

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

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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 5¹. 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 5¹ 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 and 24. 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 5¹ is a plot of monthly mean and 13-month smoothed observed A_p flux for solar

¹ 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.

cycle 23 and 24. 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 (\bar{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).

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) regarding the clarity and operational usefulness of this estimate.

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TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES

| Year | Month | Solar Flux (F_{10.7} (Series C)) | Relative Sunspot Numbers (R) | Geomagnetic Index (A_p) |
|-------------|--------------|---|---|--|
| 2011 | January | 83.4 | 27.3 | 6.0 |
| | February | 94.6 | 48.3 | 6.0 |
| | March | 115.3 | 78.6 | 8.0 |
| | April | 112.5 | 76.1 | 9.0 |
| | May | 95.8 | 58.2 | 9.0 |
| | June | 95.8 | 56.1 | 8.0 |
| | July | 94.1 | 64.5 | 8.0 |
| | August | 101.7 | 65.8 | 7.0 |
| | September | 134.5 | 120.1 | 12.0 |
| | October | 137.2 | 125.7 | 7.0 |
| | November | 153.2 | 139.1 | 5.0 |
| | December | 141.2 | 109.3 | 4.0 |
| 2012 | January | 134.8 | 94.4 | 7.0 |
| | February | 106.9 | 47.8 | 9.0 |
| | March | 115.7 | 86.6 | 16.0 |
| | April | 113.1 | 85.9 | 10.0 |
| | May | 121.4 | 96.5 | 7.0 |
| | June | 120.4 | 92 | 10.0 |
| | July | 137.8 | 100.1 | 14.0 |
| | August | 115.7 | 94.8 | 7.0 |
| | September | 123.0 | 93.7 | 8.0 |
| | October | 123.2 | 76.5 | 10.0 |
| | November | 121.2 | 87.6 | 7.0 |
| | December | 108.3 | 56.8 | 3.0 |
| 2013 | January | 127.1 | 96.1 | 5.0 |
| | February | 104.2 | 60.9 | 6.0 |
| | March | 111.3 | 78.3 | 11.0 |
| | April | 125.0 | 107.3 | 5.0 |
| | May | 131.4 | 120.2 | 10.0 |
| | June | 110.7 | 76.7 | 13.0 |
| | July | 115.6 | 86.2 | 9.0 |
| | August | 114.7 | 91.8 | 8.0 |
| | September | 102.7 | 54.5 | 5.0 |
| | October | 132.3 | 114.4 | 8.0 |
| | November | 148.8 | 113.9 | 6.0 |
| | December | 148.1 | 124.2 | 5.0 |

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

* Preliminary Estimates

TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES

| Year | Month | Solar Flux (F_{10.7} (Series C)) | Relative Sunspot Numbers (R) | Geomagnetic Index (A_p) |
|-------------|--------------|---|---|--|
| 2014 | January | 158.6 | 117 | 5.0 |
| | February | 170.3 | 146.1 | 11.0 |
| | March | 150.0 | 128.7 | 5.0 |
| | April | 144.3 | 112.5 | 8.0 |
| | May | 130.1 | 112.5 | 6.0 |
| | June | 122.4 | 102.9 | 7.0 |
| | July | 137.9 | 100.2 | 5.0 |
| | August | 124.6 | 106.9 | 8.0 |
| | September | 146.2 | 130 | 10.0 |
| | October | 153.7 | 90 | 9.0 |
| | November | 155.3 | 103.6 | 9.0 |
| | December | 158.7 | 112.9 | 11.0 |
| 2015 | January | 142.8 | 93.0 | 9.0 |
| | February | 128.9 | 66.7 | 10.0 |
| | March | 126.1 | 54.5 | 16.0 |
| | April | 129.1 | 75.3 | 11.0 |
| | May | 120.1 | 88.8 | 8.0 |
| | June | 123.2 | 66.5 | 13.0 |
| | July | 107.0 | 65.8 | 9.0 |
| | August | 105.9 | 64.4 | 14.0 |
| | September | 102.0 | 78.6 | 16.0 |
| | October | 104.0 | 63.6 | 14.0 |
| | November | 109.7 | 62.2 | 12.0 |
| | December | 112.5 | 58.0 | 14.0 |
| 2016 | January | 103.6* | 56.6* | 9.0* |
| | February | 103.7* | 57.2* | 10.0* |
| | March | 91.4* | 54.9* | 11.0* |

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (\bar{A}_p) |
|-------------|--------------|--|---|--|
| 2008 | January | 70.3 | 6.6 | 7.7 |
| | February | 69.9 | 5.6 | 7.5 |
| | March | 69.8 | 5.1 | 7.4 |
| | April | 69.8 | 5.1 | 7.3 |
| | May | 69.8 | 5.4 | 7.2 |
| | June | 69.4 | 4.8 | 7.0 |
| | July | 68.8 | 4 | 6.8 |
| | August | 68.6 | 3.8 | 6.3 |
| | September | 68.4 | 3.2 | 5.8 |
| | October | 68.2 | 2.4 | 5.4 |
| | November | 68.3 | 2.3 | 5.1 |
| | December | 68.5 | 2.2 | 4.9 |
| 2009 | January | 68.7 | 2.5 | 4.7 |
| | February | 68.9 | 2.7 | 4.7 |
| | March | 69.0 | 2.9 | 4.6 |
| | April | 69.3 | 3.3 | 4.3 |
| | May | 69.7 | 3.5 | 4.1 |
| | June | 70.2 | 4.1 | 4.0 |
| | July | 71.0 | 5.5 | 3.8 |
| | August | 72.1 | 7.4 | 3.8 |
| | September | 73.3 | 9.5 | 3.8 |
| | October | 74.2 | 10.9 | 4. |
| | November | 74.6 | 11.7 | 4.5 |
| | December | 74.9 | 12.7 | 4.8 |
| 2010 | January | 75.5 | 14 | 5.0 |
| | February | 76.5 | 16.1 | 5.1 |
| | March | 77.4 | 18.5 | 5.3 |
| | April | 78.3 | 20.8 | 5.5 |
| | May | 79.0 | 23.1 | 5.7 |
| | June | 79.7 | 24.6 | 5.8 |
| | July | 80.1 | 25.2 | 6.0 |
| | August | 80.6 | 26.4 | 6.2 |
| | September | 82.4 | 29.5 | 6.4 |
| | October | 85.3 | 34.5 | 6.5 |
| | November | 87.7 | 39.1 | 6.5 |
| | December | 89.6 | 42.5 | 6.5 |

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (\bar{A}_p) |
|-------------|--------------|--|---|--|
| 2011 | January | 91.2 | 45.7 | 6.7 |
| | February | 92.7 | 48.8 | 6.8 |
| | March | 95.8 | 53.8 | 7.0 |
| | April | 100.4 | 61.1 | 7.4 |
| | May | 105.6 | 69.3 | 7.4 |
| | June | 110.9 | 77.2 | 7.3 |
| | July | 115.5 | 83.6 | 7.5 |
| | August | 118.1 | 86.3 | 7.6 |
| | September | 118.6 | 86.6 | 8.1 |
| | October | 118.6 | 87.4 | 8.5 |
| | November | 119.7 | 89.4 | 8.4 |
| | December | 121.8 | 92.5 | 8.4 |
| 2012 | January | 124.7 | 95.5 | 8.7 |
| | February | 127.1 | 98.2 | 9.0 |
| | March | 127.2 | 98.3 | 8.8 |
| | April | 126.1 | 95.1 | 8.8 |
| | May | 124.2 | 90.9 | 9.0 |
| | June | 121.5 | 86.6 | 9.0 |
| | July | 119.8 | 84.5 | 8.9 |
| | August | 119.4 | 85.1 | 8.7 |
| | September | 119.1 | 85.3 | 8.4 |
| | October | 119.4 | 85.8 | 8.0 |
| | November | 120.3 | 87.7 | 7.9 |
| | December | 120.3 | 88.1 | 8.1 |
| 2013 | January | 119.0 | 86.8 | 8.0 |
| | February | 118.0 | 86.1 | 7.9 |
| | March | 117.1 | 84.4 | 7.8 |
| | April | 116.6 | 84.3 | 7.6 |
| | May | 118.2 | 87 | 7.5 |
| | June | 121.0 | 90.9 | 7.5 |
| | July | 123.9 | 94.6 | 7.6 |
| | August | 128.0 | 99 | 7.8 |
| | September | 132.4 | 104.7 | 7.8 |
| | October | 134.8 | 107 | 7.7 |
| | November | 135.6 | 106.9 | 7.6 |
| | December | 136.0 | 107.6 | 7.2 |

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (\bar{A}_p) |
|-------------|--------------|--|---|--|
| 2014 | January | 137.4 | 109.3 | 6.8 |
| | February | 138.7 | 110.5 | 6.6 |
| | March | 140.9 | 114.3 | 6.8 |
| | April | 143.6 | 116.4 | 7.0 |
| | May | 144.8 | 115 | 7.2 |
| | June | 145.5 | 114.1 | 7.6 |
| | July | 145.3 | 112.6 | 8.0 |
| | August | 142.9 | 108.3 | 8.1 |
| | September | 140.2 | 101.9 | 8.5 |
| | October | 138.6 | 97.3 | 9.1 |
| | November | 137.5 | 94.7 | 9.3 |
| | December | 137.1 | 92.2 | 9.7 |
| 2015 | January | 135.9 | 89.3 | 10.1 |
| | February | 133.9 | 86.1 | 10.5 |
| | March | 131.2 | 82.2 | 11.0 |
| | April | 127.3 | 78.9 | 11.5 |
| | May | 123.4 | 76.1 | 11.8 |
| | June | 119.5 | 72.1 | 12.0 |
| | July | 116.0* | 68.3* | 12.2* |
| | August | 113.3* | 66.4* | 12.2* |
| | September | 110.8* | 66.0 | 12.0* |

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
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX | | |
|-----------|-----|--------------------|-------|-------|--------------------|-------------------|------|------|
| | | PERCENTILE | | | | PERCENTILE | | |
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% |
| 2015.7503 | OCT | 112.6 | 109.1 | 106.0 | 13.4 | 12.2 | 10.8 | |
| 2015.8337 | NOV | 113.4 | 107.2 | 102.3 | 14.1 | 12.5 | 9.9 | |
| 2015.9170 | DEC | 114.4 | 105.7 | 99.5 | 15.6 | 13.0 | 9.8 | |
| 2016.0003 | JAN | 114.9 | 104.4 | 97.0 | 17.4 | 13.9 | 10.2 | |
| 2016.0837 | FEB | 114.4 | 103.0 | 93.9 | 18.6 | 14.6 | 10.7 | |
| 2016.1670 | MAR | 113.5 | 101.7 | 91.1 | 19.9 | 15.0 | 11.2 | |
| 2016.2503 | APR | 112.6 | 100.4 | 88.8 | 20.9 | 15.2 | 11.4 | |
| 2016.3337 | MAY | 110.8 | 99.0 | 86.0 | 21.4 | 14.9 | 11.1 | |
| 2016.4170 | JUN | 111.9 | 97.6 | 83.6 | 22.1 | 14.8 | 10.4 | |
| 2016.5003 | JUL | 112.7 | 96.4 | 82.3 | 22.8 | 14.6 | 9.7 | |
| 2016.5837 | AUG | 111.7 | 95.3 | 81.5 | 23.5 | 14.5 | 9.8 | |
| 2016.6670 | SEP | 111.0 | 94.2 | 80.9 | 23.9 | 14.4 | 9.8 | |
| 2016.7503 | OCT | 110.1 | 93.2 | 80.5 | 23.7 | 14.2 | 9.5 | |
| 2016.8337 | NOV | 107.7 | 92.3 | 80.3 | 22.7 | 13.6 | 9.0 | |
| 2016.9170 | DEC | 105.8 | 91.3 | 80.0 | 21.5 | 13.1 | 8.8 | |
| 2017.0003 | JAN | 104.6 | 90.2 | 79.1 | 20.2 | 12.7 | 8.7 | |
| 2017.0837 | FEB | 104.6 | 89.1 | 77.7 | 18.9 | 12.4 | 8.6 | |
| 2017.1670 | MAR | 104.5 | 88.3 | 76.7 | 18.4 | 12.5 | 8.5 | |
| 2017.2503 | APR | 103.4 | 87.4 | 76.2 | 18.1 | 12.7 | 8.5 | |
| 2017.3337 | MAY | 101.6 | 86.2 | 76.4 | 18.2 | 13.1 | 8.9 | |
| 2017.4170 | JUN | 99.1 | 85.3 | 76.6 | 18.9 | 13.7 | 9.7 | |
| 2017.5003 | JUL | 97.8 | 84.5 | 76.2 | 19.5 | 14.3 | 10.4 | |
| 2017.5837 | AUG | 96.9 | 83.7 | 75.6 | 19.8 | 14.4 | 10.4 | |
| 2017.6670 | SEP | 96.2 | 83.0 | 75.0 | 20.0 | 14.5 | 10.7 | |
| 2017.7503 | OCT | 94.8 | 82.0 | 74.3 | 20.2 | 14.7 | 11.1 | |
| 2017.8337 | NOV | 92.9 | 81.0 | 73.1 | 19.9 | 15.0 | 11.2 | |
| 2017.9170 | DEC | 91.5 | 80.4 | 71.0 | 19.5 | 15.2 | 11.3 | |
| 2018.0003 | JAN | 91.2 | 79.9 | 69.3 | 19.0 | 15.4 | 11.3 | |
| 2018.0837 | FEB | 90.2 | 79.3 | 68.5 | 19.4 | 15.6 | 11.0 | |
| 2018.1670 | MAR | 88.4 | 78.6 | 67.9 | 19.5 | 15.5 | 10.3 | |
| 2018.2503 | APR | 87.7 | 78.0 | 67.5 | 19.3 | 15.3 | 10.0 | |
| 2018.3337 | MAY | 87.1 | 77.3 | 67.1 | 18.8 | 14.9 | 9.6 | |
| 2018.4170 | JUN | 86.0 | 76.7 | 67.1 | 18.0 | 14.6 | 9.5 | |
| 2018.5003 | JUL | 84.9 | 76.2 | 67.1 | 18.0 | 14.5 | 9.8 | |
| 2018.5837 | AUG | 83.8 | 75.6 | 67.1 | 18.3 | 14.4 | 9.8 | |
| 2018.6670 | SEP | 82.8 | 75.0 | 67.1 | 18.6 | 14.3 | 9.6 | |
| 2018.7503 | OCT | 81.8 | 74.4 | 67.1 | 18.5 | 14.0 | 9.5 | |
| 2018.8337 | NOV | 80.7 | 73.9 | 67.1 | 18.1 | 13.6 | 9.5 | |
| 2018.9170 | DEC | 79.8 | 73.4 | 67.1 | 17.3 | 13.1 | 9.2 | |
| 2019.0003 | JAN | 78.9 | 72.9 | 67.1 | 16.5 | 12.6 | 8.9 | |
| 2019.0837 | FEB | 78.0 | 72.4 | 67.0 | 15.7 | 12.0 | 8.6 | |
| 2019.1670 | MAR | 77.2 | 72.0 | 67.0 | 15.0 | 11.5 | 8.3 | |
| 2019.2503 | APR | 76.4 | 71.6 | 67.0 | 14.2 | 11.1 | 8.1 | |
| 2019.3337 | MAY | 75.7 | 71.2 | 67.0 | 13.6 | 10.6 | 7.8 | |
| 2019.4170 | JUN | 75.1 | 70.9 | 67.0 | 13.0 | 10.2 | 7.6 | |
| 2019.5003 | JUL | 74.5 | 70.6 | 67.0 | 12.4 | 9.9 | 7.4 | |
| 2019.5837 | AUG | 74.1 | 70.3 | 67.0 | 12.0 | 9.6 | 7.3 | |
| 2019.6670 | SEP | 73.7 | 70.1 | 67.0 | 11.6 | 9.3 | 7.1 | |
| 2019.7503 | OCT | 73.4 | 70.0 | 67.0 | 11.3 | 9.1 | 7.0 | |
| 2019.8337 | NOV | 73.3 | 69.9 | 67.0 | 11.1 | 9.0 | 7.0 | |

TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR CYCLE 24 AND CYCLE 25

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|-------------------------------|-------|------|--------------------|------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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 | | |
| 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 | | |

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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 | | |
| 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 | | |

**TABLE 3 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|------|------|--------------------|---------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | (\bar{R}) | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|------------------------------|------|------|-------------|---------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2015.7503 | OCT | 68.8 | 63.2 | 58.0 | 13.4 | 12.2 | 10.8 | | |
| 2015.8337 | NOV | 72.3 | 61.2 | 53.4 | 14.1 | 12.5 | 9.9 | | |
| 2015.9170 | DEC | 73.9 | 59.0 | 48.4 | 15.6 | 13.0 | 9.8 | | |
| 2016.0003 | JAN | 74.2 | 56.9 | 43.4 | 17.4 | 13.9 | 10.2 | | |
| 2016.0837 | FEB | 75.9 | 55.7 | 39.3 | 18.6 | 14.6 | 10.7 | | |
| 2016.1670 | MAR | 77.0 | 53.7 | 35.7 | 19.9 | 15.0 | 11.2 | | |
| 2016.2503 | APR | 76.2 | 51.3 | 31.2 | 20.9 | 15.2 | 11.4 | | |
| 2016.3337 | MAY | 74.7 | 49.6 | 27.2 | 21.4 | 14.9 | 11.1 | | |
| 2016.4170 | JUN | 75.1 | 48.5 | 24.1 | 22.1 | 14.8 | 10.4 | | |
| 2016.5003 | JUL | 74.7 | 47.1 | 22.7 | 22.8 | 14.6 | 9.7 | | |
| 2016.5837 | AUG | 74.5 | 45.1 | 20.8 | 23.5 | 14.5 | 9.8 | | |
| 2016.6670 | SEP | 72.4 | 43.4 | 18.3 | 23.9 | 14.4 | 9.8 | | |
| 2016.7503 | OCT | 67.8 | 41.3 | 16.8 | 23.7 | 14.2 | 9.5 | | |
| 2016.8337 | NOV | 63.4 | 39.1 | 15.7 | 22.7 | 13.6 | 9.0 | | |
| 2016.9170 | DEC | 61.1 | 36.7 | 15.0 | 21.5 | 13.1 | 8.8 | | |
| 2017.0003 | JAN | 61.6 | 34.7 | 13.6 | 20.2 | 12.7 | 8.7 | | |
| 2017.0837 | FEB | 63.0 | 33.6 | 11.7 | 18.9 | 12.4 | 8.6 | | |
| 2017.1670 | MAR | 62.3 | 32.5 | 10.4 | 18.4 | 12.5 | 8.5 | | |
| 2017.2503 | APR | 61.3 | 31.1 | 10.7 | 18.1 | 12.7 | 8.5 | | |
| 2017.3337 | MAY | 59.0 | 29.5 | 11.7 | 18.2 | 13.1 | 8.9 | | |
| 2017.4170 | JUN | 57.4 | 28.2 | 11.9 | 18.9 | 13.7 | 9.7 | | |
| 2017.5003 | JUL | 56.6 | 27.0 | 10.6 | 19.5 | 14.3 | 10.4 | | |
| 2017.5837 | AUG | 54.9 | 25.9 | 9.3 | 19.8 | 14.4 | 10.4 | | |
| 2017.6670 | SEP | 52.3 | 24.7 | 8.0 | 20.0 | 14.5 | 10.7 | | |
| 2017.7503 | OCT | 50.1 | 23.4 | 5.0 | 20.2 | 14.7 | 11.1 | | |
| 2017.8337 | NOV | 48.8 | 23.2 | 1.7 | 19.9 | 15.0 | 11.2 | | |
| 2017.9170 | DEC | 47.3 | 22.9 | -1.5 | 19.5 | 15.2 | 11.3 | | |
| 2018.0003 | JAN | 44.1 | 22.1 | -4.3 | 19.0 | 15.4 | 11.3 | | |
| 2018.0837 | FEB | 41.2 | 21.5 | -5.7 | 19.4 | 15.6 | 11.0 | | |
| 2018.1670 | MAR | 39.9 | 20.6 | -6.3 | 19.5 | 15.5 | 10.3 | | |
| 2018.2503 | APR | 39.3 | 19.6 | -6.9 | 19.3 | 15.3 | 10.0 | | |
| 2018.3337 | MAY | 37.7 | 18.9 | -6.3 | 18.8 | 14.9 | 9.6 | | |
| 2018.4170 | JUN | 36.2 | 18.1 | -5.8 | 18.0 | 14.6 | 9.5 | | |
| 2018.5003 | JUL | 34.6 | 17.4 | -5.3 | 18.0 | 14.5 | 9.8 | | |
| 2018.5837 | AUG | 33.1 | 16.7 | -4.8 | 18.3 | 14.4 | 9.8 | | |
| 2018.6670 | SEP | 31.6 | 16.0 | -4.3 | 18.6 | 14.3 | 9.6 | | |
| 2018.7503 | OCT | 30.2 | 15.3 | -3.9 | 18.5 | 14.0 | 9.5 | | |
| 2018.8337 | NOV | 28.8 | 14.6 | -3.4 | 18.1 | 13.6 | 9.5 | | |
| 2018.9170 | DEC | 27.4 | 13.9 | -3.0 | 17.3 | 13.1 | 9.2 | | |
| 2019.0003 | JAN | 26.2 | 13.3 | -2.5 | 16.5 | 12.6 | 8.9 | | |
| 2019.0837 | FEB | 25.0 | 12.7 | -2.1 | 15.7 | 12.0 | 8.6 | | |
| 2019.1670 | MAR | 23.8 | 12.2 | -1.8 | 15.0 | 11.5 | 8.3 | | |
| 2019.2503 | APR | 22.8 | 11.7 | -1.4 | 14.2 | 11.1 | 8.1 | | |
| 2019.3337 | MAY | 21.8 | 11.2 | -1.1 | 13.6 | 10.6 | 7.8 | | |
| 2019.4170 | JUN | 21.0 | 10.8 | -0.8 | 13.0 | 10.2 | 7.6 | | |
| 2019.5003 | JUL | 20.2 | 10.5 | -0.6 | 12.4 | 9.9 | 7.4 | | |
| 2019.5837 | AUG | 19.6 | 10.2 | -0.4 | 12.0 | 9.6 | 7.3 | | |
| 2019.6670 | SEP | 19.1 | 9.9 | -0.2 | 11.6 | 9.3 | 7.1 | | |
| 2019.7503 | OCT | 18.7 | 9.7 | -0.1 | 11.3 | 9.1 | 7.0 | | |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED \bar{R} AND \bar{A}_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | (\bar{R}) | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|------------------------------|-------|------|-------------|---------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2019.8337 | NOV | 18.5 | 9.6 | 0.0 | 11.1 | 9.0 | 7.0 | | |
| 2019.9170 | DEC | 18.4 | 9.6 | 0.0 | 11.1 | 9.0 | 6.9 | | |
| 2020.0003 | JAN | 19.4 | 10.3 | 0.7 | 11.3 | 9.0 | 6.9 | | |
| 2020.0837 | FEB | 21.3 | 11.4 | 1.5 | 11.6 | 9.2 | 7.1 | | |
| 2020.1670 | MAR | 23.0 | 12.4 | 2.1 | 11.7 | 9.3 | 7.4 | | |
| 2020.2503 | APR | 25.6 | 13.4 | 2.8 | 11.9 | 9.4 | 7.5 | | |
| 2020.3337 | MAY | 28.5 | 14.7 | 3.2 | 12.0 | 9.5 | 7.5 | | |
| 2020.4170 | JUN | 33.4 | 16.2 | 3.9 | 12.1 | 9.6 | 7.3 | | |
| 2020.5003 | JUL | 37.0 | 17.8 | 5.0 | 12.2 | 9.7 | 7.2 | | |
| 2020.5837 | AUG | 40.7 | 19.5 | 5.4 | 12.5 | 9.9 | 7.1 | | |
| 2020.6670 | SEP | 46.2 | 21.6 | 5.5 | 12.8 | 10.1 | 7.0 | | |
| 2020.7503 | OCT | 53.3 | 23.9 | 5.8 | 13.2 | 10.5 | 7.2 | | |
| 2020.8337 | NOV | 63.8 | 26.8 | 5.8 | 13.7 | 10.8 | 7.6 | | |
| 2020.9170 | DEC | 72.8 | 30.1 | 5.9 | 14.5 | 11.1 | 7.9 | | |
| 2021.0003 | JAN | 79.8 | 33.3 | 7.0 | 15.7 | 11.4 | 7.7 | | |
| 2021.0837 | FEB | 90.0 | 37.0 | 7.1 | 16.1 | 11.6 | 7.7 | | |
| 2021.1670 | MAR | 101.3 | 41.0 | 7.1 | 16.3 | 11.8 | 7.6 | | |
| 2021.2503 | APR | 111.5 | 45.0 | 7.9 | 16.8 | 12.0 | 7.6 | | |
| 2021.3337 | MAY | 123.8 | 49.3 | 8.1 | 18.0 | 12.3 | 7.6 | | |
| 2021.4170 | JUN | 138.5 | 54.4 | 8.6 | 18.9 | 12.6 | 7.7 | | |
| 2021.5003 | JUL | 148.6 | 59.6 | 9.7 | 19.1 | 12.7 | 7.7 | | |
| 2021.5837 | AUG | 155.6 | 65.1 | 11.4 | 19.2 | 12.9 | 7.8 | | |
| 2021.6670 | SEP | 162.7 | 70.7 | 12.9 | 19.0 | 13.1 | 7.7 | | |
| 2021.7503 | OCT | 170.5 | 76.0 | 15.2 | 18.6 | 13.1 | 7.7 | | |
| 2021.8337 | NOV | 179.3 | 81.2 | 16.4 | 18.5 | 13.2 | 7.8 | | |
| 2021.9170 | DEC | 188.6 | 86.5 | 16.5 | 18.9 | 13.4 | 8.0 | | |
| 2022.0003 | JAN | 197.4 | 92.3 | 18.8 | 18.8 | 13.5 | 8.2 | | |
| 2022.0837 | FEB | 205.1 | 98.1 | 20.6 | 17.8 | 13.5 | 8.6 | | |
| 2022.1670 | MAR | 213.1 | 103.9 | 22.3 | 17.9 | 13.7 | 8.7 | | |
| 2022.2503 | APR | 217.8 | 109.7 | 24.3 | 18.5 | 13.9 | 8.7 | | |
| 2022.3337 | MAY | 224.3 | 115.1 | 25.1 | 19.1 | 14.2 | 9.0 | | |
| 2022.4170 | JUN | 225.7 | 119.9 | 26.1 | 19.6 | 14.6 | 9.4 | | |
| 2022.5003 | JUL | 226.2 | 124.5 | 27.1 | 20.3 | 14.9 | 9.6 | | |
| 2022.5837 | AUG | 231.6 | 128.4 | 27.8 | 20.3 | 15.1 | 9.6 | | |
| 2022.6670 | SEP | 234.1 | 131.7 | 28.6 | 20.3 | 15.1 | 9.8 | | |
| 2022.7503 | OCT | 236.5 | 135.4 | 28.5 | 20.5 | 15.2 | 10.0 | | |
| 2022.8337 | NOV | 239.8 | 139.1 | 27.9 | 20.8 | 15.4 | 10.5 | | |
| 2022.9170 | DEC | 242.1 | 142.9 | 27.3 | 21.2 | 15.4 | 11.1 | | |
| 2023.0003 | JAN | 248.6 | 146.3 | 28.1 | 21.3 | 15.3 | 11.6 | | |
| 2023.0837 | FEB | 256.1 | 149.3 | 29.0 | 21.4 | 15.1 | 11.3 | | |
| 2023.1670 | MAR | 261.0 | 152.2 | 31.1 | 21.6 | 15.0 | 11.2 | | |
| 2023.2503 | APR | 265.2 | 155.6 | 34.4 | 22.0 | 15.0 | 10.7 | | |
| 2023.3337 | MAY | 269.9 | 158.3 | 36.3 | 22.8 | 14.9 | 10.2 | | |
| 2023.4170 | JUN | 273.3 | 160.2 | 38.5 | 22.5 | 14.7 | 9.9 | | |
| 2023.5003 | JUL | 275.4 | 161.5 | 42.4 | 21.3 | 14.5 | 10.1 | | |
| 2023.5837 | AUG | 276.6 | 161.7 | 46.7 | 20.6 | 14.3 | 10.1 | | |
| 2023.6670 | SEP | 278.0 | 162.3 | 51.3 | 20.1 | 14.2 | 10.3 | | |
| 2023.7503 | OCT | 277.7 | 163.6 | 53.5 | 19.6 | 14.1 | 10.6 | | |
| 2023.8337 | NOV | 276.5 | 164.4 | 55.6 | 19.5 | 14.0 | 10.6 | | |
| 2023.9170 | DEC | 277.8 | 165.0 | 59.6 | 19.3 | 14.0 | 10.5 | | |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | SUNSPOT NUMBER | | | (\bar{R}) | GEOMAGNETIC INDEX | | | (\bar{A}_p) |
|-----------|-----|----------------|-------|------|-------------|-------------------|------|--|---------------|
| | | PERCENTILE | | | | PERCENTILE | | | |
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% | | |
| 2024.0003 | JAN | 277.3 | 163.6 | 62.2 | 19.1 | 14.2 | 10.5 | | |
| 2024.0837 | FEB | 271.7 | 161.4 | 66.0 | 18.9 | 14.6 | 10.5 | | |
| 2024.1670 | MAR | 265.1 | 160.1 | 68.7 | 18.9 | 14.7 | 10.3 | | |
| 2024.2503 | APR | 259.1 | 159.5 | 71.3 | 19.5 | 14.6 | 9.8 | | |
| 2024.3337 | MAY | 255.5 | 159.4 | 73.2 | 20.4 | 14.7 | 10.2 | | |
| 2024.4170 | JUN | 253.8 | 159.1 | 73.0 | 22.0 | 15.0 | 10.7 | | |
| 2024.5003 | JUL | 252.1 | 158.6 | 72.1 | 23.4 | 15.3 | 10.7 | | |
| 2024.5837 | AUG | 250.8 | 157.9 | 73.3 | 24.0 | 15.4 | 10.9 | | |
| 2024.6670 | SEP | 248.8 | 156.9 | 76.5 | 25.1 | 15.7 | 11.1 | | |
| 2024.7503 | OCT | 247.1 | 156.2 | 76.7 | 25.6 | 15.9 | 11.3 | | |
| 2024.8337 | NOV | 245.1 | 155.2 | 75.1 | 24.9 | 15.9 | 11.5 | | |
| 2024.9170 | DEC | 244.0 | 154.0 | 74.0 | 24.8 | 15.9 | 11.7 | | |
| 2025.0003 | JAN | 241.6 | 152.7 | 74.9 | 23.9 | 15.8 | 11.9 | | |
| 2025.0837 | FEB | 237.3 | 150.3 | 75.8 | 22.1 | 15.8 | 11.8 | | |
| 2025.1670 | MAR | 232.2 | 147.1 | 73.7 | 22.4 | 15.9 | 12.0 | | |
| 2025.2503 | APR | 227.9 | 144.2 | 72.9 | 23.1 | 16.0 | 11.8 | | |
| 2025.3337 | MAY | 223.3 | 142.1 | 74.5 | 23.1 | 16.0 | 11.1 | | |
| 2025.4170 | JUN | 217.2 | 140.1 | 76.2 | 22.6 | 16.0 | 10.8 | | |
| 2025.5003 | JUL | 212.3 | 137.3 | 74.2 | 22.0 | 15.8 | 10.8 | | |
| 2025.5837 | AUG | 206.6 | 134.3 | 70.9 | 21.9 | 15.8 | 10.8 | | |
| 2025.6670 | SEP | 202.1 | 132.0 | 69.3 | 22.7 | 16.1 | 10.8 | | |
| 2025.7503 | OCT | 200.6 | 130.4 | 68.8 | 23.7 | 16.5 | 10.8 | | |
| 2025.8337 | NOV | 195.3 | 128.0 | 65.5 | 23.9 | 16.7 | 10.8 | | |
| 2025.9170 | DEC | 192.5 | 125.1 | 58.4 | 23.9 | 17.0 | 10.7 | | |
| 2026.0003 | JAN | 190.7 | 122.2 | 56.8 | 23.9 | 17.1 | 10.6 | | |
| 2026.0837 | FEB | 185.9 | 119.5 | 58.9 | 23.5 | 17.2 | 10.3 | | |
| 2026.1670 | MAR | 180.3 | 117.3 | 57.6 | 22.5 | 17.2 | 10.5 | | |
| 2026.2503 | APR | 174.5 | 115.4 | 54.5 | 22.7 | 17.2 | 10.7 | | |
| 2026.3337 | MAY | 168.9 | 113.7 | 52.9 | 23.0 | 17.4 | 11.4 | | |
| 2026.4170 | JUN | 164.2 | 111.5 | 51.5 | 23.1 | 17.6 | 11.9 | | |
| 2026.5003 | JUL | 161.0 | 108.9 | 49.0 | 22.5 | 17.8 | 12.0 | | |
| 2026.5837 | AUG | 155.7 | 105.8 | 46.2 | 21.7 | 17.6 | 12.1 | | |
| 2026.6670 | SEP | 146.7 | 102.3 | 44.6 | 21.2 | 17.4 | 12.3 | | |
| 2026.7503 | OCT | 138.4 | 98.5 | 44.0 | 21.7 | 17.0 | 12.5 | | |
| 2026.8337 | NOV | 137.2 | 95.4 | 44.4 | 21.7 | 16.9 | 13.3 | | |
| 2026.9170 | DEC | 135.8 | 92.7 | 42.9 | 22.1 | 16.9 | 13.1 | | |
| 2027.0003 | JAN | 131.4 | 90.2 | 40.5 | 22.6 | 17.0 | 12.8 | | |
| 2027.0837 | FEB | 126.9 | 87.8 | 40.8 | 22.3 | 16.8 | 13.1 | | |
| 2027.1670 | MAR | 122.3 | 85.2 | 39.7 | 22.4 | 16.5 | 12.7 | | |
| 2027.2503 | APR | 116.8 | 82.5 | 37.9 | 22.7 | 16.2 | 12.5 | | |
| 2027.3337 | MAY | 115.9 | 80.0 | 36.5 | 22.9 | 15.8 | 12.1 | | |
| 2027.4170 | JUN | 116.9 | 77.4 | 34.0 | 23.5 | 15.6 | 11.2 | | |
| 2027.5003 | JUL | 115.4 | 74.6 | 31.6 | 24.1 | 15.4 | 10.5 | | |
| 2027.5837 | AUG | 114.0 | 71.8 | 27.9 | 24.8 | 15.3 | 10.7 | | |
| 2027.6670 | SEP | 111.6 | 69.9 | 24.8 | 25.3 | 15.3 | 10.8 | | |
| 2027.7503 | OCT | 107.6 | 67.9 | 22.9 | 25.6 | 15.3 | 10.6 | | |
| 2027.8337 | NOV | 103.7 | 65.9 | 19.9 | 25.4 | 15.3 | 10.8 | | |
| 2027.9170 | DEC | 100.5 | 63.7 | 17.4 | 24.9 | 15.2 | 11.0 | | |
| 2028.0003 | JAN | 99.6 | 61.4 | 15.8 | 24.0 | 15.0 | 11.1 | | |
| 2028.0837 | FEB | 98.6 | 59.2 | 14.5 | 23.0 | 14.9 | 11.3 | | |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | (\bar{R}) | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|------------------------------|------|------|-------------|---------------------------------|------|------|---------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2028.1670 | MAR | 95.5 | 57.1 | 13.2 | 22.5 | 15.0 | 11.2 | | |
| 2028.2503 | APR | 91.7 | 55.0 | 13.1 | 22.1 | 15.1 | 11.1 | | |
| 2028.3337 | MAY | 86.5 | 52.6 | 13.2 | 21.8 | 15.2 | 11.2 | | |
| 2028.4170 | JUN | 84.9 | 50.8 | 12.6 | 21.4 | 15.3 | 11.4 | | |
| 2028.5003 | JUL | 85.1 | 49.4 | 12.5 | 20.7 | 15.2 | 11.5 | | |
| 2028.5837 | AUG | 82.2 | 47.8 | 12.3 | 19.9 | 14.9 | 11.3 | | |
| 2028.6670 | SEP | 77.6 | 45.8 | 11.9 | 20.0 | 14.7 | 11.1 | | |
| 2028.7503 | OCT | 73.9 | 43.5 | 10.9 | 20.1 | 14.6 | 10.8 | | |
| 2028.8337 | NOV | 70.0 | 41.9 | 10.7 | 19.9 | 14.3 | 10.1 | | |
| 2028.9170 | DEC | 68.4 | 40.5 | 10.1 | 19.5 | 14.2 | 9.6 | | |
| 2029.0003 | JAN | 65.9 | 38.8 | 9.1 | 19.0 | 14.1 | 9.1 | | |
| 2029.0837 | FEB | 64.6 | 37.1 | 8.6 | 18.3 | 14.1 | 8.6 | | |
| 2029.1670 | MAR | 63.3 | 35.5 | 7.7 | 17.3 | 14.0 | 8.0 | | |
| 2029.2503 | APR | 62.3 | 34.1 | 6.5 | 17.4 | 13.8 | 7.5 | | |
| 2029.3337 | MAY | 60.9 | 32.4 | 5.9 | 17.5 | 13.7 | 7.6 | | |
| 2029.4170 | JUN | 59.1 | 30.9 | 5.9 | 17.6 | 13.7 | 7.8 | | |
| 2029.5003 | JUL | 57.0 | 29.5 | 5.5 | 17.5 | 13.6 | 8.3 | | |
| 2029.5837 | AUG | 54.8 | 28.1 | 5.4 | 17.7 | 13.5 | 8.6 | | |
| 2029.6670 | SEP | 51.8 | 26.5 | 4.3 | 18.1 | 13.4 | 8.5 | | |
| 2029.7503 | OCT | 48.6 | 25.0 | 3.2 | 17.9 | 13.2 | 8.6 | | |
| 2029.8337 | NOV | 44.1 | 23.7 | 2.7 | 17.6 | 12.9 | 8.5 | | |
| 2029.9170 | DEC | 38.6 | 22.1 | 2.5 | 17.3 | 12.6 | 8.5 | | |
| 2030.0003 | JAN | 34.9 | 20.3 | 2.1 | 16.3 | 12.2 | 8.4 | | |
| 2030.0837 | FEB | 33.1 | 18.4 | 1.5 | 14.8 | 11.8 | 8.4 | | |
| 2030.1670 | MAR | 32.1 | 16.8 | 1.1 | 13.8 | 11.4 | 8.3 | | |
| 2030.2503 | APR | 31.6 | 15.6 | 0.9 | 13.9 | 11.0 | 8.2 | | |
| 2030.3337 | MAY | 31.0 | 14.5 | 0.9 | 13.6 | 10.6 | 8.2 | | |
| 2030.4170 | JUN | 30.2 | 13.5 | 0.6 | 13.2 | 10.3 | 7.9 | | |
| 2030.5003 | JUL | 27.9 | 12.6 | 0.5 | 12.9 | 9.9 | 7.4 | | |
| 2030.5837 | AUG | 25.3 | 11.8 | 0.3 | 12.6 | 9.7 | 7.1 | | |
| 2030.6670 | SEP | 23.4 | 11.0 | 0.1 | 11.9 | 9.5 | 7.3 | | |
| 2030.7503 | OCT | 21.8 | 10.2 | 0.0 | 11.4 | 9.4 | 7.1 | | |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|-------|-------|--------------------|---------------------------------|------|------|---------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2015.7503 | OCT | 109.7 | 109.1 | 106.0 | 13.4 | 12.2 | 10.8 | | |
| 2015.8337 | NOV | 109.0 | 107.2 | 102.3 | 14.1 | 12.5 | 9.9 | | |
| 2015.9170 | DEC | 107.5 | 105.7 | 99.5 | 15.6 | 13.0 | 9.8 | | |
| 2016.0003 | JAN | 106.4 | 104.4 | 97.0 | 17.4 | 13.9 | 10.2 | | |
| 2016.0837 | FEB | 106.7 | 103.0 | 93.9 | 18.6 | 14.6 | 10.7 | | |
| 2016.1670 | MAR | 106.1 | 101.7 | 91.1 | 19.9 | 15.0 | 11.2 | | |
| 2016.2503 | APR | 104.5 | 100.4 | 88.8 | 20.9 | 15.2 | 11.4 | | |
| 2016.3337 | MAY | 102.6 | 99.0 | 86.0 | 21.4 | 14.9 | 11.1 | | |
| 2016.4170 | JUN | 101.0 | 97.6 | 83.6 | 22.1 | 14.8 | 10.4 | | |
| 2016.5003 | JUL | 99.6 | 96.4 | 82.3 | 22.8 | 14.6 | 9.7 | | |
| 2016.5837 | AUG | 100.2 | 95.3 | 81.5 | 23.5 | 14.5 | 9.8 | | |
| 2016.6670 | SEP | 99.7 | 94.2 | 80.9 | 23.9 | 14.4 | 9.8 | | |
| 2016.7503 | OCT | 97.9 | 93.2 | 80.5 | 23.7 | 14.2 | 9.5 | | |
| 2016.8337 | NOV | 97.1 | 92.3 | 80.3 | 22.7 | 13.6 | 9.0 | | |
| 2016.9170 | DEC | 95.7 | 91.3 | 80.0 | 21.5 | 13.1 | 8.8 | | |
| 2017.0003 | JAN | 94.6 | 90.2 | 79.1 | 20.2 | 12.7 | 8.7 | | |
| 2017.0837 | FEB | 94.2 | 89.1 | 77.7 | 18.9 | 12.4 | 8.6 | | |
| 2017.1670 | MAR | 92.9 | 88.3 | 76.7 | 18.4 | 12.5 | 8.5 | | |
| 2017.2503 | APR | 93.0 | 87.4 | 76.2 | 18.1 | 12.7 | 8.5 | | |
| 2017.3337 | MAY | 92.6 | 86.2 | 76.4 | 18.2 | 13.1 | 8.9 | | |
| 2017.4170 | JUN | 87.6 | 85.3 | 76.6 | 18.9 | 13.7 | 9.7 | | |
| 2017.5003 | JUL | 85.2 | 84.5 | 76.2 | 19.5 | 14.3 | 10.4 | | |
| 2017.5837 | AUG | 84.1 | 83.7 | 75.6 | 19.8 | 14.4 | 10.4 | | |
| 2017.6670 | SEP | 83.7 | 83.0 | 75.0 | 20.0 | 14.5 | 10.7 | | |
| 2017.7503 | OCT | 84.9 | 82.0 | 74.3 | 20.2 | 14.7 | 11.1 | | |
| 2017.8337 | NOV | 85.9 | 81.0 | 73.1 | 19.9 | 15.0 | 11.2 | | |
| 2017.9170 | DEC | 86.0 | 80.4 | 71.0 | 19.5 | 15.2 | 11.3 | | |
| 2018.0003 | JAN | 84.7 | 79.9 | 69.3 | 19.0 | 15.4 | 11.3 | | |
| 2018.0837 | FEB | 84.7 | 79.3 | 68.5 | 19.4 | 15.6 | 11.0 | | |
| 2018.1670 | MAR | 83.5 | 78.6 | 67.9 | 19.5 | 15.5 | 10.3 | | |
| 2018.2503 | APR | 82.1 | 78.0 | 67.5 | 19.3 | 15.3 | 10.0 | | |
| 2018.3337 | MAY | 80.8 | 77.3 | 67.1 | 18.8 | 14.9 | 9.6 | | |
| 2018.4170 | JUN | 80.1 | 76.7 | 67.1 | 18.0 | 14.6 | 9.5 | | |
| 2018.5003 | JUL | 79.3 | 76.2 | 67.1 | 18.0 | 14.5 | 9.8 | | |
| 2018.5837 | AUG | 78.6 | 75.6 | 67.1 | 18.3 | 14.4 | 9.8 | | |
| 2018.6670 | SEP | 77.9 | 75.0 | 67.1 | 18.6 | 14.3 | 9.6 | | |
| 2018.7503 | OCT | 77.2 | 74.4 | 67.1 | 18.5 | 14.0 | 9.5 | | |
| 2018.8337 | NOV | 76.5 | 73.9 | 67.1 | 18.1 | 13.6 | 9.5 | | |
| 2018.9170 | DEC | 75.8 | 73.4 | 67.1 | 17.3 | 13.1 | 9.2 | | |
| 2019.0003 | JAN | 75.2 | 72.9 | 67.1 | 16.5 | 12.6 | 8.9 | | |
| 2019.0837 | FEB | 74.6 | 72.4 | 67.0 | 15.7 | 12.0 | 8.6 | | |
| 2019.1670 | MAR | 74.1 | 72.0 | 67.0 | 15.0 | 11.5 | 8.3 | | |
| 2019.2503 | APR | 73.5 | 71.6 | 67.0 | 14.2 | 11.1 | 8.1 | | |
| 2019.3337 | MAY | 73.1 | 71.2 | 67.0 | 13.6 | 10.6 | 7.8 | | |
| 2019.4170 | JUN | 72.7 | 70.9 | 67.0 | 13.0 | 10.2 | 7.6 | | |
| 2019.5003 | JUL | 72.3 | 70.6 | 67.0 | 12.4 | 9.9 | 7.4 | | |
| 2019.5837 | AUG | 72.0 | 70.3 | 67.0 | 12.0 | 9.6 | 7.3 | | |
| 2019.6670 | SEP | 71.7 | 70.1 | 67.0 | 11.6 | 9.3 | 7.1 | | |
| 2019.7503 | OCT | 71.6 | 70.0 | 67.0 | 11.3 | 9.1 | 7.0 | | |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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 | | |
| 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 | | |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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 | | |
| 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 | | |

**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED $F_{10.7}$ AND A_p FOR
CYCLE 24 AND CYCLE 25**

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|------|------|--------------------|---------------------------------|------|------|---------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 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 | | |

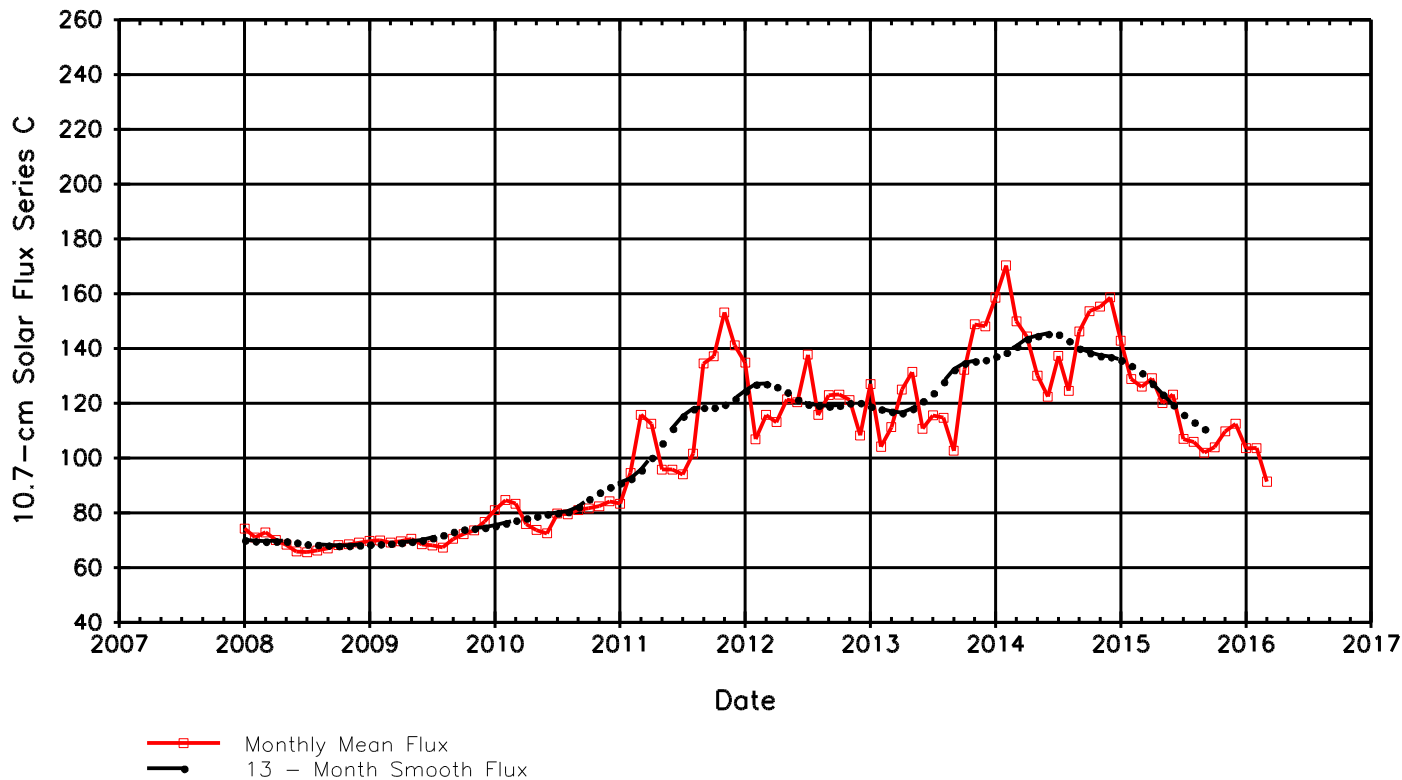


Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

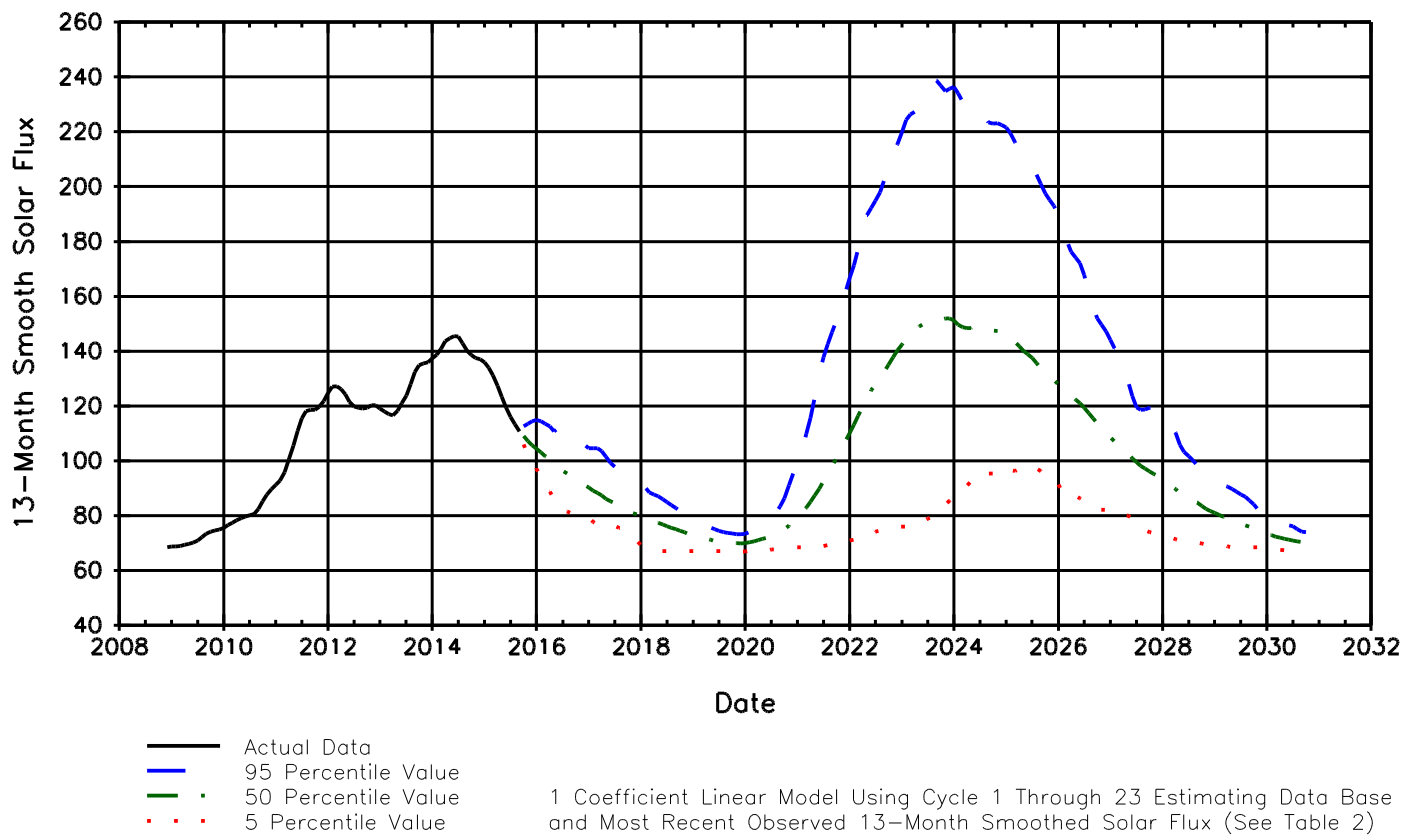


Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24

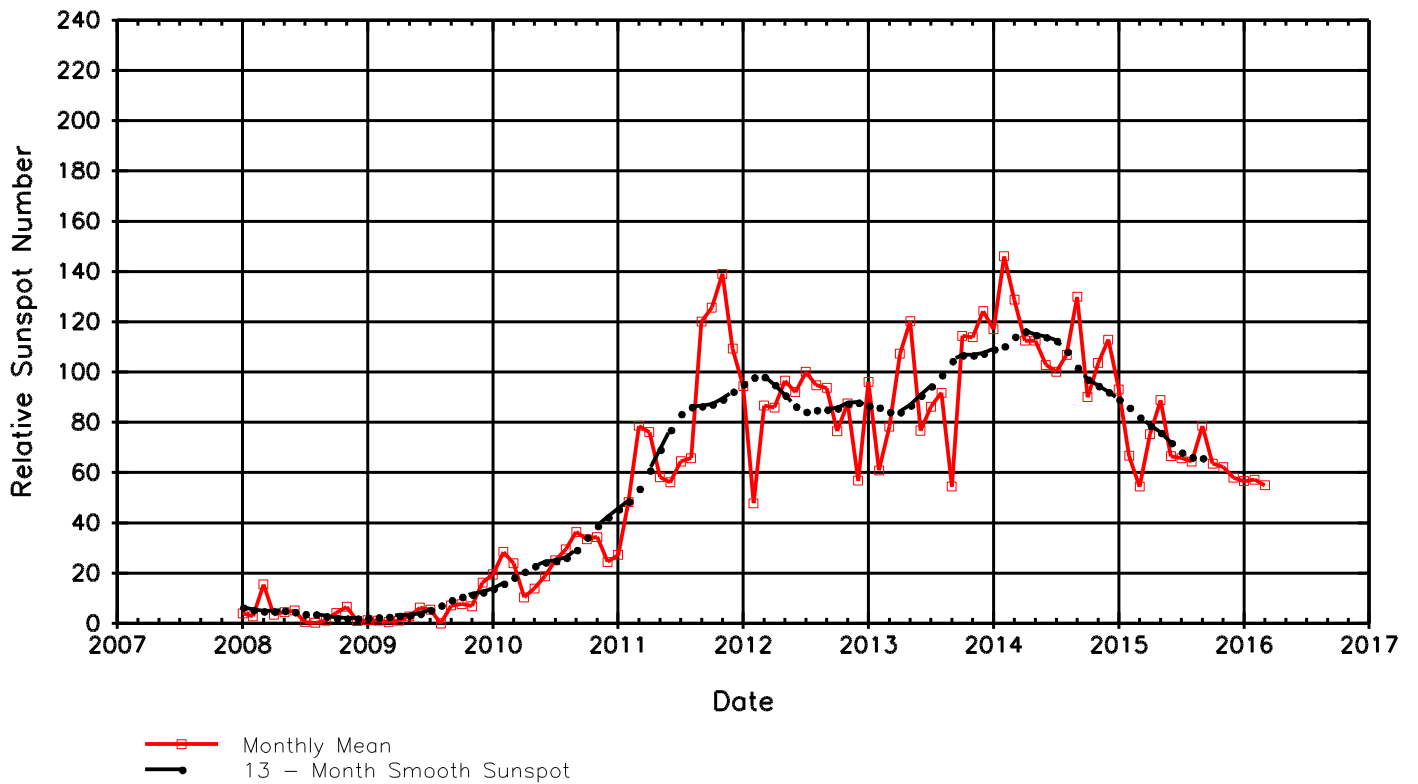


Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number

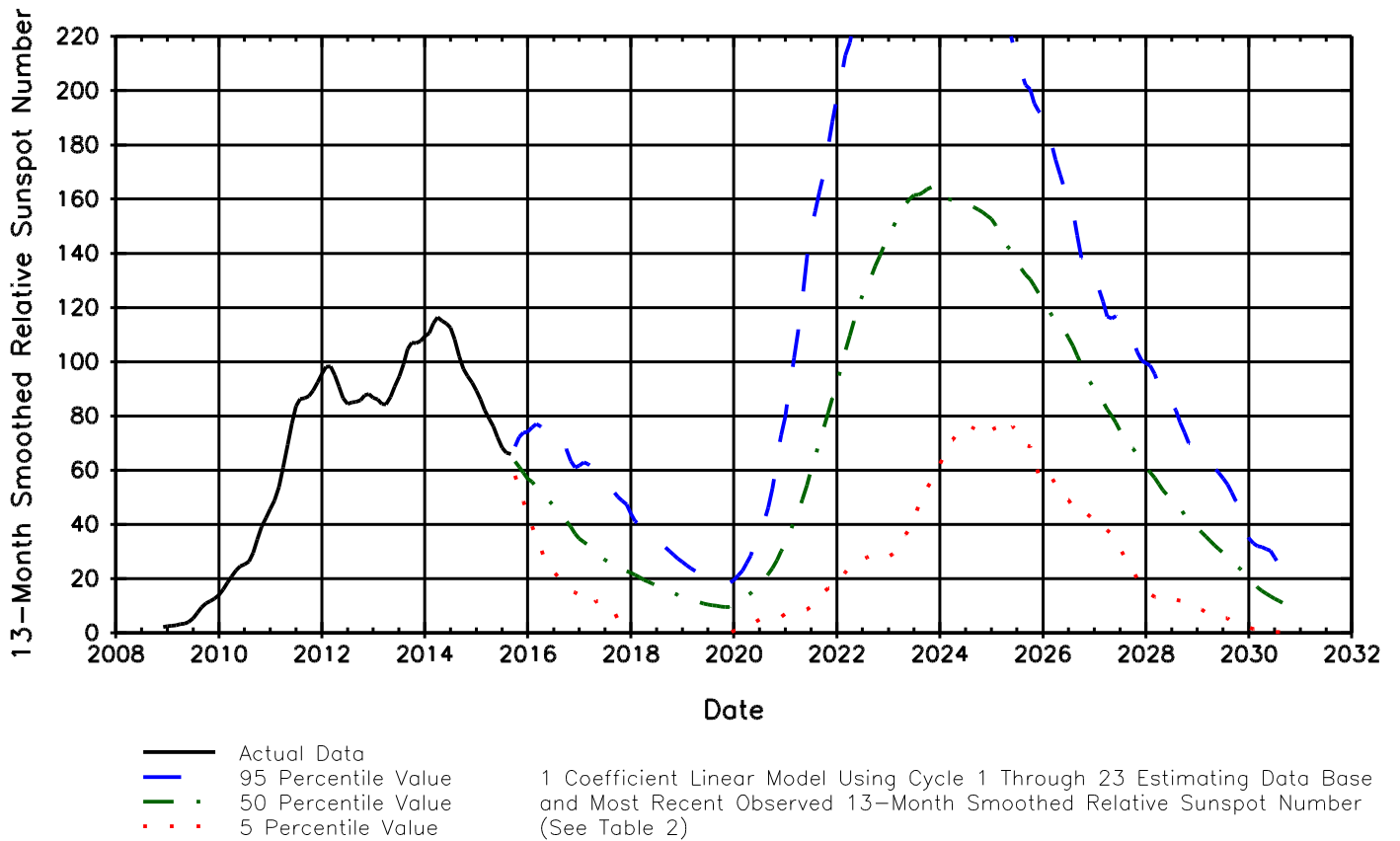


Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24

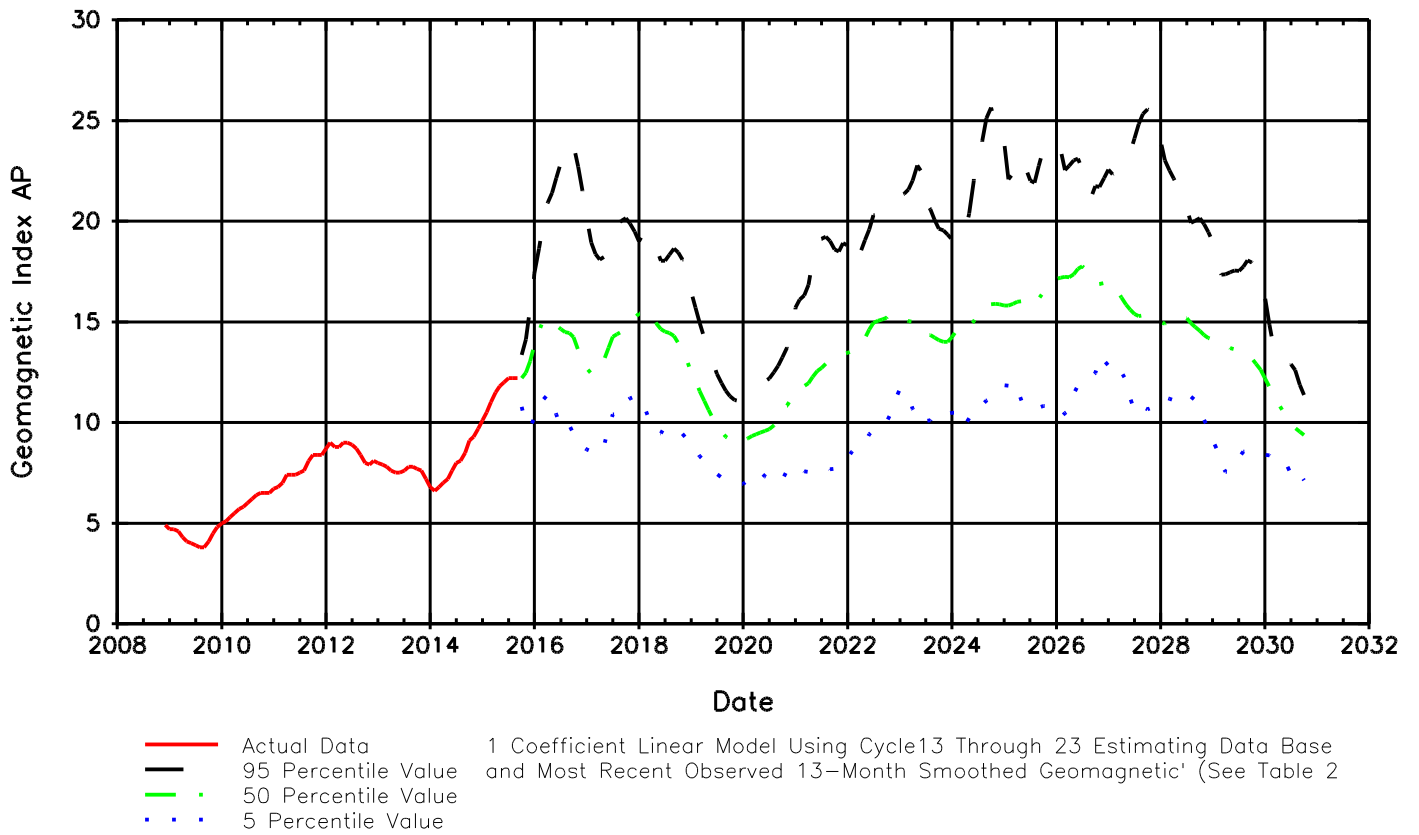


Figure 5. Estimate of 13-Month Smoothed Ap For Cycle 24* and Cycle 25

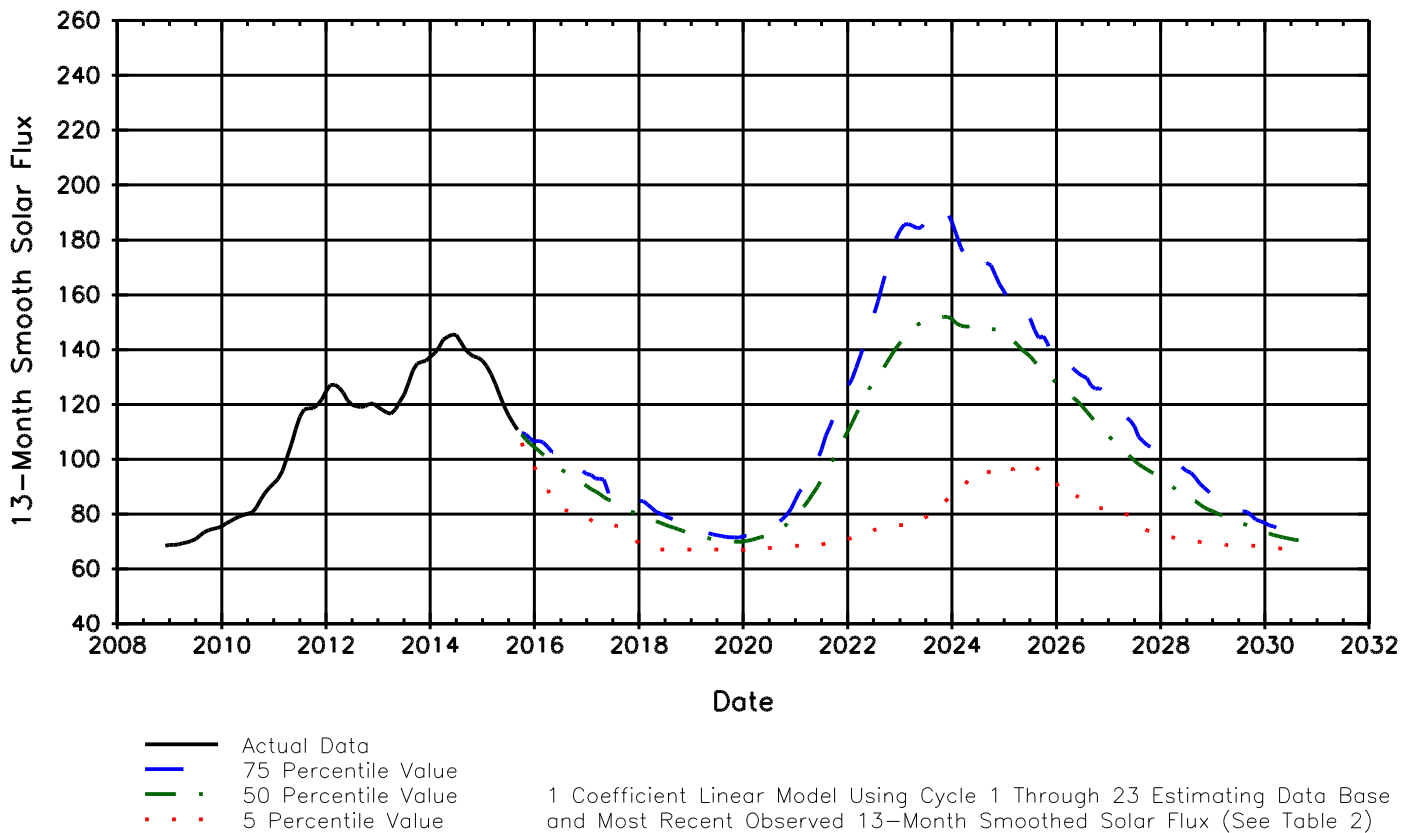


Figure 6. Estimate of 75th Percentile 13-Month Smoothed Solar Flux For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24