Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 185 Alewife Brook Parkway,
Cambridge, MA 02138 USA

Web: https://www.aavso.org/solar-bulletin
Email: solar@aavso.org
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The Solar Bulletin of the AAVSO is a summary of each months solar activity recorded by visual solar observers counts of group and sunspots, and the very low frequency (VLF) radio recordings of SID Events in the ionosphere. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 SILSO International Sunspot Number (ISN), re-calibration project

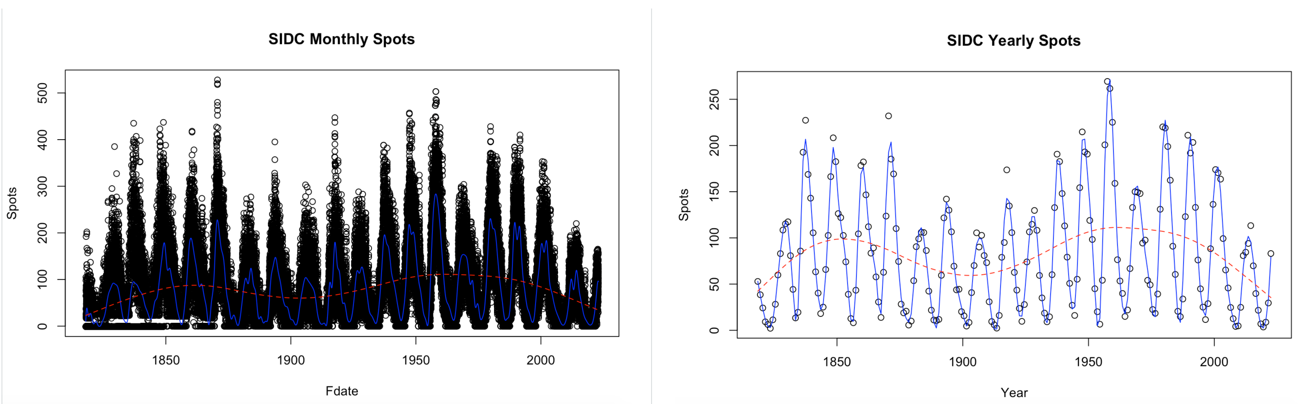


Figure 1: SIDC Monthly, back to 1818 (left), and SIDC Yearly, back to 1818 (right).

SILSO is re-constucting (re-calibrating) the ISN back at least 200 years, to 1818, as shown in its monthly (2023a) and yearly (2023b) plots with spline fits. Re-constructing and re-calibrating these past solar cycles is a complicated project requiring investigation of many ancient observations and historical observer archives (Svalgaard, 2023).

1.1 AAVSO and SIDC data for 2022

Max Surlaroute (MMAY) sends this data table and sunspot evolution graph showing a comparison of the AAVSO observations and SIDC observations for last year, 2022 (Personal communication, January, 2023)

GLOBAL DATA SUNSPOTS FOR 2022 BY MONTH

MONTH	NUMBER OF DAYS	OBSERVERS AAVSO SOLAR SECTION						OBSERVERS INTERNATIONAL GROUP			
		TOTAL OBS	Mean / Day	Raw	Mean / Day	Ra	Mean / Day	TOTAL OBS	Mean / Day	Rint	Mean / Day
1	31	1164	37,5	1743	56,2	1362	43,9	1007	32,5	1673	54,0
2	28	1049	37,5	1778	63,5	1366	48,8	1044	37,3	1671	59,7
3	31	1079	34,8	2171	70,0	1809	58,4	1277	41,2	2432	78,5
4	30	1258	41,9	2099	70,0	1772	59,1	1237	41,2	2522	84,1
5	31	1292	41,7	2680	86,5	2249	72,5	1250	40,3	2992	96,5
6	30	1330	44,3	2044	68,1	1767	58,9	1403	46,8	2110	70,3
7	31	1272	41,0	2800	90,3	2379	76,7	1304	42,1	2832	91,4
8	31	1359	43,8	2311	74,5	1961	63,3	1289	41,6	2337	75,4
9	30	1077	35,9	2606	86,9	2177	72,6	1130	37,7	2890	96,3
10	31	1162	37,5	2505	80,8	2058	66,4	1028	33,2	2957	95,4
11	30	1023	34,1	2000	66,7	1629	54,3	881	29,4	2329	77,6
12	31	829	26,7	3562	114,9	2904	93,7	726	23,4	3505	113,1
Total 2022	365	*13894*	*38,1*	*28299*	*77,5*	*23433*	*64,2*	*13576*	*37,2*	*30250*	*82,9*
Mean		1157,8	38,1	2358,3	77,5	1952,8	64,2	1131,3	37,2	2520,8	82,9
Standard Deviation		154,4	5,0	511,5	15,7	439,2	13,5	199,0	6,5	547,9	16,9

Important Notes : For a given month, the same observer can be counted as many times as there are days in the month.

Sources : For Ra and Raw, Solar Bulletin, AAVSO Solar Section. [https://www.aavso.org/solar-bulletin]
For Rint, SILSO Web site, Daily total sunspot number (1/1/1818 - now). [https://www.sidc.be/silso/INFO/sndtotcsv.php]

Figure 2: AAVSO and SIDC monthly table of data for year 2022.

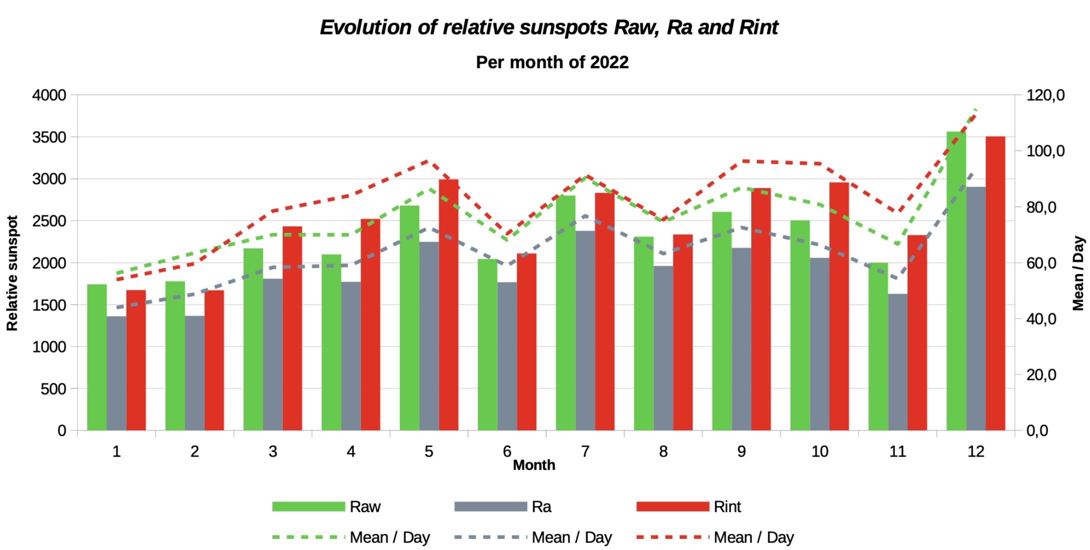


Figure 3: AAVSO, SIDC monthly comparison; RAW Wolf numbers, R_a, $Rint$, for year 2022.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

January 2023 (Figure 4): there were 22 GOES-16 XRA flares: 6 M-class and one X1.0-class: this was the most active day recorded here in Fort Collins, Colorado, with an X1.0-class flare at 22:47 UTC (U.S. Dept. of Commerce–NOAA, 2022).

