



British  
Geological  
Survey



MONTHLY MAGNETIC BULLETIN

# Lerwick Observatory

September 2023



# 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](http://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](http://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](http://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](http://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](http://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](http://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

The data presented in this bulletin are provided for personal, academic, educational, non-commercial research or other non-commercial use and are not for sale or distribution to third parties without written permission from BGS.

Reproduction of any part of this bulletin should be accompanied by the statement: 'Reproduced with the permission of the British Geological Survey ©UKRI. All rights Reserved'. Publications making use of the data should include an acknowledgment statement of the form: 'The results presented in this paper rely on the data collected at Lerwick magnetic observatory, operated by the British Geological Survey.'

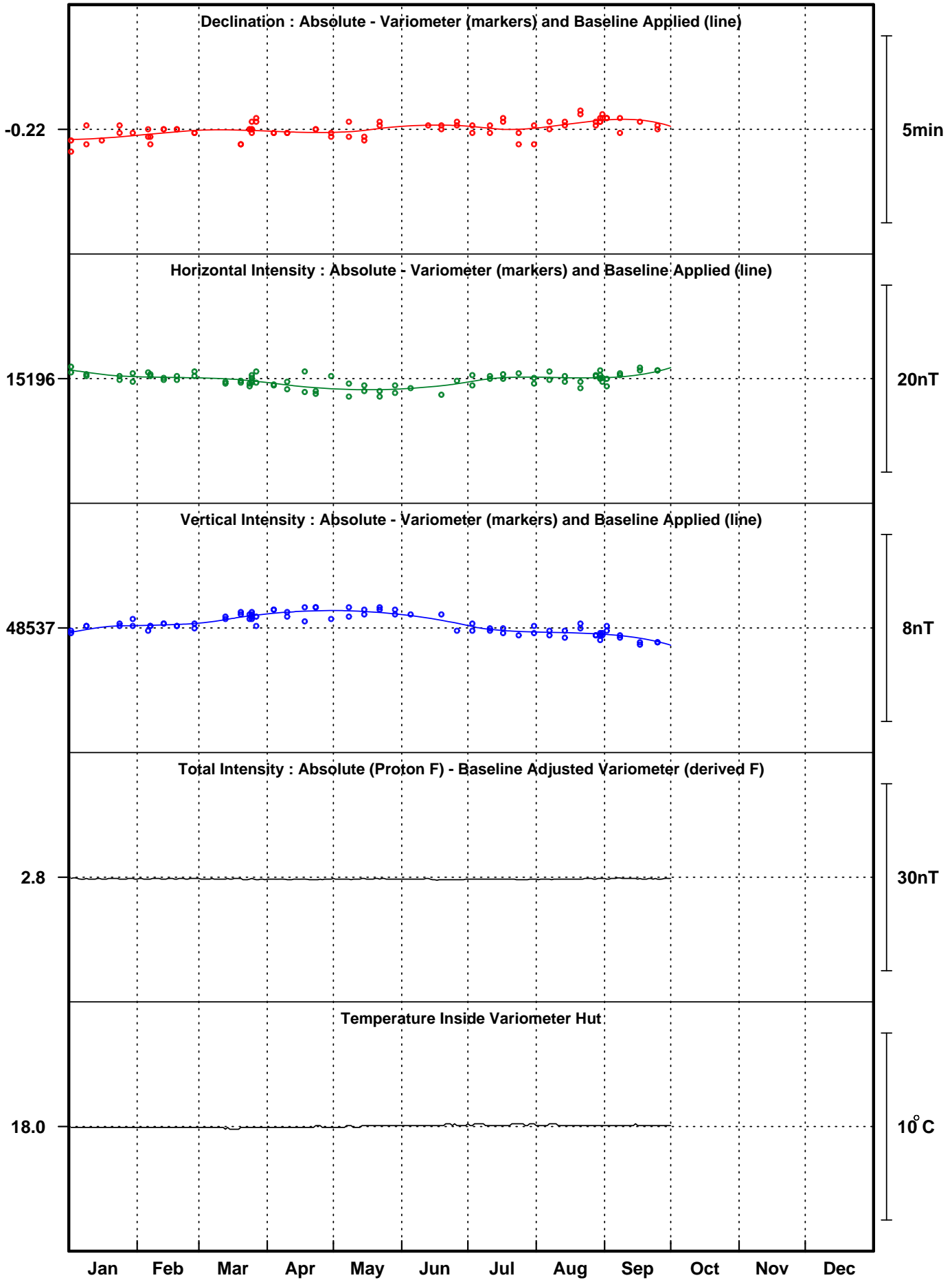
Commercial users can contact the geomagnetism team for information on the range of applications and services offered. Full contact details are available at [geomag.bgs.ac.uk/contactus/staff](http://geomag.bgs.ac.uk/contactus/staff)

# Lerwick Observatory

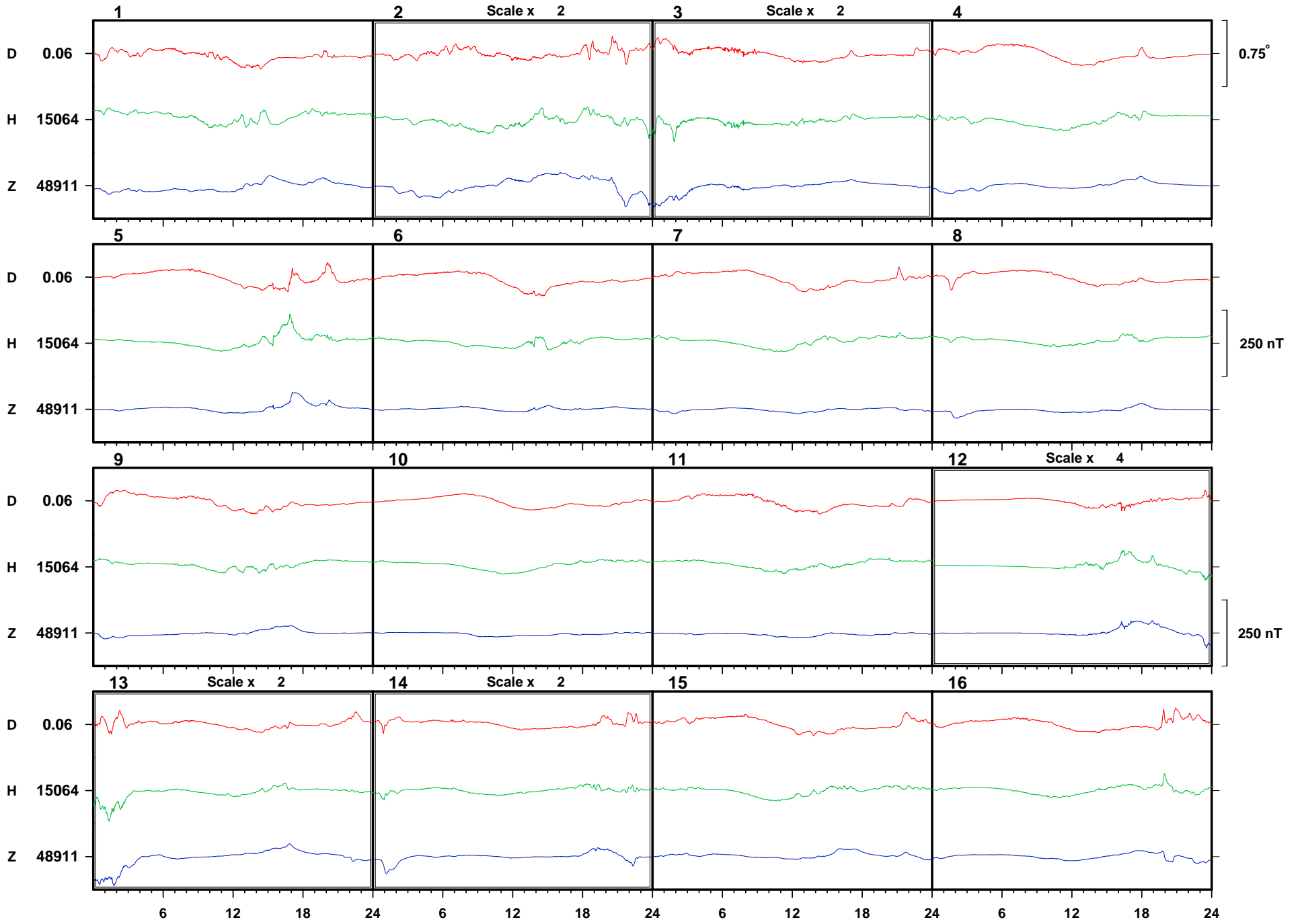
## Absolute observations

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)	
01-Sep-23	244	07:30	0.0819	-0.2100	07:43	72.8671	-2.5	51167.9	15073.5	15194.7	48897.3	48536.7	CT
01-Sep-23	244	07:55	0.0510	-0.2100	08:08	72.8640	-2.5	51163.3	15074.8	15195.5	48892.1	48536.5	CT
07-Sep-23	250	13:52	-0.0891	-0.2100	14:04	72.8648	-2.5	51171.8	15076.6	15195.9	48900.4	48536.3	OB
07-Sep-23	250	14:13	-0.0992	-0.2167	14:26	72.8601	-2.5	51176.3	15081.9	15196.1	48903.4	48536.2	OB
16-Sep-23	259	10:02	0.0857	99999.0	10:13	72.9062	-2.5	51164.6	15039.2	15196.4	48904.4	48536.0	OB
16-Sep-23	259	10:21	0.0651	-0.2117	10:31	72.9026	-2.5	51164.4	15042.2	15196.7	48903.3	48535.9	OB
24-Sep-23	267	09:57	0.0585	-0.2133	10:07	72.8985	-2.5	51156.4	15043.3	15196.4	48894.5	48536.0	OB
24-Sep-23	267	10:15	0.0381	-0.2150	10:26	72.8990	-2.5	51155.1	15042.6	15196.4	48893.4	48536.0	OB

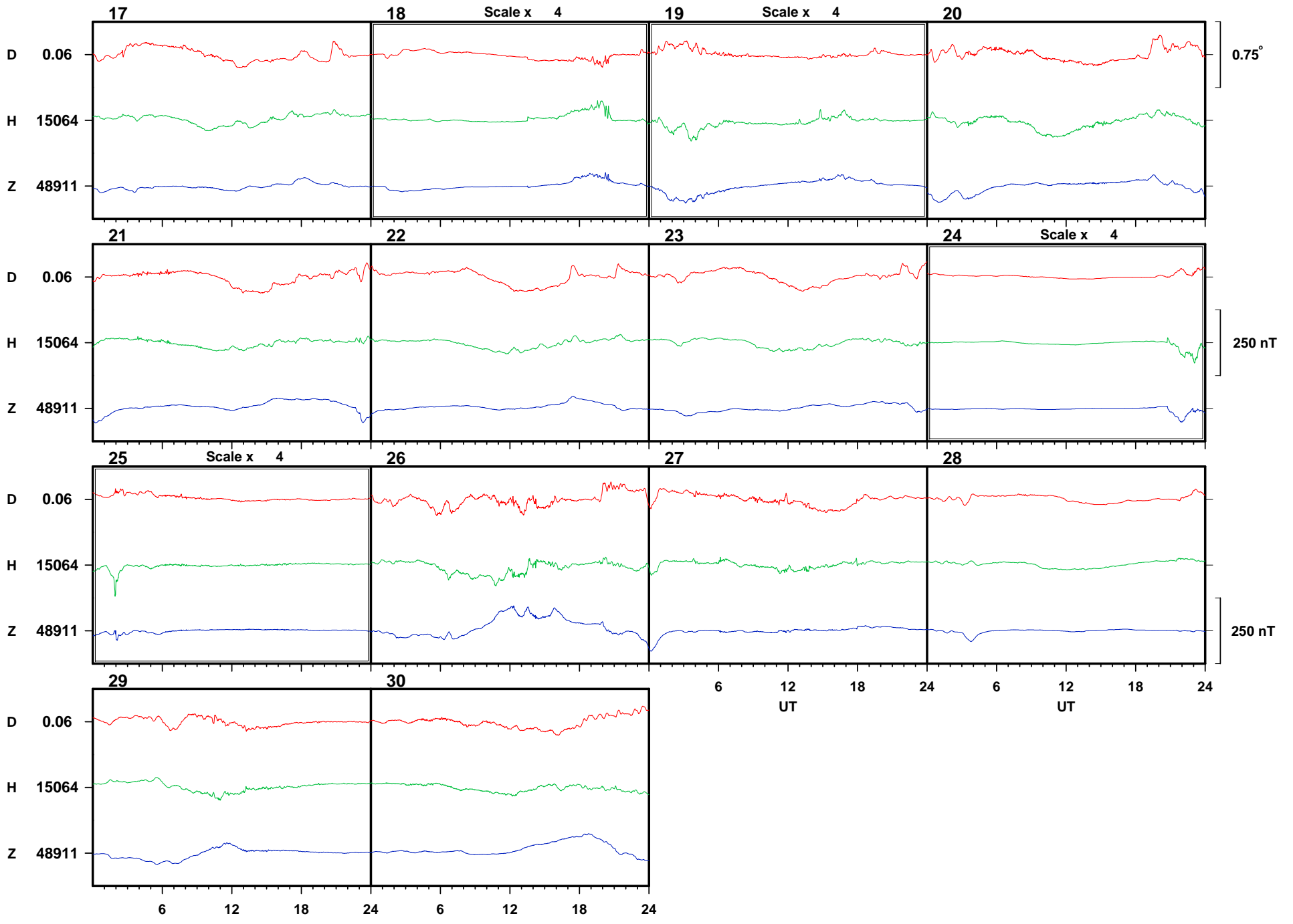
# Lerwick 2023



Lerwick September 2023





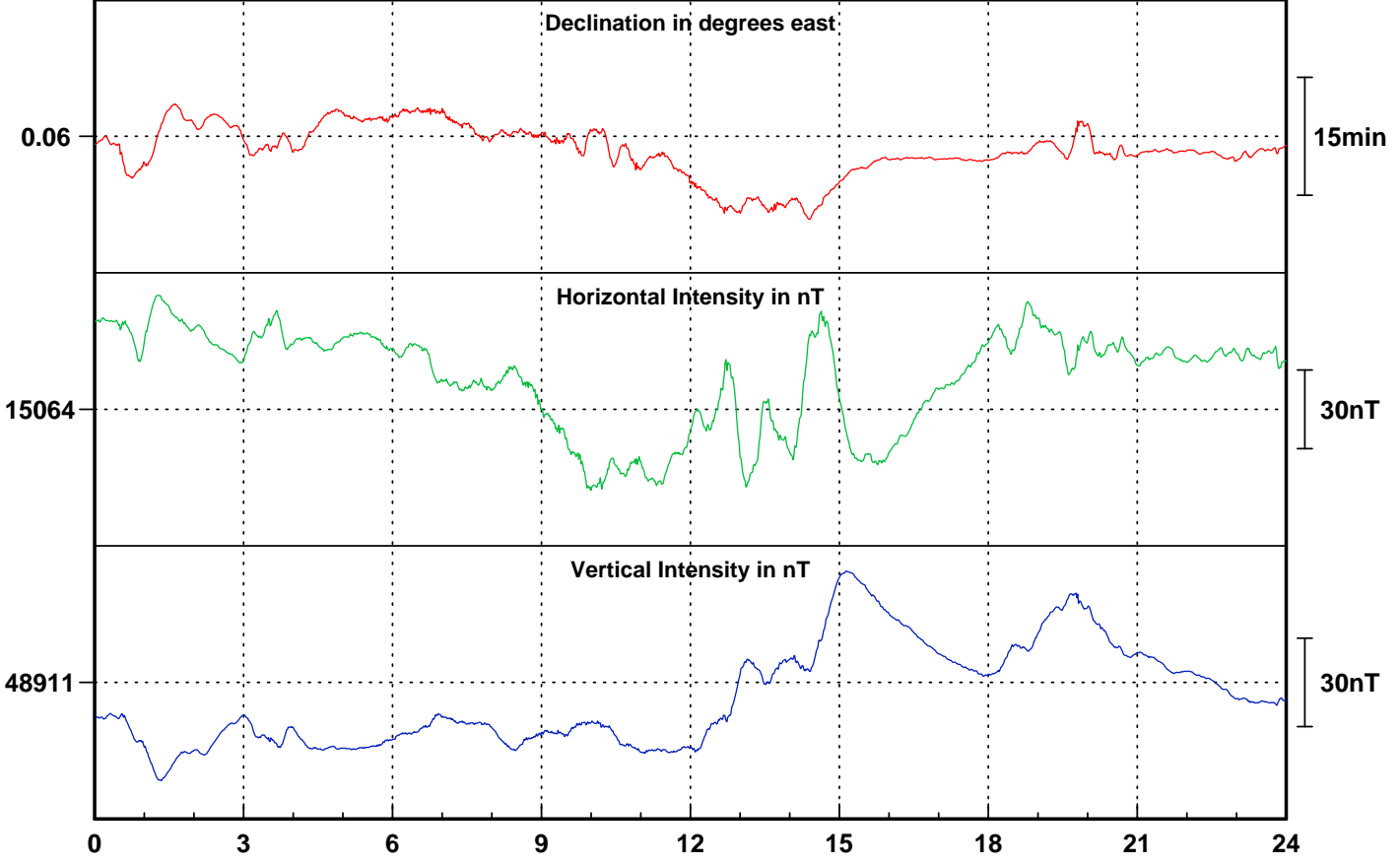


Lerwick September 2023

Date: 01-09-2023

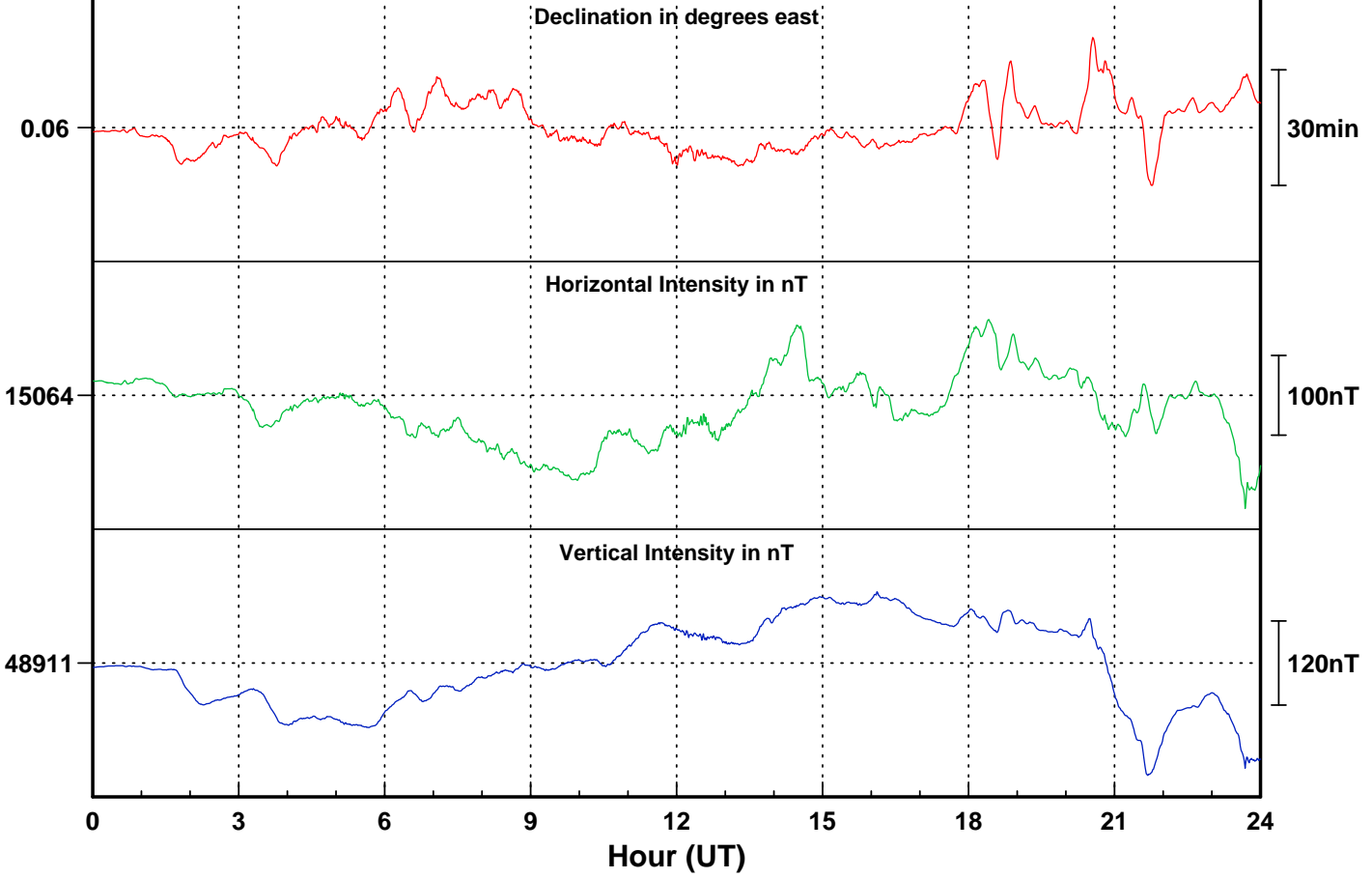
# Lerwick

Day number: 244



Date: 02-09-2023

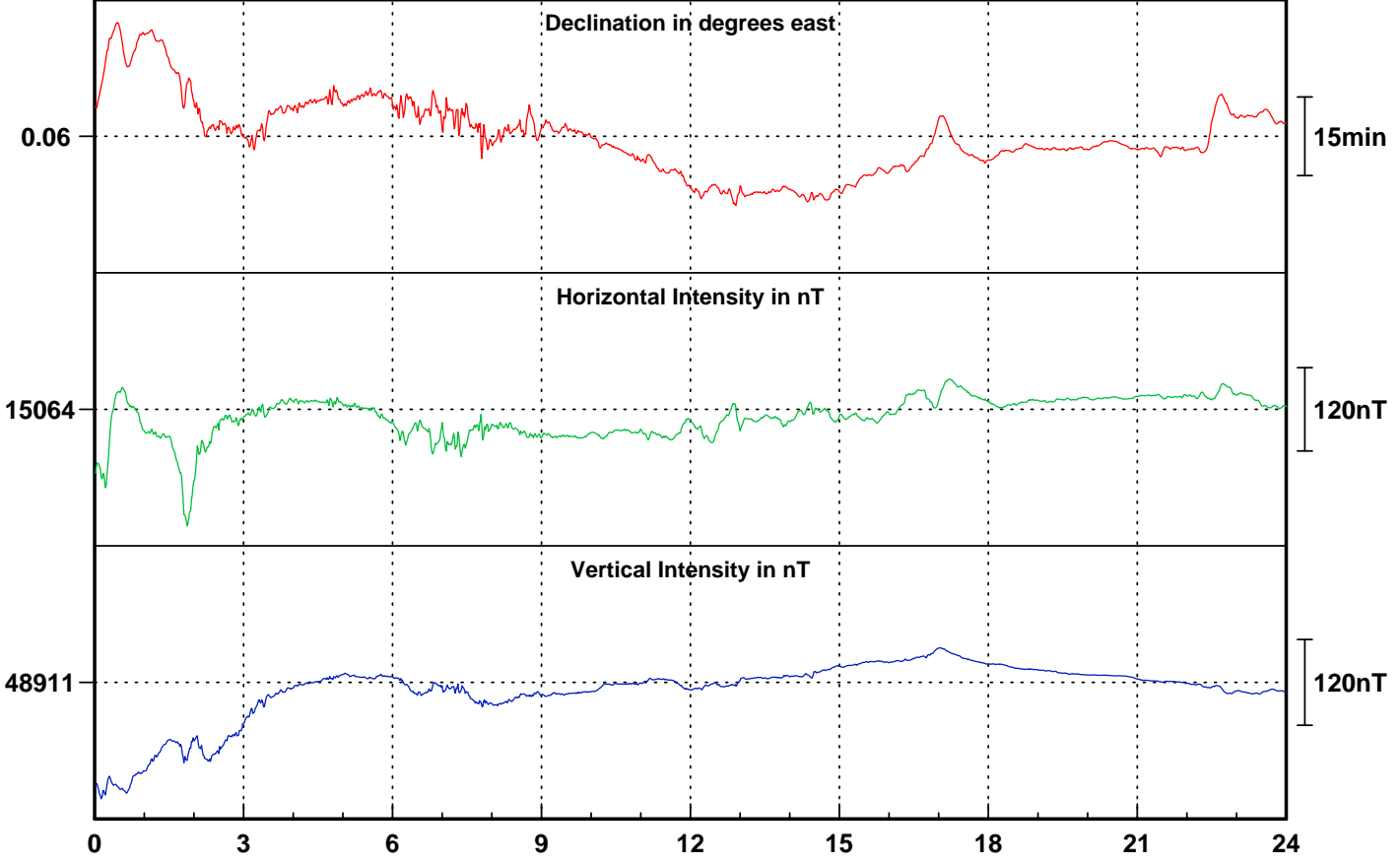
Day number: 245



Date: 03-09-2023

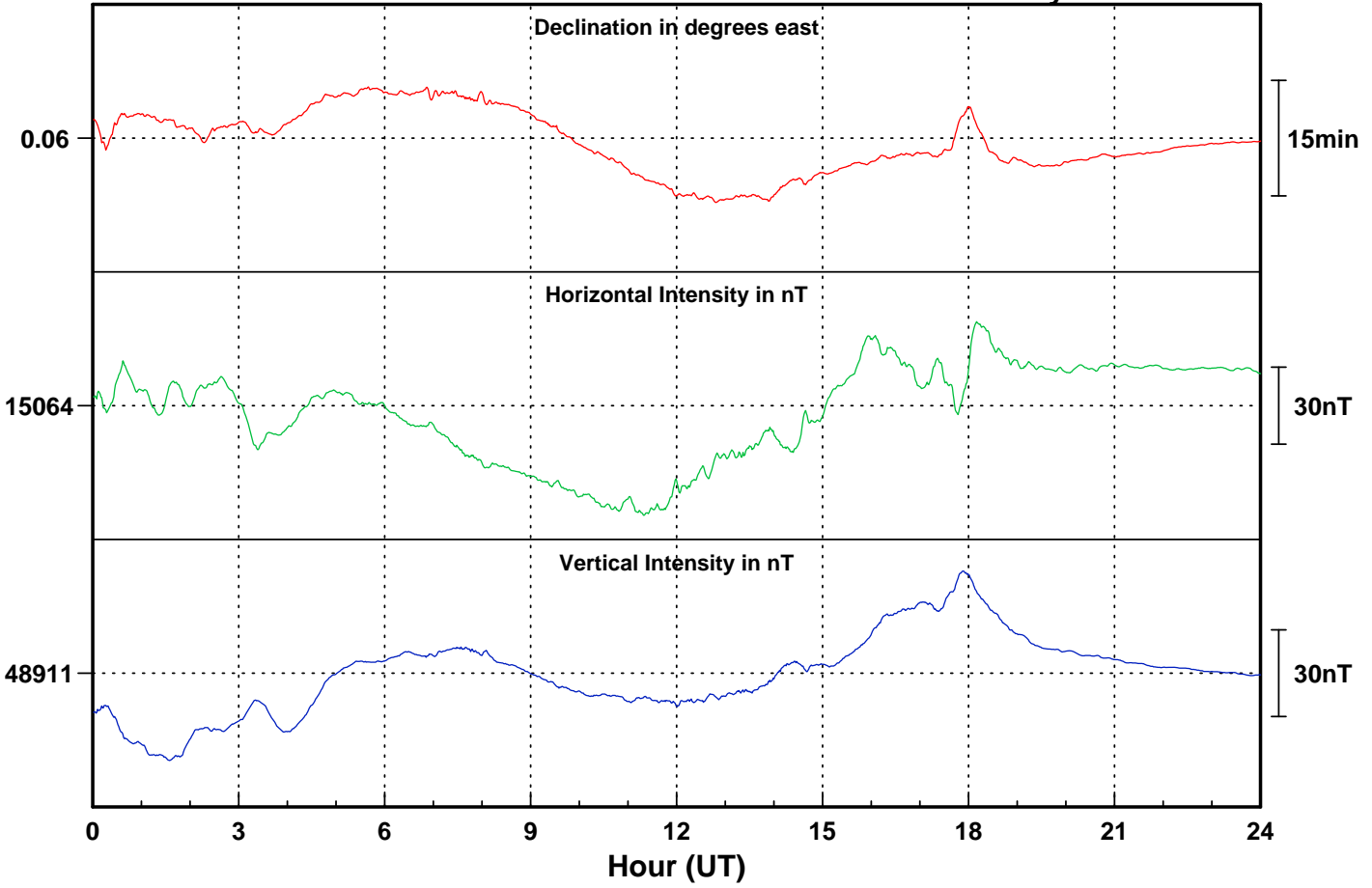
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Day number: 246



Date: 04-09-2023

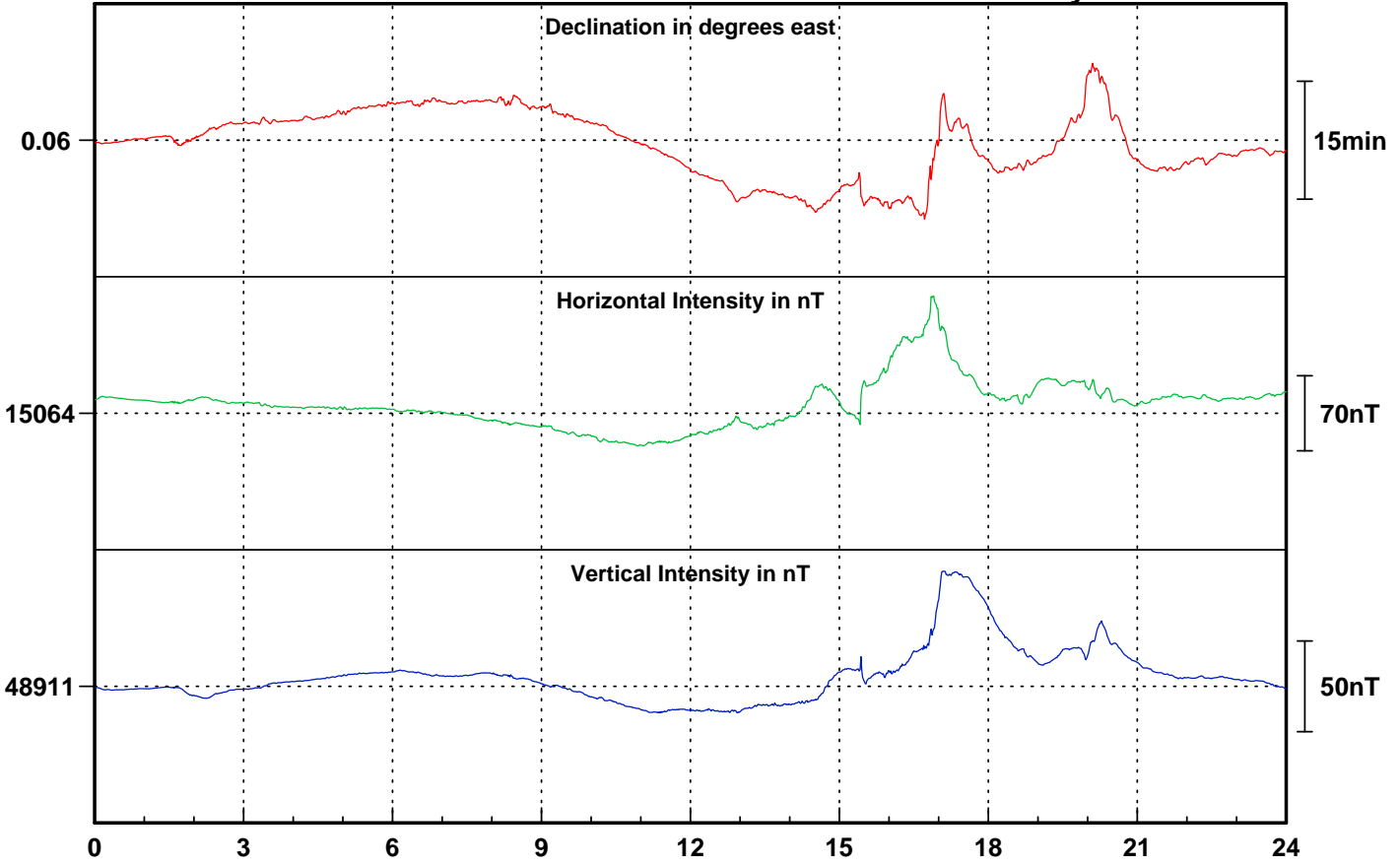
Day number: 247



Date: 05-09-2023

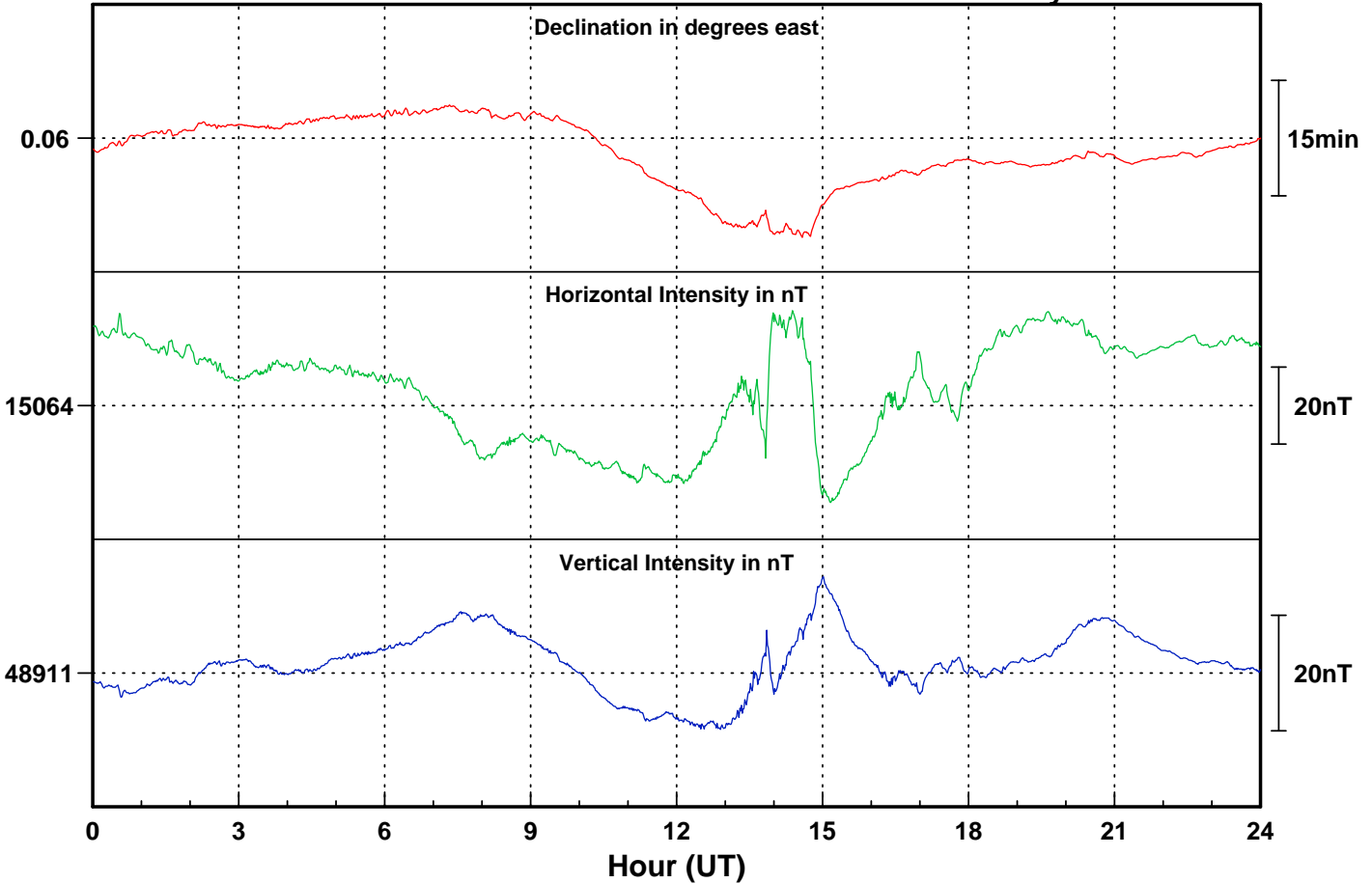
# Lerwick

Day number: 248



Date: 06-09-2023

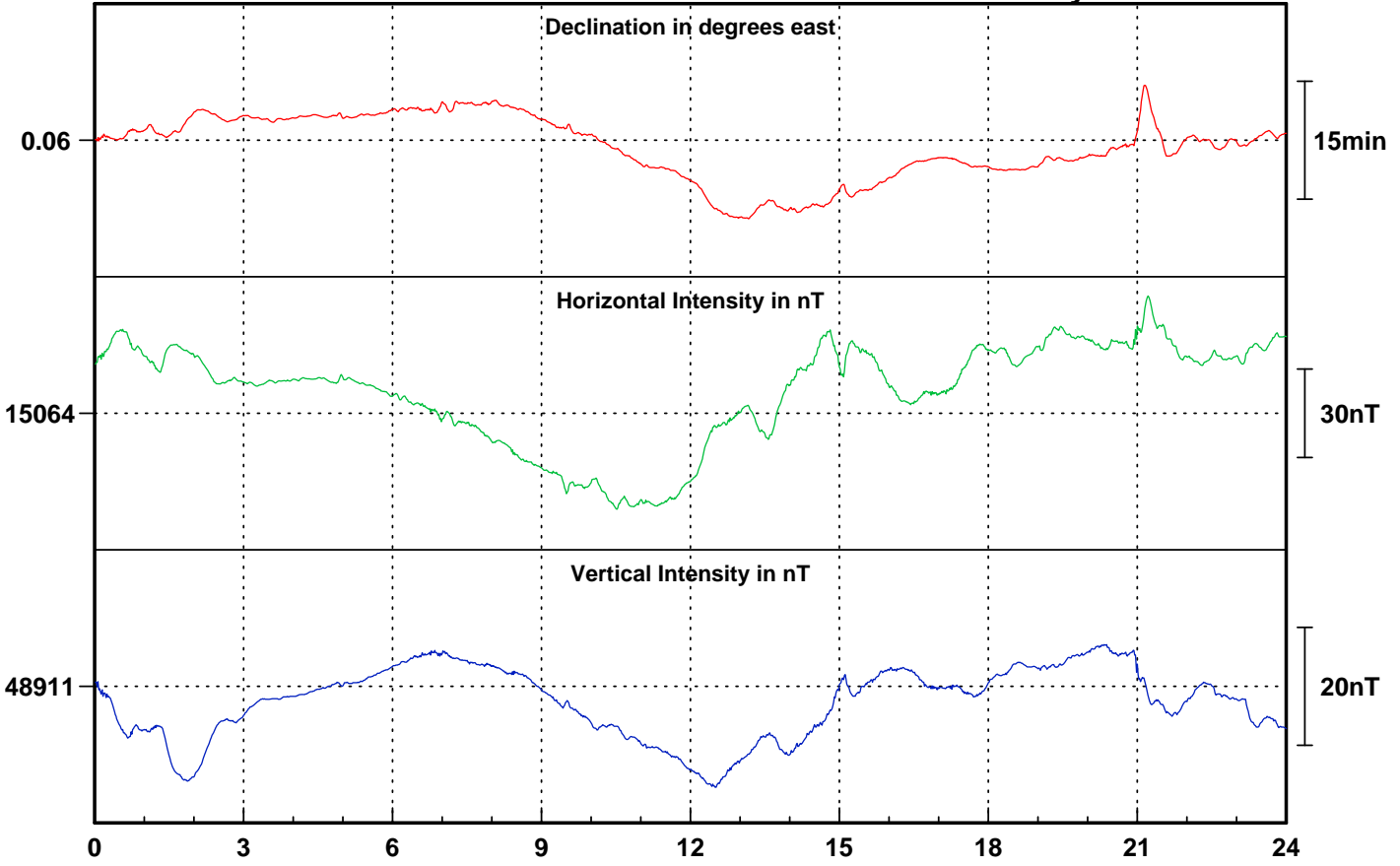
Day number: 249



Date: 07-09-2023

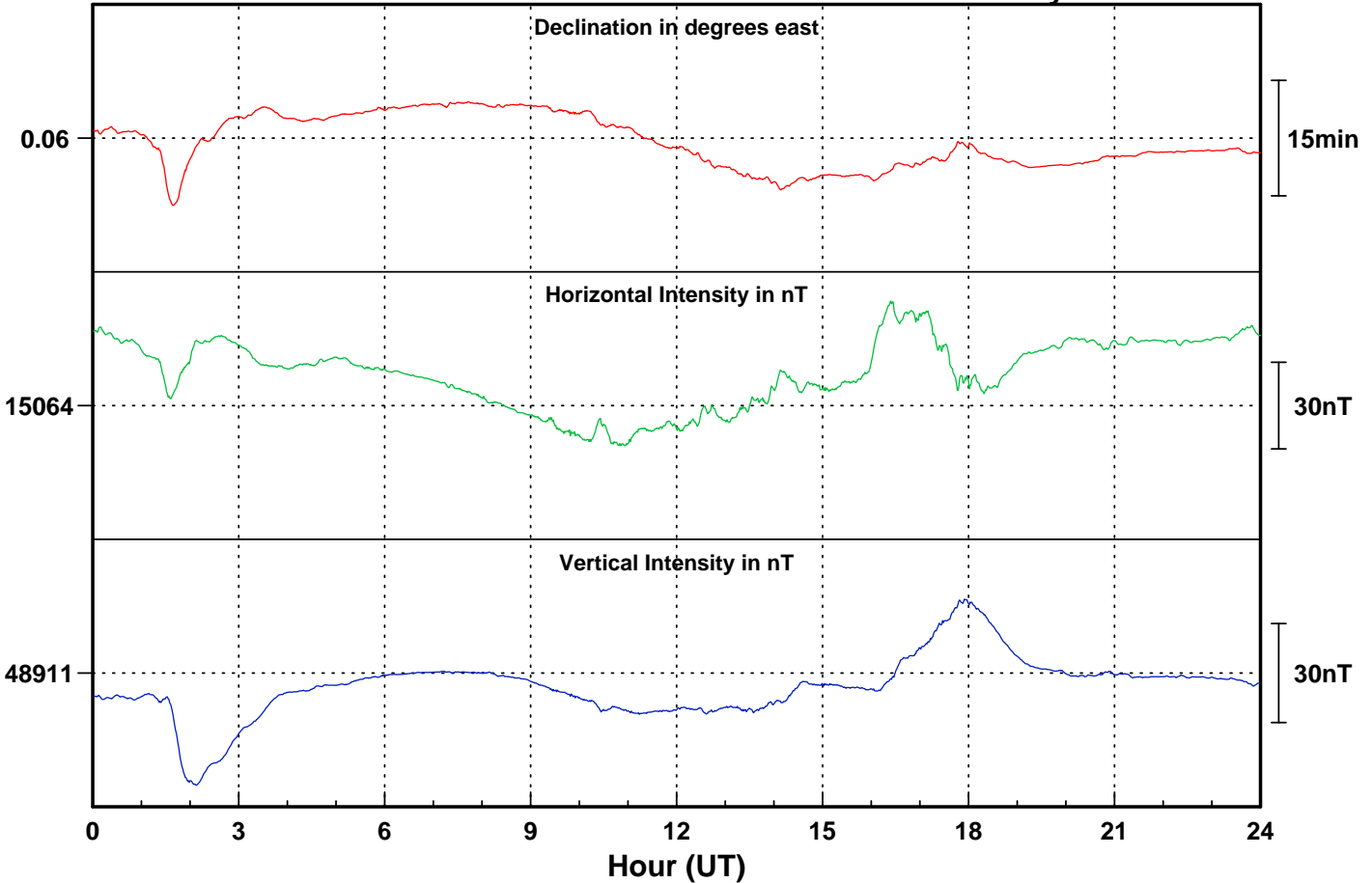
# Lerwick

Day number: 250



Date: 08-09-2023

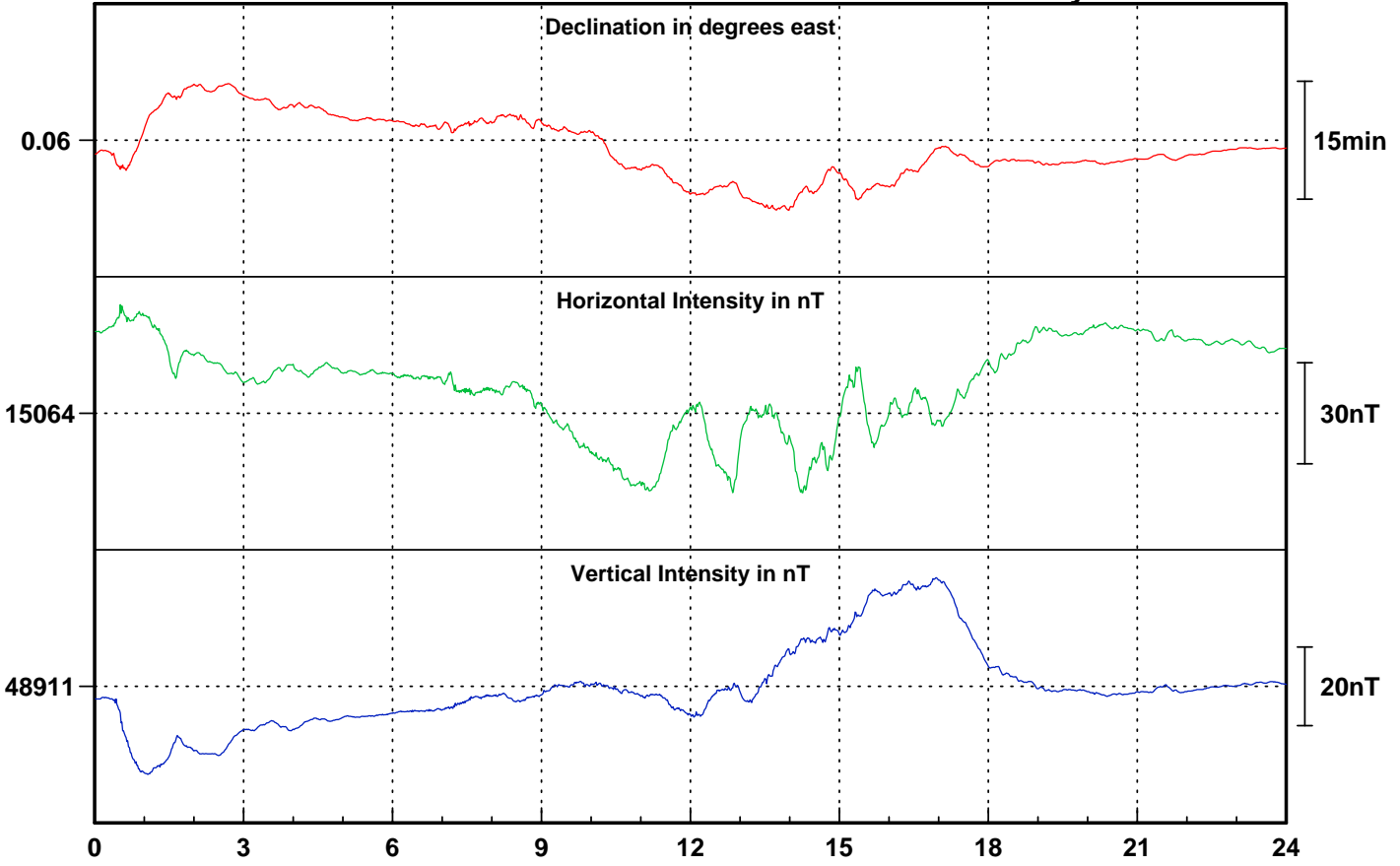
Day number: 251



Date: 09-09-2023

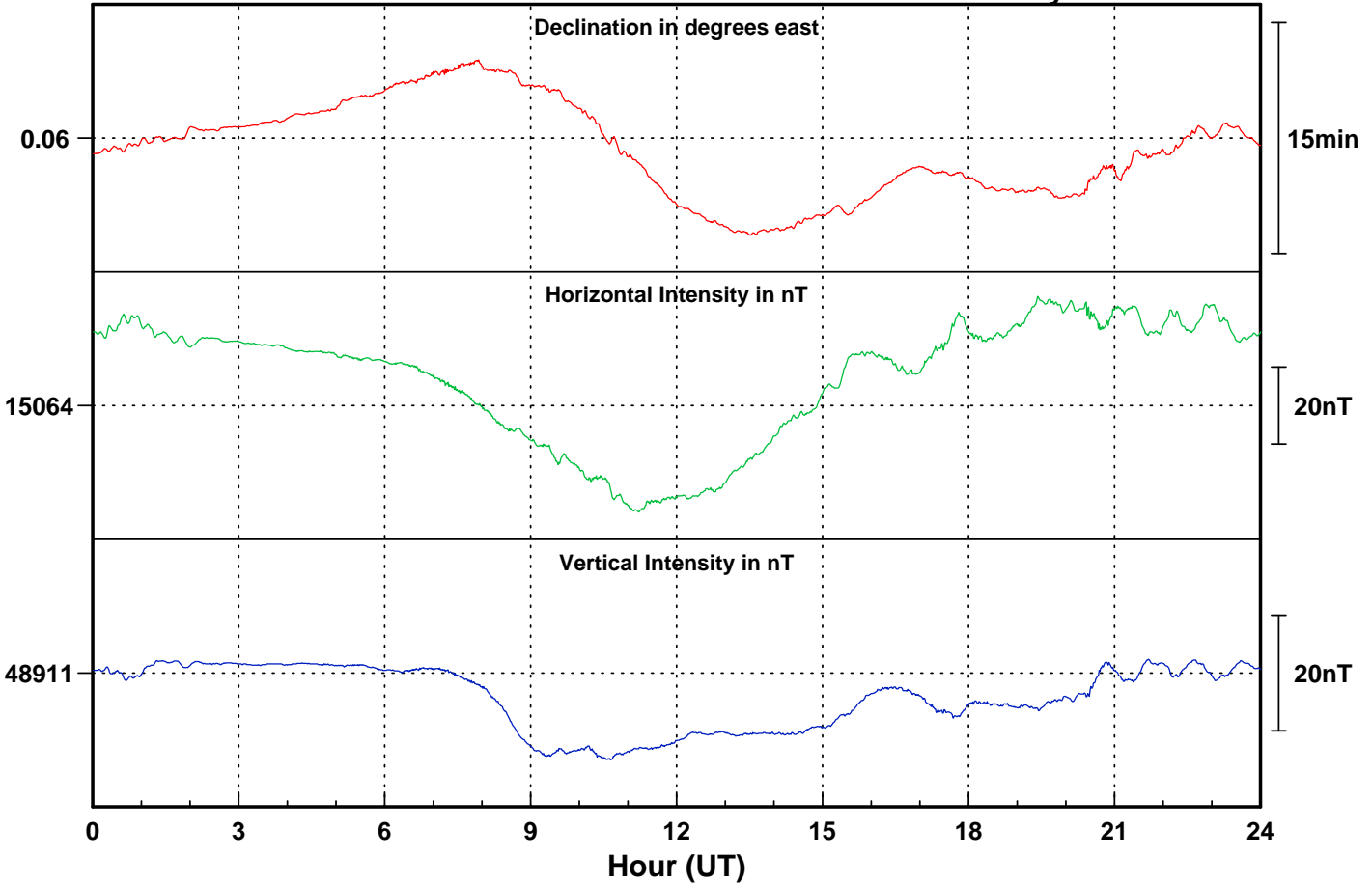
# Lerwick

Day number: 252



Date: 10-09-2023

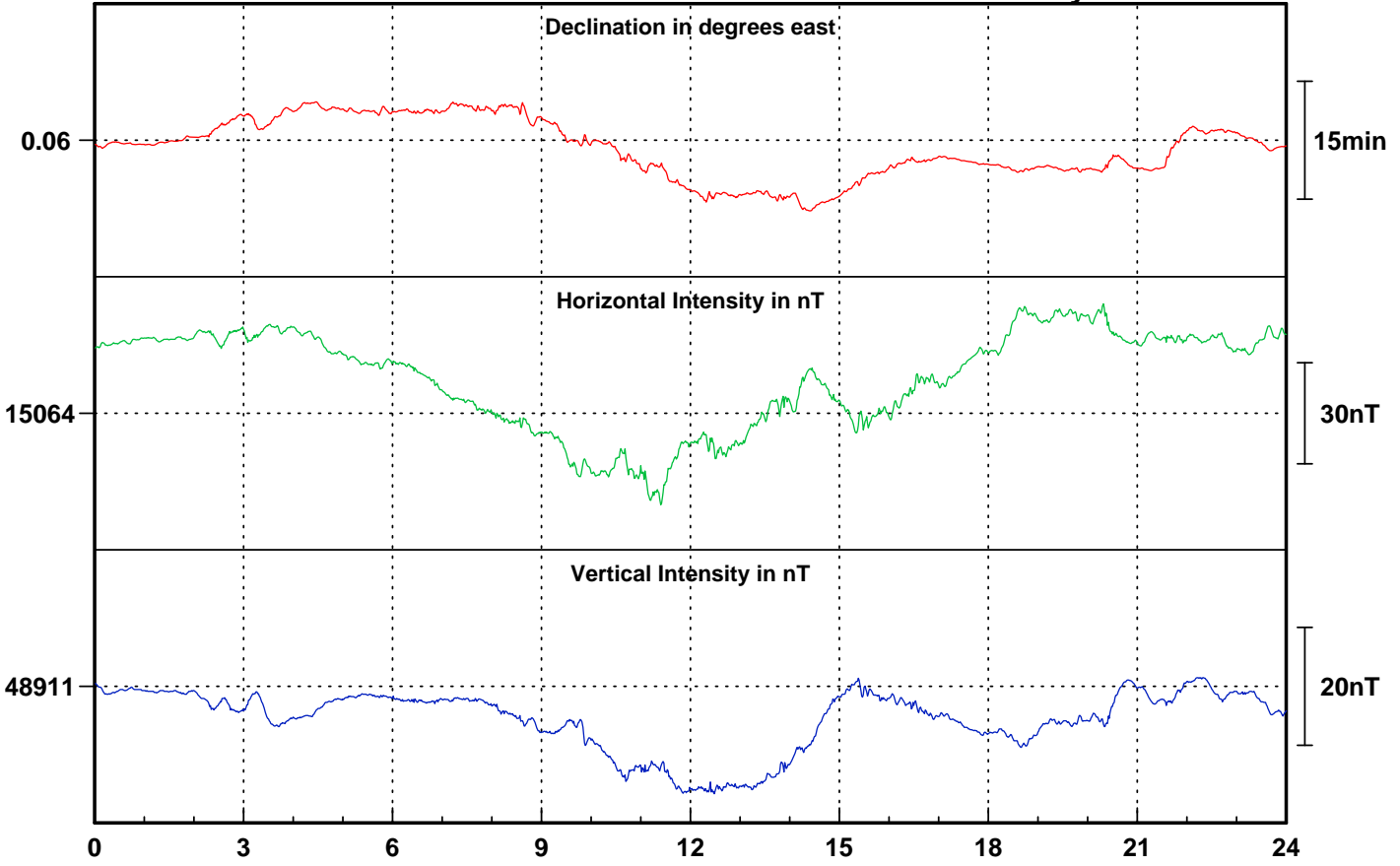
Day number: 253



Date: 11-09-2023

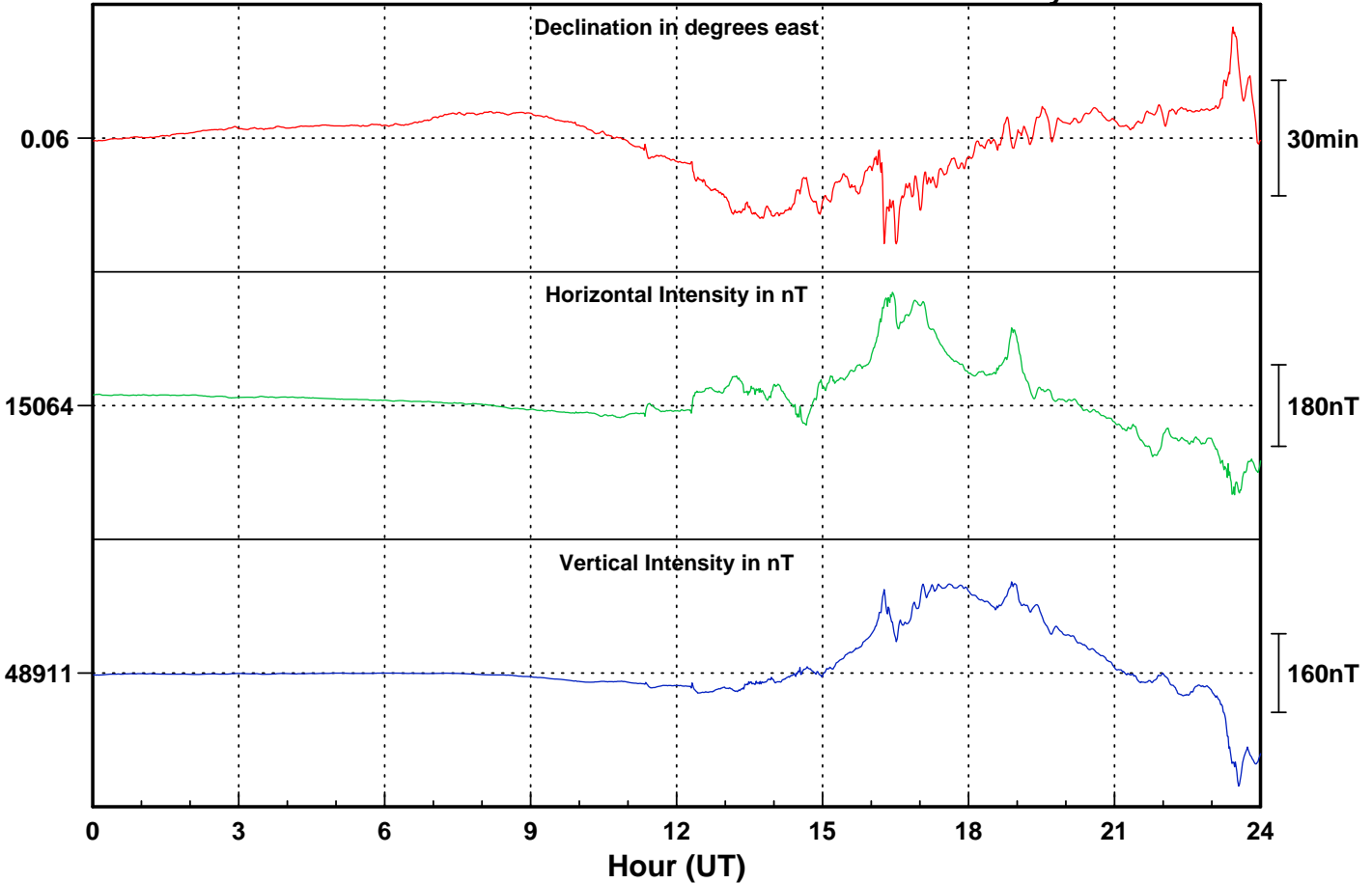
# Lerwick

Day number: 254



Date: 12-09-2023

Day number: 255

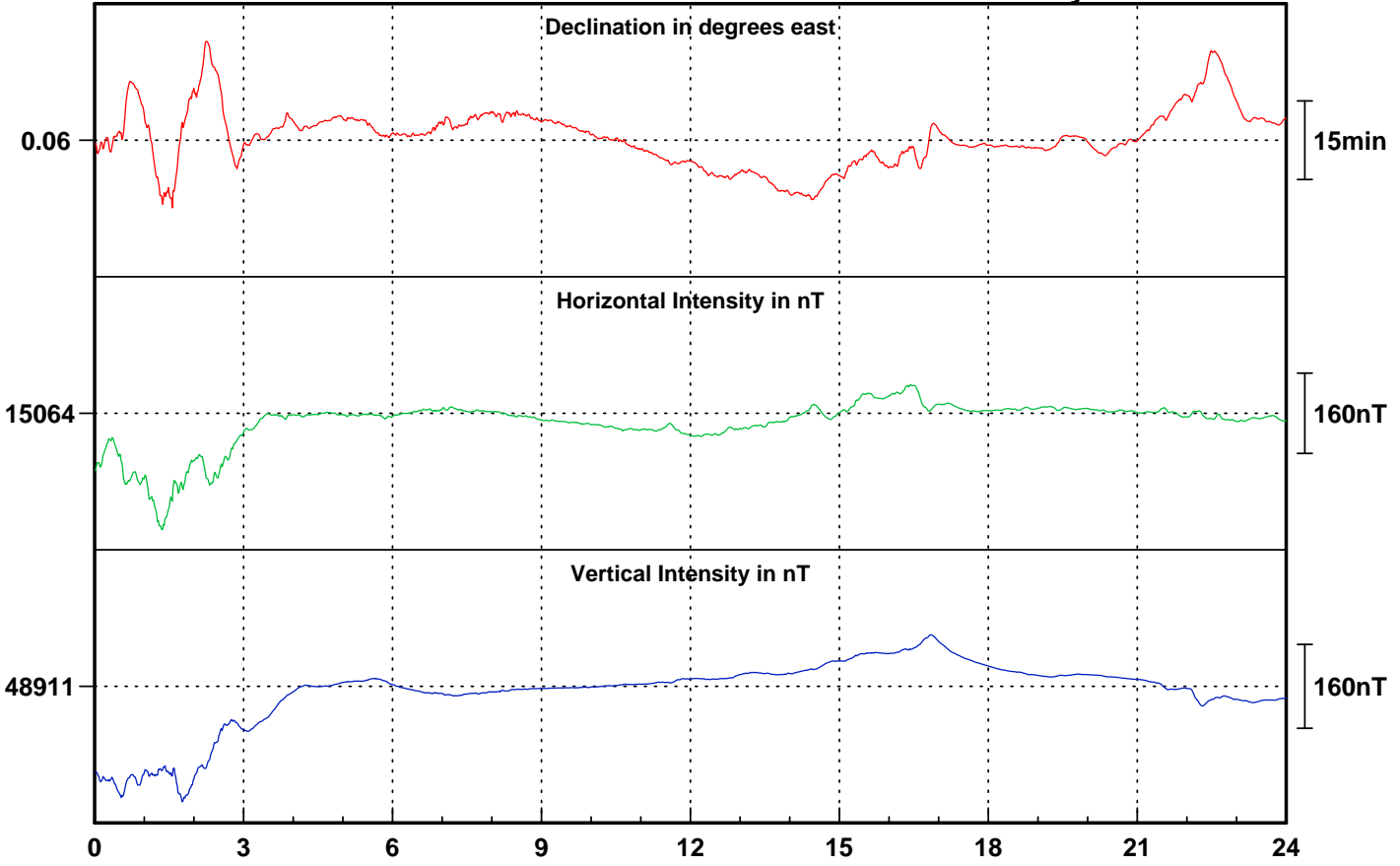


Hour (UT)

Date: 13-09-2023

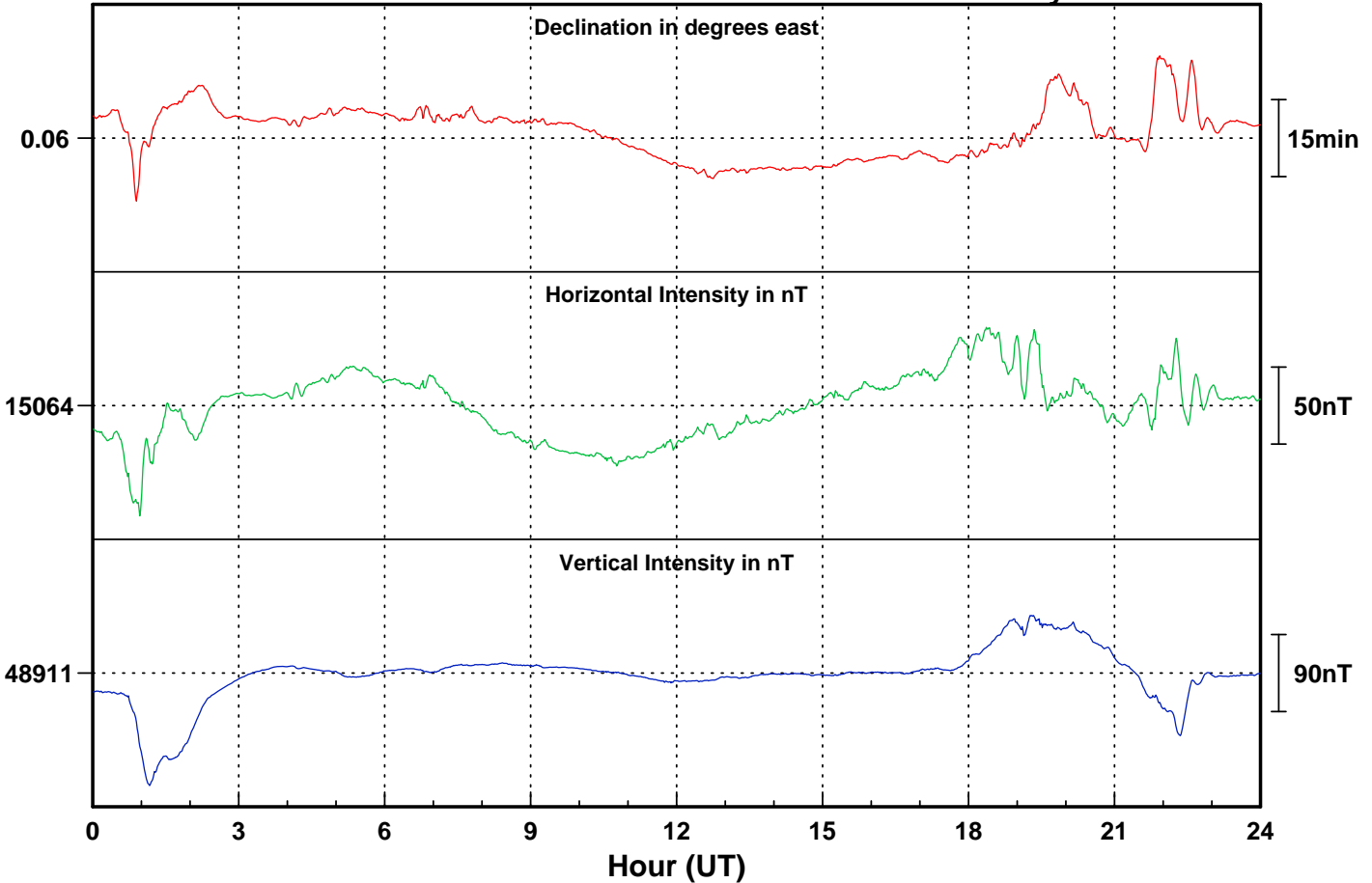
# Lerwick

Day number: 256



Date: 14-09-2023

Day number: 257

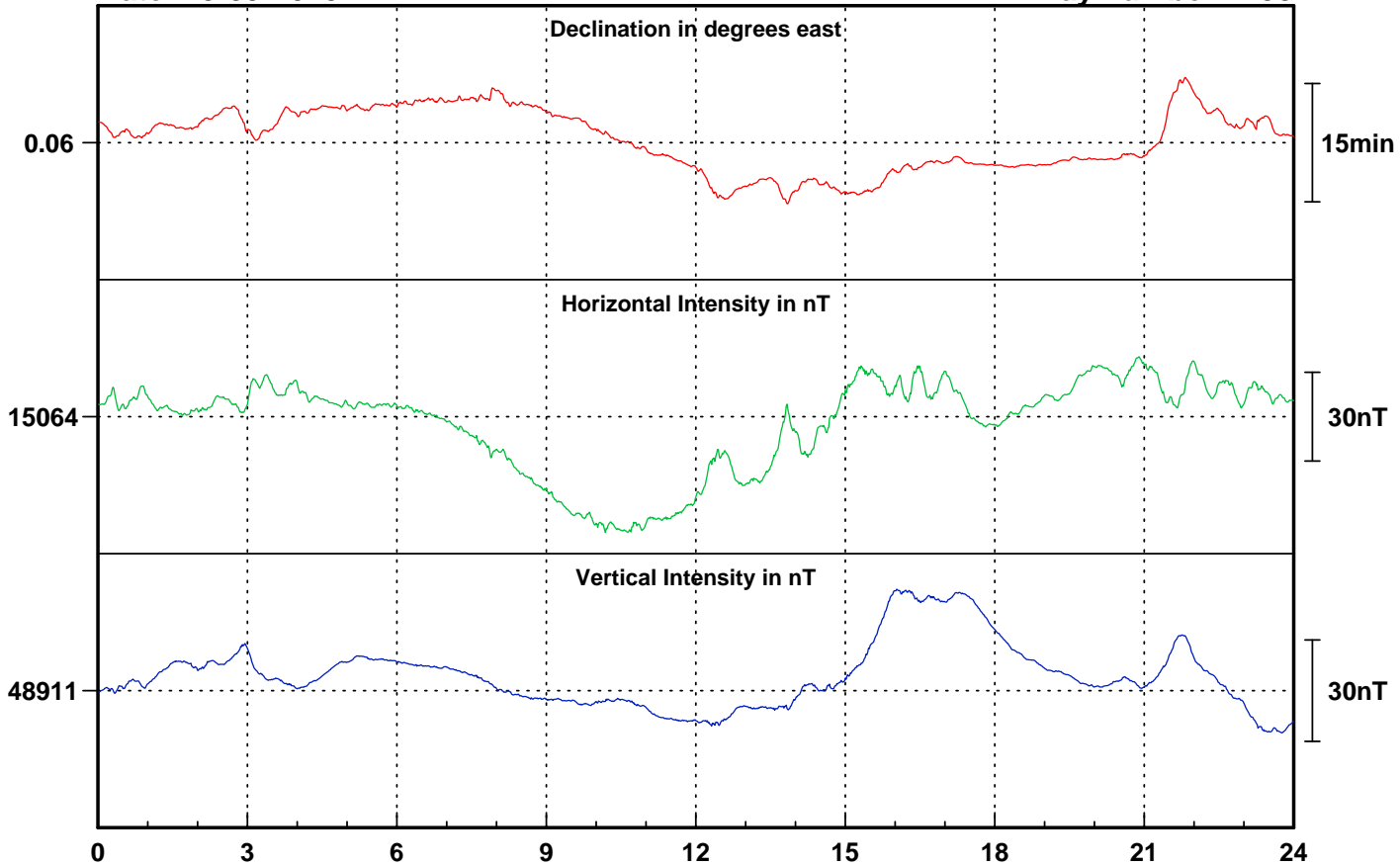




Date: 15-09-2023

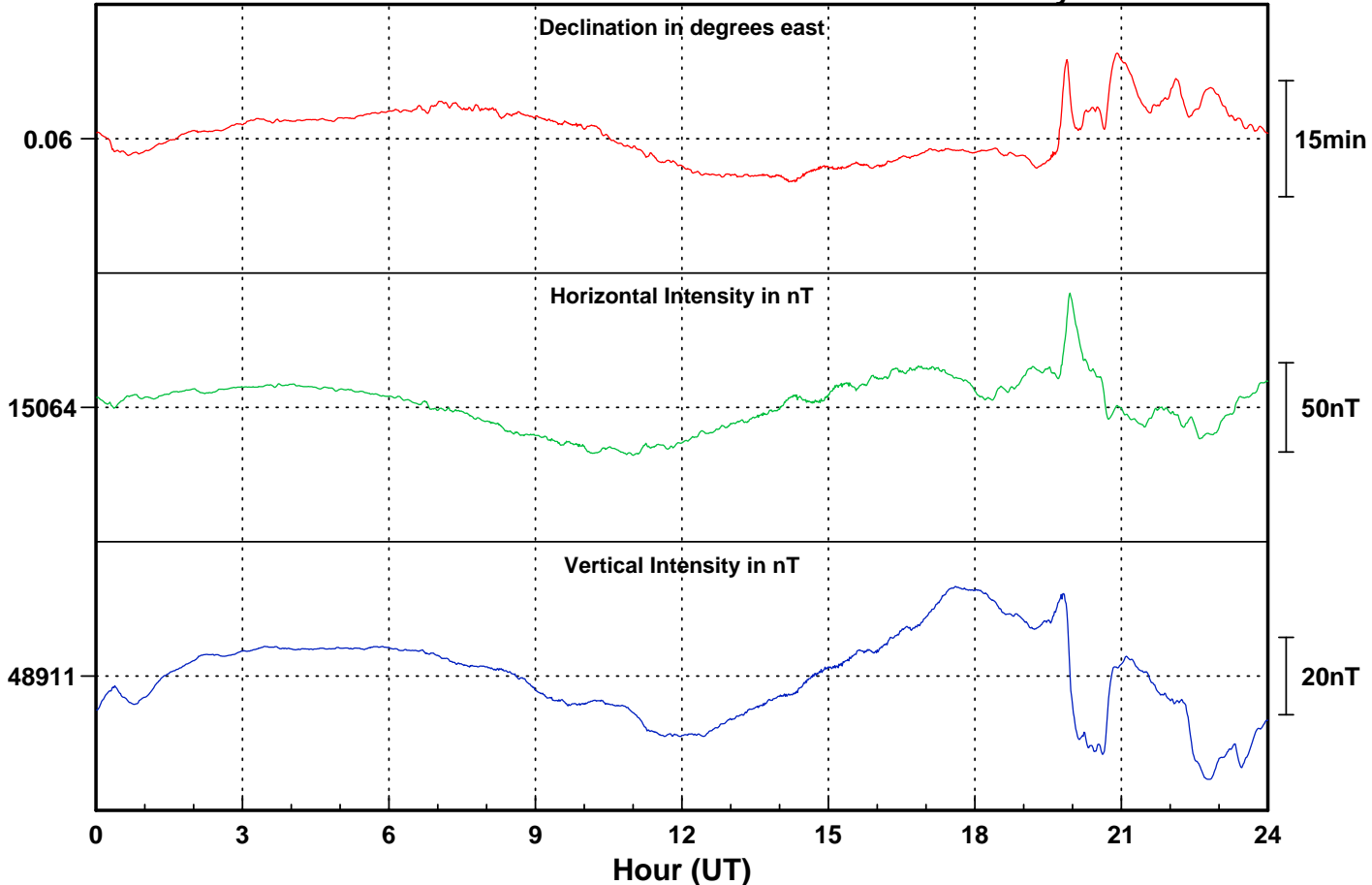
# Lerwick

Day number: 258



Date: 16-09-2023

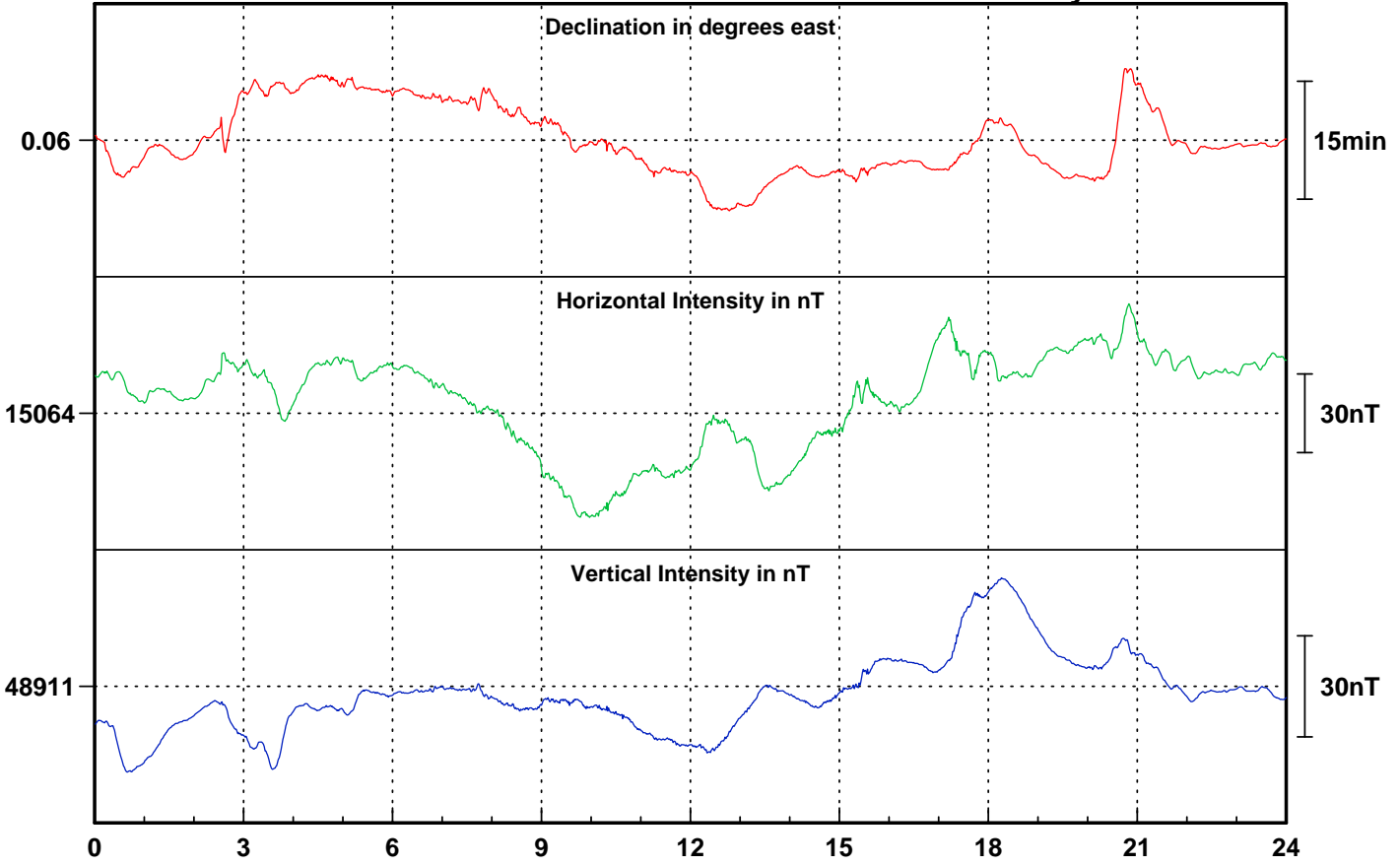
Day number: 259



Date: 17-09-2023

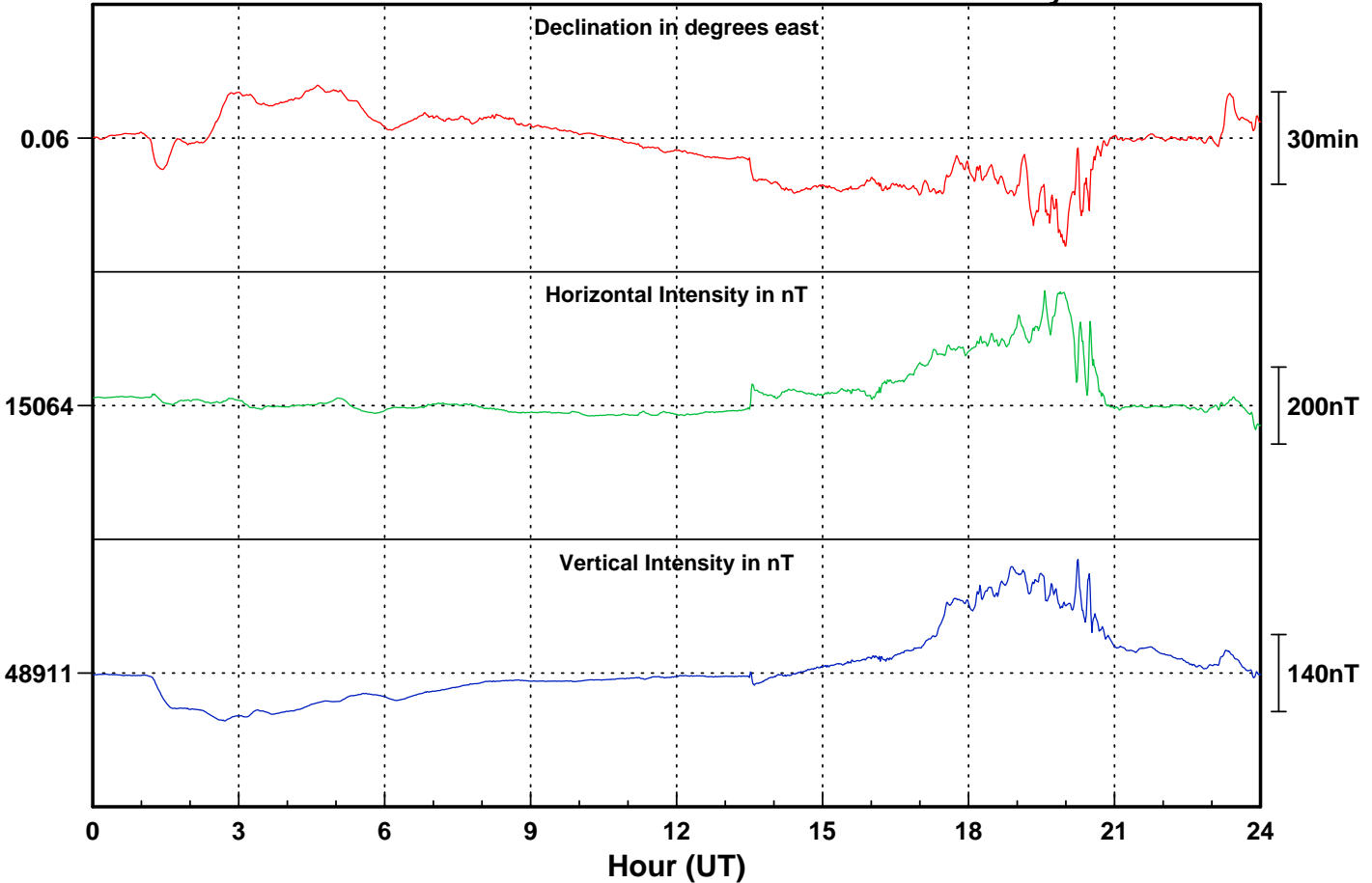
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Day number: 260

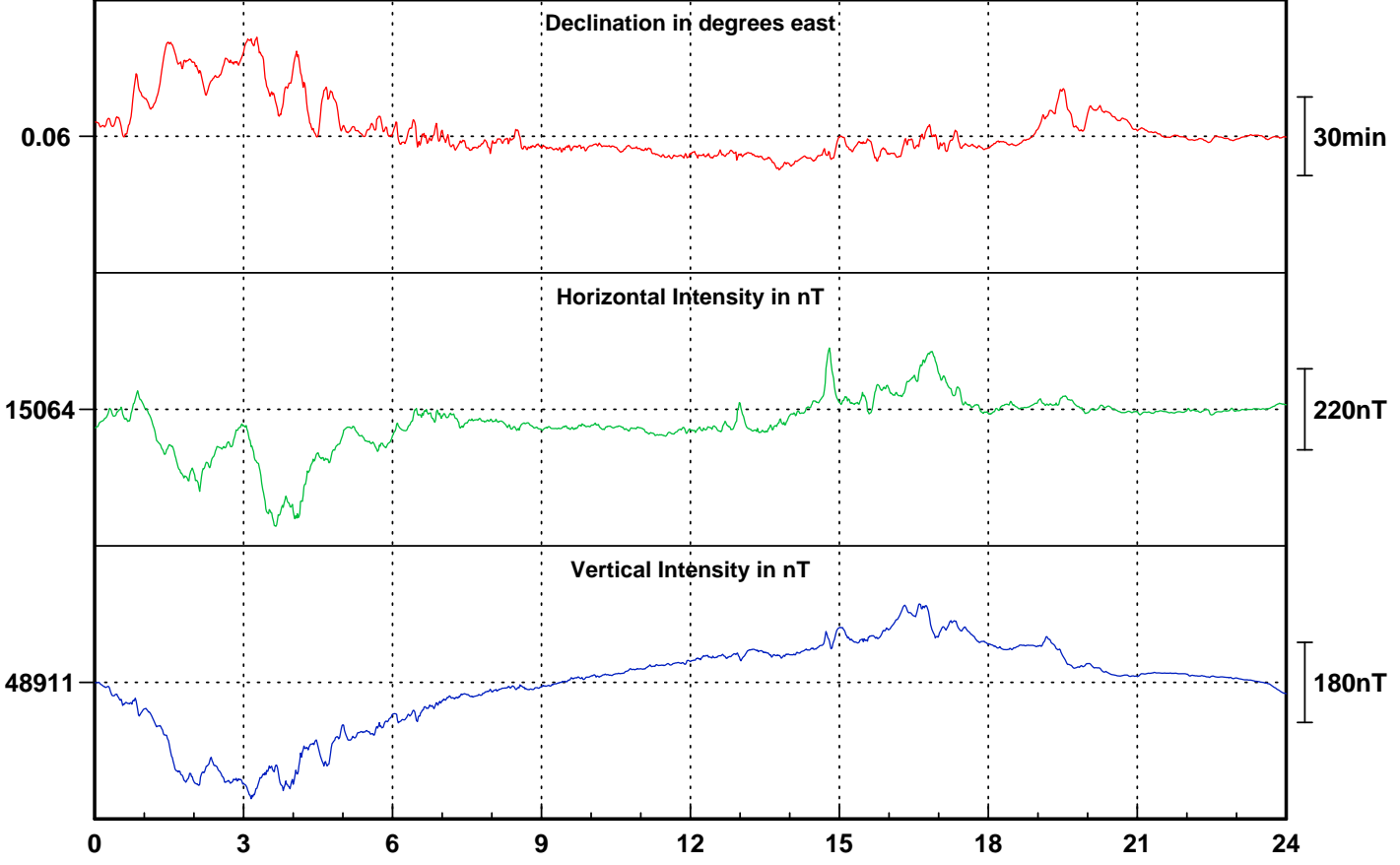


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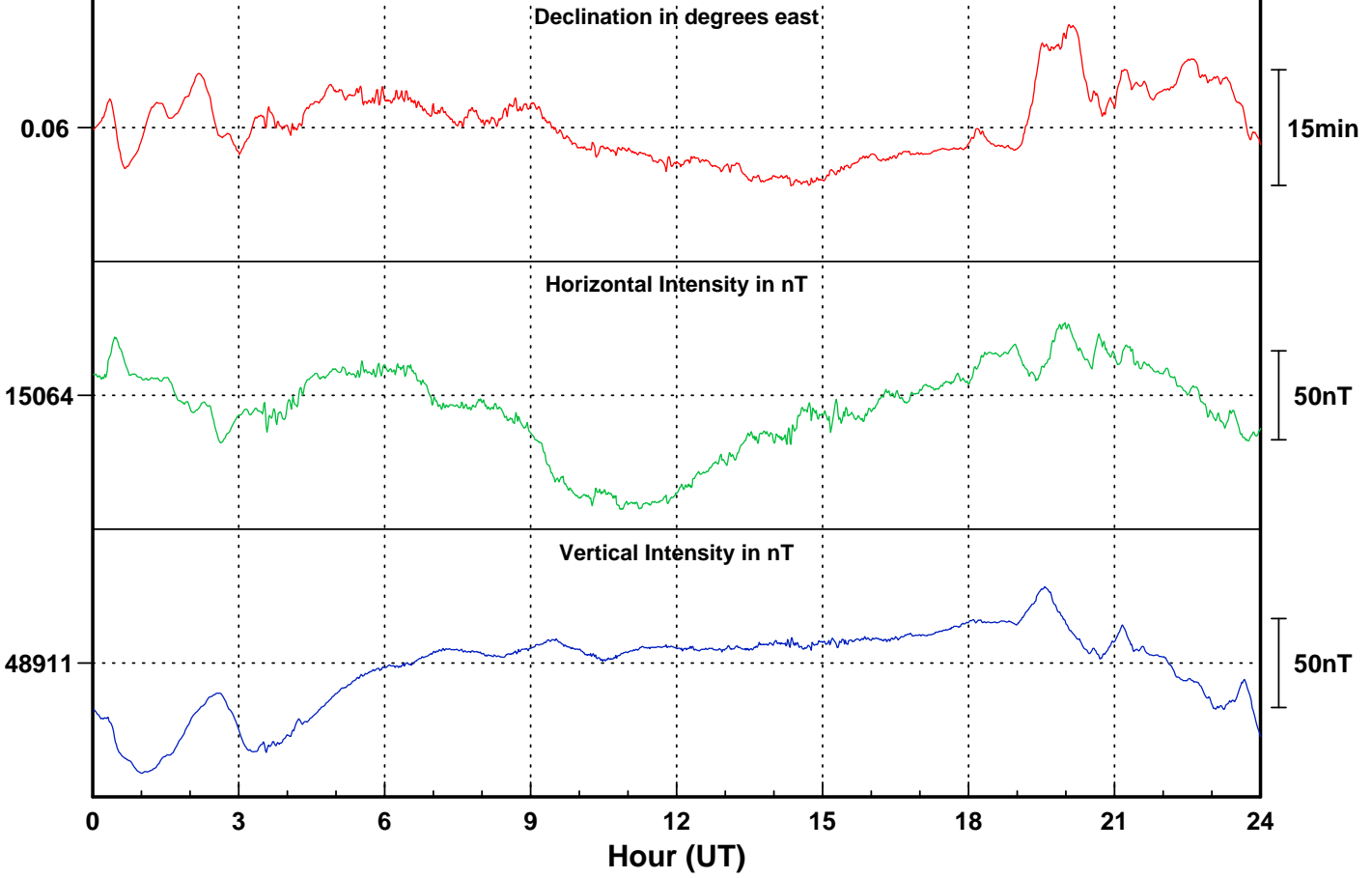
Day number: 261



Date: 19-09-2023 Lerwick Day number: 262



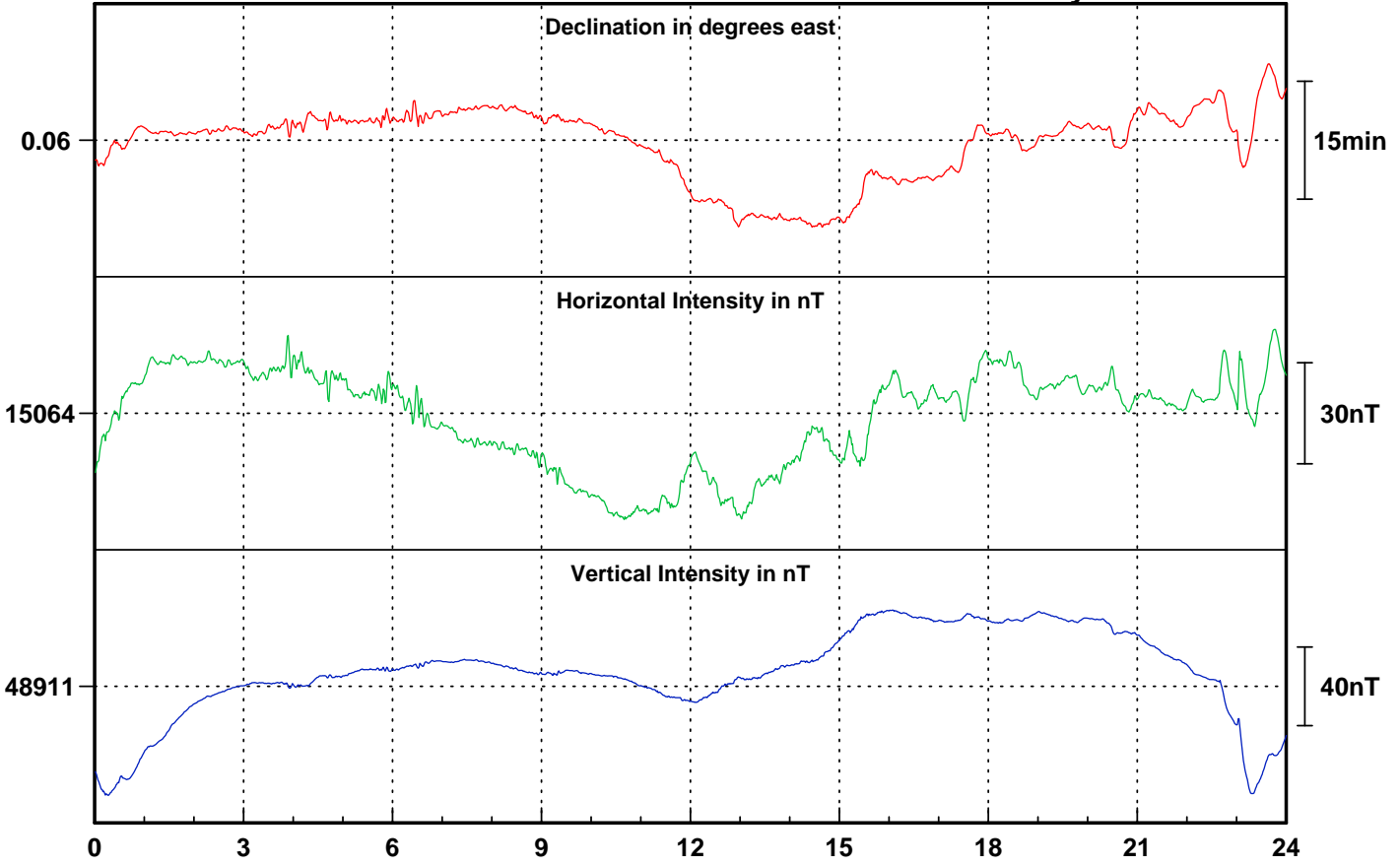
Date: 20-09-2023 Lerwick Day number: 263



Date: 21-09-2023

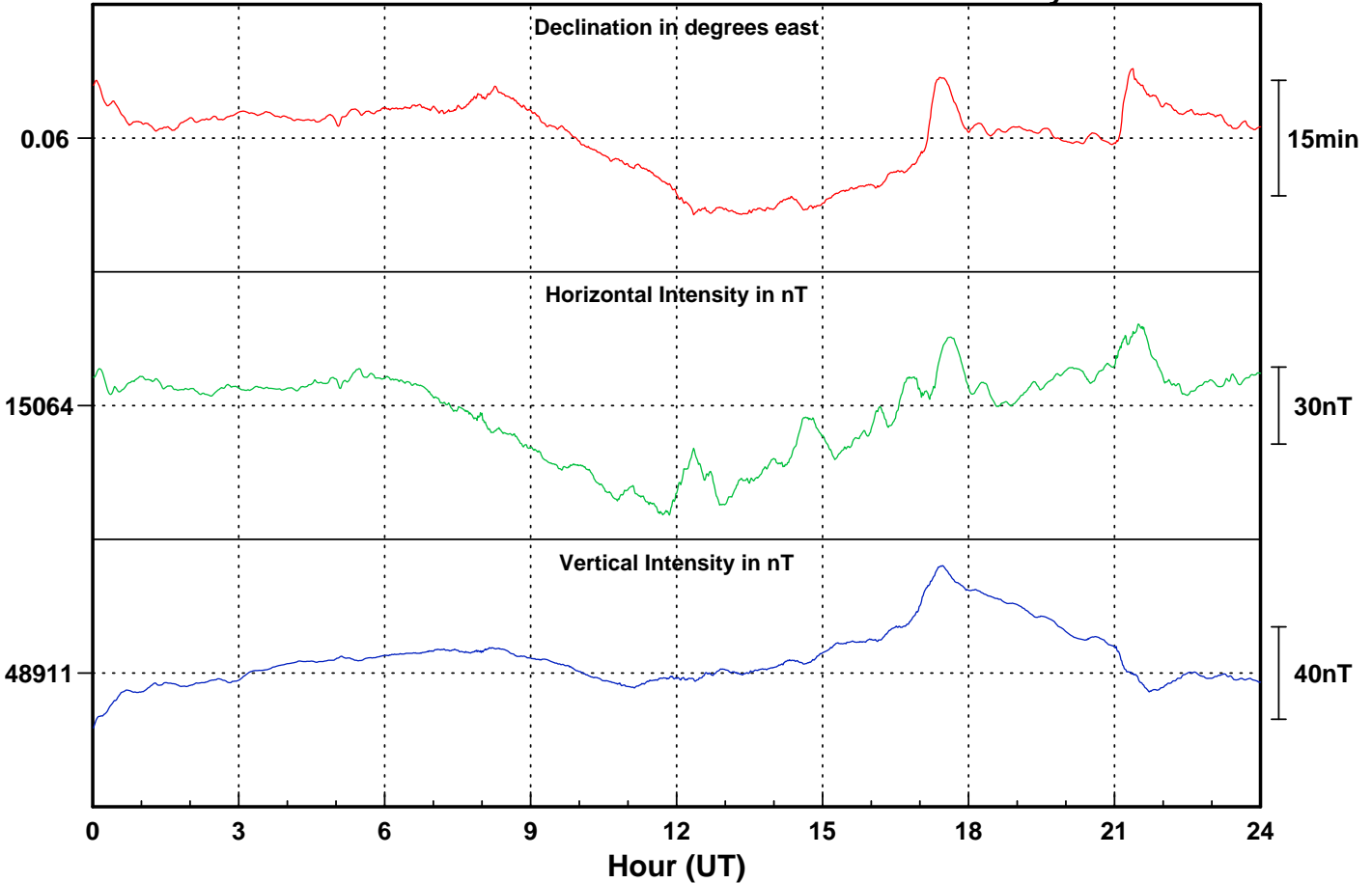
# Lerwick

Day number: 264



Date: 22-09-2023

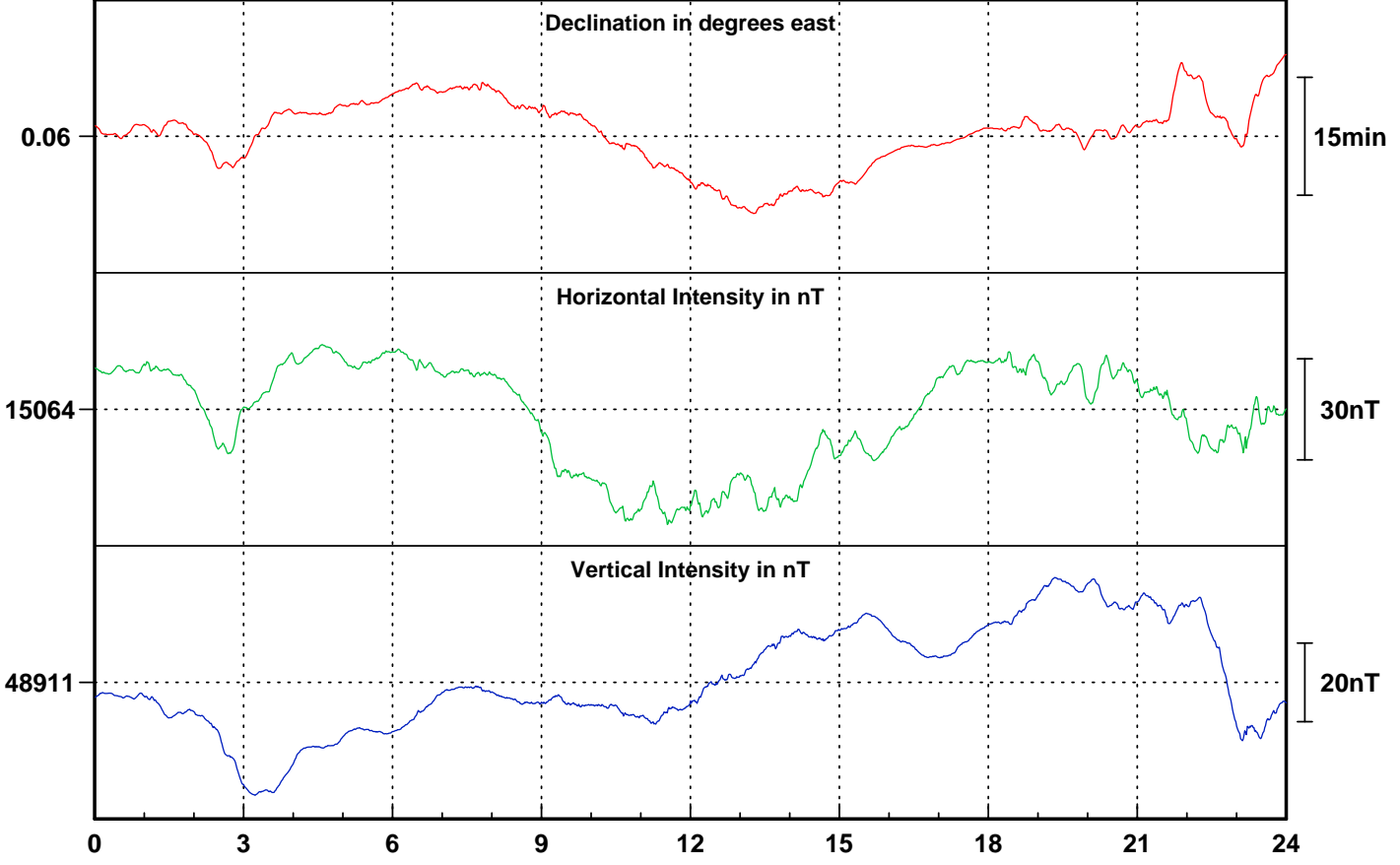
Day number: 265



Date: 23-09-2023

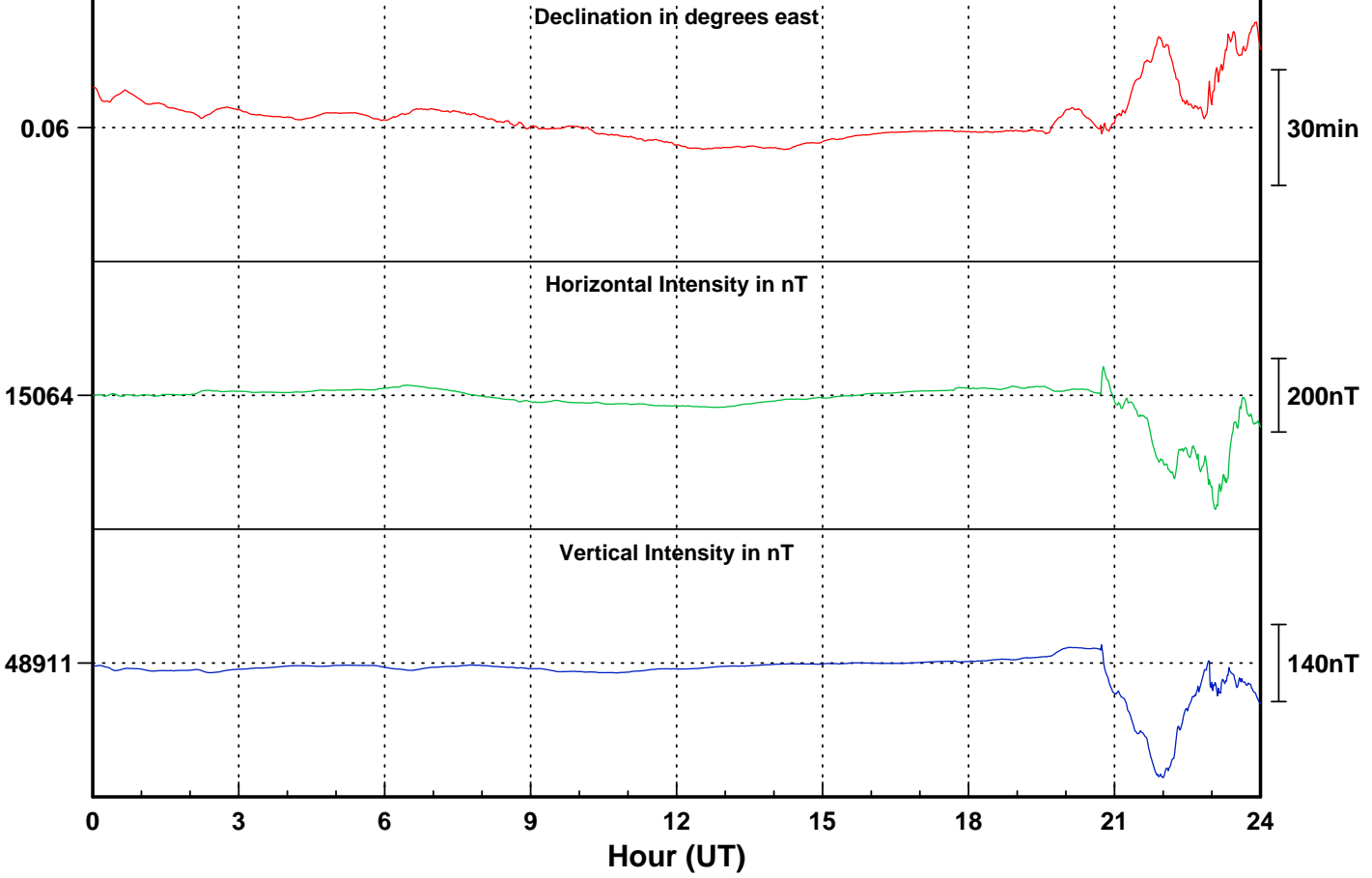
# Lerwick

Day number: 266



Date: 24-09-2023

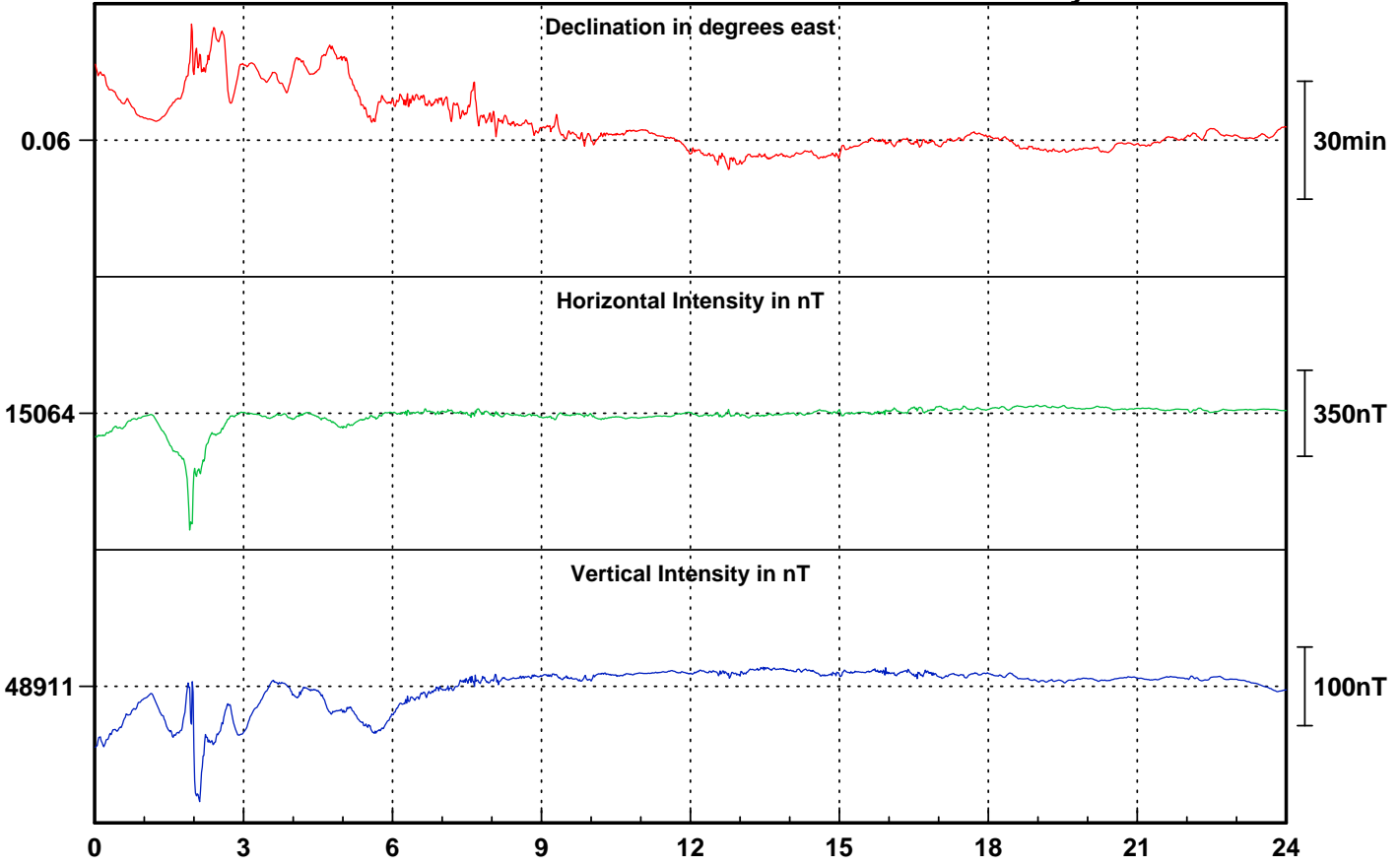
Day number: 267



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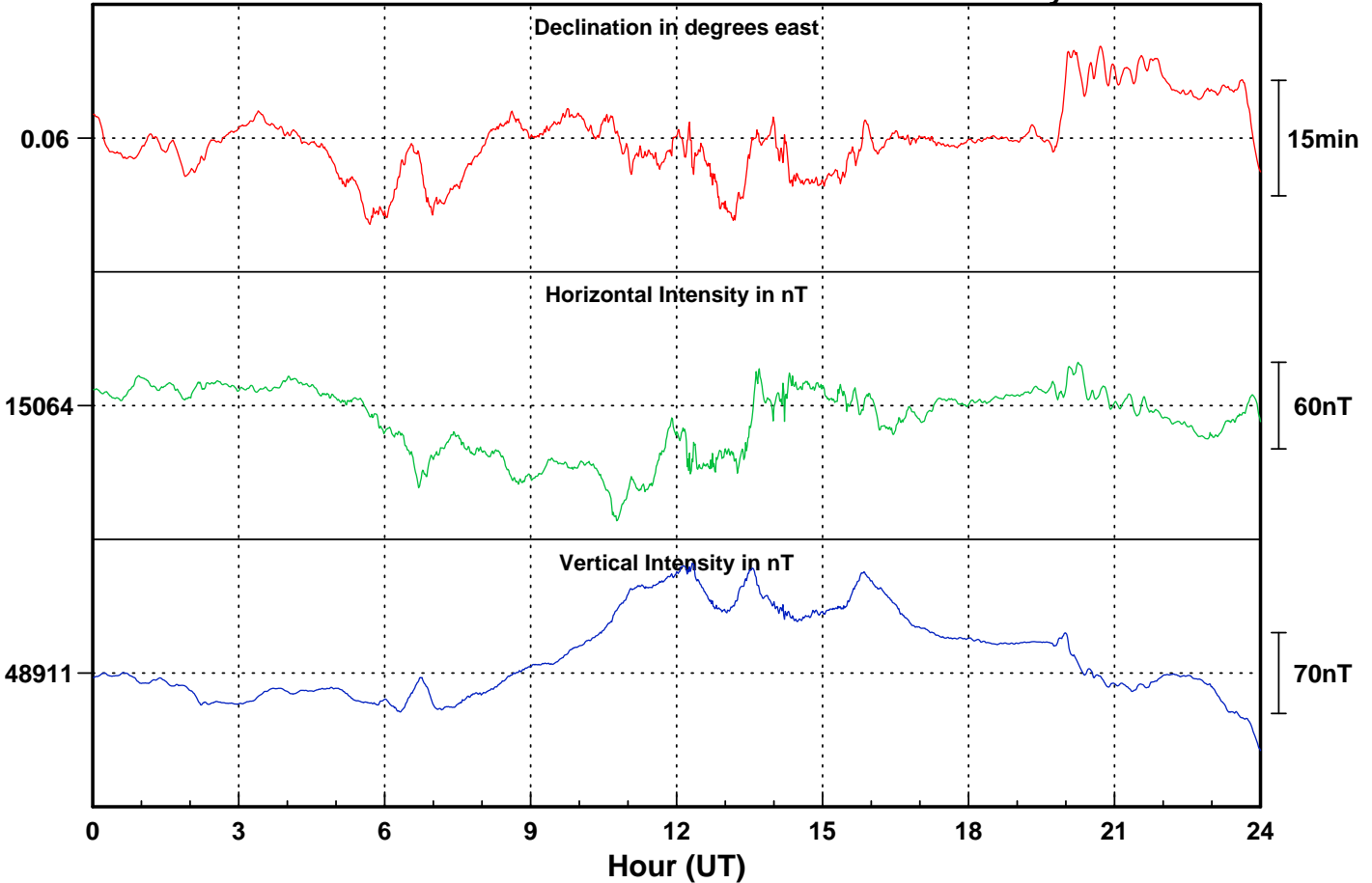
# Lerwick

Day number: 268



Date: 26-09-2023

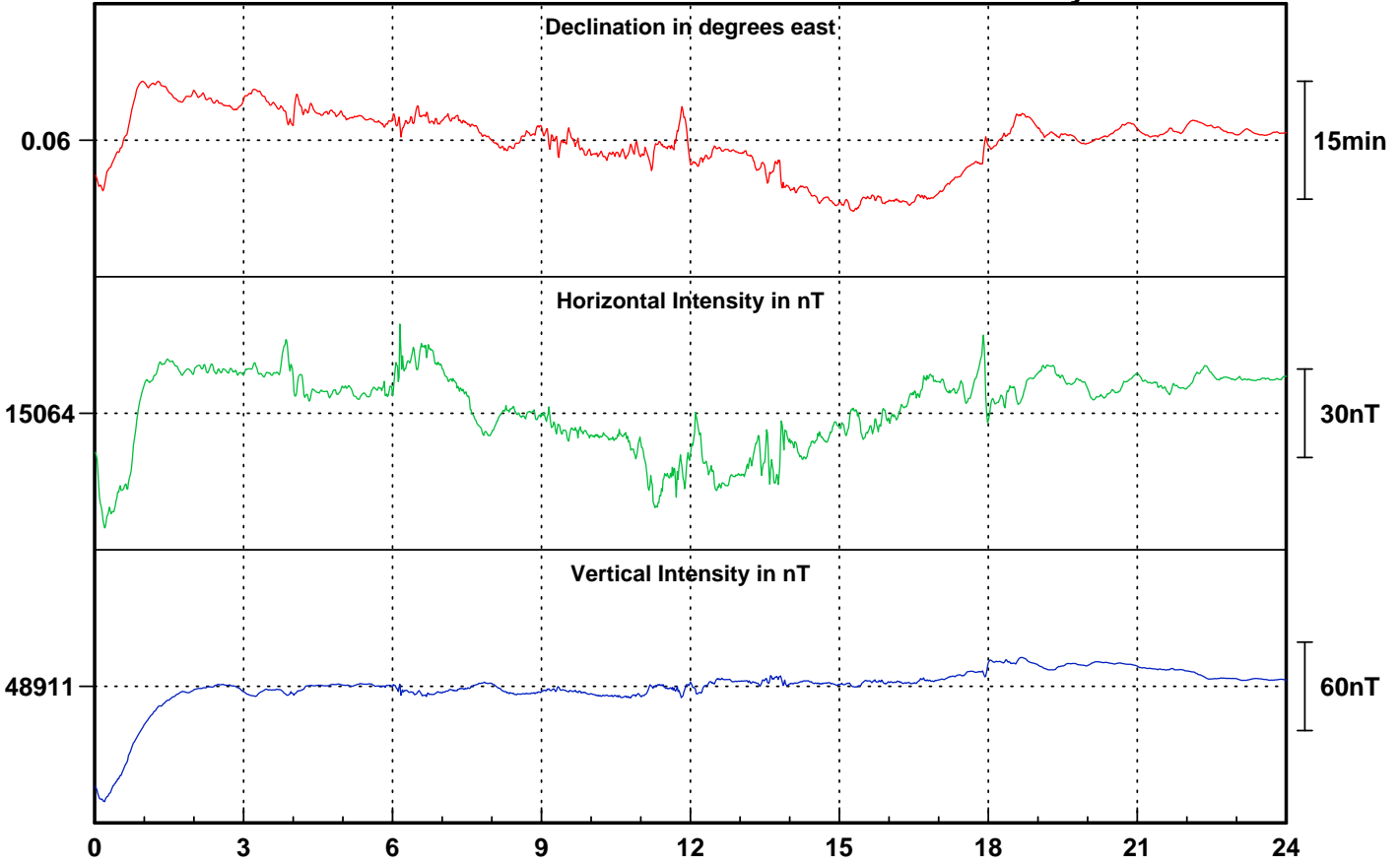
Day number: 269



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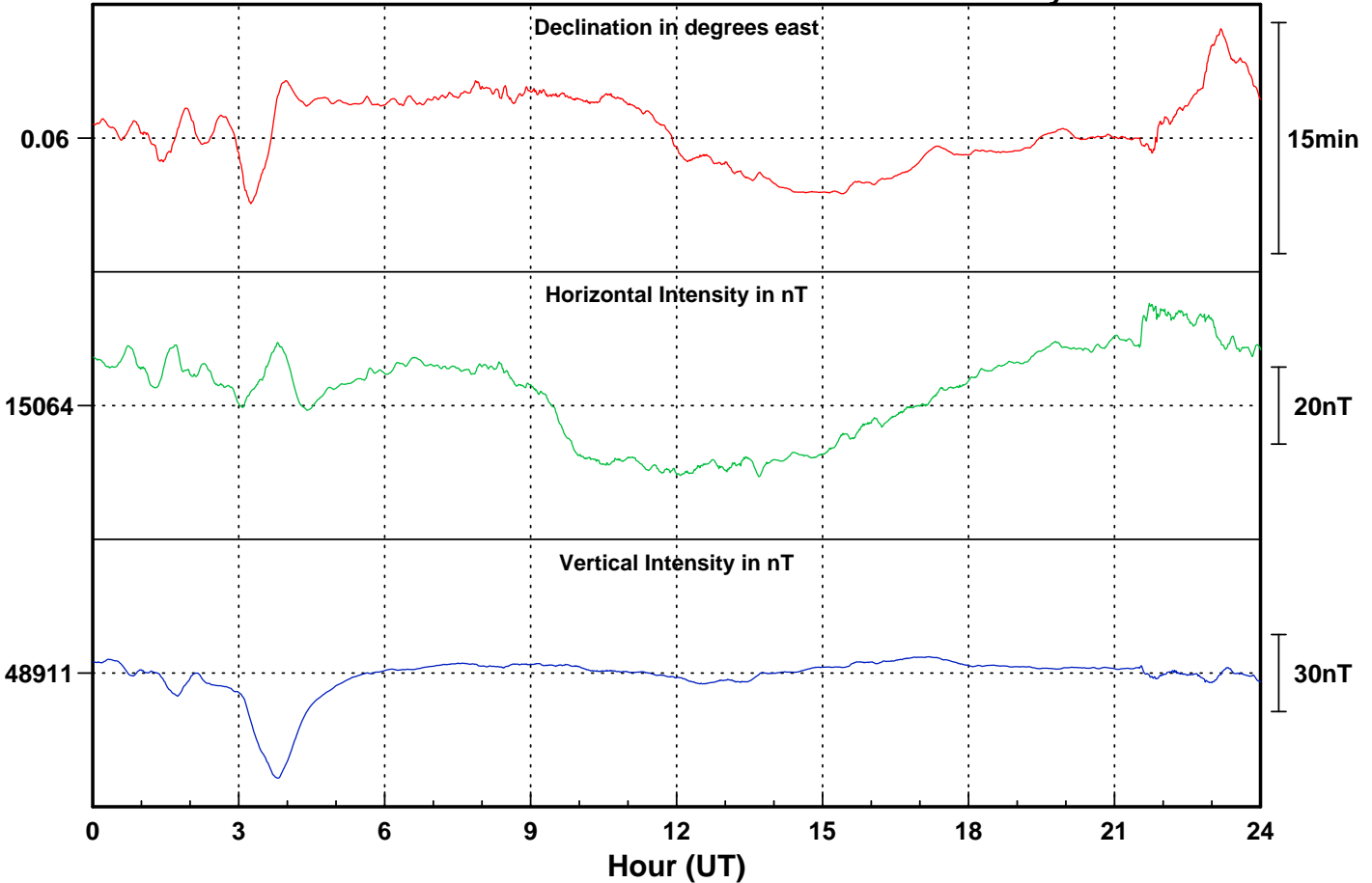
# Lerwick

Day number: 270



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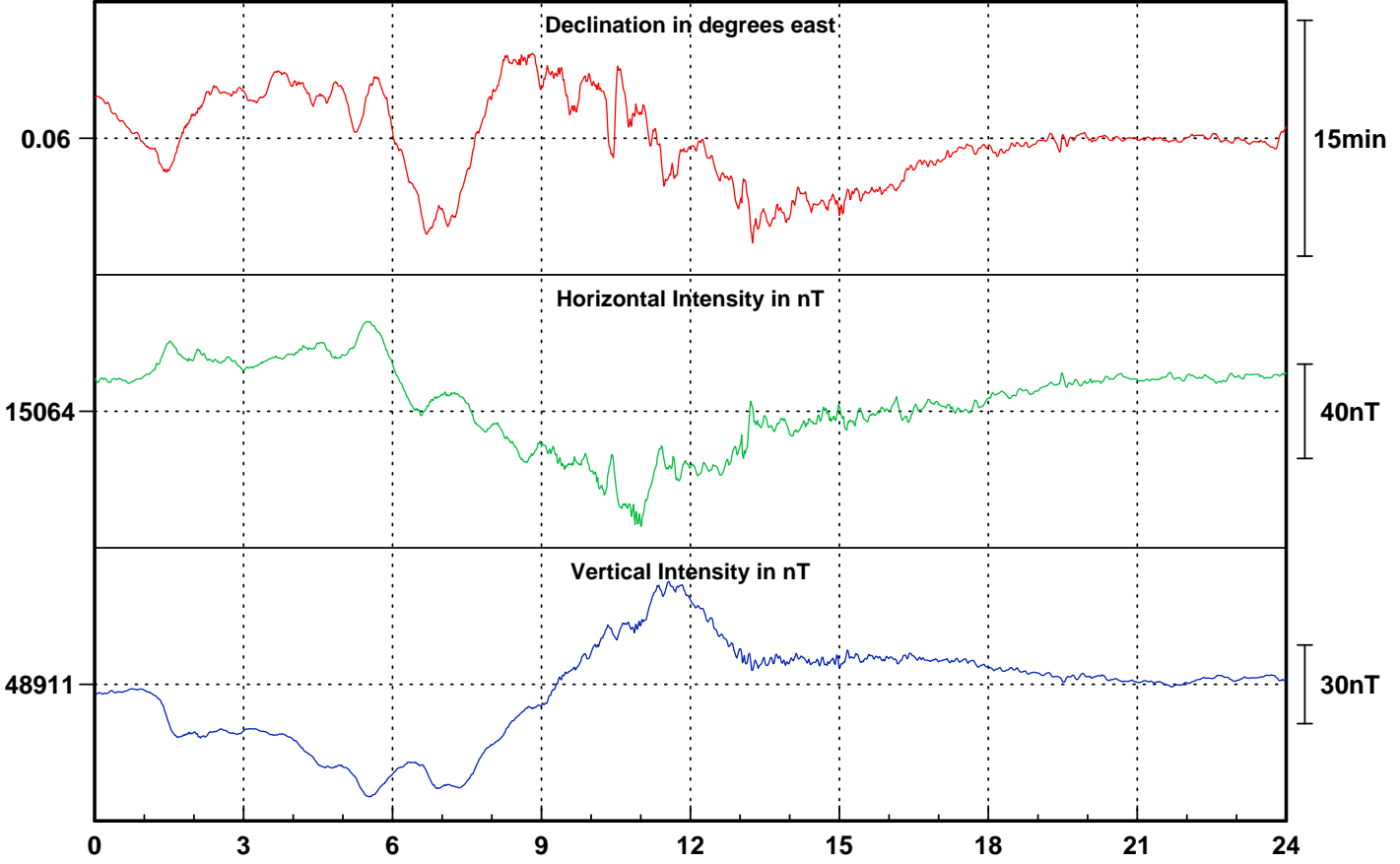
Day number: 271



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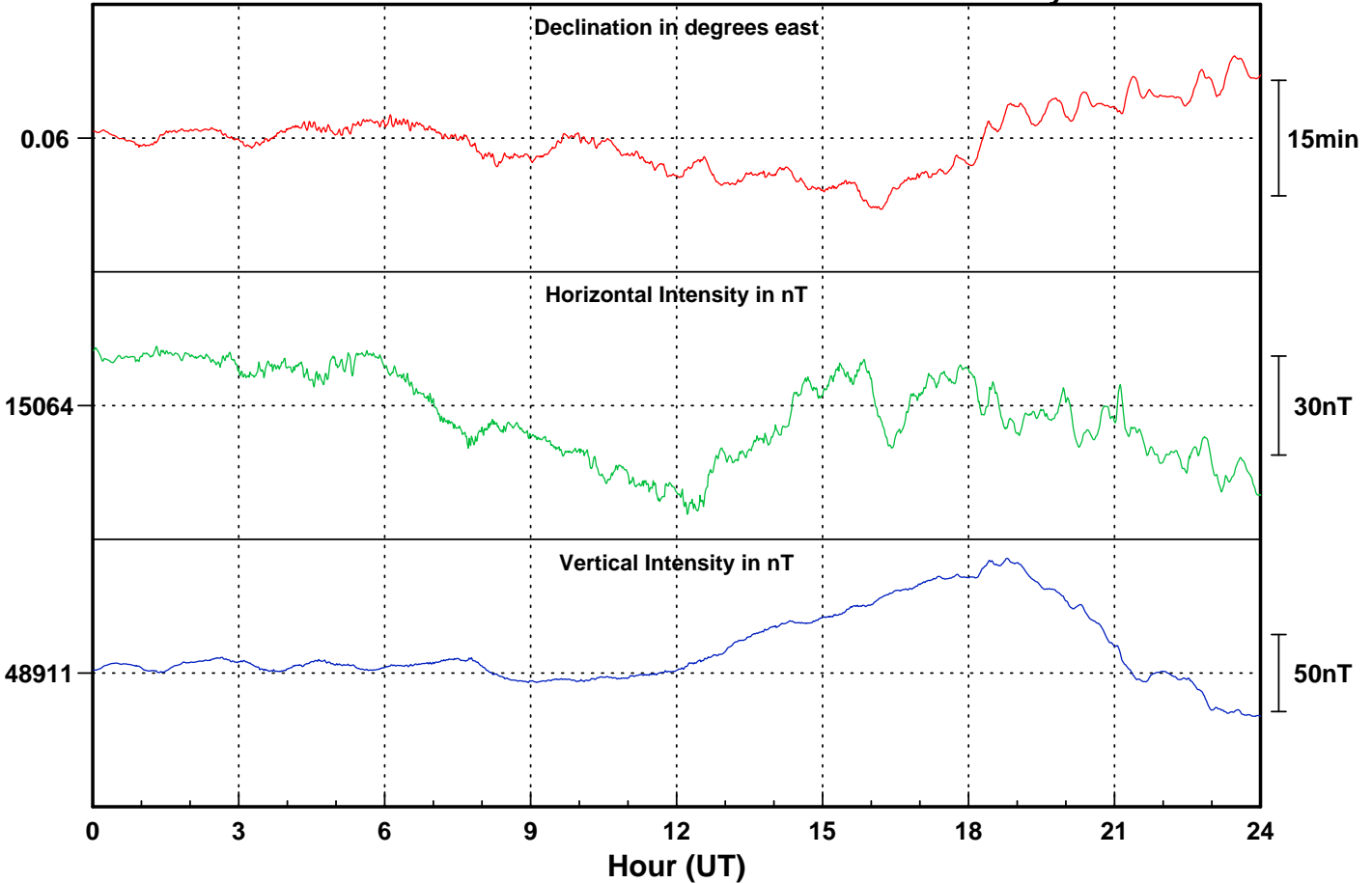
# Lerwick

Day number: 272



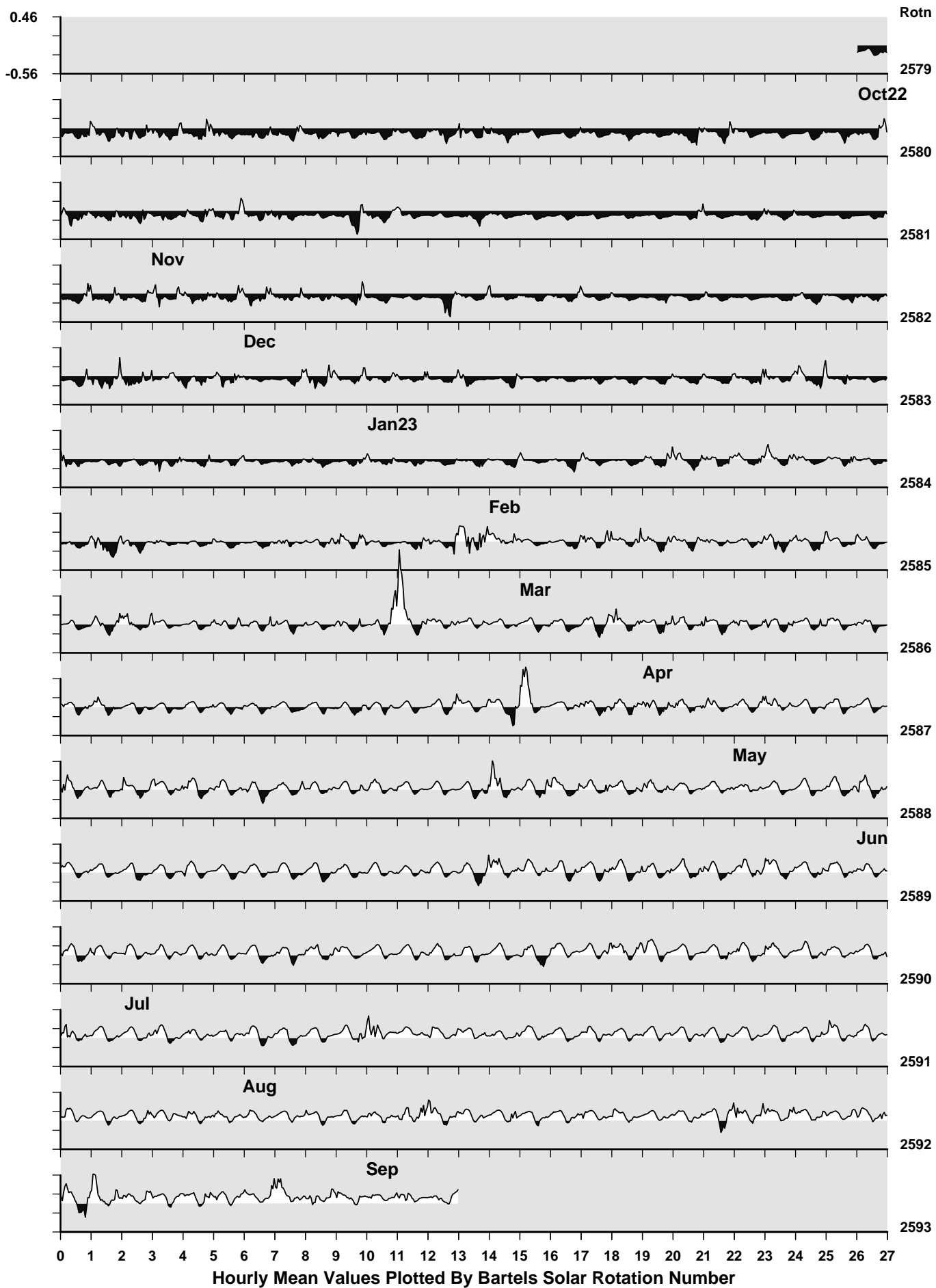
Date: 30-09-2023

Day number: 273



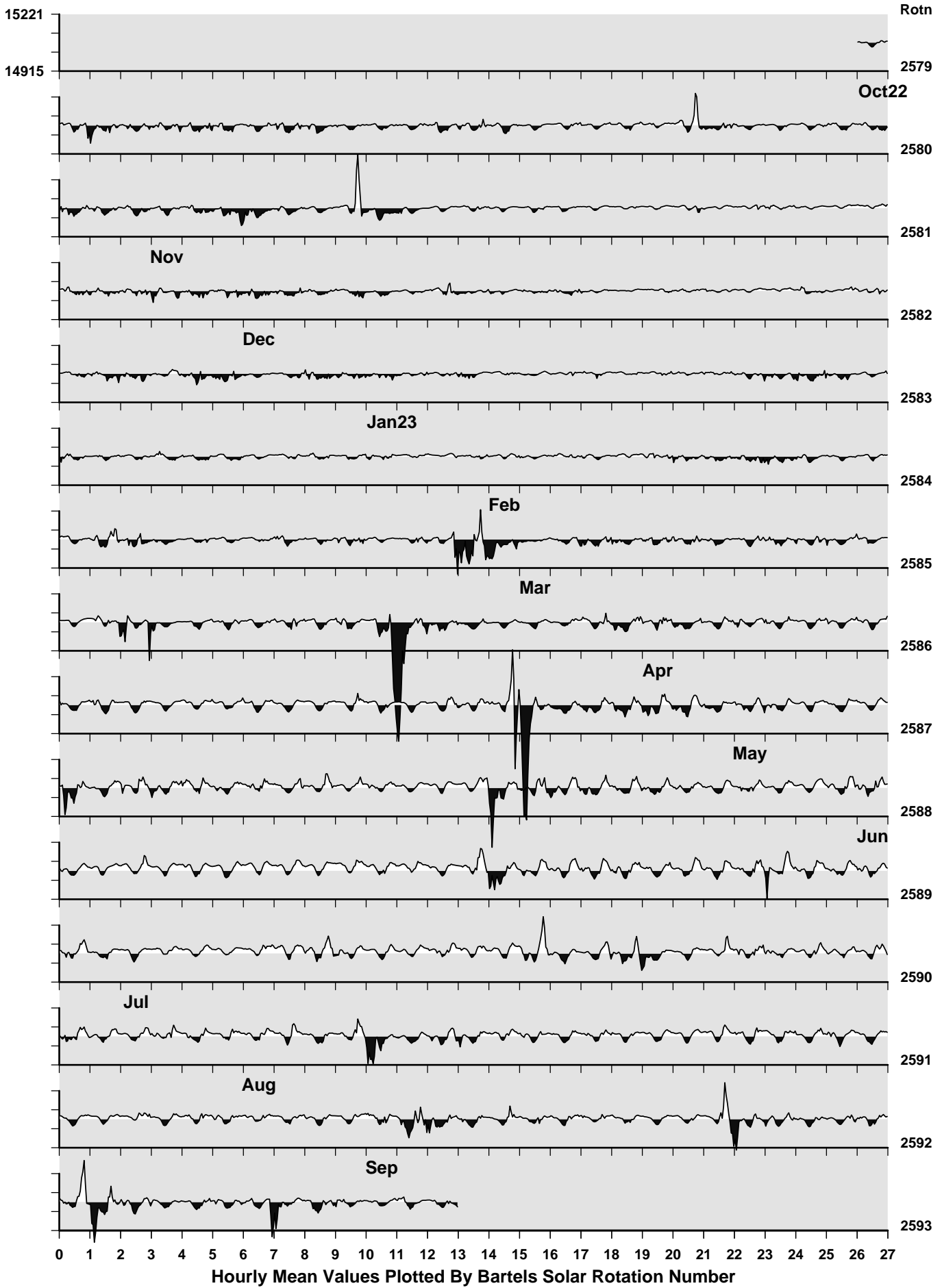


# Lerwick Observatory: Declination (degrees)

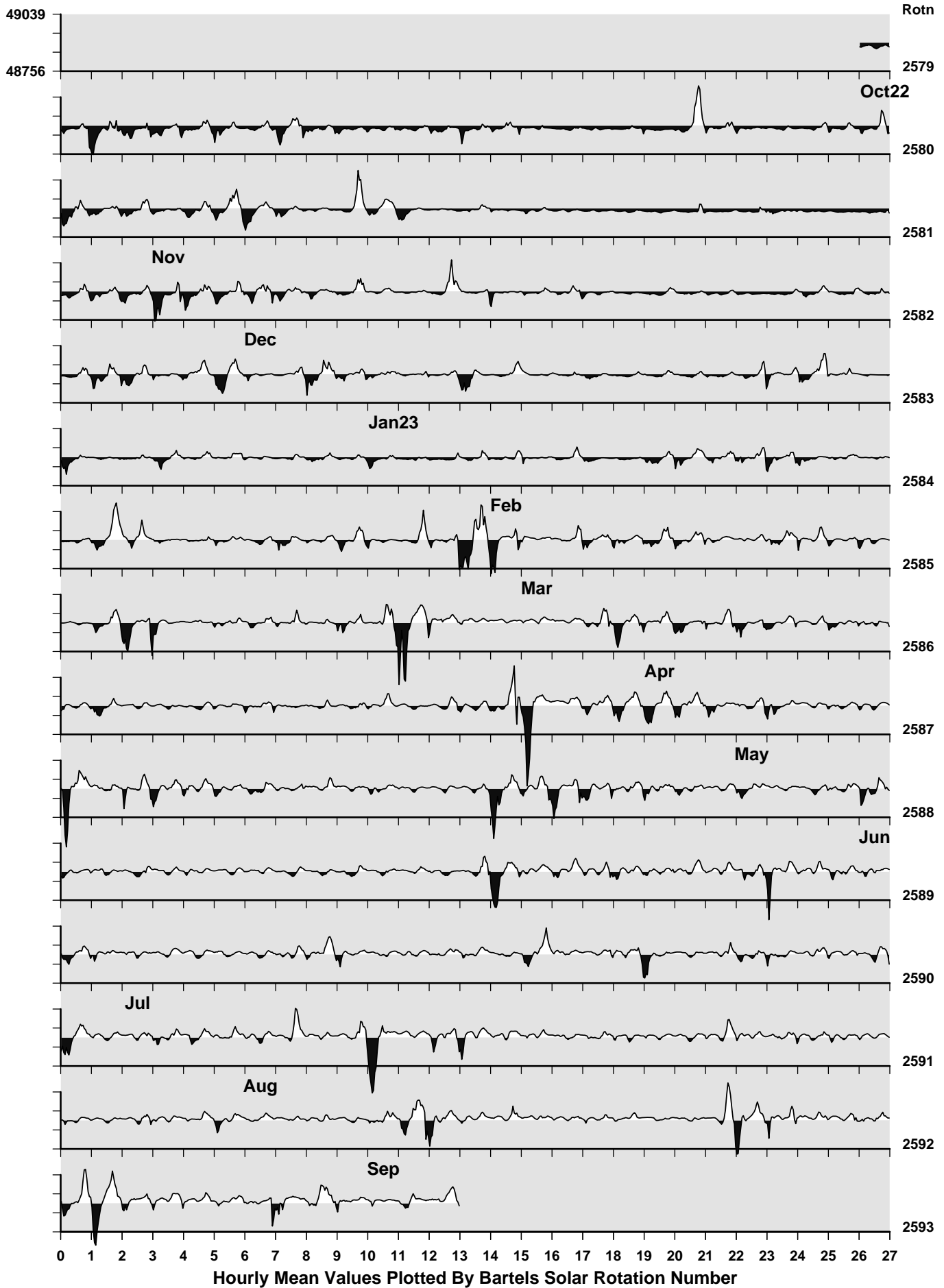


Hourly Mean Values Plotted By Bartels Solar Rotation Number

# Lerwick Observatory: Horizontal Intensity (nT)

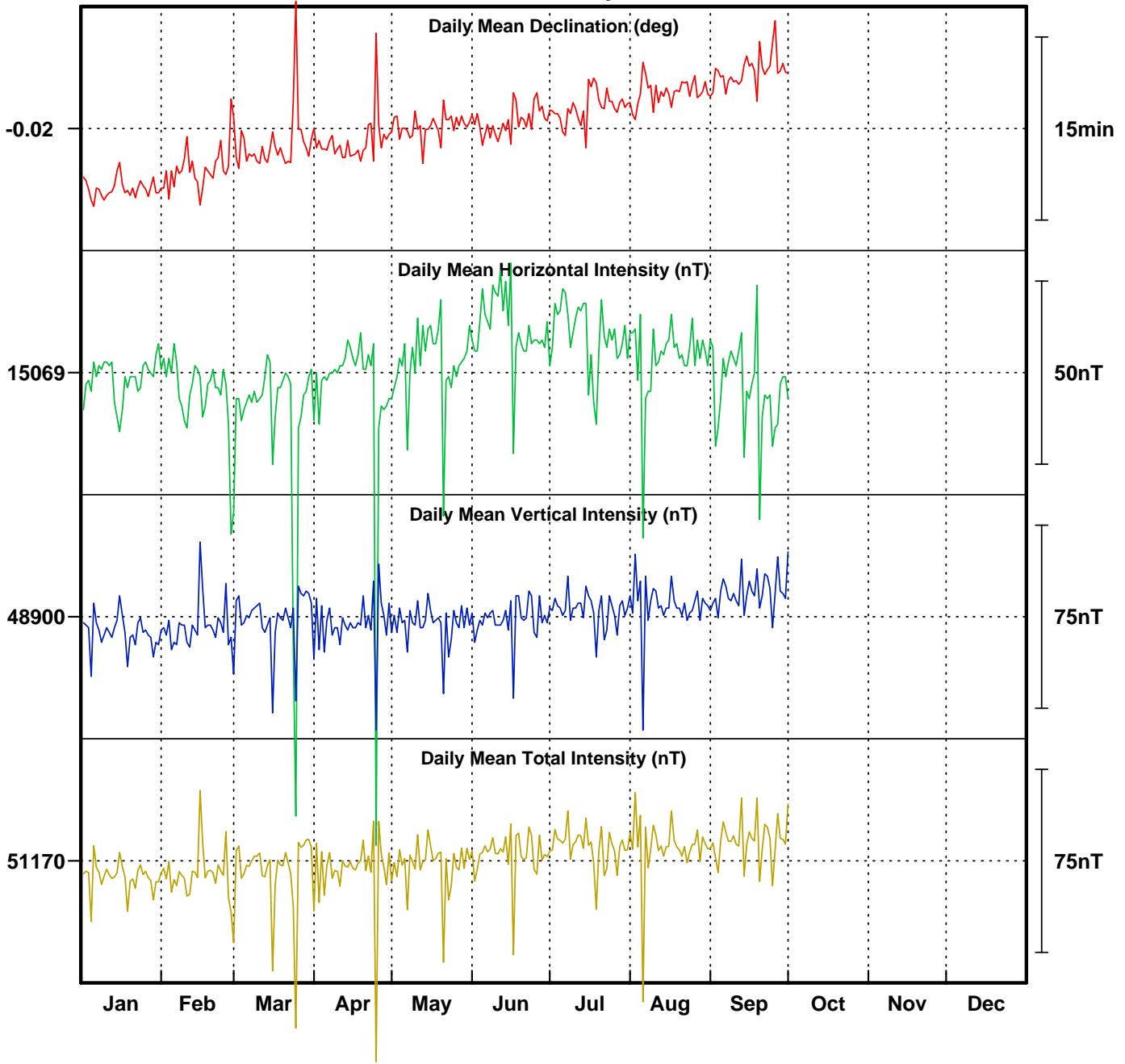


# Lerwick Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted By Bartels Solar Rotation Number

# Lerwick Observatory 2023



## Monthly mean values for Lerwick Observatory 2023

Month	<i>D</i>	<i>H</i>	<i>I</i>	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>F</i>
January	-0° 6.4′	15067 nT	72° 52.4′	15067 nT	-28 nT	48894 nT	51163 nT
February	-0° 4.6′	15063 nT	72° 52.7′	15063 nT	-20 nT	48896 nT	51164 nT
March	-0° 2.7′	15057 nT	72° 53.1′	15057 nT	-12 nT	48899 nT	51165 nT
April	-0° 2.5′	15064 nT	72° 52.6′	15064 nT	-11 nT	48898 nT	51166 nT
May	-0° 1.2′	15072 nT	72° 52.1′	15072 nT	-5 nT	48898 nT	51168 nT
June	-0° 0.8′	15081 nT	72° 51.6′	15081 nT	-4 nT	48899 nT	51172 nT
July	0° 0.3′	15079 nT	72° 51.8′	15079 nT	1 nT	48903 nT	51176 nT
August	0° 1.6′	15073 nT	72° 52.2′	15073 nT	7 nT	48905 nT	51175 nT
September	0° 3.3′	15064 nT	72° 52.9′	15064 nT	15 nT	48911 nT	51178 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)
05/09/2023	15:22	SSC*	B	26.2	-3.07	7.1
12/09/2023	11:18	SI*	C	25.9	-3.72	3.5
12/09/2023	12:16	SSC*	B	39.0	-2.39	10.4
18/09/2023	13:27	SSC*	A	65.2	-7.27	10.6
24/09/2023	17:39	SI*	B	6.1	-0.39	1.5
24/09/2023	20:41	SSC*	A	76.5	-2.17	10.2

#### 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

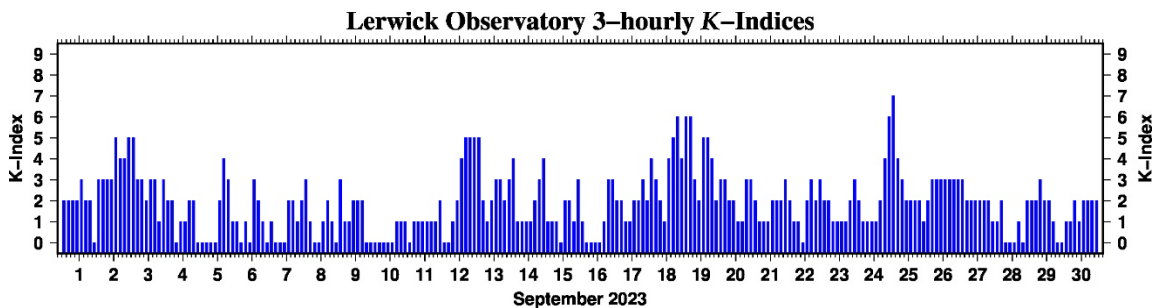
Date	Start	Universal Time Maximum	End	H (nT)	D (min)	Z (nT)
None						

#### 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	2	2	2	3	2	2	0
2	3	3	3	3	5	4	4	5
3	5	3	3	2	3	3	1	3
4	2	2	0	1	1	2	2	0
5	0	0	0	0	2	4	3	1
6	1	0	1	0	3	2	1	0
7	1	0	0	0	2	2	1	2
8	3	1	0	0	1	2	1	0
9	3	1	1	2	2	2	0	0
10	0	0	0	0	0	1	1	1
11	0	1	1	1	1	1	1	2
12	0	0	1	2	4	5	5	5
13	5	2	1	2	3	3	2	3
14	4	1	1	1	1	2	3	4
15	1	1	1	0	2	2	1	3
16	1	0	0	0	0	1	3	3
17	2	2	1	1	2	2	3	2
18	4	3	2	1	4	5	6	4
19	6	6	3	2	5	5	4	2
20	3	3	2	2	1	1	3	3
21	2	1	1	1	2	2	2	3
22	2	1	1	0	2	3	2	3
23	2	2	1	1	1	1	2	3
24	2	1	1	1	1	2	4	6
25	7	4	3	2	2	2	2	1
26	2	3	3	3	3	3	3	3
27	3	2	2	2	2	2	2	1
28	1	2	0	0	0	1	0	2
29	2	2	3	2	2	1	0	0
30	1	1	2	1	2	2	2	2



# The aa Index

Date	Day	3-hourly aa-indices								Aa <sub>am</sub>	Aa <sub>pm</sub>	Aa
01/09/2023	244	24	24	16	32	32	45	24	8	24.1	27.3	25.7
02/09/2023	245	32	45	59	81	81	45	80	59	54.3	66.3	60.3
03/09/2023	246	67	32	59	46	32	37	8	24	50.8	25.3	38.1
04/09/2023	247	12	12	8	8	8	16	20	2	9.9	11.6	10.7
05/09/2023	248	5	5	5	5	12	59	45	12	5.2	32	18.6
06/09/2023	249	8	8	12	2	32	24	8	5	7.5	17.3	12.4
07/09/2023	250	12	8	5	8	16	12	12	17	8.2	14.3	11.2
08/09/2023	251	20	8	2	5	12	16	12	5	8.8	11.3	10
09/09/2023	252	20	8	12	16	24	16	5	5	13.9	12.6	13.3
10/09/2023	253	8	2	2	2	2	8	5	8	3.8	5.8	4.8
11/09/2023	254	8	12	8	12	16	8	12	16	9.9	13	11.4
12/09/2023	255	5	5	5	32	81	102	46	45	11.9	68.4	40.1
13/09/2023	256	58	24	24	16	24	32	12	45	30.6	28.4	29.5
14/09/2023	257	37	24	32	12	12	12	45	59	26.4	32	29.2
15/09/2023	258	12	12	8	2	12	24	8	32	8.5	19	13.8
16/09/2023	259	5	2	2	8	5	12	37	20	4.5	18.5	11.5
17/09/2023	260	32	32	16	32	24	24	45	32	28.1	31.4	29.8
18/09/2023	261	58	32	24	20	67	81	81	46	33.7	68.4	51
19/09/2023	262	80	80	46	46	80	81	45	24	62.9	57.5	60.2
20/09/2023	263	37	24	24	16	16	16	37	32	25.4	25.4	25.4
21/09/2023	264	8	12	24	12	24	32	12	37	14	26.4	20.2
22/09/2023	265	12	8	16	20	24	37	16	24	14	25.4	19.7
23/09/2023	266	24	16	8	20	16	12	16	24	17	17	17
24/09/2023	267	8	8	16	20	8	5	67	102	13	45.3	29.1
25/09/2023	268	80	59	59	32	46	16	24	16	57.5	25.5	41.5
26/09/2023	269	20	45	45	59	102	32	45	37	42.4	54.1	48.3
27/09/2023	270	32	24	32	46	24	24	16	8	33.5	18	25.8
28/09/2023	271	12	20	8	9	5	5	2	16	12.2	7.2	9.7
29/09/2023	272	12	12	24	59	32	12	5	8	26.7	14.2	20.5
30/09/2023	273	8	8	16	20	24	16	24	16	13	20.1	16.5
Monthly Mean Value											25.2	

## 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<sub>am</sub>, Aa<sub>pm</sub> 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.

