Solar Bulletin

THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS
SOLAR SECTION

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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. 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 Do the Wilcox Solar Observatory (WSO) Polar data match up to North, South solar hemisphere sunspot counts?

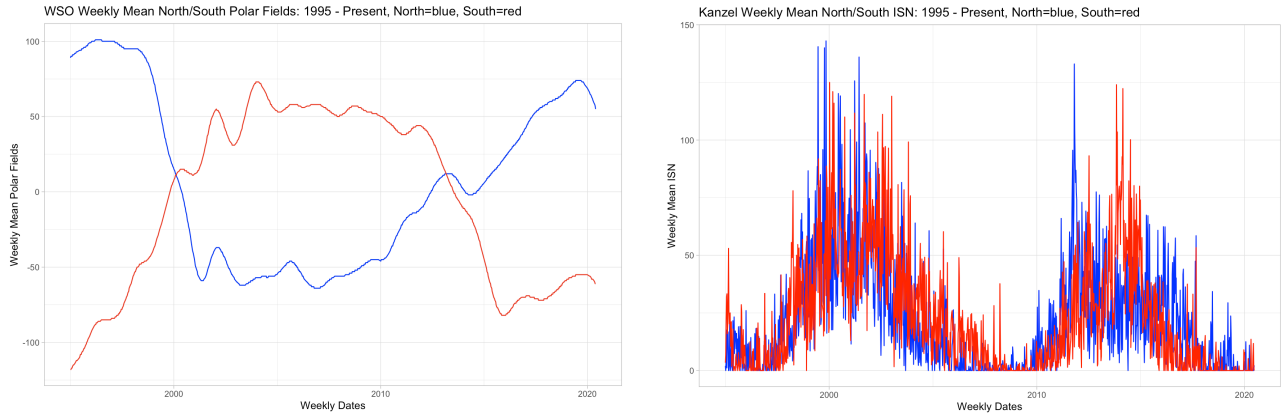

Figure 1: (left) shows an example of WSO Polar field data from 1995 to present, north in blue, south in red, (right) shows Kanzelhohe Observatory daily data from 1995, northern hemisphere in blue and southern hemisphere in red. (Graphs here with help from David Jackson!)

The WSO data do not give any indication of a match to the solar cycle 23 and cycle 24 sunspot counts. Neither north or south polar fields seem to correlate with the north or south hemisphere sunspot counts. Perhaps the use of rolling correlations can show if the northern hemisphere and southern hemisphere sunspot counts will match up to the Wilcox Solar Observatory (WSO) Polar magnetic data. These sunspot data come from the Kanzelhohe Observatory: (`https://www.kso.ac.at/index_en.php`), and the WSO Polar data come from here: (`https://wso.stanford.edu`).

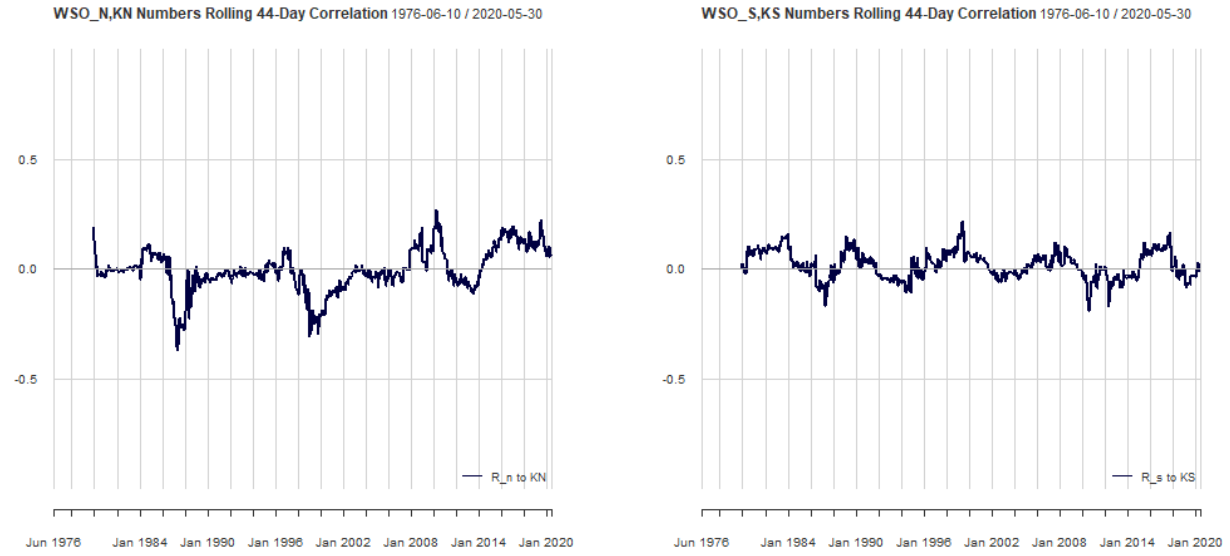

Figure 2: (left) shows the rolling correlation of WSO Polar and Kanzelhohe Observatory data for the northern hemisphere, (right) shows rolling correlations for the southern hemisphere, data back to 1976. Although there are variation differences in these rolling correlations, both north and south hemispheres have neither a large positive nor negative correlation trend.

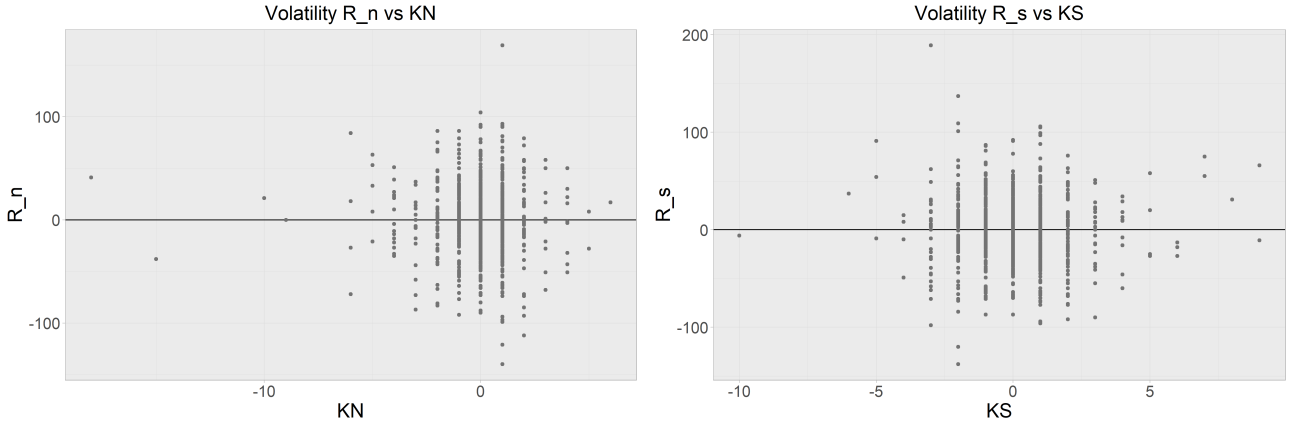

Figure 3: (left) shows zero intercept regression line for North, (right) shows zero intercept regression line for South. North intercept: -0.0004, South intercept: 0.0006

These two data sets are matched by the WSO data going back to 1976 so we can run the rolling correlation analysis and plot the slopes of their regression lines. It's fairly obvious that the north and south Kanzelhohe sunspot counts look nothing like the WSO solar polar field data for the same time frame. The rolling correlation graphs bear this out as each hemisphere has no slope in the regression line when averaged over the full 44 year time series. The implication here is that the solar polar magnetic fields have no apparent affect on the north and south sunspot counts.
Further reading on polar fields: (`https://iopscience.iop.org/article/10.1088/0004-637X/753/2/146/pdf`)

2 Sudden Ionospheric Disturbance (SID) Report

2.1 SID Records

June 2020 (Figure 4): There were no SID events recorded here in Fort Collins, Colorado for the month of June, even though on the 2nd of June, 2 B class solar flares were recorded during the night. (Please note the y-axis values in these SID graphs are non-dimensional.)

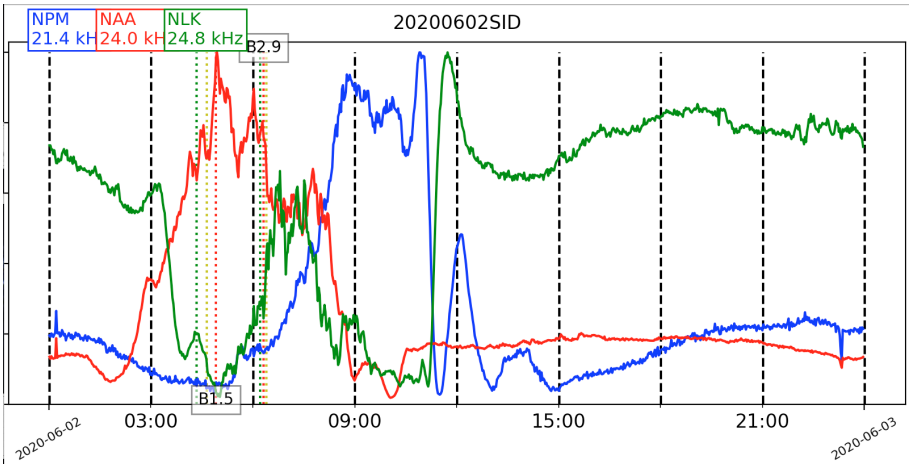

Figure 4: VLF recording at Fort Collins, Colorado.

2.2 SID Observers

In June 2020 we had 11 AAVSO SID observers who submitted VLF data as listed in Table 1. There were no observers who recorded a SID event this month, which matched to GOES-16 XRA and FLA events.

Table 1: 202006 VLF Observers

Observer	Code	Stations
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
L Ferreira	A149	NWC

Figure 5 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 5: VLF SID Events.

2.3 Solar Flare Summary from GOES-16 Data

In June 2020, there were 15 B-class flares recorded from GOES-16. Less flaring this month compared to last. There were 24 days this month with no GOES-16 reports of flares (see Figure 6).

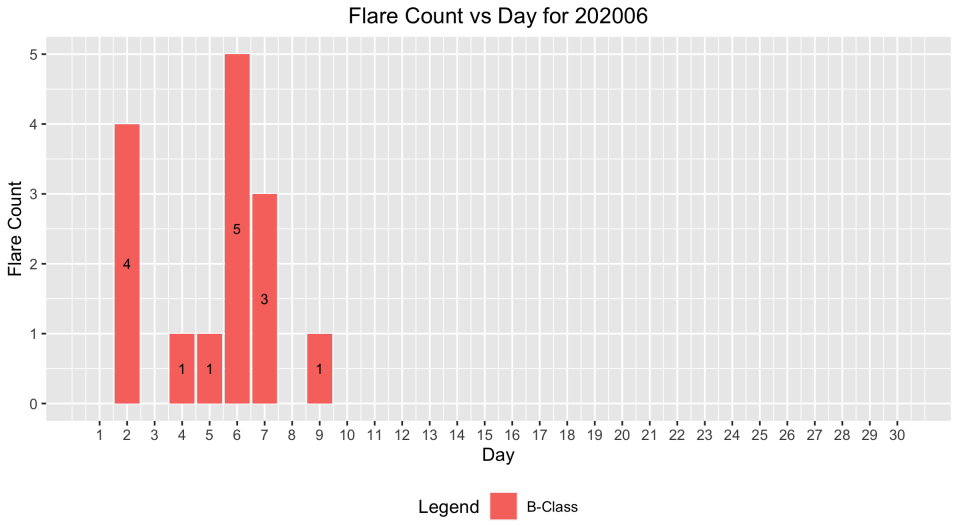

Figure 6: GOES-16 XRA flares

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 an 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 June 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 7.

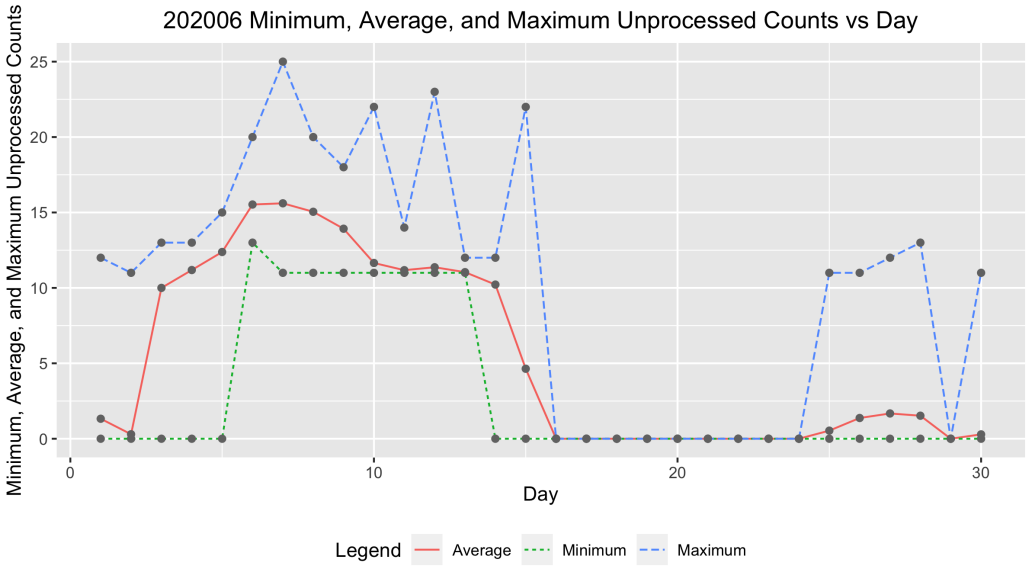

Figure 7: Raw Wolf number average, minimum and maximum by day of the month for all observers.

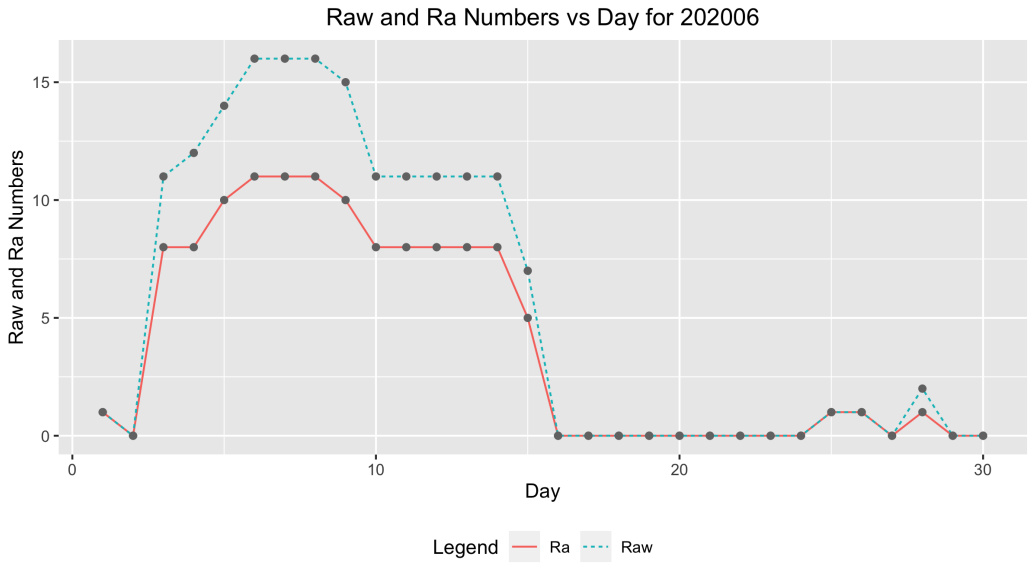

Figure 8: Raw Wolf average and R_a numbers by day of the month for all observers.

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 8, 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: 202006 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
1	43	1	1
2	37	0	0
3	39	11	8
4	38	12	8
5	42	14	10
6	36	16	11
7	46	16	11
8	43	16	11
9	39	15	10
10	46	11	8
11	40	11	8
12	46	11	8
13	46	11	8
14	41	11	8

Continued

Table 2: 202006 American Relative Sunspot Numbers (R_a).

Day	Number of Observers	Raw	R_a
15	50	7	5
16	38	0	0
17	44	0	0
18	45	0	0
19	46	0	0
20	48	0	0
21	46	0	0
22	46	0	0
23	47	0	0
24	42	0	0
25	41	1	1
26	40	1	1
27	40	0	0
28	38	2	1
29	43	0	0
30	38	0	0
Averages	42.5	5.6	3.9

3.3 Sunspot Observers

Table 3 lists the Observer Code (column 1), the Number of Observations (column 2) submitted for June 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 final rows of the table give the total number of observers who submitted sunspot counts (69), and the total number of observations submitted (1299).

Table 3: 202006 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
AAX	18	Alexandre Amorim
AJV	23	J. Alonso
ARAG	30	Gema Araujo
ASA	29	Salvador Aguirre
ATE	27	Teofilo Arranz Heras
BARH	13	Howard Barnes
BATR	4	Roberto Battaiola
BDDA	8	Diego Bastiani
BERJ	29	Jose Alberto Berdejo
BLAJ	10	John A. Blackwell
BMF	22	Michael Boschat
BRAF	19	Raffaello Braga

Continued

Table 3: 202006 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
BROB	29	Robert Brown
CHAG	24	German Morales Chavez
CIOA	21	Ioannis Chouinavas
CKB	23	Brian Cudnik
CNT	28	Dean Chantiles
DEMF	12	Frank Dempsey
DIVA	22	Ivo Demeulenaere
DJOB	17	Jorge del Rosario
DMIB	25	Michel Deconinck
DROB	5	Bob Dudley
DUBF	29	Franky Dubois
EHOA	18	Howard Eskildsen
ERB	22	Bob Eramia
FERJ	17	Javier Ruiz Fernandez
FLET	29	Tom Fleming
FUJK	19	K. Fujimori
HAYK	24	Kim Hay
HMQ	23	Mark Harris
HOWR	25	Rodney Howe
HRUT	25	Timothy Hrutkay
JDAC	6	David Jackson
JENS	5	Simon Jenner
JGE	15	Gerardo Jimenez Lopez
JPG	1	Penko Jordanov
KAND	16	Kandilli Observatory
KAPJ	17	John Kaplan
KNJS	30	James & Shirley Knight
LEVM	16	Monty Leventhal
LGEC	9	Georgios Lekkas
LKR	4	Kristine Larsen
LRRA	20	Robert Little
MARC	15	Arnaud Mengus
MARE	10	Enrico Mariani
MCE	20	Etsuiku Mochizuki
MGAR	1	Gary Myers
MILJ	21	Jay Miller
MJAF	28	Juan Antonio Moreno Quesada
MJHA	29	John McCammon
MUDG	14	George Mudry
MWU	23	Walter Maluf
OAAA	26	Al Sadeem Astronomy Observatory
ONJ	23	John O'Neill
PEKT	5	Riza Pektas

Continued

Table 3: 202006 Number of observations by observer.

Observer Code	Number of Observations	Observer Name
SDOH	30	Solar Dynamics Obs - HMI
SNE	19	Neil Simmons
SONA	17	Andries Son
STAB	30	Brian Gordon-States
SUZM	18	Miyoshi Suzuki
SVAE	4	Valery Stanimirov
TESD	26	David Teske
TPJB	2	Patrick Thibault
TST	29	Steven Toothman
URBP	26	Piotr Urbanski
VARG	30	A. Gonzalo Vargas
VIDD	8	Daniel Vidican
WGI	11	Guido Wollenhaupt
WILW	26	William M. Wilson
Totals	1299	69

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 9 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.

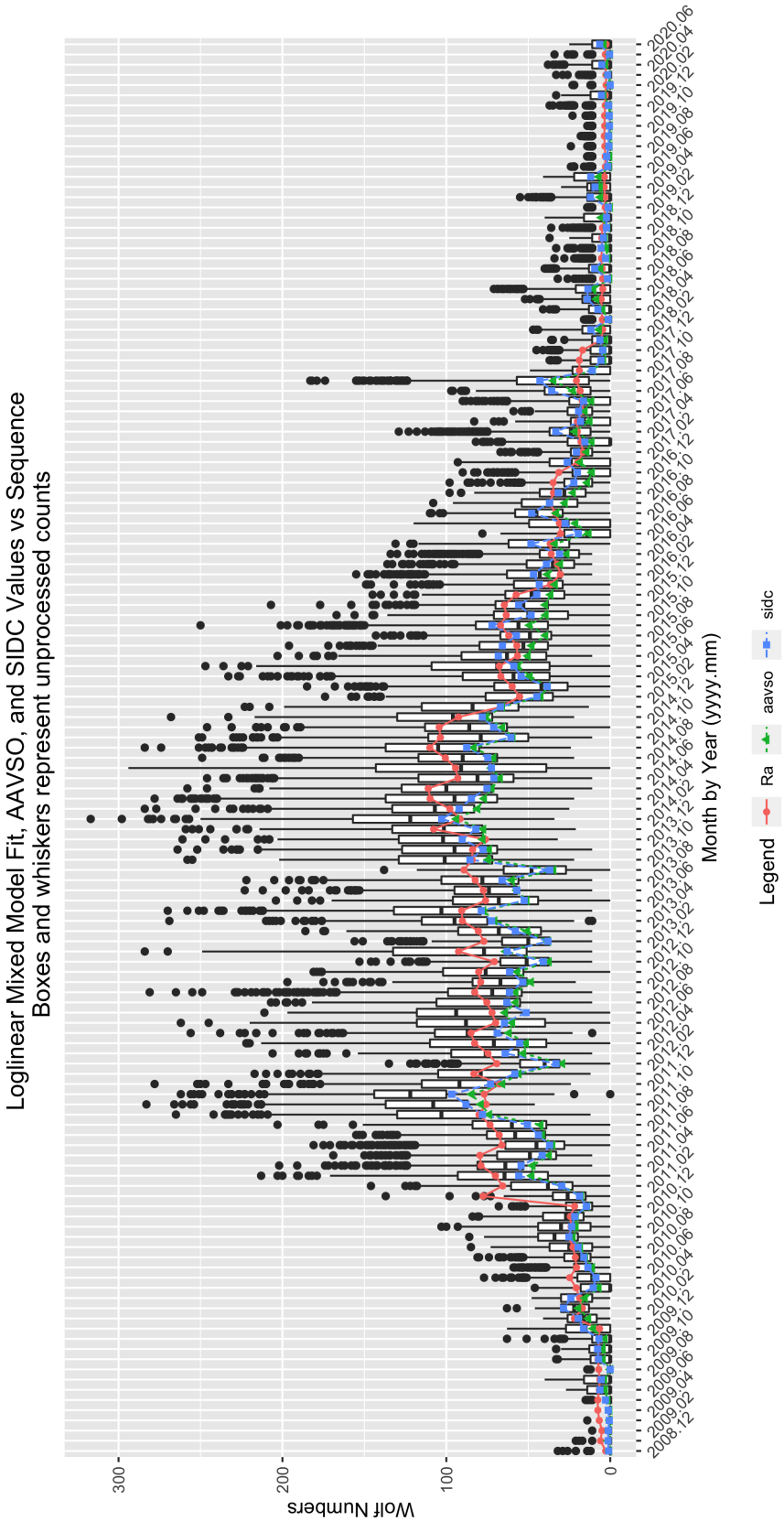

Figure 9: GLMM fitted data for R_a. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

4 Endnotes

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

Figure 10: I know that sometimes you like to add my sun's work in your bulletin, be sure that I appreciate that! Here I join the June AR2765 development. I hope that you had a nice and virus free Independence Day holiday, Kind regards, Michel Deconinck. (`https://astro.aquarellia.com`)