

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

Ronnie J. Suggs
Harold C. Euler Jr.
*George C. Marshall Space Flight Center
Huntsville, Alabama*
And
Steven W. Smith
*Morgan Research Corporation
Huntsville, Alabama*

APPROVAL:

Original Signed By

David L. Edwards
Natural Environments Branch

National Aeronautics and Space Administration
Marshall Space Flight Center • Huntsville, Alabama 35812

Spacecraft & Vehicle Systems Department
Systems Analysis & Integration Division
Natural Environments Branch

July 2008

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

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 (page 6) 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 22 converted and observed), \bar{R} (cycles 1 through 22 observed), and \bar{A}_p (cycles 13 through 22 converted and observed) and the smoothed values for cycle 23. Table 2 (page 8) presents 13-month Zurich smoothed values for Cycle 22 and 23 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 (page 6).

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 the cycle 23 maximum. For reports starting with April 2004 and continuing through October 2007, the date of the cycle 23 maximum was 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. As before, the \bar{A}_p input to the MSAFE program has been initialized at the 13-month smooth sunspot maximum for cycle 23 (April 2000).

The results of the MSAFE model calculations (i.e. the output data) to the maximum of solar cycle 24 are reported in Tables 3, 4 and 5¹. Table 3 (page 14) contains the statistical estimates of future $\bar{F}_{10.7}$ and \bar{A}_p 5, 50, and 95 Percentile values for the balance of cycle 23 and cycle 24. Table 4 (page 19) contains the statistical estimate of future \bar{R} and \bar{A}_p 5, 50, and 95 Percentile values for the balance of cycle 23 and cycle 24. Table 5¹ (page 22) contains the statistical estimates of 75 Percentile $\bar{F}_{10.7}$ and 95 Percentile \bar{A}_p values for the balance of cycle 23 and cycle 24. The extended statistical characteristics of cycle 24 beyond the maximum 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 (page 28) 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 cycles 22 and 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 23 and 24. Similarly, Figures 3 and 4 (page 29) 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 cycles 22 and 23. Figure 4 is a plot of the statistical estimates of future 13-month Zurich smoothed relative sunspot number for solar cycles 23 and 24. Figure 5¹ (page 30) is a plot of monthly mean and 13-month Zurich smoothed observed 10.7-cm solar radio flux for solar cycles 22 and 23. Figure

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.

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 23 and 24.

It should be noted that the cycle 24 5, 50, and 95 Percentile values beyond the maximum are the statistical evaluation of the past 22 cycles and are not influenced by the MSAFE model's performance. Cycle 24 values from the maximum are estimated using statistics for cycles 1 through 22 for $\bar{F}_{10.7}$ and \bar{R} , and statistics for cycles 13 through 22 are used for \bar{A}_p . The 50 percentile values in Tables 3 and 4 and in Figures 3 and 4, at and beyond maximum of cycle 24, 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 22 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 cycle 23 to the maximum of cycle 24 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 Harold Euler (Harold.C.Euler@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.

References

- Boykin, E. P. and T. J. Richards, Application of the Lincoln McNish Technique to the Prediction of the Remainder of the Twentieth Sunspot Cycle, Technical Memorandum 54/30-89, Lockheed Missiles and Space Company, Huntsville, Alabama, 1966.
- Dreher, P. E. and A. T. Lyons, Long-Term Orbital Lifetime Predictions, NASA Technical Paper 3058, NASA Marshall Space Flight Center, Huntsville, Alabama (1990).
- Hickey, M. P., The NASA Marshall Engineering Thermosphere Model, NASA CR-179359, 1988a.
- Hickey, M. P., An Improvement in the Integration Procedure Used in the NASA Marshall Engineering Thermosphere Model, NASA CR-179389, 1988b.
- Holland, R. L. and W. W. Vaughan, Lagrangian Least-Squares Prediction of Solar radio flux ($F_{10.7}$), *J. Geophys. Res.*, **89**, 11-16, 1984.
- Justus, C. G. and D. L. Johnson, "The NASA/MSFC Global Reference Atmosphere Model – 1999 Version (GRAM-99)". NASA TM 1999-209630, May 1999.
- McNish, A. G. and J. V. Lincoln, Prediction of Sunspot Numbers, *Trans. Am. Geophys. Union*, **30**, 673, 1949.
-
- Niehuss, K.O., H.C. Euler, and W.W. Vaughan, Statistical Technique for Intermediate and Long-Range Estimation of 13-Month Smoothed Solar radio flux and Geomagnetic Index, NASA TM-4759, 1996.
- Vaughan, W.W., J.K. Owens, K.O. Niehuss, and M.A. Shea, The NASA Marshall Solar Activity Model for Use in Predicting Satellite Lifetime, *Adv. Space Res.*, **23**, (4)715-(4)719, 1999.
- Waldmeier, M., *The Sunspot Activity in the Years 1610-1960*. Zurich Schulthess and Company, Switzerland, 1961.

| 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) |
| 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⁻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) |
|-------------|--------------|---|---|--|
| 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 | | | |
| | August | | | |
| | September | | | |
| | October | | | |
| | November | | | |
| | December | | | |

* 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 (A_p) |
|-------------|--------------|--|---|--|
| 1987 | January | 76.3 | 17.6 | 10.0 |
| | February | 77.8 | 19.6 | 10.2 |
| | March | 79.4 | 22.1 | 10.4 |
| | April | 80.8 | 24.4 | 10.7 |
| | May | 82.4 | 26.5 | 10.9 |
| | June | 84.3 | 28.4 | 11.0 |
| | July | 86.7 | 31.2 | 11.2 |
| | August | 89.6 | 34.8 | 11.6 |
| | September | 92.7 | 39.0 | 12.0 |
| | October | 96.0 | 43.5 | 12.5 |
| | November | 98.7 | 46.7 | 13.1 |
| | December | 102.4 | 51.3 | 13.4 |
| 1988 | January | 107.8 | 58.2 | 13.5 |
| | February | 113.3 | 64.6 | 13.3 |
| | March | 118.8 | 71.3 | 12.9 |
| | April | 124.5 | 77.5 | 12.5 |
| | May | 129.8 | 83.8 | 12.3 |
| | June | 136.5 | 93.7 | 12.4 |
| | July | 146.2 | 104.3 | 12.8 |
| | August | 156.4 | 113.7 | 13.1 |
| | September | 165.0 | 121.2 | 14.2 |
| | October | 171.6 | 125.3 | 15.6 |
| | November | 177.5 | 130.4 | 16.1 |
| | December | 184.8 | 137.6 | 16.5 |
| 1989 | January | 190.2 | 142.0 | 16.7 |
| | February | 194.0 | 145.0 | 17.0 |
| | March | 199.7 | 149.7 | 17.6 |
| | April | 204.4 | 153.5 | 18.2 |
| | May | 209.3 | 156.9 | 18.8 |
| | June | 213.1 | 158.4 | 19.2 |
| | July | 212.6 | 158.5 | 19.1 |
| | August | 209.7 | 157.7 | 19.2 |
| | September | 207.2 | 156.6 | 18.8 |
| | October | 206.3 | 157.4 | 18.2 |
| | November | 206.1 | 157.5 | 18.4 |
| | December | 203.3 | 153.5 | 18.4 |

* 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 (A_p) |
|-------------|--------------|--|---|--|
| 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

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
|-------------|--------------|--|---|--|
| 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

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
|-------------|--------------|--|---|--|
| 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

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (\bar{A}_p) |
|-------------|--------------|--|---|--|
| 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

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (\bar{A}_p) |
|-------------|--------------|--|---|--|
| 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

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
|-------------|--------------|--|---|--|
| 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* |

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 PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2008.0000 | JAN | 71.6 | 70.8 | 69.7 | 8.4 | 7.8 | 7.2 |
| 2008.0833 | FEB | 72.3 | 70.8 | 68.6 | 8.9 | 8.0 | 6.7 |
| 2008.1667 | MAR | 73.1 | 70.9 | 67.9 | 9.3 | 7.9 | 6.2 |
| 2008.2500 | APR | 73.7 | 71.1 | 67.2 | 9.7 | 7.9 | 5.9 |
| 2008.3333 | MAY | 75.2 | 71.5 | 66.5 | 10.2 | 7.9 | 5.9 |
| 2008.4167 | JUN | 76.7 | 71.8 | 65.6 | 10.7 | 8.1 | 6.0 |
| 2008.5000 | JUL | 78.1 | 72.1 | 64.9 | 10.9 | 8.3 | 6.2 |
| 2008.5833 | AUG | 79.6 | 72.6 | 64.1 | 11.1 | 8.4 | 6.3 |
| 2008.6667 | SEP | 81.7 | 73.3 | 63.5 | 12.2 | 8.7 | 6.8 |
| 2008.7500 | OCT | 83.8 | 74.2 | 62.9 | 13.8 | 9.2 | 7.3 |
| 2008.8333 | NOV | 85.8 | 75.0 | 62.3 | 14.9 | 9.6 | 7.7 |
| 2008.9167 | DEC | 88.2 | 76.1 | 62.0 | 15.4 | 9.9 | 7.7 |
| 2009.0000 | JAN | 91.0 | 77.4 | 61.8 | 16.1 | 10.4 | 7.8 |
| 2009.0833 | FEB | 94.4 | 78.9 | 61.2 | 16.4 | 10.7 | 7.7 |
| 2009.1667 | MAR | 98.7 | 80.5 | 60.6 | 16.6 | 10.8 | 7.7 |
| 2009.2500 | APR | 102.8 | 82.3 | 60.5 | 17.0 | 10.9 | 7.8 |
| 2009.3333 | MAY | 106.3 | 84.1 | 60.8 | 17.3 | 11.1 | 8.0 |
| 2009.4167 | JUN | 109.5 | 86.1 | 61.4 | 17.4 | 11.4 | 8.3 |
| 2009.5000 | JUL | 112.4 | 88.2 | 62.3 | 17.7 | 11.7 | 8.6 |
| 2009.5833 | AUG | 116.0 | 90.4 | 63.0 | 18.0 | 12.2 | 9.1 |
| 2009.6667 | SEP | 120.3 | 92.6 | 64.0 | 18.1 | 12.7 | 9.8 |
| 2009.7500 | OCT | 124.7 | 95.0 | 65.2 | 17.7 | 13.1 | 10.3 |
| 2009.8333 | NOV | 129.8 | 97.7 | 67.2 | 16.9 | 13.2 | 10.3 |
| 2009.9167 | DEC | 136.1 | 100.4 | 69.0 | 16.6 | 13.2 | 10.1 |
| 2010.0000 | JAN | 141.2 | 102.7 | 69.1 | 16.6 | 13.4 | 10.0 |
| 2010.0833 | FEB | 145.1 | 105.2 | 69.4 | 17.2 | 13.6 | 9.9 |
| 2010.1667 | MAR | 148.3 | 107.4 | 71.9 | 17.7 | 13.6 | 9.5 |
| 2010.2500 | APR | 154.5 | 109.7 | 75.1 | 18.2 | 13.7 | 9.4 |
| 2010.3333 | MAY | 161.6 | 112.2 | 77.2 | 18.4 | 13.7 | 9.2 |
| 2010.4167 | JUN | 170.0 | 115.0 | 79.3 | 18.4 | 13.4 | 8.4 |
| 2010.5000 | JUL | 175.0 | 118.3 | 80.8 | 18.6 | 13.5 | 8.6 |
| 2010.5833 | AUG | 180.0 | 121.5 | 82.3 | 18.9 | 13.6 | 8.7 |
| 2010.6667 | SEP | 185.0 | 124.8 | 83.7 | 19.1 | 13.7 | 8.9 |
| 2010.7500 | OCT | 190.0 | 127.9 | 85.1 | 19.4 | 13.8 | 9.1 |
| 2010.8333 | NOV | 194.8 | 131.0 | 86.5 | 19.6 | 13.9 | 9.2 |
| 2010.9167 | DEC | 199.5 | 134.1 | 87.9 | 19.9 | 13.9 | 9.4 |
| 2011.0000 | JAN | 204.1 | 137.0 | 89.2 | 20.1 | 14.0 | 9.6 |
| 2011.0833 | FEB | 208.5 | 139.9 | 90.5 | 20.3 | 14.1 | 9.7 |
| 2011.1667 | MAR | 212.7 | 142.6 | 91.7 | 20.5 | 14.2 | 9.8 |
| 2011.2500 | APR | 216.8 | 145.2 | 92.9 | 20.7 | 14.3 | 10.0 |
| 2011.3333 | MAY | 220.6 | 147.7 | 94.0 | 20.9 | 14.4 | 10.1 |
| 2011.4167 | JUN | 224.1 | 150.0 | 95.0 | 21.1 | 14.4 | 10.2 |
| 2011.5000 | JUL | 227.4 | 152.1 | 96.0 | 21.2 | 14.5 | 10.3 |
| 2011.5833 | AUG | 230.3 | 154.0 | 96.8 | 21.4 | 14.6 | 10.4 |
| 2011.6667 | SEP | 233.0 | 155.7 | 97.6 | 21.5 | 14.6 | 10.5 |
| 2011.7500 | OCT | 235.3 | 157.2 | 98.3 | 21.6 | 14.7 | 10.6 |
| 2011.8333 | NOV | 237.2 | 158.4 | 98.8 | 21.7 | 14.7 | 10.7 |
| 2011.9167 | DEC | 238.8 | 159.4 | 99.3 | 21.8 | 14.7 | 10.7 |
| 2012.0000 | JAN | 239.9 | 160.2 | 99.6 | 21.9 | 14.8 | 10.8 |
| 2012.0833 | FEB | 240.6 | 160.6 | 99.8 | 21.9 | 14.8 | 10.8 |
| 2012.1667 | MAR | 240.8 | 160.8 | 99.9 | 21.9 | 14.8 | 10.8 |
| 2012.2500 | APR | 237.9 | 159.6 | 98.5 | 20.6 | 14.9 | 11.5 |
| 2012.3333 | MAY | 233.7 | 157.8 | 97.8 | 20.2 | 15.0 | 11.8 |

**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 PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2012.4167 | JUN | 229.9 | 156.0 | 96.7 | 19.7 | 15.1 | 11.7 |
| 2012.5000 | JUL | 228.6 | 154.7 | 95.4 | 19.4 | 15.3 | 11.9 |
| 2012.5833 | AUG | 228.6 | 153.6 | 93.8 | 19.2 | 15.6 | 12.1 |
| 2012.6667 | SEP | 227.1 | 152.7 | 92.6 | 19.0 | 15.7 | 11.6 |
| 2012.7500 | OCT | 225.2 | 151.7 | 91.8 | 19.0 | 15.7 | 10.9 |
| 2012.8333 | NOV | 224.4 | 150.4 | 91.2 | 18.9 | 15.7 | 10.8 |
| 2012.9167 | DEC | 223.6 | 148.9 | 90.3 | 19.0 | 15.7 | 10.8 |
| 2013.0000 | JAN | 222.8 | 147.2 | 89.3 | 19.2 | 15.8 | 10.8 |
| 2013.0833 | FEB | 221.6 | 145.3 | 88.6 | 19.8 | 15.9 | 10.8 |
| 2013.1667 | MAR | 217.7 | 143.4 | 87.7 | 20.4 | 16.1 | 10.9 |
| 2013.2500 | APR | 214.3 | 141.8 | 86.2 | 21.4 | 16.3 | 10.8 |
| 2013.3333 | MAY | 211.4 | 140.6 | 85.4 | 21.9 | 16.5 | 10.7 |
| 2013.4167 | JUN | 207.1 | 139.5 | 84.9 | 21.6 | 16.6 | 10.6 |
| 2013.5000 | JUL | 206.7 | 138.5 | 84.0 | 21.3 | 16.4 | 10.3 |
| 2013.5833 | AUG | 206.0 | 137.4 | 82.7 | 21.8 | 16.5 | 10.3 |
| 2013.6667 | SEP | 203.8 | 135.6 | 81.3 | 23.1 | 16.7 | 10.4 |
| 2013.7500 | OCT | 200.3 | 133.6 | 80.4 | 23.3 | 16.9 | 10.9 |
| 2013.8333 | NOV | 196.2 | 131.5 | 79.8 | 22.7 | 17.0 | 11.7 |
| 2013.9167 | DEC | 191.2 | 129.6 | 79.1 | 22.6 | 17.0 | 11.8 |
| 2014.0000 | JAN | 185.0 | 127.8 | 78.4 | 22.7 | 16.9 | 11.9 |
| 2014.0833 | FEB | 179.1 | 126.3 | 77.5 | 23.2 | 17.1 | 12.0 |
| 2014.1667 | MAR | 178.4 | 125.2 | 76.5 | 23.9 | 17.3 | 12.1 |
| 2014.2500 | APR | 177.7 | 123.7 | 75.5 | 23.9 | 17.2 | 12.5 |
| 2014.3333 | MAY | 175.3 | 121.6 | 74.6 | 23.9 | 17.1 | 13.3 |
| 2014.4167 | JUN | 171.4 | 119.5 | 73.6 | 23.3 | 17.0 | 13.7 |
| 2014.5000 | JUL | 166.1 | 117.5 | 72.7 | 21.6 | 16.8 | 13.3 |
| 2014.5833 | AUG | 161.9 | 115.9 | 72.3 | 21.8 | 16.6 | 12.8 |
| 2014.6667 | SEP | 160.4 | 114.4 | 72.0 | 21.8 | 16.4 | 12.7 |
| 2014.7500 | OCT | 159.3 | 112.9 | 71.6 | 21.5 | 16.4 | 12.5 |
| 2014.8333 | NOV | 157.5 | 111.4 | 71.4 | 21.1 | 16.4 | 12.4 |
| 2014.9167 | DEC | 154.7 | 109.9 | 71.5 | 20.5 | 16.4 | 12.2 |
| 2015.0000 | JAN | 150.5 | 108.3 | 71.4 | 19.9 | 16.1 | 11.9 |
| 2015.0833 | FEB | 144.9 | 106.7 | 71.2 | 20.1 | 16.0 | 11.9 |
| 2015.1667 | MAR | 138.7 | 104.8 | 70.9 | 21.6 | 15.9 | 11.7 |
| 2015.2500 | APR | 132.9 | 103.0 | 70.7 | 23.2 | 15.8 | 11.7 |
| 2015.3333 | MAY | 128.3 | 101.4 | 70.5 | 24.0 | 15.8 | 11.5 |
| 2015.4167 | JUN | 124.5 | 99.9 | 70.7 | 25.1 | 15.7 | 11.3 |
| 2015.5000 | JUL | 121.4 | 98.7 | 71.1 | 25.8 | 15.7 | 11.3 |
| 2015.5833 | AUG | 119.3 | 97.7 | 71.2 | 25.0 | 15.6 | 10.8 |
| 2015.6667 | SEP | 119.4 | 96.7 | 71.4 | 25.0 | 15.6 | 10.3 |
| 2015.7500 | OCT | 119.0 | 95.6 | 71.2 | 24.1 | 15.7 | 10.7 |
| 2015.8333 | NOV | 117.9 | 94.3 | 70.7 | 22.2 | 15.7 | 10.8 |
| 2015.9167 | DEC | 117.2 | 93.0 | 70.3 | 21.4 | 15.6 | 10.8 |
| 2016.0000 | JAN | 116.2 | 91.9 | 69.9 | 21.7 | 15.8 | 11.0 |
| 2016.0833 | FEB | 116.4 | 91.1 | 69.6 | 22.4 | 16.0 | 11.2 |
| 2016.1667 | MAR | 116.7 | 90.2 | 69.2 | 22.6 | 16.0 | 11.2 |
| 2016.2500 | APR | 116.8 | 89.2 | 69.0 | 22.5 | 16.1 | 11.0 |
| 2016.3333 | MAY | 116.6 | 88.2 | 68.7 | 22.7 | 16.3 | 11.0 |
| 2016.4167 | JUN | 115.9 | 87.1 | 68.2 | 22.9 | 16.6 | 11.3 |
| 2016.5000 | JUL | 114.8 | 86.1 | 68.0 | 23.4 | 16.8 | 11.2 |
| 2016.5833 | AUG | 113.1 | 85.1 | 67.8 | 24.1 | 16.9 | 11.2 |
| 2016.6667 | SEP | 109.9 | 84.2 | 67.7 | 24.8 | 17.0 | 11.8 |
| 2016.7500 | OCT | 104.9 | 83.2 | 67.6 | 25.4 | 16.9 | 12.2 |

**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 PERCENTILE | | | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2016.8333 | NOV | 99.4 | 82.3 | 67.6 | 25.6 | 16.7 | 12.1 | | |
| 2016.9167 | DEC | 98.8 | 81.3 | 67.5 | 25.4 | 16.4 | 12.0 | | |
| 2017.0000 | JAN | 99.6 | 80.6 | 67.3 | 24.7 | 16.0 | 12.2 | | |
| 2017.0833 | FEB | 100.2 | 80.0 | 67.2 | 23.6 | 15.6 | 12.3 | | |
| 2017.1667 | MAR | 98.7 | 79.4 | 67.2 | 22.8 | 15.2 | 12.2 | | |
| 2017.2500 | APR | 95.8 | 78.8 | 67.2 | 22.4 | 14.9 | 11.8 | | |
| 2017.3333 | MAY | 93.0 | 78.2 | 67.2 | 21.9 | 14.6 | 11.2 | | |
| 2017.4167 | JUN | 91.3 | 77.8 | 67.1 | 21.6 | 14.2 | 10.7 | | |
| 2017.5000 | JUL | 91.5 | 77.2 | 67.1 | 20.9 | 13.8 | 10.0 | | |
| 2017.5833 | AUG | 91.4 | 76.6 | 67.0 | 20.0 | 13.4 | 9.4 | | |
| 2017.6667 | SEP | 90.9 | 76.0 | 67.0 | 18.7 | 13.1 | 9.0 | | |
| 2017.7500 | OCT | 90.4 | 75.6 | 67.0 | 18.2 | 12.8 | 8.5 | | |
| 2017.8333 | NOV | 89.7 | 75.1 | 67.0 | 18.7 | 12.6 | 8.0 | | |
| 2017.9167 | DEC | 88.8 | 74.7 | 67.1 | 18.7 | 12.5 | 7.8 | | |
| 2018.0000 | JAN | 88.1 | 74.4 | 67.3 | 18.4 | 12.4 | 7.4 | | |
| 2018.0833 | FEB | 87.2 | 74.0 | 67.4 | 18.4 | 12.2 | 7.0 | | |
| 2018.1667 | MAR | 85.9 | 73.7 | 67.5 | 18.8 | 12.1 | 6.6 | | |
| 2018.2500 | APR | 84.4 | 73.2 | 67.6 | 18.9 | 12.0 | 6.5 | | |
| 2018.3333 | MAY | 82.3 | 72.7 | 67.7 | 18.8 | 12.0 | 6.4 | | |
| 2018.4167 | JUN | 80.0 | 72.3 | 67.7 | 18.4 | 11.9 | 6.6 | | |
| 2018.5000 | JUL | 77.7 | 71.9 | 68.0 | 17.5 | 11.8 | 6.9 | | |
| 2018.5833 | AUG | 76.9 | 71.7 | 68.0 | 16.5 | 11.7 | 7.2 | | |
| 2018.6667 | SEP | 76.5 | 71.5 | 68.0 | 16.3 | 11.6 | 7.4 | | |
| 2018.7500 | OCT | 75.8 | 71.4 | 68.0 | 16.6 | 11.6 | 7.5 | | |
| 2018.8333 | NOV | 76.0 | 71.3 | 67.9 | 16.9 | 11.6 | 7.5 | | |
| 2018.9167 | DEC | 76.0 | 71.2 | 67.9 | 17.2 | 11.6 | 7.7 | | |
| 2019.0000 | JAN | 76.3 | 71.2 | 67.7 | 17.3 | 11.6 | 7.7 | | |
| 2019.0833 | FEB | 76.8 | 71.3 | 67.6 | 17.7 | 11.5 | 7.6 | | |
| 2019.1667 | MAR | 77.8 | 71.5 | 67.7 | 18.0 | 11.4 | 7.6 | | |
| 2019.2500 | APR | 79.5 | 71.9 | 67.6 | 18.2 | 11.4 | 7.6 | | |
| 2019.3333 | MAY | 81.5 | 72.3 | 67.6 | 18.1 | 11.3 | 7.6 | | |
| 2019.4167 | JUN | 83.2 | 72.6 | 67.7 | 17.8 | 11.2 | 7.5 | | |
| 2019.5000 | JUL | 85.4 | 73.2 | 67.9 | 17.3 | 11.1 | 7.5 | | |
| 2019.5833 | AUG | 88.2 | 74.0 | 68.1 | 16.3 | 11.0 | 7.5 | | |
| 2019.6667 | SEP | 91.0 | 74.9 | 68.5 | 15.5 | 10.9 | 7.5 | | |
| 2019.7500 | OCT | 93.8 | 75.8 | 68.6 | 16.1 | 10.8 | 7.7 | | |
| 2019.8333 | NOV | 96.7 | 76.9 | 68.8 | 16.3 | 10.8 | 7.7 | | |
| 2019.9167 | DEC | 100.7 | 78.4 | 69.1 | 16.6 | 10.9 | 7.8 | | |
| 2020.0000 | JAN | 105.5 | 80.0 | 69.3 | 16.7 | 11.0 | 7.7 | | |
| 2020.0833 | FEB | 111.4 | 81.8 | 69.6 | 16.8 | 11.1 | 7.7 | | |
| 2020.1667 | MAR | 116.6 | 83.6 | 70.2 | 17.1 | 11.1 | 7.8 | | |
| 2020.2500 | APR | 120.6 | 85.6 | 71.1 | 17.3 | 11.1 | 8.0 | | |
| 2020.3333 | MAY | 123.8 | 87.7 | 71.8 | 17.3 | 11.2 | 8.3 | | |
| 2020.4167 | JUN | 126.5 | 89.8 | 72.5 | 17.4 | 11.5 | 8.6 | | |
| 2020.5000 | JUL | 130.1 | 92.1 | 73.7 | 17.6 | 11.7 | 9.0 | | |
| 2020.5833 | AUG | 133.5 | 94.4 | 74.2 | 17.5 | 12.0 | 8.8 | | |
| 2020.6667 | SEP | 136.2 | 96.7 | 74.5 | 16.9 | 12.2 | 8.7 | | |
| 2020.7500 | OCT | 141.6 | 99.5 | 74.8 | 16.2 | 12.4 | 8.9 | | |
| 2020.8333 | NOV | 147.9 | 102.3 | 75.1 | 16.0 | 12.5 | 9.0 | | |
| 2020.9167 | DEC | 153.4 | 104.8 | 75.3 | 16.0 | 12.7 | 9.0 | | |
| 2021.0000 | JAN | 157.1 | 107.3 | 75.2 | 16.1 | 12.9 | 8.8 | | |
| 2021.0833 | FEB | 159.2 | 109.6 | 75.2 | 16.7 | 13.0 | 8.4 | | |
| 2021.1667 | MAR | 162.0 | 111.9 | 75.3 | 17.1 | 13.0 | 8.2 | | |

**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 PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2021.2500 | APR | 165.3 | 114.5 | 75.7 | 17.5 | 13.1 | 8.2 |
| 2021.3333 | MAY | 172.5 | 117.4 | 76.1 | 18.2 | 13.2 | 8.1 |
| 2021.4167 | JUN | 181.4 | 120.5 | 76.6 | 18.5 | 13.2 | 7.9 |
| 2021.5000 | JUL | 188.0 | 123.1 | 77.5 | 18.5 | 13.1 | 7.8 |
| 2021.5833 | AUG | 191.8 | 125.3 | 78.3 | 18.7 | 13.1 | 7.9 |
| 2021.6667 | SEP | 194.8 | 127.4 | 78.6 | 19.0 | 13.2 | 8.1 |
| 2021.7500 | OCT | 197.7 | 129.3 | 79.6 | 18.6 | 13.3 | 8.6 |
| 2021.8333 | NOV | 201.4 | 131.0 | 80.8 | 17.8 | 13.3 | 9.2 |
| 2021.9167 | DEC | 206.7 | 132.7 | 82.2 | 18.1 | 13.4 | 9.6 |
| 2022.0000 | JAN | 211.5 | 134.8 | 84.1 | 18.9 | 13.5 | 10.1 |
| 2022.0833 | FEB | 214.4 | 137.2 | 85.4 | 19.1 | 13.6 | 10.1 |
| 2022.1667 | MAR | 218.4 | 139.6 | 86.3 | 19.5 | 13.9 | 10.3 |
| 2022.2500 | APR | 223.8 | 142.2 | 88.1 | 20.5 | 14.1 | 10.4 |
| 2022.3333 | MAY | 227.1 | 144.8 | 90.0 | 20.2 | 14.1 | 10.6 |
| 2022.4167 | JUN | 228.9 | 146.9 | 91.1 | 20.4 | 14.1 | 10.2 |
| 2022.5000 | JUL | 230.4 | 148.9 | 93.3 | 20.7 | 14.1 | 10.2 |
| 2022.5833 | AUG | 231.8 | 150.9 | 95.7 | 21.1 | 14.2 | 9.9 |
| 2022.6667 | SEP | 234.4 | 152.8 | 97.5 | 21.4 | 14.2 | 9.8 |
| 2022.7500 | OCT | 237.7 | 154.7 | 98.7 | 21.4 | 14.4 | 10.5 |
| 2022.8333 | NOV | 239.4 | 156.3 | 98.8 | 21.6 | 14.5 | 10.9 |
| 2022.9167 | DEC | 238.3 | 157.5 | 98.2 | 21.9 | 14.7 | 10.9 |
| 2023.0000 | JAN | 237.2 | 158.9 | 97.8 | 22.4 | 14.9 | 11.0 |
| 2023.0833 | FEB | 238.5 | 160.7 | 99.1 | 22.9 | 15.1 | 11.2 |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | \bar{R} | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|------------------------------|-------|------|-----------|---------------------------------|------|------|-------------|
| | | 95.0% | 50% | 5.0% | 5.0% | 95.0% | 50% | 5.0% | |
| 2008.0000 | JAN | 6.7 | 5.0 | 3.4 | | 8.4 | 7.8 | 7.2 | |
| 2008.0833 | FEB | 8.2 | 5.3 | 1.8 | | 8.9 | 8.0 | 6.7 | |
| 2008.1667 | MAR | 9.7 | 5.7 | 0.8 | | 9.3 | 7.9 | 6.2 | |
| 2008.2500 | APR | 11.1 | 6.3 | 0.3 | | 9.7 | 7.9 | 5.9 | |
| 2008.3333 | MAY | 13.0 | 6.9 | 0.1 | | 10.2 | 7.9 | 5.9 | |
| 2008.4167 | JUN | 15.0 | 7.3 | 0.0 | | 10.7 | 8.1 | 6.0 | |
| 2008.5000 | JUL | 16.9 | 7.7 | 0.0 | | 10.9 | 8.3 | 6.2 | |
| 2008.5833 | AUG | 19.1 | 8.3 | 0.0 | | 11.1 | 8.4 | 6.3 | |
| 2008.6667 | SEP | 21.4 | 9.4 | 0.0 | | 12.2 | 8.7 | 6.8 | |
| 2008.7500 | OCT | 24.5 | 10.6 | 0.0 | | 13.8 | 9.2 | 7.3 | |
| 2008.8333 | NOV | 27.6 | 11.7 | 0.0 | | 14.9 | 9.6 | 7.7 | |
| 2008.9167 | DEC | 30.6 | 13.2 | 0.0 | | 15.4 | 9.9 | 7.7 | |
| 2009.0000 | JAN | 34.6 | 15.0 | 0.0 | | 16.1 | 10.4 | 7.8 | |
| 2009.0833 | FEB | 39.1 | 16.7 | 0.0 | | 16.4 | 10.7 | 7.7 | |
| 2009.1667 | MAR | 44.0 | 18.7 | 0.8 | | 16.6 | 10.8 | 7.7 | |
| 2009.2500 | APR | 48.1 | 21.0 | 1.8 | | 17.0 | 10.9 | 7.8 | |
| 2009.3333 | MAY | 51.1 | 23.3 | 2.2 | | 17.3 | 11.1 | 8.0 | |
| 2009.4167 | JUN | 54.1 | 25.9 | 2.8 | | 17.4 | 11.4 | 8.3 | |
| 2009.5000 | JUL | 57.6 | 28.7 | 4.2 | | 17.7 | 11.7 | 8.6 | |
| 2009.5833 | AUG | 60.5 | 31.2 | 5.3 | | 18.0 | 12.2 | 9.1 | |
| 2009.6667 | SEP | 62.8 | 33.9 | 7.5 | | 18.1 | 12.7 | 9.8 | |
| 2009.7500 | OCT | 64.4 | 36.8 | 9.9 | | 17.7 | 13.1 | 10.3 | |
| 2009.8333 | NOV | 66.4 | 40.2 | 11.6 | | 16.9 | 13.2 | 10.3 | |
| 2009.9167 | DEC | 73.0 | 43.3 | 13.0 | | 16.6 | 13.2 | 10.1 | |
| 2010.0000 | JAN | 79.8 | 45.7 | 14.0 | | 16.6 | 13.4 | 10.0 | |
| 2010.0833 | FEB | 87.7 | 48.3 | 14.9 | | 17.2 | 13.6 | 9.9 | |
| 2010.1667 | MAR | 97.1 | 50.8 | 15.1 | | 17.7 | 13.6 | 9.5 | |
| 2010.2500 | APR | 106.3 | 53.2 | 15.1 | | 18.2 | 13.7 | 9.4 | |
| 2010.3333 | MAY | 113.7 | 55.6 | 16.7 | | 18.4 | 13.7 | 9.2 | |
| 2010.4167 | JUN | 121.1 | 58.2 | 18.4 | | 18.4 | 13.4 | 8.4 | |
| 2010.5000 | JUL | 126.3 | 62.0 | 20.6 | | 18.6 | 13.5 | 8.6 | |
| 2010.5833 | AUG | 131.6 | 65.9 | 22.7 | | 18.9 | 13.6 | 8.7 | |
| 2010.6667 | SEP | 136.8 | 69.7 | 24.9 | | 19.1 | 13.7 | 8.9 | |
| 2010.7500 | OCT | 141.9 | 73.5 | 27.0 | | 19.4 | 13.8 | 9.1 | |
| 2010.8333 | NOV | 146.9 | 77.2 | 29.0 | | 19.6 | 13.9 | 9.2 | |
| 2010.9167 | DEC | 151.8 | 80.9 | 31.1 | | 19.9 | 13.9 | 9.4 | |
| 2011.0000 | JAN | 156.6 | 84.4 | 33.0 | | 20.1 | 14.0 | 9.6 | |
| 2011.0833 | FEB | 161.2 | 87.8 | 34.9 | | 20.3 | 14.1 | 9.7 | |
| 2011.1667 | MAR | 165.6 | 91.0 | 36.7 | | 20.5 | 14.2 | 9.8 | |
| 2011.2500 | APR | 169.8 | 94.1 | 38.5 | | 20.7 | 14.3 | 10.0 | |
| 2011.3333 | MAY | 173.8 | 97.1 | 40.1 | | 20.9 | 14.4 | 10.1 | |
| 2011.4167 | JUN | 177.5 | 99.8 | 41.6 | | 21.1 | 14.4 | 10.2 | |
| 2011.5000 | JUL | 180.9 | 102.3 | 43.0 | | 21.2 | 14.5 | 10.3 | |
| 2011.5833 | AUG | 183.9 | 104.6 | 44.3 | | 21.4 | 14.6 | 10.4 | |
| 2011.6667 | SEP | 186.7 | 106.6 | 45.4 | | 21.5 | 14.6 | 10.5 | |
| 2011.7500 | OCT | 189.1 | 108.4 | 46.4 | | 21.6 | 14.7 | 10.6 | |
| 2011.8333 | NOV | 191.1 | 109.9 | 47.2 | | 21.7 | 14.7 | 10.7 | |
| 2011.9167 | DEC | 192.7 | 111.1 | 47.9 | | 21.8 | 14.7 | 10.7 | |
| 2012.0000 | JAN | 193.9 | 111.9 | 48.4 | | 21.9 | 14.8 | 10.8 | |
| 2012.0833 | FEB | 194.6 | 112.5 | 48.7 | | 21.9 | 14.8 | 10.8 | |
| 2012.1667 | MAR | 194.9 | 112.6 | 48.8 | | 21.9 | 14.8 | 10.8 | |
| 2012.2500 | APR | 190.7 | 111.7 | 47.2 | | 20.6 | 14.9 | 11.5 | |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2012.3333 | MAY | 185.3 | 109.8 | 46.2 | 20.2 | 15.0 | 11.8 |
| 2012.4167 | JUN | 181.3 | 107.7 | 45.1 | 19.7 | 15.1 | 11.7 |
| 2012.5000 | JUL | 180.3 | 106.1 | 43.5 | 19.4 | 15.3 | 11.9 |
| 2012.5833 | AUG | 180.1 | 104.9 | 41.5 | 19.2 | 15.6 | 12.1 |
| 2012.6667 | SEP | 178.8 | 103.9 | 40.1 | 19.0 | 15.7 | 11.6 |
| 2012.7500 | OCT | 176.6 | 102.7 | 39.1 | 19.0 | 15.7 | 10.9 |
| 2012.8333 | NOV | 175.4 | 101.6 | 38.3 | 18.9 | 15.7 | 10.8 |
| 2012.9167 | DEC | 174.6 | 100.2 | 37.1 | 19.0 | 15.7 | 10.8 |
| 2013.0000 | JAN | 172.9 | 98.5 | 35.9 | 19.2 | 15.8 | 10.8 |
| 2013.0833 | FEB | 171.8 | 96.7 | 35.1 | 19.8 | 15.9 | 10.8 |
| 2013.1667 | MAR | 169.2 | 95.0 | 33.8 | 20.4 | 16.1 | 10.9 |
| 2013.2500 | APR | 164.9 | 93.4 | 32.0 | 21.4 | 16.3 | 10.8 |
| 2013.3333 | MAY | 161.5 | 92.2 | 30.8 | 21.9 | 16.5 | 10.7 |
| 2013.4167 | JUN | 157.3 | 91.1 | 30.4 | 21.6 | 16.6 | 10.6 |
| 2013.5000 | JUL | 153.1 | 89.9 | 29.1 | 21.3 | 16.4 | 10.3 |
| 2013.5833 | AUG | 149.3 | 88.6 | 27.2 | 21.8 | 16.5 | 10.3 |
| 2013.6667 | SEP | 146.5 | 86.9 | 25.5 | 23.1 | 16.7 | 10.4 |
| 2013.7500 | OCT | 145.1 | 85.0 | 24.2 | 23.3 | 16.9 | 10.9 |
| 2013.8333 | NOV | 142.6 | 82.8 | 23.3 | 22.7 | 17.0 | 11.7 |
| 2013.9167 | DEC | 139.5 | 80.6 | 22.3 | 22.6 | 17.0 | 11.8 |
| 2014.0000 | JAN | 134.9 | 78.5 | 21.1 | 22.7 | 16.9 | 11.9 |
| 2014.0833 | FEB | 132.1 | 76.6 | 19.8 | 23.2 | 17.1 | 12.0 |
| 2014.1667 | MAR | 132.2 | 75.0 | 18.3 | 23.9 | 17.3 | 12.1 |
| 2014.2500 | APR | 133.2 | 73.4 | 16.7 | 23.9 | 17.2 | 12.5 |
| 2014.3333 | MAY | 132.3 | 71.5 | 15.2 | 23.9 | 17.1 | 13.3 |
| 2014.4167 | JUN | 128.8 | 69.3 | 13.5 | 23.3 | 17.0 | 13.7 |
| 2014.5000 | JUL | 123.2 | 67.0 | 11.9 | 21.6 | 16.8 | 13.3 |
| 2014.5833 | AUG | 118.8 | 65.3 | 11.1 | 21.8 | 16.6 | 12.8 |
| 2014.6667 | SEP | 116.4 | 63.8 | 10.6 | 21.8 | 16.4 | 12.7 |
| 2014.7500 | OCT | 115.3 | 62.2 | 9.7 | 21.5 | 16.4 | 12.5 |
| 2014.8333 | NOV | 113.1 | 60.8 | 9.3 | 21.1 | 16.4 | 12.4 |
| 2014.9167 | DEC | 110.6 | 59.5 | 9.4 | 20.5 | 16.4 | 12.2 |
| 2015.0000 | JAN | 106.6 | 57.9 | 9.4 | 19.9 | 16.1 | 11.9 |
| 2015.0833 | FEB | 100.7 | 56.0 | 8.9 | 20.1 | 16.0 | 11.9 |
| 2015.1667 | MAR | 94.5 | 54.0 | 8.6 | 21.6 | 15.9 | 11.7 |
| 2015.2500 | APR | 88.4 | 52.2 | 8.2 | 23.2 | 15.8 | 11.7 |
| 2015.3333 | MAY | 83.4 | 50.4 | 8.0 | 24.0 | 15.8 | 11.5 |
| 2015.4167 | JUN | 79.8 | 48.4 | 8.5 | 25.1 | 15.7 | 11.3 |
| 2015.5000 | JUL | 76.6 | 46.7 | 9.1 | 25.8 | 15.7 | 11.3 |
| 2015.5833 | AUG | 73.3 | 45.5 | 9.5 | 25.0 | 15.6 | 10.8 |
| 2015.6667 | SEP | 71.2 | 44.2 | 9.7 | 25.0 | 15.6 | 10.3 |
| 2015.7500 | OCT | 71.4 | 43.1 | 9.3 | 24.1 | 15.7 | 10.7 |
| 2015.8333 | NOV | 71.6 | 41.6 | 8.5 | 22.2 | 15.7 | 10.8 |
| 2015.9167 | DEC | 70.0 | 39.9 | 7.7 | 21.4 | 15.6 | 10.8 |
| 2016.0000 | JAN | 68.6 | 38.5 | 7.0 | 21.7 | 15.8 | 11.0 |
| 2016.0833 | FEB | 68.8 | 37.4 | 6.2 | 22.4 | 16.0 | 11.2 |
| 2016.1667 | MAR | 68.7 | 36.2 | 5.5 | 22.6 | 16.0 | 11.2 |
| 2016.2500 | APR | 68.2 | 35.0 | 5.0 | 22.5 | 16.1 | 11.0 |
| 2016.3333 | MAY | 67.4 | 33.6 | 4.3 | 22.7 | 16.3 | 11.0 |
| 2016.4167 | JUN | 65.8 | 32.0 | 3.2 | 22.9 | 16.6 | 11.3 |
| 2016.5000 | JUL | 63.7 | 30.7 | 2.5 | 23.4 | 16.8 | 11.2 |
| 2016.5833 | AUG | 61.1 | 29.5 | 2.0 | 24.1 | 16.9 | 11.2 |

**TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME | | SUNSPOT NUMBER PERCENTILE | | | \bar{R} | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|------------------------------|------|------|-----------|---------------------------------|------|------|-------------|
| | | 95.0% | 50% | 5.0% | 5.0% | 95.0% | 50% | 5.0% | |
| 2016.6667 | SEP | 56.9 | 28.4 | 1.8 | 24.8 | 17.0 | 11.8 | | |
| 2016.7500 | OCT | 51.2 | 27.3 | 1.8 | 25.4 | 16.9 | 12.2 | | |
| 2016.8333 | NOV | 46.9 | 26.1 | 1.6 | 25.6 | 16.7 | 12.1 | | |
| 2016.9167 | DEC | 46.8 | 24.9 | 1.2 | 25.4 | 16.4 | 12.0 | | |
| 2017.0000 | JAN | 47.3 | 23.9 | 0.8 | 24.7 | 16.0 | 12.2 | | |
| 2017.0833 | FEB | 48.4 | 23.1 | 0.6 | 23.6 | 15.6 | 12.3 | | |
| 2017.1667 | MAR | 48.9 | 22.3 | 0.6 | 22.8 | 15.2 | 12.2 | | |
| 2017.2500 | APR | 47.1 | 21.5 | 0.6 | 22.4 | 14.9 | 11.8 | | |
| 2017.3333 | MAY | 43.6 | 20.8 | 0.5 | 21.9 | 14.6 | 11.2 | | |
| 2017.4167 | JUN | 40.7 | 19.9 | 0.3 | 21.6 | 14.2 | 10.7 | | |
| 2017.5000 | JUL | 39.0 | 19.1 | 0.2 | 20.9 | 13.8 | 10.0 | | |
| 2017.5833 | AUG | 38.6 | 18.2 | 0.1 | 20.0 | 13.4 | 9.4 | | |
| 2017.6667 | SEP | 38.0 | 17.3 | 0.0 | 18.7 | 13.1 | 9.0 | | |
| 2017.7500 | OCT | 37.4 | 16.5 | 0.0 | 18.2 | 12.8 | 8.5 | | |
| 2017.8333 | NOV | 36.5 | 15.7 | 0.0 | 18.7 | 12.6 | 8.0 | | |
| 2017.9167 | DEC | 35.4 | 15.0 | 0.3 | 18.7 | 12.5 | 7.8 | | |
| 2018.0000 | JAN | 34.4 | 14.4 | 0.8 | 18.4 | 12.4 | 7.4 | | |
| 2018.0833 | FEB | 33.3 | 13.8 | 1.0 | 18.4 | 12.2 | 7.0 | | |
| 2018.1667 | MAR | 31.7 | 13.0 | 1.3 | 18.8 | 12.1 | 6.6 | | |
| 2018.2500 | APR | 29.6 | 12.3 | 1.5 | 18.9 | 12.0 | 6.5 | | |
| 2018.3333 | MAY | 26.9 | 11.5 | 1.7 | 18.8 | 12.0 | 6.4 | | |
| 2018.4167 | JUN | 23.6 | 10.8 | 2.0 | 18.4 | 11.9 | 6.6 | | |
| 2018.5000 | JUL | 20.3 | 10.2 | 2.5 | 17.5 | 11.8 | 6.9 | | |
| 2018.5833 | AUG | 19.7 | 9.7 | 2.6 | 16.5 | 11.7 | 7.2 | | |
| 2018.6667 | SEP | 19.1 | 9.3 | 2.6 | 16.3 | 11.6 | 7.4 | | |
| 2018.7500 | OCT | 18.1 | 8.9 | 2.6 | 16.6 | 11.6 | 7.5 | | |
| 2018.8333 | NOV | 17.0 | 8.7 | 2.4 | 16.9 | 11.6 | 7.5 | | |
| 2018.9167 | DEC | 16.0 | 8.6 | 2.3 | 17.2 | 11.6 | 7.7 | | |
| 2019.0000 | JAN | 15.4 | 8.6 | 1.9 | 17.3 | 11.6 | 7.7 | | |
| 2019.0833 | FEB | 14.5 | 8.7 | 1.8 | 17.7 | 11.5 | 7.6 | | |
| 2019.1667 | MAR | 15.4 | 9.0 | 1.8 | 18.0 | 11.4 | 7.6 | | |
| 2019.2500 | APR | 16.5 | 9.4 | 1.8 | 18.2 | 11.4 | 7.6 | | |
| 2019.3333 | MAY | 18.0 | 9.6 | 1.7 | 18.1 | 11.3 | 7.6 | | |
| 2019.4167 | JUN | 20.0 | 10.0 | 1.7 | 17.8 | 11.2 | 7.5 | | |
| 2019.5000 | JUL | 22.2 | 10.7 | 2.4 | 17.3 | 11.1 | 7.5 | | |
| 2019.5833 | AUG | 24.5 | 11.8 | 3.0 | 16.3 | 11.0 | 7.5 | | |
| 2019.6667 | SEP | 27.7 | 13.0 | 3.8 | 15.5 | 10.9 | 7.5 | | |
| 2019.7500 | OCT | 30.9 | 14.3 | 4.0 | 16.1 | 10.8 | 7.7 | | |
| 2019.8333 | NOV | 34.2 | 15.9 | 4.5 | 16.3 | 10.8 | 7.7 | | |
| 2019.9167 | DEC | 38.3 | 17.8 | 5.2 | 16.6 | 10.9 | 7.8 | | |
| 2020.0000 | JAN | 43.1 | 19.7 | 5.8 | 16.7 | 11.0 | 7.7 | | |
| 2020.0833 | FEB | 47.9 | 21.7 | 6.2 | 16.8 | 11.1 | 7.7 | | |
| 2020.1667 | MAR | 52.1 | 23.9 | 7.4 | 17.1 | 11.1 | 7.8 | | |
| 2020.2500 | APR | 55.4 | 26.5 | 9.2 | 17.3 | 11.1 | 8.0 | | |
| 2020.3333 | MAY | 58.8 | 29.4 | 10.5 | 17.3 | 11.2 | 8.3 | | |
| 2020.4167 | JUN | 62.6 | 32.4 | 11.8 | 17.4 | 11.5 | 8.6 | | |
| 2020.5000 | JUL | 65.9 | 35.3 | 14.0 | 17.6 | 11.7 | 9.0 | | |
| 2020.5833 | AUG | 68.4 | 38.0 | 14.7 | 17.5 | 12.0 | 8.8 | | |
| 2020.6667 | SEP | 70.8 | 40.8 | 15.2 | 16.9 | 12.2 | 8.7 | | |
| 2020.7500 | OCT | 73.1 | 44.1 | 15.7 | 16.2 | 12.4 | 8.9 | | |
| 2020.8333 | NOV | 78.8 | 47.4 | 16.2 | 16.0 | 12.5 | 9.0 | | |
| 2020.9167 | DEC | 85.1 | 50.4 | 16.4 | 16.0 | 12.7 | 9.0 | | |

TABLE 4 ESTIMATES OF 13-MONTH SMOOTHED R AND A_p FOR
BALANCE OF CYCLE 23 AND CYCLE 24

| TIME | | SUNSPOT NUMBER PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2021.0000 | JAN | 92.8 | 53.6 | 16.3 | 16.1 | 12.9 | 8.8 |
| 2021.0833 | FEB | 102.4 | 56.5 | 16.1 | 16.7 | 13.0 | 8.4 |
| 2021.1667 | MAR | 111.8 | 59.2 | 16.2 | 17.1 | 13.0 | 8.2 |
| 2021.2500 | APR | 119.9 | 62.3 | 16.8 | 17.5 | 13.1 | 8.2 |
| 2021.3333 | MAY | 127.9 | 65.5 | 17.2 | 18.2 | 13.2 | 8.1 |
| 2021.4167 | JUN | 136.4 | 68.9 | 17.9 | 18.5 | 13.2 | 7.9 |
| 2021.5000 | JUL | 143.1 | 71.8 | 19.3 | 18.5 | 13.1 | 7.8 |
| 2021.5833 | AUG | 146.6 | 74.4 | 20.7 | 18.7 | 13.1 | 7.9 |
| 2021.6667 | SEP | 149.9 | 76.5 | 21.1 | 19.0 | 13.2 | 8.1 |
| 2021.7500 | OCT | 154.1 | 78.7 | 22.6 | 18.6 | 13.3 | 8.6 |
| 2021.8333 | NOV | 158.4 | 80.9 | 24.4 | 17.8 | 13.3 | 9.2 |
| 2021.9167 | DEC | 163.8 | 83.2 | 26.5 | 18.1 | 13.4 | 9.6 |
| 2022.0000 | JAN | 168.2 | 85.7 | 29.0 | 18.9 | 13.5 | 10.1 |
| 2022.0833 | FEB | 169.7 | 88.0 | 30.9 | 19.1 | 13.6 | 10.1 |
| 2022.1667 | MAR | 172.7 | 90.3 | 32.1 | 19.5 | 13.9 | 10.3 |
| 2022.2500 | APR | 178.2 | 93.0 | 34.4 | 20.5 | 14.1 | 10.4 |
| 2022.3333 | MAY | 182.2 | 95.8 | 36.7 | 20.2 | 14.1 | 10.6 |
| 2022.4167 | JUN | 184.8 | 98.2 | 38.2 | 20.4 | 14.1 | 10.2 |
| 2022.5000 | JUL | 187.6 | 100.5 | 40.9 | 20.7 | 14.1 | 10.2 |
| 2022.5833 | AUG | 189.9 | 102.8 | 43.9 | 21.1 | 14.2 | 9.9 |
| 2022.6667 | SEP | 192.1 | 105.0 | 45.9 | 21.4 | 14.2 | 9.8 |
| 2022.7500 | OCT | 193.6 | 106.7 | 47.3 | 21.4 | 14.4 | 10.5 |
| 2022.8333 | NOV | 194.3 | 108.3 | 47.5 | 21.6 | 14.5 | 10.9 |
| 2022.9167 | DEC | 193.6 | 109.6 | 46.7 | 21.9 | 14.7 | 10.9 |
| 2023.0000 | JAN | 192.7 | 110.9 | 46.3 | 22.4 | 14.9 | 11.0 |
| 2023.0833 | FEB | 194.4 | 112.7 | 47.8 | 22.9 | 15.1 | 11.2 |

**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 PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 75.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2008.0000 | JAN | 71.1 | 70.8 | 69.7 | 8.4 | 7.8 | 7.2 |
| 2008.0833 | FEB | 71.5 | 70.8 | 68.6 | 8.9 | 8.0 | 6.7 |
| 2008.1667 | MAR | 72.1 | 70.9 | 67.9 | 9.3 | 7.9 | 6.2 |
| 2008.2500 | APR | 73.0 | 71.1 | 67.2 | 9.7 | 7.9 | 5.9 |
| 2008.3333 | MAY | 73.5 | 71.5 | 66.5 | 10.2 | 7.9 | 5.9 |
| 2008.4167 | JUN | 74.1 | 71.8 | 65.6 | 10.7 | 8.1 | 6.0 |
| 2008.5000 | JUL | 74.5 | 72.1 | 64.9 | 10.9 | 8.3 | 6.2 |
| 2008.5833 | AUG | 75.1 | 72.6 | 64.1 | 11.1 | 8.4 | 6.3 |
| 2008.6667 | SEP | 76.1 | 73.3 | 63.5 | 12.2 | 8.7 | 6.8 |
| 2008.7500 | OCT | 77.0 | 74.2 | 62.9 | 13.8 | 9.2 | 7.3 |
| 2008.8333 | NOV | 78.2 | 75.0 | 62.3 | 14.9 | 9.6 | 7.7 |
| 2008.9167 | DEC | 79.5 | 76.1 | 62.0 | 15.4 | 9.9 | 7.7 |
| 2009.0000 | JAN | 81.6 | 77.4 | 61.8 | 16.1 | 10.4 | 7.8 |
| 2009.0833 | FEB | 84.0 | 78.9 | 61.2 | 16.4 | 10.7 | 7.7 |
| 2009.1667 | MAR | 86.5 | 80.5 | 60.6 | 16.6 | 10.8 | 7.7 |
| 2009.2500 | APR | 89.2 | 82.3 | 60.5 | 17.0 | 10.9 | 7.8 |
| 2009.3333 | MAY | 91.9 | 84.1 | 60.8 | 17.3 | 11.1 | 8.0 |
| 2009.4167 | JUN | 95.0 | 86.1 | 61.4 | 17.4 | 11.4 | 8.3 |
| 2009.5000 | JUL | 97.8 | 88.2 | 62.3 | 17.7 | 11.7 | 8.6 |
| 2009.5833 | AUG | 100.7 | 90.4 | 63.0 | 18.0 | 12.2 | 9.1 |
| 2009.6667 | SEP | 104.0 | 92.6 | 64.0 | 18.1 | 12.7 | 9.8 |
| 2009.7500 | OCT | 106.5 | 95.0 | 65.2 | 17.7 | 13.1 | 10.3 |
| 2009.8333 | NOV | 109.8 | 97.7 | 67.2 | 16.9 | 13.2 | 10.3 |
| 2009.9167 | DEC | 113.3 | 100.4 | 69.0 | 16.6 | 13.2 | 10.1 |
| 2010.0000 | JAN | 115.8 | 102.7 | 69.1 | 16.6 | 13.4 | 10.0 |
| 2010.0833 | FEB | 118.5 | 105.2 | 69.4 | 17.2 | 13.6 | 9.9 |
| 2010.1667 | MAR | 120.6 | 107.4 | 71.9 | 17.7 | 13.6 | 9.5 |
| 2010.2500 | APR | 122.4 | 109.7 | 75.1 | 18.2 | 13.7 | 9.4 |
| 2010.3333 | MAY | 124.3 | 112.2 | 77.2 | 18.4 | 13.7 | 9.2 |
| 2010.4167 | JUN | 129.7 | 115.0 | 79.3 | 18.4 | 13.4 | 8.4 |
| 2010.5000 | JUL | 134.3 | 118.3 | 80.8 | 18.6 | 13.5 | 8.6 |
| 2010.5833 | AUG | 138.9 | 121.5 | 82.3 | 18.9 | 13.6 | 8.7 |
| 2010.6667 | SEP | 143.4 | 124.8 | 83.7 | 19.1 | 13.7 | 8.9 |
| 2010.7500 | OCT | 147.8 | 127.9 | 85.1 | 19.4 | 13.8 | 9.1 |
| 2010.8333 | NOV | 152.2 | 131.0 | 86.5 | 19.6 | 13.9 | 9.2 |
| 2010.9167 | DEC | 156.5 | 134.1 | 87.9 | 19.9 | 13.9 | 9.4 |
| 2011.0000 | JAN | 160.6 | 137.0 | 89.2 | 20.1 | 14.0 | 9.6 |
| 2011.0833 | FEB | 164.6 | 139.9 | 90.5 | 20.3 | 14.1 | 9.7 |
| 2011.1667 | MAR | 168.4 | 142.6 | 91.7 | 20.5 | 14.2 | 9.8 |
| 2011.2500 | APR | 172.1 | 145.2 | 92.9 | 20.7 | 14.3 | 10.0 |
| 2011.3333 | MAY | 175.5 | 147.7 | 94.0 | 20.9 | 14.4 | 10.1 |
| 2011.4167 | JUN | 178.7 | 150.0 | 95.0 | 21.1 | 14.4 | 10.2 |
| 2011.5000 | JUL | 181.7 | 152.1 | 96.0 | 21.2 | 14.5 | 10.3 |
| 2011.5833 | AUG | 184.4 | 154.0 | 96.8 | 21.4 | 14.6 | 10.4 |
| 2011.6667 | SEP | 186.7 | 155.7 | 97.6 | 21.5 | 14.6 | 10.5 |
| 2011.7500 | OCT | 188.8 | 157.2 | 98.3 | 21.6 | 14.7 | 10.6 |
| 2011.8333 | NOV | 190.6 | 158.4 | 98.8 | 21.7 | 14.7 | 10.7 |
| 2011.9167 | DEC | 192.0 | 159.4 | 99.3 | 21.8 | 14.7 | 10.7 |
| 2012.0000 | JAN | 193.0 | 160.2 | 99.6 | 21.9 | 14.8 | 10.8 |
| 2012.0833 | FEB | 193.6 | 160.6 | 99.8 | 21.9 | 14.8 | 10.8 |
| 2012.1667 | MAR | 193.9 | 160.8 | 99.9 | 21.9 | 14.8 | 10.8 |
| 2012.2500 | APR | 192.9 | 159.6 | 98.5 | 20.6 | 14.9 | 11.5 |
| 2012.3333 | MAY | 191.7 | 157.8 | 97.8 | 20.2 | 15.0 | 11.8 |
| 2012.4167 | JUN | 188.2 | 156.0 | 96.7 | 19.7 | 15.1 | 11.7 |
| 2012.5000 | JUL | 184.1 | 154.7 | 95.4 | 19.4 | 15.3 | 11.9 |
| 2012.5833 | AUG | 180.2 | 153.6 | 93.8 | 19.2 | 15.6 | 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 PERCENTILE | | | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2012.6667 | SEP | 178.7 | 152.7 | 92.6 | 19.0 | 15.7 | 11.6 | | |
| 2012.7500 | OCT | 177.3 | 151.7 | 91.8 | 19.0 | 15.7 | 10.9 | | |
| 2012.8333 | NOV | 176.9 | 150.4 | 91.2 | 18.9 | 15.7 | 10.8 | | |
| 2012.9167 | DEC | 175.2 | 148.9 | 90.3 | 19.0 | 15.7 | 10.8 | | |
| 2013.0000 | JAN | 170.9 | 147.2 | 89.3 | 19.2 | 15.8 | 10.8 | | |
| 2013.0833 | FEB | 167.1 | 145.3 | 88.6 | 19.8 | 15.9 | 10.8 | | |
| 2013.1667 | MAR | 165.8 | 143.4 | 87.7 | 20.4 | 16.1 | 10.9 | | |
| 2013.2500 | APR | 163.6 | 141.8 | 86.2 | 21.4 | 16.3 | 10.8 | | |
| 2013.3333 | MAY | 160.6 | 140.6 | 85.4 | 21.9 | 16.5 | 10.7 | | |
| 2013.4167 | JUN | 159.8 | 139.5 | 84.9 | 21.6 | 16.6 | 10.6 | | |
| 2013.5000 | JUL | 158.8 | 138.5 | 84.0 | 21.3 | 16.4 | 10.3 | | |
| 2013.5833 | AUG | 156.3 | 137.4 | 82.7 | 21.8 | 16.5 | 10.3 | | |
| 2013.6667 | SEP | 153.6 | 135.6 | 81.3 | 23.1 | 16.7 | 10.4 | | |
| 2013.7500 | OCT | 152.4 | 133.6 | 80.4 | 23.3 | 16.9 | 10.9 | | |
| 2013.8333 | NOV | 151.6 | 131.5 | 79.8 | 22.7 | 17.0 | 11.7 | | |
| 2013.9167 | DEC | 151.1 | 129.6 | 79.1 | 22.6 | 17.0 | 11.8 | | |
| 2014.0000 | JAN | 149.3 | 127.8 | 78.4 | 22.7 | 16.9 | 11.9 | | |
| 2014.0833 | FEB | 146.2 | 126.3 | 77.5 | 23.2 | 17.1 | 12.0 | | |
| 2014.1667 | MAR | 144.8 | 125.2 | 76.5 | 23.9 | 17.3 | 12.1 | | |
| 2014.2500 | APR | 144.9 | 123.7 | 75.5 | 23.9 | 17.2 | 12.5 | | |
| 2014.3333 | MAY | 143.0 | 121.6 | 74.6 | 23.9 | 17.1 | 13.3 | | |
| 2014.4167 | JUN | 139.7 | 119.5 | 73.6 | 23.3 | 17.0 | 13.7 | | |
| 2014.5000 | JUL | 135.8 | 117.5 | 72.7 | 21.6 | 16.8 | 13.3 | | |
| 2014.5833 | AUG | 135.2 | 115.9 | 72.3 | 21.8 | 16.6 | 12.8 | | |
| 2014.6667 | SEP | 134.7 | 114.4 | 72.0 | 21.8 | 16.4 | 12.7 | | |
| 2014.7500 | OCT | 132.8 | 112.9 | 71.6 | 21.5 | 16.4 | 12.5 | | |
| 2014.8333 | NOV | 130.1 | 111.4 | 71.4 | 21.1 | 16.4 | 12.4 | | |
| 2014.9167 | DEC | 128.2 | 109.9 | 71.5 | 20.5 | 16.4 | 12.2 | | |
| 2015.0000 | JAN | 126.8 | 108.3 | 71.4 | 19.9 | 16.1 | 11.9 | | |
| 2015.0833 | FEB | 124.8 | 106.7 | 71.2 | 20.1 | 16.0 | 11.9 | | |
| 2015.1667 | MAR | 122.0 | 104.8 | 70.9 | 21.6 | 15.9 | 11.7 | | |
| 2015.2500 | APR | 119.8 | 103.0 | 70.7 | 23.2 | 15.8 | 11.7 | | |
| 2015.3333 | MAY | 116.8 | 101.4 | 70.5 | 24.0 | 15.8 | 11.5 | | |
| 2015.4167 | JUN | 115.1 | 99.9 | 70.7 | 25.1 | 15.7 | 11.3 | | |
| 2015.5000 | JUL | 113.4 | 98.7 | 71.1 | 25.8 | 15.7 | 11.3 | | |
| 2015.5833 | AUG | 111.9 | 97.7 | 71.2 | 25.0 | 15.6 | 10.8 | | |
| 2015.6667 | SEP | 111.3 | 96.7 | 71.4 | 25.0 | 15.6 | 10.3 | | |
| 2015.7500 | OCT | 110.5 | 95.6 | 71.2 | 24.1 | 15.7 | 10.7 | | |
| 2015.8333 | NOV | 109.2 | 94.3 | 70.7 | 22.2 | 15.7 | 10.8 | | |
| 2015.9167 | DEC | 107.4 | 93.0 | 70.3 | 21.4 | 15.6 | 10.8 | | |
| 2016.0000 | JAN | 106.7 | 91.9 | 69.9 | 21.7 | 15.8 | 11.0 | | |
| 2016.0833 | FEB | 106.3 | 91.1 | 69.6 | 22.4 | 16.0 | 11.2 | | |
| 2016.1667 | MAR | 103.9 | 90.2 | 69.2 | 22.6 | 16.0 | 11.2 | | |
| 2016.2500 | APR | 100.8 | 89.2 | 69.0 | 22.5 | 16.1 | 11.0 | | |
| 2016.3333 | MAY | 98.4 | 88.2 | 68.7 | 22.7 | 16.3 | 11.0 | | |
| 2016.4167 | JUN | 98.2 | 87.1 | 68.2 | 22.9 | 16.6 | 11.3 | | |
| 2016.5000 | JUL | 97.5 | 86.1 | 68.0 | 23.4 | 16.8 | 11.2 | | |
| 2016.5833 | AUG | 96.1 | 85.1 | 67.8 | 24.1 | 16.9 | 11.2 | | |
| 2016.6667 | SEP | 93.2 | 84.2 | 67.7 | 24.8 | 17.0 | 11.8 | | |
| 2016.7500 | OCT | 91.8 | 83.2 | 67.6 | 25.4 | 16.9 | 12.2 | | |
| 2016.8333 | NOV | 90.3 | 82.3 | 67.6 | 25.6 | 16.7 | 12.1 | | |
| 2016.9167 | DEC | 89.3 | 81.3 | 67.5 | 25.4 | 16.4 | 12.0 | | |
| 2017.0000 | JAN | 88.5 | 80.6 | 67.3 | 24.7 | 16.0 | 12.2 | | |
| 2017.0833 | FEB | 88.7 | 80.0 | 67.2 | 23.6 | 15.6 | 12.3 | | |
| 2017.1667 | MAR | 88.6 | 79.4 | 67.2 | 22.8 | 15.2 | 12.2 | | |
| 2017.2500 | APR | 87.2 | 78.8 | 67.2 | 22.4 | 14.9 | 11.8 | | |
| 2017.3333 | MAY | 85.8 | 78.2 | 67.2 | 21.9 | 14.6 | 11.2 | | |
| 2017.4167 | JUN | 85.0 | 77.8 | 67.1 | 21.6 | 14.2 | 10.7 | | |
| 2017.5000 | JUL | 84.0 | 77.2 | 67.1 | 20.9 | 13.8 | 10.0 | | |
| 2017.5833 | AUG | 83.1 | 76.6 | 67.0 | 20.0 | 13.4 | 9.4 | | |

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 PERCENTILE | | | $(\bar{F}_{10.7})$ | GEOMAGNETIC INDEX PERCENTILE | | | (\bar{A}_p) |
|-----------|-----|----------------------------------|-------|------|--------------------|---------------------------------|------|------|---------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2017.6667 | SEP | 81.7 | 76.0 | 67.0 | 18.7 | 13.1 | 9.0 | | |
| 2017.7500 | OCT | 80.4 | 75.6 | 67.0 | 18.2 | 12.8 | 8.5 | | |
| 2017.8333 | NOV | 79.2 | 75.1 | 67.0 | 18.7 | 12.6 | 8.0 | | |
| 2017.9167 | DEC | 78.5 | 74.7 | 67.1 | 18.7 | 12.5 | 7.8 | | |
| 2018.0000 | JAN | 78.1 | 74.4 | 67.3 | 18.4 | 12.4 | 7.4 | | |
| 2018.0833 | FEB | 77.5 | 74.0 | 67.4 | 18.4 | 12.2 | 7.0 | | |
| 2018.1667 | MAR | 76.7 | 73.7 | 67.5 | 18.8 | 12.1 | 6.6 | | |
| 2018.2500 | APR | 76.0 | 73.2 | 67.6 | 18.9 | 12.0 | 6.5 | | |
| 2018.3333 | MAY | 75.2 | 72.7 | 67.7 | 18.8 | 12.0 | 6.4 | | |
| 2018.4167 | JUN | 74.3 | 72.3 | 67.7 | 18.4 | 11.9 | 6.6 | | |
| 2018.5000 | JUL | 73.8 | 71.9 | 68.0 | 17.5 | 11.8 | 6.9 | | |
| 2018.5833 | AUG | 73.6 | 71.7 | 68.0 | 16.5 | 11.7 | 7.2 | | |
| 2018.6667 | SEP | 73.6 | 71.5 | 68.0 | 16.3 | 11.6 | 7.4 | | |
| 2018.7500 | OCT | 73.0 | 71.4 | 68.0 | 16.6 | 11.6 | 7.5 | | |
| 2018.8333 | NOV | 73.2 | 71.3 | 67.9 | 16.9 | 11.6 | 7.5 | | |
| 2018.9167 | DEC | 73.4 | 71.2 | 67.9 | 17.2 | 11.6 | 7.7 | | |
| 2019.0000 | JAN | 73.4 | 71.2 | 67.7 | 17.3 | 11.6 | 7.7 | | |
| 2019.0833 | FEB | 73.2 | 71.3 | 67.6 | 17.7 | 11.5 | 7.6 | | |
| 2019.1667 | MAR | 73.6 | 71.5 | 67.7 | 18.0 | 11.4 | 7.6 | | |
| 2019.2500 | APR | 74.0 | 71.9 | 67.6 | 18.2 | 11.4 | 7.6 | | |
| 2019.3333 | MAY | 74.8 | 72.3 | 67.6 | 18.1 | 11.3 | 7.6 | | |
| 2019.4167 | JUN | 75.5 | 72.6 | 67.7 | 17.8 | 11.2 | 7.5 | | |
| 2019.5000 | JUL | 76.4 | 73.2 | 67.9 | 17.3 | 11.1 | 7.5 | | |
| 2019.5833 | AUG | 77.5 | 74.0 | 68.1 | 16.3 | 11.0 | 7.5 | | |
| 2019.6667 | SEP | 78.8 | 74.9 | 68.5 | 15.5 | 10.9 | 7.5 | | |
| 2019.7500 | OCT | 80.1 | 75.8 | 68.6 | 16.1 | 10.8 | 7.7 | | |
| 2019.8333 | NOV | 81.4 | 76.9 | 68.8 | 16.3 | 10.8 | 7.7 | | |
| 2019.9167 | DEC | 82.8 | 78.4 | 69.1 | 16.6 | 10.9 | 7.8 | | |
| 2020.0000 | JAN | 84.6 | 80.0 | 69.3 | 16.7 | 11.0 | 7.7 | | |
| 2020.0833 | FEB | 87.1 | 81.8 | 69.6 | 16.8 | 11.1 | 7.7 | | |
| 2020.1667 | MAR | 89.6 | 83.6 | 70.2 | 17.1 | 11.1 | 7.8 | | |
| 2020.2500 | APR | 91.9 | 85.6 | 71.1 | 17.3 | 11.1 | 8.0 | | |
| 2020.3333 | MAY | 95.1 | 87.7 | 71.8 | 17.3 | 11.2 | 8.3 | | |
| 2020.4167 | JUN | 97.7 | 89.8 | 72.5 | 17.4 | 11.5 | 8.6 | | |
| 2020.5000 | JUL | 101.0 | 92.1 | 73.7 | 17.6 | 11.7 | 9.0 | | |
| 2020.5833 | AUG | 106.6 | 94.4 | 74.2 | 17.5 | 12.0 | 8.8 | | |
| 2020.6667 | SEP | 109.0 | 96.7 | 74.5 | 16.9 | 12.2 | 8.7 | | |
| 2020.7500 | OCT | 111.9 | 99.5 | 74.8 | 16.2 | 12.4 | 8.9 | | |
| 2020.8333 | NOV | 116.4 | 102.3 | 75.1 | 16.0 | 12.5 | 9.0 | | |
| 2020.9167 | DEC | 121.0 | 104.8 | 75.3 | 16.0 | 12.7 | 9.0 | | |
| 2021.0000 | JAN | 125.4 | 107.3 | 75.2 | 16.1 | 12.9 | 8.8 | | |
| 2021.0833 | FEB | 129.9 | 109.6 | 75.2 | 16.7 | 13.0 | 8.4 | | |
| 2021.1667 | MAR | 134.5 | 111.9 | 75.3 | 17.1 | 13.0 | 8.2 | | |
| 2021.2500 | APR | 139.7 | 114.5 | 75.7 | 17.5 | 13.1 | 8.2 | | |
| 2021.3333 | MAY | 144.5 | 117.4 | 76.1 | 18.2 | 13.2 | 8.1 | | |
| 2021.4167 | JUN | 147.3 | 120.5 | 76.6 | 18.5 | 13.2 | 7.9 | | |
| 2021.5000 | JUL | 149.3 | 123.1 | 77.5 | 18.5 | 13.1 | 7.8 | | |
| 2021.5833 | AUG | 150.4 | 125.3 | 78.3 | 18.7 | 13.1 | 7.9 | | |
| 2021.6667 | SEP | 151.2 | 127.4 | 78.6 | 19.0 | 13.2 | 8.1 | | |
| 2021.7500 | OCT | 151.5 | 129.3 | 79.6 | 18.6 | 13.3 | 8.6 | | |
| 2021.8333 | NOV | 153.9 | 131.0 | 80.8 | 17.8 | 13.3 | 9.2 | | |
| 2021.9167 | DEC | 156.4 | 132.7 | 82.2 | 18.1 | 13.4 | 9.6 | | |
| 2022.0000 | JAN | 160.0 | 134.8 | 84.1 | 18.9 | 13.5 | 10.1 | | |
| 2022.0833 | FEB | 163.9 | 137.2 | 85.4 | 19.1 | 13.6 | 10.1 | | |
| 2022.1667 | MAR | 167.9 | 139.6 | 86.3 | 19.5 | 13.9 | 10.3 | | |
| 2022.2500 | APR | 171.2 | 142.2 | 88.1 | 20.5 | 14.1 | 10.4 | | |
| 2022.3333 | MAY | 174.1 | 144.8 | 90.0 | 20.2 | 14.1 | 10.6 | | |
| 2022.4167 | JUN | 176.5 | 146.9 | 91.1 | 20.4 | 14.1 | 10.2 | | |
| 2022.5000 | JUL | 178.1 | 148.9 | 93.3 | 20.7 | 14.1 | 10.2 | | |
| 2022.5833 | AUG | 178.7 | 150.9 | 95.7 | 21.1 | 14.2 | 9.9 | | |

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 PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 75.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2022.6667 | SEP | 181.8 | 152.8 | 97.5 | 21.4 | 14.2 | 9.8 |
| 2022.7500 | OCT | 184.2 | 154.7 | 98.7 | 21.4 | 14.4 | 10.5 |
| 2022.8333 | NOV | 187.0 | 156.3 | 98.8 | 21.6 | 14.5 | 10.9 |
| 2022.9167 | DEC | 189.7 | 157.5 | 98.2 | 21.9 | 14.7 | 10.9 |
| 2023.0000 | JAN | 191.8 | 158.9 | 97.8 | 22.4 | 14.9 | 11.0 |
| 2023.0833 | FEB | 192.7 | 160.7 | 99.1 | 22.9 | 15.1 | 11.2 |

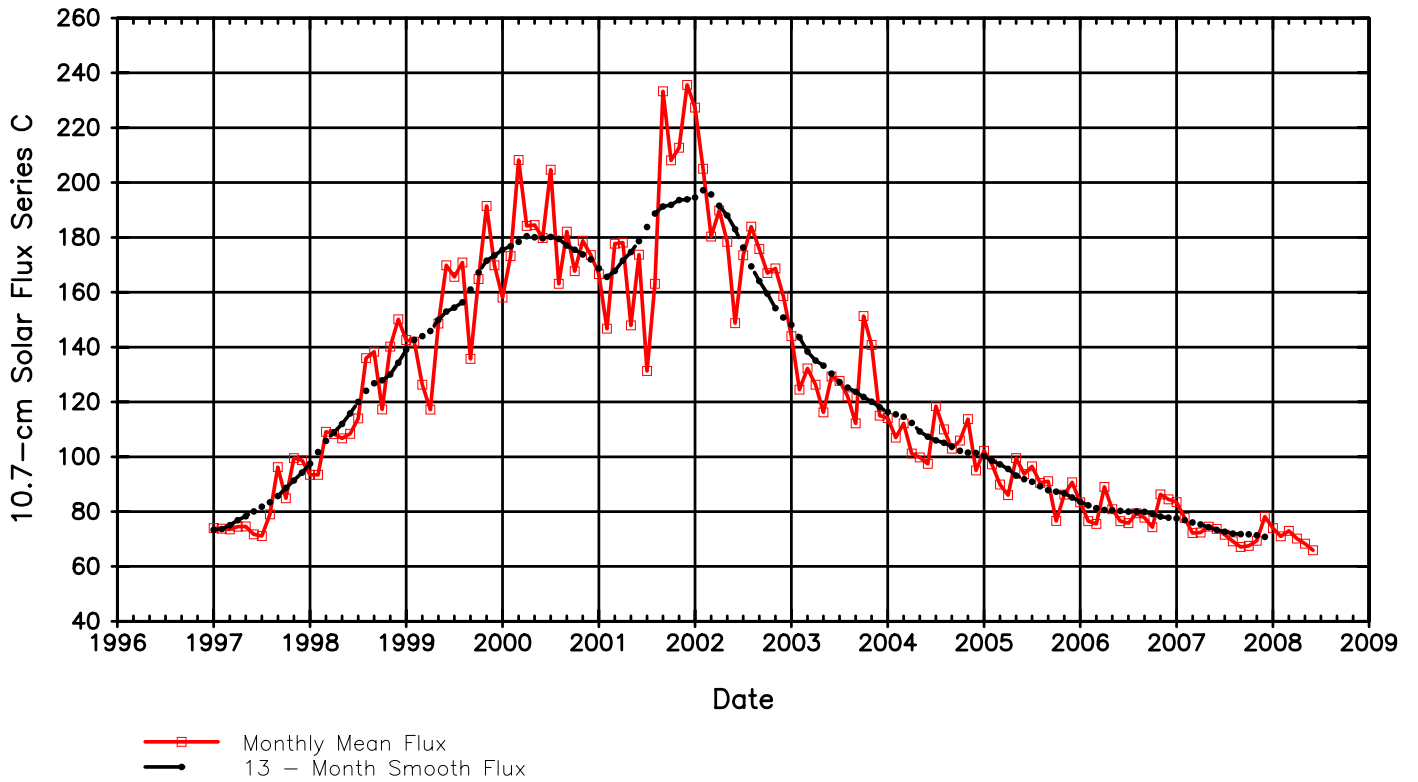


Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

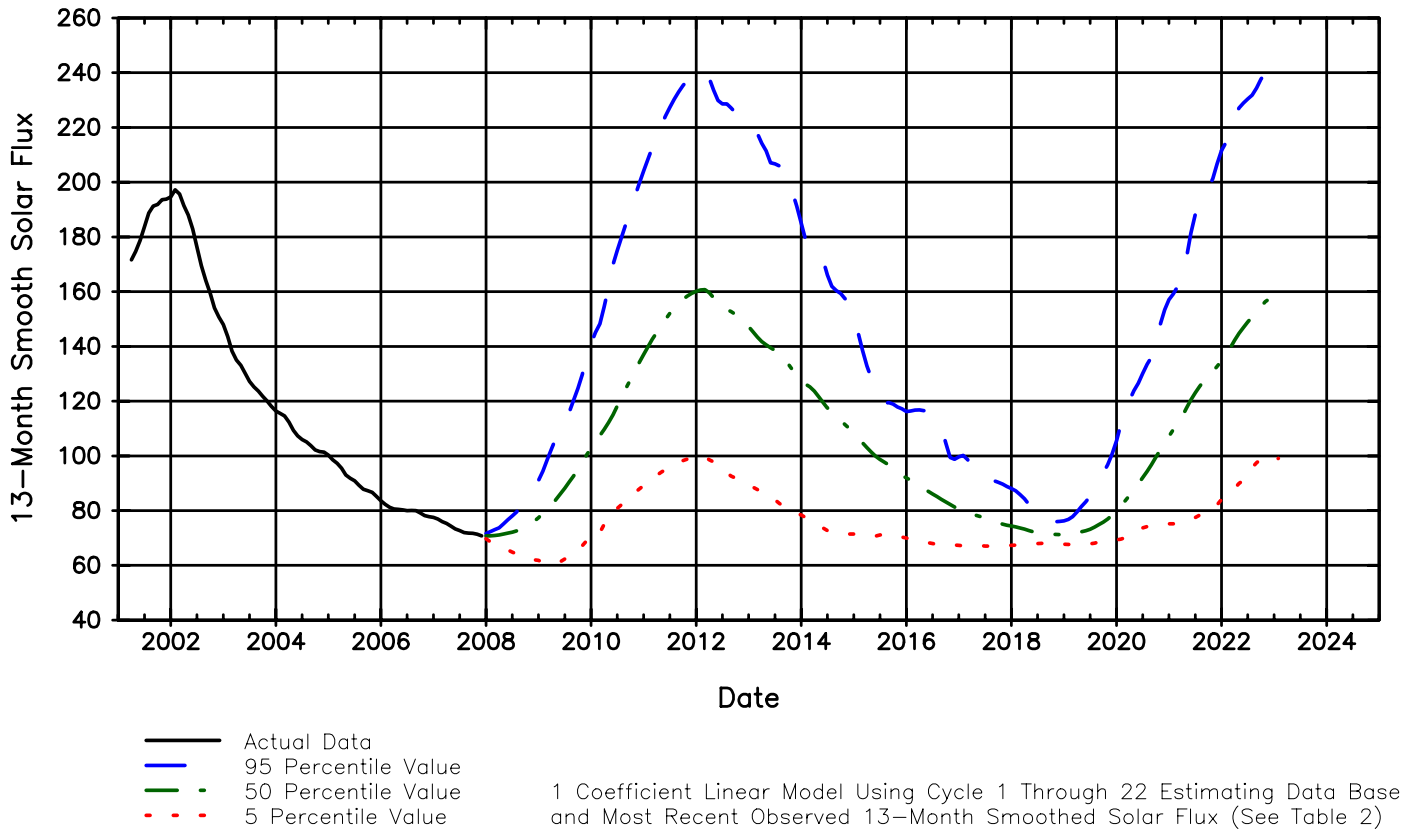


Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 23* and Cycle 24

* Program initialized from Cycle 23 smoothed maximum

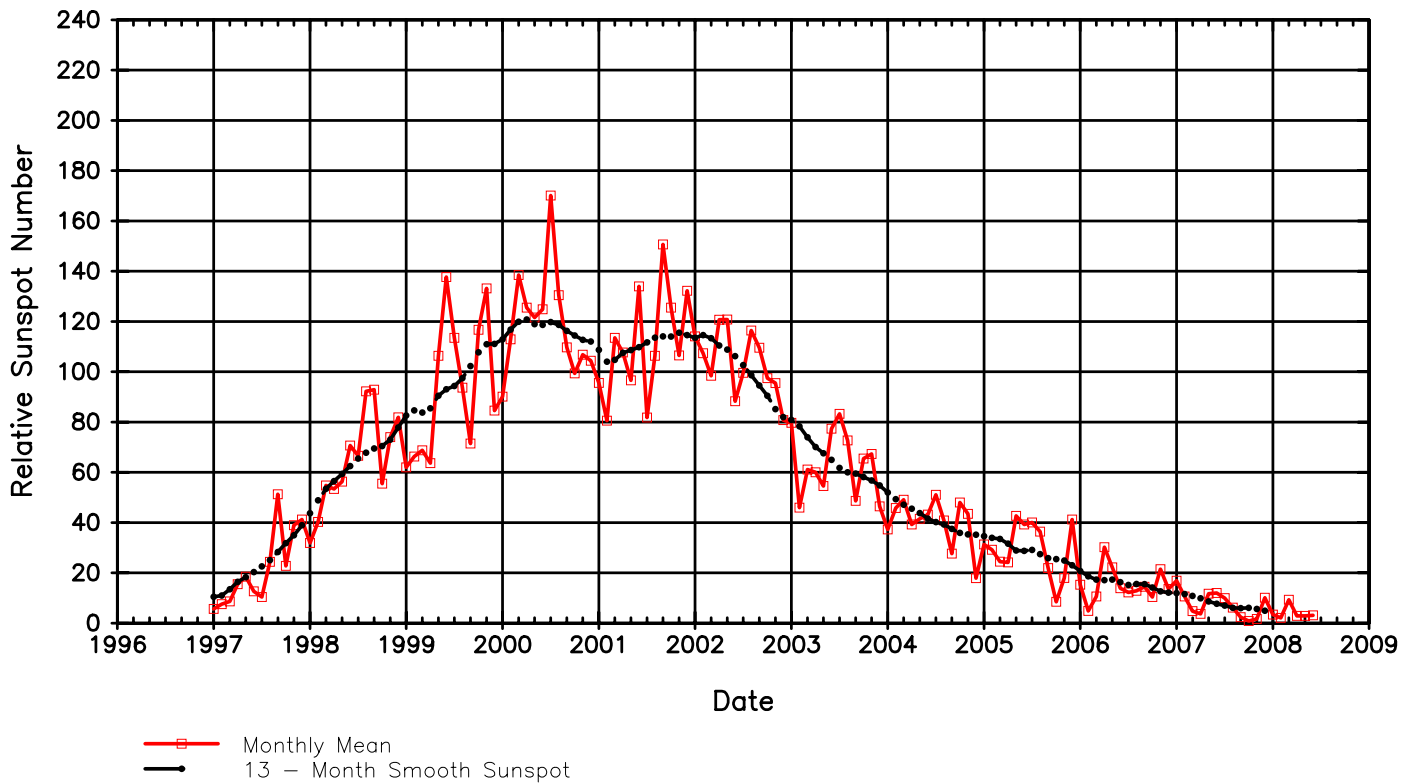


Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number

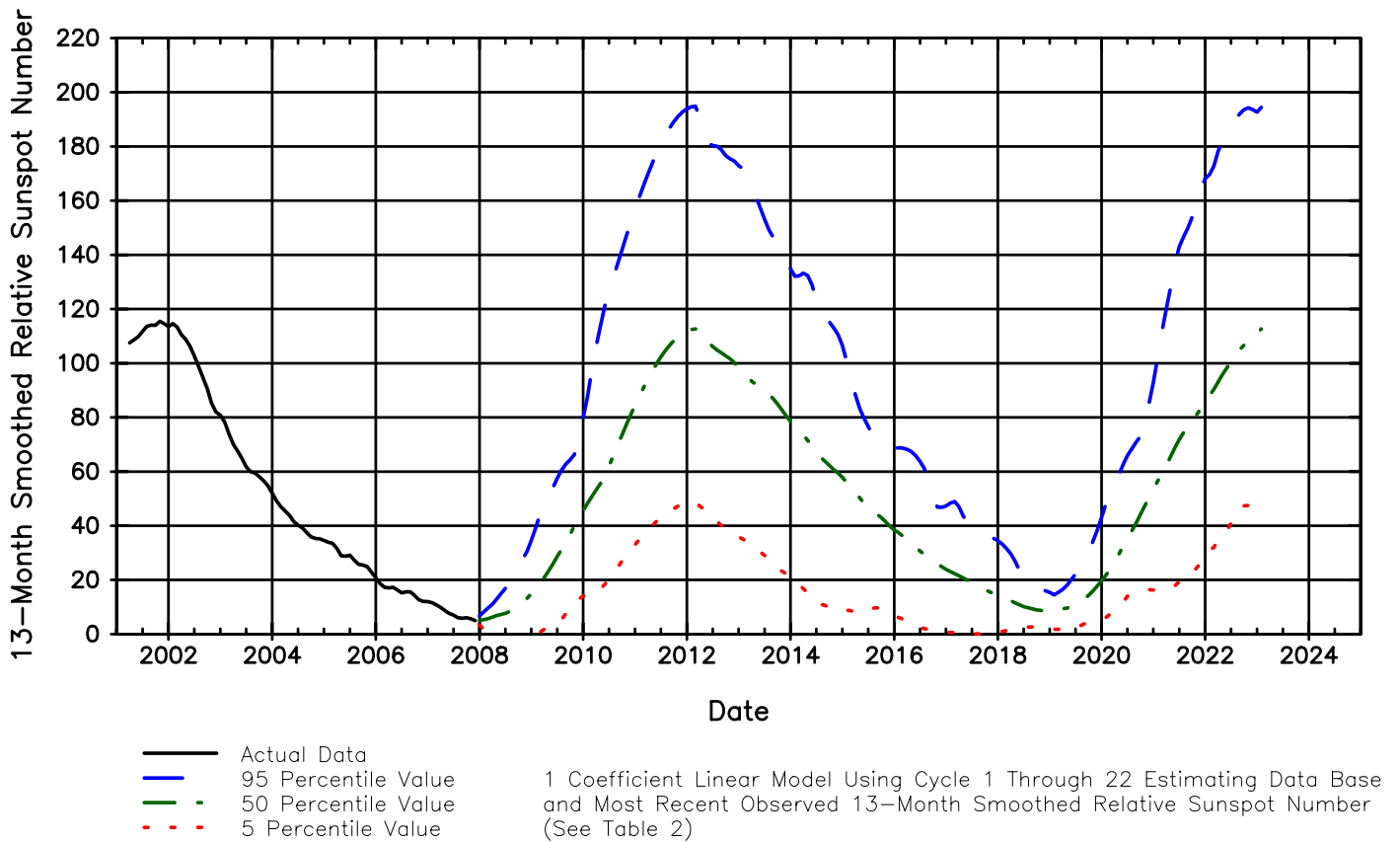


Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 23* and Cycle 24

* Program initialized from Cycle 23 smoothed maximum

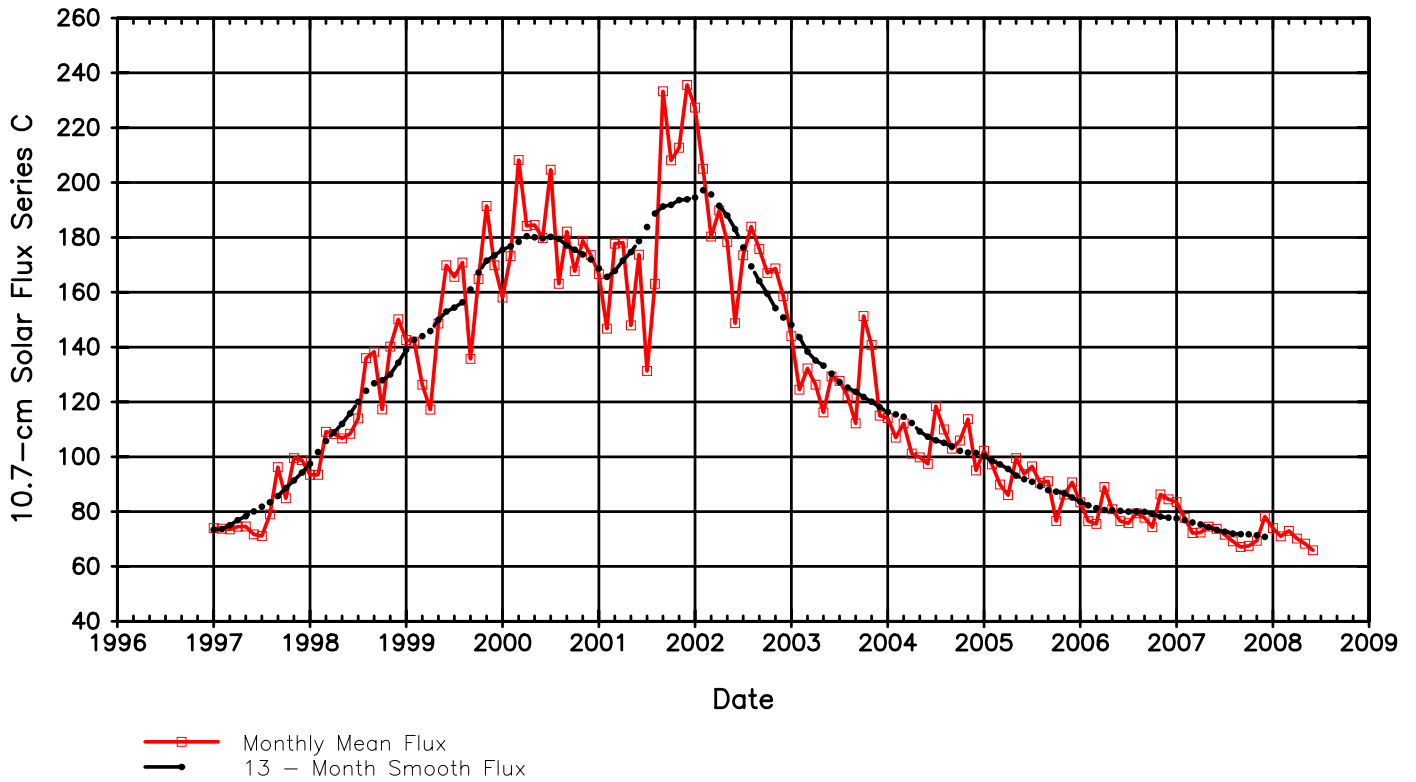


Figure 5. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

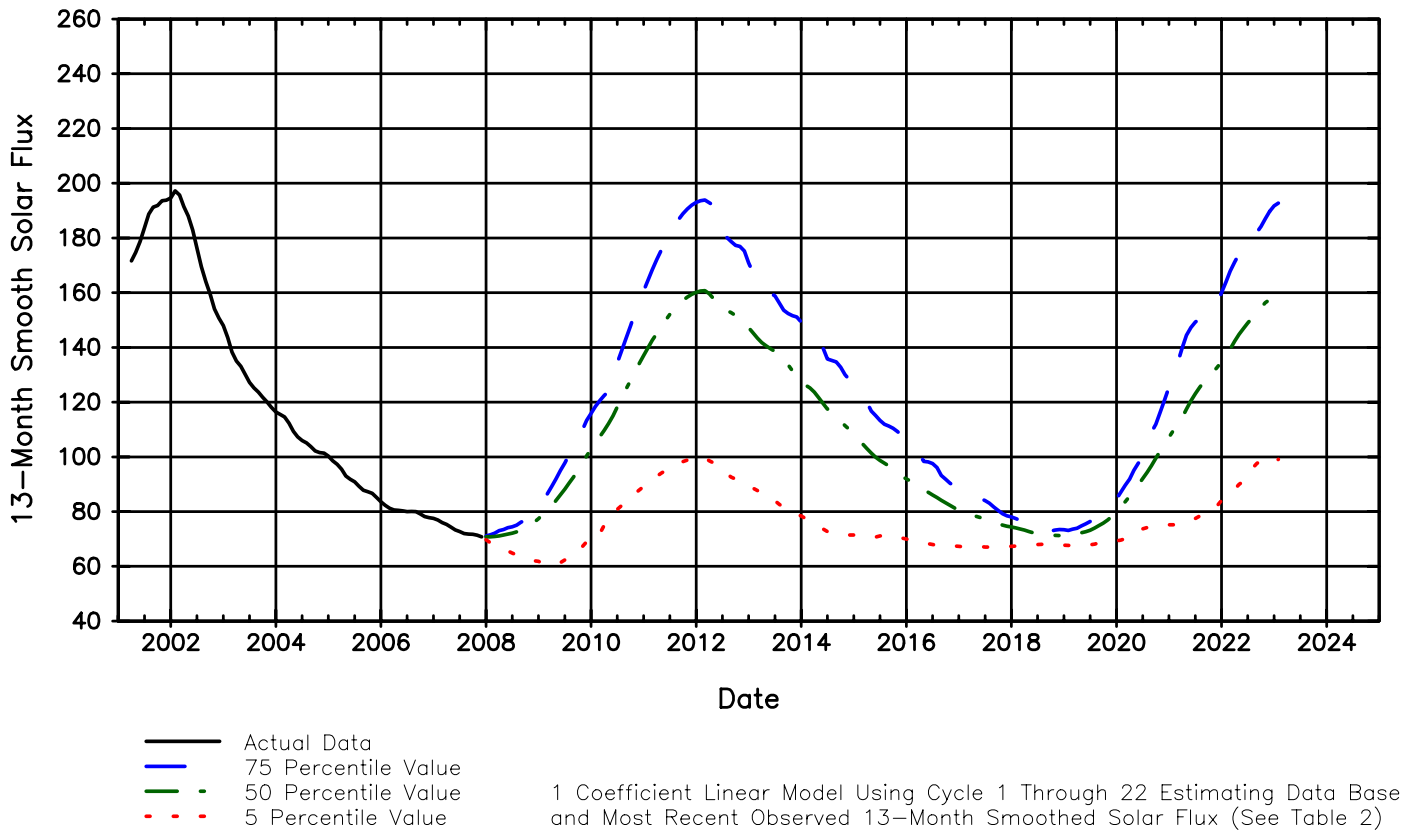


Figure 6. Estimate of 75th Percentile 13-Month Smoothed Solar Flux For Cycle 23* and Cycle 24

* Program initialized from Cycle 23 smoothed maximum