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 The south hemisphere sunspots have taken over!

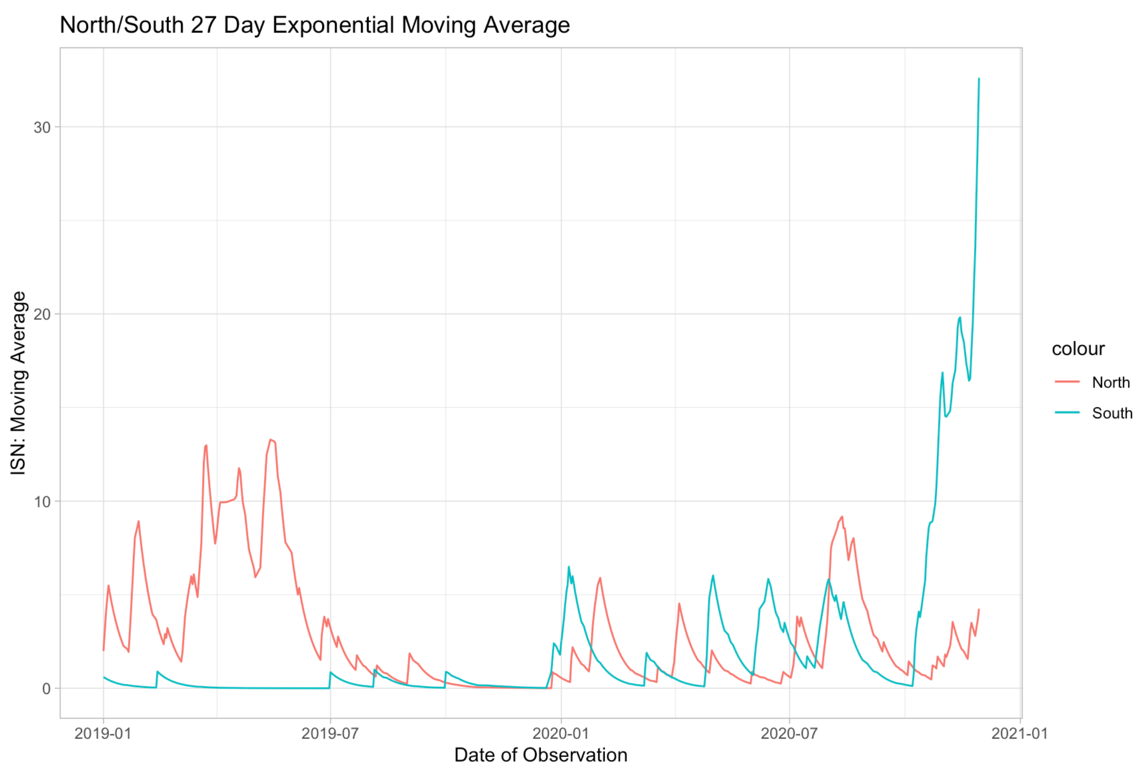

Figure 1: Over the last two months the southern hemisphere sunspot counts outnumber the northern hemisphere counts by a large margin. Graph from David Jackson.

The start of cycle 25 these last few months show many southern hemisphere formations and a large number of sunspots for November. There must have been a polarity cross-over about a year ago. Data from Kanzelhohe: (`https://www.kso.ac.at/beobachtungen/sonne_daten/sonnenflecken_rel_en.php`).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

November 2020 (Figure 2): Holger Krumnow (A152) recorded a sharp SID Event of the M4.4 flare, 29 November! (Please note the y-axis values in this SID graph are undefined units.)

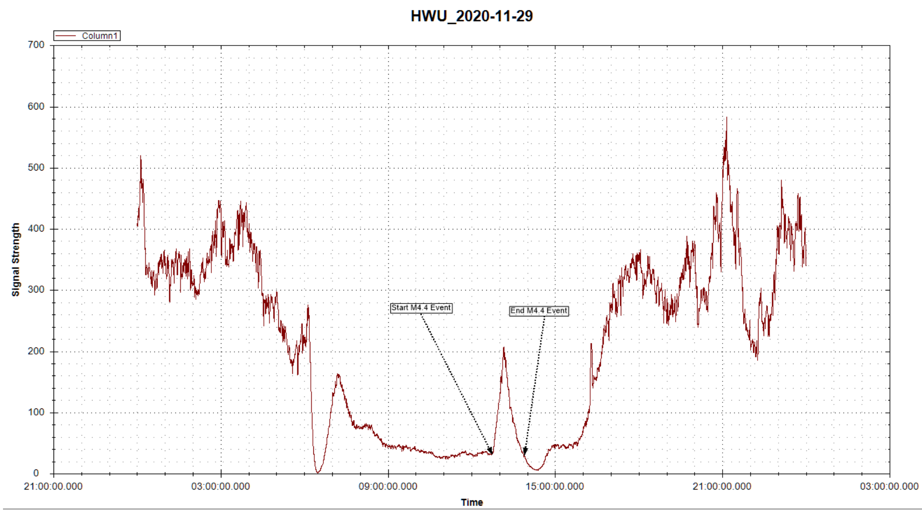

Figure 2: VLF recording from Frankfurt, Germany by Holger Krumnow.

2.2 SID Observers

In November 2020 we had 15 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202011 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
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
G Silvis	A141	NAA NML
R Rogge	A143	GQD
K Menzies	A146	NAA
L Pina	A148	NML
L Ferreira	A149	NWC
A Maevsky	A151	GQD
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.

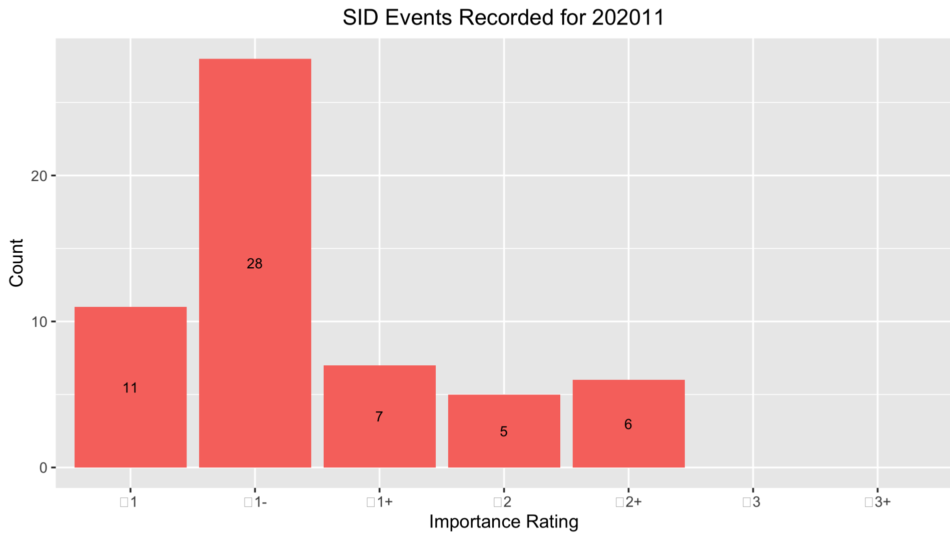

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In November 2020, there were 209 XRA flares recorded by GOES-16: zero A-class, 154 B-class, 54 C-class, and one M-class. A large increase in flaring this month compared to last month. There were 2 days this month with no GOES-16 reports of flares (see Figure 4).

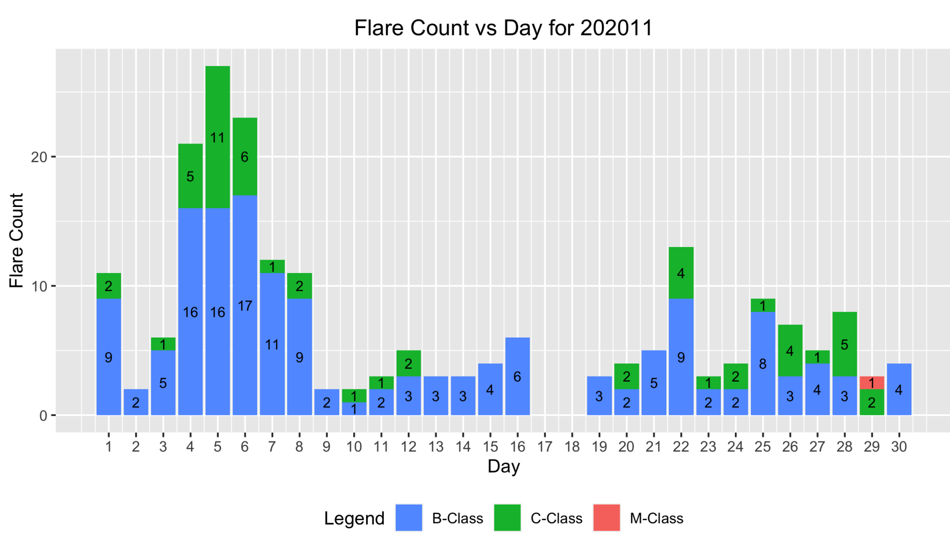

Figure 4: GOES-16 XRA flares

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 an 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 November 2020. 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.

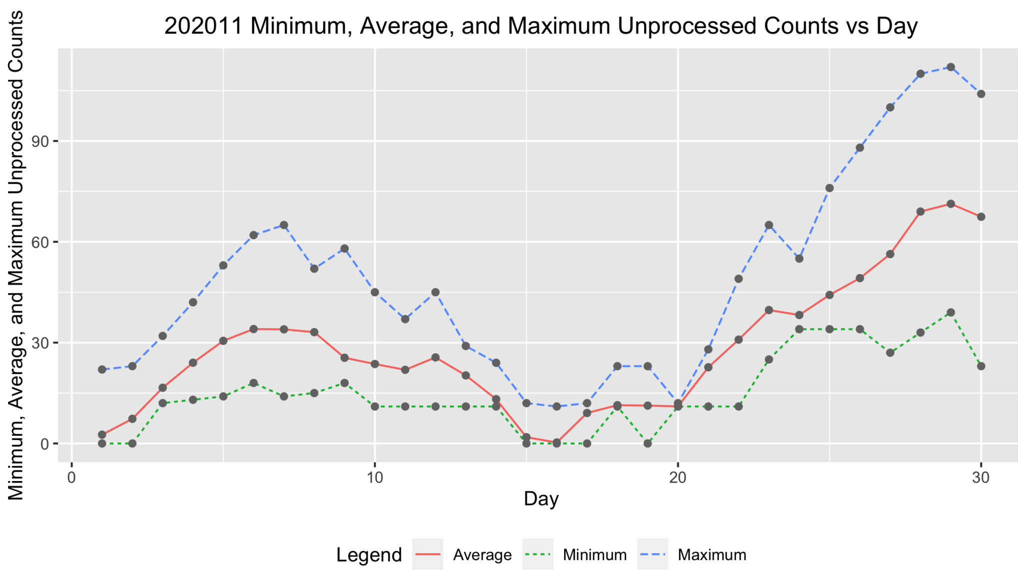

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

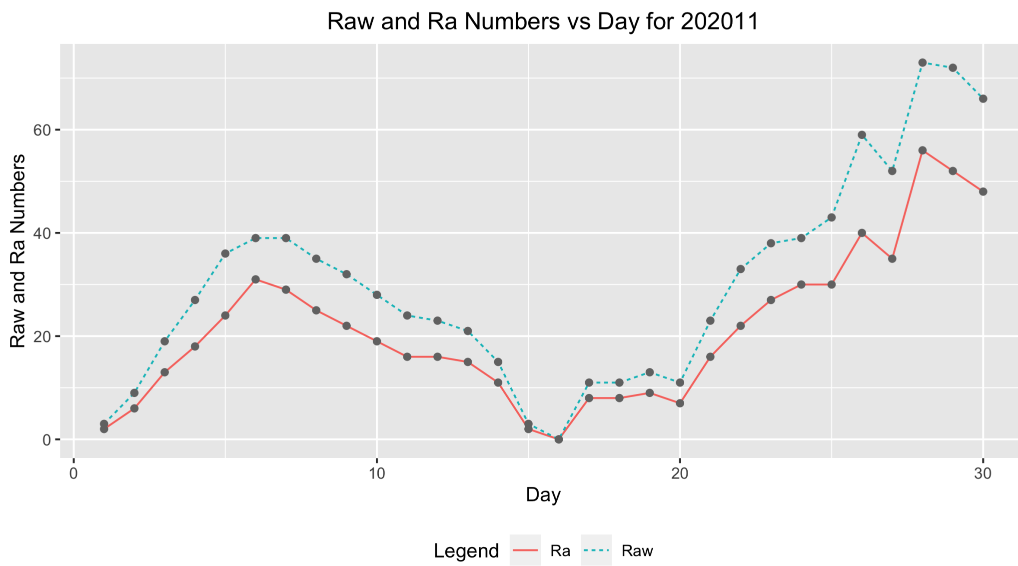

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202011 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	34	3	2
2	36	9	6
3	38	19	13
4	44	27	18
5	41	36	24
6	44	39	31
7	43	39	29
8	42	35	25
9	34	32	22
10	39	28	19
11	33	24	16
12	33	23	16
13	32	21	15
14	42	15	11

Continued

Table 2: 202011 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	30	3	2
16	38	0	0
17	39	11	8
18	41	11	8
19	38	13	9
20	41	11	7
21	42	23	16
22	29	33	22
23	39	38	27
24	41	39	30
25	37	43	30
26	31	59	40
27	31	52	35
28	39	73	56
29	33	72	52
30	29	66	48
Averages	37.1	29.9	21.2

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for November 2020, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (65), and total number of observations submitted (1113).

Table 3: 202011 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	24	Alexandre Amorim
AJV	22	J. Alonso
ARAG	29	Gema Araujo
ASA	25	Salvador Aguirre
ATE	26	Teofilo Arranz Heras
BARH	10	Howard Barnes
BATR	8	Roberto Battaiola
BERJ	20	Jose Alberto Berdejo
BLAJ	12	John A. Blackwell
BMF	22	Michael Boschat
BRAF	22	Raffaello Braga
BROB	28	Robert Brown
CHAG	25	German Morales Chavez
CKB	23	Brian Cudnik

Continued

Table 3: 202011 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	29	Dean Chantiles
CVJ	6	Jose Carvajal
DARB	6	Aritra Das
DEMF	10	Frank Dempsey
DIVA	9	Ivo Demeulenaere
DJOB	13	Jorge del Rosario
DMIB	27	Michel Deconinck
DUBF	23	Franky Dubois
EHOA	11	Howard Eskildsen
ERB	10	Bob Eramia
FERJ	23	Javier Ruiz Fernandez
FLET	28	Tom Fleming
FTAA	12	Tadeusz Figiel
GIGA	29	Igor Grgeda Mndez
HALB	3	Brian Halls
HAYK	11	Kim Hay
HOWR	25	Rodney Howe
IEWA	23	Ernest W. Iverson
JDAC	10	David Jackson
JENS	3	Simon Jenner
JGE	5	Gerardo Jimenez Lopez
JPG	2	Penko Jordanov
KAND	9	Kandilli Observatory
KAPJ	21	John Kaplan
KNJS	29	James & Shirley Knight
LEVM	18	Monty Leventhal
LGEC	7	Georgios Lekkas
LKR	11	Kristine Larsen
LRRA	18	Robert Little
MARC	22	Arnaud Mengus
MCE	26	Etsuiku Mochizuki
MGAR	2	Gary Myers
MILJ	20	Jay Miller
MJHA	24	John McCammon
MUDG	11	George Mudry
MWU	28	Walter Maluf
OAAA	24	Al Sadeem Astronomy Observatory
ONJ	19	John O'Neill
PEKT	6	Riza Pektas
SDOH	30	Solar Dynamics Obs - HMI
SNE	11	Neil Simmons
SONA	13	Andries Son
SQN	16	Lance Shaw

Continued

Table 3: 202011 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
STAB	24	Brian Gordon-States
TESD	23	David Teske
TST	20	Steven Toothman
URBP	6	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
VIDD	9	Daniel Vidican
WGI	1	Guido Wollenhaupt
WILW	21	William M. Wilson
Totals	1113	65

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 months) 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 confidence band uses the large sample approximation based on the Gaussian distribution. 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.

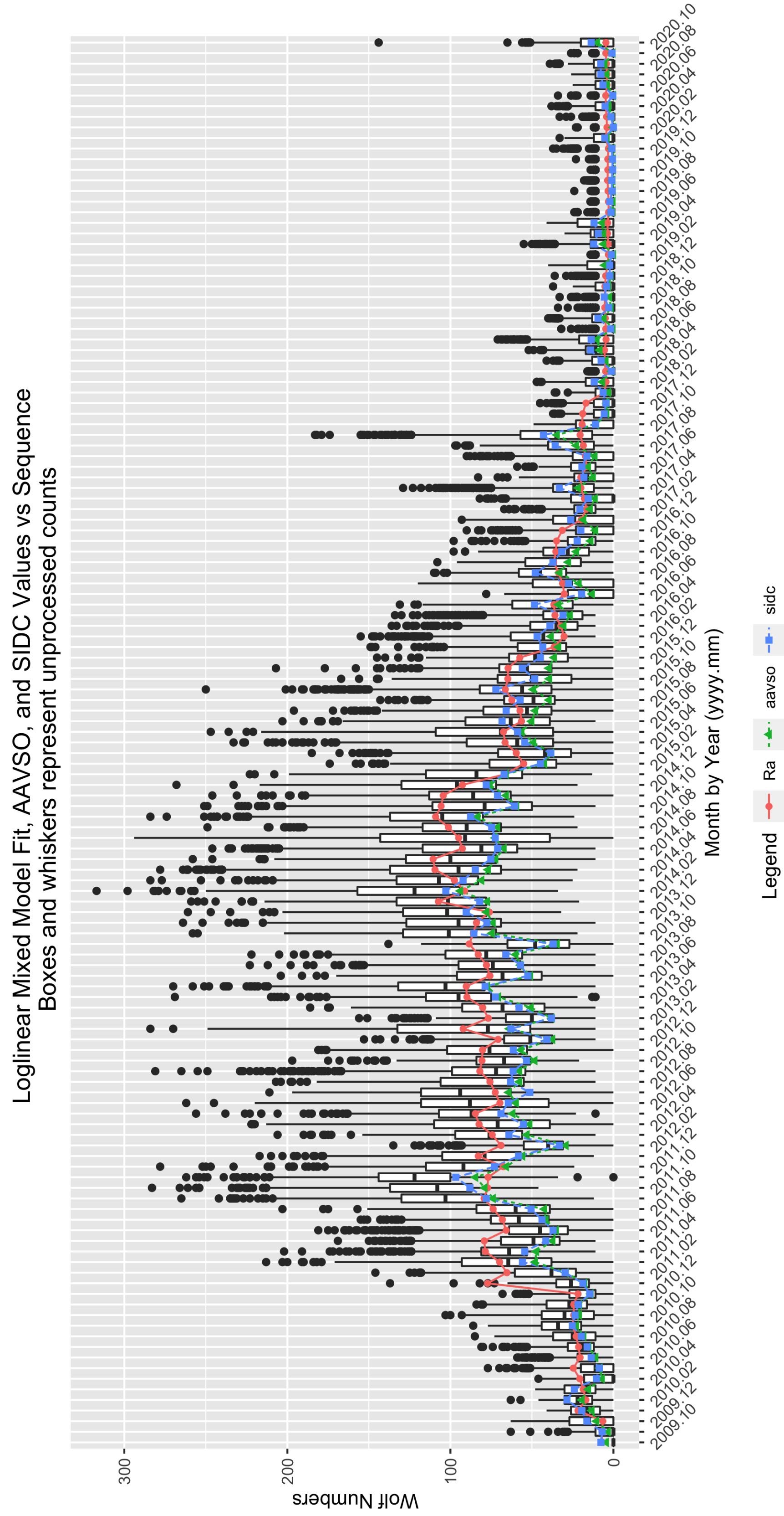

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

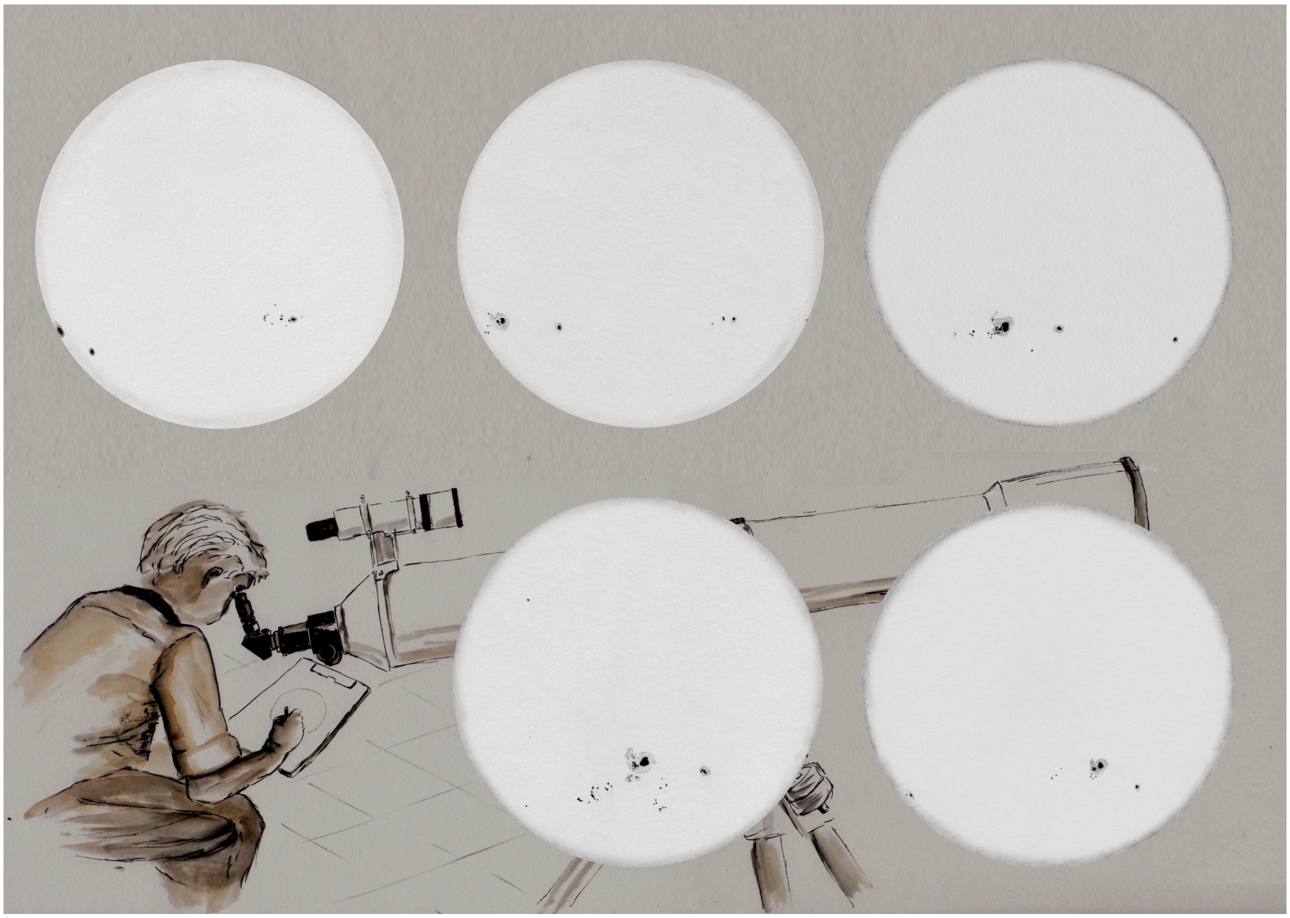

Figure 8: Just sun, paper, ink, and coffee, what else? White light sketches November 23/25/27/29 and December 01. Refactor 152mm f8 Astrozap full opening glass filter. Michel Deconinck. (`https://astro.aquarellia.com`)