Results of the Modelling of the Geomagnetic Field for a Small Territory

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Analysis of the different methods of geomagnetic field modelling on the territory of Slovakia is made. Data on the territory of Slovakia was reduced for epoch 1980.5 and compared with values from three models: linear model, IGRF 1980, IGRF, revision 1985. Study of distribution of the deviations from IGRF's for individual points have led to the conclusion there exists a systematic pattern. One of the possible explanations could be a regional anomaly of the geomagnetic field in Europe.

1. Introduction

Modelling on the basis of given sets of observations represents an important task for studying the distribution of the geomagnetic field. Models are used as a basis for the interpretation of observed data, or as a reference level for such data.

We shall compare three types of models in our paper. One will be a linear model for the territory of Slovakia. The other two models are the IGRF, for epoch 1980, IAGA (1980) and the fourth generation IGRF, IAGA (1985), together with corresponding secular variation models.

Anomalous values will be the differences between the observed values (reduced for the epoch 1980.5) and values computed from the given model.

2. Models Applied

All computations had been done on the set of data from the last geomagnetic survey on the territory of Slovakia reduced for the epoch 1980.5 (PODSKLAN, 1987).

The fundamental model was a linear model computed for epoch 1980.5, called the normal field of Slovakia.

Any component for a given epoch can be expressed in the form

$$E = E_0 + E_\varphi(\varphi - 48.5^\circ) + E_\lambda(\lambda - 19.5^\circ).$$

Coefficients E_0 , E_φ , E_λ are computed by the linear regression method. φ is the latitude, λ is the longitude and the coordinates $\varphi=48.5^\circ$ and $\lambda=19.5^\circ$ represent the approximate center of Slovakia.

Comparing the measured values reduced for the epoch 1980.5 with those from the linear model, we obtain following mean square deviations:

$$\sigma_X = 49.9 \text{ nT}, \quad \sigma_Y = 46.9 \text{ nT}, \quad \sigma_Z = 44.5 \text{ nT}, \quad \sigma_F = 44.3 \text{ nT}.$$

Distribution of deviations for all components are shown on Fig. 1.

It is evident from the distribution of the deviations, the maximum number is shifted slightly in the direction of negative values, i.e. the linear model gives rather greater values with respect to reality, approximately 10 nT for all components.

The IGRF model is widely used now. It utilizes the expression of magnetic potential in the form

$$V = a \sum_{n=1}^{\infty} \left(\frac{a}{r} \right)^{n+1} \sum_{m=0}^n P_n^m(\cos\theta) (g_n^m \cos m\lambda + h_n^m \sin m\lambda).$$

The present models are computed for $m, n=10$. For our investigation we used model IGRF for 1980, IAGA (1980) and IGRF of the fourth generation, IAGA (1985).

The mean square deviation between observed values of the field reduced for the epoch 1980.5 and IGRF 1980 are

$$\sigma_X = 54.7 \text{ nT}, \quad \sigma_Y = 49.7 \text{ nT}, \quad \sigma_Z = 118.8 \text{ nT}, \quad \sigma_F = 84.1 \text{ nT}.$$

Figure 2 represents the distribution of the deviations for all components. As shown, the maximum number is shifted in the negative direction for all components. It means the values computed on the basis of the IGRF 1980 model are systematically higher than the observed values.

Comparing the IGRF-fourth generation and the observed values, we obtain a similar result as illustrated in Fig. 3, but the mean square deviations are slightly lower for components X , Z and F and higher for Y .

Fig. 1. The mean square deviations distribution for the linear model: (a) X -component, (b) Y -component, (c) Z -component, (d) total field F .

Fig. 2. The mean square deviations distribution for the IGRF 1980 model: (a) X -component, (b) Y -component, (c) Z -component, (d) total field F .

Fig. 3. The mean square deviations distribution for the IGRF-fourth generation: (a) X -component, (b) Y -component, (c) Z -component, (d) total field F .

$$\sigma_X = 52.5, \quad \sigma_Y = 54.8 \text{ nT}, \quad \sigma_Z = 118.6 \quad \text{and} \quad \sigma_F = 76.1.$$

This fact is explainable either by using more data from observatories, allowing for model refinement, or by quantitative characteristics of geomagnetic field anomalies on the territory of Slovakia. Anomalous values X , Z and F are more “positive” and anomalous values of Y more “negative”, i.e. the first three components have greater values than some standard level and Y is lower. A similar conclusion is confirmed by a direct comparison of deviations from both IGRF models at all points in anomalous regions.

The distribution of anomalous values indicates existence of an anomalous influence. A possible explanation could be the existence of a regional magnetic field anomaly of the Earth in the European region. It seems to be systematic, the negative anomaly is connected along the Carpathians arc. It will be very convenient if we have similar data from another countries, also, to have possibility to decide whether this phenomenon is real or not.

The most promising approach seems to be by using the method SCHa (Spherical cap harmonic analysis) by HAINES (1985). Preliminary test has been made on our data, by Nevanlinna (private communication), and the more detailed study will be published later.

3. Conclusions

Comparison of IGRF 1980 and IGRF-fourth generation led us to conclude, that the latter is more accurate in components X , Z and F and the former for the Y component for the territory of Slovakia.

The models we used in our study don't describe precisely the local features of the geomagnetic field. It is necessary to develop more accurate models, where the mean square error, doesn't exceed 5–10 nT. One of the possibilities is using the SCHa method.

Analysis of these data indicates the existence of regional anomaly in Europe, a very interesting fact from the geophysical point of view.

The present commonly used global models are not adequately for detailed regional analyses. The study performed here may lead to the identification of regional anomalies such as those probably connected along the Carpathians.

REFERENCES

- HAINES, G. V., Spherical cap harmonic analysis, *J. Geophys. Res.*, **90**, 2583–2591, 1985.
 IAGA DIVISION I, WORKING GROUP I, International Geomagnetic Reference Field 1980, *Geophysics*, **47**, No. 5, 1982.
 IAGA DIVISION I, WORKING GROUP I, International Geomagnetic Reference Field Revision 1985, *IAGA News*, No. 24, 1985.
 PODSKLAN, J., Distribution of the Earth magnetic field on the territory of Slovakia for the epoch 1980.5, *Contr. Geophys. Inst. Slov. Acad. Sci.*, **17**, 111–141, 1987.