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Ukrainian geomagnetic repeat station network and results of the field work reduced to the epoch 2005.5

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ABSTRACT

The results of geomagnetic field components of the renewed Ukrainian repeat stations (RS) network are presented. The methods of absolute geomagnetic and astro-geodetic measurements are described. The reduction of geomagnetic field components is carried out to the 2005.5 epoch and a catalogue of RS is created. Maps of magnetic declination for the Ukraine are constructed and compared with results calculated by the IGRF-2005 model.

1. Introduction

Investigation of the temporal and spatial structure of the Earth's magnetic field (EMF) is important to solve some fundamental problems in geophysics. One problem is the separation of the Earth magnetic field into contribution from sources of internal and external origin, and the separation of the internal sources into the main (normal) field, arising from the dynamo process in the liquid Earth core and a lithospheric field. To solve this problem it is necessary to have precise data of the absolute values of the magnetic field components and their time changes. High quality data of the magnetic field components at the Earth's surface can be obtained from measurements at magnetic observatories (MO) as well as from the periodic measurements (2-5 years) at repeat stations (RS) or from space by satellites. These measurements are extremely important for the following tasks:
– estimation and analysis of the time-spatial dynamics of the EMF, its separation into the various parts and investigations of their nature;
– modeling of the Earth magnetic field (for example the IGRF) [Finlay et al. 2010];
– reduction of magnetic surveys and development of maps of the anomalous (lithospheric) magnetic field.

For a temporal reduction of the RS measurements a continuous record of the Earth's magnetic field vector $\mathbf{B_X}$, $\mathbf{B_Y}$, $\mathbf{B_Z}$, $\mathbf{B_F}$, $\mathbf{B_H}$, **D**, **I** from a MO is needed. Repeated measurements of the Earth magnetism elements at the RS network allow to map the secular variations (SV) of the geomagnetic field. Many organizations from the geology, geophysics, geodesy and military claim for this type of data.

2. Historical background

First general magnetic survey in the Ukraine was accomplished during the 1930s and 1940s and the second field campaign in 1969-1972 with a density of 1 point per 400 km^2. At the beginning of 1970 a new repeat station network with 39 points was installed in the Ukrainian region [Krutikhovskaya et al. 1973]. Absolute values of the field strength $\mathbf{B_F}$ were measured by the proton magnetometer, $\mathbf{B_H}$ by the quartz H-magnetometer and declination was measured with the fluxgate magnetometer on top of the demagnetized theodolite 3T2K. Mean-square errors of the measurements at this RS network for $\mathbf{B_F}$ component ±2.4 nT, $\mathbf{B_H}$ ±4.0 nT, $\mathbf{B_Z}$ ±2.5 nT, **D** 1.3 minutes of arc. The next magnetic survey at the RS network was done during 1974 and 1975. The components of the geomagnetic field were reduced to 1974.5 by using the data of the magnetic observatories data "Lviv", "Kiev" and "Odessa". This work was used for the mapping of all components of the geomagnetic field for the territory of the Ukraine and the USSR and for the mapping of the main field for the epoch 1975 year [Krutikhovskaya et al. 1982]. Some of these repeat stations were repeated until the year 1985.

After 30 years from the last magnetic survey many points of this network were lost. For this reason, the goal of this work is to analyze the condition, reviving and increasing the existing RS network in Ukraine. In the year 2003 the Carpathian Branch of the Subbotine Institute of Geophysics NAS of Ukraine (CBiGF) and Subbotine Institute of Geophysics NAS of Ukraine (IGF) started this work.

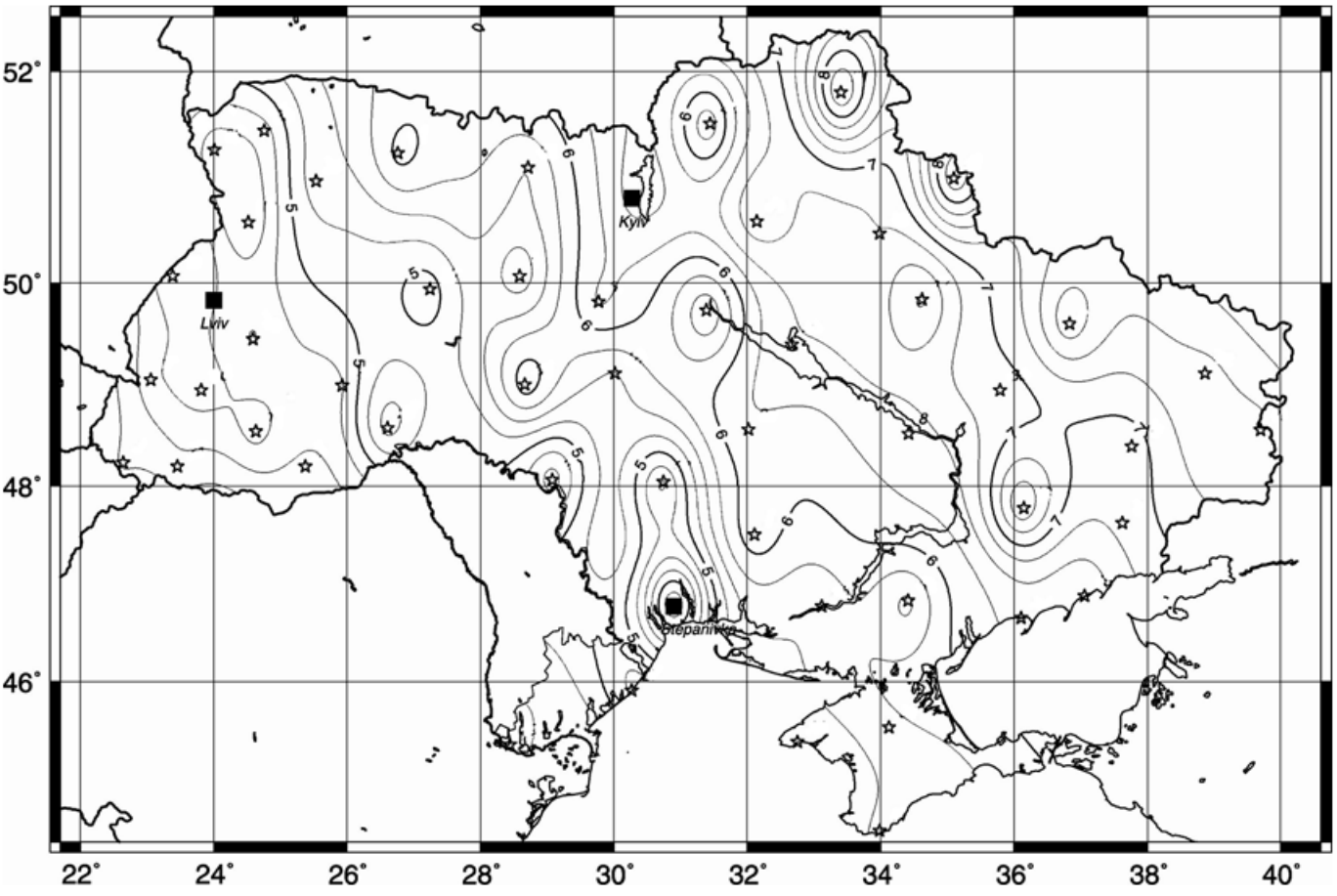

Figure 1. Ukrainian RS Network and magnetic declination D (isogonic counter lines in degree) for the epoch 2005.5. Black stars: RS network; black squares: magnetic observatories.

3. Ukrainian RS Network

The RS network in Ukraine was renewed and increased during the years 2005-2006. Most of the new points were reinstalled at the locations of the destroyed points. But reinstallation can't give us the same positions of the points as in 1972 to 1973. For this reason measured data at the new Ukrainian RS network during 2006 and 2007 cannot be used for the determination of the secular variations since 1974. This new RS network consists of 52 first order points with a distance between the points of approximately 100-150 km. The density of the RS network is one point per 10,000 km^2 with the even distribution in the Ukrainian area. For the astronomical gauge azimuth determination, or in general for the bringing of the theodolite horizontal scale to the geographic meridian several methods, we use the classical method of the horary angle of the celestial body [Pandul 1983]. As it was mentioned for the determination of all components of the Earth magnetic field, it is necessary to determined three independent components. Flux-gate magnetometers LEMI-203 [see the website of the Lviv Center of Institute for Space Research: http://www.isr.lviv.ua/products.htm#Flux-gate magnetometers], installed on top of demagnetized theodolite 3T2K, can be used for the determination of the angles D and I. Module of the complete vector $\mathbf{B}_F$ of the magnetic field was measured by the proton magnetometers MINIMAG and MB-01 (proton magnetometers with achieved accuracy 0.01 and 0.1 nT, developed by "Geologorazvedka", St. Petersburg, Russia). In general all recommendations of IAGA was take into account [Newitt et al. 1996]

4. Results

The results of the second cycle measurements at Ukrainian RS network were reduced to the epoch 2005.5 [Maksymchuk et al. 2010]. The reduction [Newitt et al. 1996] was based on the data from the magnetic observatories "Kyiv", "Belsk" and "Lviv". In Table 1 all reduced components are shown. In general, comparison of measured values with the modeled ones show us that differences between the linear components ($\mathbf{B}_X$, $\mathbf{B}_Y$, $\mathbf{B}_Z$) can reach several hundred nT. Differences in the magnetic declination angles at various regions vary from one minute to half degree. If the analytical model field is very flat without any local (regional) gradients (Figure 1), whereas the real measured field composed of big gradient in various area of Ukrainian region. Especially this is visible at the **D** component. Magnetic declination **D** in the Ukrainian region fluctuates from 4° at the West to 8° at the East with the sufficiently complicated spatial structure (Figure 2). Strong regional anomalies can be divided to the three parts: western part of Ukraine, in the region of the MO "Lviv"; southern part of Ukraine near the

Nr.	RS Name	φ, N°	λ, E°	B_X (nT)	B_Y (nT)	B_Z (nT)	D°
1	Balaklia	49.603	36.500	20465	2839	46377	7.884
2	Bashtanka	47.510	32.107	20977	2257	44673	6.128
3	Berduchiv	50.066	28.590	19788	1769	45647	5.105
4	Beregove	48.234	22.648	20587	1542	44223	4.280
5	Beregomet	48.197	25.378	20700	1610	44515	4.440
6	Bila Cerkva	49.819	29.774	19829	2179	45613	6.265
7	Borynja	49.055	23.059	20337	1665	44540	4.677
8	Verhnjodniprovsk	48.523	34.421	20390	2275	45550	6.362
9	Volnovakha	47.627	37.622	20617	2473	46000	6.829
10	Gadjach	50.476	33.985	19249	2275	46455	6.740
11	Goluba Zatoka	44.422	33.982	22691	2223	42993	5.572
12	Horokhiv	50.580	24.522	19513	1453	45747	4.259
13	Guljaipole	47.778	36.146	20775	2809	45581	7.688
14	Deljatyn	48.549	24.634	20566	1738	44598	4.827
15	Dzergynsk	48.399	37.764	20512	2479	45549	6.883
16	Dymer	50.806	30.274	19242	2103	46308	6.236
17	Dykanka	49.840	34.625	19728	2273	46134	6.571
18	Zhashkiv	49.118	30.015	19763	1900	44764	5.490
19	Zavadiv	50.064	23.390	19771	1716	45381	4.959
20	Kalna	48.953	23.814	20423	1738	44661	4.861
21	Kamjanec	48.578	26.696	20480	1998	44848	5.568
22	Kaniv	49.739	31.386	19704	1841	45433	5.336
23	Kiverci	50.971	25.533	19017	1788	45904	5.374
24	Kirovograd	48.564	32.019	20233	2199	45031	6.198
25	Kovel	51.449	24.758	18818	1532	45811	4.658
26	Kodyma	48.064	29.075	20567	1590	45109	4.412
27	Kurortne	45.904	30.268	22122	2055	43851	5.280
28	Lugansk	48.559	39.696	20253	2645	46353	7.431
29	Luboml	51.267	24.008	18753	1430	45661	4.360
30	Nemuriv	49.008	28.667	20044	2146	44674	6.106
31	Nyzhne Selyshe	48.198	23.456	20703	1597	44083	4.407
32	Nyzhni Sirogozy	46.836	34.411	21333	2047	44529	5.468
33	Ovruch	51.099	28.712	18931	1829	45642	5.521
34	Okunivka	45.364	32.751	22110	2071	43446	5.338
35	Orelka	48.956	35.794	19956	2419	45901	6.905
36	Orlovka	46.661	36.106	21531	2405	44877	6.355
37	Pervomaisk	48.041	30.747	20635	1623	44637	4.487
38	Pryluki	50.589	32.146	19263	2330	46169	6.895
39	Reni	45.338	28.441	22307	1932	43032	4.925
40	Rogatyn	49.454	24.589	20111	1580	45199	4.492
41	Sarnu	51.237	26.759	18959	2012	46164	6.062
42	Starobelsk	49.118	38.868	20242	2638	46608	7.418
43	Stepanivka	46.777	30.900	21246	1326	44222	3.554
44	Sumy	51.000	35.101	19063	2814	46419	8.397
45	Urzuf	46.886	37.061	21354	2374	44513	6.328
46	Kherson	46.777	33.116	21344	2080	44475	5.562
47	Cherkasy	49.406	32.670	19943	2261	45457	6.465
48	Chernigiv	51.512	31.443	18571	1829	46767	5.628
49	Chortkiv	48.999	25.927	20424	1697	45023	4.741
50	Shepetivka	49.938	27.247	20003	1709	45270	4.881
51	Shostka	51.803	33.402	18676	2769	46800	8.435
52	Jastrubivka	45.516	34.127	22097	2202	43647	5.688

Table 1. RS catalogue of components of the geomagnetic field for the epoch 2005.5.

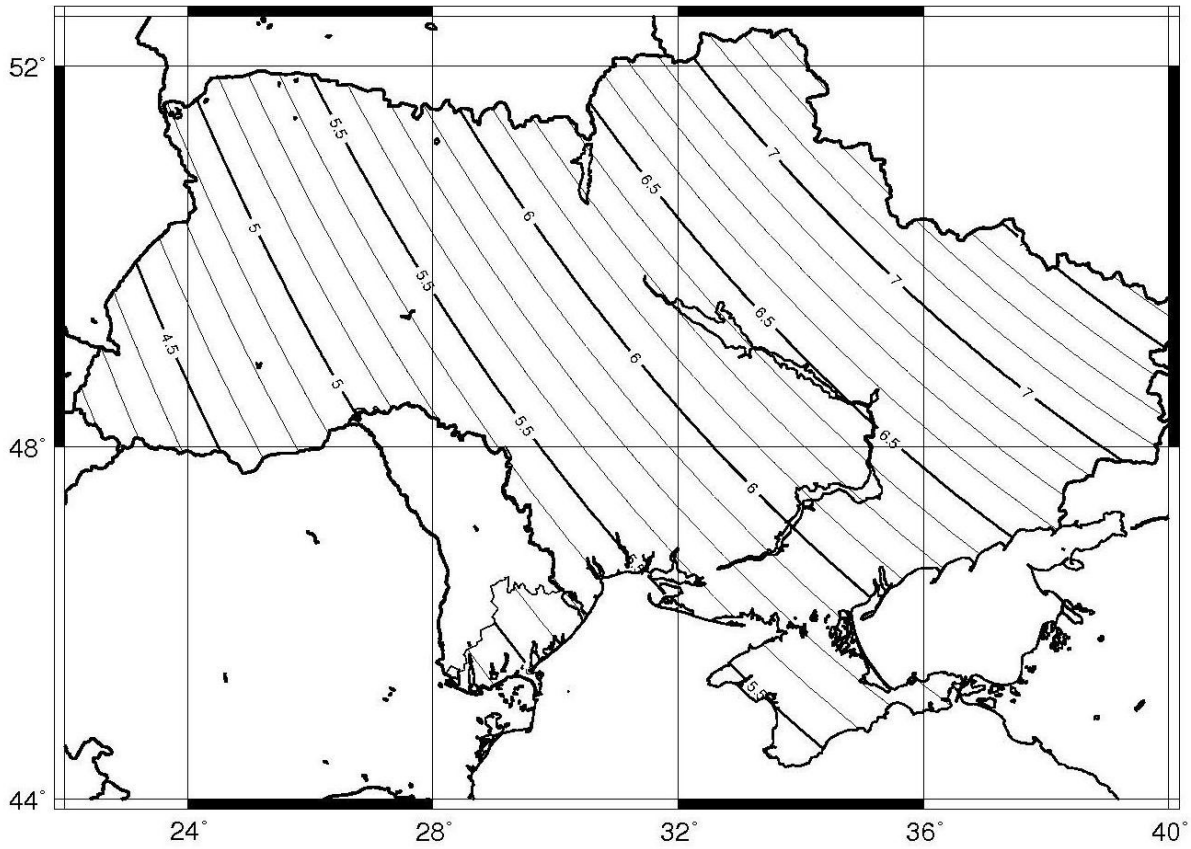

Figure 2. Magnetic declination D (degree) based on IGRF-2005 model.

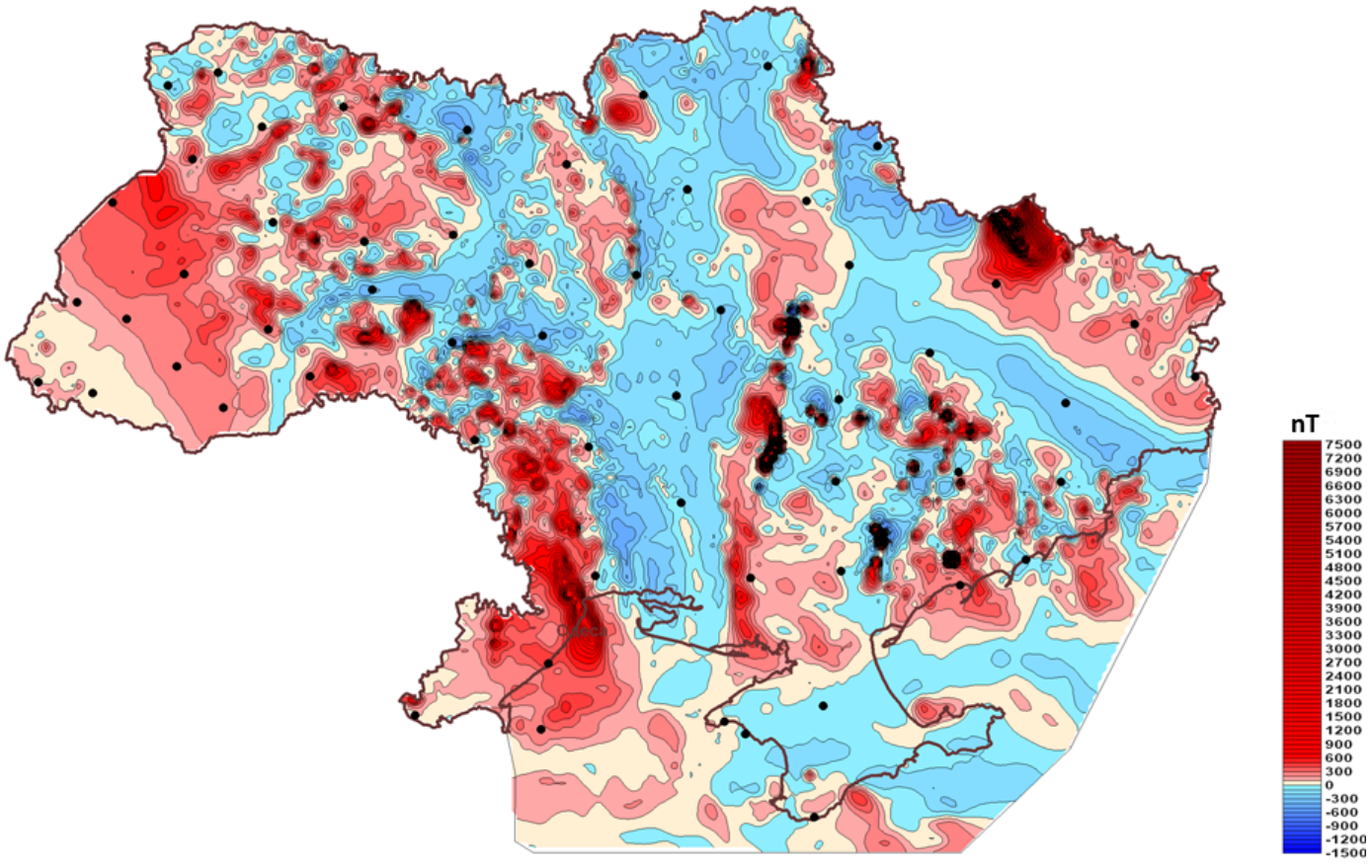

Figure 3. Anomalous magnetic field in Ukrainian area (nT) [Orlyuk and Romenets 2005].

MO "Odessa" and eastern part near the Ukrainian–Russian border. The structure of the magnetic declination in general agreed with the anomalous magnetic field (Figure 3). Anomalous values of the declination in the western Ukraine coincide with the Lviv regional magnetic anomaly, in the South with the Odessa regional magnetic anomaly, and in the East with the western fork of the Kursk magnetic anomaly. This demonstrates their common nature.

5. Conclusions

During 2003 and 2004, 52 repeat stations were renewed and installed at the Ukrainian RS network taking into account the condition of the RS network after 1972. These points are located almost uniformly on the Ukrainian area. Comparison of measured components with modeled ones from IGRF model demonstrates important differences; it is especially the case of magnetic declination **D**. To estimate with higher accuracy the real field feature and to improve existing maps of the anomalous magnetic field is necessary to densify RS network during next cycle of repeat measurements. Results of geomagnetic measurements will be applied to the adjustment of normal magnetic field model for the Ukrainian territory and for future research of secular variations of the Earth magnetic field.

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