# *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 Three groups this month on June 20th.

Michel Deconinck (DMIB) captures three groups with 18 sunspots for a Wolf number of 48 on June 20, 2018.

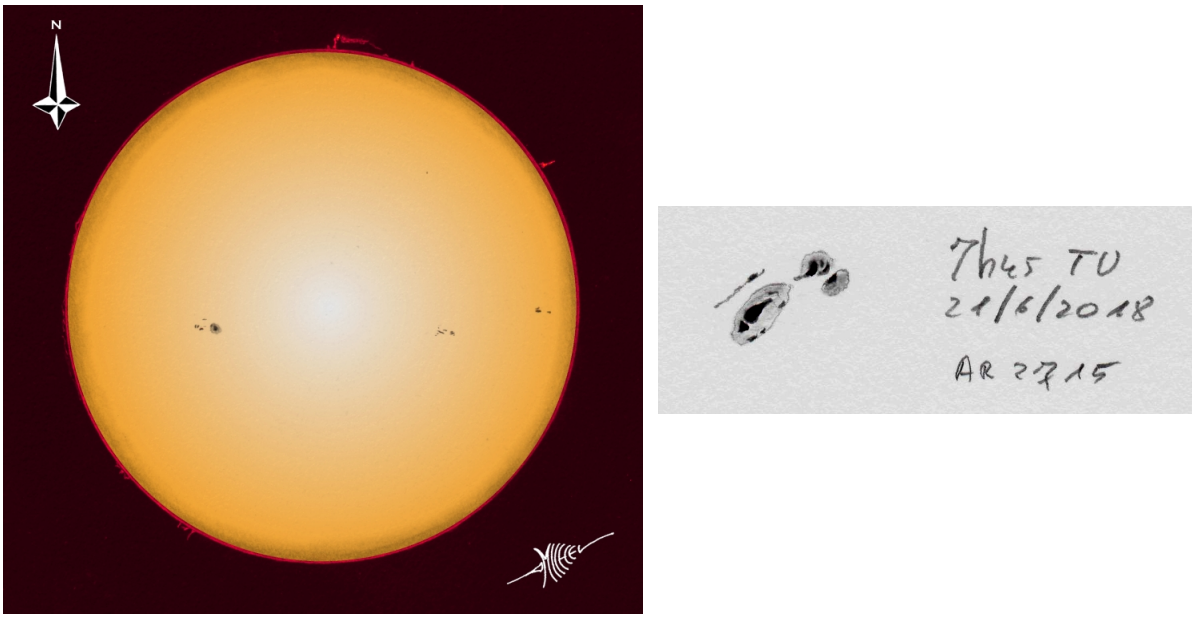


Figure 1: I did this sketch-watercolor on white paper. For the white light (disk) a Bresser refractor 102/1000 mm via a glass objective filter and a zoom eyepiece, mainly at 50x, and for the H-alpha via my mini Lunt (35mm) (left panel).

# 2 Sudden Ionospheric Disturbance (SID) Report

## 2.1 SID Records

June 2018 (Figure 2): There were 4 B class GOES events recorded on the 20th of June. There were no SID Events recorded in the ionosphere for June 20th. Also, NPM in Hawaii went down on the 8th of June and was down for the entire month.

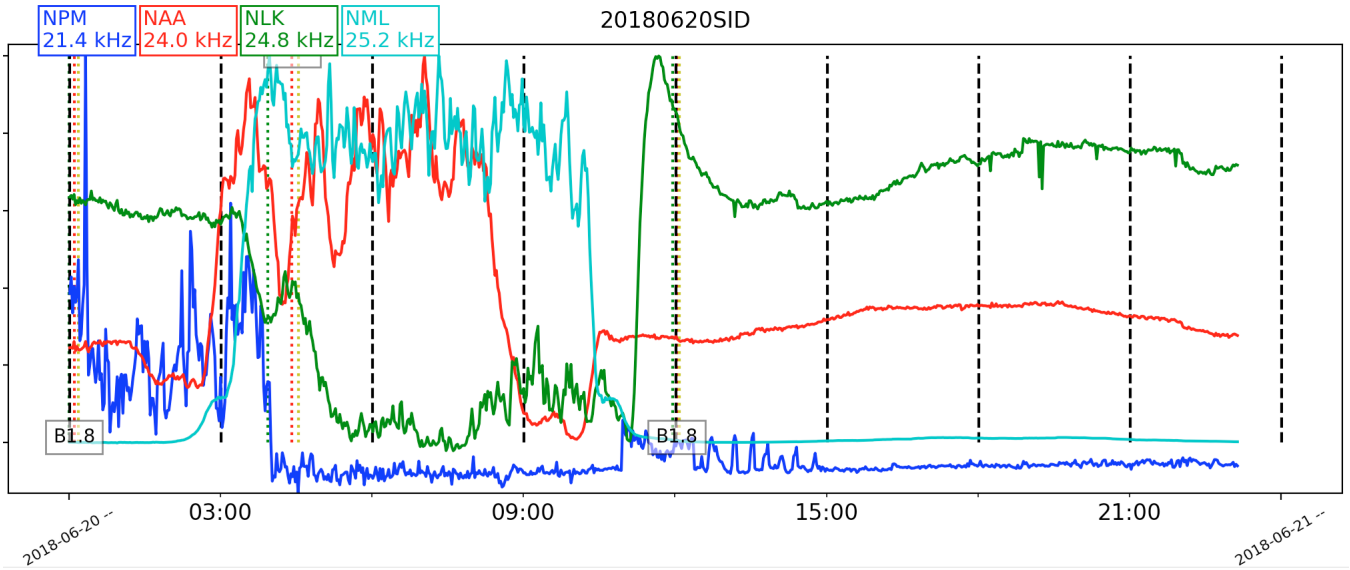


Figure 2: VLF recording at Fort Collins, Colorado.

## 2.2 SID Observers

In June 2018 we had 15 AAVSO SID observers who submitted VLF data as listed in Table 1. Observers monitor from one to three stations to provide SID data.

Figure 3 depicts the importance rating of the solar events. The durations 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.

## 2.3 Solar Flare Summary from GOES-15 Data

In June 2018, there were 52 solar flares measured by GOES-15 for June, 2018: Two C class and 50 B class flares. More flaring occurred this month compared to last with only 7 days of no reports from the GOES satellite, although mostly all the flares were from B class (see Figure 4).


Figure 3: Solar Events Y-axis, Importance Rating X-axis.

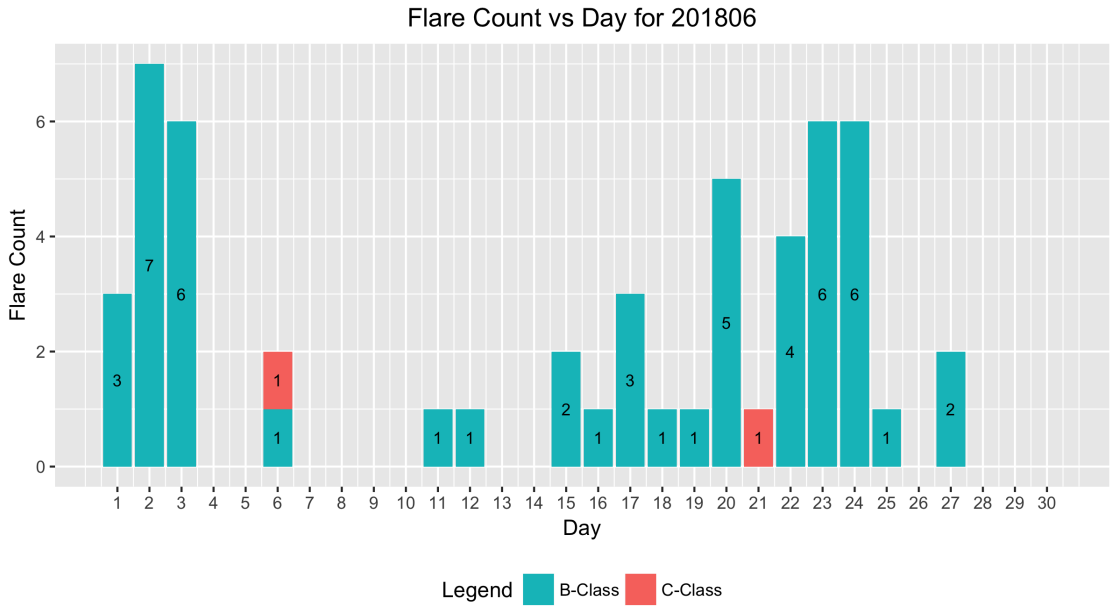


Figure 4: GOES - 15 XRA flares

Table 1: 201806 VLF Observers

| Observer | Code | Stations |
|---|---|---|
| A McWilliams | A94 | NML |
| R Battaiola | A96 | HWU |
| J Wallace | A97 | NAA |
| L Loudet | A118 | DHO |
| J Godet | A119 | GBZ ICV |
| F Adamson | A122 | NWC |
| S Oatney | A125 | NML |
| J Karlovsky | A131 | DHO ICV |
| R Green | A134 | NWC |
| S Aguirre | A138 | NPM |
| I Ryumshin | A142 | GQD |
| R Rogge | A143 | GQD |
| K Menzies | A146 | NAA |
| R Russel | A147 | NPM |
| L Ferreira | A149 | NWC |

# 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 June 2018. These counts are reported by the day of the month, and are either from data not scrubbed or corrected data.

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.

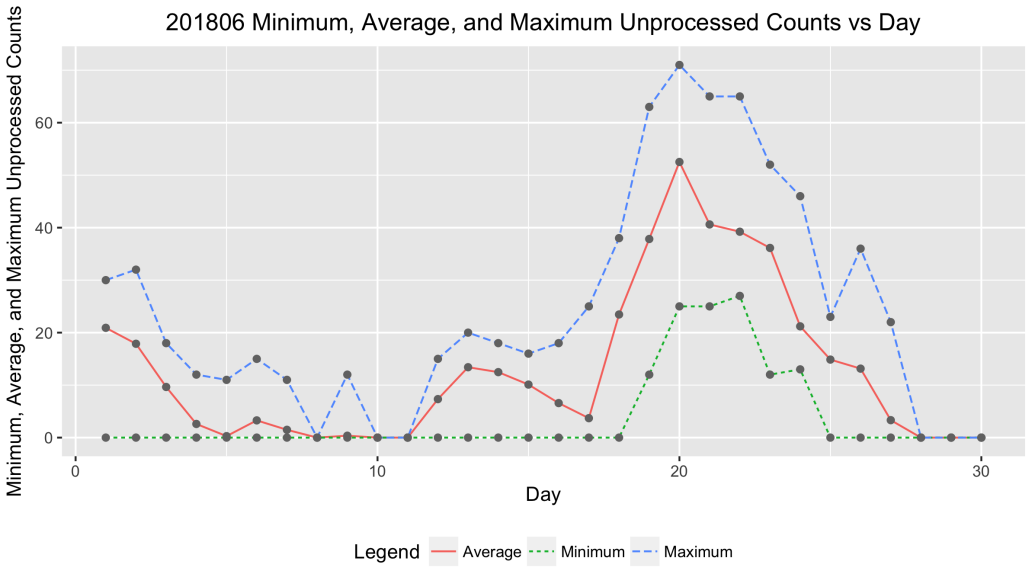


Figure 5: Raw Wolf number average, minimum and maximum by day of the month for all observers.

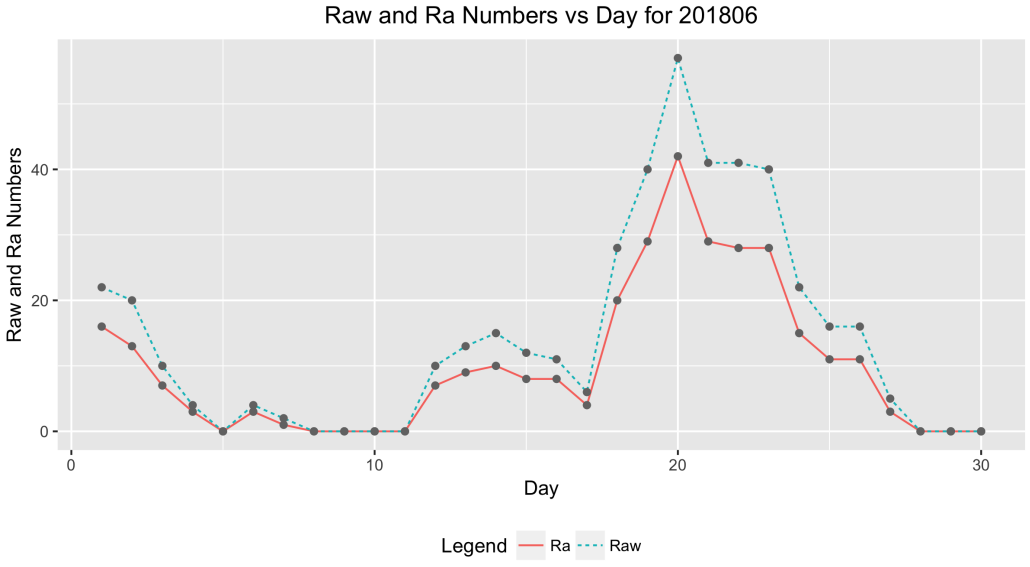


Figure 6: Raw Wolf average and $R_a$ numbers by day of the month for all observers.

### 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 and fixed effects such as seeing condition. The raw Wolf averages and calculated $R_a$ are seen in Figure 6 and Table 2.

Table 2: 201806 American Relative Sunspot Numbers $R_a$

| Day | NumObs | Raw | $R_a$ |
|---|---|---|---|
| 1 | 35 | 22 | 16 |
| 2 | 41 | 20 | 13 |
| 3 | 34 | 10 | 7 |
| 4 | 30 | 4 | 3 |
| 5 | 39 | 0 | 0 |
| 6 | 39 | 4 | 3 |
| 7 | 37 | 2 | 1 |
| 8 | 40 | 0 | 0 |
| 9 | 33 | 0 | 0 |
| 10 | 36 | 0 | 0 |
| 11 | 37 | 0 | 0 |
| 12 | 39 | 10 | 7 |
| 13 | 34 | 13 | 9 |
| 14 | 40 | 15 | 10 |
| 15 | 38 | 12 | 8 |
| 16 | 38 | 11 | 8 |
| 17 | 37 | 6 | 4 |
| 18 | 35 | 28 | 20 |
| 19 | 37 | 40 | 29 |
| 20 | 37 | 57 | 42 |
| 21 | 49 | 41 | 29 |
| 22 | 44 | 41 | 28 |
| 23 | 37 | 40 | 28 |
| 24 | 40 | 22 | 15 |
| 25 | 44 | 16 | 11 |
| 26 | 42 | 16 | 11 |
| 27 | 37 | 5 | 3 |
| 28 | 42 | 0 | 0 |
| 29 | 43 | 0 | 0 |
| 30 | 44 | 0 | 0 |
| Averages | 38.6 | 14.5 | 10.2 |

### 3.3 Sunspot Observers

Table 3 lists the observer code (obs), the number of observations (NumObs) submitted for June 2018, and the observer's name (Name). 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 67 and the total number of observations is 1158.

Table 3: 201806 Number of observations by observer

| Obs | NumObs | Name |
|---|---|---|
| AAX | 7 | Alexandre Amorim |
| AJV | 15 | J. Alonso |
| ARAG | 30 | Gema Araujo |
| ASA | 25 | Salvador Aguirre |
| ATE | 19 | Teofilo Arranz Heras |
| BARH | 10 | Howard Barnes |
| BATR | 11 | Roberto Battaiola |
| BERJ | 28 | Jose Alberto Berdejo |
| BMF | 25 | Michael Boschat |
| BRAD | 25 | David Branchett |
| BRAF | 25 | Raffaello Braga |
| BROB | 29 | Robert Brown |
| BSAB | 18 | Santanu Basu |
| CHAG | 27 | German Morales Chavez |
| CIOA | 17 | Ioannis Chouinavas |
| CKB | 23 | Brian Cudnik |
| CNT | 17 | Dean Chantiles |
| CVJ | 24 | Jose Carvajal |
| DEMF | 11 | Frank Dempsey |
| DJOB | 16 | Jorge del Rosario |
| DMIB | 24 | Michel Deconinck |
| DROB | 9 | Bob Dudley |
| DUBF | 22 | Franky Dubois |
| EHOA | 17 | Howard Eskildsen |
| ERB | 20 | Bob Eramia |
| FERJ | 19 | Javier Ruiz Fernandez |
| FLET | 23 | Tom Fleming |
| FLF | 11 | Fredirico Luiz Funari |
| FTAA | 23 | Tadeusz Figiel |
| FUJK | 21 | K. Fujimori |
| HAYK | 15 | Kim Hay |
| HOWR | 26 | Rodney Howe |
| JDAC | 7 | David Jackson |
| JENS | 3 | Simon Jenner |
| JGE | 4 | Gerardo Jimenez Lopez |
| JPG | 1 | Penko Jordanov |
| KAND | 1 | Kandilli Observatory |
| KAPJ | 25 | John Kaplan |
| KNJS | 30 | James & Shirley Knight |
| KROL | 22 | Larry Krozel |
| LEVM | 15 | Monty Leventhal |
| LKR | 2 | Kristine Larsen |

Continued on next page

Table 3: 201806 Number of observations by observer

| Obs | NumObs | Name |
|---|---|---|
| LRRA | 17 | Robert Little |
| MARE | 11 | Enrico Mariani |
| MCE | 17 | Etsuiku Mochizuki |
| MILJ | 18 | Jay Miller |
| MJAF | 29 | Juan Antonio Moreno Quesada |
| MJHA | 30 | John McCammon |
| MMAE | 3 | Aaron McNeely |
| MUDG | 16 | George Mudry |
| MWU | 13 | Walter Maluf |
| OATS | 2 | Susan Oatney |
| ONJ | 17 | John O'Neill |
| RLM | 14 | Mat Raymonde |
| SDOH | 30 | Solar Dynamics Obs - HMI |
| SMNA | 2 | Michael Stephanou |
| SNE | 5 | Neil Simmons |
| SONA | 17 | Andries Son |
| STAB | 28 | Brian Gordon-States |
| SUZM | 24 | Miyoshi Suzuki |
| TESD | 28 | David Teske |
| TPJB | 1 | Patrick Thibault |
| URBP | 27 | Piotr Urbanski |
| VARG | 26 | A. Gonzalo Vargas |
| VIDD | 7 | Daniel Vidican |
| WCHD | 6 | Charles White |
| WILW | 28 | William M. Wilson |
| Totals | 1158 | 67 |

### 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.

# 4 Endnotes

Reporting Addresses

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

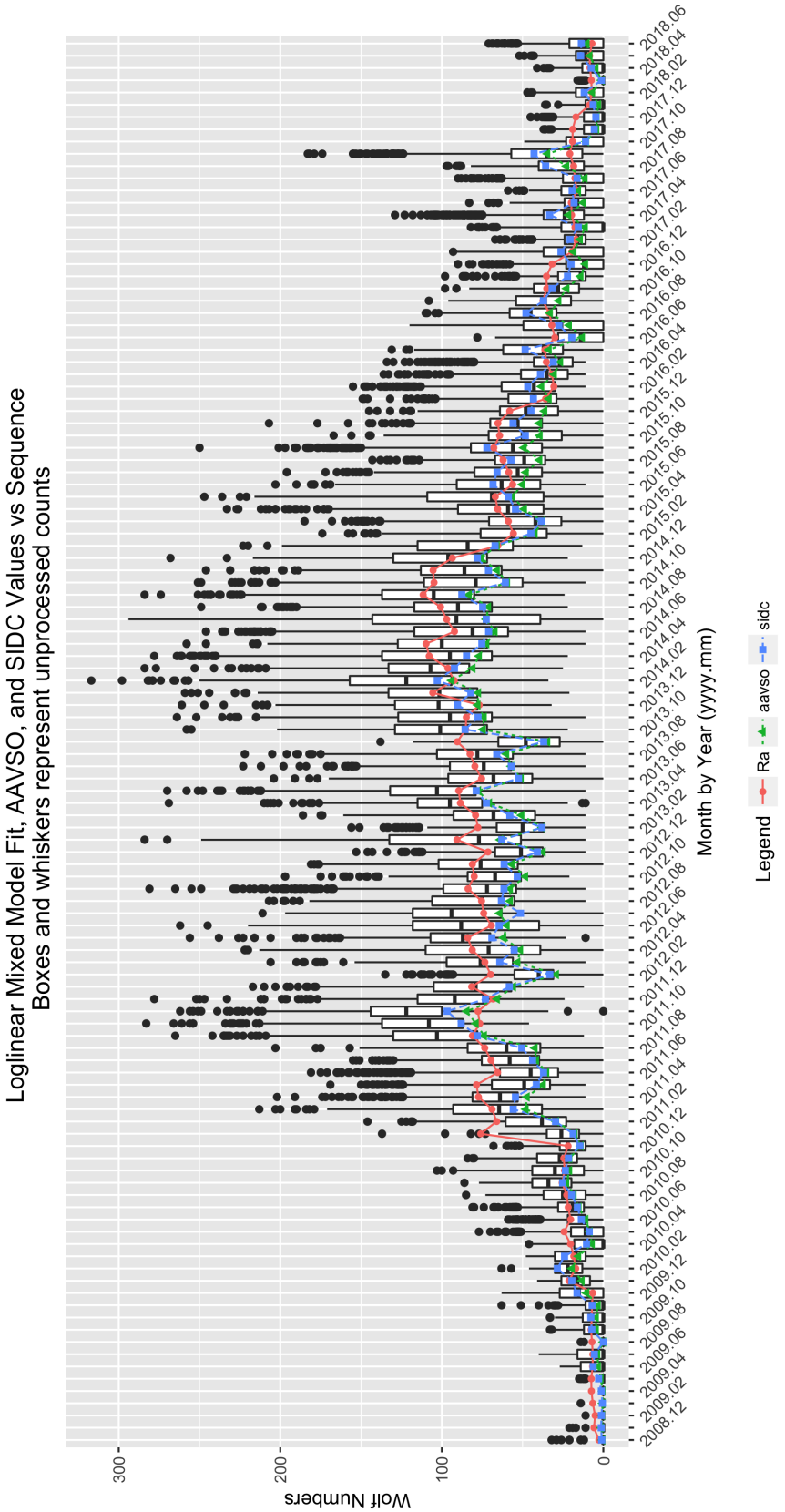


Figure 7: GLMM fitted data for $R_a$. AAVSO data: https://www.aavso.org/category/tags/solar-bulletin. SILSO data: WDC-SILSO, Royal Observatory of Belgium, Brussels