Sapporo - 2003 Minutes

Summary of Div. V WG 8 meeting Monday 7 July.

The meeting started at 7.25 pm, following the WG 9 meeting (Anomalies). Chair - Mioara Mandea, co-chair - Susan Macmillan (minutes).

1. Achievements since IAGA 2001 (Hanoi)

Meetings: European Repeat Station Workshop, Niemegk, Feb 2003 (organised by Monika Korte and Mioara Mandea), joint work and involvement with other bodies (SEDI, COSPAR), and other individual contributions to SEDI (California, July 2002), Ørsted International Science Team Meeting (Copenhagen, Sept 2002), First CHAMP Science Meeting (GFZ, Jan 2002).

Publications: Physics of the Earth and Planetary Interiors (Elsevier) -Ø special issue on Magnetic Field Modelling based on contributions to the IAGA session at IAGA/IASPEI 2001 (Hanoi) – "Main Magnetic Field and Secular Variations at Earth's Surface and Core–Mantle Boundary". Editors were Richard Holme and Mioara Mandea and there were five published papers.

2. Data collection

The meeting thanked the Ørsted team, the CHAMP team and the organisations around the world involved in operating geomagnetic observatories, repeat station networks and other magnetic surveys, for disseminating their data to the wider scientific community. Without these data global models of the Earth's magnetic field could not be determined.

3. Determination of 9th generation IGRF

It was agreed at IAGA 2001 to revise the IGRF series of models at IUGG2003, with DGRF1995 (max degree 10, 1 nT/year numerical precision) and DGRF2000 (max degree 13, 0.1 nT/year numerical precision) main-field coefficients and secular-variation coefficients for 2000.0-2005. 0 (max degree 8, 0.1 nT/year numerical precision). Candidate sets of coefficients were called for in autumn 2002, reminders sent out early 2003 and deadline for submission mid-March 2003. Some doubts were expressed in the run-up to and at this meeting about the Hanoi decision to have an IGRF revision in 2003. Three options were presented.

1. Determine DGRF1995 and DGRF2000 coefficients, but do not publish them until we publish IGRF2005 and the predictive SV for 2005.0-2010.0 (presumably in Nov/Dec 2004).
2. Determine and publish DGRF1995 and DGRF2000 coefficients but retain existing SV coefficients for 2000.0-2005.0.

3. Determine and publish DGRF1995, DGRF2000 and SV 2000.0-2005.0 coefficients.

The main points of the discussion are summarised below.

Arguments for options 3	**Arguments against option 3**
There are accuracy concerns with the 8th generation IGRF, when compared with other models	Users may be confused by IGRF revision occurring more frequently than once every 5 years (on average)
The IGRF should take advantage of the new satellite (and ground-based) data available since the 8th generation IGRF was produced	Users would not want to update their software more frequently than once every 5 years (on average)
If accuracy is not of concern to the user he can choose to continue to use the 8th generation IGRF as it is valid for the same period as the 9th generation IGRF	Shift in terminology would be required
Considerable effort had already been expended in producing the candidate models	
The differences between the candidate DGRF2000 models were typically one third of the differences when comparing individual candidate models to IGRF2000	

Considerable use of the IGRF is thought to be in its predictive mode i.e. for the 8th generation IGRF this is with input dates in 2000 and onwards. The predictive part of the IGRF should therefore be as accurate as possible.

The options were put to a vote and option 3 won.

IGRF Names

For the users, it was proposed to move away from the terms DGRF****, IGRF**** and PGRF**** (provisional) given the unusual circumstances with this revision of the IGRF which have come about because of the unprecedented amount of high-quality satellite data now available. It was generally agreed that these terms have led to much confusion in the past (DGRF**** refers to input main-field coefficients *and* output values, IGRF**** refers to input main-field *and* secular-variation coefficients *as well as* output values, PGRF**** *only* refers to output values when computed between a DGRF**** and an IGRF**** main-field model). If the term PGRF were retained for the 9th generation IGRF it would now refer to something different than what it did in previous revisions – namely the period when the output values are based on the most recent main-field coefficients and the predictive secular–variation coefficients, rather than the period when an interpolation is done between a DGRF**** and an IGRF****. It was agreed this proposed shift in terminology was a good idea, regardless of options above, and in any case it was already in use in some places. The terminology that is recommended is as follows.

Full name	Short name	Valid for	Definitive for
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 on its own, as then it is difficult to establish which reference field model was 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 also recommended that, if space permits, the full name be used, so that it can be seen whether the output values are "predictive" and are therefore less accurate.

From the table one can see for which time interval each model is definitive. Thus if one computes values from the 7th generation IGRF (revised 1995) for 31 Dec 1989, they will be the same as those computed from the 9th generation IGRF (revised 2003). However if one computes values for 31 Dec 1990 from IGRF–7 they will differ from those from IGRF–9 for the same date.

For the producers of IGRF candidate coefficients the terms DGRF**** and IGRF**** can still be used.

New coefficients

The following models were evaluated.

Model-Abbreviation	Authors (countries)
DGRF1995-BGS	Thomson & Macmillan (UK)
DGRF1995-CM	Olsen, Lowes, Sabaka (Denmark, UK, USA)
DGRF1995-GFZ	Maus, L&#65533;hr, Rother, Mai, Mandea (Germany, France)
DGRF1995-GFZ2	Wardinski & Holme (Germany, UK)
DGRF1995-IPGP	Chambodut, Langlais, Mandea (France, USA)
DGRF1995-IZM	Bondar & Golovkov (Russia)
DGRF2000-BGS	Lesur, Thomson & Macmillan (UK)
DGRF2000-CM	Olsen, Lowes, Sabaka (Denmark, UK, USA)
DGRF2000-OSVM	Olsen, Lowes, Sabaka (Denmark, UK, USA)

DGRF2000-GFZ	Maus, L&#65533;hr, Rother, Mai, Mandea (Germany, France)
DGRF2000-IPGP	Chambodut, Langlais, Mandea (France, USA)
SV-BGS	Lesur, Thomson & Macmillan (UK)
SV-CM	Olsen, Lowes, Sabaka (Denmark, UK, USA)
SV–OSVM	Olsen, Lowes, Sabaka (Denmark, UK, USA)
SV–GFZ	Maus, L&#65533;hr, Rother, Mai, Mandea (Germany, France)
SV–IPGP	Chambodut, Langlais, Mandea (France, USA)
SV–IZM	Bondar & Golovkov (Russia)
SV–IZM2	Bondar & Golovkov (Russia)

Evaluations of the models were presented by Frank Lowes, Susan Macmillan and Stefan Maus (SV only). For each model mean root mean square values of differences in F with all other models (for particular epoch) at Earth's spherical surface were computed. Range of these values for DGRF1995 was 45–63 nT, for DGRF2000 8–10 nT and SV 7–14 nT/year. Discussions and votes were taken whether to take straight means, weighted means of candidate models and whether to discard particular models. It was decided for DGRF1995 and DGRF2000 to take a straight mean of coefficients and for SV, to discard IZM, ask Olsen, Lowes, Sabaka to resubmit their

coefficients using the correct date and, providing these revised CM coefficients were satisfactory, take a straight mean of the 6 sets of coefficients.

4. 10th generation IGRF — task force

As the next generation of the IGRF would be required by December 2004, before the next meeting of IAGA, a Task Force was established to determine the 10^{th} generation IGRF. Members are Stefan Maus (who subsequently agreed to be leader), Susan Macmillan, Frank Lowes, Benoit Langlais, Terry Sabaka, Nils Olsen, Susan McLean

5. Change of spheroid from IAU66 to WGS84

The International Astronomical Union 1966 spheroid has been recommended for coordinate transformations when using the IGRF till now. The parameters of IAU66 are a=6378.160 km, b=6356.775 km, r=6371.024 km ($\sqrt[3]{(a^2b)}$) – not 6371.2 km which is commonly assumed! However the World Geodetic System 1984 datum and spheroid are more widely recognised as a standard (a=6378.137 km, b=6356.752 km, r=6371.001 km). Present-day satellite magnetic data are mostly positioned in WGS84 but for other data we are blissfully unaware which datum is used. Differences in output IGRF magnetic field values at the Earth's surface are less than 1 nT when the change of spheroid is made. It is recognised that software already in circulation uses WGS84. It is therefore recommended that the WGS84 spheroid is used for coordinate transformations for the IGRF. However, because the models were derived using the *reference* radius of 6371.2 km this must be kept in the forward code used to compute values from the models.

6. IAGA guides – on main-field modelling

Consideration was given as to whether an IAGA guide on main-field modelling, similar to those for observatories and repeat station surveys, would be useful. However the general consensus was that a guide was not necessary at the moment as the community was small, everyone already knew what other teams were doing, techniques for selecting data and removing the rapidly varying external fields were highly dependent on datasets available, and there were already existing publications which give the latest information about the various modelling techniques (eg special issues of journals).

7. Symposia for Toulouse and IAGA Resolutions

Preliminary suggestions for symposia titles, convenors, and resolutions were made and passed onto the Division V chair for further discussion at the Business Meeting.

8. New Div. V WG structure and officers

The proposed restructuring of the Working Groups in Div. V was discussed. The meeting was generally in agreement that the restructuring should go ahead, with appropriate Task Forces set up to address particular issues, though concerns were raised as to which Working Group the Task Force "World Magnetic Anomaly Map" (Korhonen, Reeves, Ravat, Maus) should report. It was subsequently decided that the Modelling Working Group was the natural "home" for this Task Force, given the current status of this project. Similarly, the Task Force "External Field Variations" (Thomson, Stauning) would report to the Modelling Working Group.

It was agreed that the new chair would be Susan Macmillan (UK) and the co-chair would Stefan Maus (Germany). The meeting finished at 9.25 pm.