# Upper atmosphere phenomena in Brazilian geomagnetic anomaly region and its surrounding area

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**Abstract**

In order to examine the effect of high energy particle precipitation in Brazilian geomagnetic anomaly region, we examined optical phenomena obtained at Brazil and Japan. During large magnetic storm, airglow phenomena with multiple bands structure were observed at Brazil, however, remarkable airglow phenomena was not recognized at Okinawa. We also examined atmospheric electric field, cosmic ray and 38.2MHz emission during this magnetic storm period. Electric field enhancements were continuously observed for more than 27 hours during the recovery phase of magnetic storm and a good relationship was seen between electric field and 38.2MHz variations. However cosmic ray enhancement was not recognized during this period. On the other hand, we installed imaging riometer at SSO, Brazil and recently Punta Arenas and Concepcion, Chile. At the present, we did not obtained simultaneous data at these 3 points. So, we shows the preliminary results of imaging riometer observations.

## Introduction

For examinations of geomagnetic anomaly region, In 1999, we installed several upper atmosphere instruments (CCD camera, photometer, Filed-Mill electric field detector, cosmic ray counter, 38.2MHz receiver etc.) at southern space observatory (SSO; 29.6S, 306E), INPE, Brazil as shown in Figure 1（Makita etal.2004a）. The location of SSO is near the center of geomagnetic anomaly region and the total geomagnetic intensity is about 22800nT. In order to compare optical phenomena at Brazilian geomagnetic anomaly region, CCD camera and photometer were also installed at Okinawa ( 26.7S, 128E) Japan where is just opposite side of earth（Makita et.al.2004b）. We examined airglow phenomena in these two regions during large geomagnetic storm occurred on 07 November 2004. During this magnetic storm, electric field enhancement was continuously observed for more than 1 day (Nov.8, 22h to Nov.9,24h UT). Generally, electric field enhancement is related with thunderstorm activity. However, it is seldom that electric field enhancement was continuously observed during such a long period. The enhancement of electric field may partly relate with magnetic storm activity as well as thunderstorm activity. On the other hand, Imaging riometer is useful for detecting high energy particle precipitation. In order to understand the characteristics of precipitation phenomena in Brazilian geomagnetic anomaly region, we recently installed Punta Arenas and Concepcion, Chile as well as SSO. Punta Arenas is located under the inner radiation belt (L= 2.0) and Concepcion is the similar geomagnetic latitude of SSO(Nishino et al.2004).

## Observation results

Magnetic storm occurred at 11hUT on November 7, 2004. The peak Dst value(−373nT) was seen at 07hUT on November 8. Another magnetic storm was continuously occurred on November 10. The peak Dst value(−289nT) was seen at 10hUT on November 10.

Optical observation by panchromatic CCD camera was carried out at SSO during the period form November 7, 23h to November 8, 05hUT. During this period, multiple bands extending from south-west to north-east move to the south-east direction. These multiple bands were continuously observed during all the night as shown in Figure2. We also examined image data obtained on November 06 in order to compare the phenomena between during magnetic storm and quiet period. Multiple bands were also observed on November 06, however, the multiple bands were extending from south-east to north-west direction and move to the south-west direction as shown in Figure 3. it indicates clearly that the moving direction of band is different between quiet and disturbed condition.

The different of moving direction of band may be due to the global electric field (ionosphere for magnetosphere electric field) direction during quiet and disturbed period. Figure 4 shows the dynamic spectrum of airglow event on November 07. It shows that band moves to the south-east direction. It was also interesting that the brightness of all-sky increased around 03h20m to 03h40m UT. This phenomena is called pre-morning brightness as reported by Makita et al.( 2002). We also compared CCD camera imagers observed at Okinawa, Japan. During the period from November 8, There were no remarkable airglow phenomena at Okinawa during this magnetic storm period.

In order to examine the effect of particle precipitation during magnetic storm condition, we analyzed Field-Mill electric field, cosmic ray and 38.2MHz radio wave data, The enhancement of electric field occurred at 21h on November 8 and continued till the end of November 9 as shown in Fig.5a and 5b. It was noted that the intensity of 38.2MHz increased at 08h20mUT and continued the end of November 9. We examined the relationships between electric field and 38.2MHz intensity as shown in Figure 6.
The enhancement of electric field and 38.2MHz shows a good coincidence each other. The positive impulse of 38.2MHz wave was corresponding to negative impulse of electric field.

Generally the enhancement of electric field occurs during thunderstorm. We checked the lightning imaging sensor data supplied by NASA. According to the data as shown in Figure 7, lightning flashes were detected during the period from 11h to 18h on November 9. Therefore, the electric filed fluctuations must be related to thunderstorm effect. However, it is unusual that electric field fluctuations were continued for such a long interval. Therefore these electric field fluctuations may be related with magnetic storm disturbance. For example, during magnetic storm period, particles in radiation belt precipitate into low altitude and induce the electric filed in Brazilian anomaly region. The part of this electric field may be observed in our observation as presented previously.

According to Torii et al. report (2002), the intensity of cosmic ray increases during lightning activity period. Since the number flux of precipitating particle is large in the geomagnetic anomaly region, so cosmic ray enhancement must be more clearly recognized in this region during thunderstorm. However, cosmic ray did not increase during the thunderstorm as presented here. This may be the reason why the sensitivity of cosmic ray counter is not sufficient to detect the increasing of cosmic ray. So we improved the counter and start cosmic ray observation again, recently.

We also examined imaging riometer data during this magnetic storm period. Unfortunately, imaging riometers installed at SSO, Brazil and Punta Arenas, Chile were not obtained data during magnetic storm period due to the trouble of instruments. Thus we showed imaging riometer data obtained at Concepcion, Chile.

During the period from November 8 to12, absorption (f=38.2MHz) was intermittently observed. Figure 8 illustrates the east-west and north-south antenna signals obtained on November 9. The impulse localized emission was seen at 17h12m and then after emission region expanded to the east-west banded region at 17h50m. These emission were related with X-ray flare reported by GOES X-ray data. In order to examine the characteristics of emission and absorption phenomena more in detail, amplitude and absorption image data were analyzed as shown in figures 9 and 10.

In figure 9 38.2MHz amplitude image, localized emission region was seen near the center of image from 17h12m to 17h46m. This period corresponds to the commencement of X-ray flare. At 17h24m in figure 10 absorption image, absorption was seen around the localized emission region. This period corresponds to the recovery phase of X-ray flare. The absorption region gradually moves to the norther part of image and finally disappears at 17h49mUT.

## Summary and Conclusions

We examined CCD camera, electric field, cosmic ray, 38.2MHz radio wave and imaging riometer data during November 7 magnetic storm obtained at Brazilian geomagnetic anomaly region. From the CCD camera images, multiple bands were continuously observed from November 7, 23h to November 8, 05h. The moving direction of this band was from north-west to south-east direction. The direction of band was different from the one during November 6 quiet period. We consider that the moving direction of band relates to the direction of global electric field. If it is true, the direction of global electric field is the eastward during magnetic storm period at mid-latitude.

From the examination of atmospheric electric field, cosmic ray and 38.2MHz radio wave during magnetic storm period, the electric filed variation unusually continued for more than one day. We consider that electric field induced by particle precipitation may add to the electric filed of thunderstorm. There was a good relationship between electric field and 38.2MHz during thunderstorm and also magnetic storm condition. Namely, electric field impulse was corresponding to 38.2MHz impulse. Although 38.2MHz wave will be excited during thunderstorm, there may be another possibility that electric field of thunderstorm accelerate particles and emit 38.2MHz. In this matter, it is necessary to examine more electric field and 38.2MHz data in order to obtain a final conclusion.

On the other hand, cosmic ray intensity did not increase in this period. The sensitivity of cosmic ray counter may be insufficient to detect the increasing of cosmic ray. So we improved cosmic ray counter and recently observation starts again.

From the Imaging riometer observation at Concepcion, X-ray flare event was recognized. However, imaging riometer at SSO Brazil and Punta Arenas, Chile were not working during this period. Therefore we could not show the characteristics of global absorption phenomena under the geomagnetic anomaly region during magnetic storm time.

It is essential to collect continuous data at these three points.

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## References

**Makita, K., T. Torii, M. Hoshino, M. Nishino, K. Shiokawa and N. J. Schuch**, 2004a, Cosmic ray and riometer observations in associated with thunderstorm at Brazilian geomagnetic anomaly region. Bulletin of Science and Engineering, Takushoku University, Vol.9(2), p37-42.

**Makita, K., M. Hoshino, E. Masuda and K. Shiokawa**, 2004b, Optical observation at Okinawa, Bulletin of Science and Engineering, Takushoku University, Vol.9(1), p19-26.

