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 10.7 cm radio flux vs. AAVSO Wolf numbers for 7 solar cycles.

How closely do the monthly Natural Resources Canada (NRC, Penticton) 10.7 cm radio flux (`http://www.spaceweather.gc.ca/sx-eng.php`) match up to the AAVSO Monthly average Wolf numbers?

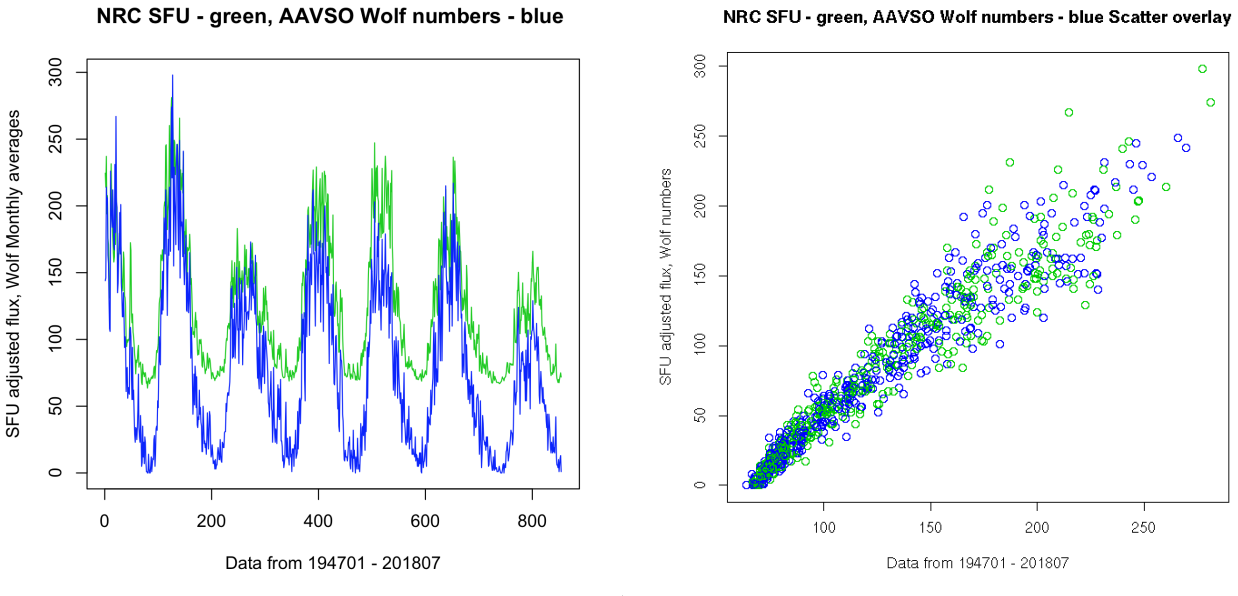

Figure 1: The SFU (solar flux unit) has a baseline above 64, which is equivalent to 0 sunspots during solar cycle minimums, but for solar cycle maximums the adjusted SFU match up pretty well. Both the Penticton data and the AAVSO go back to 1947 to present.

For further reading:
(`https://arxiv.org/abs/1304.4545`)
(`https://arxiv.org/abs/0912.5042v2`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

July 2018 (Figure 2): There was one C1.6 class GOES events recorded on the 6th of July. This Event was the only recorded SID in the ionosphere for July 2018 .

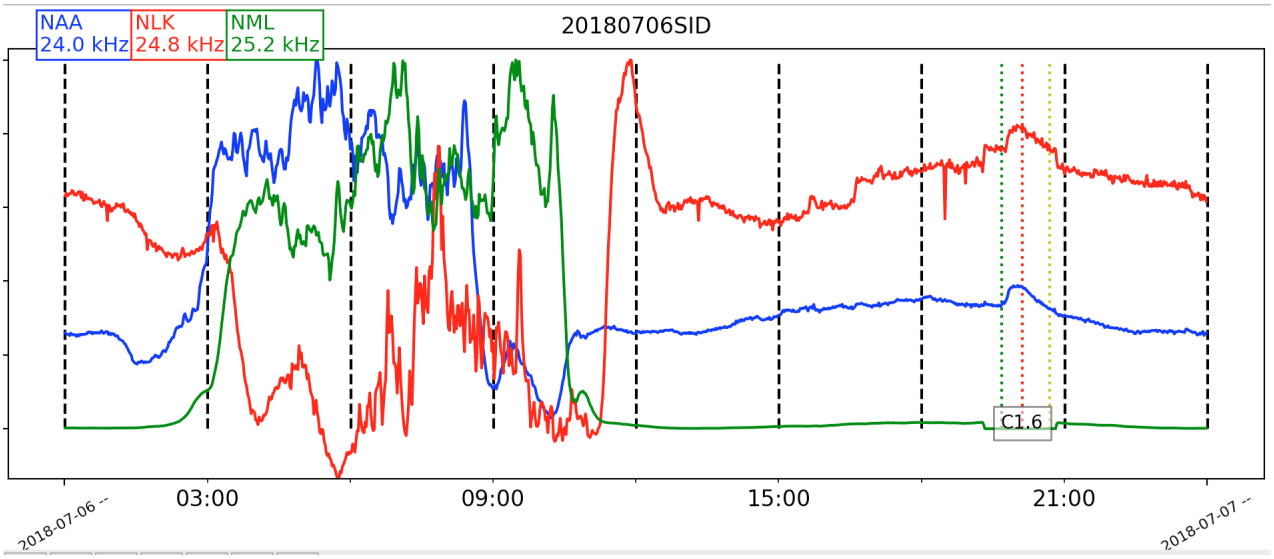

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In July 2018 we had 13 AAVSO SID observers who submitted VLF data as listed in Table 1. Observers monitor from one to three stations to provide SID data.

Table 1: 201807 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ ICV
F Adamson	A122	NWC
S Oatney	A125	NML
J Karlovsky	A131	NSY ICV
S Aguirre	A138	NPM
G Silvis	A141	NLK
I Ryumshin	A142	GQD DHO
K Menzies	A146	NAA
L Ferreira	A149	NWC
A Maevsky	A151	DHO GQD ICV

Figure 3 depicts the importance rating of the solar events. The durations 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.

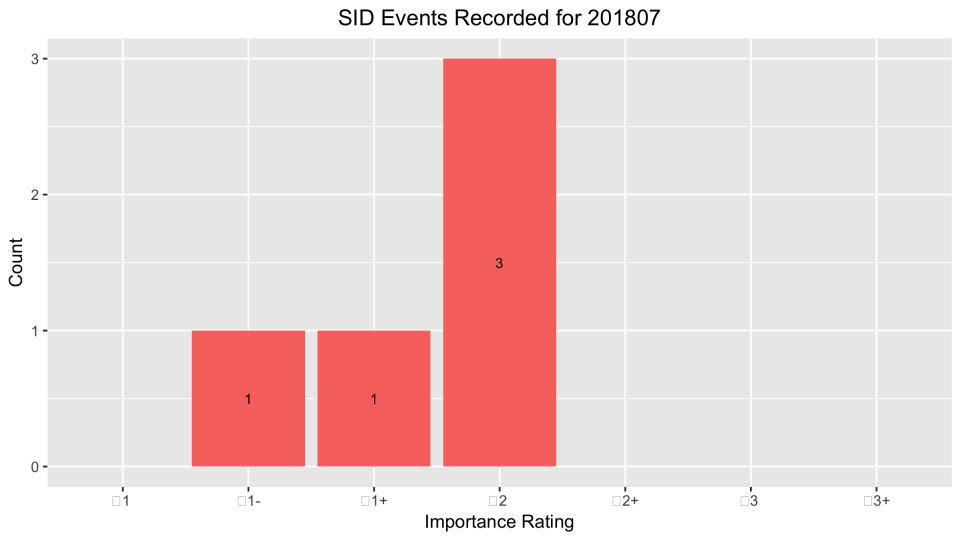

Figure 3: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In July 2018, there were 10 solar flares measured by GOES-15 for July, 2018: One C class and 8 B class flares and one A class flare. Far less flaring occurred this month compared to last with 25 days of no reports from the GOES satellite (see Figure 4).

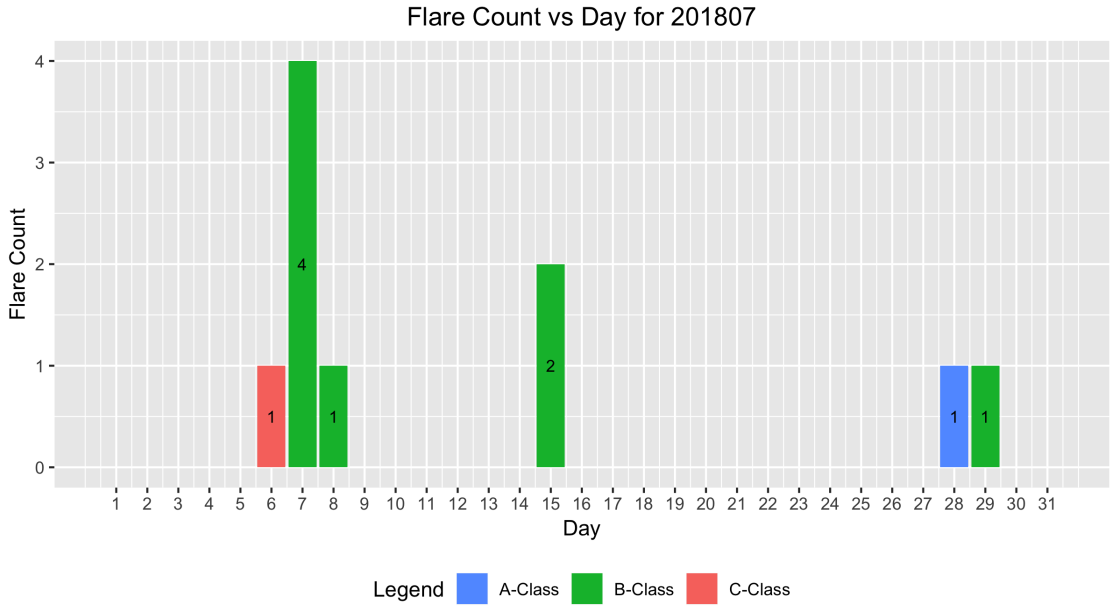

Figure 4: GOES - 15 XRA flares

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 2018. These counts are reported by the day of the month, and are either from data not scrubbed or corrected data.

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.

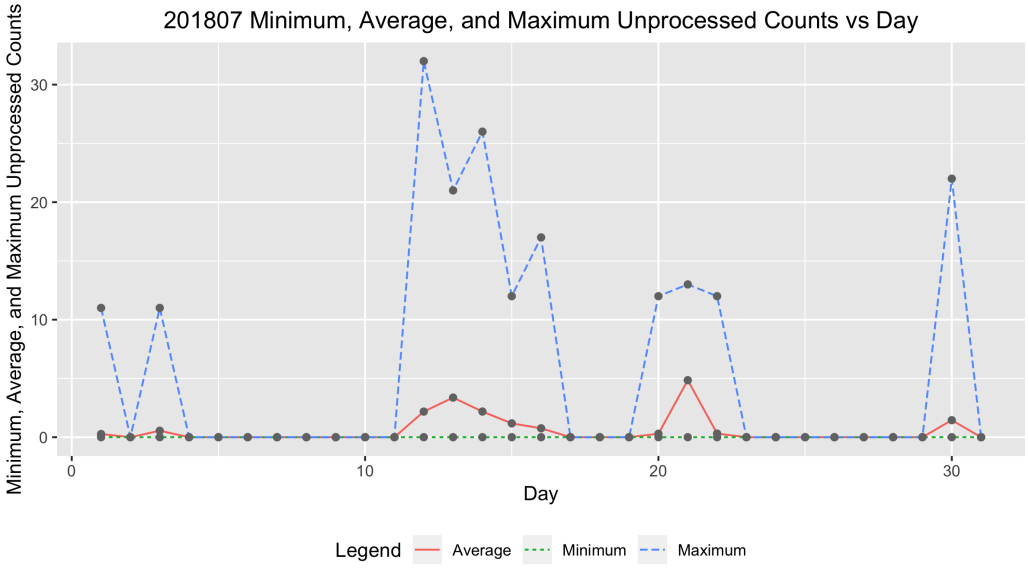

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

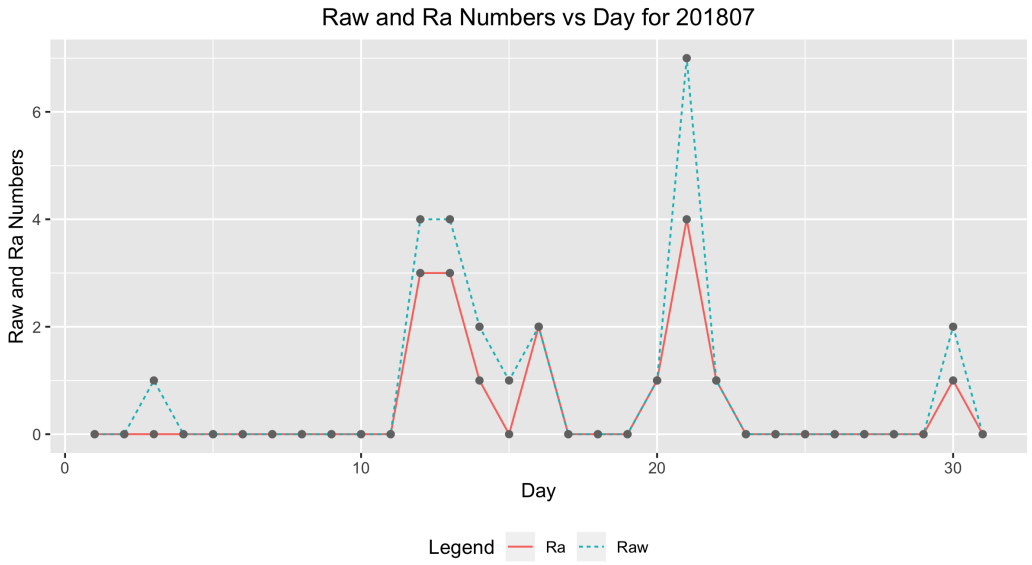

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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.

Table 2: 201807 American Relative Sunspot Numbers (R_a)

Day	NumObs	Raw	R_a
1	41	0	0
2	42	0	0
3	40	1	0
4	39	0	0
5	38	0	0
6	36	0	0
7	41	0	0
8	49	0	0
9	43	0	0
10	46	0	0
11	47	0	0
12	45	4	3
13	46	4	3
14	44	2	1
15	40	1	0
16	37	2	2
17	43	0	0
18	44	0	0

Continued

Table 2: 201807 American Relative Sunspot Numbers (R_a)

Day	NumObs	Raw	R_a
19	42	0	0
20	41	1	1
21	33	7	4
22	39	1	1
23	39	0	0
24	33	0	0
25	35	0	0
26	38	0	0
27	42	0	0
28	43	0	0
29	47	0	0
30	38	2	1
31	39	0	0
Averges	41	0.8	0.5

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations (NumObs) submitted for July 2018, and the observer's name (Name). 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 64 and the total number of observations is 1271.

Table 3: 201807 Number of observations by observer

Obs	NumObs	Name
AAP	4	A. Patrick Abbott
AAX	22	Alexandre Amorim
AJV	16	J. Alonso
ARAG	31	Gema Araujo
ASA	25	Salvador Aguirre
ATE	10	Teofilo Arranz Heras
BARH	10	Howard Barnes
BDDA	8	Diego Bastiani
BERJ	31	Jose Alberto Berdejo
BMF	24	Michael Boschat
BRAD	26	David Branchett
BRAF	23	Raffaello Braga
BROB	31	Robert Brown
BSAB	14	Santanu Basu
CHAG	31	German Morales Chavez
CIOA	18	Ioannis Chouinavas
CKB	22	Brian Cudnik
CNT	10	Dean Chantiles
CVJ	16	Jose Carvajal

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Table 3: 201807 Number of observations by observer

Obs	NumObs	Name
DJOB	20	Jorge del Rosario
DMIB	30	Michel Deconinck
DROB	5	Bob Dudley
DUBF	31	Franky Dubois
EHOA	24	Howard Eskildsen
ERB	25	Bob Eramia
FERJ	20	Javier Ruiz Fernandez
FLET	28	Tom Fleming
FUJK	24	K. Fujimori
HAYK	22	Kim Hay
HIVB	1	Ivan Hajdinjak
HOWR	27	Rodney Howe
JDAC	10	David Jackson
JENS	4	Simon Jenner
JGE	16	Gerardo Jimenez Lopez
KAND	24	Kandilli Observatory
KAPJ	27	John Kaplan
KNJS	31	James & Shirley Knight
KROL	28	Larry Krozel
LEVM	26	Monty Leventhal
LKR	3	Kristine Larsen
LRRA	9	Robert Little
MARE	13	Enrico Mariani
MCE	25	Etsuiku Mochizuki
MILJ	20	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	29	John McCammon
MUDG	23	George Mudry
MWU	25	Walter Maluf
ONJ	13	John O'Neill
RLM	13	Mat Raymonde
SDOH	31	Solar Dynamics Obs - HMI
SMNA	4	Michael Stephanou
SNE	6	Neil Simmons
SONA	30	Andries Son
STAB	30	Brian Gordon-States
SUZM	27	Miyoshi Suzuki
TESD	30	David Teske
TPJB	4	Patrick Thibault
TST	14	Steven Toothman
URBP	27	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
WCHD	8	Charles White
WGI	1	Guido Wollenhaupt

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Table 3: 201807 Number of observations by observer

Obs	NumObs	Name
WILW	30	William M. Wilson
Totals	1271	64

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

Reporting Addresses

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

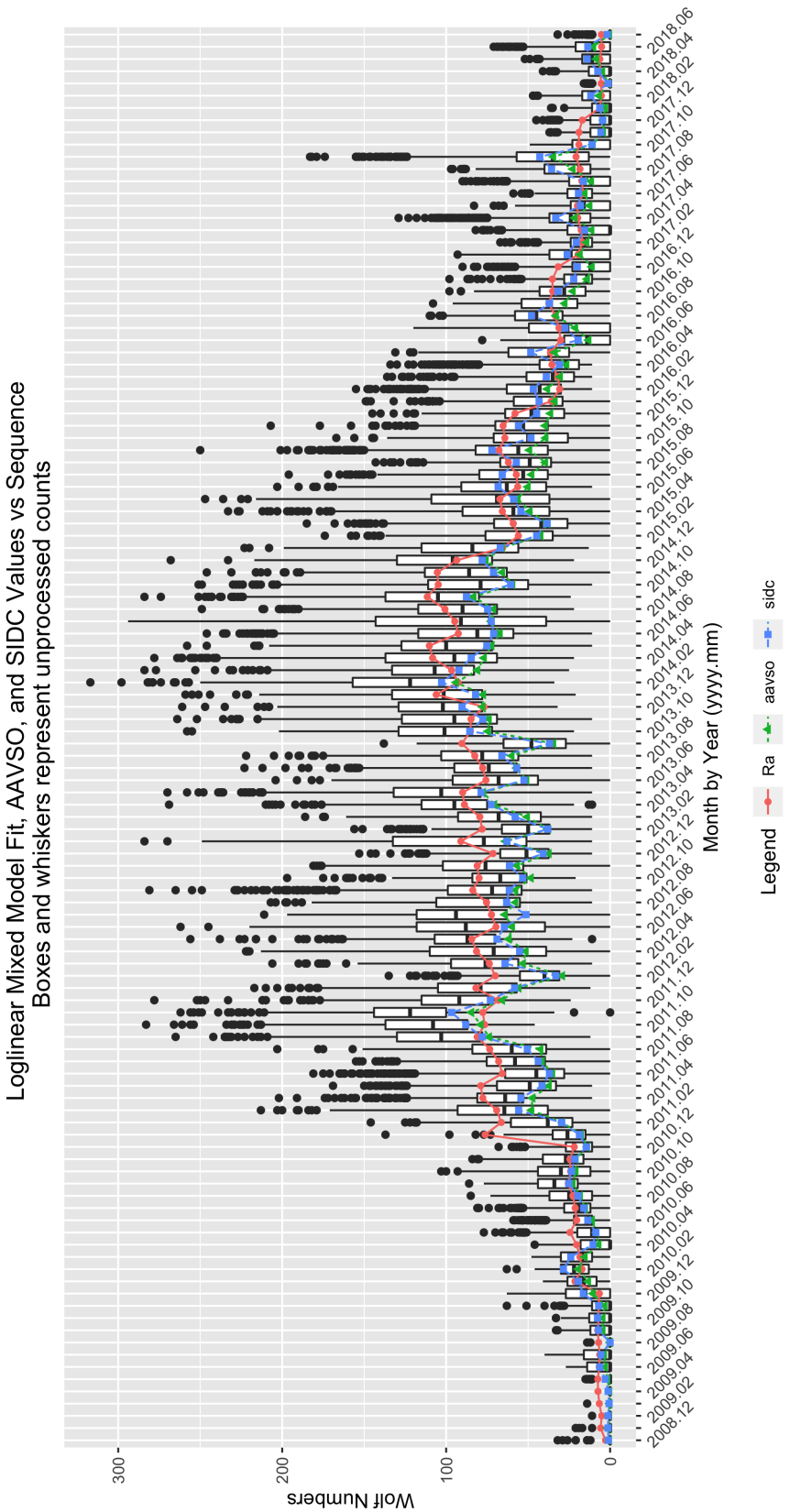

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels