Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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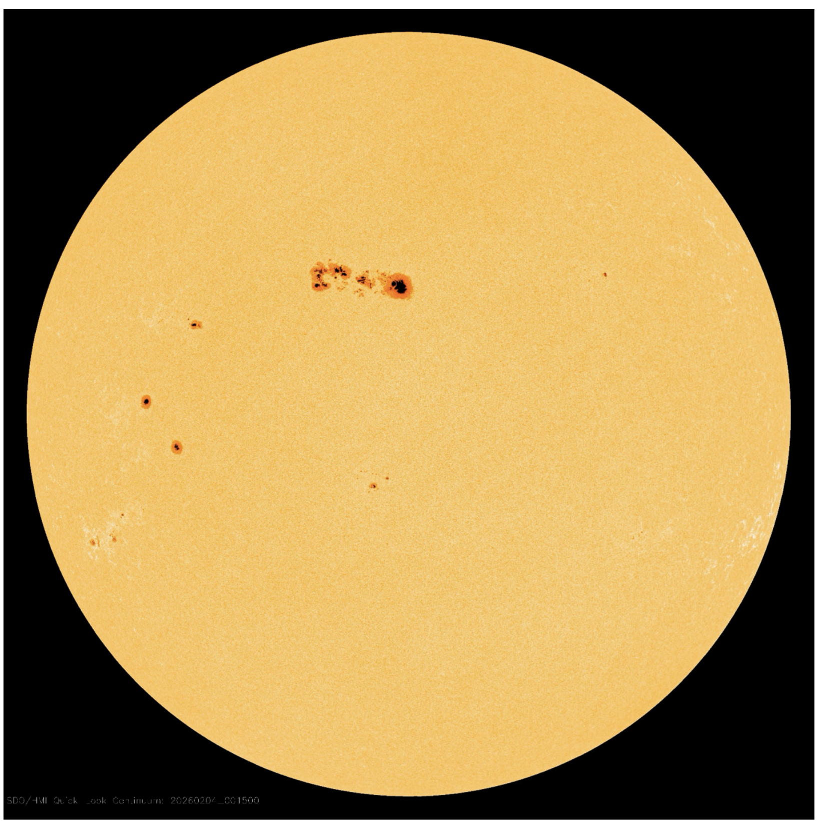
The Solar Bulletin of the AAVSO is a summary of each month's solar activity recorded by visual solar observers' counts of group and sunspots, and the VLF radio recordings of SID Events in the ionosphere. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 AR 4366 Dominates Early February Solar Observations



Sun on February 4. AR 4366 is clearly visible. Courtesy of NASA/SDO.

Figure 1: Sun on February 4. AR 4366 is clearly visible. Courtesy of NASA/SDO.

On January 31, a smattering of small sunspots could be seen near the east limb of the sun. Given the designation AR 4366, over the next few days it exploded into a mammoth, complex active region that spawned numerous high-energy flares and minor coronal mass ejections. For example, in one 24-hour period it produced 23 M-class flares and 4 X-class flares, the largest an X8. At its greatest extent (around February 4), AR 4366 sprawled across about 200,000 miles of the Suns face, including a large leading sunspot several times the diameter of Earth.

The high level of activity associated with AR 4366 correlates with its magnetic field classification of beta-gamma-delta. Beta refers to the area having two sunspots or groups of sunspots of opposite magnetic polarity, while gamma designates a more complex structure in which there are also sunspots of intermixed polarity (Jaeggli and Norton 2016, 1). Delta is appended to the active region in the case that at least one of the member sunspots has opposing polarities inside of a common penumbra separated by no more than 2 in heliographic distance (Jaeggli and Norton 2016, 1). Delta regions are prone to flare activity (as demonstrated by AR 4366). In addition to providing excitement for solar observers and astrophotographers, the extreme activity of AR 4366 provides valuable information for solar scientists, especially those studying patterns of flare and CME activity during the ascending, maximum, and descending parts of the solar cycle (Chaudhari et al. 2024).

References:

Chaudhari A., Association of Solar Flares with Magnetic Complexity of the Sunspot Groups in Solar Active Regions During Solar Cycles 23-25. Indian Journal of Physics 98.9 (2024): 3075-82.

Jaeggli, S.A., and A.A. Norton. The Magnetic Classification of Solar Active Regions 1992-2015. Astrophysical Journal Letters 820 (2016): L11.

Phillips, T. Spaceweather, February 2, 2026. `https://www.spaceweather.com/archive.php?view=1&day=02&month=02&year=2026`

Phillips, T. Spaceweather, February 4, 2026. `https://www.spaceweather.com/archive.php?view=1&day=04&month=02&year=2026`

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

February 2026 (Figure 2): there were 9 M-class, 3 C-class flares on the 3rd of February; the X1.5 shows a double SID with "shark's tails" lasting about 2 hours. This VLF scan was recorded in southern France by Lionel Laudet (A118). (U.S. Dept. of Commerce–NOAA, 2022).

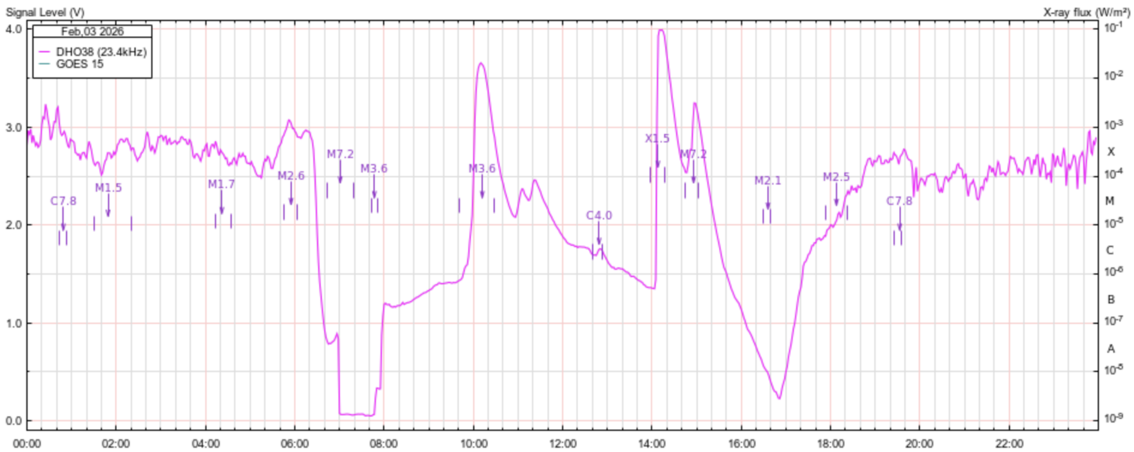


Figure 2: VLF recording from Southern France.

2.2 SID Observers

In February 2026 we had 11 AAVSO SID observers who submitted VLF data, as listed in Table 1.

Table 1: 202602 VLF Observers

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

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.

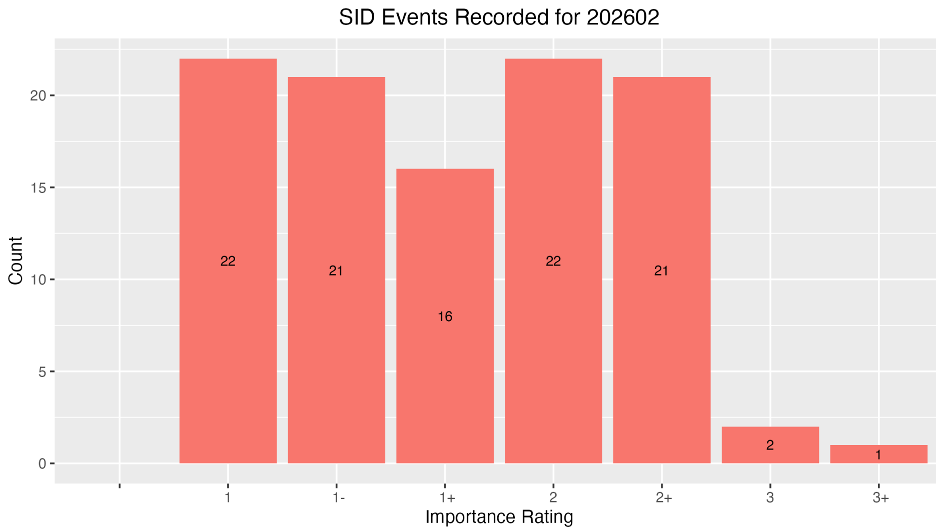


Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In February 2026, There were 241 GOES-19 XRA flares for February: six X-class, 73 M-class, 139 C-class, 23 B-class. More flaring this month than last. (see Figure 4).

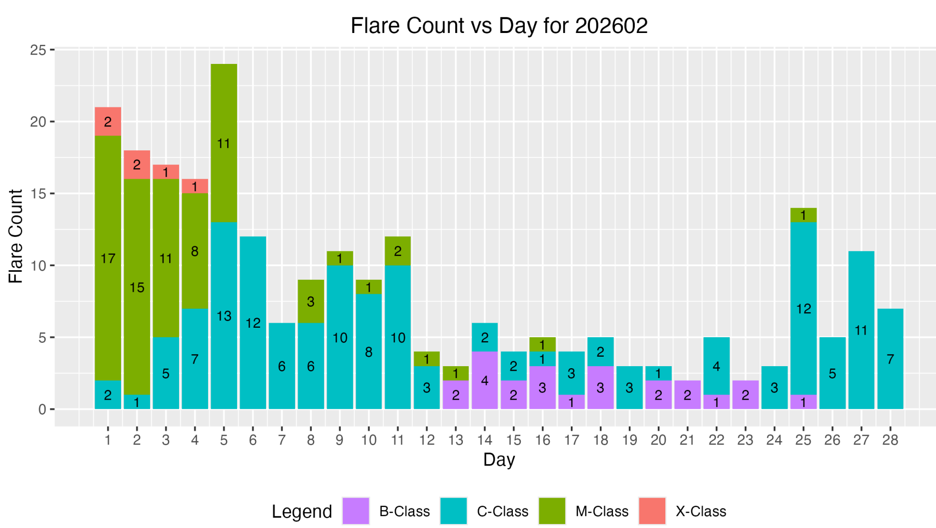


Figure 4: GOES-19 XRA flares (U.S. Dept. of Commerce–NOAA, 2023).

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 February 2026. 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.

