Solar Bulletin

AAVSO Solar Observing Section

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: https://www.aavso.org/solar-bulletin
Email: solar@aavso.org

ISSN 0271-8480

Volume 80 Number 3 March 2024

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 very low frequency (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 Observers during the Maunder Minimum

Here are all the observers during the 80+ years of the Maunder Minimum. These are from the Group Number database found at SILSO: `https://www.sidc.be/SILSO/groupnumberv3` . Therefore, today, we need to continue this heritage series in parallel with all other techniques, in order to calibrate the relation between various solar parameters (spectral irradiance, solar wind flux, global magnetic fields) and the group and sunspot numbers, all of this over the whole range of possible activity regimes (See for example Svalgaard 2017). This means that we must continue to observe the way we have for at least one or more solar cycles (Clette 2012; Arlt and Vaquero 2020).

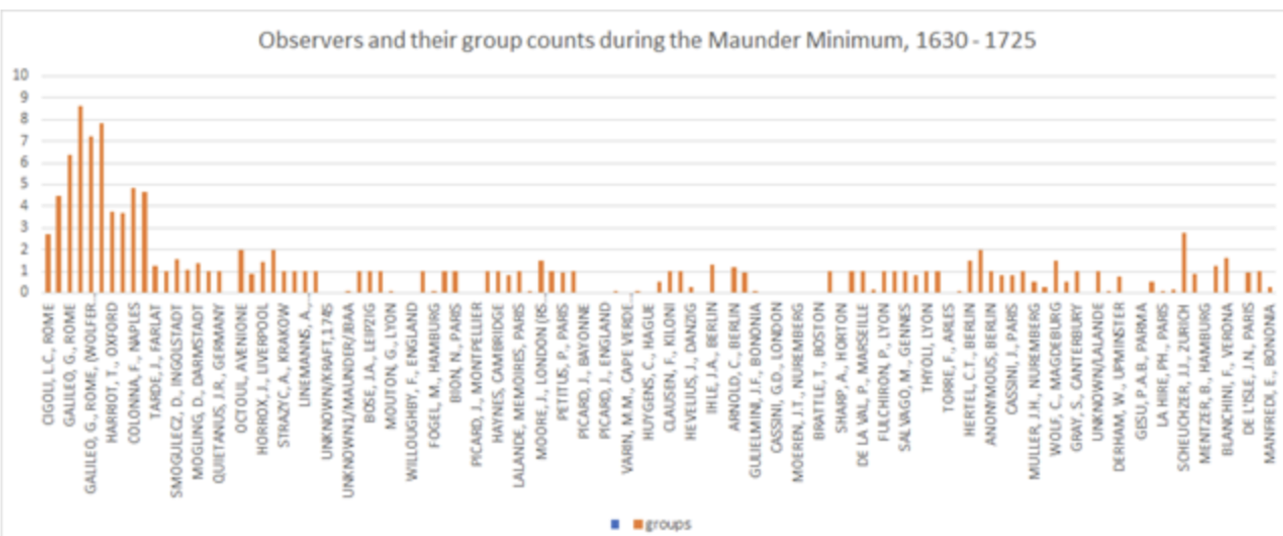

Figure 1: Observers during the 96 years of the Maunder Minimum.

1.1 Group counts during the Maunder Minimum

By 1904, Edward Maunder quantified relationships between sunspots and geomagnetic activity, uncovering a significant correlation between geomagnetic disturbance and solar rotation. He concluded that *"our magnetic disturbances have their origin in the Sun. The solar action which gives rise to them does not act equally in all directions, but along narrow, well defined streams, not necessarily radial."* (Judge 2020, p 138)

Table 1: 202403 Average Group Count from the Group Number database.

Observer	Final Year	Group averages
CIGOLI, L.C., ROME	1612	2.72
COLOGNA, S., MONREALE	1612	4.5
GALILEO, G., ROME	1612	6.39
GALILEO, G., ROME, (LEIF RECOUNT)	1612	8.6
GALILEO, G., ROME, (WOLFER COUNT)	1612	7.22
GALILEO/SAKURAI, ROME	1612	7.81
HARRIOT, T., OXFORD	1613	3.72
JUNGIUS, J., HAMBURG	1613	3.66
COLONNA, F., NAPLES	1614	4.82
SAXONIUS, P., NUREMBERG	1616	4.67
TARDE, J., FARLAT	1617	1.22
HORTENSIUS, M., LUGD. BATAV.	1625	1
SMOGULECZ, D., INGOLSTADT	1625	1.52
MALAPERT, C., BELGIUM	1626	1.09
MOGLING, D., DARMSTADT	1629	1.37
SCHICKARD, W., TUBINGA	1629	1
QUIETANUS, J.R., GERMANY	1631	1
RICCIOLI, J.B., BONONIA	1632	0
OCTOUL, AVENIONE	1635	2
MARCGRAF, G., LEIDEN	1637	0.88
HORROX, J., LIVERPOOL	1639	1.43
SCHEINER, C., ROME	1640	1.99
STRAZYC, A., KRAKOW	1640	1
RHEITA, K., BOHEMIA	1642	1
LINEMANNS, A., REGIOMONTUS	1644	1
GASSENDI, P., PARIS (LEIF RECOUNT)	1645	1.01
UNKNOWN/KRAFT,1745	1648	0
PICARD/KEILL, PARIS	1654	0
UNKNOWN1/MAUNDER/JBAA	1654	0.01
UNKNOWN2/MAUNDER/JBAA	1655	1
BOSE, J.A., LEIPZIG	1656	1
BOYLE, R., LONDON	1660	1
MOUTON, G., LYON	1661	0.11
PAYEN, A.-F., AVIGNON	1666	0
WILLOUGHBY, F., ENGLAND	1666	0
KIRCHER, A., ROME	1667	1

Continued

Table 1: 202403 Average Group Count from the Group Number database.

Observer	Final Year	Group averages
FOGEL, M., HAMBURG	1671	0.08
STETINI, LEIPZIG	1671	1
BION, N., PARIS	1672	1
RICHER, CAYENNE	1673	0
PICARD, J., MONTPELLIER	1674	0
HALLEY, E., LONDON	1676	1
HAYNES, CAMBRIDGE	1676	1
HOOK, R., LONDON	1676	0.8
LALANDE, MEMOIRES, PARIS	1676	1
MONTANARI, G., BONONIA	1676	0.1
MOORE, J., LONDON (RS ARCHIVES)	1676	1.5
HARTSOEKER, N., THE HAGUE	1677	1
PETITUS, P., PARIS	1677	0.95
MACULA IN SOLE, 1678	1678	1
PICARD, J., BAYONNE	1680	0
DESHAYES, M., ROUEN	1681	0
PICARD, J., ENGLAND	1681	0
SIVERUS, H., HAMBURG	1681	0.02
VARIN, M.M., CAPE VERDE VOYAGE	1681	0
PICARD, J., PARIS	1682	0.03
HUYGENS, C., HAGUE	1683	0
CASWELL (R.S.), LONDON	1684	0.5
CLAUSEN, F., KILONI	1684	1
ETTMULLER, M.E., WITTENBERG	1684	1
HEVELIUS, J., DANZIG	1684	0.3
JESUITS, CHINA	1686	0
IHLE, J.A., BERLIN	1687	1.33
SCHULTZ, D.G., NUREMBERG	1689	0
ARNOLD, C., BERLIN	1693	1.2
CASSINI, G.D., PARIS	1695	0.92
GULIELMINI, J.F., BONONIA	1695	0.03
CASSINI, G.D., FLANDERS	1697	0
CASSINI, G.D., LONDON	1698	0
MEYER, J., REGENSBURG	1699	0
MOEREN, J.T., NUREMBERG	1699	0
EIMMART, G.C., NUREMBERG	1702	0
BRATTLE, T., BOSTON	1703	0
HOFFMANN, J.H., BERLIN	1703	1
SHARP, A., HORTON	1703	0
DE CLAPIER, M., MONTPELLIER	1704	1
DE LA VAL, P., MARSEILLE	1704	1
EIMMART, M-C., NUREMBERG	1704	0.16
FULCHIRON, P., LYON	1704	1
ROMER, O., COPENHAGEN	1704	1

Continued

Table 1: 202403 Average Group Count from the Group Number database.

Observer	Final Year	Group averages
SALVAGO, M., GENNES	1704	1
STANNYAN, ENGLAND	1704	0.83
THYOLI, LYON	1704	1
JARTOUX, R.P., PEKING	1705	1
TORRE, F., ARLES	1706	0
AGERHOLM, C., COPENHAGEN	1707	0.01
HERTEL, C.T., BERLIN	1707	1.5
STURM, L.C., BERLIN	1707	2
ANONYMOUS, BERLIN	1708	1
BECKER, P., ROSTOCK	1709	0.8
CASSINI, J., PARIS	1709	0.79
LALANDE, HISTORIE, PARIS	1709	1
MULLER, J.H., NUREMBERG	1709	0.49
WIEDENBURG, J.B., HELMSTADT	1709	0.24
WOLF, C., MAGDEBURG	1709	1.5
KIRCH, G., BERLIN	1710	0.49
GRAY, S., CANTERBURY	1713	0.98
PARISIUS, J.C., BONONIA	1713	0
UNKNOWN/LALANDE	1713	1
FLAMSTEED, J., CAMBRIDGE	1714	0.03
DERHAM, W., UPMINSTER	1715	0.75
FONTANA, P.B.G., MODENA	1715	0
GESU, P.A.B., PARMA	1715	0
KIRCH, M.M., BERLIN	1715	0.52
LA HIRE, PH., PARIS	1718	0.05
WURZELBAUR, J.P., NUREMBERG	1718	0.12
SCHEUCHZER, J.J., ZURICH	1721	2.75
FEUILLEE, L.E., PARIS	1722	0.9
MENTZER, B., HAMBURG	1723	0
PLANTADE, J., MONTPELLIER	1726	1.26
Totals	Observers = 110	124.46

The above table shows all those observers who took counts of groups and sunspots during the Maunder Minimum. Notice the first 18 years from 1612 to 1630 where the group counts are high. From then until 1726 the group count average was low. See Figure 1.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

March 2024 (Figure 2): There were 12 M-class flares on the 23rd of March recorded here in Fort Collins, Colorado (U.S. Dept. of Commerce–NOAA, 2022).

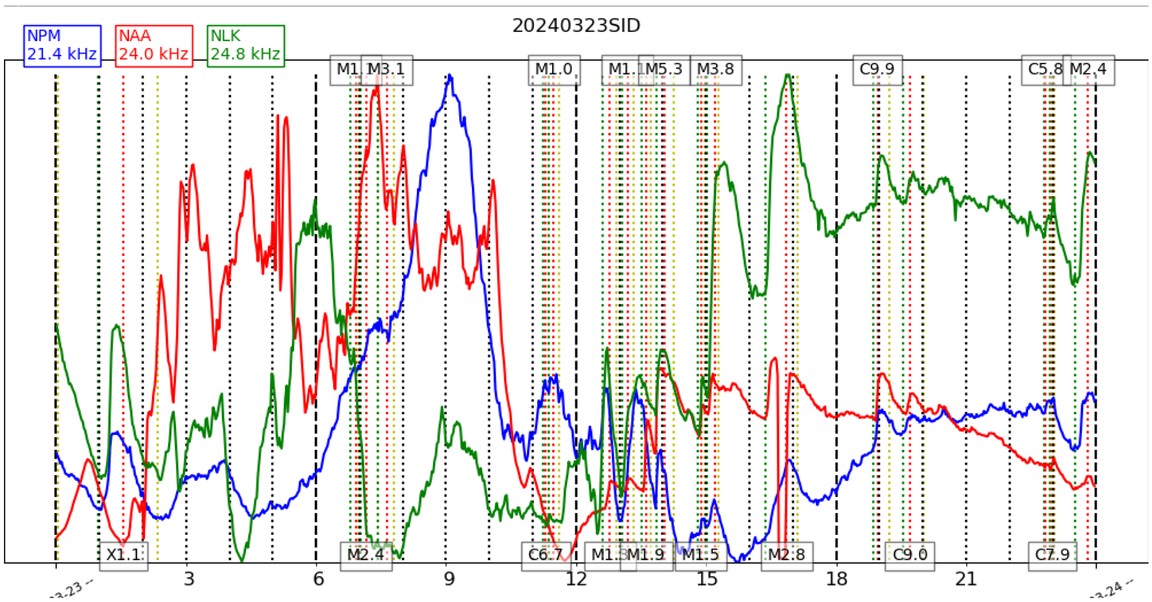

Figure 2: VLF recording from Fort Collins, Colorado for March 23rd.

2.2 SID Observers

In March 2024 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 2.

Table 2: 202403 VLF Observers

Observer	Code	Stations
R Battaiola	A96	HWU
J Wallace	A97	NAA
A Son	A112	DHO
L Loudet	A118	DHO GQD
J Godet	A119	GBZ GQD ICV
J Karlovsky	A131	TBB
S Aguirre	A138	NAA
G Silvis	A141	NAA NML NPM
L Pina	A148	NAA NLK
J Wendler	A150	NAA
H Krumnow	A152	DHO FTA GBZ
J DeVries	A153	NLK
A Nebula	A156	DHO NSY
M Salo	A157	NLK

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.

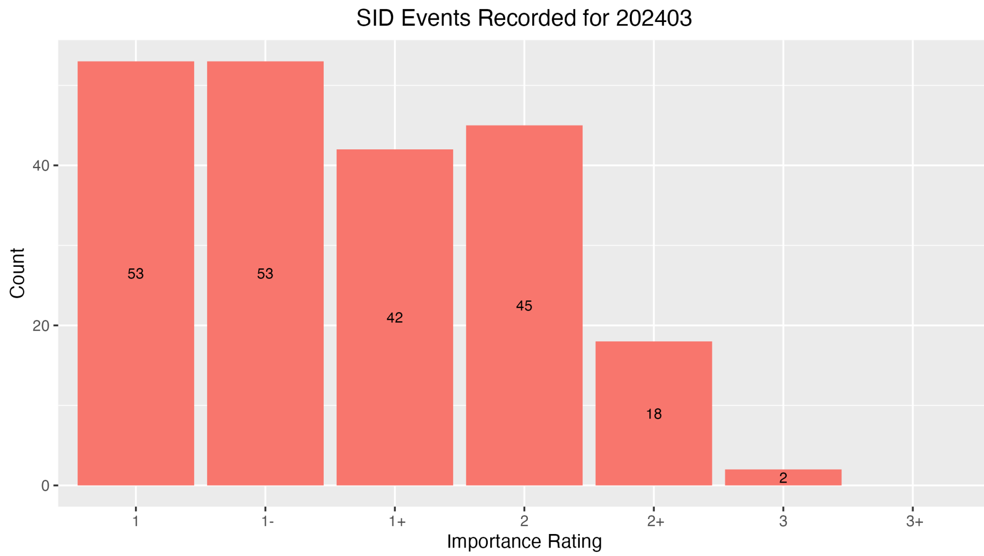

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In March 2024, there were 312 GOES-16 XRA flares: 2 X-class, 50 M-class, 250 C-class, and 10 B-class. There was far more flaring this month compared to last month. (U.S. Dept. of Commerce–NOAA, 2022). (see Figure 4).

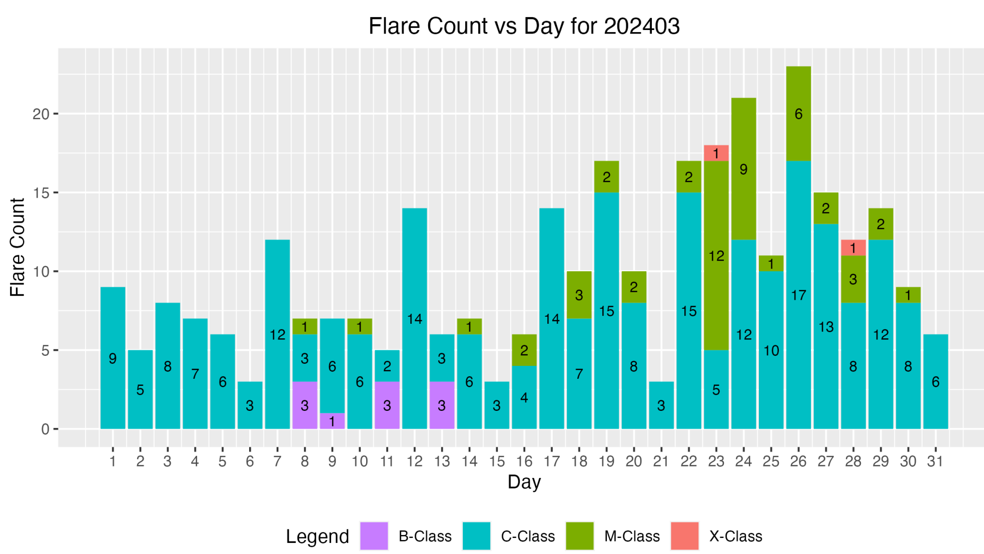

Figure 4: GOES-16 XRA flares (U.S. Dept. of Commerce–NOAA, 2022).

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 2024. 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.

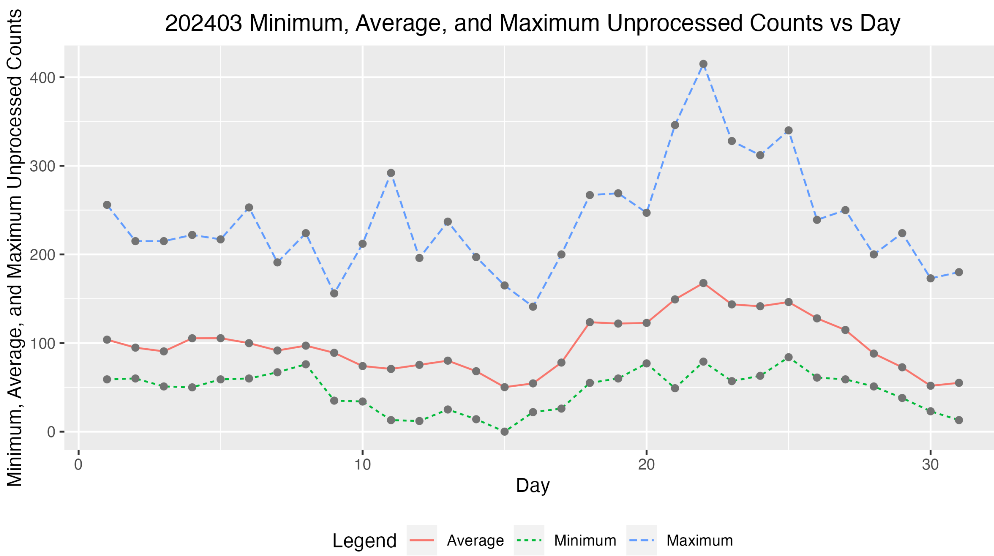

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

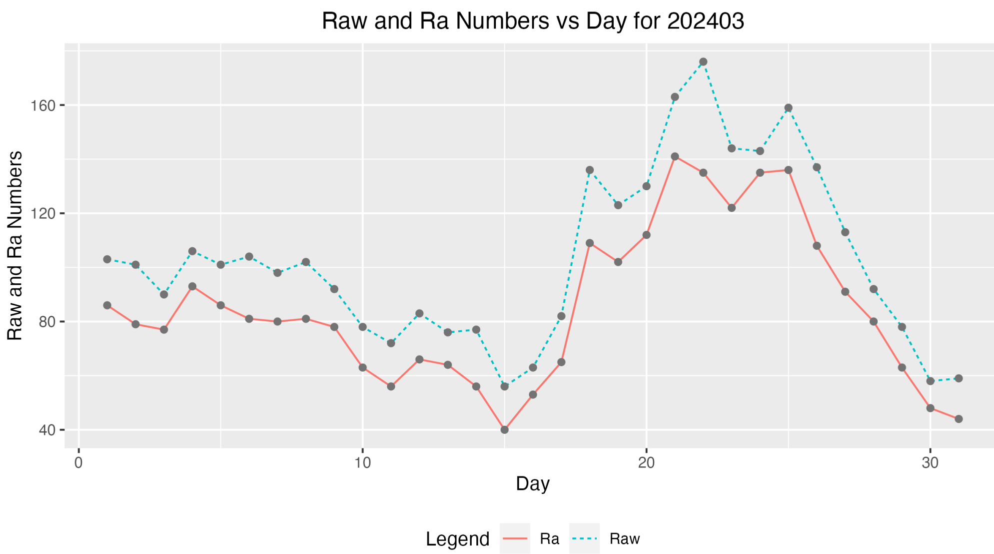

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 3 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 3: 202403 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	30	103	86
2	28	101	79
3	36	90	77
4	29	106	93
5	26	101	86
6	29	104	81
7	27	98	80
8	23	102	81
9	25	92	78
10	32	78	63
11	28	72	56
12	28	83	66
13	36	76	64
14	28	77	56
15	30	56	40

Continued

Table 3: 202403 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
16	33	63	53
17	32	82	65
18	31	136	109
19	31	123	102
20	31	130	112
21	32	163	141
22	24	176	135
23	31	144	122
24	34	143	135
25	31	159	136
26	24	137	108
27	27	113	91
28	31	92	80
29	32	78	63
30	31	58	48
31	28	59	44
Averages	29.6	103.1	84.8

3.3 Sunspot Observers

Table 4 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for March 2024, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (66), and total number of observations submitted (918).

Table 4: 202403 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	26	Alexandre Amorim
ARAG	31	Gema Araujo
ASA	2	Salvador Aguirre
BATR	3	Roberto Battaiola
BMIG	21	Michel Besson
BTB	2	Thomas Bretl
BXZ	22	Jose Alberto Berdejo
BZX	19	A. Gonzalo Vargas
CIOA	3	Ioannis Chouinavas
CKB	18	Brian Cudnik
CLDB	15	Laurent Cambon
CMAB	2	Maurizio Cervoni
CNT	26	Dean Chantiles
CPAD	5	Panagiotis Chatzistamatiou

Continued

Table 4: 202403 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
DARB	25	Aritra Das
DELS	3	Susan Delaney
DGIA	13	Giuseppe di Tommasco
DJOB	14	Jorge del Rosario
DJSA	9	Jeff DeVries
DJVA	14	Jacques van Delft
DMIB	19	Michel Deconinck
DUBF	17	Franky Dubois
EGMA	2	Georgios Epitropou
EHOA	15	Howard Eskildsen
ERB	3	Bob Eramia
FERA	12	Eric Fabrigat
FLET	24	Tom Fleming
GIGA	24	Igor Grageda Mendez
HALB	5	Brian Halls
HKY	18	Kim Hay
HOWR	21	Rodney Howe
HSR	17	Serge Hoste
IEWA	13	Ernest W. Iverson
ILUB	5	Luigi Iapichino
JGE	2	Gerardo Jimenez Lopez
KAND	21	Kandilli Observatory
KNJS	28	James & Shirley Knight
KSOB	1	Souvik Karmokar
KTOC	8	Tom Karnuta
LKR	11	Kristine Larsen
LRRA	15	Robert Little
LVY	31	David Levy
MARC	6	Arnaud Mengus
MARE	13	Enrico Mariani
MCE	23	Etsuiku Mochizuki
MJHA	27	John McCammon
MLL	7	Jay Miller
MMI	31	Michael Moeller
MSS	9	Sandy Mesics
MUDG	3	George Mudry
MWU	21	Walter Maluf
NMID	14	Milena Niemczyk
ONJ	2	John O'Neill
PLUD	18	Ludovic Perbet
RJV	14	Javier Ruiz Fernandez
SDOH	31	Solar Dynamics Obs - HMI
SNE	8	Neil Simmons

Continued

Table 4: 202403 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SQN	15	Lance Shaw
SRIE	3	Rick St. Hilaire
TDE	13	David Teske
TPJB	4	Patrick Thibault
TST	19	Steven Toothman
URBP	21	Piotr Urbanski
VIDD	9	Dan Vidican
WGI	4	Guido Wollenhaupt
WWM	18	William M. Wilson
Totals	918	66

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.

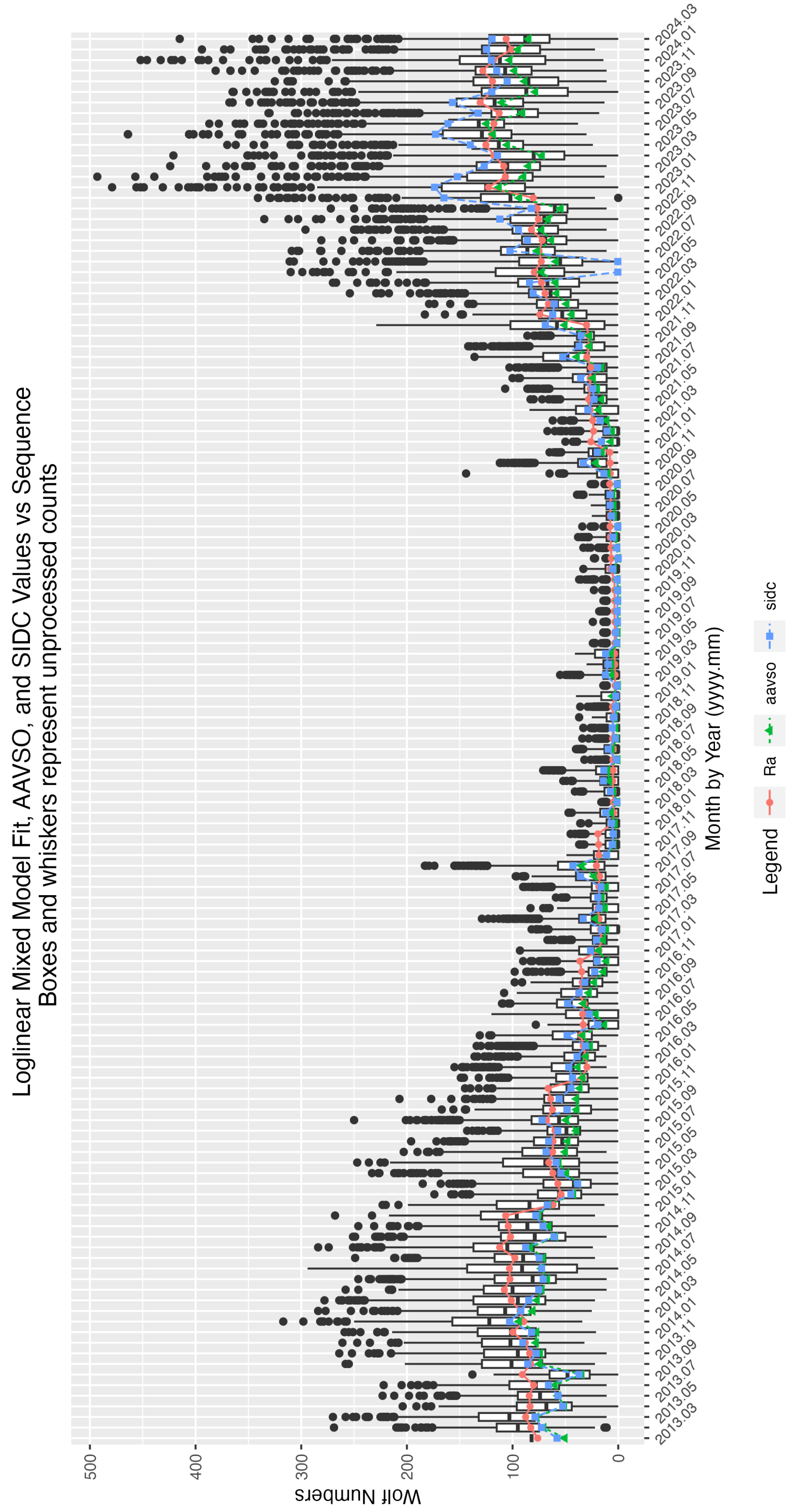

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

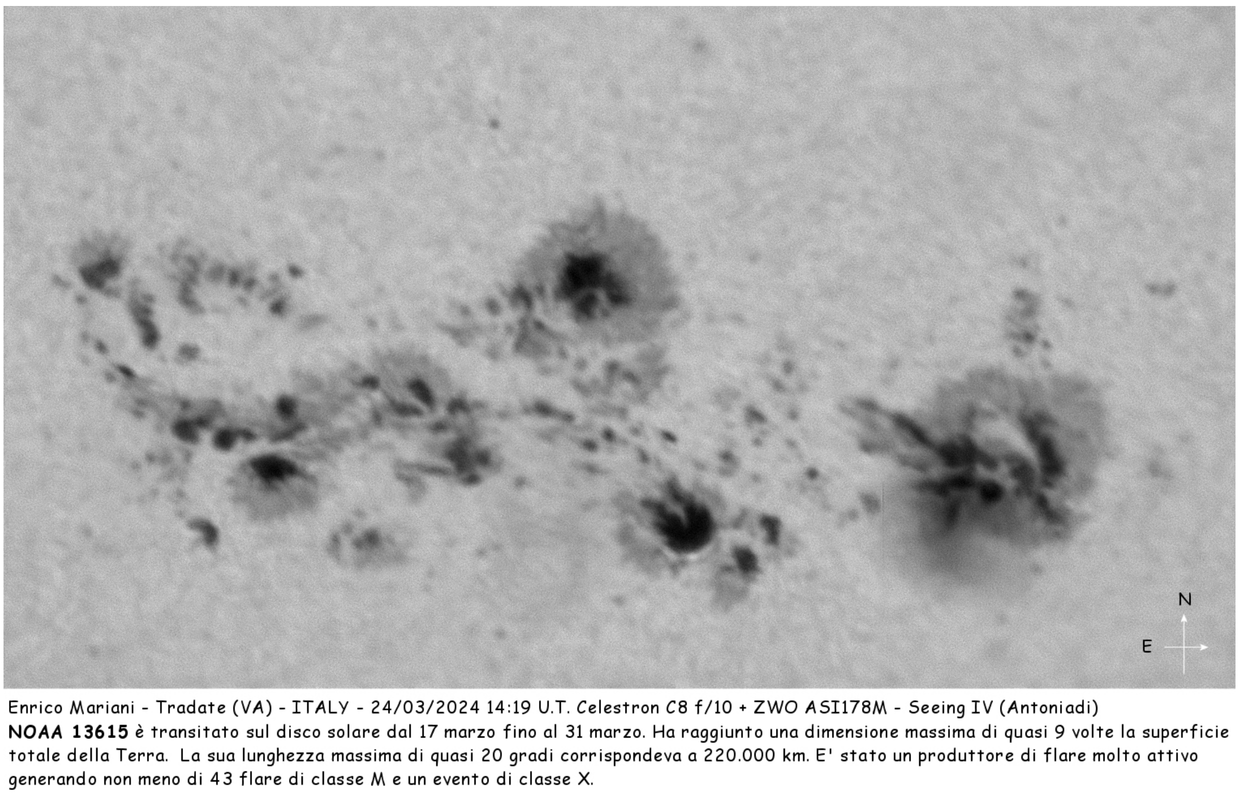

Figure 8: I send you the photo of the large active area AR13615 appeared on the Sun in the last 10 days of March. The image is the sum of 150 frames of a movie unfortunately shot with a bad seeing due to gusts of wind that made the image quite turbulent. The telescope is a Celestron C8 with a ASI178M camera. Best regards, Enrico Mariani (MARE).

5 Antique telescope project

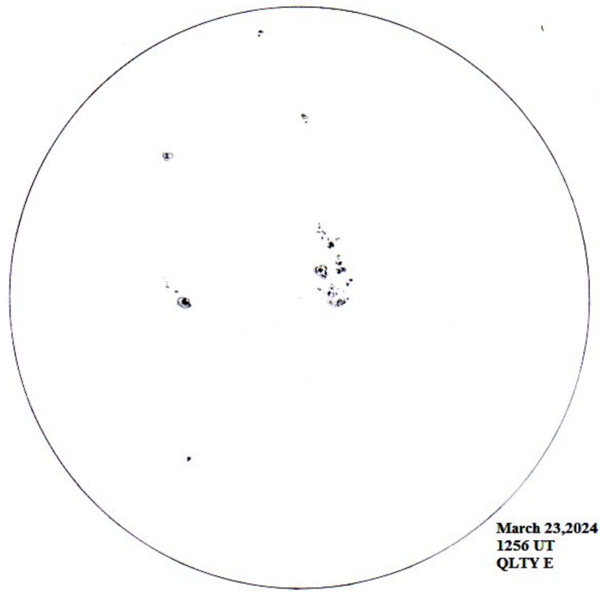

Figure 9: A recent replica of an antique telescope built by Gonzalo Vargas (BZX) in Cochabamba, Bolivia (left), and a drawing for March 23 (right).

6 References

Arlt, R., and Vaquero, Jose M. (2020) Historical sunspot records
Sunspot observations are available in fairly good numbers since 1610, (https://www.researchgate.net/publication/339511111_Historical_sunspot_records)

Clette, Frederic. (2012) Preface to Topical Issue: Recalibration of the Sunspot Number
Reconstructing the Past Solar Cycle for the Future. [data set]. Space Research Today 2012: https://link.springer.com/article/10.1007/s11207-016-1017-8.

Judge, Philip. (2020) *The Sun, A Very Short Introduction*, Oxford University Press. https://www.chirpbooks.com/audiobooks/the-sun-by-philip-judge.

Svalgaard, L. (2017), *Sunspot Group Numbers Since 1900 and Implications for the Long-term Record of Solar Activity* , https://www.researchgate.net/publication/316736457_Sunspot_Group_Numbers_Since_1900_and_Implications_for_the_Long-term_Record_of_Solar_Activity

U.S. Dept. of Commerce–NOAA, Space Weather Prediction Center, 2022.
GOES-16 XRA data. ftp://ftp.swpc.noaa.gov/pub/indices/events/