

# Monthly Report (00)

## 2021.07 Data Set

Saturday 14<sup>th</sup> August, 2021

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.

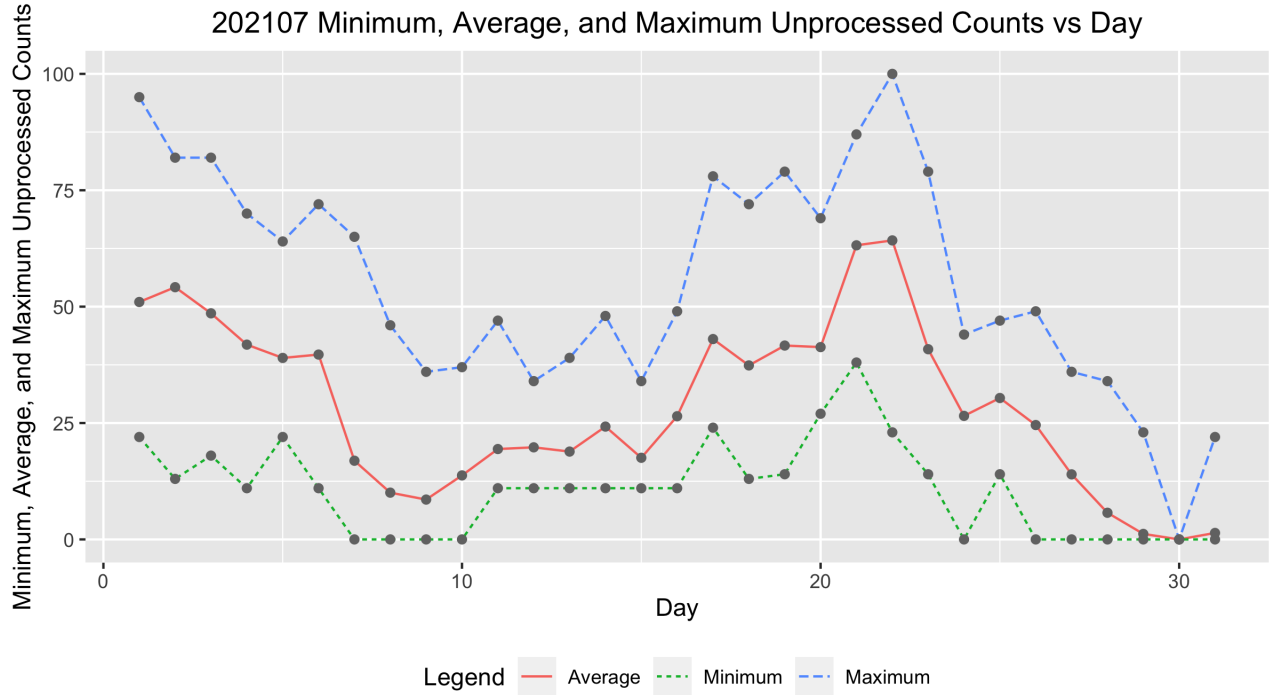


Figure 1: Raw average sunspot count by day of the month.

Table 1: 202107 Daily Raw Counts

| Day     | Submissions | Minimum | Average | Maximum  |
|---------|-------------|---------|---------|----------|
| 1.0000  | 38.0000     | 22.0000 | 51.0000 | 95.0000  |
| 2.0000  | 45.0000     | 13.0000 | 54.1778 | 82.0000  |
| 3.0000  | 39.0000     | 18.0000 | 48.5641 | 82.0000  |
| 4.0000  | 43.0000     | 11.0000 | 41.8372 | 70.0000  |
| 5.0000  | 55.0000     | 22.0000 | 38.9818 | 64.0000  |
| 6.0000  | 44.0000     | 11.0000 | 39.7045 | 72.0000  |
| 7.0000  | 42.0000     | 0.0000  | 16.9048 | 65.0000  |
| 8.0000  | 44.0000     | 0.0000  | 10.0455 | 46.0000  |
| 9.0000  | 43.0000     | 0.0000  | 8.5581  | 36.0000  |
| 10.0000 | 40.0000     | 0.0000  | 13.7500 | 37.0000  |
| 11.0000 | 41.0000     | 11.0000 | 19.4146 | 47.0000  |
| 12.0000 | 41.0000     | 11.0000 | 19.7805 | 34.0000  |
| 13.0000 | 38.0000     | 11.0000 | 18.8684 | 39.0000  |
| 14.0000 | 38.0000     | 11.0000 | 24.2368 | 48.0000  |
| 15.0000 | 45.0000     | 11.0000 | 17.5333 | 34.0000  |
| 16.0000 | 41.0000     | 11.0000 | 26.4634 | 49.0000  |
| 17.0000 | 50.0000     | 24.0000 | 43.0400 | 78.0000  |
| 18.0000 | 51.0000     | 13.0000 | 37.3725 | 72.0000  |
| 19.0000 | 42.0000     | 14.0000 | 41.6429 | 79.0000  |
| 20.0000 | 42.0000     | 27.0000 | 41.3095 | 69.0000  |
| 21.0000 | 46.0000     | 38.0000 | 63.1739 | 87.0000  |
| 22.0000 | 48.0000     | 23.0000 | 64.2292 | 100.0000 |
| 23.0000 | 41.0000     | 14.0000 | 40.8537 | 79.0000  |
| 24.0000 | 41.0000     | 0.0000  | 26.5366 | 44.0000  |
| 25.0000 | 40.0000     | 14.0000 | 30.3750 | 47.0000  |
| 26.0000 | 44.0000     | 0.0000  | 24.5682 | 49.0000  |
| 27.0000 | 40.0000     | 0.0000  | 13.9750 | 36.0000  |
| 28.0000 | 40.0000     | 0.0000  | 5.7250  | 34.0000  |
| 29.0000 | 38.0000     | 0.0000  | 1.1842  | 23.0000  |
| 30.0000 | 41.0000     | 0.0000  | 0.0000  | 0.0000   |
| 31.0000 | 41.0000     | 0.0000  | 1.3902  | 22.0000  |

### 3 Error Tables

Data are for the month of July 2021. 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  | 2.4097  | 3.1312  | 0.5000  | 1.0000  |
| 2009.01 | 5.5860  | 4.9842  | 6.1877  | 1.3000  | 1.3000  |
| 2009.02 | 4.7922  | 4.2617  | 5.3228  | 0.7000  | 1.2000  |
| 2009.03 | 6.4051  | 6.1564  | 6.6539  | 0.3000  | 0.6000  |
| 2009.04 | 7.3214  | 7.0592  | 7.5837  | 0.4000  | 1.2000  |
| 2009.05 | 7.3082  | 7.0196  | 7.5967  | 1.6000  | 2.9000  |
| 2009.06 | 6.6097  | 6.2750  | 6.9444  | 3.2000  | 6.3000  |
| 2009.07 | 6.3694  | 6.1134  | 6.6254  | 3.6000  | 5.5000  |
| 2009.08 | 6.8700  | 6.6000  | 7.1399  | 0.0000  | 0.0000  |
| 2009.09 | 7.2312  | 6.9743  | 7.4880  | 4.5000  | 7.1000  |
| 2009.10 | 6.9561  | 6.5907  | 7.3215  | 4.5000  | 7.7000  |
| 2009.11 | 7.1990  | 7.0022  | 7.3958  | 3.3000  | 6.9000  |
| 2009.12 | 6.5941  | 6.4078  | 6.7804  | 10.4000 | 16.3000 |
| 2010.01 | 20.9116 | 18.5423 | 23.2809 | 13.3000 | 19.5000 |
| 2010.02 | 16.2889 | 14.0845 | 18.4933 | 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 | 18.1570 | 15.9161 | 20.3979 | 15.4000 | 24.0000 |
| 2010.04 | 20.4954 | 18.0920 | 22.8988 | 7.0000  | 10.4000 |
| 2010.05 | 24.1429 | 23.7175 | 24.5682 | 8.4000  | 8.7000  |
| 2010.06 | 20.4944 | 20.1550 | 20.8338 | 11.0000 | 13.6000 |
| 2010.07 | 21.6185 | 21.3053 | 21.9317 | 15.2000 | 16.1000 |
| 2010.08 | 22.5580 | 22.1894 | 22.9266 | 18.3000 | 19.6000 |
| 2010.09 | 24.6408 | 24.2375 | 25.0440 | 22.8000 | 25.2000 |
| 2010.10 | 23.9842 | 23.5726 | 24.3958 | 21.0000 | 23.5000 |
| 2010.11 | 25.3868 | 24.9286 | 25.8450 | 20.9000 | 21.6000 |
| 2010.12 | 22.3443 | 21.8989 | 22.7898 | 13.9000 | 14.5000 |
| 2011.01 | 74.7732 | 73.2540 | 76.2923 | 17.7000 | 18.7000 |
| 2011.02 | 63.3836 | 62.0627 | 64.7044 | 29.1000 | 29.6000 |
| 2011.03 | 68.6254 | 67.3212 | 69.9296 | 48.0000 | 55.8000 |
| 2011.04 | 78.3414 | 76.9393 | 79.7435 | 47.3000 | 54.4000 |
| 2011.05 | 78.3188 | 77.0060 | 79.6316 | 37.3000 | 41.5000 |
| 2011.06 | 66.4471 | 65.2916 | 67.6025 | 35.2000 | 37.0000 |
| 2011.07 | 69.3613 | 68.1844 | 70.5382 | 41.5000 | 43.8000 |
| 2011.08 | 73.2020 | 72.0339 | 74.3701 | 42.4000 | 50.5000 |
| 2011.09 | 78.7297 | 77.3716 | 80.0878 | 73.8000 | 78.0000 |
| 2011.10 | 76.6225 | 75.3420 | 77.9030 | 78.9000 | 88.0000 |
| 2011.11 | 80.8878 | 79.2152 | 82.5604 | 84.6000 | 96.7000 |
| 2011.12 | 69.9989 | 68.5701 | 71.4277 | 65.8000 | 73.0000 |
| 2012.01 | 80.2324 | 78.6575 | 81.8072 | 55.8000 | 58.2000 |
| 2012.02 | 66.7960 | 65.4407 | 68.1513 | 29.2000 | 33.1000 |
| 2012.03 | 73.1165 | 71.8260 | 74.4069 | 53.1000 | 64.1000 |
| 2012.04 | 82.2060 | 80.7701 | 83.6418 | 51.4000 | 55.2000 |
| 2012.05 | 83.8112 | 82.4348 | 85.1877 | 61.8000 | 69.0000 |
| 2012.06 | 70.3942 | 69.2059 | 71.5824 | 59.7000 | 64.5000 |
| 2012.07 | 73.9593 | 72.7526 | 75.1661 | 64.2000 | 51.3000 |
| 2012.08 | 75.2625 | 74.0588 | 76.4662 | 57.7000 | 63.1000 |
| 2012.09 | 81.4028 | 79.9942 | 82.8114 | 57.7000 | 61.5000 |
| 2012.10 | 80.1099 | 78.6481 | 81.5716 | 48.3000 | 53.3000 |
| 2012.11 | 84.5718 | 82.8764 | 86.2672 | 56.7000 | 61.4000 |
| 2012.12 | 73.3772 | 71.7883 | 74.9662 | 37.4000 | 40.8000 |
| 2013.01 | 89.1381 | 87.4363 | 90.8399 | 63.8000 | 62.9000 |
| 2013.02 | 74.3711 | 72.8759 | 75.8664 | 37.8000 | 38.0000 |
| 2013.03 | 78.8634 | 77.2581 | 80.4688 | 50.6000 | 57.9000 |
| 2013.04 | 89.6227 | 88.0460 | 91.1994 | 70.6000 | 72.4000 |
| 2013.05 | 89.2868 | 87.6970 | 90.8765 | 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 | 76.5558  | 75.2048  | 77.9067  | 51.0000 | 52.5000  |
| 2013.07 | 79.4164  | 78.1418  | 80.6911  | 57.0000 | 57.0000  |
| 2013.08 | 82.4155  | 81.0900  | 83.7410  | 60.0000 | 66.0000  |
| 2013.09 | 87.7935  | 86.2272  | 89.3598  | 34.6000 | 36.9000  |
| 2013.10 | 85.3823  | 83.7985  | 86.9660  | 74.5000 | 85.6000  |
| 2013.11 | 88.5311  | 86.5424  | 90.5197  | 73.9000 | 77.6000  |
| 2013.12 | 78.9687  | 77.2806  | 80.6567  | 77.8000 | 90.3000  |
| 2014.01 | 103.9033 | 101.7162 | 106.0905 | 77.4000 | 82.0000  |
| 2014.02 | 88.4406  | 86.6963  | 90.1848  | 93.9000 | 102.8000 |
| 2014.03 | 95.9921  | 94.2421  | 97.7421  | 80.9000 | 92.2000  |
| 2014.04 | 109.2527 | 107.3412 | 111.1642 | 76.9000 | 84.7000  |
| 2014.05 | 109.4967 | 107.6296 | 111.3638 | 72.3000 | 75.2000  |
| 2014.06 | 93.6887  | 92.1064  | 95.2709  | 67.2000 | 71.0000  |
| 2014.07 | 96.8394  | 95.2264  | 98.4524  | 72.5000 | 72.5000  |
| 2014.08 | 100.6676 | 99.0970  | 102.2381 | 71.2000 | 74.7000  |
| 2014.09 | 108.4016 | 106.4912 | 110.3120 | 83.2000 | 87.6000  |
| 2014.10 | 105.0093 | 103.0769 | 106.9418 | 59.5000 | 60.6000  |
| 2014.11 | 110.0673 | 107.7802 | 112.3543 | 65.8000 | 71.1000  |
| 2014.12 | 96.0994  | 93.8748  | 98.3240  | 75.8000 | 78.0000  |
| 2015.01 | 64.1881  | 62.9052  | 65.4711  | 65.9000 | 67.0000  |
| 2015.02 | 53.3270  | 52.1532  | 54.5009  | 42.4000 | 44.8000  |
| 2015.03 | 58.6412  | 57.5704  | 59.7119  | 38.0000 | 38.4000  |
| 2015.04 | 66.3643  | 65.1826  | 67.5460  | 49.0000 | 54.4000  |
| 2015.05 | 66.7739  | 65.6734  | 67.8744  | 56.3000 | 58.8000  |
| 2015.06 | 57.0296  | 56.0076  | 58.0516  | 50.2000 | 68.3000  |
| 2015.07 | 58.4605  | 57.4687  | 59.4523  | 47.9000 | 65.8000  |
| 2015.08 | 61.9250  | 60.8894  | 62.9605  | 39.5000 | 57.2000  |
| 2015.09 | 65.8791  | 64.6864  | 67.0718  | 49.2000 | 72.1000  |
| 2015.10 | 64.2856  | 63.0472  | 65.5241  | 39.3000 | 48.3000  |
| 2015.11 | 68.0385  | 66.5605  | 69.5165  | 39.6000 | 55.9000  |
| 2015.12 | 59.4795  | 58.1676  | 60.7914  | 36.4000 | 44.8000  |
| 2016.01 | 35.1464  | 34.4151  | 35.8777  | 33.7000 | 43.3000  |
| 2016.02 | 29.3139  | 28.7038  | 29.9239  | 38.3000 | 46.8000  |
| 2016.03 | 31.7032  | 31.0718  | 32.3347  | 30.5000 | 38.9000  |
| 2016.04 | 35.7731  | 35.0935  | 36.4526  | 26.6000 | 30.9000  |
| 2016.05 | 36.1085  | 35.4514  | 36.7655  | 33.7000 | 48.4000  |
| 2016.06 | 30.4762  | 29.9573  | 30.9950  | 13.1000 | 19.5000  |
| 2016.07 | 31.8313  | 31.3227  | 32.3399  | 21.2000 | 27.5000  |
| 2016.08 | 33.3604  | 32.7766  | 33.9442  | 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 | 36.3091 | 35.6494 | 36.9688 | 27.7000 | 37.1000 |
| 2016.10 | 35.0686 | 34.3957 | 35.7415 | 22.7000 | 31.7000 |
| 2016.11 | 36.7210 | 35.9559 | 37.4861 | 14.0000 | 22.2000 |
| 2016.12 | 32.4984 | 31.8038 | 33.1931 | 11.1000 | 20.0000 |
| 2017.01 | 19.0806 | 18.6798 | 19.4813 | 18.4000 | 26.2000 |
| 2017.02 | 15.9821 | 15.6317 | 16.3325 | 14.4000 | 20.6000 |
| 2017.03 | 17.4398 | 17.1082 | 17.7714 | 11.3000 | 15.5000 |
| 2017.04 | 19.8765 | 19.5271 | 20.2260 | 21.6000 | 33.2000 |
| 2017.05 | 19.7404 | 19.4006 | 20.0802 | 12.5000 | 18.1000 |
| 2017.06 | 16.6602 | 16.3832 | 16.9372 | 15.5000 | 19.3000 |
| 2017.07 | 17.4622 | 17.1838 | 17.7405 | 11.5000 | 16.3000 |
| 2017.08 | 18.2624 | 17.9421 | 18.5827 | 22.8000 | 35.7000 |
| 2017.09 | 20.2568 | 19.8183 | 20.6952 | 34.6000 | 42.9000 |
| 2017.10 | 19.0313 | 18.6366 | 19.4260 | 10.5000 | 11.0000 |
| 2017.11 | 19.7634 | 19.3451 | 20.1818 | 4.2000  | 5.6000  |
| 2017.12 | 17.4135 | 17.1488 | 17.6783 | 4.0000  | 4.6000  |
| 2018.01 | 5.2952  | 5.1825  | 5.4078  | 3.1000  | 6.3000  |
| 2018.02 | 4.3937  | 4.2876  | 4.4997  | 6.8000  | 11.8000 |
| 2018.03 | 4.7136  | 4.6184  | 4.8088  | 1.1000  | 1.2000  |
| 2018.04 | 5.3219  | 5.2158  | 5.4280  | 4.7000  | 7.5000  |
| 2018.05 | 5.3732  | 5.2730  | 5.4733  | 8.4000  | 14.0000 |
| 2018.06 | 4.5503  | 4.4703  | 4.6303  | 10.2000 | 13.6000 |
| 2018.07 | 4.7702  | 4.7162  | 4.8242  | 0.5000  | 1.7000  |
| 2018.08 | 4.9337  | 4.8494  | 5.0179  | 5.9000  | 9.5000  |
| 2018.09 | 5.2608  | 5.1623  | 5.3593  | 1.6000  | 2.9000  |
| 2018.10 | 5.2088  | 5.1066  | 5.3110  | 2.5000  | 5.6000  |
| 2018.11 | 5.4343  | 5.3212  | 5.5475  | 3.1000  | 4.2000  |
| 2018.12 | 4.8889  | 4.7933  | 4.9844  | 1.6000  | 2.3000  |
| 2019.01 | 3.5012  | 3.4345  | 3.5679  | 5.4000  | 2.3000  |
| 2019.02 | 2.9724  | 2.9139  | 3.0309  | 0.1000  | 1.2000  |
| 2019.03 | 3.1503  | 3.0963  | 3.2044  | 6.1000  | 12.1000 |
| 2019.04 | 3.5831  | 3.5149  | 3.6512  | 6.2000  | 9.3000  |
| 2019.05 | 3.5000  | 3.4389  | 3.5611  | 7.0000  | 11.9000 |
| 2019.06 | 2.9698  | 2.9198  | 3.0198  | 0.7000  | 1.5000  |
| 2019.07 | 3.1209  | 3.0743  | 3.1675  | 0.4000  | 2.2000  |
| 2019.08 | 3.2813  | 3.2328  | 3.3298  | 0.3000  | 0.8000  |
| 2019.09 | 3.5726  | 3.5166  | 3.6286  | 0.5000  | 1.0000  |
| 2019.10 | 3.4406  | 3.3824  | 3.4988  | 0.2000  | 0.5000  |
| 2019.11 | 3.6558  | 3.5861  | 3.7254  | 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 | 3.1944  | 3.1317  | 3.2571  | 0.8000  | 1.0000  |
| 2020.01 | 7.7345  | 7.5839  | 7.8851  | 4.0000  | 5.3000  |
| 2020.02 | 6.4832  | 6.3542  | 6.6121  | 0.1000  | 0.0000  |
| 2020.03 | 6.9371  | 6.8079  | 7.0664  | 1.2000  | 1.5000  |
| 2020.04 | 7.9477  | 7.8176  | 8.0778  | 3.0000  | 5.1000  |
| 2020.05 | 7.8488  | 7.7260  | 7.9716  | 0.1000  | 0.4000  |
| 2020.06 | 6.7074  | 6.6047  | 6.8101  | 3.9000  | 6.4000  |
| 2020.07 | 6.9354  | 6.8335  | 7.0373  | 4.2000  | 7.7000  |
| 2020.08 | 7.1706  | 7.0722  | 7.2690  | 5.3000  | 7.8000  |
| 2020.09 | 7.8090  | 7.6853  | 7.9327  | 0.4000  | 0.9000  |
| 2020.10 | 7.6928  | 7.5678  | 7.8178  | 9.9000  | 13.6000 |
| 2020.11 | 8.1640  | 8.0356  | 8.2924  | 21.2000 | 33.1000 |
| 2020.12 | 7.2234  | 7.1007  | 7.3461  | 15.4000 | 19.8000 |
| 2021.01 | 19.8060 | 19.4667 | 20.1453 | 7.0000  | 15.8000 |
| 2021.02 | 16.8595 | 16.5639 | 17.1550 | 5.8000  | 10.7000 |
| 2021.03 | 18.2377 | 17.9514 | 18.5239 | 11.0000 | 17.2000 |
| 2021.04 | 20.8446 | 20.5337 | 21.1555 | 18.5000 | 28.8000 |
| 2021.05 | 20.8529 | 20.5604 | 21.1454 | 15.9000 | 22.9000 |
| 2021.06 | 17.8689 | 17.6057 | 18.1322 | 19.9000 | 24.1000 |
| 2021.07 | 18.4198 | 18.1397 | 18.7000 | 23.8000 | 35.6000 |

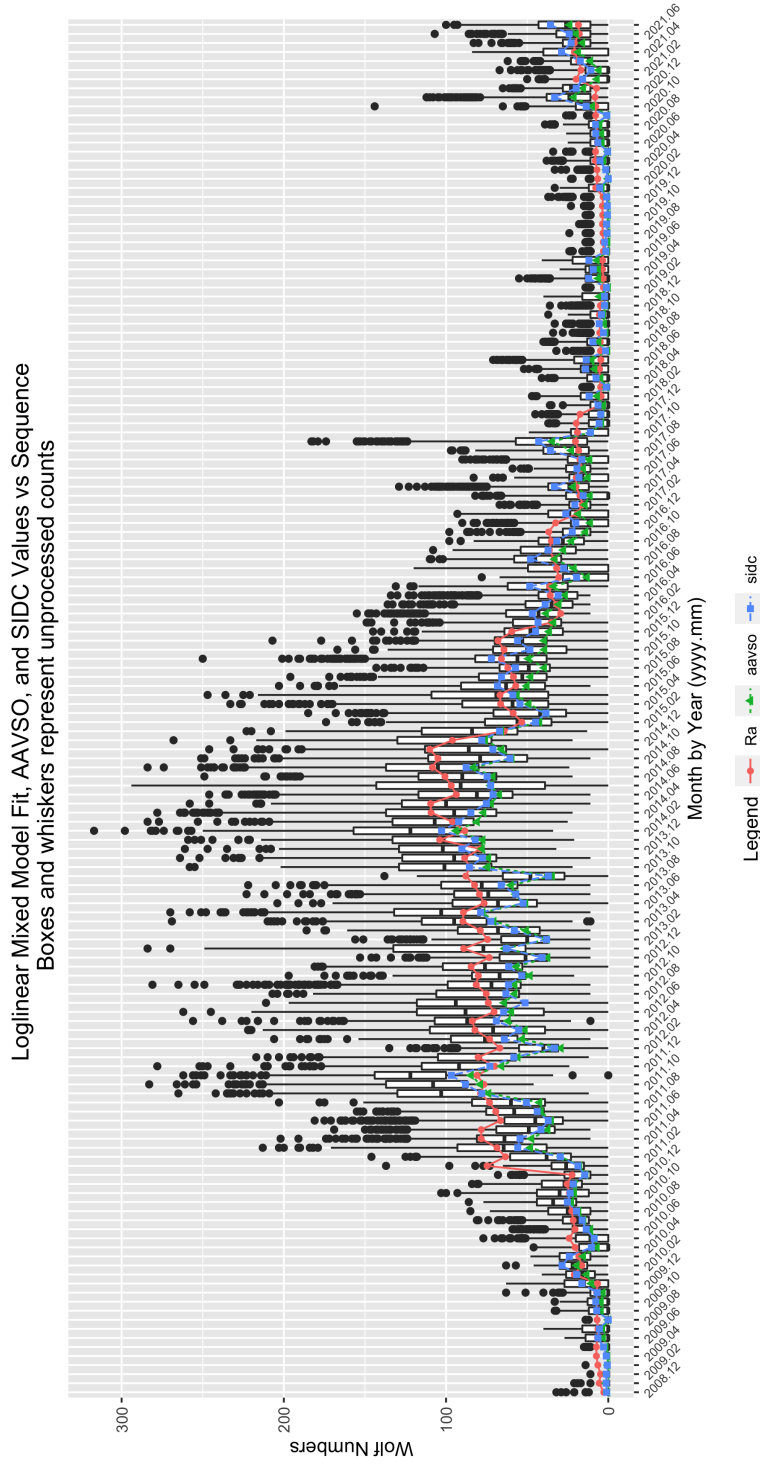


Figure 2: GLMM fitted data for  $R_a$ . AAVSO data: <https://www.aavso.org/category/tags/solar-bulletin>. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels

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.

Table 3: 202107 Parameter Estimates

|             | Estimate | Std. Error | t-value  | $Pr(> t )$ |
|-------------|----------|------------|----------|------------|
| (Intercept) | 1.4234   | 0.3100     | 4.5916   | 0.0000     |
| seeF        | -0.2193  | 0.0057     | -38.3556 | 0.0000     |
| seeG        | -0.1197  | 0.0050     | -24.0010 | 0.0000     |
| seeM        | -0.2001  | 0.0240     | -8.3390  | 0.0000     |
| seeP        | -0.3219  | 0.0082     | -39.3708 | 0.0000     |
| sidc1       | -0.0192  | 0.0296     | -0.6481  | 0.5169     |
| year2009    | 0.6539   | 0.3111     | 2.1021   | 0.0355     |
| year2010    | 1.8779   | 0.3089     | 6.0787   | 0.0000     |
| year2011    | 3.0054   | 0.3088     | 9.7316   | 0.0000     |
| year2012    | 3.0437   | 0.3088     | 9.8557   | 0.0000     |
| year2013    | 3.1392   | 0.3088     | 10.1651  | 0.0000     |
| year2014    | 3.3362   | 0.3088     | 10.8030  | 0.0000     |
| year2015    | 2.8508   | 0.3088     | 9.2310   | 0.0000     |
| year2016    | 2.2339   | 0.3089     | 7.2325   | 0.0000     |
| year2017    | 1.6268   | 0.3089     | 5.2664   | 0.0000     |
| year2018    | 0.3357   | 0.3092     | 1.0857   | 0.2776     |
| year2019    | -0.0864  | 0.3094     | -0.2791  | 0.7801     |
| year2020    | 0.7161   | 0.3091     | 2.3169   | 0.0205     |
| year2021    | 1.6672   | 0.3090     | 5.3955   | 0.0000     |
| mon2        | -0.1723  | 0.0091     | -18.9685 | 0.0000     |
| mon3        | -0.0981  | 0.0085     | -11.6109 | 0.0000     |
| mon4        | 0.0206   | 0.0081     | 2.5358   | 0.0112     |
| mon5        | 0.0170   | 0.0080     | 2.1227   | 0.0338     |
| mon6        | -0.1490  | 0.0083     | -17.8593 | 0.0000     |
| mon7        | -0.1143  | 0.0081     | -14.0859 | 0.0000     |
| mon8        | -0.0678  | 0.0081     | -8.4016  | 0.0000     |
| mon9        | 0.0143   | 0.0081     | 1.7628   | 0.0779     |
| mon10       | -0.0106  | 0.0083     | -1.2826  | 0.1996     |
| mon11       | 0.0502   | 0.0086     | 5.8470   | 0.0000     |
| mon12       | -0.0749  | 0.0088     | -8.5281  | 0.0000     |

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 4: 202107 Summary of Sunspot Numbers

| year         | mon            | day           | obs              | sidc           |
|--------------|----------------|---------------|------------------|----------------|
| Min. :2008   | Min. : 1.000   | Min. : 0.00   | Length:144079    | 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 : 6.537   | Mean :15.72   |                  | Mean :0.2524   |
| 3rd Qu.:2019 | 3rd Qu.: 9.000 | 3rd Qu.:23.00 |                  | 3rd Qu.:1.0000 |
| Max. :2021   | Max. :12.000   | Max. :31.00   |                  | Max. :1.0000   |

Table 5: 202107 Summary of Sunspot Numbers

| g              | s              | w             | see              | method           |
|----------------|----------------|---------------|------------------|------------------|
| Min. : 0.000   | Min. : 0.00    | Min. : 0.0    | Length:144079    | Length:144079    |
| 1st Qu.: 0.000 | 1st Qu.: 0.00  | 1st Qu.: 0.0  | Class :character | Class :character |
| Median : 2.000 | Median : 7.00  | Median : 26.0 | Mode :character  | Mode :character  |
| Mean : 2.645   | Mean : 15.45   | Mean : 41.9   |                  |                  |
| 3rd Qu.: 4.000 | 3rd Qu.: 23.00 | 3rd Qu.: 67.0 |                  |                  |
| Max. :19.000   | Max. :204.00   | Max. :317.0   |                  |                  |

Table 6: 202107 Summary of Sunspot Numbers

| inst             | filter           | unit             |
|------------------|------------------|------------------|
| Length:144079    | Length:144079    | Length:144079    |
| Class :character | Class :character | Class :character |
| Mode :character  | Mode :character  | Mode :character  |

Table 7: 202107 Summary of Sunspot Numbers

| aperture     | eyep           | foclen         | mag           |
|--------------|----------------|----------------|---------------|
| Min. : 0     | Min. : 0.00    | Min. : 0.0     | Min. : 0.0    |
| 1st Qu.: 60  | 1st Qu.: 4.00  | 1st Qu.: 34.0  | 1st Qu.: 40.0 |
| Median : 80  | Median : 14.00 | Median : 910.0 | Median : 57.5 |
| Mean : 91    | Mean : 33.21   | Mean : 885.3   | Mean : 182.3  |
| 3rd Qu.: 104 | 3rd Qu.: 23.00 | 3rd Qu.:1200.0 | 3rd Qu.: 76.0 |
| Max. :1524   | Max. :2010.00  | Max. :9990.0   | Max. :4591.0  |

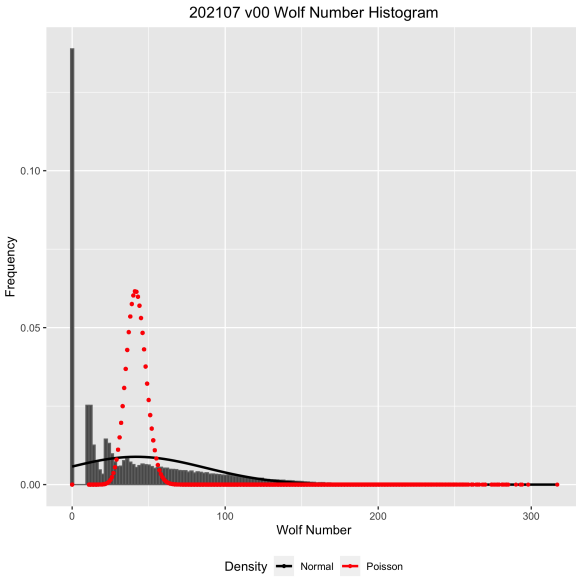


Figure 3: Box plots of raw Wolf number ( $w$ ) by observer rank.

