INSTITUTE OF GEOPHYSICS
POLISH ACADEMY OF SCIENCES

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C-105 (415)

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BELSK, HEL, HORNSUND
2011

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Results of Geomagnetic Observations Belsk, Hel, Hornsund, 2011

Mariusz NESKA, Jan REDA and Stanisław WÓJCIK

Institute of Geophysics, Polish Academy of Sciences
ul. Księcia Janusza 64, 01-452 Warszawa, Poland

1. INTRODUCTION

This publication contains basic information on geomagnetic observations carried out in 2011 in three Polish geophysical observatories: Belsk (BEL), Hel (HLP), and Hornsund (HRN). All these observatories belong to the Institute of Geophysics, Polish Academy of Sciences. Observatories Belsk and Hel are located on the territory of Poland, while Hornsund is in Spitsbergen archipelago, governed by Norway.

In 2011, like in the previous years, the Belsk, Hel and Hornsund observatories have kept a close collaboration with the world network of geomagnetic observatories INTERMAGNET. The Belsk Observatory joined INTERMAGNET in 1992, Hel in 1999, and Hornsund in 2002.

2. DESCRIPTION OF OBSERVATORIES

The location of observatories is shown in Fig. 1 and Table 1. The geomagnetic coordinates in Table 1 were calculated in relation to the geomagnetic pole located at 83.2^{o}N, 118.3^{o}W on the basis of model IGRF-11 from epoch 2010.

The methodology of geomagnetic observations in all the three observatories was very similar, based on the "Guide for Magnetic Measurements and Observatory Practice" (Jankowski and Sucksdorff 1996). The instruments were similar too. Absolute measurements were made with the use of DI-flux magnetometers and proton magnetometers. The magnetic field variations were measured with the use of PSM magnetometers equipped in Bobrov's quartz variometers. The spare sets are equipped in PSM magnetometers or LEMI flux-gate magnetometers.

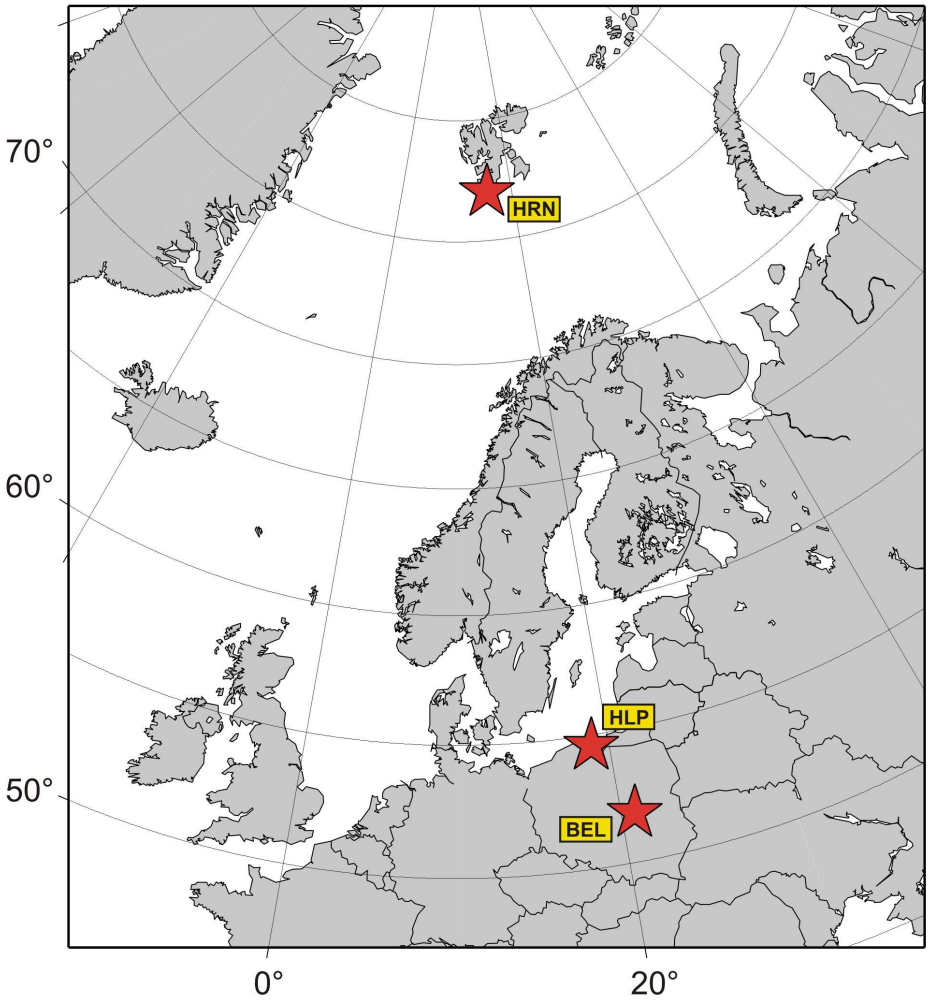

Fig. 1. Location of the Belsk, Hel and Hornsund observatories.

Table 1
Coordinates of the Polish observatories

Observatory	Geographic coordinates		Geomagnetic coordinates		Elevation
	Latitude	Longitude	Latitude	Longitude	[m]
Belsk (BEL)	51° 50.2′ N	20° 47.3′ E	49.9° N	105.1° E	180
Hel (HLP)	54° 36.5′ N	18° 49.0′ E	53.1° N	104.6° E	1
Hornsund (HRN)	77° 0.0′ N	15° 33.0′ E	73.9° N	125.3° E	15

Continuous recording has been made by means of digital loggers type NDL. Owing to the recording system we use and the fact that we strictly obey the procedures relating to the so-called magnetic service, the gaps in one-minute data from Belsk and Hel are practically absent.

It is worth mentioning that in 2011 the Belsk and Hornsund Observatories have been continuing the permanent observation of the Schumann resonance. Two horizontal magnetic components and the vertical component of the electric field have been recorded at a frequency of 100 Hz. This recording was initiated in both observatories in 2004 (Neska and Satori 2006).

2.1 Central Geophysical Observatory at Belsk, Central Poland

The Observatory at Belsk began continuous observations of the Earth magnetic field in 1965 (Jankowski and Marianiuk 2007). It continued the activity of the first Polish magnetic Observatory at Świder near Warsaw, working incessantly through the years 1920-1975. The magnetic observations were transferred from Świder to Belsk because of a strong increase of artificial noise from the Warsaw agglomeration, in particular due to the electric railroad passing nearby the Świder Observatory.

The Belsk Observatory is located at a distance of about 50 km south of Warsaw and about 2 km northwest of the village Belsk Duży. The premises of the Observatory, about 10 ha in area, is at the edge of the forest reserve Modrzewina, far away of people's settlements and automobile traffic. The Observatory is surrounded by typically agricultural regions (with fertile soil, mostly apple orchards), so the direct neighborhood is deprived of sources of major artificial geomagnetic field disturbances. It is only the electric railroad (DC powered) situated some 14 km away of the Observatory to the north that produces some small artificial magnetic disturbances, whose average level usually does not exceed 1 nT.

More information about the region in which the Observatory is located can be found, in English, Polish and German, on the internet pages of Grójec district (http://www.grojec.pl) to which the village Belsk Duży belongs. Relevant information about Belsk Observatory can be found at page http://www.igf.edu.pl/en/obserwatoria/cog_belsk.

2.2 Geophysical Observatory at Hel, Northern Poland

The Observatory at Hel began continuous observations of the earth magnetic field in 1932 (Jankowski and Marianiuk 2007). The observations were stopped in 1939, after the outbreak of World War II. During the war, the Observatory as well as its equipment and data were completely destroyed. After reconstruction, continuous observations at Hel were resumed in 1957.

The Hel Observatory is located in a small resort town at the end of Hel Peninsula by the Bay of Gdańsk. It is the area of Seaside Landscape Park (Nadmorski Park Krajobrazowy), weakly industrialized and urbanized. The region, surrounded by water from three sides, lacks any major artificial noise and is a good place for continuous magnetic observations.

The observatory premises, about 4.5 ha in area, is surrounded by mixed forest (mainly pine and birch trees). Pavilions with measurement and recording instruments are located at small clearings.

More information about the town of Hel where the Observatory is located can be found at the address: http://www.hel-miasto.pl/.

2.3 Hornsund, Spitsbergen

The Polish Polar Station Hornsund (PSP Hornsund) is situated on the White Bear Bay (Isbjørnhamna) in Hornsund Fiord, Spitsbergen Island, Svalbard archipelago. More information on the Svalbard Archipelago can be found at the address: http://svalbard.com
The Hornsund station is the northernmost Polish scientific facility carrying out year-round activity. The Hornsund region is situated in a zone of strong magnetic field activity, much stronger than on the magnetic pole. Therefore, it is a very interesting place for magnetic observations.

Polish geomagnetic observations in the Arctic were initiated during the II Polar Year; a magnetic station was then established by S. Siedlecki and C. Centkiewicz on the Bear Island. In the years 1932/33, they had carried out continuous recording of magnetic field and

performed absolute measurements. Unfortunately, all data were destroyed during the war. In the years 1957/58, in the framework of the International Geophysical Year, measurements of magnetic declination and inclination were made by J. Kowalczuk and K. Karaczun in five sites in the Hornsund Fiord region.

Since the beginning of October 1978, continuous magnetic field recording has been put into operation, and systematic absolute measurements have been implemented (Jankowski and Marianiuk 2007). Since then, PSP Hornsund has begun to fulfill all the requirements for geomagnetic observatory.

Since 1993, PSP Hornsund has been participating in the IMAGE (International Monitor for Auroral Geomagnetic Effects) project. In the framework of this project, Hornsund data are being sent to Finnish Meteorological Institute once a month on the average and available on http://www.geo.fmi.fi/image/request.html. Since 2002, PSP Hornsund is included into the global near-real-time magnetic observatory network INTERMAGNET, sending the results, via Internet, to the GIN (Geomagnetic Information Nodes) centers in Edinburgh and Paris.

3. INSTRUMENTATION

3.1 Absolute measurements

In all the three Polish observatories, the absolute measurements used for determination of bases of the recordings are performed by means of DI-flux and proton magnetometers. Di-flux magnetometers measure the absolute values of the angles of declination D and inclination I, while the proton magnetometers measure the absolute values of the total magnetic field vector F. From the measured values of F, D, and I, we can calculate all the remaining magnetic field components, H, X, Y, and Z.

The results of absolute measurements are determined by means of a special computer package ABS (author: M. Neska), which calculates the base values on the basis of data from the measurement protocol.

The instruments for absolute measurements are listed in Table 2, and the basic parameters of the instruments in Table 3.

Table 2
Instruments for absolute measurements

	Belsk	Hel	Hornsund
DI-fluxgate (fluxgate, theodolite)	ELSEC 810, THEO-10B sn: 002208	FLUX-9408 THEO-10B sn: 160334	FLUX-9408 THEO-10B sn: 160326
Proton magnetometer	PMP-8 sn: 13/1998	PMP-5 sn: 160	PMP-5 sn: 115
Frequency of measurements	6 per week	3 per week	2 per week

Table 3
Basic parameters of the instruments for absolute measurements

Fluxgate declinometer/inclinometer ELSEC 810 / THEO-10B
- Producer ..... ELSEC Oxford, UK
- Mean square error of a horizontal direction ..... $\sigma_D \approx \pm 5''$
- Mean square error of a zenith direction ..... $\sigma_I \approx \pm 5''$

Fluxgate declinometer/inclinometer FLUX-9408 / THEO-10B
- Producer (FLUX-9408).....Institute of Geophysics Pol. Acad. Sc.
- Mean square error of a horizontal direction ..... $\sigma_D \approx \pm 5''$
- Mean square error of a zenith direction ..... $\sigma_I \approx \pm 5''$

Proton magnetometer model PMP-8
- Producer ..... Institute of Geophysics Pol. Acad. Sc.
- Resolution ..... 0.01 nT
- Absolute accuracy ..... 0.2 nT

Proton magnetometer model PMP-5
- Producer ..... Institute of Geophysics Pol. Acad. Sc.
- Resolution ..... 0.1 nT
- Absolute accuracy ..... 0.2 nT

Results of base determinations and the smoothed values adopted for further computations are depicted in Figs. 2, 10 and 18 in the chapters describing individual observatories.

The mean random errors of a single base measurement, m_B, and the number of measurements *n* taken in 2011 are listed in Table 4.

Thermal coefficients of magnetic sensors are not taken into account in calculations, with a view to the following facts:
- tests made every few years indicated that the coefficients are very small, less than 0.2 nT/^{o}C,
- the magnetic sensors are located in thermostat-controlled wooden boxes where the daily temperature variations are of the order of 0.3^{o}C.

Table 4
Mean errors of measurements of B_X, B_Y and B_Z in 2011

Observatory	Element	Number of measurements n	Mean error m_B [nT]
Belsk	B_X	304	0.6
	B_Y	307	0.6
	B_Z	306	0.3
Hel	B_X	142	0.3
	B_Y	148	0.4
	B_Z	148	0.2
Hornsund	B_X	197	0.7
	B_Y	197	1.1
	B_Z	197	0.7

3.3 Recording of geomagnetic field variations

As we already mentioned, the continuous digital recordings of geomagnetic field variations in all the Polish observatories are performed by means of magnetometers PSM and digital loggers NDL In spare sets, we use magnetometers PSM or LEMI. Both the main and spare sets record the components in the rectangular coordinate system X, Y, Z. At Belsk and Hel, continuous recording of the total magnetic field modulus F is performed as well. The basic parameters of the recording systems are listed in Table 5.

Magnetometers PSM

Magnetometers PSM were designed at the Institute of Geophysics PAS with the use of torsion quartz variometers of V. N. Bobrov system (Marianiuk 1977, Jankowski *et al*. 1984). In these magnetometers, the magnet‘s deflections in response to the magnetic field changes are transformed by means of photoelectric converters into the electric current changes. Owing to a strong negative feedback, the voltage changes on the output of the converter are in linear proportion to the magnetic field changes. The magnetometers PSM are characterized by good stability, of about 3-5 nT/year, and small noise, below 10 pT.

Magnetometers LEMI

Magnetometers LEMI were designed at the Lviv Centre of the Institute of Space Research (Ukraine). They employ flux-gate sensors. These magnetometers have been successfully used as auxiliary sets. Their stability is not much less than that of PSM’s, and they are also characterized by good orthogonality of sensors and relatively small self noise.

Table 5
Basic instruments for the magnetic field variations recording

		Belsk	Hel	Hornsund
SET 1	Name of magnetometer Kind of sensor	PSM Bobrov	PSM Bobrov	PSM Bobrov
	Type	PSM-8511-01P	PSM 8511-02P	PSM-8911-05P
	Sensor's orientation	XYZ	XYZ	XYZ
	Range	+/– 850 nT	+/– 850 nT	+/– 5000 nT
	Magnetometer's producer	Institute of Geophysics PAS	Institute of Geophysics PAS	Institute of Geophysics PAS
	Digital recorder Producer	NDL TUS Electronics	NDL TUS Electronics	NDL TUS Electronics
	Sampling interval	1 s	1 s	1 s
SET 2	Name of magnetometer Kind of sensor	PSM Bobrov	PSM Bobrov	LEMI fluxgate
	Type	PSM-8511-01P	PSM 8511-03P	LEMI-003/95
	Sensor's orientation	XYZ	XYZ	XYZ
	Range	+/– 820 nT	+/– 820 nT	+/– 10,000 nT
	Magnetometer's producer	Institute of Geophysics PAS	Institute of Geophysics PAS	Institute of Geophysics PAS
	Digital recorder Producer	NDL TUS Electronics	NDL TUS Electronics	NDL TUS Electronics
	Sampling interval	1 s	1 s	1 s
Total field	Name of magnetometer	PMP-8	PMP-8	–
	Producer	Institute of Geophysics PAS	Institute of Geophysics PAS	–
	Sampling interval	30 s	30 s	–

Proton magnetometers PMP-5 and PMP-8

Magnetometers PMP-5 and PMP-8 were designed at the Institute of Geophysics PAS. These are classical proton magnetometers, in which the precession signal is forced in a cycle of proton polarization by means of direct current. The resolution of magnetometers PMP-5 is 0.1nT, that of PMP-8 being 0.01nT. The stability of both magnetometers is better than 0.3 nT/year. More information about PMP-8 magnetometer can be found on the page:

http://www.igf.edu.pl/pl/zaklady_naukowe/konstrukcji_aparatury/aparatura

Digital loggers NDL

The NDL data logger is designed for recording of analog signals, mainly coming from geophysical phenomena detectors. The instrument is equipped with six independent measuring channels; the analog-to-digital conversion is realized using 24 bit sigma-delta converters. The GPS receiver ensures high time accuracy of recorded signals. The NDL is equipped with ftp server; this allows easy access to NDL via Internet.

3.4 Calibration of magnetic sensors

The verification of scale values of recording systems in all the three observatories was made by the classical electromagnetic method: electric currents were passed through calibration coils woven over variometers. The currents induce the magnetic field of precisely known intensity. The measurements are made at least few times a year.

The scale values of magnetometers PSM and LEMI, parameters of calibration coils of PSMs, and mutual orthogonality of sensors in PSMs and LEMIs is checked every few years in large calibration coils installed at the Belsk Observatory. Adopted scale values are listed in Table 6.

Table 6
Scale values adopted for computations in 2011

Observatory	Period	Scale values		
		X [nT/bit]	Y [nT/bit]	Z [nT/bit
Belsk	Jan01-Dec31	0.00000607	0.00000605	0.00000609
Hel	Jan01-Dec31	0.00000603	0.00000605	0.00000593
Hornsund	Jan01-Dec31	0.0000356	0.0000367	0.0000360

3.5 Data processing

In processing the results of digital recordings we used the software packet developed for the needs of an observatory operating in the INTERMAGNET network. This software makes it possible to perform, among other things, the following operations:

- conversion of magnetic data into the INTERMAGNET text format IMFV1.22 and creation in this format of daily files containing one-minute means of X, Y, Z and F (author: M. Neska),
- automatic transmission of data, via the Internet, to the Institute of Geophysics PAS in Warsaw and data centers in Paris and Edinburgh (author: M. Neska),
- archiving of data and plotting of magnetograms (authors: J. Reda, M. Neska, S.Wójcik),
- calculation of results of absolute measurements (author: M. Neska),
- automatic calculation of geomagnetic indices K (Nowożyński *et al*. 1991). The indices are calculated with the use of ASm (Adaptive Smoothed) method, developed at the Institute of Geophysics PAS, and recommended by IAGA in 1991. The currently used program calculates the indices from one-minute means in the INTERMAGNET CD-ROM Data Format or in the IMFV1.22 format. The program for calculation of indices may be taken from the INTERMAGNET page:
  http://www.intermagnet.org/Software_e.php
- test printouts to check various parameters of recording adopted for calculation and a possibility of looking over current and past data curves or tables.

The diagrams illustrating the annual variations of X, Y, and Z, monthly variations of X, Y, Z and F, bases of recording sets as well as plots of K indices for 2011 were prepared with the use of programs imcdview.jar and imagplot.exe provided to us by INTERMAGNET. The diagrams prepared by means of imagplot.exe and other diagrams related to 2011 data are shown in Figs 8 .. 24.

In the present yearbook, as in previous years, we include the E indices calculated for Belsk observatory. The E indices, unlike the K indices, are calculated on the basis of energy analysis. They have been described in detail by Reda and Jankowski (2004).

3.6 Data availability

The newest data from Belsk, Hel and Hornsund observatories can be viewed in graphic form through the WEB application

http://rtbel.igf.edu.pl

described by Nowożyński and Reda (2007).

On this page, the Belsk and Hel data appear with one-hour delay, while the delay for Hornsund is few hours. The page makes it possible to view the archival data from any observatory belonging to the INTERMAGNET network (in the form of curves on the screen). It offers also a possibility of calculating the K indices according to the ASm method (Nowożyński *et al*. 1991) and E indices (Reda and Jankowski 2004).

