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TÍTULO: GRAVITY WAVES IN LOW LATITUDE F REGION

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GRAVITY WAVES IN LOW LATITUDE F REGION

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INTRODUCTION

Traveling ionospheric disturbances (TID's) have been the subject of rather extensive investigation for several years using different experimental techniques[1-5]. Following the work of Hines on internal gravity wave propagating in the ionosphere several articles have appeared[5-7] providing the evidence that TID's are in fact manifestations of such waves propagating in the F-region. So far TID's have been observed most extensively at middle latitudes. A large number of these are observed to propagate equatorward with a predominently north-south velocity suggesting that the source lies near polar regions. These disturbances have been observed in magnetically disturbed periods[5] as well as in quiet conditions[7]. Their possible sources are processes associated with aurora, tidal oscillations of the atmosphere and wind systems in the troposphere and stratosphere.

In this note we present observations and discussion of some large scale TID's seen on 30 MHz cosmic noise absorption records at São José dos Campos (22.7^{o}S, 45.2^{o}W) and a nearby station. The characteristics of the TID's are identified with those of internal gravity waves propagating in the F-region. In some cases the riometer results are compared with simultaneous records of Faraday rotation of VHF signal from a geostationary satellite.

OBSERVATIONS AND DISCUSSION

The riometer utilized for the study are conventional instruments with 4-element Yagi antennas, except for the fact that one of the riometers operates with two alternately switched identical antennas one looking vertically and the other obliquely westward at an angle of 45^{o} with the vertical. The use of two antennas offers the possibility of determination of the E-W (or N-S) component of the velocity of propagation of the disturbances from the observed phase difference at the two antennas. Some absorption events associated with TID's observed at São Josē dos Campos and Atibaia (23^{o}S, 45^{o}W) are shown in Fig. 1. The actual riometer records corresponding to some of these events are shown in Fig. 2. As seen from these figures the absorption changes are quasiperiodic with the periods ranging from 30 min. to 3 hours. These values are well within the range of periodicities predicted and observed for internal gravity waves propagating in the F-region[5-7]. A noteworthy feature of these records is the presence of dispersion; the observed period increases with time. It may be mentioned that this phenomenon is noticeable (although less pronunced) also in the spaced ionosonde observations of Klostermeyer[7] and the incoherent backscatter results of Thome[5]. This dispersion is in accord with the behavior of internal gravity waves in the F-region predicted by Chimona and Hines[8] for the case when the source is located far way from the point of observation.

The minimum speed of propagation of the TID's corresponding to a given observed period can be estimated from the beam width of the antenna. The cross section of the beam at a height of 300 km is approximately a circular area of 500 km diameter. This is a measure of the minimum wavelength of the electron density irregularities that can be detected by the riometer, since irregularities of smaller scale will not produce clear periodic variations in the integrated signal received by the antenna. Then the minimum observed period of 30 min will correspond to a minimum speed of propagation of the order of 300 m/sec.

In the records obtained with the two-antenna riometer sometimes a significant difference is observed between the positions of the maxima and minima for the two antennas. An example of this type is shown in Fig. 2c. From such records it is possible to calculate the E-W component of the velocity of propagation of the disturbances. These calculations give an eastward component lying in the range 100 - 130 m/sec. For the cases, where no time shifts occur between the records of the two antennas, it may be concluded that the propagation is predominently meridional.

The TID's discussed here have been observed mainly during night hours and all the observations pertain to magnetically quiet conditions. So far they have been found to occur only during the period September - October. However, the data are not adequate and continuous enough to attempt a study of the seasonal behavior of the occurrence of these events. But their association with a restricted period and quiet magnetic conditions does suggest that they perhaps derive their origin from wind systems in the lower atmosphere.

In Fig. 3 we compare the riometer record of the event of September 25, 1972 with the simultaneous measurement of Faraday rotation of 136 MHz signal from the geostationary satellite ATS-3. The ionospheric region traversed by the satellite signal was within the region covered by the antenna beam of the riometer. The satellite record contains a number of smaller quasiperiods superposed on longer periods which are similar to those present in the riometer record. Both the techniques detect an integrated ionospheric response to the wave motion. In the case of the satellite signal the effect of the wave motion is most well defined when the path of the signal lies in the wave front of the wave[9], a condition which is difficult to satisfy in practice. In general there will be a decrease in the magnitude of the effect due to phase cancellations. Since the Faradary rotation is proportional to the total electron content ($\int Ndh$) the effect of the phase cancellation due to nonalignment of the ray path and the wave front can be significant specialy in the case of disturbances with smaller scale sizes. However, the smaller periodicities observed would still indicate nonuniformities of smaller scale sizes in the horizontal structure of the moving disturbance. In the case of the riometer, the F-region absorption is proportional to the integrated square of the electron density ($\int N^2dh$) and hence the observations will be most sensitive to the motion of the disturbances near the peak of the F-layer. Furthermore, since the size of the detectable wavelength is large, the effect of the nonuniformities on the observed amplitude is small.

Another interesting feature of Fig. 3 is the phase difference in the larger period variations seen on the two records. Because of the different nature of the electron density dependence of Faraday rotation and cosmic noise absorption it is likely that the electron densities at levels much higher than the F_2 peak contribute to the integrated effect observed on the satellite record, whereas in the case of riometer the observed effect is mainly due to the conditions at the maximum of the F layer. Therefore the phase delay, which appears between the larger periodicities in the two records (marked AA', BB', CC' in Fig. 3) could be taken as an indication of downward phase propagation characteristic of internal gravity waves.

CONCLUSION

The characteristics of the TID's observed in the riometer records are similar to the characteristics predicted theoretically for internal gravity waves propagating in the F-region and observed experimentally by other techniques. It should be noted that the study of internal gravity waves using riometer is feasible only in regions where the F layer ionization is sufficient to cause detectable absorption of VHF radiowave. This region is generally confined to a zone approximately 30^0 wide on either side of the magnetic equator. With some modifications of the antenna system riometers can be profitably used for a detailed study of the propagation of the internal gravity waves in the F region over low and temperate latitudes.

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FIGURE CAPTIONS

Fig. 1 30 MHz riometer absorption variations, showing, internal atmospheric gravity wave propagation in the F-region of the ionosphere, over Atibaia, São Paulo on 2 and 5 September, 1972 and over São Josē dos Campos on 15, 17 and 23 September, 1973. The minima of the quasiperiods in the absorption variations are indicated by arrows. The smooth broken lines drawn in each record represent the "quiet" cosmic noise levels. Broken lines are also used for interpolation in the descontinuities in the record.

Fig. 2 Tracings of the riometer records corresponding to the events of 15 September, 1973 and 2 and 5 September, 1972, presented in Fig. 1.

Fig. 3 The absorption variations on 2 September, 1972 (ABC) presented together with the Faraday rotation angle measurement of 136 MHz signals (A'B'C') received from the geostationary satellite ATS-3.

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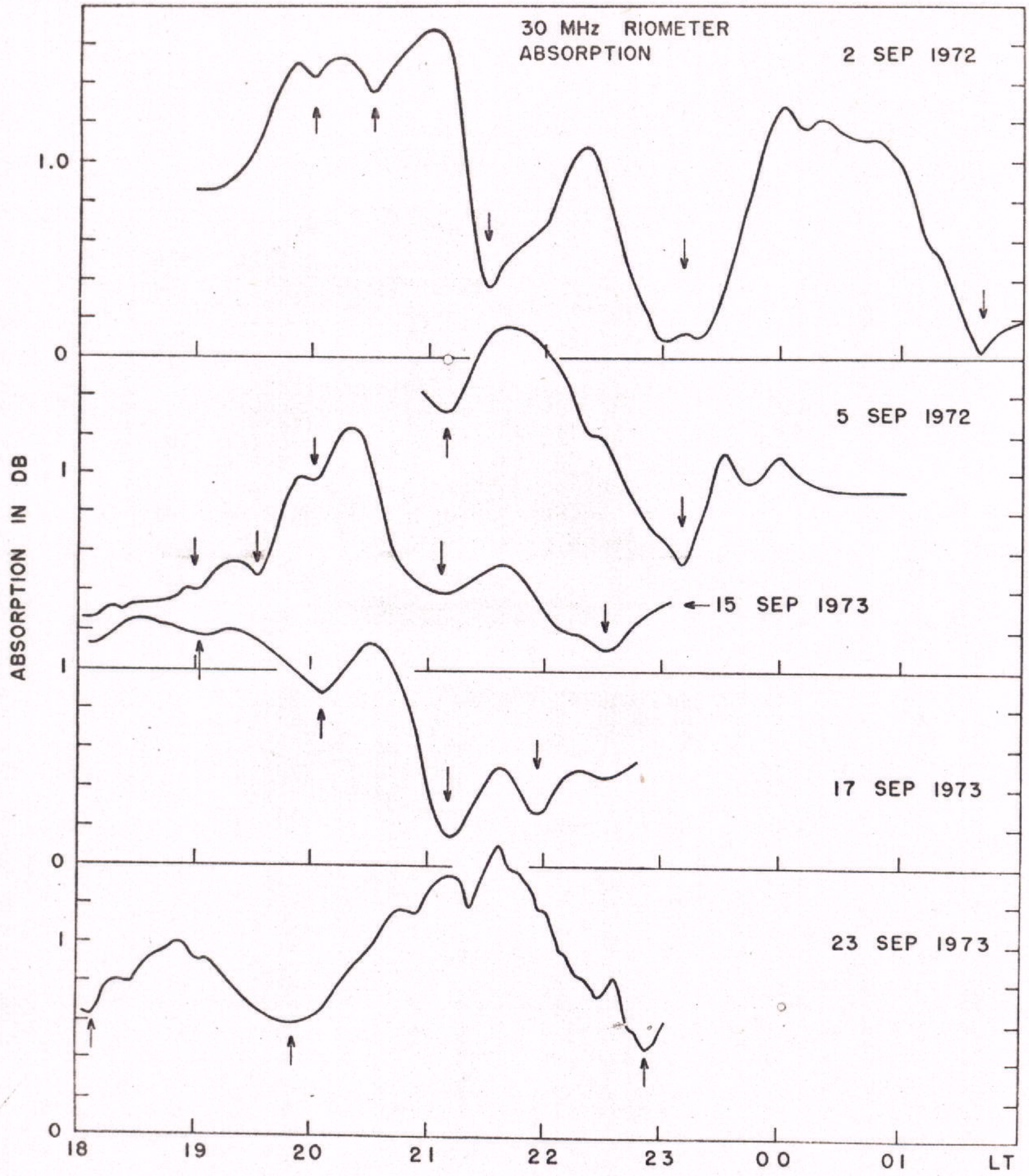
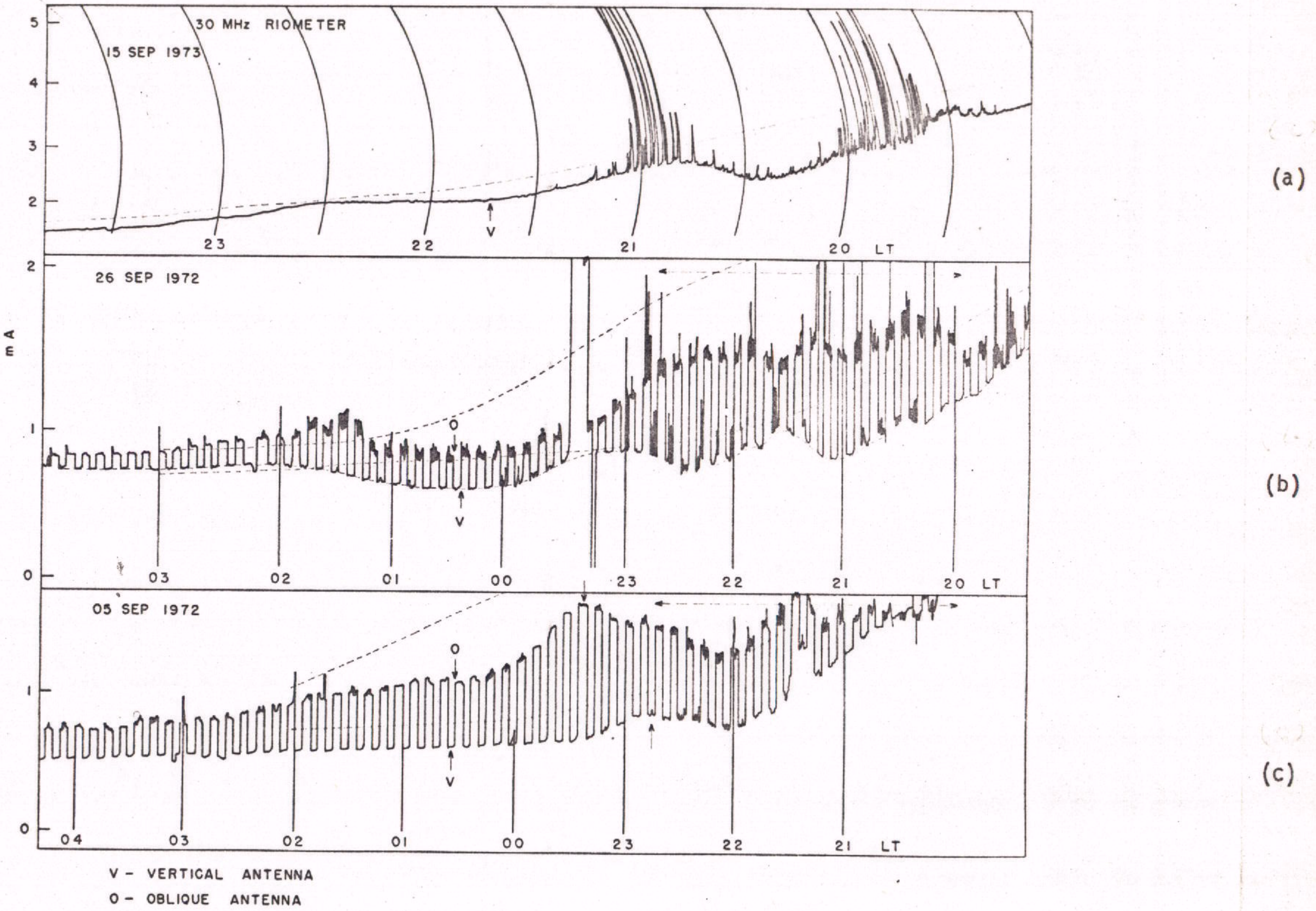

30 MHz RIOMETER
ABSORPTION
2 SEP 1972
5 SEP 1972
15 SEP 1973
17 SEP 1973
23 SEP 1973
ABSORPTION IN DB
1.0
0
1
1
0
1
0
18
19
20
21
22
23
00
01
LT

Fig. 1



30 MHz RIOMETER
15 SEP 1973
26 SEP 1972
05 SEP 1972
mA
5
4
3
2
1
0
04
03
02
01
00
23
22
21
20
LT
V
O
(a)
(b)
(c)
V - VERTICAL ANTENNA
O - OBLIQUE ANTENNA

Fig. 2

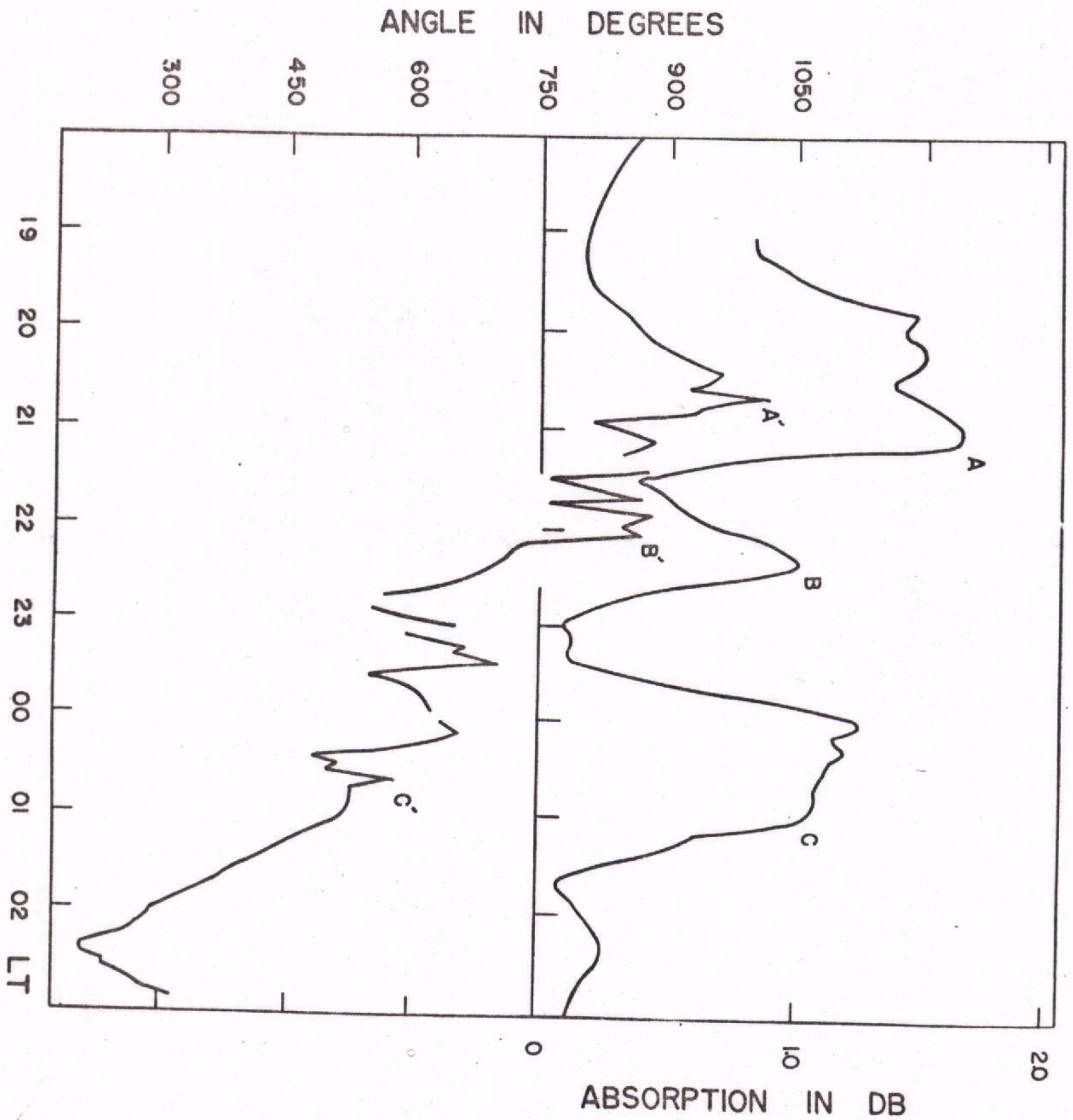

ANGLE IN DEGREES
1050
900
750
600
450
300
19
20
21
22
23
00
01
02
LT
A
A'
B
B'
C
C'
0
10
20
ABSORPTION IN DB

Fig. 3