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GEOMAGNETIC MEASUREMENTS IN LATVIA

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Abstract. The knowledge of the Earth's magnetic field elements and their dynamic fluctuations over the area concerned are important and can be used for many practical purposes in various fields, including Geodesy and Cartography.

Earth's magnetic field tends to vary over time. Unlike the field of a bar magnet, Earth's field changes over time because it is really generated by the motion of molten iron alloys in the Earth's outer core. Long-term magnetic field changes are caused mainly by processes in the Earth's interior, particularly the iron-rich core. Short-term changes of the magnetic field are mainly caused by the currents in the ionosphere and magnetosphere generated by Solar activity.

The Latvian Geospatial Information Agency (LGIA) has monumented repeat stations and started periodical Earth's magnetic field declination and inclination measurements in Latvia in 2004. The Network of 6 repeat stations is regularly distributed over the territory of Latvia. The repeat stations of Latvia are: Aglona; Ozolaine; Mikeltornis; Velena; Nigrande; Vilkene.

In every repeat station the D, I and F values were determined. Declination on territory of Latvia changes from 4° till 8° in the West – East direction. Magnetometer LEMI – 203 together with theodolite 3T2KP and proton magnetometer PMP 5 were used for measurements. Coordinates of the stations were determined by double frequency (L1/L2) GPS receivers. Determined coordinates were used to obtain geographical azimuth.

For reduction the data from Toravere (Estonia) observatory were used, where a variometer from the Nurmijarvi Geophysical Observatory is located. Repeat station points are fixed with benchmarks. Benchmarks are non-magnetic. All the data were sent to the British Geological Survey National Geoscience Data Centre.

Keywords: Geomagnetic field, geomagnetic repeat station, declination, inclination.

1. Introduction

The knowledge of the Earth's magnetic field elements and their dynamic fluctuations over the area concerned are important and can be used for many practical purposes in various fields, including Geodesy and Cartography.

The most significant magnetic field studies in the territory of Latvia have been conducted in the twenties – thirties of the 20th century by Leonid Slaucitajs and his team (Rikitake 1985). During this period, mostly the magnetic declination was measured. The Earth magnetism measurements were made in 1927–1928 on the yacht "Cecilie" in the Baltic Sea. Some measurements of magnetic declination, inclination and horizontal intensity were conducted around Riga in 1937. Riga's area repeated magnetic survey together with the previous data made possible to construct the geomagnetic map of Riga area. The geomagnetic measurements of the Latvian territory were made during the Soviet period between 1971 and 1991. New era of surveying and mapping has started in 1991 together with new activities in the Republic of Latvia. Geodesy Bureau of the Gravimetric Department of the State Land Service of Latvia started to develop a methodology of magnetic works in 2002. New systematic magnetic measurements were resumed in 2004. 6 repeat stations were established. Gravimetric and magnetometric measurements for magnetic declination determination for topographic maps (scale 1:50 000) were started in 2007 by the Latvian Geospatial Information Agency. The instruments used for the Earth's magnetic field declination and inclination determination were: magnetometer LEMI-203, non-magnetic theodolite 3T2KP. The earth's magnetic field measurements were made using proton magnetometer CSE-5. This instrument was provided by Finnish colleagues from the Finnish Meteorological Institute. Proton magnetometer CSE 5 had an overhaul and was refurbished in the Polish company TUS Electronics in 2008.

2. Geomagnetic repeat stations in Latvia

Network of geomagnetic repeat stations consists of 6 repeat stations of the first class, evenly distributed on the Latvian territory. The sites for the repeat points were chosen to meet high expectations, due to the work specifics. Neighbourhood must be free of large magnetizing objects, such as railway lines, high voltage lines, large steel structures, etc. The geomagnetic measurements were carried out following internationally used requirements (Rikitake 1985; Newitt *et al.* 1996; Jankowski, Sucksdorff 1996).

2.1. Stations coordinates and azimuth

The geographic coordinates of the repeat station were determined within accuracy of 50 millimetres. Global Positioning System Latvian base stations (LatPos) data was used for the position computations.

LatPos is a national continuously operating network of Global Navigation Satellite System stations as a next generation of ground based geodetic control network.

LatPos system includes continuously operated 23 GPS base stations evenly distributed in the territory of Latvia. Average distance between stations is 70 km. Data processing centre is located in Riga. Second epoch data from GPS receivers has been sent to data processing centre. Data is processed and distributed to users by different message types.

Post processing data available through FTP servers. User defined session length and necessary stations can be selected.

Data divided into one hour files can be obtained from FTP server. Using LatPos System an individual GPS receiver is able to correct its own position, achieving centimetre accuracy in real-time measurements.

Millimetre accuracy can be obtained by using post processing software and data from LatPos system. Reference receivers send data to a central computation server. This data is used to form a correction message, which is then transmitted to users via mobile data link. A receiver uses this information to correct GPS signals.

2.2. Geomagnetic network

Latvian geomagnetic network was built in the following way: distance between the first class repeat stations does not exceed 200 kilometres.

First class repeat points are used for geomagnetic measurements of the Earth's magnetic field and its secular changes, also to provide geomagnetic information for the second class network constructing and cartographic data for other activities of the Agency.

Second class is used for topographic maps development and renovation, as well as completing task of government and municipal bodies.

For production of topographic maps it is important that geomagnetic measurements are performed in at least in five points, located approximately on the map sheet corners and centre. Magnetic inclination measurements are made at one point closest to the centre of the map sheet.

National geomagnetic measurement network covers the territory of Latvia in the effective way and ensure collected data and information reliability. There are 6 geomagnetic repeat stations in Latvia (Fig. 1):

Aglona N 56° 07' 14" E 26° 59' 56";
Nīgrande N 56° 29' 26" E 22° 05' 08";
Ozolaine N 56° 25' 41" E 24° 30' 17";
Viļķene N 57° 37' 01" E 24° 37' 04";
Miķeļtornis N 57° 35' 50" E 21° 58' 56";
Velēna N 57° 14' 42" E 26° 24' 02".

Fig. 1. Geomagnetic repeat stations in Latvia

The new repeat station Aglona1 is installed in 2011. Aglona1 is situated near earlier destroyed station. Station is established at about 30 meters from the destroyed point site, because old site was set up too close to an underground power line that caused the interference to the measurement results of 2004. During regular repeated geomagnetic measurements, secular variations of geomagnetic field was determined (Figs. 2, 3 and 4).

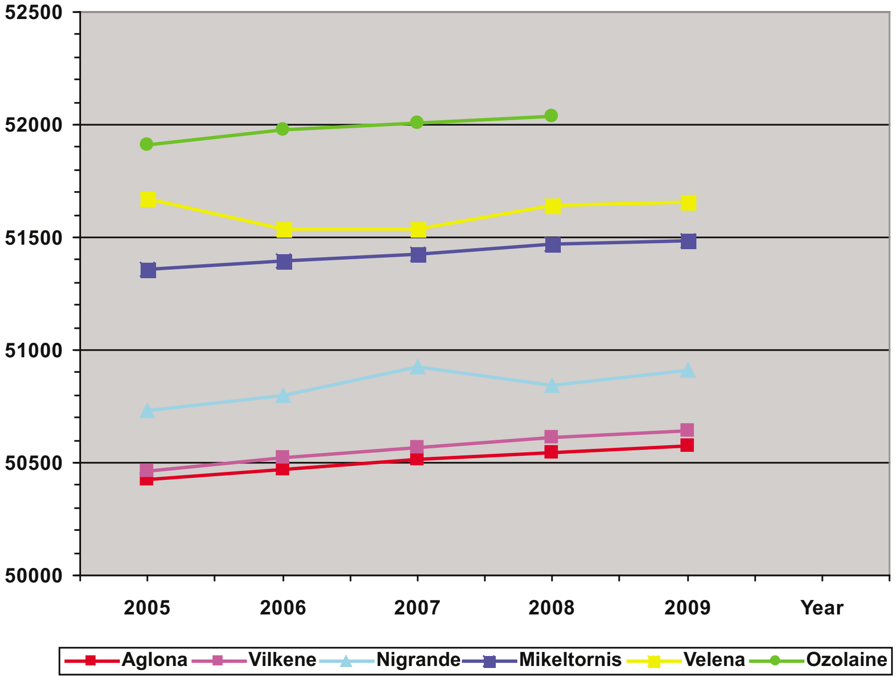

Fig. 2. The variation of total field F mean annual values in nT (during 2005–2009)

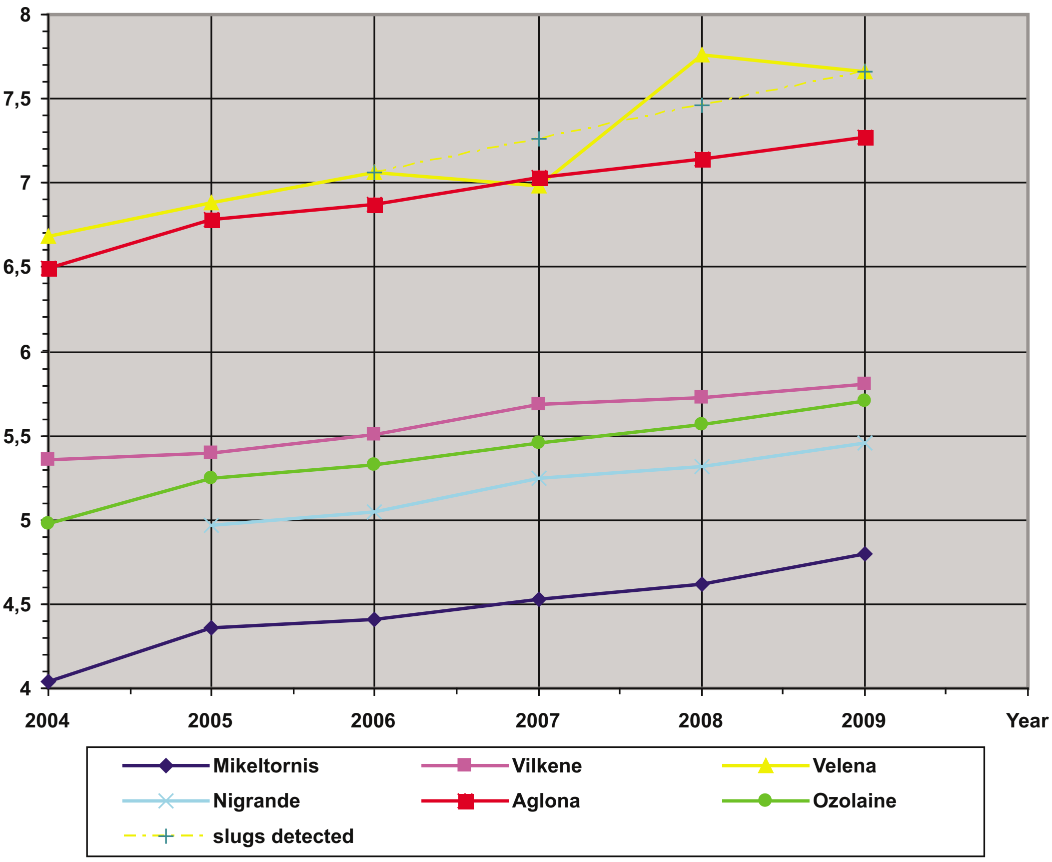

Fig. 3. The variation of declination mean annual values in degrees (during 2004–2009)

The second class geomagnetic network is useful for determination of magnetic components in the airfields and determination of areas with magnetic anomalies. The second class geomagnetic network is not fixed on sites, but the sites could be identified using coordinates and maps.

Earth's magnetic field intensity vector F (Fig. 2), declination D (Fig. 3) and inclination I (Fig. 4) is measured in each geomagnetic point of the network.

Declination rates on Latvian territory varies from 4° to 8° (Fig. 5). Geomagnetic data processing is carried out using Nurmijarvi (Finland) Geophysical Observatory variometer data, which is in Tartu (Estonia) Observatory.

3. Errors and other problems

Some metal litter has been found around the repeat station Velena in 2008 (Fig. 6).

Repeat stations are damaged by land owners, workers, roadmen and farmers who do not pay attention to notice that their activity can damage the repeat station. For example repeat station Aglona was destroyed during the road and ditch renovation (Fig. 7).

That is the reason why usually ground inspection with metal detector is going on before the start of repeat station measurements. By publisizing the importance of repeat stations and explaining how harmful metal litter could be is regularly done to the local authorities and people living around the repeat station.

Land owners of areas where repeat stations are established receive an informative notice about the work on repeat station two weeks before start of measurements. The land owners of parcels where repeat station is planned to be established receive a statement. By signing the statement owner allows the establishment of the repeat station on the property.

4. Conclusions

Based on measurement results in 2009, the declination value on the Latvian territory in 6 repeat stations varies from 4.79984 to 7.66423 degrees. Inclination value varies 70.79185 to 71.98450 degrees. Based on measurement results in 2008 the total field F varies from 50545 nT to 52038 nT.

Average increase of declination for the territory of Latvia is from 0,089582 to 0,195902° per year.

Average decrease of inclination for the territory of Latvia is from 0,017894 to 0,00154° per year.

Average increase of total field for the territory of Latvia is from 32,75 to 43,6nT per year.

For more detailed data analysis it is necessary to continue the accumulation of data. Number of repeat stations of geomagnetic network should increase in the future. The measurements at repeat station should be done once in two years. The repeat points have to be divided into two groups (one group measured in even years, the other in odd years).

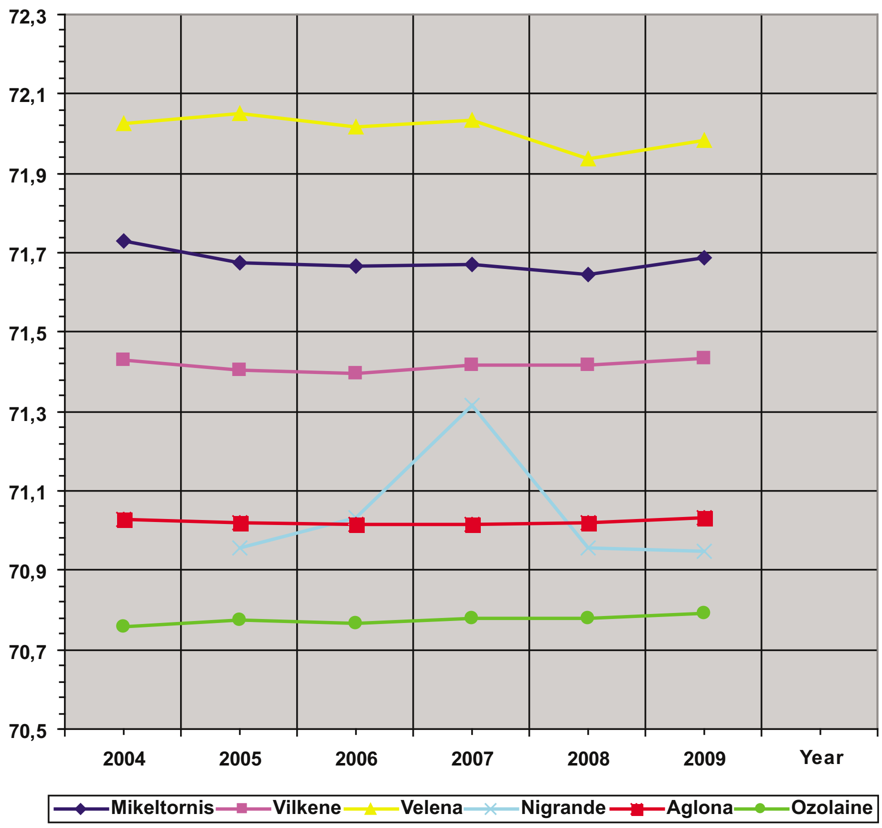

Fig. 4. The variation of inclination mean annual values in degrees (during 2004–2009)

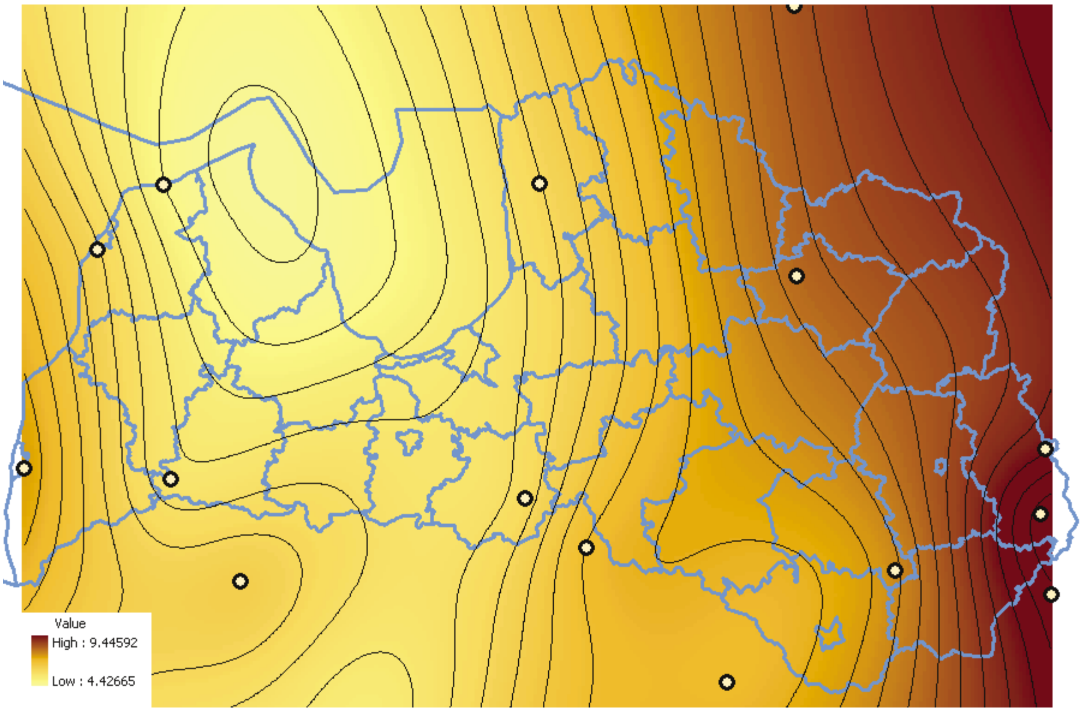

Fig. 5. Declination rates on Latvian territory varies from 4° to 8°

Fig. 6. Metal wires

For correction of measurement results and for records of temporal variations of the geomagnetic field is necessary to install variometer station on territory of Latvia, because some repeat stations are located further than 500 km from Toravere (Estonia) Observatory variometer station.

Geomagnetic operation results (STANAG 7172, STANAG 3676) are urgently required for the finalization of cartographic products. Each map sheet requires specific parameters of the corresponding magnetic anomalies and the annual variation of the data.

To ensure the mapping needs it is necessary to carry out a series of measurements:

1. Local magnetic measurement cycles for each specific area of the map sheet.

2. Regular stationary magnetic deflection measurements – to record the dynamics of the development in the entire national territory.
3. Determination of magnetic deviation correction could be improved having magnetic measurement data of every individual map sheet corners and centre.
4. Organizing national and international magnetic measurement (research) projects.
5. Creation and maintenance of the database, data processing, analysis of research results taking into account the magnetic component.
6. Production of magnetic declination maps for air and sea navigation.

The results of magnetic measurements – magnetic declination, are shown on topographic map sheets. Since the terrestrial magnetism affects the direction determination, without this information it is impossible to navigate by map. Strategic importance of these maps are predefined by the needs of army.

Magnetic surveys are essential for geophysical surveying and technology development. Magnetic surveys are prosecuted in the developed countries.

To preserve from destruction and for convenient work on site the repeat station has a concrete square plate (side of 2.5 metres) and non-magnetic direction column located in 1–1.5 metre from repeated station which indicates Latvian Geospatial Information Agency contacts.

Fig. 7. New ditch

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Research interests: geomagnetic measurements, geomagnetic field modelling.