



British  
Geological  
Survey



**MONTHLY MAGNETIC BULLETIN**

# Eskdalemuir Observatory

**December 2021**



# Eskdalemuir Observatory magnetic data

## 1. Introduction

Eskdalemuir 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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Email: [enquiries@bgs.ac.uk](mailto:enquiries@bgs.ac.uk)  
Internet: [geomag.bgs.ac.uk](http://geomag.bgs.ac.uk)

## 2. Position

The observatory is situated on a rising shoulder of open moorland in the upper part of the valley of the White Esk River in the Southern Uplands of Scotland. The observatory co-ordinates are:

*Geographic:* 55° 18'50.4"N 356° 47'38.4"E  
*Geomagnetic:* 57° 32'27.6"N 083° 11'38.4"E  
*Height above mean sea level:* 245 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 Eskdalemuir are:

0	1	2	3	4	5	6	7	8	9
0	8	15	30	60	105	180	300	500	750

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 (*Aaam*) and 12-24UT (*Aapm*) 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

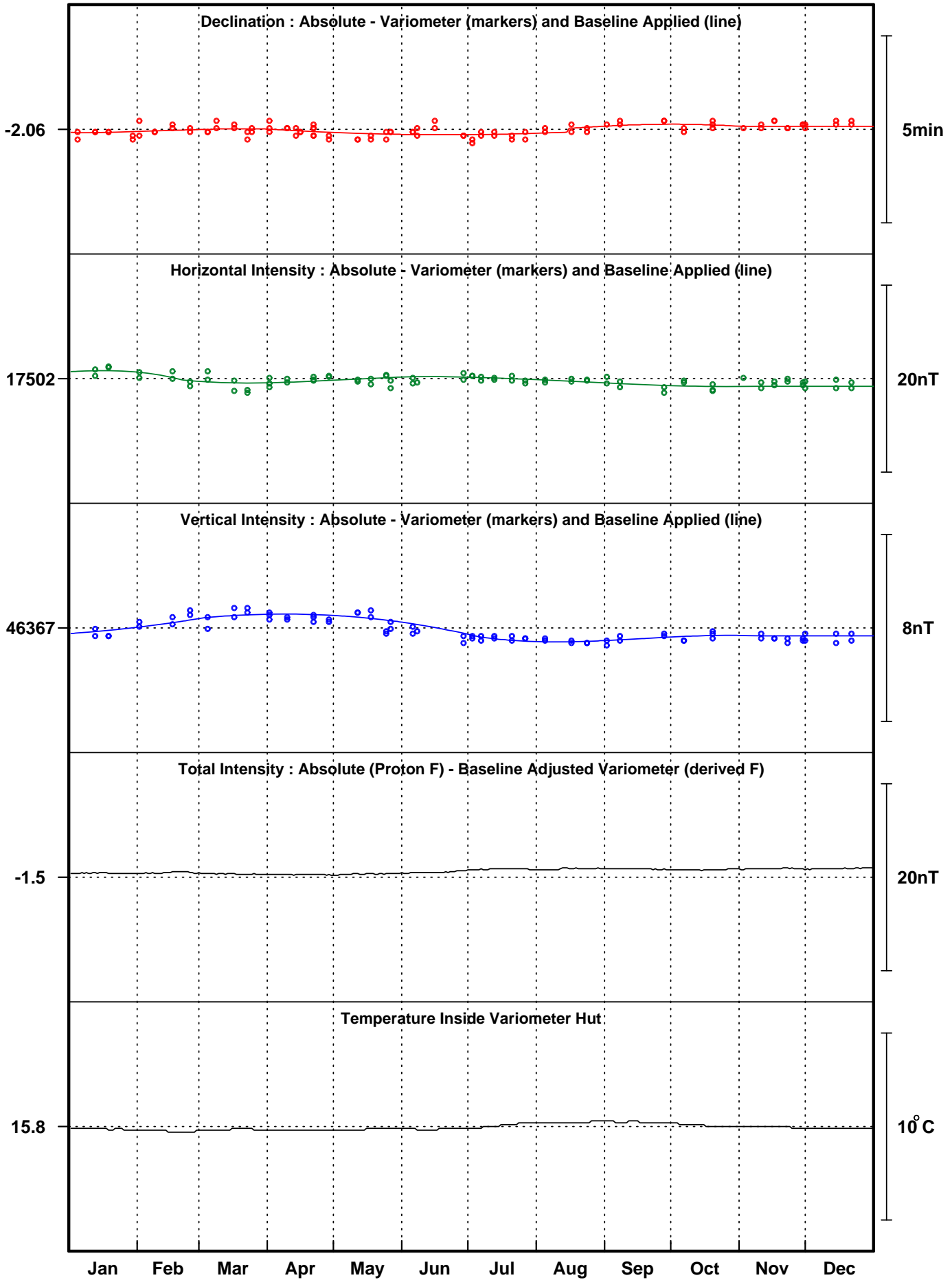
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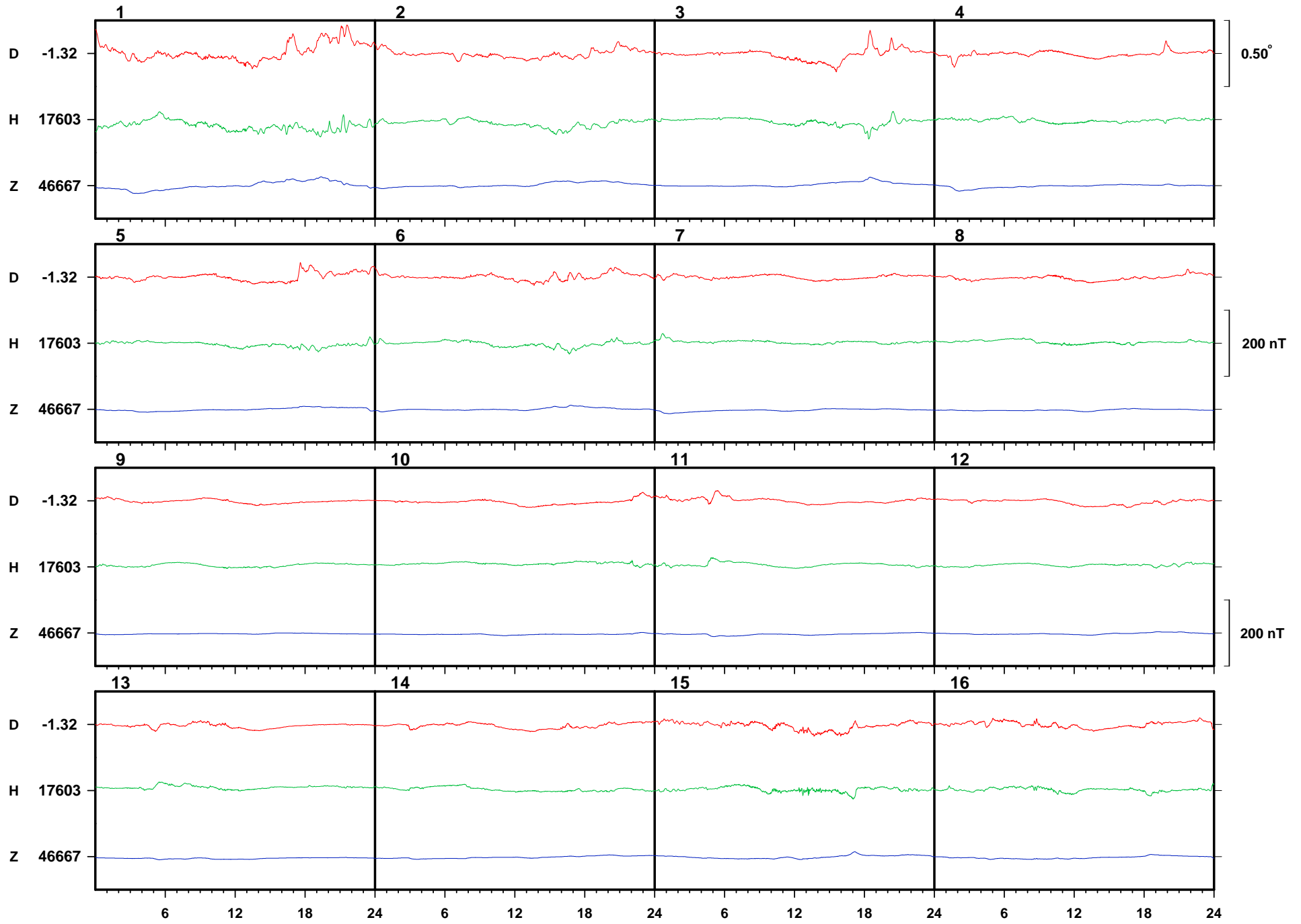
# Eskdalemuir 2021



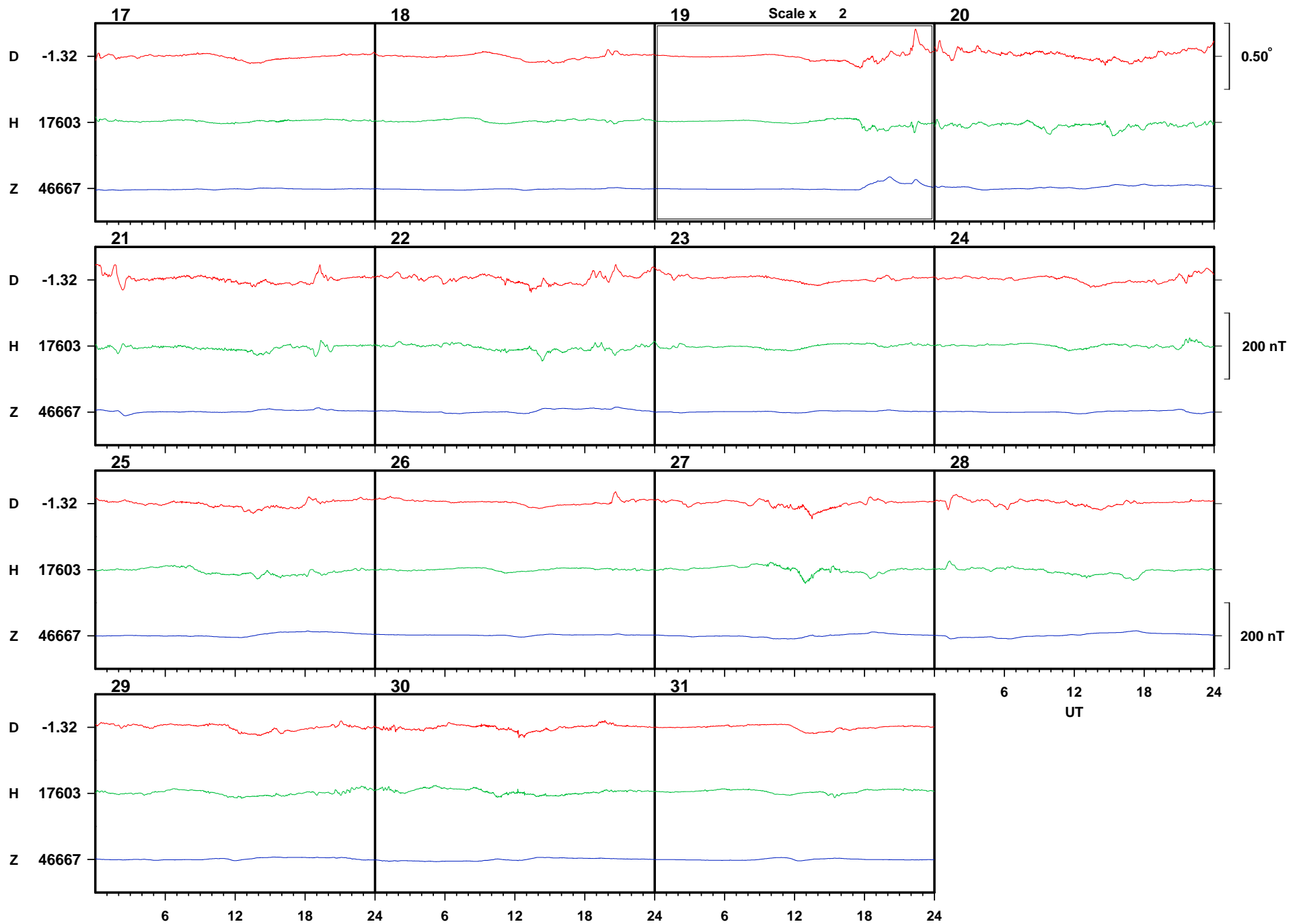
# Eskdalemuir

# December

# 2021





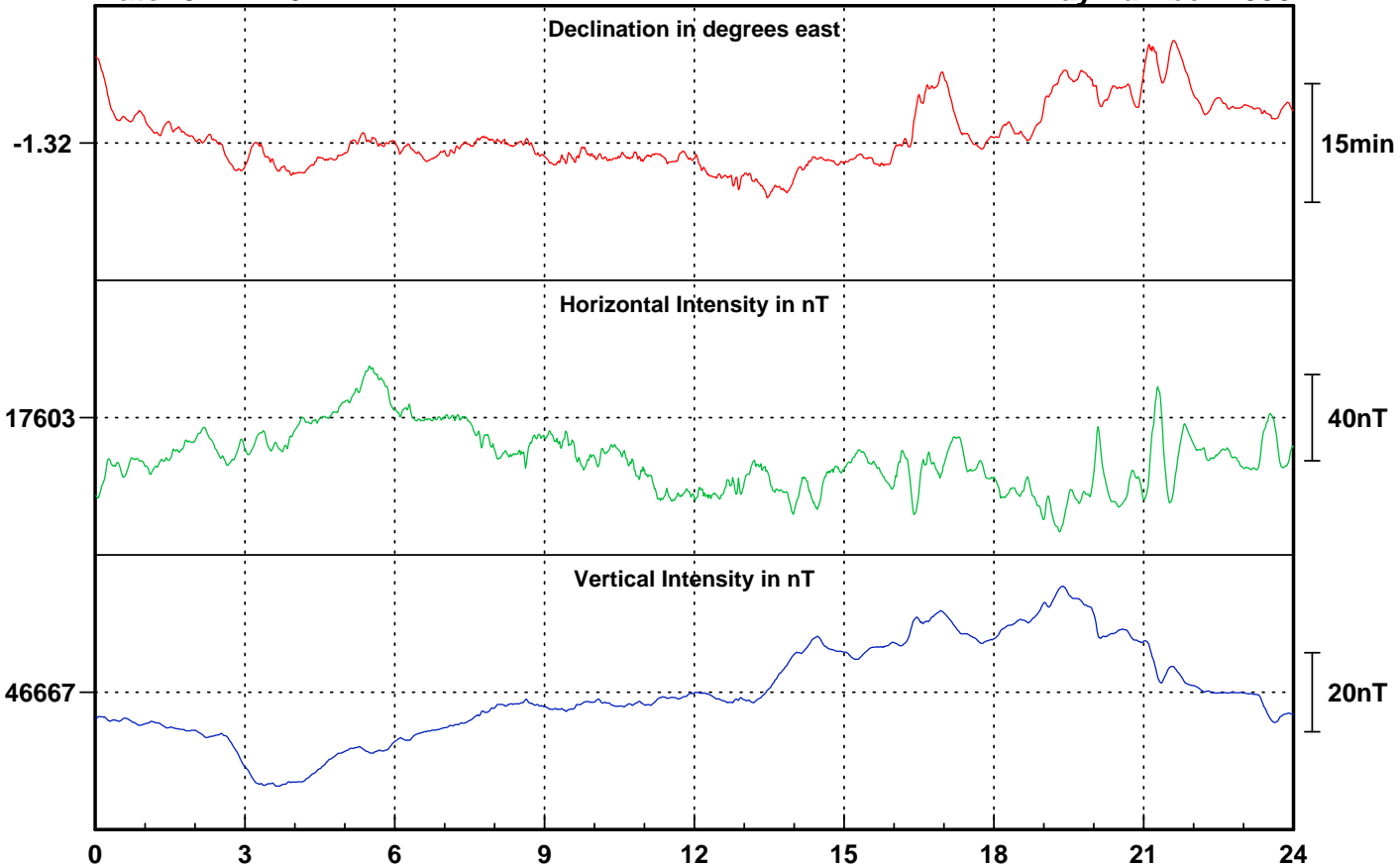


Eskdalemuir December 2021

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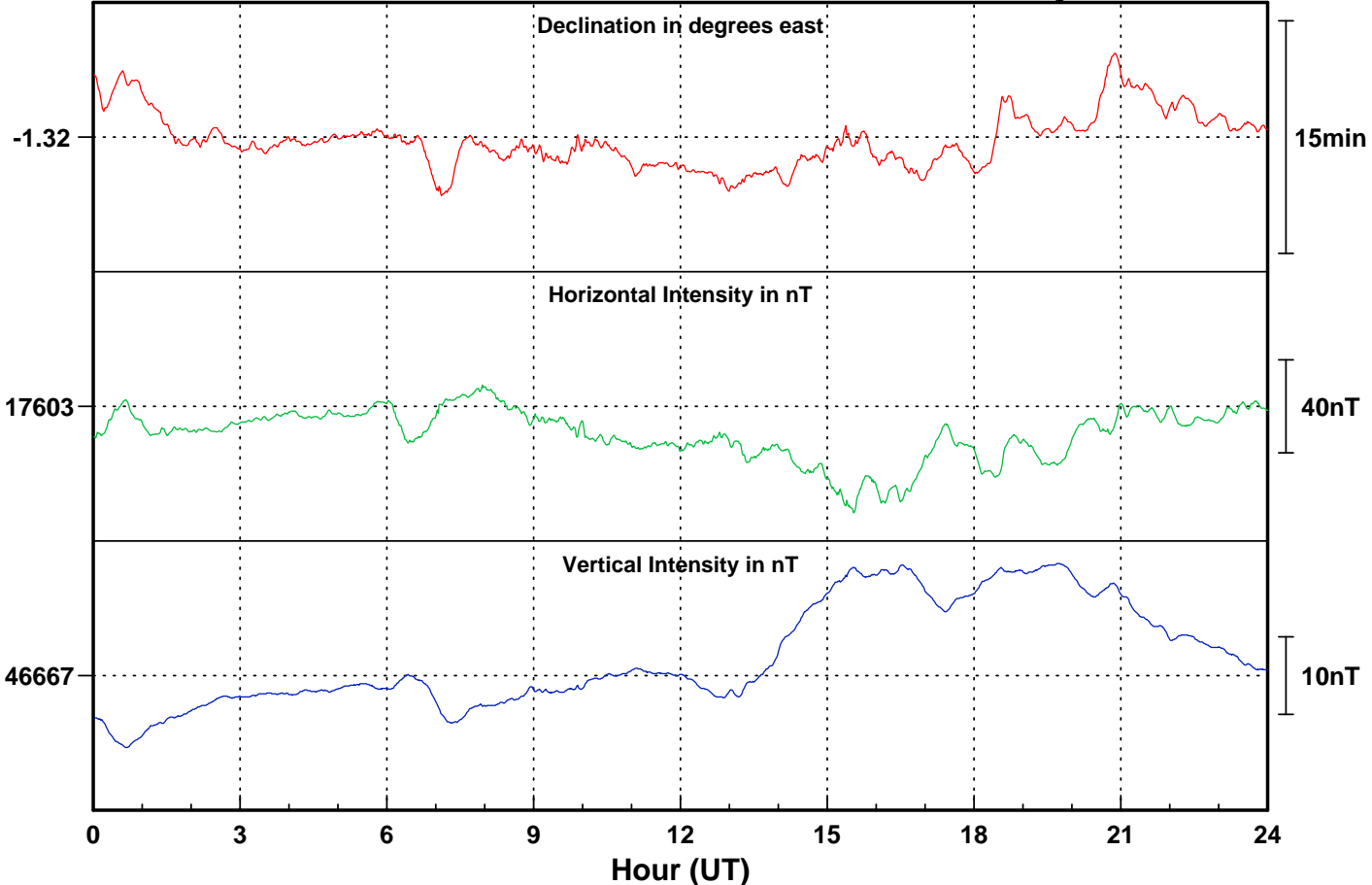
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Day number: 335



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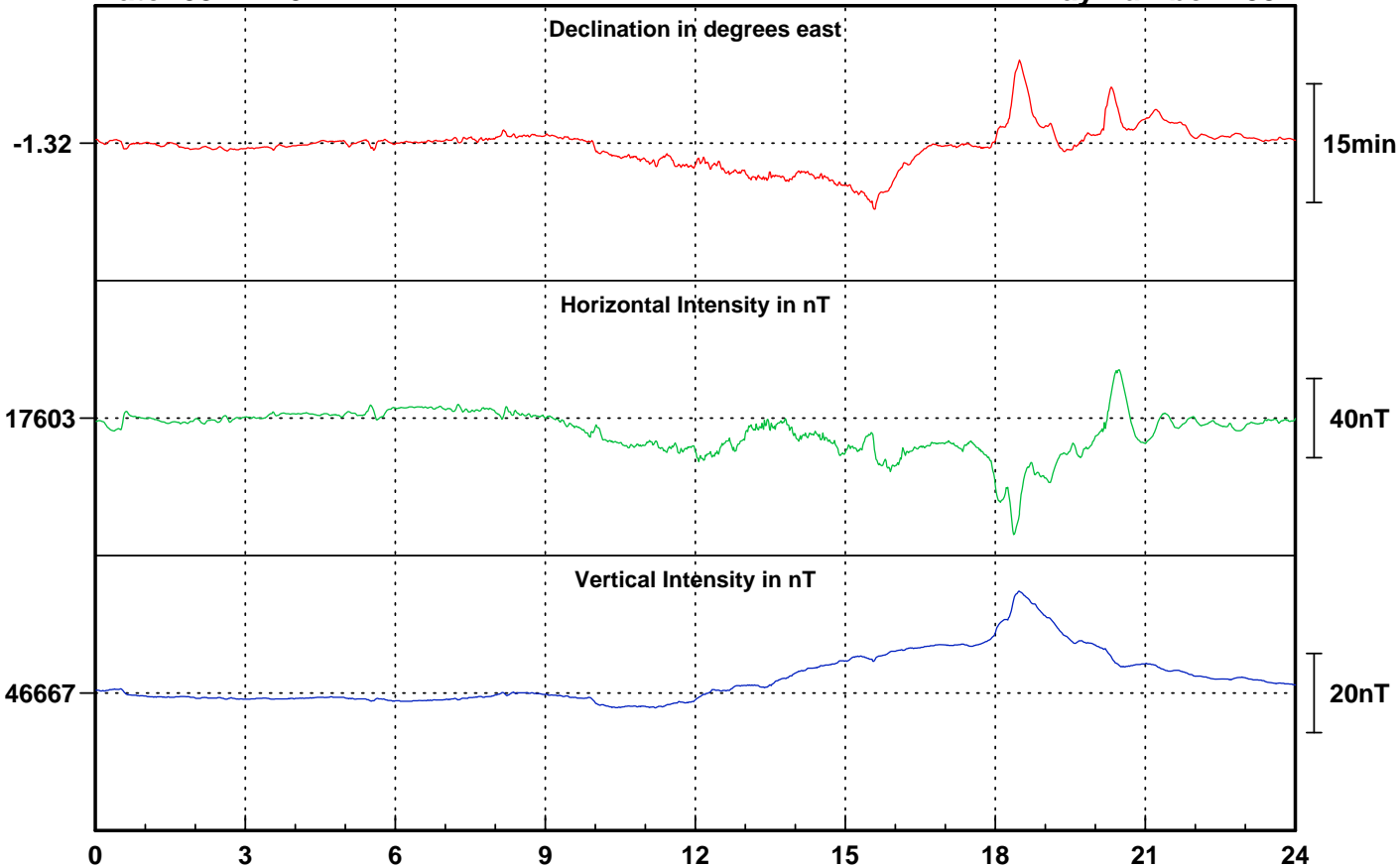
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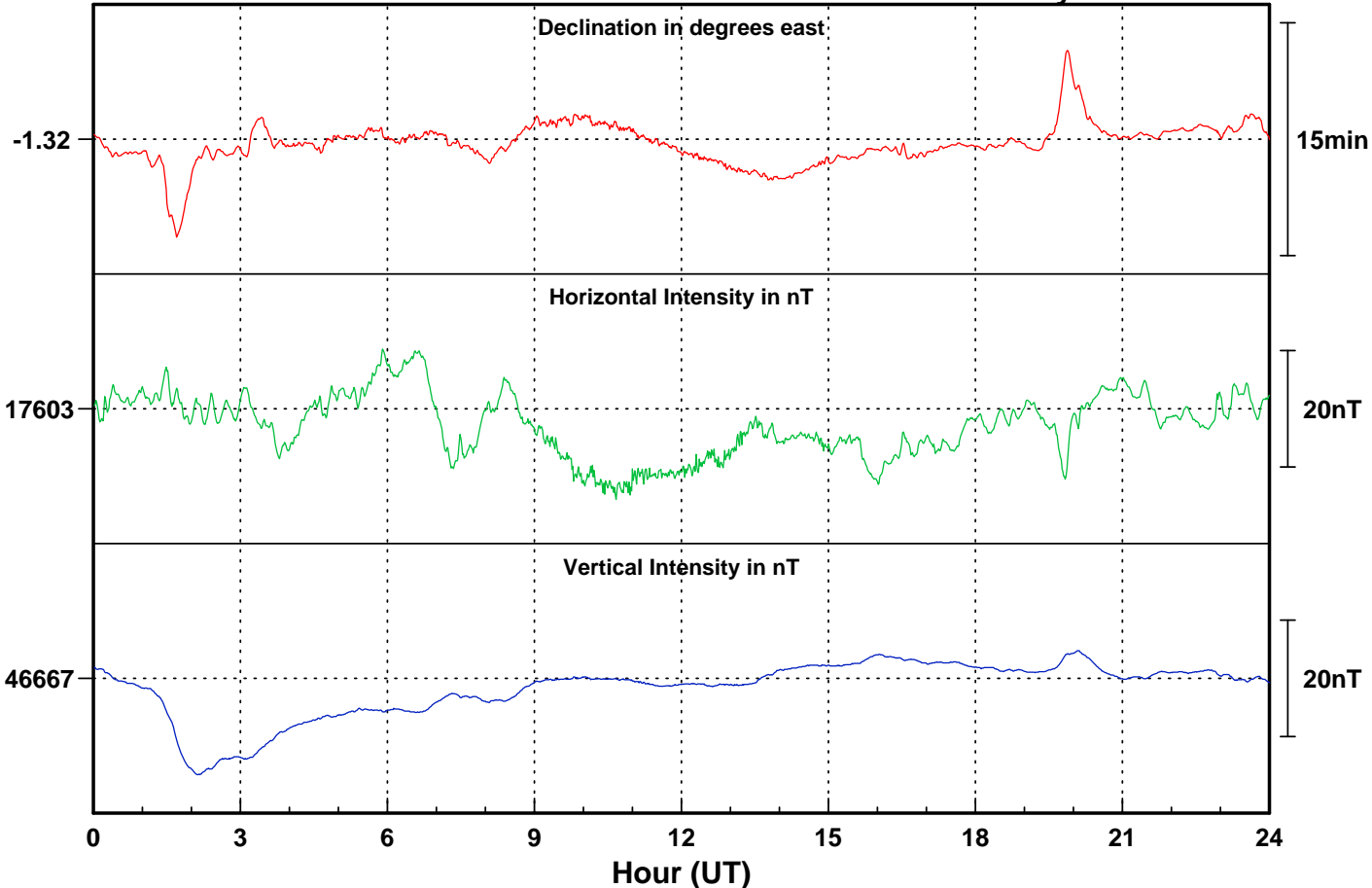
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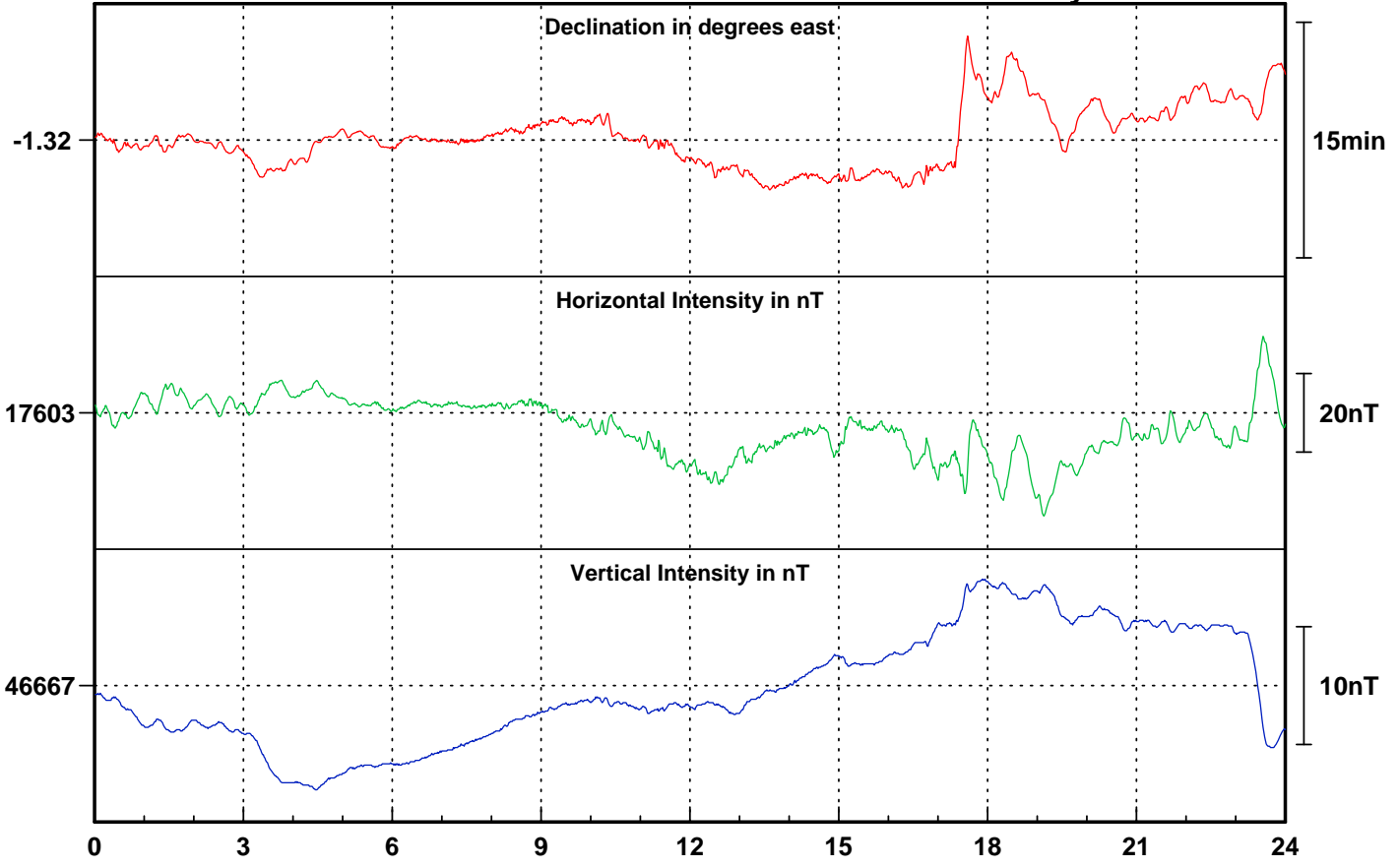
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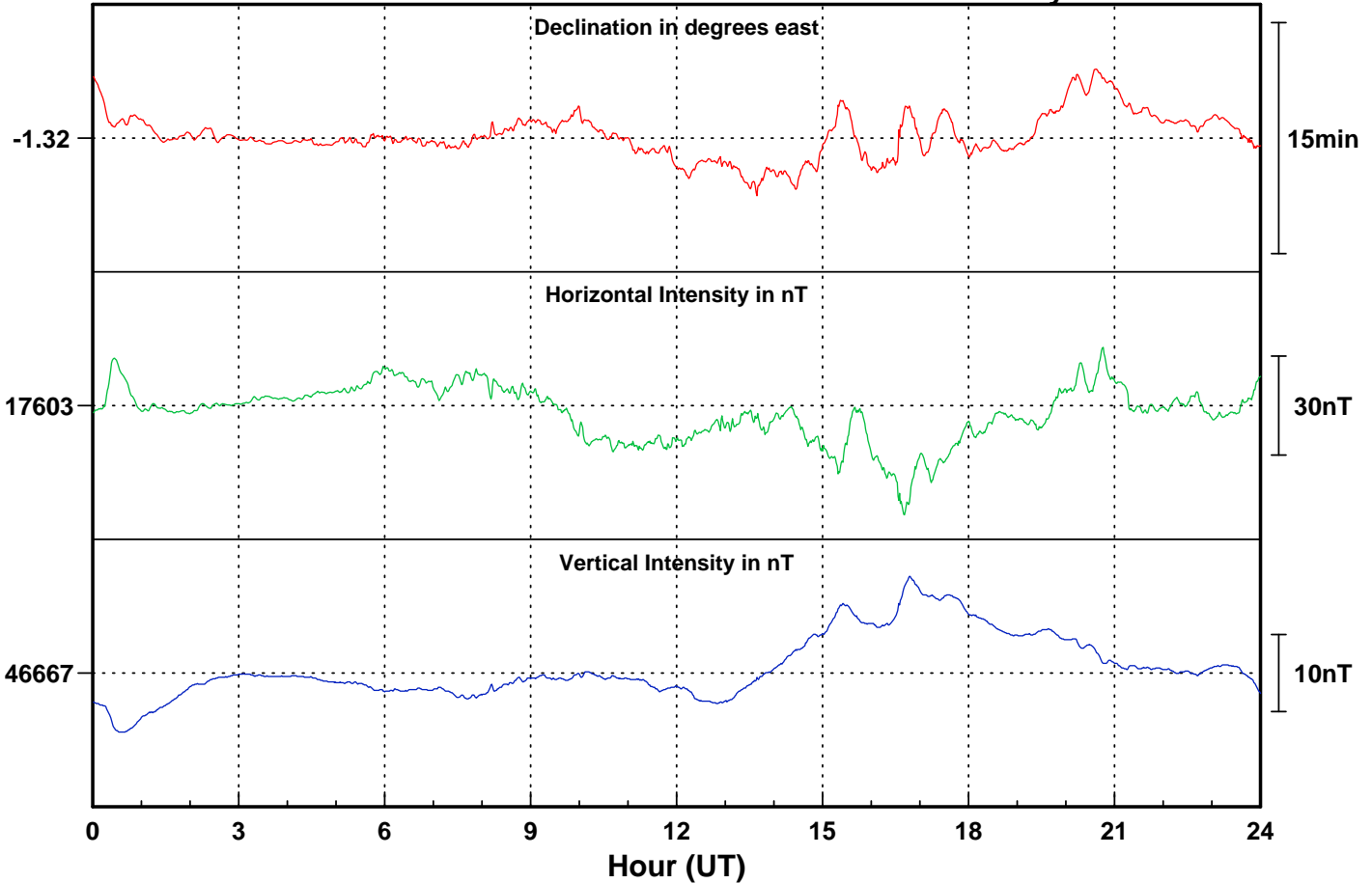
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Day number: 339



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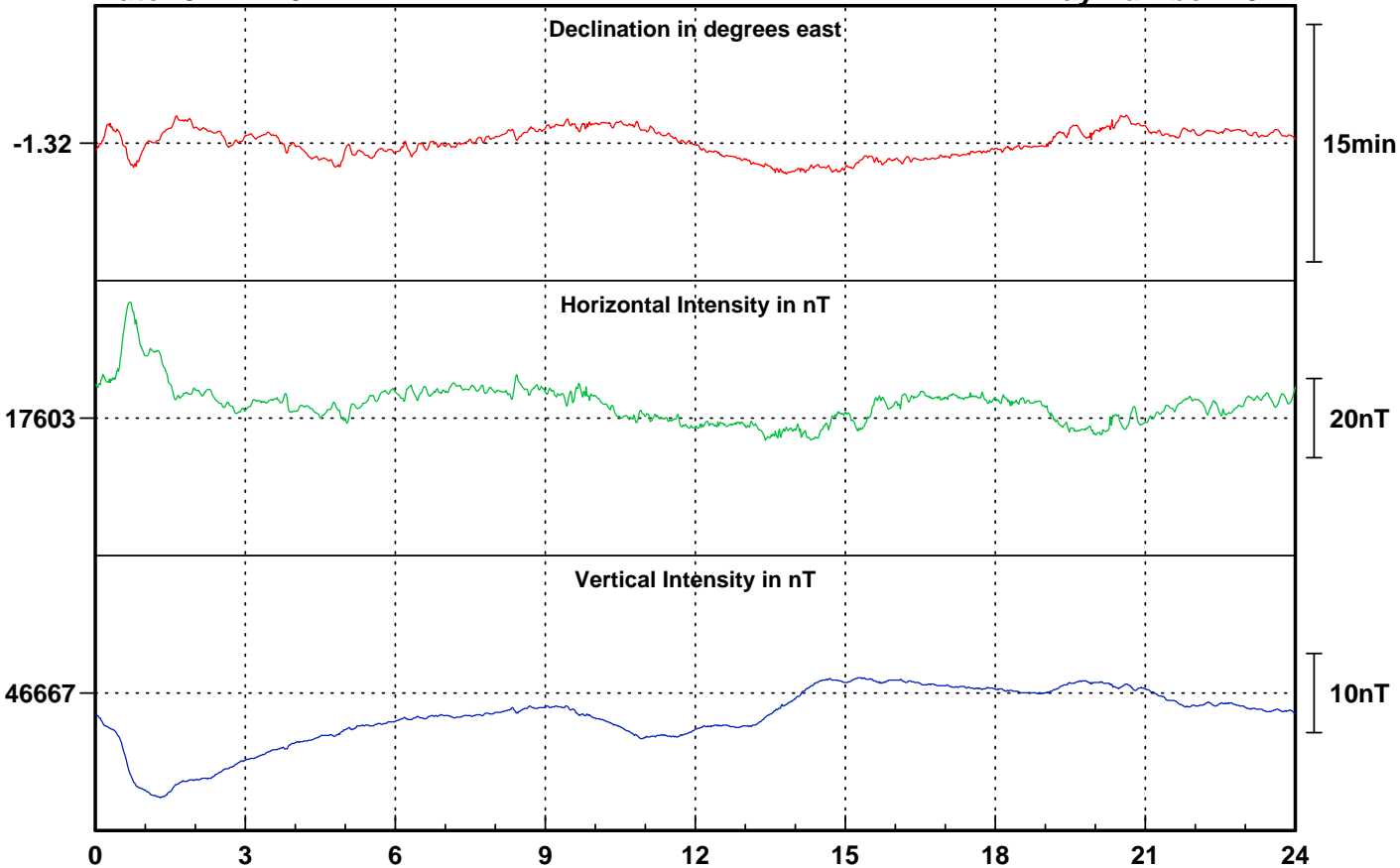
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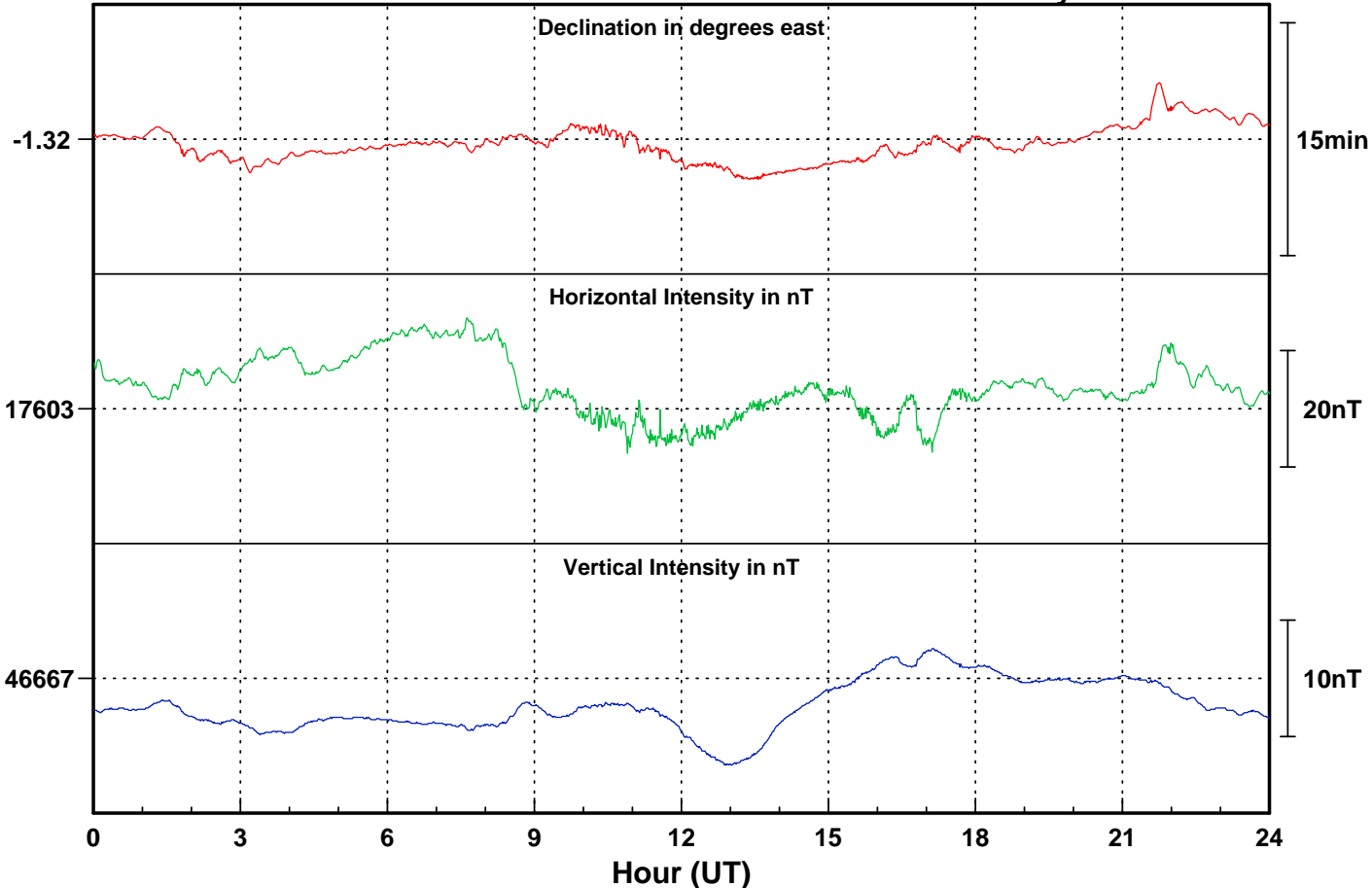
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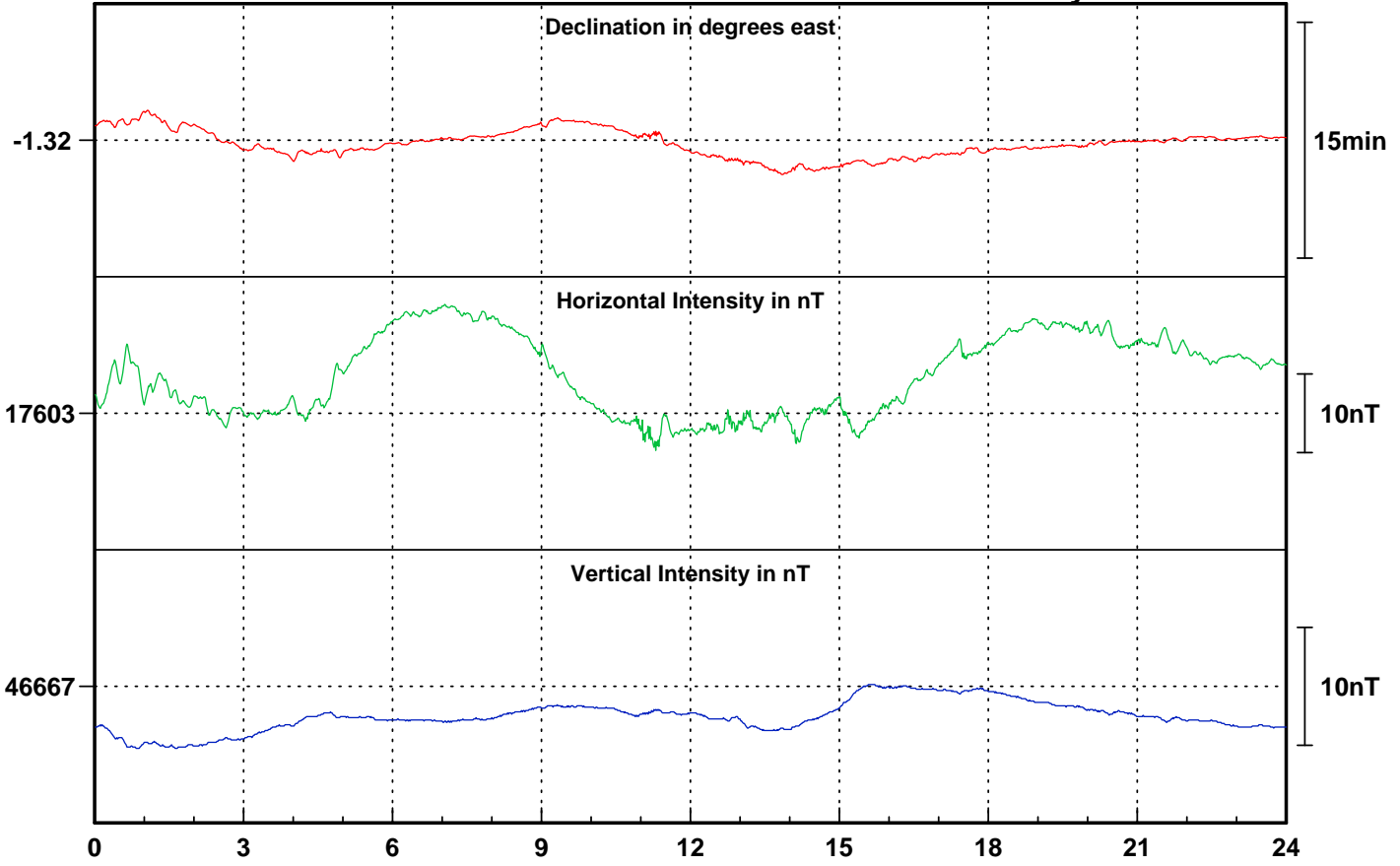
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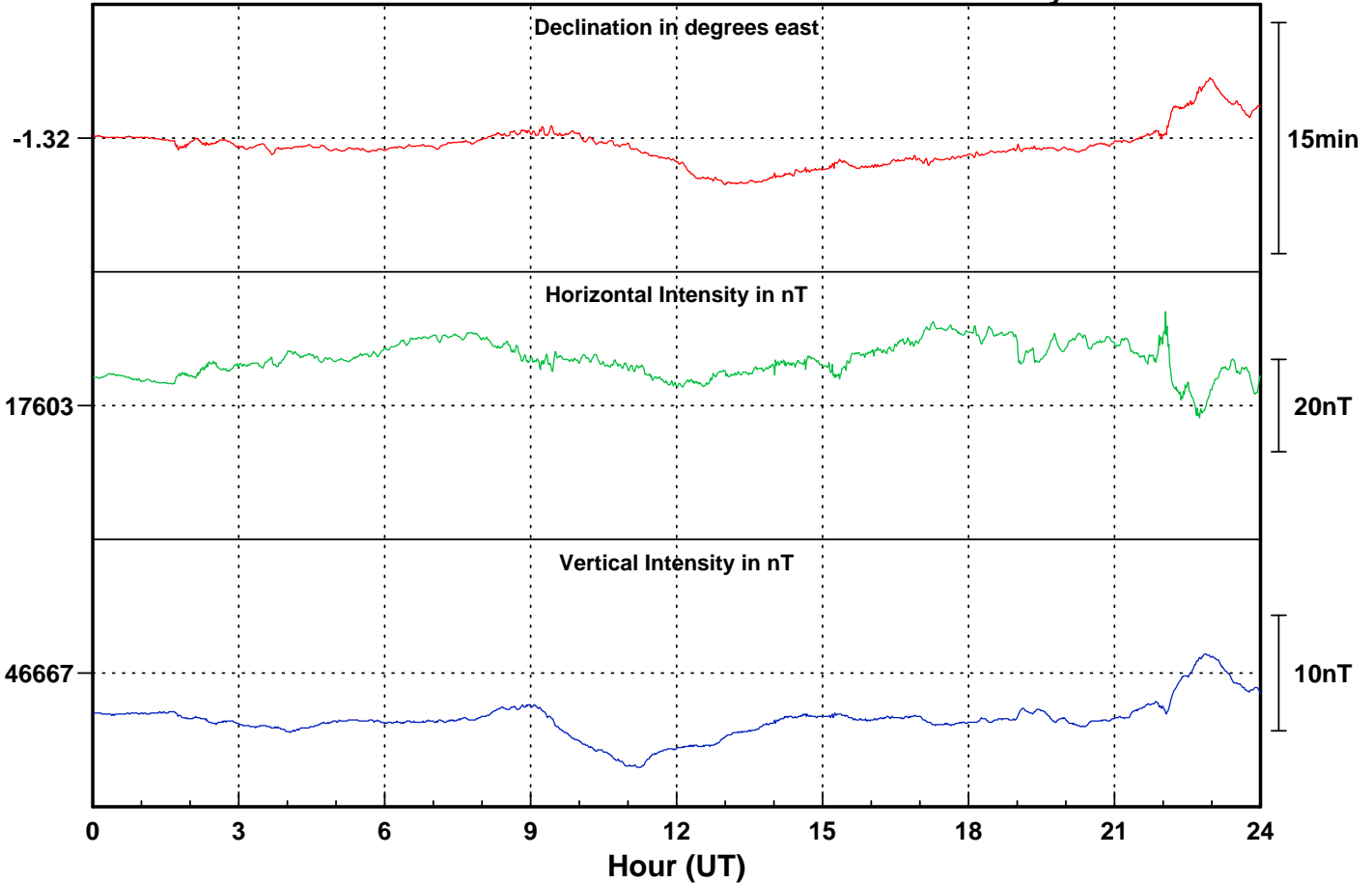
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Day number: 343



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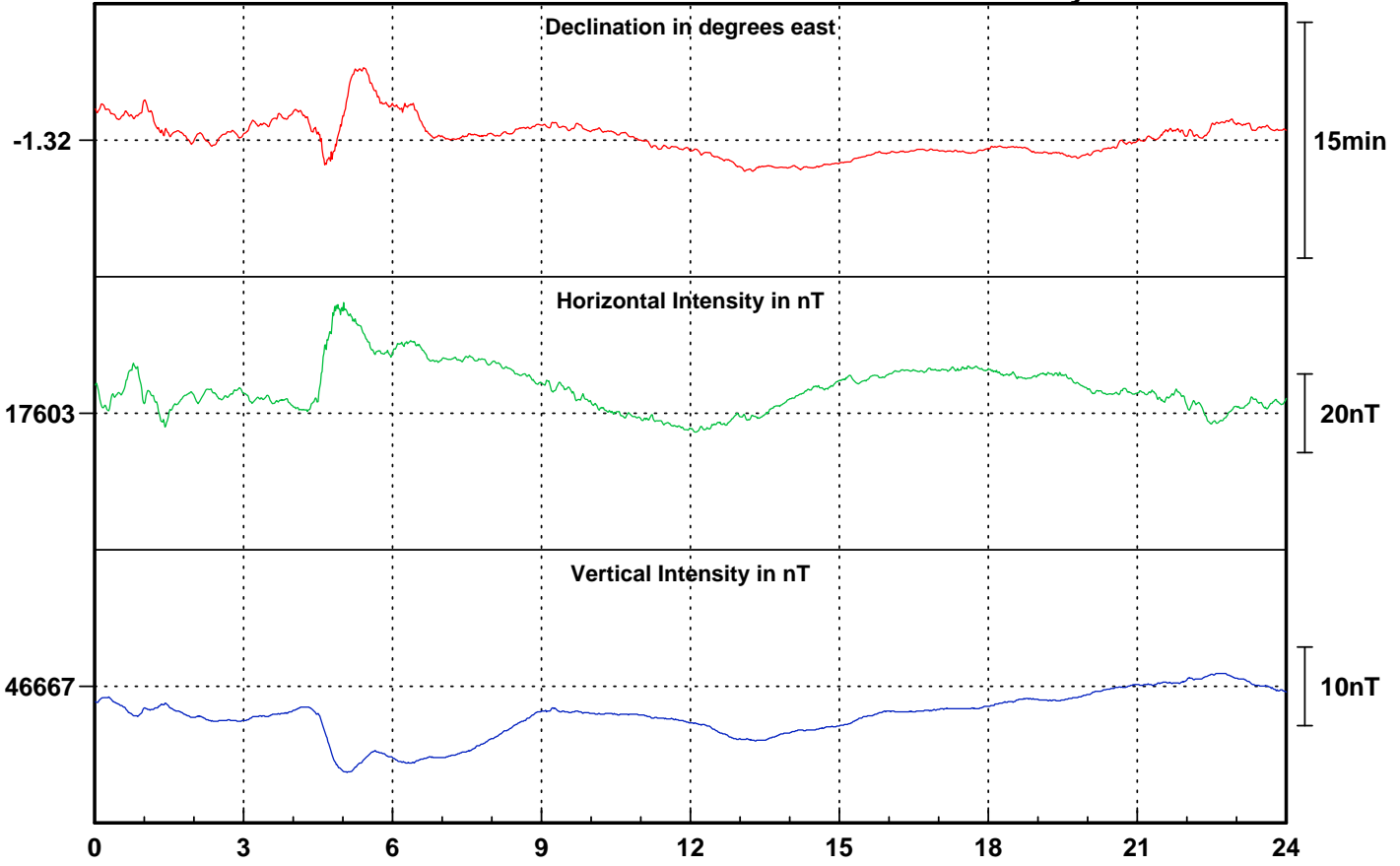
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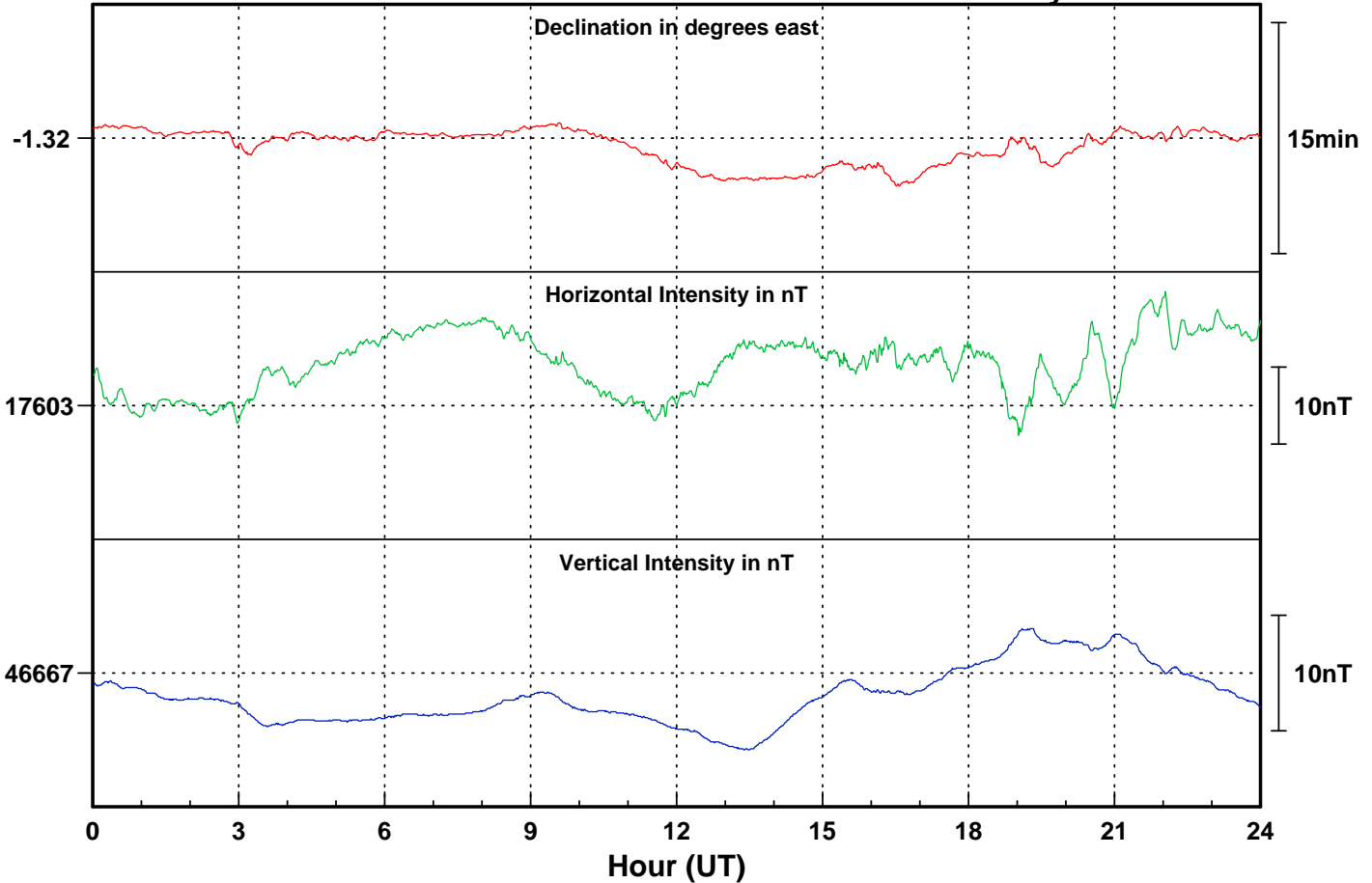
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Day number: 345



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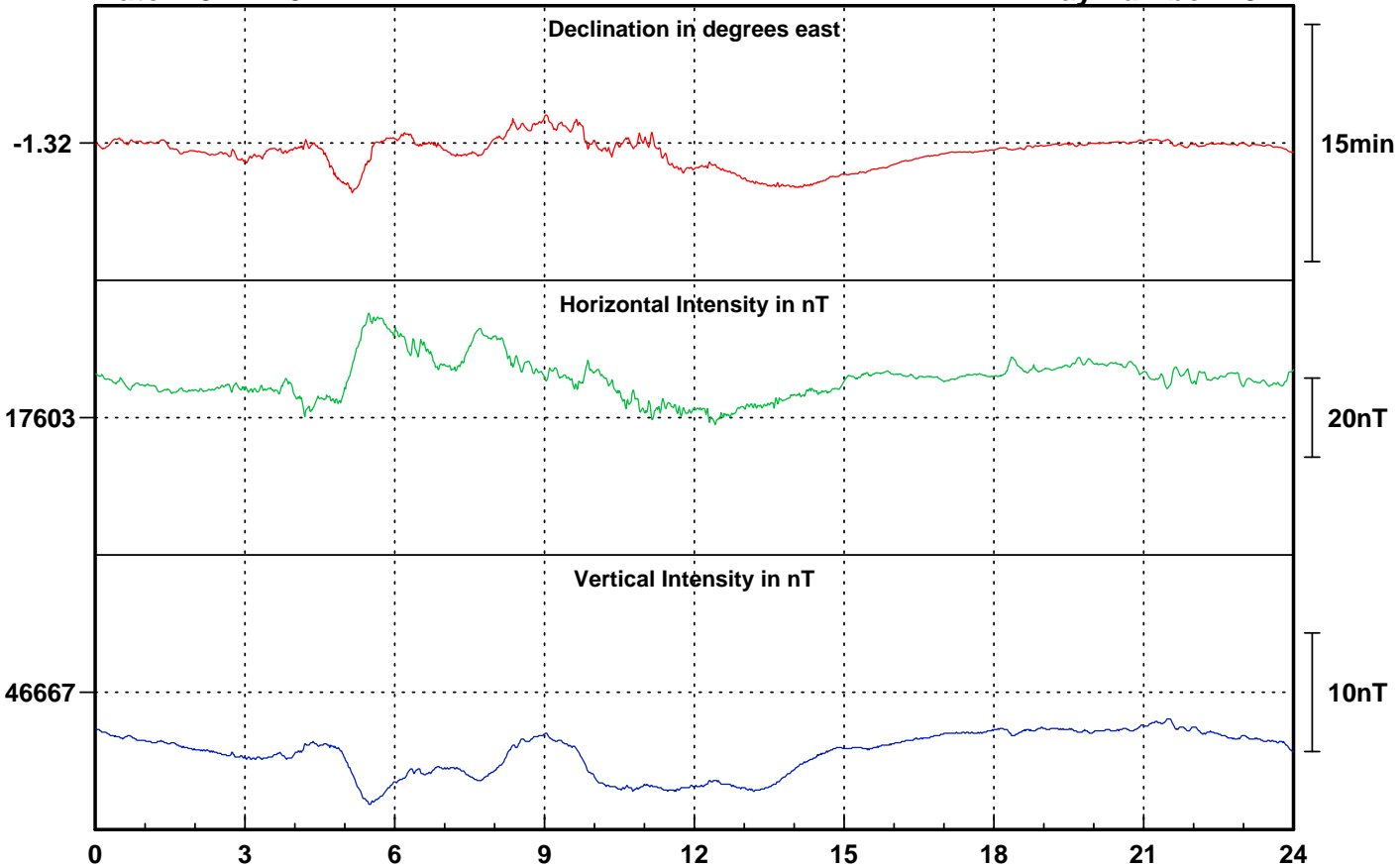
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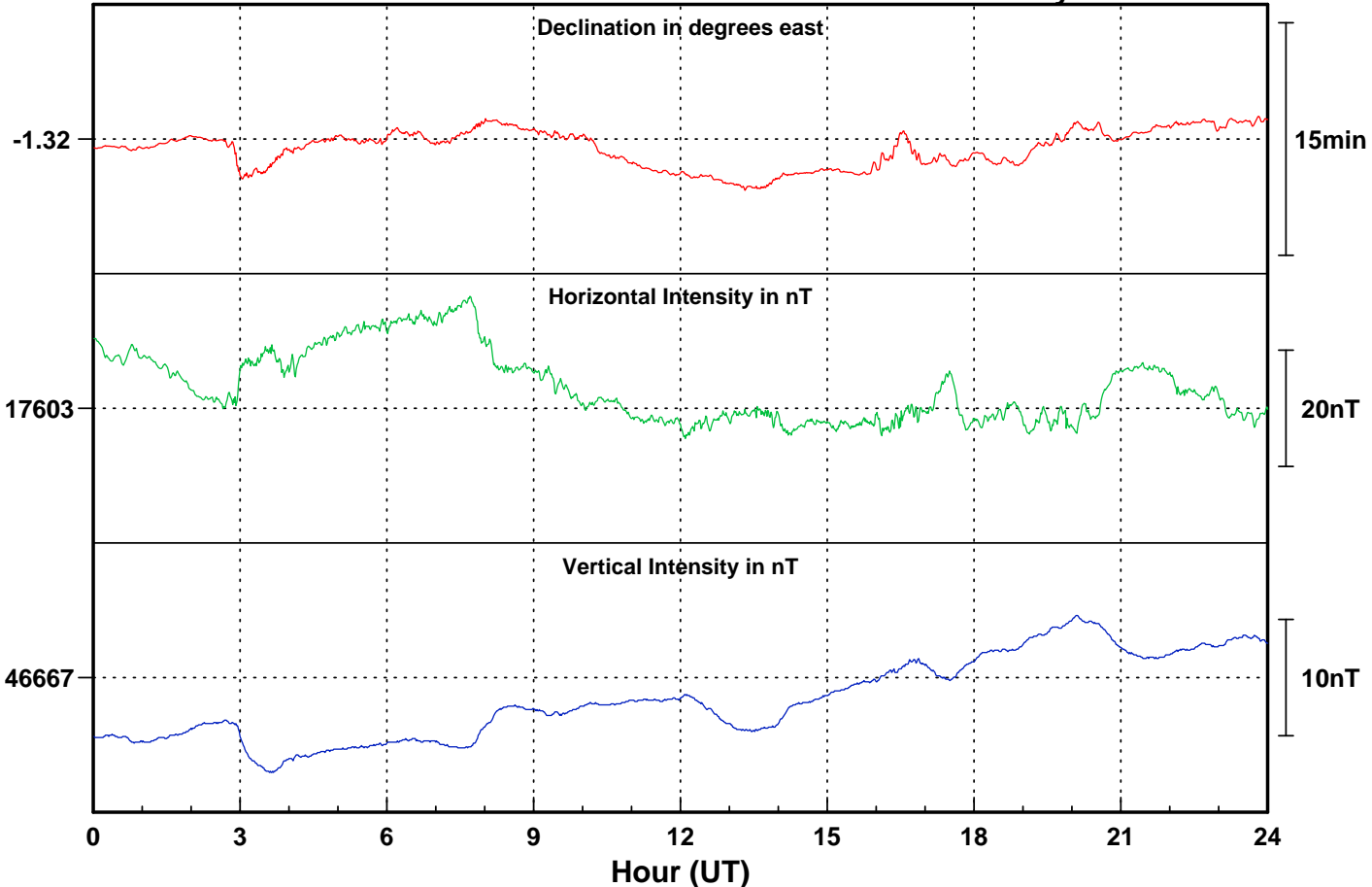
# Eskdalemuir

Day number: 347



Date: 14-12-2021

Day number: 348

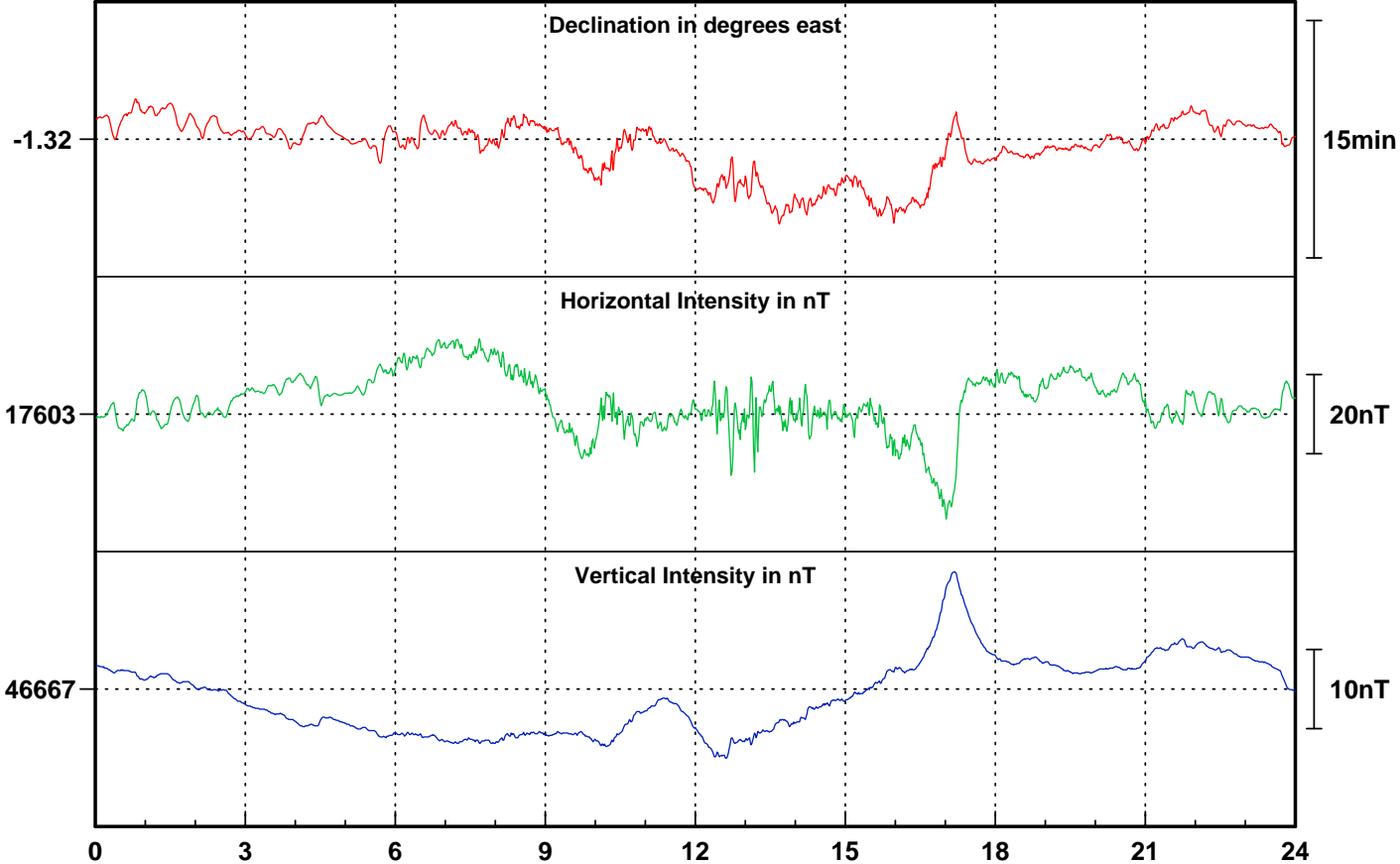




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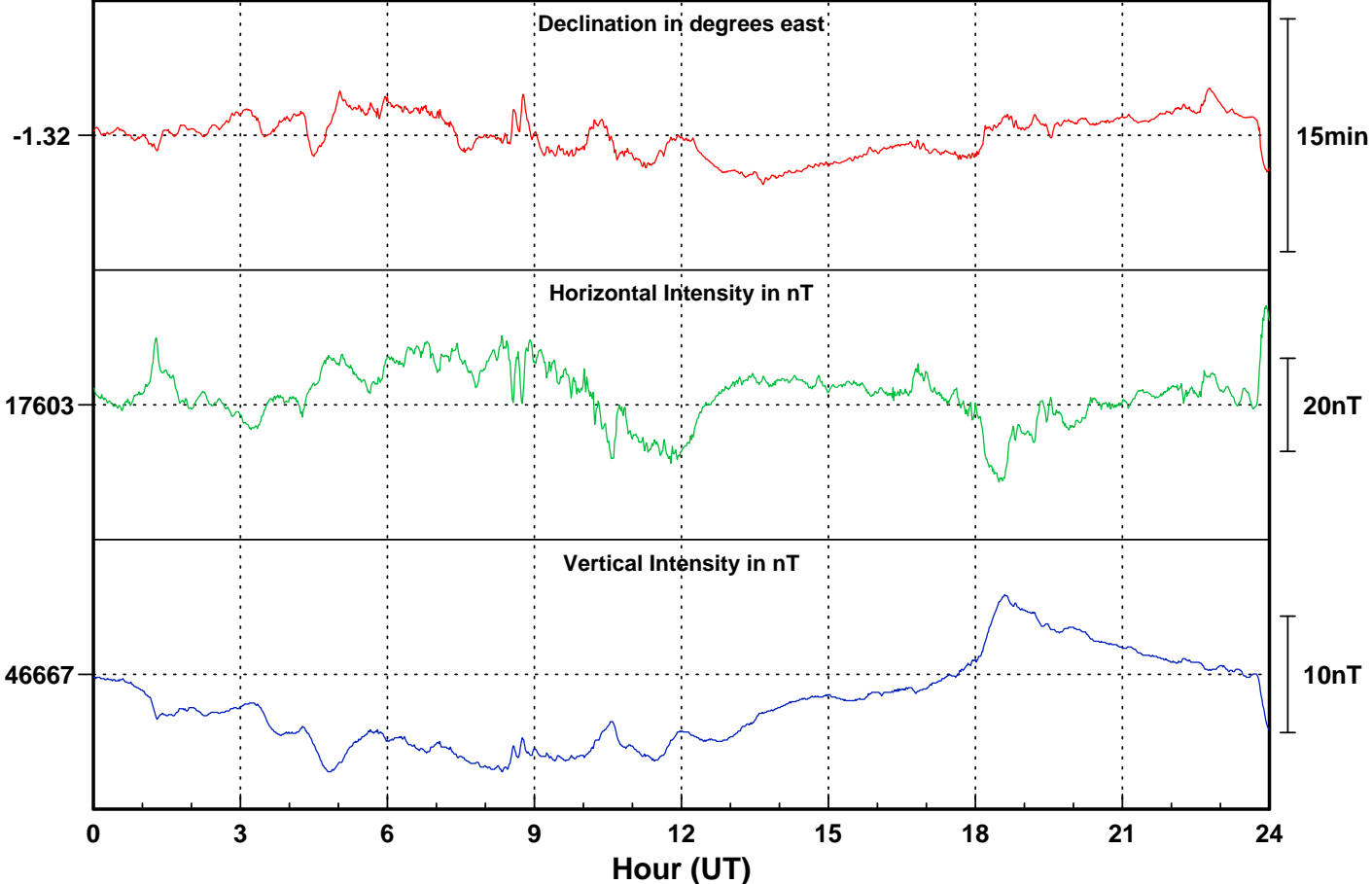
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Day number: 349



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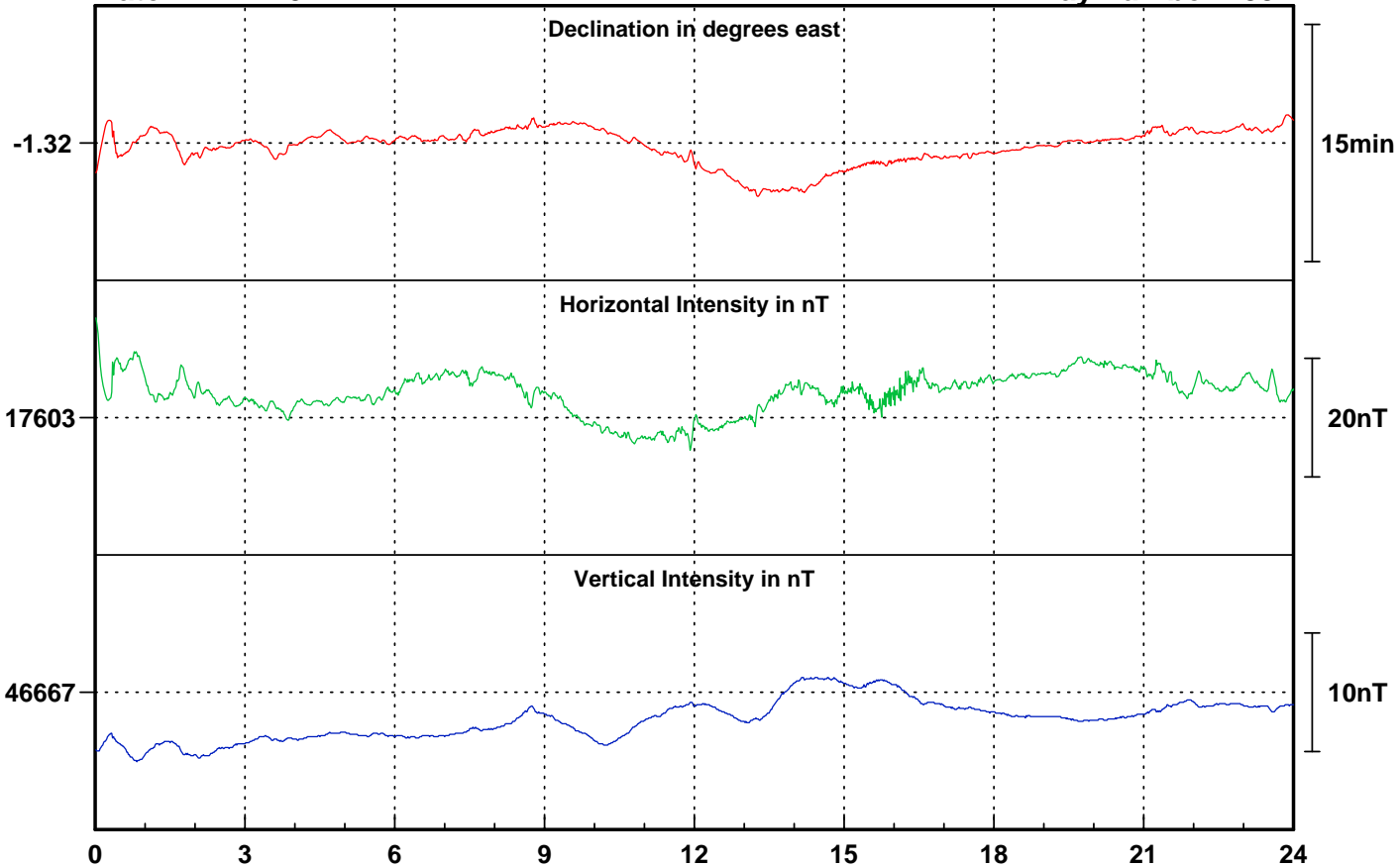
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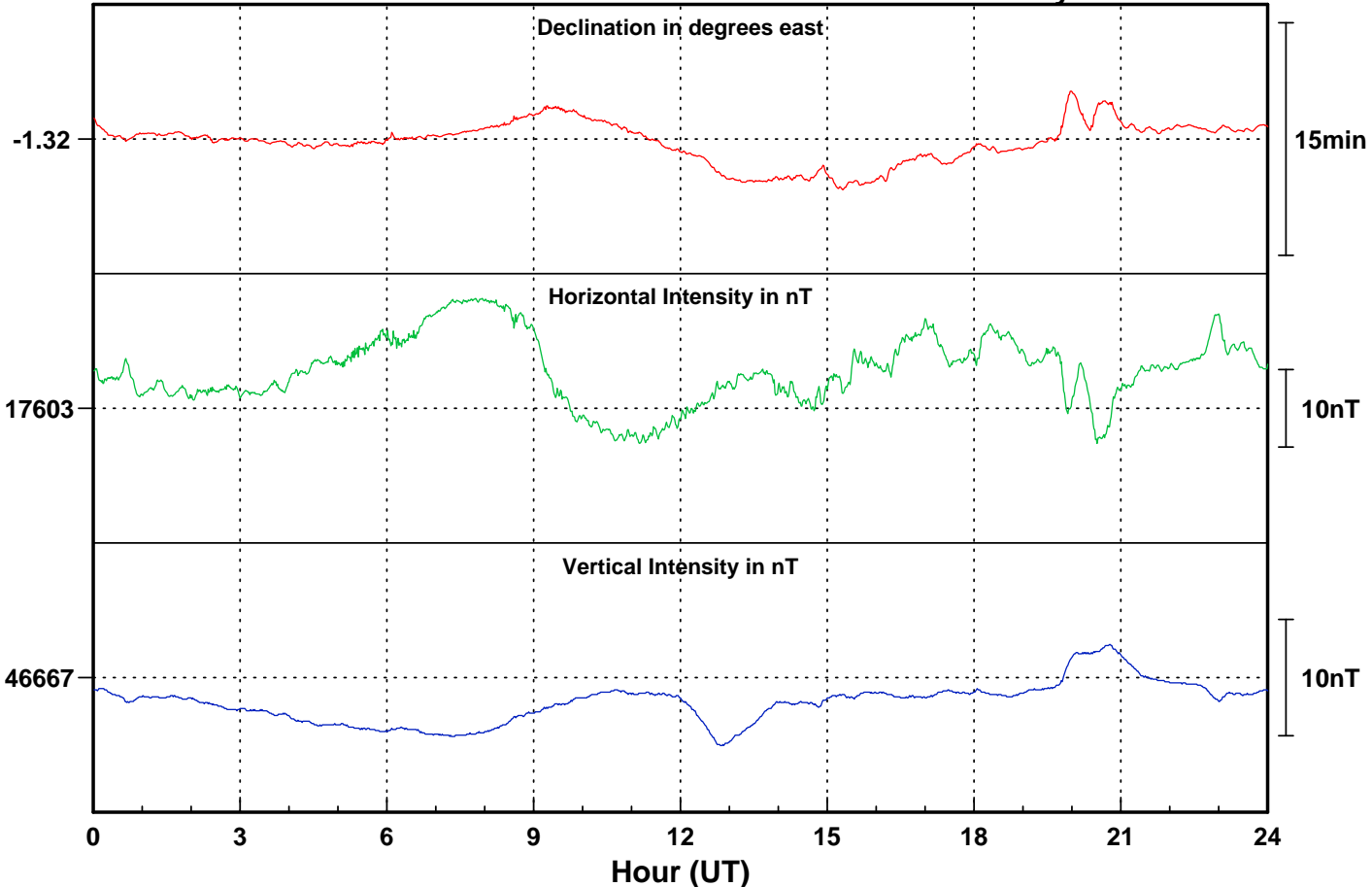
# Eskdalemuir

Day number: 351



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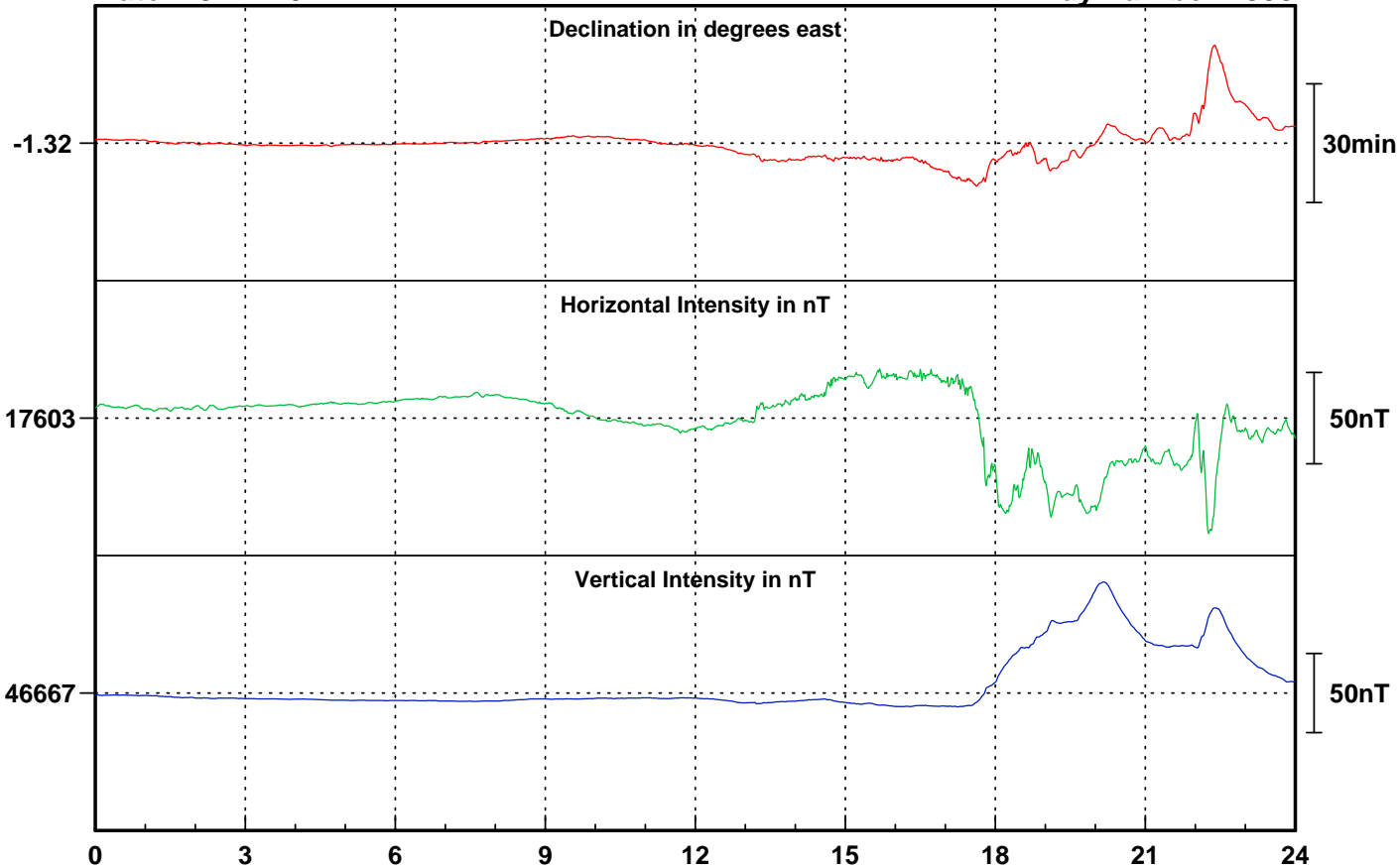
Day number: 352



Date: 19-12-2021

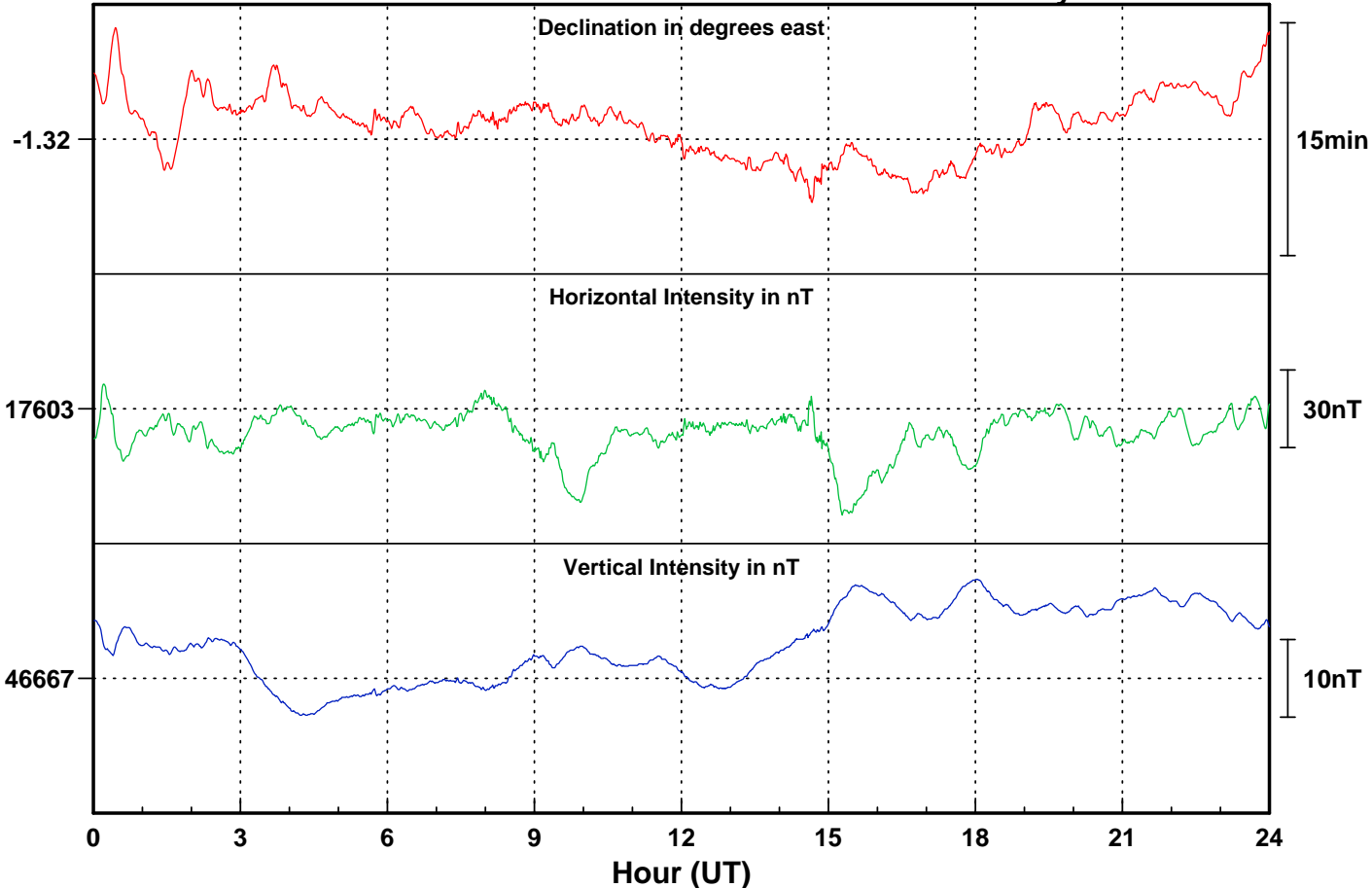
# Eskdalemuir

Day number: 353



Date: 20-12-2021

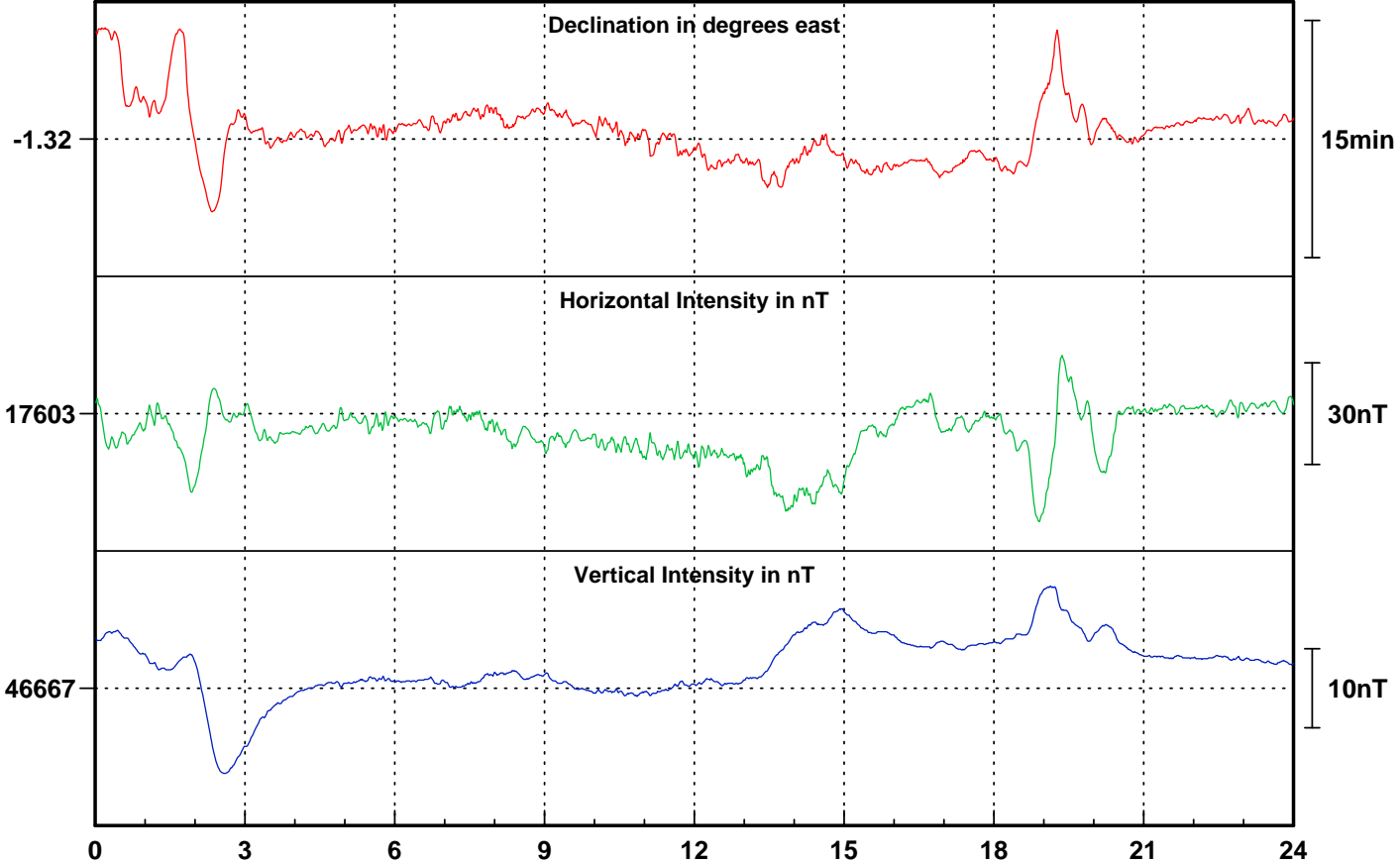
Day number: 354



# Eskdalemuir

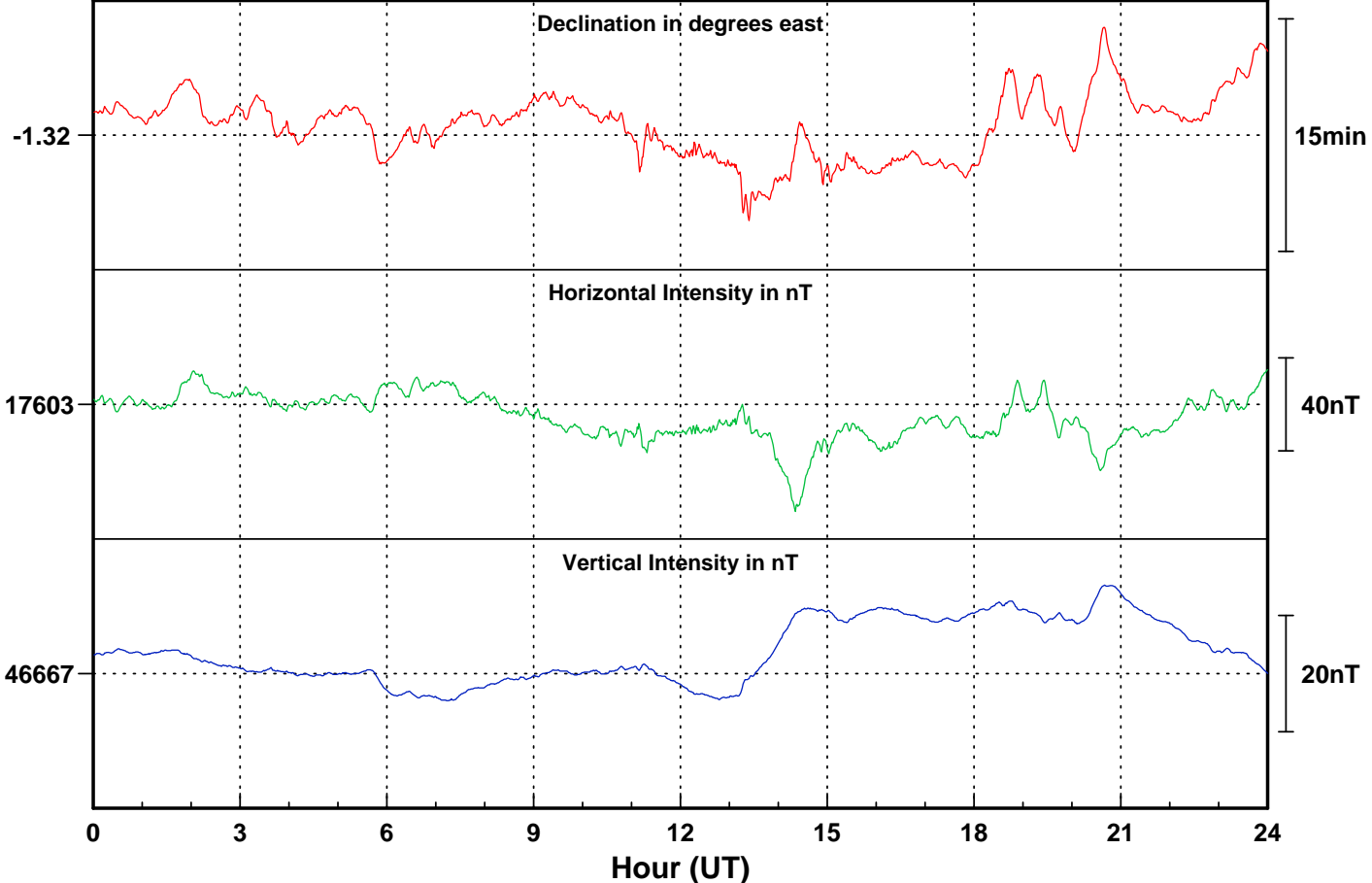
Date: 21-12-2021

Day number: 355



Date: 22-12-2021

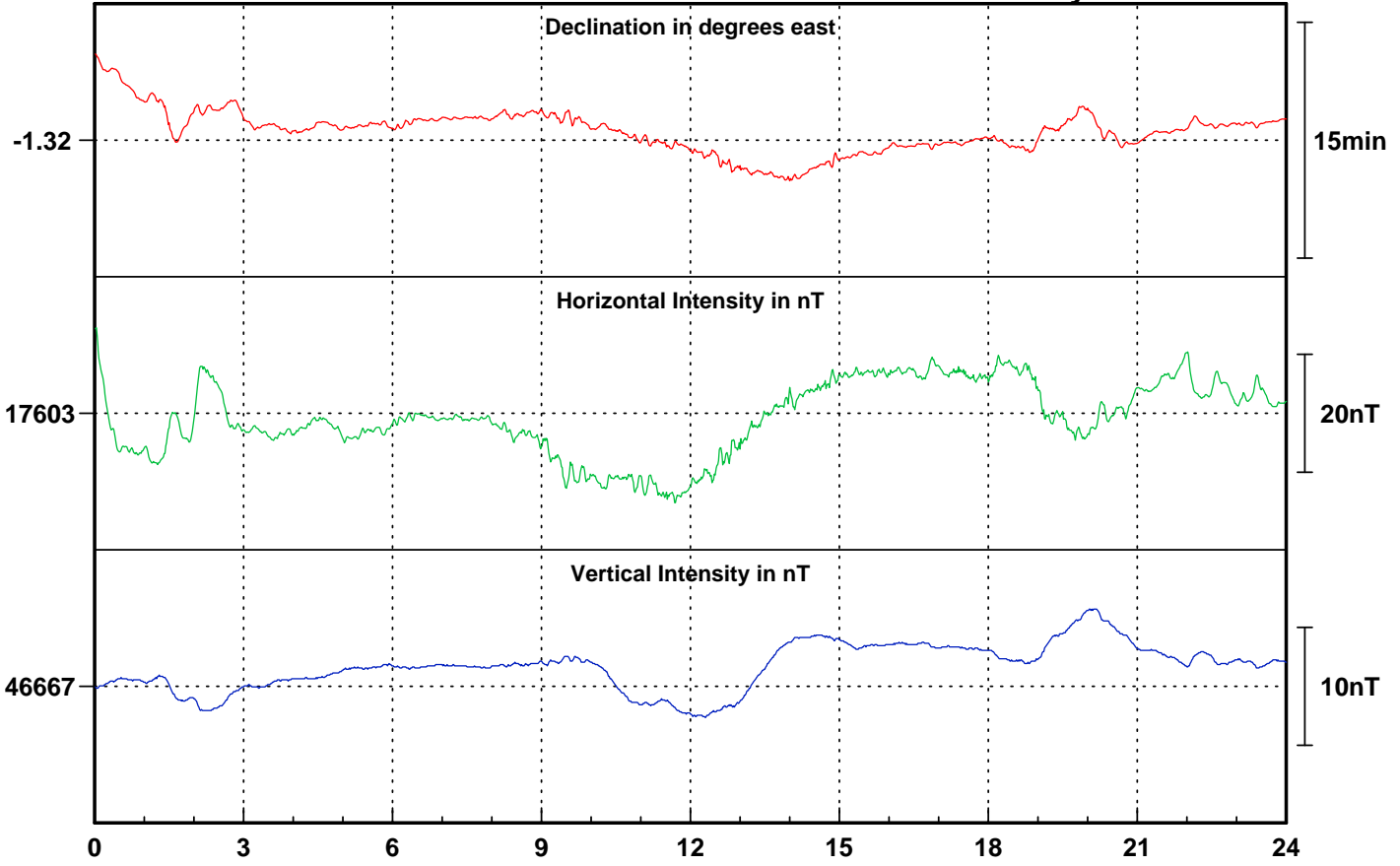
Day number: 356



Date: 23-12-2021

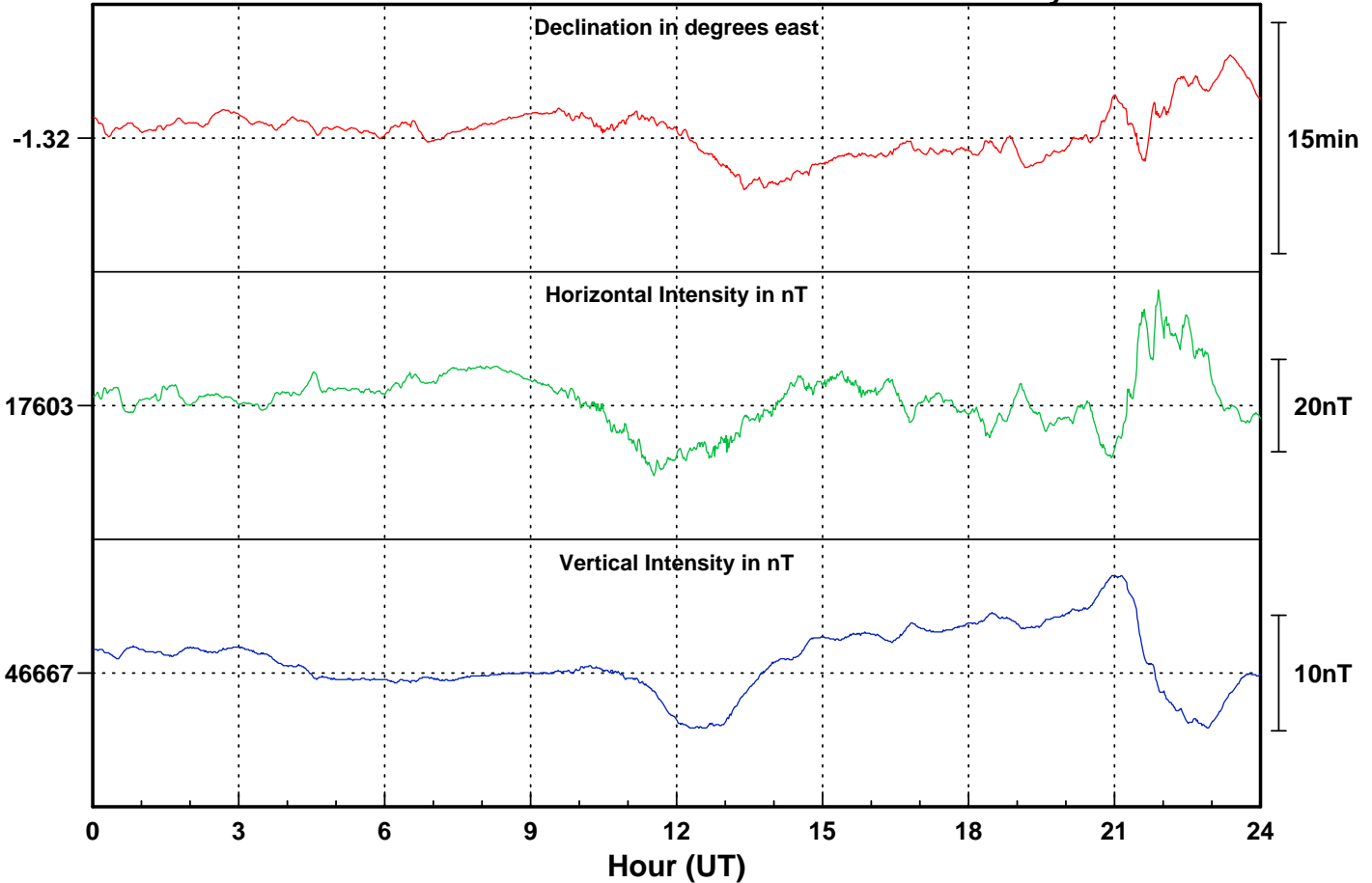
# Eskdalemuir

Day number: 357



Date: 24-12-2021

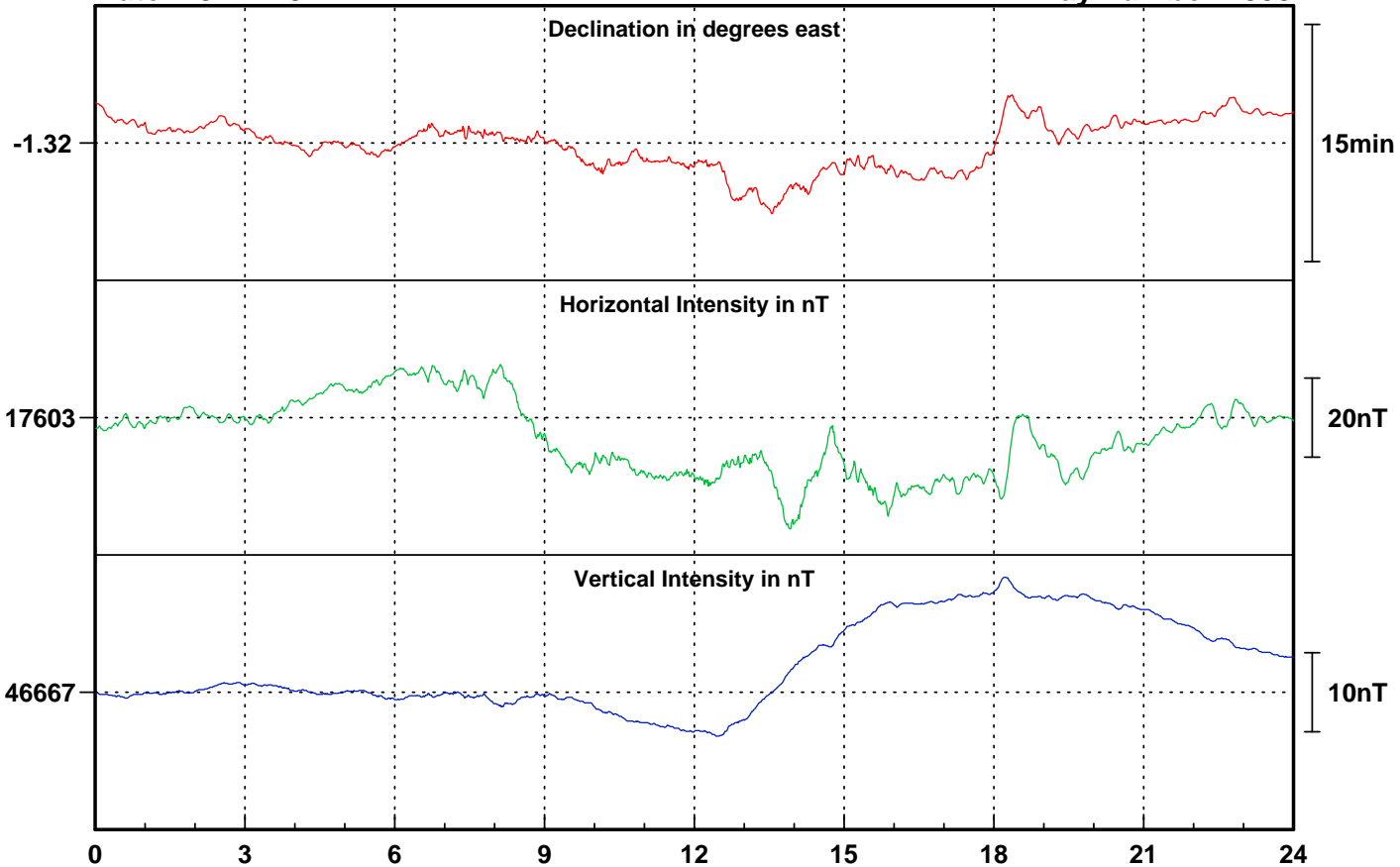
Day number: 358



Date: 25-12-2021

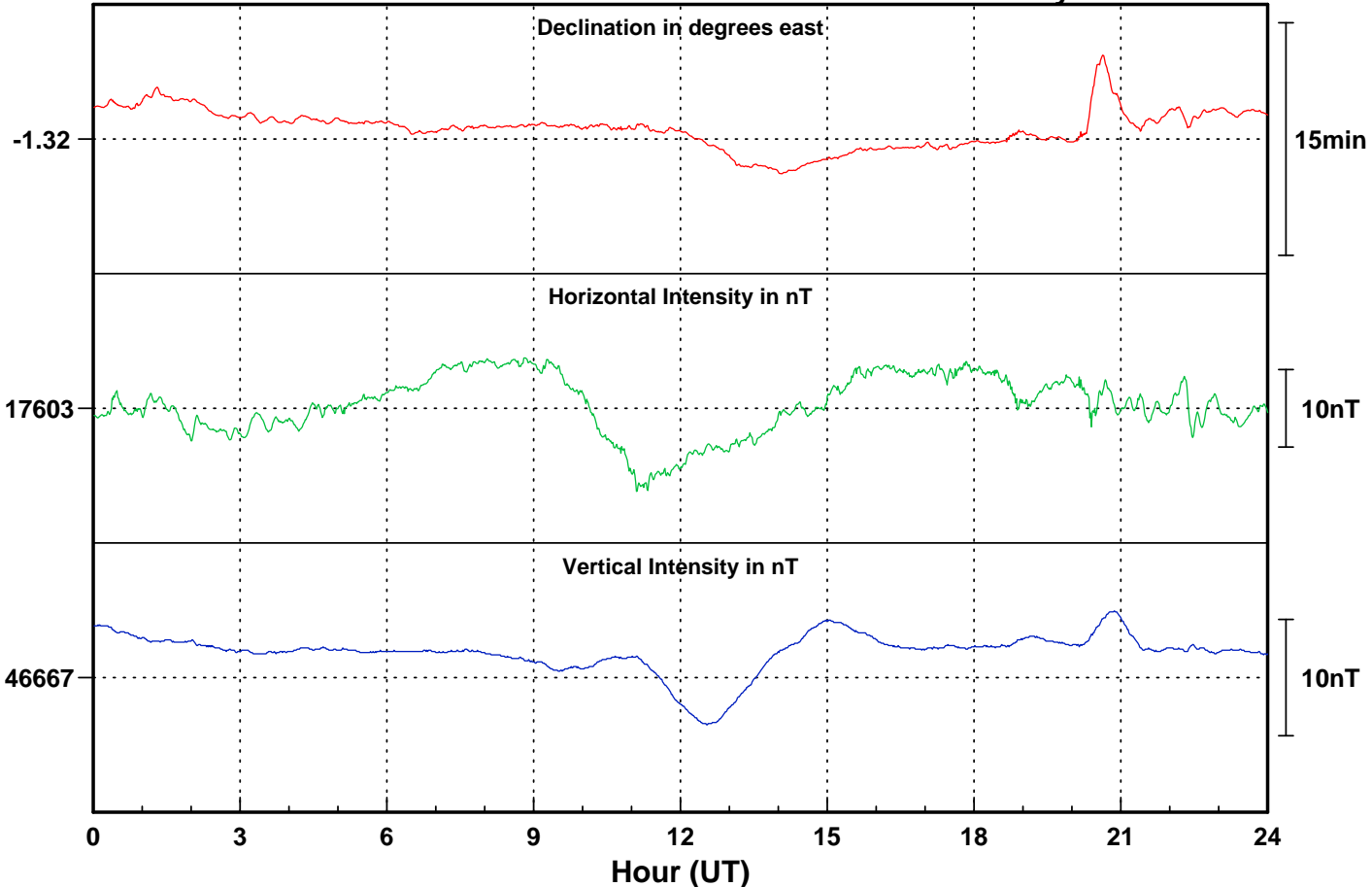
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Day number: 359



Date: 26-12-2021

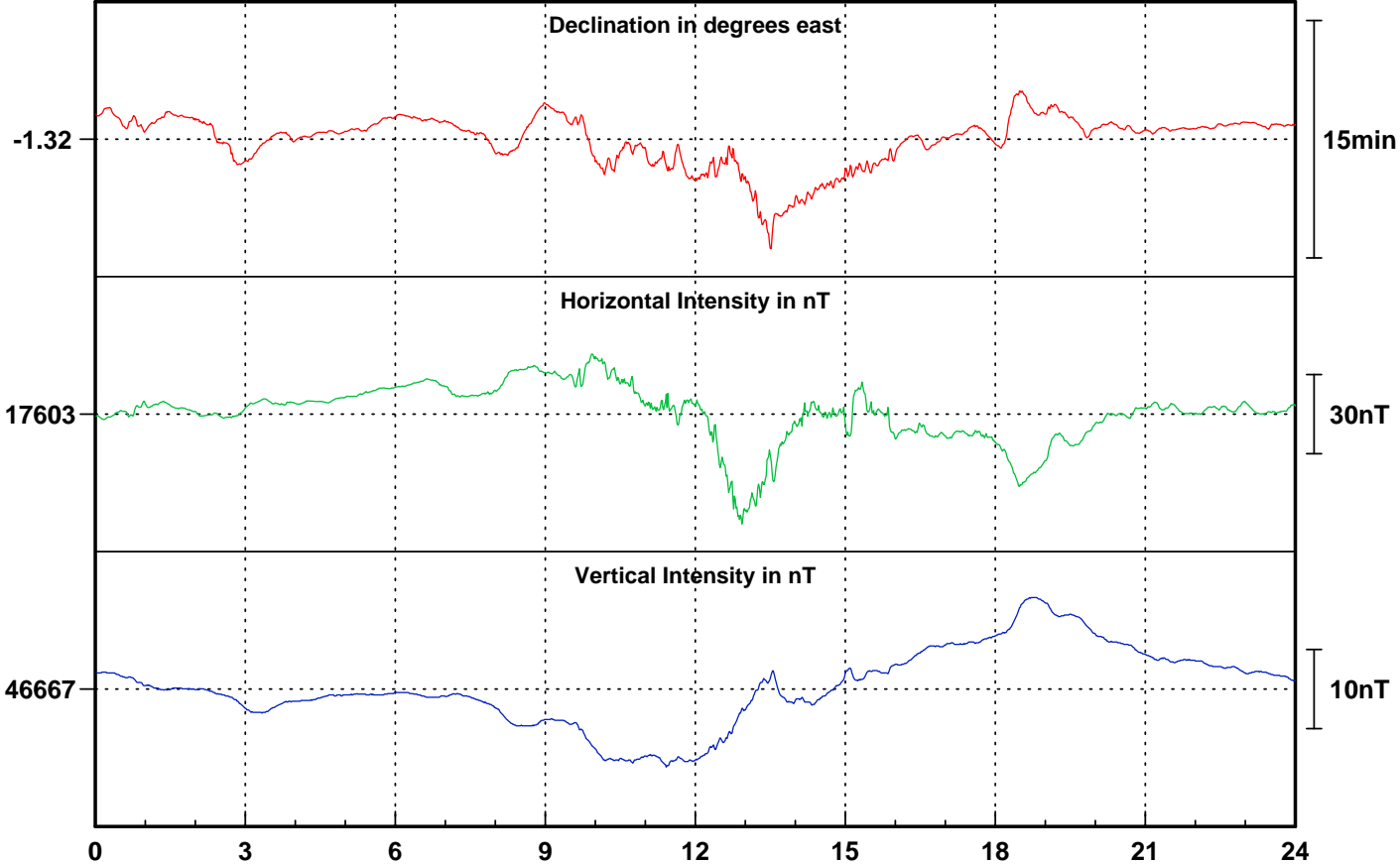
Day number: 360



Date: 27-12-2021

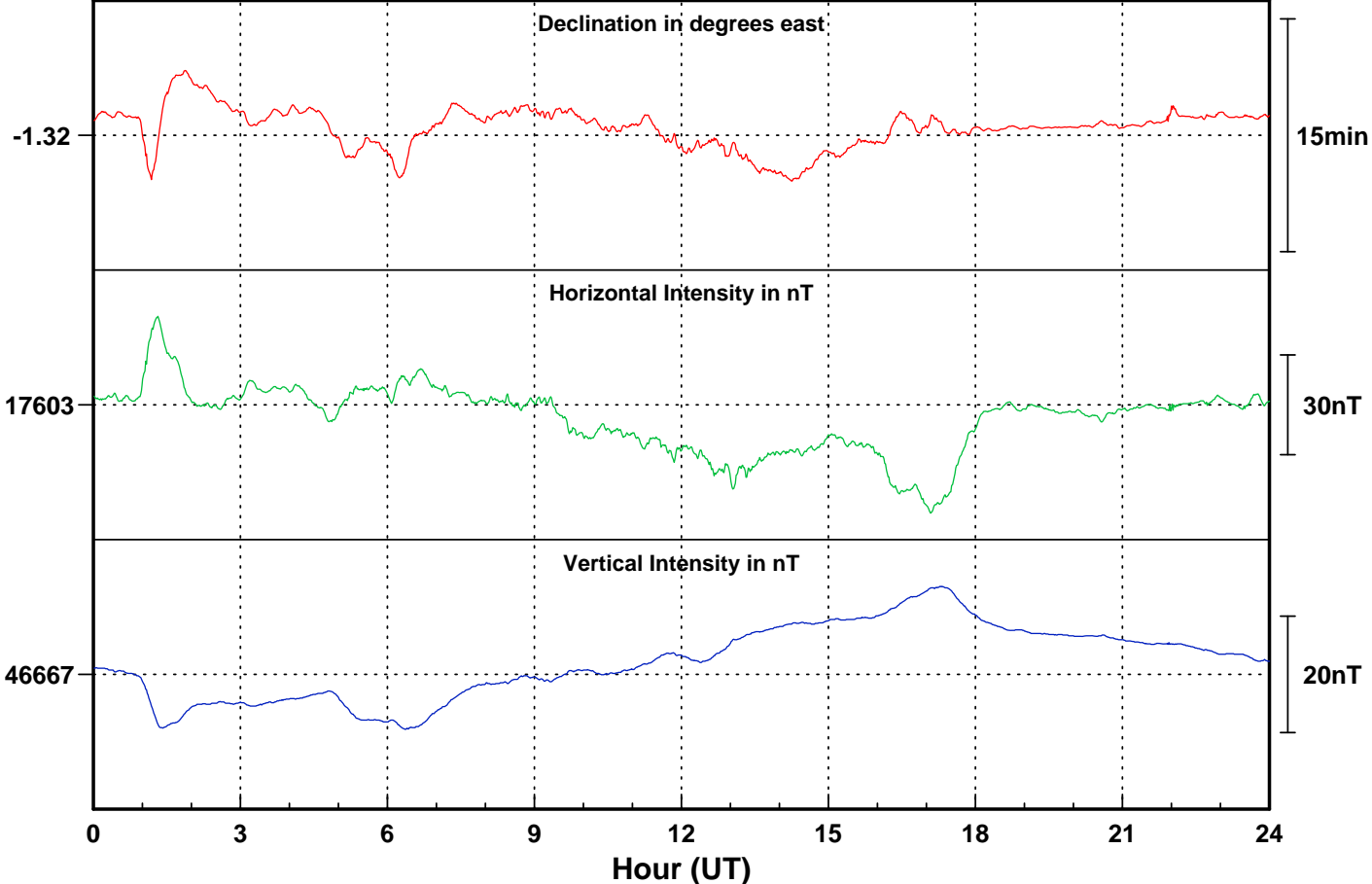
# Eskdalemuir

Day number: 361



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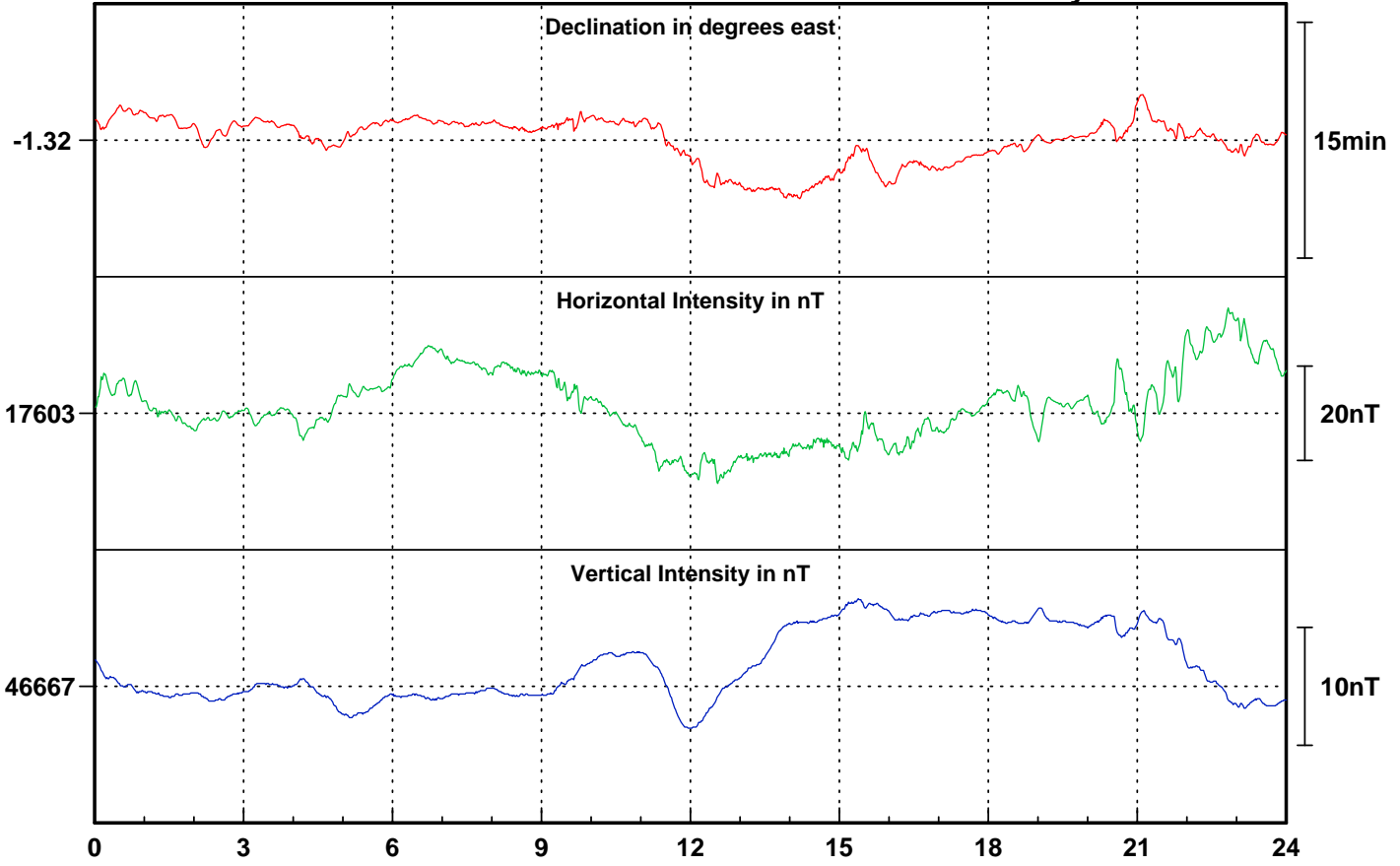
Day number: 362



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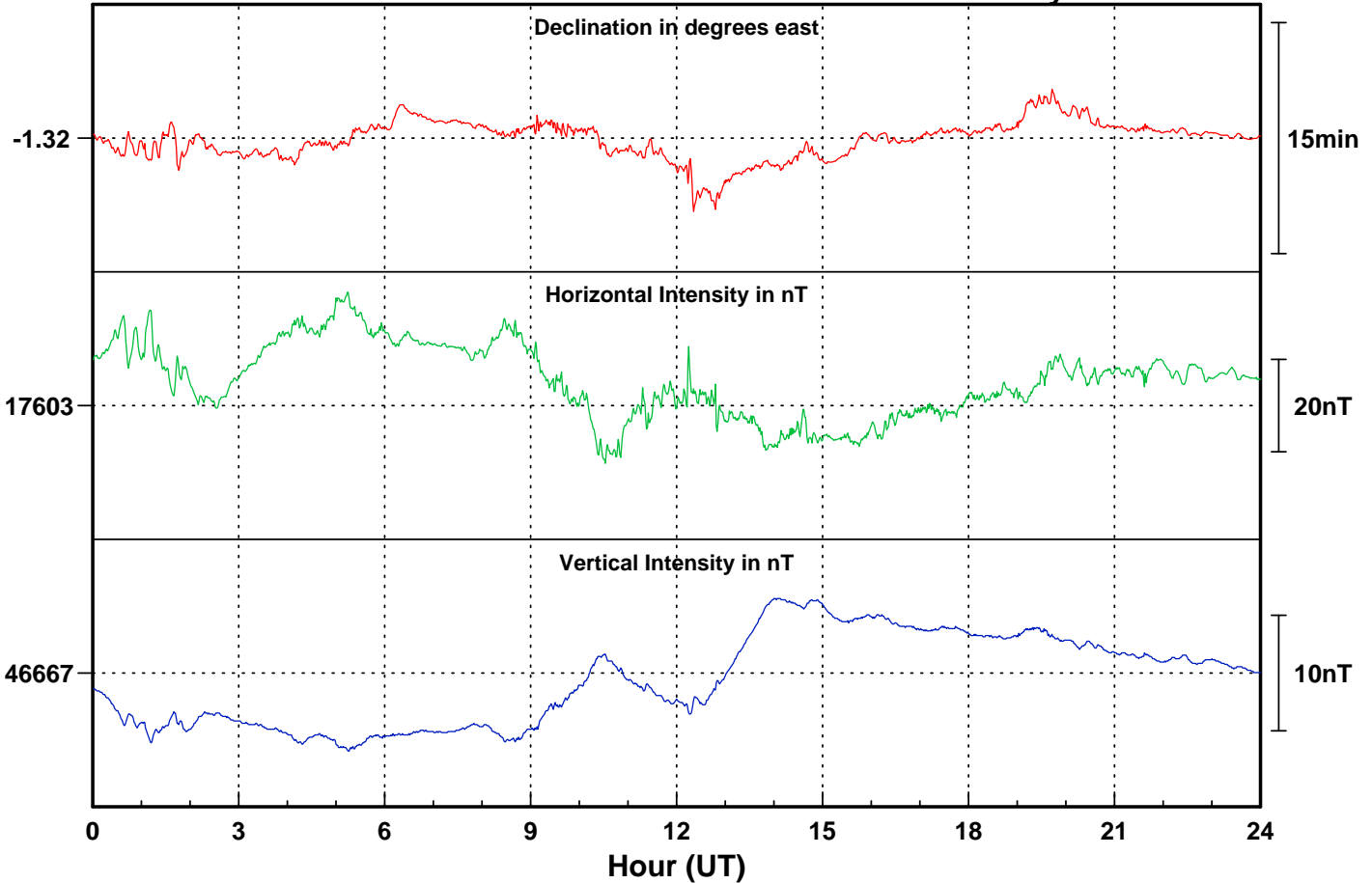
# Eskdalemuir

Day number: 363



Date: 30-12-2021

Day number: 364

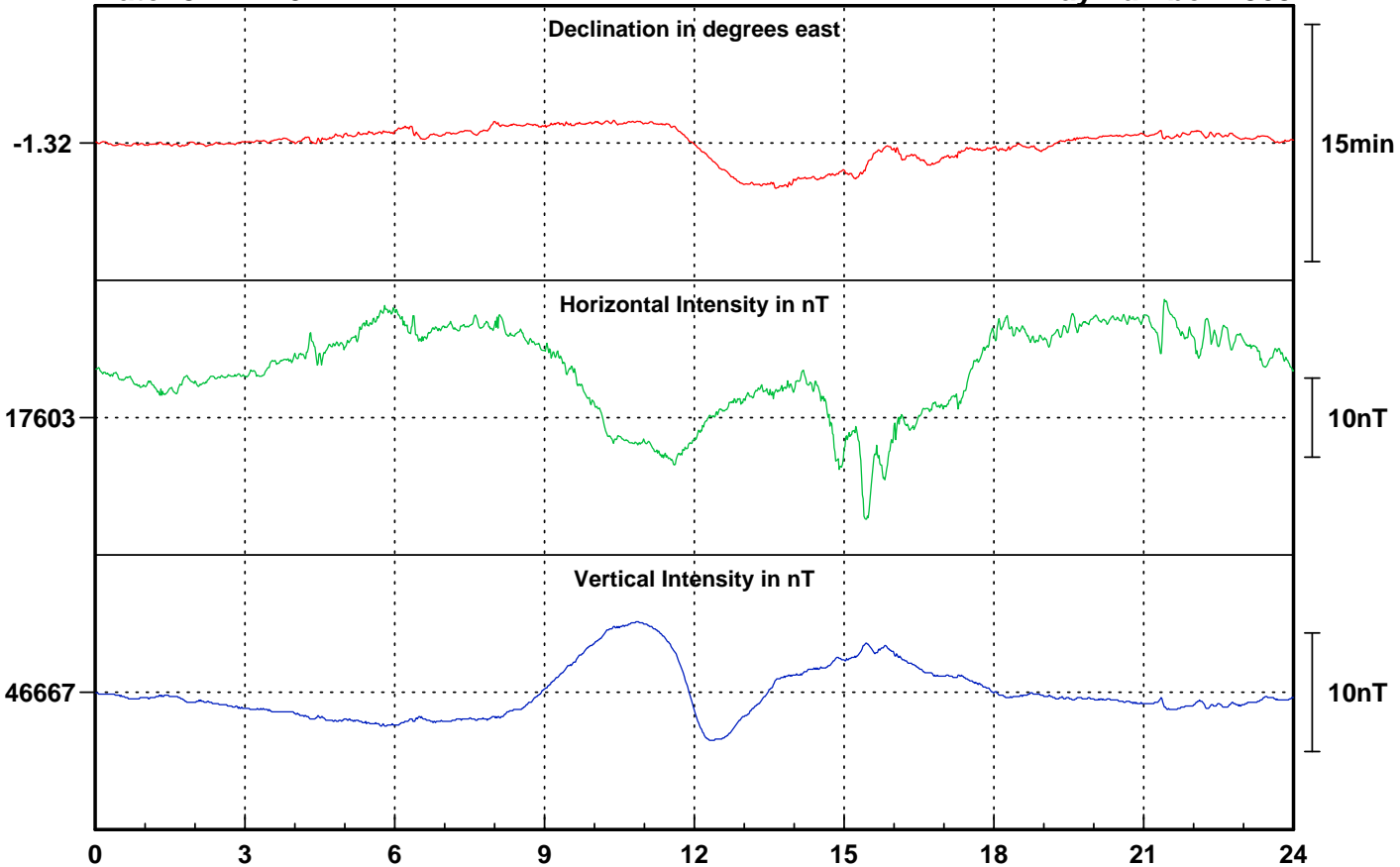




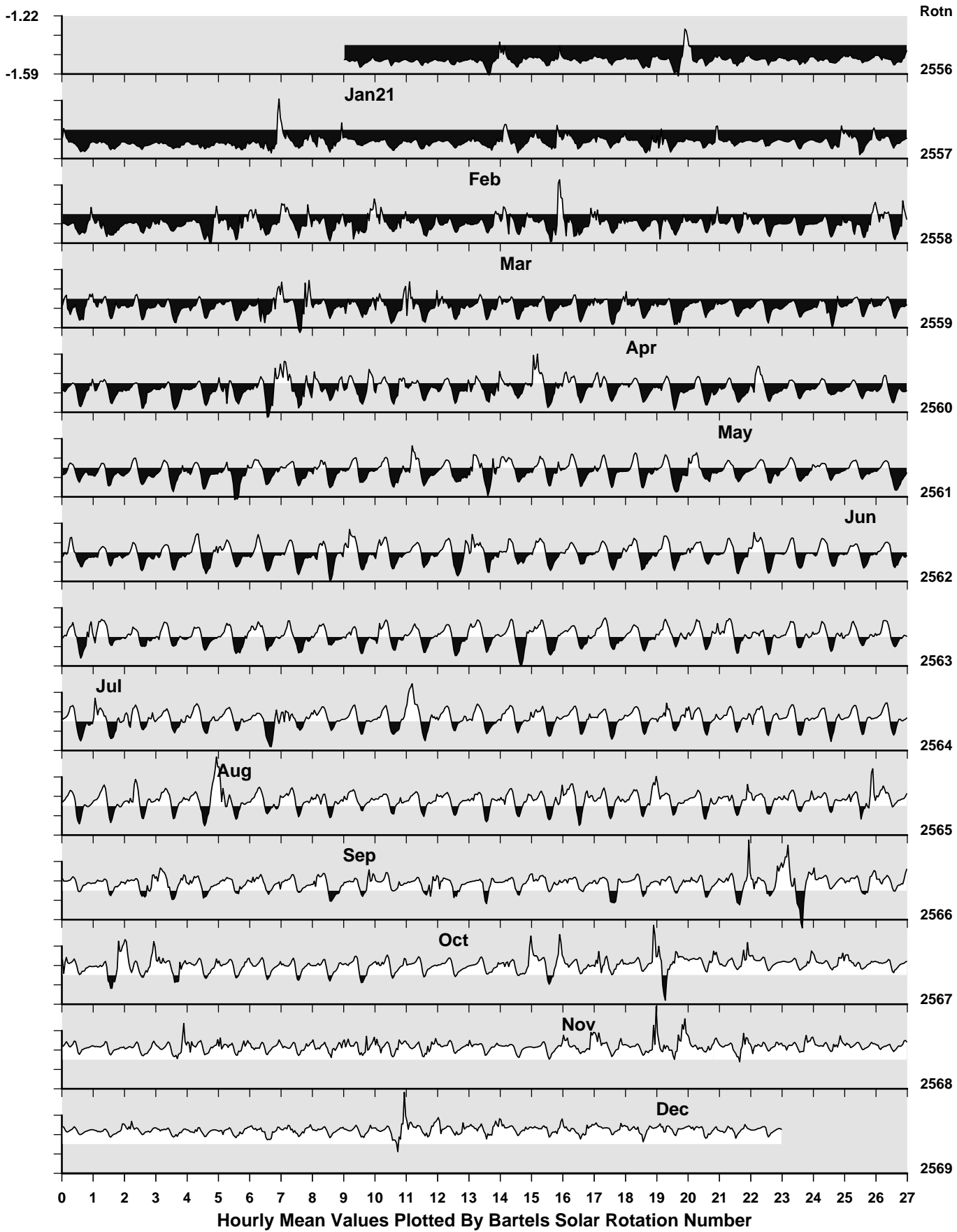
Date: 31-12-2021

# Eskdalemuir

Day number: 365

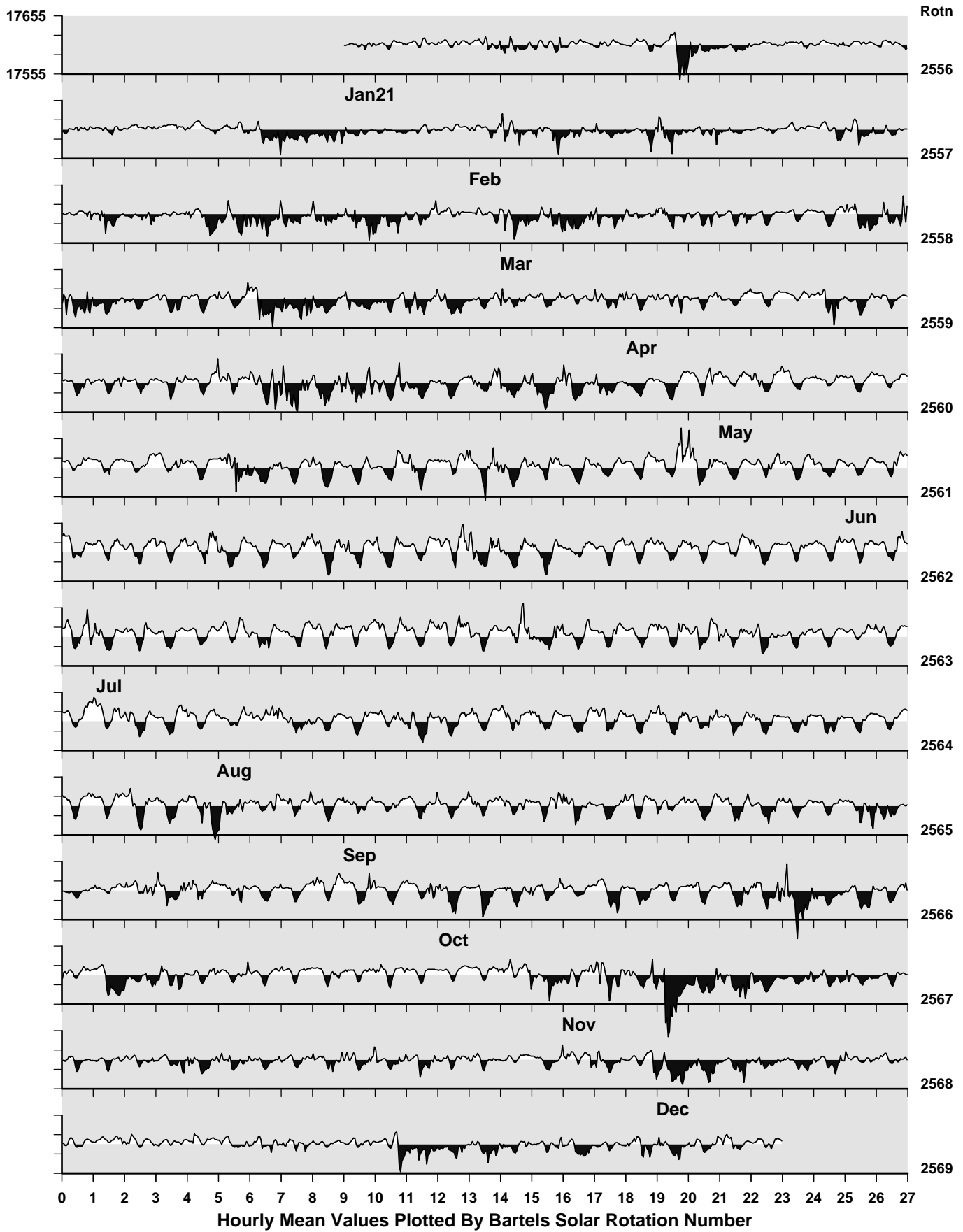


# Eskdalemuir Observatory: Declination (degrees)

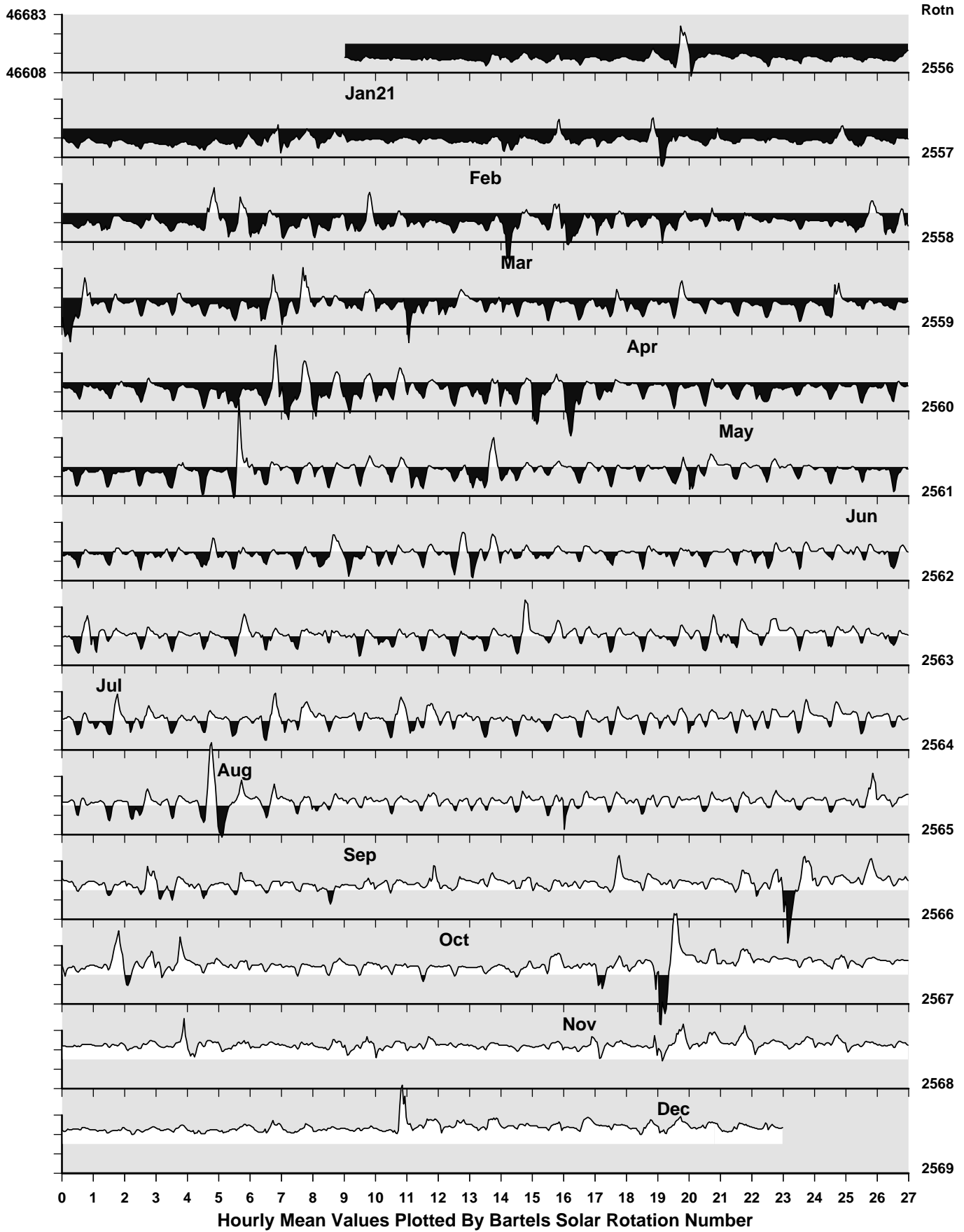


Hourly Mean Values Plotted By Bartels Solar Rotation Number

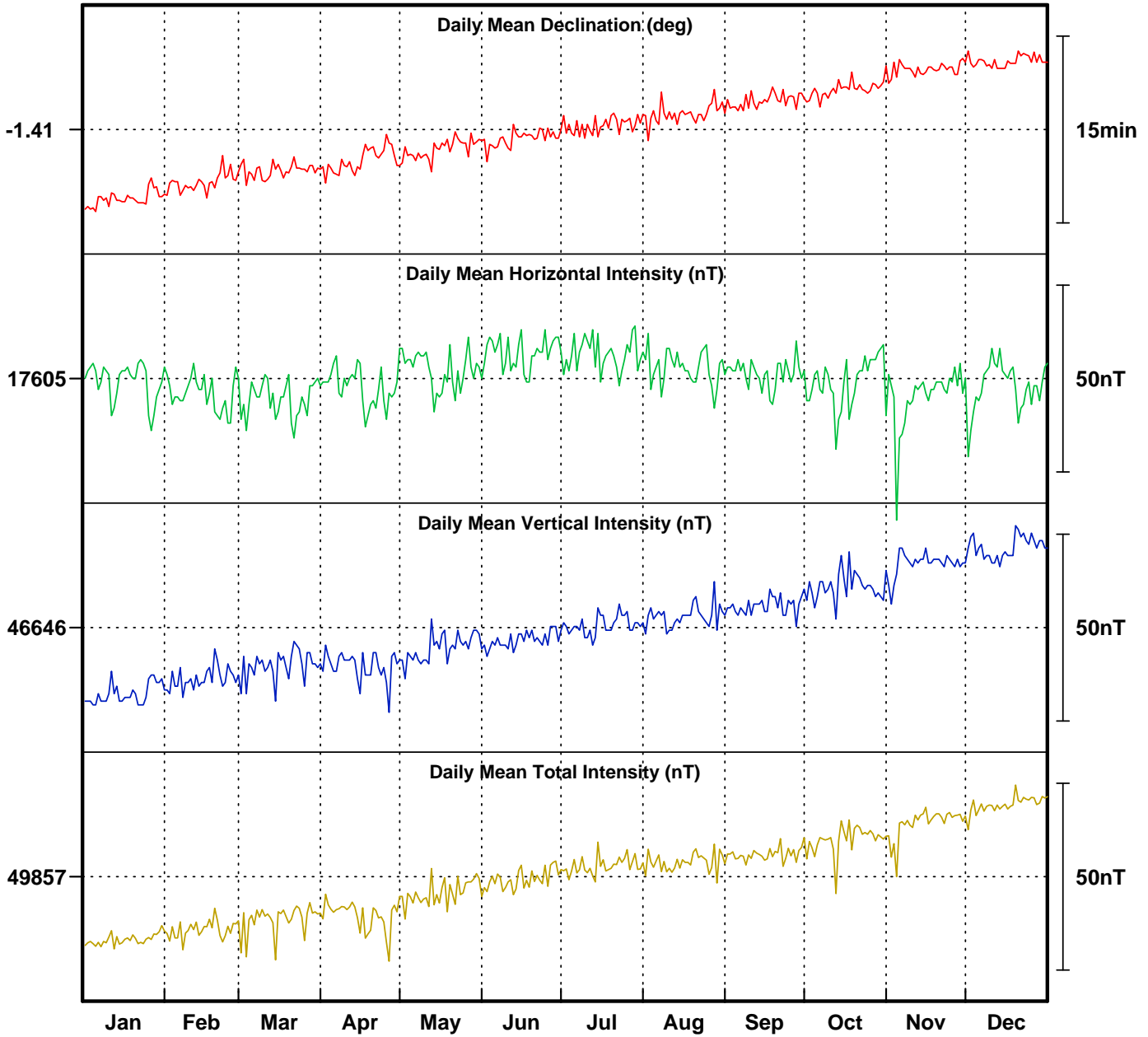
# Eskdalemuir Observatory: Horizontal Intensity (nT)



# Eskdalemuir Observatory: Vertical Intensity (nT)



# Eskdalemuir Observatory 2021



## Monthly mean values for Eskdalemuir Observatory 2021

Month	<i>D</i>	<i>H</i>	<i>I</i>	<i>X</i>	<i>Y</i>	<i>Z</i>	<i>F</i>
January	-1° 30.1′	17604 nT	69° 19.0′	17598 nT	-461 nT	46628 nT	49841 nT
February	-1° 28.7′	17601 nT	69° 19.3′	17595 nT	-454 nT	46632 nT	49843 nT
March	-1° 27.8′	17600 nT	69° 19.5′	17594 nT	-449 nT	46636 nT	49846 nT
April	-1° 27.0′	17603 nT	69° 19.2′	17597 nT	-445 nT	46635 nT	49847 nT
May	-1° 26.1′	17609 nT	69° 19.0′	17603 nT	-441 nT	46640 nT	49853 nT
June	-1° 25.2′	17612 nT	69° 18.8′	17607 nT	-437 nT	46642 nT	49857 nT
July	-1° 24.2′	17611 nT	69° 19.0′	17606 nT	-431 nT	46646 nT	49860 nT
August	-1° 23.2′	17608 nT	69° 19.3′	17602 nT	-426 nT	46649 nT	49861 nT
September	-1° 22.2′	17606 nT	69° 19.4′	17601 nT	-421 nT	46652 nT	49863 nT
October	-1° 21.3′	17604 nT	69° 19.7′	17599 nT	-416 nT	46657 nT	49867 nT
November	-1° 19.7′	17600 nT	69° 20.1′	17596 nT	-408 nT	46663 nT	49872 nT
December	-1° 19.0′	17603 nT	69° 20.0′	17598 nT	-405 nT	46667 nT	49877 nT

### Note:

i. The values shown here are provisional.

## Eskdalemuir rapid variations

### SIs and SSCs

Date	Time (UT)	Type	Quality	H (nT)	D (min)	Z (nT)
02/12/2021	07:01	SI*	C	3.9	0.30	-
19/12/2021	13:10	SSC*	C	8.1	-0.62	-

#### 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

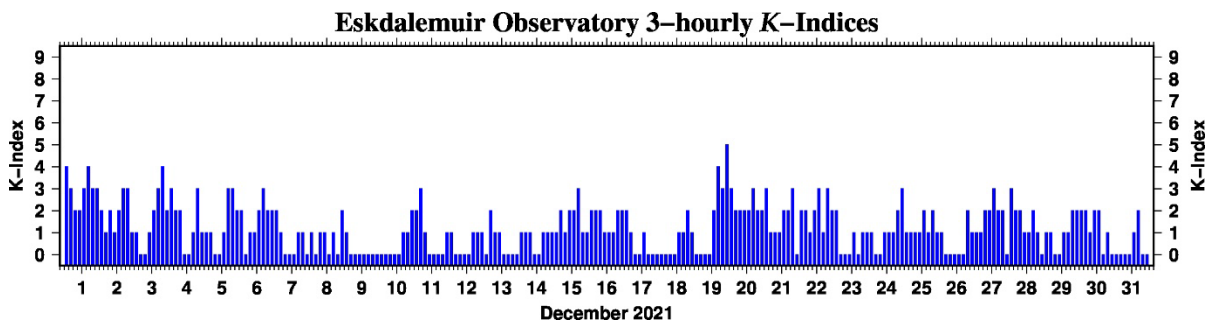
The amplitudes given are for the first chief movement of the event.

### SFEs

None

# 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	4	3	2	2	3	4	3	3
2	2	1	2	1	2	3	3	1
3	1	0	0	1	2	3	4	2
4	3	2	2	0	0	1	3	1
5	1	1	0	0	1	3	3	2
6	2	0	1	1	2	3	2	2
7	2	1	0	0	0	1	1	0
8	1	0	1	1	0	1	0	2
9	1	0	0	0	0	0	0	0
10	0	0	0	0	0	1	1	2
11	2	3	1	0	0	0	0	1
12	1	0	0	0	0	1	1	1
13	0	2	1	1	0	0	0	0
14	1	1	1	0	0	1	1	1
15	1	2	1	2	2	3	1	1
16	2	2	2	1	1	1	2	2
17	2	1	0	0	1	0	0	0
18	0	0	0	0	1	1	2	1
19	0	0	0	0	2	4	3	5
20	3	2	2	2	2	3	2	2
21	3	1	1	1	2	2	3	0
22	2	2	1	2	3	1	3	2
23	2	0	0	0	1	0	1	1
24	1	0	0	1	1	1	2	3
25	1	1	1	1	2	1	2	1
26	1	0	0	0	0	0	2	1
27	1	1	2	2	3	2	2	0
28	3	2	2	1	1	2	1	0
29	1	1	0	0	1	1	2	2
30	2	2	1	2	2	0	1	0
31	0	0	0	0	1	2	0	0





# The aa Index

Date	Day	3-hourly aa-indices								Aa <sub>am</sub>	Aa <sub>pm</sub>	Aa
01/12/2021	335	45	46	24	16	46	37	24	45	32.8	38.1	35.5
02/12/2021	336	12	12	32	12	16	32	24	16	17	22.1	19.5
03/12/2021	337	5	8	5	20	16	46	45	24	9.6	32.8	21.2
04/12/2021	338	24	16	16	8	12	12	20	8	16	12.9	14.5
05/12/2021	339	12	16	9	12	12	32	24	32	12.4	25.1	18.7
06/12/2021	340	12	9	12	12	16	32	16	12	11.3	19	15.2
07/12/2021	341	20	12	5	5	8	8	8	5	10.5	7.2	8.9
08/12/2021	342	8	5	8	8	5	8	5	12	7.1	7.5	7.3
09/12/2021	343	5	8	2	5	5	8	2	5	5.1	5.2	5.2
10/12/2021	344	2	5	5	5	8	12	8	12	4.5	9.9	7.2
11/12/2021	345	16	24	12	2	2	2	2	8	13.6	3.8	8.7
12/12/2021	346	5	8	2	2	5	12	8	5	4.5	7.5	6
13/12/2021	347	5	16	12	12	2	2	5	12	11.3	5.5	8.4
14/12/2021	348	8	8	8	9	9	16	8	8	8.2	10.3	9.2
15/12/2021	349	12	24	24	24	16	32	12	12	21.1	18.1	19.6
16/12/2021	350	12	16	24	16	16	8	12	16	17.1	13	15
17/12/2021	351	12	8	5	2	8	8	2	5	6.8	5.8	6.3
18/12/2021	352	2	5	8	8	8	8	12	8	5.8	8.8	7.3
19/12/2021	353	2	5	2	9	24	59	59	102	4.9	61	32.9
20/12/2021	354	32	24	24	24	16	32	16	24	26.1	22.1	24.1
21/12/2021	355	37	8	12	8	24	24	24	8	16.2	20	18.1
22/12/2021	356	12	16	16	12	32	16	24	16	14	22.1	18
23/12/2021	357	12	2	5	5	8	2	12	12	6.2	8.5	7.4
24/12/2021	358	8	8	8	12	12	8	16	24	8.9	15	11.9
25/12/2021	359	8	8	20	12	24	12	9	5	11.9	12.6	12.3
26/12/2021	360	5	2	2	8	8	2	20	8	4.5	9.5	7
27/12/2021	361	9	8	16	24	81	32	12	8	14.3	33.1	23.7
28/12/2021	362	20	12	24	12	16	24	8	2	17	12.6	14.8
29/12/2021	363	5	8	8	20	24	16	12	24	10.2	19.1	14.7
30/12/2021	364	24	24	16	16	24	8	12	5	20.1	12.3	16.2
31/12/2021	365	5	5	8	2	12	16	2	12	5.2	10.6	7.9
Monthly Mean Value											14.3	

## 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.

