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 Etsuiku Mochizuki at his telescope.

Figure 1: Etsuiku Mochizuki: (MCE), 29 Okuboryoke, Sakuraku, Saitama-shi, Japan, projection, refractor, 90 MM.

1.1 Monthly averages of Sunspot Counts from 1961 thru 2017

Here are data from Etsuiku Mochizuki: (MCE), 29 Okuboryoke, Sakuraku, Saitama-shi, Japan, projection, refractor, 90 MM.

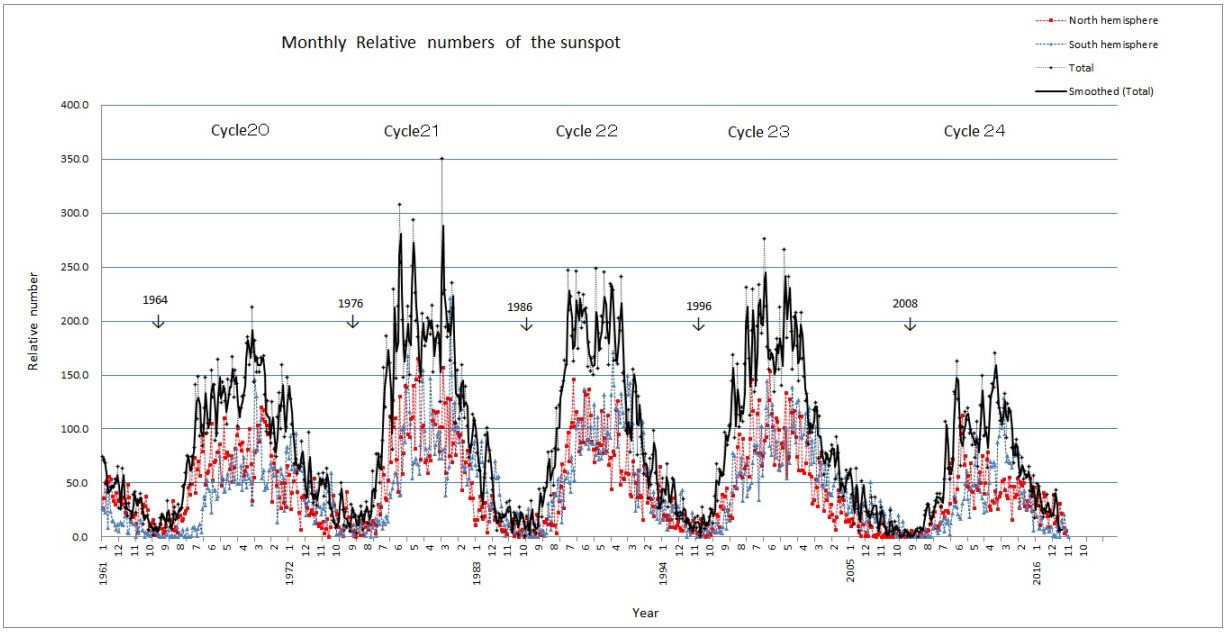

Figure 2: North and South Hemisphere monthly averages of sunspot counts from Etsuiku Mochizuki from years 1961 to 2017.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

April 2018 (Figure 3) There were 5 GOES events recorded on the 21st of April here in Fort Collins, Colorado. However none of these were strong enough to create a SID event in the ionosphere.

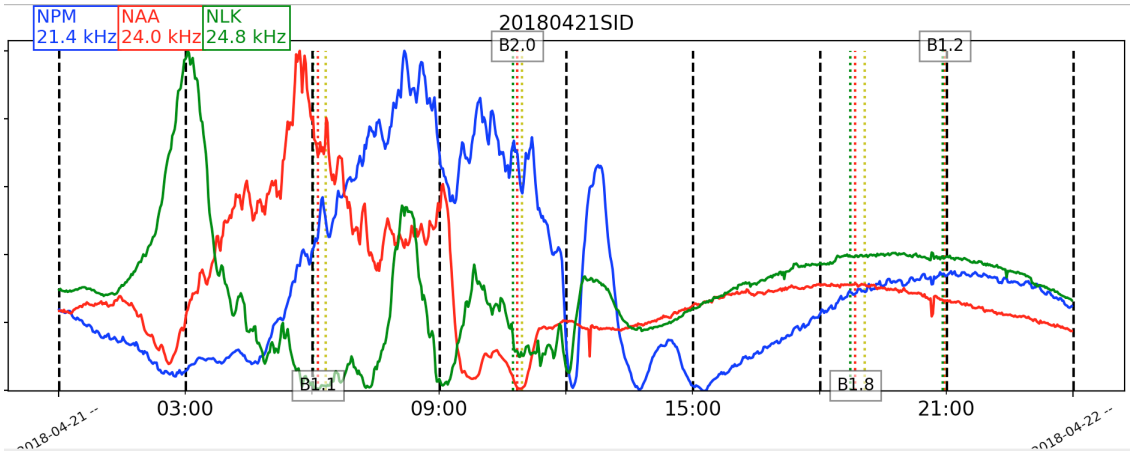

Figure 3: VLF recording using the sidmon.py software from Nathan Towne.

2.2 SID Observers

In April 2018 we have 15 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: 201804 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	GBZ DHO
J Godet	A119	GBZ GQD ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
S Oatney	A125	NML
J Karlovsky	A131	FTA NSY
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	NLK HWU
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM

Figure 4 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.

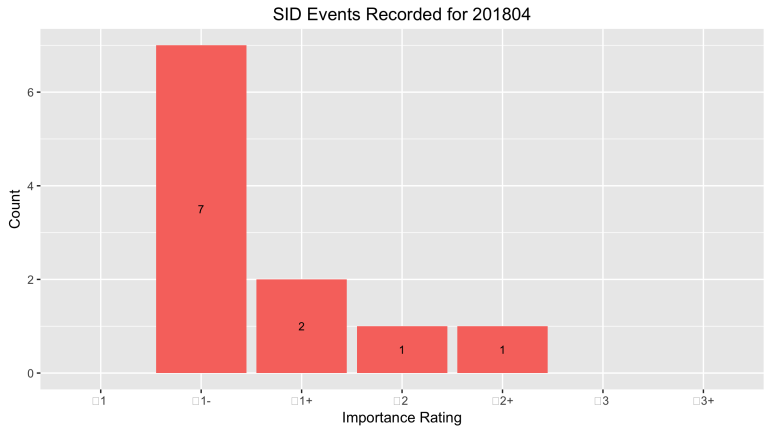

Figure 4: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In April 2018, There were 23 solar flares measured by GOES-15: 21 B class flares and 2 A class flares. About the same flaring this month compared to last month. There were 18 days this month with no GOES-15 reports of flares. (see Figure 5).

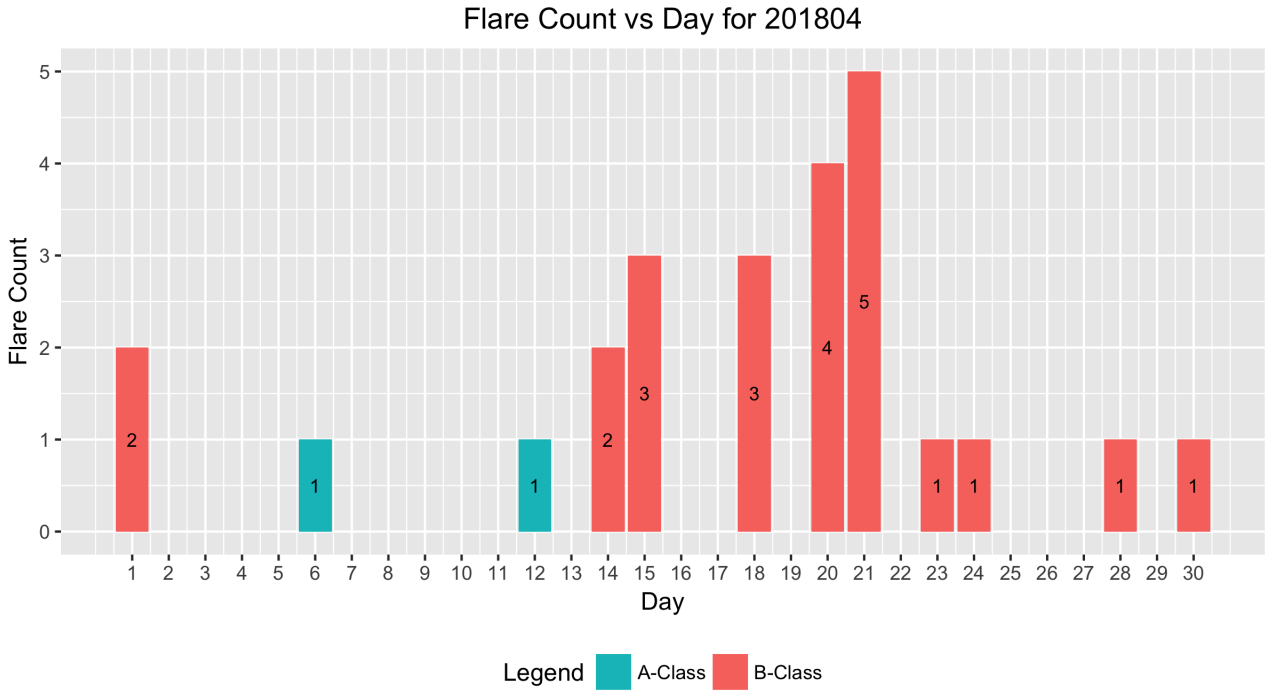

Figure 5: GOES - 15 XRA flares

3 Relative Sunspot Numbers (Ra)

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 April 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 7.

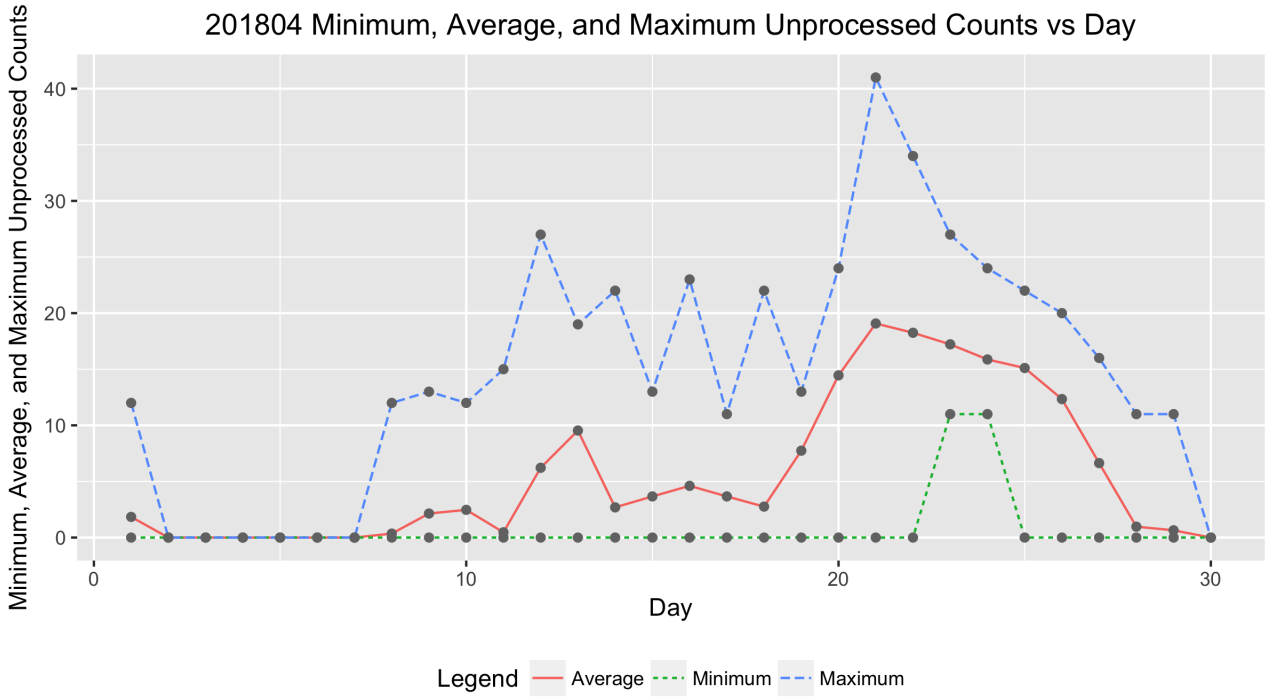

Figure 6: Raw average, minimum and maximum counts by day of the month for all observers.

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. See Table 2.

Table 2: 201804 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
1	31	1	1
2	31	0	0
3	28	0	0
4	32	0	0
5	41	0	0
6	31	0	0
7	32	0	0
8	34	0	0
9	28	4	3
10	32	3	2
11	32	1	1
12	32	13	10
13	26	12	8
14	29	6	4
15	24	6	4
16	28	6	4
17	33	3	2
18	37	4	3
19	35	10	7
20	44	16	11
21	39	22	16
22	44	20	14
23	32	18	14
24	31	17	12
25	37	16	11
26	38	15	10
27	33	6	5
28	34	0	0
29	34	0	0
30	35	0	0
Averges	33.2	6.6	4.7

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations submitted for April 2018, and the observer's 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 67 and the total number of observations is 997.

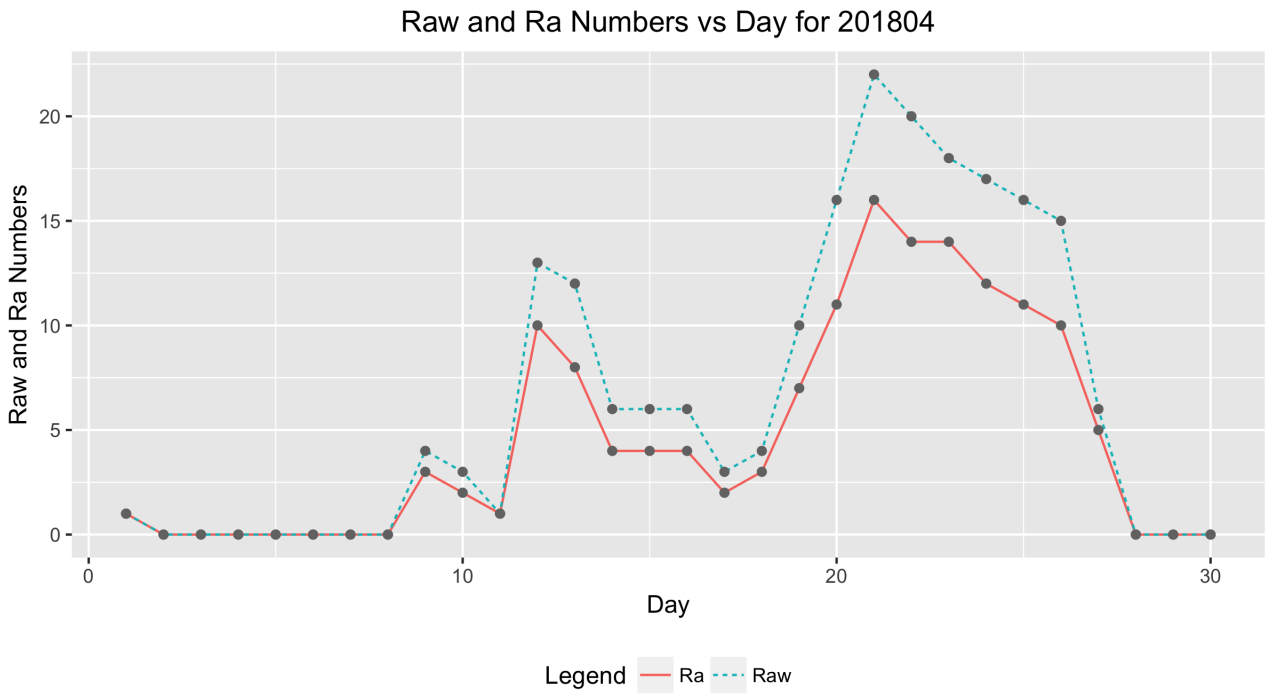

Figure 7: Raw Wolf and Ra numbers by day of the month for all observers.

Table 3: 201804 Number of observations by observer

Obs	NumObs	Name
AJV	14	J. Alonso
ARAG	29	Gema Araujo
ASA	26	Salvador Aguirre
ATE	6	Teofilo Arranz Heras
BARH	8	Howard Barnes
BATR	5	Roberto Battaiola
BDDA	11	Diego Bastiani
BERJ	19	Jose Alberto Berdejo
BGAF	1	Gabriel Bandy
BMF	20	Michael Boschat
BRAD	29	David Branchett
BRAF	24	Raffaello Braga
BROB	6	Robert Brown
BSAB	26	Santanu Basu
CHAG	29	German Morales Chavez
CIOA	18	Ioannis Chouinavas
CKB	15	Brian Cudnik
CNT	10	Dean Chantiles
CVJ	22	Jose Carvajal
DEMF	6	Frank Dempsey
DMIB	26	Michel Deconinck

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Table 3: 201804 Number of observations by observer

Obs	NumObs	Name
DROB	3	Bob Dudley
DUBF	28	Franky Dubois
ERB	12	Bob Eramia
FERJ	17	Javier Ruiz Fernandez
FLET	22	Tom Fleming
FLF	12	Fredirico Luiz Funari
FTAA	13	Tadeusz Figiel
FUJK	23	K. Fujimori
HAYK	10	Kim Hay
HIVB	2	Ivan Hajdinjak
HMQ	7	Mark Harris
HOWR	21	Rodney Howe
JDAC	9	David Jackson
JGE	2	Gerardo Jimenez Lopez
JPG	5	Penko Jordanov
KAPJ	20	John Kaplan
KNJS	30	James & Shirley Knight
KROL	18	Larry Krozel
LEVM	20	Monty Leventhal
LKR	4	Kristine Larsen
LRRA	12	Robert Little
MARE	12	Enrico Mariani
MCE	24	Etsuiku Mochizuki
MILJ	8	Jay Miller
MJHA	27	John McCammon
MUDG	11	George Mudry
MWU	15	Walter Maluf
OATS	1	Susan Oatney
ONJ	13	John O'Neill
RLM	10	Mat Raymonde
SDOH	30	Solar Dynamics Obs - HMI
SIMC	6	Clyde Simpson
SMNA	4	Michael Stephanou
SNE	2	Neil Simmons
SONA	14	Andries Son
SPIA	5	Piotr Skorupski
STAB	24	Brian Gordon-States
SUZM	22	Miyoshi Suzuki
TESD	26	David Teske
TPJB	4	Patrick Thibault
URBP	28	Piotr Urbanski
VARG	27	A. Gonzalo Vargas
VIDD	18	Daniel Vidican
WCHD	5	Charles White

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Table 3: 201804 Number of observations by observer

Obs	NumObs	Name
WGI	2	Guido Wollenhaupt
WILW	19	William M. Wilson
Totals	997	67

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 8 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

References

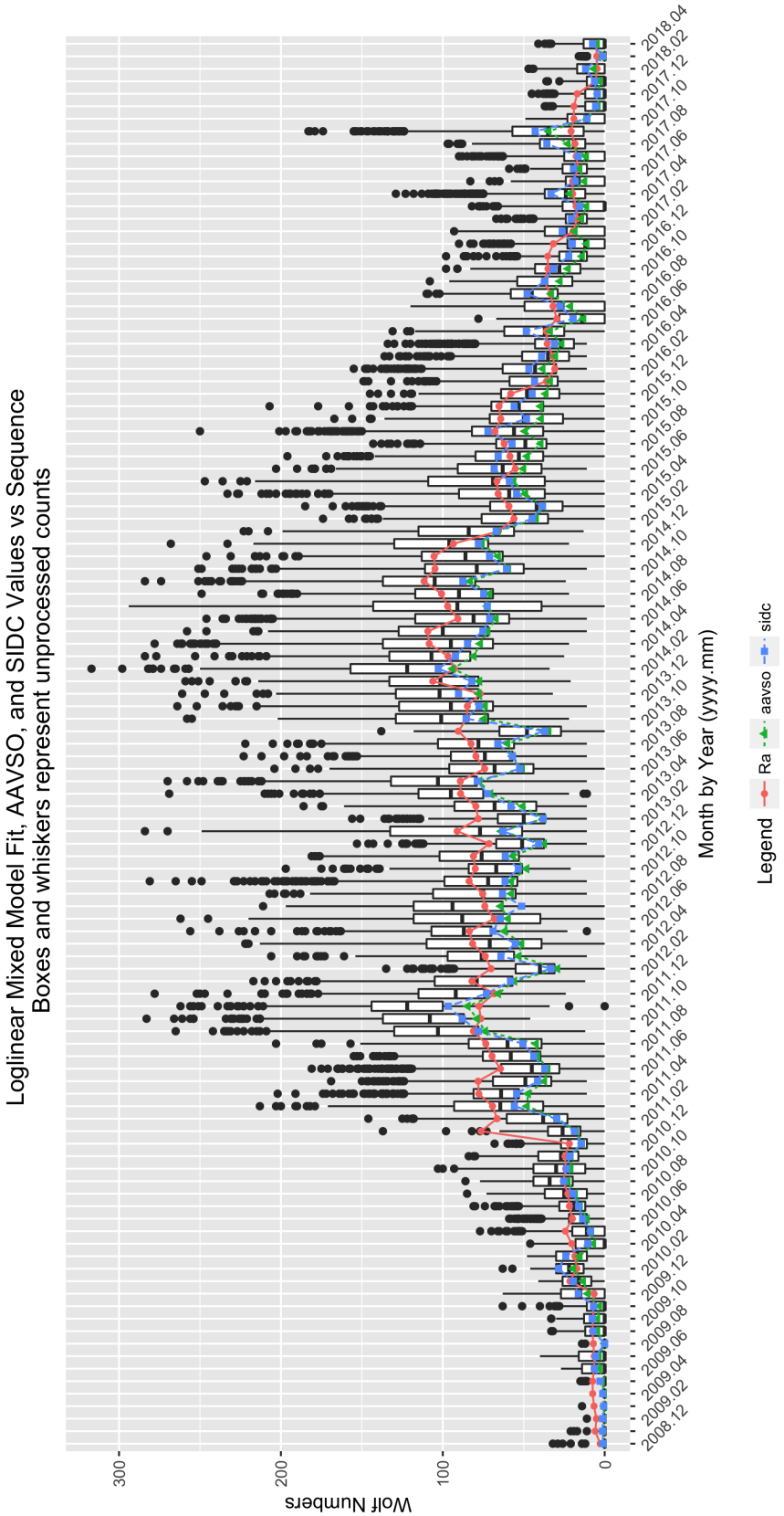

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels