

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

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

William G. Jones  
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

---

March 2005

# 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  $\bar{F}_{10.7}$ ,  $\bar{R}$ , and  $\bar{A}_p$  for up to 132 months into the future, initialized from the cycle 23 smooth sunspot number maximum. The cycle 23 smooth sunspot number maximum has been confirmed as April 2000. The established cycle 23 smooth 10.7 cm solar flux maximum ( $\bar{F}_{10.7}$ ) for use in the MSAFE program has been re-initialized based on the confirmed cycle 23 smoothed sunspot number maximum ( $\bar{R}$ ). The  $\bar{A}_p$  input to the MSAFE program has been initialized at the smooth sunspot maximum ( $\bar{R}$ ) for cycle 23. 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 5<sup>1</sup>. 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 5<sup>1</sup> (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 5<sup>1</sup> (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 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

---

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

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, ionospheric 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](mailto: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<br>(F <sub>10.7</sub> (Series C)) | Relative Sunspot<br>Numbers (R) | Geomagnetic<br>Index (A <sub>P</sub> ) |
| 2002                                               | January   | 227.3                                        | 114.1                           | 8                                      |
|                                                    | February  | 205.0                                        | 107.4                           | 10                                     |
|                                                    | March     | 180.3                                        | 98.4                            | 10                                     |
|                                                    | April     | 189.8                                        | 120.7                           | 17                                     |
|                                                    | May       | 178.4                                        | 120.8                           | 12                                     |
|                                                    | June      | 148.7                                        | 88.3                            | 7                                      |
|                                                    | July      | 173.5                                        | 99.6                            | 11                                     |
|                                                    | August    | 183.9                                        | 116.4                           | 14                                     |
|                                                    | September | 175.8                                        | 109.6                           | 13                                     |
|                                                    | October   | 167.0                                        | 97.5                            | 25                                     |
|                                                    | November  | 168.7                                        | 95.5                            | 17                                     |
|                                                    | December  | 158.6                                        | 80.8                            | 13                                     |
| 2003                                               | January   | 144.0                                        | 79.7                            | 13                                     |
|                                                    | February  | 124.5                                        | 46.0                            | 17                                     |
|                                                    | March     | 132.2                                        | 61.1                            | 21                                     |
|                                                    | April     | 126.3                                        | 60.0                            | 20                                     |
|                                                    | May       | 116.2                                        | 54.6                            | 26                                     |
|                                                    | June      | 129.3                                        | 77.4                            | 24                                     |
|                                                    | July      | 127.7                                        | 83.3                            | 19                                     |
|                                                    | August    | 122.1                                        | 72.7                            | 23                                     |
|                                                    | September | 112.2                                        | 48.7                            | 18                                     |
|                                                    | October   | 151.3                                        | 65.5                            | 35                                     |
|                                                    | November  | 140.8                                        | 67.3                            | 28                                     |
|                                                    | December  | 115.0                                        | 46.5                            | 16                                     |
| 2004                                               | January   | 114.1                                        | 37.3                            | 22                                     |
|                                                    | February  | 107.0                                        | 45.8                            | 13                                     |
|                                                    | March     | 112.0                                        | 49.1                            | 14                                     |
|                                                    | April     | 101.2                                        | 39.3                            | 11                                     |
|                                                    | May       | 99.8                                         | 41.5                            | 8                                      |
|                                                    | June      | 97.4                                         | 43.2                            | 8                                      |
|                                                    | July      | 118.5                                        | 51.1                            | 23                                     |
|                                                    | August    | 110.0*                                       | 40.9                            | 11*                                    |
|                                                    | September | 103.0*                                       | 27.7                            | 10*                                    |
|                                                    | October   | 105.9*                                       | 48.0                            | 9*                                     |
|                                                    | November  | 113.7*                                       | 43.5                            | 26*                                    |
|                                                    | December  | 95.0*                                        | 17.9                            | 11*                                    |

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

\* Preliminary Estimates

| TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES |           |                                              |                                 |                                        |
|----------------------------------------------------|-----------|----------------------------------------------|---------------------------------|----------------------------------------|
| Year                                               | Month     | Solar Flux<br>(F <sub>10.7</sub> (Series C)) | Relative Sunspot<br>Numbers (R) | Geomagnetic<br>Index (A <sub>p</sub> ) |
| 2005                                               | January   | 102.4*                                       | 31.3*                           | 22.3*                                  |
|                                                    | February  | 97.3*                                        | 29.1*                           | 10.6*                                  |
|                                                    | March     |                                              |                                 |                                        |
|                                                    | April     |                                              |                                 |                                        |
|                                                    | May       |                                              |                                 |                                        |
|                                                    | June      |                                              |                                 |                                        |
|                                                    | July      |                                              |                                 |                                        |
|                                                    | August    |                                              |                                 |                                        |
|                                                    | September |                                              |                                 |                                        |
|                                                    | October   |                                              |                                 |                                        |
|                                                    | November  |                                              |                                 |                                        |
|                                                    | December  |                                              |                                 |                                        |
| 2006                                               | January   |                                              |                                 |                                        |
|                                                    | February  |                                              |                                 |                                        |
|                                                    | March     |                                              |                                 |                                        |
|                                                    | April     |                                              |                                 |                                        |
|                                                    | May       |                                              |                                 |                                        |
|                                                    | June      |                                              |                                 |                                        |
|                                                    | July      |                                              |                                 |                                        |
|                                                    | August    |                                              |                                 |                                        |
|                                                    | September |                                              |                                 |                                        |
|                                                    | October   |                                              |                                 |                                        |
|                                                    | November  |                                              |                                 |                                        |
|                                                    | December  |                                              |                                 |                                        |
| 2007                                               | January   |                                              |                                 |                                        |
|                                                    | February  |                                              |                                 |                                        |
|                                                    | March     |                                              |                                 |                                        |
|                                                    | April     |                                              |                                 |                                        |
|                                                    | May       |                                              |                                 |                                        |
|                                                    | June      |                                              |                                 |                                        |
|                                                    | July      |                                              |                                 |                                        |
|                                                    | August    |                                              |                                 |                                        |
|                                                    | September |                                              |                                 |                                        |
|                                                    | October   |                                              |                                 |                                        |
|                                                    | November  |                                              |                                 |                                        |
|                                                    | December  |                                              |                                 |                                        |

\* Preliminary Estimates



| TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES |           |                                             |                                    |                                         |
|------------------------------------------|-----------|---------------------------------------------|------------------------------------|-----------------------------------------|
| Year                                     | Month     | +10.7-cm Solar<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>Index ( $\bar{A}_p$ ) |
| 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<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>Index ( $\bar{A}_p$ ) |
| 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<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>Index ( $\bar{A}_p$ ) |
| 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<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>Index ( $\bar{A}_p$ ) |
| 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<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>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<br>Flux ( $\bar{F}_{10.7}$ ) | ++Sunspot<br>Numbers ( $\bar{R}$ ) | +++Geomagnetic<br>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 |                                             |                                    |                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | October   |                                             |                                    |                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | November  |                                             |                                    |                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | December  |                                             |                                    |                                         |
| NOTES:<br>+ computed and assigned at the mid-point from the National Research Council of Canada, Ottawa and<br>Penticton Series C observed monthly values as received from the National Geophysical Data Center ftp site<br>++ computed and assigned at the mid-point from the Sunspot Index Data Center Brussels, Belgium observed<br>monthly values as received from the National Geophysical Data Center ftp site<br>+++ computed and assigned at the mid-point from Institute for Geophysics in Gottingen, Germany observed<br>monthly values as received from the National Geophysical Data Center ftp site |           |                                             |                                    |                                         |

\* Preliminary Estimates

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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |       | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|-------|---------------------------------|------|------|
|           |     | 95.0%                            | 50%   | 5.0%  | 95.0%                           | 50%  | 5.0% |
| 2004.6667 | SEP | 104.9                            | 103.1 | 101.5 | 14.4                            | 13.8 | 13.1 |
| 2004.7500 | OCT | 104.7                            | 100.6 | 96.3  | 15.0                            | 13.9 | 12.6 |
| 2004.8333 | NOV | 103.9                            | 98.2  | 91.4  | 15.9                            | 13.8 | 11.8 |
| 2004.9167 | DEC | 103.0                            | 96.2  | 88.6  | 16.3                            | 13.7 | 11.0 |
| 2005.0000 | JAN | 101.7                            | 94.5  | 86.7  | 16.6                            | 13.6 | 10.3 |
| 2005.0833 | FEB | 101.7                            | 92.9  | 84.0  | 16.8                            | 13.4 | 9.7  |
| 2005.1667 | MAR | 102.1                            | 91.7  | 82.3  | 16.6                            | 13.3 | 9.7  |
| 2005.2500 | APR | 100.5                            | 90.5  | 81.0  | 16.3                            | 13.1 | 10.0 |
| 2005.3333 | MAY | 97.6                             | 89.2  | 80.1  | 16.0                            | 12.9 | 9.8  |
| 2005.4167 | JUN | 95.2                             | 88.0  | 79.2  | 15.5                            | 12.5 | 9.7  |
| 2005.5000 | JUL | 94.9                             | 87.0  | 78.6  | 15.2                            | 12.2 | 9.2  |
| 2005.5833 | AUG | 95.0                             | 86.0  | 78.1  | 14.5                            | 11.7 | 8.2  |
| 2005.6667 | SEP | 94.7                             | 84.9  | 78.0  | 14.9                            | 11.2 | 7.4  |
| 2005.7500 | OCT | 94.0                             | 83.8  | 77.7  | 16.0                            | 11.1 | 7.0  |
| 2005.8333 | NOV | 93.2                             | 82.8  | 77.3  | 17.0                            | 10.9 | 6.8  |
| 2005.9167 | DEC | 92.4                             | 81.9  | 76.6  | 17.4                            | 10.7 | 6.4  |
| 2006.0000 | JAN | 91.4                             | 81.1  | 75.4  | 17.3                            | 10.5 | 6.1  |
| 2006.0833 | FEB | 90.5                             | 80.4  | 74.5  | 16.8                            | 10.2 | 5.9  |
| 2006.1667 | MAR | 89.5                             | 79.7  | 73.9  | 16.7                            | 9.8  | 5.5  |
| 2006.2500 | APR | 88.0                             | 79.1  | 73.3  | 17.1                            | 9.7  | 5.5  |
| 2006.3333 | MAY | 86.3                             | 78.3  | 72.5  | 17.2                            | 9.7  | 5.5  |
| 2006.4167 | JUN | 84.1                             | 77.3  | 71.5  | 17.2                            | 9.8  | 5.7  |
| 2006.5000 | JUL | 81.5                             | 76.5  | 71.0  | 17.0                            | 9.8  | 6.0  |
| 2006.5833 | AUG | 80.1                             | 75.7  | 70.9  | 16.1                            | 9.8  | 6.3  |
| 2006.6667 | SEP | 79.8                             | 75.0  | 70.7  | 15.2                            | 9.8  | 6.5  |
| 2006.7500 | OCT | 79.6                             | 74.4  | 70.2  | 14.3                            | 9.8  | 6.6  |
| 2006.8333 | NOV | 80.0                             | 73.8  | 69.9  | 14.6                            | 9.9  | 6.7  |
| 2006.9167 | DEC | 80.6                             | 73.5  | 69.8  | 15.1                            | 10.0 | 6.8  |
| 2007.0000 | JAN | 81.8                             | 73.1  | 69.7  | 15.6                            | 10.2 | 7.0  |
| 2007.0833 | FEB | 83.2                             | 72.8  | 69.3  | 15.9                            | 10.3 | 7.4  |
| 2007.1667 | MAR | 84.6                             | 72.5  | 68.6  | 16.3                            | 10.4 | 7.4  |
| 2007.2500 | APR | 86.5                             | 72.4  | 67.9  | 16.8                            | 10.4 | 7.4  |
| 2007.3333 | MAY | 88.9                             | 72.3  | 67.2  | 17.1                            | 10.4 | 7.4  |
| 2007.4167 | JUN | 91.5                             | 72.4  | 66.6  | 17.1                            | 10.5 | 7.4  |
| 2007.5000 | JUL | 94.8                             | 72.6  | 66.3  | 16.9                            | 10.4 | 7.4  |
| 2007.5833 | AUG | 99.8                             | 73.1  | 66.2  | 16.4                            | 10.4 | 7.3  |
| 2007.6667 | SEP | 104.9                            | 73.7  | 66.0  | 15.5                            | 10.3 | 7.3  |
| 2007.7500 | OCT | 109.7                            | 74.3  | 65.6  | 14.1                            | 10.2 | 7.4  |
| 2007.8333 | NOV | 114.0                            | 75.1  | 65.4  | 14.6                            | 10.1 | 7.6  |
| 2007.9167 | DEC | 117.3                            | 75.9  | 65.1  | 14.7                            | 9.9  | 7.5  |
| 2008.0000 | JAN | 120.4                            | 76.9  | 65.1  | 15.2                            | 10.1 | 7.7  |
| 2008.0833 | FEB | 124.4                            | 78.0  | 64.9  | 15.5                            | 10.4 | 7.6  |
| 2008.1667 | MAR | 128.5                            | 78.9  | 64.3  | 15.7                            | 10.5 | 7.6  |
| 2008.2500 | APR | 133.0                            | 80.2  | 64.4  | 16.0                            | 10.5 | 7.7  |
| 2008.3333 | MAY | 138.7                            | 81.9  | 65.0  | 16.2                            | 10.5 | 7.9  |
| 2008.4167 | JUN | 144.8                            | 84.0  | 65.6  | 16.3                            | 10.7 | 8.2  |
| 2008.5000 | JUL | 149.7                            | 86.2  | 66.4  | 16.5                            | 11.0 | 8.5  |
| 2008.5833 | AUG | 153.6                            | 88.6  | 67.6  | 16.8                            | 11.3 | 8.7  |
| 2008.6667 | SEP | 156.5                            | 91.2  | 69.1  | 17.0                            | 11.7 | 8.6  |
| 2008.7500 | OCT | 158.9                            | 93.8  | 70.8  | 16.6                            | 12.0 | 8.6  |
| 2008.8333 | NOV | 161.6                            | 96.6  | 71.9  | 15.7                            | 12.1 | 8.7  |
| 2008.9167 | DEC | 165.4                            | 99.5  | 73.2  | 14.9                            | 11.9 | 8.6  |

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum

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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |                              | GEOMAGNETIC INDEX<br>PERCENTILE |      |                         |
|-----------|-----|----------------------------------|-------|------------------------------|---------------------------------|------|-------------------------|
|           |     | 95.0%                            | 50%   | ( $\bar{F}_{10.7}$ )<br>5.0% | 95.0%                           | 50%  | ( $\bar{A}_p$ )<br>5.0% |
| 2009.0000 | JAN | 170.1                            | 102.5 | 75.0                         | 14.6                            | 12.0 | 8.5                     |
| 2009.0833 | FEB | 174.4                            | 105.7 | 76.7                         | 14.3                            | 12.1 | 8.3                     |
| 2009.1667 | MAR | 180.4                            | 109.4 | 79.1                         | 14.3                            | 12.0 | 7.9                     |
| 2009.2500 | APR | 187.2                            | 113.5 | 82.0                         | 14.1                            | 12.0 | 7.6                     |
| 2009.3333 | MAY | 192.9                            | 117.9 | 86.1                         | 14.6                            | 12.1 | 7.6                     |
| 2009.4167 | JUN | 196.9                            | 122.5 | 90.3                         | 14.6                            | 12.1 | 7.5                     |
| 2009.5000 | JUL | 199.4                            | 126.9 | 94.5                         | 15.1                            | 12.3 | 7.7                     |
| 2009.5833 | AUG | 201.2                            | 130.7 | 98.6                         | 15.6                            | 12.4 | 7.9                     |
| 2009.6667 | SEP | 204.3                            | 133.0 | 98.7                         | 16.2                            | 12.6 | 8.2                     |
| 2009.7500 | OCT | 207.4                            | 135.4 | 98.8                         | 16.7                            | 12.8 | 8.4                     |
| 2009.8333 | NOV | 210.5                            | 137.7 | 98.9                         | 17.2                            | 13.0 | 8.6                     |
| 2009.9167 | DEC | 213.5                            | 140.0 | 99.0                         | 17.6                            | 13.2 | 8.9                     |
| 2010.0000 | JAN | 216.5                            | 142.3 | 99.1                         | 18.1                            | 13.4 | 9.1                     |
| 2010.0833 | FEB | 219.4                            | 144.4 | 99.2                         | 18.6                            | 13.5 | 9.3                     |
| 2010.1667 | MAR | 222.1                            | 146.5 | 99.3                         | 19.0                            | 13.7 | 9.5                     |
| 2010.2500 | APR | 224.8                            | 148.6 | 99.3                         | 19.4                            | 13.9 | 9.7                     |
| 2010.3333 | MAY | 227.3                            | 150.5 | 99.4                         | 19.8                            | 14.0 | 9.8                     |
| 2010.4167 | JUN | 229.6                            | 152.2 | 99.5                         | 20.2                            | 14.1 | 10.0                    |
| 2010.5000 | JUL | 231.8                            | 153.9 | 99.6                         | 20.5                            | 14.3 | 10.2                    |
| 2010.5833 | AUG | 233.7                            | 155.4 | 99.6                         | 20.8                            | 14.4 | 10.3                    |
| 2010.6667 | SEP | 235.5                            | 156.7 | 99.7                         | 21.1                            | 14.5 | 10.4                    |
| 2010.7500 | OCT | 237.1                            | 157.9 | 99.8                         | 21.3                            | 14.6 | 10.5                    |
| 2010.8333 | NOV | 238.4                            | 158.9 | 99.8                         | 21.5                            | 14.6 | 10.6                    |
| 2010.9167 | DEC | 239.4                            | 159.7 | 99.8                         | 21.7                            | 14.7 | 10.7                    |
| 2011.0000 | JAN | 240.2                            | 160.3 | 99.9                         | 21.8                            | 14.7 | 10.8                    |
| 2011.0833 | FEB | 240.7                            | 160.6 | 99.9                         | 21.9                            | 14.8 | 10.8                    |
| 2011.1667 | MAR | 240.8                            | 160.8 | 99.9                         | 21.9                            | 14.8 | 10.8                    |
| 2011.2500 | APR | 236.9                            | 159.8 | 98.5                         | 20.6                            | 14.9 | 11.5                    |
| 2011.3333 | MAY | 231.7                            | 157.8 | 97.8                         | 20.2                            | 15.0 | 11.8                    |
| 2011.4167 | JUN | 229.5                            | 156.1 | 96.7                         | 19.7                            | 15.1 | 11.7                    |
| 2011.5000 | JUL | 230.3                            | 154.9 | 95.4                         | 19.4                            | 15.3 | 11.9                    |
| 2011.5833 | AUG | 229.9                            | 153.6 | 93.8                         | 19.2                            | 15.6 | 12.1                    |
| 2011.6667 | SEP | 227.4                            | 152.2 | 92.6                         | 19.0                            | 15.7 | 11.6                    |
| 2011.7500 | OCT | 225.2                            | 150.5 | 91.8                         | 19.0                            | 15.7 | 10.9                    |
| 2011.8333 | NOV | 224.6                            | 149.0 | 91.2                         | 18.9                            | 15.7 | 10.8                    |
| 2011.9167 | DEC | 223.7                            | 147.3 | 90.3                         | 19.0                            | 15.7 | 10.8                    |
| 2012.0000 | JAN | 222.3                            | 145.5 | 89.3                         | 19.2                            | 15.8 | 10.8                    |
| 2012.0833 | FEB | 218.8                            | 143.3 | 88.6                         | 19.8                            | 15.9 | 10.8                    |
| 2012.1667 | MAR | 214.8                            | 141.5 | 87.7                         | 20.4                            | 16.1 | 10.9                    |
| 2012.2500 | APR | 211.5                            | 140.1 | 86.2                         | 21.4                            | 16.3 | 10.8                    |
| 2012.3333 | MAY | 206.4                            | 139.0 | 85.4                         | 21.9                            | 16.5 | 10.7                    |
| 2012.4167 | JUN | 201.5                            | 137.8 | 84.9                         | 21.6                            | 16.6 | 10.6                    |
| 2012.5000 | JUL | 196.4                            | 136.3 | 84.0                         | 21.3                            | 16.4 | 10.3                    |
| 2012.5833 | AUG | 191.5                            | 135.1 | 82.7                         | 21.8                            | 16.5 | 10.3                    |
| 2012.6667 | SEP | 192.5                            | 133.9 | 81.3                         | 23.1                            | 16.7 | 10.4                    |
| 2012.7500 | OCT | 195.5                            | 132.6 | 80.4                         | 23.3                            | 16.9 | 10.9                    |
| 2012.8333 | NOV | 196.9                            | 131.0 | 79.8                         | 22.7                            | 17.0 | 11.7                    |
| 2012.9167 | DEC | 197.5                            | 129.4 | 79.1                         | 22.6                            | 17.0 | 11.8                    |
| 2013.0000 | JAN | 198.8                            | 128.0 | 78.4                         | 22.7                            | 16.9 | 11.9                    |
| 2013.0833 | FEB | 201.3                            | 126.8 | 77.5                         | 23.2                            | 17.1 | 12.0                    |
| 2013.1667 | MAR | 202.0                            | 125.7 | 76.5                         | 23.9                            | 17.3 | 12.1                    |
| 2013.2500 | APR | 201.3                            | 124.2 | 75.5                         | 23.9                            | 17.2 | 12.5                    |

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum



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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |                              | GEOMAGNETIC INDEX<br>PERCENTILE |      |                         |
|-----------|-----|----------------------------------|-------|------------------------------|---------------------------------|------|-------------------------|
|           |     | 95.0%                            | 50%   | ( $\bar{F}_{10.7}$ )<br>5.0% | 95.0%                           | 50%  | ( $\bar{A}_p$ )<br>5.0% |
| 2013.3333 | MAY | 201.3                            | 122.2 | 74.6                         | 23.9                            | 17.1 | 13.3                    |
| 2013.4167 | JUN | 200.8                            | 120.3 | 73.6                         | 23.3                            | 17.0 | 13.7                    |
| 2013.5000 | JUL | 200.5                            | 118.7 | 72.7                         | 21.6                            | 16.8 | 13.3                    |
| 2013.5833 | AUG | 200.8                            | 117.4 | 72.3                         | 21.8                            | 16.6 | 12.8                    |
| 2013.6667 | SEP | 200.1                            | 116.1 | 72.0                         | 21.8                            | 16.4 | 12.7                    |
| 2013.7500 | OCT | 197.7                            | 114.5 | 71.6                         | 21.5                            | 16.4 | 12.5                    |
| 2013.8333 | NOV | 193.9                            | 112.8 | 71.4                         | 21.1                            | 16.4 | 12.4                    |
| 2013.9167 | DEC | 189.6                            | 111.0 | 71.5                         | 20.5                            | 16.4 | 12.2                    |
| 2014.0000 | JAN | 183.5                            | 109.0 | 71.4                         | 19.9                            | 16.1 | 11.9                    |
| 2014.0833 | FEB | 176.7                            | 107.1 | 71.2                         | 20.1                            | 16.0 | 11.9                    |
| 2014.1667 | MAR | 169.9                            | 105.4 | 70.9                         | 21.6                            | 15.9 | 11.7                    |
| 2014.2500 | APR | 163.7                            | 104.0 | 70.7                         | 23.2                            | 15.8 | 11.7                    |
| 2014.3333 | MAY | 158.4                            | 102.7 | 70.5                         | 24.0                            | 15.8 | 11.5                    |
| 2014.4167 | JUN | 154.5                            | 101.3 | 70.7                         | 25.1                            | 15.7 | 11.3                    |
| 2014.5000 | JUL | 150.7                            | 100.1 | 71.1                         | 25.8                            | 15.7 | 11.3                    |
| 2014.5833 | AUG | 144.6                            | 98.8  | 71.2                         | 25.0                            | 15.6 | 10.8                    |
| 2014.6667 | SEP | 137.6                            | 97.6  | 71.4                         | 25.0                            | 15.6 | 10.3                    |
| 2014.7500 | OCT | 132.6                            | 96.5  | 71.2                         | 24.1                            | 15.7 | 10.7                    |
| 2014.8333 | NOV | 129.3                            | 95.2  | 70.7                         | 22.2                            | 15.7 | 10.8                    |
| 2014.9167 | DEC | 127.0                            | 94.0  | 70.3                         | 21.4                            | 15.6 | 10.8                    |
| 2015.0000 | JAN | 126.3                            | 93.2  | 70.0                         | 21.7                            | 15.8 | 11.0                    |
| 2015.0833 | FEB | 125.2                            | 92.5  | 69.6                         | 22.4                            | 16.0 | 11.2                    |
| 2015.1667 | MAR | 123.2                            | 91.5  | 69.2                         | 22.6                            | 16.0 | 11.2                    |
| 2015.2500 | APR | 121.2                            | 90.4  | 69.0                         | 22.5                            | 16.1 | 11.0                    |
| 2015.3333 | MAY | 119.0                            | 89.3  | 68.7                         | 22.7                            | 16.3 | 11.0                    |
| 2015.4167 | JUN | 116.5                            | 88.2  | 68.2                         | 22.9                            | 16.6 | 11.3                    |
| 2015.5000 | JUL | 114.4                            | 87.0  | 68.0                         | 23.4                            | 16.8 | 11.2                    |
| 2015.5833 | AUG | 110.6                            | 85.9  | 67.8                         | 24.1                            | 16.9 | 11.2                    |
| 2015.6667 | SEP | 108.0                            | 84.8  | 67.7                         | 24.8                            | 17.0 | 11.8                    |
| 2015.7500 | OCT | 104.4                            | 83.7  | 67.6                         | 25.4                            | 16.9 | 12.2                    |
| 2015.8333 | NOV | 101.3                            | 82.8  | 67.6                         | 25.6                            | 16.7 | 12.1                    |
| 2015.9167 | DEC | 99.0                             | 81.8  | 67.5                         | 25.4                            | 16.4 | 12.0                    |
| 2016.0000 | JAN | 99.7                             | 80.9  | 67.3                         | 24.7                            | 16.0 | 12.2                    |
| 2016.0833 | FEB | 100.2                            | 80.2  | 67.2                         | 23.6                            | 15.6 | 12.3                    |
| 2016.1667 | MAR | 98.7                             | 79.6  | 67.2                         | 22.8                            | 15.2 | 12.2                    |
| 2016.2500 | APR | 95.8                             | 78.9  | 67.2                         | 22.4                            | 14.9 | 11.8                    |
| 2016.3333 | MAY | 93.0                             | 78.4  | 67.2                         | 21.9                            | 14.6 | 11.2                    |
| 2016.4167 | JUN | 91.3                             | 77.9  | 67.1                         | 21.6                            | 14.2 | 10.7                    |
| 2016.5000 | JUL | 91.5                             | 77.3  | 67.1                         | 20.9                            | 13.8 | 10.0                    |
| 2016.5833 | AUG | 91.4                             | 76.8  | 67.0                         | 20.0                            | 13.4 | 9.4                     |
| 2016.6667 | SEP | 90.9                             | 76.2  | 67.0                         | 18.7                            | 13.1 | 9.0                     |
| 2016.7500 | OCT | 90.4                             | 75.7  | 67.0                         | 18.2                            | 12.8 | 8.5                     |
| 2016.8333 | NOV | 89.7                             | 75.2  | 67.0                         | 18.7                            | 12.6 | 8.0                     |
| 2016.9167 | DEC | 88.8                             | 74.9  | 67.1                         | 18.7                            | 12.5 | 7.8                     |
| 2017.0000 | JAN | 88.1                             | 74.6  | 67.3                         | 18.4                            | 12.4 | 7.4                     |
| 2017.0833 | FEB | 87.2                             | 74.2  | 67.4                         | 18.4                            | 12.2 | 7.0                     |
| 2017.1667 | MAR | 85.9                             | 73.9  | 67.5                         | 18.8                            | 12.1 | 6.6                     |
| 2017.2500 | APR | 84.4                             | 73.6  | 67.6                         | 18.9                            | 12.0 | 6.5                     |
| 2017.3333 | MAY | 82.3                             | 73.1  | 67.7                         | 18.8                            | 12.0 | 6.4                     |
| 2017.4167 | JUN | 80.0                             | 72.7  | 67.7                         | 18.4                            | 11.9 | 6.6                     |
| 2017.5000 | JUL | 77.7                             | 72.3  | 68.0                         | 17.5                            | 11.8 | 6.9                     |
| 2017.5833 | AUG | 77.2                             | 72.1  | 68.0                         | 16.5                            | 11.7 | 7.2                     |

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum

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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |                              | GEOMAGNETIC INDEX<br>PERCENTILE |      |                         |
|-----------|-----|----------------------------------|-------|------------------------------|---------------------------------|------|-------------------------|
|           |     | 95.0%                            | 50%   | ( $\bar{F}_{10.7}$ )<br>5.0% | 95.0%                           | 50%  | ( $\bar{A}_p$ )<br>5.0% |
| 2017.6667 | SEP | 76.5                             | 71.9  | 68.0                         | 16.3                            | 11.6 | 7.4                     |
| 2017.7500 | OCT | 77.5                             | 71.7  | 68.0                         | 16.6                            | 11.6 | 7.5                     |
| 2017.8333 | NOV | 78.4                             | 71.6  | 67.9                         | 16.9                            | 11.6 | 7.5                     |
| 2017.9167 | DEC | 80.0                             | 71.7  | 67.9                         | 17.2                            | 11.6 | 7.7                     |
| 2018.0000 | JAN | 82.0                             | 71.8  | 67.7                         | 17.3                            | 11.6 | 7.7                     |
| 2018.0833 | FEB | 83.9                             | 72.0  | 67.6                         | 17.7                            | 11.5 | 7.6                     |
| 2018.1667 | MAR | 86.3                             | 72.3  | 67.7                         | 18.0                            | 11.4 | 7.6                     |
| 2018.2500 | APR | 89.2                             | 72.6  | 67.6                         | 18.2                            | 11.4 | 7.6                     |
| 2018.3333 | MAY | 92.3                             | 73.0  | 67.6                         | 18.1                            | 11.3 | 7.6                     |
| 2018.4167 | JUN | 95.7                             | 73.4  | 67.7                         | 17.8                            | 11.2 | 7.5                     |
| 2018.5000 | JUL | 101.0                            | 74.1  | 67.9                         | 17.3                            | 11.1 | 7.5                     |
| 2018.5833 | AUG | 106.6                            | 75.0  | 68.1                         | 16.3                            | 11.0 | 7.5                     |
| 2018.6667 | SEP | 111.8                            | 76.1  | 68.5                         | 15.5                            | 10.9 | 7.5                     |
| 2018.7500 | OCT | 116.5                            | 77.2  | 68.6                         | 16.1                            | 10.8 | 7.7                     |
| 2018.8333 | NOV | 120.1                            | 78.2  | 68.8                         | 16.3                            | 10.8 | 7.7                     |
| 2018.9167 | DEC | 123.6                            | 79.5  | 69.1                         | 16.6                            | 10.9 | 7.8                     |
| 2019.0000 | JAN | 127.8                            | 80.8  | 69.3                         | 16.7                            | 11.0 | 7.7                     |
| 2019.0833 | FEB | 132.4                            | 82.2  | 69.6                         | 16.8                            | 11.1 | 7.7                     |
| 2019.1667 | MAR | 137.2                            | 83.7  | 70.2                         | 17.1                            | 11.1 | 7.8                     |
| 2019.2500 | APR | 143.0                            | 85.5  | 71.1                         | 17.3                            | 11.1 | 8.0                     |
| 2019.3333 | MAY | 149.1                            | 87.6  | 71.8                         | 17.3                            | 11.2 | 8.3                     |
| 2019.4167 | JUN | 153.9                            | 89.7  | 72.5                         | 17.4                            | 11.5 | 8.6                     |
| 2019.5000 | JUL | 157.5                            | 91.8  | 73.7                         | 17.6                            | 11.7 | 9.0                     |
| 2019.5833 | AUG | 159.6                            | 93.8  | 74.2                         | 17.5                            | 12.0 | 8.8                     |
| 2019.6667 | SEP | 161.3                            | 95.8  | 74.5                         | 16.9                            | 12.2 | 8.7                     |
| 2019.7500 | OCT | 163.5                            | 98.2  | 74.8                         | 16.2                            | 12.4 | 8.9                     |
| 2019.8333 | NOV | 166.6                            | 100.6 | 75.1                         | 16.0                            | 12.5 | 9.0                     |
| 2019.9167 | DEC | 170.2                            | 102.6 | 75.3                         | 16.0                            | 12.7 | 9.0                     |
| 2020.0000 | JAN | 173.5                            | 104.9 | 75.2                         | 16.1                            | 12.9 | 8.8                     |
| 2020.0833 | FEB | 178.1                            | 107.3 | 75.2                         | 16.7                            | 13.0 | 8.4                     |
| 2020.1667 | MAR | 183.8                            | 109.8 | 75.3                         | 17.1                            | 13.0 | 8.2                     |
| 2020.2500 | APR | 187.7                            | 112.2 | 75.7                         | 17.5                            | 13.1 | 8.2                     |
| 2020.3333 | MAY | 189.8                            | 114.8 | 76.1                         | 18.2                            | 13.2 | 8.1                     |
| 2020.4167 | JUN | 190.7                            | 117.3 | 76.6                         | 18.5                            | 13.2 | 7.9                     |
| 2020.5000 | JUL | 191.4                            | 119.6 | 77.5                         | 18.5                            | 13.1 | 7.8                     |
| 2020.5833 | AUG | 194.0                            | 121.7 | 78.3                         | 18.7                            | 13.1 | 7.9                     |
| 2020.6667 | SEP | 196.9                            | 123.6 | 78.6                         | 19.0                            | 13.2 | 8.1                     |
| 2020.7500 | OCT | 199.5                            | 125.3 | 79.6                         | 18.6                            | 13.3 | 8.6                     |
| 2020.8333 | NOV | 203.8                            | 127.2 | 80.8                         | 17.8                            | 13.3 | 9.2                     |
| 2020.9167 | DEC | 209.3                            | 129.1 | 82.2                         | 18.1                            | 13.4 | 9.6                     |
| 2021.0000 | JAN | 212.7                            | 131.4 | 84.1                         | 18.9                            | 13.5 | 10.1                    |
| 2021.0833 | FEB | 214.5                            | 133.8 | 85.4                         | 19.1                            | 13.6 | 10.1                    |
| 2021.1667 | MAR | 218.5                            | 136.2 | 86.3                         | 19.5                            | 13.9 | 10.3                    |
| 2021.2500 | APR | 222.8                            | 138.9 | 88.1                         | 20.5                            | 14.1 | 10.4                    |
| 2021.3333 | MAY | 225.1                            | 141.5 | 90.0                         | 20.2                            | 14.1 | 10.6                    |
| 2021.4167 | JUN | 226.6                            | 143.9 | 91.1                         | 20.4                            | 14.1 | 10.2                    |
| 2021.5000 | JUL | 228.5                            | 146.5 | 93.3                         | 20.7                            | 14.1 | 10.2                    |
| 2021.5833 | AUG | 230.7                            | 149.1 | 95.7                         | 21.1                            | 14.2 | 9.9                     |
| 2021.6667 | SEP | 233.6                            | 151.4 | 97.5                         | 21.4                            | 14.2 | 9.8                     |
| 2021.7500 | OCT | 236.4                            | 153.5 | 98.7                         | 21.4                            | 14.4 | 10.5                    |
| 2021.8333 | NOV | 238.3                            | 155.6 | 98.8                         | 21.6                            | 14.5 | 10.9                    |
| 2021.9167 | DEC | 238.0                            | 157.6 | 98.2                         | 21.9                            | 14.7 | 10.9                    |

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum

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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |                              | GEOMAGNETIC INDEX<br>PERCENTILE |      |                         |
|-----------|-----|----------------------------------|-------|------------------------------|---------------------------------|------|-------------------------|
|           |     | 95.0%                            | 50%   | ( $\bar{F}_{10.7}$ )<br>5.0% | 95.0%                           | 50%  | ( $\bar{A}_p$ )<br>5.0% |
| 2022.0000 | JAN | 238.0                            | 159.7 | 97.8                         | 22.4                            | 14.9 | 11.0                    |
| 2022.0833 | FEB | 239.9                            | 161.7 | 99.1                         | 22.9                            | 15.1 | 11.2                    |

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum

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

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE<br>( $\bar{R}$ ) |      |      | GEOMAGNETIC INDEX<br>PERCENTILE<br>( $\bar{A}_p$ ) |      |      |
|-----------|-----|-----------------------------------------------|------|------|----------------------------------------------------|------|------|
|           |     | 95.0%                                         | 50%  | 5.0% | 95.0%                                              | 50%  | 5.0% |
| 2004.6667 | SEP | 39.8                                          | 37.9 | 36.4 | 14.4                                               | 13.8 | 13.1 |
| 2004.7500 | OCT | 40.4                                          | 36.5 | 32.8 | 15.0                                               | 13.9 | 12.6 |
| 2004.8333 | NOV | 40.1                                          | 35.0 | 28.3 | 15.9                                               | 13.8 | 11.8 |
| 2004.9167 | DEC | 39.8                                          | 33.5 | 24.0 | 16.3                                               | 13.7 | 11.0 |
| 2005.0000 | JAN | 39.0                                          | 32.0 | 21.5 | 16.6                                               | 13.6 | 10.3 |
| 2005.0833 | FEB | 37.7                                          | 30.7 | 20.6 | 16.8                                               | 13.4 | 9.7  |
| 2005.1667 | MAR | 38.4                                          | 29.7 | 18.8 | 16.6                                               | 13.3 | 9.7  |
| 2005.2500 | APR | 39.3                                          | 28.7 | 16.7 | 16.3                                               | 13.1 | 10.0 |
| 2005.3333 | MAY | 37.9                                          | 27.7 | 15.4 | 16.0                                               | 12.9 | 9.8  |
| 2005.4167 | JUN | 34.8                                          | 27.0 | 14.4 | 15.5                                               | 12.5 | 9.7  |
| 2005.5000 | JUL | 33.6                                          | 26.1 | 13.6 | 15.2                                               | 12.2 | 9.2  |
| 2005.5833 | AUG | 34.2                                          | 24.9 | 12.9 | 14.5                                               | 11.7 | 8.2  |
| 2005.6667 | SEP | 34.5                                          | 23.6 | 12.6 | 14.9                                               | 11.2 | 7.4  |
| 2005.7500 | OCT | 34.6                                          | 22.4 | 13.1 | 16.0                                               | 11.1 | 7.0  |
| 2005.8333 | NOV | 34.4                                          | 21.3 | 12.4 | 17.0                                               | 10.9 | 6.8  |
| 2005.9167 | DEC | 33.8                                          | 20.3 | 10.0 | 17.4                                               | 10.7 | 6.4  |
| 2006.0000 | JAN | 32.9                                          | 19.4 | 8.8  | 17.3                                               | 10.5 | 6.1  |
| 2006.0833 | FEB | 32.1                                          | 18.6 | 8.4  | 16.8                                               | 10.2 | 5.9  |
| 2006.1667 | MAR | 30.8                                          | 17.8 | 8.2  | 16.7                                               | 9.8  | 5.5  |
| 2006.2500 | APR | 29.1                                          | 16.8 | 7.8  | 17.1                                               | 9.7  | 5.5  |
| 2006.3333 | MAY | 27.2                                          | 15.8 | 7.4  | 17.2                                               | 9.7  | 5.5  |
| 2006.4167 | JUN | 24.6                                          | 14.7 | 6.7  | 17.2                                               | 9.8  | 5.7  |
| 2006.5000 | JUL | 21.6                                          | 13.6 | 5.4  | 17.0                                               | 9.8  | 6.0  |
| 2006.5833 | AUG | 18.4                                          | 12.6 | 4.6  | 16.1                                               | 9.8  | 6.3  |
| 2006.6667 | SEP | 17.2                                          | 12.0 | 4.7  | 15.2                                               | 9.8  | 6.5  |
| 2006.7500 | OCT | 18.1                                          | 11.6 | 4.2  | 14.3                                               | 9.8  | 6.6  |
| 2006.8333 | NOV | 17.2                                          | 11.1 | 3.1  | 14.6                                               | 9.9  | 6.7  |
| 2006.9167 | DEC | 15.7                                          | 10.6 | 2.3  | 15.1                                               | 10.0 | 6.8  |
| 2007.0000 | JAN | 15.4                                          | 10.2 | 1.9  | 15.6                                               | 10.2 | 7.0  |
| 2007.0833 | FEB | 15.8                                          | 10.0 | 1.8  | 15.9                                               | 10.3 | 7.4  |
| 2007.1667 | MAR | 16.3                                          | 9.9  | 1.2  | 16.3                                               | 10.4 | 7.4  |
| 2007.2500 | APR | 16.9                                          | 9.8  | 1.0  | 16.8                                               | 10.4 | 7.4  |
| 2007.3333 | MAY | 17.5                                          | 9.8  | 1.6  | 17.1                                               | 10.4 | 7.4  |
| 2007.4167 | JUN | 17.9                                          | 9.7  | 2.5  | 17.1                                               | 10.5 | 7.4  |
| 2007.5000 | JUL | 18.9                                          | 9.8  | 2.7  | 16.9                                               | 10.4 | 7.4  |
| 2007.5833 | AUG | 20.1                                          | 10.2 | 3.2  | 16.4                                               | 10.4 | 7.3  |
| 2007.6667 | SEP | 21.3                                          | 10.7 | 3.2  | 15.5                                               | 10.3 | 7.3  |
| 2007.7500 | OCT | 22.7                                          | 11.4 | 3.4  | 14.1                                               | 10.2 | 7.4  |
| 2007.8333 | NOV | 24.1                                          | 12.1 | 3.6  | 14.6                                               | 10.1 | 7.6  |
| 2007.9167 | DEC | 25.3                                          | 13.1 | 3.6  | 14.7                                               | 9.9  | 7.5  |
| 2008.0000 | JAN | 27.4                                          | 14.4 | 3.7  | 15.2                                               | 10.1 | 7.7  |
| 2008.0833 | FEB | 29.9                                          | 15.7 | 4.1  | 15.5                                               | 10.4 | 7.6  |
| 2008.1667 | MAR | 32.5                                          | 17.2 | 4.1  | 15.7                                               | 10.5 | 7.6  |
| 2008.2500 | APR | 34.9                                          | 18.9 | 4.9  | 16.0                                               | 10.5 | 7.7  |
| 2008.3333 | MAY | 39.0                                          | 20.9 | 5.7  | 16.2                                               | 10.5 | 7.9  |
| 2008.4167 | JUN | 44.5                                          | 23.2 | 6.3  | 16.3                                               | 10.7 | 8.2  |
| 2008.5000 | JUL | 48.8                                          | 25.6 | 7.1  | 16.5                                               | 11.0 | 8.5  |
| 2008.5833 | AUG | 52.4                                          | 28.0 | 7.9  | 16.8                                               | 11.3 | 8.7  |
| 2008.6667 | SEP | 55.4                                          | 30.5 | 8.8  | 17.0                                               | 11.7 | 8.6  |
| 2008.7500 | OCT | 62.9                                          | 33.3 | 9.8  | 16.6                                               | 12.0 | 8.6  |
| 2008.8333 | NOV | 71.0                                          | 36.3 | 10.2 | 15.7                                               | 12.1 | 8.7  |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE<br>$(\bar{R})$ |       |      | GEOMAGNETIC INDEX<br>PERCENTILE<br>$(\bar{A}_p)$ |      |      |
|-----------|-----|---------------------------------------------|-------|------|--------------------------------------------------|------|------|
|           |     | 95.0%                                       | 50%   | 5.0% | 95.0%                                            | 50%  | 5.0% |
| 2008.9167 | DEC | 78.4                                        | 39.3  | 10.7 | 14.9                                             | 11.9 | 8.6  |
| 2009.0000 | JAN | 84.9                                        | 42.2  | 11.5 | 14.6                                             | 12.0 | 8.5  |
| 2009.0833 | FEB | 92.1                                        | 45.4  | 12.2 | 14.3                                             | 12.1 | 8.3  |
| 2009.1667 | MAR | 100.4                                       | 48.5  | 13.3 | 14.3                                             | 12.0 | 7.9  |
| 2009.2500 | APR | 108.6                                       | 51.4  | 14.5 | 14.1                                             | 12.0 | 7.6  |
| 2009.3333 | MAY | 115.8                                       | 54.4  | 15.9 | 14.6                                             | 12.1 | 7.6  |
| 2009.4167 | JUN | 123.1                                       | 57.7  | 16.1 | 14.6                                             | 12.1 | 7.5  |
| 2009.5000 | JUL | 128.3                                       | 61.5  | 18.4 | 15.1                                             | 12.3 | 7.7  |
| 2009.5833 | AUG | 133.5                                       | 65.2  | 20.8 | 15.6                                             | 12.4 | 7.9  |
| 2009.6667 | SEP | 138.6                                       | 68.9  | 23.1 | 16.2                                             | 12.6 | 8.2  |
| 2009.7500 | OCT | 143.6                                       | 72.6  | 25.3 | 16.7                                             | 12.8 | 8.4  |
| 2009.8333 | NOV | 148.6                                       | 76.2  | 27.5 | 17.2                                             | 13.0 | 8.6  |
| 2009.9167 | DEC | 153.4                                       | 79.7  | 29.7 | 17.6                                             | 13.2 | 8.9  |
| 2010.0000 | JAN | 158.1                                       | 83.1  | 31.8 | 18.1                                             | 13.4 | 9.1  |
| 2010.0833 | FEB | 162.6                                       | 86.4  | 33.9 | 18.6                                             | 13.5 | 9.3  |
| 2010.1667 | MAR | 167.0                                       | 89.6  | 35.8 | 19.0                                             | 13.7 | 9.5  |
| 2010.2500 | APR | 171.1                                       | 92.6  | 37.7 | 19.4                                             | 13.9 | 9.7  |
| 2010.3333 | MAY | 175.0                                       | 95.4  | 39.4 | 19.8                                             | 14.0 | 9.8  |
| 2010.4167 | JUN | 178.6                                       | 98.0  | 41.1 | 20.2                                             | 14.1 | 10.0 |
| 2010.5000 | JUL | 182.0                                       | 100.4 | 42.6 | 20.5                                             | 14.3 | 10.2 |
| 2010.5833 | AUG | 185.0                                       | 102.7 | 43.9 | 20.8                                             | 14.4 | 10.3 |
| 2010.6667 | SEP | 187.7                                       | 104.6 | 45.2 | 21.1                                             | 14.5 | 10.4 |
| 2010.7500 | OCT | 190.1                                       | 106.3 | 46.2 | 21.3                                             | 14.6 | 10.5 |
| 2010.8333 | NOV | 192.1                                       | 107.8 | 47.1 | 21.5                                             | 14.6 | 10.6 |
| 2010.9167 | DEC | 193.7                                       | 108.9 | 47.8 | 21.7                                             | 14.7 | 10.7 |
| 2011.0000 | JAN | 194.8                                       | 109.8 | 48.3 | 21.8                                             | 14.7 | 10.8 |
| 2011.0833 | FEB | 195.5                                       | 110.3 | 48.7 | 21.9                                             | 14.8 | 10.8 |
| 2011.1667 | MAR | 195.8                                       | 110.5 | 48.8 | 21.9                                             | 14.8 | 10.8 |
| 2011.2500 | APR | 192.0                                       | 109.8 | 47.2 | 20.6                                             | 14.9 | 11.5 |
| 2011.3333 | MAY | 187.4                                       | 108.5 | 46.2 | 20.2                                             | 15.0 | 11.8 |
| 2011.4167 | JUN | 183.2                                       | 107.1 | 45.1 | 19.7                                             | 15.1 | 11.7 |
| 2011.5000 | JUL | 181.5                                       | 105.9 | 43.5 | 19.4                                             | 15.3 | 11.9 |
| 2011.5833 | AUG | 180.9                                       | 104.9 | 41.5 | 19.2                                             | 15.6 | 12.1 |
| 2011.6667 | SEP | 179.8                                       | 104.1 | 40.1 | 19.0                                             | 15.7 | 11.6 |
| 2011.7500 | OCT | 178.4                                       | 103.1 | 39.1 | 19.0                                             | 15.7 | 10.9 |
| 2011.8333 | NOV | 176.8                                       | 102.1 | 38.3 | 18.9                                             | 15.7 | 10.8 |
| 2011.9167 | DEC | 176.2                                       | 100.7 | 37.1 | 19.0                                             | 15.7 | 10.8 |
| 2012.0000 | JAN | 174.8                                       | 99.2  | 35.9 | 19.2                                             | 15.8 | 10.8 |
| 2012.0833 | FEB | 173.9                                       | 97.4  | 35.1 | 19.8                                             | 15.9 | 10.8 |
| 2012.1667 | MAR | 172.8                                       | 95.9  | 33.8 | 20.4                                             | 16.1 | 10.9 |
| 2012.2500 | APR | 169.3                                       | 94.3  | 32.0 | 21.4                                             | 16.3 | 10.8 |
| 2012.3333 | MAY | 165.6                                       | 93.1  | 30.8 | 21.9                                             | 16.5 | 10.7 |
| 2012.4167 | JUN | 162.5                                       | 92.1  | 30.4 | 21.6                                             | 16.6 | 10.6 |
| 2012.5000 | JUL | 158.1                                       | 91.3  | 29.1 | 21.3                                             | 16.4 | 10.3 |
| 2012.5833 | AUG | 156.8                                       | 90.4  | 27.2 | 21.8                                             | 16.5 | 10.3 |
| 2012.6667 | SEP | 156.5                                       | 88.9  | 25.5 | 23.1                                             | 16.7 | 10.4 |
| 2012.7500 | OCT | 152.5                                       | 87.0  | 24.2 | 23.3                                             | 16.9 | 10.9 |
| 2012.8333 | NOV | 149.4                                       | 85.0  | 23.3 | 22.7                                             | 17.0 | 11.7 |
| 2012.9167 | DEC | 150.9                                       | 83.1  | 22.3 | 22.6                                             | 17.0 | 11.8 |
| 2013.0000 | JAN | 150.5                                       | 81.4  | 21.1 | 22.7                                             | 16.9 | 11.9 |
| 2013.0833 | FEB | 148.5                                       | 79.8  | 19.8 | 23.2                                             | 17.1 | 12.0 |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE<br>( $\bar{R}$ ) |      |      | GEOMAGNETIC INDEX<br>PERCENTILE<br>( $\bar{A}_p$ ) |      |      |
|-----------|-----|-----------------------------------------------|------|------|----------------------------------------------------|------|------|
|           |     | 95.0%                                         | 50%  | 5.0% | 95.0%                                              | 50%  | 5.0% |
| 2013.1667 | MAR | 146.8                                         | 78.6 | 18.3 | 23.9                                               | 17.3 | 12.1 |
| 2013.2500 | APR | 144.1                                         | 77.0 | 16.7 | 23.9                                               | 17.2 | 12.5 |
| 2013.3333 | MAY | 140.8                                         | 75.0 | 15.2 | 23.9                                               | 17.1 | 13.3 |
