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 Kurinji and the Sunspot Cycle

Figure 1: The Kurinji flower blooms once every 12 years.

"Kodaikanal, home to Indians oldest solar observatory, is known for its wide variety of flowers. Peruvian lily, cactus aloe, viola daisy, orchids, jasmine and chrysanthemum are some of the common flowers that greet visitors to Kodaikanal. Not so familiar are some 50 varieties of a rare species called Kurinji, of which a violet-coloured flower (Phelobophyllum Kunthanum) is famous, as it blooms only once in 12 years, exhibiting some strange, as yet unexplained, relation with the Sunspot cycle.

The flower is native to south India, seen in the Pazhani, Aanamalai and Nilagiri hills. Nowhere else in the world can one find this flower. It last appeared in 1994 and 12 years later, it was seen not only in Kodaikanal but also in the Nilagiri mountains and some tea gardens in parts of Kerala. Natures colorful signature was somewhat subdued, perhaps indicating a delayed start of the 24th solar cycle, now expected to peak in 2011."

(`http://spaceyug.com/they-mystery-of-sunspots/`)

1.1 Raw Sunspot Counts from 1961 thru 2017

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

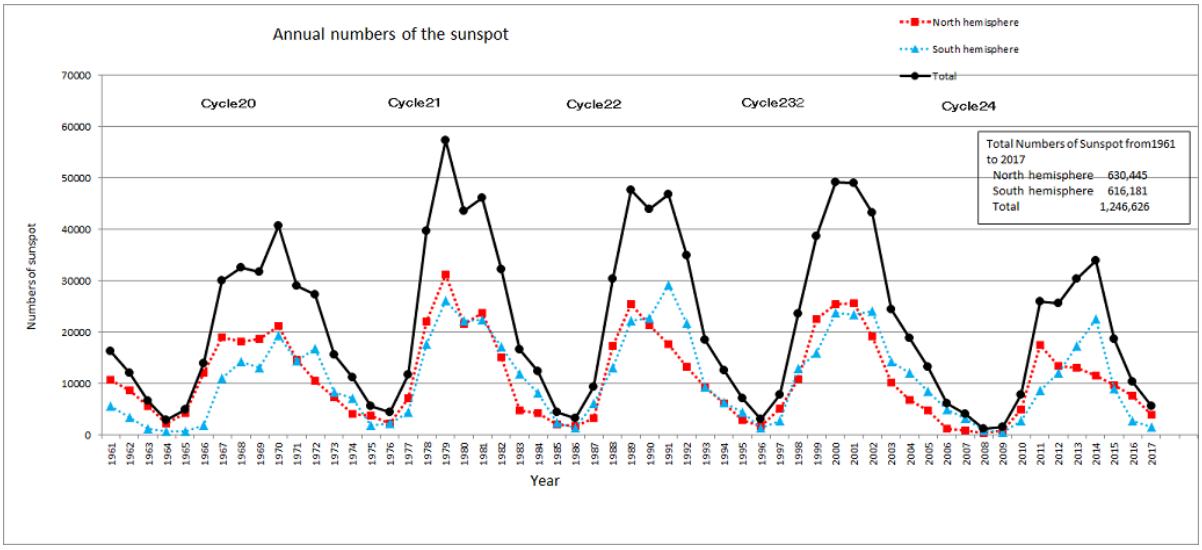

Figure 2: North and South Hemisphere sunspot counts from Etsuiku Mochizuki from years 1961 to 2017.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

March 2018 (Figure 3) There were 6 SID events recorded on the 30th of March here in Fort Collins, Colorado. However none of these were strong enough to create a SID event in the ionosphere.

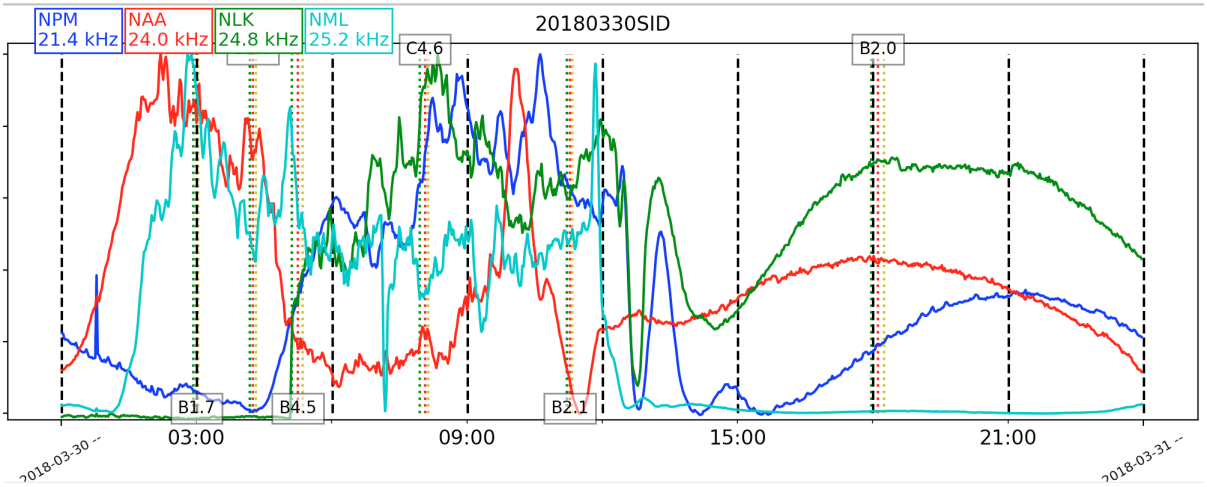

Figure 3: VLF recording using the sidmon.py software from Nathan Towne.

2.2 SID Observers

In March 2018 we have 17 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: 201803 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
R Mrllak	A136	NSY GQD
S Aguirre	A138	NPM
G Silvis	A141	NLK HWU
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
L Ferreira	A149	NWC

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.

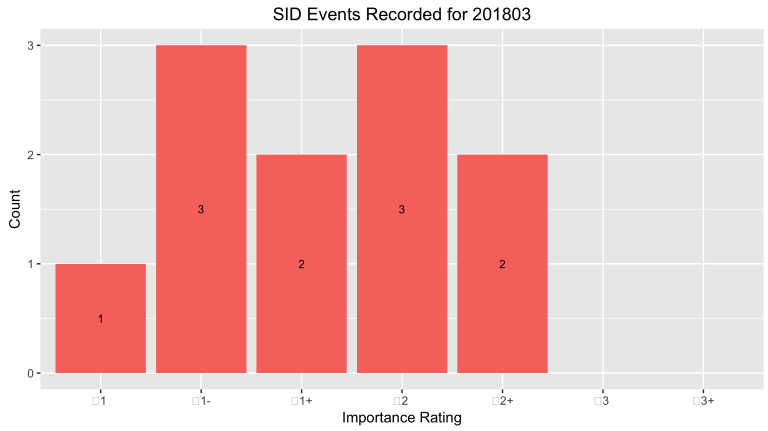

Figure 4: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In March 2018, There were 19 solar flares measured by GOES-15. Two C class, 14 B class flares and 3 A class flares. A lot less flaring this month compared to last month. There were 21 days this month with no GOES-15 reports of flares. (see Figure 5).

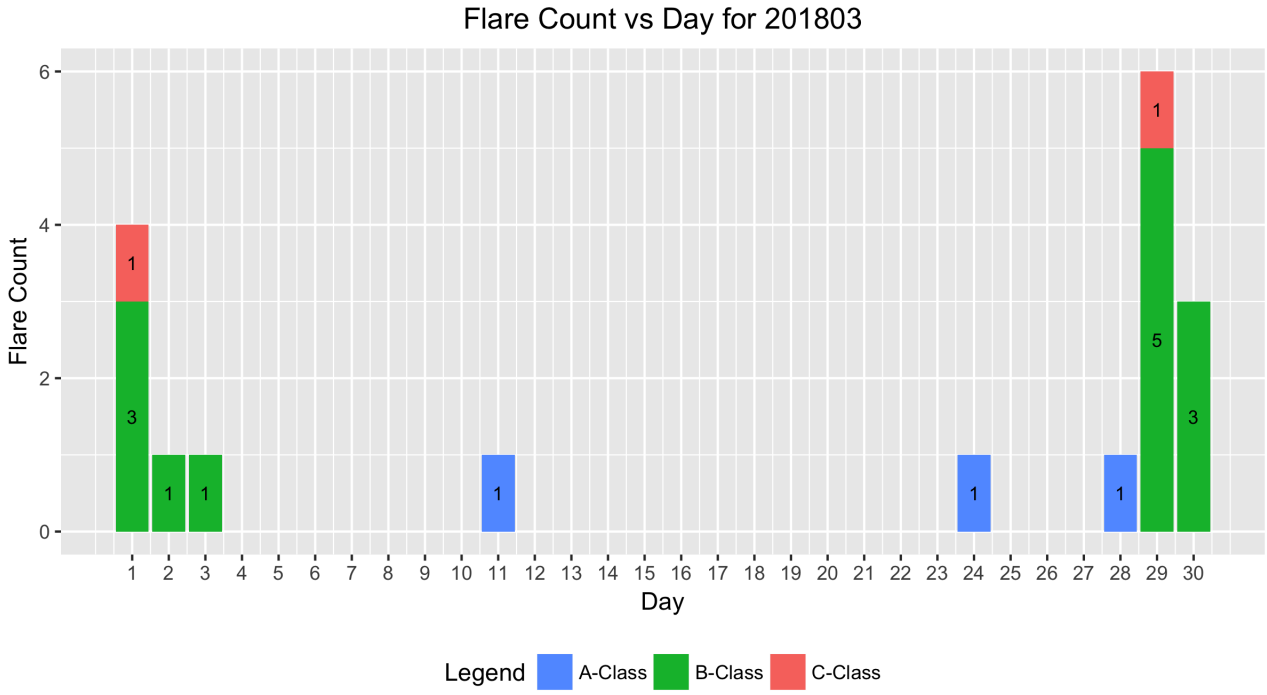

Figure 5: GOES - 15 XRA flares

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 March 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.

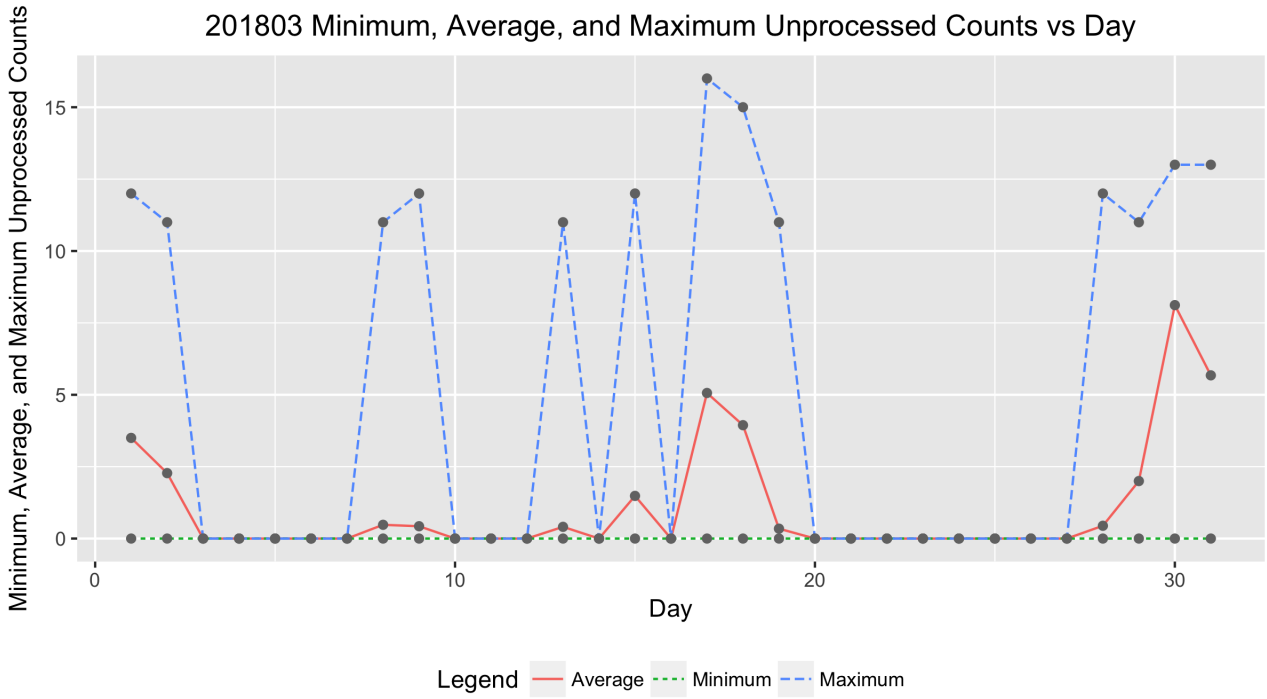

Figure 6: Raw average, minimum and maximum counts by day of the month by observer.

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: 201803 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
1	26	8	5
2	29	3	2
3	36	0	0
4	37	0	0
5	31	0	0
6	34	0	0
7	22	0	0
8	23	0	0
9	28	0	0
10	32	0	0
11	34	0	0
12	29	0	0
13	27	0	0
14	28	0	0
15	31	3	2

Continued

Table 2: 201803 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
16	27	0	0
17	32	6	5
18	35	10	6
19	32	1	1
20	29	0	0
21	30	0	0
22	31	0	0
23	30	0	0
24	35	0	0
25	40	0	0
26	36	0	0
27	30	0	0
28	27	0	0
29	33	1	1
30	34	10	7
31	37	7	5
Averges	31.1	1.6	1.1

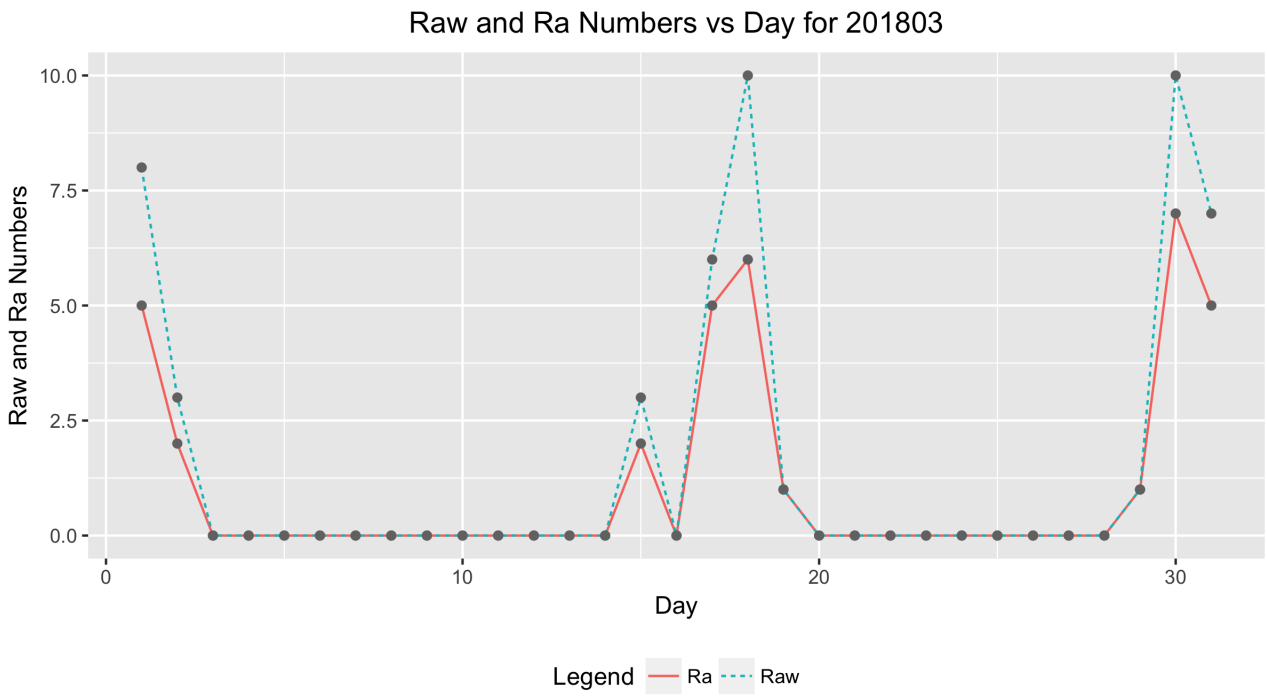

Figure 7: Raw Wolf and Ra numbers by day of the month by observer.

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations submitted for March 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 59 and the total number of observations is 965.

Table 3: 201803 Number of observations by observer

Obs	NumObs	Name
AAX	16	Alexandre Amorim
AJV	11	J. Alonso
ARAG	30	Gema Araujo
ASA	28	Salvador Aguirre
BARH	17	Howard Barnes
BATR	2	Roberto Battaiola
BDDA	12	Diego Bastiani
BERJ	22	Jose Alberto Berdejo
BMF	21	Michael Boschat
BRAD	30	David Branchett
BRAF	10	Raffaello Braga
BROB	21	Robert Brown
BSAB	29	Santanu Basu
CHAG	27	German Morales Chavez
CIOA	28	Ioannis Chouinavas
CKB	24	Brian Cudnik
CNT	7	Dean Chantiles
CVJ	3	Jose Carvajal
DEMF	7	Frank Dempsey
DMIB	24	Michel Deconinck
DROB	6	Bob Dudley
ERB	15	Bob Eramia
FERJ	18	Javier Ruiz Fernandez
FLET	26	Tom Fleming
FLF	13	Fredirico Luiz Funari
FTAA	5	Tadeusz Figiel
FUJK	21	K. Fujimori
HAYK	14	Kim Hay
HMQ	4	Mark Harris
HOWR	25	Rodney Howe
JDAC	12	David Jackson
JGE	5	Gerardo Jimenez Lopez
KAPJ	6	John Kaplan
KNJS	31	James & Shirley Knight
KROL	19	Larry Krozel
LEVM	13	Monty Leventhal
LKR	1	Kristine Larsen
LRRA	9	Robert Little

Continued on next page

Table 3: 201803 Number of observations by observer

Obs	NumObs	Name
MARE	2	Enrico Mariani
MCE	25	Etsuiku Mochizuki
MILJ	13	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	31	John McCammon
MUDG	12	George Mudry
MWU	26	Walter Maluf
ONJ	1	John O'Neill
SDOH	31	Solar Dynamics Obs - HMI
SIMC	9	Clyde Simpson
SMNA	1	Michael Stephanou
SNE	6	Neil Simmons
SONA	12	Andries Son
STAB	24	Brian Gordon-States
SUZM	24	Miyoshi Suzuki
TESD	25	David Teske
TPJB	4	Patrick Thibault
URBP	14	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
VIDD	14	Daniel Vidican
WILW	18	William M. Wilson
Totals	965	59

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 ob-

servers. 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

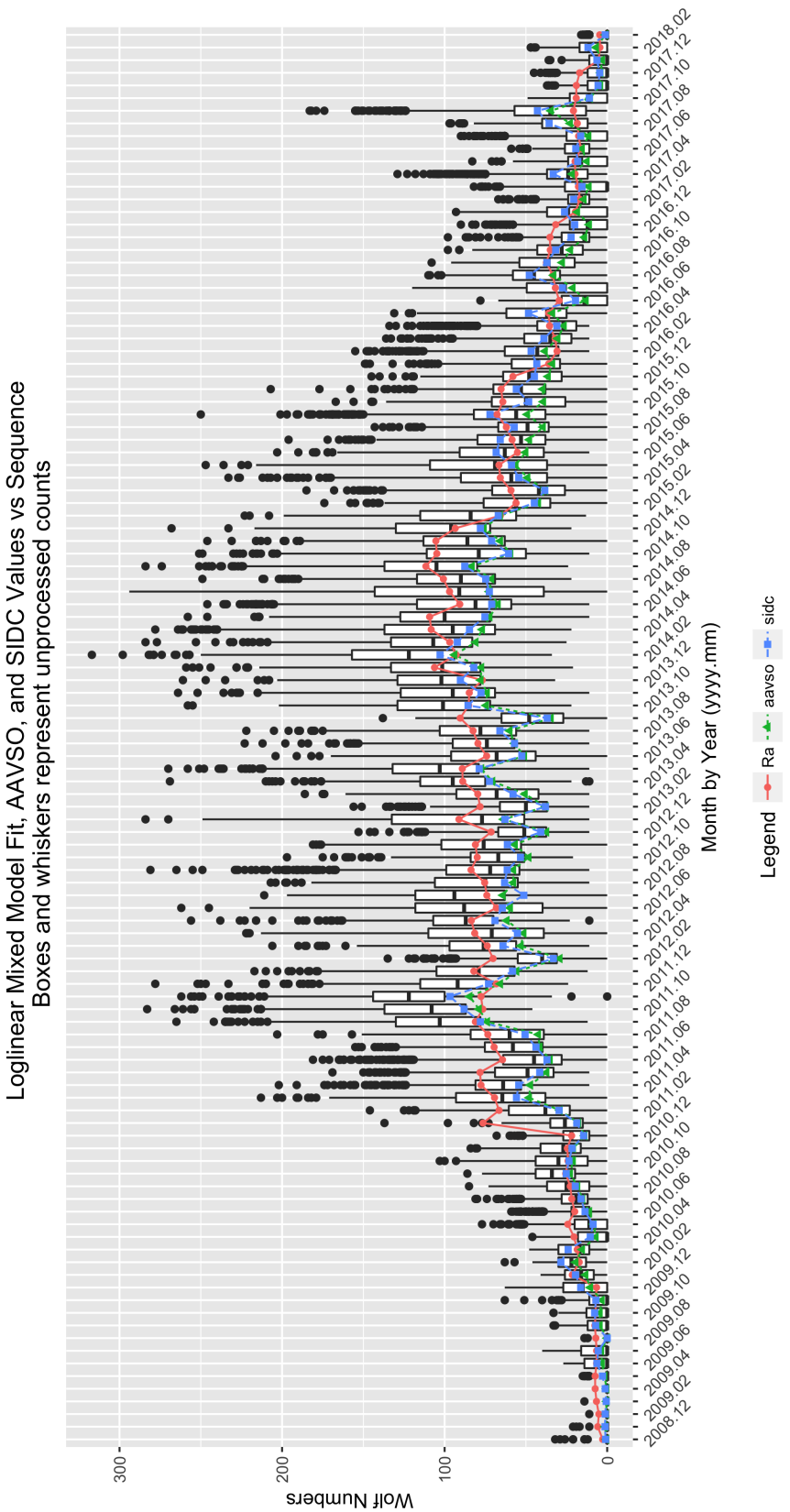

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels