2nd Evaluation of candidates for IGRF-10 and SV-2005-2010

(Stefan Maus, NGDC, 26-Nov-04)

This evaluation follows up on Frank Lowes' assertion that the model IGRF-D1 is not just somewhat noisier but contains systematic errors which are concentrated at low orders. Indeed, this assertion is confirmed here. Repeating the analysis for the SV candidates, I find that the model SV-B3 is also erroneous.

Methodology

The Mauersberger/Lowes spectrum of the main field is known to be almost constant at the core/mantle boundary, meaning that there is comparable power in each degree. Only the first degree has significantly larger power, even at the CMB, and is therefore excluded from this analysis.

Two types of power distributions at the CMB are displayed: The usual distribution of power versus degree, and the distribution of power versus the *azimuth*, defined as m/n.

Since SV spectra are less steep and slope upward when downward continued to the CMB, the SV spectra are further divided by n^2 for the sole reason of having comparable expected power levels in all degrees.

Power spectra of the main field in 2005

Figure 1 shows the Mauersberger/Lowes spectra at the CMB. Differences are too small to detect meaningful differences. However, the situation is quite different for the azimuthal power distribution (Fig. 2). As proposed by Frank Lowes, the near-zonal (m/n close to 0) coefficients of the D1 model have powers which are definitely erratic. In particular, the azimuthal power distribution in all other models is very similar to the one of the field in 2000, while D1 implies a change in the field that is entirely unrealistic.

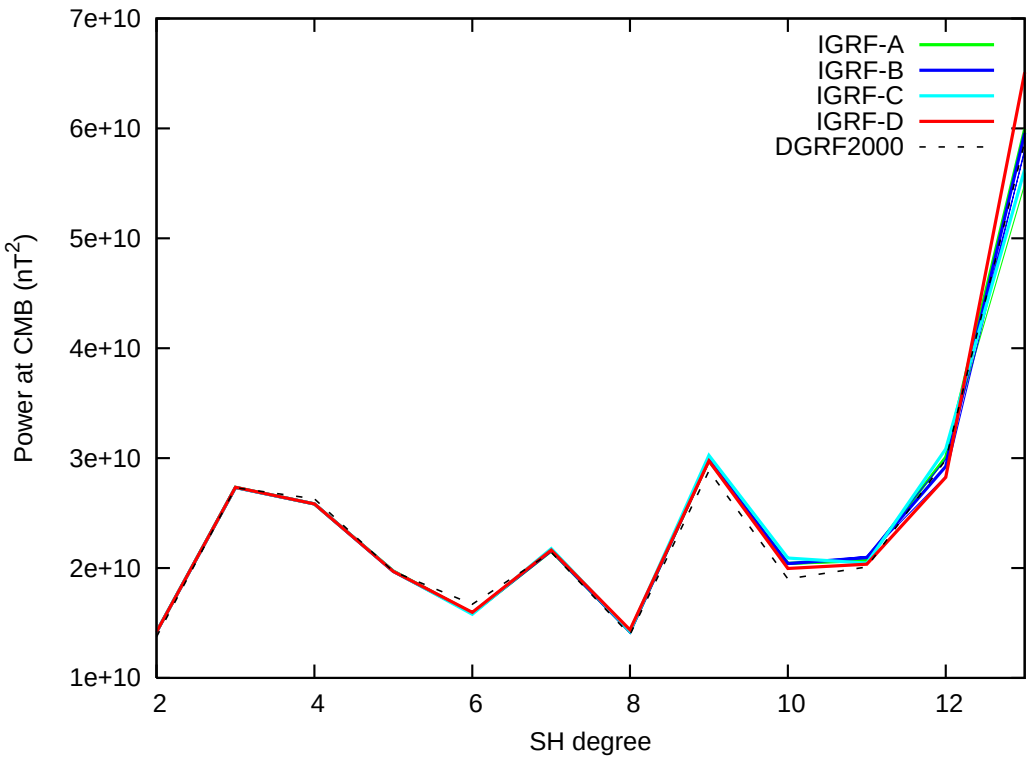

Figure 1: Mauersberger/Lowes spectra of models A1, B3, C1, and D1 at the CMB, compared with the spectrum of DGRF-2000.

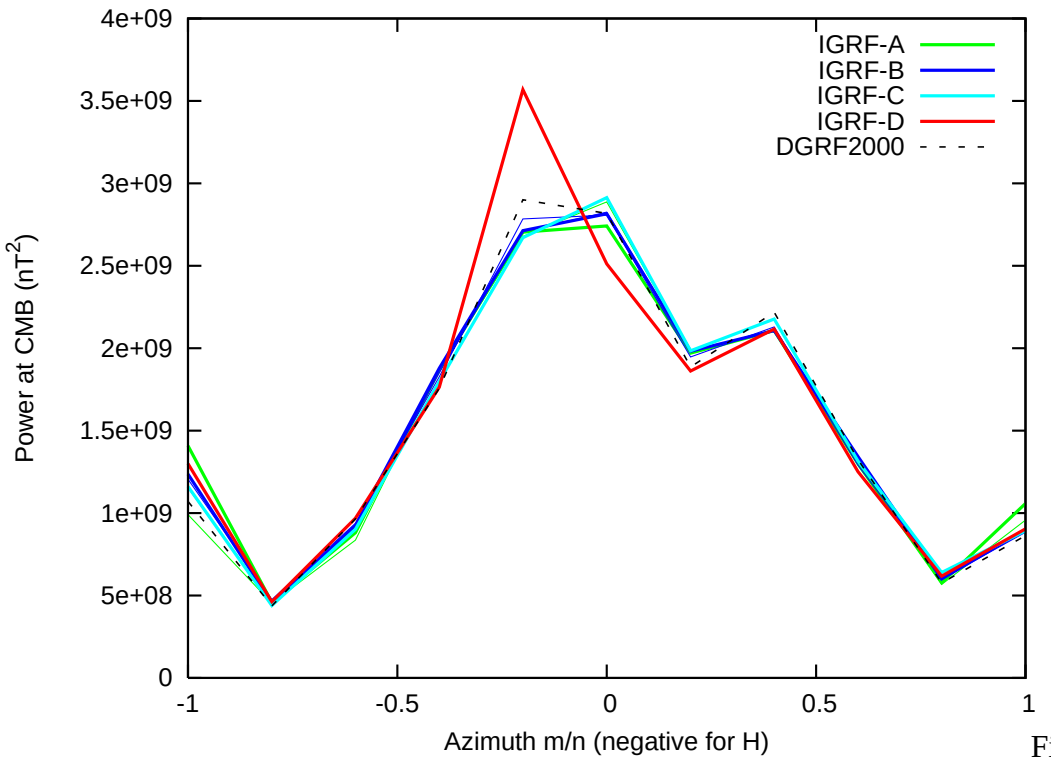

Figure 2: Azimuthal distribution of powers in models A1, B3, C1, and D1 at the CMB, compared with the DGRF-2000.

Secular variation 2005-2010

Figure 3 shows the Mauersberger/Lowes spectra of the candidates for the secular variation 2005-2010. The first observation is that the models A1, A2 and D1, which provide SV estimates for 2005 generally have lower power. The quadratic extrapolation of the SV into the future by A3, B1, B2, and B3 leads to increased power levels, which is not entirely unexpected. The combination of the quadratic forecast with linear prediction from observatory time series used for C1 has successfully prevented such an increase in power. The power level at higher degrees is particularly high in the B3 model.

Figure 4 shows the azimuthal distribution of SV power at the CMB. While the spread in powers is quite large, model B3 clearly has unrealistically high power in the H coefficients for high orders. I have verified that this increased power is caused by the inclusion of observatory annual means. While I anticipated that a long time series of observatory data would have a stabilizing effect on the secular acceleration, this was not achieved with model B3.

The combined CHAMP/Oersted model without observatory annual means (as given by parent model of IGRF-B3), has a power distribution which is very similar to the SV-A3 model (comparison not shown here). While the CHAMP-only SV-B1 model has slightly elevated power at low orders, the deviation still appears acceptable.

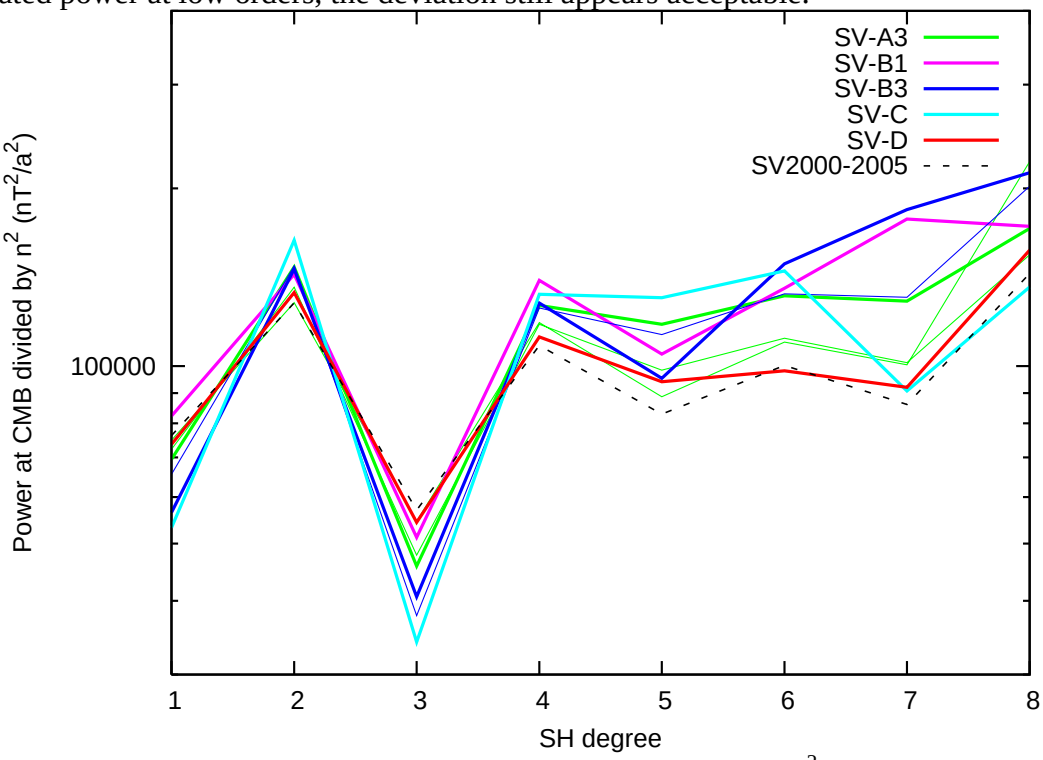

Figure 3: Mauersberger/Lowes spectra, further divided by n^2, of SV models A3, B1, B3, C1, and D1 at the CMB, compared with the *true* SV from 2000-2005, as defined in my 1st evaluation. Thin lines represent models A1, A2 (green) and B2 (blue).

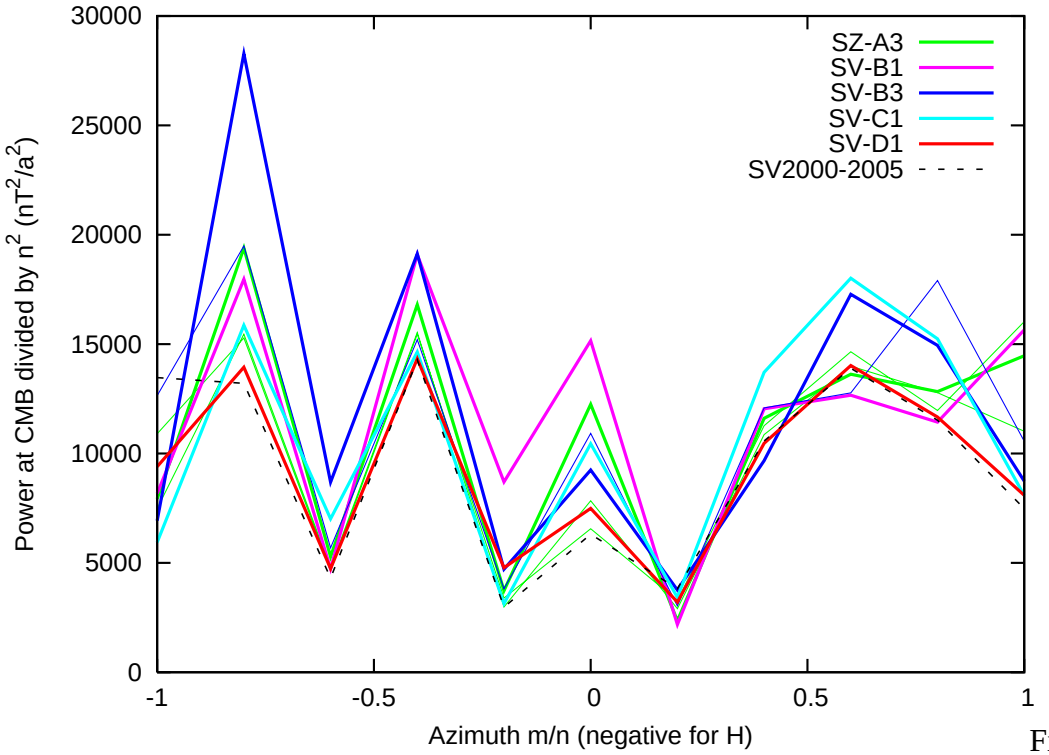

Figure 2: Azimuthal distribution of powers in SV models A1, B1, B3, C1, and D1 at the CMB, compared with the *true* SV from 2000-2005, as defined in my 1st evaluation. Thin lines represent models A1, A2 (green) and B2 (blue).

Summary and recommendation

Main field 2003

The azimuthal distribution of powers shows a significant deviation of model D1 from the other candidates. Since this deviation is **much** larger than the deviation between the other candidates and the DGRF-2000, this must be considered as a severe error in the D1 model. Contrary to the recommendation in my 1st evaluation (which did not reveal the problems at higher degrees), model D1 is obviously erroneous and should not be included in the IGRF-10, which should be a straight average of A1, B3 and C1.

SV 2005-2010

The straight-forward extrapolation via quadratic terms used for models A3 and B1-3 generally lead to larger SV powers at higher degrees. Models A1, A2 and D1, essentially giving the present SV, have the lowest powers. The method used for C1 obviously allowed for an extrapolation without increasing the power at degrees 7 and 8 (unless the model was regularized?).

The azimuthal distribution of powers shows that model SV-B3 has systematic errors and should be discarded. As in my 1st evaluation, I therefore recommend including model SV-B1, instead of SV-B3, in a straight average with models SV-A3, SV-C1 and SV-D1.