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. Section 1 gives contributions by our members. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 Cycle 25 is on the rise

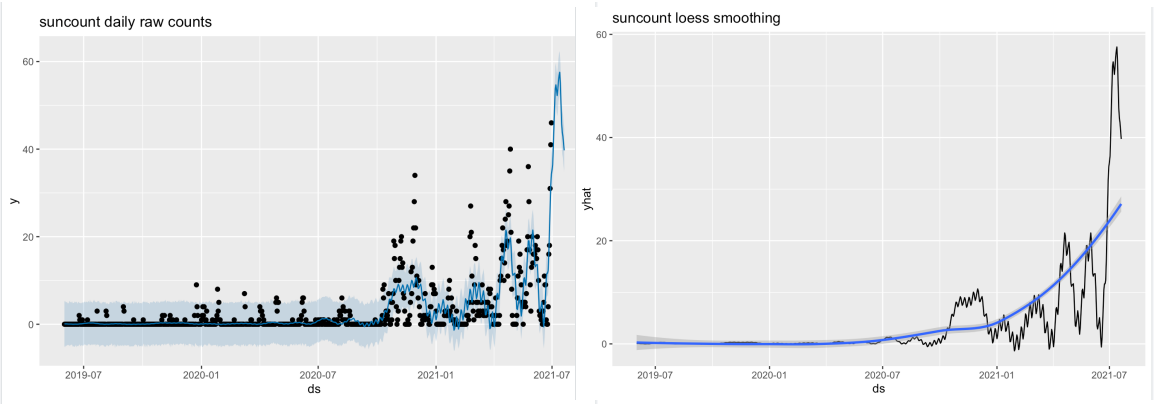

Figure 1: AAVSO data of sunspot counts showing two years of solar minimum and the most recent rise toward cycle 25. Left panel is raw sunspot counts with a geometric line (blue); right panel is a loess smoothing line (blue).

AAVSO raw sunspot counts of the past five years, including two years of solar minimum, coupled with two smoothing models, one a geometric model and one a loess model, which show the dramatic rise of cycle 25 (`http://r-statistics.co/Loess-Regression-With-R.html`).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

August 2021 (Figure 2): two SID Events on the 29th of August, one in the early morning hours (C7.4) and one right around noon (C2.9 at 18:00 UT) recorded here in Fort Collins, Colorado.

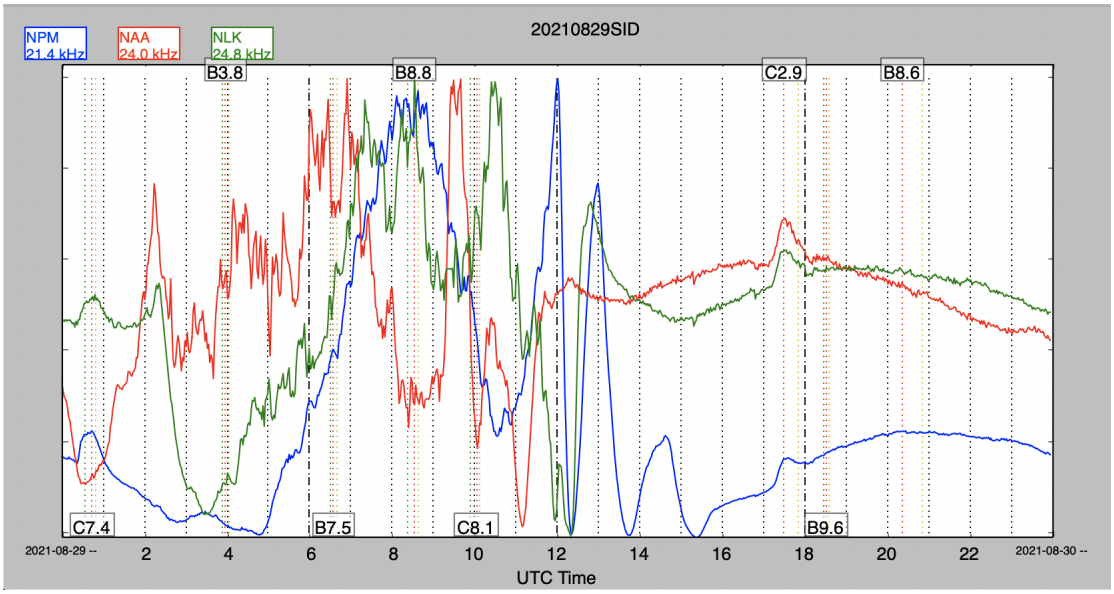

Figure 2: VLF recording on the 29th of August

2.2 SID Observers

In August 2021 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202108 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD
B Terrill	A120	NWC
F Adamson	A122	NWC
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
K Menzies	A146	NAA
L Pina	A148	NAA NLK
L Ferreira	A149	NWC
J Wendler	A150	NAA
H Krumnow	A152	FTA GBZ
J DeVries	A153	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.

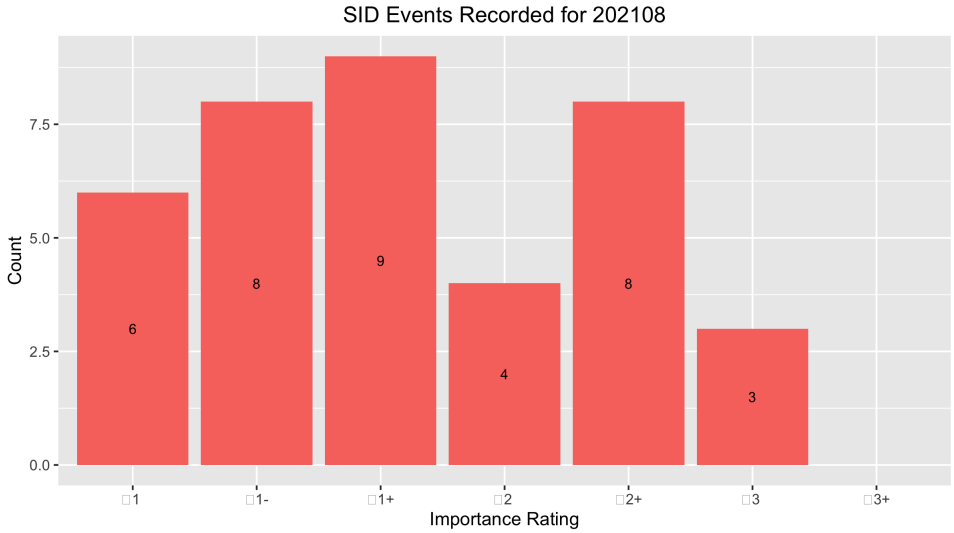

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In August 2021, there were 164 XRA flares: 127 B-Class, 36 C-Class, and one M-Class. There were eight days this month with no flares. Far fewer flares this month than last (see Figure 4).

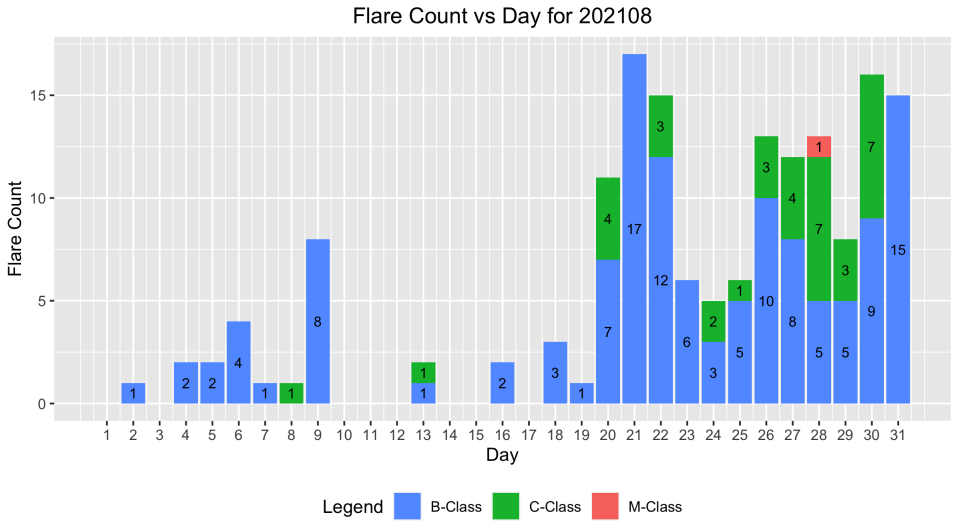

Figure 4: GOES-16 XRA flares

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 2021. 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.

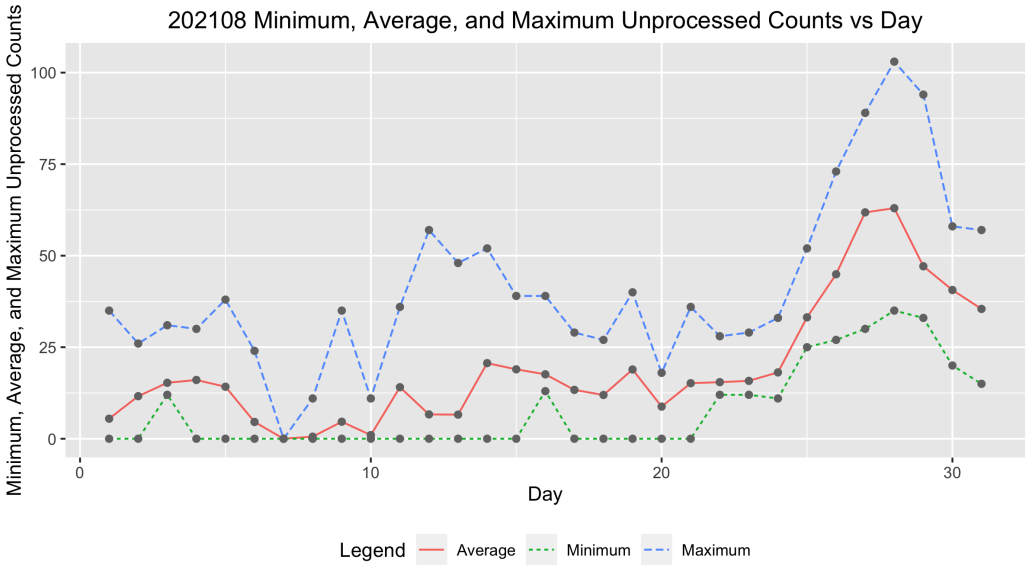

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

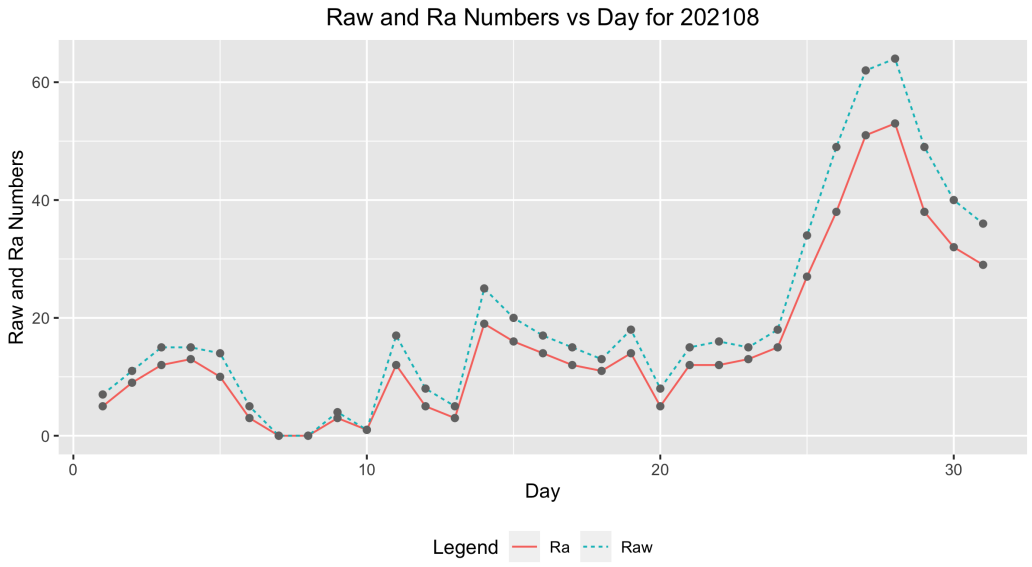

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202108 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	42	7	5
2	48	11	9
3	43	15	12
4	43	15	13
5	44	14	10
6	43	5	3
7	32	0	0
8	39	0	0
9	48	4	3
10	44	1	1
11	41	17	12
12	39	8	5
13	41	5	3
14	40	25	19

Continued

Table 2: 202108 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	47	20	16
16	44	17	14
17	38	15	12
18	38	13	11
19	43	18	14
20	36	8	5
21	47	15	12
22	42	16	12
23	41	15	13
24	43	18	15
25	45	34	27
26	41	49	38
27	49	62	51
28	45	64	53
29	46	49	38
30	39	40	32
31	44	36	29
Averages	42.4	19.9	15.7

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for August 2021, 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 (1315).

Table 3: 202108 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	22	Alexandre Amorim
AJV	21	J. Alonso
ARAG	31	Gema Araujo
ASA	20	Salvador Aguirre
ATE	30	Teofilo Arranz Heras
BARH	8	Howard Barnes
BATR	10	Roberto Battaiola
BERJ	22	Jose Alberto Berdejo
BLAJ	9	John A. Blackwell
BMF	24	Michael Boschat
BRAF	9	Raffaello Braga
BROB	24	Robert Brown
CKB	30	Brian Cudnik

Continued

Table 3: 202108 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMOD	3	Mois Carlo
CNT	27	Dean Chantiles
CVJ	15	Jose Carvajal
DARB	14	Aritra Das
DDIB	11	Dipankar Dey
DEMF	15	Frank Dempsey
DJOB	16	Jorge del Rosario
DMIB	30	Michel Deconinck
DUBF	28	Franky Dubois
EHOA	12	Howard Eskildsen
ERB	21	Bob Eramia
FERJ	27	Javier Ruiz Fernandez
FLET	29	Tom Fleming
GIGA	29	Igor Grageda Mendez
HALB	10	Brian Halls
HAYK	24	Kim Hay
HOWR	24	Rodney Howe
IEWA	28	Ernst W. Iverson
JDAC	12	David Jackson
JENJ	12	Jamey Jenkins
JENS	2	Simon Jenner
JGE	12	Gerardo Jimenez Lopez
KAMB	9	Amoli Kakkar
KAND	23	Kandilli Observatory
KAPJ	18	John Kaplan
KNJS	30	James & Shirley Knight
KZAD	13	Zachary Knoles
LEVM	25	Monty Leventhal
LGEC	3	Georgios Lekkas
LKR	4	Kristine Larsen
LRRA	22	Robert Little
MARC	4	Arnaud Mengus
MARE	11	Enrico Mariani
MCE	22	Etsuiku Mochizuki
MILJ	16	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	31	John McCammon
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MUDG	13	George Mudry
MWU	27	Walter Maluf
OAAA	23	Al Sadeem Astronomy Obs.
ONJ	16	John O'Neill

Continued

Table 3: 202108 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
PEKT	8	Riza Pektas
RFDA	20	Filipp Romanov
SDOH	31	Solar Dynamics Obs - HMI
SNE	5	Neil Simmons
SONA	16	Andries Son
SUZM	20	Miyoshi Suzuki
TESD	30	David Teske
TST	24	Steven Toothman
URBP	21	Piotr Urbanski
VARG	31	A. Gonzalo Vargas
VIDD	22	Dan Vidican
WGI	3	Guido Wollenhaupt
WILW	2	William M. Wilson
WND	18	Denis Wallian
Totals	1315	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. For more details: *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 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.

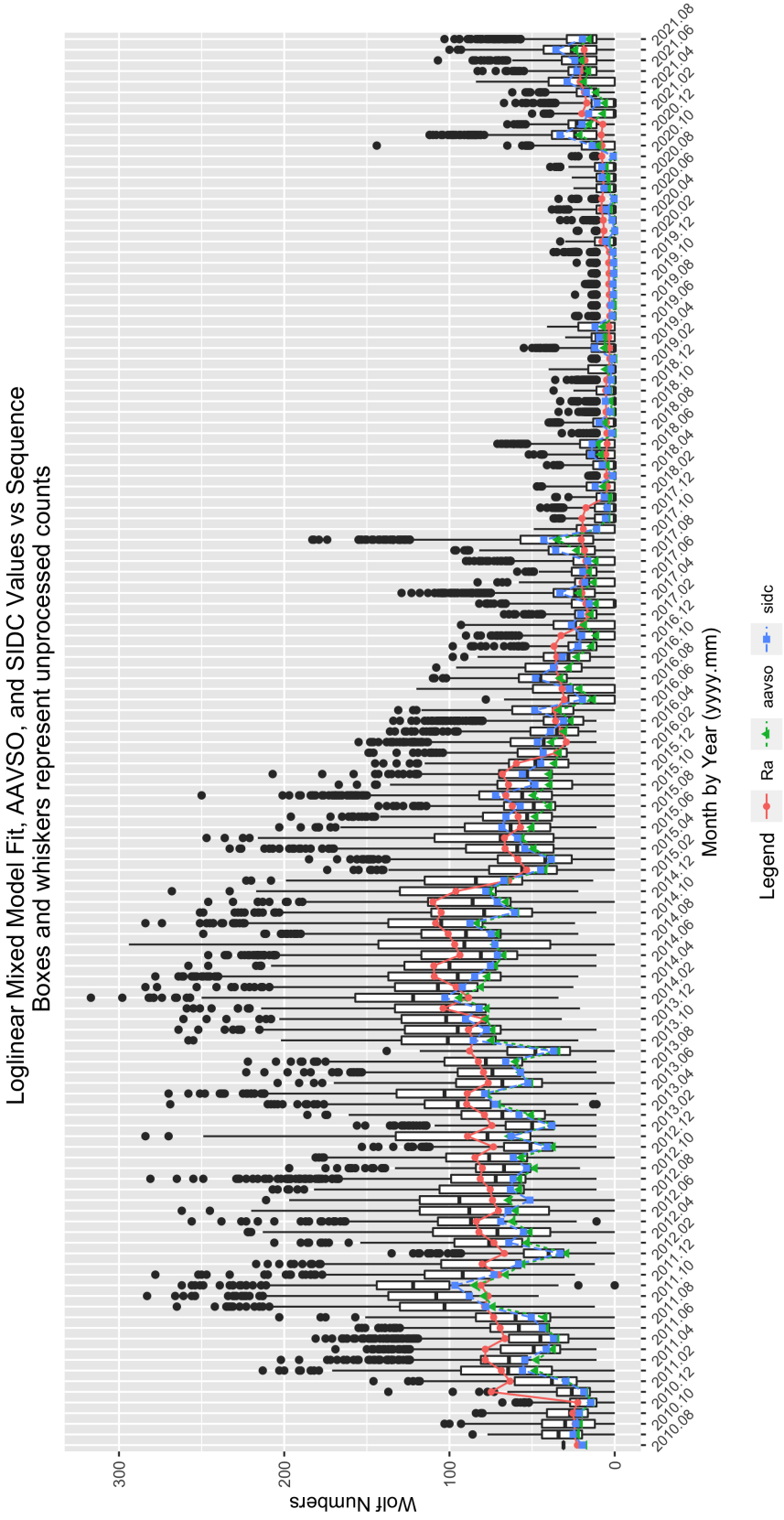

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

Figure 8: German Morales has over 7,000 sunspot observations (he had 7,034 as of his last report in May 2021). His first observations in our database were in January 2000, so that is more than 21 years of observations! (`https://www.astronomia.org.bo`)