Slovak geomagnetic repeat stations – the 2006.5 epoch

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A b s t r a c t : The Slovak repeat station network consists of six stations. It was established in 2004 in a way to provide long time series of geomagnetic measurements at the same, or nearly the same, places, with the beginning in the middle of the 19th century. The new geomagnetic network was measured first time in 2004. It was reoccupied in the middle of 2006. In this paper, long time series of three geomagnetic elements D, I and F at the repeat stations are completed, the results of the last geomagnetic measurements, reduced to the 2006.5 epoch, are presented, and a comparison with those from the 2004.5 epoch is performed.

Key words: magnetic field, secular variations, magnetic survey

1. Introduction

The geomagnetic field is of different strength and direction on different places and it varies in time, too. Therefore regular measurements of the geomagnetic field elements at a net of geomagnetic repeat stations scattered over the country are requested to be performed.

A new Slovak geomagnetic repeat station network was established in 2004. It consists of six repeat stations that were chosen in a way, which enabled to have as long time series as possible *(Valach et al., 2004)*. For this reason some observation points occupied in the first geomagnetic surveys, carried out on the Slovak territory in the 19th century, are employed. (They are the same or at least the very close observation points to the points from the 19th century.) Geographical positions and altitudes of the stations are given in Table 1 *(Valach et al., 2004, 2006)*.

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The 19th century's measurements are summarized in *(Barta, 1954)*. Later geomagnetic surveys, carried out in the 20th century, are published in *(Čechura, 1934; Běhounek, 1939; Ochaba, 1954; Krajčovič and Németh, 1972; Podsklan, 1987; Váczyová, 1999)*. The geomagnetic repeat station survey accomplished in 2004, with the results reduced to the 2004.5 epoch, is referred in *(Valach et al., 2006)*. The network of the secular stations avoids strong local geomagnetic anomalies, the observation points are free of artificial disturbances in the geomagnetic field, and they are distributed over the country as regularly as possible. The density of the network is about 1 station per 7500 square kilometres.

Table 1. Geographical positions and altitudes of the repeat stations

No.	Name of the Station	Geograph. Latitude [°]	Geograph. Longitude [°]	Altitude [m]
1.	Hurbanovo	47.88	18.20	112
2.	Očkov	48.65	17.755	160
3.	Rajec	49.09	18.65	487
4.	Rimavská Sobota	48.375	20.02	239
5.	Spišské Podhradie	49.00	20.73	520
6.	Úbrež	48.79	22.125	140

2. Equipment and methods od data processing

At the repeat stations, complete series of D and I measurements with the DI-flux theodolite, Zeiss Theo 015B with Elsec 810, were performed. Each DI-flux measurement was supplemented with 10 PPM measurements of the total magnetic field with EDA magnetometer. The measurements were carried out in daytime with no special requirements, about what part of day to use, adopted. Only limitations arisen from the method for the determination of astronomical azimuths, for which the observations of the Sun were used.

The data were reduced to the 2006.5 epoch with the help of the records of the geomagnetic field from the Hurbanovo Geomagnetic Observatory. The assumption of identical transient variations of the geomagnetic field on the whole territory of Slovakia was considered for this purpose. The following formula was used to obtain the reduced value of an element at a repeat station:

$$E_{ST,2006.5} = E_{ST,t} - (E_{HRB,t} - E_{HRB,2006.5}), \tag{1}$$

where $E_{ST,t}$ is the value of the geomagnetic field element measured at the repeat station at time of the measurement t, $E_{HRB,t}$ is the element's value at Hurbanovo Observatory for time t and $E_{HRB,2006.5}$ is the observatory value for the 2006.5 epoch.

In order to model the distribution of the geomagnetic elements over the territory of Slovakia, a linear model was computed. It was done employing the mean square method.

3. Geomagnetic elements and their secular variations

Reduced to the 2006.5 epoch data at the six repeat stations are presented in Table 2. Using these data, the time series of the geomagnetic elements at the repeat stations, published earlier in *(Valach et al., 2006)*, can be completed (Figs. 1–3).

Table 2. Geomagnetic repeat station data for the 2006.5 epoch

Repeat Station	**Declination**	**Inclination**	**Total Field**
Hurbanovo	3° 11.86'	64° 13.8'	48 307.81 nT
Očkov	3° 07.18'	64° 53.5'	48 596.00 nT
Rajec	3° 22.27'	65° 18.1'	48 646.79 nT
Rimavská Sobota	3° 46.59'	64° 49.6'	48 586.75 nT
Spišské Podhradie	3° 55.29'	65° 22.1'	48 789.00 nT
Úbrež	4° 13.35'	65° 12.8'	48 814.97 nT

In order to describe the distribution of geomagnetic elements D, I and F over the territory of Slovakia, linear models were computed. They can be expressed by equations

$$D_{2006.5} = (3.228 \pm 0.029) + (0.023 \pm 0.036).(\varphi - \varphi_{HRB}) + \\ + (0.2581 \pm 0.0097).(\lambda - \lambda_{HRB}), \tag{2}$$

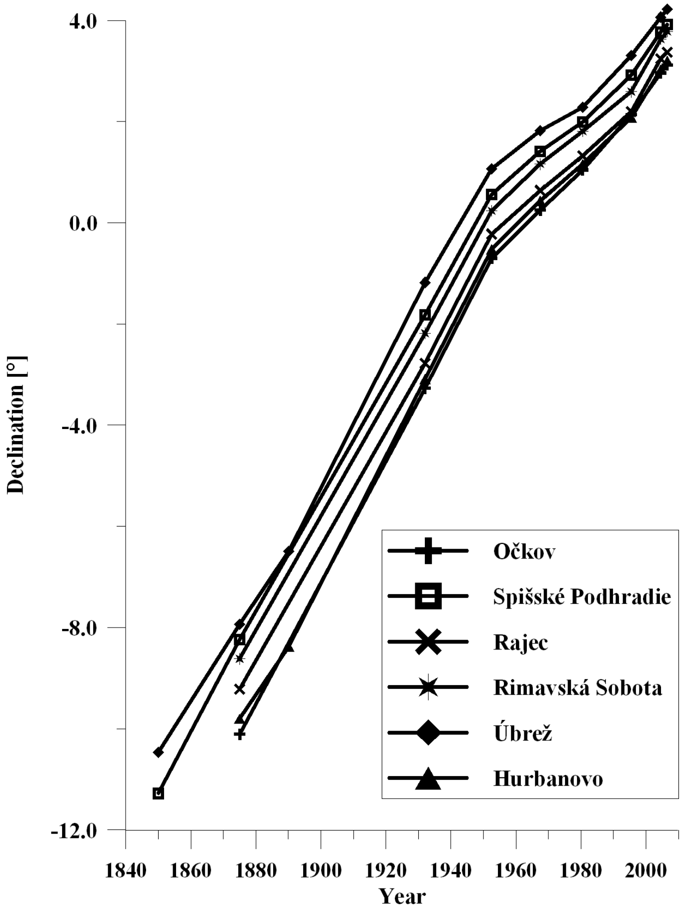

Fig. 1. Declination at the six Slovak repeat stations since the 19th century to the 2006.5 epoch.

$$I_{2006.5} = (64.254 \pm 0.027) + (0.856 \pm 0.034).(\varphi - \varphi_{HRB}) + \\ + (0.0543 \pm 0.0090).(\lambda - \lambda_{HRB}), \quad (3)$$

$$F_{2006.5} = (48318 \pm 14) + (256 \pm 17).(\varphi - \varphi_{HRB}) + \\ + (69.3 \pm 4.5).(\lambda - \lambda_{HRB}). \quad (4)$$

Here geomagnetic elements D and I, as well as geographical longitude λ and latitude φ, are expressed in arc degrees. Total magnetic field, F, is

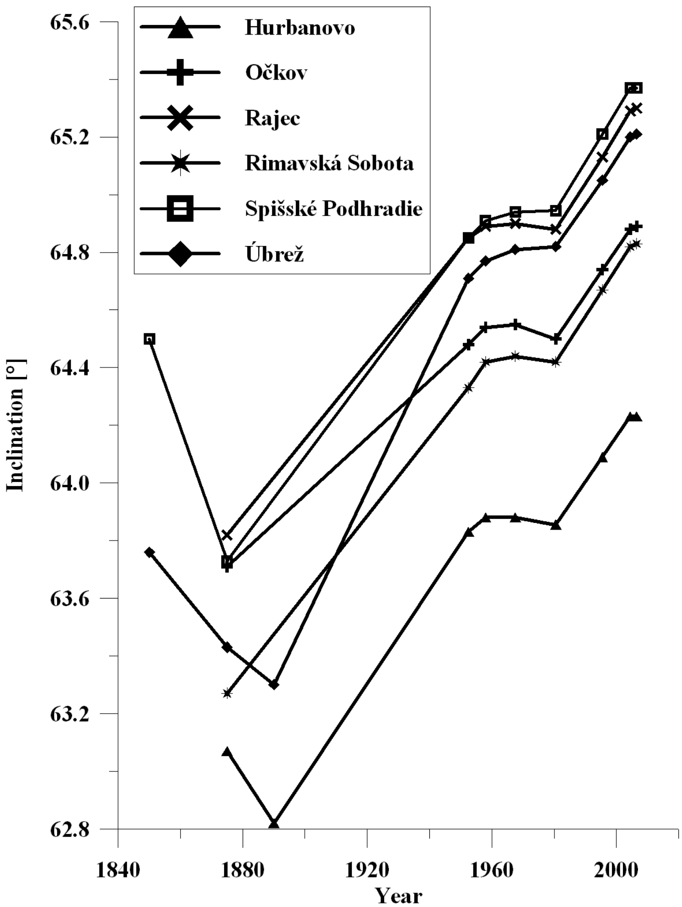

Fig. 2. Inclination at the six Slovak repeat stations since the 19th century to the 2006.5 epoch.

expressed in nT. The coefficients in the parentheses are written together with their probable errors, i.e., $2\sigma/3$.

Secular variations of the geomagnetic elements, i.e., the rates of the geomagnetic elements change with time, can also be described by linear models. They were calculated comparing the current values with those measured in 2004 *(Valach et al., 2006)*. Their distribution in Slovakia can be expressed by equations

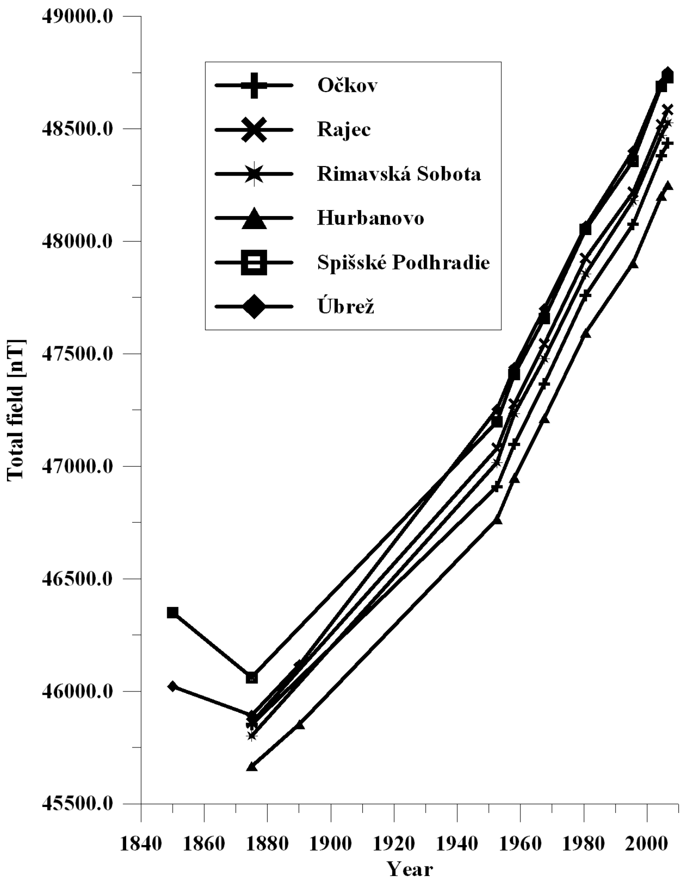

Fig. 3. Total magnetic field at the six Slovak repeat stations since the 19th century to the 2006.5 epoch.

$$\dot{D} = (5.09 \pm 0.19) - (0.80 \pm 0.23).(\varphi - \varphi_{HRB}) + \\ + (0.082 \pm 0.062).(\lambda - \lambda_{HRB}), \quad (5)$$

$$\dot{I} = (10.7 \pm 6.6) + (14.2 \pm 8.2).(\varphi - \varphi_{HRB}) - \\ - (2.3 \pm 2.2).(\lambda - \lambda_{HRB}), \quad (6)$$

$$\dot{F} = (28.0 \pm 2.1) + (5.3 \pm 2.6).(\varphi - \varphi_{HRB}) -$$

$$- (22.2 \pm 0.70).(\lambda - \lambda_{HRB}). \qquad (7)$$

Here $\dot{D}$ is expressed in arc minutes per year, $\dot{I}$ is in arc seconds per year and $\dot{F}$ is in nT per year. The coefficients in Eqs. (5)–(7) are written together with their probable errors.

The secular variation of declination can be visualized, if the isogones for both the current and the previous epochs are drawn together in the same picture. Such isogones for declination (linear model) in the 2004.5 and 2006.5 epochs are shown in Fig. 4. In the same way secular variations for inclination and total magnetic field are shown in Figs. 5 and 6. (For inclination the secular variation is very small.)

3. Conclusion

Slovak geomagnetic repeat stations were reoccupied in 2006. The measurements of the geomagnetic field at the six observation points were reduced to the middle of 2006, i.e., to the 2006.5 epoch. Complete time series of geomagnetic elements D, I and F at these observation points, with the beginning in the middle of the 19th century, are shown. Linear models for

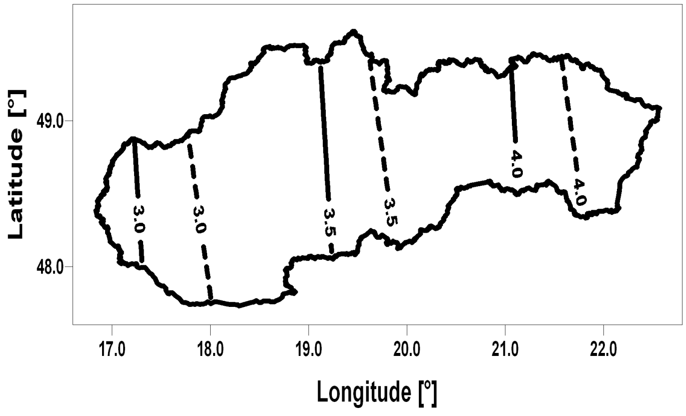

Fig. 4. The distribution of declination for the 2004.5 (dashed lines) and 2006.5 (solid lines) epochs. The values at the isogones are in arc degrees.

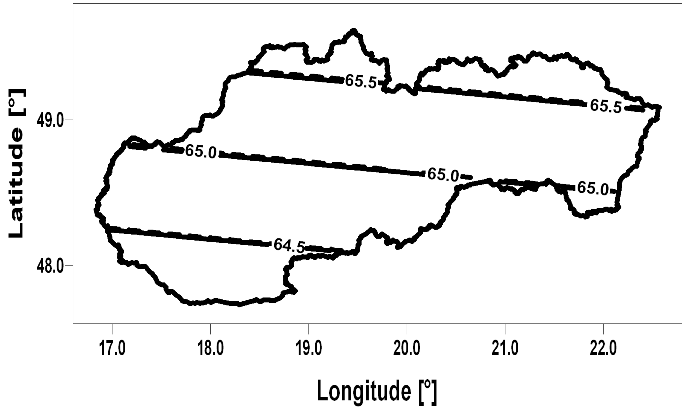

Fig. 5. The distribution of inclination for the 2004.5 (dashed lines) and 2006.5 (solid lines) epochs. The values at isolines are in arc degrees.

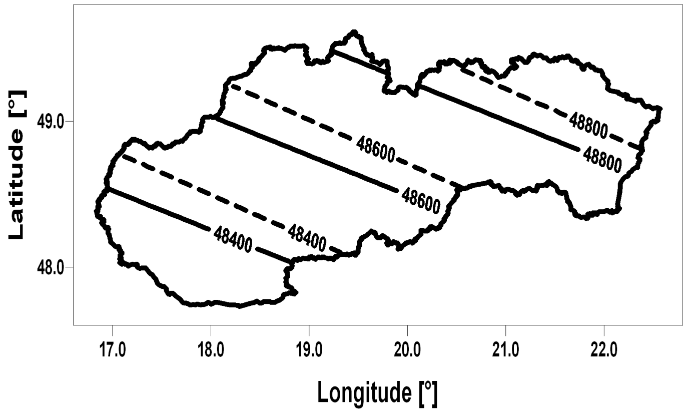

Fig. 6. The distribution of total magnetic field for the 2004.5 (dashed lines) and 2006.5 (solid lines) epochs. The values at the isolines are in nT.

the distribution of declination, inclination and total magnetic field, as well as for the secular variations of them were calculated.

We compared the observed values with the IGRF-10 model (`http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html`). Average differences for the geomagnetic elements, observed values minus the IGRF ones, were found to be $\overline{\Delta D} = (-2.73 \pm 1.17)$', $\overline{\Delta I} = (-1.85 \pm 0.47)$' and $\overline{\Delta F} = (-85.0 \pm 5.1)$ nT.

(The differences are written together with their probable errors.) It means that the IGRF model gives some higher values of D, I and F compared with the observed ones. The modelled values are shifted systematically – the estimated probable errors are much less than the differences themselves. Therefore the proposed linear models for the distribution of the geomagnetic field on the Slovak territory are possibly capable of describing the geomagnetic field better than the IGRF model.

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