Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 78 Number 10 October 2022

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 Antique telescope project, and first light by Gonzalo Vargas (BZX)

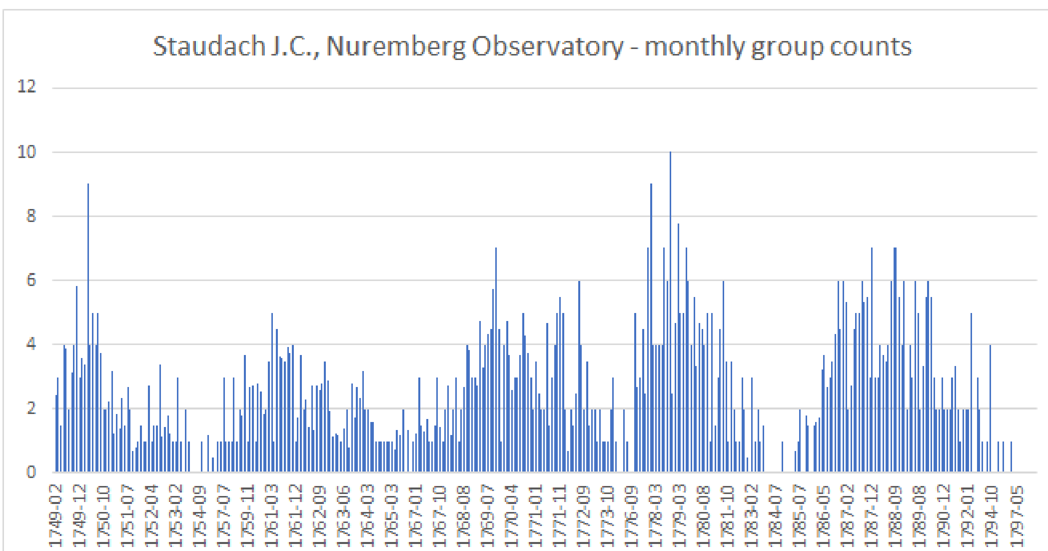

Figure 1: Graph of 368 monthly group counts from Staudach, 1749-1799. Solar cycles 0 through 4 (Svalgaard, 2016).

According to the AAVSO Antique Solar Observing Project leaders, "To better interpret sunspot drawings of German amateur astronomer Johann Caspar Staudach, it occurred to Leif Svalgaard that current solar activity could be observed with telescopes similar to the 18th century one used by Staudach." To that end: `https://www.aavso.org/solar-observing-project`. According to Svalgaard (2015), "We have examined the more than 1100 drawings of the solar disk made by the German astronomy amateur Johann Caspar Staudach during 1749-1799, and counted the spots on each image. Using the modern perception of how to group spots into active regions, we regrouped the spots as a modern observer would. The resulting number of groups was found to be on average 25 percent higher than the first count of groups performed by Wolf in 1857, and used by Hoyt and Schatten in their construction of the Group Sunspot Number. Compared to other observers at the time, Staudach's drawings have a very low average number, ~2, of spots per group, possibly indicating an inferior telescope likely suffering from spherical and chromatic aberration as would be typical of amateur telescopes of the day. We have initiated an ongoing project aimed at observing sunspots using antique telescopes with similar defects in order to determine the factor necessary to bring the Staudach observations onto a modern scale."

1.1 First light, by Gonzalo Vargas (BZX)

AAVSO Antique Solar Observing Project member, Gonzalo Vargas (AAVSO solar observer BZX), provided the following update on his own antique telescope project. "Finally after a long journey. At my home I made an antique refactor scope for solar observation and it took its first light taking advantage of the presence of two quite large solar groups in the solar disk (AR 3105 and AR 3107). The solar image is achieved in the small refactor telescope with 35 mm aperture and 750 mm focal length, using a 12 mm eyepiece. In the October image obtained active regions are seen. The solar image was clear to see the big solar sunspots, the first solar observation was in the yard, so I think that the solar image will be more clear if the solar scope is put inside in a dark room. It is required to install a weight to adjust the balance of the tube when moving in height" Gonzalo Vargas (BZX).

Figure 2: Gonzalo took first light with his antique telescope.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

October 2022 (Figure 3): There were 230 GOES XRA flares: one X-class, 18 M-class, 172 C-class, and 39 B-class flares. About the same number of flares as last month.

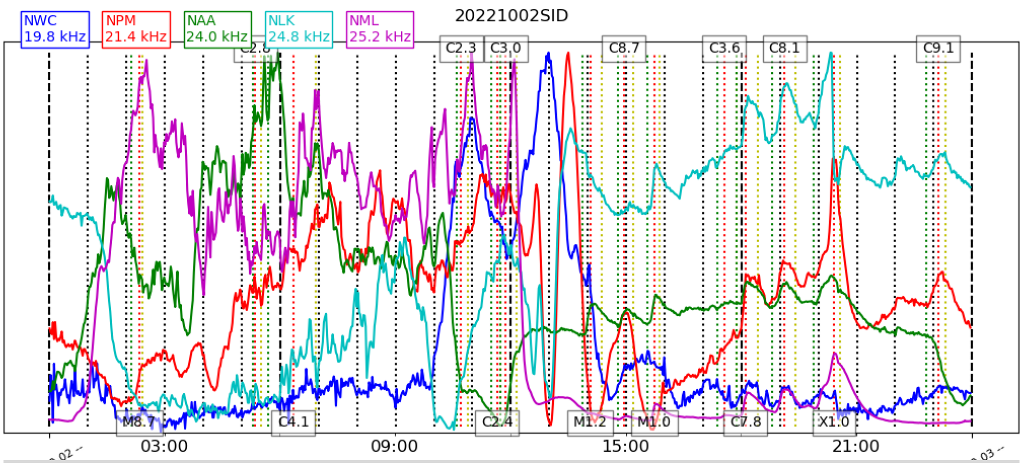

Figure 3: VLF recording from Fort Collins, Colorado.

2.2 SID Observers

In October 2022, 16 AAVSO SID observers submitted VLF data as listed in Table 1.

Table 1: 202210 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
J Karlovsky	A131	DHO NAA TBB
R Mrllak	A136	GQD NSY
S Aguirre	A138	NPM NAA
G Silvis	A141	NAA NML NLK
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
J Wendler	A150	NAA
H Krumnow	A152	FTA GBZ HWU
J DeVries	A153	NLK
R Mazur	A155	NLK NML

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.

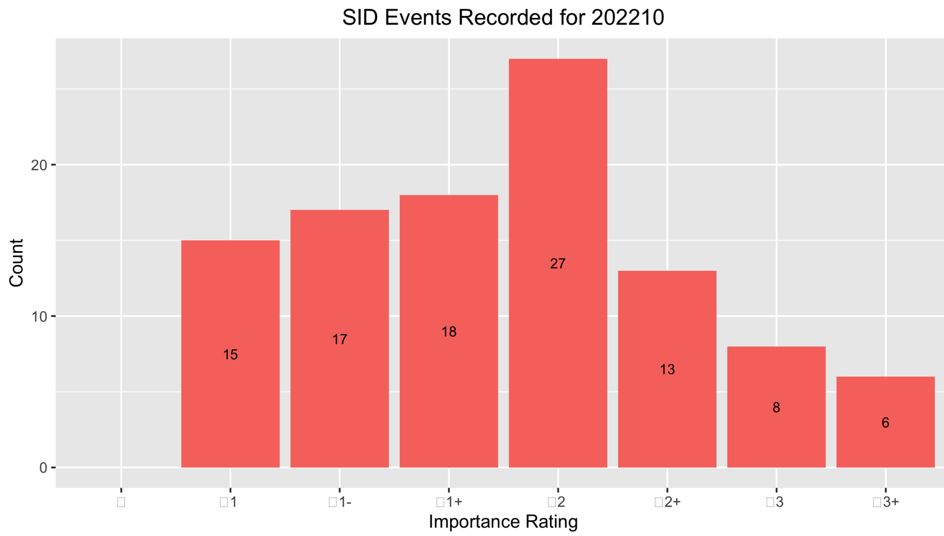

Figure 4: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In October 2022, there were 57 XRA flares detected from the GOES-16 satellite: 55 B-Class and 2 C-Class flares (NOAA, 2022). About the same flaring this month compared to last. There were 15 days this month with no GOES-16 reports of flares (Figure 5).

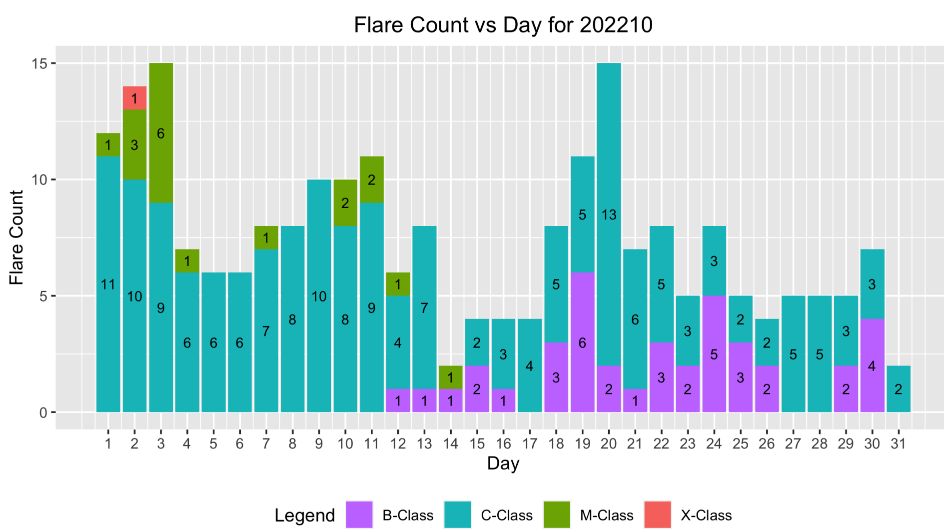

Figure 5: GOES-16 XRA flares (NOAA, 2022)

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 October 2022. 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.

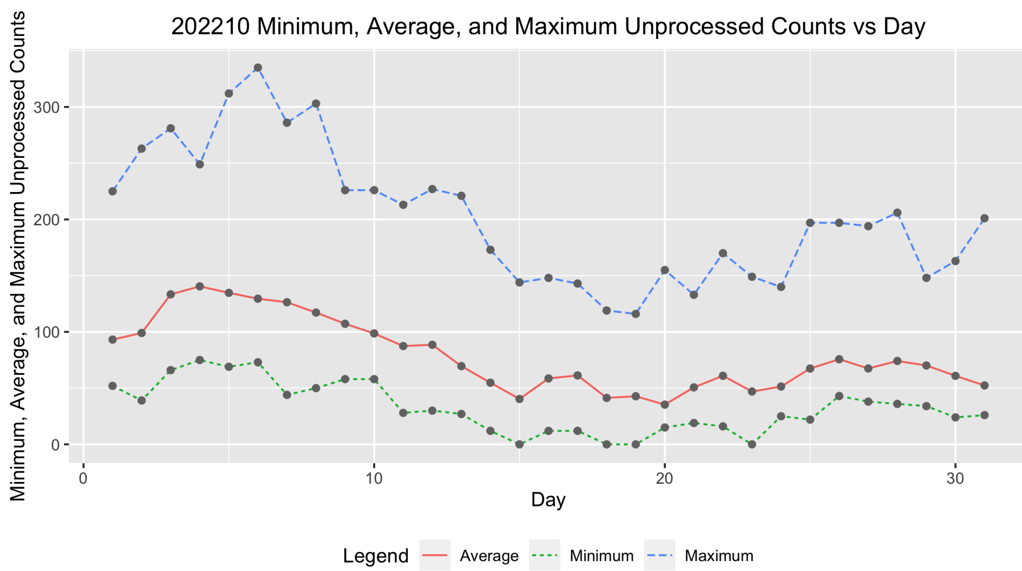

Figure 6: Raw Wolf number average, minimum, and maximum by day of the month for all observers.

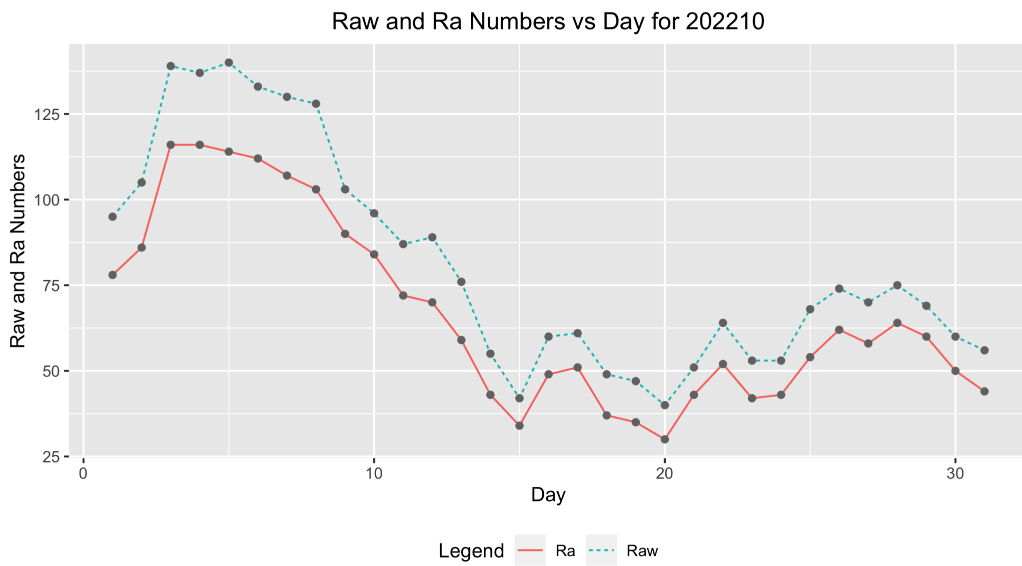

Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202210 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	37	95	78
2	47	105	86
3	43	139	116
4	40	137	116
5	37	140	114
6	39	133	112
7	35	130	107
8	42	128	103
9	41	103	90
10	35	96	84
11	43	87	72
12	37	89	70
13	34	76	59
14	37	55	43

Continued

Table 2: 202210 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	39	42	34
16	42	60	49
17	34	61	51
18	37	49	37
19	34	47	35
20	33	40	30
21	33	51	43
22	40	64	52
23	33	53	42
24	29	53	43
25	34	68	54
26	37	74	62
27	40	70	58
28	38	75	64
29	43	69	60
30	38	60	50
31	31	56	44
Averages	37.5	80.8	66.4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for October 2022, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (70), and total number of observations submitted (1162).

Table 3: 202210 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	20	Alexandre Amorim
AJV	13	J. Alonso
ARAG	31	Gema Araujo
ASA	23	Salvador Aguirre
ATE	18	Teofilo Arranz Heras
BATR	5	Roberto Battaiola
BMF	21	Michael Boschat
BMIG	22	Michel Besson
BROB	31	Robert Brown
BXZ	20	Jose Alberto Berdejo
BZX	22	A. Gonzalo Vargas
CIOA	4	Ioannis Chouinavas
CKB	24	Brian Cudnik

Continued

Table 3: 202210 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMOD	2	Moise Carlo
CNT	28	Dean Chantiles
CVJ	2	Jose Carvajal
DARB	12	Aritra Das
DELS	12	Susan Delaney
DFR	12	Frank Dempsey
DJOB	14	Jorge del Rosario
DMIB	26	Michel Deconinck
DUBF	28	Franky Dubois
EGMA	4	Georgios Epitropou
EHOA	5	Howard Eskildsen
ERB	21	Bob Eramia
FLET	27	Tom Fleming
FTAA	4	Tadeusz Figiel
GIGA	30	Igor Grageda Mendez
HALB	11	Brian Halls
HKY	23	Kim Hay
HMQ	4	Mark Harris
HOWR	26	Rodney Howe
HRUT	20	Timothy Hrutkay
IEWA	26	Ernest W. Iverson
ILUB	8	Luigi Iapichino
JDAC	4	David Jackson
JGE	6	Gerardo Jimenez Lopez
JSI	4	Simon Jenner
KAMB	31	Amoli Kakkar
KAND	25	Kandilli Observatory
KAPJ	14	John Kaplan
KNJS	27	James & Shirley Knight
LKR	11	Kristine Larsen
MARC	6	Arnaud Mengus
MARE	13	Enrico Mariani
MCE	11	Etsuiku Mochizuki
MJAF	28	Juan Antonio Moreno Quesada
MJHA	26	John McCammon
MLL	13	Jay Miller
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MWU	14	Walter Maluf
OAAA	21	Al Sadeem Astronomy Obs.
ONJ	11	John O'Neill
PLUD	9	Ludovic Perbet
RJUB	7	Justus Randolph

Continued

Table 3: 202210 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
RJV	17	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	14	Neil Simmons
SRIE	22	Rick St. Hilaire
SVAE	7	Valery Stanimirov
TDE	30	David Teske
TNIA	2	Nick Tonkin
TPJB	5	Patrick Thibault
TST	24	Steven Toothman
URBP	26	Piotr Urbanski
VIDD	13	Dan Vidican
WGI	1	Guido Wollenhaupt
WND	3	Denis Wallian
WWM	25	William M. Wilson
Totals	1162	70

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.

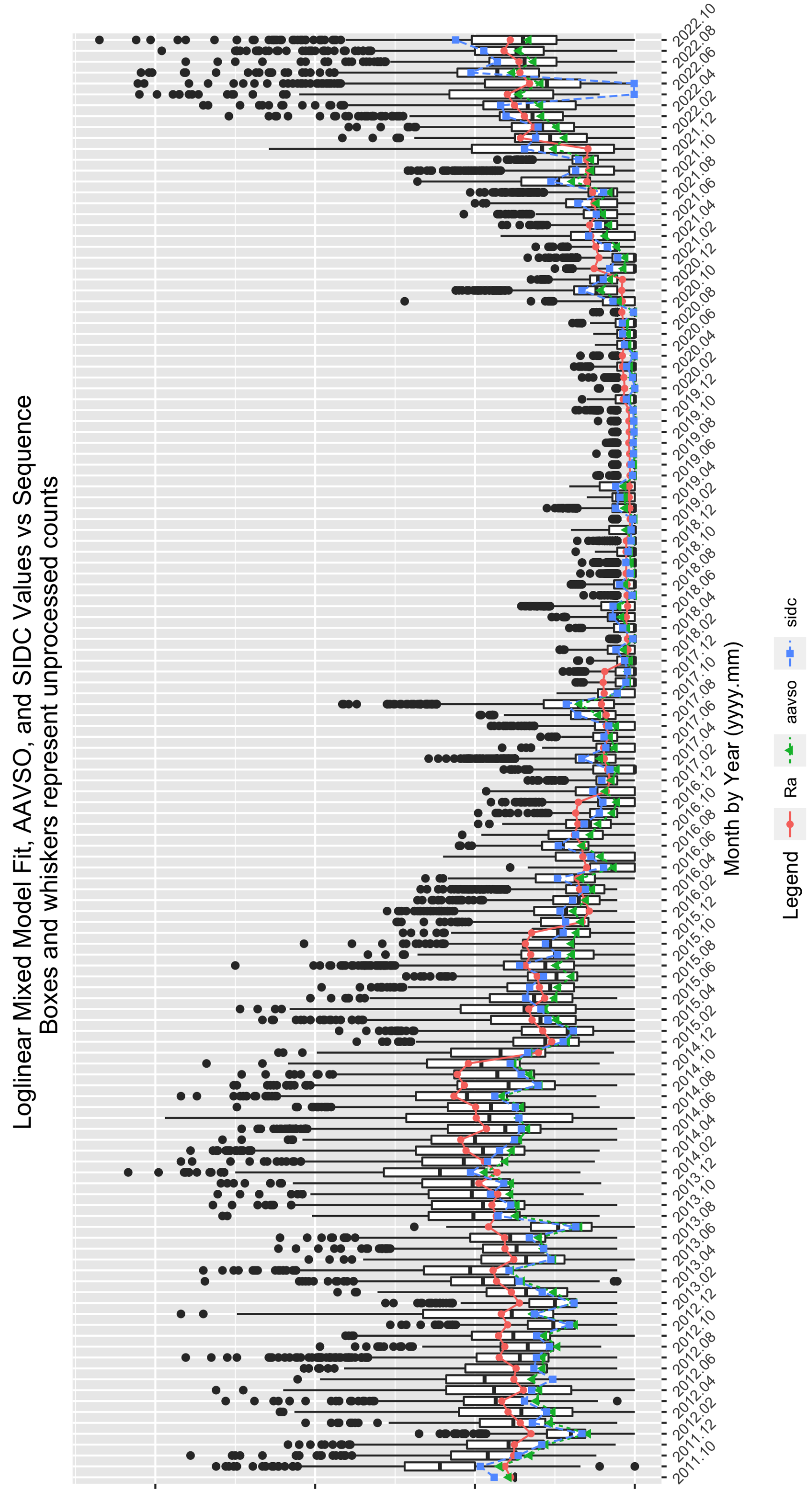

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

References

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