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 Comparison of SIDC and AAVSO North/South hemisphere data for Cycle 24

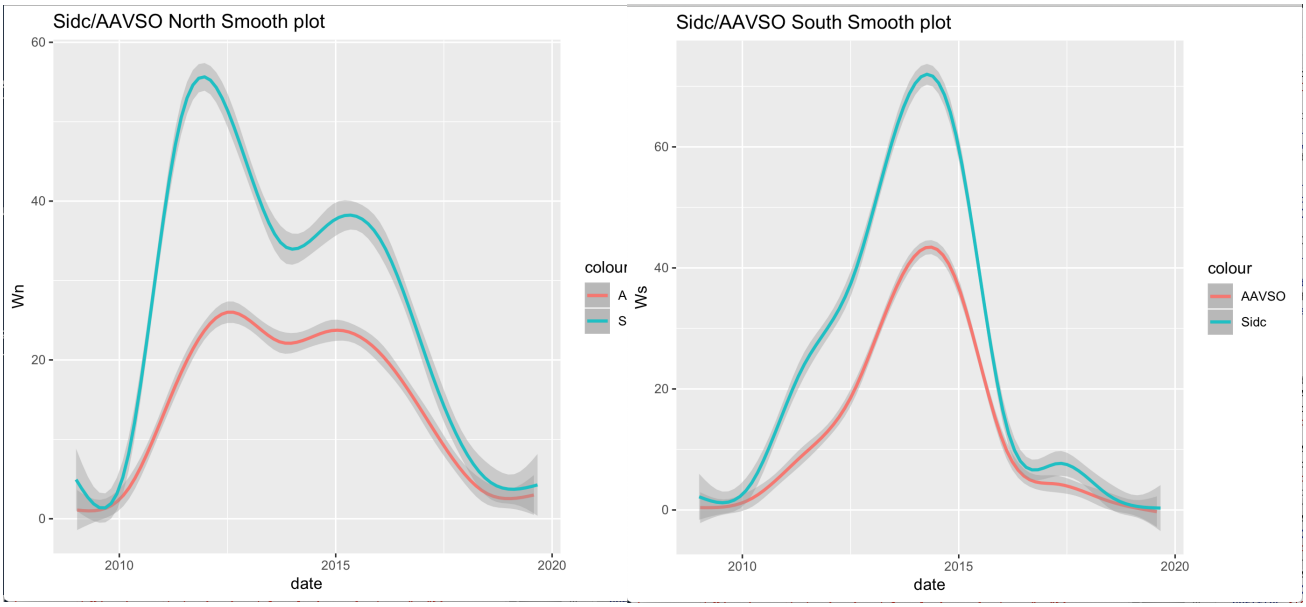

Figure 1: (left) SIDC and AAVSO northern hemisphere monthly data from 2009 to present. (right) SIDC and AAVSO southern hemisphere monthly data from 2009 to present (Cycle 24).

SIDC data can be found here: (`http://sidc.be/silso/datafiles`) One thing to notice is that these two networks of observer's data don't match up at all. This may in part be the way SILSO (SIDC) treats their ISN (International Sunspot Number) calculations, where their Northern and Southern sunspot number averages are not the same as the AAVSO North and South Wolf number averages. How might this affect the predictions for the next solar cycle 25?

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

August 2019 (Figure 2): There were no SID events recorded here in Fort Collins, Colorado for the month of August. (Please note the y-axis values in these SID graphs are non-dimensional.)

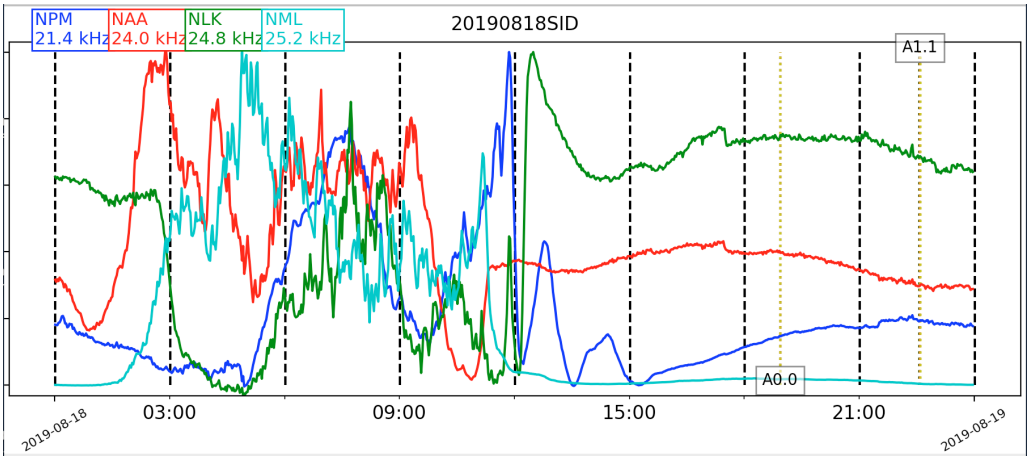

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In August 2019 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1. There were no observers who recorded SID events this month, which matched to GOES-15 XRA and FLA events.

Table 1: 201908 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
J Wallace	A97	NAA
L Loudet	A118	DHO GBZ
J Godet	A119	GBZ
B Terrill	A120	NWC
F Adamson	A122	NWC
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
L Ferreira	A149	NWC

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.

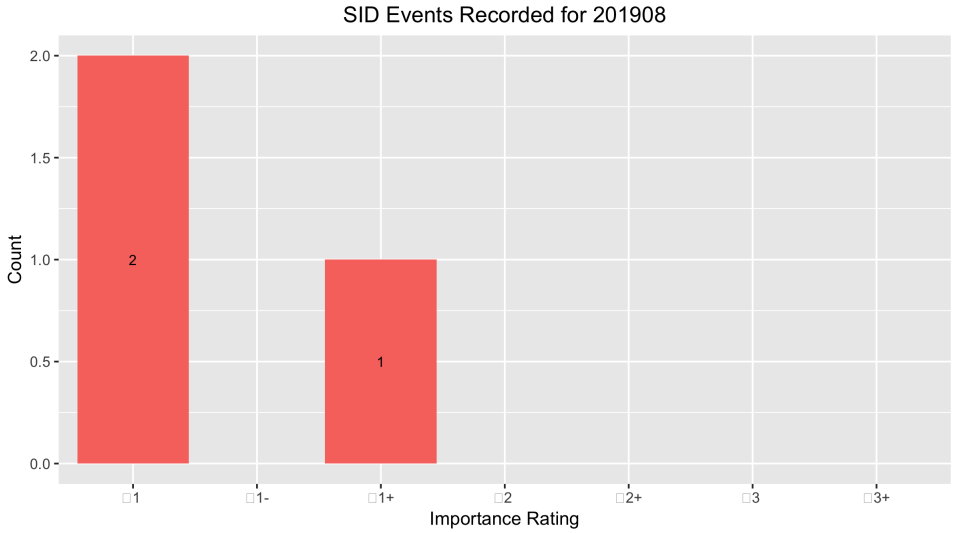

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In August 2019, there were three A class, 5 B class flares recorded from GOES-15. About the same flaring this month compared to last. There were 27 days this month with no GOES-15 reports of flares. (see Figure 4).

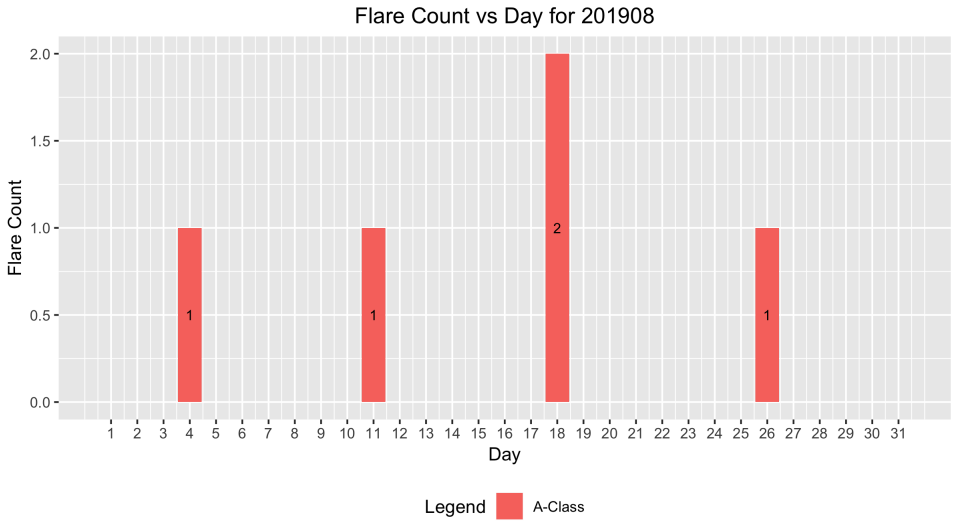

Figure 4: GOES - 15 XRA flares

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 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 2019. 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.

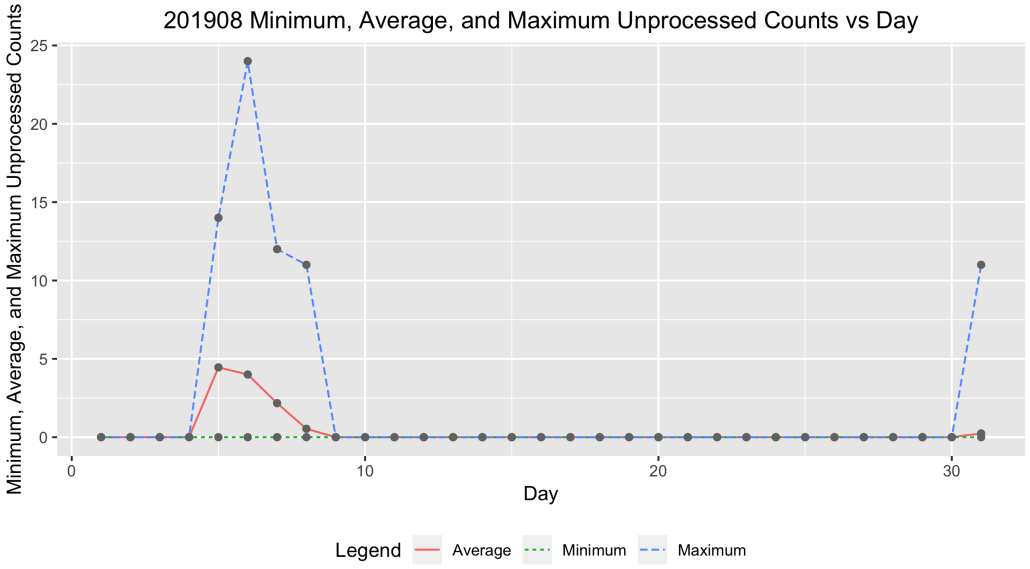

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

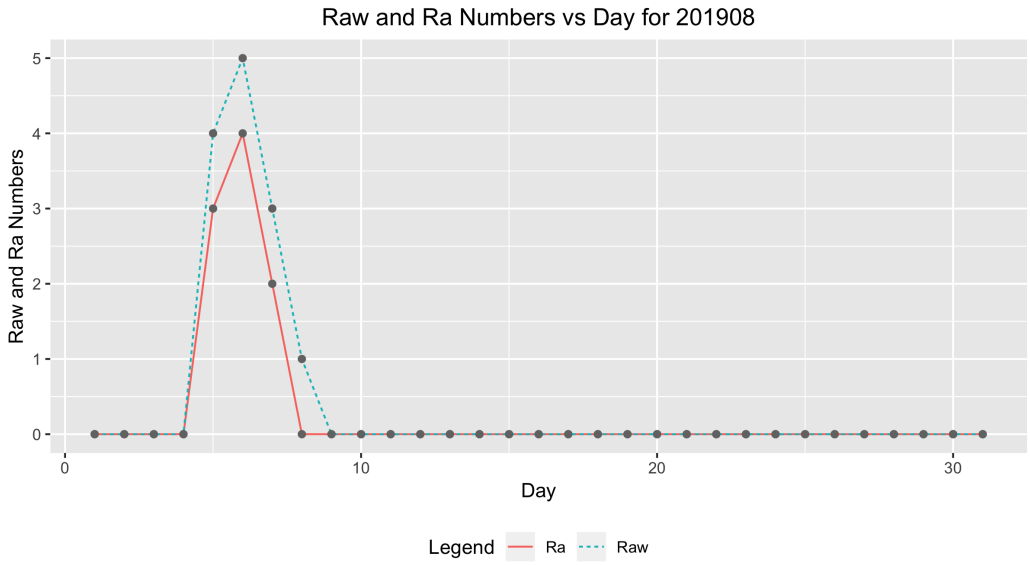

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 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 (column 1) of the observation, the Number of Observations is in column 2, the raw Wolf number is in column 3, and the Shapley correction (R_a) is in column 4.

Table 2: 201908 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	43	0	0
2	44	0	0
3	42	0	0
4	41	0	0
5	44	4	3
6	34	5	4
7	41	3	2
8	41	1	0
9	44	0	0
10	42	0	0
11	43	0	0
12	46	0	0
13	44	0	0
14	44	0	0

Continued

Table 2: 201908 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	44	0	0
16	43	0	0
17	39	0	0
18	45	0	0
19	40	0	0
20	46	0	0
21	42	0	0
22	39	0	0
23	37	0	0
24	43	0	0
25	40	0	0
26	42	0	0
27	43	0	0
28	39	0	0
29	48	0	0
30	45	0	0
31	46	0	0
Averages	42.4	0.4	0.3

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for August 2019, and the Observer Name (column 3). The final rows of the table give the total number of observers who submitted sunspot counts and the total number of observations submitted. The total number of observers is 61 and the total number of observations is 1314.

Table 3: 201908 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	18	Alexandre Amorim
AJV	31	J. Alonso
ARAG	31	Gema Araujo
ASA	26	Salvador Aguirre
ATE	29	Teofilo Arranz Heras
BARH	10	Howard Barnes
BERJ	29	Jose Alberto Berdejo
BMF	26	Michael Boschat
BRAF	23	Raffaello Braga
BROB	30	Robert Brown
BSAB	17	Santanu Basu
CHAG	31	German Morales Chavez

Continued

Table 3: 201908 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CKB	25	Brian Cudnik
CNT	30	Dean Chantiles
CVJ	14	Jose Carvajal
DEMF	13	Frank Dempsey
DIVA	24	Ivo Demeulenaere
DJOB	26	Jorge del Rosario
DMIB	30	Michel Deconinck
DROB	8	Bob Dudley
DUBF	29	Franky Dubois
EHOA	21	Howard Eskildsen
ERB	26	Bob Eramia
FERJ	19	Javier Ruiz Fernandez
FLET	28	Tom Fleming
FTAA	1	Tadeusz Figiel
FUJK	24	K. Fujimori
HAYK	22	Kim Hay
HMQ	23	Mark Harris
HOWR	23	Rodney Howe
HRUT	25	Timothy Hrutkay
JENS	2	Simon Jenner
JGE	9	Gerardo Jimenez Lopez
KAND	31	Kandilli Observatory
KAPJ	25	John Kaplan
KNJS	30	James & Shirley Knight
KROL	23	Larry Krozel
LEVM	23	Monty Leventhal
LGEC	10	Georgios Lekkas
LKR	6	Kristine Larsen
MARC	19	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	27	Etsuiku Mochizuki
MILJ	23	Jay Miller
MJHA	31	John McCammon
MUDG	16	George Mudry
MWU	23	Walter Maluf
OAAA	27	Al Sadeem Astronomy Observatory
ONJ	16	John O'Neill
SDOH	31	Solar Dynamics Obs - HMI
SMNA	4	Michael Stephanou
SNE	3	Neil Simmons
SONA	14	Andries Son
STAB	29	Brian Gordon-States
SUZM	25	Miyoshi Suzuki

Continued

Table 3: 201908 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
TESD	27	David Teske
TST	18	Steven Toothman
URBP	27	Piotr Urbanski
VARG	29	A. Gonzalo Vargas
VIDD	14	Daniel Vidican
WILW	28	William M. Wilson
Totals	1314	61

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 a paper (GLMM05) on http://www.spesi.org/?page_id=65 of the sunspot counts research page. The paper title is *A Generalized Linear Mixed Model for Enumerated Sunspots*.

Figure 7 shows the monthly GLMM R_a numbers for the 24th solar cycle to date. 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 confidence band uses the large sample approximation based on the Gaussian distribution. 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.

4 Endnotes

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

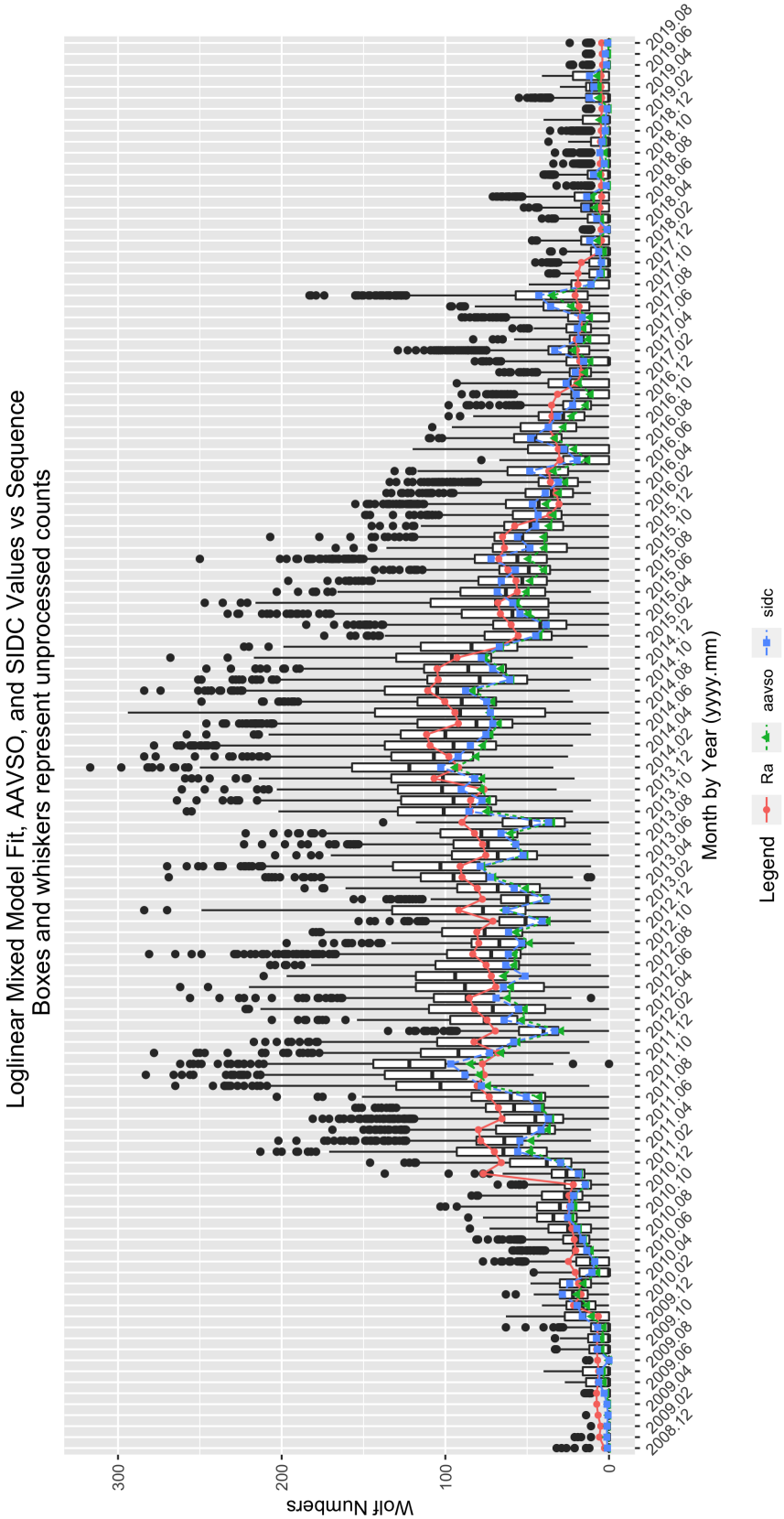

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels