# Cosmic noise Absorption observed by imaging riometer in South America and Japan during quiet period

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Cosmic noise absorption (CNA) at INPE Southern Space Obs. (SSO), Concepcion, Punta Arenas, Kakioka obtained by imaging riometer was examined during extremely quiet period. It is found that similar tendency of CNA are observed at these four stations although occurrence time are different. CNA at Concepcion and Punta Arenas are often seen in midnight to morning sectors. These two stations are nearly similar longitude in the southern hemisphere. CNA at SSO is observed in noon to evening sectors .On the other hands, Occurrence of CNA at Kakioka is observed in morning to noon sectors. The absorption structure shows strip type. We consider that these CNA may be two different types. One is due to electron density variations of F-layer and another is particle precipitation from inner radiation belt.

## (1) Introduction

The Geomagnetic field is especially weak in South Atlantic Geomagnetic Anomaly and energetic particles are precipitating in this region. We named this special particle precipitation region as Geomagnetic Hole (GH) [1].

We first installed imaging riometer, CCD camera, photometer and others at INPE Southern Space Observatory (SSO), RS. Brazil for monitoring of these particle precipitations[2]. Then after, we installed imaging riometer at Concepcion, Punta Arenas in Chile and Kakioka Geomagnetic Observatory in Japan. Recently, we also installed imaging riometer at Trelew in Argentina and San Jose dos Campos in Brazil.

On the other hands, we also installed 1channel riometer (wide beam) at more than 10 points in Brazil, Argentina and Chile（Fig.1）. We call these riometer network observations from equator to Antarctica region as SARINET(South America Riometer Network).


Fig.1 South America Riometer Network(SARINET)

## (2) Data Analysis

We received 38.2MHz cosmic noise which is propagating from Center of galaxy (Milky Way).The intensity of cosmic noise shows time variation among one day (Fig.2).

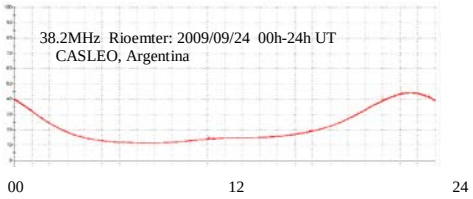


Fig.2 One day variation of cosmic noise

Our imaging riometer is 4 x 4 (16) antennas and each antenna receive cosmic noise in narrow sky area. Using one month data, we calculate Quiet Day Curve (QDC) of cosmic noise for each antenna signals. The example of QDC (Red line) and one month data (Blue line) for 16 antennas are shown in Fig.3.

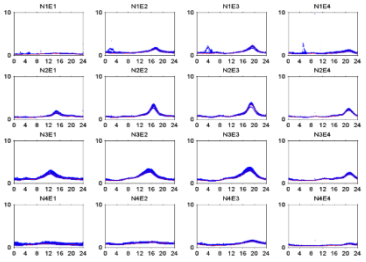

Fig.3 QDC at Concepcion (Chile) in 2007/05 (one month)

On the basis of QDC, we calculate absorption intensity of 16 antenna signals for a certain day and obtain the absorption image as shown in Fig.4

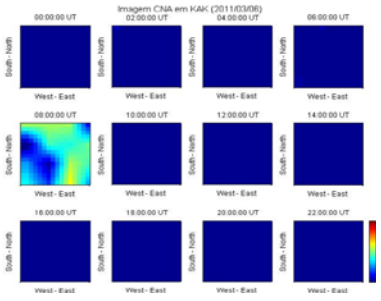

Fig.4 Absorption image at Kakioka in 2011/03/06

### (3) Cosmic Noise Absorption (CNA) phenomena

#### (A) CNA during magnetic storm period

So far, we examined CNA events during large magnetic storm time. We show such example in Fig.5. The magnetic storm is occurred on April, 05, 2010 in the top pane, large AE index value is seen around 09h49m UT. It is reported that communicate satellite GALAXY-15 is flying around South America region and breakdown in this time. We examined simultaneous SSO and Kakioka imaging riometer data. The time and special CNA variation (keogram) is shown in the middle (SSO) and bottom (Kakioka) panel. Remarkable CNA is seen at SSO during 09h50m to 10h00m in the right image panel. This time corresponds to GALAXY-15 breakdown time. On the other hands, CNA is not observed at Kakioka data. We consider that high energetic particles precipitated around SSO and GALAXY-15 flight region. This precipitation must be related to GALAXY-15 breakdown.

