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16.Sumário/Notas *Magnetogramas de observatórios geomagnéticos situados nas mediações da Anomalia Magnética do Atlântico Sul são analisados e comparados com magnetogramas de outros observatórios de baixas latitudes localizadas fora da Anomalia. A análise espectral das flutuações geomagnéticas é correlacionada com intensidades de partículas carregadas e de raio-X observadas na altura de balão. Registros simultâneos de absorção de ruído cósmico em 30 MHz são utilizados para verificação dos consequentes efeitos ionosféricos. Os períodos analisados são: 4-5 de Agôsto de 1972; 16-22 de Outubro de 1973; e de 4-7 de Julho de 1974. Flutuações geomagnéticas com períodos da ordem de alguns minutos mostram boa correlação com o fenômeno de precipitação de partículas carregadas na região da Anomalia.*

17.Observações *Trabalho a ser apresentado na XXVII Reunião Anual da SBPC.*

GEOMAGNETIC FLUCTUATIONS AND ASSOCIATED PARTICLE PRECIPITATIONS IN THE SOUTH ATLANTIC MAGNETIC ANOMALY

N.B. Trivedi, J.M. da Costa and I.S. Batista

Instituto de Pesquisas Espaciais - INPE

São José dos Campos - SP

ABSTRACT

Magnetograms obtained at observations situated in the South Atlantic Magnetic Anomaly are analysed and compared with a magnetogram obtained at a station well outside the anomaly. The spectral analysis of geomagnetic fluctuations is correlated with charged particles and X-rays intensities measured at balloon heights. Simultaneous cosmic radio noise absorption measurements are utilized to verify the effects in the ionosphere. The periods analysed are 4-5 August 1972, 16-22 October 1973, and 4-7 July 1974. Geomagnetic fluctuations of the order of few minutes shaw good correlation with the precipitation of charged particles in the region of the anomaly.

RESUMO

Magnetogramas de observatórios geomagnéticos situados nas mediações da Anomalia Magnética do Atlântico Sul são analisados e comparados com magnetogramas de outros observatórios de baixas latitudes localizadas fora da Anomalia. A análise espectral das flutuações geomagnéticas é correlacionada com intensidades de partículas carregadas e de raio-X observadas na altura de balão. Registros simultâneos da absorção de ruído cósmico em 30 MHz são utilizados para verificação dos consequentes efeitos ionosféricos. Os períodos são: 4-5 de Agôsto de 1972; 16-22 de Outubro de 1973; e de 4-7 de Julho de 1974. Flutuações geomagnéticas com períodos da ordem de alguns minutos mostram boa correlação com o fenômeno de precipitação de partículas carregadas na região da Anomalia.

We conduct on routine basis geomagnetic field measurements and recording at INPE, São José dos Campos. Other research group at INPE studies bremsstrahlung X-rays by launching X-ray and charged particle detectors in the upper atmosphere by balloons. During one of the flights on 17th Dec. 1971 a moderate geomagnetic storm occurred when the balloon was floating at ceiling altitude of ~3 mbr. Marked changes in the measured particle flux were observed in association with the changes in the geomagnetic field. To our knowledge this is the first detection of particle precipitation in the magnetic anomaly at balloon heights. This measurement was begining of our interest in the study of relationship between geomagnetic variations and particle precipitation.

On 17th Dec. 1971 the sudden increase in the geomagnetic field (S.J. Campos) coincides with increase in the precipitated particles. On 4th Aug. 1972 we recorded a big geomagnetic storm on this day we did not have a balloon data however, we could infer particle precipitation from the observation of absorption of cosmic radio noise intensity measured by Riometers. The storm started with 60γ sudden commencement at about 2050 UT followed by quasi-periodic oscillations of the field; at 2240 UT a much larger sudden commencement of about 200 γ occurred and soon after the main phase of the storm began. A noteworthy feature of this magnetogram is the existence of quasi-periodic fluctuations. Before the onset of the large sudden commencement the magnetic field undergoes fluctuations with a period of about 20-25 minutes on which more rapid fluctuations with a period of about 4-6 minutes are superimposed. During the main phase of the storm also short period fluctuations are observed and there is a suggestion of large period fluctuations with a period of 40-50 minutes. In the Figure 1 it is seen that absorption is present at the S.J. Campos and shortly after when fluctuations in the geomagnetic field reach its peak. The precipitation of the trapped particles could be caused by fluctuations of the geomagnetic field with periods shorter than the longitudinal drift periods of the trapped particles. (Sood et al., 1970). For the central regions of the Brazilian magnetic anomaly L = 1.18 the drift periods for electrons with energy ≥ 5 MeV is of the order of ~10 minutes; for electrons of lower energies the periods are corresponding by larger. The effect of magnetic storm on trapped radiation without particular reference to particle precipitation phenomenon was studied by Parker (1960), Davis and Chang (1962) and Fälthammar (1965).

This led us to examine the storm on 4th August 1972 at other station viz. Hermanus ($34^{o}26$'S, $19^{o}14$'W) in the anomaly zone and San Juan ($18^{o}23$'N, $66^{o}07$'W) well outside the anomaly.

The magnetograms of all the three stations were scaled at the interval of one minute. The data obtained by one minute interval scaling was subject to power spectrum analysis. Before subjecting the data to power spectrum analysis new time series of the data was obtained by taking the running average of twelve data point and, the new data series obtained by taking running average was subtracted from the corresponding previous data series. Effectively low pass filtering was done to remove the periodicities of twelve minutes and more. The data obtained after filtering was subjected to power spectrum analysis. The power spectrum was calculated by taking

Fourier transforms of the auto-correlation function.

The results of the power spectrum analysis are plotted in the Figure 2. The plot of the harmonic (cycles per 240 minutes) versus power indicate presence of pronounced periodicities of about two minutes in the case of S.J. Campos and Hermanus. Whereas in the case of San Juan this periodicity is not at all pronounced. If San Juan represents normal world wide magnetic variations at low latitudes the magnetic variations at Hermanus and S.J. Campos differ markedly from that of San Juan. A comparison of the three curves in Figure 2 offers the basis for the qualitative conclusion that the magnetic field in the anomaly region undergoes more short period fluctuations than the other low latitude regions. Since the short period fluctuations are considered more effective in causing the precipitation of high energy (>50 KeV) electrons (Trivedi et al., 1973), onde would expect at this time an increase in the precipitation of electron in SAME region. A noteworthy feature in Figure 2 is that the nature of the fluctuations observed at S.J. Campos is qualitatively different from those observed at Hermanus. This seems to suggest that over the anomaly region there is a considerable amount of inhomogeneity in the horizontal configuration of the magnetosphere,since S.J. Campos is almost near the center of the anomaly, whereas Hermanus is beyond its eastern edge. Although at present there is no basis even for guessing the scale over which the magnetic field changes significantly, it could be argued qualitatively that at least for high energy protons (>1 MeV for which Larmor radius $\geq 10^6$cm) even the first two adiabatic invariants would be violated during the storm period. Depending on this scale electrons with energies higher than 1 MeV (Larmor radius $\approx 10^4$cm) may also be affected. Thus at least near the center of the anomaly there would be an increased flux of high energy particles. Another aspect of the harmonic analysis is the existence of a pronounced two-minutes periodicity at S.J. Campos; at San Juan it is practically nonexistent, while at Hermanus it is considerably less significant. Since the bounce periods of protons with $E \geq 10$ MeV is of the order of this periodicity, these short period fluctuations would again contribute to the increased precipitation of these particles. However, a quantitative analysis of these effects must await acquisition of larger amount of such data.

The problem regarding the origin of the short period fluctuations also needs to be investigated. One can conjecture that the fluctuations must be related to the oscillations in the impinging shock wave at the magnetospheric boundary and (during the main phase) to certain changes occurring in the ring current due to injection and loss of particles. However, it is not clear whether the precipitation of particles into the anomaly region is purely an effect induced by the fluctuations or it also has some feedback to generate them. Detailed surface and satellite data are required to undertake this kind of study.

From the cosmic noise absorption data one can roughly estimate the flux of precipitating particles. The maximum absoprtion during the storm was of the order of 0.5 dB. If one assumes that at least at the maximum the increase in absorption was mainly due to the ionization in the D-region, the flux of electrons with $E > 40$ KeV must be of the order of 150 electrons $cm^{-2}s^{-1}$. A previous balloon measurement of charged particles flux (Martin et al., 1972) gave an increase of flux of electrons with E > 7.5 MeV as 135 electrons $cm^{-2}s^{-1}$ in association with a sudden commencement of 40γ. In the present case the amplitude of sudden commencement was about 200γ. If one considers the available stable flux of electrons above 50 KeV (STASSINOPOULOS) the extrapolated increase in the flux for this range from the 40γ sudden commencement would be of the order of 5 electrons $cm^{-2}s^{-1}$. These estimates are too crude to attempt any empirical relationship between the precipitating flux and the magnitude of the disturbance. However, they do indicate that the precipitating flux increase with the magnitude of the sudden commencement and only beyond a certain threshold value of sudden increase detectable ionospheric effects can be produced by the enhanced precipitation.

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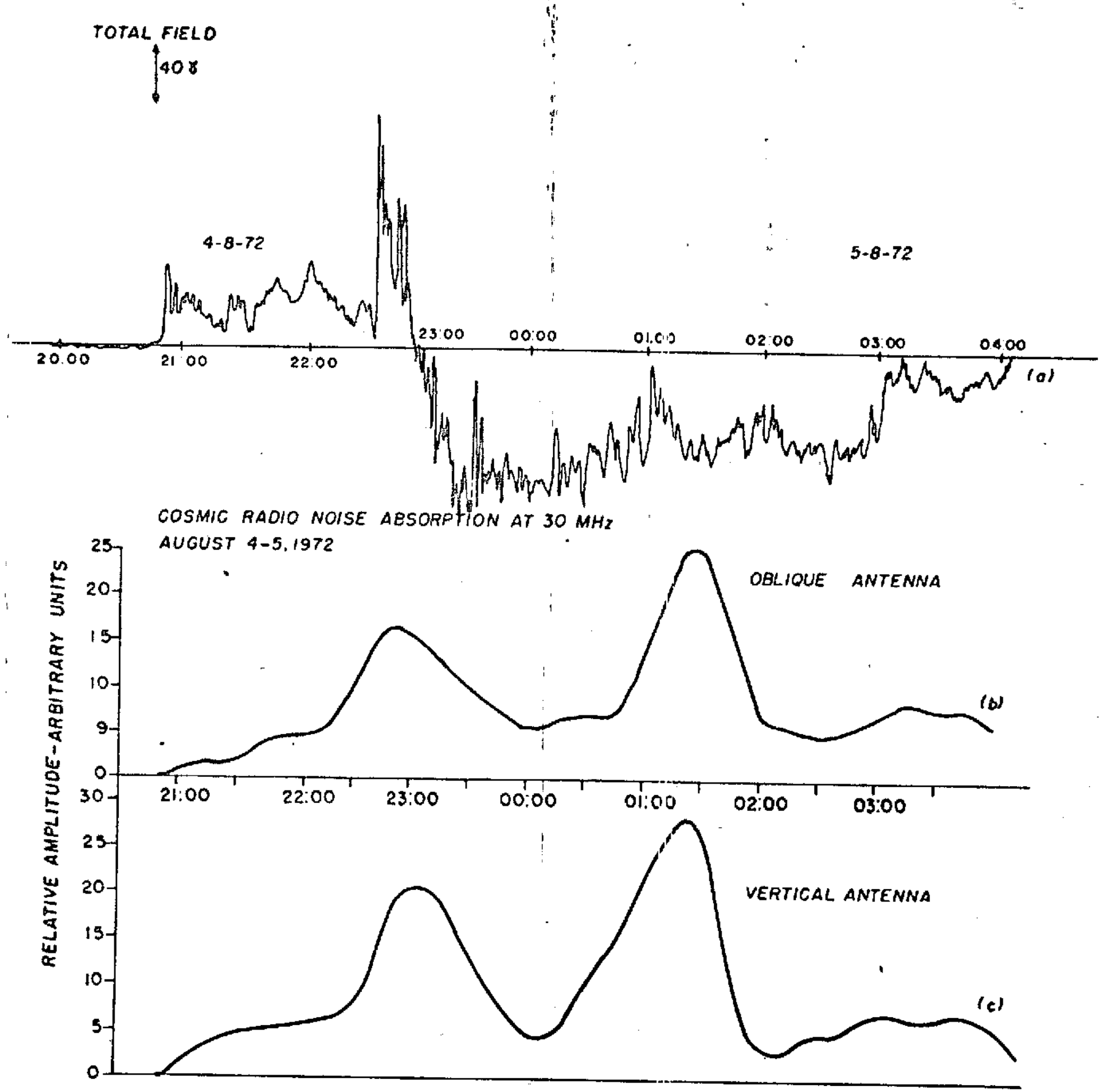
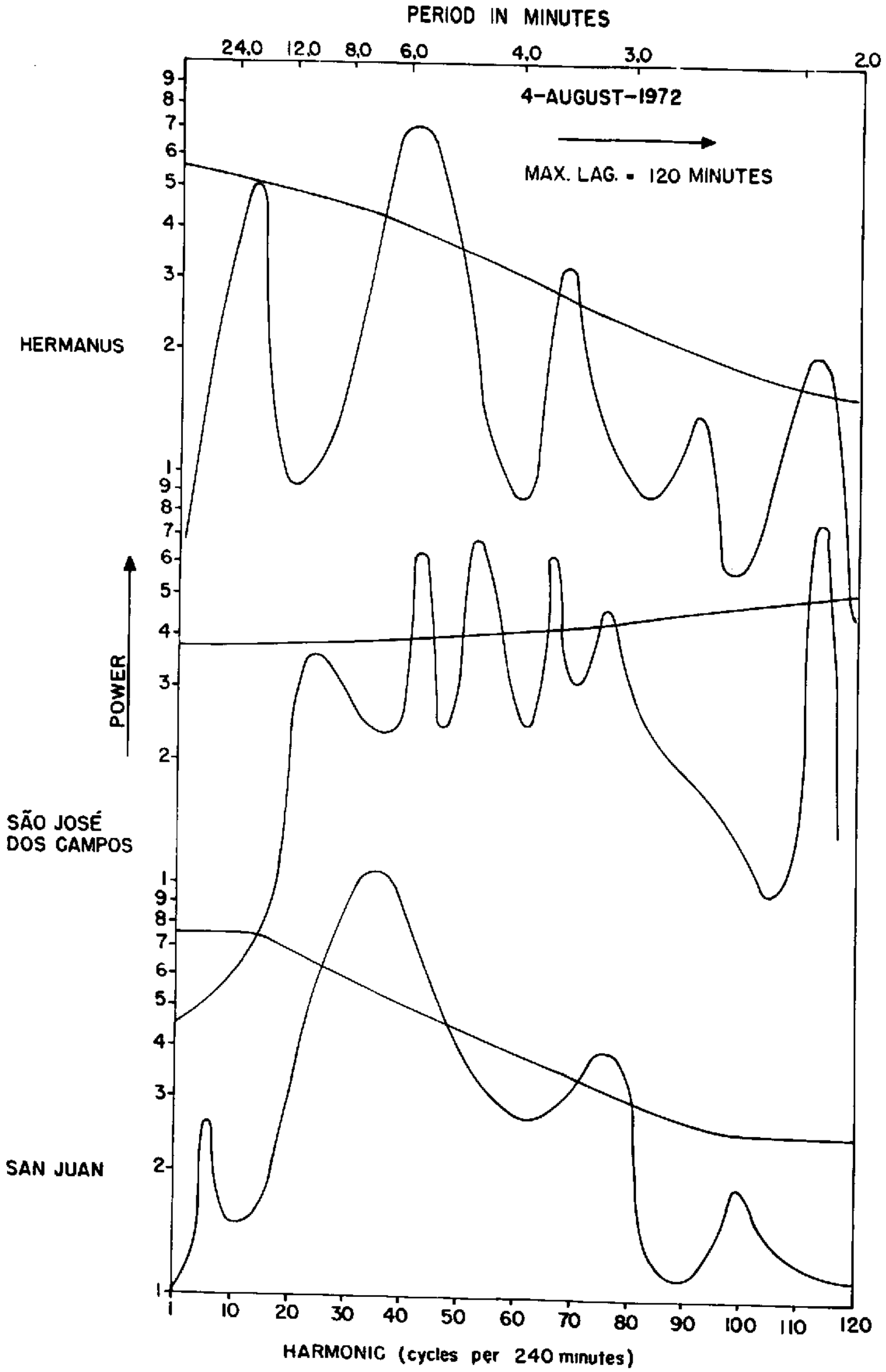

TOTAL FIELD
40 γ
4-8-72
5-8-72
20.00
21 00
22.00
23:00
00:00
01:00
02:00
03:00
04:00
(a)
COSMIC RADIO NOISE ABSORPTION AT 30 MHz
AUGUST 4-5, 1972
RELATIVE AMPLITUDE-ARBITRARY UNITS
25
20
15
10
9
0
30
5
OBLIQUE ANTENNA
(b)
21:00
22:00
23:00
00:00
01:00
02:00
03:00
VERTICAL ANTENNA
(c)


PERIOD IN MINUTES
24.0 12.0 8.0 6.0 4.0 3.0 2.0
4-AUGUST-1972
MAX. LAG. = 120 MINUTES
HERMANUS
SÃO JOSÉ
DOS CAMPOS
SAN JUAN
POWER
1 10 20 30 40 50 60 70 80 90 100 110 120
HARMONIC (cycles per 240 minutes)