Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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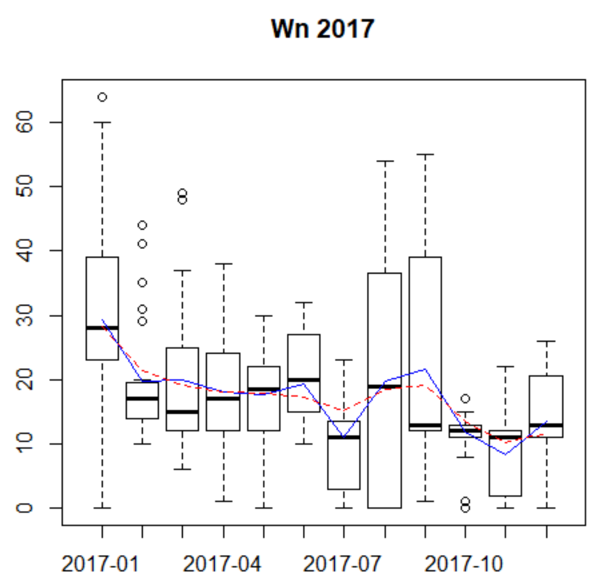
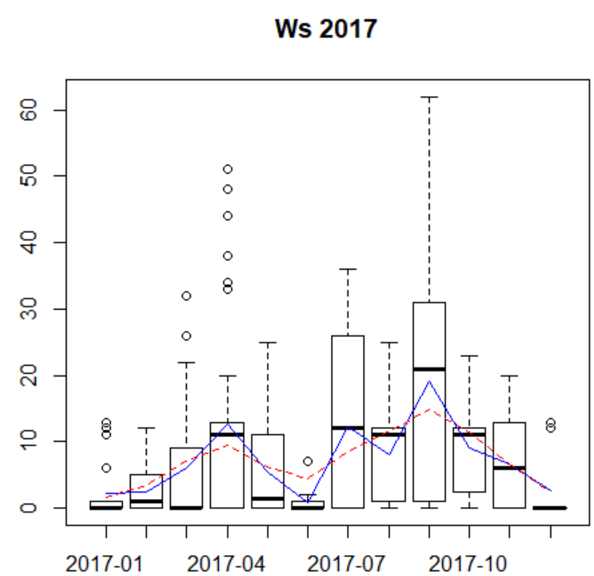
The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots and the VLF radio recordings of SID Events in the ionosphere. Section 1 gives contributions by our members. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.





As many as 38 of the observers who submit sunspot counts to the AAVSO have recorded the North and South hemisphere sunspots this last year. Here are monthly Wolf averages for both hemispheres.

1 Carrington Rotation for North and South Hemispheres

Using Grant Foster's R routines (Rcodes) for creating periodograms for the North and South Hemispheres of the sun we find that the average Carrington Rotation period for the North is 30.8 days. The period for the South Hemisphere is 26.9 days. And for both North and South Hemispheres the Carrington Rotation period is 27.25 days. This might indicate that the Northern Hemisphere sunspot Wolf numbers favor higher latitudes, and the Southern Hemisphere sunspot Wolf numbers are closer to the solar equator. 1 and 2.

(Rcodes. Release Date: 7/15/2010 This set of software, in the statistical language "R" (https://www.R-project.org), is meant to accompany Grant Foster's book, Analyzing Light Curves: A Practical Guide. (https://www.aavso.org/software-directory))

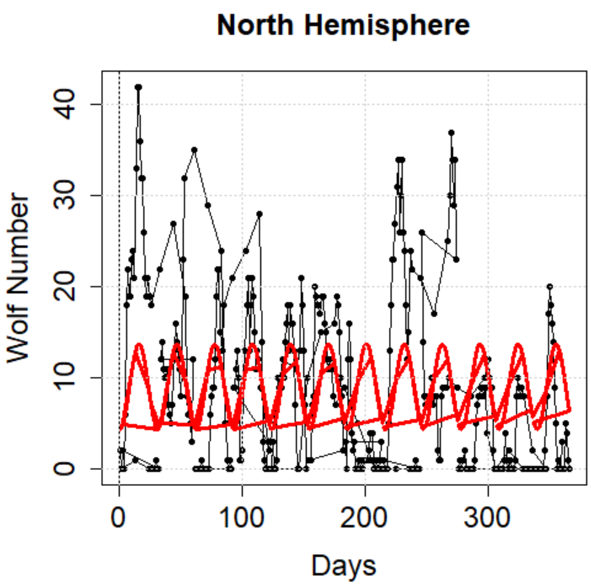


Figure 1: The 2017 Wolf numbers for the North Hemisphere period is 30.8 days.

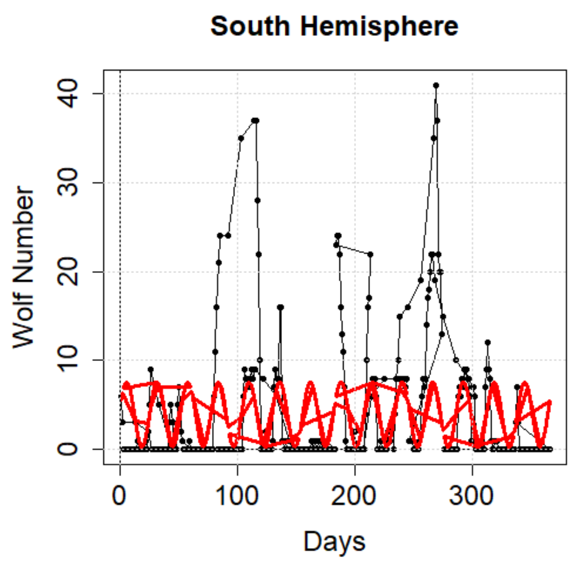


Figure 2: The 2017 Wolf numbers for the South Hemisphere period is 26.9 days.

Figures 1 and 2. Show the Carrington Rotation periods for the North and South Hemispheres of the sun for 2017.

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. Here we show how a 24 bit external sound card can be used to record VLF SID data without a receiver or any electric amplification: (`https://www.asus.com/us/Sound-Cards/Xonar_U5/`) I bought one of these because an electrical engineer, Nathan Towne, who works at the NRAO Very Large Array in New Mexico has written Python software for it: (`http://myplace.frontier.com/~nathan56/sidmon/sidmon.html#equipment`) I put the SID loop antenna right into the mic input of the Xonar, no need for amplification (SuperSID or otherwise).

2.1 SID Records

December 2017 (Figure 3) The day with most flares was on the 22nd of December (right after the winter solstice), with 9 B class flares, however none were during the day time hours here in Fort Collins, Colorado.

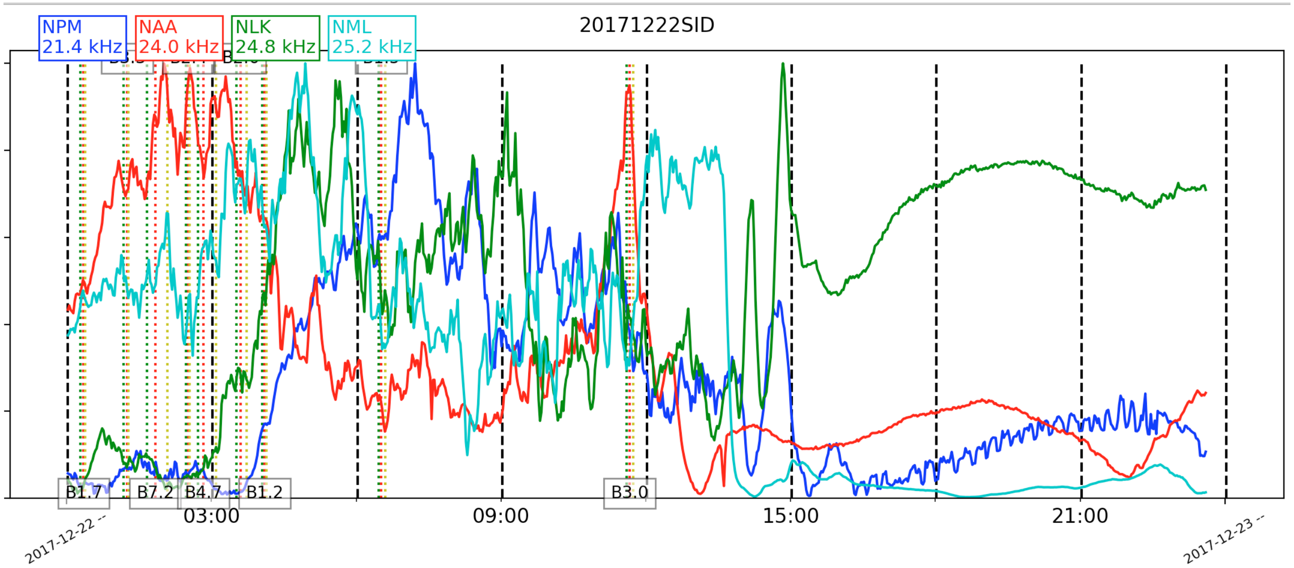


Figure 3: VLF recording using the sidmon.py software from Nathan Towne.

2.2 SID Observers

In December 2017 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: 201712 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	ICV
J Wallace	A97	NAA
L Loudet	A118	GBZ
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	NWC
S Aguirre	A138	NPM
G Silvis	A141	NAA
I Ryumshin	A142	ICV DHO
R Rogge	A143	DHO GQD ICV
K Menzies	A146	NAA
D Russel	A147	NML
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.

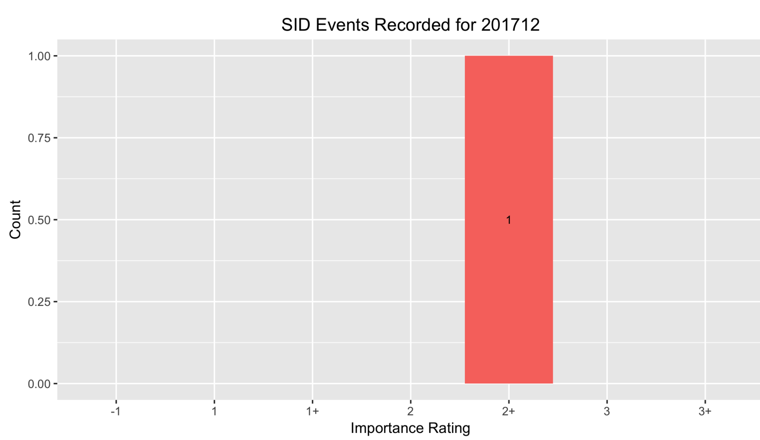


Figure 4: Solar Events Y-axis, Importance Rating X-axis.

2.3 Solar Flare Summary from GOES-15 Data

In December 2017, There were 27 solar flares measured by GOES-15. 27 B class flares. A little more flaring this month compared to last month. There were 12 days this month with no GOES-15 reports of flares. (see Figure 5).

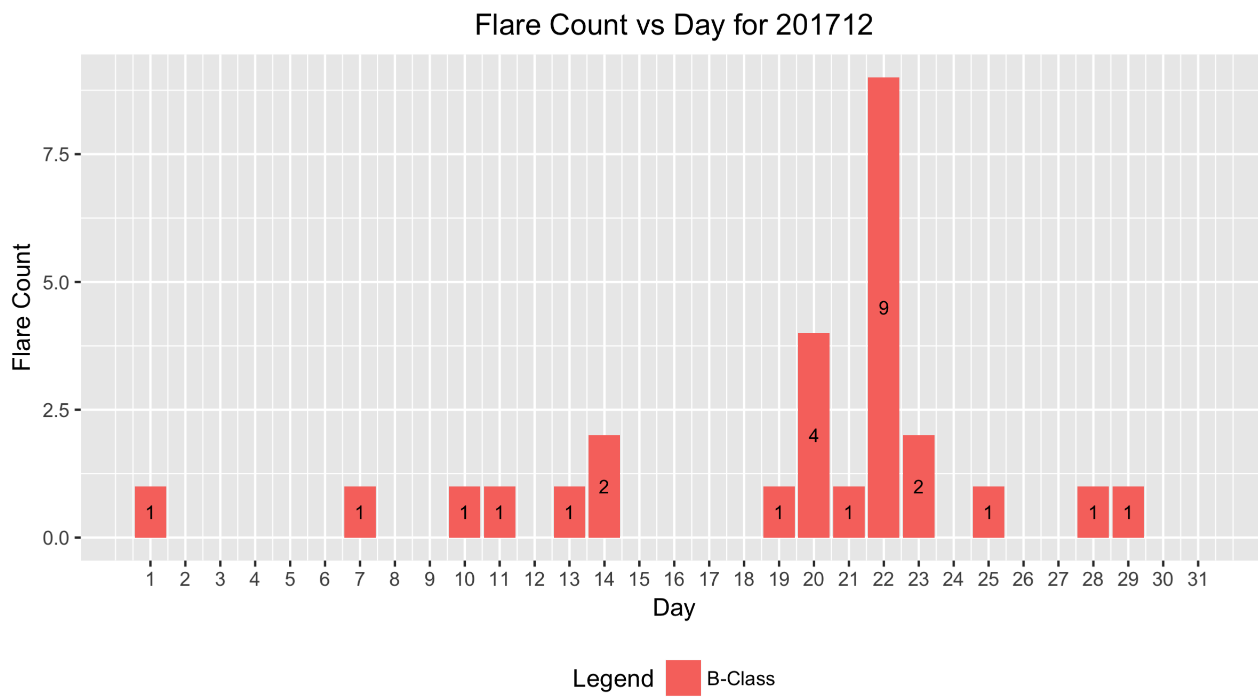


Figure 5: GOES - 15 XRA flares

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 December 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 7.

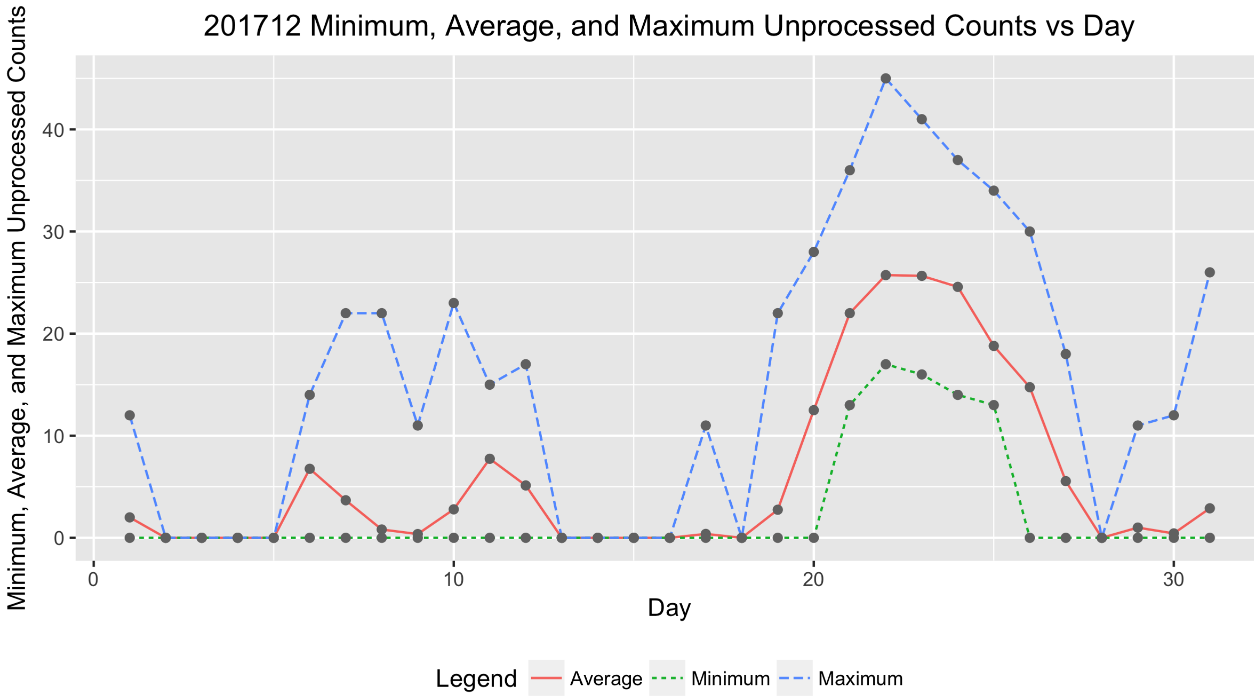


Figure 6: Raw average, minimum and maximum counts by day of the month by observer.

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: 201712 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
1	28	2	1
2	31	0	0
3	34	0	0
4	28	0	0
5	25	0	0
6	29	8	5
7	34	4	3
8	27	0	0
9	30	0	0
10	33	2	2
11	27	10	6
12	31	6	4
13	25	0	0
14	29	0	0
15	26	0	0

Continued

Table 2: 201712 American Relative Sunspot Numbers (Ra)

Day	NumObs	Raw	Ra
16	38	0	0
17	29	0	0
18	27	0	0
19	28	4	2
20	28	15	9
21	26	20	13
22	26	27	18
23	32	28	18
24	26	26	16
25	29	18	12
26	28	15	10
27	31	6	4
28	31	0	0
29	22	1	1
30	28	2	1
31	27	0	0
Averges	28.8	6.3	4.4

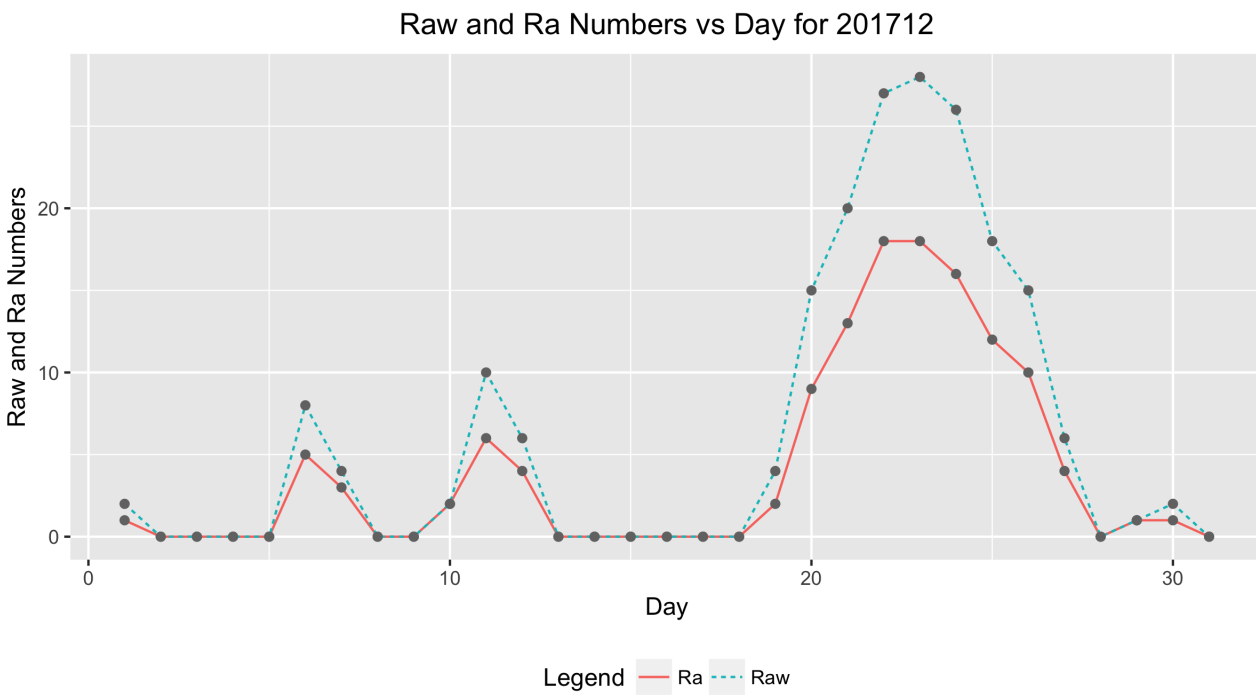


Figure 7: Raw Wolf and Ra numbers by day of the month by observer.

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations submitted for December 2017, 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 65 and the total number of observations is 893.

Table 3: 201712 Number of observations by observer

Obs	NumObs	Name
AAX	16	Alexandre Amorim
AJV	22	Javier Alonso Santiago
ARAG	31	Gema Araujo
ASA	22	Salvador Aguirre
BARH	18	Howard Barnes
BATR	5	Roberto Battaiola
BERJ	22	Jose Alberto Berdejo
BMF	16	Michael Boschat
BRAF	11	Raffaello Braga
BROB	30	Robert Brown
BSAB	25	Santanu Basu
CHAG	22	German Morales
CIOA	17	IOANNIS CHOUINAVAS
CKB	12	Brian Cudnik
CNT	9	Dean Chantiles
CVJ	13	Jose Carvajal
DEMF	1	Frank Dempsey
DJOB	12	Jorge
DROB	4	Robert Dudley
DUBF	17	Franky Dubois
ERB	4	Bob Eramia
FERJ	11	Javier Ruiz
FLET	20	Tom Fleming
FLF	11	Frederico Luiz Funari
FTAA	4	Tadeusz Figiel
FUJK	26	Kenichi Fujimori
HAYK	9	Kim Hay
HIVB	1	Ivan Hajdinjak
HMQ	4	Mark
HOWR	21	Rodney Howe
JDAC	12	David Jackson
JGE	9	Gerardo
KAPJ	12	John Kaplan
KNJS	31	Jim and Shirley Knight
KROL	19	Larry Krozel
LEVM	17	Monty Leventhal OAM
LKR	2	Kristine Larsen
LRRA	15	Robert Little

Continued on next page

Table 3: 201712 Number of observations by observer

Obs	NumObs	Name
MARE	9	Enrico Mariani
MCE	27	E. Mochizuki
MILJ	10	Jay H. Miller
MJAF	29	Juan Antonio Moreno Quesada
MJHA	28	JOHN H MCCAMMON
MMAV	31	Marcelino Vazquez Munoz
MUDG	6	George Mudry
MWU	12	Walter Jose maluf
ONJ	2	John O'Neill
RLM	10	MAT
SDOH	31	Jan Alvestad
SIMC	2	Clyde Simpson
SMNA	5	Michael Nicholas Stephanou
SNE	1	Neil Simmons
SONA	3	son
SPIA	4	Piotr Skorupski
STAB	19	Brian Gordon-States
SUZM	26	Miyoshi Suzuki
TESD	19	David Teske
TPJB	2	Patrick Thibault
URBP	8	PIOTR URBANSKI
VARG	20	A. Gonzalo Vargas B.
VIDD	12	Dan Vidican
WAU	1	Artur Wargin
WCHD	8	Charles White
WILW	14	William M. Wilson
WRP	1	Russell Wheeler
Totals	893	65

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 8 shows the monthly GLMM R_a numbers. 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

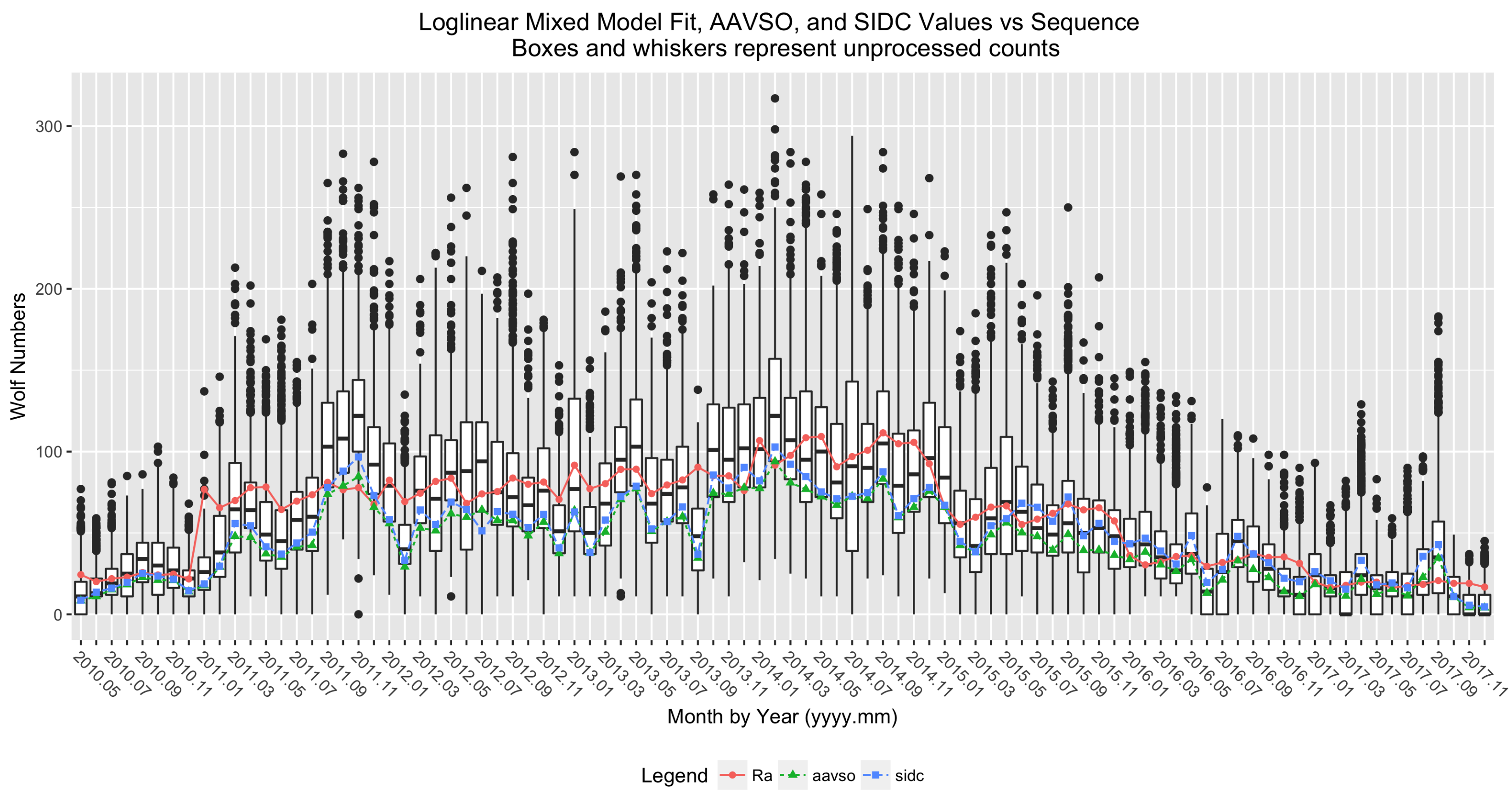


Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels