Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

Rodney Howe, Kristine Larsen, Co-Chairs
c/o AAVSO, 49 Bay State Rd
Cambridge, MA 02138 USA

Web: http://www.aavso.org/solar-bulletin
Email: solar@aavso.org
ISSN 0271-8480

Volume 77 Number 2 February 2021

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 Antique telescope project

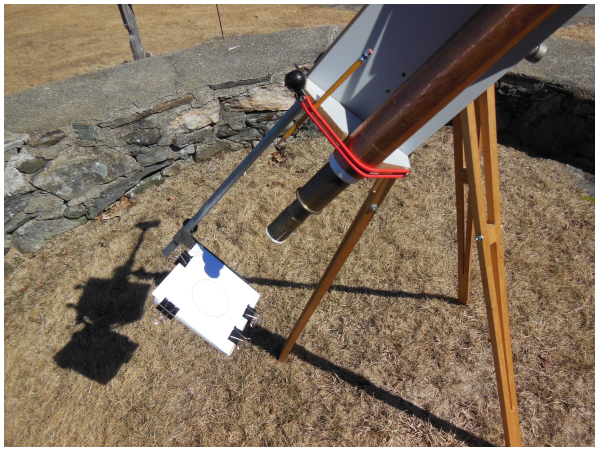

Figure 1: Shows a couple examples of antique telescopes you can build.

For those who like to build telescopes, here is a project for duplicating antique telescopes from the past. These are small aperture telescopes that will be useful for collecting data for a project being sponsored by solar physicist Dr. Leif Svalgaard, with initial observers John Briggs, Ken Spencer, and Walter Stephani. According to the AAVSO Solar Observing Project leaders, "To better interpret sunspot drawings of German amateur astronomer Johann Caspar Staudach, it occurred to Svalgaard that current solar activity could be observed with telescopes similar to the 18th century one used by Staudach. To that end, Svalgaard appealed to the Antique Telescope Society in 2015 to recruit observers able to use 18th century telescopes or simple reproductions of what such instruments were" (`https://www.aavso.org/solar-observing-project`). To contribute to this ongoing project, please visit the aforementioned web page.

For a graph of 368 monthly group counts from Staudach (1749-1799), solar cycles 0 thru 4, and its analysis, refer to the End Notes, Figure 8.

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

February 2021 (Figure 2): There were 7 B-Class flares on the 27th of February, and one C-Class flare during the daytime where we can see a small SID Event around 18:00 UT.

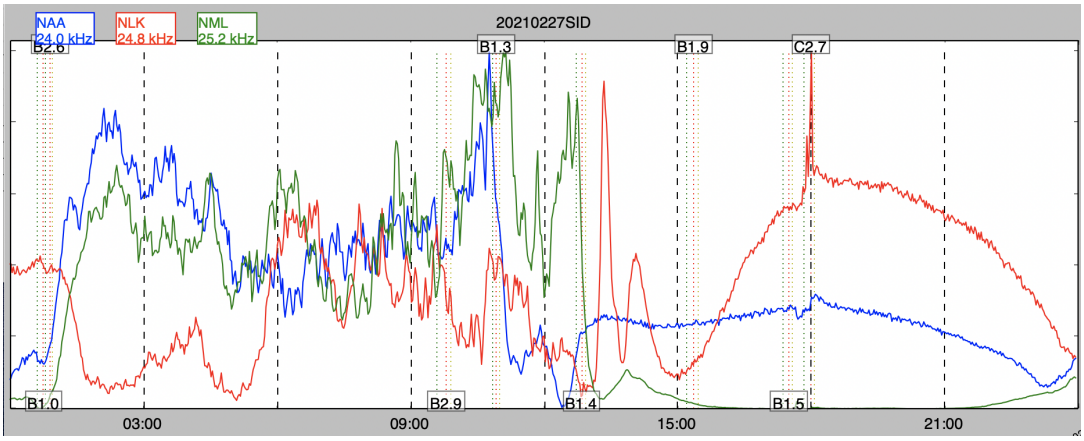

Figure 2: VLF recording from Fort Collins, Colorado.

2.2 SID Observers

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

Table 1: 202102 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
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	NAA NML
R Rogge	A143	GQD
K Menzies	A146	NAA
R Russel	A147	NPM
L Pina	A148	NML
L Ferreira	A149	NWC
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.

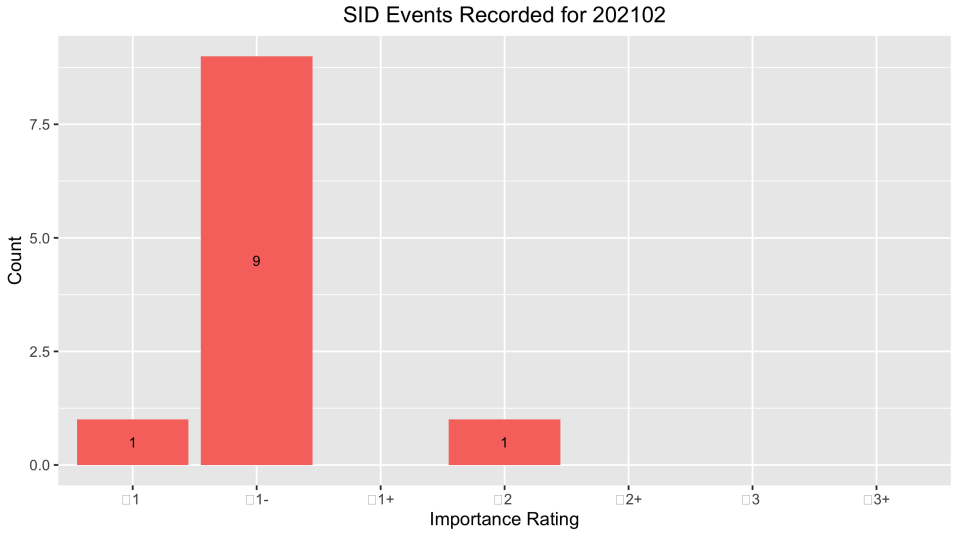

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In February 2021, there were 57 XRA flares detected from the GOES 16 satellite: 55 B-Class and 2 C-Class flares. About the same flaring this month compared to last. There were 15 days this month with no GOES-16 reports of flares (see Figure 4).

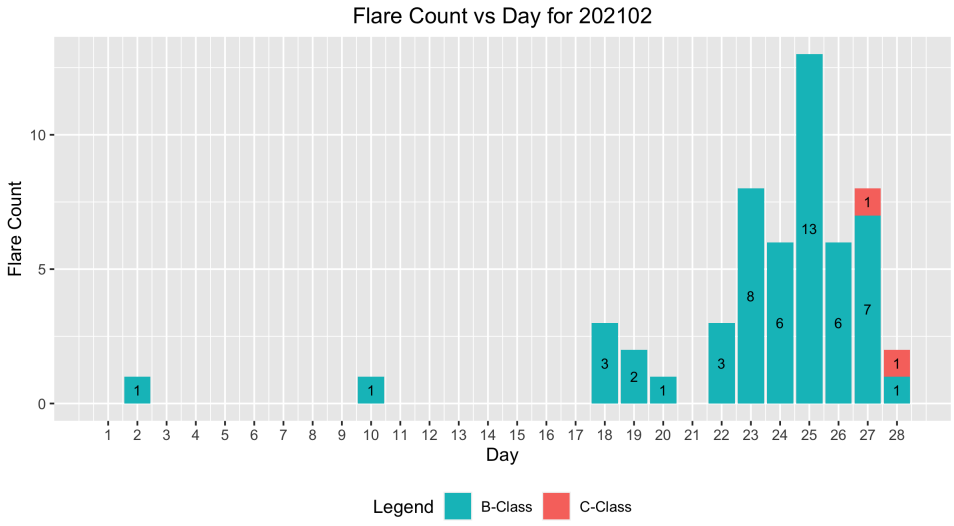

Figure 4: GOES-16 XRA flares

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 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 February 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 5.

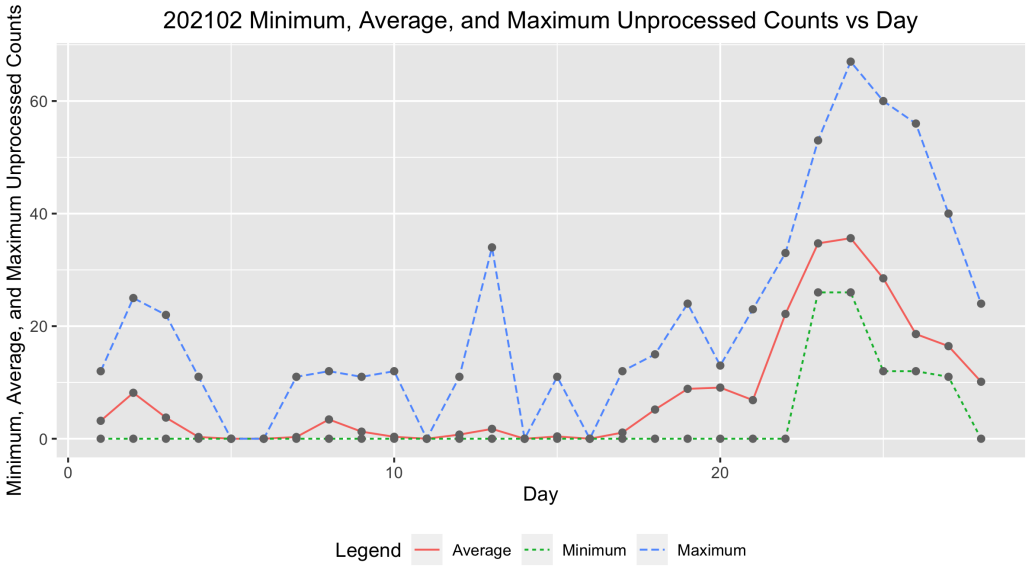

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

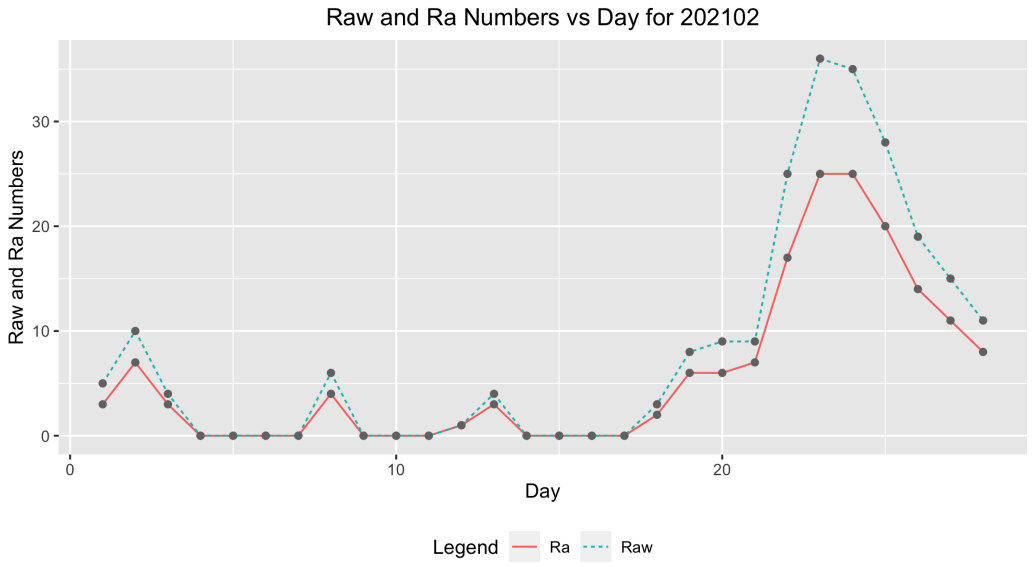

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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: 202102 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	32	5	3
2	37	10	7
3	41	4	3
4	36	0	0
5	33	0	0
6	35	0	0
7	36	0	0
8	33	6	4
9	35	0	0
10	35	0	0
11	35	0	0
12	30	1	1
13	32	4	3
14	35	0	0

Continued

Table 2: 202102 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	27	0	0
16	37	0	0
17	32	0	0
18	27	3	2
19	36	8	6
20	46	9	6
21	43	9	7
22	35	25	17
23	45	36	25
24	46	35	25
25	48	28	20
26	47	19	14
27	42	15	11
28	41	11	8
Averages	37	8.1	5.8

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for February 2021, and the Observer Name (column 3). The final row gives the total number of observers who submitted sunspot counts (70), and total number of observations submitted (1043).

Table 3: 202102 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	26	Alexandre Amorim
AJV	9	J. Alonso
ARAG	28	Gema Araujo
ASA	27	Salvador Aguirre
ATE	21	Teofilo Arranz Heras
BARH	13	Howard Barnes
BATR	6	Roberto Battaiola
BERJ	21	Jose Alberto Berdejo
BLAJ	6	John A. Blackwell
BMF	23	Michael Boschat
BRAF	10	Raffaello Braga
BROB	21	Robert Brown
CHAG	24	German Morales Chavez
CIOA	17	Ioannis Chouinavas
CKB	15	Brian Cudnik
CMOD	5	Mois Carlo

Continued

Table 3: 202102 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
CNT	25	Dean Chantiles
CVJ	3	Jose Carvajal
DARB	14	Aritra Das
DEMF	10	Frank Dempsey
DJOB	13	Jorge del Rosario
DMIB	25	Michel Deconinck
DUBF	23	Franky Dubois
EHOA	18	Howard Eskildsen
ERB	11	Bob Eramia
FDAE	5	David Fox
FERJ	14	Javier Ruiz Fernandez
FLET	13	Tom Fleming
GIGA	24	Igor Grageda Mendez
HALB	4	Brian Halls
HAYK	16	Kim Hay
HMQ	13	Mark Harris
HOWR	15	Rodney Howe
IEWA	13	Ernest. W. Iverson
JDAC	2	David Jackson
JENS	2	Simon Jenner
JGE	2	Gerardo Jimenez Lopez
KAND	10	Kandilli Observatory
KAPJ	19	John Kaplan
KNJS	28	James & Shirley Knight
LGEC	7	Georgios Lekkas
LKR	5	Kristine Larsen
LRRA	11	Robert Little
MARC	8	Arnaud Mengus
MCE	26	Etsuiku Mochizuki
MILJ	10	Jay Miller
MJAF	28	Juan Antonio Moreno Quesada
MJHA	26	John McCammon
MMAY	13	Max Surlaroute
MUDG	12	George Mudry
MWU	22	Walter Maluf
OAAA	17	Al Sadeem Astronomy Observatory
ONJ	11	John O'Neill
PEKT	11	Riza Pektas
RFDA	23	Filipp Romanov
RMW	3	Michael Rapp
SDOH	28	Solar Dynamics Obs - HMI
SNE	9	Neil Simmons
SONA	17	Andries Son

Continued

Table 3: 202102 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SQN	6	Lance Shaw
STAB	22	Brian Gordon-States
SUZM	25	Miyoshi Suzuki
TESD	15	David Teske
TPJB	11	Patrick Thibault
TST	11	Steven Toothman
URBP	13	Piotr Urbanski
VARG	24	A. Gonzalo Vargas
VIDD	16	Daniel Vidican
WGI	5	Guido Wollenhaupt
WILW	8	William M. Wilson
Totals	1043	70

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.

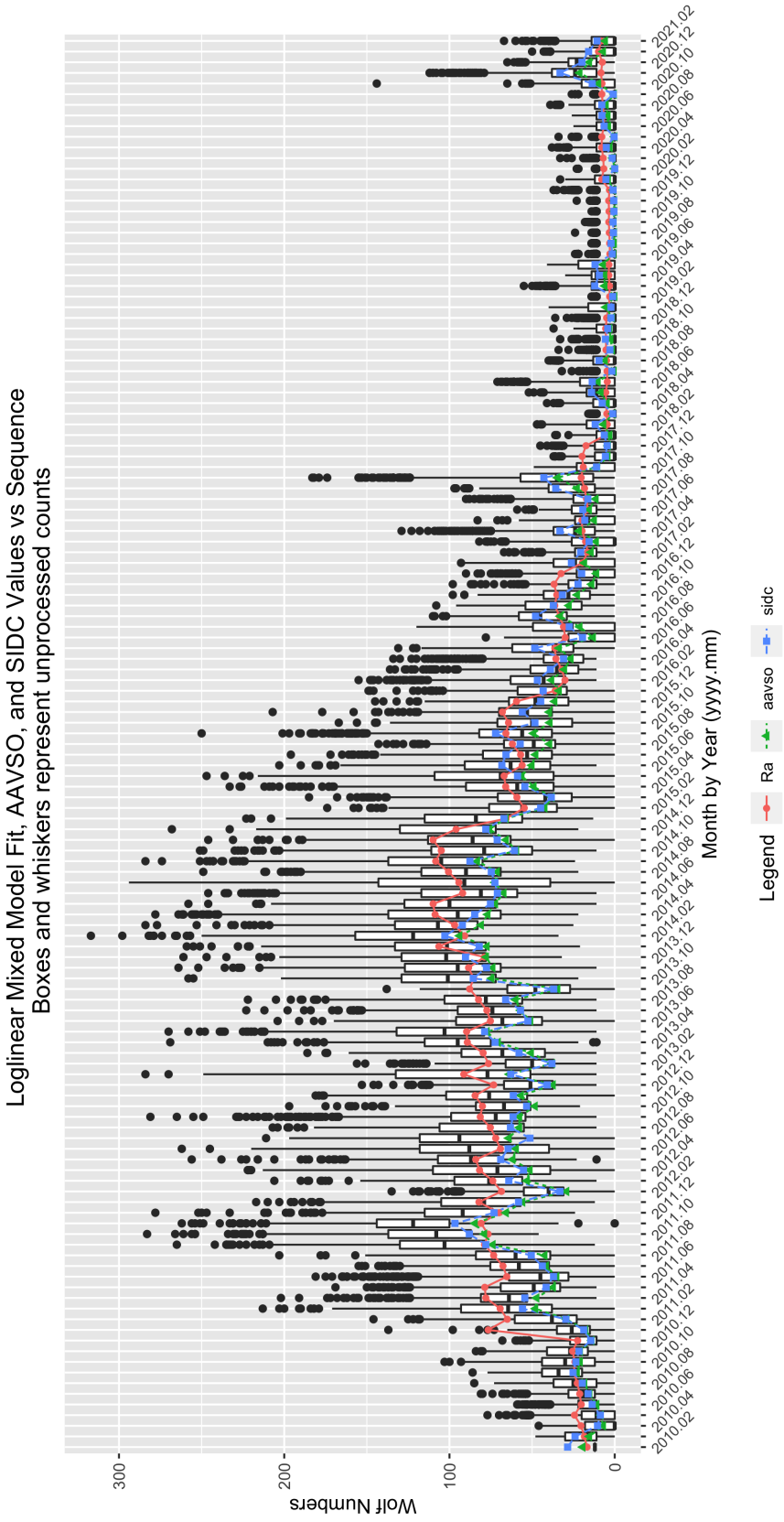

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SIDC data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

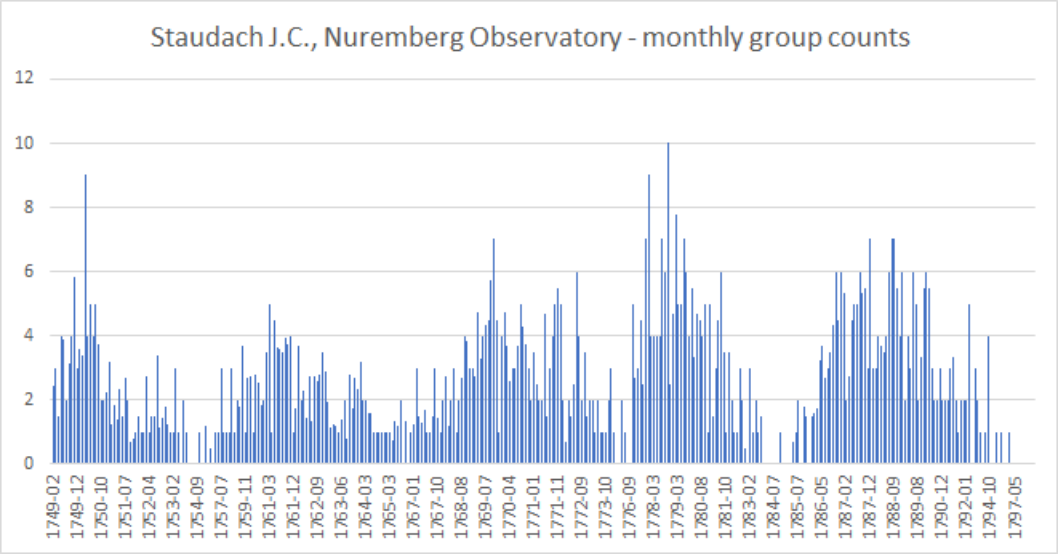

Figure 8: Graph of 368 monthly group counts from Staudach, 1749 - 1799. Solar cycles 0 thru 4.

"We have examined the more than 1100 drawings of the solar disk made by the German astronomy amateur Johann Caspar Staudach during 1749-1799 and counted the spots on each image. Using the modern perception of how to group spots into active regions we regrouped the spots as a modern observer would. The resulting number of groups was found to be on average 25 percent higher than the first count of groups performed by Wolf in 1857, and used by Hoyt and Schatten in their construction of the Group Sunspot Number. Compared to other observers at the time, Staudachs drawings have a very low average number, 2, of spots per group, possibly indicating an inferior telescope likely suffering from spherical and chromatic aberration as would be typical of amateur telescopes of the day. We have initiated an ongoing project aiming at observing sunspots with antique telescopes having similar defects in order to determine the factor necessary to bring the Staudach observations onto a modern scale." From; *A Recount of Sunspot Groups on Staudachs Drawings* by Leif Svalgaard `leif@leif.org`. Data for the graph in the GN database from here: `https://www.leif.org/research/GNLIST.txt`