



British
Geological
Survey



MONTHLY MAGNETIC BULLETIN

Hartland Observatory

December 2021



Hartland Observatory magnetic data

1. Introduction

Hartland 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 the NW boundary of the village of Hartland in North Devon. The observatory co-ordinates are:

Geographic: 50° 59'42.0"N 355° 30'57.6"E
Geomagnetic: 53° 35'09.6"N 079° 50'16.8"E
Height above mean sea level: 95 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 Hartland are:

0	1	2	3	4	5	6	7	8	9
0	5	10	20	40	70	120	200	330	500

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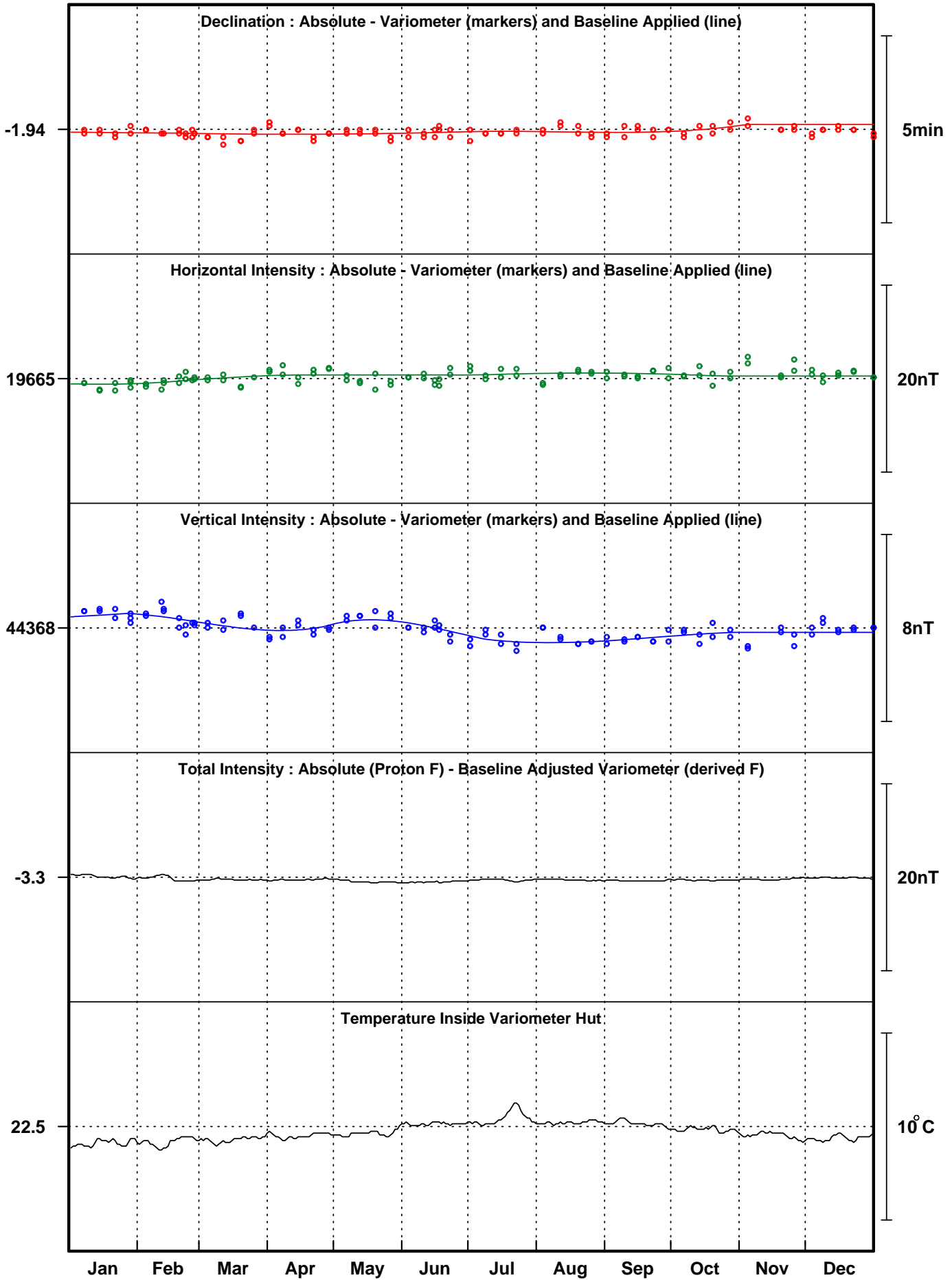
Commercial users can contact the geomagnetism team for information on the range of applications and services offered. Full contact details are available at geomag.bgs.ac.uk/contactus/staff

Hartland 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)	
03-Dec-21	337	09:00	-1.0490	-1.9483	09:08	65.9888	3.6	48739.8	19832.9	19665.1	44522.1	44368.4	BC
03-Dec-21	337	09:14	-1.0516	-1.9467	09:22	65.9901	3.6	48737.6	19831.1	19665.6	44520.6	44368.1	BC
08-Dec-21	342	09:28	-1.0545	-1.9450	09:36	65.9897	3.6	48742.3	19833.3	19664.3	44524.7	44368.8	BC
08-Dec-21	342	09:41	-1.0487	-1.9450	09:48	65.9903	3.6	48741.0	19832.2	19665.0	44523.8	44368.6	BC
15-Dec-21	349	08:36	-1.0501	-1.9433	08:44	65.9787	3.6	48740.8	19841.2	19665.0	44519.6	44368.3	BC
15-Dec-21	349	08:50	-1.0567	-1.9450	08:57	65.9801	3.6	48739.6	19839.7	19665.3	44519.0	44368.2	BC
22-Dec-21	356	08:54	-1.0337	-1.9450	09:02	65.9947	3.6	48742.3	19829.4	19665.5	44526.5	44368.3	BC
22-Dec-21	356	09:08	-1.0268	-1.9450	09:15	65.9970	3.6	48739.9	19826.6	19665.4	44525.1	44368.4	BC
31-Dec-21	365	12:41	-1.0944	-1.9467	12:49	65.9937	3.6	48742.2	19830.1	19664.8	44526.0	44368.4	BC
31-Dec-21	365	12:56	-1.1060	-1.9483	13:03	65.9934	3.6	48742.9	19830.7	19664.8	44526.6	44368.4	BC

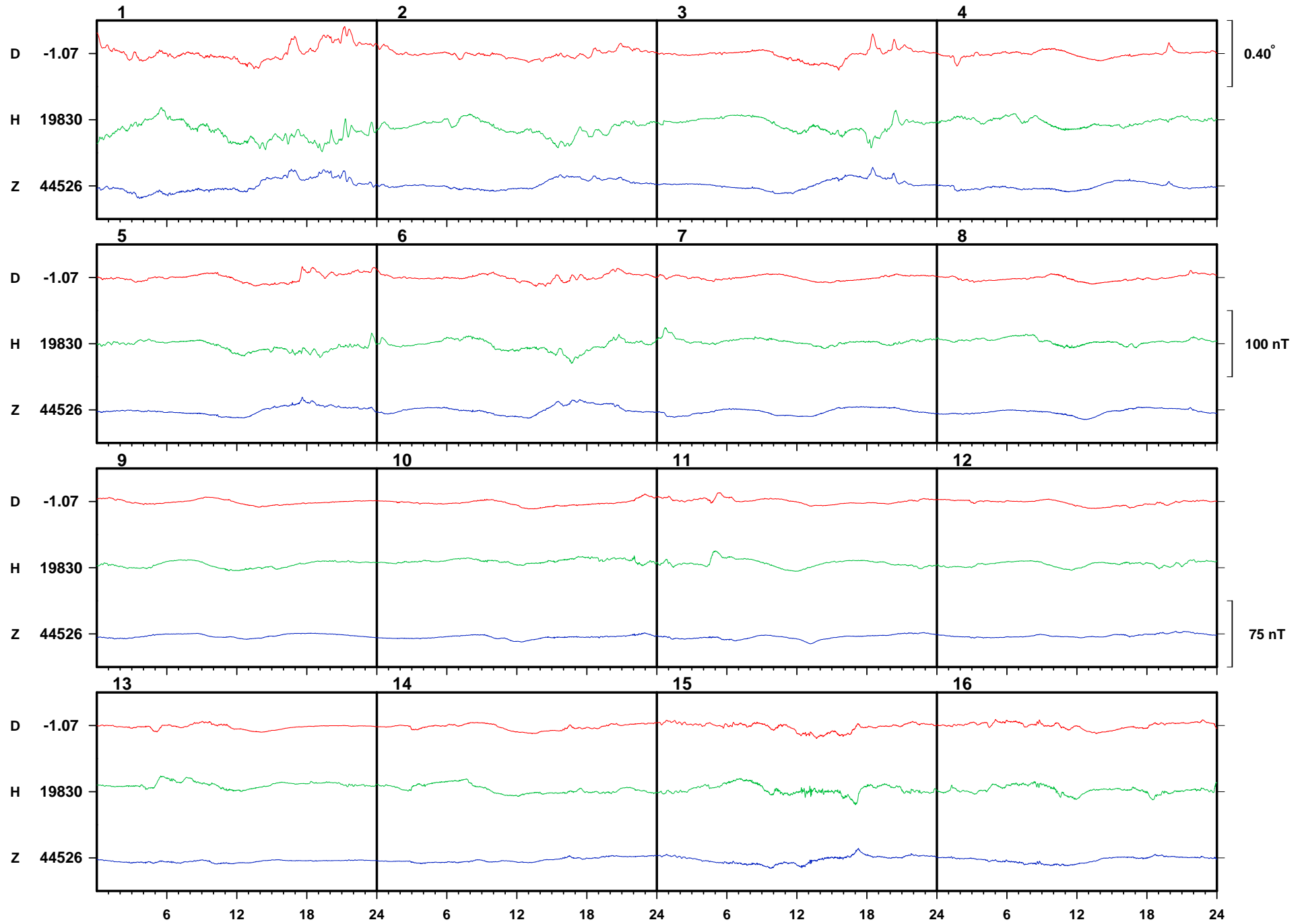
Hartland 2021

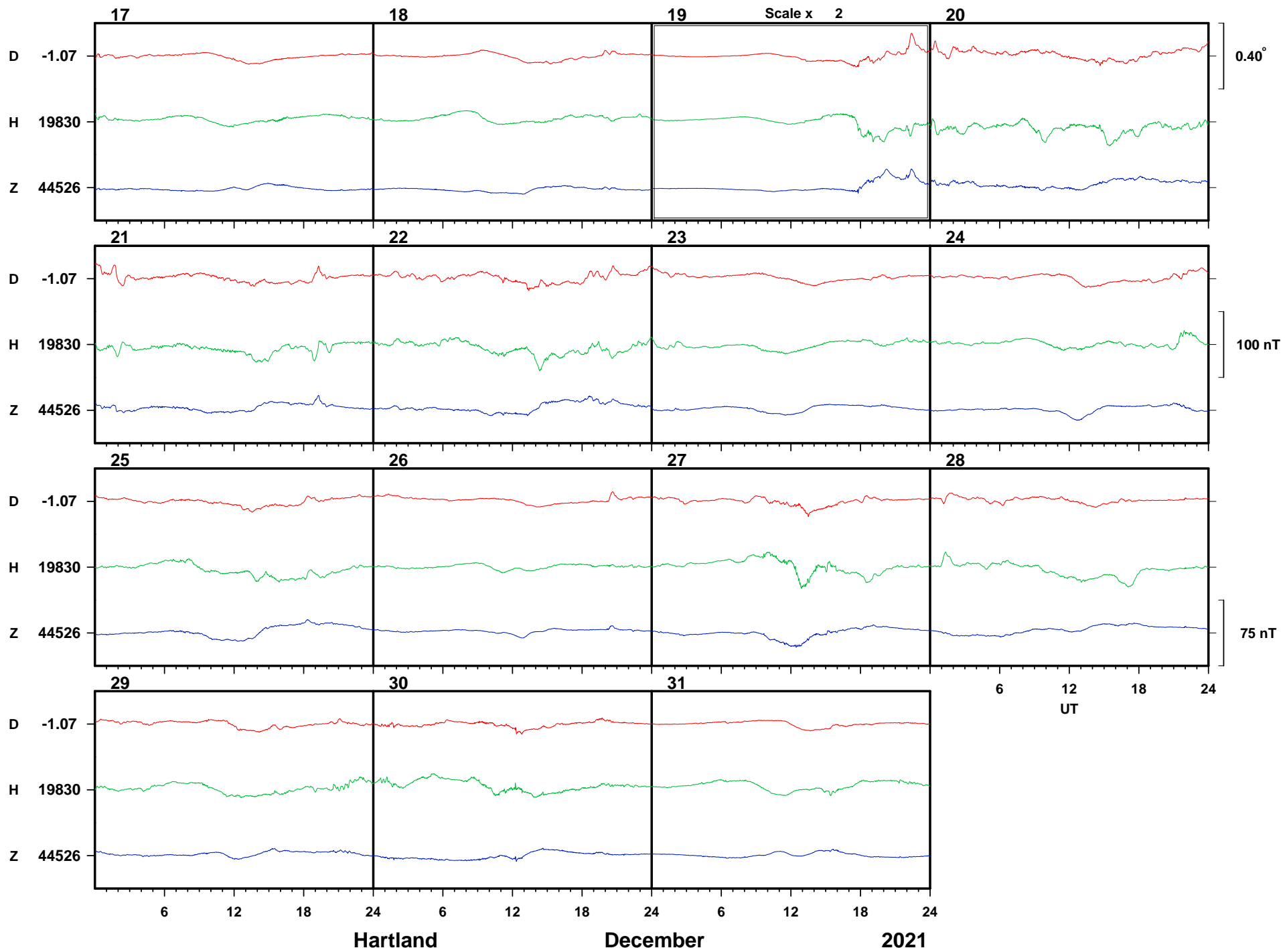


Hartland

December

2021

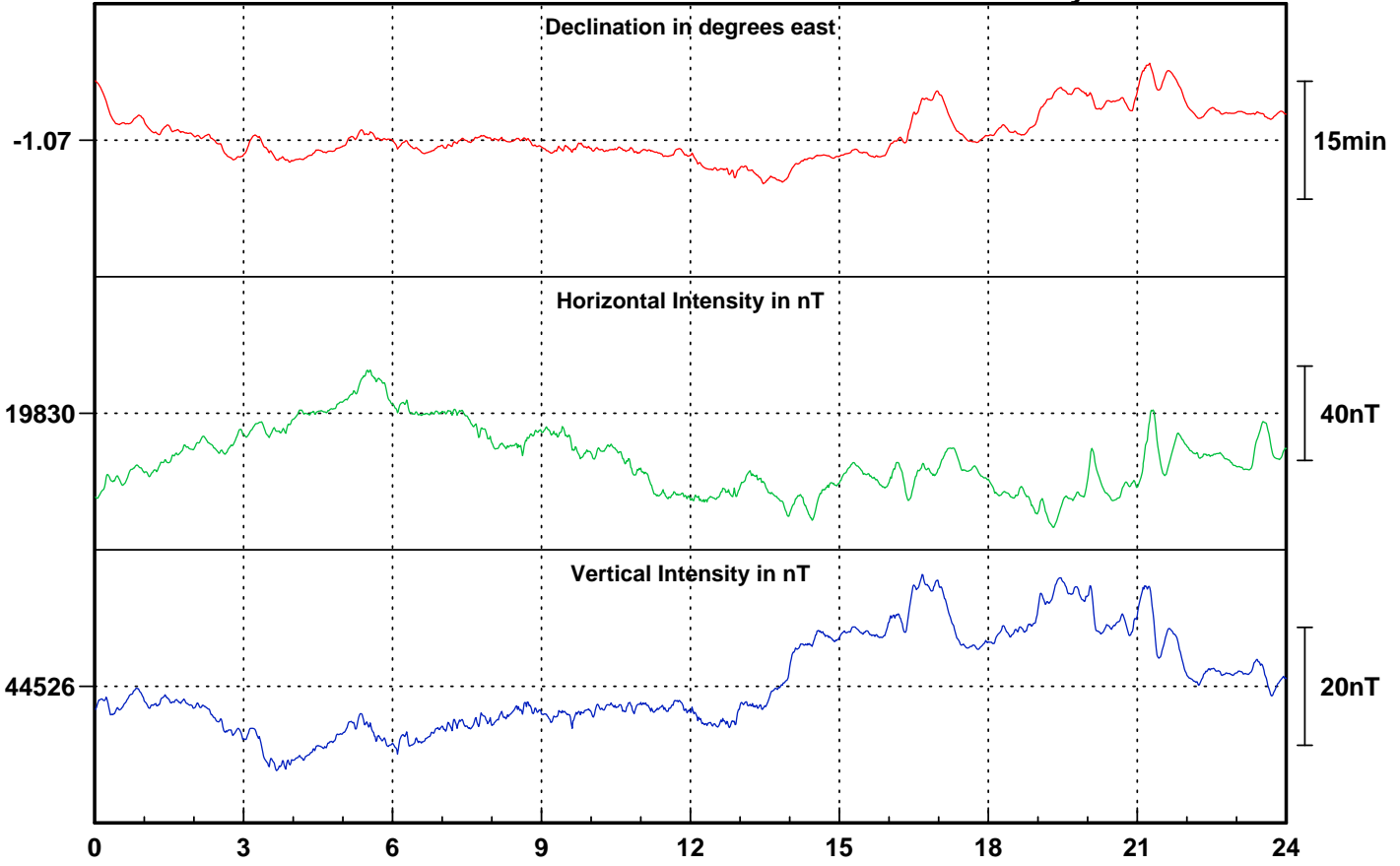




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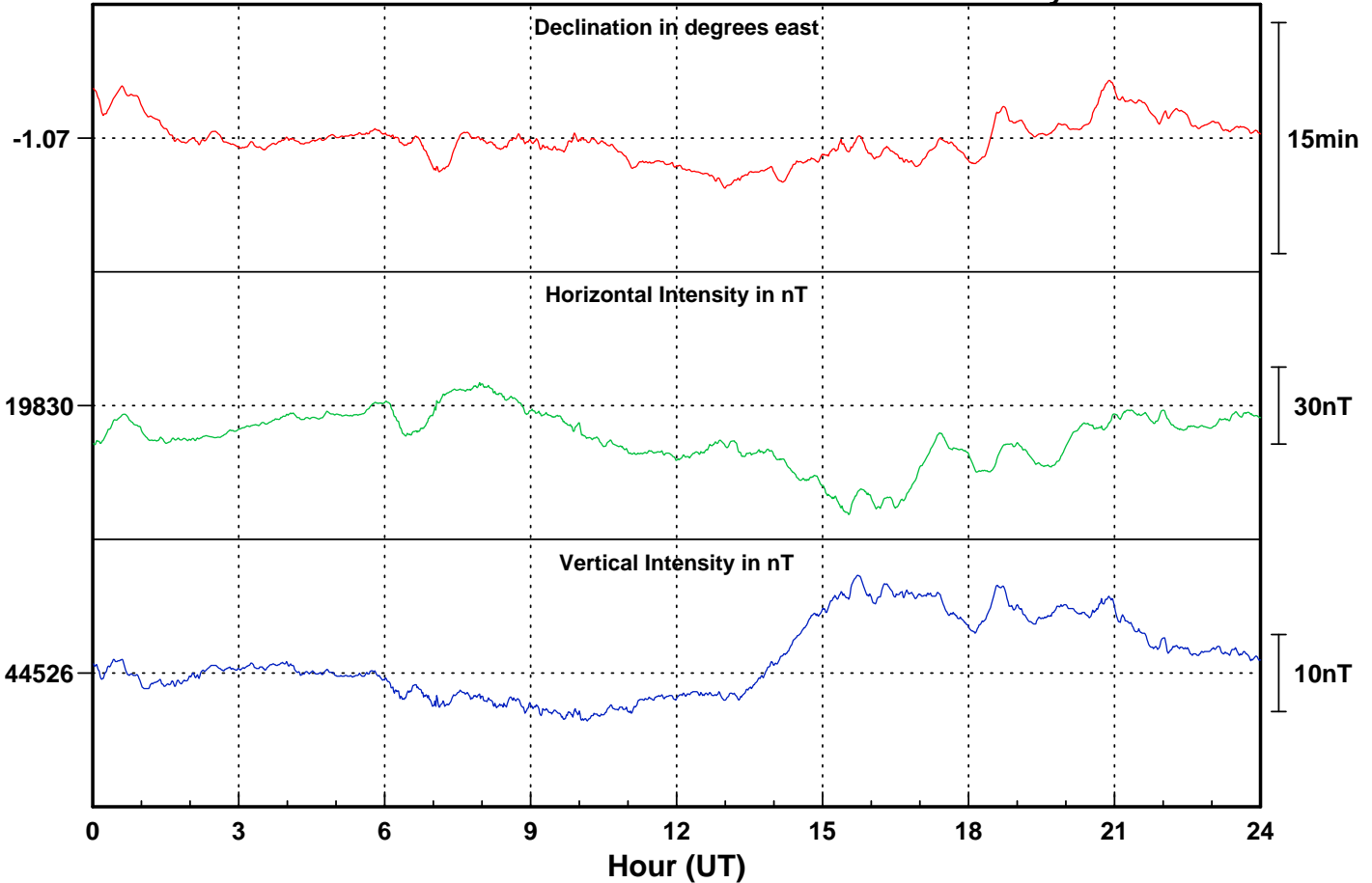
Hartland

Day number: 335



Date: 02-12-2021

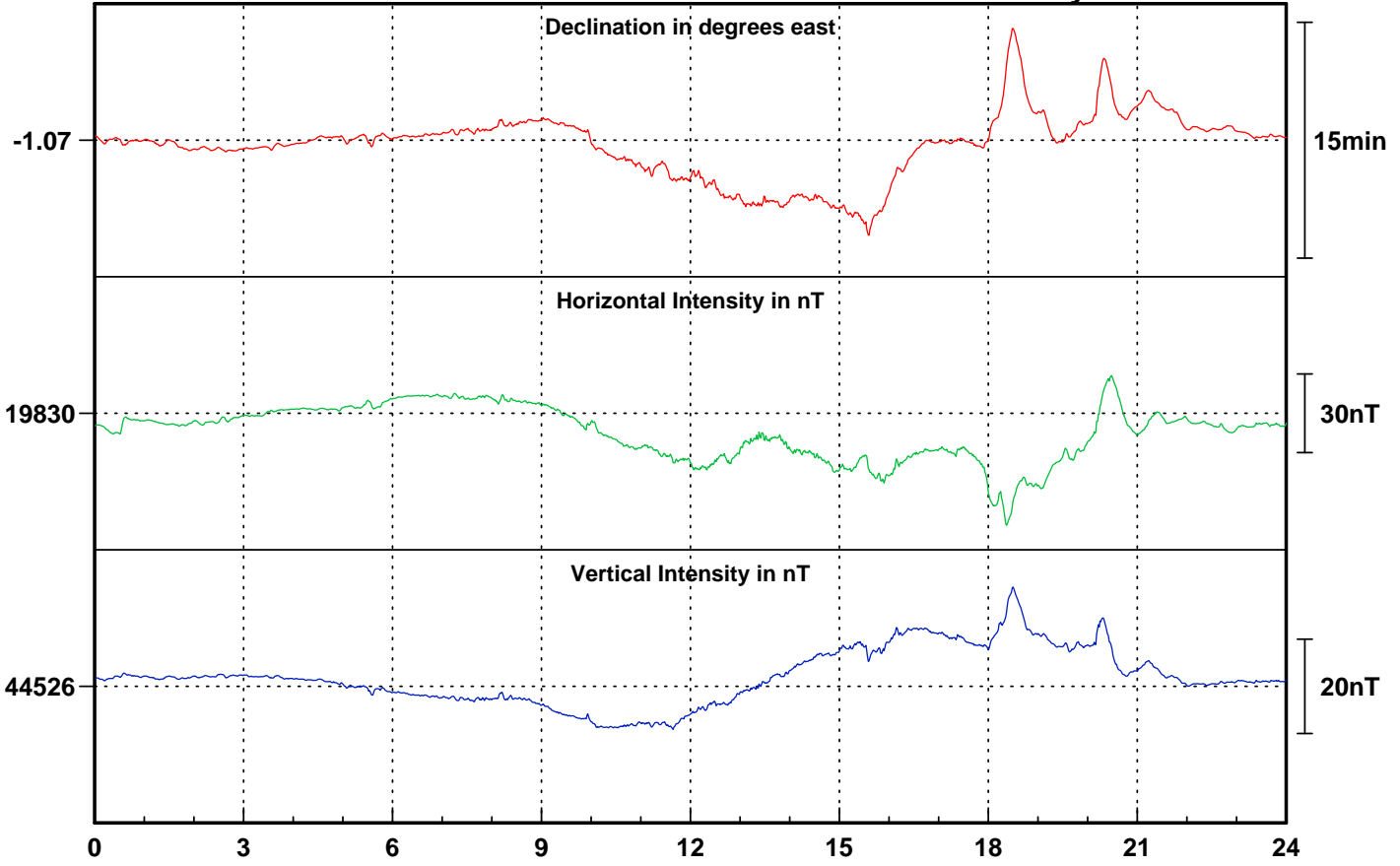
Day number: 336



Date: 03-12-2021

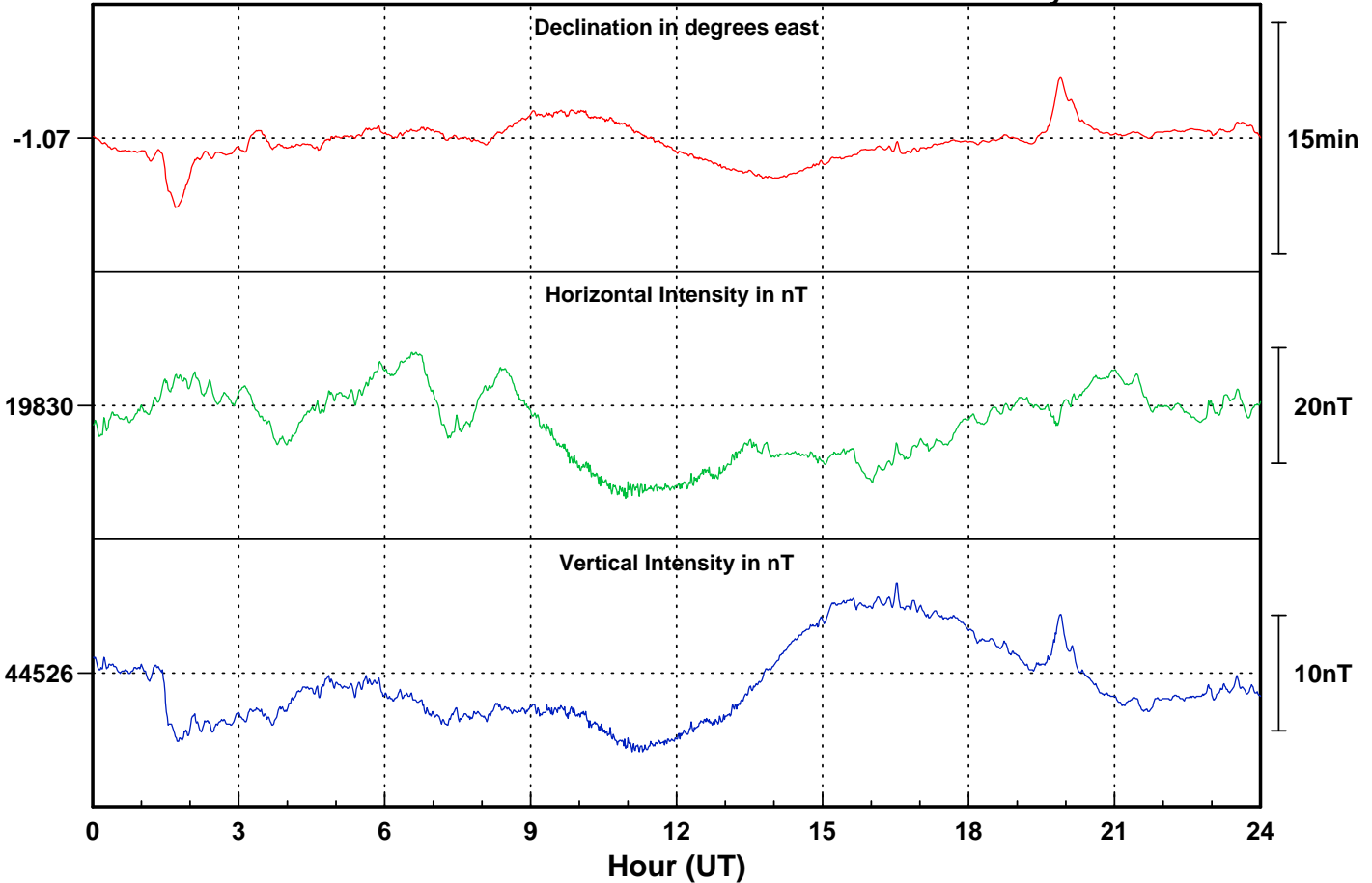
Hartland

Day number: 337



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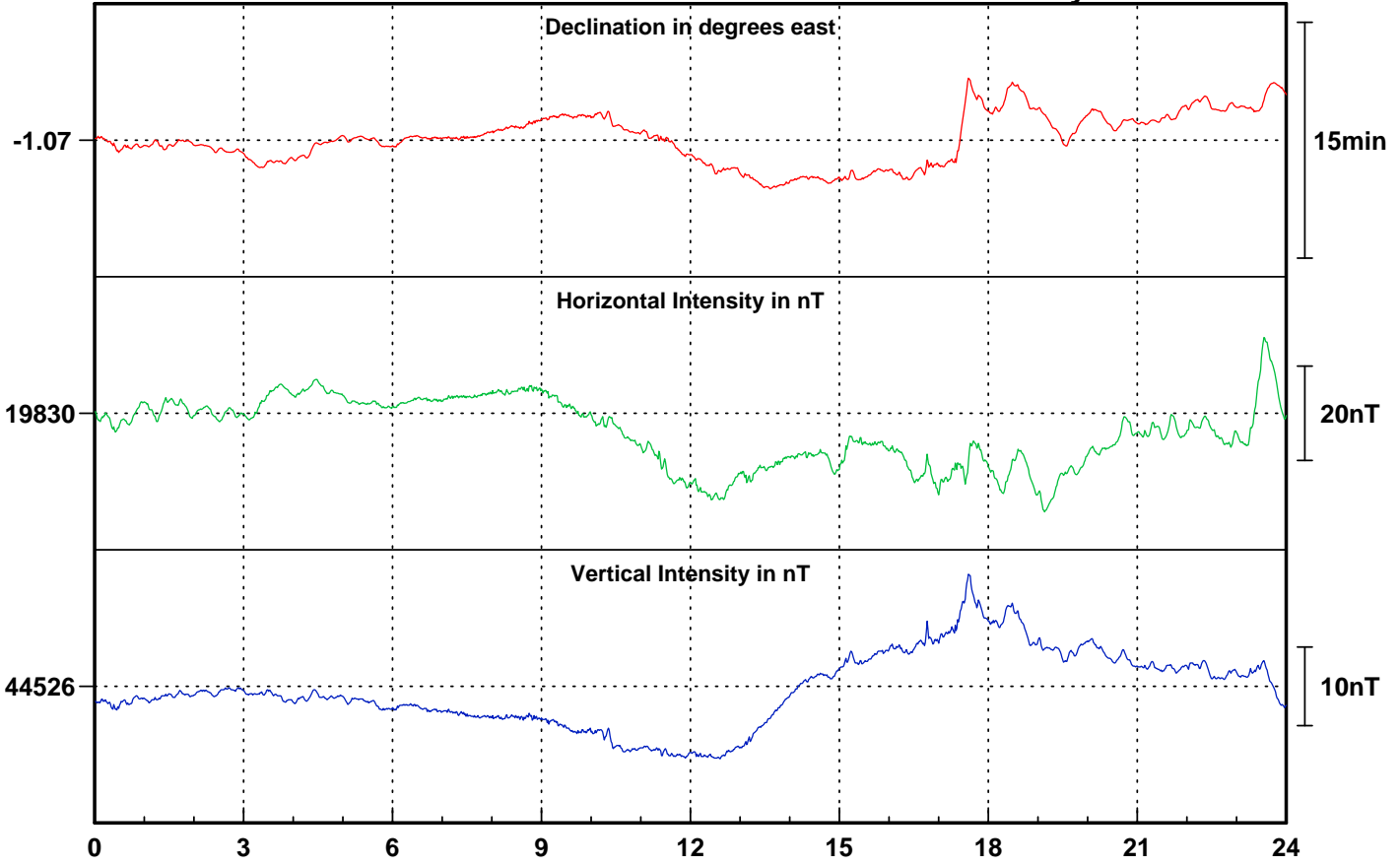
Day number: 338



Date: 05-12-2021

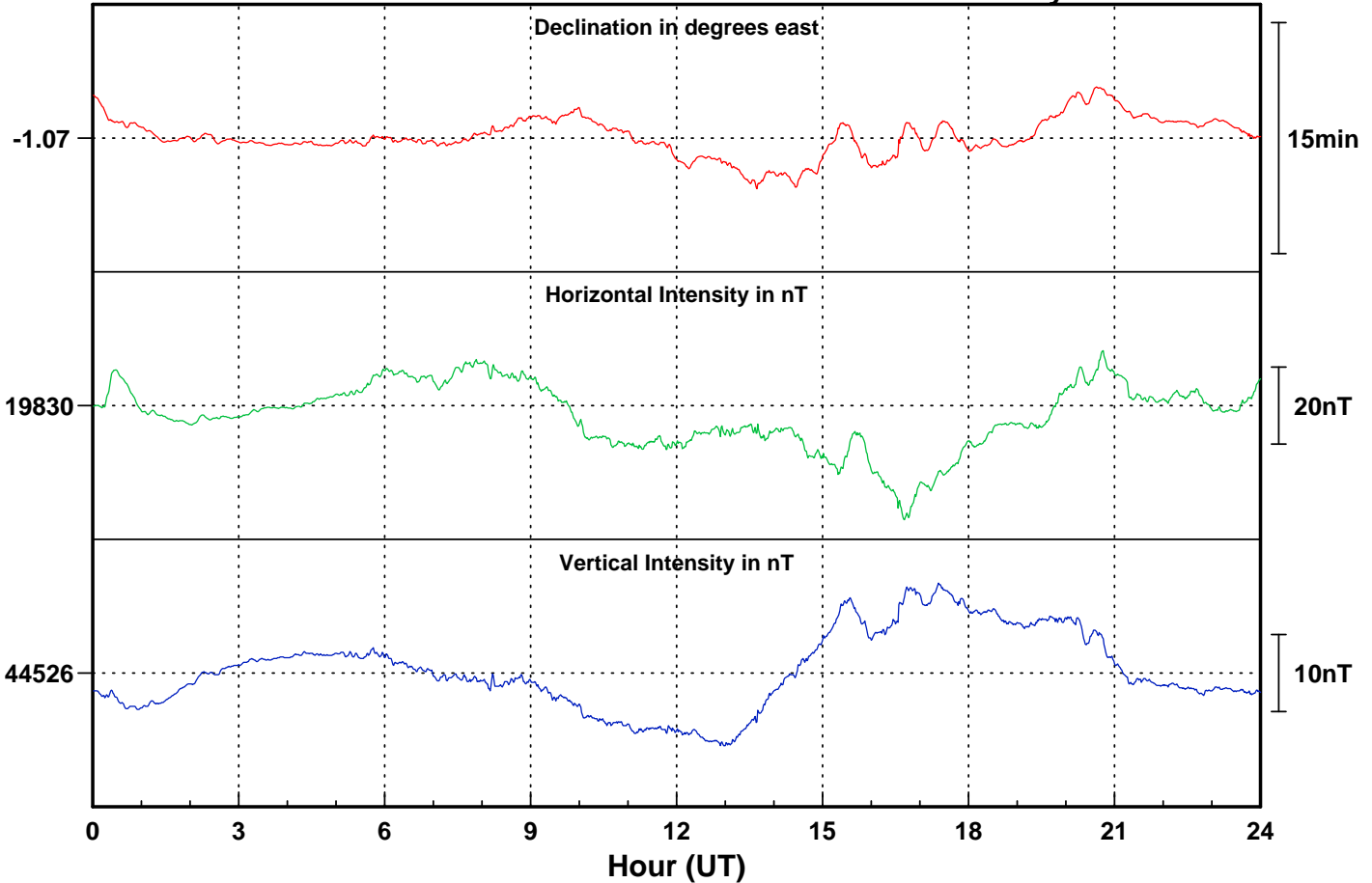
Hartland

Day number: 339



Date: 06-12-2021

Day number: 340

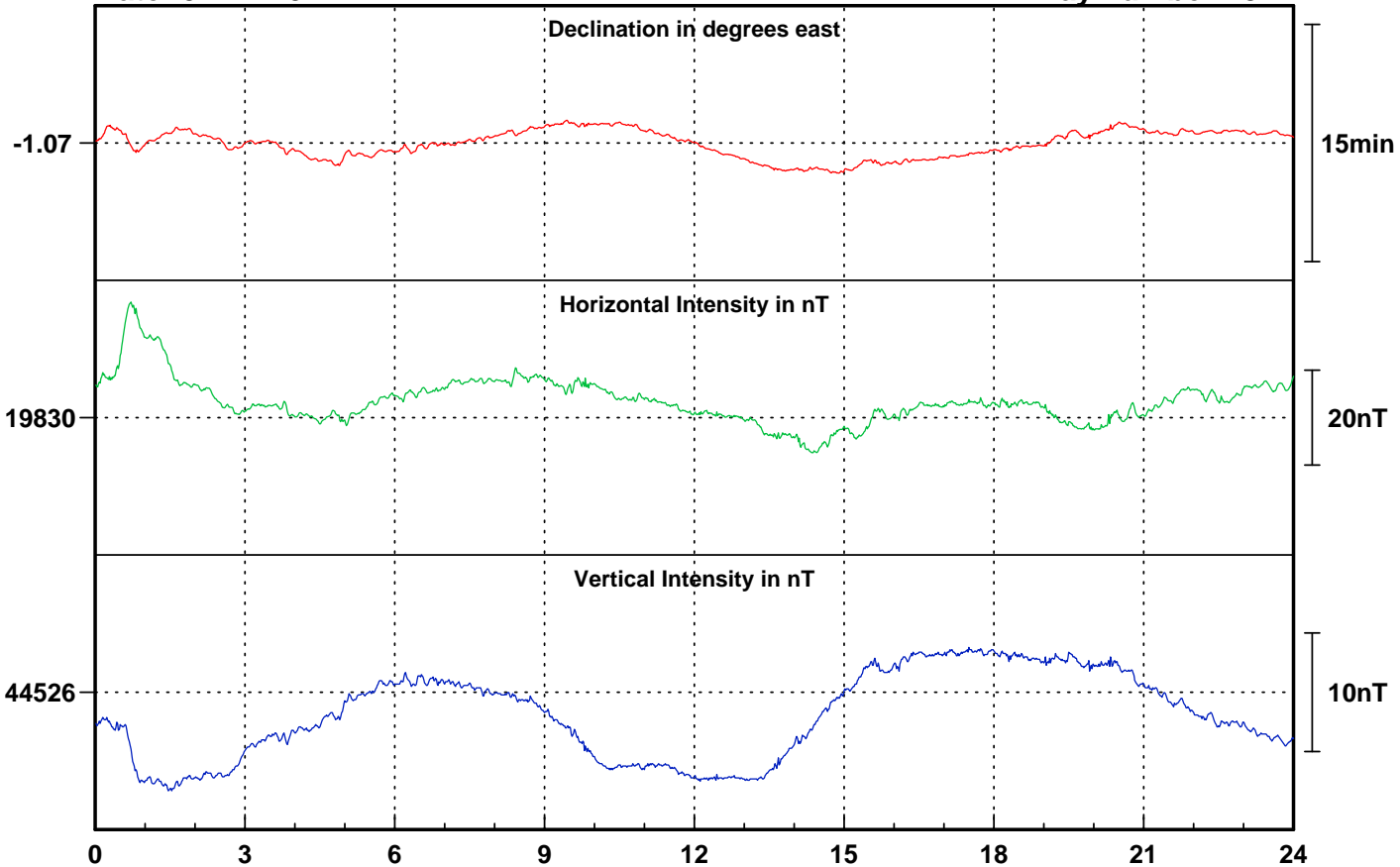


Hour (UT)

Date: 07-12-2021

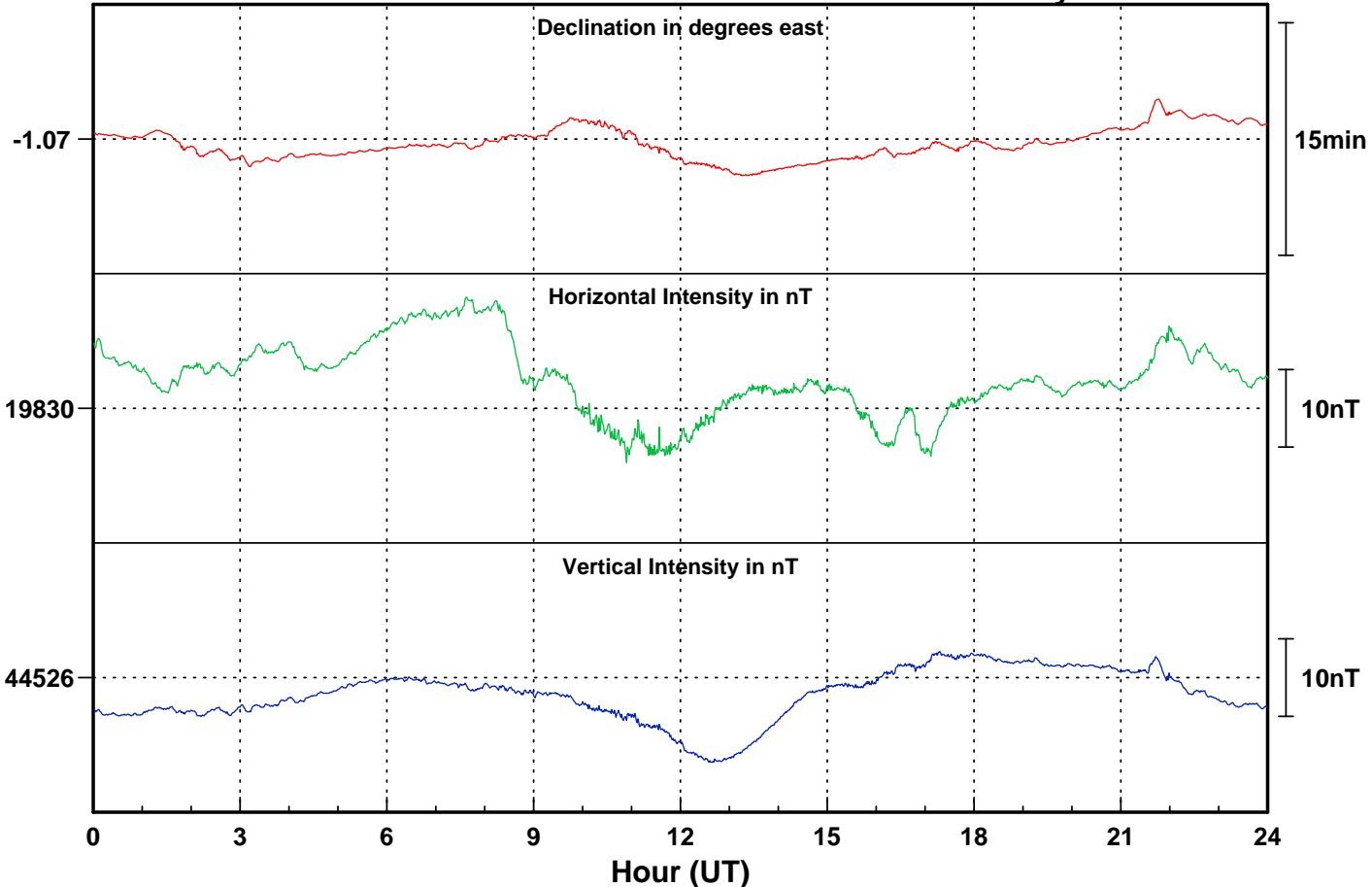
Hartland

Day number: 341



Date: 08-12-2021

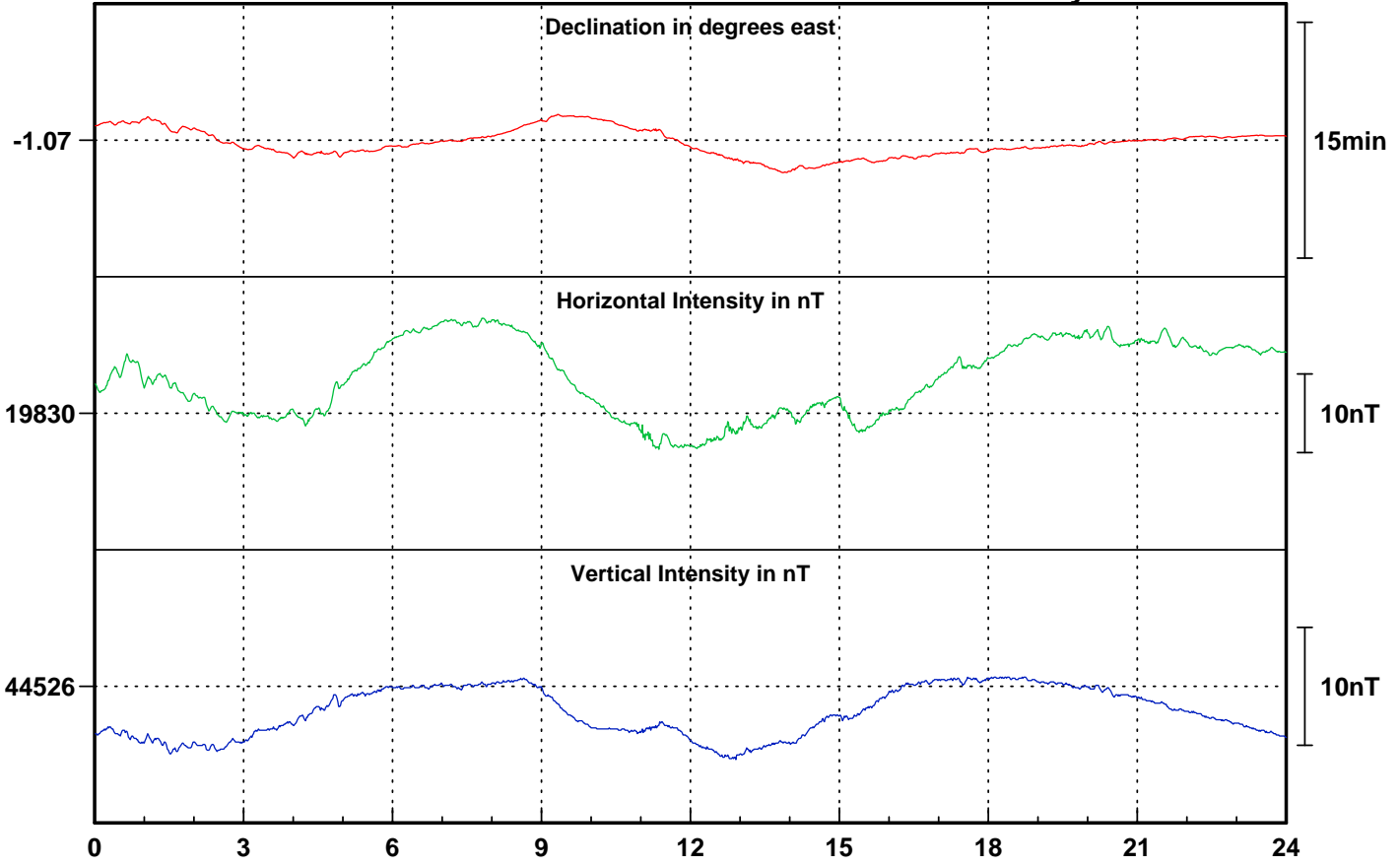
Day number: 342



Date: 09-12-2021

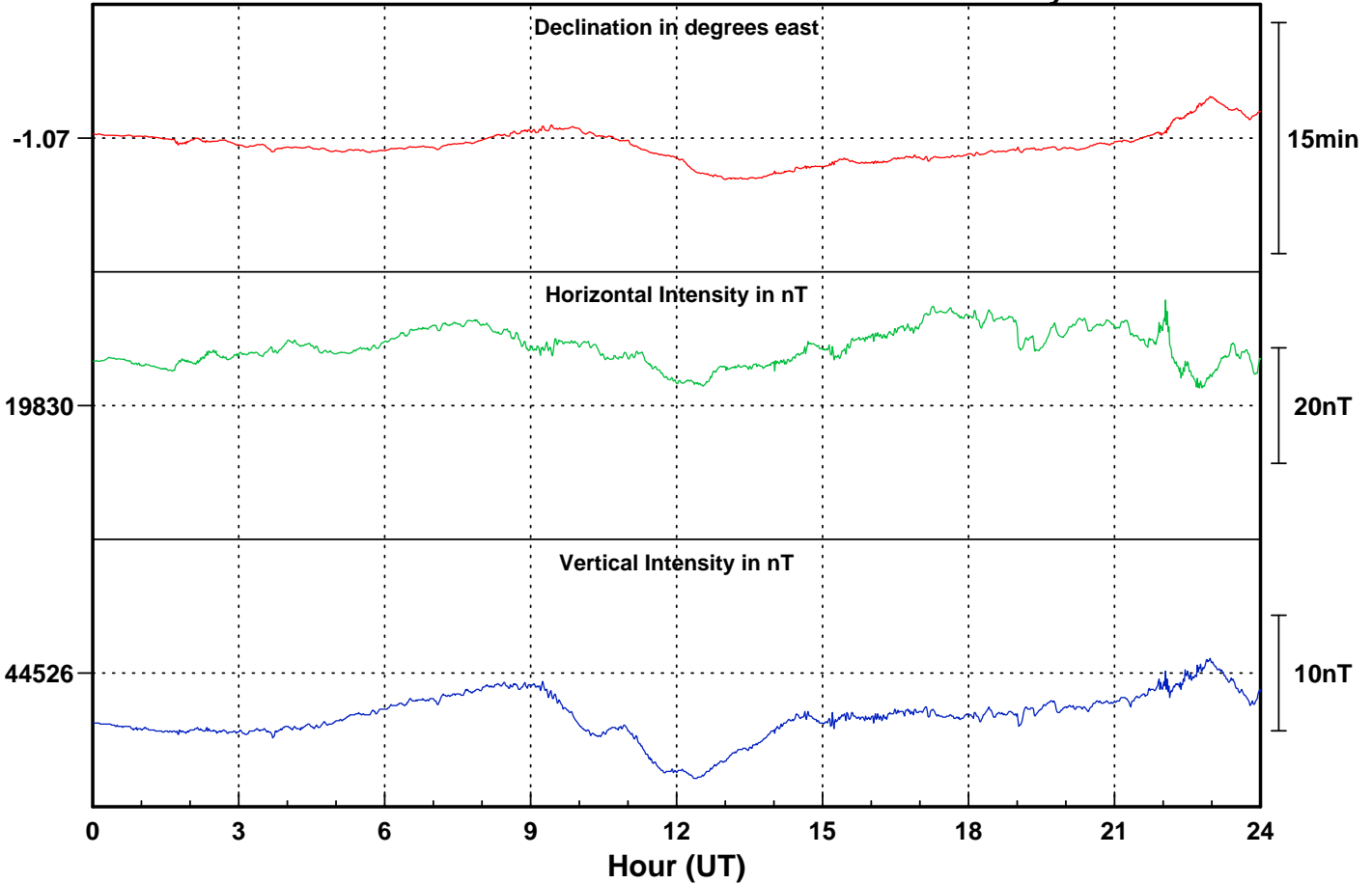
Hartland

Day number: 343



Date: 10-12-2021

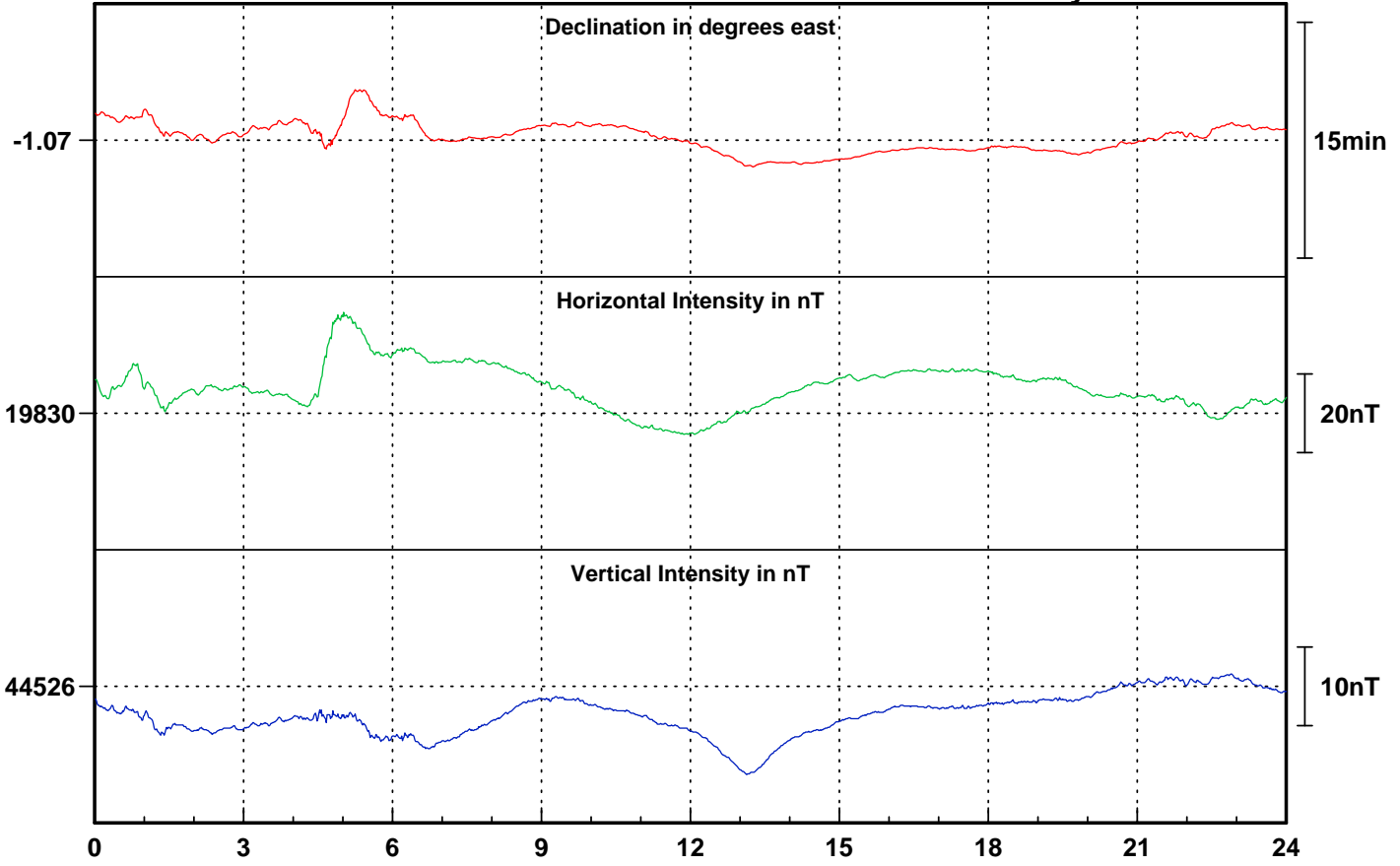
Day number: 344



Date: 11-12-2021

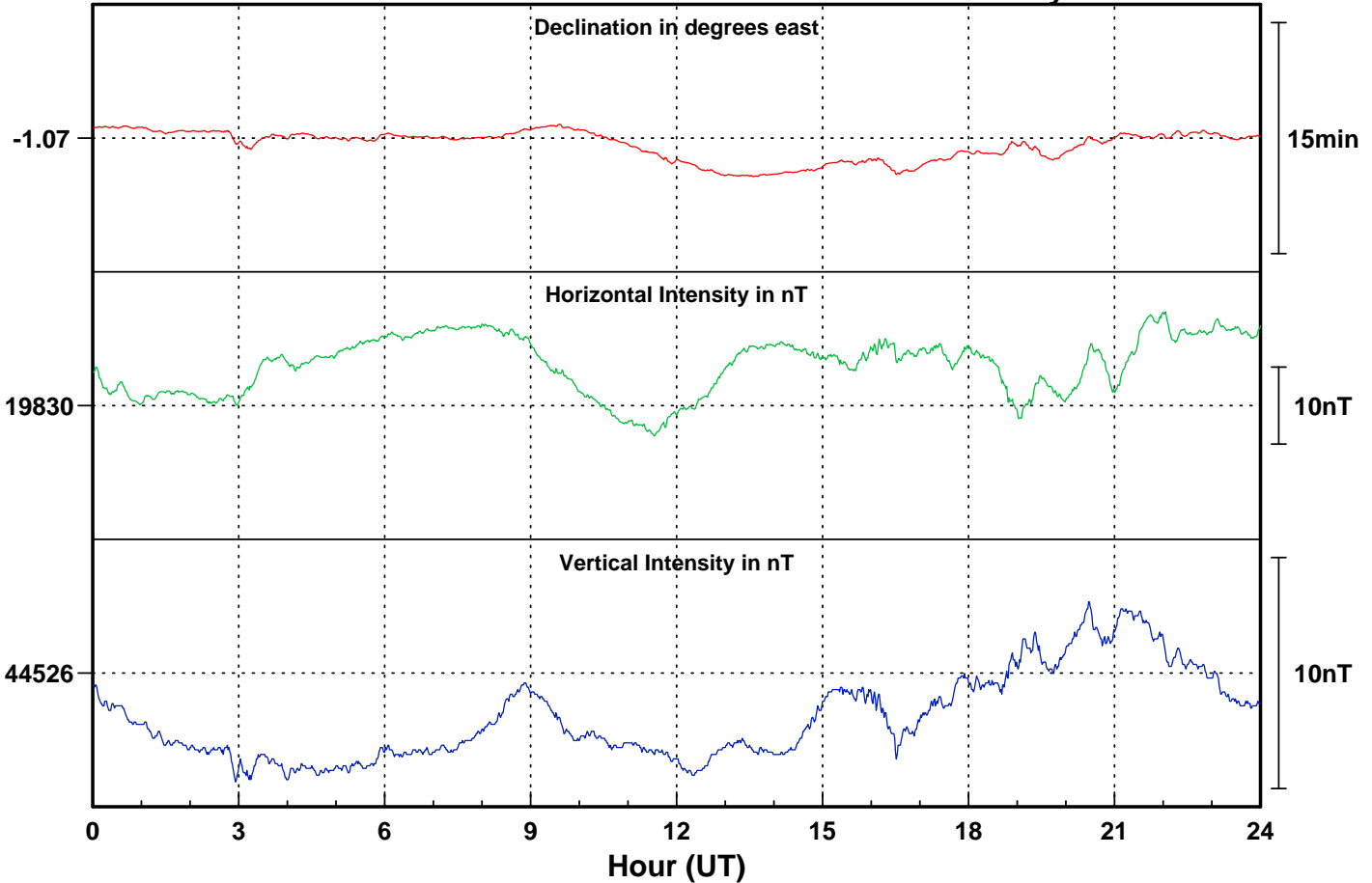
Hartland

Day number: 345



Date: 12-12-2021

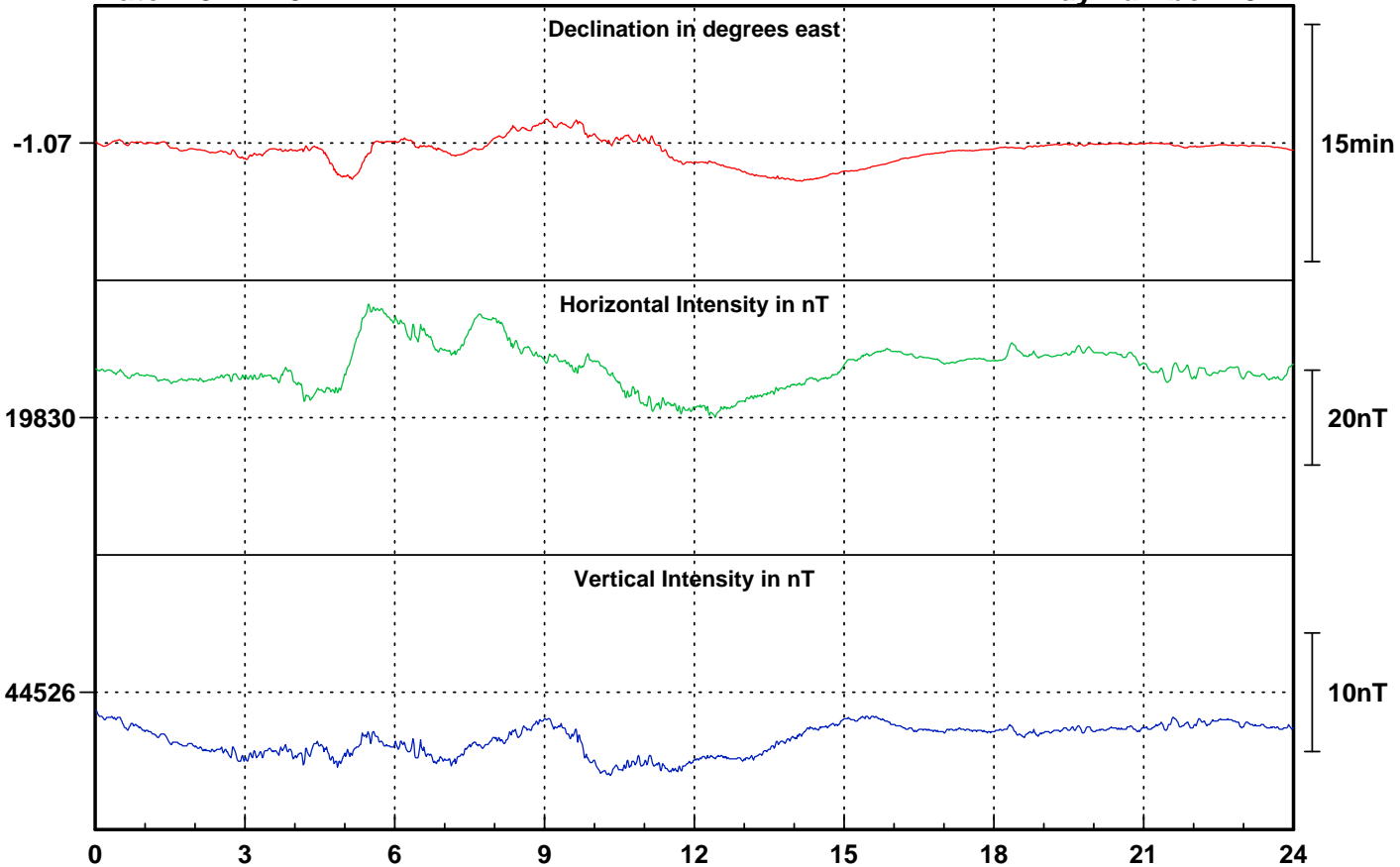
Day number: 346



Date: 13-12-2021

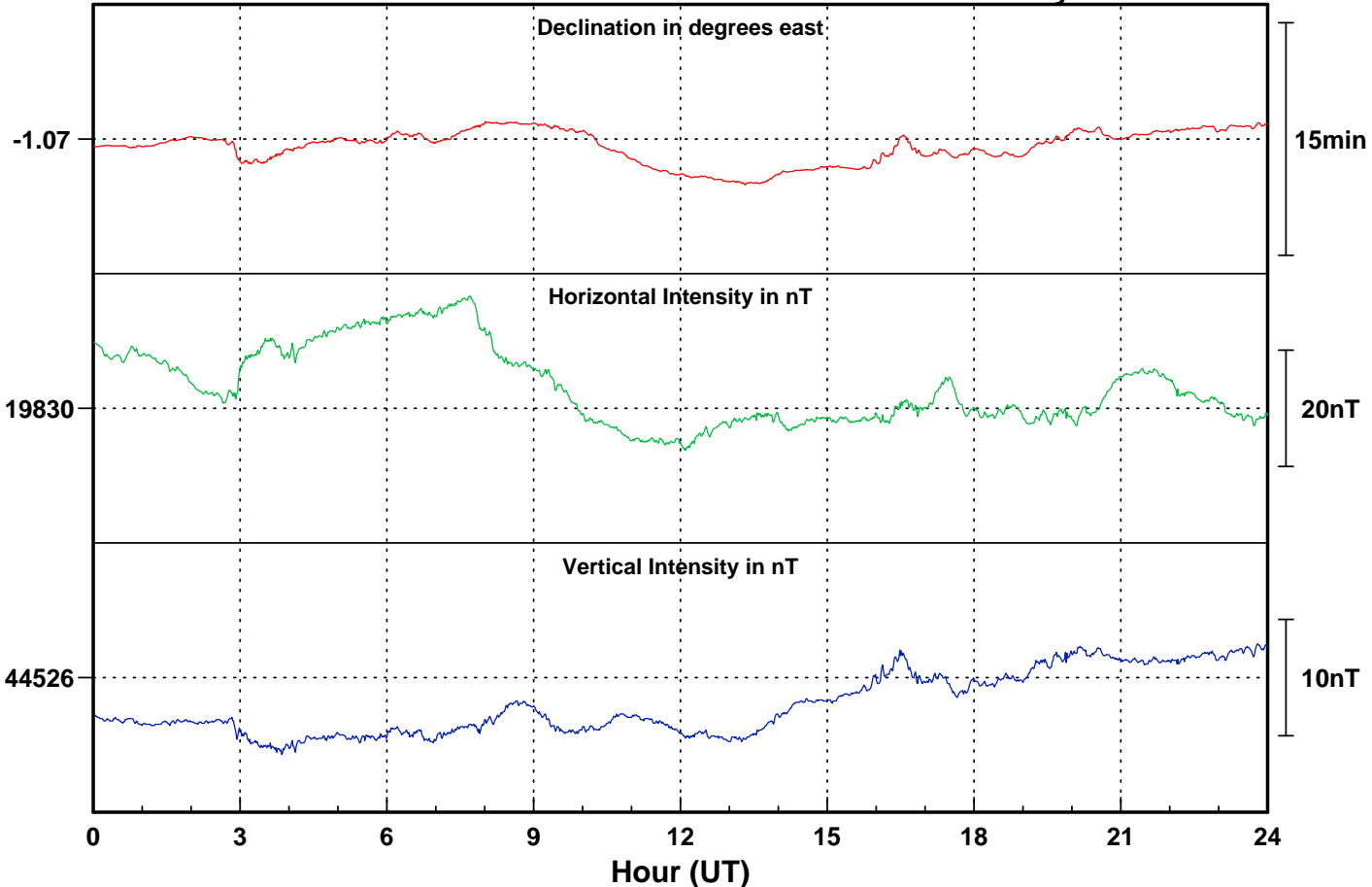
Hartland

Day number: 347



Date: 14-12-2021

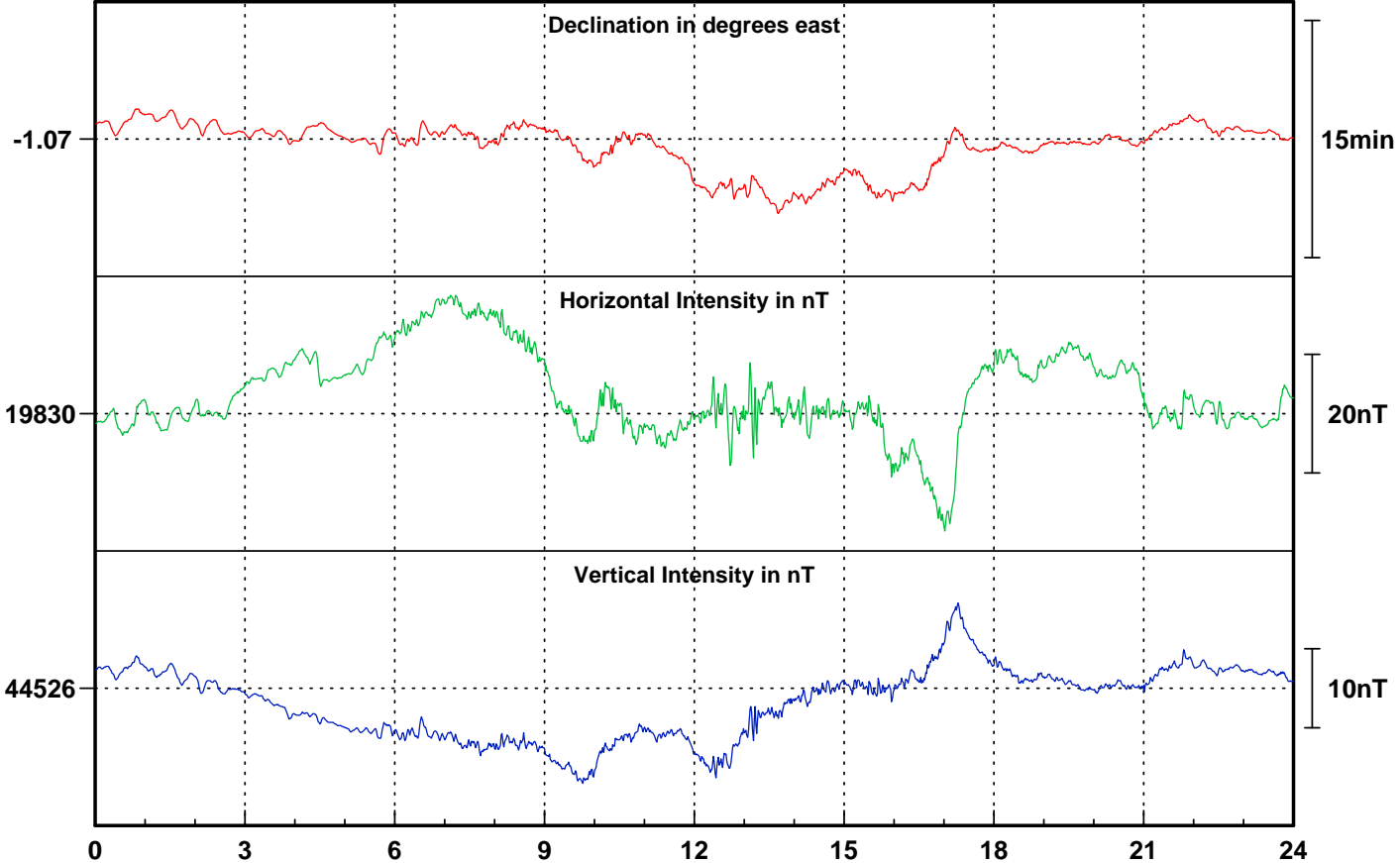
Day number: 348



Date: 15-12-2021

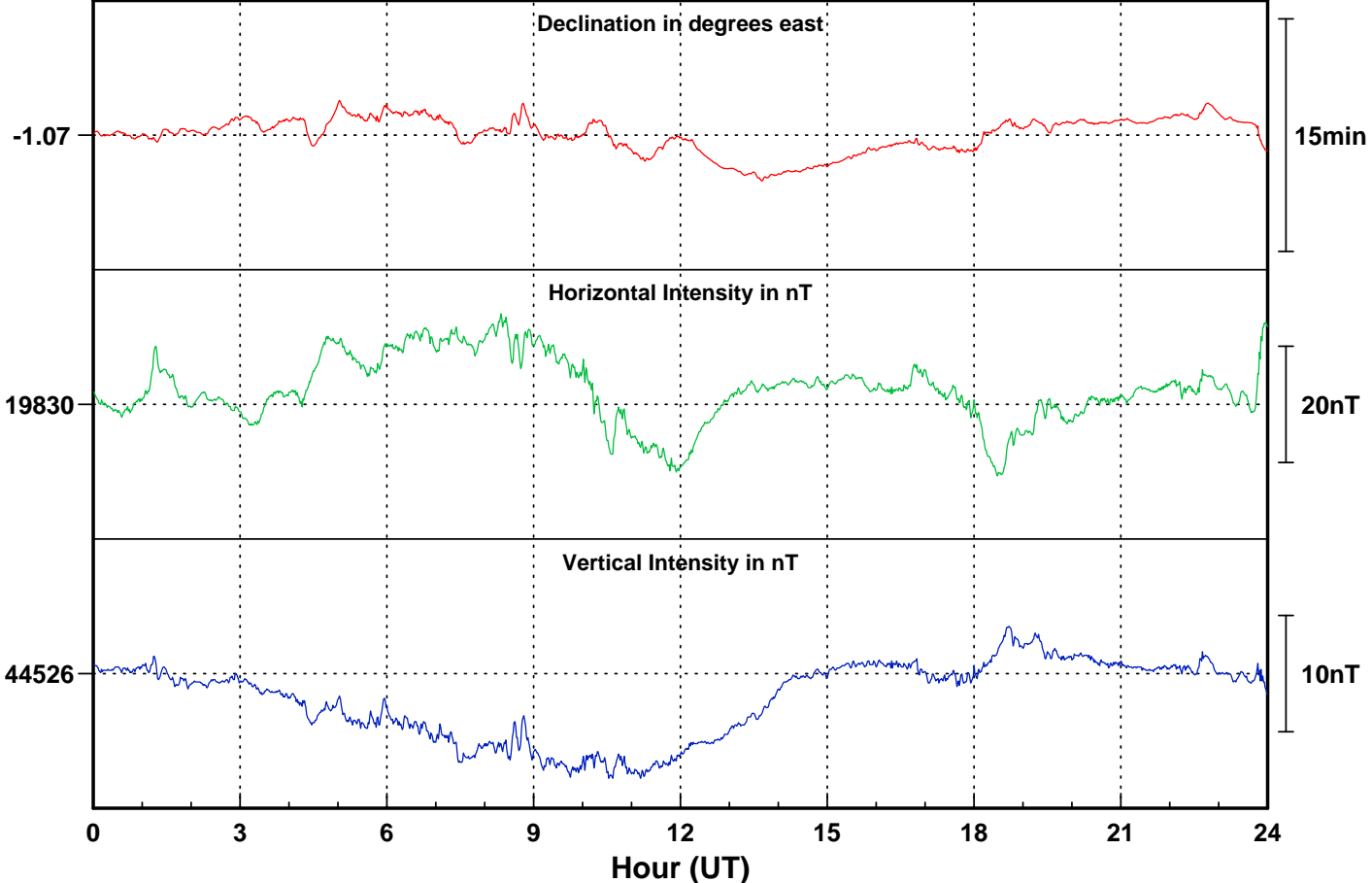
Hartland

Day number: 349



Date: 16-12-2021

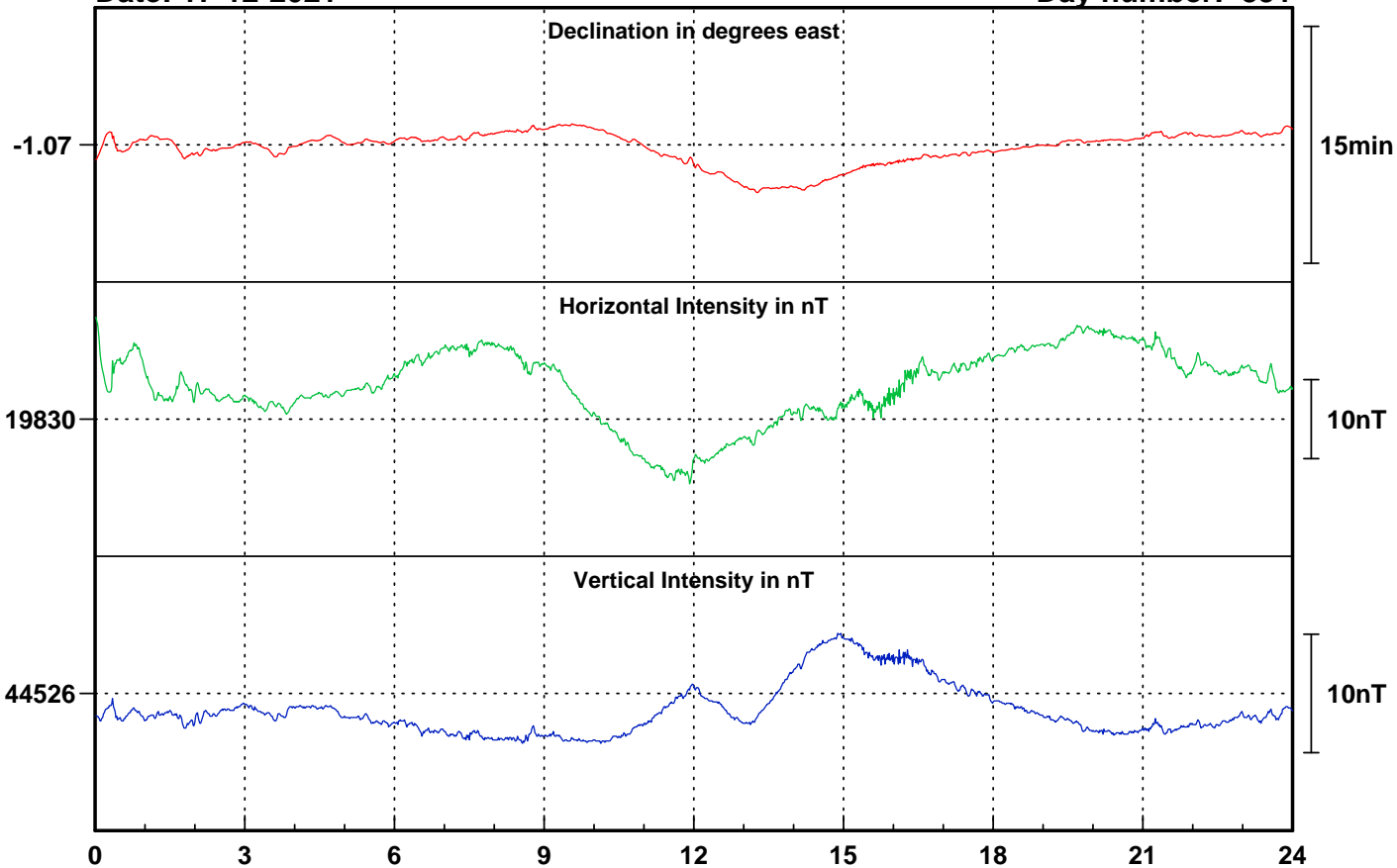
Day number: 350



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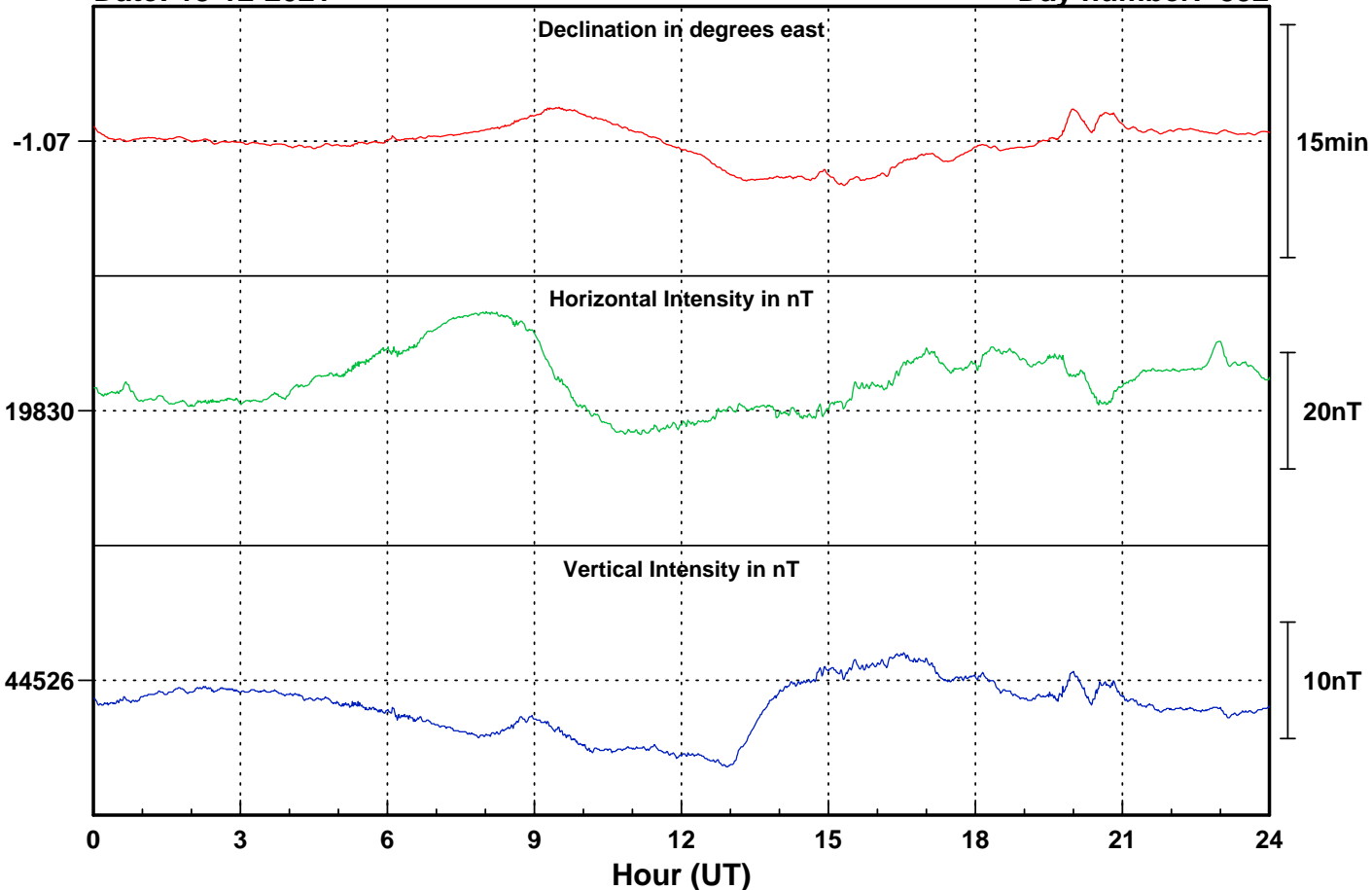
Hartland

Day number: 351



Date: 18-12-2021

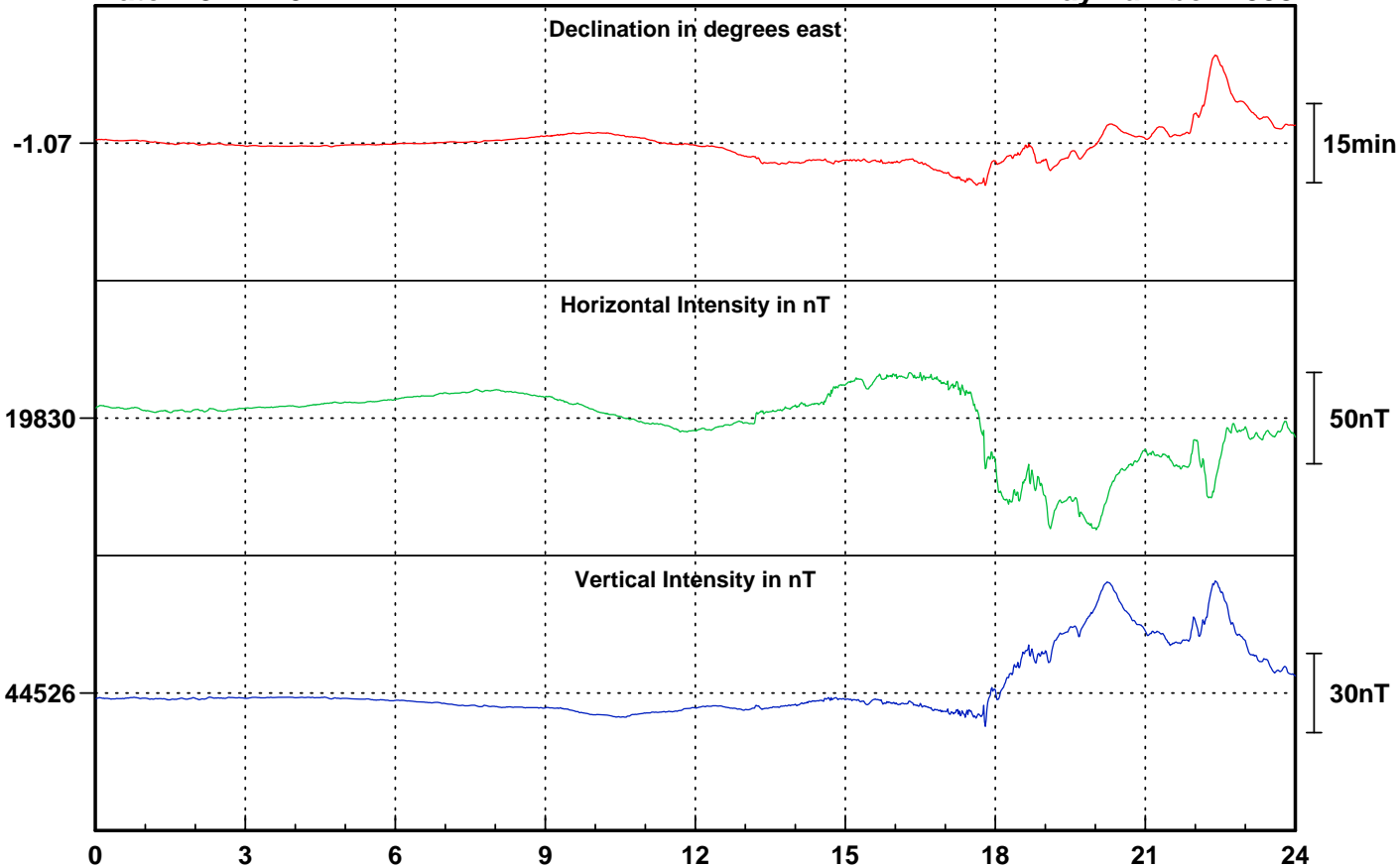
Day number: 352



Date: 19-12-2021

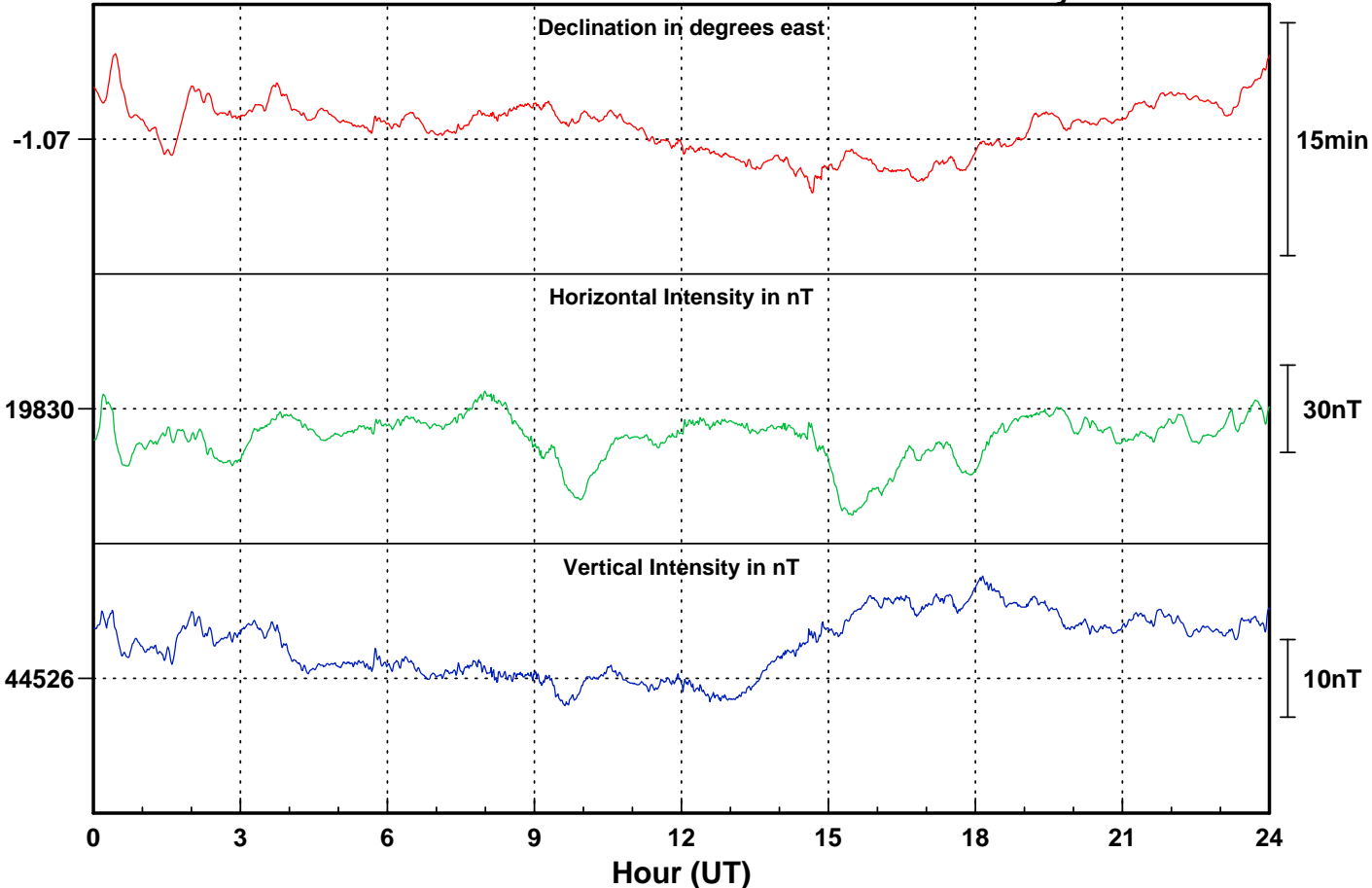
Hartland

Day number: 353



Date: 20-12-2021

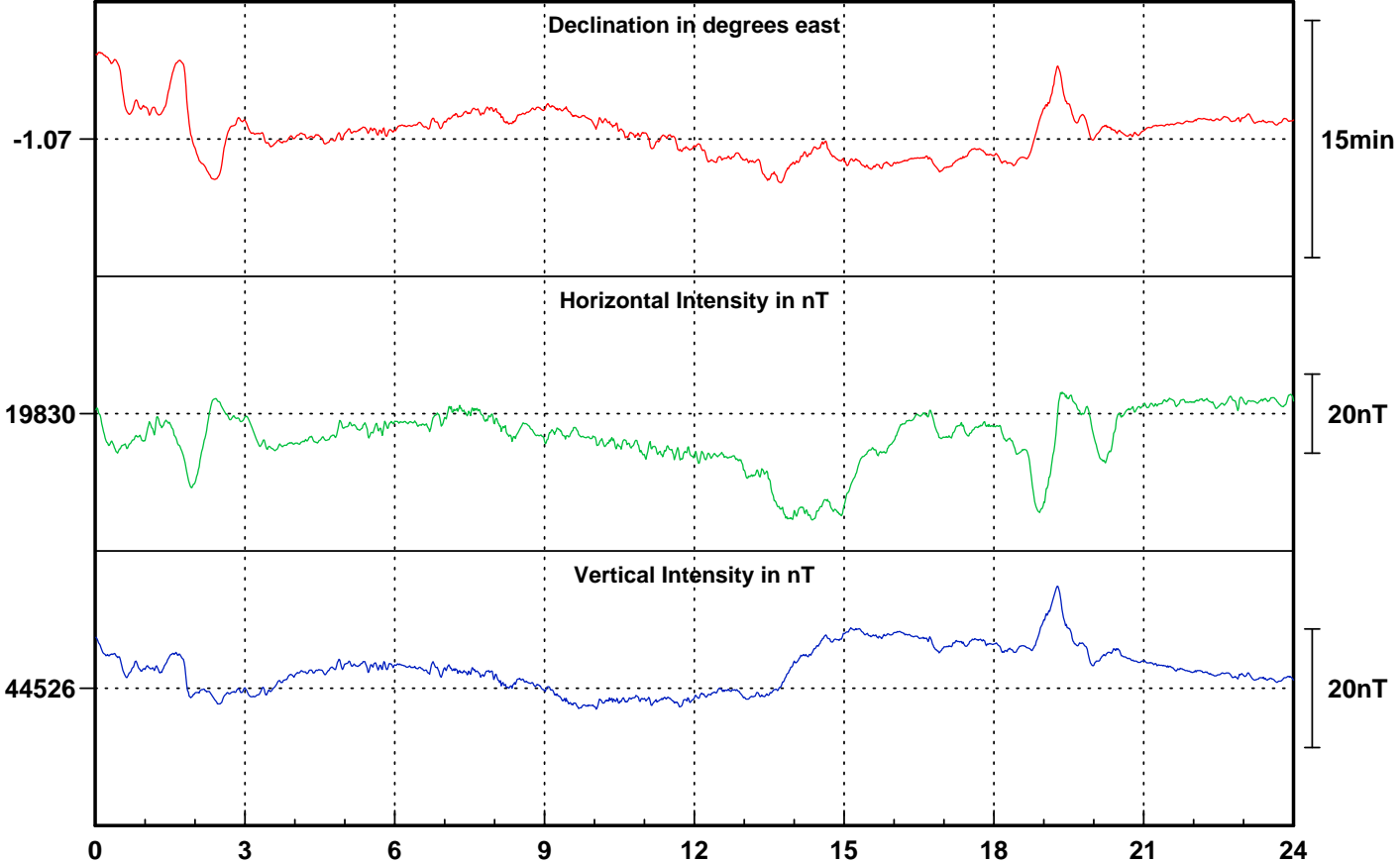
Day number: 354



Date: 21-12-2021

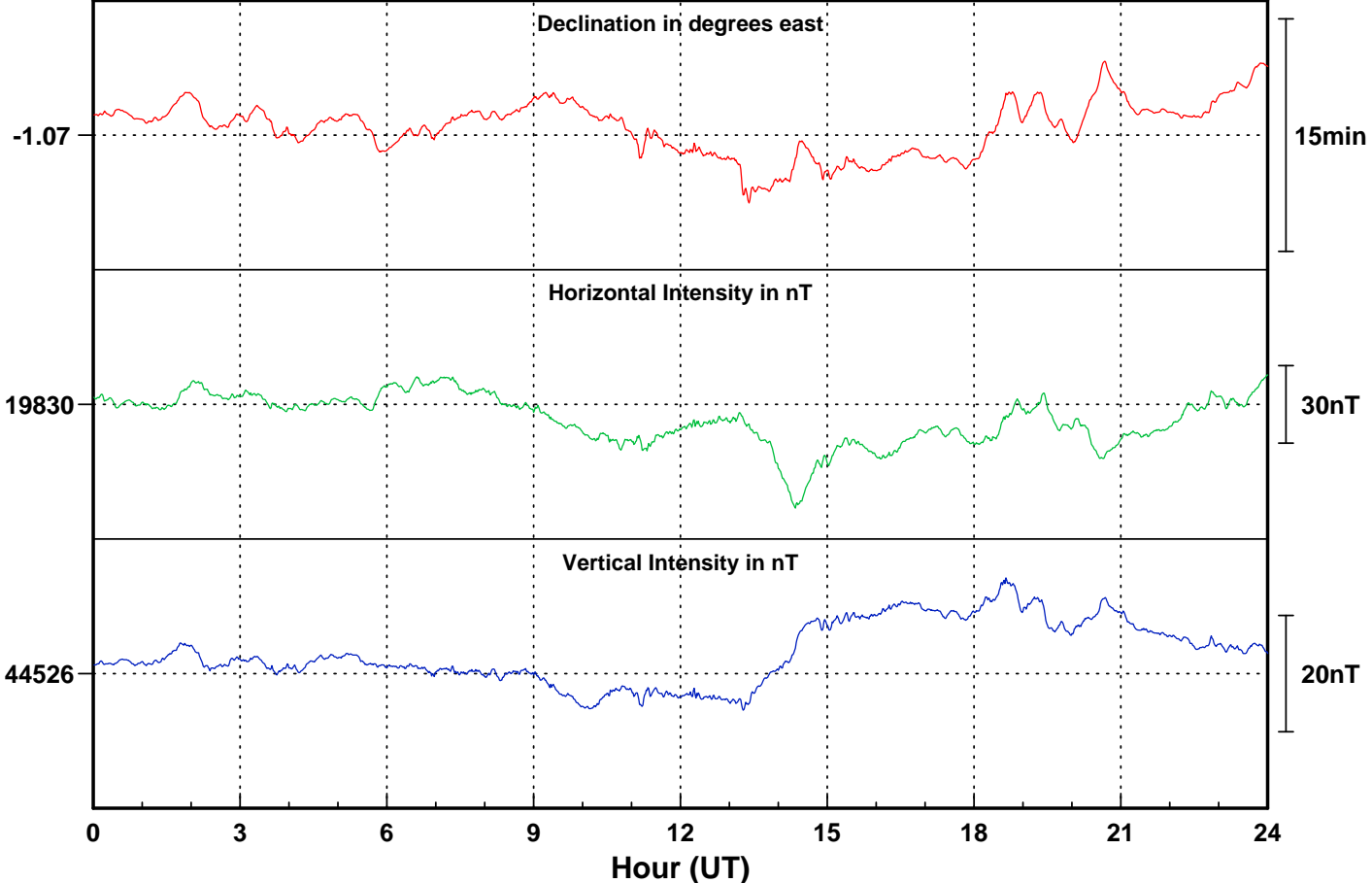
Hartland

Day number: 355



Date: 22-12-2021

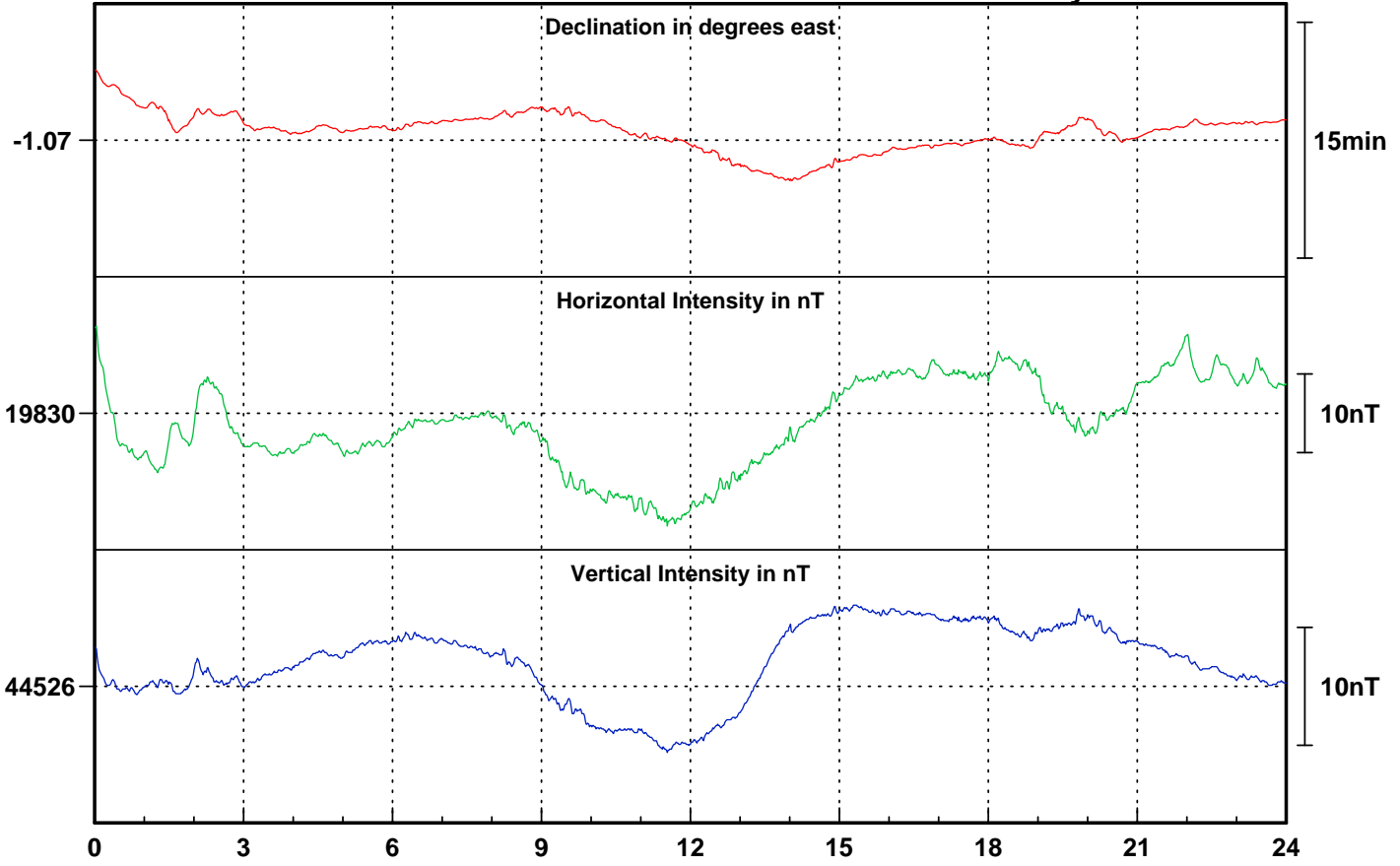
Day number: 356



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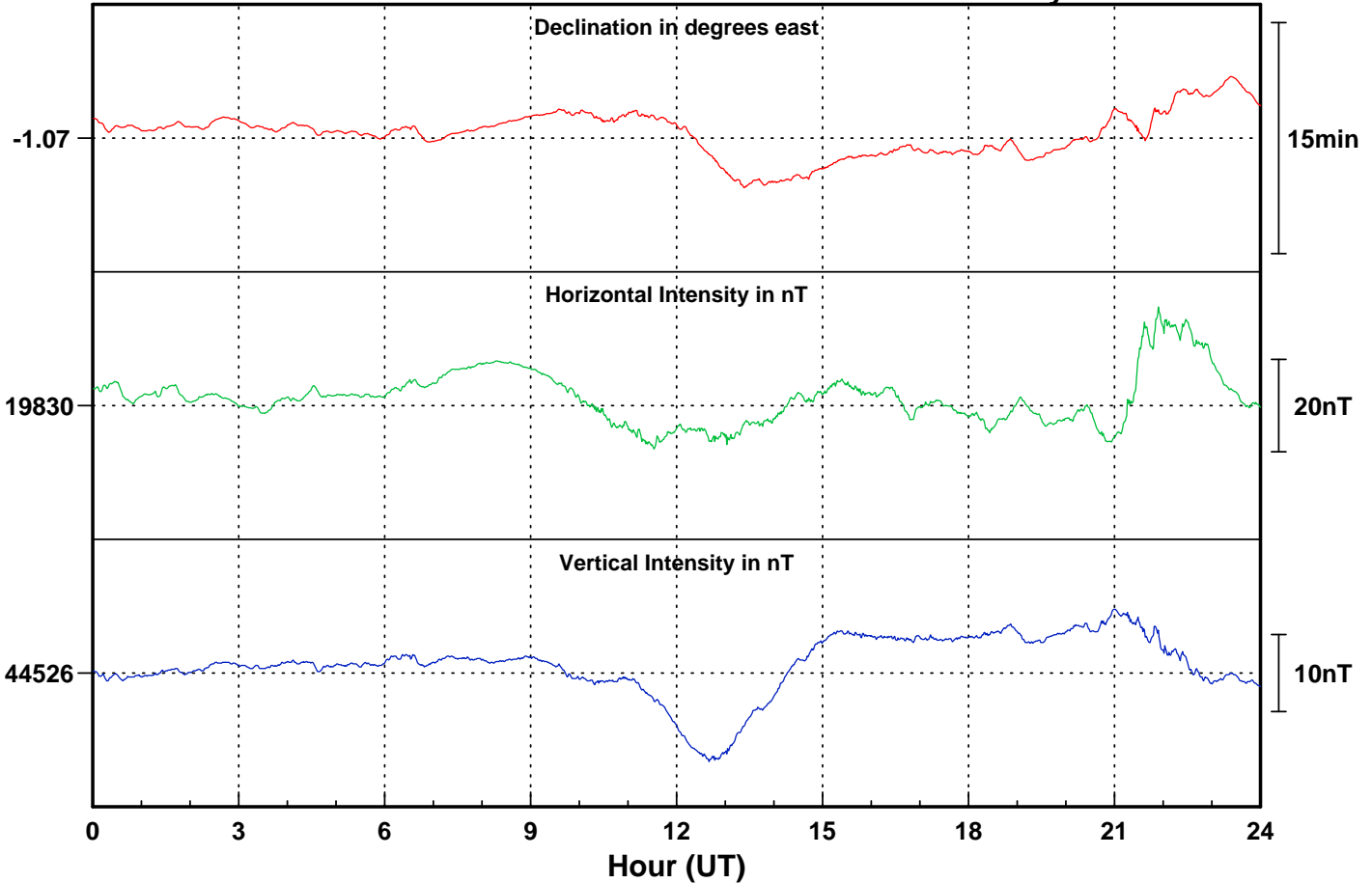
Hartland

Day number: 357



Date: 24-12-2021

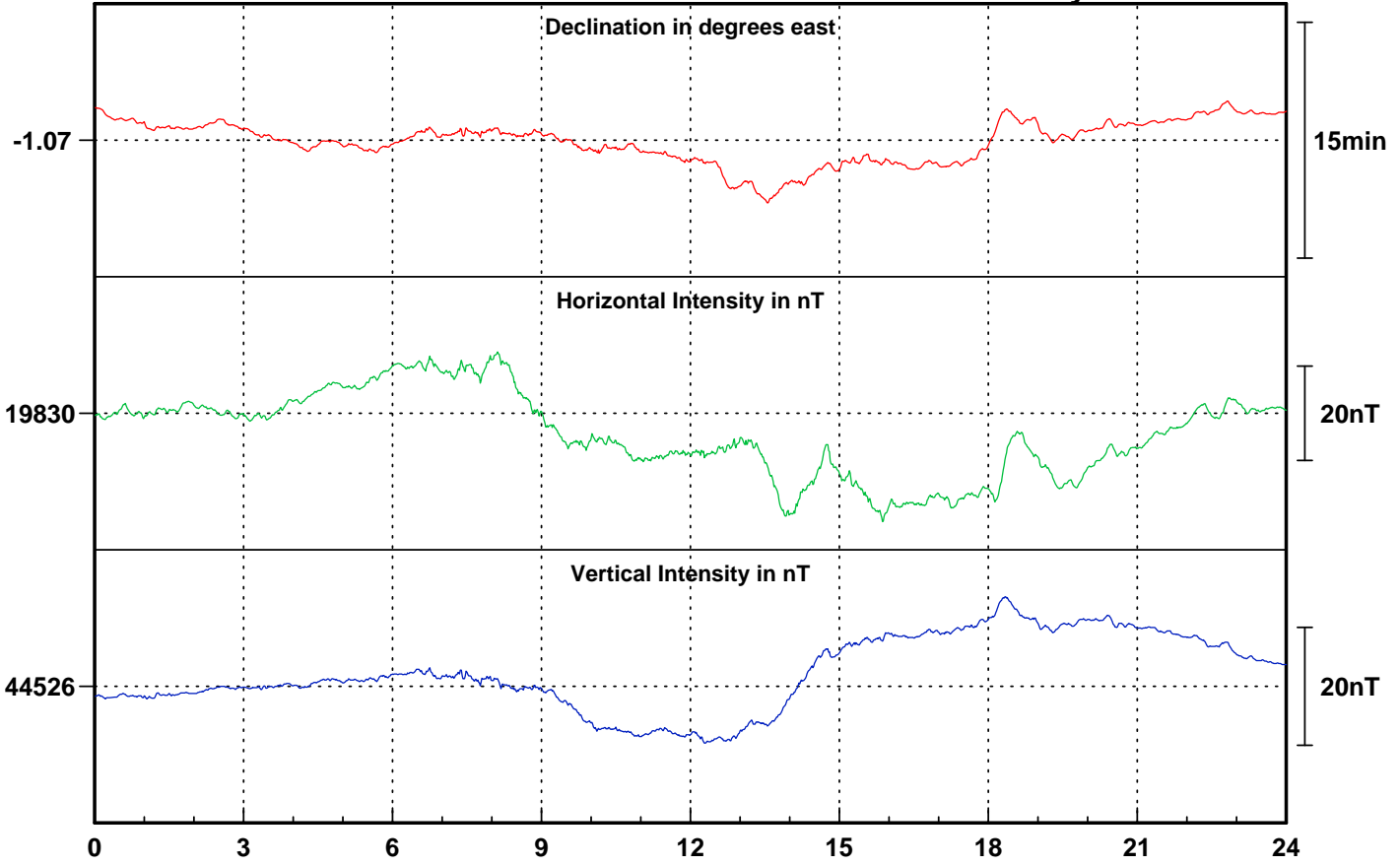
Day number: 358



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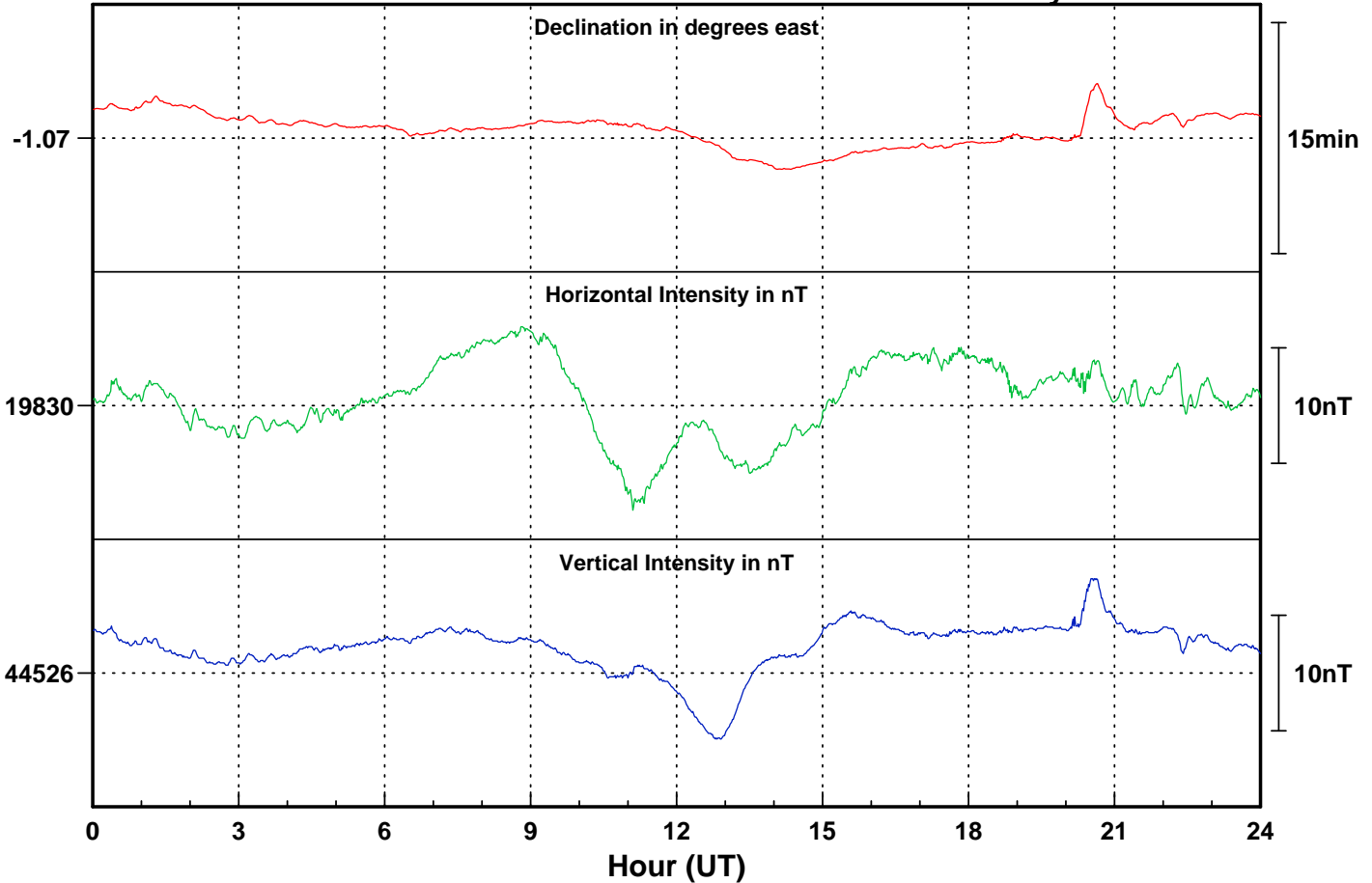
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Day number: 359



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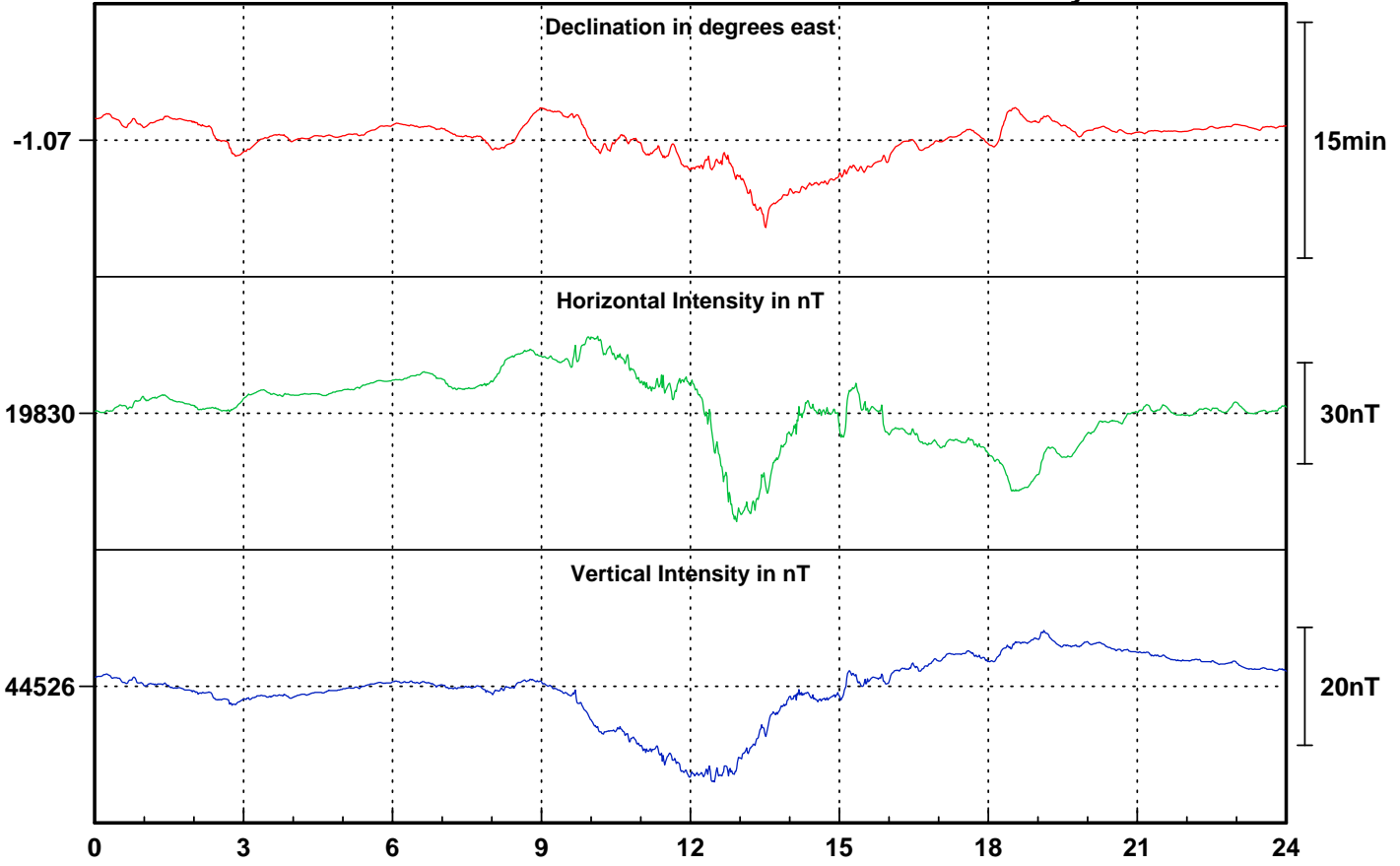
Day number: 360



Date: 27-12-2021

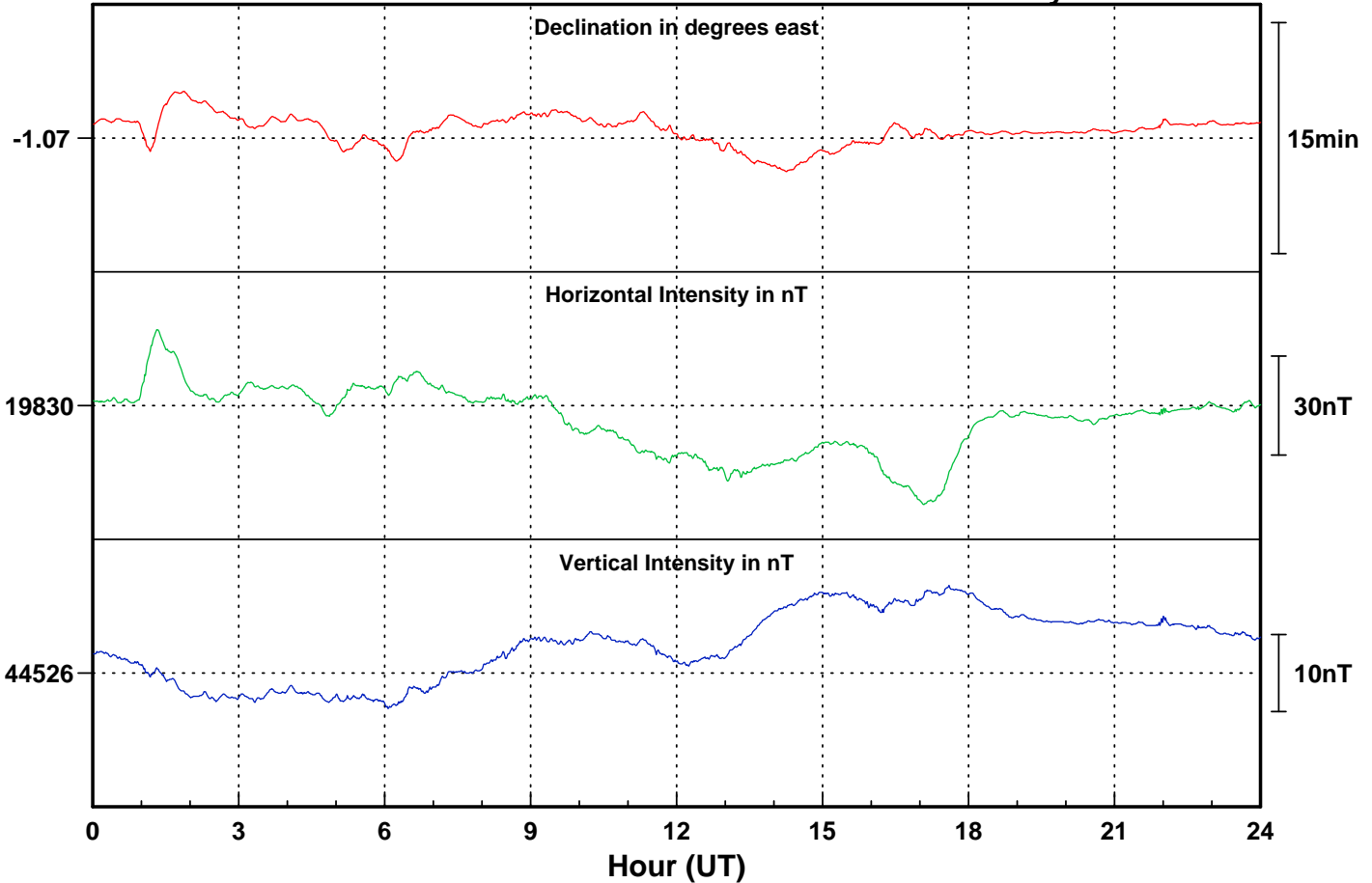
Hartland

Day number: 361



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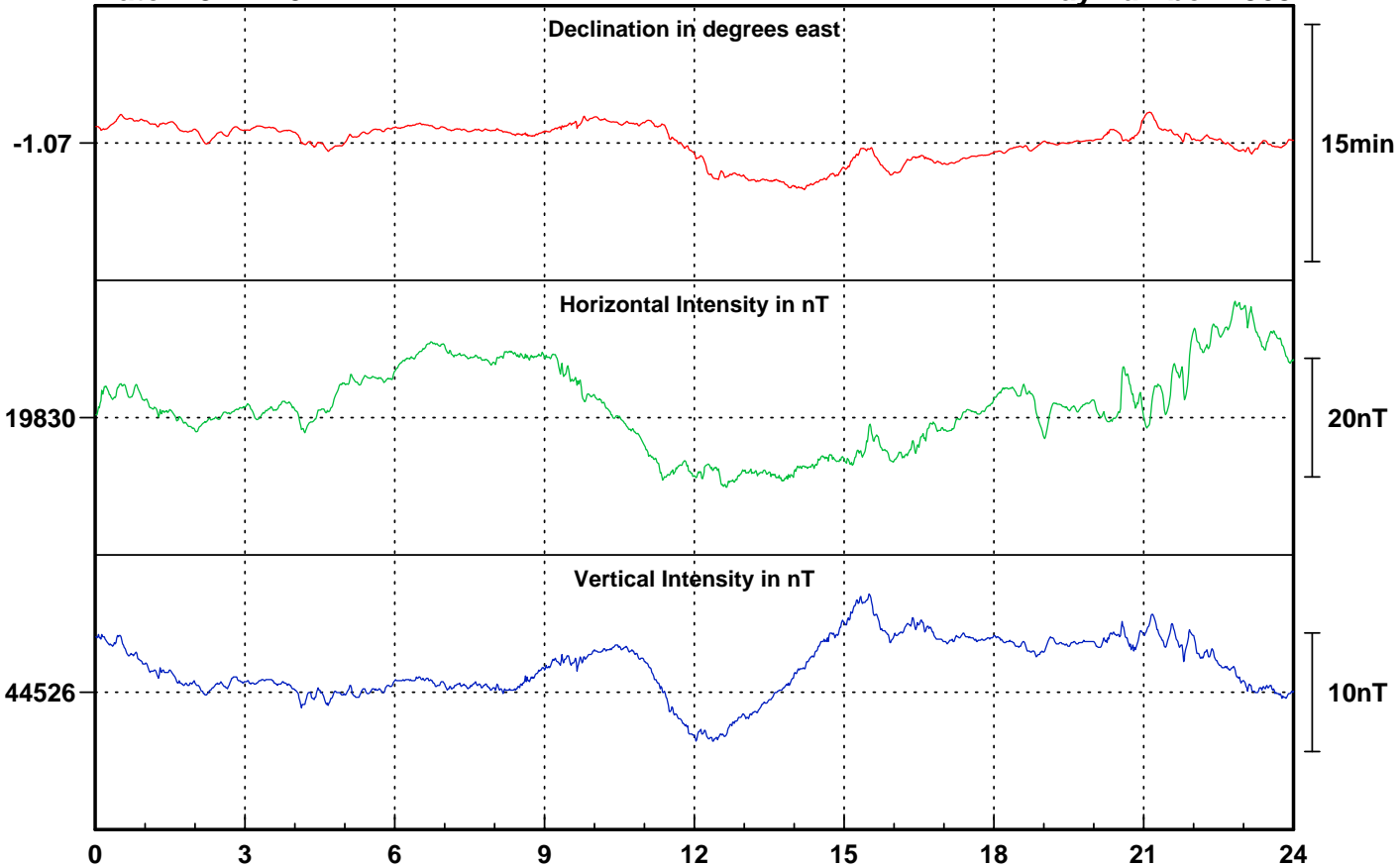
Day number: 362



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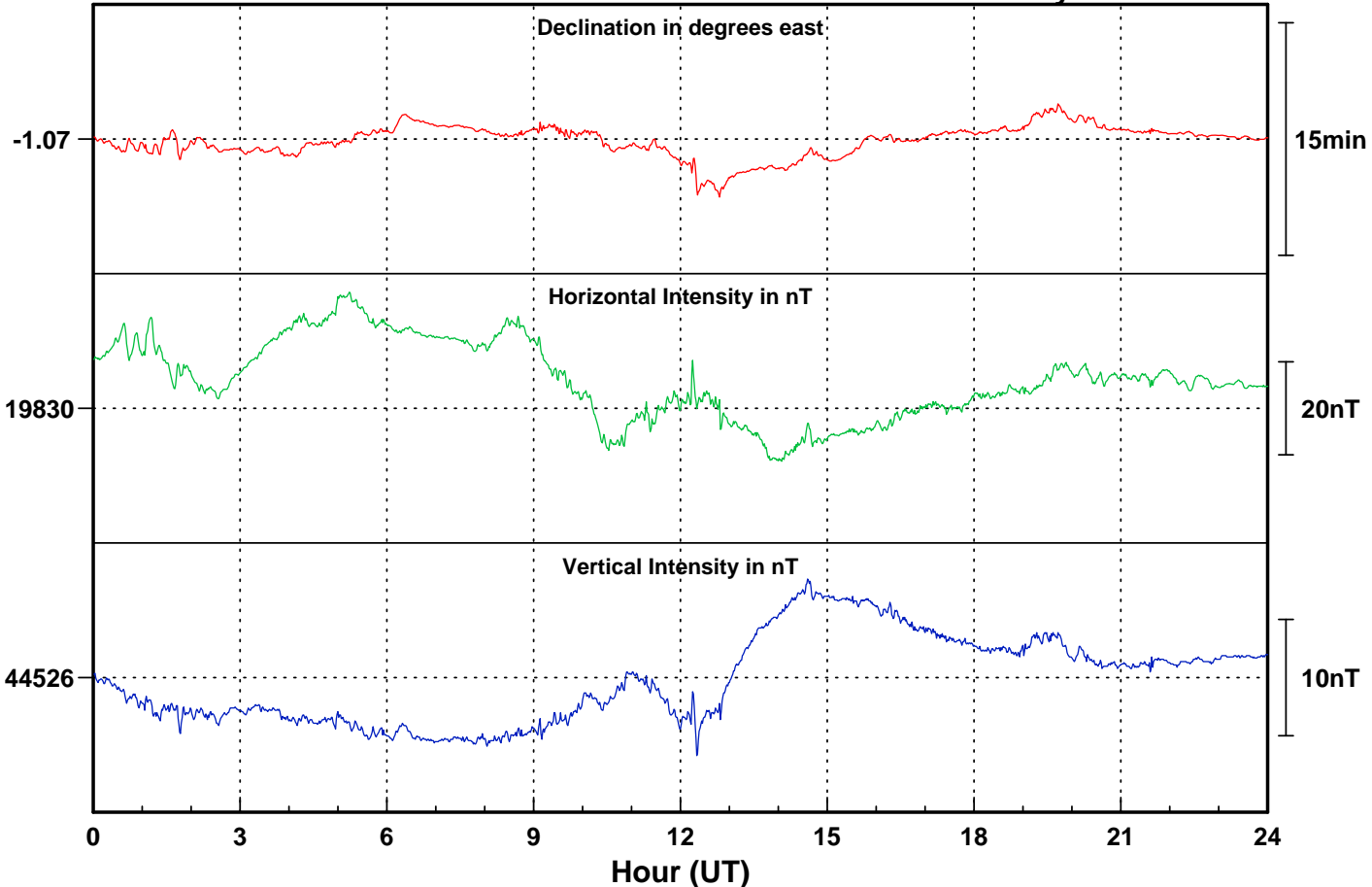
Hartland

Day number: 363



Date: 30-12-2021

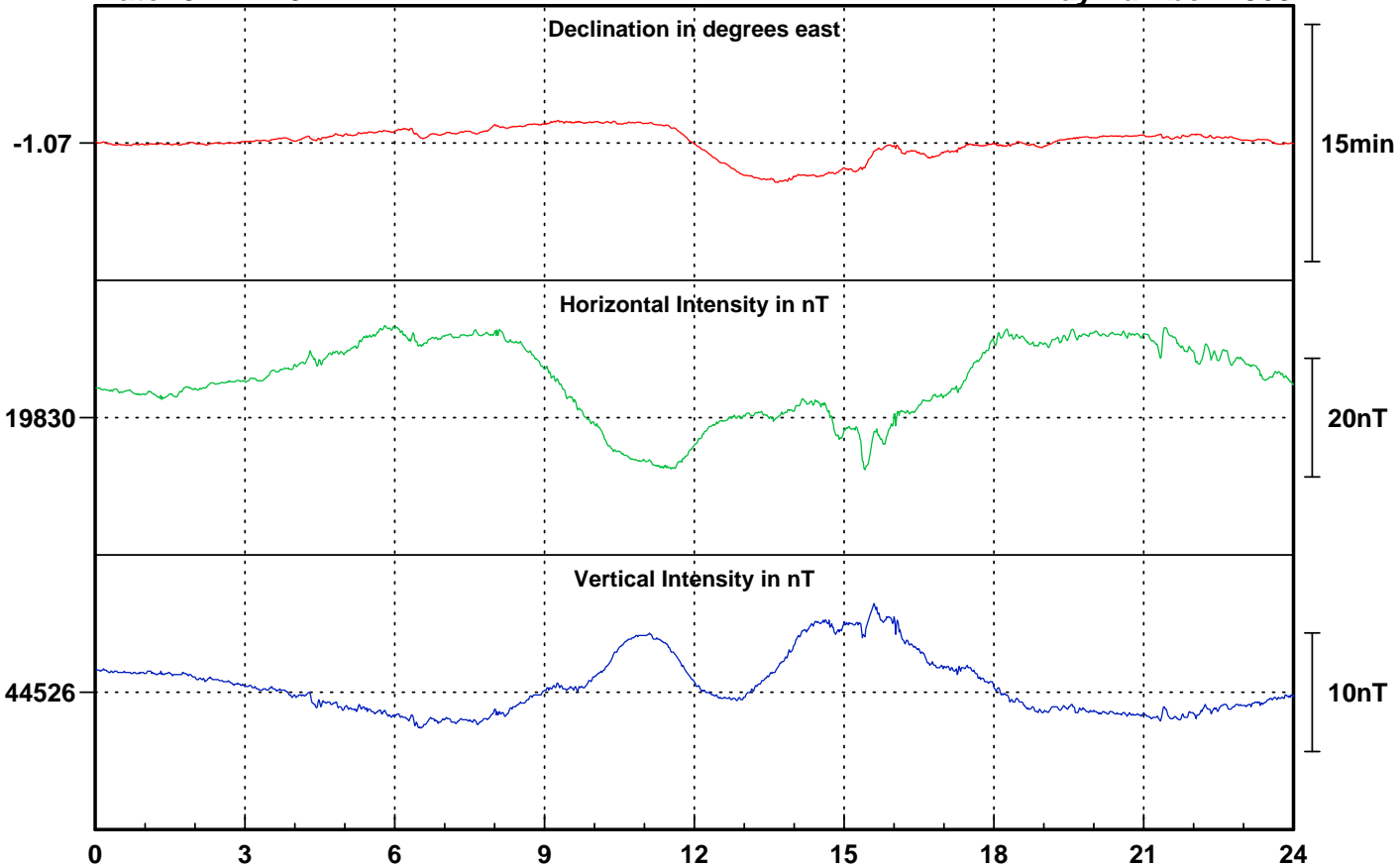
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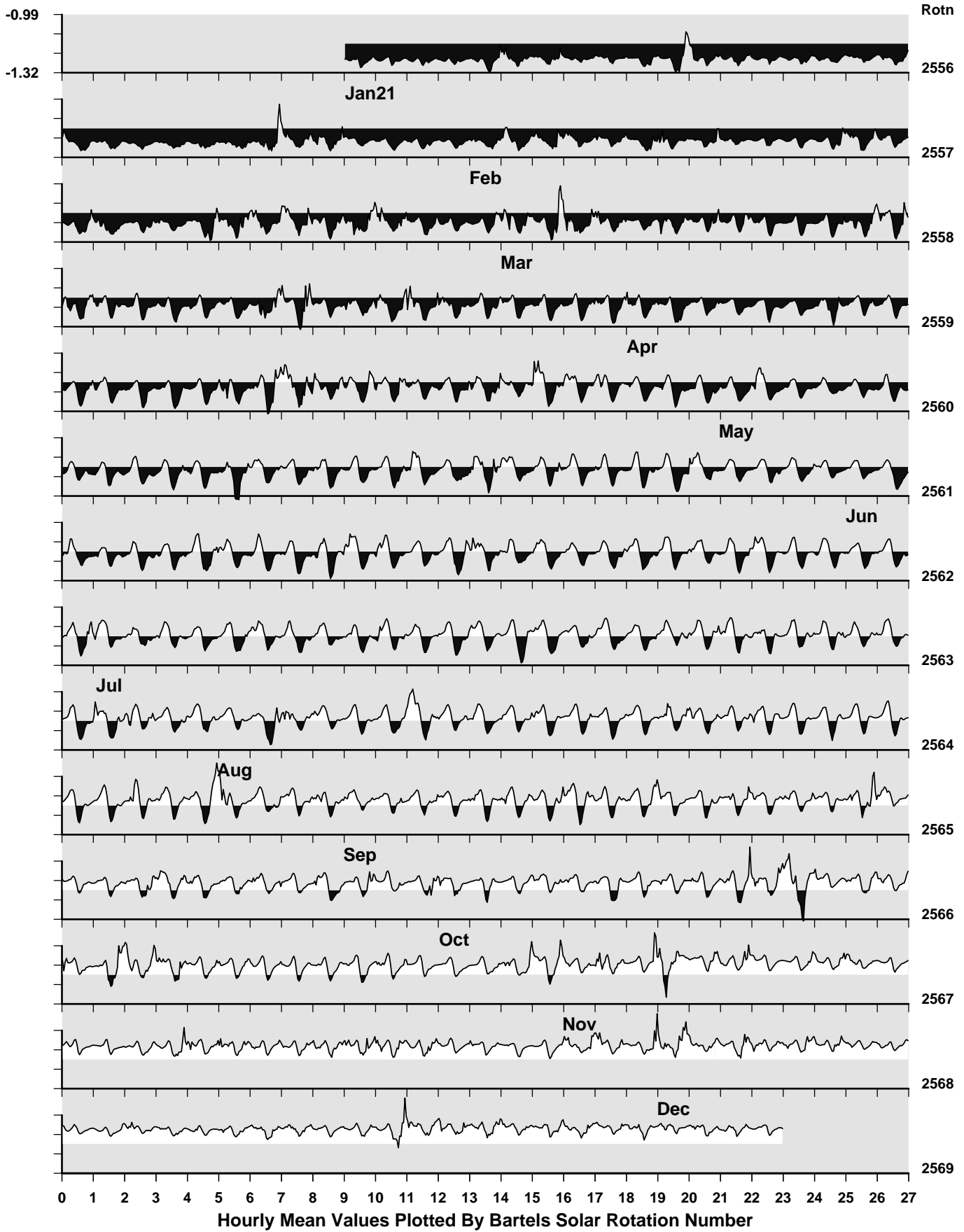
Date: 31-12-2021

Hartland

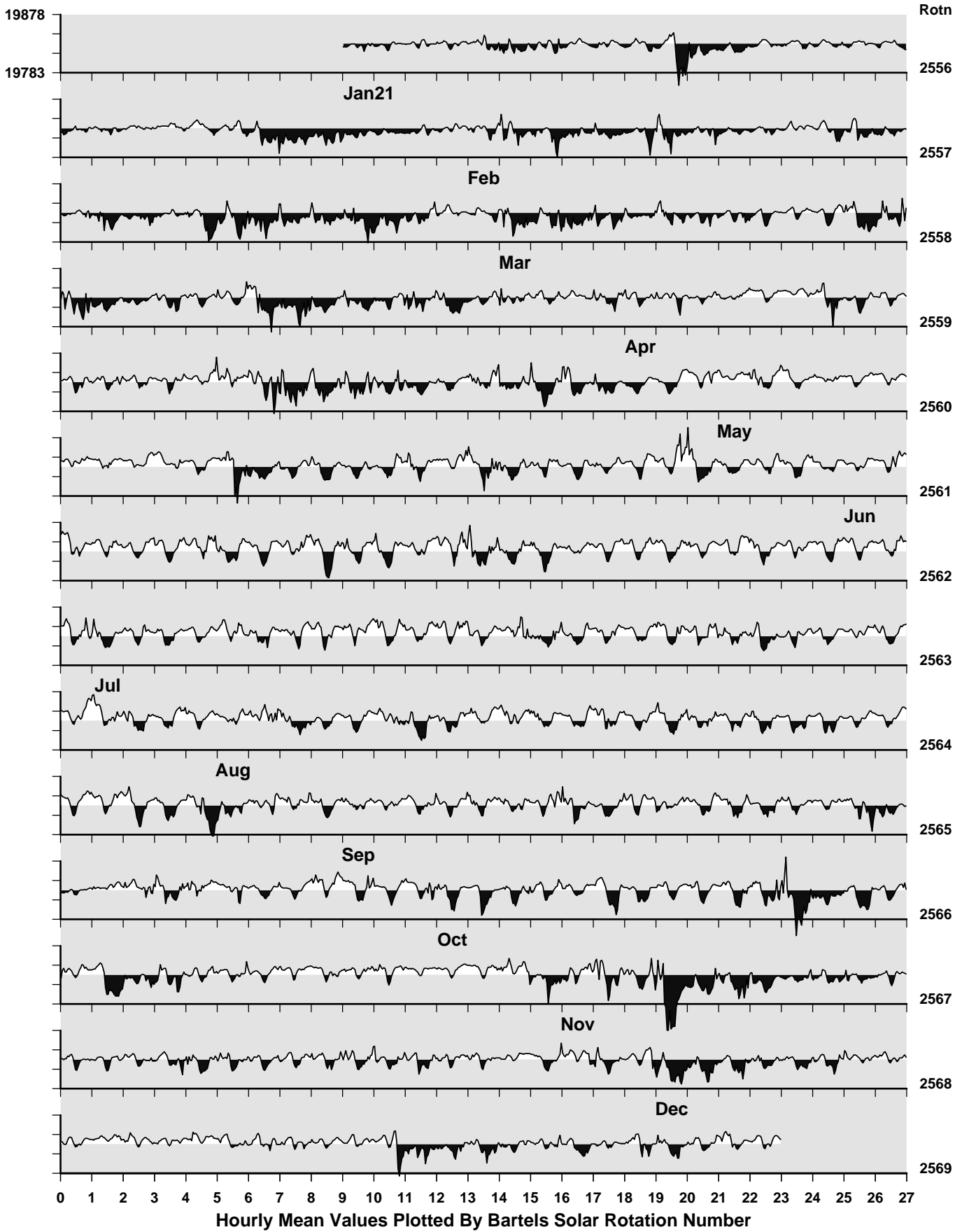
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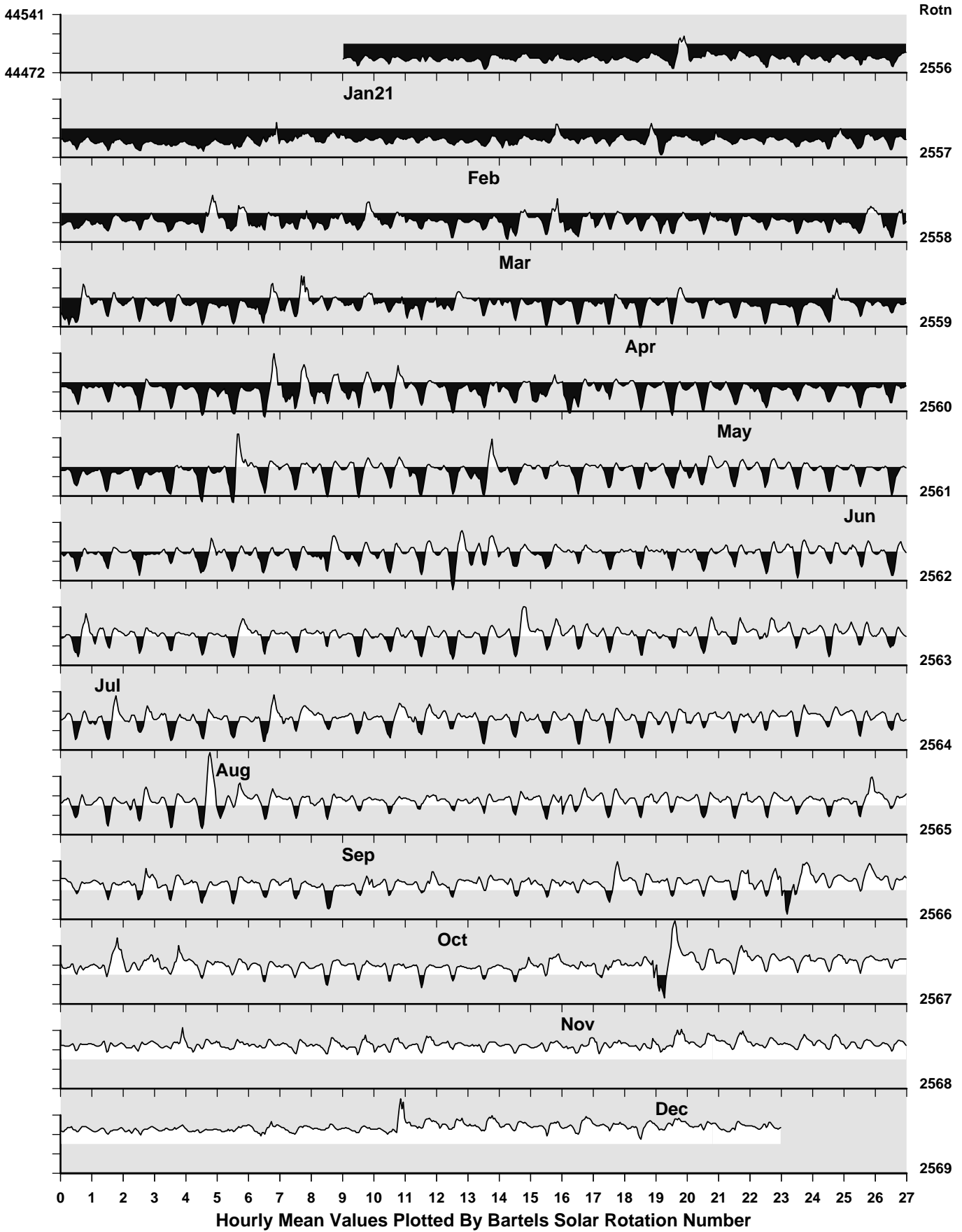
Hartland Observatory: Declination (degrees)



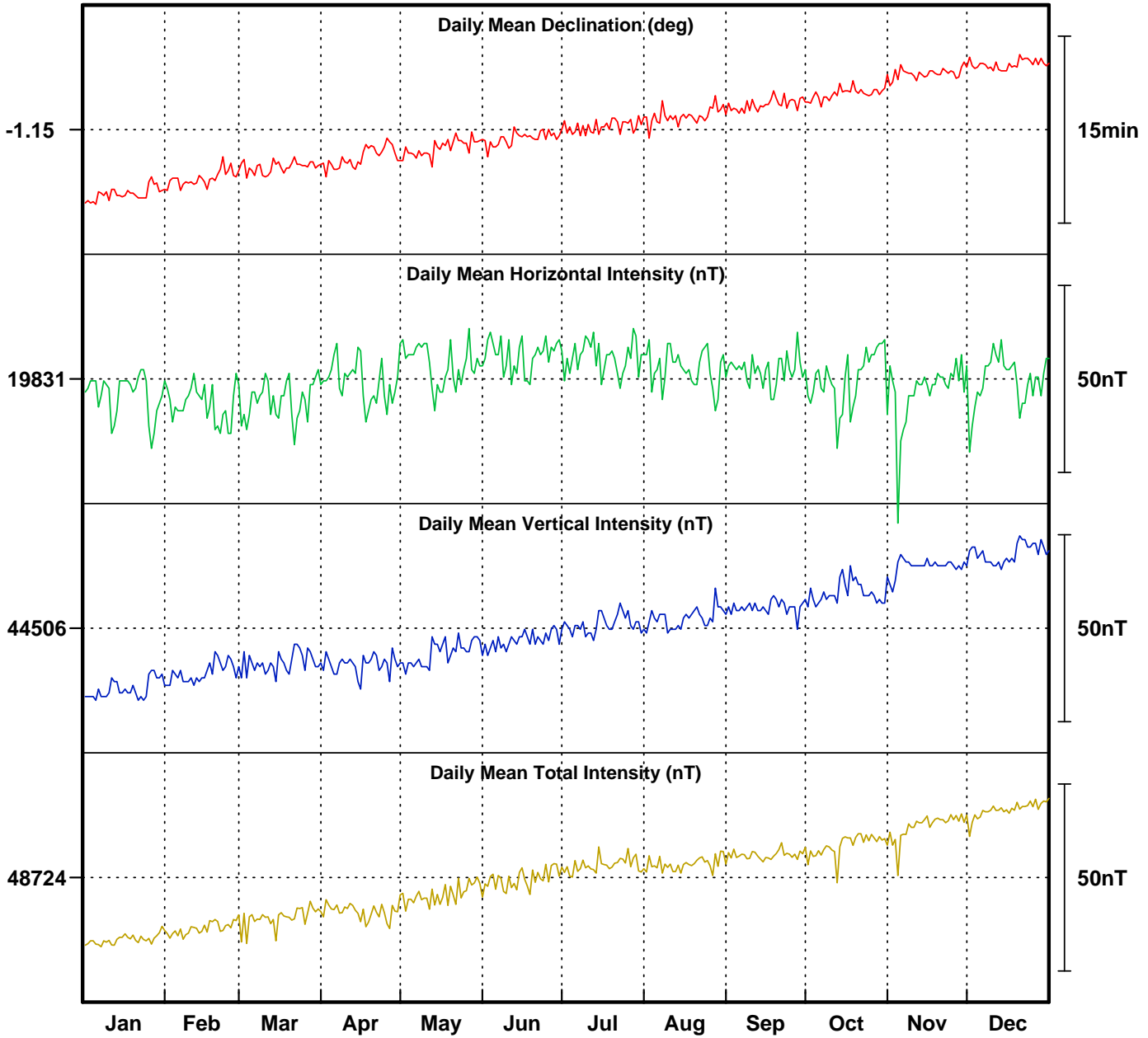
Hartland Observatory: Horizontal Intensity (nT)



Hartland Observatory: Vertical Intensity (nT)



Hartland Observatory 2021



Monthly mean values for Hartland 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° 14.4′	19826 nT	65° 58.8′	19822 nT	-429 nT	44490 nT	48708 nT
February	-1° 13.1′	19824 nT	65° 59.1′	19819 nT	-422 nT	44495 nT	48711 nT
March	-1° 12.2′	19825 nT	65° 59.1′	19820 nT	-416 nT	44497 nT	48713 nT
April	-1° 11.4′	19830 nT	65° 58.8′	19826 nT	-412 nT	44497 nT	48715 nT
May	-1° 10.6′	19834 nT	65° 58.6′	19830 nT	-408 nT	44500 nT	48720 nT
June	-1° 9.9′	19837 nT	65° 58.5′	19833 nT	-403 nT	44503 nT	48724 nT
July	-1° 9.0′	19836 nT	65° 58.7′	19832 nT	-398 nT	44507 nT	48728 nT
August	-1° 8.1′	19833 nT	65° 58.9′	19829 nT	-393 nT	44509 nT	48728 nT
September	-1° 7.2′	19833 nT	65° 59.0′	19829 nT	-388 nT	44512 nT	48730 nT
October	-1° 6.3′	19830 nT	65° 59.3′	19826 nT	-382 nT	44516 nT	48733 nT
November	-1° 4.7′	19827 nT	65° 59.7′	19824 nT	-373 nT	44523 nT	48738 nT
December	-1° 4.0′	19830 nT	65° 59.6′	19827 nT	-369 nT	44526 nT	48743 nT

Note:

i. The values shown here are provisional.

Hartland rapid variations

SIs and SSCs

Date	Time (UT)	Type	Quality	H (nT)	D (min)	Z (nT)
02/12/2021	07:01	SI*	C	3.7	0.25	1.4
19/12/2021	13:10	SSC*	C	5.9	-0.43	1.1

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

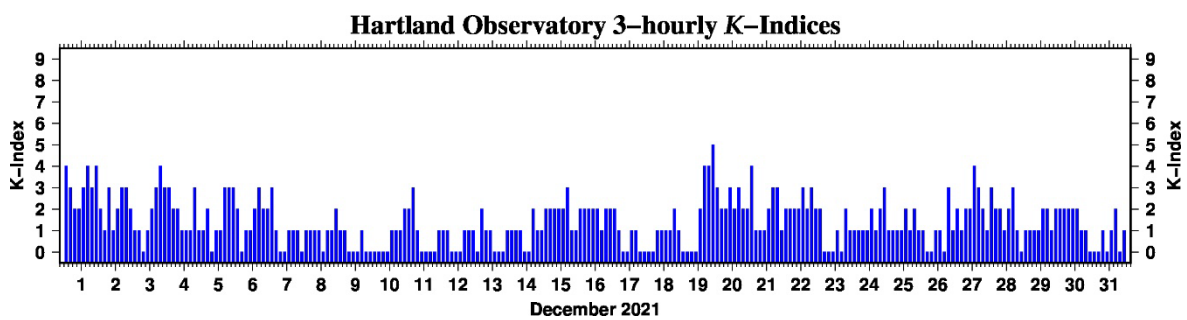
The amplitudes given are for the first chief movement of the event.

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



The aa Index

Date	Day	3-hourly aa-indices								Aa _{am}	Aa _{pm}	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_{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.

