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TÍTULO: NIGHT TIME IONIZATION BY CHARGED PARTICLE PRECIPITATION IN BRAZILIAN GEOMAGNETIC ANOMALY

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NIGHT TIME IONIZATION BY CHARGED PARTICLE PRECIPITATION IN BRAZILIAN GEOMAGNETIC ANOMALY

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INTRODUCTION

The detection of trapped radiation at low altitudes in the region of the Brazilian geomagnetic anomaly by satellites [1,2] stimulated considerable interest in the investigation of problems concerning the interaction of these particles with the atmosphere. The presence of enhanced flux of bremsstrahlung x-rays produced by the precipitating inner belt electrons at balloon altitudes has been confirmed[3] and marked increases in their precipitation intensity has been detected during magnetic storms[4] . More recently the ionization in the lower ionosphere produced by electrons during their azimuthal drift has also been detected by a riometer during a severe magnetic storm; during this storm significant changes were also observed in VLF signals that had a part of their propagation path lying in the region of anomaly[5] . However, so far there has been no clear evidence of particle precipitation and associated ionospheric effects in magnetically quiet conditions. Thus the question as to the relative importance of the particle precipitation as an ionization source in the region of the anomaly has remained open.

In this note we present some direct evidence of the effectiveness of particle precipitation as a significant ionization source in the region of the geomagnetic anomaly even during quiet conditions. It is based on a preliminary study of night time ionograms obtained from an ionosonde (frequency range 250 KHz to 20 MHz) which started operating at Cachoeira Paulista (22.7^{o}S, 45.2^{o}W). The observations indicate an additional ionization source on almost all nights with the maximum intensity during the post midnight hours. Supporting evidence from a 30 MHz riometer observations is also presented. Some characteristic features of these ionograms during magnetically disturbed periods are also pointed.

OBSERVATIONS AND DISCUSSION

On the ionograms obtained during night hours a trace in the lower frequency band appears corresponding to reflection from a layer situated at about 90 - 95 km. The frequency range of these echoes is 300 - 600 KHz. This layer is observed almost every night and often occurs in association with sporadic E. The features which distinguish it from E_S are its lower height of occurrence (< 100 km) and its opacity. Figure 1 shows some examples of ionograms containing this layer with and without echoes from sporadic E. In Fig. 1a and b there are no echoes from sporadic E at frequencies that are reflected from this layer. In this respect this layer is reminiscent of the "night E" layer observed at subauroral latitudes at the time of auroral display. Reflections from this layer are rarely observed in the frequency range 350 KHz - 1 MHz. This could be perhaps attributed at least partly to the group retardation at the gyrofrequency which is about 700 KHz.

The frequent occurrence of sporadic E is another characteristic feature of the night-time ionograms. Typical ionograms of this type are shown in Fig. 2. The highest frequency reflected from the E_S layer generally lies in the range 3 - 4 MHz, but at times the echoes may extend to 6 - 7 MHz. A comparison with the day-time ionograms shows that in this region sporadic E occurs more frequently during night hours. This is in clear contrast to the behavior of occurrence of E_S over equatorial or low-latitude stations[7,8]. The behavior observed in our ionograms is more characteristic of auroral zone[8] and may be taken as an evidence of quiet-time precipitation of charged particles in the region of anomaly.

The observation discussed above refer to magnetically quiet conditions. The nature of these echoes changes markedly during magnetically disturbed periods and the effect is more pronounced during night hours. The echoes from the "night E layer" continues to be present and the E_S become very intense with the highest reflected frequencies extending, at times, to 10 - 12 MHz and the F layer is completely blanketed. An example of such ionograms is given in Fig. 3 corresponding to the magnetic storm of October 16, 1973. Although in previous studies[4,5] it has been inferred that the electron precipitation in the anomaly region increases during magnetic storms, these ionograms give a more clear evidence of the increase.

The electron densities present in the layer mentioned above (this could be shown to be of the order of 10^{-4} cm^{-3}) are not sufficient to cause measurable absorption changes in the 30 MHz riometer, unless there is a marked enhancement in the intensity of the precipitation. An examination of some previous riometer records indicates an increase in 30 MHz cosmic noise absorption during these hours on some occasions. Some examples of such absorption events are shown in Fig. 4. The riometer operated with two antennas, one with its beam pointing vertically and the other at an angle of 45^0 looking westward. The difference in the absorption observed on the two antennas during some of these events is a characteristic of particle precipitation having spatial nonuniformity[5] . All these records pertain to magnetically quiet conditions and are different from the absorption changes associated with magnetic field changes during the initial and main phases of a magnetic storm [5,10]. Considering that the riometer would indicate increased absorption only in those cases when the precipitating flux is considerably larger, the occurrence of these absorption events at precisely the same hours as the "night E layer" may be taken as an independent manifestation of the same phenomenon.

As mentioned above, during quiet conditions the "night E layer" occurs during mignight and post-midnight hours. Considering the fact that the layer is observed almost every night, the only source of ionization that could cause these echoes is an enhancement of the particle precipitation. In this connection it is important to note that in this region the magnetic field intensity has its diurnal minimum near midnight hours. Therefore an enhancement of particle precipitation during these hours could concievably occur due to the lowering of the mirror heights. It may be mentioned here that on the days, when noticeable absorption changes are observed in the riometer records, the absolute value of the magnetic field intensity at its minimum is unusually low; the stronger the absorption, the lower is the field intensity. It should also be pointed out that the change in the absorption would occur mainly due to changes in the electron density above the E layer and, hence, a strict correspondence between the ocurrence of the "night E layer" and increased absorption can not be expected. A detailed investigation of the phenomena is possible only with further measurements of the spectrum of the trapped electrons in the inner radiation belt over the region of the anomaly.

In conclusion we believe that particle precipitation in magnetically quiet conditions at night is a significant factor in the ionization balance of the ionosphere over the geomagnetic anomaly. The higher frequency of occurrence of E_S during night hours, which is a characteristic of the auroral zones, provides an additional support for this suggestion. It is generally believed that the formation of E_S proceeds only if favored by the dynamics of the atmosphere[9] . However, in view of our observations it would appear that the ionization by particle precipitation is a significant contributing factor in the formation of E_S in this region.

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FIGURE CAPTIONS

1. Typical ionograms showing the night time low frequency trace corresponding to reflections from the layer at 90 - 95 km. The height markers are at 100 km interval in all the ionograms.

2. Ionograms showing echoes from E_S layer at night.

3. An example of an ionogram showing strong E_S layer which blanketed the F layer almost completely during the magnetic storm of October 16, 1973.

4. Some absorption events during night-hours recorded by a 30 MHz riometer using vertical and oblique antennas during magnetically quiet conditions. The absorption values are measured relative to the cosmic noise levels on the previous days.

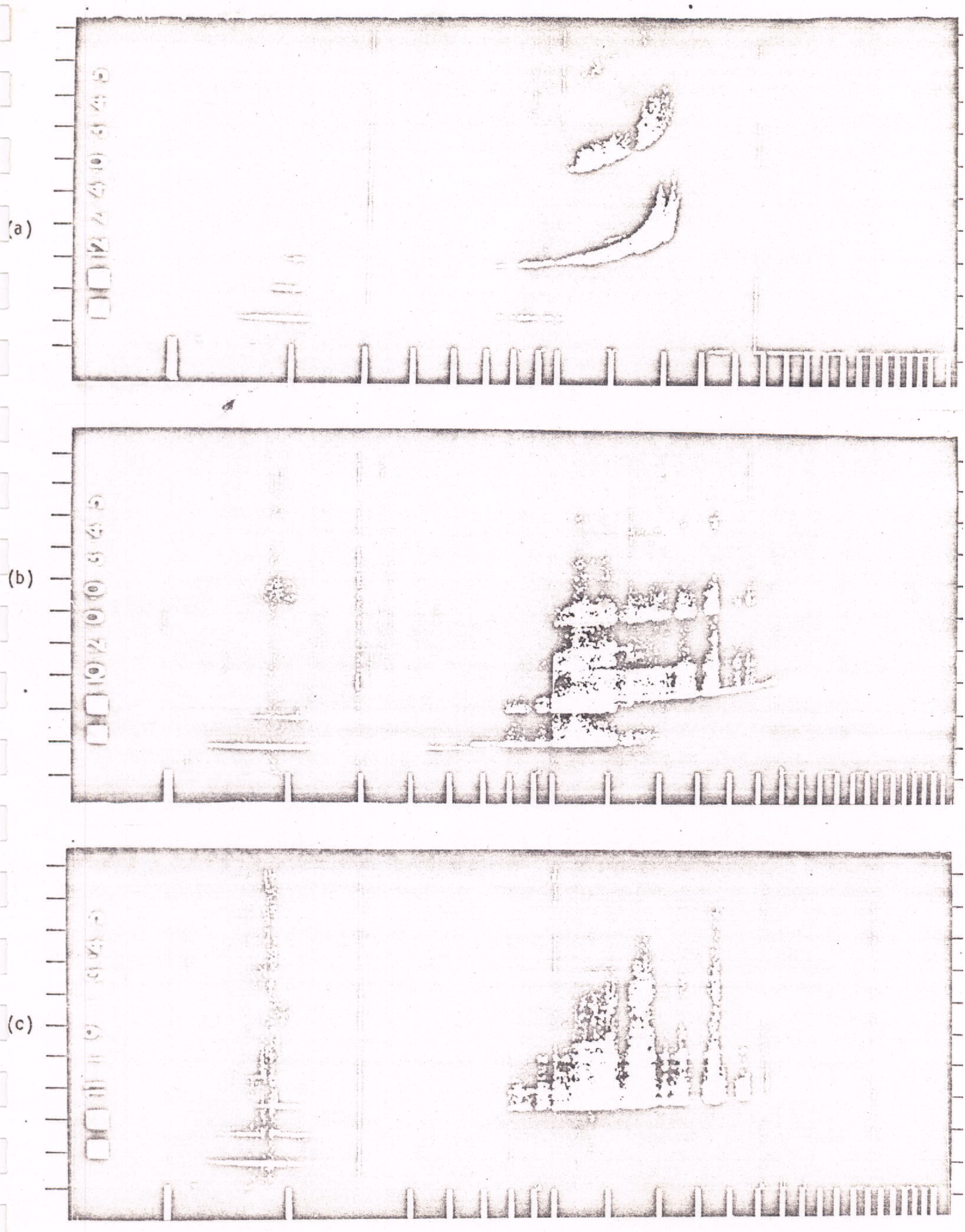


Figure 1

(a)

(b)

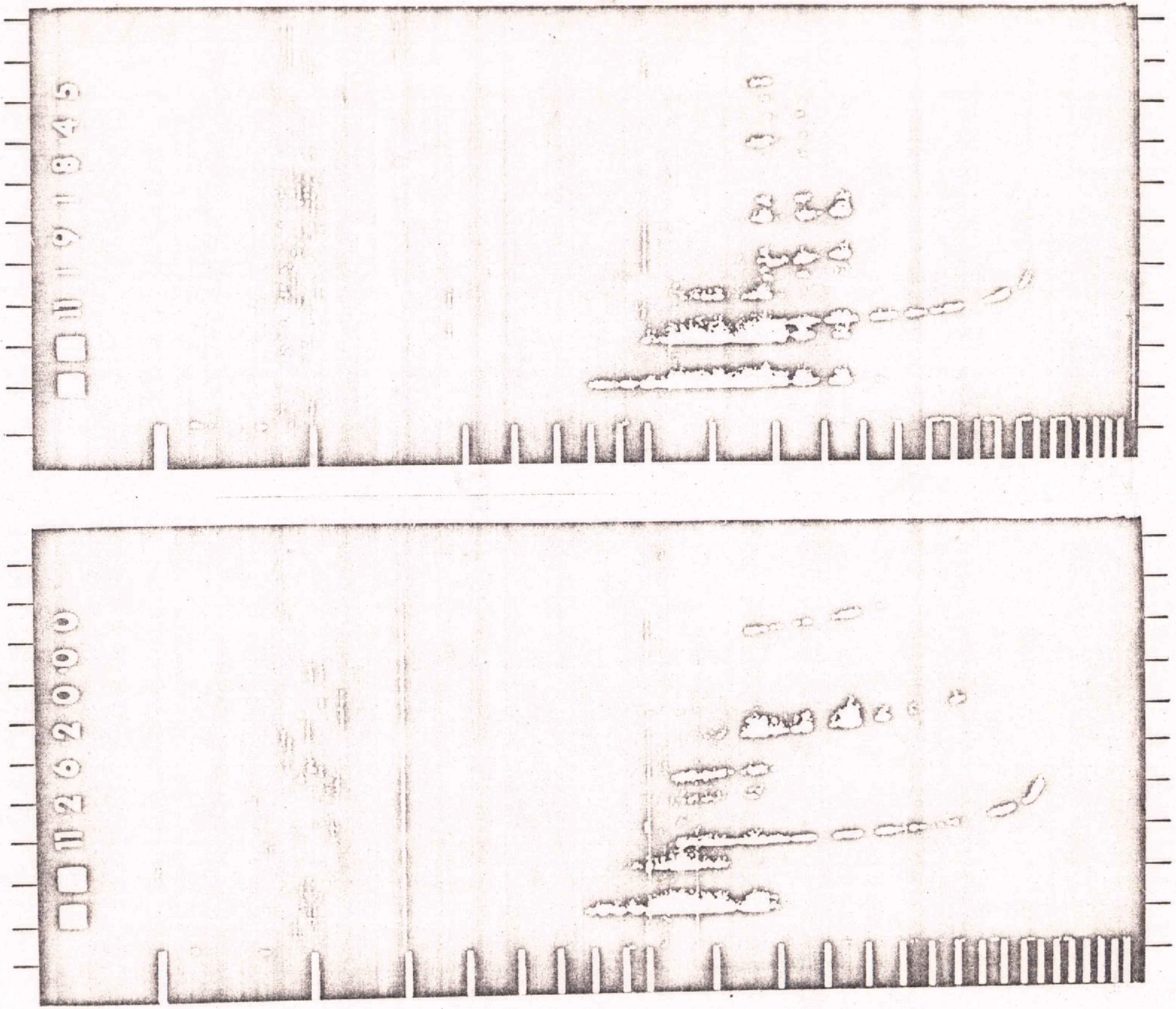


Figure 2

(a)

(b)

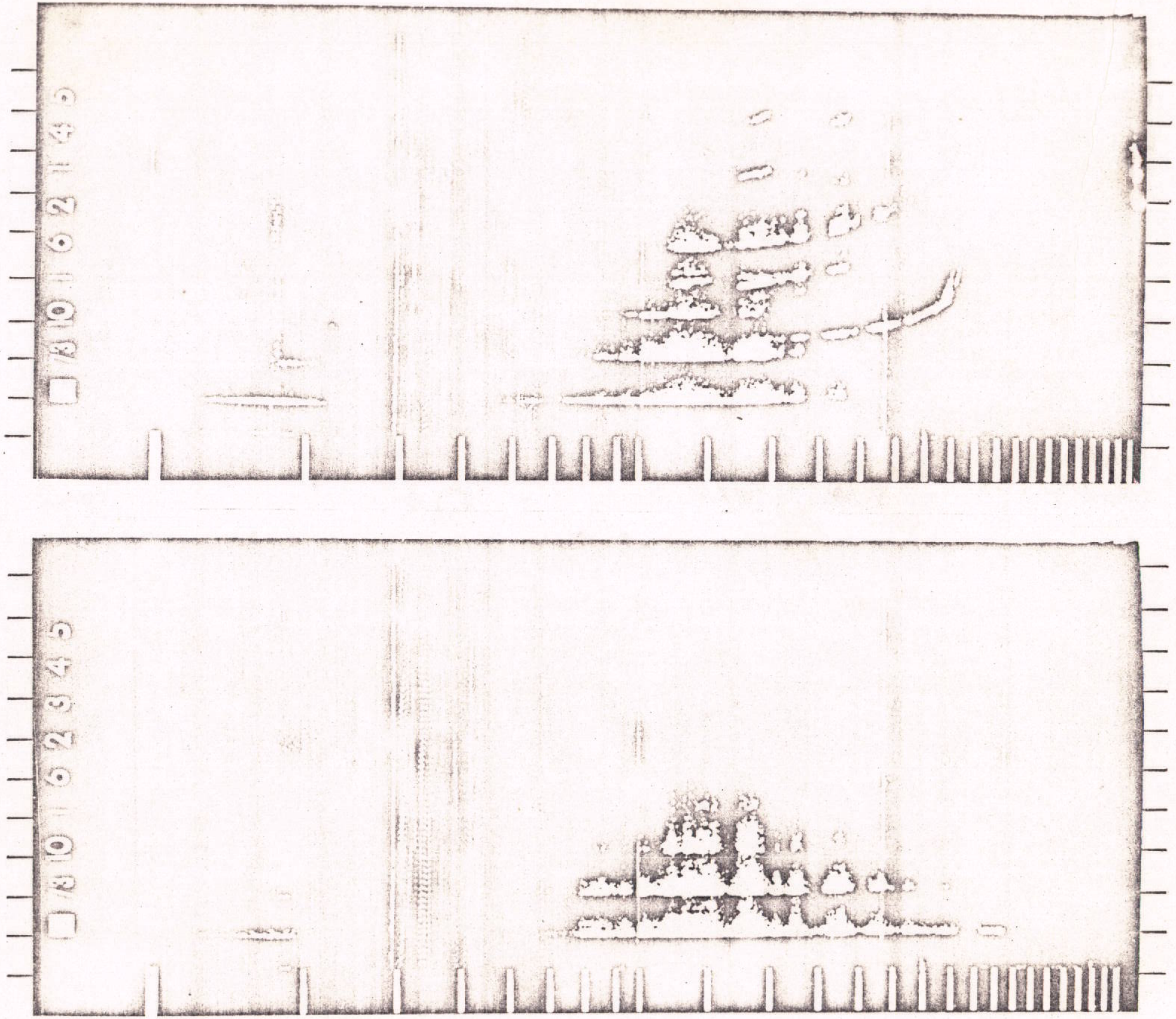
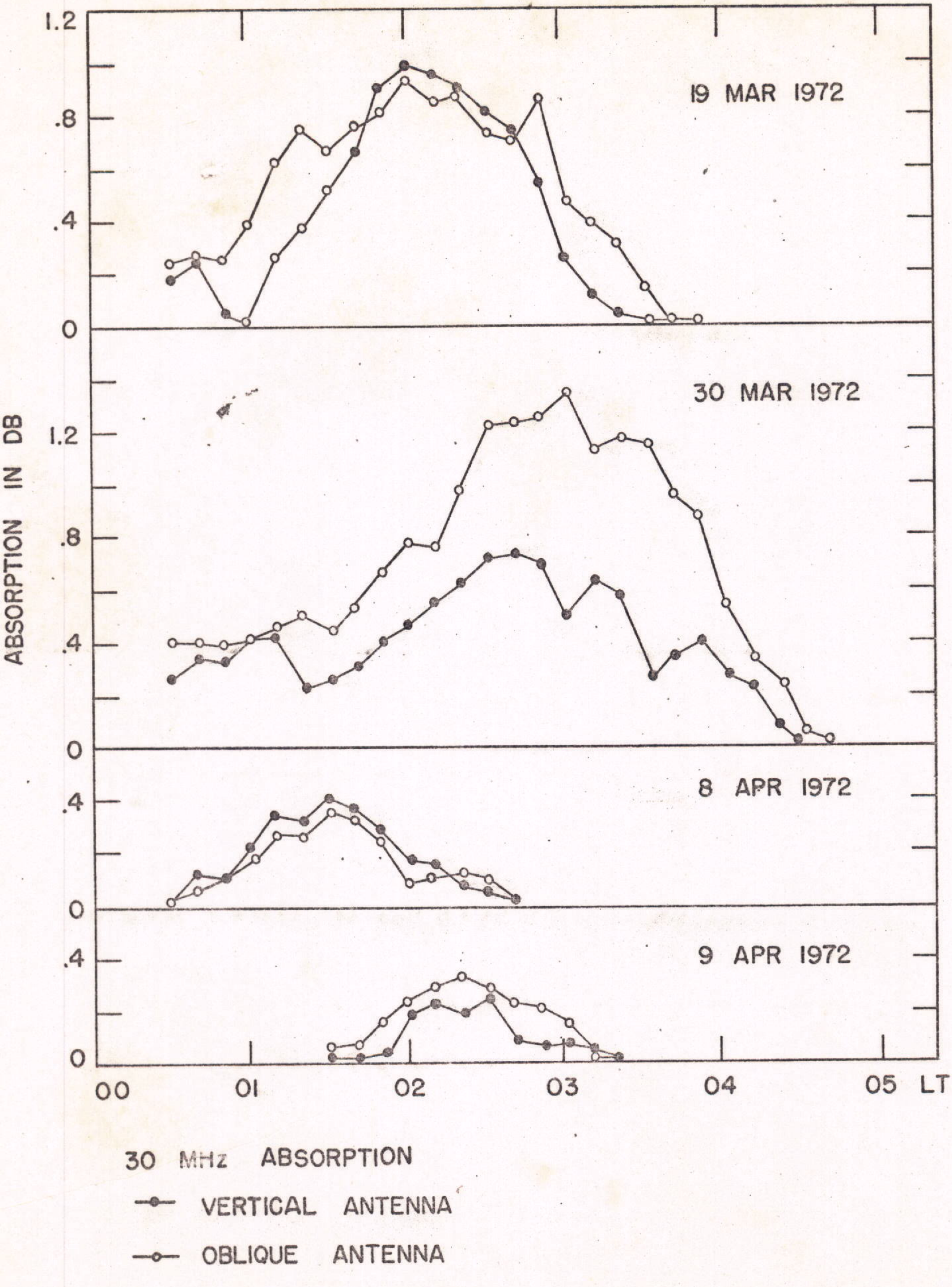


Figure 3



ABSORPTION IN DB
19 MAR 1972
30 MAR 1972
8 APR 1972
9 APR 1972
1.2
.8
.4
0
00
01
02
03
04
05 LT
30 MHz ABSORPTION
VERTICAL ANTENNA
OBLIQUE ANTENNA

Figure 4