IGRF – INTERNATIONAL GEOMAGNETIC REFERENCE FIELD

History of the IGRF

The IGRF is an internationally agreed global spherical harmonic model of the Earth's magnetic field of which the sources are in the Earth's core (see *spherical harmonics* and *main field modelling*). It is revised every five years under the auspices of the International Association of Geomagnetism and Aeronomy (see *IAGA*).

The concept of an IGRF grew out of discussions concerning the presentation of the results of the World Magnetic Survey (WMS). The WMS was a deferred element in the programme of the International Geophysical Year which, during 1957-1969, encouraged magnetic surveys on land, at sea, in the air and from satellites and organised the collection and analysis of the results. At a meeting in 1960, the Committee on World Magnetic Survey and Magnetic Charts of IAGA recommended that, as part of the WMS programme, a spherical harmonic analysis be made using the results of the WMS, and this proposal was accepted. Another eight years of argument and discussion followed this decision and a summary of this, together with a detailed description of the WMS programme, is given by Zmuda (1971). The first IGRF was ratified by IAGA in 1969.

The original idea of an IGRF had come from global modellers, including those who produced such models in association with the production of navigational charts. However, the IGRF as it was first formulated was not considered to be accurate or detailed enough for navigational purposes.

The majority of potential users of the IGRF at this time consisted of geophysicists interested in the geological interpretation of regional magnetic surveys. An initial stage in such work is the removal of a background field from the observations that approximates the field whose sources are in the Earth's core. With different background fields being used for different surveys, difficulties arose when adjacent surveys had to be combined. An internationally agreed global model, accurately representing the field from the core, eased this problem considerably.

Another group of researchers who were becoming increasingly interested in descriptions of the geomagnetic field at this time were those studying the ionosphere and magnetosphere and behaviour of cosmic rays in the vicinity of the Earth. This remains an important user community today.

Development of the IGRF

The IGRF has been revised and updated many times since 1969 and a summary of the revision history is given in Table 1 (see also Barton, 1997, and references therein).

Table 1 Summary of IGRF history

Full name	Short name	Valid for	Definitive for
IGRF 10th generation (revised 2004)	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	-

Each generation of the IGRF comprises several constituent models at five-year intervals which are designated definitive or non-definitive. Once a constituent model is designated definitive it is called a Definitive Geomagnetic Reference Field (DGRF) and it is not revised in subsequent generations of the IGRF.

New constitutent models are carefully produced and widely documented. The IAGA Working Group charged with the production of the IGRF invites submissions of candidate models several months in advance of decision dates. Detailed evaluations are then made of all submitted models, and the final decision is usually made at an IAGA Assembly if it occurs in the appropriate year, otherwise by the IAGA Working Group. The evaluations are also widely documented. The coefficients of the new constituent models are derived by taking means (sometimes weighted) of the coefficients of selected candidate models. This method of combining several candidate models has been used in almost all generations as, not only are different selections of available data made by the teams submitting models, there are many different methods for dealing with the fields which are not modelled by the IGRF, for example the ionospheric and magnetospheric fields and crustal fields. The constituent main-field models of the most recent generation of the IGRF (IAGA, 2005) extend to spherical harmonic degree 10 up to and including epoch 1995.0, thereafter they extend to degree 13 to take advantage of the excellent coverage and quality of satellite data provided by Ørsted and CHAMP (see *Ørsted* and *CHAMP*). The predictive secular-variation model extends to degree 8.

Future of the IGRF

Firstly, no model of the geomagnetic field can be better than the data on which it is based. An assured supply of high-quality data distributed evenly over the Earth's surface is therefore a fundamental prerequisite for a continuing and acceptably accurate IGRF. Data from magnetic observatories (see *observatories, an overview*) continue to be the most important source of information about time-varying fields. However their spatial distribution is poor and although data from other sources such as repeat stations (see *repeat stations)*, Project MAGNET (see *Project MAGNET*) and marine magnetic surveys (see *marine magnetic surveys*) have all helped to fill in the gaps, the best spatial coverage is provided by near-polar satellites. Measurements made by the POGO satellites (1965-1971) (see *POGO*), Magsat (1979-1980), POGS (1990-1993), Ørsted (1999-) and CHAMP (2000-) have all been utilised in the production of the IGRF.

Secondly, the future of the IGRF depends on the continuing ability of the groups who have contributed candidate models to the IGRF revision process to produce global geomagnetic field models. This ability is dependent on the willingness of the relevant funding authorities to continue to support this type of work.

Thirdly, the continued interest of IAGA is a necessary requirement for the future of the IGRF. This is assured as long as there is, as at present, a large and diverse group of IGRF-users world wide. One reason why the IGRF has gained the reputation it has is because it is endorsed and recommended by IAGA, the recognised international organisation for geomagnetism.

A topic still under discussion is how best to extend the IGRF backwards in time. The current generation includes non-definitive models at five-year intervals covering the interval 1900.0 to 1940.0, and, more importantly, some of the earlier DGRFs are of questionable quality. Constructing an internationally acceptable model that describes the time variation better than the IGRF using splines is one way forward (see *time-dependent models of the main magnetic field*).

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Bibliography

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