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REPORT ON THE MEASUREMENT SESSION DURING THE XIVth IAGA WORKSHOP AT CHANGCHUN MAGNETIC OBSERVATORY

Yufei He[1*], Dongmei Yang[1], Benliang Zou[2], Jianjun Wang[3]

* [1]*Institute of Geophysics, China Earthquake Administration (CEA)*
**Email:* heyufei_bj@163.com
[2] *Changchun Magnetic Observatory, Earthquake Administration of Jilin Province, China*
[3] *Earthquake Administration of Gansu Province, China*

1 INTRODUCTION

The Absolute Measurement Session during *the XIVth IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing* was held at the Changchun Magnetic Observatory (CNH) September 14-17, 2010. Approximately 50 participants joined in this session. During the session, 27 DI-Flux magnetometers were used to make and compare measurements, and several total field comparison measurements were conducted to look for errors within 4 total field instruments. This session also included absolute measurement training with lectures and practical training, an introduction to INTERMAGNET, and the demonstration of Autodif MKII and DI3.

2 DI FLUX COMPARISON

Absolute measurements of declination and inclination were made at pillars 1, 3, 4, 5, and 6 (the Autodif MKII was demonstrated on pillar 2) fixed in the absolute house of the observatory. The pillars are 3 meters away from each other. The plan of the absolute house is displayed in Figure 1.

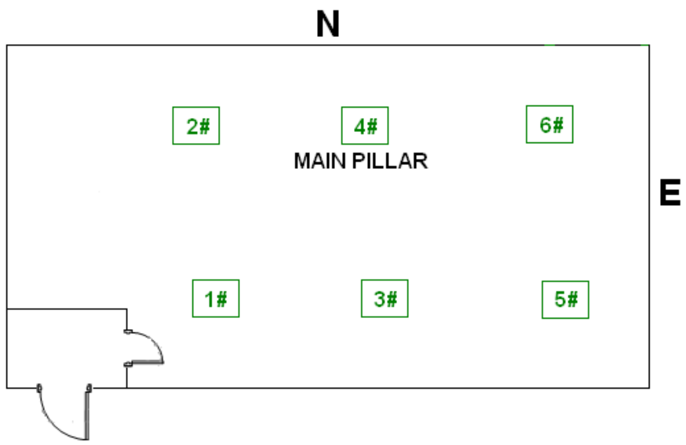

Figure 1. The plan of the absolute house

There were 28 observers with 27 DI-fluxes that participated in the DI-flux comparison measurement. They are listed in Table 1 below.

Table 1. List of DI-fluxes and observers

No.	Observer	Country	Instrument
1	Adrian Hitchman	Australia	Zeiss 010B 160459/0610H
2	Alan Berarducci	USA	Zeiss 020 DMI-model G
3	Anne Geese/ Ulrich Auster	Germany	DI3/Zeiss
4	Baishun Ma	China	Mingeo DIM (Zeiss 010 / FGE G)
5	Tomas Bayer	Czech	Theo 010B
6	Changjiang Xin	China	Mingeo DIM (Zeiss 010 / FGE G)
7	David Calp	Canada	Theo 010/Mag01-H
8	Fu Zhang	China	Mingeo DIM (Zeiss 010 / FGE G)
9	Fuxi Yang	China	Mingeo DIM (Zeiss 010 / FGE G)
10	Guihua Qi	China	Mingeo DIM (Zeiss 010 / FGE G)
11	Hailong Dong	China	Mingeo DIM (Zeiss 010 / FGE G),CNH
12	Josef Horacek	Czech	Theo 010B
13	Jian Lin	China	Mingeo DIM (Zeiss 010 / FGE G)
14	Junfeng Chen	China	CTM-DI
15	Junxiang Zhao	China	Zeiss 015/MAG-01H
16	K.C.S. Rao	India	DI-Flux SI.NO.51F7 EDA-CANADA
17	Kari Pajunpaa/ Tero Raita	Finland	Zeiss Jena THEO 010B + DMI fluxgate
18	Lars W. Pedersen	Denmark	Zeiss 010B/DMI
19	Mutaek Lim	Korea	THEO 010B /MAG01-H
20	Hans. J. Linthe	Germany	THEO 010B/MAG01-H
21	Yasuhiro Minamoto	Japan	THEO 010B
22	Na Deng	China	Mingeo DIM (Zeiss 010 / FGE G)
23	Tero Raita	Finland	Zeiss Jena THEO 010B + DMI fluxgate
24	Tie Zhuang	China	Mingeo DIM (Zeiss 010 / FGE G)
25	Bill Worthington	USA	Zeiss 010 814503
26	Xianqi Shang	China	Mingeo DIM (Zeiss 010 / FGE G)
27	Xijing Li	China	Mingeo DIM (Zeiss 010 / FGE G),QIX
28	Xijing Li	China	Mingeo DIM (Zeiss 010 / FGE G),IGP
29	Zhiye Wang	China	Mingeo DIM (Zeiss 010 / FGE G)

The adopted pillar differences for *D*, *I,* and *F* are shown in Table 2. They were determined by extensive measurements.

Table 2. Pillar differences for *D*, *I*, and *F* referred to pillar 4

Pillar No.	Dcorr (min)	Icorr (min)	Fcorr (nT)
Pillar 1	0.02	0.04	-0.05
Pillar 2	0.00	0.03	-0.05
Pillar 3	0.14	0.01	-0.34
Pillar 5	-0.04	-0.01	-0.39
Pillar 6	-0.01	0.05	-0.58

The observatory baselines were determined on pillar 4 in the absolute house. Reduction of the measurements was made using the suspended FGE fluxgate magnetometer and GSM-90 magnetometer at the observatory. The stability of these magnetometers is approximately 3-5nT/year. See Figure 2 below.

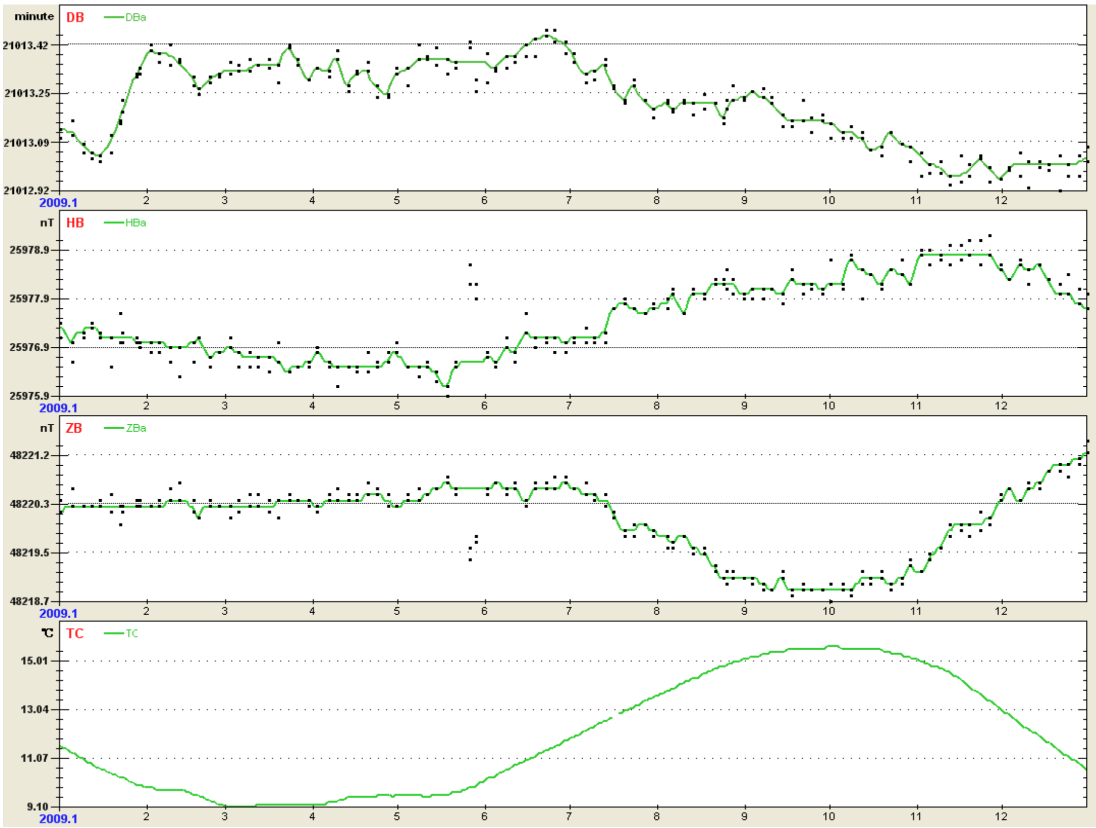

Figure 2. Observed and adopted baseline values for Changchun Observatory, 2009

The D_B and I_B results during the absolute measurement session are shown in Figures 3 and 4, respectively. In these figures, the reference levels (zero level) for D_B and I_B are adopted from the mean value of all the measurements made by the session's participants, excluding measurements outside two standard deviations. Two standard deviations are 0.14 minutes for D_B and 0.06 minutes for I_B.

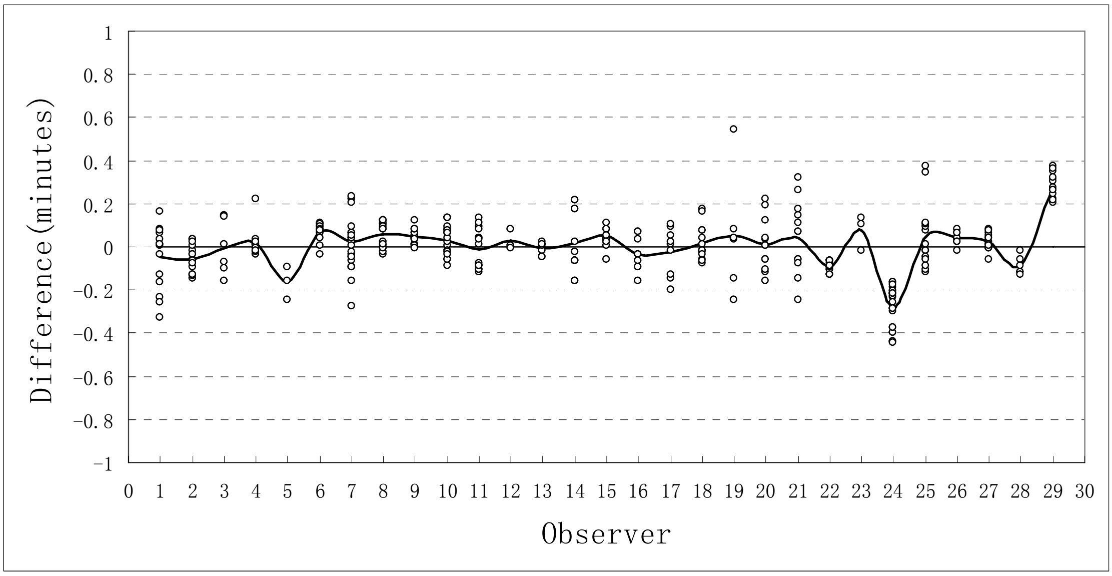

Figure 3. Individual observer's difference from workshop average (D_B) with measurements outside of two standard deviations being removed

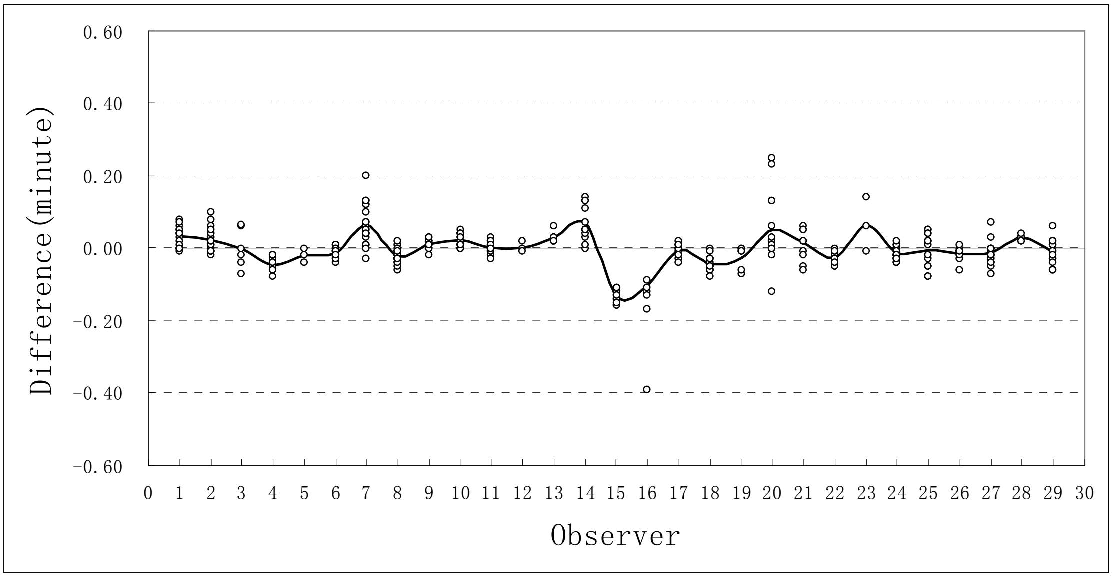

Figure 4. Individual observer's difference from workshop average (I_B) with measurements outside of two standard deviations being removed

3 TOTAL FIELD MAGNETOMETER COMPARISON

In this session, the total field magnetometers were tested in two ways. One method compared their samples with the simultaneous samples of the continuous recording Overhauser magnetometer at the Changchun Observatory. The other method calibrated these sensors by use of a frequency generator.

Several observers participated in the session. They were Dr. Hans-Joachim Linthe from Germany, Haizhi Liu, Guihua Qi, Fuxi Yang, and Suqin Zhang from China. Dr. Linthe provided the frequency generator for the test. The instruments and the corresponding information are listed in Table 3.

Table 3. Instruments and testing specifications

Participants	Instruments type	Date of test	Start time (UTC)	Duration of test(s)	Sampling rate (Samples/Second)	Number of samples
H.J. Linthe, Germany	GSM19	Sep 16, 2010	04:29:57	185	1/5	37
Suqin Zhang, China	G856AX	Sep 16, 2010	04:25:38	100	1/5	20
Haizhi Liu(26#), China	G856T	Sep 16, 2010	04:12:20	100	1/5	20
Haizhi Liu(27#), China	G856T	Sep 16, 2010	04:19:24	170	1/5	34

All tests were performed on Sep 16th, 2010. These test systems were compared against the Changchun Observatory GSM-90 Overhauser magnetometer with 1Hz sampling rate. The data collected by the GSM-90 Overhauser magnetometer at Changchun Observatory were displayed in Figure 5.

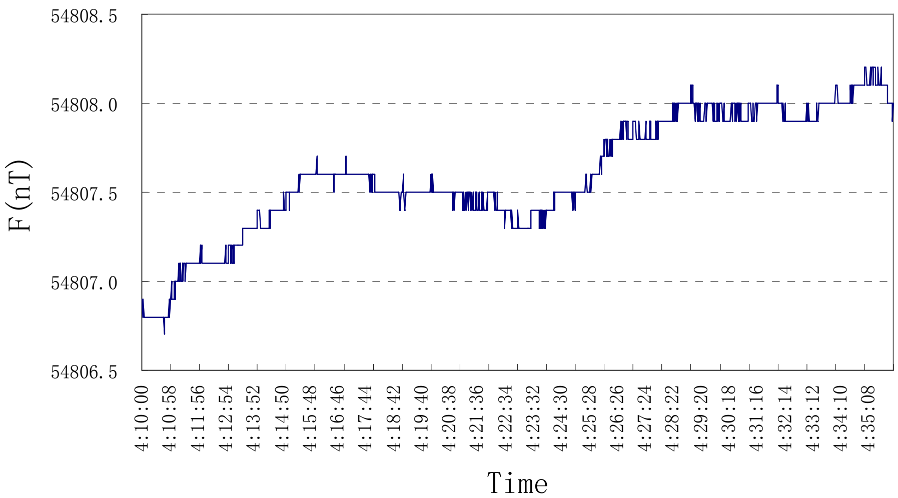

Figure 5. Second data curve of GSM-90 at Changchun Observatory in the observation period

The data collected by test systems were directly compared to the corresponding samples collected by the Changchun Observatory system. The pier difference (ΔF) for each system is plotted in Figure 6, and the mean values and standard deviations were also calculated as presented in Table 4.

Table 4. Pier difference (ΔF) results

Participants	Mean ΔF	Standard Deviation ΔF
H. J. Linthe, Germany	2.77nT	0.03nT
Suqin Zhang, China	2.77nT	0.15nT
Haizhi Liu(26#), China	3.97nT	0.15nT
Haizhi Liu(27#), China	3.10nT	0.09nT

Range in ΔF	1.2nT

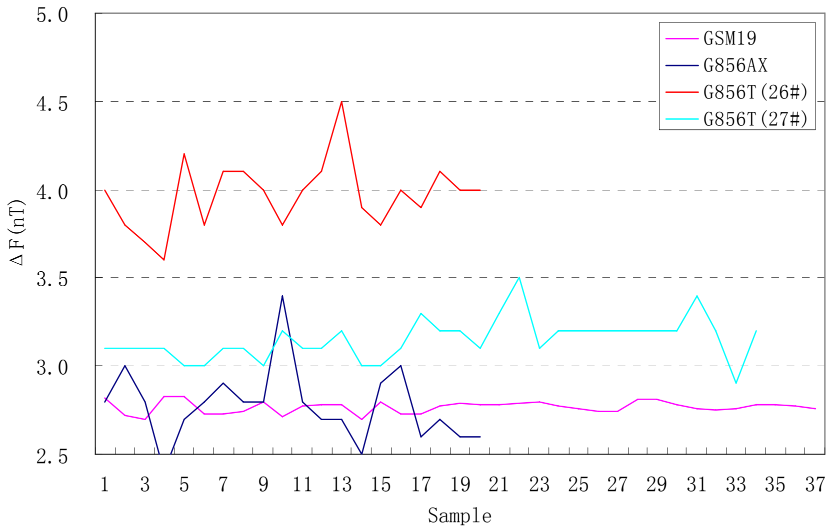

Figure 6. Pier difference (ΔF) for each system.

The frequency test was also applied to total field magnetometer comparison. The proton precession magnetometer or simply proton magnetometer is based on free precession of protons in a liquid. The angular precession ω of protons depends linearly on the magnetic field (Jankowski & Sucksdorff, 1996),

$$\omega=2\pi f=\gamma p F \qquad (1)$$

where γp is the gyromagnetic ratio of the proton, which is a natural constant known with high accuracy. The value adopted by IAGA is $\gamma p=2.6751525*10^{8}T^{-1}s^{-1}$. The gyrofrequency f of protons is measurable in magnetic fields that are of the same order of magnitude as the field of the Earth. F and f are connected by Equation (1). From this equation it follows that 1 Hz corresponds to 23.48720 nT. Therefore, the frequency generator can be used to calibrate the sensors. The test data for each system are listed in Tables 5 to 8, and the Summary of Proton Magnetometer Frequency Test is shown in Table 9.

Table 5. Proton Magnetometer Frequency Test of GSM19

No.	Frequency/Hz	Nominal reading /nT	Real reading /nT	Derivation /nT
3	1,066.67	25053.10	25052.97	-0.13
4	1,280.00	30063.62	30063.57	-0.05
5	1,600.00	37579.53	37579.44	-0.09
6	2,133.33	50105.96	50105.92	-0.04
7	3,199.99	75158.82	75158.86	0.04
Average				-0.05

Table 6. Proton Magnetometer Frequency Test of G856AX

No.	Frequency/Hz	Nominal reading /nT	Real reading /nT	Derivation /nT
3	1,066.67	25053.10	25053.00	-0.10
4	1,280.00	30063.62	30063.40	-0.22
5	1,600.00	37579.53	37579.40	-0.13
6	2,133.33	50105.96	50105.80	-0.16
7	3,199.99	75158.82	75158.80	-0.02
Average				-0.13

Table 7. Proton Magnetometer Frequency Test of G856T(26#)

No.	Frequency/Hz	Nominal reading /nT	Real reading /nT	Derivation /nT
3	1066.67	25053.10	25053.30	0.20
4	1,280.00	30063.62	30063.80	0.18
5	1,600.00	37579.53	37579.90	0.37
6	2,133.33	50105.96	50106.50	0.54
7	3,199.99	75158.82	75159.10	0.28
Average				0.31

Table 8. Proton Magnetometer Frequency Test of G856T(27#)

No.	Frequency/Hz	Nominal reading /nT	Real reading /nT	Derivation /nT
3	1,066.67	25053.10	25053.30	0.20
4	1,280.00	30063.62	30064.00	0.38
5	1,600.00	37579.53	37579.90	0.37
6	2,133.33	50105.96	50106.50	0.54
7	3,199.99	75158.82	75159.00	0.18
Average				0.33

Table 9. Summary of Proton Magnetometer Frequency Test

No.	Frequency/Hz	GSM19	G856AX	G856T(26#)	G856T(27#)
3	1066.67	-0.13	-0.10	0.2	0.2
4	1280.00	-0.05	-0.22	0.18	0.38
5	1600.00	-0.09	-0.13	0.37	0.37
6	2133.33	-0.04	-0.16	0.54	0.54
7	3199.99	0.04	-0.02	0.28	0.18
Average		-0.05	-0.13	0.31	0.33

4 CONCLUSIONS

After intense systematic comparison measurements made by all the participating observers, rather good and encouraging results were achieved in the measurement session. In addition, information and experience exchanged amongst participants will be beneficial to future studies of the Earth's magnetic field at geomagnetic observatories.

5 REFERENCES

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