Eleventh Indian Expedition to Antarctica, Scientific Report, 1995
Department of Ocean Development, Technical Publication No. 9, pp. 103-113

HF Communication Between India-Antarctica During 1992, and its Dependence on a) Geomagnetic Activity, b) Season

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Abstract

Observations made at the Indian station Maitri in East Antarctica during the period spanning between July 1992 and January 1993, reveal that the state of HF communication between India and Antarctica is greatly dependent on the electromagnetic state of Earth's environment (as depicted by magnetograms). It is noticed that the radio signal intensity is also dependent on season. Present work reports on some of these observations.

Introduction

A high frequency (HF) radio link has been operating between India and Antarctica right since 1984, the very first year of wintering at Dakshin Gangotri (DG with geographic coordinates 70°05'S:12°00'E). The same has been continued from the present station Maitri (MAI with geographic coordinates 70°46'S: 11 °45'E) since 1989.During 1992, the radio frequencies used between Maitri and Delhi (DEL with geographic coordinates 28°42'N:77°20'E) were 16.94 MHz and 14.450 MHz. The link was regularly operated by the Indian avy for a few hours centred around noon every day at MAI. Over the period July 1992 to January 1993, the Indian Institute of Geomagnetism in collaboration with the Indian Navy, kept a close watch on the state of this HF radio link in terms of amplitude and quality of radio signal between MAI-DEL, in both the forward and reverse directions. These observations were compared with the magnetograms recorded at MAI.

Relationship between magnetograms and state of India-Antarctica HF link

The HF communication link between Maitri and Delhi was generally operated everyday between 10 UT and 15 UT. During this period was built up satisfactorily, the electron density in the F region of ionosphere which supports HF communication. Since the distance between Delhi and Maitri i s over 10,000 km, the chances are remote that this HF link operated in one-hop reflection mode. It is likely that a two-hop propagation takes place as shown in Fig 1, and on occasions there could even be a three-hop mode (Saveskie, 1980). Recording of the geomagnetic elements X (component in the north-south direction), Y (component in the east-west direction) and Z (component in the vertical direction) at MAI, was carried out by means of a Fluxgate Magnetometer. For the daily variation (DV) records, the Riken-Denshi Speedex Chart recorder was run at a speed of 3cm/hr. The sensitivity of the recorder was changed from a value of 10 Volts Full Scale Deflection (FSD) to over 40 Volts FSD depending on the degree of geomagnetic disturbance. A block diagram of the experimental set- up is shown in Fig 2.

The HF radio signal intensity has been assigned index values of 1,2,3,4 and 5 in conformity with the classification described by Saveskie (1980). In this categorisation -

Index 1 represents Very poor communication

Index 2 represents Poor communication

Index 3 represents Fair communication

Index 4 represents Good communication

Index 5 represents Very good communication.

Very often the HF radio link between MAI -DEL could not be established at the planned hour of 10 UT and delays of 1 to 2 hours or even more could occur by the time the communication was established. The characteristics of both, the signal intensity and time of onset of communication, were found to be well related to the degree of geomagnetic activity seen on magnetograms being obtained simultaneously at Maitri.

Looking at a sample magnetogram, that of 17 August 1992 (Fig 3), it is seen that the day was magnetically quiet with dKp = 8_0. Kp is a three hourly index of planetary magnetic activity published regularly by the IUGG from Gottingen in Germany, and dKp represents the sum of eight 3-hourly Kp values for any day. A value of dKp less than 10 would represent very quiet conditions, while a value exceeding 20 would represent disturbed conditions, Fig 3 shows that the X,Y and Z traces of the magpetogram for 17 August 1992 are extremely

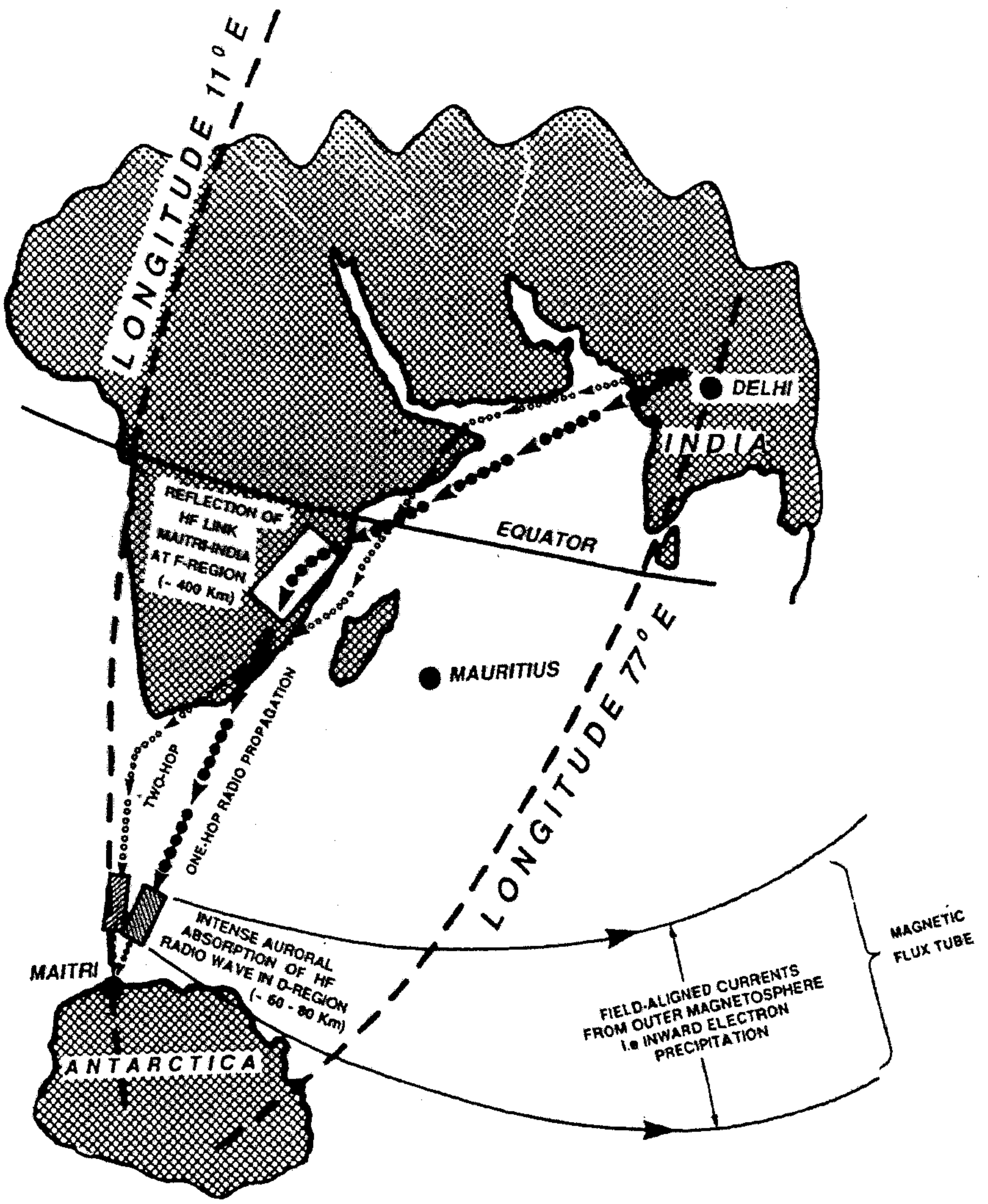

Fig 1:Sketch showing usual two hop (small Open circles) and rare one hop(large full dots) propagation path for HF communication between Maitri and Delhi

calm between 05 UT and 20 UT. On this day the HF radio link between Maitri and India was very good with an almost constant signal streagth index of 3. Contact could be maintained over the time interval marked by arrows on the magnetogram i.e. 10 to 14 UT.

In contrast to above picture. Fig 4 shows the magnetogram for a very disturbed day of the same month, the 5th of August 1992, with dKp = 33-. The

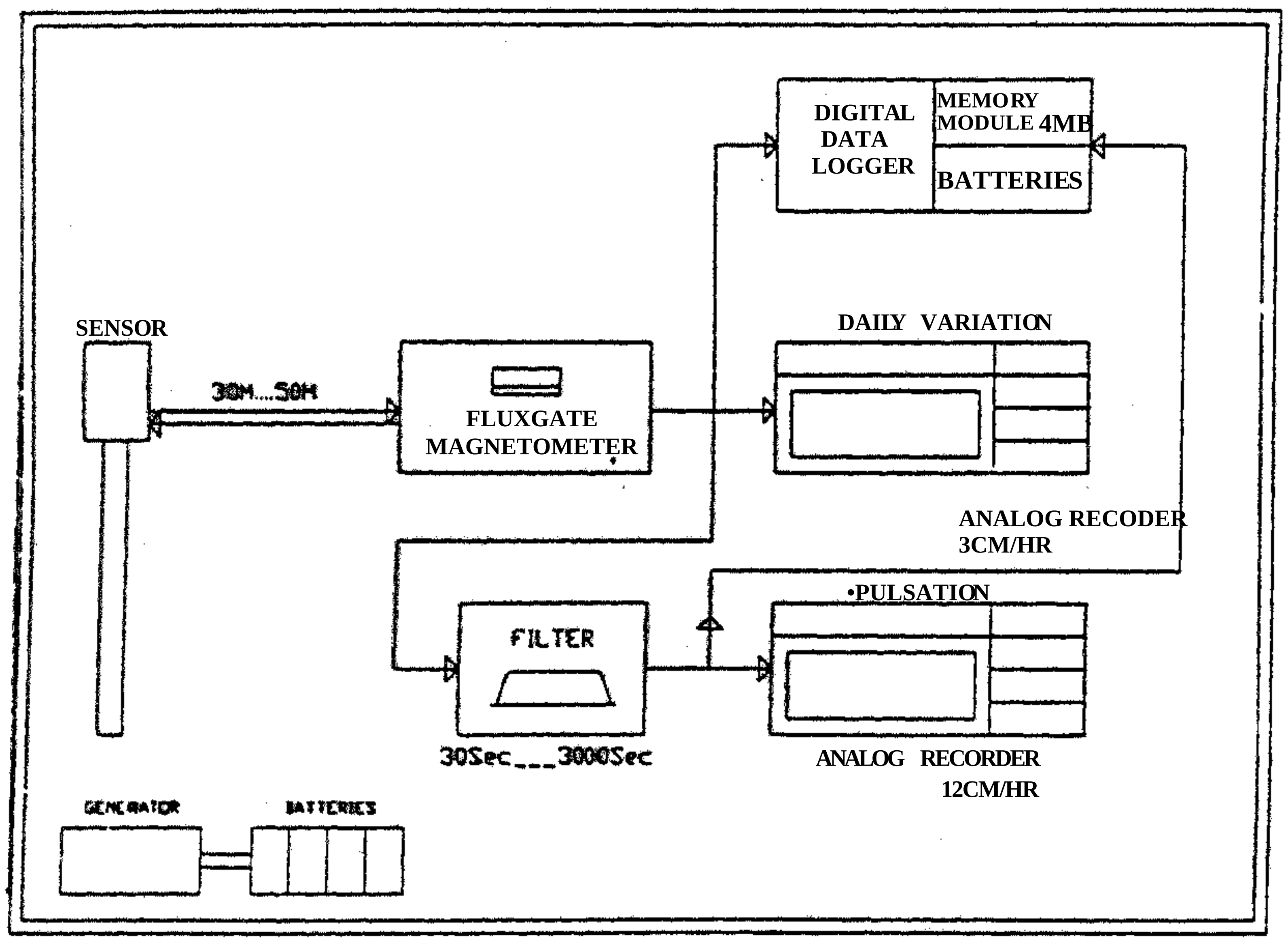

Fig 2 : Block diagram of the fluxgate magnetometer set-up used at Maitri.

highly disturbed nature of X,Y,Z traces indicate that a geomagnetic storm was in progress on that day. Not only is the amplitude of the variations large, but superposed on this are a number of short period magnetic pulsations. As a consequence of this disturbed state of electromagnetic environment of the Earth, the ionosphere would also be in a very disturbed state, notably in the auroral regions. On this day the HF radio contact from Maitri to India could not be established till 1330 UT whereafter it lasted for a very brief period of 20 minutes during which the signal strength index varied between 0 and 1.

The above two examples demonstrate how the state of geomagnetic field variations in a sense can almost predict the state of HF communication between India and Antarctica on a particular day. Several examples of such correlations exist for the observed year 1992.

Variation of the state of HF radio link with season

The observations on HF radio signal intensity over July 1992 to January 1993 suggest that it showed clear response to season . In order to check this the percentage of days for each month was plotted along with the indices of signal intensity 1-2, 2, 2-3 and higher. This is presented in Fig 5 as bar diagram. The upper part of Fig 5 shows the percentage of days with different indices of signal

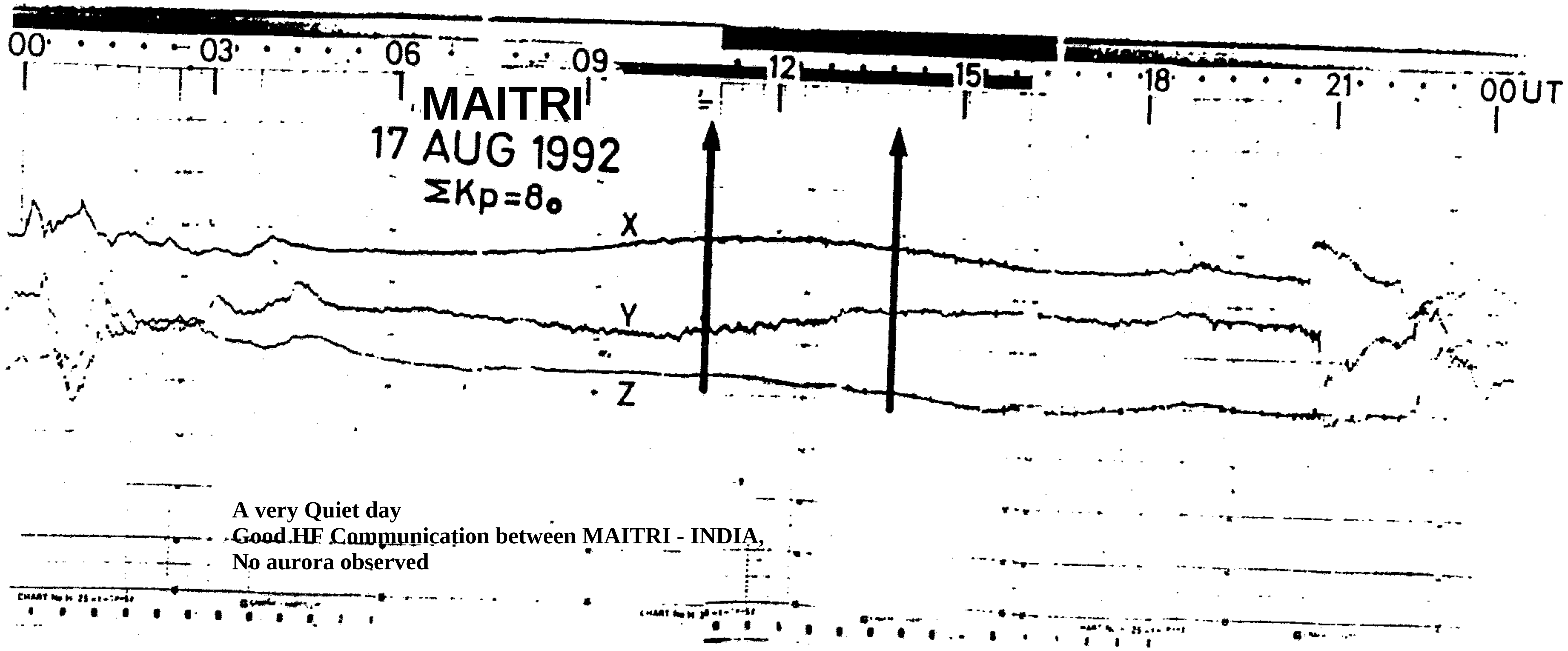

Fig 3 : Traces of X Y and Z geomagnetic components on a magnetically quiet day (17 Aug 1992) at Maitri.

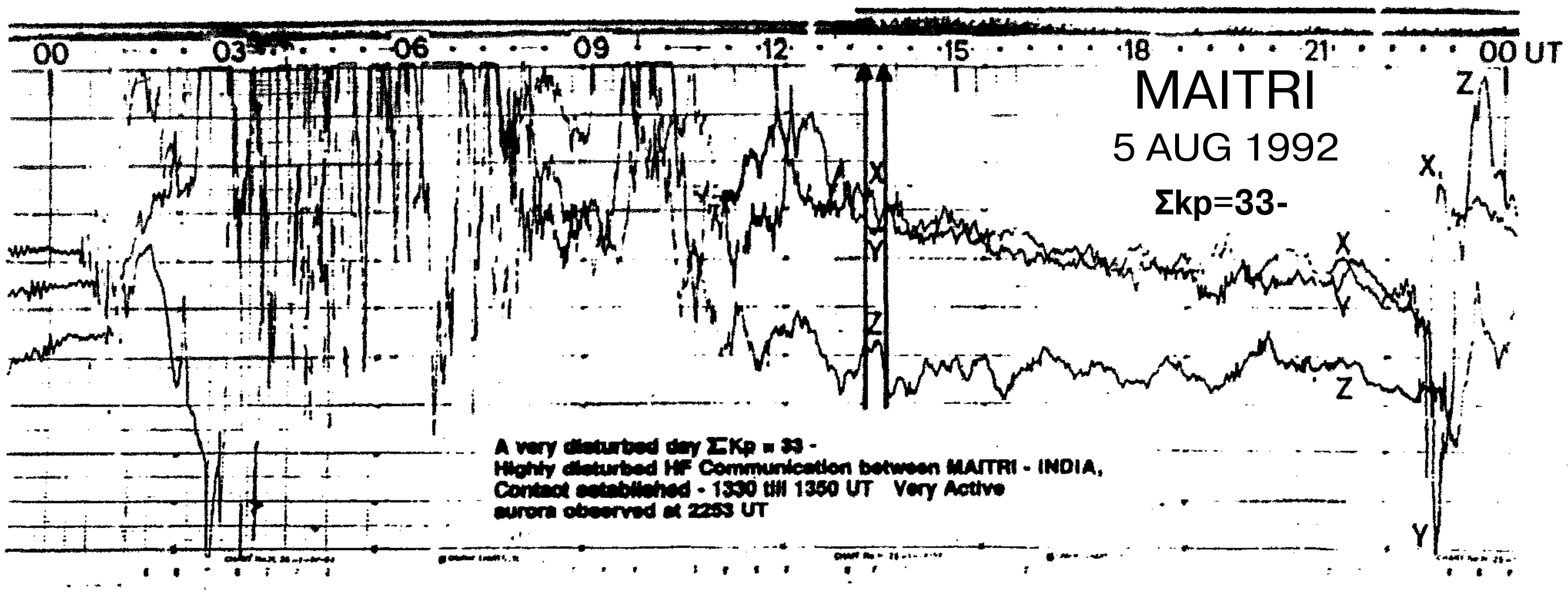

Fig 4 : Traces of X, Y and Z components on a magnetically disturbed day (5 Aug 1992) at Maitri.

intensity of HF from Maitri to Delhi. The lower part shows the same for signals received at Maitri from Delhi. Fig 5 clearly shows a decrease in the height of bar representing very poor to poor reception, from July 1992 to January 1993 i .e. from austral winter to austral summer. Keeping in step with this observation, the bar height representing good to very good signal intensity steadily increases from July 1992 to January 1993, These features are more distinct for the transmitted signal than for the received signal

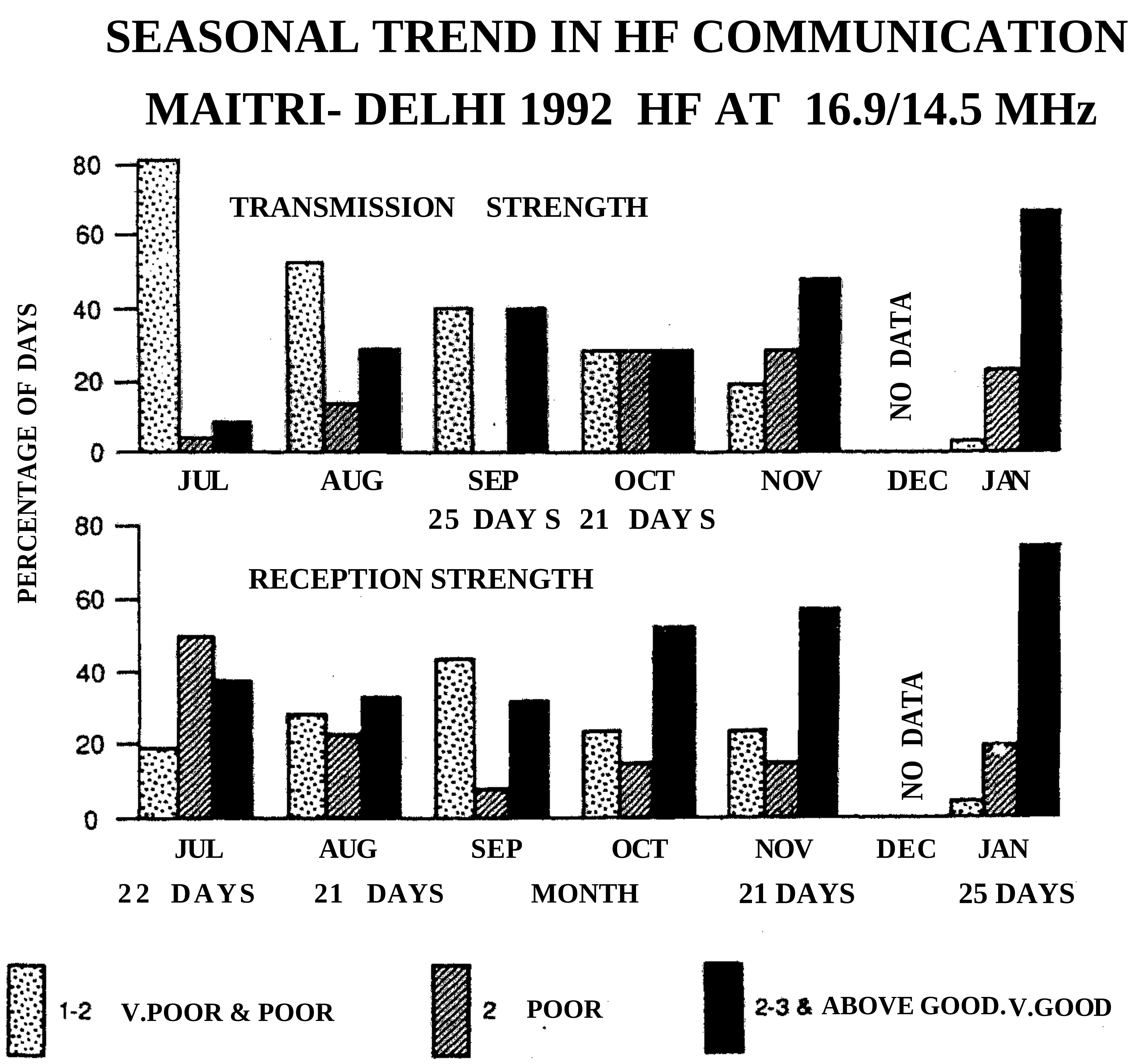

Fig 5: Seasonal trend as noted in HF communication at 16.9/14.5 MHz between Maitri and Delhi during 1992;

Discussion

Effect of magnetic disturbance on MAI - DEL HF radio link

The perturbing effect of ionosphere on HF communication is known to occur all over the globe, particularly near the auroral zones (Ratcliffe, 1970). A diagram (Fig 6 from Ratcliffe, 1970) illustrates how unsuitable ionospheric conditions in auroral regions resulted in longer loss of radio communication between London and Montreal when the radio waves travelled through the shorter, direct auroral path, than when they travelled by a longer relay path through low latitudes.

