STUDY ON THE STABILITY AND ACCURACY OF BASELINE VALUES MEASURED DURING THE CALIBRATING TIME INTERVALS

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ABSTRACT

In order to investigate quantitatively the accuracy of geomagnetic daily variation recorded by the FGE magnetometer, we analyzed the stability and precision of some groups' baseline values continuously recorded one day at seven observatories in 2009. The results show that the standard deviation and variable amplitude of the baseline values are small in D, H, and Z components, the standard deviation values are $\delta D \leq 0.03'$, $\delta H \leq 0.3nT$, $\delta Z \leq 0.3nT$ *respectively, and the variable amplitude values are* $\Delta D \leq |0.05'|$, $\Delta H \leq |0.5'|$, $\Delta Z \leq |0.5'|$ *respectively. Then we selected the baseline values continuously recorded one day at CDP and KSH observatories in 2009 and 2010 and analyzed the influence of absolute measurement intervals on the stability of the baselines.*

Keywords: Absolute measurement, Baseline values, Stability and precision, Calibration

1 INTRODUCTION

The testing and calibrating of instruments is an essential part of all measurements and especially important at observatories (Jerzy & Christian, 1996). Errors exist between geomagnetic daily variations recorded by the FGE magnetometer and true values because of the influences of the orthogonality of the sensors, scale value, the accuracy and stability of the orientation of the sensor, and temperature coefficients of variometer sensors. In spite of the fact that the manufacturers of the instruments give values for the instrument parameters, these quantities may change through time and during the transportation of the instrument (Jerzy & Christian, 1996). The geomagnetic station should test the variometer regularly and investigate quantitatively the accuracy of geomagnetic daily variations recorded by the FGE magnetometer, in order to determine the suitable intervals for absolute measurement, research, and application of data.

Few researchers do this, in spite of the fact that IAGA highly recommends the calibrating of the variometers at all observatories, because it may take years before a suitable magnetic disturbance happens to occur at the same time that the observer has an opportunity to make the long series of observations needed. Lu (2008) analyzed the stability and precision of the baseline value at observatories based on 46 groups of continuous absolute measurements carried out at Zhaoqing Geomagnetic Observatory on September 18, 2007, and showed that the absolute measurements of different time periods have a small influence on the stability of the baseline value on a quiet day.

It was recommended that calibration of variometers should be done during a magnetic disturbance at the China Geomagnetic Network. Absolute values were measured twice each hour from 8:30 to 16:30 local time on that day, and lasted at least nine hours. Then the difference (baseline values) between absolute values and data produced by the variometer were compared.

The accuracy and stability of data from calibration of the variometers were analyzed at seven observatories during 2009, and the data from CDP and WHN observatories in 2009 and 2010 were analyzed to study the influence of absolute measurement intervals on the baseline values.

2 DATA AND INSTRUMENTS

We used the baseline values measured on the day of calibration of variometers at WHN, LZH, THJ, CNH, CDP, KSH, and JYG observatories in 2009, the baseline values at CDP and KSH in 2009 and 2010, and the hourly mean values during the same time intervals at CDP and KSH in 2009 and 2010.

At these observatories, the absolute values D and I were measured with MINGEO DIM fluxgate theodolites made in Hungary; F was measured by an Overhauser magnetometer made in Canada, and magnetic field variations were recorded by an FGE magnetometer made in Denmark. The parameters of the instruments are listed in Table 1.

Table 1. The main parameters of the absolute instruments and variometer

Instruments	MINGEO DIM fluxgate theodolite	Overhauser magnetometer	FGE magnetometer
Specifications	Analogue output: ±10 V Dynamic range: User specified Resolution: 0.1nT	Resolution: 0.01 nT Accuracy: 0.2 nT Sampling interval: 2 s measuring range: 20000 ～ 120000 nT	Analogue output: ±10 V Dynamic range: User specified Resolution: 0.1nT Long term drift: < 3 nT/year Temp. coeff. <0.25 nT/℃

3 DATA PRE-PROCESSING AND ANALYZING

3.1 The accuracy and stability of baseline values during the calibrating time intervals

We drew the curves of D_B, H_B, and Z_B in Figures 1 - 3. Noteworthily, in order to make the figure clearer, we show every baseline value minus its average value.

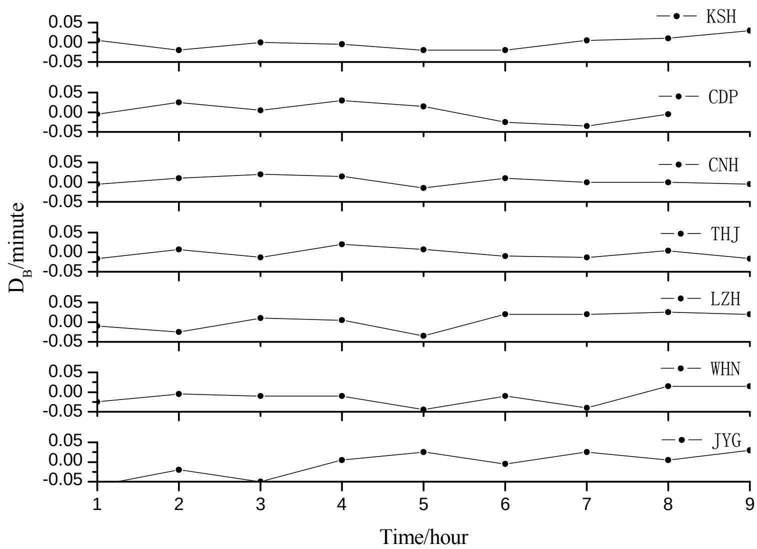

Figure 1. Baseline values of the D component

Figure 1 shows that the deviation of the baseline value for the D component (D_B) was largest at 12:30 local time at the CNH, LZH, WHN, and JYG observatories, but baseline values at other observatories were stable.

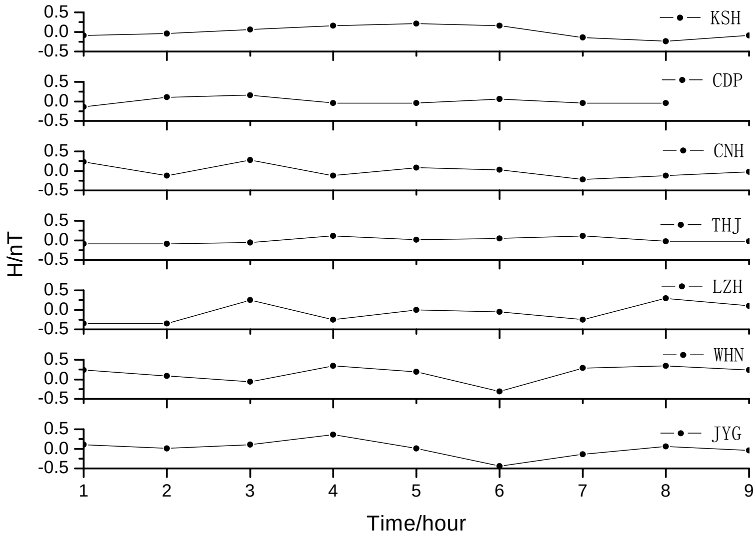

Figure 2. Baseline values of the H component

Figure 2 shows that the baseline values of the H component (H_B) clearly fluctuated from 11:00 to 14:00 local time at the WHN and JYG observatories. Other observatories were stable except for individual values.

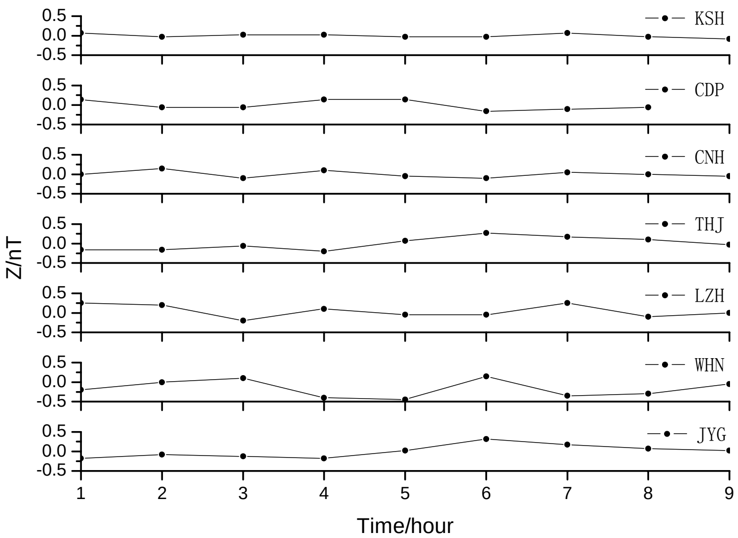

Figure 3. Baseline values of the Z component

Figure 3 shows that the baseline values of the Z component (Z_B) clearly fluctuated from 10:00 to 13:00 local time at the WHN observatory. Other observatories were stable except for individual values.

Table 2 gives the calibrated dates and relevant K indices of seven observatories in 2009.

Table 2. Calibrated date and relevant K index of every observatory in 2009

		8h-11h	11h-14h	14-17h
WHN	20090803	3-	2	2
LZH	20090618	0	0+	0+
THJ	20091031	0+	0	0
CNH	20090825	0+	1	0
CDP	20090903	0+	0+	1-
KSH	20091015	0	0	2
JYG	20090717	0	0+	0

Because the geomagnetic field was quiet in 2009, it was difficult to select a disturbed day to calibrate the variometer. By contrast, the K index of WHN showed the largest fluctuation among all observatories.

As a whole, D_B, H_B, and Z_B clearly fluctuated at the WHN observatory, possibly because the geomagnetic field was active during the calibration time intervals at WHN. It is a problem worth considering why the D_B and H_B clearly fluctuated at JYG, but the calibration time intervals at JYG were very quiet.

Table 3. The standard deviation and variable amplitude of D_B, H_B, and Z_B during the calibration time intervals at all observatories

	Standard Deviation			**Variable Amplitude**		
	D	**H**	**Z**	**D**	**H**	**Z**
WHN	0.02	0.21	0.22	0.06	0.65	0.60
LZH	0.02	0.25	0.16	0.06	0.65	0.45
THJ	0.01	0.08	0.16	0.04	0.20	0.47
CNH	0.01	0.17	0.09	0.03	0.50	0.25
CDP	0.02	0.10	0.12	0.06	0.30	0.30
KS	0.02	0.16	0.05	0.05	0.45	0.15
JYG	0.03	0.22	0.17	0.09	0.80	0.50

Table 3 shows the standard deviations of D_B, H_B, and Z_B were small at all observatories, $\delta D \leq 0.03'$, $\delta H \leq 0.3nT$, $\delta Z \leq 0.3nT$. The D_B, H_B, and Z_B were stable during all calibration time intervals with no abrupt jumps; the variable amplitude of D_B was no more than $0.09'$, and the variable amplitudes of H_B and Z_B were no more than 0.80nT and 0.60nT respectively.

3.2 Study on the influence of absolute measurement time intervals on baseline values

We used the baseline values during the calibration time intervals at the CDP and KSH observatories during 2009 and 2010 and the hourly mean values during the corresponding period, in order to study the influence of absolute measurement time intervals on baseline values (Figure 4). The left column shows baseline value curves, and the right column shows hourly mean value curves in Figure 4.

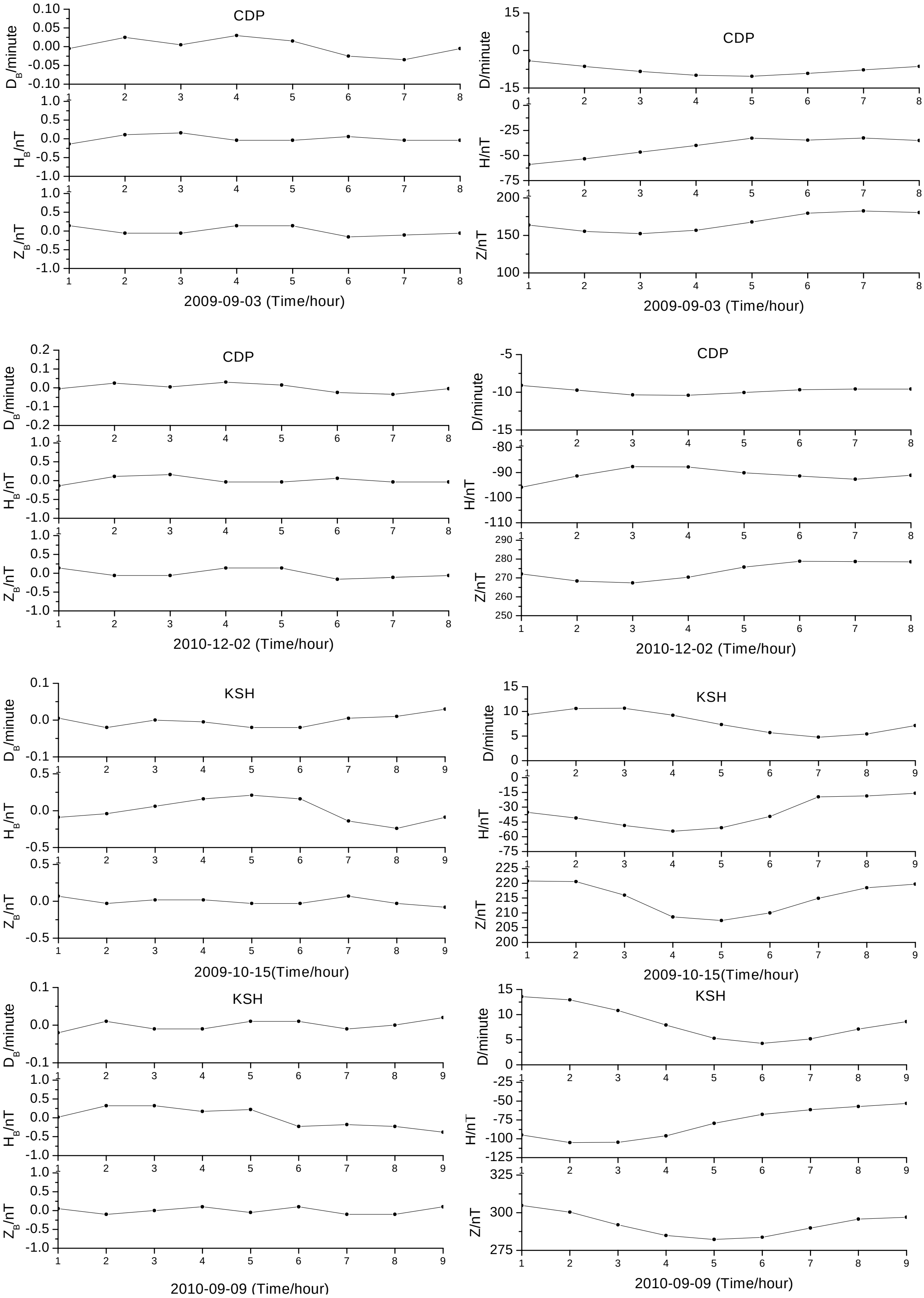

Figure 4. Baseline values and hourly mean values during the calibration time intervals at the CDP and WHN observatories

Figure 4 shows that there were no obvious correlations between baseline values and hourly mean values, except for D_B and H_B at the CDP observatory on December 2.

4 CONCLUSIONS AND DISCUSSION

(1) The standard deviations of D_B, H_B, and Z_B were small, $\delta D \le 0.03'$, $\delta H \le 0.3nT$, $\delta Z \le 0.3nT$, at all observatories that meet the requirement of standard deviations of baseline values $\delta D \le 0.1'$, $\delta H \le 1.0nT$, $\delta Z \le 1.0nT$ at geomagnetic stations (GNC, 2010).
(2) The D_B, H_B, and Z_B were stable during the calibration time intervals; the variable amplitude of D_B was no more than 0.09′, and the variable amplitudes of H_B and Z_B were no more than 0.80nT and 0.60nT, respectively. This meets the accuracy requirement for definitive data and the 5nT that INTERMAGNET recommends. That is to say, the observers' skill and the FGE magnetometer are working well.
The D_B and H_B clearly fluctuated at the JYG observatory. This may have been influenced by many factors: observer skill, orientation of variometer sensors, orthogonality of variometer sensors, and so on.
(3) There were no obvious correlations between baseline values and hourly mean values, except for D_B and H_B at the CDP observatory on December 2, 2010. That is to say, the geomagnetic field activity showed no obvious influence on the accuracy of baseline values. We recommend making absolute measurements while avoiding intervals of magnetic disturbance, in order to improve the stability and accuracy of baseline values.
(4) The geomagnetic field was quiet in 2009; the above mentioned results are perhaps related to this fact.

5 ACKNOWLEDGEMENTS

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