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 Solar Section on Display at the 108th AAVSO Annual Meeting

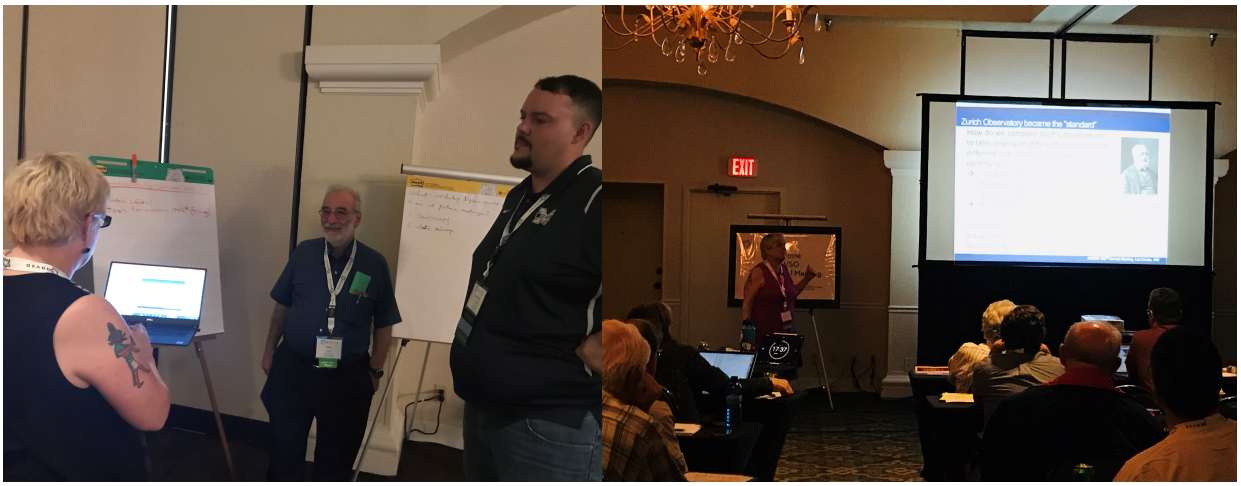

Figure 1: (left) Kristine Larsen, with Bob Eramia, Al Beltzer Sweeney. (right) Kristine presenting.

My very first responsibility as the new co-chair of the Solar Section was to represent our observers at the recent AAVSO annual meeting in Las Cruces, New Mexico. First, I was very excited to be able to speak with solar observers and those curious about becoming solar observers at a special lunch-time break out session for observing sections. The next day I presented a talk on behalf of Rodney and myself explaining how we safely observe the sun and keep our observations statistically consistent over time. It was a thrill to be able to share some of the history of our section, including colorful characters such as Casper 'Cap' Hossfield (1918-2002), the section chair from 1963 to 1979 who first introduced me to the joys of solar observing in 1989. Discussion ensued afterwards concerning the importance of observing the sun at minimum, especially prolonged minimum such as we are now enjoying. But as you all know by now, Cycle 25 is starting to get its act together, and we will be regularly seeing sunspots once more before too long. Hopefully after the publicity we received at the annual meeting we will see a few new names added to our monthly list of contributing observers in the Solar Bulletin! - Kristine Larsen

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

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

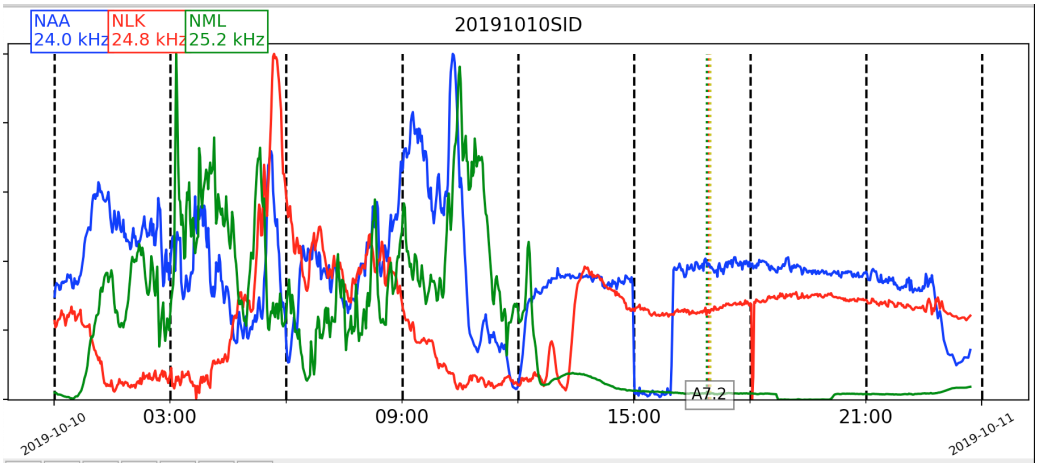

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In October 2019 we had 15 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: 201910 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO GBZ
J Godet	A119	GBZ
B Terrill	A120	NWC
F Adamson	A122	NWC
G Meyers	A124	NPM
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
R Rogge	A143	GQD
R Russel	A147	NPM
A Maevsky	A151	GQD

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.

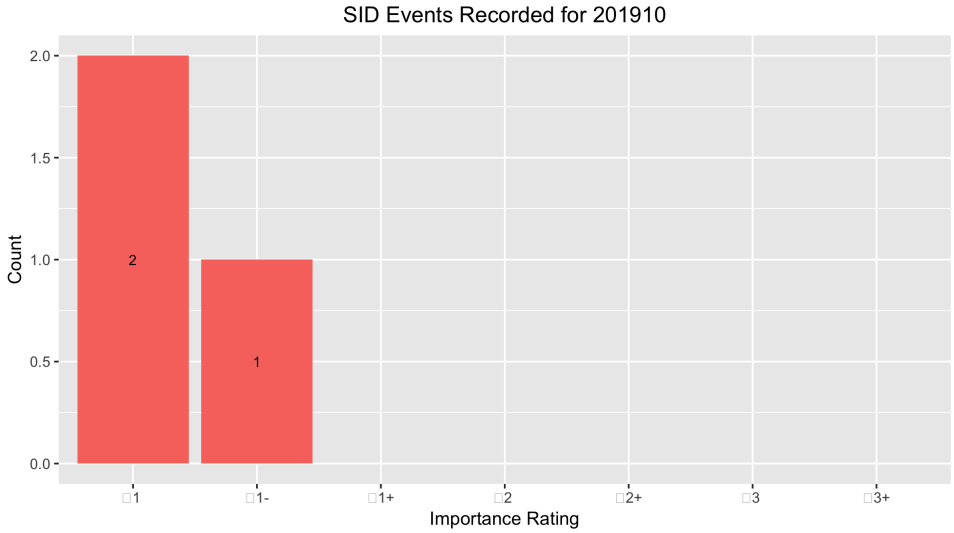

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In October 2019, there was one B class and two A class flares recorded from GOES-15. A little more flaring this month compared to last. There were 28 days this month with no GOES-15 reports of flares (see Figure 4).

