INSTITUTE OF GEOPHYSICS
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PUBLICATIONS OF THE INSTITUTE OF GEOPHYSICS POLISH ACADEMY OF SCIENCES

C-109 (419)

RESULTS OF GEOMAGNETIC OBSERVATIONS BELSK, HEL, HORNSUND 2015

WARSZAWA 2016

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WARSZAWA 2016

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Instytut Geofizyki Polskiej Akademii Nauk
ul. Księcia Janusza 64, 01-452 Warszawa, Poland

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Internet Edition

ISBN 978-83-88765-96-4
ISSN 2299-8020

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PUBLICATIONS OF THE INSTITUTE OF GEOPHYSICS
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C-107 (417) (Internet Edition) Results of geomagnetic observations, Belsk, Hel, Hornsund, 2013

C-108 (418) (Internet Edition) Results of geomagnetic observations, Belsk, Hel, Hornsund, 2014

ISBN 978-83-88765-96-4

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PUBLS. INST. GEOPHYS. POL. ACAD. SC., C-109 (419) (2016)

Results of Geomagnetic Observations Belsk, Hel, Hornsund, 2015

Mariusz NESKA, Jan REDA, Stanisław WÓJCIK and Paweł CZUBAK

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 2015 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, under Norwegian administration.

In 2015, 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., photos of observatories are shown in Fig. 2, 3, and 4. The geomagnetic coordinates in Table 1 were calculated on the basis of mode IGRF-12 from epoch 2015 (http://www.geomag.bgs.ac.uk/data_service/models_compass/coord_calc.html).

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 as well as by GEOMAG and LEMI flux-gate magnetometers.

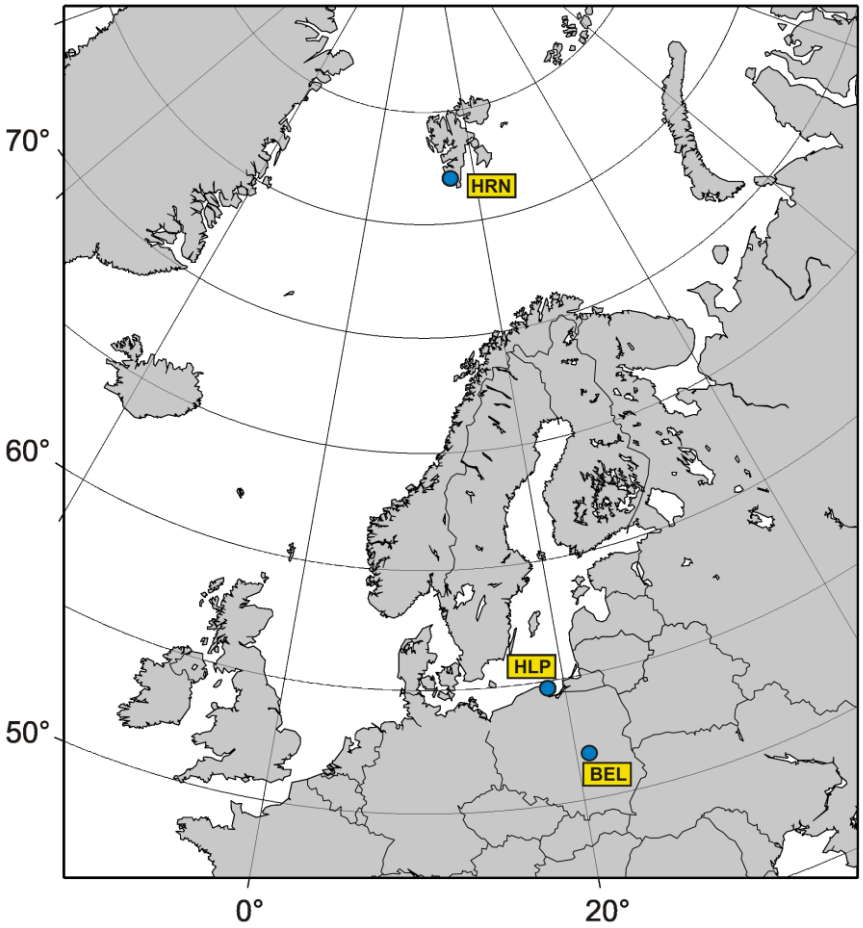

Fig. 1. Location of the Belsk, Hel and Hornsund observatories.

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	49.3° N	104.8° E	180
Hel (HLP)	54° 36.5′ N	18° 49.0′ E	52.7° N	104.3° E	1
Hornsund (HRN)	77° 0.0′ N	15° 33.0′ E	74.1° N	124.7° 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, gaps in one-minute XYZ elements from Belsk and Hel are practically absent.

It is worth mentioning that in 2015 the Belsk and Hornsund Observatories have been continuing the permanent observation of the Schumann resonance. Two horizontal magnetic components and the vertical component (Belsk) 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.

Fig. 2. Belsk Observatory- Absolute.

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 on the internet pages of Grójec district (https://en.wikipedia.org/wiki/Gr%C3%B3jec_County) to which the village Belsk Duży belongs. Relevant information about Belsk Observatory can be found at page http://www.igf.edu.pl/.

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.

Fig. 3 . Hel Observatory – the main gate.

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://en.wikipedia.org/wiki/Hel,_Poland .

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://en.wikipedia.org/wiki/Svalbard .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.

Fig. 4 . The Absolute House in Polish Polar Station Hornsund, Spitsbergen.

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)	GEOMAG 03, THEO-010B sn: 03-2012	FLUX-9408 THEO-10B sn: 160334	ELSEC 810 THEO-10B sn: 002208
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 GEOMAG 03 / THEO-010B	
Producer	GEOMAGNET, Ukraine
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 ELSEC 810 / THEO-010B	
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-010B	
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, 5 and 8 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 2015 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, B_Z and B_F in 2015

Observatory	Element	Number of measurements n	Mean error m_B [nT]
Belsk	B_X	294	0.34
	B_Y	296	0.33
	B_Z	298	0.17
Hel	B_X	131	0,29
	B_Y	136	0,28
	B_Z	141	0,20
	B_F	140	0,26
Hornsund	B_X	152	1.07
	B_Y	156	0.86
	B_Z	163	0.82

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 equipped with Bobrov's variometers (PSM) or flux-gate sensors (GEOMAG, LEMI) 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.

PSM magnetometers

The PSM magnetometers 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.

GEOMAG and LEMI magnetometers

The magnetometers of GEOMAG and LEMI type were designed at the GEOMAGNET company and the Lviv Centre of the Institute of Space Research, respectively, in Ukraine. They employ flux-gate sensors. 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	Geomag fluxgate
	Type	PSM-8811-01P	PSM 8511-02P	Geomag-02
	Sensor's orientation	XYZ	XYZ	XYZ
	Range	+/– 5000 nT	+/– 5000 nT	+/– 3200 nT
	Magnetometer's producer	Institute of Geophysics PAS	Institute of Geophysics PAS	GEOMAGNET (Ukraine)
	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-8511-06P	PSM 8511-03P	LEMI-003/95
	Sensor's orientation	XYZ	XYZ	XYZ
	Range	+/– 5000 nT	+/– 5000 nT	+/– 10,000 nT
	Magnetometer's producer	Institute of Geophysics PAS	Institute of Geophysics PAS	Lviv Centre of the Institute of Space Research (Ukraine)
	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

The magnetometers of type 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.

NDL digital data loggers

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, GEOMAG and LEMI, parameters of calibration coils of PSMs, and mutual orthogonality of sensors in magnetometers is checked every few years in large calibration coils installed at the Belsk Observatory.

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 IAF INTERMAGNET archive format (DVD/CD-ROM) 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 (Figs 6,9,12), bases of recording sets (Figs 5,8,12) as well as plots of K indices for 2015 (Figs 7,10,13) were prepared with the use of program imcdview.jar provided to us by INTERMAGNET.

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

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/

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/

4.3 Hornsund

Mariusz Neska, Paweł Czubak
Central Geophysical Observatory
05-622 Belsk
POLAND
Tel.: +48 486610833 Fax: +48 486610840
Email: nemar@igf.edu.pl (M.Neska), pczubak@igf.edu.pl (P.Czubak),
http://hornsund.igf.edu.pl/
http://www.igf.edu.pl/

5 PERSONNEL TAKING PART IN THE WORK OF BELSK, HEL AND HORNSUND OBSERVATORIES IN 2015

5.1 Belsk

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

5.2 Hel

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

5.3 Hornsund

– Mariusz Neska (head of geomagnetic observations)
– Piotr Łepkowski (observer in 1-st half-year)
– Tymoteusz Salamon (observer in 2-nd half-year)
– Jan Reda (data processing)
– Paweł Czubak (data processing)

Acknowledgments:

This work was supported within statutory activities No 3841/E-41/S/2015 of the Ministry of Science and Higher Education of Poland.

