Seasonal dependence of SC amplitude on MLT and IMF

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It has been generally believed that the amplitude of sudden commencement (SC) observed in low and middle latitudes on the ground tends to be larger in the noon sector than in the night sector [e.g., Russell et al., 1994]. However, in resent studies, it is shown that the SC amplitude tends to be abruptly enhanced in the midnight sector [Russell et al., 1994; Araki et al., 2006]. Russell et al. [1994] found that the SC amplitude in the case of the southward IMF is much more enhanced in the night sector, compared with that in the case of the northward IMF. From a case study, Araki et al. [2006] also showed that a large enhancement of the SC amplitude in the night sector occurs in the case of the southward IMF. However, in the above studies, a statistical view of magnetic local time (MLT) and seasonal dependence of the SC amplitude on the IMF direction has not yet been clarified due to the lack of SC events. In the present study, we analyzed 12202 SC events which have been identified in term of the SYM-H index within a period from 1976 to 2007 to clarify the affect of the diurnal and seasonal variations of the SC amplitude on the IMF direction.

We picked up these SC events as a rapid increase of the SYM-H value with more than 5 nT within ten minutes in the SYM-H index data. For each SC event, the precise onset time, rise time, and amplitude were identified by referring the H-component geomagnetic variation from the rapid sampling records with the time resolution of 1 second obtained at Kakioka Magnetic Observatory. In the present analysis, the SC amplitude obtained at Kakioka has been normalized by the amplitude in the SYM-H index in order to minimize the contribution of the rapid change in solar wind dynamic pressure. On the other hand, we used solar wind data obtained from the IMP-8, Geotail, Wind and ACE satellites within a period from 1976 to 2007.

The diurnal variation of the normalized SC amplitude showed a clear MLT dependence with noon-night and dawn-dusk asymmetries. The two peak amplitudes appear in the noon (10-15 h MLT) and night (22-02 h MLT) sectors, respectively. On the other hand, the two minimum amplitudes appear in the morning (05-07 h MLT) and evening (16-18 h MLT) sectors, respectively. The nighttime peak value is about 1.5-1.6 times larger than that in the dayside sector. The diurnal variation can be explain by a superimpose of magnetic field disturbances produced by the R-1 field-aligned currents and resultant ionospheric currents, in addition to the magnetopause current.

Next, we investigated a seasonal dependence of the diurnal variation of the SC amplitude on the IMF condition. Here, we classified the average variations of the IMF Bz direction during about 10 minutes before and after the solar wind shock or discontinuity into four types: steady northward (type I), southward turning (type II), northward turning (type III), and steady southward (type IV). In the case of type I, the diurnal variation curves showed that the difference between the minimum and maximum values tends to be larger in summer than in winter. This result implies that the R-1 field-aligned and resultant ionospheric currents produced during the main impulse (MI) phase of SCs become strong in summer due to the enhancement of the ionospheric conductivity. On the other hand, the diurnal variations in the case of type IV showed a larger noon-night asymmetry than in the case of type I. The asymmetry tends to be much stronger in summer and fall than in winter seasons. This result means that the R-1 field-aligned currents (FACs) and resultant ionospheric currents via magnetic reconnection process between the southward IMF and earth's magnetic field are developed at the same time as that of the MI current system associated with the enhancements of solar wind dynamic pressure. Moreover, the magnitude of the R-1 FACs strongly depends on the ionospheric conductance from the seasonal effect of the diurnal variations of the SC amplitude.