Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 77 Number 10 October 2021

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 Contour line spectra of Deuterium on the sun at 327 MHz

The spectrum (electron-magnetic) phasing and beam-forming checks on the Sun for Deuterium is somewhat dubious, as Deuterium is totally consumed during the fusion process on the sun. So, what we see is part of the total electron-magnetic spectrum at 327 MHz, not necessarily the Deuterium. Alan Rogers describes his Deuterium array: `https://www.haystack.mit.edu/wp-content/uploads/2020/07/memo_deuterium_068.pdf`.

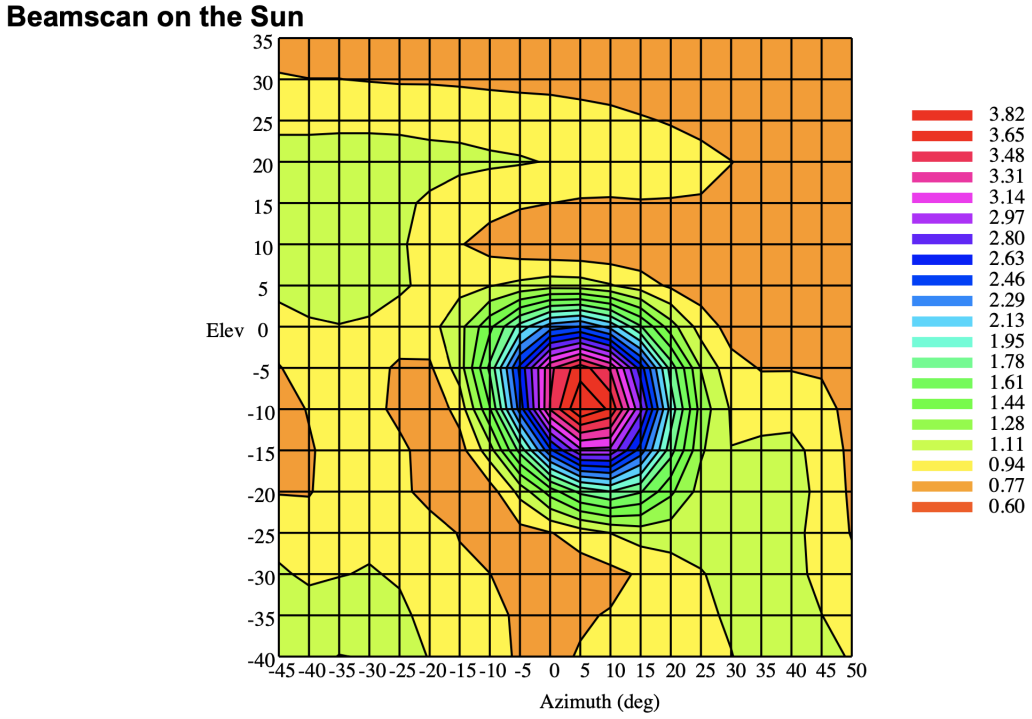

Figure 1: 327 MHz contour image of Deuterium on the sun.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

October 2021 (Figure 2): a X1.0 flare from NAA at 15:25 UT created a huge SID Event recorded by John Wendler (A150), Durham, ME.

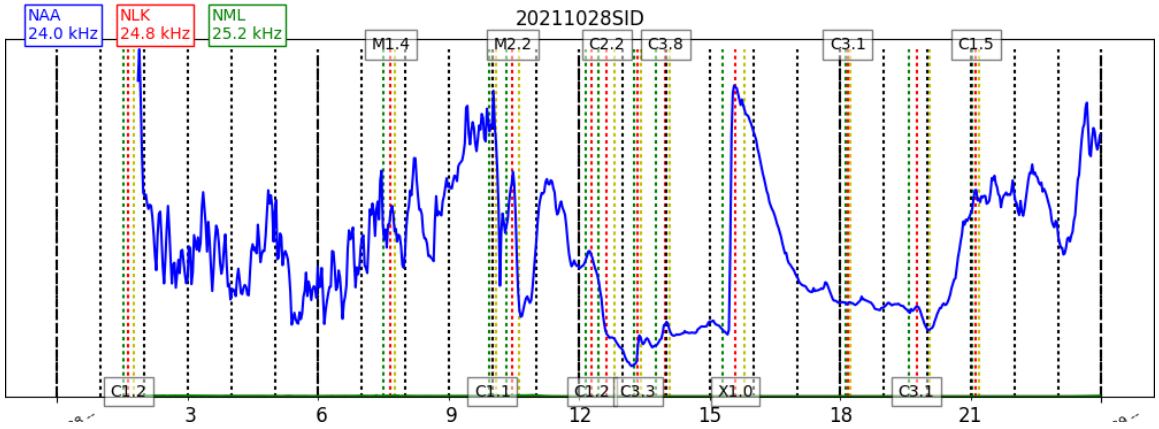

Figure 2: VLF recording on the 28th of October

2.2 SID Observers

In October 2021, 17 AAVSO SID observers submitted VLF data, as listed in Table 1.

Table 1: 202110 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD
B Terrill	A120	NWC
F Adamson	A122	NWC
J Karlovsky	A131	FTA
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	NAA NLK
R Rogge	A143	GQD
K Menzies	A146	NAA
L Pina	A148	NAA NLK
L Ferreira	A149	NWC
J Wendler	A150	NAA
H Krumnow	A152	FTA GBZ
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.

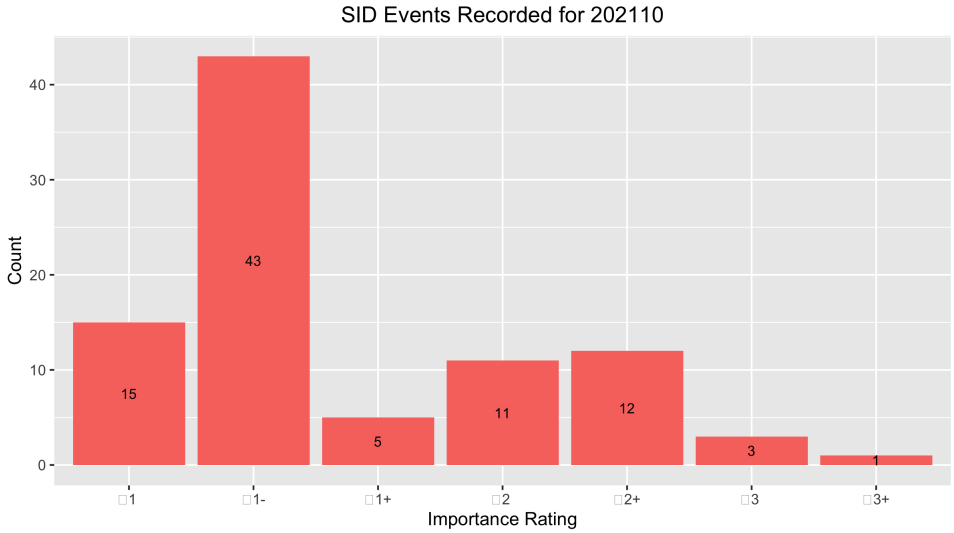

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In October 2021, there were 229 GOES-16 XRA flares: one X-Class, six M-Class, 68 C-Class, and 154 B-Class flares. About the same amount of flaring this month compared to last month, with only one day of no flares (Figure 4).

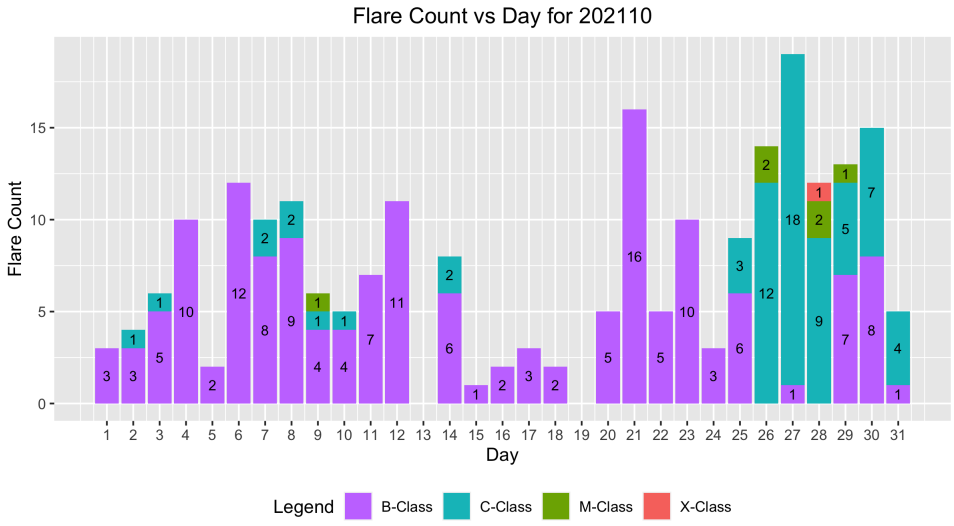

Figure 4: GOES-16 XRA flares

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 October 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.

