

# Monthly Report (00)

## 2022.07 Data Set

Wednesday 17<sup>th</sup> August, 2022

Prepared for

**Statistics for Physical and Engineering Sciences**

by

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## 1 Introduction

The process of reporting monthly Sunspot numbers consists of submitting 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 using the R statistics package (<http://www.R-project.org/>). This report is the portion of the analysis concerned with both the raw daily average counts and the data Accuracy, Consistency, and Completeness measures for a particular month. The checks are used to scrub or filter the data to assure only error-free data are used to determine the monthly sunspot number.

This report consists of four sections: the raw daily average counts (Section 2), the known data errors (Section 3), the processed counts using a Generalized Linear Mixed Model to produce the relative sunspot numbers (Section 4), and supporting information on the model construction (Section 5).

The raw daily average of counts consist of submitted counts from all observers who provided data in the particular month. These averaged counts are reported by the day of the month, and are either from data not scrubbed or corrected data. The table captions indicate which. The errors, if any, are reported according to type.

The Error Tables section contains reported errors on missing data, inconsistencies in year and month, inconsistencies in the reported day number (1-31), seeing coding errors, number of annual observations by observer, and inconsistencies between the reported Wolf number and the calculated Wolf number from the group counts and sunspot counts, among other errors that are given in that section.

The relative sunspot numbers  $R_a$  section contains the sunspot numbers after the submitted data are scrubbed and modeled by a Generalized Linear Mixed Model (GLMM). The GLMM is a statistical model that accounts for variation due to random effects and fixed effects. For the  $R_a$  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 the sunspot counts research page. The paper title is *A Generalized Linear Mixed Model for Enumerated Sunspots*.

The supporting information for the model is provided for clarification.

## 2 Raw Daily Average Counts

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 1 and Table 1.

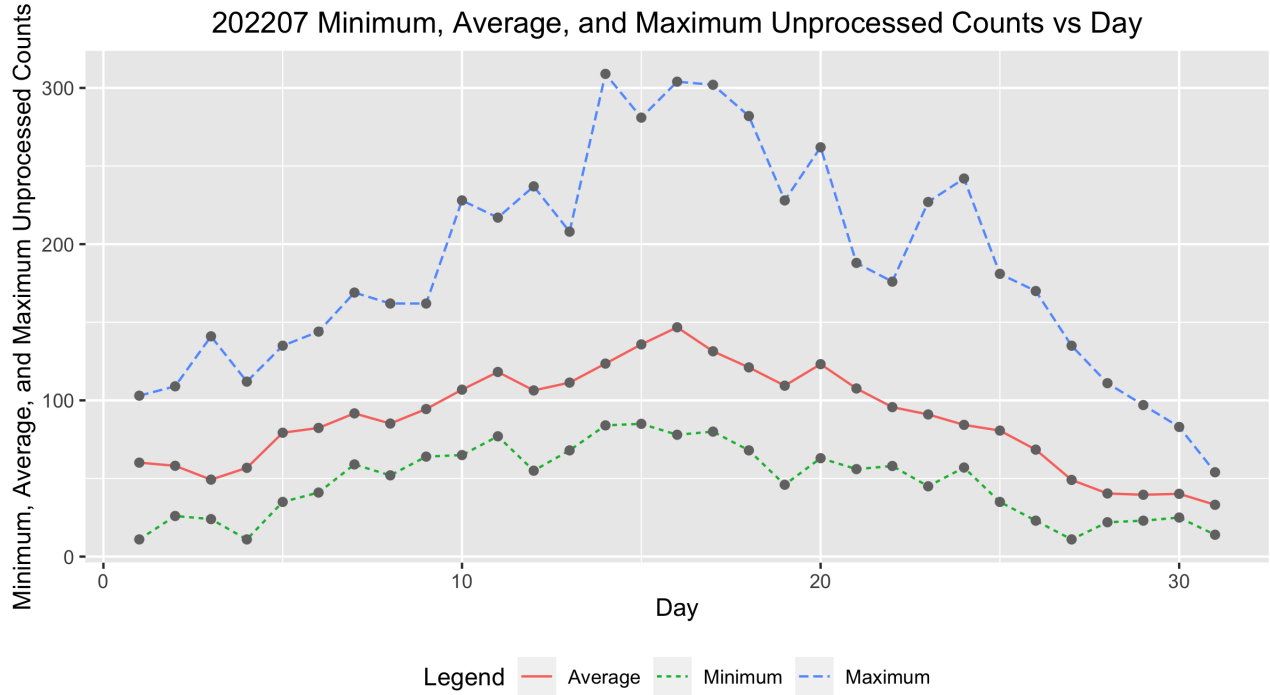


Figure 1: Raw average sunspot count by day of the month.

Table 1: 202207 Daily Raw Counts

Day	Submissions	Minimum	Average	Maximum
1.0000	47.0000	11.0000	60.1489	103.0000
2.0000	40.0000	26.0000	58.1250	109.0000
3.0000	41.0000	24.0000	49.2683	141.0000
4.0000	44.0000	11.0000	56.8182	112.0000
5.0000	38.0000	35.0000	79.2895	135.0000
6.0000	41.0000	41.0000	82.3659	144.0000
7.0000	44.0000	59.0000	91.6818	169.0000
8.0000	46.0000	52.0000	85.1739	162.0000
9.0000	46.0000	64.0000	94.4565	162.0000
10.0000	48.0000	65.0000	106.8542	228.0000
11.0000	43.0000	77.0000	118.1860	217.0000
12.0000	43.0000	55.0000	106.3721	237.0000
13.0000	44.0000	68.0000	111.3636	208.0000
14.0000	37.0000	84.0000	123.5405	309.0000
15.0000	46.0000	85.0000	135.8261	281.0000
16.0000	40.0000	78.0000	146.7750	304.0000
17.0000	41.0000	80.0000	131.4146	302.0000
18.0000	35.0000	68.0000	121.1143	282.0000
19.0000	48.0000	46.0000	109.4167	228.0000
20.0000	43.0000	63.0000	123.1860	262.0000
21.0000	39.0000	56.0000	107.6154	188.0000
22.0000	40.0000	58.0000	95.6750	176.0000
23.0000	42.0000	45.0000	91.0000	227.0000
24.0000	36.0000	57.0000	84.3333	242.0000
25.0000	36.0000	35.0000	80.6667	181.0000
26.0000	34.0000	23.0000	68.4706	170.0000
27.0000	36.0000	11.0000	49.0833	135.0000
28.0000	37.0000	22.0000	40.4054	111.0000
29.0000	38.0000	23.0000	39.5789	97.0000
30.0000	42.0000	25.0000	40.1905	83.0000
31.0000	37.0000	14.0000	33.1622	54.0000

### 3 Error Tables

Data are for the month of July 2022. No errors were found, and hence no errors are reported.

### 4 Relative Sunspot Numbers

All data errors, if any, have been corrected prior to determining the following relative sunspot numbers. A Generalized Linear Mixed Model (GLMM) was constructed to provide monthly sunspot numbers (see Table 2). The GLMM treats observer as a random effect, with year, month, seeing conditions, observer rank, and dual submission to both AAVSO and SILSO as fixed effects.

Figure 2 shows the monthly  $R_a$  numbers for the years and months (ym) in Table 2. The solid cyan curve that connects the cyan X's are the GLMM model estimates given in 2. 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 dashed red curve connecting the red O's are the SILSO values for the monthly sequence.

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 of the box plot represents the InterQuartile Range (IQR), which depicts from the 25<sup>th</sup> through the 75<sup>th</sup> quartiles. The lower and upper whiskers extend 1.5 times the IQR below the 25<sup>th</sup> quartile, and 1.5 times the IQR above the 75<sup>th</sup> quartile. The black circles below and above the whiskers traditionally are considered outliers, but with GLMM modeling, they are observations that comprise overdispersion. Overdispersion skews the counts data from a true Poisson distribution. The GLMM adjusts for this overdispersion.

Table 2: Year Month (ym) Relative Sunspot Numbers with 99% CI

ym	Ra	lci99	uci99	aavso	sidc
2008.12	2.7705	2.4227	3.1183	0.5000	1.0000
2009.01	5.1739	4.6368	5.7110	1.3000	1.3000
2009.02	4.6010	4.1099	5.0921	0.7000	1.2000
2009.03	6.1402	5.9115	6.3690	0.3000	0.6000
2009.04	6.9256	6.6901	7.1611	0.4000	1.2000
2009.05	7.1156	6.8469	7.3843	1.6000	2.9000
2009.06	6.3947	6.0816	6.7078	3.2000	6.3000
2009.07	6.3798	6.1303	6.6292	3.6000	5.5000
2009.08	6.6515	6.4051	6.8980	0.0000	0.0000
2009.09	7.3715	7.1211	7.6218	4.5000	7.1000
2009.10	6.8718	6.5208	7.2228	4.5000	7.7000
2009.11	7.0999	6.9064	7.2933	3.3000	6.9000
2009.12	7.0008	6.8029	7.1988	10.4000	16.3000
2010.01	19.5251	17.3947	21.6555	13.3000	19.5000
2010.02	15.7543	13.7061	17.8025	19.4000	28.5000

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Table 2: Year Month (ym) Relative Sunspot Numbers with 99% CI

ym	Ra	lci99	uci99	aavso	sidc
2010.03	17.7614	15.6483	19.8745	15.4000	24.0000
2010.04	19.7292	17.4999	21.9584	7.0000	10.4000
2010.05	23.6689	23.2502	24.0875	8.4000	8.7000
2010.06	19.9775	19.6393	20.3158	11.0000	13.6000
2010.07	21.8196	21.4957	22.1435	15.2000	16.1000
2010.08	21.9597	21.5911	22.3284	18.3000	19.6000
2010.09	25.3119	24.8884	25.7354	22.8000	25.2000
2010.10	23.9104	23.4890	24.3318	21.0000	23.5000
2010.11	25.1856	24.7260	25.6451	20.9000	21.6000
2010.12	23.9258	23.4463	24.4052	13.9000	14.5000
2011.01	70.1632	68.7346	71.5917	17.7000	18.7000
2011.02	61.5339	60.2400	62.8279	29.1000	29.6000
2011.03	67.2501	65.9598	68.5404	48.0000	55.8000
2011.04	75.7824	74.3800	77.1848	47.3000	54.4000
2011.05	77.8805	76.5498	79.2112	37.3000	41.5000
2011.06	65.6600	64.4997	66.8203	35.2000	37.0000
2011.07	70.8263	69.6124	72.0402	41.5000	43.8000
2011.08	72.0837	70.9164	73.2510	42.4000	50.5000
2011.09	81.8811	80.4482	83.3139	73.8000	78.0000
2011.10	77.3709	76.0571	78.6847	78.9000	88.0000
2011.11	81.3321	79.6476	83.0167	84.6000	96.7000
2011.12	75.8213	74.2692	77.3734	65.8000	73.0000
2012.01	75.3914	73.9032	76.8795	55.8000	58.2000
2012.02	65.0015	63.6701	66.3329	29.2000	33.1000
2012.03	71.7513	70.4766	73.0260	53.1000	64.1000
2012.04	79.4402	78.0218	80.8587	51.4000	55.2000
2012.05	83.3707	81.9763	84.7651	61.8000	69.0000
2012.06	69.6835	68.4927	70.8743	59.7000	64.5000
2012.07	75.7317	74.4794	76.9840	64.2000	51.3000
2012.08	74.2365	73.0280	75.4450	57.7000	63.1000
2012.09	84.7899	83.3095	86.2703	57.7000	61.5000
2012.10	80.9445	79.4531	82.4358	48.3000	53.3000
2012.11	85.2656	83.5445	86.9866	56.7000	61.4000
2012.12	79.5782	77.8455	81.3109	37.4000	40.8000
2013.01	83.7136	82.1029	85.3243	63.8000	62.9000
2013.02	72.3131	70.8461	73.7802	37.8000	38.0000
2013.03	77.3355	75.7476	78.9234	50.6000	57.9000
2013.04	86.6362	85.0930	88.1794	70.6000	72.4000
2013.05	88.8209	87.2154	90.4263	77.4000	78.7000

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Table 2: Year Month (ym) Relative Sunspot Numbers with 99% CI

ym	Ra	lci99	uci99	aavso	sidc
2013.06	75.7445	74.3860	77.1030	51.0000	52.5000
2013.07	81.2962	79.9672	82.6251	57.0000	57.0000
2013.08	81.3773	80.0473	82.7072	60.0000	66.0000
2013.09	91.4494	89.7998	93.0990	34.6000	36.9000
2013.10	86.2768	84.6603	87.8933	74.5000	85.6000
2013.11	89.3370	87.3046	91.3694	73.9000	77.6000
2013.12	85.6959	83.8551	87.5368	77.8000	90.3000
2014.01	97.7189	95.6479	99.7899	77.4000	82.0000
2014.02	86.1791	84.4578	87.9003	93.9000	102.8000
2014.03	94.2504	92.5142	95.9866	80.9000	92.2000
2014.04	105.7391	103.8635	107.6147	76.9000	84.7000
2014.05	109.0287	107.1513	110.9062	72.3000	75.2000
2014.06	92.8325	91.2432	94.4217	67.2000	71.0000
2014.07	99.2760	97.5962	100.9557	72.5000	72.5000
2014.08	99.4934	97.9234	101.0635	71.2000	74.7000
2014.09	113.0857	111.0683	115.1030	83.2000	87.6000
2014.10	106.2035	104.2330	108.1739	59.5000	60.6000
2014.11	111.1375	108.8066	113.4683	65.8000	71.1000
2014.12	104.1822	101.7618	106.6026	75.8000	78.0000
2015.01	60.3528	59.1414	61.5642	65.9000	67.0000
2015.02	52.0097	50.8492	53.1702	42.4000	44.8000
2015.03	57.6368	56.5740	58.6995	38.0000	38.4000
2015.04	64.3069	63.1441	65.4697	49.0000	54.4000
2015.05	66.4582	65.3488	67.5677	56.3000	58.8000
2015.06	56.4029	55.3892	57.4166	50.2000	68.3000
2015.07	59.7564	58.7435	60.7693	47.9000	65.8000
2015.08	61.0524	60.0323	62.0724	39.5000	57.2000
2015.09	68.6158	67.3718	69.8599	49.2000	72.1000
2015.10	64.8754	63.6239	66.1268	39.3000	48.3000
2015.11	68.5124	67.0181	70.0066	39.6000	55.9000
2015.12	64.5217	63.0888	65.9546	36.4000	44.8000
2016.01	33.0293	32.3405	33.7181	33.7000	43.3000
2016.02	28.5187	27.9237	29.1138	38.3000	46.8000
2016.03	31.1236	30.5017	31.7455	30.5000	38.9000
2016.04	34.5779	33.9182	35.2376	26.6000	30.9000
2016.05	35.8689	35.2142	36.5237	33.7000	48.4000
2016.06	30.1311	29.6174	30.6448	13.1000	19.5000
2016.07	32.5423	32.0209	33.0637	21.2000	27.5000
2016.08	32.8765	32.2995	33.4535	33.0000	47.9000

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Table 2: Year Month (ym) Relative Sunspot Numbers with 99% CI

ym	Ra	lci99	uci99	aavso	sidc
2016.09	37.8174	37.1281	38.5066	27.7000	37.1000
2016.10	35.4395	34.7580	36.1211	22.7000	31.7000
2016.11	37.0084	36.2350	37.7818	14.0000	22.2000
2016.12	35.2945	34.5361	36.0529	11.1000	20.0000
2017.01	17.8460	17.4692	18.2229	18.4000	26.2000
2017.02	15.4767	15.1359	15.8176	14.4000	20.6000
2017.03	17.0266	16.7016	17.3516	11.3000	15.5000
2017.04	19.0991	18.7620	19.4362	21.6000	33.2000
2017.05	19.5309	19.1933	19.8685	12.5000	18.1000
2017.06	16.3770	16.1041	16.6498	15.5000	19.3000
2017.07	17.7616	17.4768	18.0464	11.5000	16.3000
2017.08	17.8989	17.5860	18.2118	22.8000	35.7000
2017.09	20.9256	20.4877	21.3636	34.6000	42.9000
2017.10	19.0931	18.6999	19.4862	10.5000	11.0000
2017.11	19.8061	19.3853	20.2268	4.2000	5.6000
2017.12	18.7801	18.4925	19.0676	4.0000	4.6000
2018.01	4.9807	4.8742	5.0872	3.1000	6.3000
2018.02	4.2743	4.1704	4.3782	6.8000	11.8000
2018.03	4.6243	4.5306	4.7180	1.1000	1.2000
2018.04	5.1287	5.0257	5.2317	4.7000	7.5000
2018.05	5.3215	5.2218	5.4212	8.4000	14.0000
2018.06	4.4806	4.4016	4.5596	10.2000	13.6000
2018.07	4.8636	4.8085	4.9186	0.5000	1.7000
2018.08	4.8479	4.7649	4.9309	5.9000	9.5000
2018.09	5.4604	5.3580	5.5627	1.6000	2.9000
2018.10	5.2513	5.1480	5.3547	2.5000	5.6000
2018.11	5.4651	5.3506	5.5795	3.1000	4.2000
2018.12	5.2854	5.1818	5.3889	1.6000	2.3000
2019.01	3.2907	3.2278	3.3535	5.4000	2.3000
2019.02	2.8882	2.8315	2.9449	0.1000	1.2000
2019.03	3.0882	3.0356	3.1408	6.1000	12.1000
2019.04	3.4656	3.4003	3.5308	6.2000	9.3000
2019.05	3.4839	3.4234	3.5445	7.0000	11.9000
2019.06	2.9470	2.8974	2.9965	0.7000	1.5000
2019.07	3.1937	3.1463	3.2410	0.4000	2.2000
2019.08	3.2333	3.1854	3.2812	0.3000	0.8000
2019.09	3.7237	3.6655	3.7819	0.5000	1.0000
2019.10	3.4716	3.4124	3.5308	0.2000	0.5000
2019.11	3.6907	3.6198	3.7616	0.3000	0.6000

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Table 2: Year Month (ym) Relative Sunspot Numbers with 99% CI

ym	Ra	lci99	uci99	aavso	sidc
2019.12	3.4760	3.4073	3.5447	0.8000	1.0000
2020.01	7.2865	7.1436	7.4295	4.0000	5.3000
2020.02	6.3216	6.1944	6.4487	0.1000	0.0000
2020.03	6.8273	6.6994	6.9552	1.2000	1.5000
2020.04	7.7008	7.5739	7.8276	3.0000	5.1000
2020.05	7.8174	7.6949	7.9399	0.1000	0.4000
2020.06	6.6457	6.5441	6.7473	3.9000	6.4000
2020.07	7.1016	6.9976	7.2055	4.2000	7.7000
2020.08	7.0809	6.9829	7.1788	5.3000	7.8000
2020.09	8.1271	7.9973	8.2569	0.4000	0.9000
2020.10	7.7640	7.6365	7.8916	9.9000	13.6000
2020.11	8.1861	8.0549	8.3172	21.2000	33.1000
2020.12	7.7325	7.5946	7.8704	15.4000	19.8000
2021.01	25.4863	25.0335	25.9390	7.0000	15.8000
2021.02	22.4635	22.0627	22.8643	5.8000	10.7000
2021.03	24.4309	24.0428	24.8191	11.0000	17.2000
2021.04	27.5457	27.1182	27.9733	18.5000	28.8000
2021.05	28.2626	27.8585	28.6666	15.9000	22.9000
2021.06	23.9628	23.6136	24.3121	19.9000	24.1000
2021.07	25.5615	25.1658	25.9572	23.8000	35.6000
2021.08	26.2895	25.8818	26.6973	15.7000	19.5000
2021.09	29.9219	29.4483	30.3956	39.1000	52.5000
2021.10	28.8102	28.3305	29.2900	27.1000	37.0000
2021.11	30.2975	29.8125	30.7825	27.2000	35.1000
2021.12	29.3971	28.8726	29.9217	50.6000	69.0000
2022.01	71.1158	69.9368	72.2947	43.9000	62.0000
2022.02	62.5319	61.4588	63.6050	48.8000	60.5000
2022.03	68.6032	67.4402	69.7662	58.4000	80.6000
2022.04	74.9365	73.8162	76.0568	59.1000	83.9000
2022.05	79.3074	78.0844	80.5305	72.5000	0.4000
2022.06	65.5302	64.5382	66.5222	58.9000	0.4000
2022.07	71.4048	70.2800	72.5296	76.7000	102.5000

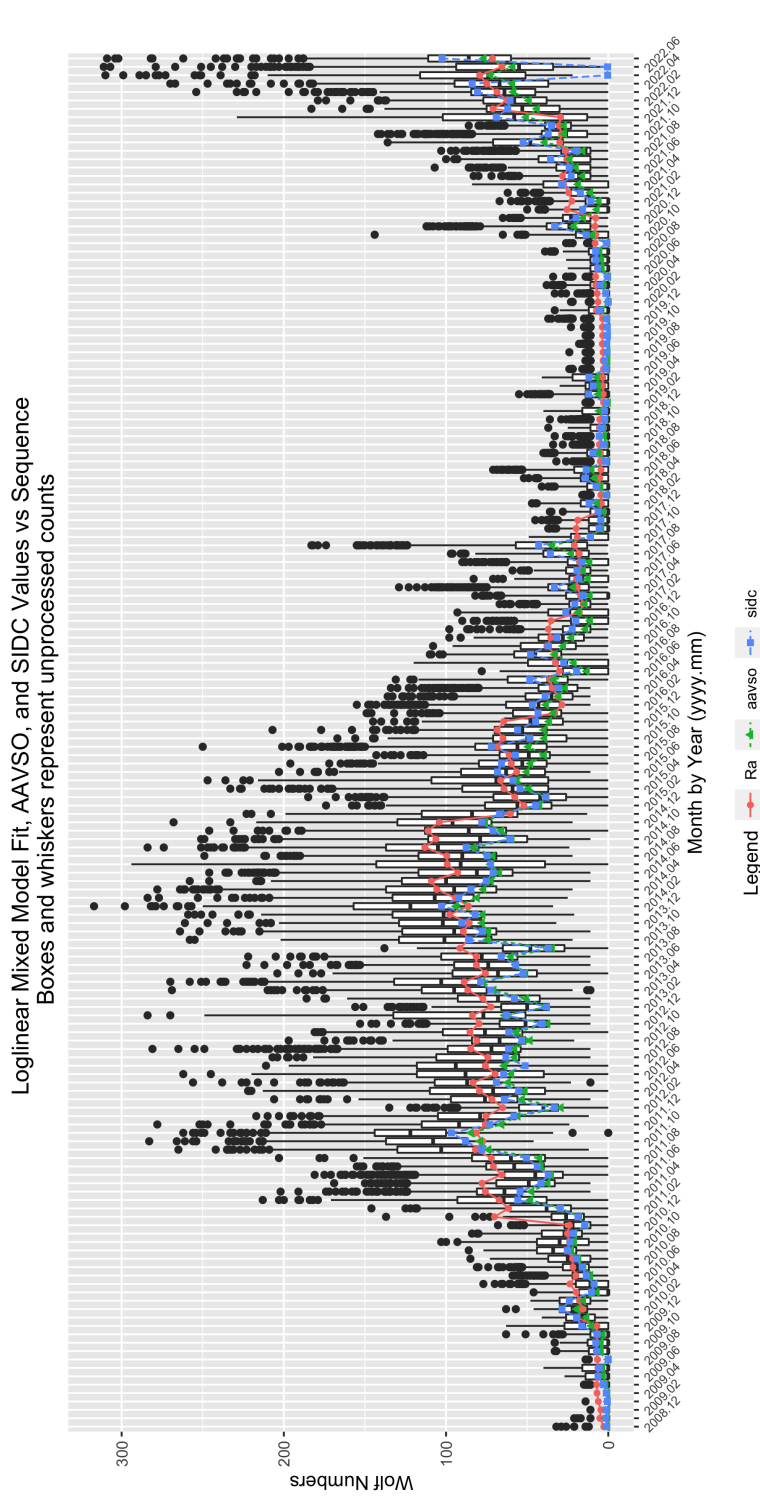


Figure 2: GLMM fitted data for  $R_a$ . AAVSO data: <https://www.aavso.org/category/tags/solar-bulletin>. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

The GLMM parameter estimates and measures of importance in the determining the monthly  $R_a$  values are given in Table 3. The parameter estimates and levels of statistical significance are determined for the residual error size combined with the observer random effect error size. Thus, the parameter estimates are adjusted for the random effect of observer. The significance level is set at 0.05. Any  $\Pr(>|z|)$  values equal to or less than 0.05 are considered statistically significant.

The year effect levels are given as year2011, year2012, and year2013. The yearly effect is significant as  $\Pr(>|z|) < 0.05$ . So the year in which the observations are made is commensurate with the expected rise toward and anticipated sunspot number maximum. Similarly, the monthly effect, denoted as mon2 through mon12, is significant at the 0.05 level.

The seeing conditions account for a significant amount of deviation in sunspot numbers. The seeing conditions are denoted as seeF (Fair), seeG (Good), and seeP (Poor), and are significant at the 0.05 level. Therefore, seeing conditions influence the reported sunspot numbers, as intuition anticipates.

The level of observer experience (denoted r1000B through r5000H, which is least to most experience) is not significant at the 0.05 significance level. It therefore does not contribute to changes in the monthly sunspot numbers.

Whether an observer contributes counts to the SILSO as well as the AAVSO (silsoy) is not significant at the 0.05 level, and hence we conclude that those observers who contribution to both institutions tend to differ from those observers contributing only to the AAVSO.

## 5 Supporting Information

Table 3: 202207 Parameter Estimates

	Estimate	Std. Error	t-value	Pr(> t )
(Intercept)	1.2557	0.3166	3.9664	0.0001
seeF	-0.2253	0.0055	-41.0061	0.0000
seeG	-0.1216	0.0048	-25.3510	0.0000
seeM	-0.1913	0.0245	-7.8235	0.0000
seeP	-0.3237	0.0079	-41.0597	0.0000
sidc1	0.0482	0.0151	3.1918	0.0014
year2009	0.7197	0.3180	2.2632	0.0236
year2010	1.9531	0.3158	6.1847	0.0000
year2011	3.0948	0.3157	9.8031	0.0000
year2012	3.1351	0.3157	9.9310	0.0000
year2013	3.2308	0.3157	10.2342	0.0000
year2014	3.4289	0.3157	10.8620	0.0000
year2015	2.9446	0.3157	9.3274	0.0000
year2016	2.3281	0.3157	7.3740	0.0000
year2017	1.7169	0.3158	5.4373	0.0000
year2018	0.4327	0.3161	1.3692	0.1709
year2019	0.0148	0.3163	0.0469	0.9626
year2020	0.8204	0.3159	2.5968	0.0094
year2021	2.0995	0.3157	6.6495	0.0000
year2022	3.0669	0.3157	9.7132	0.0000
mon2	-0.1375	0.0086	-15.9628	0.0000
mon3	-0.0547	0.0081	-6.7844	0.0000
mon4	0.0488	0.0078	6.2927	0.0000
mon5	0.0734	0.0076	9.6554	0.0000
mon6	-0.0977	0.0079	-12.3377	0.0000
mon7	-0.0295	0.0077	-3.8376	0.0001
mon8	-0.0194	0.0079	-2.4580	0.0140
mon9	0.1176	0.0079	14.9405	0.0000
mon10	0.0622	0.0081	7.6916	0.0000
mon11	0.1210	0.0084	14.4776	0.0000
mon12	0.0700	0.0084	8.3213	0.0000

Table 4: 202207 Summary of Sunspot Numbers

year	mon	day	obs	sidc
Min. :2008	Min. : 1.000	Min. : 0.00	Length:158366	Min. :0.0000
1st Qu.:2013	1st Qu.: 4.000	1st Qu.: 8.00	Class :character	1st Qu.:0.0000
Median :2016	Median : 7.000	Median :16.00	Mode :character	Median :0.0000
Mean :2016	Mean : 6.532	Mean :15.72		Mean :0.2468
3rd Qu.:2019	3rd Qu.: 9.000	3rd Qu.:23.00		3rd Qu.:0.0000
Max. :2022	Max. :12.000	Max. :31.00		Max. :1.0000

Table 5: 202207 Summary of Sunspot Numbers

g	s	w	see	method
Min. : 0.000	Min. : 0.00	Min. : 0.00	Length:158366	Length:158366
1st Qu.: 0.000	1st Qu.: 0.00	1st Qu.: 0.00	Class :character	Class :character
Median : 2.000	Median : 8.00	Median : 29.00	Mode :character	Mode :character
Mean : 2.746	Mean : 15.86	Mean : 43.31		
3rd Qu.: 4.000	3rd Qu.: 23.00	3rd Qu.: 69.00		
Max. :19.000	Max. :204.00	Max. :317.00		

Table 6: 202207 Summary of Sunspot Numbers

inst	filter	unit
Length:158366	Length:158366	Length:158366
Class :character	Class :character	Class :character
Mode :character	Mode :character	Mode :character

Table 7: 202207 Summary of Sunspot Numbers

aperture	eyep	foclen	mag
Min. : 0.00	Min. : 0.00	Min. : 0.0	Min. : 0.0
1st Qu.: 60.00	1st Qu.: 5.00	1st Qu.: 36.0	1st Qu.: 40.0
Median : 80.00	Median : 14.00	Median : 900.0	Median : 57.0
Mean : 91.99	Mean : 35.94	Mean : 889.4	Mean : 180.6
3rd Qu.: 104.00	3rd Qu.: 23.00	3rd Qu.:1200.0	3rd Qu.: 75.0
Max. :1524.00	Max. :2010.00	Max. :9990.0	Max. :4591.0

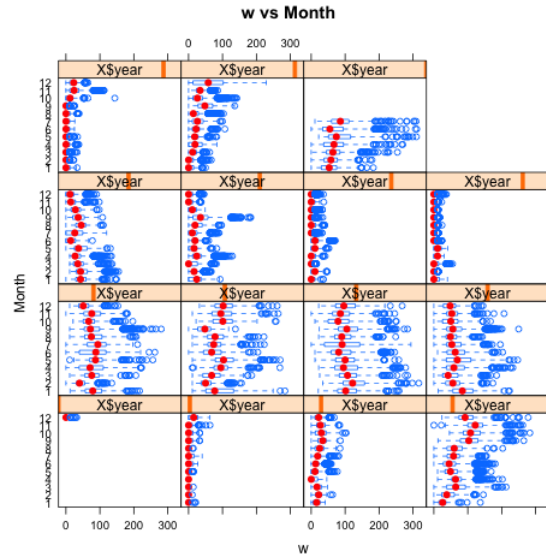
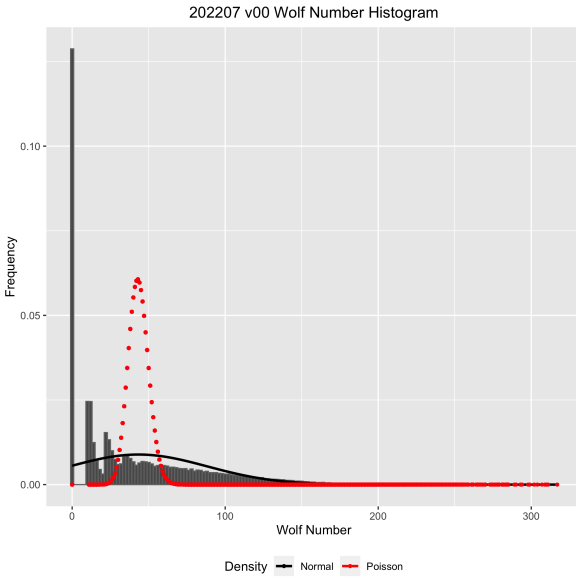


Figure 3: Box plots of raw Wolf number (w) by observer rank.

Figure 4: Box plots of raw Wolf number (w) by month and year.

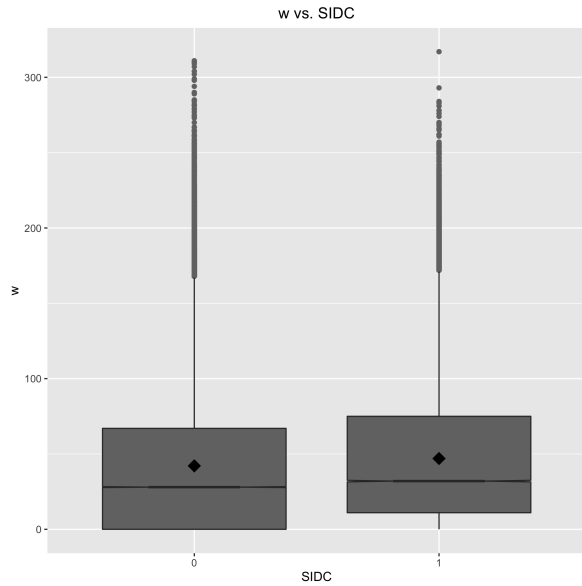
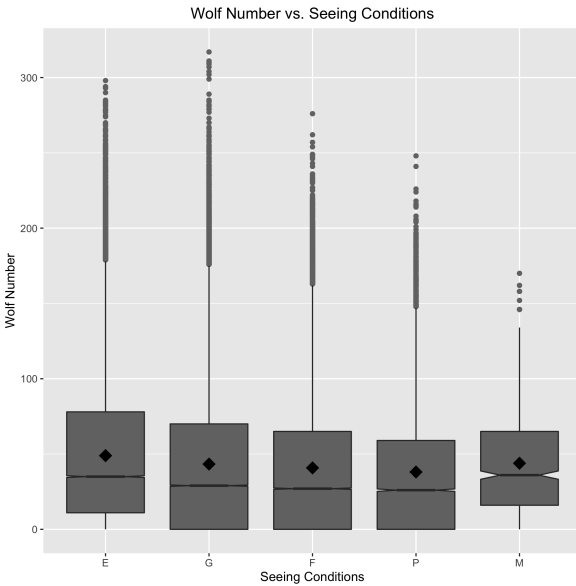


Figure 5: Box plots of raw Wolf number (w) by seeing condition.

Figure 6: Box plots of raw Wolf number (w) by organization.

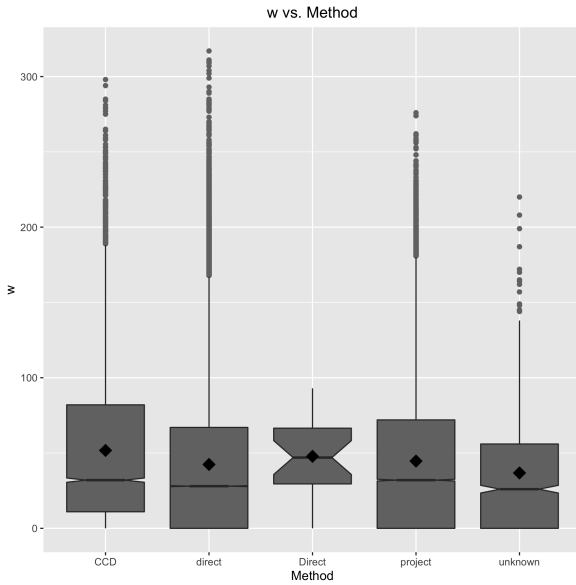


Figure 7: Box plots of raw Wolf number (w) by observer rank.

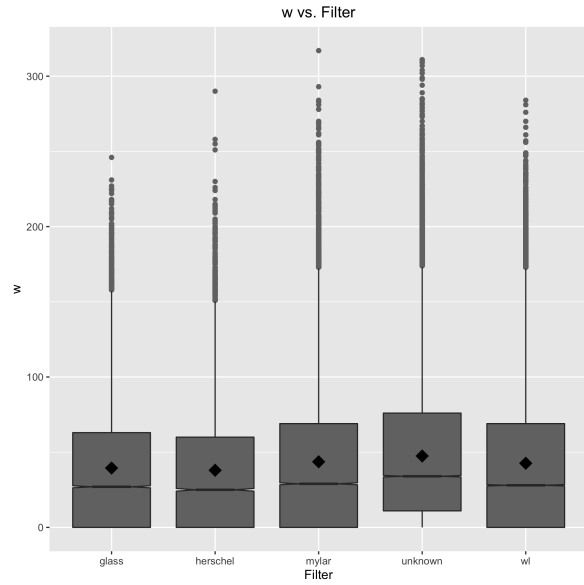


Figure 8: Box plots of raw Wolf number (w) by month and year.

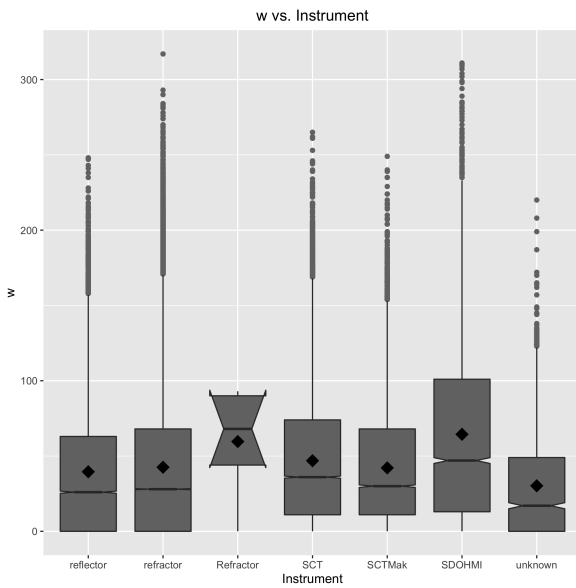


Figure 9: Box plots of raw Wolf number (w) by seeing condition.

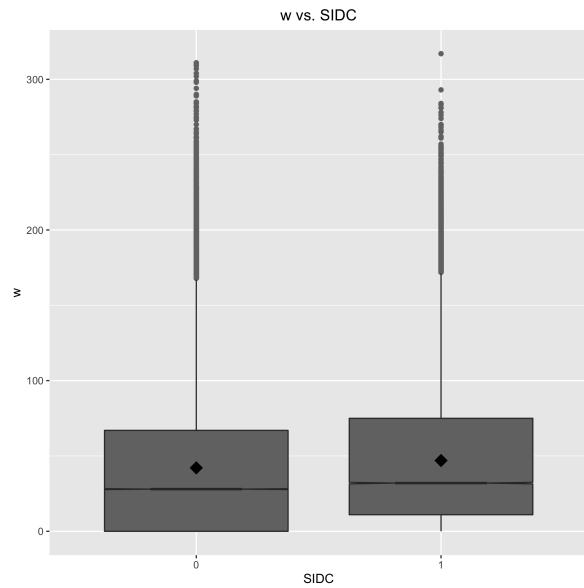


Figure 10: Box plots of raw Wolf number (w) by organization.



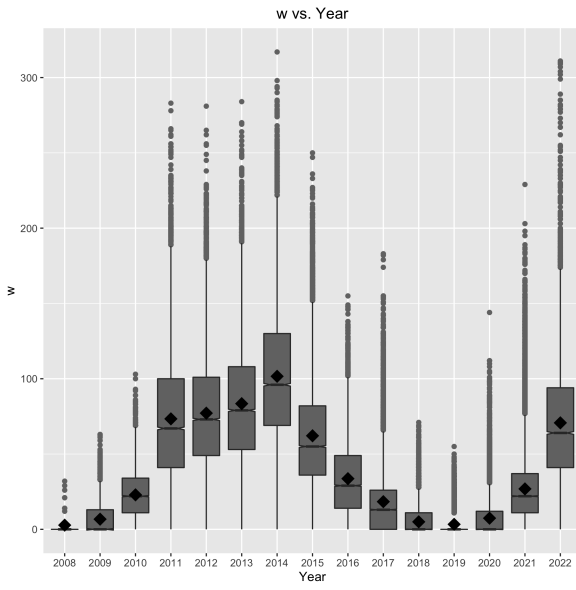


Figure 11: Box plots of raw Wolf number ( $w$ ) by year.

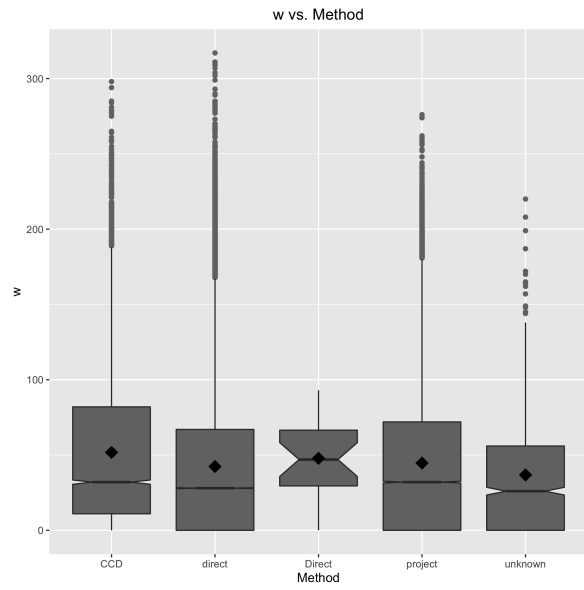


Figure 12: Box plots of raw Wolf number ( $w$ ) by observing method.