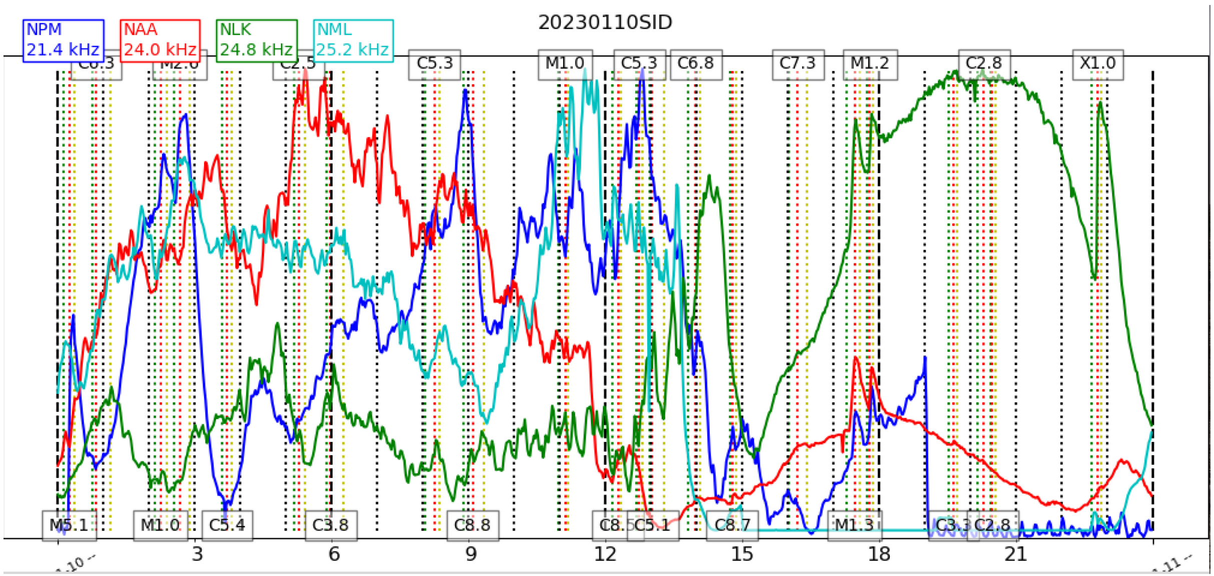


Figure 4: VLF recording from Fort Collins, Colorado for the 10th.

2.2 SID Observers

In January 2023, 14 AAVSO SID observers submitted VLF data as listed in Table 1.

Table 1: 202211 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD ICV
F Adamson	A122	NWC
J Karlovsky	A131	DHO NAA TBB
R Mrllak	A136	GQD NSY
S Aguirre	A138	NPM NAA
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
J Wendler	A150	NAA
H Krumnow	A152	FTA GBZ HWU
J DeVries	A153	NLK
R Mazur	A155	NLK NML

Figure 5 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.

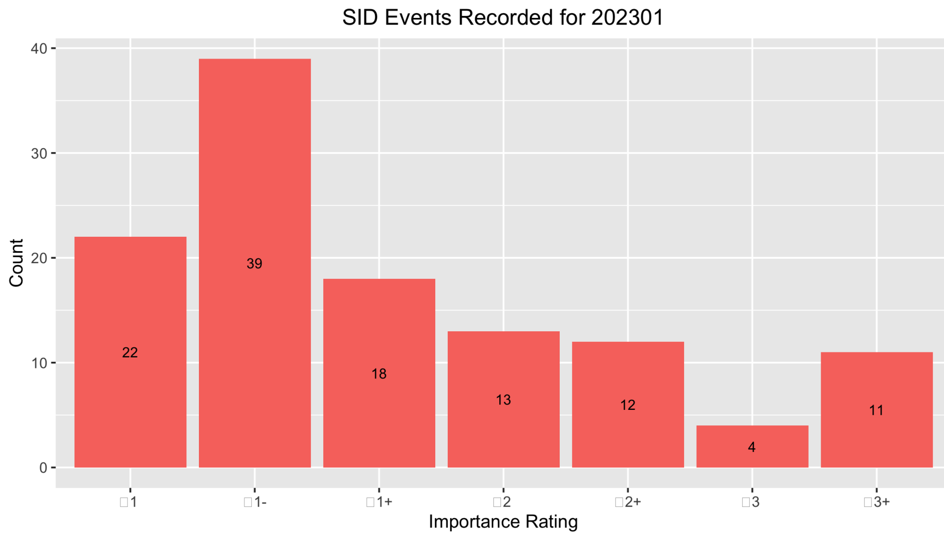


Figure 5: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In January 2023, there were 279 GOES XRA flares for January 2023: three X-class, 40 M-class, 235 C-class and one B-class flare (U.S. Dept. of Commerce–NOAA, 2022). About the same flaring this month compared to last (Figure 6).

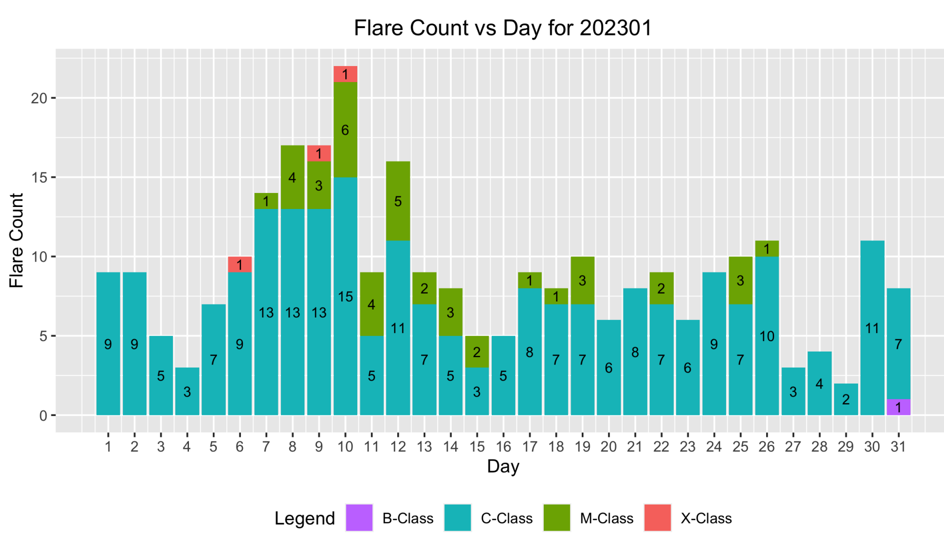


Figure 6: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 January 2023. 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 7.

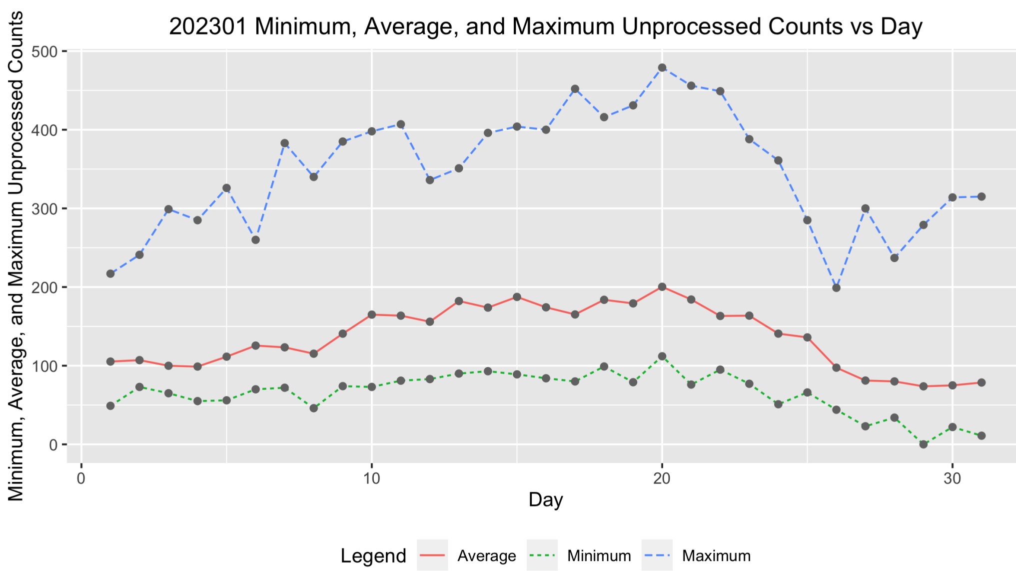


Figure 7: Raw Wolf number average, minimum and maximum by day of the month for all observers.

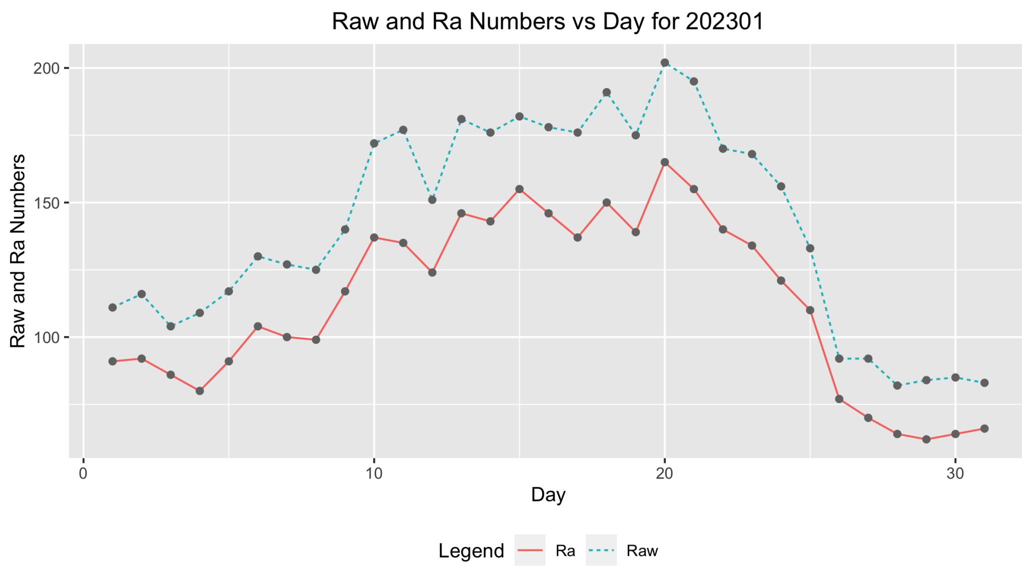


Figure 8: Raw Wolf average and R_a numbers by day of the month for all observers.

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 8, 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: 202301 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	111	91
2	24	116	92
3	29	104	86
4	20	109	80
5	27	117	91
6	32	130	104
7	30	127	100
8	30	125	99
9	33	140	117
10	28	172	137
11	30	177	135
12	27	151	124
13	21	181	146
14	28	176	143

Continued

Table 2: 202301 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	26	182	155
16	26	178	146
17	25	176	137
18	27	191	150
19	28	175	139
20	29	202	165
21	29	195	155
22	30	170	140
23	22	168	134
24	27	156	121
25	20	133	110
26	33	92	77
27	30	92	70
28	26	82	64
29	25	84	62
30	30	85	64
31	32	83	66
Averages	27.5	141.3	112.9

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for January 2023, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (63), and total number of observations submitted (854).

Table 3: 202301 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	27	Alexandre Amorim
AJV	11	J. Alonso
ARAG	30	Gema Araujo
ASA	19	Salvador Aguirre
ATE	23	Teofilo Arranz Heras
BATR	3	Roberto Battaiola
BMF	14	Michael Boschat
BMIG	12	Michel Besson
BROB	19	Robert Brown
BXZ	21	Jose Alberto Berdejo
BZX	13	A. Gonzalo Vargas
CIOA	1	Ioannis Chouinavas
CKB	18	Brian Cudnik

Continued

Table 3: 202301 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMAB	8	Maurizio Cervoni
CNT	19	Dean Chantiles
CVJ	4	Jose Carvajal
DARB	19	Aritra Das
DELS	9	Susan Delaney
DJOB	8	Jorge del Rosario
DMIB	16	Michel Deconinck
DUBF	22	Franky Dubois
EGMA	9	Georgios Epitropou
EHOA	23	Howard Eskildsen
ERB	9	Bob Eramia
FERA	9	Eric Fabrigat
FLET	24	Tom Fleming
GIGA	23	Igor Grageda Mendez
HALB	9	Brian Halls
HKY	11	Kim Hay
HOWR	13	Rodney Howe
IEWA	15	Ernest W. Iverson
ILUB	3	Luigi Iapichino
JGE	5	Gerardo Jimenez Lopez
JSI	2	Simon Jenner
KAMB	31	Amoli Kakkar
KAND	14	Kandilli Observatory
KAPJ	4	John Kaplan
KNJS	30	James & Shirley Knight
LKR	6	Kristine Larsen
LRRA	14	Robert Little
MARC	3	Arnaud Mengus
MARE	8	Enrico Mariani
MCE	25	Etsuiku Mochizuki
MJAF	21	Juan Antonio Moreno Quesada
MJHA	26	John McCammon
MMI	31	Michael Moeller
MSS	1	Sandy Mesics
MUDG	1	George Mudry
MWU	15	Walter Maluf
ONJ	6	John O'Neill
PLUD	16	Ludovic Perbet
RJV	17	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	1	Neil Simmons
SRIE	12	Rick St. Hilaire
TDE	20	David Teske

Continued

Table 3: 202301 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
TNIA	1	Nick Tonkin
TPJB	2	Patrick Thibault
TST	12	Steven Toothman
URBP	7	Piotr Urbanski
VIDD	6	Dan Vidican
WGI	5	Guido Wollenhaupt
WWM	17	William M. Wilson
Totals	854	63

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 9 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 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.

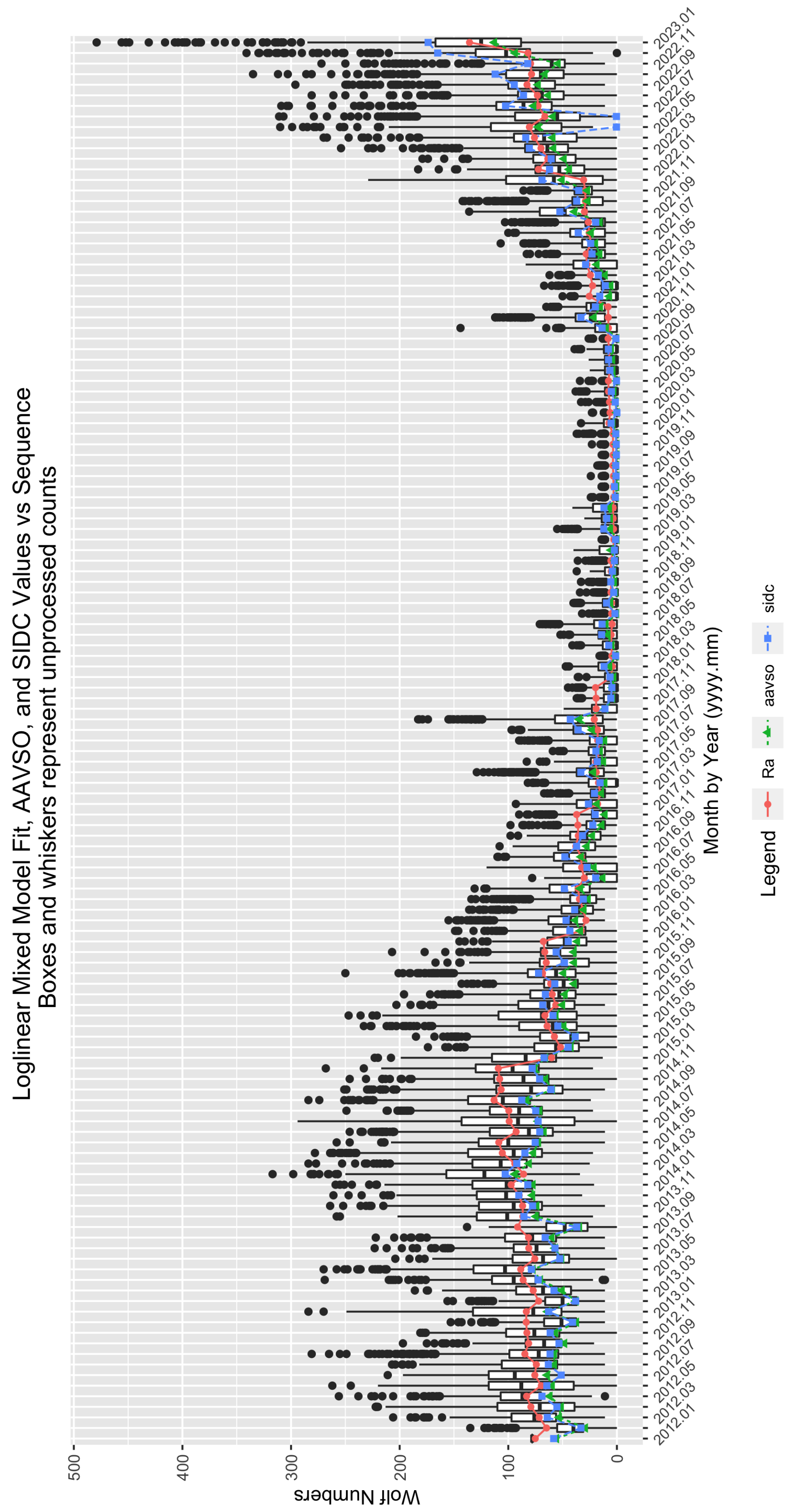
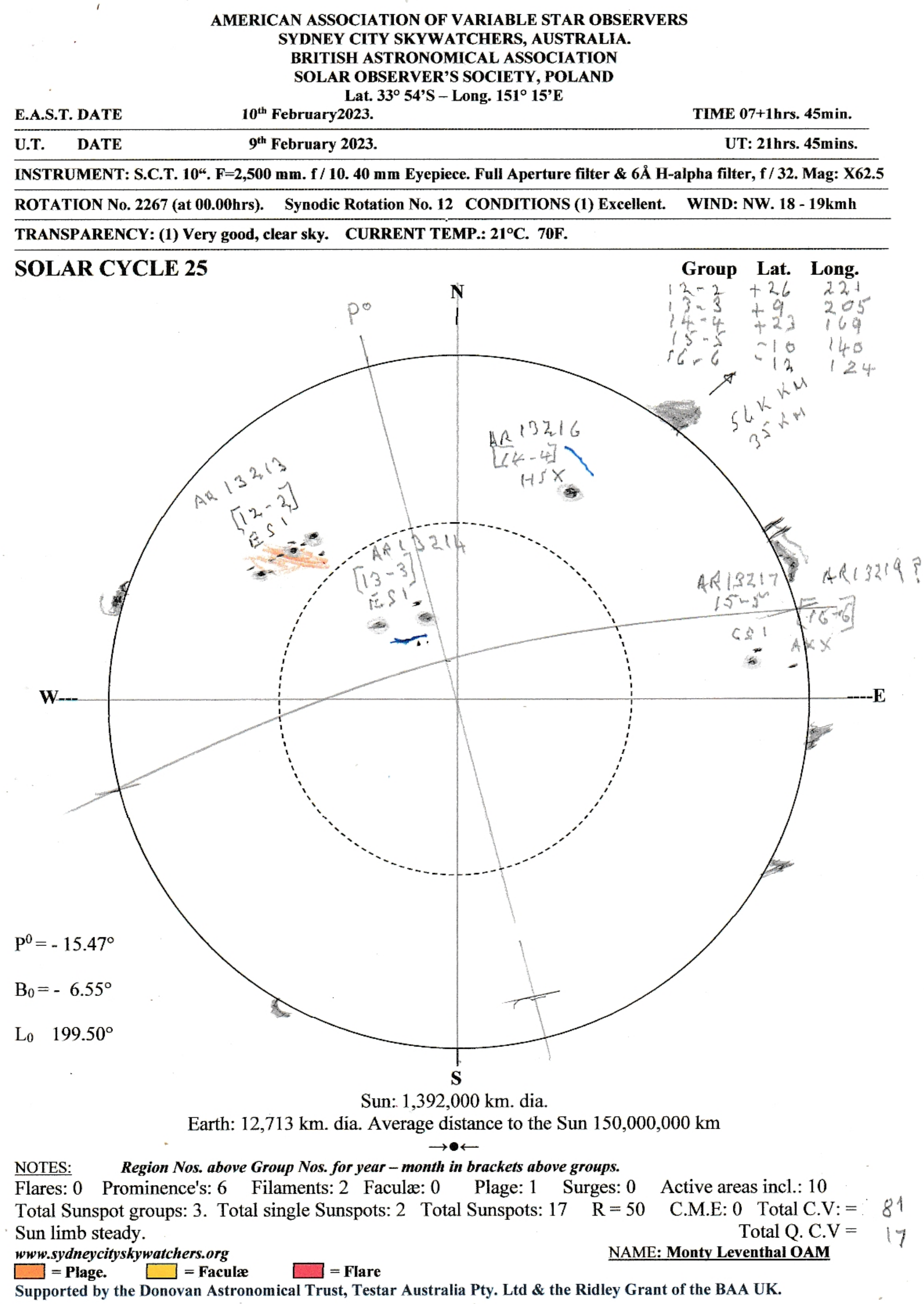


Figure 9: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe rhowe137@icloud.com

4.1 Groups and Sunspots drawing


AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SYDNEY CITY SKYWATCHERS, AUSTRALIA.
BRITISH ASTRONOMICAL ASSOCIATION
SOLAR OBSERVER'S SOCIETY, POLAND
Lat. 33° 54'S – Long. 151° 15'E

E.A.S.T. DATE 10th February2023. TIME 07+1hrs. 45min.

U.T. DATE 9th February 2023. UT: 21hrs. 45mins.

INSTRUMENT: S.C.T. 10". F=2,500 mm. f / 10. 40 mm Eyepiece. Full Aperture filter & 6Å H-alpha filter, f / 32. Mag: X62.5

ROTATION No. 2267 (at 00.00hrs). Synodic Rotation No. 12 CONDITIONS (1) Excellent. WIND: NW. 18 - 19kmh

TRANSPARENCY: (1) Very good, clear sky. CURRENT TEMP.: 21°C. 70F.

SOLAR CYCLE 25

Group	Lat.	Long.
12-2	+26	221
13-3	+9	205
14-4	+23	169
15-5	-10	140
16-6	-12	124

P^0 = - 15.47°

B_0 = - 6.55°

L_0 199.50°

Sun: 1,392,000 km. dia.
Earth: 12,713 km. dia. Average distance to the Sun 150,000,000 km

NOTES: *Region Nos. above Group Nos. for year – month in brackets above groups.*
Flares: 0 Prominence's: 6 Filaments: 2 Faculæ: 0 Plage: 1 Surges: 0 Active areas incl.: 10
Total Sunspot groups: 3. Total single Sunspots: 2 Total Sunspots: 17 R = 50 C.M.E: 0 Total C.V: = 81
Sun limb steady. Total Q. C.V = 17
www.sydneycityskywatchers.org NAME: Monty Leventhal OAM
= Plage. = Faculæ = Flare
Supported by the Donovan Astronomical Trust, Testar Australia Pty. Ltd & the Ridley Grant of the BAA UK.

Figure 10: Graph of groups and sunspots by Monty Leventhal (LEVM)

5 References

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Svalgaard, L (2023, January), *Re-calibration of the Sunspot Number; Status Report.* Leif Svalgaard's Research page. https://www.researchgate.net/publication/366902688_Re-calibration_of_the_Sunspot_Number_Status_Report

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