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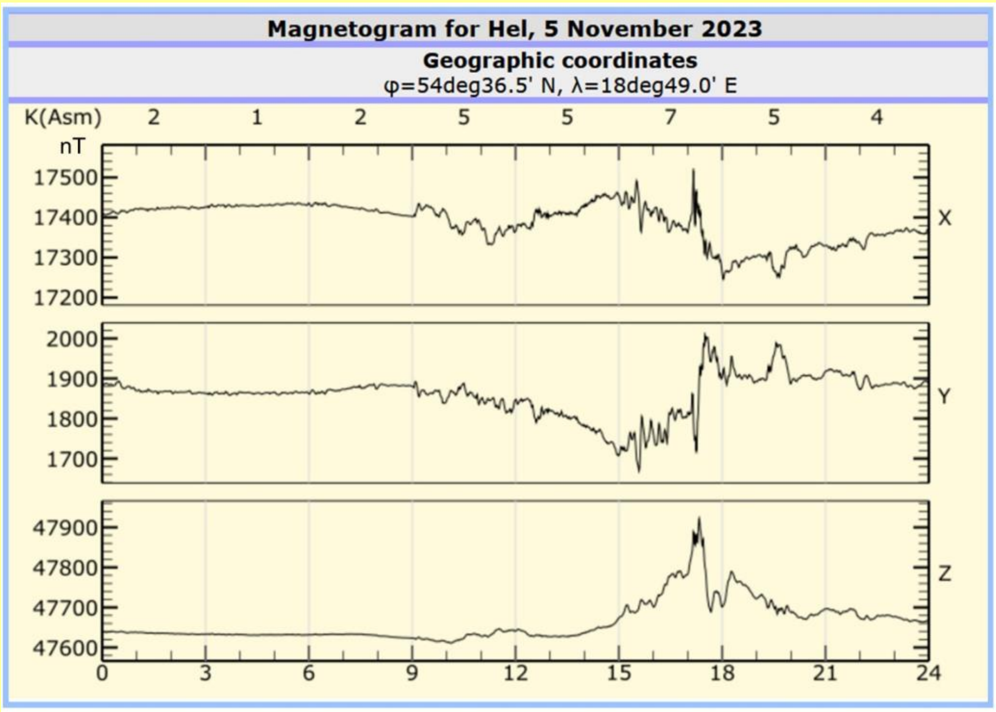
Geophysical Data Bases, Processing and Instrumentation

451 (C-118)

Results of Geomagnetic Observations: Belsk, Hel, Hornsund, 2023



Warsaw 2024 (Issue 2)

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Results of Geomagnetic Observations Belsk, Hel, Hornsund, 2023

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1. INTRODUCTION

This publication contains basic information on geomagnetic observations carried out in 2023 in three Polish geophysical observatories: Belsk, Hel, and Hornsund. IAGA codes are respectively: BEL, HLP, and 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 2023, 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. Data of geomagnetic field components XYZF have been sent to the INTERMAGNET centre in real time so they are publicly available on the Internet. At the beginning of 2024 have been prepared the final data (status Definitive) for the whole 2023 year observations. Definitive Data are published on INTERMAGNET website too.

Both the Polish Polar Station Hornsund and Hel Observatory are working for the IMAGE program. The primary objective of IMAGE is to study auroral electrojets and moving two-dimensional current systems.

Belsk and Hel observatories are providing their data, both real-time and final, to EMMA network (European quasi-Meridional Magnetometer Array). These data are exploited for investigation of the plasmasphere.

2. WHAT IS OBSERVED

Magnetic observatories continuously measure the strength and direction of the Earth's magnetic field over many years (Macmillan 2007).
The Earth's magnetic field can be divided into two components:

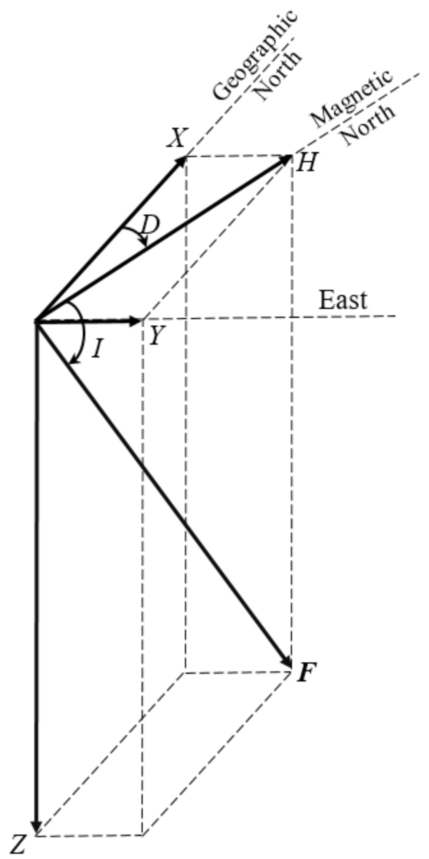
- a slowly changing large part called the main field,
- the external field, which usually has 1–10% of the main field and is characterized by relatively rapid changes.

For the above reason, the instrumentation of geomagnetic observatories is twofold. Extensive effort is paid to determine with high accuracy the absolute measurements of the Earth's field, which is essential for observing the Earth's main field. It is mainly due to absolute measurements we can reliably observe secular changes of the Earth's magnetic field. On the other hand, changes of geomagnetic field are recorded with relative instruments, the so-called variometers (Geese 2011).

For all three Polish observatories, we record changes in the *XYZF* components of the geomagnetic field (Fig. 1) and perform absolute measurements of Declination, Inclination, and total field *F*.

The described duality is also reflected in the observatory buildings. Absolute measurements and registration of magnetic field changes are carried out in separate non-magnetic buildings: the absolute house (eg. Figs. 3 and 5) and the variometer house (eg. Fig. 5).

One of the most important products of a multi-stage observational effort is time series data of the Definitive type. It is kind of combination of data from variometers and absolute measurements. This involves correcting variometer data with adopted baselines obtained from absolute measurements. This publication is prepared based on Definitive-type data.



$H = \sqrt{X^2 + Y^2}$
$F = X^2 + Y^2 + Z^2$
$H = F \times \cos(I)$
$Z = F \times \sin(I)$
$X = H \times \cos(D)$
$Y = H \times \sin(D)$

where:

X – north component
Y – east component
Z – vertical component
H – horizontal component
F – total intensity
D – magnetic declination
I – magnetic inclination

Fig. 1. Components of the Earth's magnetic field and the relations between them.

3. DESCRIPTION OF OBSERVATORIES

The location of observatories is shown in Fig. 2 and Table 1. The geomagnetic coordinates in Table 1 were calculated on the basis of model IGRF-13 from epoch 2023.5 (http://www.geomag.bgs.ac.uk/data_service/models_compass/coord_calc.html).

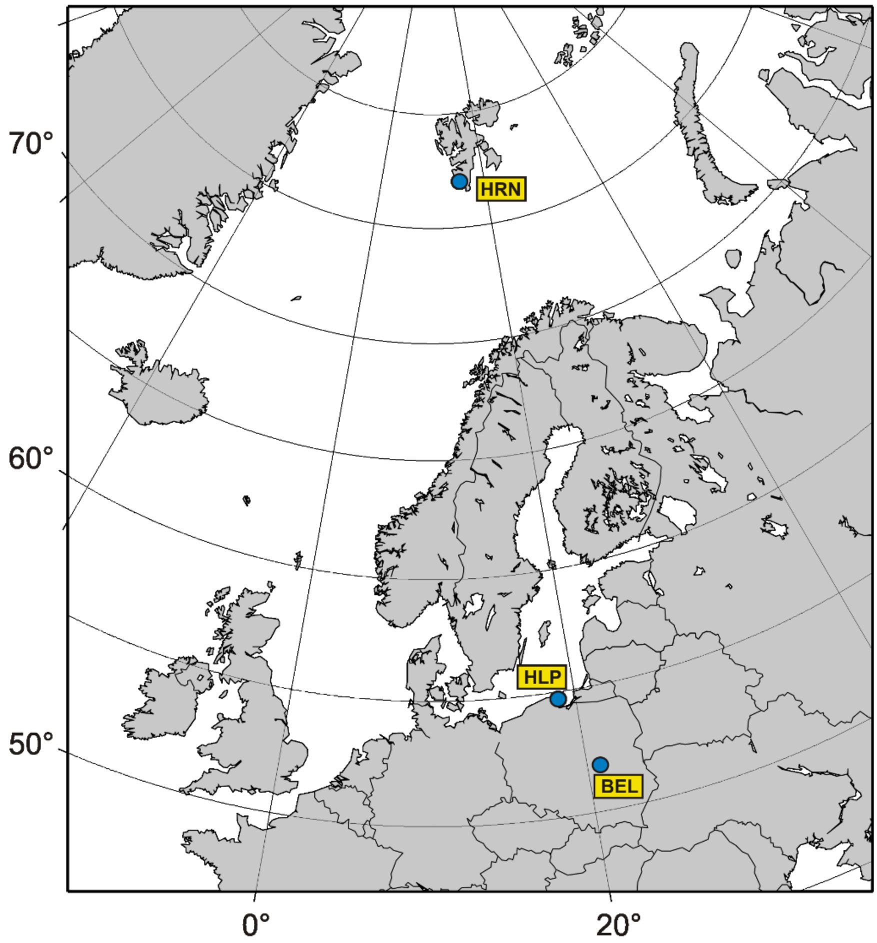


Fig. 2. Location of the Belsk, Hel, and Hornsund observatories.

Table 1
Coordinates of the Polish observatories

Observatory	Geographic coordinates		Geomagnetic coordinates		Elevation [m]
	Latitude	Longitude	Dipole latitude	Dipole longitude	
Belsk (BEL)	51° 50.2′ N	20° 47.3′ E	50.37° N	104.72° E	180
Hel (HLP)	54° 36.2′ N	18° 48.6′ E	53.35° N	104.02° E	1
Hornsund (HRN)	77° 0.0′ N	15° 33.0′ E	74.37° N	123.43° E	15

The methodology of geomagnetic observations in all 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. In turn, the magnetic field variations were measured with the use of GEOMAG and LEMI flux-gate magnetometers.

Continuous recording has been made by means of digital loggers type NDL. Due to the hardware and organizational solutions used, gaps in one-minute *XYZ* components from Belsk and Hel are practically absent.

It is worth mentioning that in 2023 the Hornsund and Suwałki stations have been continuing the permanent observation of the Schumann resonance phenomenon. Two horizontal magnetic components have been recorded at a frequency of 100 Hz. This recording was initiated in 2004 (Neska and Satori 2006).

3.1 Central Geophysical Observatory at Belsk, Central Poland

The Observatory at Belsk began continuous observations of the Earth's 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. 3. 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 from 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 from 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/.

3.2 Geophysical Observatory at Hel, Northern Poland

The Observatory at Hel (Fig. 4) 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 reasumed in 1953.

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.

Fig. 4. Hel Observatory – Variometer House.

3.3 Polish Polar Station Hornsund, Spitsbergen

The Polish Polar Station Hornsund (PSP Hornsund, Fig. 5) 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.

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. 5. The Variometer House (left) and the Absolute House (right) in PSP 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 average and available on http://www.geo.fmi.fi/image/request.html. Since 2002, PSP Hornsund has been included into the global near-real-time magnetic observatory network INTERMAGNET, sending the results, via Internet, to the GIN (Geomagnetic Information Nodes) center in Edinburgh.

4. INSTRUMENTATION

4.1 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 written in Java (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: 07-2019	FLUX-9408 THEO-10B sn: 160334	GEOMAG-03 THEO-010B sn: 03-2012
Proton magnetometer	GSM-90 sn: 9038262/96334	PMP-8 sn: 21/2006	PMP-5 sn: 115
Frequency of measurements	3, 4 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-5	
Producer	Institute of Geophysics Pol. Acad. Sc.
Resolution	0.1 nT
Absolute accuracy	0.2 nT
Proton magnetometer model PMP-8	
Producer	Institute of Geophysics Pol. Acad. Sc.
Resolution	0.01 nT
Absolute accuracy	0.2 nT
Overhauser magnetometer model GSM-90	
Producer	GEM Systems, Canada
Resolution	0.01 nT
Absolute accuracy	0.2 nT

The results of base determinations and the smoothed values adopted for further computations are depicted in Figs. 6, 9, and 12 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 2023 are listed in Table 4.

Table 4
Mean errors of measurements of B_X, B_Y, B_Z, and B_F in 2023

Observatory	Component	Number of measurements n	Mean error m_B [nT]
Belsk	B_X	137	0.43
	B_Y	170	0.52
	B_Z	175	0.19
Hel	B_X	149	0.50
	B_Y	149	0.37
	B_Z	147	0.29
Hornsund	B_X	164	1.49
	B_Y	168	0.87
	B_Z	168	0.51

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.

4.2 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 flux-gate sensors (GEOMAG, LEMI) and digital loggers NDL. In spare sets, we use LEMI magnetometers. Both the main and spare sets record the components in the rectangular coordinate system X, Y, Z. In all three observatories, the total field F is recorded using GSM 90 Overhauser proton magnetometers. The basic parameters of the recording systems are listed in Tables 5a, 5b, 5c.

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. They are characterized by good orthogonality of sensors and relatively small self noise.

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 0.1 nT, that of PMP-8 being 0.01 nT. 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).

Table 5a
Basic instruments for the magnetic field variations recording in Belsk Observatory

Set / Period	Parameter name	Value
Set 1 Vector magnetometer	Name of magnetometer	GEOMAG-02
	Kind of sensor	Fluxgate
	Serial No.	No. 37
	Sensor's orientation	XYZ
	Range	+/– 3200 nT
	Magnetometer's producer	GEOMAGNET
	Digital recorder	NDL
	Producer	TUS Electronics
	Sampling interval	1 s
Set 2 Vector magnetometer	Name of magnetometer	LEMI 008
	Kind of sensor	Fluxgate
	Serial No.	No. 10
	Sensor's orientation	XYZ
	Range	+/– 3200 nT
	Magnetometer's producer	Lviv Centre of the Institute of Space Research
	Digital recorder	NDL
	Producer	TUS Electronics
	Sampling interval	1 s
Set 1 Scalar magnetometer	Name of magnetometer	GSM-90
	Kind of sensor	Overhauser proton magnetometer
	Serial No.	No. 9038261
	Magnetometer's producer	GEM Systems
	Sampling interval	1 s

GSM-90 scalar magnetometer

The Canadian GSM-90 is a scalar Overhauser effect magnetometer characterized by high absolute accuracy (0.2 nT) and a low long-term drift (0.05 nT/year). Therefore it is ideally suited for continuous recording of total field F in magnetic observatories.

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.

Table 5b
Basic instruments for the magnetic field variations recording in Hel Observatory

Set / Period	Parameter name	Value
Set 1 Vector magnetometer	Name of magnetometer	GEOMAG-02
	Kind of sensor	Fluxgate
	Serial No.	No. 25
	Sensor's orientation	XYZ
	Range	+/– 3200 nT
	Magnetometer's producer	GEOMAGNET
	Digital recorder	NDL
	Producer	TUS Electronics
	Sampling interval	1 s
Set 2 Vector magnetometer	Name of magnetometer	LEMI-03/95
	Kind of sensor	Fluxgate
	Serial No.	No. 03
	Sensor's orientation	XYZ
	Range	+/– 1000 nT
	Magnetometer's producer	Lviv Centre of the Institute of Space Research
	Digital recorder	LB-480
	Producer	LAB-EL
	Sampling interval	1 s
Set 1 Scalar magnetometer	Name of magnetometer	GSM-90
	Kind of sensor	Overhauser proton magnetometer
	Serial No.	No. 9038264
	Magnetometer's producer	GEM Systems
	Sampling interval	1 s

LB-480 digital data loggers

The LB-480 is equipped with 24-bits sigma-delta A/D converter, GPS receiver, Ethernet and USB interfaces, and GSM modem. The logger allows simultaneously recording up to 6 analog signals, and can be used in geophysics.

4.3 Calibration of magnetic sensors

The verification of scale values of recording systems in all 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.

Table 5c
Basic instruments for the magnetic field variations recording in Hornsund Observatory

Set / Period	Parameter name	Value
Set 1 Vector magnetometer	Name of magnetometer	GEOMAG-02
	Kind of sensor	Fluxgate
	Serial No.	No. 40
	Sensor's orientation	XYZ
	Range	+/– 3200 nT
	Magnetometer's producer	GEOMAGNET
	Digital recorder	NDL
	Producer	TUS Electronics
	Sampling interval	1 s
Set 2 Vector magnetometer	Name of magnetometer	LEMI-03
	Kind of sensor	Fluxgate
	Serial No.	No. 12
	Sensor's orientation	XYZ
	Range	+/– 3200 nT
	Magnetometer's producer	Lviv Centre of the Institute of Space Research
	Digital recorder	NDL
	Producer	TUS Electronics
	Sampling interval	1 s
Set 1 Scalar magnetometer	Name of magnetometer	GSM-90
	Kind of sensor	Overhauser proton magnetometer
	Serial No.	No. 9038263
	Magnetometer's producer	GEM Systems
	Sampling interval	1 s

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

4.4 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 binary format IAF and creation in this format of monthly files containing one-minute means of *X*, *Y*, *Z*, and Δ*F* (author: M. Neska),
- automatic transmission of data, via the Internet, to the Institute of Geophysics PAS in Warsaw and data centers in 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 Format (INTERMAGNET Archive 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. 7, 10, and 13), bases of recording sets as well as plots of *K* indices for 2023 (Figs. 8, 11, and 14) 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. The monthly mean values of 2023 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.

4.5 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 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 https://wdc.kugi.kyoto-u.ac.jp/.

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

5. CONTACT PERSONS, POSTAL ADDRESSES, CONTACT DETAILS

5.1 Belsk Observatory

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5.2 Hel Observatory

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5.3 Hornsund Observatory

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http://hornsund.igf.edu.pl/
http://www.igf.edu.pl/

6. PERSONNEL TAKING PART IN THE WORK OF BELSK, HEL, AND HORNSUND OBSERVATORIES IN 2023

Jan Reda (project leader of geomagnetic observations in Belsk, Hel, Hornsund)
Paweł Czubak
Krzysztof Kucharski
Robert Szymko (Hornsund, observer in the 1-st half of 2023)
Mariusz Neska
Szymon Szyszko (Hornsund, observer in the 2-nd half of 2023)
Anna Wójcik
Stanisław Wójcik

7. TABLES AND PLOTS FOR BELSK OBSERVATORY

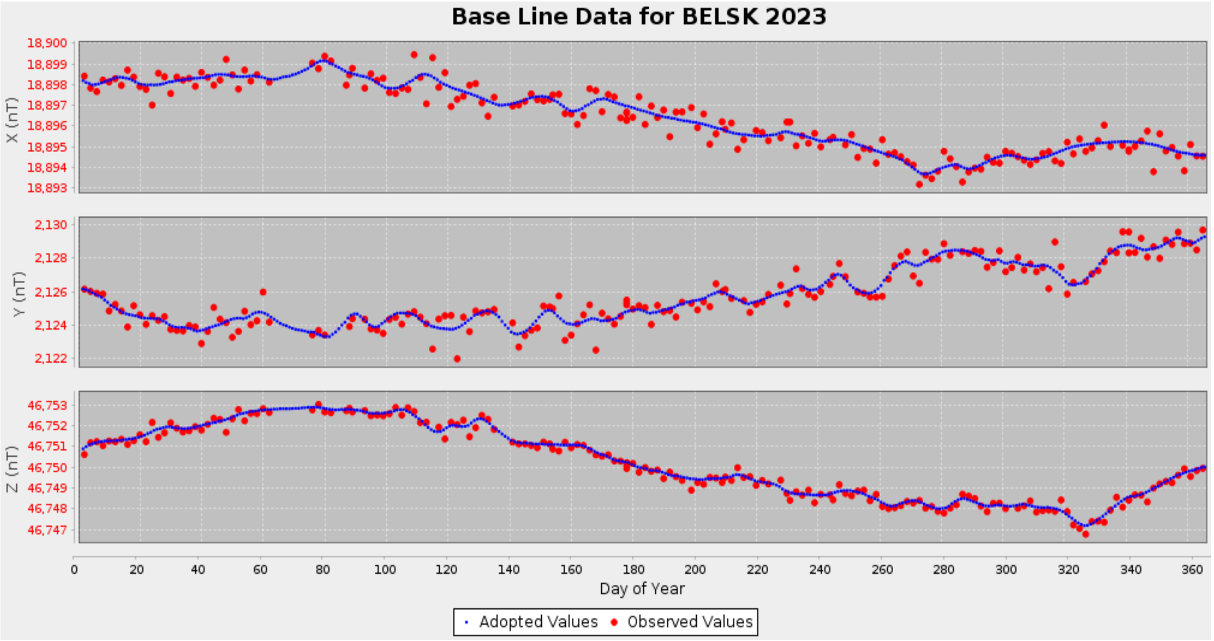

Fig. 6. Base values of set 1, Belsk 2023.

Table 6
Annual mean values of magnetic components 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 components 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
53	2018	6 15.5	19032	46648	18918	2075	67 48.3	50381
54	2019	6 24.9	19033	46712	18914	2127	67 49.9	50441
55	2020	6 33.4	19029	46775	18905	2173	67 51.7	50497
56	2021	6 41.3	19024	46840	18894	2216	67 53.8	50556
57	2022	6 49.5	19015	46907	18880	2259	67 56.0	50614
58	2023	6 56.7	19011	46966	18872	2299	67 57.7	50668

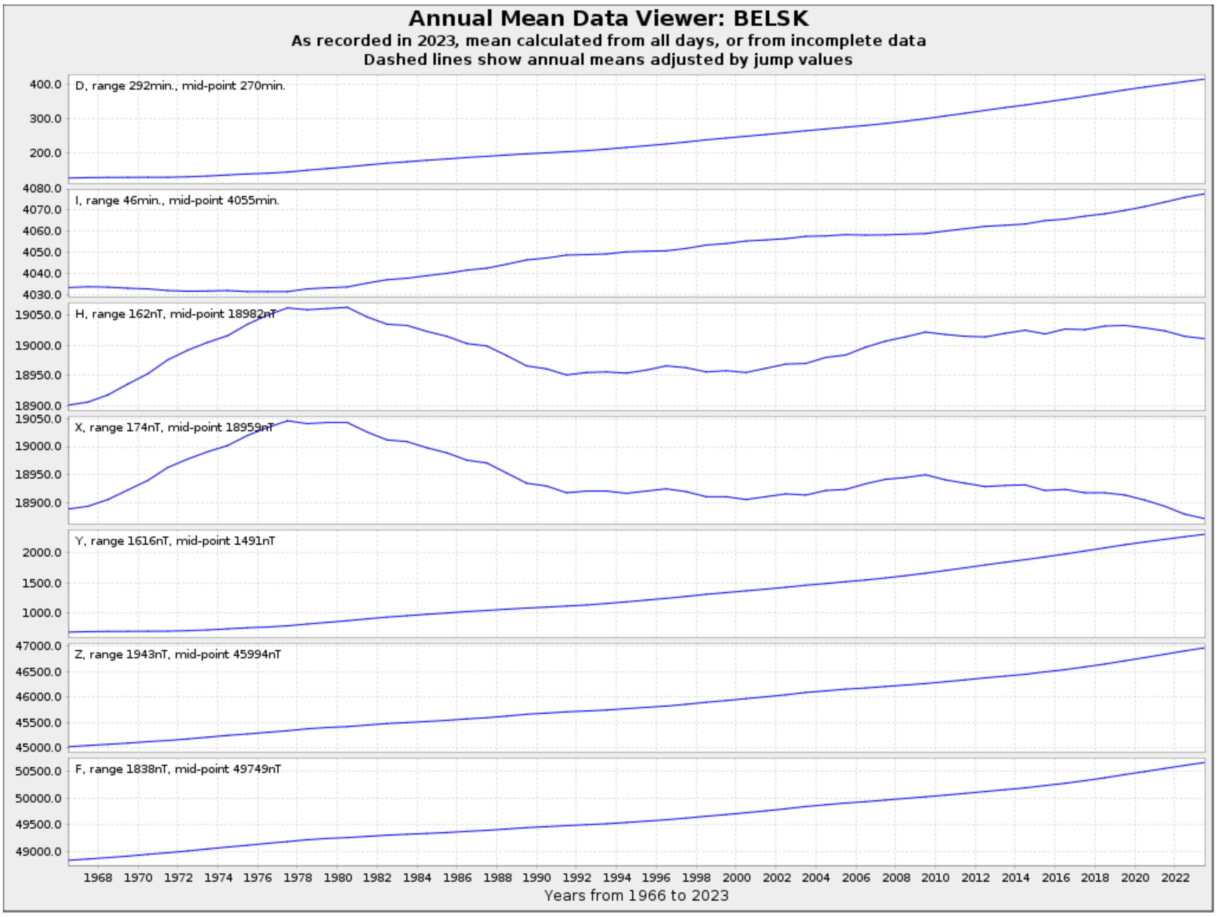

Fig. 7. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Belsk.

Table 7
Monthly and yearly mean values of magnetic components
BEL 2023

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 18500 + ... in nT													
All days	375	368	366	371	377	382	381	377	365	370	361	367	372
Quiet days	381	381	372	382	383	391	385	378	377	378	374	377	380
Disturbed days	367	344	350	348	369	377	370	369	351	359	332	350	357
East component: 2000 + ... in nT													
All days	281	286	290	291	295	296	300	302	308	309	314	316	299
Quiet days	279	282	288	287	293	292	297	301	305	307	310	313	296
Disturbed days	282	294	299	299	298	300	303	304	313	313	320	318	303
Vertical component: 46500 + ... in nT													
All days	441	447	453	453	457	460	465	469	477	480	491	495	466
Quiet days	440	441	454	447	455	456	463	467	472	478	486	493	463
Disturbed days	442	457	451	461	460	461	469	472	482	484	502	499	470

Table 8
Three-hour-range *K* indices
Belsk, January–March 2023
The limit of *K* = 9 is 450

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2323 2355	25	1101 1233	12	3113 1232	16
2	2212 2234	18	4211 1011	11	1123 2234	18
3	1111 1333	14	2211 2332	16	4333 3245	27
4	4532 3221	22	3211 1101	10	3333 2244	24
5	0112 3333	16	0111 1122	9	3332 4444	27
6	1011 1122	9	3223 3244	23	3333 3334	25
7	2211 2331	15	4333 3333	25	3233 2221	18
8	2222 3221	16	3323 3343	24	1222 1243	17
9	2011 1222	11	3333 2434	25	1333 3322	20
10	1111 1323	13	4323 3243	24	4211 1323	17
11	2222 1223	16	3222 2111	14	3211 1124	15
12	3222 2223	18	2212 1232	15	3233 1011	14
13	2122 1244	18	1011 2221	10	1001 1211	7
14	3322 1133	18	2122 1222	14	2333 3335	25
15	4334 3445	30	2344 3435	28	4543 2236	29
16	4133 3421	21	3244 5512	26	4212 0111	12
17	0121 1104	10	2322 2111	14	0122 2113	12
18	4433 3321	23	1112 2133	14	2223 2231	17
19	0133 2111	12	3121 2222	15	1222 2352	19
20	1111 1322	12	1123 2232	16	3112 3423	19
21	2432 2443	24	4323 3212	20	3122 1222	15
22	2123 2242	18	2022 1222	13	4323 2441	23
23	1221 3323	17	4433 3544	30	1134 5477	32
24	1111 2111	9	2122 2100	10	7743 2454	36
25	0112 2222	12	1122 1443	18	2233 3233	21
26	2222 3331	18	3223 3256	26	3221 1233	17
27	1112 3313	15	4555 5666	42	1111 0121	8
28	3221 3332	19	5433 2154	27	2011 2112	10
29	1122 1312	13			2111 1222	12
30	1012 1123	11			3222 3463	25
31	0222 2422	16			4433 2344	27

Table 9
Three-hour-range *K* indices
Belsk, April–June 2023
The limit of $K = 9$ is 450

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2123 3333	20	3222 2334	21	3332 4232	22
2	4323 3123	21	3223 2121	16	2221 1122	13
3	4112 3343	21	0011 1213	9	1112 2112	11
4	3323 2134	21	212* 1313	*	2223 3343	22
5	3122 3443	22	2111 0111	8	1113 1132	13
6	2112 2242	16	4535 4332	29	2212 3221	15
7	3222 2123	17	1222 3523	20	1112 1112	10
8	1121 1213	12	4212 4433	23	2212 2221	14
9	3111 1222	13	4222 2325	22	2101 1222	11
10	3332 3312	20	4535 5433	32	1012 2221	11
11	0121 2221	11	3222 2233	19	2322 2322	18
12	0111 2111	8	2333 5432	25	1222 3322	17
13	2111 1223	13	2222 2334	20	1212 2311	13
14	1122 2213	14	1211 3422	16	3111 1111	10
15	2122 2223	16	1111 1241	12	2223 5545	28
16	1121 2111	10	222* ****	*	4535 4323	29
17	1222 1212	13	**** 1111	*	2222 2332	18
18	1111 5543	21	1111 0011	6	3212 2342	19
19	2113 4221	16	0111 2224	13	3222 3343	22
20	1111 2322	13	5444 3433	30	2223 2323	19
21	2212 2344	20	3212 3555	26	2211 3223	16
22	2211 1223	14	5323 2444	27	0223 3233	18
23	2123 4586	31	2333 2244	23	2212 3333	19
24	5754 4333	34	2213 3332	19	2323 3333	22
25	1111 3343	17	3233 2232	20	5322 3343	25
26	2223 3333	21	2322 2222	17	2332 3323	21
27	4333 3433	26	1111 1113	10	2232 2222	17
28	3323 3444	26	3322 3222	19	2322 3233	20
29	3333 4443	27	1112 1211	10	2334 2444	26
30	2222 2212	15	1122 2222	14	3122 3311	16
31			2122 3333	19		

Table 10
Three-hour-range *K* indices
Belsk, July–September 2023
The limit of *K* = 9 is 450

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2212 2211	13	2223 4332	21	3223 4232	21
2	1212 2211	12	2123 4432	21	3435 4554	33
3	2112 2112	12	2223 2200	13	5443 4423	29
4	1111 2111	9	0122 3444	20	3211 2330	15
5	1111 2323	14	5544 3211	25	0112 2442	16
6	2224 4323	22	0000 0111	3	2121 3311	14
7	3334 3334	26	3213 2234	20	2112 2223	15
8	3112 1121	12	3112 2321	15	3111 2221	13
9	0012 2211	9	2122 3223	17	2123 3311	16
10	1212 2221	13	2222 2322	17	1001 0222	8
11	2122 3322	17	1121 2211	11	1222 2222	15
12	2112 2331	15	2222 2222	16	1023 5545	25
13	2222 3432	20	2111 1211	10	5223 3424	25
14	3333 3554	29	2111 2222	13	4232 2245	24
15	3213 2111	14	0111 1112	8	2211 2223	15
16	0111 1134	12	3111 4321	16	1011 1243	13
17	3234 3243	24	3111 2322	15	3323 2443	24
18	4322 4242	23	2233 2333	21	3332 5444	28
19	1212 2211	12	3212 2233	18	5533 5553	34
20	1122 2542	19	3223 2222	18	4232 2243	22
21	3322 1334	21	2233 3222	19	2222 3323	19
22	3323 2122	18	2322 2111	14	2112 2423	17
23	1121 2322	14	1111 1112	9	2213 2123	16
24	2121 2223	15	0111 2334	15	2122 1165	20
25	1121 2224	15	2111 1211	10	5443 3333	28
26	3533 3332	25	1221 2322	15	2334 5443	28
27	2223 2331	18	4321 2232	19	3333 3321	21
28	0001 3234	13	2111 2331	14	2311 1113	13
29	3312 3332	20	0002 2113	9	2223 2111	14
30	1323 3322	19	3112 2221	14	1222 3333	19
31	1122 2312	14	1112 1232	13		

Table 11
Three-hour-range *K* indices
Belsk, October–December 2023
The limit of *K* = 9 is 450

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	3121 2133	16	1223 3312	17	4335 5555	35
2	3211 2213	15	2111 2212	12	5311 0202	14
3	1212 2323	16	0111 1000	4	2222 3432	20
4	3232 2224	20	1111 2354	18	2233 3111	16
5	3333 2112	18	3125 5754	32	3323 3423	23
6	2222 1213	15	3544 2564	33	2222 3422	19
7	1121 1122	11	5333 3433	27	1111 1123	11
8	2222 1223	16	2432 1253	22	1011 1232	11
9	3122 2332	18	2332 2243	21	0011 1110	5
10	1211 0100	6	2322 2212	16	1111 1132	11
11	0111 1112	8	2111 1111	9	1111 1100	6
12	1011 1110	6	1143 2223	18	0101 4421	13
13	1233 3433	22	5212 3321	19	1211 2333	16
14	2112 2142	15	2111 2321	13	4424 3223	24
15	0011 0123	8	3221 3342	20	1013 3343	18
16	2011 2000	6	1121 2314	15	3332 3144	23
17	0001 1001	3	0000 1320	6	3434 5524	30
18	0213 3333	18	0110 0022	6	2343 3335	26
19	2212 2221	14	1111 1011	7	4322 2223	20
20	1112 2234	16	1112 1111	9	4322 2321	19
21	4432 3421	23	1243 3354	25	3112 1210	11
22	2122 2242	17	3443 4553	31	0111 0111	6
23	1011 1110	6	2221 1000	8	1111 2311	11
24	0011 1122	8	2112 2343	18	3222 2222	17
25	0011 1212	8	3334 4574	33	0111 1121	8
26	2224 4455	28	3321 2122	16	0112 2210	9
27	3332 2221	18	1122 2322	15	2212 1111	11
28	1323 4334	23	2222 2221	15	0011 0102	5
29	4443 5444	32	1111 1130	9	1112 2123	13
30	4323 3132	21	1211 1021	9	1222 1110	10
31	2222 2122	15			0110 1121	7

Table 12
Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, January–March 2023

Day	January		February		March	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	2323 2354	24	1000 1233	10	3112 1132	14
2	2211 2225	17	4210 1011	10	0113 1244	16
3	1011 1334	14	2211 2331	15	4423 4255	29
4	4542 2220	21	4301 1101	11	3333 2245	25
5	0011 3333	14	0101 1121	7	4442 4454	31
6	1001 1022	7	4323 3255	27	4333 3344	27
7	1211 1420	12	4433 3333	26	3333 2220	18
8	2221 4220	15	3334 3344	27	1222 1253	18
9	2011 1231	11	4333 2445	28	2444 4332	26
10	1111 1324	14	4323 3244	25	4110 1333	16
11	2222 1233	17	3212 2110	12	4110 1124	14
12	3222 2224	19	1212 1243	16	3233 1010	13
13	3222 2155	22	1010 2120	7	0000 1100	2
14	4322 0033	17	2031 1213	13	3433 4445	30
15	5334 3446	32	3444 4536	33	4643 2136	29
16	3123 3510	18	3254 5512	27	4212 0010	10
17	0121 1004	9	2331 1020	12	0123 2004	12
18	5533 3421	26	1111 2043	13	2223 2231	17
19	0033 2011	10	4111 3222	16	1332 2351	20
20	1102 1312	11	0022 2233	14	3012 4513	19
21	2532 2444	26	4334 3112	21	3113 1312	15
22	2123 1351	18	2013 1322	14	4333 2350	23
23	0121 3224	15	5433 3554	32	0134 5477	31
24	1111 2100	7	2121 2000	8	6743 2455	36
25	0003 3322	13	1012 1544	18	2234 3343	24
26	1323 3241	19	3223 3256	26	3211 1143	16
27	1013 3413	16	5565 5766	45	1001 0011	4
28	3221 3332	19	5433 2155	28	2001 2112	9
29	0012 1303	10			2001 1221	9
30	1002 1114	10			3223 3463	26
31	0222 1532	17			4433 3355	30

*) see Reda and Jankowski (2004)

Table 13
Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, April–June 2023

Day	April		May		June	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	2124 4444	25	3122 2334	20	4342 4242	25
2	4422 2134	22	3323 2120	16	2111 1112	10
3	4112 3454	24	0001 1113	7	1101 1011	6
4	3323 2124	20	111* 0313	*	2123 2242	18
5	3122 3244	21	2011 0011	6	0013 0122	9
6	2101 1242	13	5635 4332	31	3213 3110	14
7	4222 2024	18	1222 3533	21	0102 1112	8
8	1111 1103	9	5112 4524	24	2112 2120	11
9	3010 1223	12	4221 3325	22	1000 0121	5
10	4333 3421	23	4525 5432	30	0012 2221	10
11	0131 1220	10	3212 2233	18	3322 2422	20
12	0011 2111	7	2333 5422	24	1122 3222	15
13	2100 0223	10	2221 2344	20	1212 2411	14
14	1012 2213	12	1211 2432	16	3111 0100	7
15	2122 2214	16	1011 1241	11	2123 5555	28
16	0121 2111	9	312* ****	*	5645 4323	32
17	1122 1311	12	**** 1110	*	2222 1342	18
18	0110 4543	18	0101 0000	2	3312 2252	20
19	3114 4321	19	0011 2334	14	3223 3433	23
20	0111 2211	9	5544 3444	33	2223 2323	19
21	1112 2345	19	3212 3555	26	2311 2124	16
22	3211 1314	16	5333 2444	28	0223 3244	20
23	2113 5587	32	3333 1255	25	3212 3323	19
24	6754 4323	34	2213 3443	22	2334 3444	27
25	1001 3344	16	4234 2242	23	5222 3343	24
26	2223 4434	24	2222 2222	16	2323 4424	24
27	4334 4544	31	0111 1012	7	2233 3322	20
28	3433 4543	29	3432 4222	22	3322 3222	19
29	3334 5443	29	1112 0211	9	3424 2445	28
30	3221 2212	15	0011 1113	8	3122 4300	15
31			3122 3343	21		

*) see Reda and Jankowski (2004)

Table 14
Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, July–September 2023

Day	July		August		September	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	2212 2111	12	2223 4342	22	3333 4231	22
2	1212 2201	11	2113 5431	20	3445 5565	37
3	2111 1112	10	2213 2300	13	6343 4523	30
4	1111 2111	9	0122 3555	23	2211 2320	13
5	1111 2423	15	5554 3211	26	0011 2552	16
6	2224 4323	22	0000 0121	4	1121 3311	13
7	3334 3344	27	3113 3235	21	2012 2213	13
8	4111 1111	11	4112 1331	16	3101 1320	11
9	0011 1211	7	2122 2323	17	3123 3200	14
10	1101 1210	7	2211 2322	15	1001 0112	6
11	2132 3322	18	1111 1211	9	1112 2123	13
12	2112 2231	14	2322 2332	19	0013 5645	24
13	2121 3421	16	3102 1111	10	6222 3425	26
14	3333 3553	28	2000 2122	9	5331 2345	26
15	4214 2111	16	0111 1111	7	2211 2313	15
16	0001 1145	12	3101 4411	15	1011 0143	11
17	4144 3254	27	3111 2221	13	3323 3443	25
18	5322 4231	22	2333 1334	22	4332 4544	29
19	0112 2210	9	2111 1243	15	6543 5552	35
20	0111 2542	16	4223 2132	19	4232 2254	24
21	3323 1434	23	2133 3131	17	2221 3434	21
22	3323 1012	15	2321 1111	12	2112 2524	19
23	0121 2433	16	1101 1002	6	3213 2134	19
24	2111 2123	13	0011 2444	16	2122 1156	20
25	1121 3225	17	2101 1211	9	5544 3333	30
26	4544 3343	30	1221 2322	15	3344 5453	31
27	2112 2231	14	4221 2331	18	3244 3331	23
28	0001 3233	12	2111 1331	13	1311 1103	11
29	4312 3332	21	0002 2112	8	3333 2110	16
30	0413 3322	18	3012 2120	11	1222 3343	20
31	1122 2312	14	0112 1122	10		

*) see Reda and Jankowski (2004)

Table 15
Three-hour-range *E* indices
based on power spectrum estimation (*)
Belsk, October–December 2023

Day	October		November		December	
	E	*SE*	*E*	*SE*	*E*	*SE*
1	3122 2022	14	1222 3322	17	5336 6455	37
2	3311 2223	17	2211 1212	12	5310 0101	11
3	0112 2334	16	0110 1000	3	2222 2432	19
4	4232 2224	21	0101 2364	17	2233 3111	16
5	4423 2112	19	2126 6765	35	3323 4433	25
6	3213 1213	16	4544 2565	35	2222 3432	20
7	1110 0022	7	5332 3443	27	1111 1124	12
8	2222 0123	14	2432 1253	22	1001 1242	11
9	3112 2331	16	3222 2254	22	0000 0100	1
10	1111 0100	5	2322 3213	18	0000 0131	5
11	0101 1002	5	1011 1110	6	0000 0100	1
12	1011 0010	4	0043 2213	15	0101 4430	13
13	0333 3432	21	6212 3211	18	0112 1334	15
14	1112 1152	14	1001 1331	10	5424 3223	25
15	0001 0122	6	4121 4453	24	2012 3354	20
16	1011 2000	5	1121 2314	15	4331 2044	21
17	0000 0001	1	0000 0310	4	4444 6623	33
18	0213 3423	18	0000 0012	3	2354 4346	31
19	2312 2221	15	0001 1011	4	4421 1223	19
20	1122 2144	17	1112 1111	9	5322 2420	20
21	5542 3521	27	2243 3455	28	4002 0110	8
22	2122 2241	16	3554 4663	36	0011 0110	4
23	0000 1000	1	2221 1000	8	0111 1301	8
24	0011 0121	6	3112 2253	19	3223 2212	17
25	0010 1213	8	3435 5575	37	0100 0120	4
26	3234 5455	31	4221 1012	13	0112 1110	7
27	3333 2321	20	1121 3423	17	2212 1110	10
28	1323 4444	25	1122 1321	13	0000 0101	2
29	5444 5554	36	0110 1030	6	1112 2123	13
30	5213 4133	22	1211 1020	8	1221 1100	8
31	2222 3033	17			0010 0111	4

*) see Reda and Jankowski (2004)

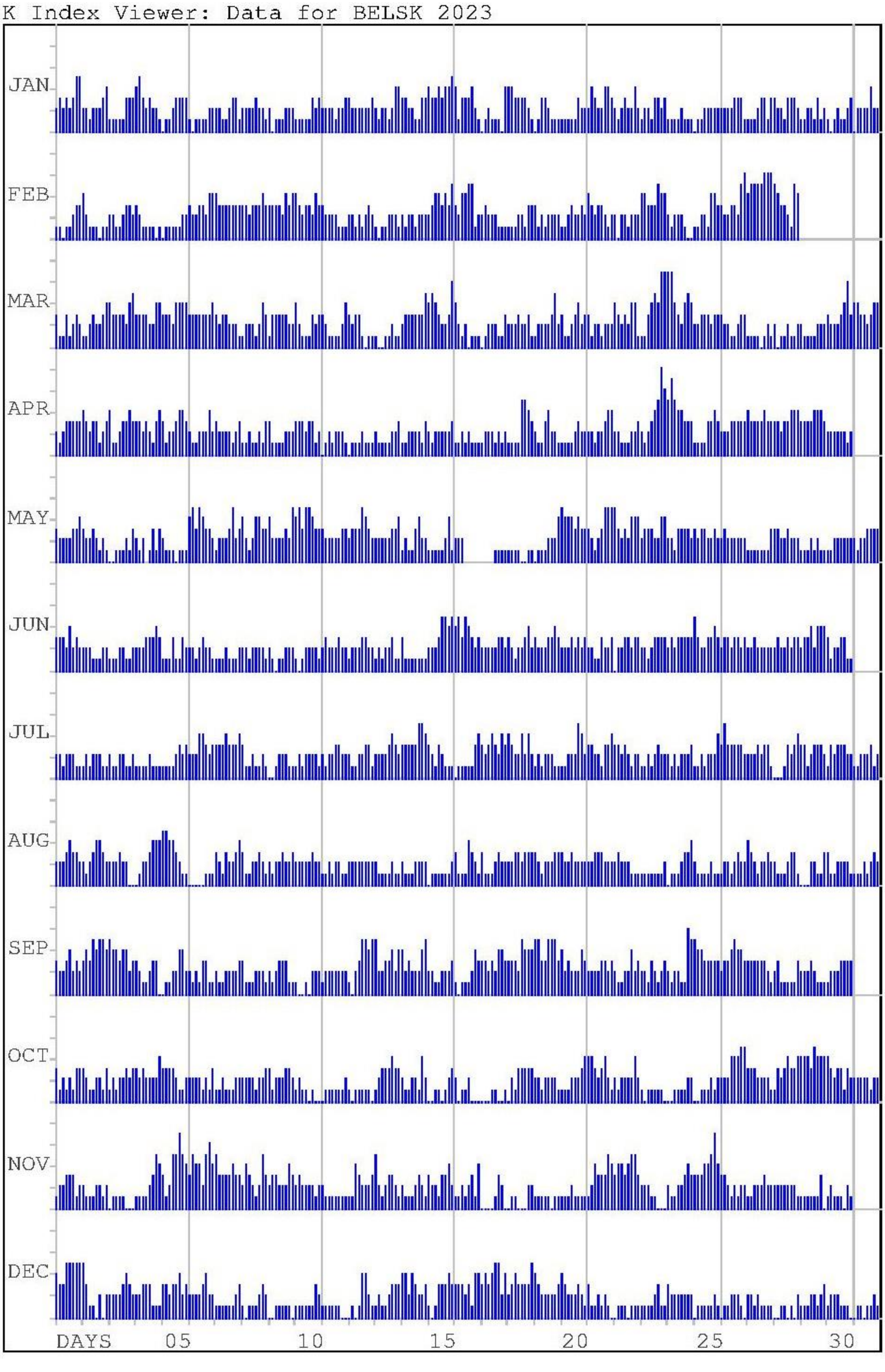

Fig. 8. *K*-indices in graphical form, Belsk 2023.

8. TABLES AND PLOTS FOR HEL OBSERVATORY

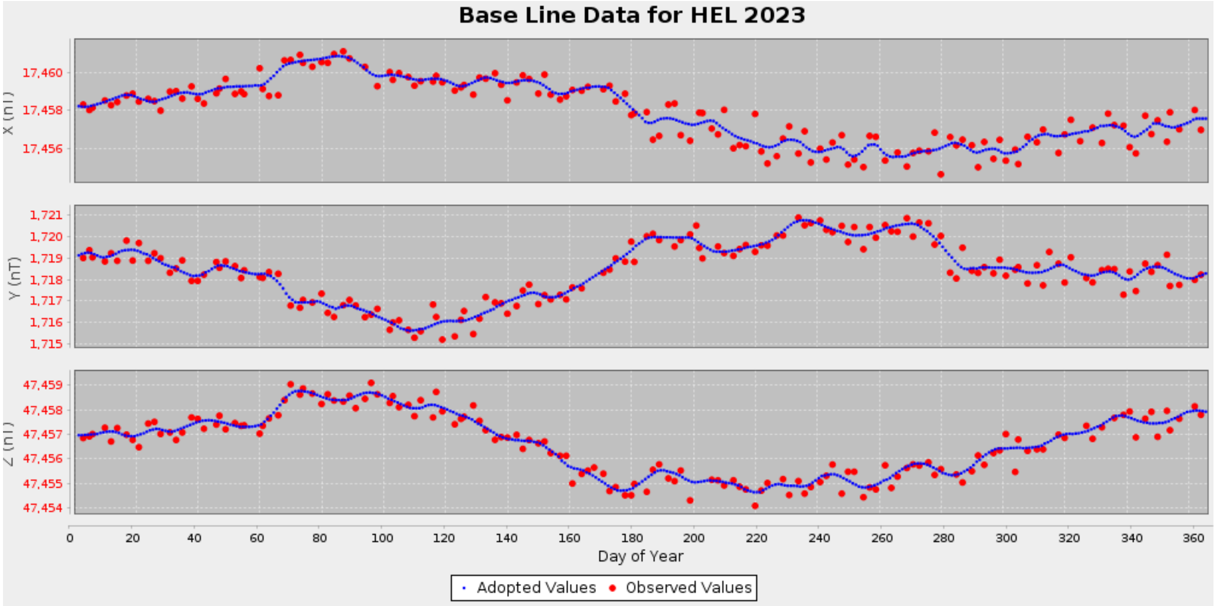

Fig. 9. Base values of set 1, Hel 2023.

Table 16
Annual mean values of magnetic components 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

to be continued

Table 16 (continuation)
Annual mean values of magnetic components in Hel Observatory

No.	Year	*D* [º ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [º ‘]	*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
59	2011	4 09.2	17564	47014	17518	1272	69 30.9	50188

to be continued

Table 16 (continuation)
Annual mean values of magnetic components in Hel Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
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
66	2018	5 15.7	17570	47305	17496	1611	69 37.4	50463
J	2019.0	0 –0.2	5	–2	5	–1	0 –0.4	0
67	2019	5 26.1	17564	47366	17485	1664	69 39.3	50518
68	2020	5 35.6	17560	47425	17477	1712	69 40.9	50571
69	2021	5 44.7	17553	47487	17464	1757	69 42.9	50627
70	2022	5 53.7	17543	47550	17450	1802	69 45.0	50683
71	2023	6 2.2	17536	47607	17439	1844	69 467.7	50735

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

2019.0 – jump caused by change the method for measuring declination/inclination from residual to zero method.

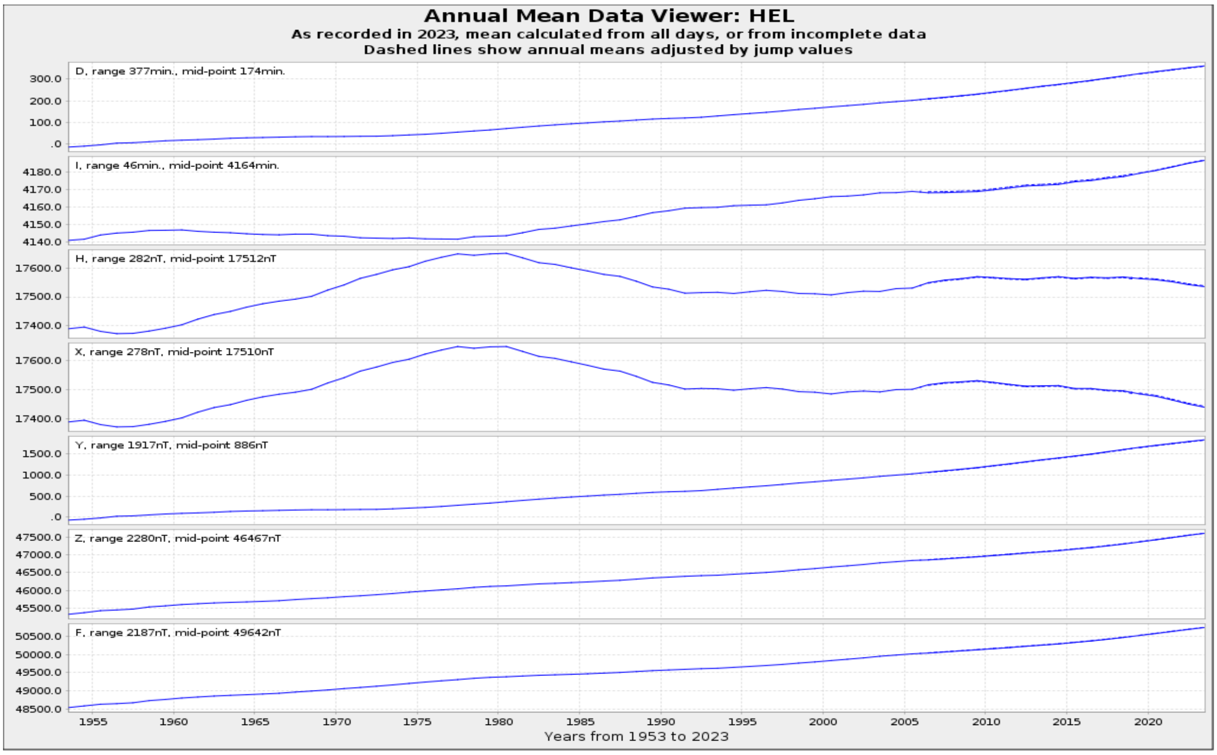

Fig. 10. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Hel.

Table 17
Monthly and yearly mean values of magnetic components
HLP 2023

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 17000 + ... in nT													
All days	443	437	434	438	445	450	449	443	432	437	428	434	439
Quiet days	449	448	440	449	450	458	452	444	442	445	440	443	447
Disturbed days	435	414	418	417	438	446	439	437	419	426	403	418	426
East component: 1500 + ... in nT													
All days	325	330	335	336	340	341	345	347	354	355	361	363	344
Quiet days	323	326	333	332	339	337	343	347	351	354	358	361	342
Disturbed days	326	337	344	343	343	345	348	348	359	360	366	365	349
Vertical component: 47000 + ... in nT													
All days	584	590	595	596	598	601	605	610	618	622	633	637	607
Quiet days	583	584	598	591	596	597	603	608	613	621	628	634	605
Disturbed days	585	600	590	603	599	601	609	611	624	625	646	641	611

Table 18
Three-hour-range *K* indices
Hel, January–March 2023
The limit of $K = 9$ is 550

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2323 1354	23	0000 1232	8	3023 1232	16
2	2211 2234	17	4211 1011	11	0112 2233	14
3	2111 1223	13	2211 2331	15	4333 3244	26
4	4432 3221	21	3210 1101	9	3333 2244	24
5	0002 3333	14	0101 1121	7	3332 4343	25
6	1001 2022	8	3223 3244	23	3233 3333	23
7	2110 1320	10	4333 3323	24	3233 2110	15
8	2222 3120	14	3333 3343	25	1122 2242	16
9	1011 1121	8	3333 2334	24	2333 3222	20
10	1111 1313	12	4223 3233	22	3111 1322	14
11	2212 1223	15	2222 2110	12	3111 1023	12
12	2112 2223	15	1212 1232	14	2223 1011	12
13	2122 1144	17	0011 2121	8	0001 1211	6
14	3322 0033	16	2022 1113	12	2333 3335	25
15	4223 3445	27	2344 3435	28	4533 3225	27
16	3132 3311	17	3244 5412	25	4212 0010	10
17	0111 1004	8	2222 2110	12	0123 2003	11
18	4423 2321	21	1112 2132	13	2223 2231	17
19	0023 2011	9	3021 2121	12	1222 2342	18
20	1101 1212	9	0013 2232	13	2012 3323	16
21	2442 2333	23	4323 2111	17	3113 1222	15
22	2112 1241	14	2022 1222	13	4333 2340	22
23	0121 3213	13	4332 3434	26	1124 6477	32
24	1111 1110	7	2122 2100	10	7743 2454	36
25	0002 2211	8	1012 1433	15	2233 3233	21
26	1222 3331	17	3233 3256	27	3212 1132	15
27	1112 2312	13	4554 5666	41	0000 0011	2
28	3221 3232	18	5433 1144	25	2011 2112	10
29	0111 1202	8			2101 1221	10
30	1012 0013	8			3223 2463	25
31	0222 1422	15			3333 2344	25

Table 19
Three-hour-range *K* indices
Hel, April–June 2023
The limit of *K* = 9 is 550

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2123 3334	21	3122 2324	19	3232 4232	21
2	3323 3124	21	2223 2121	15	2111 1111	9
3	4112 3343	21	0011 1112	7	1011 1011	6
4	3323 2134	21	1011 1313	11	2123 3342	20
5	2112 3443	20	2011 0111	7	1113 1132	13
6	1112 2142	14	4534 4332	28	2212 3110	12
7	3212 2113	15	1222 3523	20	0102 1112	8
8	1111 1213	11	4211 4433	22	2112 2220	12
9	2111 1222	12	3212 3225	20	1010 0221	7
10	3333 3312	21	4525 5432	30	1012 2221	11
11	0121 1221	10	3222 2223	18	2322 3321	18
12	0011 2101	6	2233 6432	25	1112 3322	15
13	2101 0223	11	2221 2334	19	1112 2311	12
14	1022 2213	13	1212 3322	16	3111 1100	8
15	2112 2223	15	1001 2231	10	2123 5534	25
16	0121 2111	9	2222 2222	16	4534 4323	28
17	1112 2211	11	1101 1111	7	2222 2332	18
18	0110 5543	19	0001 0000	1	3211 2342	18
19	2113 4211	15	0011 2224	12	3122 3343	21
20	0111 2312	11	5534 3333	29	2112 2323	16
21	2112 2343	18	3212 4555	27	2211 3223	16
22	2111 1212	11	5323 3443	27	0223 3233	18
23	2113 4586	30	2333 2244	23	2212 3322	17
24	5754 3333	33	2213 3332	19	2333 3333	23
25	1111 3333	16	3233 2232	20	5222 3343	24
26	2223 4333	22	2222 2212	15	2222 3323	19
27	3333 3433	25	1111 1113	10	2222 2322	17
28	3323 3433	24	2322 3222	18	2312 2222	16
29	2333 4433	25	0112 0211	8	2333 2433	23
30	2222 3211	15	1112 2212	12	2112 3300	12
31			2122 3333	19		

Table 20
Three-hour-range *K* indices
Hel, July–September 2023
The limit of *K* = 9 is 550

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2211 1211	11	2212 4332	19	3223 4232	21
2	1212 2201	11	2113 5422	20	3334 4455	31
3	1112 2111	10	1223 2200	12	5443 4413	28
4	1111 1111	8	0122 3444	20	2211 2330	14
5	1101 2323	13	5544 3211	25	0112 2442	16
6	2224 4323	22	0000 0111	3	2021 3310	12
7	3324 3344	26	3212 2234	19	2012 2223	14
8	3111 1111	10	3102 2221	13	3101 2211	11
9	0002 2211	8	1112 3222	14	2123 3211	15
10	1201 2221	11	2211 2322	15	1001 0111	5
11	2122 3322	17	1121 2211	11	1112 2222	13
12	2111 2231	13	2222 2222	16	0014 5545	24
13	2222 3422	19	2101 2211	10	5223 3423	24
14	3333 3444	27	2111 2222	13	4232 2244	23
15	3213 2100	12	0001 1112	6	2211 2213	14
16	0011 1134	11	3101 4321	15	1011 1143	12
17	3134 3243	23	3110 2221	12	3323 3333	23
18	4322 4242	23	2233 2323	20	3332 5444	28
19	1212 2211	12	2112 2232	15	5543 6543	35
20	0111 2442	15	3222 2222	17	4232 2343	23
21	3322 2334	22	2233 3221	18	2222 3323	19
22	3323 2112	17	2222 1111	12	2112 2423	17
23	0121 3322	14	1101 2112	9	2213 2123	16
24	1111 3123	13	0111 2333	14	2121 1165	19
25	1121 2224	15	2101 1211	9	5444 4323	29
26	3533 3332	25	1121 2322	14	2334 5333	26
27	2113 2221	14	3321 2222	17	3333 3321	21
28	0001 3233	12	2111 2331	14	2211 1003	10
29	3312 3332	20	0002 2112	8	2223 3111	15
30	1313 3322	18	2112 2220	12	1222 3333	19
31	1112 2312	13	1112 1221	11		

Table 21
Three-hour-range *K* indices
Hel, October–December 2023
The limit of *K* = 9 is 550

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	3112 2022	13	1213 3312	16	4325 5454	32
2	3211 2113	14	2111 2212	12	5311 0202	14
3	1112 2323	15	0111 1000	4	2222 3332	19
4	3122 2124	17	1001 2354	16	2222 3111	14
5	4423 2112	19	2125 5754	31	3323 3322	21
6	2212 1213	14	3443 2564	31	2222 3322	18
7	1120 1122	10	4333 3433	26	1111 1023	10
8	2122 0122	12	2333 1253	22	1001 1232	10
9	3122 2332	18	2232 2233	19	0010 0010	2
10	1111 0000	4	2222 2212	15	1001 0121	6
11	0011 1001	4	1121 1010	7	0000 0000	0
12	1011 0110	5	0032 2213	13	0100 3321	10
13	1233 3432	21	5212 3221	18	0111 1333	13
14	2112 2142	15	2101 1321	11	4423 3223	23
15	0002 0123	8	3221 3342	20	1003 3343	17
16	2011 2000	6	1111 2313	13	3332 3144	23
17	0001 0001	2	0000 1320	6	3434 5523	29
18	0213 3323	17	0000 0022	4	2243 3335	25
19	2212 1221	13	0001 0011	3	4322 1223	19
20	0012 3134	14	1112 1111	9	4221 2320	16
21	4432 3411	22	2232 3344	23	2002 1110	7
22	2012 1232	13	3443 3553	30	0001 0010	2
23	0011 1010	4	2221 2000	9	0111 1201	7
24	0011 1122	8	2112 2333	17	3222 2221	16
25	0000 1112	5	3334 4574	33	0111 1121	8
26	2224 4355	27	3321 2012	14	0112 2110	8
27	3332 1221	17	1112 2312	13	2112 1111	10
28	1323 3334	22	2112 1221	12	0001 0002	3
29	4343 4443	29	0111 1030	7	1112 2122	12
30	4323 3132	21	1201 2021	9	1211 1110	8
31	2122 2122	14			0000 0111	3

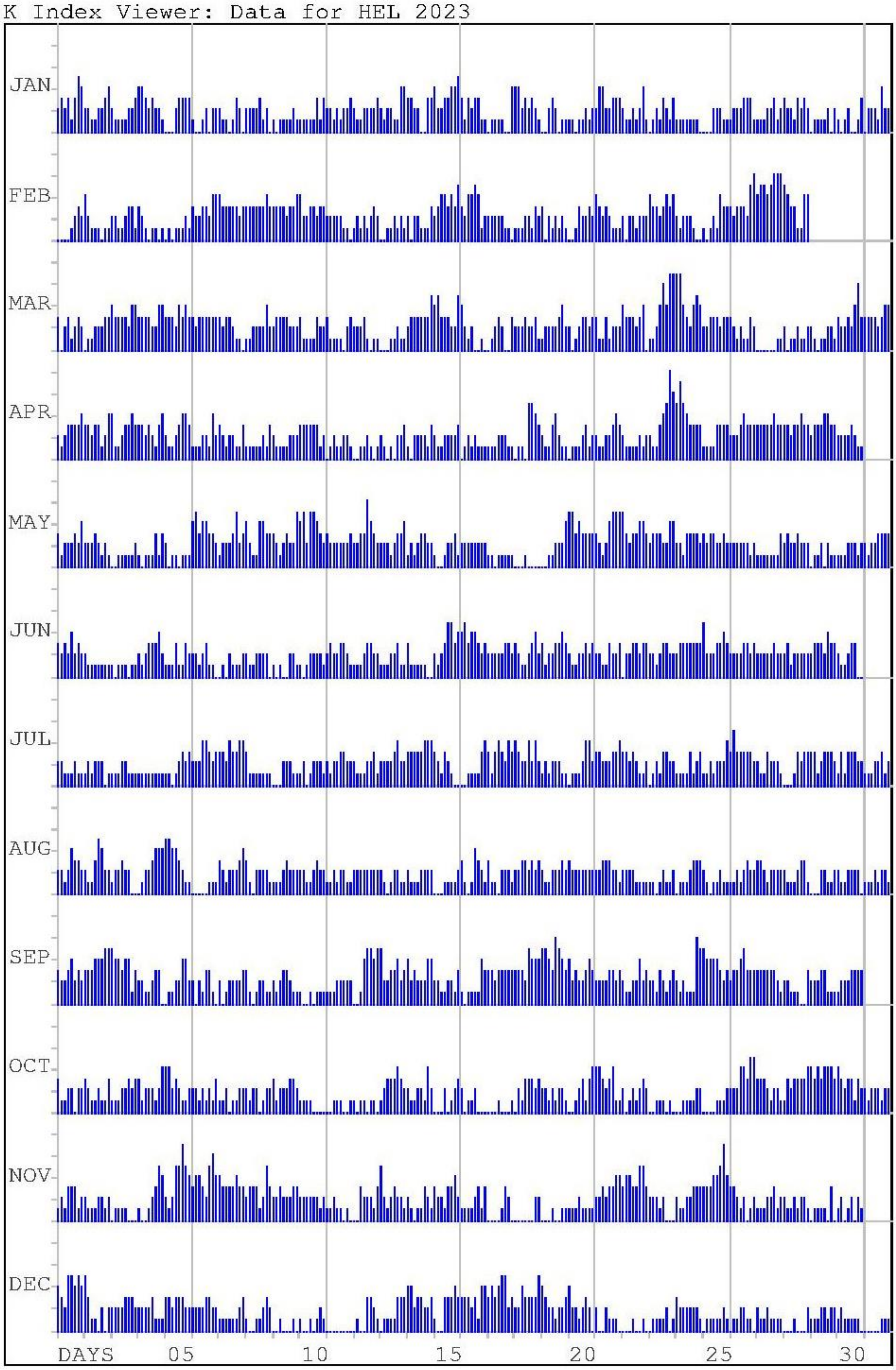

Fig. 11. *K*-indices in graphical form, Hel 2023.

9. TABLES AND PLOTS FOR HORNSUND OBSERVATORY

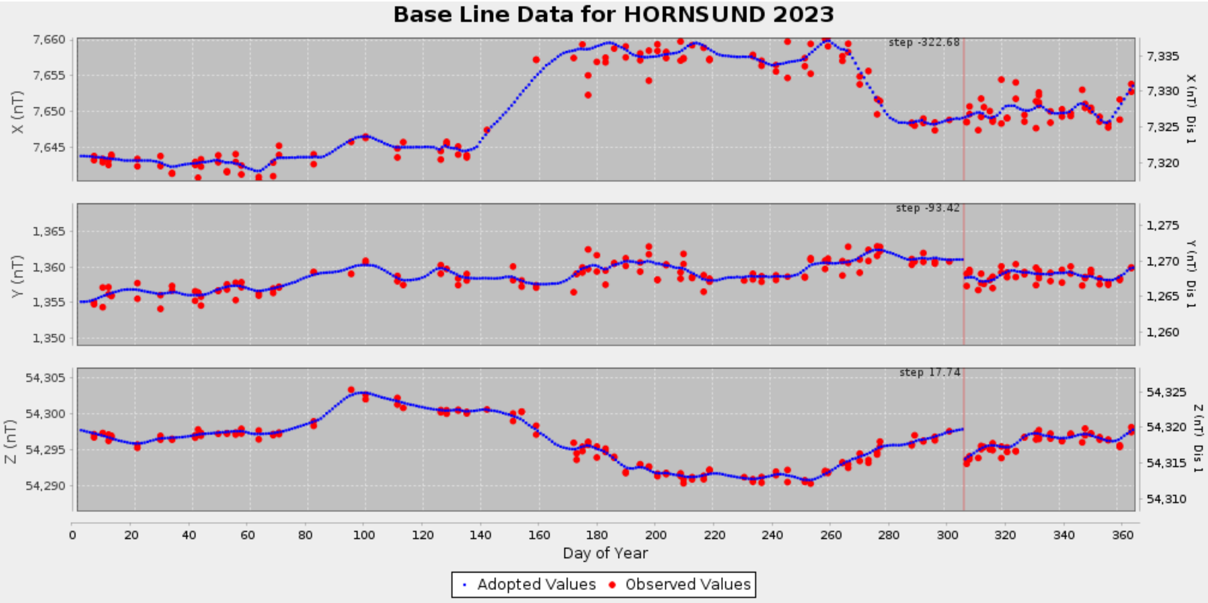

Fig. 12. Base values, Hornsund 2023.

Table 22

Annual mean values of magnetic components 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

to be continued

Table 22 (continuation)
Annual mean values of magnetic components in Hornsund Observatory

No.	Year	*D* [° ‘]	*H* [nT]	*Z* [nT]	*X* [nT]	*Y* [nT]	*I* [° ‘]	*F* [nT]
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
40	2018	8 40.6	7830	54098	7740	1181	81 45.9	54662
41	2019	9 04.5	7814	54141	7717	1233	81 47.2	54702
42	2020	9 28.2	7797	54189	7691	1283	81 48.7	54747
43	2021	9 49.5	7780	54238	7666	1327	81 50.2	54793
44	2022	10 12.3	7770	54291	7647	1376	81 51.3	54844
45	2023	10 34.8	7760	54333	7628	1425	81 52.3	54885

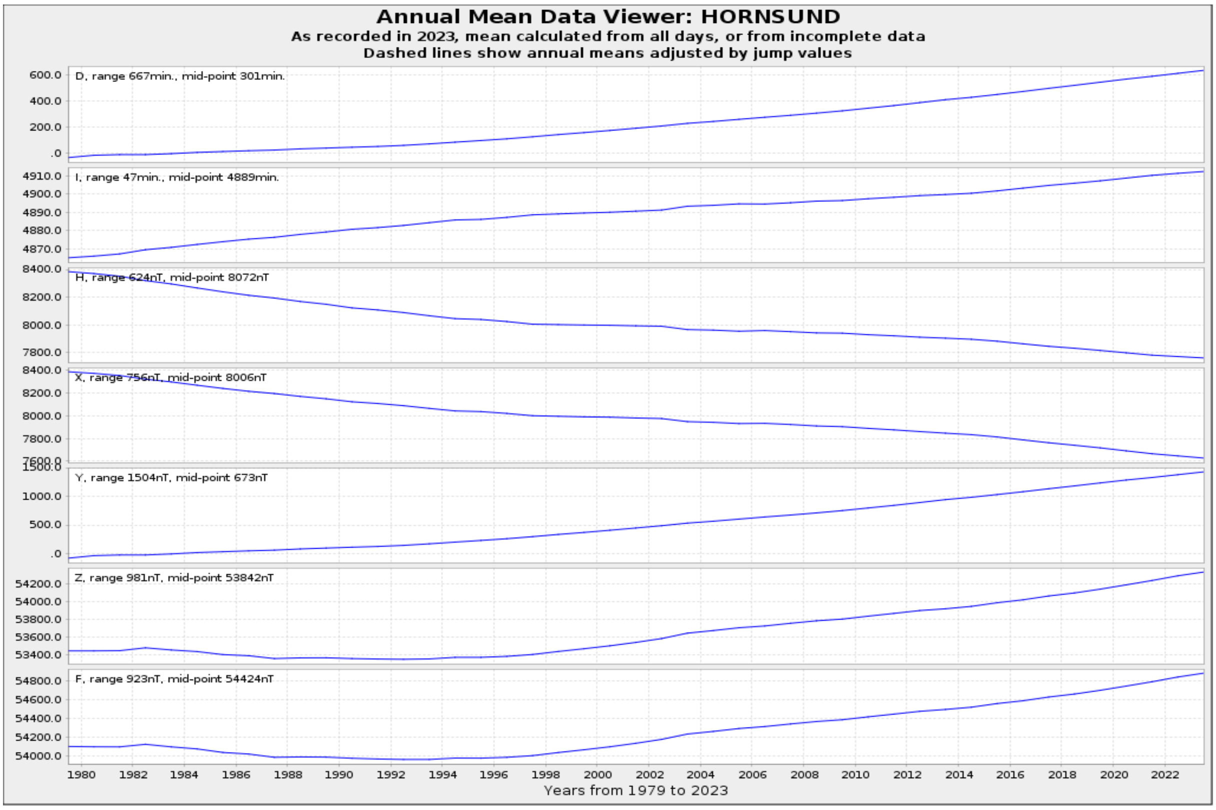

Fig. 13. Secular changes of *H*, *X*, *Y*, *Z*, *F*, *D* and *I* at Hornsund.

Table 23
Monthly and yearly mean values of magnetic components
HRN 2023

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
North component: 7500 + ... in nT													
All days	120	113	122	133	146	149	162	146	123	117	101	101	128
Quiet days	128	131	132	142	145	156	163	137	129	122	118	112	134
Disturbed days	107	92	115	111	155	123	140	151	99	94	62	75	110
East component: 1000 + ... in nT													
All days	403	408	413	414	412	418	419	426	435	443	448	454	425
Quiet days	402	409	405	410	414	407	419	424	434	441	445	450	422
Disturbed days	414	417	424	428	417	430	430	428	447	457	453	464	434
Vertical component: 5400 + ... in nT													
All days	318	329	335	325	327	318	319	322	343	345	357	360	333
Quiet days	307	314	316	316	324	325	329	320	334	338	346	345	326
Disturbed days	337	350	360	330	315	309	320	322	366	363	380	376	344

Table 24
Three-hour-range *K* indices
Hornsund, January–March 2023
The limit of *K* = 9 is 2500

Day	January		February		March	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2333 2254	24	1221 1111	10	2223 1121	14
2	2422 2224	20	3221 0021	11	0132 2222	14
3	2221 1233	16	0111 2310	9	2444 3164	28
4	5423 3100	18	4211 1100	10	4343 2255	28
5	1012 3111	10	0112 1100	6	2444 4343	28
6	3011 1024	12	4343 3265	30	4343 3353	28
7	3231 2311	16	5534 2224	27	3343 2240	21
8	1232 3120	14	2334 3254	26	1132 2232	16
9	1121 1121	10	4452 3242	26	1434 3321	21
10	3111 1023	12	3233 3244	24	4131 2212	16
11	2223 1111	13	3344 2011	18	2122 3112	14
12	4332 2114	20	3322 2322	19	4243 1000	14
13	3121 2132	15	1111 1211	9	0001 1000	2
14	3132 0024	15	0132 1111	10	2444 3343	27
15	5422 1235	24	3324 2213	20	5554 3224	30
16	3233 2300	16	2244 4422	24	2313 0000	9
17	0232 1002	10	2332 2042	18	1232 3004	15
18	3322 2301	16	0122 2132	13	2233 2151	19
19	0122 1023	11	4132 2131	17	1332 2332	19
20	2111 2313	14	1123 3222	16	2222 4312	18
21	1342 2352	22	3332 3211	18	2223 2222	17
22	3222 2252	20	1132 2332	17	3333 2341	22
23	1221 2233	16	4433 3365	31	1244 3463	27
24	2322 2201	14	2222 3000	11	5444 2223	26
25	0112 2212	11	0122 2332	15	2334 3252	24
26	1332 2221	16	2243 3234	23	3322 2233	20
27	2123 2514	20	5434 3666	37	1110 0001	4
28	2232 2224	19	6333 2155	28	2111 3231	14
29	1232 1312	15			2212 3221	15
30	1123 2002	11			3433 3354	28
31	0123 1532	17			4444 3455	33

Table 25
Three-hour-range *K* indices
Hornsund, April–June 2023
The limit of *K* = 9 is 2500

Day	April		May		June	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	3233 4332	23	2333 2343	23	3354 4432	28
2	3454 2114	24	3344 2241	23	3322 1112	15
3	4232 3333	23	0112 2112	10	2132 1011	11
4	4333 2124	22	1332 2223	18	2243 2222	19
5	2223 3233	20	2222 1121	13	2233 2122	17
6	2222 2141	16	4445 3232	27	2324 3111	17
7	4232 2102	16	2233 3322	20	1222 3221	15
8	1132 2102	12	3344 4334	28	2333 3221	19
9	2222 2221	15	4333 3224	24	2211 1132	13
10	3344 3211	21	4436 5332	30	2232 2111	14
11	0142 2131	14	2333 3223	21	3433 3323	24
12	0122 2101	9	2354 4332	26	1232 3232	18
13	2211 2222	14	2341 2145	22	2344 3332	24
14	1133 3212	16	2332 3332	21	3222 1211	14
15	2334 3122	20	2121 2251	16	2334 5445	30
16	1232 2121	14	2333 3231	20	5556 4333	34
17	2232 3211	16	2212 2111	12	2343 3242	23
18	1221 3432	18	1221 1220	11	3433 3331	23
19	2224 *321	*	0122 3232	15	3333 3433	25
20	1111 1201	8	3366 3334	31	3333 4324	25
21	2223 2332	19	2223 3355	25	3432 2123	20
22	2322 1113	15	5354 3243	29	2344 3322	23
23	4333 5465	33	2343 2245	25	3333 3222	21
24	6454 4323	31	3323 3242	22	4453 3333	28
25	2122 3344	21	4445 4252	30	3333 3333	24
26	2334 4342	25	3333 2122	19	2444 3434	28
27	3365 3535	33	2322 1112	14	3434 3323	25
28	3334 3454	29	4344 3123	24	3433 3223	23
29	3445 5542	32	2123 1211	13	3544 4334	30
30	2343 3201	18	2122 2123	15	3334 5211	22
31			3343 3*33	*		

Table 26
Three-hour-range *K* indices
Hornsund, July–September 2023
The limit of $K = 9$ is 2500

Day	July		August		September	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	3322 2122	17	3232 3332	21	2334 4232	23
2	2333 3333	23	2233 3322	20	3533 4365	32
3	3222 2232	18	1233 2310	15	4354 4321	26
4	2343 3111	18	1235 4353	26	1222 3220	14
5	1212 2332	16	3455 4312	27	1122 3541	19
6	2345 4224	26	1110 1221	9	2222 3232	18
7	3455 5333	31	3322 5235	25	2122 3111	13
8	3332 1221	17	3223 3232	20	2122 2210	12
9	2122 3321	16	2343 3223	22	2223 3320	17
10	2222 2222	16	2322 3322	19	1112 1112	10
11	3233 3234	23	2233 2111	15	1223 *112	*
12	3333 3321	21	3332 3322	21	1113 4432	19
13	2232 2222	17	2323 3102	16	3243 3412	22
14	2343 3333	24	2121 3212	14	4342 2154	25
15	4223 3111	17	1111 1001	6	2221 3212	15
16	2212 2134	17	2222 3311	16	1131 1242	15
17	3244 4154	27	2331 3220	16	2433 3254	26
18	4343 4221	23	1443 1223	20	4332 4333	25
19	1233 3211	16	2323 3132	19	6254 3542	31
20	2222 3332	19	5424 3222	24	3333 2233	22
21	2333 2224	21	2234 3141	20	1333 3445	26
22	3333 3112	19	1432 2112	16	3333 3332	23
23	1232 3343	21	1211 2103	11	1333 2222	18
24	3323 4113	20	1121 3433	18	1223 2136	20
25	2231 4223	19	1212 2221	13	4444 3332	27
26	4545 3222	27	1242 3222	18	2322 3555	27
27	2223 3121	16	4532 3322	24	5444 4222	27
28	1122 3*23	*	1333 2321	18	2412 2112	15
29	3223 4222	20	1102 3101	9	2224 2110	14
30	2343 4222	22	1222 4120	14	1333 3322	20
31	2333 4312	21	2231 1132	15		

Table 27
Three-hour-range *K* indices
Hornsund, October–December 2023
The limit of *K* = 9 is 2500

Day	October		November		December	
	K	*SK*	*K*	*SK*	*K*	*SK*
1	2122 3113	15	1223 3342	20	5435 4445	34
2	2222 3123	17	13** 1243	*	5210 0100	9
3	1211 2311	12	0321 1000	7	1233 2213	17
4	2332 2124	19	0111 2222	11	1443 2213	20
5	4443 3112	22	1224 5442	24	3434 3313	24
6	2223 1122	15	3333 2255	26	3333 2443	25
7	0220 0011	6	5233 3444	28	2233 2133	19
8	1221 1111	10	*443 2143	*	3223 1152	19
9	1232 2221	15	2332 2254	23	0121 0000	4
10	1111 2110	8	2233 3234	22	0121 1033	11
11	0111 2002	7	3242 1030	15	1210 1102	8
12	1010 0000	2	0243 2101	13	0111 3321	12
13	0133 3331	17	6222 2110	16	0122 2132	13
14	1222 2044	17	1100 2331	11	3302 2001	11
15	1001 0043	9	3322 3232	20	0112 3333	16
16	2112 3000	9	1223 2234	19	5452 2024	24
17	0010 0001	2	0121 1111	8	3444 5411	26
18	0212 3442	18	0111 0012	6	1333 2245	23
19	1212 1222	13	0112 1022	9	2432 1114	18
20	1233 2222	17	1222 2001	10	6332 2421	23
21	3222 1211	14	1222 2223	16	4222 2110	14
22	0112 2121	10	2333 3534	26	0211 0000	4
23	1110 1000	4	2331 2000	11	0111 1201	7
24	0021 0012	6	2222 3123	17	2421 2111	14
25	1211 1011	8	2333 3335	25	0221 1011	8
26	2233 5365	29	3421 2011	14	0122 1111	9
27	2223 2242	19	1323 2512	19	2322 2001	12
28	1433 2333	22	1232 1331	16	0001 1000	2
29	3444 4455	33	1221 2121	12	2222 1113	14
30	5433 3123	24	1321 2010	10	0221 1100	7
31	1333 3**2	*			0000 1112	5

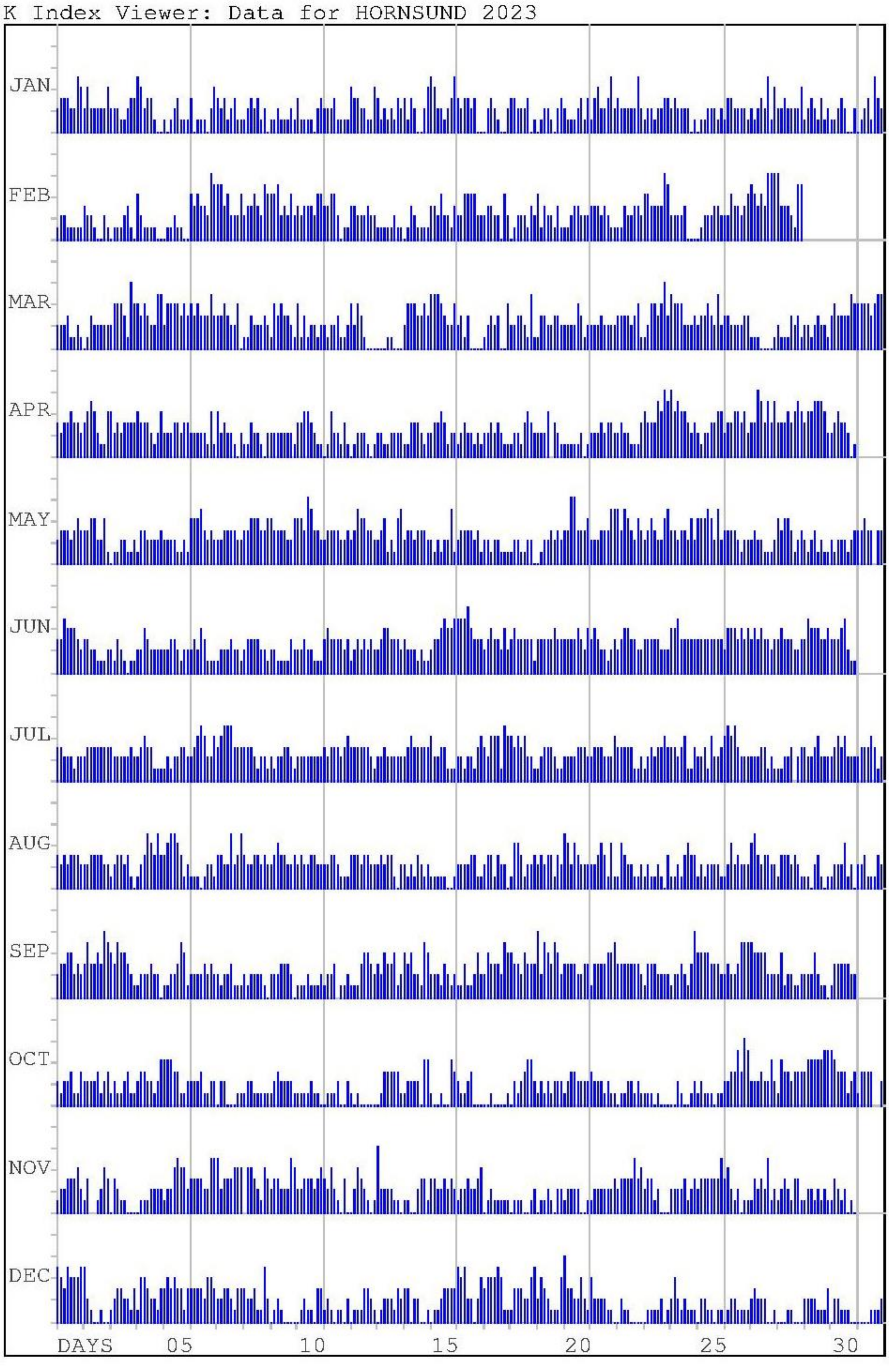

Fig. 14. *K*-indices in graphical form, Hornsund 2023.

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