Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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ISSN 0271-8480

Volume 76 Number 2 February 2020

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 Compare the AAVSO visual Ra index and SDO Wolf numbers during this solar minimum.

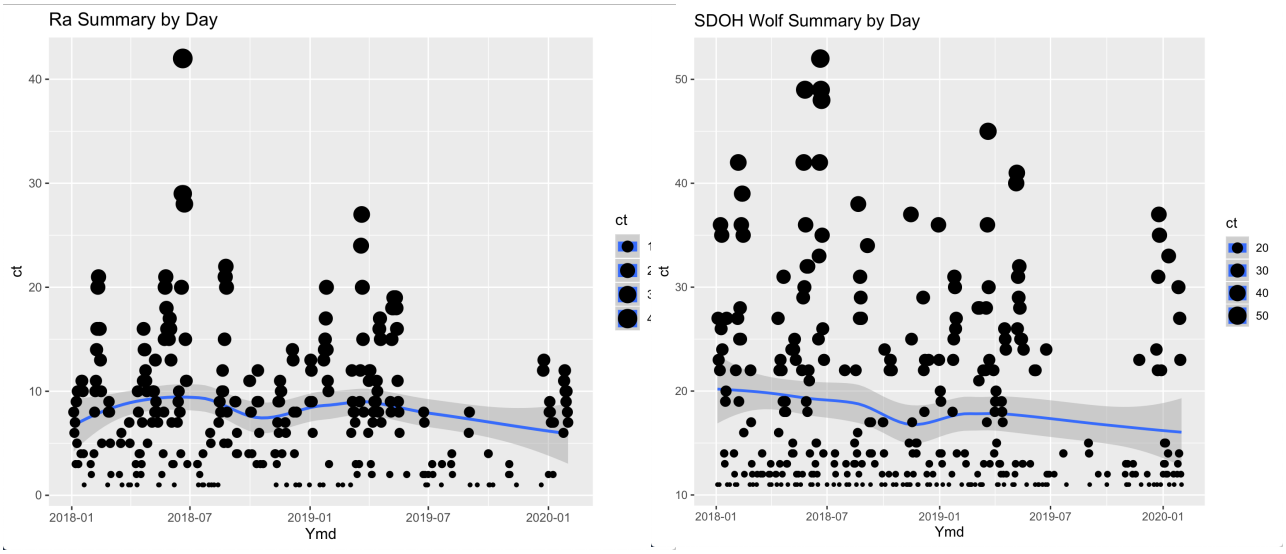

Figure 1: (left) AAVSO visual Ra index (all visual observers) numbers from 2018-2020. (right) SDO satellite Wolf numbers from 2018-2020.

The AAVSO Ra index (calculated from the observers Wolf number), from daily data during the last two years of solar minimum (`https://www.aavso.org/sites/default/files/solar/NOAAfiles/daily.csv`), is accompanied by a Loess smoothing estimate to show how the previous two years are pretty flat.

The SDO satellite counts from Jan Alvestad show a greater dispersion over the last two years of solar minimum, with overall higher counts (ct) (`https://www.solen.info/solar/`). There is a distinct difference between the ground based observations and the space based SDO satellite observations!

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

February 2020 (Figure 2): There were no SID events recorded here in Fort Collins, Colorado for the month of February, nor on the 26th of February, as one A.9 class solar flare was recorded late in the day. (Please note the y-axis values in these SID graphs are non-dimensional.)

