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 VLF stations recording the upcoming solar eclipse in August, 2017

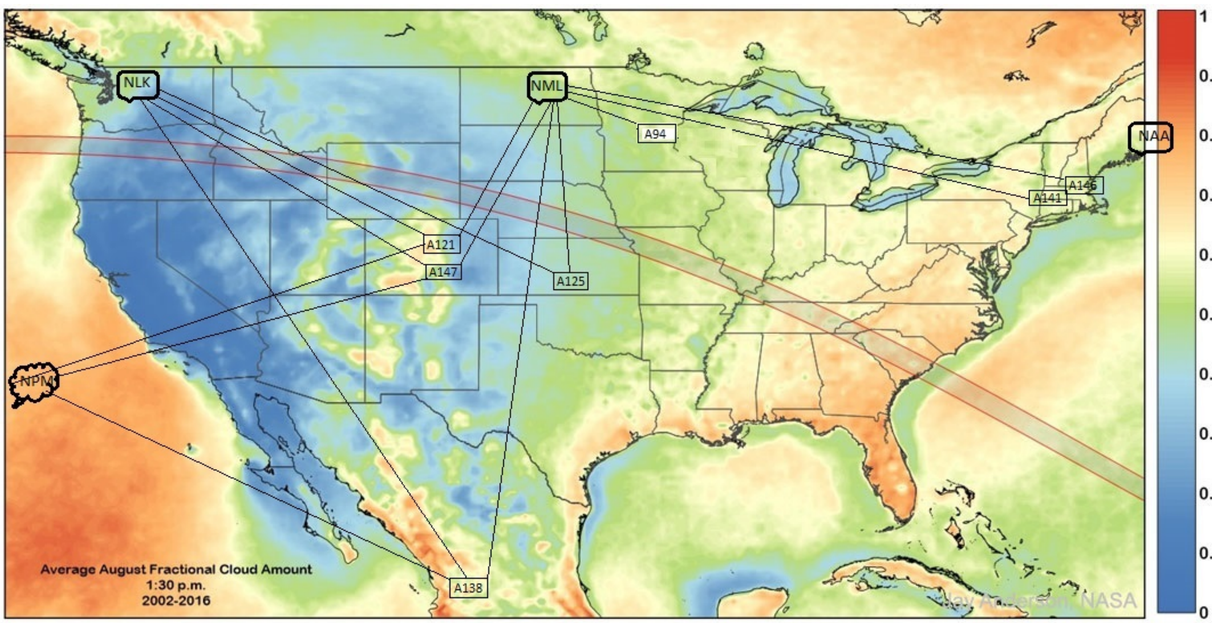

Figure 1: Map of the path of the August 21, 2017 total solar eclipse.

The map in Figure 1 are areas of cloudless skies during the August 21, 2017 total solar eclipse (https://apod.nasa.gov/apod/ap170131.html) Times for the sun along the path may be found at the website https://www.timeanddate.com/eclipse/solar/2017-august-21. Very Low Frequency (VLF) receivers from the following observers in Table 1 are to be used for collecting the bow shock created by the moon as it eclipses the sun:

"In order to detect a potential unusual effect caused by the eclipse, a comparison with measurements made at the same time the three days before and the three days after the eclipse should be made. To that purpose, data needs to be collected to show the minimum, average and maximum

Table 1: VLF observers.

Name	Code	Station
A McWilliams	A94	NML
R Howe	A121	NLK
S Oatney	A125	NML
S Aguirre	A138	NPM
G Silvis	A141	NAA
K Menzies	A146	NAA
R Russel	A147	NML

values of the daily signal strength on August 18, 19, 20, 21, 22, 23, 24. This allows us to determine if the amplitude variation observed during the eclipse is within normal daily changes. This point is especially important since the eclipse happens from some VLF locations early in the morning, during the sunrise amplitude pattern of the transition between night and day propagation modes." From: Measurement of VLF propagation perturbations during the January 4, 2011 Partial Solar Eclipse, by Lionel Loudet, January 2011

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

May, 2017 (Figure 2) show three days of recording NML (25.2 kHz) data from Al McWilliams (A94) in Minnesota. These data are a good example of recorded data before the August 2017 solar eclipse.

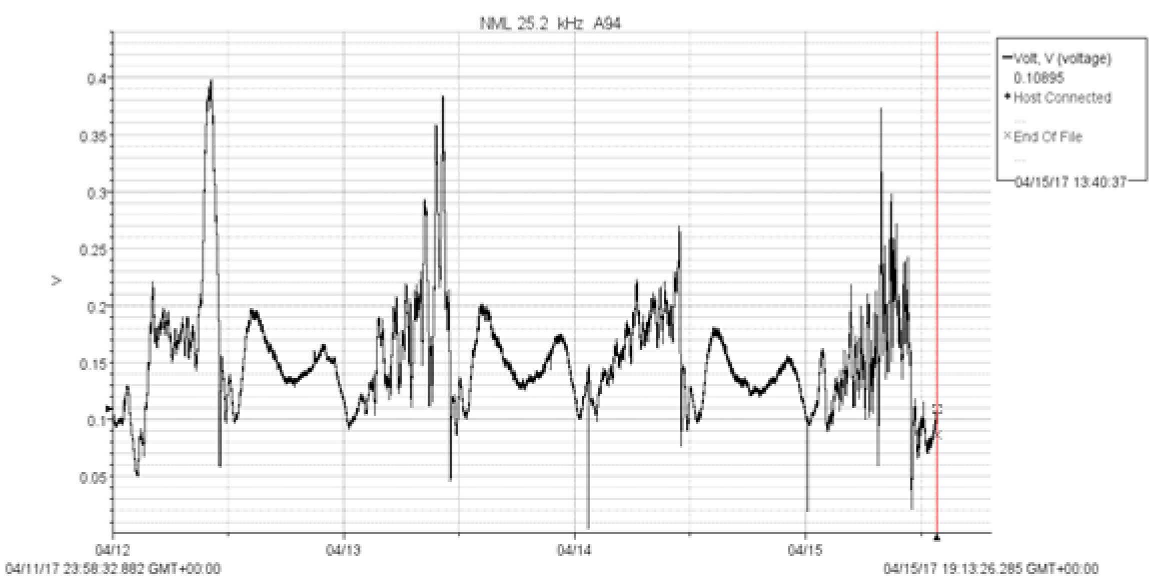

Figure 2: VLF three day plot of NML

2.2 SID Observers

May, 2017 we have 17 AAVSO SID observers who submitted VLF data as listed in Table 2.

Table 2: 201705 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	HWU
L Loudet	A118	NAA
J Godet	A119	GBZ GQD ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
S Oatney	A125	NML
J Karlovsky	A131	DHO
R Green	A134	NPM
S Aguirre	A138	NPM
G Silvis	A141	NAA
I Ryumshin	A142	DHO GQD
R Rogge	A143	GQD
K Menzies	A146	NAA
D Russel	A147	NML
G Vargas	A148	NPM
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.

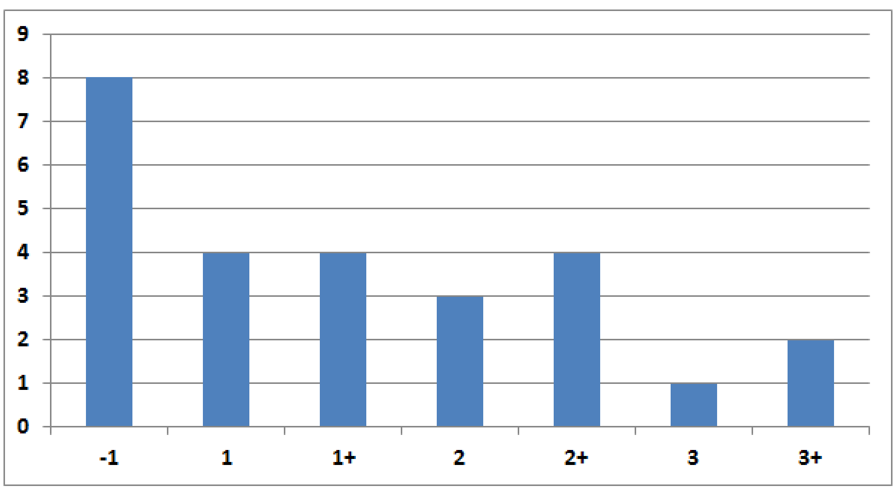

Figure 3: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In May, 2017, there were 62 solar flares measured by GOES-15 (see Figure 4). There are five C class and 57 B class flares. There is many less solar flares this month compared to last month with 16 days of 'no reports from the GOES satellite.

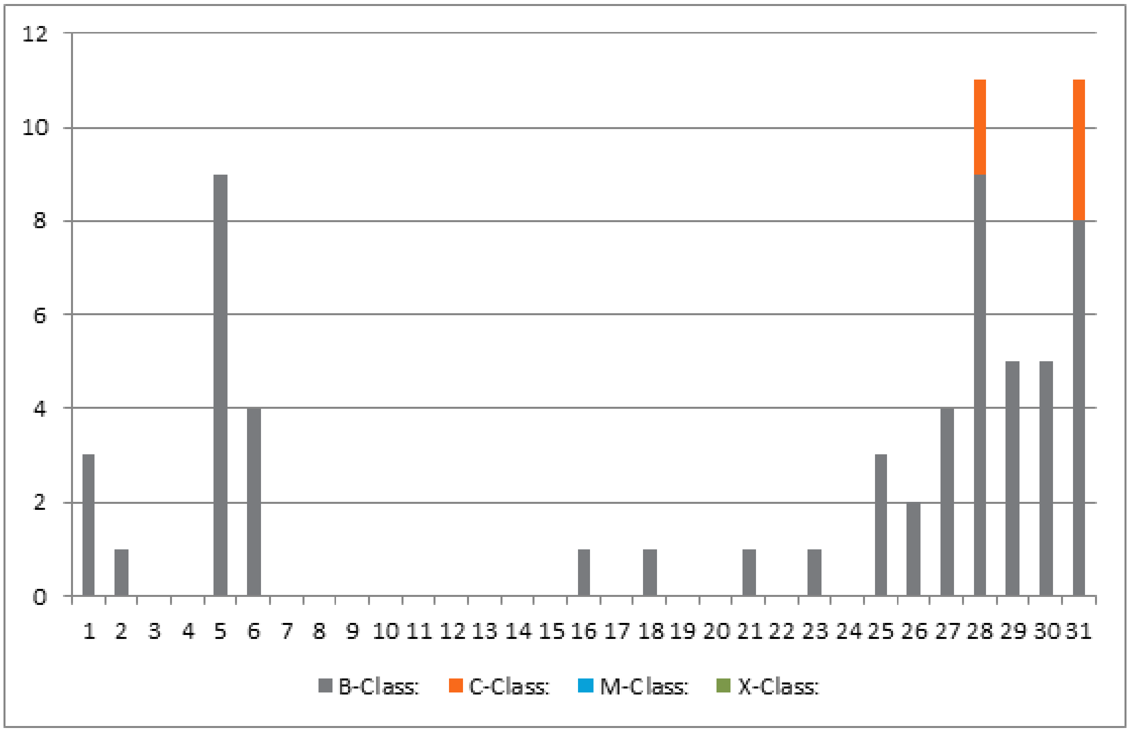

Figure 4: GOES - 15 XRA flares

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 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 May, 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 5.

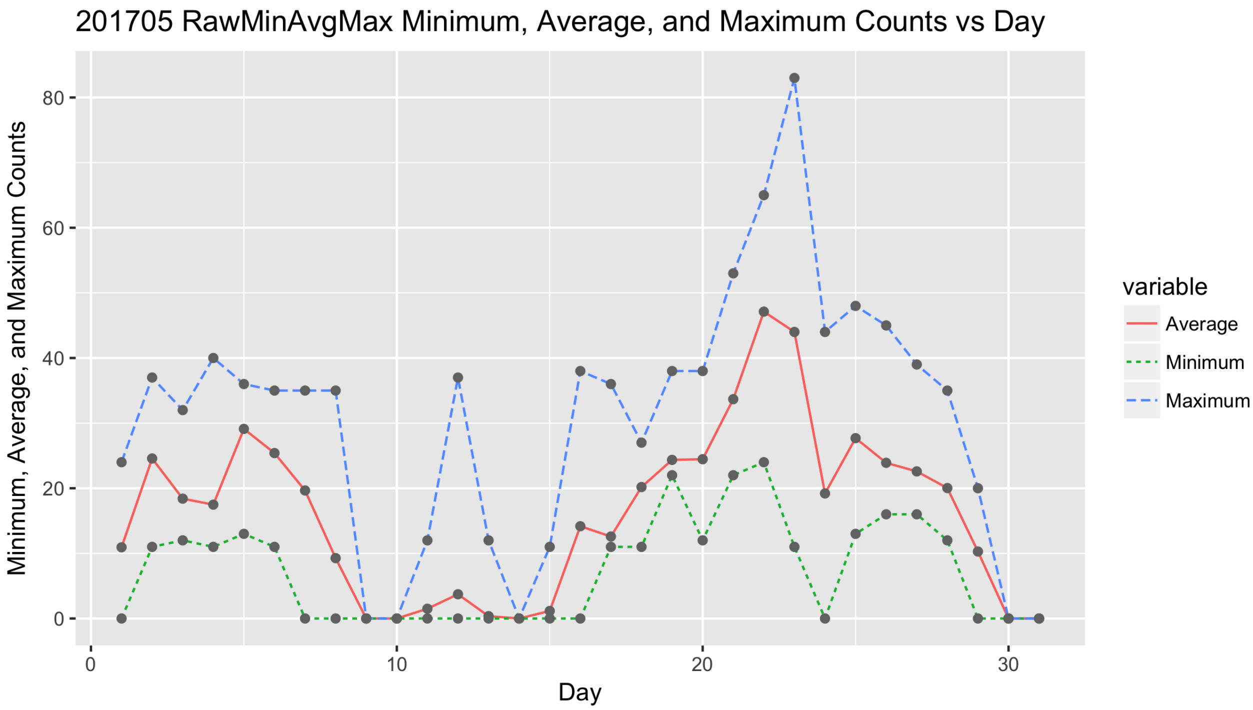

Figure 5: Raw minimum, average, and maximum sunspot count by day of the month by observer.

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 3.

Table 3: 201705 American Relative Sunspot Numbers (Ra)

DAY	NumObs	RAW	Ra
1	32.0	11.0	8.0
2	35.0	24.0	19.0
3	31.0	18.0	15.0
4	29.0	17.0	14.0
5	36.0	29.0	23.0
6	36.0	25.0	20.0
7	36.0	19.0	15.0
8	33.0	8.0	6.0
9	30.0	0.0	0.0
10	24.0	0.0	0.0
11	29.0	2.0	1.0
12	28.0	3.0	2.0
13	36.0	0.0	0.0
14	36.0	0.0	0.0
15	41.0	1.0	1.0

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Table 3: 201705 American Relative Sunspot Numbers (Ra)

DAY	NumObs	RAW	Ra
16	42.0	14.0	10.0
17	35.0	12.0	10.0
18	29.0	19.0	15.0
19	34.0	24.0	19.0
20	40.0	24.0	19.0
21	36.0	33.0	26.0
22	35.0	47.0	37.0
23	31.0	43.0	33.0
24	30.0	18.0	14.0
25	27.0	26.0	21.0
26	33.0	23.0	18.0
27	36.0	23.0	19.0
28	36.0	20.0	16.0
29	37.0	10.0	8.0
30	30.0	0.0	0.0
31	37.0	0.0	0.0
Average	33.5	15.8	12.5

3.3 Sunspot Observers

Table 4 lists the observer code (obs), the number of observations submitted for May, 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.

Table 4: 201705 Number of observations by observer

Obs	NObs	Name
AAP	7	A. Patrick Abbott
AAX	12	Alexandre Amorim
AJV	24	J. Alonso
ARAG	31	Gema Araujo
ASA	25	Salvador Aguirre
BARH	12	Howard Barnes
BATR	9	Roberto Battaiola
BERJ	25	Jose Alberto Berdejo
BRAB	31	Brenda Branchett
BRAF	24	Raffaello Braga
BROB	30	Robert Brown
BSAB	13	Santanu Basu
CHAG	27	German Morales Chavez
CIOA	11	Ioannis Chouinavas
CKB	26	Brian Cudnik
CNT	8	Dean Chantiles
CVJ	19	Jose Carvajal

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Table 4: 201705 Number of observations by observer

Obs	NObs	Name
DEMF	6	Frank Dempsey
DUBF	24	Franky Dubois
FERJ	25	Javier Ruiz Fernandez
FLET	23	Tom Fleming
FLF	10	Fredirico Luiz Funari
FTAA	11	Tadeusz Figiel
FUJK	20	K. Fujimori
HAYK	16	Kim Hay
HIVB	3	Ivan Hajdinjak
HMQ	10	Mark Harris
HOWR	26	Rodney Howe
JDAC	14	David Jackson
JENS	1	Simon Jenner
JGE	6	Gerardo Jimenez Lopez
KAND	29	Kandilli Observatory
KAPJ	16	John Kaplan
KNJS	24	James & Shirley Knight
KROL	17	Larry Krozel
LEVM	22	Monty Leventhal
LKR	2	Kristine Larsen
LRRA	26	Robert Little
MARE	11	Enrico Mariani
MCE	23	Etsuiku Mochizuki
MILJ	12	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	28	John McCammon
MUDG	3	George Mudry
MWU	17	Walter Maluf
OATS	3	Susan Oatney
ONJ	16	John O'Neill
RLM	10	Mat Raymonde
RRO	1	Ralph Rogge
SDOH	31	Solar Dynamics Obs - HMI
SIMC	5	Clyde Simpson
SMNA	2	Michael Stephanou
SNE	17	Neil Simmons
SONA	16	Andries Son
SPIA	4	Piotr Skorupski
STAB	29	Brian Gordon-States
SUZM	25	Miyoshi Suzuki
TESD	29	David Teske
TPJB	1	Patrick Thibault
URBP	26	Piotr Urbanski
VARG	28	A. Gonzalo Vargas

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Table 4: 201705 Number of observations by observer

Obs	NObs	Name
VIDD	10	Dan Vidican
WILW	23	William M. Wilson
WRP	5	Russell Wheeler
	64	Total observers
	1071	Total Observations

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 6 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

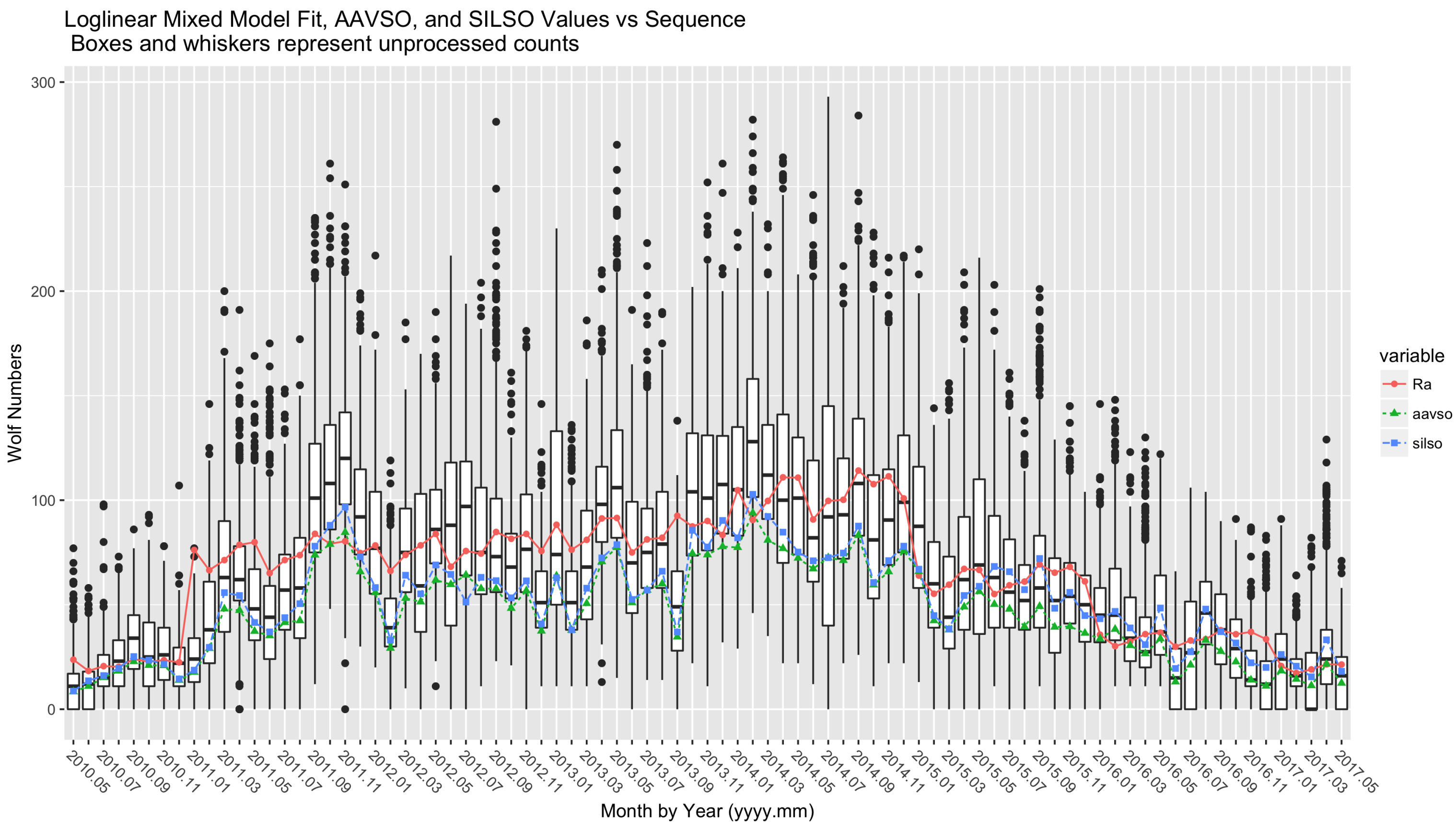

Figure 6: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels