Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 185 Alewife Brook Parkway,
Cambridge, MA 02138 USA

Web: http://www.aavso.org/solar-bulletin
Email: solar@aavso.org
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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 Solar magnetic fields from two data sets

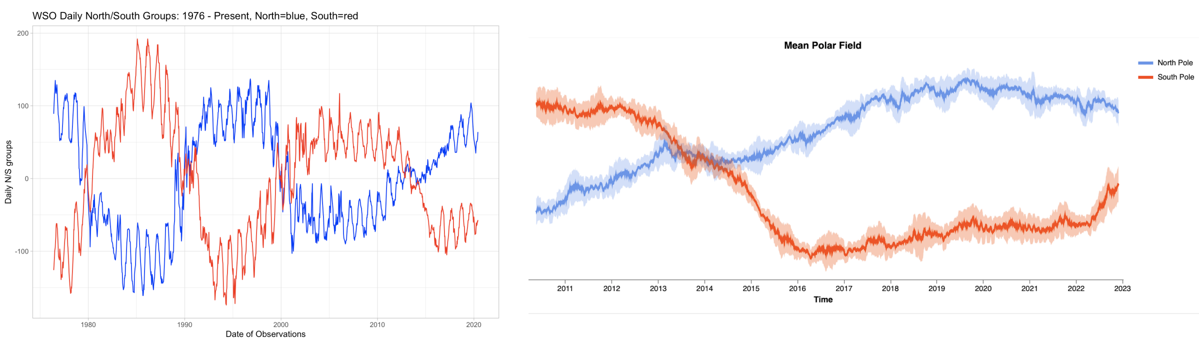

Figure 1: Wilcox Solar Observatory (2022) and Solar Dynamics Observatory (2022) satellite data.

These two data sets are used to determine the solar north and south magnetic polarity and the cross-overs for the 22-year magnetic cycle. A 44-year time series (1976 to present) of daily average data was recorded by the WSO. The SDO satellite data (Project Jupyter et al., 2016) begin in 2010, and show the cycle 24 polarity fields and how they are predicted to cross over in a year or two (Courtesy of NASA/SDO and the AIA, EVE, and HMI science teams, 2022). There has been an overall decline in the magnetic flux during the last 44 years, implying the solar polar magnetic fields have weakened over the last 4 solar cycles (Munoz-Jaramillo, 2012).

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

November 2022 (Figure 2): on the 11th, there were 21 flares recorded here in Fort Collins, Colorado.

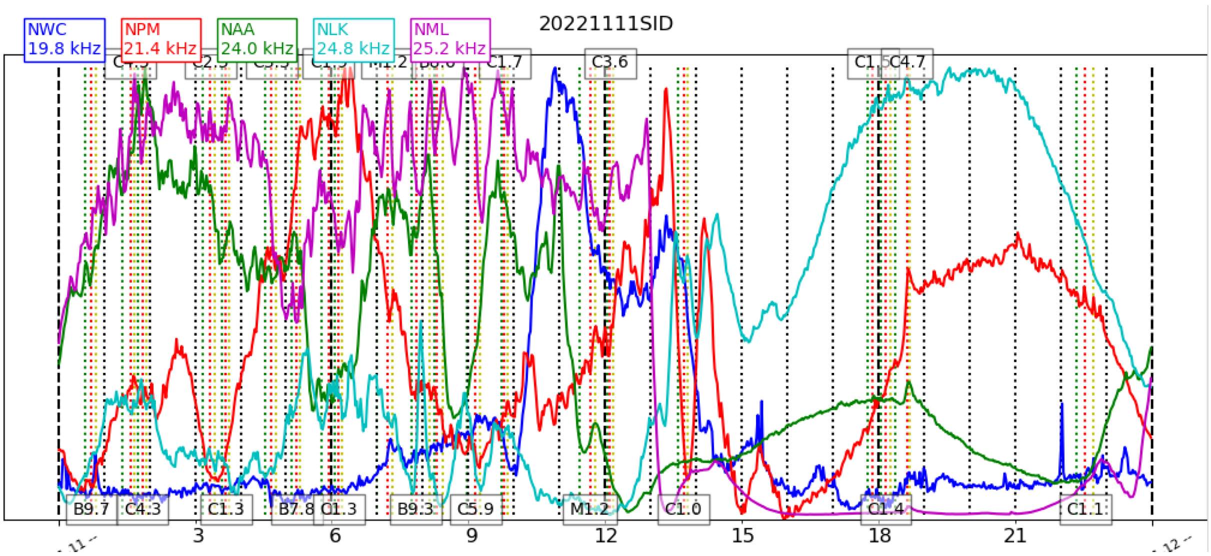

Figure 2: VLF recording from Fort Collins, Colorado.

2.2 SID Observers

In November 2022, 11 AAVSO SID observers who submitted VLF data as listed in Table 1.

Table 1: 202211 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
F Adamson	A122	NWC
J Karlovsky	A131	DHO NAA TBB
R Mrllak	A136	GQD NSY
S Aguirre	A138	NPM NAA
K Menzies	A146	NAA
L Pina	A148	NAA NLK NML
H Krumnow	A152	FTA GBZ HWU
J DeVries	A153	NLK
R Mazur	A155	NLK 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.

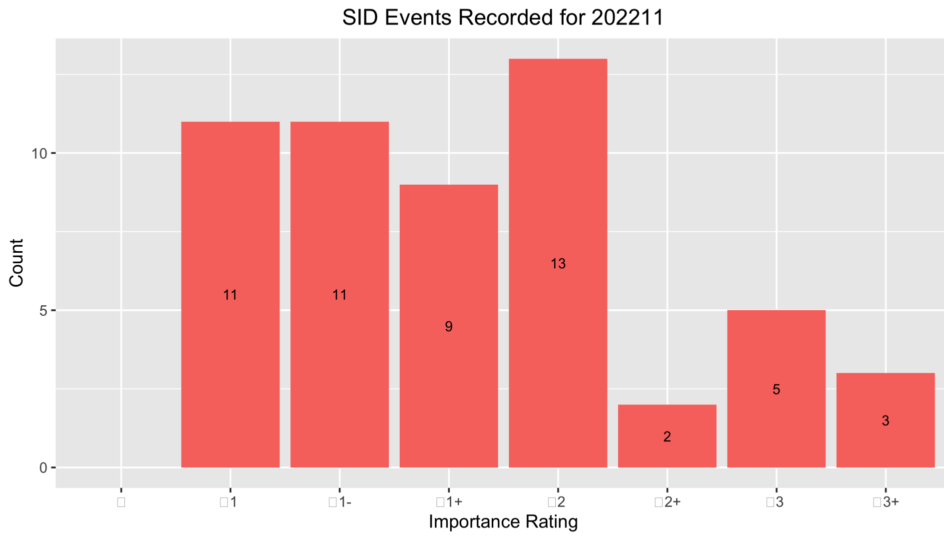

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In November 2022, there were 223 XRA flares: 6 M-class, 155 C-class, and 62 B-class flares (NOAA, 2022). A little less flaring this month compared to last month (Figure 4).

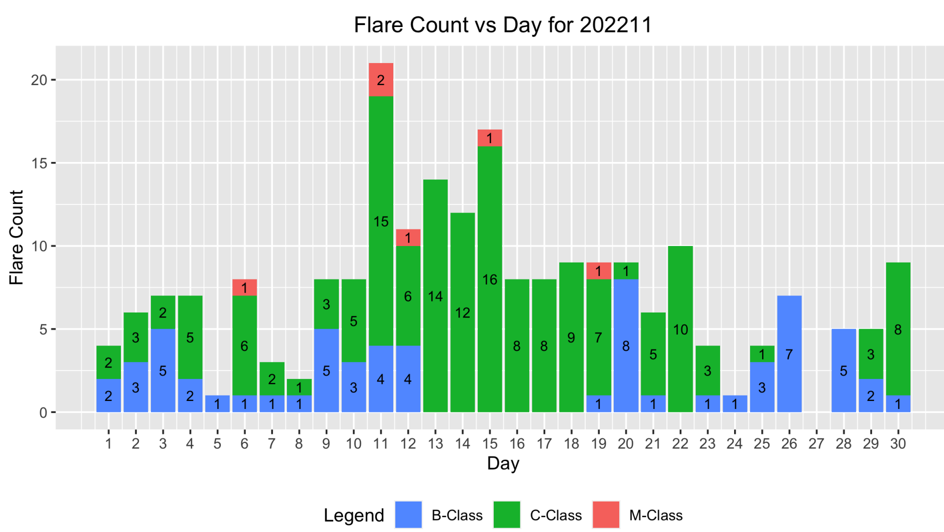

Figure 4: GOES-16 XRA flares

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 November 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.

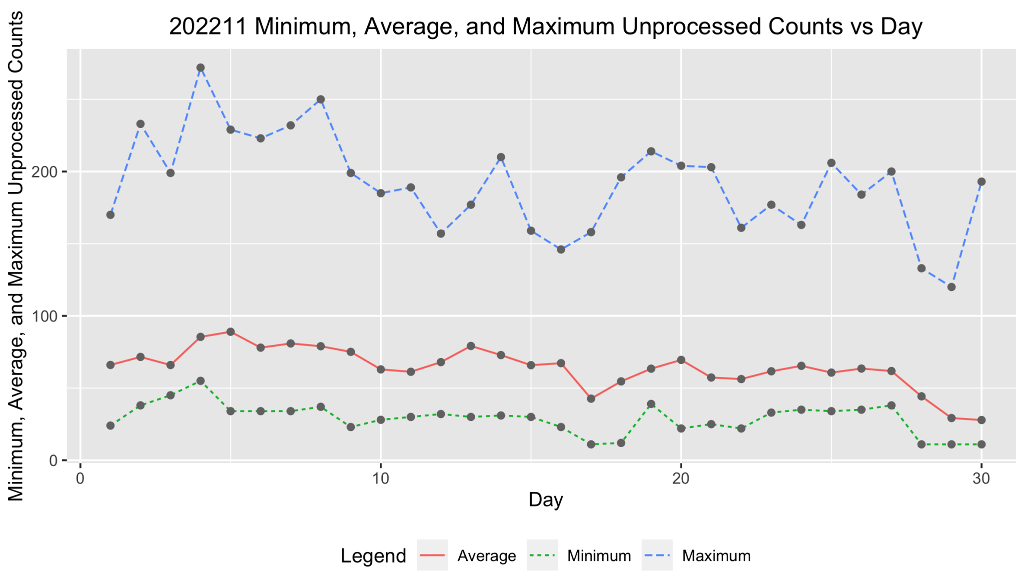

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

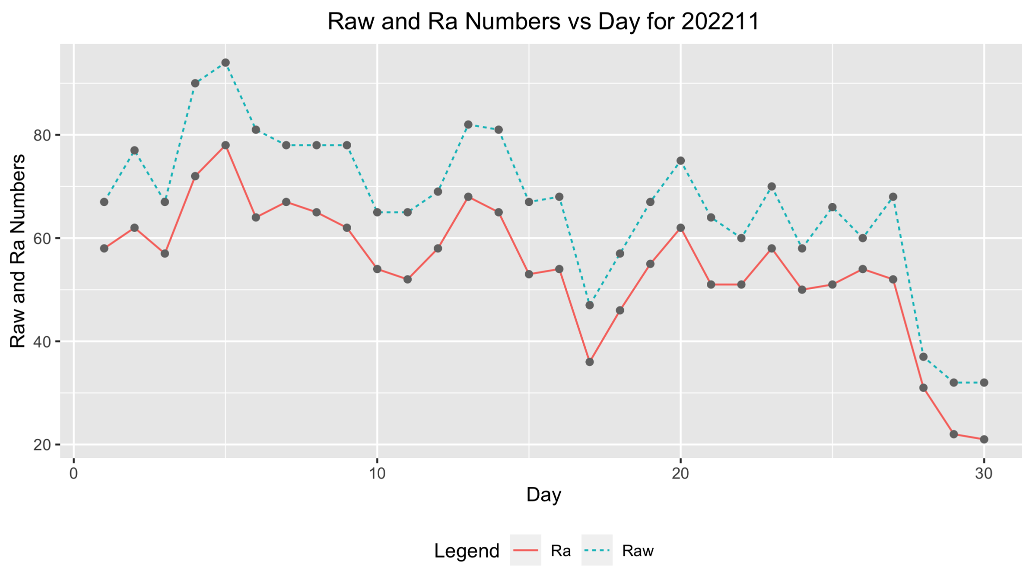

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202211 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	33	67	58
2	40	77	62
3	38	67	57
4	41	90	72
5	39	94	78
6	36	81	64
7	39	78	67
8	38	78	65
9	39	78	62
10	39	65	54
11	33	65	52
12	29	69	58
13	37	82	68
14	26	81	65

Continued

Table 2: 202211 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	26	67	53
16	32	68	54
17	32	47	36
18	35	57	46
19	36	67	55
20	38	75	62
21	30	64	51
22	35	60	51
23	36	70	58
24	35	58	50
25	34	66	51
26	36	60	54
27	34	68	52
28	29	37	31
29	22	32	22
30	26	32	21
Averages	34.1	66.7	54.3

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for November 2022, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (67), and total number of observations submitted (1023).

Table 3: 202211 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	21	Alexandre Amorim
AJV	16	J. Alonso
ARAG	27	Gema Araujo
ASA	21	Salvador Aguirre
ATE	18	Teofilo Arranz Heras
BATR	6	Roberto Battaiola
BMF	23	Michael Boschat
BMIG	17	Michel Besson
BXZ	16	Jose Alberto Berdejo
BZX	26	A. Gonzalo Vargas
CIOA	8	Ioannis Chouinavas
CKB	23	Brian Cudnik
CMAB	11	Maurizio Cervoni
CMOD	1	Mois Carlo

Continued

Table 3: 202211 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	21	Dean Chantiles
CVJ	2	Jose Carvajal
DARB	1	Aritra Das
DELS	14	Susan Delaney
DFR	6	Frank Dempsey
DJOB	13	Jorge del Rosario
DMIB	16	Michel Deconinck
DUBF	22	Franky Dubois
EGMA	26	Georgios Epitropou
EHOA	8	Howard Eskildsen
ERB	13	Bob Eramia
FERA	6	Eric Fabrigat
FLET	21	Tom Fleming
GIGA	30	Igor Grageda Mendez
HALB	10	Brian Halls
HKY	20	Kim Hay
HOWR	21	Rodney Howe
IEWA	15	Ernest W. Iverson
ILUB	6	Luigi Iapichino
JDAC	1	David Jackson
JGE	3	Gerardo Jimenez Lopez
KAMB	30	Amoli Kakkar
KAND	20	Kandilli Observatory
KAPJ	8	John Kaplan
KNJS	30	James & Shirley Knight
LEVM	12	Monty Leventhal
LKR	10	Kristine Larsen
LRRA	21	Robert Little
MARC	4	Arnaud Mengus
MARE	9	Enrico Mariani
MCE	21	Etsuiku Mochizuki
MJAF	28	Juan Antonio Moreno Quesada
MJHA	29	John McCammon
MLL	13	Jay Miller
MMAY	30	Max Surlaroute
MMI	30	Michael Moeller
MUDG	1	George Mudry
MWU	18	Walter Maluf
OAAA	14	Al Sadeem Astronomy Obs.
ONJ	13	John O'Neill
PLUD	18	Ludovic Perbet
RJV	13	Javier Ruiz Fernandez
SDOH	30	Solar Dynamics Obs - HMI

Continued

Table 3: 202211 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SNE	9	Neil Simmons
SRIE	23	Rick St. Hilaire
SVAE	1	Valery Stanimirov
TDE	26	David Teske
TPJB	3	Patrick Thibault
TST	18	Steven Toothman
URBP	5	Piotr Urbanski
VIDD	6	Dan Vidican
WGI	3	Guido Wollenhaupt
WWM	18	William M. Wilson
Totals	1023	67

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.

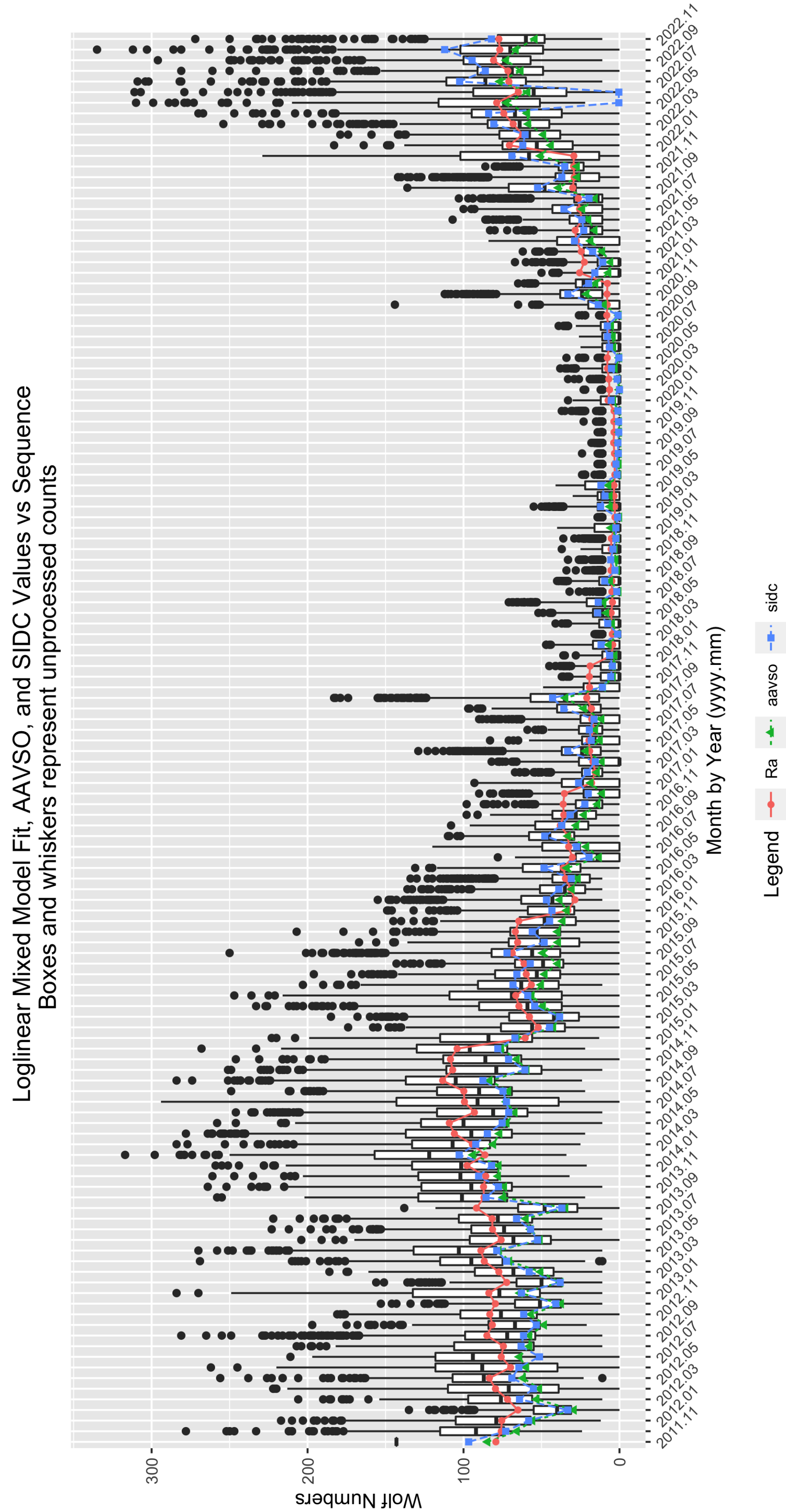

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels (2022).

4 Endnotes

- Sunspot Reports: Kim Hay solar@aavso.org
- SID Solar Flare Reports: Rodney Howe rhowe137@icloud.com

Max Surlaroute (MMAY) used data from Wilcox Solar Observatory (2022) at Stanford for magnetic fields as well as data from Kanzelhoe Solar Observatory (2022), Austria, for the number of North and South hemisphere sunspots.

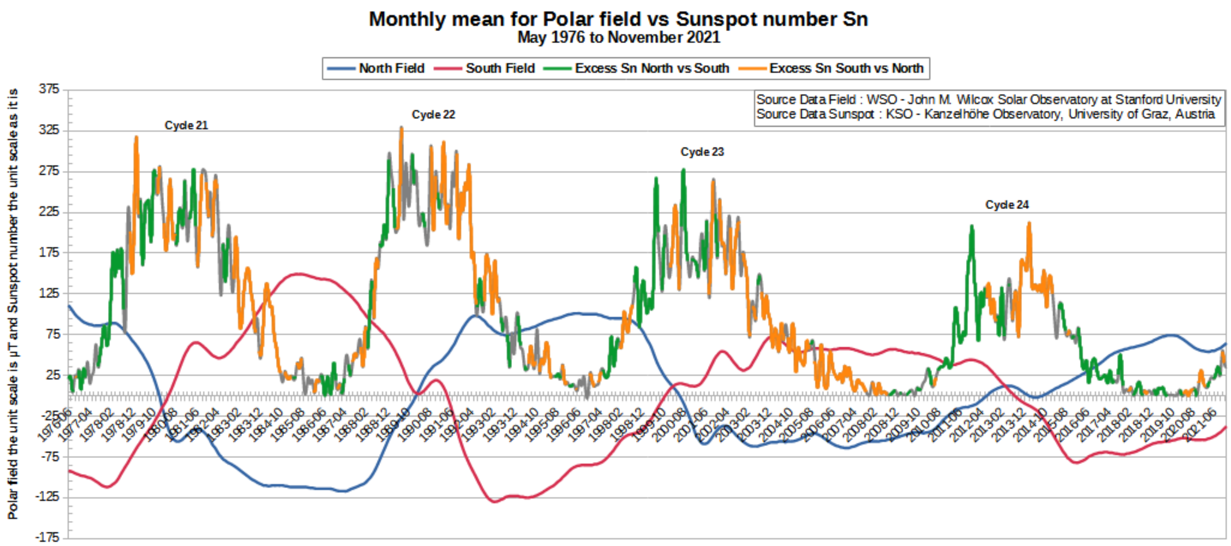

Figure 8: This graph was created by Max Surlaroute (MMAY). Notice how the Wilcox Solar Observatory polar field data and the Kanzelhoe Solar Observatory sunspot data have weakened over the last four solar cycles. Data for this graph come from both observatories.

References

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