Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 185 Alewife Brook Pkwy, Ste 410
Cambridge, MA 02138 USA

Web: https://www.aavso.org/solar-bulletin
Email: solar@aavso.org
ISSN 0271-8480

Volume 81 Number 9 September 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 The Carrington Event of 1859

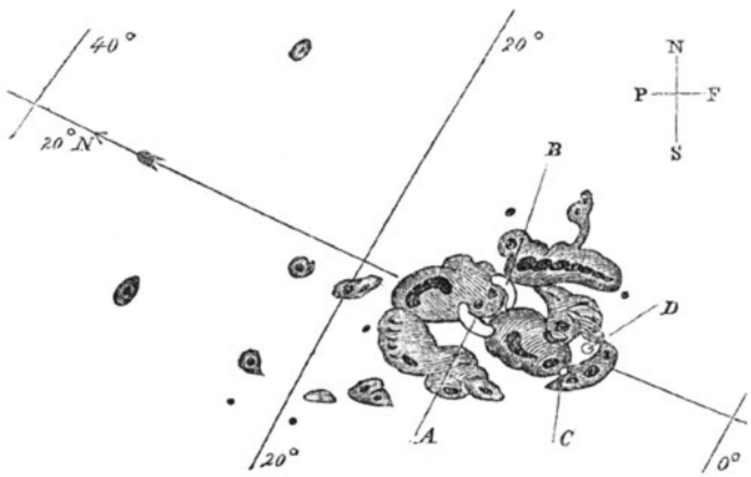

Figure 1: Richard Carrington's sketch of the white light flare and related sunspot group, September 1, 1859. Public domain.

September marks the anniversary of a series of solar outbursts that led to an infamous geomagnetic storm against which all others are measured in the public imagination. Collectively, these solar outbursts and their terrestrial consequences are generally known as the Carrington Event. Amateur astronomer Richard Carrington (1826-1875) was a conscientious solar observer, and discovered not only that the average latitude of sunspots shifts over the solar cycle (resulting in the Butterfly Diagram first plotted by Edward Maunder in 1904), but that the Sun rotates at different speeds at different latitudes (differential rotation). Carrington and Richard Hodgson (1804-1872) independently made the first known visual observations of a solar flare (often termed a white light flare) on September 1, 1859, one in a number of significant solar events that occurred in late August through early September that year. Being just before the maximum of Solar Cycle 10, solar activity of all varieties was on the rise, including flares, and, although not observable with then current technology, probably coronal mass ejections. A large sunspot group was visible near the Sun's equator, even without a telescope.[1]

This enhanced solar activity caused geomagnetic storms for a week, with significant auroral displays seen from August 28 – September 4. In the Northern Hemisphere some of the displays were seen as far south as Hawaii (20 N) and in the Southern Hemisphere as far north as Santiago, Chile (33 S). An eyewitness report in *The Rocky Mountain News* describes campers being awakened shortly after midnight on September 2 by aurorae "so bright that one could easily read common print", and that fooled some in the party into believing it was breakfast time.[2] The high technology of the day was the telegraph – the "Victorian Internet" – which was plagued with significant disruptions by the geomagnetic storms.[3] The problem was electric currents induced in the miles and miles of wires over which the telegraph signals travelled. This overloaded transformers and batteries and gave some operators electrical shocks. Some operators found that they could still send messages, using the current induced in the system, even after disconnecting the power sources. Some equipment sparked, causing fires.[4] There was also an associated SEP event (solar energetic particles) that is estimated to have reduced the Earth's ozone layer by as much as 5 percent and took four years to replenish.[5]

1. Sten F. Odenwald and James L. Green. "Bracing for a Solar Superstorm". *Scientific American* 299.2 (2008): 83.

2. National Research Council. *Severe Space Weather Events: Understanding Societal and Economic Impacts* (The National Academies Press, 2009), 14-5. DOI:10.17226/12643.

3. National Research Council, 15.

4. Robert Giegengack. "The Carrington Coronal Mass Ejection of 1859". *Proceedings of the American Philosophical Society* 159 (2015): 423-4.

5. Odenwald and Green, 83-4.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

September 2025 (Figure 2): There were 3 C-class flares on the 2nd of September; one 6.1 shows a nice SID with a "sharks" tail, recorded in Milan, Italy, by Lionel Laudet (A118). (U.S. Dept. of Commerce–NOAA, 2022).

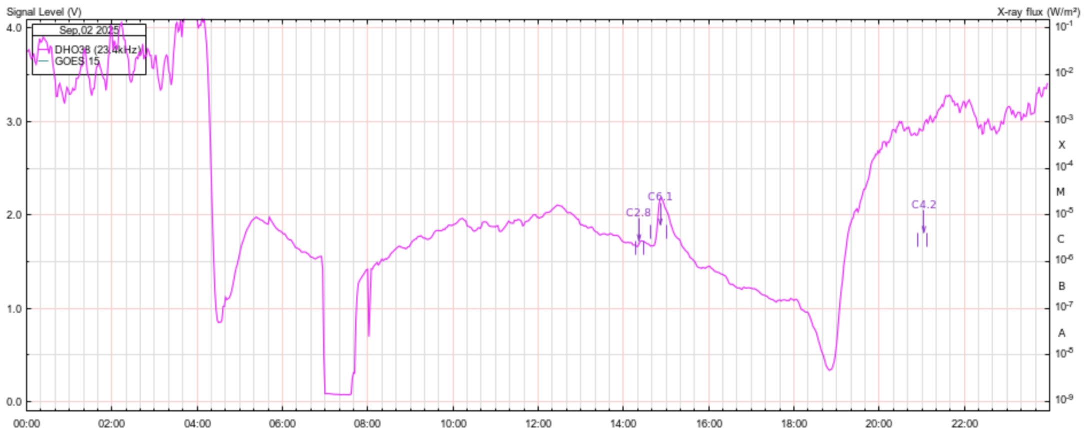

Figure 2: VLF recording from Milan, Italy, for September 2, 2025.

2.2 SID Observers

In September 2025 we had 11 AAVSO SID observers who submitted VLF data, as listed in Table 1.

Table 1: 202509 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
L Loudet	A118	DHO
J Godet	A119	DHO GBZ GQD
J Karlovsky	A131	DHO
R Mrllak	A136	NSY
S Aguirre	A138	NLK
G Silvis	A141	NAA NPM NLK
L Pina	A148	NAA NML
H Krumnow	A152	DHO GBZ
J DeVries	A153	NLK
M Cervoni	A154	DHO ICV

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.

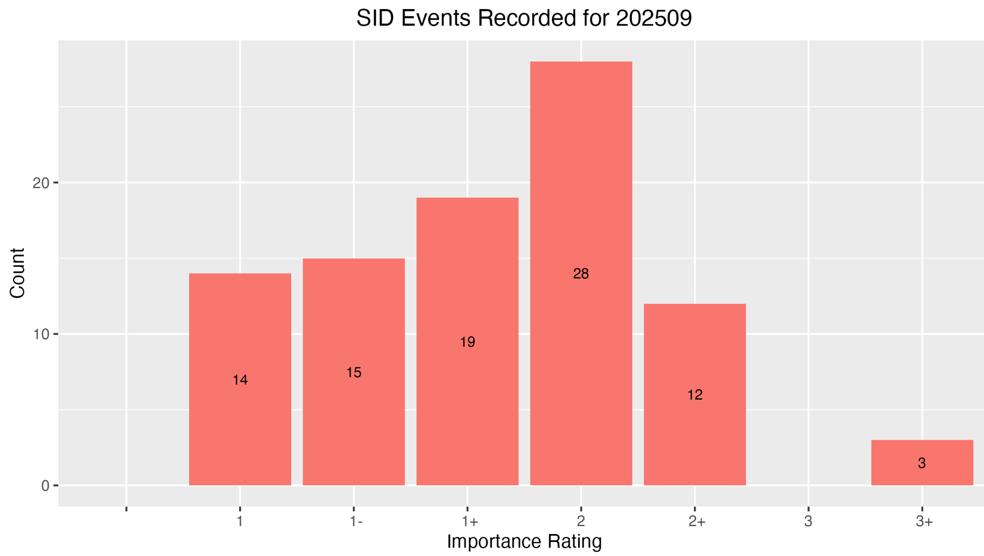

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In September 2025, there were 239 GOES-16 XRA flares: 18 M-Class, 218 C-Class, and 3 B-Class flares. Far less flaring than last month. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 4).

