Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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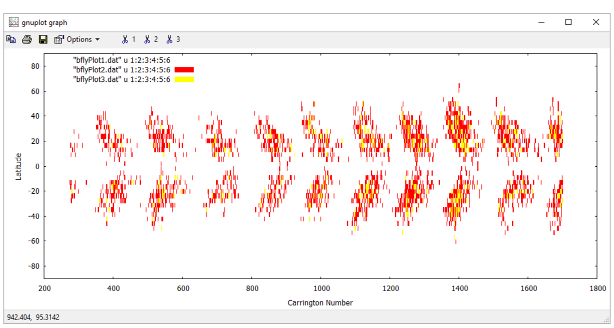
The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots, and the very low frequency (VLF) radio recordings of SID Events in the ionosphere. The Co-Chairs thank all of our observers for their diligent work in making scientifically 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 Carrington Rotation butterfly plots from RGO and SONNE data



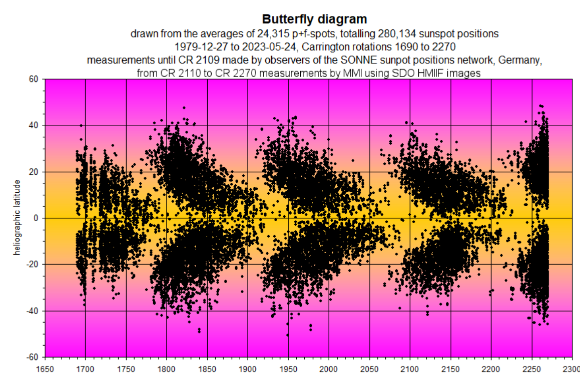


Figure 1: Royal Greenwich Observatory (RGO) butterfly plot (left) shows data up to 1999 (Jiang et al. 2011). Michael Moeller (MMI), from the SONNE group, sends the most recent butterfly plot up to present.

Michael Moeller (MMI) from the SONNE group sends us the following information: "Between 1999 and 2012 I was the contact person and analyst for the Sunspot Positionsnetwork of SONNE, the German Solar Observers Group of Vereinigung der Sternfreunde, VdS. Data input by hand, since there wasn't an unified reporting format necessary for the participants. The analysis results were synoptic maps and some statistical tables for each Carrington rotation published in our magazine SONNE and the SONNE-Datenblatt (datareport, published each year in German and English, which was edited by me from 1987-1996). In 2002 I had the idea to create a Butterfly diagram from all sunpot positions of the network available to me. The updated diagram you will find in the attachements. Up to rotation no. 2109 the positions are taken from the solar positions network, with the beginning of rotation 2110 the positions are measured by me based on SDO HMIIF 4096 images."

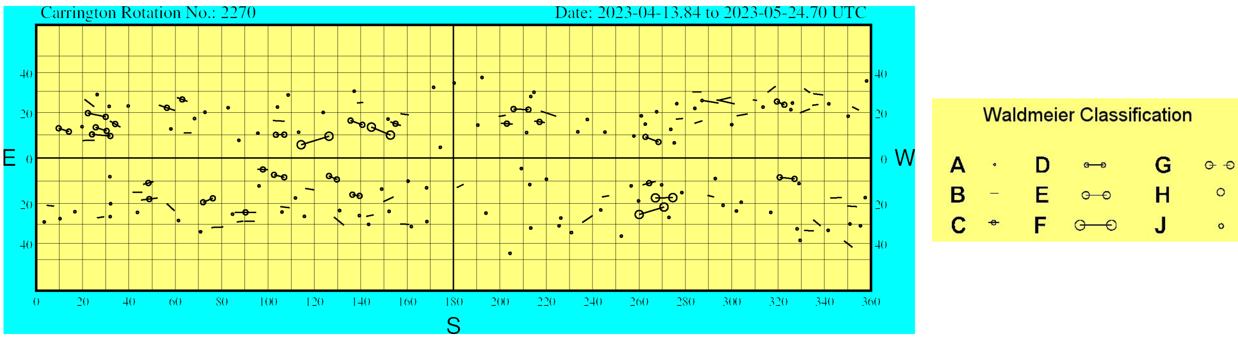


Figure 2: The attached synoptic map of Carrington rotation 2270 shows schematically the distribution of the different sunpot groups classified in the Waldmeier scheme. (Michael Moeller (MMI))

The Royal Greenwich Observatory (RGO) data only go to 2016, (`https://solarscience.msfc.nasa.gov/greenwch.shtml`) so it is good to see most recent butterfly plots from the SONNE group and Michael Moeller (MMI) up to present.

1.1 MHD and the solar dynamo, using butterfly plots

Paul Charboneau (2013) explains that "Helioseismology has changed forever the way we go about modelling the solar dynamo, as it provides us with vital information on the flows pervading the solar interior. These flows are the dominant energy source for the magnetohydrodynamical (MHD) dynamo process powering all of solar activity."

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

June 2023 (Figure 3): On the 20th there was an X1.1 flare recorded here at Fort Collins, Colorado. (U.S. Dept. of Commerce–NOAA 2022).

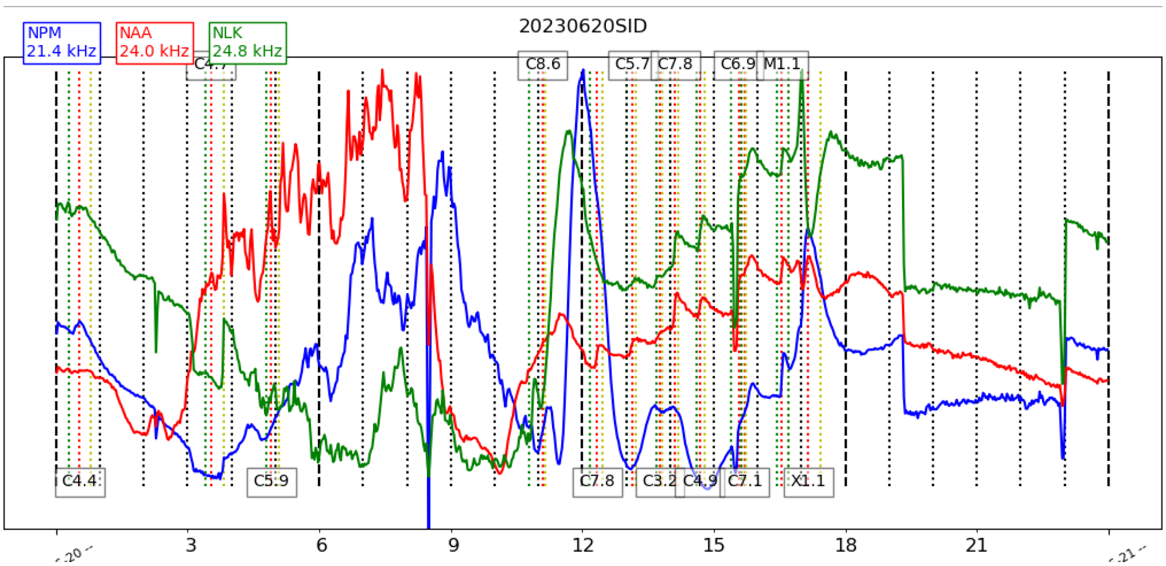


Figure 3: VLF recording from Fort Collins, Colorado.

2.2 SID Observers

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

Table 1: 202306 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
F Adamson	A122	NWC
J Karlovsky	A131	DHO NAA TBB
S Aguirre	A138	NPM NAA
G Silvis	A141	NAA NAU NLK
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
J Wendler	A150	NAA
J DeVries	A153	NLK
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.

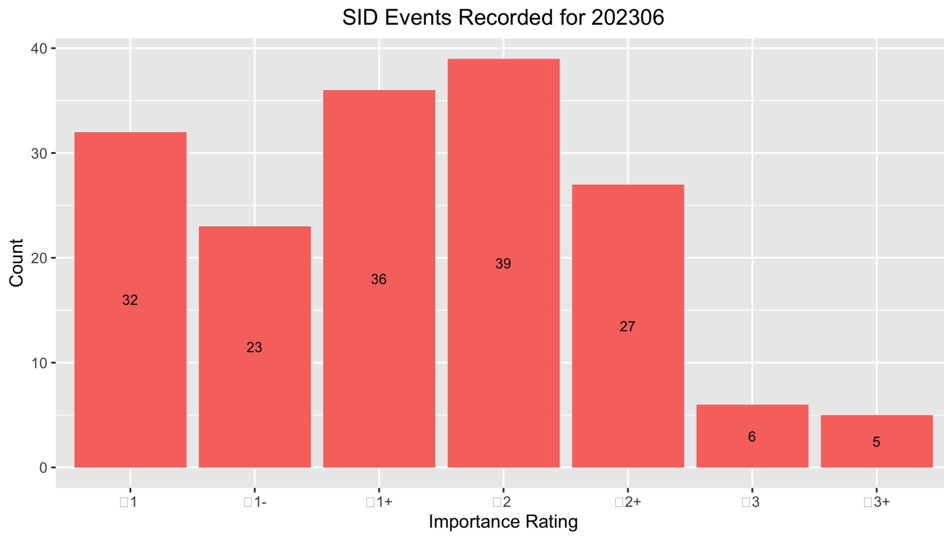


Figure 4: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In June 2023, there were 265 GOES-16 XRA flares: 244 C-class and 20 M-class and one X-class flares. Less flaring this month compared to last month. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 5).

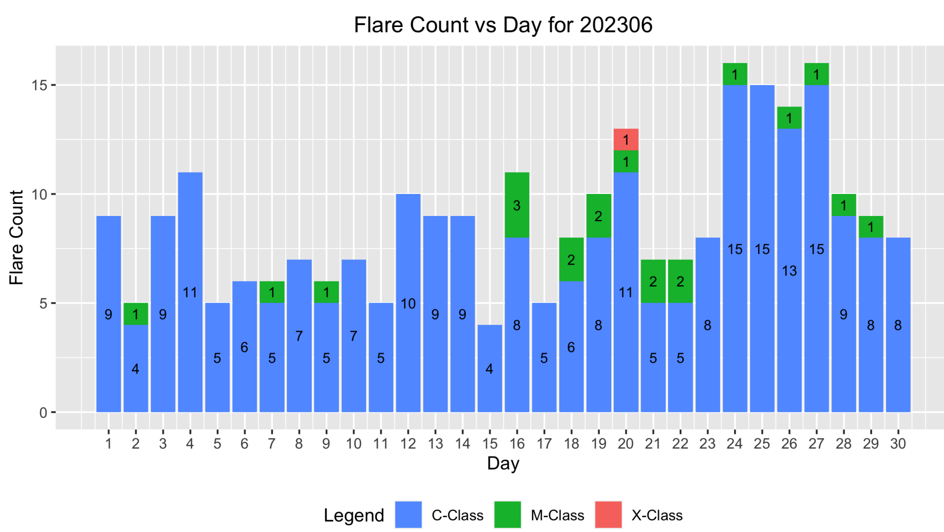


Figure 5: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 are then 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 June 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 6.

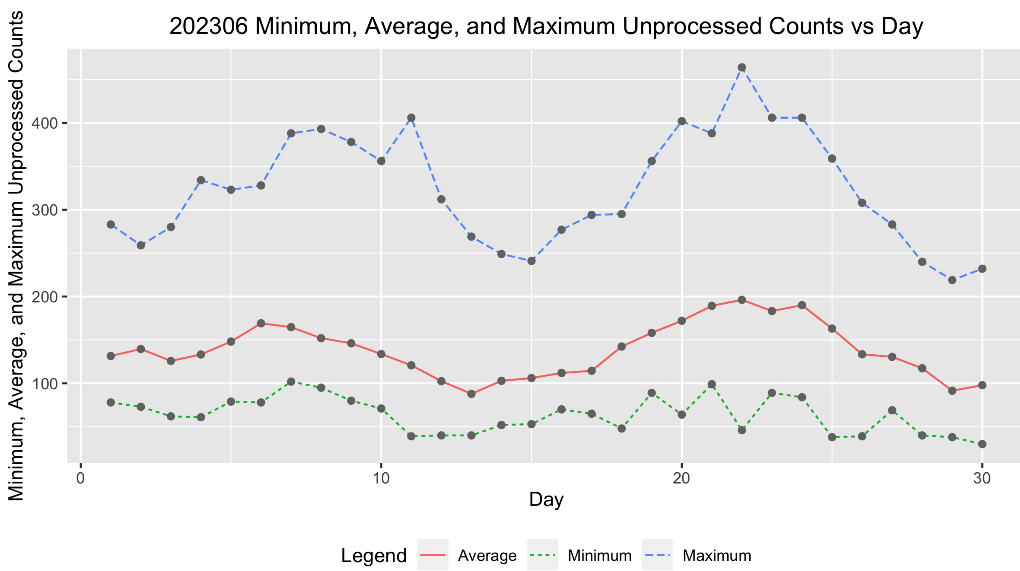


Figure 6: Raw Wolf number average, minimum and maximum by day of the month for all observers.

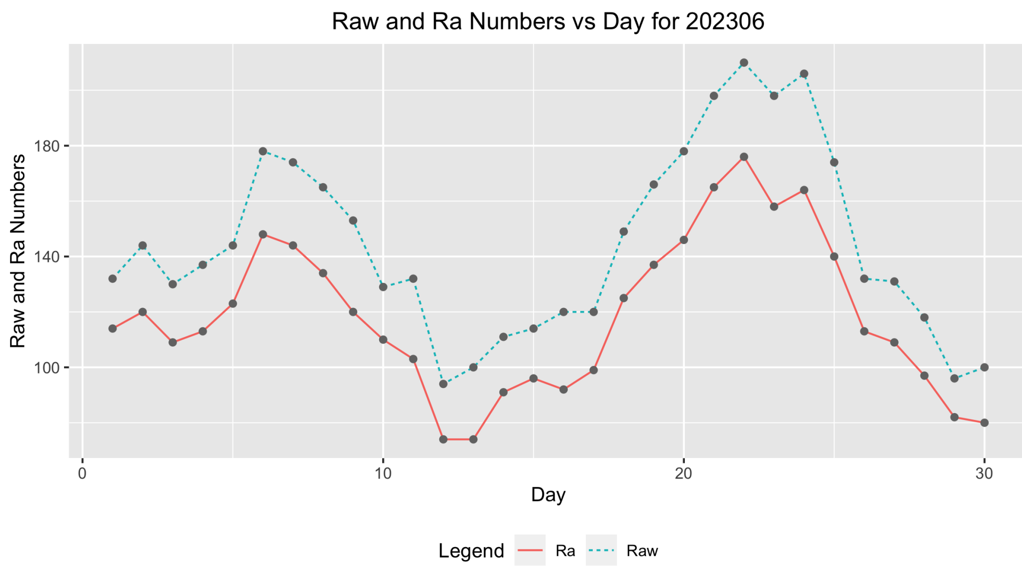


Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202306 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	44	132	114
2	38	144	120
3	39	130	109
4	37	137	113
5	34	144	123
6	34	178	148
7	35	174	144
8	36	165	134
9	33	153	120
10	42	129	110
11	40	132	103
12	27	94	74
13	30	100	74
14	30	111	91

Continued

Table 2: 202306 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	37	114	96
16	34	120	92
17	36	120	99
18	27	149	125
19	35	166	137
20	29	178	146
21	34	198	165
22	35	210	176
23	33	198	158
24	42	206	164
25	42	174	140
26	39	132	113
27	34	131	109
28	33	118	97
29	38	96	82
30	27	100	80
Averages	35.1	144.4	118.5

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for June 2023, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (66), and total number of observations submitted (1058).

Table 3: 202306 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	22	Alexandre Amorim
AJV	22	J. Alonso
ARAG	30	Gema Araujo
ASA	1	Salvador Aguirre
BATR	2	Roberto Battaiola
BMF	13	Michael Boschat
BMIG	27	Michel Besson
BROB	27	Robert Brown
BXZ	24	Jose Alberto Berdejo
BZX	25	A. Gonzalo Vargas
CKB	29	Brian Cudnik
CLDB	15	Laurent Cambon
CMAB	7	Maurizio Cervoni
CNT	16	Dean Chantiles

Continued

Table 3: 202306 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CVJ	3	Jose Carvajal
DARB	14	Aritra Das
DELS	3	Susan Delaney
DFR	11	Frank Dempsey
DJOB	9	Jorge del Rosario
DJSA	6	Jeff DeVries
DJVA	10	Jacques van Delft
DUBF	29	Franky Dubois
EHOA	20	Howard Eskildsen
ERB	20	Bob Eramia
FERA	10	Eric Fabrigat
FLET	27	Tom Fleming
GIGA	23	Igor Grageda Mendez
GJLB	9	Josep Maria Llenas Garcia
HALB	26	Brian Halls
HKY	16	Kim Hay
HOWR	19	Rodney Howe
IEWA	22	Ernest W. Iverson
ILUB	4	Luigi Iapichino
JGE	6	Gerardo Jimenez Lopez
JSI	10	Simon Jenner
KAND	28	Kandilli Observatory
KAPJ	18	John Kaplan
KNJS	22	James & Shirley Knight
KSOB	11	Souvik Karmokar
KZAD	11	Zachary Knoles
LKR	4	Kristine Larsen
LRRA	16	Robert Little
LVY	21	David Levy
MARC	7	Arnaud Mengus
MARE	13	Enrico Mariani
MCE	18	Etsuiku Mochizuki
MJHA	22	John McCammon
MLL	12	Jay Miller
MMI	30	Michael Moeller
MSS	11	Sandy Mesics
MWMB	4	William McShan
MWU	15	Walter Maluf
ONJ	10	John O'Neill
PLUD	25	Ludovic Perbet
RJV	20	Javier Ruiz Fernandez
SDOH	30	Solar Dynamics Obs - HMI
SNE	5	Neil Simmons

Continued

Table 3: 202306 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SRIE	15	Rick St. Hilaire
TDE	30	David Teske
TNIA	13	Nick Tonkin
TPJB	2	Patrick Thibault
URBP	30	Piotr Urbanski
VIDD	8	Dan Vidican
WGI	3	Guido Wollenhaupt
WND	19	Denis Wallian
WWM	28	William M. Wilson
Totals	1058	66

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.

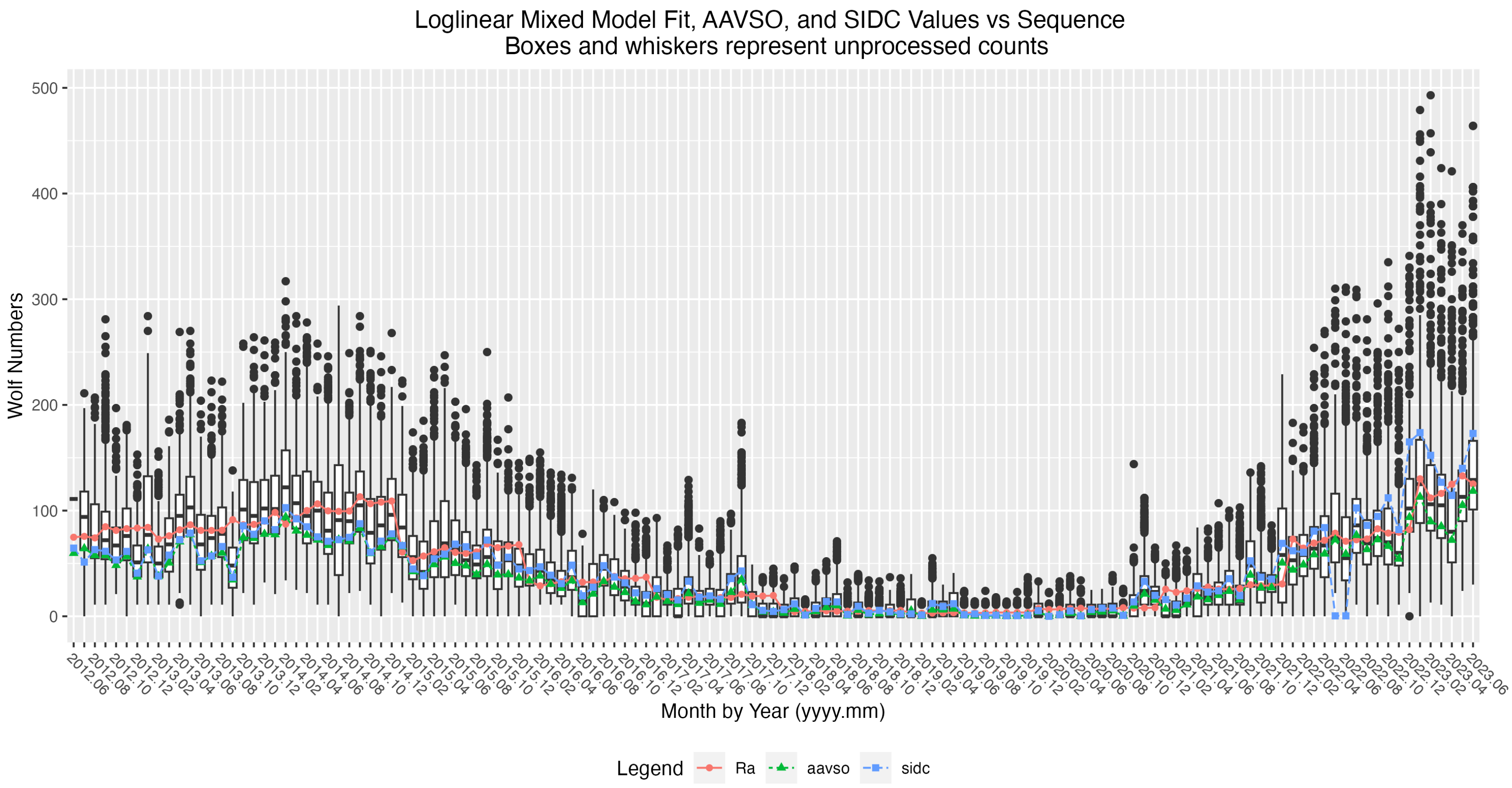


Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

4.1 Antique telescope project

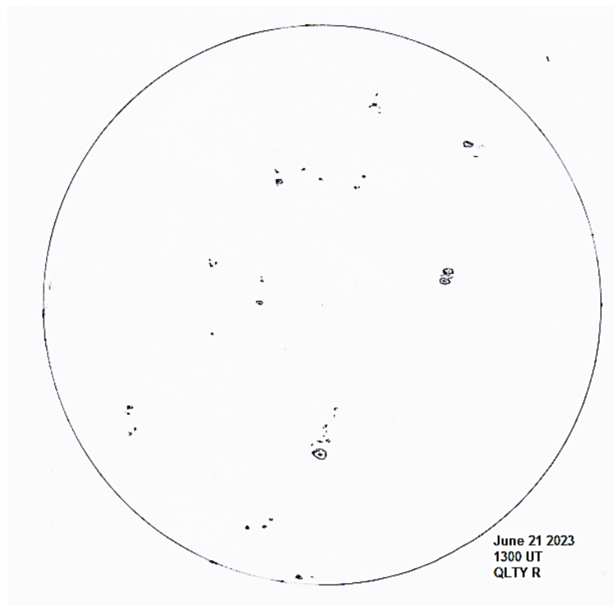


Figure 9: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) (left), and a drawing for June 21 (right).

5 References

Jiang, J., et al. 2011,
The solar magnetic field since 1700: I. Characteristics of sunspot group emergence and reconstruction of the butterfly diagram
`https://arxiv.org/abs/1102.1266v1`

Charbonneau, P. 2013, J. Phys.: Conf. Ser. 440 012014
`https://iopscience.iop.org/article/10.1088/1742-6596/440/1/012014/pdf`.

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