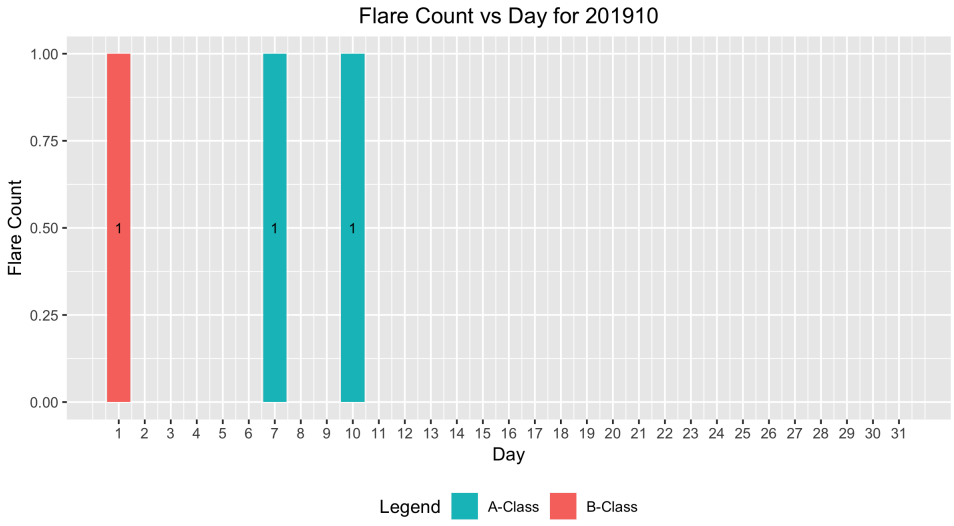

Figure 4: GOES - 15 XRA flares

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 October 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.

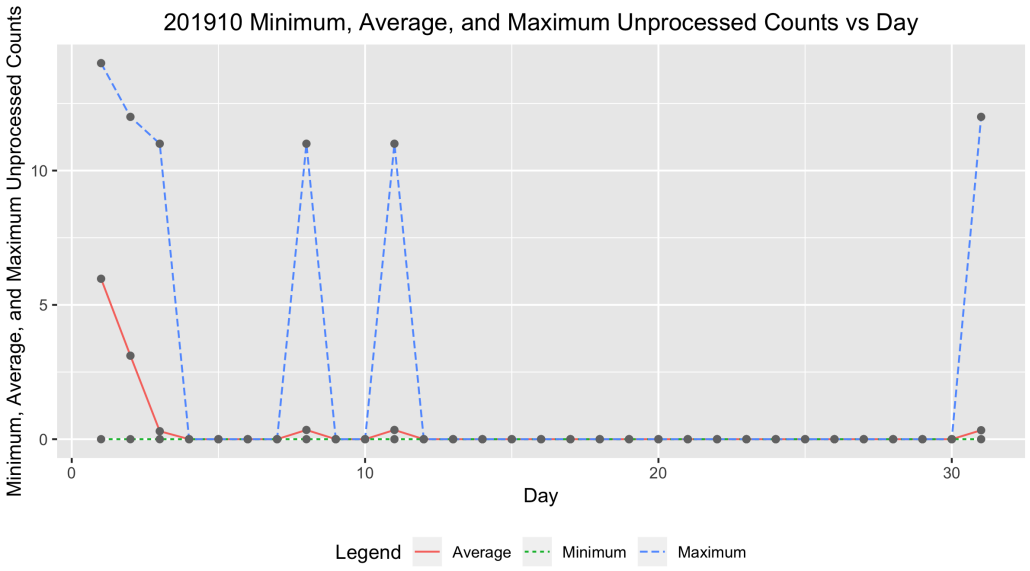

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

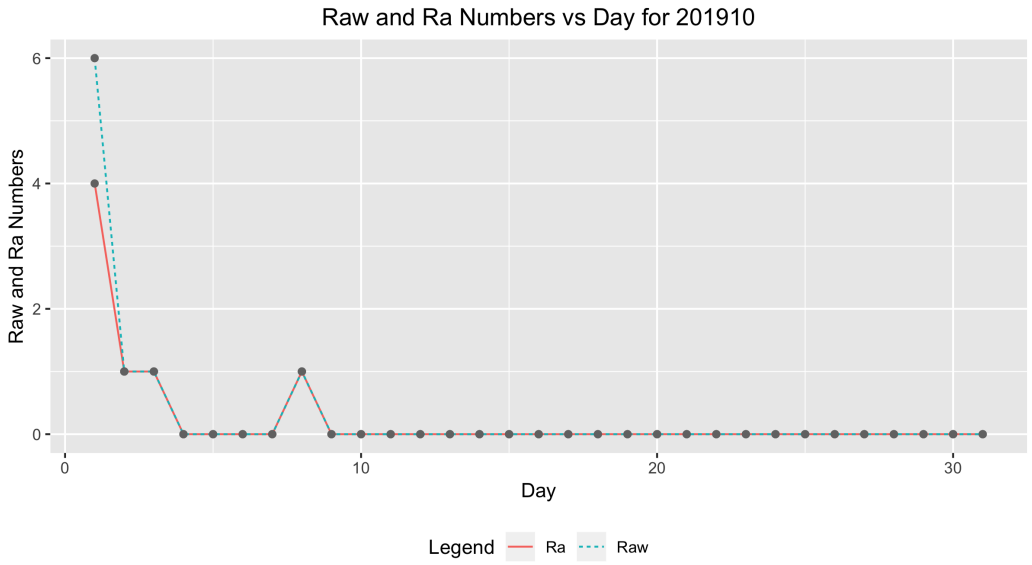

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 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 Observations (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 201910 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	37	6	4
2	37	1	1
3	37	1	1
4	39	0	0
5	44	0	0
6	34	0	0
7	33	0	0
8	32	1	1
9	44	0	0
10	41	0	0
11	32	0	0
12	36	0	0
13	46	0	0
14	35	0	0

Continued

Table 2: 201910 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	41	0	0
16	32	0	0
17	28	0	0
18	31	0	0
19	36	0	0
20	38	0	0
21	30	0	0
22	34	0	0
23	39	0	0
24	39	0	0
25	29	0	0
26	37	0	0
27	36	0	0
28	43	0	0
29	30	0	0
30	34	0	0
31	36	0	0
Averages	36.1	0.3	0.2

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for October 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 63 and the total number of observations is 1120.

Table 3: 201910 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	16	Alexandre Amorim
AJV	21	J. Alonso
ARAG	31	Gema Araujo
ASA	30	Salvador Aguirre
ATE	31	Teofilo Arranz Heras
BARH	11	Howard Barnes
BATR	5	Roberto Battaiola
BDDA	2	Diego Bastiani
BERJ	29	Jose Alberto Berdejo
BLAJ	1	John A. Blackwell
BMF	21	Michael Boschat
BRAF	6	Raffaello Braga

Continued

Table 3: 201910 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
BROB	30	Robert Brown
BSAB	25	Santanu Basu
CHAG	28	German Morales Chavez
CKB	21	Brian Cudnik
CNT	26	Dean Chantiles
CVJ	15	Jose Carvajal
DIVA	17	Ivo Demeulenaere
DJOB	10	Jorge del Rosario
DMIB	24	Michel Deconinck
DUBF	23	Franky Dubois
EHOA	19	Howard Eskildsen
ERB	20	Bob Eramia
FERJ	17	Javier Ruiz Fernandez
FLET	25	Tom Fleming
FLF	1	Fredirico Luiz Funari
FTAA	3	Tadeusz Figiel
FUJK	14	K. Fujimori
HAYK	16	Kim Hay
HMQ	19	Mark Harris
HOWR	22	Rodney Howe
HRUT	30	Timothy Hrutkay
JDAC	5	David Jackson
JENS	4	Simon Jenner
JGE	5	Gerardo Jimenez Lopez
KAND	28	Kandilli Observatory
KAPJ	8	John Kaplan
KNJS	31	James & Shirley Knight
KROL	11	Larry Krozel
LEVM	24	Monty Leventhal
LGEC	22	Georgios Lekkas
LKR	3	Kristine Larsen
MARC	9	Arnaud Mengus
MCE	19	Etsuiku Mochizuki
MILJ	12	Jay Miller
MJAF	28	Juan Antonio Moreno Quesada
MJHA	27	John McCammon
MUDG	14	George Mudry
MWU	20	Walter Maluf
OAAA	26	Al Sadeem Astronomy Observatory
ONJ	12	John O'Neill
SDOH	31	Solar Dynamics Obs - HMI
SNE	8	Neil Simmons
SONA	8	Andries Son

Continued

Table 3: 201910 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
STAB	25	Brian Gordon-States
SUZM	17	Miyoshi Suzuki
TESD	22	David Teske
TST	17	Steven Toothman
URBP	22	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VIDD	6	Daniel Vidican
WILW	19	William M. Wilson
Totals	1120	63

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

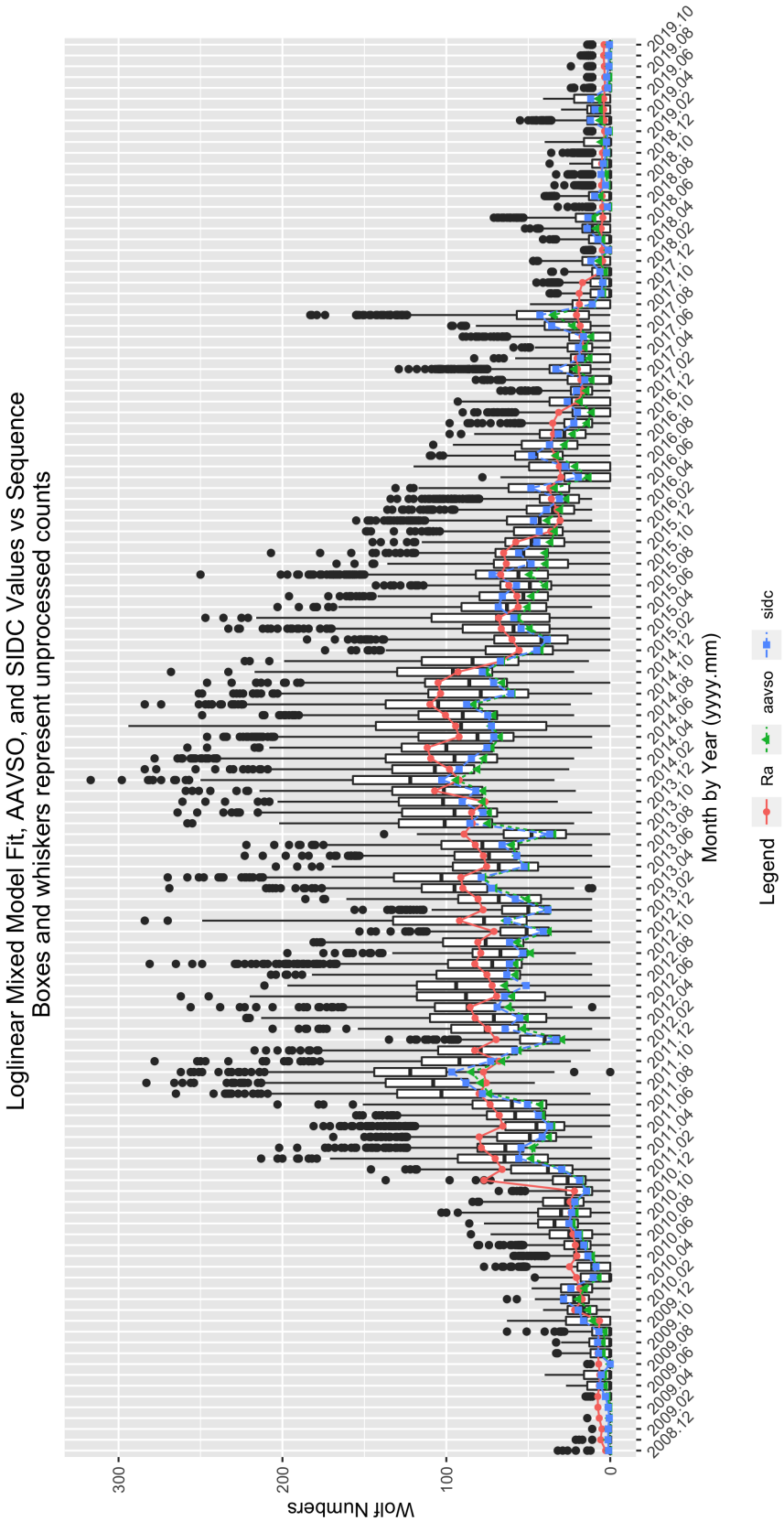

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels