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 sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 RGO data to test for asymmetry of South and North solar hemispheres

Here we use the Royal Greenwich Observatory (RGO) Carrington Rotations and umbra area daily observations (Hathaway 2016) for the time period from January 2000 through November 2016. With these data we can use the RGO South and North hemisphere distributions to do normality statistical time series tests to identify any solar asymmetry of the South and North hemispheres.

Figure 1 shows the SIDC ISN monthly averaged data from 2000 to 2016 including the solar cycles covered, and RGO of South and North Carrington Rotations and umbral areas of the same time frame along with longitude and latitude data for both hemispheres.

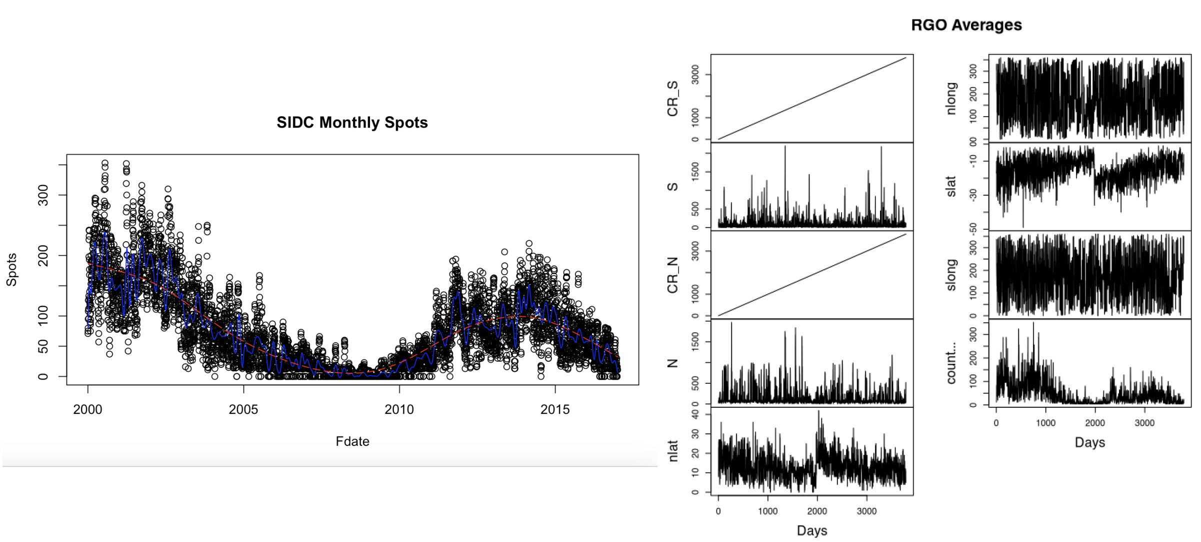

Figure 1: The SIDC monthly data from 2000 to 2016 (left panel) and RGO Carrington Rotations data elements used in this study (right panel).

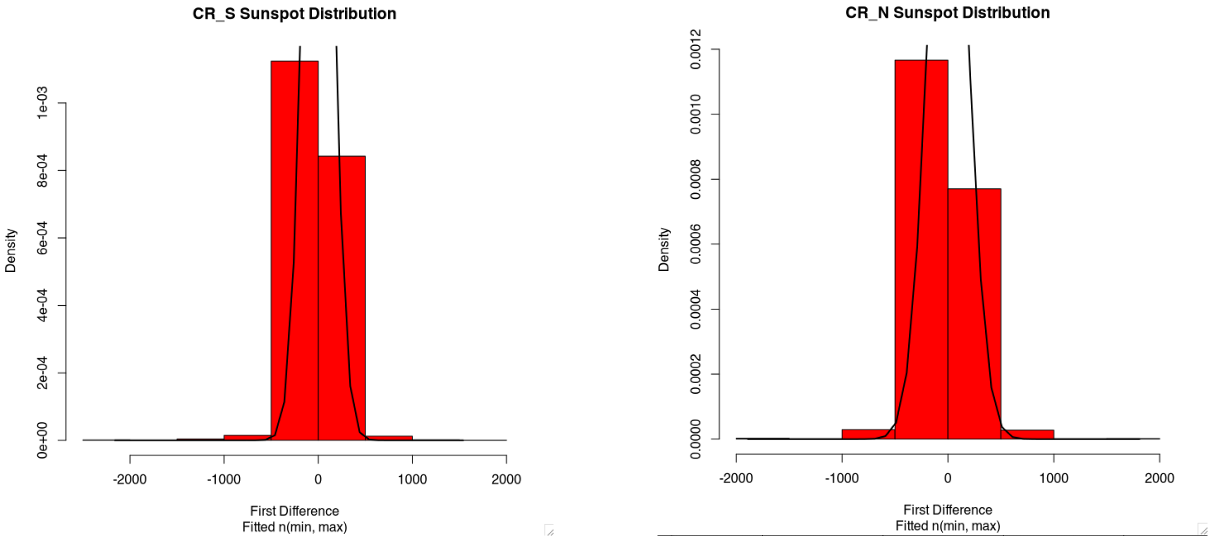

Figure 2: The RGO data for South and North hemispheres show a slight difference in their distributions, where South (left panel) is more narrow (black lines) than the North (right panel).

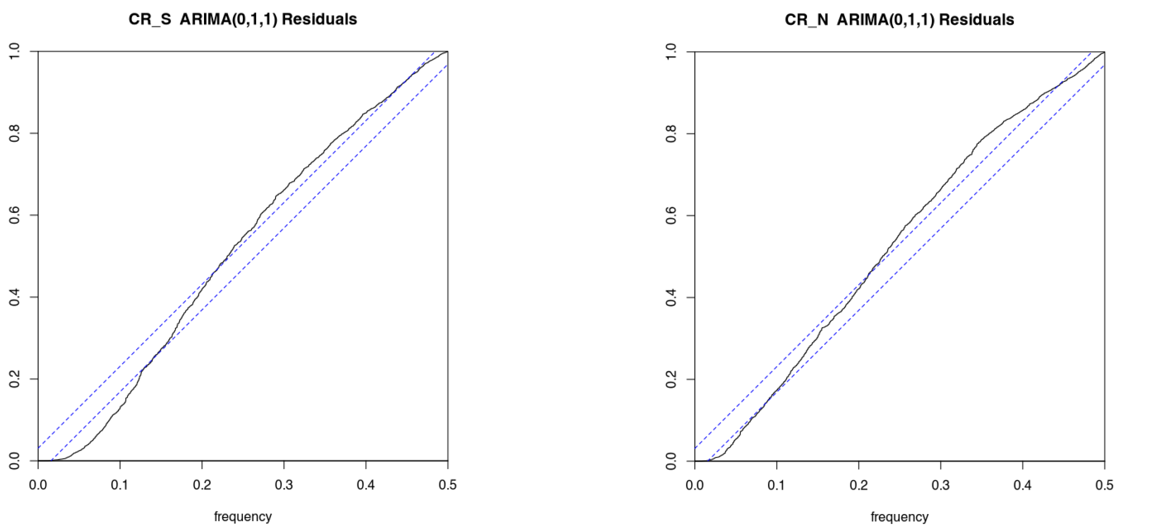

Figure 3: RGO data for South hemisphere Arima (left panel) are not within the normal bounds (blue lines) for the lower frequencies, and the North hemisphere Arima is not within the normal bounds at the higher frequencies (right panel).

1.1 Some statistics for being normal

Here we look at some statistical time series tests to identify any possible asymmetry of the RGO data, where the null hypothesis is that there is NO difference between the South and North hemisphere umbral area numbers. Here's a definition for the null hypothesis: (`https://simple.wikipedia.org/wiki/Null_hypothesis`).

Now we figure what the p values mean for rejecting the null hypothesis with p value interpretation of different statistical tests (`https://en.wikipedia.org/wiki/P-value`.)

These are time series data so we have to take the first difference of each of the data streams (`https://people.duke.edu/~rnau/411diff.htm`) to begin considering these data as normal distributions in order to do the statistical testing. (The following statistical tests come from the R project libraries: (`https://cran.r-project.org`).

The first will be the Welch Two Sample t-test; (`https://en.wikipedia.org/wiki/Welch%27s_t-test`)

t.test(tmp[,South],tmp[,North])

Welch Two Sample t-test

data: tmp[,South] and tmp[,North] t = 0.0057052, df = 7218.7, p-value = 0.9954 alternative hypothesis: true difference in means is not equal to 0; 95 percent confidence interval: -7.237328 to +7.279578 sample estimates: mean of x mean of y 0.018484288 -0.002640613
These results show a large p value for the Welch test where these two data streams are likely not to have a large difference between their means.

The next test will be the Asymptotic two-sample Kolmogorov-Smirnov test; (`http://www.real-statistics.com/non-parametric-tests/goodness-of-fit-tests/two-sample-kolmogorov-smirnov-test/`)

ks.test(tmp[,South],tmp[,North])

Asymptotic two-sample Kolmogorov-Smirnov test

data: tmp[,South] and tmp[,North] D = 0.036176, p-value = 0.01408 alternative hypothesis: two-sided: Warning message: In ks.test.default(tmp[,South], tmp[,North]) : p-value will be approximate in the presence of ties: This shows a small p value for the KS test so there may be a large difference in the cumulative distribution between the two data sets and we can reject the null hypothesis.

The final test will be Pearson's product-moment correlation:

(`https://statistics.laerd.com/statistical-guides/pearson-correlation-coefficient-statistica php`)
cor.test(tmp[,South],tmp[,North])

Pearson's product-moment correlation

data: tmp[,South] and tmp[,North] t = 0.0030425, df = 3785, p-value = 0.9976 alternative hypothesis: true correlation is not equal to 0; 95 percent confidence interval: -0.03180178 to +0.03190059 sample estimates: cor 4.945386e-05
A large p value for the Pearson's test suggests there may be a large difference in the linear association between the two data streams and we cannot reject the null hypothesis that there is no difference between them.

It seems these 3 statistical tests can't agree among themselves about the normality of the South and North RGO time series, so it's really up to the observer whether the South and North hemispheres are asymmetrical.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

August 2024 (Figure 4): An average day with 8 flares: 6 C class and 2 M class, for August 12th recorded here in Fort Collins, Colorado (U.S. Dept. of Commerce–NOAA, 2022).

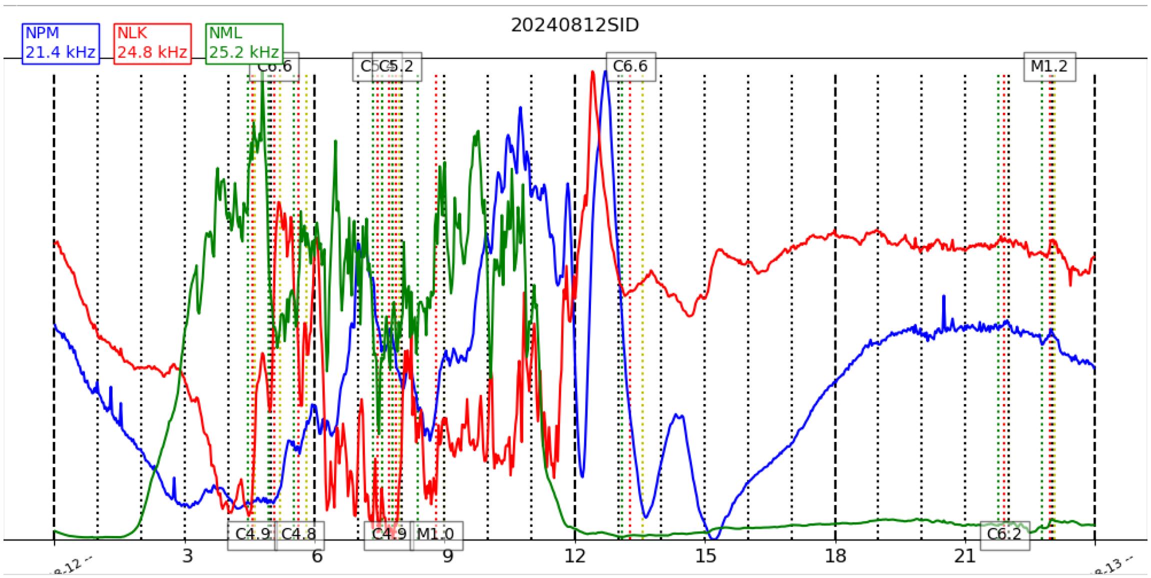

Figure 4: VLF recording from Fort Collins, Colorado for the 12th of August.

2.2 SID Observers

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

Table 1: 202408 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
J Karlovsky	A131	DHO FTA
S Aguirre	A138	NAA
G Silvis	A141	NAA NML NPM
L Pina	A148	NAA NML
J Wendler	A150	NAA
J DeVries	A153	NAA
A Nebula	A156	DHO NSY
M Salo	A157	NLK

Figure 5 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.

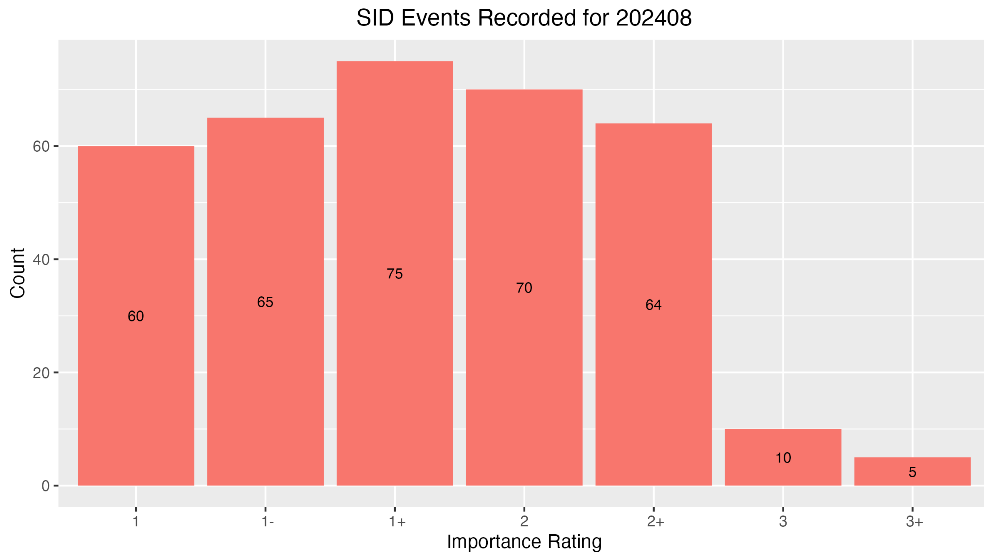

Figure 5: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In August 2024, there were 347 GOES-16 XRA flares: 4 X-class, 119 M-class and 224 C-class. More flaring this month compared to last. (U.S. Dept. of Commerce–NOAA, 2024). (see Figure 6).

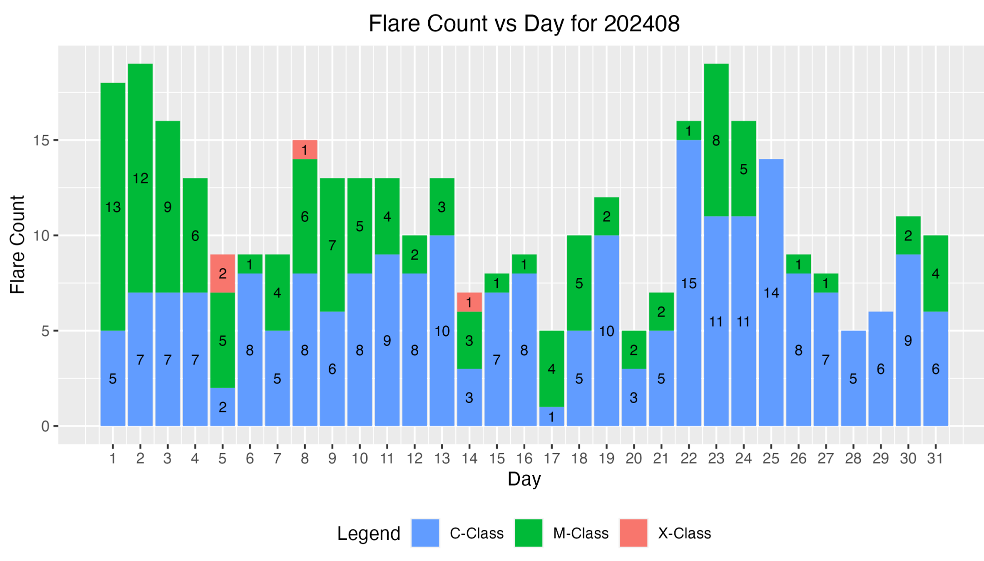

Figure 6: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2024).

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 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 7.

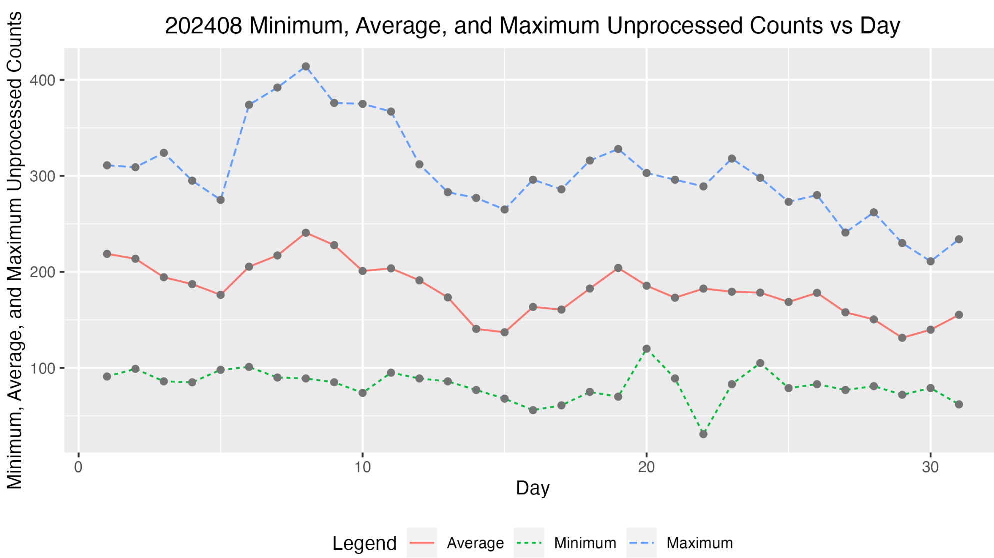

Figure 7: Raw Wolf number average, minimum and maximum by day of the month for all observers.

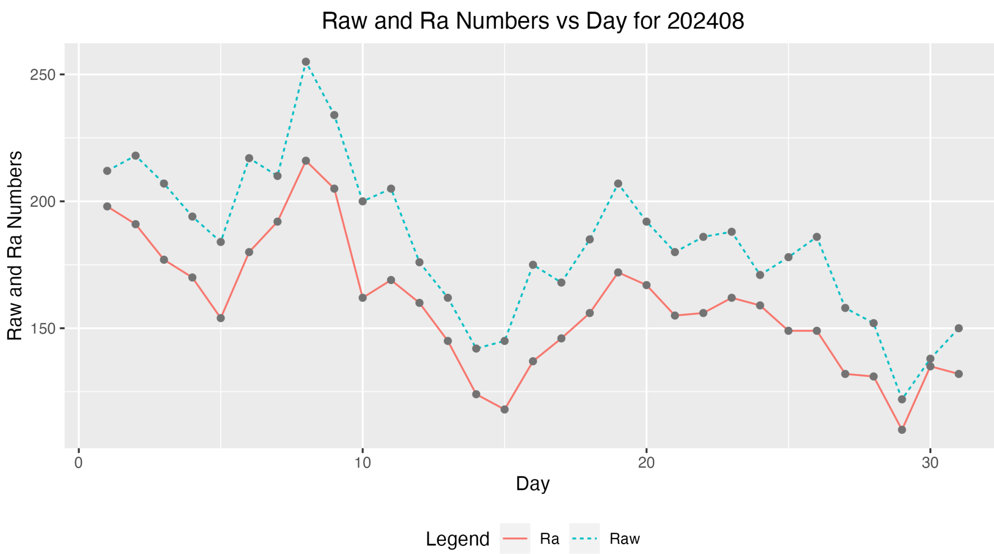

Figure 8: Raw Wolf average and R_a numbers by day of the month for all observers.

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 8, 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: 202408 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	39	212	198
2	34	218	191
3	36	207	177
4	36	194	170
5	41	184	154
6	39	217	180
7	39	210	192
8	35	255	216
9	42	234	205
10	43	200	162
11	41	205	169
12	45	176	160
13	41	162	145
14	37	142	124
15	35	145	118

Continued

Table 2: 202408 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	37	175	137
17	35	168	146
18	25	185	156
19	34	207	172
20	38	192	167
21	37	180	155
22	39	186	156
23	38	188	162
24	33	171	159
25	38	178	149
26	38	186	149
27	39	158	132
28	39	152	131
29	38	122	110
30	31	138	135
31	30	150	132
Averages	37.2	183.8	158.4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for August 2024, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (68), and total number of observations submitted (1152).

Table 3: 202408 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	24	Alexandre Amorim
AJV	14	J. Alonso
ARAG	31	Gema Araujo
ASA	4	Salvador Aguirre
BATR	7	Roberto Battaiola
BKL	12	John A. Blackwell
BMIG	30	Michel Besson
BTB	22	Thomas Bretl
BXZ	26	Jose Alberto Berdejo
BZX	27	A. Gonzalo Vargas
CIOA	14	Ioannis Chouinavas
CKB	25	Brian Cudnik
CLDB	16	Laurent Cambon
CMAB	6	Maurizio Cervoni

Continued

Table 3: 202408 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	31	Dean Chantiles
CVJ	10	Jose Carvajal
DARB	14	Aritra Das
DAT	12	Adam Derdzikowski
DELS	3	Susan Delaney
DFR	11	Frank Dempsey
DJOB	16	Jorge del Rosario
DJSA	3	Jeff DeVries
DJVA	30	Jacques van Delft
DMIB	25	Michel Deconinck
DUBF	21	Franky Dubois
EHOA	7	Howard Eskildsen
FARC	3	Arnaud Fiocret
FERA	31	Eric Fabrigat
FLET	27	Tom Fleming
GFAD	8	Fabrizio Guida
HALB	15	Brian Halls
HKY	19	Kim Hay
HOWR	25	Rodney Howe
HSR	24	Serge Hoste
IEWA	22	Ernest W. Iverson
ILUB	6	Luigi Iapichino
JGE	2	Gerardo Jimenez Lopez
JSI	6	Simon Jenner
KAND	30	Kandilli Observatory
KAPJ	18	John Kaplan
KNJS	24	James & Shirley Knight
KTOC	18	Tom Karnuta
LKR	8	Kristine Larsen
LRRA	22	Robert Little
LVY	30	David Levy
MARC	4	Arnaud Mengus
MARE	19	Enrico Mariani
MJHA	27	John McCammon
MLL	9	Jay Miller
MMI	31	Michael Moeller
MSS	11	Sandy Mesics
MUDG	8	George Mudry
MWMB	11	William McShan
MWU	20	Walter Maluf
NMID	13	Milena Niemczyk
ONJ	1	John O'Neill
PLUD	23	Ludovic Perbet

Continued

Table 3: 202408 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
RJV	16	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	3	Neil Simmons
SQN	21	Lance Shaw
SRIE	13	Rick St. Hilaire
TDE	20	David Teske
TST	26	Steven Toothman
URBP	31	Piotr Urbanski
VIDD	18	Dan Vidican
WGI	1	Guido Wollenhaupt
WND	16	Denis Wallian
Totals	1152	68

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 9 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.

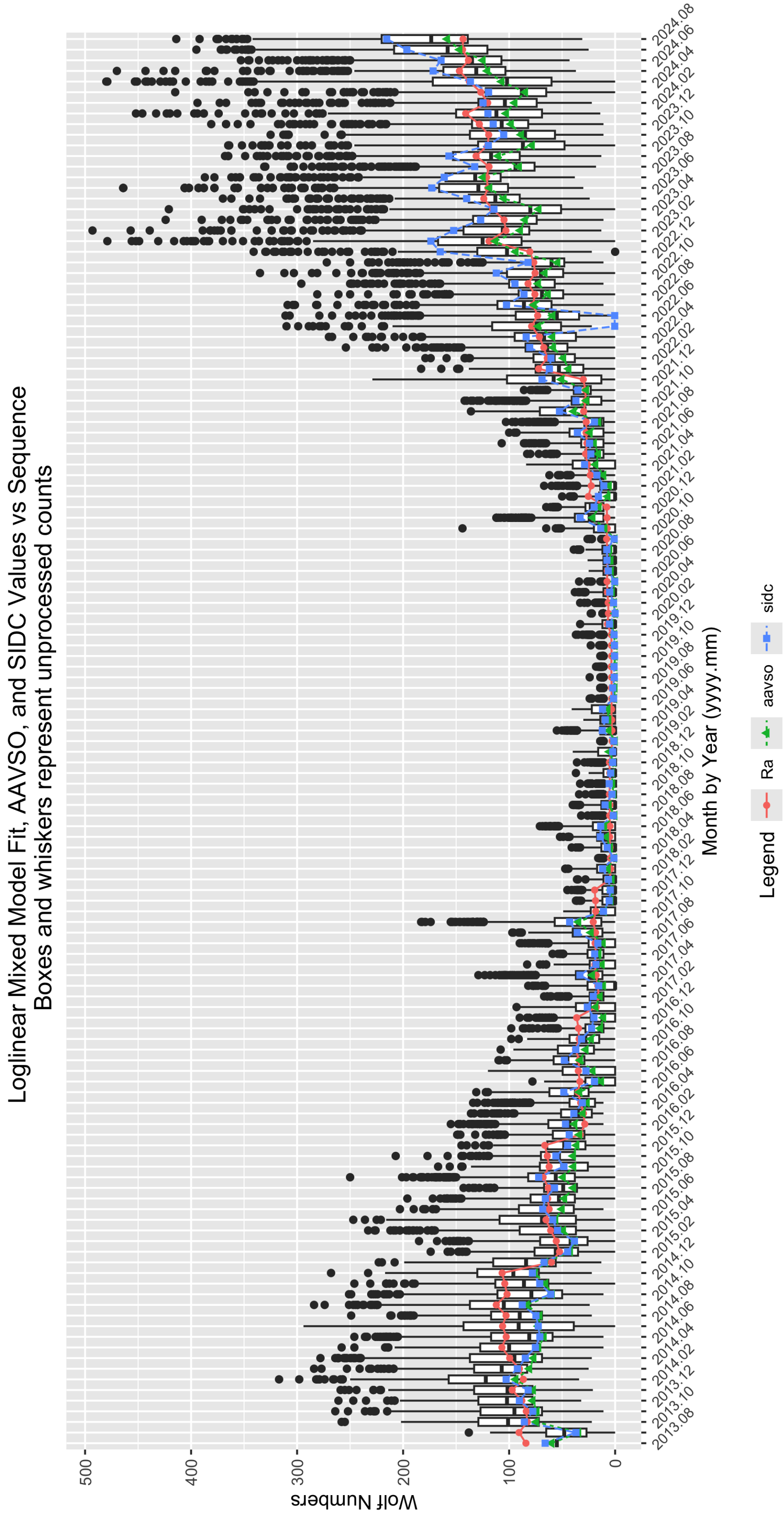

Figure 9: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

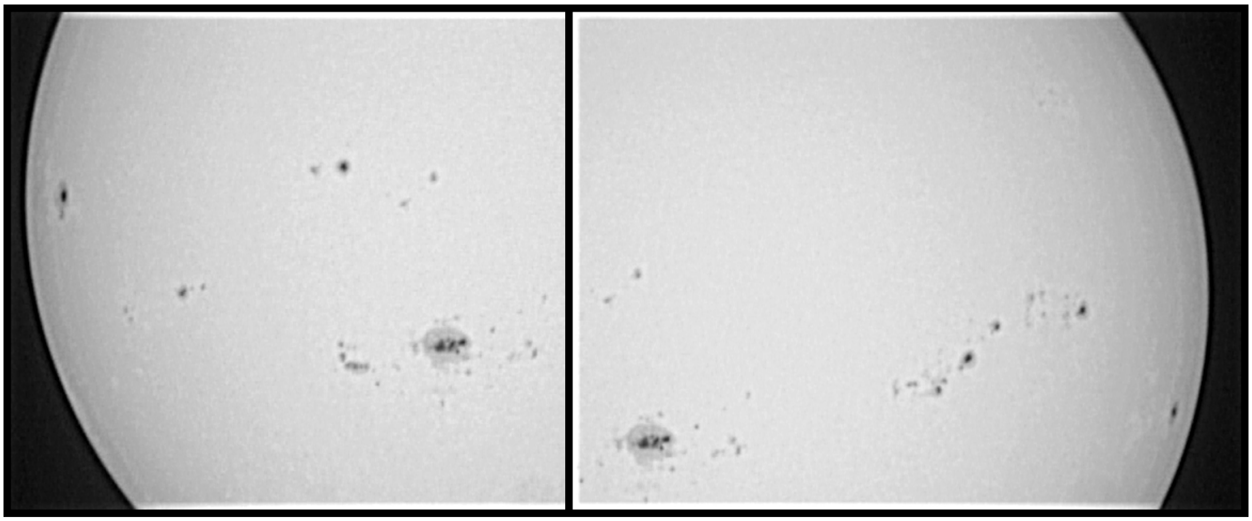

Figure 10: Two video images of the sun for the 9th of August, where the central group, AR3777, sent off the X class flare, by Dan Vidican (VIDD). Plasma from a previous CME on the 8th arived 4 days later on the 12th. (https://www.spaceweather.com/archive.php?view=1&day=09&month=08&year=2024)

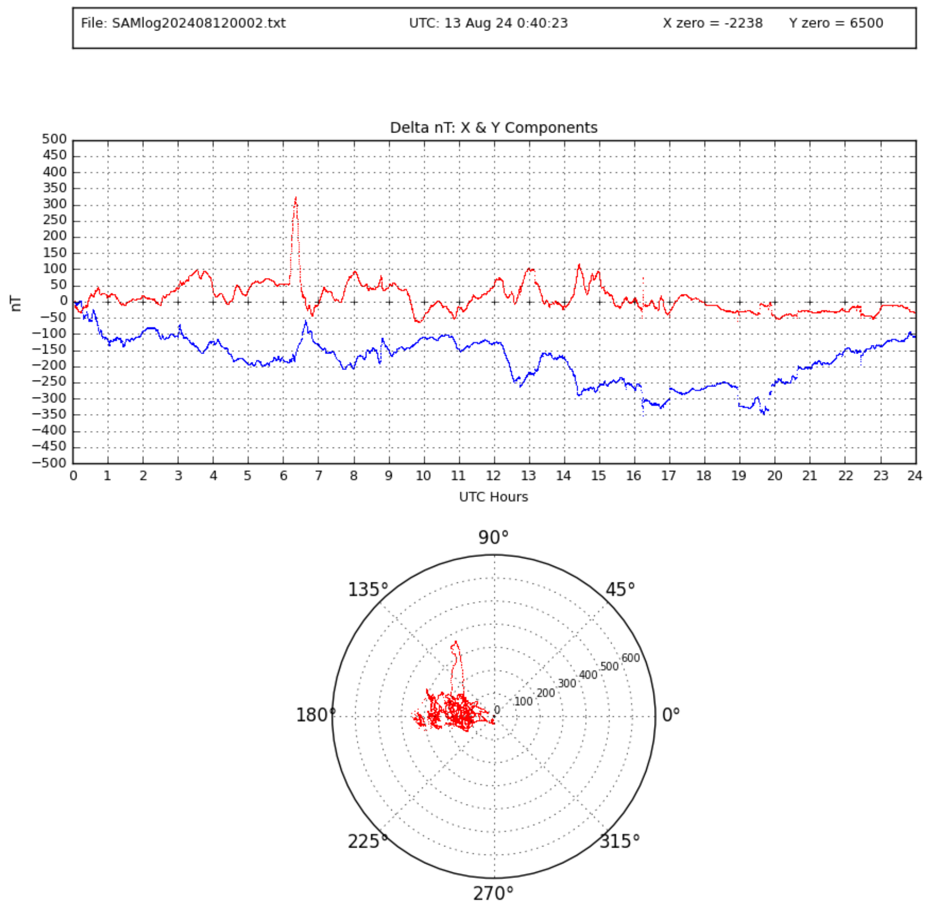

Figure 11: An active day for the magnetic polarities recorded here in Fort Collins, CO on the 12th of August.

5 Antique telescope project

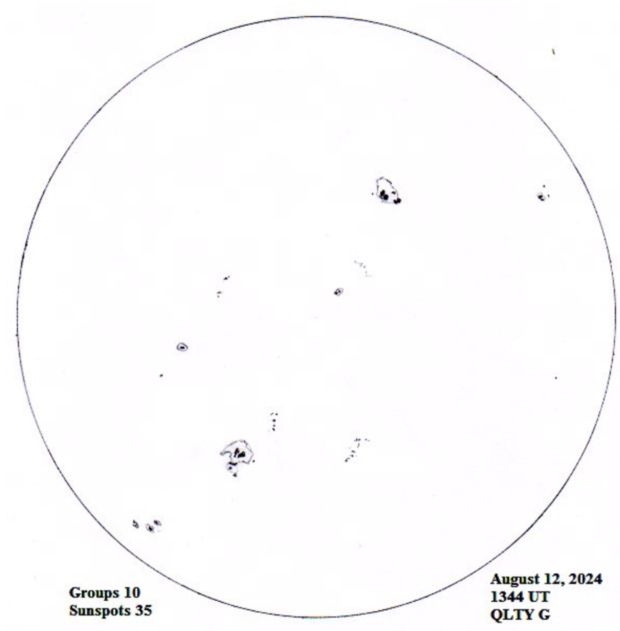

Figure 12: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) in Cochabamba, Bolivia (left), and a drawing for the 12th of August (right).

6 References

Hathaway, D. (2016) Royal Observatory, Greenwich - USAF/NOAA Sunspot Data. `https://solarscience.msfc.nasa.gov/greenwch.shtml`

SIDC data (2024) WDC-SILSO, Royal Observatory of Belgium, Brussels. `https://www.sidc.be/silso/datafiles`

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center (2024). *GOES-16 XRA data.* `ftp://ftp.swpc.noaa.gov/pub/indices/events/`