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. Section 1 gives contributions by our members. The sudden ionospheric disturbance report is in Section 2. The relative sunspot numbers are in Section 3. Section 4 has endnotes.

1 Solar Dynamics Observatory satellite images of AR12835

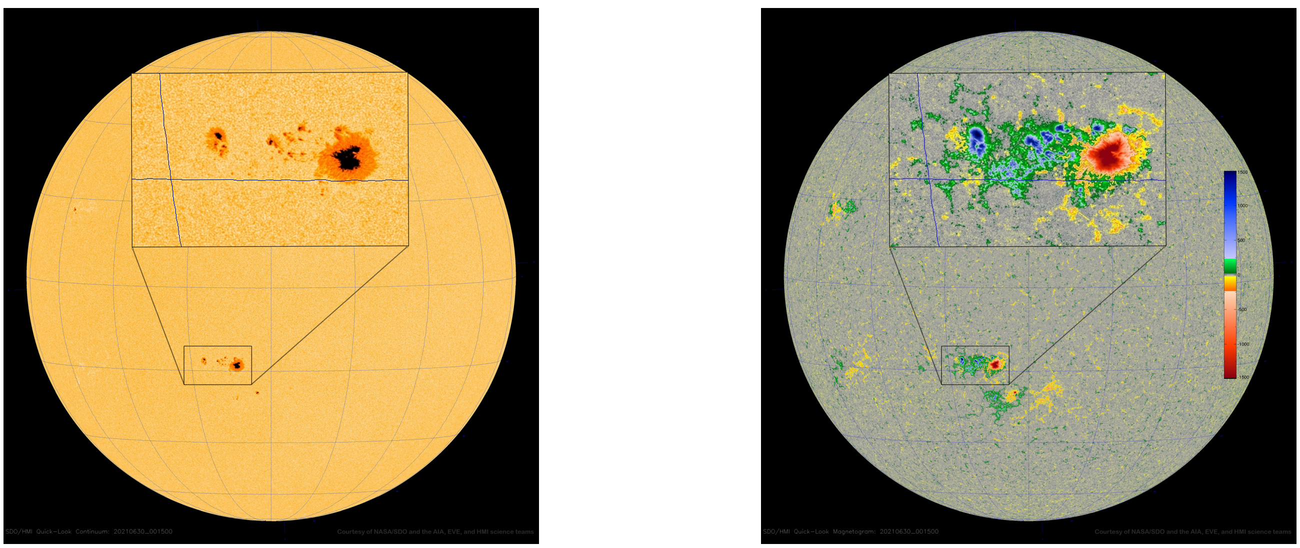


Figure 1: Left panel is SDO visual intensity, right panel Helioseismic Magnetic Image (HMI).

Two detail blowups: left is visual 'white light' and right is same area in magnetic spectrum.
`https://www.nasa.gov/content/goddard/sdo-hmi-magnetogram/`

Here is a montage of the active region AR12835 on 06/30/21 at 00:15:00 which clearly illustrates that "behind" each sunspot is "hiding" a magnetic activity just as important as the sunspot is. The assembly consists of a superposition of two images of the sun captured by Solar Dynamics Observatory (SDO), the first of which was produced with the "HMII / Continuum" instrument and the second with the "HMII / Magnetogram" instrument. For each of these images I inserted the lines of latitudes and longitudes using the "Helioviewer2" application. Finally, the game of supperpostion by transparency and the enlargement windows were completed with Photoshop. By Max Surlaroute (MMAY). For further reading on solar magnetics, see the Endnotes section.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

June 2021 (Figure 2): the 8th was a very active day with B-class flares and a C2.4 flare with a small SID Event around 1730 UT, recorded here in Fort Collins, Colorado.

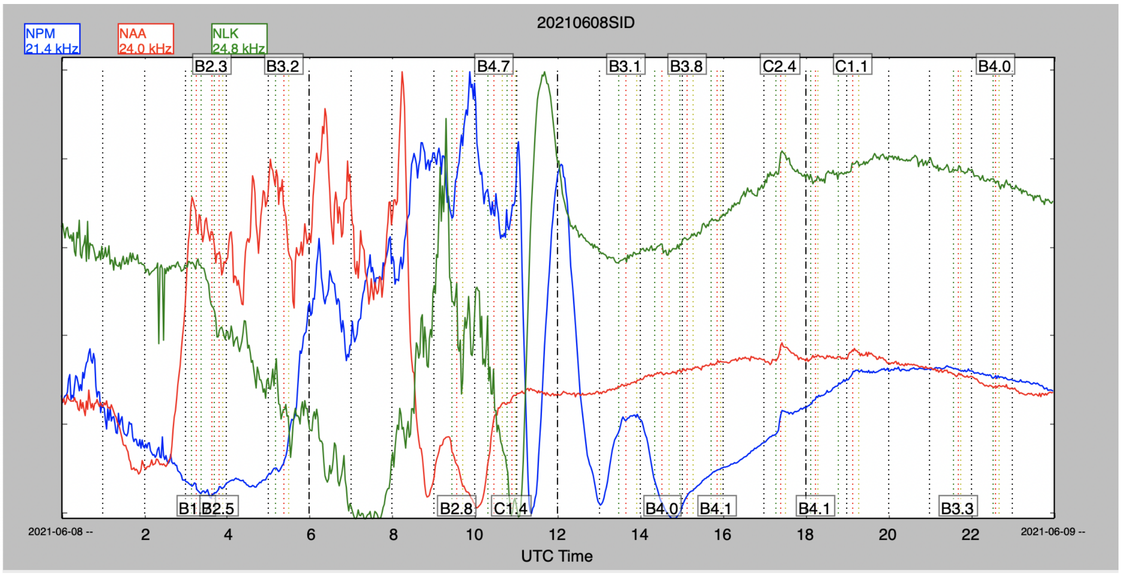


Figure 2: VLF recording on the 8th of June from Fort Collins, Colorado

2.2 SID Observers

In June 2021 we had 10 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202106 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO GBZ
J Godet	A119	GBZ
F Adamson	A122	NWC
S Aguirre	A138	NPM
R Rogge	A143	GQD
K Menzies	A146	NAA
L Pina	A148	NML
H Krumnow	A152	HWU GQD DHO

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.

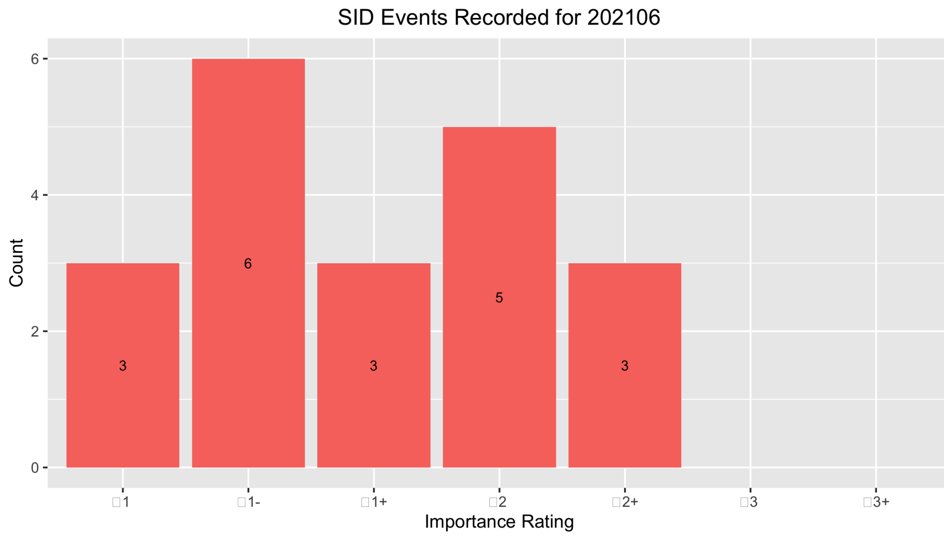


Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In June 2021, there were 132 XRA flares for the month of June 2021; 12 C-class flares and 120 B-class flares. Less flaring this month compared to last. There were 6 days this month with no flares. (see Figure 4).

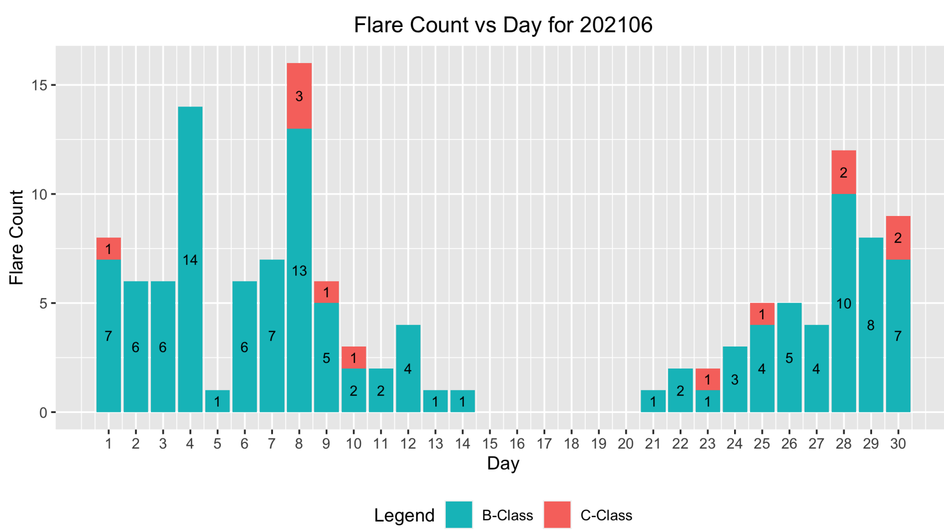


Figure 4: GOES-16 XRA flares

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 2021. 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.

