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1 - INTRODUCTION

The southern polar ionospheric research is very important not only because it is less favoured by the number of observing sites than its counterpart in the northern hemisphere, but also because there exist important hemispheric asymmetries mainly caused by the eccentricity of the equivalent geomagnetic dipole. For instance, because of the greater offset of the geomagnetic pole from the geographic pole, the longitudinal changes are more noticeable in the southern ionosphere (Rees and Fuller-Rowell, 1987).

The riometer is still one of the most useful instruments to study the D-region of the ionosphere through cosmic noise absorption (CNA) measurements specially in the polar cap (Reid, 1961), moving auroral oval (Miyazaki, 1975; Kikuchi et al., 1988) and subauroral regions (Potemra and Zmuda, 1970; Abdu and Vogan, 1971), where studies of energetic solar protons released by solar flares and magnetospheric electrons can be conducted. CNA measurements are based on cosmic noise intensity (CNI) measurements performed by the riometer which are then compared with same measurements during "quiet days" (days with least ionospheric absorption), in order to evaluate the relative absorption.

A diurnal quiet day behavior of the measured CNI depends on the view direction of riometer antenna, therefore on the celestial distribution of stars. Sky maps of cosmic noise for different frequencies have been published (Cane, 1978; Ellis, 1982; Ellis and Mendillo, 1987) such as to make possible the estimate of the intensity to be measured by a directional antenna at those frequencies.

This paper reports CNI measurements performed by three riometers operating at 30 MHz frequency, at the Brazilian Antarctic Station Comandante Ferraz (62°S, 58.4°W) which have being in continuous operation since Dec. 1988. All three riometers use the same type of Yagi-Uda antenna consisting of 5 elements (3 directors, 1 reflector and 1 active) with half-power beamwidth of 58° in the E-plane and 68° in the H-plane, respectively. One of the antennas is directed to the zenith while the other two are directed to the magnetic south and west at 40° zenith angle, respectively. (These directions, in geographic coordinates are: 76.43°S, 154.74°E and 38.04°S, 111.5°W.)

2 - CNI OBSERVATIONS

Although the experiment is not designed to study cosmic noise by itself, the knowledge of the CNI daily variation as seen by an antenna with fixed direction, is important because all ionospheric absorption is based on a logarithmic comparison between the CNI measured during quiet days and the disturbed periods when usually more absorption is expected due to electron density enhancements. Substantial increases in the electron density are produced as a consequence of additional ionization sources such as particle precipitation directly from solar origin (solar proton events) or magnetospheric origin (mostly electrons accelerated in the tail of the magnetosphere).

Since the first months of the riometers operation only one maximum of intensity was noticed from the zenital direction as well as from the west direction, but two maxima appeared in the riometer with antenna directed to the south. This same behavior was noticed for all other days along the year and at the same sidereal hours, which revealed that the two maxima from the southward direction were not due to solar or geomagnetic effects. On the upper panel of Figure 1 are shown typical quiet day CNI measurements for the three riometers, in local sidereal time, for day 164, 1989. Data points joined with a continuous line represent the zenith direction, those with long dashes correspond to the west direction and the curve with small dashes corresponds to the south.

Small peaks present on all three curves between 3:00 and 9:00 local sidereal time (LST) represent interference due to the local radio - communications. Notice that the measured CNI exhibit - only one maximum for the case of the zenith and west directions, while the southern direction (curve of lowest intensity) exhibits two maxima, one around 13:00 LST and other around 22:00 LST.

3 - INTEGRATION OVER THE SKY

In order to find out whether the diurnal variation measured by the riometers, in each case, are those that should be expected, in special, whether the two intensity maxima found from the south direction measurements are from cosmic origin or rather due to an instrumental malfunction, an integration over the sky, over the solid angle of each antenna, using a published 30 MHz sky map was performed. Figure 2 is a partial reproduction of the 30 MHz brightness temperature contour map (background light curves) in a Hammer equal-area projection in galactic coordinates published by Cane (1978). The three concentric oval heavy curves (which are rather circles on the sky) are the trajectories of the three central directions of each antenna, being from the outer to the inner the west, zenith and south directions, respectively (naturally, the central point at $b = -27.4°$, $l = 303°$ corresponds to the projection of the south geographic pole).

The total intensity $I_T(\alpha, \delta)$ seen by an antenna pointing to a central direction, defined by the right ascension and declination, is given by

$$I_T(\alpha, \delta) = \int_0^{2\pi} d\phi \int_0^{\chi/2} I_{\alpha\delta}(\theta,\phi)\, G(\theta,\phi) \sin\theta \, d\theta \qquad (1)$$

where (θ, ϕ) are the spherical coordinates, $I_{\alpha\delta}(\theta, \delta)$ is the intensity per unit solid angle for a given central direction, $G(\theta, \phi)$ is the main lobe's radiation pattern value of the antenna and χ is the mean half-power beamwidth of the main lobe. The LST is defined by the right ascension.

The integral variables in Eq. (1) were transformed into the galactic coordinates in order to make possible the integration using Cane's map. The new integral formula actually used in the numerical integration is:

$$I_T(\alpha,\delta) = \sum_{m=1}^{N} \sum_{k} i_{\alpha\delta}(b_k,l_k) g_m(b_k,l_k) f(b_k,l_k) \Delta b_k \Delta l_k \qquad (2)$$

where $i_{\alpha\delta}(b_k,l_k)$ and $g_m(b_k,l_k)$ have the same meaning as $I_{\alpha\delta}$ and G in Eq. (1), m is an integer that reflects the discrete number of constant G-value projections (actually N = 5, with g_1 = 0.5 and g_5 = 0.98; in Figure 2 the discontinuous heavy closed curves are the projection of the constant g_m values for the case of the vertical direction centered at 04:00 LST and for the south direction at 07:00 LST). The factor $f(b_k,l_k)$ is a geometrical function to correct for the Hammer equal-area projection.

The results of the integration are shown on the lower panel of Figure 1 where, as for the case of the upper panel of same figure, the continuous curve corresponds to the intensity (in arbitrary units) expected for the antenna directed to the zenith, the curves with long and short dashes correspond to the magnetic west and south, respectively. To make the calculations more complete, the contribution of the largest side lobe of the radiation pattern was also included for the case of the southern direction because its orientation (37.29°S, 52.31°W) is such that around 17:00 LST it points to the center of the galaxy. Comparing corresponding measured and calculated curves one can see that the vertical and west directions are very similar in behavior, including the small peak around 12:00 LST found in the calculated west direction, which appears also in the measurements although a little hidden. However, for the case of the south direction the measurements are quite different from the expected diurnal variation specially because to the maximum of the calculated intensity (around 06:00 LST), it corresponds a minimum in the measured intensity. (As was said before, the interval between 03:00 and 09:00 depicts peaks that correspond to local interference.)

4 - DISCUSSION AND RESULTS

The general agreement between the calculated and experimentally observed CNI during a sidereal day, for the cases of the zenith and west directions, suggests that the riometer-antenna independent systems for both directions are operating adequately. This appears not to be the case for the southern direction.

The more important difference between the observed and calculated CNI for the southern direction is, first, from the observations there are two maxima in a sidereal day whereas the integration predicts only one and, second, that none of the maxima of the measurements coincide with the predictions. As for the orientation of the antenna, it has been checked and found to be correct. Therefore it is concluded that the antenna might be operating with a radiation pattern other than the expected. In fact, it is possible that this radiation pattern might exhibit two main lobes. Similar effects have been noticed by other investigators with same type of riometer (manufactured by La Jolla Sciences, Cal.) although with different antenna (Foppiano, 1990).

