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
ISSN 0271-8480

Volume 80 Number 10 October 2024

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 The Hurdle model can be used when solar minimums have zero values for North and South solar hemispheres

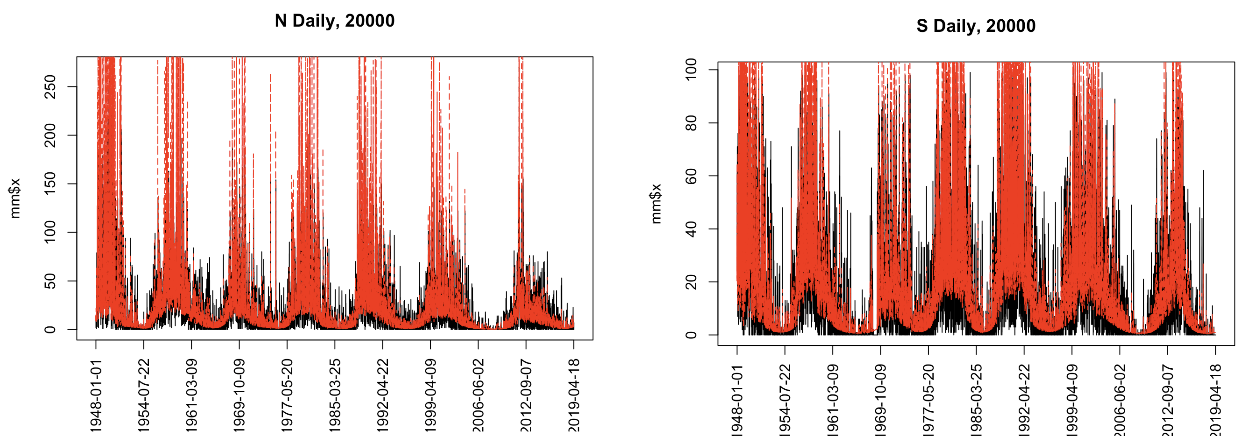

Figure 1: (left panel) shows geometric distribution for the North Hemisphere for the last 7 cycles back to 1947. The (right panel) shows the South Hemisphere which has denser distribution of sunspots, Kenzelhoe's data from 1947 thru 2019. Kanzelhoe Observatory:(`http://cesar.kso.ac.at/`), Graphs by Mark Heiple.

"Hurdle models were introduced by John G. Cragg in 1971,[1] where the non-zero values of x were modelled using a normal model, and a probit model was used to model the zeros." (`https://en.wikipedia.org/wiki/Hurdle_model#:~:text=Hurdle%20models%20were%20introduced%20by,used%20to%20model%20the%20zeros.`) The Hurdle model is used when there are zero values in the observational data which may skew the fit from a normal bell curve-like distribution; as the solar cycles somewhat look like a normal bell curve, it cannot be normal with so many zero sunspot days before and after the cycles. The red lines are how the geometric and negative binomial distributions try to fit to the data.

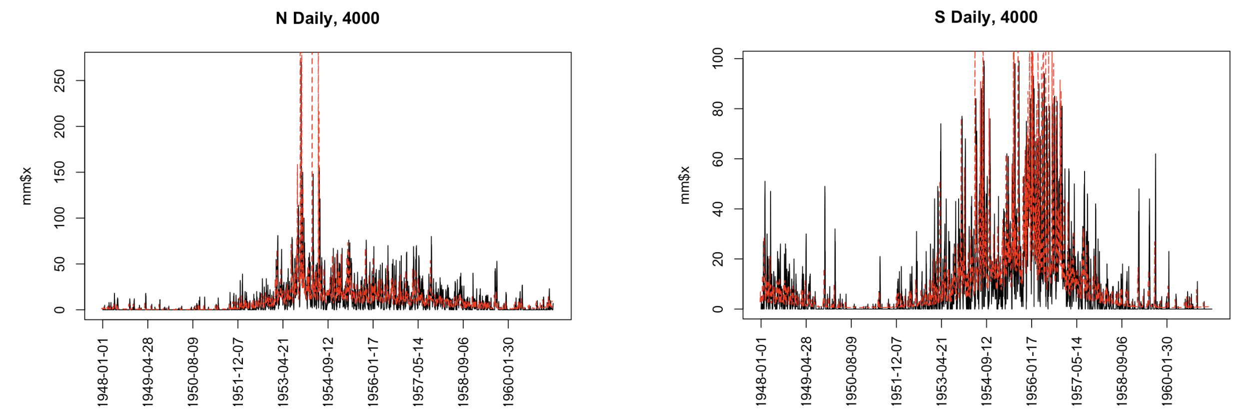

Figure 2: For example: here are the North Hemisphere sunspot counts during cycle 19 (the grand maximum of all cycles since 1610), left panel, and the South Hemisphere sunspot counts during cycle 19, right panel. Notice the y -axis on these graphs, the North Daily has a maximum of 250, and the South Daily a maximum of 100. The distribution of sunspots between the North and South is very different.

"Hurdle count models are two-component models with a truncated count component for positive counts and a hurdle component that models the zero counts. Thus, unlike zero-inflation models, there are not two sources of zeros: the count model is only employed if the hurdle for modeling the occurence of zeros is exceeded. The count model is typically a truncated Poisson or negative binomial regression (with log link). The geometric distribution is a special case of the negative binomial with size parameter equal to 1. For modeling the hurdle (occurence of positive counts) either a binomial model can be employed or a censored count distribution. Binomial logit and censored geometric models as the hurdle part both lead to the same likelihood function and thus to the same coefficient estimates. A censored negative binomial model for the zero hurdle is only identified if there is at least one non-constant regressor with (true) coefficient different from zero (and if all coefficients are close to zero the model can be poorly conditioned)."(`https://rdrr.io/rforge/countreg/man/hurdle.html`)

The geometric model fills in with higher estimates and does not fit the solar cycles as well as the negative binomial distribution.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

October 2024 (Figure 3): There was an X9.0 flare during the day recorded in Milan, Italy by Roberto Battaiolia. (U.S. Dept. of Commerce–NOAA, 2022).

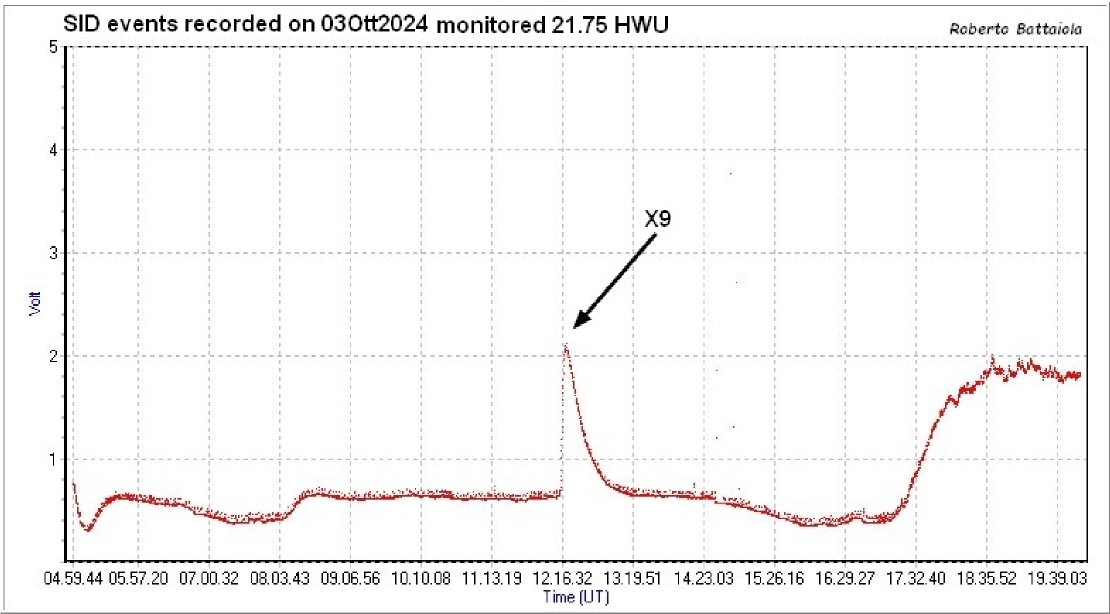

Figure 3: VLF recording of the X9 flare from Milan, Italy, on the 3rd of October, (Roberto Battaiolia).

