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 Two images of the July 2nd Solar Eclipse; one from Bolivia, the other from Chile

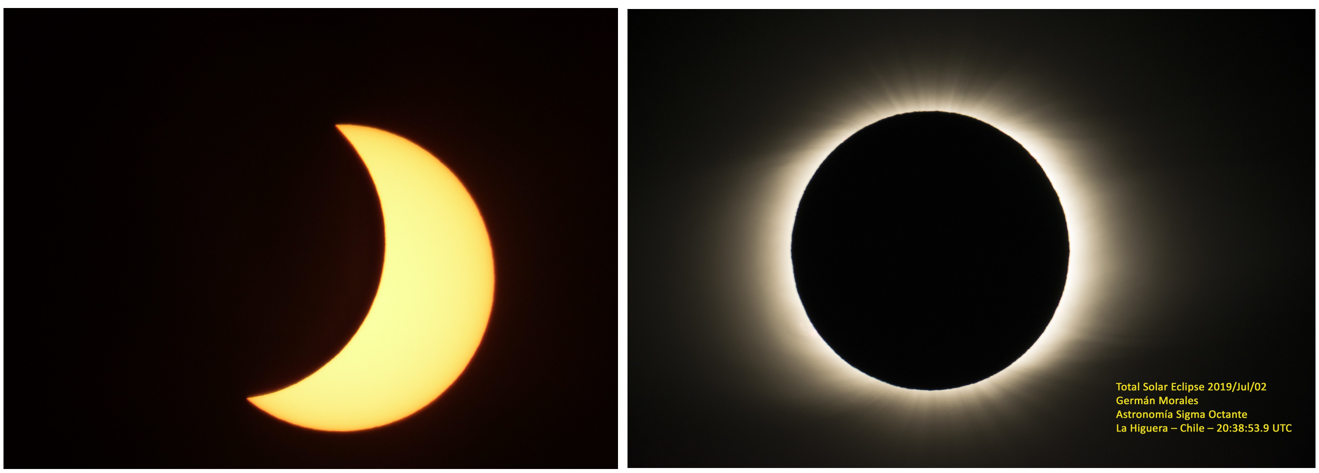

Figure 1: (left) Gonzalo Vargas (VARG) takes a photo of the partial eclipse from Cochabamba, Bolivia. (right) German Morales (CHAG) images the total eclipse from close to La Higuera, Chile.

Gonzalo's photo (left) was taken from lat: 17 23 S, long: 66 9 25 W at 20:49 UTC. German's photo (right) was taken from lat: 29 30 S, long: 71 16 W at 20:39 UTC. For details of German's eclipse trip look here: (`http://www.astronomia.org.bo/astro/256-MemoriasEclipseTotalSol.pdf`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

July 2019 (Figure 2): There were no SID events recorded here in Fort Collins, Colorado for the month of July. However there was a small inverted SID during the peak time of the July 2nd eclipse. Although, it is most likely a coincidence and not associated with the eclipse. (Please note the y-axis values in these SID graphs are non-dimensional.)

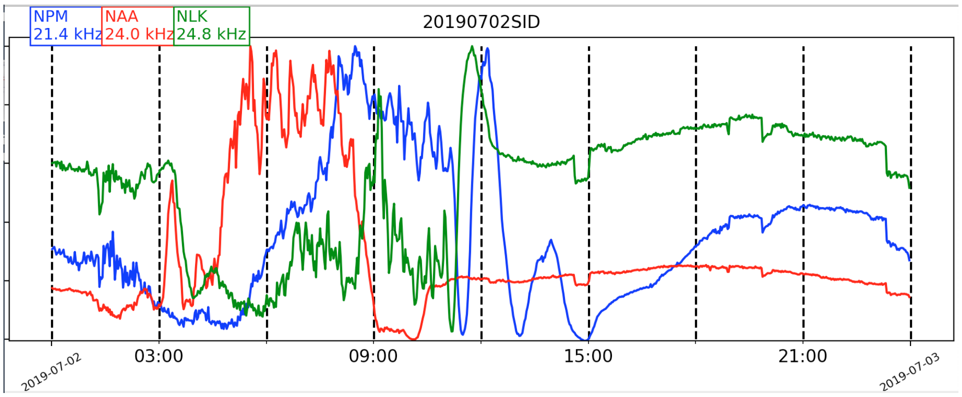

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In July 2019 we had 17 AAVSO SID observers who submitted VLF data as listed in Table 1. There were some observers who recorded SID events this month, which matched to GOES-15 XRA and FLA events.

Table 1: 201907 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
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	HWU NAU
I Ryumshin	A142	GQD DHO
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.

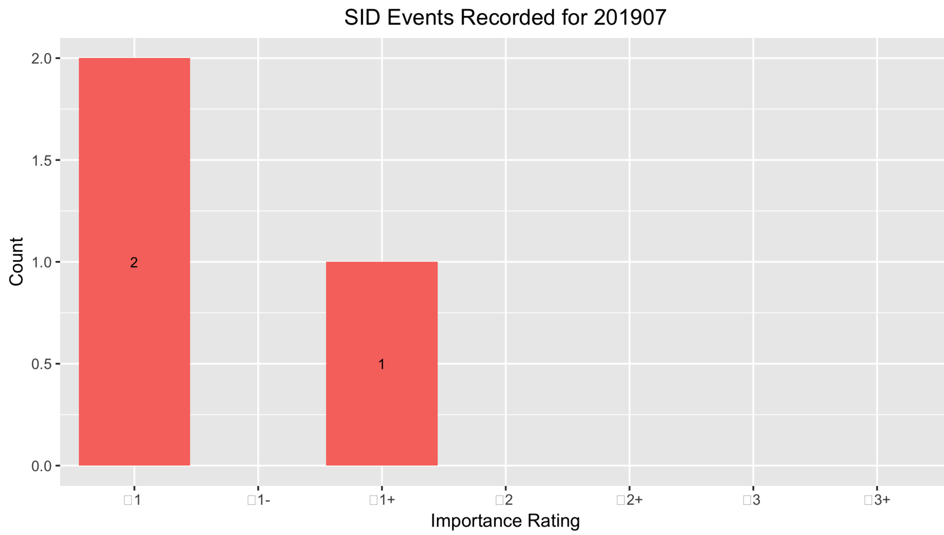

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In July 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).

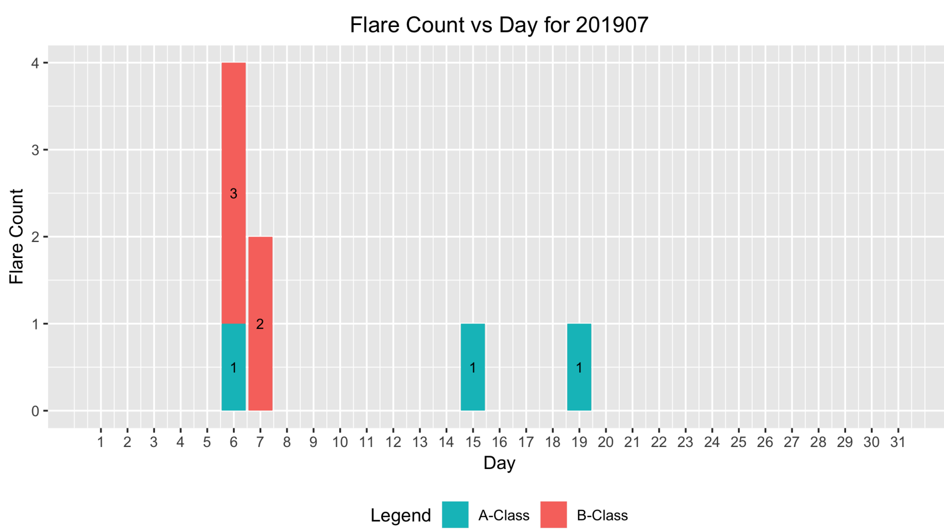

Figure 4: GOES - 15 XRA flares

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 July 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.

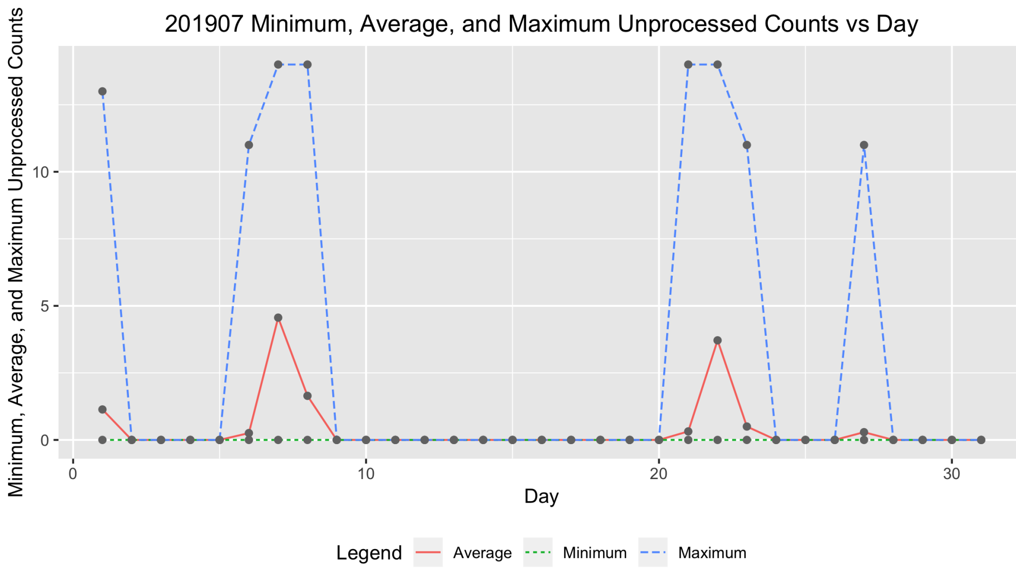

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

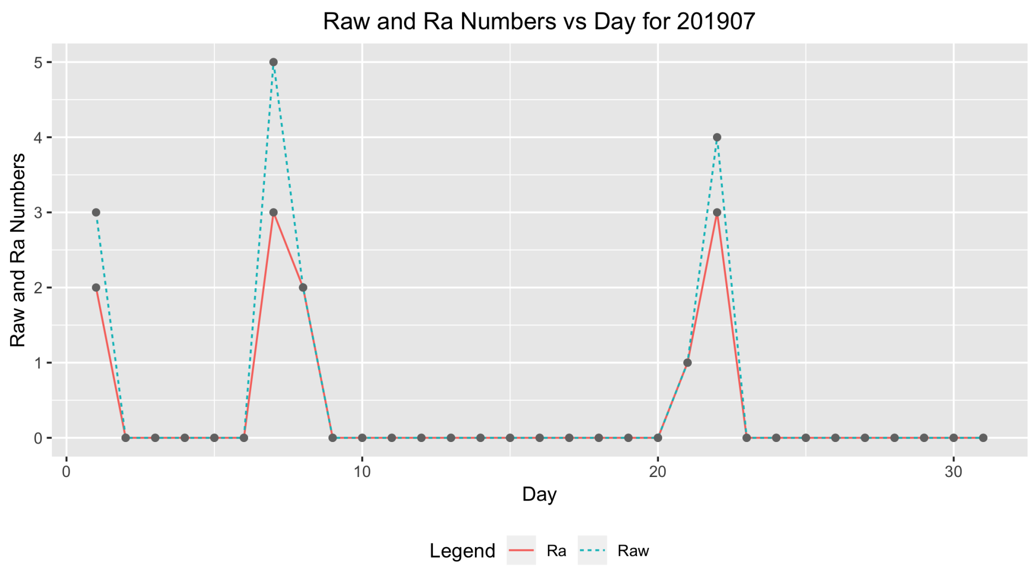

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 201907 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	44	3	2
2	42	0	0
3	40	0	0
4	41	0	0
5	38	0	0
6	43	0	0
7	41	5	3
8	45	2	2
9	48	0	0
10	46	0	0
11	42	0	0
12	46	0	0
13	44	0	0
14	38	0	0

Continued

Table 2: 201907 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	42	0	0
16	43	0	0
17	41	0	0
18	38	0	0
19	44	0	0
20	43	0	0
21	44	1	1
22	42	4	3
23	44	0	0
24	47	0	0
25	44	0	0
26	49	0	0
27	38	0	0
28	39	0	0
29	40	0	0
30	44	0	0
31	41	0	0
Averages	42.6	0.5	0.4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for July 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 65 and the total number of observations is 1321.

Table 3: 201907 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	21	Alexandre Amorim
AJV	18	J. Alonso
ARAG	31	Gema Araujo
ASA	27	Salvador Aguirre
ATE	27	Teofilo Arranz Heras
BARH	16	Howard Barnes
BATR	6	Roberto Battaiola
BERJ	31	Jose Alberto Berdejo
BMF	27	Michael Boschat
BRAF	17	Raffaello Braga
BROB	31	Robert Brown
BSAB	19	Santanu Basu

Continued

Table 3: 201907 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CHAG	26	German Morales Chavez
CKB	29	Brian Cudnik
CNT	18	Dean Chantiles
CVJ	3	Jose Carvajal
DEMF	9	Frank Dempsey
DIVA	20	Ivo Demeulenaere
DJOB	14	Jorge del Rosario
DMIB	30	Michel Deconinck
DROB	10	Bob Dudley
DUBF	28	Franky Dubois
EHOA	24	Howard Eskildsen
ERB	19	Bob Eramia
FERJ	15	Javier Ruiz Fernandez
FLET	26	Tom Fleming
FLF	15	Fredirico Luiz Funari
FUJK	18	K. Fujimori
HAYK	23	Kim Hay
HMQ	28	Mark Harris
HOWR	19	Rodney Howe
HRUT	29	Timothy Hrutkay
JDAC	4	David Jackson
JENS	3	Simon Jenner
JGE	10	Gerardo Jimenez Lopez
KAND	29	Kandilli Observatory
KAPJ	27	John Kaplan
KNJS	27	James & Shirley Knight
KROL	28	Larry Krozel
LEVM	21	Monty Leventhal
LKR	6	Kristine Larsen
LRRA	4	Robert Little
MARC	23	Arnaud Mengus
MARE	10	Enrico Mariani
MCE	15	Etsuiku Mochizuki
MILJ	23	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	31	John McCammon
MUDG	17	George Mudry
MWU	28	Walter Maluf
OAAA	26	Al Sadeem Astronomy Observatory
ONJ	11	John O'Neill
RLM	7	Mat Raymonde
SDOH	31	Solar Dynamics Obs - HMI
SMNA	4	Michael Stephanou

Continued

Table 3: 201907 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
SNE	11	Neil Simmons
SONA	20	Andries Son
STAB	31	Brian Gordon-States
SUZM	15	Miyoshi Suzuki
TESD	30	David Teske
TST	20	Steven Toothman
URBP	29	Piotr Urbanski
VARG	29	A. Gonzalo Vargas
VIDD	19	Daniel Vidican
WILW	27	William M. Wilson
Totals	1321	65

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.

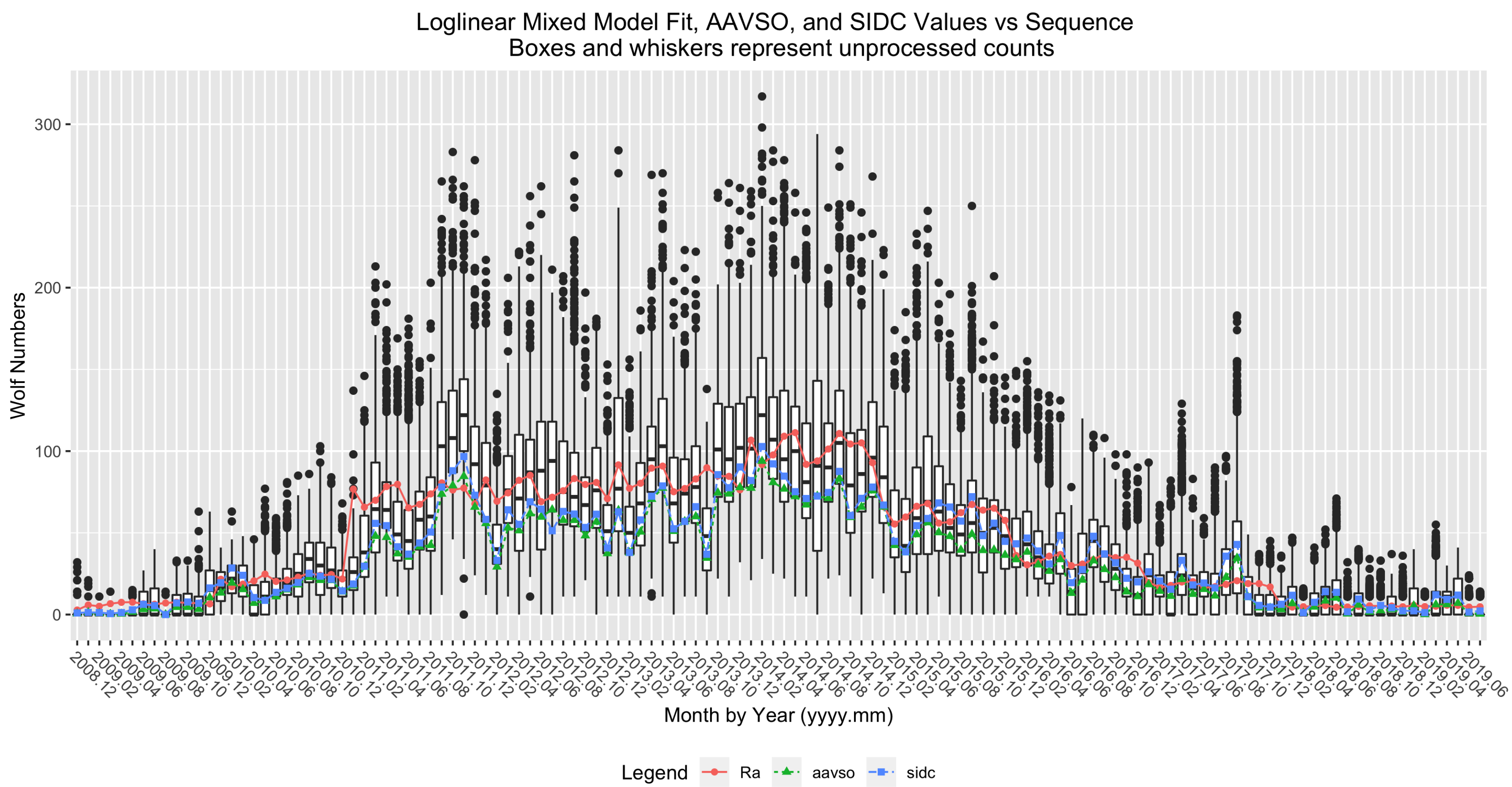

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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