

# POLAR CURRENT SYSTEMS AT THE MAIN PHASE OF A GEOMAGNETIC STORM

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**Abstract.** By the method of Artificial Neural Networks (ANN) the connection of magnetic disturbances in auroral region and mid and low latitude magnetic disturbances at the main phase of a geomagnetic storm is investigated. The search of nonlinear correlations between indices of auroral electrojets intensity (AU, AL) and indices of a ring current intensity (SYM, ASY) confirms a well-known relationship between westward electrojet and asymmetric part of the ring current as well as eastward electrojet and symmetric part. The opportunity of comprehensible neural network recovery of auroral electrojets intensity indices according to indices of a ring current intensity is proved. Characteristic quantities of forestalling times in development of mid-latitude magnetospheric processes relatively polar processes are determined.

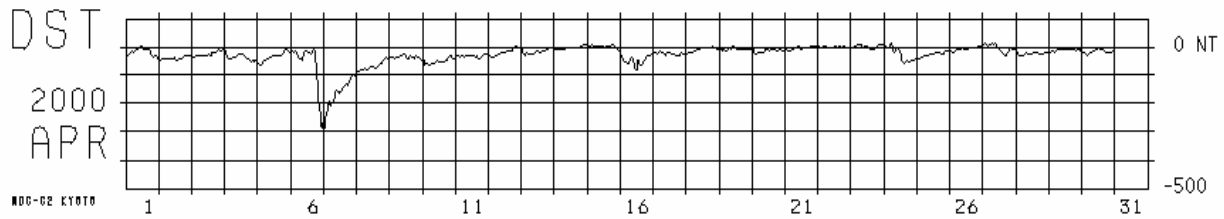
## 1. Introduction

Within the framework of classical representations on the development of ionospheric and magnetospheric current systems there is a set of models which describe their evolution depending on a level of geomagnetic activity. However the problem of development and unification of these current systems by present time remains not solved. In this connection the study of a spatial-temporal behaviour of a geomagnetic field and construction of the corresponding theoretical models describing process of generation, development and collapse of current systems in terrestrial magnetosphere proceeds.

In [1] the search of linear connection between indices describing development of symmetric (SYM) and asymmetric (ASY) parts of a ring current and indices of eastward (AU) and westward (AL) electrojets intensity has been made. On the basis of the correlation connections analysis between the specified indices at the main phase of a geomagnetic storm it has been established, that the symmetric part of a ring current develops synchronously with eastward electrojet and is behind of westward electrojet for about 2 hours. The asymmetric part of a ring current has connection with both electrojets and during the main phase of a geomagnetic storm they develops m synchronously. The present study is sequential of the work [1]. At that work the connection between indices of ring current and auroral electrojets intensity was studied on the basis of concrete geomagnetic storms. Basic difference of the present research is that the general tendencies of indices relationship between storms of various intensity are analyzed. Besides, as the tool for search of connection of ring current elements with auroral electrojets the Elman's artificial neural network is used, which helps to show nonlinear character of the connection. The developed method helps to reply the question – whether general laws in development of geomagnetic storms exist, and as consequence, whether is possible to recovery of auroral electrojets intensity indices according to indices of a ring current intensity at the main phase of a geomagnetic storm.

## 2. Data and research technique

For investigation of nonlinear connections between pairs of indices SYM-AU, SYM-AL, ASY-AU and ASY-AL 15 geomagnetic storms of various intensity ( $-300 \leq \text{Dst} \leq -50$  nT) for the period 2000-2001 were selected. Selection of events was carried out on the basis of the shape of the Dst index. Those geomagnetic events were selected, which time behavior corresponded to classical development of Dst-index (Fig. 1).



**Fig. 1.** A time behavior of Dst index in April, 2000. Storms of April, 6 and 24 were selected for the present study

Each of the chosen events has been divided on the main phase and a recovery phase of geomagnetic storm. In offered research the nonlinear connection between current systems was established only for the main phase of geomagnetic storm since during this period a ring current and auroral electrojets are most developed.

The search of such connection between the mentioned pairs of indices was carried out according to sequence:

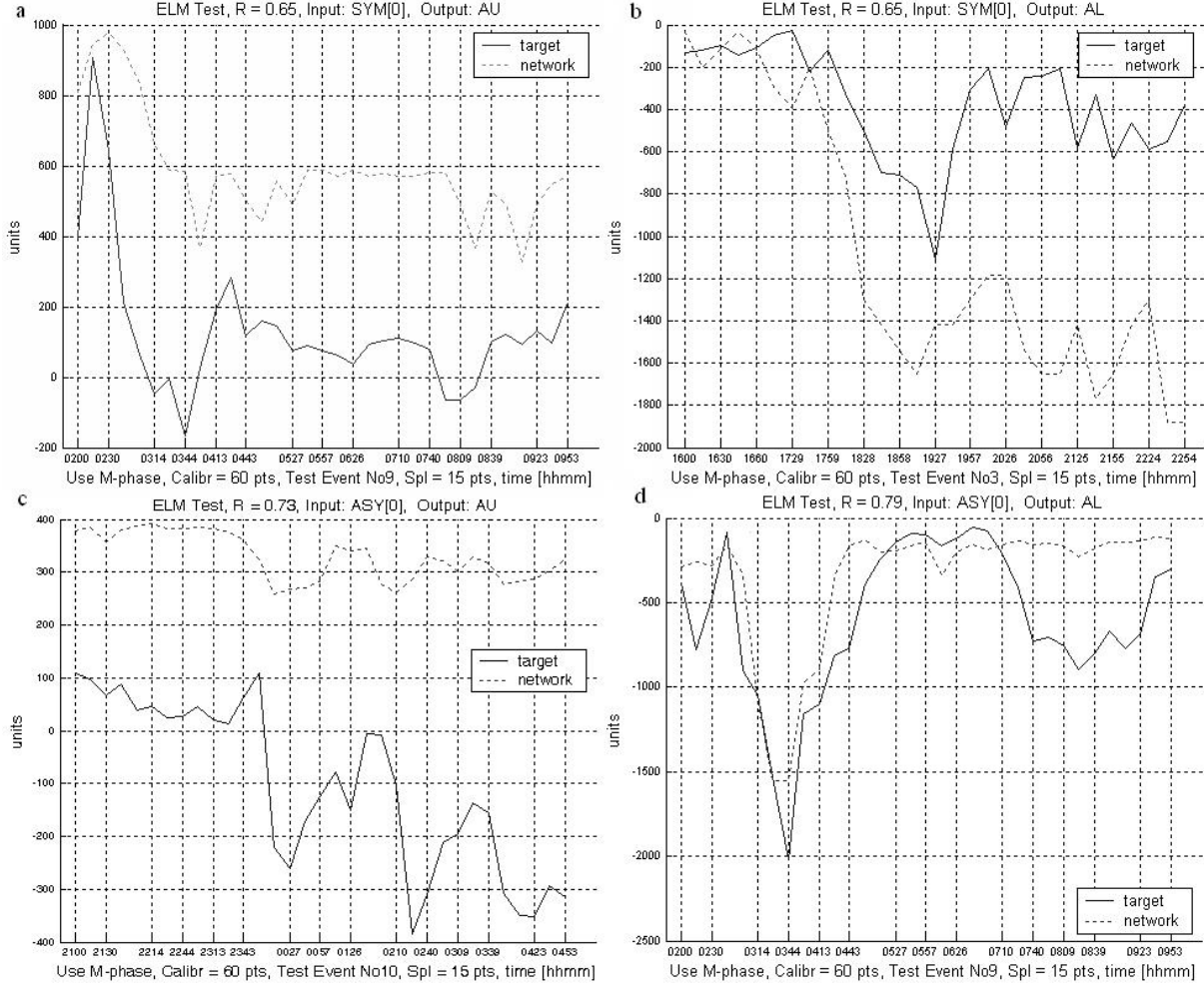
1. For elimination of «neural network jitter» general time of averaging for all examined indices got out. In this case it made 15 minutes. Such "ANN jitter" frequently arises because of the large amplitude sharp peaks in AU and AL indices. Classical fifteen-minutes averaging allows to smooth such peaks and to reveal the general tendency in development of auroral current systems.
2. At the given stage the training of neural network for one of considered events was carried out. During training there was a weights adjustment, i.e. the neural network established connection between indices SYM, ASY and indices AU, AL within the limits of a concrete geomagnetic storm.
3. With the help of the neural network already trained, connections between pairs of indices SYM-AU, SYM-AL, ASY-AU and ASY-AL for the others 14 events were examined. For this purpose data recovery of indices AU, AL on values of indices SYM, ASY was carried out. Data recovery was accepted effective at reception of linear correlation between real and recovered sequence greater than 0.5. Presence of high linear correlation in this case showed, that connection between mid-latitude and polar current systems has the same character, as in event used for training. Absence of linear correlation says that in new event the character of connection is essentially other. Thus, it is possible to determine a distinction in development united ionosphere-magnetospheric current system for different geomagnetic storms.

According to this scheme all 15 events are considered. It is necessary to note, that at neural network experiments for improvement of data recovery quality the delay time of development mid-latitude current systems relatively to auroral current systems has been entered. For SYM-AU pair it is 0.5 hour on average, and for SYM-AL pair – 2 hours [1]. For other pairs of indices the time delay appeared equal to zero.

### 3. Results and conclusions

As a result of neural network experiments it is revealed, that acceptable data recovery of eastward and westward electrojets intensity indices according to indices of a symmetric and asymmetric parts of ring current is possible. Entering of a delay in development mid-latitude current systems relatively polar current systems in some cases essentially improves data recovery quality for AU and AL indices on SYM index data. It means in the general case that for a ring current it is typical to have a delay in development relatively auroral electrojets for geomagnetic storms of different intensity.

Examples of auroral electrojets intensity indices data recovery on ring current intensity indices for each of considered pairs are given on Fig. 2.

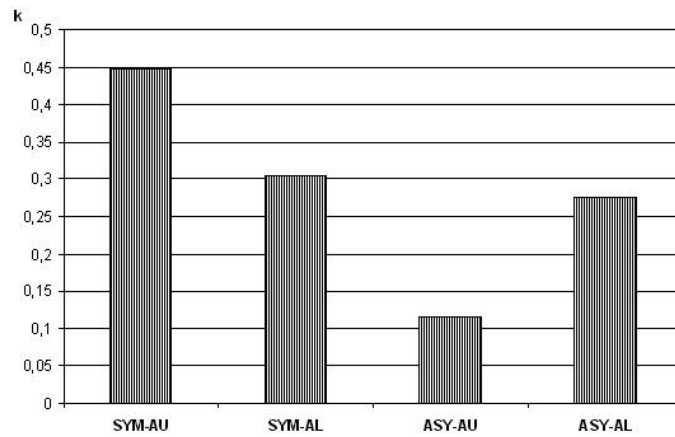


**Fig. 2.** Examples of data recovery of index AU on index SYM (a); index AL on index SYM (b); index AU on index ASY (c); index AL on index ASY (d)

The establishment of characteristic dependences in development of examined current systems is possible by carrying out of the statistical analysis of neural network data recovery results. For this purpose the weight of number of satisfactory correlation cases for each pair of indices (SYM-AU, SYM-AL, ASY-AU, ASY-AL) in the general number of possible events combinations is calculated:

$$W = \frac{N}{C_n^m},$$

where  $N$  – number of cases with correlation coefficient  $> 0.5$ ,  $C_n^m$  – the general number of events combinations from  $m$  on  $n$ . Values of weights  $W$  for each pair of indices is shown on Fig. 3.



**Fig. 3.** Values of weight  $W$  of number of satisfactory correlations for each pair of considered indices

Thus, the statistical analysis of recovery data results shows that for SYM-AU and ASY-AL index pairs the greatest quantity of events with correlation coefficient  $> 0.5$  between real and recovered sequences is observed. It means that current systems of a symmetric part of a ring current and eastward electrojet as well as current systems of an asymmetric part of a ring current and westward electrojet have steady connection and the similar scenario of development within the limits of geomagnetic storms of different intensity.

In the first case (for SYM-AU pairs) it can be caused by activation considered current systems by a unified source. Indeed, current system SYM is self-contained system and does not require association with eastward electrojet AU. For ASY-AL pair appreciable correlation can say about association of their current systems. Such conclusion agrees with results of works [1, 2]. The received low correlation level for ASY-AU pairs also does not contradict the results of paper [2].

This study is a basis for an establishment of the general interrelation of ionosphere-magnetospheric processes at different phases of storm development.

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## References

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