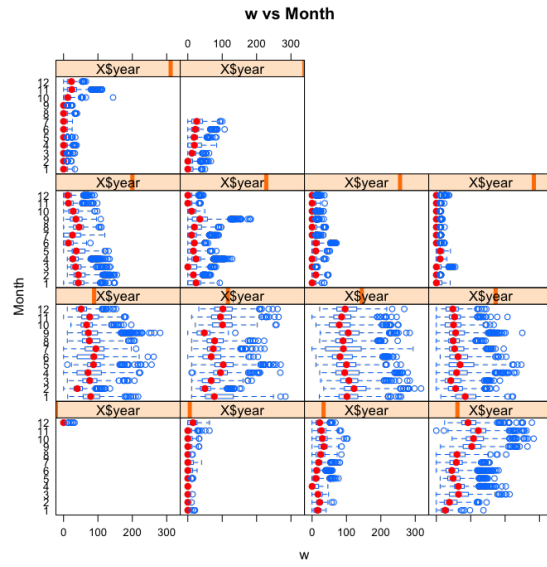


Figure 4: Box plots of raw Wolf number ( $w$ ) by month and year.

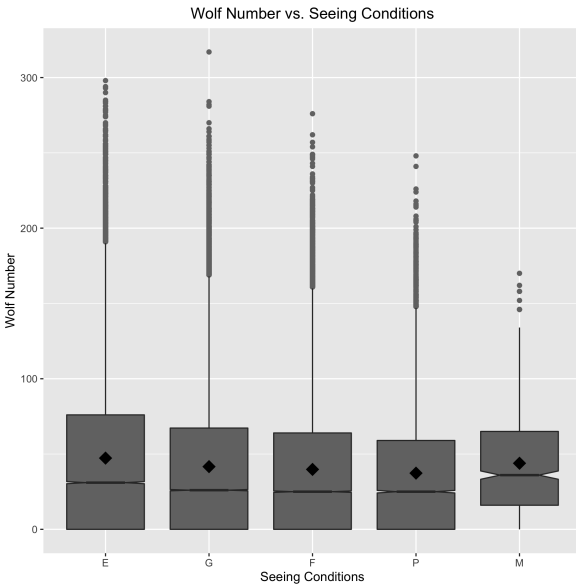


Figure 5: Box plots of raw Wolf number ( $w$ ) by seeing condition.

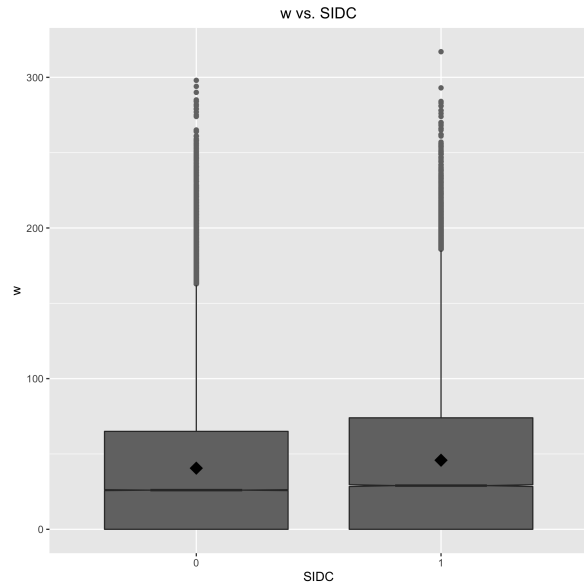


Figure 6: Box plots of raw Wolf number ( $w$ ) by organization.

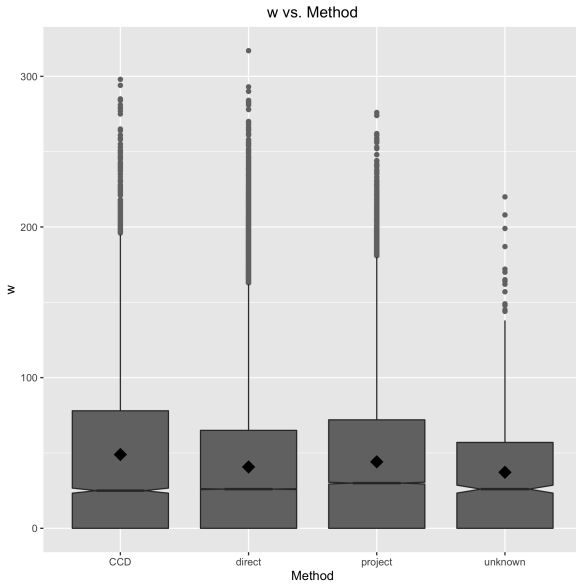


Figure 7: Box plots of raw Wolf number ( $w$ ) by observer rank.

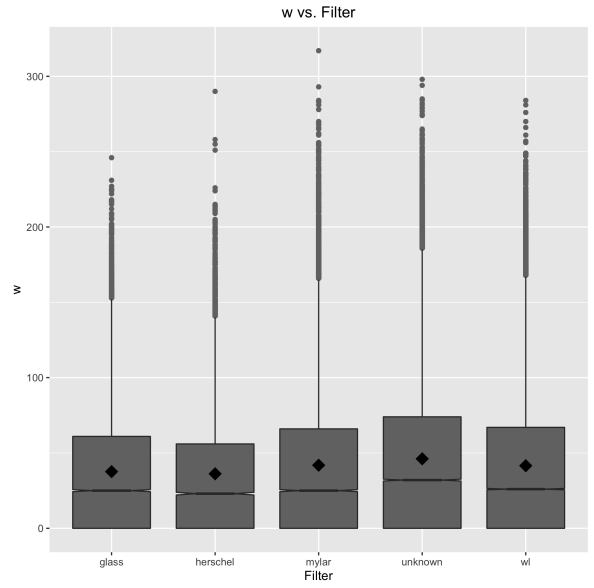


Figure 8: Box plots of raw Wolf number ( $w$ ) by month and year.

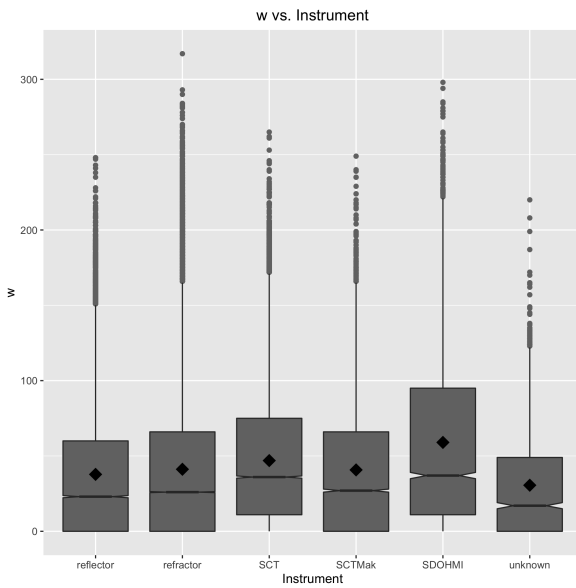


Figure 9: Box plots of raw Wolf number ( $w$ ) by seeing condition.

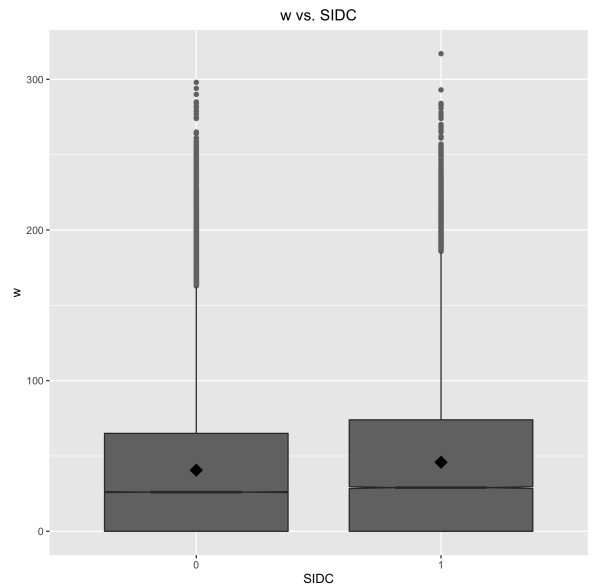


Figure 10: Box plots of raw Wolf number ( $w$ ) by organization.



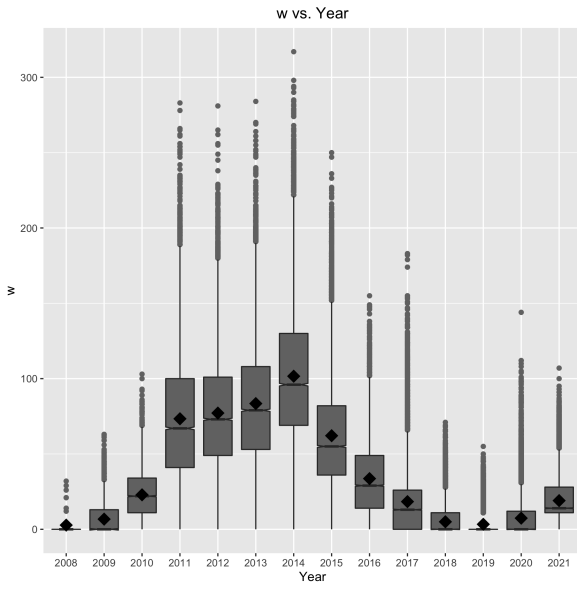


Figure 11: Box plots of raw Wolf number ( $w$ ) by year.

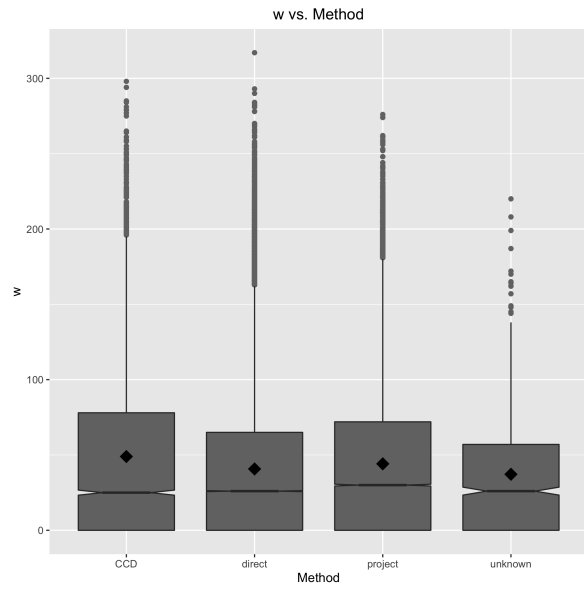


Figure 12: Box plots of raw Wolf number ( $w$ ) by observing method.