

ANALYSIS OF THE RELATION OF THE SYM, ASYM INDICES OF THE RING CURRENT MAGNETIC FIELD TO THE AE (AU, AL) INDICES

N.A. Barkhatov^{1,2}, A.E. Levitin³, O.M. Tserkovniuk²

¹ Radiophysical Research Institute (NIRFI), Russia

² Nizhniy Novgorod State Pedagogical University, Russia

³ Institute Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN), Russia

Abstract. The research of indices connection describing symmetrical (SYM) and asymmetric (ASYM) parts of a magnetic disturbance, created by a ring current, with the indices of auroral electrojet activity (AE, AU, AL) is carried out during the main phases and recovery phases for separate magnetic storms in period with 2000 on 2001.

1. Introduction

uring magnetic storms the energy going in the magnetosphere, results in activation of a ring current and auroral current systems. The main phase of the storm corresponds to the time interval, during which will substorms be activated [Grafe and Feldstein, 2000]. The knowledge on the connection of global and polar current systems are based on the fact of existence of unified magnetospheric physical process [Nishida, 1980] In the paper [Grafe et al., 1997] the stronger connection of the disturbance field asymmetry with the western electrojet, than with the eastern one in the low latitudes is presented. However this can happen because the connection of a ring current (DR) field with an auroral magnetic disturbance (DP) field is not clear [Liemohn et al., 2001]. Such uncertainty in conclusions testifies to the necessity of further research of the given problem.

2. Data

The data representing indices of geomagnetic activity Dst, SYM, ASYM, AU, AL, AE are parsed during separate magnetic storms having a place in 2000 - 2001. 15 intervals of greatest magnetic disturbances in total are studied which was determined on the basis of an index Dst. Each of intervals contained a main phase of a magnetic storm and a recovery phase. For these 30 considered phases there were investigated one--minute auroral indices.

3. Correlation analysis of relationship between global and polar indexes

For the check of connection between magnetic disturbance, created by the ring current (DR), and auroral electrojets intensities there was executed the correlation analysis, in which the delay from 0,5 till 2 hours between indices SYM, ASYM and indices AE, AU, AL was used. As a result the following features of correlation connections were identified:

- The best coefficient of correlation for the main phase of a geomagnetic storm is observed for indices SYM and AU, ASYM and AL;
- In the recovery phase of a magnetic storm all correlate more closely among themselves ASYM and AE; ASYM and AL; SYM and AE.

Thus, the asymmetric part of a magnetic disturbance created by the ring current during a geomagnetic storm, correlates with the eastern and western electrojets in the high latitude ionosphere region both during the main phase of the storm, and during the recovery phase.

The study of temporary dynamics of the connection of indices AE, AU, AL with those of SYM and ASYM was conducted on the basis of calculation of correlation coefficients between them using a time delay of indices SYM, ASYM concerning the indices of auroral electrojets intensity on time from 0.5 till 2 hours. The plots in Fig. 1 and Fig. 2, respectively, for the main phase of the storm and for the recovery phase demonstrate this dynamics.

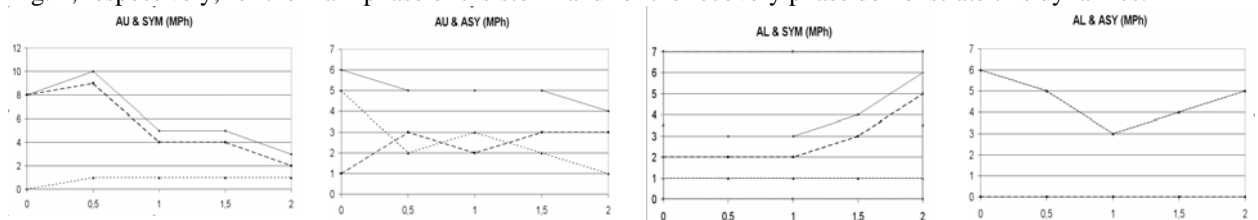


Fig. 1. The main phase of a geomagnetic storm. Dynamics of quantity of correlation cases between values of indices AE, AU, AL and those of SYM, ASYM with a module of a correlation coefficient $R > 0.5$ (light line), positive correlation $R > 0.5$ (dotted lines) and negative correlation $R < -0.5$ (small-sized dotted line) depending on the time delay of the ring current indices concerning the indices of electrojets intensity.

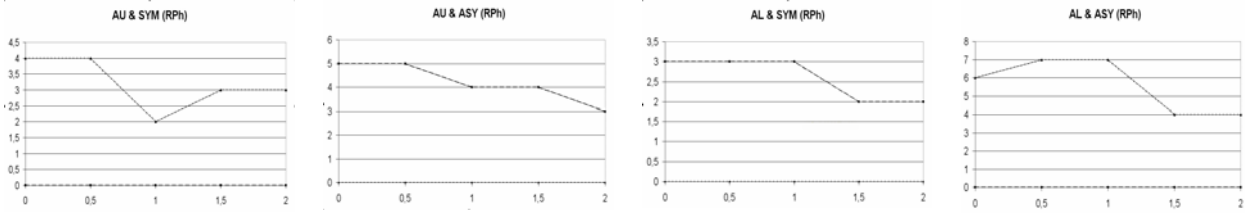


Fig. 2. The recovery phase. Dynamics of quantity of correlation cases between values of indices AE, AU, AL and indices SYM, ASYM with a module of the correlation coefficient $R > 0.5$ (light line), positive correlation $R > 0.5$ (dotted lines) and negative correlation $R < -0.5$ (small-sized dotted line) depending on the time delay of ring current indices concerning the indices of electrojets intensity.

On the main phase the asymmetric part of ring current develops simultaneously with auroral electrojets, and the symmetric part of ring current shows a good correlation with the east electrojet intensity, and then with the west electrojet intensity for the increased time delays. In the recovery phase the dynamics of symmetric and asymmetric parts changes simultaneously with east and west electrojets. In the recovery phase the dynamics of symmetric and asymmetric parts of the ring current changes simultaneously with temporary dynamics of these electrojets intensity. The analysis of plus/minus sign of correlation coefficients between the considered indices within the main and recovery phases showed:

1. The correlation between AU and SYM indices is positive for the main phase. For ASYM and AU pair, plenty of events with negative correlation are observed in case of no delay. Correlation between AL and ASYM is negative within the main phase.
2. The plus/minus sign of correlation for AU, SYM pair changes when passing the main recovery phase and entering the recovery one.
3. Within the recovery phase the signs of correlation coefficients for all couples are unchanging for all pairs – they are always strictly positive or strictly negative.

The temporary dynamics of intensity aurora of electrojets depending on the dynamics of the development of symmetrical and asymmetric parts of the ring current magnetic field can also be analyzed on the basis of temporary shift between indices AE, AU, AL and indices SYM and ASYM. In Fig. 3 and Fig. 4, respectively, for the main phase of the magnetic storm and phase of recovery dynamics of coefficients of correlation is presented depending on the time of the used delay.

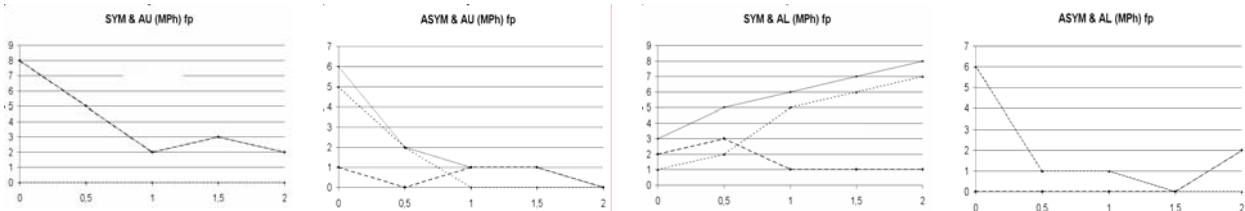


Fig. 3. The main phase of a geomagnetic storm. Dynamics of quantity of correlation cases between values of indices AE, AU, AL and indices SYM, ASYM with a module of a correlation coefficient $R > 0.5$ (light line), positive correlation $R > 0.5$ (dotted lines) and negative correlation $R < -0.5$ (small-sized dotted line) depending on the time of delay of auroral electrojets indices concerning the indices of the ring current.

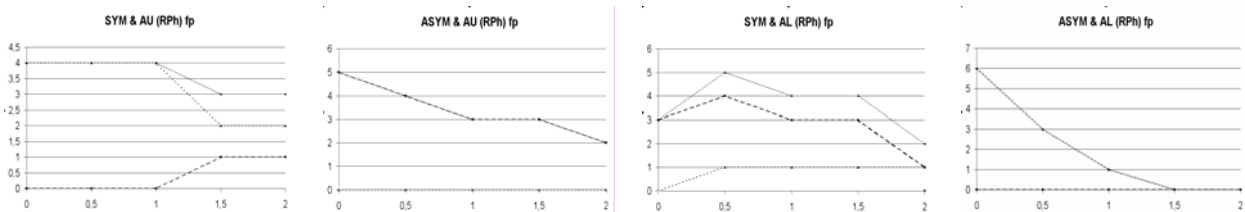


Fig. 4. The recovery phase. Dynamics of quantity of correlation cases between values of indices AE, AU, AL and indices SYM, ASYM with a module of a correlation coefficient $R > 0.5$ (light line), positive correlation $R > 0.5$ (dotted lines) and negative correlation $R < -0.5$ (small-sized dotted line) depending on the time of delay of auroral electrojets indices concerning indices of the ring current.

The conducted analysis for the period of the main phase of a geomagnetic storm displays:

- The symmetric part of the ring current magnetic field is already present by the onset of the main phase – the correlation between SYM, AU is positive and decreases significantly at the increase of delay; for SYM, AL negative correlation grows with the increase of delay;
- For indices ASYM, AU and ASYM, AL correlation is negative and it decreases with the increase in delay

The conducted analysis for the recovery phase of a geomagnetic storm displays:

- Correlation between indices SYM and AU is negative and between indices SYM and AL is positive.
- the correlation between indices ASYM and AU is positive and is reduced at the increase of delay; between indices ASYM, AL the correlation negative, and at the application of delay as is essentially reduced.

At the transition from the main phase of a magnetic storm to the recovery phase the signs of correlation of indices AU, AL with an index SYM changes.

On the level of correlation it is possible to analyze the role of influence of current systems, arising during physical processes, causing asymmetry of a ring current [Grafe et al., 1997; Liemohn et al., 2001]. At the absence of temporary delay the highest anticorrelation between indices ASYM and AL exists, as the analysis displays, for temporary sectors «evening», «evening – night», «night», «night – morning» and «morning».

So we can assume that the current system of the asymmetric part of ring current presents in these sectors and its direction is opposite to the direction of the westward electrojet current system. Correlation between ASYM and AU indices is positive and the strongest for “morning-day” and “day” sectors. So the asymmetric part of ring current is present in these sectors and its direction is the same as the eastward auroral electrojet direction (AU). For sectors “night” and “night-morning”, the correlation of these data is negative, so the corresponding current systems are counter directed.

The outcomes of the analysis of the diurnal histograms of a summarized correlation between all the considered indices are presented in Fig. 5.

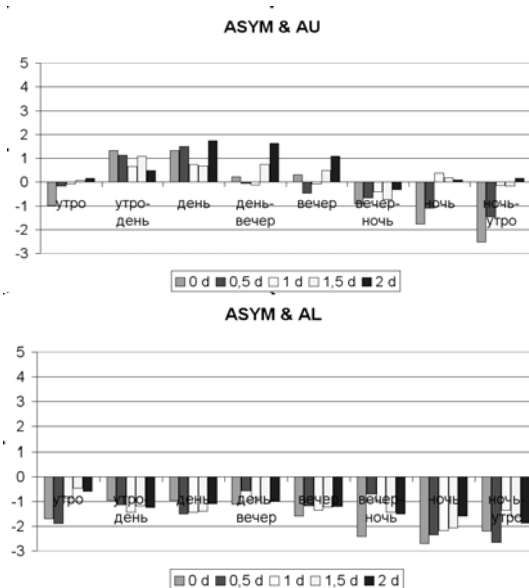


Fig. 5. Histograms of the summarized coefficient of correlation between indices SYM, ASYM and indices AU, AL for all the considered events in stretch of day; the time delays from 0 to 2 hours.

4. Outcomes of the activity

1. The existence of correlation between the current systems, arising at generation of a ring current asymmetry in two phases of a magnetic storm [Grafe et al., 1997; Liemohn et al., 2001], and auroral electrojets is established.
2. The correlations of currents directions, arising in the high latitude ionosphere at generation of a ring current asymmetry, and auroral electrojets at the main phase of storm under different temporary delay are determined (Fig. 5).
3. On the basis of statistical analysis of the data it is found, that the symmetrical ring current exists to the moment of the beginning of the main phase. The asymmetry of the ring current develops synchronously with temporary dynamics of east and western electrojets intensity.

4. The symmetrical and asymmetric part of ring current develop synchronously with east and western electrojets during the recovery phase of a magnetic storm.
1. When switching from the main to the recovery phase, temporary dynamics of the symmetric part changes compared to the westward electrojet temporary dynamics. Time dynamics of SYM index in comparison to temporary dynamics of AL index is not changing. There are no changes in temporary dynamics of the asymmetric ring current.
2. Plus/minus signs of correlation coefficients for AU and SYM and AL and SYM change into opposite ones when switching from the main phase to the recovery phase.

Acknowledgements. The study was carried out under the financial support of the RFBR (grant 06-05-64482).

References

- Grafe A., Feldstein Y.I., About the relationship between auroral electrojets and ring currents, *Annales Geophysicae*, 2000, 18, 874.
- Grafe A., Bespalov P.A., Trakhtengerts V.Y., Demekhov A.G., Afternoon mid-latitude current system and low-latitude geomagnetic field asymmetry during geomagnetic storms, *Annales Geophysicae*, 1997, 15, 1537.
- Liemohn M.V., Kozyra J.U., Tomsen M.F., Roeder J.L., Lu G., Borovsky J.E., Cayton T.E.: Dominant role of the asymmetric ring current in producing the storm-time Dst*, *J. Geophys. Res.*, 2001, 10883.
- Nishida A. Geomagnetic diagnosis of the Magnetosphere, 1978, New York-Heidelberg-Berlin, «Springer-Verlag», 300 p.