Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Editor, Chair
c/o AAVSO, 49 Bay State Rd
Cambridge, MA 02138 USA

Web: http://www.aavso.org/solar-bulletin
Email: solar@aavso.org
ISSN 0271-8480

Volume 75 Number 2 February 2019

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 cycle proxy from 30 cm radio observatory in France

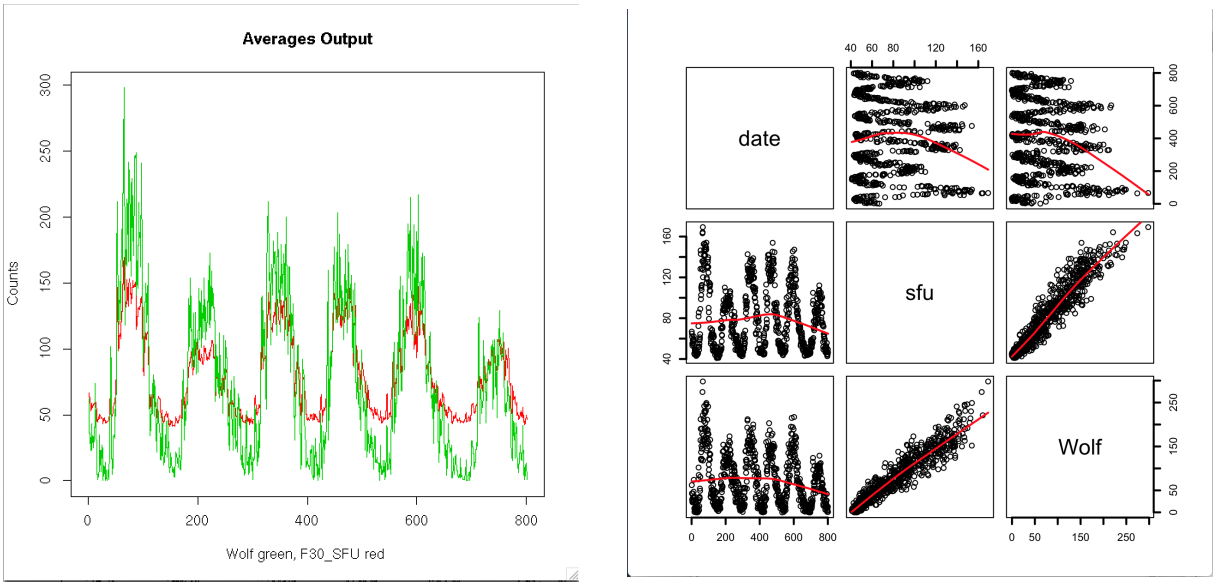

Figure 1: Compare the F30 Solar Flux Unit with the AAVSO monthly Wolf numbers from 1951 thru 2018. Left panel shows how closely the AAVSO Wolf numbers match to the F30 data, the right panel gives an idea of how tight the regression lines are for each data set.

Radio emissions at the 30 centimeter wavelength have been routinely monitored since the 1950 s, thereby offering prospects for building proxies that may be better tailored to space weather needs. The 30 cm flux contains a relatively larger proportion of emissions coming from solar features such as plages, faculae and hot coronal loops.

Daily F30 data from here: (`https://spaceweather.cls.fr.`)

Further reading: (`http://adsabs.harvard.edu/abs/2017JSWSC...7A...9D`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

February 2019 (Figure 2): The only two B class flares this month were on the 1st of February recorded here Fort Collins, Colorado. However, these were during the night and difficult to detect SID event flares in the ionosphere. (Please note the y-axis values in these SID graphs are non-dimensional.)

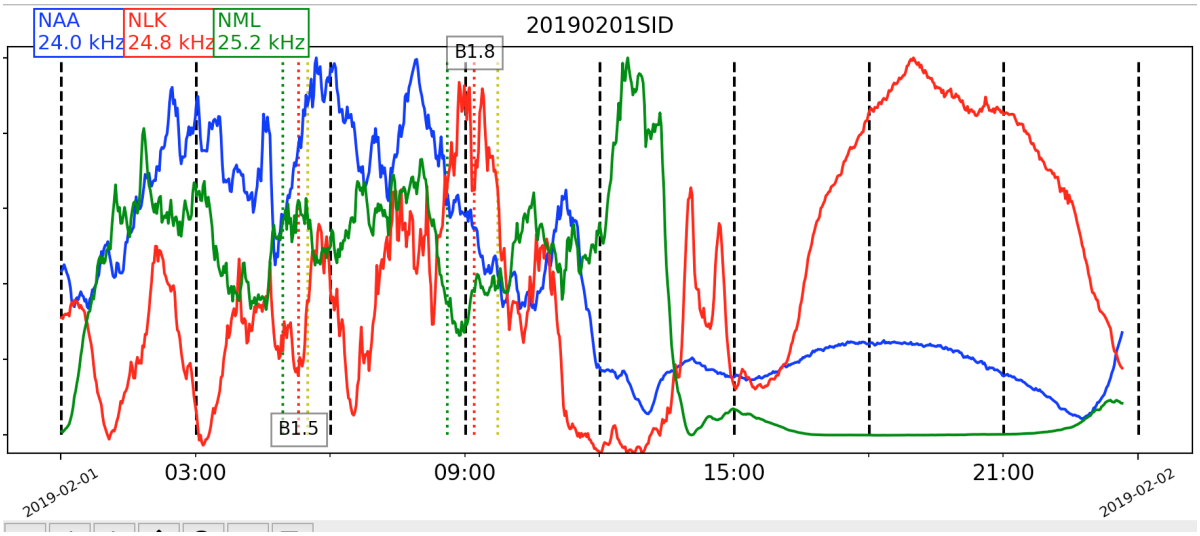

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In February 2019 we had 18 AAVSO SID observers who submitted VLF data as listed in Table 1. There were no observers who recorded any SID event this month. Any VLF SID Events were mostly noise and did not match to any GOES-15 flare events.

Table 1: 201902 VLF Observers

Observer	Code	Stations
S Hansen	A59	NAA
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	NAA
G Meyers	A124	NPM
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
R Mrllak	A136	NSY GQD
S Aguirre	A138	NPM
G Silvis	A141	NLK
R Rogge	A143	GQD
L Ferreira	A149	NWC
G Wood	A150	NML

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.

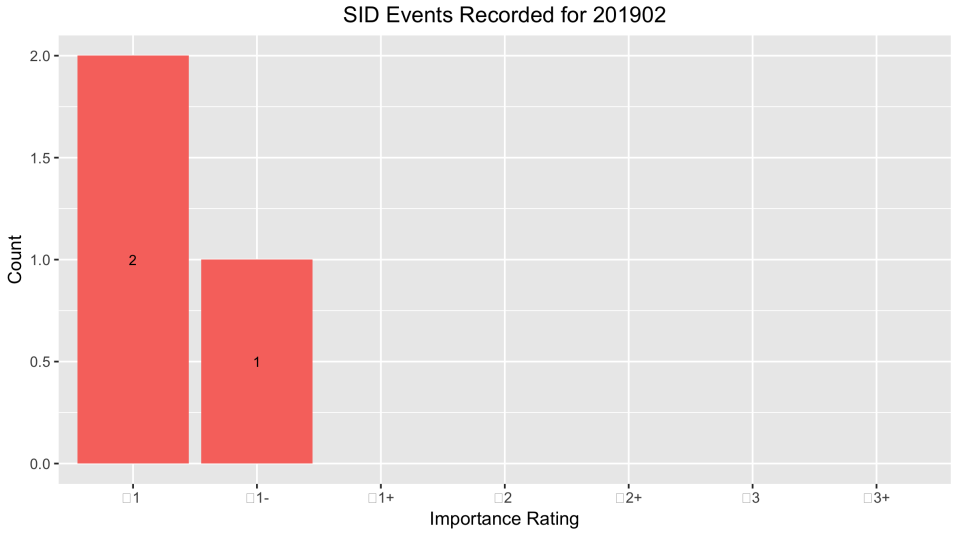

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In February 2019, there were 5 flares reported by GOES-15 this month. Far less flaring than last month: Three A class, 2 B class flares. There were 24 days this month with no GOES-15 reports of flares. (see Figure 4).

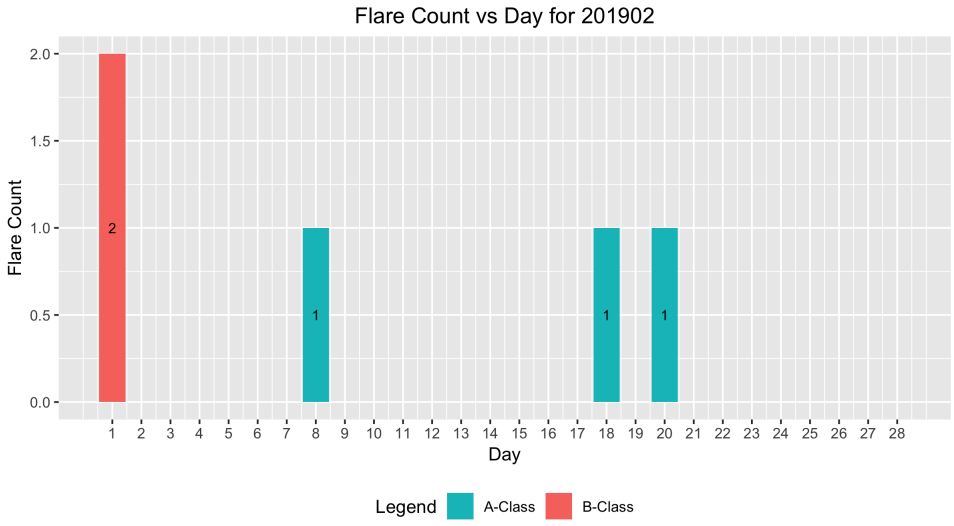

Figure 4: GOES - 15 XRA flares

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 February 2019. 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.

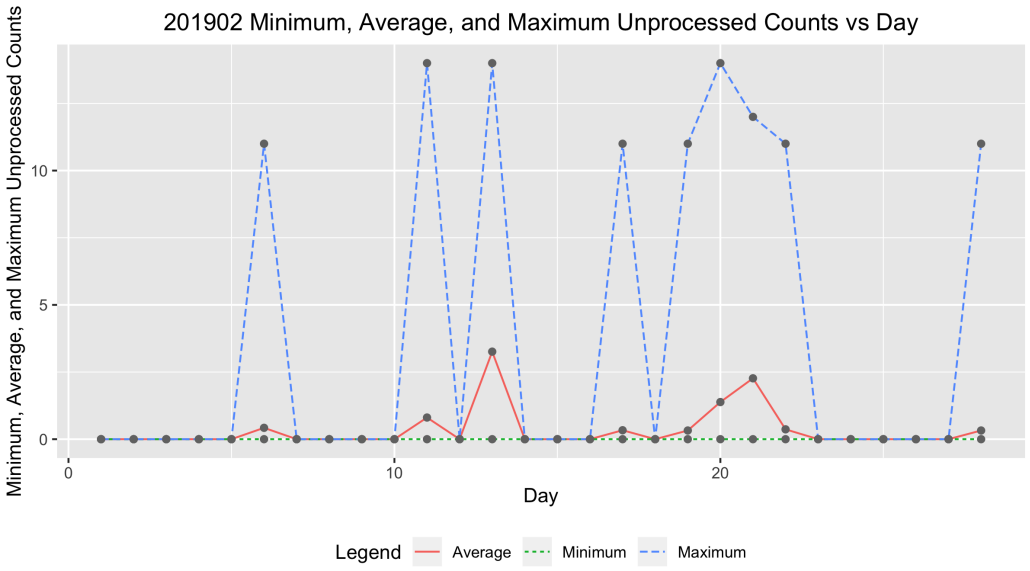

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

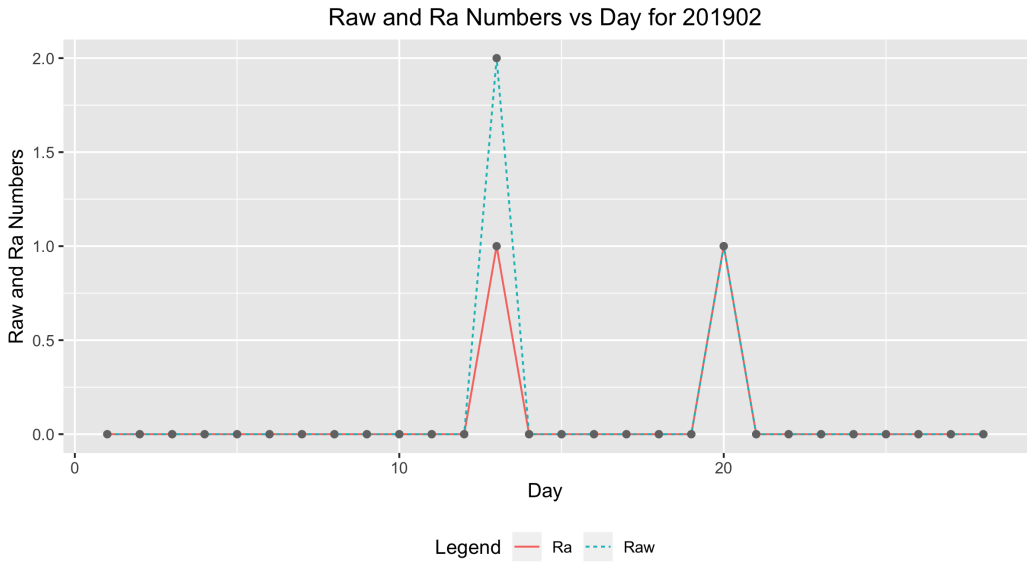

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 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: 201902 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	0	0
2	27	0	0
3	29	0	0
4	25	0	0
5	29	0	0
6	26	0	0
7	29	0	0
8	30	0	0
9	38	0	0
10	26	0	0
11	31	0	0
12	29	0	0
13	27	2	1
14	33	0	0
15	34	0	0

Continued

Table 2: 201902 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	40	0	0
17	33	0	0
18	32	0	0
19	34	0	0
20	34	1	1
21	30	0	0
22	30	0	0
23	36	0	0
24	40	0	0
25	38	0	0
26	30	0	0
27	26	0	0
28	34	0	0
Averges	31.4	0.1	0.1

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for February 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 880.

Table 3: 201902 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	18	Alexandre Amorim
AJV	18	J. Alonso
ARAG	28	Gema Araujo
ASA	19	Salvador Aguirre
ATE	22	Teofilo Arranz Heras
BARH	11	Howard Barnes
BATR	5	Roberto Battaiola
BERJ	26	Jose Alberto Berdejo
BMF	18	Michael Boschat
BRAD	24	David Branchett
BRAF	12	Raffaello Braga
BROB	10	Robert Brown
BSAB	19	Santanu Basu
CIOA	8	Ioannis Chouinavas
CKB	10	Brian Cudnik
CNT	15	Dean Chantiles
CVJ	15	Jose Carvajal

Continued

Table 3: 201902 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
DEMF	4	Frank Dempsey
DIVA	19	Ivo Demeulenaere
DJOB	12	Jorge del Rosario
DMIB	26	Michel Deconinck
DUBF	24	Franky Dubois
EHOA	15	Howard Eskildsen
ERB	5	Bob Eramia
FERJ	19	Javier Ruiz Fernandez
FLET	14	Tom Fleming
FLF	7	Fredirico Luiz Funari
HAYK	9	Kim Hay
HOWR	22	Rodney Howe
HRUT	19	Timothy Hrutkay
JDAC	5	David Jackson
JENS	4	Simon Jenner
JGE	3	Gerardo Jimenez Lopez
JPG	1	Penko Jordanov
KAND	16	Kandilli Observatory
KAPJ	9	John Kaplan
KNJS	28	James & Shirley Knight
KROL	22	Larry Krozel
LEVM	18	Monty Leventhal
LKR	3	Kristine Larsen
LRRA	5	Robert Little
MARE	1	Enrico Mariani
MCE	20	Etsuiku Mochizuki
MILJ	14	Jay Miller
MJAF	27	Juan Antonio Moreno Quesada
MJHA	25	John McCammon
MUDG	5	George Mudry
MWU	10	Walter Maluf
OAAA	19	Al Sadeem Astronomy Observatory
ONJ	5	John O'Neill
RRO	1	Ralph Rogge
SDOH	28	Solar Dynamics Obs - HMI
SNE	1	Neil Simmons
SONA	11	Andries Son
STAB	22	Brian Gordon-States
SUZM	24	Miyoshi Suzuki
TESD	17	David Teske
TST	5	Steven Toothman
URBP	17	Piotr Urbanski
VARG	24	A. Gonzalo Vargas

Continued

Table 3: 201902 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
VIDD	7	Daniel Vidican
WGI	1	Guido Wollenhaupt
WILW	9	William M. Wilson
Totals	880	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

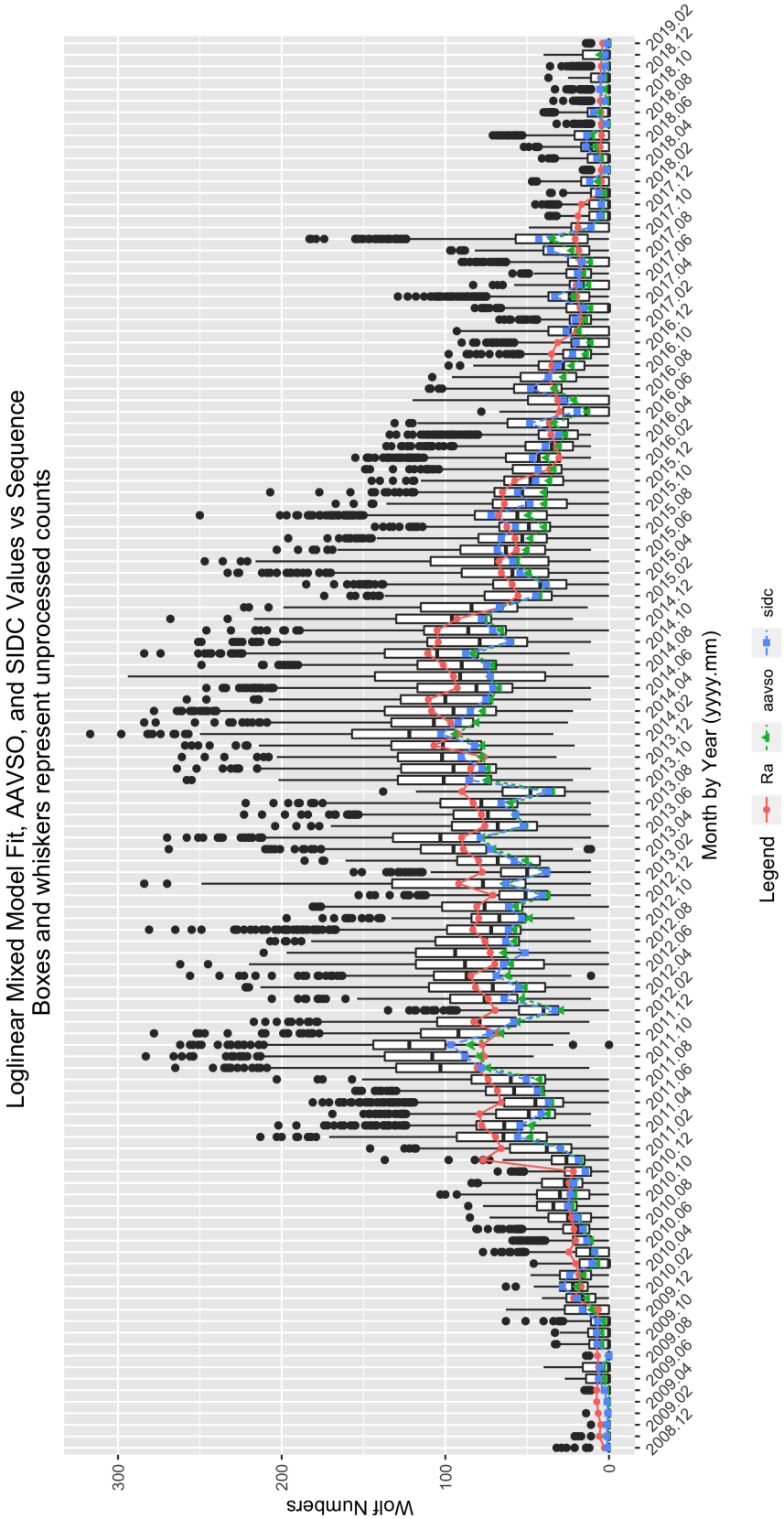

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels