Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 78 Number 3 March 2022

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 SID Events and solar X1.3 flare for March 30, 2022

The Very Low Frequency (VLF) graphs and solar H-Alpha image of the sun were made by Jon Wallace (A97).

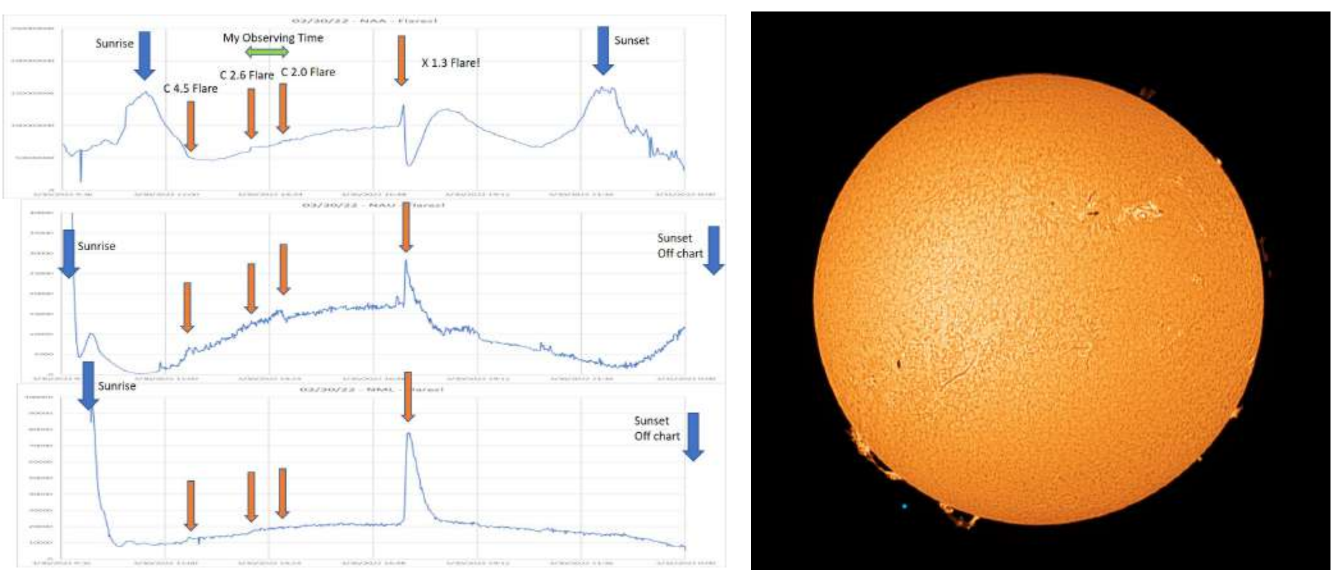

Figure 1: Composite sunspot solar image with a PST (40 mm) H-Alpha scope on an alt-az mount(https://optcorp.com/products/coronado-pst-40mm-h-alpha-solar-telescope).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

March 2022 (Figure 2) The X1.3 flare recorded by Radovan Mrllak (A136), Czech Republic.

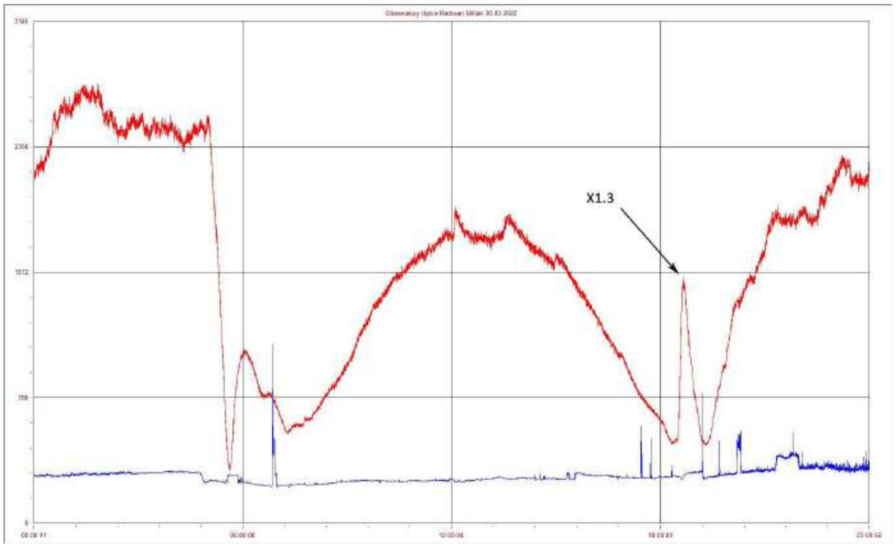

Figure 2: VLF recording on the 30th of March.

2.2 SID Observers

In March 2022, 16 AAVSO SID observers submitted VLF data as listed in Table 1.

Table 1: 202202 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
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 NML NLK
L Pina	A148	NAA NLK NML
H Krumnow	A152	DHO GBZ
J DeVries	A153	NLK
R Mazur	A155	NAA NML

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.

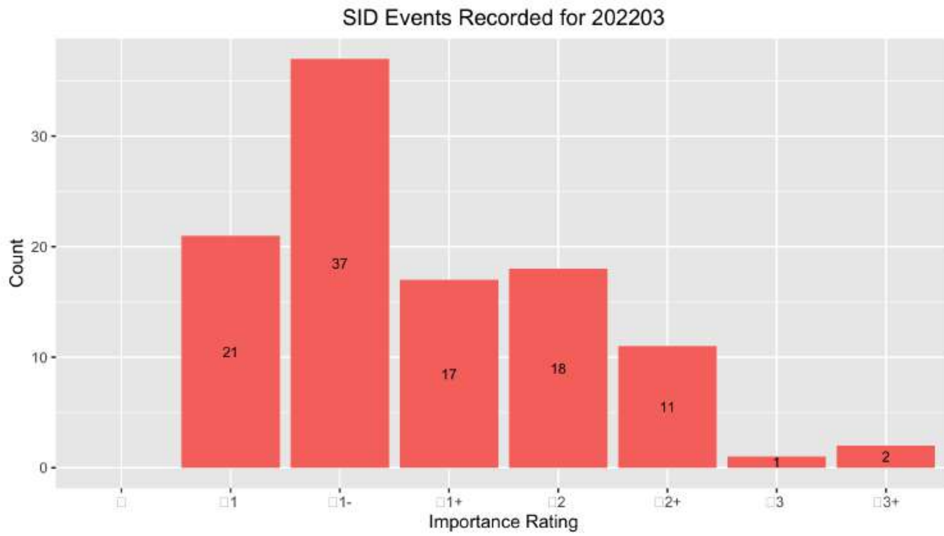

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In March 2022, there were 258 GOES-16 XRA flares for March 2022 : one X-class, 14 M-class, 135 C-class, and 108 B-class flares. Far more flaring this month compared to last (see Figure 4).

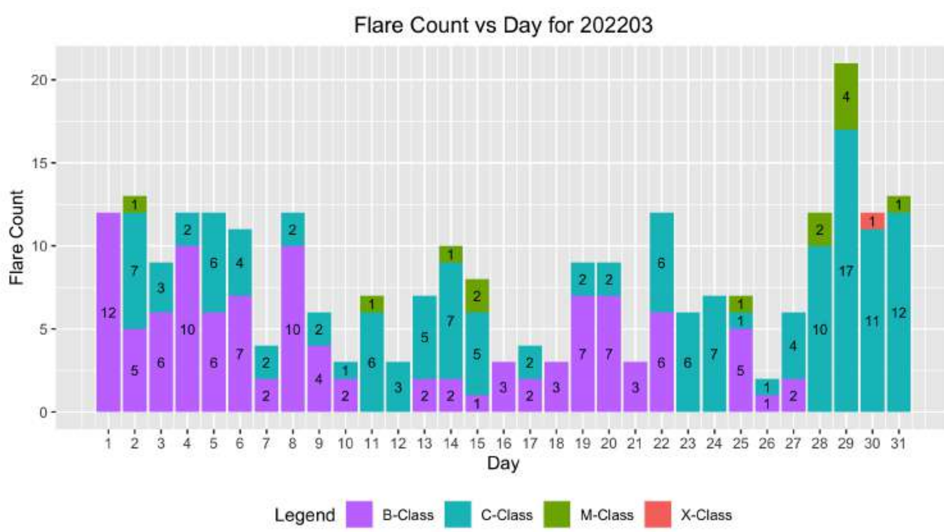

Figure 4: GOES-16 XRA flares.

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 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 March 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.

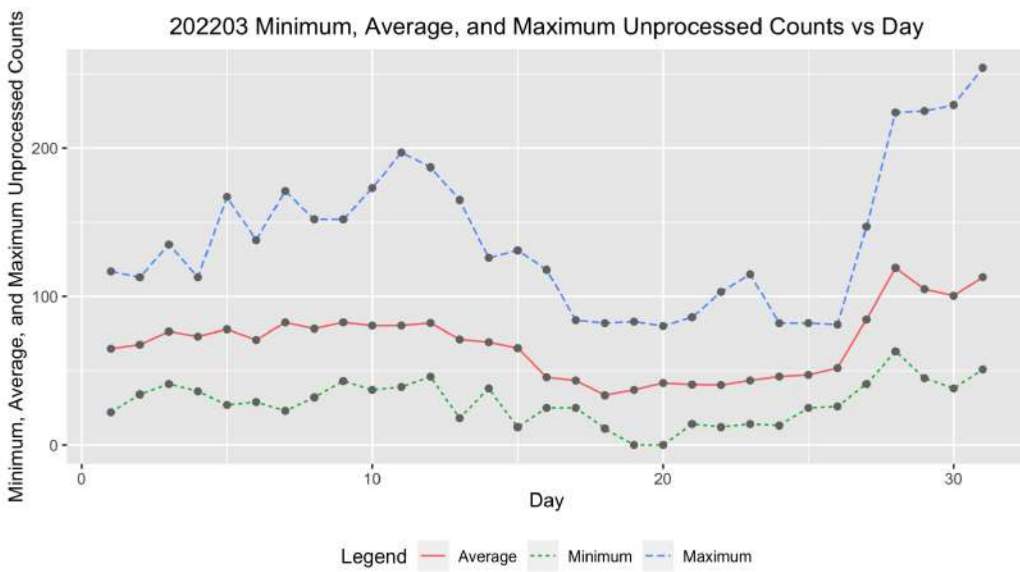

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

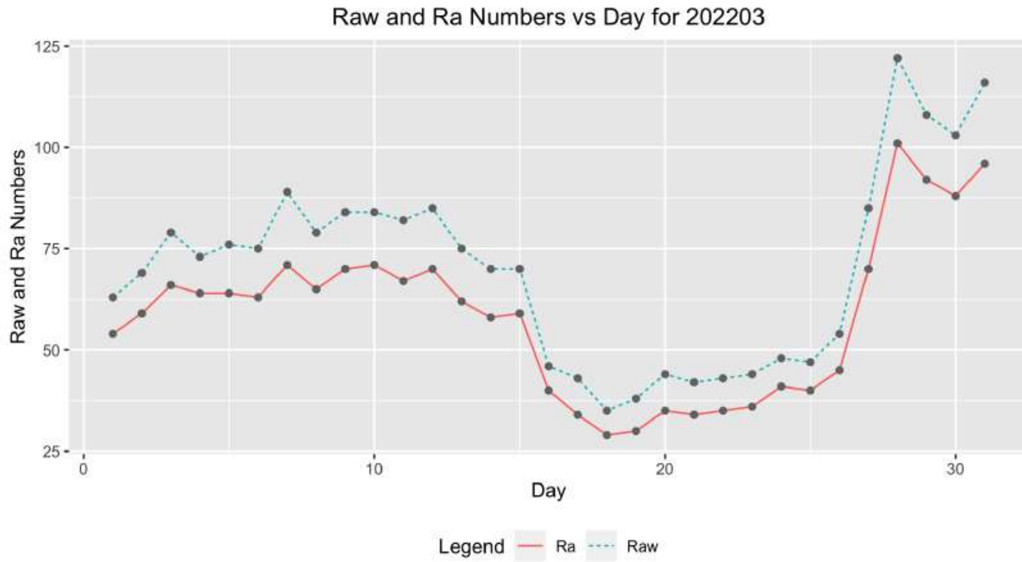

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 (`https://adsabs.harvard.edu/full/1949PASP...61...13S`). 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: 202203 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	37	63	54
2	40	69	59
3	38	79	66
4	38	73	64
5	32	76	64
6	32	75	63
7	29	89	71
8	34	79	65
9	35	84	70
10	43	84	71
11	32	82	67
12	33	85	70
13	40	75	62
14	33	70	58

Continued

Table 2: 202203 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	26	70	59
16	24	46	40
17	32	43	34
18	33	35	29
19	30	38	30
20	33	44	35
21	34	42	34
22	38	43	35
23	37	44	36
24	44	48	41
25	38	47	40
26	40	54	45
27	37	85	70
28	39	122	101
29	33	108	92
30	31	103	88
31	34	116	96
Averages	34.8	70	58.4

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for March 2022, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (72), and total number of observations submitted (1079).

Table 3: 202203 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	19	Alexandre Amorim
AJV	17	J. Alonso
ARAG	30	Gema Araujo
ASA	7	Salvador Aguirre
ATE	19	Teofilo Arranz Heras
BATR	14	Roberto Battaiola
BKL	1	John A. Blackwell
BMF	21	Michael Boschat
BMIG	25	Michel Besson
BROB	23	Robert Brown
BXZ	11	Jose Alberto Berdejo
BZX	23	A. Gonzalo Vargas
CIOA	10	Ioannis Chouinavas

Continued

Table 3: 202203 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CKB	25	Brian Cudnik
CNT	28	Dean Chantiles
CPAD	1	Panagiotis Chatzistamatiou
CVJ	1	Jose Carvajal
DARB	21	Aritra Das
DFR	7	Frank Dempsey
DJOB	11	Jorge del Rosario
DMIB	23	Michel Deconinck
DROB	3	Bob Dudley
DUBF	25	Franky Dubois
EHOA	14	Howard Eskildsen
ERB	16	Bob Eramia
FDAE	2	David Fox
FERA	10	Eric Fabrigat
FLET	25	Tom Fleming
GIGA	22	Igor Grageda Mendez
HALB	10	Brian Halls
HKY	14	Kim Hay
HMQ	8	Mark Harris
HOWR	19	Rodney Howe
HRUT	20	Timothy Hrutkay
IEWA	20	Ernest W. Iverson
ILUB	18	Luigi Iapichino
JDAC	6	David Jackson
JGE	5	Gerardo Jimenez Lopez
JSI	6	Simon Jenner
KAND	14	Kandilli Observatory
KAPJ	15	John Kaplan
KNJS	31	James & Shirley Knight
LKR	2	Kristine Larsen
LRRA	22	Robert Little
MARC	6	Arnaud Mengus
MARE	5	Enrico Mariani
MCE	25	Etsuiku Mochizuki
MJAF	29	Juan Antonio Moreno Quesada
MJHA	25	John McCammon
MLL	10	Jay Miller
MMAY	31	Max Surlaroute
MMI	31	Michael Moeller
MSS	4	Sandy Mesics
MUDG	2	George Mudry
MWU	22	Walter Maluf
OAAA	21	Al Sadeem Astronomy Obs.

Continued

Table 3: 202203 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
ONJ	12	John O'Neill
PEKT	2	Riza Pektas
PLUD	12	Ludovic Perbet
RJV	12	Javier Ruiz Fernandez
SATH	23	Andries Son
SDOH	31	Solar Dynamics Obs - HMI
SNE	1	Neil Simmons
SQN	10	Lance Shaw
SRIE	11	Rick St. Hilaire
TDE	23	David Teske
TPJB	3	Patrick Thibault
TST	11	Steven Toothman
URBP	23	Piotr Urbanski
WGI	8	Guido Wollenhaupt
WTIC	1	Timothy Weaver
WWM	21	William M. Wilson
Totals	1079	72

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.

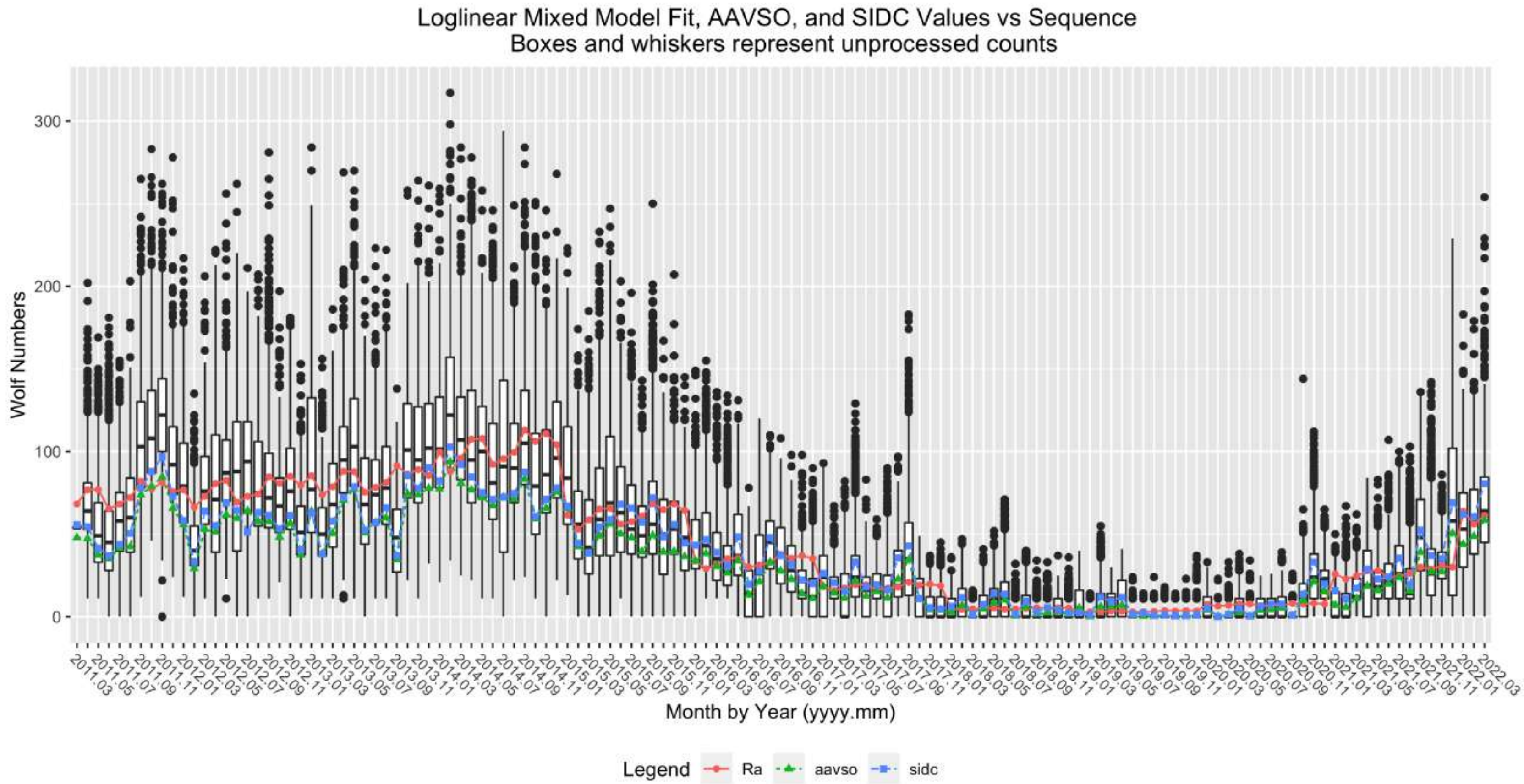

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

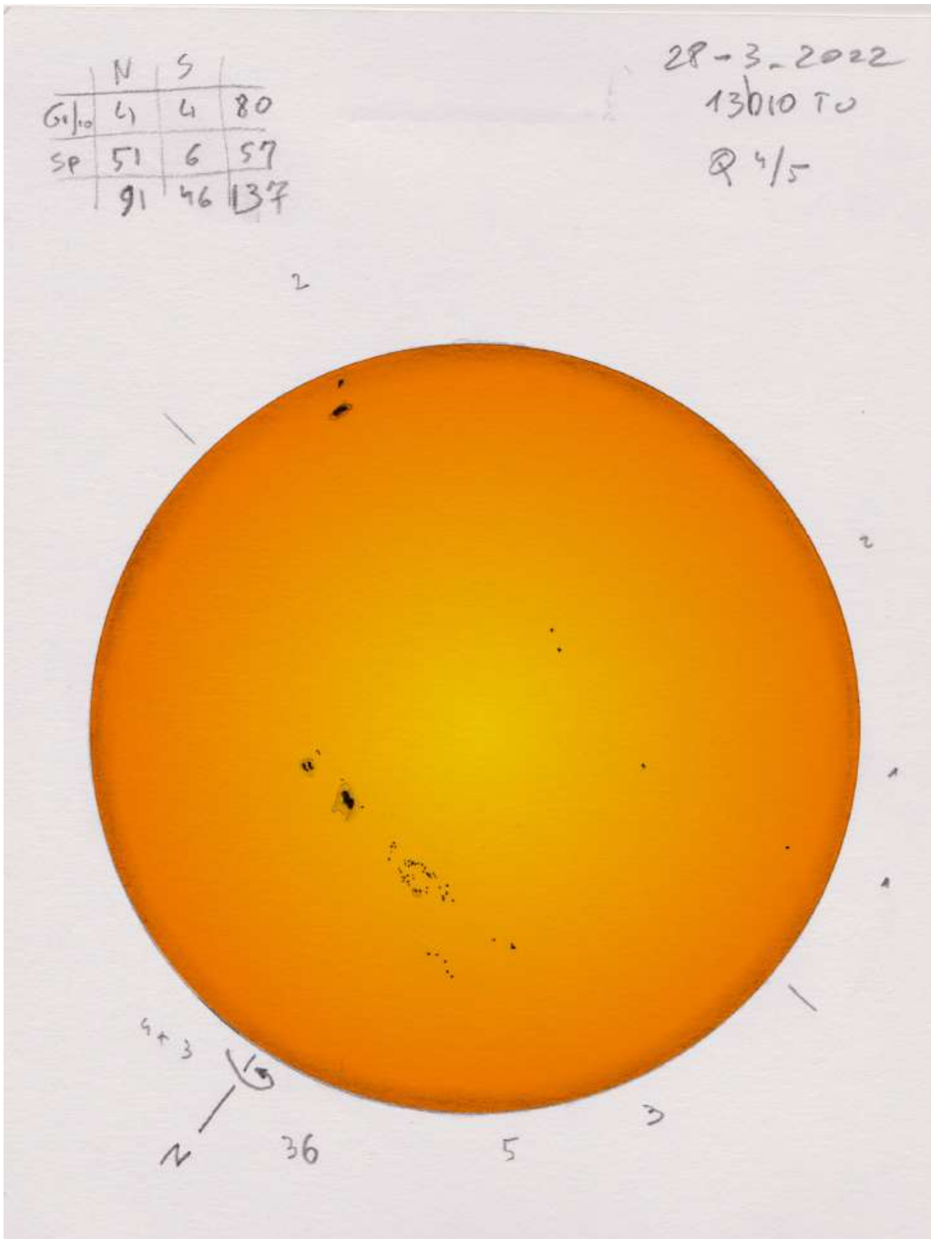

Figure 8: "I took a long trip to the north of Europe, in Lapland, up to the polar circle. I made a solar estimation at midnight UTC! I attach here one of the last sketch's I made, just the coloration was added by computer, so it's a sketch," Michel Deconinck (`https://astro.aquarellia.com`).