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
ISSN 0271-8480

Volume 81 Number 6 June 2025

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 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 SOHO MDI contours for showing Umbral areas and SDO HMI data for hemisphere sunspot counts

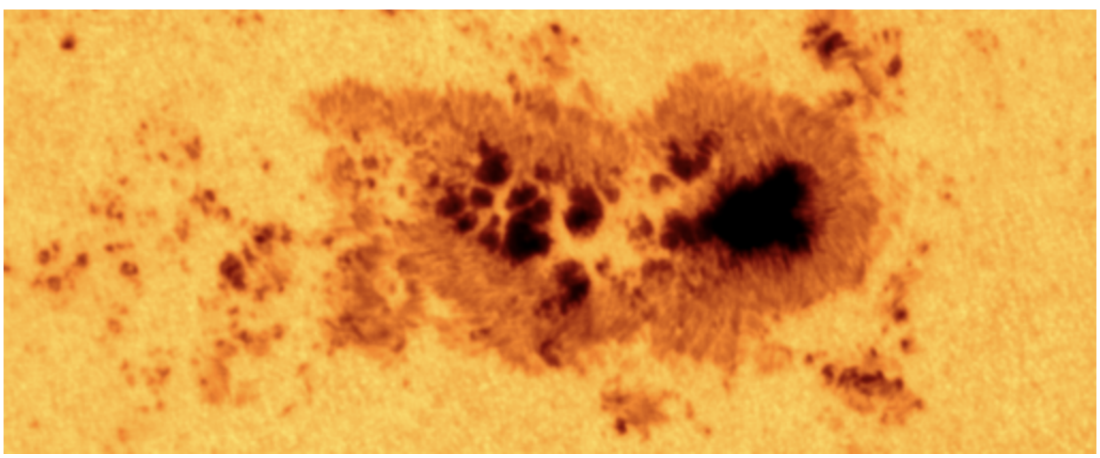

Figure 1: From a satellite image of a huge sunspot from 2012. How would computer software create a sunspot count from such satellite images?

As noted by Verbeeck et al. (2013), "The MDI instrument on SOHO provides almost continuous observations of the Sun in the white-light continuum, in the vicinity of the Ni I 676.78 nm photospheric absorption line. These photospheric-intensity images are primarily used for sunspot observations. MDI data are available in several processed levels. We used level-2 images, which are smoothed, filtered, and rotated (Scherrer et al., 1995). SOHO has provided two to four MDI photospheric intensity images per day with continuous coverage since 1995. Using the same instrument level 1.8 line-of-sight (LOS) MDI magnetograms are recorded with a nominal cadence of 96 minutes. The magnetograms show the magnetic fields of the solar photosphere, with negative (represented as black) and positive (as white) areas indicating opposite LOS magnetic-field orientations."

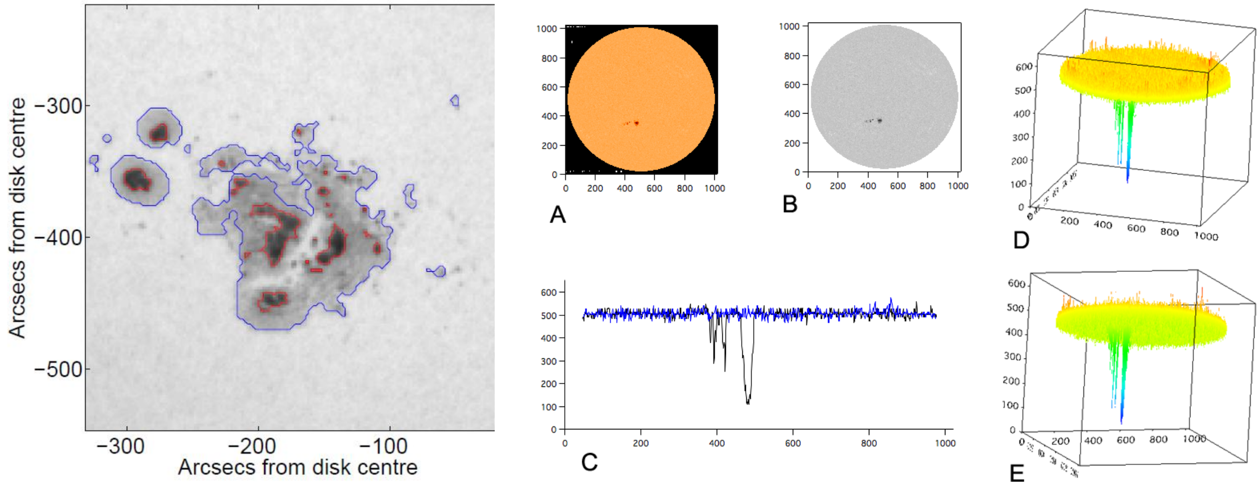

Figure 2: SOHO MDI contours. (http://soi.stanford.edu/sssc/doc/MDI_example.html)

Making contours of Active Regions (AR) requires software that processes the MDI magnetograms step-by-step from A to E (right panel), then drawing contours around the AR intensity peaks in the left panel. Once the contour lines are drawn the area in Mm^2 of the active region can be calculated along with estimated sunspot counts.

Table 1: 2012 SOHO MDI Areas

Date	sunspots	MDI Area
2012.06.09	5	114949807
2012.06.10	11	120388221
2012.06.11	10	135794233
2012.06.12	21	130903719
2012.06.13	25	16087666
2012.06.14	24	271016159
2012.06.15	29	372134607
2012.06.16	21	378326061
2012.06.17	9	350695927
2012.06.18	7	338272913
2012.06.19	4	287955903
2012.06.20	3	246749527

The final outcome would be to use these SOHO/MDI umbral areas to create a solar cycle light curve of magnetic areas and then calculated sunspot counts.

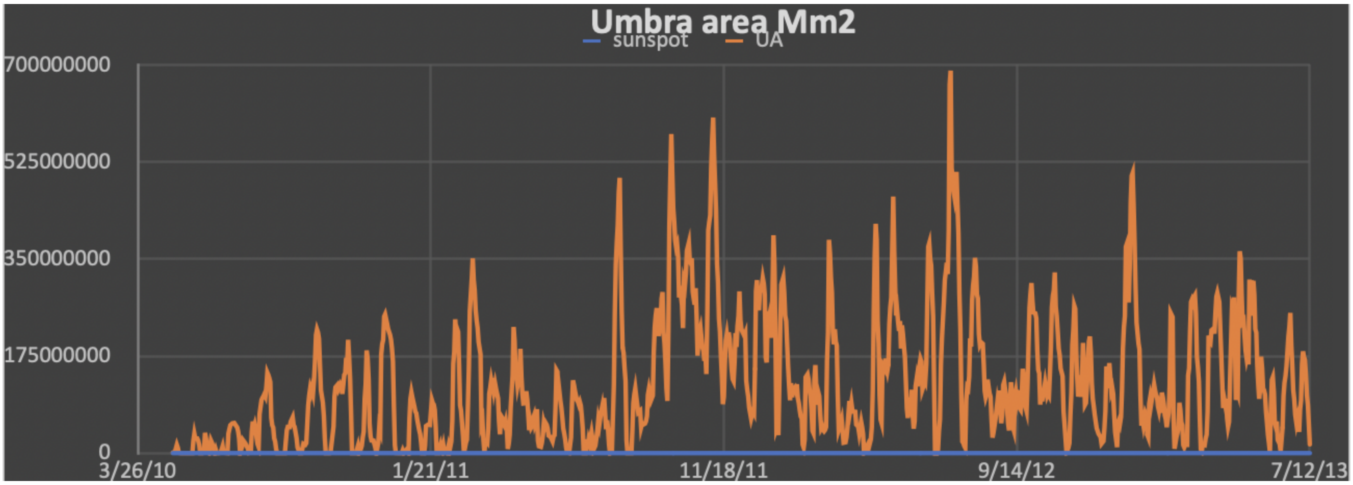

Figure 3: SOHO MDI magnetograms calculated Umbra areas from 2010 through 2013 (Verbeeck et al., 2013).

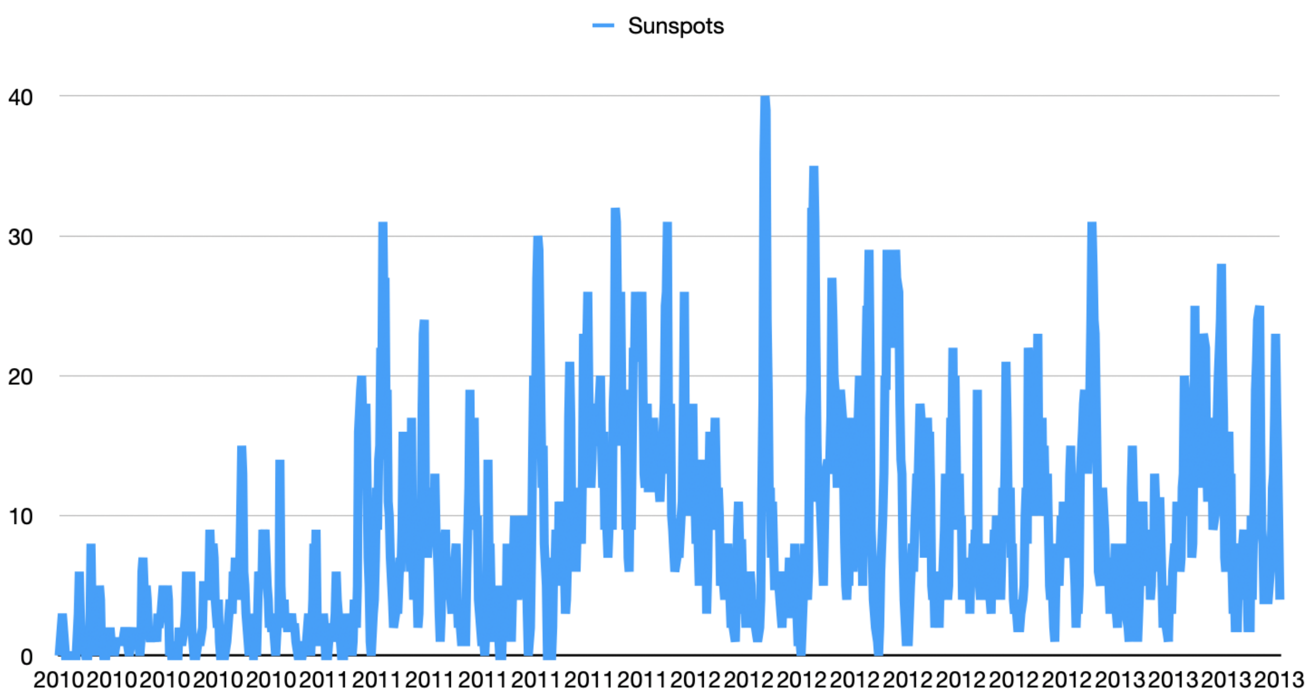

Figure 4: From SOHO MDI magnetograms, calculated sunspots from 2010 through 2013 (Verbeeck et al., 2013).

Jan Alvestad (SDOH) took over the STARA code from Fraser Watson (of Verbeeck et al.) in 2012 and used the SDO HMI magnetograms and visual intensity images to create all north and south hemisphere sunspot counts and Wolf numbers. Alvestad shared his data with the AAVSO from 2012 through the end of 2024. We can average his daily data to monthly hemisphere group and sunspot counts for the north and south hemispheres.

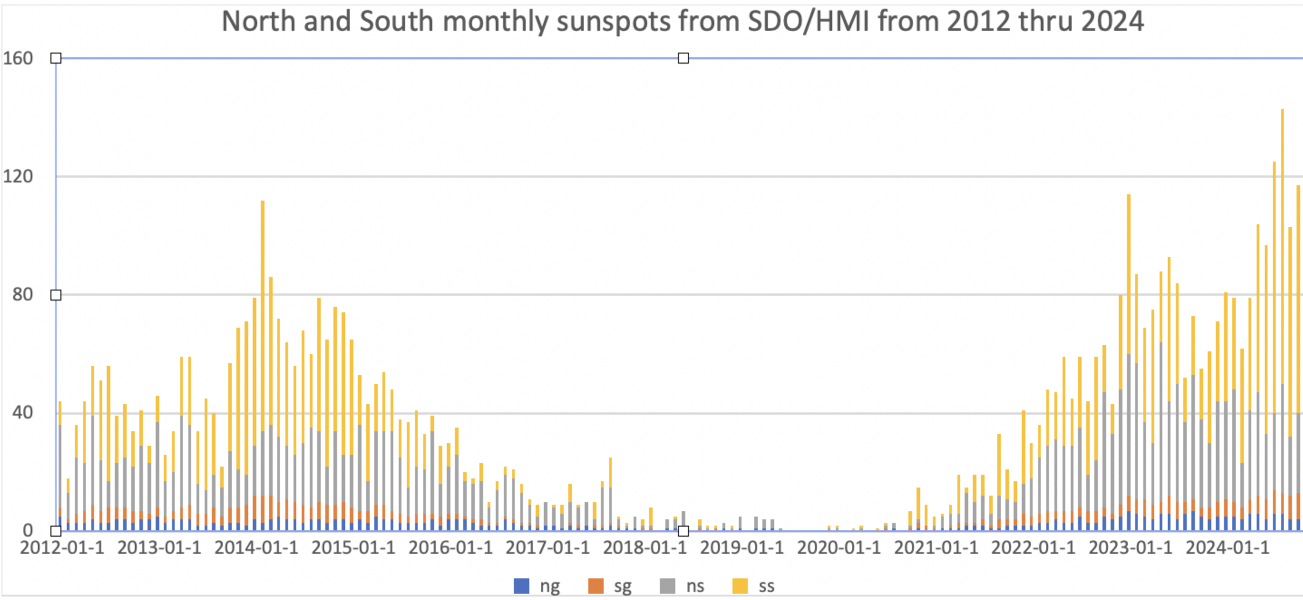

Figure 5: From 2012 through 2024, north and south hemisphere sunspots calculated from SDO/HMI (Jan Alvestad) (SDOH). `http://www.solen.info/solar/`

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

June 2025 (Figure 6): on the 15th there were 4 M-Class and 12 C-class flares recorded by Lionel Laudet (A118) from Milan, Italy. (U.S. Dept. of Commerce–NOAA, 2022).

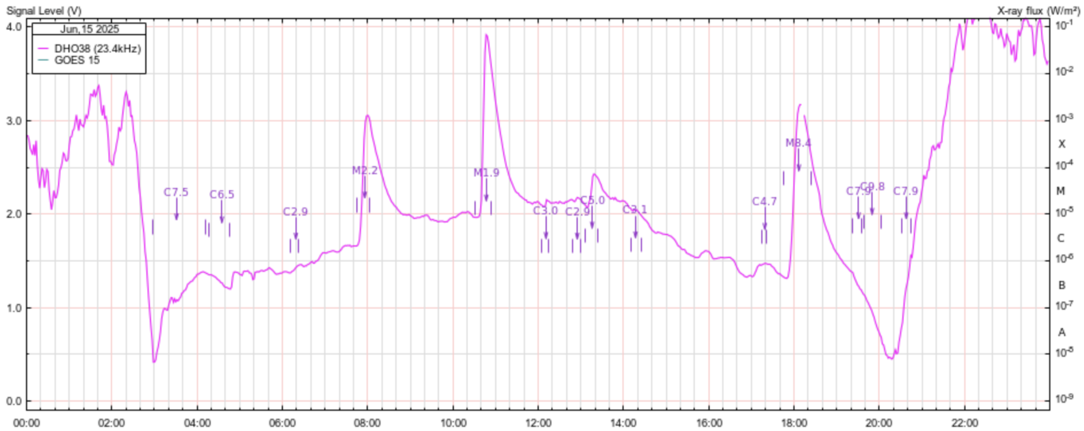

Figure 6: VLF recording from Lionel Laudet (A118) for the 15th of June, one of the most active days.

2.2 SID Observers

In June 2025 we had 13 AAVSO SID observers who submitted VLF data as listed in Table 2.

