地磁気急始に伴う中低緯度電離圏電場応答の磁気地方時依存性

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MLT dependence in the response of Ionospheric electric fields at mid-low latitude during geomagnetic sudden commencements

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Geomagnetic sudden commencement (SC) is globally observed as a rapid variation of the H-component of geomagnetic field on the ground, and is caused by an enhancement of the magnetopause current associated with the compression of the magnetosphere due to Coronal Mass Ejection (CME). The geomagnetic field variation during SC is explained by the 3-demensional current systems composed of the magnetopause current, the field-aligned currents, and the ionospheric currents [cf. Araki, 1994]. The signature of SC related electric fields is observed in the ionosphere and plasmasphere on the basis of the HF Doppler and the geomagnetic field observations [Kikuchi et al., 1985; Kikuchi, 1986] and Akebono [Shinbori et al., 2006], respectively. An initial excursion of electric field associated with preliminary impulse (PI) depends on magnetic local time (MLT) by the HF Doppler observations [Kikuchi et al., 1985] and by model calculations [Tsunomura et al., 1984]. However, the detailed response of electric fields without the effect of ionospheric conductivity has not yet been clarified due to few in-situ satellites which measured the electric field in the ionosphere. Therefore, we analyzed the in-situ ionospheric electric field data by ROCSAT-1 and show the onset timing of SC, the peak timing of PI, and the MLT distribution.

The ROCSAT-1 was in low-earth and near-circular orbit at an altitude of about 600 km and with an inclination of 35 degrees, and had observed from 27 Jan. 1999 to 16 Jun. 2004. Since the observation period corresponds to the high solar activity, many ionospheric disturbances associated with SC events have been detected [Shinbori et al., 2009]. Ionospheric electric field was derived from the drift velocity observed by the Ionospheric Plasma and Electrodynamics Instrument (IPEI) onboard ROCSAT-1 with magnetic field assumed from the IGRF-10 model. We also referred the geomagnetic field variations at low latitude and dip equator with the time resolution of 1 s. We selected the SC events from the list of Shinbori et al. (2009) with the following criteria; (1) IPEI observation is available (11 Mar. 1999 ˜13 Jun. 2004), (2) the PI amplitude was more than 2nT near the dayside dip equator, and (3) the preliminary reverse impulse (PRI) signature was found.

We identified 203 SC events under these conditions, and confirmed that the SC onset in both ionospheric electric fields and geomagnetic fields occurred at almost the same timing except for the SC events influenced by plasma bubble. Since this simultaneity was observed independently of MLT, it would appear that the fast response of ionospheric electric fields is globally a common phenomenon. We also pursued Superposed Epoch Analysis (SEA) as a reference of the PI peak time of the ionospheric electric field and estimated the transmission time delay between them. As a result, the PI signature of electric field appeared faster than that of geomagnetic field near dip equator with ˜10 seconds of delay, which affirm the transmission line model [Kikuchi and Araki, 1979]. Namely, the onset timing depends on the transmitting velocity, while the PI peak timing is determined by time constant L/R of equivalence circuit which contacts between mid-latitude (ROCSAT-1 position) and dip equator (locations of geomagnetic stations). The time lag is occurred by large time constant due to high ionospheric conductivity at dip equator. In addition, we showed the MLT distribution of the SC amplitude, and the PRI signature which is dayside characteristics was detected at 18-21h (after evening terminator sector). This coincides to the model included the effect of field-aligned currents in the current structure during SC [Tsunomura et al., 1984], and is affirmed by the physical quantity ionospheric electric fields independent of magnetic fields. Since the ionospheric dayside variation is also the same feature, we suggest that the transmission of electric field from magnetosphere affects their processes.