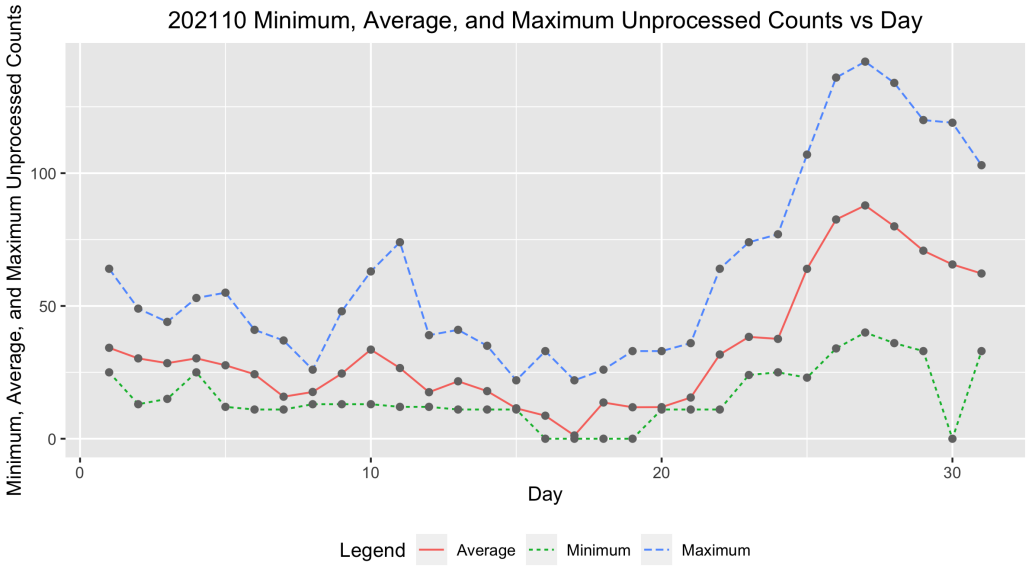

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

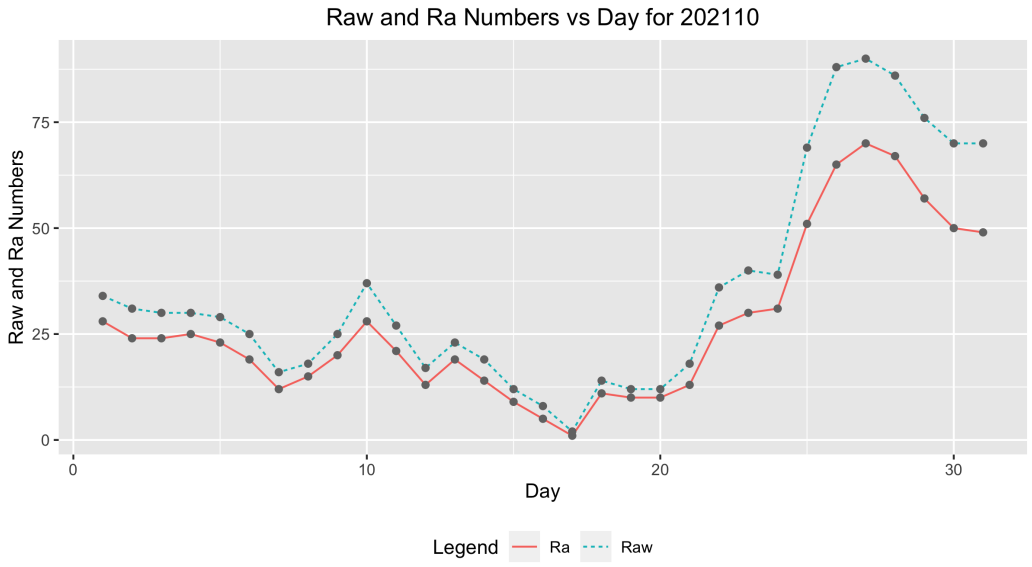

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202110 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	46	34	28
2	39	31	24
3	35	30	24
4	36	30	25
5	38	29	23
6	35	25	19
7	40	16	12
8	41	18	15
9	42	25	20
10	45	37	28
11	39	27	21
12	38	17	13
13	41	23	19
14	41	19	14

Continued

Table 2: 202110 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	41	12	9
16	46	8	5
17	36	2	1
18	40	14	11
19	41	12	10
20	40	12	10
21	37	18	13
22	35	36	27
23	40	40	30
24	45	39	31
25	35	69	51
26	34	88	65
27	40	90	70
28	42	86	67
29	37	76	57
30	27	70	50
31	32	70	49
Averages	38.8	35.6	27.1

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for October 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 (1206).

Table 3: 202110 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	12	Alexandre Amorim
AJV	5	J. Alonso
ARAG	25	Gema Araujo
ASA	21	Salvador Aguirre
ATE	28	Teofilo Arranz Heras
BARH	7	Howard Barnes
BATR	8	Roberto Battaiola
BERJ	26	Jose Alberto Berdejo
BLAJ	6	John A. Blackwell
BMF	24	Michael Boschat
BMIG	25	Michel Besson
BRAF	8	Raffaello Braga
BROB	22	Robert Brown

Continued

Table 3: 202110 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CIOA	6	Ioannis Chouinavas
CKB	28	Brian Cudnik
CMOD	5	Mois Carlo
CNT	31	Dean Chantiles
CVJ	9	Jose Carvajal
DARB	12	Aritra Das
DEMF	10	Frank Dempsey
DJOB	11	Jorge del Rosario
DMIB	25	Michel Deconinck
DROB	7	Bob Dudley
DUBF	25	Franky Dubois
EHOA	11	Howard Eskildsen
ERB	13	Bob Eramia
FERJ	24	Javier Ruiz Fernandez
FLET	29	Tom Fleming
FTAA	12	Tadeusz Figiel
GIGA	28	Igor Grageda Mendez
HALB	11	Brian Halls
HAYK	15	Kim Hay
HMQ	1	Mark Harris
HOWR	23	Rodney Howe
HRUT	25	Timothy Hrutkay
IEWA	28	Ernest W. Iverson
ILUB	15	Luigi Lapichino
JDAC	9	David Jackson
JENJ	2	Jamey Jenkins
JENS	4	Simon Jenner
JGE	7	Gerardo Jimenez Lopez
KAND	22	Kandilli Observatory
KKEA	2	Kerry Kelso
KNJS	30	James & Shirley Knight
KZAD	15	Zachary Knoles
LEVM	22	Monty Leventhal
LKR	5	Kristine Larsen
LRRA	20	Robert Little
MARC	13	Arnaud Mengus
MCE	22	Etsuiku Mochizuki
MILJ	9	Jay Miller
MJAF	30	Juan Antonio Moreno Quesada
MJHA	28	John McCammon
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MUDG	2	George Mudry

Continued

Table 3: 202110 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
MWU	14	Walter Maluf
OAAA	22	Al Sadeem Astronomy Obs.
ONJ	9	John O'Neill
PLUD	21	Ludovic Perbet
RFDA	23	Filipp Romanov
SDOH	31	Solar Dynamics Obs - HMI
SNE	1	Neil Simmons
SONA	13	Andries Son
SQN	5	Lance Shaw
TESD	26	David Teske
TPJB	5	Patrick Thibault
TST	18	Steven Toothman
URBP	18	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VIDD	16	Dan Vidican
WGI	6	Guido Wollenhaupt
WILW	14	William M. Wilson
WND	11	Denis Wallian
Totals	1206	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.

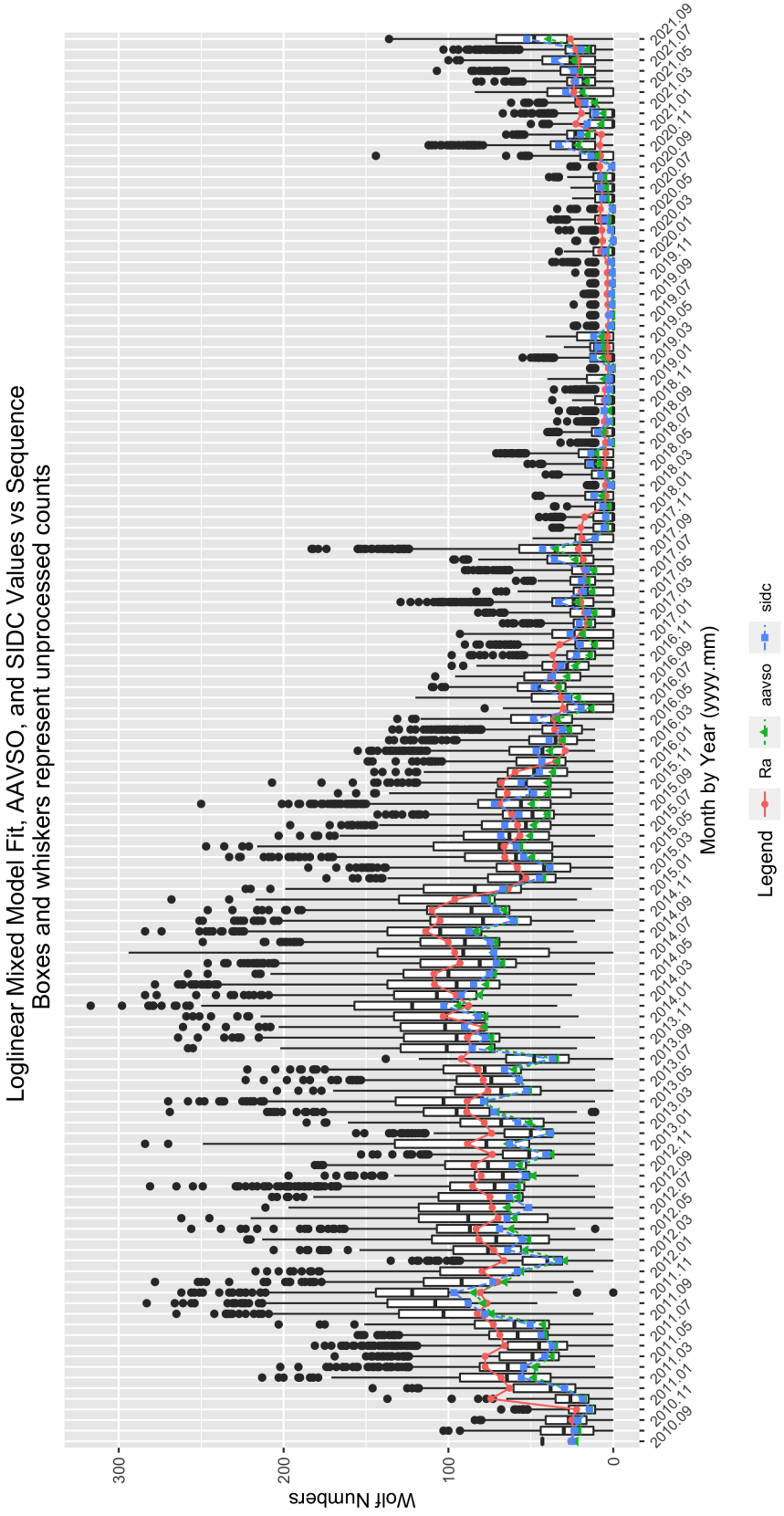

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

Figure 8: White light Baader filter of two active regions (groups) for October 28, 2021.

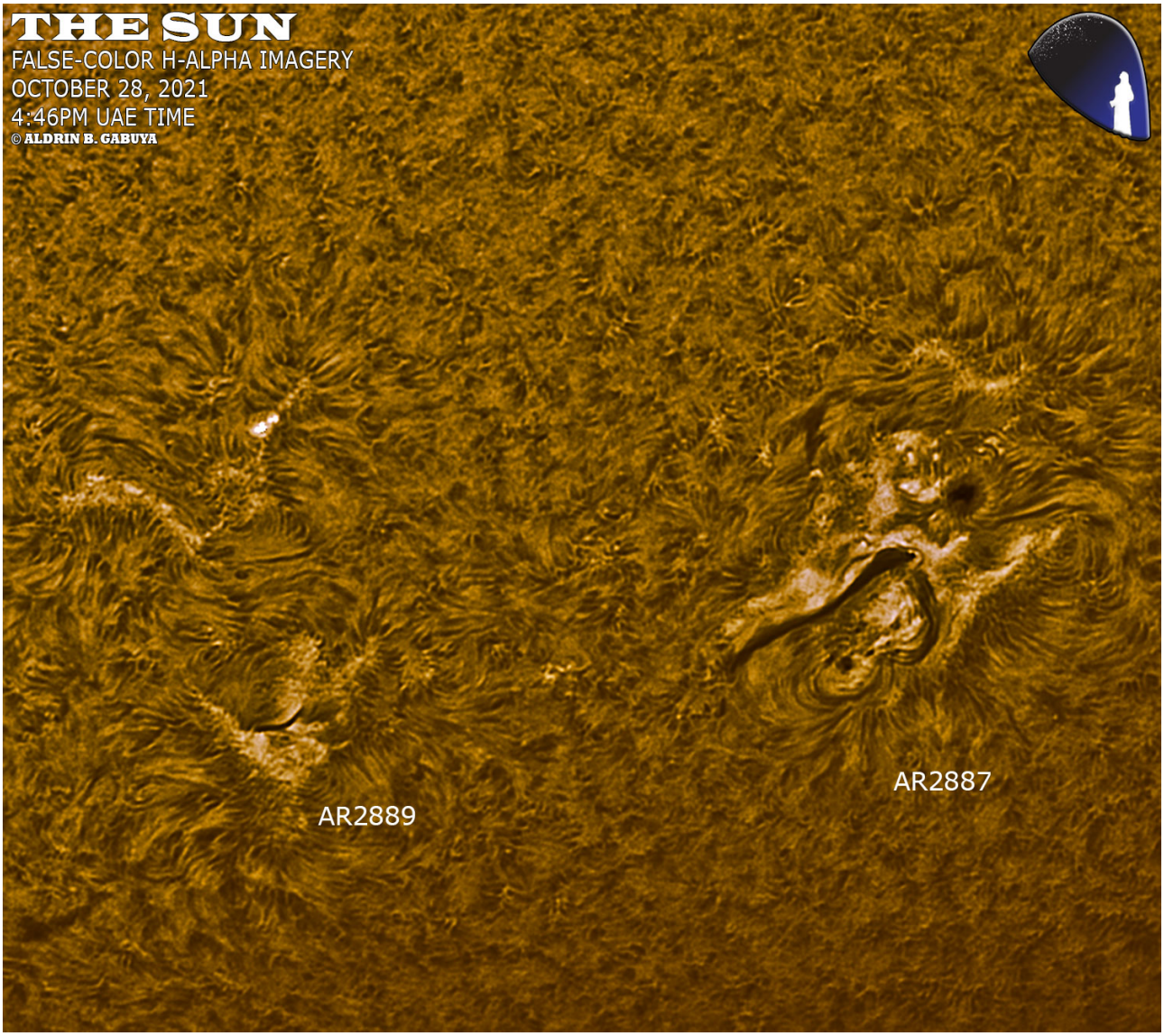

Figure 9: H Alpha filter of two active regions (groups) for October 28, 2021.

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Al Wathba South, Abu Dhabi, UAE