Seasonal dependence of magnetic field variations from sub-auroral latitude to the magnetic equator during geomagnetic sudden commencements

SA41A-1707

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1. Introduction

1.1 Seasonal variation of SC amplitude in the past studies

It is important to investigate seasonal dependence of ground magnetic perturbations produced by the region-1 type field-aligned currents (FACs) and resultant ionospheric currents during the main impulse (MI) of geomagnetic sudden commencements (SCs) in order to understand the process and feature of ionosphere-magnetosphere coupling associated with the sudden compression of the magnetosphere due to an arrival of solar wind shocks or discontinuities.

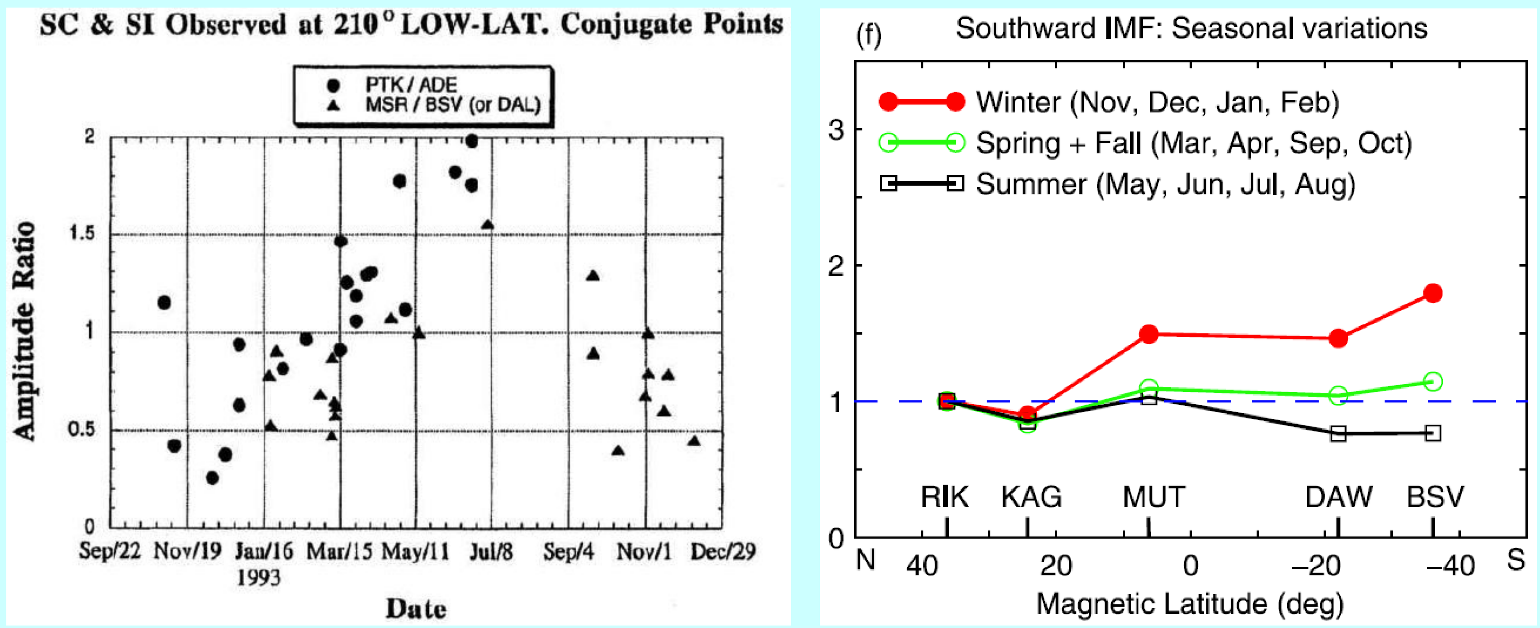

Fig.1. Seasonal variation of north-south asymmetry of SC amplitude in the middle latitudes as a function of day and month (a) [Yumoto et al., 1996] and in a region from the middle latitudes to magnetic equator as a function of magnetic latitude (b) [Huang and Yumoto, 2006].

It has been shown that the SC amplitude in the low and middle latitudes tends to enhance significantly in summer. Yumoto et al. [1996] interpreted that the seasonal variation of SC amplitude leads to the variation of ionospheric current driven by the polar electric field due to ionospheric conductivity variation. On the other hand, Huang and Yumoto [2006] proposed that the SC amplitude could vary due to an effect of dipole tilt angle.

1.2 Problems of the past studies and purpose of this study

However, there are a few of reports on a detailed and systematic investigation of seasonal variation of SC amplitude as functions of magnetic local time and latitude due to the following reasons:

1. **Shortage of SC events and the geomagnetic station where we can obtain the high-time resolution data (1 second).**
2. **There has not been an appreciate environment for us to easily make a number of time-series plots with comparison between solar wind and geomagnetic field data. Moreover, the data format is different from different data providers.**

In this study, we try to clarify seasonal dependence of SC amplitude in a wide region from the sub-auroral latitude to equator, using the geomagnetic field data with high-time resolution (1 sec) obtained from the NSWM [Kikuchi et al., 2008] and CPMN [Yumoto et al., 1996] chains and provided from WDC Kyoto for geomagnetism.

2. Date sets and analysis

(1) Identification of SC events

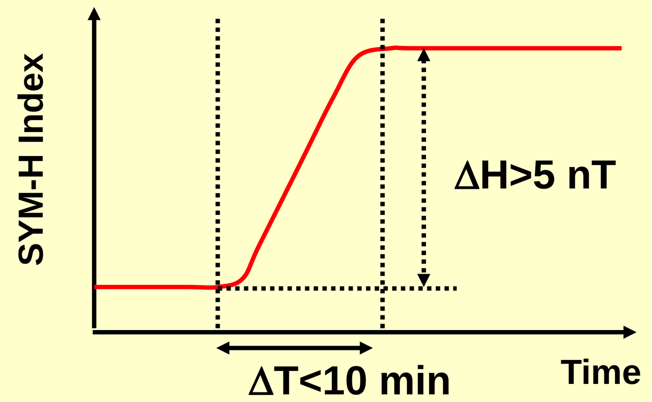

Fig. 2. An schematic view of the SYM-H variation associated with an abrupt increase of solar wind dynamic pressure.

SC event is defined as a rapid increase event of more than 5 nT within 10 minutes in the SYM-H index.

In this case, in order to exclude the magnetic disturbances related to substorm activity, we have checked the occurrence of Pi 2 pulsations around the SC onset obtained from the above definition.

(2) Definition of SC amplitude

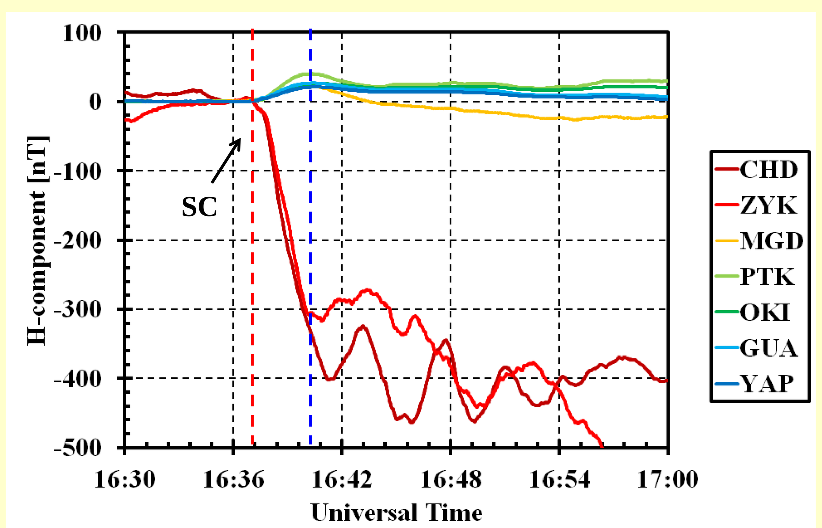

Fig. 3. An SC event at 16:35:48 (UT) on September 7, 2002 observed at 7 stations (CHD, ZYK, MGD, PTK, OKI, GUA, and YAP). The vertical dotted red and blue lines indicate the SC onset and the maximum of SC amplitude in the low latitude (OKI).

SC amplitude is defined as a difference between the H-components at the SC onset and the time of the maximum of magnetic field variations in the low latitudes as shown in Figure 3.

In this analysis, we have normalized the SC amplitude by the SYM-H value with correction of magnetic latitude.

3. Results

3.1 Distribution of geomagnetic station used in this study

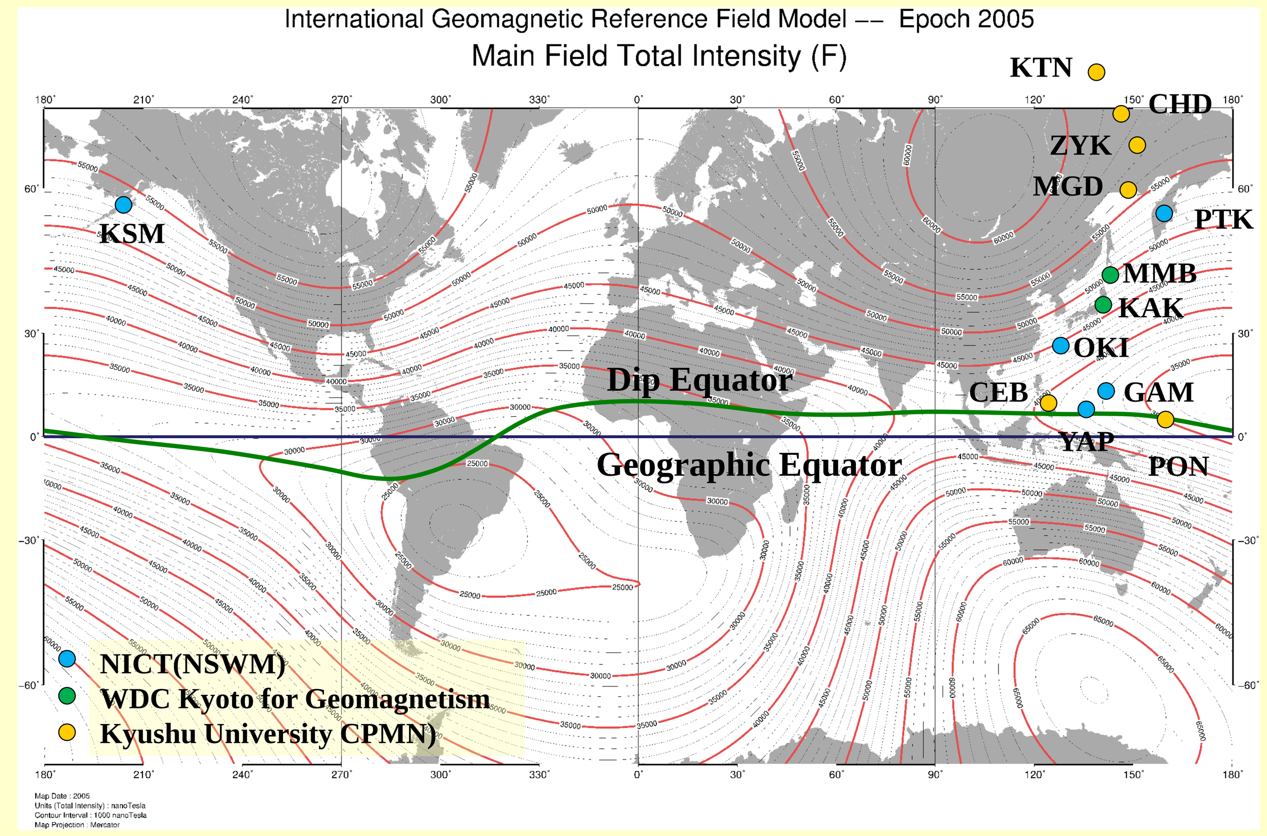

Fig. 4. A global map of the geomagnetic station used in this study. The blue and green lines are the geographical equator and dip equator, respectively. The counter lines is the ambient magnetic field intensity.

3.2 Seasonal variation of SC amplitude

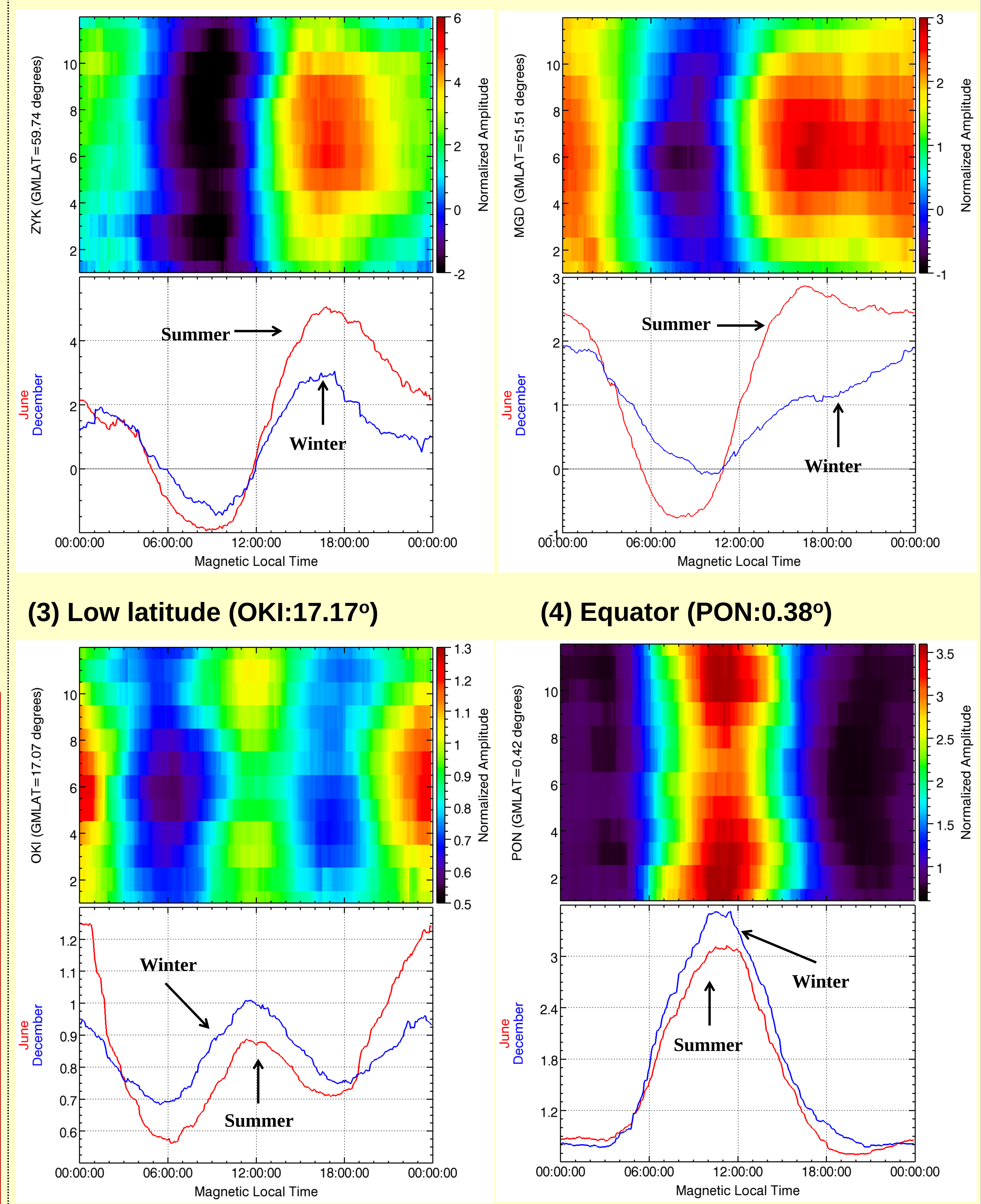

Fig. 5. Seasonal variation of SC amplitude from the subauroral region (1) to the magnetic equator (4). In the subauroral and middle latitudes, the SC amplitude tends to enhanced significantly, while it tends to depress slightly in a region from the low latitude to equator. The seasonal dependence indicates a different feature between the middle latitude and magnetic equator.

3.3 Latitudinal profile of SC amplitude

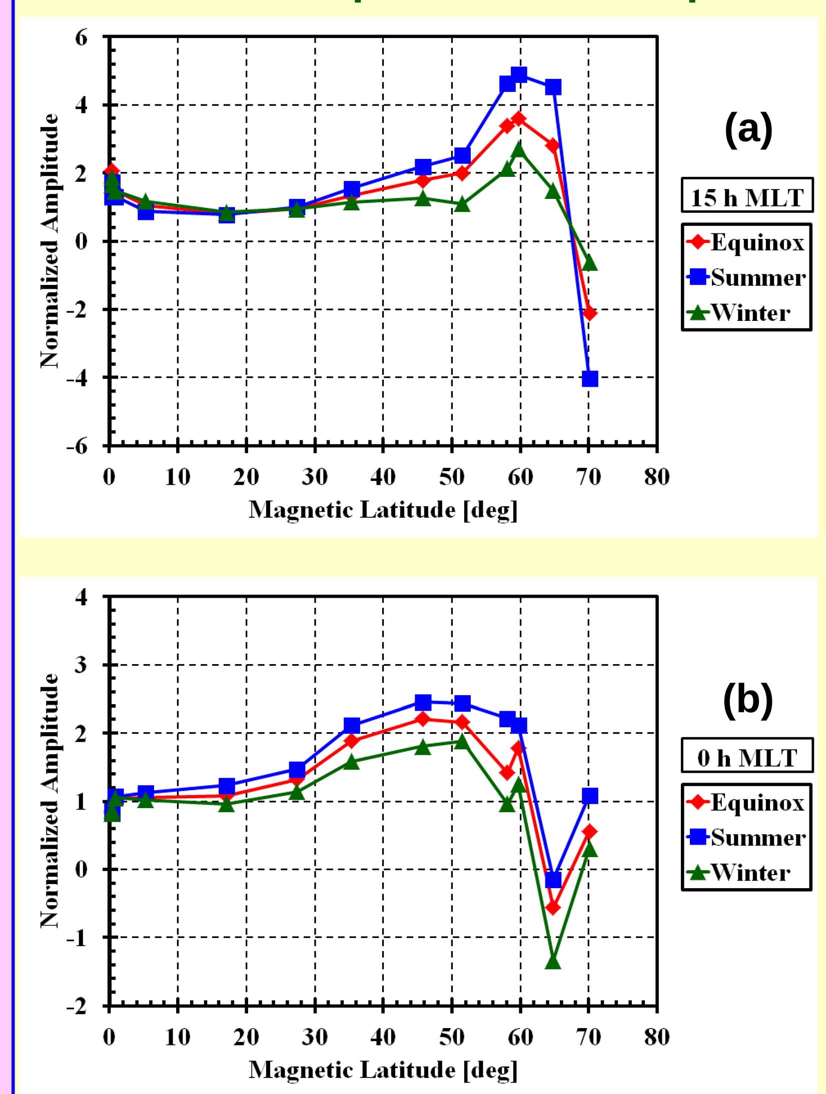

Fig. 6. Latitudinal profiles of SC amplitude in a wide region from high latitudes (GMLAT=70.08°) to magnetic equator (GMLAT=0.42°) of the afternoon (15 h MLT) (a) and midnight (0 h MLT) (b) sectors, respectively. The red, blue and green lines are SC amplitudes in three periods of equinox (2-4 and 8-10), summer (5-7) and winter (11-1).

The SC amplitude in both the afternoon and midnight sectors tends to be enhanced significantly during summer, but to be suppressed slightly in a region from the low latitude to magnetic equator.

4. Conclusion

1. **Seasonal dependence of ground magnetic perturbations during the main impulse (MI) of geomagnetic sudden commencements (SCs) in a region from auroral latitude (KTN: geomagnetic latitude (GMLAT) = 70.08 degrees) to low latitude (PON: GMLAT = 0.42 degrees) has been investigated using the long-term geomagnetic field data with high time resolution of 1 sec within a period from 1996 to 2010.**
2. **In a region from the sub-auroral to middle latitudes, the DP 2-type magnetic disturbance in the daytime sector, produced by the ionospheric currents, tends to be enhanced significantly during summer when the ionospheric conductivity is large. Moreover, the SC amplitude in the nighttime sector also tends to increase during the same season. Araki et al. [2006] and Shinbori et al. [2009] demonstrated that the nighttime magnetic disturbance associated with SCs is produced by the magnetic effect of region-1 type field-aligned currents (FACs) generated by the sudden compression of the magnetosphere. Based on the above result of the previous works, seasonal variation of the nighttime magnetic signature indicates the seasonal variation of the intensity of SC-associated FACs. Therefore, it can be concluded that the large-scale SC current system connecting between the ionosphere and magnetosphere is the voltage generator.**
3. **The daytime SC amplitude in a region from the low latitude to magnetic equator tends to be suppressed slightly during summer, whose tendency is quite different from the seasonal dependence of SC amplitude in the middle latitude. This depression mechanism should be solved in future study using the thermosphere wind data obtained from the meteor and MF radars provided from the IUGONET project.**