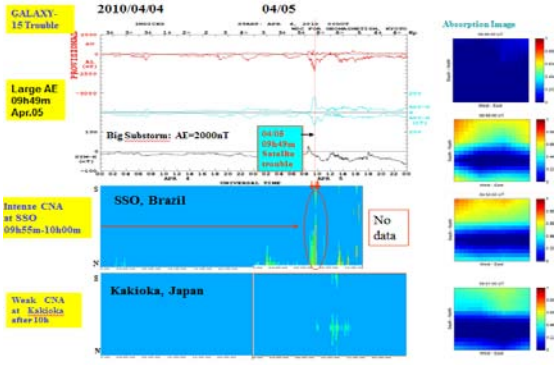


Fig.5 AE index, CNA Keogram at SSO and Kakioka. Right side images are CNA at SSO when GALAXY-15 is breakdown.

#### (B) CNA during extremely quiet period

We interest in CNA phenomena during extremely quiet period. Because, upper atmosphere condition may be not so much affected by solar activity during quiet period. Thus it is useful to examine the quiet ionosphere condition and also ground-state particle precipitation in South Atlantic Anomaly. We examined four CNA events during extremely quiet period (Red arrow in Fig.6) observed by imaging riometer at four stations.

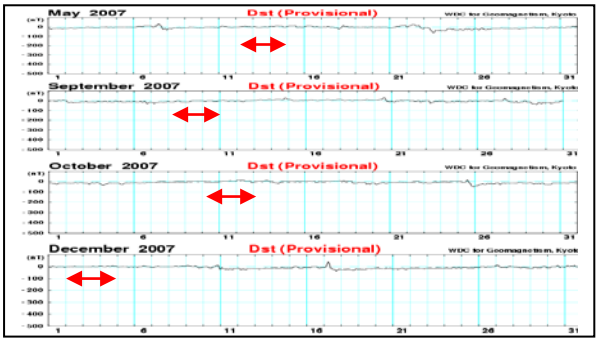


Fig.6 Dst index (May.12-14, Sep.8-10, Oct.10-12 and Nov.5-7: Red arrow) when CNA phenomena was observed.

#### (i) 2007 September 8 -10 event

In this event, magnetic activity is low and ΣKp of Sep.8, 9 and 10 are 13, 3 and 4-, respectively. Although Sep.8 is not extremely quiet, but extremely quiet in Sep.9 and Sep.10. Fig.6 shows CNA Keogram of imaging riometer . From the top to bottom panels are SSO(Brazil), Concepcion and Punta Arenas (Chile) and Kakioka (Japan), respectively. It is clearly shown that CNA phenomena are periodically and also systematically seen during 3 days at four stations

Remarkable CNA at SSO is observed around 16h-20h UT which is corresponding to noon to evening sector (13h – 17h LT). The CNA at Concepcion and Punta Arenas are observed around 04h -08h UT which is corresponding to midnight to morning sector (00h – 04h LT). It is notice that CNA at Punta Arenas is also seen around 16h-20h UT on Sep.10 which is nearly the similar time of CNA at SSO (Red arrow). CNA at Kakioka is seen around 23h – 04h UT which is corresponding to morning to noon sector (08h – 13h LT). It notices that occurrence time becomes earlier than the previous day for all stations.

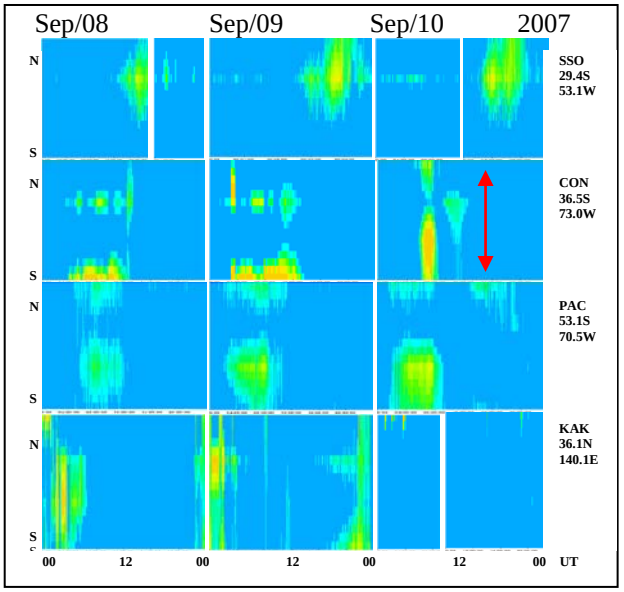


Fig.7 CNA Keogram of imaging riometer at SSO (Brazil), Concepcion and Punta Arenas (Chile) and Kakioka (Japan).

#### (ii) 2007 October 10 -12 event

In this event, magnetic activity is low and ΣKp of Oct.10, 11 and 12 are 2-, 1 and 9-, respectively. Fig.7 shows CNA Keogram of imaging riometer. From the top to the bottom panels are SSO (Brazil), Concepcion, Punta Arenas and Kakioka. The periodical CNA phenomena are observed at all stations. CNA at SSO is observed around 12h – 24h UT on Oct.11. Concepcion CNA is periodically seen around 08h – 14h UT from Oct.10 to 12. Weak CNA is seen at Punta Arenas and the occurrence time is corresponding to the Concepcion. On the other hands, Kakioka CNA is observed around 00h-12h UT for Oct. 10 – 12. It is also noticed that occurrence time of CNA at Concepcion, Punta Arenas and Kakioka becomes earlier time than the previous day as similar as Fig.6 data.

From these two events, it suggests that occurrence local time of CNA is different for each station. For example, CNA at SSO is seen around 12h-20h LT( noon to evening sector) , CNA at Concepcion and Punta Arenas are nearly same and seen around 4h-10h LT(midnight to morning sector) and CNA at Kakioka is seen around 09-17h LT (morning to afternoon sector). It is noticed that that CNA are periodically observed in these days for all stations.

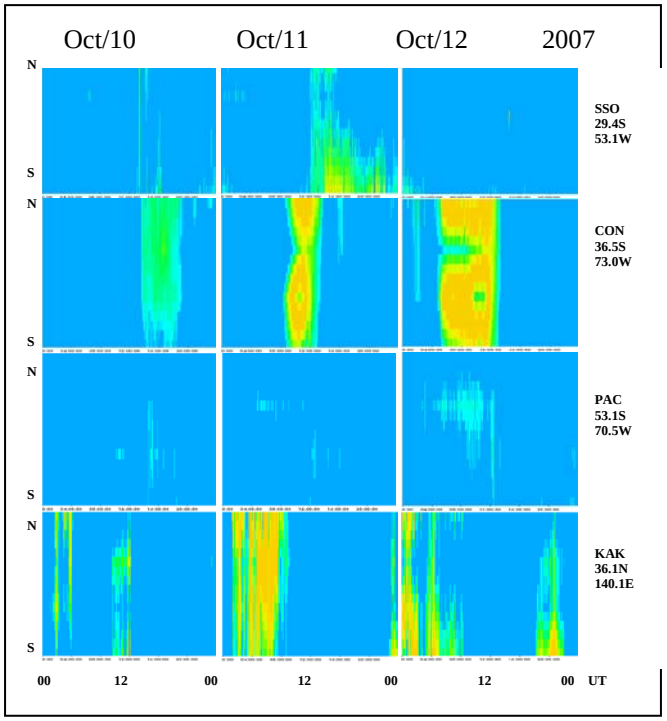


Fig.8 CNA Keogram of imaging riometer at SSO (Brazil), Concepcion and Punta Arenas (Chile) and Kakioka (Japan).

**(iii) 2007 May 12-14 event**

In this event, magnetic activity is extremely low and ΣKp of May 12, 13 and 14 are 4 , 4- and 5-, respectively. Fig.7 shows imaging riometer data obtained at four stations. In the top SSO panel, strong CNA event is observed around 13h-22h UT on May 13( noon to evening sector), but in other days, there is no strong CNA at SSO. Second panel is Concepcion data and strong CNA is also seen around 05h -13 h UT on May 13 (midnight to morning sector). In other days, there is no strong CNA. Third panel is Punta Arenas. Moderate CNA is seen on May 12 and 13. There were two CNA events in May 13. One event is seen around 05h-12h UT (midnight to morning sector) which is same interval of Concepcion CNA. Another CNA is seen around 15h -23h UT (noon to evening sector) which is same interval of SSO CNA (Red arrow). On the other hands, strong CNA is also seen at Kakioka from 05-13h UT (afternoon to evening sector).

It is noticed that occurrence time of CNA at Kakioka is nearly same time when Concepcion CNA is occurred. It also shows that time-space variation of Kakioka CNA is resemble to SSO and Concepcion CNA, although the duration time of CNA at Kakioka is short.

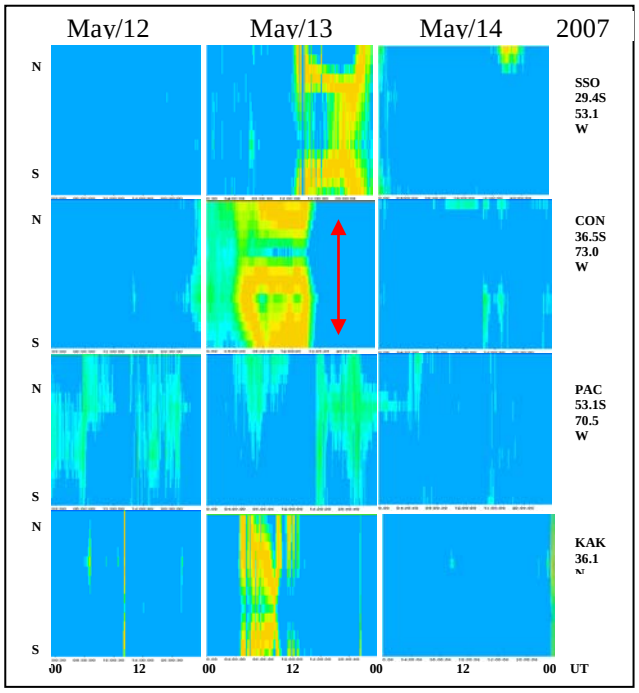


Fig.9 CNA Keogram of imaging riometer at SSO (Brazil), Concepcion and Punta Arenas (Chile) and Kakioka (Japan).

**(iv) 2007 December 02 -04 event**

In this event, magnetic activity is extremely low and ΣKp of December 02, 03 and 04 are 3+, 1 and 2-, respectively. Fig.9 shows imaging riometer data obtained at four stations. SSO data in the top panel, weak CNA is intermittently observed on Dec.02 and strong CNA is observed around 14h-20h UT(noon to evening sector) on Dec. 04. Second panel is Concepcion data. Weak CNA is seen in every days around 12h -16h UT on Dec .2 ,3 ,4. In the third panel of Punta Arenas data, weak CNA is seen around 14h-20h UT on Dec.04. In the lowest panel of kakioka data, strong CNA is seen around 20h -08hh UT on Dec. 2 ,3, 4 and also seen around 10h - 18h UT evening to midnight sector) on Dec.03.

It is noticed that CNA at SSO observed around 10h-20h UT on Dec.04 seems to be corresponding to Punta Arenas CNA (Red arrow in Fig.9). Usually occurrence time of CNA at SSO is different from occurrence time of Concepcion and also Kakioka CNA. It suggests that the source of SSO CNA may be different from Concepcion and Kakioka. Sometimes, CNA at SSO and Punta Arenas are observed near similar time. It may suggest that the source of these two stations CNA are similar.

From CNA analysis during extremely quiet period, there is a tendency that appearance time of CNA is observed around similar local time for each station. For example. CNA at SSO is mostly observed around noon to evening sector. CNA at Concepcion is mostly observed around midnight to morning sector. CNA at Punta Arenas is mostly observed near the same local time of Concepcion but sometimes observed near the SSO local time. CNA at Kakioka is observed around morning to noon sector. At present, I CAN not explain why the appearance local time

of CNA is different for each station during extremely quiet time.

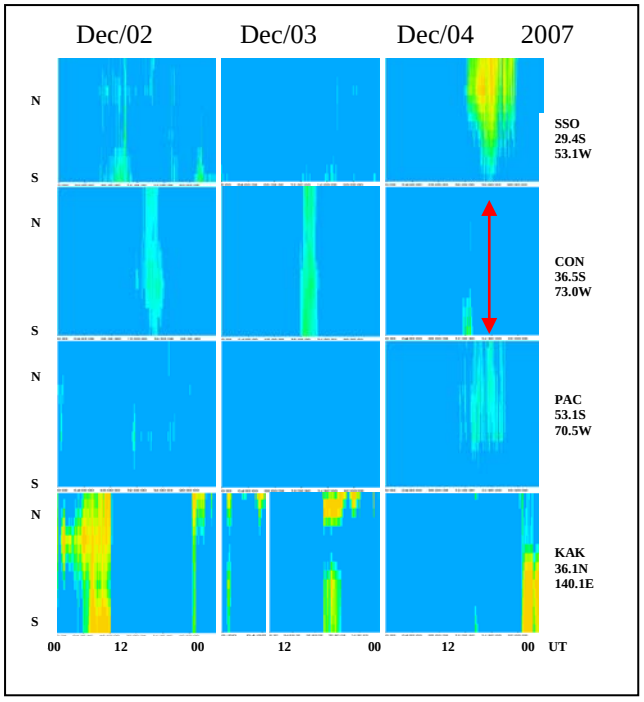


Fig.10 CNA Keogram of imaging riometer at SSO (Brazil), Concepcion and Punta Arenas (Chile) and Kakioka (Japan).

## (4) Summary and Conclusions

We examined four CNA events during extremely quiet period. It is found that the occurrence time of CNA is different and mostly observed around similar local time for each stations.The appearance local time of CNA are summarized in Fig.11. We CNAnot explain the reason why CNA occurres in different local time for each stations.

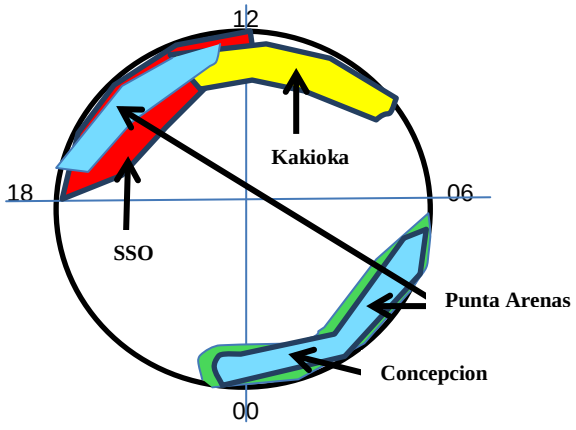


Fig.11 Occurrence local time of CNA for each stations during extremely quiet period

We consider that most of CNA at Concepcion and Punta Arenas are observed simultaneously. This is the reason why both stations are located near the same longitude. On the other hands, the longitude of SSO is not so different from Concepcion, but the occurrence time of CNA at SSO is quite different from Concepcion CNA. This result suggests that source of CNA is different between Concepcion and SSO.

Furthermore, sometimes the occurrence period of Punta Arenas CNA is similar to SSO CNA around 16h-22h UT on Sep.10, May 13 and Dec.04 (Red arrow). It may suggest that source of CNA at SSO and Punta Arenas must be partly same.

Although, in one case, the CNA phenomena was simultaneously observed at Kakioka and Concepcion on May 13. However, in other most cases, occurrence time of CNA at Kakioka is different from Concepcion. Sometimes its different time is about 10 hours or less.

From these observation results, we propose that there are two different kinds of CNA phenomena as follows.

(1) CNA at Concepcion and Kakioka may be similar kind of phenomena. These CNA phenomena must be occurred due to the electron density variation in F-layer

(2) CNA at SSO seems different source phenomena. Occurrence of CNA at SSO is observed in the same period of Punta Arenas CNA. Since Punta Arenas is located under the inner radiation belt, thus CNA at SSO may be also induced by particle precipitation from inner radiation belt.

## References

1) Kazuo Makita, Study of Geomagnetic Hole, Study series of Takushoku University , Natural science 7, pp.1-167, 2007 (in Japanese).

2) Nishino M., K .Makita, K .Yumoto, F. S. Rodorigues , N. J. Schuch and M. A .Abdu, unusual ionospheric characterizing energetic electron precipitation into the South Atlantic magnetic anomaly, Earth Planets Space,54,907-916,2002