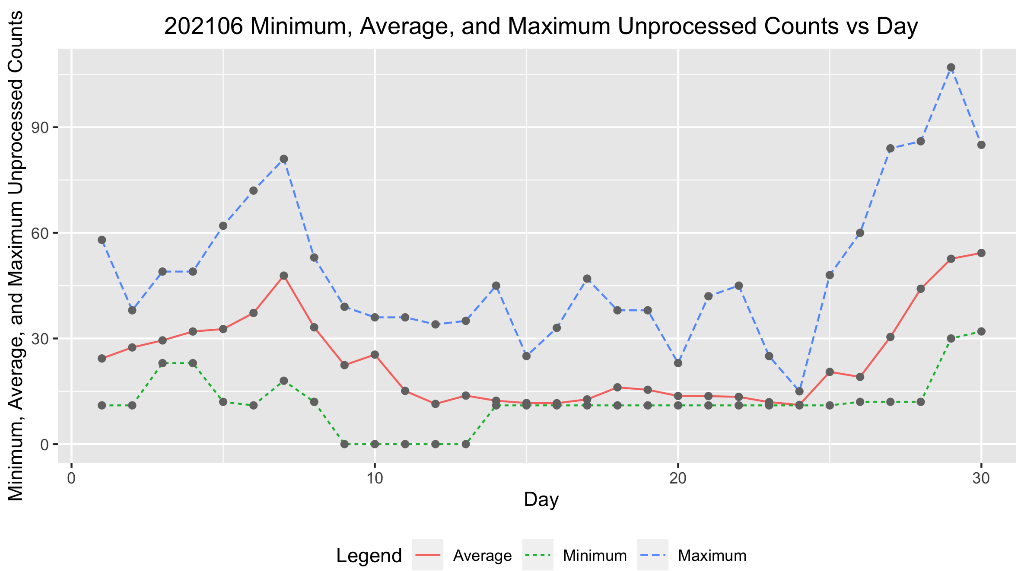


Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

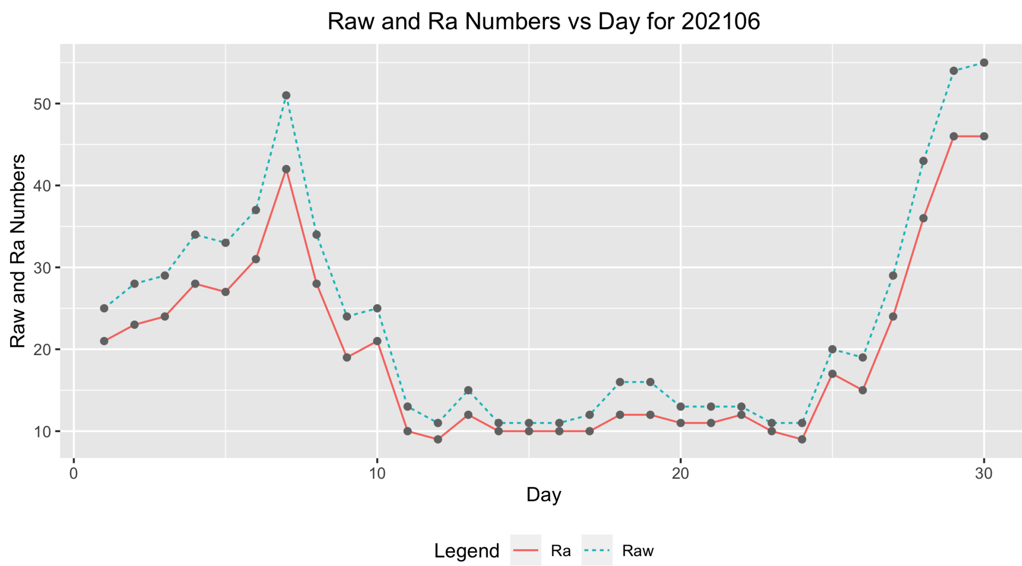


Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202106 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	47	25	21
2	44	28	23
3	46	29	24
4	44	34	28
5	53	33	27
6	53	37	31
7	47	51	42
8	41	34	28
9	42	24	19
10	48	25	21
11	39	13	10
12	47	11	9
13	45	15	12
14	47	11	10

Continued

Table 2: 202106 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	46	11	10
16	44	11	10
17	40	12	10
18	43	16	12
19	42	16	12
20	42	13	11
21	44	13	11
22	39	13	12
23	51	11	10
24	46	11	9
25	45	20	17
26	47	19	15
27	49	29	24
28	43	43	36
29	46	54	46
30	42	55	46
Averages	45.1	23.9	19.9

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for June 2021, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (74), and total number of observations submitted (1354).

Table 3: 202106 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	19	Alexandre Amorim
AJV	22	J. Alonso
ARAG	30	Gema Araujo
ASA	18	Salvador Aguirre
ATE	29	Teofilo Arranz Heras
BARH	10	Howard Barnes
BATR	15	Roberto Battaiola
BERJ	25	Jose Alberto Berdejo
BLAJ	20	John A. Blackwell
BMF	29	Michael Boschat
BRAF	20	Raffaello Braga
BROB	21	Robert Brown
CKB	27	Brian Cudnik
CMOD	3	Mois Carlo

Continued

Table 3: 202106 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	27	Dean Chantiles
CVJ	6	Jose Carvajal
DARB	10	Aritra Das
DJOB	13	Jorge del Rosario
DMIB	23	Michel Deconinck
DROB	12	Bob Dudley
DUBF	21	Franky Dubois
EHOA	10	Howard Eskildsen
ERB	25	Bob Eramia
FDAE	4	David Fox
FERJ	18	Javier Ruiz Fernandez
FLET	27	Tom Fleming
GIGA	28	Igor Grageda Mendez
HALB	18	Brian Halls
HAYK	17	Kim Hay
HMQ	9	Mark Harris
HOWR	22	Rodney Howe
IEWA	27	Ernest W. Iverson
JDAC	14	David Jackson
JENJ	11	Jamey Jenkins
JENS	11	Simon Jenner
JGE	8	Gerardo Jimenez Lopez
JPG	1	Penko Jordanov
KAMB	29	Amoli Kakkar
KAND	21	Kandilli Observatory
KAPJ	21	John Kaplan
KNJS	26	James & Shirley Knight
KZAD	30	Zachary Knoles
LEVM	16	Monty Leventhal
LGEC	3	Georgios Lekkas
LKR	9	Kristine Larsen
LRRA	21	Robert Little
MARC	10	Arnaud Mengus
MARE	12	Enrico Mariani
MCE	24	Etsuiku Mochizuki
MILJ	18	Jay Miller
MJAF	30	Juan Antonio Moreno Quesada
MJHA	30	John McCammon
MMAY	30	Max Surlaroute
MMI	30	Michael Moeller
MUDG	14	George Mudry
MWU	25	Walter Maluf
OAAA	21	Al Sadeem Astronomy Obs.

Continued

Table 3: 202106 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
ONJ	18	John O'Neill
PEKT	5	Riza Pektas
RFDA	18	Filipp Romanov
SDOH	30	Solar Dynamics Obs - HMI
SNE	13	Neil Simmons
SONA	21	Andries Son
SQN	8	Lance Shaw
SUZM	22	Miyoshi Suzuki
SVAE	5	Valery Stanimirov
TESD	24	David Teske
TPJB	2	Patrick Thibault
TST	22	Steven Toothman
URBP	30	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
VIDD	7	Dan Vidican
WGI	4	Guido Wollenhaupt
WILW	25	William M. Wilson
Totals	1354	74

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. For more details, *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 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.

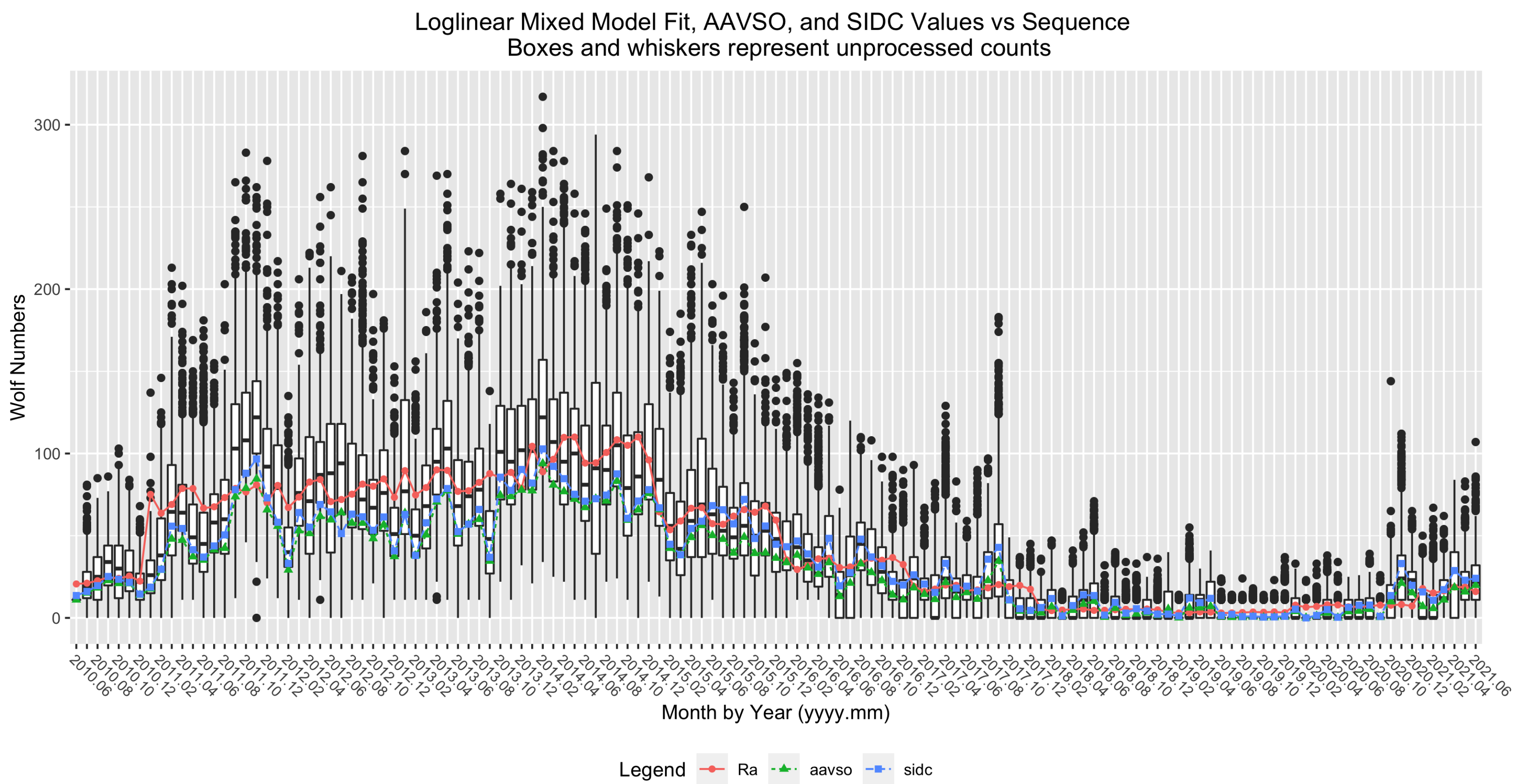
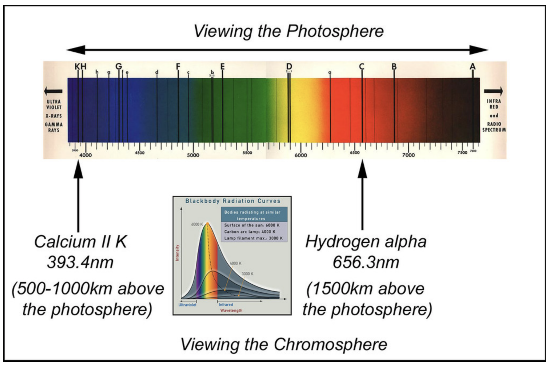


Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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



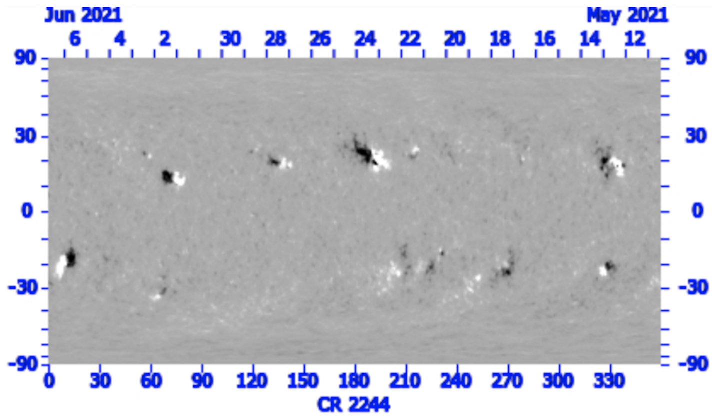


Figure 8: Left panel shows the Calcium line spectra, right panel shows the Carrington Rotation image from GONG: (https://gong2.nso.edu/oQR/mqj/202105/mrmqj210525/mrmqj210525t0157c2244_000.jpg)

"The suns rotation, chromospheric emissions, and magnetisms follow the inverse square root relation. This was discovered when Skumanich studied the ionized calcium line, and Leighton discovered it to be tightly related to the solar surface magnetism. All this relates to how solar magnetic fields operate over time. Skumanich set the observational basis for understanding the evolution of stellar angular momentum (rotation) and magnetism." (Philip Judge, 2020)

(https://www2.hao.ucar.edu/sites/default/files/users/sheryls/Skumanich_1.pdf)

5 References

Philip Judge, 2020, THE SUN, Oxford University Press, OX2 6DP, United Kingdom: (https://global.oup.com/academic/product/the-sun-a-very-short-introduction-9780198832690?cc=us&lang=en&)