviolet Radiation on Aquatic Ecosystems." The Effects of Ozone Depletion on Aquatic Ecosystems. Ed. Hader, P. Donet. Austin. Texas: R.G. Landes Company, 1997. 5.

15. Harm and Walter. Biological Effects of Ultraviolet Radiation. Cambridge: Cambridge University Press, 1980.

16. Hays. J and Q.Pang, "UV-B-inducible and constitutive genes that mediate repair and toleration of UV-B-damaged DNA in Arabidopsis thaliana", In: (R. H.Biggs and M. E. B.Joyner eds.) Stratospheric Ozone Depletion/UV-B Radiation in the Biosphere, NATO ASI Series, Vol. I 18. Springer-Verlag, Berlin, pp. 107-122 (1991).

17. Johnston. H.S., Reduction of stratospheric ozone by nitrogen oxide catalysts from supersonic transport exhaust. Science 173:517-522,1971.

18. Johanson U., C.Gehrke, L. O.Bjorn and T. V.Callaghan, "The effects of enhanced UV-B radiation on the growth of dwarf shrubs in a Subarctic heathland", Funct. Ecology., 9, 713-719 (1995).

19. Karentz. D.. Ecological consideration of Antarctic Ozone Depletion, Antarct. Sci., 3. 3-11. (1991).

20. Kormondy. 1 Edward., "Concepts of Ecology", Prentice Hail of India Pv ltd. 1989.

Li J. Y. T. M. Oulee. R. Raba. R. G. Amundson and R. L. Last, "Arabidopsis flavonioid mutants are hypersensitive to UV-B irradiation", Photochem. Ph Plant Cell., 5,171-179 (1993).

22. Lokendra Singh, M.K.Agarwal., Air Microflora of Antarctica. Fourteen Indian Expedition to Antarctica, Department of Ocean Development, Technical Publication, No. 12, pp 193-198,1998.

23. Moorhead D.I. and T. VCallaghan, "Effects ofincreasingultraviolet-B radiation on decomposition and soil organic matter dynamics: a synthesis and modelling study", Biol. Fertil. Soils., 18,19-26 (1994).

24. Musil C.F., "Ultraviolet-B irradiation of seeds affects photochemical and reproductive performance of the arid-environment ephemeral Dimorphotheca pluvialis", Environ. Exp. Bot., 34,371-378 (1994).

25. Murphy T. M., "Membranes as targets of ultraviolet radiation", Physiol. Plant., 58,381-388 (1983).

26. Morys Marian and Daniel Berger., The accurate measurements of biologically effective ultraviolet radiation. International Symposium on High Latitude Optics, Tromso, Norway, July 1993.

27. Nolan, Canice. "Making Links: From Causes to Effects to Action." The Effects of Ozone Depletion on Aquatic Ecosystems. Ed. Hader, P. Doner. Austin, Texas: R.G. Landes Company, 1997. 5.

28. Odum, Eugene. P., "Fundamental of Ecology", W.B. Suanders Company Publication, Toppan Com. Pvt Ltd. Tokyo, Japan 1971.

29. Pang Q. and J. B.Hays, "UV-B inducible and temperature-sensitive photoreactivation of cyclobutane pyhmidine dimers in Arabidopsis thaliana", Plant Physiol., 95, 536-543 (1991).

30. Pfundel E.E, R. S.PanandR. A.DiIley, "Inhibition of violaxanthin deepoxidation by ultraviolet-B radiation in isolated chloroplasts and intact leaves", Plant Physiol., 98,1372-1380 (1992).

31. Quaite, F.E., B.M. Sutherland, and J.C. Sutherland, Action Spectrum for DNA Damage in Alfalfa Lowers Predicted Impact of Ozone Depletion, Nature 358:576-578,1992a.

32. Quaite, F.E., B.M. Sutherland, and J.C. Sutherland, Quantitation of pyrimidine dimers in DNA from UV-B-irradiated alfalfa (Medicago sativa L.) seedlings, Applied and Theoretical Electrophoresis 2:171-175,1992b.

33. Rozema J., M. Tosserams and E. Magendans, "Impact of solar UV-B radiation on plants from terrestrial ecosystems", In: (S. Zwerver, et al., eds.) Climate Change Research: Evaluation and policy implications. (Elsevier, Amsterdam, 1994),

34. Runeckles VC. and S. V. Krupa, "The impact of UV-B radiation and ozone on terrestrial vegetation", Environ. Pollut., 83, 191-213 (1994).

35. SCOPE, "Effects of increased ultraviolet radiation on global ecosystems", Proc. Workshop, Tramariglio, Sardinia, Oct. 1992 (1993).

36. Setlow, R.B., The wavelengths in sunlight effective in producing skin cancer: a theoretical analysis, Proceedings of the National Academy of Science USA 71:3363-3366, 1974.