The current data (of status REPORTED) from all the three observatories can be found in INTERMAGNET at the Internet address:

http://www.intermagnet.org/apps/dl_data_prel_e.php

Data from Belsk, Hel and Hornsund are also available from the WDCs. Addresses of some WDC pages with magnetic data are the following:

WDC for Geomagnetism, Edinburgh http://www.wdc.bgs.ac.uk/catalog/master.html

WDC for Geomagnetism, Kyoto http://swdc234.kugi.kyoto-u.ac.jp/

All the three observatories have in their archives the original data, whose sampling periods are listed in Table 5. For those interested, these data can be made available on request.

4 CONTACT PERSONS, POSTAL ADDRESSES, CONTACT DETAILS

4.1 Belsk Observatory

Jan Reda, Mariusz Neska
Central Geophysical Observatory
05-622 Belsk
Poland
Tel.: +48 486610830 Fax: +48 486610840
Email: jreda@igf.edu.pl (J.Reda), nemar@igf.edu.pl (M.Neska)
http://www.igf.edu.pl/en/obserwatoria/cog_belsk

4.2 Hel Observatory

Stanisław Wójcik
Geophysical Observatory
ul. Sosnowa 1
84-150 Hel
POLAND
Tel./Fax +48 58 6750480
Email: hel@igf.edu.pl

http://www.igf.edu.pl/en/obserwatoria/hel

4.3 Hornsund

Mariusz Neska
Central Geophysical Observatory
05-622 Belsk
POLAND
Tel.: +48 486610833 Fax: +48 486610840
Email: nemar@igf.edu.pl
http://hornsund.igf.edu.pl/index_en.php
http://www.igf.edu.pl/en/zaklady_naukowe/zaklad_badan_polarnych/obserwatoria

5 PERSONNEL TAKING PART IN THE WORK OF BELSK, HEL AND HORNSUND OBSERVATORIES IN 2011

5.1 Belsk

– Jan Reda (project leader of geomagnetic observations in Belsk, Hel, Hornsund)
– Mariusz Neska (data processing)
– Paweł Czubak (data processing)
– Michał Sawicki (apparatus service)
– Krzysztof Kucharski (observer)
– Halina Suska (data processing, observer)
– Józef Skowroński (observer)

5.2 Hel

– Stanisław Wójcik (head of Geophysical Observatory)
– Anna Wójcik (observer)
– Mariusz Neska (data processing)
– Jan Reda (data processing)

5.3 Hornsund

– Mariusz Neska (head of geomagnetic observations)
– Michał Sawicki (observer in 1-st half-year)
– Jacek Renkas (observer in 2-nd half-year)
– Jan Reda (data processing)

L i t e r a t u r e

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Jankowski, J., J. Marianiuk, A. Ruta, C. Sucksdorff, and M. Kivinen (1984), *Long-term stability of a torque-balance variometer with photoelectric converters in observatory practice*, Geophys. Surv. **6**, 3/4, 367-380.

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Marianiuk, J. (1977), *Photoelectric converter for recording the geomagnetic field elements: construction and principle of operation*, Publs. Inst. Geophys. Pol. Acad. Sc. **C-4 (114)**, 57-73.

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Nowożyński, K., T. Ernst and J. Jankowski (1991), *Adaptive smoothing method for computer derivation of K-indices*, Geophys. J. Int. **104**, 85-93.

Nowożyński, K., and J. Reda (2007), *Comparison of observatory data in quasi-real time*, Publs. Inst. Geophys. Pol. Acad. Sc. **C-99 (398)**, 123-127.

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Reda, J., and J. Jankowski (2004), *Three hour activity index based on power spectra estim tion*, Geophys. J. Int. **157**, 141-146.

Reda, J. (editor) (2007), *XII IAGA Workshop on Geomagnetic Observatory Instruments, Data Acquisition and Processing, Belsk, 19-24 June 2006, Monographic Volume*, Publs. Inst. Geophys. Pol. Acad. Sc. **C-99 (398)**, 397 pp.

Technical data of PMP-8:
http://www.igf.edu.pl/pl/zaklady_naukowe/konstrukcji_aparatury/aparatura

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6. TABLES AND PLOTS FOR BELSK OBSERVATORY

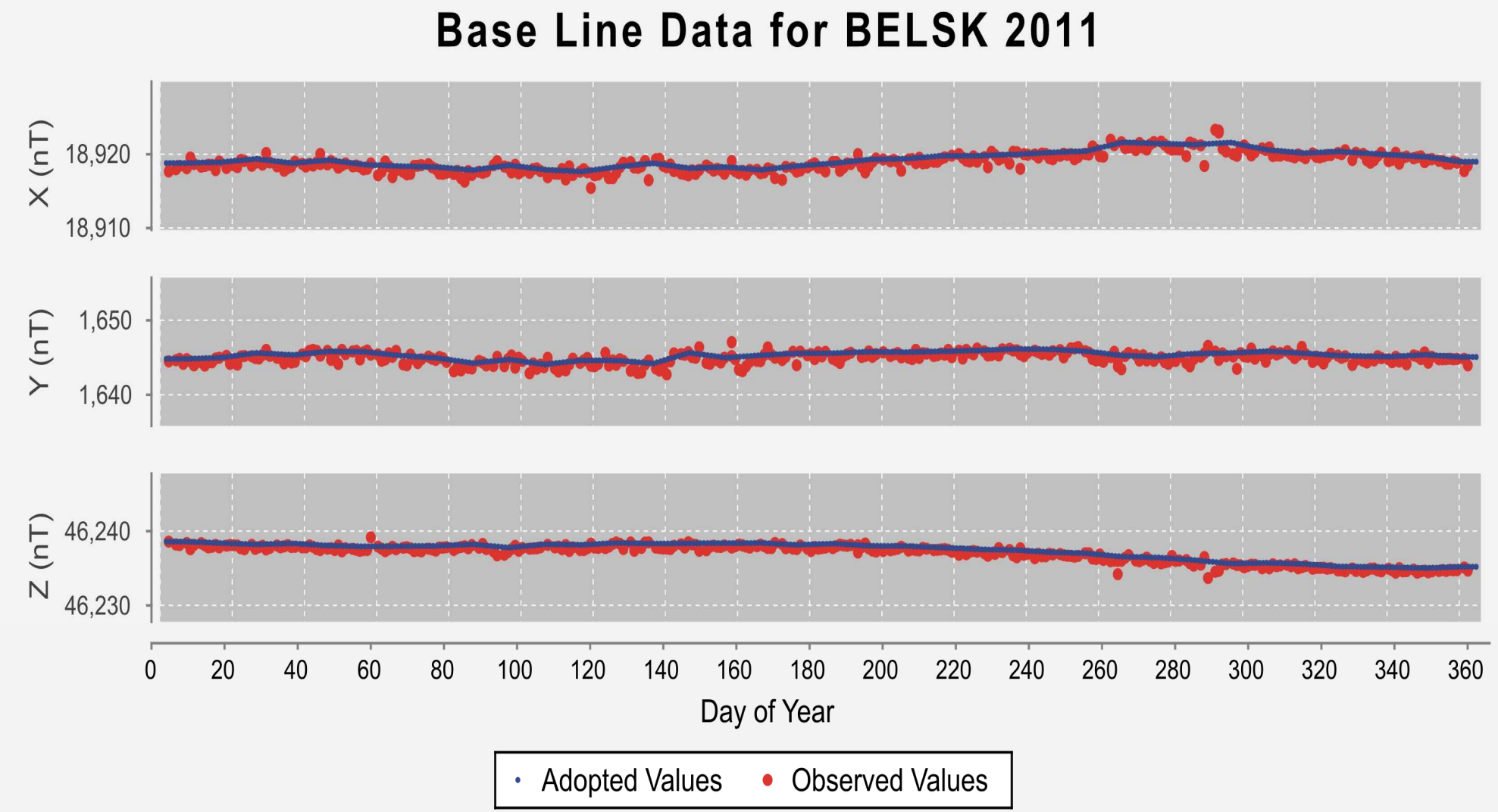

Fig. 2. Base values of set 1, Belsk 2011.

Annual mean values of magnetic elements in Belsk Observatory

No	Year	D [º ‘]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [º ‘]	F [nT]
1	1966	2 04.2	18901.2	45023.3	18888.9	682.8	67 13.6’	48829.8
2	1967	2 05.6	18906.2	45047.7	18893.6	690.7	67 14.0	48854.3
3	1968	2 06.2	18917.8	45071.3	18905.5	694.6	67 13.8	48880.5
4	1969	2 06.3	18935.7	45093.5	18922.9	695.6	6713.3	48907.9
5	1970	2 06.6	18953.0	45123.1	18940.2	697.7	67 13.0	48941.9
6	1971	2 06.6	18975.5	45146.4	18962.6	698.8	67 12.2	48972.1
7	1972	2 08.0	18991.6	45176.3	18978.4	706.7	67 11.9	49005.9
8	1973	2 10.2	19004.6	45210.8	18991.0	719.4	67 12.0	49042.8
9	1974	2 13.3	19016.3	45245.6	19002.0	737.1	67 12.2	49079.3
10	1975	2 16.4	19035.2	45273.5	19020.2	754.9	67 11.7	49112.4
11	1976	2 18.5	19049.7	45306.9	19034.3	767.3	67 11.7	49148.8
12	1977	2 22.0	19062.1	45336.6	19045.8	787.4	67 11.7	49181.0
13	1978	2 27.4	19058.6	45375.7	19041.1	817.1	67 13.0	49215.7
14	1979	2 32.3	19061.4	45401.4	19042.7	844.2	67 13.5	49240.5
15	1980	2 37.2	19063.2	45418.4	19043.3	871.2	67 13.9	49256.8
16	1981	2 42.9	19047.1	45448.9	19025.7	902.0	67 15.7	49278.7
17	1982	2 48.3	19034.8	45478.8	19012.0	931.3	67 17.3	49301.6
18	1983	2 52.4	19032.6	45498.8	19008.7	953.8	67 18.0	49319.2
19	1984	2 56.9	19022.8	45519.8	18997.6	978.4	67 19.2	49334.8
20	1985	3 00.8	19015.2	45542.0	18988.9	999.5	67 20.3	49352.3
21	1986	3 05.1	19003.3	45570.4	18975.8	1022.8	67 21.8	49373.9
22	1987	3 08.5	18999.1	45592.7	18970.6	1041.2	67 22.7	49392.9
23	1988	3 12.4	18983.0	45626.4	18953.3	1062.0	67 24.6	49417.8
24	1989	3 15.9	18966.2	45662.1	18935.4	1080.3	67 26.6	49444.3
25	1990	3 18.8	18961.5	45684.3	18929.8	1095.9	67 27.5	49463.1
26	1991	3 22.2	18950.8	45709.3	18918.0	1114.1	67 28.8	49482.0
27	1992	3 25.3	18954.8	45726.1	18921.0	1131.2	67 29.1	49499.1
28	1993	3 29.8	18956.4	45743.7	18921.1	1156.0	67 29.4	49516.0
29	1994	3 34.8	18953.6	45772.4	18916.6	1183.3	67 30.4	49541.4
30	1995	3 39.8	18959.3	45796.8	18920.6	1211.5	67 30.7	49566.2
31	1996	3 45.0	18965.7	45821.9	18925.1	1240.6	67 30.9	49591.8
32	1997	3 50.9	18962.8	45856.9	18920.0	1272.7	67 32.0	49623.0
33	1998	3 57.3	18955.8	45897.1	18910.6	1307.6	67 33.6	49657.5
34	1999	4 02.5	18957.8	45930.6	18910.6	1336.4	67 34.3	49689.2
35	2000	4 07.8	18955.4	45968.7	18906.2	1365.4	67 35.5	49723.5
36	2001	4 13.0	18962.4	46004.8	18911.1	1394.2	67 36.0	49759.6
37	2002	4 18.4	18969.2	46043.6	18915.6	1424.4	67 36.6	49798.0
38	2003	4 24.2	18970.2	46089.6	18914.2	1456.7	67 37.7	49840.9
39	2004	4 29.4	18980.3	46121.0	18922.0	1486.0	67 37.9	49873.8
40	2005	4 34.7	18984.3	46154.6	18923.7	1515.5	67 38.5	49906.4
41	2006	4 39.8	18996.7	46177.2	18933.8	1544.3	67 38.3	49932.0
42	2007	4 45.8	19007.4	46206.7	18941.8	1578.4	67 38.4	49963.4
43	2008	4 52.5	19014.0	46236.3	18945.2	1615.9	67 38.7	49993.3
44	2009	4 59.7	19022.2	46264.5	18949.9	1656.4	67 39.0	50022.5
45	2010	5 08.0	19017.6	46301.3	18941.4	1701.4	67 40.2	50054.7
46	2011	5 16.1	19015.0	46338.0	18934.7	1745.7	67 41.3	50087.7

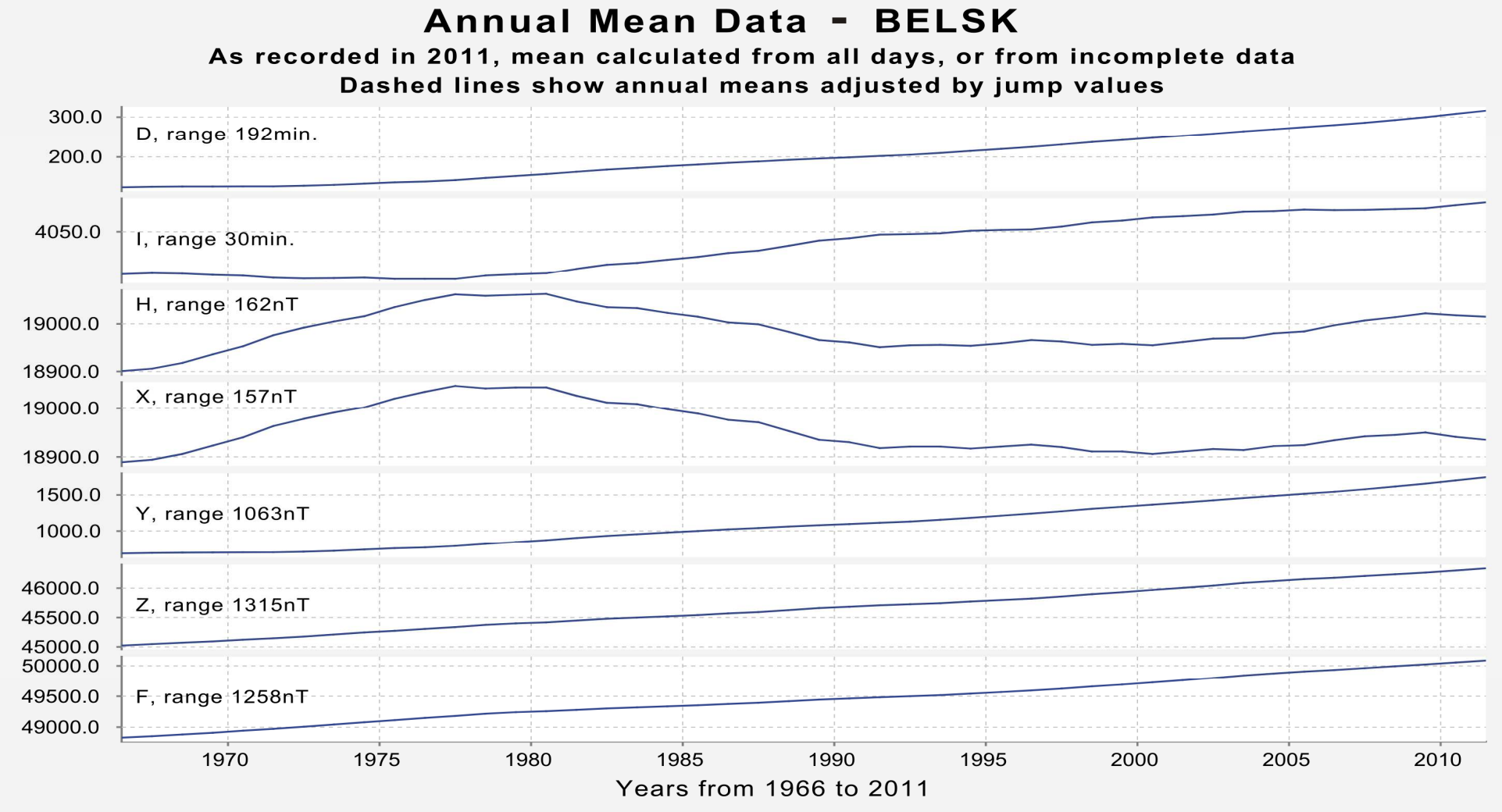

Fig. 3. Secular changes of H, X, Y, Z, F, D and I at Belsk.

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

BEL 2011

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 18500 + ... in nT													
All days	439	435	435	436	438	438	438	433	428	430	430	436	435
Quiet days	441	441	441	442	444	439	440	438	434	433	435	440	439
Disturbed days	433	430	418	428	423	435	439	430	417	421	416	433	427
EAST COMPONENT: 1500 + ... in nT													
All days	225	230	233	236	238	244	247	251	255	259	263	265	246
Quiet days	225	229	232	236	235	242	247	248	252	258	261	265	244
Disturbed days	227	234	239	238	241	247	247	255	261	261	266	266	248
VERTICAL COMPONENT: 46000 + ... in nT													
All days	322	325	327	328	332	337	339	342	346	350	354	354	338
Quiet days	321	323	325	327	330	336	338	340	344	350	352	353	337
Disturbed days	323	325	330	331	338	338	339	339	348	351	358	355	340

Three-hour-range K indices
Belsk, January - March, 2011
The limit of K=9 is 450

Day	January		February		March	
	K	SK	K	SK	K	SK
1	2101 1213	11	2222 2432	19	2233 4664	30
2	1211 0222	11	2222 2231	16	4322 3543	26
3	1111 1233	13	1011 0111	6	3332 3444	26
4	1211 2231	13	2322 2366	26	1122 3444	21
5	0001 1121	6	5322 2343	24	2212 2133	16
6	1101 1114	10	2222 3433	21	0111 2224	13
7	5222 2343	23	2101 1123	11	2112 2244	18
8	2122 3333	19	2211 0022	10	2221 1222	14
9	1212 2233	16	1011 1111	7	2111 1121	10
10	2112 2232	15	0122 1112	10	2233 3244	23
11	2211 2344	19	1101 1232	11	4532 2445	29
12	2222 2132	16	2221 1120	11	4222 1154	21
13	2201 2334	17	0011 1022	7	1012 2541	16
14	3221 2433	20	0011 1346	16	2121 0000	6
15	1211 2212	12	2222 2223	17	0100 0100	2
16	1101 2232	12	1211 1001	7	0021 1001	5
17	3212 2211	14	0010 0111	4	1111 1141	11
18	2111 1112	10	3443 3423	26	1111 0111	7
19	3212 2331	17	3122 2112	14	1112 2112	11
20	1112 1132	12	1122 2332	16	1111 2224	14
21	1110 2221	10	2211 2233	16	2110 0223	11
22	1110 1121	8	2111 0100	6	3312 2112	15
23	0110 1110	5	0111 1110	6	3233 2443	24
24	0022 1233	13	1111 0000	4	1011 2111	8
25	3011 1123	12	0112 1122	10	0012 2121	9
26	1011 0231	9	0011 1212	8	1001 1001	4
27	2011 1011	7	0001 1110	4	0000 0112	4
28	2111 1221	11	0101 1121	7	0001 2111	6
29	3111 1210	10			1001 0312	8
30	0100 0001	2			2112 1001	8
31	0111 1232	11			0112 1111	8

Three-hour-range K indices
Belsk, April - June, 2011
The limit of K=9 is 450

Day	April			May			June		
	K		SK	K		SK	K		SK
1	2122	1443	19	3223	4422	22	3132	3423	21
2	4334	3245	28	3333	3333	24	2222	2131	15
3	3333	3244	25	3333	3332	23	1122	2211	12
4	4222	1111	14	2122	1211	12	0110	1155	14
5	2212	1133	15	2211	2231	14	5444	3232	27
6	2215	4544	27	0122	1112	10	2122	2322	16
7	2211	1121	11	1111	3333	16	0112	1344	16
8	1112	3345	20	1111	0012	7	3411	3223	19
9	3222	1111	13	2101	1310	9	2311	2233	17
10	1000	1112	6	2223	4443	24	2033	3333	20
11	2012	2332	15	2212	1121	12	2333	4222	21
12	2344	4413	25	2111	0111	8	2123	3321	17
13	4333	2111	18	1111	2211	10	2123	3422	19
14	1122	1112	11	1111	1213	11	2224	1223	18
15	1112	2112	11	2223	3423	21	2123	3222	17
16	0212	1111	9	3234	4332	24	1212	2310	12
17	1001	2111	7	2234	3233	22	2312	3431	19
18	0133	3312	16	2212	2311	14	2111	2211	11
19	1112	2113	12	1112	2110	9	1112	2112	11
20	3433	3222	22	1201	2110	8	2222	2222	16
21	1111	1221	10	0112	1122	10	2322	4332	21
22	2223	2202	15	2322	2221	16	3213	3443	23
23	2012	1111	9	1111	2222	12	4333	4333	26
24	1111	1223	12	2212	3311	15	2223	3443	23
25	2211	1211	11	1111	1112	9	2212	2222	15
26	1011	1111	7	2211	2322	15	3322	3221	18
27	0111	1110	6	1112	3334	18	1111	1222	11
28	0011	1222	9	4345	5314	29	1111	2100	7
29	1211	2336	19	4444	4543	32	0111	1111	7
30	4334	3344	28	3222	2223	18	1222	2222	15
31				3323	2344	24			

Three-hour-range K indices
Belsk, July - September, 2011
The limit of K=9 is 450

Day	July			August			September		
	K		SK	K		SK	K		SK
1	2333	4432	24	2322	2112	15	1101	1101	6
2	0011	2223	11	2111	2111	10	1111	1131	10
3	2312	2221	15	1111	2212	11	2333	2333	22
4	1312	3344	21	0211	1213	11	3312	2431	19
5	4322	1232	19	3211	1376	24	1111	2342	15
6	2232	2323	19	5434	4423	29	1222	2221	14
7	2112	2232	15	4221	1232	17	3112	1121	12
8	1122	2223	15	2222	3122	16	1211	1111	9
9	2313	2323	19	2332	1232	18	0112	5565	25
10	2322	3322	19	2222	2121	14	5433	3545	32
11	2234	2432	22	1211	1132	12	3211	3324	19
12	3212	3331	18	1112	1220	10	4333	3454	29
13	3213	3221	17	1101	2112	9	4433	2133	23
14	2223	3322	19	2222	2434	21	1112	2122	12
15	1211	2211	11	4223	2333	22	1112	2222	13
16	1112	1221	11	2222	3112	15	0111	1112	8
17	1111	1222	11	3212	2221	15	1244	5553	29
18	1323	2212	16	1111	2110	8	2112	2212	13
19	1224	3443	23	0011	1112	7	0021	1120	7
20	3224	4334	25	1211	2223	14	0212	2122	12
21	3223	3323	21	1111	1121	9	0112	2212	11
22	3232	3332	21	2131	1232	15	1002	1122	9
23	2212	2222	15	2122	3342	19	1111	1111	8
24	0111	2222	11	4212	2213	17	0012	2112	9
25	2223	4332	21	2112	2232	15	1112	2221	12
26	2222	2121	14	0011	1223	10	1112	4665	26
27	1111	1212	10	2111	2221	12	5443	3335	30
28	1112	0111	8	2122	1232	15	3432	4422	24
29	0102	3310	10	3133	2222	18	5432	3442	27
30	1113	3444	21	1001	1121	7	3111	1233	15
31	3223	2333	21	1011	1100	5			

Three-hour-range K indices
Belsk, October - December, 2011
The limit of K=9 is 450

Day	October		November		December	
	K	SK	K	SK	K	SK
1	4322 3233	22	3124 3323	21	3212 2131	15
2	1232 2433	20	3222 2211	15	1011 1243	13
3	0111 3221	11	1111 1110	7	2132 2244	20
4	1122 2212	13	0001 1122	7	3111 2101	10
5	2124 3442	22	2111 1011	8	0010 1033	8
6	1312 3221	15	0111 1202	8	0000 1110	3
7	1212 1211	11	0111 1321	10	0011 0011	4
8	1111 1335	16	2222 2210	13	1001 1120	6
9	3231 2223	18	1011 0110	5	1002 1211	8
10	2110 0111	7	1001 1121	7	3222 1233	18
11	0021 2221	10	1212 0010	7	2122 3331	17
12	1121 1131	11	0022 1200	7	2111 2322	14
13	1211 1110	8	0011 0111	5	2111 2112	11
14	0011 1111	6	0111 0000	3	1110 1011	6
15	4212 2312	17	0122 3202	12	0110 1010	4
16	2222 3213	17	2211 1011	9	0001 1110	4
17	3111 0103	10	1111 1121	9	0000 0002	2
18	1110 2210	8	1110 1111	7	1001 1022	7
19	2212 2111	12	1010 0000	2	2211 1232	14
20	2211 1131	12	0011 0111	5	1111 1232	12
21	2121 1111	10	1111 1214	12	0111 2233	13
22	1111 1000	5	2112 2312	14	3111 1121	11
23	0011 1212	8	2222 1123	15	1111 1000	5
24	2121 1166	20	2112 3234	18	0111 1122	9
25	7533 3211	25	3211 1112	12	1111 1110	7
26	1111 1212	10	1011 1123	10	0110 0100	3
27	1122 2012	11	1122 1210	10	1001 0001	3
28	0011 1001	4	0000 0013	4	1002 2221	10
29	0010 0100	2	3322 1241	18	1223 2233	18
30	1112 2312	13	3112 3333	19	1211 1333	15
31	4122 2143	19			3112 1133	15

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, January - March, 2011

Day	January		February		March	
	K	SE	K	SE	K	SE
1	2100 1213	10	2211 2432	17	3233 4655	31
2	1111 0222	10	2121 2231	14	5322 4543	28
3	1001 1233	11	0000 0010	1	3332 3555	29
4	1211 1341	14	1422 2377	28	1123 3554	24
5	0001 1121	6	5422 1344	25	1212 1233	15
6	1000 0115	8	2123 3533	22	0101 1215	11
7	5222 2454	26	1100 1123	9	2212 2254	20
8	2112 3233	17	2301 0022	10	2221 1222	14
9	1211 1343	16	0001 0110	3	2111 1021	9
10	2111 2142	14	0112 1012	8	2234 3255	26
11	2101 2454	19	1101 1242	12	5542 2446	32
12	2222 1132	15	2220 1130	11	4222 1155	22
13	2101 1344	16	0010 0012	4	0003 2541	15
14	3222 2444	23	0000 0347	14	1111 0000	4
15	1211 2111	10	2111 2223	14	0000 0000	0
16	1100 2232	11	0211 0000	4	0010 0000	1
17	3212 2121	14	0000 0110	2	0110 1141	9
18	2111 0112	9	3354 3423	27	1011 0000	3
19	3212 3331	18	3112 3111	13	1012 2101	8
20	0011 1141	9	1132 2343	19	1111 2224	14
21	1000 1221	7	2312 2244	20	2000 0224	10
22	1110 1021	7	2001 0000	3	3312 2102	14
23	0010 0100	2	0010 1010	3	3223 1554	25
24	0011 0144	11	0101 0000	2	1012 1010	6
25	3011 1124	13	0001 1122	7	0011 2111	7
26	2000 0140	7	0001 1112	6	0001 0000	1
27	2001 1010	5	0001 0110	3	0000 0112	4
28	2110 0321	10	0101 0011	4	0002 2011	6
29	4101 1200	9			0000 0212	5
30	0000 0000	0			2101 1000	5
31	0100 0333	10			0012 1211	8

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, April – June, 2011

Day	April K	April SE	May K	May SE	June K	June SE
1	2023 1354	20	4333 4533	28	3132 3424	22
2	5334 2155	28	4343 3444	29	2232 2231	17
3	4333 3355	29	3423 3343	25	1111 2200	8
4	4322 1101	14	2121 1211	11	0010 1146	13
5	1112 0043	12	1211 3130	12	5443 3332	27
6	2215 6645	31	0111 1102	7	2121 2321	14
7	2211 0121	10	1001 3333	14	0011 1244	13
8	1012 3345	19	1000 0012	4	4411 4223	21
9	4221 1101	12	2001 1310	8	3311 2233	18
10	1000 1212	7	1123 3443	21	2023 3333	19
11	3002 2431	15	1201 1120	8	2343 4222	22
12	1355 5414	28	2010 0111	6	2123 3321	17
13	4333 1101	16	1011 1210	7	3213 3432	21
14	0121 0003	7	1100 1212	8	3224 1113	17
15	1112 2112	11	2213 3423	20	2122 2212	14
16	0112 1101	7	3234 4342	25	1111 2400	10
17	0001 2111	6	1233 3223	19	2311 3431	18
18	0033 4312	16	1211 1311	11	2111 1101	8
19	1111 1112	9	1011 2000	5	1011 2012	8
20	4543 3111	22	0100 1100	3	2222 2122	15
21	1111 1111	8	0011 1122	8	2321 4442	22
22	2213 2102	13	2311 1210	11	3212 3444	23
23	2012 0100	6	0101 2222	10	4333 4334	27
24	0111 1224	12	3112 3211	14	2222 3553	24
25	1210 1110	7	2101 0102	7	1212 1323	15
26	0001 1011	4	2110 2312	12	2411 2331	17
27	0011 1110	5	1122 3444	21	1111 1112	9
28	0000 0222	6	5355 6324	33	1111 2000	6
29	1211 1346	19	5544 4554	36	0101 1100	4
30	4335 3355	31	3122 2233	18	1222 1222	14
31			3333 2444	26		

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, July - September, 2011

Day	July		August		September	
	K	SE	K	SE	K	SE
1	2343 5532	27	1322 1112	13	1101 0101	5
2	0011 2223	11	3111 1110	9	0100 1131	7
3	3312 2111	14	0000 3112	7	2333 2423	22
4	1212 3344	20	0211 1203	10	4411 2531	21
5	4422 1242	21	4201 0367	23	1011 1342	13
6	2231 2324	19	6434 4423	30	1222 2121	13
7	2112 2232	15	4221 1133	17	3111 1131	12
8	1121 2223	14	2223 3112	16	1100 0000	2
9	2413 2423	21	2332 1131	16	0111 5676	27
10	3332 3422	22	2122 1121	12	5543 3556	36
11	2134 2542	23	1111 1131	10	4211 4335	23
12	4212 4440	21	0102 1220	8	5343 3465	33
13	2213 3221	16	0110 1112	7	5533 2133	25
14	1213 3312	16	3212 1434	20	1002 1122	9
15	1311 2211	12	5213 2334	23	1112 1222	12
16	1112 1211	10	2213 3122	16	0001 1112	6
17	1101 1122	9	3111 2111	11	0245 6554	31
18	1323 1212	15	0000 2110	4	1012 2212	11
19	0224 3544	24	0011 1001	4	0010 0110	3
20	3335 4344	29	0211 2223	13	0312 2121	12
21	4222 3323	21	1000 1011	4	0012 2211	9
22	3332 3333	23	2131 0333	16	1002 1122	9
23	2312 2232	17	2022 3442	19	1001 0001	3
24	0101 1221	8	4111 2203	14	0012 2112	9
25	2223 4232	20	2112 2232	15	0002 2221	9
26	2222 2021	13	0000 0233	8	1012 5775	28
27	1100 1201	6	2111 2221	12	6443 4335	32
28	1111 0112	8	2112 1232	14	4443 4532	29
29	0101 3300	8	3123 1212	15	6442 3442	29
30	1113 3454	22	0002 1120	6	3001 0233	12
31	3223 2234	21	0011 1000	3		

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, October - December, 2011

Day	October		November		December	
	K	SE	K	SE	K	SE
1	5423 3244	27	4124 4423	24	4212 1031	14
2	2233 3524	24	2222 3211	15	1011 0143	11
3	0012 3221	11	1111 0210	7	2022 2244	18
4	1022 1312	12	0001 1122	7	3111 1101	9
5	2124 3532	22	2110 0010	5	0010 0013	5
6	0312 2221	13	0001 1201	5	0000 1110	3
7	0112 1211	9	0011 0211	6	0000 0011	2
8	1111 0345	16	2221 2310	13	0000 0020	2
9	4231 2224	20	0000 0000	0	0001 1301	6
10	1110 0100	4	0001 0122	6	4222 1134	19
11	0010 2221	8	0112 0010	5	2121 3331	16
12	0120 1131	9	0012 1200	6	3111 1322	14
13	1201 1000	5	0011 0000	2	2111 2112	11
14	0011 1000	3	0100 0000	1	1100 0010	3
15	5202 2311	16	0012 3202	10	0100 0000	1
16	2212 4114	17	2211 0011	8	0000 0000	0
17	3111 0003	9	1111 0121	8	0000 0002	2
18	1110 1210	7	0110 1001	4	0001 0011	3
19	2213 2001	11	0000 0000	0	2111 1232	13
20	2211 0130	10	0000 0011	2	1112 0142	12
21	3110 1010	7	0011 1215	11	0101 2243	13
22	1111 1000	5	2112 2412	15	2101 0111	7
23	0001 1112	6	2321 1133	16	1101 0000	3
24	2021 0166	18	2111 3244	18	0011 1022	7
25	7643 3210	26	3210 0002	8	1111 0000	4
26	0110 0112	6	1011 1113	9	0010 0000	1
27	0112 2002	8	1122 1310	11	0000 0000	0
28	0001 0000	1	0000 0014	5	0002 2221	9
29	0000 0000	0	4321 1251	19	1223 1233	17
30	1013 2413	15	3013 4443	22	1211 1233	14
31	5012 2154	20			3012 0032	11

* - see literature: Reda and Jankowski, 2004

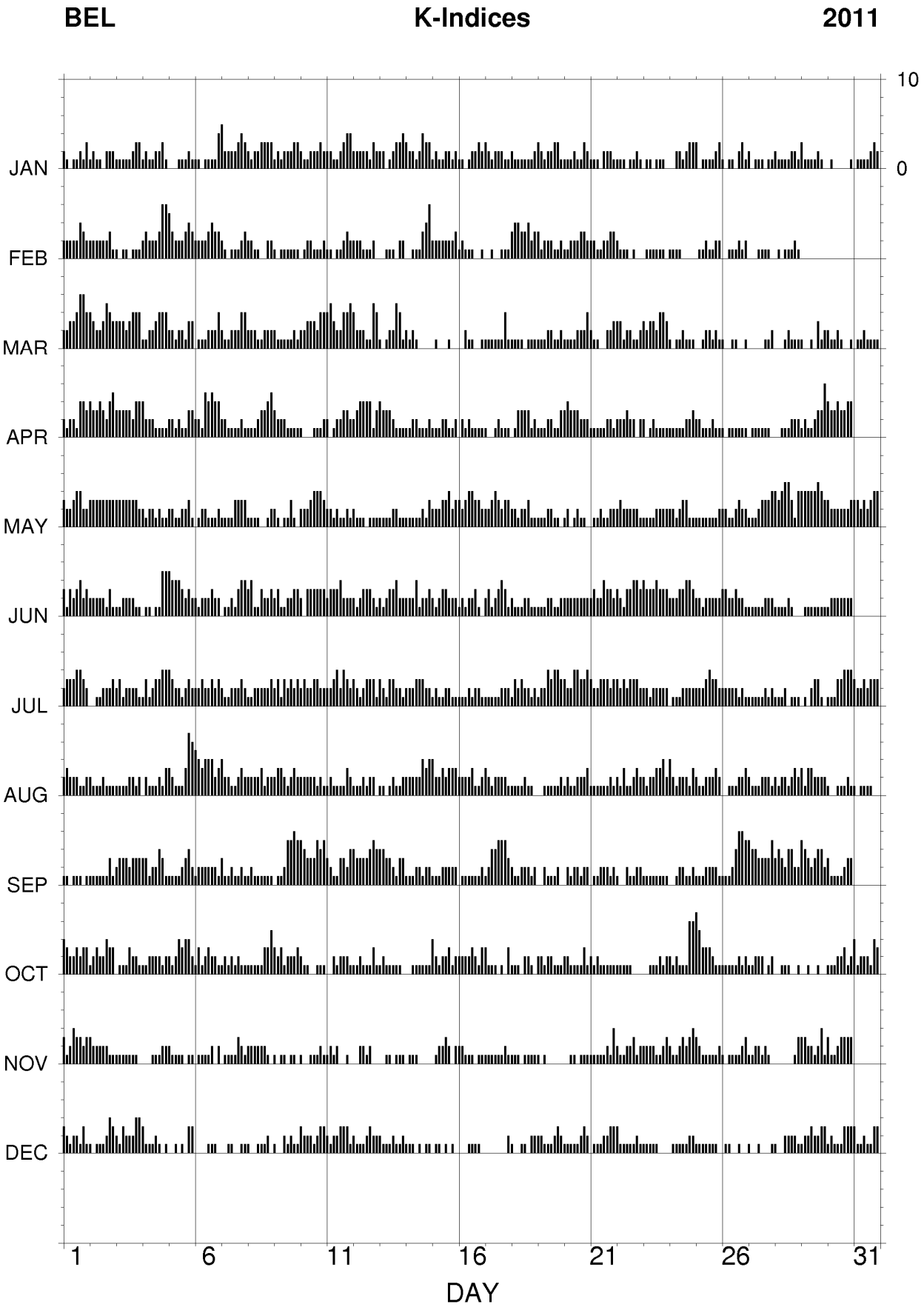

Fig. 4. K-indices in graphical form, Belsk 2011.

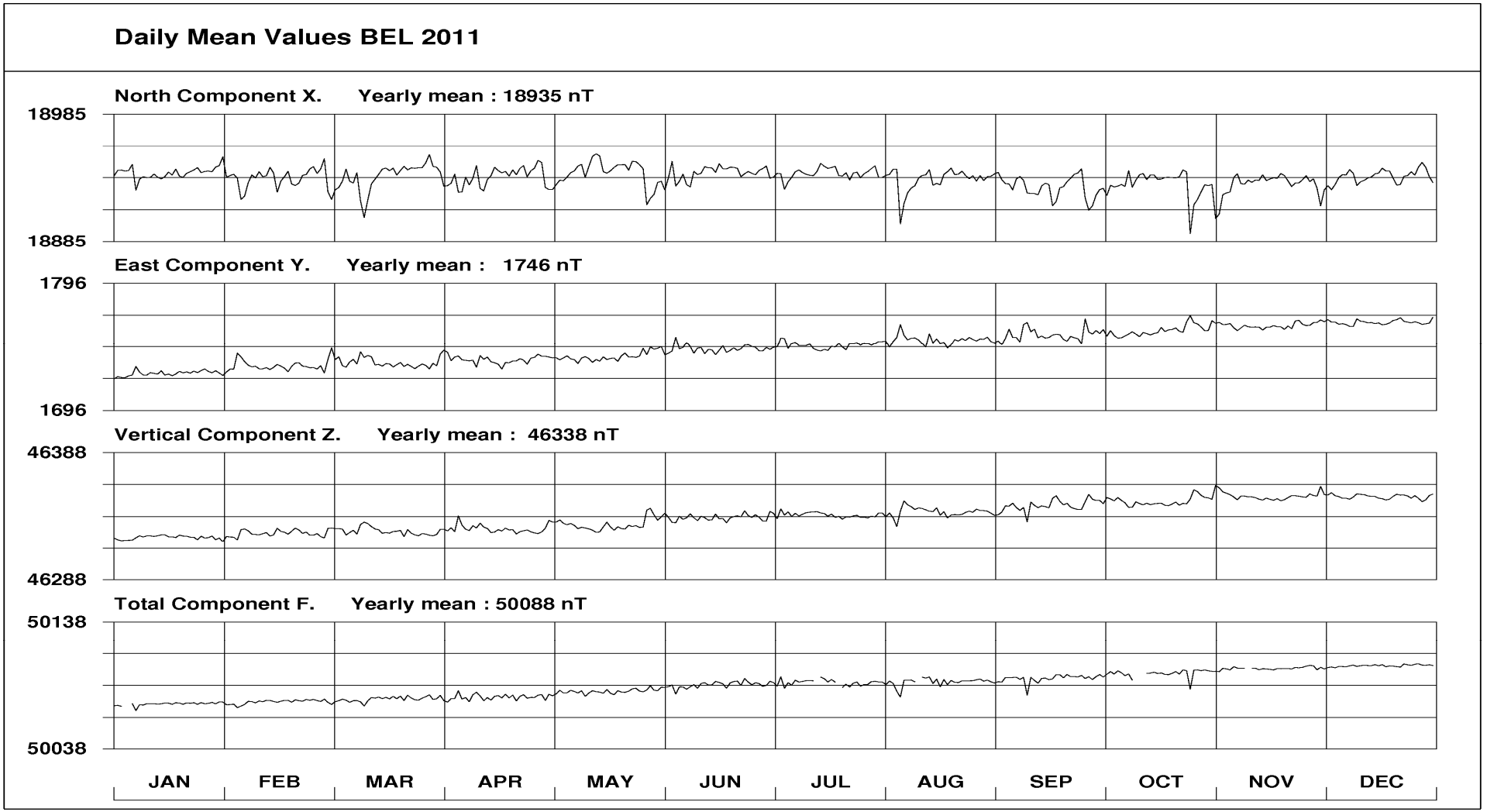

Fig. 5. Daily mean data plot for Belsk 2011.

