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 observer's 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 Zero Sunspots: The Importance of Zeros in Solar Minima

Daily sunspot counts by each observer are samples from a population of observers needed to estimate monthly sunspot numbers. While we have no control over the numbers of sunspots, we do have control over the number of observers to make accurate sunspot number estimates.

Figure 1 is a bar plot of the number of monthly sunspot count submissions by you observers in sequence by year. The submissions begin in May, 2010 and end in June, 2017. Your monthly contributions are exemplary.

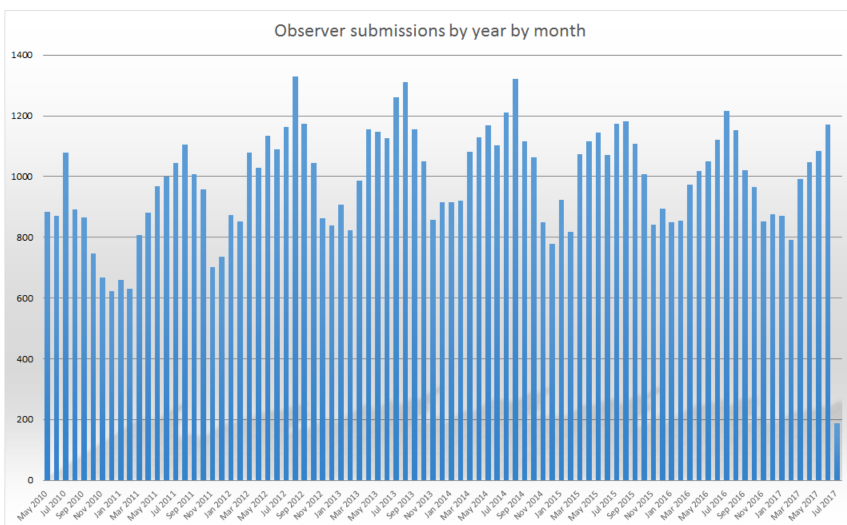

Figure 1: Number of sunspot count submissions from all contributors by year and month.

Observers are indispensable in times of solar minima. Why? Without a sufficient sample from observers, the determination of the times of sunspot minimum onset can be wrong. Similarly, the sunspot minimum end time cannot be ascertained within sampling certainty.

Sunspot counts are not the only sampled quantity. Another critical quantity is the time the sunspot count is obtained. The day and time of the sunspot sample acquisition determines a critical feature: the sunspot cycle. The sunspot cycle timing reveals current (or very recent) changes which are significant in a historical context. Connection of current sunspot counts with historical solar behavior constitutes a major area of scientific inquiry.

In statistics theory and practice, sunspot sampling (in our case) assumes counts come from each day of the month by a representative portion of the AAVSO observer population. When this occurs, count errors (sampling errors) result from only a portion of the population of days and observers in the monthly submissions. When only a few observers submit counts, the sample becomes unrepresentative of the population leading to bias in sunspot number calculations. Response by sunspot observers must be maintained during sunspot minima to reduce sampling error and therefore improving solar cycle minima onset and end time determination. Maintaining high levels of responses by observers has the added benefit of identifying and accounting for sunspot detectability errors to minimize overall count errors.

Continued submission of sunspot counts, even counts of zero, is crucial to maintaining and understanding the state of the solar cycle. Without the significant contributions of you, the data gatherers of solar activity, accurate and precise conclusions on the solar cycle behavior are not possible.

Contributed by Dr. Jamie Riggs, Northwestern University, Solar System Section Head, International Astrostatistics Association.

2 Sudden Ionospheric Disturbance (SID) Report

Sudden ionospheric disturbances (SID) occur in Earth's atmosphere by solar flares, causing large increases in the ionization in the ionosphere over the daytime regions of the Earth.

2.1 SID Records

June, 2017 (Figure 2) John DuBois in Massachusetts captures the largest flare this month, on the 2nd of June, recording data from NAA (Cutler Maine at 24 kHz).

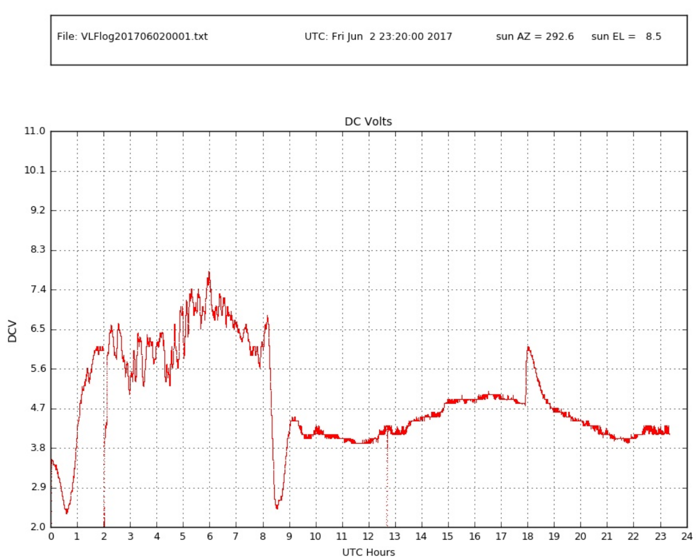

Figure 2: VLF recording of a C8.0 flare

2.2 SID Observers

In June, 2017 we have 14 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: 201705 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO NAA
J Godet	A119	GBZ GQD ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
S Oatney	A125	NML
J Karlovsky	A131	DHO NSY
R Green	A134	NPM
S Aguirre	A138	NPM
R Rogge	A143	GQD
D Russel	A147	NML
L Ferreira	A149	NWC

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.

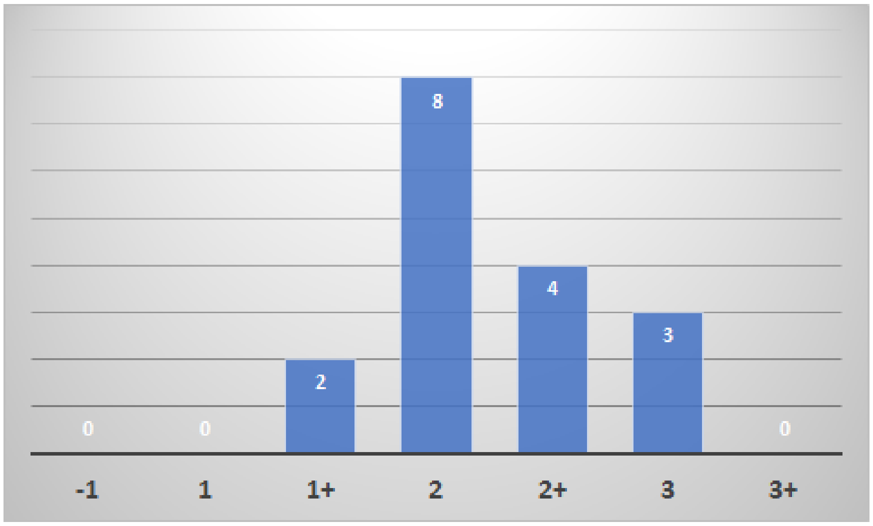

Figure 3: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In June, 2017, there were 77 solar flares measured by GOES-15 (see Figure 4). There were 16 C class and 61 B class flares. Slightly more flaring this month compared to last month with only 9 days of no reports from the GOES satellite.

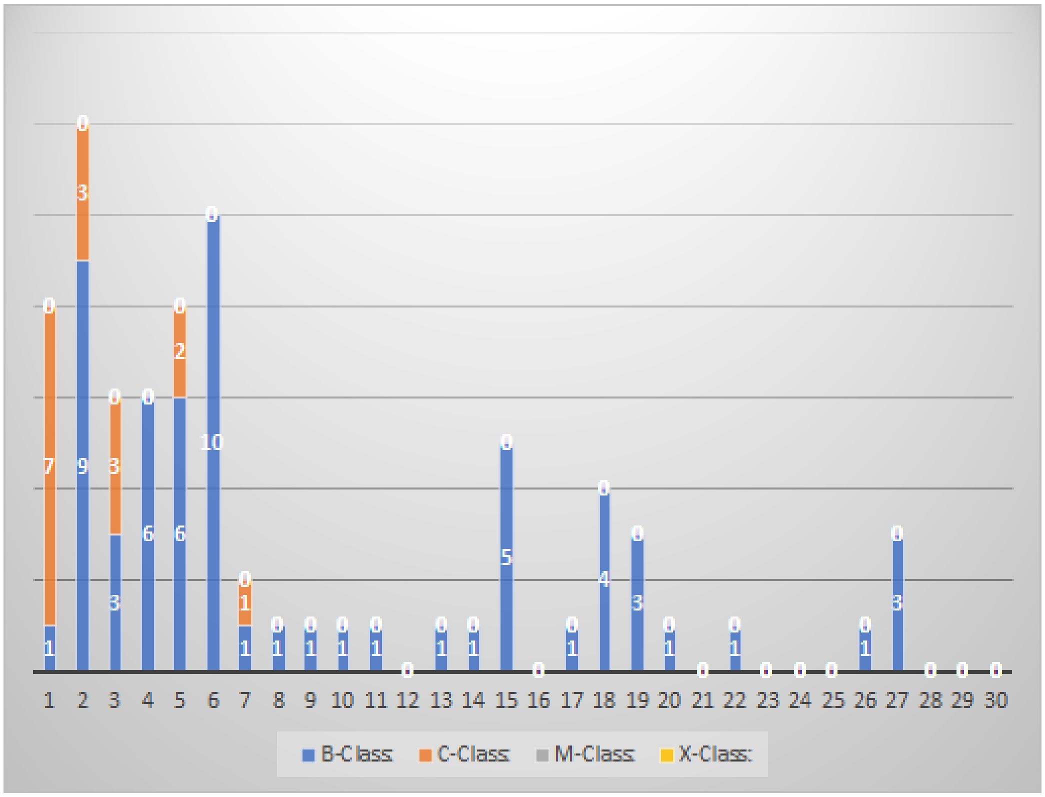

Figure 4: GOES - 15 XRA flares

3 Relative Sunspot Numbers (Ra)

Reporting monthly sunspot numbers consists of submitting 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 June, 2017. 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 6.

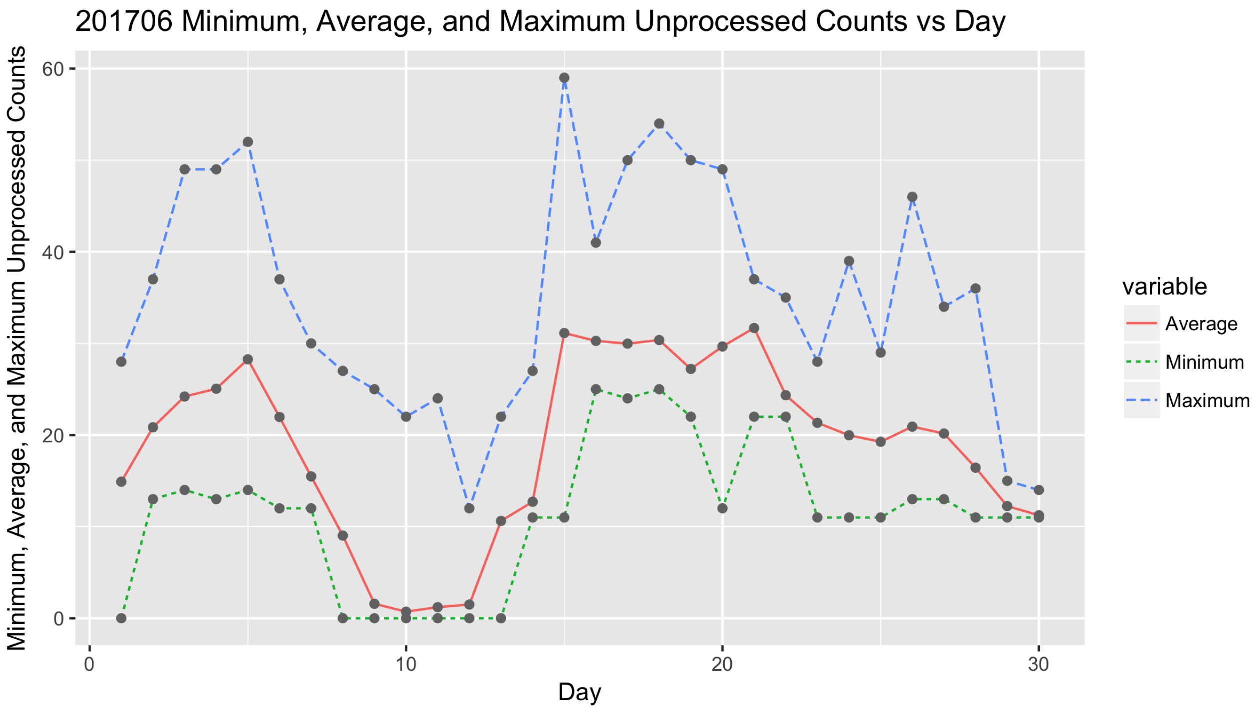

Figure 5: Raw minimum, average, and maximum sunspot count by day of the month by observer.

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: 201706 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
1	42	17	14
2	39	21	18
3	44	25	21
4	37	26	21
5	30	28	22
6	33	23	18
7	35	16	13
8	38	8	6
9	38	1	1
10	46	0	0
11	47	0	0
12	38	2	1
13	40	10	9
14	39	13	11
15	38	31	26

Continued

Table 2: 201706 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
16	40	30	25
17	41	29	25
18	38	30	25
19	42	27	22
20	42	31	24
21	38	32	27
22	32	24	21
23	33	21	16
24	36	20	16
25	42	20	16
26	49	21	17
27	37	20	17
28	37	17	13
29	41	13	10
30	37	11	10
Averges	36.7	18.5	15.0

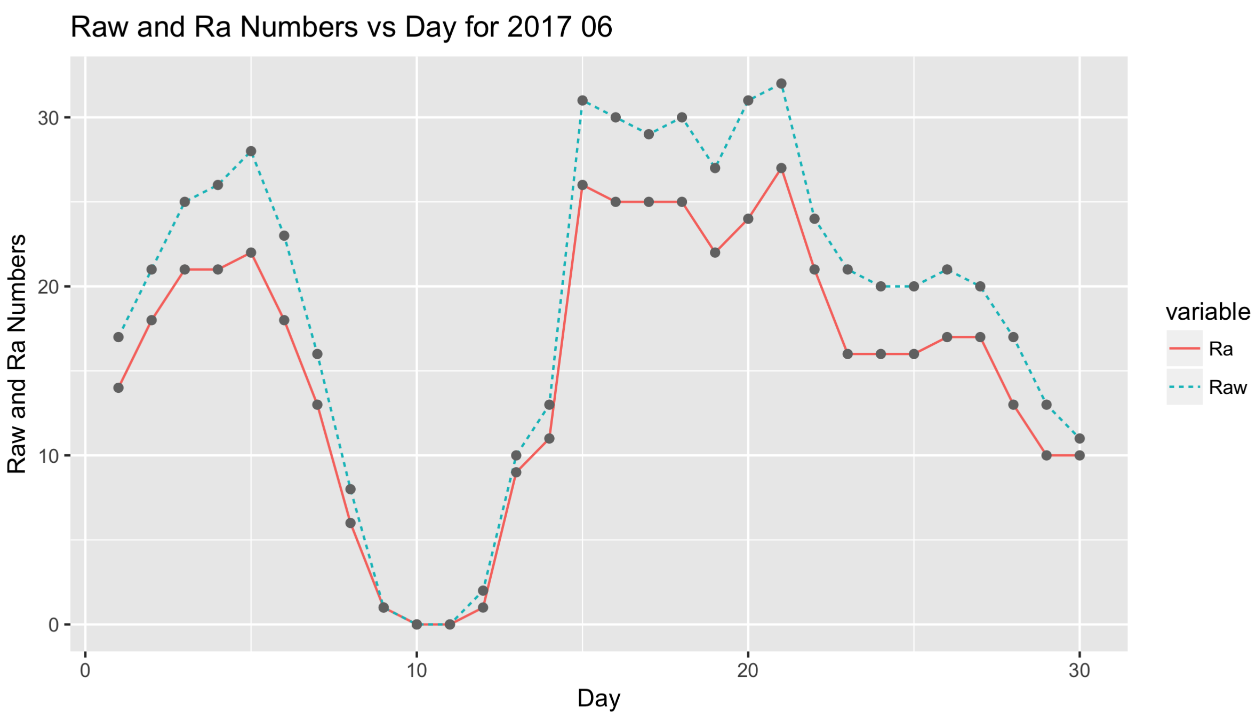

Figure 6: Raw minimum, average, and maximum sunspot count by day of the month by observer.

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations submitted for June, 2017, and the observer's name. The final rows of the table give 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 1169.

Table 3: 201706 Number of observations by observer.

Obs	NumObs	Name
AAP	9	A. Patrick Abbott
AAX	16	Alexandre Amorim
AJV	27	J. Alonso
ARAG	30	Gema Araujo
ASA	26	Salvador Aguirre
BARH	11	Howard Barnes
BATR	3	Roberto Battaiola
BDDA	7	Diego Bastiani
BERJ	24	Jose Alberto Berdejo
BRAB	27	Brenda Branchett
BRAF	22	Raffaello Braga
BROB	30	Robert Brown
BSAB	22	Santanu Basu
CHAG	30	German Morales Chavez
CIOA	17	Ioannis Chouinavas
CKB	19	Brian Cudnik
CNT	12	Dean Chantiles
CVJ	25	Jose Carvajal
DEMF	8	Frank Dempsey
DJOB	17	Jorge del Rosario
DUBF	29	Franky Dubois
FERJ	12	Javier Ruiz Fernandez
FLET	27	Tom Fleming
FLF	11	Fredirico Luiz Funari
FUJK	22	K. Fujimori
HAYK	16	Kim Hay
HIVB	3	Ivan Hajdinjak
HMQ	3	Mark Harris
HOWR	27	Rodney Howe
HRUT	27	Timothy Hrutkay
JDAC	17	David Jackson
JENS	5	Simon Jenner
JGE	9	Gerardo Jimenez Lopez
KAND	24	Kandilli Observatory
KAPJ	26	John Kaplan
KNJS	30	James & Shirley Knight
KROL	25	Larry Krozel
LEVM	16	Monty Leventhal

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Table 3: 201706 Number of observations by observer.

Obs	NumObs	Name
LKR	4	Kristine Larsen
LRRA	21	Robert Little
MARE	13	Enrico Mariani
MCE	22	Etsuiku Mochizuki
MILJ	15	Jay Miller
MJAF	30	Juan Antonio Moreno Quesada
MJHA	29	John McCammon
MMAE	6	Aaron McNeely
MMAV	21	Marcelino
MUDG	2	George Mudry
MWU	14	Walter Maluf
OATS	2	Susan Oatney
ONJ	16	John O'Neill
RLM	10	Mat Raymonde
SDOH	30	Solar Dynamics Obs - HMI
SIMC	7	Clyde Simpson
SMNA	5	Michael Stephanou
SNE	15	Neil Simmons
SONA	14	Andries Son
STAB	29	Brian Gordon-States
SUZM	26	Miyoshi Suzuki
TESD	22	David Teske
TPJB	3	Patrick Thibault
URBP	29	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VIDD	18	Dan Vidican
WGI	2	Guido Wollenhaupt
WILW	23	William M. Wilson
WRP	2	Russell Wheeler
Totals	1169	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 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 . The solid cyan curve that connects the red X's are 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 doted curve connecting the green triangles are the Shapley method R_a numbers. The dashed blue curve connecting the blue O's are 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 of 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

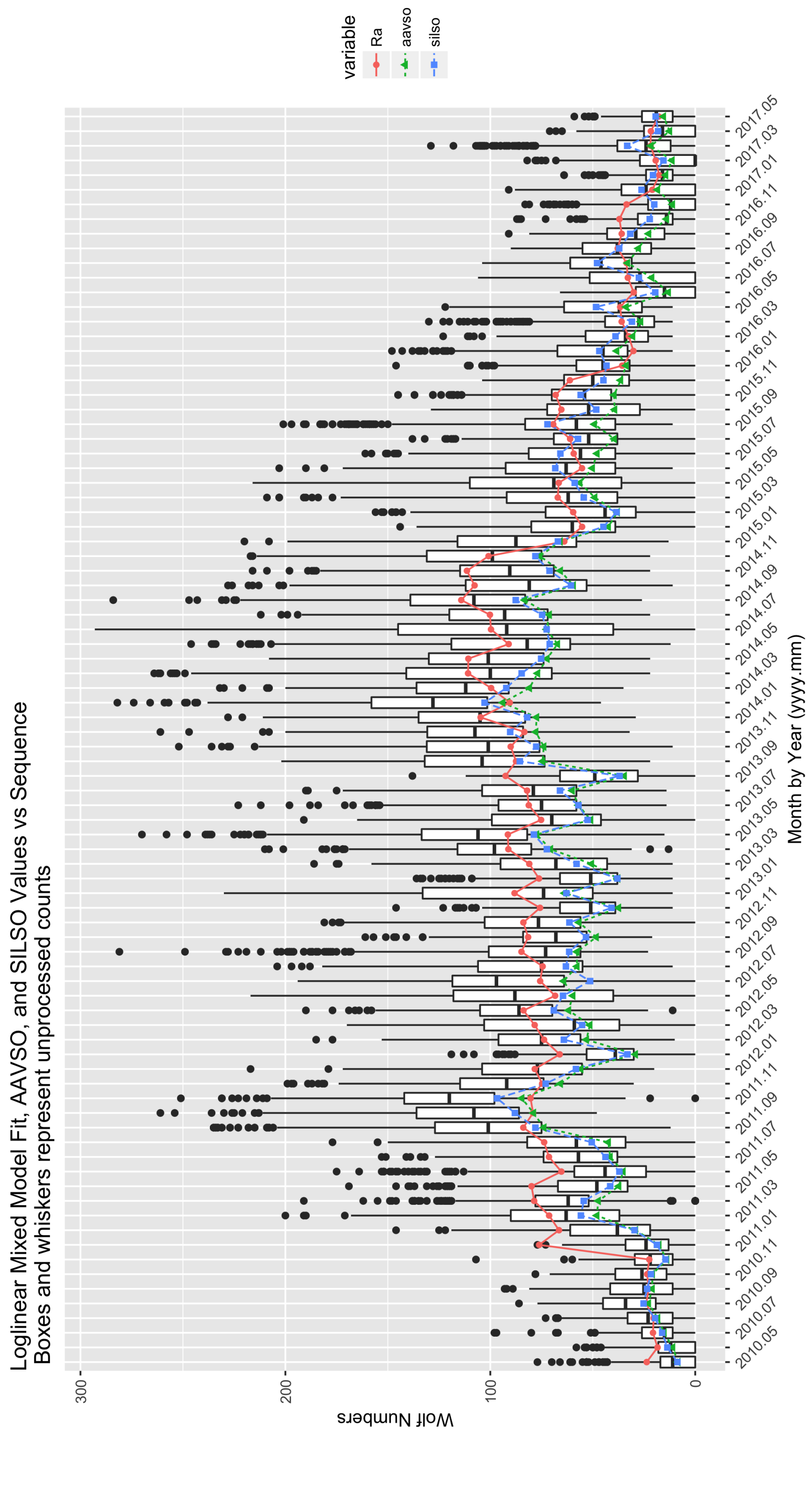

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels