

BRITISH GEOLOGICAL SURVEY

Lerwick Observatory

Monthly Magnetic Bulletin

June 2016

16/06/LE



SHETLAND ISLANDS



British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

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:

Geomagnetism Team
Earth Hazards and Systems
British Geological Survey
Murchison House, West Mains Road
Edinburgh EH9 3LA
Scotland, UK

Tel: +44 (0) 131 667 1000
Fax: +44 (0) 131 668 2683
E-mail: enquiries@bgs.ac.uk
Internet: www.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°47'56"N 088°45'40"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 12th generation International Geomagnetic Reference Field (IGRF) at epoch 2016.5. On-line access to models (including IGRF), charts and navigational data are available at

www.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 www.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 www.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

www.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 www.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, LATMOS, 4 Avenue de Neptune, F-94107 Saint Maur 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 ©NERC. 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 www.geomag.bgs.ac.uk/contactus/staff

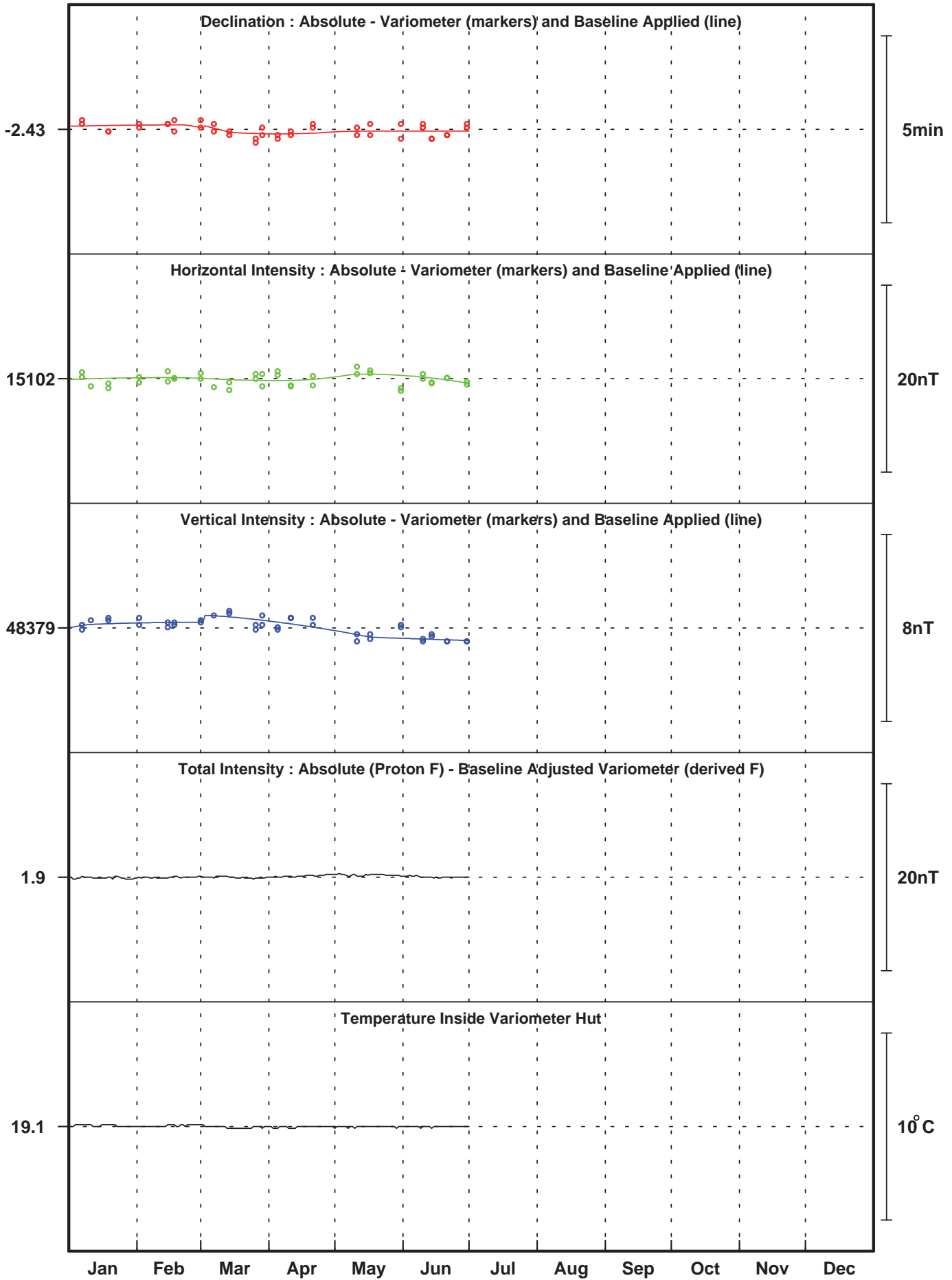
**This product includes mapping data licensed from Ordnance Survey with the permission of HMSO © Crown copyright. All rights reserved.
Licence Number: 100017897/2016**

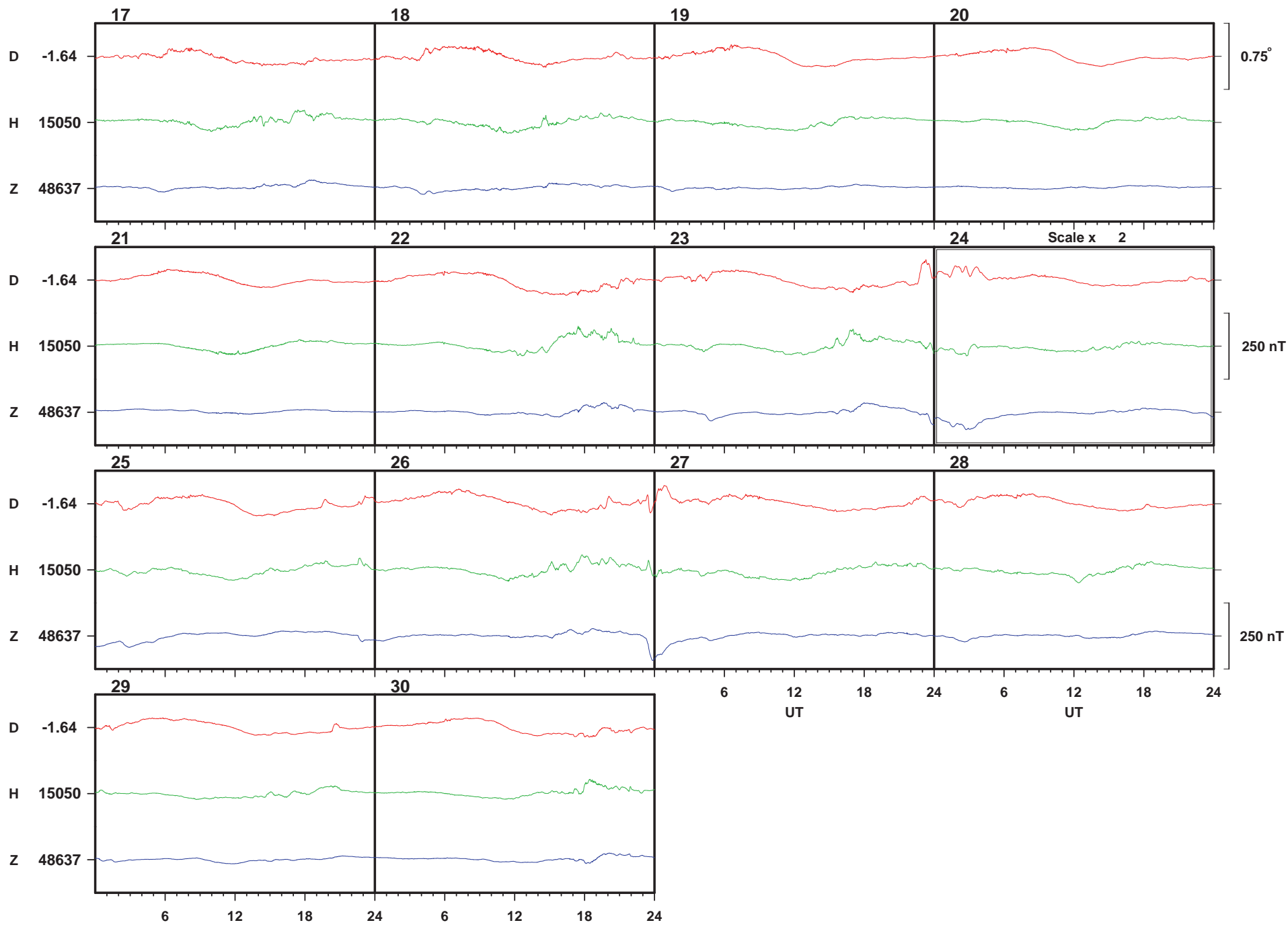
LERWICK OBSERVATORY

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)	
09-Jun-16	161	09:31	-1.5572	-2.4283	09:54	72.8289	-1.9	50908.1	15029.4	15102.2	48638.9	48378.1	CT
09-Jun-16	161	10:06	-1.5654	-2.4267	10:24	72.8357	-1.9	50906.3	15023.1	15102.7	48639.0	48378.0	CT
13-Jun-16	165	16:29	-1.6847	-2.4333	16:43	72.7969	-1.9	50920.9	15060.4	15101.8	48642.8	48378.2	WH
13-Jun-16	165	16:53	-1.6798	-2.4333	17:05	72.7935	-1.9	50924.3	15064.3	15101.7	48645.1	48378.3	WH
20-Jun-16	172	16:29	-1.6897	-2.4317	16:40	72.8010	-1.9	50924.9	15058.1	15102.3	48647.7	48378.0	WH
20-Jun-16	172	16:51	-1.6799	-2.4317	17:05	72.8028	-1.9	50923.7	15056.2	15102.3	48647.0	48378.0	WH
29-Jun-16	181	14:27	-1.7125	-2.4267	14:41	72.8109	-1.9	50906.5	15044.2	15101.6	48632.7	48378.0	IQ
29-Jun-16	181	14:54	-1.7226	-2.4283	15:10	72.8006	-1.9	50908.4	15053.5	15101.9	48631.8	48378.0	IQ

Lerwick 2016





Lerwick

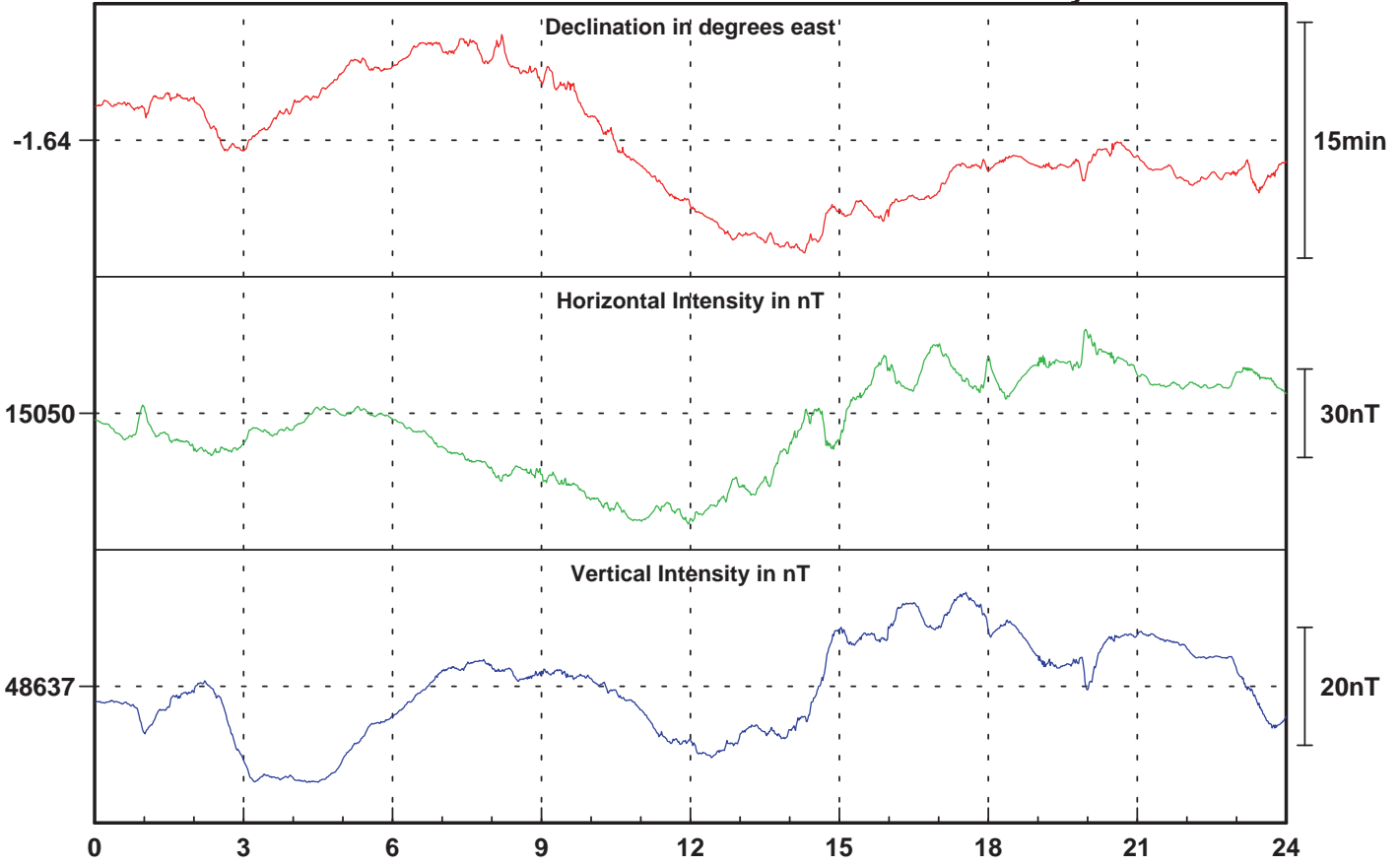
June

2016

Date: 01-06-2016

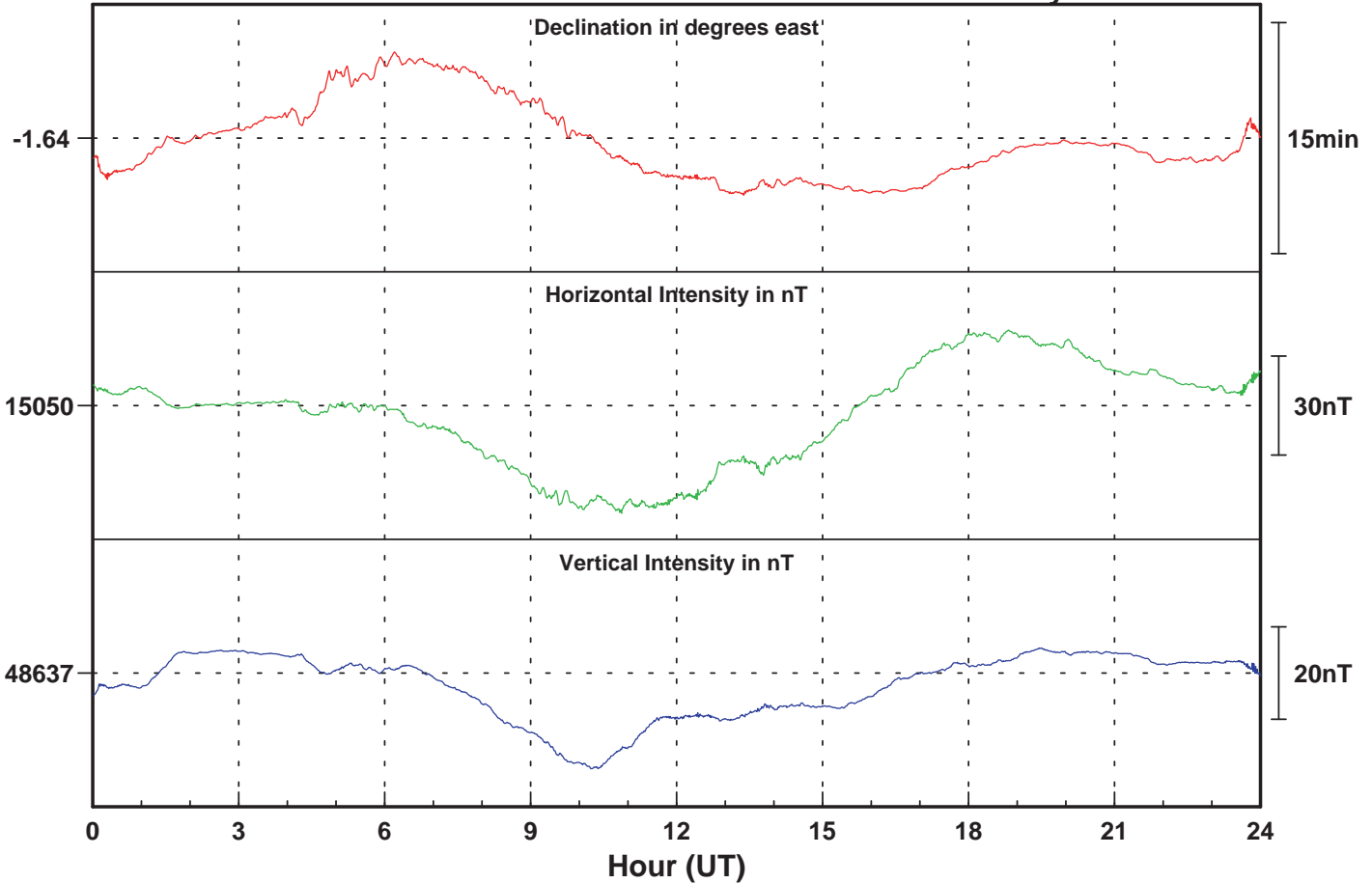
Lerwick

Day number: 153



Date: 02-06-2016

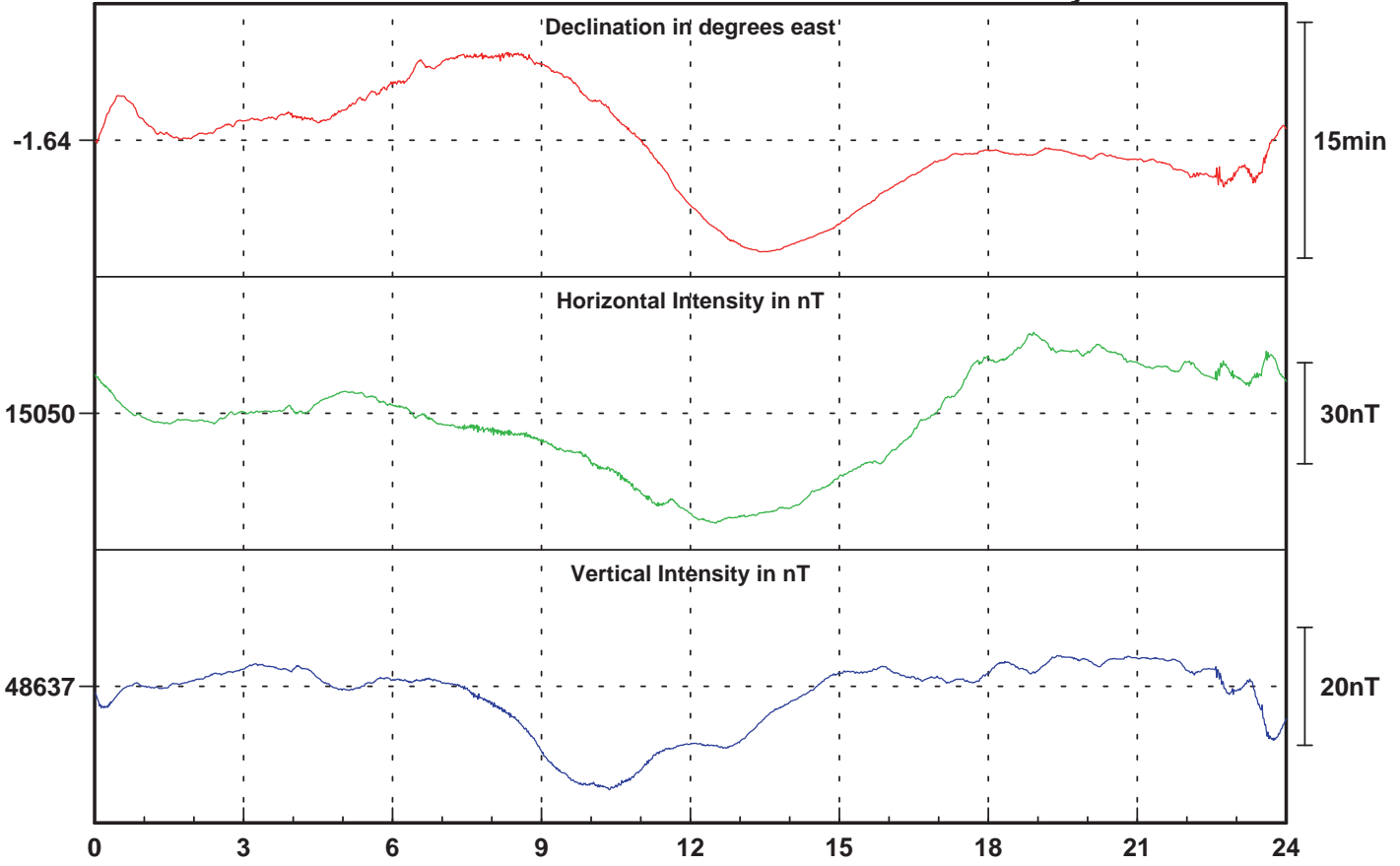
Day number: 154



Date: 03-06-2016

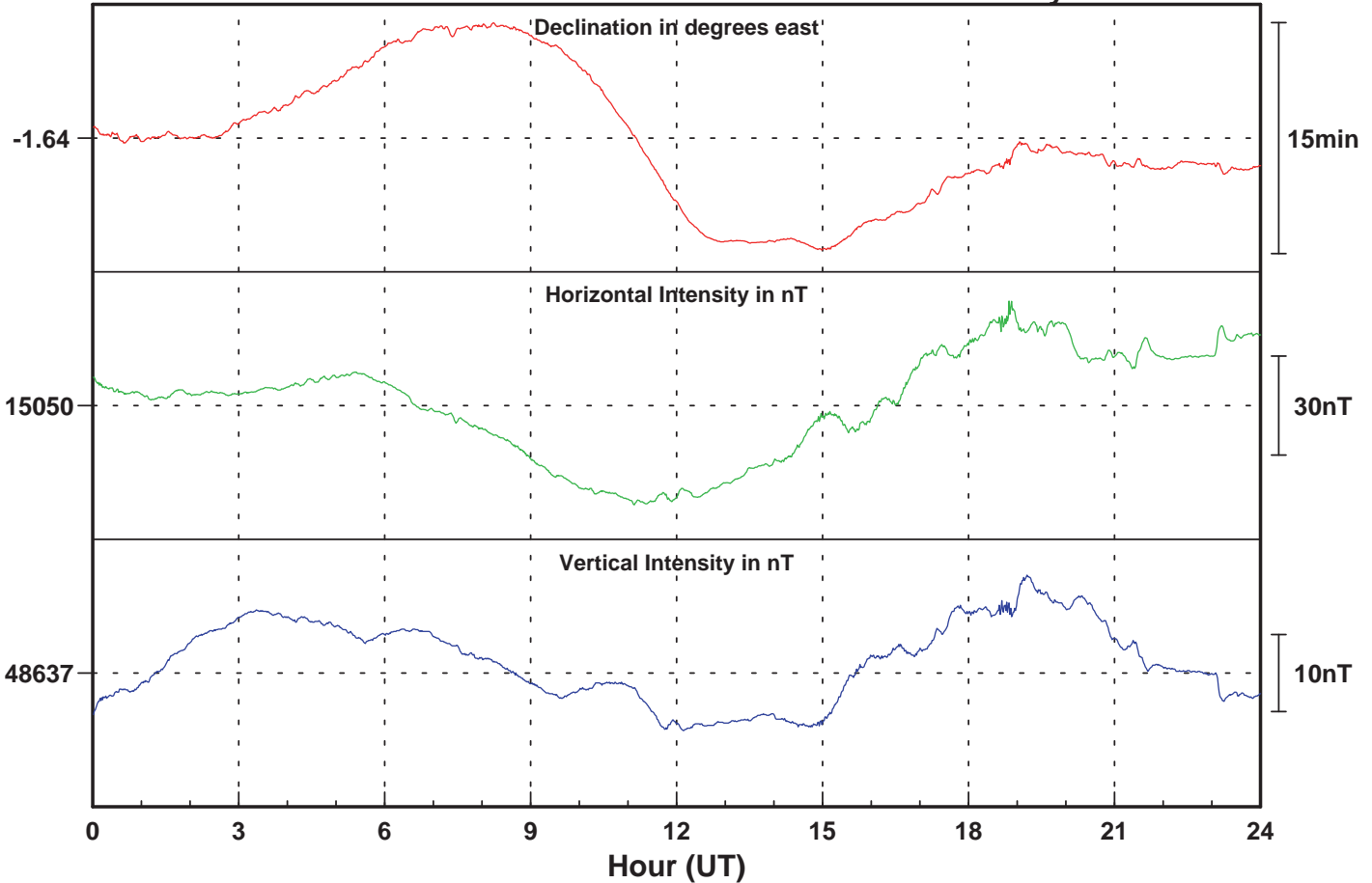
Lerwick

Day number: 155



Date: 04-06-2016

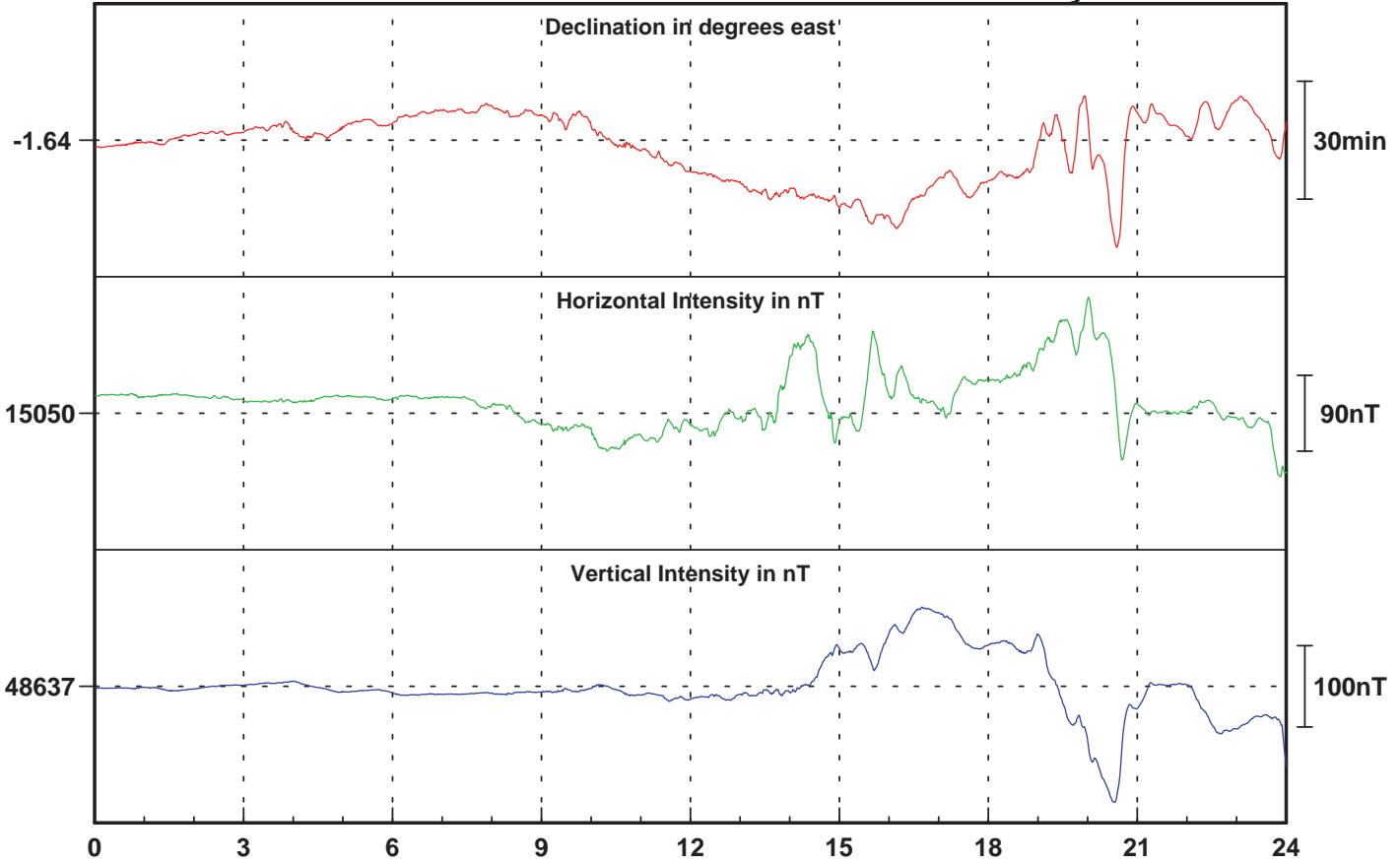
Day number: 156



Date: 05-06-2016

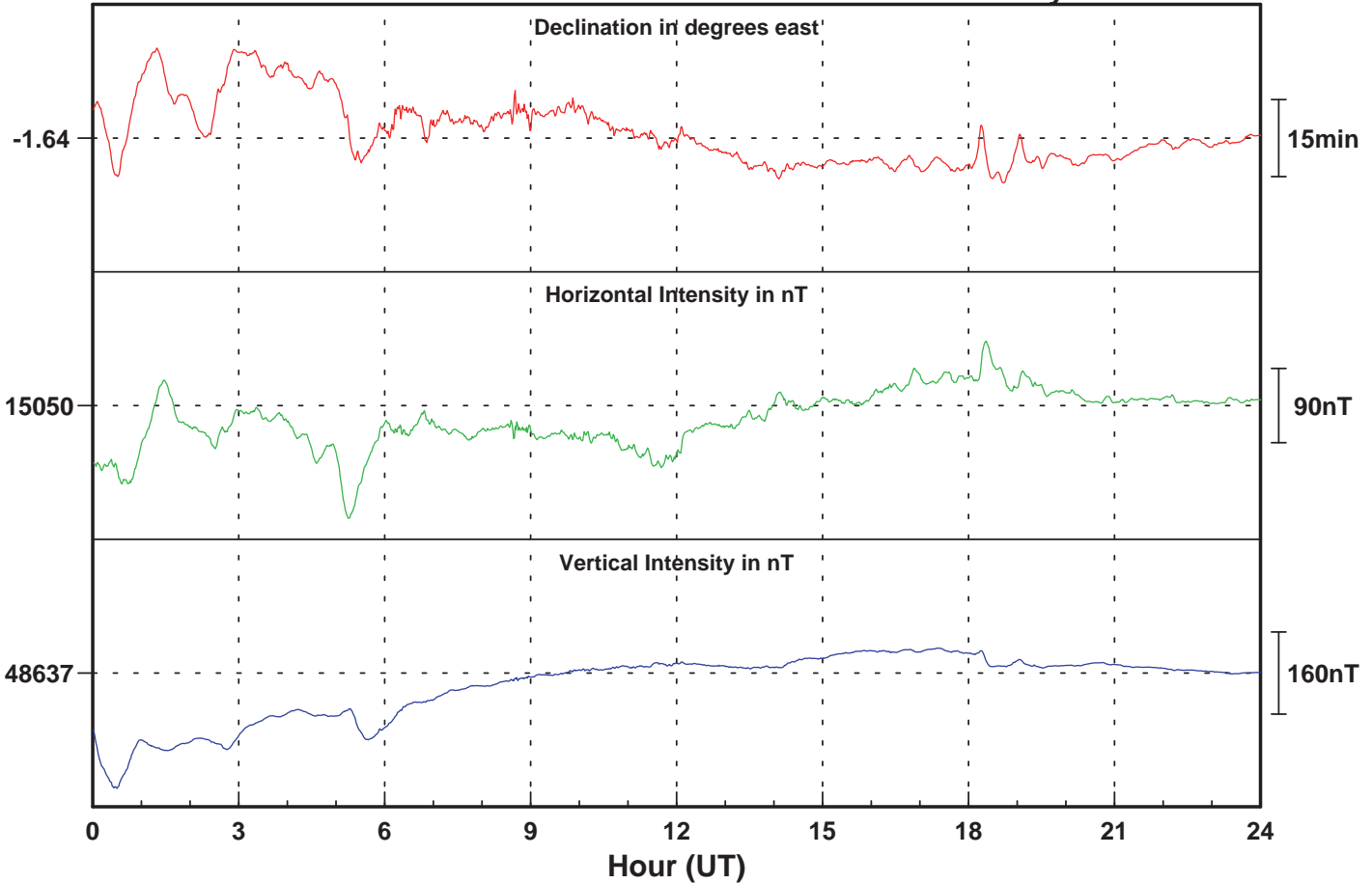
Lerwick

Day number: 157



Date: 06-06-2016

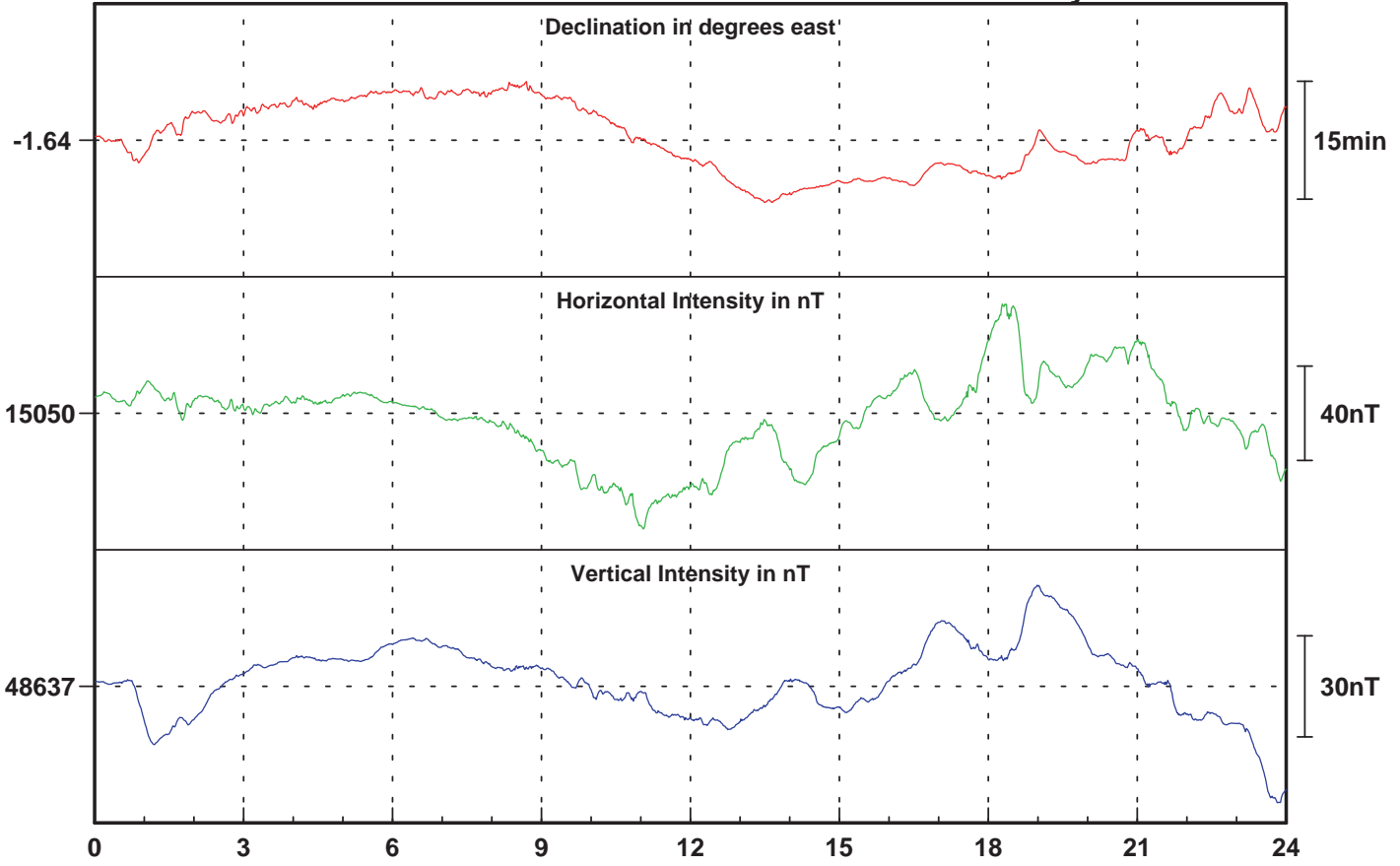
Day number: 158



Date: 07-06-2016

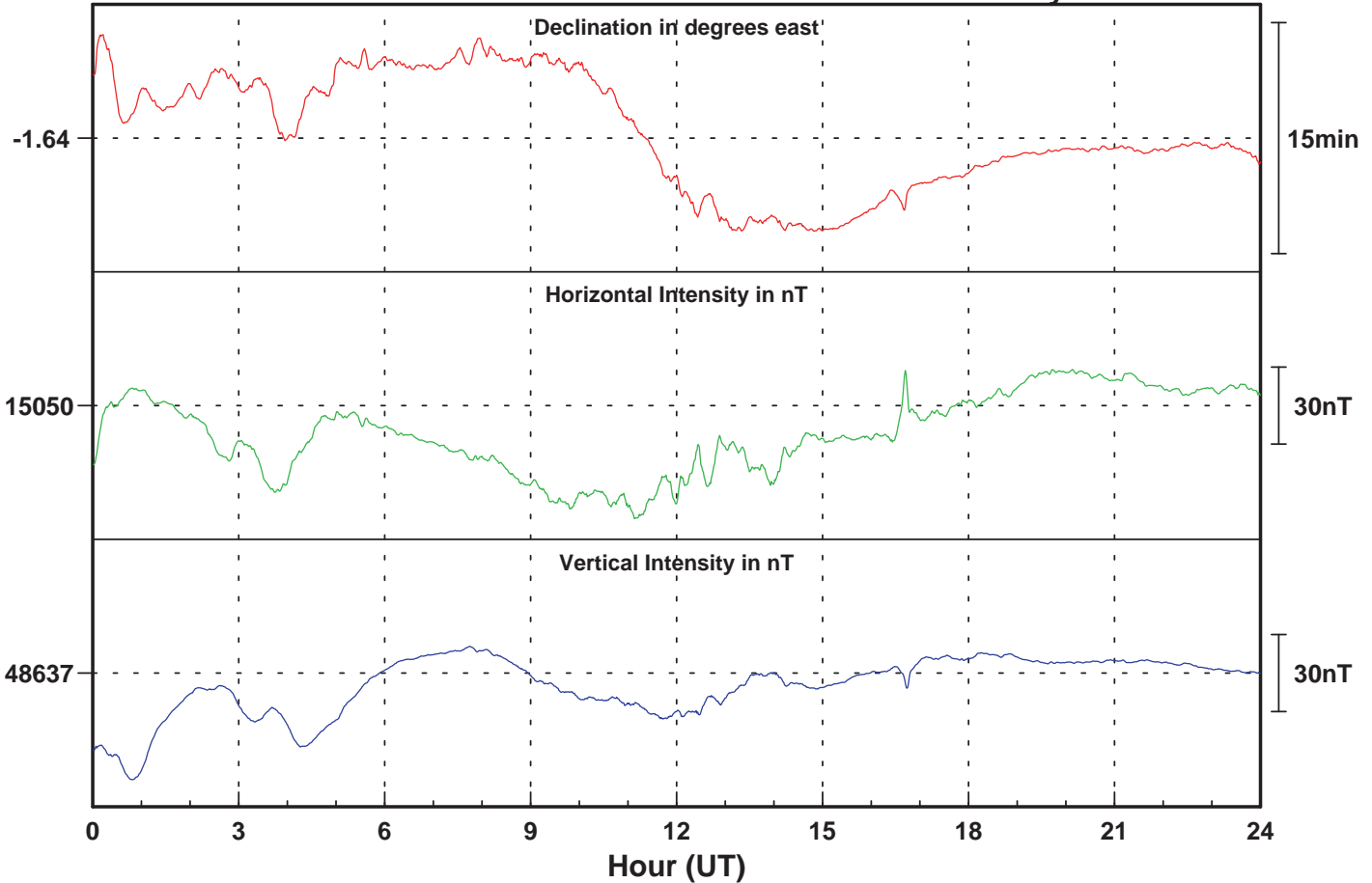
Lerwick

Day number: 159



Date: 08-06-2016

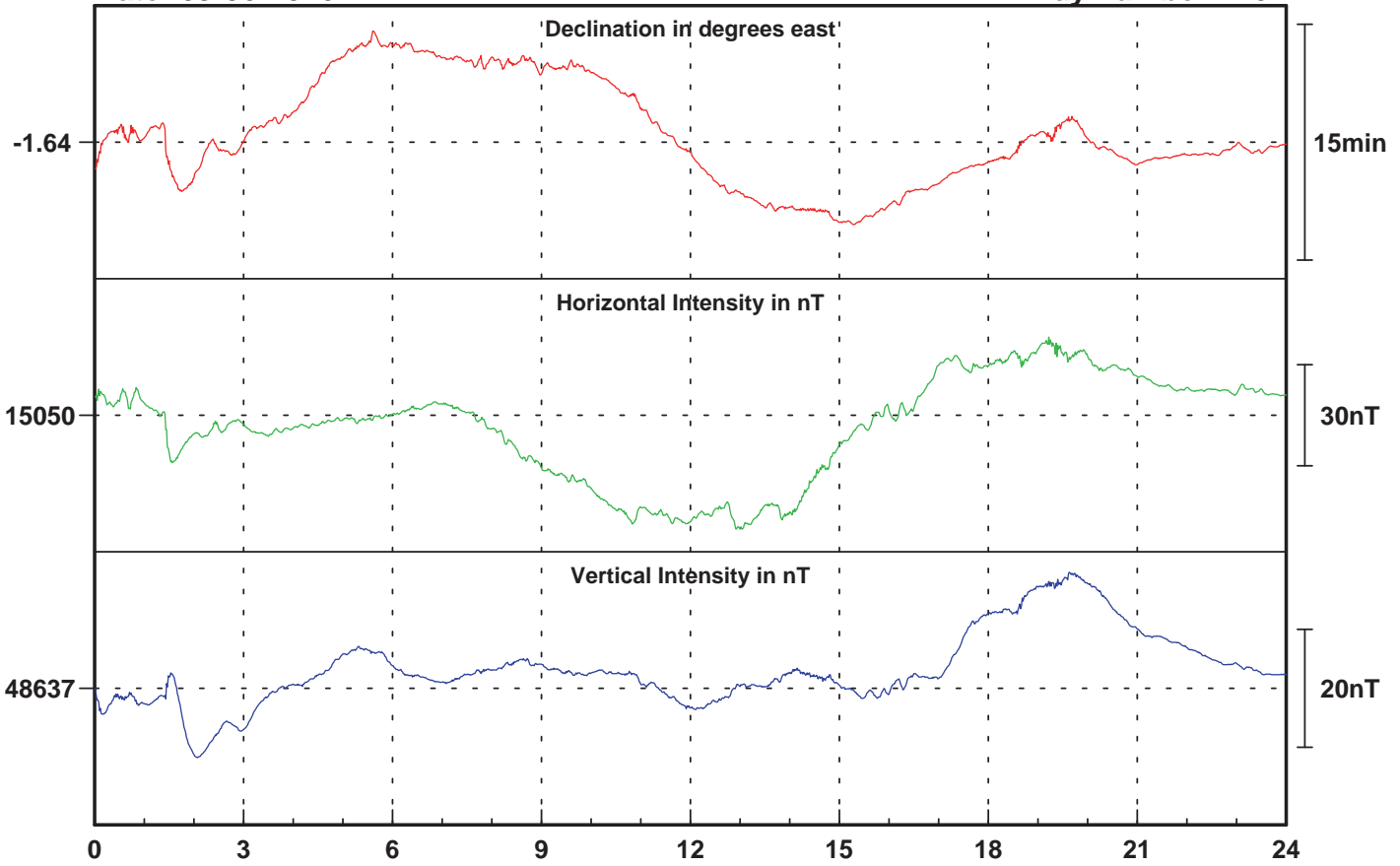
Day number: 160



Date: 09-06-2016

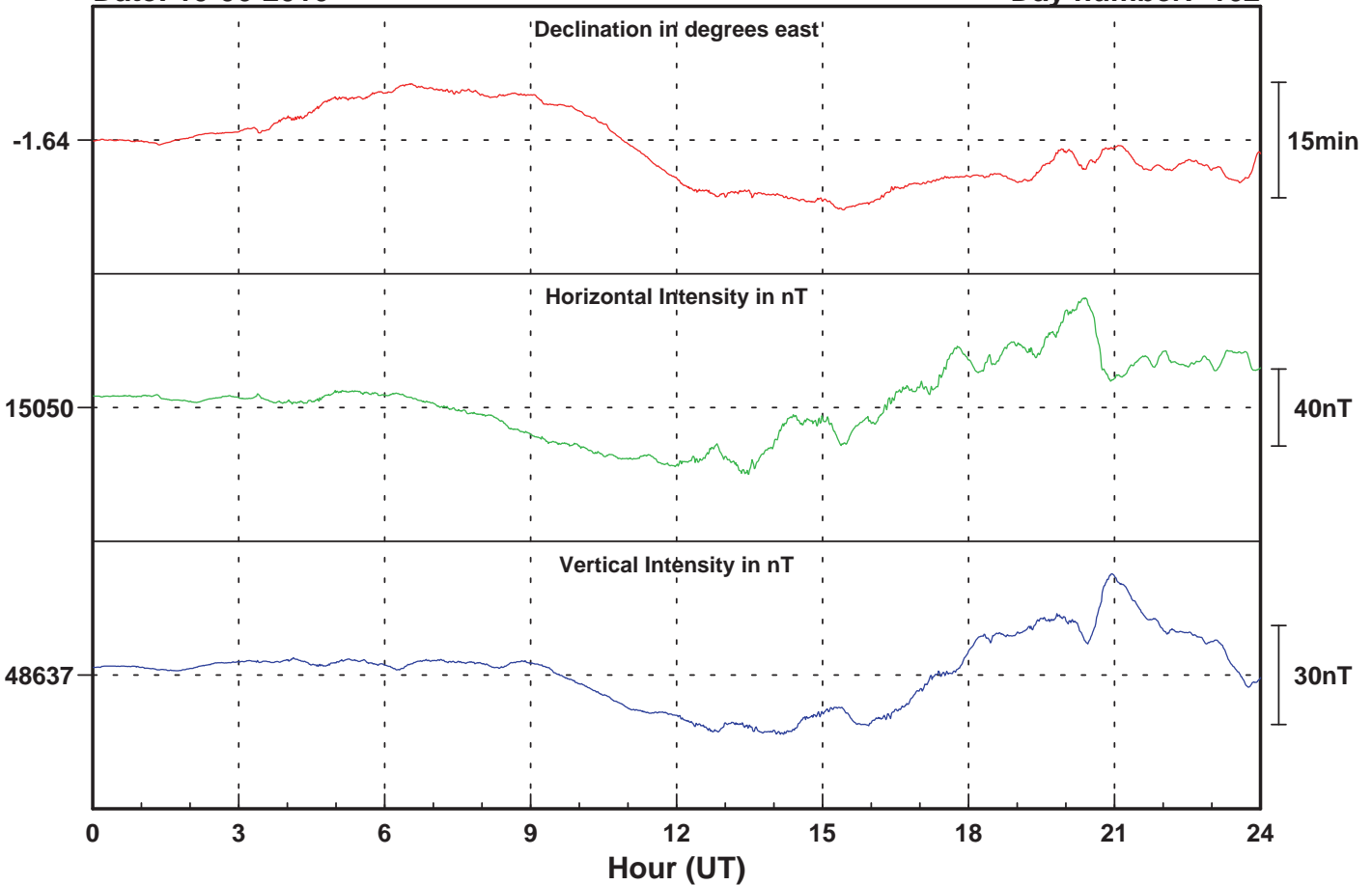
Lerwick

Day number: 161



Date: 10-06-2016

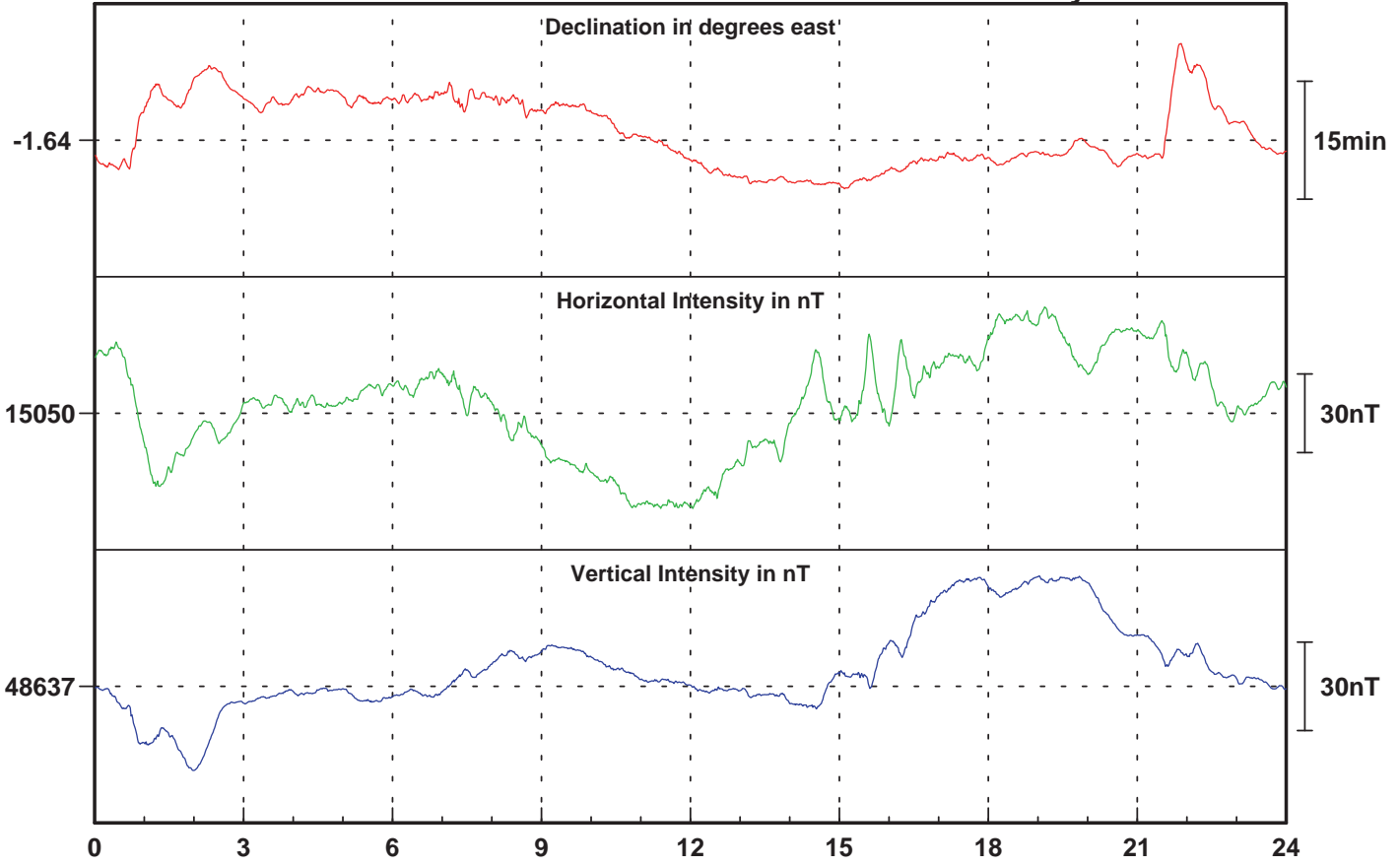
Day number: 162



Date: 11-06-2016

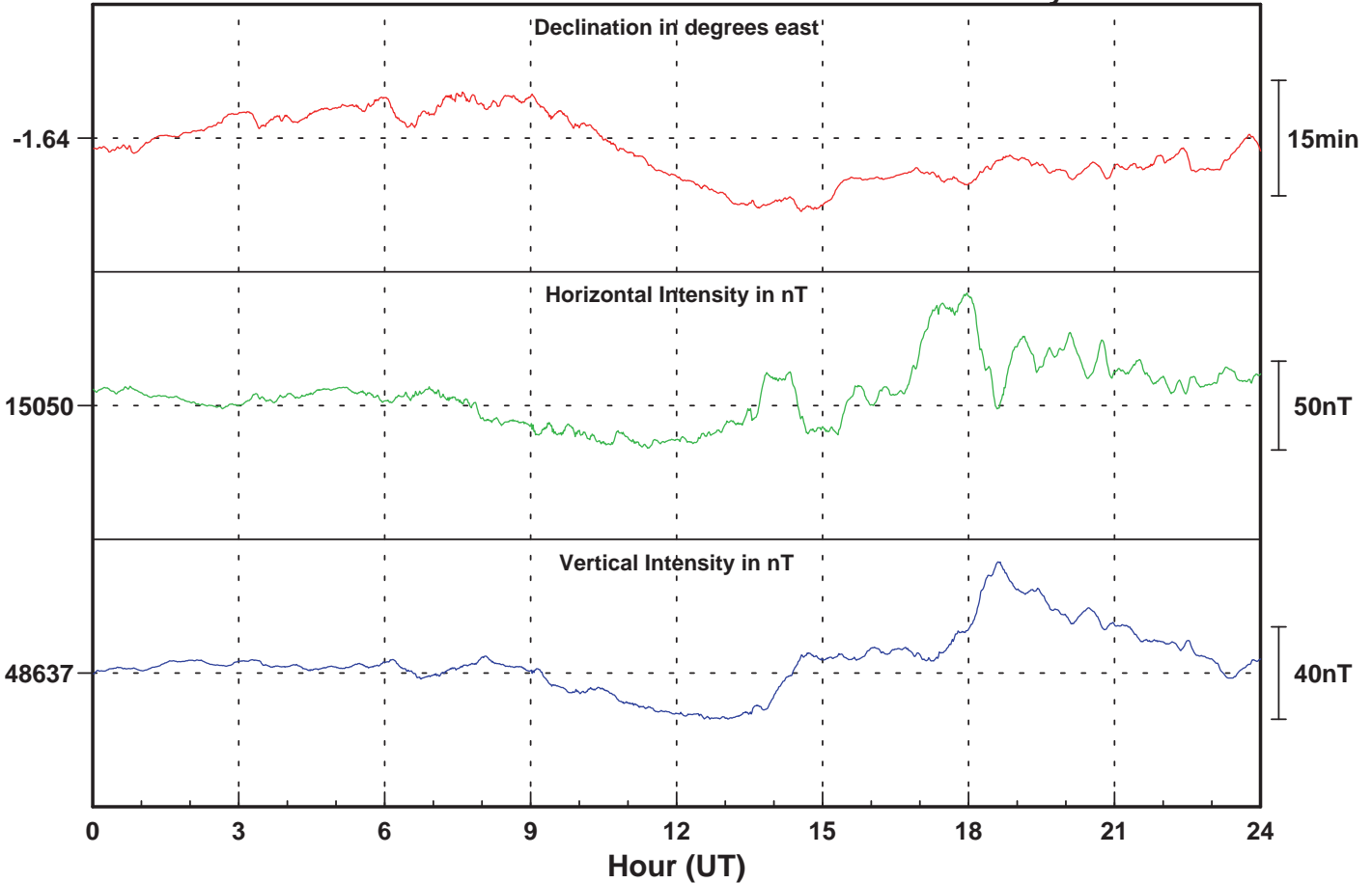
Lerwick

Day number: 163



Date: 12-06-2016

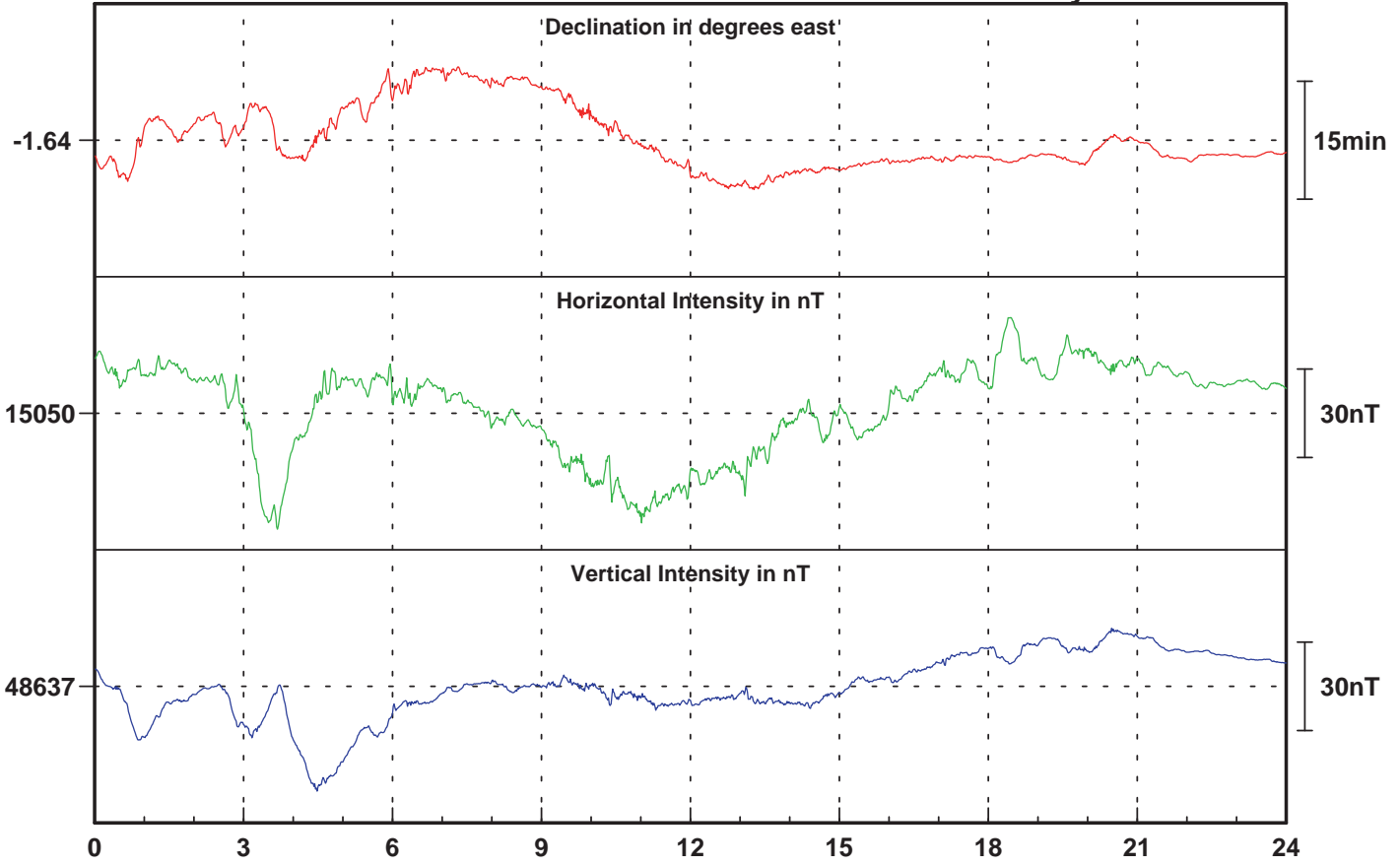
Day number: 164



Date: 13-06-2016

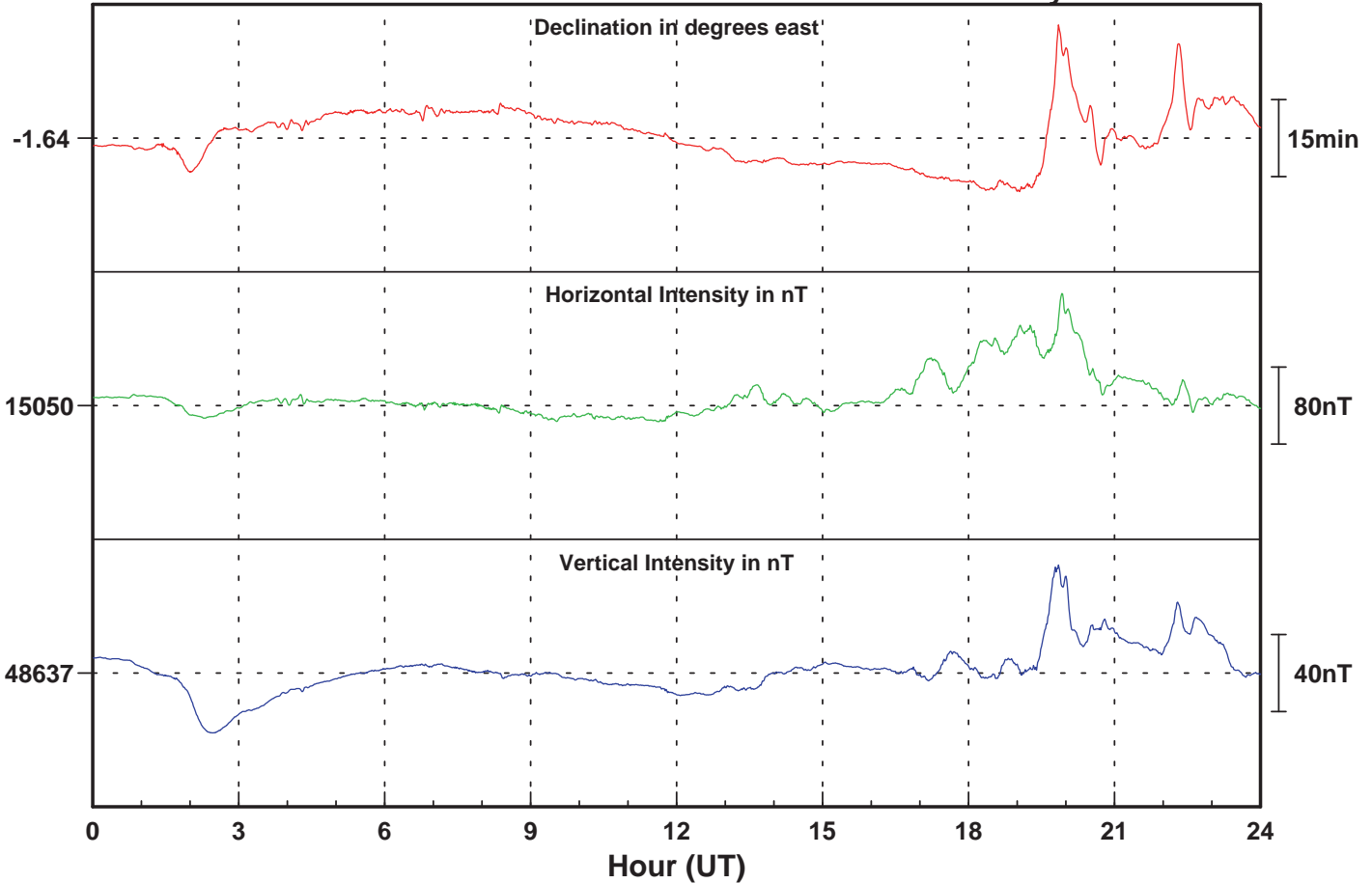
Lerwick

Day number: 165



Date: 14-06-2016

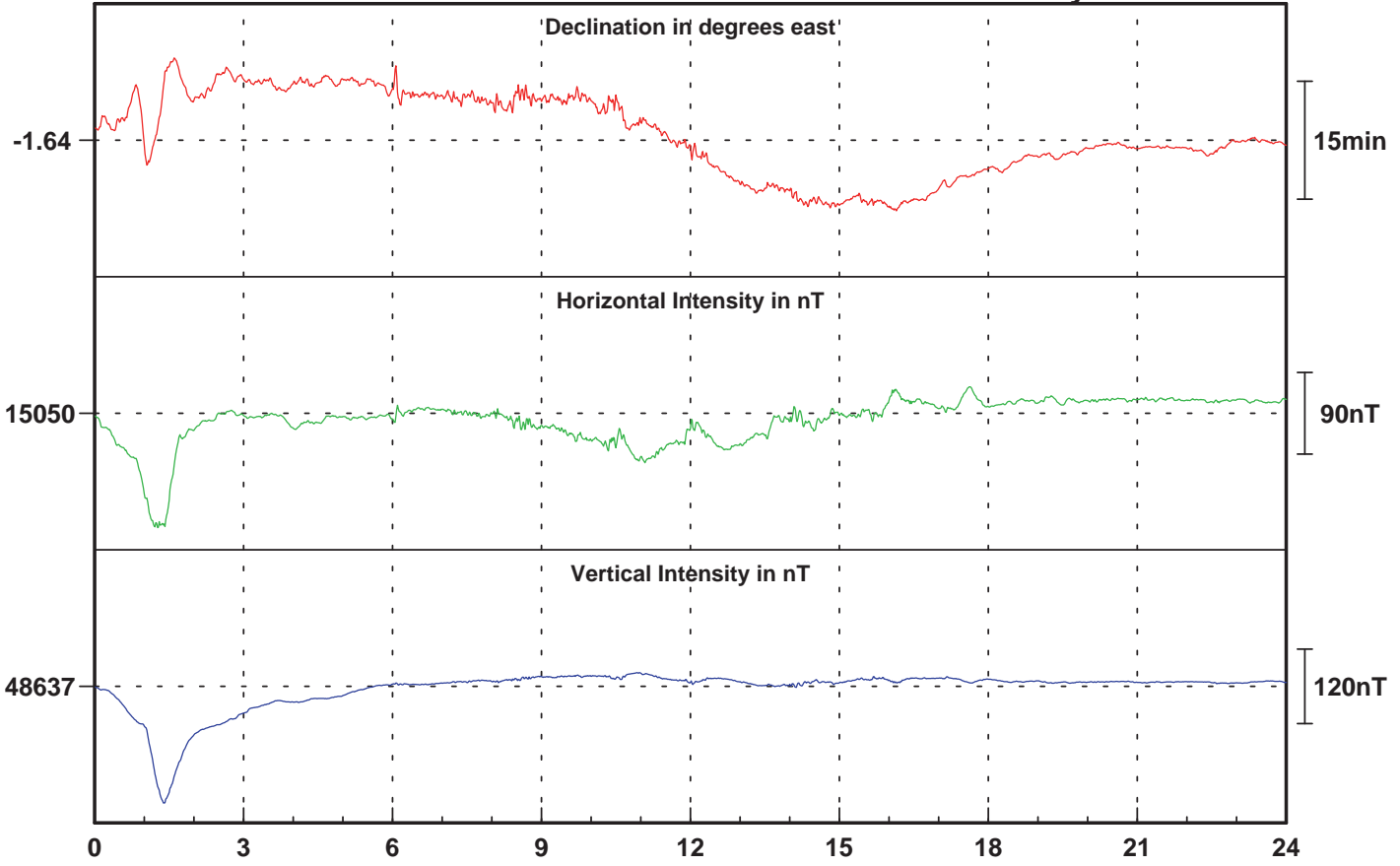
Day number: 166



Date: 15-06-2016

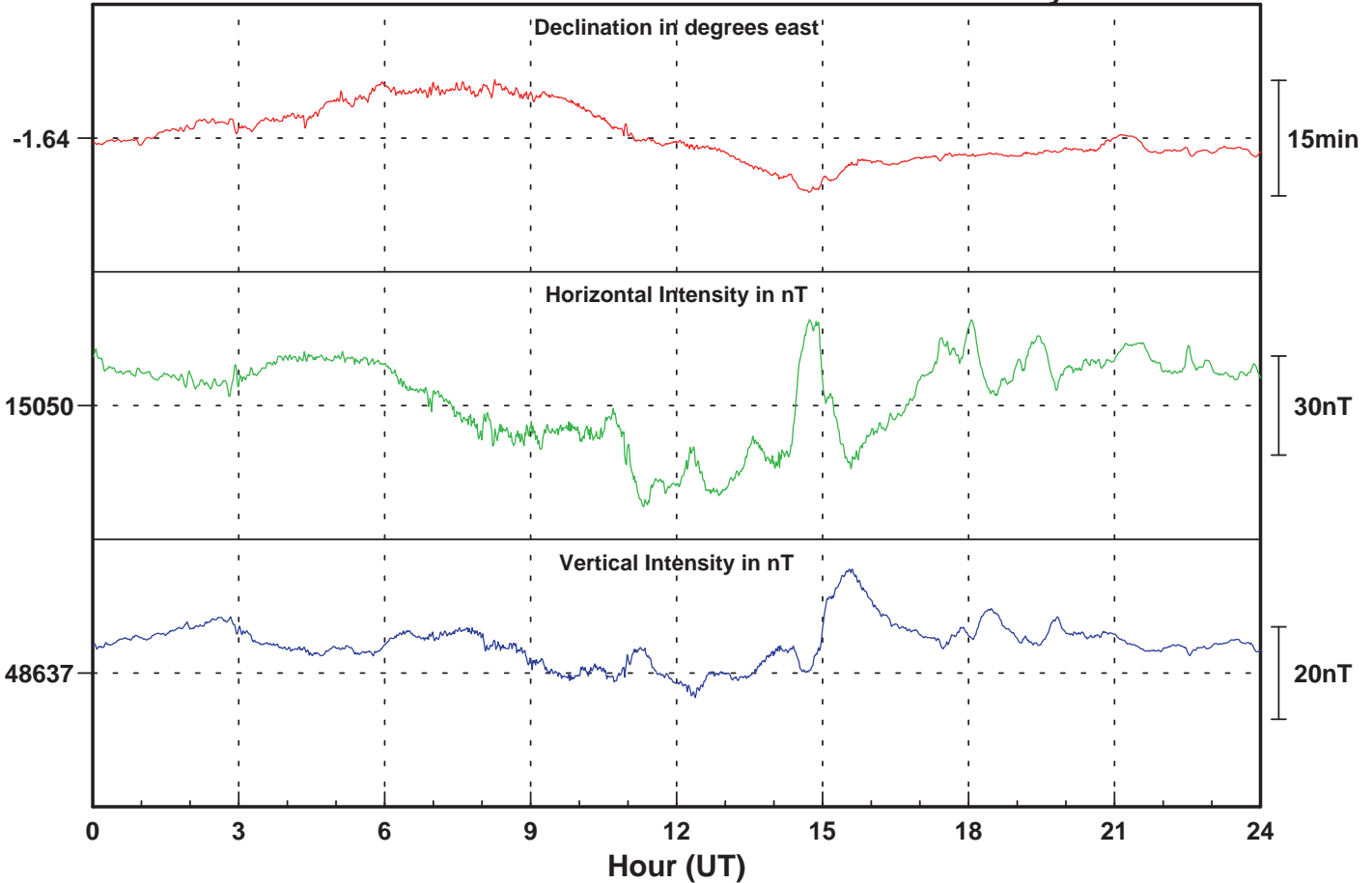
Lerwick

Day number: 167



Date: 16-06-2016

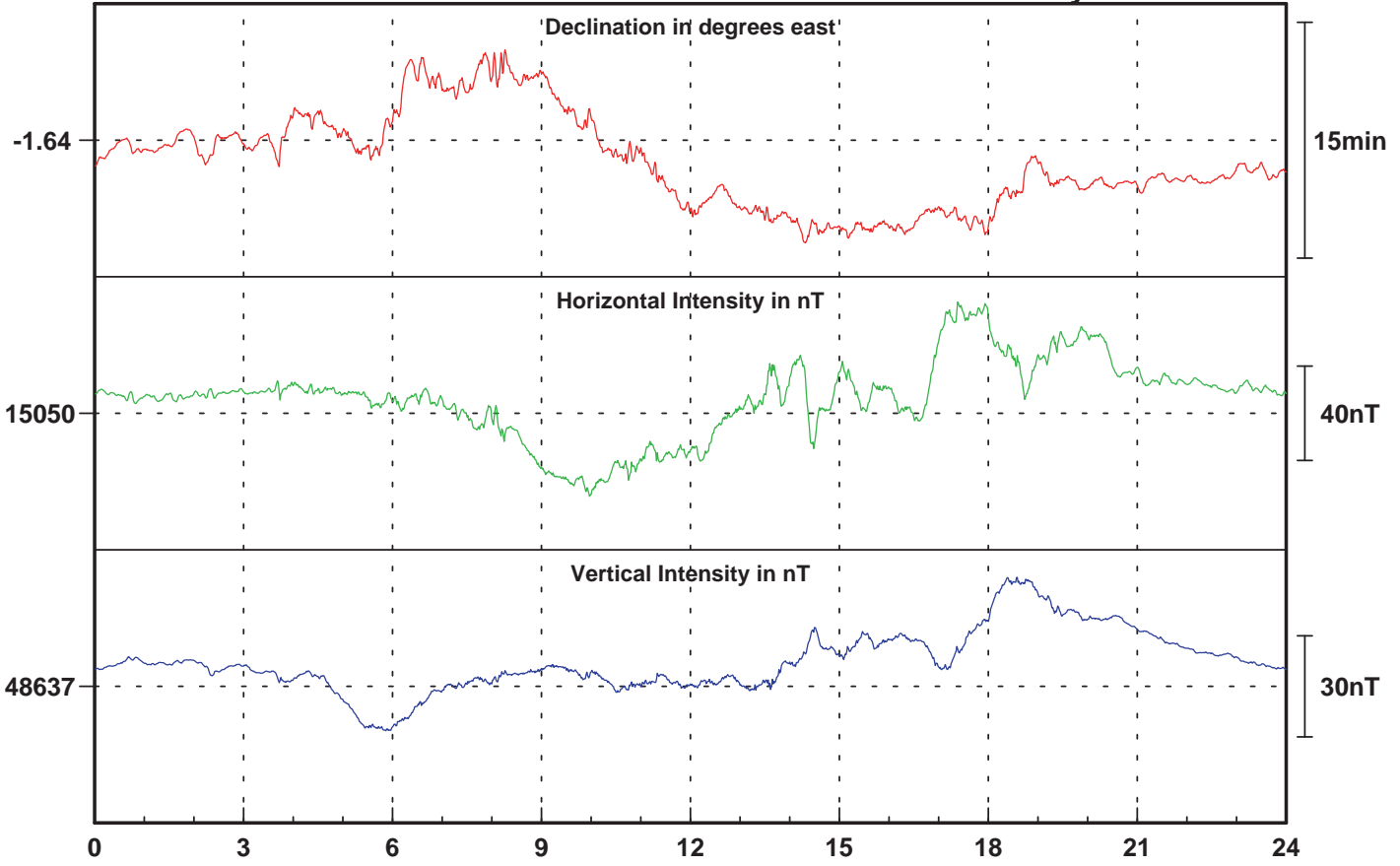
Day number: 168



Date: 17-06-2016

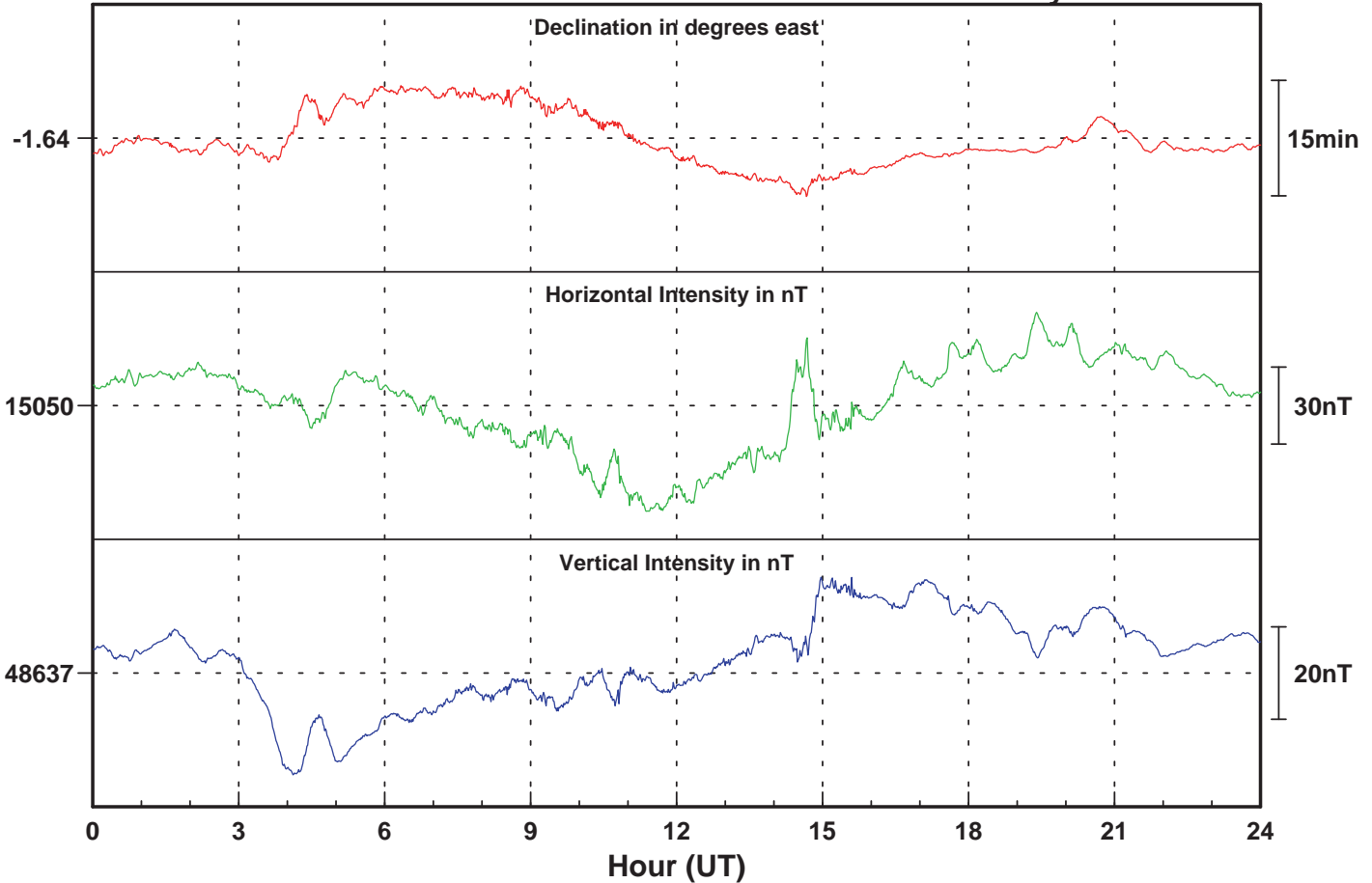
Lerwick

Day number: 169



Date: 18-06-2016

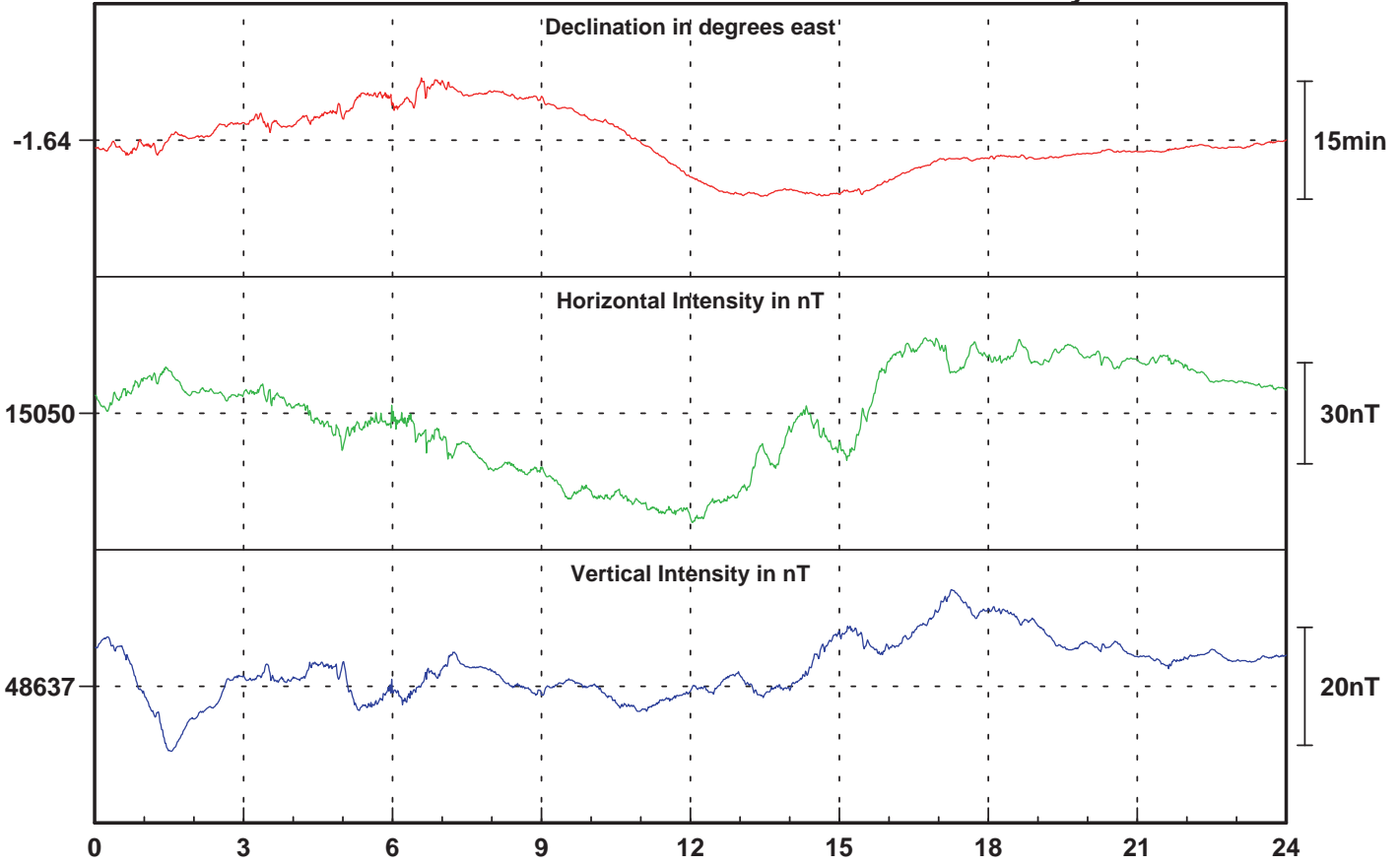
Day number: 170



Date: 19-06-2016

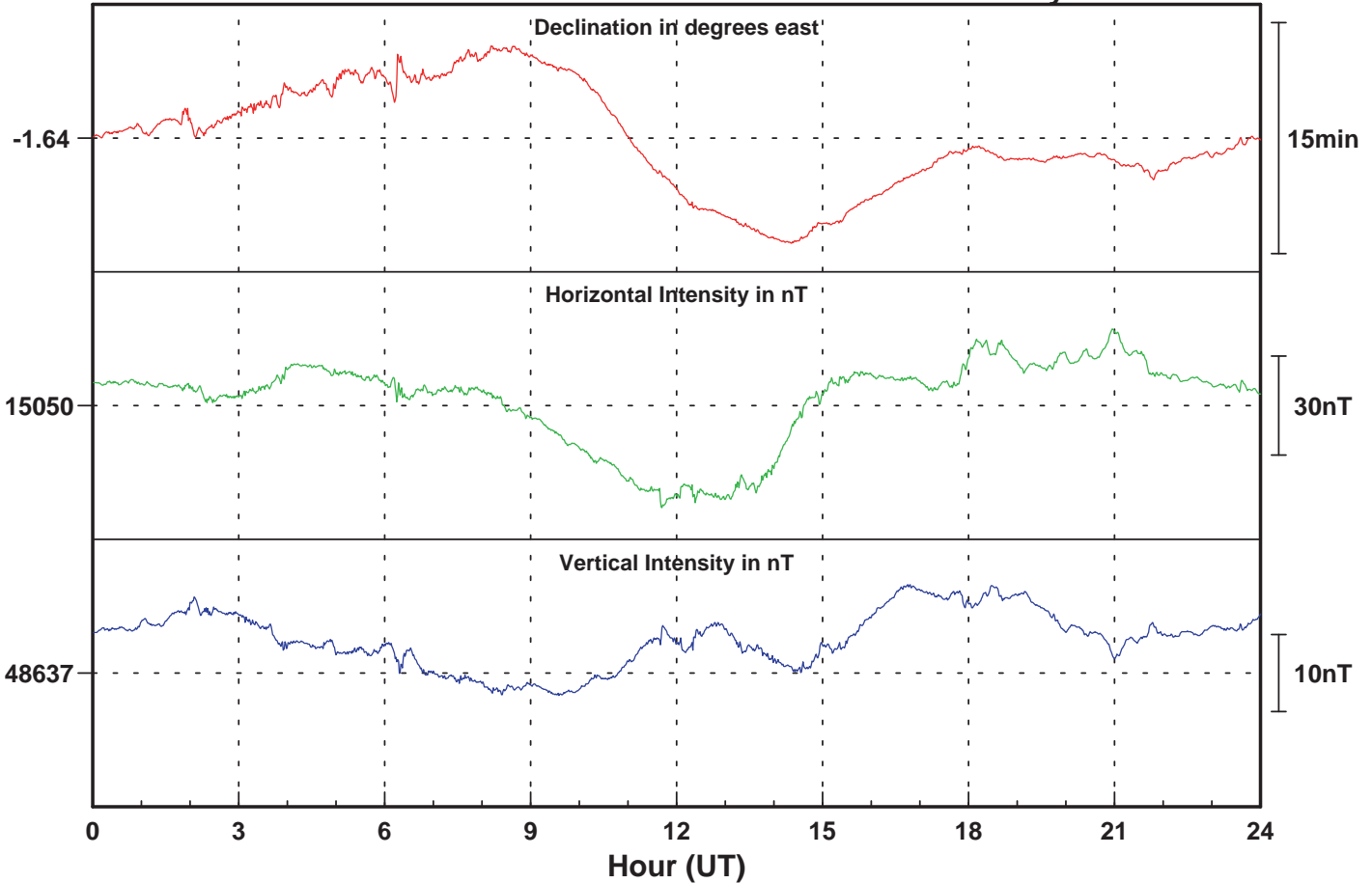
Lerwick

Day number: 171



Date: 20-06-2016

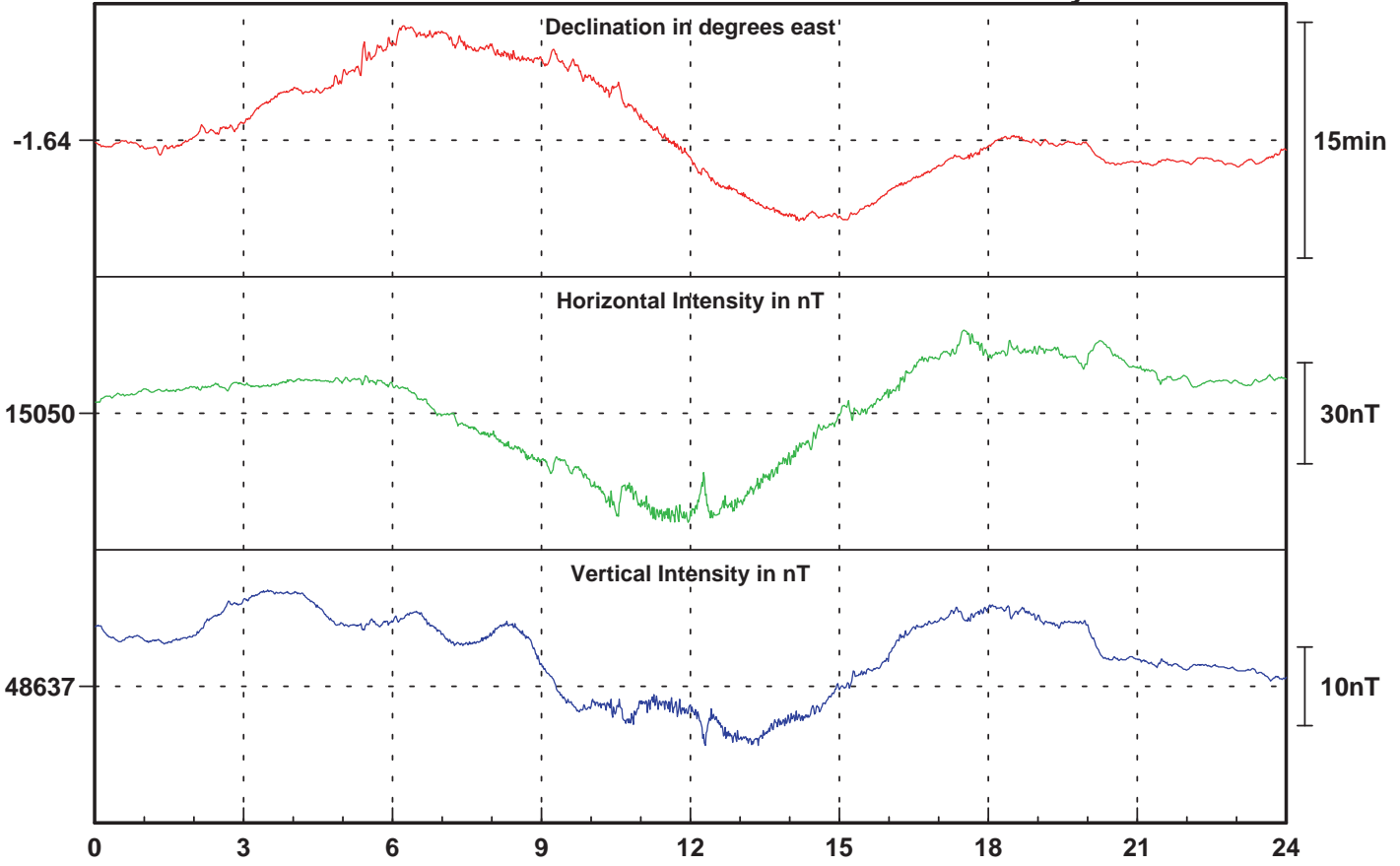
Day number: 172



Date: 21-06-2016

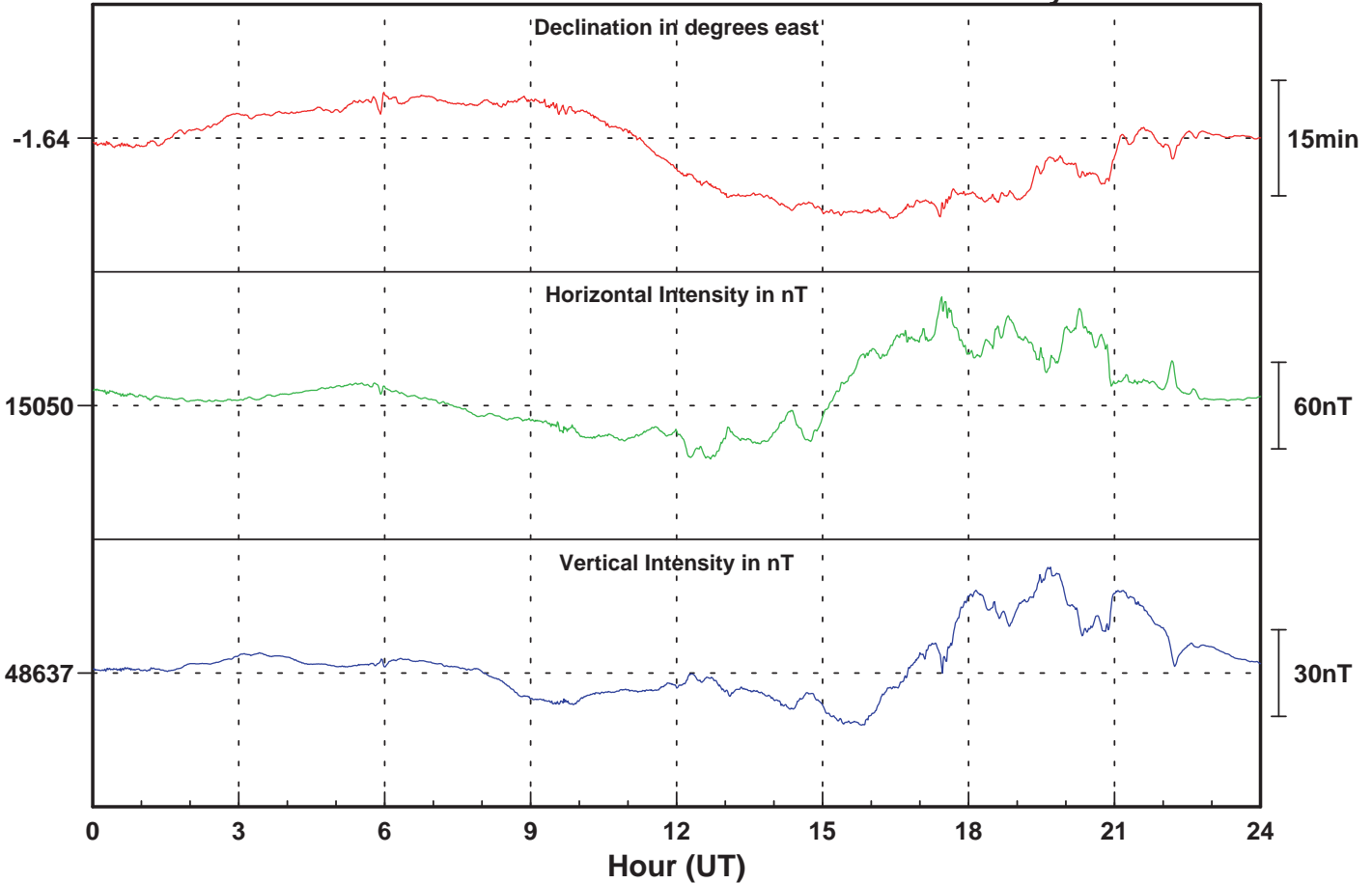
Lerwick

Day number: 173



Date: 22-06-2016

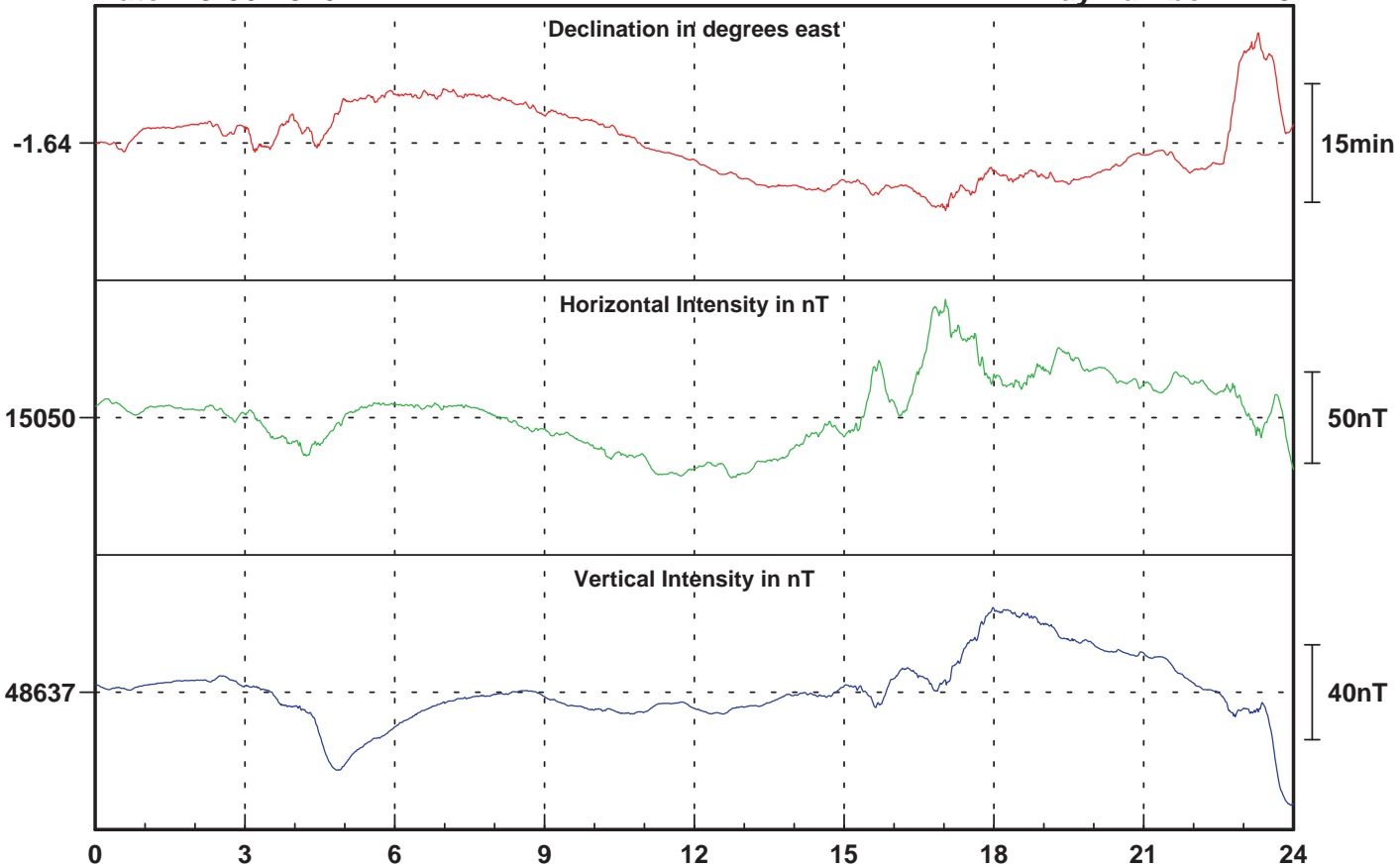
Day number: 174



Date: 23-06-2016

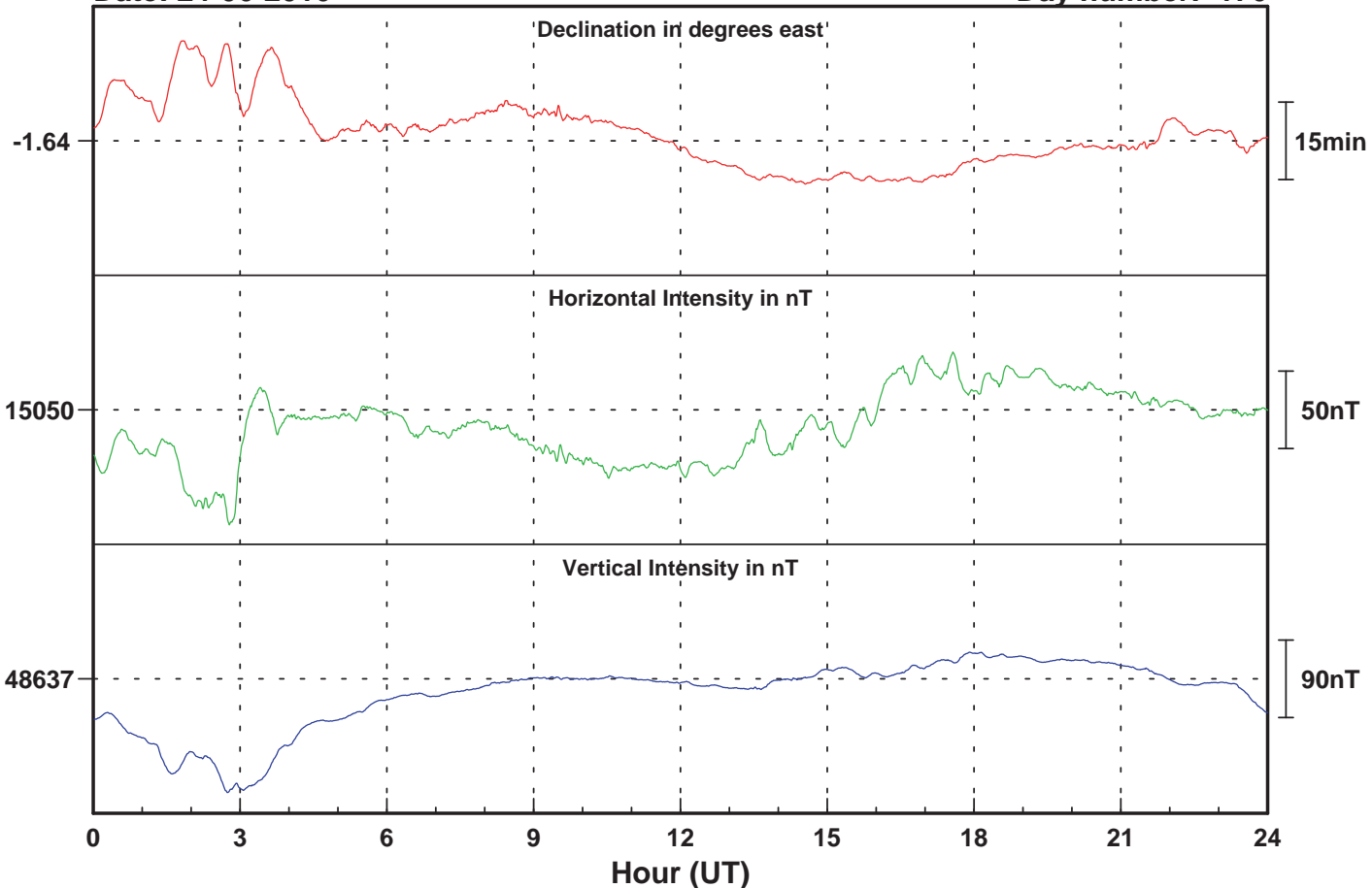
Lerwick

Day number: 175



Date: 24-06-2016

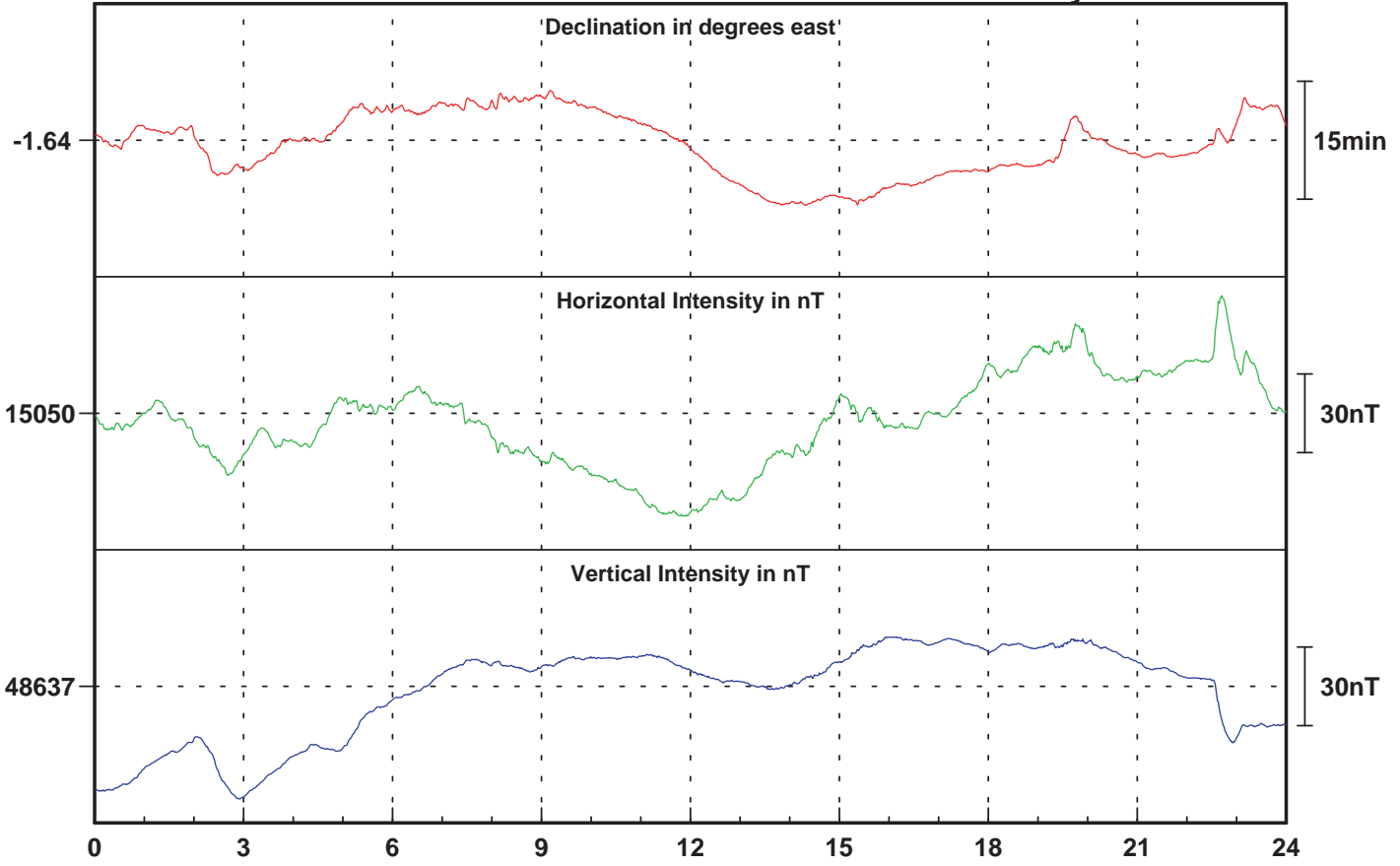
Day number: 176



Date: 25-06-2016

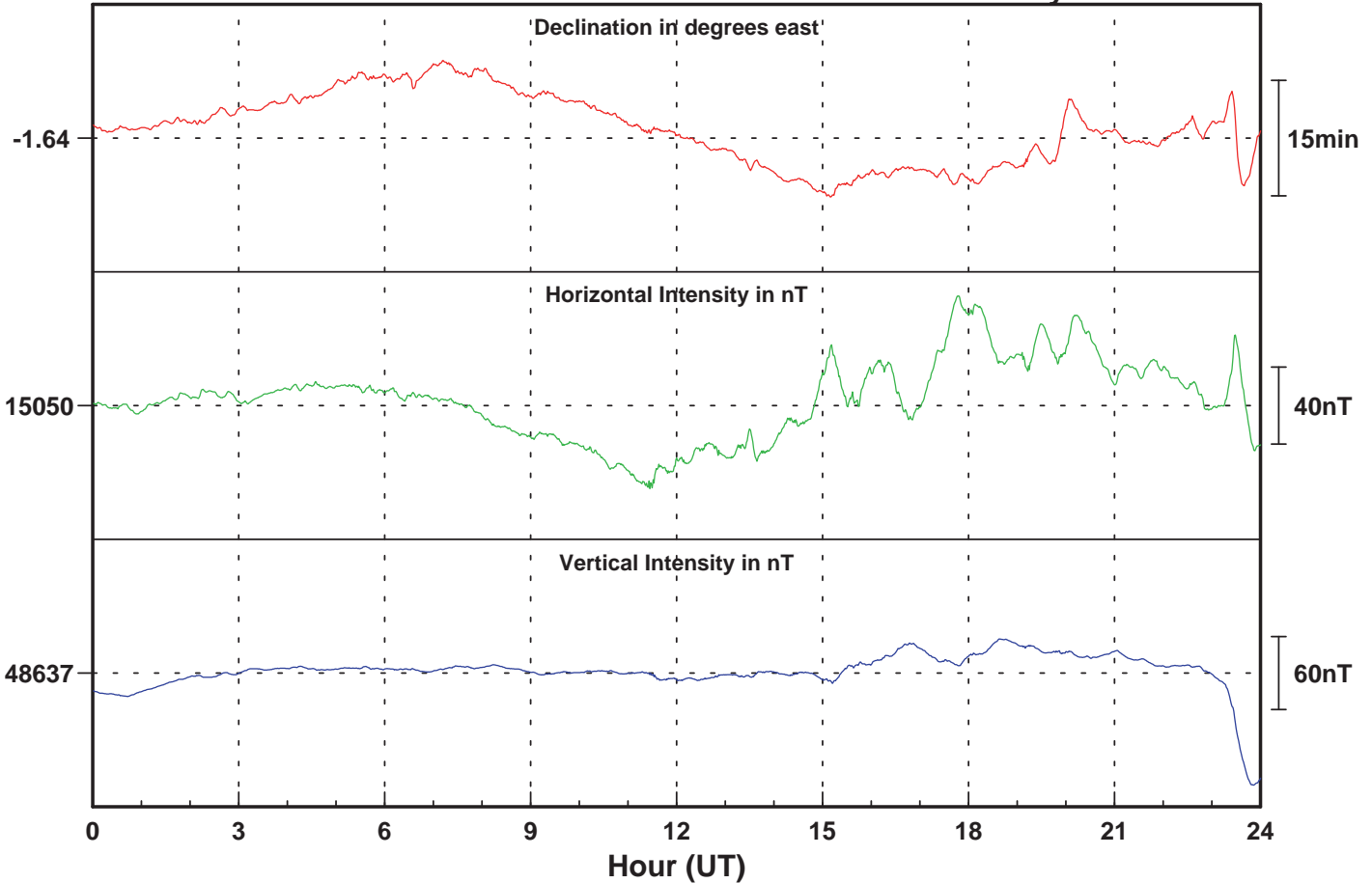
Lerwick

Day number: 177



Date: 26-06-2016

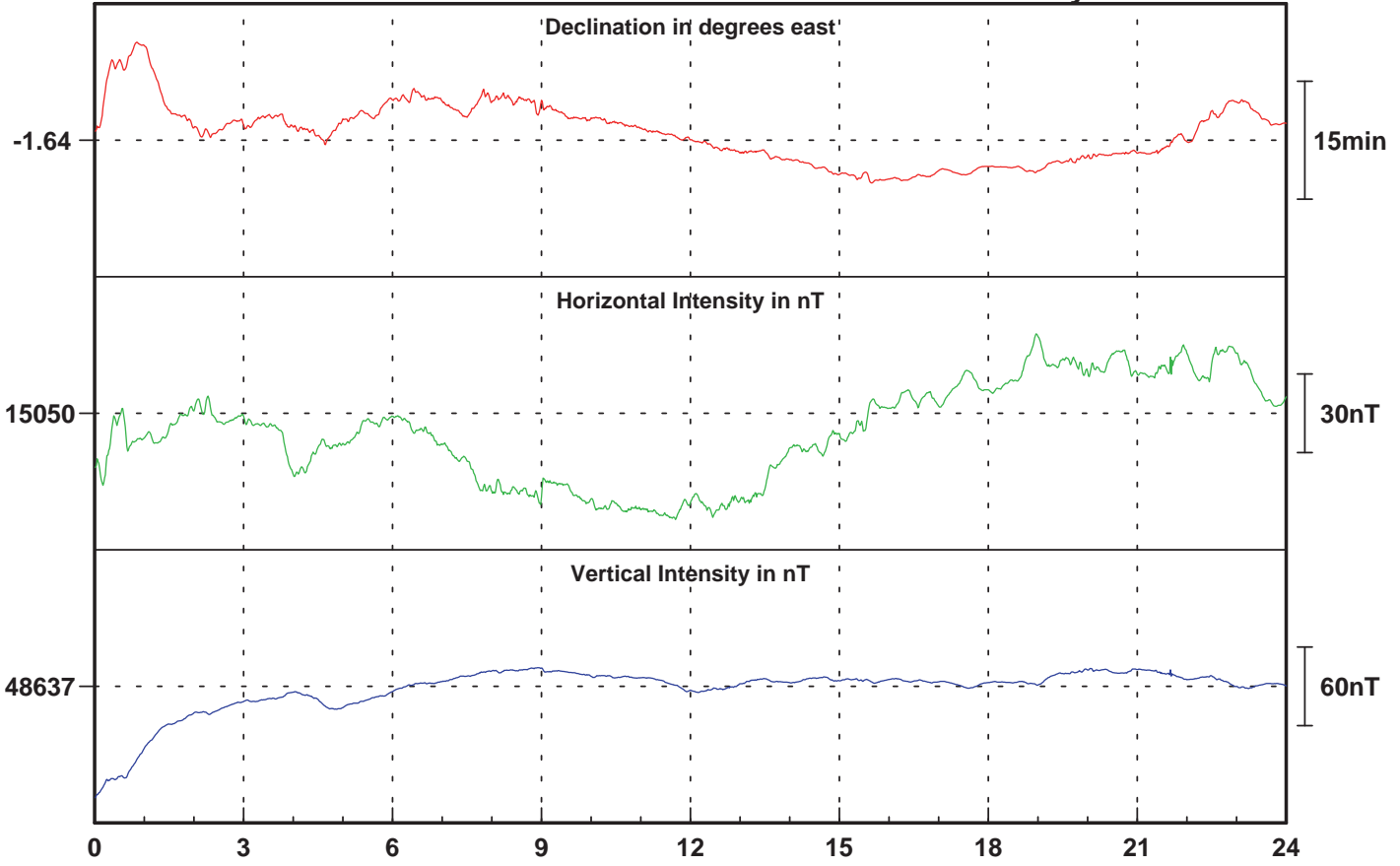
Day number: 178



Date: 27-06-2016

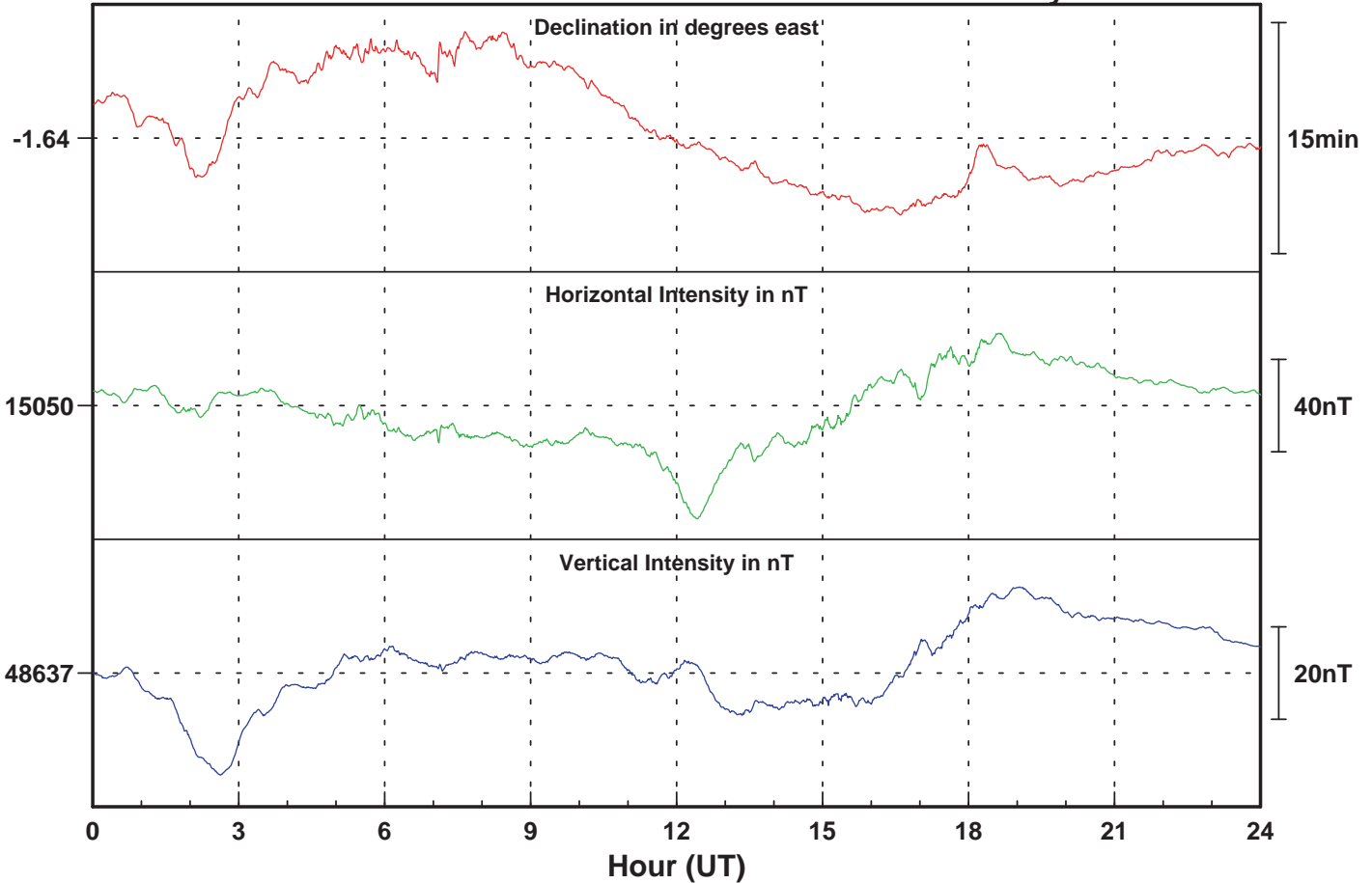
Lerwick

Day number: 179



Date: 28-06-2016

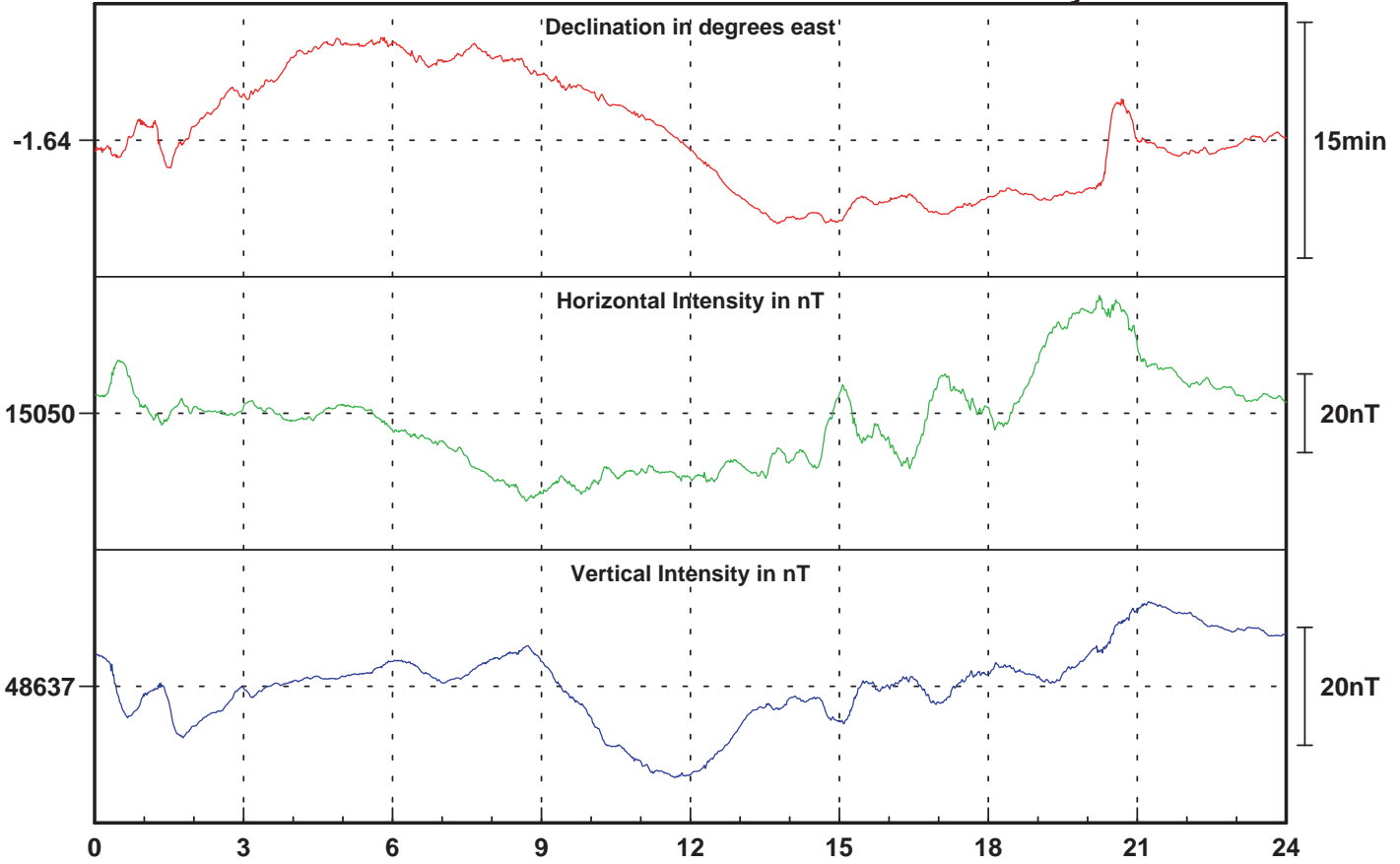
Day number: 180



Date: 29-06-2016

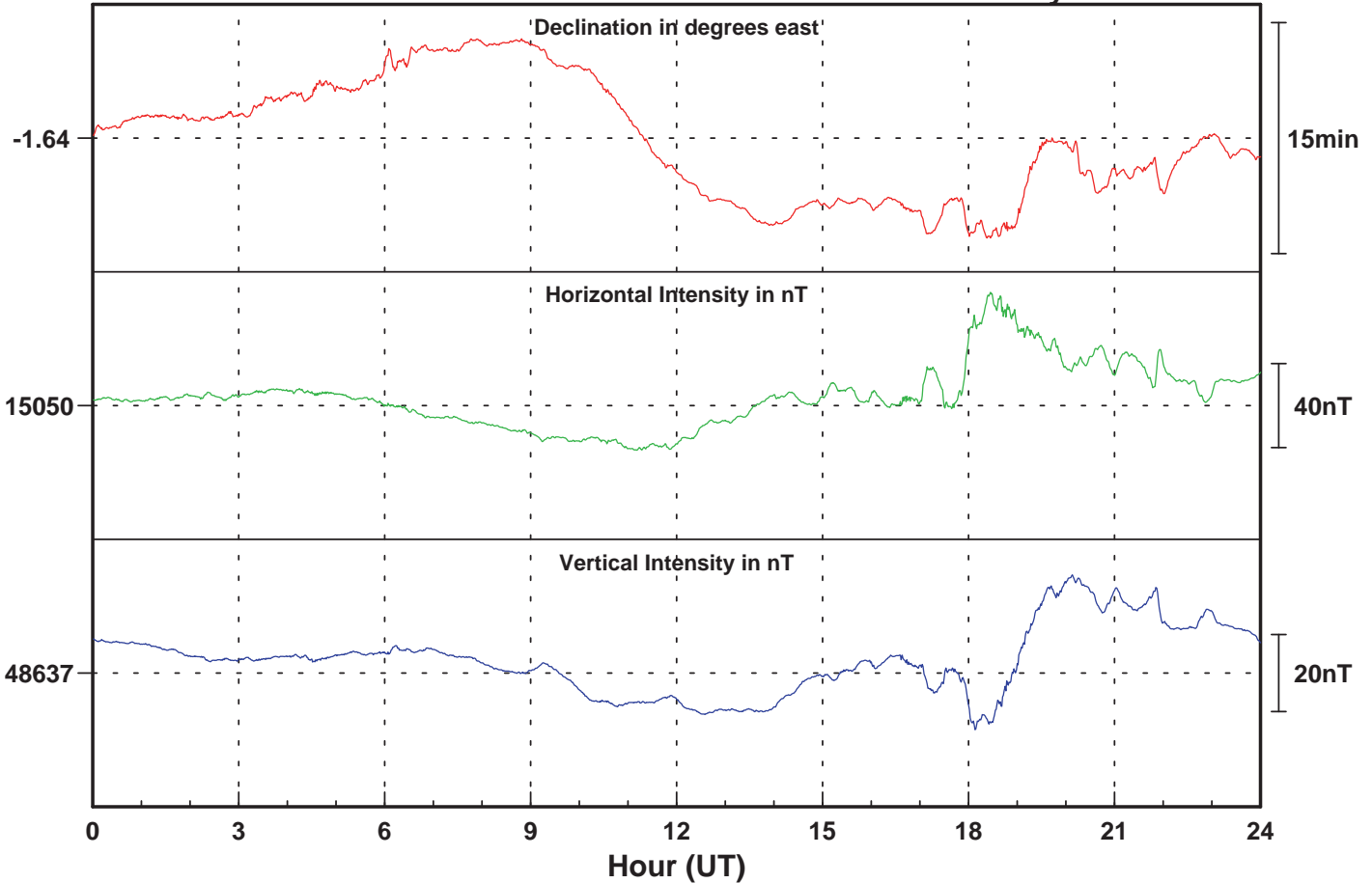
Lerwick

Day number: 181

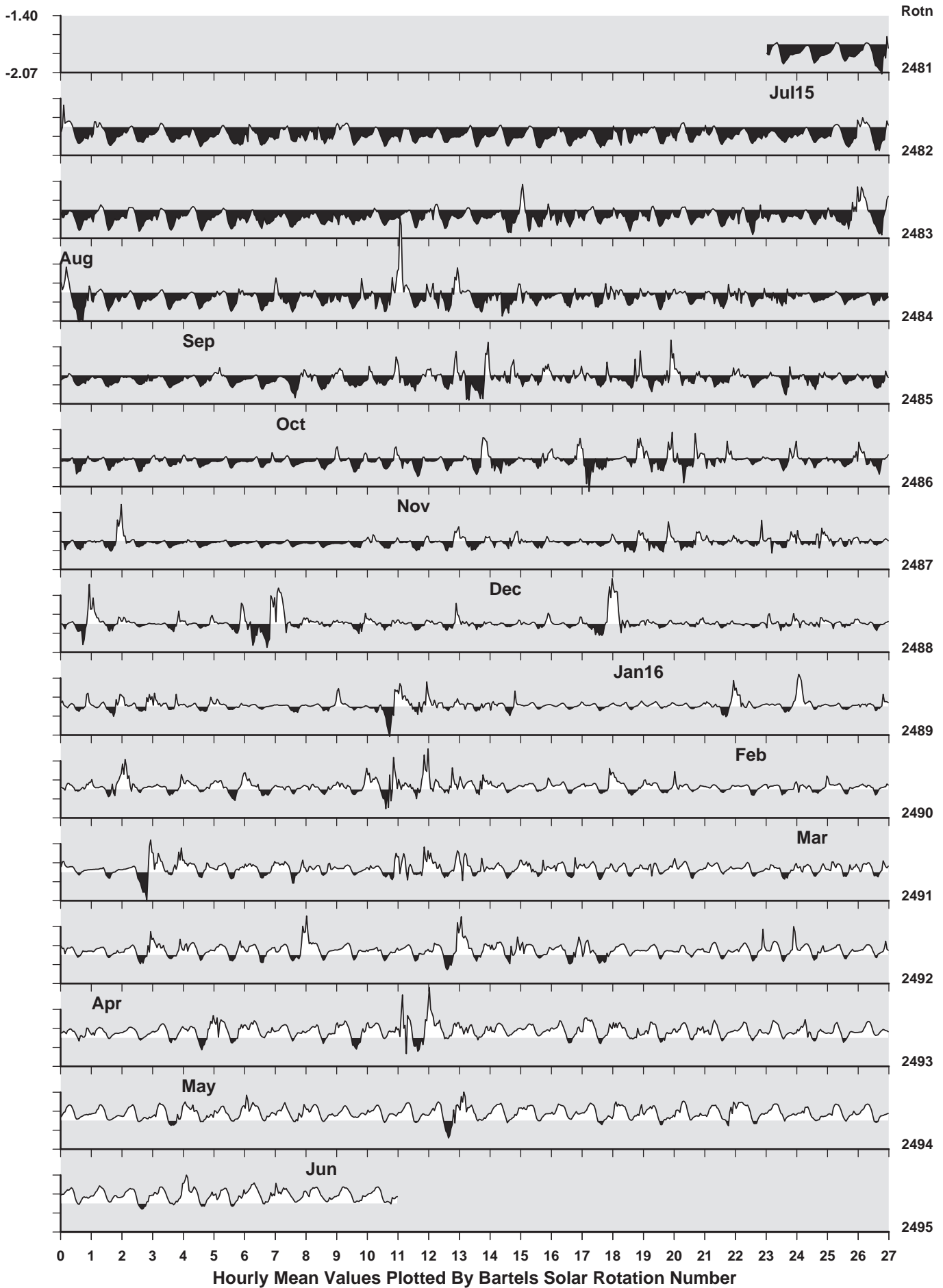


Date: 30-06-2016

Day number: 182

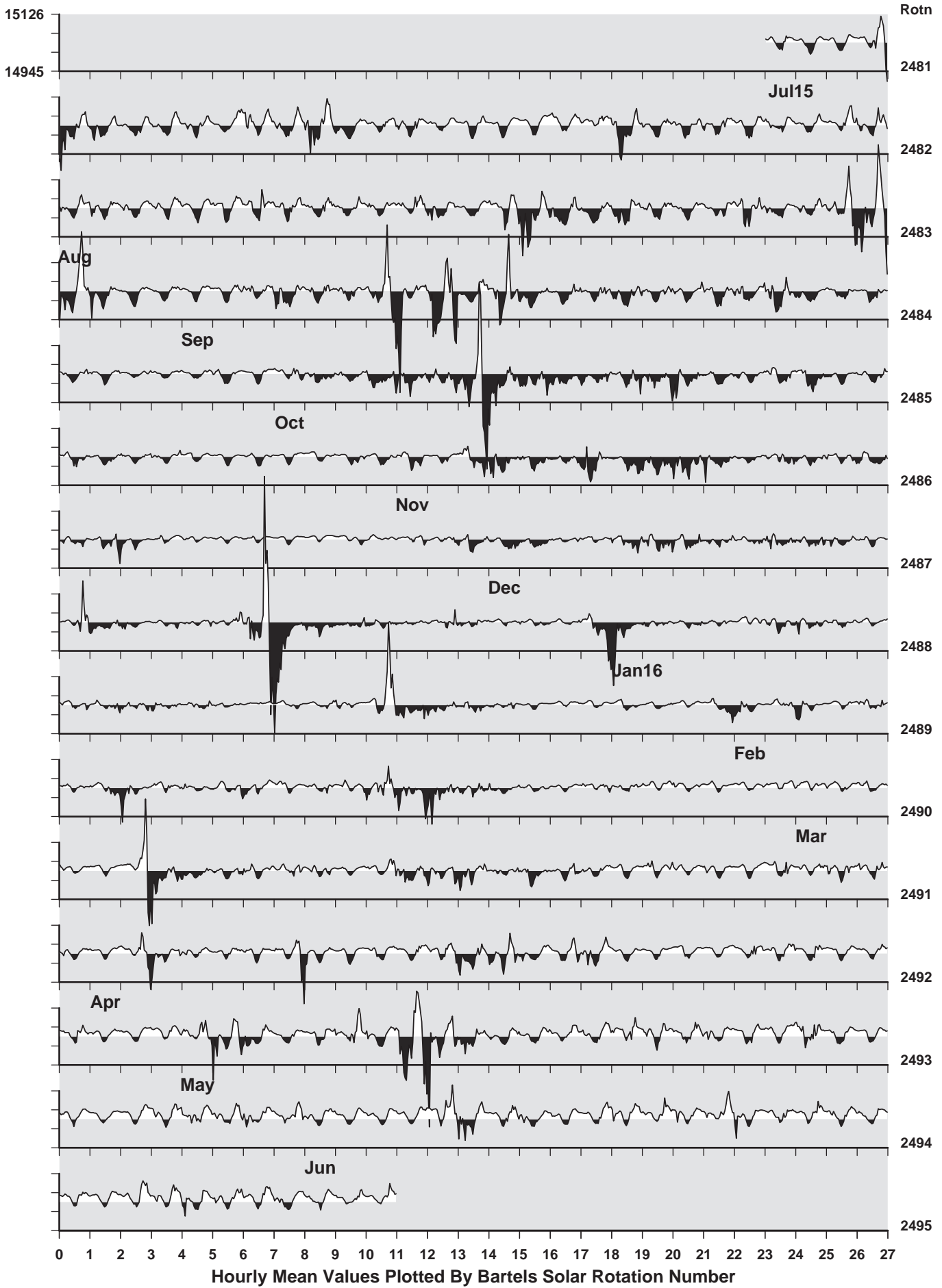


Lerwick Observatory: Declination (degrees)



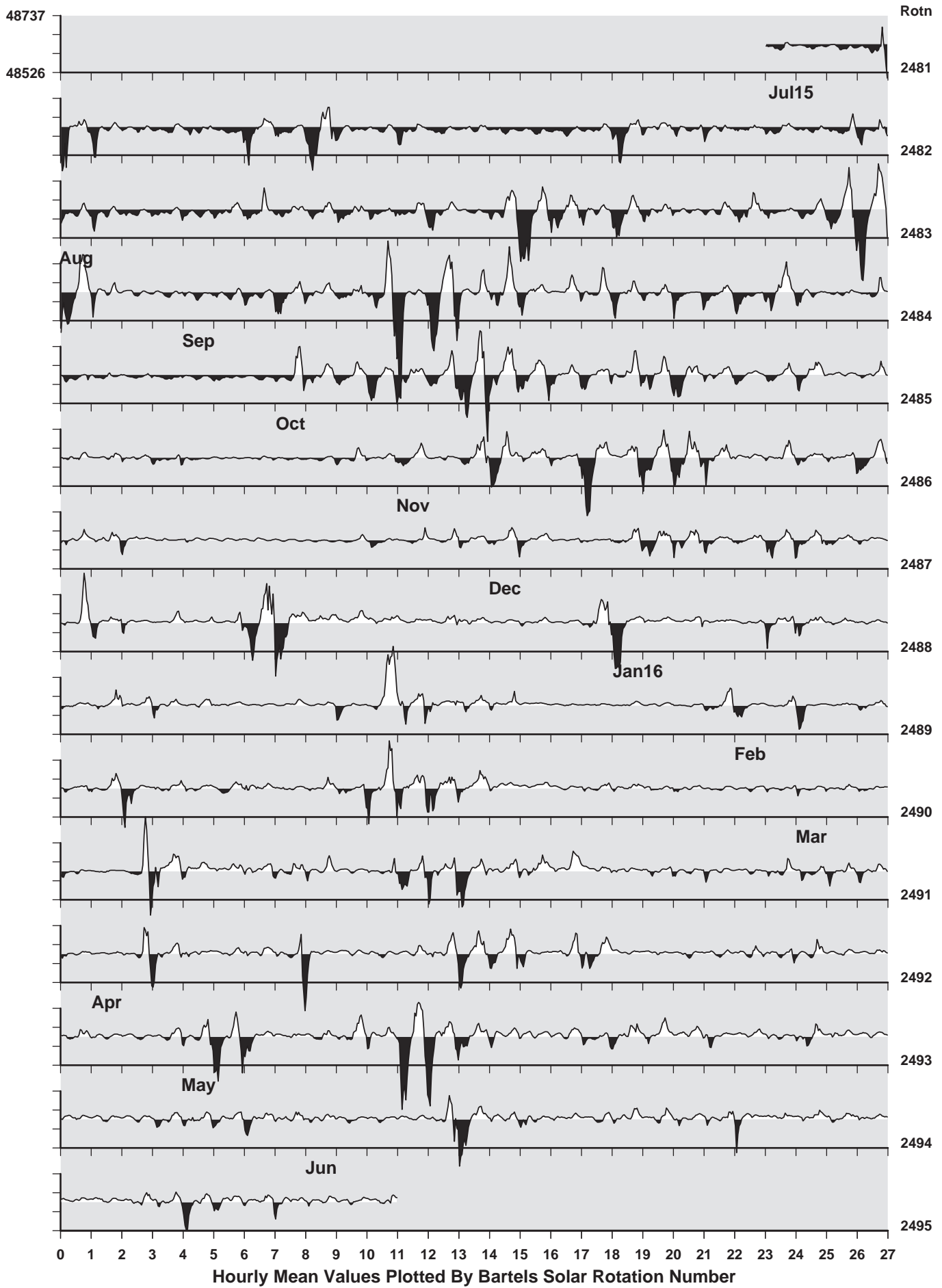
Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory: Horizontal Intensity (nT)



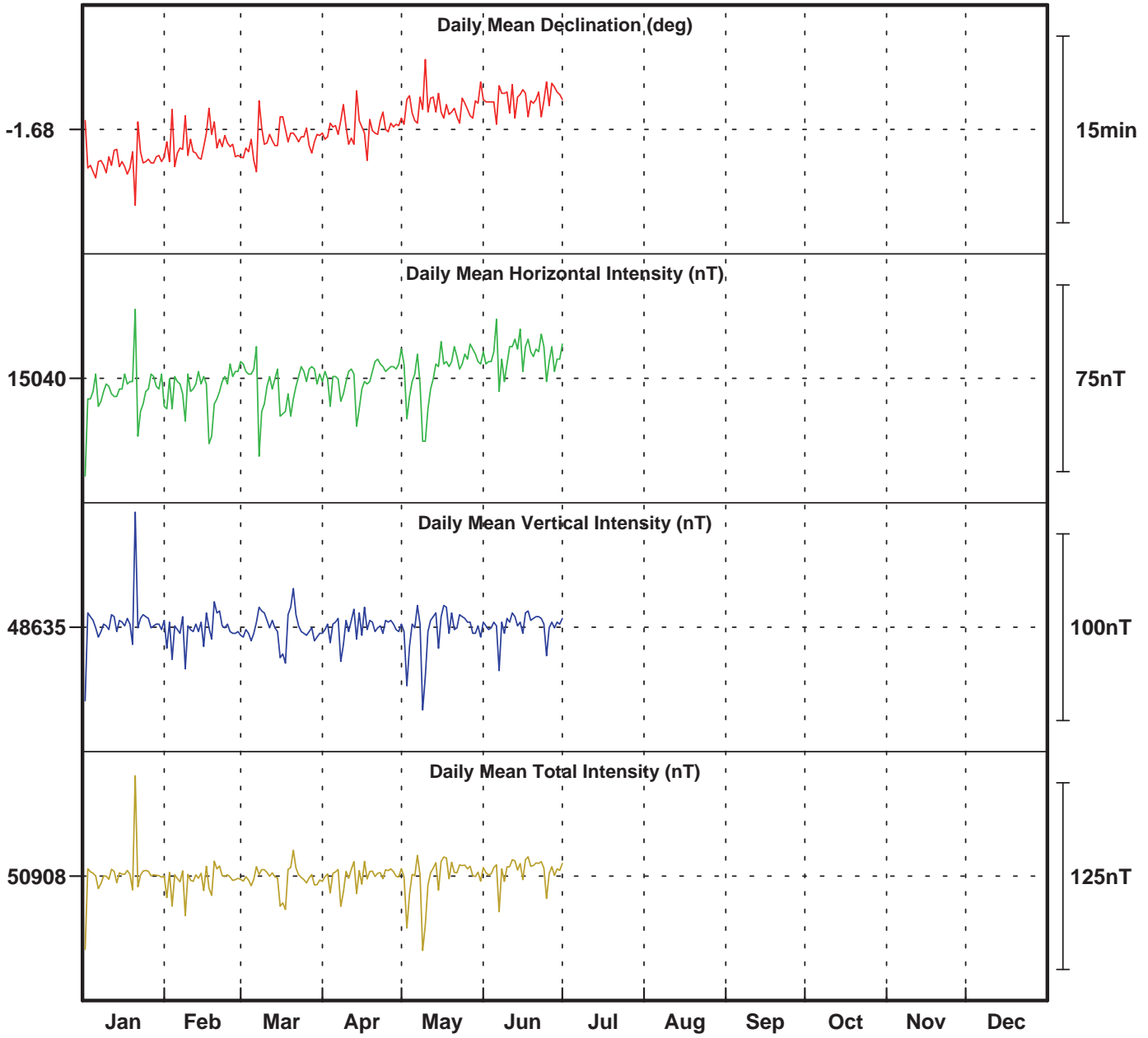
Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory: Vertical Intensity (nT)



Hourly Mean Values Plotted By Bartels Solar Rotation Number

Lerwick Observatory 2016



Monthly Mean Values for Lerwick Observatory 2016

Month	<i>D</i>	<i>H</i>	<i>I</i>	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>F</i>
January	-1° 43.3′	15035 nT	72° 49.4′	15028 nT	-452 nT	48638 nT	50908 nT
February	-1° 42.0′	15036 nT	72° 49.2′	15030 nT	-446 nT	48634 nT	50905 nT
March	-1° 41.6′	15037 nT	72° 49.1′	15031 nT	-444 nT	48635 nT	50906 nT
April	-1° 40.6′	15041 nT	72° 48.9′	15034 nT	-440 nT	48635 nT	50908 nT
May	-1° 38.9′	15043 nT	72° 48.8′	15037 nT	-433 nT	48634 nT	50907 nT
June	-1° 38.3′	15050 nT	72° 48.4′	15044 nT	-430 nT	48637 nT	50912 nT

Note

i. The values shown here are provisional.

LERWICK RAPID VARIATIONS

SI and SSCs

Date	Time (UT)	Type	Quality	H (nT)	D (min)	Z (nT)
None						

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

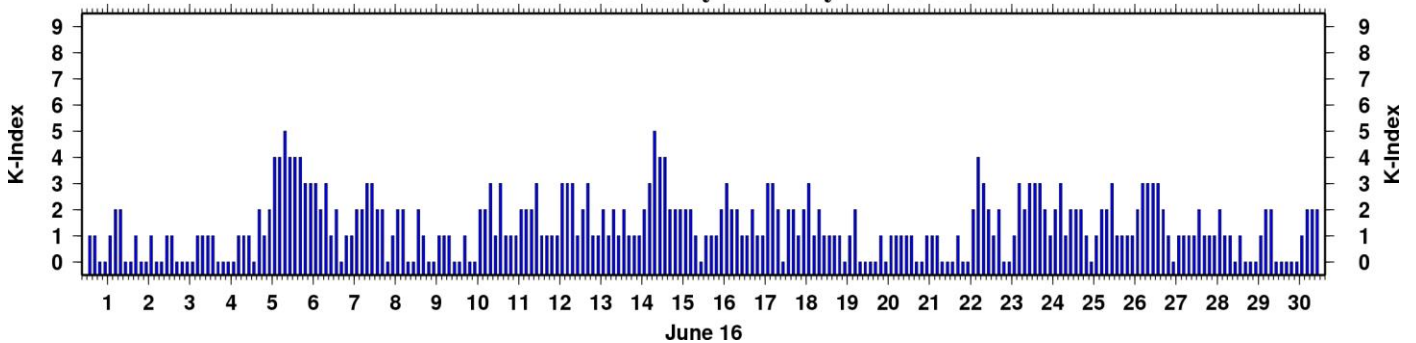
Note:

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

Lerwick Observatory 3-hourly K-Indices



The *aa* Index

Date	Day	3-hourly <i>aa</i> -indices								<i>Aa_{am}</i>	<i>Aa_{pm}</i>	<i>Aa</i>
01-06-16	153	12	8	8	9	16	16	20	5	9.2	14.3	11.7
02-06-16	154	5	5	5	5	8	5	5	5	5.1	5.8	5.5
03-06-16	155	5	5	2	2	2	2	2	5	3.8	3.1	3.5
04-06-16	156	5	5	2	2	2	5	12	8	3.8	6.8	5.3
05-06-16	157	12	12	24	46	80	80	67	37	23.4	66.0	44.7
06-06-16	158	45	59	32	81	59	24	24	12	54.3	29.8	42.0
07-06-16	159	12	8	8	24	12	24	32	12	12.9	20.0	16.5
08-06-16	160	12	16	5	24	16	20	5	2	14.3	10.9	12.6
09-06-16	161	12	5	2	2	8	5	8	2	5.5	5.8	5.6
10-06-16	162	2	2	5	5	16	12	24	17	3.8	17.3	10.5
11-06-16	163	24	8	12	12	24	20	20	37	14.0	25.2	19.6
12-06-16	164	5	12	16	12	24	37	45	12	11.3	29.6	20.5
13-06-16	165	24	37	12	24	16	8	12	5	24.3	10.2	17.3
14-06-16	166	24	12	8	8	16	37	102	45	12.9	50.1	31.5
15-06-16	167	45	12	16	32	32	24	12	5	26.4	18.3	22.3
16-06-16	168	12	9	5	16	16	20	12	8	10.6	13.9	12.2
17-06-16	169	8	12	16	24	32	24	24	8	15.0	22.0	18.5
18-06-16	170	12	16	16	16	24	12	12	8	15.0	13.9	14.5
19-06-16	171	12	16	12	5	8	16	5	2	11.3	7.9	9.6
20-06-16	172	8	12	12	5	5	5	8	8	9.2	6.5	7.8
21-06-16	173	2	5	5	8	8	5	5	2	5.1	5.1	5.1
22-06-16	174	8	9	8	8	16	45	45	24	8.2	32.7	20.4
23-06-16	175	8	32	8	5	5	37	24	45	13.2	27.9	20.6
24-06-16	176	37	37	32	16	32	24	16	24	30.7	24.1	27.4
25-06-16	177	16	12	8	5	8	8	16	24	10.2	13.9	12.1
26-06-16	178	8	5	8	20	16	45	20	37	10.2	29.6	19.9
27-06-16	179	32	24	32	8	12	5	12	12	24.0	10.2	17.1
28-06-16	180	16	12	12	12	16	16	12	2	13.0	11.7	12.3
29-06-16	181	12	5	8	8	5	12	12	5	8.2	8.5	8.3
30-06-16	182	5	5	5	5	5	20	24	24	5.1	18.2	11.7
Monthly Mean Value											16.2	

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_{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.

3-hourly *aa*-indices

