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THE ANALYSIS OF THE RELATIONSHIP BETWEEN MAGNETIC FIELD GLOBAL INDICES (SYM, ASY) AND AURORAL ELECTROJET INDICES (AU, AL) UNDER THE ACCOUNT OF PARAMETERS OF A SOLAR WIND AND AN INTERPLANETARY MAGNETIC FIELD

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Abstract

The connection of the symmetric and asymmetrical parts of the ring current (SYM, ASY) with auroral electrojets (AU, AL) at the main and recovery phases of a geomagnetic storm is found. There has been determined the role of magnetosphere-ionospheric current systems in generation of asymmetry of the magnetic field on the ground in particular sectors of the local time. The study was conducted in view of parameters of Solar Wind (PSW) and interplanetary magnetic field (IMF) for various time delays of indices SYM, ASY relatively AU, AL. There has been revealed the efficiency of the influence of state in the Solar Wind on the development of the ring current and auroral electrojets. For this purpose the correlation study of connection of SYM, ASY, AU, AL indices with particular parameters of the near-earth space is carried out.

1. Introduction

It is well-known, that geomagnetic activity is a consequence of large scale electrodynamics processes in the Earth magnetosphere. The energy, which is necessary for generation of these processes, enters from the interplanetary space. As main parameters of Solar Wind (PSW) it is common practice to consider the SW concentration, the module and components of velocity and plasma temperature (n, V, Vx, Vy, Vz, T). For interplanetary magnetic field (IMF) the parameters are the module and components of the magnetic field (B, Bx, By, Bz). Many investigations show that the main factors, which are responsible for geomagnetic activity, are the velocity of Solar Wind V and vertical Bz component of the interplanetary magnetic field [Vennerstroem, 2001]. It is proved as well, that the southern direction of Bz component is necessary for the development of an intensive magnetic storm [Gonzales and Tsurutani, 1987]. Furthermore in papers [Xiaoyan Zhou and Bruce T. Tsurutani, 2001] the influence of IMF Bz component on the magnetospheric substorm activity is revealed. However, for the successful prediction of geomagnetic activity it is important to establish both the basic agents causing the activation of a ring current or auroral electrojets, and to establish the time, necessary for magnetospheric response on perturbation in interplanetary space.

2. Data preparation

In the present paper the indices of geomagnetic activity Dst, SYM, ASY, AU, AL, AE were analyzed during magnetic storms, taking place in 2000 - 2001. There were selected 15 intervals of the greatest magnetic storms which was determined on the basis of Dst index. Every interval contained the main phase of a magnetic storm and the recovery phase. Data of PSW and values of IMF components were obtained from ACE spacecraft, which was near to the libration point during the considered cases. All data were taken with two hour forestalling of a geomagnetic disturbance, plus an interval equal to duration of every viewed disturbance. It was recognized that the forestalling time should be derived from the time which is necessary to transport the Solar Wind to magnetopause, and the time bounded with development of inner magnetosphere processes, which are reflected in geomagnetic disturbances.

3. The study of relationship between indices of the ring current intensity and auroral electrojets

The analysis of relationship between indices of intensity of the symmetric and asymmetrical parts of ring current (SYM, ASY) and indices of intensity of eastward and westward electrojets (AU, AL) at different phases of magnetic storm was carried out. The study was conducted for various time delays (0 - 2 hours) of indices SYM, ASY relatively to AU, AL and vice versa. At the main phase and at the recovery phase a precise connection of the development of symmetric and asymmetric parts of a ring current with auroral electrojets is found. The intensity of the eastward electrojet varies synchronously with indices SYM, ASY. The correlation of the westward electrojet with symmetric part of the ring current is the highest in the case of a time delay of 2 hours. Connection of the westward electrojet with index SYM is the highest, when the delay of 2 hours is applied. The role of magnetosphere-ionospheric current systems in the generation of asymmetry of the magnetic field at the ground level is specified in particular sectors of local time. During a magnetic storm the westward electrojet takes almost the entire area of the auroral oval, and the eastward electrojet dislocates from the classical spatial situation (MLT ~ 17 - 22) to the day time region.

4. Connection of a ring current and auroral electrojets with PSW and IMF

During the considered interval, the average distance of the ACE spacecraft to the Earth was $1{,}5 \cdot 10^6$ km (Fig. 1). Hence, it is possible to determine almost precisely the time of transport of the magnetized Solar Wind up to the boundaries of the bow shock for each of the considered events. Further it is possible to calculate the average time of this transport for every group of events (weak, moderate and strong storms). Finally, one can find the average time of magnetospheric response to perturbations in the Solar Wind. It has been done by defining the average time between PSW and IMF perturbations and those in the ring current and auroral current systems and the subsequent extraction of the time, which is necessary to immediate transport of the perturbed Solar Wind up to the boundary of the bow shock.

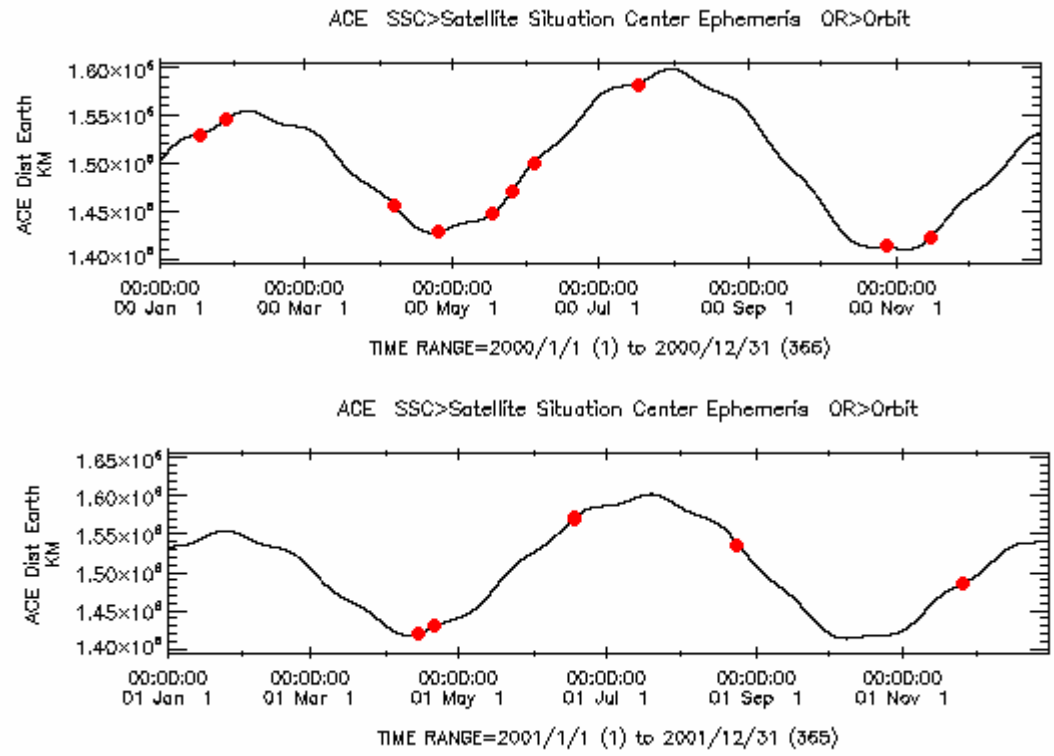

Fig. 1. The change of distance from spacecraft ACE up to the Earth within 2000-2001. Dots mark the investigated geomagnetic storm events.

The main results of the correlation analysis of indices SYM, ASY with changes in PSW and IMF:

1. Velocity and concentration of the Solar Wind have the greater influence on the ring current (SYM, ASY), than on auroral electrojets. That is manifested in a sharp increase of the correlation coefficient (up to 0.8) at the particular time delay. This feature is traced most precisely in case of strong storms and storms of small intensity. Similar changes of correlation are noted also at the analysis of connection of these indices with By component.

2. The analysis of changing of the correlation coefficient has shown, that the characteristic times of display PSW and component By IMF in the symmetric and asymmetrical currents are about 70-80 (30-40) minutes for storms of high intensity, about 80 (30) minutes for storms of medium intensity and about 50 (10) minutes and less for weak storms. Here, in brackets the average time of forestalling minus the time of transport of PSW and IMF to the magnetopause is specified.
3. By considering the obtained correlation relationship between indices of SYM, ASY and PSW, IMF it has been found that PSW and IMF are reflected in the symmetric part of the ring current more often in comparison with its asymmetrical part. Such behaviour of the correlation relationship does not depend on storms intensity.

The main results of the correlation analysis of indices SYM, ASY with changes of auroral electrojets:

1. Components of IMF By and Bz have the greatest influence on auroral electrojets. This is reflected in geomagnetic storms of any intensity. Further on the importance are the concentration and the velocity of the Solar Wind. Moreover, for storms of strong intensity the influence of the Solar Wind velocity is manifested to a greater extent, than for storms of medium intensity or week storms. Thus, for auroral indices the other active agents (components of IMF) have been found unlike those for the ring current.
2. Under the estimation of time of the influence of the chosen parameter (according to a sharp change of the correlation coefficient), it is noted, that these characteristic times for storms of the strong intensity are about 75-80 (30-40) minutes from the moment of a two-hour forestalling. For storms of medium intensity this time is 70-80 (20-30) minutes, and for week storms - about 50 (10) minutes. Here in brackets the the average time of forestalling minus time of transport of PSW and IMF to the magnetopanse is also specified
3. According to results of the carried out correlation it is impossible to find, which of electrojets (eastward or westward) experience the greatest influence of the parameters of the Solar Wind and IMF. The dominant role of these parameters in the development of electrojets is different for all cases of geomagnetic storms.
4. For the majority of cases at the approach to the time of a storm beginning the correlation of indices of intensity of auroral electrojets with Bz component of IMF is essentially decreased. Thus, influence of this component is the same as for global currents, and it is displayed earlier in comparison with other parameters.

5. Connection of parameters of the viewed storms with characteristics of interplanetary space

To find the general influence of parameters of the near earth space on the ring current and auroral current systems, there has been carried out a correlation examination of the dependence of intensity and the duration of the considered geomagnetic storms from PSW, IMF, an impulse and dynamic pressure of a Solar Wind which had been observed for one hour prior to their beginning. Correlations between the hourly average values of the considered parameters were calculated. It was found, that the duration of storms correlates the best with the concentration (R = 0.59), the impulse of the Solar Wind (R = 0.42) and Bz component of IMF (R = 0.47), but their intensity - only with Bz component (R = 0.44). Fig. 2 and 3 present these dependences, and also the relevant equations of regression.

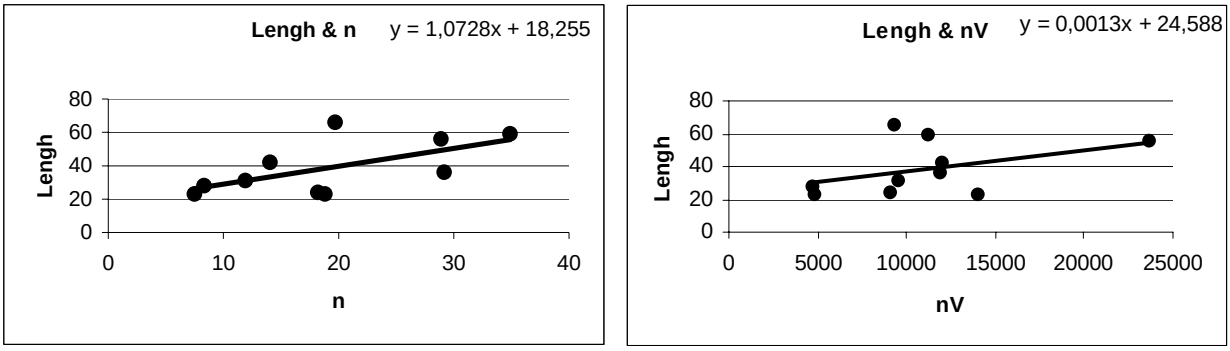

Fig. 2 Dependences (the equations of regression) of a storm duration on the concentration of the Solar Wind (a) and on an impulse of the Solar Wind (b)

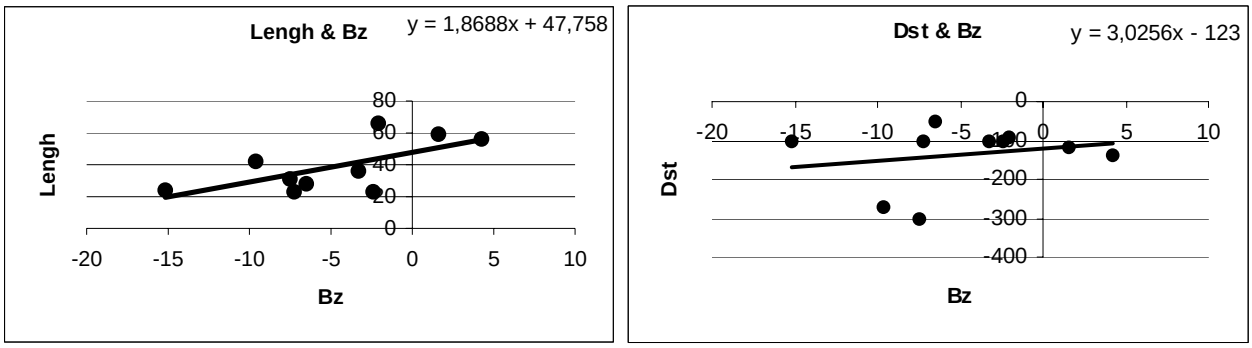

Fig. 3 Dependences (the equations of regression) of a storm(a) duration and intensities on Bz component (b)

6. Conclusions

In this study the relationship between the global indices describing the symmetric and asymmetrical parts of a ring current (SYM, ASY), and the indices describing the intensities of eastward and westward electrojets (AU, AL), at different phases of development of a geomagnetic storm is found. The analysis of a delay of global indices comparative to auroral indices by 0 to 2 hours testifies that for the main phase of a storm the best correlation is observed between couples SYM - AU and ASY - AL, and at the recovery phase the best correlation is ASY - AU and ASY - AL. The analysis of a delay of auroral indices relatively global ones testifies that the correlation between indices AU - SYM, AU - ASY and AL - ASY essentially decreases at the increase of the delay at the main phase of a storm; for indices AL - SYM the correlation grows with the increase of the delay. The correlation of couples AU - ASY, AL - ASY is essentially decreased with the growth of the delay at the recovery phase. On the basis of a diurnal correlation there have been set sectors to local time in which asymmetrical part of a ring current presumably takes place. The intensity of the relationship between asymmetrical part of a ring current (ASY) and index AU varies depending on the Universal Time. It is obviously bounded by that during a magnetic storm the westward electrojet (AL) takes almost the entire area of the auroral oval, and the eastward electrojet (AU) displaces from the usual (standard) attitude (MLT ~ 17 - 22 h) to a day time region.
The results of correlation examination of relationship of indices SYM and ASY with PSW and IMF show, that the Dst variation is the most subject to influence of the velocity and concentration change of the Solar Wind. The average time of response of magnetosphere for PSW changes, which constitutes about 30-40 minutes for geomagnetic storms of high and medium intensities (Dst < -100 nT). The greatest influence on auroral electrojets is due to changes of components By and Bz IMF during geomagnetic storms of any intensity. The characteristic time of response of the polar magnetosphere for the change of By component is about 30 minutes. There is practically no time delay in the case of component Bz. The duration of storms in the best way correlates with the concentration, the impulse of Solar Wind, and Bz component of IMF, but their intensity - only with Bz component.

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