Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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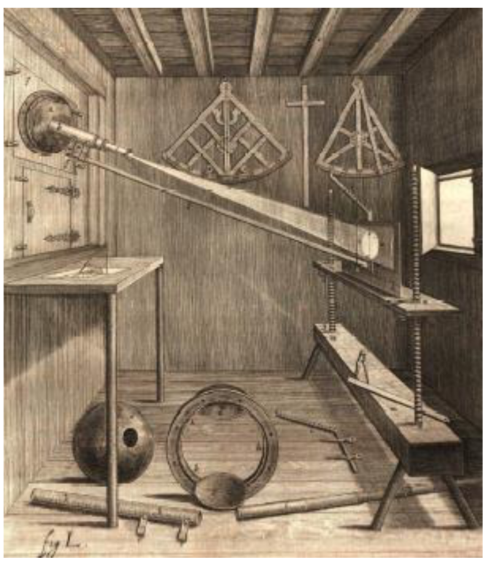
The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots, and the VLF radio recordings of SID Events in the ionosphere. Section 1 gives contributions by our members. The sudden ionospheric disturbance report is in Section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

1 Solar projection observatory, Hevelius, circa 1679.



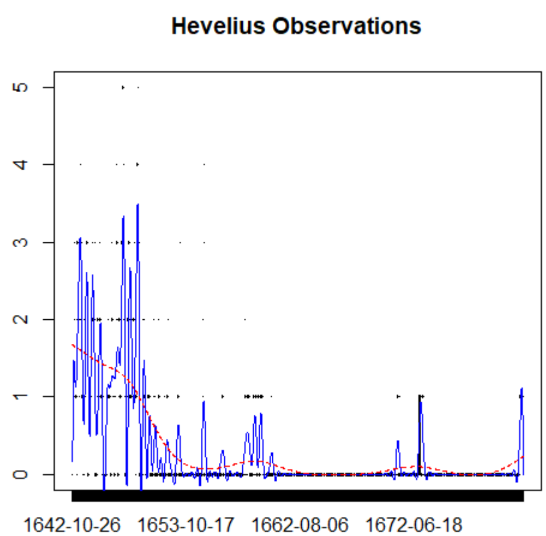


Figure 1: Astronomical instruments for solar observations used by Hevelius from his book Machina Coelestis (1679) (Courtesy of Library of the Astronomical Observatory of the Spanish Navy). Hevelius took 1672 observations from 1642 to 1684 (right panel).

For further reading: (`https://www.researchgate.net/publication/308127781_A_Revised_Collection_of_Sunspot_Group_Numbers`) and (`www.sidc.be/silso/groupnumberv3`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

September 2018 (Figure 2): Sometimes, as recorded here in Fort Collins, Colorado, I can pick up NWC (19.8 kHz) from the North West Cape in Australia, however it is a very noisy signal, but the small A1.0 flare shows a small detection from NWC. NWC would be the only transmitter to detect a flare during the night-time hours here in Fort Collins, CO.

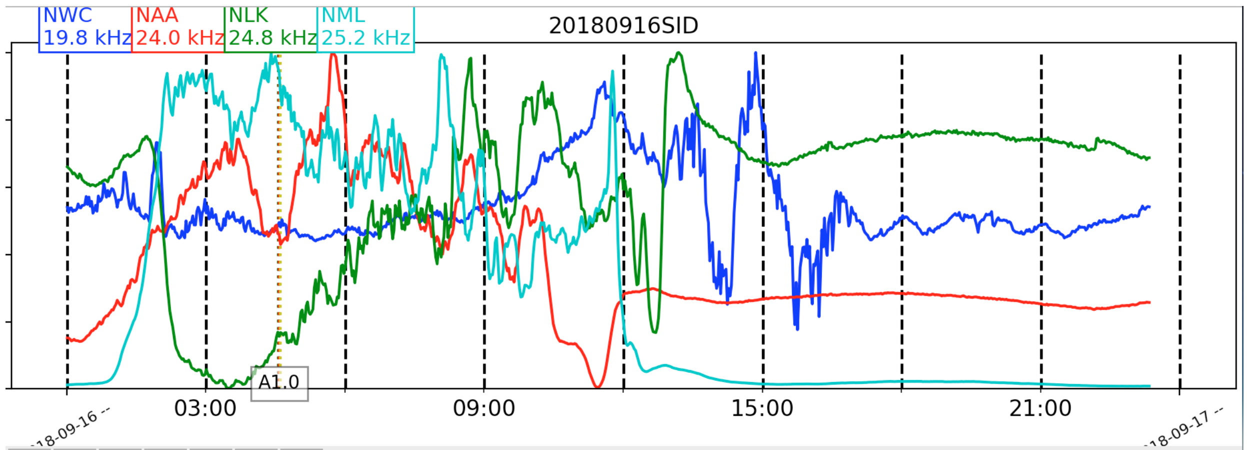


Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

This is an interesting observer from long ago, in Australia: "Overlooked No More: Ruby Payne-Scott, Who Explored Space With Radio Waves" Payne-Scott helped establish the field of radio astronomy by using radio waves to detect solar bursts, but she was forced to resign after she got married. (`https://www.nytimes.com/2018/08/29/obituaries/ruby-payne-scott-overlooked.html`)

In September 2018 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1. Not one of these observers recorded any SID events.

Table 1: 201809 VLF Observers

Observer	Code	Stations
A McWilliams	A94	NML
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
J Karlovsky	A131	NSY ICV
S Aguirre	A138	NPM
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
L Ferreira	A149	NWC
A Maevsky	A151	DHO GQD ICV

Figure 3: Pi 0 computer in the foreground, and Xonar sound card.

Figure 3, shows the receiver running on a Pi 0 computer and the Xonar sound card to record the NWC transmission, a possible detection of the A1.0 GOES-15 flare on September 16th.

2.3 Solar Flare Summary from GOES-15 Data

In September 2018, There were six solar flare events. One B class and 5 A class flares. Hardly any flaring this month compared to last month. There were 24 days this month with no GOES-15 reports of flares. (see Figure 4).

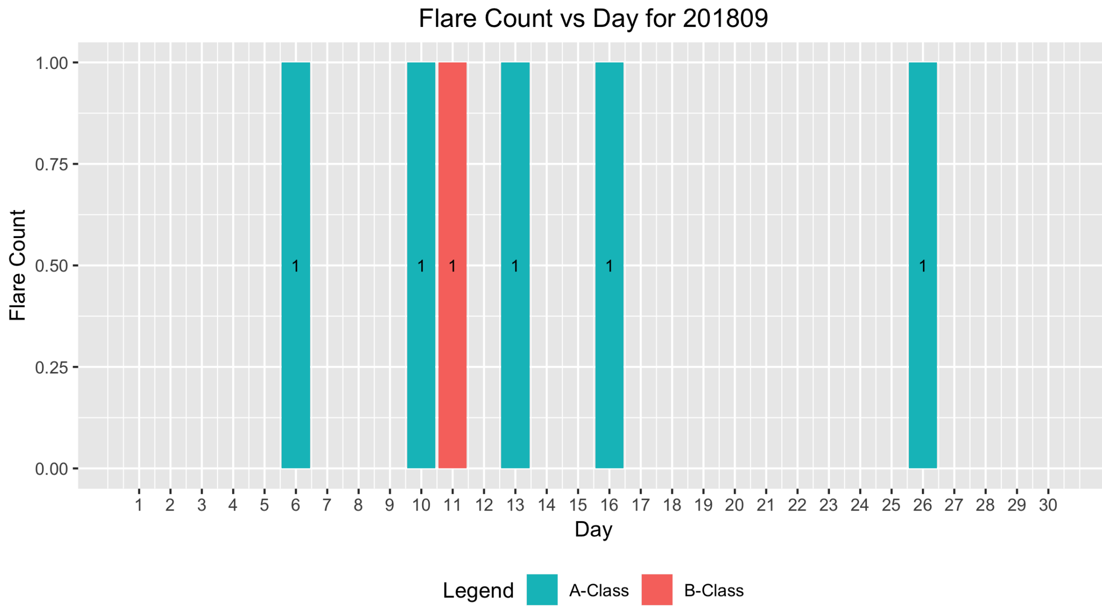


Figure 4: GOES - 15 XRA flares

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 September 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.

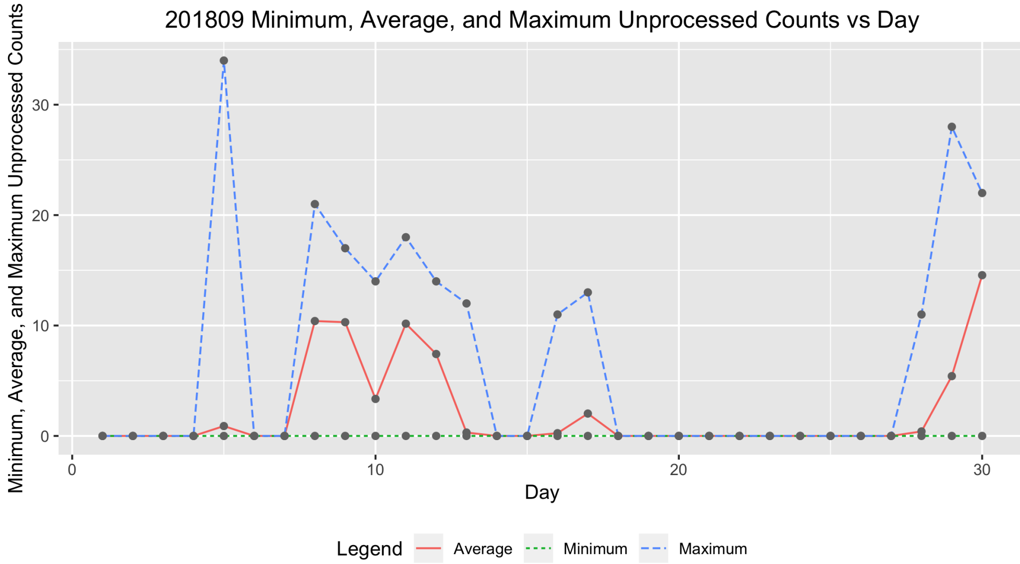


Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

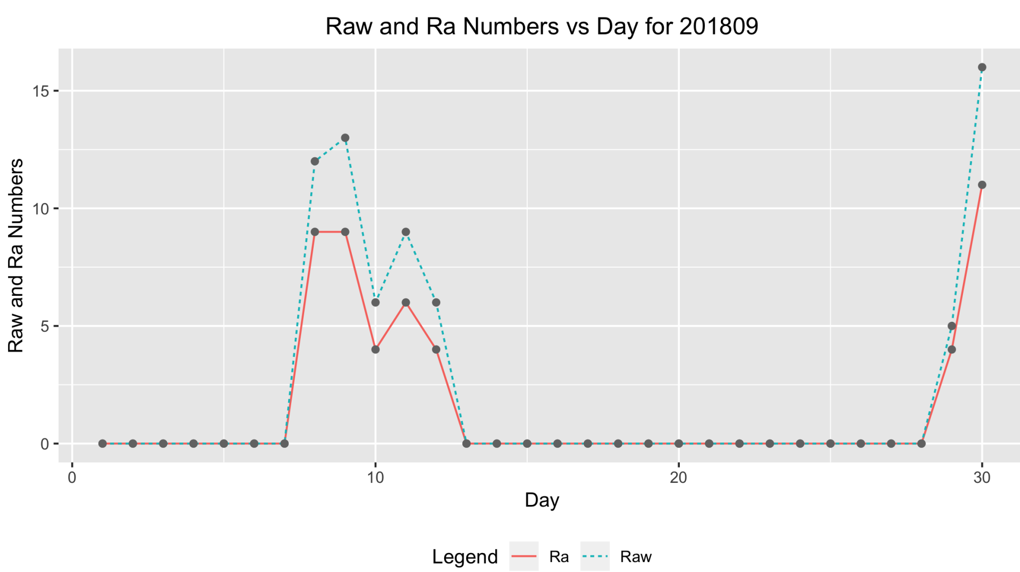


Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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.

Table 2: 201809 American Relative Sunspot Numbers (R_a)

Day	NumObs	Raw	R_a
1	36	0	0
2	41	0	0
3	41	0	0
4	36	0	0
5	38	0	0
6	38	0	0
7	35	0	0
8	37	12	9
9	40	13	9
10	34	6	4
11	30	9	6
12	31	6	4
13	39	0	0
14	35	0	0
15	37	0	0
16	44	0	0
17	38	0	0
18	34	0	0
19	40	0	0
20	31	0	0
21	32	0	0
22	36	0	0
23	41	0	0
24	39	0	0
25	30	0	0
26	32	0	0
27	33	0	0
28	27	0	0
29	36	5	4
30	34	16	11
Averages	35.8	2.2	1.6

3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations (NumObs) submitted for September 2018, and the observer's name (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 1075.

Table 3: 201809 Number of observations by observer

Obs	NumObs	Name
AAP	1	A. Patrick Abbott
AAX	14	Alexandre Amorim
AJV	20	J. Alonso
ARAG	30	Gema Araujo
ASA	28	Salvador Aguirre
ATE	6	Teofilo Arranz Heras
BARH	12	Howard Barnes
BATR	8	Roberto Battaiola
BERJ	30	Jose Alberto Berdejo
BLAJ	12	John A. Blackwell
BMF	24	Michael Boschat
BRAD	27	David Branchett
BRAF	20	Raffaello Braga
BROB	30	Robert Brown
BSAB	22	Santanu Basu
CHAG	30	German Morales Chavez
CIOA	24	Ioannis Chouinavas
CKB	13	Brian Cudnik
CNT	24	Dean Chantiles
DEMF	14	Frank Dempsey
DJOB	12	Jorge del Rosario
DMIB	29	Michel Deconinck
DROB	6	Bob Dudley
DUBF	28	Franky Dubois
EHOA	9	Howard Eskildsen
ERB	20	Bob Eramia
FERJ	22	Javier Ruiz Fernandez
FLET	19	Tom Fleming
FLF	13	Fredirico Luiz Funari
FUJK	16	K. Fujimori
HAYK	16	Kim Hay
HIVB	1	Ivan Hajdinjak
HOWR	25	Rodney Howe
JDAC	5	David Jackson
JENS	1	Simon Jenner
JGE	8	Gerardo Jimenez Lopez
JPHA	5	Philip Jackman
KAND	23	Kandilli Observatory
KAPJ	25	John Kaplan
KNJS	30	James & Shirley Knight
KROL	20	Larry Krozel
LEVM	19	Monty Leventhal

Continued on next page

Table 3: 201809 Number of observations by observer

Obs	NumObs	Name
LRRA	9	Robert Little
MARE	10	Enrico Mariani
MCE	18	Etsuiku Mochizuki
MILJ	9	Jay Miller
MJHA	27	John McCammon
MUDG	13	George Mudry
ONJ	8	John O'Neill
RLM	12	Mat Raymonde
SDOH	30	Solar Dynamics Obs - HMI
SMNA	3	Michael Stephanou
SNE	4	Neil Simmons
SONA	20	Andries Son
STAB	28	Brian Gordon-States
SUZM	17	Miyoshi Suzuki
TESD	21	David Teske
TPJB	2	Patrick Thibault
TST	13	Steven Toothman
URBP	26	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VRUA	1	Ruben Verboven
WAU	1	Artur Wargin
WCHD	14	Charles White
WILW	20	William M. Wilson
Totals	1075	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 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

Reporting Addresses

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

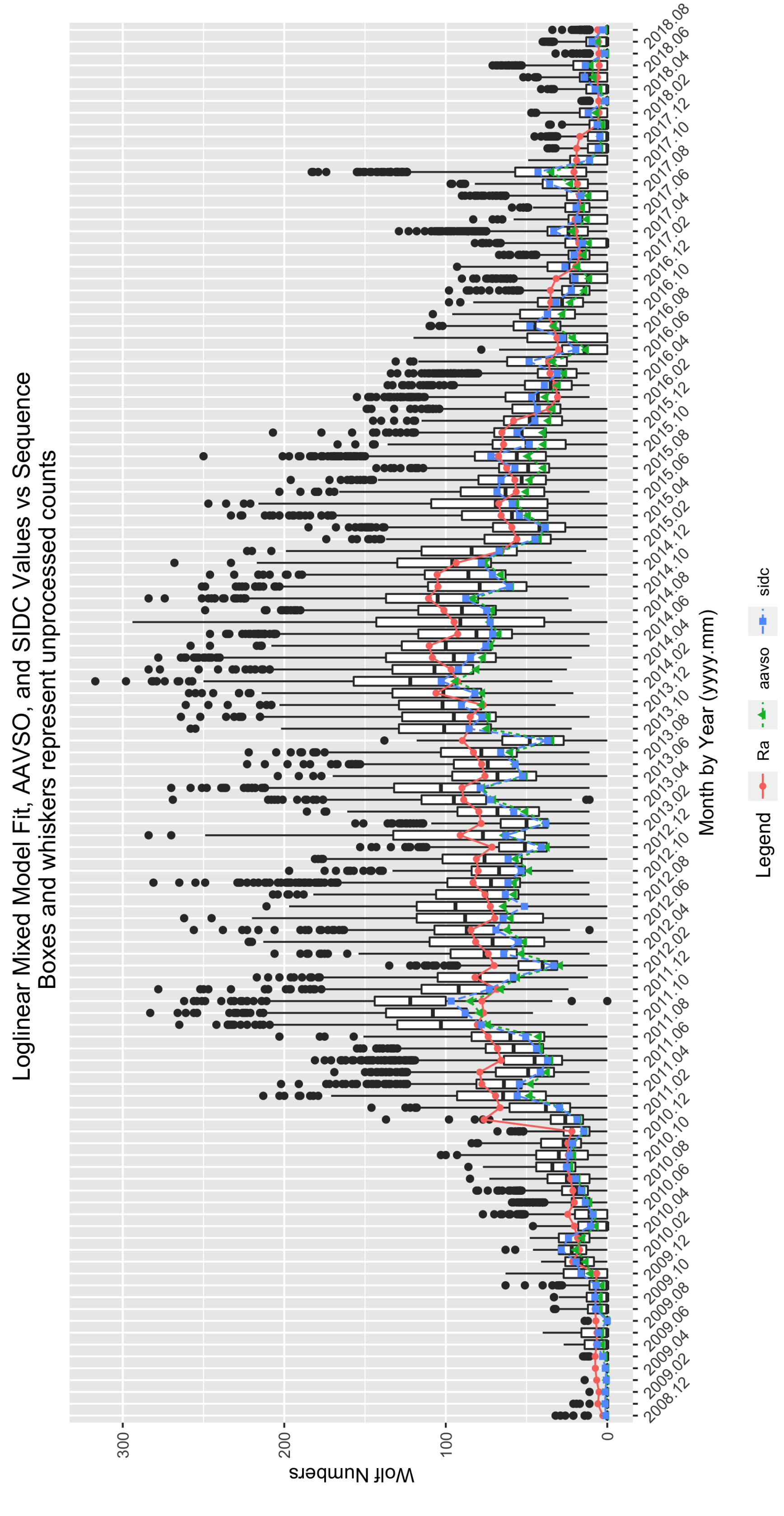


Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels