

REGION 1 FIELD-ALIGNED CURRENTS IN THE MAGNETOSPHERE DERIVED FROM OBSERVATIONS

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Abstract. Spatial distribution of the magnetic fields produced by the currents associated with the southward IMF component has been constructed in the region $|z_{sm}| > 3 R_E$, based on magnetic observations. It is found that the azimuthal component of the magnetic field is determined by the field-aligned currents (FAC) flowing into or out of the ionosphere in Regions 1 and 2.

1. Introduction

In our previous paper [Maltsev and Ostapenko, 2004], for the analysis of the ring current, a spatial distribution of magnetic fields in the region of $|z_{sm}| < 3 R_E$ was considered. It is necessary to complete the picture with the distribution of the fields at large values of $|z_{sm}| (> 3 R_E)$. This is a subject of the present paper. The field values include not only ground-based measurements but also magnetosphere observations.

The effects of the field-aligned currents have been repeatedly studied by ground-based measurements (in this way they were first revealed). In the present paper, the effects of the Region 1 and Region 2 FACs is found by magnetic measurements in the magnetosphere. In our work, we use the database of Tsyganenko [2002], which includes spacecraft measurements obtained in the last ten years during strong disturbances. The time of data averaging is 5 minutes.

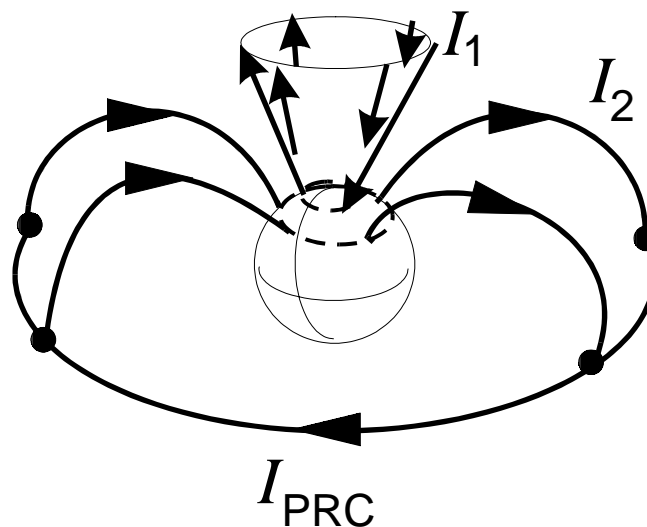


Fig.1. The pattern of the Region 1 (I_1) and Region 2 (I_2) field-aligned currents. A view from the magnetospheric tail.

Fig.1 represents the pattern of the Region 1 (I_1) and Region 2 (I_2) field-aligned currents (a view from the night side, morning is on the right, evening is on the left). These FACs actually form current sheets in the neighborhood of the Earth. It is assumed that the intensity of the FACs versus magnetic local time (MLT) changes by sinusoidal law, with the maximum absolute values achieved at 06 and 18 MLT.

2. Procedure of data processing

In the present study we have applied the Fourier analysis. The fields are separated in cylindrical coordinates by radii ρ , altitude z and azimuth φ (local time). In the analysis we restrict ourselves with two harmonics – the zeroth one and the first one. The zeroth harmonics describes the constant field, so it has not been considered in this paper. We only used the first harmonics, i.e. the expansion over sine, suggesting that the morning-evening asymmetry is small. The first harmonics describes the daily variation of the fields. The averaged data do not exhibit field discontinuities but rather the fields with large gradients. The amplitude of the first harmonics depends on two coordinates: ρ and z . We analyzed different data subsets, with selecting the data over the Interplanetary Magnetic Field (IMF), since the intensity of the FACs is most of all influenced by the IMF.

3. Results

At a crossing of current sheets, there must be observed a discontinuity of the tangential component of the magnetic field

$$\mathbf{B}_2 - \mathbf{B}_1 = \mu_0 \mathbf{J}, \tag{1}$$

where μ_0 is the magnetic permeability of the vacuum, \mathbf{J} the full current flowing in the current sheet, \mathbf{B}_1 and \mathbf{B}_2 are the values of the magnetic fields on each side of the sheet. The most convenient component in the case under study, is the azimuthal one. The structure of the azimuthal component in the morning is represented in Fig.2.

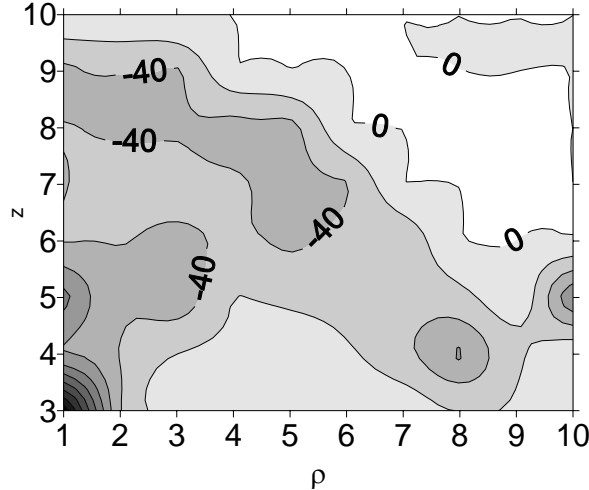


Fig.2. The map of the azimuthal component.

This structure refers to the data selected for the times when the IMF was in the range of $-20 \text{ nT} < B_z < 0 \text{ nT}$. Along the axes in Fig. 2 are the radial distances ρ and the altitude z in the Earth’s radii R_E , the figures near the isolines of azimuthal component stand for the value of the component in nT. In the vicinity of the current sheets, the azimuthal component of the field must change the sign. Field averaging results in appearance of zero field values.

Unfortunately, one can see fluctuations in the map. This is caused by the fact that in this region a strong influence of the tail current system is observed. We described in detail the fields of these currents in the paper [Maltsev and Ostapenko, 2002]. The X component of the field contributes much to the azimuthal component. Therefore, in the analysis, one has first to subtract the tail fields from the observed fields. The filtered map, obtained in this way is shown in Fig.3. There are two isolines with zero values of the azimuthal component. The upper line refers to Region 1 (high latitudes), while the lower line refers to Region 2 (auroral latitudes). This structure is observed in the magnetosphere.

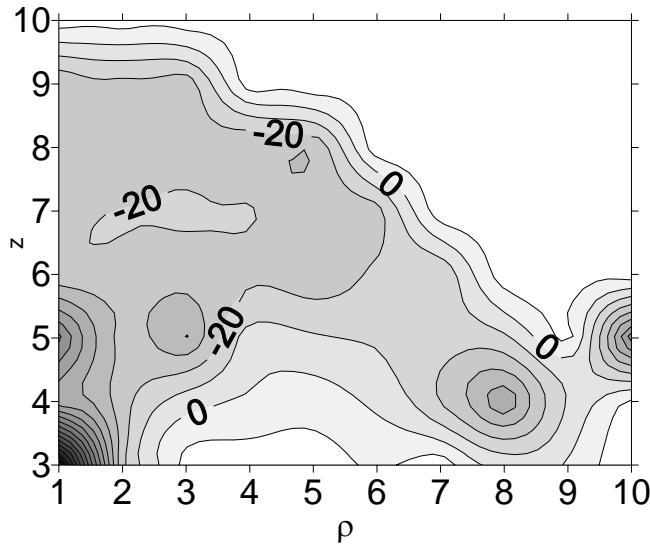


Fig.3. The filtered map of the azimuthal component.

4. Discussion

Due to field expansion over the sine in longitude, the sign of the azimuthal component of the magnetic field is true for all local times. There is an obvious lack of data for plotting smooth maps of the fields for other ranges of the IMF (large fluctuations arise). Thus for $|B_z \text{ IMF}| > 20$ nT, the drawbacks of the database used start to manifest, although it contains 140000 of measurements. It should be noted that most of these are measurements performed at geostationary spacecraft, which can not provide a complete concept of magnetic field structure in the magnetospheric regions of interest.

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