

NATIONAL ANTARCTIC RESEARCH PROGRAM

Mario Zucchelli Station, Antarctica Geomagnetic Observatory

Magnetic Observation Results 2012-2013

G. Benedetti, L. Cafarella, G. Dominici, S. Lepidi, M. Pietrolungo, L. Santarelli and A. Zirizzotti

Geomagnetic Observation Results 2012-2013 Mario Zucchelli Station - Antarctica

Introduction

This report deals with activities undertaken at the Antarctic Italian Geomagnetic Observatory during the austral summer 2012-2013.

The coordinates of the Observatory at OASI are the following:

Geographic latitude:	74.6936°S
Geographic longitude:	164.0975°E
Corrected Geomagnetic latitude (IGRF13):	79.92°S
Corrected Geomagnetic longitude (IGRF13):	306.40°E
Magnetic local time midnight:	08:17 UT

This report describes the activities performed from October 29 to November 25, 2012.

For the present work H, D and Z INTERMAGNET formatted data from the fluxgate magnetometer EDA have been used.

The proton precession magnetometers used to record F total values were Overhauser type; for a description of instruments we refer to geomagnetism text books, for example Parkinson (1983) and Wienert (1970).

Since the total intensity F time variations, at polar latitudes, where values of inclination is almost 90°, are very close to the vertical component Z time variations, the plots of total intensity time variations are not shown. They can however be obtained from the well known equation:

$$F^2=H^2+Z^2$$

Absolute measurements

For the normal absolute measurements-taking at the Observatory, a standard fluxgate magnetometer theodolite for the determination of D, I angles has been used.

At OASI three different azimuth marks are available, for the computation of the Declination (please refer to the 2001/2002 report for details). The coordinates of geodetic points (mark piers and measuring location) were established on the basis of GPS measurements. From these coordinates the azimuth values 152° 44' 04'', 60° 13' 36'' and 338° 07' 59'' were found.

The proton magnetometer recordings, continuously undertaken during the execution of the DI measurements, have allowed the calculation of the absolute intensive elements.

Table 1 shows absolute measurement values for each element; the values of the intensive components H and Z (rounded off to the nT) were computed using the relations:

$$H = F \cdot \cos I$$
$$Z = F \cdot \sin I$$

H₀ and D₀ reference values computation

Since the fluxgate was magnetically oriented in the horizontal plane, as in the previous installations, it was necessary to compute H₀ and D₀ reference values, comparing absolute and relative measurements, at the same time. For the Z component, once the vertical levelling of the sensor was assured, it was assumed that the variations measured by fluxgate were actually the vertical component of the geomagnetic field variations.

In the description the mathematical procedure used for computation of H₀ and D₀, the following symbols are used:

H ₀ , D ₀	Reference values
H _{abs} , D _{abs}	Values of absolute measurements at time t
x,y	Instantaneous variations recorded by fluxgate system at time t

For each absolute measurement, the reference values were computed as:

$$H_0 = H_{abs} \cos(\varphi) - x$$
$$D_0 = D_{abs} - \varphi$$

where

$$\varphi = \arcsin (y/H_{abs})$$

In order to reduce this dispersion in the set, the Chauvenet criterion was used. The method, based on the hypothesis of a Gauss probability distribution for the data, consists in the elimination of measurements whose difference from the average is greater than a multiple of the standard deviation fixed by the sample dimension (in this case a value 2.74 σ , corresponding to a sample of about 91 data elements, was used). This method, however, cannot be applied more than once, since an iterative procedure could exclude most of the values up to the complete elimination of the data (Worthing and Jeffner, 1943).

The average values of H₀ and D₀ are:

$$H_0 = (8028 \pm 8) \text{ nT}$$
$$D_0 = (136.02 \pm 0.07) \text{ deg}$$

Daily base lines computation

After H₀ and D₀ reference values are found, the computation of the base lines in relation to absolute measurements and then the computation of the daily base lines for all days, can follow. The available data are the H, D and Z magnetic element variations recorded by fluxgate system (sampling rate 1 minute) and the absolute measurements recorded from October 29 to November 25, 2012.

The base lines computation was undertaken by two different procedures. In the case of Z, assuming that the fluxgate recordings show the variations of the vertical components, the base line (B_Z) was

computed as the difference between the absolute measurements (Z_{abs}) and the fluxgate measurements (z). On the other hand, in the case of H and D, the magnetic orientation of the fluxgate system axes was taken into account. Using H_0 and D_0 reference values, the H and D base lines were computed for each absolute measurement as:

$$B_H = H_{abs} - [(H_0+x)^2 + y^2]^{1/2}$$
$$B_D = D_{abs} - D_0 - \arctg[y/(x+ H_0)]$$

Mean daily values of the base lines were obtained for those days in which more than one absolute measurement was available.

In order to have a daily base line for each magnetic element, a linear regression analysis using the least squares method has been undertaken. The results are shown in Fig. 1, where the experimental data, as well as the best fit lines are reported.

Using the daily base lines, one minute values for the three field elements H, D and Z were computed as:

$$H = [(H_0+x)^2 + y^2]^{1/2} + B_H$$
$$D = D_0 + \arctg[y/(x+ H_0)] + B_D$$
$$Z = z + B_Z$$

The measurements are reduced to the old site subtracting the following gradient:

$$\Delta H = -1.5 \text{ nT}$$
$$\Delta D = 13.0'$$
$$\Delta Z = 0.7 \text{ nT}$$

In Tables 2, 3, 4 all the hourly and daily averages and the total mean values for the H, D and Z elements on the entire measuring period (from October 29 to November 25, 2012) are reported; the relative plots are shown in Fig. 2. The plots of the one minute data follow in succession.

Geomagnetic field trend (1987-2013)

The availability of a long series of data since 1987 allows to evaluate the geomagnetic field trend. For each antarctic campaign we computed the average value of H, D, Z and F over the time period in which the absolute measurements were performed. In Fig.10 we show these values together with the corresponding IGRF values obtained from the web site: <http://www.geomag.bgs.ac.uk>.

References

- Azzara R., E. Bozzo, G. Caneva, A. Meloni and G. Romeo, 1989, Geomagnetic Observation results 1986-1987, National Antarctic Research Program, PNRA, 78p.
- Azzara R., E. Bozzo, G. Caneva, A. Meloni and G. Romeo, 1990, Geomagnetic Observation results 1987-1988, National Antarctic Research Program, PNRA, 80p.
- Azzara R., E. Bozzo, G. Caneva, A. Meloni and G. Romeo, 1991, Geomagnetic Observation results 1988-1989, National Antarctic Research Program, PNRA, 52p.
- Baskaradas J. A., L. Cafarella, M. Di Persio, S. Lepidi, M. Pietrolungo and L. Santarelli, 2012, Geomagnetic Observation results 2010-2011, National Antarctic Research Program, PNRA, 26p.
http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari
- Benedetti G., L. Cafarella, G. Dominici, S. Lepidi, M. Pietrolungo, L. Santarelli and A. Zirizzotti, 2015 Geomagnetic Observation results 2011-2012, National Antarctic Research Program, PNRA, 57p.
http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari
- Bozzo E., G. Caneva, A. Meloni, P. Palangio, B. Palombo, L. Perrone and G. Romeo, 1992, Geomagnetic Observation results 1989-1990, National Antarctic Research Program, PNRA, 79p.
- Bozzo E., G. Caneva, A. Meloni, P. Palangio, L. Perrone and G. Romeo, 1994, Geomagnetic Observation results 1990-1991, Mario Zucchelli Station - Antarctica, Terra Antarctica, Vol. 1, 185-217.
- Bozzo E., L. Cafarella, G. Caneva, C. Falcone, A. Meloni, P. Palangio and A. Zirizzotti, 1995, Geomagnetic Observation results 1991-1992/1992-1993, National Antarctic Research Program, PNRA, 54p.
- Bozzo E., L. Cafarella, G. Caneva, A. Meloni, P. Palangio and A. Zirizzotti, 1996, Geomagnetic Observation results 1993-1994, National Antarctic Research Program, PNRA, 71p.
- Cafarella L., M. Chiappini, A. Meloni and P. Palangio, 1997, Geomagnetic Observation results 1994-1995, National Antarctic Research Program, PNRA, 58p.
- Cafarella L., S. Lepidi, A. Meloni and P. Palangio, 1998, Geomagnetic Observation results 1995-1996, National Antarctic Research Program, PNRA, 55p.
- Cafarella L., S. Lepidi, A. Meloni and P. Palangio, 1998, Geomagnetic Observation results 1996-1997, National Antarctic Research Program, PNRA, 56p.
- Cafarella L., S. Lepidi, A. Meloni, P. Palangio, L. Santarelli, 2002, Geomagnetic Observation results 1998-1999, National Antarctic Research Program, PNRA, 61p.
- Cafarella L., D. Di Mauro, S. Lepidi, A. Meloni, P. Palangio, L. Santarelli and A. Zirizzotti, 2004, Geomagnetic Observation results 2000-2001, National Antarctic Research Program, PNRA, 39p.
- Cafarella L., D. Di Mauro, S. Lepidi, L. Magno, A. Meloni, P. Palangio, L. Santarelli and A. Zirizzotti, 2007, Geomagnetic Observation results 2001-2002 / 2002-2003, National Antarctic Research Program, PNRA, 66p.
- Cafarella L., D. Di Mauro, S. Lepidi, L. Magno, A. Meloni, P. Palangio, L. Santarelli and A. Zirizzotti, 2007, Geomagnetic Observation results 2003-2004 / 2004-2005, National Antarctic Research Program, PNRA, 36p.
- Cafarella L., S. Lepidi, A. Meloni, P. Palangio, M. Pietrolungo, L. Santarelli and A. Zirizzotti, 2008, Geomagnetic Observation results 2005-2006, National Antarctic Research Program, PNRA, 54p.
- Cafarella L., S. Lepidi, A. Meloni, P. Palangio, M. Pietrolungo, L. Santarelli and A. Zirizzotti, 2008, Geomagnetic Observation results 2006-2007, National Antarctic Research Program, PNRA, 31p.
http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari
- Cafarella L., S. Lepidi, A. Meloni, P. Palangio, M. Pietrolungo and L. Santarelli, 2011, Geomagnetic Observation results 2007-2008, National Antarctic Research Program, PNRA, 23p.

http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari

Cafarella L., S. Lepidi, A. Meloni, P. Palangio, M. Pietrolungo and L. Santarelli, 2011, Geomagnetic Observation results 2008-2009, National Antarctic Research Program, PNRA, 27p. http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari

Cafarella L., S. Lepidi, A. Meloni, P. Palangio, M. Pietrolungo, L. Santarelli and J. A. Baskaradas, 2011, Geomagnetic Observation results 2009-2010, National Antarctic Research Program, PNRA, 25p. http://roma2.rm.ingv.it/it/risorse/banche_dati/32/dati_osservatorio_di_stazione_mario_zucchelli/46/annuari

Parkinson, W.D., 1983. Introduction to Geomagnetism. Scottish Academic Press. Edinburgh, London, 433 pp.

Wienert, K.A., 1970. Notes on Geomagnetic Observatory and survey practice; Unesco, Parigi.

Worthing, A. G., Jeffner J., 1943. Treatment of experimental data, John Wiley, New York.

Table captions

Table 1: Absolute measurement values 2012/2013

Table 2: Horizontal intensity hourly and daily means
(from October 29 to November 25, 2012)

Table 3: Declination hourly and daily means
(from October 29 to November 25, 2012)

Table 4: Vertical intensity hourly and daily means
(from October 29 to November 25, 2012)

Figure Captions

Fig 1: Scatter plot and linear regression for daily H, D and Z^1 base lines.

Fig 2: Hourly means of the H, D and Z^1 elements during the whole campaign.

Fig. 3 – 17: Daily plots of the one minute values of the H, D and Z^1 elements.

Fig. 18: Geomagnetic field trend since 1987.

¹ Z values must be considered negative

TNB Geomagnetic Observatory

Mean values

Campaign	H(nT)	D(deg min)		Z(nT)	F(nT)
1986/1987	7391	136	49	64494	64916
1987/1988	7432	136	54	64452	64879
1988/1989	7444	136	40	64355	64784
1989/1990	7509	136	48	64325	64762
1990/1991	7522	136	45	64254	64693
1991/1992	7564	136	29	64228	64672
1992/1993	7582	136	40	64166	64612
1993/1994	7610	136	41	64148	64598
1994/1995	7643	136	46	64112	64566
1995/1996	7682	136	29	64062	64521
1996/1997	7716	136	33	64018	64481
1997/1998	7756	136	27	63979	64447
1998/1999	7789	136	24	63932	64405
1999/2000	7829	136	14	63886	64364
2000/2001	7861	136	18	63848	64330
2001/2002	7889	136	02	63794	64280
2002/2003	7916	135	58	63761	64251
2003/2004	7929	135	48	63729	64220
2004/2005	7976	135	47	63697	64194
2005/2006	8002	135	40	63624	64125
2006/2007	8027	135	44	63587	64092
2007/2008	8062	135	38	63521	64031
2008/2009	8102	135	20	63467	63981
2009/2010	8136	135	14	63417	63936
2010/2011	8181	135	09	63370	63897
2011/2012	8231	134	41	63306	63840
2012/2013	8264	134	42	63292	63828

Table 1

Mario Zucchelli Station Geomagnetic Observatory

Absolute measurements 2012/2013

date julian day	D		(+)	I		(-)	(+)	(+)	(-)
	beg	end	D	beg	end	I	F	H	Z
	(UT)		(deg min)	(UT)		(deg min)	(nT)	(nT)	(nT)
303	06:04	6:09	134 47.6	6:11	6:19	82 29.9	63826	8334	63280
303	06:25	6:29	134 46.0	6:31	6:35	82 29.8	63829	8335	63282
304	04:50	4:54	134 48.6	4:56	5:01	82 29.6	63811	8337	63264
304	05:07	5:11	134 44.1	5:12	5:16	82 29.2	63815	8345	63267
304	05:21	5:25	134 41.2	5:27	5:32	82 29.2	63816	8344	63268
304	05:36	5:39	134 38.2	5:41	5:44	82 29.7	63816	8335	63269
305	06:37	6:40	134 29.4	6:42	6:45	82 31.0	63827	8313	63283
305	06:50	6:52	134 27.0	6:54	6:57	82 31.8	63824	8297	63282
305	07:01	7:04	134 24.5	7:05	7:08	82 31.8	63823	8297	63282
306	05:25	5:28	135 29.8	5:29	5:33	82 29.1	63820	8347	63272
306	05:38	5:42	135 22.8	5:44	5:48	82 29.0	63823	8348	63275
306	05:55	5:58	135 14.8	5:59	6:04	82 28.6	63828	8356	63279
306	06:09	6:12	135 01.6	6:15	6:18	82 27.9	63843	8372	63291
307	06:33	6:36	134 23.8	6:38	6:42	82 30.8	63897	8326	63352
307	06:48	6:51	134 21.6	6:52	6:55	82 31.3	63856	8312	63313
308	06:26	6:30	134 45.0	6:31	6:35	82 32.2	63835	8292	63294
308	06:40	6:43	134 43.9	6:44	6:48	82 32.0	63835	8294	63294
308	06:53	6:56	134 42.3	6:58	7:02	82 32.2	63837	8292	63297
309	05:53	5:56	134 27.1	5:57	6:02	82 30.0	63815	8329	63269
309	06:07	6:10	134 27.3	6:12	6:16	82 29.7	63821	8336	63275
309	06:21	6:24	134 26.6	6:26	6:30	82 30.0	63822	8330	63276
309	06:34	6:37	134 26.4	6:39	6:42	82 29.8	63826	8335	63280
310	05:09	5:13	134 33.6	5:14	5:18	82 31.0	63822	8312	63279
310	05:24	5:27	134 33.2	5:29	5:32	82 30.7	63819	8318	63274
310	05:37	5:40	134 36.1	5:41	5:45	82 30.8	63823	8315	63278
310	05:50	5:53	134 37.5	5:54	5:57	82 31.3	63826	8307	63283
311	04:42	4:45	135 07.0	4:46	4:51	82 31.2	63845	8312	63302
311	04:56	4:59	135 07.8	5:01	5:05	82 30.7	63818	8318	63274
311	05:10	5:13	135 07.2	5:15	5:18	82 30.1	63826	8329	63280
311	05:24	5:27	134 43.4	5:29	5:32	82 30.5	63827	8322	63282
312	08:38	8:41	134 21.0	8:43	8:47	82 29.6	-----	-----	-----
312	08:52	8:56	134 23.2	8:58	9:01	82 30.9	-----	-----	-----
312	09:06	9:09	134 14.2	9:10	9:14	82 31.4	-----	-----	-----
313	05:33	5:36	134 36.1	5:38	5:41	82 32.2	-----	-----	-----
313	05:45	5:48	134 40.4	5:49	5:52	82 32.3	-----	-----	-----
313	05:56	5:58	134 40.8	6:00	6:03	82 32.9	-----	-----	-----
313	06:07	6:09	134 35.4	6:11	6:14	82 32.9	-----	-----	-----
314	05:12	5:16	134 29.3	5:17	5:20	82 29.9	63828	8332	63282
314	05:26	5:29	134 31.4	5:30	5:34	82 29.8	63826	8334	63280
314	05:39	5:42	134 29.8	5:44	5:48	82 29.9	63828	8333	63282
314	05:53	5:55	134 26.9	5:57	6:00	82 29.9	63829	8332	63282
315	09:03	9:06	134 34.4	9:08	9:11	82 33.7	63836	8264	63299
315	09:16	9:20	134 33.1	9:22	9:25	82 33.4	63838	8271	63300
315	09:30	9:32	134 35.5	9:34	9:38	82 33.7	63837	8264	63300
315	09:43	9:46	134 34.8	9:47	9:50	82 33.6	63839	8265	63302
316	08:32	8:34	134 26.9	8:36	8:39	82 31.5	63837	8305	63294
316	08:42	8:45	134 26.2	8:47	8:50	82 30.9	63839	8316	63295
316	08:55	8:57	134 27.5	8:59	9:02	82 30.1	63842	8330	63296
317	05:01	5:04	134 30.9	5:05	5:08	82 30.4	63797	8321	63252
317	05:12	5:15	134 32.2	5:17	5:20	82 30.3	63801	8323	63256
317	05:24	5:27	134 32.6	5:28	5:30	82 30.1	63805	8326	63260

