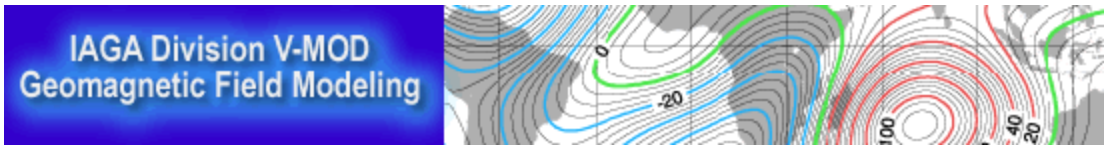

International Geomagnetic Reference Field

Key words: IGRF, geomagnetic reference field, geomagnetic field model, secular variation

IGRF-10 coefficients (MS Excel, text file), New! Geomag 6.1 C software and model (Windows zip exe , Linux tar file), Model in Fortran Software

The International Association of Geomagnetism and Aeronomy (IAGA) released the 10 th Generation International Geomagnetic Reference Field — the latest version of a standard mathematical description of the Earth's main magnetic field and used widely in studies of the Earth's deep interior, its crust and its ionosphere and magnetosphere. The coefficients for this degree and order 13 main field model were finalized by a task force of IAGA in December 2004. The IGRF is the product of a collaborative effort between magnetic field modellers and the institutes involved in collecting and disseminating magnetic field data from satellites and from observatories and surveys around the world.

The IGRF is a series of mathematical models of the Earth's main field and its annual rate of change (secular variation). In source-free regions at the Earth's surface and above, the main field, with sources internal to the Earth, is the negative gradient of a scalar potential *V* which can be represented by a truncated series expansion:

$$V(r,\theta,\lambda,t) = R\sum_{n=1}^{n_{max}}\left(\frac{R}{r}\right)^{n+1}\sum_{m=0}^{n}(g_n^m(t)\cos m\lambda + h_n^m(t)\sin m\lambda)P_n^m(\theta)$$

where *r, θ, λ* are geocentric coordinates (*r* is the distance from the centre of the Earth, *θ* is the colatitude, i.e. 90° - latitude, and *λ* is the longitude), *R* is a reference radius (6371.2 km); $g_n^m(t)$ and $h_n^m(t)$ are the coefficients at time *t* and $P_n^m(\theta)$ are the Schmidt semi-normalised associated Legendre functions of degree *n* and order *m*. The main field coefficients are functions of time and for the IGRF the change is assumed to be linear over five-year intervals. For the upcoming five-year epoch, the rate of change is given by predictive secular variation coefficients. For more details on main-field modelling, see Chapman and Bartels (1940) and Langel (1987).

It is now recommended that the World Geodetic System 1984 datum and spheroid be used for coordinate transformations rather than the International Astronomical Union 1966 spheroid previously recommended. Differences in output IGRF magnetic field values at the Earth's surface are less than 1 nT when the change of spheroid is made. The parameters of the WGS84 are *a*=6378.137 km, *b*=6356.752 km whereas the old IAU66 are *a*=6378.160 km, *b*=6356.775 km.

The satellite magnetic missions of the International Decade of Geopotential Research are providing an unprecedented wealth of highly accurate magnetic field measurements. In order to

ensure that the accuracy of the IGRF reflects the high quality of available data, IAGA decided in 2001 that the main-field coefficients of the IGRF from the year 2000 onwards should extend to degree n_{max}=13 and be quoted to 0.1 nT precision. Pre-2000 coefficients extend to degree 10 or 8 and are quoted to 1 nT precision. The predictive secular variation coefficients for the upcoming five-year epoch are given to degree 8 with a precision of 0.1 nT/year. The coefficients of the 10 th Generation IGRF are listed in MS Excel format and also as a text file. The latest International Geomagnetic Reference Field Model is also available for download (Windows zip exe or Linux tar file, containing the C software, model and readme file) or for online access from the British Geological Survey (www.geomag.bgs.ac.uk/gifs/igrf_form.shtml). The previous generation IGRF models are no longer distributed, but are available by request from the archive.

Summary of nomenclature and IGRF history

Full name	Short name	Valid for	Definitive for
IGRF 10 th generation (revised 2005)	IGRF-10	1900.0-2010.0	1945.0-2000.0
IGRF 9th generation (revised 2003)	IGRF-9	1900.0-2005.0	1945.0-2000.0
IGRF 8th generation (revised 1999)	IGRF-8	1900.0-2005.0	1945.0-1990.0
IGRF 7th generation (revised 1995)	IGRF-7	1900.0-2000.0	1945.0-1990.0
IGRF 6th generation (revised 1991)	IGRF-6	1945.0-1995.0	1945.0-1985.0
IGRF 5th generation (revised 1987)	IGRF-5	1945.0-1990.0	1945.0-1980.0
IGRF 4th generation (revised 1985)	IGRF-4	1945.0-1990.0	1965.0-1980.0
IGRF 3rd generation (revised 1981)	IGRF-3	1965.0-1985.0	1965.0-1975.0
IGRF 2nd generation (revised 1975)	IGRF-2	1955.0-1980.0	-
IGRF 1st generation (revised 1969)	IGRF-1	1955.0-1975.0	-

It is recommended not to use the term IGRF without reference to the generation, as then it is difficult to establish which coefficients were actually used. For example, one cannot recover the original full-field data from an aeromagnetic anomaly dataset in order to tie it with adjacent surveys if one does not know which generation of the IGRF was used. It is also recommended that the full name be used, so that it is more apparent whether the output values are "predictive" and are

therefore less accurate.

The 10 th Generation IGRF coefficients were computed from candidate sets of coefficients produced by the participating members of IAGA Working Group V-MOD. Their institutes and the many organisations involved in operating magnetic survey satellites, observatories, magnetic survey programmes and World Data Centers are to be thanked for their continuing support of the IGRF project.

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URL: http://www.ngdc.noaa.gov/IAGA/vmod/igrf.html
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