The 9th International Conference "ENVIRONMENTAL ENGINEERING"
22–23 May 2014, Vilnius, Lithuania
SELECTED PAPERS
eISSN 2029-7092 / eISBN 978-609-457-640-9
Available online at *http://enviro.vgtu.lt*

Section: Technologies of Geodesy and Cadastre

Latest research on geomagnetic field in Lithuania

Petras Petroskevicius[a], Arunas Buga[b], Romuald Obuchovski[a]

[a]*Department of Geodesy and Cartography, Vilnius Gediminas Technical University, Sauletekio av. 11, 10223 Vilnius, Lithuania*
[b]*Institute of Geodesy, Vilnius Gediminas Technical University, Sauletekio av. 11, 10223 Vilnius, Lithuania*

Abstract

Lithuania, supported by Polish specialists, has successfully integrated in the European geomagnetic field research activities. Six repeat stations were established in 1999 and precise geomagnetic field measurements were performed in 1999, 2001, 2004 and 2007 there. Additional measurements in four airports of Lithuania were done in 2006, 2007 and 2010. Based on measured data, analysis of geomagnetic field parameter changes was performed. Accumulated data was processed and used for updating Lithuanian declination map and magnetic declination model accuracy estimating. Institute of geodesy acquired the modern equipment for geomagnetic field measurement in 2012. Equipment consists of two units of antimagnetic theodolite Theo010B with D/I FLUXGATE magnetometer, dIdD magnetometer and ENVI PRO magnetometer/gradiometer. Experimental measurements of geomagnetic field were performed at VGTU zero order gravity point. Diurnal magnetic field variations at measuring station and neighbouring observatories were analysed. Best correlation between data changes in observatory and measuring station was analysed. Data of research are useful for data reductions and best observatory selection.

Keywords: geomagnetic field; geomagnetic field secular variations; repeat stations.

1. Introduction

Most complete and accurate measurements of geomagnetic field parameters are performed at geomagnetic observatories. Distribution of observatories is not sufficient therefore secular variation stations are used. There geomagnetic field parameters are measured periodically every 2–4 years. There are no geomagnetic observatories in Lithuania but geomagnetic field parameters are measured periodically in repeat stations and airports. Geomagnetic declination in the airports is measured according ICAO specifications every 5 years [1]. 4 observation cycles were performed at secular variation stations from 1999 [2–4]. By performing observations at repeat stations at least 3 geomagnetic field parameters are determined; other parameters can be computed using reference formulas. Subject to instruments available the magnetic declination, inclination and intensity of geomagnetic field are measured most often. Lately non-magnetic theodolite with magnetometer sensor Fluxgate attached to telescope is used. By means of these the direction of geomagnetic field lines and their inclination from horizontal plane are measured. Proton magnetometer most often is used for measurements of geomagnetic field intensity.

Due to permanent variation of geomagnetic field parameters observed data should be reduced to particular moment. Most often reduction is done to the middle of the year [5]. Measurements at repeat stations are done at various time of the year, therefore continuous geomagnetic field parameter measurements at geomagnetic observatories are used for data reduction to the middle of the year. Geomagnetic field parameters at geomagnetic observatories are measured continuously therefore nature of geomagnetic field parameters variation can be determined not only for the time of observation at repeat station but for the whole year.

Peculiarities of data reduction are analysed in this publication. Data of geomagnetic field intensity obtained during 2007 were taken for the research. Data were reduced to 2007.5 epoch. Reduction was performed relative to three neighboring observatories: Belsk (Poland), Hel (Poland) and Uppsala (Sweden).

Corresponding author: Romuald Obuchovski. E-mail address: romuald.obuchovski@vgtu.lt
http://dx.doi.org/10.3846/enviro.2014.237

2. Reduction of geomagnetic field observation data

The geomagnetic field is variable in time. The first results of a geomagnetic survey are geomagnetic field parameters values measured at the different stations at different measuring moments. These data are not valuable, because of the variations of the geomagnetic field. Data should be reduced to annual mean values. Measured data reduction referenced according to standard equation:

$$E(x_i, t_{ann}) = \frac{\sum_{k=1}^{n}(E(x_i, t_k) - E(O, t_k))}{n} + E(O, t_{ann}) \qquad (1)$$

where $E(x_i, t_{ann})$ is the mean annual value of geomagnetic field parameter (declination, inclination or geomagnetic field intensity) at any location x_i , $E(x_i, t_k)$ is the value of the same geomagnetic parameter E at the same x_i place at observation time t_k . $E(O, t_k)$ is the value of the same geomagnetic field parameter at observatory O at the same observation time t_k . $E(O_i, t_{ann})$ is the mean annual value of geomagnetic field parameter at reference observatory.

Reduction method is based on the assumption that all geomagnetic field variations are the same at the observatory and the station. Reduction errors are influenced by selection of suitable period of observations, distances between observing point and observatory, status of geomagnetic field i.e. nature of variation of geomagnetic field parameters at the station and observatory. It is important to pay attention to mentioned circumstances if improved accuracy for data reduction is needed. Best results of reduction are obtained when variation of geomagnetic field parameters at the repeat station and observatory is running uniformly. It is important for selection of observatory for reduction to research which of neighbouring observatories is most suitable for reduction. Data of 2007 secular variations measurements were used for research. To ensure statistical reliability of research the geomagnetic intensity was used because most of data are geomagnetic field intensity measurements. Practically at every station geomagnetic intensity was measured in three turns (one hour each) and geomagnetic intensity readings were taken every minute. Linear relation was computed between data determined at secular variation stations and observatories. Three neighbouring observatories data were used for research: Belsk, Hel and Uppsala. Location of observatories and secular variations stations are represented on Figure 1. Data of other neighbouring observatories were not used for the research because F parameter was not measured there at that time.

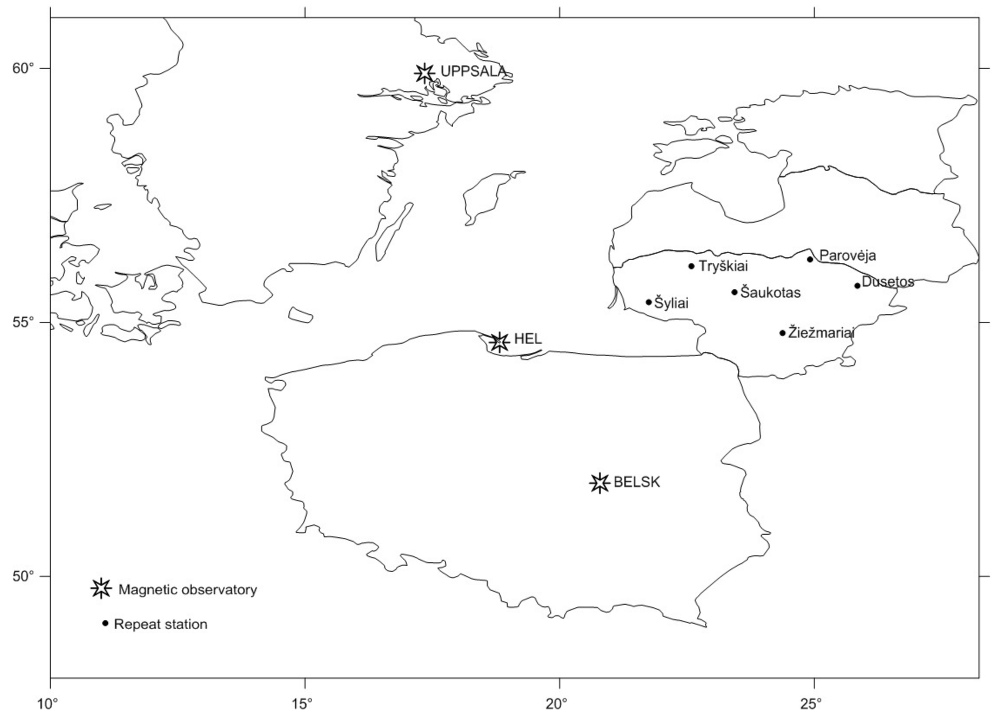

Fig. 1. Lithuanian secular variation stations and neighbouring observatories location

Observation intervals at repeat stations in UT (Universal Time) are presented in Table 1.

From Table 1 is clear that at least 3 measurements were done at every station and their duration was about 3 hours.

It is important to assure when geomagnetic observations are performed and later reduced in relation to observatory that magnetic field was changing uniformly and no geomagnetic storms were present. Change of geomagnetic field during the measurement period in neighbouring observatories is represented in Figure 2–4.

Table 1. Geomagnetic field intensity observations at secular variation stations

Repeat station	Date and time 06.08.07	07.08.07	08.08.07	09.08.07	10.08.07	11.08.07	12.08.07	13.08.07	14.08.07
Žiežmariai	6:05–6:41; 11:05–11:58	8:18–9:20							
Dusetos		12:58–13:53	5:05–5:54; 12:30–13:32	4:55–5:48					
Parovėja			8:32–9:40	7:31–8:14; 13:31–14:23	5:14– 6:04				
Šaukotas					14:27–15:32	5:35–6:33; 14:56–15:26			
Tryškiai						8:43–9:42; 11:44–12:25	7:05–8:31		
Šyliai								8:09–9:15; 13:59–14:39	3:49–4:57

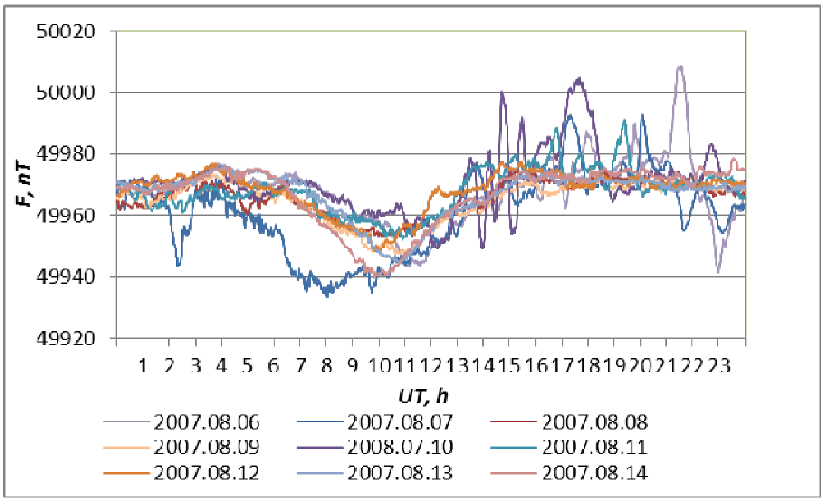

Fig. 2. Intensity variation during the day in Belsk observatory

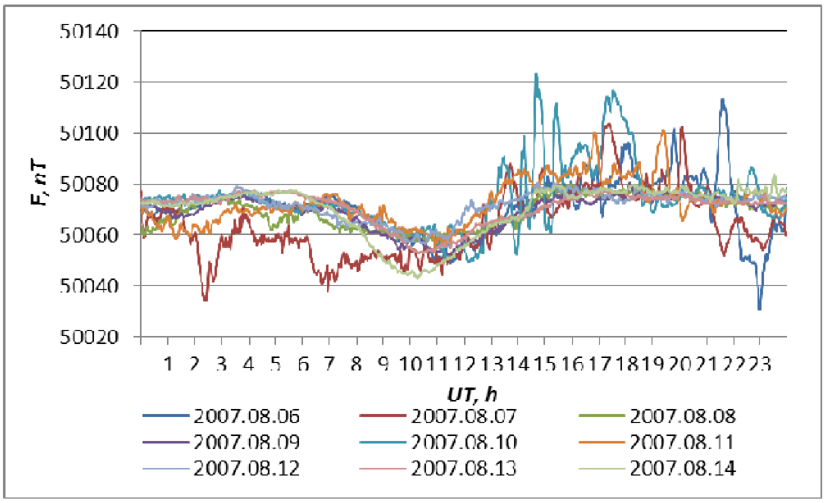

Fig. 3. Intensity variation during the day in Hel observatory

From Figures 2–4 can be seen that in all observatories larger intensity variation diapasons are during 6th, 7th and 10th day. During magnetically calm period geomagnetic field intensity varies in diapason of around 20 nT (e.g. on 08.08.2007.), but during magnetically non-calm period it can vary 40 nT (e.g. on 08.07.2007.). It is necessary to research such variation during mentioned period.

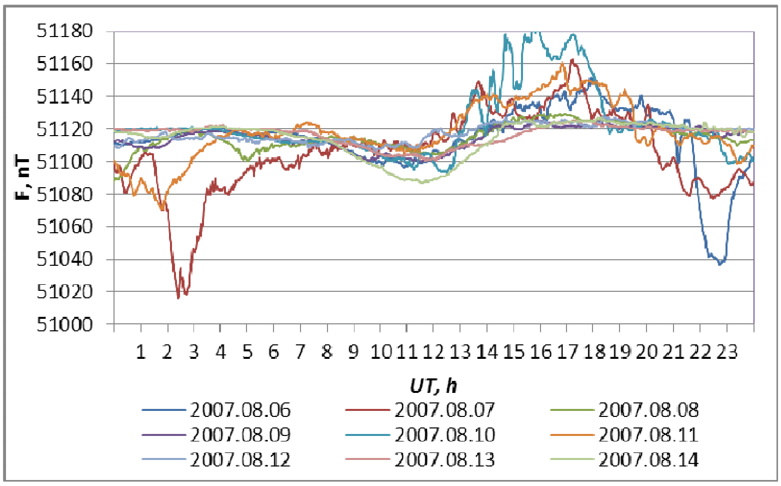

Fig 4. Intensity variation during the day in Uppsala observatory

Using formula 1 for reduction of data in relation to observatory differences of geomagnetic field parameters between stations and observatory are computed. Researched linear relation – the correlation between data of observatory and station. By this the nature of variation of geomagnetic field intensity in observatory and repeat station are estimated. Correlation coefficient values of geomagnetic field intensity measured at station and observatory are presented in Table 2. Correlation coefficients computed at separate periods which could be divided into morning measurements and measurements after the lunch.

Table 2. Correlation coefficient values from separate measurements

Repeat station	Correlation coefficient values								
	06.08.07	07.08.07	08.08.07	09.08.07	10.08.07	11.08.07	12.08.07	13.08.07	14.08.07
Žiežmariai	0.88(1) 0.87(2); 0.85(3) 0.90(1), 0.82(2); 0.96(3)	0.16(1); 0.64(2) 0.11(3)							
Dusetos		0.98(1); 0.98(2); 0.98(3)	0.54(1); 0.65(2); 0.96(3) 0.91(1) 0.86(2); 0.98(3)	0.80(1) 0.83(2) 0.90(3)					
Parovėja			0.84(1); 0.48(2) 0.26(3)	0.94(1); 0.86(2) 0.79(3) 0.82(1) 0.99(2) 0.99(3)	0.37(1) 0.54(2) 0.03(3)				
Šaukotas					0.98(1) 0.97(2) 0.95(3)	0.05(1) 0.54(2) 0.45(3) 0.58(1) 0.66(2) 0.72(3)			
Tryškiai						0.40(1) 0.82(2) 0.67(3) 0.59(1) 0.97(2) 0.98(3)	0.71(1) 0.50(2) 0.41(3)		
Šyliai								0.96(1) 0.91(2) 0.86(3) 0.92(1) 0.89(2) 0.93(3)	0.60(1) 0.52(2) 0.82(3)

0.88 (1) – correlation coefficient values obtained by comparing data measured at station with Belsk observatory
0.87 (2) – correlation coefficient values obtained by comparing data measured at station with Hel observatory
0.85 (3) – correlation coefficient values obtained by comparing data measured at station with Uppsala observatory

Results of correlation coefficients computation confirm complexity of geomagnetic field intensity variation presented in Figures 2–4. Correlation coefficient is very small during geomagnetically non-calm periods. This shows low linear relation between measurement data from observatory and repeat station. Such data cannot be used for reduction.

It is not unambiguously clear from analysis of obtained correlation coefficient values in relation to which observatory data reduction at secular variation stations should be done. During separate periods and at separate stations correlation coefficients values change significantly. Based on correlation coefficient values from separate periods is possible to determine which measurement is not quality data. Such data must be removed before reduction to mid of the year. From performed measurements it is clear that measurements should be distributed through few days, and time of measurement distributed during the day time.

After removing data of non-calm period differences between stations and separate observatories were computed. As well as their standard deviation. Using formula 1, mean intensity values of the year were computed. Results of reduction are presented in Table 3.

Table 3. Differences, standard deviation and mean annual values of geomagnetic intensity between observatories and repeat stations for the moments of observations in 2007

No	Repeat Station	BELSK $F_{2007.5}=49963$ nT			HEL $F_{2007.5}=50067$ nT			UPPSALA $F_{2007.5}=51113$ nT		
		F, nT	m_F, n,T	$F_{2007.5}$, nT	F, nT	m_F, nT	$F_{2007.5}$, nT	F, nT	m_F, nT	$F_{2007.5}$, nT
1	Žiežmariai	821.3	3.8	50784.3	716.9	1.5	50783.9	-330.1	4.4	50782.9
2	Dusetos	1303.5	4.1	51266.5	1199.9	3.3	51266.9	151.3	6.4	51264.3
3	Parovėja	395.5	1.1	50358.5	289.5	1.3	50356.5	-760.0	2.2	50353.0
4	Šaukotas	264.9	6.9	50227.9	153.0	8.6	50220.0	-911.7	6.4	50201.3
5	Tryškiai	525.9	2.5	50488.9	419.8	3.4	50486.8	-627.6	2.9	50485.4
6	Šyliai	1135.8	1.0	51098.8	1032.7	1.3	51099.7	-12.3	2.6	51100.7

By analysing obtained yearly geomagnetic field intensity values we see that differences from separate observatories are small enough. Only Šaukotas station has larger differences.

Summary and Conclusions

- For reduction of observation data in relation to selected geomagnetic observatory is necessary to research nature of data variation. For reduction the data should be used only from geomagnetic calm period.
- After performing analysis of correlation coefficients of separate moments of measurements can be stated that it is important to organize longer observations and observe during different time of the day.
- After reducing observation data to middle of the year in relation of different observatories it is obvious that mean yearly values differ insignificantly. Larger differences are only in Šaukotas and Parovėja repeat stations.

References

[1] Sas-Uhrynowski, A.; Mroczek, S.; Abromavicius, R.; Obuchowski, R. 2002. Investigations of the Magnetic Field over the Territory of Lithuania, *Geodesy and Cartography* 28(3): 88–94.
[2] Petroškevičius, P.; Būga, A.; Obuchovski, R. 2008. Continuation of research on magnetic field secular variation in Lithuania, *The 7th International conference Environmental Engineering* 3: 1434–1438.
[3] Kowalik, B.; Obuchovski, R. 2005. Geomagnetic field survey activities in Lithuania, *The 6th International conference Environmental engineering* 2: 908–912.
[4] Welker, E.; Sas–Uhrynowski, A.; Obuchovski, R. 2003. Changes of magnetic declination in the period of 1941–2000 at the former Eastern Polish and near-by territories, *Geodesy and Cartography (Geodezija ir kartografija)* 19(4): 106–114.
[5] Newitt, L. R.; Barton, C. E.; Bitterly, J. 1996. *Guide for Magnetic Repeat Station Surveys.* IAGA, published by Secretary-General of IAGA, WGV-8, NOAA space Environment Center, Boulder, CO 80303-3328, USA, Warsaw, 8–112 p.