Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 81 Number 1 January 2025

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 VLF radio recordings of SID Events in the ionosphere. The sudden ionospheric disturbance report is in Section 3. The relative sunspot numbers are in Section 4. Section 5 has endnotes.

1 From many to few sunspots in January drawings, by Jesus E. Blanco (BVZ)

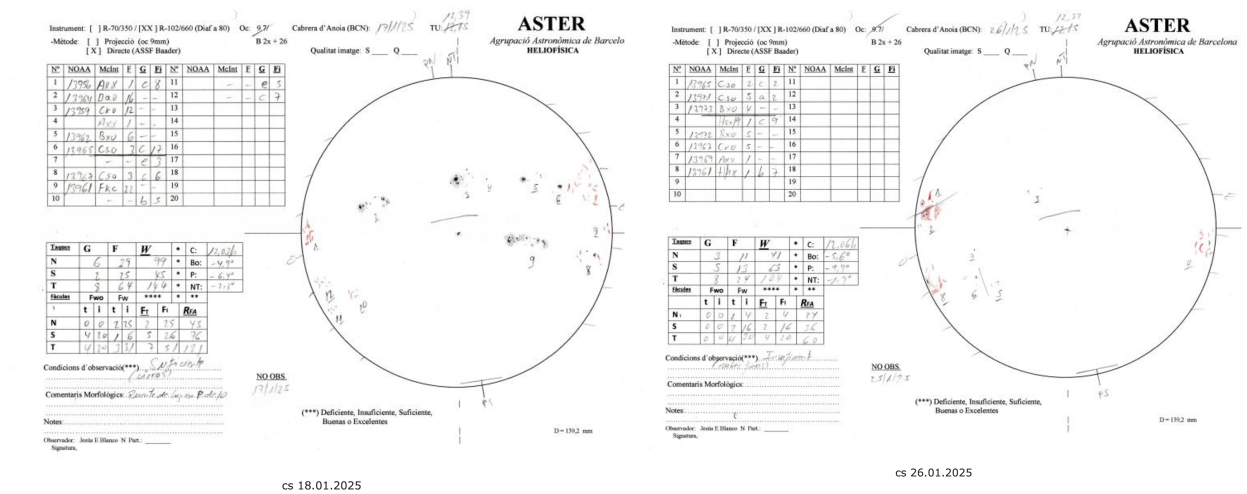

Figure 1: I have been a solar observer for many years. Usually, I use a R102–660 (diaphragm to 80 mm) with filter ASSF Baader, Barlow 2x, yellow filter (W 15) and, generally, an eyepiece of 26 mm. My observations are found at: (`https://aster.cat/album/dibujossol`) , of ASTER, Agrupacio Astronomica de Barcelona (Spain). The left panel are sunspot counts for the 18th of January, one of the most active flare days. The right panel is the 26th of January, a day with almost no sunspots and few flares.

2 Rethinking Solar Superflares

Sunlike stars sometimes produce what astronomers term superflares. Although a precise definition is elusive in the literature, a superflare is generally characterized as releasing at least ten to a hundred times more energy than the largest known solar flares (the Carrington event of 1859, with estimated total bolometric energy of $4-6X10^{32}$ ergs). Most of these events are associated with stars that are younger than and rotate faster than the sun, but not all. For example, the Kepler Space Telescope found that the amount of energy released by large superflares does not correlate with the rotation of the star. Stars with superflare behavior appear to fluctuate in brightness by about 1 percent as they rotate, suggesting that they may have impressive starspots. Models suggest that superflares can only be generated in super-large starspots ten times larger than what we observe on the Sun, which might explain the lack of evidence, at least in the observational record (Notsu et al. 2013, 1; Shibayama et al. 2013, 1). However, sudden spikes in the amount of the radioisotopes carbon-14 and beryllium-10 in our atmosphere can be associated with energetic solar flares, leaving evidence in the geological record. For example, a radioisotope spike dated to 774-5 CE has been suggested as the result of a minimal superflare emitted by the Sun (Battersby 2019, 23369).

A December 2024 article published in *Science* (Vasilyev et al. 2024, 1301) announced the identification of 2889 superflares affiliated with 2527 Sunlike stars in the Kepler data. The results suggest that main sequence stars with a surface temperature similar to the Sun produce superflares with energies higher than 10^{34} ergs about once a century. These results suggest that the Sun might not only be capable of producing superflares, but that (at least statistically speaking) we might be overdue for one.

Citations:

Battersby, Stephen, "What Are the Chances of a Hazardous Solar Superflare?," *PNAS* 116 (2019): 23369.

Notsu, Yuta, et al., "Superflares on Solar-type Stars Observed with Kepler II. Photometric Variability of Superflare-generating Stars: a Signature of Stellar Rotation and Starspots," *ApJ* 771 (2013): 127.

Shibayama, Takuya, et al.,"Superflares on Solar-type Stars Observed with Kepler.1. Statistical Properties of Superflares," *ApJ Supp. Series* 209 (2013): 5.

Vasilyev, Valeriy, et al. "Sunlike Stars Produce Superflares Roughly Once Per Century." *Science* 386: 1301.

3 Sudden Ionospheric Disturbance (SID) Report

3.1 SID Records

January 2025 (Figure 2): there were 9 M-class, and 18 C-class flares, on the 17th. (U.S. Dept. of Commerce–NOAA, 2023).

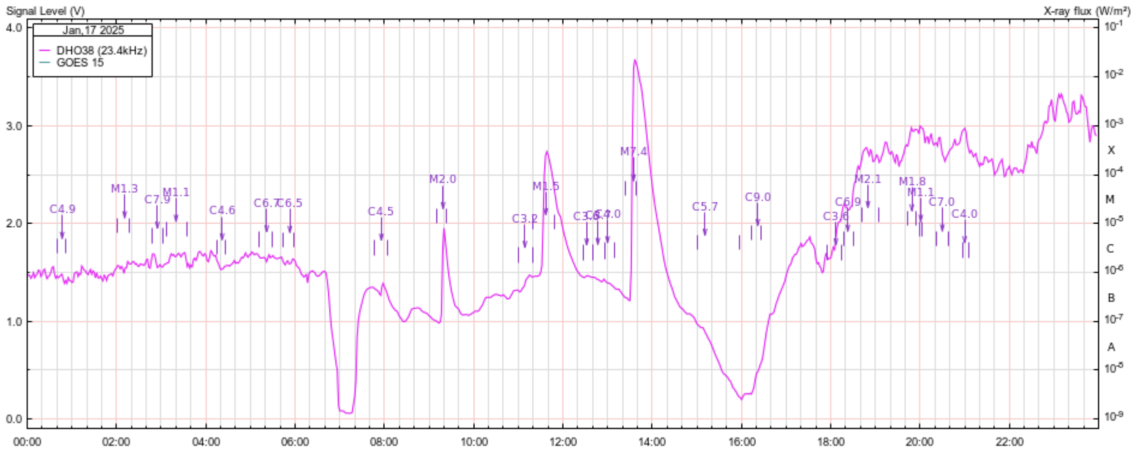

Figure 2: VLF recording from Lionel Loudet on the most active day of the month, January 17th.

3.2 SID Observers

In January 2025 we had 11 AAVSO SID observers who submitted VLF data, as listed in Table 1.

Table 1: 202501 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	DHO GBZ GQD
J Karlovsky	A131	DHO
R Mrllak	A136	GQD NSY
S Aguirre	A138	NLK
G Silvis	A141	HWU NAU NLK
L Pina	A148	NAA NML
J Wendler	A150	NAA
J DeVries	A153	NLK

Figure 3 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.

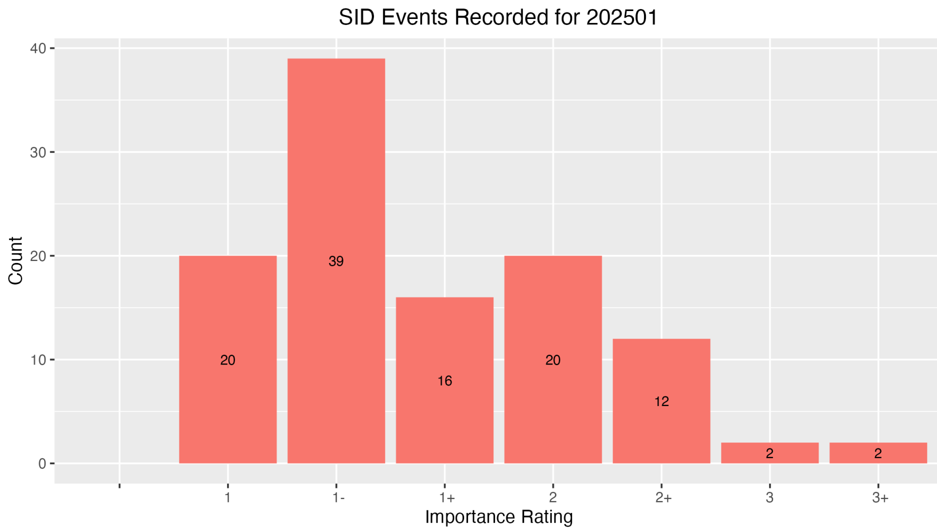

Figure 3: VLF SID Events.

3.3 Solar Flare Summary from GOES-16 Data

In January 2025, there were 278 GOES-16 XRA flares: 3 X-class, 42 M-class, and 233 C-class flares, about the same flaring as last month. U.S. Dept. of Commerce-NOAA (see Figure 4).

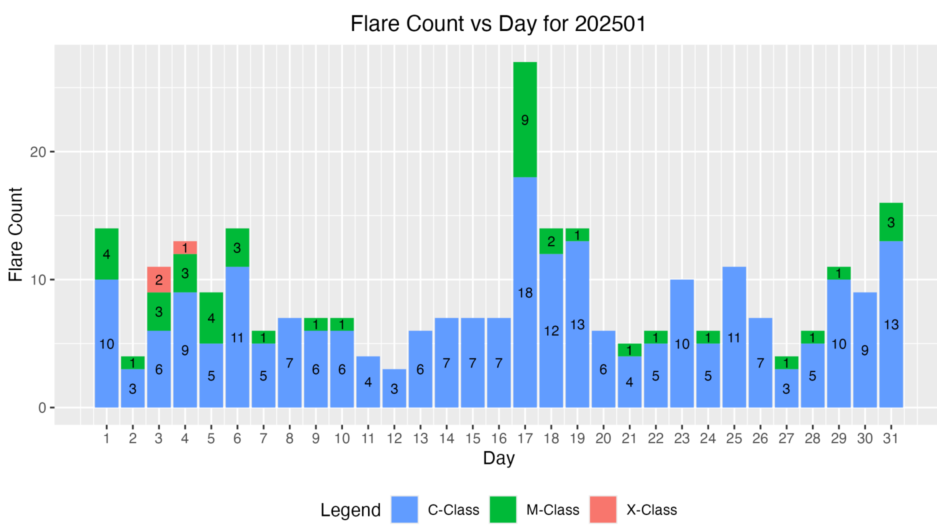

Figure 4: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2023).

4 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.

4.1 Raw Sunspot Counts

The raw daily sunspot counts consist of submitted counts from all observers who provided data in January 2025. 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 5.

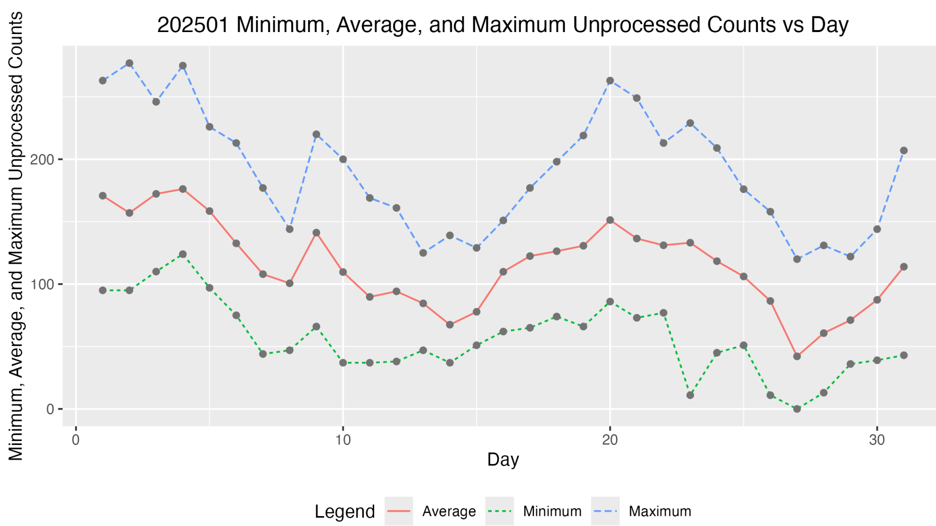

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

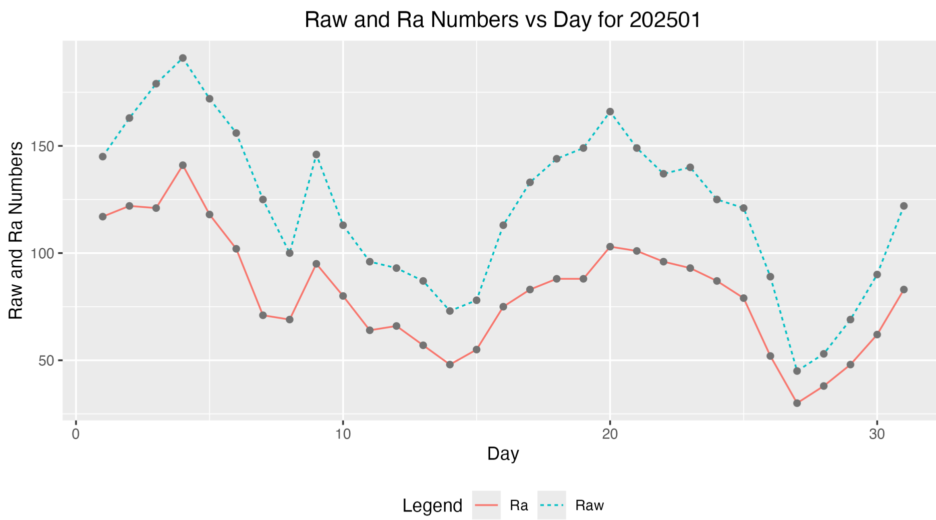

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

4.2 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 6, 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: 202501 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	20	145	117
2	22	163	122
3	27	179	121
4	20	191	141
5	20	172	118
6	19	156	102
7	21	125	71
8	23	100	69
9	23	146	95
10	24	113	80
11	25	96	64
12	32	93	66
13	28	87	57
14	32	73	48
15	26	78	55
16	20	113	75

Continued

Table 2: 202501 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
17	23	133	83
18	20	144	88
19	20	149	88
20	20	166	103
21	23	149	101
22	21	137	96
23	28	140	93
24	31	125	87
25	26	121	79
26	21	89	52
27	27	45	30
28	29	53	38
29	23	69	48
30	24	90	62
31	26	122	83
Averages	24	121.4	81.7

4.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for January 2025, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (61), and total number of observations submitted (744).

Table 3: 202501 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	19	Alexandre Amorim
AJV	11	J. Alonso
ARAG	31	Gema Araujo
ASA	3	Salvador Aguirre
BATR	5	Roberto Battaiola
BKL	2	John A. Blackwell
BMIG	21	Michel Besson
BTB	10	Thomas Bretl
BVZ	22	Jesus E. Blanco
BXZ	16	Jose Alberto Berdejo
BZX	5	A. Gonzalo Vargas
CKB	15	Brian Cudnik
CLDB	13	Laurent Cambon
CMAB	4	Maurizio Cervoni
CNT	20	Dean Chantiles

Continued

Table 3: 202501 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DARB	31	Aritra Das
DGIA	13	Giuseppe di Tommasco
DJOB	16	Jorge del Rosario
DJSA	3	Jeff DeVries
DJVA	30	Jacques van Delft
DMIB	16	Michel Deconinck
DUBF	15	Franky Dubois
EHOA	17	Howard Eskildsen
FERA	14	Eric Fabrigat
FJOF	7	Joe Fazio
FLET	21	Tom Fleming
GALQ	1	Alejandro Gonzalez-Ojeda
HALB	9	Brian Halls
HKY	19	Kim Hay
HOWR	16	Rodney Howe
HSR	5	Serge Hoste
IEWA	11	Ernest W. Iverson
ILUB	4	Luigi Iapichino
JGE	4	Gerardo Jimenez Lopez
JSI	2	Simon Jenner
KAND	21	Kandilli Observatory
KAPJ	2	John Kaplan
KNJS	28	James & Shirley Knight
KTOC	8	Tom Karnuta
LKR	5	Kristine Larsen
LRRA	9	Robert Little
MARC	3	Arnaud Mengus
MARE	8	Enrico Mariani
MCE	20	Etsuiku Mochizuki
MJHA	25	John McCammon
MLL	3	Jay Miller
MMI	25	Michael Moeller
MUDG	1	George Mudry
MWMB	16	William McShan
MWU	16	Walter Maluf
NMID	5	Milena Niemczyk
PLUD	10	Ludovic Perbet
RJV	9	Javier Ruiz Fernandez
SNE	3	Neil Simmons
SQN	8	Lance Shaw
SRIE	8	Rick St. Hilaire
TDE	20	David Teske
TPJB	2	Patrick Thibault

Continued

Table 3: 202501 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
TST	6	Steven Toothman
URBP	21	Piotr Urbanski
VIDD	11	Dan Vidican
Totals	744	61

4.4 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 4 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 7 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.

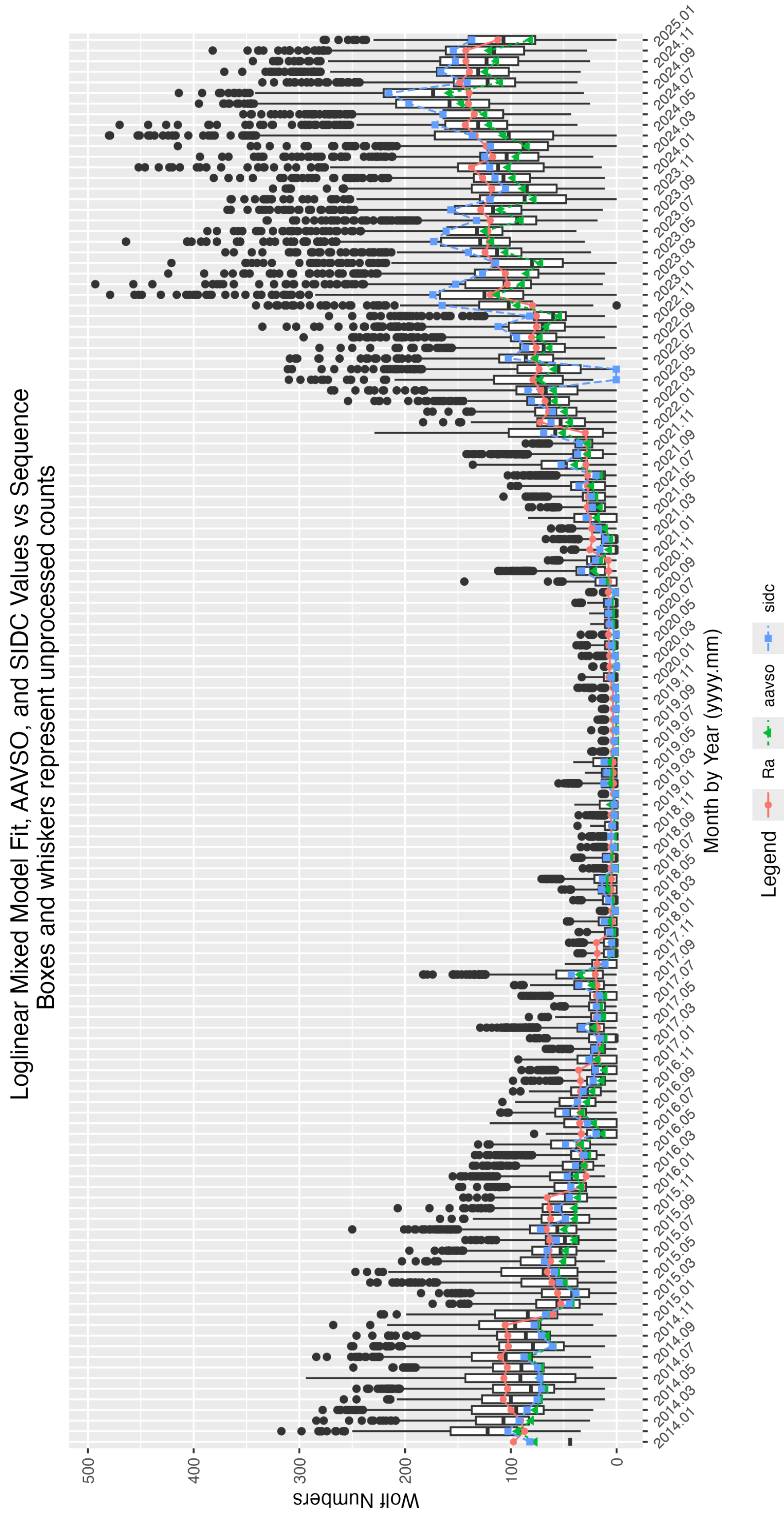

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

5 Endnotes

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

5.1 Antique telescope project

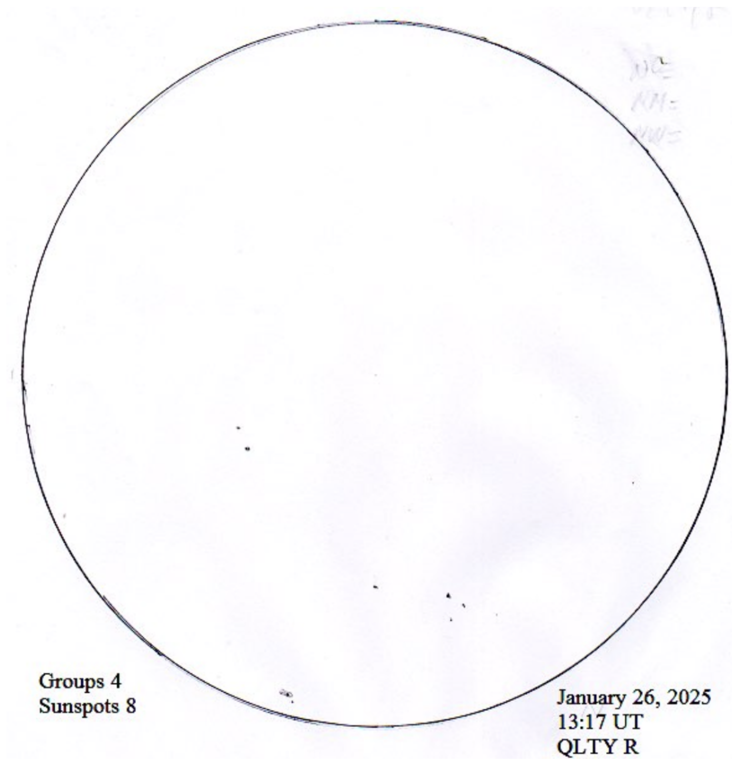

Figure 8: An antique telescope built by Gonzalo Vargas (BZX) (left). Drawing for the 26th of January, from Cochabamba, Bolivia (right).

6 References

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center (2023), *GOES-16 XRA data.* `ftp://ftp.swpc.noaa.gov/pub/indices/events/`