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 F30 Radio Flux and Oulu Neutron Monitor data

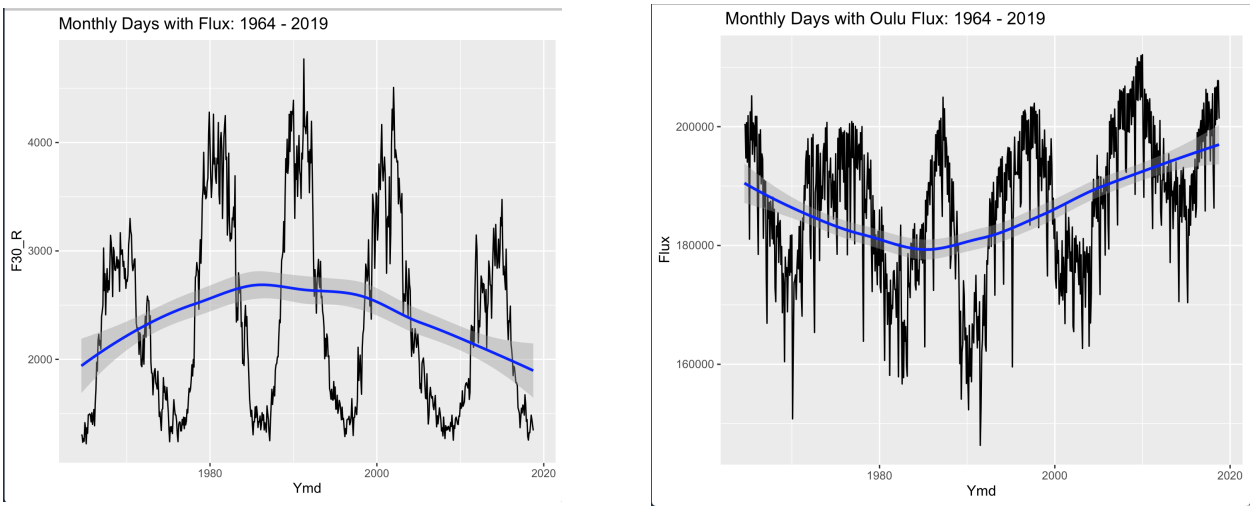

Figure 1: (left) The F30 cm radio data from France. (right) Oulu Neutron Monitor data from Finland.

The F30 radio data covers the last 5 solar cycles (`https://spaceweather.cls.fr/services/radioflux/`): With a Lowess smoothing estimate the graph shows how the previous 3 cycles (21 - 23) peak and then decline for cycle 24.

The Oulu Neutron Monitor data covers the same time span (1964 - 2019) (`http://cosmicrays.oulu.fi`) The Neutron data recorded Cosmic Rays. The reverse Lowess smoothing line shows where, during solar minimums, the Cosmic Ray counts are higher. Notice that the Neutron flux has higher enough counts than the F30 radio data that these two graphs cannot be put on the same y-axis scale.

Further reading on LOWESS smoothing: (`https://en.wikipedia.org/wiki/Local_regression`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

January 2020 (Figure 2): There were no SID events recorded here in Fort Collins, Colorado for the month of January, nor on the 10th of January, as two B.1 class solar flares were recorded during the early morning. (Please note the y-axis values in these SID graphs are non-dimensional.)

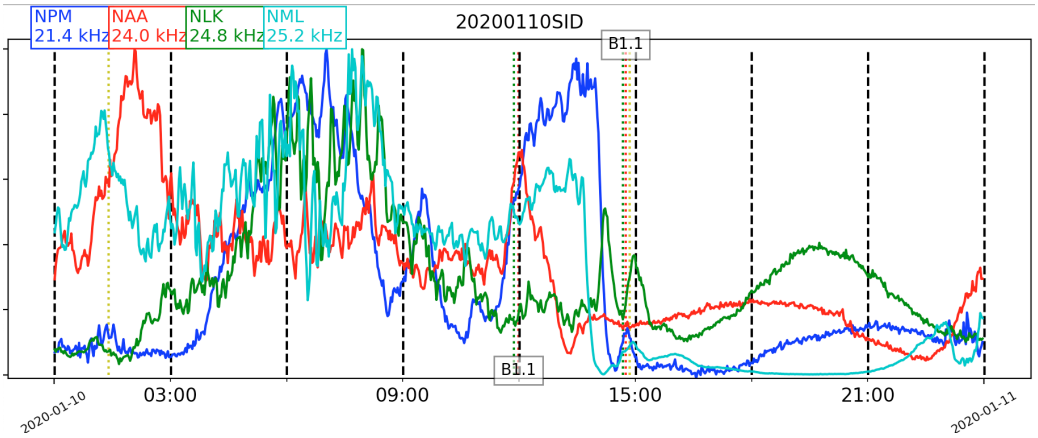

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In January 2020 we had 11 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: 202001 VLF Observers

Observer	Code	Stations
J Wallace	A97	NAA
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
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.

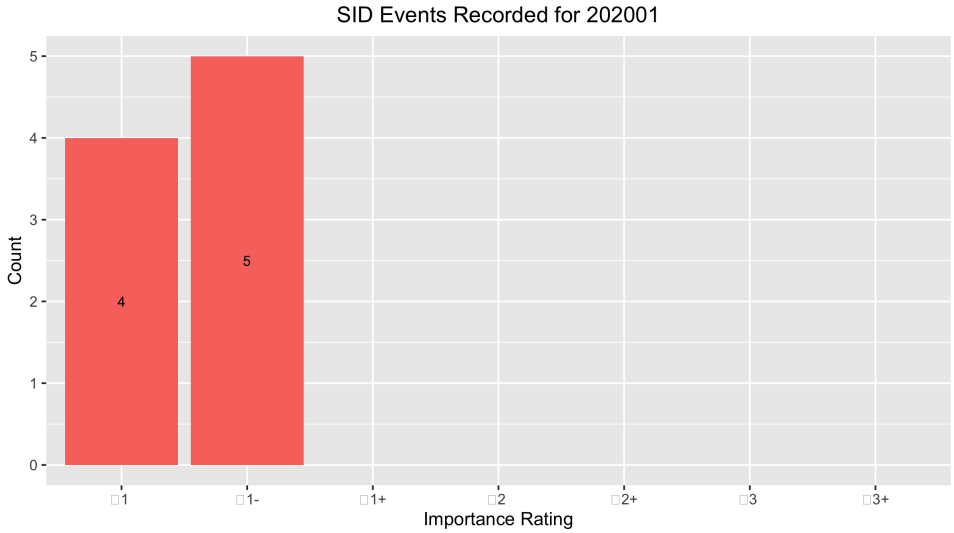

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In January 2020, there were three A-class flares and 5 B-class flares recorded from GOES-15. A little more flaring this month compared to last. There were 24 days this month with no GOES-15 reports of flares (see Figure 4).

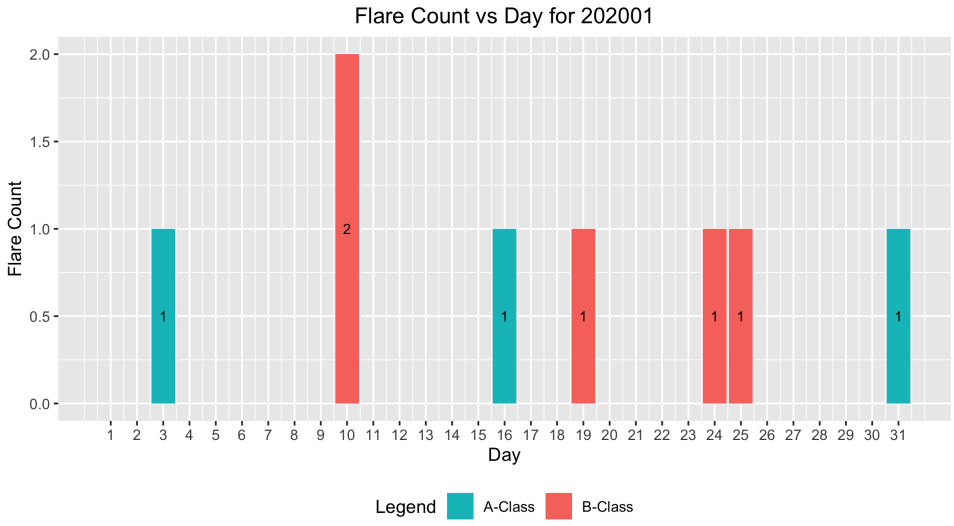

Figure 4: GOES - 15 XRA flares

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 January 2020. 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.

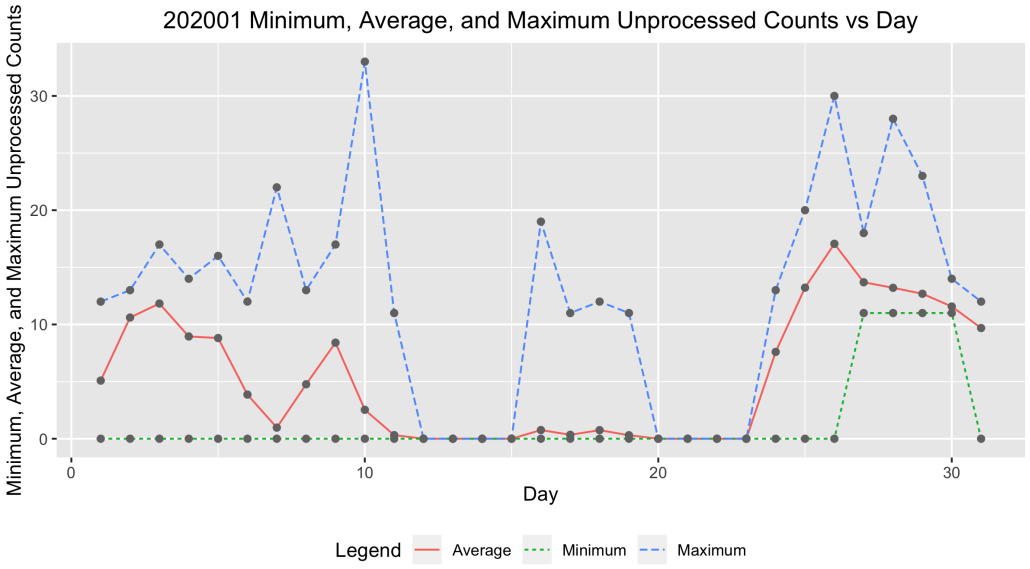

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

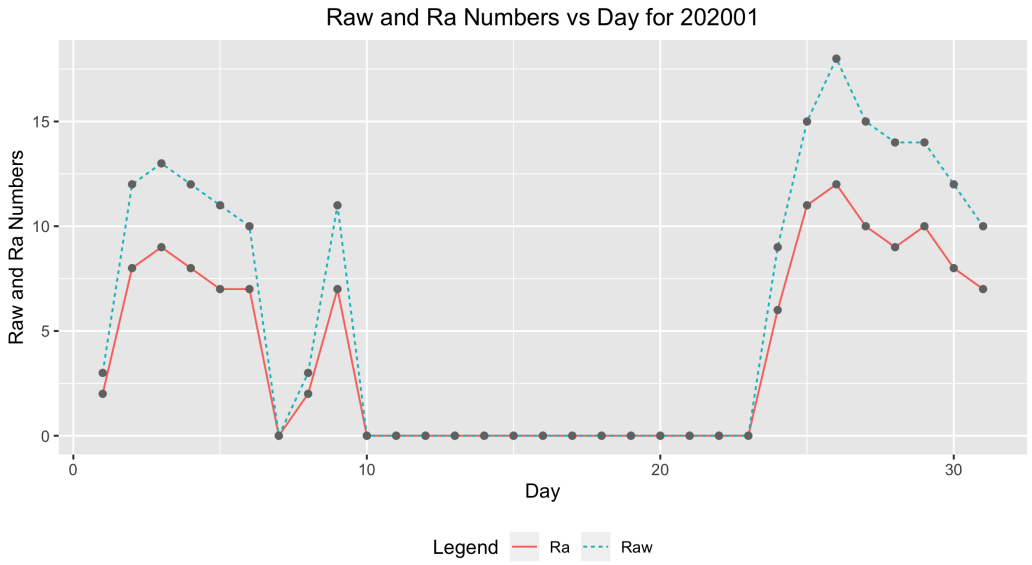

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202001 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	34	3	2
2	28	12	8
3	24	13	9
4	39	12	8
5	37	11	7
6	44	10	7
7	34	0	0
8	30	3	2
9	27	11	7
10	32	0	0
11	35	0	0
12	39	0	0
13	28	0	0
14	26	0	0

Continued

Table 2: 202001 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	33	0	0
16	25	0	0
17	32	0	0
18	32	0	0
19	36	0	0
20	35	0	0
21	31	0	0
22	24	0	0
23	24	0	0
24	30	9	6
25	32	15	11
26	34	18	12
27	26	15	10
28	29	14	9
29	32	14	10
30	28	12	8
31	32	10	7
Averages	31.4	5.9	4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for January 2020, 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 64 and the total number of observations is 972.

Table 3: 202001 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	25	Alexandre Amorim
AJV	16	J. Alonso
ARAG	30	Gema Araujo
ASA	19	Salvador Aguirre
ATE	14	Teofilo Arranz Heras
BARH	15	Howard Barnes
BATR	6	Roberto Battaiola
BERJ	24	Jose Alberto Berdejo
BMF	20	Michael Boschat
BRAF	11	Raffaello Braga
BROB	22	Robert Brown
BSAB	22	Santanu Basu

Continued

Table 3: 202001 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CHAG	26	German Morales Chavez
CIOA	8	Ioannis Chouinavas
CKB	16	Brian Cudnik
CNT	20	Dean Chantiles
CVJ	11	Jose Carvajal
DEMF	3	Frank Dempsey
DIVA	9	Ivo Demeulenaere
DJOB	15	Jorge del Rosario
DMIB	21	Michel Deconinck
DUBF	17	Franky Dubois
EHOA	25	Howard Eskildsen
ERB	6	Bob Eramia
FERJ	19	Javier Ruiz Fernandez
FLET	16	Tom Fleming
FUJK	23	K. Fujimori
HAYK	6	Kim Hay
HMQ	10	Mark Harris
HOWR	18	Rodney Howe
HRUT	25	Timothy Hrutkay
JDAC	5	David Jackson
JGE	5	Gerardo Jimenez Lopez
KAND	19	Kandilli Observatory
KAPJ	5	John Kaplan
KNJS	31	James & Shirley Knight
LEVM	12	Monty Leventhal
LGEC	16	Georgios Lekkas
LKR	3	Kristine Larsen
LRRA	12	Robert Little
MARC	7	Arnaud Mengus
MARE	7	Enrico Mariani
MCE	21	Etsuiku Mochizuki
MGAR	1	Gary Myers
MILJ	13	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	30	John McCammon
MUDG	8	George Mudry
MWU	21	Walter Maluf
OAAA	19	Al Sadeem Astronomy Observatory
ONJ	21	John O'Neill
PEKT	6	Riza Pektas
SDOH	31	Solar Dynamics Obs - HMI
SMNA	2	Michael Stephanou
SNE	2	Neil Simmons

Continued

Table 3: 202001 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
STAB	22	Brian Gordon-States
TESD	24	David Teske
TPJB	2	Patrick Thibault
TST	5	Steven Toothman
URBP	13	Piotr Urbanski
VARG	22	A. Gonzalo Vargas
VIDD	18	Daniel Vidican
VRUA	9	Ruben Verboven
WILW	11	William M. Wilson
Totals	972	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

- Sunspot Reports: Kim Hay solar@aavso.org

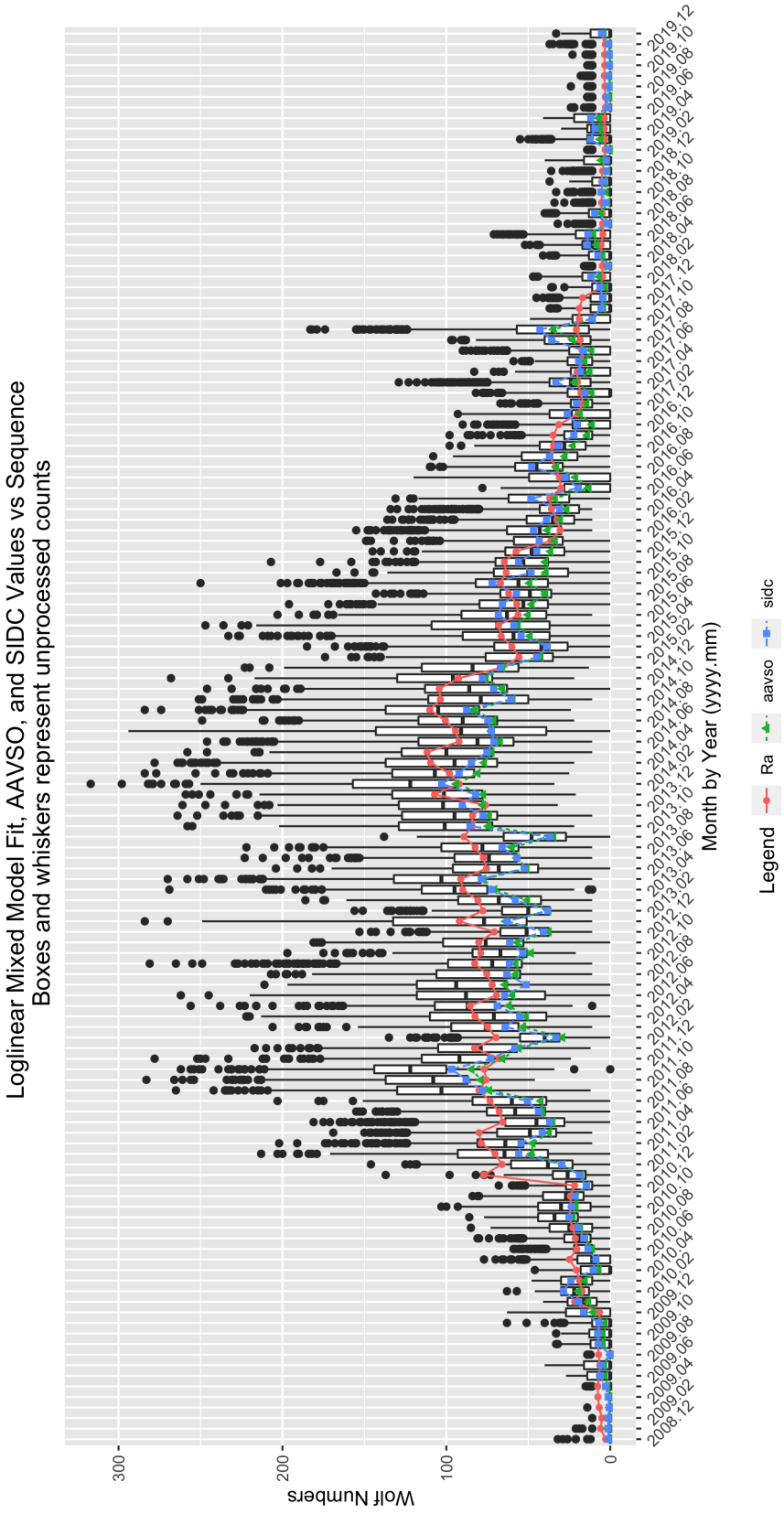

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels