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 November 11, 2019 Mercury Transit

Figure 1: (left) Charlie Davis at Red Feather Lakes, Colorado. (right) German Morales at Cochabamba, Bolivia.

From Charlie Davis for the Northern Colorado Astronomical Society. (`http://www.nocoastro.org`): "It cleared early in Red Feather Lakes for the Mercury transit, but seeing was pretty poor. If you take enough photos, some will find stable air."

From German Morales (CHAG) (`http://www.astronomia.org.bo/obs/SolarObs.html`): "The forecast for Cochabamba, was cloudy for the day of transit, but I took a total of 85 photos. Many of them with clouds or with the Sun through deep holes in the clouds or clear spaces. The principle was hidden by clouds. From 14:40 to 17:20 UTC, the sky was completely overcast, and the last 40 minutes of transit were possible to see it again and take some pictures, but the clouds were constantly disturbing. I apologize for my brevity, but the situation here was not good."

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

November 2019 (Figure 2): There were no SID events recorded by Nathan Towne at Magdalena, New Mexico for the month of November, and one B class flare was right at the terminator on the 18th of November. (Please note the y-axis values in these SID graphs are non-dimensional.)

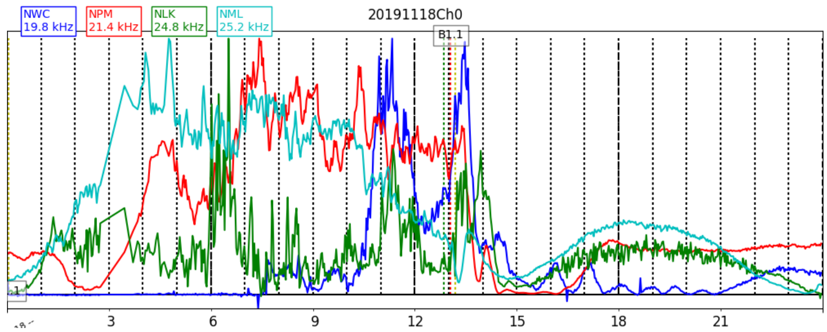

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In November 2019 we had 16 AAVSO SID observers who submitted VLF data as listed in Table 1. There were no observers who recorded SID events this month, which matched to GOES-15 XRA and FLA events.

Table 1: 201911 VLF Observers

Observer	Code	Stations
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
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	HWU NAU
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 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.

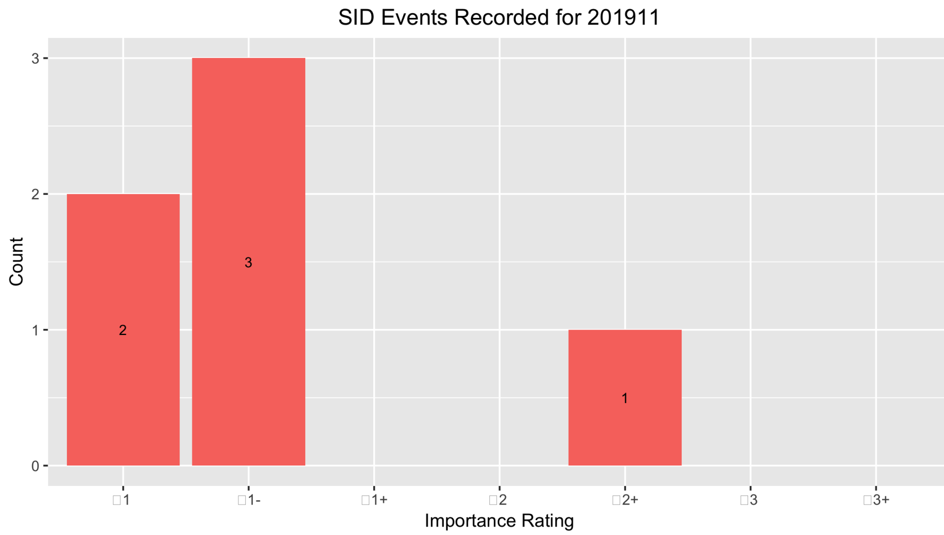

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In November 2019, there were two B class and four A class flares recorded from GOES-15. A little more flaring this month compared to last. There were 25 days this month with no GOES-15 reports of flares (see Figure 4).

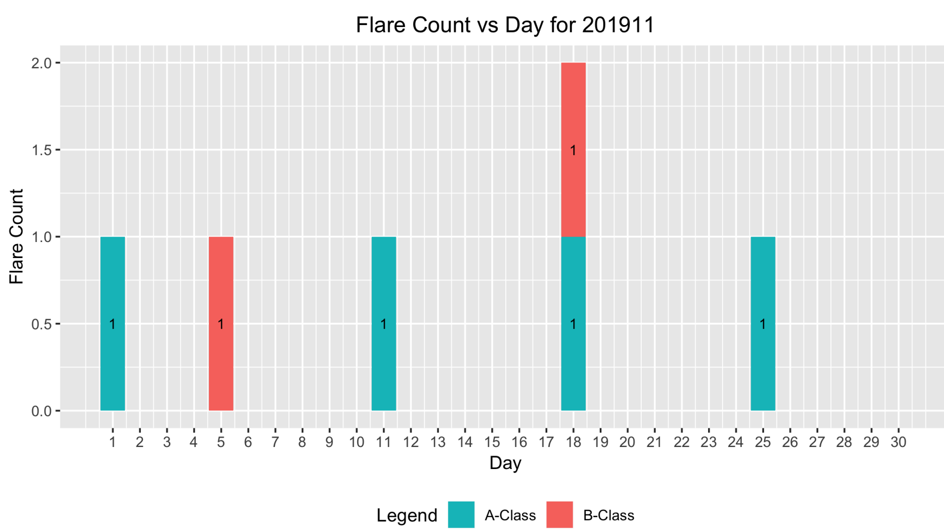

Figure 4: GOES - 15 XRA flares

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 2019. These counts are reported by the day of the month. 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.

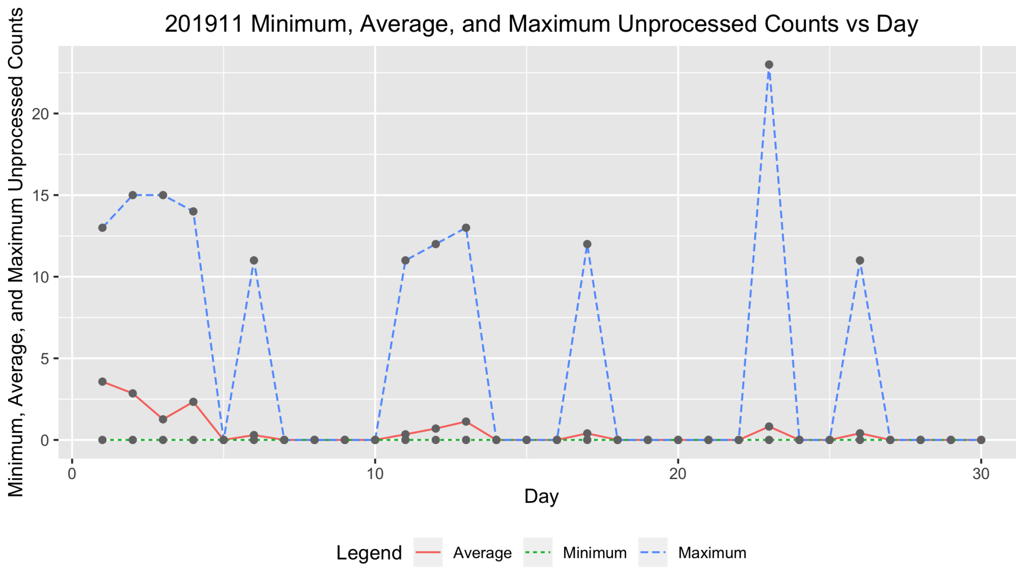

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

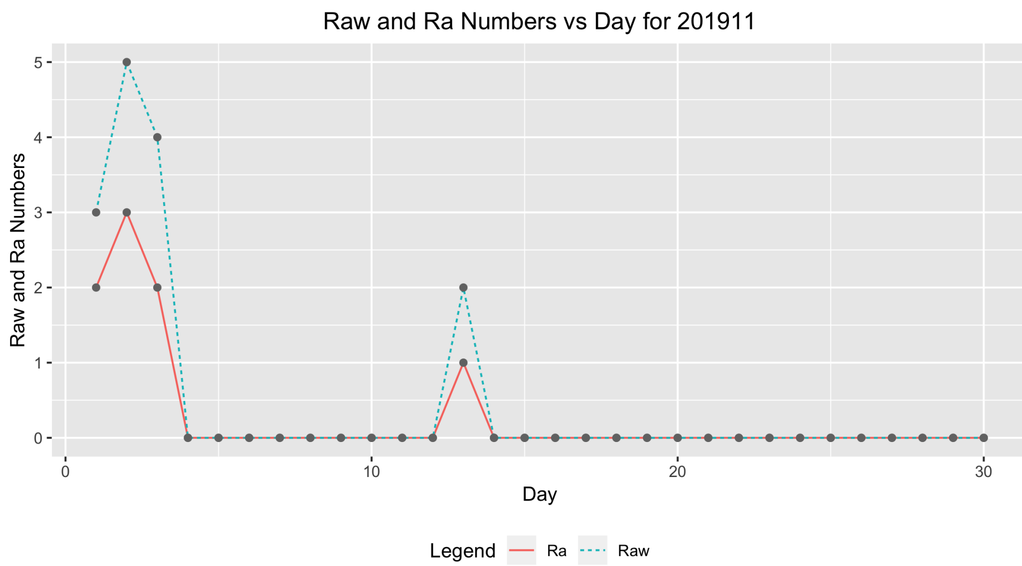

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 group selection, 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 of the observation (column 1), the Number of Observations (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 201911 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	35	3	2
2	34	5	3
3	38	4	2
4	36	0	0
5	35	0	0
6	37	0	0
7	29	0	0
8	36	0	0
9	33	0	0
10	32	0	0
11	32	0	0
12	33	0	0
13	32	2	1
14	27	0	0

Continued

Table 2: 201911 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	27	0	0
16	37	0	0
17	30	0	0
18	32	0	0
19	28	0	0
20	31	0	0
21	25	0	0
22	25	0	0
23	28	0	0
24	29	0	0
25	32	0	0
26	27	0	0
27	23	0	0
28	16	0	0
29	35	0	0
30	35	0	0
Averages	31	0.5	0.3

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for November 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 57 and the total number of observations is 929.

Table 3: 201911 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	18	Alexandre Amorim
AJV	11	J. Alonso
ARAG	29	Gema Araujo
ASA	20	Salvador Aguirre
ATE	12	Teofilo Arranz Heras
BARH	16	Howard Barnes
BERJ	27	Jose Alberto Berdejo
BMF	22	Michael Boschat
BRAF	2	Raffaello Braga
BROB	25	Robert Brown
BSAB	22	Santanu Basu
CHAG	25	German Morales Chavez
CKB	18	Brian Cudnik

Continued

Table 3: 201911 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CNT	22	Dean Chantiles
CVJ	2	Jose Carvajal
DIVA	17	Ivo Demeulenaere
DJOB	10	Jorge del Rosario
DMIB	15	Michel Deconinck
DUBF	24	Franky Dubois
EHOA	19	Howard Eskildsen
ERB	14	Bob Eramia
FERJ	6	Javier Ruiz Fernandez
FLET	20	Tom Fleming
FLF	1	Fredirico Luiz Funari
FUJK	25	K. Fujimori
HAYK	13	Kim Hay
HMQ	15	Mark Harris
HOWR	18	Rodney Howe
HRUT	22	Timothy Hrutkay
JDAC	9	David Jackson
JGE	1	Gerardo Jimenez Lopez
KAND	28	Kandilli Observatory
KAPJ	11	John Kaplan
KNJS	30	James & Shirley Knight
KROL	11	Larry Krozel
LEVM	19	Monty Leventhal
LGEC	9	Georgios Lekkas
LKR	6	Kristine Larsen
MARC	3	Arnaud Mengus
MCE	18	Etsuiku Mochizuki
MILJ	10	Jay Miller
MJAF	29	Juan Antonio Moreno Quesada
MJHA	27	John McCammon
MUDG	7	George Mudry
MWU	15	Walter Maluf
OAAA	21	Al Sadeem Astronomy Observatory
ONJ	9	John O'Neill
SDOH	30	Solar Dynamics Obs - HMI
SNE	4	Neil Simmons
SONA	4	Andries Son
STAB	23	Brian Gordon-States
SUZM	26	Miyoshi Suzuki
TESD	25	David Teske
TST	7	Steven Toothman
URBP	8	Piotr Urbanski
VARG	29	A. Gonzalo Vargas

Continued

Table 3: 201911 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
WILW	20	William M. Wilson
Totals	929	57

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

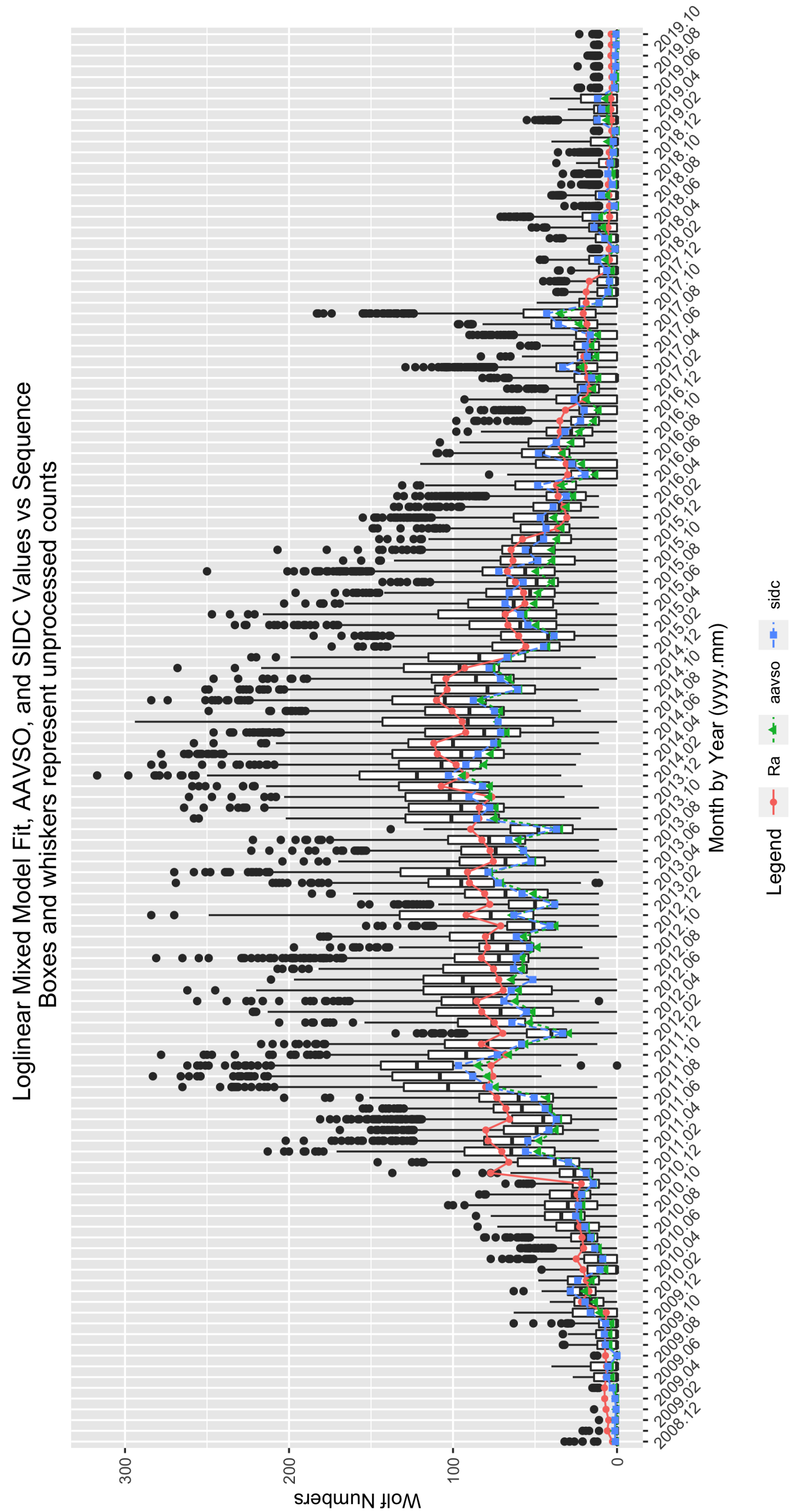

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels