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 Looking for those solar minimums!

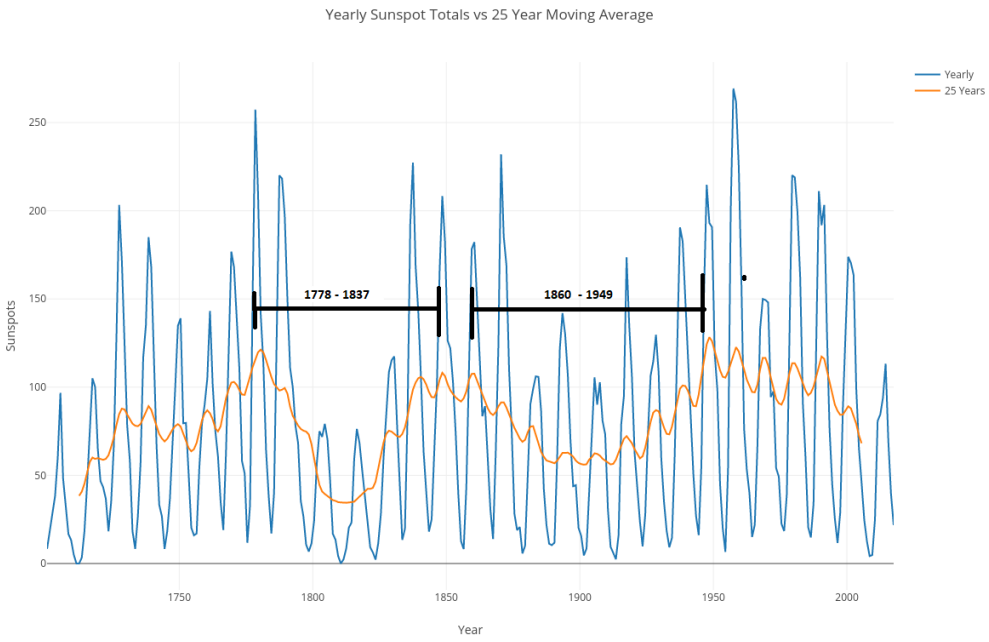

Figure 1: This chart was made using the SIDC's Yearly mean data from 1700-2010. The chart consist of a (blue) plot of the raw yearly data, and a (orange)25 year moving average plot. It looks like that in addition to the 11 year solar minimum cycle there 2 longer cycles consisting of several solar minimums. David Jackson (JDAC), Data from here: (`http://sidc.be/silso/DATA/SN_d_tot_V2.0.csv`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

November 2018 (Figure 2): There was one B class flare on the 24th of November recorded here Fort Collins, CO. However, this was during the night time so no ionosphere SID event was detected.

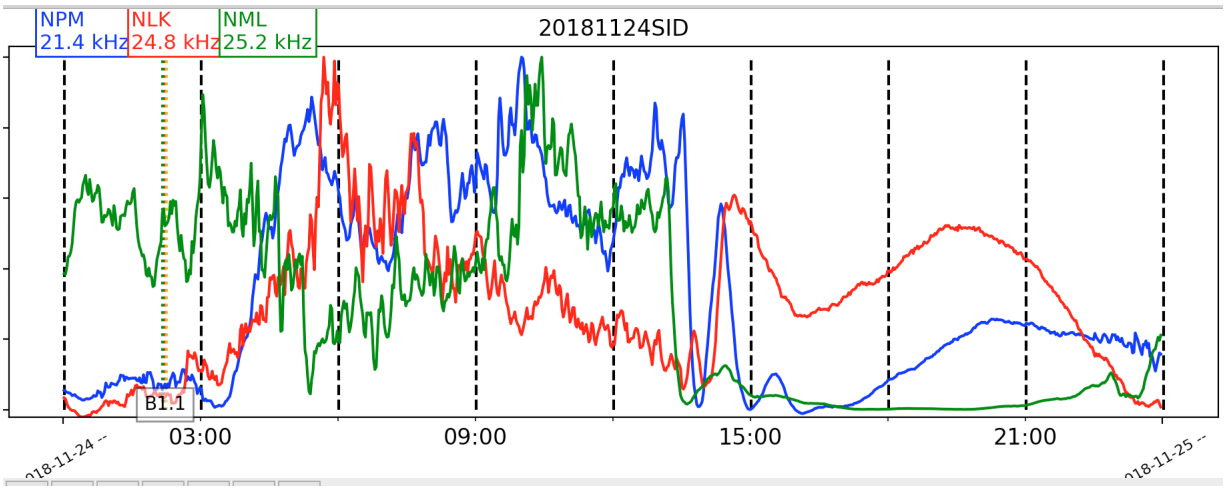

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In November 2018 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1. There were a few observers who recorded the SID event on the 24th this month.

Table 1: 201811 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ ICV
F Adamson	A122	NWC
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	NLK
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	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.

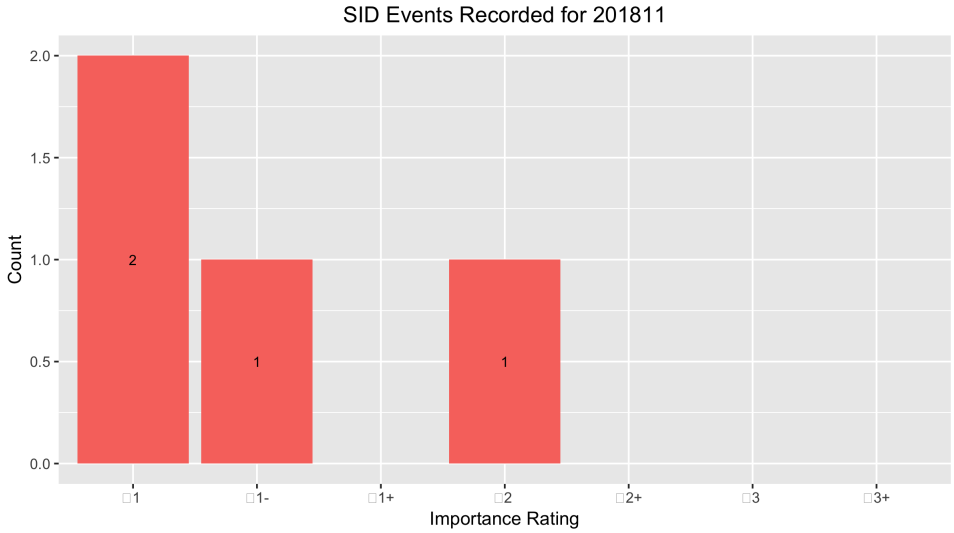

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In November 2018, there were six solar flares measured by GOES-15. Five A class and 1 B class flares. The sun was less active this month compared to last. There were 24 days this month with no GOES-15 reports of flares. (see Figure 4).

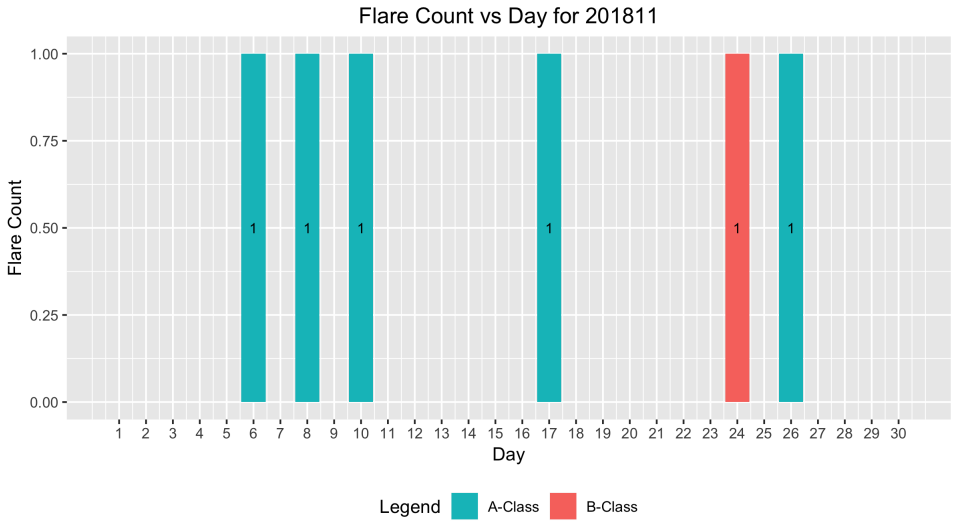

Figure 4: GOES - 15 XRA flares

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 November 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 5.

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

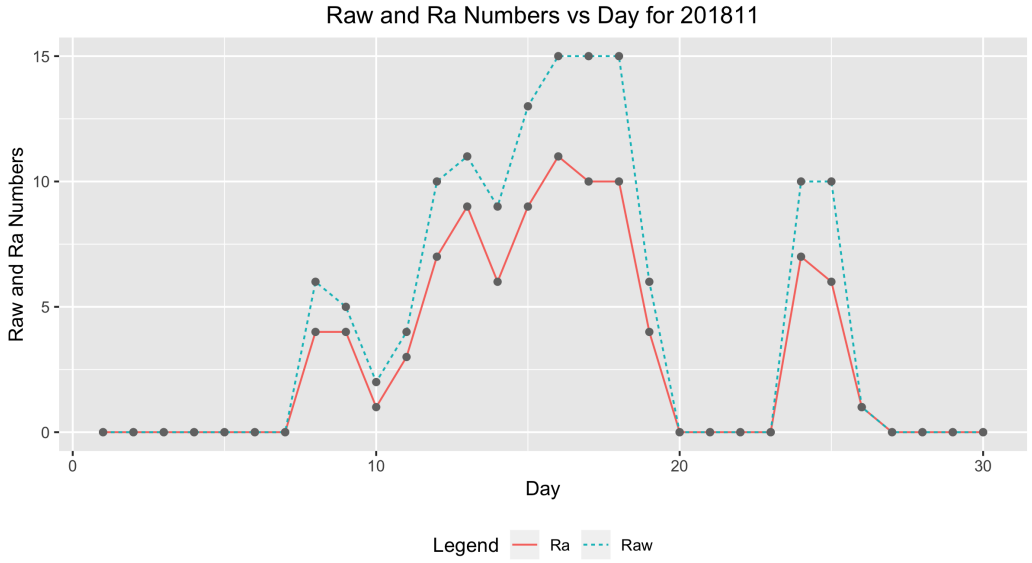

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 201811 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	31	0	0
2	27	0	0
3	36	0	0
4	32	0	0
5	26	0	0
6	23	0	0
7	32	0	0
8	29	6	4
9	27	5	4
10	29	2	1
11	33	4	3
12	28	10	7
13	30	11	9
14	28	9	6
15	32	13	9
16	25	15	11
17	37	15	10
18	27	15	10
19	26	6	4
20	23	0	0
21	31	0	0
22	21	0	0
23	34	0	0
24	26	10	7
25	29	10	6
26	25	1	1
27	30	0	0
28	32	0	0
29	24	0	0
30	31	0	0
Averages	28.8	4.4	3.1

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for November 2018, 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 64 and the total number of observations is 864.

Table 3: 201811 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	19	Alexandre Amorim
AJV	17	J. Alonso
ARAG	29	Gema Araujo
ASA	27	Salvador Aguirre
ATE	8	Teofilo Arranz Heras
BARH	11	Howard Barnes
BATR	3	Roberto Battaiola
BERJ	24	Jose Alberto Berdejo
BLAJ	2	John A. Blackwell
BMF	17	Michael Boschat
BRAD	25	David Branchett
BRAF	4	Raffaello Braga
BROB	24	Robert Brown
BSAB	29	Santanu Basu
CHAG	24	German Morales Chavez
CIOA	16	Ioannis Chouinavas
CKB	15	Brian Cudnik
CNT	23	Dean Chantiles
DEMF	2	Frank Dempsey
DIVA	13	Ivo Demeulenaere
DJOB	5	Jorge del Rosario
DMIB	14	Michel Deconinck
DROB	3	Bob Dudley
DUBF	20	Franky Dubois
EHOA	22	Howard Eskildsen
ERB	10	Bob Eramia
FERJ	20	Javier Ruiz Fernandez
FLET	16	Tom Fleming
FLF	5	Fredirico Luiz Funari
FTAA	4	Tadeusz Figiel
FUJK	23	K. Fujimori
HAYK	5	Kim Hay
HOWR	20	Rodney Howe
JDAC	5	David Jackson
JGE	3	Gerardo Jimenez Lopez
KAND	16	Kandilli Observatory
KAPJ	9	John Kaplan

Continued

Table 3: 201811 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
KNJS	30	James & Shirley Knight
KROL	13	Larry Krozel
LEVM	20	Monty Leventhal
LKR	1	Kristine Larsen
LRRA	4	Robert Little
MCE	21	Etsuiku Mochizuki
MILJ	12	Jay Miller
MJHA	25	John McCammon
MUDG	2	George Mudry
MWU	13	Walter Maluf
OATS	1	Susan Oatney
ONJ	6	John O'Neill
RLM	11	Mat Raymonde
SDOH	30	Solar Dynamics Obs - HMI
SMNA	5	Michael Stephanou
SNE	1	Neil Simmons
SONA	9	Andries Son
STAB	20	Brian Gordon-States
SUZM	25	Miyoshi Suzuki
TESD	21	David Teske
TPJB	3	Patrick Thibault
TST	2	Steven Toothman
TVT	2	Vince Tramazzo
URBP	9	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
VIDD	2	Daniel Vidican
WILW	14	William M. Wilson
Totals	864	64

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.

4 Endnotes

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

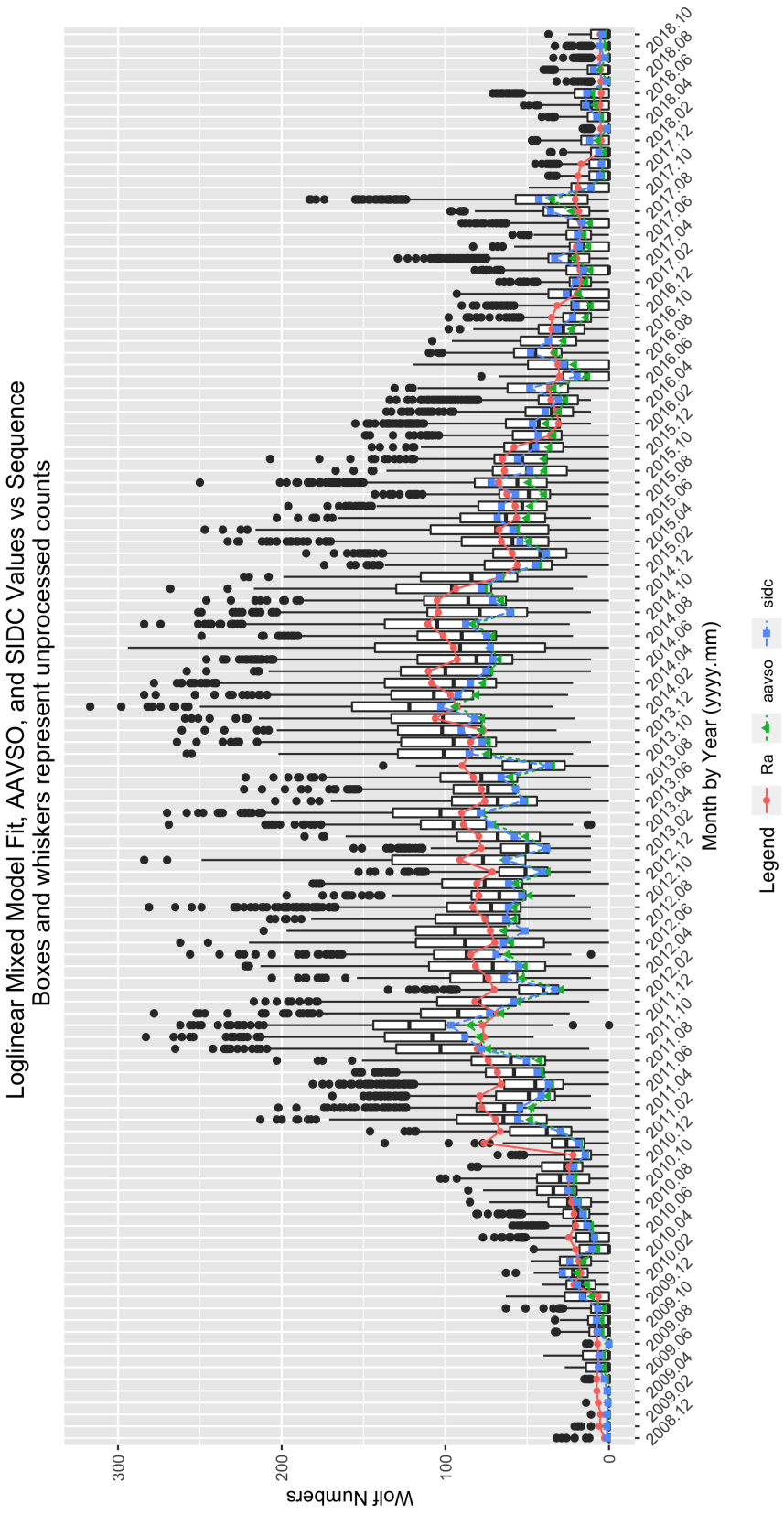

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels