Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 49 Bay State Rd
Cambridge, MA 02138 USA

Web: http://www.aavso.org/solar-bulletin
Email: solar@aavso.org
ISSN 0271-8480

Volume 77 Number 1 January 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. 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 Older data from Franky Dubois (DUBF)

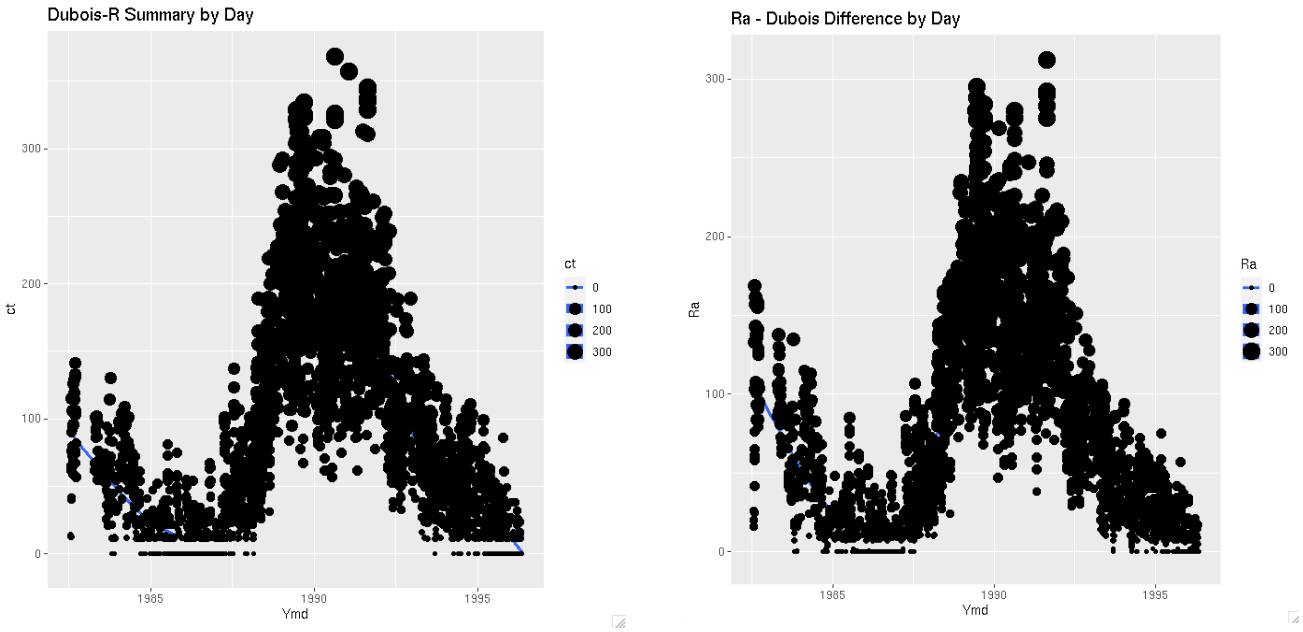

Figure 1: Compares data from Franky Dubois from 1982 to 1996 (left panel) with the AAVSO Ra numbers (right panel) for the same period.

Franky Dubois has been observing the sun since 1982 and sends us his data from 1982 - 1996. We compare his data with the AAVSO Ra number for the same time series. Franky's data match up with only a few minor differences. These AAVSO Ra numbers come from all observers in the AAVSO solar database for this period. (`https://www.aavso.org/sites/default/files/solar/NOAAfiles/daily.csv`).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

January 2021 (Figure 2): Although there were B-Class and one C-Class flares on the 20th of January none were strong enough to show a SID Event.

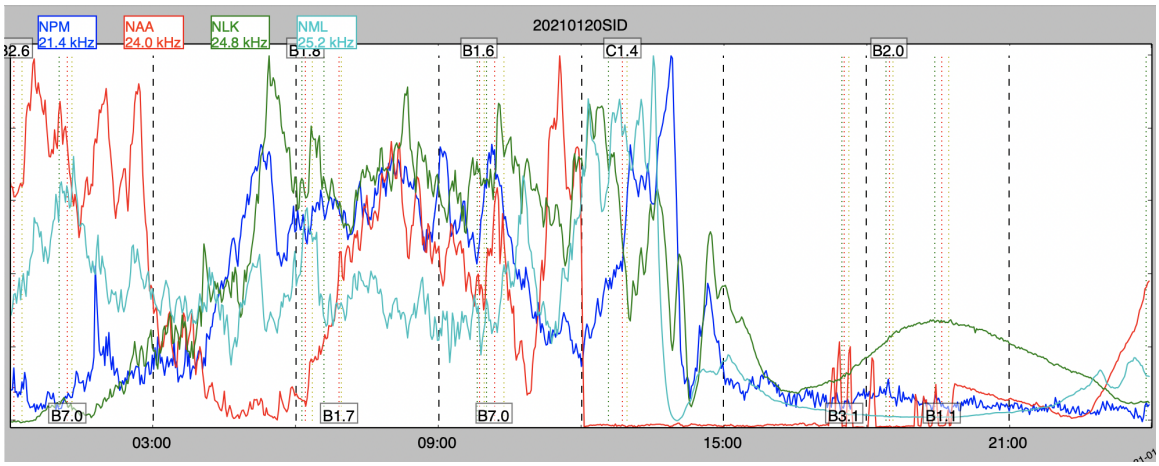

Figure 2: VLF recording from Fort Collins, Colorado.

2.2 SID Observers

In January 2021 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202101 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
L Loudet	A118	DHO GBZ
J Godet	A119	GBZ
B Terrill	A120	NWC
F Adamson	A122	NWC
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	NAA NML
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
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 January 2021, there were 47 XRA flares detected from the GOES 16 satellite: 45 B-Class and 2 C-Class flares. Less than half the flaring this month compared to last. There were 19 days this month with no GOES-16 reports of flares (see Figure 4).

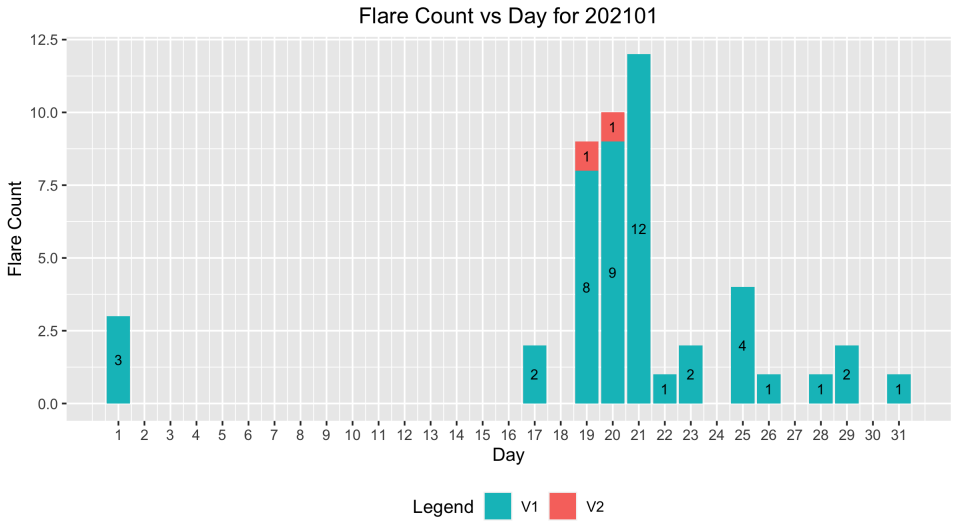

Figure 4: GOES-16 XRA flares

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 January 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.

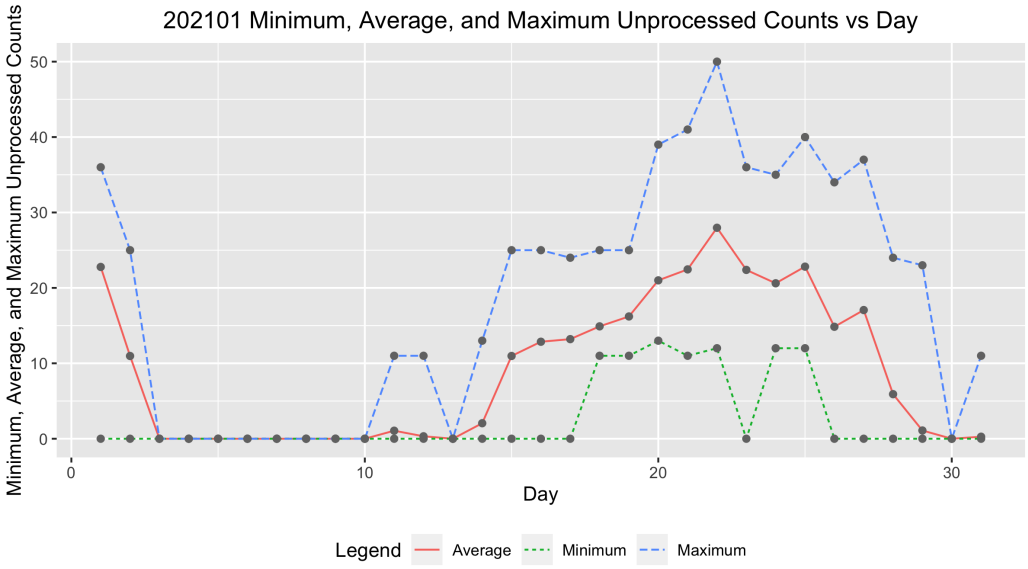

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

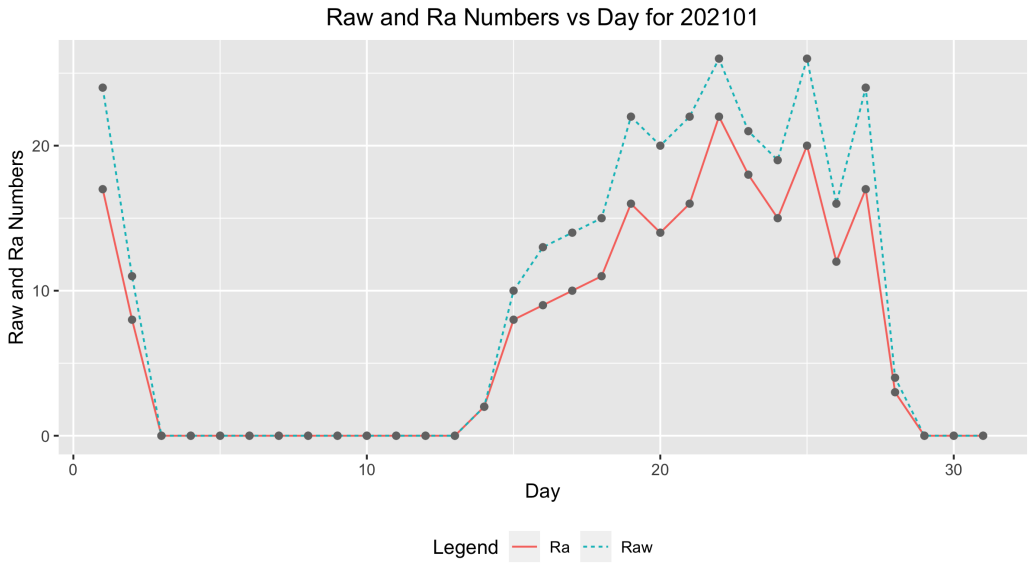

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202101 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	27	24	17
2	35	11	8
3	28	0	0
4	33	0	0
5	28	0	0
6	34	0	0
7	28	0	0
8	37	0	0
9	36	0	0
10	29	0	0
11	31	0	0
12	34	0	0
13	38	0	0
14	35	2	2

Continued

Table 2: 202101 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	37	10	8
16	36	13	9
17	34	14	10
18	30	15	11
19	33	22	16
20	32	20	14
21	31	22	16
22	37	26	22
23	39	21	18
24	31	19	15
25	33	26	20
26	26	16	12
27	32	24	17
28	33	4	3
29	33	0	0
30	28	0	0
31	41	0	0
Averages	32.9	9.3	7

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for January 2021, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (70), and total number of observations submitted (1019).

Table 3: 202101 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	19	Alexandre Amorim
AJV	14	J. Alonso
ARAG	26	Gema Araujo
ASA	25	Salvador Aguirre
ATE	22	Teofilo Arranz Heras
BARH	13	Howard Barnes
BATR	2	Roberto Battaiola
BERJ	24	Jose Alberto Berdejo
BLAJ	9	John A. Blackwell
BMF	19	Michael Boschat
BRAF	14	Raffaello Braga
CHAG	24	German Morales Chavez
CIOA	12	Ioannis Chouinavas

Continued

Table 3: 202101 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CKB	20	Brian Cudnik
CMOD	9	Mois Carlo
CNT	26	Dean Chantiles
DARB	22	Aritra Das
DEMF	7	Frank Dempsey
DIVA	2	Ivo Demeulenaere
DJOB	13	Jorge del Rosario
DMIB	15	Michel Deconinck
DUBF	17	Franky Dubois
EHOA	11	Howard Eskildsen
ERB	11	Bob Eramia
FDAE	5	David Fox
FERJ	15	Javier Ruiz Fernandez
FLET	22	Tom Fleming
FTAA	3	Tadeusz Figiel
GIGA	26	Igor Grageda Mendez
HALB	10	Brian Halls
HAYK	13	Kim Hay
HMQ	18	Mark Harris
HOWR	19	Rodney Howe
IEWA	19	Ernest W. Iverson
JDAC	4	David Jackson
JGE	3	Gerardo Jimenez Lopez
JPG	1	Penko Jordanov
KADB	1	Andrea de Oliveira Kovacs
KAND	18	Kandilli Observatory
KAPJ	16	John Kaplan
KNJS	31	James & Shirley Knight
LEVM	19	Monty Leventhal
LGEC	3	Georgios Lekkas
LKR	3	Kristine Larsen
LRRA	18	Robert Little
MARC	3	Arnaud Mengus
MCE	23	Etsuiku Mochizuki
MILJ	15	Jay Miller
MJHA	29	John McCammon
MUDG	7	George Mudry
MWU	29	Walter Maluf
OAAA	23	Al Sadeem Astronomy Observatory
ONJ	18	John O'Neill
PEKT	2	Riza Pektas
RFDA	27	Filipp Romanov
RMW	6	Michael Rapp

Continued

Table 3: 202101 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SDOH	31	Solar Dynamics Obs - HMI
SNE	6	Neil Simmons
SONA	6	Andries Son
SQN	16	Lance Shaw
STAB	18	Brian Gordon-States
SUZM	24	Miyoshi Suzuki
TESD	19	David Teske
TPJB	5	Patrick Thibault
TST	10	Steven Toothman
URBP	7	Piotr Urbanski
VARG	24	A. Gonzalo Vargas
VIDD	10	Daniel Vidican
WGI	2	Guido Wollenhaupt
WILW	16	William M. Wilson
Totals	1019	70

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.

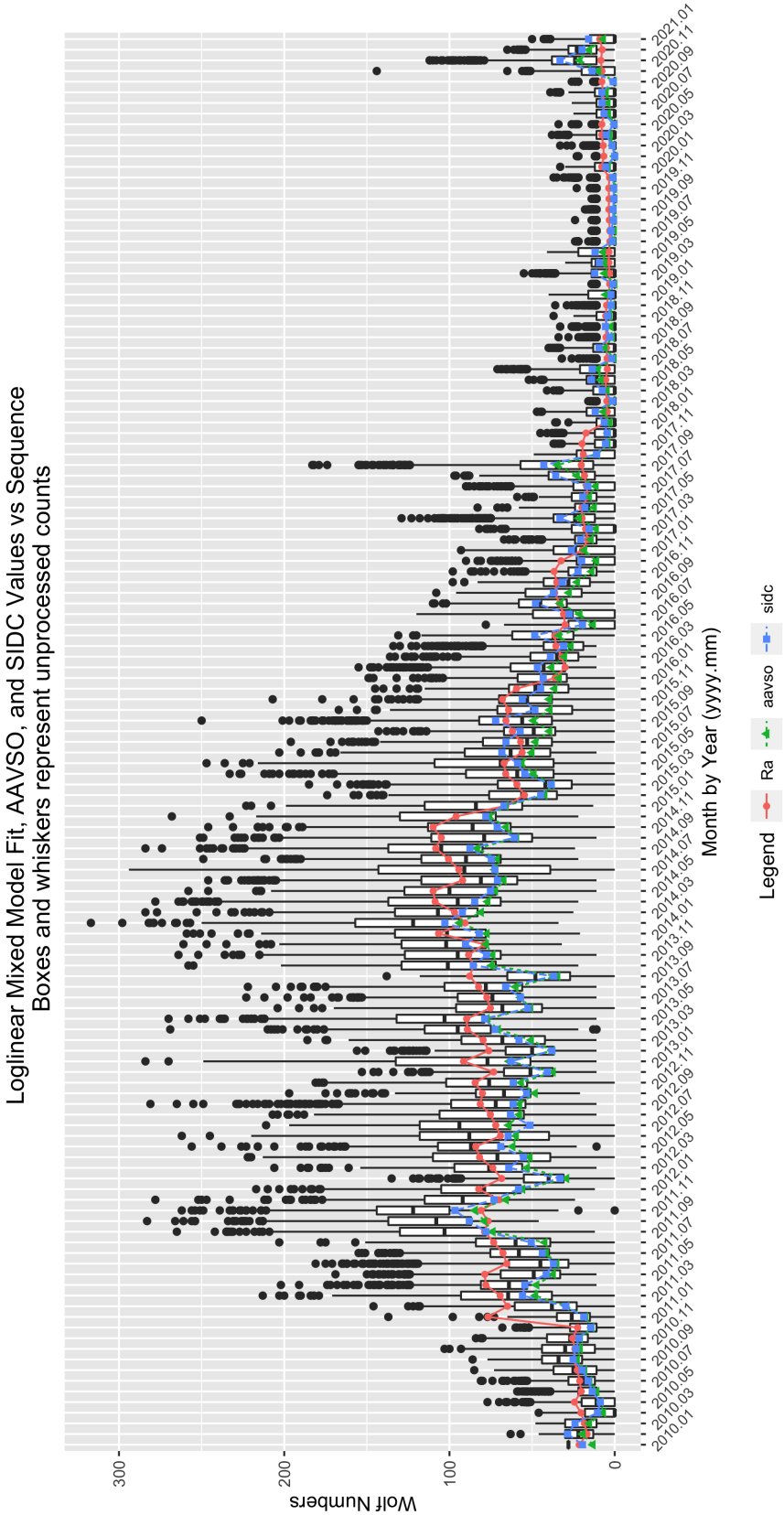

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

Figure 8: Image from AAVSO observer, Filipp Romanov (RFDA).

Description about photo: In Primorsky Krai (where I am now - in my small homeland) of Russia, January is one of the sunniest months of the year. Astronomical seeing was excellent on January 20, 2021, so I was able to capture (on 05:35 UT, from Yuzhno-Morskoy, near Nakhodka) this photo of sunspots (trailing section of AR 2797 was reassigned AR 2798 on this date) and faculae near the solar limb. Equipment: Canon EOS 60D, 60/700mm refracting telescope (with solar filter), 640x480 video, stacked 650 frames in RegiStax 5.1.