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Received February 23, 2015

Accepted April 22, 2015

6. TABLES AND PLOTS FOR BELSK OBSERVATORY

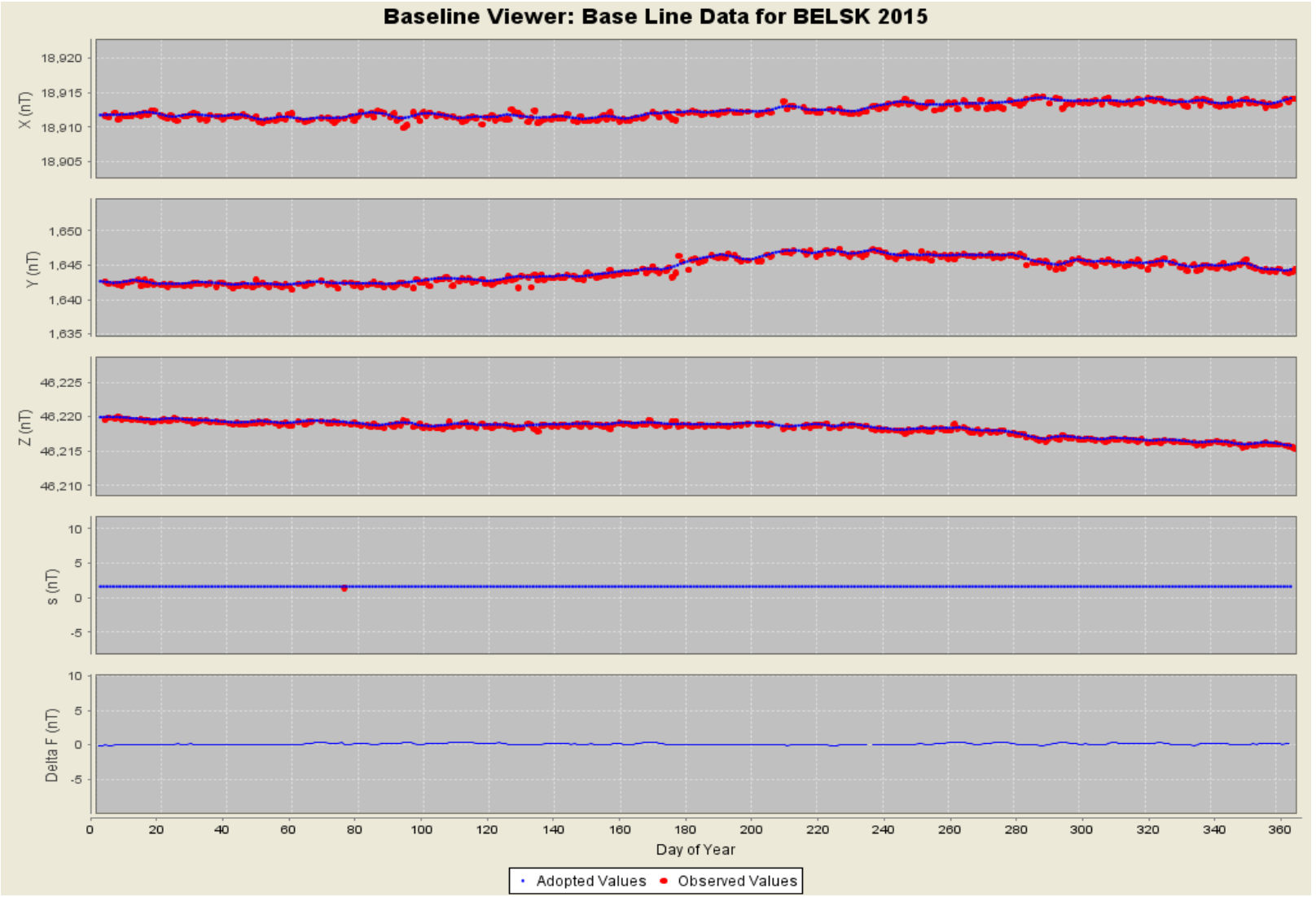

Fig. 5. Base values of set 1, Belsk 2015

Annual mean values of magnetic elements in Belsk Observatory

No	Year	D [° ‘]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [° ‘]	F [nT]
1	1966	2 04.2	18901	45023	18889	683	67 13.6’	48830
2	1967	2 05.6	18906	45048	18894	691	67 14.0	48854
3	1968	2 06.2	18917	45071	18906	695	67 13.8	48880
4	1969	2 06.3	18935	45094	18923	696	6713.3	48908
5	1970	2 06.6	18953	45123	18940	698	67 13.0	48942
6	1971	2 06.6	18976	45146	18963	699	67 12.2	48972
7	1972	2 08.0	18992	45176	18978	707	67 11.9	49006
8	1973	2 10.2	19005	45211	18991	719	67 12.0	49043
9	1974	2 13.3	19016	45246	19002	737	67 12.2	49079
10	1975	2 16.4	19035	45274	19020	755	67 11.7	49112
11	1976	2 18.5	19050	45307	19034	767	67 11.7	49149
12	1977	2 22.0	19062	45337	19046	787	67 11.7	49181
13	1978	2 27.4	19059	45376	19041	817	67 13.0	49216
14	1979	2 32.3	19061	45401	19043	844	67 13.5	49240
15	1980	2 37.2	19063	45418	19043	871	67 13.9	49257
16	1981	2 42.9	19047	45449	19026	902	67 15.7	49279
17	1982	2 48.3	19035	45479	19012	931	67 17.3	49302
18	1983	2 52.4	19033	45499	19009	954	67 18.0	49319
19	1984	2 56.9	19023	45520	18998	978	67 19.2	49335
20	1985	3 00.8	19015	45542	18989	999	67 20.3	49352
21	1986	3 05.1	19003	45570	18976	1023	67 21.8	49374
22	1987	3 08.5	18999	45593	18971	1041	67 22.7	49393
23	1988	3 12.4	18983	45626	18953	1062	67 24.6	49418
24	1989	3 15.9	18966	45662	18935	1080	67 26.6	49444
25	1990	3 18.8	18962	45684	18930	1096	67 27.5	49463
26	1991	3 22.2	18951	45709	18918	1114	67 28.8	49482
27	1992	3 25.3	18954	45726	18921	1131	67 29.1	49499
28	1993	3 29.8	18956	45744	18921	1156	67 29.4	49516
29	1994	3 34.8	18954	45772	18917	1183	67 30.4	49541
30	1995	3 39.8	18959	45797	18921	1212	67 30.7	49566
31	1996	3 45.0	18966	45822	18925	1241	67 30.9	49592
32	1997	3 50.9	18963	45857	18920	1273	67 32.0	49623
33	1998	3 57.3	18956	45897	18911	1308	67 33.6	49658
34	1999	4 02.5	18958	45931	18911	1336	67 34.3	49689
35	2000	4 07.8	18955	45969	18906	1365	67 35.5	49724
36	2001	4 13.0	18962	46005	18911	1394	67 36.0	49760
37	2002	4 18.4	18969	46044	18916	1424	67 36.6	49798
38	2003	4 24.2	18970	46090	18914	1457	67 37.7	49841
39	2004	4 29.4	18980	46121	18922	1486	67 37.9	49874
40	2005	4 34.7	18984	46155	18924	1515	67 38.5	49906
41	2006	4 39.8	18997	46177	18934	1544	67 38.3	49932
42	2007	4 45.8	19007	46207	18942	1578	67 38.4	49963
43	2008	4 52.5	19014	46236	18945	1616	67 38.7	49993
44	2009	4 59.7	19022	46264	18950	1656	67 39.0	50022
45	2010	5 08.0	19018	46301	18941	1701	67 40.2	50055

Annual mean values of magnetic elements in Belsk Observatory
(continuation)

No	Year	D [° ‘]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [° ‘]	F [nT]
46	2011	5 16.1	19015	46338	18935	1746	67 41.3	50088
47	2012	5 24.6	19014	46377	18929	1793	67 42.4	50123
48	2013	5 32.8	19020	46411	18931	1838	67 42.9	50157
49	2014	5 40.3	19025	46446	18932	1880	67 43.5	50191
50	2015	5 48.8	19019	46495	18922	1926	67 45.1	50235

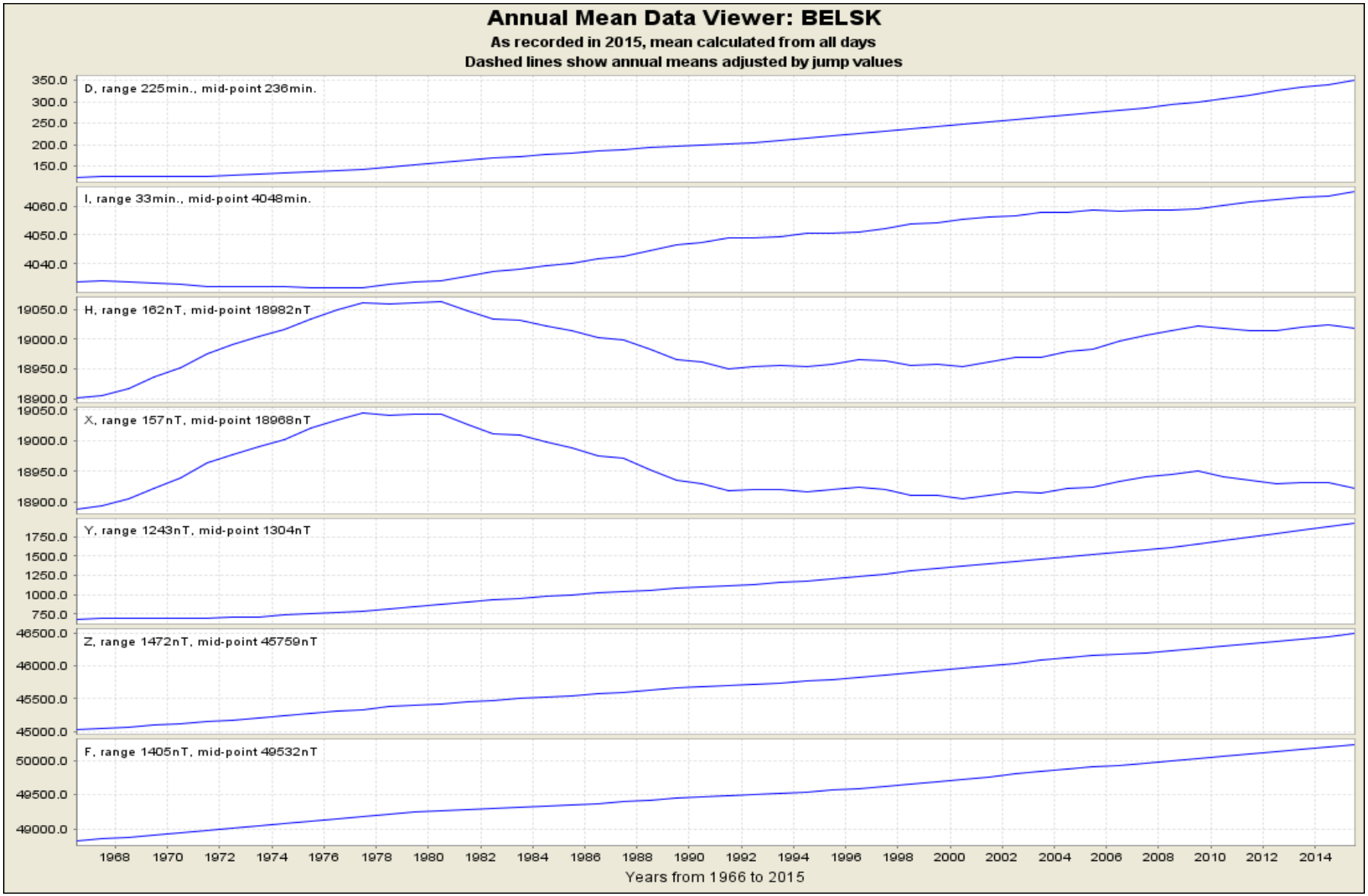

Fig. 6. Secular changes of H, X, Y, Z, F, D and I at Belsk.

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

BEL 2015

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 18500 + ... in nT													
All days	421	426	419	426	430	426	425	419	418	415	418	415	422
Quiet days	428	433	431	432	430	438	430	424	430	427	430	426	430
Disturbed days	405	417	391	414	422	410	418	405	403	397	402	393	406
EAST COMPONENT: 1500 + ... in nT													
All days	404	407	413	414	417	423	429	432	436	442	444	449	426
Quiet days	403	405	410	413	417	417	426	432	435	440	442	446	424
Disturbed days	408	413	427	421	419	428	431	435	441	448	442	454	431
VERTICAL COMPONENT: 46000 + ... in nT													
All days	477	475	482	483	484	491	496	502	505	511	514	519	495
Quiet days	475	473	478	480	486	483	494	500	501	508	510	516	492
Disturbed days	482	475	490	487	487	497	496	507	510	517	517	524	499

Three-hour-range K indices
Belsk, January - March, 2015
The limit of K=9 is 450

Day	January		February		March	
	K	SK	K	SK	K	SK
1	2111 1223	13	4232 2355	26	5443 2233	26
2	2112 2235	18	4433 2453	28	3444 3442	28
3	5323 2120	18	3322 3433	23	2322 2144	20
4	0112 3544	20	2212 3422	18	2123 3123	17
5	5222 2234	22	2322 3433	22	1112 2322	14
6	2333 2341	21	0123 1110	9	2232 2234	20
7	2145 3123	21	1122 1331	14	3323 3543	26
8	3322 2323	20	1222 1233	16	3223 4231	20
9	2222 2222	16	3111 2233	16	4211 1112	13
10	2312 2411	16	0220 1123	11	1211 1011	8
11	3122 2224	18	1312 2101	11	0322 2231	15
12	1112 2322	14	2111 2221	12	1322 2211	14
13	2212 2322	16	0011 1110	5	1012 3211	11
14	2111 3131	13	0111 0002	5	1221 2113	13
15	0112 3200	9	0212 3222	14	3222 1232	17
16	1222 1021	11	0111 2224	13	2343 3421	22
17	2312 1013	13	4333 3345	28	2445 6867	42
18	0001 1112	6	5323 2233	23	5334 5555	35
19	2101 0123	10	3222 2232	18	4334 4334	28
20	1011 0011	5	1112 2113	12	4343 3245	28
21	1222 2432	18	2211 1213	13	4232 3222	20
22	4312 4132	20	3212 1112	13	1365 3121	22
23	3222 1211	14	3223 3344	24	4423 4334	27
24	0121 2233	14	5533 2223	25	1113 3422	17
25	1201 1123	11	1132 3320	15	2224 4343	24
26	3233 2332	21	1111 1111	8	3121 2334	19
27	3222 2334	21	0011 1112	7	3222 3112	16
28	3222 2211	15	1222 2343	19	0232 2323	17
29	3112 2253	19			3322 2232	19
30	3221 1143	17			1111 1112	9
31	1212 2334	18			0123 3332	17

Three-hour-range K indices
Belsk, April - June, 2015
The limit of K=9 is 450

Day	April			May			June		
	K		SK	K		SK	K		SK
1	1122	1323	15	1211	1222	12	3112	0220	11
2	1223	2344	21	2222	2233	18	1101	1110	6
3	3222	2323	19	3222	1221	15	0112	2110	8
4	3222	3421	19	2222	3321	17	0111	1120	7
5	1221	1223	14	1113	3211	13	0101	1111	6
6	2121	2111	11	3234	5552	29	1213	2211	13
7	2210	1121	10	2222	3322	18	0112	2233	14
8	2001	1231	10	2222	1111	12	3355	4534	32
9	2223	2333	20	1013	2333	16	3332	4332	23
10	5544	4342	31	2124	4132	19	3233	3323	22
11	4322	2332	21	3322	3324	22	2223	3322	19
12	0111	1121	8	1223	3333	20	1212	3322	16
13	2221	2120	12	4554	4454	35	3223	2322	19
14	1111	3444	19	2332	2223	19	4233	2333	23
15	3225	5453	29	1323	2122	16	2223	4432	22
16	4434	3456	33	1111	2122	11	3222	2432	20
17	4433	3331	24	2211	2221	13	3223	5311	20
18	2232	2342	20	1223	3234	20	3112	3320	15
19	3212	1233	17	5223	2321	20	2112	2100	9
20	3222	2233	19	2222	2110	12	0111	1011	6
21	3323	4434	26	0011	2111	7	1011	2433	15
22	2232	3223	19	2111	1111	9	1343	5585	34
23	1311	2111	11	0112	1211	9	6655	4344	37
24	2211	1110	9	1111	1122	10	3333	3332	23
25	0000	0010	1	1012	1111	8	2355	6532	31
26	0111	1111	7	1211	2321	13	2223	1212	15
27	0012	2222	11	0112	3112	11	3332	2222	19
28	2122	2221	14	2223	3221	17	3332	4232	22
29	1011	2111	8	1323	3323	20	1122	2210	11
30	2121	1121	11	1111	3222	13	1211	2223	14
31				2112	1312	13			

Three-hour-range K indices
Belsk, July - September, 2015
The limit of K=9 is 450

Day	July		August		September	
	K	SK	K	SK	K	SK
1	1112 3311	13	3223 2322	19	1111 1113	10
2	1111 1100	6	3232 3322	20	1111 2343	16
3	0111 2110	7	1222 2222	15	2312 2223	17
4	0212 4344	20	1222 2123	15	3333 3333	24
5	4424 3333	26	1111 2223	13	2222 3553	24
6	3332 2131	18	2233 3233	21	2233 4252	23
7	2212 2123	15	2243 4422	23	2232 4655	29
8	1112 2221	12	2222 4233	20	5432 3224	25
9	1212 1121	11	2224 2323	20	4544 5465	37
10	0111 1224	12	3222 3231	18	2121 3454	22
11	4444 3333	28	3322 2213	18	3366 5634	36
12	3323 3333	23	2221 3434	21	4243 2322	22
13	3444 3453	30	3322 3221	18	1123 2443	20
14	3112 3222	16	0012 2111	8	2122 2553	22
15	1211 3323	16	3245 5534	31	4323 3323	23
16	3222 3322	19	4443 3434	29	2221 2434	20
17	1121 2211	11	3333 4442	26	4222 2103	16
18	0102 1111	7	3221 2222	16	2232 3243	21
19	0111 0010	4	4432 4333	26	3432 2014	19
20	0111 2111	8	3222 4323	21	3454 4633	32
21	3333 3122	20	1222 3121	14	3223 3222	19
22	1212 3432	18	2113 4322	18	3232 2222	18
23	4342 3333	25	3344 4342	27	2233 2432	21
24	2222 3223	18	222- 2221	--	2121 2233	16
25	3123 2223	18	2212 1332	16	1122 3112	13
26	3112 1332	16	3334 4654	32	1111 1232	12
27	2123 3322	18	5543 3436	33	1122 1122	12
28	2223 3222	18	5322 4554	30	1111 1122	10
29	2112 2120	11	3223 2331	19	2222 0111	11
30	2212 3334	20	2111 1221	11	0001 1111	5
31	2323 4433	24	2112 1221	12		

Three-hour-range K indices
Belsk, October - December, 2015
The limit of K=9 is 450

Day	October		November		December	
	K	SK	K	SK	K	SK
1	1112 3434	19	1322 3231	17	2312 4434	23
2	2332 3342	22	0011 3312	11	2222 3322	18
3	2221 2322	16	3244 4454	30	1111 1112	9
4	3333 3235	25	4543 5232	28	1211 1112	10
5	4334 4233	26	2233 3434	24	2133 3443	23
6	3332 3455	28	4122 2355	24	2324 4454	28
7	4544 4665	38	4654 4352	33	3333 4552	28
8	4544 5554	36	1112 3455	22	3223 3223	20
9	3333 4555	31	4333 3455	30	2211 2343	18
10	3232 2423	21	4345 5544	34	3433 3544	29
11	3221 3354	23	4233 4552	28	4333 3544	29
12	1323 2545	25	1112 1212	11	2332 2332	20
13	2334 2455	28	1112 3544	21	2222 2111	13
14	3433 3343	26	3122 2222	16	2211 3556	25
15	2212 2233	17	2212 1234	17	4322 3423	23
16	2221 2111	12	3222 3333	21	3311 0011	10
17	2212 2242	17	1211 1332	14	1111 2342	15
18	3234 3433	25	1312 2355	22	2111 1113	11
19	0122 1022	10	3223 1121	15	1110 1445	17
20	1212 2343	18	1122 0111	9	3553 5666	39
21	1214 4222	18	2111 0111	8	7543 3224	30
22	1111 1232	12	1111 0010	5	3234 2132	20
23	3112 2222	15	0010 1000	2	2222 3344	22
24	3221 1143	17	0000 0000	0	3232 2232	19
25	2122 3211	14	0000 0000	0	2222 2222	16
26	1011 0110	5	0000 0021	3	3222 4435	25
27	0011 1123	9	3222 1211	14	3222 4232	20
28	0101 0000	2	1111 2234	15	1112 2101	9
29	1012 1013	9	1122 2234	17	2001 2233	13
30	2111 2324	16	2343 2233	22	0011 1113	8
31	1012 2223	13			3233 5565	32

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, January - March, 2015

Day	January			February			March		
	E		SE	E		SE	E		SE
1	2111	1223	13	5332	2355	28	6454	1234	29
2	2112	2235	18	4534	2563	32	4455	3543	33
3	5323	3110	18	4322	2433	23	2322	2144	20
4	0013	3645	22	2112	4422	18	2114	4014	17
5	6322	3244	26	2323	3533	24	1012	3321	13
6	2334	2431	22	0122	1110	8	1232	2225	19
7	2146	3123	22	1033	1331	15	4423	4544	30
8	4322	3324	23	2322	1243	19	2223	4320	18
9	2121	3223	16	3110	3234	17	4200	0101	8
10	3312	2510	17	0310	1124	12	1111	1010	6
11	3132	2114	17	1311	2100	9	0332	2340	17
12	0112	3332	15	2101	2221	11	1322	2200	12
13	1212	3332	17	0001	0100	2	1011	4111	10
14	3011	3131	13	0110	0001	3	0221	2103	11
15	0012	4100	8	0122	3222	14	3222	1241	17
16	1321	2030	12	0011	1135	12	2443	2321	21
17	3312	1003	13	4234	3355	29	1455	6767	41
18	0001	1113	7	5433	2244	27	6444	5565	39
19	3001	0123	10	4222	2232	19	5335	4434	31
20	1011	0000	3	0112	2013	10	5353	4355	33
21	1222	2442	19	2111	1113	11	4233	3222	21
22	4313	4142	22	2212	1112	12	1365	3121	22
23	3222	2311	16	4223	3455	28	4424	5415	29
24	0011	1232	10	6634	3214	29	1112	4522	18
25	1201	1114	11	0132	4430	17	2224	4343	24
26	4224	3432	24	2011	1012	8	3111	2234	17
27	3331	1324	20	0011	1103	7	3223	3112	17
28	4232	1112	16	1223	2454	23	0232	2224	17
29	3112	2263	20				4312	2232	19
30	2221	1153	17				1111	0013	8
31	1222	1335	19				0123	3331	16

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, April – June, 2015

Day	April			May			June		
	E		SE	E		SE	E		SE
1	1123	1323	16	1211	1221	11	3212	0120	11
2	1223	2355	23	2212	1233	16	0101	1000	3
3	3222	2224	19	2222	1221	14	0112	2110	8
4	3122	3522	20	2122	3321	16	0000	0010	1
5	1111	1224	13	1013	3211	12	0001	0111	4
6	2121	2000	8	4234	5551	29	0212	2111	10
7	2200	1020	7	1211	3322	15	0111	2223	12
8	2000	1131	8	3122	1111	12	4465	4535	36
9	2223	3233	20	0003	2433	15	4332	4433	26
10	5543	4343	31	2125	4132	20	4233	3323	23
11	5433	2431	25	4422	3335	26	2223	3411	18
12	0011	1121	7	2334	3344	26	1211	3321	14
13	2221	1120	11	5654	5555	40	3233	2322	20
14	0011	3545	19	2232	2123	17	5233	2433	25
15	2325	5464	31	1212	2122	13	2212	5432	21
16	5444	3466	36	1111	1121	9	3331	2432	21
17	4433	3342	26	2111	2220	11	3233	5401	21
18	2221	2352	19	1124	3235	21	3111	3420	15
19	2212	1233	16	5223	2221	19	3112	1000	8
20	4312	2133	19	2321	2110	12	0111	1000	4
21	4334	4434	29	0000	2101	4	1000	1433	12
22	2232	3124	19	1101	1000	4	1343	5585	34
23	1311	1012	10	0102	1211	8	6655	4344	37
24	2201	0110	7	1101	1022	8	4343	3331	24
25	0000	0000	0	0011	1010	4	2355	6532	31
26	0001	1001	3	1112	2321	13	2223	1202	14
27	0012	2222	11	0102	3113	11	3332	2123	19
28	2012	2211	11	2223	3221	17	3332	5232	23
29	1000	2112	7	1213	3323	18	1122	2210	11
30	2021	0030	8	1111	2112	10	1211	1223	13
31				1112	0312	11			

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, July - September, 2015

Day	July			August			September		
	E		SE	E		SE	E		SE
1	1112	3310	12	3212	2423	19	1101	1113	9
2	0011	1000	3	4231	3322	20	2110	2343	16
3	0000	1100	2	2222	2212	15	3311	1223	16
4	0102	4355	20	1212	2124	15	4543	3244	29
5	5524	2333	27	1111	2223	13	2233	2542	23
6	4331	2131	18	3123	3233	20	2233	4362	25
7	2113	1113	13	3244	5422	26	3233	4666	33
8	0002	2321	10	2222	4233	20	6522	3215	26
9	1212	1122	12	2224	2334	22	4554	5576	41
10	0101	1225	12	4222	3232	20	2121	2454	21
11	4444	4343	30	4222	1213	17	3466	5734	38
12	3323	3343	24	2221	3435	22	4243	3412	23
13	3554	4464	35	4322	2221	18	1113	2444	20
14	4111	2222	15	0001	1111	5	2122	2554	23
15	0211	3313	14	3245	5544	32	5423	3424	27
16	3222	3311	17	5544	3544	34	2221	3534	22
17	1121	1100	7	3344	4353	29	5222	1104	17
18	0001	1021	5	3321	1312	16	2232	3353	23
19	0011	0010	3	4433	4443	29	3433	2014	20
20	0011	2111	7	3223	4424	24	2465	5633	34
21	3233	2122	18	1222	2121	13	3213	2221	16
22	1112	3432	17	2112	4332	18	3231	3231	18
23	4342	3343	26	4354	5352	31	1133	2531	19
24	2211	3223	16	322-	3121	--	2121	1233	15
25	3123	1223	17	2212	1342	17	1112	4002	11
26	3113	0332	16	4434	4655	35	1011	1232	11
27	2134	3222	19	5653	3546	37	1111	0122	9
28	2213	3222	17	5422	5565	34	1001	1022	7
29	1112	1020	8	4223	2341	21	2222	0011	10
30	2212	3345	22	1110	1121	8	0001	0011	3
31	2322	4534	25	2101	1221	10			

* - see literature: Reda and Jankowski, 2004

Three-hour-range E indices
based on power spectrum estimation(*)
Belsk, October - December, 2015

Day	October			November			December		
	E		SE	E		SE	E		SE
1	1112	3545	22	1322	3231	17	2312	3544	24
2	2342	2342	22	0001	3301	8	2222	4331	19
3	2211	2322	15	2354	5564	34	1100	0012	5
4	4333	3226	26	5544	5222	29	0210	1002	6
5	5435	5133	29	2234	4544	28	2134	3553	26
6	3332	4555	30	4122	2255	23	2424	5554	31
7	4544	5776	42	5655	4351	34	3333	4552	28
8	4554	5665	40	1012	5465	24	4322	3224	22
9	3322	5555	30	5343	4556	35	2201	2353	18
10	3231	1423	19	4445	5645	37	4533	3555	33
11	3311	3354	23	5233	4651	29	4233	3654	30
12	1324	2655	28	1012	0112	8	3321	2432	20
13	2334	1556	29	1012	2455	20	2212	2111	12
14	4443	4442	29	3222	3123	18	2201	3556	24
15	2221	2334	19	2212	1235	18	5422	3424	26
16	2221	2101	11	4222	3334	23	4310	0000	8
17	2312	3251	19	1311	0341	14	0010	2352	13
18	3245	3433	27	0312	2365	22	2111	0014	10
19	0112	1022	9	3213	1020	12	1000	1455	16
20	1212	2244	18	1122	0001	7	3653	6676	42
21	1114	4332	19	2110	0010	5	7544	3224	31
22	0110	0242	10	1010	0010	3	3234	1143	21
23	3111	2222	14	0000	1000	1	2212	3345	22
24	3321	0143	17	0000	0000	0	3222	2143	19
25	2021	3211	12	0000	0000	0	2222	2222	16
26	0010	0000	1	0000	0021	3	3222	4336	25
27	0010	1014	7	3222	1211	14	3222	4232	20
28	0100	0000	1	1002	2234	14	2112	3102	12
29	0001	0013	5	1122	3244	19	2001	2233	13
30	2101	2314	14	3344	2233	24	0000	1003	4
31	0002	2224	12				3234	5565	33

* - see literature: Reda and Jankowski, 2004

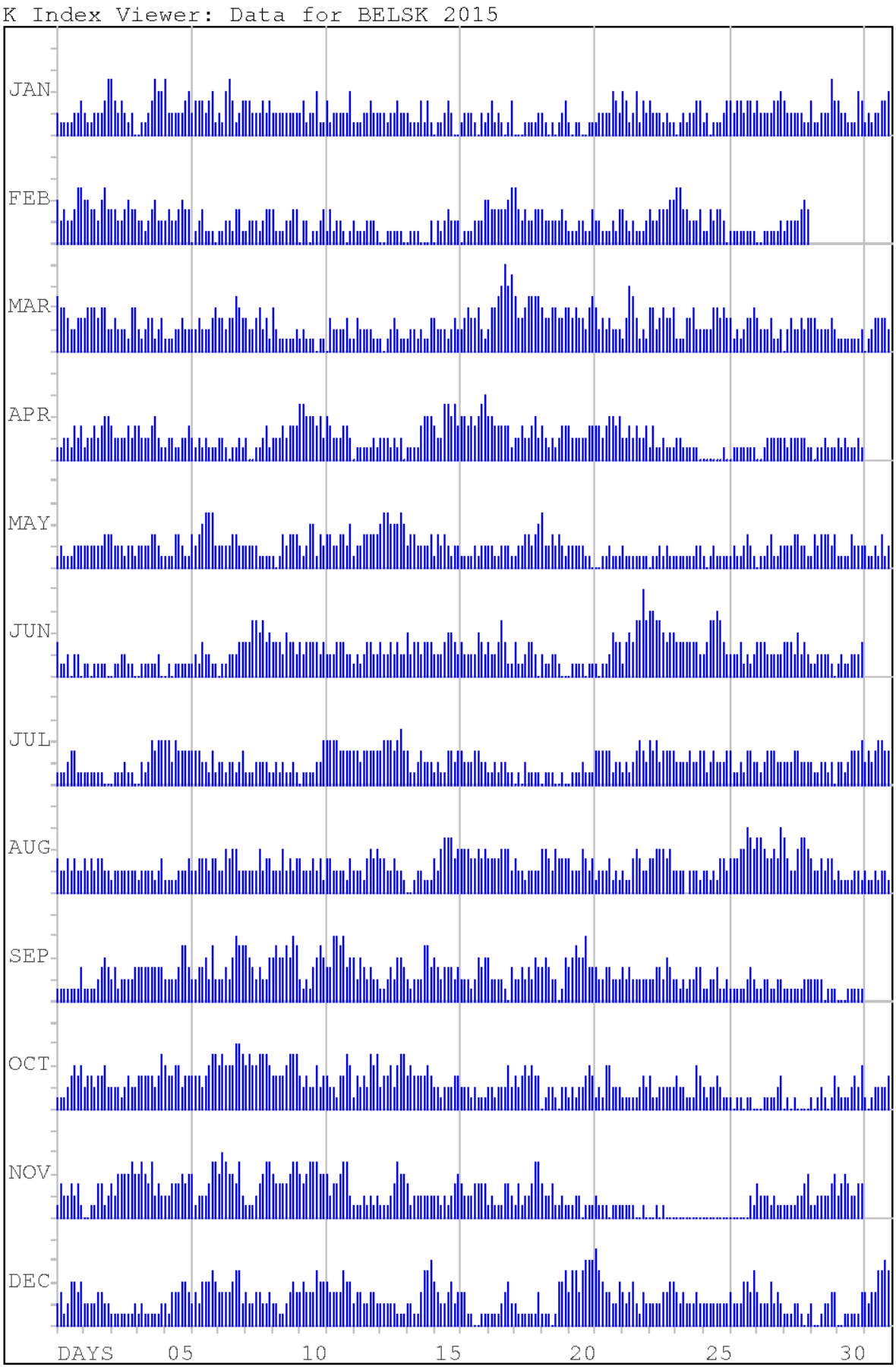

Fig. 7. K-indices in graphical form, Belsk 2015.

7. TABLES AND PLOTS FOR HEL OBSERVATORY

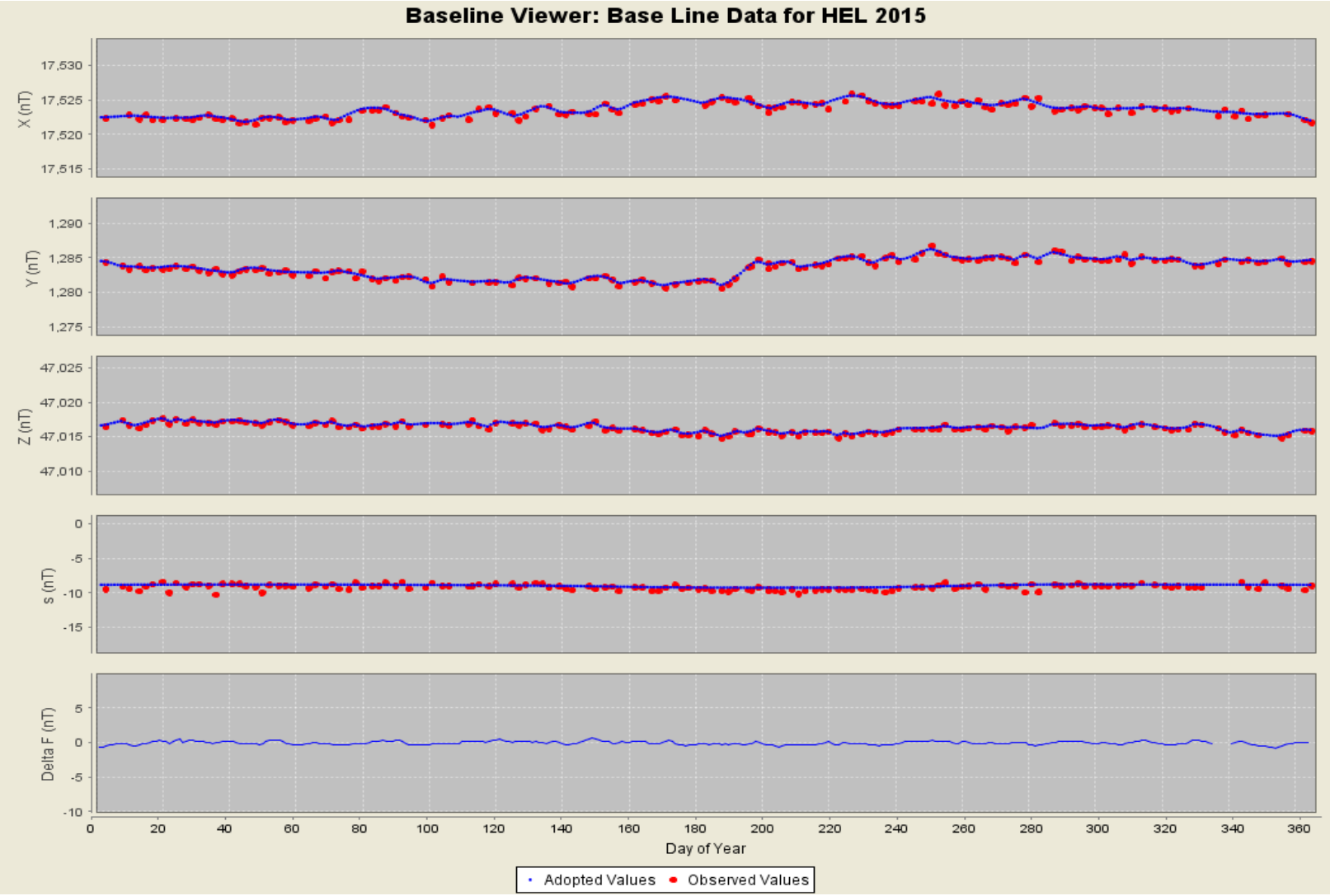

Fig. 8. Base values of set 1, Hel 2015.

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

Annual mean values of magnetic elements in Hel Observatory
(continuation)

No	Year	D [º ‘]	H [nT]	Z [nT]	X [nT]	Y [nT]	I [º ‘]	F [nT]
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
60	2012	4 18.7	17562	47053	17512	1321	69 32.0	50223
61	2013	4 28.2	17567	47084	17513	1369	69 32.4	50254
62	2014	4 36.3	17571	47117	17514	1411	69 32.9	50286
63	2015	4 45.5	17565	47163	17504	1457	69 34.4	50328

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

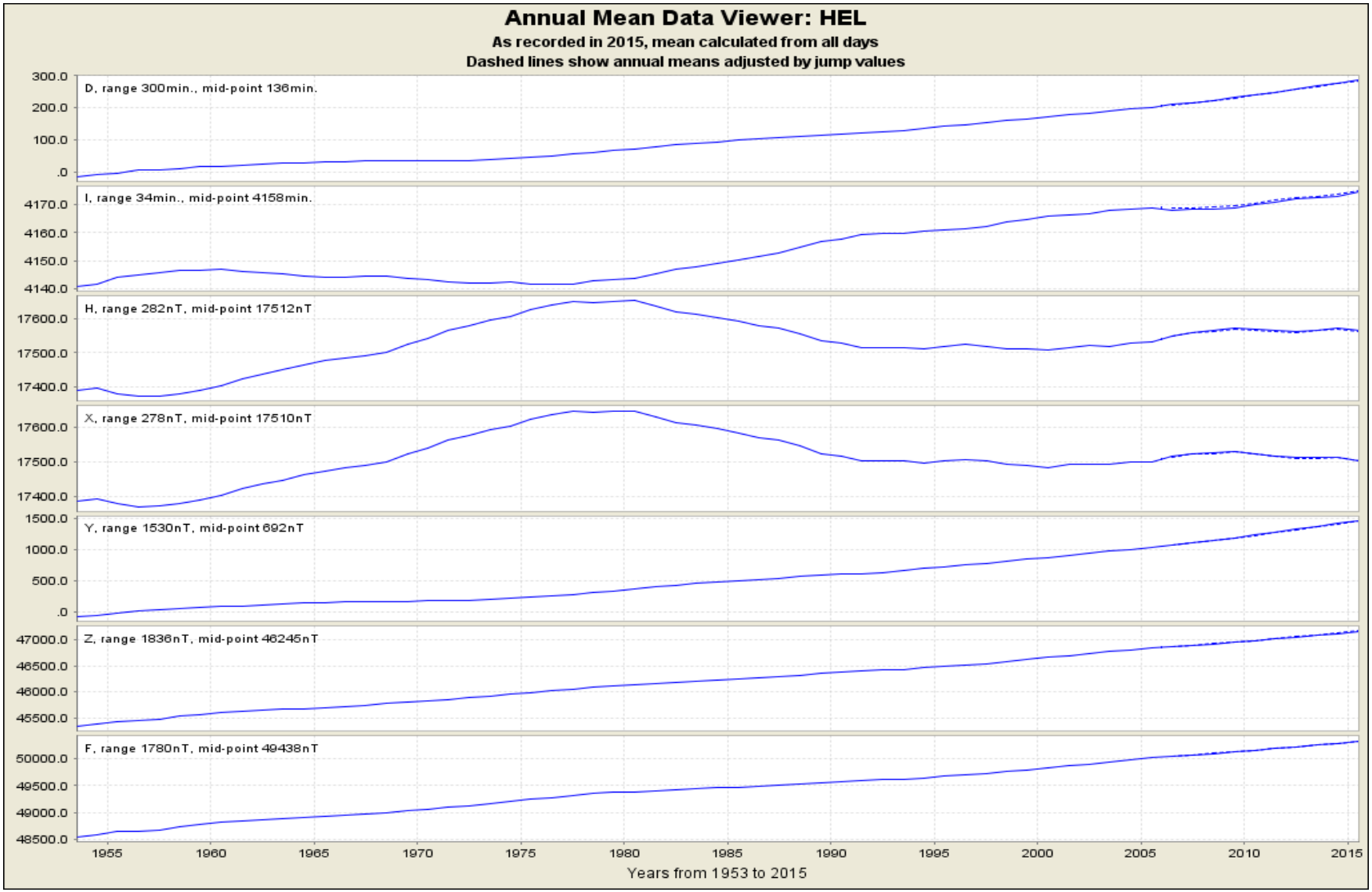

Fig. 9. Secular changes of H, X, Y, Z, F, D and I at Hel.

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

HLP 2015

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 17000 + ... in nT													
All days	504	508	502	508	513	510	508	502	500	497	499	496	504
Quiet days	510	514	513	513	513	520	512	502	502	506	508	497	509
Disturbed days	489	500	477	497	506	495	512	507	503	482	488	503	497
EAST COMPONENT: 1000 + ... in nT													
All days	436	439	444	444	448	452	459	463	468	473	476	481	457
Quiet days	435	436	440	443	447	447	455	461	468	471	476	482	455
Disturbed days	440	445	458	451	449	457	455	462	468	477	476	478	460
VERTICAL COMPONENT: 47000 + ... in nT													
All days	147	144	151	151	153	159	164	169	173	179	182	187	163
Quiet days	145	143	146	149	155	151	164	168	173	175	179	192	162
Disturbed days	152	143	159	154	156	164	164	165	173	184	185	182	165

Three-hour-range K indices
Hel, January - March, 2015
The limit of K=9 is 550

Day	January		February		March	
	K	SK	K	SK	K	SK
1	2111 1223	13	4232 2355	26	5443 2233	26
2	2122 2235	19	4433 3453	29	3444 3432	27
3	5313 2110	16	3322 2323	20	2222 2134	18
4	0112 3534	19	2112 3312	15	2124 3123	18
5	5222 2233	21	1213 3432	19	1112 2322	14
6	2233 2331	19	0123 1110	9	1232 2234	19
7	2145 3123	21	1122 1221	12	3323 3443	25
8	3322 2223	19	1222 1233	16	2223 3220	16
9	2122 2222	15	3210 3233	17	4210 1111	11
10	2212 2410	14	0221 1123	12	1111 1011	7
11	3122 2123	16	1302 2101	10	0232 2231	15
12	0112 2222	12	1101 2121	9	1323 2210	14
13	1212 2222	14	0001 1110	4	1012 3111	10
14	2111 2131	12	0111 0002	5	0122 2003	10
15	0012 3200	8	0111 3222	12	2122 1231	14
16	1221 1021	10	0011 2124	11	2333 3321	20
17	2212 1003	11	4233 3344	26	2444 6867	41
18	0001 1112	6	4322 2233	21	5334 5554	34
19	2101 0123	10	3222 2231	17	4334 4334	28
20	1011 0001	4	0111 2002	7	4343 3244	27
21	1222 2432	18	2111 1113	11	4233 2222	20
22	4323 3132	21	2212 1112	12	2365 3021	22
23	3222 2211	15	3223 3344	24	4323 4334	26
24	0011 2232	11	5533 3223	26	1113 3422	17
25	1201 1123	11	1132 3320	15	1224 4343	23
26	3233 2332	21	1011 2001	6	2121 2323	16
27	2222 1323	17	0001 1112	6	3122 3112	15
28	3222 2111	14	1122 2343	18	0222 2323	16
29	2112 2252	17			3312 2232	18
30	2221 1143	16			1111 0112	8
31	1212 2334	18			0033 3332	17

Three-hour-range K indices
Hel, April - June, 2015
The limit of K=9 is 550

Day	April			May			June		
	K		SK	K		SK	K		SK
1	1112	2323	15	1212	1222	13	3113	1220	13
2	1123	2344	20	2212	2233	17	0101	2110	6
3	3222	2323	19	3222	2221	16	0112	2110	8
4	3223	3421	20	1222	3321	16	0101	1110	5
5	1221	1223	14	0013	3211	11	0001	0111	4
6	2111	2111	10	3234	5542	28	1213	2211	13
7	2201	1110	8	2212	3312	16	0112	3223	14
8	2000	1121	7	2122	1111	11	3355	4534	32
9	2223	3333	21	0003	2333	14	3332	4332	23
10	5444	5332	30	2124	4122	18	3233	3223	21
11	4332	2322	21	3322	3323	21	2223	3311	17
12	0111	1121	8	2233	3333	22	1111	3322	14
13	2211	1221	12	4554	4454	35	2223	2322	18
14	0111	3444	18	2322	2222	17	4233	2333	23
15	2235	5453	29	1323	2122	16	2223	4432	22
16	4434	3456	33	1121	2221	12	2222	2332	18
17	4333	3332	24	2211	2221	13	2223	5401	19
18	2222	3342	20	1123	4235	21	3112	3320	15
19	3212	2222	16	5223	2321	20	2112	1000	7
20	3212	2233	18	2222	3110	13	0110	0001	3
21	3323	4434	26	0001	2111	6	1011	2423	14
22	2132	3223	18	2101	1000	5	1343	5584	33
23	1212	2102	11	0112	1211	9	6655	4333	35
24	2101	1110	7	1111	1121	9	3333	3332	23
25	0001	0000	1	0011	1010	4	2355	6532	31
26	0000	1101	3	1112	2321	13	2223	1202	14
27	0013	2212	11	0111	3212	11	3222	2212	16
28	2112	2221	13	2213	2321	16	3332	4221	20
29	1011	2111	8	1222	3322	17	1122	2211	12
30	2111	1021	9	1111	3222	13	1211	1222	12
31				2111	1312	12			

Three-hour-range K indices
Hel, July - September, 2015
The limit of K=9 is 550

Day	July		August		September	
	K	SK	K	SK	K	SK
1	1112 3310	12	3213 2322	18	1112 1113	11
2	0001 1100	3	3222 3322	19	1111 2333	15
3	0110 1110	5	1212 2212	13	2212 2323	17
4	1102 4344	19	1221 2223	15	4333 3333	25
5	4424 3323	25	1102 2213	12	2222 3543	23
6	3322 2131	17	2123 4232	19	1233 3252	21
7	2212 2112	13	2233 5422	23	2233 4556	30
8	1112 2221	12	2223 4233	21	5532 3224	26
9	1211 2121	11	2224 2323	20	4544 5465	37
10	0101 1225	12	3222 3221	17	2122 3443	21
11	4334 4233	26	3222 2113	16	3365 5633	34
12	3324 3333	24	2221 3433	20	4233 3312	21
13	3444 3453	30	3312 3211	16	1213 2443	20
14	3112 3222	16	0002 1111	6	2122 2553	22
15	1111 3323	15	3235 5534	30	4323 3323	23
16	3222 3211	16	4433 3433	27	2221 3434	21
17	1111 2210	9	3333 3342	24	4222 1103	15
18	0001 2110	5	3221 2212	15	1122 3242	17
19	0011 1010	4	3432 4333	25	3432 2014	19
20	0011 2111	7	3222 3323	20	3354 4533	30
21	2223 3122	17	1122 3112	13	3223 3211	17
22	1112 3432	17	2013 4322	17	2232 3222	18
23	3342 3332	23	3344 4342	27	1233 3322	19
24	1222 3222	16	2122 3211	14	2121 2133	15
25	3123 2222	17	2112 2332	16	1122 3102	12
26	3112 1232	15	3324 4554	30	1001 1232	10
27	2123 3322	18	5543 3436	33	1111 1122	10
28	2223 4222	19	5322 5554	31	1001 1122	8
29	2112 2120	11	3223 2331	19	1222 0011	9
30	2212 2334	19	1111 1121	9	0000 0011	2
31	2323 4433	24	2102 1211	10		

Three-hour-range K indices
Hel, October - December, 2015
The limit of K=9 is 550

Day	October			November			December		
	K		SK	K		SK	K		SK
1	1112	3434	19	1322	3220	15	2212	4434	22
2	2232	3331	19	0001	3302	9	2121	3322	16
3	2221	2222	15	2244	4453	28	1110	0012	6
4	4323	3235	25	4433	5222	25	1110	0102	6
5	4324	4133	24	2233	3434	24	2133	2443	22
6	2332	3445	26	4122	2255	23	2324	4444	27
7	3534	4665	36	4554	4342	31	3333	4542	27
8	3554	5554	36	1012	3354	19	3222	2223	18
9	3333	5555	32	4233	3455	29	2111	1342	15
10	3332	2322	20	3345	4544	32	3433	3544	29
11	3211	2243	18	4233	4542	27	3223	3543	25
12	1223	3544	24	1112	1101	8	2331	2322	18
13	2234	2445	26	1112	2444	19	2222	1111	12
14	3333	4343	26	2122	2122	14	2201	3455	22
15	2112	2223	15	2111	1234	15	4332	3413	23
16	2112	1111	10	3222	2333	20	3211	0000	7
17	2211	2242	16	1211	1331	13	1111	1342	14
18	2234	3433	24	1312	2245	20	1021	0013	8
19	0122	1022	10	3123	1010	11	1000	1344	13
20	1212	2343	18	0022	0101	6	4543	5766	40
21	1214	3222	17	2111	0011	7	6543	3224	29
22	1110	1232	11	1010	0010	3	2234	2133	20
23	3112	2222	15	0000	0000	0	2212	3234	19
24	2222	1143	17	0000	0000	0	3222	2232	18
25	1121	3211	12	0000	0000	0	2222	2222	16
26	1010	0000	2	0000	0021	3	2222	3335	22
27	0001	1013	6	3212	1111	12	3222	3232	19
28	0100	0000	1	1101	2133	12	1122	2101	10
29	0012	0013	7	1022	2133	14	2001	2232	12
30	2111	2314	15	2233	2133	19	0011	1112	7
31	0012	2123	11				3223	5454	28

Fig. 10. K-indices in graphical form, Hel 2015.

8. TABLES AND PLOTS FOR HORNSUND OBSERVATORY

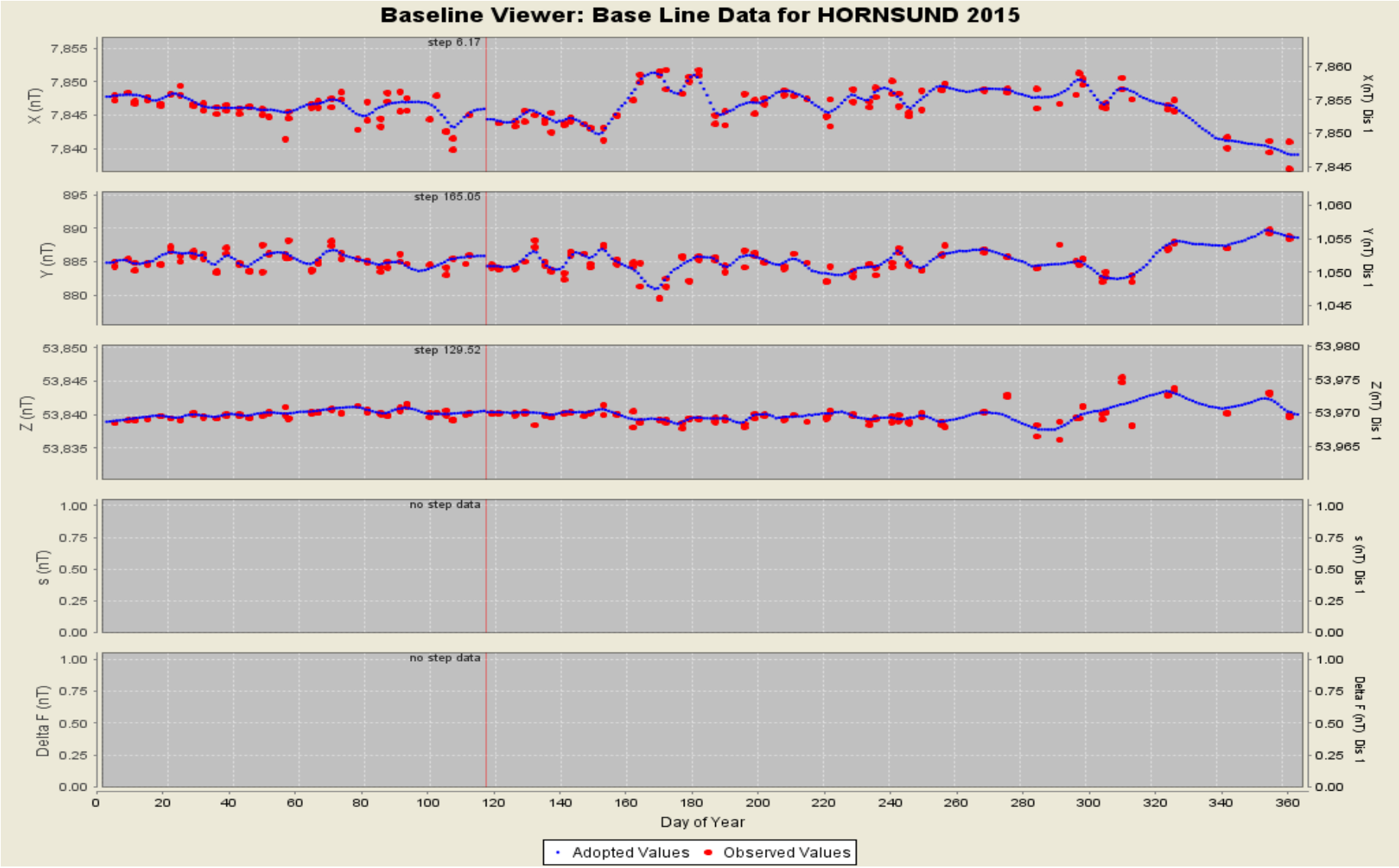

Fig. 11. Base values, Hornsund 2015.

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
2012	6 28.2	7910	53900	7860	891	81 39.1	54477
2013	6 50.8	7903	53920	7846	942	81 39.7	54497
2014	7 08.8	7895	53947	7833	982	81 40.4	54521
2015	7 30.6	7881	53988	7813	1030	81 41.7	54560

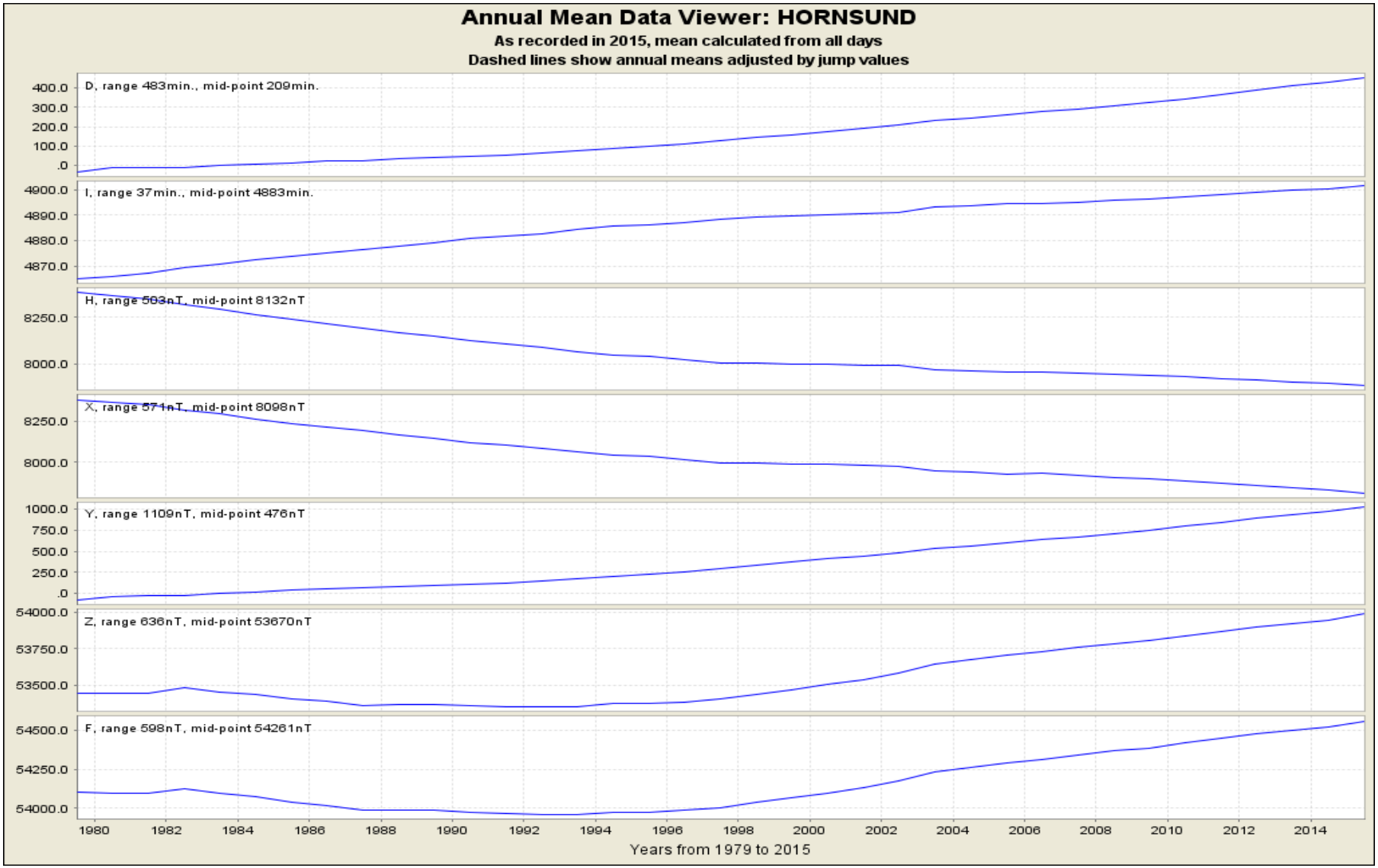

Fig. 12. Secular changes of H, X, Y, Z, F, D and I at Hornsund

MONTHLY AND YEARLY MEAN VALUES OF MAGNETIC ELEMENTS

HRN 2015

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
NORTH COMPONENT: 7500 + ... in nT													
All days	305	308	307	325	338	340	340	337	307	295	282	272	313
Quiet days	320	319	320	324	336	333	332	318	307	306	303	299	318
Disturbed days	292	292	261	314	329	333	355	319	279	258	231	236	292
EAST COMPONENT: 500 + ... in nT													
All days	510	514	521	517	520	525	527	531	539	542	552	558	530
Quiet days	508	510	516	515	521	519	532	531	537	540	545	554	527
Disturbed days	511	524	529	530	520	528	527	538	548	544	571	568	536
VERTICAL COMPONENT: 53500 + ... in nT													
All days	472	477	482	476	465	475	483	486	504	507	509	518	488
Quiet days	468	467	477	470	476	474	485	487	493	493	490	504	482
Disturbed days	478	502	523	486	443	462	481	517	527	536	530	548	503

Three-hour-range K indices
Hornsund, January - March, 2015
The limit of K=9 is 2500

Day	January		February		March	
	K	SK	K	SK	K	SK
1	0332 3234	20	4352 2235	26	2353 2133	22
2	4233 2222	20	5444 2552	31	3334 4333	26
3	4333 2120	18	5442 3544	31	3332 2142	20
4	0222 2531	17	3332 3523	24	2323 2012	15
5	3333 2123	20	1322 3423	20	1232 2311	15
6	3243 2311	19	2232 1101	12	1342 2113	17
7	1143 2212	16	0212 2231	13	2333 3544	27
8	2332 2224	20	1222 1244	18	1343 4200	17
9	2222 2413	18	2341 2145	22	4321 1101	13
10	4232 3311	19	0221 2134	15	1221 1001	8
11	2222 2324	19	1322 2100	11	1343 2231	19
12	2222 2333	19	1111 2121	10	1343 2111	16
13	1232 2232	17	0011 1110	5	1122 3111	12
14	2122 3233	18	0211 0000	4	1123 2002	11
15	0223 3200	12	0121 2223	13	1221 2120	11
16	1432 2021	15	0112 2022	10	1343 2312	19
17	1322 2002	12	1133 2232	17	3445 6455	36
18	0111 1111	7	4333 2254	26	4444 4656	37
19	2111 0012	8	3232 2222	18	5345 3323	28
20	1112 0000	5	0232 2002	11	5444 3355	33
21	0111 2342	14	2221 2112	13	3443 2212	21
22	2333 3143	22	2122 1100	9	1354 3131	21
23	4232 2210	16	1334 3332	22	2534 4225	27
24	1121 1245	17	3532 2212	20	1323 3621	21
25	1221 1113	12	0233 3331	18	1433 3222	20
26	4333 3232	23	1223 2003	13	2332 2223	19
27	2332 2135	21	0121 2103	10	4322 3202	18
28	2232 1101	12	0233 2322	17	0252 2223	18
29	4223 2141	19			3333 3212	20
30	2231 2122	15			1212 2012	11
31	1232 2222	16			0133 3220	14

Three-hour-range K indices
Hornsund, April - June, 2015
The limit of K=9 is 2500

Day	April		May		June	
	K	SK	K	SK	K	SK
1	0123 2211	12	2322 2212	16	2233 1111	14
2	0243 2345	23	2322 2323	19	1121 2111	10
3	2233 3112	17	2443 2221	20	1122 3111	12
4	2333 3343	24	2233 3211	17	1210 1121	9
5	1331 2112	14	1224 3112	16	1101 1111	7
6	1232 2211	14	3464 4332	29	1223 3211	15
7	2311 2131	14	2212 2211	13	1232 2123	16
8	1000 2221	8	3332 2121	17	4565 3535	36
9	2333 3231	20	1213 2232	16	3443 3343	27
10	3444 4332	27	2334 4131	21	3344 3432	26
11	3323 2311	18	4233 5332	25	2534 3522	26
12	1121 2111	10	2356 4332	28	2222 3322	18
13	1321 1110	10	3454 4543	32	3334 3322	23
14	1222 3421	17	2343 2225	23	6346 3333	31
15	1235 5362	27	2433 3132	21	2323 4323	22
16	3335 3455	31	2232 2211	15	4444 3433	29
17	3443 3241	24	1332 2231	17	3334 5322	25
18	2333 2353	24	2233 3223	20	2432 4522	24
19	1223 3232	18	4344 3221	23	3323 2110	15
20	2232 2133	18	2332 3231	19	1111 1112	9
21	3445 4224	28	1222 3222	16	1221 2322	15
22	2334 3123	21	2201 2111	10	1565 5565	38
23	2322 2101	13	0112 1111	8	5454 5333	32
24	2311 0123	13	1322 1011	11	5554 5532	34
25	0001 0000	1	1122 1110	9	3366 5431	31
26	0111 1100	5	1222 2221	14	2433 2212	19
27	1122 3221	14	1222 3322	17	3342 2213	20
28	1223 3200	13	2323 4222	20	2354 4342	27
29	0122 2111	10	2234 3222	20	2333 3121	18
30	1222 1021	11	2232 3111	15	2331 1321	16
31			2222 3242	19		

Three-hour-range K indices
Hornsund, July - September, 2015
The limit of K=9 is 2500

Day	July		August		September	
	K	SK	K	SK	K	SK
1	2223 3321	18	3333 3322	22	1222 2114	15
2	1211 1111	9	3333 3311	20	2222 2231	16
3	1121 2110	9	2332 4212	19	2232 2213	17
4	1212 3253	19	2323 3234	22	3434 4324	27
5	4444 3223	26	2223 3114	18	2333 3552	26
6	5342 2131	21	3344 5343	29	1344 4263	27
7	3233 2113	18	2445 6312	27	3354 4546	34
8	1222 2332	17	2355 5245	31	5432 3334	27
9	2322 3122	17	2344 3223	23	4433 3336	29
10	2111 1212	11	3233 3122	19	2132 3332	19
11	3455 5333	31	3334 3213	22	2355 3423	27
12	3434 3442	27	2232 4333	22	3344 3432	26
13	3445 3342	28	2333 3221	19	1223 2452	21
14	4323 3223	22	1112 2132	13	1334 3332	22
15	2232 3234	21	32-6 4433	--	4343 3424	27
16	4333 3333	25	6344 3543	32	2333 -444	--
17	2332 3211	17	3356 4352	31	5332 3004	20
18	1221 2141	14	2342 3322	21	4344 3362	29
19	1222 2000	9	4344 5422	28	4453 2003	21
20	0122 2100	8	2434 4223	24	2354 5432	28
21	3344 3223	24	2342 4121	19	3333 3210	18
22	1223 3222	17	2123 3222	17	2443 2141	21
23	3455 3242	28	2356 5352	31	1344 4341	24
24	3333 3323	23	2333 2221	18	2332 2222	18
25	3333 2223	21	2332 2322	19	2343 3201	18
26	3233 3322	21	3335 4324	27	2222 1131	14
27	3345 4221	24	2444 3424	27	0222 1010	8
28	2344 4222	23	5333 3333	26	2101 2041	11
29	2232 2131	16	3334 2222	21	3322 0000	10
30	1322 3333	20	2222 2223	17	0001 0011	3
31	3334 4335	28	2222 1111	12		

Three-hour-range K indices
Hornsund, October - December, 2015
The limit of K=9 is 2500

Day	October			November			December		
	K		SK	K		SK	K		SK
1	1213	3432	19	1222	2231	15	1233	3353	23
2	2332	3322	20	0111	3200	8	2222	3243	20
3	2333	3322	21	0344	4664	31	1212	1011	9
4	2123	3344	22	2644	4212	25	1122	1004	11
5	2334	3223	22	2434	3645	31	2223	2233	19
6	2553	2325	27	4333	2345	27	2543	4264	30
7	3434	4555	33	4633	2343	28	3443	4664	34
8	3454	3665	36	1122	3354	21	5333	2225	25
9	3454	4665	37	4222	1353	22	3322	1253	21
10	2443	3544	29	4334	3746	34	4443	3665	35
11	2433	3253	25	3433	3741	28	5343	3765	36
12	1334	4745	31	1222	2131	14	2352	3444	27
13	2344	2456	30	2222	2244	20	2243	2144	22
14	3534	3353	29	2222	2132	16	2222	3226	21
15	3343	2222	21	1232	1243	18	5442	2215	25
16	2223	2100	12	3322	2123	18	4431	0002	14
17	1332	3161	20	1221	1142	14	2121	1252	16
18	3343	3552	28	1423	3255	25	2132	1004	13
19	0223	2021	12	4233	2010	15	1112	2325	17
20	1222	3121	14	0121	1000	5	2541	3433	25
21	1333	3212	18	1321	1010	9	3432	2225	23
22	1231	2121	13	0221	0010	6	2244	2142	21
23	3222	2222	17	0001	1000	2	2322	3255	24
24	2333	1142	19	0000	0000	0	2243	2143	21
25	2221	2100	10	0000	0000	0	3333	2113	19
26	0011	0001	3	0000	0010	1	2443	2236	26
27	0101	1013	7	1332	1002	12	3233	3241	21
28	0200	0000	2	1211	2122	12	1233	2102	14
29	0011	1022	7	1232	2254	21	2211	2244	18
30	2101	1214	12	2343	3112	19	1232	2114	16
31	1102	1124	12				3344	3355	30

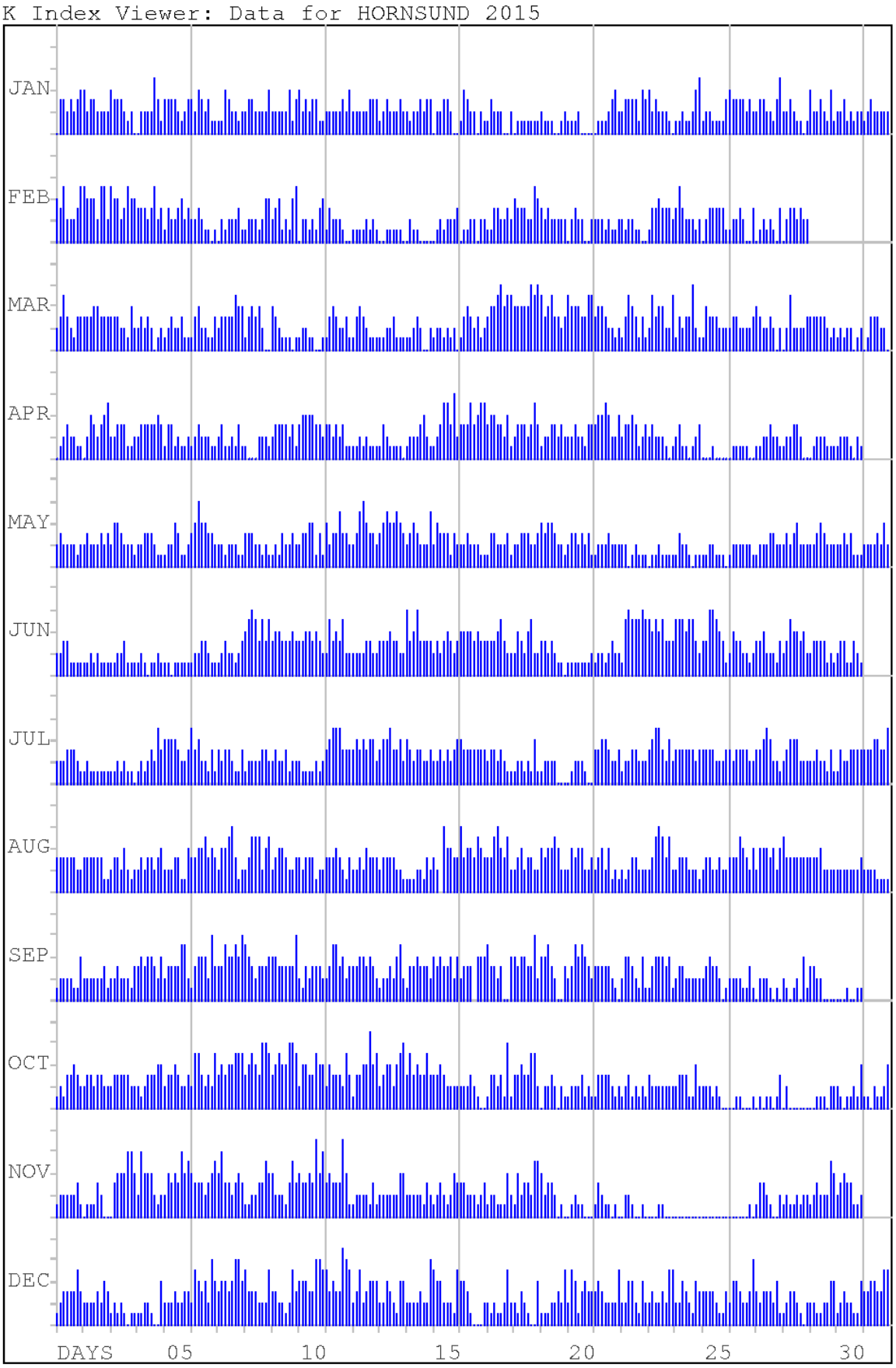

Fig. 13. K-indices in graphical form, Hornsund 2015.

C O N T E N T S