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THE DECREASE OF THE GEOMAGNETIC FIELD MAGNITUDE DURING SSC EVENT

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Abstract. On the basis of solar wind data from the WIND satellite, magnetic field data from GOES satellite and ground-based magnetic data the influence of secondary rarefaction wave on the geomagnetic field is examined. This secondary rarefaction wave is arising in the magnetosheath during the interaction of interplanetary shock wave with the bow shock-magnetopause system. The secondary rarefaction wave decreases the magnitude of the magnetic field during *SSC*.

Introduction

It is known that arrival of interplanetary shock wave to the Earth's magnetosphere cause compression of magnetosphere and *SSC* (sudden storm commencement) event, which may be the beginning of the magnetic storm. The interplanetary shock wave is characterized by step increase of solar wind density, velocity and magnetic field.
The field of *SSC* is consisting of field on the low latitudes (*DL*) and polar latitudes (*DP*) **(1)**. *DP* consists of main impulse (MI) and preliminary impulse (PI). The currents on the magnetopause cause *DL* field, while the currents in polar ionosphere cause *DP* field [*Araki T., 1994*].

$$D_{SSC} = DL + DP_{PI} + DP_{MI} \tag{1}$$

[*Grib et al., 1979*] theoretically show that during interaction of during interaction of interplanetary shock wave with the bow shock-magnetopause system the secondary rarefaction wave in the magnetosheath is arisen. The mechanism of interaction of interplanetary shock wave with the bow shock-magnetopause system schematically is shown by **(2)**. The result of interaction of interplanetary shock wave S_2 with the bow shock S_{1bow} are two shock waves (forward and backward) and tangential discontinuity T. Then refracted shock wave moves through the magnetosheath. The result of interaction of refracted shock wave S_4 with the magnetopause T_m are the rarefaction wave R, magnetopause T_m and shock wave S_5 moving inside the magnetosphere. This rarefaction wave R reflects from the rear side of the bow shock S''_{bow} and the secondary rarefaction wave R' moves to the magnetopause.
In papers [*Samsonov et al., 2006, 2007*] MHD-simulation of the interaction of interplanetary shock wave with the bow shock and magnetopause and passing of the shock wave through the magnetosheath were performed. It was shown that result of the interaction of the fast shock wave with the magnetopause gives a shock wave or a rarefaction wave. But even the product of the interaction of shock wave with rear side of the bow shock is the rarefaction wave that consistent with results obtained in the work [*Grib et al., 1979*].
In the work [*Safrankova J. et al., 2007*] on the basis of MHD-simulation it was shown that during interaction of interplanetary shock wave with the bow shock at first it is seen the motion of the bow shock in antisunward direction

$$\begin{aligned} &S_{2\rightarrow\leftarrow} S_{1bow} \rightarrow S_{3bow\leftarrow} T\, S_{4\rightarrow} \\ &S_{4\rightarrow} T_m \rightarrow R\, T_m S_{5\rightarrow} \\ &R_{\rightarrow} S''_{bow} \rightarrow R' T_m S_{5\rightarrow} \end{aligned} \tag{2}$$

and then in sunward direction. Possibly this motion is the result of the interaction of interplanetary shock wave with the magnetopause.
In the paper [*Zhuang et al., 1981*] on the basis of ISEE satellite data the existence of rarefaction wave reflected from the magnetopause is confirmed. The attempts to detect secondary rarefaction wave in the magnetosheath is too difficult due to turbulence and vortexes in the magnetosheath.
So the purpose of this paper is to show how secondary rarefaction wave may influence on the geomagnetic field.

Methods

We choose events when the rise time of solar wind dynamic pressure equals more than 5 min, because secondary rarefaction wave need approximately 3-5 min to arrive to the magnetopause after an arrival of the interplanetary shock wave. We choose such events in order to show that the rarefaction wave does not exist in the solar wind but is the result of the interaction of interplanetary shock wave with the bow shock-magnetopause system.
Due to the limitation of the paper we consider only two *SSC* events: on 6 May 2005 and on 9 July 2006. We examine 1-min magnetic data from the WIND, GOES satellites and *H*-component of the magnetic filed from the ground-based stations.
We examine GOES satellite data when the GOES is located on the dayside magnetosphere because magnetopause currents an influence on the dayside magnetic filed. But when the GOES is located on the nightside the decrease on the magnetic field is observed. This decrease of the magnetic field on the nightside geostationary orbit is associated with tail currents.

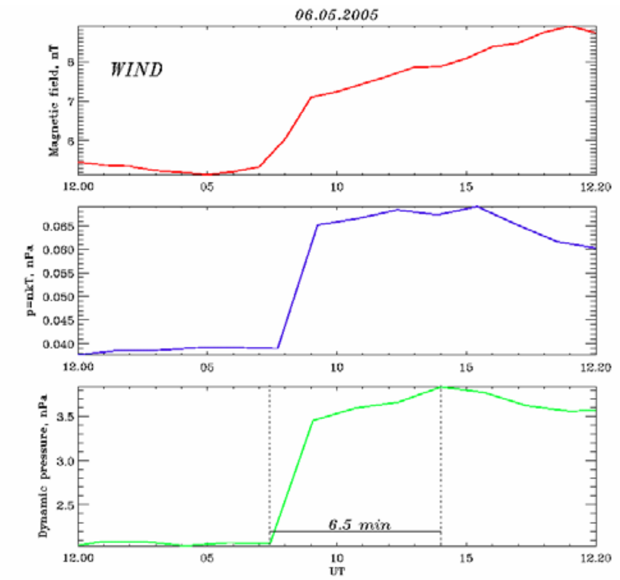

Fig.1. Total interplanetary magnetic filed, solar wind thermal pressure and solar wind dynamic pressure at WIND satellite

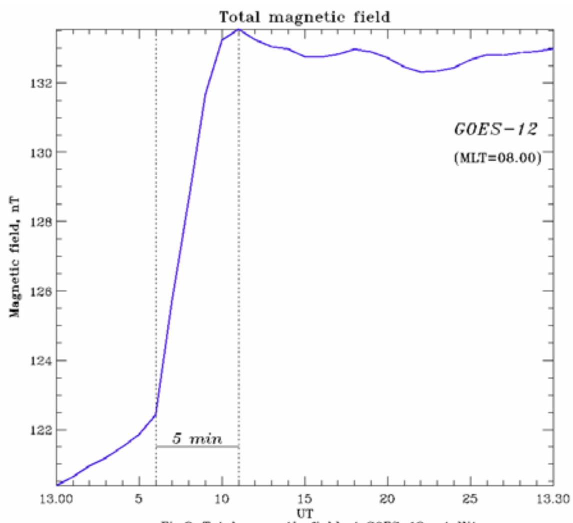

Fig.2. Total magnetic field at GOES-12 satellite.

The dependence of magnetic filed at geostationary orbit is shown in [*Kokubun, S., 1983*].

On the ground we choose low latitude geomagnetic stations because *H*-component of the magnetic field at this latitudes well correlate with the solar wind dynamic pressure [*Russell, C. T., 1992*]. We choose the events when the satellite is located near the Sun-Earth line.

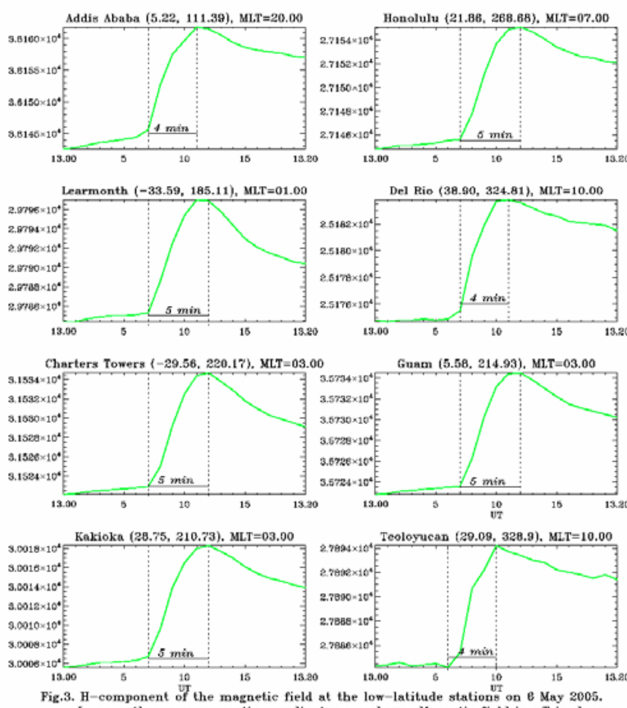

Fig.3. H–component of the magnetic field at the low–latitude stations on 6 May 2005. In parentheses geomagnetic coordinates are shown. Magnetic field in nT is shown on vertical axe.

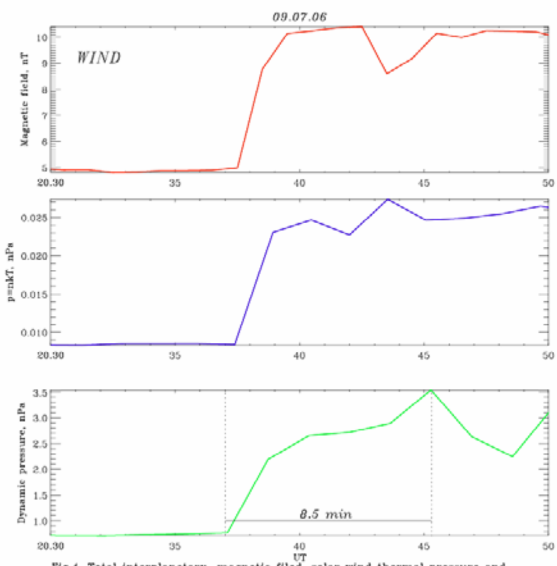

Fig.4. Total interplanetary magnetic filed, solar wind thermal pressure and solar wind dynamic pressure at WIND satellite

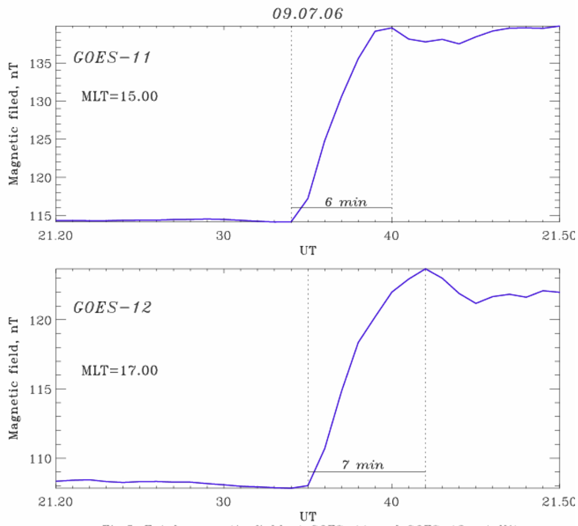

Fig.5. Total magnetic field at GOES−11 and GOES−12 satellite.

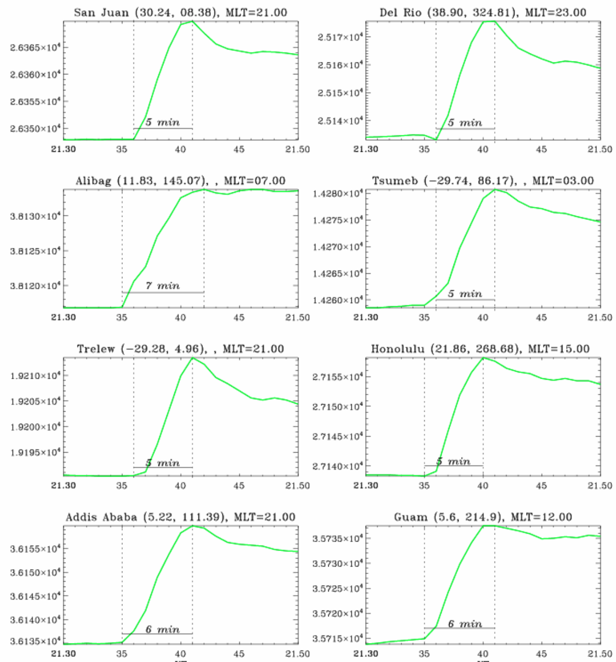

Fig.6. H−component of the magnetic field at the low−latitude stations on 6 May 2005. In parentheses geomagnetic coordinates are shown. Magnetic field in nT is shown on vertical axe.

Results

6 May 2005. On the fig.1 the total magnetic field, solar wind dynamic pressure and thermal pressure are shown. The WIND satellite is located in the point (214, -2, 23) Re in the GSE coordinate system. Rise time of the solar wind dynamic pressure is equal 6.5 min. *Dst*-index during this event is equal 2 nT, so this is *SI* event. *SSC* event registered on the Earth at 13.05 UT.

On the fig.2 the total magnetic field is shown on GOES-12 satellite, which located at 08.00 MLT during *SSC* event. Corrected geomagnetic coordinate is shown in the brackets. The rise time on GOES-12 is equal 5 min.

On the fig.3 the *H*-component of low latitude stations is shown. The vertical line gives the magnetic field in nT. The rise time on the low-latitude stations is equal 4-5 min.

9 July 2006. Total magnetic field, solar wind dynamic pressure and thermal pressure are shown by fig.4. The WIND satellite is located at the point (262, -15, 21) Re in the GSE coordinate system. Rise time of the solar wind dynamic pressure is equal 8.5 min.

On the fig.5 the total magnetic field is shown on GOES-11 and GOES-12 satellites, which are located at 15.00 MLT and 17.00 MLT during *SSC* event. Corrected geomagnetic coordinate is shown in the brackets. Rise time on GOES-11 is equal 6 min and rise time on GOES-12 is equal 7 min.

On the fig. 6 the *H*-component of low latitude stations is shown. On the vertical line the magnetic field is shown in nT. The rise time on the low-latitude stations is equal to 5-7 min.

Discussion

So we see that from two examined cases that the rise time on the ground and at the geostationary orbit are less than rise time of the solar wind dynamic pressure. [*Koval A. et al., 2005*] show that parameters of interplanetary shock wave during propagation thought the solar wind are similar and parameters of the shock wave strongly change during propagation through the magnetosheath.

The variations of the *H*-component of the geomagnetic field at the low-latitude stations quantitatively depend on the variations of the solar wind dynamic pressure. See for example formulae (3) from [*Siscoe G.L., 1968*].

It is known that two main factors determine *SSC* rise time: orientation and velocity of interplanetary shock. When interplanetary shock is highly inclined the *SSC* rise may be longer than the rise time of the solar wind dynamic pressure [*T.Takeuchi et al., 2002*]. Velocity of shock is greater in the interplanetary medium than in the

$$\Delta B_{SSC} = k(\sqrt{p_S} - \sqrt{p_{S0}}) \qquad (3)$$

magnetosheath. So shock with smaller velocity would produce greater *SSC* rise time.

Besides taking into account these two factors we consider that the rise time observed at the Earth's surface would be smaller than the observed rise time because orientation of the shock and smaller shock velocity increase the *SSC* rise time.

In all cases we see that rise time of the magnetic field on the ground and at geostationary orbit are proportional to the rise time of solar wind dynamic pressure. At the same time the magnetic field on the ground and in the magnetosphere in all cases less than rise time of the solar wind dynamic pressure. We associate these differences in the rise time with an influence of secondary rarefaction wave on the geomagnetic field.

Conclusions

We obtain that the magnitude of the magnetic field decrease during SSC event**.** We suppose that this decrease is associated with the generation of secondary rarefaction wave appearing in the magnetosheath during the interaction of interplanetary shock wave with the bow shock-magnetopause system.

The data from the WIND and GOES satellites ware taken from the site http://cdaweb.gsfc.nasa.gov/.
The data from the ground-based stations ware taken from the site http://swdcwww.kugi.kyoto-u.ac.jp/

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