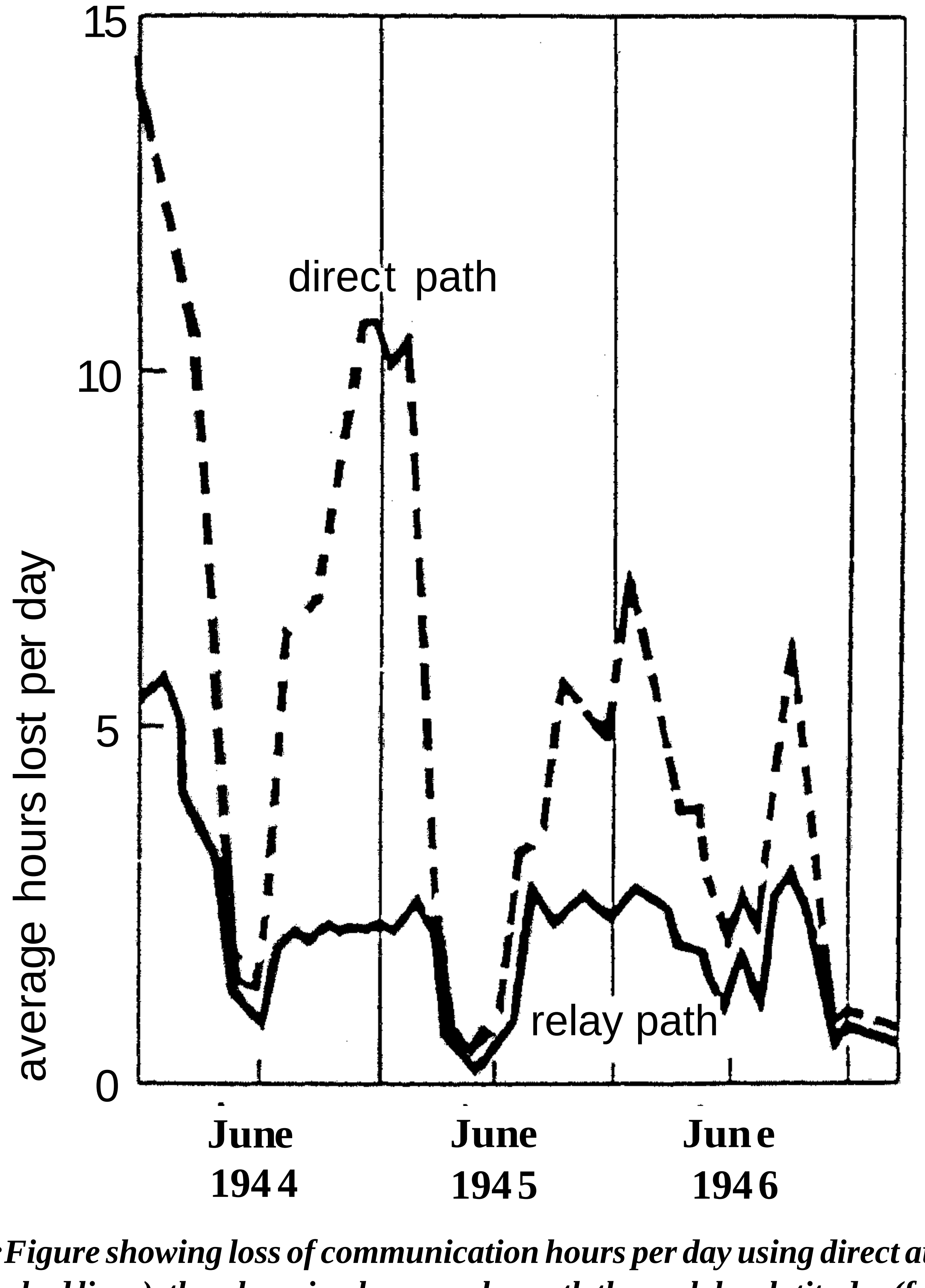

Fig 6:Figure showing loss of communication hours per day using direct auroral path (dashed lines). than by using longer relay path through low latitudes (full lines).

Radio communication disturbance usually takes the form of a Sudden ionospheric Disturbance (SID) or a Short Wave Fade out (SWF). Both these effects are due to a sharp increase in ionisation of the D region which is located at an altitude of roughly 60 to 90 km. This increase in D region electrons is now recognised to occur because of increased electron precipitation in the auroral ionosphere. During magnetically disturbed conditions, intense field aligned currents flow so as to link ionosphere and the distant magnetosphere.The precipitation of electrons increases the ionisation in the auroral ionosphere and causes secondary ionisation within the ionosphere. The net result is a rapid increase of electron concentration in the D region auroral ionosphere.

The concentration of extra electrons results in their repeated collision with radio wave in the D region thereby releasing energy. The situation is illustrated in Fig 1. The absorption of radio waves takes place in case of both the incoming and outgoing signals between Maitri and Delhi. While most of the HF radio wave absorption is confined to auroral region, there are other worldwide

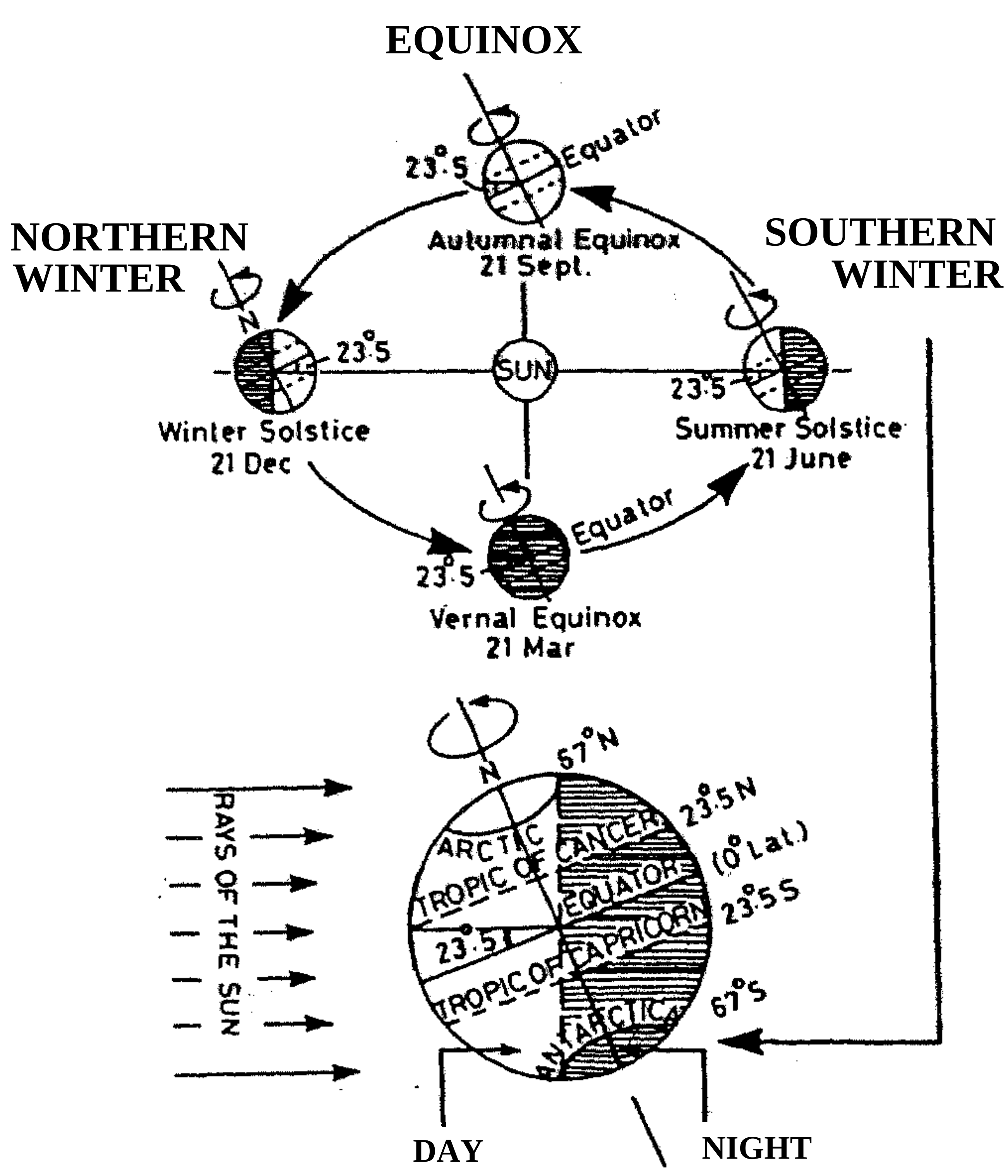

Fig 7: Differential summer-winter solar UV radiation affecting the global hemispheres.

changes which result in the weakening of ionospheric radio propagation. F region ionisation is known to decrease at most latitudes of Earth during a geomagnetic disturbance. If this reduction in F region ionisation were to occur at points of reflection of the HF radio link shown in Fig 1, it is quite possible for the HF signal to get weakened. This would explain why signal intensity is greatly reduced during magnetically disturbed conditions.

Seasonal effects on MAI – DEL HF radio link

Fig 5 clearly shows a tendency for the HF radio signal strength index to increase towards good conditions with approach of Antarctic summer. The cause for this lies in increased F region ionisation at the reflection point of HF radio link. Fig 1 shows that for a 2 - hop propagation mode, the first reflection of the radio wave transmitted from Maitri occurs at mid-latitudes while the second reflection occurs at low-latitudes. While the former is dependent on summer or winter weather conditions, latter is not greatly affected by seasonal variations. The lower part of Fig 7 shows the situation for June solstice. At the southern hemisphere a marked seasonal change takes place from southern hemisphere winter during June solstice to southern hemisphere summer during December solstice. This means the atmosphere over Maitri experiences short duration solar UV illumination and longer hours of its absence in June-July Solar UV in the spectral band of 796 A -1027 A is directly responsible for the formation of F region of ionosphere which explains why reflection of radio waves giving rise to better communication between MAI and DEL improved from July 1992 to January 1993 i.e. with the approach of southern hemisphere summer conditions.

Conclusion

It is clear from above discussion that the strength of HF radio signal between India and Maitri systematically increases from Antarctic winter months of June-July towards Antarctic summer months of December-January. A few other salient features noticed are -

1) During the southern summer months of November, December and January MAI-DEL HF radio contact is established as soon as the operator switches on the receiver at 1000 UT. During southern winter months, however, contact is seldom established before 1130 UT. This change-over occurs gradually during equinoxial months of March-April and September-October.

2) Magnetically disturbed conditions at Maitri can persist for two or more days; on such days the possibility of establishing radio contact between India and Antarctica becomes almost nil. When the magnetogram traces show a

return to conditions of magnetic calm, there is a steady improvement in the quality of HF radio link between these places.

3) A sub-storm is a magnetic disturbance of 2-3 hours which is a night time characteristic of auroral regions. The occurrence of such sub-storms during night at Maitri can, on occasions, cause a delay in establishing contact between India and Maitri, the following day.

Acknowledgement

Thanks are due to the communication personnel of Indian Navy especially to Lt Cdr MS.Prakash for extending all cooperation to one of the authors (KJ) at Maitri station during the austral winter of 1992. The study was possible because of the facilities and opportunity provided by the Department of Ocean Development, New Delhi.

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