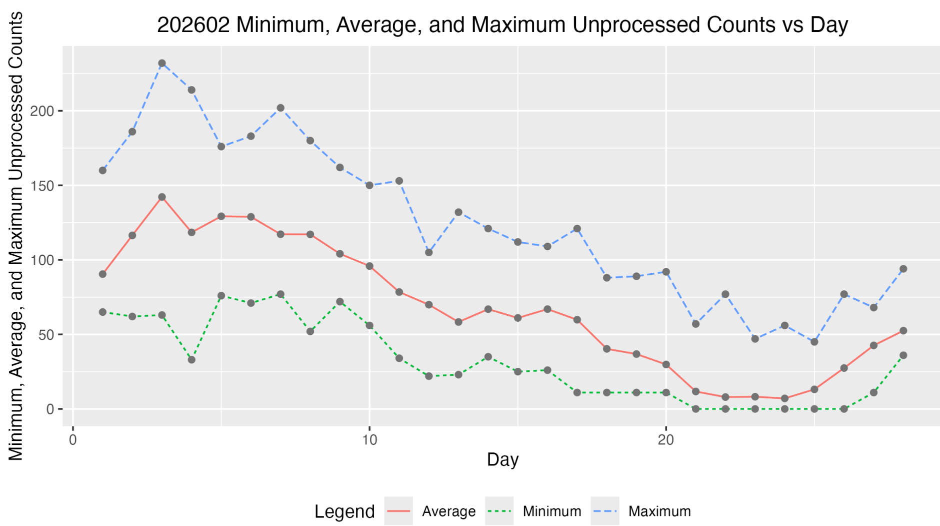


Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

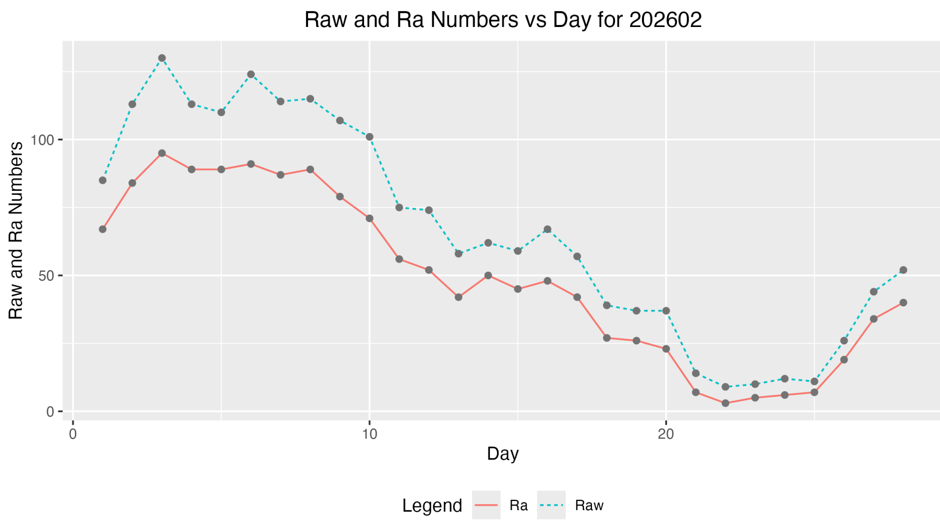


Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202602 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	85	67
2	24	113	84
3	20	130	95
4	29	113	89
5	28	110	89
6	29	124	91
7	28	114	87
8	33	115	89
9	27	107	79
10	22	101	71
11	23	75	56
12	29	74	52
13	24	58	42
14	27	62	50
15	31	59	45
16	24	67	48

Continued

Table 2: 202602 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
17	24	57	42
18	27	39	27
19	26	37	26
20	25	37	23
21	27	14	7
22	26	9	3
23	30	10	5
24	29	12	6
25	30	11	7
26	40	26	19
27	35	44	34
28	36	52	40
Averages	28	66.2	49

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for February 2026, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (60), and total number of observations submitted (783).

Table 3: 202602 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	24	Alexandre Amorim
AJV	8	J. Alonso
ARAG	26	Gema Araujo
ASA	1	Salvador Aguirre
BATR	3	Roberto Battaiola
BMIG	9	Michel Besson
BTB	10	Thomas Bretl
BVZ	11	Jesus E. Blanco
BXZ	19	Jose Alberto Berdejo
BZX	19	A. Gonzalo Vargas
CKB	7	Brian Cudnik
CMAB	6	Maurizio Cervoni
CNT	20	Dean Chantiles
CWD	1	David Cowall
DARB	23	Aritra Das
DELS	1	Susan Delaney
DFR	8	Frank Dempsey
DGIA	8	Giuseppe di Tommasco

Continued

Table 3: 202602 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DIL	23	Bill Dillon
DJOB	15	Jorge del Rosario
DJSA	8	Jeff DeVries
DJVA	27	Jacques van Delft
DMIB	18	Michel Deconinck
DUBF	19	Franky Dubois
EHOA	17	Howard Eskildsen
FALB	9	Allen Frohardt
FERA	7	Eric Fabrigat
GCNA	1	Candido Gomez
GIGA	16	Igor Grageda Mendez
HKY	16	Kim Hay
HOWR	15	Rodney Howe
HRUT	24	Timothy Hrutkay
ILUB	3	Luigi Iapichino
JDAC	3	David Jackson
JSI	2	Simon Jenner
KAMB	28	Amoli Kakkar
KAND	12	Kandilli Observatory
KAPJ	11	John Kaplan
KNJS	25	James & Shirley Knight
KTOC	11	Tom Karnuta
LKR	4	Kristine Larsen
LLEC	27	Leroy Leonard
LRRA	20	Robert Little
MARC	2	Arnaud Mengus
MARE	12	Enrico Mariani
MJHA	28	John McCammon
MMI	28	Michael Moeller
MUDG	7	George Mudry
MWMB	4	William McShan
MWU	15	Walter Maluf
PLUD	6	Ludovic Perbet
RJV	13	Javier Ruiz Fernandez
SDOH	28	Solar Dynamics Obs - HMI
SNE	6	Neil Simmons
SRIE	14	Rick St. Hilaire
TDE	22	David Teske
TPJB	3	Patrick Thibault
TST	13	Steven Toothman
URBP	16	Piotr Urbanski
YAAA	1	Anam Yargatti

Continued

Table 3: 202602 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
Totals	783	60

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.

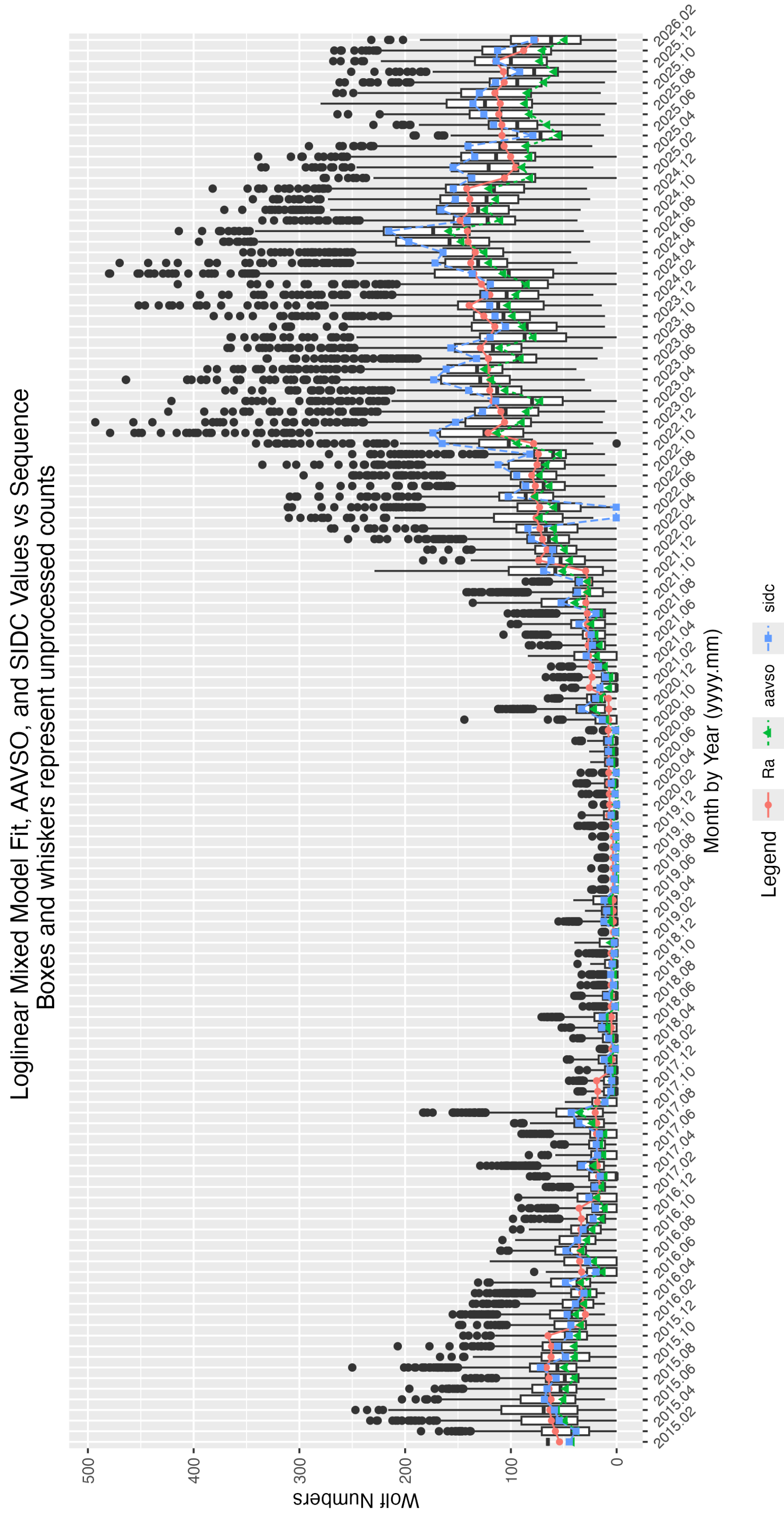


Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

5 Projection scans: Observation Report of AR 4366

Telescope Details: Aperture 100 mm with a focal length of 1000 mm (f/10 focal ratio), using a 25 mm eyepiece.

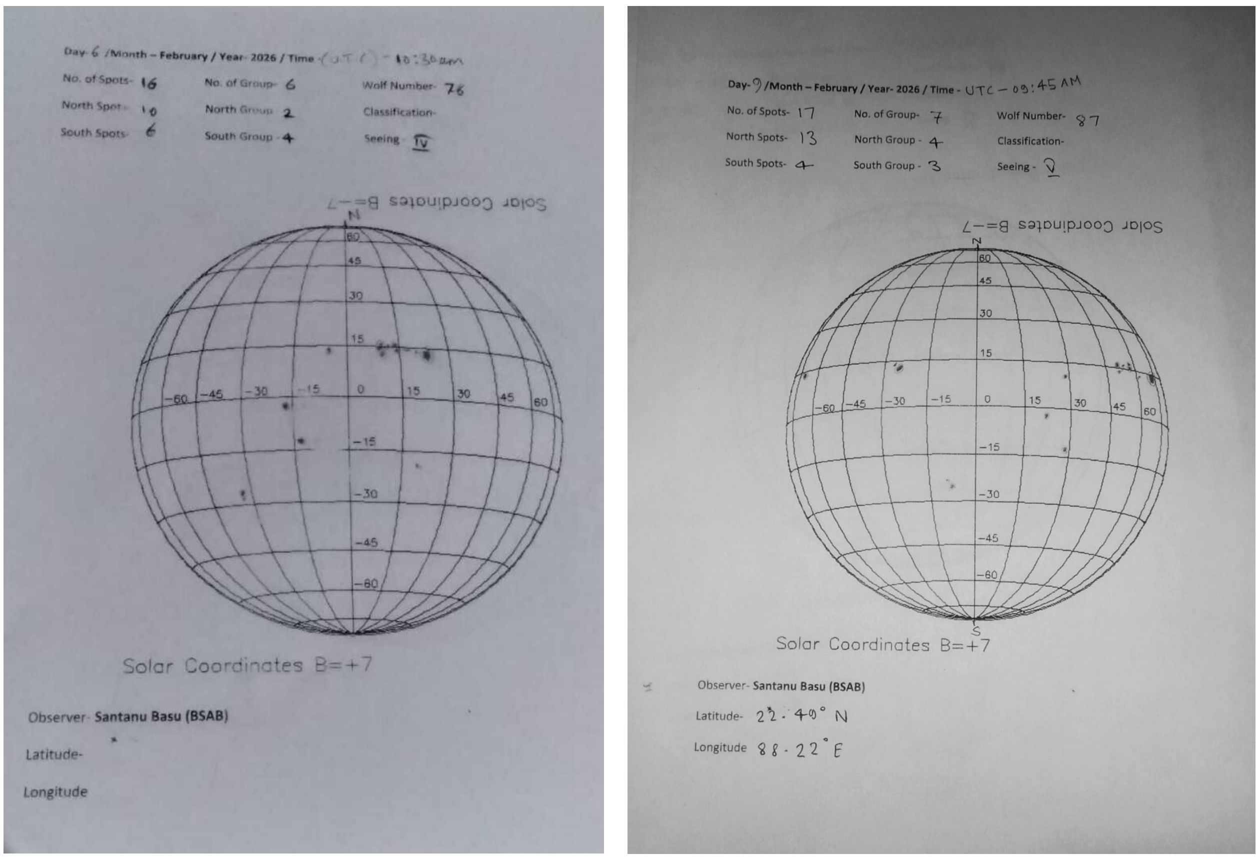


Figure 8: This report presents my observational sketches (BSAB) of Active Region (AR) 4366, along with other active regions. AR 4366 triggered an X-class flare last week. The upper images correspond to observations made on 6 February and 9 February. On 6 February, the AR 4366 was nearly facing Earth, while on 9 February AR 4366 was positioned close to the solar limb (left) The sunspots were classified as Fac (33) on 6 February and Fai (24) on 9 February according to the McIntosh classification system, indicating the slow evolution of AR 4366. Additionally, the region exhibited an unstable betagammadelta magnetic field configuration. This slow evolution may suggest that the preceding spots could return with an Hax or Hsx classification after approximately 13 days (right).(https://www.spaceweatherlive.com/en/help/the-classification-of-sunspots-after-malde.html) (https://www.nasa.gov/image-article/solar-rotation-varies-by-latitude/

6 References

Dr. Jamie Riggs, Solar System Science Section Head, International Astrostatistics R Statistical Software (2023), TSA Libraries: https://cran.r-project.org

SIDC data (2023), WDC-SILSO, Royal Observatory of Belgium, Brussels https://www.sidc.be/silso/datafiles

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center (2023), *GOES-16 XRA data.* ftp://ftp.swpc.noaa.gov/pub/indices/events/