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THE PROBLEM OF FIELD-ALIGNED CURRENTS RECONSTRUCTION

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Abstract. Density of ionospheric currents was calculated on the base of EISCAT Cross chain of magnetometers. The comparison of them with auroral image obtained by Viking shows a good spatial correspondence. The motions of electrojets allows us to estimate the east-west component of ionospheric electric field. The values of this component were confirmed by EISCAT electric field measurements. The measurements of precipitating electrons on board the Viking satellite were used to calculate ionospheric Hall and Pedersen conductivities. Therefrom we can estimate field-aligned currents. To prove the correctness of this method we consider in detail the April 9, 1986 event for which satellite data on field-aligned currents are available.

The interaction between the solar wind, the magnetosphere and ionosphere is one of the most interesting problems of modern geophysics. To investigate this problem, the study of field-aligned currents is required. These currents carry out the connection between the magnetosphere and ionosphere, and the problem of their reconstruction is very important. At present several approaches to this problem are known. Some of them [1 and references in it] are based on the idea that if satellite is crossing the layer of field-aligned currents it must register variations in magnetic field. The value of field aligned current can be estimated as

$$J = 8 \cdot 10^{-6} \partial B / \partial L, \tag{1}$$

where ∂B is disturbance of magnetic field (in nT),and ∂L L is a distance along the trajectory of satellite (in sm).

However, we must keep in mind that in this method the thickness of a layer is important. Increasing of thickness causes the significant growth of inaccuracy of calculations. Other methods are based on ground-based measurements of the magnetic field [1 and references in it]. This approach requests a knowledge of ionospheric electric field and Hall and Pedersen conductivities. There have been many attempts to estimate or calculate distributions of all these values, but they are rather large-scale or/and statistical.

In our study we try to reconstruct mesa - scale (the thickness of a layer is about 100 km) field-aligned currents for concrete events in the midnight sector of the ionosphere. In this region the situation when ionospheric currents flow along a geomagnetic latitude is typical. For these events we assume that variations of electrodynamic parameters of the ionosphere along the latitude are much smaller than those along the meridian. In this case the east-west component of the electric field must be constant for the whole latitudinal interval under consideration. Introduce the coordinate system in which x axis is directed to the east, y axis is northward and z axis complete the right system. In this system using the equation of current discontinuity and the Ohm's law in general form, we can derive that

$$J = \partial\left(\frac{S_p}{S_h} \cdot J_x - E_x \cdot \left(S_h + S_p \cdot \frac{S_p}{S_h}\right)\right) / \partial y, \tag{2}$$

where S_p, S_h are Pedersen and Hall conductivities, E_x is electric field, J_x is density of ionospheric currents. If we know the values of J_x, S_p, S_h and E_x, we can reconstruct field aligned current distribution. The developed by *Kotikov et al.* [2] method of calculation of ionospheric current density give us values of J_x. This method is described in detail in [3]. The possibility of estimation of east-west electric field component by the motion of westward electrojet to the North or to the South was proved in [4]. The main idea of this method is following: the electrojet is moving under the action of crossed electric and magnetic fields. Therefore if we know the velocity of electrojet motion, we can estimate the electric field.

Fortunately we have data from EISCAT Cross chain of magnetometers and EISCAT measured electric field for November 4, 1986. We calculate the density of ionospheric current by the magnetic data and compare our results with an auroral image from Viking satellite for this date [5]. We want to point out that the locations of westward electrojet maxima coincide with the most bright forms of auroras (see Figure 1). Similar results were obtained in [6]. Certainly we can estimate the electric field only in that latitudinal and time intervals in which the motion of electrojet is clearly seen. When we can define the electric field its values are very close to EISCAT- measured data (see Figure 2).

We used the chance to calculate field-aligned currents for this event because the Viking obtained data on precipitating electrons were available. These data allow us to calculate Hall and Pedersen conductivities [7]. Then, using (2), we calculate field-aligned current. The results appeared reasonable: upward currents located at equatorward edge of the westward jet and downward currents were at the poleward edge of the electrojet.

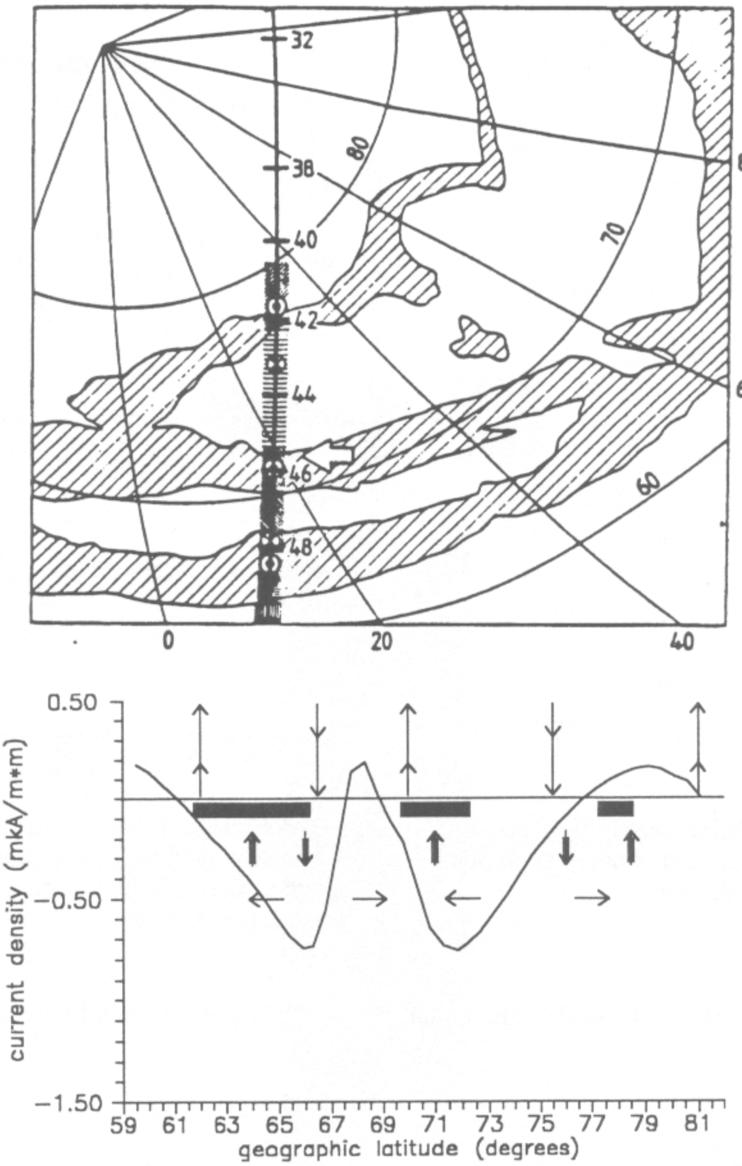

Figure1. Sketch of the Viking image and distributin of ionospheric and field-aligned currents corresponding to it. At the bottom plane: thin vertical arrows correspond to reconstructed field-aligned currents; thick arrows are field-aligned currents from Viking measurements; thin horizontal arrows correspond to electric field; rectangles present positions of active auroral forms.

To confirm our results we reproduce the whole procedure for the April 09, 1986 event. For this event data from DMSP F7 satellite on magnetic filed and precipitating electrons are available. This satellite crossed the auroral zone close to the midnight meridian. We fulfilled the simulations for two passes of the satellite. One of them was at the growth phase of the substorm. In this period the electric field was rather strong and we surely estimate it as approximately 15mV/m. The second pass occurred in 1.5 hour at the recovery phase of the substorm when the electric field was approximately 0. The results of our calculations are presented in Figure 3. One can see very good correspondence between them and field-aligned currents independently obtained by equation (1) from data on magnetic field on board DMSP.

Obviously in our method the estimation of conductivities is the most difficult problem. If we could find the way to obtain them from ground-based data, we would have a simple method for reconstruction of field-aligned current in midnight ionosphere.

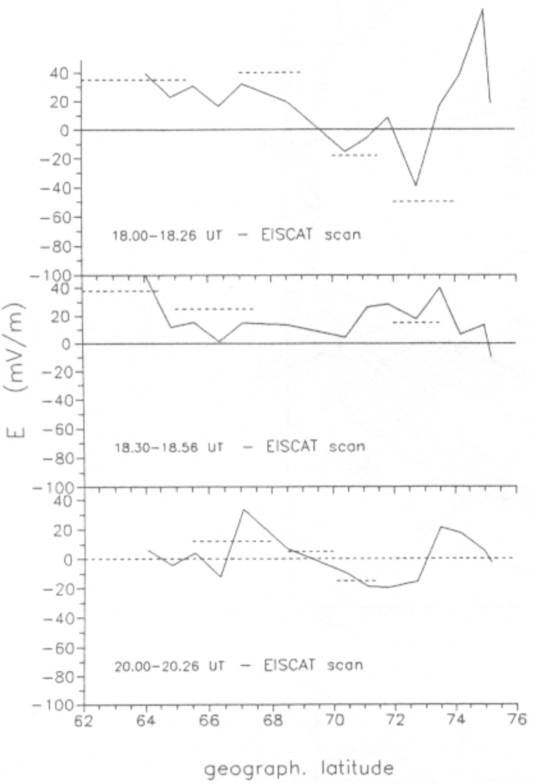

Fig.2. East-west ionospheric electric field obtained by EISCAT (solid line) and from jet's motion (dashed line). November 4, 1986.

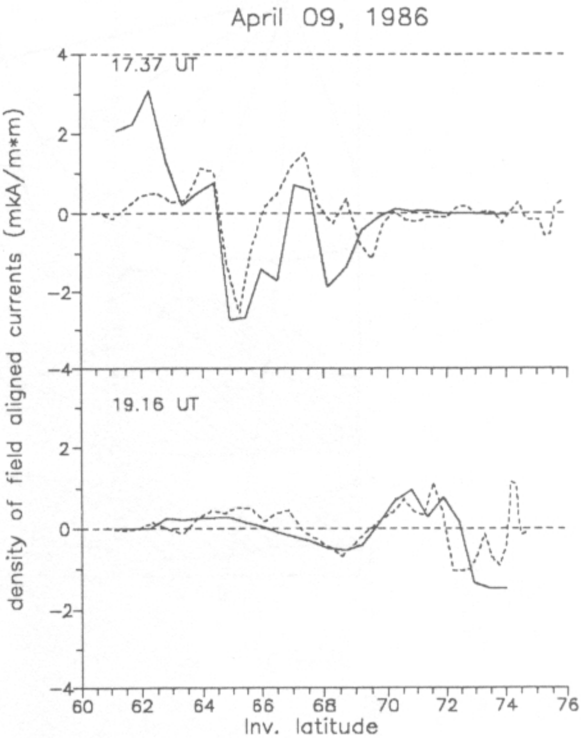

Fig.3. Distribution of field-aligned current calculated from magnetic field measurements on board DMSP F7 (dashed line) and reconstructed by groun-based magnetic data (solid line).

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