Table 2: 202506 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
A Son	A112	DHO
L Loudet	A118	DHO
J Godet	A119	DHO GBZ GQD
R Mrllak	A136	GQD NSY
S Aguirre	A138	NLK
G Silvis	A141	NAA NPM NLK
L Pina	A148	NAA NML
J Wendler	A150	NAA
H Krumnow	A152	DHO GBZ
J DeVries	A153	NLK
M Cervoni	A154	DHO ICV

Figure 7 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.

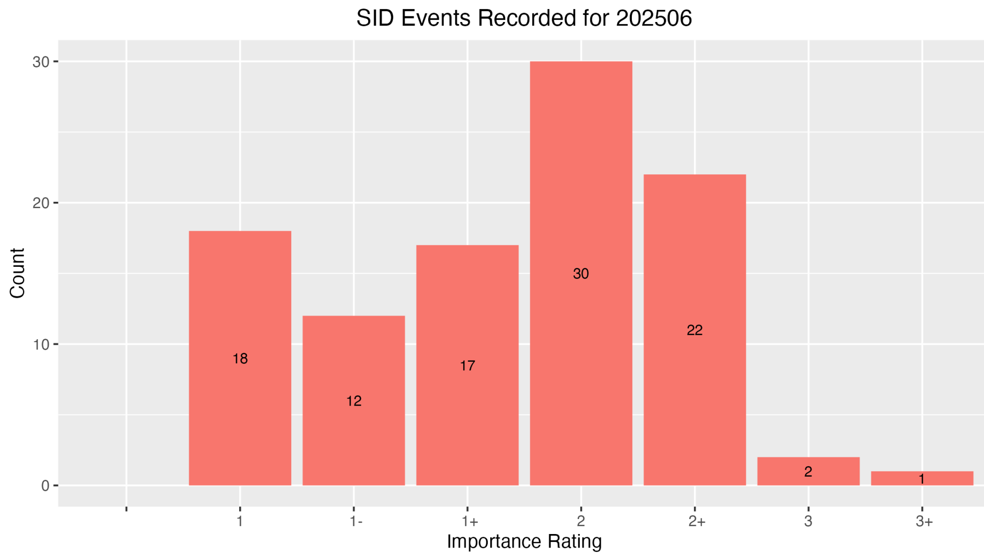

Figure 7: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In June 2025, there were 259 GOES-16 XRA flare events: 2 X-Class, 18 M-Class, 211 C-Class and 28 B-Class flares. About the same flaring this month compared to last month. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 8).

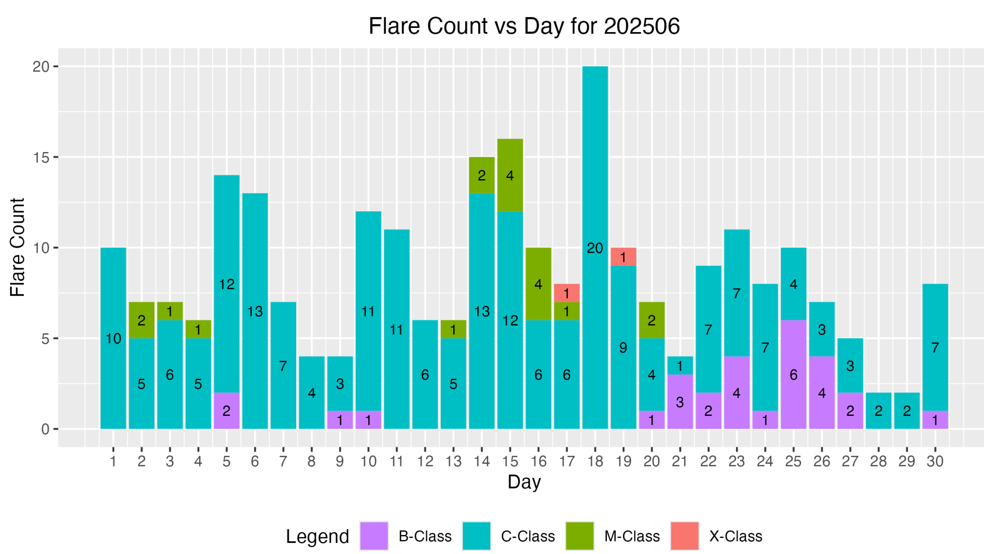

Figure 8: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 June 2025. 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 9.

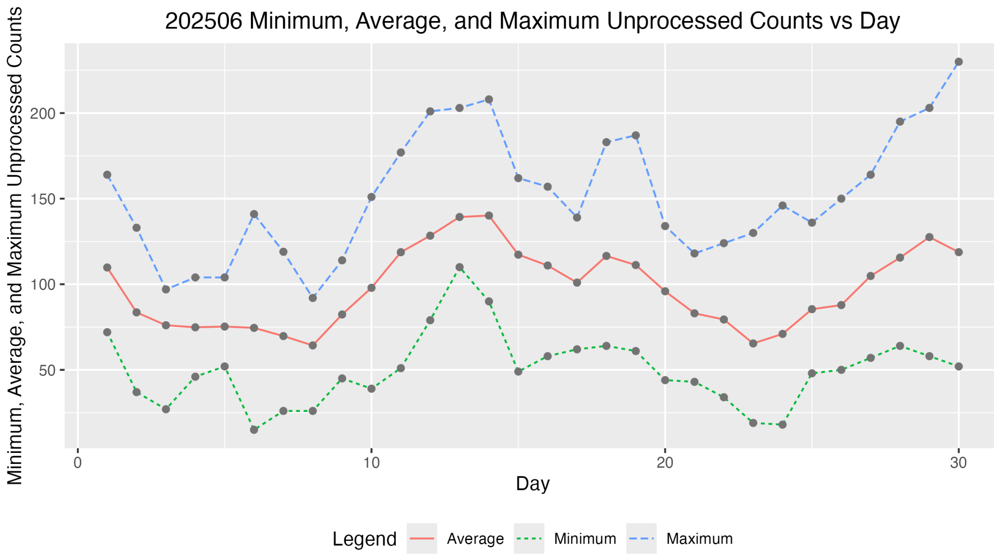

Figure 9: Raw Wolf number average, minimum and maximum by day of the month for all observers.

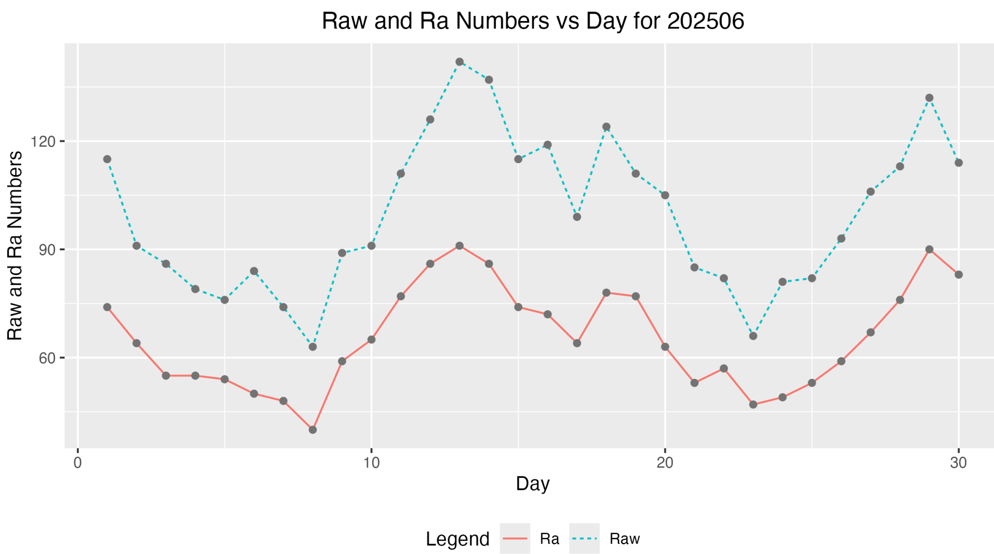

Figure 10: Raw Wolf average and R_a numbers by day of the month for all observers.

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 10, and Table 3 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 3: 202506 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	115	74
2	29	91	64
3	24	86	55
4	28	79	55
5	27	76	54
6	25	84	50
7	23	74	48
8	29	63	40
9	28	89	59
10	25	91	65
11	29	111	77
12	29	126	86
13	24	142	91
14	30	137	86
15	24	115	74

Continued

Table 3: 202506 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	23	119	72
17	28	99	64
18	31	124	78
19	26	111	77
20	25	105	63
21	29	85	53
22	29	82	57
23	28	66	47
24	27	81	49
25	27	82	53
26	20	93	59
27	26	106	67
28	21	113	76
29	33	132	90
30	29	114	83
Averages	26.9	99.7	65.5

3.3 Sunspot Observers

Table 4 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for June 2025, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (52), and the total number of observations submitted (806).

Table 4: 202506 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	22	Alexandre Amorim
ARAG	1	Gema Araujo
ASA	1	Salvador Aguirre
BATR	5	Roberto Battaiola
BKL	17	John A. Blackwell
BMIG	29	Michel Besson
BTB	14	Thomas Bretl
BVZ	25	Jesus E. Blanco
BXZ	27	Jose Alberto Berdejo
CKB	16	Brian Cudnik
CMAB	24	Maurizio Cervoni
CNT	24	Dean Chantiles
CWD	4	John Cowall
DARB	18	Aritra Das
DGIA	14	Giuseppe di Tommasco

Continued

Table 4: 202506 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DJOB	12	Jorge del Rosario
DJSA	1	Jeff DeVries
DJVA	28	Jacques van Delft
DUBF	29	Franky Dubois
EHOA	13	Howard Eskildsen
FERA	23	Eric Fabrigat
GCNA	13	Candido Gomez
GIGA	26	Igor Grageda Mendez
HALB	16	Brian Halls
HKY	22	Kim Hay
HOWR	14	Rodney Howe
ILUB	6	Luigi Iapichino
JGE	6	Gerardo Jimenez Lopez
JSI	2	Simon Jenner
KAND	30	Kandilli Observatory
KAPJ	12	John Kaplan
KNJS	18	James & Shirley Knight
KTOC	19	Tom Karnuta
LKR	3	Kristine Larsen
LRRA	16	Robert Little
MARC	4	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	14	Etsuiku Mochizuki
MMI	30	Michael Moeller
MWU	19	Walter Maluf
NMID	6	Milena Niemczyk
NPAB	2	Panagiotis Ntais
PLUD	12	Ludovic Perbet
RJV	19	Javier Ruiz Fernandez
SNE	3	Neil Simmons
SQN	14	Lance Shaw
SRIE	17	Rick St. Hilaire
TDE	22	David Teske
TST	25	Steven Toothman
URBP	29	Piotr Urbanski
WGI	6	Guido Wollenhaupt
WND	22	Denis Wallian
Totals	806	52

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 11 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.

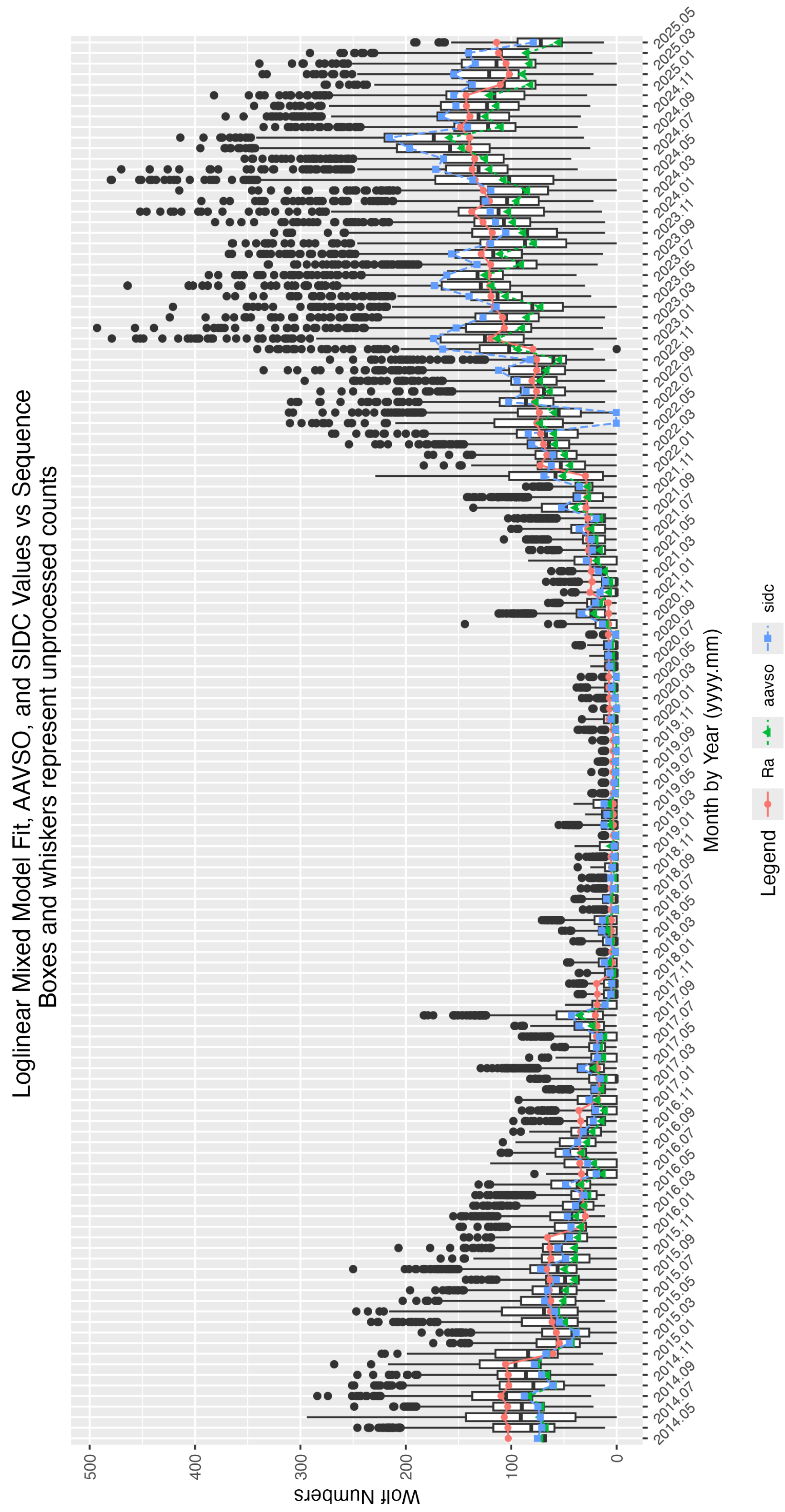

Figure 11: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

Figure 12: The telescope is a EXPLORE SCIENTIFIC ED APO 80MM F/6 FCD-1 ALU 2" RP FOCUSER OTA (no solar filter, cloudy sky, we teach them how to make alignment, collimation etc), Best regards, Santanu Basu (BSAB).

An internship program for undergraduate students was organized by the Sky Watchers Association, Kolkata. It is a project-based curriculum with its main focus on observational and computational astronomy. A total of 15 students from Narendrapur Ramakrishna Mission Residential College (Autonomous) have participated in this 60-hour internship program. Theoretical and practical classes were held in online and offline mode. Project mentors were designated to guide the interns throughout their respective projects. The classes were conducted by the members of the Sky Watchers Association and the projects were guided by Mr. Santanu Basu, Miss Sreya Ghosh, Mr. Subhadip Ghosh, Mr. Aniket Bhattacharyea, and Mr. Dipankar Dey. The theoretical classes were designed to develop the basic concepts of observational and computational astronomy, along with a touch on the field of astrophotography and image processing. Each student had gone through an evaluation and project viva to complete the internship successfully and obtained the certificate of completion. (`https://rkmrc.in/`)

5 References

Verbeeck, C., et al. 2013, A Multi-wavelength Analysis of Active Regions and Sunspots by Comparison of Automatic Detection Algorithms
IMAGE PROCESSING IN THE PETABYTE ERA
https://www.researchgate.net/publication/225762161_A_Multi-Wavelength_Analysis_of_Active_Regions_and_Sunspots_by_Comparison_of_Automated_Detection_Algorithms.

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center, 2022.
GOES-16 XRA data. ftp://ftp.swpc.noaa.gov/pub/indices/events/