Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 185 Alewife Brook Parkway,
Cambridge, MA 02138 USA

Web: https://www.aavso.org/solar-bulletin
Email: solar@aavso.org
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The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers counts of group and sunspots, and the very low frequency (VLF) radio recordings of SID Events in the ionosphere. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 The origin of the Butterfly Plots

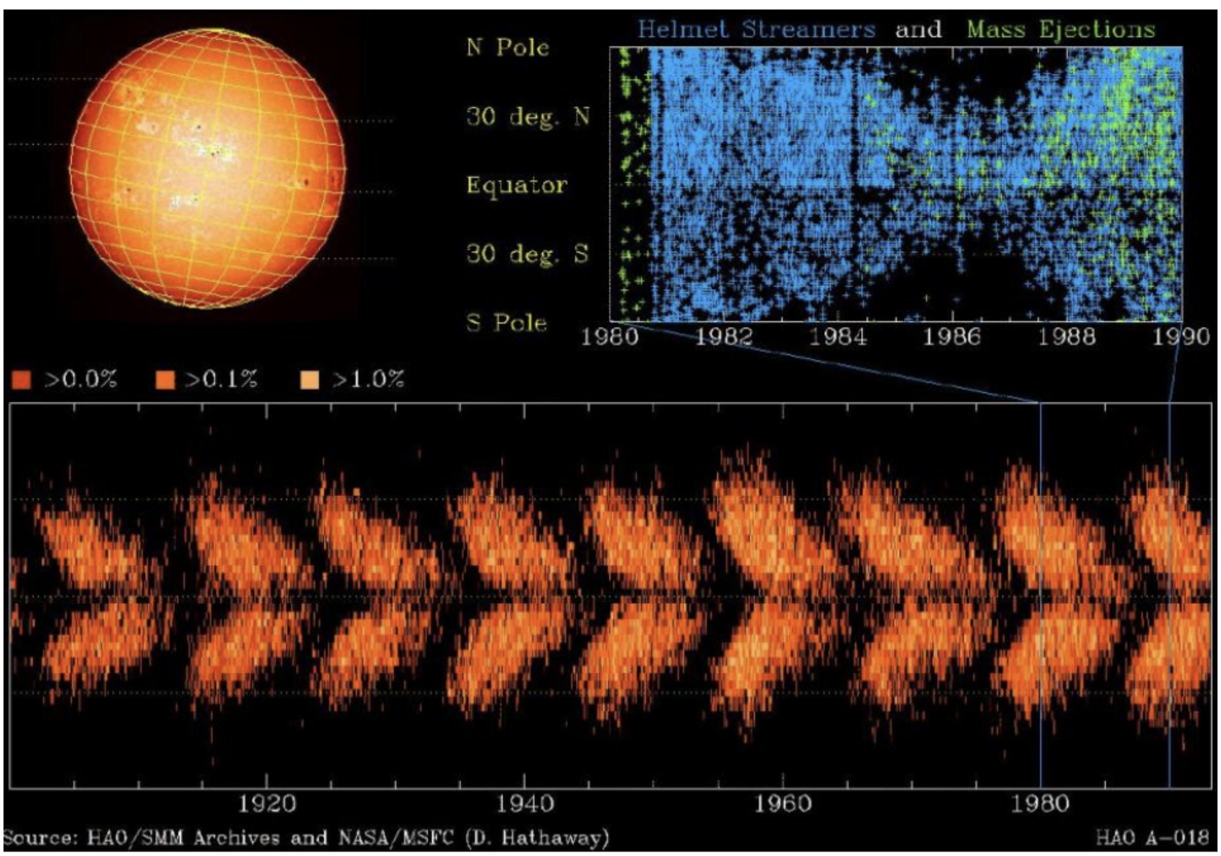

Figure 1: North/South residuals (`https://www2.hao.ucar.edu/education/pictorial/butterfly-diagram`)

In 1904, Annie and Walter Maunder at the Royal Greenwich Observatory made a hand-drawn plot of the appearance of sunspots on the solar disk. They explained: "We made this diagram in the week of evenings, one dictating and the other ruling these little lines. We had to do it a hurry because we wanted to get before the [Royal Astronomical] Society at the same meeting as the other sunspot observers, whose views we knew to be heretical. As it turned out the diagram wiped [the other observers'] clean off the slate." On 21 May 1940, Annie mailed the drawing from London to a friend in the USA, to save from possible destruction during the Blitz. (Judge 2020, pp 67)

As Charbonneau and White explain, "one begins by laying a coordinate grid on, for example, a solar white light or calcium image, with, as in the case of geographic coordinates on Earth, the rotation axis defining the North-South vector. The visible solar disk is then divided in latitudinal strips of constant projected area, and for each such strip the percentage of the area covered by sunspots and/or active regions is calculated and color coded. This defines a one-dimensional (vertical) array describing the average sunspot coverage at one time." (Charbonneau and White 1995)

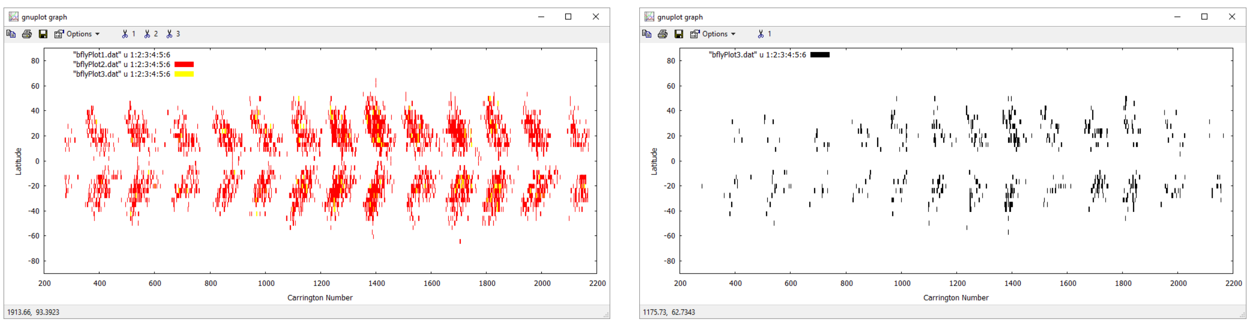

Figure 2: (Hathaway 2016) Carrington Rotation Butterfly plot from RGO data back to 1874 (left), same data but only large sunspot areas (right).

"In producing my butterfly diagram (142 kb GIF image) (184 kb pdf-file) (showing total sunspot area as a function of time and latitude) I have retained the RGO Spot Areas prior to 1977 as reported but increased the USAF/NOAA Spot Areas by a factor of 1.4 after 1976. The data plotted in the Butterfly Diagram is contained in a 453KB ASCII text file with a single record containing the Carrington rotation number followed by five records containing 10 values each of the total sunspot area (in units of millionths of a hemisphere) found in 50 latitude bins distributed uniformly in Sine(latitude). Text files containing the monthly averages of the daily sunspot areas (again in units of millionths of a hemisphere) are also available for the full sun, the northern hemisphere, and the southern hemisphere. Another text file contains daily sunspot areas (1.51 Mb). These derived data include the correction factor of 1.4 for data after 1976. The missing days within the dataset are indicated by sunspot area values of -1 in the daily sunspot area file." `https://solarscience.msfc.nasa.gov/greenwch.shtml`

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

July 2024 (Figure 3): An average day with 10 flares: 5 C class and 5 M class, for July 27th recorded here in Fort Collins, Colorado (U.S. Dept. of Commerce–NOAA, 2022).

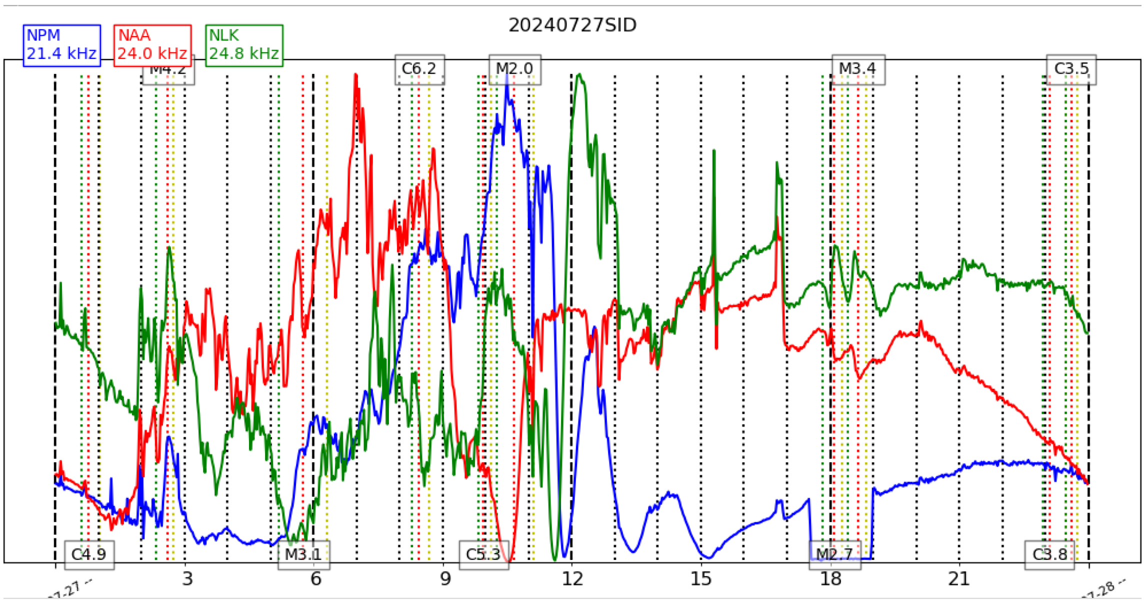

Figure 3: VLF recording from Fort Collins, Colorado for the 27th of July.

2.2 SID Observers

In July 2024 we had 13 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202407 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
A Son	A112	DHO
L Loudet	A118	DHO
J Godet	A119	GBZ GQD ICV
J Karlovsky	A131	DHO FTA
S Aguirre	A138	NAA
L Pina	A148	NAA NML
J Wendler	A150	NAA
J DeVries	A153	NAA
A Nebula	A156	DHO NSY
M Salo	A157	NLK

Figure 4 depicts the importance rating of the solar events. The duration in minutes are -1: LT 19, 1: 19-25, 1+: 26-32, 2: 33-45, 2+: 46-85, 3: 86-125, and 3+: GT 125.

Figure 4: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In July 2024, there were 334 GOES-16 XRA flares, 3 X-Class, 93 M-Class and 238 C-Class flares. More flaring was reported this month compared to last. (U.S. Dept. of Commerce–NOAA, 2024). (see Figure 5).

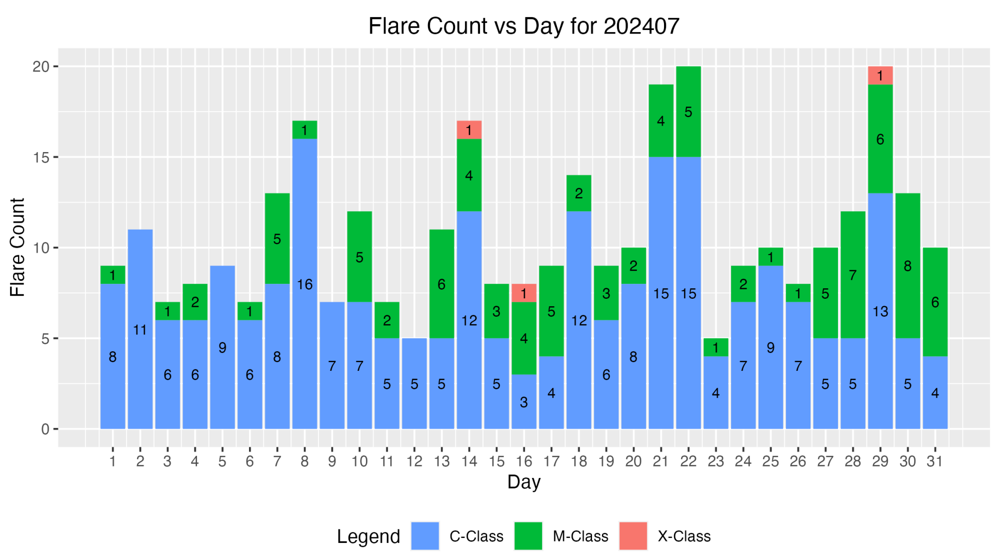

Figure 5: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2024).

3 Relative Sunspot Numbers (R_a)

Reporting monthly sunspot numbers consists of submitting an individual observer's daily counts for a specific month to the AAVSO Solar Section. These data are maintained in a Structured Query Language (SQL) database. The monthly data then are extracted for analysis. This section is the portion of the analysis concerned with both the raw and daily average counts for a particular month. Scrubbing and filtering the data assure error-free data are used to determine the monthly sunspot numbers.

3.1 Raw Sunspot Counts

The raw daily sunspot counts consist of submitted counts from all observers who provided data in July 2024. These counts are reported by the day of the month. The reported raw daily average counts have been checked for errors and inconsistencies, and no known errors are present. All observers whose submissions qualify through this month's scrubbing process are represented in Figure 6.

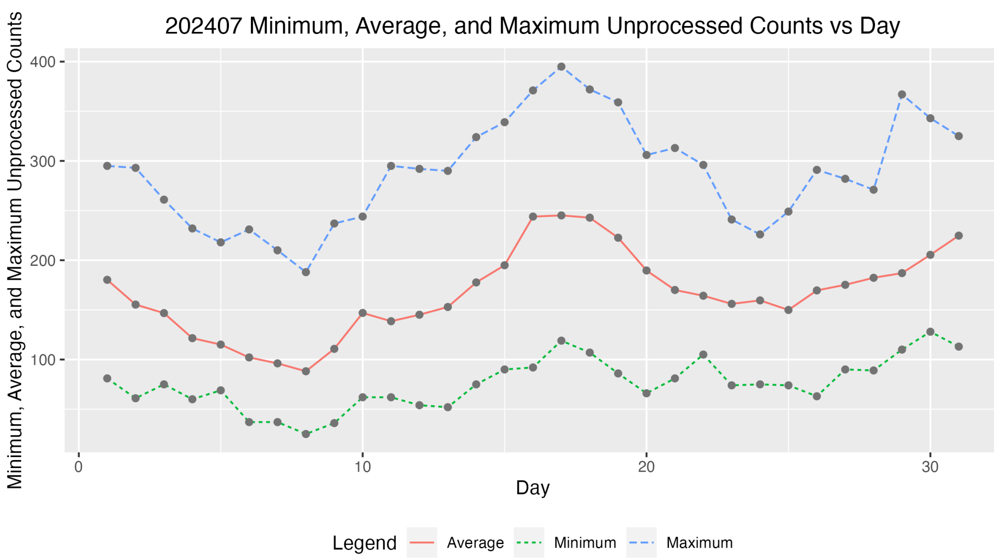

Figure 6: Raw Wolf number average, minimum and maximum by day of the month for all observers.

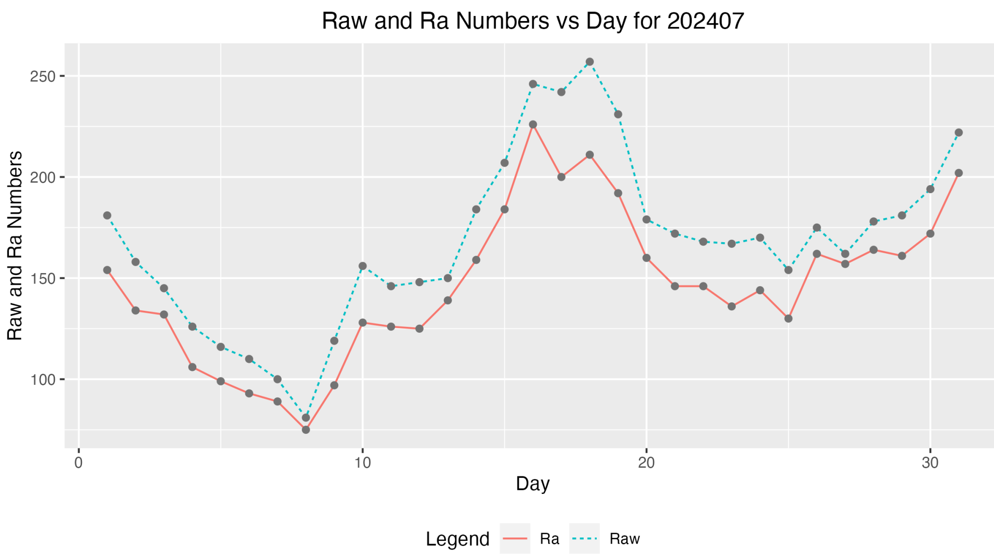

Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

3.2 American Relative Sunspot Numbers

The relative sunspot numbers, R_a, contain the sunspot numbers after the submitted data are scrubbed and modeled by Shapley's method with k-factors (`http://iopscience.iop.org/article/10.1086/126109/pdf`). The Shapley method is a statistical model that agglomerates variation due to random effects, such as observer group selection, and fixed effects, such as seeing condition. The raw Wolf averages and calculated R_a are seen in Figure 7, and Table 2 shows the Day of the observation (column 1), the Number of Observers recording that day (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 202407 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	28	181	154
2	38	158	134
3	34	145	132
4	35	126	106
5	33	116	99
6	35	110	93
7	30	100	89
8	44	81	75
9	33	119	97
10	37	156	128
11	36	146	126
12	36	148	125
13	38	150	139
14	41	184	159
15	40	207	184

Continued

Table 2: 202407 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	37	246	226
17	38	242	200
18	40	257	211
19	37	231	192
20	44	179	160
21	37	172	146
22	36	168	146
23	37	167	136
24	36	170	144
25	31	154	130
26	40	175	162
27	33	162	157
28	41	178	164
29	39	181	161
30	36	194	172
31	35	222	202
Averages	36.6	168.5	146.7

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for July 2024, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (68), and total number of observations submitted (1135).

Table 3: 202407 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	19	Alexandre Amorim
ARAG	24	Gema Araujo
ASA	2	Salvador Aguirre
BATR	4	Roberto Battaiola
BKL	15	John A. Blackwell
BMIG	30	Michel Besson
BTB	28	Thomas Bretl
BXZ	26	Jose Alberto Berdejo
BZX	25	A. Gonzalo Vargas
CIOA	8	Ioannis Chouinavas
CKB	19	Brian Cudnik
CLDB	20	Laurent Cambon
CMAB	6	Maurizio Cervoni
CNT	31	Dean Chantiles

Continued

Table 3: 202407 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CVJ	4	Jose Carvajal
DARB	18	Aritra Das
DAT	21	Adam Derdzikowski
DELS	2	Susan Delaney
DGIA	8	Giuseppe di Tommasco
DJOB	6	Jorge del Rosario
DJSA	4	Jeff DeVries
DJVA	31	Jacques van Delft
DMIB	13	Michel Deconinck
DUBF	18	Franky Dubois
EHOA	21	Howard Eskildsen
FERA	31	Eric Fabrigat
FLET	26	Tom Fleming
GFAD	11	Fabrizio Guida
GIGA	30	Igor Grageda Mendez
HALB	15	Brian Halls
HKY	27	Kim Hay
HOWR	26	Rodney Howe
HSR	17	Serge Hoste
IEWA	14	Ernest W. Iverson
ILUB	3	Luigi Iapichino
JGE	6	Gerardo Jimenez Lopez
JSI	4	Simon Jenner
KAND	30	Kandilli Observatory
KNJS	21	James & Shirley Knight
KTOC	24	Tom Karnuta
LKR	6	Kristine Larsen
LRRA	21	Robert Little
LVY	31	David Levy
MARC	5	Arnaud Mengus
MARE	16	Enrico Mariani
MJHA	28	John McCammon
MLL	10	Jay Miller
MMAE	1	Aaron McNeely
MMI	31	Michael Moeller
MUDG	6	George Mudry
MWMB	16	William McShan
MWU	22	Walter Maluf
NMID	18	Milena Niemczyk
ONJ	15	John O'Neill
PLUD	22	Ludovic Perbet
RJV	23	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI

Continued

Table 3: 202407 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SNE	2	Neil Simmons
SQN	27	Lance Shaw
SRAL	1	Raidel Sosa Armas
SRIE	19	Rick St. Hilaire
TDE	16	David Teske
TPJB	1	Patrick Thibault
TST	22	Steven Toothman
URBP	26	Piotr Urbanski
VIDD	21	Dan Vidican
WGI	2	Guido Wollenhaupt
WND	8	Denis Wallian
Totals	1135	68

3.4 Generalized Linear Model of Sunspot Numbers

Dr. Jamie Riggs, Solar System Science Section Head, International Astrostatistics Association, maintains a relative sunspot number (R_a) model containing the sunspot numbers after the submitted data are scrubbed and modeled by a Generalized Linear Mixed Model (GLMM), which is a different model method from the Shapley method of calculating R_a in Section 3 above. The GLMM is a statistical model that accounts for variation due to random effects and fixed effects. For the GLMM R_a model, random effects include the AAVSO observer, as these observers are a selection from all possible observers, and the fixed effects include seeing conditions at one of four possible levels. More details on GLMM are available in the paper, *A Generalized Linear Mixed Model for Enumerated Sunspots* (see 'GLMM06' in the sunspot counts research page at http://www.spesi.org/?page_id=65).

Figure 8 shows the monthly GLMM R_a numbers for a rolling eleven-year (132-month) window beginning within the 24th solar cycle and ending with last month's sunspot numbers. The solid cyan curve that connects the red *X's* is the GLMM model R_a estimates of excellent seeing conditions, which in part explains why these R_a estimates often are higher than the Shapley R_a values. The dotted black curves on either side of the cyan curve depict a 99% confidence band about the GLMM estimates. The green dotted curve connecting the green triangles is the Shapley method R_a numbers. The dashed blue curve connecting the blue *O's* is the SILSO values for the monthly sunspot numbers.

The tan box plots for each month are the actual observations submitted by the AAVSO observers. The heavy solid lines approximately midway in the boxes represent the count medians. The box plot represents the InterQuartile Range (IQR), which depicts from the 25^{th} through the 75^{th} quartiles. The lower and upper whiskers extend 1.5 times the IQR below the 25^{th} quartile, and 1.5 times the IQR above the 75^{th} quartile. The black dots below and above the whiskers traditionally are considered outliers, but with GLMM modeling, they are observations that are accounted for by the GLMM model.

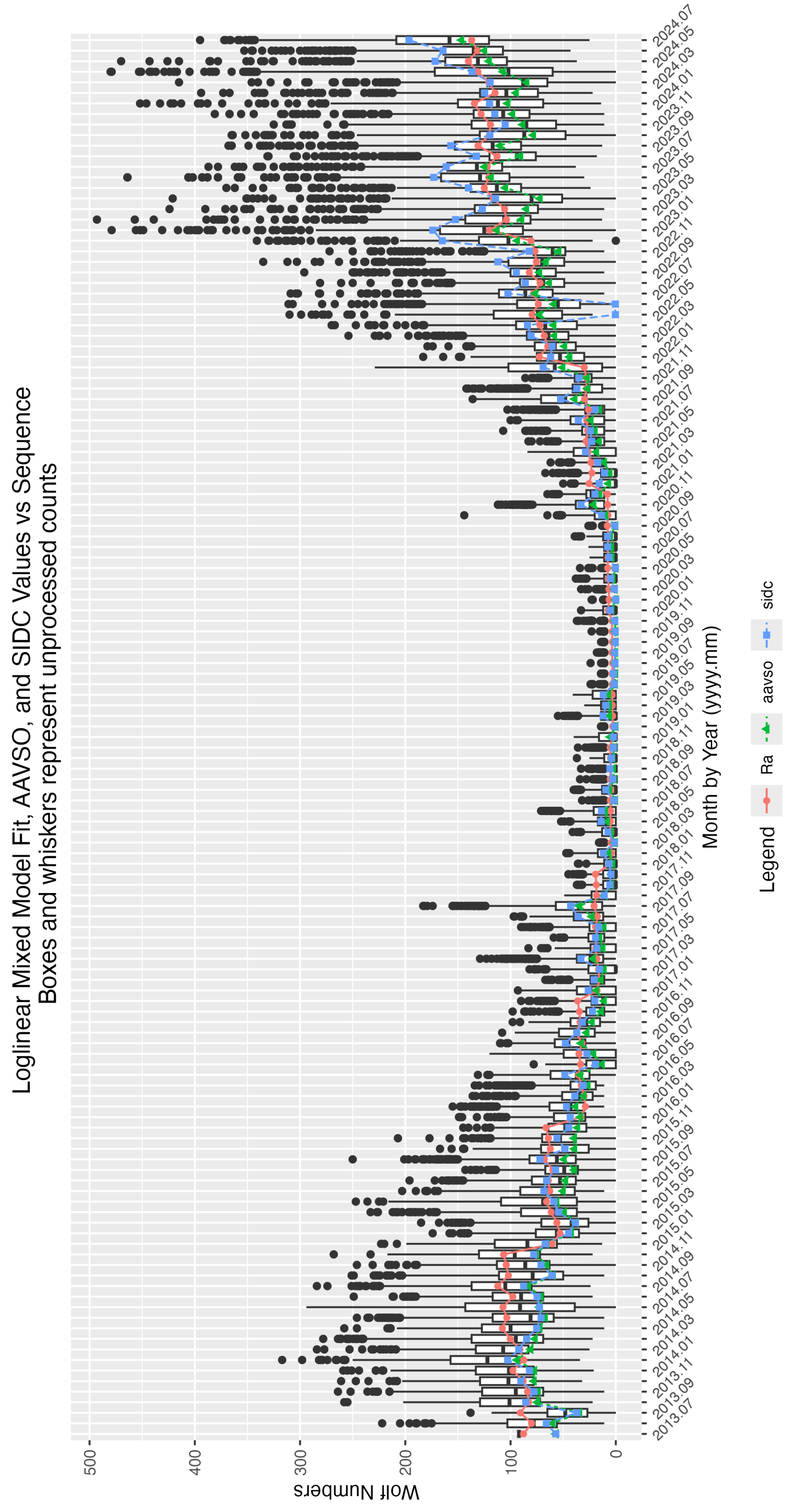

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe rhowe137@icloud.com

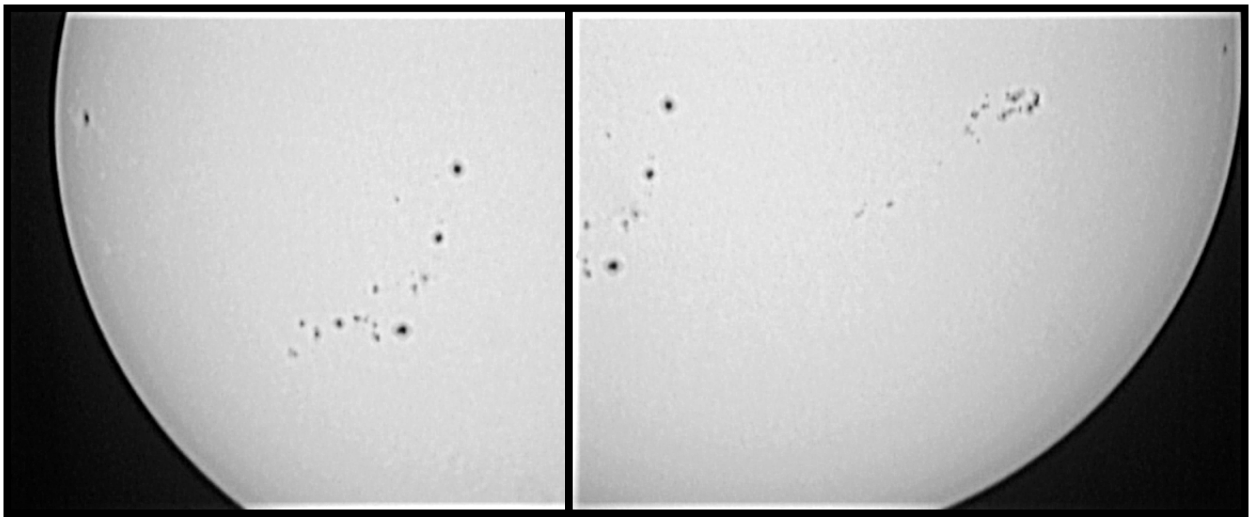

Figure 9: Two video images of the sun for the 27th of July, by Dan Vidican (VIDD).

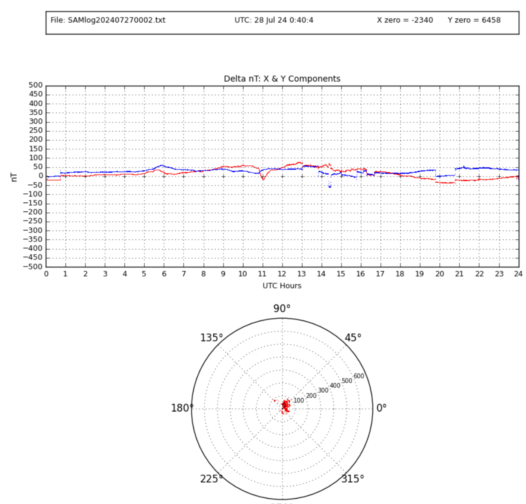

Figure 10: A quiet day for the magnetic polarities on the 27th of July, although, there are a few ripples.

5 Antique telescope project

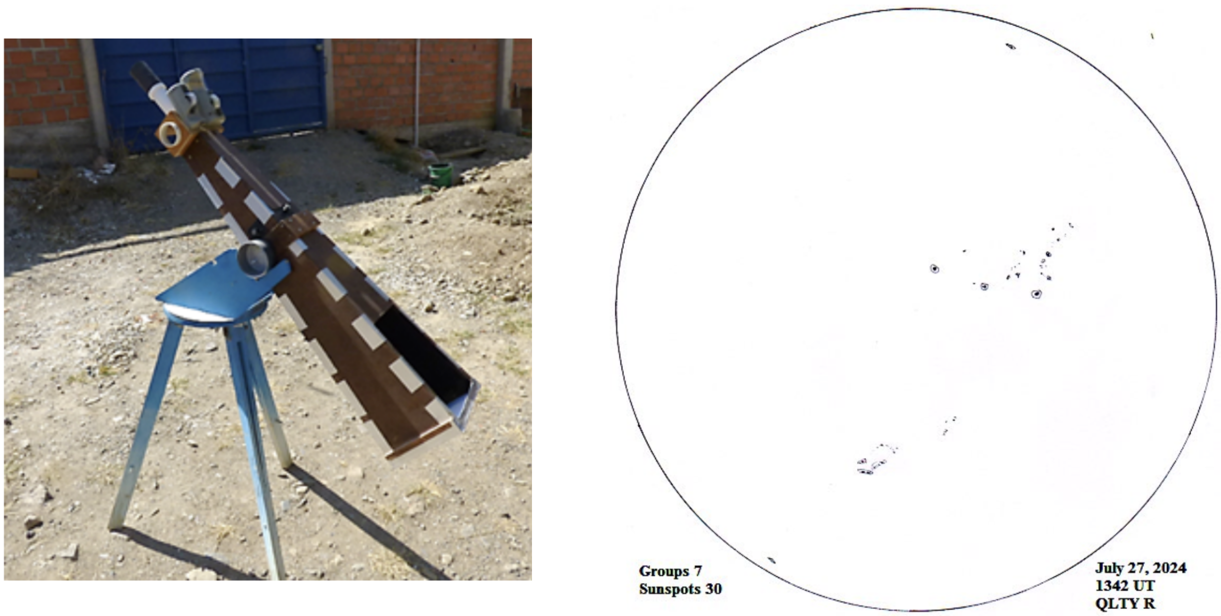

Figure 11: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) in Cochabamba, Bolivia (left), and a drawing for the 27th of July (right).

6 References

(Charbonneau, P., and White, O. R. (1995) The Butterfly Diagram. https://www2.hao.ucar.edu/education/pictorial/butterfly-diagram.

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