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 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 Observing the Sunspots group on 10th and 11th February 2024 from Bhalopahar, Purulia, West Bengal, India, by Santanu Basu (BSAB)

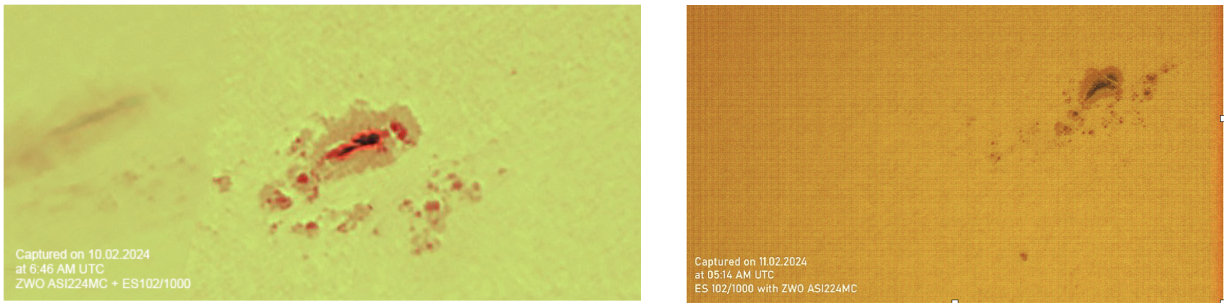

Figure 1: Kolkata Sky Watchers Association organized an annual astronomy and sky watching camp at Bhalopahar, Purulia. (Lat- 22.79 Long 86.47) on the second week of February 2024.

Here I report the F class sunspots group AR 3576 and 3579 (Zurich, 1945) which were observed on the Solar surface at the end of the first week of February 2024. It was the first F class sunspots of this year. On the 10th of February the spots were very compact in the group with its leading spots as well as its asymmetric penumbra and it was categorized with the sub-class of Fac (Left panel). On the next day, 11th February, the spots became more or less elongated and open with its leading spots along with the penumbra changes with small spots and it was categorized by Fro (See sub-classifications here)(`https://www.cv-helios.net/cvtable.html`).

I observed this solar group of spots with my team, Mr. Souvik Karmakar and Mr. Subhadeep Ghosh. Souvik Karmakar took these images. I also acknowledge the other team members who are helping us in these observations. Thanks to Dipankar Dey, Shouvik Ghosh, Drubo Ghosh, Samindra Basu, Krittika and Shreya.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

February 2024 (Figure 2): The 22nd of February we had an X6.3 flare recorded from Salvador Aguirre (A138) in Hermosillo Mexico.

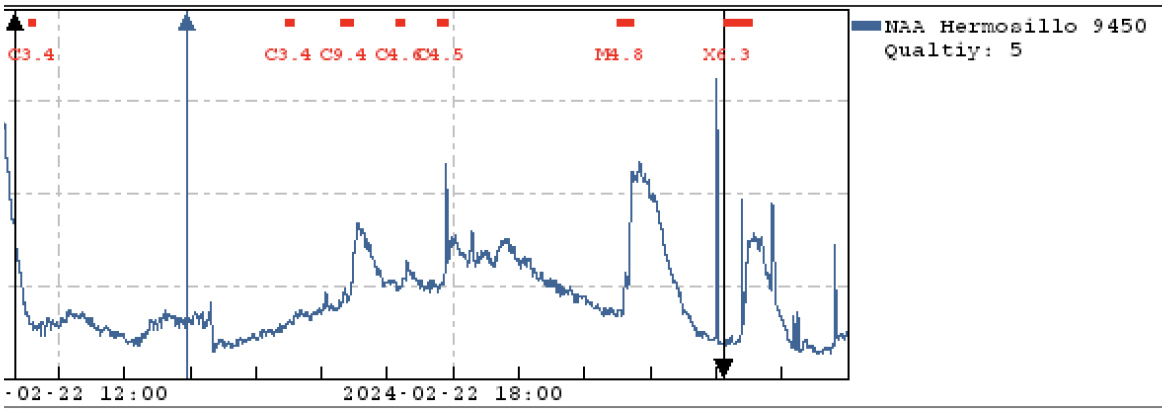

Figure 2: VLF recording from Fort Collins, CO.

2.2 SID Observers

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

Table 1: 202402 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
A Son	A112	DHO
L Loudet	A118	DHO GQD
J Godet	A119	GBZ GQD ICV
J Karlovsky	A131	TBB
S Aguirre	A138	NAA
G Silvis	A141	NAA NML NPM
L Pina	A148	NAA NLK
J Wendler	A150	NAA
J DeVries	A153	NLK
A Nebula	A156	DHO NSY
M Salo	A157	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.

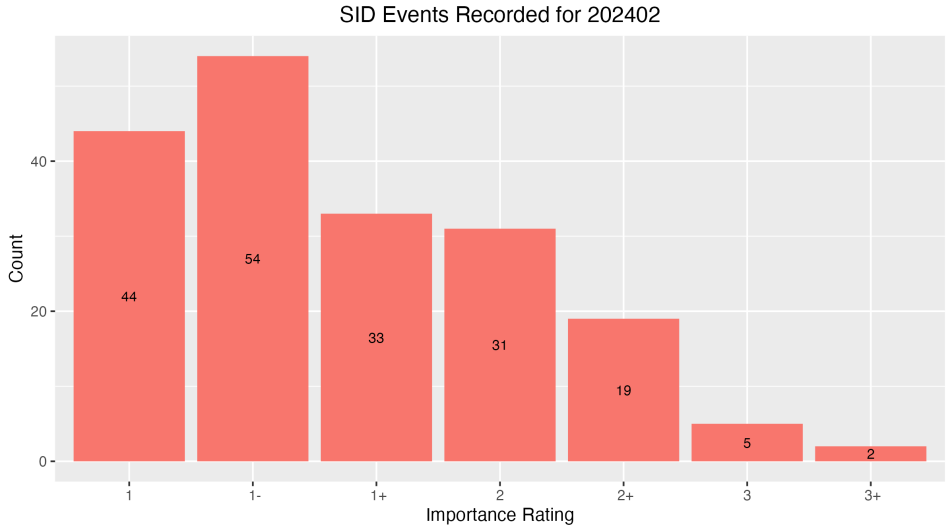

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In February 2024, there were 296 GOES-16 XRA flares; 245 C-class, 46 M-class, and 5 X-class flares. There was more flaring this month compared to last. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 4).

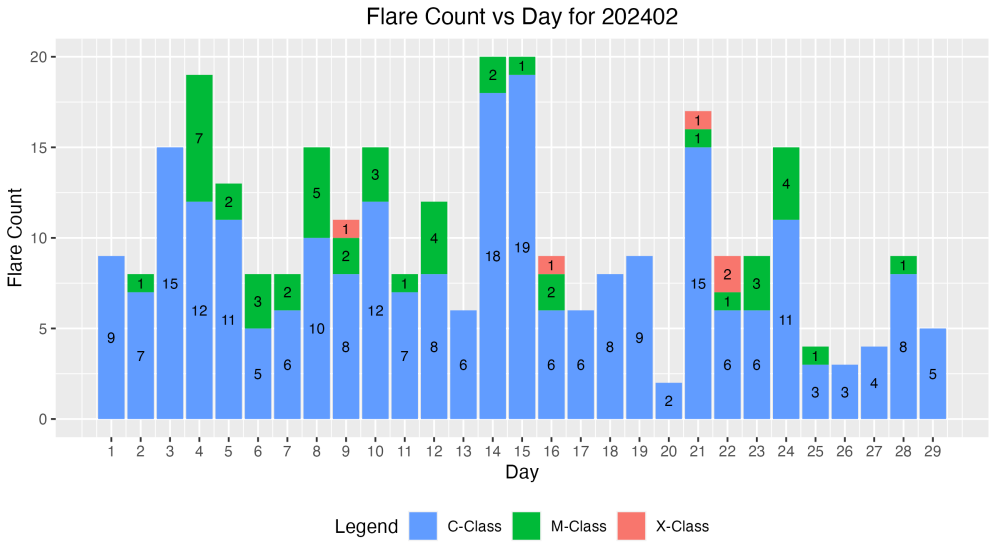

Figure 4: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 February 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 5.

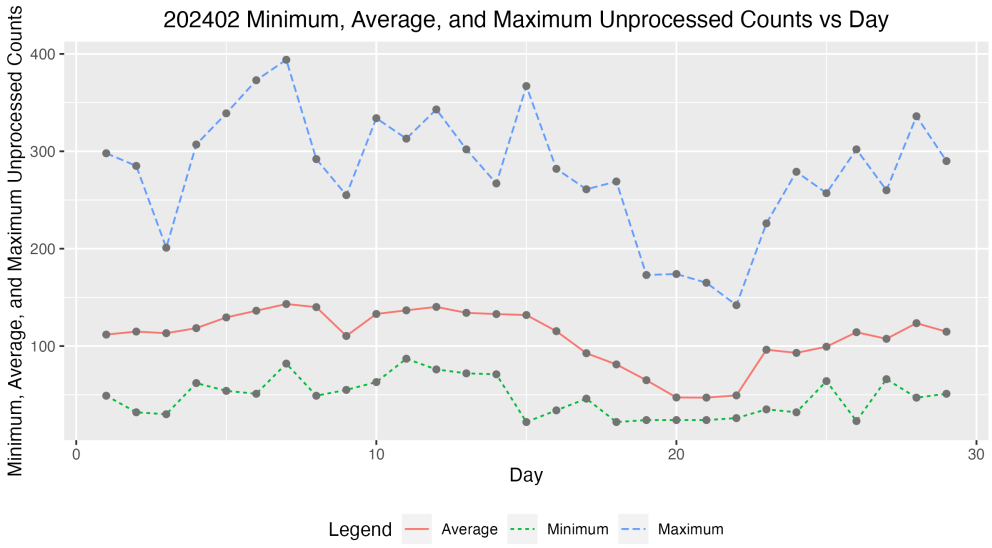

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

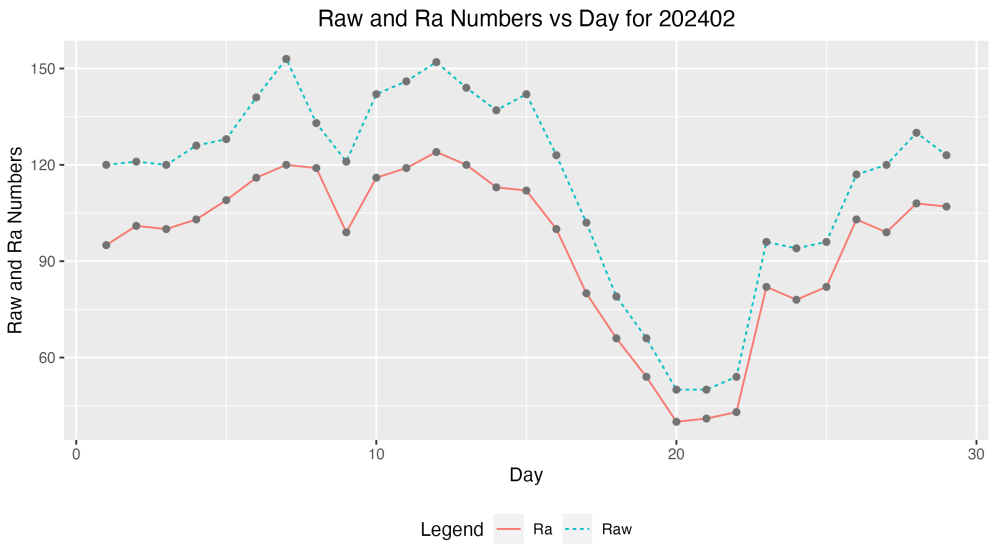

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202402 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	28	120	95
2	27	121	101
3	36	120	100
4	40	126	103
5	28	128	109
6	32	141	116
7	30	153	120
8	25	133	119
9	23	121	99
10	21	142	116
11	24	146	119
12	33	152	124
13	31	144	120
14	31	137	113
15	26	142	112

Continued

Table 2: 202402 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	24	123	100
17	33	102	80
18	36	79	66
19	33	66	54
20	35	50	40
21	35	50	41
22	26	54	43
23	33	96	82
24	39	94	78
25	33	96	82
26	36	117	103
27	29	120	99
28	26	130	108
29	28	123	107
Averages	30.4	114.7	94.8

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for February 2024, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (67), and total number of observations submitted (883).

Table 3: 202402 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AJV	22	J. Alonso
ARAG	27	Gema Araujo
ASA	3	Salvador Aguirre
BATR	1	Roberto Battaiola
BKL	10	John A. Blackwell
BMIG	20	Michel Besson
BXZ	18	Jose Alberto Berdejo
BZX	13	A. Gonzalo Vargas
CKB	22	Brian Cudnik
CLDB	12	Laurent Cambon
CMAB	7	Maurizio Cervoni
CNT	19	Dean Chantiles
CPAD	2	Panagiotis Chatzistamatiou
CVJ	1	Jose Carvajal
DARB	20	Aritra Das
DELS	10	Susan Delaney

Continued

Table 3: 202402 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DGIA	10	Giuseppe di Tommasco
DJOB	13	Jorge del Rosario
DJSA	5	Jeff DeVries
DJVA	20	Jacques van Delft
DMIB	18	Michel Deconinck
DUBF	12	Franky Dubois
EGMA	2	Georgios Epitropou
EHOA	16	Howard Eskildsen
ERB	5	Bob Eramia
FERA	8	Eric Fabrigat
FLET	18	Tom Fleming
GIGA	20	Igor Grageda Mendez
GJLB	3	Josep Maria Llenas Garcia
HALB	2	Brian Halls
HKY	20	Kim Hay
HOWR	20	Rodney Howe
HSR	12	Serge Hoste
IEWA	14	Ernest W. Iverson
ILUB	2	Luigi Iapichino
JGE	6	Gerardo Jimenez Lopez
KAMB	29	Amoli Kakkar
KAND	21	Kandilli Observatory
KNJS	29	James & Shirley Knight
KSOB	10	Souvik Karmokar
KTOC	13	Tom Karnuta
LKR	13	Kristine Larsen
LRRA	18	Robert Little
LVY	29	David Levy
MARC	2	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	19	Etsuiku Mochizuki
MJHA	26	John McCammon
MMI	29	Michael Moeller
MUDG	4	George Mudry
MWU	11	Walter Maluf
ONJ	4	John O'Neill
PLUD	6	Ludovic Perbet
RARD	7	Arnav Ranjekar
RJV	3	Javier Ruiz Fernandez
SDOH	29	Solar Dynamics Obs - HMI
SNE	12	Neil Simmons
SQN	20	Lance Shaw
SRIE	18	Rick St. Hilaire

Continued

Table 3: 202402 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
TDE	19	David Teske
TPJB	3	Patrick Thibault
TST	20	Steven Toothman
URBP	9	Piotr Urbanski
VIDD	12	Dan Vidican
WGI	3	Guido Wollenhaupt
WWM	18	William M. Wilson
Totals	883	67

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. 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.

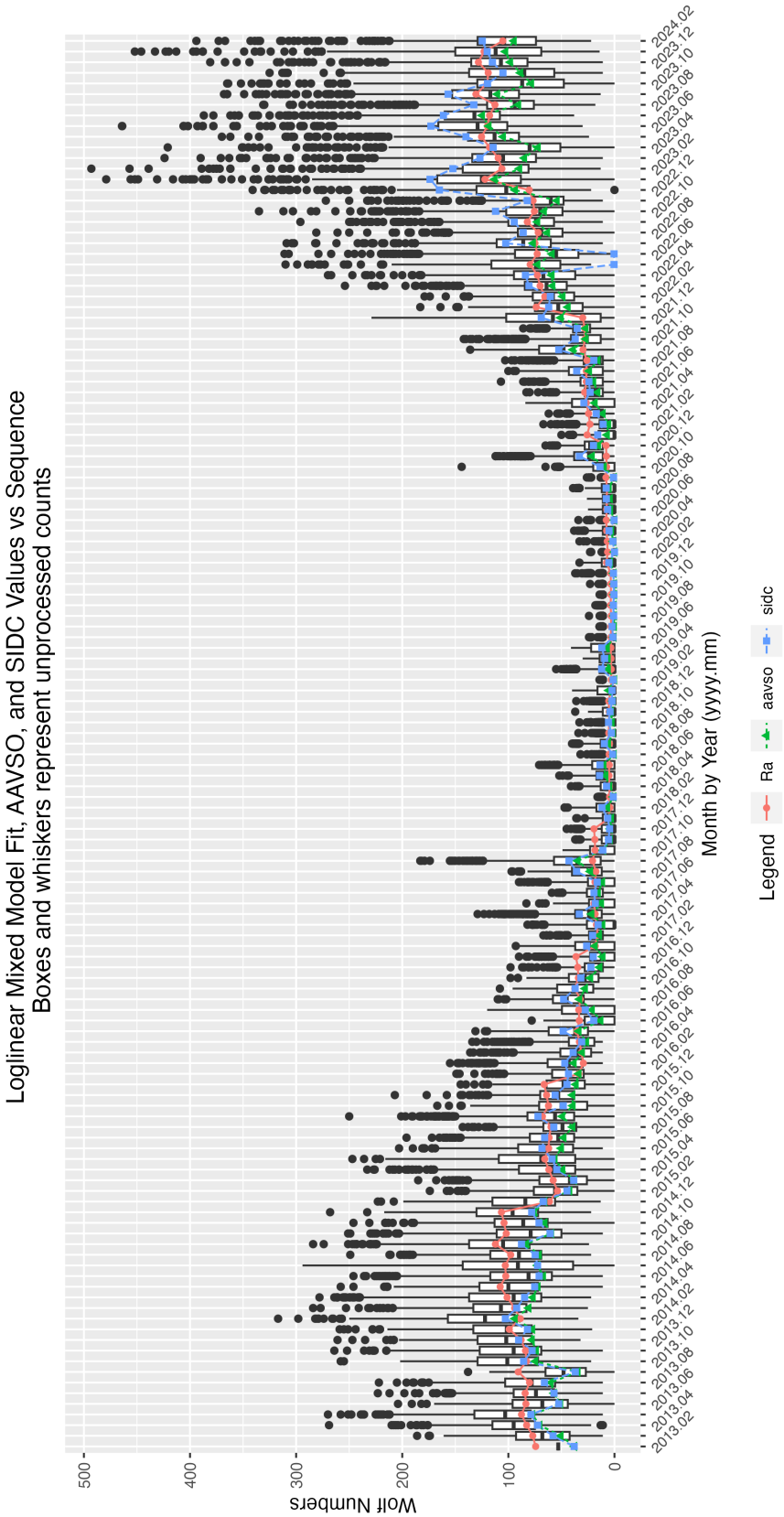

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

5 Michael Boschat (BMF) with 24 years of observations

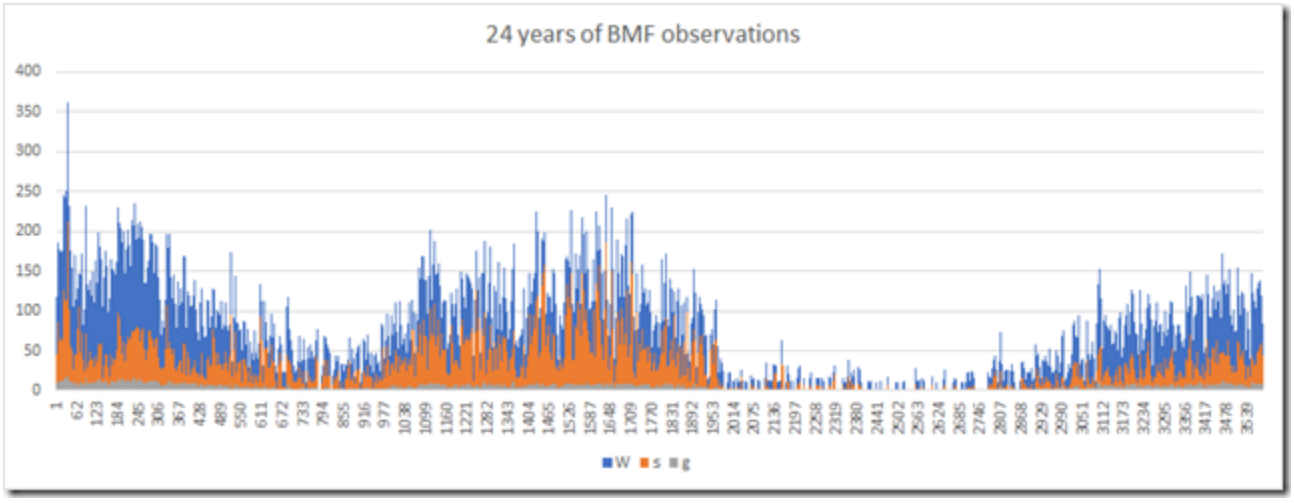

Figure 8: Here are 3865 observations from Michael Boschat. From 2001 to present we can see cycles 23, 24, and the long solar minimum before cycle 25.

Here's an example of data from a long time observer showing 3 solar cycles. Our solar observers continue to observe the sun because our daily observations might aid solar scientists in further improving their models and lead to enhanced prediction methods in the future. There are many long term observers in the AAVSO Solar Section data base; here's just one arbitrary pull of data from one observer looking at the groups, sunspots and calculated Wolf number for each observation.

6 Antique telescope project

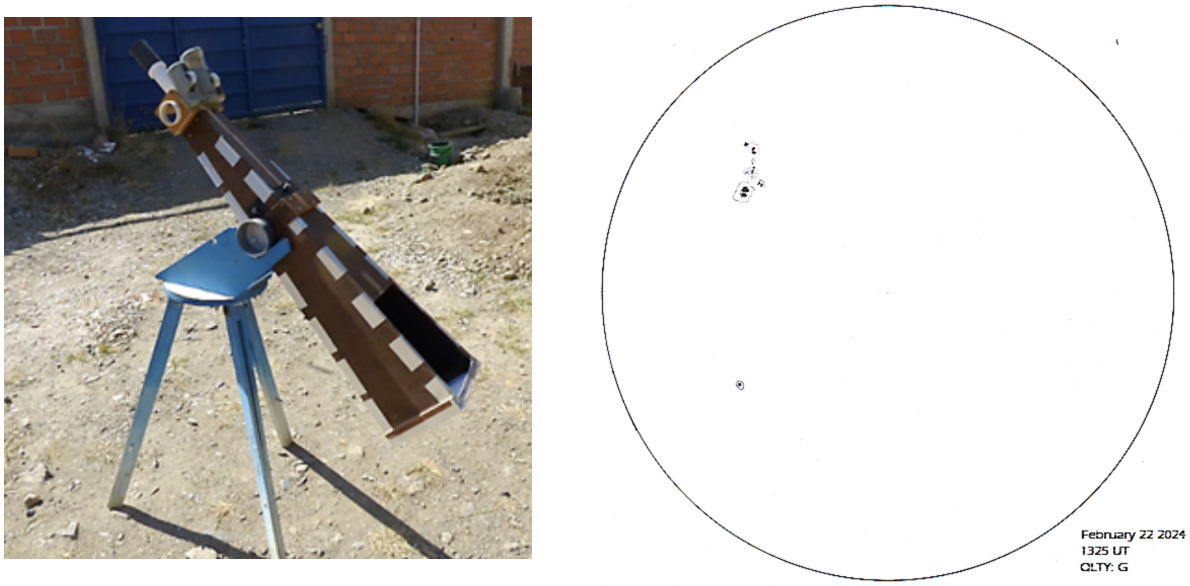

Figure 9: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) in Cochabamba Bolivia (left), and a drawing for February 22 (right).

7 References

Zurich, 1945, The Zurich Classification System of Sunspot Groups
`https://www.aavso.org/zurich-classification-system-sunspot-groups`

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