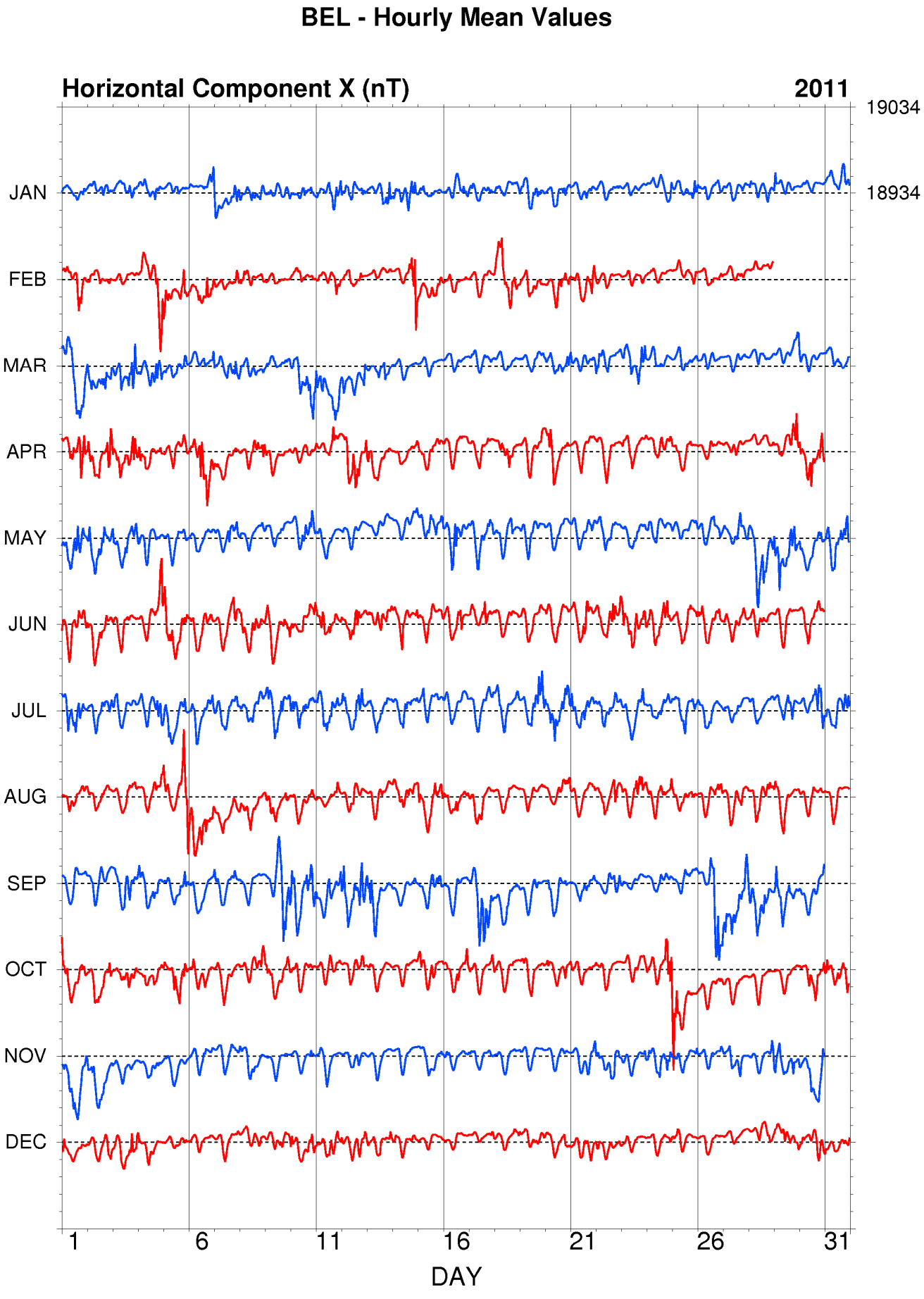

Fig. 6. Hourly mean data plot of X component for Belsk 2011.

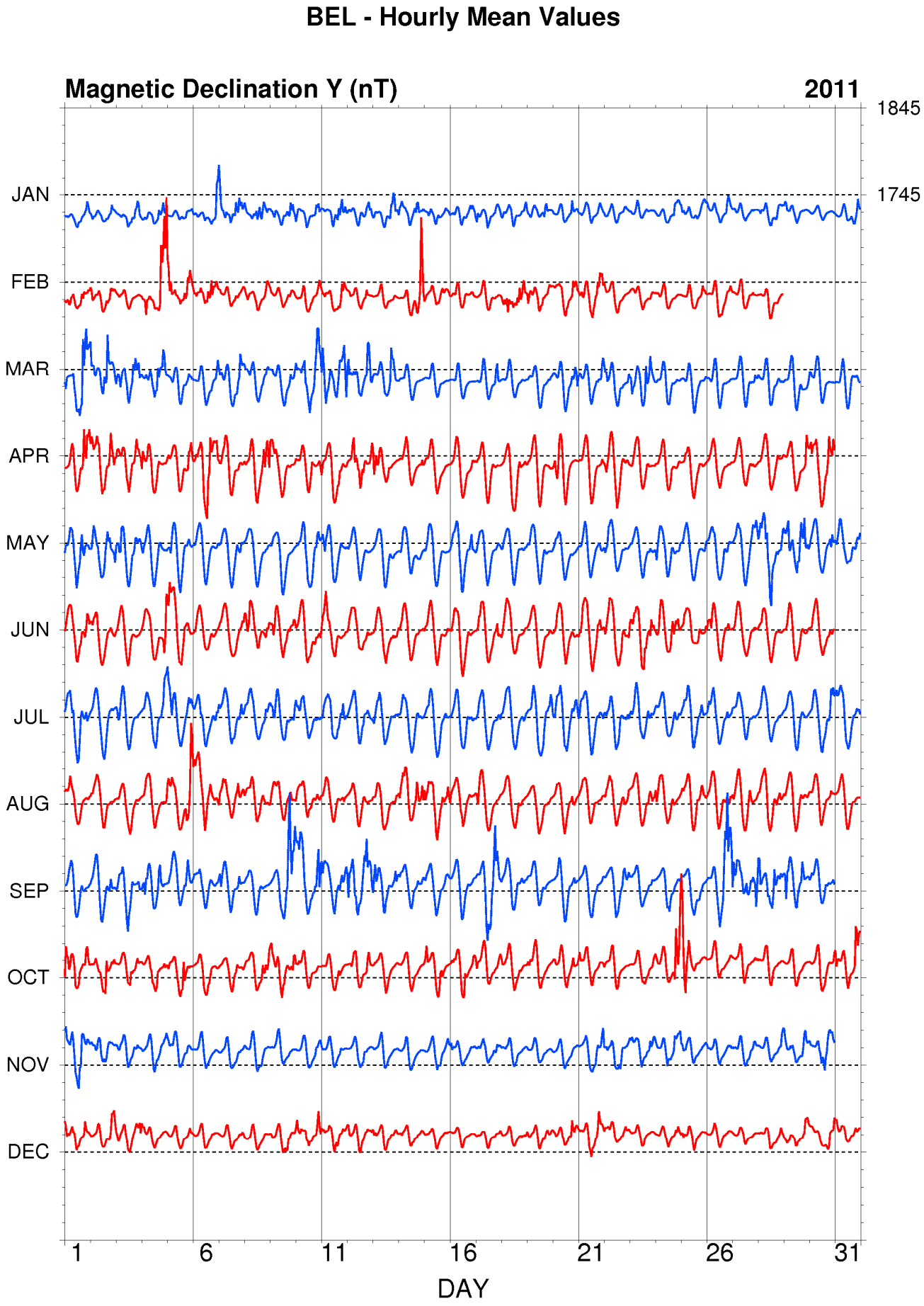

Fig. 7. Hourly mean data plot of Y component for Belsk 2011.

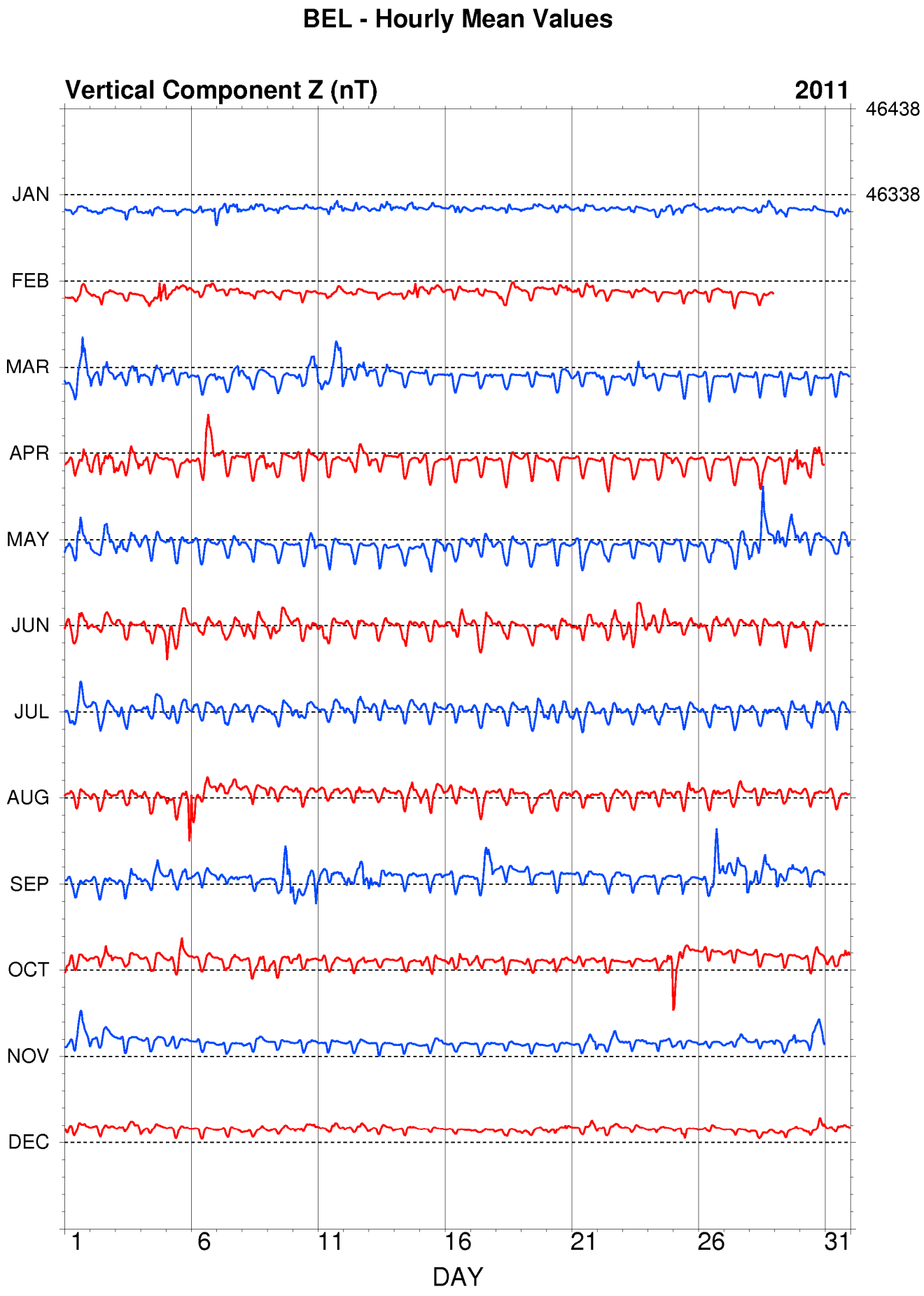

Fig. 8. Hourly mean data plot of Z component for Belsk 2011.

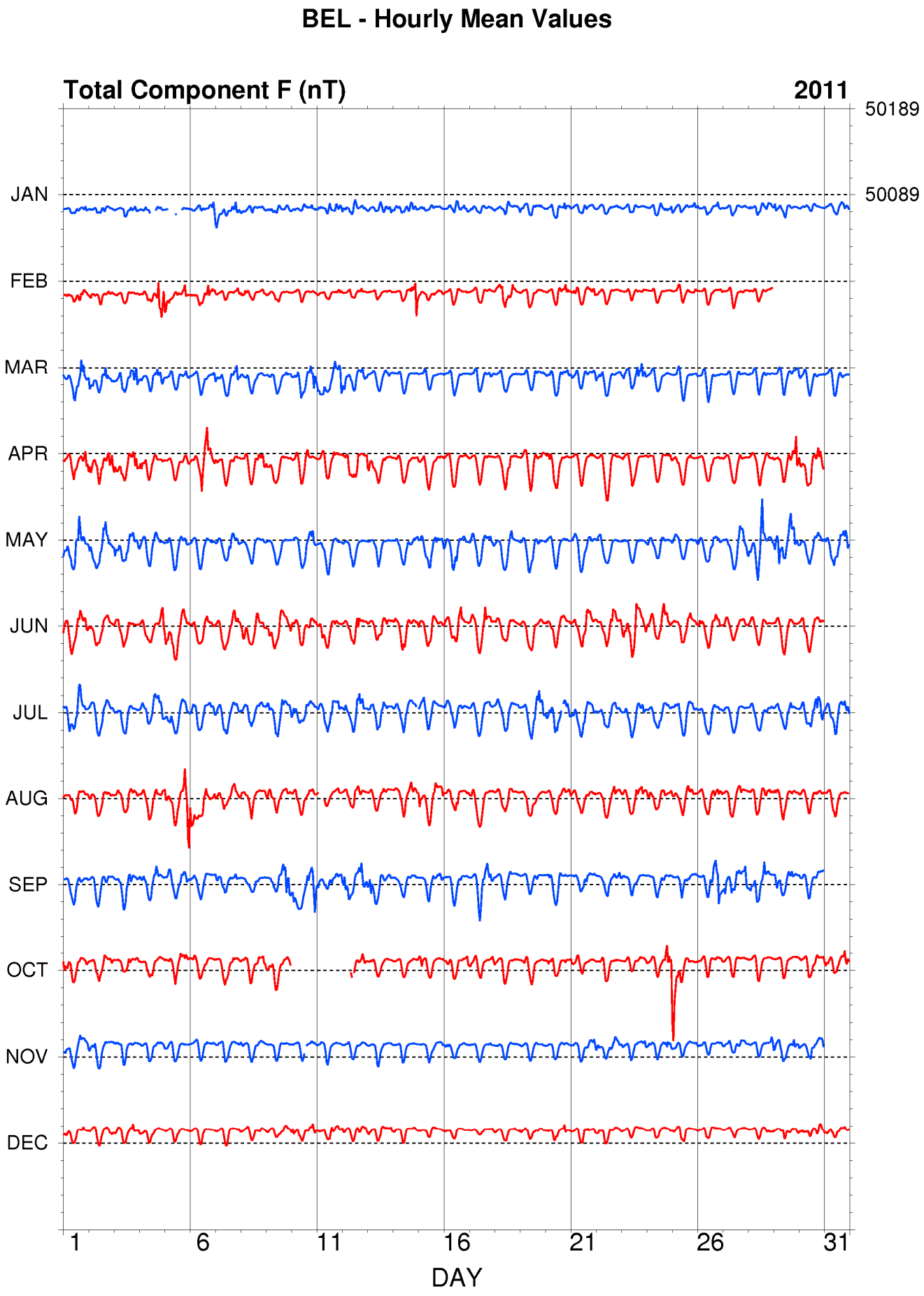

Fig. 9. Hourly mean data plot of F component for Belsk 2011.

7. TABLES AND PLOTS FOR HEL OBSERVATORY

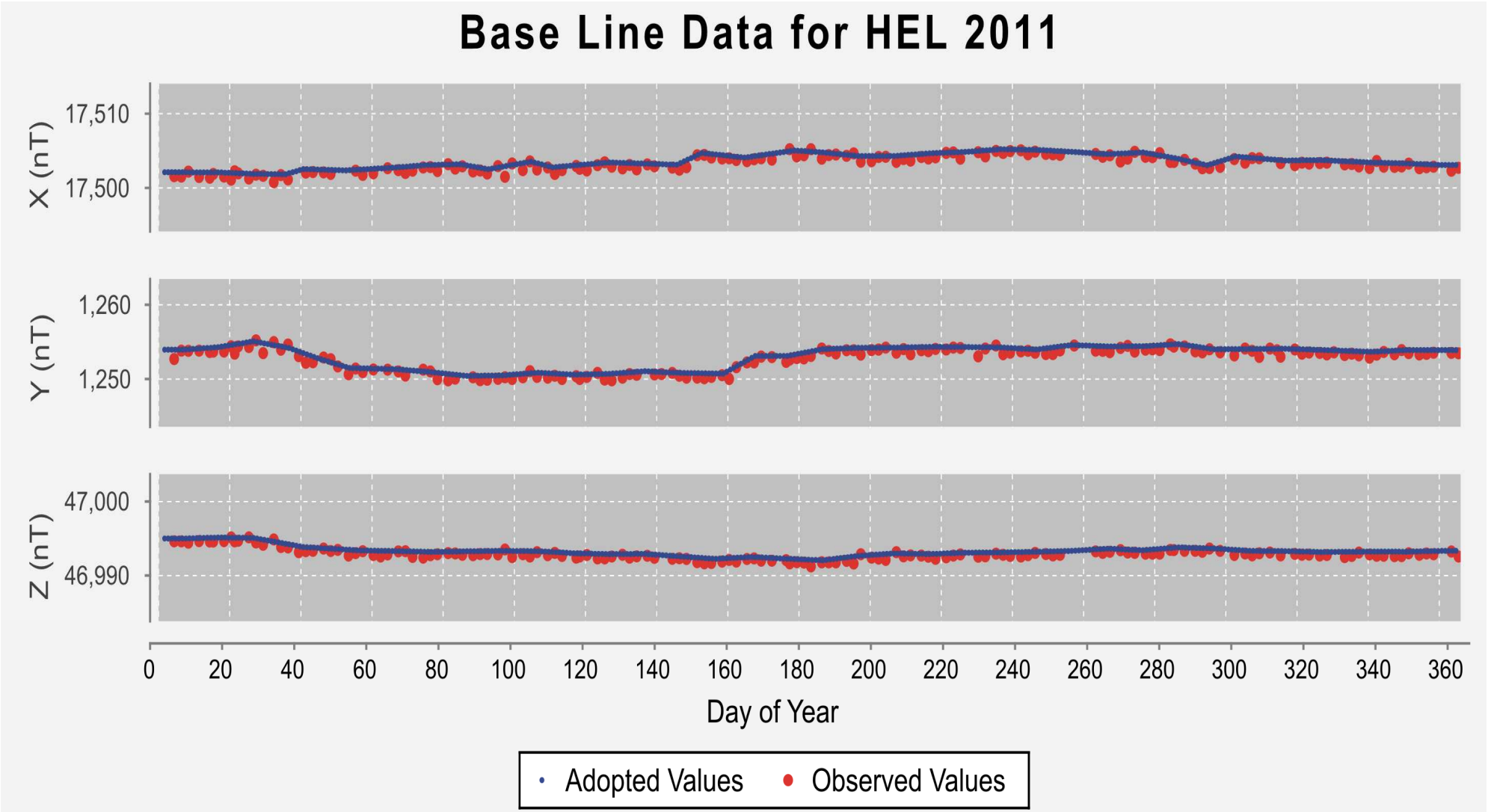

Fig. 10. Base values of set 1, Hel 2011.

Annual mean values of magnetic elements in Hel Observatory

No	Year	D [º ‘]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [º ‘]	F [nT]
1	1953	-0 14.5	17388	45327	17388	-73	69 00.8	48548
2	1954	-0 10.0	17394	45374	17394	-51	69 01.5	48594
3	1955	-0 04.2	17379	45430	17379	-21	69 03.9	48640
4	1956	0 03.9	17371	45450	17371	20	69 05.0	48656
5	1957	0 05.7	17372	45475	17372	29	69 05.5	48680
6	1958	0 10.2	17380	45535	17380	52	69 06.5	48739
7	1959	0 14.7	17390	45565	17390	74	69 06.6	48771
8	1960	0 17.6	17402	45602	17402	89	69 06.8	48810
9	1961	0 19.8	17422	45625	17422	100	69 06.0	48838
10	1962	0 22.7	17438	45647	17438	115	69 05.5	48864
11	1963	0 26.5	17449	45663	17448	134	69 05.2	48883
12	1964	0 28.6	17464	45676	17463	145	69 04.6	48901
13	1965	0 30.0	17476	45692	17475	152	69 04.2	48920
14	1966	0 31.6	17485	45710	17484	161	69 04.0	48940
15	1967	0 33.3	17492	45743	17491	169	69 04.4	48973
16	1968	0 34.4	17502	45769	17501	175	69 04.4	49001
17	1969	0 34.3	17524	45792	17523	175	69 03.5	49030
18	1970	0 34.8	17542	45824	17541	178	69 03.2	49067
19	1971	0 35.7	17565	45849	17564	182	69 02.3	49098
20	1972	0 36.1	17579	45880	17578	184	69 02.1	49132
21	1973	0 38.5	17595	45912	17594	197	69 01.9	49168
22	1974	0 41.9	17606	45951	17605	215	69 02.2	49208
23	1975	0 45.0	17625	45984	17623	231	69 01.7	49246
24	1976	0 49.6	17639	46015	17637	254	69 01.6	49280
25	1977	0 55.0	17651	46045	17649	282	69 01.5	49312
26	1978	1 00.2	17646	46085	17643	309	69 02.9	49349
27	1979	1 05.1	17651	46112	17648	334	69 03.2	49375
28	1980	1 11.5	17653	46127	17649	367	69 03.5	49390
29	1981	1 17.5	17637	46156	17632	398	69 05.2	49411
30	1982	1 23.4	17620	46184	17615	427	69 07.1	49431
31	1983	1 28.6	17614	46200	17608	454	69 07.8	49444
32	1984	1 33.5	17602	46219	17596	479	69 09.1	49457
33	1985	1 37.9	17591	46239	17584	501	69 10.3	49472

34	1986	1 42.7	17579	46263	17571	525	69 11.6	49490
35	1987	1 46.3	17572	46285	17564	543	69 12.6	49508
36	1988	1 51.0	17555	46318	17546	567	69 14.6	49533
37	1989	1 55.5	17535	46352	17525	589	69 16.7	49558
38	1990	1 58.4	17527	46374	17516	604	69 17.8	49575
39	1991	2 00.6	17513	46398	17502	614	69 19.3	49593
40	1992	2 03.9	17515	46416	17504	631	69 19.6	49611
41	1993	2 10.0	17516	46428	17503	662	69 19.8	49622
42	1994	2 15.9	17512	46456	17498	692	69 20.7	49647
43	1995	2 21.3	17518	46481	17503	720	69 21.0	49672
44	1996	2 26.6	17523	46506	17507	747	69 21.2	49698
45	1997	2 32.9	17519	46539	17502	779	69 22.3	49727
46	1998	2 39.8	17512	46581	17493	814	69 23.8	49764
47	1999	2 45.4	17511	46615	17491	842	69 24.7	49796
48	2000	2 51.9	17507	46657	17485	875	69 25.9	49833
49	2001	2 57.7	17515	46692	17492	905	69 26.2	49869
50	2002	3 03.7	17520	46730	17495	936	69 26.9	49906
51	2003	3 10.8	17519	46777	17492	972	69 28.1	49950
52	2004	3 16.6	17529	46809	17500	1002	69 28.2	49983
53	2005	3 22.3	17531	46843	17501	1031	69 28.9	50016
J	2006.0	0 -1.5	-2	9	-2	-8	0 0.6	7
54	2006	3 29.9	17550	46859	17517	1071	69 28.1	50038
55	2007	3 36.7	17559	46887	17524	1106	69 28.2	50067
56	2008	3 43.8	17564	46917	17527	1143	69 28.5	50097
57	2009	3 51.3	17571	46945	17531	1181	69 28.8	50126
58	2010	4 00.5	17568	46980	17525	1228	69 29.8	50157
59	2011	4 09.2	17564	47014	17518	1272	69 30.9	50188

Note: Since 2006 the observatory has stopped introducing the so-called historical corrections. The corrections were related, among other things, with the variable location of the instruments for absolute measurements. In the 2006.0 line we include the jump value J relating to the neglect of historical corrections. The jump values are defined as follows:

jump value J = old site value - new site value

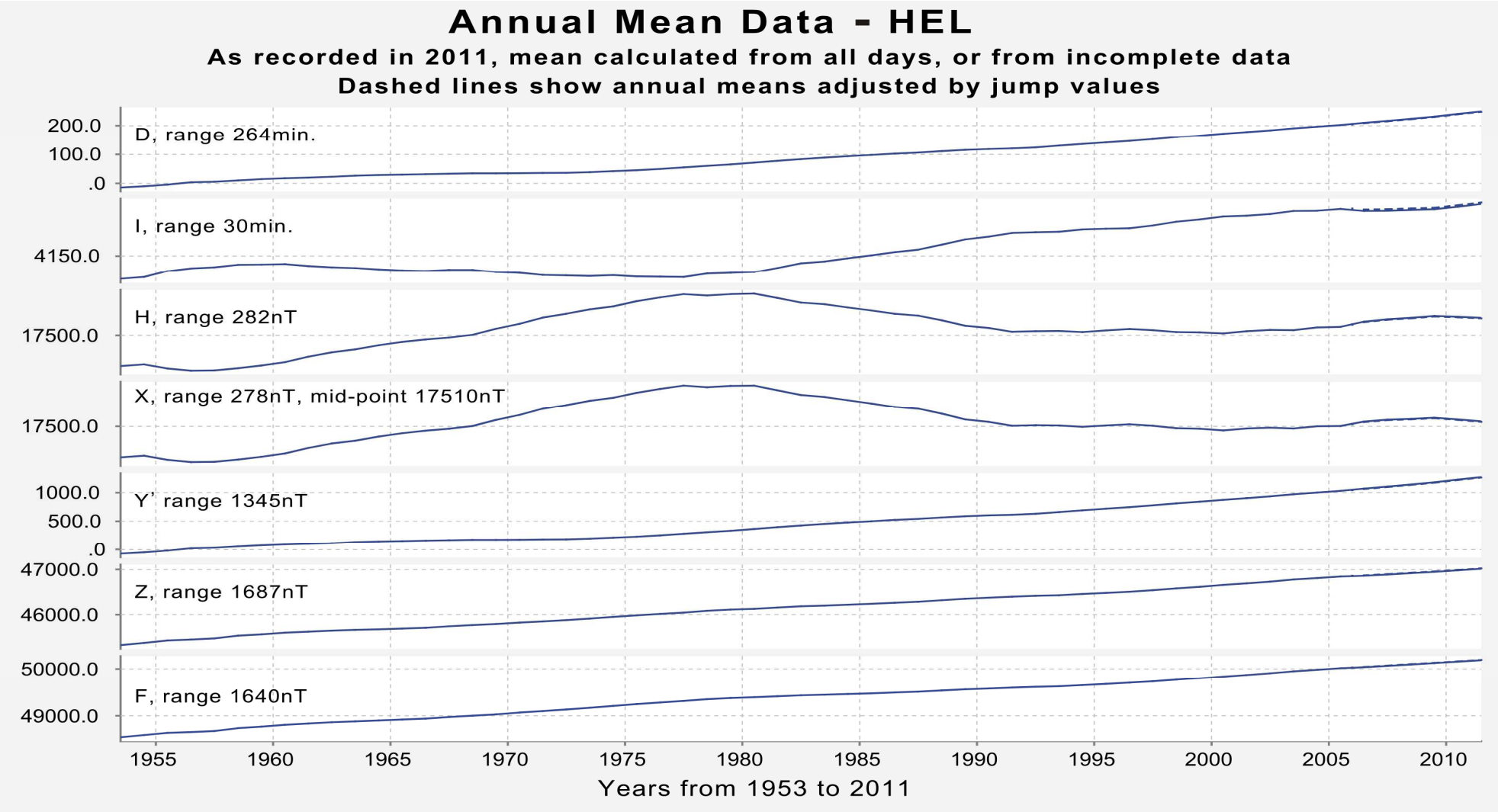

Fig. 11. Secular changes of H, X, Y, Z, F, D and I at Hel.

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

HLP 2011

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 17000 + ... in nT													
All days	521	518	519	519	522	523	522	517	511	512	512	518	518
Quiet days	523	523	524	524	526	524	524	521	516	515	517	521	522
Disturbed days	516	513	501	512	508	520	523	514	501	504	500	515	511
EAST COMPONENT: 1000 + ... in nT													
All days	252	255	258	261	263	270	274	279	283	287	290	292	272
Quiet days	252	253	256	261	260	269	274	276	280	286	288	292	271
Disturbed days	254	260	263	263	265	273	274	283	290	289	293	293	275
VERTICAL COMPONENT: 46500 + ... in nT													
All days	499	501	502	504	508	512	514	518	523	527	532	531	514
Quiet days	499	499	501	503	506	511	514	517	521	528	529	530	513
Disturbed days	500	501	505	507	513	512	514	514	523	527	537	532	516

Three-hour-range K indices
Hel, January - March, 2011
The limit of K=9 is 550

Day	January		February		March	
	K	SK	K	SK	K	SK
1	2100 1113	9	2222 1332	17	2223 4654	28
2	1211 0122	10	2112 1221	12	4222 3443	24
3	1101 1233	12	0010 0010	2	2332 3444	25
4	1101 1231	10	2322 2266	25	1123 3444	22
5	0001 1121	6	5321 1243	21	1212 2133	15
6	1100 0114	8	2122 3432	19	0111 2224	13
7	4222 2343	22	2101 0112	8	2112 2243	17
8	2122 3333	19	1201 0012	7	2121 1122	12
9	1212 1233	15	1001 0111	5	1121 1121	10
10	2112 2132	14	0112 1012	8	2133 3243	21
11	2101 1344	16	1101 0232	10	4432 2345	27
12	2212 1132	14	1210 1120	8	3222 1144	19
13	2111 1344	17	0000 0022	4	0013 1441	14
14	2222 2333	19	0010 1346	15	2111 0000	5
15	0211 2111	9	2222 2222	16	0000 0000	0
16	1101 2232	12	1111 1001	6	0021 1001	5
17	3112 2211	13	0010 0111	4	1111 1131	10
18	211- --12	--	3443 3322	24	1011 0000	3
19	3212 2331	17	3111 2112	12	1012 2101	8
20	1011 1131	9	1122 2232	15	1111 2214	13
21	0100 2221	8	2211 2233	16	2010 0113	8
22	1110 1121	8	2110 0000	4	3312 3002	14
23	0000 0100	1	0010 1010	3	3233 2343	23
24	0022 1133	12	0101 0000	2	1011 2110	7
25	3012 1123	13	0012 1122	9	0012 2111	8
26	1000 0131	6	0001 1112	6	1000 0000	1
27	1010 0010	3	0001 1110	4	0000 0012	3
28	2101 0221	9	0011 1011	5	0001 1111	5
29	3111 1100	8			0001 1312	8
30	0000 0000	0			3102 1000	7
31	0101 0232	9			0113 1111	9

Three-hour-range K indices
Hel, April - June, 2011
The limit of K=9 is 550

Day	April		May		June	
	K	SK	K	SK	K	SK
1	1023 2443	19	3233 4422	23	3122 3423	20
2	4333 3244	26	3333 3333	24	2222 2231	16
3	3323 3234	23	3334 3332	24	1122 2101	10
4	3222 1111	13	2112 1201	10	0010 1155	13
5	2112 0133	13	1212 2221	13	5444 3232	27
6	2214 4543	25	0012 1102	7	2122 2221	14
7	2111 1121	10	1001 3332	13	0011 2243	13
8	1012 3334	17	1000 0012	4	3311 3222	17
9	3212 1111	12	2001 1200	6	2312 2122	15
10	1000 1112	6	2113 4433	21	2033 3323	19
11	2012 3432	17	2211 1110	9	2333 4222	21
12	2344 4413	25	1110 0111	6	2123 3321	17
13	3333 2101	16	1111 2211	10	2113 3422	18
14	1122 1002	9	1100 1212	8	2223 2212	16
15	1112 2112	11	2223 3422	20	2123 3211	15
16	0113 1111	9	3224 4332	23	1212 2300	11
17	0001 2111	6	2224 3232	20	3212 3431	19
18	0023 4312	15	1212 3311	14	2111 2211	11
19	1111 1113	10	1111 2100	7	1112 2111	10
20	3433 3212	21	0101 1110	5	2222 2221	15
21	1111 1221	10	0111 1112	8	2222 4332	20
22	2223 2202	15	2211 2210	11	3212 3433	21
23	2012 1111	9	0101 2222	10	3323 4333	24
24	1112 2223	14	2112 3311	14	2222 3443	22
25	1211 1211	10	1101 1111	7	2212 2223	16
26	0011 1111	6	2111 3312	14	3312 2221	16
27	0011 1110	5	1223 3334	21	1111 1112	9
28	0001 1212	7	4344 6214	28	1101 2100	6
29	1111 1235	15	4444 4543	32	0101 1111	6
30	4334 4344	29	2232 2222	17	1211 2221	12
31			3223 2334	22		

Three-hour-range K indices
Hel, July - September, 2011
The limit of K=9 is 550

Day	July			August			September		
	K		SK	K		SK	K		SK
1	2343	4421	23	1322	2111	13	1101	1101	6
2	0012	2223	12	2111	2110	9	0101	1121	7
3	2212	2221	14	0011	2112	8	2323	3333	22
4	1212	3344	20	0101	1213	9	3311	3421	18
5	4322	1232	19	3211	1366	23	1011	2342	14
6	1232	2223	17	5434	4413	28	1222	2121	13
7	2012	2222	13	4121	1232	16	3112	2120	12
8	1122	2223	15	2122	3112	14	1101	0000	3
9	2313	2323	19	2222	1122	14	0112	5565	25
10	2321	3321	17	2222	1121	13	5433	4545	33
11	2133	2432	20	0211	1132	11	3212	3224	19
12	3222	3331	19	1112	1220	10	4333	4354	29
13	3212	3222	17	0111	2112	9	4433	2123	22
14	1223	3212	16	2222	2433	20	1112	2122	12
15	1311	2211	12	4223	2223	20	1111	2222	12
16	1112	1211	10	2223	3112	16	0001	1112	6
17	1101	1222	10	2112	2121	12	0244	5553	28
18	1223	2211	14	1001	2110	6	2102	3112	12
19	1124	3443	22	0011	1102	6	0011	1110	5
20	3224	4333	24	1211	3223	15	0212	2122	12
21	3223	3322	20	1111	2121	10	0012	2212	10
22	3232	3332	21	2121	0232	13	1002	1212	9
23	1212	2222	14	2013	3332	17	0011	1101	5
24	0101	2222	10	4212	2203	16	0022	2011	8
25	2223	4332	21	2112	2221	13	0012	2221	10
26	2222	2121	14	0011	1222	9	2112	5665	28
27	1111	1201	8	2111	2221	12	5443	3335	30
28	1101	1111	7	2112	1232	14	3433	4322	24
29	0002	3310	9	3133	2212	17	5432	3342	26
30	1113	3444	21	0002	1120	6	3001	1133	12
31	3223	2233	20	0010	1100	3			

Three-hour-range K indices
Hel, October - December, 2011
The limit of K=9 is 550

Day	October		November		December	
	K	SK	K	SK	K	SK
1	4322 3233	22	3124 3323	21	3112 1031	12
2	1232 2434	21	3222 2211	15	1011 1243	13
3	0111 2221	10	1010 0110	4	2122 1243	17
4	1022 2212	12	0001 1122	7	3111 1100	8
5	2133 3432	21	2101 0011	6	0000 0022	4
6	1212 3221	14	0001 1202	6	0000 1110	3
7	1112 1211	10	0111 0221	8	0000 0011	2
8	1111 1334	15	2212 2210	12	0000 0020	2
9	3231 2223	18	0000 0000	0	0001 1201	5
10	2110 0110	6	0000 1121	5	3122 1123	15
11	0020 2211	8	0212 0010	6	2112 2331	15
12	1121 1121	10	0022 1200	7	2111 1222	12
13	1211 1000	6	0011 0001	3	2111 2112	11
14	0001 1111	5	0001 0000	1	1110 0010	4
15	3212 2311	15	0012 2202	9	0000 0000	0
16	2222 3113	16	2211 0011	8	0000 0000	0
17	2111 0102	8	1111 2121	10	0000 0002	2
18	1110 1210	7	1001 1101	5	0001 0021	4
19	2112 2011	10	0000 0000	0	2211 1232	14
20	2211 1120	10	0011 0111	5	1111 0132	10
21	2110 1011	7	0001 1214	9	0101 2233	12
22	1000 1000	2	2012 2312	13	3111 0111	9
23	0001 1202	6	2221 1123	14	1001 0000	2
24	1111 1155	16	2102 3234	17	0011 0021	5
25	7533 3210	24	2210 0012	8	1111 0000	4
26	1111 1211	9	1011 1122	9	0100 0000	1
27	0111 2011	7	1122 1210	10	0000 0000	0
28	0001 0000	1	0000 0013	4	0001 2221	8
29	0000 0000	0	3321 1241	17	1123 1233	16
30	1002 2312	11	3103 3333	19	1211 1233	14
31	4023 2143	19			3112 0022	11

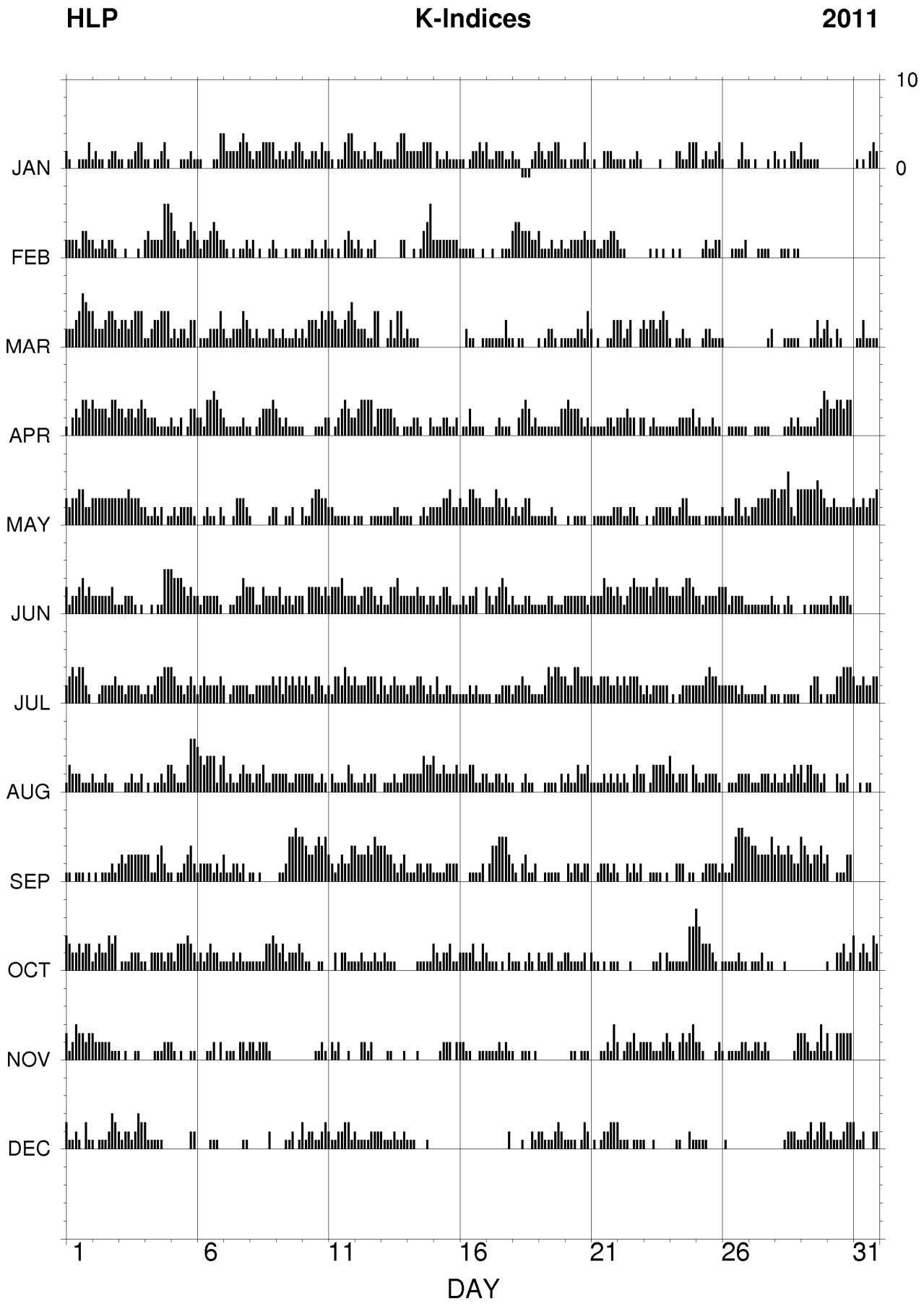

Fig. 12. K-indices in graphical form, Hel 2011.

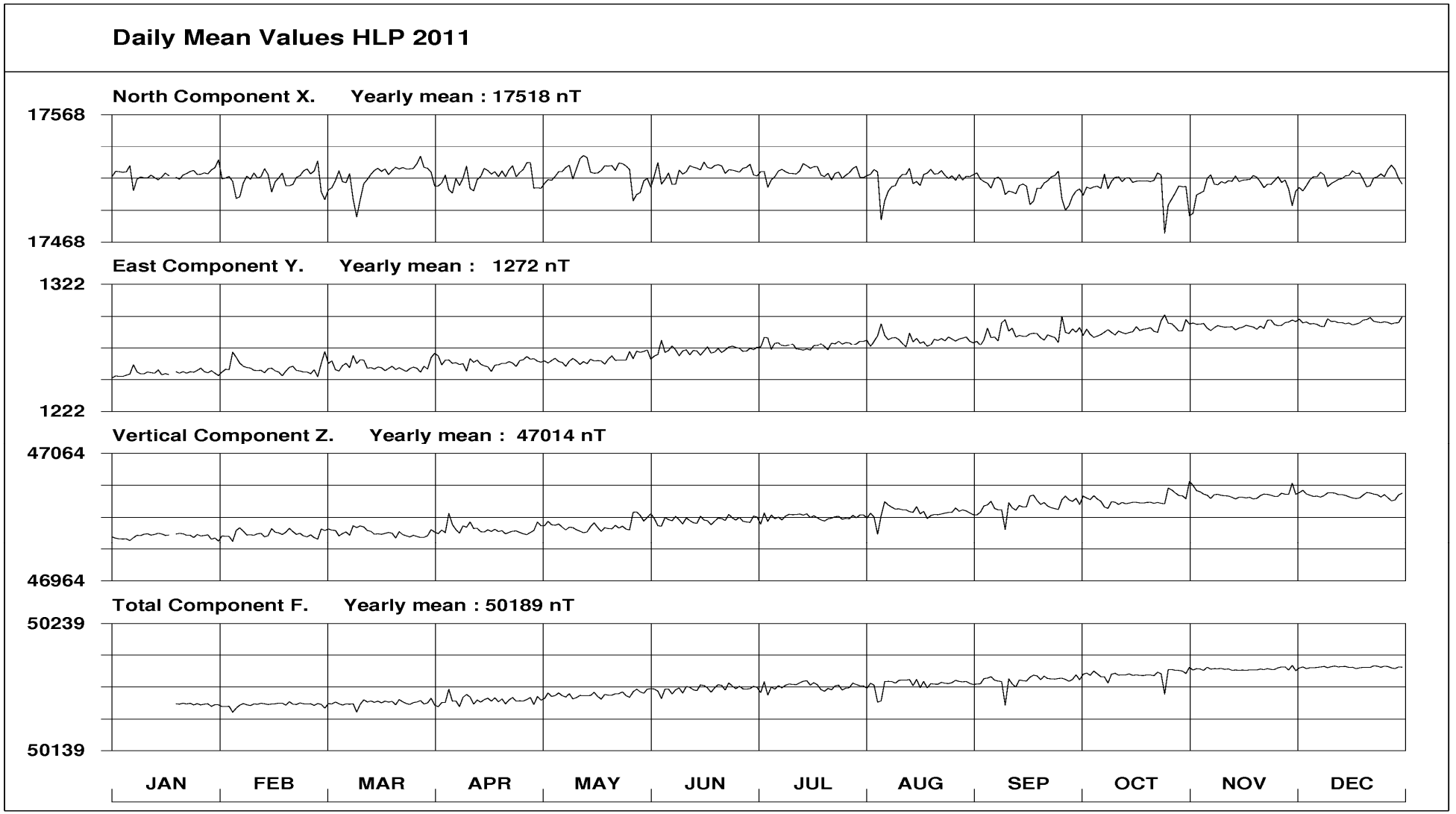

Fig. 13. Daily mean data plot for Hel 2011.

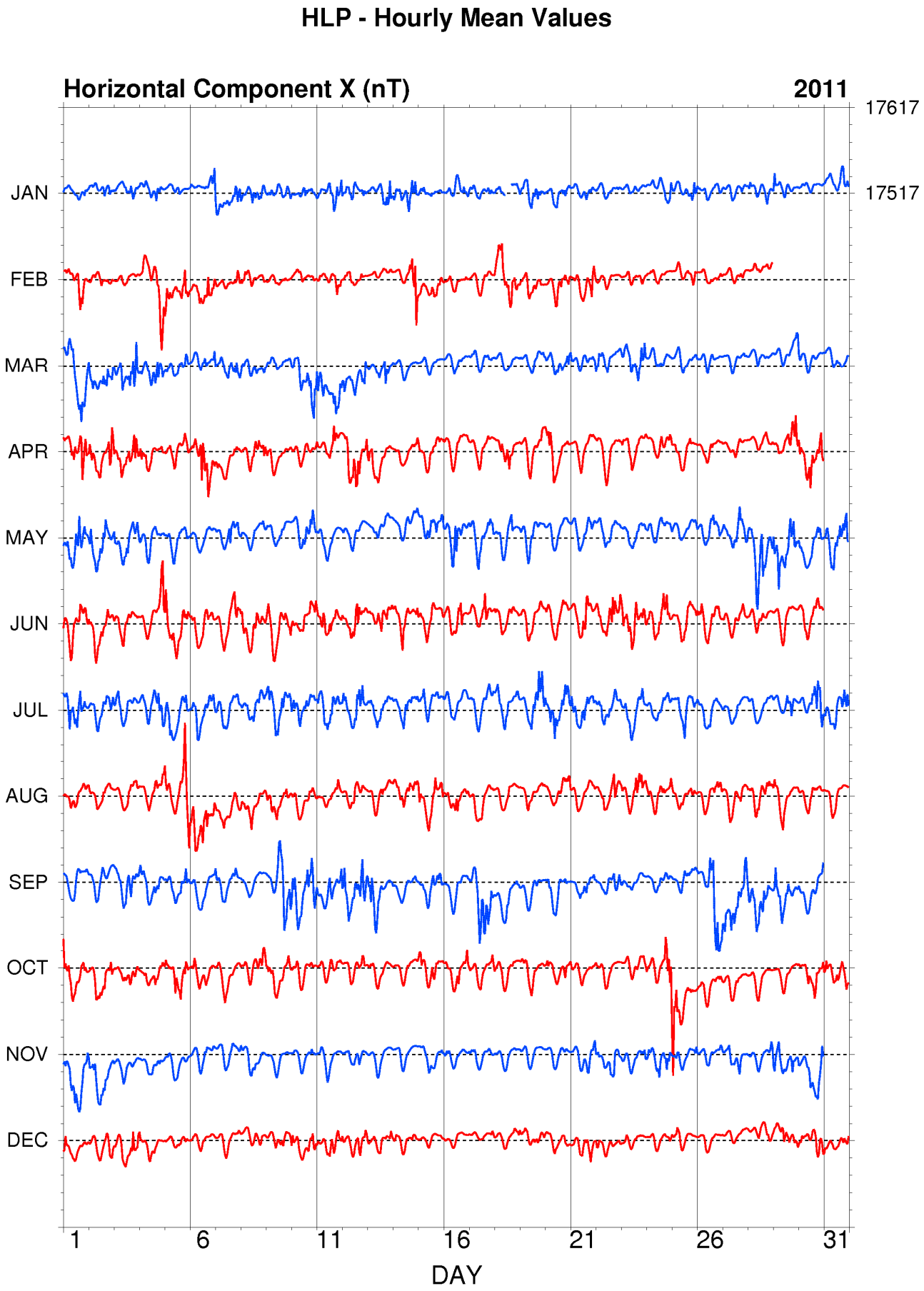

Fig. 14. Hourly mean data plot of X component for Hel 2011.

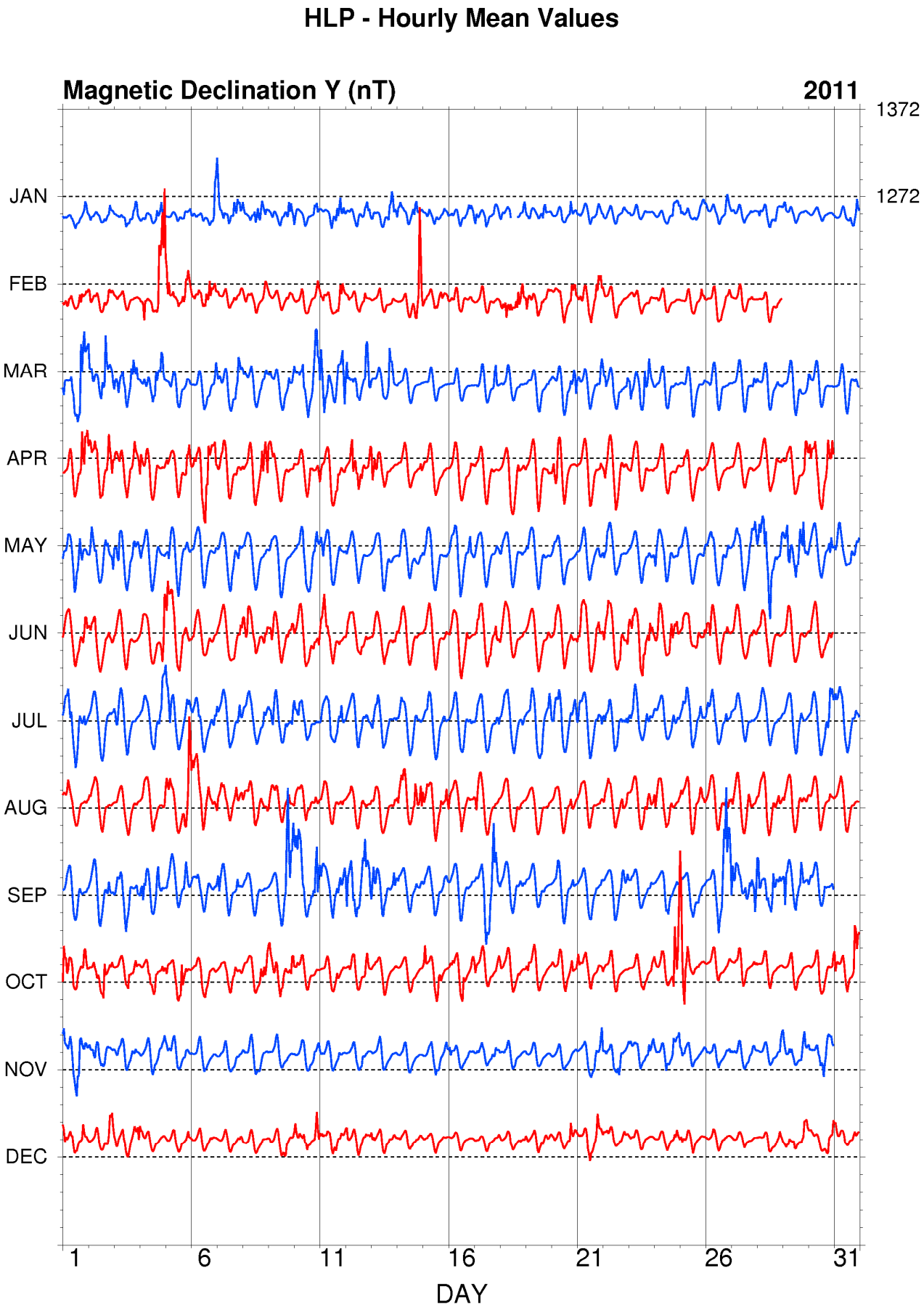

Fig. 15. Hourly mean data plot of Y component for Hel 2011.

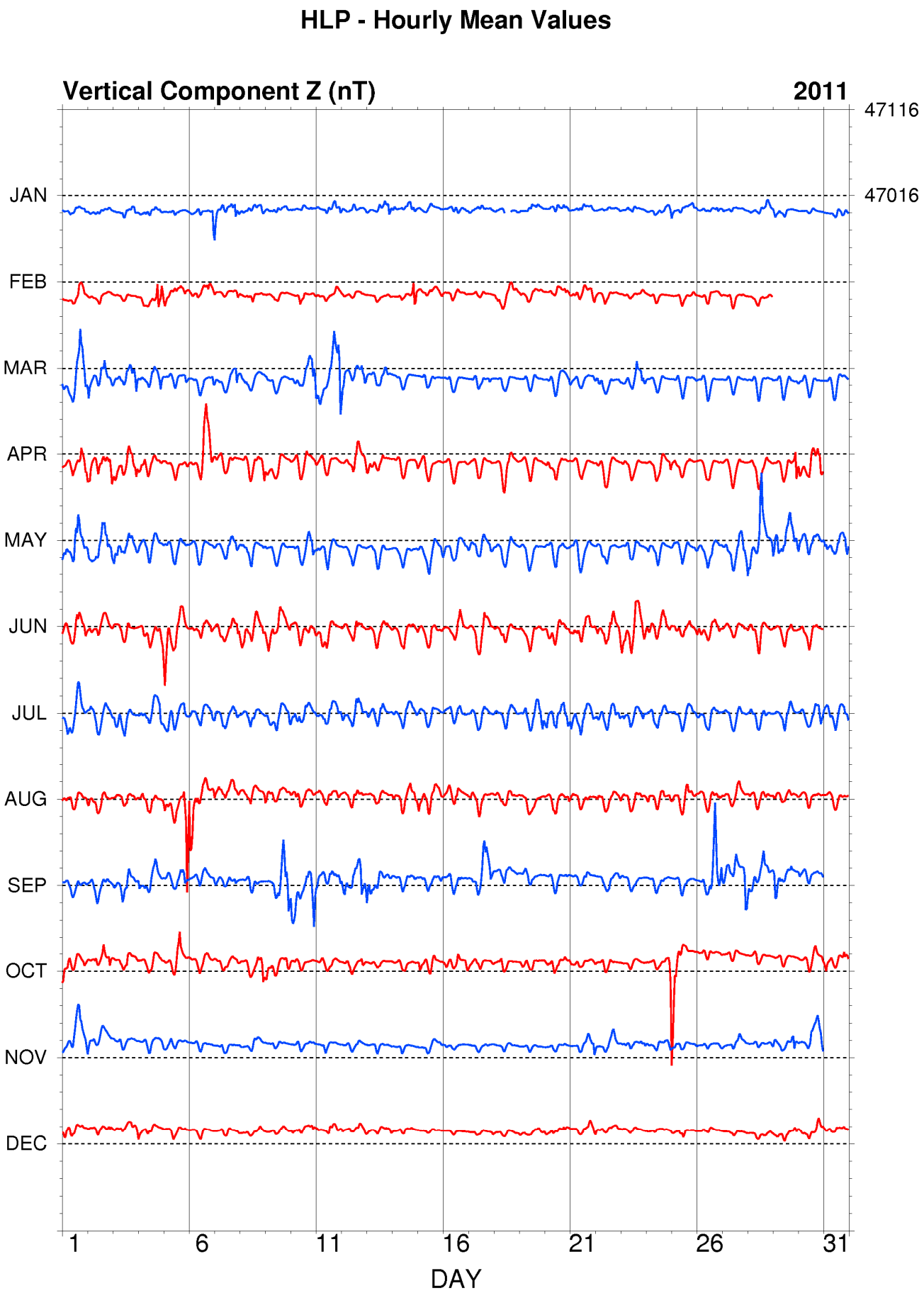

Fig. 16. Hourly mean data plot of Z component for Hel 2011.

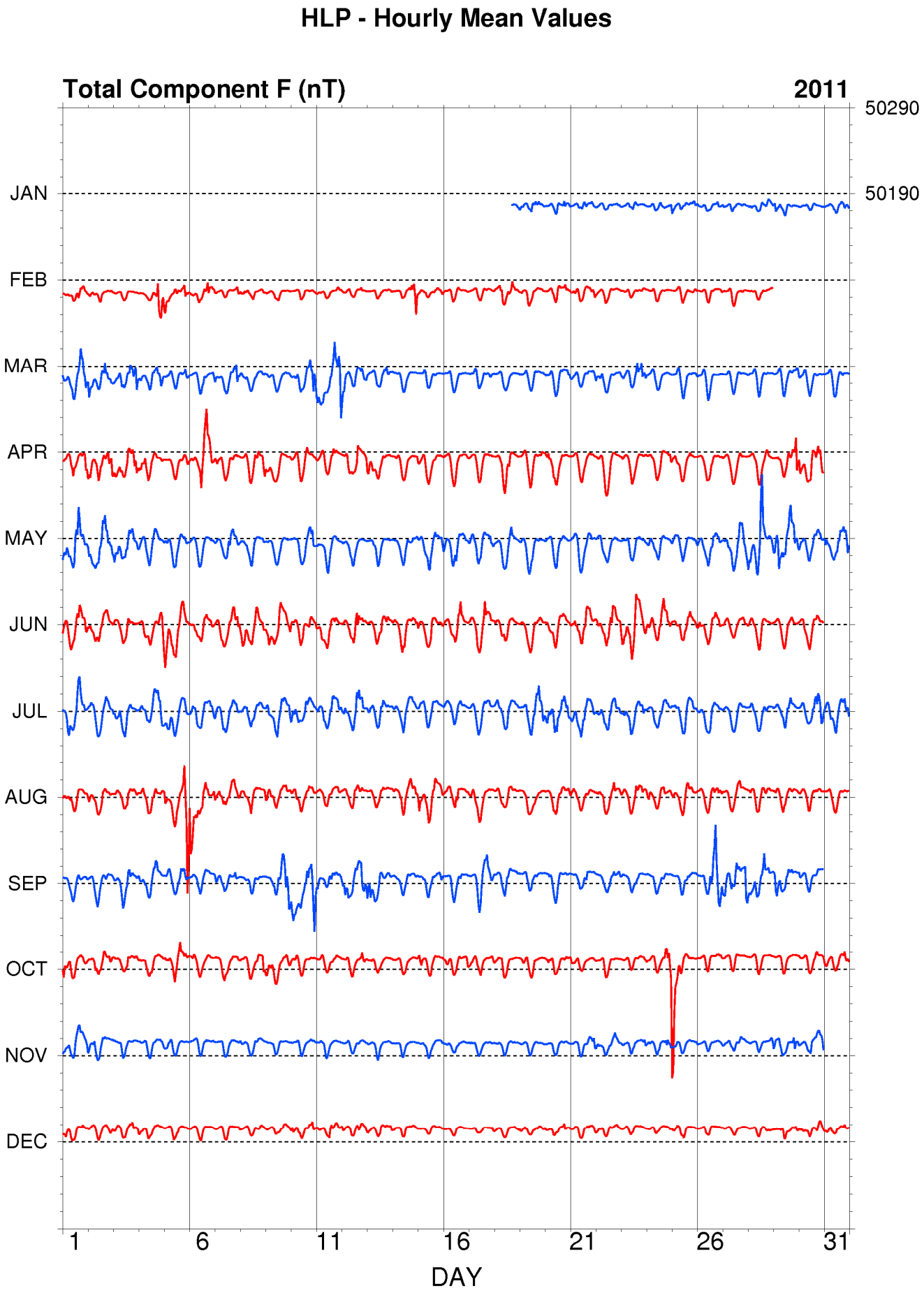

Fig. 17. Hourly mean data plot of F component for Hel 2011.

8. TABLES AND PLOTS FOR HORNSUND OBSERVATORY

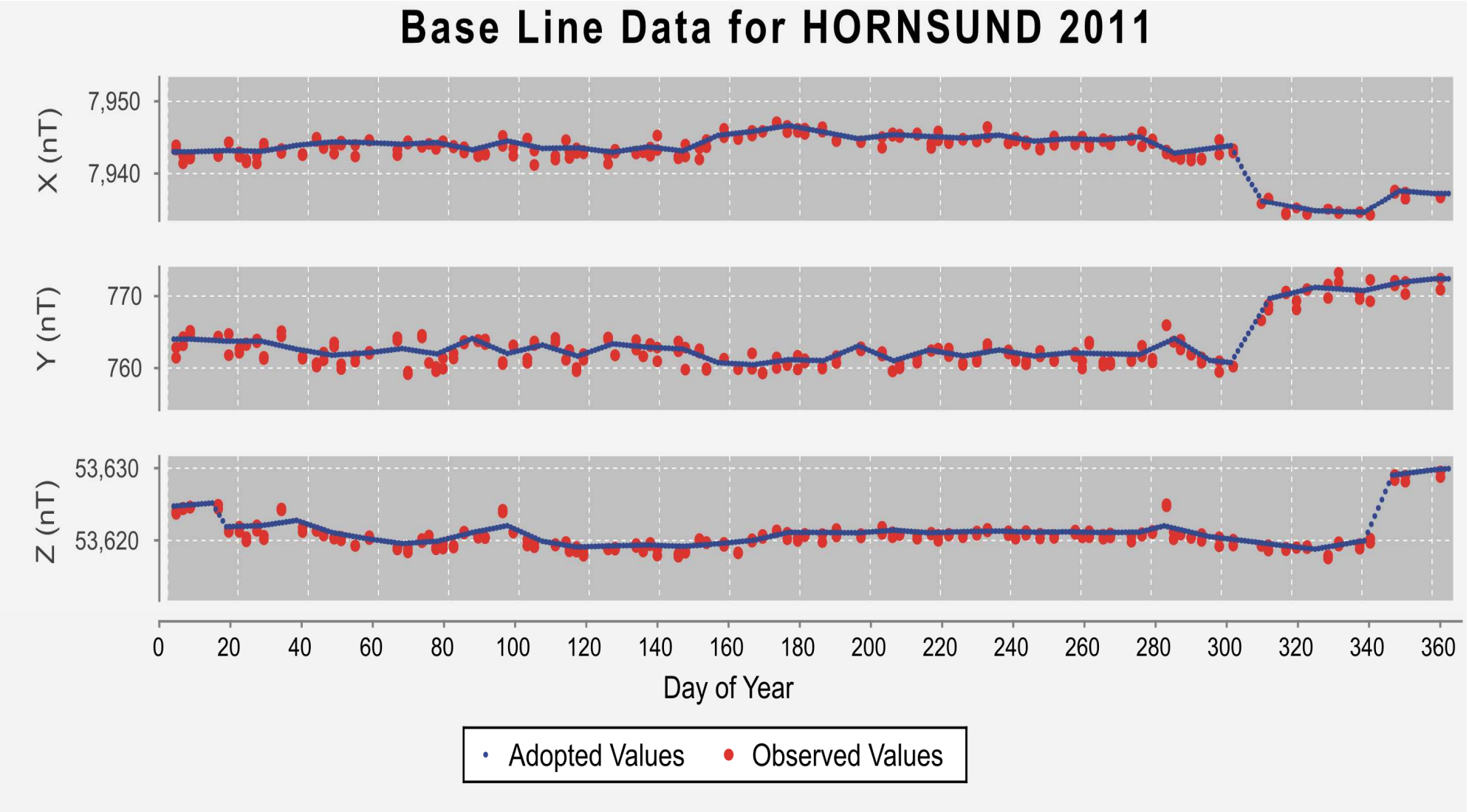

Fig. 18. Base values, Hornsund 2011.

Annual mean values of magnetic elements in Hornsund Observatory

Year	D [°´]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [°´]	F [nT]
1979	-0 32.2	8384	53447	8384	-79	81 05.1	54101
1980	-0 14.2	8370	53447	8370	-35	81 06.0	54098
1981	-0 09.3	8351	53449	8351	-23	81 07.2	54097
1982	-0 09.4	8319	53481	8319	-23	81 09.5	54124
1983	-0 02.0	8295	53457	8295	-5	81 10.8	54097
1984	0 07.7	8266	53439	8266	19	81 12.4	54075
1985	0 14.3	8238	53405	8238	34	81 13.9	54037
1986	0 20.4	8213	53392	8213	49	81 15.3	54020
1987	0 25.6	8193	53360	8193	61	81 16.3	53985
1988	0 34.7	8168	53368	8168	82	81 17.9	53989
1989	0 40.8	8148	53369	8147	97	81 19.2	53987
1990	0 47.2	8122	53360	8121	112	81 20.7	53975
1991	0 53.0	8107	53355	8106	125	81 21.6	53967
1992	1 01.4	8088	53352	8087	144	81 22.8	53962
1993	1 12.9	8065	53356	8063	171	81 24.3	53962
1994	1 25.9	8044	53374	8041	201	81 25.8	53977
1995	1 38.4	8038	53374	8035	230	81 26.1	53976
1996	1 51.4	8023	53385	8019	260	81 27.2	53985
1997	2 07.2	8004	53406	7999	296	81 28.6	54003
1998	2 24.0	8001	53440	7994	335	81 29.1	54036
1999	2 39.1	7998	53471	7989	370	81 29.6	54066
2000	2 55.5	7996	53504	7986	408	81 30.0	54098
2001	3 12.4	7992	53542	7979	447	81 30.6	54135
2002	3 29.7	7989	53585	7974	487	81 31.2	54177
2003	3 49.8	7965	53646	7947	532	81 33.3	54234
2004	4 04.2	7961	53675	7941	565	81 33.8	54262
2005	4 20.5	7953	53707	7930	602	81 34.6	54293
2006	4 36.2	7958	53727	7932	639	81 34.5	54314
2007	4 51.3	7950	53757	7922	673	81 35.2	54342
2008	5 07.9	7941	53785	7909	710	81 36.1	54368
2009	5 25.4	7939	53804	7903	750	81 36.4	54387
2010	5 45.7	7928	53837	7888	796	81 37.4	54418
2011	6 05.8	7920	53868	7875	841	81 38.2	54447

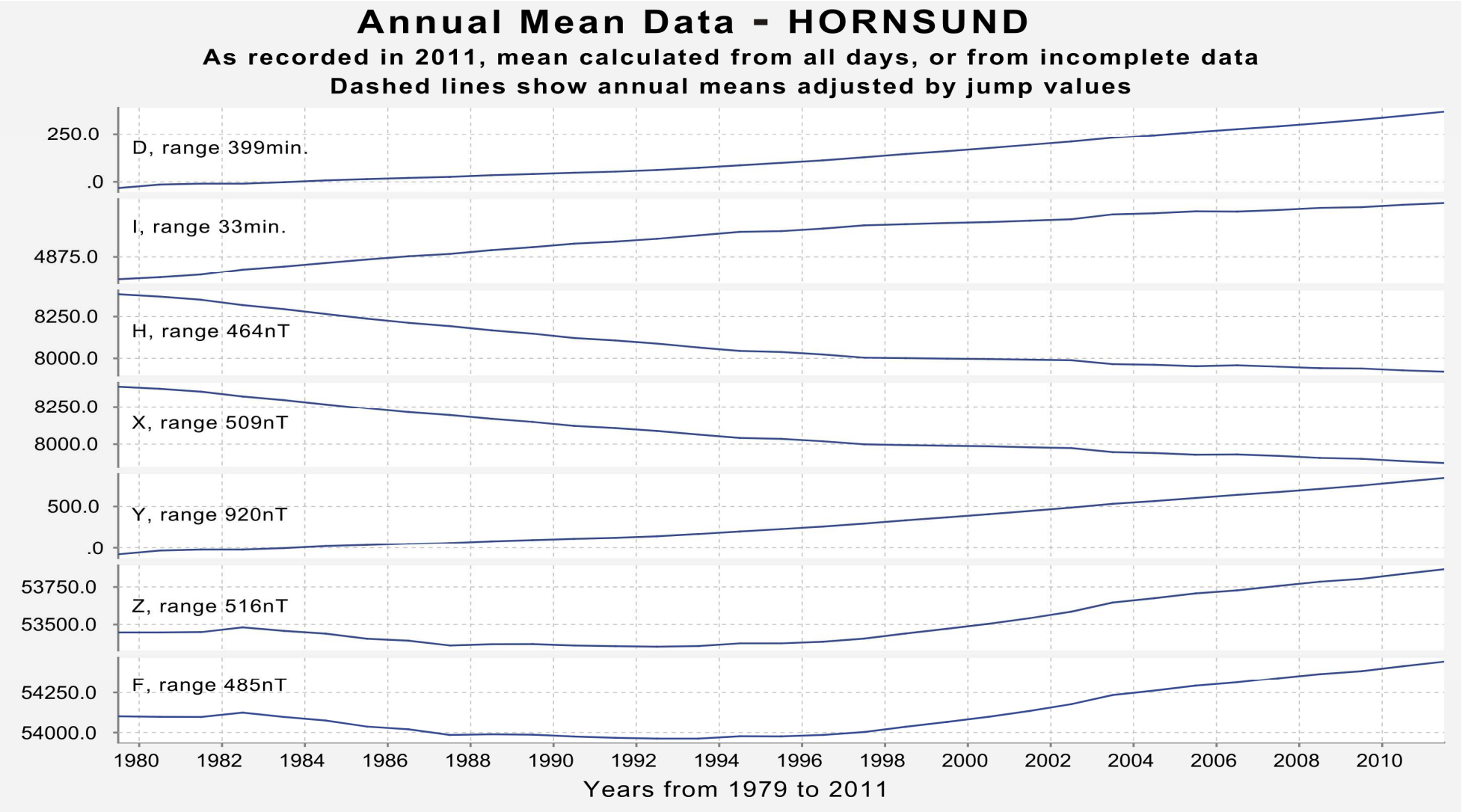

Fig. 19. Secular changes of H, X, Y, Z, F, D and I at Hornsund.

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

HRN 2011

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 7500 + ... in nT													
All days	370	368	373	380	388	394	387	379	370	366	361	360	375
Quiet days	378	378	381	389	392	390	386	378	372	370	367	365	379
Disturbed days	355	340	334	354	353	382	386	363	343	361	348	350	356
EAST COMPONENT: 500 + ... in nT													
All days	322	325	326	330	332	333	340	347	352	359	360	364	341
Quiet days	322	324	328	325	331	339	340	346	353	358	361	365	341
Disturbed days	323	325	330	336	352	333	340	346	357	365	358	364	344
VERTICAL COMPONENT: 53500 + ... in nT													
All days	353	359	366	365	358	360	366	369	379	382	378	378	368
Quiet days	346	352	361	355	362	358	364	362	372	373	374	374	363
Disturbed days	360	374	382	363	368	351	354	378	403	391	387	375	374

Three-hour-range K indices
Hornsund, January - March, 2011
The limit of K=9 is 2500

Day	January		February		March	
	K	SK	K	SK	K	SK
1	2211 2213	14	1222 2321	15	2334 3352	25
2	2222 1113	14	1222 1122	13	6344 4463	34
3	1112 1143	14	0112 0012	7	2343 3544	28
4	1222 2144	18	2542 2265	28	2243 3554	28
5	0010 1144	11	4422 2265	27	2323 2144	21
6	1221 0115	13	3333 2644	28	0221 2104	12
7	6232 2366	30	3222 2114	17	3232 2124	19
8	2344 3235	26	3322 0024	16	2232 2223	18
9	1233 3344	23	2111 2133	14	2122 2142	16
10	2323 3133	20	0223 2014	14	1444 2232	22
11	4222 1355	24	2221 1143	16	3232 2555	27
12	2333 2023	18	1322 2142	17	5333 2163	26
13	2222 2242	18	0111 1011	6	2213 2441	19
14	1333 3555	28	0000 1226	11	1323 1000	10
15	1322 3143	19	0231 1234	16	0211 1000	5
16	2122 2243	18	2332 1003	14	0021 1000	4
17	3332 3124	21	1231 1120	11	0221 1051	12
18	3232 2013	16	2444 2221	21	1111 1111	8
19	2333 2241	20	2323 3233	21	1123 2001	10
20	1232 2043	17	4234 2353	26	1221 2213	14
21	1211 2233	15	2122 2223	16	2221 1125	16
22	1211 2144	16	3221 1112	13	3322 2002	14
23	2212 1121	12	1221 1113	12	2233 3453	25
24	0132 1024	13	0311 1000	6	1112 2101	9
25	3222 1124	17	0112 1022	9	0022 2111	9
26	2022 1051	13	0111 2122	10	1111 0000	4
27	2111 1020	8	0101 1111	6	0010 0011	3
28	3311 1210	12	0010 1000	2	1201 2121	10
29	4221 0122	14			0001 1221	7
30	0100 0000	1			2201 1001	7
31	0100 0113	6			0112 2210	9

Three-hour-range K indices
Hornsund, April - June, 2011
The limit of K=9 is 2500

Day	April		May		June	
	K	SK	K	SK	K	SK
1	1123 3255	22	2333 4553	28	3233 3335	25
2	5333 3166	30	4344 3654	33	2244 2332	22
3	5433 3365	32	3434 3342	26	2222 3111	14
4	4332 2122	19	1333 3322	20	1120 1124	12
5	3331 0024	16	2322 3241	19	6444 4442	32
6	2325 4535	29	1113 2102	11	2333 4222	21
7	1222 1123	14	1112 3323	16	1322 2154	20
8	0123 3554	23	2111 1012	9	3332 4324	24
9	3343 2210	18	1201 2100	7	4422 3322	22
10	2231 3321	17	2223 3234	21	3034 3233	21
11	2123 3221	16	2222 2111	13	2353 4232	24
12	2245 4314	25	2221 0111	10	2234 3222	20
13	3344 3311	22	1223 2201	13	3224 5233	24
14	1222 1002	10	1210 1201	8	3244 2223	22
15	1222 3111	13	2224 3322	20	3334 3213	22
16	0333 2112	15	2354 4232	25	1212 3321	15
17	1002 1111	7	2244 3224	23	3322 4432	23
18	0133 4212	16	2333 3331	21	2232 2211	15
19	1222 2111	12	1223 3211	15	2223 3022	16
20	2553 3101	20	1211 2110	9	2333 3122	19
21	1212 2111	11	1222 2231	15	2433 4342	25
22	3323 2323	21	2321 2111	13	3233 3342	23
23	2223 2110	13	1222 2232	16	4433 4344	29
24	0112 3324	16	3323 3222	20	3443 4554	32
25	2221 2231	15	2211 1112	11	3333 3332	23
26	1222 2111	12	2322 2222	17	3533 3332	25
27	1121 1120	9	1333 3343	23	2312 2103	14
28	0120 1242	12	3353 5313	26	1201 1110	7
29	1222 2225	18	4464 4553	35	1101 0101	5
30	4345 4245	31	4344 2334	27	2322 2221	16
31			3544 3355	32		

Three-hour-range K indices
Hornsund, July - September, 2011
The limit of K=9 is 2500

Day	July			August			September		
	K		SK	K		SK	K		SK
1	1363	3422	24	3343	3101	18	0101	0001	3
2	1222	2112	13	3332	1132	18	1212	2221	13
3	2533	2111	18	1121	2113	12	2234	3321	20
4	3223	3323	21	0112	3213	13	3332	3521	22
5	4233	2143	22	4321	2257	26	1222	3342	19
6	2342	3224	22	6555	4323	33	2233	3331	20
7	3223	3244	23	3232	3234	22	1243	2152	20
8	2222	2232	17	2333	4222	21	1211	2102	10
9	2523	3344	26	3442	2242	23	0322	4545	25
10	3333	3222	21	2333	2223	20	6445	2343	31
11	3346	4343	30	1322	2134	18	2332	3335	24
12	4333	3452	27	2323	3231	19	4444	4453	32
13	3433	3221	21	1312	3042	16	3544	3113	24
14	2233	3333	22	2322	2333	20	1223	2122	15
15	2421	1122	15	3332	2232	20	1232	2223	17
16	2232	2121	15	1333	3231	19	1222	2104	14
17	1222	2222	15	1313	3102	14	1443	3354	27
18	1333	2222	18	1112	3021	11	1113	3321	15
19	2233	3334	23	0011	2101	6	0120	1100	5
20	2444	3235	27	1322	2132	16	1333	2123	18
21	4343	3232	24	1111	1112	9	0212	2201	10
22	3343	2233	23	3222	1222	16	1111	2131	11
23	1432	3353	24	2122	3242	18	0110	0002	4
24	2222	2232	17	3223	2204	18	1021	2021	9
25	2333	4232	22	2232	3332	20	0102	2211	9
26	3332	3133	21	0130	1144	14	2223	4573	28
27	2211	0101	8	2222	3311	16	4342	4224	25
28	2112	1002	9	1333	1131	16	3333	2544	27
29	1112	2311	12	3333	3112	19	7643	4331	31
30	2223	3453	24	2112	3142	16	3211	2212	14
31	4334	2243	25	1021	1000	5			

Three-hour-range K indices
Hornsund, October - December, 2011
The limit of K=9 is 2500

Day	October			November			December		
	K		SK	K		SK	K		SK
1	6433	4344	31	3213	2222	17	5323	2053	23
2	2443	2325	25	2210	2331	14	1122	1023	12
3	1222	3231	16	1211	0120	8	1122	2264	20
4	1122	2222	14	0010	1232	9	3331	2101	14
5	2333	4622	25	2110	0010	5	0111	1014	9
6	1322	2221	15	0100	1000	2	0000	1122	6
7	1222	1121	12	0130	0011	6	0000	0024	6
8	0221	1214	13	2221	2100	10	1000	0041	6
9	3123	1112	14	0000	0000	0	1111	2201	9
10	1210	0100	5	1110	0133	10	5322	1145	23
11	0020	1100	4	2321	1020	11	2121	2252	17
12	1322	2142	17	0032	0210	8	4232	2212	18
13	1222	1000	8	0011	0000	2	2223	2113	16
14	0111	2000	5	0100	-000	--	2421	0030	12
15	4322	1200	14	0012	2103	9	0121	0011	6
16	1422	3105	18	2221	0012	10	0000	0000	0
17	1221	0003	9	3222	3022	16	0000	0002	2
18	1221	1100	8	1220	1000	6	1000	0020	3
19	1221	2000	8	0000	0000	0	2221	1141	14
20	2211	1020	9	0000	0031	4	2222	1141	15
21	1122	0111	9	0111	1115	11	0121	2132	12
22	2011	1000	5	2112	1310	11	2321	1110	11
23	0111	1221	9	1331	0033	14	0112	0000	4
24	2232	1266	24	3222	3143	20	0221	0024	11
25	6443	3221	25	2221	0014	12	1212	0000	6
26	1222	0102	10	2122	1123	14	0100	0000	1
27	1122	2002	10	2333	2223	20	0110	0000	2
28	0000	0000	0	2121	1015	13	0000	1112	5
29	1000	0000	1	3333	1131	18	1323	1123	16
30	1202	2212	12	3112	3433	20	1222	1112	12
31	4223	2131	18				4332	0034	19

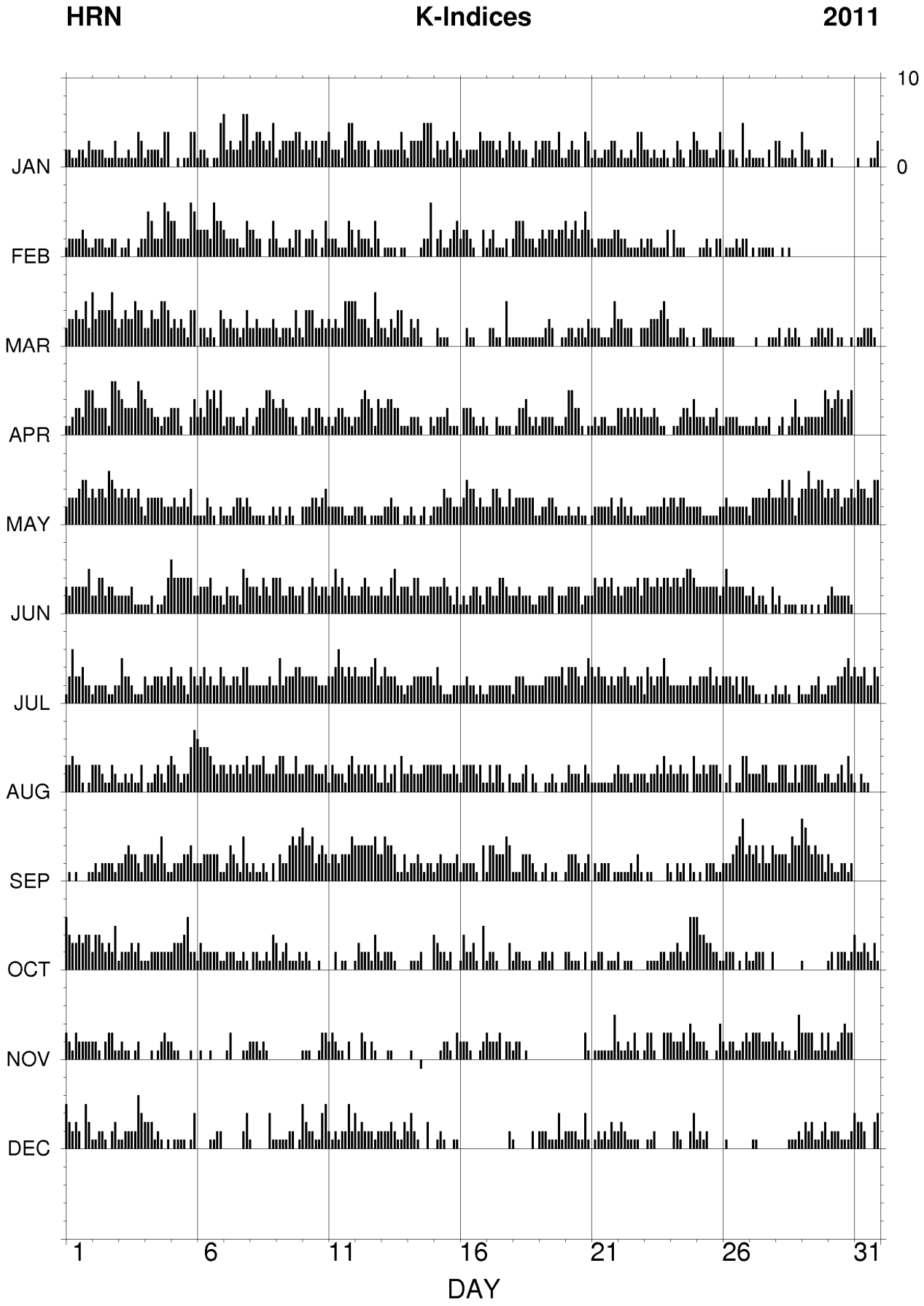

Fig. 20. K-indices in graphical form, Hornsund 2011.

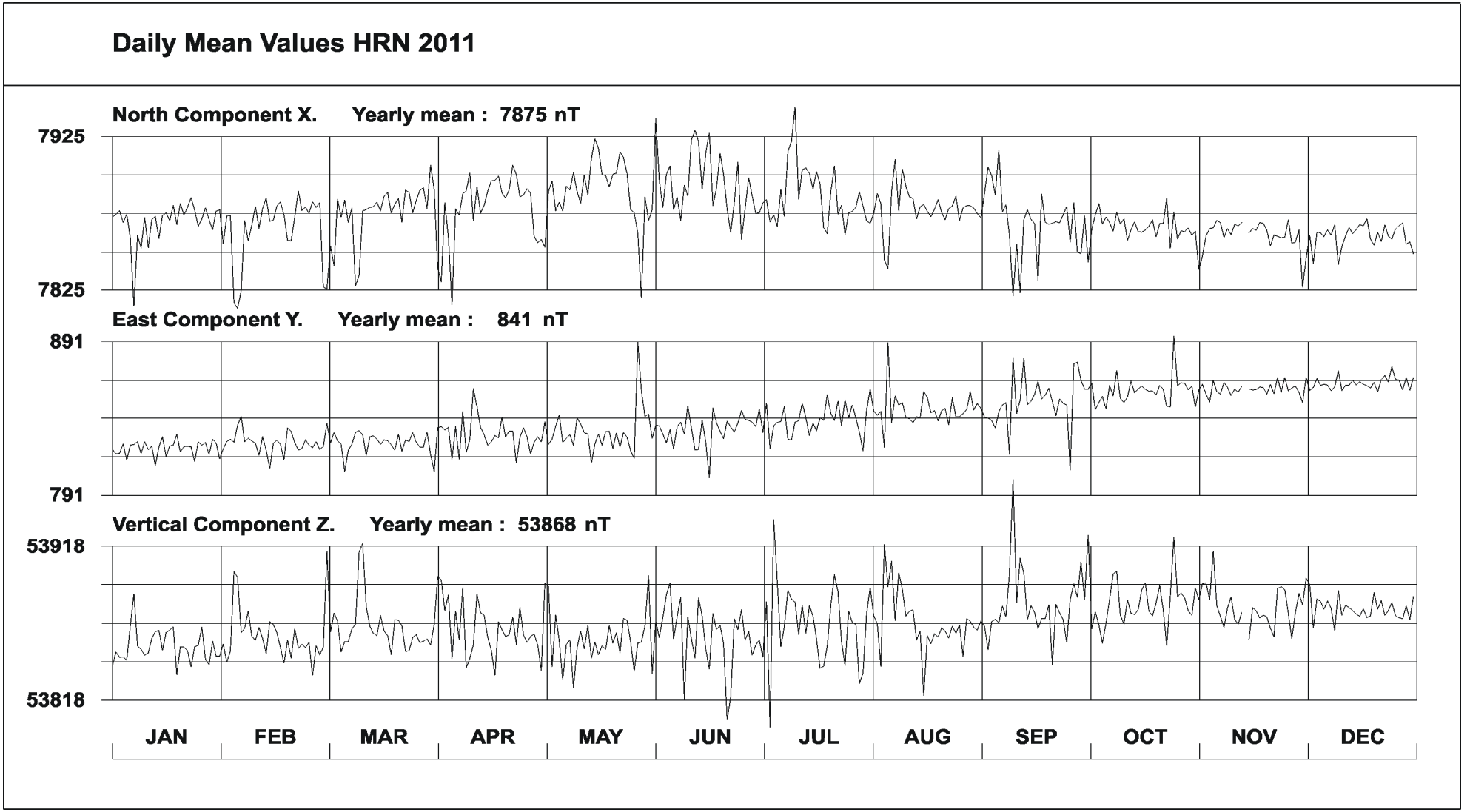

Fig. 21. Daily mean data plot for Hornsund 2011.

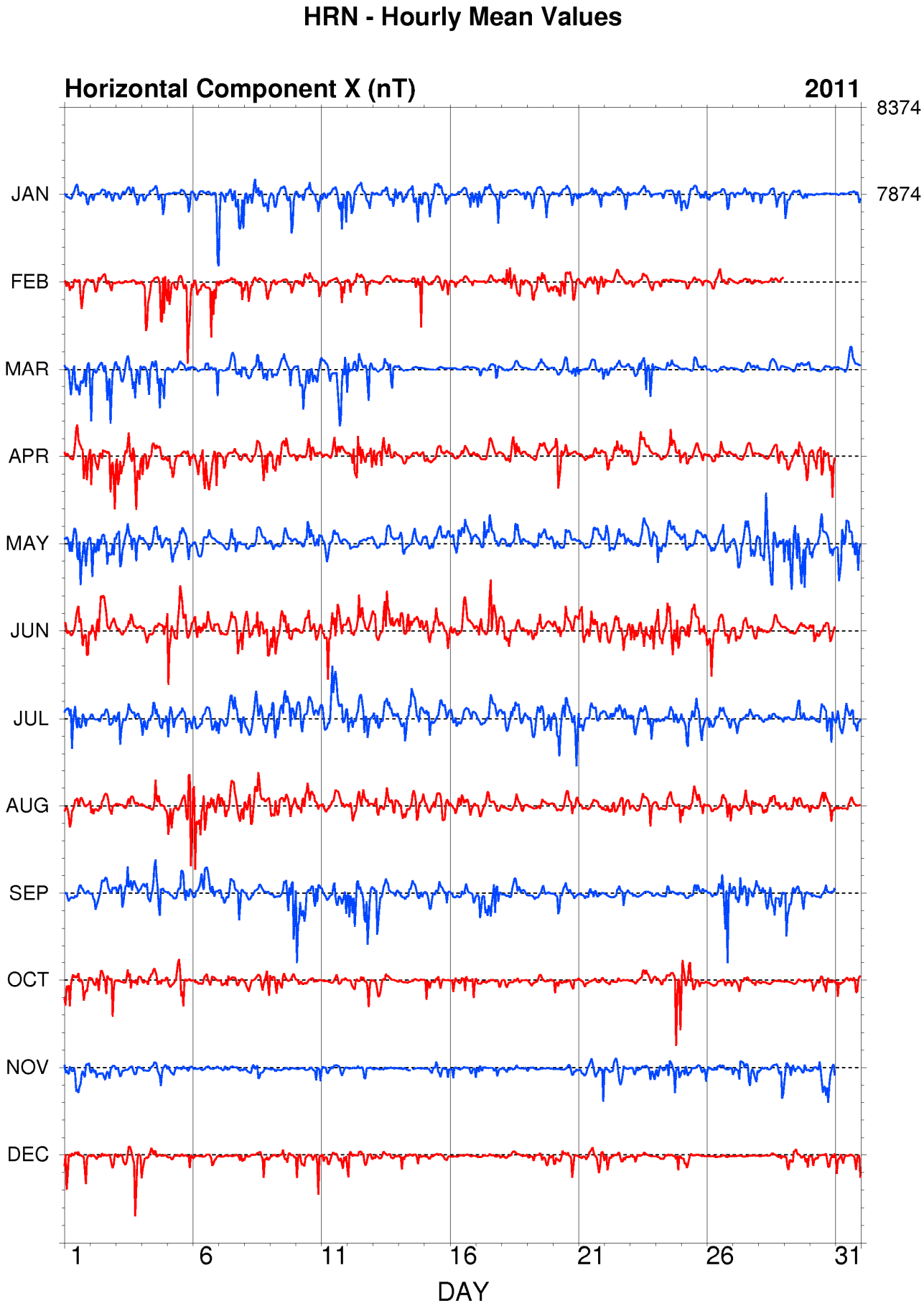

Fig. 22. Hourly mean data plot of X component for Hornsund 2011.

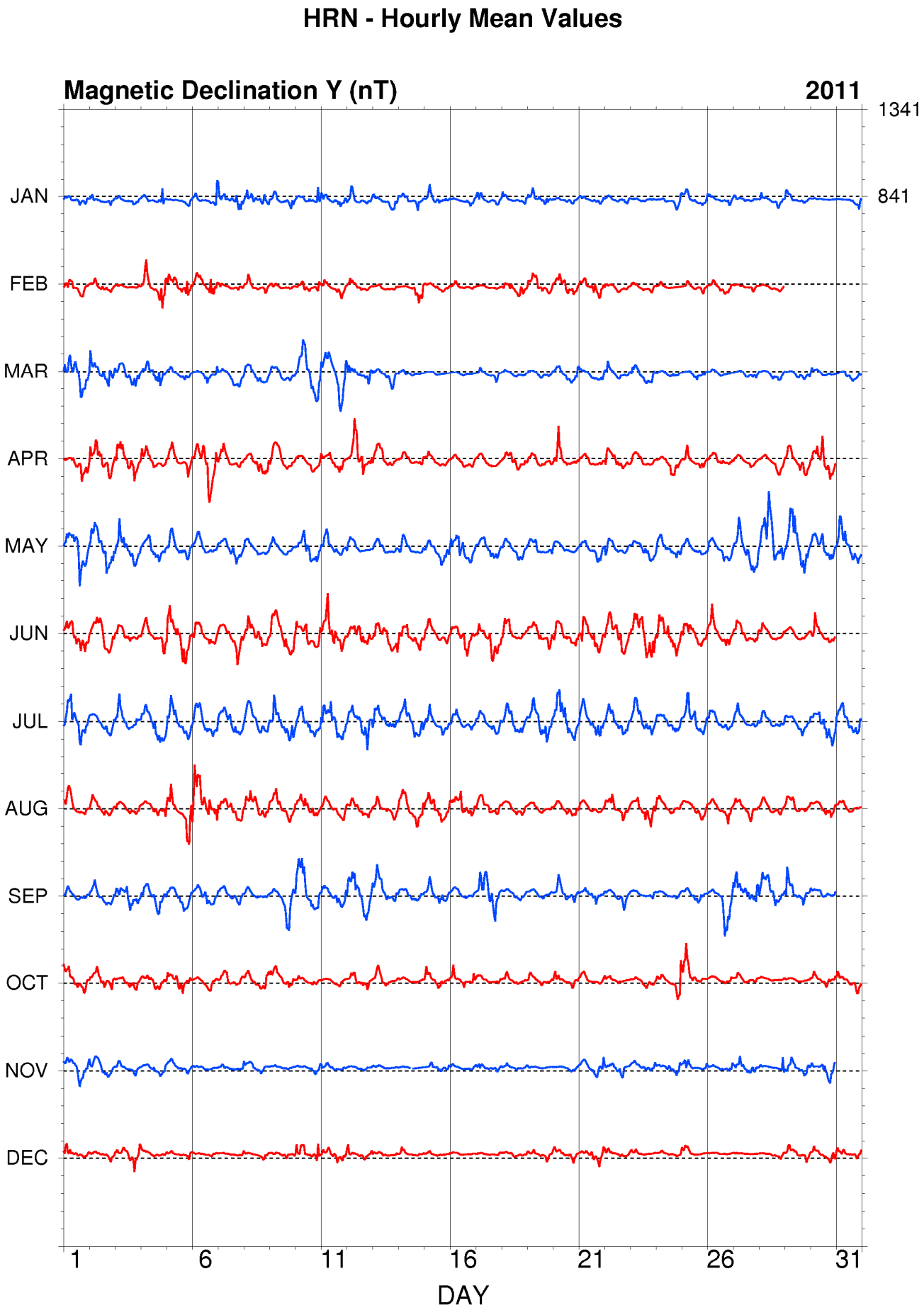

Fig. 23. Hourly mean data plot of Y component for Hornsund 2011.

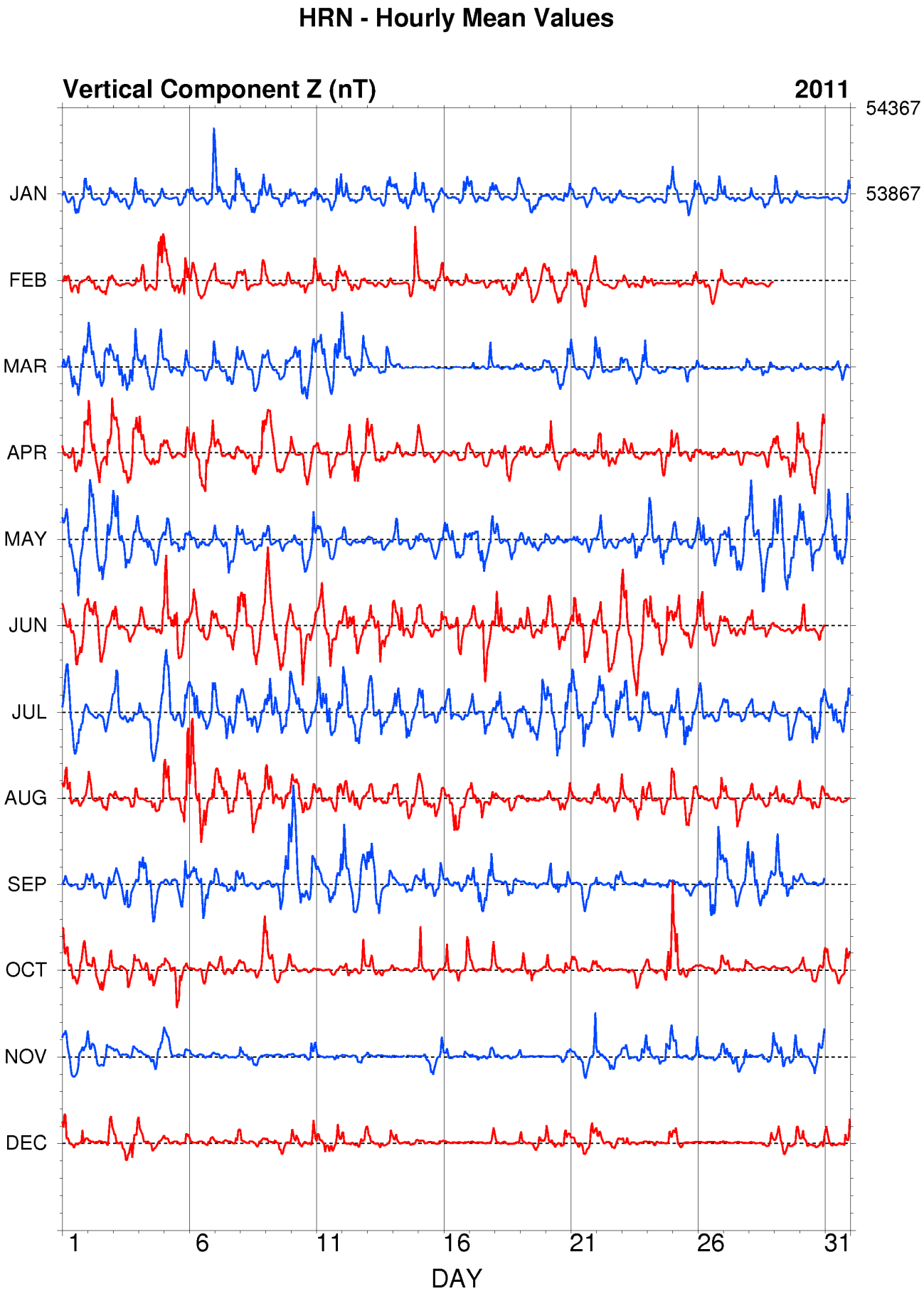

Fig. 24. Hourly mean data plot of Z component for Hornsund 2011.

C O N T E N T S