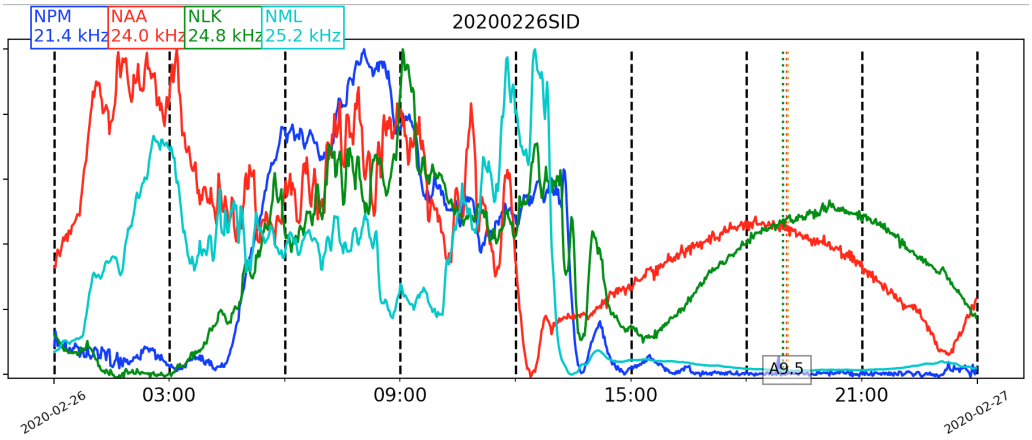

Figure 2: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In February 2020 we had 14 AAVSO SID observers who submitted VLF data as listed in Table 1. There were no observers who recorded SID events this month, which matched to GOES-15 XRA and FLA events.

Table 1: 202002 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
S Oatney	A125	NML NLK NAA
J Karlovsky	A131	NSY ICV
R Green	A134	NWC
S Aguirre	A138	NPM
G Silvis	A141	HWU NAU
R Rogge	A143	GQD
K Menzies	A146	NAA
A Maevsky	A151	GQD

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.

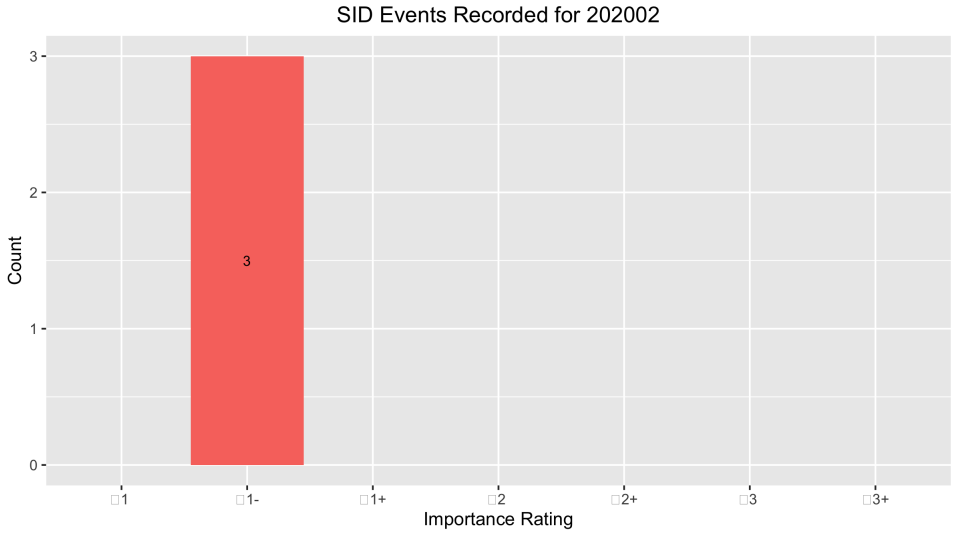

Figure 3: VLF SID Events.

2.3 Solar Flare Summary from GOES-15 Data

In February 2020, there were three A-class flares recorded from GOES-15. A lot less flaring this month compared to last. There were 26 days this month with no GOES-15 reports of flares (see Figure 4).

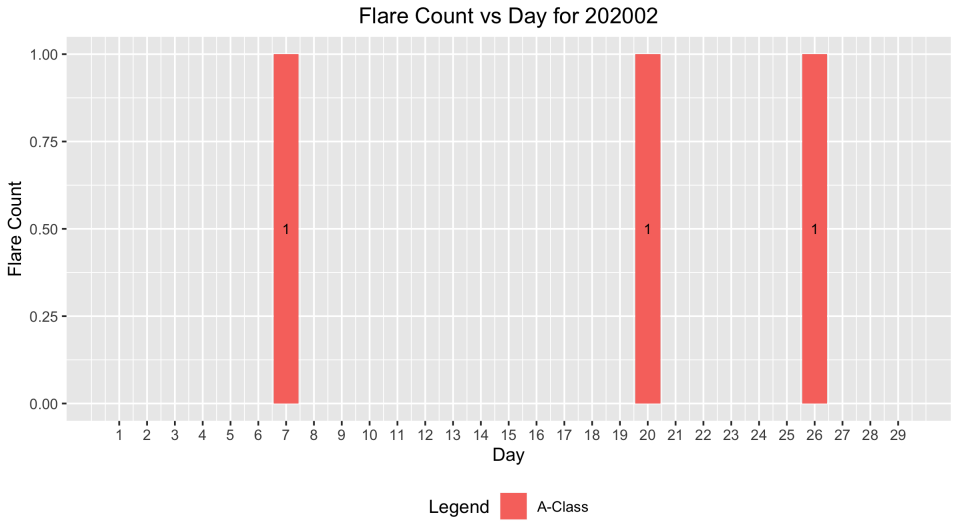

Figure 4: GOES - 15 XRA flares

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 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 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.

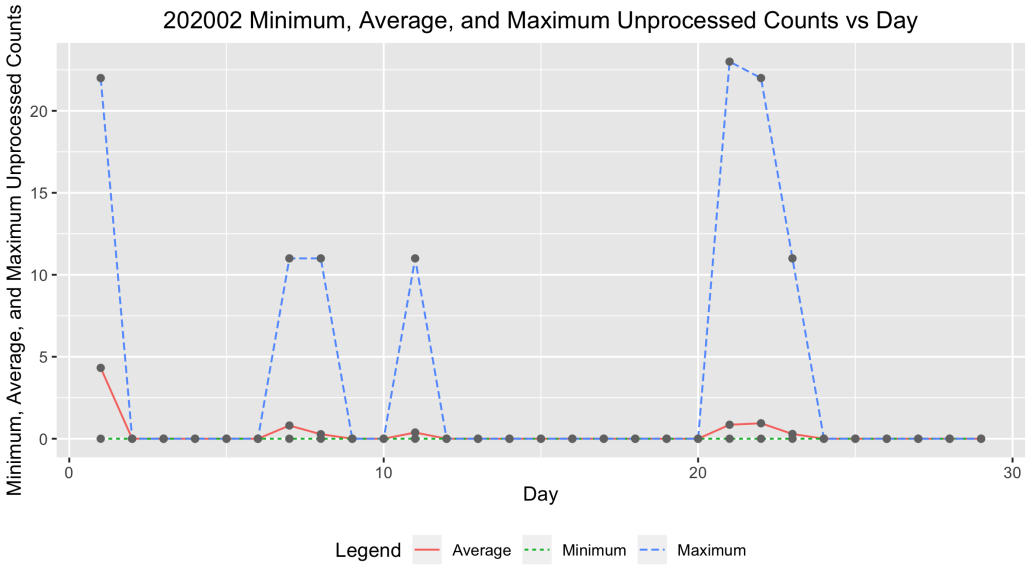

Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

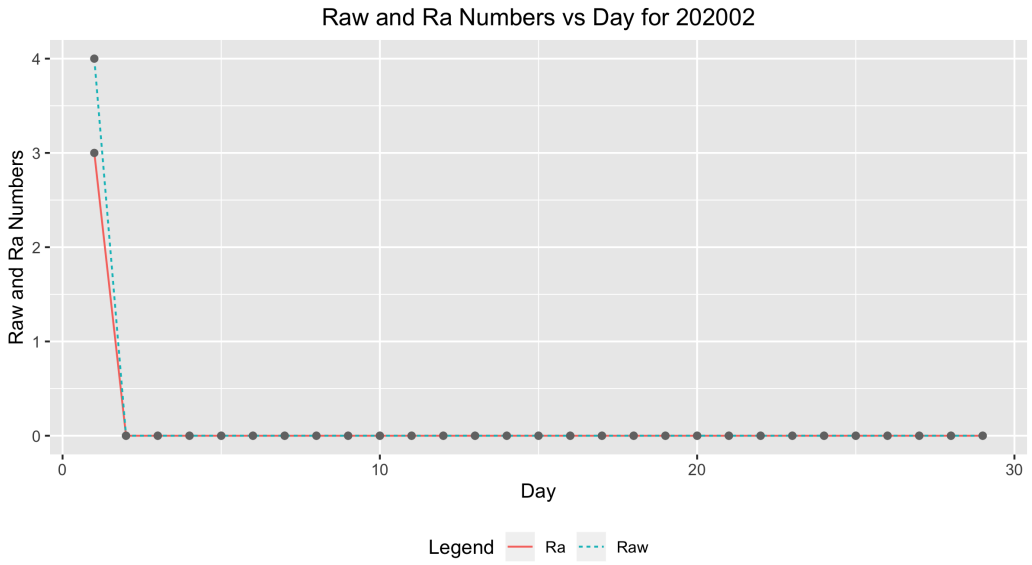

Figure 6: Raw Wolf average and R_a numbers by day of the month for all observers.

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 Observations (column 2), the raw Wolf number (column 3), and the Shapley Correction (R_a) (column 4).

Table 2: 202002 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	31	4	3
2	37	0	0
3	37	0	0
4	26	0	0
5	32	0	0
6	27	0	0
7	41	0	0
8	40	0	0
9	31	0	0
10	27	0	0
11	29	0	0
12	30	0	0
13	29	0	0
14	40	0	0

Continued

Table 2: 202002 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	40	0	0
16	32	0	0
17	35	0	0
18	27	0	0
19	31	0	0
20	32	0	0
21	41	0	0
22	35	0	0
23	38	0	0
24	35	0	0
25	26	0	0
26	28	0	0
27	36	0	0
28	38	0	0
29	41	0	0
Averages	33.5	0.1	0.1

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for February 2020, and the Observer Name (column 3). The final rows of the table give the total number of observers who submitted sunspot counts and the total number of observations submitted. The total number of observers is 66 and the total number of observations is 972.

Table 3: 202002 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
AAX	21	Alexandre Amorim
AJV	25	J. Alonso
ARAG	29	Gema Araujo
ASA	16	Salvador Aguirre
ATE	26	Teofilo Arranz Heras
BARH	16	Howard Barnes
BATR	6	Roberto Battaiola
BERJ	12	Jose Alberto Berdejo
BMF	18	Michael Boschat
BRAF	9	Raffaello Braga
BROB	28	Robert Brown
BSAB	27	Santanu Basu
CHAG	18	German Morales Chavez
CIOA	6	Ioannis Chouinavas

Continued

Table 3: 202002 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
CKB	14	Brian Cudnik
CNT	22	Dean Chantiles
CVJ	6	Jose Carvajal
DEMF	4	Frank Dempsey
DIVA	14	Ivo Demeulenaere
DJOB	16	Jorge del Rosario
DMIB	14	Michel Deconinck
DUBF	22	Franky Dubois
EHOA	10	Howard Eskildsen
ERB	18	Bob Eramia
FERJ	16	Javier Ruiz Fernandez
FLET	20	Tom Fleming
FTAA	2	Tadeusz Figiel
FUJK	20	K. Fujimori
HASA	1	Andrew Humphreys
HAYK	15	Kim Hay
HMQ	7	Mark Harris
HOWR	17	Rodney Howe
HRUT	22	Timothy Hrutkay
JDAC	3	David Jackson
JENS	3	Simon Jenner
JGE	2	Gerardo Jimenez Lopez
KAND	15	Kandilli Observatory
KAPJ	19	John Kaplan
KNJS	29	James & Shirley Knight
LGEC	18	Georgios Lekkas
LKR	2	Kristine Larsen
LRRA	1	Robert Little
MARC	7	Arnaud Mengus
MARE	6	Enrico Mariani
MCE	25	Etsuiku Mochizuki
MILJ	11	Jay Miller
MJAF	28	Juan Antonio Moreno Quesada
MJHA	25	John McCammon
MUDG	14	George Mudry
MWU	10	Walter Maluf
OAAA	21	Al Sadeem Astronomy Observatory
ONJ	16	John O'Neill
PEKT	8	Riza Pektas
SDOH	29	Solar Dynamics Obs - HMI
SNE	7	Neil Simmons
SONA	1	Andries Son
STAB	24	Brian Gordon-States

Continued

Table 3: 202002 Number of observations by observer.

Observer Code	Number of Observers	Observer Name
SUZM	24	Miyoshi Suzuki
TESD	19	David Teske
TPJB	3	Patrick Thibault
TST	10	Steven Toothman
URBP	14	Piotr Urbanski
VARG	24	A. Gonzalo Vargas
VIDD	18	Daniel Vidican
VRUA	4	Ruben Verboven
WILW	15	William M. Wilson
Totals	972	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 a paper (GLMM05) on http://www.spesi.org/?page_id=65 of the sunspot counts research page. The paper title is *A Generalized Linear Mixed Model for Enumerated Sunspots.*

Figure 7 shows the monthly GLMM R_a numbers for the 24th solar cycle to date. 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.

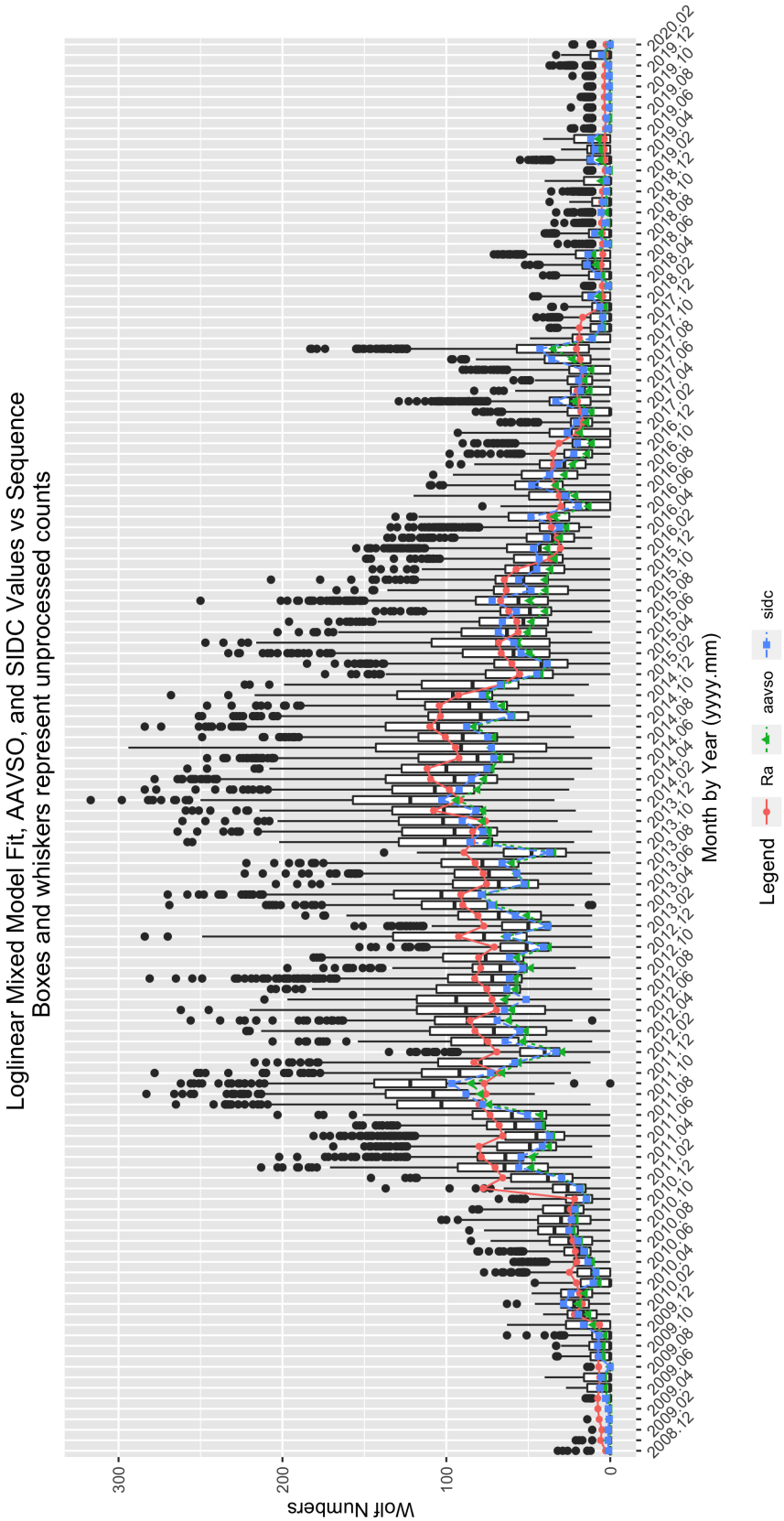

Figure 7: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

Two of our observers died this month:

- Al McWilliams (A94): Al had over 240 monthly VLF SID reports. He began submitting these to the AAVSO in 1999.

  (`http://www.danielfuneralhome.com/obituary/alexander-s-mcwilliams-4396/`)

- Larry Krozel (KROL): Larry had 2155 observations in our database and received his 2000-level sunspot observing award in 2018. His first observation in our database was made in October 2002. (`https://www.biegafuneralhome.com/obituary/lawrence-m-krozel-ii`)

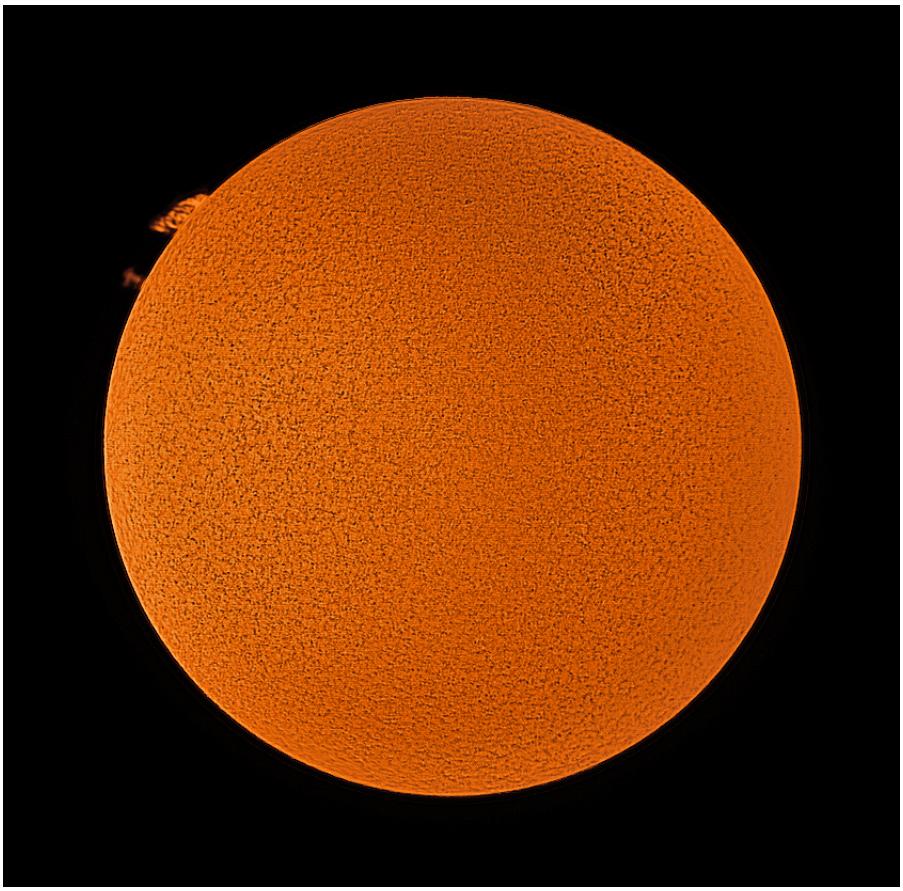

Figure 8: Jon Wallace takes this composite of an H-Alpha photosphere.

This image was taken using a Coronado PST H-alpha scope and a ZWO-174MM (monochorme) camera on February 20th in the morning between 9 and 10 AM. Each individual image is from a stack of 500. For the composite I shot the surface and then the prominence (each requires a separate telescope etalon tuning and camera focus/brightness adjustment). I then chose my favorite images and used Photo Shop to add sharpening, etc. and then layered them on top of each other. Color was added by me to make it more appealing for the students and teachers I visit in schools. I try to shoot every clear day here in Maine - so about 4-5 times a month. Last month's weather was horrible - only 2 clear sunny days - I missed one for a school visit. Take care! Jon