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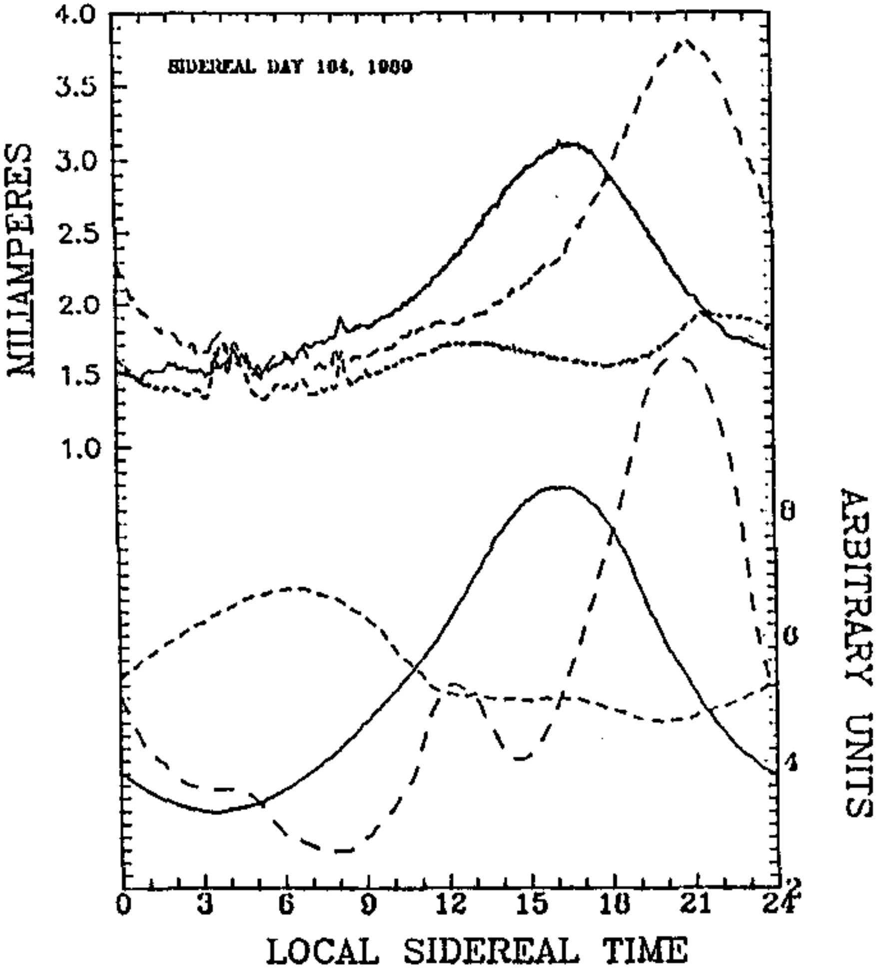

Fig. 1 - Upper panel: CNI measurements with antennas directed to the zenith (continuous line), magnetic south (small dashes) and west (long dashes) at 40^{0} zenith angle.

Lower panel: Results of the integration over the sky. Curves with continuous, short dashed and long dashed lines correspond to the same directions as the upper panel.

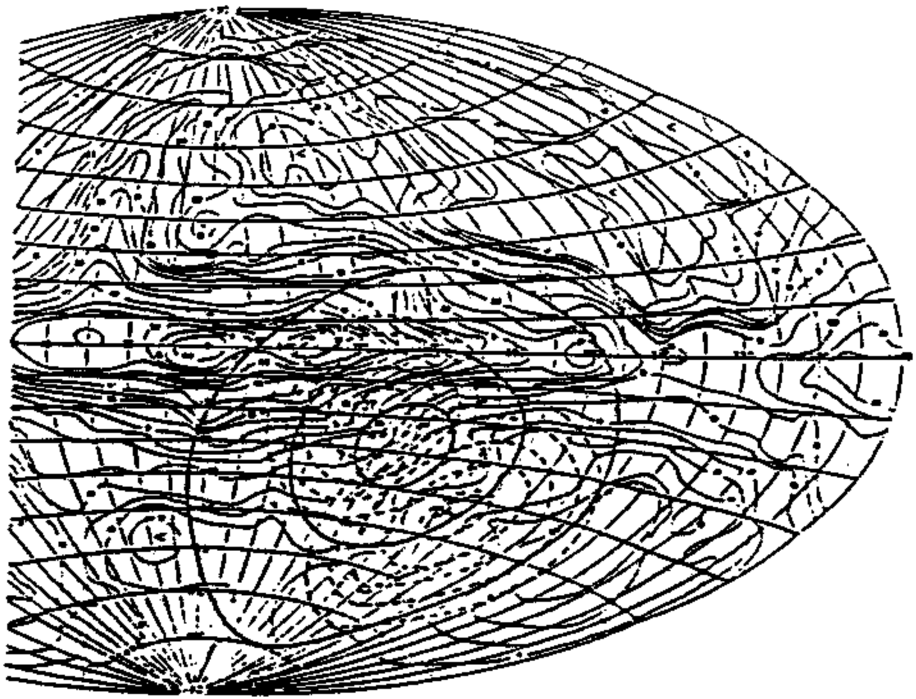

Fig. 2 - 30 MHz brightness temperature (contour unit 1000 K) in galatic coordinates. Concentric heavy-line curves from the outer to the inner: central view directions projections of the west, zenith and south riometer antennas.