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Local and Global Longitudinal Geomagnetic SC Effects at High-Latitudes: Case Study of the Interval of March 07-15, 2012

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Abstract

The geomagnetically active interval of March 7-17, 2012 was the first long interval with high geomagnetic activity in the ascending phase of Solar Cycle 24. It was selected by SCOSTEP for intensive study of the space weather features. Four different magnetic storms with SC have been observed during this time interval It was found that this storm development was accompanied by an enhancement of the magnetic activity at the high latitudes of the Earth. Here we present the results of our study of the SC longitudinal effects on the high-latitude geomagnetic disturbances. The analysis of the ground-based magnetic observations showed that the longitudinal distribution of the high-latitude geomagnetic effect of the SC events depends on the Interplanetary Magnetic Field (IMF) direction as well as on the amplitude of a jump in the solar wind dynamic pressure (*Psw*).

Introduction

The overview of major solar, interplanetary, magnetospheric, and ionospheric features of the geomagnetically active interval of March 7-17, 2012 was reported in [*Tsurutani et al.*, 2014, *Gopalswamy* et al, 2015]. These authors particularly discussed the interplanetary conditions in this interval leading to the developing of the magnetic storms on 7, 9, 12, and 15 March with the peaks of the $SymH_{min}$ of -98 nT, -148 nT, -75 nT, and -79 nT, respectively, associated with the arriving of the magnetic clouds (MC). They found that there were strong interplanetary shocks preceding these magnetic storms. *Tsurutani& Zhou* (2003) found that under the southward IMF, such shocks could cause the substorm occurrence at auroral latitudes.

However, the global scale high-latitude geomagnetic activity in this interval remained outside the scope of these papers. The aim of our paper is to show the global high-latitude geomagnetic disturbances associated with the interplanetary shocks observed as four SC events during the interval of March 7-15, 2012

Observations and discussion

Figure 1 shows the development of the global(*SymH*) and auroral (*AL*) geomagnetic activity, and the IMF the and solar wind conditions as variations of the IMF *Bz* component and the solar wind dynamic pressure during the interval under study during the interval of March 7-15, 2012

Four magnetic storms with SC have been observed during this time interval. They are shown by arrows on the SymH index panel. SC-1 occurred under the strong negative IMF *Bz*, during SC-2 the IMF *Bz* was strong positive. During SC-3, SC-4 the IMF *Bz* changed from negative to positive, the amplitudes of jump of the solar wind dynamic were different from each other that should caused different magnification of SC events as well.

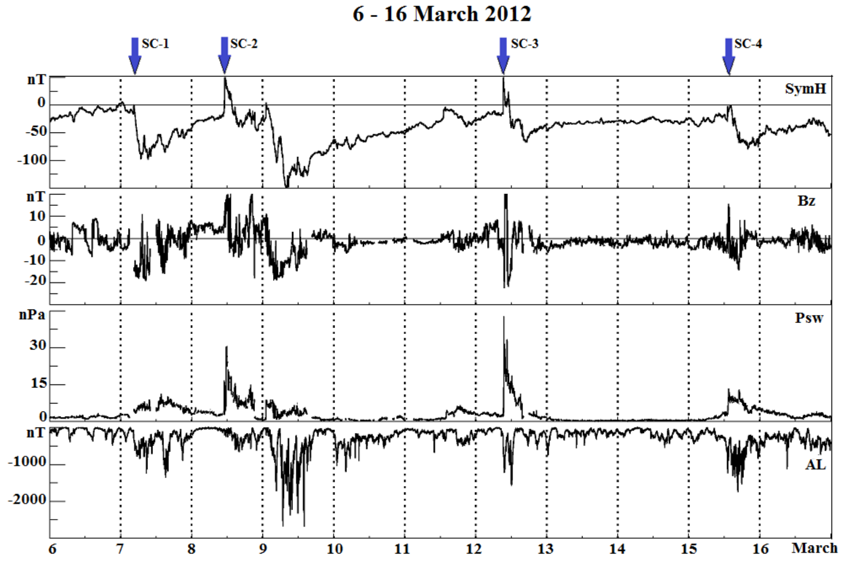
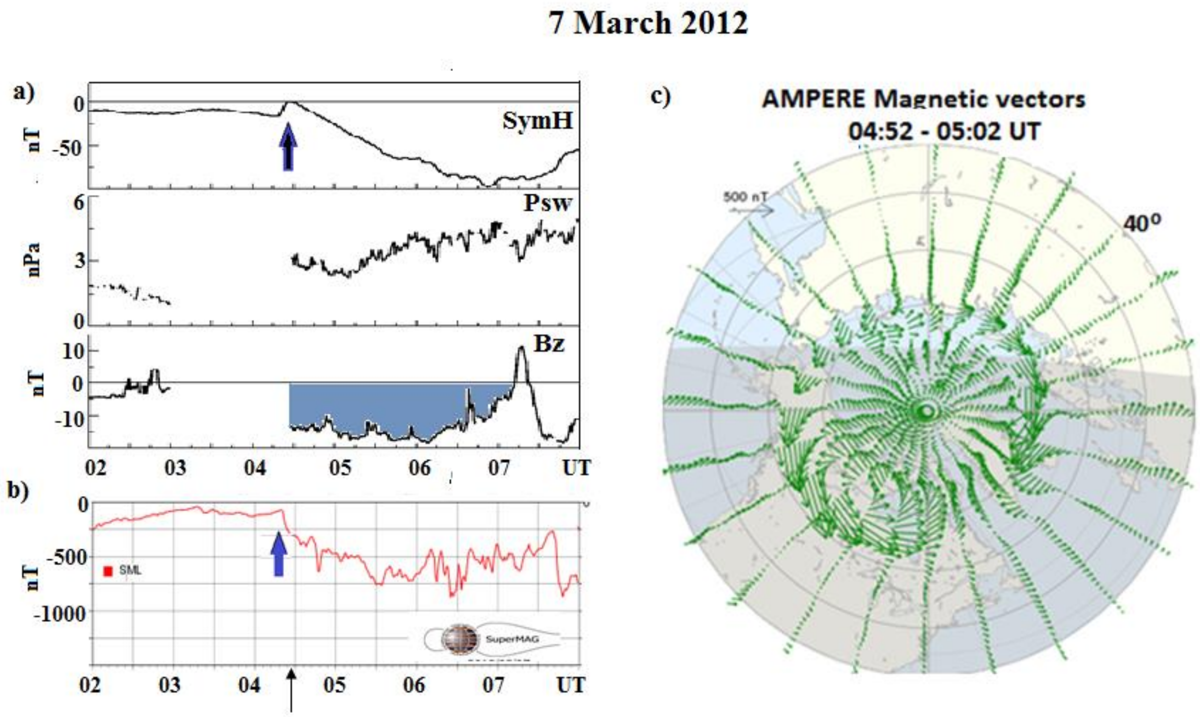


Fig. 1. Interval of March 6-16,2012. Variations of the index of a magnetic storm intensity SymH, IMF Bz component, solar wind dynamic pressure Psw, and index of auroral activity AL Blue arrows point the UT moment of the SCs arrival.

SC-1 event

The IMF *Bz* was stable strong negative and isn't changed during 2,5 hours after SC-1. The amplitude of the *Psw* jump was small (Fig.2a).



- *Fig.2. SC-1 on 7 March 7, 2012: (a) Variations of the SymH index, Psw and the IMF Bz; the interval of the negative IMF Bz are marked by blue; thick arrow shows the SC-1 time. (b) SML index of the auroral activity. (c) The AMPERE magnetic field perturbations over the high-latitude region as the result of spherical harmonic analysis; location of some polar and auroral stations is shown by circles. Arrow on the UT-time axis of (b) points the map moments.*

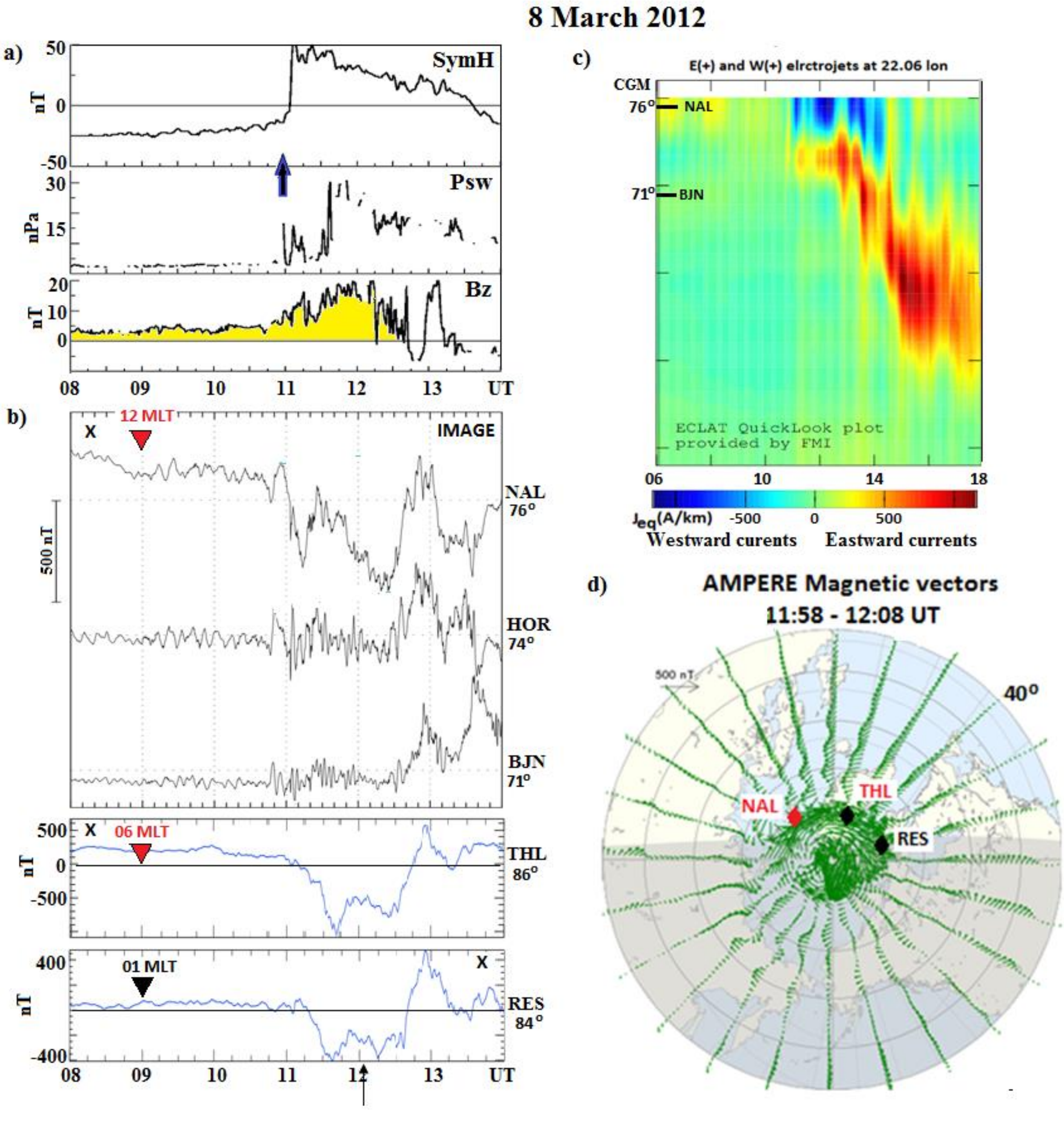
Negative strong Bz and the small jump of Psw (SC-1) initiated strong beginning of the magnetic storm that always accompanied by a sequence of substorms (Fig.2b) that is seen on

SML index panel. AMPERE map shows the geomagnetic disturbances at auroral latitudes (Fig. 2c), no noticeable geomagnetic disturbances were observed at the polar latitudes.

SC-2 event

The IMF *Bz* was stable strong positive and isn't changed during long time interval before and after the PSW jumps. The first *Psw* jump wasn't large (SC-2). Later the IMF *Bz* graduallyincreasing, and the *Psw* sharply jumped to large value (Fig.3 a).

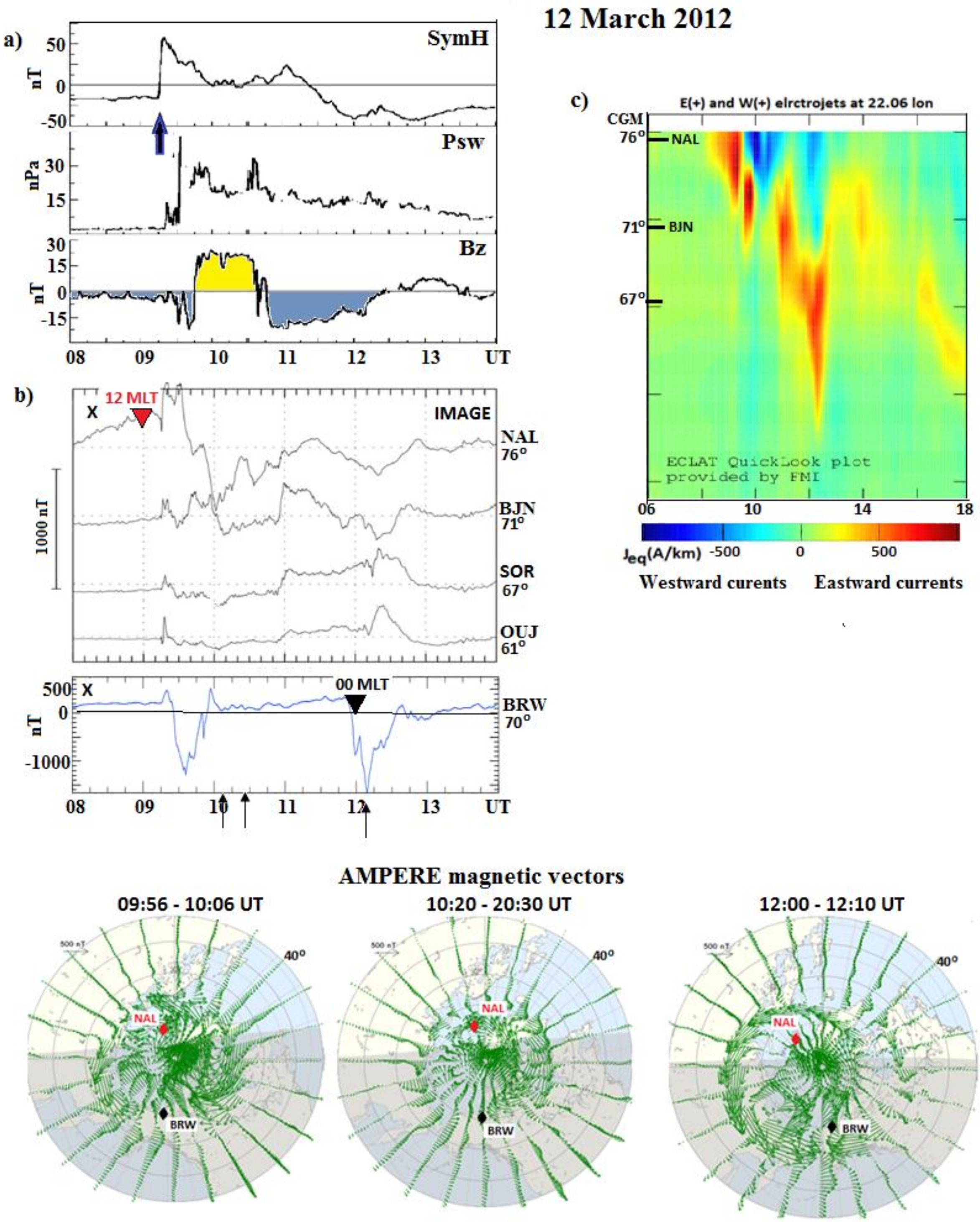
Positive Bz and large jump of Psw led to magnetic bays observed at the polar stations of the dayside, (NAL, HOR), morning (THL) and night (RES) sectors (Fig.3b,c). But the auroral activity was weak (Fig. 3d).



- *Fig.3. SC-2 on March 8, 2012: (a) Variations the index SymH, Psw and the IMF Bz; thick arrow the time of SC-2 arrival. (b) IMAGE and Intermagnet magnetograms of the high latitude stations, triangles show the local geomagnetic time at the 09 UT. (c) Equivalent ionospheric currents by ECLAT model. (d) The AMPERE distribution of the magnetic field as it is shown in Fig. 2c.*

SC-3 event

The negative IMF *Bz* was stable in long interval before the large Psw jump (SC-3). Later Bz briefly changed from negative to strong positive and remained stable during ~ 1 hour, at the same time *Psw* sharply jumped to very large value. Then the IMF *Bz* returned to negative value and was stable about 2,5 hours. (Fig. 4a).

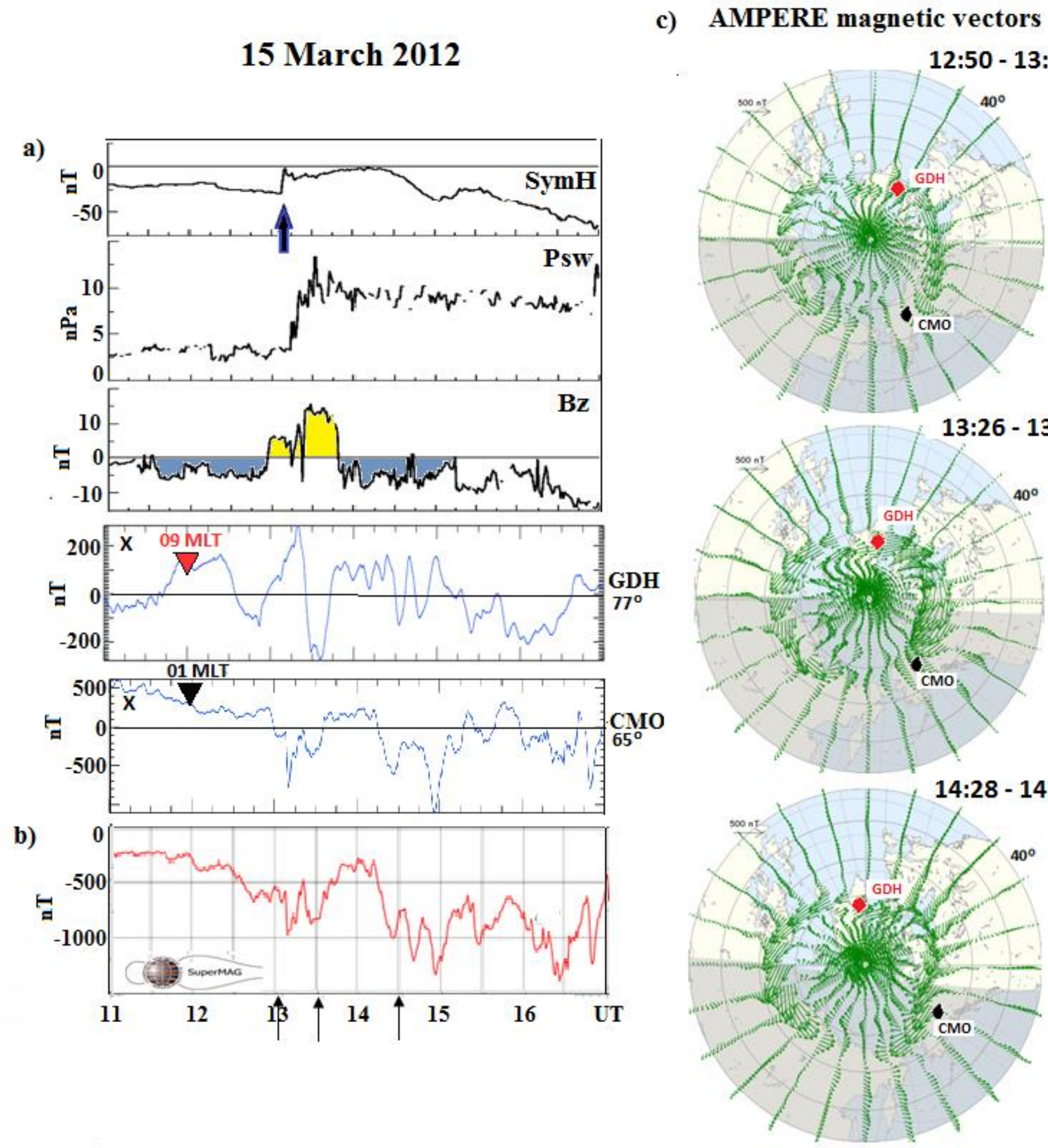


\- *Fig.3. SC-2 on March 8, 2012: (a) Variations the index SymH, Psw and the IMF Bz; thick arrow the time of SC-2 arrival. (b) IMAGE and Intermagnet magnetograms of the high latitude stations, triangles show the local geomagnetic time at the 09 UT. (c) Equivalent ionospheric currents by ECLAT model. (d) The AMPERE distribution of the magnetic field as it is shown in Fig. 2c.*

The long interval *of the negative IMF Bz* preceding the SC-4 and *large jump of Psw* led to the development of global substorms, which were observed in all sectors of the polar and auroral latitudes. With the IMF *Bz* sharp changing to large *positive values,* the substorm in auroral latitudes stopped, and the polar disturbances are observed in the daytime sector only (Fig. 4b, c, d).

SC-4 event

As in SC-3 event, the negative IMF *Bz* was stable in long interval before the small Psw jump (SC-4). Then Bz briefly changed from negative to positive and gradually increasing, remained stable during ~ 1 hour, at the same time *Psw* gradually reached large value. 3)Then the IMF Bz returned to negative value remained stable in a long time (Fig.5a).



- *Fig. 5. SC-4 on March 15, 2012: (a) Variations the SymH index, the IMF Bz and Psw; thick arrow shows the time of SC-4 arrival. (b) Intermagnet magnetograms of the high latitude stations, triangles point the local geomagnetic noon (red) and midnight(black). (c) The AMPERE distribution of the magnetic field as it is shown in Fig.2c.*

The long interval of the *negative IMF Bz* preceding the arrival of SC-4 event and *small jump of the PSW* under *positive IMF Bz* did not change common signature of the geomagnetic activity at the high latitude region. The sharp *small Psw jump* under *the positive IMF Bz* led to development of the magnetic activity in the dayside sector of the polar latitudes without any auroral activity. The IMF *Bz* changing from positive to negative leds to development of the auroral activity with weak disturbances in the polar region. (Fig.5b.c.d).

Conclusion

The magnification of four SC events during the interval of March 7-15, 2012 has been studied.

The analysis of the ground-based magnetic observations showed that the longitudinal distribution of SC high-latitude geomagnetic effect depended on the interplanetary magnetic field (IMF) direction as well as on the amplitude of a jump in the solar wind dynamic pressure (Psw).

We found that under the *positive IMF Bz* and the *large amplitude* (~15 nPa) *of the Psw jump*, the high-latitude SC effects were observed around the pole in all longitudes at the polar latitudes with weak auroral activity. But under a *small Psw jump* (~3-4 nPa), this effect was observed only in the dayside sector of the polar latitudes.

However, under the *negative IMF Bz* and the *large Psw jump*, the high-latitude SC effects were observed as a development of the substorms in the global scale, i.e. in all longitudes of the auroral and polar latitudes, but under the *small Psw jump*, this effect was observed only at the night-side auroral latitudes.

Data

Our study is based on: OMNI database of the Interplanetary Magnetic field (IMF) data of the 1-min resolution (http://omniweb.gsfc.nasa.gov); ground-based magnetic data of the IMAGE magnetometer chain (http://space.fmi.fi/image/) and the global network of observatories INTERMAGNET (http://www.intermagnet.org/)); SML-index derived as analog of AL-index from the magnetometer data of all available ground magnetometer stations at geomagnetic latitudes between 40º and 80º provided by the global SuperMAG network (http://supermag.jhuapl.edu/indices); the AMPERE data, based on the ionospheric magnetic measurements on 66 low-altitude globally distributed Iridium communication satellites (http://ampere.jhuapl.edu/products/plots); the model ECLAT of the equivalent ionospheric currents (http://space.fmi.fi/image/).

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