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 A couple of images of the one large group during April

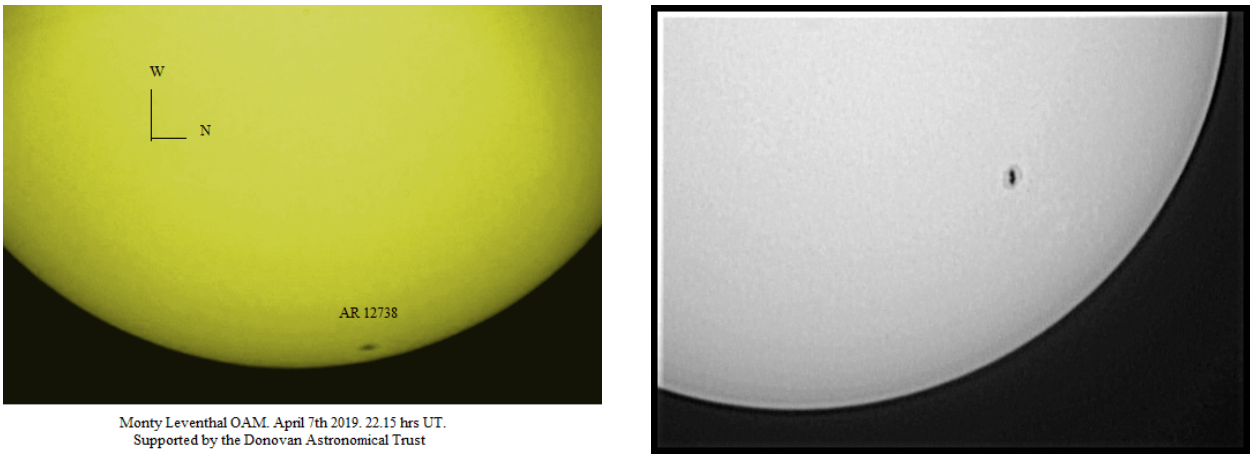

Figure 1: The left panel shows a CCD image from Monty Leventhal (LEVM). Right panel shows a CCD image from Dan Vidican (VIDD).

For the left panel: "April 7th digital filtergram shows a new large Sunspot group of 2 spots within a Penumbra. Something this large I have not seen for a long time." Best wishes, Monty Leventhal. For the right panel: "Sun spot image from 10 April UT 9h15m." Best regards, Dan Vidican.

This large group raises the question about the Zurich classification of sunspots and how might a sunspot decay from a C, or D, (AR2736) class which occurred last March (around March 22nd) to an H class sunspot like AR2738 which appeared a couple weeks later? (`http://www.spaceweather.com/archive.php?view=1&day=22&month=03&year=2019`)

Further reading: (`https://www.academia.edu/3773294/On_Learning_of_Sunspot_Classification`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

April 2019 (Figure 2): The most active day this month was the 8th of April where there were 6 B class flares recorded by GOES-15 XRA. However none of these flares shows up as a SID event here in Fort Collins, Colorado. (Please note the y-axis values in these SID graphs are non-dimensional.)

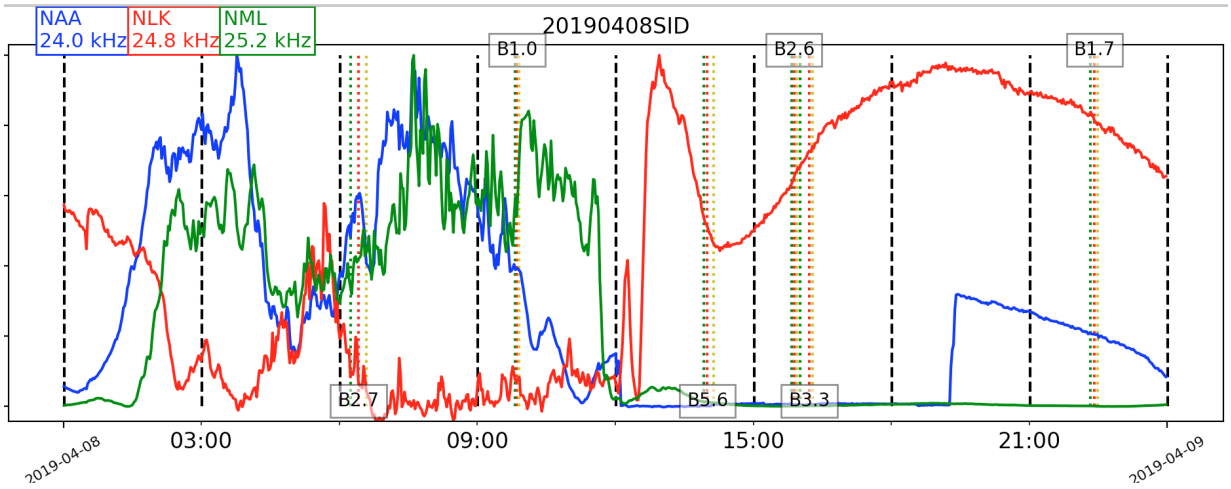

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In April 2019 we had 20 AAVSO SID observers who submitted VLF data as listed in Table 1. There were some observers who recorded SID events this month, all B class flares on the 8th, which matched to GOES-15 XRA and FLA events.

Table 1: 201904 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	NWC
G Meyers	A124	NPM
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	HWU NAU
I Ryumshin	A142	GQD DHO
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
G Wood	A150	NML
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.

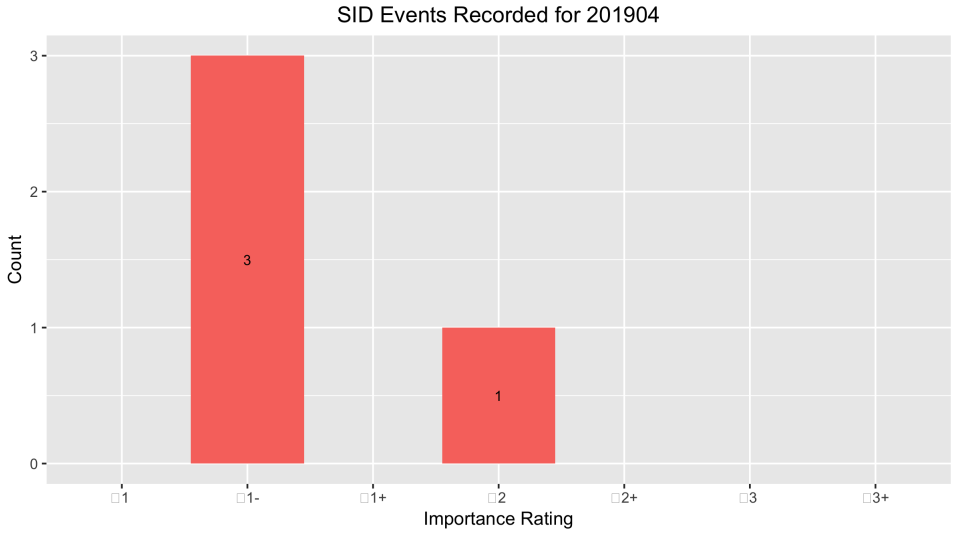

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In April 2019, there were 32 XRA flares from GOES-15 for April 2019. 32 B class flares. Far less flares this month compared to last. There were 19 days this month with no GOES-15 reports of flares. (see Figure 4).

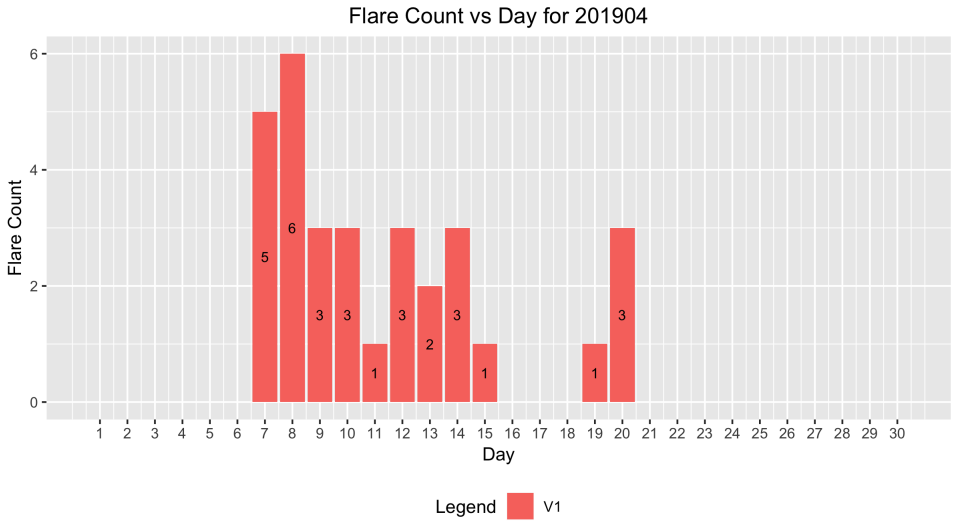

Figure 4: GOES - 15 XRA flares

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 April 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.

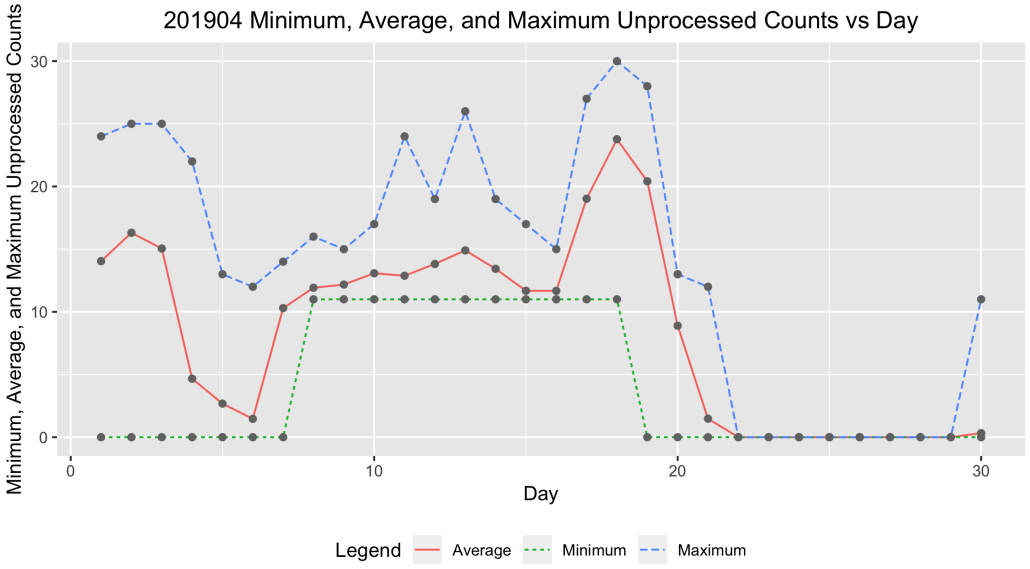

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

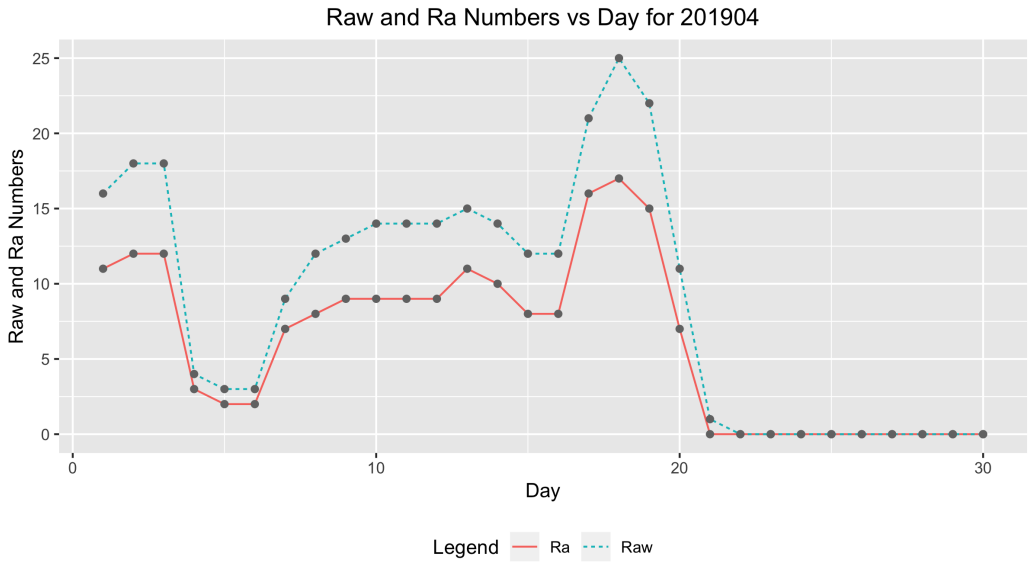

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 201904 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	46	16	11
2	42	18	12
3	40	18	12
4	33	4	3
5	31	3	2
6	39	3	2
7	34	9	7
8	37	12	8
9	40	13	9
10	38	14	9
11	41	14	9
12	33	14	9
13	41	15	11
14	37	14	10
15	47	12	8

Continued

Table 2: 201904 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	43	12	8
17	42	21	16
18	39	25	17
19	34	22	15
20	37	11	7
21	38	1	0
22	35	0	0
23	34	0	0
24	36	0	0
25	38	0	0
26	41	0	0
27	42	0	0
28	42	0	0
29	41	0	0
30	34	0	0
Averages	38.5	9	6.2

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for April 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 71 and the total number of observations is 1155.

Table 3: 201904 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	20	Alexandre Amorim
AJV	12	J. Alonso
ARAG	30	Gema Araujo
ASA	29	Salvador Aguirre
ATE	19	Teofilo Arranz Heras
BARH	21	Howard Barnes
BATR	6	Roberto Battaiola
BERJ	23	Jose Alberto Berdejo
BLAJ	2	John A. Blackwell
BMF	18	Michael Boschat
BRAD	25	David Branchett
BRAF	15	Raffaello Braga
BROB	25	Robert Brown
BSAB	23	Santanu Basu
CADA	1	Adair Cardoso

Continued

Table 3: 201904 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CHAG	27	German Morales Chavez
CIOA	7	Ioannis Chouinavas
CKB	23	Brian Cudnik
CLUB	1	Lucas Camargo da Silva
CNT	20	Dean Chantiles
CVJ	4	Jose Carvajal
DEMF	6	Frank Dempsey
DIVA	23	Ivo Demeulenaere
DJOB	11	Jorge del Rosario
DMIB	16	Michel Deconinck
DROB	6	Bob Dudley
DUBF	27	Franky Dubois
EHOA	19	Howard Eskildsen
ERB	13	Bob Eramia
FERJ	20	Javier Ruiz Fernandez
FLET	24	Tom Fleming
FTAA	11	Tadeusz Figiel
HAYK	12	Kim Hay
HOWR	21	Rodney Howe
HRUT	29	Timothy Hrutkay
JDAC	20	David Jackson
JENS	2	Simon Jenner
JGE	2	Gerardo Jimenez Lopez
JPG	5	Penko Jordanov
KAND	28	Kandilli Observatory
KAPJ	15	John Kaplan
KNJS	30	James & Shirley Knight
KROL	19	Larry Krozel
KWD	4	Carl Kwadrat
LEVM	23	Monty Leventhal
LKR	6	Kristine Larsen
LRRA	19	Robert Little
MARC	5	Arnaud Mengus
MARE	8	Enrico Mariani
MCE	21	Etsuiku Mochizuki
MILJ	13	Jay Miller
MJAF	26	Juan Antonio Moreno Quesada
MJHA	25	John McCammon
MUDG	7	George Mudry
MWU	17	Walter Maluf
OAAA	24	Al Sadeem Astronomy Observator
OATS	4	Susan Oatney
ONJ	7	John O'Neill

Continued

Table 3: 201904 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
SDOH	30	Solar Dynamics Obs - HMI
SMNA	6	Michael Stephanou
SNE	4	Neil Simmons
SONA	18	Andries Son
STAB	27	Brian Gordon-States
SUZM	22	Miyoshi Suzuki
TESD	24	David Teske
TPJB	2	Patrick Thibault
TST	15	Steven Toothman
URBP	28	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VIDD	13	Daniel Vidican
WILW	19	William M. Wilson
Totals	1155	71

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.

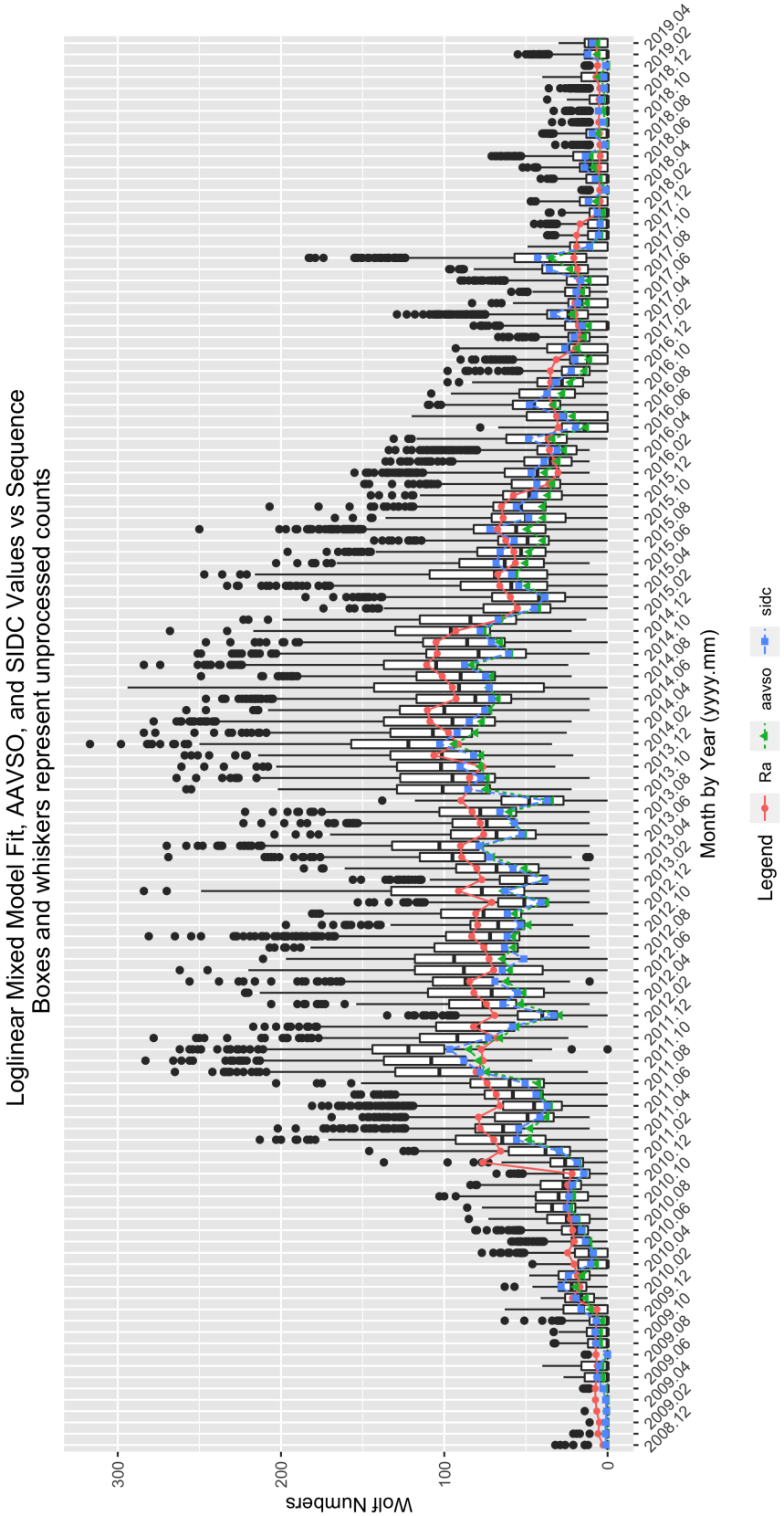

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe ahowe@frii.com