

# Future Solar Activity Estimates for Use in Prediction of Space Environmental Effects on Spacecraft Orbital Lifetime and Performance

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**Jan. 2010**

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## Introduction

The main sources of uncertainty in spacecraft orbital lifetime prediction are estimated future solar radio flux and geomagnetic activity, modeled atmospheric density, and the ballistic factor. The major source of uncertainty in models estimating future atmospheric density at orbital altitude is the solar extreme ultraviolet heat input values. The observed 10.7-cm solar radio flux (not adjusted to 1 AU) is used as a proxy for this most significant input and is the basis for the development of most orbital altitude atmospheric density models in current use for spacecraft orbital lifetime and performance predictions.

## Marshall Solar Activity Future Estimates (MSAFE) Model

Because no generally accepted physical solar model is available to accurately predict future solar activity, the NASA Marshall Space Flight Center (MSFC) developed a 13-month Zurich smoothed solar radio flux ( $\bar{F}_{10.7}$ ) and geomagnetic ( $\bar{A}_p$ ) index intermediate (months) and long-range (years) statistical estimation technique [Niehuss *et al.*, 1996; Vaughan *et al.*, 1999]. The technique is also applicable to the 13-month smoothed sunspot number ( $\bar{R}$ ). The 13-month Zurich smoothing technique is a running average with a 13-month kernel size and the first and thirteenth months given half the weight of the others. This technique was developed by the Swiss Federal Observatory, Zurich, Switzerland [Waldmeier, 1961].

The primary reason for developing the MSFC Solar Activity Future Estimation (MSAFE) model, and for issuing intermediate and long-range solar radio flux and geomagnetic index future estimates, is the need for updated inputs to the upper atmosphere (thermosphere) density models used for spacecraft orbital lifetime predictions and performance requirement analyses [Dreher and Lyons, 1990]. Mission analysis and planning for future spacecraft launches and on-orbit operations require estimates of orbital lifetimes, altitudes, inclinations, and eccentricities as well as various space environment parameters important to selection of materials and parts and equipment design.

The MSFC Solar Activity Future Estimation (MSAFE) linear regression program is a modified McNish-Lincoln model [McNish and Lincoln, 1949; Boykin and Richards, 1966] based on the Lagrangian least-squares statistical technique of Holland and Vaughan [1984]. A detailed explanation of the MSAFE model, its computer program, and modifications that took place in 1995 and 1996 is given by Niehuss *et al.* [1996], copies of which are available on request. This model is built to provide the capability to provide monthly updates of future  $\bar{F}_{10.7}$ ,  $\bar{R}$ , and  $\bar{A}_p$  estimates with associated statistical confidence bounds, i.e. 95 Percentile, etc.

## Observed Data

Generation of the information provided in this report begins each month with the acquisition of recently observed solar activity data. Table 1 contains recent monthly mean observed 10.7 cm solar radio flux, sunspot number, and planetary geomagnetic index values. The information in this table is based upon data from the National Research Council of Canada for the Series C 10.7-cm solar radio flux ( $F_{10.7}$ ) data, the Sunspot Index Data Center Brussels, Belgium for the monthly mean relative

sunspot number ( $R$ ), and the Institute for Geophysics in Gottingen, Germany for the monthly mean geomagnetic index ( $A_p$ ) data as received from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) via their National Geophysical Data Center (NGDC) site. When there is insufficient data at the NGDC site to provide information through the most recently completed month, preliminary values are calculated using daily values from the NOAA Space Environment Center (SEC) and the Sunspot Index Data Center site.

The inputs used by the MSAFE model computer program are databases comprising Lagrangian interpolated  $\bar{F}_{10.7}$  (cycles 1 through 23 converted and observed),  $\bar{R}$  (cycles 1 through 23 observed), and  $\bar{A}_p$  (cycles 13 through 23 converted and observed) and the smoothed values for cycle 24. Table 2 presents 13-month Zurich smoothed values for Cycle 23 and 24 of the observed 10.7 cm solar radio flux, sunspot number, and planetary geomagnetic index values assigned at the midpoint calculated from monthly values in Table 1 .

### Future Estimates

Using these smoothed values as inputs, the MSAFE program estimates the intermediate-term (months) and long-term (years) behavior of  $\bar{F}_{10.7}$ ,  $\bar{R}$ , and  $\bar{A}_p$  for up to 132 months into the future, initialized from a cycle minimum or a cycle maximum. For reports starting with April 2004 and continuing through October 2007, MSAFE was initialized from the cycle 23 maximum determined to be April 2000 indicated by the 13-month smoothed sunspot values. This date was used for  $\bar{F}_{10.7}$ ,  $\bar{R}$ , and  $\bar{A}_p$  predictions. Beginning with the November 2007 report, MSAFE was re-initialized from the cycle 23 maximum using a date determined from a 27-month running mean. This was done to smooth the double peaks observed in the 13-month smoothed values in order to reduce the inconsistency in the dates of cycle maximum for  $\bar{F}_{10.7}$ ,  $\bar{R}$ . The new date used for cycle 23 maximum of  $\bar{F}_{10.7}$ ,  $\bar{R}$  is April 2001. For reports starting with September 2009, MSAFE was initialize using the date of the beginning of cycle 24 determined to be Dec 2008 indicated by the 13-month smoothed sunspot values. This date was used for  $\bar{F}_{10.7}$ ,  $\bar{R}$ , and  $\bar{A}_p$  predictions.

The results of the MSAFE model calculations (i.e. the output data) for solar cycle 24 are reported in Tables 3, 4 and 5<sup>1</sup>. Table 3 contains the statistical estimates of future  $\bar{F}_{10.7}$  and  $\bar{A}_p$  5, 50, and 95 Percentile values for cycle 24. Table 4 contains the statistical estimate of future  $\bar{R}$  and  $\bar{A}_p$  5, 50, and 95 Percentile values for cycle 24. Table 5<sup>1</sup> contains the statistical estimates of 75 Percentile  $\bar{F}_{10.7}$  and 95 Percentile  $\bar{A}_p$  values for cycle 24. The extended statistical characteristics of cycle 25 are included to permit use of the information in long range spacecraft programs planning and analysis.

The computer program's input and output data are also depicted in graphical form. Figures 1 and 2 illustrate the inputs and application of the MSAFE model to the 10.7-cm solar radio flux. Figure 1 is a plot of monthly mean and 13-month Zurich smoothed observed 10.7-cm solar radio flux for solar cycle 23. Figure 2 is a plot of the statistical estimates of future 13-month Zurich smoothed 10.7-cm solar radio flux for solar cycles 24 and 25. Similarly, Figures 3 and 4 demonstrate inputs and application of the MSAFE algorithm to sunspot number. Figure 3 is a plot of the monthly mean and 13-month Zurich smoothed observed sunspot number for solar cycle 23. Figure 4 is a plot of the statistical estimates of future 13-month Zurich smoothed relative sunspot number for solar cycles 24 and 25. Figure 5<sup>1</sup> is a plot of monthly mean and 13-month Zurich smoothed observed 10.7-cm solar

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<sup>1</sup> Table 5, Figure 5 and Figure 6 were added in June 2002 on the request of the NASA/JSC Vehicle Integration Performance and Resources (VIPeR) team.

radio flux for solar cycle 23. Figure 6 is a plot of the statistical estimates of future 13-month Zurich smoothed 75 Percentile 10.7-cm solar radio flux for solar cycles 24 and 25.

It should be noted that the cycle 25, 5, 50, and 95 Percentile values are the statistical evaluation of the past 23 cycles and are not influenced by the MSAFE model's performance. Cycle 25 values are estimated using statistics for cycles 1 through 23 for  $\bar{F}_{10.7}$  and  $\bar{R}$ , and statistics for cycles 13 through 23 are used for  $\bar{A}_p$ . The 50 percentile values in Tables 3 and 4 and in Figures 3 and 4, at and beyond the beginning of cycle 25, are computed arithmetic means and are given with 95 Percentile and 5 Percentile values. Since the planetary geomagnetic data are only available for solar cycles 13 through 23 to produce the statistics, the small sample size requires that the 95 Percentile and 5 Percentile values for the  $\bar{A}_p$  are only approximations. The mean solar cycle period of 11 years (132 months) is assumed for the period of cycles 24 and 25 based on the nominal solar cycle period from past records.

## Applications

General. The observed and predicted solar activity information presented in this report is provided as input data for atmospheric and space environment models to ensure compatibility between calculations made for prediction of environmental effects on spacecraft orbital lifetime and performance, e.g. ambient density, ionosphere plasma density, cosmic ray flux, etc. The Marshall Engineering Thermosphere Model [Hickey, 1988a, 1988b], as well as the NASA/MSFC Global Reference Atmospheric Model-1999 Version [Justus et al., 1999], were developed on the basis of inputs of the daily 10.7-cm solar radio flux ( $F_{10.7}$ ) and the 3-hourly planetary geomagnetic index ( $a_p$ ) to compute atmospheric density. Some ionosphere models, such as the International Reference Ionosphere (IRI) and the Fully Analytical Ionospheric Model (FAIM), and newly emerging cosmic ray models utilize sunspot number ( $R$ ) inputs. Therefore, the statistical estimates produced by the MSAFE model provide future 13-month smoothed values of the smoothed sunspot number ( $R$ ).

Changes of thermospheric and ionospheric density associated with short-term (days) variations in  $F_{10.7}$ ,  $R$ , and  $A_p$ , required as inputs to the thermospheric and ionospheric models, are not represented by the 13-month Zurich smoothed statistical estimates of these parameters as provided by the MSAFE model and reported in this document. Future estimates of this dynamic component of the solar activity cannot be made with any acceptable degree of statistical confidence using existing techniques, so estimates from the MSAFE model represent the best information available for computing future orbital altitude atmospheric density and space environment parameters. Representative data sets, based on past  $F_{10.7}$ ,  $R$ , and  $A_p$  values, may be utilized to compute the effects of the dynamic component on the ambient densities, etc. at orbital altitudes.

Design Requirements. Design requirements for solar activity and associated values of atmospheric space environment parameters are specified in the appropriate spacecraft and space vehicle project design requirements documentation. These documents should be consulted for this information. For spacecraft projects requiring minimum risk design for lifetime orbital altitude(s), re-boost activities, and control capability, the envelopes of 95 percentile estimates of future smoothed solar radio flux ( $\bar{F}_{10.7}$ ) and geomagnetic index ( $\bar{A}_p$ ) that are recommended. These estimates permit statistically conservative spacecraft design and mission planning. Critical project considerations such as orbital lifetime predictions should be based on the most current MSAFE model intermediate and long-range statistical estimates of future solar and geophysical data that are

consistent with the critical project development and operational decision time points prior to the planned launch of the spacecraft.

**Additional Information**

Questions on the contents of this report may be addressed to Ron Suggs ([ron.suggs@nasa.gov](mailto:ron.suggs@nasa.gov)).

**Customer Feedback**

Marshall Space Flight Center's ISO 9000 process solicits customer feedback on all of our products. Please send an email to Dr. Rob Suggs ([Rob.M.Suggs@nasa.gov](mailto:Rob.M.Suggs@nasa.gov)) regarding the clarity and operational usefulness of this estimate.

## References

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**TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES**

| <b>Year</b> | <b>Month</b> | <b>Solar Flux<br/>(F<sub>10.7</sub> (Series C))</b> | <b>Relative Sunspot<br/>Numbers (R)</b> | <b>Geomagnetic<br/>Index (A<sub>p</sub>)</b> |
|-------------|--------------|---|---|--|
| 2005        | January      | 102.2   | 31.3                                    | 24.0   |
|             | February     | 97.2  | 29.2                                    | 11.0   |
|             | March        | 89.9  | 24.5                                    | 12.0   |
|             | April        | 86.0  | 24.2                                    | 11.0   |
|             | May          | 99.5  | 42.7                                    | 19.0   |
|             | June         | 93.7  | 39.3                                    | 12.0   |
|             | July         | 96.5  | 40.1                                    | 14.0   |
|             | August       | 90.5  | 36.4                                    | 14.0   |
|             | September    | 91.1  | 21.9                                    | 20.0   |
|             | October      | 76.6  | 8.7                                     | 8.0  |
|             | November     | 86.2  | 18.0                                    | 8.0  |
|             | December     | 90.7  | 41.1                                    | 9.0  |
| 2006        | January      | 83.4  | 15.3                                    | 6.0  |
|             | February     | 76.5  | 4.9                                     | 5.0  |
|             | March        | 75.5  | 10.6                                    | 8.0  |
|             | April        | 89.0  | 30.2                                    | 11.0   |
|             | May          | 80.9  | 22.2                                    | 7.0  |
|             | June         | 76.5  | 13.9                                    | 7.0  |
|             | July         | 75.8  | 12.2                                    | 7.0  |
|             | August       | 79.4  | 12.9                                    | 9.0  |
|             | September    | 77.8  | 14.5                                    | 8.0  |
|             | October      | 74.3  | 10.4                                    | 9.0  |
|             | November     | 86.3  | 21.5                                    | 9.0  |
|             | December     | 84.5  | 13.6                                    | 15.0   |
| 2007        | January      | 83.5  | 16.9                                    | 10.0   |
|             | February     | 77.7  | 10.6                                    | 7.0  |
|             | March        | 72.2  | 4.8                                     | 8.0  |
|             | April        | 72.4  | 3.7                                     | 9.0  |
|             | May          | 74.5  | 11.7                                    | 8.0  |
|             | June         | 73.7  | 12.0                                    | 6.0  |
|             | July         | 71.6  | 10.0                                    | 7.0  |
|             | August       | 69.2  | 6.2                                     | 6.0  |
|             | September    | 67.1  | 2.4                                     | 9.0  |
|             | October      | 67.5  | 0.9                                     | 9.0  |
|             | November     | 69.6  | 1.7                                     | 7.0  |
|             | December     | 78.2  | 10.1                                    | 6.0  |

Solar flux in units of  $10^4$  JANSKY (where one JANSKY equals  $10^{-26}$  W m<sup>-2</sup> Hz<sup>-1</sup> Bandwidth)

\* Preliminary Estimates

**TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES**

| <b>Year</b> | <b>Month</b> | <b>Solar Flux<br/>(F<sub>10.7</sub> (Series C))</b> | <b>Relative Sunspot<br/>Numbers (R)</b> | <b>Geomagnetic<br/>Index (A<sub>p</sub>)</b> |
|-------------|--------------|---|---|--|
| 2008        | January      | 74.0  | 3.4                                     | 8.0  |
|             | February     | 71.0  | 2.1                                     | 11.0   |
|             | March        | 73.0  | 9.3                                     | 11.0   |
|             | April        | 70.2  | 2.9                                     | 9.0  |
|             | May          | 68.3  | 2.9                                     | 6.0  |
|             | June         | 65.9  | 3.1                                     | 7.0  |
|             | July         | 65.8  | 0.5                                     | 5.0  |
|             | August       | 66.4  | 0.5                                     | 5.0  |
|             | September    | 67.1  | 1.1                                     | 6.0  |
|             | October      | 68.3  | 2.9                                     | 7.0  |
|             | November     | 68.6  | 4.1                                     | 4.0  |
|             | December     | 69.2  | 0.8                                     | 4.0  |
| 2009        | January      | 69.8  | 1.5                                     | 4.0  |
|             | February     | 70.1  | 1.4                                     | 5.0  |
|             | March        | 69.2  | 0.7                                     | 5.0  |
|             | April        | 69.7  | 1.2                                     | 4.0  |
|             | May          | 70.5  | 2.9                                     | 4.0  |
|             | June         | 68.6  | 2.6                                     | 4.0  |
|             | July         | 68.2  | 3.5                                     | 4.0  |
|             | August       | 67.4  | 0.0                                     | 5.0  |
|             | September    | 70.5  | 4.2                                     | 4.0  |
|             | October      | 72.3  | 4.6                                     | 3.0  |
|             | November     | 73.6  | 4.2                                     | 3.0  |
|             | December     | 76.8*   | 10.6*                                   | 1.0*   |

\* Preliminary Estimates



**TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>A_p</math>)</b> |
|-------------|--------------|--|---|--|
| 1990        | January      | 200.3  | 150.6   | 18.6   |
|             | February     | 200.5  | 152.9   | 18.8   |
|             | March        | 198.7  | 152.0   | 18.6   |
|             | April        | 195.6  | 149.3   | 18.2   |
|             | May          | 192.4  | 147.0   | 17.6   |
|             | June         | 189.9  | 143.8   | 16.8   |
|             | July         | 190.4  | 140.6   | 16.2   |
|             | August       | 193.9  | 140.5   | 15.4   |
|             | September    | 198.3  | 142.1   | 15.0   |
|             | October      | 200.6  | 142.1   | 14.8   |
|             | November     | 201.2  | 141.7   | 14.4   |
|             | December     | 202.7  | 143.9   | 15.7   |
| 1991        | January      | 205.5  | 147.6   | 17.4   |
|             | February     | 206.3  | 147.6   | 18.4   |
|             | March        | 205.9  | 146.6   | 19.1   |
|             | April        | 206.8  | 146.5   | 20.0   |
|             | May          | 207.1  | 145.5   | 21.7   |
|             | June         | 207.4  | 145.2   | 23.0   |
|             | July         | 207.7  | 146.3   | 23.6   |
|             | August       | 206.8  | 146.6   | 24.7   |
|             | September    | 203.9  | 144.9   | 25.0   |
|             | October      | 199.7  | 141.7   | 24.2   |
|             | November     | 195.4  | 138.1   | 24.1   |
|             | December     | 188.9  | 131.7   | 23.0   |
| 1992        | January      | 181.8  | 123.7   | 21.1   |
|             | February     | 174.8  | 115.4   | 19.8   |
|             | March        | 168.5  | 108.2   | 19.4   |
|             | April        | 162.9  | 103.3   | 18.9   |
|             | May          | 158.9  | 100.3   | 17.5   |
|             | June         | 154.3  | 97.1  | 16.6   |
|             | July         | 146.7  | 90.7  | 16.6   |
|             | August       | 138.9  | 84.0  | 16.1   |
|             | September    | 133.8  | 79.5  | 15.9   |
|             | October      | 130.5  | 76.4  | 16.7   |
|             | November     | 128.2  | 74.4  | 16.6   |
|             | December     | 127.4  | 73.2  | 16.1   |

\* Preliminary Estimates

**TABLE 2 : 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>\bar{A}_p</math>)</b> |
|-------------|--------------|--|---|--|
| 1993        | January      | 125.7  | 71.4  | 16.0   |
|             | February     | 123.1  | 69.3  | 15.9   |
|             | March        | 120.7  | 66.6  | 15.3   |
|             | April        | 118.1  | 63.6  | 14.9   |
|             | May          | 114.8  | 59.9  | 14.9   |
|             | June         | 111.3  | 56.1  | 15.0   |
|             | July         | 109.6  | 54.7  | 14.9   |
|             | August       | 107.6  | 52.3  | 15.4   |
|             | September    | 103.9  | 48.4  | 16.0   |
|             | October      | 100.4  | 44.9  | 16.4   |
|             | November     | 97.5   | 41.2  | 17.4   |
|             | December     | 94.8   | 38.4  | 18.1   |
| 1994        | January      | 92.7   | 36.6  | 18.2   |
|             | February     | 91.2   | 34.8  | 18.1   |
|             | March        | 90.2   | 34.1  | 17.8   |
|             | April        | 89.3   | 33.7  | 18.0   |
|             | May          | 88.1   | 32.5  | 18.3   |
|             | June         | 86.7   | 30.8  | 18.2   |
|             | July         | 84.5   | 28.5  | 18.1   |
|             | August       | 82.5   | 26.8  | 17.5   |
|             | September    | 81.7   | 26.6  | 16.5   |
|             | October      | 81.4   | 26.5  | 15.5   |
|             | November     | 81.2   | 26.2  | 14.7   |
|             | December     | 81.0   | 25.6  | 14.3   |
| 1995        | January      | 80.6   | 24.2  | 14.0   |
|             | February     | 80.2   | 23.0  | 14.0   |
|             | March        | 79.9   | 22.1  | 14.0   |
|             | April        | 79.2   | 20.6  | 13.8   |
|             | May          | 78.5   | 19.2  | 13.4   |
|             | June         | 77.7   | 18.2  | 13.0   |
|             | July         | 76.9   | 17.0  | 12.6   |
|             | August       | 76.0   | 15.4  | 12.2   |
|             | September    | 74.8   | 13.4  | 11.8   |
|             | October      | 73.8   | 12.1  | 11.5   |
|             | November     | 73.2   | 11.4  | 10.8   |
|             | December     | 72.8   | 10.8  | 10.0   |

\* Preliminary Estimates

**TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>A_p</math>)</b> |
|-------------|--------------|--|---|--|
| 1996        | January      | 72.4   | 10.4  | 9.7  |
|             | February     | 72.2   | 10.1  | 9.7  |
|             | March        | 72.1   | 9.7   | 9.8  |
|             | April        | 71.6   | 8.4   | 9.7  |
|             | May          | 71.4   | 8.0   | 9.5  |
|             | June         | 71.8   | 8.5   | 9.4  |
|             | July         | 72.0   | 8.4   | 9.3  |
|             | August       | 72.1   | 8.3   | 9.4  |
|             | September    | 72.3   | 8.4   | 9.3  |
|             | October      | 72.6   | 8.8   | 9.1  |
|             | November     | 73.0   | 9.8   | 9.1  |
|             | December     | 73.3   | 10.4  | 9.2  |
| 1997        | January      | 73.4   | 10.5  | 9.3  |
|             | February     | 73.7   | 11.0  | 9.2  |
|             | March        | 75.1   | 13.5  | 8.9  |
|             | April        | 76.8   | 16.5  | 8.6  |
|             | May          | 78.4   | 18.3  | 8.6  |
|             | June         | 80.1   | 20.3  | 8.6  |
|             | July         | 81.8   | 22.6  | 8.5  |
|             | August       | 83.4   | 25.0  | 8.3  |
|             | September    | 85.7   | 28.3  | 8.4  |
|             | October      | 88.6   | 31.8  | 8.6  |
|             | November     | 91.3   | 35.0  | 9.0  |
|             | December     | 94.2   | 39.0  | 9.5  |
| 1998        | January      | 97.5   | 43.7  | 9.9  |
|             | February     | 101.7  | 48.9  | 10.5   |
|             | March        | 105.8  | 53.4  | 11.1   |
|             | April        | 108.9  | 56.5  | 11.3   |
|             | May          | 112.0  | 59.4  | 11.6   |
|             | June         | 115.8  | 62.5  | 12.0   |
|             | July         | 120.0  | 65.5  | 12.2   |
|             | August       | 124.1  | 67.8  | 12.5   |
|             | September    | 126.8  | 69.5  | 12.7   |
|             | October      | 127.9  | 70.5  | 12.8   |
|             | November     | 130.0  | 73.0  | 12.5   |
|             | December     | 134.3  | 77.9  | 12.0   |

\* Preliminary Estimates

**TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>\bar{A}_p</math>)</b> |
|-------------|--------------|--|---|--|
| 1999        | January      | 139.0  | 82.6  | 11.8   |
|             | February     | 142.6  | 84.6  | 11.6   |
|             | March        | 144.0  | 83.8  | 11.8   |
|             | April        | 145.8  | 85.5  | 12.2   |
|             | May          | 149.9  | 90.5  | 12.4   |
|             | June         | 152.9  | 93.1  | 12.4   |
|             | July         | 154.4  | 94.3  | 12.6   |
|             | August       | 156.3  | 97.5  | 12.9   |
|             | September    | 161.0  | 102.3   | 12.8   |
|             | October      | 167.2  | 107.8   | 12.7   |
|             | November     | 171.5  | 111.0   | 13.1   |
|             | December     | 173.4  | 111.1   | 13.8   |
| 2000        | January      | 175.5  | 112.9   | 14.5   |
|             | February     | 176.8  | 116.8   | 15.0   |
|             | March        | 178.4  | 119.9   | 15.0   |
|             | April        | 180.5  | 120.8   | 14.9   |
|             | May          | 180.1  | 119.0   | 15.0   |
|             | June         | 179.7  | 118.7   | 15.0   |
|             | July         | 180.2  | 119.8   | 14.7   |
|             | August       | 179.5  | 118.6   | 14.2   |
|             | September    | 177.1  | 116.3   | 14.2   |
|             | October      | 175.6  | 114.5   | 15.0   |
|             | November     | 173.8  | 112.7   | 15.1   |
|             | December     | 172.1  | 112.0   | 14.7   |
| 2001        | January      | 168.7  | 108.7   | 14.0   |
|             | February     | 165.6  | 104.0   | 13.3   |
|             | March        | 167.8  | 104.8   | 12.8   |
|             | April        | 171.6  | 107.5   | 12.5   |
|             | May          | 174.7  | 108.6   | 12.5   |
|             | June         | 178.7  | 109.8   | 12.4   |
|             | July         | 183.8  | 111.7   | 12.4   |
|             | August       | 188.7  | 113.6   | 13.0   |
|             | September    | 191.3  | 114.1   | 12.7   |
|             | October      | 191.9  | 114.0   | 12.1   |
|             | November     | 193.6  | 115.5   | 12.0   |
|             | December     | 193.8  | 114.6   | 12.4   |

\* Preliminary Estimates

**TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>A_p</math>)</b> |
|-------------|--------------|--|---|--|
| 2002        | January      | 194.6  | 113.5   | 12.3   |
|             | February     | 197.2  | 114.6   | 13.1   |
|             | March        | 195.7  | 113.3   | 12.2   |
|             | April        | 191.5  | 110.5   | 12.5   |
|             | May          | 188.0  | 108.8   | 12.7   |
|             | June         | 182.9  | 106.2   | 12.9   |
|             | July         | 176.3  | 102.7   | 13.7   |
|             | August       | 169.5  | 98.7  | 14.2   |
|             | September    | 164.1  | 94.6  | 15.0   |
|             | October      | 159.4  | 90.5  | 15.6   |
|             | November     | 154.1  | 85.2  | 15.8   |
|             | December     | 150.7  | 82.0  | 17.1   |
| 2003        | January      | 148.0  | 80.8  | 18.2   |
|             | February     | 143.6  | 78.3  | 18.9   |
|             | March        | 138.3  | 74.0  | 19.5   |
|             | April        | 135.0  | 70.1  | 20.1   |
|             | May          | 133.1  | 67.6  | 22.0   |
|             | June         | 130.2  | 65.0  | 21.5   |
|             | July         | 127.2  | 61.8  | 22.0   |
|             | August       | 125.2  | 60.0  | 22.2   |
|             | September    | 123.7  | 59.5  | 21.8   |
|             | October      | 121.8  | 58.2  | 21.1   |
|             | November     | 120.1  | 56.7  | 20.0   |
|             | December     | 118.0  | 54.8  | 18.6   |
| 2004        | January      | 116.4  | 52.0  | 18.1   |
|             | February     | 115.5  | 49.3  | 17.7   |
|             | March        | 114.6  | 47.1  | 16.9   |
|             | April        | 112.3  | 45.6  | 15.5   |
|             | May          | 109.3  | 43.8  | 14.3   |
|             | June         | 107.3  | 41.6  | 14.0   |
|             | July         | 106.0  | 40.2  | 13.8   |
|             | August       | 105.1  | 39.2  | 13.8   |
|             | September    | 103.8  | 37.5  | 13.6   |
|             | October      | 102.2  | 35.9  | 13.5   |
|             | November     | 101.6  | 35.3  | 14.0   |
|             | December     | 101.4  | 35.2  | 14.7   |

\* Preliminary Estimates

| <b>TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES</b> |              |  |   |  |
|---|--------------|--|---|--|
| <b>Year</b>                                     | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>A_p</math>)</b> |
| 2005  | January      | 100.3  | 34.6  | 14.1   |
|   | February     | 98.6   | 33.9  | 13.9   |
|   | March        | 97.3   | 33.5  | 14.6   |
|   | April        | 95.5   | 31.6  | 15.1   |
|   | May          | 93.2   | 28.9  | 14.4   |
|   | June         | 91.8   | 28.8  | 13.6   |
|   | July         | 90.9   | 29.1  | 12.8   |
|   | August       | 89.2   | 27.4  | 11.8   |
|   | September    | 87.8   | 25.8  | 11.4   |
|   | October      | 87.3   | 25.5  | 11.3   |
|   | November     | 86.7   | 24.9  | 10.8   |
|   | December     | 85.2   | 23.0  | 10.1   |
| 2006  | January      | 83.6   | 20.8  | 9.6  |
|   | February     | 82.3   | 18.6  | 9.1  |
|   | March        | 81.2   | 17.4  | 8.4  |
|   | April        | 80.6   | 17.1  | 7.9  |
|   | May          | 80.5   | 17.3  | 7.9  |
|   | June         | 80.2   | 16.3  | 8.3  |
|   | July         | 80.0   | 15.3  | 8.7  |
|   | August       | 80.1   | 15.6  | 8.9  |
|   | September    | 80.0   | 15.6  | 8.9  |
|   | October      | 79.1   | 14.2  | 8.8  |
|   | November     | 78.2   | 12.7  | 8.8  |
|   | December     | 77.8   | 12.1  | 8.8  |
| 2007  | January      | 77.5   | 12.0  | 8.7  |
|   | February     | 76.9   | 11.6  | 8.5  |
|   | March        | 76.0   | 10.8  | 8.4  |
|   | April        | 75.3   | 9.9   | 8.4  |
|   | May          | 74.3   | 8.7   | 8.3  |
|   | June         | 73.3   | 7.7   | 7.8  |
|   | July         | 72.7   | 7.0   | 7.3  |
|   | August       | 72.0   | 6.1   | 7.4  |
|   | September    | 71.8   | 5.9   | 7.7  |
|   | October      | 71.7   | 6.1   | 7.8  |
|   | November     | 71.4   | 5.7   | 7.8  |
|   | December     | 70.8   | 5.0   | 7.7  |

\* Preliminary Estimates

**TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES**

| <b>Year</b> | <b>Month</b> | <b>+10.7-cm Solar Flux (<math>\bar{F}_{10.7}</math>)</b> | <b>++Sunspot Numbers (<math>\bar{R}</math>)</b> | <b>+++Geomagnetic Index (<math>\bar{A}_p</math>)</b> |
|-------------|--------------|--|---|--|
| 2008        | January      | 70.0   | 4.2   | 7.7  |
|             | February     | 69.8   | 3.6   | 7.5  |
|             | March        | 69.7   | 3.3   | 7.4  |
|             | April        | 69.8   | 3.3   | 7.3  |
|             | May          | 69.8   | 3.5   | 7.2  |
|             | June         | 69.2   | 3.2   | 7.0  |
|             | July         | 68.8   | 2.7   | 6.8  |
|             | August       | 68.6   | 2.6   | 6.3  |
|             | September    | 68.4   | 2.2   | 5.8  |
|             | October      | 68.2   | 1.8   | 5.4  |
|             | November     | 68.3   | 1.7   | 5.1  |
|             | December     | 68.5   | 1.7   | 4.9  |
| 2009        | January      | 68.7   | 1.8   | 4.7  |
|             | February     | 68.9   | 1.9   | 4.7  |
|             | March        | 69.0   | 2.0   | 4.6  |
|             | April        | 69.3   | 2.2   | 4.3  |
|             | May          | 69.7   | 2.3   | 4.1  |
|             | June         | 70.2   | 2.7   | 4.0  |
|             | July         |  |   |  |
|             | August       |  |   |  |
|             | September    |  |   |  |
|             | October      |  |   |  |
|             | November     |  |   |  |
|             | December     |  |   |  |
| 2010        | January      |  |   |  |
|             | February     |  |   |  |
|             | March        |  |   |  |
|             | April        |  |   |  |
|             | May          |  |   |  |
|             | June         |  |   |  |
|             | July         |  |   |  |
|             | August       |  |   |  |
|             | September    |  |   |  |
|             | October      |  |   |  |
|             | November     |  |   |  |
|             | December     |  |   |  |

NOTES:

+ computed and assigned at the mid-point from the National Research Council of Canada, Ottawa and Penticton Series C observed monthly values as received from the National Geophysical Data Center ftp site.  
 ++ computed and assigned at the mid-point from the Sunspot Index Data Center Brussels, Belgium observed monthly values as received from the National Geophysical Data Center ftp site.  
 +++ computed and assigned at the mid-point from Institute for Geophysics in Gottingen, Germany observed monthly values as received from the National Geophysical Data Center ftp site.

\* Preliminary Estimates

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $\bar{A}_p$ |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
|           |     | 95.0%                            | 50%   | 5.0% |                  | 95.0%                           | 50%  | 5.0% |             |
| 2009.5003 | JUL | 71.3                             | 70.6  | 70.0 | 4.1              | 3.9                             | 3.6  |      |             |
| 2009.5837 | AUG | 72.5                             | 71.1  | 69.7 | 4.3              | 3.6                             | 3.2  |      |             |
| 2009.6670 | SEP | 73.8                             | 71.7  | 69.6 | 4.4              | 3.4                             | 2.9  |      |             |
| 2009.7503 | OCT | 75.8                             | 72.3  | 69.4 | 4.3              | 3.3                             | 2.6  |      |             |
| 2009.8337 | NOV | 78.3                             | 73.0  | 69.5 | 4.6              | 3.3                             | 2.4  |      |             |
| 2009.9170 | DEC | 80.9                             | 74.0  | 69.9 | 4.5              | 2.9                             | 1.8  |      |             |
| 2010.0003 | JAN | 82.7                             | 75.0  | 69.8 | 3.8              | 2.1                             | 0.8  |      |             |
| 2010.0837 | FEB | 85.6                             | 76.2  | 69.4 | 4.0              | 1.8                             | 0.2  |      |             |
| 2010.1670 | MAR | 89.0                             | 77.5  | 69.3 | 4.3              | 1.5                             | -0.6 |      |             |
| 2010.2503 | APR | 92.6                             | 78.9  | 68.9 | 4.5              | 1.1                             | -1.6 |      |             |
| 2010.3337 | MAY | 97.1                             | 80.5  | 68.7 | 5.6              | 1.4                             | -1.8 |      |             |
| 2010.4170 | JUN | 102.1                            | 82.1  | 68.8 | 6.7              | 1.8                             | -1.3 |      |             |
| 2010.5003 | JUL | 105.9                            | 84.0  | 68.9 | 6.9              | 2.0                             | -1.3 |      |             |
| 2010.5837 | AUG | 110.6                            | 86.3  | 69.2 | 6.6              | 1.9                             | -1.5 |      |             |
| 2010.6670 | SEP | 114.7                            | 88.5  | 69.6 | 5.5              | 1.2                             | -2.1 |      |             |
| 2010.7503 | OCT | 118.8                            | 90.7  | 70.3 | 4.4              | 0.7                             | -2.3 |      |             |
| 2010.8337 | NOV | 124.1                            | 93.1  | 71.0 | 3.5              | 0.4                             | -2.3 |      |             |
| 2010.9170 | DEC | 130.4                            | 95.5  | 71.3 | 3.0              | 0.4                             | -2.3 |      |             |
| 2011.0003 | JAN | 136.3                            | 97.9  | 71.1 | 3.0              | 0.6                             | -1.9 |      |             |
| 2011.0837 | FEB | 142.8                            | 100.2 | 71.0 | 4.3              | 1.5                             | -1.0 |      |             |
| 2011.1670 | MAR | 150.3                            | 102.6 | 70.9 | 5.3              | 2.5                             | -0.3 |      |             |
| 2011.2503 | APR | 157.7                            | 105.2 | 71.4 | 5.2              | 2.9                             | -0.1 |      |             |
| 2011.3337 | MAY | 162.4                            | 107.9 | 72.7 | 5.6              | 3.3                             | 0.0  |      |             |
| 2011.4170 | JUN | 164.9                            | 110.3 | 74.4 | 6.4              | 3.7                             | -0.2 |      |             |
| 2011.5003 | JUL | 167.4                            | 112.6 | 75.5 | 7.1              | 3.9                             | -0.5 |      |             |
| 2011.5837 | AUG | 169.5                            | 114.5 | 75.3 | 7.5              | 4.4                             | -0.3 |      |             |
| 2011.6670 | SEP | 173.9                            | 116.4 | 75.5 | 8.4              | 5.1                             | 0.2  |      |             |
| 2011.7503 | OCT | 180.0                            | 118.7 | 77.0 | 9.6              | 5.9                             | 0.9  |      |             |
| 2011.8337 | NOV | 184.7                            | 121.2 | 77.8 | 10.8             | 6.6                             | 1.2  |      |             |
| 2011.9170 | DEC | 187.9                            | 123.6 | 78.2 | 11.5             | 7.1                             | 1.4  |      |             |
| 2012.0003 | JAN | 192.3                            | 125.6 | 79.2 | 12.0             | 7.9                             | 1.6  |      |             |
| 2012.0837 | FEB | 197.0                            | 127.6 | 81.6 | 13.2             | 8.5                             | 2.0  |      |             |
| 2012.1670 | MAR | 200.0                            | 129.3 | 84.8 | 14.0             | 8.9                             | 2.5  |      |             |
| 2012.2503 | APR | 202.4                            | 131.1 | 88.4 | 14.6             | 9.1                             | 2.8  |      |             |
| 2012.3337 | MAY | 204.6                            | 132.5 | 90.8 | 15.4             | 9.0                             | 2.5  |      |             |
| 2012.4170 | JUN | 206.6                            | 133.6 | 91.2 | 16.0             | 9.5                             | 3.0  |      |             |
| 2012.5003 | JUL | 209.8                            | 134.8 | 90.1 | 16.3             | 10.5                            | 4.4  |      |             |
| 2012.5837 | AUG | 213.3                            | 135.6 | 90.0 | 16.9             | 11.4                            | 5.9  |      |             |
| 2012.6670 | SEP | 215.0                            | 136.0 | 90.4 | 16.8             | 11.6                            | 6.6  |      |             |
| 2012.7503 | OCT | 213.8                            | 136.4 | 91.6 | 16.4             | 11.5                            | 6.8  |      |             |
| 2012.8337 | NOV | 213.4                            | 136.9 | 93.3 | 16.6             | 11.6                            | 7.3  |      |             |
| 2012.9170 | DEC | 214.7                            | 137.4 | 95.0 | 16.2             | 11.5                            | 7.2  |      |             |
| 2013.0003 | JAN | 215.2                            | 136.9 | 96.0 | 14.7             | 10.7                            | 6.2  |      |             |
| 2013.0837 | FEB | 212.9                            | 135.9 | 96.6 | 13.4             | 10.2                            | 5.9  |      |             |
| 2013.1670 | MAR | 209.8                            | 135.4 | 97.4 | 11.4             | 8.8                             | 4.8  |      |             |
| 2013.2503 | APR | 206.7                            | 135.5 | 97.1 | 10.3             | 7.3                             | 3.4  |      |             |
| 2013.3337 | MAY | 205.0                            | 135.9 | 95.6 | 10.3             | 6.9                             | 2.7  |      |             |
| 2013.4170 | JUN | 204.9                            | 136.3 | 94.1 | 11.0             | 6.4                             | 1.9  |      |             |
| 2013.5003 | JUL | 204.6                            | 136.5 | 92.2 | 11.4             | 5.9                             | 1.3  |      |             |
| 2013.5837 | AUG | 203.8                            | 136.4 | 89.0 | 11.6             | 5.8                             | 1.3  |      |             |
| 2013.6670 | SEP | 202.6                            | 136.0 | 85.8 | 12.1             | 5.5                             | 1.1  |      |             |
| 2013.7503 | OCT | 202.2                            | 135.4 | 82.3 | 12.2             | 5.4                             | 1.0  |      |             |
| 2013.8337 | NOV | 201.8                            | 135.2 | 80.7 | 12.3             | 6.1                             | 1.8  |      |             |



**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 95.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2013.9170 | DEC | 201.7                            | 135.1 | 79.5 | 12.7               | 6.4                             | 2.3  |      |               |
| 2014.0003 | JAN | 200.8                            | 134.4 | 78.1 | 12.0               | 6.5                             | 3.1  |      |               |
| 2014.0837 | FEB | 197.7                            | 133.2 | 76.8 | 11.2               | 6.8                             | 3.6  |      |               |
| 2014.1670 | MAR | 193.7                            | 131.7 | 74.5 | 11.4               | 7.2                             | 4.1  |      |               |
| 2014.2503 | APR | 190.6                            | 129.8 | 72.9 | 12.8               | 7.9                             | 4.9  |      |               |
| 2014.3337 | MAY | 187.1                            | 127.8 | 70.3 | 13.3               | 8.3                             | 5.2  |      |               |
| 2014.4170 | JUN | 183.0                            | 126.4 | 68.9 | 13.7               | 8.9                             | 5.5  |      |               |
| 2014.5003 | JUL | 179.9                            | 125.1 | 68.4 | 14.2               | 9.3                             | 5.9  |      |               |
| 2014.5837 | AUG | 176.6                            | 123.7 | 68.9 | 12.9               | 8.4                             | 5.2  |      |               |
| 2014.6670 | SEP | 172.8                            | 122.3 | 70.0 | 12.1               | 7.8                             | 4.5  |      |               |
| 2014.7503 | OCT | 170.3                            | 121.4 | 71.3 | 12.7               | 7.8                             | 4.3  |      |               |
| 2014.8337 | NOV | 167.9                            | 120.7 | 72.5 | 12.0               | 7.4                             | 3.8  |      |               |
| 2014.9170 | DEC | 165.8                            | 119.9 | 74.1 | 11.1               | 6.9                             | 3.2  |      |               |
| 2015.0003 | JAN | 163.1                            | 118.7 | 75.8 | 10.5               | 6.6                             | 2.7  |      |               |
| 2015.0837 | FEB | 160.0                            | 117.2 | 76.4 | 10.6               | 7.0                             | 2.6  |      |               |
| 2015.1670 | MAR | 157.6                            | 116.3 | 77.0 | 12.4               | 8.0                             | 3.5  |      |               |
| 2015.2503 | APR | 155.8                            | 115.7 | 77.8 | 13.6               | 8.7                             | 4.2  |      |               |
| 2015.3337 | MAY | 153.6                            | 114.7 | 77.7 | 14.6               | 9.3                             | 4.7  |      |               |
| 2015.4170 | JUN | 150.8                            | 113.4 | 76.8 | 15.3               | 10.0                            | 4.8  |      |               |
| 2015.5003 | JUL | 147.8                            | 112.1 | 77.2 | 15.4               | 10.7                            | 5.5  |      |               |
| 2015.5837 | AUG | 143.7                            | 111.0 | 79.0 | 15.6               | 11.4                            | 6.7  |      |               |
| 2015.6670 | SEP | 139.2                            | 109.7 | 80.2 | 16.0               | 12.0                            | 7.8  |      |               |
| 2015.7503 | OCT | 136.1                            | 108.0 | 79.2 | 17.3               | 12.5                            | 9.0  |      |               |
| 2015.8337 | NOV | 133.8                            | 106.1 | 77.2 | 18.2               | 13.2                            | 10.0 |      |               |
| 2015.9170 | DEC | 132.1                            | 104.4 | 76.1 | 19.0               | 14.2                            | 10.2 |      |               |
| 2016.0003 | JAN | 129.2                            | 102.9 | 75.1 | 20.0               | 14.8                            | 10.5 |      |               |
| 2016.0837 | FEB | 125.8                            | 101.4 | 74.4 | 20.0               | 14.7                            | 10.4 |      |               |
| 2016.1670 | MAR | 122.8                            | 100.0 | 74.5 | 20.2               | 14.6                            | 10.3 |      |               |
| 2016.2503 | APR | 120.6                            | 98.9  | 74.3 | 20.5               | 14.3                            | 10.1 |      |               |
| 2016.3337 | MAY | 119.7                            | 97.8  | 74.1 | 20.6               | 13.8                            | 9.5  |      |               |
| 2016.4170 | JUN | 119.6                            | 96.7  | 74.5 | 20.8               | 13.2                            | 8.3  |      |               |
| 2016.5003 | JUL | 119.9                            | 95.6  | 74.0 | 20.8               | 12.4                            | 6.8  |      |               |
| 2016.5837 | AUG | 119.3                            | 94.5  | 73.5 | 20.6               | 11.5                            | 6.0  |      |               |
| 2016.6670 | SEP | 119.1                            | 93.5  | 72.7 | 20.7               | 11.2                            | 5.5  |      |               |
| 2016.7503 | OCT | 118.1                            | 92.5  | 72.3 | 20.6               | 11.0                            | 5.1  |      |               |
| 2016.8337 | NOV | 115.9                            | 91.7  | 72.2 | 20.0               | 10.4                            | 4.7  |      |               |
| 2016.9170 | DEC | 113.8                            | 91.0  | 71.9 | 19.0               | 9.9                             | 4.4  |      |               |
| 2017.0003 | JAN | 113.1                            | 90.0  | 71.4 | 18.0               | 9.7                             | 4.5  |      |               |
| 2017.0837 | FEB | 112.5                            | 89.2  | 71.0 | 17.4               | 9.9                             | 5.0  |      |               |
| 2017.1670 | MAR | 111.3                            | 88.6  | 70.6 | 17.7               | 10.7                            | 5.7  |      |               |
| 2017.2503 | APR | 109.2                            | 87.9  | 70.7 | 17.6               | 11.1                            | 6.1  |      |               |
| 2017.3337 | MAY | 106.1                            | 86.9  | 70.8 | 18.1               | 11.9                            | 7.0  |      |               |
| 2017.4170 | JUN | 103.2                            | 85.9  | 70.7 | 18.5               | 12.8                            | 8.2  |      |               |
| 2017.5003 | JUL | 101.3                            | 85.1  | 70.5 | 18.8               | 13.4                            | 9.3  |      |               |
| 2017.5837 | AUG | 100.4                            | 84.4  | 70.5 | 18.9               | 13.7                            | 9.9  |      |               |
| 2017.6670 | SEP | 98.5                             | 83.6  | 70.5 | 19.4               | 13.9                            | 10.2 |      |               |
| 2017.7503 | OCT | 96.9                             | 82.5  | 70.2 | 19.8               | 14.1                            | 10.3 |      |               |
| 2017.8337 | NOV | 94.9                             | 81.5  | 70.0 | 20.0               | 14.5                            | 10.3 |      |               |
| 2017.9170 | DEC | 93.9                             | 80.8  | 70.0 | 20.3               | 15.3                            | 10.7 |      |               |
| 2018.0003 | JAN | 93.4                             | 80.1  | 69.9 | 20.8               | 16.5                            | 11.5 |      |               |
| 2018.0837 | FEB | 92.3                             | 79.3  | 69.9 | 21.1               | 17.7                            | 12.2 |      |               |
| 2018.1670 | MAR | 91.0                             | 78.7  | 69.7 | 22.1               | 18.4                            | 12.2 |      |               |
| 2018.2503 | APR | 89.7                             | 78.0  | 69.5 | 22.2               | 18.5                            | 12.1 |      |               |

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 95.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2018.3337 | MAY | 88.4                             | 77.4  | 69.3 | 21.8               | 18.2                            | 11.9 |      |               |
| 2018.4170 | JUN | 87.1                             | 76.8  | 69.1 | 21.0               | 17.7                            | 11.8 |      |               |
| 2018.5003 | JUL | 85.9                             | 76.2  | 68.9 | 20.9               | 17.9                            | 12.5 |      |               |
| 2018.5837 | AUG | 84.7                             | 75.6  | 68.7 | 21.4               | 18.6                            | 13.5 |      |               |
| 2018.6670 | SEP | 83.5                             | 75.0  | 68.5 | 21.9               | 18.9                            | 13.9 |      |               |
| 2018.7503 | OCT | 82.3                             | 74.4  | 68.4 | 22.0               | 18.9                            | 14.1 |      |               |
| 2018.8337 | NOV | 81.2                             | 73.8  | 68.2 | 21.6               | 18.5                            | 13.9 |      |               |
| 2018.9170 | DEC | 80.2                             | 73.3  | 68.0 | 20.4               | 17.4                            | 13.1 |      |               |
| 2019.0003 | JAN | 79.2                             | 72.8  | 67.9 | 19.2               | 16.3                            | 12.3 |      |               |
| 2019.0837 | FEB | 78.2                             | 72.4  | 67.8 | 18.0               | 15.2                            | 11.5 |      |               |
| 2019.1670 | MAR | 77.3                             | 71.9  | 67.6 | 16.9               | 14.2                            | 10.8 |      |               |
| 2019.2503 | APR | 76.5                             | 71.5  | 67.5 | 15.8               | 13.3                            | 10.1 |      |               |
| 2019.3337 | MAY | 75.8                             | 71.1  | 67.4 | 14.8               | 12.4                            | 9.4  |      |               |
| 2019.4170 | JUN | 75.2                             | 70.8  | 67.3 | 13.9               | 11.5                            | 8.8  |      |               |
| 2019.5003 | JUL | 74.6                             | 70.5  | 67.2 | 13.1               | 10.8                            | 8.3  |      |               |
| 2019.5837 | AUG | 74.1                             | 70.3  | 67.1 | 12.4               | 10.2                            | 7.8  |      |               |
| 2019.6670 | SEP | 73.7                             | 70.1  | 67.1 | 11.8               | 9.7                             | 7.5  |      |               |
| 2019.7503 | OCT | 73.4                             | 70.0  | 67.0 | 11.4               | 9.3                             | 7.2  |      |               |
| 2019.8337 | NOV | 73.3                             | 69.9  | 67.0 | 11.1               | 9.0                             | 7.0  |      |               |
| 2019.9170 | DEC | 73.2                             | 69.9  | 67.0 | 11.1               | 9.0                             | 6.9  |      |               |
| 2020.0003 | JAN | 73.3                             | 70.0  | 67.0 | 11.3               | 9.0                             | 6.9  |      |               |
| 2020.0837 | FEB | 74.0                             | 70.3  | 67.1 | 11.6               | 9.2                             | 7.1  |      |               |
| 2020.1670 | MAR | 74.8                             | 70.7  | 67.2 | 11.7               | 9.3                             | 7.4  |      |               |
| 2020.2503 | APR | 75.6                             | 71.0  | 67.2 | 11.9               | 9.4                             | 7.5  |      |               |
| 2020.3337 | MAY | 76.7                             | 71.5  | 67.4 | 12.0               | 9.5                             | 7.5  |      |               |
| 2020.4170 | JUN | 78.2                             | 72.0  | 67.5 | 12.1               | 9.6                             | 7.3  |      |               |
| 2020.5003 | JUL | 79.6                             | 72.6  | 67.6 | 12.2               | 9.7                             | 7.2  |      |               |
| 2020.5837 | AUG | 81.0                             | 73.3  | 67.8 | 12.5               | 9.9                             | 7.1  |      |               |
| 2020.6670 | SEP | 83.3                             | 74.1  | 67.9 | 12.8               | 10.1                            | 7.0  |      |               |
| 2020.7503 | OCT | 86.3                             | 75.1  | 68.0 | 13.2               | 10.5                            | 7.2  |      |               |
| 2020.8337 | NOV | 91.0                             | 76.3  | 68.3 | 13.7               | 10.8                            | 7.6  |      |               |
| 2020.9170 | DEC | 95.4                             | 77.7  | 68.4 | 14.5               | 11.1                            | 7.9  |      |               |
| 2021.0003 | JAN | 98.8                             | 79.2  | 68.4 | 15.7               | 11.4                            | 7.7  |      |               |
| 2021.0837 | FEB | 103.9                            | 80.9  | 68.4 | 16.1               | 11.6                            | 7.7  |      |               |
| 2021.1670 | MAR | 109.8                            | 82.9  | 68.4 | 16.3               | 11.8                            | 7.6  |      |               |
| 2021.2503 | APR | 115.6                            | 85.1  | 68.3 | 16.8               | 12.0                            | 7.6  |      |               |
| 2021.3337 | MAY | 122.9                            | 87.3  | 68.6 | 18.0               | 12.3                            | 7.6  |      |               |
| 2021.4170 | JUN | 131.3                            | 89.9  | 68.7 | 18.9               | 12.6                            | 7.7  |      |               |
| 2021.5003 | JUL | 137.8                            | 92.6  | 68.9 | 19.1               | 12.7                            | 7.7  |      |               |
| 2021.5837 | AUG | 142.5                            | 95.4  | 69.2 | 19.2               | 12.9                            | 7.8  |      |               |
| 2021.6670 | SEP | 146.9                            | 98.2  | 69.2 | 19.0               | 13.1                            | 7.7  |      |               |
| 2021.7503 | OCT | 151.3                            | 101.0 | 69.5 | 18.6               | 13.1                            | 7.7  |      |               |
| 2021.8337 | NOV | 156.2                            | 103.9 | 69.9 | 18.5               | 13.2                            | 7.8  |      |               |
| 2021.9170 | DEC | 161.5                            | 107.0 | 70.6 | 18.9               | 13.4                            | 8.0  |      |               |
| 2022.0003 | JAN | 166.8                            | 110.1 | 70.9 | 18.8               | 13.5                            | 8.2  |      |               |
| 2022.0837 | FEB | 171.3                            | 113.2 | 71.3 | 17.8               | 13.5                            | 8.6  |      |               |
| 2022.1670 | MAR | 177.2                            | 116.5 | 71.5 | 17.9               | 13.7                            | 8.7  |      |               |
| 2022.2503 | APR | 184.7                            | 119.7 | 72.1 | 18.5               | 13.9                            | 8.7  |      |               |
| 2022.3337 | MAY | 189.7                            | 122.9 | 72.9 | 19.1               | 14.2                            | 9.0  |      |               |
| 2022.4170 | JUN | 192.2                            | 125.7 | 73.3 | 19.6               | 14.6                            | 9.4  |      |               |
| 2022.5003 | JUL | 194.8                            | 128.2 | 74.1 | 20.3               | 14.9                            | 9.6  |      |               |
| 2022.5837 | AUG | 197.9                            | 130.5 | 74.7 | 20.3               | 15.1                            | 9.6  |      |               |
| 2022.6670 | SEP | 202.4                            | 132.6 | 75.1 | 20.3               | 15.1                            | 9.8  |      |               |

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 95.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2022.7503 | OCT | 208.5                            | 135.1 | 75.6 | 20.5               | 15.2                            | 10.0 |      |               |
| 2022.8337 | NOV | 212.6                            | 137.7 | 75.9 | 20.8               | 15.4                            | 10.5 |      |               |
| 2022.9170 | DEC | 215.4                            | 140.3 | 76.1 | 21.2               | 15.4                            | 11.1 |      |               |
| 2023.0003 | JAN | 219.9                            | 142.4 | 76.1 | 21.3               | 15.3                            | 11.6 |      |               |
| 2023.0837 | FEB | 224.3                            | 144.3 | 76.0 | 21.4               | 15.1                            | 11.3 |      |               |
| 2023.1670 | MAR | 226.4                            | 146.0 | 76.1 | 21.6               | 15.0                            | 11.2 |      |               |
| 2023.2503 | APR | 227.3                            | 147.7 | 76.6 | 22.0               | 15.0                            | 10.7 |      |               |
| 2023.3337 | MAY | 229.2                            | 149.0 | 76.9 | 22.8               | 14.9                            | 10.2 |      |               |
| 2023.4170 | JUN | 231.4                            | 149.9 | 77.6 | 22.5               | 14.7                            | 9.9  |      |               |
| 2023.5003 | JUL | 234.2                            | 150.8 | 78.9 | 21.3               | 14.5                            | 10.1 |      |               |
| 2023.5837 | AUG | 237.3                            | 151.2 | 79.7 | 20.6               | 14.3                            | 10.1 |      |               |
| 2023.6670 | SEP | 238.6                            | 151.4 | 80.6 | 20.1               | 14.2                            | 10.3 |      |               |
| 2023.7503 | OCT | 236.8                            | 151.7 | 82.2 | 19.6               | 14.1                            | 10.6 |      |               |
| 2023.8337 | NOV | 234.8                            | 151.9 | 83.8 | 19.5               | 14.0                            | 10.6 |      |               |
| 2023.9170 | DEC | 235.8                            | 152.0 | 85.6 | 19.3               | 14.0                            | 10.5 |      |               |
| 2024.0003 | JAN | 236.3                            | 151.2 | 86.4 | 19.1               | 14.2                            | 10.5 |      |               |
| 2024.0837 | FEB | 234.1                            | 149.7 | 87.8 | 18.9               | 14.6                            | 10.5 |      |               |
| 2024.1670 | MAR | 230.9                            | 148.7 | 89.5 | 18.9               | 14.7                            | 10.3 |      |               |
| 2024.2503 | APR | 227.3                            | 148.4 | 90.7 | 19.5               | 14.6                            | 9.8  |      |               |
| 2024.3337 | MAY | 225.6                            | 148.5 | 93.0 | 20.4               | 14.7                            | 10.2 |      |               |
| 2024.4170 | JUN | 226.0                            | 148.9 | 94.2 | 22.0               | 15.0                            | 10.7 |      |               |
| 2024.5003 | JUL | 226.2                            | 149.0 | 95.5 | 23.4               | 15.3                            | 10.7 |      |               |
| 2024.5837 | AUG | 225.0                            | 148.7 | 95.8 | 24.0               | 15.4                            | 10.9 |      |               |
| 2024.6670 | SEP | 223.5                            | 148.1 | 95.4 | 25.1               | 15.7                            | 11.1 |      |               |
| 2024.7503 | OCT | 223.0                            | 147.5 | 95.4 | 25.6               | 15.9                            | 11.3 |      |               |
| 2024.8337 | NOV | 223.0                            | 147.3 | 96.9 | 24.9               | 15.9                            | 11.5 |      |               |
| 2024.9170 | DEC | 222.6                            | 147.2 | 97.7 | 24.8               | 15.9                            | 11.7 |      |               |
| 2025.0003 | JAN | 221.7                            | 146.4 | 97.2 | 23.9               | 15.8                            | 11.9 |      |               |
| 2025.0837 | FEB | 219.4                            | 145.1 | 96.4 | 22.1               | 15.8                            | 11.8 |      |               |
| 2025.1670 | MAR | 216.2                            | 143.5 | 96.3 | 22.4               | 15.9                            | 12.0 |      |               |
| 2025.2503 | APR | 213.5                            | 141.8 | 96.8 | 23.1               | 16.0                            | 11.8 |      |               |
| 2025.3337 | MAY | 210.9                            | 140.1 | 96.3 | 23.1               | 16.0                            | 11.1 |      |               |
| 2025.4170 | JUN | 207.5                            | 138.8 | 95.5 | 22.6               | 16.0                            | 10.8 |      |               |
| 2025.5003 | JUL | 206.4                            | 137.4 | 96.1 | 22.0               | 15.8                            | 10.8 |      |               |
| 2025.5837 | AUG | 204.4                            | 135.6 | 97.1 | 21.9               | 15.8                            | 10.8 |      |               |
| 2025.6670 | SEP | 201.0                            | 133.7 | 96.2 | 22.7               | 16.1                            | 10.8 |      |               |
| 2025.7503 | OCT | 197.5                            | 132.2 | 94.5 | 23.7               | 16.5                            | 10.8 |      |               |
| 2025.8337 | NOV | 195.1                            | 130.9 | 93.8 | 23.9               | 16.7                            | 10.8 |      |               |
| 2025.9170 | DEC | 193.0                            | 129.5 | 93.6 | 23.9               | 17.0                            | 10.7 |      |               |
| 2026.0003 | JAN | 189.1                            | 127.8 | 91.7 | 23.9               | 17.1                            | 10.6 |      |               |
| 2026.0837 | FEB | 184.5                            | 125.9 | 88.3 | 23.5               | 17.2                            | 10.3 |      |               |
| 2026.1670 | MAR | 180.1                            | 124.6 | 87.9 | 22.5               | 17.2                            | 10.5 |      |               |
| 2026.2503 | APR | 176.3                            | 123.5 | 88.7 | 22.7               | 17.2                            | 10.7 |      |               |
| 2026.3337 | MAY | 174.0                            | 122.3 | 87.3 | 23.0               | 17.4                            | 11.4 |      |               |
| 2026.4170 | JUN | 172.1                            | 121.0 | 86.3 | 23.1               | 17.6                            | 11.9 |      |               |
| 2026.5003 | JUL | 167.8                            | 119.3 | 85.7 | 22.5               | 17.8                            | 12.0 |      |               |
| 2026.5837 | AUG | 161.4                            | 117.4 | 84.8 | 21.7               | 17.6                            | 12.1 |      |               |
| 2026.6670 | SEP | 155.5                            | 115.6 | 83.6 | 21.2               | 17.4                            | 12.3 |      |               |
| 2026.7503 | OCT | 151.9                            | 113.7 | 82.5 | 21.7               | 17.0                            | 12.5 |      |               |
| 2026.8337 | NOV | 149.6                            | 111.7 | 82.1 | 21.7               | 16.9                            | 13.3 |      |               |
| 2026.9170 | DEC | 147.1                            | 110.0 | 82.1 | 22.1               | 16.9                            | 13.1 |      |               |
| 2027.0003 | JAN | 144.1                            | 108.6 | 82.0 | 22.6               | 17.0                            | 12.8 |      |               |
| 2027.0837 | FEB | 141.1                            | 107.0 | 80.9 | 22.3               | 16.8                            | 13.1 |      |               |

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
|           |     | 95.0%                            | 50%   | 5.0% | 95.0%                           | 50%  | 5.0% |
| 2027.1670 | MAR | 137.5                            | 105.5 | 80.5 | 22.4                            | 16.5 | 12.7 |
| 2027.2503 | APR | 133.8                            | 104.0 | 80.6 | 22.7                            | 16.2 | 12.5 |
| 2027.3337 | MAY | 129.6                            | 102.5 | 80.0 | 22.9                            | 15.8 | 12.1 |
| 2027.4170 | JUN | 123.6                            | 100.9 | 79.1 | 23.5                            | 15.6 | 11.2 |
| 2027.5003 | JUL | 119.4                            | 99.4  | 77.7 | 24.1                            | 15.4 | 10.5 |
| 2027.5837 | AUG | 118.6                            | 98.2  | 75.6 | 24.8                            | 15.3 | 10.7 |
| 2027.6670 | SEP | 118.7                            | 97.1  | 74.5 | 25.3                            | 15.3 | 10.8 |
| 2027.7503 | OCT | 119.2                            | 96.1  | 74.0 | 25.6                            | 15.3 | 10.6 |
| 2027.8337 | NOV | 119.6                            | 95.2  | 73.6 | 25.4                            | 15.3 | 10.8 |
| 2027.9170 | DEC | 118.8                            | 94.2  | 73.4 | 24.9                            | 15.2 | 11.0 |
| 2028.0003 | JAN | 117.4                            | 92.9  | 73.0 | 24.0                            | 15.0 | 11.1 |
| 2028.0837 | FEB | 115.8                            | 91.7  | 72.7 | 23.0                            | 14.9 | 11.3 |
| 2028.1670 | MAR | 113.7                            | 90.7  | 71.9 | 22.5                            | 15.0 | 11.2 |
| 2028.2503 | APR | 110.2                            | 89.6  | 71.4 | 22.1                            | 15.1 | 11.1 |
| 2028.3337 | MAY | 105.8                            | 88.4  | 71.0 | 21.8                            | 15.2 | 11.2 |
| 2028.4170 | JUN | 103.2                            | 87.3  | 70.7 | 21.4                            | 15.3 | 11.4 |
| 2028.5003 | JUL | 101.6                            | 86.5  | 70.4 | 20.7                            | 15.2 | 11.5 |
| 2028.5837 | AUG | 100.2                            | 85.6  | 70.5 | 19.9                            | 14.9 | 11.3 |
| 2028.6670 | SEP | 98.1                             | 84.7  | 70.3 | 20.0                            | 14.7 | 11.1 |
| 2028.7503 | OCT | 96.6                             | 83.5  | 69.8 | 20.1                            | 14.6 | 10.8 |
| 2028.8337 | NOV | 94.6                             | 82.4  | 69.6 | 19.9                            | 14.3 | 10.1 |
| 2028.9170 | DEC | 93.5                             | 81.7  | 69.5 | 19.5                            | 14.2 | 9.6  |
| 2029.0003 | JAN | 93.2                             | 81.0  | 69.4 | 19.0                            | 14.1 | 9.1  |
| 2029.0837 | FEB | 92.3                             | 80.3  | 69.3 | 18.3                            | 14.1 | 8.6  |
| 2029.1670 | MAR | 91.3                             | 79.6  | 69.1 | 17.3                            | 14.0 | 8.0  |
| 2029.2503 | APR | 90.5                             | 78.9  | 68.8 | 17.4                            | 13.8 | 7.5  |
| 2029.3337 | MAY | 89.7                             | 78.2  | 68.5 | 17.5                            | 13.7 | 7.6  |
| 2029.4170 | JUN | 88.7                             | 77.5  | 68.3 | 17.6                            | 13.7 | 7.8  |
| 2029.5003 | JUL | 87.7                             | 77.0  | 68.4 | 17.5                            | 13.6 | 8.3  |
| 2029.5837 | AUG | 86.9                             | 76.5  | 68.4 | 17.7                            | 13.5 | 8.6  |
| 2029.6670 | SEP | 85.5                             | 75.9  | 68.5 | 18.1                            | 13.4 | 8.5  |
| 2029.7503 | OCT | 84.1                             | 75.4  | 68.4 | 17.9                            | 13.2 | 8.6  |
| 2029.8337 | NOV | 82.2                             | 74.9  | 68.4 | 17.6                            | 12.9 | 8.5  |
| 2029.9170 | DEC | 79.9                             | 74.2  | 68.3 | 17.3                            | 12.6 | 8.5  |
| 2030.0003 | JAN | 78.4                             | 73.5  | 68.0 | 16.3                            | 12.2 | 8.4  |
| 2030.0837 | FEB | 77.5                             | 72.8  | 67.8 | 14.8                            | 11.8 | 8.4  |
| 2030.1670 | MAR | 77.0                             | 72.3  | 67.6 | 13.8                            | 11.4 | 8.3  |
| 2030.2503 | APR | 76.9                             | 72.0  | 67.6 | 13.9                            | 11.0 | 8.2  |
| 2030.3337 | MAY | 76.6                             | 71.6  | 67.5 | 13.6                            | 10.6 | 8.2  |
| 2030.4170 | JUN | 76.5                             | 71.2  | 67.2 | 13.2                            | 10.3 | 7.9  |
| 2030.5003 | JUL | 76.1                             | 70.9  | 67.1 | 12.9                            | 9.9  | 7.4  |
| 2030.5837 | AUG | 75.1                             | 70.6  | 67.1 | 12.6                            | 9.7  | 7.1  |
| 2030.6670 | SEP | 74.2                             | 70.3  | 67.0 | 11.9                            | 9.5  | 7.3  |
| 2030.7503 | OCT | 74.0                             | 70.1  | 67.0 | 11.4                            | 9.4  | 7.1  |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A<sub>p</sub> FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE |      |      | ( $\bar{R}$ ) | GEOMAGNETIC INDEX<br>PERCENTILE |      |  | ( $\bar{A}_p$ ) |
|-----------|-----|------------------------------|------|------|---------------|---------------------------------|------|--|-----------------|
|           |     | 95.0%                        | 50%  | 5.0% | 95.0%         | 50%                             | 5.0% |  |                 |
| 2009.5003 | JUL | 4.1                          | 3.1  | 1.4  | 4.1           | 3.9                             | 3.6  |  |                 |
| 2009.5837 | AUG | 6.7                          | 3.7  | 0.6  | 4.3           | 3.6                             | 3.2  |  |                 |
| 2009.6670 | SEP | 9.8                          | 4.2  | 0.1  | 4.4           | 3.4                             | 2.9  |  |                 |
| 2009.7503 | OCT | 11.9                         | 4.7  | 0.1  | 4.3           | 3.3                             | 2.6  |  |                 |
| 2009.8337 | NOV | 13.7                         | 5.1  | 0.0  | 4.6           | 3.3                             | 2.4  |  |                 |
| 2009.9170 | DEC | 15.8                         | 5.7  | 0.0  | 4.5           | 2.9                             | 1.8  |  |                 |
| 2010.0003 | JAN | 17.8                         | 6.6  | 0.0  | 3.8           | 2.1                             | 0.8  |  |                 |
| 2010.0837 | FEB | 20.3                         | 7.3  | 0.0  | 4.0           | 1.8                             | 0.2  |  |                 |
| 2010.1670 | MAR | 24.4                         | 8.4  | 0.0  | 4.3           | 1.5                             | -0.6 |  |                 |
| 2010.2503 | APR | 28.9                         | 9.9  | 0.0  | 4.5           | 1.1                             | -1.6 |  |                 |
| 2010.3337 | MAY | 34.7                         | 11.2 | 0.0  | 5.6           | 1.4                             | -1.8 |  |                 |
| 2010.4170 | JUN | 41.3                         | 12.4 | 0.0  | 6.7           | 1.8                             | -1.3 |  |                 |
| 2010.5003 | JUL | 48.1                         | 14.5 | 0.0  | 6.9           | 2.0                             | -1.3 |  |                 |
| 2010.5837 | AUG | 54.5                         | 17.0 | 0.0  | 6.6           | 1.9                             | -1.5 |  |                 |
| 2010.6670 | SEP | 60.4                         | 19.5 | 0.0  | 5.5           | 1.2                             | -2.1 |  |                 |
| 2010.7503 | OCT | 66.5                         | 22.1 | 0.0  | 4.4           | 0.7                             | -2.3 |  |                 |
| 2010.8337 | NOV | 73.7                         | 24.3 | 0.0  | 3.5           | 0.4                             | -2.3 |  |                 |
| 2010.9170 | DEC | 81.6                         | 26.4 | 0.0  | 3.0           | 0.4                             | -2.3 |  |                 |
| 2011.0003 | JAN | 88.6                         | 28.7 | 0.0  | 3.0           | 0.6                             | -1.9 |  |                 |
| 2011.0837 | FEB | 94.8                         | 30.8 | 0.0  | 4.3           | 1.5                             | -1.0 |  |                 |
| 2011.1670 | MAR | 101.8                        | 32.8 | 0.0  | 5.3           | 2.5                             | -0.3 |  |                 |
| 2011.2503 | APR | 109.3                        | 35.3 | 0.0  | 5.2           | 2.9                             | -0.1 |  |                 |
| 2011.3337 | MAY | 113.5                        | 37.3 | 0.0  | 5.6           | 3.3                             | 0.0  |  |                 |
| 2011.4170 | JUN | 115.4                        | 39.3 | 0.6  | 6.4           | 3.7                             | -0.2 |  |                 |
| 2011.5003 | JUL | 118.3                        | 41.3 | 0.9  | 7.1           | 3.9                             | -0.5 |  |                 |
| 2011.5837 | AUG | 121.0                        | 42.8 | 0.0  | 7.5           | 4.4                             | -0.3 |  |                 |
| 2011.6670 | SEP | 124.9                        | 44.4 | 0.2  | 8.4           | 5.1                             | 0.2  |  |                 |
| 2011.7503 | OCT | 130.5                        | 46.4 | 2.0  | 9.6           | 5.9                             | 0.9  |  |                 |
| 2011.8337 | NOV | 134.9                        | 48.6 | 3.4  | 10.8          | 6.6                             | 1.2  |  |                 |
| 2011.9170 | DEC | 137.7                        | 51.2 | 4.3  | 11.5          | 7.1                             | 1.4  |  |                 |
| 2012.0003 | JAN | 142.5                        | 54.1 | 6.9  | 12.0          | 7.9                             | 1.6  |  |                 |
| 2012.0837 | FEB | 148.1                        | 56.6 | 10.5 | 13.2          | 8.5                             | 2.0  |  |                 |
| 2012.1670 | MAR | 151.5                        | 58.7 | 14.2 | 14.0          | 8.9                             | 2.5  |  |                 |
| 2012.2503 | APR | 154.4                        | 60.8 | 15.8 | 14.6          | 9.1                             | 2.8  |  |                 |
| 2012.3337 | MAY | 157.6                        | 62.6 | 16.3 | 15.4          | 9.0                             | 2.5  |  |                 |
| 2012.4170 | JUN | 160.4                        | 64.4 | 15.9 | 16.0          | 9.5                             | 3.0  |  |                 |
| 2012.5003 | JUL | 162.8                        | 66.3 | 16.0 | 16.3          | 10.5                            | 4.4  |  |                 |
| 2012.5837 | AUG | 165.2                        | 68.5 | 18.0 | 16.9          | 11.4                            | 5.9  |  |                 |
| 2012.6670 | SEP | 167.5                        | 70.5 | 19.8 | 16.8          | 11.6                            | 6.6  |  |                 |
| 2012.7503 | OCT | 167.0                        | 71.2 | 20.9 | 16.4          | 11.5                            | 6.8  |  |                 |
| 2012.8337 | NOV | 166.4                        | 72.0 | 22.5 | 16.6          | 11.6                            | 7.3  |  |                 |
| 2012.9170 | DEC | 167.9                        | 73.1 | 24.1 | 16.2          | 11.5                            | 7.2  |  |                 |
| 2013.0003 | JAN | 168.5                        | 73.3 | 24.7 | 14.7          | 10.7                            | 6.2  |  |                 |
| 2013.0837 | FEB | 166.7                        | 73.5 | 25.1 | 13.4          | 10.2                            | 5.9  |  |                 |
| 2013.1670 | MAR | 164.1                        | 74.8 | 26.4 | 11.4          | 8.8                             | 4.8  |  |                 |
| 2013.2503 | APR | 161.5                        | 76.4 | 28.9 | 10.3          | 7.3                             | 3.4  |  |                 |
| 2013.3337 | MAY | 160.0                        | 77.0 | 30.8 | 10.3          | 6.9                             | 2.7  |  |                 |
| 2013.4170 | JUN | 159.5                        | 77.0 | 31.2 | 11.0          | 6.4                             | 1.9  |  |                 |
| 2013.5003 | JUL | 158.9                        | 77.2 | 31.6 | 11.4          | 5.9                             | 1.3  |  |                 |
| 2013.5837 | AUG | 158.6                        | 77.8 | 32.4 | 11.6          | 5.8                             | 1.3  |  |                 |
| 2013.6670 | SEP | 158.1                        | 78.0 | 33.7 | 12.1          | 5.5                             | 1.1  |  |                 |
| 2013.7503 | OCT | 157.5                        | 77.7 | 32.6 | 12.2          | 5.4                             | 1.0  |  |                 |
| 2013.8337 | NOV | 157.7                        | 76.9 | 30.5 | 12.3          | 6.1                             | 1.8  |  |                 |
| 2013.9170 | DEC | 157.4                        | 76.7 | 29.7 | 12.7          | 6.4                             | 2.3  |  |                 |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A<sub>p</sub> FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | SUNSPOT NUMBER |      |      | $\bar{R}$ | GEOMAGNETIC INDEX |      |  | $\bar{A}_p$ |
|-----------|-----|----------------|------|------|-----------|-------------------|------|--|-------------|
|           |     | PERCENTILE     |      |      |           | PERCENTILE        |      |  |             |
|           |     | 95.0%          | 50%  | 5.0% | 95.0%     | 50%               | 5.0% |  |             |
| 2014.0003 | JAN | 156.4          | 76.5 | 30.2 | 12.0      | 6.5               | 3.1  |  |             |
| 2014.0837 | FEB | 153.3          | 75.5 | 29.5 | 11.2      | 6.8               | 3.6  |  |             |
| 2014.1670 | MAR | 148.5          | 73.1 | 27.1 | 11.4      | 7.2               | 4.1  |  |             |
| 2014.2503 | APR | 144.8          | 71.1 | 24.7 | 12.8      | 7.9               | 4.9  |  |             |
| 2014.3337 | MAY | 141.2          | 69.6 | 22.6 | 13.3      | 8.3               | 5.2  |  |             |
| 2014.4170 | JUN | 136.4          | 67.9 | 20.6 | 13.7      | 8.9               | 5.5  |  |             |
| 2014.5003 | JUL | 132.8          | 66.1 | 19.5 | 14.2      | 9.3               | 5.9  |  |             |
| 2014.5837 | AUG | 129.4          | 64.4 | 19.0 | 12.9      | 8.4               | 5.2  |  |             |
| 2014.6670 | SEP | 126.3          | 63.8 | 19.7 | 12.1      | 7.8               | 4.5  |  |             |
| 2014.7503 | OCT | 124.0          | 63.9 | 21.4 | 12.7      | 7.8               | 4.3  |  |             |
| 2014.8337 | NOV | 120.7          | 63.6 | 22.9 | 12.0      | 7.4               | 3.8  |  |             |
| 2014.9170 | DEC | 118.1          | 62.4 | 23.8 | 11.1      | 6.9               | 3.2  |  |             |
| 2015.0003 | JAN | 115.9          | 61.6 | 23.9 | 10.5      | 6.6               | 2.7  |  |             |
| 2015.0837 | FEB | 113.5          | 61.2 | 24.4 | 10.6      | 7.0               | 2.6  |  |             |
| 2015.1670 | MAR | 111.5          | 60.3 | 23.1 | 12.4      | 8.0               | 3.5  |  |             |
| 2015.2503 | APR | 108.9          | 59.2 | 21.5 | 13.6      | 8.7               | 4.2  |  |             |
| 2015.3337 | MAY | 106.0          | 58.1 | 20.7 | 14.6      | 9.3               | 4.7  |  |             |
| 2015.4170 | JUN | 102.2          | 56.8 | 19.8 | 15.3      | 10.0              | 4.8  |  |             |
| 2015.5003 | JUL | 98.0           | 55.8 | 19.0 | 15.4      | 10.7              | 5.5  |  |             |
| 2015.5837 | AUG | 95.6           | 54.9 | 18.6 | 15.6      | 11.4              | 6.7  |  |             |
| 2015.6670 | SEP | 90.5           | 53.6 | 18.2 | 16.0      | 12.0              | 7.8  |  |             |
| 2015.7503 | OCT | 85.1           | 51.7 | 17.9 | 17.3      | 12.5              | 9.0  |  |             |
| 2015.8337 | NOV | 80.4           | 49.6 | 17.6 | 18.2      | 13.2              | 10.0 |  |             |
| 2015.9170 | DEC | 78.2           | 47.2 | 16.3 | 19.0      | 14.2              | 10.2 |  |             |
| 2016.0003 | JAN | 76.3           | 45.1 | 15.2 | 20.0      | 14.8              | 10.5 |  |             |
| 2016.0837 | FEB | 73.8           | 43.6 | 14.8 | 20.0      | 14.7              | 10.4 |  |             |
| 2016.1670 | MAR | 71.1           | 42.2 | 13.0 | 20.2      | 14.6              | 10.3 |  |             |
| 2016.2503 | APR | 69.1           | 41.3 | 10.6 | 20.5      | 14.3              | 10.1 |  |             |
| 2016.3337 | MAY | 67.1           | 40.6 | 9.1  | 20.6      | 13.8              | 9.5  |  |             |
| 2016.4170 | JUN | 66.8           | 40.0 | 8.6  | 20.8      | 13.2              | 8.3  |  |             |
| 2016.5003 | JUL | 65.4           | 38.7 | 7.8  | 20.8      | 12.4              | 6.8  |  |             |
| 2016.5837 | AUG | 65.4           | 37.6 | 7.2  | 20.6      | 11.5              | 6.0  |  |             |
| 2016.6670 | SEP | 64.5           | 36.5 | 6.3  | 20.7      | 11.2              | 5.5  |  |             |
| 2016.7503 | OCT | 62.2           | 35.0 | 5.2  | 20.6      | 11.0              | 5.1  |  |             |
| 2016.8337 | NOV | 61.6           | 34.0 | 4.8  | 20.0      | 10.4              | 4.7  |  |             |
| 2016.9170 | DEC | 61.4           | 33.3 | 4.5  | 19.0      | 9.9               | 4.4  |  |             |
| 2017.0003 | JAN | 60.7           | 32.8 | 4.5  | 18.0      | 9.7               | 4.5  |  |             |
| 2017.0837 | FEB | 59.6           | 32.4 | 4.9  | 17.4      | 9.9               | 5.0  |  |             |
| 2017.1670 | MAR | 57.5           | 31.9 | 5.0  | 17.7      | 10.7              | 5.7  |  |             |
| 2017.2503 | APR | 54.2           | 31.2 | 5.5  | 17.6      | 11.1              | 6.1  |  |             |
| 2017.3337 | MAY | 50.5           | 30.0 | 5.8  | 18.1      | 11.9              | 7.0  |  |             |
| 2017.4170 | JUN | 47.5           | 28.8 | 5.5  | 18.5      | 12.8              | 8.2  |  |             |
| 2017.5003 | JUL | 48.5           | 28.3 | 5.7  | 18.8      | 13.4              | 9.3  |  |             |
| 2017.5837 | AUG | 47.9           | 27.7 | 6.1  | 18.9      | 13.7              | 9.9  |  |             |
| 2017.6670 | SEP | 44.9           | 26.1 | 5.9  | 19.4      | 13.9              | 10.2 |  |             |
| 2017.7503 | OCT | 42.1           | 24.4 | 5.4  | 19.8      | 14.1              | 10.3 |  |             |
| 2017.8337 | NOV | 40.4           | 23.3 | 5.1  | 20.0      | 14.5              | 10.3 |  |             |
| 2017.9170 | DEC | 39.5           | 22.1 | 4.8  | 20.3      | 15.3              | 10.7 |  |             |
| 2018.0003 | JAN | 37.2           | 20.6 | 4.2  | 20.8      | 16.5              | 11.5 |  |             |
| 2018.0837 | FEB | 34.4           | 19.1 | 3.5  | 21.1      | 17.7              | 12.2 |  |             |
| 2018.1670 | MAR | 31.7           | 17.9 | 2.6  | 22.1      | 18.4              | 12.2 |  |             |
| 2018.2503 | APR | 30.3           | 17.0 | 2.4  | 22.2      | 18.5              | 12.1 |  |             |
| 2018.3337 | MAY | 28.9           | 16.2 | 2.2  | 21.8      | 18.2              | 11.9 |  |             |
| 2018.4170 | JUN | 27.5           | 15.4 | 2.0  | 21.0      | 17.7              | 11.8 |  |             |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A<sub>p</sub> FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE |      |      | $\bar{R}$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $\bar{A}_p$ |
|-----------|-----|------------------------------|------|------|-----------|---------------------------------|------|------|-------------|
|           |     | 95.0%                        | 50%  | 5.0% |           | 95.0%                           | 50%  | 5.0% |             |
| 2018.5003 | JUL | 26.2                         | 14.6 | 1.9  | 20.9      | 17.9                            | 12.5 |      |             |
| 2018.5837 | AUG | 24.9                         | 13.7 | 1.7  | 21.4      | 18.6                            | 13.5 |      |             |
| 2018.6670 | SEP | 23.6                         | 13.0 | 1.5  | 21.9      | 18.9                            | 13.9 |      |             |
| 2018.7503 | OCT | 22.3                         | 12.2 | 1.4  | 22.0      | 18.9                            | 14.1 |      |             |
| 2018.8337 | NOV | 21.1                         | 11.5 | 1.2  | 21.6      | 18.5                            | 13.9 |      |             |
| 2018.9170 | DEC | 20.0                         | 10.8 | 1.0  | 20.4      | 17.4                            | 13.1 |      |             |
| 2019.0003 | JAN | 18.9                         | 10.1 | 0.9  | 19.2      | 16.3                            | 12.3 |      |             |
| 2019.0837 | FEB | 17.8                         | 9.4  | 0.8  | 18.0      | 15.2                            | 11.5 |      |             |
| 2019.1670 | MAR | 16.9                         | 8.9  | 0.6  | 16.9      | 14.2                            | 10.8 |      |             |
| 2019.2503 | APR | 16.0                         | 8.3  | 0.5  | 15.8      | 13.3                            | 10.1 |      |             |
| 2019.3337 | MAY | 15.2                         | 7.8  | 0.4  | 14.8      | 12.4                            | 9.4  |      |             |
| 2019.4170 | JUN | 14.4                         | 7.4  | 0.3  | 13.9      | 11.5                            | 8.8  |      |             |
| 2019.5003 | JUL | 13.8                         | 7.0  | 0.2  | 13.1      | 10.8                            | 8.3  |      |             |
| 2019.5837 | AUG | 13.3                         | 6.7  | 0.2  | 12.4      | 10.2                            | 7.8  |      |             |
| 2019.6670 | SEP | 12.8                         | 6.4  | 0.1  | 11.8      | 9.7                             | 7.5  |      |             |
| 2019.7503 | OCT | 12.5                         | 6.2  | 0.1  | 11.4      | 9.3                             | 7.2  |      |             |
| 2019.8337 | NOV | 12.3                         | 6.1  | 0.0  | 11.1      | 9.0                             | 7.0  |      |             |
| 2019.9170 | DEC | 12.3                         | 6.1  | 0.0  | 11.1      | 9.0                             | 6.9  |      |             |
| 2020.0003 | JAN | 12.9                         | 6.5  | 0.4  | 11.3      | 9.0                             | 6.9  |      |             |
| 2020.0837 | FEB | 14.2                         | 7.2  | 0.9  | 11.6      | 9.2                             | 7.1  |      |             |
| 2020.1670 | MAR | 15.4                         | 7.8  | 1.2  | 11.7      | 9.3                             | 7.4  |      |             |
| 2020.2503 | APR | 16.6                         | 8.5  | 1.7  | 11.9      | 9.4                             | 7.5  |      |             |
| 2020.3337 | MAY | 18.1                         | 9.3  | 1.8  | 12.0      | 9.5                             | 7.5  |      |             |
| 2020.4170 | JUN | 20.6                         | 10.2 | 2.3  | 12.1      | 9.6                             | 7.3  |      |             |
| 2020.5003 | JUL | 23.0                         | 11.2 | 2.9  | 12.2      | 9.7                             | 7.2  |      |             |
| 2020.5837 | AUG | 25.1                         | 12.3 | 3.1  | 12.5      | 9.9                             | 7.1  |      |             |
| 2020.6670 | SEP | 28.3                         | 13.6 | 3.2  | 12.8      | 10.1                            | 7.0  |      |             |
| 2020.7503 | OCT | 32.2                         | 15.1 | 3.5  | 13.2      | 10.5                            | 7.2  |      |             |
| 2020.8337 | NOV | 38.2                         | 16.9 | 3.5  | 13.7      | 10.8                            | 7.6  |      |             |
| 2020.9170 | DEC | 43.7                         | 19.0 | 3.5  | 14.5      | 11.1                            | 7.9  |      |             |
| 2021.0003 | JAN | 47.9                         | 21.0 | 4.2  | 15.7      | 11.4                            | 7.7  |      |             |
| 2021.0837 | FEB | 54.1                         | 23.4 | 4.3  | 16.1      | 11.6                            | 7.7  |      |             |
| 2021.1670 | MAR | 60.7                         | 25.9 | 4.3  | 16.3      | 11.8                            | 7.6  |      |             |
| 2021.2503 | APR | 66.8                         | 28.4 | 4.8  | 16.8      | 12.0                            | 7.6  |      |             |
| 2021.3337 | MAY | 74.4                         | 31.2 | 4.8  | 18.0      | 12.3                            | 7.6  |      |             |
| 2021.4170 | JUN | 83.1                         | 34.5 | 5.2  | 18.9      | 12.6                            | 7.7  |      |             |
| 2021.5003 | JUL | 89.9                         | 37.8 | 5.8  | 19.1      | 12.7                            | 7.7  |      |             |
| 2021.5837 | AUG | 95.1                         | 41.3 | 6.8  | 19.2      | 12.9                            | 7.8  |      |             |
| 2021.6670 | SEP | 100.0                        | 44.8 | 7.7  | 19.0      | 13.1                            | 7.7  |      |             |
| 2021.7503 | OCT | 105.0                        | 48.2 | 9.1  | 18.6      | 13.1                            | 7.7  |      |             |
| 2021.8337 | NOV | 110.5                        | 51.5 | 9.8  | 18.5      | 13.2                            | 7.8  |      |             |
| 2021.9170 | DEC | 116.5                        | 54.9 | 9.9  | 18.9      | 13.4                            | 8.0  |      |             |
| 2022.0003 | JAN | 122.0                        | 58.5 | 11.2 | 18.8      | 13.5                            | 8.2  |      |             |
| 2022.0837 | FEB | 126.8                        | 62.1 | 12.4 | 17.8      | 13.5                            | 8.6  |      |             |
| 2022.1670 | MAR | 134.1                        | 65.8 | 13.4 | 17.9      | 13.7                            | 8.7  |      |             |
| 2022.2503 | APR | 141.4                        | 69.4 | 14.6 | 18.5      | 13.9                            | 8.7  |      |             |
| 2022.3337 | MAY | 146.1                        | 72.7 | 15.1 | 19.1      | 14.2                            | 9.0  |      |             |
| 2022.4170 | JUN | 147.9                        | 75.6 | 15.6 | 19.6      | 14.6                            | 9.4  |      |             |
| 2022.5003 | JUL | 151.0                        | 78.5 | 16.2 | 20.3      | 14.9                            | 9.6  |      |             |
| 2022.5837 | AUG | 154.7                        | 80.9 | 16.7 | 20.3      | 15.1                            | 9.6  |      |             |
| 2022.6670 | SEP | 158.4                        | 83.0 | 17.1 | 20.3      | 15.1                            | 9.8  |      |             |
| 2022.7503 | OCT | 163.8                        | 85.3 | 17.1 | 20.5      | 15.2                            | 10.0 |      |             |
| 2022.8337 | NOV | 167.3                        | 87.7 | 16.7 | 20.8      | 15.4                            | 10.5 |      |             |
| 2022.9170 | DEC | 169.1                        | 90.1 | 16.4 | 21.2      | 15.4                            | 11.1 |      |             |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A<sub>p</sub> FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | SUNSPOT NUMBER |       |      | $\bar{R}$ | GEOMAGNETIC INDEX |      |  |
|-----------|-----|----------------|-------|------|-----------|-------------------|------|--|
|           |     | PERCENTILE     |       |      |           | PERCENTILE        |      |  |
|           |     | 95.0%          | 50%   | 5.0% | 95.0%     | 50%               | 5.0% |  |
| 2023.0003 | JAN | 172.9          | 92.3  | 16.8 | 21.3      | 15.3              | 11.6 |  |
| 2023.0837 | FEB | 177.6          | 94.2  | 17.5 | 21.4      | 15.1              | 11.3 |  |
| 2023.1670 | MAR | 180.4          | 96.2  | 18.7 | 21.6      | 15.0              | 11.2 |  |
| 2023.2503 | APR | 182.4          | 98.4  | 20.6 | 22.0      | 15.0              | 10.7 |  |
| 2023.3337 | MAY | 185.0          | 100.2 | 21.8 | 22.8      | 14.9              | 10.2 |  |
| 2023.4170 | JUN | 187.4          | 101.3 | 23.1 | 22.5      | 14.7              | 9.9  |  |
| 2023.5003 | JUL | 189.5          | 102.2 | 25.4 | 21.3      | 14.5              | 10.1 |  |
| 2023.5837 | AUG | 190.7          | 102.4 | 28.1 | 20.6      | 14.3              | 10.1 |  |
| 2023.6670 | SEP | 192.2          | 102.8 | 30.7 | 20.1      | 14.2              | 10.3 |  |
| 2023.7503 | OCT | 192.5          | 103.6 | 32.1 | 19.6      | 14.1              | 10.6 |  |
| 2023.8337 | NOV | 192.1          | 104.1 | 33.4 | 19.5      | 14.0              | 10.6 |  |
| 2023.9170 | DEC | 193.4          | 104.4 | 35.7 | 19.3      | 14.0              | 10.5 |  |
| 2024.0003 | JAN | 193.9          | 103.6 | 37.4 | 19.1      | 14.2              | 10.5 |  |
| 2024.0837 | FEB | 190.8          | 102.1 | 39.6 | 18.9      | 14.6              | 10.5 |  |
| 2024.1670 | MAR | 186.3          | 101.2 | 41.2 | 18.9      | 14.7              | 10.3 |  |
| 2024.2503 | APR | 181.9          | 100.7 | 42.7 | 19.5      | 14.6              | 9.8  |  |
| 2024.3337 | MAY | 179.6          | 100.4 | 43.9 | 20.4      | 14.7              | 10.2 |  |
| 2024.4170 | JUN | 178.9          | 100.1 | 43.8 | 22.0      | 15.0              | 10.7 |  |
| 2024.5003 | JUL | 177.8          | 99.7  | 43.3 | 23.4      | 15.3              | 10.7 |  |
| 2024.5837 | AUG | 176.5          | 99.1  | 44.0 | 24.0      | 15.4              | 10.9 |  |
| 2024.6670 | SEP | 175.3          | 98.5  | 45.9 | 25.1      | 15.7              | 11.1 |  |
| 2024.7503 | OCT | 174.5          | 98.0  | 46.0 | 25.6      | 15.9              | 11.3 |  |
| 2024.8337 | NOV | 173.4          | 97.4  | 45.1 | 24.9      | 15.9              | 11.5 |  |
| 2024.9170 | DEC | 172.3          | 96.6  | 44.4 | 24.8      | 15.9              | 11.7 |  |
| 2025.0003 | JAN | 170.7          | 95.7  | 44.9 | 23.9      | 15.8              | 11.9 |  |
| 2025.0837 | FEB | 168.1          | 94.1  | 45.4 | 22.1      | 15.8              | 11.8 |  |
| 2025.1670 | MAR | 164.2          | 92.1  | 44.3 | 22.4      | 15.9              | 12.0 |  |
| 2025.2503 | APR | 161.0          | 90.3  | 43.7 | 23.1      | 16.0              | 11.8 |  |
| 2025.3337 | MAY | 157.9          | 89.1  | 44.7 | 23.1      | 16.0              | 11.1 |  |
| 2025.4170 | JUN | 153.9          | 87.8  | 45.7 | 22.6      | 16.0              | 10.8 |  |
| 2025.5003 | JUL | 150.5          | 86.2  | 44.6 | 22.0      | 15.8              | 10.8 |  |
| 2025.5837 | AUG | 146.4          | 84.3  | 42.6 | 21.9      | 15.8              | 10.8 |  |
| 2025.6670 | SEP | 142.9          | 82.9  | 41.6 | 22.7      | 16.1              | 10.8 |  |
| 2025.7503 | OCT | 142.0          | 81.8  | 41.3 | 23.7      | 16.5              | 10.8 |  |
| 2025.8337 | NOV | 138.7          | 80.3  | 39.3 | 23.9      | 16.7              | 10.8 |  |
| 2025.9170 | DEC | 136.4          | 78.4  | 35.0 | 23.9      | 17.0              | 10.7 |  |
| 2026.0003 | JAN | 135.3          | 76.6  | 34.1 | 23.9      | 17.1              | 10.6 |  |
| 2026.0837 | FEB | 132.3          | 74.9  | 35.4 | 23.5      | 17.2              | 10.3 |  |
| 2026.1670 | MAR | 128.8          | 73.5  | 34.6 | 22.5      | 17.2              | 10.5 |  |
| 2026.2503 | APR | 124.8          | 72.3  | 32.7 | 22.7      | 17.2              | 10.7 |  |
| 2026.3337 | MAY | 120.7          | 71.1  | 31.7 | 23.0      | 17.4              | 11.4 |  |
| 2026.4170 | JUN | 117.2          | 69.7  | 30.9 | 23.1      | 17.6              | 11.9 |  |
| 2026.5003 | JUL | 114.8          | 68.0  | 29.4 | 22.5      | 17.8              | 12.0 |  |
| 2026.5837 | AUG | 110.8          | 66.0  | 27.7 | 21.7      | 17.6              | 12.1 |  |
| 2026.6670 | SEP | 104.4          | 63.7  | 26.7 | 21.2      | 17.4              | 12.3 |  |
| 2026.7503 | OCT | 97.6           | 61.3  | 26.3 | 21.7      | 17.0              | 12.5 |  |
| 2026.8337 | NOV | 93.7           | 59.4  | 26.6 | 21.7      | 16.9              | 13.3 |  |
| 2026.9170 | DEC | 92.5           | 57.7  | 25.8 | 22.1      | 16.9              | 13.1 |  |
| 2027.0003 | JAN | 91.4           | 56.1  | 24.3 | 22.6      | 17.0              | 12.8 |  |
| 2027.0837 | FEB | 88.9           | 54.7  | 24.4 | 22.3      | 16.8              | 13.1 |  |
| 2027.1670 | MAR | 86.8           | 53.1  | 23.8 | 22.4      | 16.5              | 12.7 |  |
| 2027.2503 | APR | 83.1           | 51.4  | 22.7 | 22.7      | 16.2              | 12.5 |  |
| 2027.3337 | MAY | 79.8           | 49.8  | 21.9 | 22.9      | 15.8              | 12.1 |  |
| 2027.4170 | JUN | 76.3           | 48.2  | 20.4 | 23.5      | 15.6              | 11.2 |  |



**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A<sub>p</sub> FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE |      |      | $\bar{R}$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $\bar{A}_p$ |
|-----------|-----|------------------------------|------|------|-----------|---------------------------------|------|------|-------------|
|           |     | 95.0%                        | 50%  | 5.0% |           | 95.0%                           | 50%  | 5.0% |             |
| 2027.5003 | JUL | 71.0                         | 46.4 | 18.9 | 24.1      | 15.4                            | 10.5 |      |             |
| 2027.5837 | AUG | 69.8                         | 44.7 | 16.7 | 24.8      | 15.3                            | 10.7 |      |             |
| 2027.6670 | SEP | 70.1                         | 43.5 | 14.9 | 25.3      | 15.3                            | 10.8 |      |             |
| 2027.7503 | OCT | 69.7                         | 42.3 | 13.7 | 25.6      | 15.3                            | 10.6 |      |             |
| 2027.8337 | NOV | 69.6                         | 41.1 | 11.9 | 25.4      | 15.3                            | 10.8 |      |             |
| 2027.9170 | DEC | 68.8                         | 39.7 | 10.4 | 24.9      | 15.2                            | 11.0 |      |             |
| 2028.0003 | JAN | 66.8                         | 38.2 | 9.5  | 24.0      | 15.0                            | 11.1 |      |             |
| 2028.0837 | FEB | 64.1                         | 36.8 | 8.7  | 23.0      | 14.9                            | 11.3 |      |             |
| 2028.1670 | MAR | 60.9                         | 35.5 | 7.9  | 22.5      | 15.0                            | 11.2 |      |             |
| 2028.2503 | APR | 56.4                         | 34.1 | 7.8  | 22.1      | 15.1                            | 11.1 |      |             |
| 2028.3337 | MAY | 52.1                         | 32.5 | 7.9  | 21.8      | 15.2                            | 11.2 |      |             |
| 2028.4170 | JUN | 49.0                         | 31.3 | 7.6  | 21.4      | 15.3                            | 11.4 |      |             |
| 2028.5003 | JUL | 49.8                         | 30.5 | 7.5  | 20.7      | 15.2                            | 11.5 |      |             |
| 2028.5837 | AUG | 49.0                         | 29.5 | 7.4  | 19.9      | 14.9                            | 11.3 |      |             |
| 2028.6670 | SEP | 46.4                         | 28.2 | 7.1  | 20.0      | 14.7                            | 11.1 |      |             |
| 2028.7503 | OCT | 44.0                         | 26.8 | 6.5  | 20.1      | 14.6                            | 10.8 |      |             |
| 2028.8337 | NOV | 42.0                         | 25.7 | 6.5  | 19.9      | 14.3                            | 10.1 |      |             |
| 2028.9170 | DEC | 40.9                         | 24.9 | 6.1  | 19.5      | 14.2                            | 9.6  |      |             |
| 2029.0003 | JAN | 39.5                         | 23.8 | 5.5  | 19.0      | 14.1                            | 9.1  |      |             |
| 2029.0837 | FEB | 38.8                         | 22.8 | 5.2  | 18.3      | 14.1                            | 8.6  |      |             |
| 2029.1670 | MAR | 38.1                         | 21.9 | 4.6  | 17.3      | 14.0                            | 8.0  |      |             |
| 2029.2503 | APR | 37.7                         | 21.0 | 3.8  | 17.4      | 13.8                            | 7.5  |      |             |
| 2029.3337 | MAY | 36.9                         | 20.0 | 3.6  | 17.5      | 13.7                            | 7.6  |      |             |
| 2029.4170 | JUN | 35.9                         | 19.2 | 3.5  | 17.6      | 13.7                            | 7.8  |      |             |
| 2029.5003 | JUL | 34.7                         | 18.3 | 3.3  | 17.5      | 13.6                            | 8.3  |      |             |
| 2029.5837 | AUG | 33.3                         | 17.4 | 3.2  | 17.7      | 13.5                            | 8.6  |      |             |
| 2029.6670 | SEP | 31.6                         | 16.5 | 2.6  | 18.1      | 13.4                            | 8.5  |      |             |
| 2029.7503 | OCT | 29.7                         | 15.5 | 2.0  | 17.9      | 13.2                            | 8.6  |      |             |
| 2029.8337 | NOV | 27.1                         | 14.8 | 1.6  | 17.6      | 12.9                            | 8.5  |      |             |
| 2029.9170 | DEC | 24.5                         | 13.8 | 1.6  | 17.3      | 12.6                            | 8.5  |      |             |
| 2030.0003 | JAN | 22.1                         | 12.6 | 1.3  | 16.3      | 12.2                            | 8.4  |      |             |
| 2030.0837 | FEB | 20.3                         | 11.5 | 0.9  | 14.8      | 11.8                            | 8.4  |      |             |
| 2030.1670 | MAR | 19.2                         | 10.5 | 0.6  | 13.8      | 11.4                            | 8.3  |      |             |
| 2030.2503 | APR | 18.9                         | 9.7  | 0.6  | 13.9      | 11.0                            | 8.2  |      |             |
| 2030.3337 | MAY | 18.5                         | 9.1  | 0.5  | 13.6      | 10.6                            | 8.2  |      |             |
| 2030.4170 | JUN | 18.2                         | 8.5  | 0.4  | 13.2      | 10.3                            | 7.9  |      |             |
| 2030.5003 | JUL | 16.8                         | 8.0  | 0.3  | 12.9      | 9.9                             | 7.4  |      |             |
| 2030.5837 | AUG | 15.9                         | 7.5  | 0.2  | 12.6      | 9.7                             | 7.1  |      |             |
| 2030.6670 | SEP | 15.8                         | 7.0  | 0.1  | 11.9      | 9.5                             | 7.3  |      |             |
| 2030.7503 | OCT | 15.0                         | 6.5  | 0.0  | 11.4      | 9.4                             | 7.1  |      |             |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 75.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2009.5003 | JUL | 70.8                             | 70.6  | 70.0 | 4.1                | 3.9                             | 3.6  |      |               |
| 2009.5837 | AUG | 71.5                             | 71.1  | 69.7 | 4.3                | 3.6                             | 3.2  |      |               |
| 2009.6670 | SEP | 72.4                             | 71.7  | 69.6 | 4.4                | 3.4                             | 2.9  |      |               |
| 2009.7503 | OCT | 72.9                             | 72.3  | 69.4 | 4.3                | 3.3                             | 2.6  |      |               |
| 2009.8337 | NOV | 74.1                             | 73.0  | 69.5 | 4.6                | 3.3                             | 2.4  |      |               |
| 2009.9170 | DEC | 75.6                             | 74.0  | 69.9 | 4.5                | 2.9                             | 1.8  |      |               |
| 2010.0003 | JAN | 76.8                             | 75.0  | 69.8 | 3.8                | 2.1                             | 0.8  |      |               |
| 2010.0837 | FEB | 77.8                             | 76.2  | 69.4 | 4.0                | 1.8                             | 0.2  |      |               |
| 2010.1670 | MAR | 79.7                             | 77.5  | 69.3 | 4.3                | 1.5                             | -0.6 |      |               |
| 2010.2503 | APR | 82.1                             | 78.9  | 68.9 | 4.5                | 1.1                             | -1.6 |      |               |
| 2010.3337 | MAY | 84.7                             | 80.5  | 68.7 | 5.6                | 1.4                             | -1.8 |      |               |
| 2010.4170 | JUN | 86.9                             | 82.1  | 68.8 | 6.7                | 1.8                             | -1.3 |      |               |
| 2010.5003 | JUL | 91.0                             | 84.0  | 68.9 | 6.9                | 2.0                             | -1.3 |      |               |
| 2010.5837 | AUG | 93.2                             | 86.3  | 69.2 | 6.6                | 1.9                             | -1.5 |      |               |
| 2010.6670 | SEP | 97.2                             | 88.5  | 69.6 | 5.5                | 1.2                             | -2.1 |      |               |
| 2010.7503 | OCT | 100.6                            | 90.7  | 70.3 | 4.4                | 0.7                             | -2.3 |      |               |
| 2010.8337 | NOV | 103.7                            | 93.1  | 71.0 | 3.5                | 0.4                             | -2.3 |      |               |
| 2010.9170 | DEC | 105.9                            | 95.5  | 71.3 | 3.0                | 0.4                             | -2.3 |      |               |
| 2011.0003 | JAN | 107.0                            | 97.9  | 71.1 | 3.0                | 0.6                             | -1.9 |      |               |
| 2011.0837 | FEB | 108.2                            | 100.2 | 71.0 | 4.3                | 1.5                             | -1.0 |      |               |
| 2011.1670 | MAR | 111.9                            | 102.6 | 70.9 | 5.3                | 2.5                             | -0.3 |      |               |
| 2011.2503 | APR | 114.7                            | 105.2 | 71.4 | 5.2                | 2.9                             | -0.1 |      |               |
| 2011.3337 | MAY | 116.8                            | 107.9 | 72.7 | 5.6                | 3.3                             | 0.0  |      |               |
| 2011.4170 | JUN | 118.6                            | 110.3 | 74.4 | 6.4                | 3.7                             | -0.2 |      |               |
| 2011.5003 | JUL | 121.3                            | 112.6 | 75.5 | 7.1                | 3.9                             | -0.5 |      |               |
| 2011.5837 | AUG | 124.6                            | 114.5 | 75.3 | 7.5                | 4.4                             | -0.3 |      |               |
| 2011.6670 | SEP | 128.8                            | 116.4 | 75.5 | 8.4                | 5.1                             | 0.2  |      |               |
| 2011.7503 | OCT | 133.1                            | 118.7 | 77.0 | 9.6                | 5.9                             | 0.9  |      |               |
| 2011.8337 | NOV | 136.9                            | 121.2 | 77.8 | 10.8               | 6.6                             | 1.2  |      |               |
| 2011.9170 | DEC | 140.2                            | 123.6 | 78.2 | 11.5               | 7.1                             | 1.4  |      |               |
| 2012.0003 | JAN | 143.9                            | 125.6 | 79.2 | 12.0               | 7.9                             | 1.6  |      |               |
| 2012.0837 | FEB | 147.1                            | 127.6 | 81.6 | 13.2               | 8.5                             | 2.0  |      |               |
| 2012.1670 | MAR | 149.0                            | 129.3 | 84.8 | 14.0               | 8.9                             | 2.5  |      |               |
| 2012.2503 | APR | 151.7                            | 131.1 | 88.4 | 14.6               | 9.1                             | 2.8  |      |               |
| 2012.3337 | MAY | 154.0                            | 132.5 | 90.8 | 15.4               | 9.0                             | 2.5  |      |               |
| 2012.4170 | JUN | 157.3                            | 133.6 | 91.2 | 16.0               | 9.5                             | 3.0  |      |               |
| 2012.5003 | JUL | 160.5                            | 134.8 | 90.1 | 16.3               | 10.5                            | 4.4  |      |               |
| 2012.5837 | AUG | 157.7                            | 135.6 | 90.0 | 16.9               | 11.4                            | 5.9  |      |               |
| 2012.6670 | SEP | 153.8                            | 136.0 | 90.4 | 16.8               | 11.6                            | 6.6  |      |               |
| 2012.7503 | OCT | 153.9                            | 136.4 | 91.6 | 16.4               | 11.5                            | 6.8  |      |               |
| 2012.8337 | NOV | 155.2                            | 136.9 | 93.3 | 16.6               | 11.6                            | 7.3  |      |               |
| 2012.9170 | DEC | 156.6                            | 137.4 | 95.0 | 16.2               | 11.5                            | 7.2  |      |               |
| 2013.0003 | JAN | 156.7                            | 136.9 | 96.0 | 14.7               | 10.7                            | 6.2  |      |               |
| 2013.0837 | FEB | 155.3                            | 135.9 | 96.6 | 13.4               | 10.2                            | 5.9  |      |               |
| 2013.1670 | MAR | 157.6                            | 135.4 | 97.4 | 11.4               | 8.8                             | 4.8  |      |               |
| 2013.2503 | APR | 160.7                            | 135.5 | 97.1 | 10.3               | 7.3                             | 3.4  |      |               |
| 2013.3337 | MAY | 160.5                            | 135.9 | 95.6 | 10.3               | 6.9                             | 2.7  |      |               |
| 2013.4170 | JUN | 159.7                            | 136.3 | 94.1 | 11.0               | 6.4                             | 1.9  |      |               |
| 2013.5003 | JUL | 159.8                            | 136.5 | 92.2 | 11.4               | 5.9                             | 1.3  |      |               |
| 2013.5837 | AUG | 160.2                            | 136.4 | 89.0 | 11.6               | 5.8                             | 1.3  |      |               |
| 2013.6670 | SEP | 158.0                            | 136.0 | 85.8 | 12.1               | 5.5                             | 1.1  |      |               |
| 2013.7503 | OCT | 158.3                            | 135.4 | 82.3 | 12.2               | 5.4                             | 1.0  |      |               |
| 2013.8337 | NOV | 156.9                            | 135.2 | 80.7 | 12.3               | 6.1                             | 1.8  |      |               |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $\bar{A}_p$ |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
|           |     | 75.0%                            | 50%   | 5.0% |                  | 95.0%                           | 50%  | 5.0% |             |
| 2013.9170 | DEC | 154.5                            | 135.1 | 79.5 | 12.7             | 6.4                             | 2.3  |      |             |
| 2014.0003 | JAN | 152.4                            | 134.4 | 78.1 | 12.0             | 6.5                             | 3.1  |      |             |
| 2014.0837 | FEB | 153.2                            | 133.2 | 76.8 | 11.2             | 6.8                             | 3.6  |      |             |
| 2014.1670 | MAR | 153.9                            | 131.7 | 74.5 | 11.4             | 7.2                             | 4.1  |      |             |
| 2014.2503 | APR | 153.3                            | 129.8 | 72.9 | 12.8             | 7.9                             | 4.9  |      |             |
| 2014.3337 | MAY | 152.5                            | 127.8 | 70.3 | 13.3             | 8.3                             | 5.2  |      |             |
| 2014.4170 | JUN | 145.5                            | 126.4 | 68.9 | 13.7             | 8.9                             | 5.5  |      |             |
| 2014.5003 | JUL | 140.2                            | 125.1 | 68.4 | 14.2             | 9.3                             | 5.9  |      |             |
| 2014.5837 | AUG | 135.7                            | 123.7 | 68.9 | 12.9             | 8.4                             | 5.2  |      |             |
| 2014.6670 | SEP | 133.7                            | 122.3 | 70.0 | 12.1             | 7.8                             | 4.5  |      |             |
| 2014.7503 | OCT | 133.3                            | 121.4 | 71.3 | 12.7             | 7.8                             | 4.3  |      |             |
| 2014.8337 | NOV | 134.8                            | 120.7 | 72.5 | 12.0             | 7.4                             | 3.8  |      |             |
| 2014.9170 | DEC | 134.5                            | 119.9 | 74.1 | 11.1             | 6.9                             | 3.2  |      |             |
| 2015.0003 | JAN | 131.4                            | 118.7 | 75.8 | 10.5             | 6.6                             | 2.7  |      |             |
| 2015.0837 | FEB | 131.9                            | 117.2 | 76.4 | 10.6             | 7.0                             | 2.6  |      |             |
| 2015.1670 | MAR | 131.8                            | 116.3 | 77.0 | 12.4             | 8.0                             | 3.5  |      |             |
| 2015.2503 | APR | 128.9                            | 115.7 | 77.8 | 13.6             | 8.7                             | 4.2  |      |             |
| 2015.3337 | MAY | 126.0                            | 114.7 | 77.7 | 14.6             | 9.3                             | 4.7  |      |             |
| 2015.4170 | JUN | 122.5                            | 113.4 | 76.8 | 15.3             | 10.0                            | 4.8  |      |             |
| 2015.5003 | JUL | 122.1                            | 112.1 | 77.2 | 15.4             | 10.7                            | 5.5  |      |             |
| 2015.5837 | AUG | 122.4                            | 111.0 | 79.0 | 15.6             | 11.4                            | 6.7  |      |             |
| 2015.6670 | SEP | 123.3                            | 109.7 | 80.2 | 16.0             | 12.0                            | 7.8  |      |             |
| 2015.7503 | OCT | 122.2                            | 108.0 | 79.2 | 17.3             | 12.5                            | 9.0  |      |             |
| 2015.8337 | NOV | 119.2                            | 106.1 | 77.2 | 18.2             | 13.2                            | 10.0 |      |             |
| 2015.9170 | DEC | 115.7                            | 104.4 | 76.1 | 19.0             | 14.2                            | 10.2 |      |             |
| 2016.0003 | JAN | 114.1                            | 102.9 | 75.1 | 20.0             | 14.8                            | 10.5 |      |             |
| 2016.0837 | FEB | 112.8                            | 101.4 | 74.4 | 20.0             | 14.7                            | 10.4 |      |             |
| 2016.1670 | MAR | 110.6                            | 100.0 | 74.5 | 20.2             | 14.6                            | 10.3 |      |             |
| 2016.2503 | APR | 108.4                            | 98.9  | 74.3 | 20.5             | 14.3                            | 10.1 |      |             |
| 2016.3337 | MAY | 107.0                            | 97.8  | 74.1 | 20.6             | 13.8                            | 9.5  |      |             |
| 2016.4170 | JUN | 106.0                            | 96.7  | 74.5 | 20.8             | 13.2                            | 8.3  |      |             |
| 2016.5003 | JUL | 104.3                            | 95.6  | 74.0 | 20.8             | 12.4                            | 6.8  |      |             |
| 2016.5837 | AUG | 101.5                            | 94.5  | 73.5 | 20.6             | 11.5                            | 6.0  |      |             |
| 2016.6670 | SEP | 100.5                            | 93.5  | 72.7 | 20.7             | 11.2                            | 5.5  |      |             |
| 2016.7503 | OCT | 100.8                            | 92.5  | 72.3 | 20.6             | 11.0                            | 5.1  |      |             |
| 2016.8337 | NOV | 99.6                             | 91.7  | 72.2 | 20.0             | 10.4                            | 4.7  |      |             |
| 2016.9170 | DEC | 99.7                             | 91.0  | 71.9 | 19.0             | 9.9                             | 4.4  |      |             |
| 2017.0003 | JAN | 99.7                             | 90.0  | 71.4 | 18.0             | 9.7                             | 4.5  |      |             |
| 2017.0837 | FEB | 98.9                             | 89.2  | 71.0 | 17.4             | 9.9                             | 5.0  |      |             |
| 2017.1670 | MAR | 97.5                             | 88.6  | 70.6 | 17.7             | 10.7                            | 5.7  |      |             |
| 2017.2503 | APR | 98.2                             | 87.9  | 70.7 | 17.6             | 11.1                            | 6.1  |      |             |
| 2017.3337 | MAY | 98.7                             | 86.9  | 70.8 | 18.1             | 11.9                            | 7.0  |      |             |
| 2017.4170 | JUN | 96.9                             | 85.9  | 70.7 | 18.5             | 12.8                            | 8.2  |      |             |
| 2017.5003 | JUL | 94.6                             | 85.1  | 70.5 | 18.8             | 13.4                            | 9.3  |      |             |
| 2017.5837 | AUG | 93.4                             | 84.4  | 70.5 | 18.9             | 13.7                            | 9.9  |      |             |
| 2017.6670 | SEP | 91.7                             | 83.6  | 70.5 | 19.4             | 13.9                            | 10.2 |      |             |
| 2017.7503 | OCT | 88.8                             | 82.5  | 70.2 | 19.8             | 14.1                            | 10.3 |      |             |
| 2017.8337 | NOV | 88.1                             | 81.5  | 70.0 | 20.0             | 14.5                            | 10.3 |      |             |
| 2017.9170 | DEC | 87.8                             | 80.8  | 70.0 | 20.3             | 15.3                            | 10.7 |      |             |
| 2018.0003 | JAN | 86.3                             | 80.1  | 69.9 | 20.8             | 16.5                            | 11.5 |      |             |
| 2018.0837 | FEB | 84.1                             | 79.3  | 69.9 | 21.1             | 17.7                            | 12.2 |      |             |
| 2018.1670 | MAR | 83.3                             | 78.7  | 69.7 | 22.1             | 18.4                            | 12.2 |      |             |
| 2018.2503 | APR | 82.4                             | 78.0  | 69.5 | 22.2             | 18.5                            | 12.1 |      |             |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

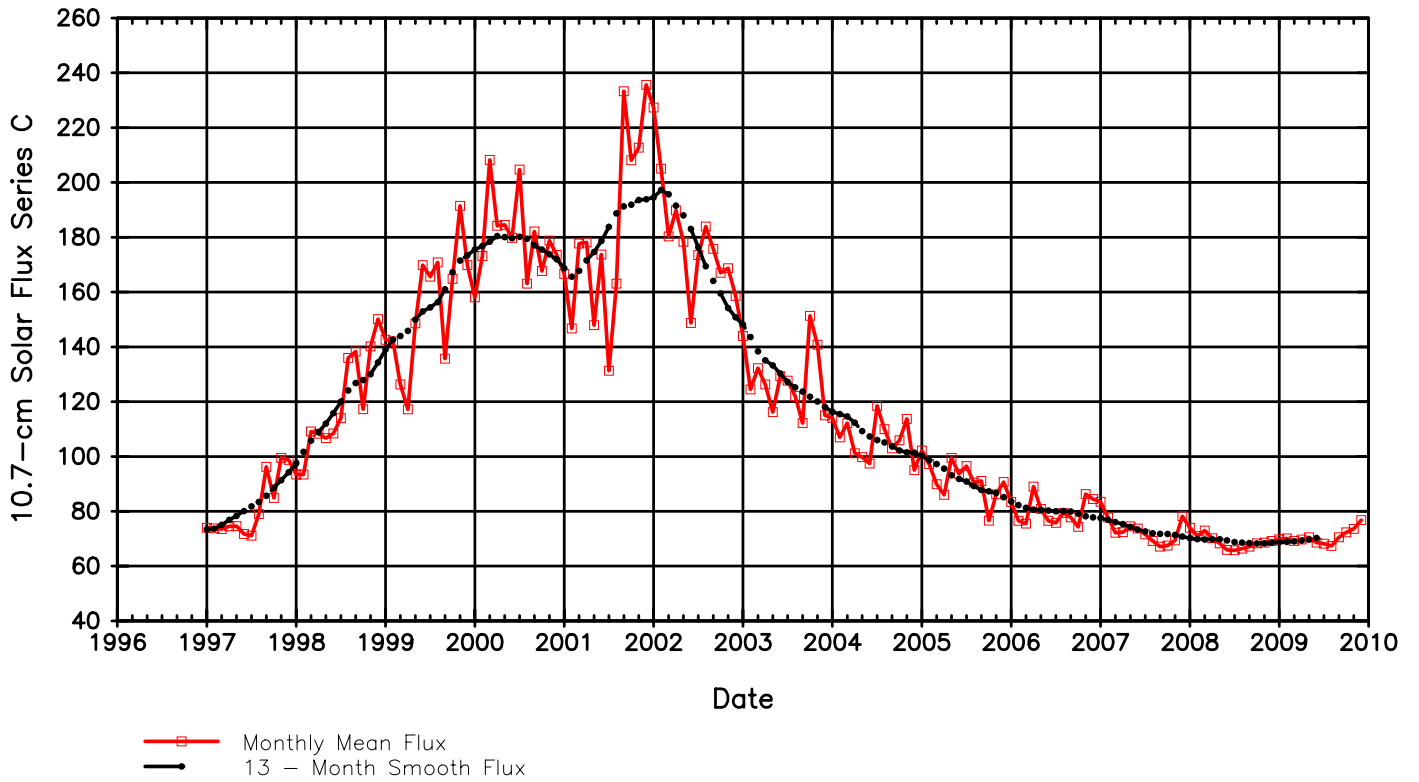
| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 75.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2018.3337 | MAY | 81.5                             | 77.4  | 69.3 | 21.8               | 18.2                            | 11.9 |      |               |
| 2018.4170 | JUN | 80.7                             | 76.8  | 69.1 | 21.0               | 17.7                            | 11.8 |      |               |
| 2018.5003 | JUL | 79.9                             | 76.2  | 68.9 | 20.9               | 17.9                            | 12.5 |      |               |
| 2018.5837 | AUG | 79.0                             | 75.6  | 68.7 | 21.4               | 18.6                            | 13.5 |      |               |
| 2018.6670 | SEP | 78.3                             | 75.0  | 68.5 | 21.9               | 18.9                            | 13.9 |      |               |
| 2018.7503 | OCT | 77.5                             | 74.4  | 68.4 | 22.0               | 18.9                            | 14.1 |      |               |
| 2018.8337 | NOV | 76.8                             | 73.8  | 68.2 | 21.6               | 18.5                            | 13.9 |      |               |
| 2018.9170 | DEC | 76.0                             | 73.3  | 68.0 | 20.4               | 17.4                            | 13.1 |      |               |
| 2019.0003 | JAN | 75.4                             | 72.8  | 67.9 | 19.2               | 16.3                            | 12.3 |      |               |
| 2019.0837 | FEB | 74.7                             | 72.4  | 67.8 | 18.0               | 15.2                            | 11.5 |      |               |
| 2019.1670 | MAR | 74.2                             | 71.9  | 67.6 | 16.9               | 14.2                            | 10.8 |      |               |
| 2019.2503 | APR | 73.6                             | 71.5  | 67.5 | 15.8               | 13.3                            | 10.1 |      |               |
| 2019.3337 | MAY | 73.1                             | 71.1  | 67.4 | 14.8               | 12.4                            | 9.4  |      |               |
| 2019.4170 | JUN | 72.7                             | 70.8  | 67.3 | 13.9               | 11.5                            | 8.8  |      |               |
| 2019.5003 | JUL | 72.3                             | 70.5  | 67.2 | 13.1               | 10.8                            | 8.3  |      |               |
| 2019.5837 | AUG | 72.0                             | 70.3  | 67.1 | 12.4               | 10.2                            | 7.8  |      |               |
| 2019.6670 | SEP | 71.7                             | 70.1  | 67.1 | 11.8               | 9.7                             | 7.5  |      |               |
| 2019.7503 | OCT | 71.6                             | 70.0  | 67.0 | 11.4               | 9.3                             | 7.2  |      |               |
| 2019.8337 | NOV | 71.4                             | 69.9  | 67.0 | 11.1               | 9.0                             | 7.0  |      |               |
| 2019.9170 | DEC | 71.4                             | 69.9  | 67.0 | 11.1               | 9.0                             | 6.9  |      |               |
| 2020.0003 | JAN | 71.9                             | 70.0  | 67.0 | 11.3               | 9.0                             | 6.9  |      |               |
| 2020.0837 | FEB | 72.1                             | 70.3  | 67.1 | 11.6               | 9.2                             | 7.1  |      |               |
| 2020.1670 | MAR | 72.8                             | 70.7  | 67.2 | 11.7               | 9.3                             | 7.4  |      |               |
| 2020.2503 | APR | 72.5                             | 71.0  | 67.2 | 11.9               | 9.4                             | 7.5  |      |               |
| 2020.3337 | MAY | 72.9                             | 71.5  | 67.4 | 12.0               | 9.5                             | 7.5  |      |               |
| 2020.4170 | JUN | 73.3                             | 72.0  | 67.5 | 12.1               | 9.6                             | 7.3  |      |               |
| 2020.5003 | JUL | 73.8                             | 72.6  | 67.6 | 12.2               | 9.7                             | 7.2  |      |               |
| 2020.5837 | AUG | 75.1                             | 73.3  | 67.8 | 12.5               | 9.9                             | 7.1  |      |               |
| 2020.6670 | SEP | 76.7                             | 74.1  | 67.9 | 12.8               | 10.1                            | 7.0  |      |               |
| 2020.7503 | OCT | 78.1                             | 75.1  | 68.0 | 13.2               | 10.5                            | 7.2  |      |               |
| 2020.8337 | NOV | 79.9                             | 76.3  | 68.3 | 13.7               | 10.8                            | 7.6  |      |               |
| 2020.9170 | DEC | 82.0                             | 77.7  | 68.4 | 14.5               | 11.1                            | 7.9  |      |               |
| 2021.0003 | JAN | 85.2                             | 79.2  | 68.4 | 15.7               | 11.4                            | 7.7  |      |               |
| 2021.0837 | FEB | 88.2                             | 80.9  | 68.4 | 16.1               | 11.6                            | 7.7  |      |               |
| 2021.1670 | MAR | 90.2                             | 82.9  | 68.4 | 16.3               | 11.8                            | 7.6  |      |               |
| 2021.2503 | APR | 92.2                             | 85.1  | 68.3 | 16.8               | 12.0                            | 7.6  |      |               |
| 2021.3337 | MAY | 95.6                             | 87.3  | 68.6 | 18.0               | 12.3                            | 7.6  |      |               |
| 2021.4170 | JUN | 99.1                             | 89.9  | 68.7 | 18.9               | 12.6                            | 7.7  |      |               |
| 2021.5003 | JUL | 103.5                            | 92.6  | 68.9 | 19.1               | 12.7                            | 7.7  |      |               |
| 2021.5837 | AUG | 108.5                            | 95.4  | 69.2 | 19.2               | 12.9                            | 7.8  |      |               |
| 2021.6670 | SEP | 112.0                            | 98.2  | 69.2 | 19.0               | 13.1                            | 7.7  |      |               |
| 2021.7503 | OCT | 116.5                            | 101.0 | 69.5 | 18.6               | 13.1                            | 7.7  |      |               |
| 2021.8337 | NOV | 120.8                            | 103.9 | 69.9 | 18.5               | 13.2                            | 7.8  |      |               |
| 2021.9170 | DEC | 124.1                            | 107.0 | 70.6 | 18.9               | 13.4                            | 8.0  |      |               |
| 2022.0003 | JAN | 126.7                            | 110.1 | 70.9 | 18.8               | 13.5                            | 8.2  |      |               |
| 2022.0837 | FEB | 129.2                            | 113.2 | 71.3 | 17.8               | 13.5                            | 8.6  |      |               |
| 2022.1670 | MAR | 133.3                            | 116.5 | 71.5 | 17.9               | 13.7                            | 8.7  |      |               |
| 2022.2503 | APR | 138.2                            | 119.7 | 72.1 | 18.5               | 13.9                            | 8.7  |      |               |
| 2022.3337 | MAY | 142.8                            | 122.9 | 72.9 | 19.1               | 14.2                            | 9.0  |      |               |
| 2022.4170 | JUN | 148.3                            | 125.7 | 73.3 | 19.6               | 14.6                            | 9.4  |      |               |
| 2022.5003 | JUL | 152.9                            | 128.2 | 74.1 | 20.3               | 14.9                            | 9.6  |      |               |
| 2022.5837 | AUG | 157.7                            | 130.5 | 74.7 | 20.3               | 15.1                            | 9.6  |      |               |
| 2022.6670 | SEP | 163.7                            | 132.6 | 75.1 | 20.3               | 15.1                            | 9.8  |      |               |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

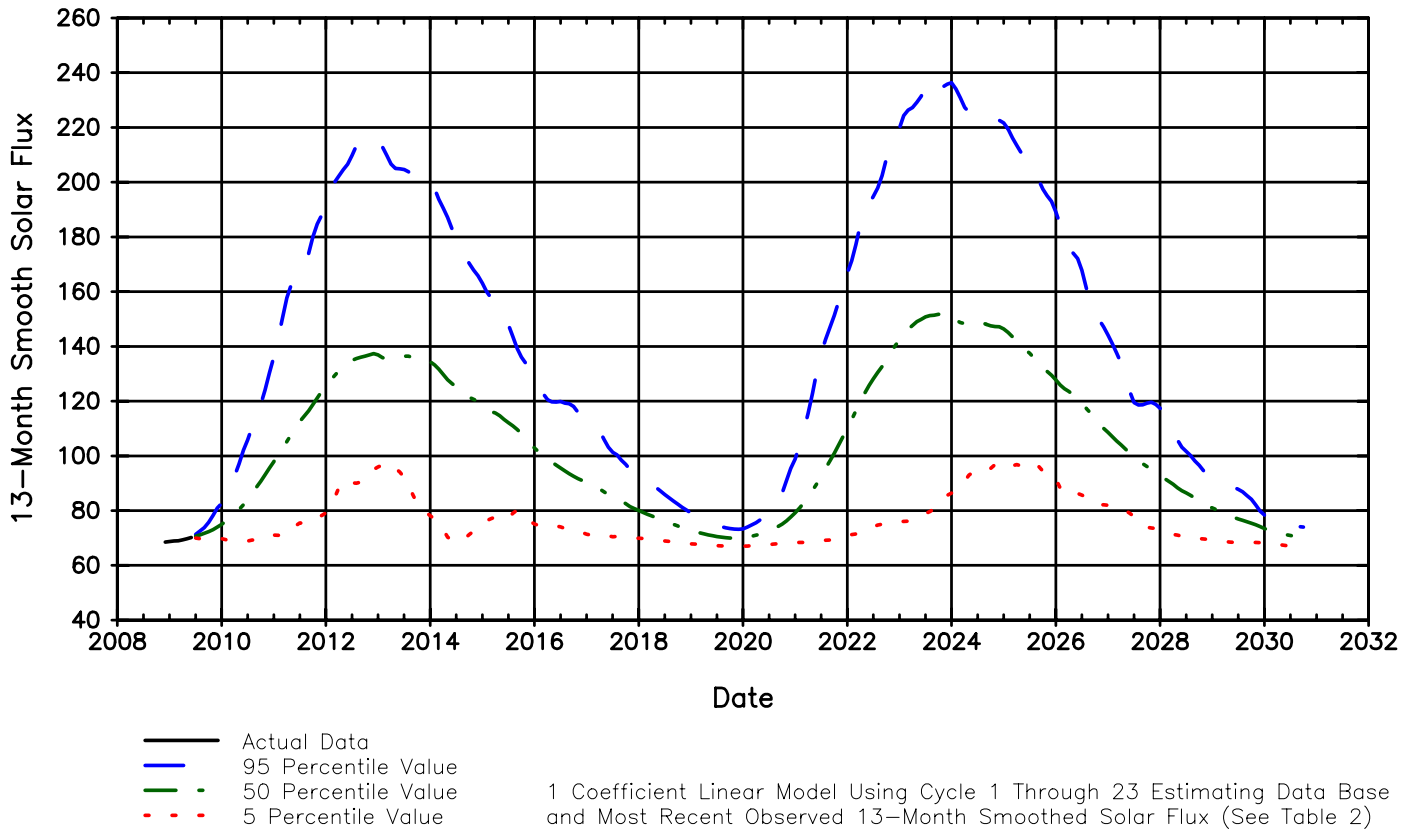
| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX<br>PERCENTILE |      |      | $(\bar{A}_p)$ |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
|           |     | 75.0%                            | 50%   | 5.0% |                    | 95.0%                           | 50%  | 5.0% |               |
| 2022.7503 | OCT | 169.4                            | 135.1 | 75.6 | 20.5               | 15.2                            | 10.0 |      |               |
| 2022.8337 | NOV | 174.6                            | 137.7 | 75.9 | 20.8               | 15.4                            | 10.5 |      |               |
| 2022.9170 | DEC | 180.2                            | 140.3 | 76.1 | 21.2               | 15.4                            | 11.1 |      |               |
| 2023.0003 | JAN | 183.5                            | 142.4 | 76.1 | 21.3               | 15.3                            | 11.6 |      |               |
| 2023.0837 | FEB | 185.6                            | 144.3 | 76.0 | 21.4               | 15.1                            | 11.3 |      |               |
| 2023.1670 | MAR | 185.7                            | 146.0 | 76.1 | 21.6               | 15.0                            | 11.2 |      |               |
| 2023.2503 | APR | 185.2                            | 147.7 | 76.6 | 22.0               | 15.0                            | 10.7 |      |               |
| 2023.3337 | MAY | 184.2                            | 149.0 | 76.9 | 22.8               | 14.9                            | 10.2 |      |               |
| 2023.4170 | JUN | 184.6                            | 149.9 | 77.6 | 22.5               | 14.7                            | 9.9  |      |               |
| 2023.5003 | JUL | 187.3                            | 150.8 | 78.9 | 21.3               | 14.5                            | 10.1 |      |               |
| 2023.5837 | AUG | 190.1                            | 151.2 | 79.7 | 20.6               | 14.3                            | 10.1 |      |               |
| 2023.6670 | SEP | 191.7                            | 151.4 | 80.6 | 20.1               | 14.2                            | 10.3 |      |               |
| 2023.7503 | OCT | 191.8                            | 151.7 | 82.2 | 19.6               | 14.1                            | 10.6 |      |               |
| 2023.8337 | NOV | 191.4                            | 151.9 | 83.8 | 19.5               | 14.0                            | 10.6 |      |               |
| 2023.9170 | DEC | 189.8                            | 152.0 | 85.6 | 19.3               | 14.0                            | 10.5 |      |               |
| 2024.0003 | JAN | 186.5                            | 151.2 | 86.4 | 19.1               | 14.2                            | 10.5 |      |               |
| 2024.0837 | FEB | 182.2                            | 149.7 | 87.8 | 18.9               | 14.6                            | 10.5 |      |               |
| 2024.1670 | MAR | 177.4                            | 148.7 | 89.5 | 18.9               | 14.7                            | 10.3 |      |               |
| 2024.2503 | APR | 173.9                            | 148.4 | 90.7 | 19.5               | 14.6                            | 9.8  |      |               |
| 2024.3337 | MAY | 177.0                            | 148.5 | 93.0 | 20.4               | 14.7                            | 10.2 |      |               |
| 2024.4170 | JUN | 176.6                            | 148.9 | 94.2 | 22.0               | 15.0                            | 10.7 |      |               |
| 2024.5003 | JUL | 173.8                            | 149.0 | 95.5 | 23.4               | 15.3                            | 10.7 |      |               |
| 2024.5837 | AUG | 172.7                            | 148.7 | 95.8 | 24.0               | 15.4                            | 10.9 |      |               |
| 2024.6670 | SEP | 171.7                            | 148.1 | 95.4 | 25.1               | 15.7                            | 11.1 |      |               |
| 2024.7503 | OCT | 170.6                            | 147.5 | 95.4 | 25.6               | 15.9                            | 11.3 |      |               |
| 2024.8337 | NOV | 167.1                            | 147.3 | 96.9 | 24.9               | 15.9                            | 11.5 |      |               |
| 2024.9170 | DEC | 163.8                            | 147.2 | 97.7 | 24.8               | 15.9                            | 11.7 |      |               |
| 2025.0003 | JAN | 161.2                            | 146.4 | 97.2 | 23.9               | 15.8                            | 11.9 |      |               |
| 2025.0837 | FEB | 158.7                            | 145.1 | 96.4 | 22.1               | 15.8                            | 11.8 |      |               |
| 2025.1670 | MAR | 155.9                            | 143.5 | 96.3 | 22.4               | 15.9                            | 12.0 |      |               |
| 2025.2503 | APR | 155.7                            | 141.8 | 96.8 | 23.1               | 16.0                            | 11.8 |      |               |
| 2025.3337 | MAY | 156.4                            | 140.1 | 96.3 | 23.1               | 16.0                            | 11.1 |      |               |
| 2025.4170 | JUN | 154.9                            | 138.8 | 95.5 | 22.6               | 16.0                            | 10.8 |      |               |
| 2025.5003 | JUL | 151.2                            | 137.4 | 96.1 | 22.0               | 15.8                            | 10.8 |      |               |
| 2025.5837 | AUG | 147.1                            | 135.6 | 97.1 | 21.9               | 15.8                            | 10.8 |      |               |
| 2025.6670 | SEP | 144.2                            | 133.7 | 96.2 | 22.7               | 16.1                            | 10.8 |      |               |
| 2025.7503 | OCT | 144.9                            | 132.2 | 94.5 | 23.7               | 16.5                            | 10.8 |      |               |
| 2025.8337 | NOV | 142.3                            | 130.9 | 93.8 | 23.9               | 16.7                            | 10.8 |      |               |
| 2025.9170 | DEC | 137.0                            | 129.5 | 93.6 | 23.9               | 17.0                            | 10.7 |      |               |
| 2026.0003 | JAN | 134.3                            | 127.8 | 91.7 | 23.9               | 17.1                            | 10.6 |      |               |
| 2026.0837 | FEB | 134.9                            | 125.9 | 88.3 | 23.5               | 17.2                            | 10.3 |      |               |
| 2026.1670 | MAR | 134.0                            | 124.6 | 87.9 | 22.5               | 17.2                            | 10.5 |      |               |
| 2026.2503 | APR | 134.3                            | 123.5 | 88.7 | 22.7               | 17.2                            | 10.7 |      |               |
| 2026.3337 | MAY | 132.9                            | 122.3 | 87.3 | 23.0               | 17.4                            | 11.4 |      |               |
| 2026.4170 | JUN | 131.5                            | 121.0 | 86.3 | 23.1               | 17.6                            | 11.9 |      |               |
| 2026.5003 | JUL | 130.4                            | 119.3 | 85.7 | 22.5               | 17.8                            | 12.0 |      |               |
| 2026.5837 | AUG | 129.7                            | 117.4 | 84.8 | 21.7               | 17.6                            | 12.1 |      |               |
| 2026.6670 | SEP | 126.8                            | 115.6 | 83.6 | 21.2               | 17.4                            | 12.3 |      |               |
| 2026.7503 | OCT | 125.7                            | 113.7 | 82.5 | 21.7               | 17.0                            | 12.5 |      |               |
| 2026.8337 | NOV | 125.9                            | 111.7 | 82.1 | 21.7               | 16.9                            | 13.3 |      |               |
| 2026.9170 | DEC | 124.1                            | 110.0 | 82.1 | 22.1               | 16.9                            | 13.1 |      |               |
| 2027.0003 | JAN | 122.4                            | 108.6 | 82.0 | 22.6               | 17.0                            | 12.8 |      |               |
| 2027.0837 | FEB | 120.8                            | 107.0 | 80.9 | 22.3               | 16.8                            | 13.1 |      |               |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
|           |     | 75.0%                            | 50%   | 5.0% | 95.0%                           | 50%  | 5.0% |
| 2027.1670 | MAR | 118.9                            | 105.5 | 80.5 | 22.4                            | 16.5 | 12.7 |
| 2027.2503 | APR | 116.4                            | 104.0 | 80.6 | 22.7                            | 16.2 | 12.5 |
| 2027.3337 | MAY | 115.2                            | 102.5 | 80.0 | 22.9                            | 15.8 | 12.1 |
| 2027.4170 | JUN | 114.2                            | 100.9 | 79.1 | 23.5                            | 15.6 | 11.2 |
| 2027.5003 | JUL | 111.9                            | 99.4  | 77.7 | 24.1                            | 15.4 | 10.5 |
| 2027.5837 | AUG | 108.1                            | 98.2  | 75.6 | 24.8                            | 15.3 | 10.7 |
| 2027.6670 | SEP | 106.6                            | 97.1  | 74.5 | 25.3                            | 15.3 | 10.8 |
| 2027.7503 | OCT | 105.0                            | 96.1  | 74.0 | 25.6                            | 15.3 | 10.6 |
| 2027.8337 | NOV | 104.3                            | 95.2  | 73.6 | 25.4                            | 15.3 | 10.8 |
| 2027.9170 | DEC | 102.5                            | 94.2  | 73.4 | 24.9                            | 15.2 | 11.0 |
| 2028.0003 | JAN | 100.8                            | 92.9  | 73.0 | 24.0                            | 15.0 | 11.1 |
| 2028.0837 | FEB | 99.1                             | 91.7  | 72.7 | 23.0                            | 14.9 | 11.3 |
| 2028.1670 | MAR | 98.3                             | 90.7  | 71.9 | 22.5                            | 15.0 | 11.2 |
| 2028.2503 | APR | 98.3                             | 89.6  | 71.4 | 22.1                            | 15.1 | 11.1 |
| 2028.3337 | MAY | 97.9                             | 88.4  | 71.0 | 21.8                            | 15.2 | 11.2 |
| 2028.4170 | JUN | 97.0                             | 87.3  | 70.7 | 21.4                            | 15.3 | 11.4 |
| 2028.5003 | JUL | 95.7                             | 86.5  | 70.4 | 20.7                            | 15.2 | 11.5 |
| 2028.5837 | AUG | 95.0                             | 85.6  | 70.5 | 19.9                            | 14.9 | 11.3 |
| 2028.6670 | SEP | 93.3                             | 84.7  | 70.3 | 20.0                            | 14.7 | 11.1 |
| 2028.7503 | OCT | 91.0                             | 83.5  | 69.8 | 20.1                            | 14.6 | 10.8 |
| 2028.8337 | NOV | 89.6                             | 82.4  | 69.6 | 19.9                            | 14.3 | 10.1 |
| 2028.9170 | DEC | 88.2                             | 81.7  | 69.5 | 19.5                            | 14.2 | 9.6  |
| 2029.0003 | JAN | 86.7                             | 81.0  | 69.4 | 19.0                            | 14.1 | 9.1  |
| 2029.0837 | FEB | 86.0                             | 80.3  | 69.3 | 18.3                            | 14.1 | 8.6  |
| 2029.1670 | MAR | 85.4                             | 79.6  | 69.1 | 17.3                            | 14.0 | 8.0  |
| 2029.2503 | APR | 84.3                             | 78.9  | 68.8 | 17.4                            | 13.8 | 7.5  |
| 2029.3337 | MAY | 82.9                             | 78.2  | 68.5 | 17.5                            | 13.7 | 7.6  |
| 2029.4170 | JUN | 81.8                             | 77.5  | 68.3 | 17.6                            | 13.7 | 7.8  |
| 2029.5003 | JUL | 81.3                             | 77.0  | 68.4 | 17.5                            | 13.6 | 8.3  |
| 2029.5837 | AUG | 81.0                             | 76.5  | 68.4 | 17.7                            | 13.5 | 8.6  |
| 2029.6670 | SEP | 80.8                             | 75.9  | 68.5 | 18.1                            | 13.4 | 8.5  |
| 2029.7503 | OCT | 79.4                             | 75.4  | 68.4 | 17.9                            | 13.2 | 8.6  |
| 2029.8337 | NOV | 78.0                             | 74.9  | 68.4 | 17.6                            | 12.9 | 8.5  |
| 2029.9170 | DEC | 77.4                             | 74.2  | 68.3 | 17.3                            | 12.6 | 8.5  |
| 2030.0003 | JAN | 76.8                             | 73.5  | 68.0 | 16.3                            | 12.2 | 8.4  |
| 2030.0837 | FEB | 75.8                             | 72.8  | 67.8 | 14.8                            | 11.8 | 8.4  |
| 2030.1670 | MAR | 75.6                             | 72.3  | 67.6 | 13.8                            | 11.4 | 8.3  |
| 2030.2503 | APR | 74.6                             | 72.0  | 67.6 | 13.9                            | 11.0 | 8.2  |
| 2030.3337 | MAY | 73.4                             | 71.6  | 67.5 | 13.6                            | 10.6 | 8.2  |
| 2030.4170 | JUN | 73.5                             | 71.2  | 67.2 | 13.2                            | 10.3 | 7.9  |
| 2030.5003 | JUL | 72.6                             | 70.9  | 67.1 | 12.9                            | 9.9  | 7.4  |
| 2030.5837 | AUG | 72.3                             | 70.6  | 67.1 | 12.6                            | 9.7  | 7.1  |
| 2030.6670 | SEP | 72.2                             | 70.3  | 67.0 | 11.9                            | 9.5  | 7.3  |
| 2030.7503 | OCT | 71.9                             | 70.1  | 67.0 | 11.4                            | 9.4  | 7.1  |

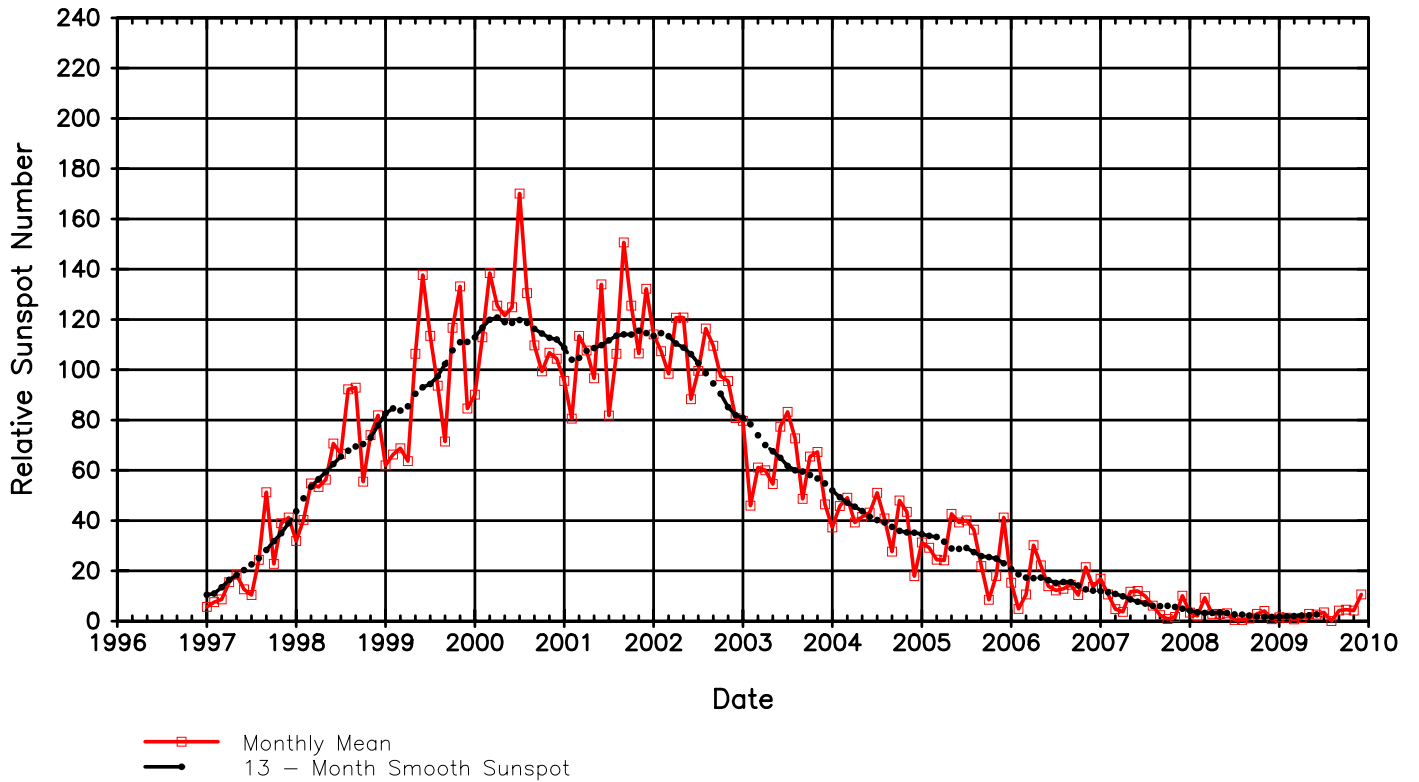


**Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux**

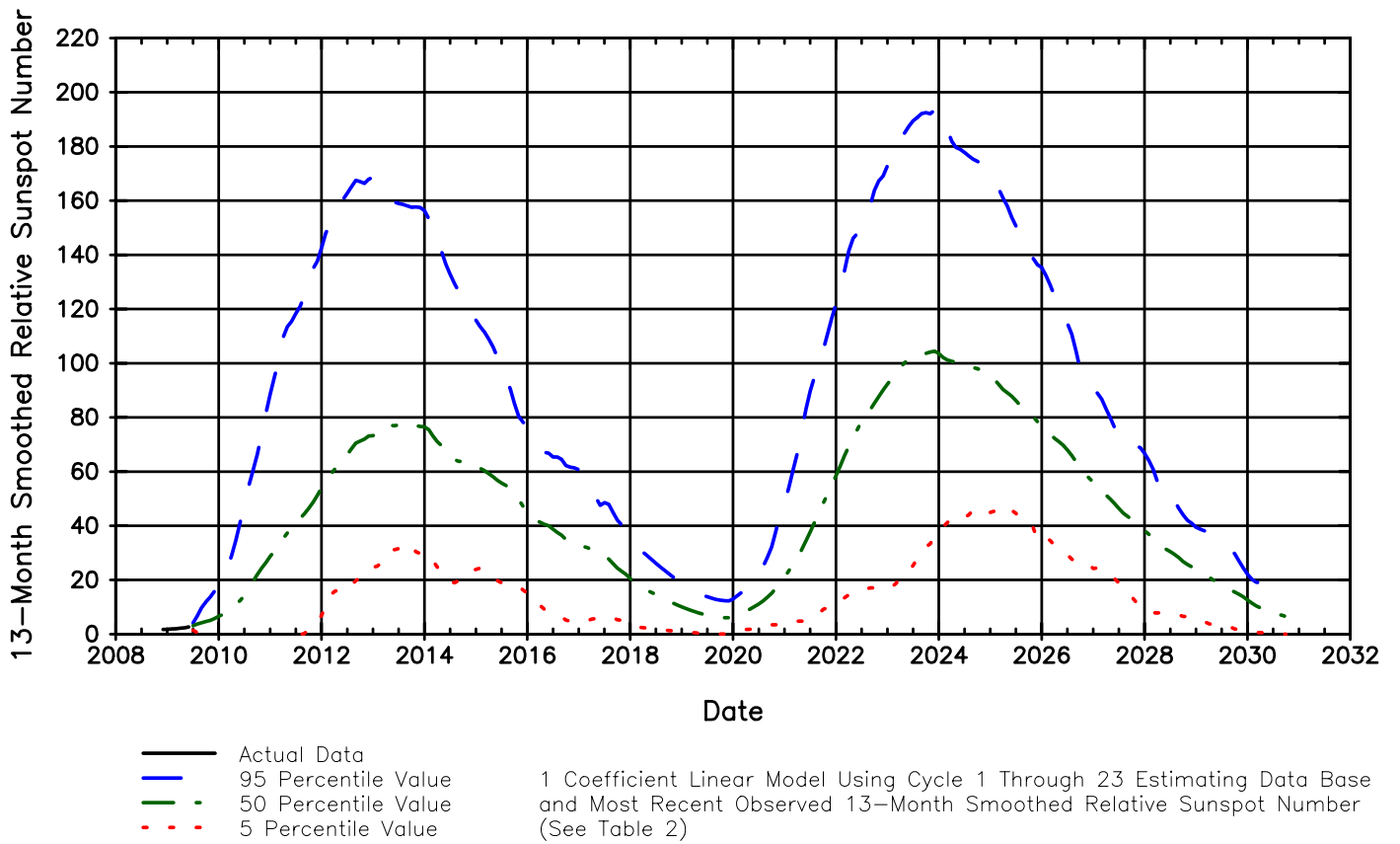


**Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 23\* and Cycle 24**

\* Program initialized from the start of Cycle 24



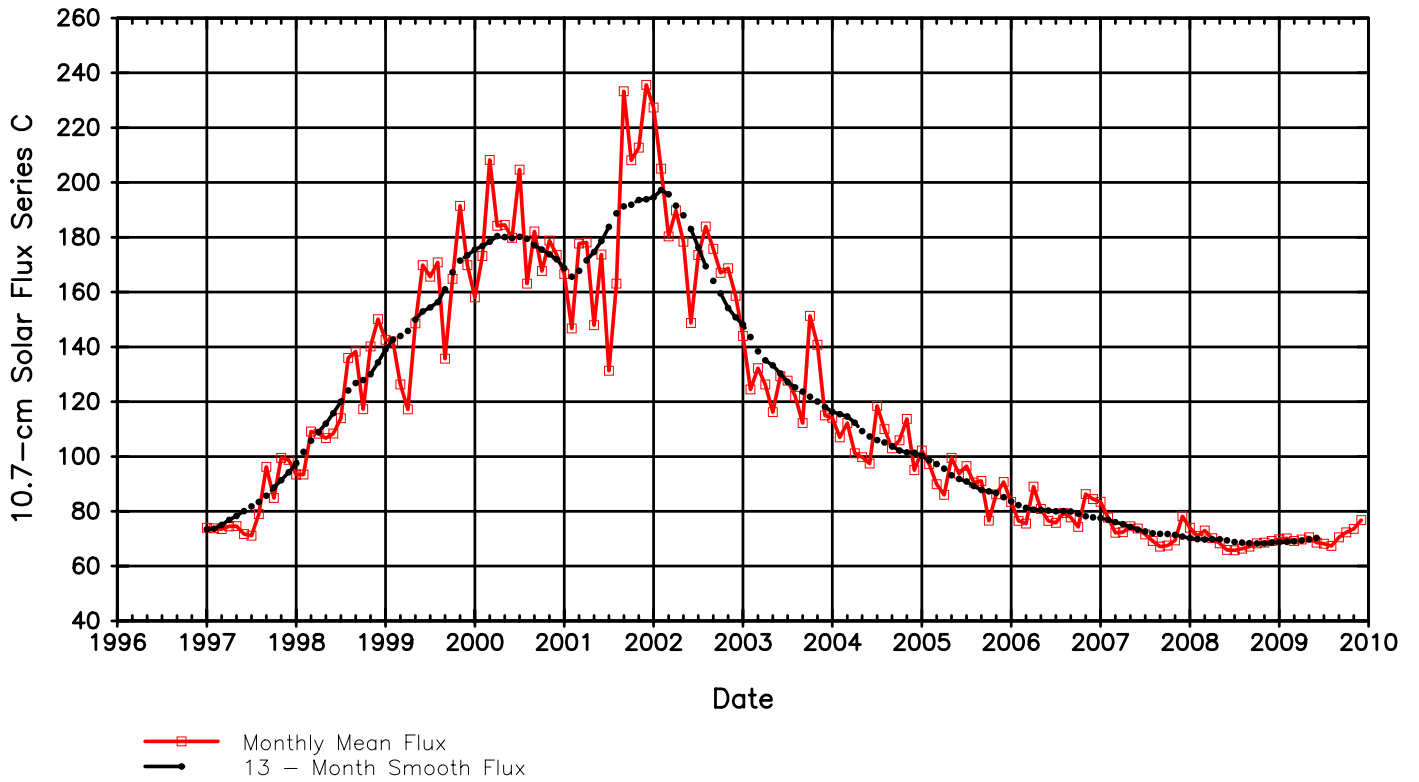
**Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number**



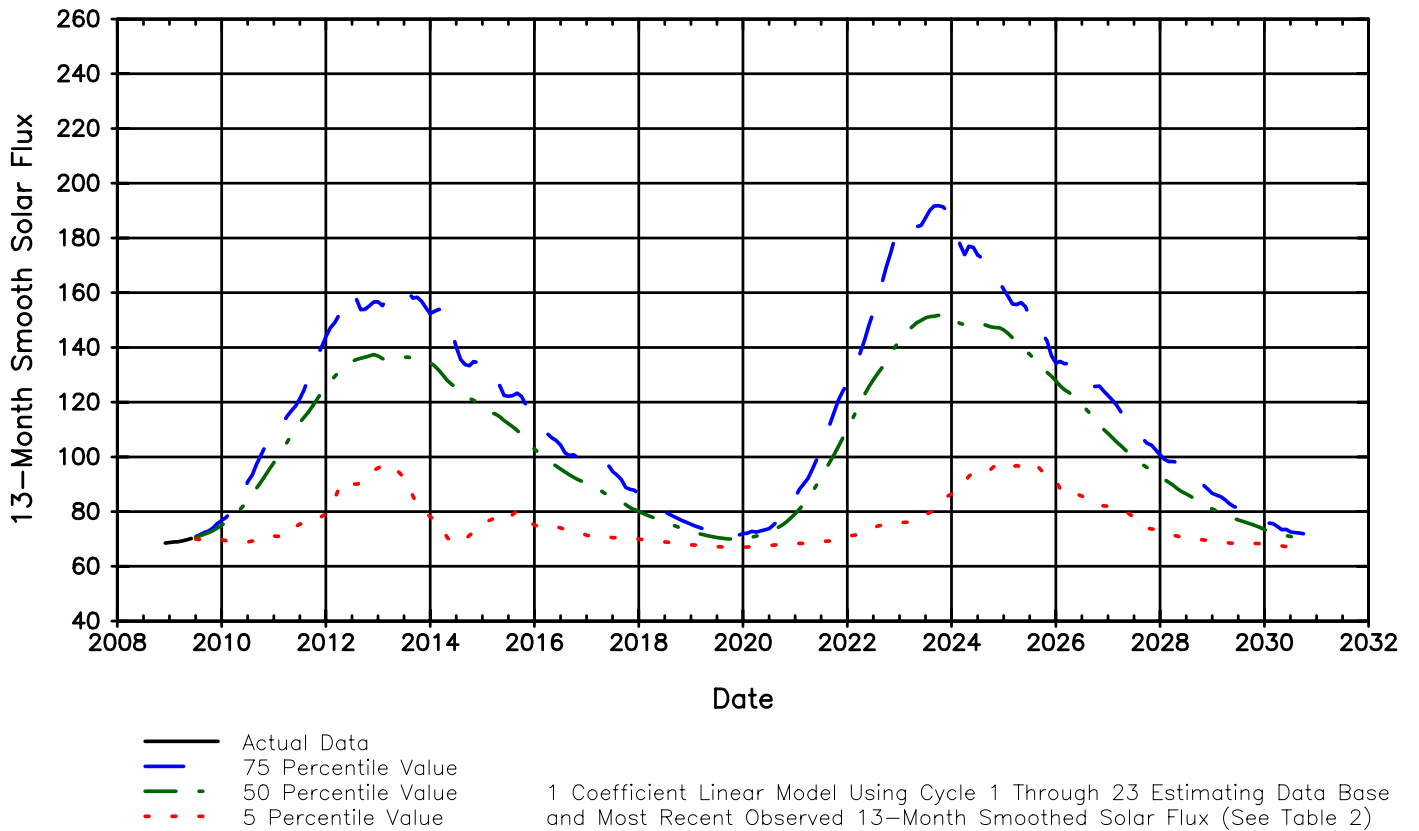
**Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 23\* and Cycle 24**

\* Program initialized from the start of Cycle 24





**Figure 5. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux**



**Figure 6. Estimate of 75<sup>th</sup> Percentile 13-Month Smoothed Solar Flux For Cycle 23\* and Cycle 24**

\* Program initialized from the start of Cycle 24