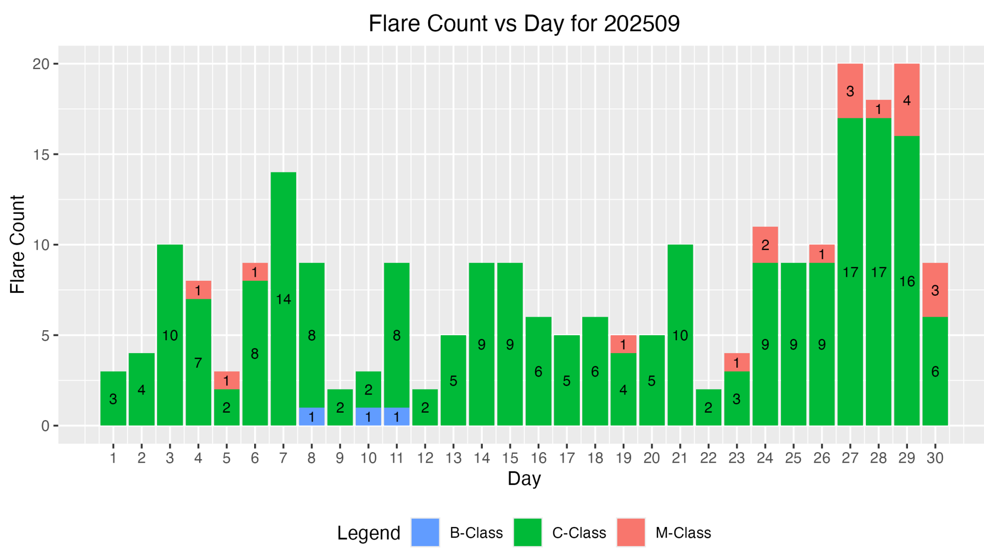

Figure 4: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 are then 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 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 5.

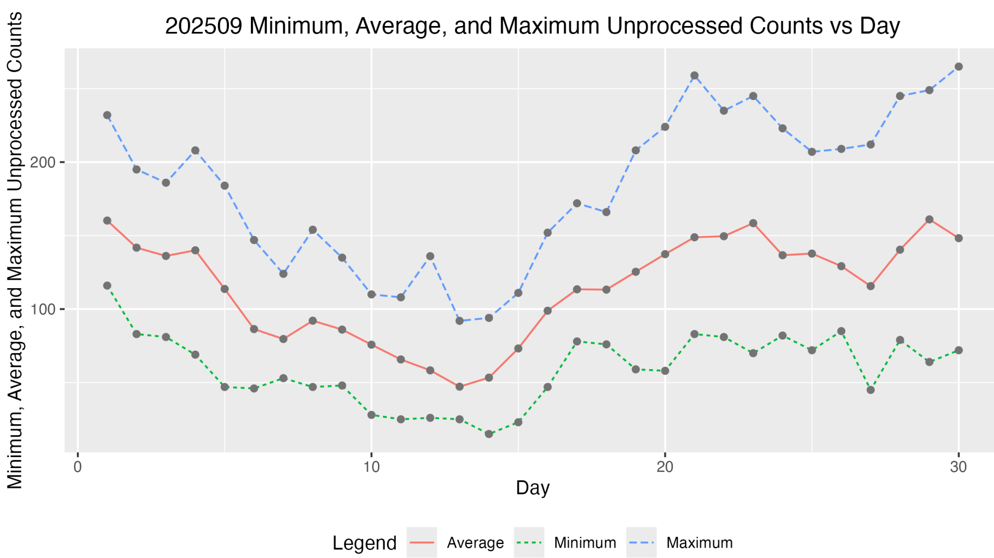

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

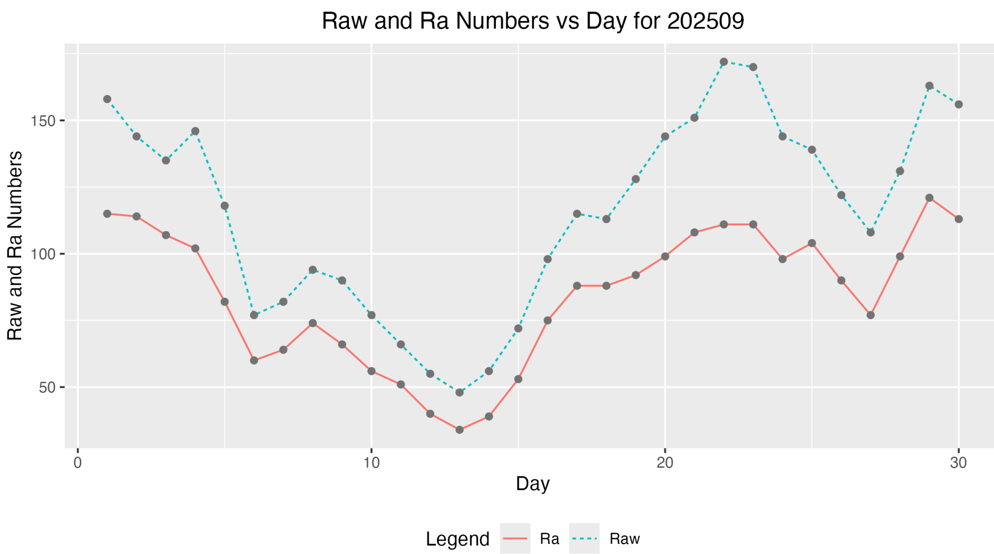

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202509 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	158	115
2	34	144	114
3	32	135	107
4	33	146	102
5	29	118	82
6	30	77	60
7	25	82	64
8	29	94	74
9	30	90	66
10	28	77	56
11	33	66	51
12	29	55	40
13	24	48	34
14	28	56	39
15	29	72	53

Continued

Table 2: 202509 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	27	98	75
17	33	115	88
18	29	113	88
19	37	128	92
20	38	144	99
21	30	151	108
22	21	172	111
23	23	170	111
24	26	144	98
25	26	139	104
26	30	122	90
27	27	108	77
28	30	131	99
29	27	163	121
30	32	156	113
Averages	29.3	115.7	84.4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for September 2025, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (57), and total number of observations submitted (879).

Table 3: 202509 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	23	Alexandre Amorim
AJV	19	J. Alonso
ASA	2	Salvador Aguirre
BATR	2	Roberto Battaiola
BKL	9	John A. Blackwell
BMIG	25	Michel Besson
BTB	20	Thomas Bretl
BVZ	19	Jesus E. Blanco
BXZ	29	Jose Alberto Berdejo
BZX	20	A. Gonzalo Vargas
CKB	29	Brian Cudnik
CMAB	15	Maurizio Cervoni
CNT	26	Dean Chantiles
CWD	9	David Cowall
DARB	18	Aritra Das

Continued

Table 3: 202509 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DELS	12	Susan Delaney
DFR	14	Frank Dempsey
DGIA	4	Giuseppe di Tommasco
DJOB	18	Jorge del Rosario
DJSA	4	Jeff DeVries
DJVA	28	Jacques van Delft
DMIB	7	Michel Deconinck
DUBF	25	Franky Dubois
EHOA	12	Howard Eskildsen
FALB	21	Allen Frohardt
FERA	25	Eric Fabrigat
GCNA	4	Candido Gomez
HKY	21	Kim Hay
HOWR	26	Rodney Howe
ILUB	4	Luigi Iapichino
JGE	3	Gerardo Jimenez Lopez
JSI	3	Simon Jenner
KAND	27	Kandilli Observatory
KAPJ	10	John Kaplan
KNJS	22	James & Shirley Knight
KTOC	13	Tom Karnuta
LKR	7	Kristine Larsen
LRRA	11	Robert Little
MARC	3	Arnaud Mengus
MARE	12	Enrico Mariani
MJHA	26	John McCammon
MMI	30	Michael Moeller
MUDG	15	George Mudry
MWMB	6	William McShan
MWU	23	Walter Maluf
NPAB	3	Panagiotis Ntais
PLUD	21	Ludovic Perbet
RJV	19	Javier Ruiz Fernandez
SDOH	30	Solar Dynamics Obs - HMI
SNE	12	Neil Simmons
SRIE	9	Rick St. Hilaire
TDE	23	David Teske
TPJB	3	Patrick Thibault
TST	25	Steven Toothman
URBP	26	Piotr Urbanski
WGI	1	Guido Wollenhaupt
WND	6	Denis Wallian

Continued

Table 3: 202509 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
Totals	879	57

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 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.

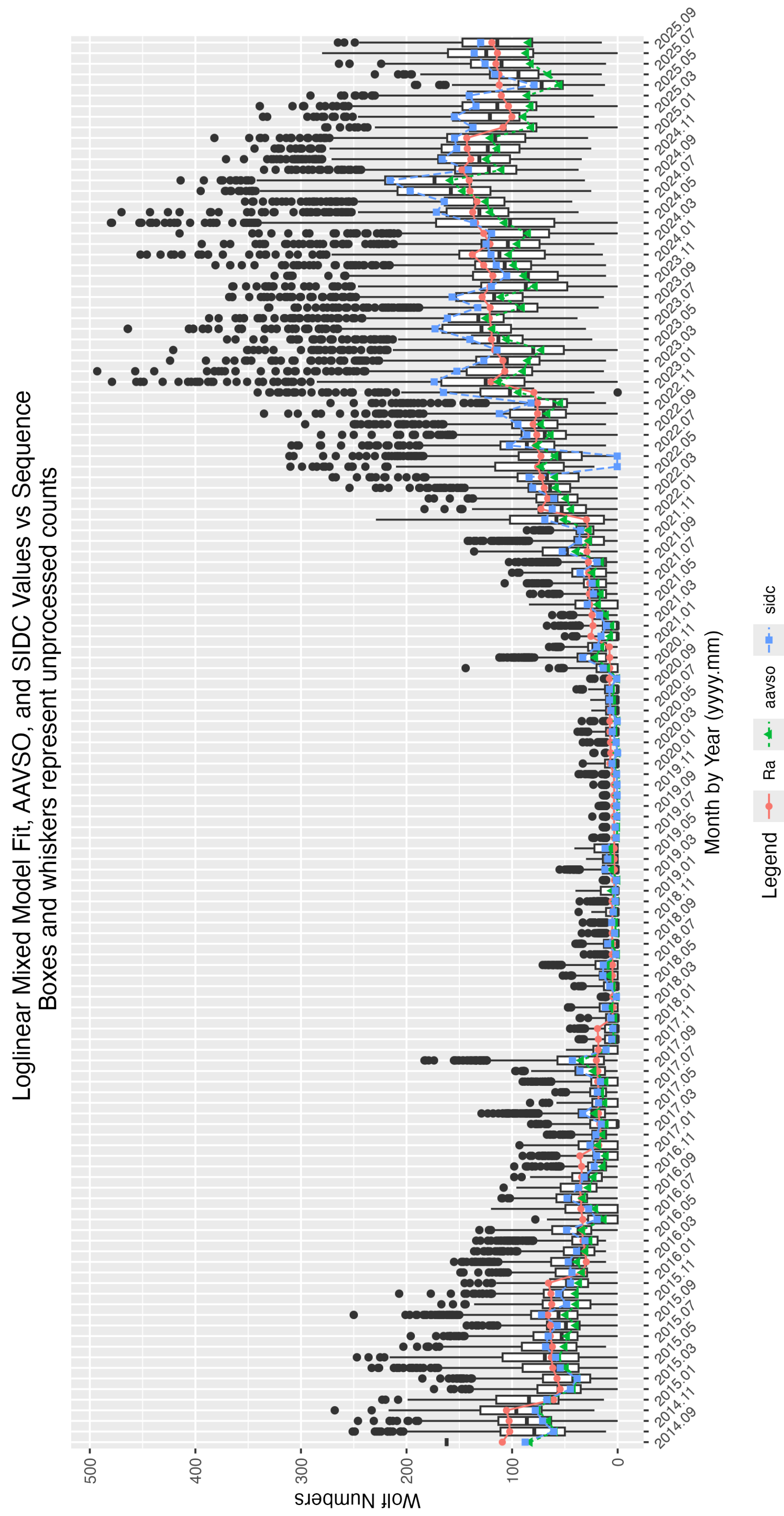

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

5 August Active Regions by Enrico Mariani

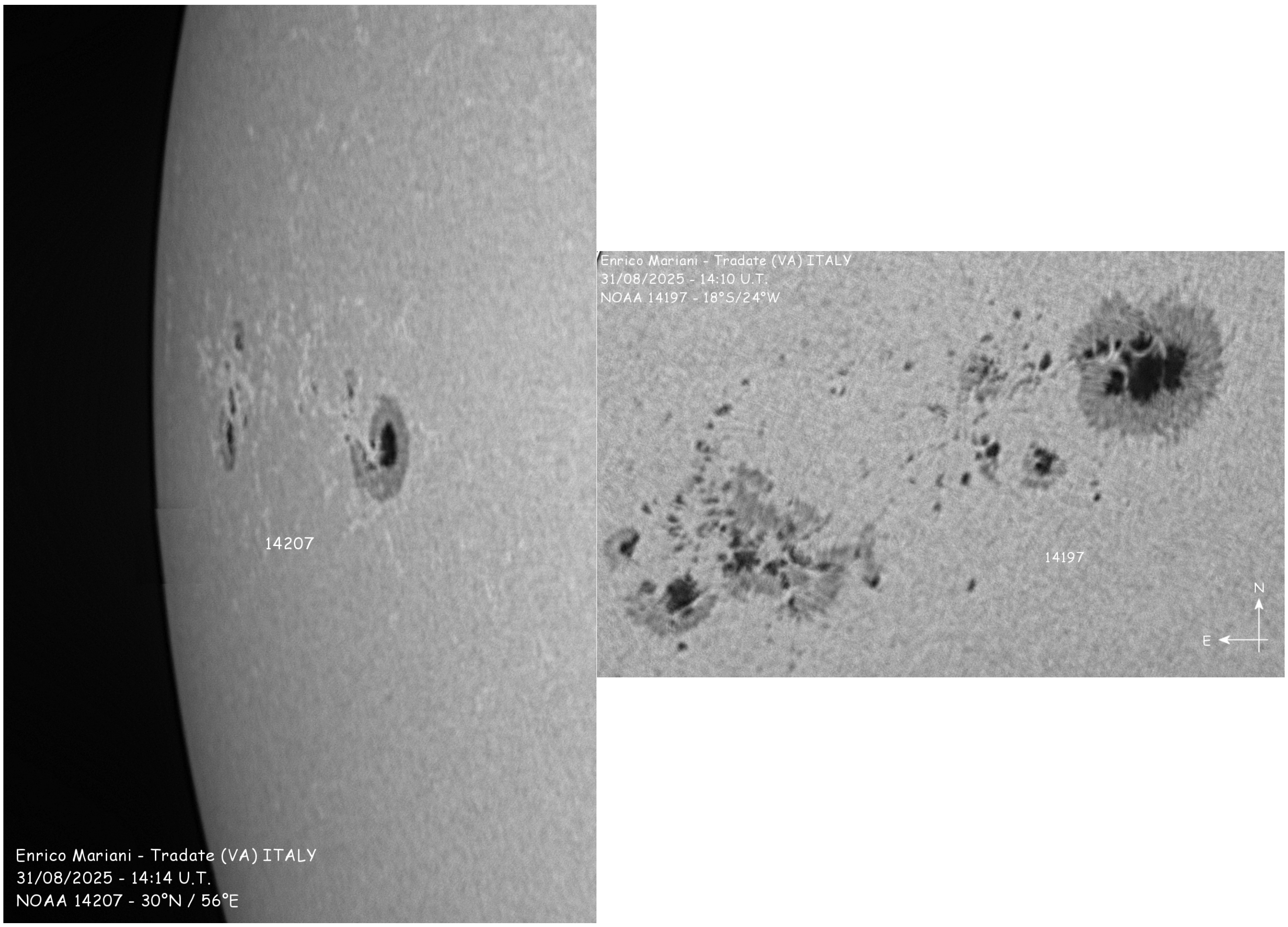

Figure 8: Photos of two active regions of the Sun on August 31 (RA14207 and RA14197) taken with a Celestron C8 and ASI ZWO178MM camera with a UV/IR cut filter.

6 References

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