Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 81 Number 10 October 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 3. The relative sunspot numbers are in Section 4. Section 5 has endnotes.

1 The Sun's North/South magnetic fields and Starspots in the News

Careful monitoring of the magnetic activity of other stars combined with solar observations improves our understanding of how stars evolve magnetically.

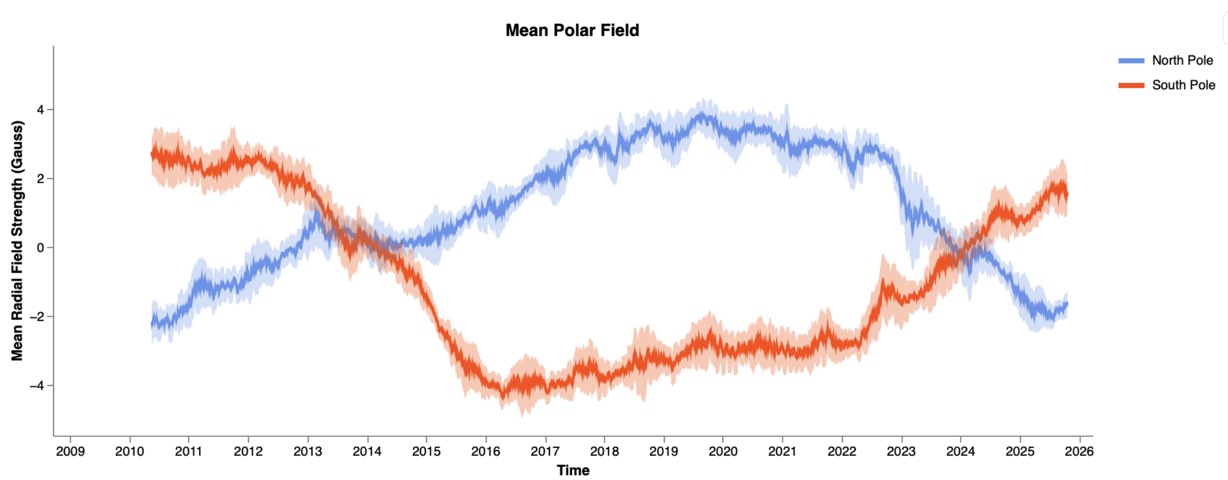

Figure 1: The SDO satellite records the North/South magnetic field from 2011 to present, Jupyter Lab (2025)
`https://svs.gsfc.nasa.gov/search/?keywords=Solar%20Magnetic%20Field`

Spots are a normal surface feature of sunlike stars; some stars (particularly M dwarfs) have much larger brightness variations than our sun due to the relative size of the spots compared to the star's surface area. Studying starspots can lead to further understanding of the solar cycle, and vice versa. Over the past few months, there have been a number of interesting professional papers published on starspots:

"Starspots as the origin of ultrafast drifting radio bursts from an active M dwarf", Jiale Zhang and an international group of collaborators have shown that a specific type of radio bursts from M dwarf stars are best explained by starspot activity. (`https://www.science.org/doi/10.1126/sciadv.adw6116`)

"Polka-dotted Stars: A Hierarchical Model for Mapping Stellar Surfaces Using Occultation Light Curves and the Case of TOI-3884", Sabina Sagynbayeva of Stony Brook University and colleagues have developed a method for turning exoplanet light curves into maps of starspots on a star's surface. Such studies can aid in the analysis of latitudinal distributions of starspots, similar to what happens in the solar cycle. (`https://iopscience.iop.org/article/10.3847/1538-4357/adf6be`)

"Multiband, Multiepoch Photometry of the Spot-crossing System TOI-3884: Refined System Geometry and Spot Properties", Mayuko Mori (Astrobiology Center and National Astronomical Observatory of Japan) and an international group of colleagues published a detailed analysis of transit data for the TOI-3884 system, an M dwarf that shows spot-crossing features in every transit. They were able to improve our understanding of the star's rotation, and better determine the location of a persistent spot near one stellar pole and the overall geometry of the planet's orbit. (`https://iopscience.iop.org/article/10.3847/1538-3881/ade2df`)

"The Relationship of Stellar Radius Inflation to Rotation and Magnetic Starspots at 10670 Myr", Lyra Cao and Keivan G. Stassun of Vanderbilt University have connected the unusually large diameters of some active young low-mass stars with the fraction of their surface covered in starspots. This work gives further insight into models of stellar evolution and how a star's rotation and magnetic field change during this early evolution. (`https://iopscience.iop.org/article/10.3847/2041-8213/ade875`)

"Starspot Area Coverage: Correlation with Age and Spectral Type in FGK and M Stars", Alexandre Arajo and a team affiliated with the Centro de Rdio Astronomia e Astrofsica Mackenzie, Brazil, also studied spotted stars in order to learn about magnetic field changes over a star's evolution. They found that older stars had lower surface area coverage by spots, but that the relationship between a star's rotation and starspot coverage was more complicated. (`https://iopscience.iop.org/article/10.3847/2041-8213/add338`)

2 Kepler star KIC 10414643 and 100 days of AAVSO solar data

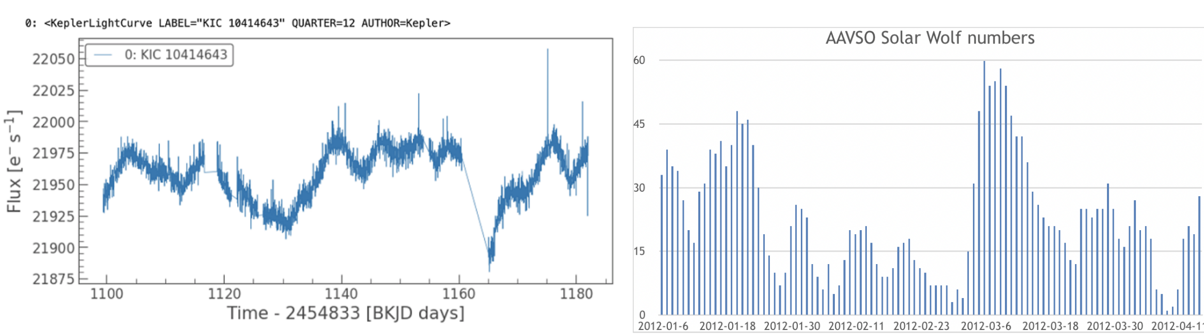

Figure 2: Kepler data (Kluyver et al. 2016) and (Saunders, 2020), compared to AAVSO Solar data for same 100-day time series during solar cycle 24.

KIC 10414643 is a star with a similar rotation period to the Sun. The Kepler Space Telescope recorded flux data for this star from 2009 to 2012. The above shows 100 days of KIC 10414643 data (Zhang et al., 2020) and 100 days of AAVSO Wolf numbers. Note that changes in the solar Wolf numbers might show an inverse relationship in variability where brighter faculae tend to overcompensate for darker sunspots.

3 Sudden Ionospheric Disturbance (SID) Report

3.1 SID Records

October 2025 (Figure 3): There were 2 M-class flares on the 3rd of October; one shows a nice SID with a "shark's tail" during the day, recorded in southern France, by Lionel Laudet (A118). (U.S. Dept. of Commerce–NOAA, 2022).

Figure 3: VLF recording from southern France, for October 3rd, 2025.

3.2 SID Observers

In October 2025 we had 10 AAVSO SID observers who submitted VLF data, as listed in Table 1.

Table 1: 202510 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 4 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.

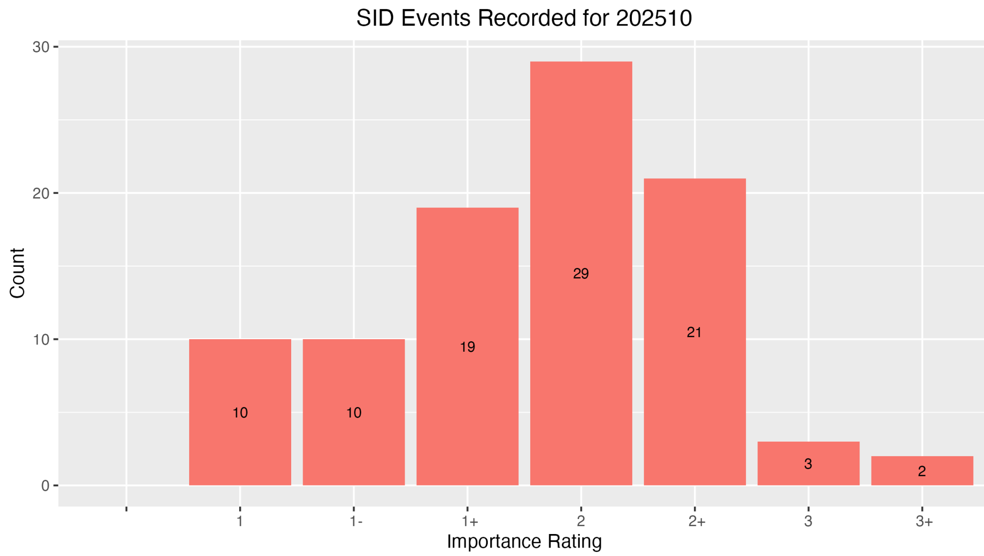

Figure 4: VLF SID Events.

