Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 185 Alewife Brook Parkway,
Suite 410, Cambridge, MA 02138 USA

Web: https://www.aavso.org/solar-bulletin
Email: solar@aavso.org
ISSN 0271-8480

Volume 79 Number 5 May 2023

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 Co-Chairs thank all of our observers for their diligent work in making scientifically useful measurements of our star's activity. Our goal is to make this Bulletin as informational as possible; if you have ideas for material you would like to see included, please email us at the address above. We are also looking for volunteers to write short (less than 500 words in length) articles related to solar observing or the sun in general. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 Looking at solar velocity Local Standard of Rest (VLSR) and Groombridge 1830 VLSR (IRAF, 2023)

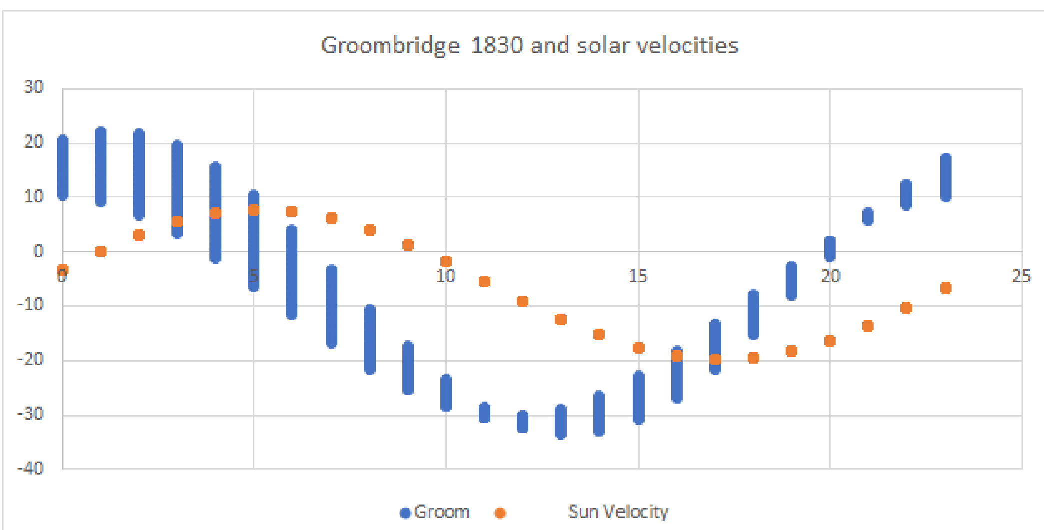

Figure 1: Groombridge 1830, a star in Ursa Major, using a 30 day VLSR shows variable velocities when compared to the solar velocities as the earth rotates daily. (Beardsley, W. R., et al., 1974)

Groombridge 1830, (RA 11 52 58.7, Dec 37 43 7.35) in Ursa Major, is metal-poor subdwarf with an extremely large proper motion. It is also of interest to astronomers because there is evidence of a companion star with flaring behavior, although the data are contradictory. See Heintz (1984).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

May 2023 (Figure 2): Jean-Pierre Godet (A119): Tavolara ICV 20.27 kHz and Skelton GQD 22.10 kHz are here as attachment. I also attach the graph of May 20th, not for its scientific interest but for its aesthetic aspect.

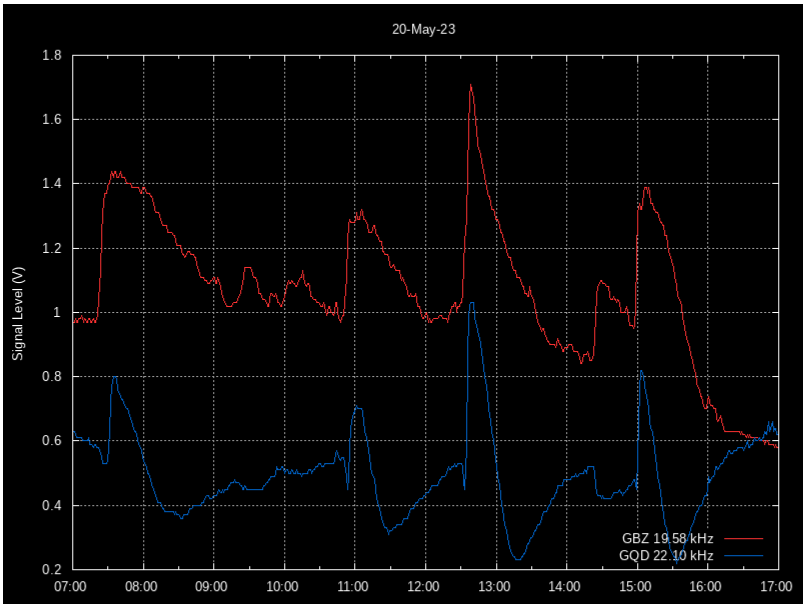

Figure 2: VLF recording from Jean-Pierre Godet (A119) .

2.2 SID Observers

In May 2023 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202305 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD ICV
F Adamson	A122	NWC
J Karlovsky	A131	DHO NAA TBB
R Mrllak	A136	GQD NSY
S Aguirre	A138	NPM NAA
G Silvis	A141	NAA NML NLK
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
J Wendler	A150	NAA
H Krumnow	A152	FTA GBZ HWU
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.

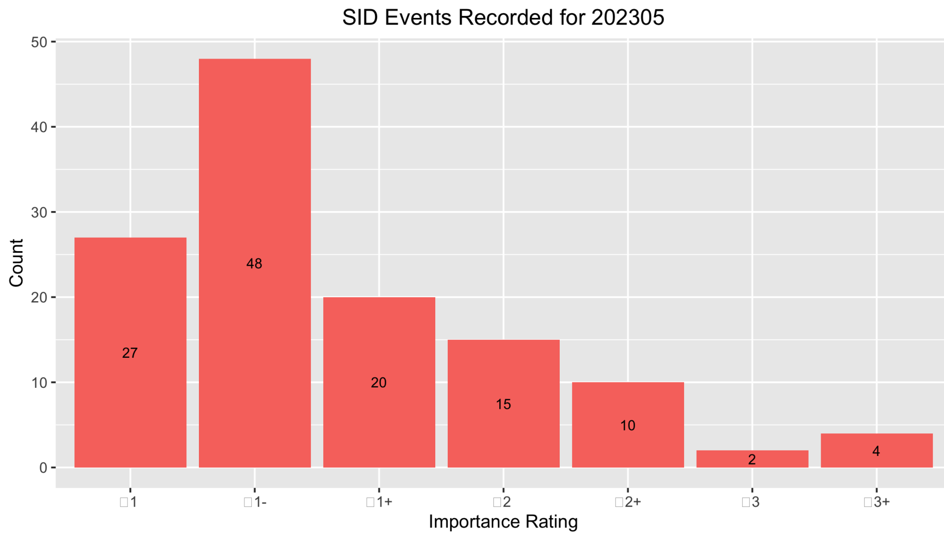

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In May 2023, there were 361 GOES-16 XRA flares: 303 C-class and 58 M-class flares. More flaring this month with M-Class flares compared to last. (U.S. Dept. of CommerceNOAA, 2022). (see Figure 4).

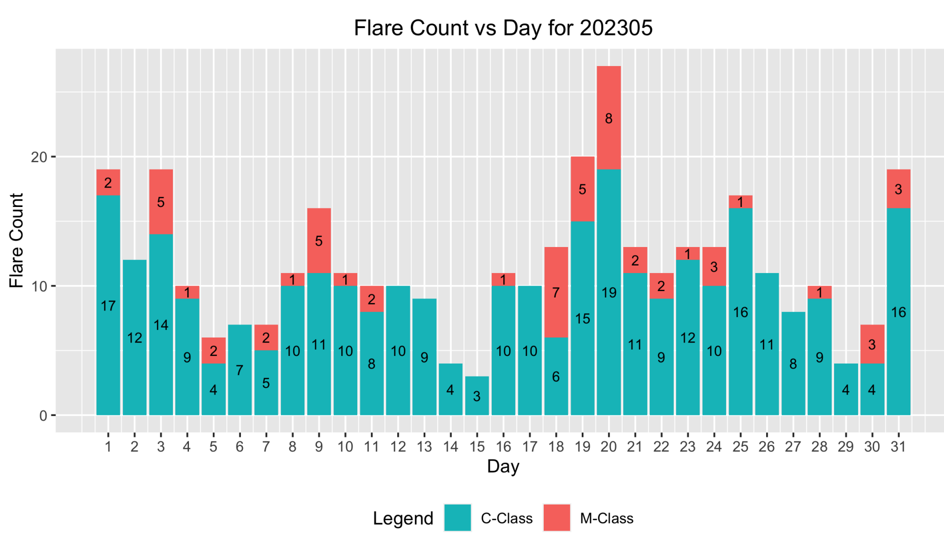

Figure 4: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 May 2023. 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.

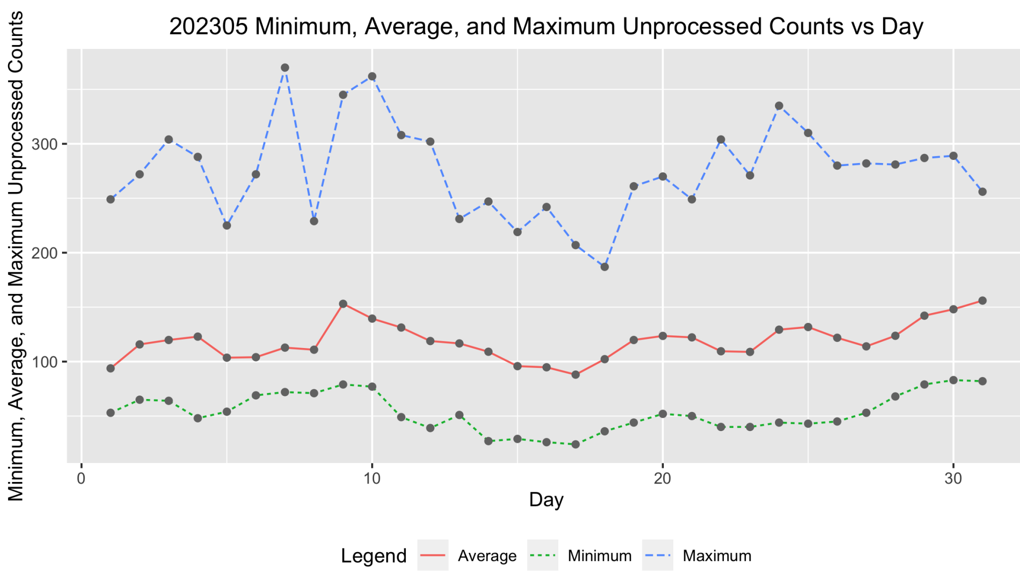

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

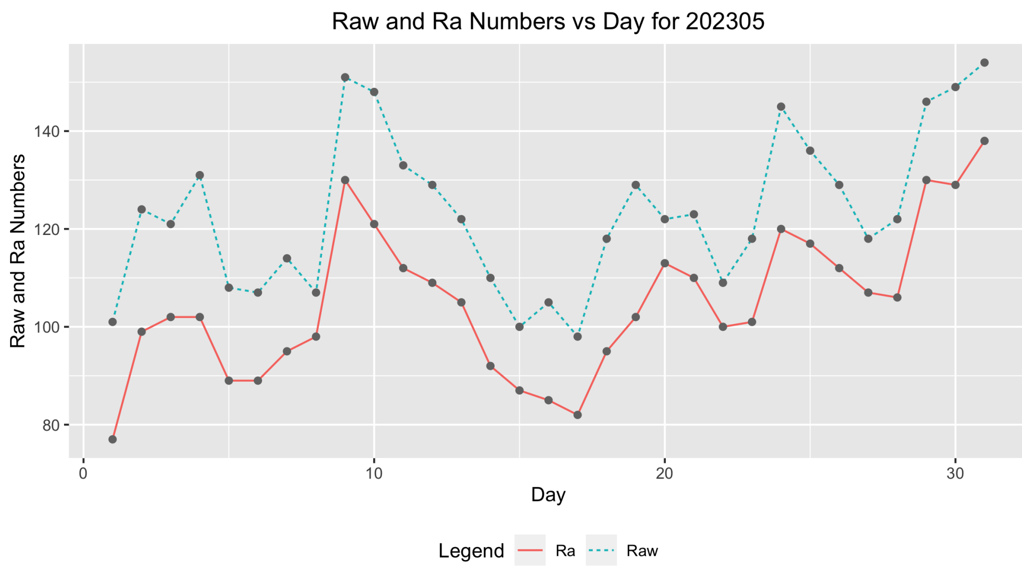

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 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: 202305 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	35	101	77
2	37	124	99
3	38	121	102
4	32	131	102
5	37	108	89
6	34	107	89
7	35	114	95
8	34	107	98
9	30	151	130
10	34	148	121
11	35	133	112
12	38	129	109
13	33	122	105
14	35	110	92

Continued

Table 2: 202305 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	39	100	87
16	36	105	85
17	37	98	82
18	39	118	95
19	31	129	102
20	34	122	113
21	43	123	110
22	34	109	100
23	41	118	101
24	44	145	120
25	43	136	117
26	50	129	112
27	45	118	107
28	41	122	106
29	45	146	130
30	40	149	129
31	40	154	138
Averages	37.7	123.5	105

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for May 2023, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (72), and total number of observations submitted (1169).

Table 3: 202305 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	21	Alexandre Amorim
AJV	14	J. Alonso
ARAG	30	Gema Araujo
ASA	2	Salvador Aguirre
ATE	15	Teofilo Arranz Heras
BATR	2	Roberto Battaiola
BMF	23	Michael Boschat
BMIG	21	Michel Besson
BROB	26	Robert Brown
BXZ	8	Jose Alberto Berdejo
BZX	21	A. Gonzalo Vargas
CKB	26	Brian Cudnik
CLDB	16	Laurent Cambon

Continued

Table 3: 202305 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMAB	4	Maurizio Cervoni
CNT	25	Dean Chantiles
CVJ	3	Jose Carvajal
DARB	22	Aritra Das
DELS	10	Susan Delaney
DFR	19	Frank Dempsey
DJOB	12	Jorge del Rosario
DJSA	9	Jeff DeVries
DJVA	2	Jacques van Delft
DMIB	14	Michel Deconinck
DUBF	24	Franky Dubois
EGMA	2	Georgios Epitropou
EHOA	7	Howard Eskildsen
ERB	23	Bob Eramia
FALB	17	Allen Frohardt
FERA	22	Eric Fabrigat
FLET	21	Tom Fleming
FTAA	5	Tadeusz Figiel
GIGA	20	Igor Grageda Mendez
GJLB	22	Josep Maria Llenas Garcia
HALB	17	Brian Halls
HKY	24	Kim Hay
HOWR	20	Rodney Howe
IEWA	19	Ernest W. Iverson
ILUB	3	Luigi Iapichino
JGE	5	Gerardo Jimenez Lopez
JSI	5	Simon Jenner
KAND	21	Kandilli Observatory
KAPJ	18	John Kaplan
KNJS	26	James & Shirley Knight
KSOB	7	Souvik Karmokar
LKR	9	Kristine Larsen
LRRA	22	Robert Little
LVY	17	David Levy
MARC	7	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	18	Etsuiku Mochizuki
MJAF	27	Juan Antonio Moreno Quesada
MJHA	27	John McCammon
MLL	14	Jay Miller
MMI	31	Michael Moeller
MSS	16	Sandy Mesics
MUDG	4	George Mudry

Continued

Table 3: 202305 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
MWU	25	Walter Maluf
ONJ	19	John O'Neill
PLUD	15	Ludovic Perbet
RJV	18	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	7	Neil Simmons
SRIE	21	Rick St. Hilaire
TDE	29	David Teske
TNIA	16	Nick Tonkin
TPJB	1	Patrick Thibault
TST	25	Steven Toothman
URBP	25	Piotr Urbanski
VIDD	17	Dan Vidican
WGI	4	Guido Wollenhaupt
WND	12	Denis Wallian
WWM	27	William M. Wilson
Totals	1169	72

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 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.

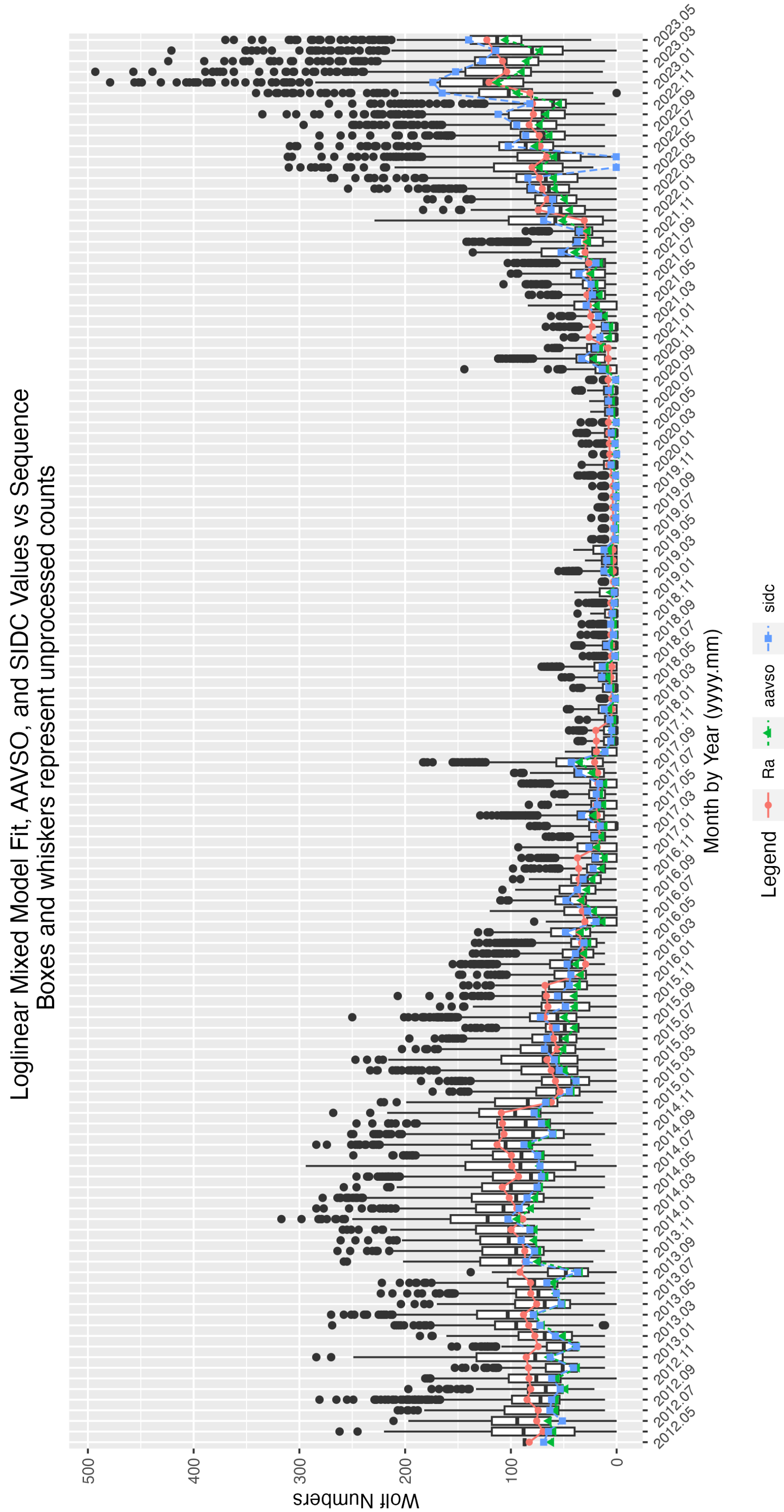

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

4.1 Antique telescope project

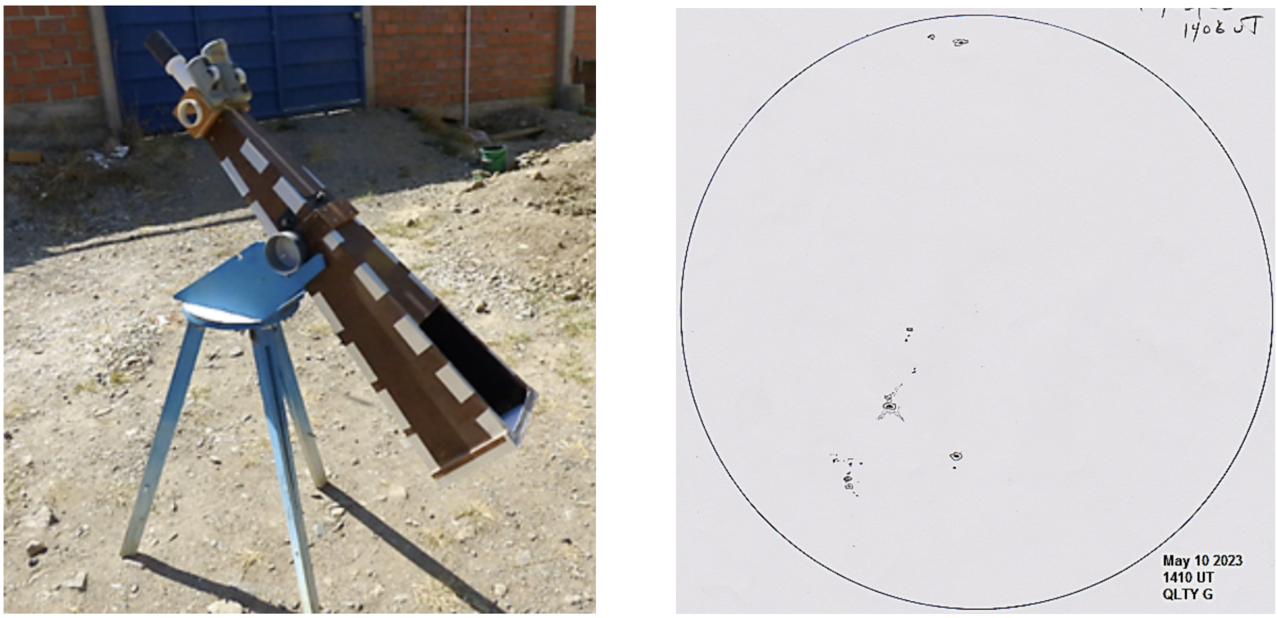

Figure 8: A recent replica of an ancient telescope built by Gonzalo Vargas (BZX) (left), and a drawing for May 10 (right).

5 References

Beardsley, W. R., Gatewood, G., Kamper, K. W., 1974, ApJ, 194, 637

Heintz, W. D., 1984, *Astrometric Study of the Subdwarf HR 4550*
https://iopscience.iop.org/article/10.1086/131379/pdf

IRAF, 2023, Copyright 1986 Association of Universities for Research in Astronomy Inc..
Revision 602304f8.
https://iraf.readthedocs.io/en/latest/tasks/noao/rv/rvcorrect.html
https://web.mit.edu/8.13/www/srt_software/vlsr.pdf

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center (2022),
GOES-16 XRA data. ftp://ftp.swpc.noaa.gov/pub/indices/events/