XVth IAGA WORKSHOP

ON GEOMAGNETIC OBSERVATORY INSTRUMENTS,

DATA ACQUISITION AND PROCESSING

(San Fernando, Cádiz, Spain, June 4th – 14th, 2012)

Measurement Session Results

Introduction

The absolute measurement session of the XV IAGA Workshop was held at San Fernando Magnetic Observatory (SFS) [June 5-8, 2012] at Garrapilos. The main focus of this session was for observers to make and compare measurements using DI-Flux magnetometers, scalar magnetometers and variometers. The session also included absolute measurement training carry out by Anca Isac (Geological Institute of Romania) and Errol Julies (SANSA Space Science, South Africa).

Testing and demonstration of three instruments under development were also carried out during the absolute measurement session:

- The auto DI Flux - Dr. Jean Rasson (Royal Meteorological Institute of Belgium).
- A triaxial DI Flux – Uli Auster (TU Braunschweig, Germany).
- A delta Declination/delta Inclination (dIdD) magnetometer - Laszlo Hegymegi (Mingeo Ltd, Hungary).

Scalar Magnetometer frequency test and comparison

The procedure consisted on a frequency test based on a checking through standard frequencies (instrument provided by H.J. Linthe - Niemegk Geomagnetic Observatory, Germany) and an inter-comparison with our master for a period of about 20 minutes with a sampling rate of 10 sec.

Scalar magnetometers, participants and results in this measurement session are listed below in Table 1.

Table 1

List of scalar magnetometers, observers and differences with master (model GSM-90F1)

No	NAME	COUNTRY	INSTRUMENT	DATE	DIFFERENCE (nT)
1	B. Leitcher	Austria	Elsec 820 S/N 002084	06/06/2012	1.86+/-0.67
2	H.J. Linthe	Germany	GSM-19 S/N 410376	06/06/2012	0.48+/-0.09
3	L. Iancu(*)	Romania	Geometrics G-856 AX S/N 277996	06/06/2012	-0.08+/-0.32
4	J.L. Marin	Belgium	GSM-19W S/N 9053243	07/06/2012	0.58+/-0.10
5	S. Marsal	Spain	GSM-19 S/N 1041065	08/06/2012	-0.28+/-0.08
6	P. Covisa	Spain	GSM-19 S/N 707714	08/06/2012	-0.13+/-0.18
7	P. Covisa	Spain	G-856 S/N 50453	08/06/2012	-0.08+/-0.14

(*) This instrument was subjected to a frequency test. This checking shows an average error of -0.43 nT.

Variometer comparison

The procedure consisted of an inter-comparison using as masters SFS's variometers during one night period. These instruments are located inside the variometer hut, which is thermally isolated using an external air conditioning system. The orientation for the variometers used as masters were HDZ with a 5 sec.-sampling rate. The instruments to be checked were located on an external pier under a tent without temperature control. LOC performed absolute observations at the beginning and end of the intercomparison period to base the analysis on absolutes values, minimizing the effect of misorientations.

Two variometers have been brought for intercomparison: A. Marusenkov (Lviv Centre of Institute for Space Research, Ukraine) model LEMI-031 low power (called **Var1** from now onward), and by U. Auster and Sandra Suarez (Magson GmbH, Germany) (called **Var2** from now onward).

We have compared both variometers registers against our two, which were installed on a Temperature controlled house as previously stated.

The temperature register shows three phases, which are delimited by two black vertical lines. The first period cover from the beginning of register until sunset. It shows a variation of 12ºC (approx.). A second period covers nighttime. During this period of time, temperature varied in a smoothly way. A third period starts at sunrise and extends until completion of register. This last period shows the strongest rate in temperature variation (7ºC/hr approx.). See figure 1.

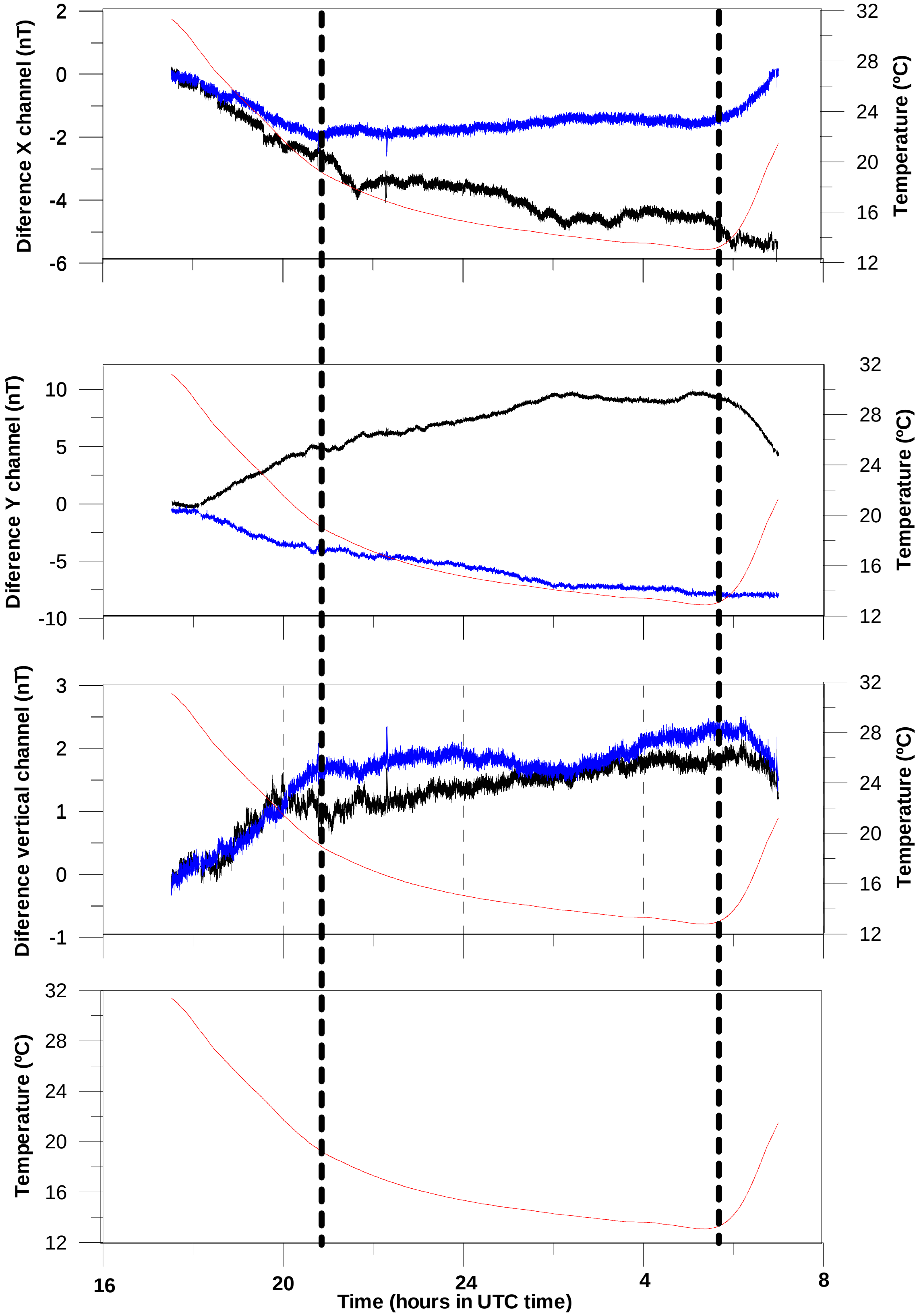

Figure 1: Black color corresponds to Var1. Blue color corresponds to Var2. In red the temperature variation is plotted. Uppermost, mid-upper and mid-lower plots denote residuals obtained after comparison against one of our variometers. Lowermost plot shows the variation of Temperature along the whole period of analysis. Two black dotted vertical lines divide the analysis in three segments: before sunset (First period), nighttime (Second period), and after sunrise (third period).

We include in Table 2 some temperature coefficient where possible, avoiding those periods where the rate of temperature variation was not uniform, as it distorted the correlation between both variables (magnetic component residual and temperature).

Table 2: Variometers Temperature Coefficients

		First Period	Second period	Third period
X residual (T. Coeff. - nT/°C)	**Var1**	0.23	0.25	-0.02
	Var2	0.16	-0.04	0.18
Y residual (T. Coeff. - nT/°C)	**Var1**	-0.55	-0.68	-0.68
	Var2	0.33	0.64	0.005
Z residual (T. Coeff. - nT/°C)	**Var1**	-0.13	-0.12	-0.04
	Var2	-0.11	Not clear	-0.09

DI Flux Comparison

Prior to the workshop several Total field and absolute measurements of declination and inclination were made at pillars 1, 2, 3, 4, 5 and 6 to calculate D (declination), H (horizontal intensity), and Z (vertical intensity) and scalar differences between pillars. Measurements were made by SFS staff, using their absolute instrumentation (MAG01H fluxgate magnetometer, and GEM Systems GSM-90F1 scalar magnetometer). The location of pillars 1 through 6 is showed in Figure 2 and the adopted D, H, Z, and F differences are shown in Table 3. Pillar 1 was chosen as reference. Offset between pillars were measured again after installation of the tents to assure that they do not introduce any magnetic bias or noise.

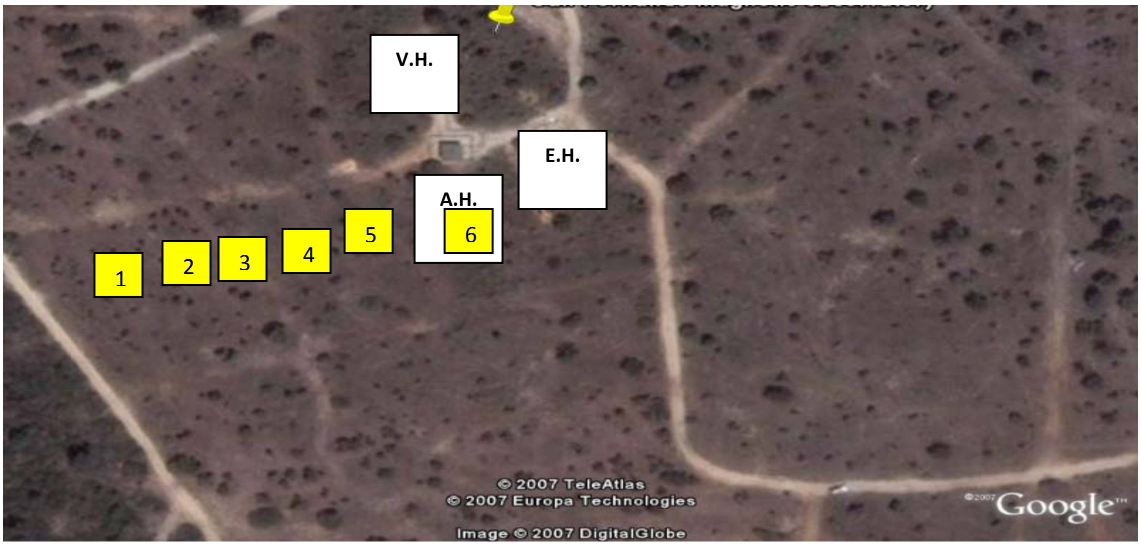

Figure 2: pillar locations. V.H.: Variometer Hut., E.H.: Electronic House, A.H.: Absolute House.

Table 3: D, H, Z and F differences for measurements pillars

	CorrD to Pillar 1 (min)	CorrH to Pillar 1 (nT)	CorrZ to Pillar 1 (nT)	CorrF to Pillar 1 (nT)
Pillar 2	0.57	0.70	-0.99	-0.30
Pillar 3	0.29	-1.05	1.45	0.40
Pillar 4	0.59	-0.14	-3.78	-3.10
Pillar 5	0.81	-1.28	-2.26	-2.50
Pillar 6	3.56	-7.58	-4.14	-8.05

During the workshop was detected that the window near pier 6 (absolute house) could interfere when opened. After the workshop SFS staff performed absolute measurements with the window completed closed and completed opened to quantify this effect. No differences were appreciated.

In the afternoon of June 5th and during 15 minutes, a car inadvertently parked close to the variometer house. It caused interferences. Four observations in that period were rejected (they affected to the following observers: A. Csontos, M. Sale and U. Auster).

The reference levels (zero level) for D, H, and Z were adopted from the average of all the measurements performed by the session's participants once referred to pillar 1, and the series of absolutes observations performed prior the workshop. Measurements outside two standard deviations were discarded. The reference level for D is 145.9±0.94 minutes; H is 27349.2±3.96 nT; Z is 33054.9±3.26 nT.

41 magnetometers and 35 observers participated in the DI-Flux absolute measurement session. The DI-Flux magnetometers and observers that participated in the absolute measurement session are listed below in Table 4.

Table 4

List of DI-Flux instruments and observers

No	NAME	COUNTRY	INSTRUMENT
1	A. Berarducci	United States	Zeiss-Theo 020 DTU fluxgate magnetometer S/N 313836
2	A. Berarducci	United States	Zeiss-Theo 020 DTU fluxgate magnetometer (Compass Rose Surveying, Inc) S/N 616061
3	A. Berarducci	United States	Zeiss-Theo 020 DTU fluxgate magnetometer (Samoa) S/N 618312
4	A. Berarducci	United States	Zeiss-Theo 010 (L. Hegymegi´s fluxet magnetometer-Mingeo) S/N 107702
5	A. Csontos	Hungary	Theo-010B / S/N 107702 (L. Hegymegi´s fluxet prototipe)
6	A. Csontos	Hungary	Theo-010A / S/N 398205
7	A. Muslim	Maldives	Zeiss-Theo 020 DTU fluxgate magnetometer (Compass Rose Surveying, Inc) S/N 616061
8	B Harbour	United States	Zeiss-Theo 010 S/N 109648 / DTU Fluxgate S/N 0145
9	B. Leichter	Austria	Zeiss-Theo 010B S/N 154167 / MAG01H S/N 0619H
10	B. Worthington	United States	Zeiss-Theo 010 S/N 109648 / DTU Fluxgate S/N 0145
11	C. Turbitt	United Kingdom	Theo 010A S/N 814835 / Mag01H 0754H
12	D. Calp	Canada	Jena/Zeiss-Theo 010A S/N 392476 / Bartington MAG01H S/N 000772H
13	E. Cabrera	Argentina	Theo 010A S/N 814635 / MAG01H S/N 0754H
14	E. Julies	South Africa	Zeiss-Theo 010B S/N 152471
15	E. Nahayo	South Africa	Zeiss-Theo 010B S/N 152471
16	F. Valach	Slovakia	Theo-3T2KPNM S/N 39601 / LEMI-203
17	G. Cifuentes	México	Zeiss-Theo 020A S/N 3047
18	H.J. Linthe	Germany	Zeiss-Theo 010B S/N 105958 / MAG01H Bartington S/N 0714H
19	J. Horacek	Czech Republic	Theo 010B / MAG 01H Bartington S/N 154031
20	J.E. Hernández	México	Zeiss-Theo 010A S/N 200059
21	J.L. Marin	Belgium	Zeiss-Theo 020A S/N 616124 / FLM2/A
22	K. Pajunpáá	Finland	Theo 010B S/N 153456
23	L. Iancu	Romania	Zeiss-Theo 010B S/N 160496 / MAG 01H S/N 402, S/N 0658H
24	L. Wang	Australia	Zeiss-Theo 010B S/N 160459 / MAG01H S/N 0610H
25	L.W. Perdersen	Denmark	Zeiss 010B S/N 107591 / D-I Fluxgate magnetometer, model G
26	M. Lim	Republic of Korea	Zeiss-Theo 010B S/N 105963 MAG01H Bartington S/N 788H
27	M. Vaczyova	Slovakia	Theo-3T2KPNM S/N 39601 / LEMI-203
28	M. Vlk	Czech Republic	Theo 010B / MAG 01H Bartington S/N 154031
29	Me Sale	Samoa	Zeiss-Theo 020 DTU fluxgate magnetometer S/N 313836
30	Me Sale	Samoa	Zeiss-Theo 020 DTU fluxgate magnetometer (Samoa) S/N 618312
31	P. Covisa	Spain	Zeiss-Theo 010B S/N 154747
32	R. Leonhardt	Austria	Theo-Leica F.-Nr: 231067 / MAG01H, S/N 562 Electronic S/N 1024H
33	S. Marsal	Spain	Zeiss-Theo 010B S/N 152076 / Elsec
34	S. Nagamachi	Japan	Theo 010B S/N 0624H
35	T. Bayer	Czech Republic	Theo 010B / MAG 01H Bartington S/N 154031
36	T. Raita	Finland	Theo 010B S/N 153456
37	T. Shanahan	United Kingdom	Carls-Zeiss Jena 010A S/N 814835 / Bartington MAG-01H S/N 0754H
38	U. Auster	Germany	Zeiss-Theo 010B S/N 101245 / Magson GmbH 3D fluxgate magnetometer
39	U. Auster	Germany	Zeiss-Theo 020 S/N 618312 / Magson GmbH 3D fluxgate magnetometer
40	W.S. Kim	Republic of Korea	Zeiss-Theo 010A S/N 811815
41	Y. Lipko	Russian Federation	Zeiss-Theo 010B S/N 152471

Results of the absolute measurement session of D, H, and Z are displayed in figures 3, 4, and 5 respectively. Results are shown in tabular form in Tables 5, 6, and 7.

Yellow cells in Tables 5, 6, and 7 show values which were excluded from the calculation of averages (these values were outside two standard deviations and are shown for information only), in the same Tables some values in red, clearly out of range, have been disregarded.

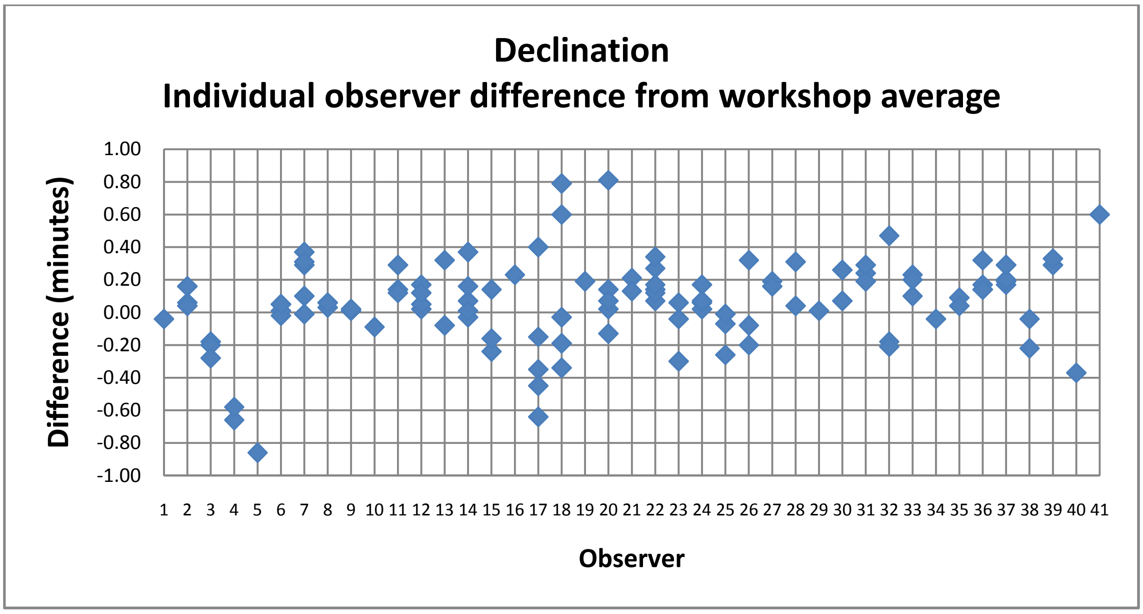

Figure 3

Individual observer differences from workshop average (Declination) referred to pillar 1. All measurements outside two standard deviations have been removed.

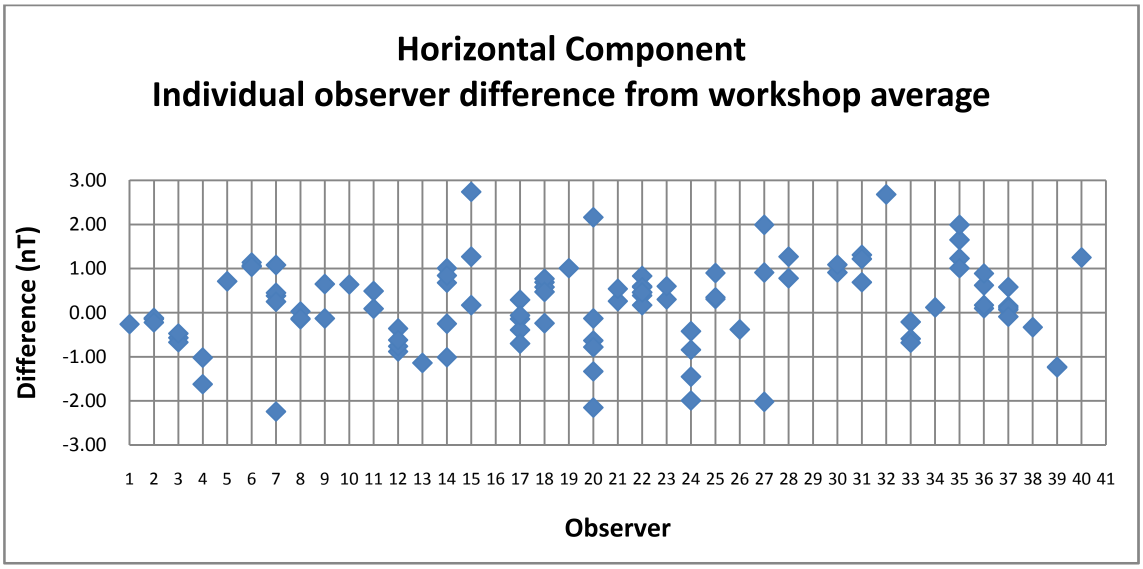

Figure 4

Individual observer difference from workshop average (Horizontal component) referred to pillar 1. All measurements outside two standard deviations have been removed.

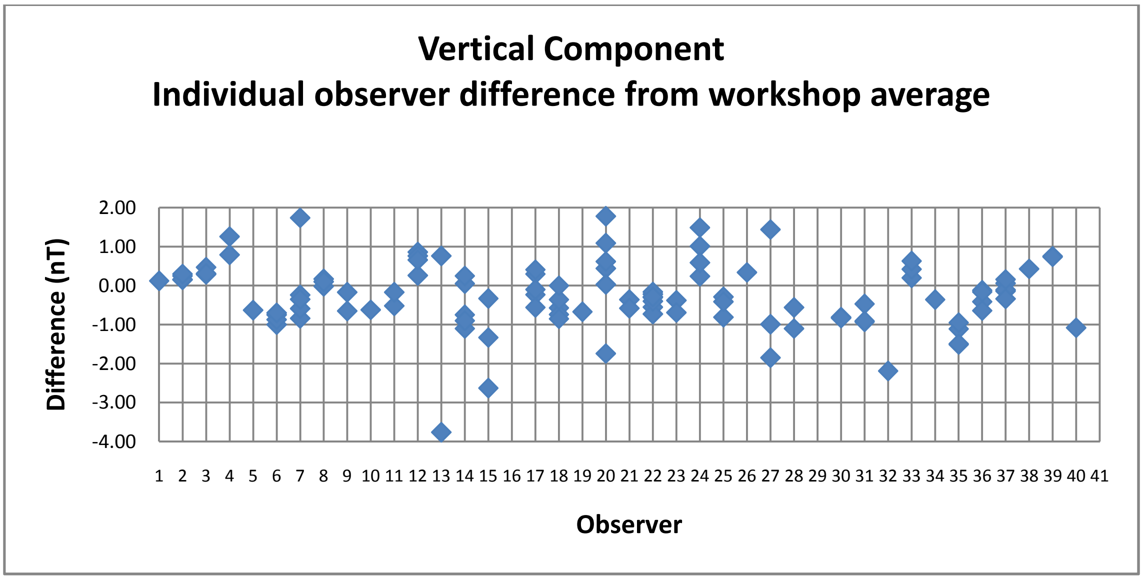

Figure 5

Individual observer difference from workshop average (Vertical component) referred to pillar 1. All measurements outside two standard deviations have been removed.

Table 5

Individual observer difference from workshop average (declination). Measurements outside two standard deviations were not used in calculating workshop averages. Units in minutes. *Obs*: Observation

No	Obs 1	Obs2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Average	Std
1	-0.04							-0.04	0.00
2	0.06	0.04	0.16	0.16				0.10	0.06
3	-0.18	-0.20	-0.28					-0.22	0.05
4	-0.66	-0.58						-0.62	0.06
5	-0.86							-0.86	0.00
6	0.01	-0.02	0.05	0.05				0.02	0.03
7	0.1	0.29	0.37	-0.01	0.31			0.21	0.16
8	0.03	0.06	0.06					0.05	0.02
9	0.01	0.02						0.02	0.01
10	-0.09							-0.09	0.00
11	0.14	0.29	0.12					0.18	0.09
12	0.02	0.05	0.17	0.12				0.09	0.07
13	-0.08	0.32						0.12	0.28
14	-0.03	0.07	0.01	0.16	0.37			0.12	0.16
15	-0.24	-0.16	0.14					-0.09	0.20
16	0.23							0.23	0.00
17	-0.64	0.4	-0.15	-0.35	-0.45			-0.24	0.40
18	0.79	-0.34	-0.19	0.6	-0.03			0.17	0.50
19	0.19							0.19	0.00
20	0.81	0.02	0.14	-1.48	0.07	-0.13		0.18	0.36
21	0.21	0.13						0.17	0.06
22	0.14	0.27	0.34	0.07	0.14	0.12	0.17	0.18	0.09
23	-0.30	0.06	-0.04					-0.09	0.19
24	0.17	0.02	0.06	0.07				0.08	0.06
25	-0.07	-0.01	-0.26					-0.11	0.13
26	0.32	-0.08	-0.2					0.01	0.27
27	0.19	0.16	0.16					0.17	0.02
28	0.04	0.31						0.17	0.19
29	0.01							0.01	0.00
30	0.26	0.07						0.16	0.13
31	0.24	0.19	0.29					0.24	0.05
32	0.47	-0.18	-0.21					0.03	0.38
33	0.10	0.23	0.20					0.18	0.07
34	-0.04							-0.04	0.00
35	-2.76	-2.90	0.09	0.04				0.07	0.04
36	0.32	0.14	0.17	0.14				0.19	0.09
37	0.17	0.29	0.19	0.20	0.29			0.23	0.06
38	-0.22	-0.04						-0.13	0.13
39	0.29	0.33						0.31	0.03
40	-138.58	-0.37						-0.37	0.00
41	0.60							0.60	0.00

Table 6

Individual observer difference from workshop average (Horizontal component). Measurements outside two standard deviations were not used in calculating workshop averages. Units in nT.

No	Obs 1	Obs2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Average	Std
1	-0.26							-0.26	0.00
2	-0.14	-0.14	-0.12	-0.22				-0.16	0.04
3	-0.57	-0.67	-0.47					-0.57	0.10
4	-1.02	-1.62						-1.32	0.42
5	0.71							0.71	0.00
6	1.05	1.07	1.14	1.04				1.07	0.05
7	0.38	1.08	0.45	0.25	-2.24			-0.02	1.28
8	-0.15	0.03	-0.13					-0.08	0.10
9	-0.13	0.65						0.26	0.55
10	0.64							0.64	0.00
11	0.49	0.09						0.29	0.28
12	-0.36	-0.88	-0.76	-0.62				-0.66	0.22
13	4.28	-1.14						-1.14	0.00
14	1.01	0.68	0.84	-0.25	-1.01			0.25	0.86
15	2.74	1.27	0.17					1.39	1.29
16	-48.03								
17	-0.14	-0.39	0.29	-0.7	-0.06			-0.20	0.37
18	0.69	0.58	0.77	0.47	-0.24			0.45	0.40
19	1.01							1.01	0.00
20	2.16	-0.63	-0.13	-2.15	-0.78	-1.33		-0.48	1.46
21	0.26	0.54						0.40	0.20
22	0.39	0.46	0.6	0.83	0.58	0.17	0.46	0.50	0.20
23	-8.70	0.30	0.60					0.45	0.21
24	-1.45	-1.99	-0.42	-0.84				-1.18	0.69
25	0.90	0.31	0.35					0.52	0.33
26			-0.38					-0.38	0.00
27	1.99	-2.02	0.91					0.29	2.07
28	0.78	1.27						1.02	0.35
29	-12.76								
30	0.91	1.09						1.00	0.13
31	0.69	1.31	1.22					1.07	0.34
32		-9.27	2.68					2.68	0.00
33	-0.21	-0.59	-0.68					-0.49	0.25
34	0.12							0.12	0.00
35	1.23	1.65	1.01	1.99				1.47	0.44
36	0.62	0.10	0.89	0.17				0.45	0.38
37	0.07	0.15	0.11	-0.09	0.58			0.16	0.25
38		-0.33						-0.33	0.00
39	-1.24	-1.23						-1.23	0.01
40	-202.23	1.25						1.25	0.00
41	-36.81								

Table 7

Individual observer difference from workshop average (Vertical component). Measurements outside two standard deviations were not used in calculating workshop averages. Units in nT.

No	Obs 1	Obs2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Average	Std
1	0.12							0.12	0.00
2	0.15	0.25	0.16	0.3				0.21	0.07
3	0.29	0.47	0.31					0.36	0.10
4	0.79	1.26						1.02	0.33
5	-0.63							-0.63	0.00
6	-0.75	-1.00	-0.87	-0.70				-0.83	0.13
7	-0.24	-0.84	-0.59	-0.35	1.74			-0.06	1.03
8	0.17	-0.02	0.10					0.08	0.10
9	-0.17	-0.65						-0.41	0.34
10	-0.62							-0.62	0.00
11	-0.52	-0.17						-0.35	0.25
12	0.26	0.86	0.76	0.66				0.64	0.26
13	-3.76	0.76						-1.50	3.20
14	-1.10	-0.75	-0.90	0.05	0.25			-0.49	0.60
15	-2.63	-1.33	-0.33					-1.43	1.15
16	39.79								
17	0.3	0.41	-0.23	-0.1	-0.56			-0.04	0.40
18	-0.57	-0.74	-0.85	-0.36	0.00			-0.50	0.34
19	-0.67							-0.67	0.00
20	-1.74	0.44	0.03	1.78	0.62	1.09		0.37	1.20
21	-0.36	-0.58						-0.47	0.16
22	-0.22	-0.3	-0.55	-0.73	-0.4	-0.16	-0.29	-0.38	0.20
23	6.90	-0.38	-0.69					-0.54	0.22
24	1.01	1.49	0.24	0.59				0.83	0.54
25	-0.81	-0.29	-0.41					-0.50	0.27
26			0.34					0.34	0.00
27	-1.85	1.44	-0.99					-0.47	1.71
28	-0.56	-1.10						-0.83	0.38
29	10.38								
30	-0.81	-0.83						-0.82	0.01
31	-0.47	-0.93	-0.91					-0.77	0.26
32		7.51	-2.19					-2.19	0.00
33	0.20	0.42	0.63					0.42	0.22
34	-0.36							-0.36	0.00
35	-1.11	-1.51	-0.95	-1.49				-1.26	0.28
36	-0.41	-0.12	-0.64	-0.16				-0.33	0.24
37	0.06	-0.14	-0.11	0.16	-0.34			-0.07	0.19
38		0.43						0.43	0.00
39	0.75	0.74						0.75	0.01
40	166.58	-1.08						-1.08	0.00
41	29.87								