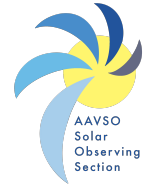


Solar Bulletin



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 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 A chat with artificial intelligence (OpenAI, ChatGPT), by David Jackson (JDAC)

Here is an example of how OpenAI (Creator of ChatGPT plus) software interface gives 'authoritative' content. If you ask the correct questions. <https://platform.openai.com/docs/guides/gpt>

I see that you've uploaded an Excel file named "silso-sunspots.xlsx". Let's start by loading the contents of the file to see what sheets are available.

JDAC: Let's use the combined-solar sheet.

ChatGPT: Finished working, Show work, Here's a preview of the "combined-solar" sheet:

Date, total-spots, northern-spots, southern-spots, polar-field-north, polar-field-south, polar-field-total-north, polar-field-total-south, polar-field-total2 X

JDAC: What is the min and max Date?

ChatGPT: Finished working, Show work, The date range in the "combined-solar" sheet spans from January 8, 1992, to July 14, 2023. What would you like to do next?

JDAC: Let's do some Descriptive statistics.

ChatGPT: Certainly! Descriptive statistics provide a summary of the main aspects of the data. I'll compute statistics such as the mean, standard deviation, minimum, 25th percentile, median (50th percentile), 75th percentile, and maximum for all numeric columns in the "combined-solar" sheet. Let's proceed. Finished working, Show work, Here are the descriptive statistics for the numeric columns in the "combined-solar" sheet: total-spots Count: 1140, Mean: 64.18, Standard Deviation: 61.99, Minimum: 0

25th Percentile: 14 Median: 47

75th Percentile: 100

... Maximum: 300 northern-spots Mean: 30.99

... Maximum: 195 southern-spots Mean: 33.19

... Maximum: 180 polar-field-north Mean: 16.20

... Maximum: 137 polar-field-south Mean: -18.25

... Maximum: 117 polar-field-total Mean: 17.23

... Maximum: 125 polar-field-total-south Mean: 16.08

... Maximum: 101 polar-field-total2 Mean: -18.37

(Note: For brevity, I've only provided selected statistics for each variable.) Would you like to explore any specific aspect further or perform any other analysis on this data?

JDAC: What do the above IQR and Standard Deviation tell us about the data?

ChatGPT: The Interquartile Range (IQR) and Standard Deviation (SD) are both measures of data spread or dispersion. Here's what they tell us about the data: IQR: It measures the spread of the middle 50 percent of the data. IQR is robust against outliers as it focuses only on the middle 50 percent of the data. A larger IQR suggests a wider spread in the middle values of the dataset. Standard Deviation (SD): It measures the average distance between each data point and the mean. A larger SD indicates that the data points are spread out over a wider range of values. It can be sensitive to outliers since it considers every data point in its calculation.

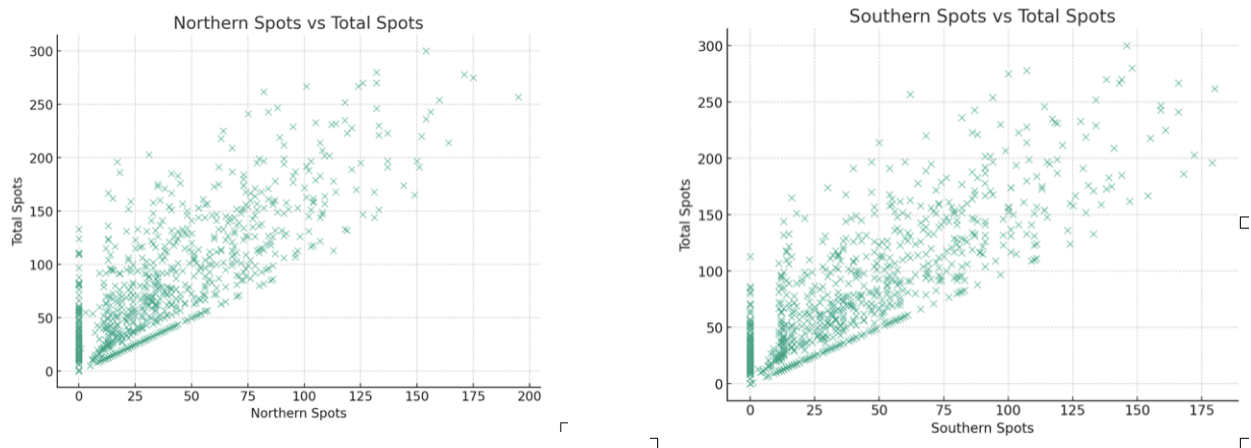


Figure 1: Bivariate Analysis: Here, we'll analyze the relationship between pairs of variables. For this data set, it might be interesting to see how the northern and southern sunspots relate to the total sunspots. We can do this using scatter plots.

Visual Analysis: Now, let's create some time series plots to see how the sunspots and polar fields have evolved over time. Finished working, Show work:

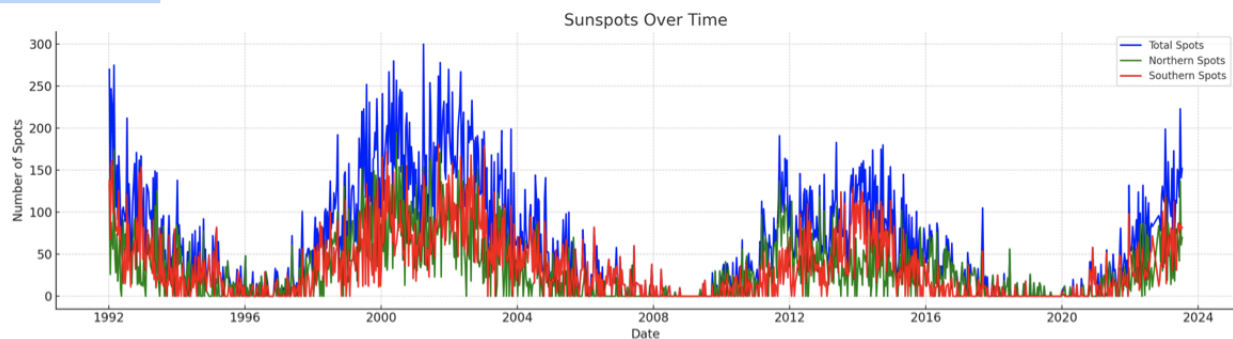


Figure 2: Graph of SILSO sunspot counts from 1992 Solar cycles 22 thru 25.

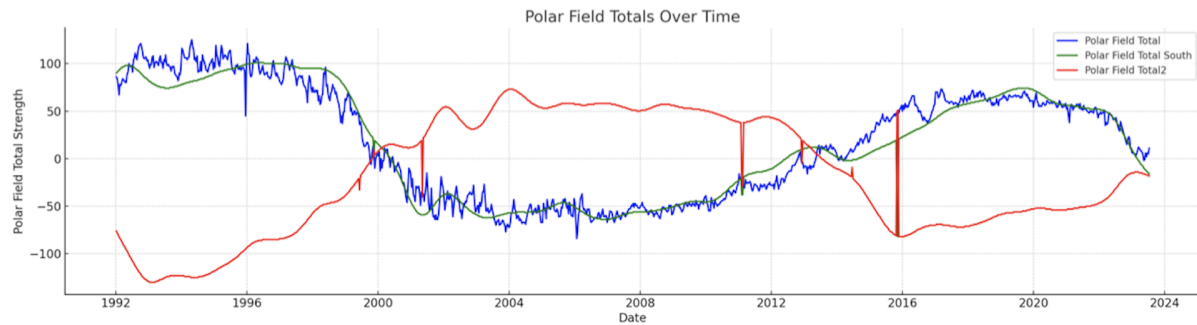


Figure 3: Graph of WSO polar fields from 1992 Solar cycles 22 thru 25.

These visualizations provide insights into the dynamic nature of solar activity over the observed period. Would you like to delve deeper into any specific aspect or move on to a different analysis?

JDAC: Predict total sunspots for next 30 days.

ChatGPT: To predict the total sunspots for the next 30 days, we'll employ a time series forecasting method. Given the cyclical pattern we observed in the sunspots data, the ARIMA (AutoRegressive Integrated Moving Average) model might be suitable. ARIMA is a popular statistical method for analyzing and forecasting time series data. Now, let's fit the ARIMA model using these parameters and then proceed to forecast the total sunspots for the next 30 days. Finished working, Show work, Here are the predicted total sunspots for the next 30 days:

Day 1 : 150.11 Day 2 : 145.21 Day 3 : 149.91 Day 4 : 146.64... : ... Day 30 : 147.91

(Note: For brevity, only selected days are shown. The full list is available.) The forecast suggests a slight decline in the sunspot numbers in the immediate next days, followed by stabilization around the 147-149 range. Would you like to visualize these predictions or proceed with any other analysis?

JDAC: Create new plot using the sunspots numbers since 2014 and the predicted values

ChatGPT: Finished working, Show work:

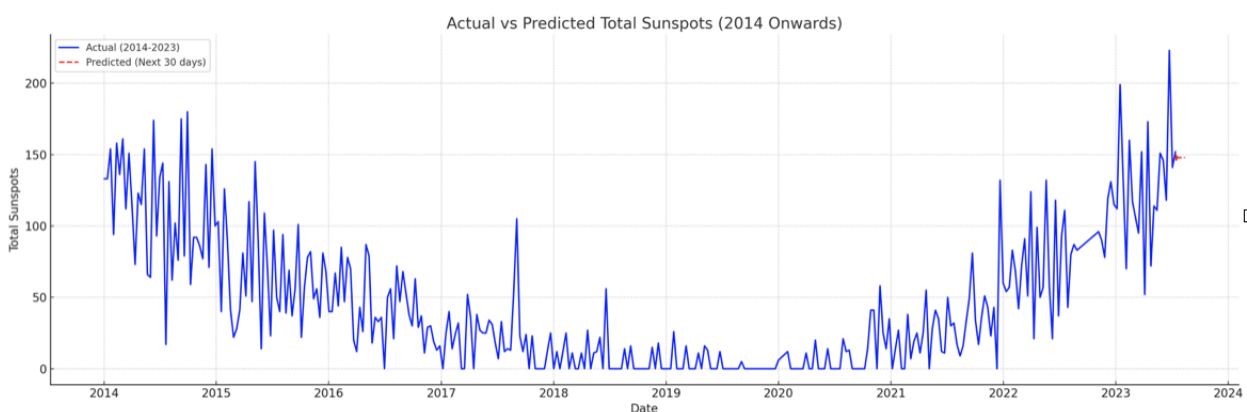


Figure 4: The blue line represents the actual total sunspots from 2014 onward. The red dashed line indicates the predicted sunspots for the next 30 days. (ARIMA is not an accurate predictor.)

“This Solar Bulletin is an AI Free Zone! ChatGPT is spreading rapidly across the Internet. It’s well-written, artificial, frequently inaccurate. If you find a mistake in the following Solar Bulletin, rest assured it was made by a real human being.” <https://www.spaceweather.com>

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

August 2023 (Figure 5): There were two M-Class flares and an X1.6 flare during the daytime recorded in Fort Collins, CO, (also thunder storms before the X1.6 flare) on the 5th of August.

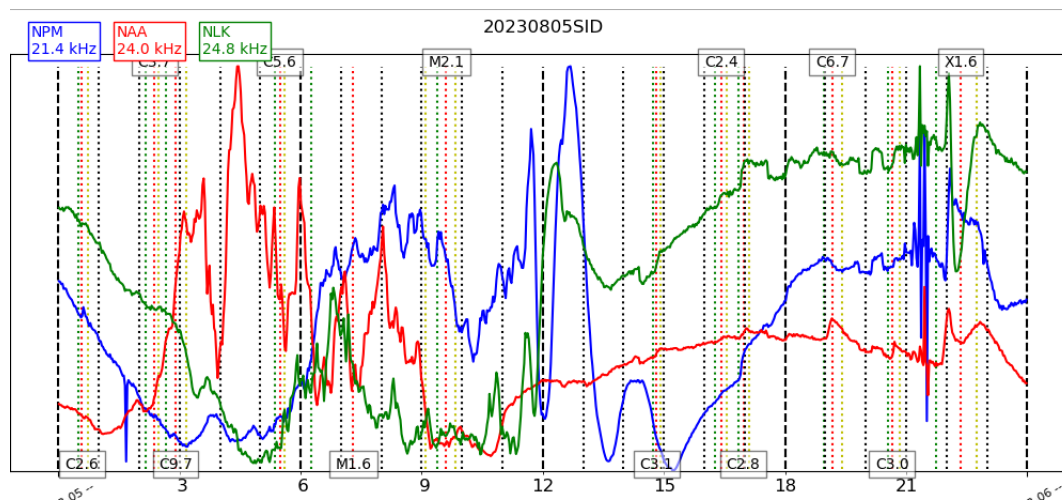


Figure 5: VLF recording from Fort Collins, CO.

2.2 SID Observers

In August 2023 we had 15 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202307 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
F Adamson	A122	NWC
J Karlovsky	A131	TBB
R Mrlak	A136	GQD NSY
S Aguirre	A138	NAA
G Silvis	A141	NAA NAU NLK
L Pina	A148	NAA NLK
J Wendler	A150	NAA
H Krumnow	A152	DHO FTA GBZ
J DeVries	A153	NLK
M Salo	A157	NLK

Figure 6 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 6: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In August 2023, there were 219 GOES-16 flares: two X-class, 25 M-class, 185 C-class, and 7 B-class. There was far less flaring this month compared to last. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 7).

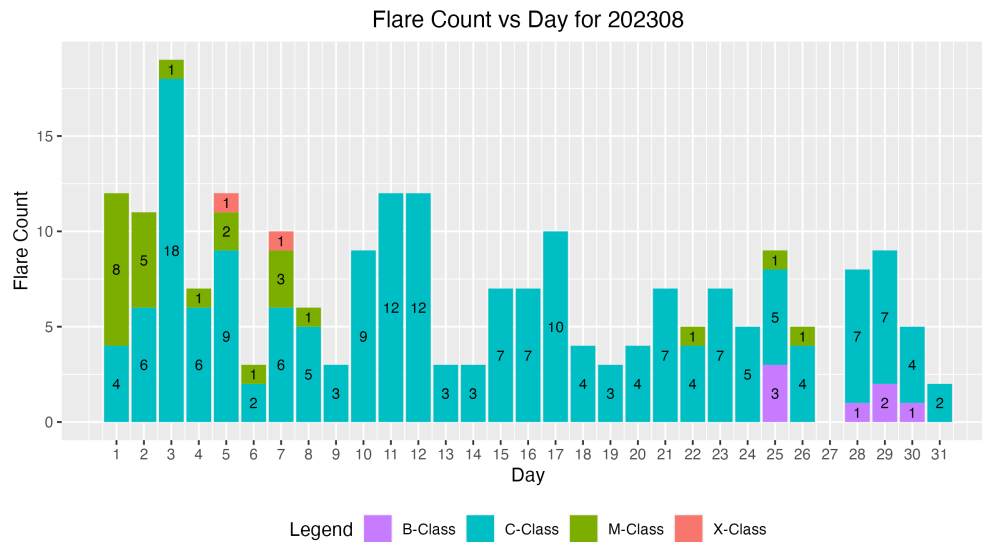


Figure 7: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 August 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 8.

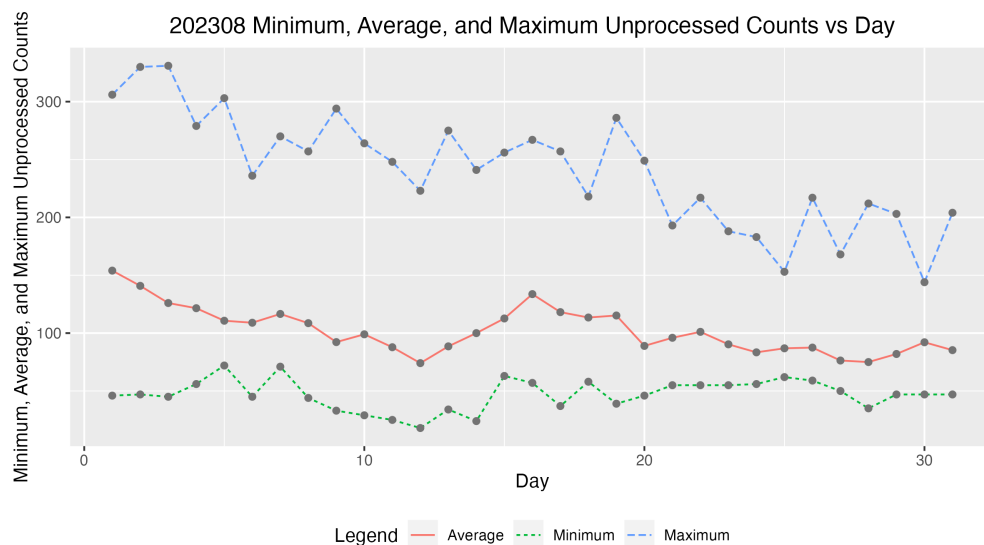


Figure 8: Raw Wolf number average, minimum and maximum by day of the month for all observers.

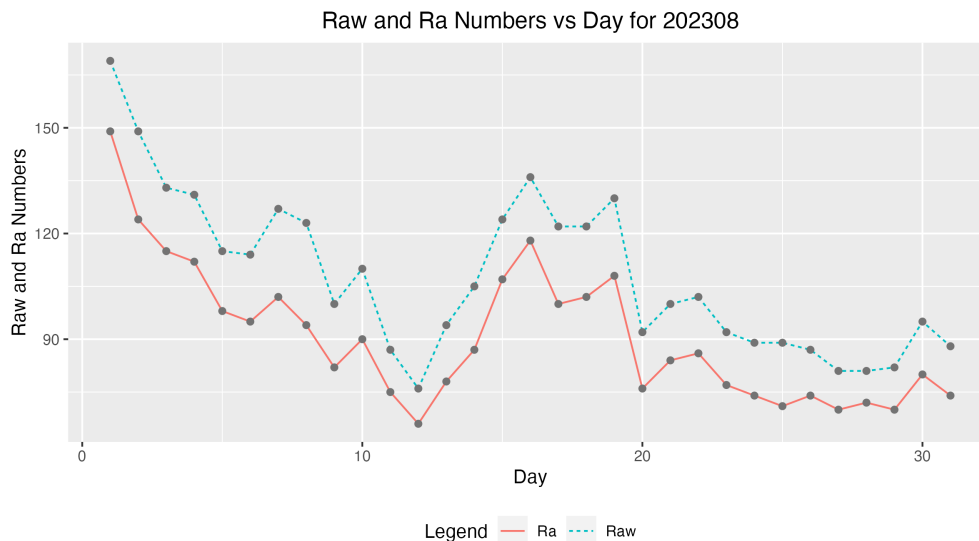


Figure 9: Raw Wolf average and R_a numbers by day of the month for all observers.

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>). Wolf averages and calculated R_a are seen in Figure 9, 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: 202308 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	45	169	149
2	42	149	124
3	41	133	115
4	40	131	112
5	41	115	98
6	42	114	95
7	39	127	102
8	36	123	94
9	41	100	82
10	43	110	90
11	52	87	75
12	43	76	66
13	41	94	78
14	41	105	87
15	41	124	107
16	37	136	118
17	38	122	100

Continued

Table 2: 202308 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
18	37	122	102
19	45	130	108
20	43	92	76
21	43	100	84
22	41	102	86
23	48	92	77
24	38	89	74
25	31	89	71
26	36	87	74
27	37	81	70
28	36	81	72
29	38	82	70
30	32	95	80
31	34	88	74
Averages	40.1	107.9	90.6

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for August 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 (1242).

Table 3: 202308 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	18	Alexandre Amorim
AJV	21	J. Alonso
ARAG	31	Gema Araujo
ASA	5	Salvador Aguirre
ATE	12	Teofilo Arranz Heras
BATR	10	Roberto Battaola
BKL	19	John A. Blackwell
BMF	21	Michael Boschat
BMIG	28	Michel Besson
BROB	28	Robert Brown
BXZ	26	Jose Alberto Berdejo
BZX	26	A. Gonzalo Vargas
CKB	30	Brian Cudnik
CLDB	16	Laurent Cambon
CMAB	14	Maurizio Cervoni
CNT	29	Dean Chantiles

Continued

Table 3: 202308 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CVJ	11	Jose Carvajal
DARB	12	Aritra Das
DELS	1	Susan Delaney
DFR	10	Frank Dempsey
DJOB	12	Jorge del Rosario
DJSA	5	Jeff DeVries
DJVA	24	Jacques van Delft
DMIB	28	Michel Deconinck
DUBF	28	Franky Dubois
EHOA	16	Howard Eskildsen
ERB	4	Bob Eramia
FALB	22	Allen Frohardt
FERA	15	Eric Fabrigat
FLET	30	Tom Fleming
GIGA	30	Igor Grageda Mendez
HALB	22	Brian Halls
HKY	23	Kim Hay
HMQ	7	Mark Harris
HOWR	22	Rodney Howe
HSR	18	Serge Hoste
IEWA	27	Ernest W. Iverson
ILUB	10	Luigi Iapichino
JGE	4	Gerardo Jimenez Lopez
JSI	7	Simon Jenner
KAND	26	Kandilli Observatory
KAPJ	20	John Kaplan
KNJS	29	James & Shirley Knight
KSOB	3	Souvik Karmokar
KTOC	11	Tom Karnuta
LKR	7	Kristine Larsen
LVY	26	David Levy
MARC	6	Arnaud Mengus
MARE	13	Enrico Mariani
MCE	26	Etsuiku Mochizuki
MJHA	29	John McCammon
MLL	9	Jay Miller
MMI	31	Michael Moeller
MSS	6	Sandy Mesics
MUDG	2	George Mudry
MWMB	10	William McShan
MWU	23	Walter Maluf
ONJ	9	John O'Neill
PLUD	19	Ludovic Perbet

Continued

Table 3: 202308 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
RJV	22	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	6	Neil Simmons
SRIE	13	Rick St. Hilaire
TDE	30	David Teske
TNIA	8	Nick Tonkin
TPJB	4	Patrick Thibault
TST	25	Steven Toothman
URBP	25	Piotr Urbanski
VIDD	16	Dan Vidican
WGI	3	Guido Wollenhaupt
WND	10	Denis Wallian
WWM	22	William M. Wilson
Totals	1242	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 10 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 25th through the 75th quartiles. The lower and upper whiskers extend 1.5 times the IQR below the 25th quartile, and 1.5 times the IQR above the 75th 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.

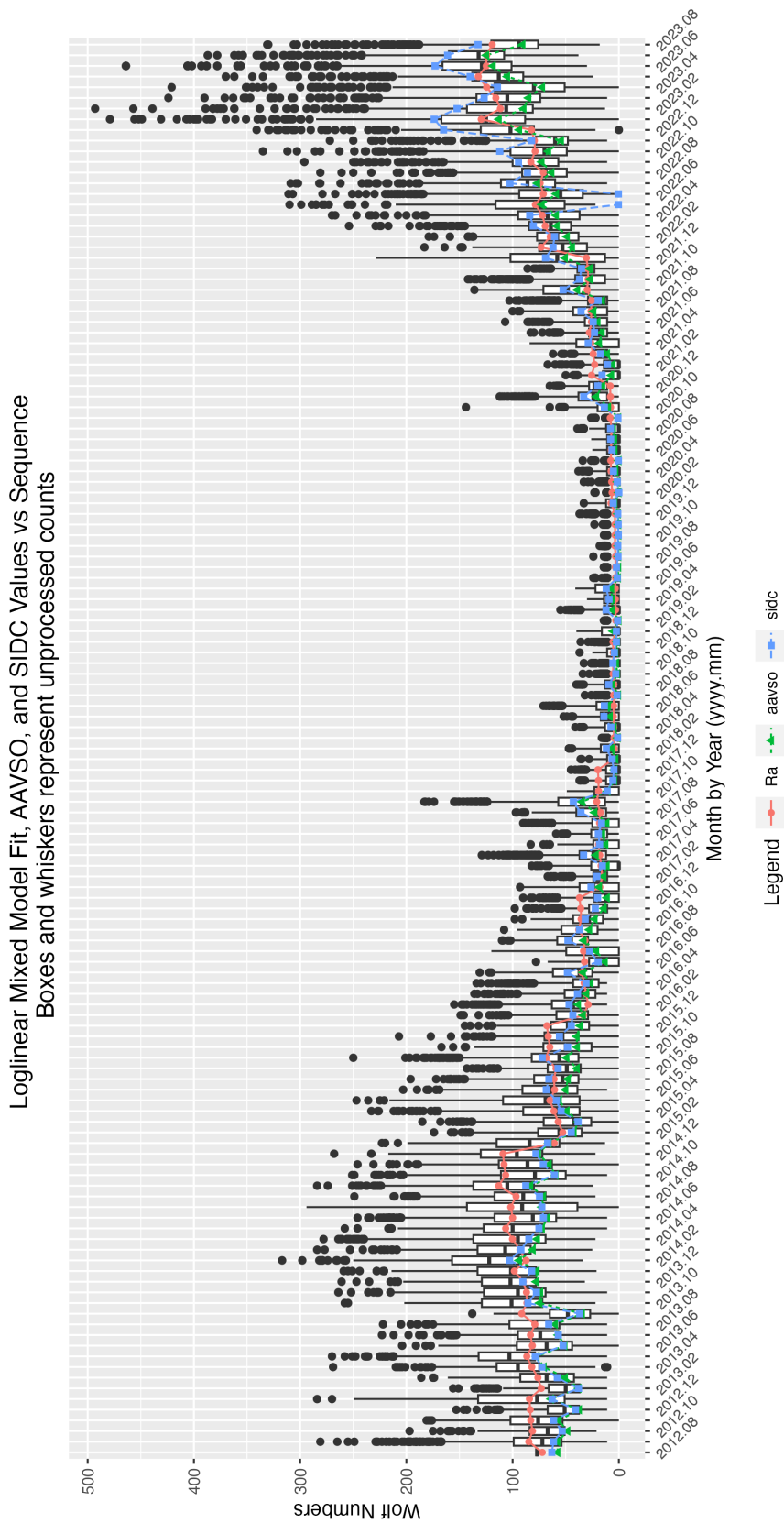


Figure 10: GLMM fitted data for R_a . AAVSO data: <https://www.aavso.org/category/tags/solar-bulletin>. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

4.1 Antique telescope project

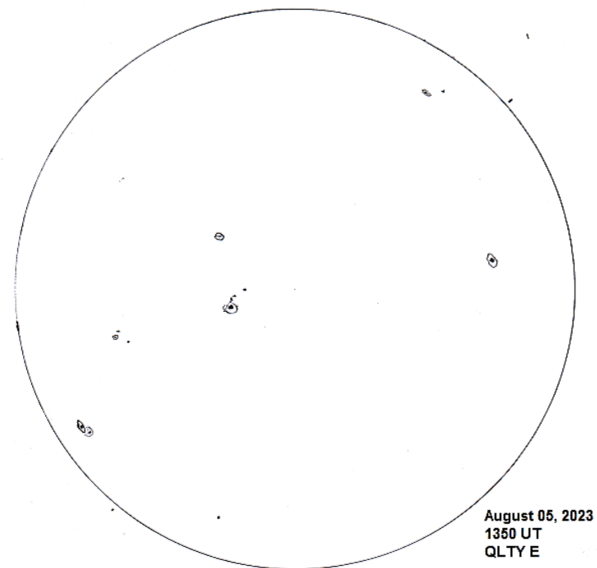


Figure 11: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) (left), and a drawing for August 05 (right).

5 References

OpenAI, *OpenAI is an American artificial intelligence (AI) research laboratory*
<https://en.wikipedia.org/wiki/OpenAI>

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