



British
Geological
Survey



MONTHLY MAGNETIC BULLETIN

Lerwick Observatory

September 2022



Lerwick Observatory magnetic data

1. Introduction

Lerwick Observatory is one of three geomagnetic observatories in the UK operated and maintained by the British Geological Survey (BGS).

This bulletin is published to provide rapid access to the provisional geomagnetic observatory results. The information is freely available for personal, academic, educational and non-commercial research or use. Magnetic observatory data are presented as a series of plots of one-minute, hourly and daily values, followed by tabulations of monthly values, reports of rapid variations and geomagnetic activity indices. The operation of the observatory and presentation of data are described in the rest of this section.

Enquiries about the data should be addressed to:

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Internet: geomag.bgs.ac.uk

2. Position

The observatory is situated on a ridge of high ground about 2.5 km to the SW of the port of Lerwick in Shetland. The observatory co-ordinates are:

Geographic: 60° 08'16.8"N 358° 49'01.2"E
Geomagnetic: 61° 48'36.0"N 088° 02'31.2"E
Height above mean sea level: 85 m

The geographical coordinates are measured by a handheld GPS device, which uses WGS84 as the reference coordinate system. The height above MSL is determined from the best available contour maps. The geomagnetic co-ordinates are approximations, calculated using the 13th generation International Geomagnetic Reference Field (IGRF) at epoch 2021.5. On-line access to models (including IGRF), charts and navigational data are available at geomag.bgs.ac.uk/data_service/models_compass/home

3. The observatory operation

3.1 GDAS

The observatory operates under the control of the Geomagnetic Data Acquisition System (GDAS), which was developed by BGS staff, installed in 2002, and became fully operational in January 2003. The data acquisition software, running on QNX operated computers, controls the data logging and the communications.

There are two sets of sensors used for making magnetic measurements. A tri-axial linear-core fluxgate magnetometer, manufactured by the Danish Meteorological Institute, is used to measure the variations in the horizontal (H) and vertical (Z) components of the field. The third sensor is oriented perpendicular to these, and measures variations, which are proportional to the changes in declination (D). Measurements are made at a rate of 1 Hz.

In addition to the fluxgate sensors there is a proton precession magnetometer (PPM) making measurements of the absolute total field intensity (F) at a rate of 0.1Hz.

The raw unfiltered data are retrieved automatically via Internet connections to the BGS office in Edinburgh in near real-time. The fluxgate data are filtered to produce one-minute values using a 61-point cosine filter and the total field intensity samples are filtered using a 7-point cosine filter. The one-minute values provide input for various data products, available on-line at geomag.bgs.ac.uk/data_service/home

3.2 Back-up systems

There are two other fully independent identical systems, GDAS 2 and GDAS 3, operating at the observatory. The data from these are also processed in near real-time and used for quality control purposes. They are also used to fill any gaps or replace any corrupt values in the primary system, GDAS 1.

3.3 Absolute observations

The GDAS fluxgate magnetometers accurately measure variations in the components of the geomagnetic field, but not the absolute magnitudes. Two sets of absolute measurements of the field are made manually once per week. A fluxgate sensor mounted on a theodolite is used to determine D and inclination (I); the GDAS PPM measurements, with a site difference correction applied, are used for F . The absolute observations are used in conjunction with the GDAS variometer measurements to produce a continuous record of the absolute values of the geomagnetic field elements as if they had been measured at the observatory reference pillar.

4. Observatory results

The data presented in the bulletin are in the form of plots and tabulations described in the following sections.

4.1 Absolute observations

The absolute observation measurements made during the month are tabulated. Also included are the corresponding baseline values, which are the differences between the absolute measurements and the variometer measurements of D , H and Z (in the sense absolute-variometer). These are also plotted (markers) along with the derived preliminary daily baseline values (line) throughout the year. Daily mean differences between the measured absolute F and the F computed from the baseline corrected H and Z values are plotted in the fourth panel (in the sense measured-derived). The bottom panel shows the daily mean temperature in the fluxgate chamber.

4.2 Summary magnetograms

Small-scale magnetograms are plotted which allow the month's data to be viewed at a glance. They are plotted 16 days to a page and show the one-minute variations in D , H and Z . The scales are shown on the right-hand side of the page. On disturbed days the scales are multiplied by a factor, which is indicated above the panel for that day. The variations are centred on the monthly mean value, shown on the left side of the page.

4.3 Magnetograms

The daily magnetograms are plotted using one-minute values of D , H and Z from the fluxgate sensors, with any gaps filled using back-up data. The magnetograms are plotted to a variable scale; scale bars are shown to the right of each plot. The absolute level (the monthly mean value) is indicated on the left side of the plots.

4.4 Hourly mean value plots

Hourly mean values of D , H and Z for the past 12 months are plotted in 27-day segments corresponding to the Bartels solar rotation number. Magnetic disturbances associated with active regions and/or coronal holes on the Sun may recur after 27 days: the same is true for geomagnetically quiet intervals. Plotting the data in this way highlights this recurrence. Diurnal variations are also clear in these plots and the amplitude changes throughout the year highlight the seasonal changes. Longer term secular variation is also illustrated.

Full lists of the UK observatory hourly mean values from 1983 to the present day are available at geomag.bgs.ac.uk/data_service/data/obs_data/hourly_means

4.5 Daily and monthly mean values

Daily mean values of D , H , Z and F are plotted throughout the year. In addition, a table of monthly mean values of all the geomagnetic elements is provided. These values depend on accurate specification of the fluxgate sensor baselines. It is anticipated that these provisional values will not be altered by more than a few nT or tenths of arcminutes before being made definitive at the end of the year.

4.6 Rapid variations

Charged particles stream from the Sun in the solar wind. The solar wind interacts with the geomagnetic field to create a cavity, the magnetosphere, in which the field is confined. When a region of enhanced velocity and/or density in the solar wind arrives at the dayside boundary of the magnetosphere (at about 10 earth radii) the boundary is pushed towards the Earth. Currents set up on the boundary of the magnetosphere can cause an abrupt change in the geomagnetic field measured on the ground and this is recorded on observatory magnetograms as a sudden impulse (si). If, following an si , there is a change in the rhythm of activity, the si is termed a storm sudden commencement (ssc). A classical magnetic storm exhibiting initial, main and recovery phases (shown by, for instance, the Dst ring current index) can often occur after a ssc , in which case the start of the storm is taken as the time of the ssc .

Solar flares, seen at optical wavelengths as a sudden brightening of a small region of the Sun's surface, are also responsible for increased X-ray emissions. These X-rays cause increased ionisation in the ionosphere, which leads to absorption of short-wave radio signals. A solar flare effect (sfe), or "crochet", may be observed on a magnetogram during geomagnetically quiet times. It is a relatively short-term change (tens of minutes) to the normal diurnal variation and can vary in size (tens of nT) depending on local time (LT), geomagnetic latitude and solar zenith angle.

4.7 Local geomagnetic activity indices

The Observatory K index. This summarises geomagnetic activity at an observatory by assigning a code, an integer in the range 0 to 9, to each 3-hour Universal Time (UT) interval. The index for each 3-hour UT interval is determined from the maximum range in H or D

(scaled in nT), with allowance made for the regular (undisturbed) diurnal variation. The conversion from range to an index value is made using a quasi-logarithmic scale, with the scale values dependent on the geomagnetic latitude of the observatory. The lower bounds (in nT) for the classification of each period at Lerwick are:

0	1	2	3	4	5	6	7	8	9
0	10	20	40	80	140	240	400	660	1000

The K index retains the LT and seasonal dependence of activity associated with the position of the observatory. The 3-hourly K indices for the month are tabulated and also plotted as a histogram. All UK observatory K indices are available at geomag.bgs.ac.uk/data_service/data/magnetic_indices/k_indices

4.8 Global geomagnetic activity indices

The aa index. A number of 3-hour geomagnetic indices are computed by combining K indices from networks of observatories to characterise global activity levels and to eliminate LT and seasonal effects. The simplest of these is the aa index, computed using the K indices from two approximately antipodal observatories: Hartland in the UK and Canberra in Australia. The aa index is calculated from linearisations of the Hartland and Canberra K indices, and has units of nT. The 3-hourly aa indices are tabulated along with the daily mean value of aa (denoted Aa), the mean values of aa for the intervals 00-12UT (Aa_{am}) and 12-24UT (Aa_{pm}) and the monthly mean value. The 3-hourly aa indices for the month are also plotted as a histogram.

Although the aa index is based on data from only two observatories, provided averages over 12 hours or longer are used, the index is strongly correlated with the ap and am indices, which are derived using data from more extensive observatory networks.

The aa indices listed in this bulletin are available at geomag.bgs.ac.uk/data_service/data/magnetic_indices/aaindex as well as the full data set from 1868.

Definitive aa are published by the International Service for Geomagnetic Indices, EOST, 5 rue René Descartes, 67084 Strasbourg Cedex, France.

5. Conditions of use

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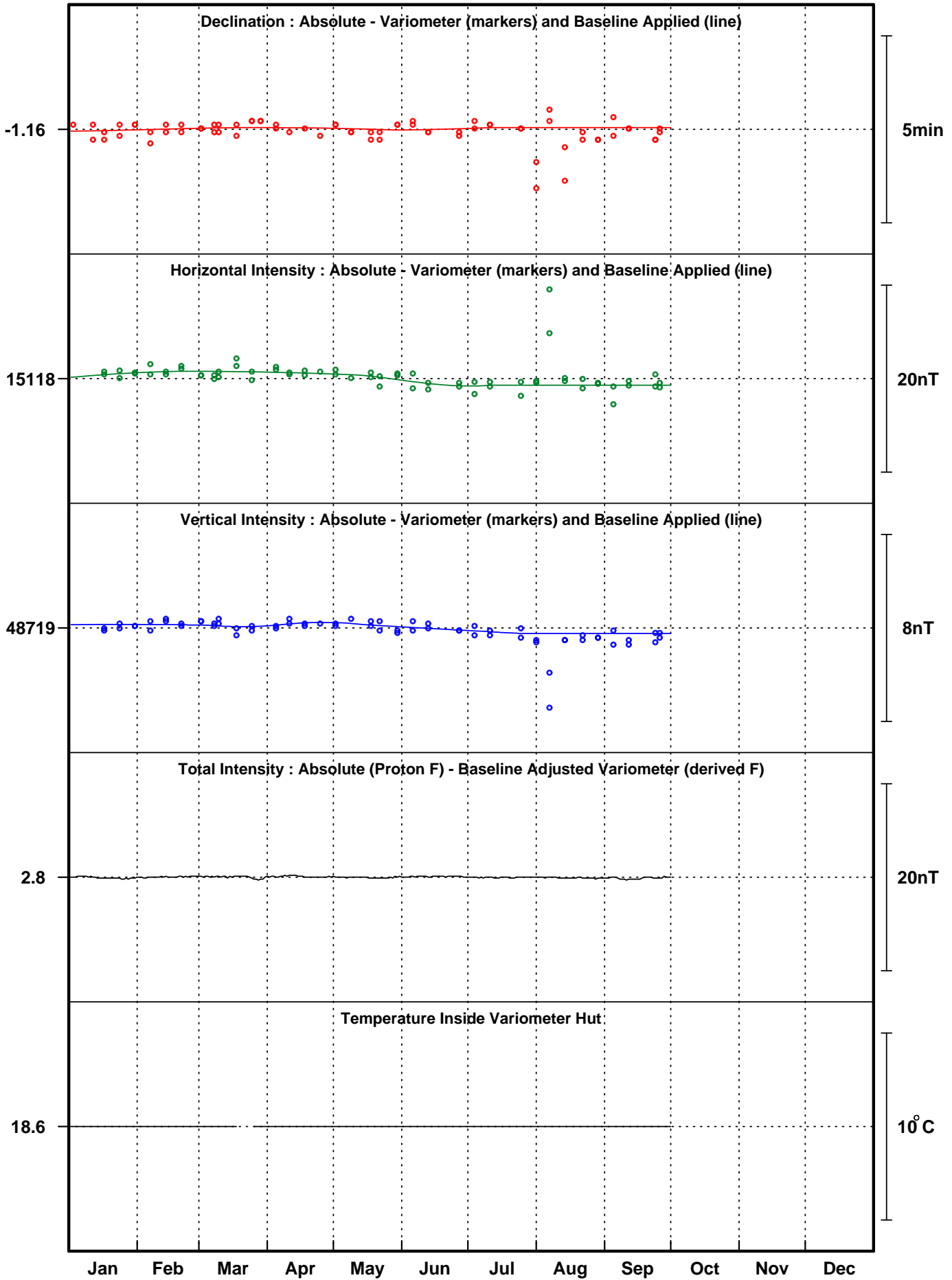
Commercial users can contact the geomagnetism team for information on the range of applications and services offered. Full contact details are available at geomag.bgs.ac.uk/contactus/staff

Lerwick Observatory

Absolute observations

Date	Day Number	Declination			Inclination		Total field		Horizontal intensity		Vertical intensity		Observer
		Time (UT)	Absolute (°)	Baseline (°)	Time (UT)	Absolute (°)	Site difference (nT)	Absolute corrected (nT)	Absolute (nT)	Baseline (nT)	Absolute (nT)	Baseline (nT)	
04-Sep-22	247	16:40	-0.1057	-1.1567	16:58	72.7922	-2.8	51298.0	15175.9	15116.8	49001.8	48718.2	MT
04-Sep-22	247	17:11	-0.1716	-1.1650	17:21	72.7844	-2.8	51317.1	15188.2	15114.9	49018.0	48718.8	MT
11-Sep-22	254	14:25	-0.3054	-1.1617	14:38	72.8817	-2.8	51165.8	15060.5	15116.9	48899.1	48718.4	PAN
11-Sep-22	254	14:50	-0.2620	-1.1617	15:02	72.8799	-2.8	51171.2	15063.5	15117.4	48903.8	48718.2	PAN
23-Sep-22	266	05:45	-0.1575	-1.1667	05:58	72.8407	-2.8	51147.4	15090.0	15116.8	48870.8	48718.7	OB
23-Sep-22	266	06:10	-0.1518	-1.1667	06:24	72.8364	-2.8	51147.3	15093.6	15118.1	48869.6	48718.3	OB
25-Sep-22	268	09:33	-0.1312	-1.1617	09:43	72.8827	-2.8	51141.2	15052.3	15116.7	48875.9	48718.7	NJL
25-Sep-22	268	09:51	-0.1397	-1.1633	10:00	72.8860	-2.8	51139.8	15049.1	15117.2	48875.4	48718.5	NJL

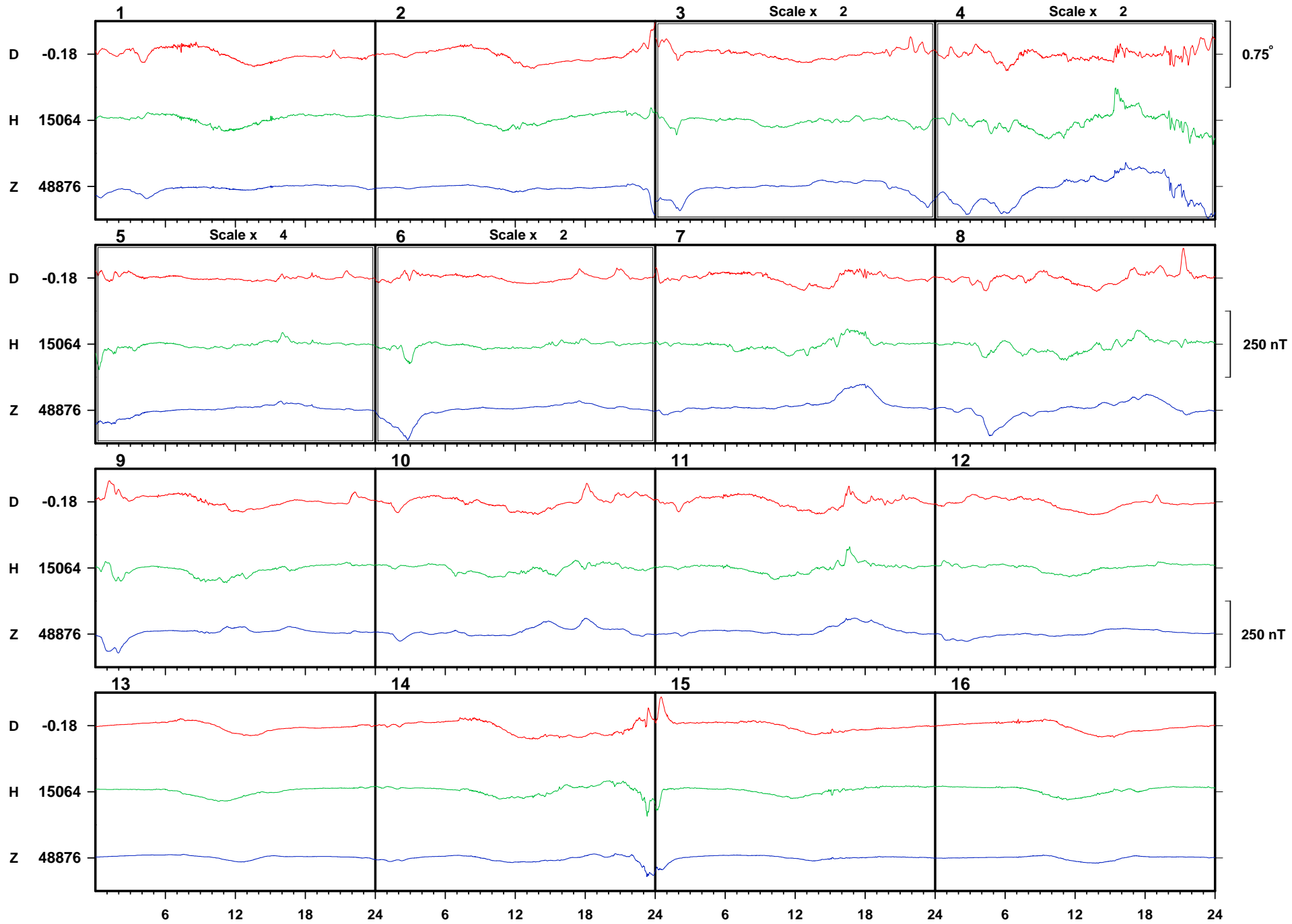
Lerwick 2022

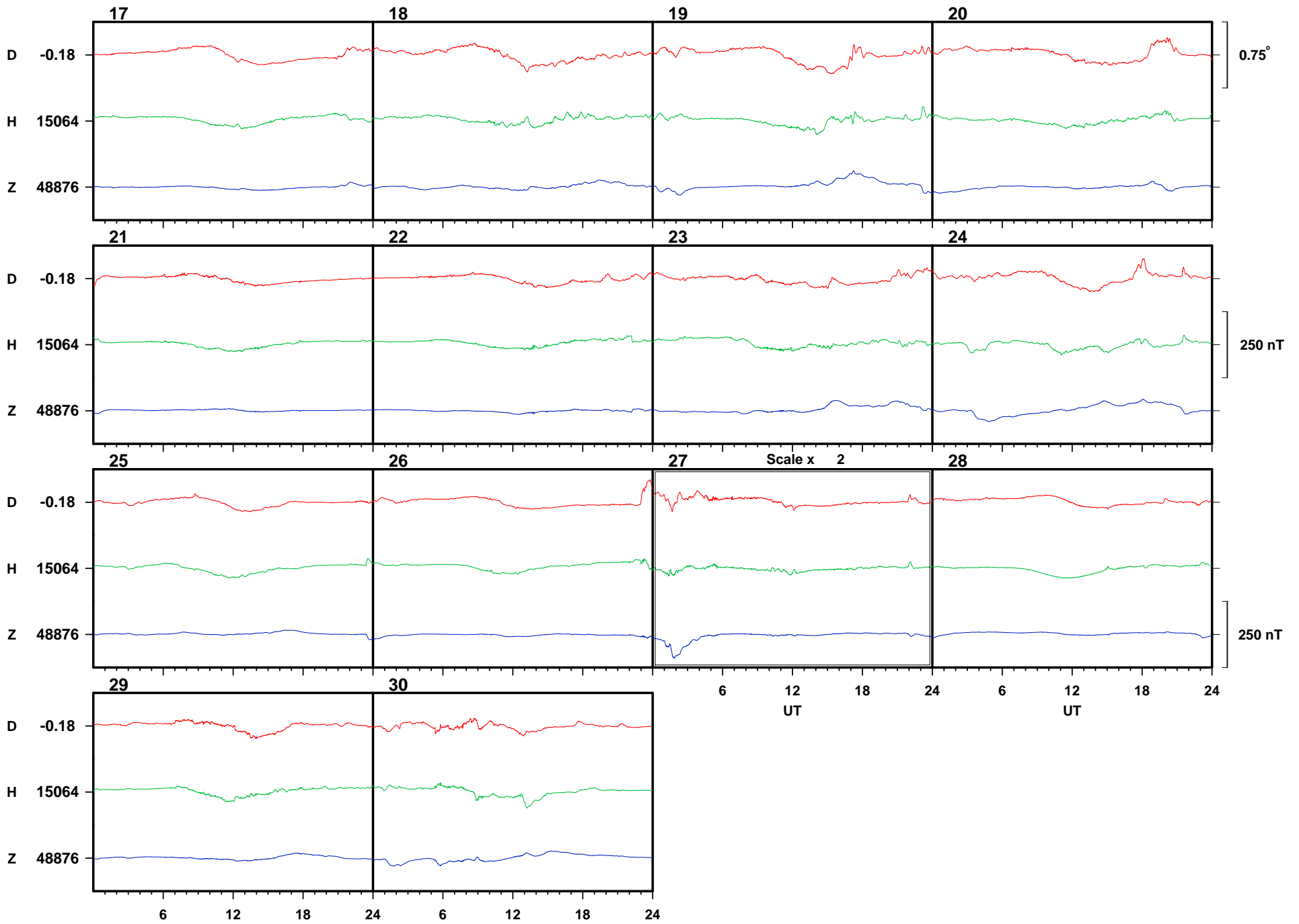


Lerwick

September

2022





Lerwick

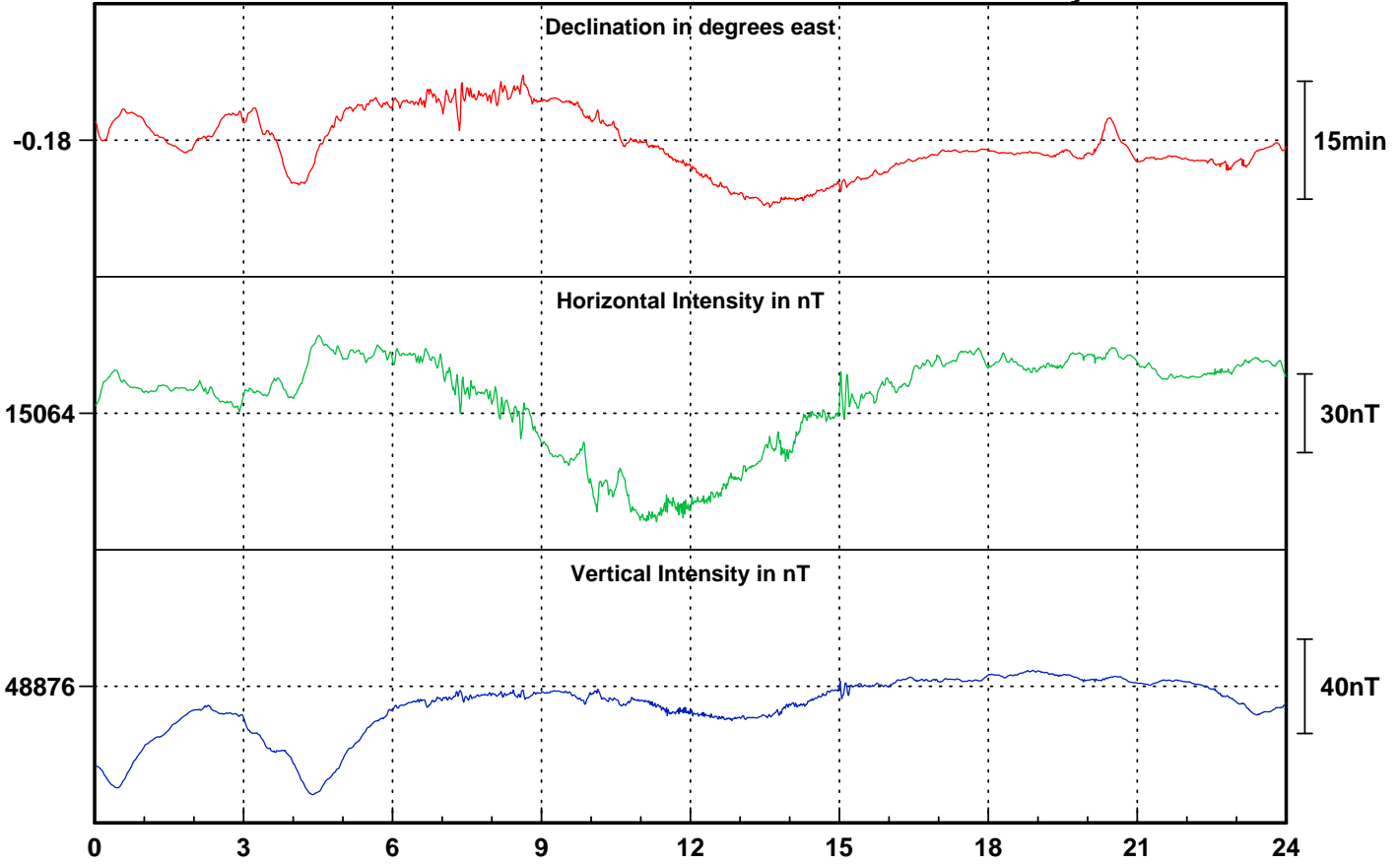
September

2022

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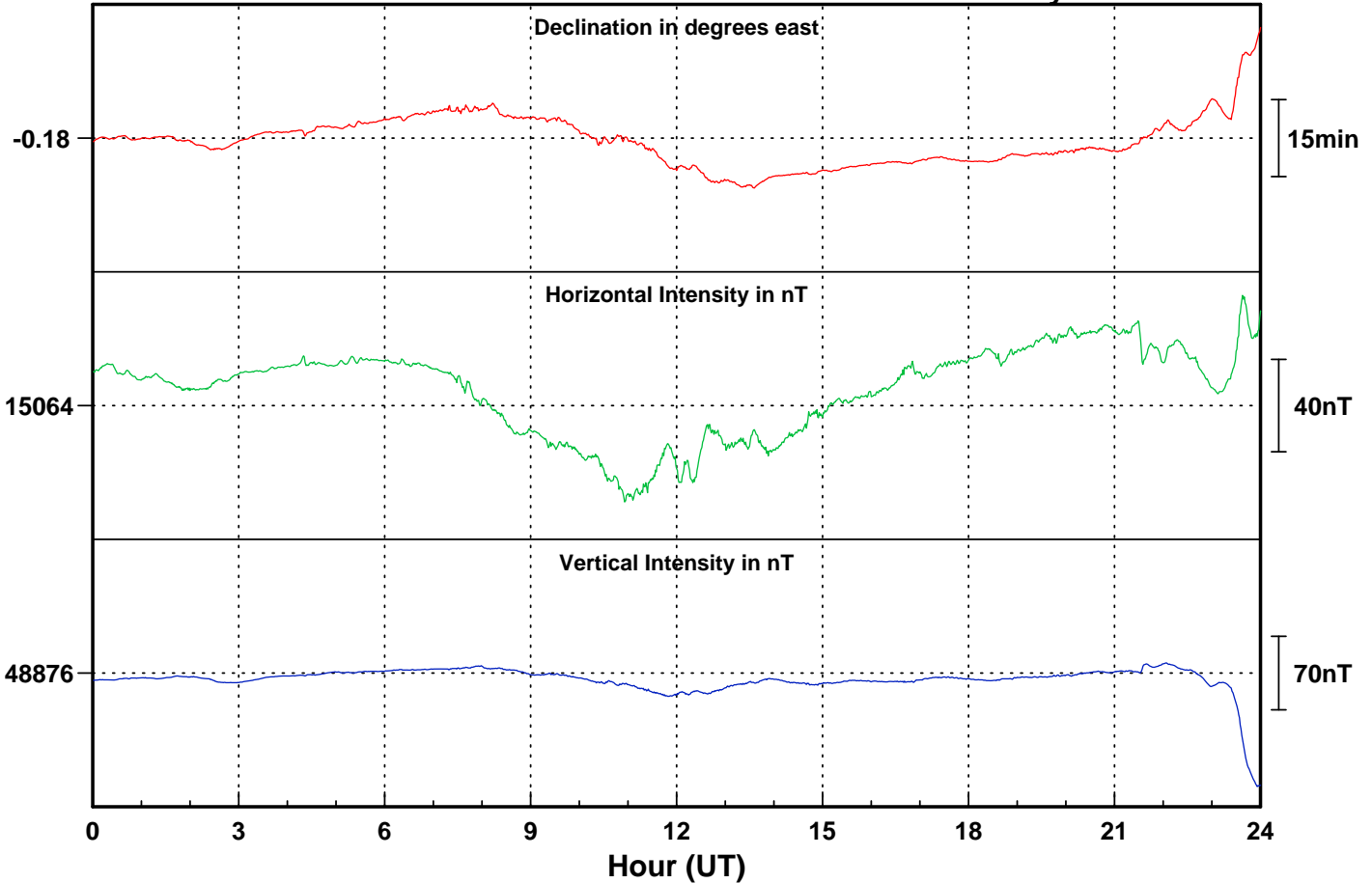
Lerwick

Day number: 244



Date: 02-09-2022

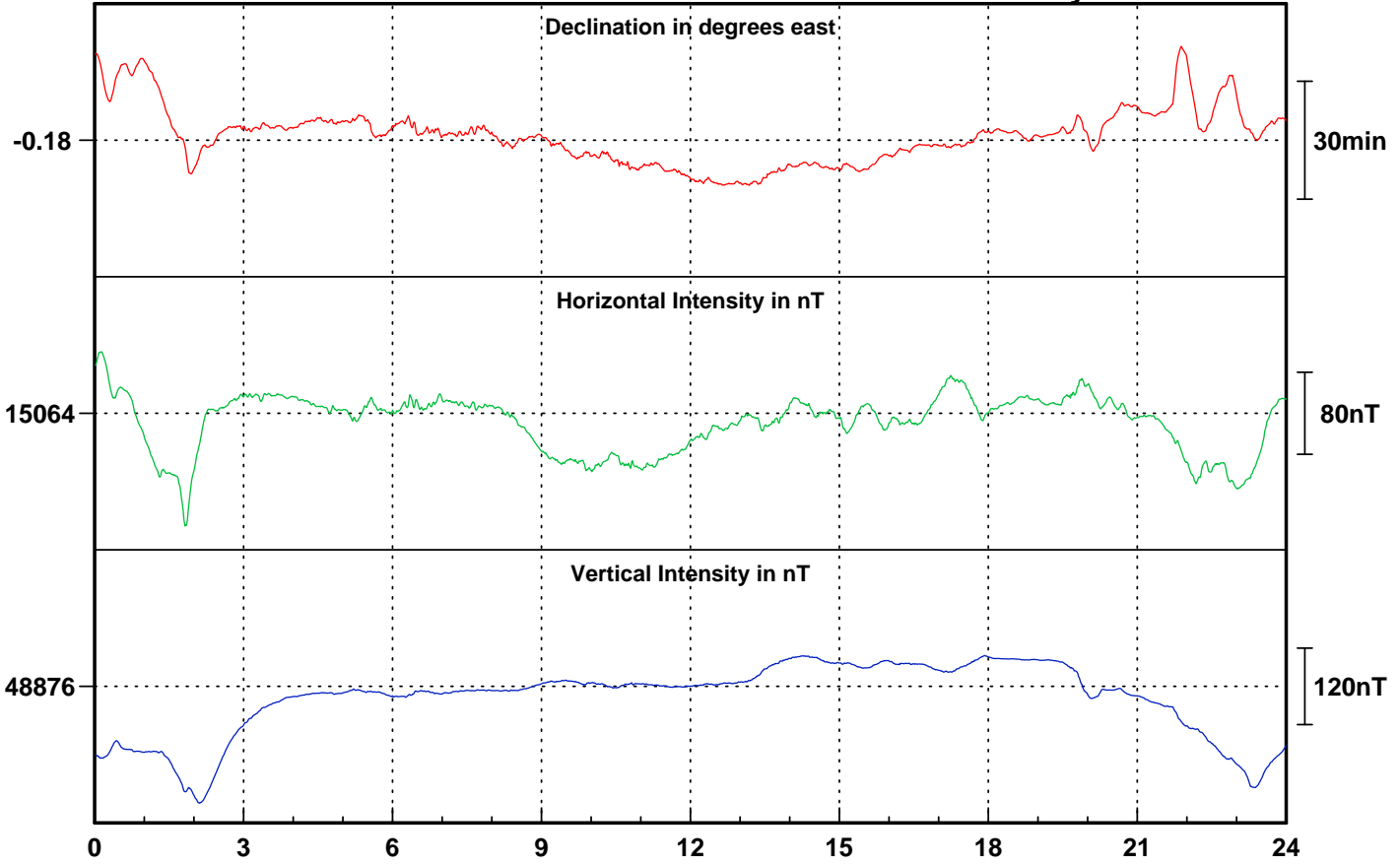
Day number: 245



Date: 03-09-2022

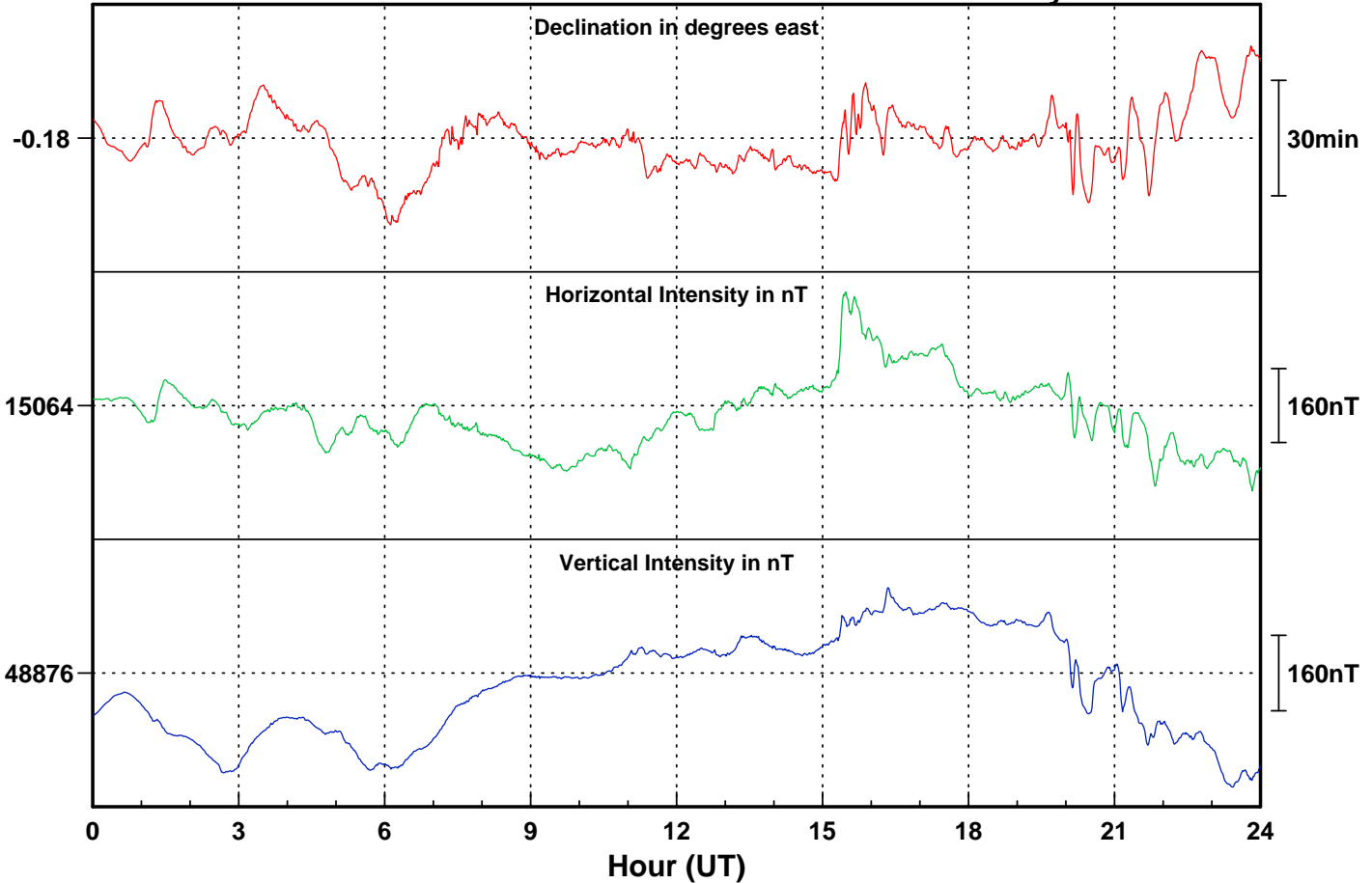
Lerwick

Day number: 246



Date: 04-09-2022

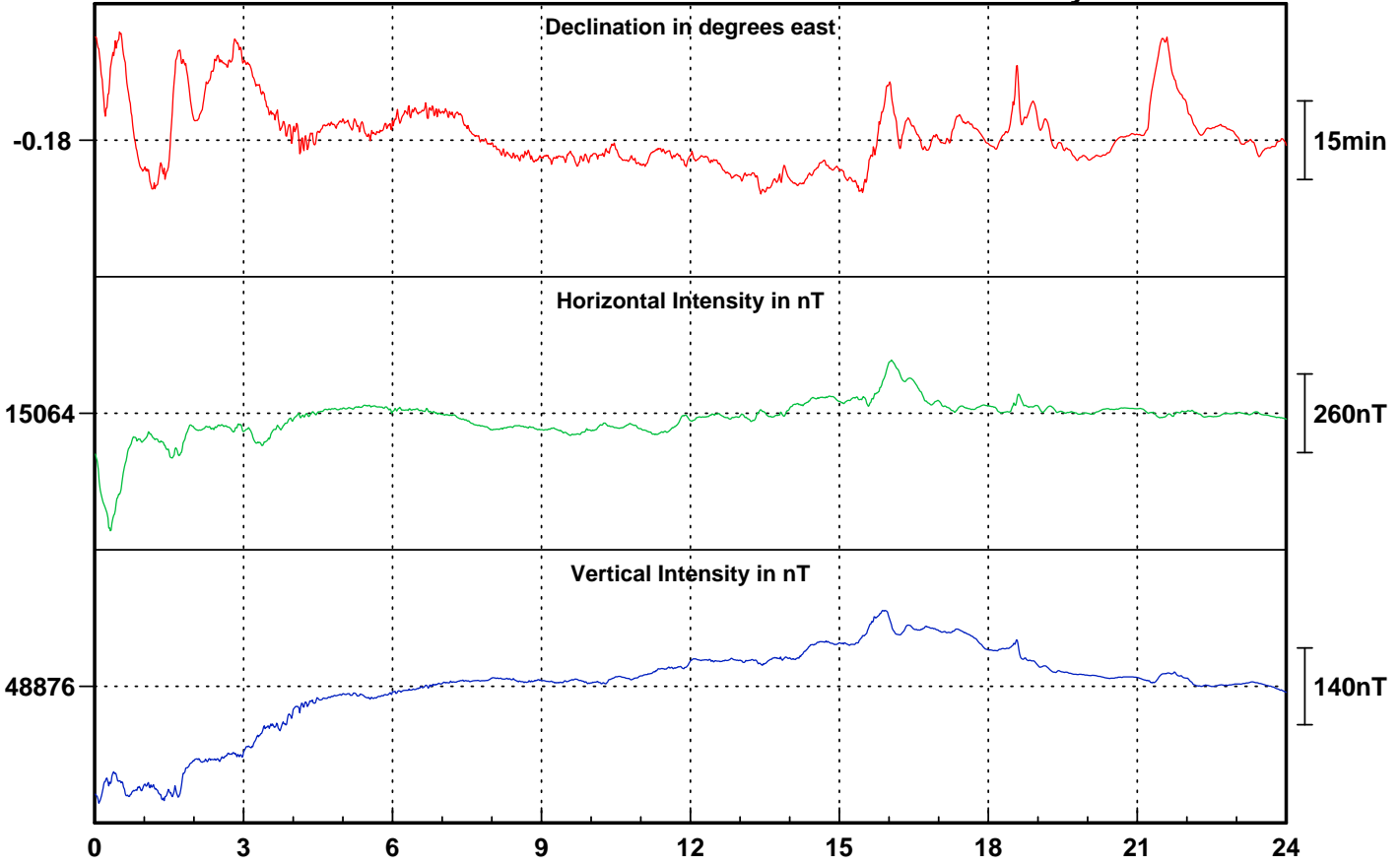
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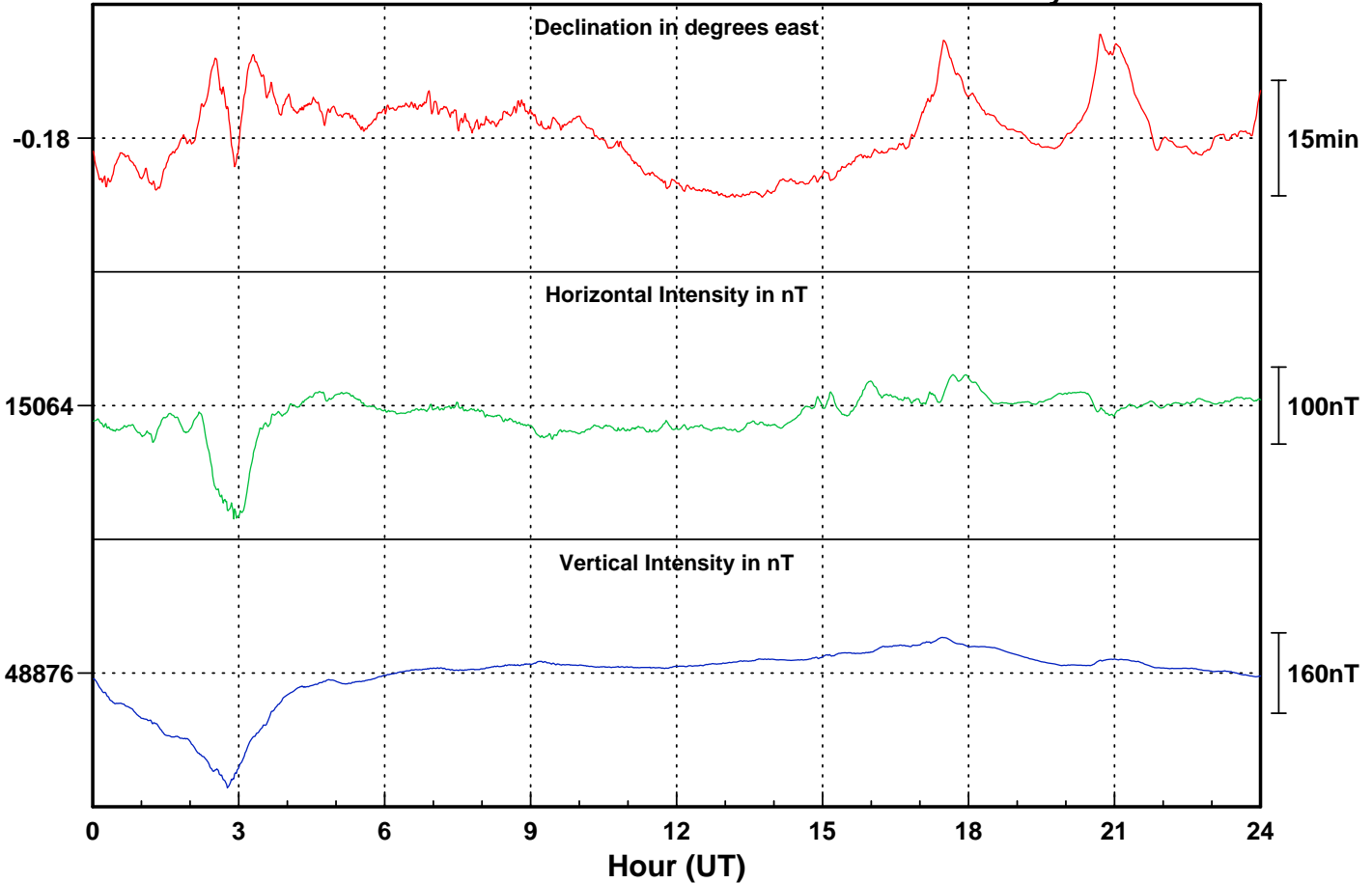
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Day number: 248



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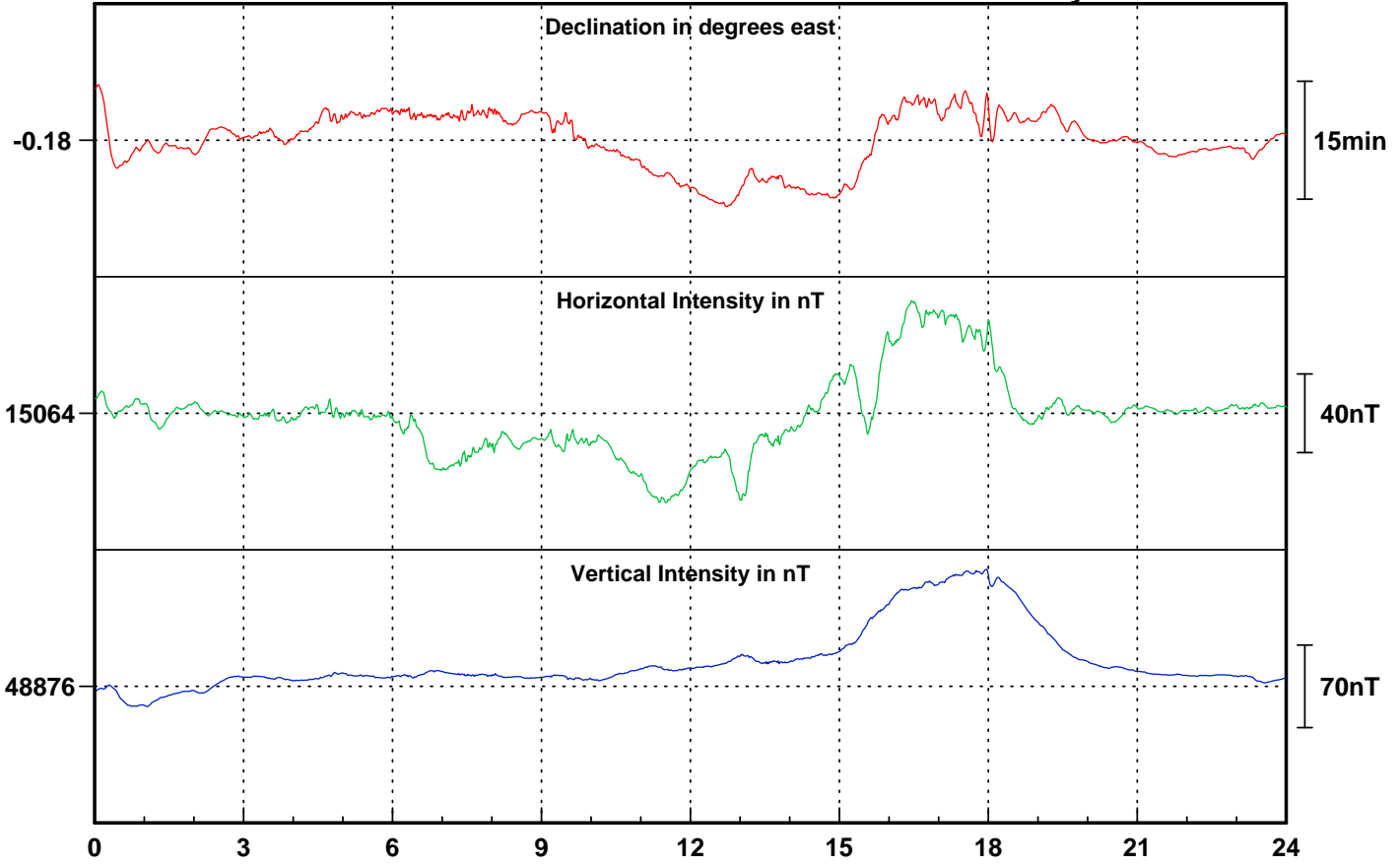
Day number: 249



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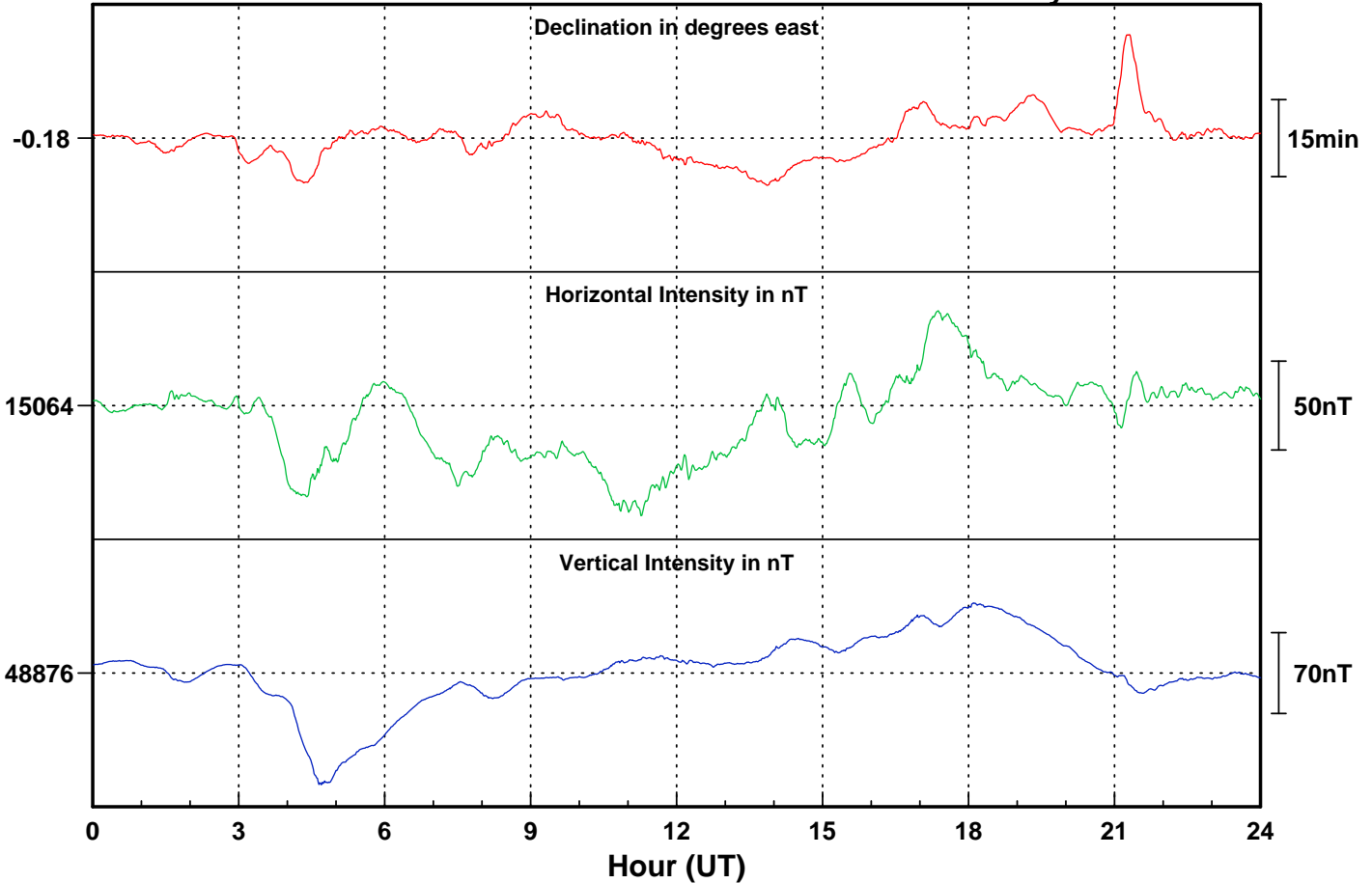
Lerwick

Day number: 250



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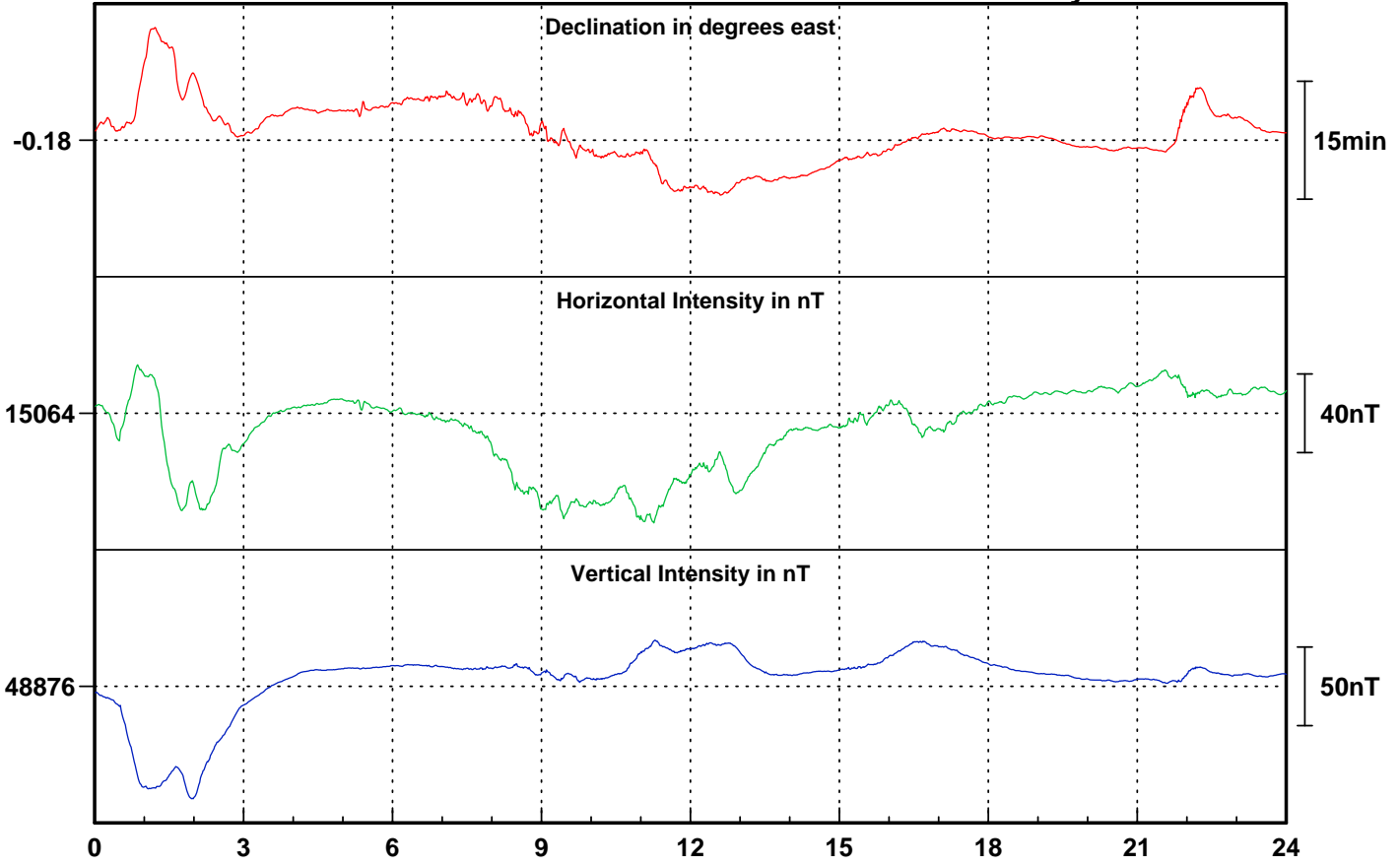
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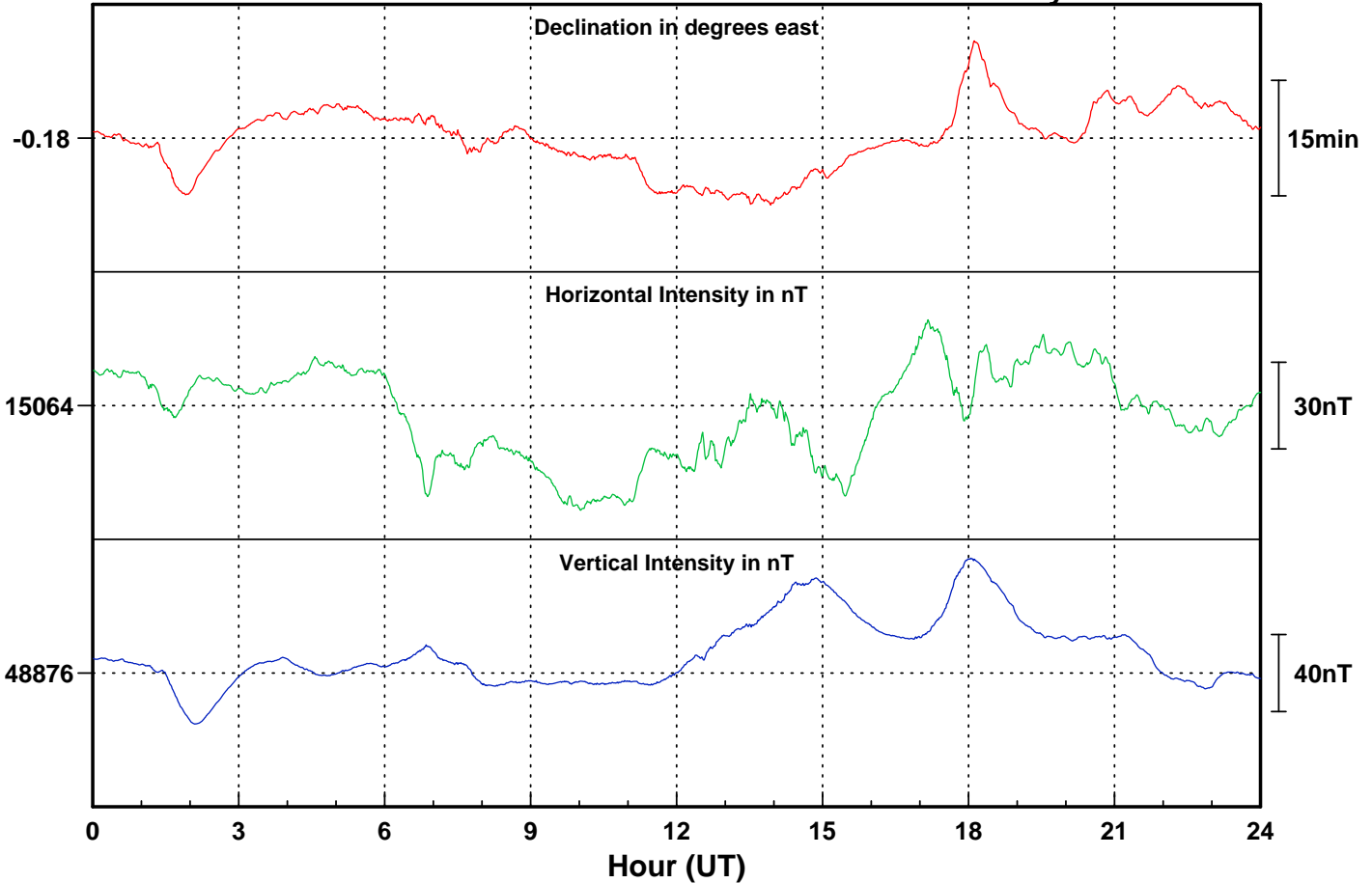
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Day number: 252



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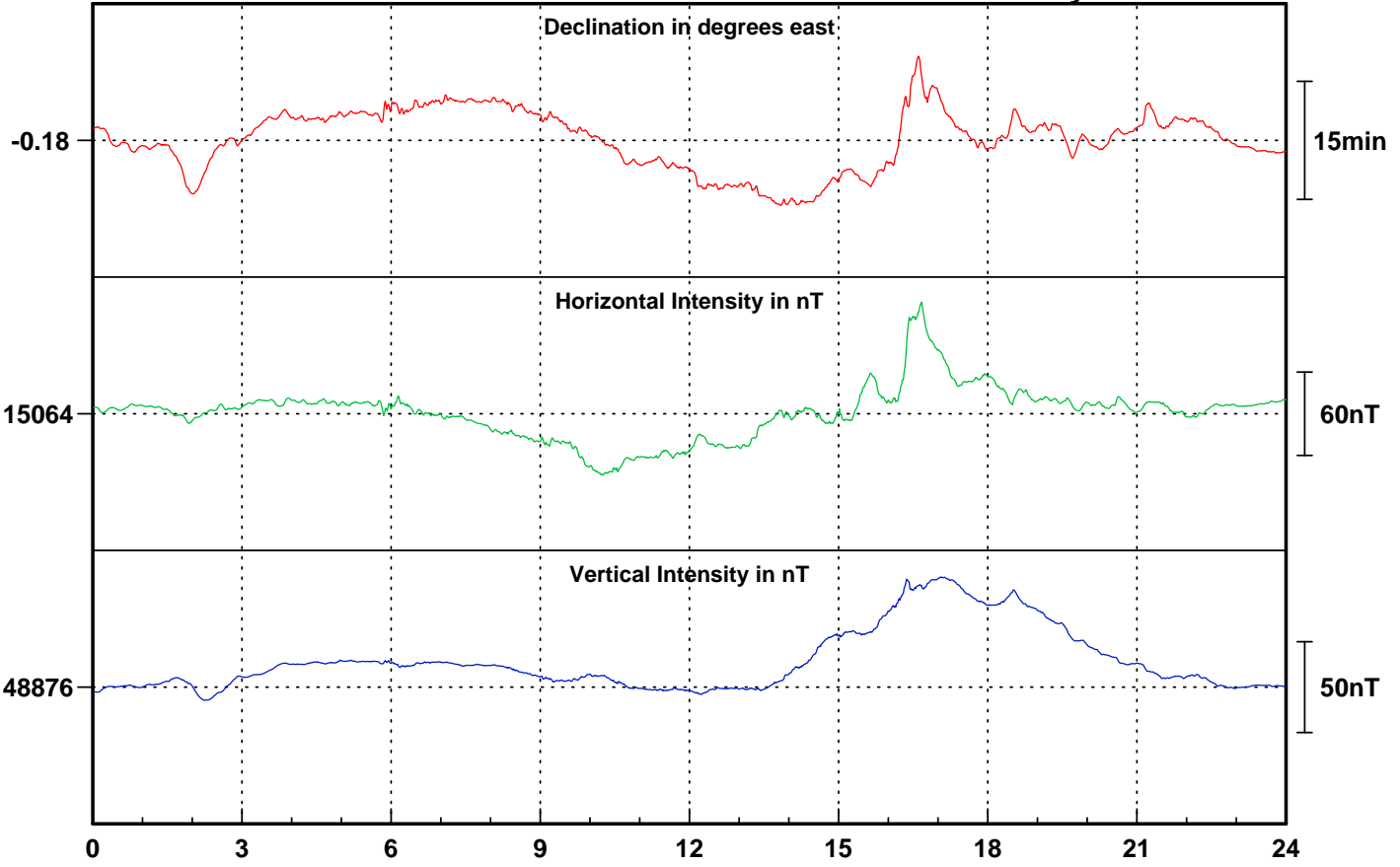
Day number: 253



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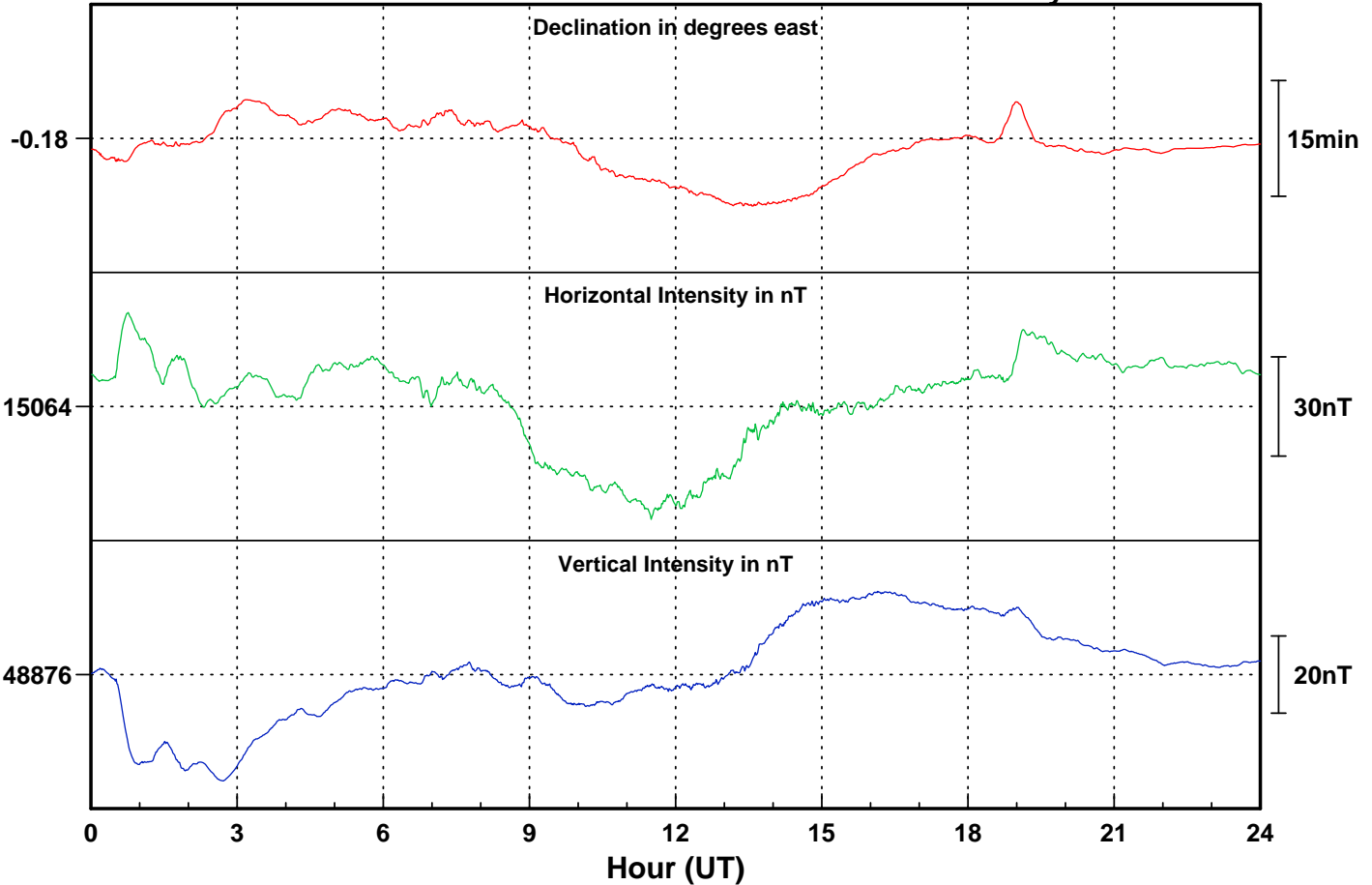
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Day number: 254



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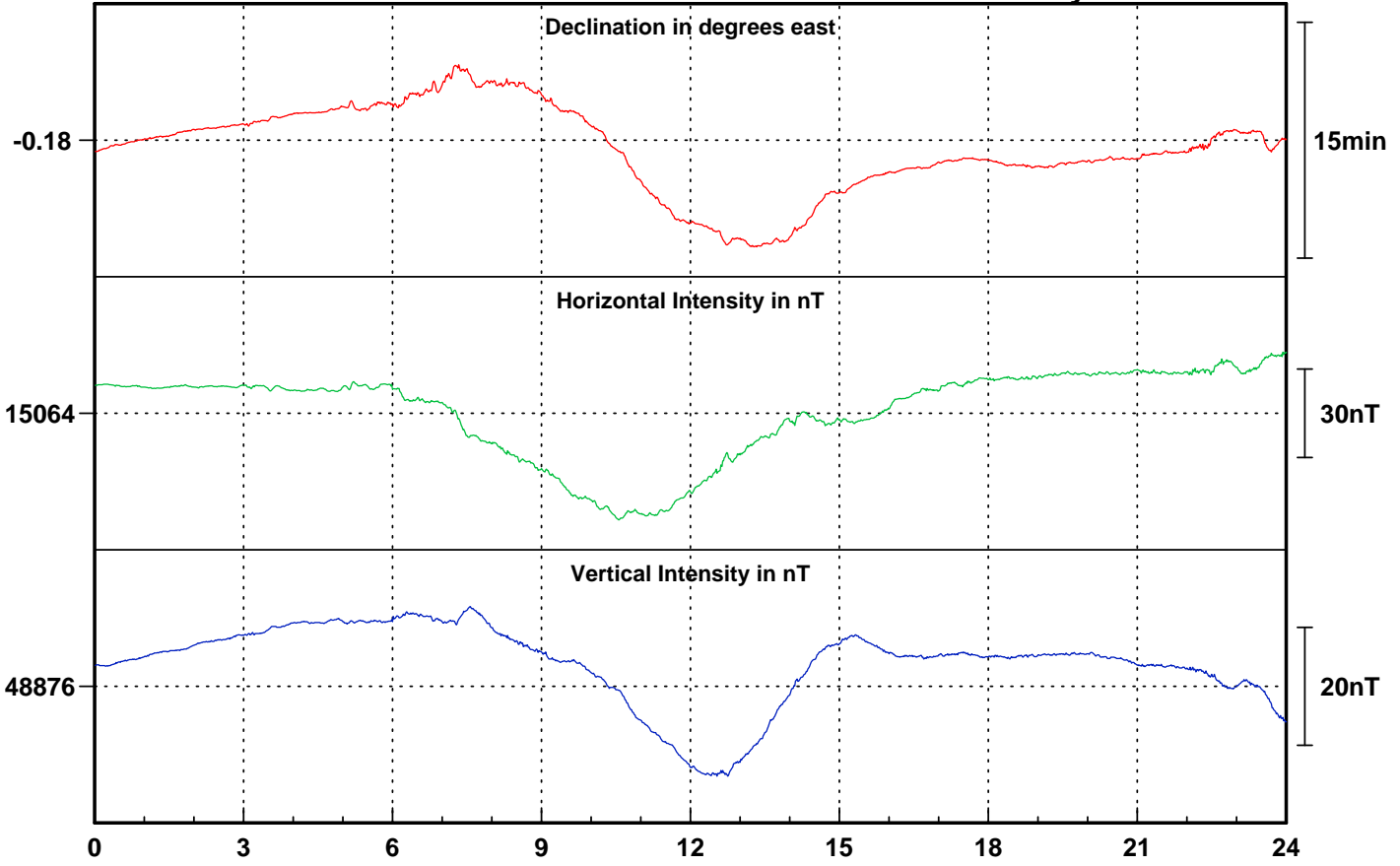
Day number: 255



Date: 13-09-2022

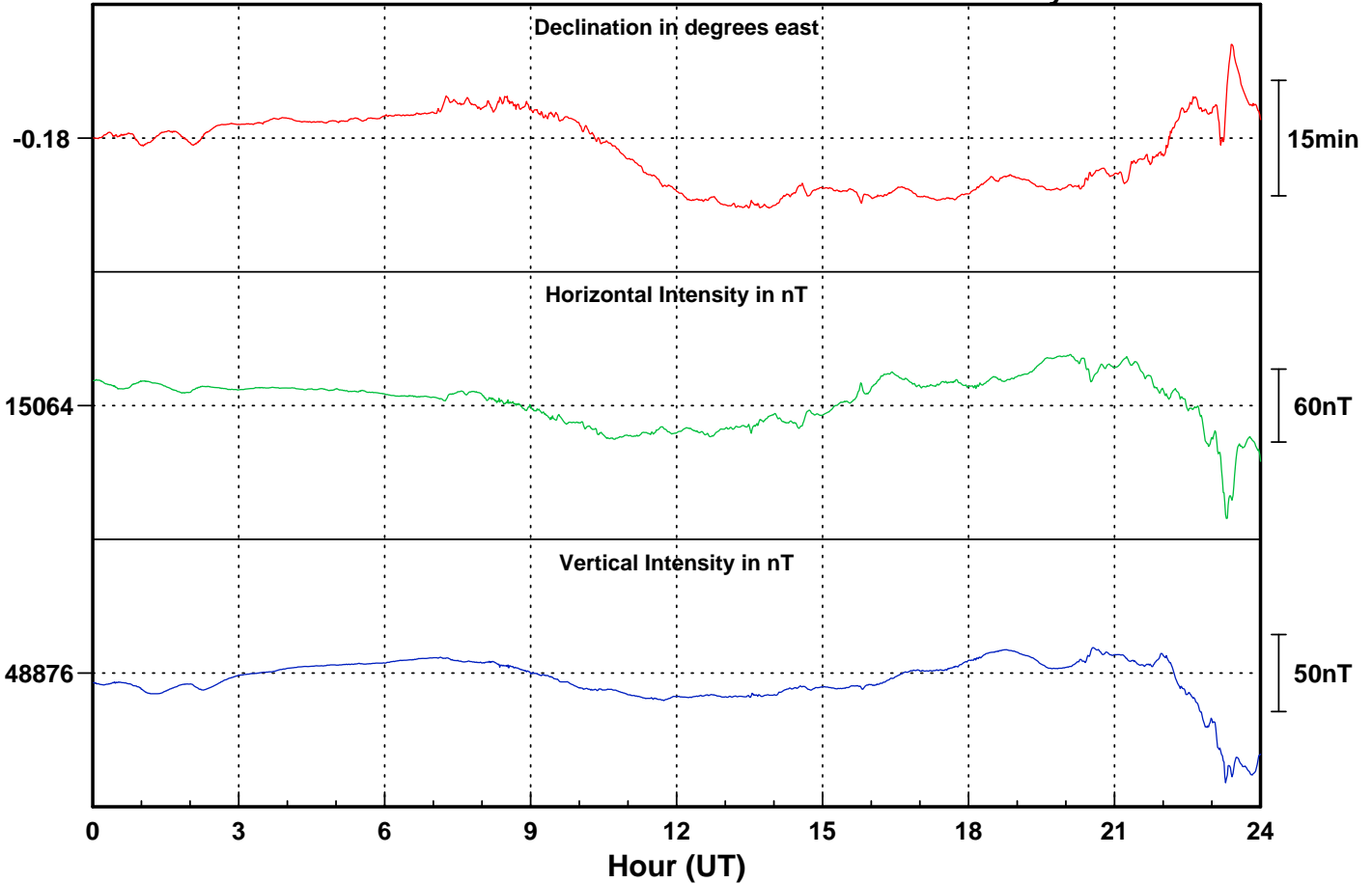
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Day number: 256



Date: 14-09-2022

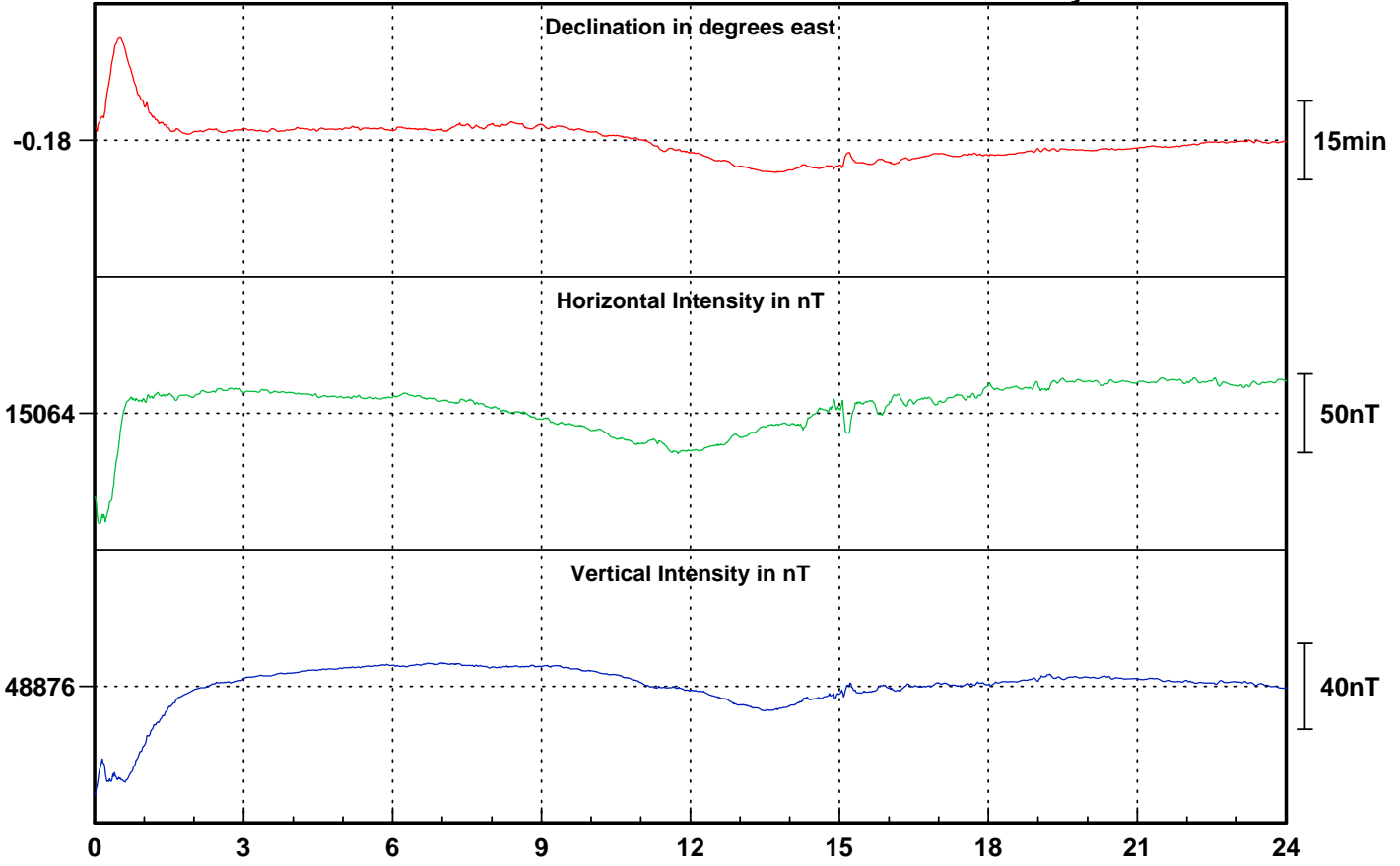
Day number: 257



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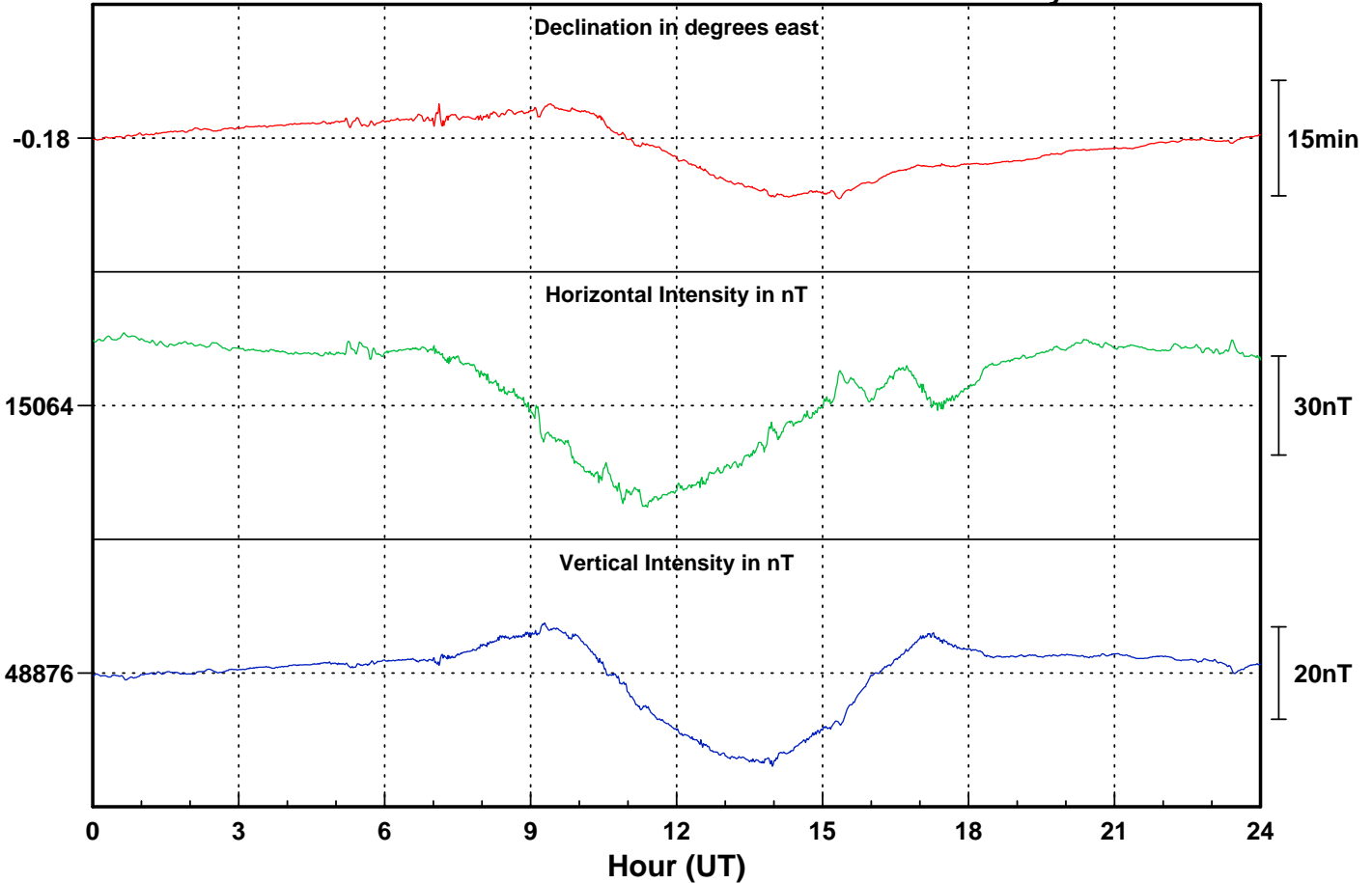
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Day number: 258



Date: 16-09-2022

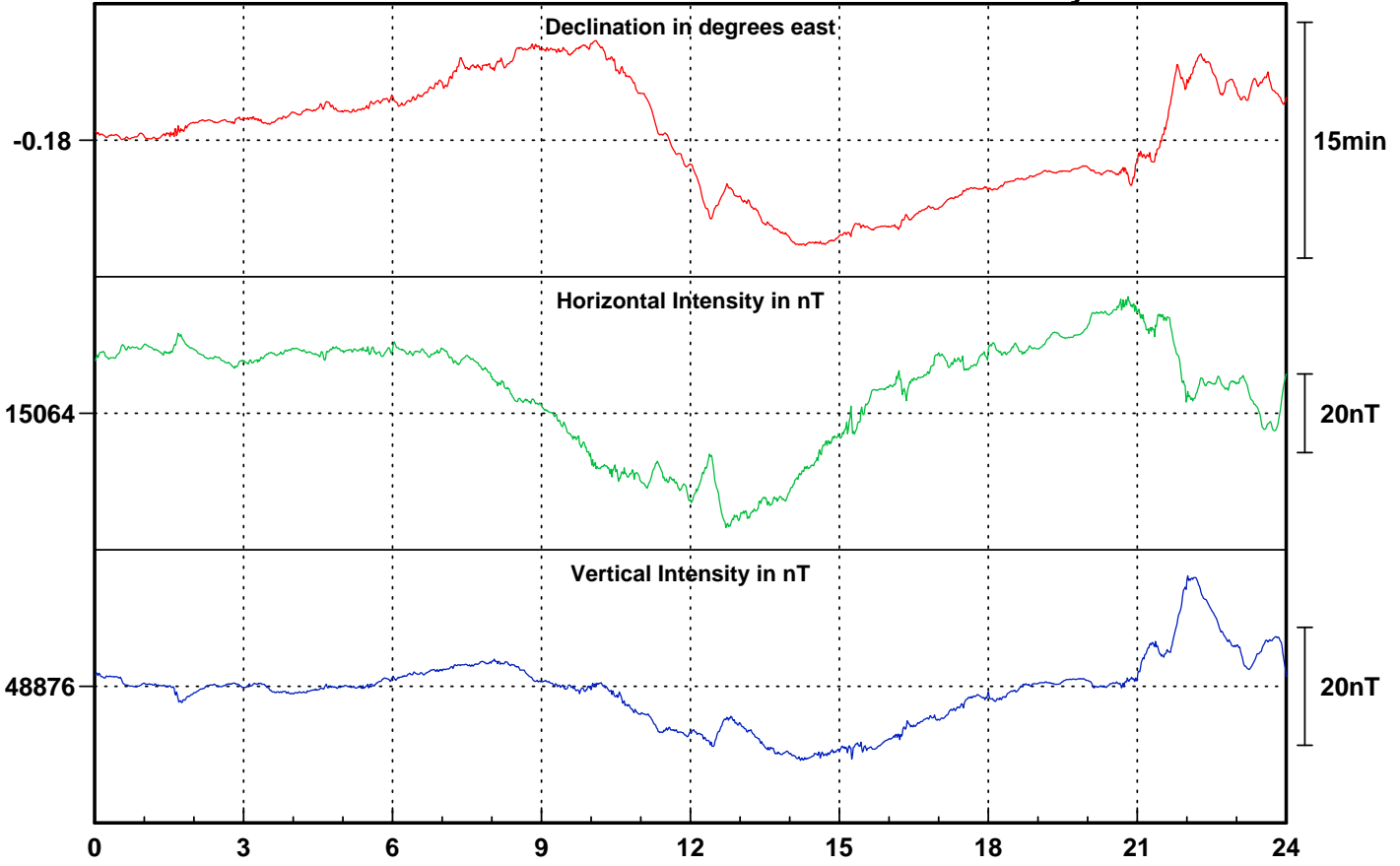
Day number: 259



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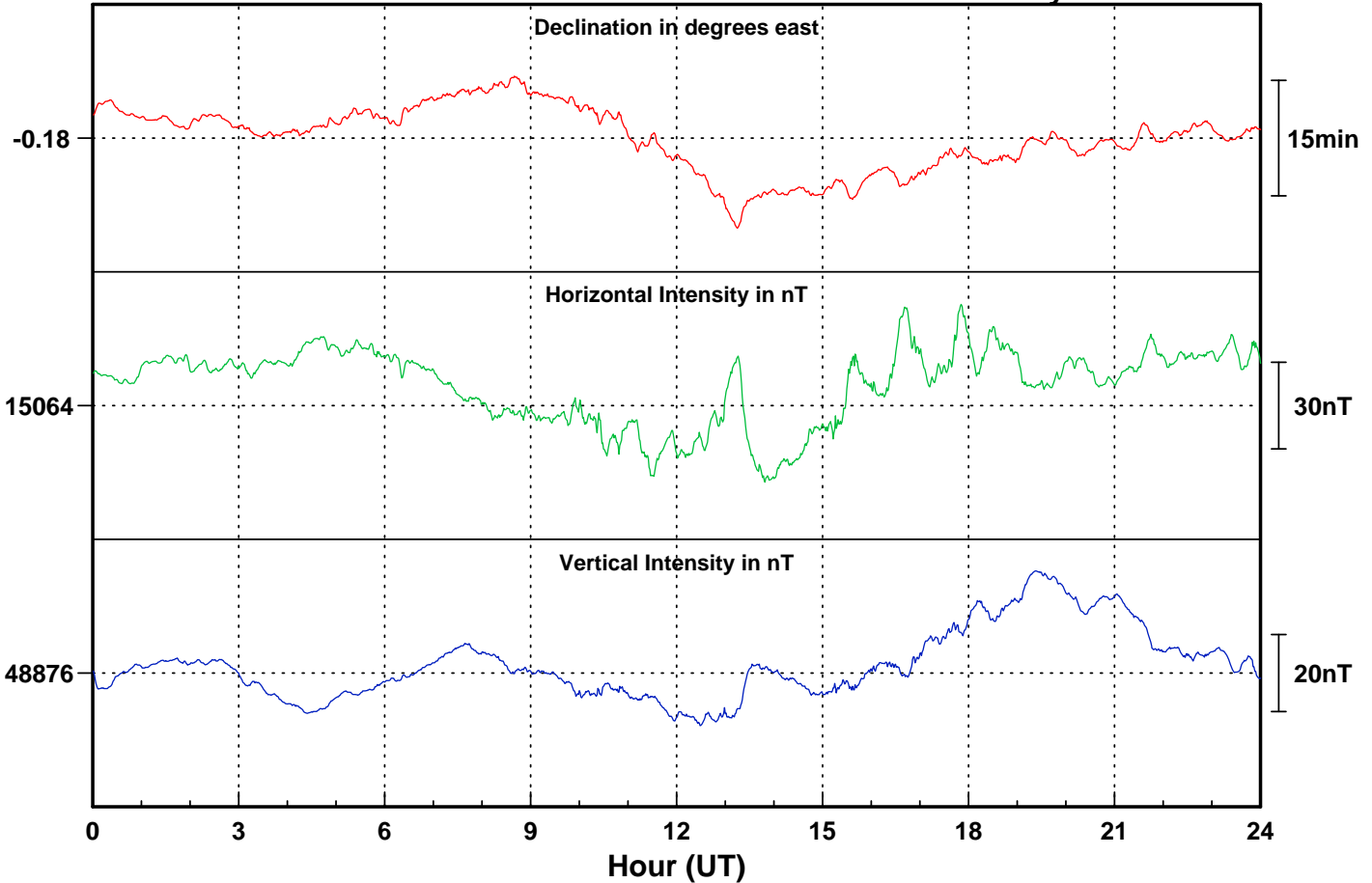
Lerwick

Day number: 260



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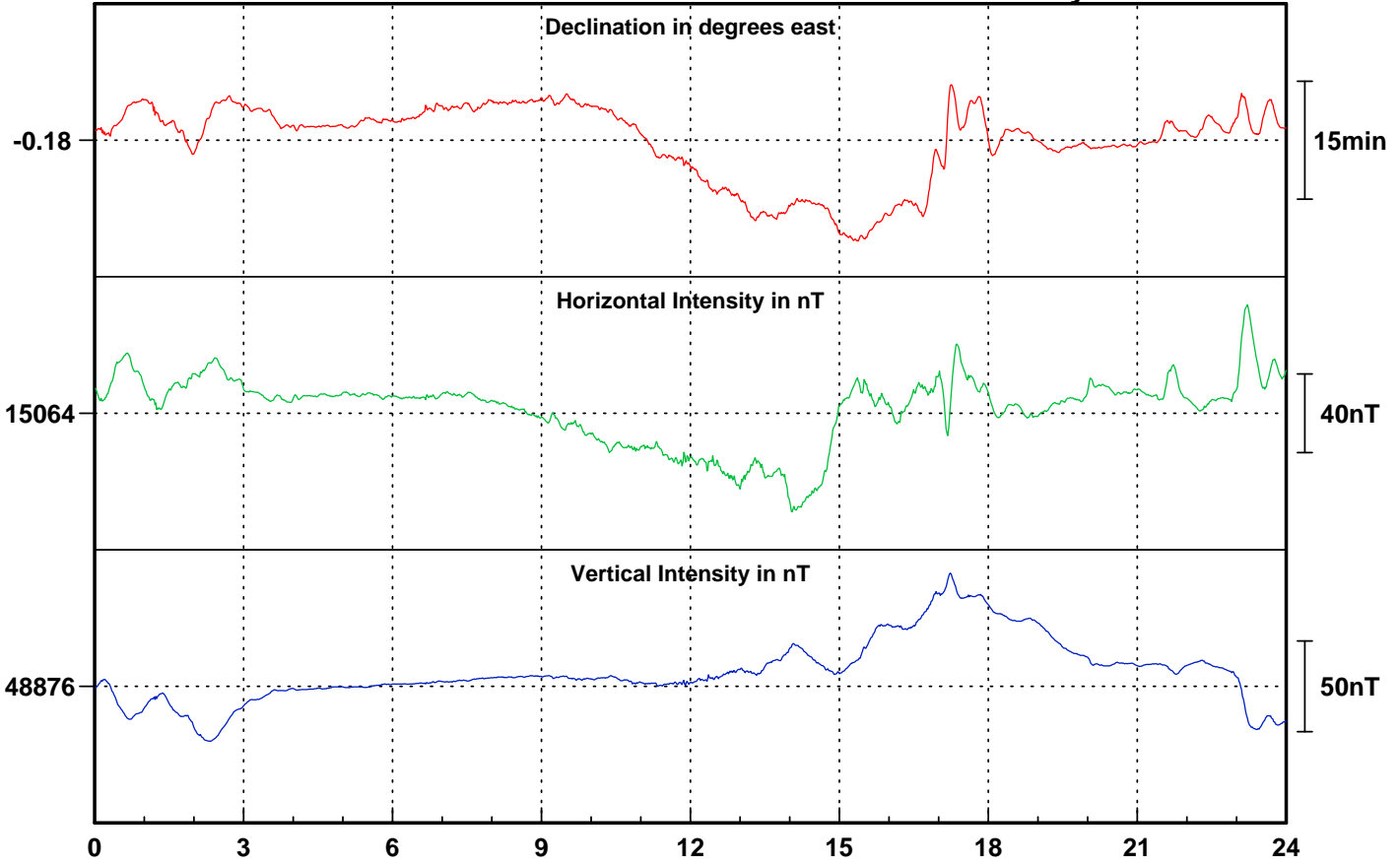
Day number: 261



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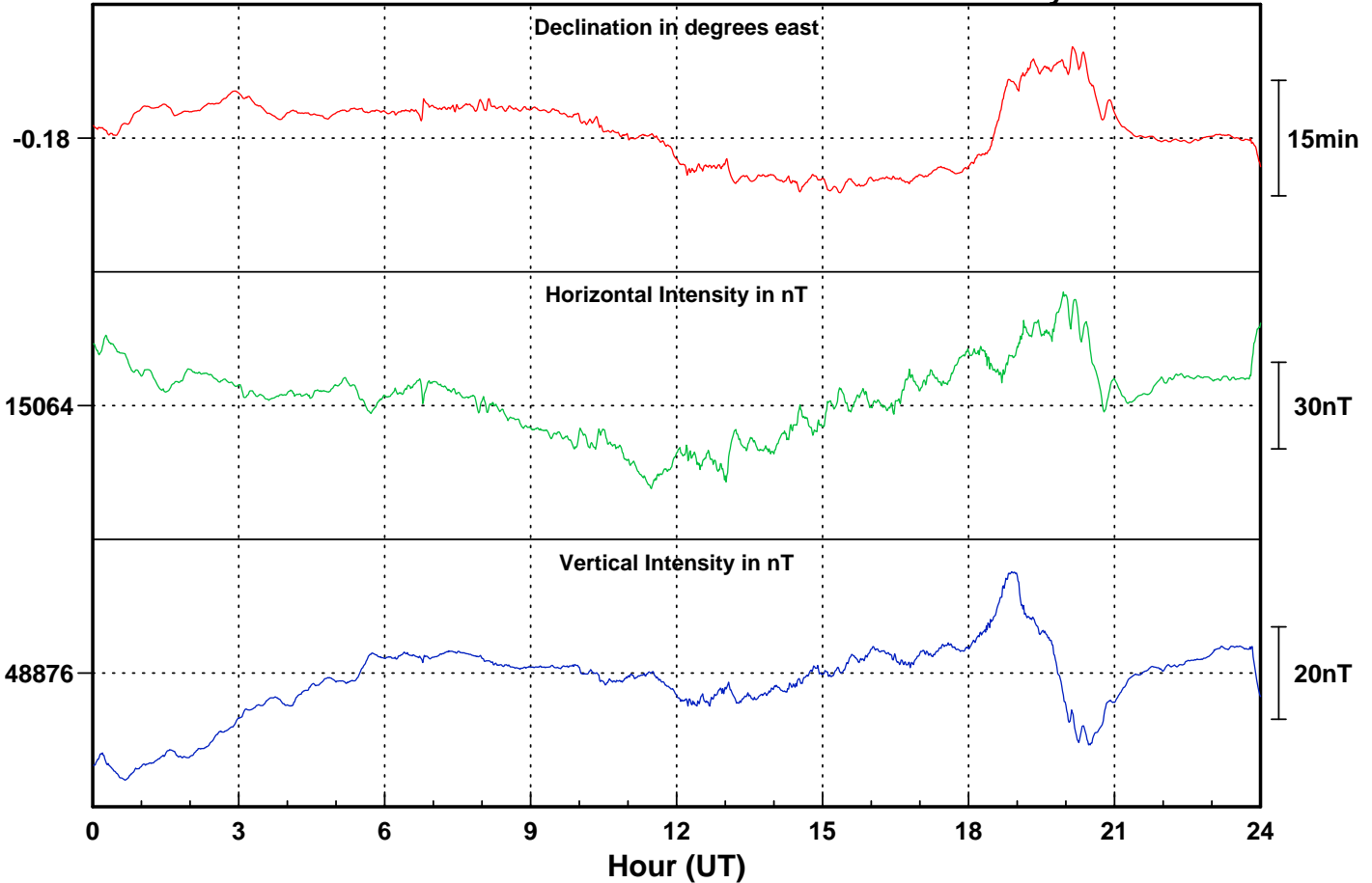
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Day number: 262



Date: 20-09-2022

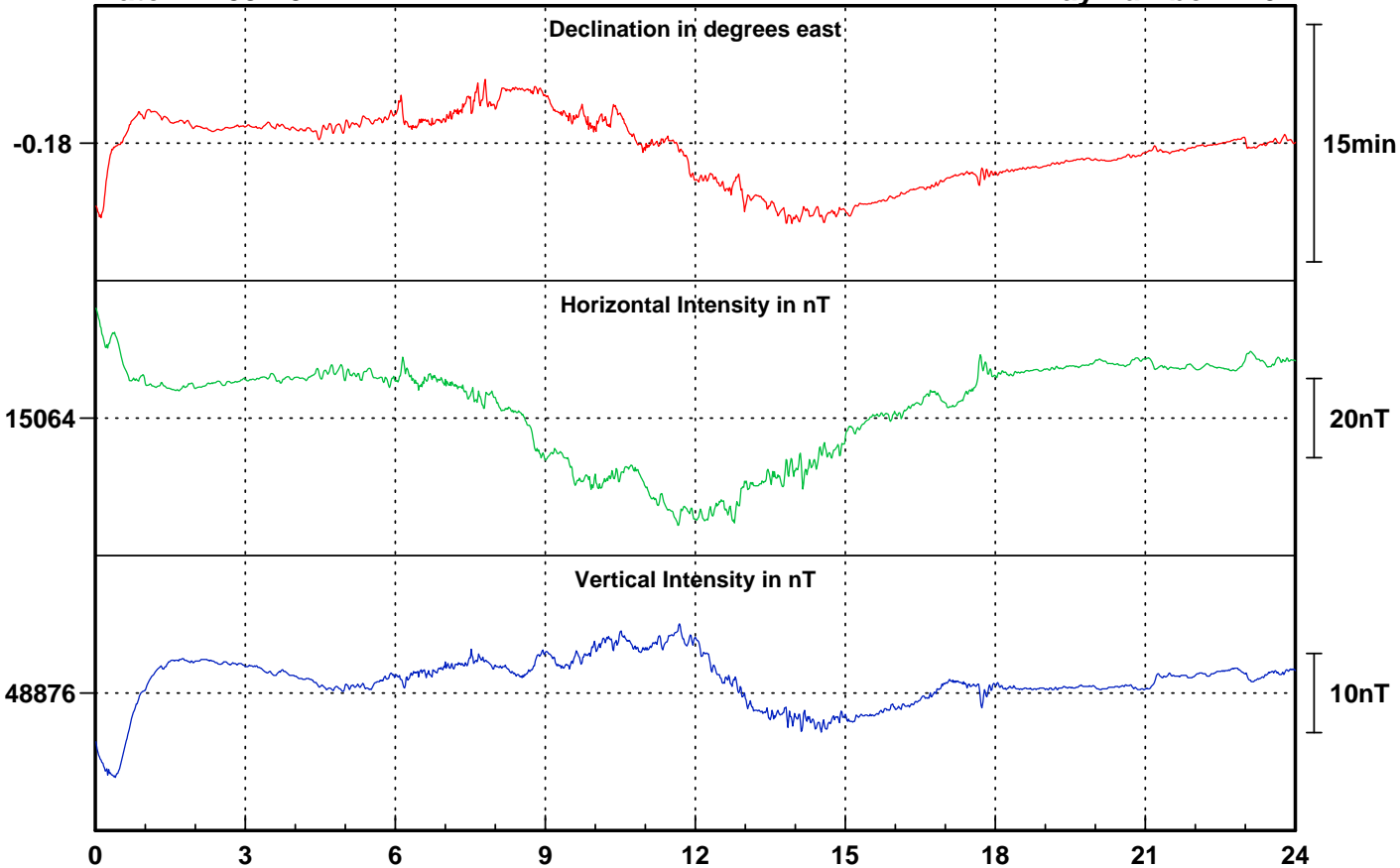
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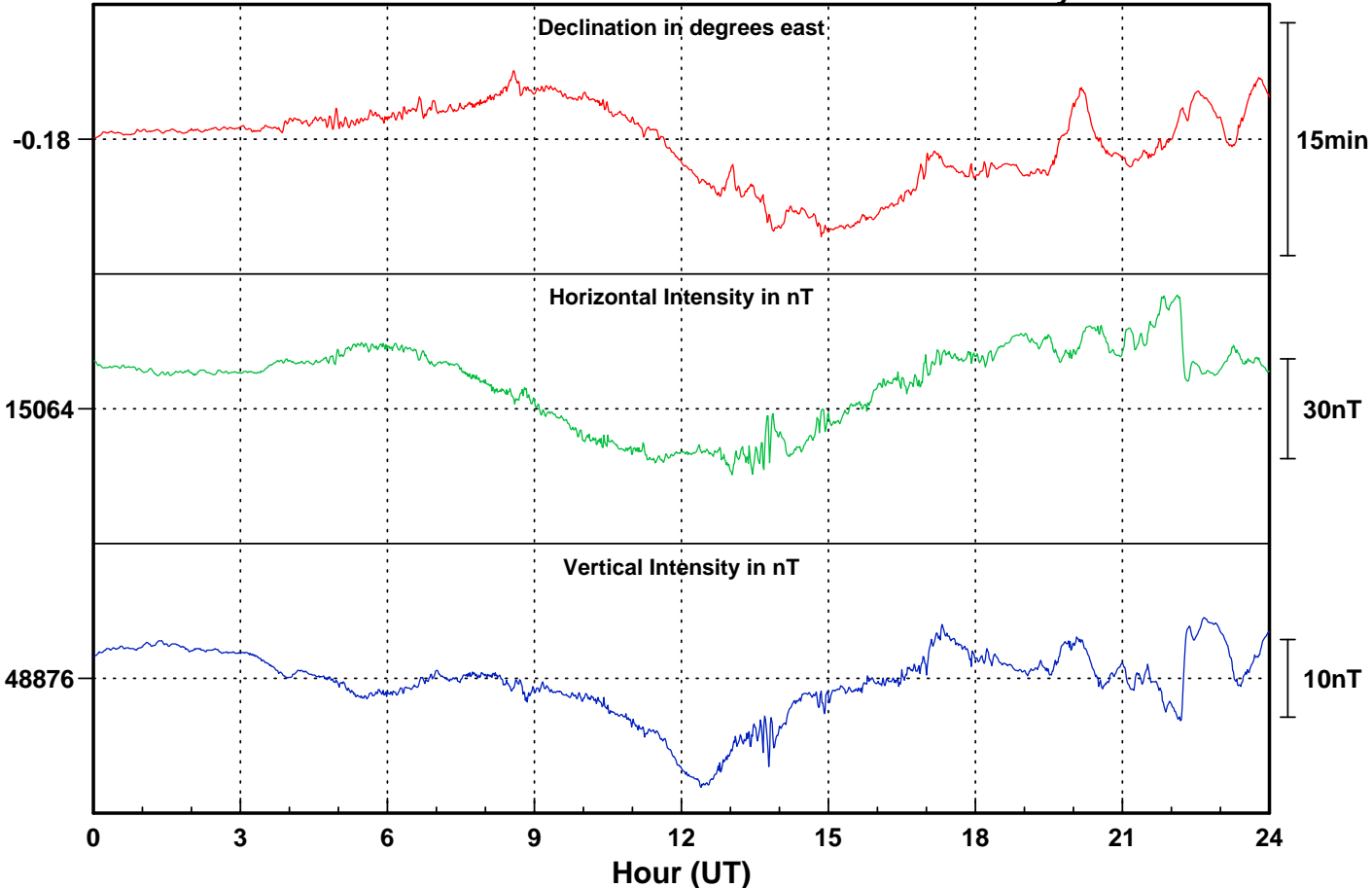
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Day number: 264



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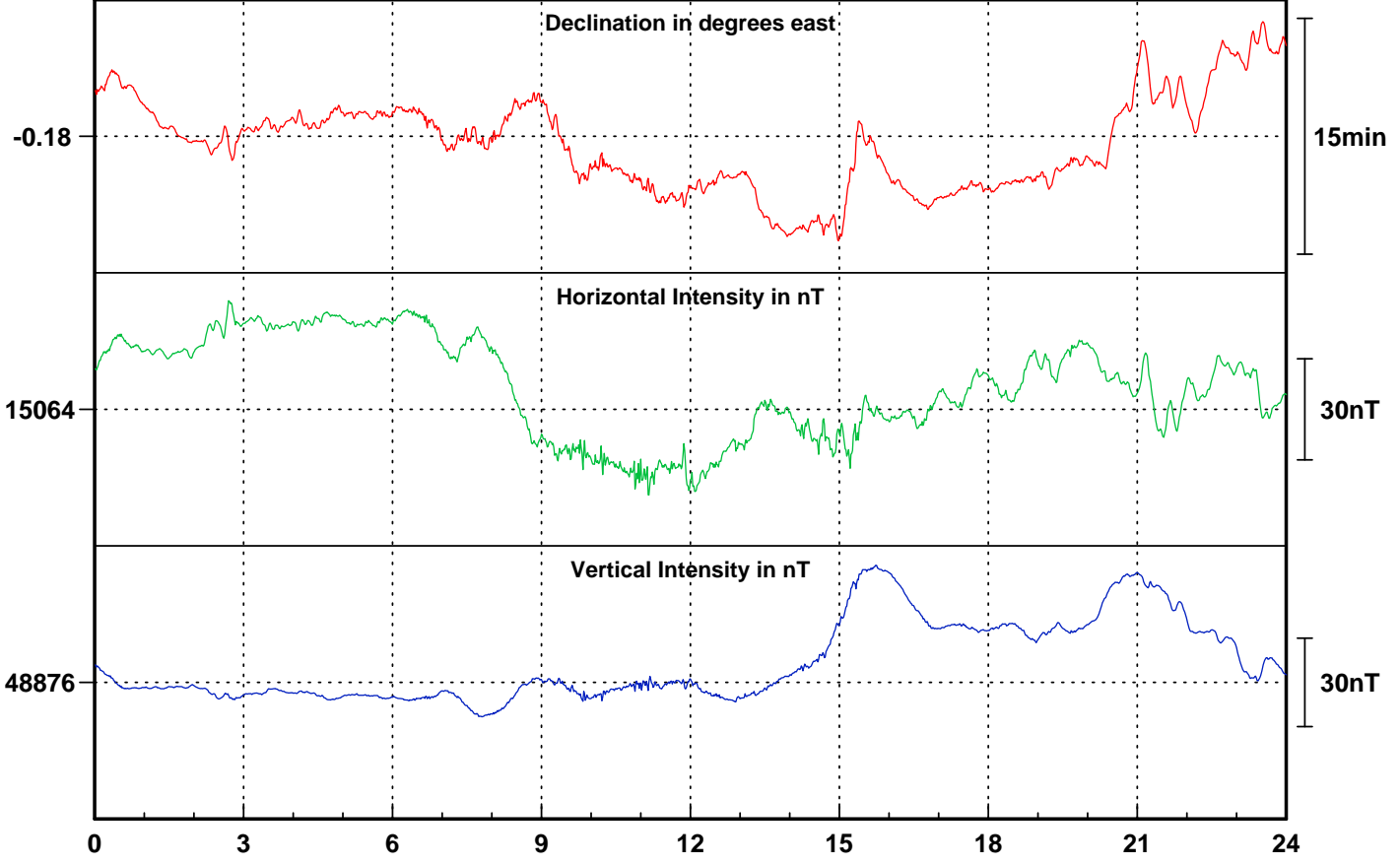
Day number: 265



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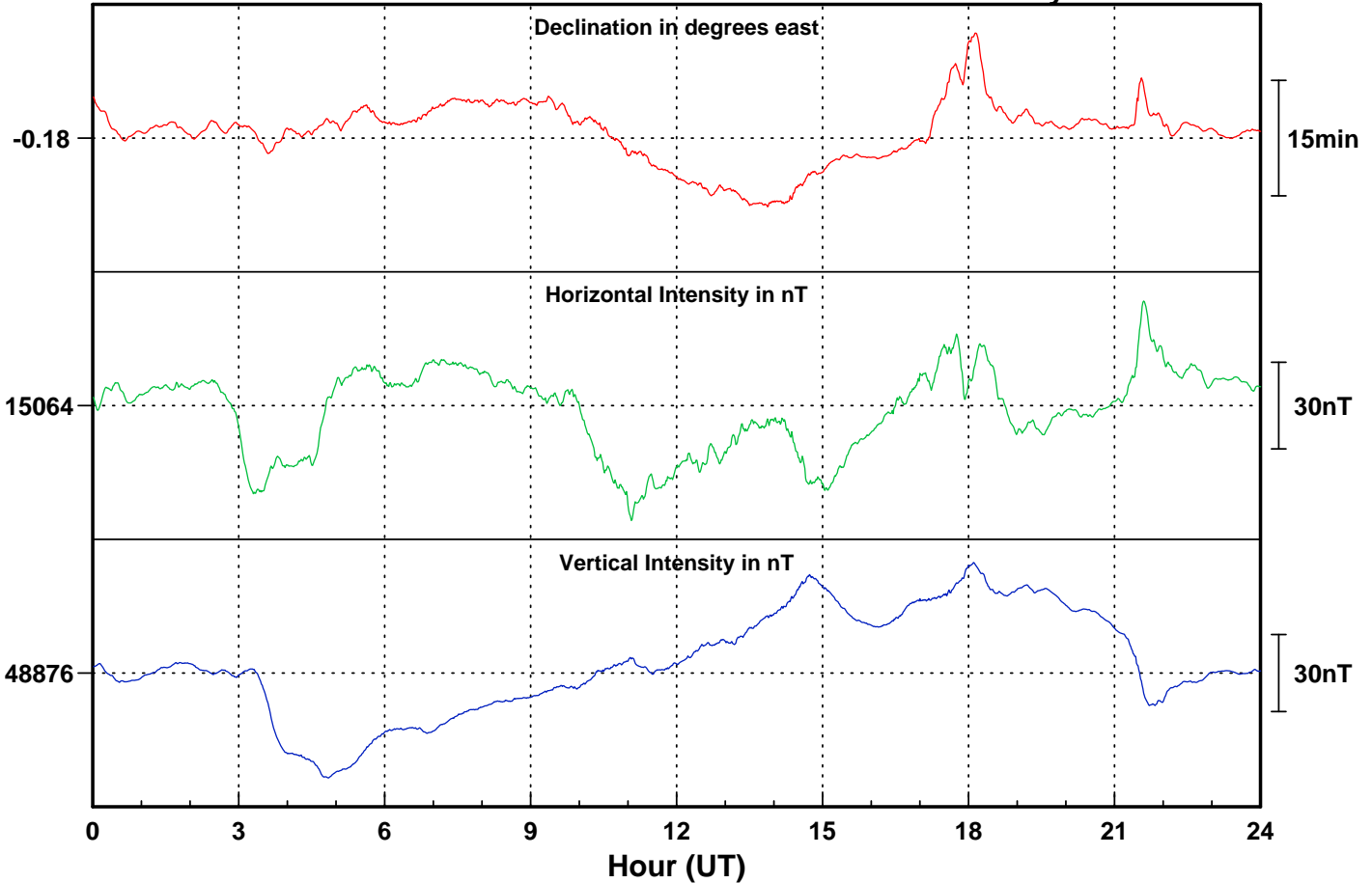
Lerwick

Day number: 266



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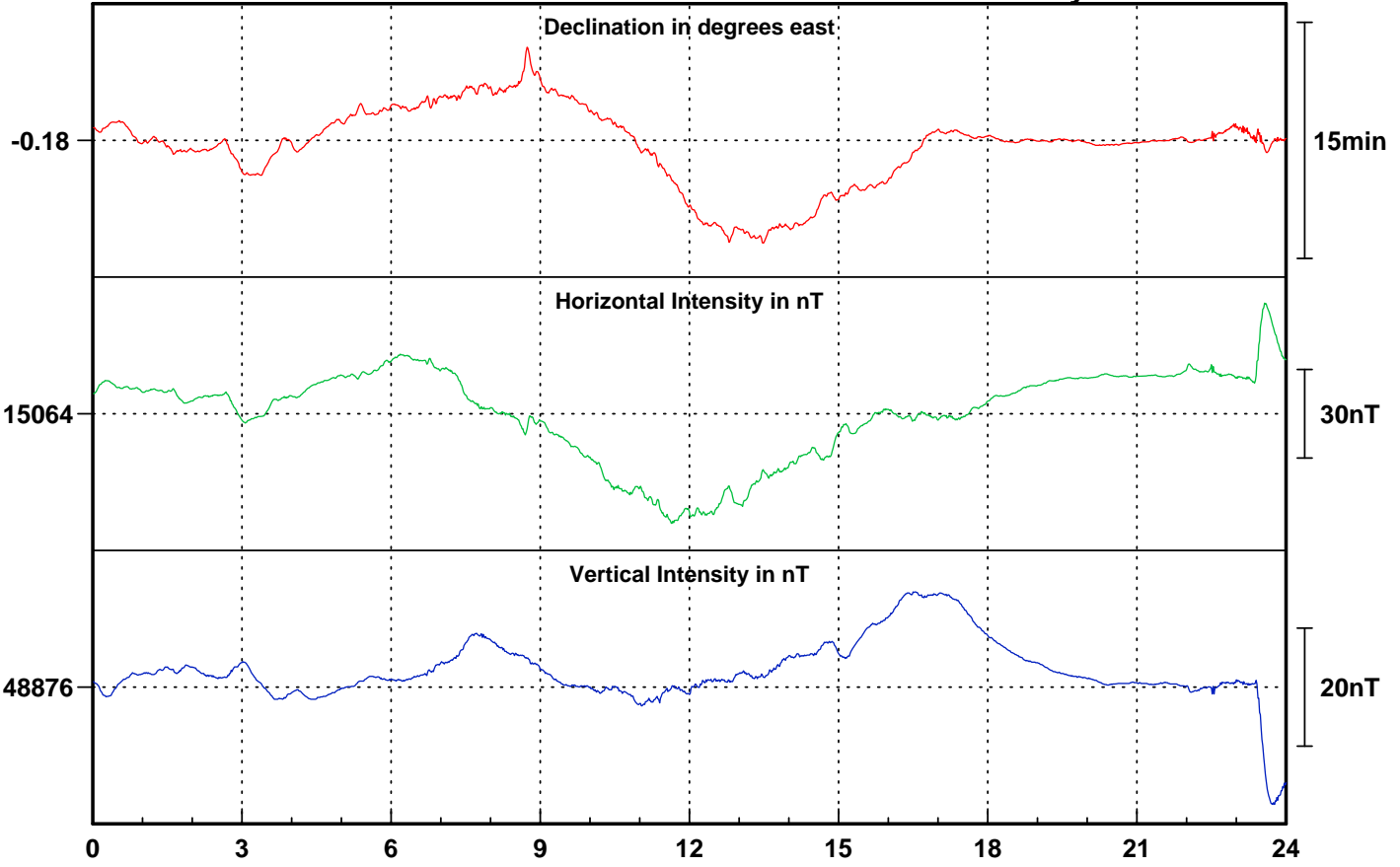
Day number: 267



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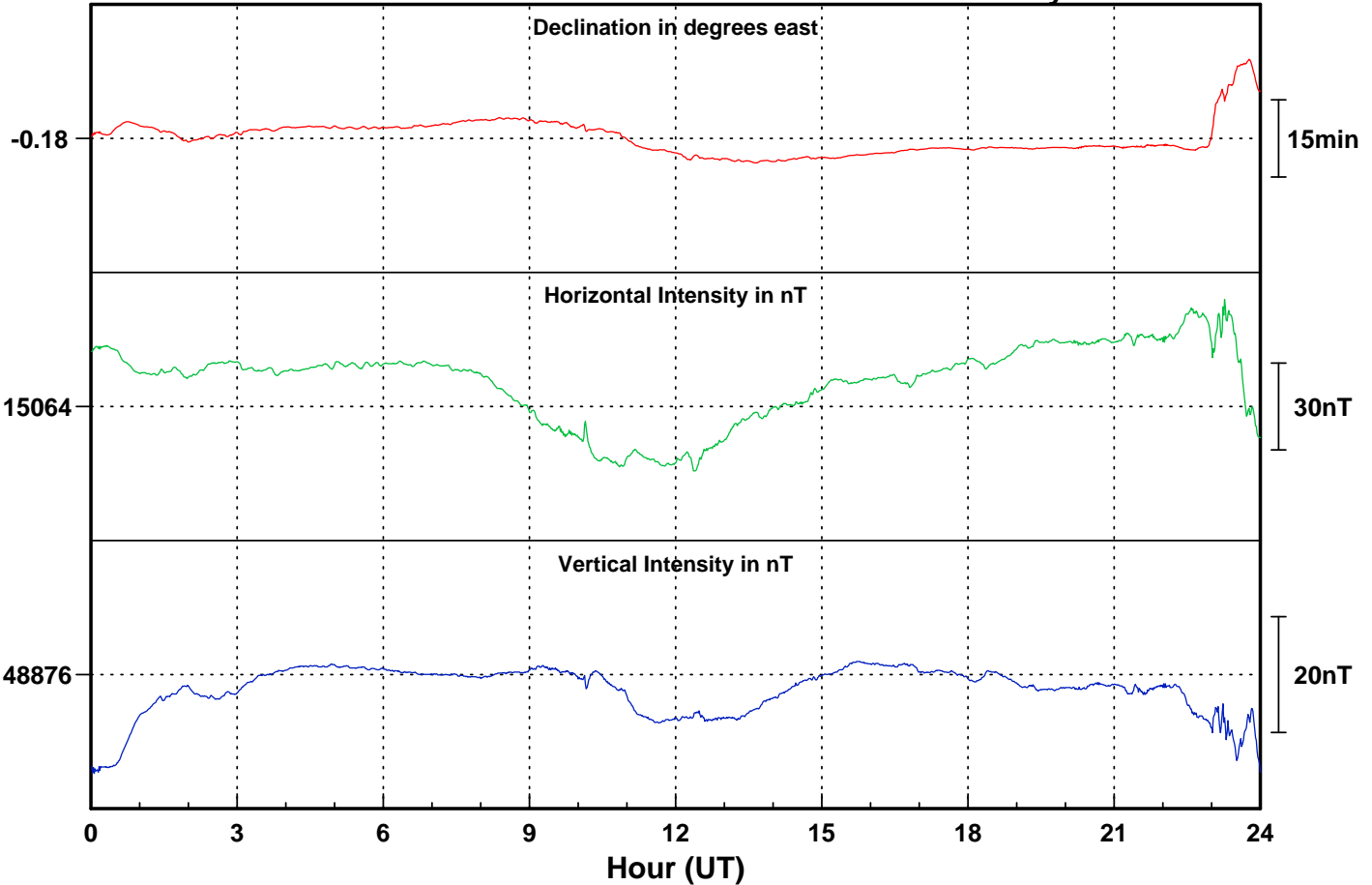
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Day number: 268



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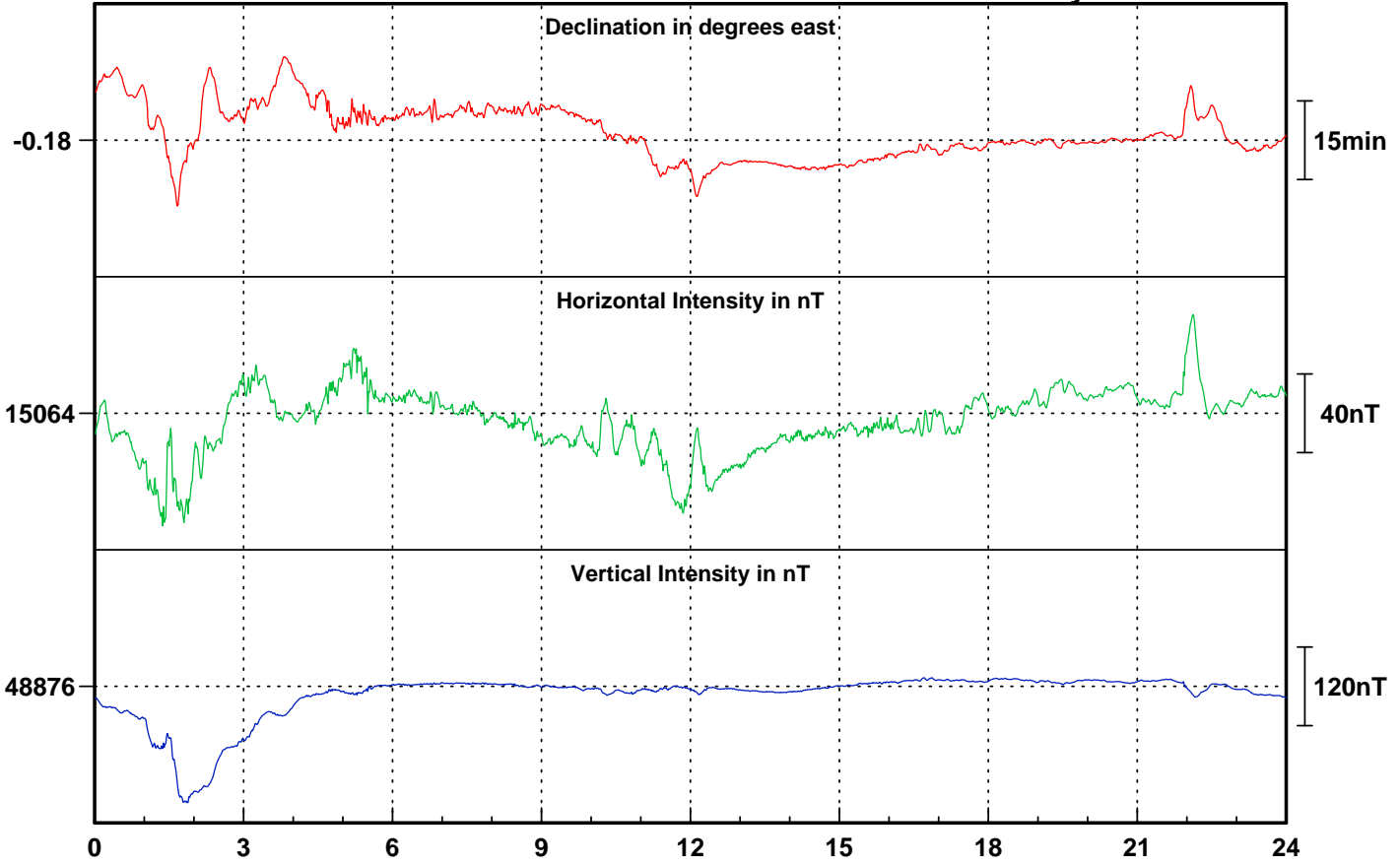
Day number: 269



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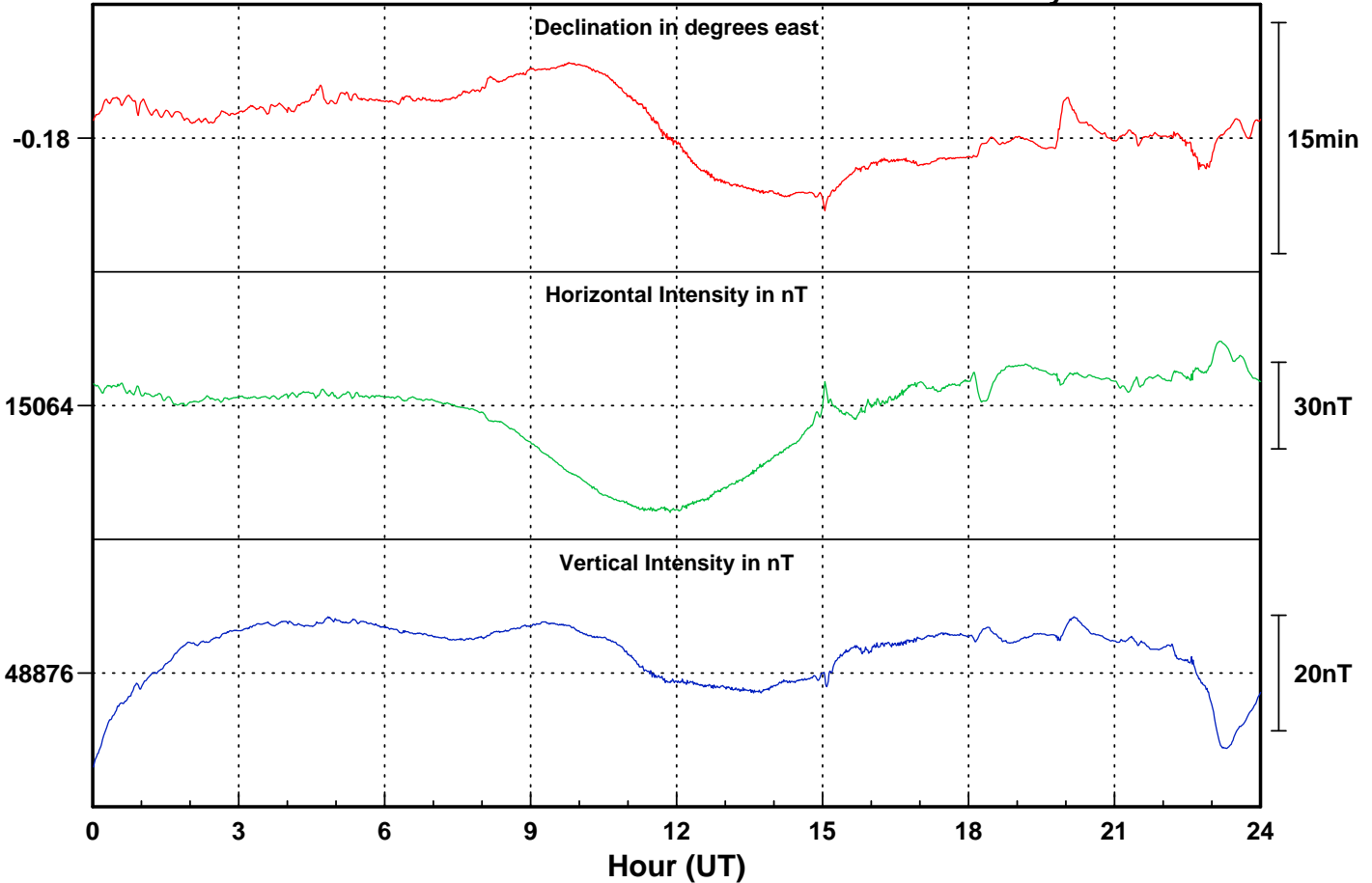
Lerwick

Day number: 270



Date: 28-09-2022

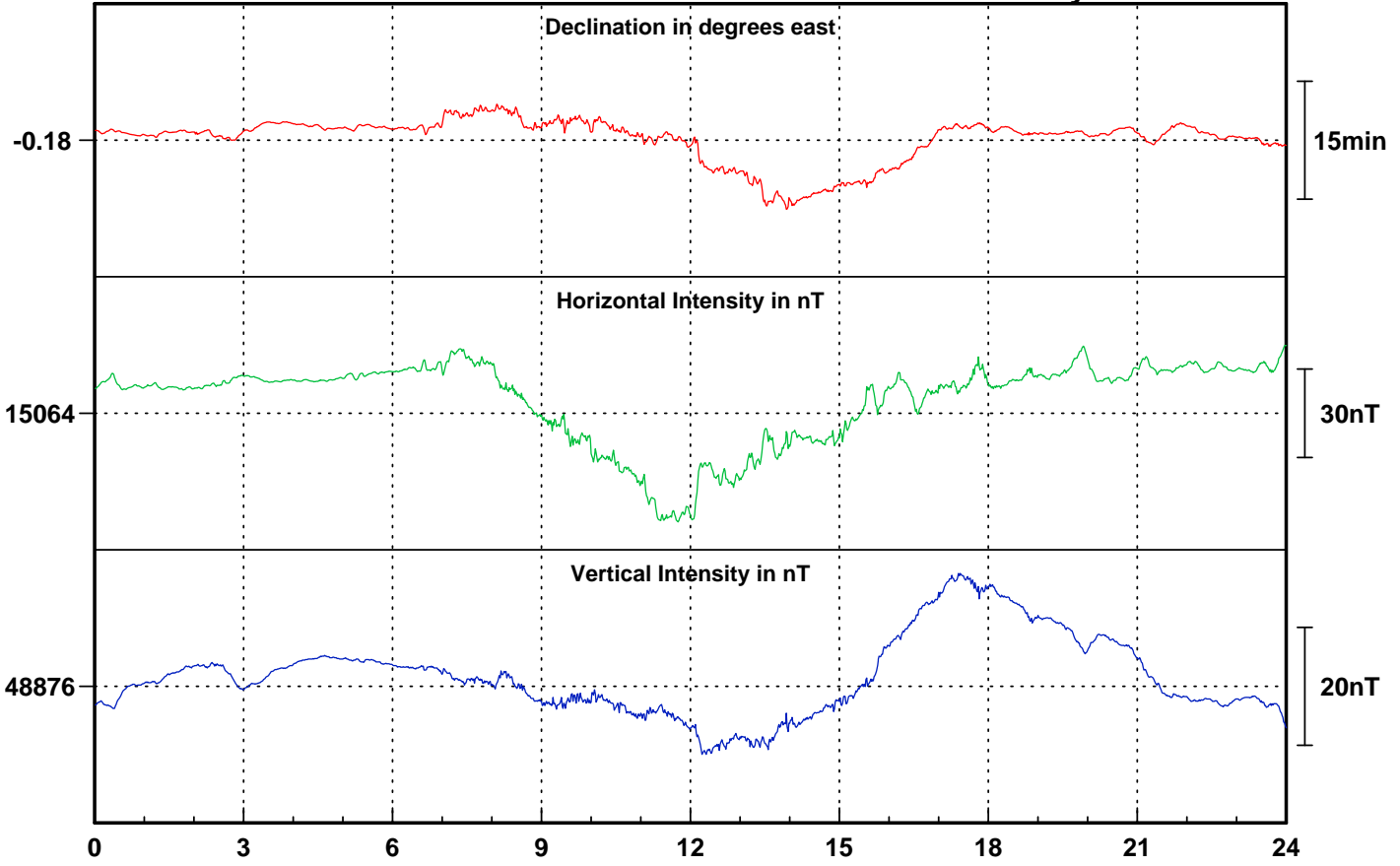
Day number: 271



Date: 29-09-2022

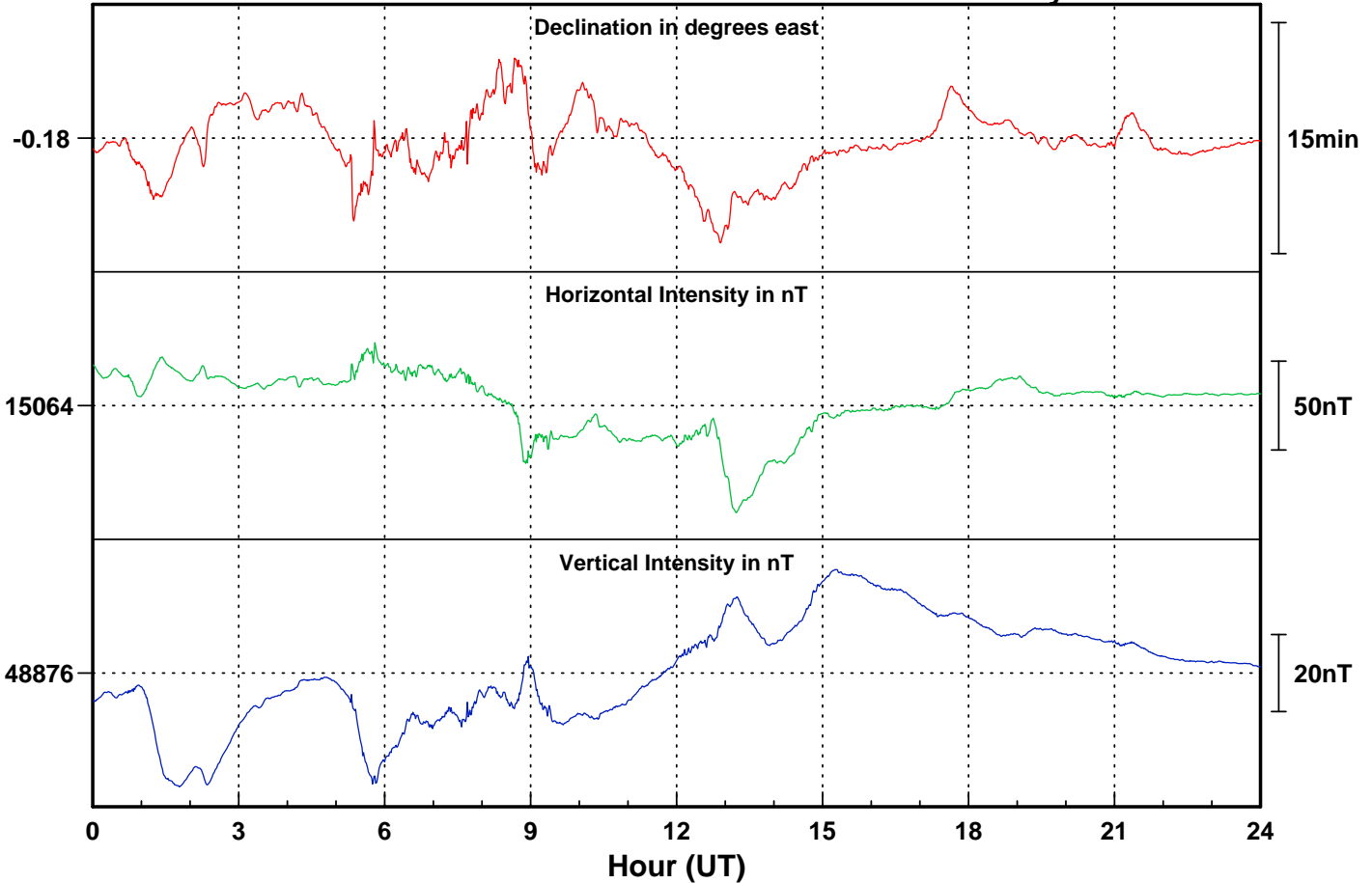
Lerwick

Day number: 272

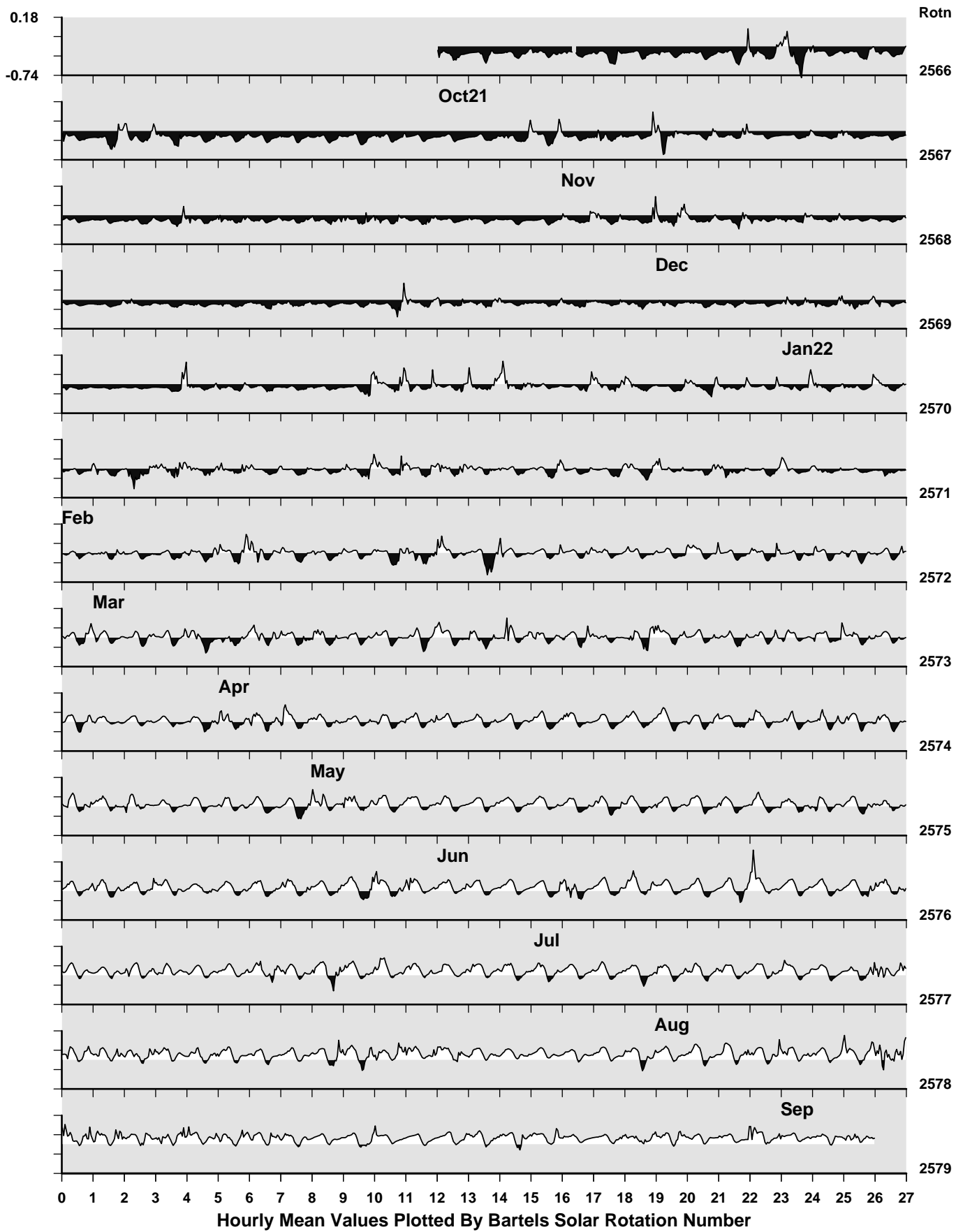


Date: 30-09-2022

Day number: 273

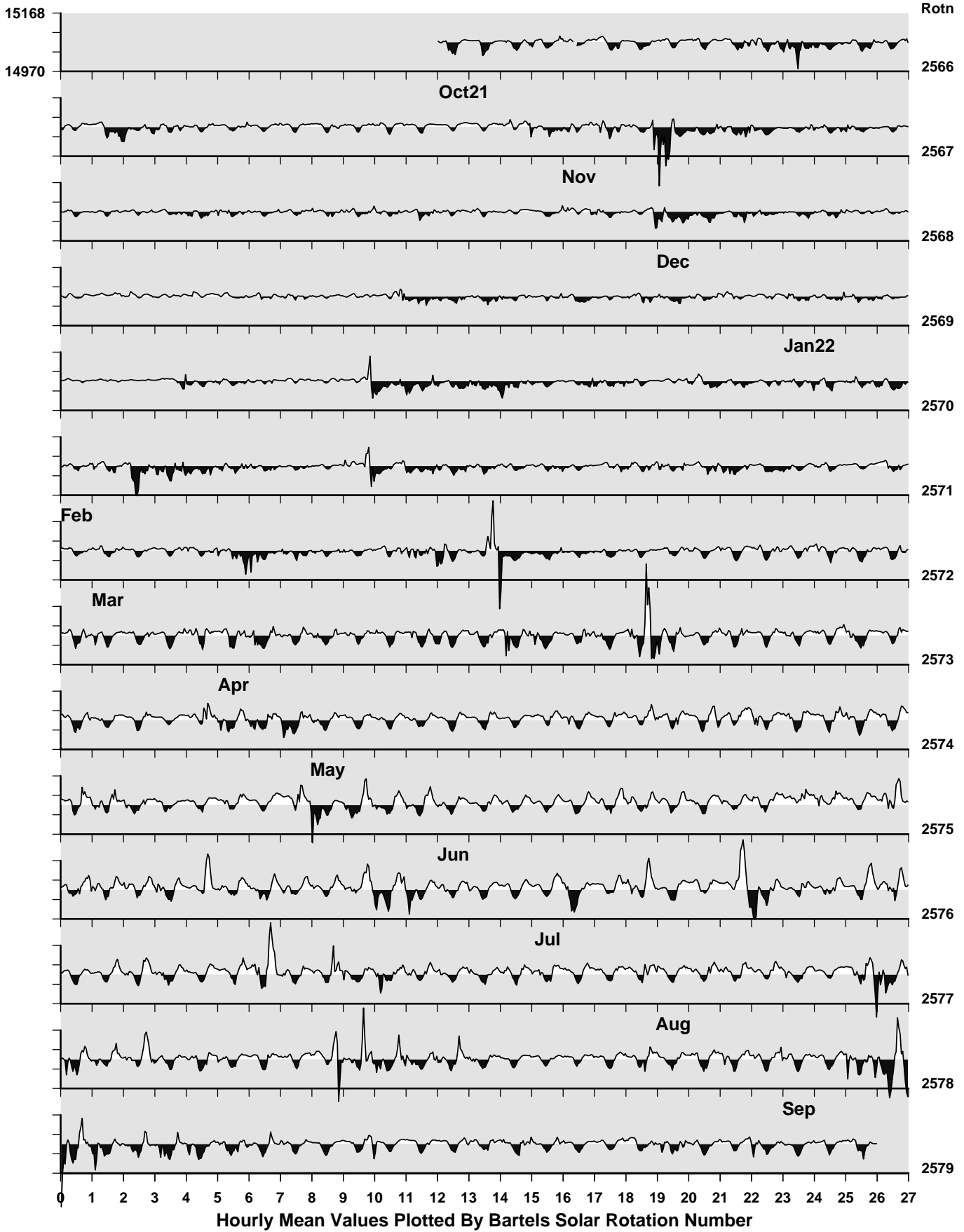


Lerwick Observatory: Declination (degrees)



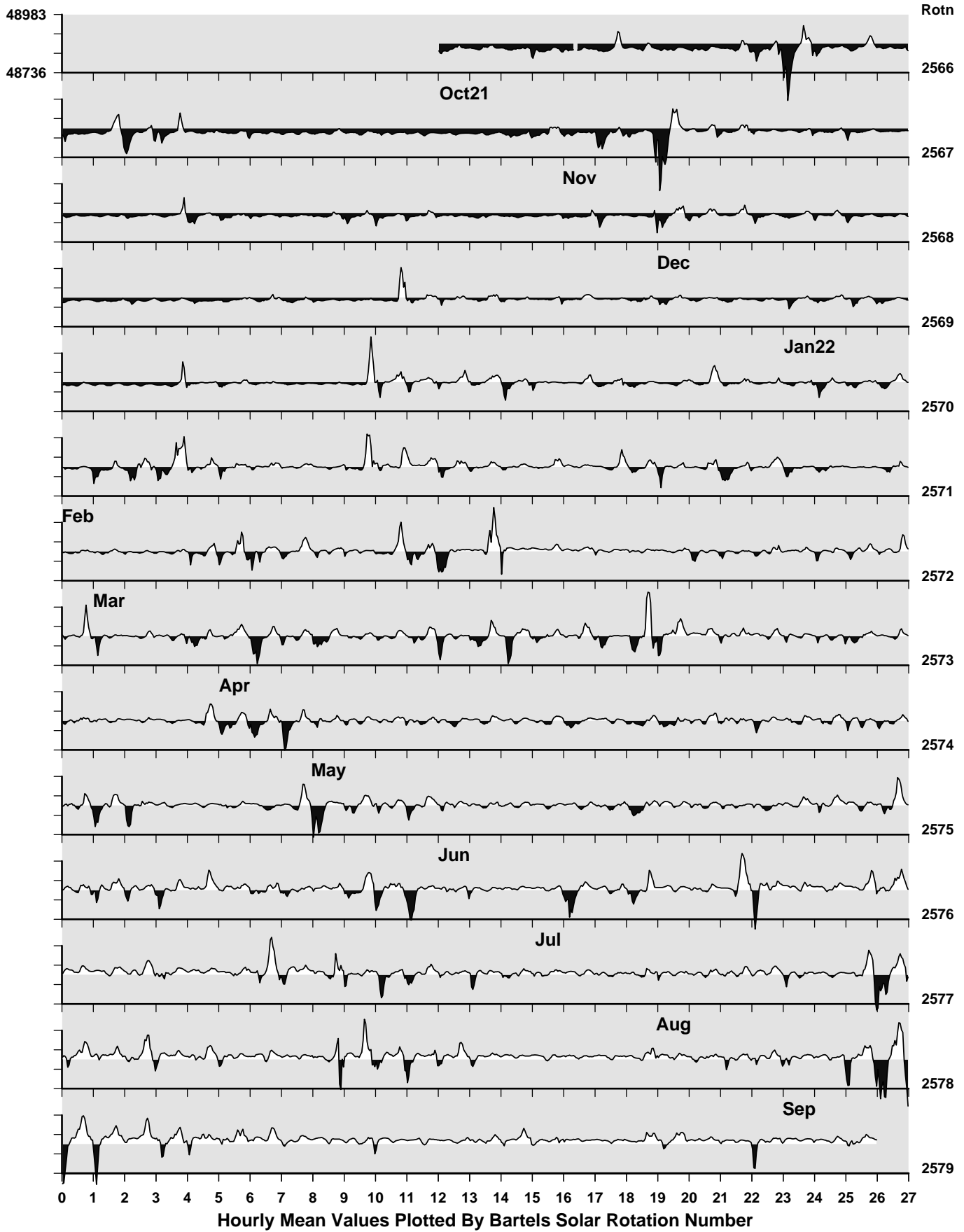
Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory: Horizontal Intensity (nT)



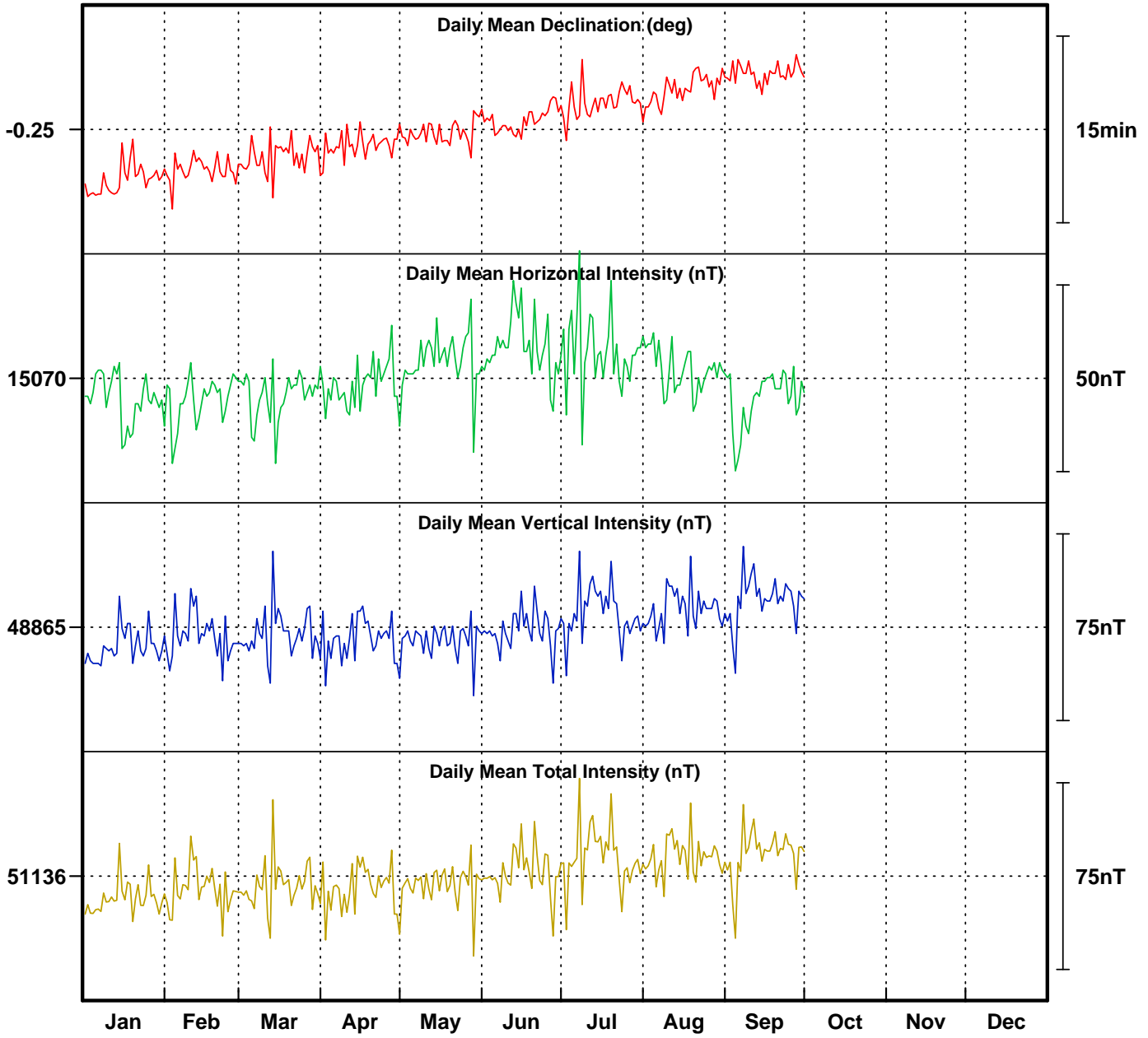
Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory 2022



Monthly mean values for Lerwick Observatory 2022

Month	<i>D</i>	<i>H</i>	<i>I</i>	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>F</i>
January	-0° 19.1′	15064 nT	72° 51.8′	15064 nT	-84 nT	48857 nT	51126 nT
February	-0° 18.4′	15064 nT	72° 51.9′	15064 nT	-80 nT	48861 nT	51130 nT
March	-0° 17.3′	15065 nT	72° 51.9′	15065 nT	-76 nT	48862 nT	51131 nT
April	-0° 16.3′	15068 nT	72° 51.6′	15068 nT	-71 nT	48860 nT	51130 nT
May	-0° 15.4′	15075 nT	72° 51.2′	15075 nT	-67 nT	48860 nT	51133 nT
June	-0° 14.4′	15078 nT	72° 51.0′	15078 nT	-63 nT	48864 nT	51137 nT
July	-0° 13.0′	15077 nT	72° 51.3′	15077 nT	-57 nT	48870 nT	51143 nT
August	-0° 11.8′	15072 nT	72° 51.6′	15072 nT	-52 nT	48872 nT	51143 nT
September	-0° 10.6′	15064 nT	72° 52.2′	15064 nT	-46 nT	48876 nT	51145 nT

Note:

i. The values shown here are provisional.

Lerwick rapid variations

SIs and SSCs

Date	Time (UT)	Type	Quality	H (nT)	D (min)	Z (nT)
02/09/2022	21:29	SSC	A	-18.4	1.14	7.6
04/09/2022	15:17	SSC*	B	169.5	14.84	53.5
20/09/2022	06:42	SSC*	B	-8.72	2.90	-1.4/1.6

Notes:

An asterisk (*) indicates that the principal impulse was preceded by a smaller reversed impulse.

The quality of the event is classified as follows:

- A = very distinct
- B = fair, ordinary, but unmistakable
- C = doubtful

The amplitudes given are for the first chief movement of the event.

SFEs

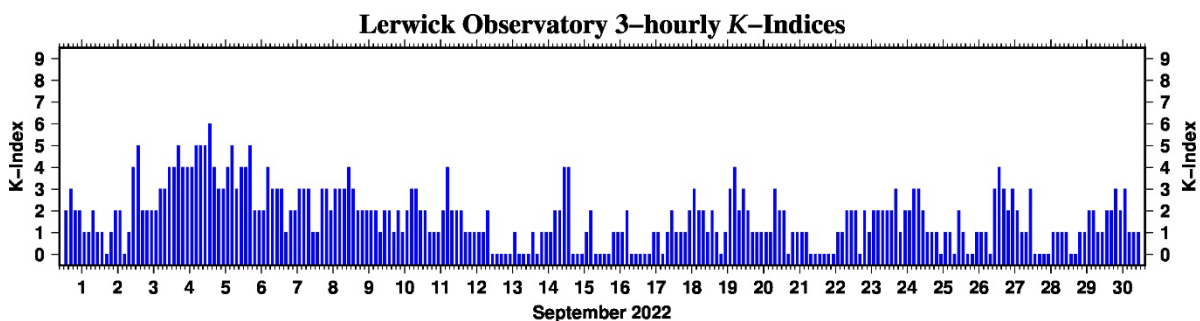
Date	Start	Universal Time Maximum	End	H (nT)	D (min)	Z (nT)
None						

Note:

The amplitudes given are for the first chief movement of the event.

Indices of geomagnetic activity

Day	K- INDICES FOR THREE-HOUR INTERVAL							
	00-03	03-06	06-09	09-12	12-15	15-18	18-21	21-24
1	2	3	2	2	1	1	2	1
2	1	0	1	2	2	0	1	4
3	5	2	2	2	2	3	3	4
4	4	5	4	4	4	5	5	5
5	6	4	3	3	4	5	3	4
6	4	5	2	2	2	4	3	3
7	3	1	2	2	3	3	3	1
8	1	3	3	2	3	3	3	4
9	3	2	2	2	2	2	1	2
10	2	1	2	1	2	3	3	2
11	2	1	1	1	2	4	2	2
12	2	1	1	1	1	1	2	0
13	0	0	0	0	1	0	0	0
14	1	0	1	1	1	2	2	4
15	4	0	0	0	1	2	0	0
16	0	0	1	1	1	2	0	0
17	0	0	0	1	1	0	1	2
18	1	1	1	2	3	2	2	1
19	2	1	0	1	3	4	2	3
20	2	1	1	1	1	1	3	2
21	2	0	1	1	1	1	0	0
22	0	0	0	0	1	1	2	2
23	2	0	2	1	2	2	2	2
24	2	3	1	2	2	3	3	2
25	1	1	1	0	1	1	0	2
26	1	0	0	1	1	1	0	3
27	4	3	2	3	2	1	1	3
28	0	0	0	0	1	1	1	1
29	0	0	1	1	2	2	1	1
30	2	2	3	2	3	1	1	1



The aa Index

Date	Day	3-hourly aa-indices								Aa _{am}	Aa _{pm}	Aa
01/09/2022	244	12	32	24	16	8	9	12	8	21	9.2	15.1
02/09/2022	245	8	8	16	16	16	5	8	37	11.9	16.6	14.3
03/09/2022	246	67	32	45	32	46	32	45	45	44.1	42.2	43.1
04/09/2022	247	80	59	102	137	81	80	67	45	94.5	68.2	81.3
05/09/2022	248	67	45	45	67	59	59	45	45	56.2	52.2	54.2
06/09/2022	249	46	46	32	24	32	45	37	37	36.9	38	37.5
07/09/2022	250	24	16	16	16	32	45	32	8	18.1	29.4	23.7
08/09/2022	251	16	32	45	24	24	32	24	45	29.4	31.4	30.4
09/09/2022	252	37	9	16	67	24	16	2	16	32.5	14.7	23.6
10/09/2022	253	24	12	24	24	38	45	32	12	21	31.8	26.4
11/09/2022	254	20	12	16	12	16	45	16	12	15	22.4	18.7
12/09/2022	255	20	16	24	12	20	5	9	8	18	10.6	14.3
13/09/2022	256	2	5	8	8	8	5	2	5	5.8	5.1	5.5
14/09/2022	257	5	5	12	8	12	16	24	45	7.5	24.3	15.9
15/09/2022	258	37	5	8	8	5	16	5	8	14.5	8.5	11.5
16/09/2022	259	2	12	12	8	5	12	5	8	8.6	7.5	8
17/09/2022	260	5	5	5	8	12	8	5	16	5.8	10.2	8
18/09/2022	261	8	12	24	24	32	12	16	16	17.1	19	18.1
19/09/2022	262	24	5	5	20	32	45	16	37	13.6	32.7	23.2
20/09/2022	263	8	8	5	8	16	12	33	20	7.1	20.2	13.7
21/09/2022	264	9	5	8	12	8	5	2	12	8.5	6.8	7.7
22/09/2022	265	2	8	12	5	12	16	12	32	6.9	18	12.4
23/09/2022	266	16	8	24	16	32	32	20	24	16	27	21.5
24/09/2022	267	12	20	12	32	32	45	32	20	19	32.4	25.7
25/09/2022	268	5	5	12	20	12	12	2	20	10.6	11.6	11.1
26/09/2022	269	9	2	2	8	12	2	5	37	5.5	14.2	9.8
27/09/2022	270	80	81	24	59	32	16	16	24	61	22.1	41.5
28/09/2022	271	8	8	2	2	8	12	8	12	5.1	9.9	7.5
29/09/2022	272	8	2	12	20	24	16	8	12	10.6	15	12.8
30/09/2022	273	24	46	46	32	32	16	8	5	36.9	15.3	26.1
Monthly Mean Value											22.1	

Notes

- i. The units of the aa index are nT.
- ii. The 3-hour aa values are rounded to the nearest integer. Where $aa = *.5$, aa is rounded down.
- iii. Daily values (Aa_{am} , Aa_{pm} and Aa) are computed from aa values of original resolution.
- iv. The monthly mean value is computed from the daily mean values, Aa .
- v. Definitive aa indices are derived and published by the International Service for Geomagnetic Indices.

