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Belsk, Hel, Hornsund, 2017

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

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Results of Geomagnetic Observations Belsk, Hel, Hornsund, 2017

Jan REDA✉, Mariusz NESKA, Stanisław WÓJCIK, and Paweł CZUBAK

Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland
✉ jreda@igf.edu.pl

1. INTRODUCTION

This publication contains basic information on geomagnetic observations carried out in 2017 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 2017, 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 on the basis of model 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.

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 2017 the Belsk and Hornsund observatories have been continuing the permanent observation of the Schumann resonance. Two horizontal magnetic components have been recorded at a frequency of 100 Hz. This recording was initiated in both observatories in 2004 (Neska and Satori 2006).

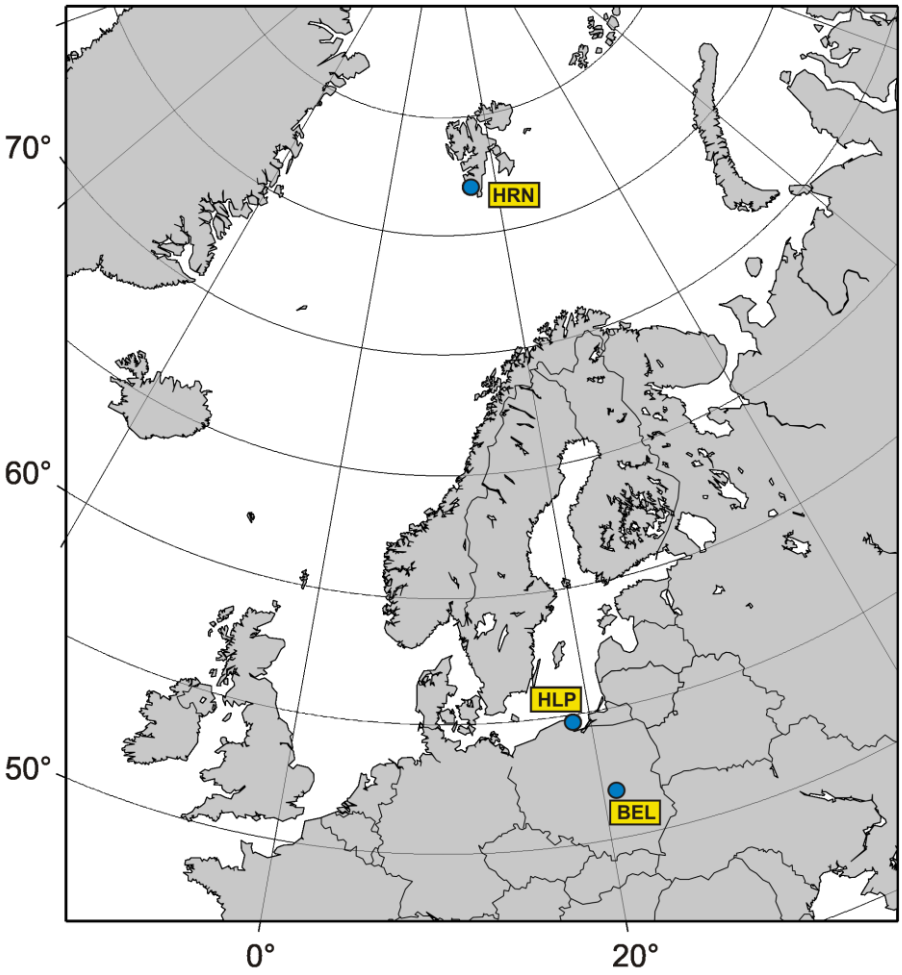

Fig. 1. Location of the Belsk, Hel, and Hornsund observatories.

Table 1

Coordinates of the Polish observatories

Observatory	Geographic coordinates		Geomagnetic coordinates		Elevation [m]
	Latitude	Longitude	Latitude	Longitude	
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° 00.0′ N	15° 33.0′ E	74.1° N	124.7° E	15

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 House.

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 (Fig. 2). 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 the war observations were reasumed in 1953. At the beginning annual means of geomagnetic field were determined on the basis of absolute measurements only. From mid-1957 geomagnetic field changes were registered on photographic papers with standard recording speed (Czyszek *et al.* 1991).

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),

Fig. 3. Hel Observatory – the main gate.

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 (Fig. 3).

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 Polish Polar Station Hornsund, Spitsbergen

The Polish Polar Station Hornsund (PSP Hornsund) is situated on the White Bear Bay (Isbjørnhamna) in Hornsund Fiord, Spitsbergen Island, Svalbard archipelago (Fig. 4). 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.

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 1932-1933, they had carried out continuous recording of magnetic field and performed absolute measurements. Unfortunately, all data were destroyed during the war. In the years 1957-1958, 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.

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

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	4 per week	3 per week	4 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. 5, 8, and 11 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 2017 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/°C,
– the magnetic sensors are located in thermostat-controlled wooden boxes where the daily temperature variations are of the order of 0.3°C.

Table 4

Mean errors of measurements of B_X, B_Y, B_Z, and B_F in 2017

Observatory	Element	Number of measurements n	Mean error m_B [nT]
Belsk	B_X	183	0.45
	B_Y	183	0.47
	B_Z	183	0.25
Hel	B_X	156	0.43
	B_Y	156	0.45
	B_Z	156	0.36
Hornsund	B_X	189	1.29
	B_Y	189	0.95
	B_Z	180	0.36

3.2 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/ PSM 8511-07P	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	LEMI fluxgate	PSM Bobrov	LEMI fluxgate
	Type	LEMI-003 PM	PSM 8511-03 P	LEMI-003 PM
	Sensor's orientation	*XYZ*	*XYZ*	*XYZ*
	Range	+/– 1000 nT	+/– 5000 nT	+/– 10 000 nT
	Magnetometer's producer	Lviv Centre of the Institute of Space Research (Ukraine)	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. The calibration of proton magnetometers is performed according to the method described by Reda and Neska (2007).

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.

3.3 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.

3.4 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 IMFV1.23 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 IMFV1.23 format. The program for calculation of indices may be taken from the INTERMAGNET page: http://www.intermagnet.org/publication-software/software-eng.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, and 12), bases of recording sets as well as plots of *K* indices for 2017 (Figs. 7, 10, and 13) were prepared with the use of program imcdview.jar.

As in previous years, we include the *E* indices calculated for Belsk observatory in the present yearbook (Tables 12-15). 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).

Annual mean values for Belsk, Hel, and Hornsund are listed in Tables 6, 16, and 22, respectively. Monthly mean values of 2017 for Belsk, Hel, and Hornsund are listed in Tables 7, 17, and 23, respectively.

Three-hour-range *K* indices for Belsk are listed in Tables 8-11, for Hel in Tables 18-21, and for Hornsund in Tables 24-27.

3.5 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
E-mails: 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
E-mail: hel@igf.edu.pl
http://www.igf.edu.pl/

4.3 Hornsund Observatory

Mariusz Neska, Paweł Czubak
Central Geophysical Observatory
05-622 Belsk
Poland
Tel.: +48 486610833 Fax: +48 486610840
E-mails: 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 2017

5.1 Belsk Observatory

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

5.2 Hel Observatory

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

5.3 Hornsund Observatory

Mariusz Neska (head of geomagnetic observations)
Lukasz Mazurkiewicz (observer in 1-st half-year)
Mariusz Dmochowski (observer in 2-nd half-year)
Jan Reda (data processing)
Paweł Czubak (data processing)

6. TABLES AND PLOTS FOR BELSK OBSERVATORY

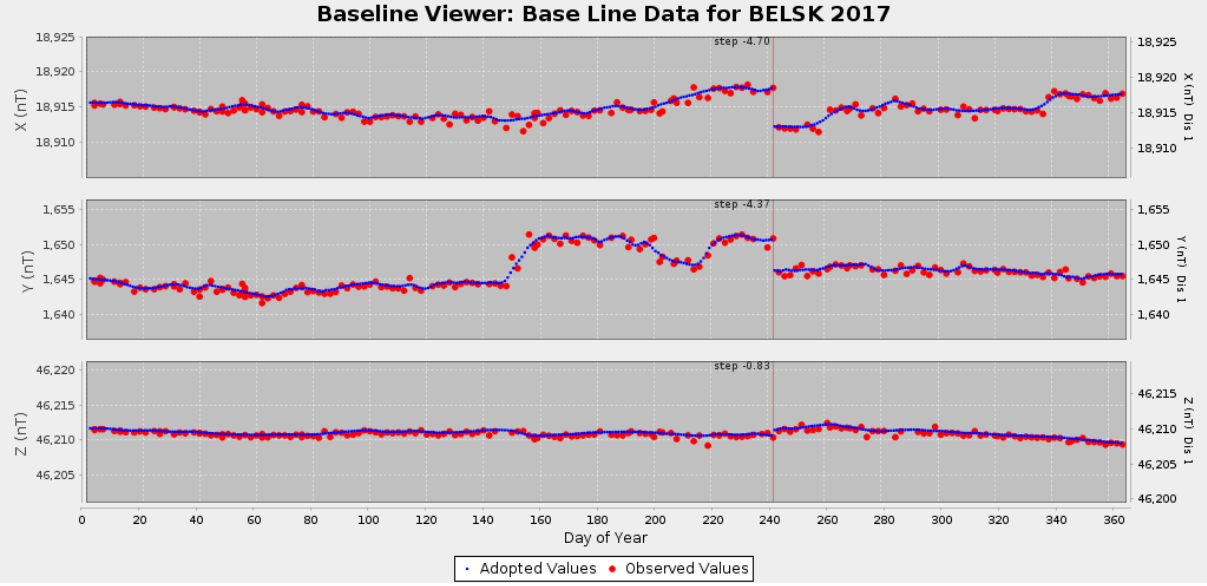

Fig. 5. Base values of set 1, Belsk 2017.

Table 6

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

to be continued

Table 6 (continuation)

Annual mean values of magnetic elements in Belsk Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
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
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
51	2016	5 57.2	19027	46538	18924	1974	67 45.8	50277
52	2017	6 06.4	19026	46592	18918	2024	67 47.2	50327

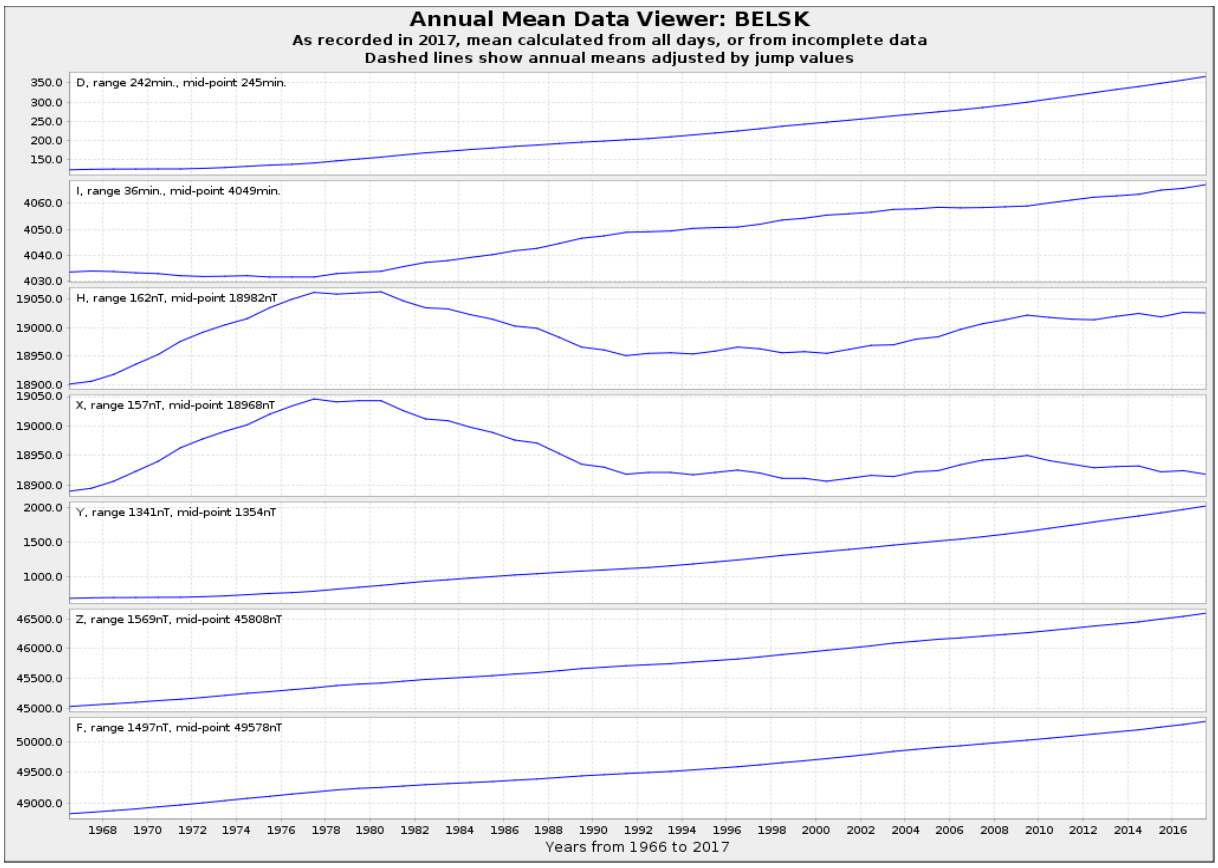

Fig. 6. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Belsk.

Table 7

Monthly and yearly mean values of magnetic elements
BEL 2017

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 18500 + ... in nT													
All days	423	423	419	417	426	428	424	420	403	410	411	416	418
Quiet days	428	428	430	423	426	428	429	422	408	418	419	421	423
Disturbed days	419	415	409	405	420	426	419	410	392	396	398	407	410
East component: 1500 + ... in nT													
All days	500	505	509	514	515	520	526	529	538	539	544	547	524
Quiet days	498	502	506	511	516	520	523	529	536	538	540	544	522
Disturbed days	503	507	512	517	515	521	527	532	545	543	547	549	527
Vertical component: 46000 + ... in nT													
All days	566	568	574	580	580	586	591	597	609	613	618	620	592
Quiet days	564	567	571	577	580	584	588	597	611	612	614	618	590
Disturbed days	566	570	575	582	581	586	594	601	609	615	619	621	593

Table 8

Three-hour-range *K* indices
Belsk, January-March 2017
The limit of *K* = 9 is 450

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	4322 3432	23	4333 4645	32	3324 4455	30
2	1222 1311	13	3333 3554	29	4334 5453	31
3	0123 2444	20	2332 3443	24	3333 3521	23
4	1222 2353	20	2222 2232	17	4333 3435	28
5	3222 3444	24	3332 2452	24	3222 3454	25
6	3222 3334	22	2222 3434	22	4313 5455	30
7	4332 4543	28	2212 2221	14	2223 3443	23
8	3223 3344	24	0011 2212	9	3222 3244	22
9	3222 4423	22	2122 1232	15	3223 3243	22
10	2221 1432	17	2111 2323	15	2223 2212	16
11	3221 1342	18	2011 0111	7	1111 0124	11
12	2211 0023	11	1011 1231	10	3311 2212	15
13	1101 1222	10	3111 0332	14	0111 1000	4
14	1211 1121	10	0000 0011	2	1111 2212	11
15	2111 1131	11	0001 1121	6	1112 1123	12
16	1000 0021	4	0121 2333	15	3101 1022	10
17	1001 1301	7	1333 2435	24	0111 0112	7
18	0223 4454	24	5322 1244	23	1000 0012	4
19	3313 2222	18	3332 1430	19	0011 0111	5
20	3321 3133	19	1322 2341	18	1001 0121	6
21	4112 2244	20	2111 0113	10	1343 3564	29
22	3222 2222	17	4222 1222	17	4223 4555	30
23	0110 1232	10	2222 2434	21	4321 1322	18
24	1101 0021	6	5324 4333	27	1221 3311	14
25	2211 0002	8	3222 1113	15	0101 1102	6
26	0022 3543	19	1201 1000	5	2011 2111	9
27	5333 3423	26	1112 1243	15	2335 4565	33
28	2221 1124	15	3222 1132	16	4433 3343	27
29	2211 2221	13			3233 3534	26
30	1121 2213	13			3322 3454	26
31	3233 3545	28			4443 3534	30

Table 9

Three-hour-range *K* indices
Belsk, April-June 2017
The limit of $K = 9$ is 450

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2223 2533	22	2200 1122	10	1111 2423	15
2	2122 2310	13	1212 1102	10	2111 112*	*
3	0012 2212	10	2101 2200	8	*122 3422	*
4	2334 3223	22	0222 1124	14	1111 1001	6
5	2122 2334	19	3212 2110	12	1101 3312	12
6	1112 3321	14	1222 2121	13	2121 2211	12
7	3122 1134	17	2222 2242	18	1221 2202	12
8	3332 3345	26	2222 1221	14	1111 2212	11
9	3332 2312	19	1112 3322	15	3111 1110	9
10	2111 3212	13	2101 3222	13	1111 0111	7
11	1123 2243	18	1322 2222	16	0122 4543	21
12	3111 1000	7	2233 3222	19	2211 3333	18
13	1011 1231	10	1112 2112	11	3213 2311	16
14	3222 3242	20	2223 3333	21	0223 3321	16
15	3121 1221	13	0224 3343	21	1112 2120	10
16	0111 0121	7	2222 4211	16	2344 4435	29
17	0011 1112	7	2123 2222	16	3312 3344	23
18	2011 1223	12	4332 1222	19	4323 3332	23
19	2331 1243	19	2322 3443	23	1222 2111	12
20	4534 3343	29	3333 4442	26	0110 1200	5
21	1111 2555	21	2222 2232	17	0111 1332	12
22	4443 4545	33	2213 3333	20	2111 1131	11
23	3343 5654	33	2322 2233	19	1111 1123	11
24	3333 2443	25	1101 1110	6	2223 3232	19
25	3212 4332	20	0101 2211	8	2233 3322	20
26	2121 2322	15	2001 0011	5	3213 2231	17
27	2221 1231	14	1000 1435	14	2112 2211	12
28	1111 2223	13	5644 3311	27	2211 1100	8
29	2122 2233	17	0112 4431	16	0222 1111	10
30	1102 1222	11	2322 1211	14	0112 1212	10
31			0100 2222	9		

Table 10

Three-hour-range *K* indices
Belsk, July-September 2017
The limit of *K* = 9 is 450

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	1322 3442	21	1122 3211	13	3324 4224	24
2	3345 4334	29	1112 2212	12	4443 2433	27
3	2212 1212	13	0102 3454	19	2112 3312	15
4	1211 1112	10	2334 4433	26	4322 2345	25
5	0101 1011	5	3323 3443	25	4232 2241	20
6	0122 2324	16	3224 3232	21	2114 4213	18
7	2111 1212	11	1222 2111	12	3333 3236	26
8	2112 1111	10	1111 1221	10	7344 6765	42
9	4325 2443	27	0012 2222	11	2111 1000	6
10	3221 2*12	*	0122 3212	13	0000 1224	9
11	2232 231*	*	1212 2232	15	3222 3342	21
12	*111 2211	*	3322 2233	20	1122 3255	21
13	1111 2111	9	3222 2222	17	6233 2231	22
14	1111 *111	*	2212 2222	15	2113 3644	24
15	1111 1111	8	0111 1112	8	5343 4365	33
16	2145 5555	32	2111 1233	14	5433 4333	28
17	3433 4521	25	3244 4445	30	232* 5431	*
18	2222 1111	12	4323 4353	27	4333 3334	26
19	0111 1221	9	4344 4534	31	2112 1332	15
20	1112 2333	16	4433 3433	27	3322 2131	17
21	4332 3423	24	2233 1223	18	1122 2133	15
22	3244 2323	23	4432 3334	26	1111 1233	13
23	4223 3334	24	3322 4553	27	1111 1141	11
24	3232 3323	21	3332 3211	18	1112 1233	14
25	2113 3323	18	0112 2213	12	2211 0111	9
26	4241 3220	18	1111 1221	10	1112 1012	9
27	1112 2313	14	2102 2333	16	3244 3466	32
28	2112 3342	18	1101 1111	7	5453 4445	34
29	1122 1211	11	1112 134*	*	3223 3333	22
30	1211 0120	8	***0 1010	*	2232 4533	24
31	0111 2111	8	1354 4443	28		

Table 11

Three-hour-range *K* indices
Belsk, October-December 2017
The limit of $K = 9$ is 450

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	3222 3424	22	1011 1122	9	2221 2341	17
2	1212 2110	10	2111 2214	14	1001 1321	9
3	2221 1112	12	3222 3122	17	0000 0112	4
4	2211 1132	13	1211 1212	11	0111 2245	16
5	2111 0114	11	0010 0111	4	4334 5644	33
6	2222 2223	17	1000 0011	3	2322 3342	21
7	1111 1121	9	1223 4465	27	2122 3333	19
8	2111 1111	9	4534 5546	36	1111 2112	10
9	2000 0111	5	3323 3544	27	1011 2220	9
10	0000 1113	6	2233 4443	25	0011 1212	8
11	4343 4554	32	3212 2212	15	1222 3331	17
12	5244 4435	31	2111 1233	14	2222 2353	21
13	2423 5465	31	1212 1310	11	1121 224*	*
14	5334 4533	30	3321 2333	20	*1** 1122	*
15	4323 5441	26	2223 2433	21	1011 2212	10
16	2222 2232	17	4422 1233	21	0011 1113	8
17	1112 2221	12	1112 2111	10	3343 3453	28
18	1111 1123	11	2122 2222	15	4333 3331	23
19	3212 2433	20	0122 1112	10	1111 2233	14
20	4121 2123	16	1111 1234	14	2112 1230	12
21	1122 2334	18	4443 3544	31	0011 1110	5
22	3122 1232	16	1312 3332	18	0011 0012	5
23	2112 1112	11	2122 2233	17	1212 1111	10
24	1122 5635	25	3211 0154	17	1222 3434	21
25	3243 2334	24	3211 1220	12	3122 2243	19
26	3232 4541	24	0011 1222	9	3212 2244	20
27	311* 1122	*	2111 3222	14	2211 2323	16
28	1112 1321	12	322* 2121	*	1111 2222	12
29	1111 1121	9	1121 1222	12	1111 1231	11
30	1111 1101	7	1412 3422	19	1111 1223	12
31	2011 2001	7			0001 0123	7

Table 12

Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, January-March 2017

Day	January		February		March	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	4322 3533	25	5333 4656	35	3324 5566	34
2	1211 1311	11	4343 3554	31	5435 5563	36
3	0124 2444	21	3442 3554	30	4343 4520	25
4	1212 3354	21	2322 2332	19	4323 3535	28
5	4323 4555	31	4332 3552	27	3233 4465	30
6	3323 3444	26	2311 3535	23	5213 4565	31
7	4332 5553	30	2201 3231	14	2233 3454	26
8	3223 4455	28	0001 1201	5	3212 3255	23
9	4212 4413	21	2112 1233	15	4224 3243	24
10	2111 1542	17	2111 2324	16	1333 2213	18
11	2121 1342	16	3011 0010	6	1010 0125	10
12	2201 0013	9	1000 0130	5	4410 3211	16
13	1100 1222	9	3101 0321	11	0011 1000	3
14	1211 0121	9	0000 0001	1	1111 1112	9
15	2010 1140	9	0000 1032	6	1012 1034	12
16	1000 0020	3	0120 2323	13	3000 1013	8
17	1000 1300	5	1344 2535	27	0010 0012	4
18	0222 4454	23	5422 1354	26	1000 0012	4
19	4323 1221	18	4331 1440	20	0001 0012	4
20	4321 3142	20	0321 1451	17	0001 0110	3
21	4122 2354	23	2110 0103	8	1343 3565	30
22	3222 3313	19	4222 1222	17	4333 4555	32
23	0010 0243	10	2312 2434	21	4322 1211	16
24	2000 0021	5	5324 5334	29	1211 2310	11
25	2311 0002	9	3222 0013	13	0101 0101	4
26	0022 4453	20	0100 0000	1	2001 1001	5
27	5433 4533	30	0111 1254	15	2445 5575	37
28	2311 0135	16	4212 1142	17	4534 4354	32
29	3211 2220	13			3333 3534	27
30	0111 2324	14			4432 3555	31
31	3223 3655	29			5544 3545	35

*) see Reda and Jankowski (2004)

Table 13

Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, April-June 2017

Day	April		May		June	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	2223 3543	24	2100 0123	9	0011 2323	12
2	2122 2410	14	0212 0103	9	2111 102*	*
3	0001 2201	6	1001 1200	5	*022 4521	*
4	2344 3113	21	0111 1024	10	1100 1000	3
5	1112 1335	17	3201 1000	7	0101 3212	10
6	1012 3421	14	0112 1111	8	2121 1100	8
7	4122 0134	17	1222 1253	18	1211 1202	10
8	3342 2335	25	2122 1221	13	1000 2101	5
9	4433 3412	24	2102 2222	13	3101 1110	8
10	1001 2111	7	1100 3112	9	1100 0100	3
11	1124 2253	20	1321 2211	13	0121 4542	19
12	4101 0000	6	2133 2122	16	2111 3333	17
13	1000 0241	8	0111 1111	7	3213 1310	14
14	4222 3352	23	2114 4332	20	0213 3211	13
15	3121 1131	13	0124 3353	21	1111 2010	7
16	0011 0021	5	2222 4211	16	0245 5445	29
17	0011 1001	4	2123 2222	16	3412 3453	25
18	3000 1123	10	4431 1221	18	4332 3332	23
19	3431 1343	22	2331 3543	24	1212 2100	9
20	4544 3343	30	4344 4543	31	0110 1200	5
21	0110 2565	20	2322 2132	17	0001 1232	9
22	5544 5655	39	2213 4343	22	3111 1121	11
23	5353 6655	38	1312 2243	18	0111 1133	11
24	4433 3443	28	1101 1000	4	2224 3243	22
25	3212 4242	20	0102 1201	7	2233 3322	20
26	2131 2332	17	2001 0010	4	3113 2231	16
27	2231 0131	13	1000 1426	14	2112 1211	11
28	1010 2223	11	6644 4211	28	1211 1000	6
29	2112 1242	15	0012 4530	15	0222 0011	8
30	1101 0123	9	2411 1111	12	0001 1113	7
31			0100 2221	8		

*) see Reda and Jankowski (2004)

Table 14

Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, July-September 2017

Day	July		August		September	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	1422 4431	21	1122 3211	13	4324 4325	27
2	3345 4333	28	1112 2202	11	4553 2434	30
3	2212 1112	12	0002 2544	17	3212 3312	17
4	0211 0112	8	2444 4444	30	4313 2455	27
5	0100 1001	3	3432 4553	29	4232 2241	20
6	0122 2324	16	3224 3243	23	1113 4313	17
7	2212 0212	12	1122 2100	9	3433 2227	26
8	2112 0000	6	1111 1320	10	7443 6765	42
9	5335 2453	30	0012 2222	11	2112 1000	7
10	3321 1*02	*	0112 3112	11	0000 0324	9
11	2232 231*	*	2212 2241	16	4222 2343	22
12	*011 2210	*	2412 2143	19	1122 3256	22
13	1110 2111	8	2222 1222	15	6232 1130	18
14	0101 *101	*	3101 1221	11	2113 4655	27
15	0101 0011	4	0101 0012	5	6343 5465	36
16	2145 5655	33	2111 1233	14	6534 4444	34
17	3533 4621	27	3245 4445	31	332* 5431	*
18	2321 1111	12	5323 4353	28	5444 4444	33
19	0111 0111	6	4354 4635	34	2112 1343	17
20	0112 2334	16	4533 2534	29	3322 3141	19
21	4332 3423	24	2233 1123	17	1122 2123	14
22	3244 2322	22	5432 3334	27	1111 1243	14
23	3223 4335	25	3433 5563	32	1010 1141	9
24	2231 3334	21	3322 3200	15	1111 0243	13
25	2123 3334	21	0112 2213	12	2211 0110	8
26	4241 3220	18	0001 1211	6	0011 0001	3
27	0111 2313	12	3103 1344	19	3245 4476	35
28	1112 3341	16	1101 0101	5	5564 5545	39
29	1112 1211	10	1111 134*	*	4223 4344	26
30	1110 0120	6	***0 0000	*	2232 4533	24
31	0111 1111	7	1255 5544	31		

*) see Reda and Jankowski (2004)

Table 15

Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, October-December 2017

Day	October		November		December	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	4132 2524	23	1011 2012	8	2221 1440	16
2	1312 2110	11	2111 2114	13	1000 0410	6
3	2221 0112	11	4223 3122	19	0000 0002	2
4	2200 0033	10	1101 1102	7	0011 3345	17
5	3110 0114	11	0010 0000	1	4334 6655	36
6	2211 2224	16	1000 0000	1	2322 4342	22
7	1001 1121	7	1324 4476	31	1121 4343	19
8	1110 0100	4	5534 6646	39	1121 2112	11
9	3000 0000	3	3323 3545	28	1000 2220	7
10	0000 0103	4	3334 4554	31	0000 1212	6
11	4443 4655	35	3212 2213	16	1222 4441	20
12	5234 5545	33	1101 1223	11	3322 1363	23
13	2513 5566	33	1212 1310	11	1011 234*	*
14	5445 4544	35	4321 1433	21	*1** 0022	*
15	5424 5541	30	2123 3422	19	0011 2211	8
16	2312 2142	17	4431 1234	22	0001 1002	4
17	1111 2121	10	1112 2001	8	3353 3564	32
18	1101 0024	9	2112 2313	15	4343 4321	24
19	4212 3543	24	0121 0011	6	0000 1234	10
20	4111 2123	15	1000 1235	12	3112 1230	13
21	1122 2334	18	5443 2555	33	0011 1100	4
22	4211 0122	13	1312 4342	20	0010 0003	4
23	2112 0002	8	2113 3334	20	1212 0011	8
24	1023 5636	26	4210 0154	17	1212 3535	22
25	4253 2444	28	3211 0110	9	2113 2253	19
26	3243 4651	28	0010 1121	6	2212 2354	21
27	311* 0012	*	1111 1121	9	1211 2424	17
28	2111 1321	12	321* 2111	*	1011 2213	11
29	1100 1020	5	1111 0122	9	0101 1241	10
30	0001 0101	3	2402 3423	20	1100 1213	9
31	2000 1000	3			0000 0113	5

*) see Reda and Jankowski (2004)

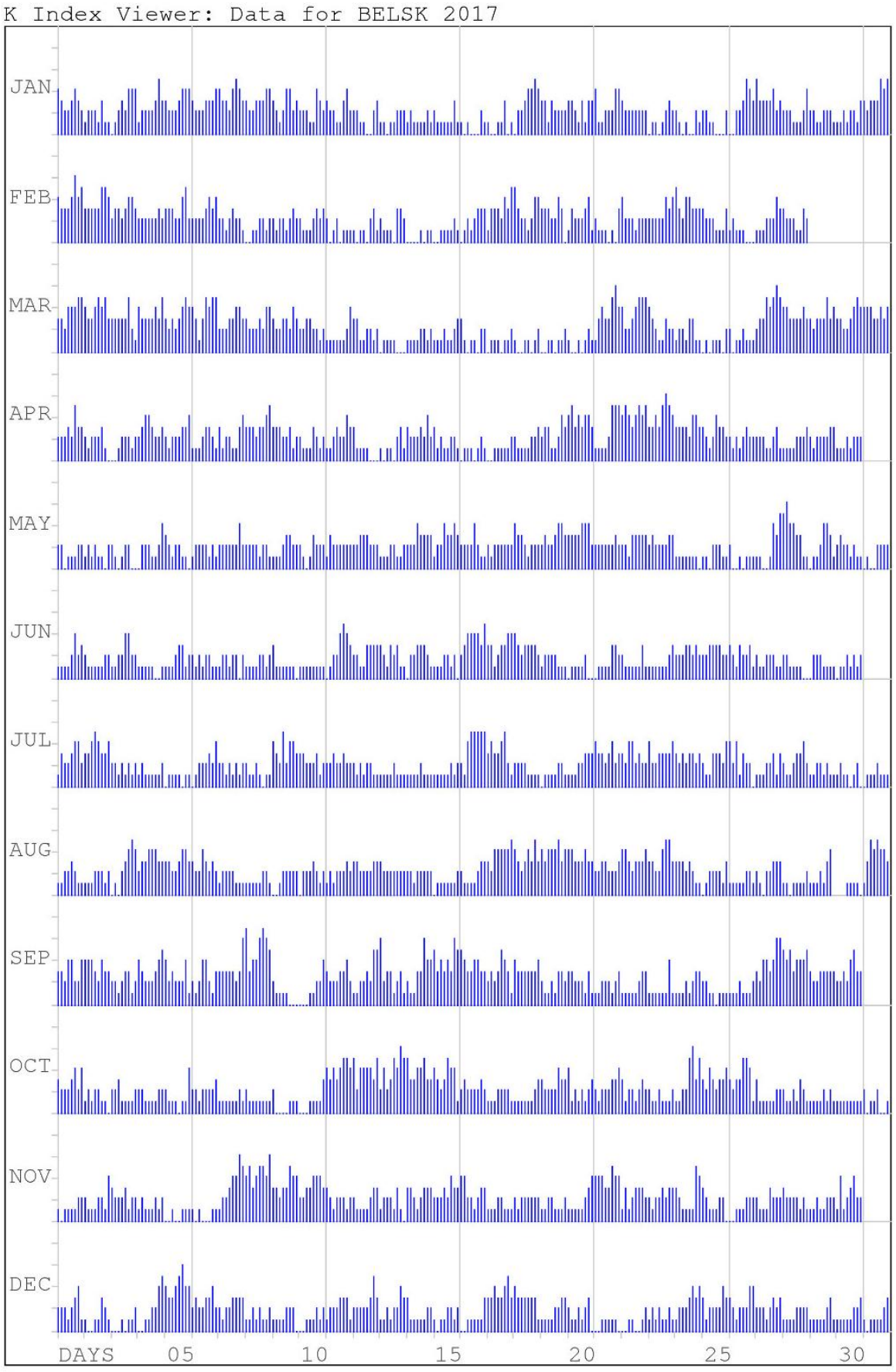

Fig. 7. *K*-indices in graphical form, Belsk 2017.

7. TABLES AND PLOTS FOR HEL OBSERVATORY

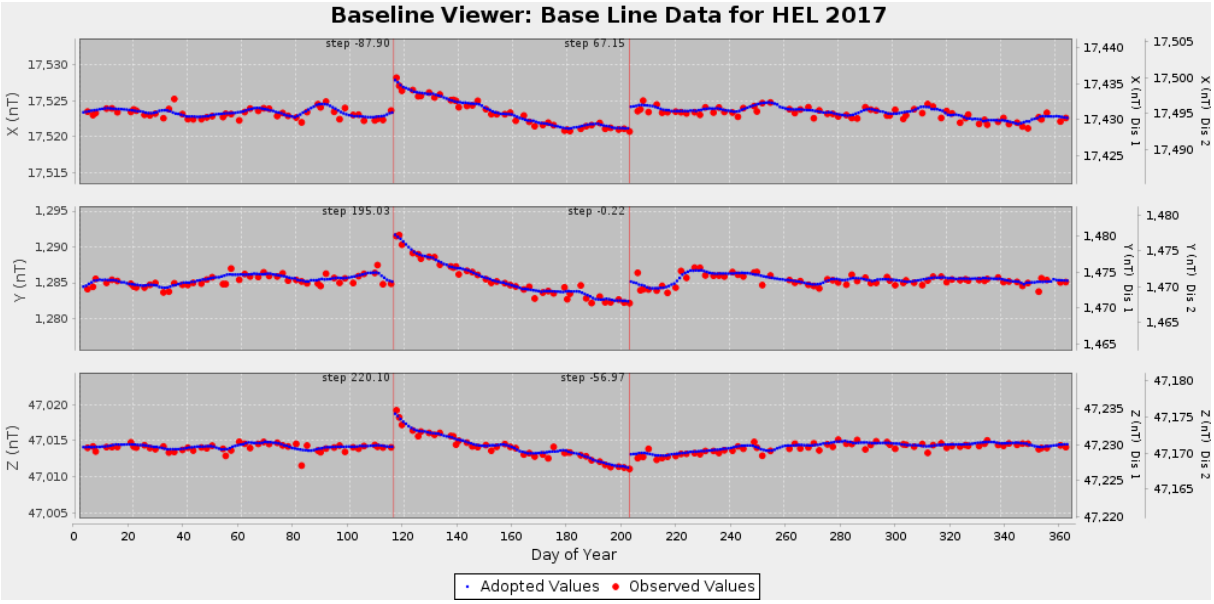

Fig. 8. Base values of set 1, Hel 2017.

Table 16

Annual mean values of magnetic elements in Hel Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*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

to be continued

Table 16 (continuation)

Annual mean values of magnetic elements in Hel Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
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

to be continued

Table 16 (continuation)

Annual mean values of magnetic elements in Hel Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
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
64	2016	4 54.7	17569	47203	17504	1504	69 35.1	50367
65	2017	5 05.5	17567	47253	17498	1559	69 36.4	50413

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

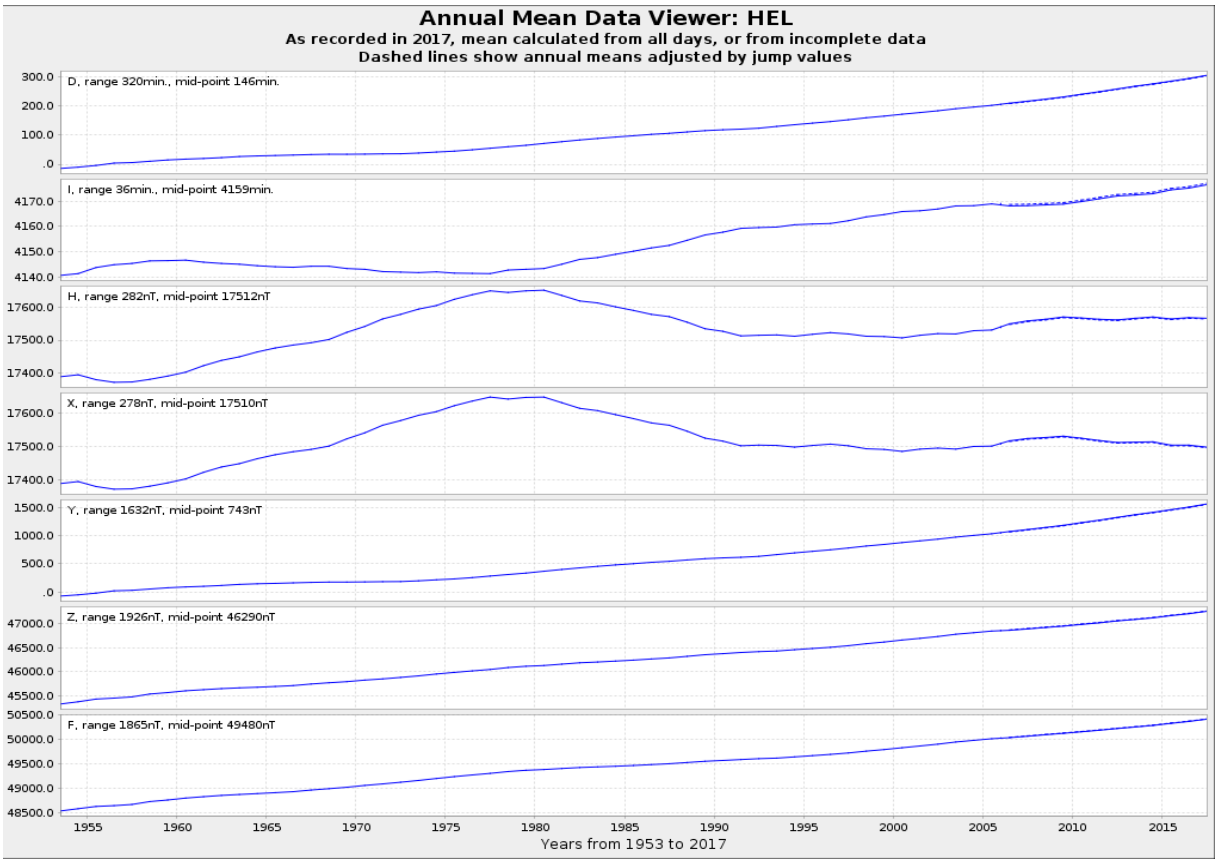

Fig. 9. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Hel.

Table 17

Monthly and yearly mean values of magnetic elements
HLP 2017

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 17000 + ... in nT													
All days	502	501	498	496	505	508	504	499	484	490	490	494	498
Quiet days	507	507	507	502	505	508	508	501	488	497	499	499	502
Disturbed days	499	494	489	485	500	506	500	491	474	475	478	486	490
East component: 1000 + ... in nT													
All days	533	538	543	547	550	554	559	565	574	576	581	584	559
Quiet days	531	535	539	545	550	553	556	565	572	575	578	582	557
Disturbed days	537	540	546	550	550	554	560	568	582	580	585	587	561
Vertical component: 47000 + ... in nT													
All days	230	232	236	241	241	247	251	257	269	274	278	280	253
Quiet days	229	231	234	240	242	245	248	257	272	273	274	278	252
Disturbed days	230	232	236	243	241	247	255	262	267	275	279	281	254

Table 18

Three-hour-range *K* indices
Hel, January-March 2017
The limit of $K = 9$ is 550

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	4322 3433	24	4333 4645	32	3334 5556	34
2	2222 2311	15	3334 3554	30	4334 5453	31
3	0123 2444	20	3342 3543	27	3343 3521	24
4	1222 2353	20	2322 2233	19	4333 3435	28
5	3223 3454	26	3332 2452	24	3233 3454	27
6	3323 3334	24	2222 3434	22	4223 5455	30
7	4233 5543	29	3212 3232	18	2333 3443	25
8	3224 3345	26	1012 2212	11	3222 3255	24
9	3213 4423	22	2212 1233	16	4224 3243	24
10	3222 1443	21	2111 2333	16	2233 2213	18
11	3221 1342	18	3012 0121	10	2121 1124	14
12	2211 0023	11	1011 1231	10	4311 2222	17
13	1101 1232	11	3111 0332	14	0122 1100	7
14	2211 1121	11	0001 1011	4	1111 2222	12
15	3021 1131	12	0011 1132	9	1112 1134	14
16	1000 0021	4	0121 2333	15	3111 2123	14
17	1001 1300	6	2334 2435	26	0011 0112	6
18	1223 4454	25	4422 2344	25	1001 0012	5
19	3323 2222	19	3332 2431	21	0011 0112	6
20	4322 3133	21	1322 2342	19	0001 0220	5
21	4122 2354	23	2111 0103	9	1343 4564	30
22	3322 3223	20	4222 1222	17	4333 4555	32
23	0110 1233	11	2222 2435	22	4322 2322	20
24	2111 0021	8	5334 4333	28	2221 3311	15
25	2311 0002	9	3222 1113	15	0102 1212	9
26	0022 3553	20	0211 1000	5	2012 2202	11
27	5433 3423	27	1212 1244	17	2445 4565	35
28	2222 1134	17	3222 2132	17	4433 4344	29
29	3222 2221	16			3333 4534	28
30	1111 2213	12			3422 3555	29
31	3233 3555	29			5444 4534	33

Table 19

Three-hour-range *K* indices
Hel, April-June 2017
The limit of *K* = 9 is 550

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2223 3543	24	2201 1123	12	1121 3433	18
2	2122 3420	16	1213 1112	12	2212 2122	14
3	0112 2211	10	1111 2210	9	1133 4522	21
4	2344 3223	23	0222 2134	16	1111 2011	8
5	2122 3334	20	3202 3111	13	1112 4322	16
6	2113 3421	17	1222 2122	14	2222 2211	14
7	3122 1134	17	2222 2242	18	1222 2212	14
8	3333 3345	27	2223 2322	18	2111 2212	12
9	4333 3322	23	1212 3322	16	3112 2211	13
10	2012 3212	13	2101 4223	15	1111 1111	8
11	1234 3243	22	2322 2222	17	1122 5543	23
12	3111 1100	8	2233 4222	20	2212 3333	19
13	1001 1232	10	1112 2112	11	3223 2311	17
14	4232 4342	24	2224 4333	23	0223 3321	16
15	3121 2221	14	1234 3343	23	2112 2120	11
16	0112 1122	10	3323 4212	20	2354 5545	33
17	0111 2112	9	2223 2323	19	4313 3344	25
18	3011 2233	15	4432 1222	20	4333 3332	24
19	3332 2244	23	2322 3443	23	1223 2111	13
20	4534 4443	31	3344 5542	30	0120 2200	7
21	1111 2565	22	2222 3232	18	0001 2332	11
22	4544 5645	37	2223 3333	21	2111 1132	12
23	3344 6654	35	2322 3333	21	1111 1123	11
24	3433 3544	29	1112 1110	8	2224 3333	22
25	3223 4334	24	0102 2212	10	2333 3322	21
26	4122 2333	20	2111 1110	8	3223 2232	19
27	2222 1232	16	1110 2436	18	2112 2211	12
28	1111 2223	13	6644 4311	29	2212 2100	10
29	2122 2233	17	1113 4431	18	0222 2111	11
30	1112 2223	14	2322 1211	14	0012 2212	10
31			0201 2222	11		

Table 20

Three-hour-range *K* indices
Hel, July-September 2017
The limit of $K = 9$ is 550

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2333 4442	25	1122 3211	13	3324 4324	25
2	3345 4334	29	2112 3212	14	4443 3434	29
3	2222 2223	17	0102 3454	19	2212 3312	16
4	1212 1222	13	3434 4543	30	4323 2445	27
5	0100 1011	4	3433 4543	29	4332 2342	23
6	1122 3324	18	3234 3233	23	2223 4314	21
7	2222 1222	15	1223 2211	14	3433 3237	28
8	2112 1111	10	1111 2321	12	7445 7775	46
9	4325 3443	28	0022 2222	12	2211 2000	8
10	3232 1312	17	1222 3212	15	0010 1334	12
11	2332 2312	18	2223 3332	20	3223 4343	24
12	2112 2211	12	3422 2243	22	2222 3256	24
13	1011 3112	10	3223 3222	19	5233 2230	20
14	1101 2211	9	2212 2222	15	2113 4655	27
15	1101 1221	9	1111 1112	9	5343 4465	34
16	2145 6665	35	2112 2223	15	5433 4443	30
17	3433 4521	25	3245 4445	31	2323 5432	24
18	2322 2211	15	4323 4453	28	4433 3444	29
19	1111 1221	10	4344 4535	32	2212 2343	19
20	1112 2333	16	4433 3434	28	3322 3142	20
21	4332 4423	25	2233 2323	20	1122 2123	14
22	3244 3323	24	4433 3334	27	1111 1233	13
23	3223 4434	25	3333 4663	31	1111 1142	12
24	2332 3334	23	3322 3200	15	1122 2243	17
25	2113 4334	21	0122 2213	13	2222 1111	12
26	4342 3320	21	1011 2221	10	1122 1013	11
27	1112 3313	15	3103 2344	20	3244 4466	33
28	2113 3342	19	1111 0102	7	5554 4455	37
29	1122 2211	12	2112 2353	19	3223 4334	24
30	1211 1120	9	2211 1110	9	2232 4533	24
31	0111 2211	9	2355 5443	31		

Table 21

Three-hour-range *K* indices
Hel, October-December 2017
The limit of *K* = 9 is 550

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	4222 3424	23	2011 1022	9	2221 1341	16
2	1212 2110	10	2222 2214	17	1001 1321	9
3	2231 1212	14	3223 3122	18	0000 0002	2
4	2211 1033	13	2111 1112	10	0011 2345	16
5	2121 1124	14	1010 0011	4	4334 5644	33
6	2222 2223	17	1000 0001	2	3332 3342	23
7	2101 1122	10	1224 4476	30	2222 4333	21
8	2111 1111	9	5534 5556	38	1122 2112	12
9	2001 0001	4	4323 3445	28	1011 2220	9
10	0010 0213	7	3334 4444	29	0010 1212	7
11	4343 4554	32	3212 2213	16	1322 3341	19
12	5244 4445	32	1111 1233	13	3222 1353	21
13	2423 5465	31	1212 1310	11	1121 2343	17
14	5445 4544	35	3321 2334	21	3111 0022	10
15	4423 5441	27	2223 2432	20	1012 2212	11
16	2322 2233	19	4432 1234	23	0011 1113	8
17	1112 2221	12	1112 2001	8	3343 3554	30
18	1211 1023	11	2222 2322	17	4333 3331	23
19	3222 2433	21	0132 1121	11	1111 2233	14
20	4222 2123	18	1111 1234	14	2112 1230	12
21	2122 2334	19	4443 3544	31	1011 1100	5
22	3212 1122	14	1312 4342	20	0000 0002	2
23	3113 1112	13	2223 3234	21	1122 1111	10
24	1023 5635	25	3211 0144	16	1222 3434	21
25	3353 3344	28	3211 0220	11	3112 2243	18
26	3232 5542	26	0010 1121	6	3322 2254	23
27	3112 1022	12	2111 3222	14	2221 2323	17
28	2112 1321	13	2222 1121	13	1111 2222	12
29	1101 1021	7	1121 0223	12	1101 1131	9
30	1101 1111	7	2412 3423	21	1110 1223	11
31	2001 2000	5			1001 0123	8

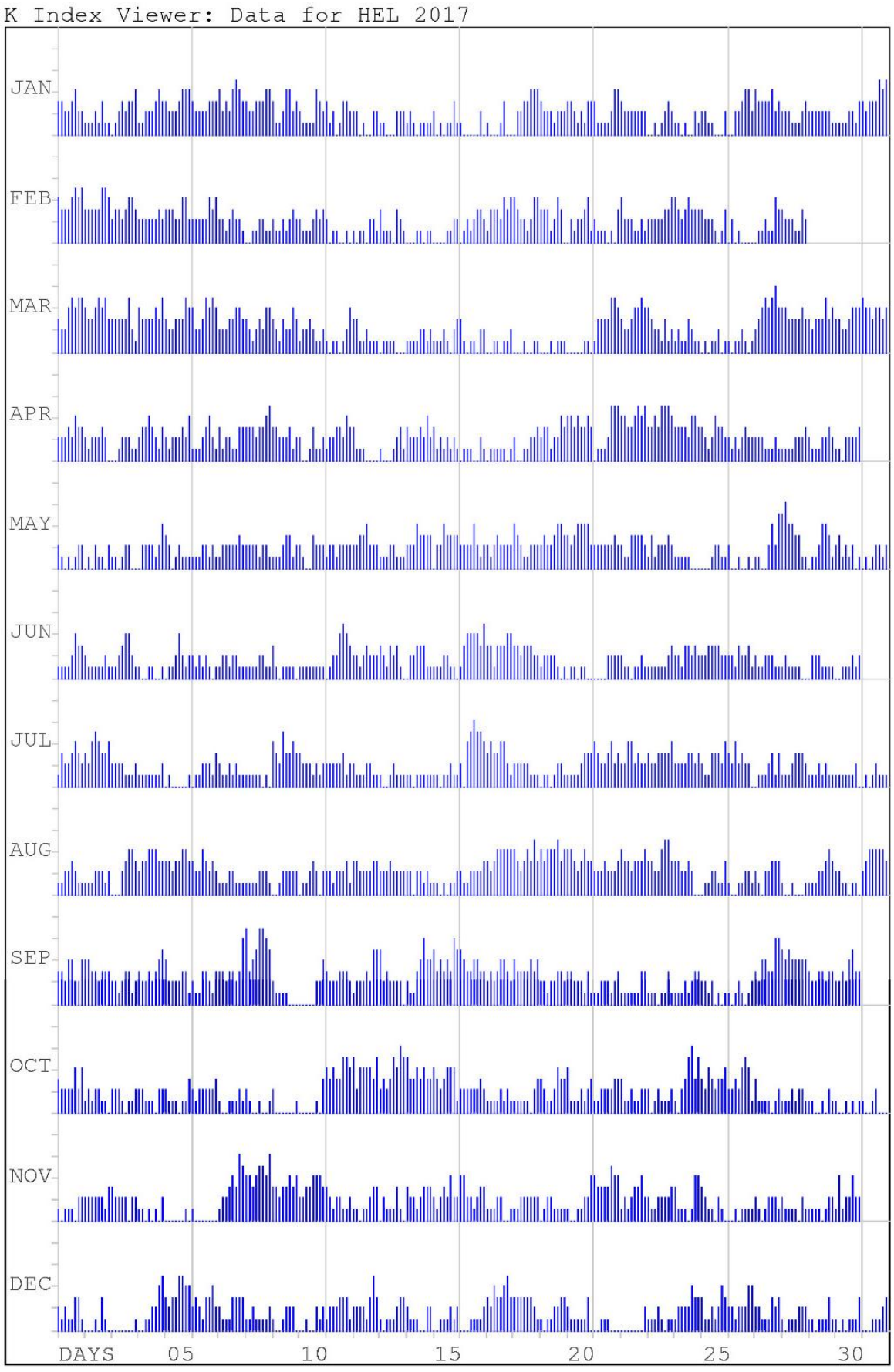

Fig. 10. *K*-indices in graphical form, Hel 2017.

8. TABLES AND PLOTS FOR HORNSUND OBSERVATORY

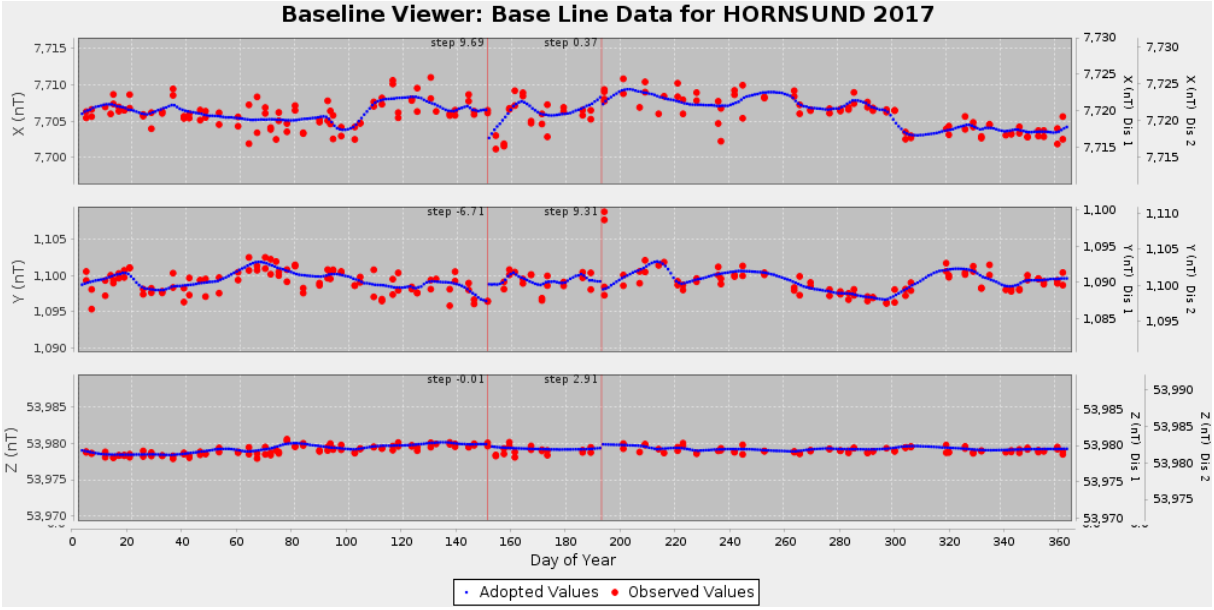

Fig. 11. Base values, Hornsund 2017.

Table 22

Annual mean values of magnetic elements in Hornsund Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
1	1979	-0 32.2	8384	53447	8384	-79	81 05.1	54101
2	1980	-0 14.2	8370	53447	8370	-35	81 06.0	54098
3	1981	-0 09.3	8351	53449	8351	-23	81 07.2	54097
4	1982	-0 09.4	8319	53481	8319	-23	81 09.5	54124
5	1983	-0 02.0	8295	53457	8295	-5	81 10.8	54097
6	1984	0 07.7	8266	53439	8266	19	81 12.4	54075
7	1985	0 14.3	8238	53405	8238	34	81 13.9	54037
8	1986	0 20.4	8213	53392	8213	49	81 15.3	54020
9	1987	0 25.6	8193	53360	8193	61	81 16.3	53985
10	1988	0 34.7	8168	53368	8168	82	81 17.9	53989
11	1989	0 40.8	8148	53369	8147	97	81 19.2	53987
12	1990	0 47.2	8122	53360	8121	112	81 20.7	53975
13	1991	0 53.0	8107	53355	8106	125	81 21.6	53967
14	1992	1 01.4	8088	53352	8087	144	81 22.8	53962
15	1993	1 12.9	8065	53356	8063	171	81 24.3	53962
16	1994	1 25.9	8044	53374	8041	201	81 25.8	53977
17	1995	1 38.4	8038	53374	8035	230	81 26.1	53976
18	1996	1 51.4	8023	53385	8019	260	81 27.2	53985
19	1997	2 07.2	8004	53406	7999	296	81 28.6	54003
20	1998	2 24.0	8001	53440	7994	335	81 29.1	54036
21	1999	2 39.1	7998	53471	7989	370	81 29.6	54066
22	2000	2 55.5	7996	53504	7986	408	81 30.0	54098
23	2001	3 12.4	7992	53542	7979	447	81 30.6	54135
24	2002	3 29.7	7989	53585	7974	487	81 31.2	54177
25	2003	3 49.8	7965	53646	7947	532	81 33.3	54234
26	2004	4 04.2	7961	53675	7941	565	81 33.8	54262
27	2005	4 20.5	7953	53707	7930	602	81 34.6	54293
28	2006	4 36.2	7958	53727	7932	639	81 34.5	54314
29	2007	4 51.3	7950	53757	7922	673	81 35.2	54342
30	2008	5 07.9	7941	53785	7909	710	81 36.1	54368
31	2009	5 25.4	7939	53804	7903	750	81 36.4	54387
32	2010	5 45.7	7928	53837	7888	796	81 37.4	54418
33	2011	6 05.8	7920	53868	7875	841	81 38.2	54447
34	2012	6 28.2	7910	53900	7860	891	81 39.1	54477
35	2013	6 50.8	7903	53920	7846	942	81 39.7	54497
36	2014	7 08.8	7895	53947	7833	982	81 40.4	54521
37	2015	7 30.6	7881	53988	7813	1030	81 41.7	54560
38	2016	7 53.5	7862	54021	7787	1079	81 43.2	54590
39	2017	8 17.6	7844	54064	7762	1131	81 44.7	54630

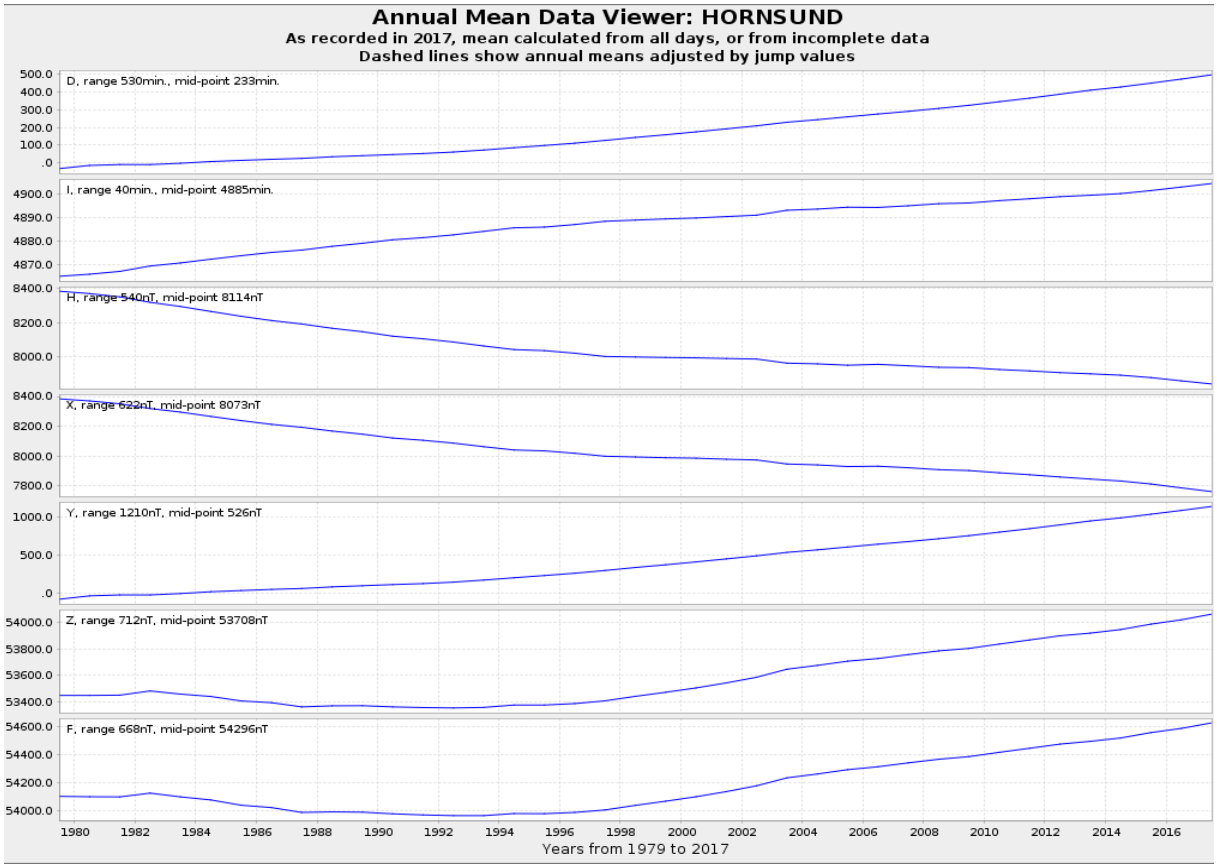

Fig. 12. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Hornsund.

Table 23

Monthly and yearly mean values of magnetic elements
HRN 2017

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 7500 + ... in nT													
All days	257	258	248	267	281	289	286	269	255	249	241	238	261
Quiet days	277	276	274	277	287	285	277	280	262	260	255	254	272
Disturbed days	229	231	200	242	264	274	297	247	217	222	222	212	238
East component: 1000 + ... in nT													
All days	109	113	123	123	124	120	125	135	143	147	154	157	131
Quiet days	105	110	115	117	122	121	126	134	144	145	149	154	129
Disturbed days	108	119	136	138	131	120	122	138	158	153	162	168	138
Vertical component: 53500 + ... in nT													
All days	544	551	559	560	546	548	555	562	588	588	588	580	564
Quiet days	533	536	542	541	537	549	546	554	584	574	571	576	554
Disturbed days	558	566	576	580	559	548	557	576	620	612	613	601	581

Table 24

Three-hour-range *K* indices
Hornsund, January-March 2017
The limit of $K = 9$ is 2500

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	5676 5995	52	9777 7789	61	5689 8699	60
2	4664 4553	37	6688 6797	57	9678 7795	58
3	2566 5578	44	6877 6599	57	6777 7643	47
4	3565 5586	43	6777 6588	54	6687 7889	59
5	6777 7689	57	8676 6665	50	5687 7999	60
6	7677 7776	54	7876 6669	55	8768 8899	63
7	9787 7999	65	7555 6544	41	5677 7796	54
8	7777 7599	58	5455 5423	33	7566 5588	50
9	6677 7746	50	4657 5557	44	6677 7568	52
10	6775 4997	54	5564 6636	41	4777 7525	44
11	5675 5564	43	5555 3335	34	4455 4555	37
12	5655 4249	40	3464 4453	33	5665 5554	41
13	4434 4546	34	5554 3664	38	3675 5422	34
14	3663 4376	38	3343 3233	24	3554 5454	35
15	4465 4573	38	3433 4354	29	4456 5346	37
16	3443 2233	24	3565 6645	40	5535 5347	37
17	3433 3533	27	4766 5779	51	3454 4425	31
18	2465 7699	48	9786 5589	57	3334 3234	25
19	7776 4565	47	8887 5895	58	2445 3344	29
20	5676 6597	51	3776 5695	48	3344 3343	27
21	8567 6577	51	4454 4225	30	3786 6797	53
22	9865 6655	50	6676 5565	46	5778 7889	59
23	3453 3598	40	4676 5667	47	7875 5544	45
24	3543 2254	28	8677 7666	53	4455 6535	37
25	4664 3226	33	5677 4337	42	2544 4424	29
26	3365 6695	43	4744 4222	29	4373 6523	33
27	7877 7866	56	3655 5377	41	4689 6797	56
28	5776 5349	46	7755 5565	45	6987 7696	58
29	5765 5553	41			5777 7955	52
30	3565 6646	41			5986 6899	60
31	5487 6689	53			6788 6999	62

Table 25

Three-hour-range *K* indices
Hornsund, April-June 2017
The limit of $K = 9$ is 2500

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	6676 7967	54	4545 5456	38	4554 6566	41
2	4666 6763	44	4555 3445	35	6655 5454	40
3	3455 5564	37	3555 6543	36	4575 8855	47
4	5878 6554	48	3564 4435	34	4445 5333	31
5	4555 4648	41	5534 4333	30	4655 6444	38
6	4555 7643	39	4454 5434	33	5645 6533	37
7	5566 5487	46	5656 5675	45	4765 4544	39
8	7678 5669	54	5675 4554	41	5554 5443	35
9	7658 6654	47	4554 5574	39	5435 5443	33
10	5434 6533	33	4543 6535	35	4544 4443	32
11	3666 6585	45	4754 5533	36	4565 6665	43
12	5555 4432	33	4476 6456	42	5667 7656	48
13	3554 4485	38	4666 5334	37	5666 6643	42
14	6886 6696	55	5555 6534	38	4666 7444	41
15	5564 5553	38	3667 6687	49	4556 5442	35
16	3555 4344	33	5677 7544	45	4678 7789	56
17	3444 5434	31	5566 5575	44	7656 6777	51
18	4545 5445	36	5675 4444	39	6667 6587	51
19	5586 6566	47	5665 6886	50	4786 5457	46
20	6979 7697	60	5799 8977	61	4554 5532	33
21	3555 7887	48	5776 6676	50	2345 6444	32
22	6778 8999	63	6666 8676	51	6765 4344	39
23	8799 8887	64	5665 6677	48	4445 6556	39
24	6899 7667	58	5656 5354	39	5677 6655	47
25	6677 6785	52	3435 4434	30	6677 7655	49
26	5566 6875	48	5445 5364	36	6567 5464	43
27	5774 5484	44	4433 5657	37	5666 5554	42
28	6663 5655	42	8877 6545	50	5766 5444	41
29	5566 5577	46	4457 9754	45	4666 5456	42
30	5556 4455	39	5764 5556	43	4456 5347	38
31			4654 6454	38		

Table 26

Three-hour-range *K* indices
Hornsund, July-September 2017
The limit of *K* = 9 is 2500

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	6677 7775	52	4666 5444	39	6769 7546	50
2	7788 6656	53	4445 7435	36	7888 6766	56
3	4565 4447	39	4444 6767	42	5656 6745	44
4	5655 4357	40	7799 9658	60	7667 7799	58
5	4433 4344	29	6677 7997	58	8667 5686	52
6	4565 6646	42	7678 6578	54	4677 7766	50
7	5754 5655	42	4567 6433	38	7798 6679	59
8	4544 4445	34	4455 6753	39	9899 9899	70
9	8869 7867	59	4446 6665	41	6554 5323	33
10	7866 5545	46	3655 6555	40	3343 4676	36
11	5676 6656	47	4655 6574	42	6667 7695	52
12	5665 5644	41	6665 4497	47	5677 9699	58
13	4545 5455	37	6666 5557	46	9686 5543	46
14	4545 5443	34	6546 6765	45	5566 8867	51
15	3444 4545	33	4544 4334	31	9787 7697	60
16	6599 9998	64	5556 5565	42	7777 8696	57
17	6867 7966	55	5689 7777	56	5787 8775	54
18	7875 6346	46	6676 8795	54	7987 6866	57
19	4655 3444	35	8878 7979	63	5765 5598	50
20	3544 7767	43	7887 6986	59	7676 6476	49
21	7786 7656	52	5667 6556	46	3557 6355	39
22	6788 7956	56	9987 6779	62	3656 4764	41
23	6787 8689	59	6666 6888	54	3555 5464	37
24	7787 6666	53	5676 7433	41	3445 5455	35
25	5577 6866	50	3566 5445	38	4555 4334	33
26	6686 6553	45	4464 5463	36	4456 3333	31
27	3674 7545	41	6546 6745	43	5668 6699	55
28	6656 6696	50	4456 5445	37	8788 7997	63
29	4556 6555	41	4545 5565	39	5677 6687	52
30	4555 6545	39	3554 4443	32	5577 8965	52
31	3545 5454	35	4699 8675	54		

Table 27

Three-hour-range *K* indices
Hornsund, October-December 2017
The limit of $K = 9$ is 2500

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	7576 5976	52	3443 4245	29	6665 5792	46
2	4755 5663	41	4554 4348	37	3434 4676	37
3	6864 3345	39	7666 6357	46	2223 3326	23
4	4655 4344	35	5555 4327	36	3545 6655	39
5	6553 3337	35	3443 2332	24	5677 7998	58
6	5566 5437	41	5322 2112	18	5865 6584	47
7	4433 5444	31	3666 6597	48	5665 7567	47
8	3643 4233	28	8767 6758	54	5585 5447	43
9	5443 3212	24	5765 6979	54	4444 4573	35
10	2333 3225	23	5667 6676	49	2333 3344	25
11	6577 7666	50	7766 6465	47	4666 6566	45
12	9567 7789	58	4645 4676	42	5665 4598	48
13	7777 9899	63	3545 5733	35	4464 5678	44
14	9788 8975	61	8755 4767	49	7444 3165	34
15	6677 5674	48	5566 6654	43	4345 5363	33
16	4786 6476	48	6965 4467	47	2444 5357	34
17	4465 5653	38	4666 5324	36	5696 6898	57
18	3655 4268	39	4663 4555	38	8776 6763	50
19	6564 7664	44	3586 4243	35	4445 6499	45
20	5565 5468	44	4654 2375	36	6565 4463	39
21	4555 5566	41	6766 6897	55	3445 5333	30
22	6555 3245	35	6766 7794	52	2343 3227	26
23	5546 3334	33	4556 6556	42	4565 3233	31
24	4356 8758	46	5555 3389	43	3666 6579	48
25	8687 6569	55	6655 3763	41	8656 4488	49
26	5766 5983	49	3443 4343	28	6865 5498	51
27	4564 3345	34	4554 4477	40	6656 5745	44
28	5676 4473	42	4554 4346	35	3455 4436	34
29	3543 3263	29	3564 3357	36	2434 5384	33
30	2444 4343	28	4966 6767	51	4454 4335	32
31	5334 6233	29			3454 3335	30

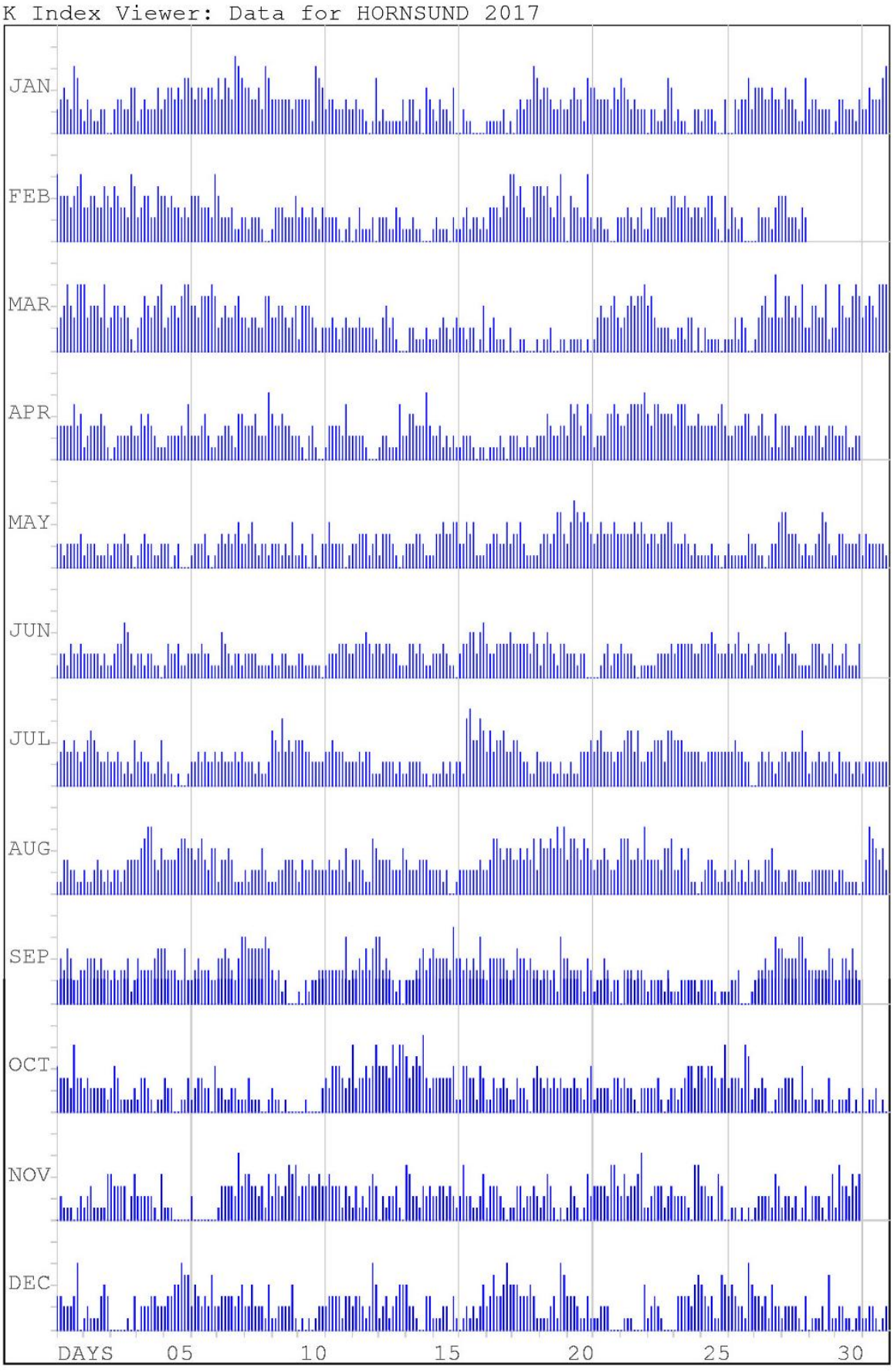

Fig. 13. *K*-indices in graphical form, Hornsund 2017.

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