**Nishino, M., K. Makita, M. Sato, Y. Kato, N. J. Schuch, A. Foppiano and R. Monreal,** 2004, network observations of imaging riometers in south America, Bulletin of Science and Engineering, Takushoku University, Vol.9(2), p31-36

**Makita, K.,S.Monteiro, N. J. Schuch, H.Takahashi, F.Augusto, A.Mangalathayil and A.Buriti,** 2002, optical emission in Brazilian geomagnetic anomaly region(2), Bulletin of Science and Engineering, Takushoku University, Vol.8(3), p23-30

**Torii, T., M. Takeishi and T. Hosono,** 2002, Observation of gamma - ray dose increases associated with winter thunderstorm and lightning activity, J.Geophys. Res. Vol.107(D17), p4324-4332

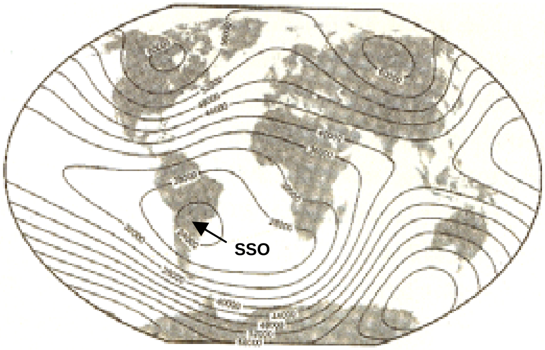
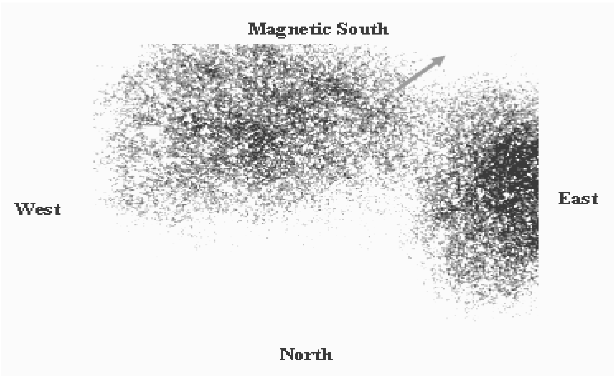



Fig.1 Total intensity of geomagnetic field (IGRFmodel). SSO locates near the center of geomagnetic anomaly.




**2. CCD Camera image obtained on 2004/11/07,23h53m (Storm period: Bands move south-east direction)**

iFig

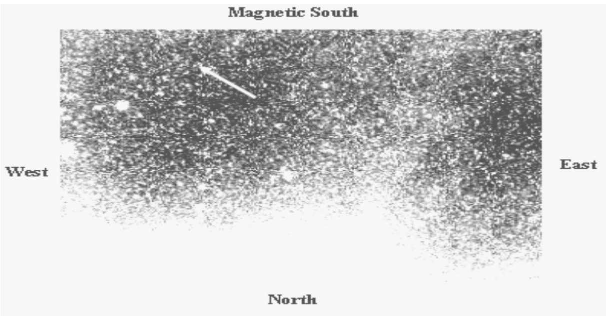



**Fig.3. CCD Camera image obtained on 2004/11/06,23h47m (Quiet period: Bands move south-west direction)**

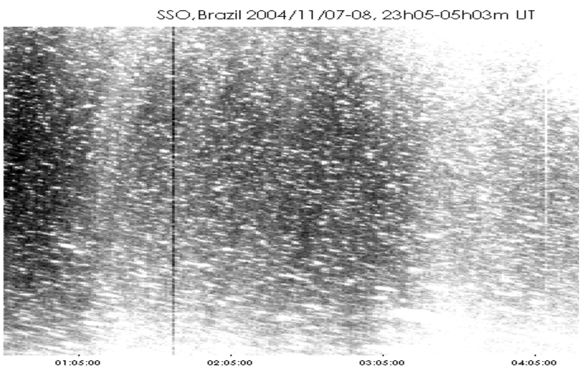



Fig.4 Dynamic spectrum of airglow by CCD Camera Bright region is moving to south-east direction.

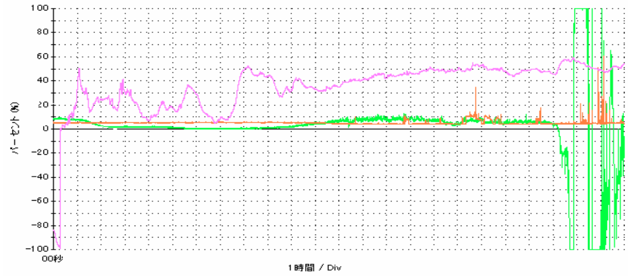


Fig.5a H-comp magneto gram (pink), electric field (green) and 38.2MHz (orange) observed on November 8. Enhancement of electric field is occurred at 21h UT.

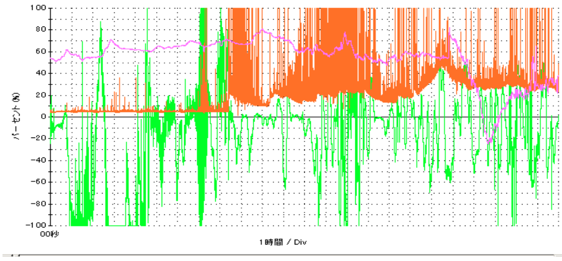


Fig.5b H-comp magneto gram (pink), electric field(green) and 38.2MHz (orange) observed on November 9, 2004, Electric field enhancement were continued during a whole day. Intensity of 38.2MHz radio wave increased at 08h20m UT.

Fig.6 The relationships between electric field and 38.2MHz from 21h33m to 22h03m on November 9. It shows a good coincidence between electric field negative pulse and 38.2MHz positive pulse.

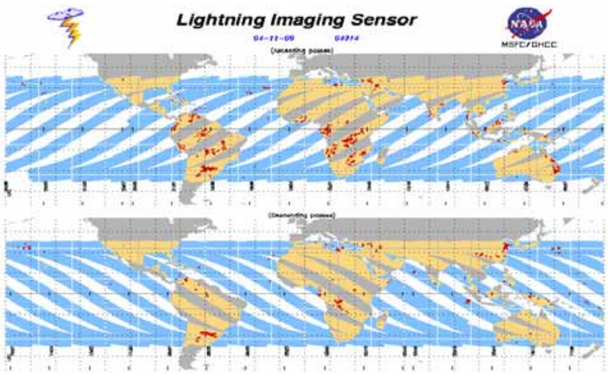



Fig.7 Lightning imaging sensor (LIS) data supplied by NASA. Lightning flashes were observed during the period from 11h to 18h, November 9.

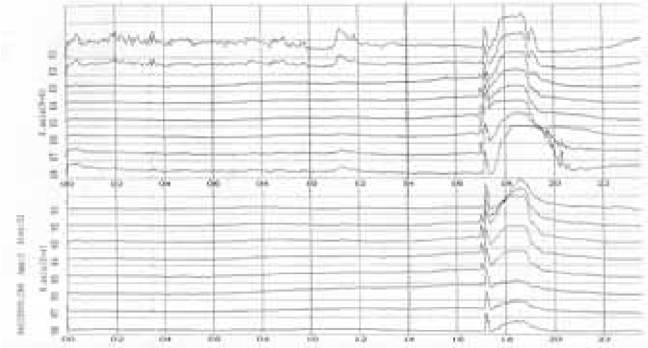


Fig.8 Imaging Rio meter data obtained at Conception on November 9, 00h-24h UT. Upper and bottom 8 channels data correspond East-West and North-South antenna signals, respectively. The impulse absorption was seen from17h12m to19h50m in associated with X-ray flare event.

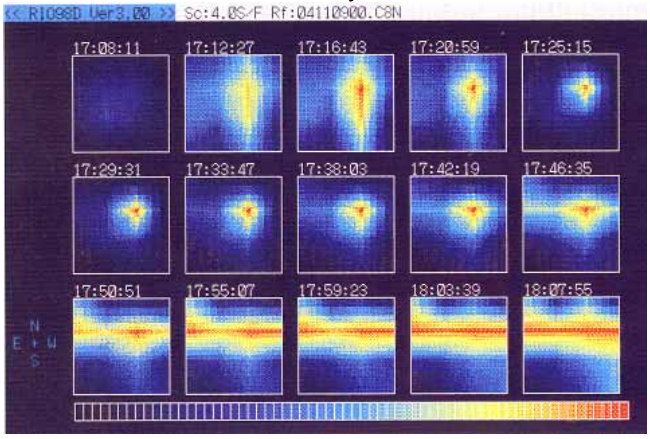



Fig.9 Emission images in every 4 minutes were illustrated. Up side direction is the magnetic north and right side is the magnetic west. Localized intense region was seen from 17h12m to 17h46m. After 17h50m, intense emission region expands east-west direction.

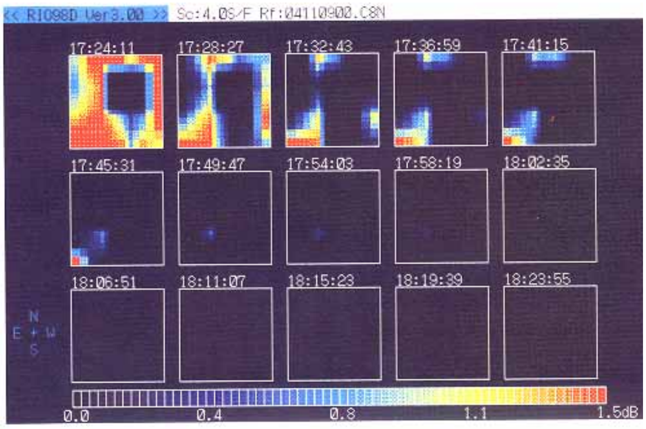



Fig.10 Absorption images data from 18h12m to 19h12m on November 07. Absorption region expands to the northern part at 17h28m UT and the absorption region disappeared at 17h49m.