2.2 SID Observers

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

Table 1: 202409 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	DHO GBZ GQD
J Karlovsky	A131	DHO
R Mrllak	A136	GQD NSY
S Aguirre	A138	NLK
G Silvis	A141	HWU NAU NLK
L Pina	A148	NAA 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.

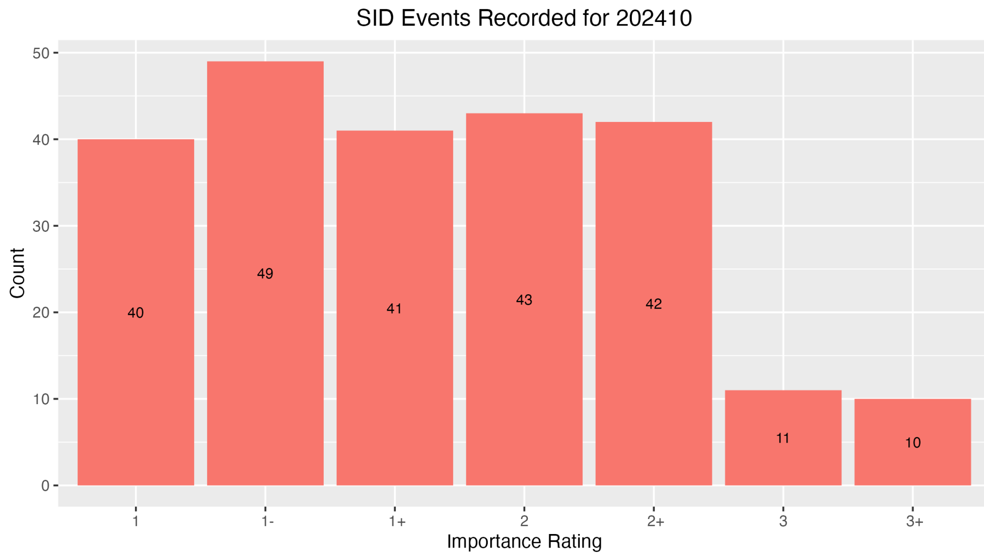

Figure 4: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In October 2024, there were 277 GOES-16 flares: 9 X-class, 80 M-class, and 188 C-class. There was a lot more flaring this month compared to last. (U.S. Dept. of Commerce–NOAA, 2024). (see Figure 5).

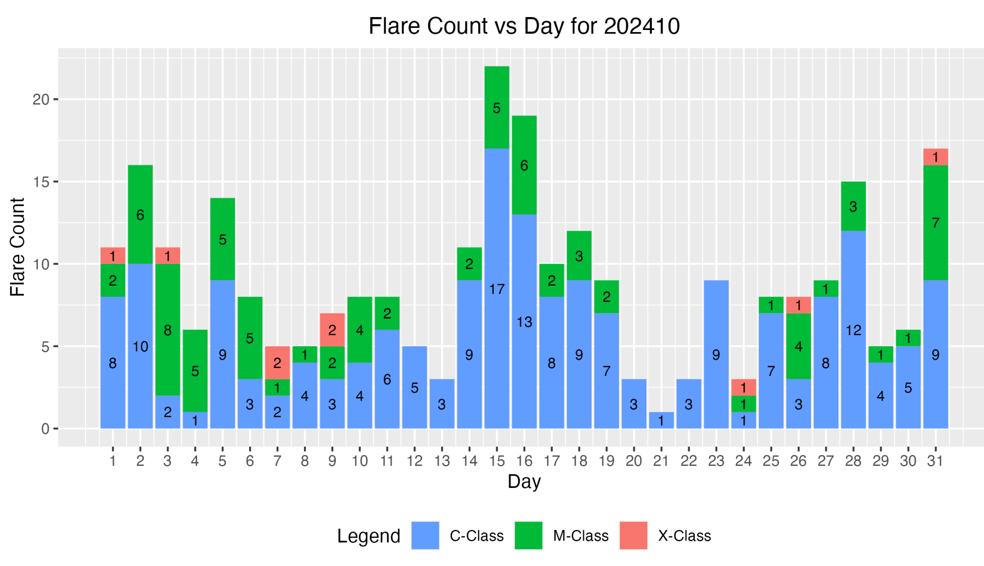

Figure 5: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2024).

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 October 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 6.

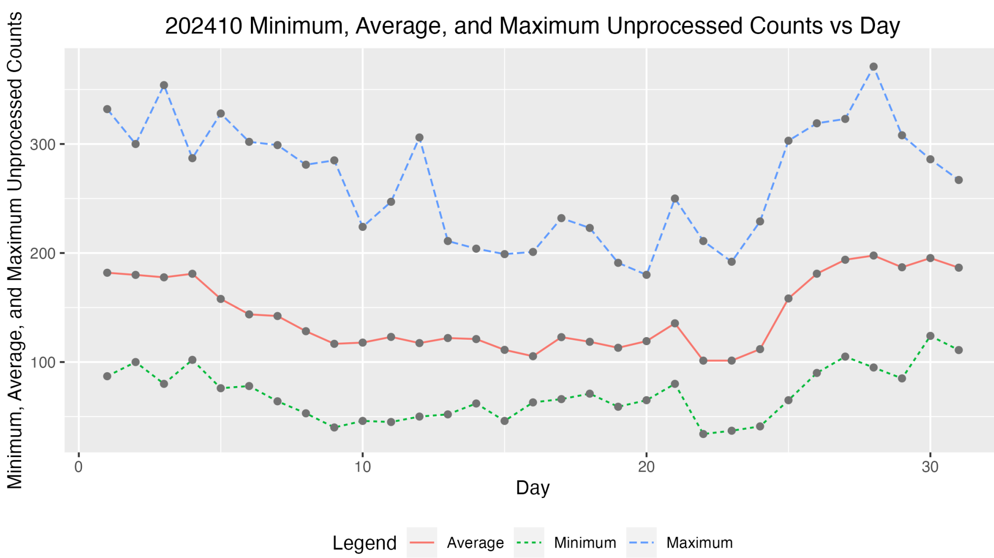

Figure 6: Raw Wolf number average, minimum and maximum by day of the month for all observers.

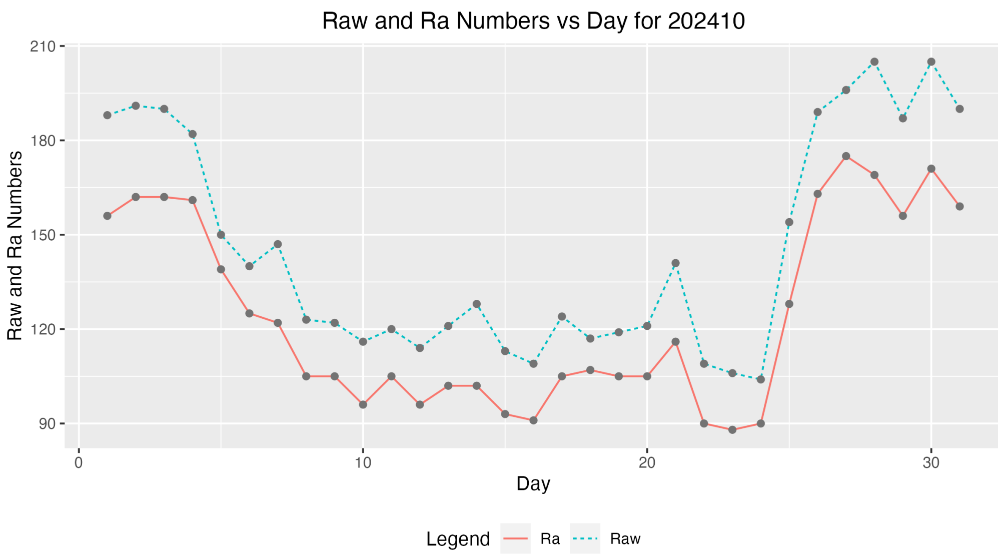

Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202410 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	25	188	156
2	37	191	162
3	31	190	162
4	33	182	161
5	41	150	139
6	33	140	125
7	31	147	122
8	31	123	105
9	25	122	105
10	31	116	96
11	36	120	105
12	27	114	96
13	36	121	102
14	26	128	102
15	28	113	93

Continued

Table 2: 202410 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	31	109	91
17	31	124	105
18	33	117	107
19	35	119	105
20	37	121	105
21	32	141	116
22	37	109	90
23	36	106	88
24	36	104	90
25	28	154	128
26	32	189	163
27	30	196	175
28	30	205	169
29	28	187	156
30	24	205	171
31	27	190	159
Averages	31.5	145.8	124.2

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for October 2024, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (62), and total number of observations submitted (980).

Table 3: 202410 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	21	Alexandre Amorim
AJV	19	J. Alonso
ARAG	30	Gema Araujo
ASA	2	Salvador Aguirre
BATR	3	Roberto Battaiola
BKL	8	John A. Blackwell
BMIG	14	Michel Besson
BTB	13	Thomas Bretl
BXZ	20	Jose Alberto Berdejo
BZX	22	A. Gonzalo Vargas
CKB	31	Brian Cudnik
CLDB	12	Laurent Cambon
CMAB	6	Maurizio Cervoni
CNT	13	Dean Chantiles

Continued

Table 3: 202410 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CPAD	2	Panagiotis Chatzistamatiou
DARB	20	Aritra Das
DFR	9	Frank Dempsey
DJOB	17	Jorge del Rosario
DJSA	3	Jeff DeVries
DJVA	28	Jacques van Delft
DMIB	13	Michel Deconinck
DUBF	19	Franky Dubois
EHOA	13	Howard Eskildsen
FLET	28	Tom Fleming
GALQ	2	Alejandro Gonzalez-Ojeda
HALB	15	Brian Halls
HKY	24	Kim Hay
HOWR	25	Rodney Howe
HSR	14	Serge Hoste
IEWA	26	Ernest W. Iverson
ILUB	4	Luigi Iapichino
JGE	2	Gerardo Jimenez Lopez
JSI	4	Simon Jenner
KAND	28	Kandilli Observatory
KAPJ	12	John Kaplan
KNJS	30	James & Shirley Knight
KTOC	8	Tom Karnuta
LKR	11	Kristine Larsen
LRRA	25	Robert Little
LVY	28	David Levy
MARC	4	Arnaud Mengus
MARE	10	Enrico Mariani
MCE	8	Etsuiku Mochizuki
MJHA	30	John McCammon
MLL	10	Jay Miller
MMI	31	Michael Moeller
MUDG	5	George Mudry
MWMB	13	William McShan
MWU	20	Walter Maluf
NMID	7	Milena Niemczyk
PLUD	17	Ludovic Perbet
RJV	12	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	13	Neil Simmons
SQN	15	Lance Shaw
SRIE	15	Rick St. Hilaire
TDE	27	David Teske

Continued

Table 3: 202410 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
TPJB	1	Patrick Thibault
TST	24	Steven Toothman
URBP	26	Piotr Urbanski
VIDD	16	Dan Vidican
WWM	21	William M. Wilson
Totals	980	62

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. 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.

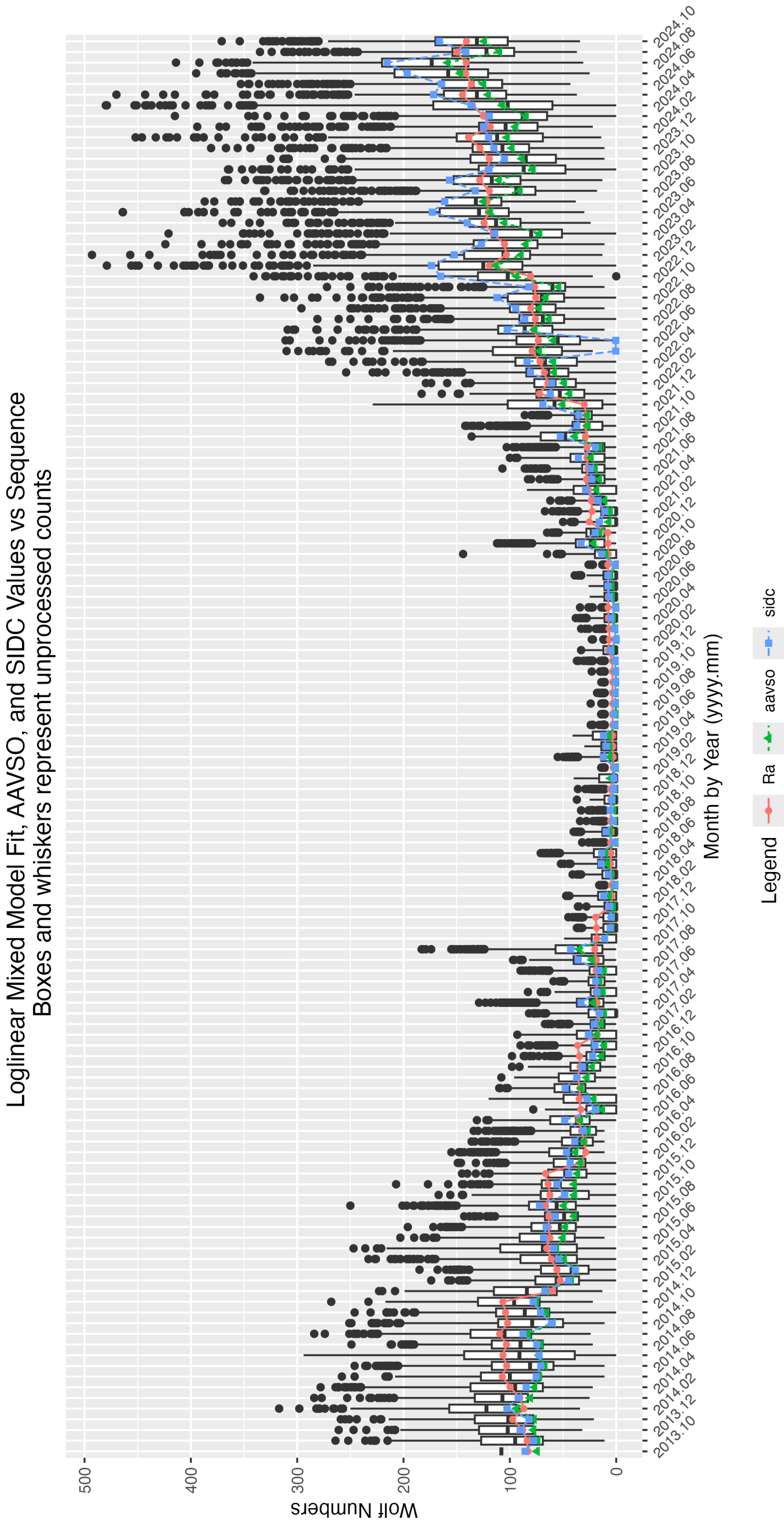

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

5 Antique telescope project

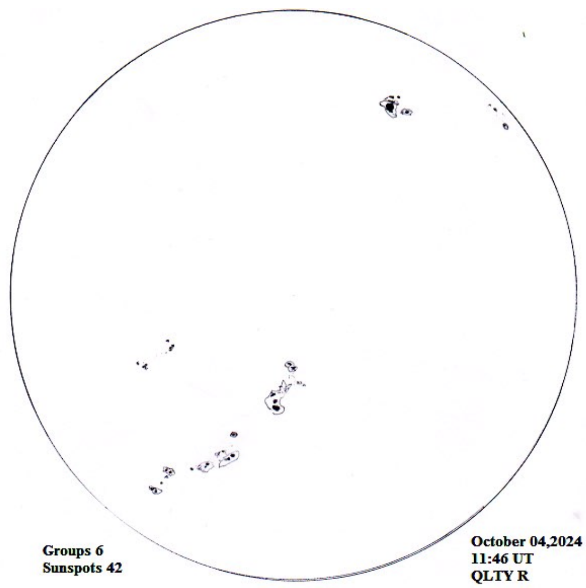

Figure 9: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) in Cochabamba, Bolivia (left), and a drawing for the 4th of October (right).

6 References

Riggs, Jamie (2017), Solar System Science Section Head, International Astrostatistics (using R Statistical Software (2023), TSA Libraries: (`https://cran.r-project.org`)

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