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 Compare SILSO(SIDC) sunspot counts (ISN) with AAVSO R_a sunspot counts for 2021

This graph was made by Max Surlaroute (AAVSO Observer code MMAY). SILSO's ISN construction is at `https://wwwbis.sidc.be/silso/newdataset`. The AAVSO R_a index using the Shapley method with k-factors: `http://iopscience.iop.org/article/10.1086/126109/pdf`.

GLOBAL DATA SUNSPOTS FOR 2021 BY MONTH

MONTH	NUMBER OF DAYS	OBSERVERS AAVSO SOLAR SECTION						OBSERVERS INTERNATIONAL GROUP			
		TOTAL OBS	Mean / Day	Raw	Mean / Day	Ra	Mean / Day	TOTAL OBS	Mean / Day	Rint	Mean / Day
1	31	1019	32,9	287	9,3	216	7,0	833	26,9	322	10,4
2	28	1037	37,0	228	8,1	162	5,8	959	34,3	231	8,3
3	31	1298	41,9	479	15,5	341	11,0	1322	42,6	532	17,2
4	30	1335	44,5	681	22,7	554	18,5	1277	42,6	736	24,5
5	31	1390	44,8	598	19,3	493	15,9	1237	39,9	656	21,2
6	30	1352	45,1	717	23,9	586	19,5	1196	39,9	761	25,4
7	31	1322	42,6	919	29,6	739	23,8	1222	39,4	1066	34,4
8	31	1315	42,4	616	19,9	487	15,7	1250	40,3	694	22,4
9	30	1213	40,4	1436	47,9	1172	39,1	1151	38,4	1545	51,5
10	31	1204	38,8	1103	35,6	841	27,1	1124	36,3	1182	38,1
11	30	1124	37,5	1026	34,2	815	27,2	898	29,9	1051	35,0
12	31	987	31,8	2055	66,3	1569	50,6	724	23,4	2096	67,6
Total 2021	365	*14596*	*40,0*	*10145*	*27,8*	*7975*	*21,8*	*13193*	*36,1*	*10872*	*29,8*
Mean		1216,3	40,0	845,4	27,8	664,6	21,8	1099,4	36,1	906,0	29,8
Standard Deviation		142,3	4,5	513,5	16,6	401,4	13,0	196,0	6,3	525,8	17,0

Important Notes : For a given month, the same observer can be counted as many times as there are days in the month.

Figure 1: Beige cells are the AAVSO R_a monthly sunspot counts and orange cells are the SIDC ISN monthly sunspot counts for 2021.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

January 2022 (Figure 2): The most active day in January was the 29th with 25 GOES XRA flares, two of which were M1.1 at the end of the day

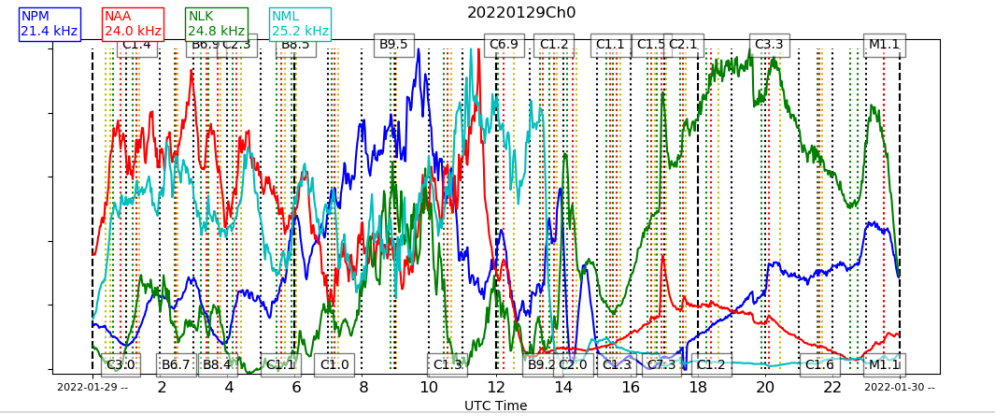

Figure 2: VLF recording on the 29th of January.

2.2 SID Observers

In January 2022, 19 AAVSO SID observers submitted VLF data as listed in Table 1.

Table 1: 202201 VLF Observers

Observer	Code	Stations
R Battaiola	A96	ICV
J Wallace	A97	NAA
L Loudet	A118	DHO
J Godet	A119	GBZ GQD ICV
B Terrill	A120	NWC
F Adamson	A122	NWC
G Perry	A126	DHO
J Karlovsky	A131	DHO TBB
R Green	A134	NWC
R Mrllak	A136	GQD
S Aguirre	A138	NPM
G Silvis	A141	NAA
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
L Ferreira	A149	NWC
J Wendler	A150	NAA
H Krumnow	A152	DHO GBZ
J DeVries	A153	NLK
K Meteor	A154	FTA HWU GBZ

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.

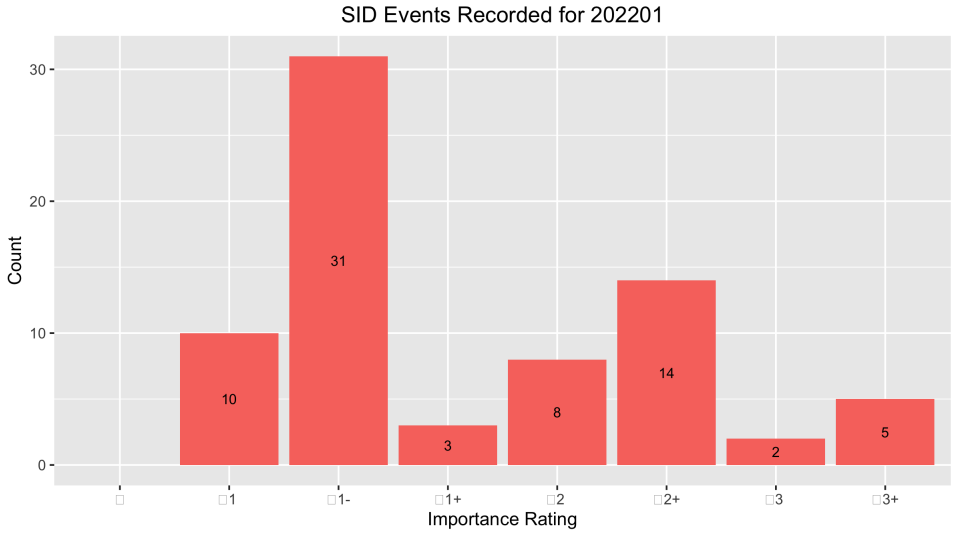

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In January 2022, there were 267 GOES-16 XRA flares: 6 M-Class, 91 C-Class, and 170 B-Class flares. A little less flaring this month compared to last (see Figure 4).

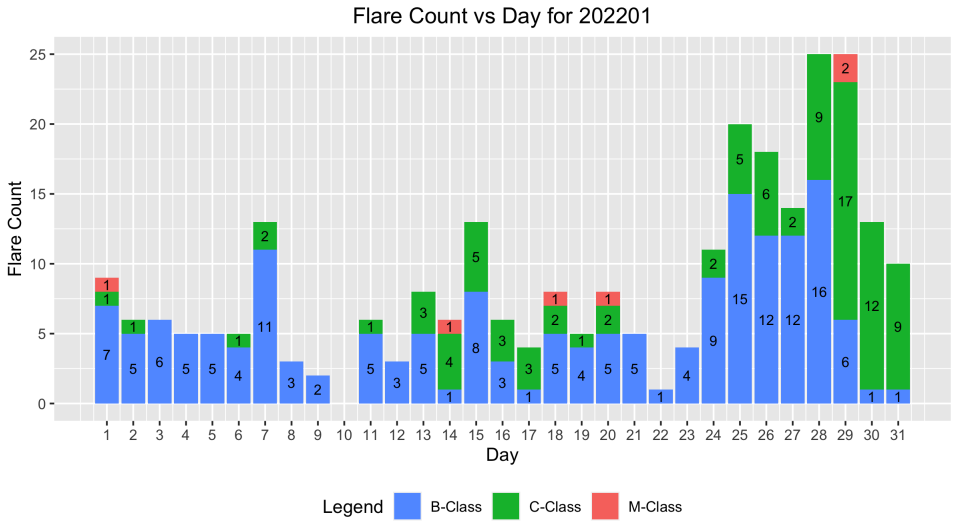

Figure 4: GOES-16 XRA flares.

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 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 January 2022. 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.

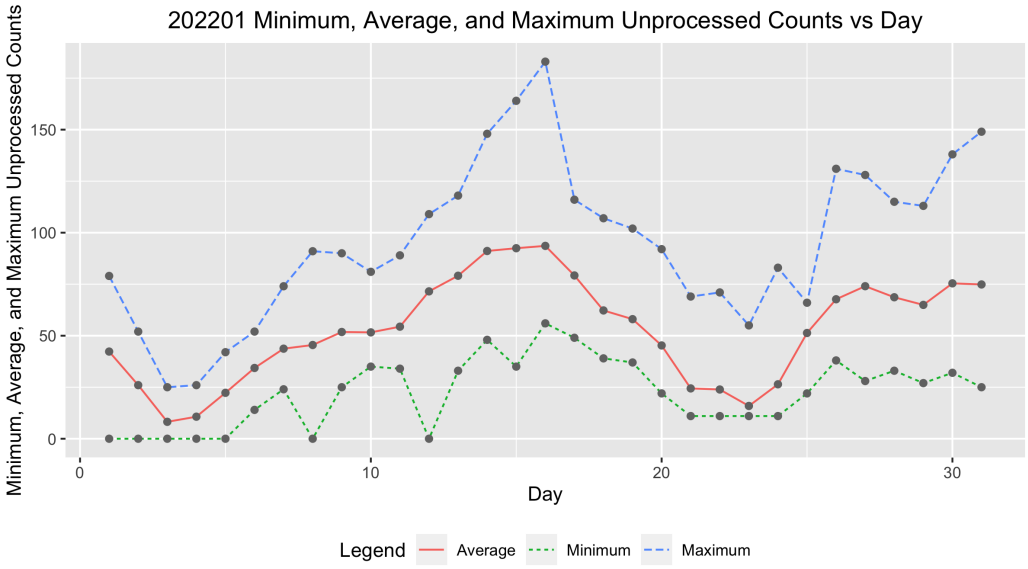

Figure 5: Raw Wolf number average, minimum, and maximum by day of the month for all observers.

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: 202201 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	33	45	34
2	30	27	22
3	34	10	7
4	33	11	9
5	29	24	19
6	35	36	28
7	37	47	37
8	41	53	40
9	30	53	41
10	31	55	45
11	42	57	46
12	39	80	62
13	41	85	67
14	46	98	76

Continued

Table 2: 202201 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	37	97	81
16	44	94	75
17	34	82	65
18	43	64	50
19	32	61	43
20	33	47	36
21	38	26	20
22	38	26	20
23	42	16	12
24	31	31	22
25	38	56	47
26	45	73	58
27	40	83	61
28	41	75	56
29	40	68	54
30	49	83	65
31	38	80	64
Averages	37.5	56.2	43.9

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for January 2022, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (73), and total number of observations submitted (1164).

Table 3: 202201 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	26	Alexandre Amorim
AJV	17	J. Alonso
ARAG	31	Gema Araujo
ASA	17	Salvador Aguirre
ATE	29	Teofilo Arranz Heras
BATR	13	Roberto Battaiola
BMF	17	Michael Boschat
BMIG	18	Michel Besson
BROB	24	Robert Brown
BXZ	27	Jose Alberto Berdejo
BZX	25	A. Gonzalo Vargas
CIOA	11	Ioannis Chouinavas
CKB	17	Brian Cudnik

Continued

Table 3: 202201 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CMOD	7	Moise Carlo
CNT	26	Dean Chantiles
CPAD	11	Panagiotis Chatzistamatiou
CVJ	10	Jose Carvajal
DARB	14	Aritra Das
DFR	12	Frank Dempsey
DJOB	14	Jorge del Rosario
DMIB	28	Michel Deconinck
DROB	7	Bob Dudley
DUBF	21	Franky Dubois
EHOA	20	Howard Eskildsen
ERB	9	Bob Eramia
FERA	19	Eric Fabrigat
FLET	28	Tom Fleming
GIGA	28	Igor Grageda Mendez
HALB	10	Brian Halls
HKY	17	Kim Hay
HMQ	7	Mark Harris
HOWR	18	Rodney Howe
HRUT	24	Timothy Hrutkay
IEWA	25	Ernest W. Iverson
ILUB	10	Luigi Iapichino
JDAC	3	David Jackson
JGE	9	Gerardo Jimenez Lopez
JSI	2	Simon Jenner
KAND	12	Kandilli Observatory
KAPJ	14	John Kaplan
KNJS	31	James & Shirley Knight
KZAD	10	Zachary Knoles
LEVM	13	Monty Leventhal
LKR	7	Kristine Larsen
LRRA	16	Robert Little
MARC	13	Arnaud Mengus
MCE	26	Etsuiku Mochizuki
MJAF	27	Juan Antonio Moreno Quesada
MJHA	26	John McCammon
MLL	6	Jay Miller
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MSS	1	Sandy Mesics
MUDG	7	George Mudry
MWU	18	Walter Maluf
OAAA	12	Al Sadeem Astronomy Obs.

Continued

Table 3: 202201 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
ONJ	1	John O'Neill
PEKT	6	Riza Pektas
PLUD	21	Ludovic Perbet
RJV	20	Javier Ruiz Fernandez
SATH	4	Andries Son
SDOH	31	Solar Dynamics Obs - HMI
SNE	2	Neil Simmons
SQN	14	Lance Shaw
SRIE	17	Rick St. Hilaire
TDE	26	David Teske
TPJB	4	Patrick Thibault
TST	14	Steven Toothman
URBP	10	Piotr Urbanski
VIDD	14	Dan Vidican
VRUA	5	Ruben Verboven
WGI	2	Guido Wollenhaupt
WWM	21	William M. Wilson
Totals	1164	73

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 24$^{\text{th}}$ 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$^{\text{th}}$ through the 75$^{\text{th}}$ quartiles. The lower and upper whiskers extend 1.5 times the IQR below the 25$^{\text{th}}$ quartile, and 1.5 times the IQR above the 75$^{\text{th}}$ 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.

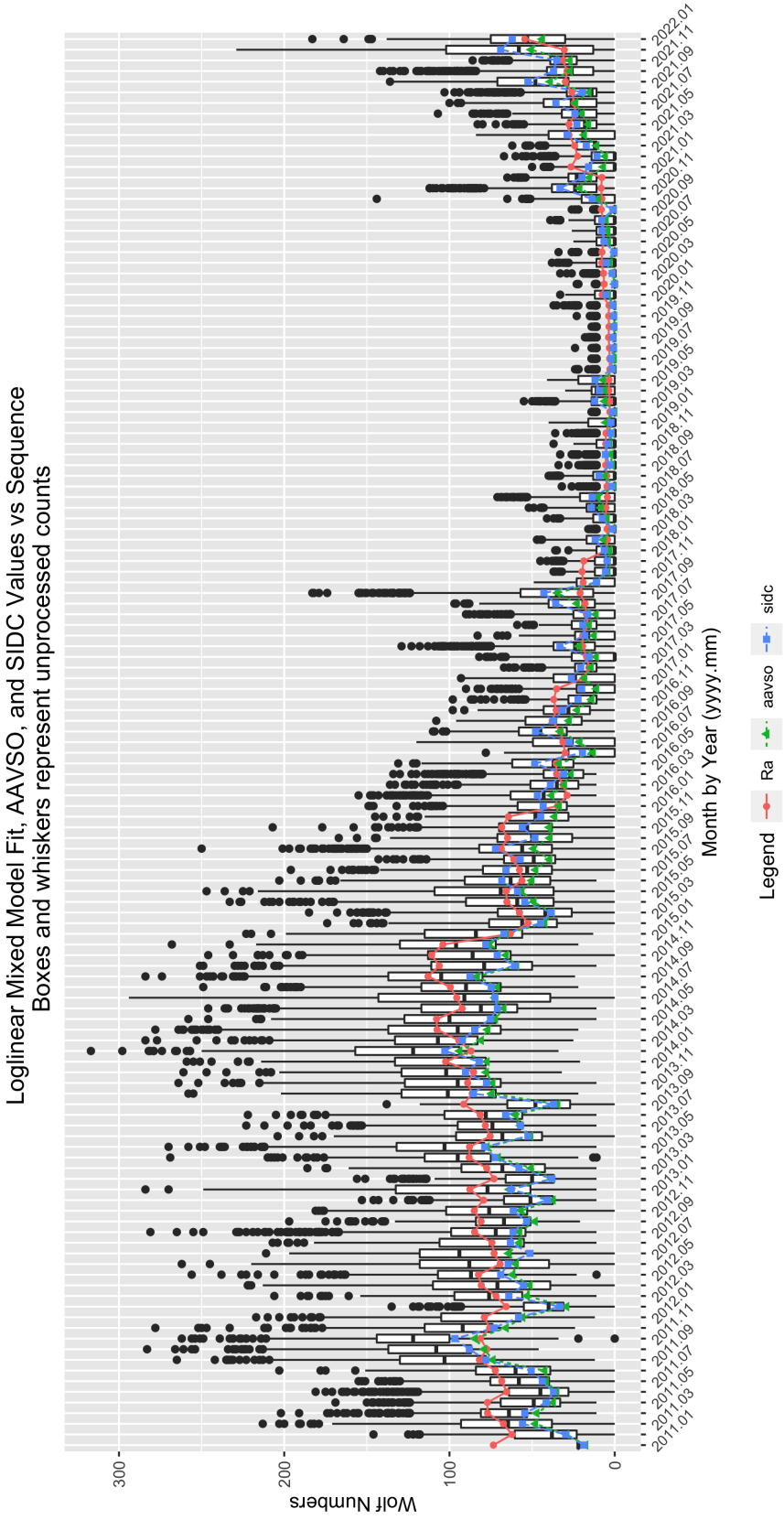

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

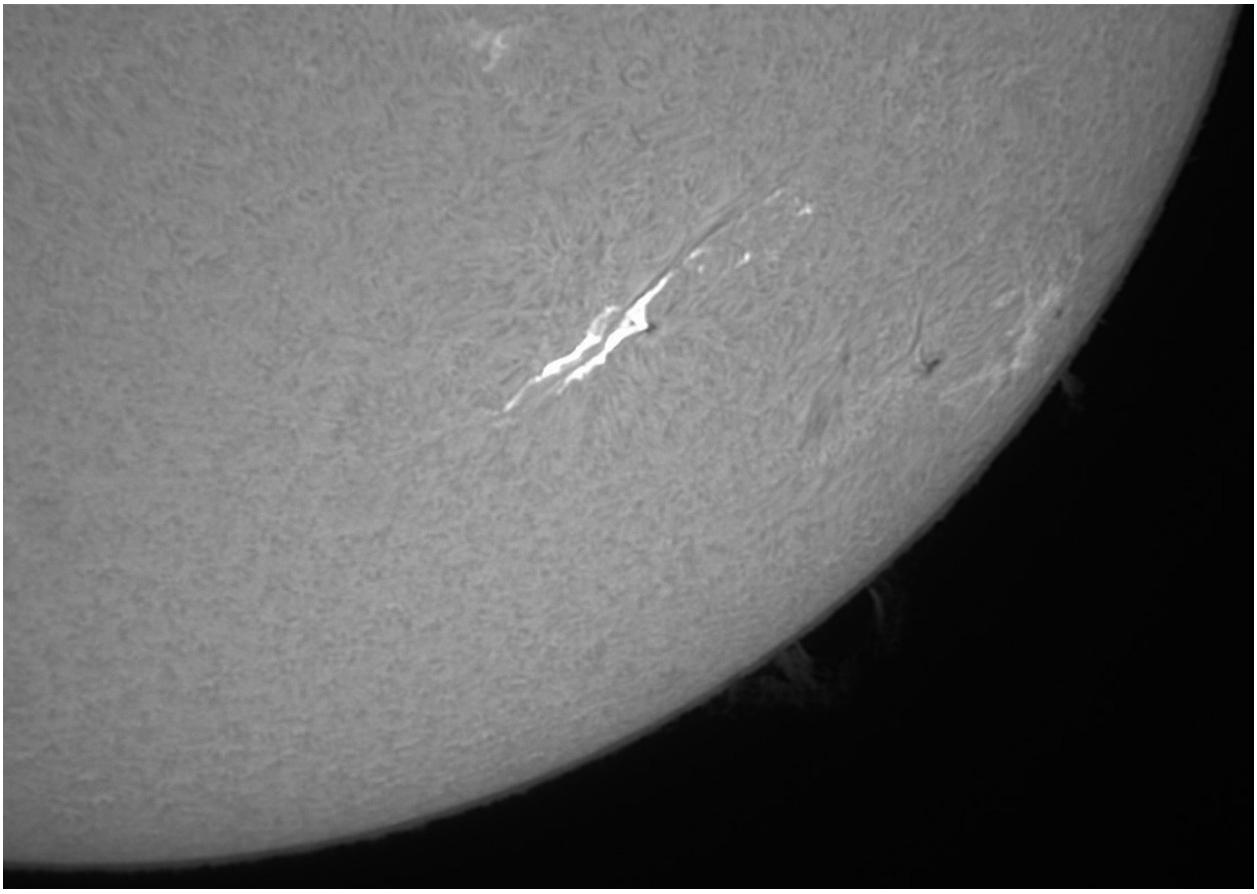

Figure 8: From Brian Halls (AAVSO observer code HALB), processed with an H-alpha filter showing the emerging C-class flare on the 14th of January, 2022.