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Intercomparison of Momentary Values: an Application to Check the Reliability of Ebre Observatory Data

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Abstract

Intercomparison of momentary values from observatories across Europe has been used as a test of reliability for the magnetic stations of this area, as well as for the whole net. One of the techniques used, based on the standard deviation of the mutual differences of monthly mean values, has permitted to obtain a measure of quality of the Ebre Observatory (EBR) magnetic elements for the period 1997-2001. The results nearly coincide with those obtained for the most significant observatories of the network, pointing out a good performance of EBR observatory.

1. Introduction

During the 1950s a few central European observatories agreed to exchange their respective data for intercomparison purposes. Data from the different stations were collected by Wingst Observatory (WNG), and a series of procedures was applied to establish the quality of their records, as well as the quality of the network itself (several applications of the comparisons are shown in Schulz and Beblo 1996). Particularly, these procedures were based on the momentary values (MV) comparison, i.e., the observatories' magnetic field values (H, D, Z and F) of the ten selected quietest days of each month taken at 02:00 UT, which is supposed to coincide with the period least disturbed by Sq on central European longitudes. Along the time, the number of participating observatories progressively increased, and in the quinquennium 1997-2001 a total of 26 observatories presented their data, Ebre Observatory (EBR) being one of them. Some preliminary results are presented here for EBR, specifically those resulting from the application of linear regressions to the standard deviation of the mutual differences of the MV monthly means, once detrended by the secular variation (SV).

2. Procedure and Objectives

Once the 5-year data from the participating observatories have been collected, Wingst Observatory is in charge of selecting and averaging the ten MVs of each month. A list of monthly mean values is therefore obtained for each observatory. Direct comparison of these values is not adequate, since they are affected by the “constant” trends associated to the SV; hence, a detrending is applied by means of first order regression models estimated from five epoch values for each magnetic element, virtually eliminating in this way the internal magnetic field influence. The resulting values are now equally distributed around a mean that we can artificially set as zero. In an ideal situation, and supposing identical external field conditions for each observatory, as well as identical crustal response to the external fields, the obtained values should coincide. Just in order to minimize the external field differences among the observatories, the momentary values are taken from the quietest days at 02 UT. Nevertheless, in a real situation several departures from these ideal assumptions are observed, and in consequence, the detrended monthly means of the participating stations do not coincide, especially in case of:

- defective absolute instruments
- incorrect adjustments
- magnetic impurities in the immediate vicinity of the pier
- electromagnetic interferences

(see Schulz and Gentz 1998). As well, this technique is not only sensible to instrumental pathologies or noise, but also to unavoidable natural phenomena, as:

- latitudinal effects, like the ring or the field aligned currents (FACs)
- longitudinal differences of the participating observatories
- differential induced magnetic fields
- annual and lunar variation.

In order to evaluate the natural or artificial origin of such residual differences among observatories, it is reasonable to assume that, if they have a natural origin, similar variations should correspond to close locations. On the contrary, if the difference is due to an instrumental problem, no rules of vicinity apply. Therefore, the following step to evaluate a given observatory, in this case EBR, consists of computing the standard deviation of the differences of the detrended monthly mean values between EBR and each one of the remaining stations, and afterwards representing them against their relative location, either distance, longitude or latitude differences with respect to EBR. The standard deviations are denoted as $\sigma_Y^{XXX\text{-}EBR}$, where Y stands for the magnetic element (D, H, Z and F) and XXX for the station concerned. A linear regression is then fitted, being the axis intercept the value of interest, which intuitively corresponds to the standard deviation predicted by the net at the point the concerned station (EBR in this case) is located; obviously, the ideal value for the axis intercept is zero, and its absolute actual value constitutes a quality factor for the concerned magnetic element measured at that observatory. In general, large intercepts should be interpreted as poor coherency of the observatory or malfunction of the sensors. Nevertheless, as pointed out by Schulz and Gentz (1998), care should be taken in this interpretation, because intercept values may be strongly affected by the quality of nearby stations and their location within the network, in such a way that the technique is less reliable for extremely located observatories, as EBR.

3. Results and Evaluation

In Fig. 1 the standard deviation of the detrended monthly mean differences among EBR and the different observatories of the network are represented as a function of distance, latitude and longitude for D, H, Z and F. As mentioned, the meaningful parameter is the axis intercept, but also the correlation coefficient R (or equivalently R^2), which provides information on the degree of dependency of the standard deviations with respect to the variable used in each case to represent the relative observatory locations. In view of the plots, at least two traits are discerned:

- In all cases longitude with respect to EBR is the worst variable (i.e., R is low) to predict the standard deviation values, as expected if an appropriate choice of the quietest days has been made; nevertheless, significant dependencies with longitude are still found for both, σ_D and σ_H, which indicates that residual longitudinal effects are still present, probably due to the network extension.
- In all cases the relation between standard deviations and latitude are highly significant (i.e., given the number of experimental points, R denotes a very good correlation between both variables; see Taylor 1982). This fact denotes the influence of the abovementioned latitudinal effects as ring currents, ionospheric currents associated to the FAC's system or differential annual magnetic variation among southern and northern observatories, separated by more than 20º.

Let us now evaluate the EBR behavior. If this is to be done, a unique value for the axis intercept is to be given, either that coming from distance, latitude, or longitude. To do it, we have decided to choose the variable with the most significant correlation in each case, i.e., distance for both D and H and latitude for both Z and F.

σ_D (DIST = 0) = –0.10 ± 0.14 arc-min; R = 0.77,

σ_H (DIST = 0) = 0.6 ± 0.6 nT; R = 0.57,

σ_Z (LAT = LAT_{EBR}) = 1.1 ± 0.7 nT; R = 0.40,

σ_F (LAT = LAT_{EBR}) = 0.8 ± 0.6 nT; R = 0.83,

where the reported uncertainties correspond to the standard deviation of the observatory values with respect to the regression lines. It is worth mentioning that the ideal zero is inside the uncertainty for D and H, while it is outside for both F and especially for Z. A different concept is the uncertainty associated to the axis intercept value, which is 0.04 arcmin for D, 0.2 nT for both H and F, and 0.1 nT for Z. If distance is taken as the independent variable for Z and F, σ_Z (DIST = 0) = 0.8 ± 0.7 nT and σ_F (DIST = 0) = 0.8 ± 0.9 nT.

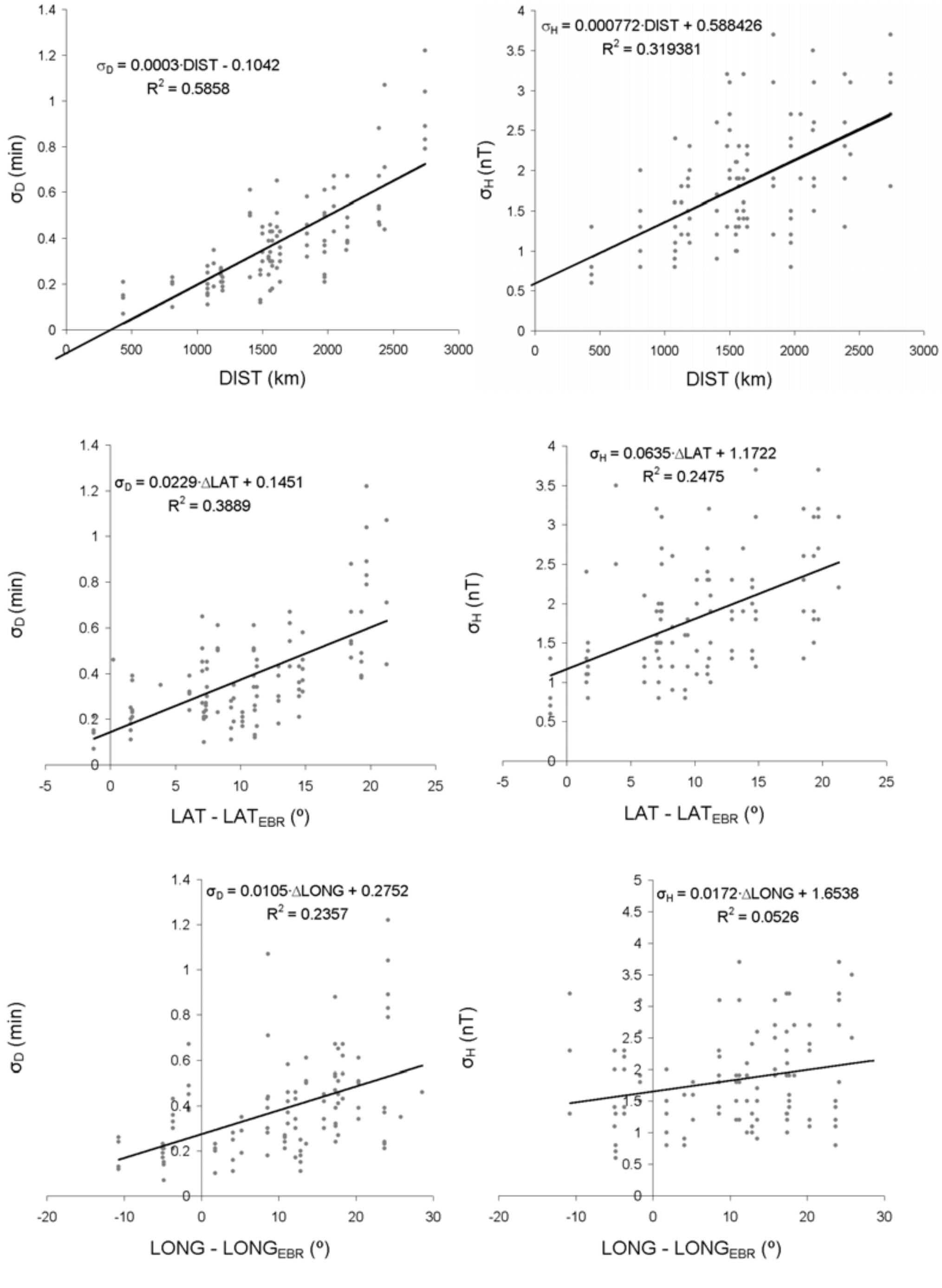

Fig. 1. Standard deviations σ_D (left) and σ_H (right) against distance, latitude and longitude with respect to Ebre.

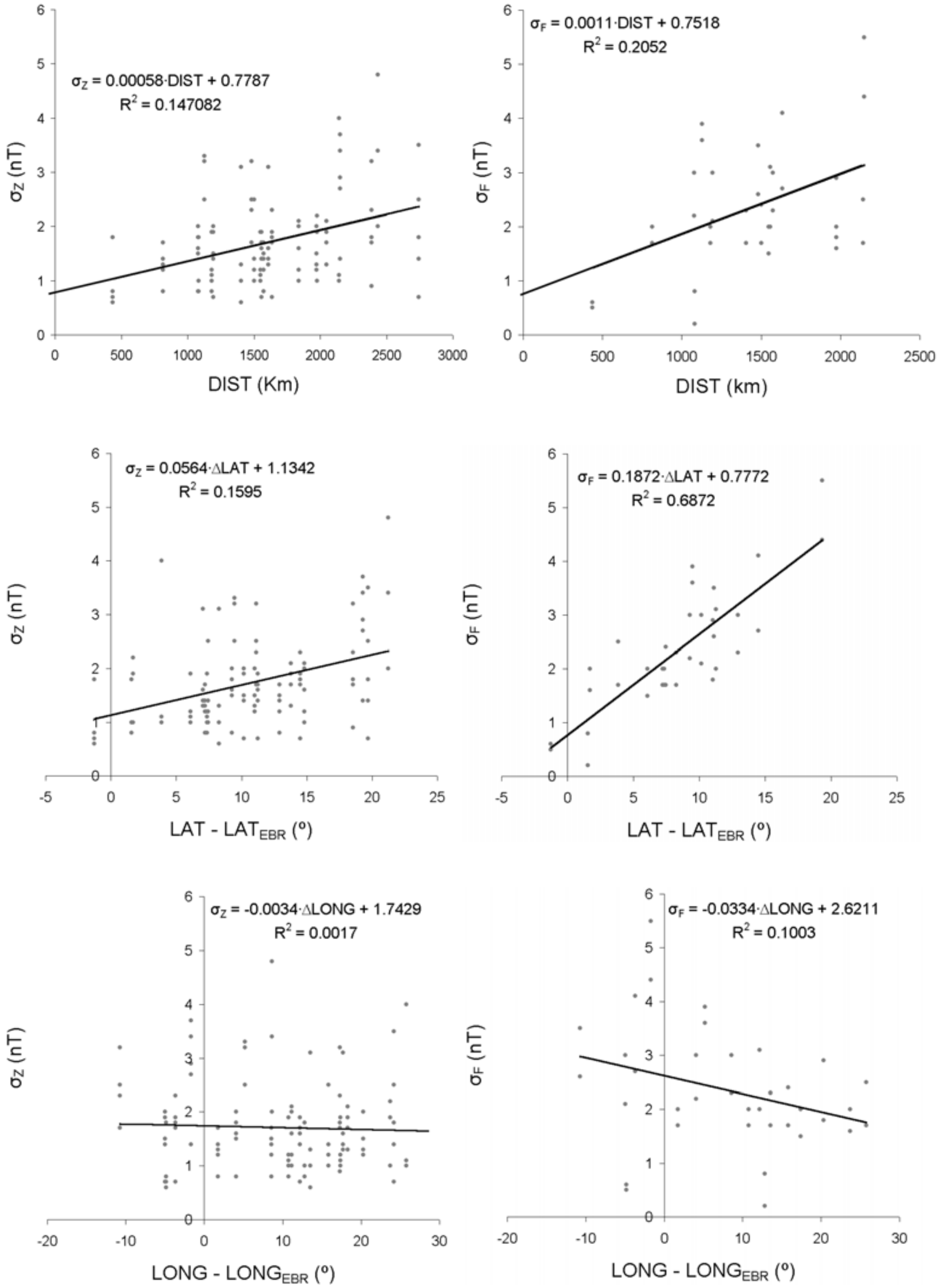

Fig. 1. (cont.) Standard deviations σ_Z (left) and σ_F (right) against distance, latitude, and longitude with respect to Ebre.

In order to check the repeatability of the axis intercept values, and in view that longitude and latitude are not sufficient to describe separately the standard deviation behavior by themselves, we have fitted a bi-dimensional function to the standard deviation, of the form σ_Y (ΔLONG, ΔLAT) = A + B·ΔLONG + C·ΔLAT. The results for the axis intercepts are now the following:

σ_D (LONG = $LONG_{EBR}$, LAT = LAT_{EBR}) = 0.03 arc-min; R = 0.80

σ_H (LONG = $LONG_{EBR}$, LAT = LAT_{EBR}) = 0.6 nT; R = 0.55

σ_Z (LONG = $LONG_{EBR}$, LAT = LAT_{EBR}) = 1.2 nT; R = 0.40

σ_F (LONG = $LONG_{EBR}$, LAT = LAT_{EBR}) = 0.8 nT; R = 0.83

Except for D, the axis intercept values, as well as the quality of the adjustments (expressed by means of the correlation coefficients), are approximately the same, showing a good agreement between the discrete techniques used.

Finally, a comparison between mean values of the Ebre intercepts for this quinquennium with the intercepts of the whole network for the preceding years is shown in Fig. 2. The solid line represents approximately the upper limit of this measure of coherence. Data from the network were obtained by Schulz and Gentz (1998).

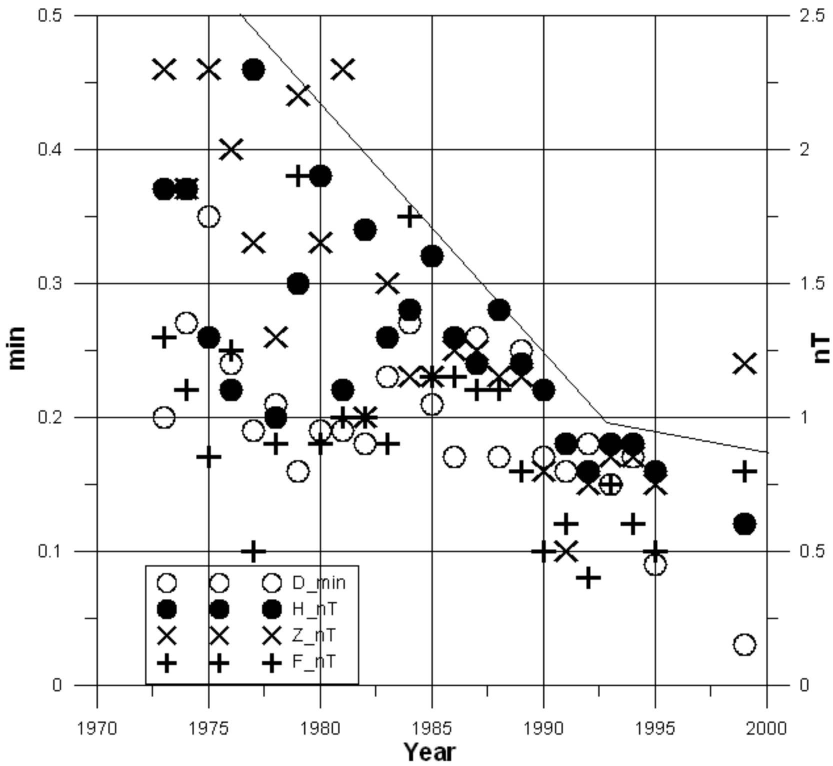

Fig. 2. Temporal evolution of the mean values of the intercepts for the whole network (1973-1995). Mean values for Ebre (obtained from the bi-dimensional fit) for the period 1997-2001 are displayed centred at 1999.

4. Conclusions

Ebre results for the quinquennium 1997-2001 are in general in perfect concordance with those of the whole network, even considering its extreme location.

Investigation is in progress in order to explain the slight departure of the Z axis intercept for Ebre, which could be explained by means of inductive effects due to the earth conductivity, rather than malfunction of the observatory standards.

The net has been improving its performance along the time. Intercomparison between observatory and international standards, with use of QHM magnetometers in the seventies and the generalized use of D/I fluxgate theodolites in the eighties (Bitterly 1990), contributed to this improvement.

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