Eighteenth Indian Expediton to Antarctica. Scientific Report 2002
Department of Ocean Development. Technical Publication No. 16 pp 51-58

ELF-VLF emissions observed on the Ground at Maitri, Antarctica

Sushil Kumar*, Sunil K. Singh** and A. K. Gwal**
* Department of Physics, Faculty of Science, Agra College,
Agra-282 002
**Space Science Laboratory, Institute of Physics & Electronics,
Barkatullah University, Bhopal-462 026

Abstract

Ground based observations of extremely low frequency (ELF) and very low frequency (VLF) emissions, at the Indian station Maitri in Antarctica have been reported here. The ELF-VLF recording experiment was successfully installed during the 18^{th} Indian Scientific Expedition to Antarctica (ISEA) and observations were carried out during the Jan-Feb., 1999 using the T-type antenna installed during the 17^{th} ISEA. The spectrograms of analyzed data have revealed the occurrence of various events like, discrete chorus emissions, emissions of rising type, falling emissions of hook type, multiple emissions, periodic and quasi-periodic emissions.

Introduction

The wave and wave particle interactions occurring in the magnetosphere generate a wide variety of emissions in the ELF-VLF range. The ELF-VLF emissions are basically a mid- and high-latitude phenomena. These emissions over the past decade have become a very important diagnostic tool for proving the plasmasphere and beyond. These emissions although less well understood than whistlers are believed to nave origin in the ionosphere-magnetosphere coupled system and may be due to plasma instabilities or in-situ electromagnetic radiation from high energy particles. Helliwell (1965) has classified these emissions in to hiss, chorus, hook, periodic, quasi-periodic and triggered emissions etc. The group of ELF-VLF emissions is further divided into two groups: (I) continuous emissions in both the time and frequency which tend to maintain a study state such as hiss, resonance bands, noise band near the ion-cyclotron frequency, (II) discrete emissions often with periodic and quasi-periodic nature. An extensive survey of whistler and VLF phenomena was carried immediately following the International Geophysical Year (IGY) 1957-58 with some more 50 monitoring stations extending from equator to poles. It soon became clear that Antarctica is an ideal place for VLF research. Further favorable factors in Antarctica include low levels of both man made and natural electromagnetic noise. In 1992, a well-calibrated long term

ELF/VLF monitoring equipment called VELOX (Smith, 1995) was set up at Helley, and few of results from this experiment have been reported by Smith and Jenkins (1998). Periodic and quasi-periodic emissions, chorus and various other transient discrete emissions such as VLF risers, falters and hooks have been reported at Antarctica (Morrison et al., 1994. Smith et al.. 1998, Smith and Nunn, 1998). Smith et al. (1998) have reported periodic and quasi-periodic ELF-VLF emissions observed at Halley and south pole stations which lie approximately in the same meridian and geomagnetic latitude of 61° and 74° respectively.

In this report, we present some events of ELF-VLF emissions observed at lndianAntarcticgroundwavestation Maitri (70°46'S, 11° 44'E) duhngJan-Feb. 1999 as a summer part of the 18th Indian Scientific Expedition to Antarctica.

Experimental Setup

A new ground based station was setup at Maitri, Antarctica, during the XVII expedition in the year 1998 with the same set of equipments as that required for the observations of whistlers. This consists of T-type antenna, transistorised audio frequency amplifiers and Digital Audio Tape Recorder (DAT) model PCM 300. The ELF-VLF emissions were recorded with this setup during summer part of this expedition. The emissions received, as usual by T-type antenna, were amplified by pre-amplifier kept at the bottom of the pole at which the antenna is installed. The output of the pre-amplifier was further amplified by main amplifier and recorded using the DAT on magnetic tapes. A simplified block diagram of VLF experiment is shown in Fig I. The data recorded on magnetic tapes were analyzed at Central Electronics Engineering Research Institute (CEERI), New Delhi.

Results and Discussion

The ELF/VLF emissions for decades, and have been widely used for investigating the magnetospheric processes of wave generation and propagation, wave-particle interactions, wave-induced particle precipitation and for probing of magnetospheric plasma structures and motions (Carpenter, 1978). From the detailed analysis of the data collected during the expedition, it is reported here that ELF-VLF emissions of different types such as discrete chorus emissions, periodic and quasi-periodic emissions, rising and falling emissions of hook type, rising emissions, hiss etc. frequently occur at Maitri, with a maximum occurrence of discrete chorus type emissions. In Fig. 2, we show the frequency-time spectrogram of discrete chorus emission observed on 28 January, 1999 at 0622 UT. The mean upper boundary frequency for these risers is 3 and 5 kHz. Morphological features of discrete chorus emissions throughout the magnetosphere have been investigated by several workers on ground and satellite based observations

(Hayakawa and Iwai, 1975; Nunn and Sazhin, 1991, Sazhin and Hayakawa, 1992). The spectra in Fig, 3 shows unusual rising emissions recorded on 20 January 1999 in the frequency range 2.5-4.2 kHz. The noise below 1.7 kHz is due to instrument which has been found to occur in our all records. In Fig. 4 we present an example of discrete emissions between frequency range of 4.0-5.5 kHz observed on 20 January 1999 at 1420 UT. An interesting feature of these emissions is that they show hooks near their upper and lower cut-off frequencies. The hook emissions are known to be caused by wave particle interactions between up-and down-going energetic electrons and whistler mode waves along the field lines near the magnetic equator at higher L shells (L>2) hence are generally observed at high latitudes. Shown in Fig.5, is a type of periodic emission (PE) observed on 7 February 1999 at 1315 UT. Many other events of PE and quasi-periodic (QP) emissions in the ELF-VLF data recorded during this expedition have been detected. QP VLF emissions are basically a predominantly daytime phenomena. QP emissions were further classified into type I coincident to geomagnetic pulsations and type [1 not correlated with geomagnetic pulsations (Sato et al., 1974).The events which are closely correlated with coincident geomagnetic pulsations (type I) are likely to be caused by quasi-periodic fluctuations in the resonant conditions at ELF/VLF wave generation region governed by magnetic field oscillations. (Kimura 1974). Sazhin and Hayakawa (1994) have reviewed the subject on PE and QP emissions. Smith et al. (1998) have reported the PEs and QPs observed at an array of Antarctic Stations. They have further examined the different possibilities of their generations. The detailed study of the ELF-VLF emissions observed during this expedition, their associations with storms and substorms, geomagnetic pulsations, and their interactions is in progress which may put light on the many questions on the nature of PEs and QPs and their relationships to substorms and magnetic pulsations.

Acknowledgements

This project has been funded by the Department of Ocean Development (DOD), Govt. of India, New Delhi, and we gratefully acknowledge the help and support of the various officials of this department, We thank Mr. Ajay Dhar, Leader, 18th ISEA, logistic team and expedition members who provided us all help in transportation and installation of the equipments at Maitri.

References

Carpenter D. L, Rev. Geophys., 26, 535,1978.

Helliwell R. A., Whistlers and Related Ionospheric Phenomena, Stanford Univ. Press, California, 1965.

Hayakawa M, and Iwai A., J. Atmos. Terr. Phys., 39, 1211,1975.

Kimura I, Space Sci. Rev., 16,398,1974.

Morrison K., Engebretson M. J,, Beck J. R., Johnson J. E., Arnold R. L., Cahilljr. L J., Carpenter D. L. Ann. Geophys. 12, 139,1994.

Nimn D., and Sazhin S. S., Ann. Geophys., 9,603,1991.

Sato N., Hayashi k., Kokubun S., Oggati T., and Fukunishi H., J. Atmos. Terr. Phys., 3 1515,1974.

Sazhin S. S., and Hayakawa M., Planet Space Sci., 40,681,1992.

Sazhin S. S., Hayakawa M., J. Atmos. Terr. Phys., 56,735,1994.

Smith A. J., Engebretson M. J., Klatt E. M., Inan U. S., Arnoldy R. I. and Fukunishi h., J. Geophys. Res., 103,23,611,1998.

Smith A. J., and Nunn D., J. Geophys. Res., 103,6771,1998.

Smith A. J., J. Atmos. Terr. Phys., 57,507, 1995.

Smith A. J. and Jenkins P. J., J. Atmos. Terr. Phys., 60,263-277,1998.

Figure Captions

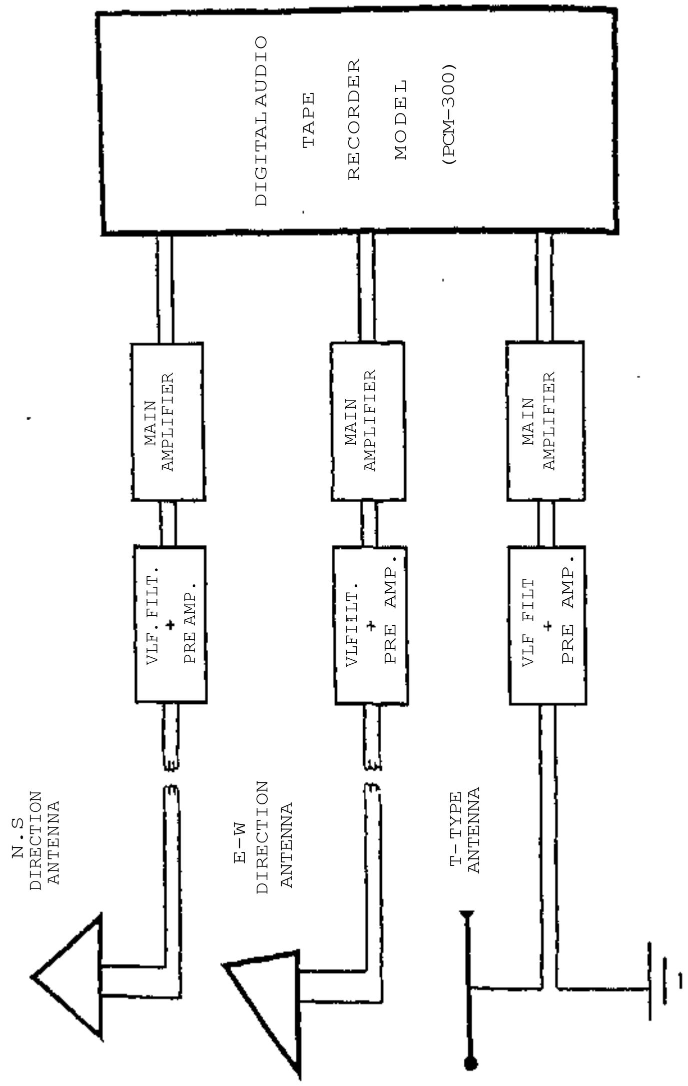
Fig. 1.. Block diagram of experimental set up For ELF-VLF recording at Indian Antarctic Station Maitri.

Fig.2. Spectrogram oF discrete chorus emissions observed at Maitri on 28 January 1999 at 0622 UT.

Fig.3. An example of rising emissions recorded at Maitri on 20 January 1999 at 1210UT

Fig.4. Discrete Falling emissions oFhook type recorded at Maitri on 20 January 1999 at 1420 U T

Fig. 5. Spectrogram of periodic emission observed at Maitri on 7 February 1999 at 13I5UT.


DIGITAL AUDIO TAPE RECORDER MODEL (PCM-300)
MAIN AMPLIFIER
MAIN AMPLIFIER
MAIN AMPLIFIER
VLF. FILT. + PRE AMP.
VLF FIILT. + PRE AMP.
VLF FILT + PRE AMP.
N.S DIRECTION ANTENNA
E-W DIRECTION ANTENNA
T-TYPE ANTENNA

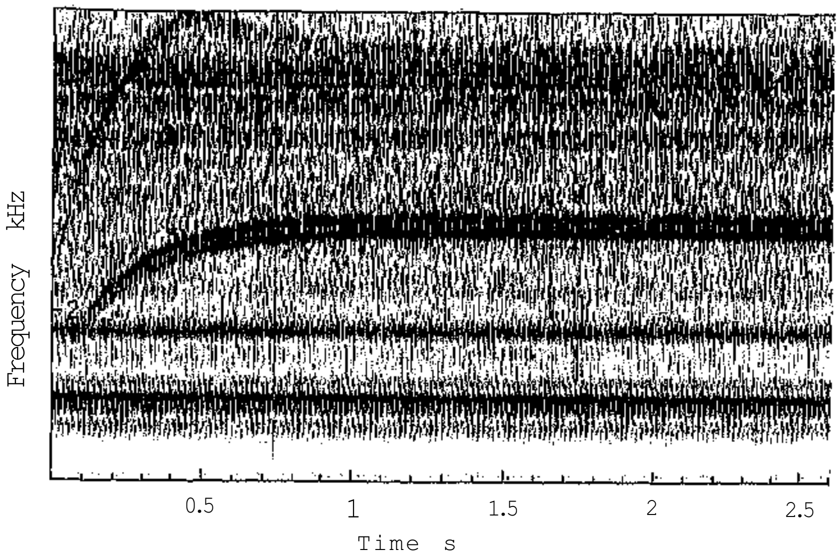

Frequency kHz
2
0.5
1
1.5
2
2.5
Time s

Fig. 2

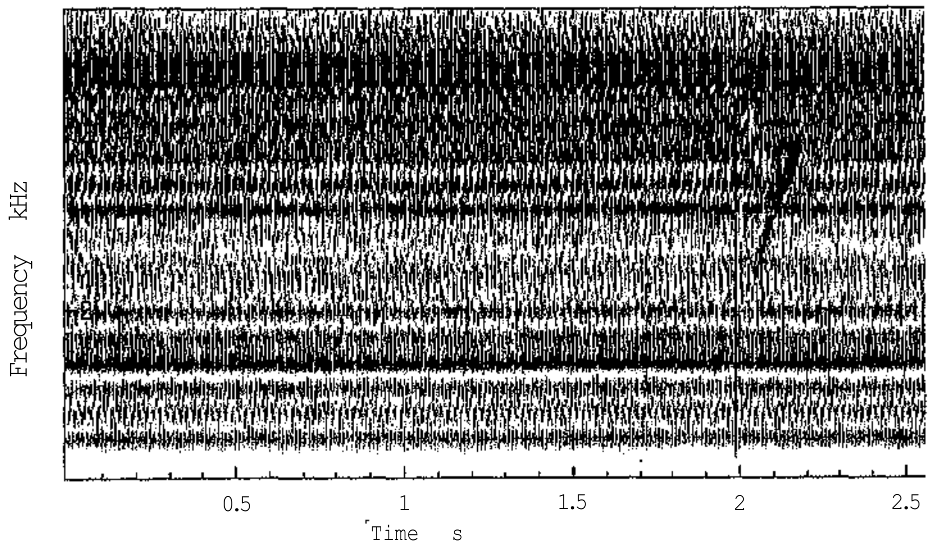

Frequency kHz
2
0.5
1
1.5
2
2.5
Time s

Fig. 3

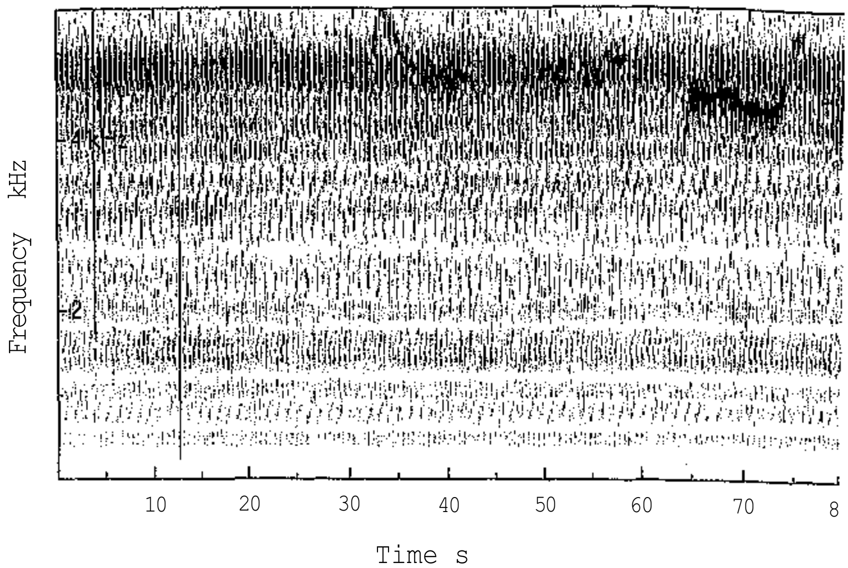

Frequency kHz
2
10
20
30
40
50
60
70
8
Time s

Fig. 4

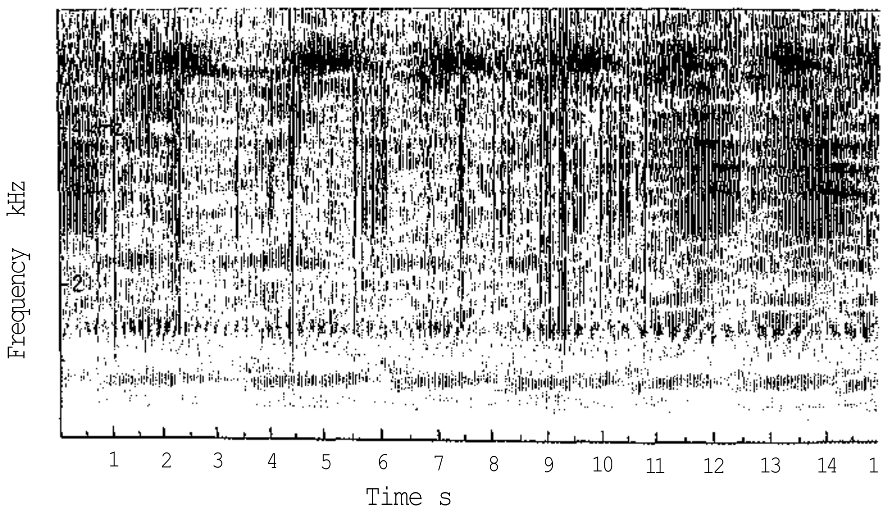

Frequency kHz
2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1
Time s

Fig. 5