3.3 Solar Flare Summary from GOES-16 Data

In October 2025, there were 244 GOES-16 XRA flares: 20 M-Class, 209 C-Class, and 15 B-Class flares. A little less flaring than last month. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 5).

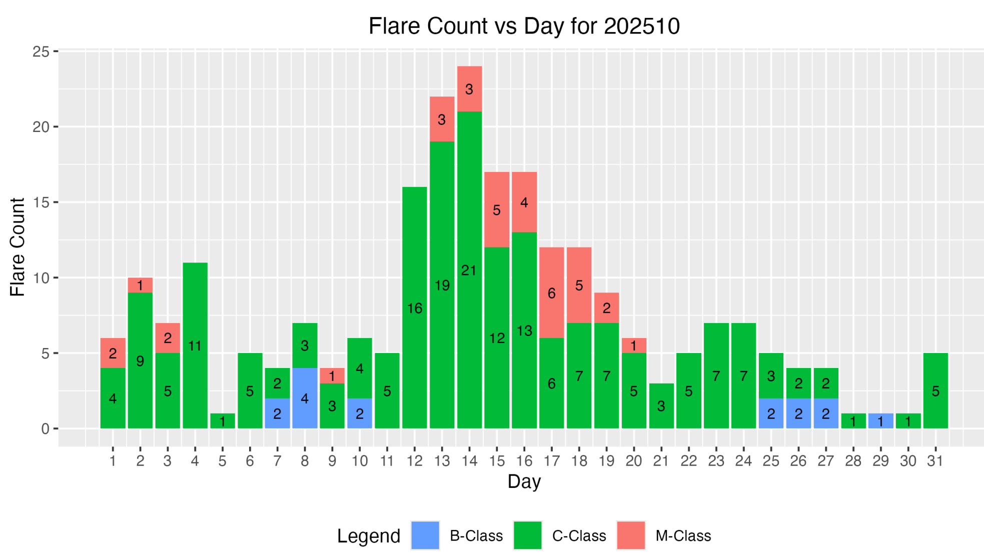

Figure 5: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

4 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.

4.1 Raw Sunspot Counts

The raw daily sunspot counts consist of submitted counts from all observers who provided data in October 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 6.

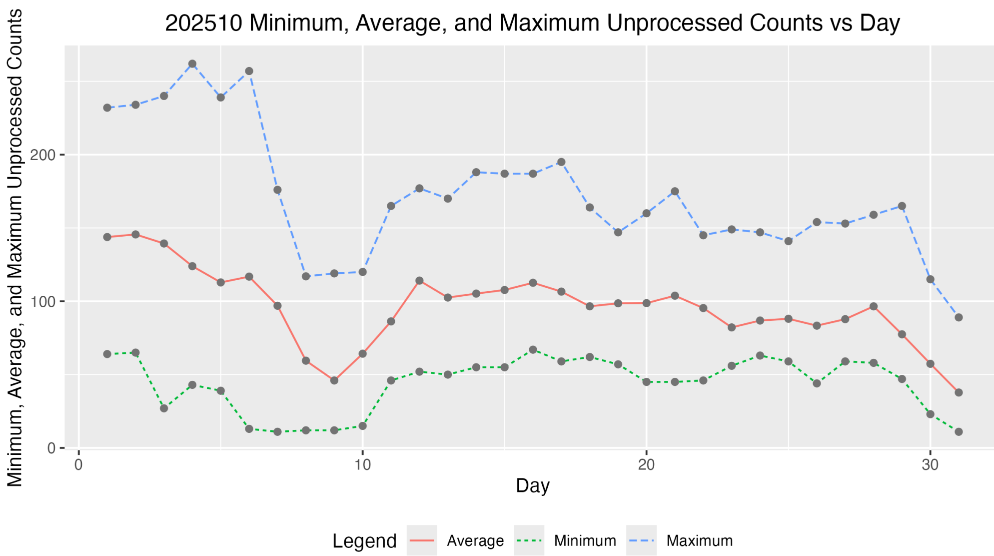

Figure 6: Raw Wolf number average, minimum and maximum by day of the month for all observers.

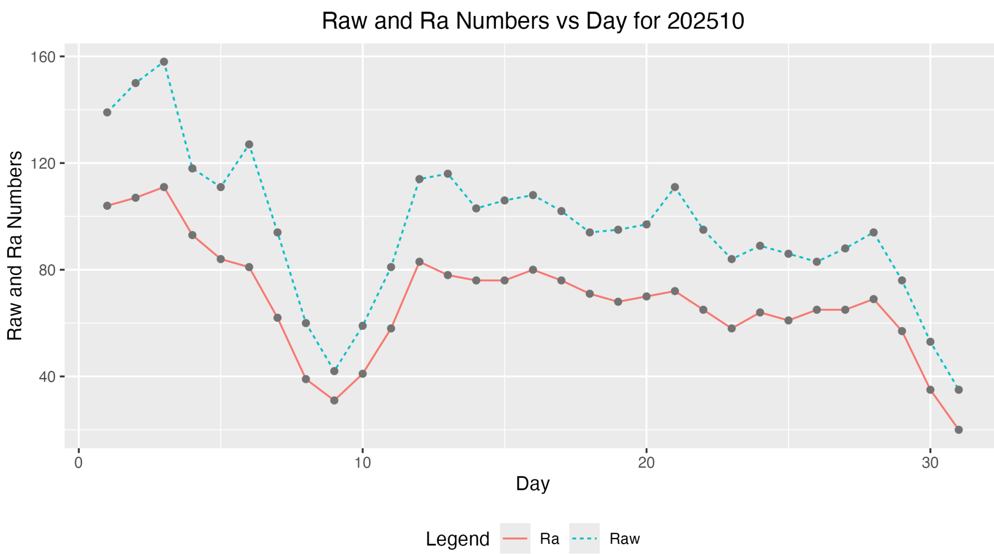

Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

4.2 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 7, 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: 202510 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	139	104
2	31	150	107
3	30	158	111
4	34	118	93
5	33	111	84
6	27	127	81
7	22	94	62
8	26	60	39
9	26	42	31
10	24	59	41
11	25	81	58
12	22	114	83
13	26	116	78
14	31	103	76
15	27	106	76

Continued

Table 2: 202510 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	31	108	80
17	24	102	76
18	23	94	71
19	21	95	68
20	26	97	70
21	31	111	72
22	27	95	65
23	23	84	58
24	32	89	64
25	19	86	61
26	29	83	65
27	25	88	65
28	24	94	69
29	21	76	57
30	22	53	35
31	18	35	20
Averages	26.1	95.7	68.4

4.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for October 2025, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (52), and total number of observations submitted (810).

Table 3: 202510 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	17	Alexandre Amorim
AJV	22	J. Alonso
ASA	3	Salvador Aguirre
BATR	4	Roberto Battaiola
BMIG	18	Michel Besson
BTB	18	Thomas Bretl
BVZ	21	Jesus E. Blanco
BXZ	26	Jose Alberto Berdejo
CKB	31	Brian Cudnik
CMAB	7	Maurizio Cervoni
CNT	21	Dean Chantiles
CWD	8	David Cowall
DARB	23	Aritra Das
DELS	6	Susan Delaney

Continued

Table 3: 202510 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DFR	16	Frank Dempsey
DGIA	1	Giuseppe di Tommasco
DJOB	11	Jorge del Rosario
DJSA	5	Jeff DeVries
DJVA	30	Jacques van Delft
DMIB	19	Michel Deconinck
DUBF	21	Franky Dubois
EHOA	6	Howard Eskildsen
FALB	8	Allen Frohardt
FERA	16	Eric Fabrigat
GIGA	25	Igor Grageda Mendez
HKY	19	Kim Hay
HOWR	20	Rodney Howe
ILUB	3	Luigi Iapichino
JGE	1	Gerardo Jimenez Lopez
JSI	3	Simon Jenner
KAND	22	Kandilli Observatory
KAPJ	19	John Kaplan
KNJS	28	James & Shirley Knight
KTOC	11	Tom Karnuta
LKR	7	Kristine Larsen
LRRA	21	Robert Little
MARC	3	Arnaud Mengus
MARE	13	Enrico Mariani
MJHA	25	John McCammon
MMI	31	Michael Moeller
MUDG	8	George Mudry
MWMB	5	William McShan
MWU	19	Walter Maluf
PLUD	21	Ludovic Perbet
RJV	19	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	12	Neil Simmons
SRIE	11	Rick St. Hilaire
TDE	23	David Teske
TPJB	5	Patrick Thibault
TST	24	Steven Toothman
URBP	23	Piotr Urbanski
Totals	810	52

4.4 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 4 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 8 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.

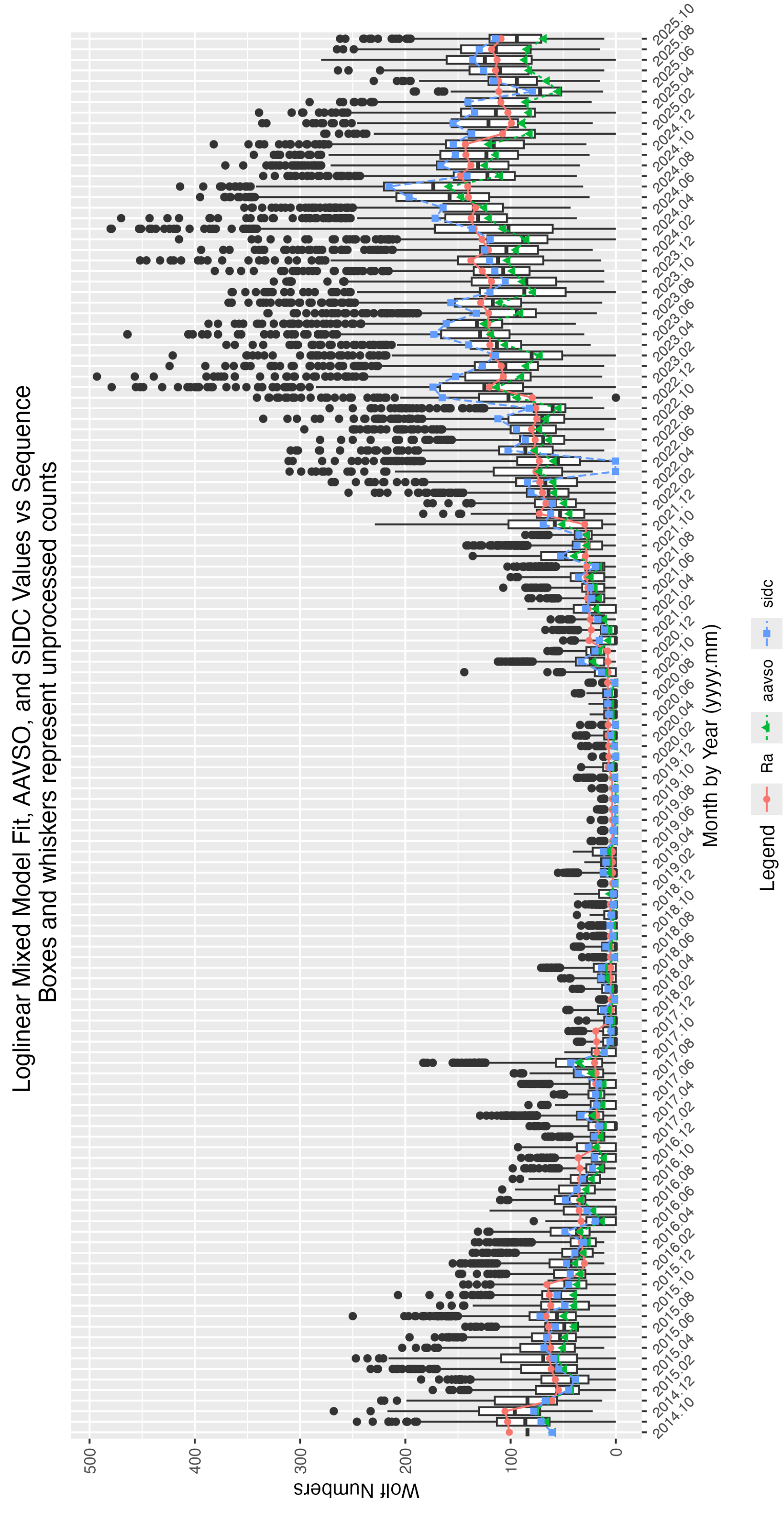

Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

5 Endnotes

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

6 References

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