Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 77 Number 7 July 2021

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 A rare high latitude sunspot AR2844

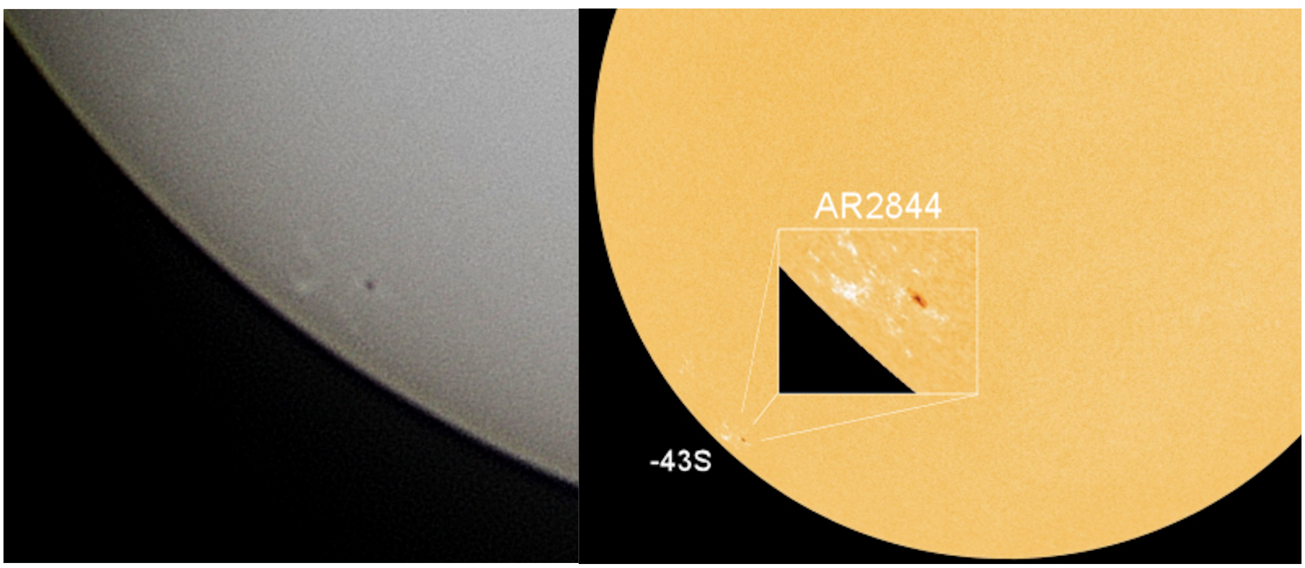

Figure 1: Detail blowups. Left panel is AAVSO observer Filipp Romanov's image of AR2844 in visual 'white light;' right panel is spaceweather.com's satellite image of AR2844 (`https://spaceweather.com/archive.php?view=1&day=17&month=07&year=` 2021).

"On the left panel is a rare high-latitude sunspot AR2844 on July 17, 2021, 07:11 UT. This image is result of stacking of 100 frames from the video (taken by me from Yuzhno-Morskoy, near Nakhodka, Russia) taken with my camera Canon IXUS 185 through the eyepiece of 60mm refractor, through the haze in the sky. With best regards, Filipp Romanov (AAVSO observer code RFDA)."

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

July 2021 (Figure 2): "Attached you can find as always the files with the results of my observations from last month. In addition I put a diagram what shows the situation on 3rd July with the first X-Class Flare in that cycle. I took that from the plot in the SuperSID-Software with three different stations/frequencies: HWU, FTA and GBZ. All three graphs show the flares on that day depending of their signal strength on my receiver. Kind regards Holger (A152)."

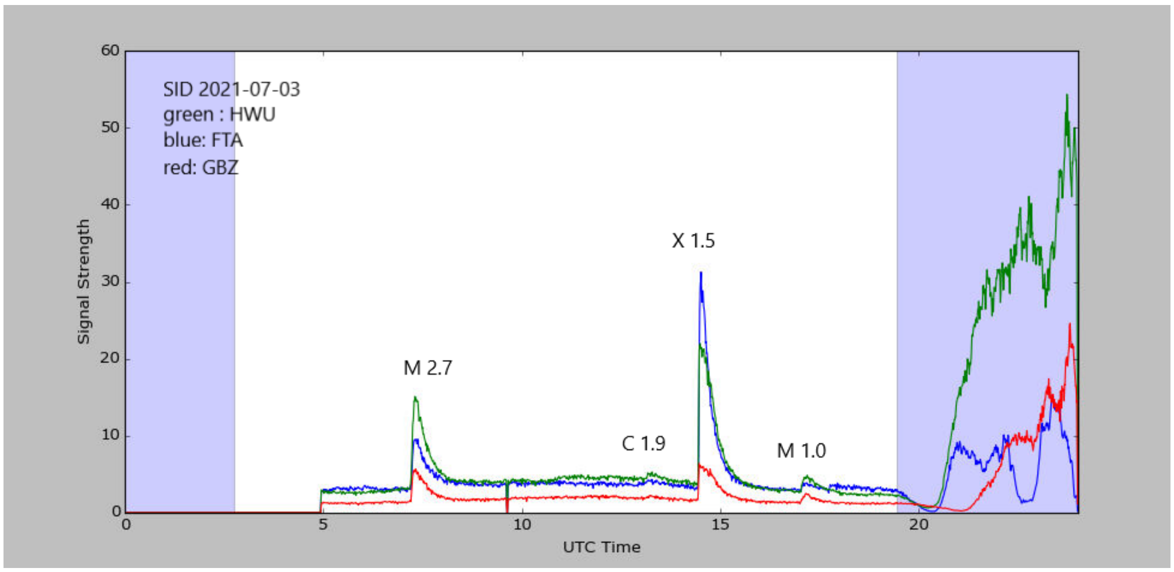

Figure 2: VLF recording on the 3rd of July from Frankfurt, Germany

2.2 SID Observers

In July 2021, 13 AAVSO SID observers submitted VLF data as listed in Table 1.

Table 1: 202107 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD
B Terrill	A120	NWC
F Adamson	A122	NWC
R Green	A134	NWC
G Silvis	A141	NAA NML NLK
K Menzies	A146	NAA
L Pina	A148	NML
J Wendler	A150	NAA
H Krumnow	A152	HWU FTA GBZ
J DeVries	A153	NML

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.

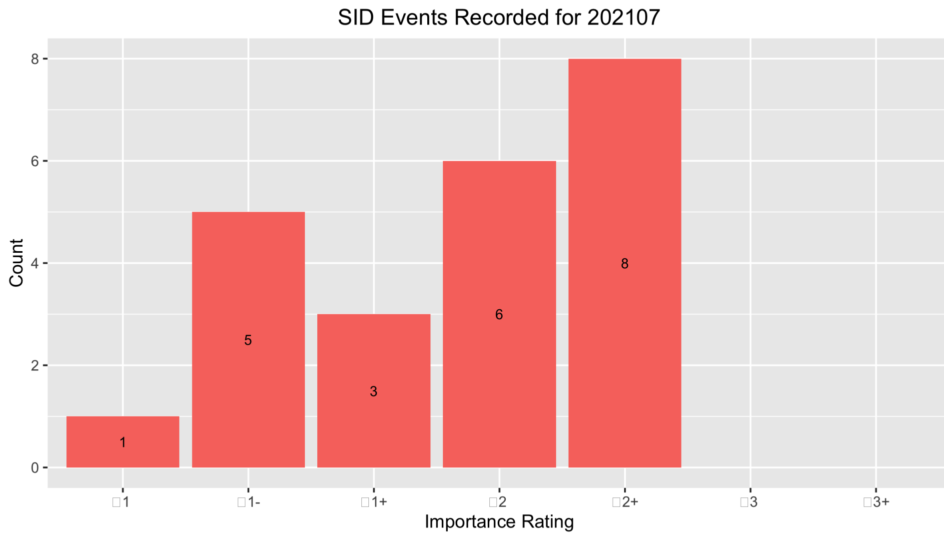

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In July 2021, there were 207 GOES-16 XRA flares: one X-class, three M-class, 22 C-class, and 181 B-class. Far more flaring this month than last, with only two days with no flares (Figure 4).

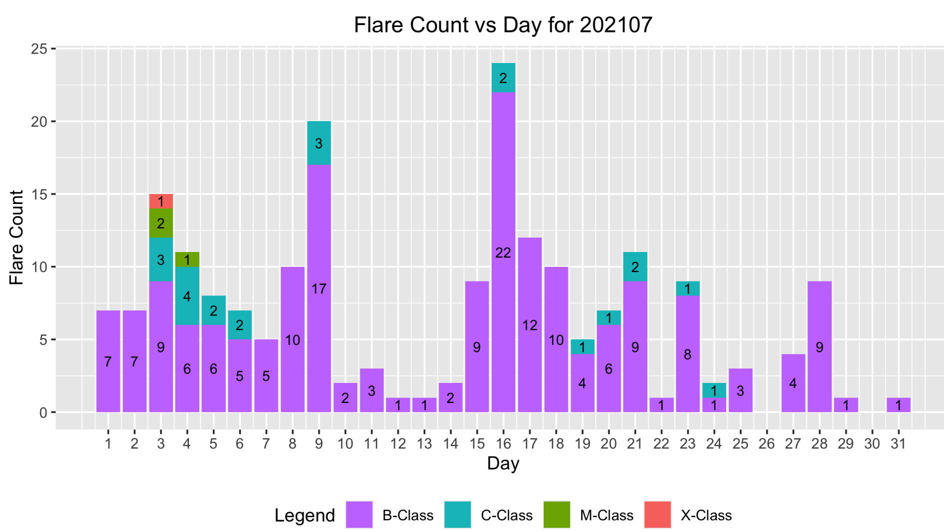

Figure 4: GOES-16 XRA flares

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 a Structured Query Language (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 July 2021. 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.

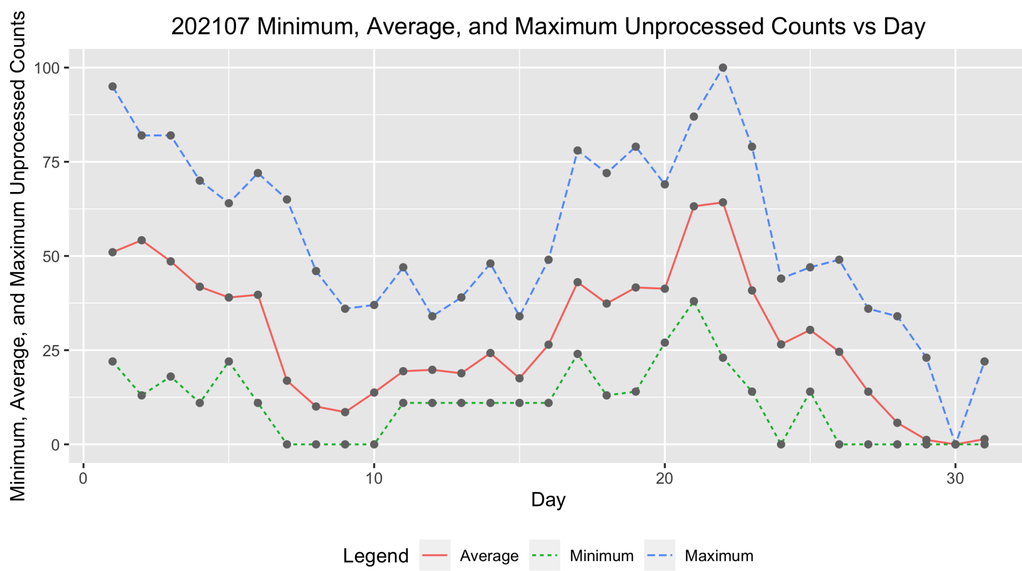

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

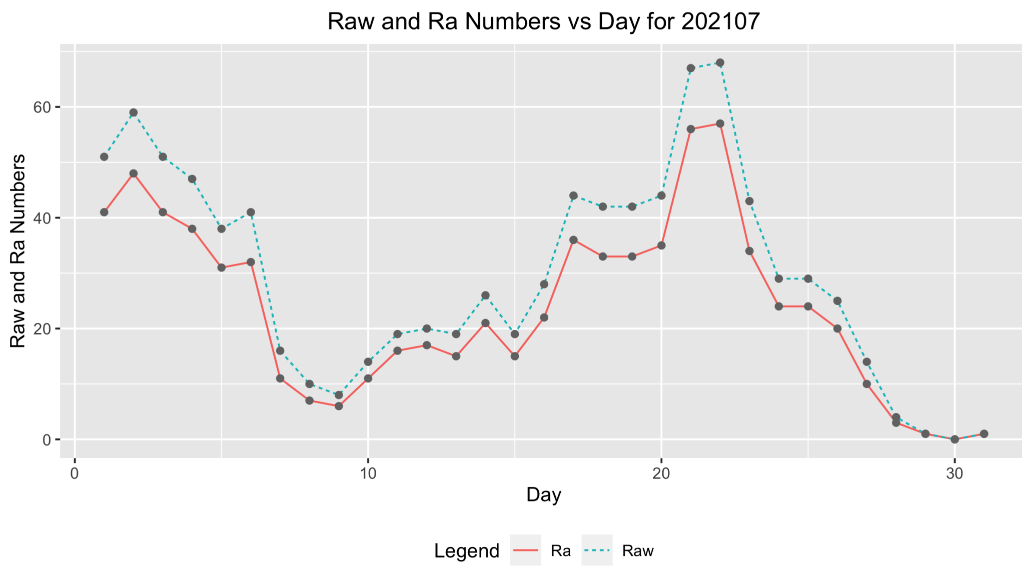

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202107 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	38	51	41
2	45	59	48
3	39	51	41
4	43	47	38
5	55	38	31
6	44	41	32
7	42	16	11
8	44	10	7
9	43	8	6
10	40	14	11
11	41	19	16
12	41	20	17
13	38	19	15
14	38	26	21

Continued

Table 2: 202107 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	45	19	15
16	41	28	22
17	50	44	36
18	51	42	33
19	42	42	33
20	42	44	35
21	46	67	56
22	48	68	57
23	41	43	34
24	41	29	24
25	40	29	24
26	44	25	20
27	40	14	10
28	40	4	3
29	38	1	1
30	41	0	0
31	41	1	1
Averages	42.6	29.6	23.8

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for July 2021, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (72), and total number of observations submitted (1322).

Table 3: 202107 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	18	Alexandre Amorim
AJV	20	J. Alonso
ARAG	31	Gema Araujo
ASA	16	Salvador Aguirre
ATE	29	Teofilo Arranz Heras
BATR	5	Roberto Battaiola
BERJ	24	Jose Alberto Berdejo
BLAJ	11	John A. Blackwell
BMF	24	Michael Boschat
BRAF	17	Raffaello Braga
BROB	30	Robert Brown
CKB	19	Brian Cudnik
CMOD	4	Mois Carlo

Continued

Table 3: 202107 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	29	Dean Chantiles
CVJ	13	Jose Carvajal
DARB	13	Aritra Das
DEMF	13	Frank Dempsey
DJOB	21	Jorge del Rosario
DMIB	31	Michel Deconinck
DROB	3	Bob Dudley
DUBF	26	Franky Dubois
EHOA	22	Howard Eskildsen
ERB	28	Bob Eramia
FDAE	2	David Fox
FERJ	23	Javier Ruiz Fernandez
FLET	25	Tom Fleming
GIGA	31	Igor Grageda Mendez
HALB	16	Brian Halls
HAYK	18	Kim Hay
HMQ	13	Mark Harris
HOWR	17	Rodney Howe
IEWA	27	Ernest W. Iverson
JDAC	9	David Jackson
JENJ	8	Jamey Jenkins
JENS	8	Simon Jenner
JGE	14	Gerardo Jimenez Lopez
KAMB	31	Amoli Kakkar
KAND	24	Kandilli Observatory
KAPJ	21	John Kaplan
KNJS	29	James & Shirley Knight
KZAD	28	Zachary Knoles
LEVM	23	Monty Leventhal
LGEC	3	Georgios Lekkas
LKR	3	Kristine Larsen
LRRA	24	Robert Little
MARC	4	Arnaud Mengus
MARE	10	Enrico Mariani
MILJ	20	Jay Miller
MJAF	31	Juan Antonio Moreno Quesada
MJHA	30	John McCammon
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MUDG	6	George Mudry
MWU	28	Walter Maluf
OAAA	17	Al Sadeem Astronomy Obs.
ONJ	17	John O'Neill

Continued

Table 3: 202107 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
PEKT	5	Riza Pektas
RFDA	15	Filipp Romanov
SDOH	31	Solar Dynamics Obs - HMI
SNE	8	Neil Simmons
SONA	15	Andries Son
SQN	4	Lance Shaw
SVAE	1	Valery Stanimirov
TESD	26	David Teske
TPJB	2	Patrick Thibault
TST	29	Steven Toothman
URBP	30	Piotr Urbanski
VARG	31	A. Gonzalo Vargas
VIDD	23	Dan Vidican
WGI	8	Guido Wollenhaupt
WILW	15	William M. Wilson
WND	10	Denis Wallian
Totals	1322	72

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. For more details, *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 a rolling eleven-year (132-month) window beginning within the 24th solar cycle and ending with last month's sunspot 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 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 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.

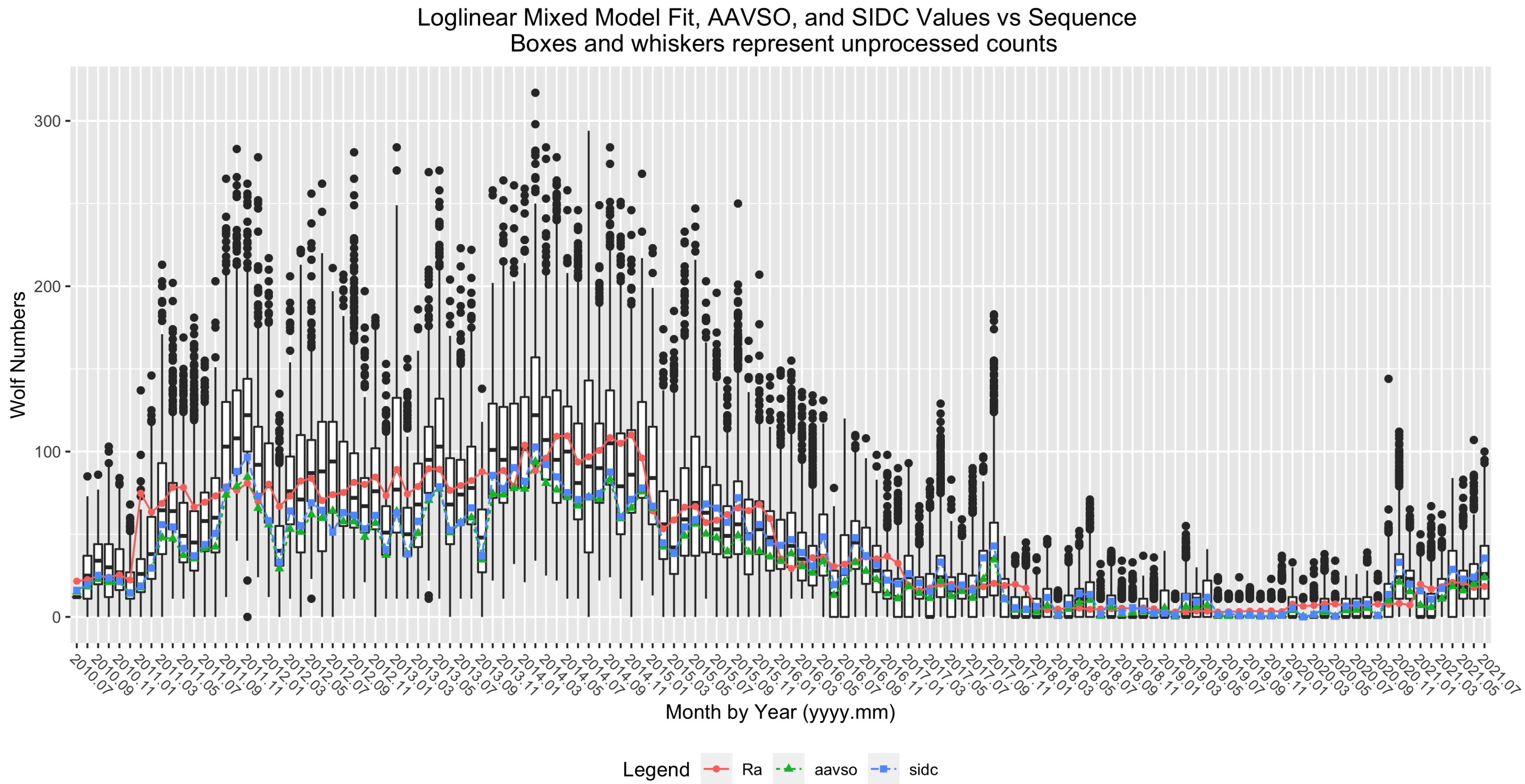

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

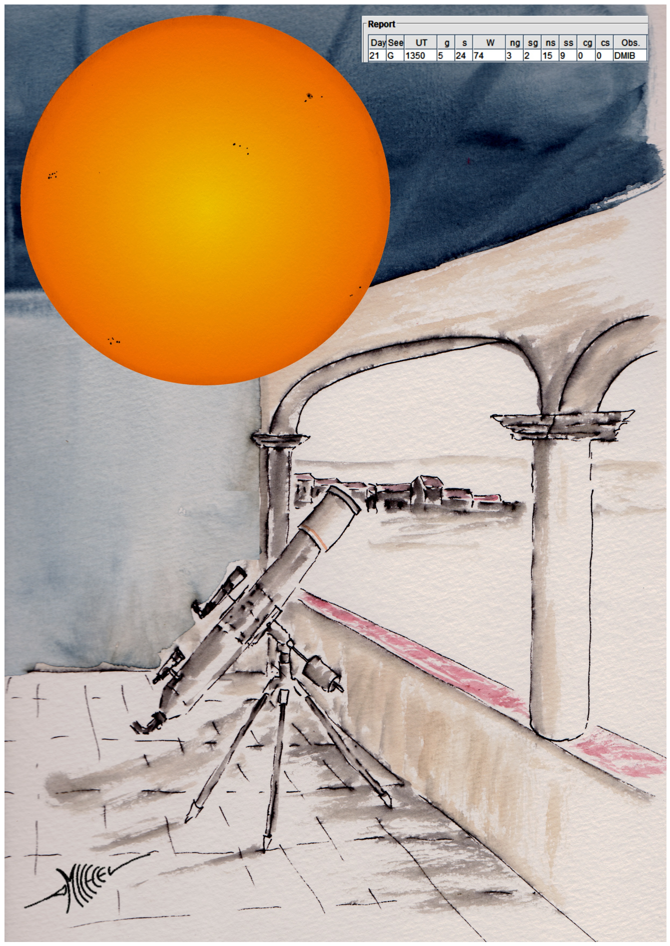

Figure 8: From Michel Deconinck (DMIB) a sketch and sun image. "Here I join my watercolor made from my terrace" (https://www.aquarellia.com).

Date: the target was sketched, July 21 2021 - 13h50 UTC.
Location when sketching: Artignosc-sur-Verdon - Provence - France.
Equipment: Bresser refractor - as shown -152/1200 EP zoom here 24mm, filter white light.
Magnification used: 50x.
Sketching medium: pigment ink and coffee watercolor; for the sun, alizarine crimson and orange.
Conditions (good seeing, transparency).
Quality AAVSO Solar: 3/4, with some light clouds, temperature 32C.