318	05:57	6:00	133	37.8	6:02	6:05	82	29.4	63867	8347	63319
318	06:09	6:12	133	41.2	6:14	6:17	82	32.2	63845	8292	63305
318	06:21	6:24	133	21.3	6:26	6:31	82	33.2	63817	8271	63279
318	06:35	6:38	133	27.0	6:39	6:42	82	32.7	63768	8274	63229
319	05:46	5:50	134	17.8	5:52	5:55	82	19.1	63877	8538	63304
319	06:04	6:06	134	19.4	6:08	6:11	82	19.2	63869	8536	63296
319	06:15	6:19	134	17.4	6:20	6:23	82	20.5	63861	8511	63292
319	06:27	6:30	134	23.5	6:31	6:34	82	21.2	63862	8498	63294
320	05:08	5:11	135	02.2	5:13	5:17	82	31.2	63843	8310	63300
320	05:21	5:24	135	04.8	5:26	5:30	82	31.3	63839	8308	63296
320	05:35	5:38	134	58.9	5:39	5:43	82	31.5	63847	8307	63305
320	05:47	5:50	134	56.9	5:51	5:55	82	30.9	63853	8317	63309
321	06:00	6:03	134	27.8	6:05	6:08	82	28.3	63809	8360	63259
321	06:12	6:15	134	22.5	6:16	6:20	82	28.5	63822	8358	63272
321	06:25	6:27	134	22.8	6:29	6:33	82	28.2	63818	8363	63267
321	06:37	6:40	134	18.6	6:41	6:45	82	29.6	63811	8336	63264
322	05:32	5:35	134	28.1	5:36	5:40	82	31.2	63773	8302	63231
322	05:44	5:47	134	30.5	5:50	5:54	82	31.3	63790	8303	63247
322	05:58	6:01	134	29.3	6:02	6:05	82	30.2	63806	8324	63261
322	06:11	6:14	134	25.6	6:15	6:18	82	29.6	63804	8335	63258
323	05:53	5:56	134	16.7	5:59	6:02	82	24.1	63837	8442	63276
323	06:07	6:10	134	33.0	6:11	6:15	82	25.1	63831	8422	63273
323	06:27	6:30	134	55.1	6:32	6:35	82	26.8	63825	8390	63271
324	05:46	5:48	134	59.2	5:50	5:53	82	31.1	63797	8307	63254
324	05:58	6:01	134	57.9	6:03	6:07	82	30.9	63807	8313	63264
324	06:11	6:14	134	54.6	6:15	6:18	82	30.7	63817	8316	63272
324	06:22	6:25	134	58.2	6:27	6:30	82	31.0	63818	8311	63274
325	04:58	5:00	135	25.1	5:01	5:05	82	25.5	63785	8409	63228
325	05:09	5:12	135	21.8	5:13	5:17	82	25.6	63788	8408	63232
325	05:21	5:24	135	20.8	5:25	5:28	82	25.8	63792	8403	63236
325	05:32	5:35	135	13.0	5:37	5:40	82	25.9	63810	8403	63254
326	05:56	5:59	134	56.7	6:01	6:05	82	29.8	63825	8335	63279
326	06:10	6:13	135	02.3	6:14	6:18	82	29.9	63819	8333	63273
326	06:22	6:25	134	54.0	6:26	6:30	82	29.6	63830	8338	63283
329	06:28	6:31	133	58.3	6:32	6:36	82	23.4	63894	8462	63331
329	06:39	6:42	134	10.7	6:43	6:46	82	24.6	63874	8437	63314
329	06:51	6:54	134	08.1	6:55	6:57	82	24.0	63888	8449	63326
330	06:11	6:14	134	09.7	6:16	6:19	82	29.8	63809	8332	63263
330	06:24	6:28	133	34.9	6:29	6:32	82	31.0	63813	8311	63269
330	06:37	6:40	133	33.8	6:41	6:44	82	33.0	63835	8276	63296

Table 2

Mario Zucchelli Station Antarctica, Italian Geomagnetic Observatory

Hourly H values (nT) from Oct 29 to Nov 25, 2012

UT	0	1	2	3	4	5	6	7	8	9	10	11	DAILY MEAN
	12	13	14	15	16	17	18	19	20	21	22	23	
julian day													
303	8250	8247	8266	8298	8311	8332	8332	8328	8317	8285	8271	8269	
	8257	8251	8252	8248	8242	8244	8226	8231	8208	8220	8227	8254	8265
304	8263	8256	8307	8338	8336	8343	8326	8316	8300	8294	8272	8264	
	8243	8256	8254	8257	8261	8268	8266	8262	8257	8252	8230	8265	8279
305	8275	8282	8284	8297	8308	8310	8314	8296	8288	8273	8266	8274	
	8260	8250	8239	8224	8226	8247	8294	8276	8240	8375	8226	8280	8275
306	8328	8213	8254	8264	8325	8341	8378	8409	8389	8325	8334	8267	
	8218	8143	8099	8053	8137	8139	8112	8116	8112	8180	8256	8324	8238
307	8362	8329	8314	8346	8357	8321	8320	8309	8282	8260	8258	8269	
	8259	8258	8257	8254	8255	8262	8253	8248	8221	8225	8247	8261	8280
308	8275	8288	8294	8303	8306	8302	8294	8287	8270	8258	8259	8265	
	8257	8264	8241	8246	8202	8150	8134	8179	8174	8235	8239	8266	8250
309	8295	8302	8330	8330	8339	8328	8334	8330	8298	8289	8278	8270	
	8256	8242	8239	8227	8207	8205	8245	8253	8253	8255	8256	8259	8276
310	8275	8284	8289	8296	8310	8312	8313	8331	8316	8308	8280	8266	
	8260	8256	8249	8213	8183	8185	8161	8164	8150	8175	8200	8208	8249
311	8242	8294	8348	8314	8287	8332	8321	8306	8325	8296	8273	8243	
	8258	8256	8199	8203	8185	8204	8212	8227	8147	8218	8248	8249	8258
312	8265	8279	8306	8290	8316	8299	8284	-----	-----	-----	-----	-----	
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	8291
313	-----	-----	-----	-----	-----	-----	-----	8285	8280	8288	8277	8272	
	8249	8258	8253	8254	8249	8253	8261	8258	8251	8241	8274	8247	8262
314	8255	8287	8294	8324	8305	8331	8329	8336	8307	8287	8276	8264	
	8258	8256	8255	8253	8252	8250	8247	8250	8244	8255	8256	8262	8276
315	8270	8274	8291	8299	8296	8301	8299	8280	8269	8265	8265	8266	
	8268	8257	8257	8247	8247	8244	8244	8239	8206	8207	8212	8251	8261
316	8265	8287	8314	8334	8338	8330	8318	8310	8310	8315	8274	8258	
	8266	8263	8224	8226	8237	8245	8259	8271	8267	8248	8264	8270	8279
317	8268	8295	8323	8317	8325	8332	8328	8299	8274	8270	8270	8276	
	8270	8271	8259	8256	8261	8259	8225	8138	8130	8126	8142	8083	8250
318	8188	8304	8407	8301	8402	8407	8292	8277	8275	8272	8234	8259	
	8254	8233	8180	8141	8125	8059	7997	8000	8002	8061	8094	8177	8206
319	8254	8269	8338	8381	8518	8555	8495	8452	8375	8376	8249	8255	
	8227	8136	8222	8239	8202	8233	8287	8324	8312	8268	8245	8197	8309
320	8195	8236	8282	8297	8309	8309	8307	8296	8276	8268	8258	8281	
	8281	8261	8237	8229	8240	8180	8164	8185	8142	8160	8202	8221	8242
321	8227	8265	8257	8319	8372	8373	8351	8313	8290	8297	8301	8307	
	8278	8256	8270	8239	8229	8215	8173	8144	8161	8143	8207	8261	8260
322	8276	8289	8337	8391	8395	8328	8323	8296	8287	8288	8285	8255	
	8266	8233	8233	8197	8213	8222	8174	8199	8165	8172	8176	8208	8259
323	8237	8245	8272	8302	8337	8415	8392	8340	8333	8313	8288	8255	
	8259	8246	8254	8226	8199	8239	8243	8191	8176	8161	8165	8168	8261
324	8184	8242	8275	8317	8350	8309	8311	8365	8352	8336	8332	8290	
	8262	8248	8228	8221	8220	8216	8193	8187	8190	8187	8220	8246	8262
325	8257	8271	8295	8336	8424	8406	8387	8336	8363	8323	8279	8276	
	8267	8265	8228	8206	8190	8148	8111	8097	8038	8094	8185	8206	8249
326	8169	8271	8317	8317	8387	8352	8347	8392	8365	8367	8313	8281	
	8281	8261	8253	8266	8220	8207	8188	8161	8137	8173	8240	8254	8272
327	8268	8270	8290	8299	8328	8342	8321	8297	8280	8299	8308	8271	
	8262	8235	8244	8236	8211	8187	8205	8203	8216	8182	8200	8231	8258
328	8253	8257	8279	8292	8311	8332	8357	8336	8316	8306	8298	8297	
	8276	8259	8234	8225	8223	8209	8198	8201	8181	8164	7977	8054	8243
329	8131	8196	8277	8256	8346	8388	8441	8424	8403	8302	8268	8260	

	8236	8266	8247	8271	8284	8291	8326	8373	8355	8362	8313	8288	8304
330	8289	8318	8343	8364	8327	8308	8312	8293	8272	8279	8269	8261	
	8293	8285	8226	8231	8260	8279	8296	8328	8342	8301	8205	8234	8288

TOTAL MEAN = 8264 nT

Table 3

Mario Zucchelli Station Antarctica, Italian Geomagnetic Observatory

*Hourly D values from Oct 29 to Nov 25, 2012
(degrees: first three digits, minutes: second two digits)*

UT	0	1	2	3	4	5	6	7	8	9	10	11	DAILY MEAN
	12	13	14	15	16	17	18	19	20	21	22	23	
julian day													
303	13502	13458	13504	13504	13502	13453	13446	13437	13428	13435	13434	13438	
	13440	13442	13442	13444	13446	13448	13451	13453	13453	13501	13451	13456	13449
304	13451	13507	13511	13501	13453	13440	13432	13427	13427	13430	13433	13435	
	13438	13436	13437	13435	13434	13432	13433	13435	13438	13449	13509	13460	13443
305	13505	13504	13443	13434	13434	13426	13428	13426	13424	13430	13436	13431	
	13434	13433	13429	13423	13425	13415	13420	13447	13357	13344	13517	13422	13431
306	13435	13551	13546	13544	13534	13524	13454	13438	13424	13350	13337	13343	
	13354	13359	13407	13408	13428	13442	13448	13503	13520	13508	13513	13452	13444
307	13448	13440	13430	13432	13418	13428	13423	13436	13436	13438	13440	13440	
	13440	13441	13438	13436	13430	13425	13436	13430	13429	13441	13444	13441	13435
308	13439	13443	13443	13446	13444	13444	13446	13440	13436	13436	13435	13437	
	13439	13433	13443	13431	13437	13459	13513	13510	13509	13520	13512	13456	13448
309	13431	13426	13430	13439	13435	13427	13426	13425	13423	13426	13430	13433	
	13437	13440	13442	13444	13448	13457	13450	13448	13458	13501	13459	13453	13439
310	13445	13446	13434	13440	13432	13435	13444	13438	13432	13425	13432	13437	
	13436	13434	13431	13424	13421	13441	13452	13506	13512	13515	13524	13517	13444
311	13517	13433	13505	13454	13447	13438	13425	13420	13419	13413	13426	13425	
	13426	13417	13430	13428	13434	13446	13442	13439	13503	13438	13447	13460	13438
312	13451	13446	13444	13432	13431	13437	13434	-----	-----	-----	-----	-----	
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	13439
313	-----	-----	-----	-----	-----	-----	-----	13433	13427	13430	13432	13435	
	13435	13438	13439	13437	13437	13434	13435	13447	13434	13356	13435	13459	13434
314	13459	13441	13437	13430	13432	13429	13427	13425	13428	13429	13431	13434	
	13434	13438	13439	13433	13438	13440	13439	13419	13418	13441	13452	13457	13435
315	13503	13453	13439	13433	13440	13437	13433	13431	13431	13434	13436	13435	
	13435	13437	13436	13438	13436	13429	13422	13436	13440	13442	13504	13505	13439
316	13455	13447	13447	13439	13438	13437	13432	13430	13428	13421	13418	13422	
	13428	13419	13429	13432	13442	13444	13440	13428	13452	13502	13448	13446	13437
317	13451	13439	13439	13439	13434	13432	13428	13427	13429	13429	13429	13431	
	13430	13427	13428	13427	13409	13418	13443	13517	13450	13500	13513	13545	13440
318	13529	13425	13418	13403	13433	13417	13333	13357	13412	13428	13425	13441	
	13445	13442	13439	13454	13508	13516	13534	13524	13525	13523	13544	13606	13448
319	13636	13631	13624	13620	13545	13442	13427	13405	13331	13320	13411	13415	
	13408	13354	13405	13426	13442	13504	13453	13457	13503	13442	13507	13515	13451
320	13507	13516	13526	13523	13506	13460	13441	13435	13438	13436	13434	13434	
	13428	13433	13443	13448	13430	13444	13459	13506	13530	13542	13518	13504	13456
321	13458	13512	13524	13523	13447	13430	13421	13403	13420	13419	13418	13419	
	13421	13417	13411	13429	13413	13406	13412	13420	13410	13442	13426	13421	13429
322	13424	13439	13445	13444	13441	13433	13426	13418	13426	13434	13434	13431	
	13428	13432	13426	13438	13438	13446	13427	13444	13456	13511	13509	13511	13439
323	13512	13506	13519	13523	13513	13443	13448	13446	13440	13425	13431	13434	
	13437	13436	13426	13434	13443	13449	13447	13460	13518	13532	13536	13531	13455
324	13530	13504	13444	13437	13456	13503	13458	13437	13432	13431	13420	13420	
	13430	13434	13441	13437	13444	13449	13451	13515	13530	13541	13525	13517	13453
325	13522	13546	13539	13549	13523	13513	13502	13446	13439	13423	13430	13419	
	13407	13350	13408	13404	13417	13425	13421	13426	13451	13452	13515	13531	13447
326	13617	13620	13612	13533	13507	13501	13453	13433	13411	13421	13415	13403	
	13409	13417	13423	13415	13442	13423	13443	13452	13457	13459	13508	13501	13451
327	13507	13518	13504	13454	13454	13447	13433	13425	13426	13430	13430	13437	
	13435	13436	13436	13441	13436	13444	13453	13449	13452	13501	13511	13518	13447
328	13520	13500	13455	13504	13459	13453	13442	13441	13435	13430	13419	13421	
	13428	13426	13433	13449	13448	13437	13447	13441	13449	13513	13606	13607	13452
329	13547	13559	13609	13608	13551	13520	13422	13424	13428	13434	13438	13434	
	13430	13404	13418	13404	13415	13407	13403	13357	13327	13319	13352	13356	13435

330 13404 13345 13350 13339 13342 13346 13339 13401 13420 13422 13424 13435
13434 13416 13411 13418 13419 13409 13409 13411 13409 13428 13448 13451 13411

TOTAL MEAN = 134° 42'

Table 4

Mario Zucchelli Station Antarctica, Italian Geomagnetic Observatory

Hourly Z values (nT) from Oct 29 to Nov 25, 2012 (values must be considered negative)

UT	0	1	2	3	4	5	6	7	8	9	10	11	DAILY MEAN
	12	13	14	15	16	17	18	19	20	21	22	23	
julian day													
303	63235	63236	63245	63243	63254	63271	63282	63299	63318	63318	63323	63327	
	63330	63327	63320	63323	63323	63320	63312	63295	63280	63262	63244	63244	63289
304	63233	63225	63207	63210	63249	63269	63277	63285	63297	63307	63311	63318	
	63320	63318	63312	63309	63308	63308	63311	63320	63311	63289	63235	63254	63283
305	63242	63236	63261	63266	63274	63289	63285	63288	63296	63300	63311	63314	
	63314	63315	63309	63311	63298	63299	63279	63277	63221	63225	63338	63282	63285
306	63166	63212	63260	63284	63280	63279	63296	63310	63313	63337	63408	63421	
	63421	63395	63402	63419	63405	63352	63318	63292	63258	63197	63123	63144	63304
307	63168	63204	63216	63233	63266	63282	63310	63306	63315	63320	63314	63318	
	63322	63323	63323	63333	63346	63327	63307	63323	63281	63254	63255	63231	63287
308	63229	63248	63268	63278	63284	63285	63293	63300	63314	63317	63309	63315	
	63320	63332	63324	63341	63366	63412	63363	63308	63278	63271	63254	63279	63304
309	63263	63266	63250	63253	63257	63264	63274	63280	63291	63305	63311	63317	
	63328	63335	63341	63355	63350	63338	63305	63305	63304	63291	63287	63279	63298
310	63264	63241	63246	63285	63279	63274	63287	63297	63301	63308	63317	63328	
	63335	63353	63360	63366	63398	63403	63377	63307	63287	63281	63262	63237	63308
311	63285	63243	63159	63192	63279	63273	63281	63295	63291	63293	63294	63300	
	63317	63325	63319	63289	63317	63292	63261	63235	63225	63171	63287	63282	63271
312	63240	63242	63268	63296	63286	63291	63303	-----	-----	-----	-----	-----	
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	63275
313	-----	-----	-----	-----	-----	-----	-----	63307	63305	63303	63300	63309	
	63317	63323	63316	63315	63317	63307	63291	63295	63328	63247	63289	63303	63304
314	63289	63276	63264	63263	63266	63280	63284	63300	63298	63303	63310	63325	
	63320	63321	63323	63343	63338	63323	63331	63337	63306	63296	63283	63276	63302
315	63256	63250	63256	63273	63281	63282	63293	63302	63300	63298	63300	63307	
	63314	63314	63313	63316	63320	63338	63340	63317	63267	63258	63247	63225	63290
316	63231	63217	63205	63229	63247	63258	63276	63286	63294	63298	63294	63302	
	63314	63325	63305	63308	63322	63305	63289	63317	63301	63262	63255	63237	63278
317	63209	63221	63227	63228	63240	63259	63264	63267	63283	63295	63292	63302	
	63314	63305	63305	63313	63324	63283	63229	63278	63296	63290	63282	63242	63273
318	63214	63192	63095	63269	63223	63278	63275	63259	63264	63282	63282	63309	
	63348	63416	63474	63539	63415	63332	63387	63399	63362	63322	63266	63244	63310
319	63236	63236	63258	63269	63286	63310	63297	63322	63341	63367	63336	63349	
	63331	63341	63378	63341	63358	63294	63237	63276	63333	63362	63310	63249	63309
320	63261	63286	63285	63280	63292	63302	63317	63322	63325	63331	63320	63317	
	63317	63319	63341	63330	63344	63324	63311	63281	63285	63265	63253	63231	63302
321	63247	63234	63198	63253	63264	63252	63265	63277	63276	63285	63305	63311	
	63318	63345	63355	63338	63338	63308	63262	63254	63233	63227	63192	63175	63271
322	63239	63256	63241	63183	63206	63229	63266	63282	63289	63307	63313	63320	
	63312	63341	63354	63314	63350	63316	63330	63301	63279	63262	63249	63229	63282
323	63186	63180	63189	63190	63230	63272	63271	63286	63302	63323	63331	63336	
	63342	63335	63338	63354	63389	63326	63314	63283	63269	63283	63257	63247	63285
324	63233	63190	63179	63228	63216	63242	63277	63313	63321	63320	63322	63329	
	63361	63364	63367	63344	63351	63338	63308	63263	63244	63256	63231	63172	63282
325	63177	63176	63204	63196	63217	63244	63278	63300	63321	63333	63342	63357	
	63368	63419	63411	63425	63358	63349	63323	63263	63241	63295	63335	63265	63300
326	63181	63174	63175	63194	63219	63253	63286	63305	63313	63311	63312	63326	
	63337	63339	63330	63323	63335	63341	63335	63323	63282	63265	63217	63231	63279
327	63212	63219	63254	63265	63262	63273	63294	63300	63299	63304	63308	63314	
	63327	63329	63335	63363	63370	63356	63319	63291	63259	63244	63244	63228	63290
328	63234	63232	63226	63231	63248	63275	63290	63296	63303	63313	63323	63332	
	63340	63340	63368	63362	63356	63358	63328	63312	63297	63290	63233	63239	63297

329	63251	63236	63196	63236	63226	63266	63317	63320	63312	63330	63356	63371	
	63381	63395	63383	63329	63278	63244	63222	63314	63393	63382	63370	63335	63310
330	63292	63256	63236	63245	63228	63309	63277	63275	63291	63293	63303	63297	
	63325	63318	63294	63288	63301	63307	63287	63282	63337	63406	63241	63237	63288

TOTAL MEAN = 63292 *nT*

Mario Zucchelli Station Z, H and D base lines 2012/2013

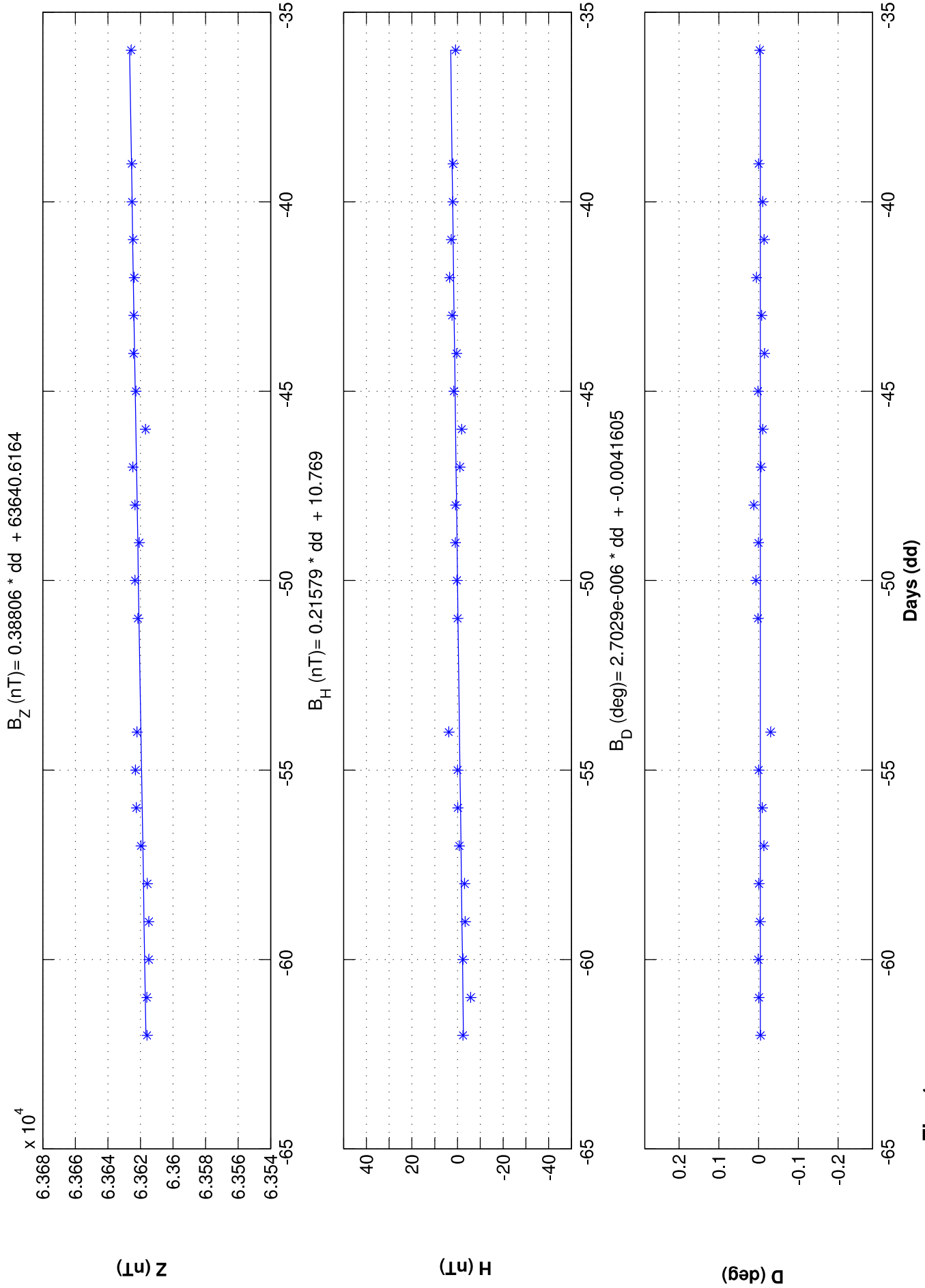


Fig. 1

TNB hourly means 2012 / 2013

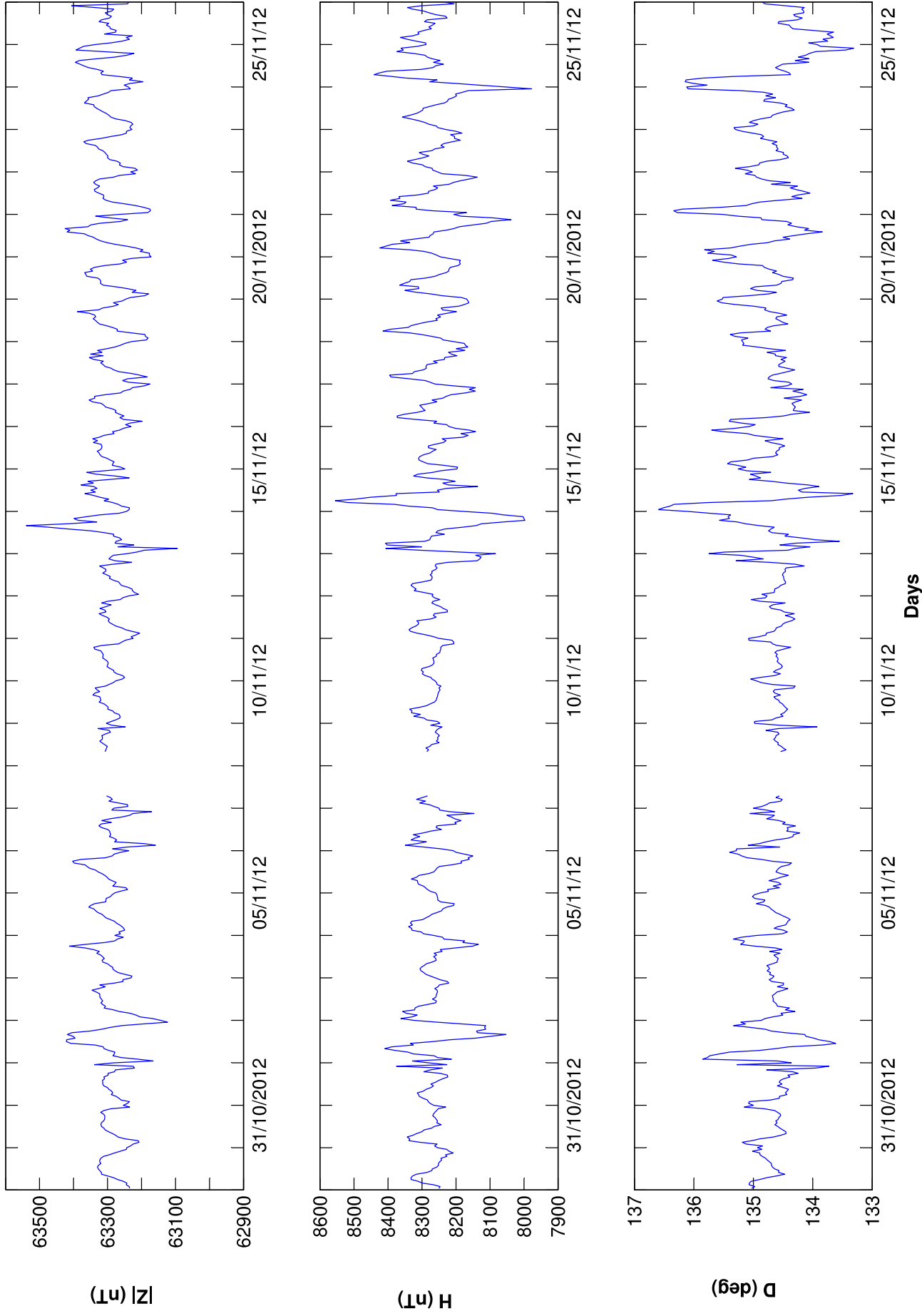
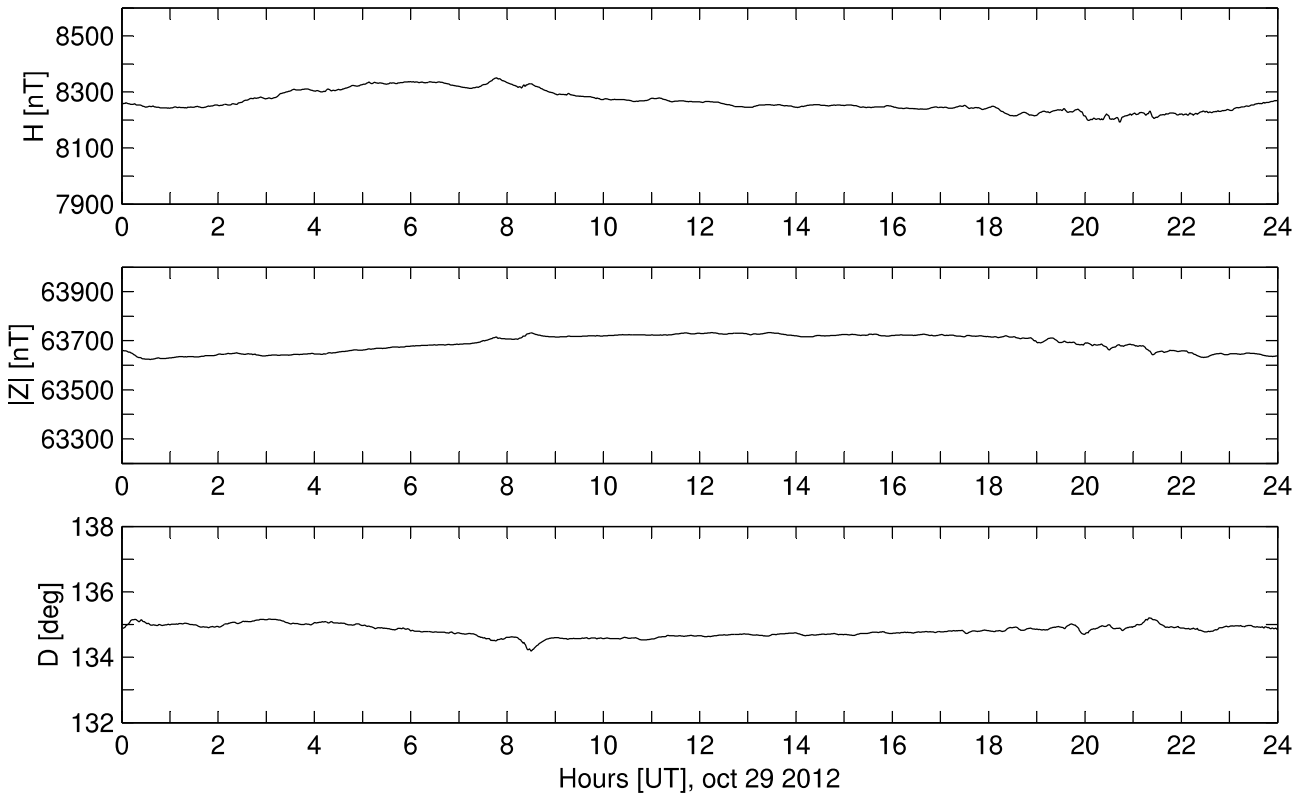


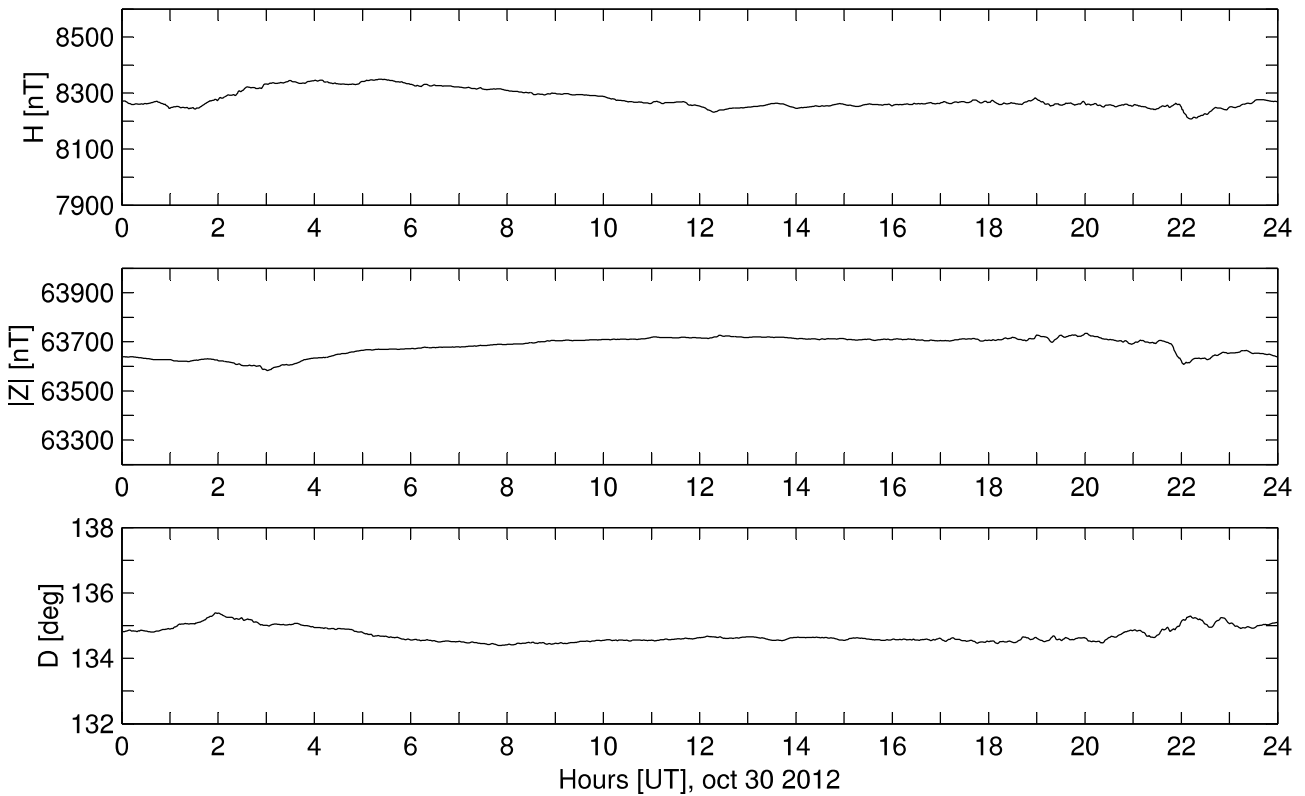
Fig. 2

Fig. 3 - 17

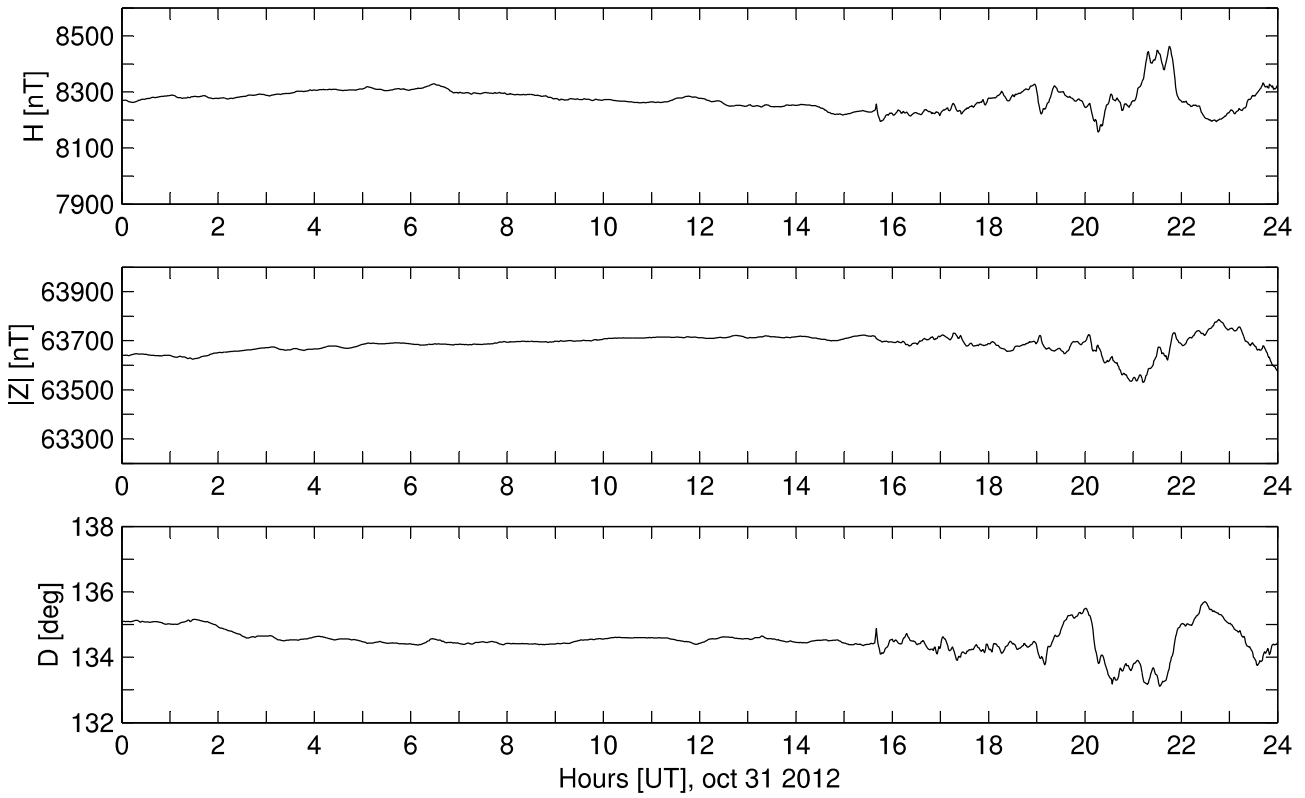
TNB Italian Geomagnetic Observatory, Antarctica



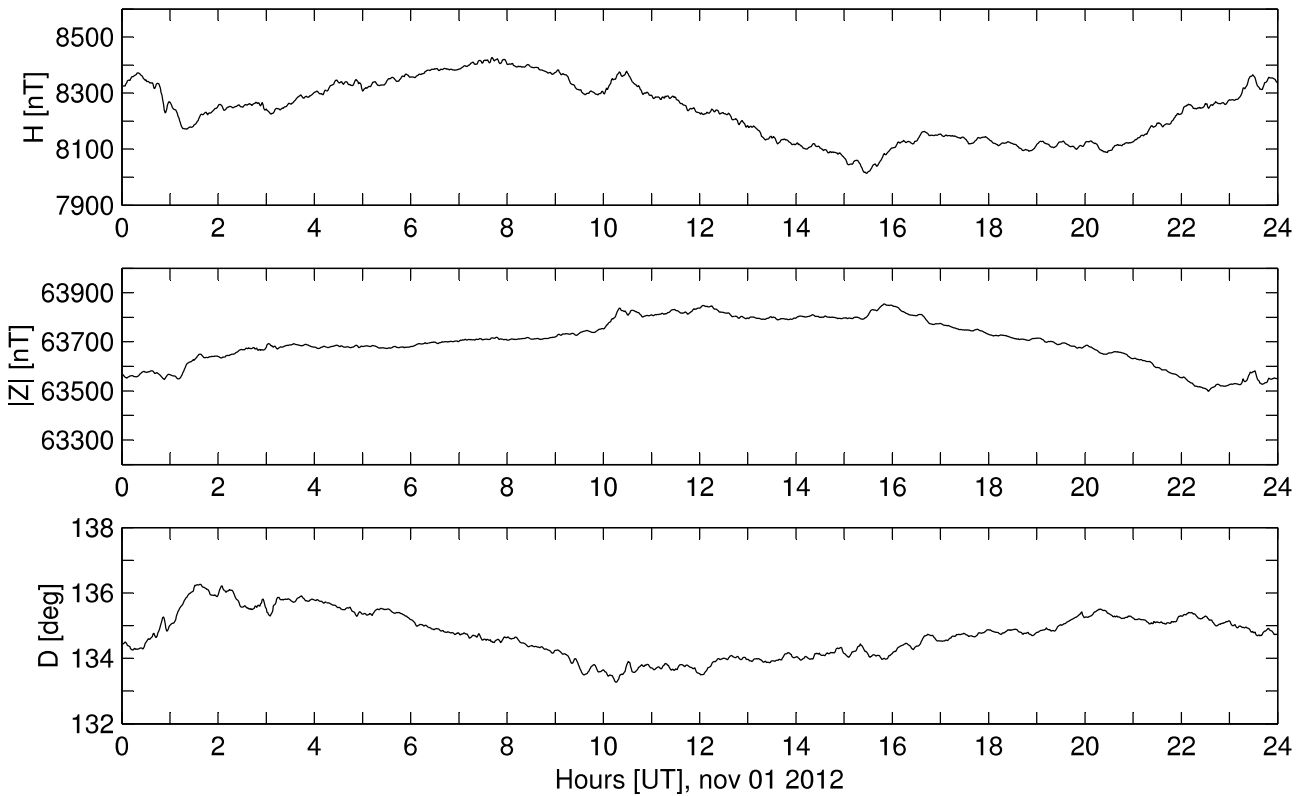
TNB Italian Geomagnetic Observatory, Antarctica



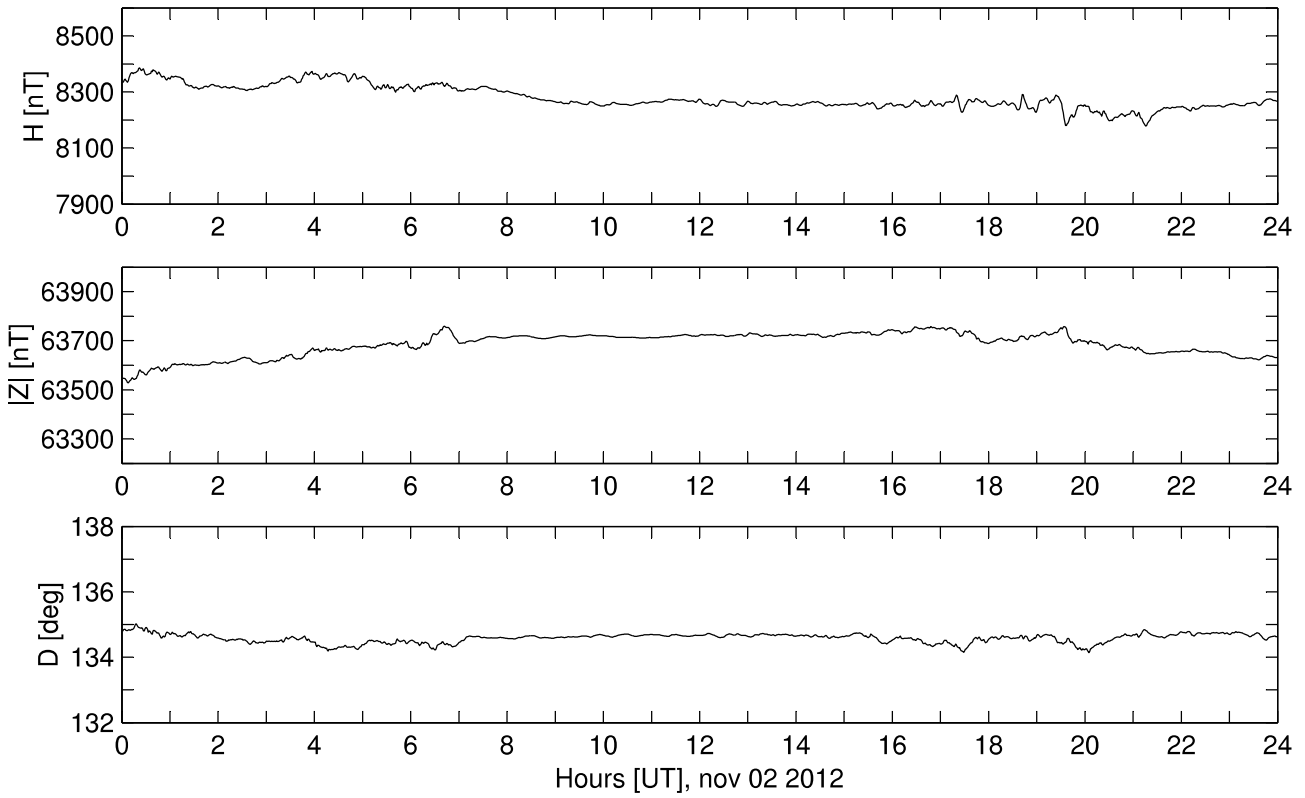
TNB Italian Geomagnetic Observatory, Antarctica



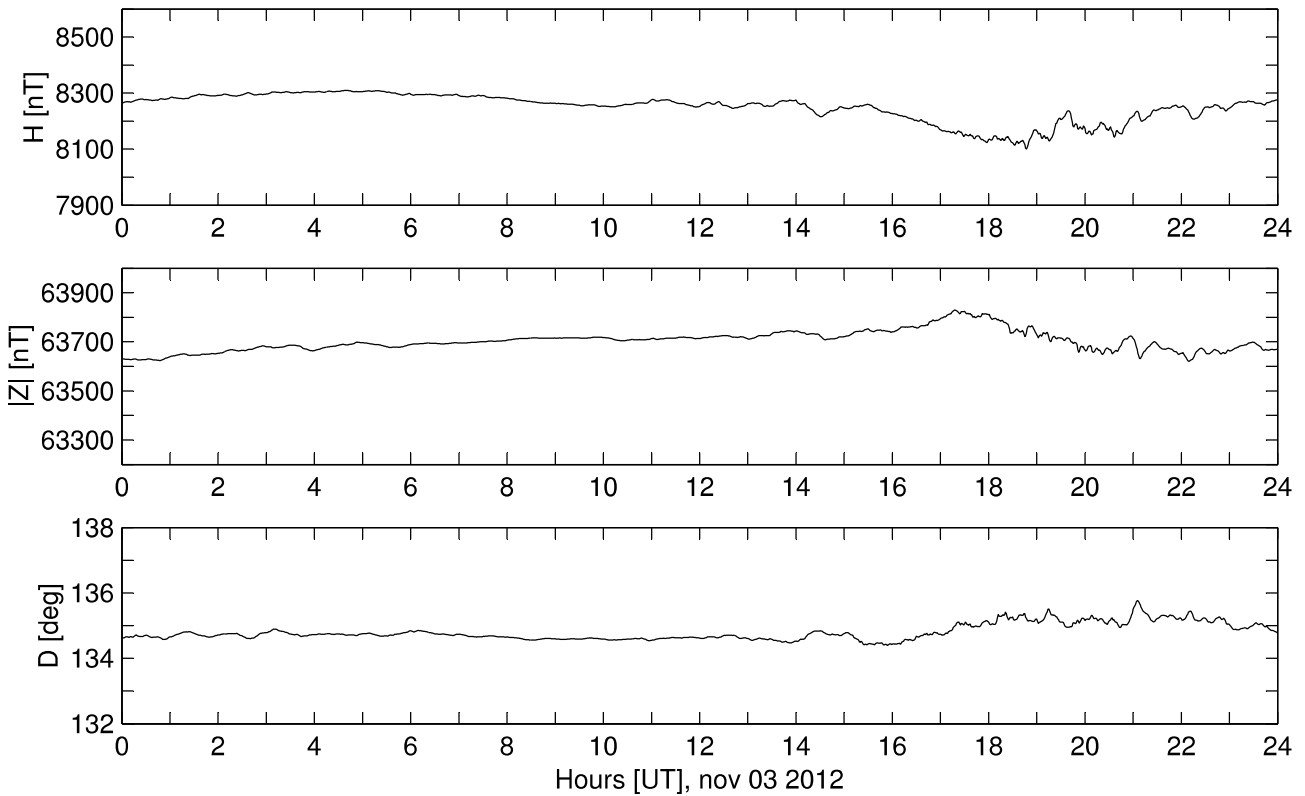
TNB Italian Geomagnetic Observatory, Antarctica



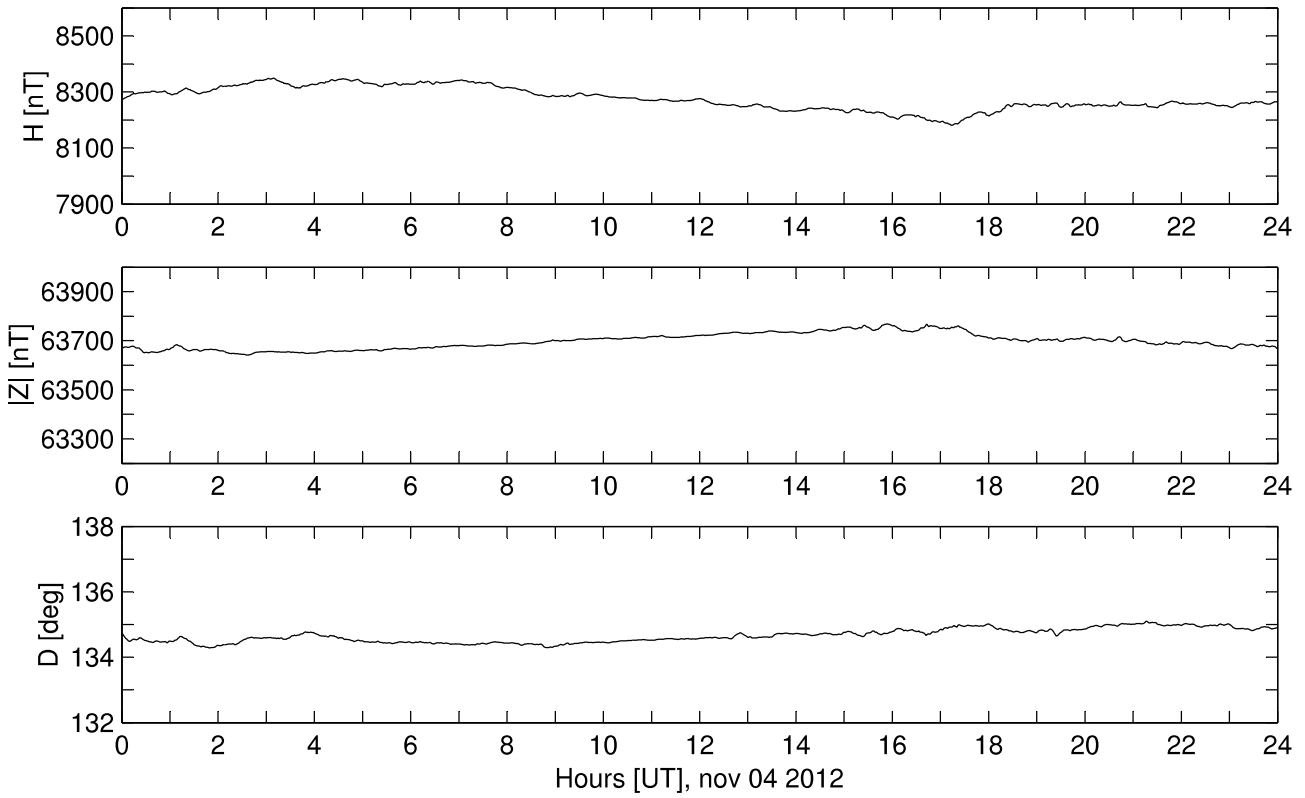
TNB Italian Geomagnetic Observatory, Antarctica



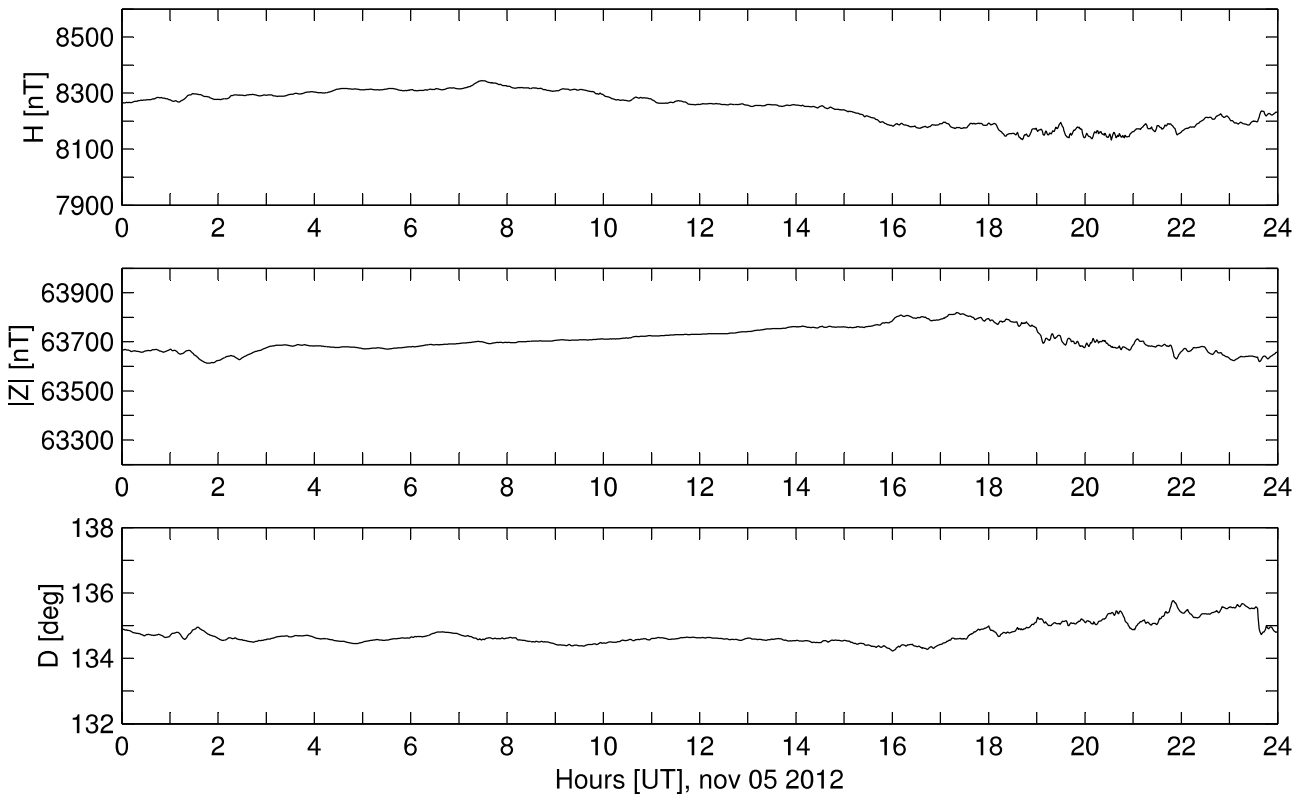
TNB Italian Geomagnetic Observatory, Antarctica



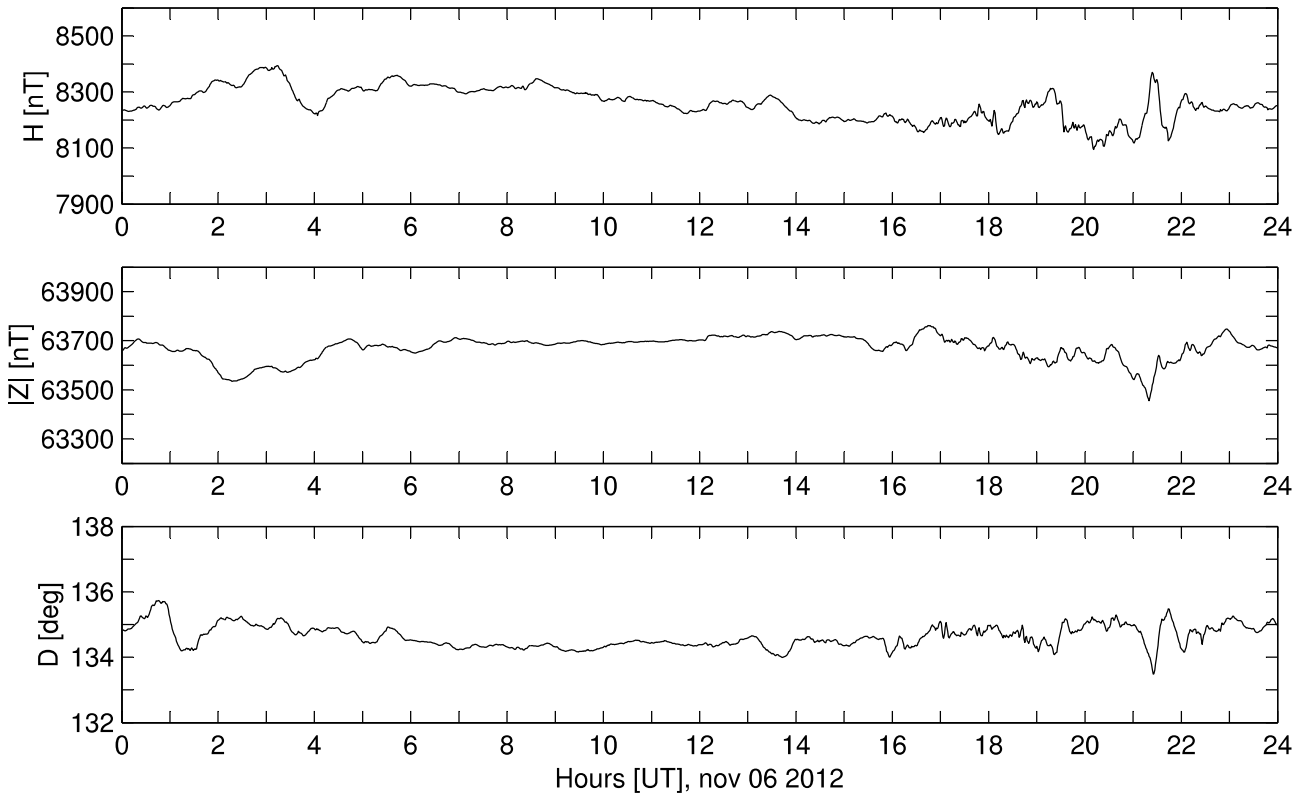
TNB Italian Geomagnetic Observatory, Antarctica



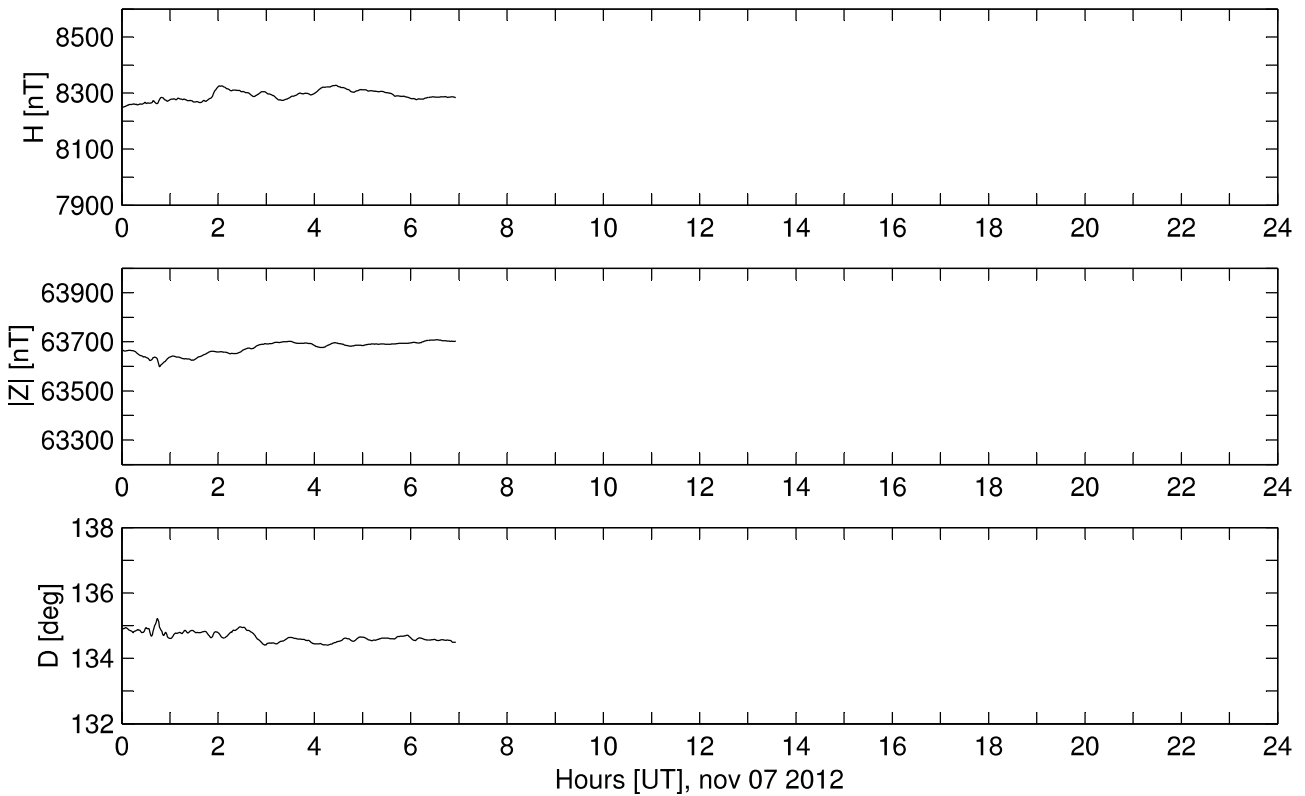
TNB Italian Geomagnetic Observatory, Antarctica



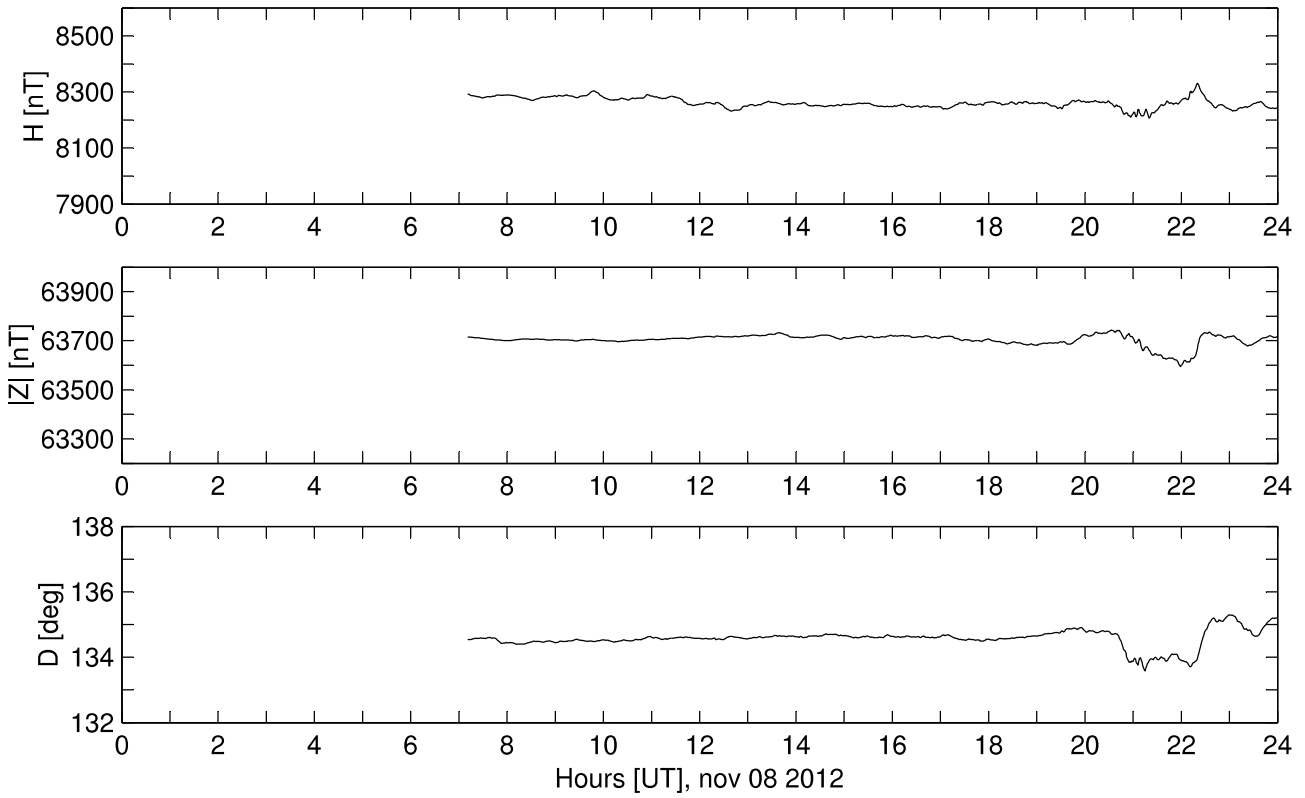
TNB Italian Geomagnetic Observatory, Antarctica



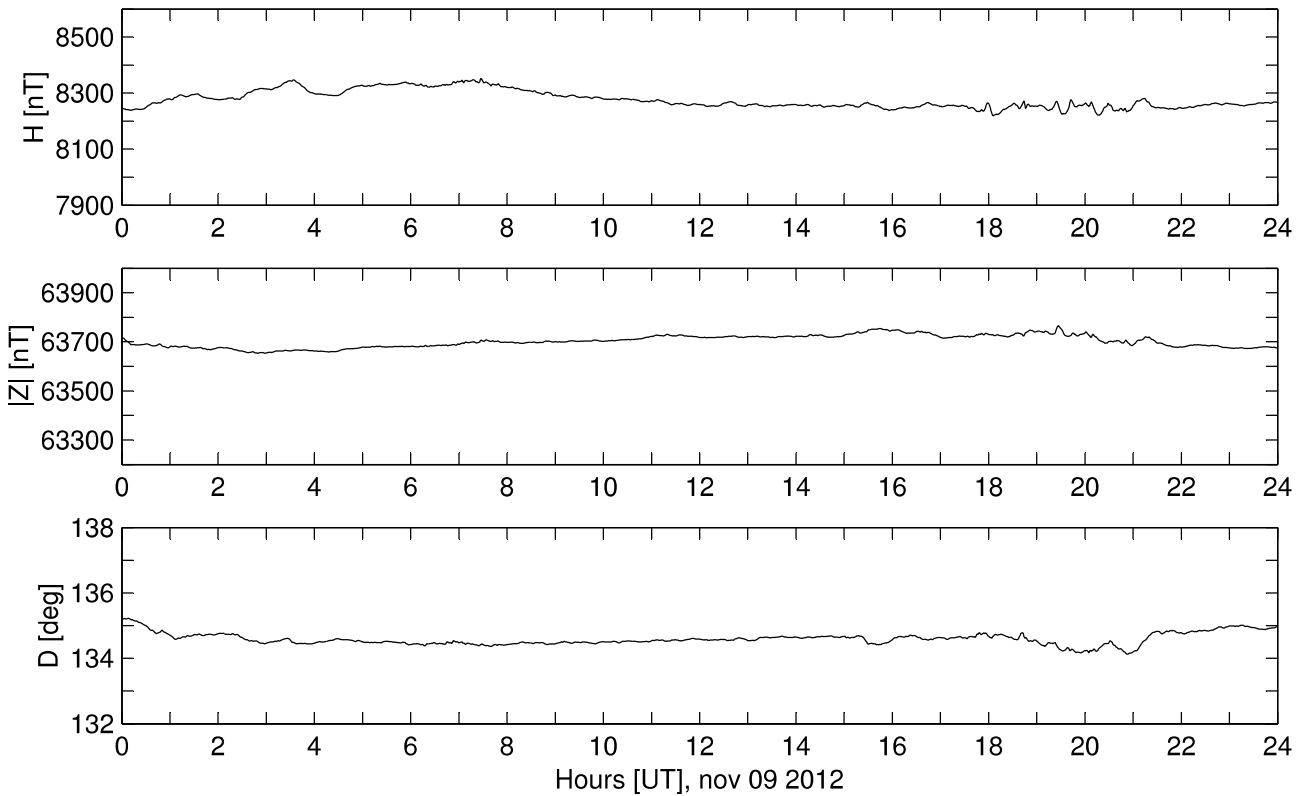
TNB Italian Geomagnetic Observatory, Antarctica



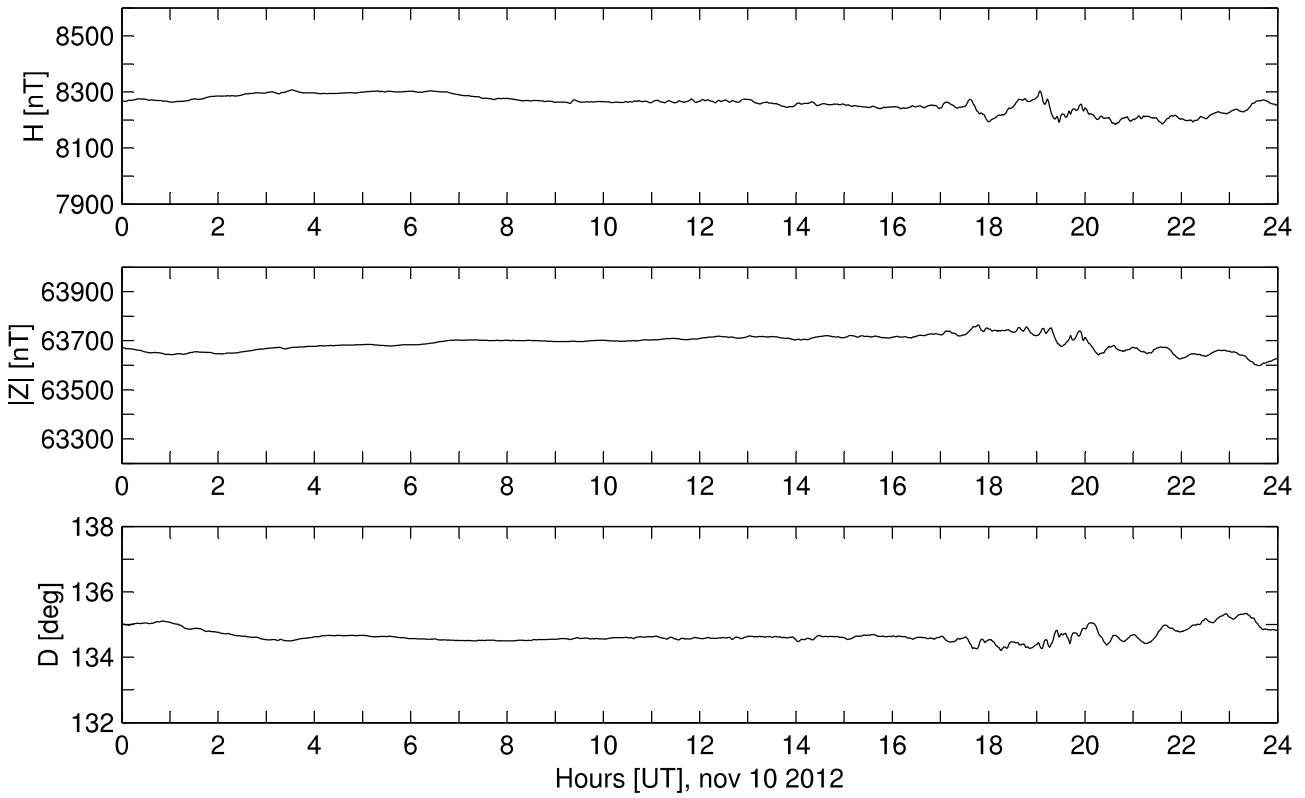
TNB Italian Geomagnetic Observatory, Antarctica



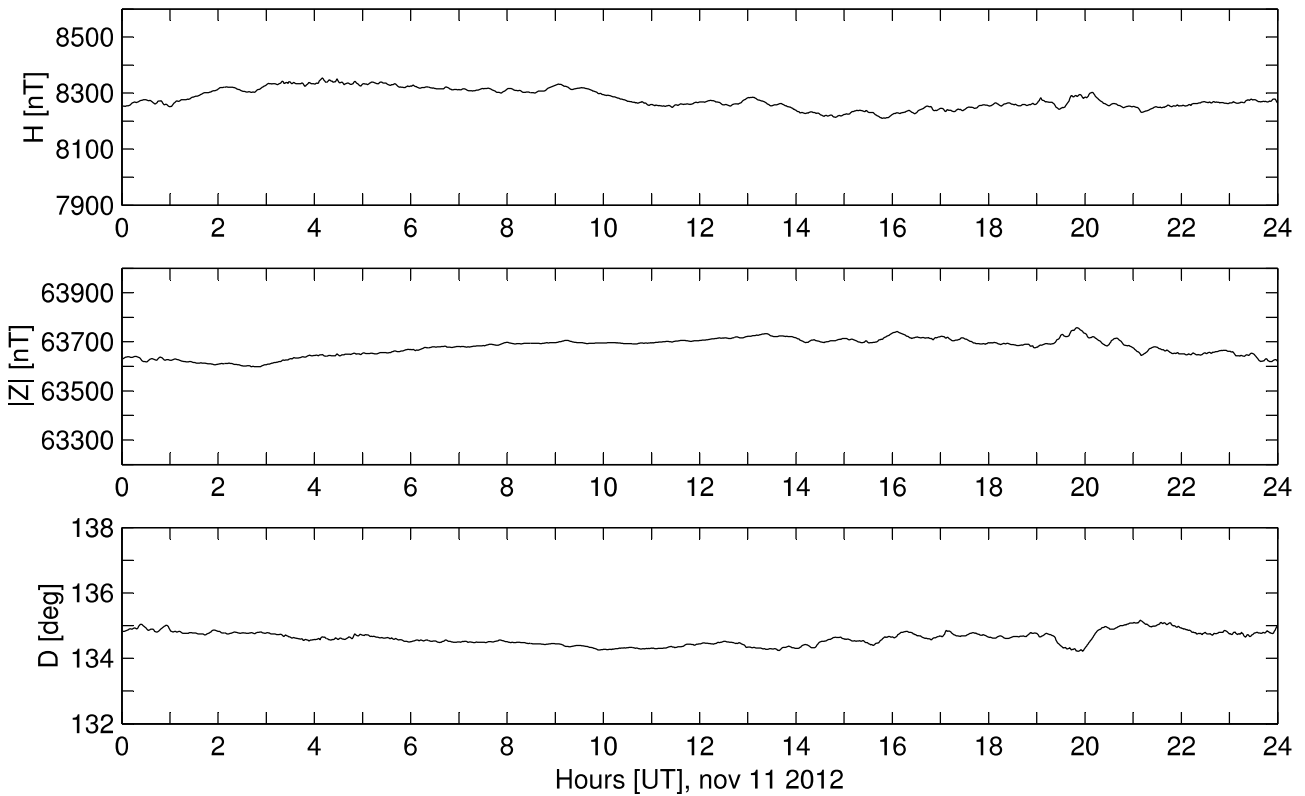
TNB Italian Geomagnetic Observatory, Antarctica



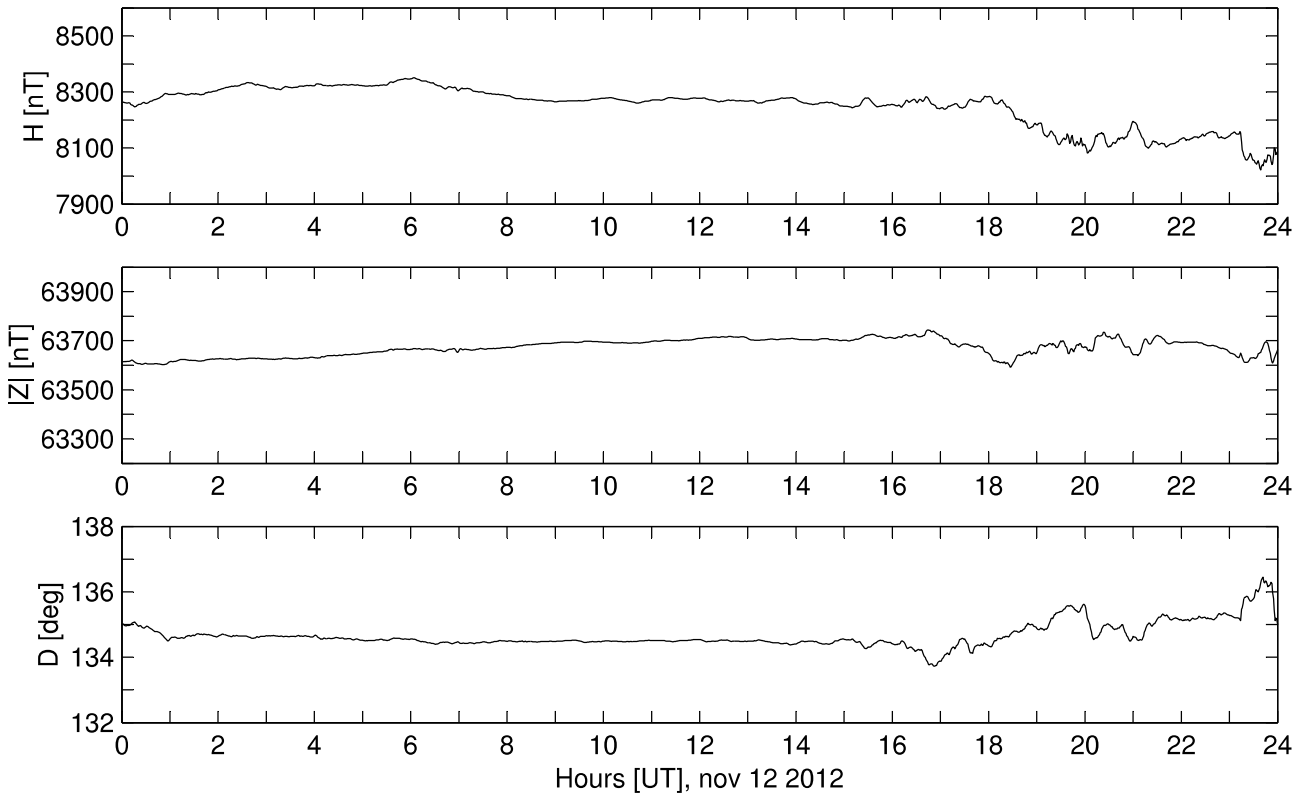
TNB Italian Geomagnetic Observatory, Antarctica



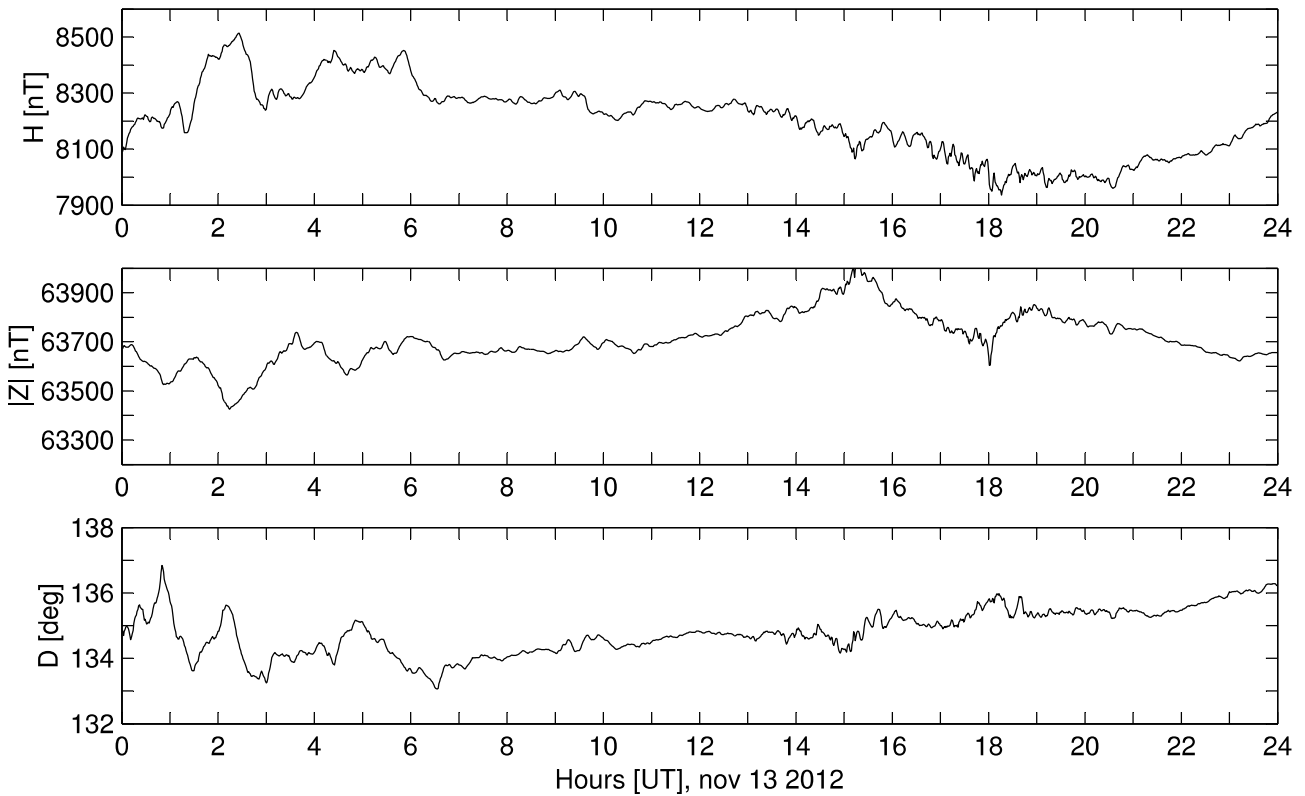
TNB Italian Geomagnetic Observatory, Antarctica



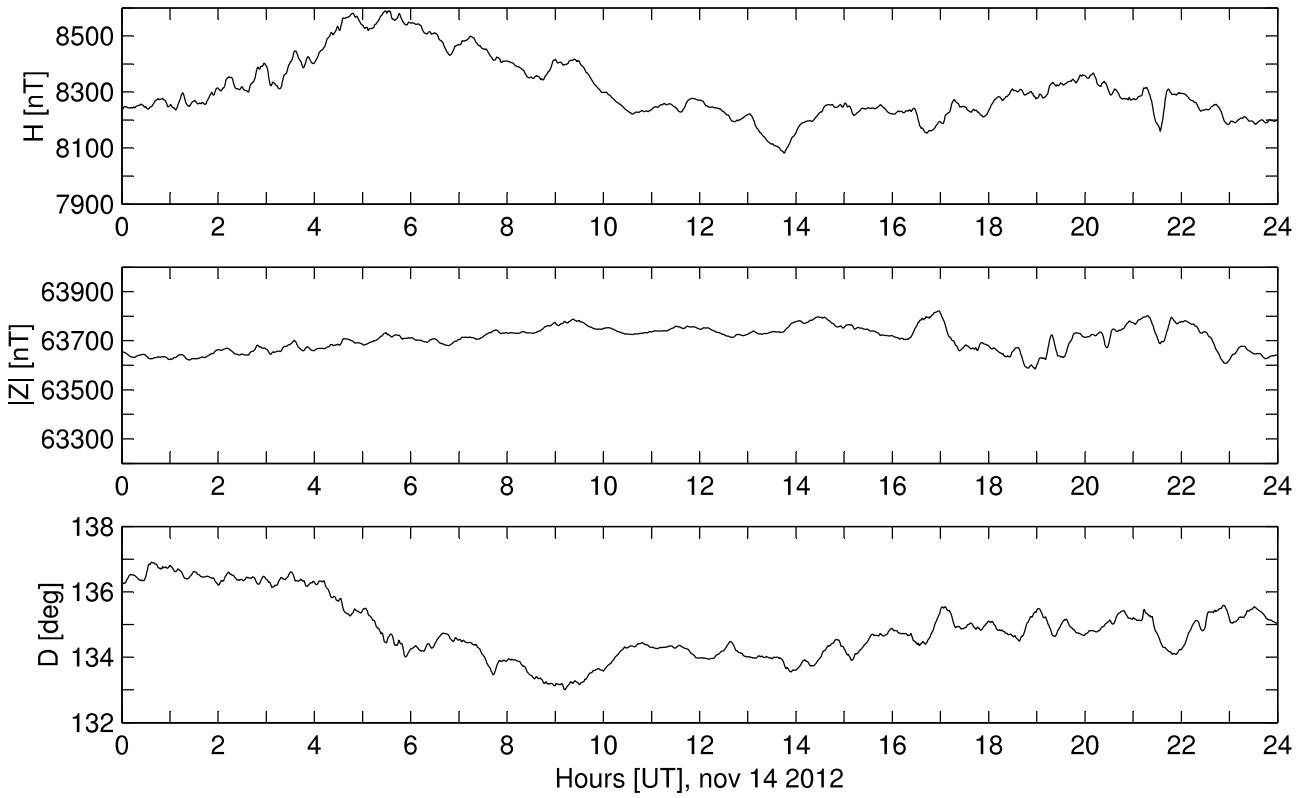
TNB Italian Geomagnetic Observatory, Antarctica



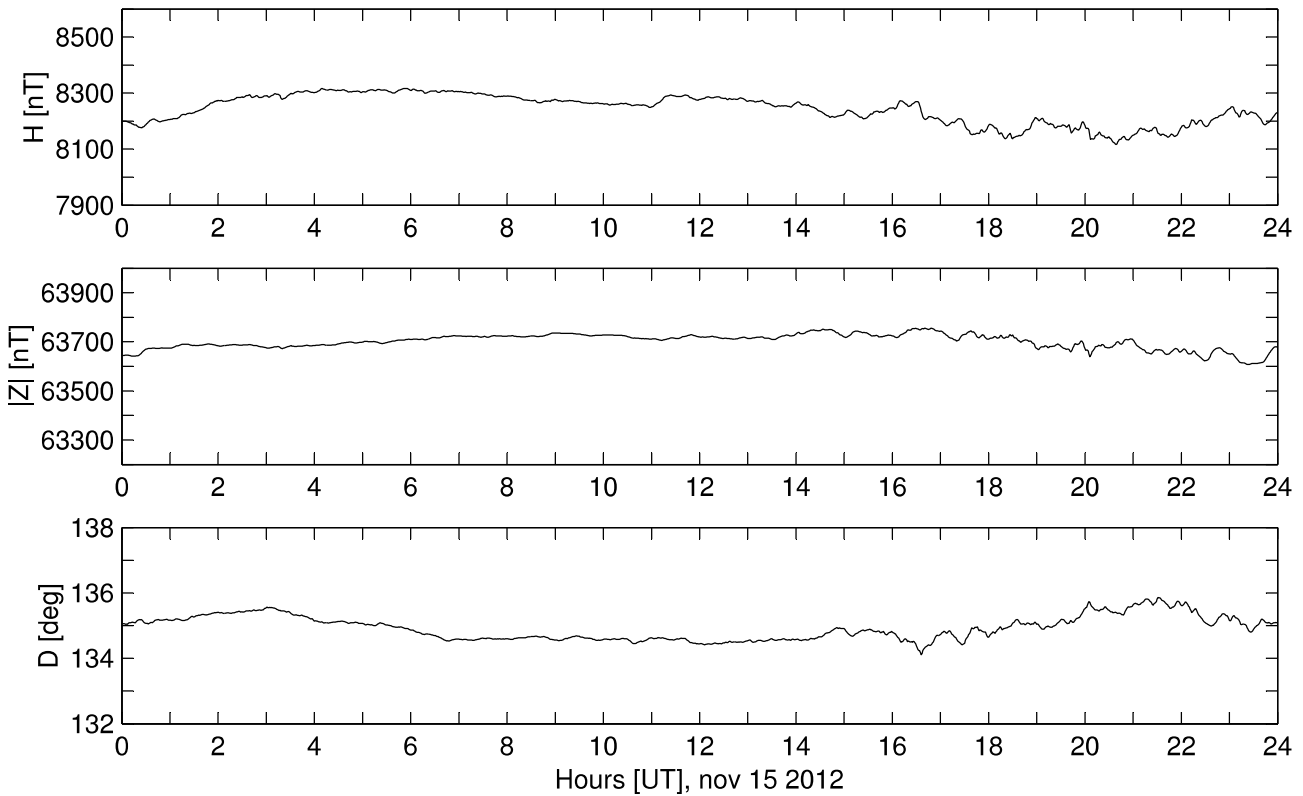
TNB Italian Geomagnetic Observatory, Antarctica



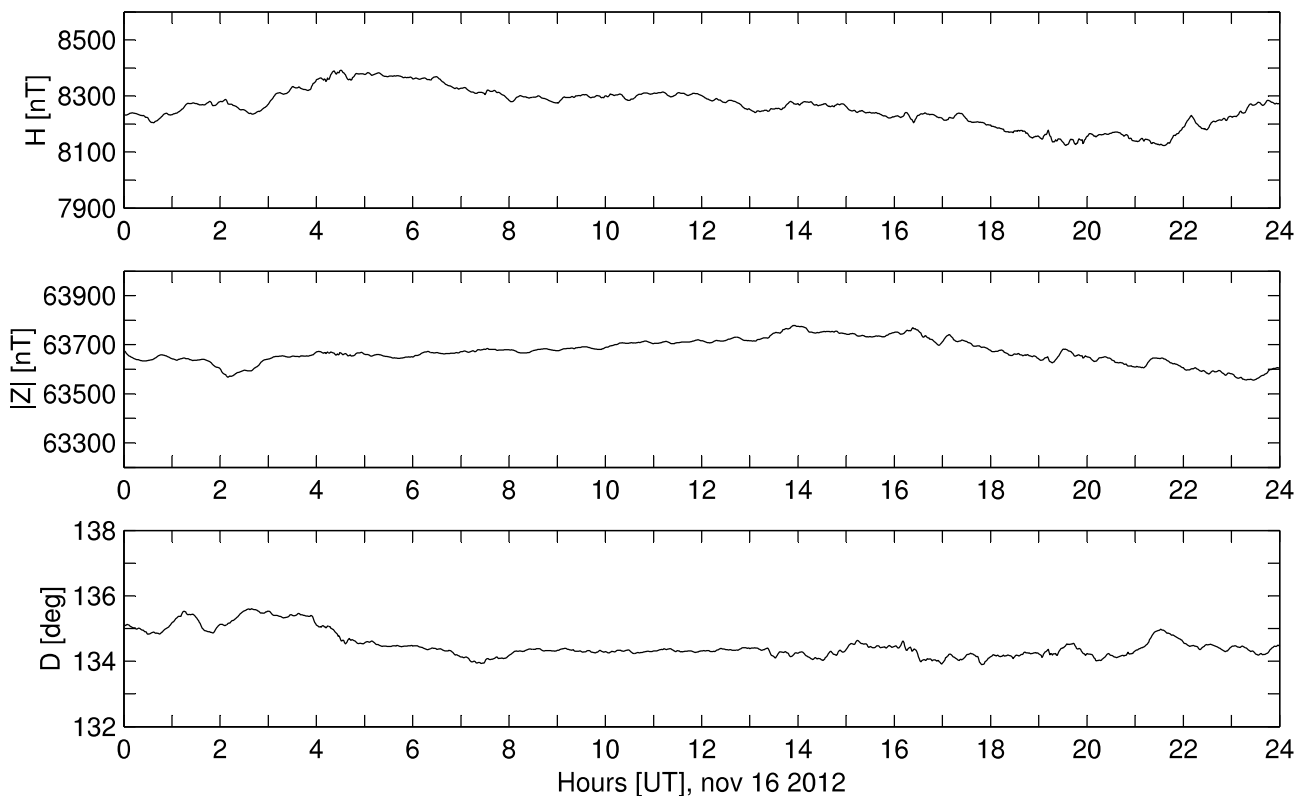
TNB Italian Geomagnetic Observatory, Antarctica



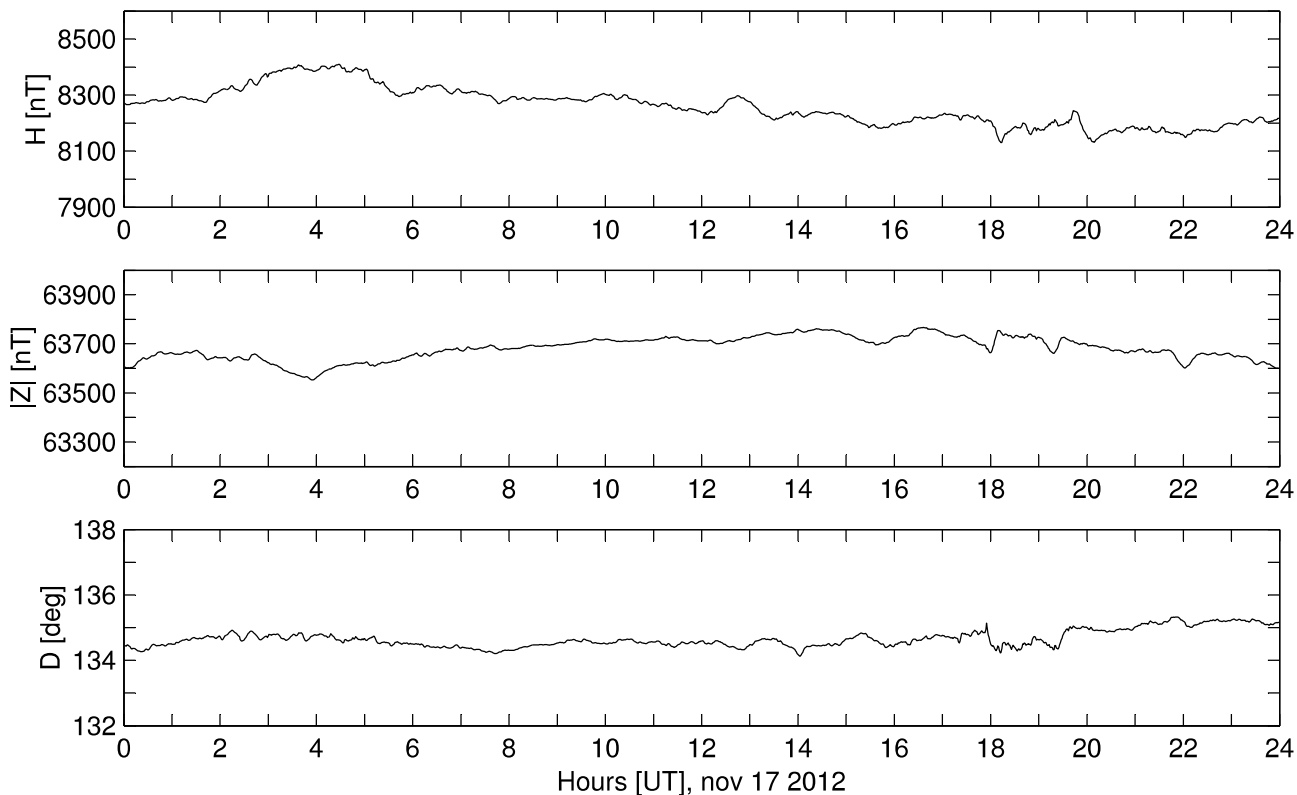
TNB Italian Geomagnetic Observatory, Antarctica



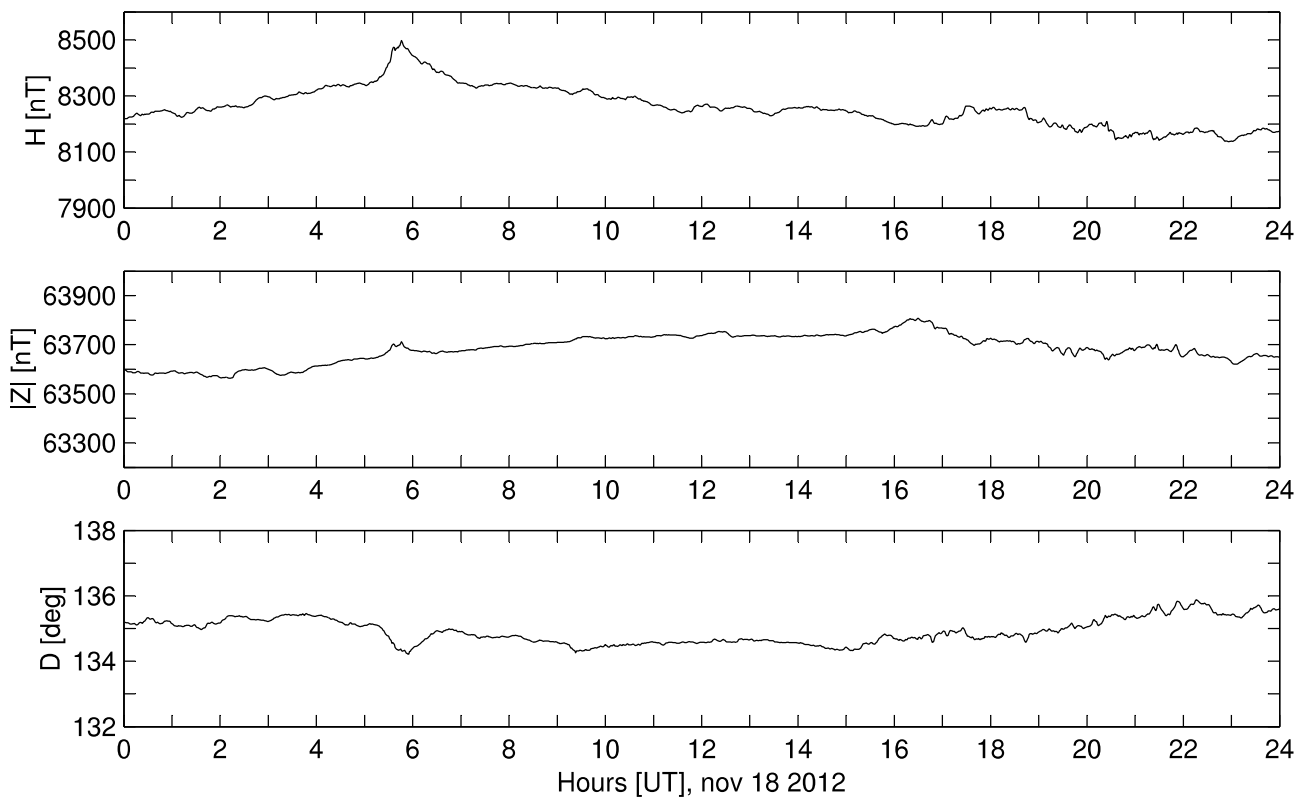
TNB Italian Geomagnetic Observatory, Antarctica



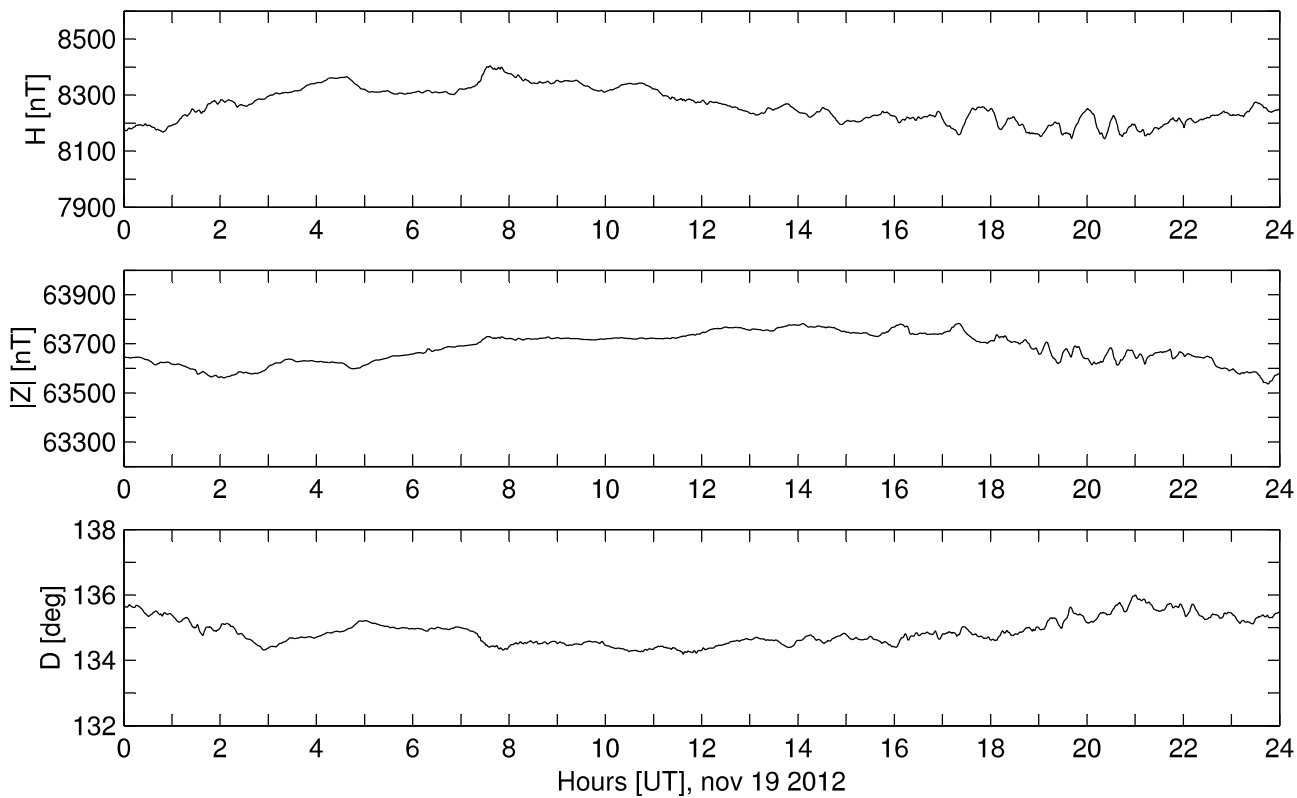
TNB Italian Geomagnetic Observatory, Antarctica



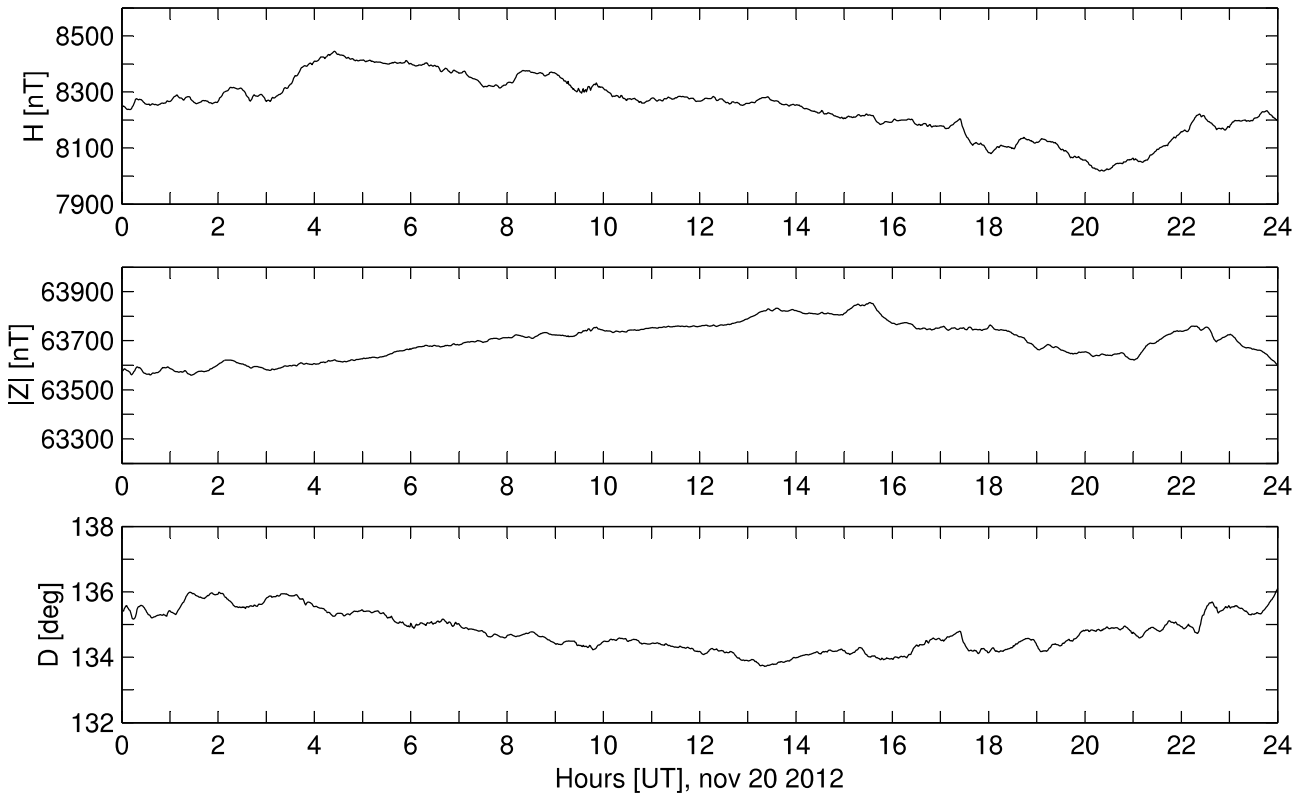
TNB Italian Geomagnetic Observatory, Antarctica



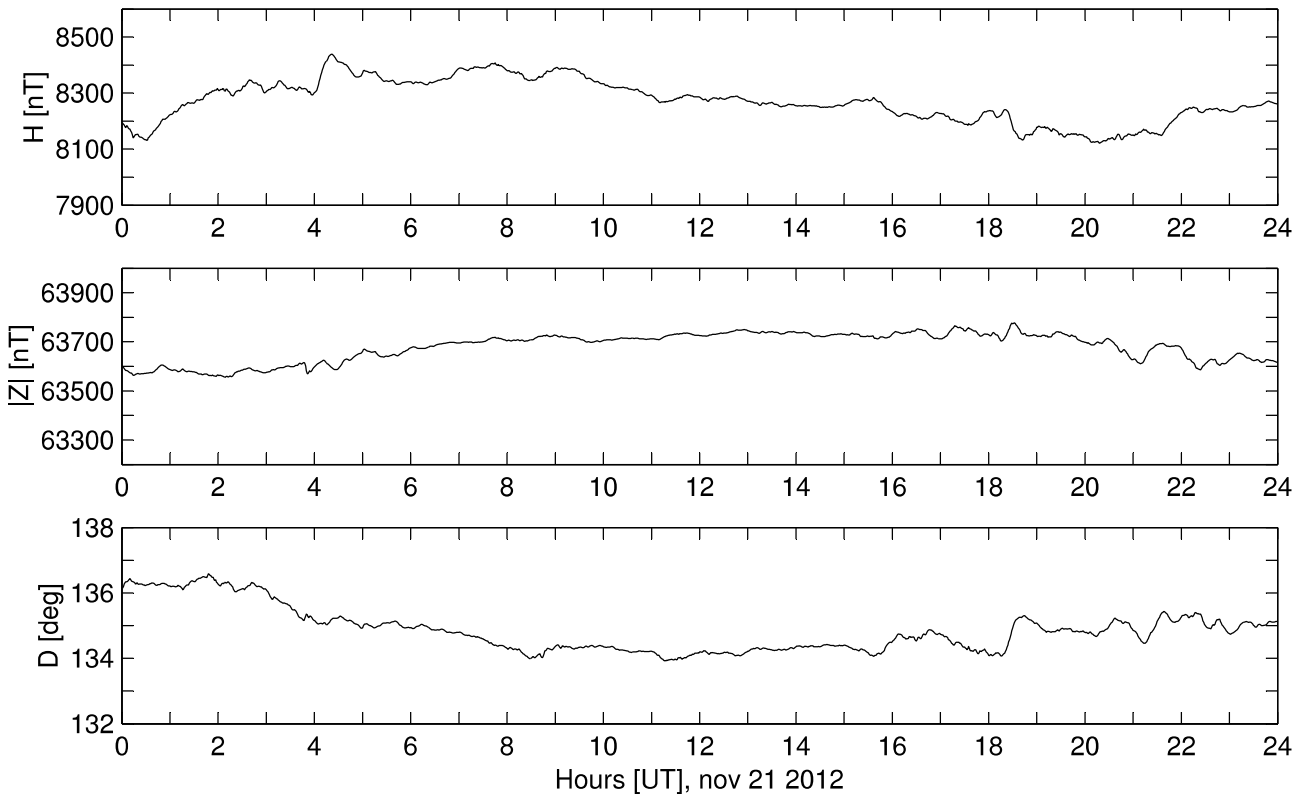
TNB Italian Geomagnetic Observatory, Antarctica



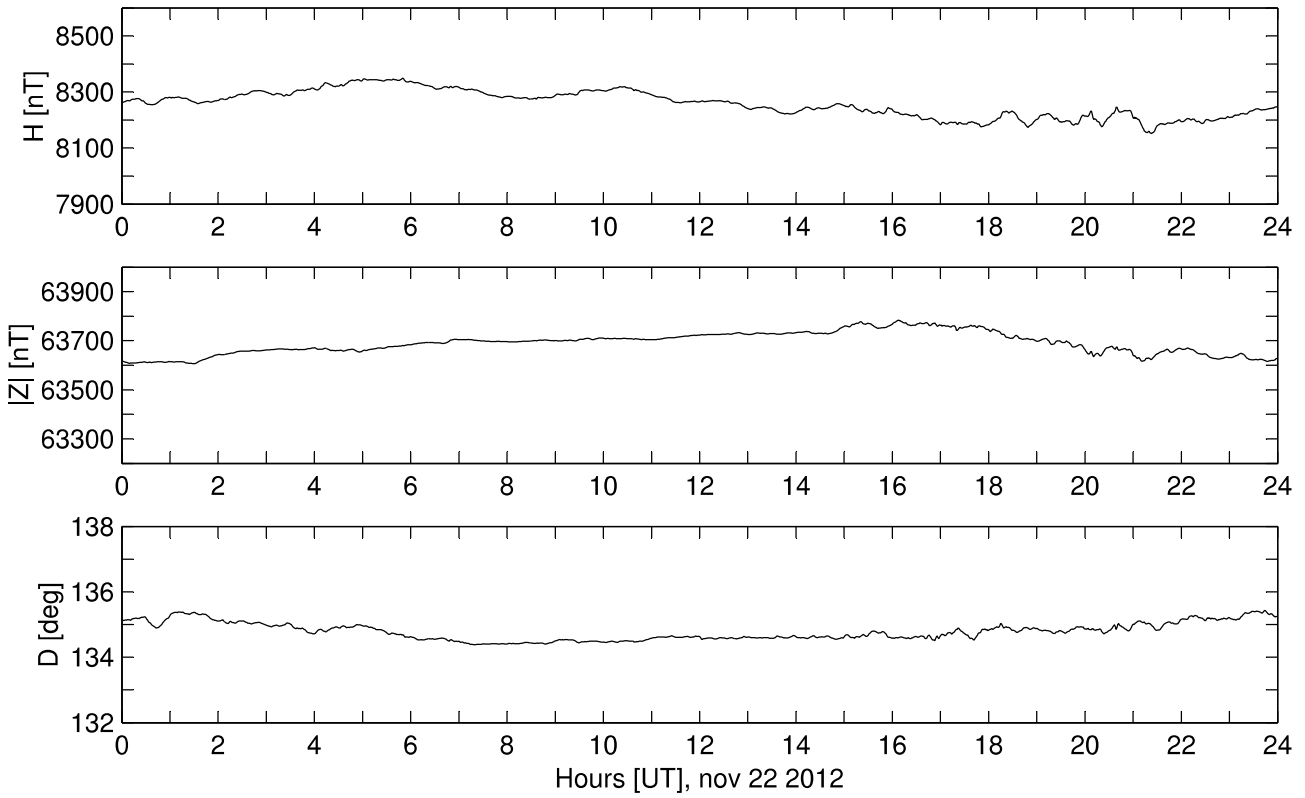
TNB Italian Geomagnetic Observatory, Antarctica



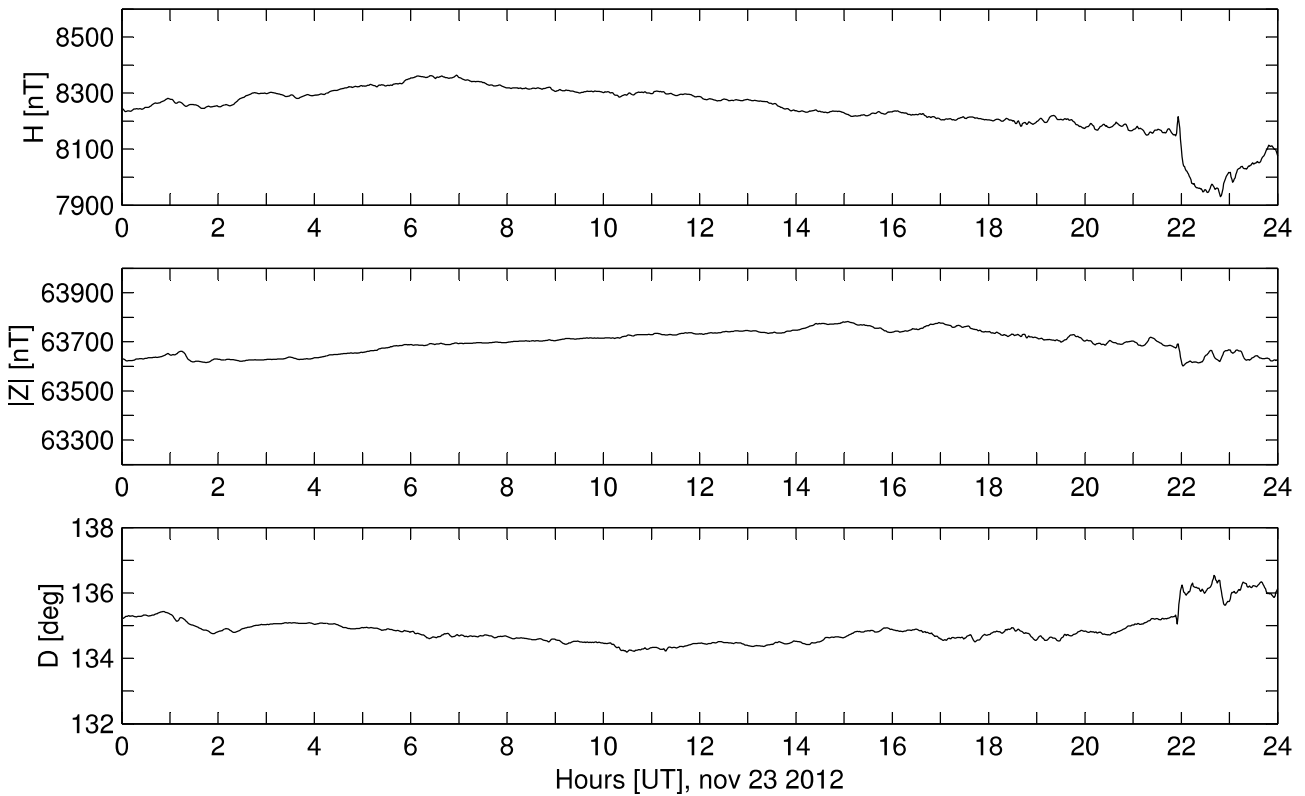
TNB Italian Geomagnetic Observatory, Antarctica



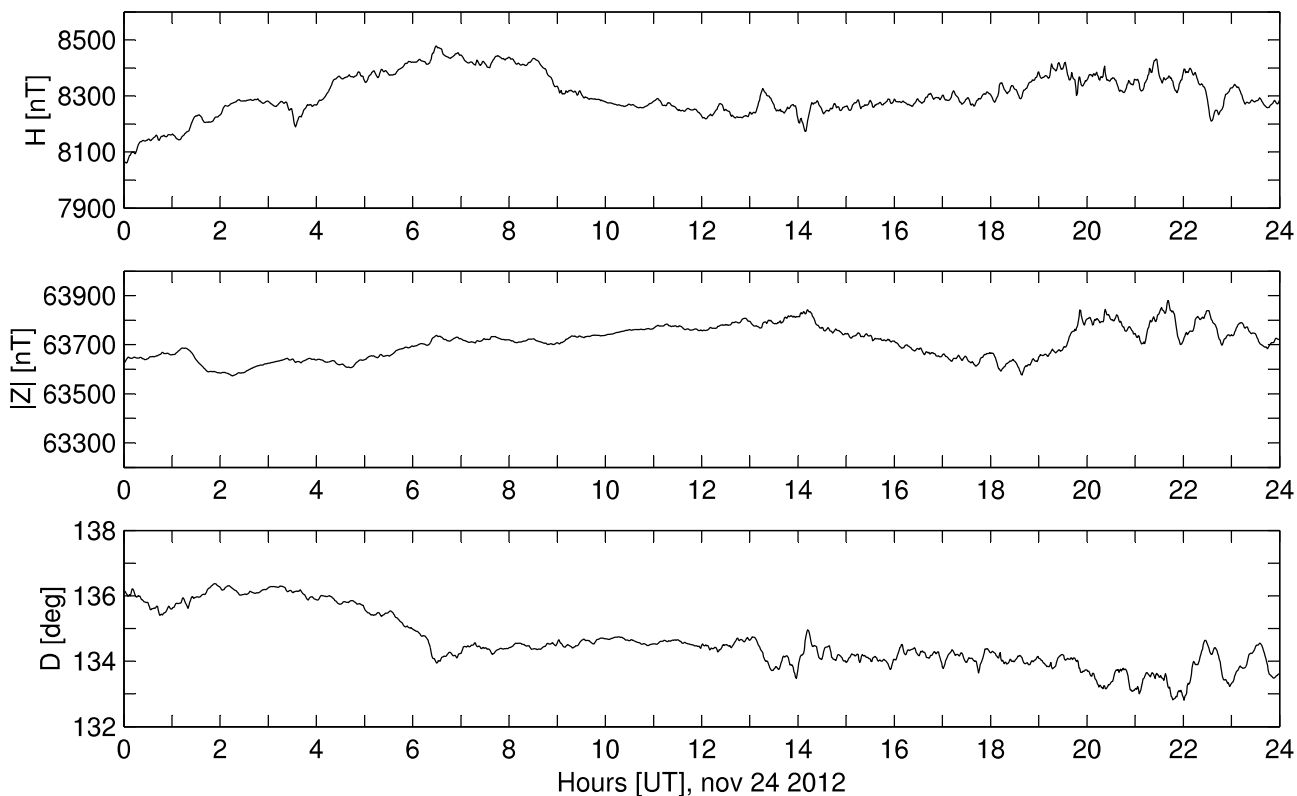
TNB Italian Geomagnetic Observatory, Antarctica



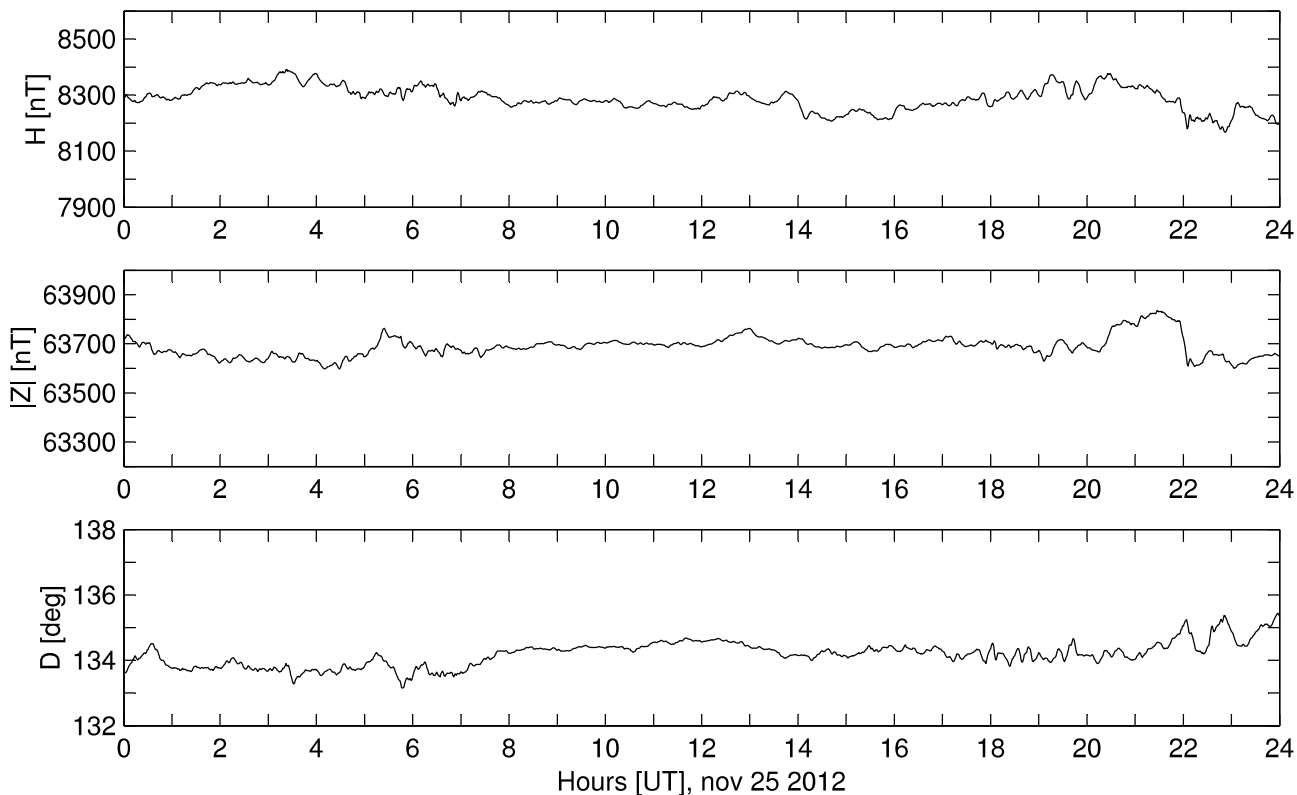
TNB Italian Geomagnetic Observatory, Antarctica



TNB Italian Geomagnetic Observatory, Antarctica



TNB Italian Geomagnetic Observatory, Antarctica



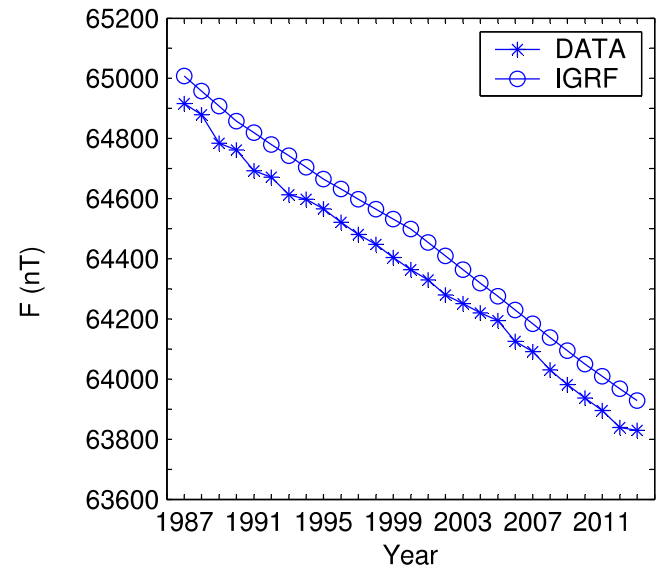
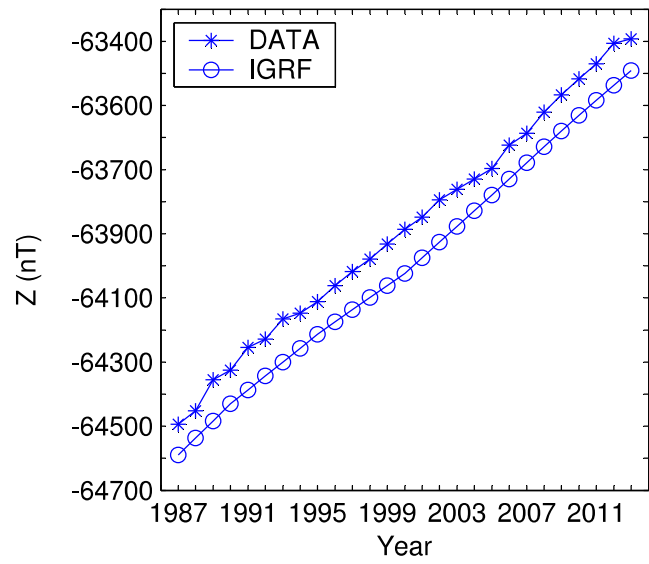
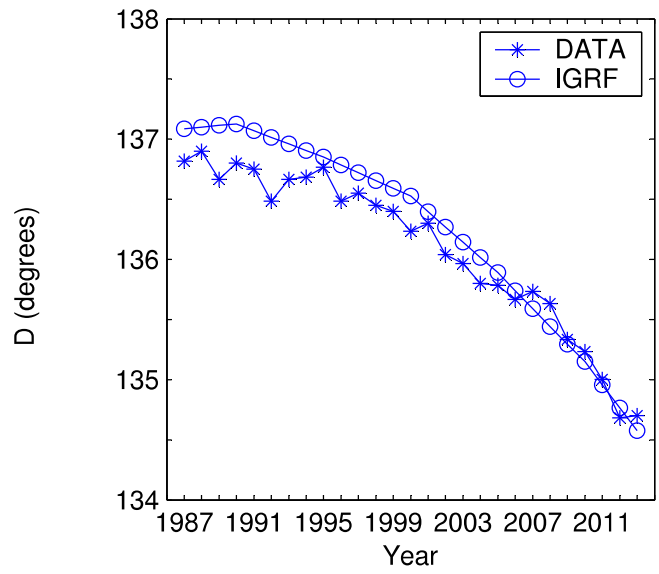
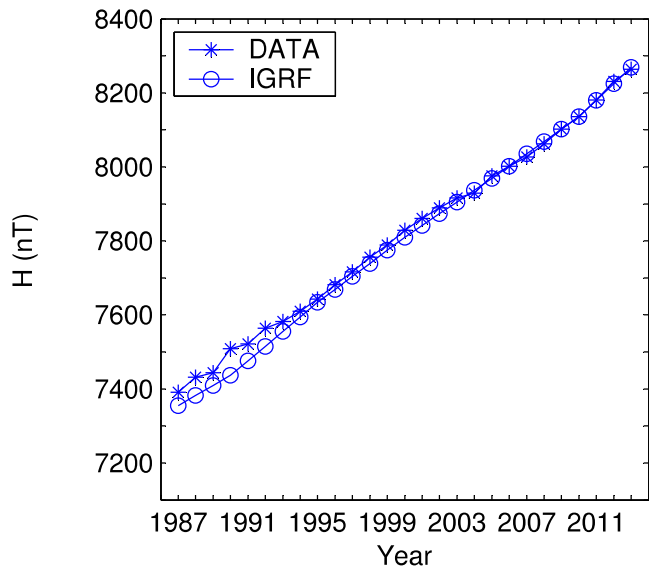


Fig. 18