DGRF Candidate model

Dataset

We start from the dataset provided to us by Stefan Maus. The following describe the data selection and corrections applied.

Corrections

- Estimated angular corrections for the misalignment of the magnetometer reference system to the spacecraft reference system for the CHAMP satellite and corrected the vector data accordingly.

- Subtracted the magnetic signal of motional induction in the oceans due to the 8 major tidal constituents up to spherical harmonic degree 45, as predicted by Kuvshinov and Olsen (CHAMP Mission Results, 2004).

- We did not use the data corrected for the so-called "diamagnetic effect ".

- Data were apparently corrected for a crustal field model, probably MF6. This has to be checked with Stefan. However, further tests suggested that crustal field correction do not influence the modelling when considering short time spans. This has no impact on IGRF like model for low SV degree (lower than 13).

Data selection

Data were sub-sampled to 20 seconds, corresponding to about 160 km along-track spacing. Separate data sets were compiled for low latitudes (-60 to 60 magnetic latitude) and polar regions (> 50 and <-50 degrees). Vector data were only used at low latitudes. Data at high latitudes were selected for 22:00-5:00 local time for CHAMP. Data in the polar regions were used for all local times. No exclusion for solar zenith angle was made.

CHAMP-specific:
- Dual-head star camera mode
- PLP density and temperature measurements available

Maximum Dst: ± 30 nT

Polar regions specific:
Max Dst derivative: 5nT/h
Max IMF-By: ± 8 nT
Min IMF-Bz: -2 nT
Max IMF-Bz: 6 nT
Max merging electric field at the magnetopause: 0.8 mV/m
Max Am: 27
Max Am 3 hours before: 27

Low latitude specific:
Max Dst derivative: 2nT/h
Max Am: 12
Max Am 3 hours before: 15

- Oersted data were not used.

This original dataset was further decimated in order to have the almost equal balance for data prior and posterior to the centre epoch. The optimum time interval was thoroughly studies using the best trade-off between the concept of "snapshot" and the condition number of the invert matrix (given a fixed model parameterization). We found that an interval of +/- ~240 days around 2005.0 would be the optimum situation. The considered dataset contains: 13867 vector data with average epoch at 2004.9622 between 2004.48 and 2005.6622. 31789 scalar data with average epoch: 2004.9741 between 2004.3546 and 2005.6622.

Modelling

Parameterization

We use a spherical harmonic modelling to SH degree 16 for the main field including SV up to SH degree 10 and a secular acceleration to SH degree 5 using a Taylor expansion of the Gauss coefficient:

$$g=g_0+(t-t_0)\delta g+0.5(t-t_0)^2\delta\delta g.$$

With t0=2005.0.
According to synthetic test, this parameterization with the considered time interval does not require regularization. One may actually question the usefulness of secular acceleration for such a small time interval. It does not hamper the correct modelling anyway.

A SH degree 2 static external field was co-estimated. The external field was further parameterized with Ist and Est indices for SH degree 1. The considered indices were downloaded here:
ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/EST_IST/

We used the file: `Est_Ist_index.pli`

We realized, as an aside, that authors could occasionally use different version of Ist/Dst (see Readme.txt online). Our tests did not show any significant variation in the internal field Gauss coefficients when considering different conventions and quiet times. However, this may slightly changes the two digits of external field coefficients.

Inverse problem

The data were weighted according to geographic coverage (equal-area) + an extra weight was applied in the overlapping region between mid-latitude and high-latitude. These latter weights were provided in the original dataset.

The inverse problem involving scalar data requires some kind of linearization. We started from POMME-5 model and iterated four times until convergence was reached. We did not reject data at the end. The final statistics are RMS F: 5.8 nT, B (vector): 4.2 nT; all data : 4.9 nT

Gauss coefficients are attached:
DGRF_2005_candidate.cof

Note: We recognize the need for Gauss coefficients statistics. However, we could only derive a formal error from the covariance matrix. We do not find this information useful, as we do not consider this formal error as realistic (different data selection lead to different “robust” model with error too small to overlap with each other).

IGRF model

Exactly the same strategy was employed to derive the IGRF candidate model. The original data was further decimated to obtain equal number of data before and after epoch 2009.0.

MEAN EPOCH OF SCALAR DATA: 2008.9902
------------ MEAN EPOCH OF VECTOR DATA: 2008.9902
Number of scalar data: 30013 average epoch: 2008.9902 between: 2008.3462 and 2009.6112
MEAN EPOCH OF VECTOR DATA: 2009.0208
------------ MEAN EPOCH OF VECTOR DATA: 2009.0208
Number of vector data: 15102 average epoch: 2009.0208 between: 2008.3583 and 2009.6112

Note that the time window was fixed according to **an important extra criterium. When analyzing non-definitive BCMT data, Chulliat et al. (in preparation) suspected a jerk occurring between epoch 2007.5 and 2008.2 (depending on the observatories).** Our selected time window tried to avoid this possible jerk and its detrimental effect on the estimation of the secular variation.

The same initial POMME-5 core field model was used to linearise the inverse problem for the first iteration. We reached convergence before the fourth iteration. We did not reject outliers at the final iteration (no significant outliers). The final statistics are RMS F: 5.14 nT, B (vector): 4.2 nT; all data : 4.6 nT.

We tested the stability of the SV model to SH 10 using different data-selection and an independent datasets: ORESTED and provisional BCMT observatory data. The SV model proved to be stable enough to extrapolate the model from epoch 2009 to 2010.

Gauss coefficients are attached:
IGRF_2010_candidate.cof

Because we suspect a jerk around 2007.5, the SV obtained with data from 2008.2 is also our candidate for the time interval 2010-2015. Considering larger time interval led to rather low estimate of G10, for instance.

Gauss coefficients are attached:
SV_2010-15_Candidate.cof

IPGP/EOST team.