37. Somme, L. 1985, Terrestrial habitats invertebrates in: Key environment, Antarctica, 106-117 (eds) Bonner, W.N. and D. W. H. Walton, Pergamen Press.

38. Steinmuller, D., On the effect of ultraviolet radiation (UV-B) on leaf surface structure and on the mode of action of cuticular lipid biosynthesis in some crop plants, Karlsr. Beitr. Entw. Okophysiol. 6:1-174, 1986.

39. Strid A, W. S. Chow and J. M. Anderson, "UV-B damage and protection at the molecular level in plants", Photosynthesis Res., 39, 475-489 (1994).

40. Teramura A.H. and J. H. Sullivan, "Effects of UV-B radiation on photosynthesis andgrowthofterrestrialplants", PhotosynthesisRes., 39, 463473 (1994).

41. Teramura A.H. and J. H. Sullivan, "Effects of UV-B radiation on photosynthesis and growth of terrestrial plants", Photosynthesis Res., 39, 463-473 (1994).

42. Tevini M, (ed.), UV-B radiation and Ozone Depletion: Effects on humans animals plants microorganisms and materials (CRC Press/Lewis Publishers Inc.: Boca Raton, 1993).

43. UrbachF. and R.W. Gange, theBiological effects of UVA Radiation, Chapter2, Praeger Publishers, New York, 1986

44. WMO/UNEP Scientific assessment of ozone depletion: 1994, WMO global ozone research and monitoring report no. 37.

45. Zepp R.G., T. VCallaghan and D.J. Erickson, "Effects of increased solar ultraviolet radiation on biogeochemical cycles", In: Environmental Effects of Depletion: 1994 assessment. Ambio, 24, 181-187.

Table 2: Radiation Amplification Factor (RAF) of selected biologic action spectra (30° SZA, 2.7mm Ozone) and correlation coefficient R^2 between UV-meter reading and biologic effect. (Morys and Berger, 1993)

Action Spectrum	RAF	R^2 vs UV-Bio-meter	R^2 vs RB meter
Typhimurium Killing	2.65	0.944	0,913
DNA Break	1.26	0.9990	0.9909
Erythema	1.24	0.9993	0.9913
DNA-Protein Crosslinks	1.07	0.9988	0.9969
UV-Biometer	1.03		0.995
RB Meter	0.77	0.995	
Phytoplankton Photoinhibition	0.70	0.981	0.9957
Polychromatic Action Spectrum For Higher Plants	0.47	0.965	0.9833

Table: 3 Three Months Weather Summary of the Indian Antarctic Station Maitri (1999).

Blizzard	Temperature (^0C)	Sky condition	Weather	History of blizzards (Wind speed >= 23Kts)
October, 1999				
a) No. of blizzards: 02 b) No. of days with blizzard: 05 c) Longest duration (hrs): 50	a) Average: -12.9 b) Highest/dt: -03.0/21st c) Lowest/dt: -25.4/1st d) Av. Max: -09.8 e) Av. Min: -17.1	a) No. of days with clear sky : 15 b) No. of days with obscured sky: 02 c) Overcast days: 05	a) Snowfall days (S/F): 06 b) Month total S/F: 039.1mm c) Cumulative Yearly S/F: 269.0mm d) No. of days with fog : 00 e) Special phenomena with date: Aurora 11th, 12th	1) Commencement: 1st/1905 hr Cessation: 2nd/0500 hr 2) Commencement: 18th/1800 hr Cessation: 20th/2340 hr
November, 1999				
a) No. of blizzards: 00 b) No. of days with blizzard: 00 c) Longest duration (hrs): 00	a) Average: -05.4 b) Highest/dt: 04.0/9th c) Lowest/dt: -14.3/1st d) Av. Max: -02.9 e) Av. Min: -08.7	a) No. of days with clear sky: 15 b) No. of days with obscured sky: 00 c) Overcast days: 06	a) Snowfall days (S/F): 02 b) Months total S/F: Trace c) Cumulative Yearly S/F: 269.0mm d) No. of days with fog : 01	Nil
December, 1999				
a) No. of blizzards : 01 b) No. of days with blizzard: 02 c) Longest duration (hrs): 21	a) Average: 0^0 b) Highest/dt : 04.5/24th c) Lowest/dt: -11.6/5th d) Av. max: 0° Av. min. 0°	a) No. of days with clear sky: 08 b) No. of days with obscured sky: 00 c) Overcast days: 09	a) Snowfall days (S/F): 10 b) Month total S/F: 004.7mm c) Cumulative Yearly S/F: 273.7mm d) No. of days with fog: 00	1) Commencement: 20th/0430 hr Cessation: 21st/0100 hr

Source: Winter Team (IMD) Members of the 18th Indian Scientific Expedition to Antarctica