Evaluation of IGRF-11 candidate models, secular variation

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We compare local estimates of the secular variation (SV) at 87 INTERMAGNET magnetic observatories from the eight candidate models (A, B, C2, D, E, F, G and H) with annual differences of observatory monthly means.

Two tests are performed:
- Test 1: monthly means from 9 BCMT observatories producing quasi-definitive data (using the method presented by Chulliat *et al.*, 11th IAGA, Sopron, 2009) are used, from November 2007 to October 2009.
- Test 2: monthly means from 86 observatories are used, from January 2007 to December 2008 (definitive data).

For each test and each observatory, twelve SV values are calculated by taking the difference between monthly means at t+6 months and t-6 months, in order to remove seasonal variations in the data. The following SV values / averages are used for the statistics:
- the SV at the end of the time interval (April 2009 for Test 1, June 2008 for Test 2);
- the mean of the last four SV values (January to April 2009 for Test 1, March to June 2008 for Test 2);
- the mean of the twelve SV values (May 2008 to April 2009 for Test 1, July 2007 to June 2008 for Test 2)

Only results for the Y component are reported; results for the X and Z components are available on request.

1) Comparison with BCMT quasi-definitive data, November 2007 - October 2009

The following 9 observatories are used (Test 1): AAE, BOX, CLF, KOU, LZH, MBO, PHU, PPT, TAM (for full names and positions of observatories, see www.intermagnet.org).

These observatories produced quasi-definitive data up to 31 October 2009.

Histograms of differences between model and observatory SV values, as well as average and rms differences are plotted for each candidate model in Figures 1, 2 and 3. Each figure corresponds to a different time interval for the calculation of the observatory SV (one, four and twelve months).

Four categories of models may be distinguished:
- B and F have the smallest average and rms differences, whatever the time interval.
- A and C2 have small rms differences for the one and twelve months time intervals, respectively, but large average differences relatively to other models.
- D, E and H have intermediate average and rms differences.
- G has a much larger rms difference (> 10 nT) than other models, for all time intervals.
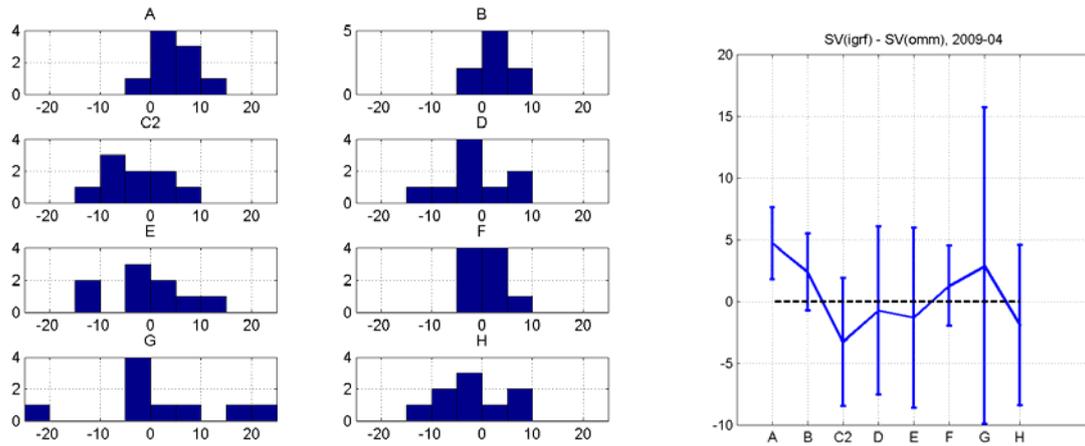
Figure 1: Histograms of differences (in nT) between SV from the eight candidates and the observed SV in April 2009 at the 9 observatories selected for Test 1 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).
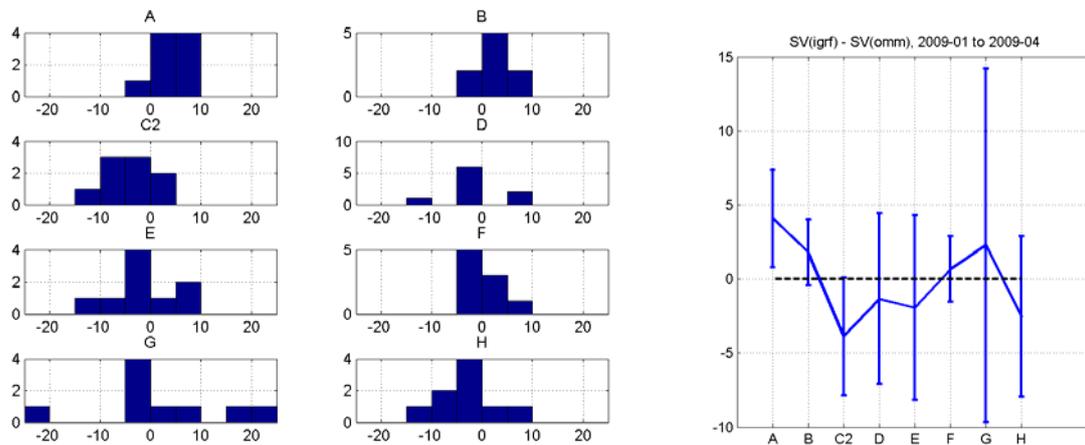

Figure 2: Histograms of differences (in nT) between SV from the eight candidates and the observed SV between January and April 2009 at the 9 observatories selected for Test 1 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).
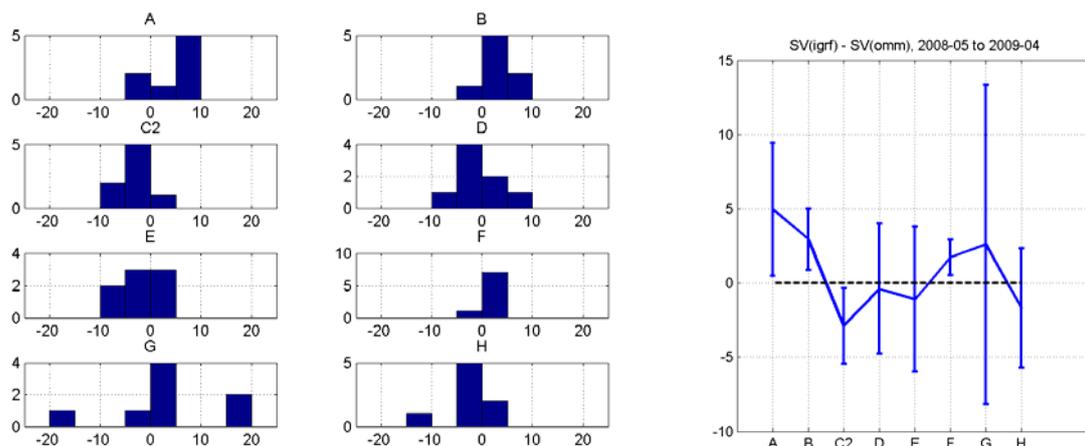

Figure 3: Histograms of differences (in nT) between SV from the eight candidates and the observed SV between May 2008 and April 2009 at the 9 observatories selected for Test 1 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).

2) Comparison with INTERMAGNET definitive, January 2007 - December 2008

The following 86 observatories are used: AAA, AAE, AIA, AMS, ASC, ASP, BDV, BEL, BFE, BFO, BLC, BMT, BOU, BOX, BRW, BSL, CBB, CLF, CMO, CNB, CTA, CZT, DOU, DRV, EBR, ESK, EYR, FCC, FRD, FRN, FUR, GCK, GNA, GUA, GUI, HAD, HBK, HER, HLP, HON, HRB, HRN, HUA, IQA, IRT, IZN, KAK, KDU, KOU, KNY, LER, LRM, LVV, MAB, MAW, MBO, MCQ, MEA, MMB, NAQ, NCK, NEW, NGK, NUR, NVS, PAF, PHU, PPT, PST, RES, SBA, SHU, SIT, SJG, SOD, SPT, STJ, TAM, THL, THY, TRW, TUC, UPS, VAL, VIC, VSS (for full names and positions of observatories, see www.intermagnet.org).

Other INTERMAGNET observatories were not selected due to either problematic or missing data on the considered time interval.

Histograms of differences between model and observatory SV values, as well as average and rms differences are plotted for each candidate model in Figures 4, 5 and 6. Each figure corresponds to a different time interval for the calculation of the observatory SV (one, four and twelve months).

Unlike results of Test 1, the average and rms differences vary very little when changing the time interval.

Two categories of models may be distinguished:
- A and G have the largest rms differences (> 6 nT); A also has the largest average differences (> 2 nT).
- B, C2, D, E, F and H have smaller rms differences than the other two models.

3) Assessment

For an individual observatory, Test 1 is better than Test 2 as it compares two secular variations at closer epochs (2010.0 for the IGRF candidates, up to 2009.3 for the observatories in Test 1, up to 2008.5 for the observatories in Test 2). However, its statistical significance is probably lower than that of Test 2, due to the smaller number of observatories considered. Still, it is perhaps not so low, as the nine observatories of Test 1 are globally distributed, with 3 observatories in Africa (AAE, MBO and TAM), 2 in Eastern Asia (LZH and PHU), 1 in South America (KOU), 1 in Russia (BOX), 1 in Europe (CLF) and 1 in the Pacific Ocean (PPT). In fact, this geographical distribution might help avoiding the usual bias toward Europe of the global distribution of INTERMAGNET observatories.

From this analysis we may conclude:
- Models B and F have the lowest differences between model and observatory SV in both tests.
- Model A, C2, D, E and H have intermediate differences in both tests or large differences in one test.
- Model G has the largest differences in both tests.

Overall results from the analysis of the X and Z components of the SV are in agreement with these conclusions, although less clear-cut.
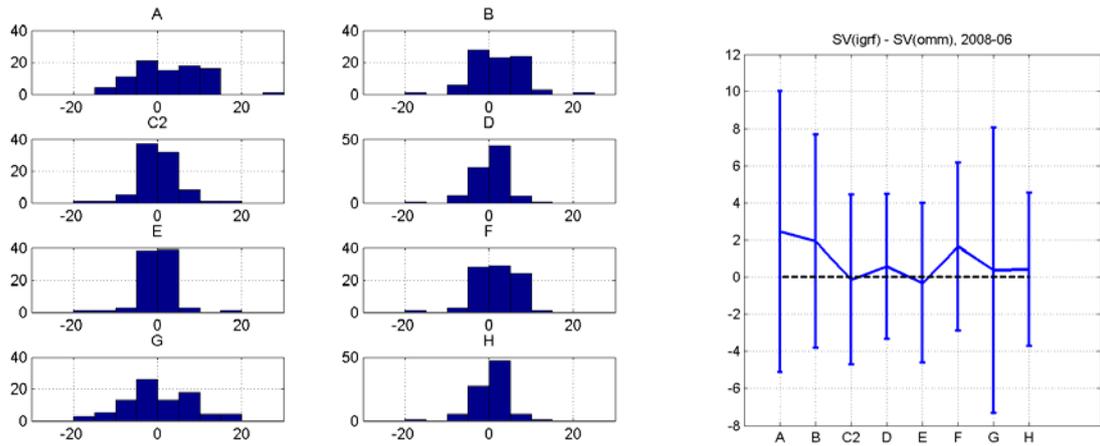
Figure 4: Histograms of differences (in nT) between SV from the eight candidates and the observed SV in June 2008 at the 86 observatories selected for Test 2 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).
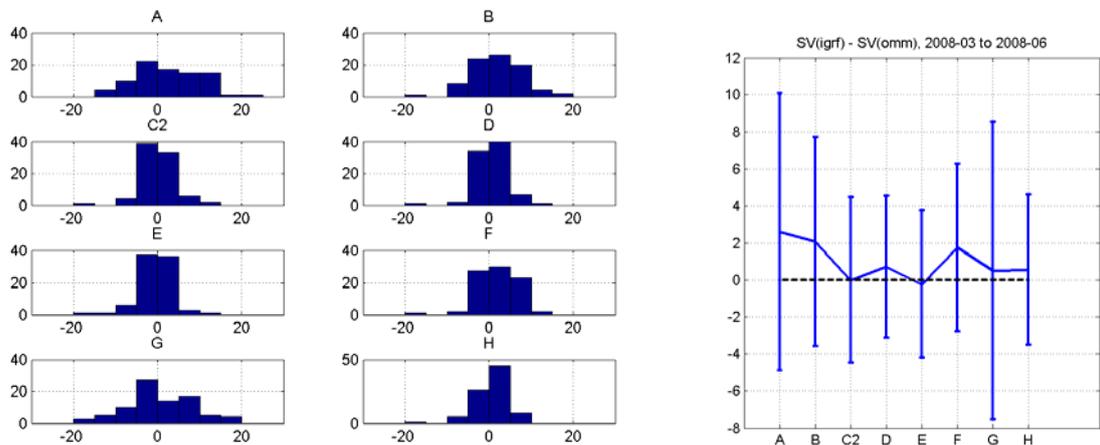

Figure 5: Histograms of differences (in nT) between SV from the eight candidates and the observed SV between March and June 2008 at the 86 observatories selected for Test 2 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).
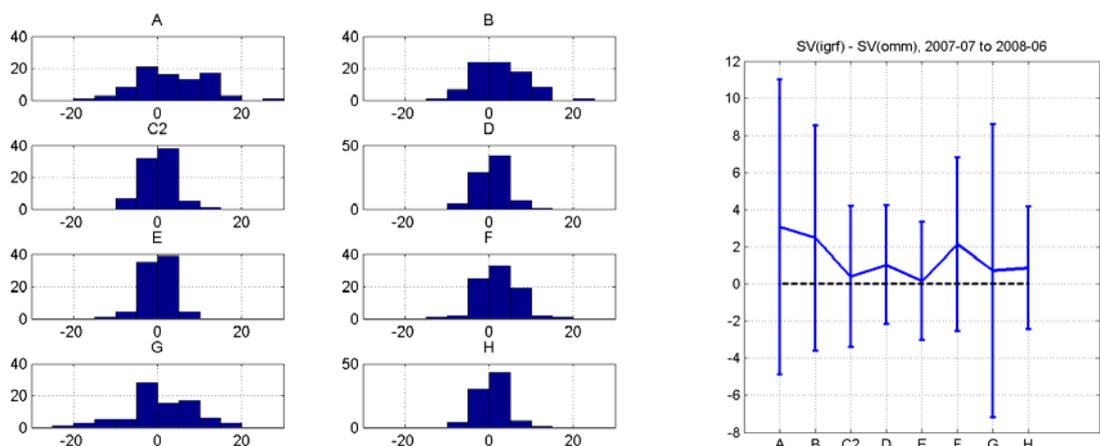

Figure 6: Histograms of differences (in nT) between SV from the eight candidates and the observed SV between July 2007 and June 2008 at the 86 observatories selected for Test 2 (left); mean and standard deviation (represented as an error bar) of differences (in nT) for each candidate model (right).