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 Do the Schwabe cycle durations depend on the number of zero sunspot days in that cycle?

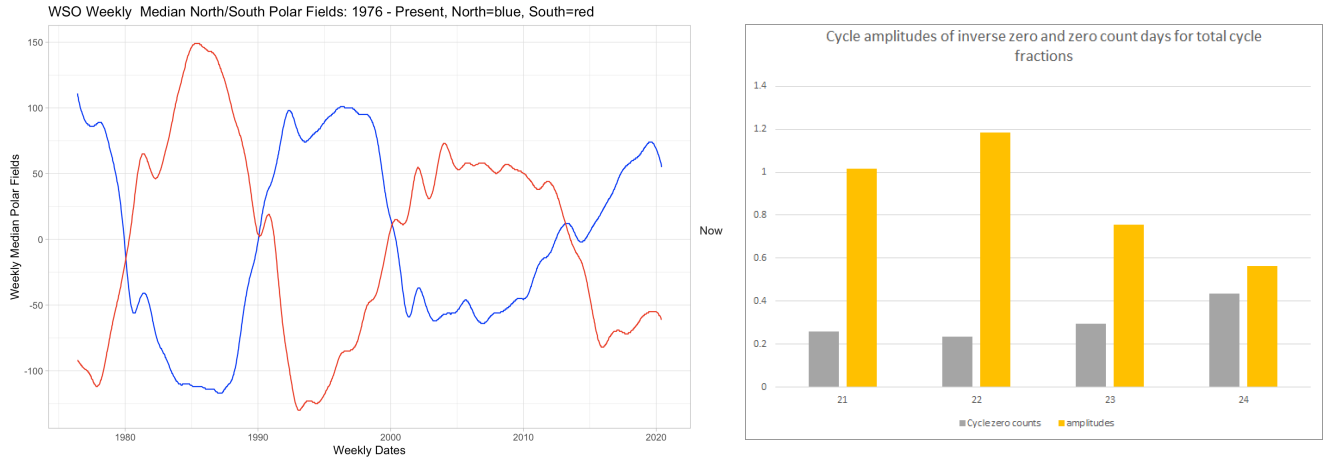

Figure 1: (left) Wilcox Solar Observatory (WSO) Solar Polar fields (PF) show where the cross-over of north and south PF determines the start of next solar cycle, (right) The association of the number of zero sunspot days during these cycle minimums (cycles 21 - 24) and how the amplitudes (yellow bars) of these cycles appear to match the declining amplitudes of the WSO PF data.

These WSO data show how the amplitudes of solar cycles 21 through 24 decline as the cross-over or duration of the cycle increases in years. If we count the number of zero days (no sunspots recorded by the AAVSO observers during solar minimums), we can show the increase of zero counts for each solar cycle (grey bars on right graph). The inverse fraction of these days (yellow bars) show declining amplitudes that match the declining amplitudes of the WSO PF. Perhaps we have a proxy (zero sunspot days) for the Schwabe cycles? The WSO Polar data come from here: (`https://wso.stanford.edu`). Further reading on polar fields: (`https://solen.info/solar/polarfields/polar.html`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

August 2020 (Figure 2): There were no SID events recorded here in Fort Collins, Colorado for the month of August. There was one C2 flare on the 15th of August, however it was during the night time. (Please note the y-axis values in these SID graphs are non-dimensional.)

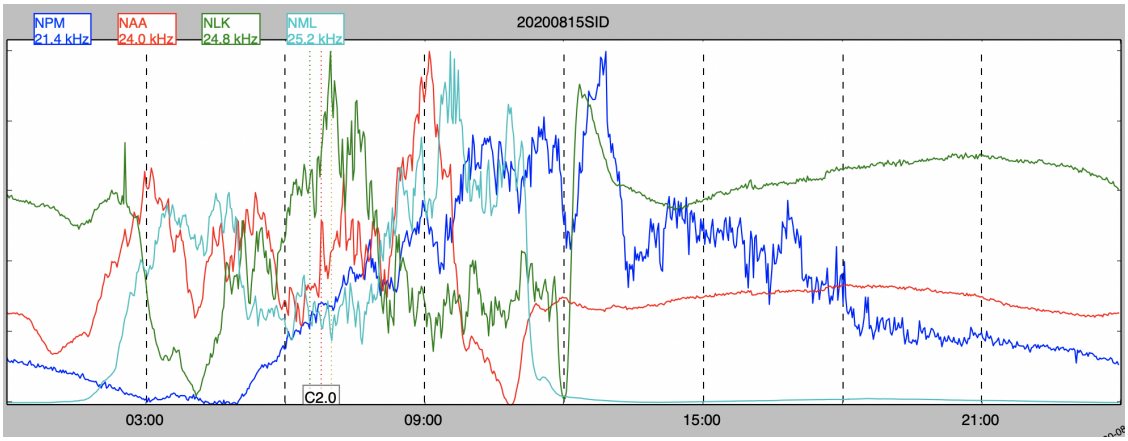

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In August 2020 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1. Frank Adamson (A122) recorded the C2 flare and a SID event this month from the NWC transmitter in Australia, which matched to GOES-16 XRA and FLA events.

Table 1: 202008 VLF Observers

Observer	Code	Stations
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
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-16 Data

In August 2020, there were two A-class flares recorded from GOES-16. Far less flaring this month compared to last. There were 29 days this month with no GOES-16 reports of flares (see Figure 4).

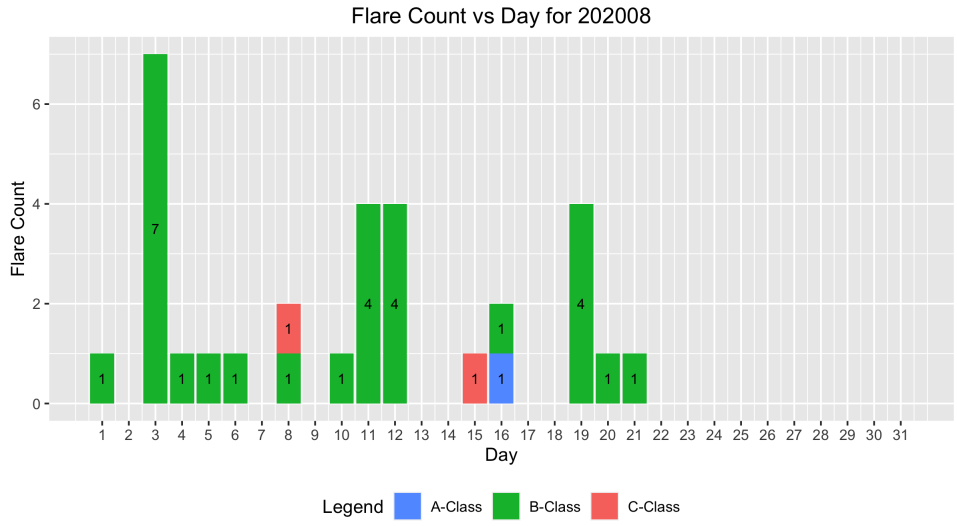

Figure 4: GOES-16 XRA flares

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 an 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 August 2020. 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.

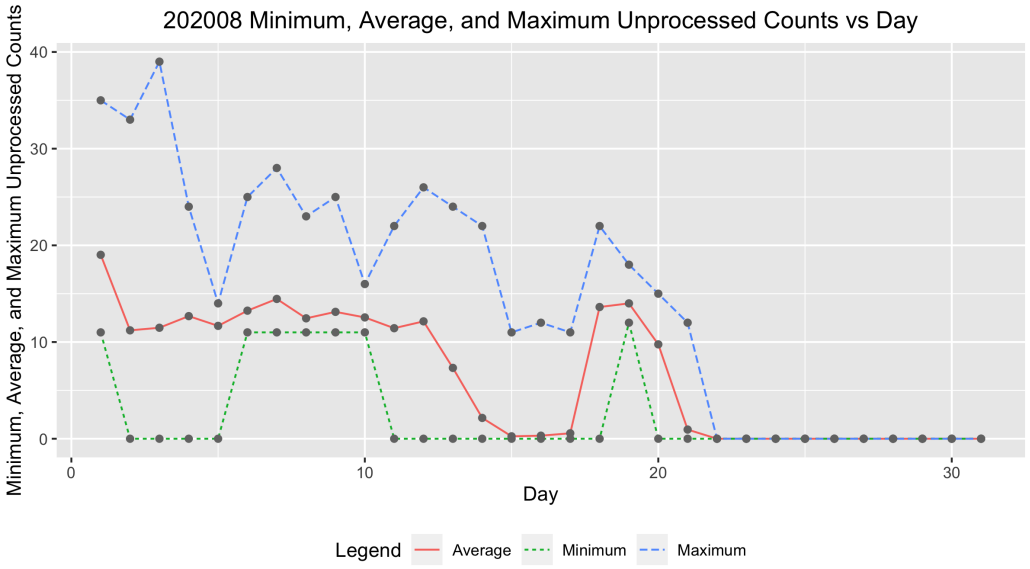

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

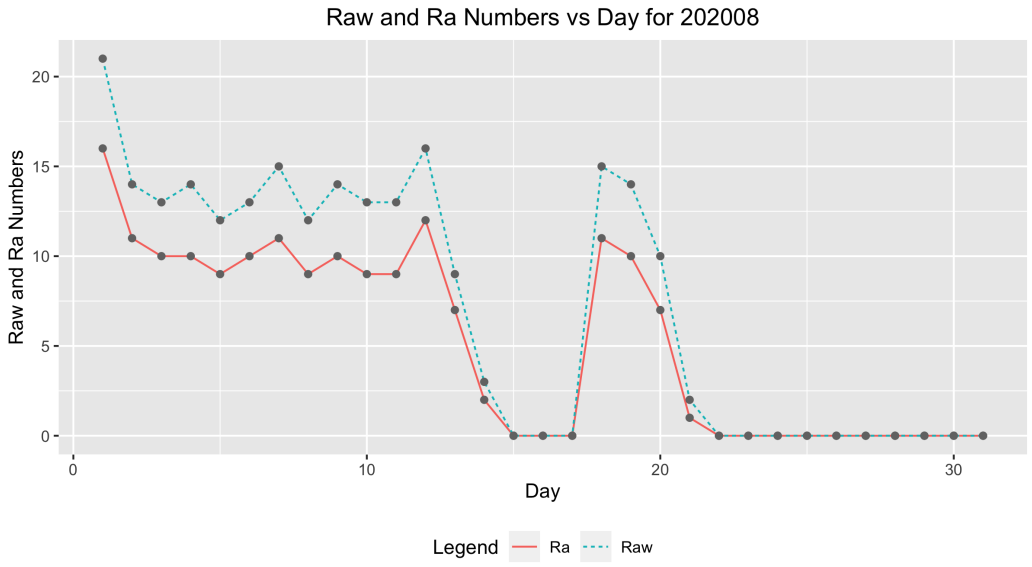

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 Observers recording that day (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 202008 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	47	21	16
2	43	14	11
3	46	13	10
4	47	14	10
5	55	12	9
6	49	13	10
7	48	15	11
8	42	12	9
9	49	14	10
10	44	13	9
11	44	13	9
12	43	16	12
13	46	9	7
14	46	3	2

Continued

Table 2: 202008 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	44	0	0
16	38	0	0
17	39	0	0
18	45	15	11
19	44	14	10
20	42	10	7
21	38	2	1
22	45	0	0
23	44	0	0
24	45	0	0
25	45	0	0
26	39	0	0
27	40	0	0
28	41	0	0
29	39	0	0
30	47	0	0
31	45	0	0
Averages	44.2	7.2	5.3

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for August 2020, and the Observer Name (column 3). The final rows of the table give the total number of observers who submitted sunspot counts (68), and the total number of observations submitted (1398).

Table 3: 202008 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	23	Alexandre Amorim
AJV	18	J. Alonso
ARAG	31	Gema Araujo
ASA	23	Salvador Aguirre
ATE	30	Teofilo Arranz Heras
BARH	13	Howard Barnes
BATR	10	Roberto Battaiola
BERJ	30	Jose Alberto Berdejo
BLAJ	15	John A. Blackwell
BMF	29	Michael Boschat
BRAF	16	Raffaello Braga
BROB	29	Robert Brown

Continued

Table 3: 202008 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CHAG	30	German Morales Chavez
CIOA	19	Ioannis Chouinavas
CKB	28	Brian Cudnik
CNT	30	Dean Chantiles
CVJ	18	Jose Carvajal
DEMF	9	Frank Dempsey
DIVA	19	Ivo Demeulenaere
DJOB	17	Jorge del Rosario
DMIB	31	Michel Deconinck
DROB	6	Bob Dudley
DUBF	29	Franky Dubois
EHOA	20	Howard Eskildsen
ERB	25	Bob Eramia
FERJ	25	Javier Ruiz Fernandez
FLET	30	Tom Fleming
FUJK	25	K. Fujimori
GIGA	29	Igor Grgeda Mndez
HALB	22	Brian Halls
HAYK	21	Kim Hay
HMQ	29	Mark Harris
HOWR	27	Rodney Howe
HRUT	20	Timothy Hrutkay
JDAC	2	David Jackson
JENS	3	Simon Jenner
JGE	10	Gerardo Jimenez Lopez
KAND	23	Kandilli Observatory
KAPJ	19	John Kaplan
KNJS	30	James & Shirley Knight
LEVM	25	Monty Leventhal
LGEC	6	Georgios Lekkas
LKR	1	Kristine Larsen
LRRA	26	Robert Little
MARC	12	Arnaud Mengus
MARE	10	Enrico Mariani
MCE	31	Etsuiku Mochizuki
MILJ	20	Jay Miller
MJHA	28	John McCammon
MUDG	14	George Mudry
MWU	26	Walter Maluf
OAAA	21	Al Sadeem Astronomy Observatory
ONJ	23	John O'Neill
PEKT	7	Riza Pektas
SDOH	31	Solar Dynamics Obs - HMI

Continued

Table 3: 202008 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SJAH	27	Jim Soos
SNE	20	Neil Simmons
SONA	23	Andries Son
STAB	29	Brian Gordon-States
SVAE	1	Valery Stanimirov
TESD	29	David Teske
TPJB	2	Patrick Thibault
TST	28	Steven Toothman
URBP	24	Piotr Urbanski
VARG	31	A. Gonzalo Vargas
VIDD	10	Daniel Vidican
WGI	5	Guido Wollenhaupt
WILW	25	William M. Wilson
Totals	1398	68

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 the paper, *A Generalized Linear Mixed Model for Enumerated Sunspots* (see 'GLMM06' in the sunspot counts research page at http://www.spesi.org/?page_id=65).

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.

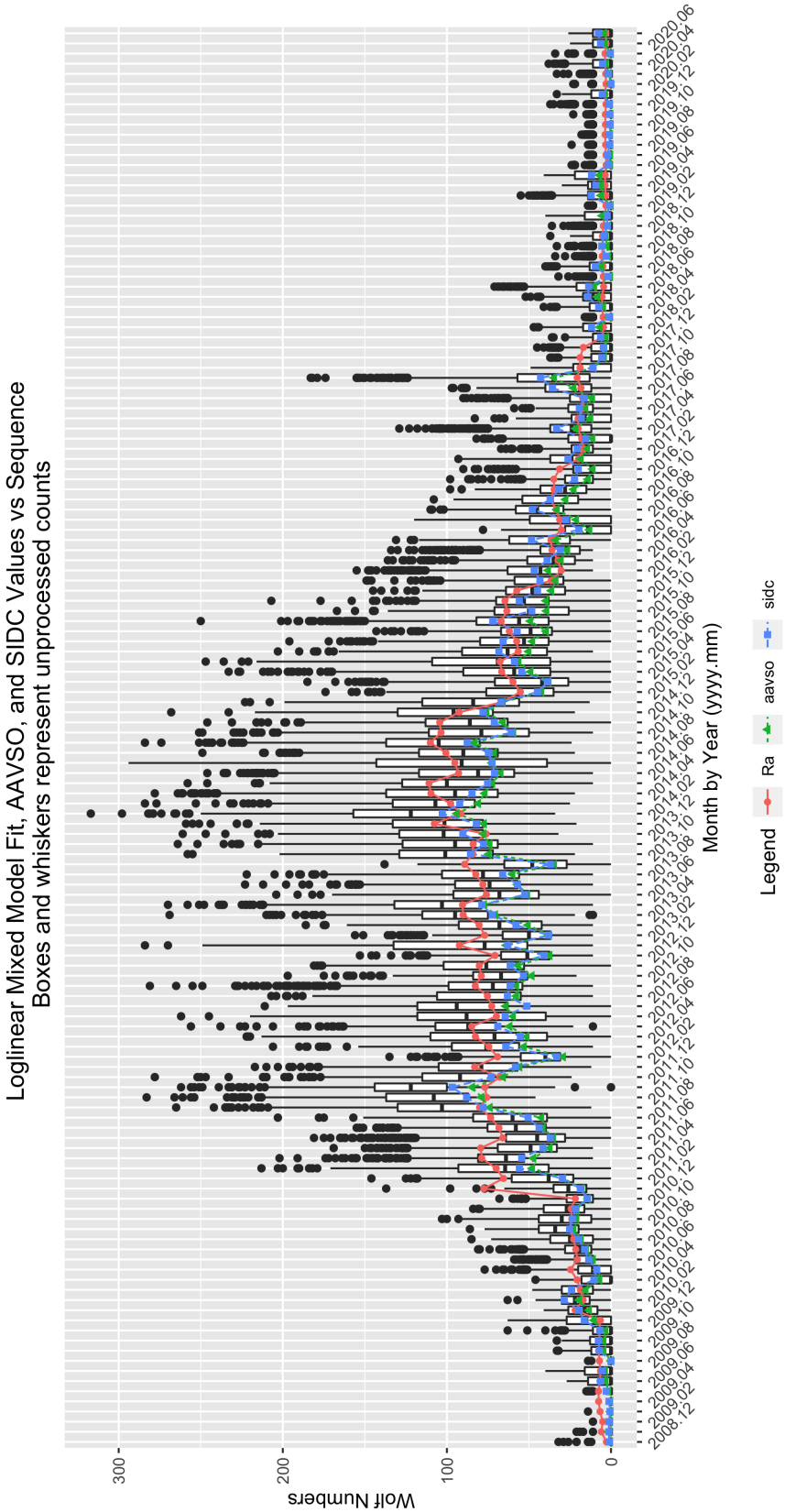

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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