COMPARISON OF THE MODELS-CANDIDATES IGRF 2005.0 AND IGRF SV 2007.5

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1.Introduction

The models- candidates IGRF 2005.0 and IGRF SV 2007.5 developed by four teams are presented on the website www.dsri.dk/Oersted/Field_models/

Models A were developed by DSRI/NASA team;

Models B were developed by NGDC/GFZ team;

Models C were developed by BGS team;

Models D were developed by IZMIRAN team.

All listed models were developed mainly on base of data obtained with satellites Oersted and CHAMP for period from their launch and till the beginning of autumn 2004. In the model C1 the data from magnetic observatories were also used. Parent models as multiparametrical space-time ones were developed by means of analysis of the data obtained up to present days. They included the SV terms, which coefficients depend on time linearly or quadrically for considered interval. The candidate models 2005.0 were derived by time extrapolation of coefficients of developed SV models up to mentioned epoch. In its turn models SV 2007.5 were derived by time extrapolation of the same SV model forward to epoch 2007.5. Below one can see the results of mutual comparison of the presented models and besides the comparison with observatory data (model 2005.0) or with independent models (model 2007.5), D2 and D3 or with model of averaged SV for interval 1980-2000 (model E1). The discussion of the results of such comparison and estimations of reliability of developed models follows further.

2. The additional data

As independent data we used the annual means of geomagnetic field components from the set of observatories situated in regions where the candidate models 2005.0 differ most significantly. As it would be clear later these regions in the first turn correspond to the high latitudes of the North hemisphere. That's why we used the observatory data with $\theta<30^\circ$ and latest values dated from 2003.5.

3. The additional models.

The model D2 was developed in IZMIRAN using the data from magnetic observatory network by means of linear, quadratic, or qubic extrapolation of the series of annual means of the geomagnetic field SV components forward to epoch 2007.5. The data used covered the time interval from 1900

to last year, which data were available. So we used the data series from 167 observatories. A few examples of extrapolation of series of annual means of SV from world observatory network for epoch 2007.5 are presented in Fig.1. The values marked with crosses were obtained by means of quadratic or cubic approximation depending on a curve's form. The forecast values, derived by such way, were applied for development of SH model up to n=m=8. In addition to the observatory data, 21 points in Pacific and Indian ocean's regions were filled with values calculated with model D1.

The model D3 was developed from mutual analysis of DGRF 80.0, DGRF 2000.0 and candidate models of the geomagnetic field for epoch 2005.0, presented by IZMIRAN. The coefficients D3 were obtained by the following way:

$$g_{nt}^{m} = g_{n80}^{m} + \dot{g}_{n}^{m}\Delta t + \frac{1}{2}\ddot{g}_{n}^{m}(\Delta t)^{2}$$

Substituting g_{nt}^{m} with values of coefficients for epoch 2000.0 ($\Delta t = 20$) and 2005.0 ($\Delta t = 25$) we derived the values of dotted coefficients and calculated the values $g_{n2010.0}^{m}$.

The coefficients for SV2007.5 we calculated as

$$g_{n2007.5}^{m} = \frac{g_{n2010}^{m} - g_{n2005}^{m}}{5}$$

Beside these forecast models comparison was done between models of SV model averaged for 1980.0-2000.0 (E1) and 2000.0-2005.0 (E2).

Model D2 has been developed by T.N. Bondar and V.P. Golovkov, D3 by S.V. Yakovleva and V.P. Golovkov.

4. Comparison of candidate models of the field.

The most appropriate method of comparing the similar candidate models of the field is the mapping of differences between each presented model and the model derived by averaging of all candidates (model F(A,B,C,D)). The maps of these differences are presented in Fig.2 (a-d): (a)- (F-A2); (b) – (F-B3); (c) – (F-C1); (d) – (F-D1). As one can see from these figures the model D1 differs from the averaged one more significantly. The main differences are concentrated in high latitude regions.

The estimation of accuracy of presented models could be carried out by comparison of the geomagnetic field change obtained from magnetic observatories with the corresponding values calculated with SV models either averaged one from candidate models A3, B3, C1, D1 or only D1. This comparison was fulfilled on time interval two or three years. The results of such comparison for Z components are presented in the Table 1. As one can see in the Table the modeled changes are more close to data from observatories for candidate model D1.

5. Comparison of candidate models of SV.

The first step. Maps of SV are presented in Fig.3 (a-f): (a)-E1; (b)-E2; (c)-(A3+B3+C1+D1)/4; (d)-D1; (e)-D2; (f)- D3.

As one can see from these figures the common patterns of SV for the end of XX century differ significantly from ones of the beginning of XXI century. The last maps have the similar structure of foci, located in the same regions, but different foci magnitudes. The averaged model of all candidates for the epoch 2007.5 have the largest magnitudes of two main foci in the East hemisphere, which exceed 110 nT per year. The total conclusion is resulted from the fact that a principle reorganization of foci system (strong jerk) took place at the border-line of two centuries. Estimating the reliability of candidates, this phenomenon should be consider as positive one because a probability of appearance of another such strong jerk in the next 5-year interval is negligible. Hence, even the linear extrapolation of SV for the first 5-year interval of XXI century to the next one permits enough accuracy forecast to be made.

The second step. The most appropriate method of comparing the similar candidate models seems to be the mapping of differences between each presented model and the model derived by averaging of all candidates. The maps of these differences are presented in Fig.4 (a-d): (a)- ($\overline{SV}$-A3); (b) – ($\overline{SV}$-B3); (c) – ($\overline{SV}$-C1); (d) – ($\overline{SV}$-D1). As one can see from these figures the model D1 differs from the averaged one more significantly. Having common feature D1 has considerably low magnitudes of SV foci in the East hemisphere.

The results of comparison of the models SV 2007.5 are presented in the Table 2 as mean square values of deviations of SV elements $\Delta X, \Delta Y, \Delta Z$ from the averaged models. The forth part of the table contains the mean square values of the deviations of these elements if comparing the particular models with averaged SV model for interval 1980.0-2000.0. It is characteristic that all models D differ less from the abovementioned model than the models A,B, and C.

Table1. The results of comparison of changes of the geomagnetic field from observatories with corresponding values obtained with models of SV ($\overline{SV}(A,B,C)$ and SV-D1) on time interval two or three years.

					model $\overline{SV}(A,B,C)$		model SV_D1	
Name of obs.	Code	Lat	Long	SV_Z_{obs}	SV_Z_{sint}	ΔZ_1	SV_Z_{sint}	ΔZ_2
Cape Chelyuskin	CCS	77.7	104.3	109.	144.4	35.4	170.6	61.6
Thule	THL	77.5	290.8	31.	57.9	26.9	65.2	34.2
Dixon	DIK	73.6	80.6	135.	136.0	1.0	155.8	20.8
Tixie Bay	TIK	71.6	129.0	55.	111.7	56.7	124.2	69.2

Godhavn	GDH	69.2	306.5	-20.	-9.9	10.1	-19.1	.9
Sodankyla	SOD	67.4	26.6	137.	146.5	9.5	155.6	18.6
Oulujarvi	OUJ	64.5	27.2	133.	141.6	8.6	149.9	16.9
Leirvogur	LRV	64.2	338.3	55.	69.4	14.4	64.6	9.6
Narsarsuaq	NAQ	61.2	314.6	-74.	-61.1	12.9	-67.0	7.0

Table 2.
The results of comparison of all models with the average of three models (A3, B3, C1) for epoch 2007,5.

Model	σ_X	σ_Y	σ_Z
SV-A3 (DSRI/NASA)	3.8	2.7	5.6
SV-B3 (NGDC/GFZ)	3.8	3.2	5.9
SV-C1 (BGS)	3.0	2.9	4.6
SV-D1 (IZMIRAN)	5.9	8.2	11.8
SV-D3 (IZMIRAN)	7.2	8.4	13.2
SV-D2 (IZMIRAN)	4.7	7.5	9.9

The results of comparison of all models with the average of four models (A3, B3, C1,D1) for epoch 2007,5.

Model	σ_X	σ_Y	σ_Z
SV-A3 (DSRI/NASA)	4.0	2.7	5.8
SV-B3 (NGDC/GFZ)	4.2	3.9	6.6
SV-C1 (BGS)	3.3	4.0	6.0
SV-D1 (IZMIRAN)	4.5	6.1	8.8
SV-D2 (IZMIRAN)	6.0	6.5	10.5
SV-D3 (IZMIRAN)	4.0	6.0	8.0

The results of comparison of all models with extrapolated observatory values for epoch 2007,5.

Model	σ_X	σ_Y	σ_Z
SV-A3 (DSRI/NASA)	10.5	11.8	19.2
SV-B3 (NGDC/GFZ)	9.3	10.9	16.4
SV-C1 (BGS)	10.9	13.2	20.5
SV-D1 (IZMIRAN)	6.1	7.0	9.7
SV-D2 (IZMIRAN)	4.5	6.2	6.2
SV-D3 (IZMIRAN)	7.1	7.4	12.7

The results of comparison of all models with SV model obtained from averaged for 1980.0-2000.0.

Model	σ_X	σ_Y	σ_Z
SV-A3 (DSRI/NASA)	22.0	20.4	37.9
SV-B3 (NGDC/GFZ)	22.5	21.8	39.3
SV-C1 (BGS)	22.0	21.6	39.2
SV-D1 (IZMIRAN)	17.4	15.3	29.7
SV-D2 (IZMIRAN)	16.9	16.3	29.3
SV-D3 (IZMIRAN)	21.7	20.3	37.3

6. Conclusion.

Results of the field and SV candidate models comparing show that all field models are very close.

Most significantly they deviate in high latitude region of the North hemisphere. Comparison with

data from observatories votes rather in favor of D1. Comparison between SV models shows the significant difference of D group from others. We have no arguments in favor of ABC or D groups.