

# An evaluation of candidate geomagnetic field models for IGRF 2000

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A global evaluation is made of the four candidate models for IGRF 2000 (main field and secular variation) that were submitted to the IAGA Working Group V-8 by the deadline in February 1999. A description of the data used and the method of modelling is summarised for each candidate model. The models are then compared with one another and with recent data from observatories and magnetic surveys. It is concluded that none of the candidate main-field models is sufficiently good for an IGRF and that a new model should be derived using Ørsted data.

## 1. Introduction

For IGRF 2000, four models, each comprising a main-field model for 2000.0 and a predictive secular-variation model for 2000.0–2005.0, were submitted for evaluation to IAGA Working Group (WG) V-8. The models were submitted by Institut de Physique du Globe de Paris (IPGP model), British Geological Survey/US Geological Survey (UKUS model), IZMIRAN (IZM model) and by the chairman of WG V-8 (IGRF7). Based on notes submitted to WG V-8 with the models, a brief description of the data used and the method of modelling for each of the candidate models is given; more details can be found in other papers in this issue. The models are then compared with one another and with recent data from observatories and magnetic surveys.

## 2. Data Used and Modelling Method for the Candidate Main-Field Models

**IPGP** Observatory, repeat station and marine data were used; there were no satellite or Project MAGNET data. A weighting scheme was used based on geographical distribution and data type. No synthetic data were used so the model is almost independent of previous models.

**UKUS** POGS satellite, Project MAGNET, observatory and repeat station data were all used, though indirectly by updating an earlier model to epoch 2000.0 with new secular-variation models. No marine data were used. A weighting scheme based on latitude and data type was used.

**IZM** Observatory data and synthetic data on a 20° latitude/longitude grid from a previous IZMIRAN model were used. Limited information was submitted with the model.

**IGRF7** This is the 1995.0 model updated to 2000.0 using 7th generation IGRF secular-variation model (IAGA Division V, Working Group 8, 1995).

## 3. Data Used and Modelling Method for the Candidate Secular-Variation Models

**IPGP** Only observatory data were used. Predictions to 2000.0 were based on monthly means but those beyond 2000.0 were based on annual sets of spherical harmonic coefficients rather than on data from individual observatories.

**UKUS** Predictions were based on secular-variation data from individual observatories and repeat stations. Synthetic data from a secular-variation model which included POGS (2.7 year duration) and Project MAGNET data were also used.

**IZM** A natural orthogonal components analysis based on annual means and predictions from 28 observatories was used.

**IGRF7** Secular variation is effectively assumed to be constant for the 10-year period 1995.0–2005.0.

## 4. Inter-Model Comparisons

The models were first compared with each other using the same method as in Macmillan and Barraclough (1997). Global RMS differences were computed (Tables 1 and 2) and plots of differences in  $X$ ,  $Y$ ,  $Z$  and  $F$  were made. It should be noted that the global RMS differences for the  $X$  and  $Y$  components assume orthogonality of these components over the sphere. According to De Santis *et al.* (1995) this is not the case but the values computed here are still useful for comparative purposes. Some very large differences (>1000 nT) occur, predominantly in areas where there are no data or only POGS satellite scalar data. Even in areas where there are data there are still some large differences (>200 nT). The global RMS differences between main-field models are at least twice those reported for candidate IGRF models for 1995.0 (Macmillan and Barraclough, 1997).

## 5. Comparisons of Models with Data

The candidate models were compared with observatory annual means, repeat station and other land magnetic survey data (reduced to quiet levels) and marine scalar data (110 km

Table 1. RMS differences between candidate IGRF main-field models for 2000.0.

	$X$ (nT)	$Y$ (nT)	$Z$ (nT)	$F$ (nT)
IGRF7/UKUS	67	65	106	141
UKUS/IZM	136	129	206	278
IZM/IGRF7	134	132	207	280
UKUS/IPGP	172	175	270	365
IPGP/IGRF7	175	190	285	384
IPGP/IZM	230	220	348	471

Table 2. RMS differences between candidate IGRF secular-variation models for 2000.0–2005.0.

	$X$ (nT/yr)	$Y$ (nT/yr)	$Z$ (nT/yr)	$F$ (nT/yr)
IGRF7/UKUS	9	8	14	18
UKUS/IZM	8	10	15	20
UKUS/IPGP	10	11	17	23
IZM/IGRF7	10	13	19	25
IPGP/IZM	11	13	19	25
IPGP/IGRF7	14	15	24	32

Table 3. RMS deviations of models from observatory annual means in  $X$ ,  $Y$  and  $Z$  (nT).

Year	Number	IPGP	UKUS	IZM	IGRF7
1995	473	254	239	254	215
1996	419	250	238	257	210
1997	389	258	240	269	213
1998	154	267	234	294	231
All	1435	255	238	263	215

Table 4. RMS deviations of models from repeat station and other land magnetic survey data in  $X$ ,  $Y$ ,  $Z$  and, where any of these are missing,  $F$  (nT).

Year	Number	IPGP	UKUS	IZM	IGRF7
1995	1432	228	196	238	190
1996	438	281	270	282	216
1997	272	261	260	281	195
1998	285	327	313	335	231
All	2427	253	230	262	200

Table 5. RMS deviations of models from marine  $F$  data (110 km along-track averages of quiet data) (nT).

Year	Number	IPGP	UKUS	IZM	IGRF7
1995	142	262	258	619	217

along-track averages of quiet data), all for 1995 and onwards. The results are presented in Tables 3, 4 and 5. Some of these data have not been used in any of the candidate models so constitute a partially independent dataset.

Model values were derived from a linear interpolation in time between the 7th generation IGRF at 1995.0 and the candidate model for 2000.0. The RMS deviations are about 30% larger than the equivalent deviations computed when

considering the candidate models for the 7th generation IGRF (Macmillan and Barraclough, 1997).

## 6. Conclusions

None of the candidate models are particularly good. The differences between models and differences between models and data are all much greater than those calculated for the 7th generation IGRF candidate model evaluation. The UKUS and the IGRF7 models are most alike, for both the main-field and the secular-variation parts. In addition, these two models fit the data marginally better than the other candidate models. It is recommended that a main-field model for 2000.0 be computed using Ørsted data and that this is considered for IGRF 2000.

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## References

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