Proc. NIPR Symp. Upper Atmos. Phys., 12, 108–114, 1998

NORTHERN/SOUTHERN HEMISPHERE ASYMMETRY OF sc/si IN THE NIGHTTIME SECTOR

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Abstract: Magnetic field data from two pairs of conjugate stations along the 210° MM (Magnetic Meridian) are analyzed to re-examine characteristics of northern/southern hemisphere asymmetry of sc (sudden commencement)/si (sudden impulse) magnetic variations.

We found that the seasonal variation of the asymmetry of sc/si can be seen even in the nighttime sector, where the ionospheric conductivity is much lower than that in the daytime sector. In order to interpret the observational fact, we have estimated the magnetic fields in the magnetosphere produced by the Chapman-Ferraro current (CF current) flowing at the dayside magnetopause, by using the Tsyganenko 96 model.

It is found that the observed northern/southern hemisphere asymmetry of sc/si in the nighttime sector can be explained by invoking the seasonal variation in the tilt angle of Earth's dipole axis.

1. Introduction

Characteristics of sc/si magnetic variations have been studied and clarified by many investigators. In general, magnetic variations of sc/si observed on the ground are decomposed into two components (ARAKI, 1977, 1994). One is called the DL-field that is produced by an enhanced CF current due to sudden increase of the solar wind dynamic pressure, which drives northward magnetic field variation propagating earthward from the dayside magnetopause as a compressional wave (TAMAO, 1964a, 1964b). Another is the DP-field caused by the ionospheric current. This current is driven by the electric fields penetrating from the magnetosphere into the polar ionosphere.

The northern/southern asymmetry of sc/si between the conjugate stations along the 210° magnetic meridian was first found by YUMOTO *et al.* (1996a). They considered that the asymmetry is associated with that of the ionospheric conductivity, because the H-component amplitude of sc/si observed in the summer hemisphere was larger than that in the winter hemisphere. It means that the asymmetry of sc/si is due to that of the DP-field component caused by the ionospheric current.

In this paper, we re-examined the asymmetry at low and middle latitudes in the nighttime sector, where the effect of ionospheric conductivity would not be dominant. From a view point of small effect of the ionospheric conductivity in the nighttime sector, we examined a possibility that the DL-field component of sc/si can produce the northern/southern hemisphere asymmetry of sc/si in the nighttime sector.

2. Data Analysis

The 210° magnetic meridian (MM) magnetic observations were conducted during the Solar Terestrial Energy Program (STEP) period in cooperation with many institutes and organizations. The member of the 210° MM observation group is listed in YUMOTO *et al.* (1996b).

Two pairs of conjugate stations along the 210° magnetic meridian are used to compare the H-component of sc/si magnetic variations. The conjugate stations are, St. Paratunka (PTK, $L=2.10$), Moshiri (MSR, $L=1.57$), Birdsville (BRV, $L=1.55$) and Adelaide (ADL, $L=2.11$) (see YUMOTO *et al.*, 1996b). Figure 1 shows the amplitude ratio of H component between the northern and southern stations. We analyzed 26 sc/si events occurred in the interval from 1993 to 1994. These events were selected by using

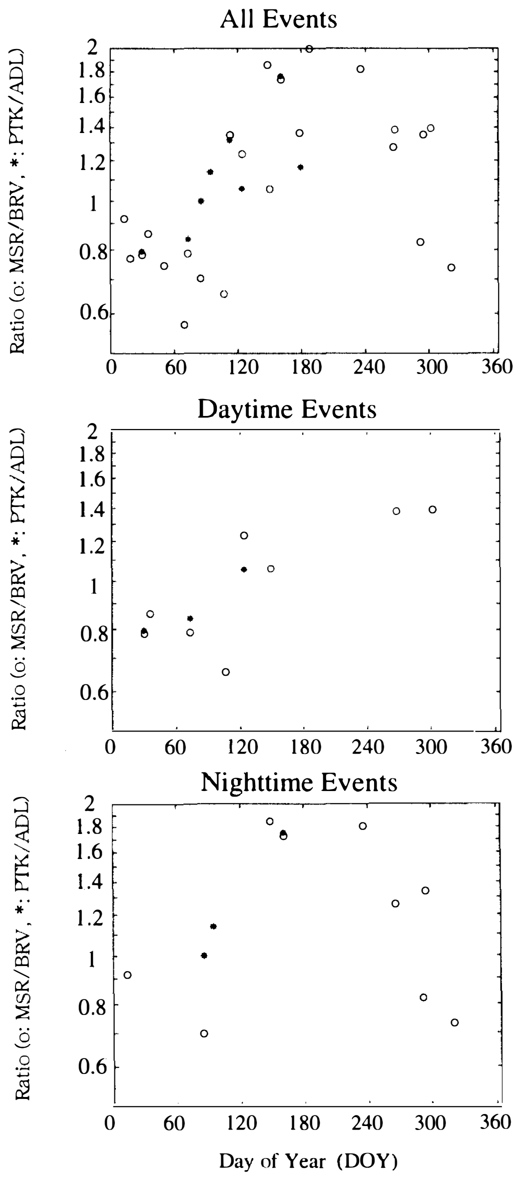

Fig. 1. H-component amplitude ratio of sc/si magnetic variations between the northern and southern stations along the 210° magnetic meridian. The top panel is for all events. The middle and bottom panels are for the events occurred in the daytime (09–15 LT) and nighttime (21–03 LT) sectors, respectively. The circle and asterisk indicate the ratio of MSR/BRV and PTK/ADL, respectively.

the following two conditions:
(1) The H-component amplitude of sc/si is greater than 10 nT.
(2) The wave form is clear enough to identify the onset and peak points.

The top panel represents the amplitude-ratio distribution of all sc/si events, which shows a seasonal variation of the asymmetry of H component. The sc/si amplitude at PTK and MSR in the northern hemisphere is greater than that at BRV and ADL in the southern hemisphere during northern-hemisphere summer, and smaller during northern-hemisphere winter. Basically, this result is consistent with that of YUMOTO *et al.* (1996a). In order to investigate the local time dependence of the asymmetry, we re-plot all events as shown in the middle and bottom panels. The middle and bottom panels show the amplitude of the sc/si event occurred in the daytime (09–15 LT) and nighttime (21–03 LT) sectors, respectively. It is clear that in the nighttime sector the asymmetry of H component of sc/si has a seasonal variation. In the daytime sector, number of plots is not enough to represent a clear seasonal variation, but for the first six months the amplitude ratio certainly increases with increasing of day of year (DOY). This characteristic in the daytime sector was explained by the seasonal variation in the ionospheric conductivity (YUMOTO *et al.*, 1996a). However, the asymmetry in the nighttime sector cannot be interpreted by the asymmetry of ionospheric conductivity, because the ionospheric conductivity is much lower in the nighttime. The northern/southern asymmetry of sc/si in the nighttime might be produced by that of the DL-field component.

3. Estimations of sc/si Asymmetry by Tsyganenko 96 Model

We estimated the magnetic field produced on the ground by the sudden increase of CF current. Figure 2 shows a schema for this estimation. The CF current flowing at the dayside magnetopause would be enhanced by a sudden increase in the solar wind dynamic pressure. This current generates the northward magnetic field in the magneto-

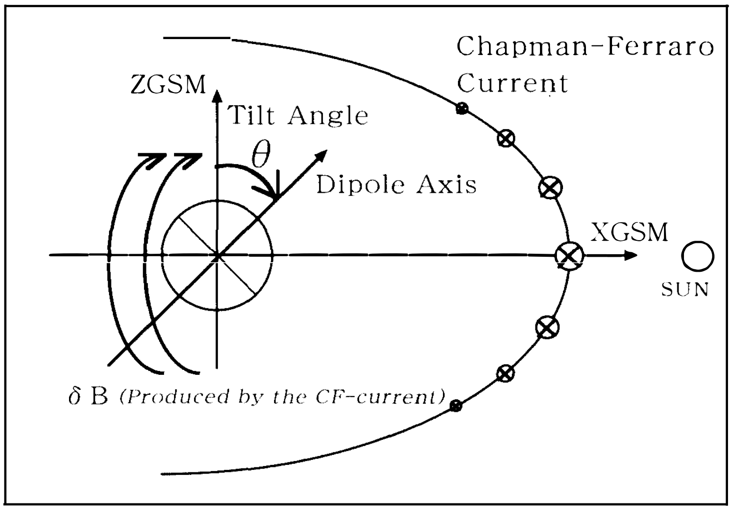

Fig. 2. A schematic illustration for estimations of the DL-field magnetic variation by using Tsyganenko 96 model.

sphere. It causes the sudden increase of the northward magnetic field also on the ground. It was called the DL-field of sc/si (ARAKI, 1977, 1994). We considered that this northward magnetic field on the ground might be dependent on the season, because the tilt angle formed by the Earth's dipole axis and Z-axis of the GSM coordinate system is as a function of the season. The seasonal variation in the tilt angle could be a cause of the northern/southern asymmetry of the DL-field component.

We calculated the magnetic field variation for each season by using Tsyganenko 96 model (T96). The code of T96 requires the solar wind dynamic pressure as one of the input parameters to decide the shape and intensity of the CF current, and shows a steady state magnetic field in the magnetosphere (*cf.* TSYGANENKO, 1995, 1996). We took a component associated with the CF current, and calculated the difference of magnetic field produced by the CF current for high and low solar wind dynamic pressures. In the real magnetosphere the magnetic field on the ground due to the solar wind dynamic pressure will depend also on many other factors, such as the developments of ring current, tail current and so on. But it can be considered that transient (and/or step-like) increase of the magnetic field on the ground is caused only by the CF current, because the time constant of CF current changes is too short for the ring current and the tail current to develop. Therefore, we are allowed to assume the DL-field component as the difference of two steady states before and after sc/si.

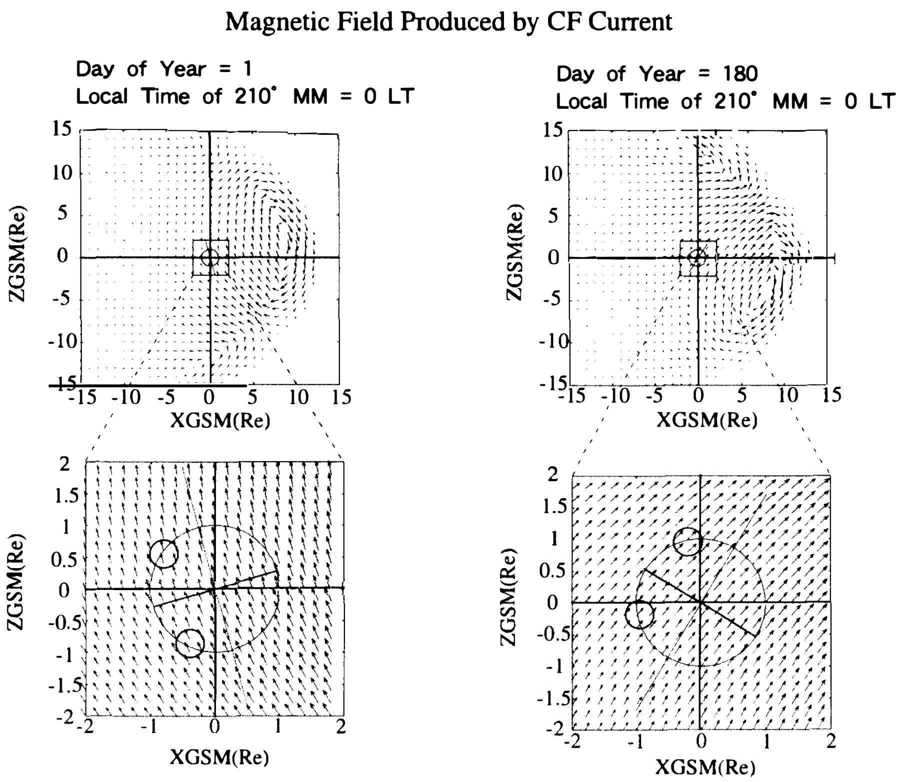

Fig. 3. The magnetic fields produced by sudden increases of Chapman-Ferraro currents using Tsyganenko 96 model. The left two panels are on 1 DOY and the right two panels are on 180 DOY, where the 210° magnetic meridian is located at local midnight. The scales of XGSM and ZGSM axes for each upper and lower panel are from $-15\ R_E$ to $15\ R_E$, and from $-2\ R_E$ to $2\ R_E$, respectively.

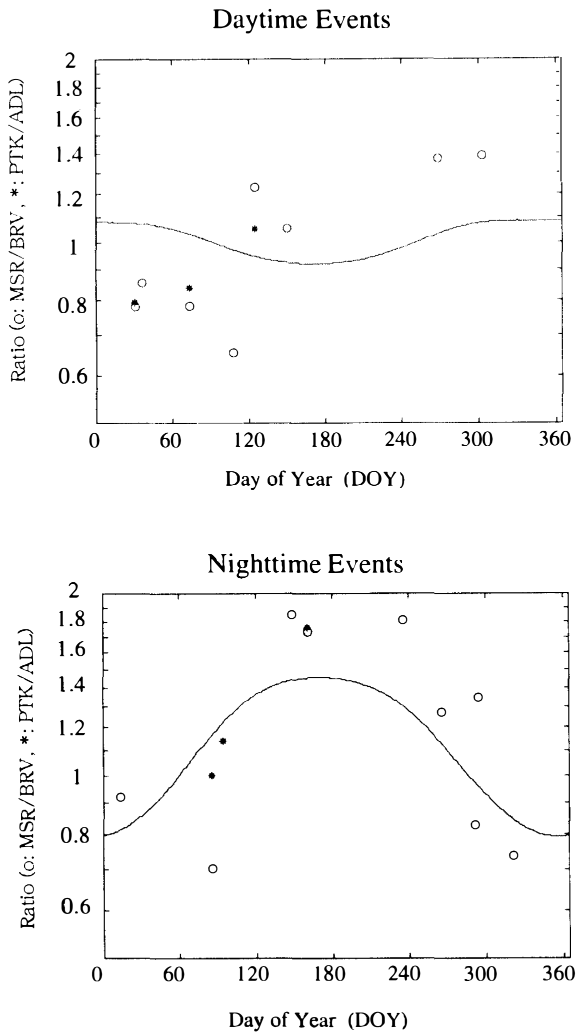

Fig. 4. The estimated H-component amplitude ratios (solid lines) and the observed plots of sc/si magnetic variations at the conjugate stations. The solid lines are obtained by using Tsyganenko 96 model.

The results of the estimation are shown in Figs. 3 and 4. The magnetic field produced by the CF current is represented in Fig. 3. In this figure the inputted universal time is always 14 UT, meaning that the 210° magnetic meridian is located at local midnight. The left panel shows the magnetic field produced by sudden increase of the CF current on January 1 (DOY = 1), and the right panel on June 29 (DOY = 180). The center of the CF current is shifted northward from the subsolar point on January 1, and shifted southward on June 29. This trend on June 29 appears more clear than that on January 1. Moreover, it is also clear that inclination of the magnetic field on the Earth's surface in the northern hemisphere is larger than that in the southern hemisphere on January 1, and smaller on June 29. We considered that the difference of the inclination might be the cause of northern/southern asymmetry of sc/si observed in the nighttime sector on the ground.

Then we calculated the amplitude ratio of H-component magnetic variations at the magnetic latitudes of 37° between the both hemispheres, which are near the conjugate stations of MSR and BRV. The plots of Fig. 1 are shown again in Fig. 4. The smoothed solid line shows a noticeable seasonal dependence of N-S ratio of H-values at sc/si in the nighttime sector, but not in the daytime sector. From these results, we can conclude that the northern/southern asymmetry of sc/si magnetic variations in the nighttime sector on the ground is caused by that of the DL-field component of sc/si which is produced by the sudden increase of the CF current, while in the daytime sector the asymmetry must be produced by that of the DP-field component due to the ionospheric higher conductivity.

However, we have to make more careful examination for these phenomena, because the present study did not include many magnetospheric effects such as the deformation of the compressional wave front by the plasmasphere, the effects of the Earth as the perfect conductor and any time dependent effects. Furthermore, these characteristics of the asymmetry must be dependent on the magnetic longitude. More analysis for other magnetic meridians is needed to check these characteristics.

4. Summary

We can summarize the results in this paper as follows;

(1) The H-component magnetic variation of sc/si observed in the summer hemisphere is larger than that in the winter hemisphere in the nighttime sector as well as in the daytime sector. The amplitude ratio of asymmetries shows a seasonal variation.

(2) From our estimations by using Tsyganenko 96 model, in the nighttime sector the magnetic field inclination of DL-field component in the winter hemisphere is found to be larger than that in the summer hemisphere, and it is vice versa in the daytime sector.

We conclude that the northern/southern asymmetries of sc/si in the nighttime and daytime sectors are produced mainly by the DL-field and DP-field component, respectively.

Acknowledgments

The Tsyganenko 96 model and related software (GEOPACK) were provided from NSSDC (National Space Science Data Center). Our sincere thanks go to all members of the 210° MM Magnetic Observation Project for their ceaseless support.

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(Received November 18, 1997; Revised manuscript accepted March 4, 1998)