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 Earth's magnetic field during the end of September

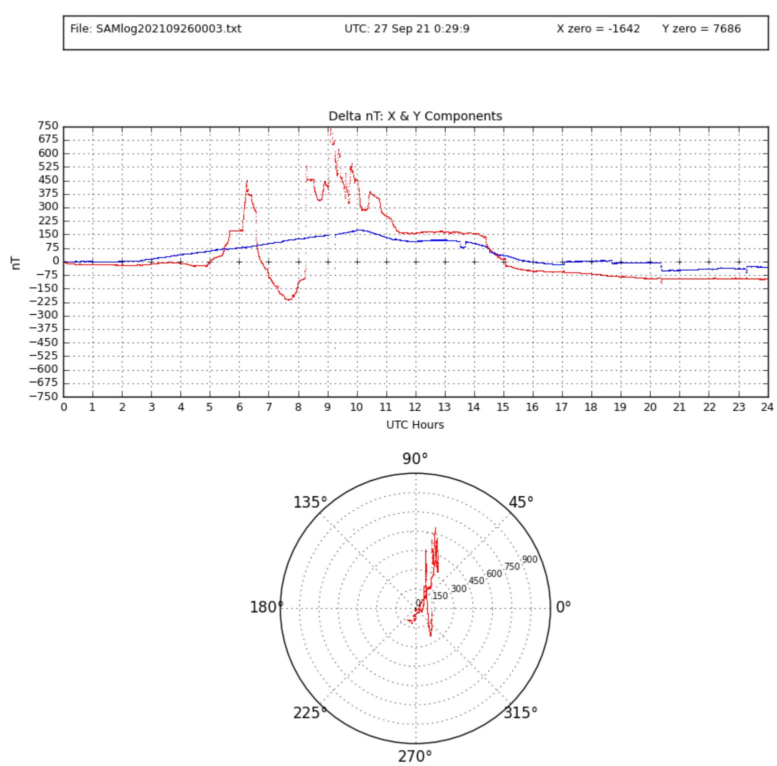


Figure 1: On the 26th of September there is magnetic response from a CME.

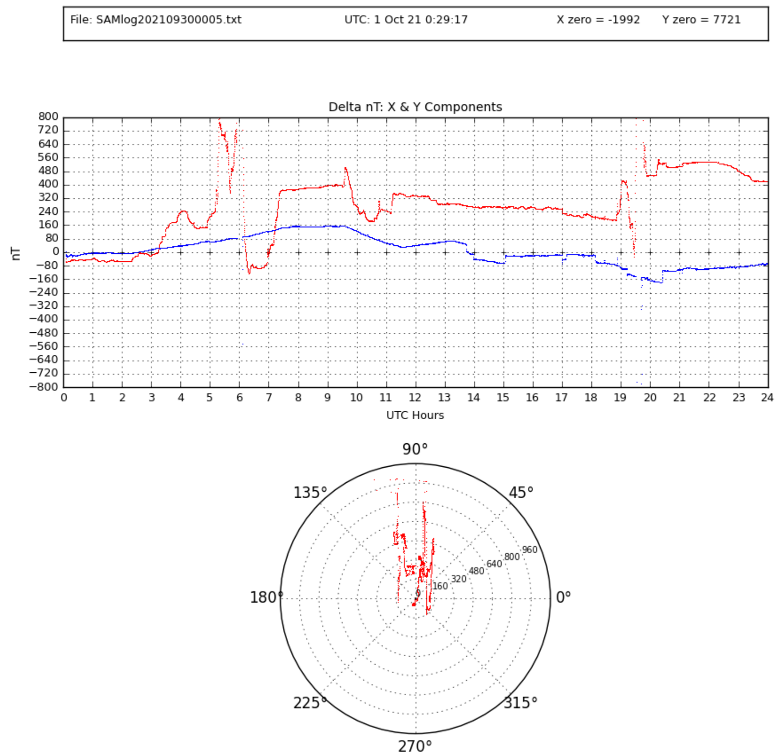


Figure 2: On the 30th of September there is magnetic response from a CME.

The Top panel for the 26th and bottom panel for the 30th. There were two CMEs (coronal mass ejections) approximately 3 days before each of these magnetic events. The y-axis is in Nano-Tesla. Red is north facing flux-gate, blue is east facing flux-gate. The circle plots below each graph attempt to show the aurora orientations based on either north or east flux-gate and time of day. The recording device is the SAM unit: (`http://sam-magnetometer.net`). Software for these graphs was written in Python 27 by John DuBois.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

September 2021 (Figure 3): a M1.8 flare from NAA at 15:45 UT created a SID Event here in Fort Collins, CO.

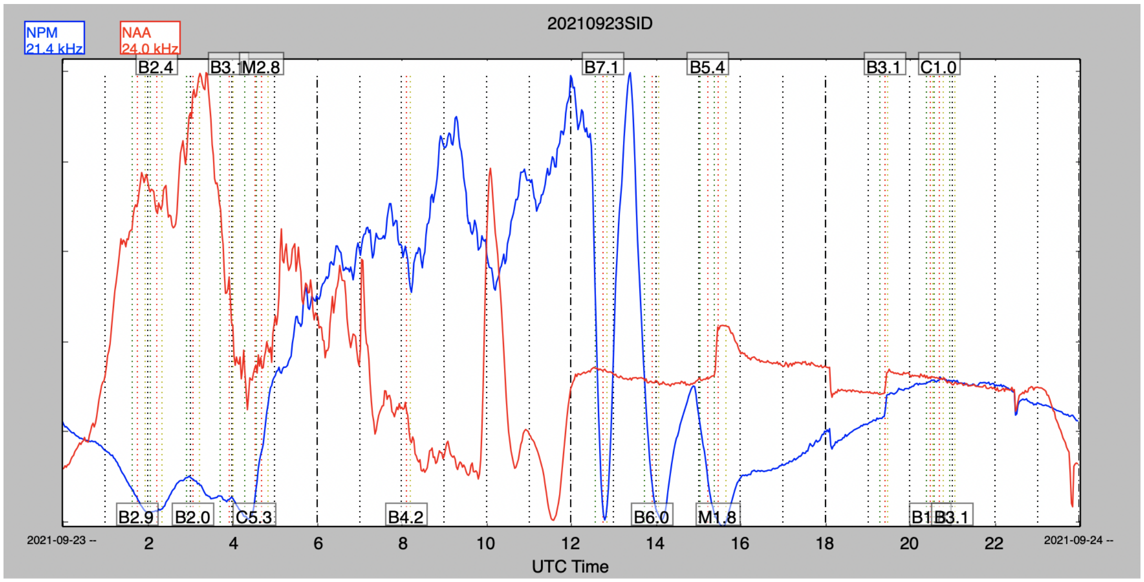


Figure 3: VLF recording on the 23rd of September

2.2 SID Observers

In September 2021 we had 15 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202109 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
R Green	A134	NWC
S Aguirre	A138	NPM
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 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.

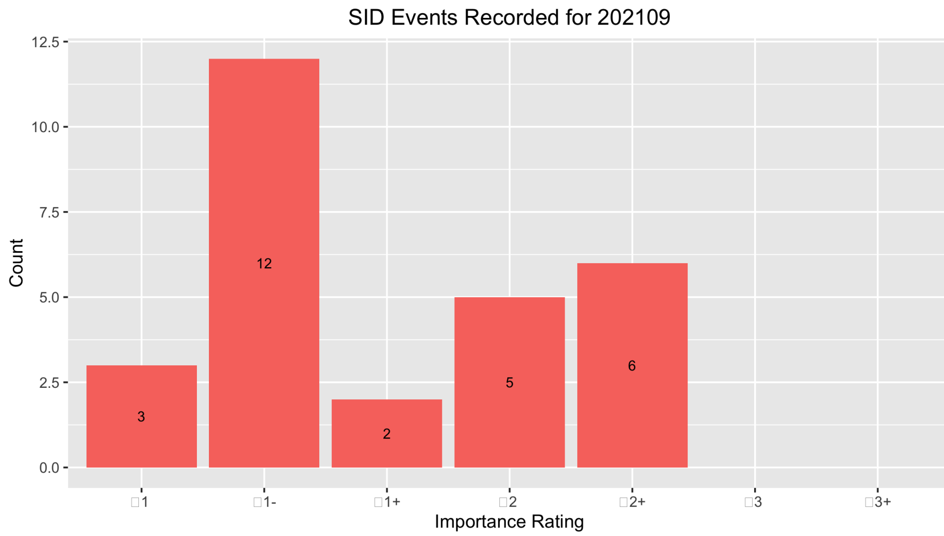


Figure 4: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In September 2021, there were 257 GOES-16 XRA flares for September 2021; 221 B-Class, 34 C-class and two M-Class flares. Far more flaring this month compared to last with only 2 days of no flares. (see Figure 5).

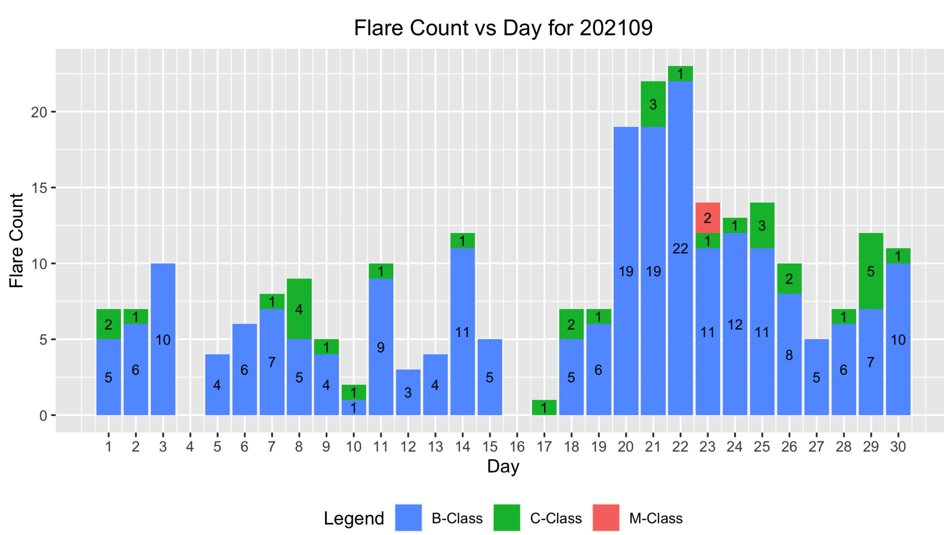


Figure 5: GOES-16 XRA flares

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 September 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 6.

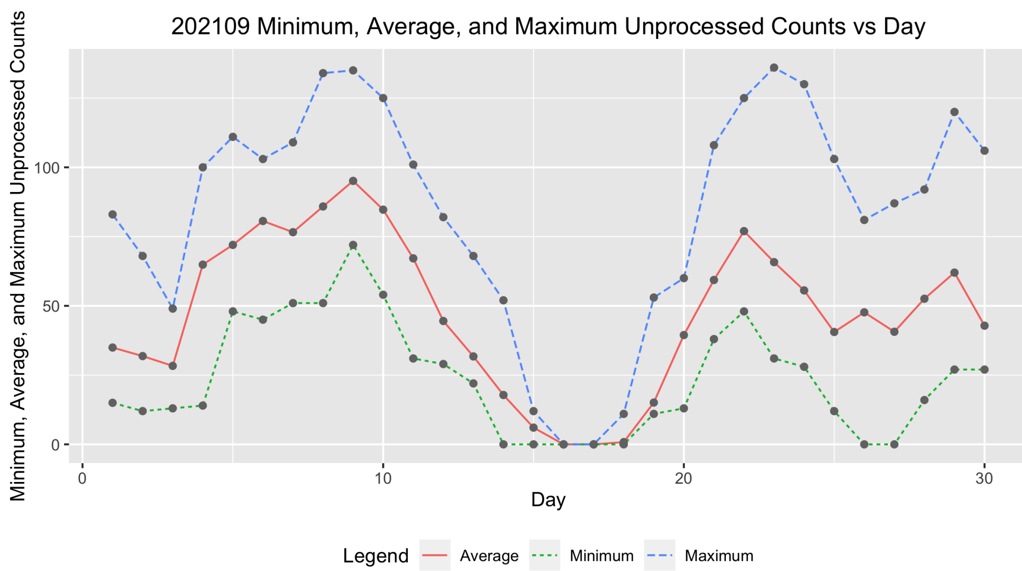


Figure 6: Raw Wolf number average, minimum and maximum by day of the month for all observers.

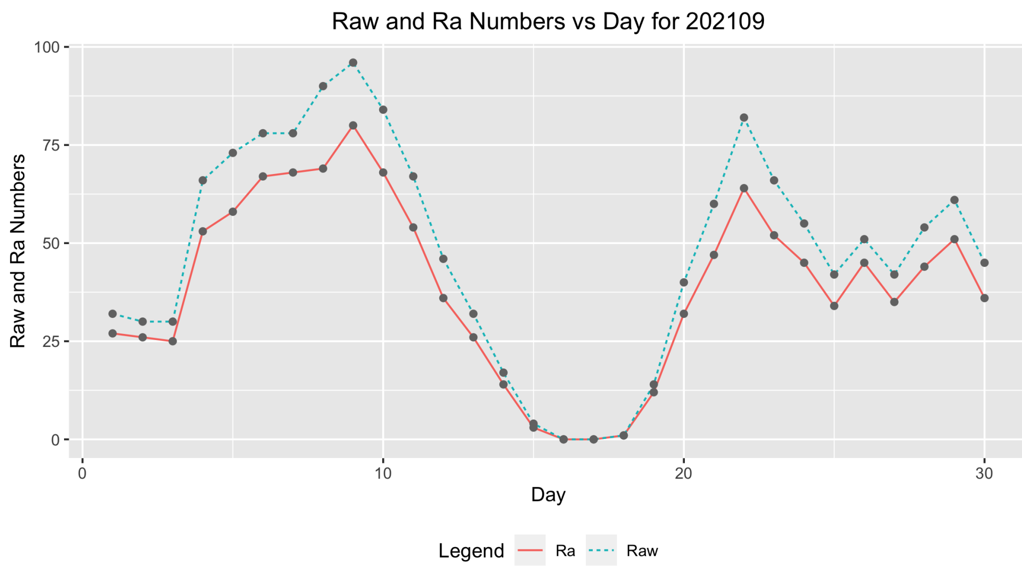


Figure 7: Raw Wolf average and R_a numbers by day of the month for all observers.

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 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: 202109 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	38	32	27
2	43	30	26
3	46	30	25
4	47	66	53
5	46	73	58
6	48	78	67
7	46	78	68
8	45	90	69
9	40	96	80
10	42	84	68
11	43	67	54
12	45	46	36
13	39	32	26
14	33	17	14

Continued

Table 2: 202109 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	26	4	3
16	32	0	0
17	35	0	0
18	41	1	1
19	44	14	12
20	40	40	32
21	39	60	47
22	38	82	64
23	40	66	52
24	42	55	45
25	41	42	34
26	41	51	45
27	36	42	35
28	39	54	44
29	41	61	51
30	37	45	36
Averages	40.4	47.9	39.1

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for September 2021, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (71), and total number of observations submitted (1213).

Table 3: 202109 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	22	Alexandre Amorim
AJV	20	J. Alonso
ARAG	30	Gema Araujo
ASA	19	Salvador Aguirre
ATE	28	Teofilo Arranz Heras
BATR	9	Roberto Battaiola
BERJ	24	Jose Alberto Berdejo
BLAJ	10	John A. Blackwell
BMF	18	Michael Boschat
BRAF	14	Raffaello Braga
BROB	29	Robert Brown
CIOA	4	Ioannis Chouinavas
CKB	25	Brian Cudnik
CMOD	5	Moise Carlo

Continued

Table 3: 202109 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	22	Dean Chantiles
CVJ	9	Jose Carvajal
DARB	13	Aritra Das
DDIB	12	Dipankar Dey
DEMF	14	Frank Dempsey
DJOB	15	Jorge del Rosario
DMIB	30	Michel Deconinck
DROB	7	Bob Dudley
DUBF	25	Franky Dubois
EHOA	18	Howard Eskildsen
ERB	19	Bob Eramia
FERJ	21	Javier Ruiz Fernandez
FLET	28	Tom Fleming
GIGA	27	Igor Grageda Mendez
HALB	10	Brian Halls
HAYK	22	Kim Hay
HMQ	7	Mark Harris
HOWR	26	Rodney Howe
IEWA	27	Ernst W. Iverson
ILUB	8	Luigi Lapichino
JDAC	15	David Jackson
JENJ	4	Jamey Jenkins
JENS	2	Simon Jenner
JGE	5	Gerardo Jimenez Lopez
KAMB	30	Amoli Kakkar
KAND	20	Kandilli Observatory
KAPJ	22	John Kaplan
KNJS	28	James & Shirley Knight
KZAD	4	Zachary Knoles
LGEC	1	Georgios Lekkas
LKR	8	Kristine Larsen
LRRA	21	Robert Little
MARC	10	Arnaud Mengus
MCE	15	Etsuiku Mochizuki
MILJ	13	Jay Miller
MJHA	26	John McCammon
MMAY	30	Max Surlaroute
MMI	30	Michael Moeller
MWU	29	Walter Maluf
OAAA	16	Al Sadeem Astronomy Obs.
ONJ	18	John O'Neill
PEKT	9	Riza Pektas
PPAF	3	Pablo Prieto Banos

Continued

Table 3: 202109 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
RFDA	19	Filipp Romanov
SDOH	30	Solar Dynamics Obs - HMI
SNE	4	Neil Simmons
SONA	24	Andries Son
SQN	3	Lance Shaw
SUZM	15	Miyoshi Suzuki
TESD	27	David Teske
TST	27	Steven Toothman
URBP	24	Piotr Urbanski
VARG	28	A. Gonzalo Vargas
VIDD	11	Dan Vidican
WGI	4	Guido Wollenhaupt
WILW	1	William M. Wilson
WND	20	Denis Wallian
Totals	1213	71

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 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 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.

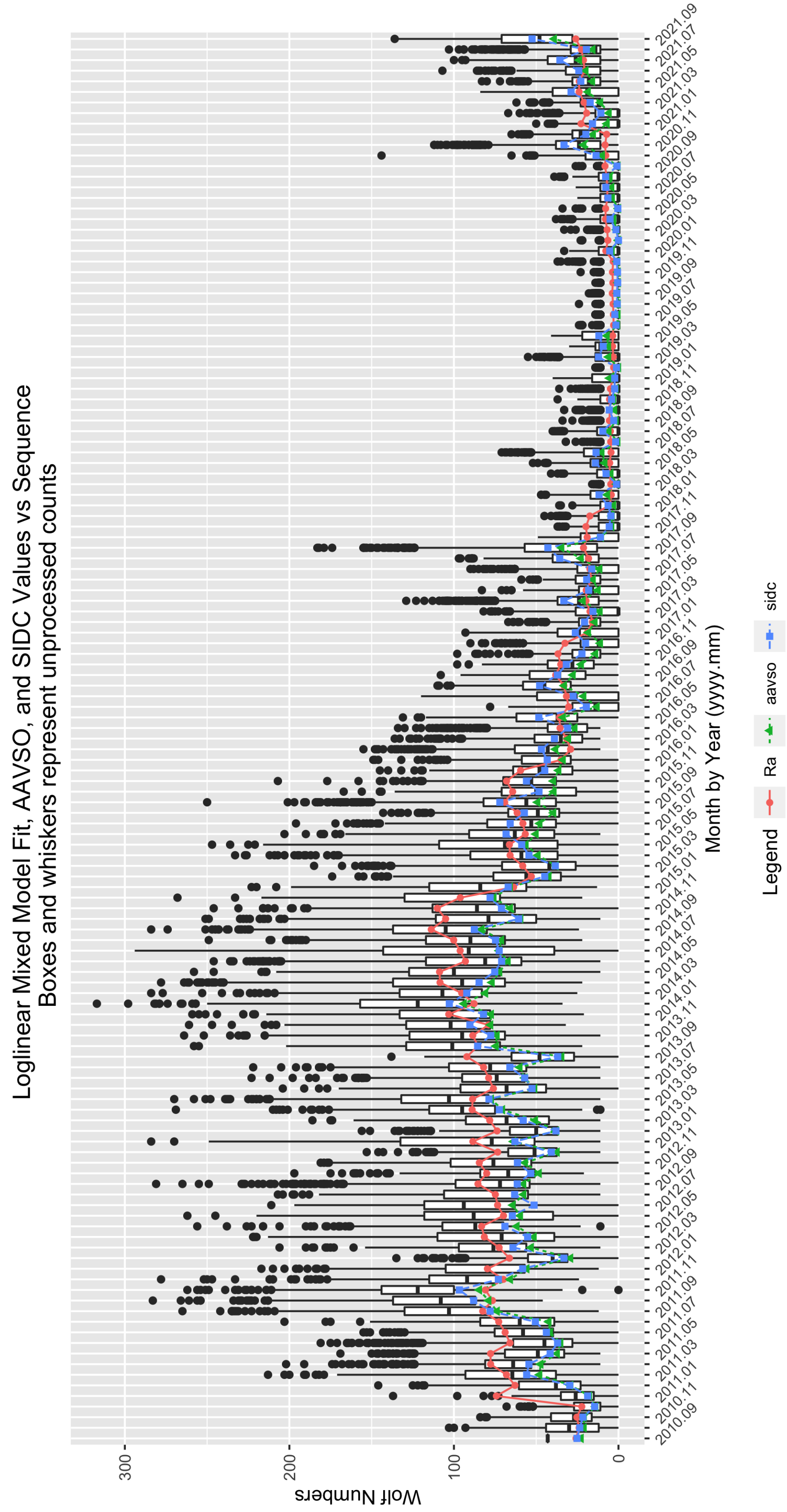


Figure 8: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

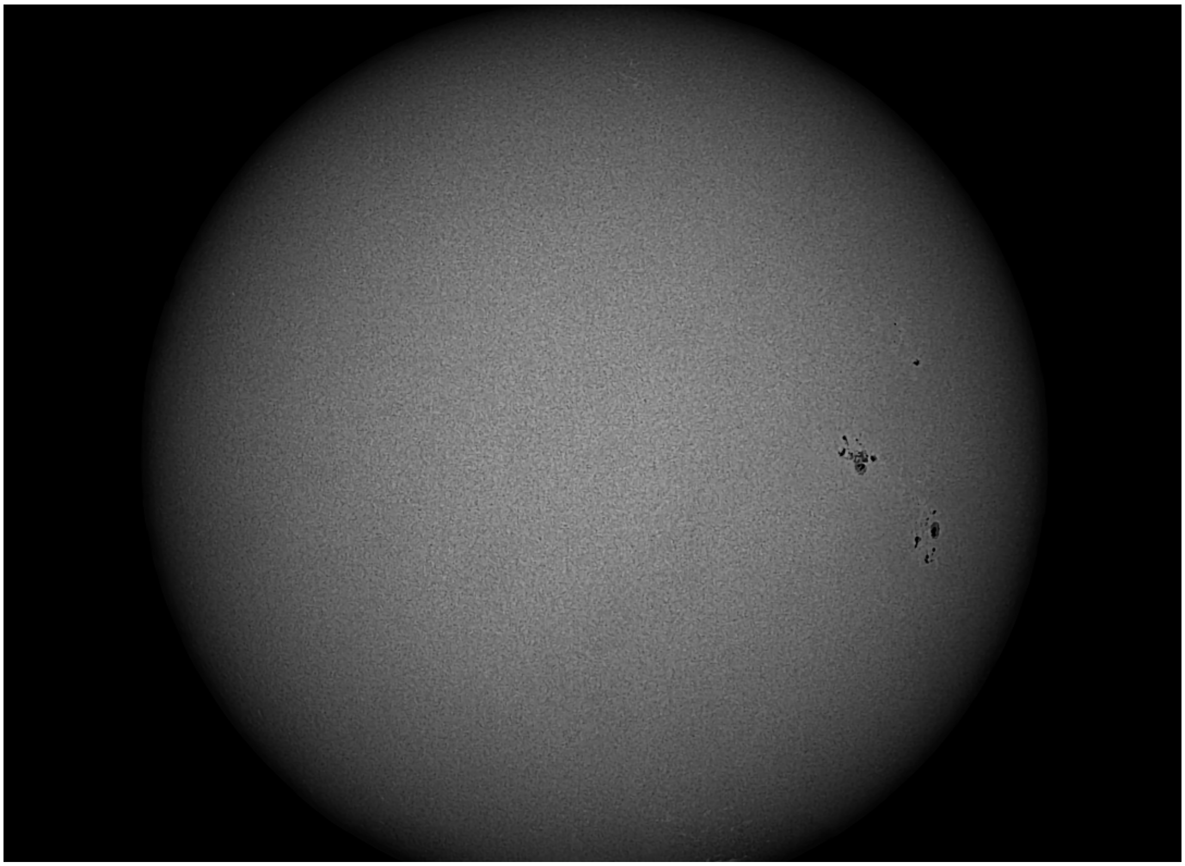
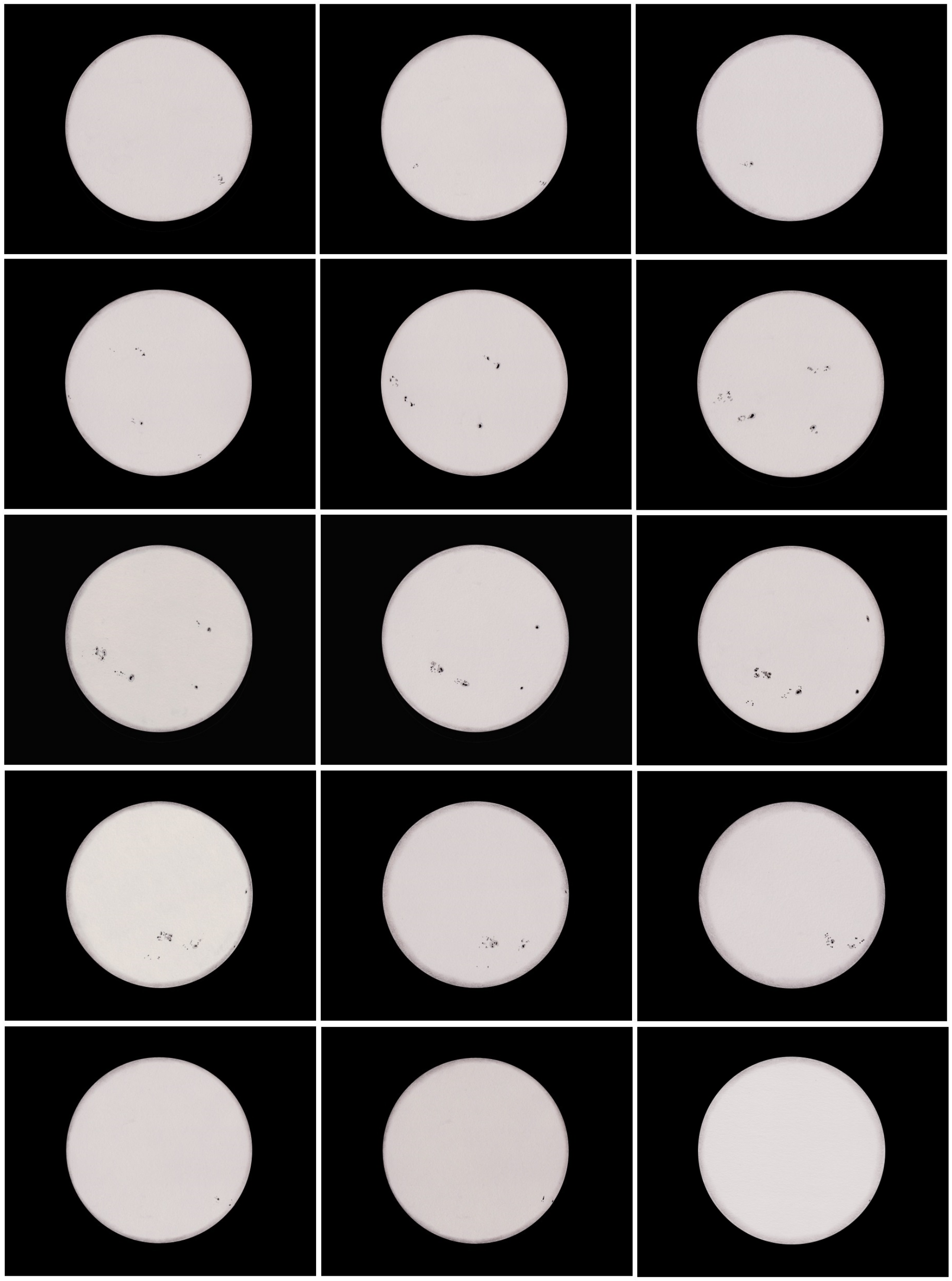


Figure 9: Pablo Prietobanos, takes the above image and sends this for his instruments:

Telescope: ts 102/714 mm, Herschel prism, continuum filter, chamber: thus 120 mm.
'Mi clave de obervador es: PPAF'

4.1 Observing Sunspots, a 15 day composite



Hi all solar team

Sketches made with a Refractor Takahashi FC-100DC with filter full objective. All made during a trip in the French high-Alps from September 1st to the 15th.

Thanks to you all for your always complete solar monthly bulletin!

Regards

Michel Deconinck. (https://astro.aquarellia.com)