PUSHKOV INSTITUTE OF TERRESTRIAL MAGNETISM, IONOSPHERE AND RADIO WAVE PROPAGATION (IZMIRAN)

Candidate Models for IGRF 2010 and IGRF SV 2012.5

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(Noted added by IGRF-11 Task force Chair C.Finlay 24/10/2009: DGRF-2005 candidate received late on 13/10/2009. Was decided to include in evaluation along with other resubmitted models. No additional description yet received from IZMIRAN.)

(Note added by IGRF-11 Task force Chair C.Finlay 8/10/2009: No coefficients for the IZMIRAN DGRF-2005 candidate were received and given the previously documented problems with the IZMIRAN IGRF-10 candidate (Maus, Macmillan, Lowes and Bondar, 2005) it was decided to proceed without a DGRF-2005 candidate from IZMIRAN)

The DGRF 2005 used are the same that we submitted for as candidate model for IGRF-10
For IGRF 2010 n=m=13.
For IGRF SV 2012.5 n=m=8

Data

CHAMP vector data of sampling rate 1 second for obtaining IGRF 2010 and DGRF 2005 where used. Time period of the used data is Jan 2004 before Apr 2009. The same CHAMP data and data of the 153 observatories during all period of their activity for IGRF SV 2012.5 where used.

The data selection and rejection – none

Weights, allocated to the data – none

Modelling method

The model of the main geomagnetic field has been constructed using the data of the high-precision measurements of the CHAMP satellite from January 2004 to April 2009.
The daily average spherical harmonious models calculated for the four-day interval, are used as source data to which the method of natural orthogonal components (NOCs) can be applied.
It has been indicated that the obtained NOC series rapidly converges. The secular variation, secular acceleration and *Dst* variation are distinguished as individual NOC components. This makes it possible to construct the main field model.
For the NOC analysis data were organized as a rectangular matrix constructed from spherical

harmonic coefficients of daily models (column)- day numbers (rows).
All days mean value of each coefficient was extracted from the corresponding line and the matrix obtained in this way was used for NOC analysis.
Thus mean values of coefficients give the main field model for middle day of the time interval.
NOC1 is varying close to a straight line on the whole time interval and can be interpreted as the linear secular change of the field. NOC2 - as secular acceleration. NOC3 corresponds to the series of daily mean Dst indices. NOC4 corresponds to the seasonal variation. Thus, obtained space-time model can be represented as $a+bt+f_1(t)+f_2(t)$, where two last terms depend on time parametrically and have wellknown physical origin. Both these terms can be omitted for the only main field model.
Taking into account the straight line character of the SV, NOC1 was taken for the IGRF 2010.0 candidate model developing. Presented here IGRF 2010 model of degree-order 13 was a result of extrapolation of series of daily models using our NOC1 as SV model and NOC2 – as secular acceleration. The spherical harmonic model of the main field is received up to degree/order 13.
We also derived a candidate model for secular variation, assuming that the straight line approximation of the field change 2004-2009 interval can be continued for 2010 – 2015 one. Besides, for obtain values of SV for the period with 2010 to 2015 the data of each component from each observatory was plotted, to continue a Taylor series up to third or higher degree. Were needed 3 (three) iterations.
This assumption seems to be enough good if a new jerk will not appear during next five years.
The spherical harmonic model of the IGRF SV 2012.5 is received up to degree/order 10.

Taking into account two steps of averaging in the space-time model developing, being both the averaging in the daily models and the NOC expansion on a few years time interval, which allows to extract the NOC's, describing Dst, seasonal variation and almost negligible uncorrelated NOC's of k>3, we have no need in any special extraction of data, any kinds of weighting, use scalar data in the high latitude regions and so on.

Candidate for main field 2010

				uncertainty	
n	m	gnm	hnm	gnm	hnm
1	0	-29497.56	0.00	0.	0.
1	1	-1584.54	4944.44	0.	0.

2	0	-2393.75	0.00	0.	0.
2	1	3025.80	-2709.07	0.	0.
2	2	1668.33	-574.71	0.	0.
3	0	1340.22	0.00	0.	0.
3	1	-2326.71	-160.37	0.	0.
3	2	1231.20	251.75	0.	0.
3	3	634.55	-536.95	0.	0.
4	0	911.88	0.00	0.	0.
4	1	808.92	286.80	0.	0.
4	2	166.68	-210.99	0.	0.
4	3	-357.15	164.60	0.	0.
4	4	90.73	-309.27	0.	0.
5	0	-230.62	0.00	0.	0.
5	1	357.41	44.41	0.	0.
5	2	200.21	189.22	0.	0.
5	3	-140.99	-118.24	0.	0.
5	4	-162.84	0.12	0.	0.
5	5	-7.33	100.99	0.	0.
6	0	73.35	0.00	0.	0.
6	1	68.58	-20.47	0.	0.
6	2	76.08	44.42	0.	0.
6	3	-141.30	61.43	0.	0.
6	4	-22.92	-66.77	0.	0.
6	5	13.24	2.78	0.	0.
6	6	-78.92	54.55	0.	0.
7	0	80.99	0.00	0.	0.
7	1	-74.95	-57.70	0.	0.
7	2	-4.83	-21.37	0.	0.
7	3	44.84	6.83	0.	0.
7	4	14.16	24.32	0.	0.
7	5	10.51	7.16	0.	0.
7	6	1.27	-27.70	0.	0.
7	7	4.85	-2.96	0.	0.
8	0	24.54	0.00	0.	0.
8	1	8.55	10.91	0.	0.
8	2	-14.25	-19.98	0.	0.
8	3	-5.66	12.12	0.	0.
8	4	-19.38	-17.64	0.	0.
8	5	11.63	16.80	0.	0.
8	6	11.07	7.14	0.	0.
8	7	-14.25	-10.73	0.	0.
8	8	-3.36	2.16	0.	0.
9	0	5.70	0.00	0.	0.
9	1	9.50	-20.65	0.	0.
9	2	3.46	11.42	0.	0.
9	3	-5.29	12.77	0.	0.
9	4	3.04	-7.07	0.	0.
9	5	-12.32	-7.61	0.	0.
9	6	-0.56	8.16	0.	0.
9	7	8.37	2.19	0.	0.
9	8	-8.12	-5.73	0.	0.
9	9	-10.15	6.62	0.	0.

10	0	-1.74	0.00	0.	0.
10	1	-5.92	2.65	0.	0.
10	2	1.05	-0.10	0.	0.
10	3	-1.34	4.44	0.	0.
10	4	-0.27	4.48	0.	0.
10	5	2.55	-7.18	0.	0.
10	6	-0.53	-0.99	0.	0.
10	7	2.19	-4.41	0.	0.
10	8	3.32	-1.92	0.	0.
10	9	-0.79	-1.87	0.	0.
10	10	-2.96	-7.95	0.	0.
11	0	3.83	0.00	0.	0.
11	1	-1.24	0.17	0.	0.
11	2	-2.26	1.42	0.	0.
11	3	1.38	-0.46	0.	0.
11	4	-0.44	-1.74	0.	0.
11	5	0.57	0.60	0.	0.
11	6	-0.93	-0.19	0.	0.
11	7	0.50	-2.61	0.	0.
11	8	1.73	-1.35	0.	0.
11	9	0.38	-2.34	0.	0.
11	10	0.84	-1.99	0.	0.
11	11	4.37	-1.65	0.	0.
12	0	-1.69	0.00	0.	0.
12	1	0.58	-0.79	0.	0.
12	2	0.41	0.00	0.	0.
12	3	0.41	2.30	0.	0.
12	4	-0.93	-2.49	0.	0.
12	5	1.12	0.47	0.	0.
12	6	0.01	0.74	0.	0.
12	7	0.40	0.18	0.	0.
12	8	-0.50	0.39	0.	0.
12	9	-0.11	0.09	0.	0.
12	10	0.41	-0.85	0.	0.
12	11	-0.82	-0.57	0.	0.
12	12	-0.68	0.47	0.	0.
13	0	0.65	0.00	0.	0.
13	1	-0.28	-0.71	0.	0.
13	2	-0.02	0.16	0.	0.
13	3	0.47	2.07	0.	0.
13	4	-0.46	-0.46	0.	0.
13	5	1.29	-1.36	0.	0.
13	6	-0.41	-0.03	0.	0.
13	7	0.67	0.64	0.	0.
13	8	0.03	0.10	0.	0.
13	9	0.38	0.34	0.	0.
13	10	-0.10	0.26	0.	0.
13	11	0.22	-0.32	0.	0.
13	12	-0.50	-0.41	0.	0.
13	13	-0.13	-0.74	0.	0.

Candidate for SV 2012.5

1	0	11.67	0.00	0.	0.
1	1	16.85	-28.03	0.	0.
2	0	-11.57	0.00	0.	0.
2	1	-4.44	-22.61	0.	0.
2	2	2.73	-12.84	0.	0.
3	0	1.27	0.00	0.	0.
3	1	-3.66	8.35	0.	0.
3	2	-3.08	-3.03	0.	0.
3	3	-7.23	-1.81	0.	0.
4	0	-1.51	0.00	0.	0.
4	1	1.95	0.29	0.	0.
4	2	-9.03	2.88	0.	0.
4	3	4.25	3.76	0.	0.
4	4	-1.81	-0.63	0.	0.
5	0	-0.49	0.00	0.	0.
5	1	0.73	0.44	0.	0.
5	2	-1.56	1.51	0.	0.
5	3	-0.73	0.88	0.	0.
5	4	1.12	3.76	0.	0.
5	5	1.61	-0.59	0.	0.
6	0	-0.34	0.00	0.	0.
6	1	-0.44	0.05	0.	0.
6	2	-0.24	-2.20	0.	0.
6	3	2.05	-0.39	0.	0.
6	4	-1.66	-0.54	0.	0.
6	5	-0.15	0.68	0.	0.
6	6	1.86	0.44	0.	0.
7	0	0.29	0.00	0.	0.
7	1	0.10	0.59	0.	0.
7	2	-0.59	0.29	0.	0.
7	3	1.37	0.00	0.	0.
7	4	0.29	-0.15	0.	0.
7	5	0.10	-0.78	0.	0.
7	6	-0.83	-0.34	0.	0.
7	7	0.49	0.24	0.	0.
8	0	-0.15	0.00	0.	0.
8	1	0.00	0.05	0.	0.
8	2	-0.54	0.20	0.	0.
8	3	0.29	0.49	0.	0.
8	4	-0.29	0.54	0.	0.
8	5	0.24	0.15	0.	0.
8	6	0.24	0.00	0.	0.
8	7	-0.59	0.39	0.	0.
8	8	0.15	0.44	0.	0.