| 2013.4167 | JUN | 140.1                                         | 73.1 | 13.5 | 23.3                                               | 17.0 | 13.7 |
| 2013.5000 | JUL | 141.3                                         | 71.3 | 11.9 | 21.6                                               | 16.8 | 13.3 |
| 2013.5833 | AUG | 141.3                                         | 69.7 | 11.1 | 21.8                                               | 16.6 | 12.8 |
| 2013.6667 | SEP | 140.2                                         | 68.2 | 10.6 | 21.8                                               | 16.4 | 12.7 |
| 2013.7500 | OCT | 141.1                                         | 66.8 | 9.7  | 21.5                                               | 16.4 | 12.5 |
| 2013.8333 | NOV | 143.7                                         | 65.4 | 9.3  | 21.1                                               | 16.4 | 12.4 |
| 2013.9167 | DEC | 143.7                                         | 64.0 | 9.4  | 20.5                                               | 16.4 | 12.2 |
| 2014.0000 | JAN | 142.5                                         | 62.5 | 9.4  | 19.9                                               | 16.1 | 11.9 |
| 2014.0833 | FEB | 142.2                                         | 61.0 | 8.9  | 20.1                                               | 16.0 | 11.9 |
| 2014.1667 | MAR | 140.8                                         | 59.3 | 8.6  | 21.6                                               | 15.9 | 11.7 |
| 2014.2500 | APR | 139.4                                         | 57.6 | 8.2  | 23.2                                               | 15.8 | 11.7 |
| 2014.3333 | MAY | 139.2                                         | 56.0 | 8.0  | 24.0                                               | 15.8 | 11.5 |
| 2014.4167 | JUN | 139.0                                         | 54.3 | 8.5  | 25.1                                               | 15.7 | 11.3 |
| 2014.5000 | JUL | 137.9                                         | 52.9 | 9.1  | 25.8                                               | 15.7 | 11.3 |
| 2014.5833 | AUG | 135.6                                         | 51.7 | 9.5  | 25.0                                               | 15.6 | 10.8 |
| 2014.6667 | SEP | 132.6                                         | 50.4 | 9.7  | 25.0                                               | 15.6 | 10.3 |
| 2014.7500 | OCT | 127.7                                         | 49.2 | 9.3  | 24.1                                               | 15.7 | 10.7 |
| 2014.8333 | NOV | 120.8                                         | 47.4 | 8.5  | 22.2                                               | 15.7 | 10.8 |
| 2014.9167 | DEC | 113.1                                         | 45.5 | 7.7  | 21.4                                               | 15.6 | 10.8 |
| 2015.0000 | JAN | 106.0                                         | 43.9 | 7.0  | 21.7                                               | 15.8 | 11.0 |
| 2015.0833 | FEB | 100.7                                         | 42.6 | 6.2  | 22.4                                               | 16.0 | 11.2 |
| 2015.1667 | MAR | 96.9                                          | 41.0 | 5.5  | 22.6                                               | 16.0 | 11.2 |
| 2015.2500 | APR | 94.3                                          | 39.4 | 5.0  | 22.5                                               | 16.1 | 11.0 |
| 2015.3333 | MAY | 89.7                                          | 37.7 | 4.3  | 22.7                                               | 16.3 | 11.0 |
| 2015.4167 | JUN | 83.6                                          | 36.0 | 3.2  | 22.9                                               | 16.6 | 11.3 |
| 2015.5000 | JUL | 79.2                                          | 34.7 | 2.5  | 23.4                                               | 16.8 | 11.2 |
| 2015.5833 | AUG | 76.2                                          | 33.5 | 2.0  | 24.1                                               | 16.9 | 11.2 |
| 2015.6667 | SEP | 73.8                                          | 32.2 | 1.8  | 24.8                                               | 17.0 | 11.8 |
| 2015.7500 | OCT | 72.4                                          | 30.9 | 1.8  | 25.4                                               | 16.9 | 12.2 |
| 2015.8333 | NOV | 70.5                                          | 29.5 | 1.6  | 25.6                                               | 16.7 | 12.1 |
| 2015.9167 | DEC | 68.4                                          | 28.2 | 1.2  | 25.4                                               | 16.4 | 12.0 |
| 2016.0000 | JAN | 65.9                                          | 27.0 | 0.8  | 24.7                                               | 16.0 | 12.2 |
| 2016.0833 | FEB | 63.0                                          | 26.1 | 0.6  | 23.6                                               | 15.6 | 12.3 |
| 2016.1667 | MAR | 59.9                                          | 25.2 | 0.6  | 22.8                                               | 15.2 | 12.2 |
| 2016.2500 | APR | 56.2                                          | 24.4 | 0.6  | 22.4                                               | 14.9 | 11.8 |
| 2016.3333 | MAY | 54.1                                          | 23.8 | 0.5  | 21.9                                               | 14.6 | 11.2 |
| 2016.4167 | JUN | 52.2                                          | 23.0 | 0.3  | 21.6                                               | 14.2 | 10.7 |
| 2016.5000 | JUL | 48.8                                          | 22.0 | 0.2  | 20.9                                               | 13.8 | 10.0 |
| 2016.5833 | AUG | 45.5                                          | 20.9 | 0.1  | 20.0                                               | 13.4 | 9.4  |
| 2016.6667 | SEP | 42.3                                          | 19.9 | 0.0  | 18.7                                               | 13.1 | 9.0  |
| 2016.7500 | OCT | 39.5                                          | 18.9 | 0.0  | 18.2                                               | 12.8 | 8.5  |
| 2016.8333 | NOV | 37.6                                          | 18.1 | 0.0  | 18.7                                               | 12.6 | 8.0  |
| 2016.9167 | DEC | 36.4                                          | 17.3 | 0.3  | 18.7                                               | 12.5 | 7.8  |
| 2017.0000 | JAN | 35.3                                          | 16.7 | 0.8  | 18.4                                               | 12.4 | 7.4  |
| 2017.0833 | FEB | 34.3                                          | 15.9 | 1.0  | 18.4                                               | 12.2 | 7.0  |
| 2017.1667 | MAR | 33.1                                          | 15.1 | 1.3  | 18.8                                               | 12.1 | 6.6  |
| 2017.2500 | APR | 31.6                                          | 14.2 | 1.5  | 18.9                                               | 12.0 | 6.5  |
| 2017.3333 | MAY | 29.4                                          | 13.3 | 1.7  | 18.8                                               | 12.0 | 6.4  |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE<br>$(\bar{R})$ |      |      | GEOMAGNETIC INDEX<br>PERCENTILE<br>$(\bar{A}_p)$ |      |      |
|-----------|-----|---------------------------------------------|------|------|--------------------------------------------------|------|------|
|           |     | 95.0%                                       | 50%  | 5.0% | 95.0%                                            | 50%  | 5.0% |
| 2017.4167 | JUN | 27.0                                        | 12.3 | 2.0  | 18.4                                             | 11.9 | 6.6  |
| 2017.5000 | JUL | 25.7                                        | 11.4 | 2.5  | 17.5                                             | 11.8 | 6.9  |
| 2017.5833 | AUG | 25.5                                        | 10.9 | 2.6  | 16.5                                             | 11.7 | 7.2  |
| 2017.6667 | SEP | 25.3                                        | 10.5 | 2.6  | 16.3                                             | 11.6 | 7.4  |
| 2017.7500 | OCT | 24.9                                        | 10.0 | 2.6  | 16.6                                             | 11.6 | 7.5  |
| 2017.8333 | NOV | 23.9                                        | 9.6  | 2.4  | 16.9                                             | 11.6 | 7.5  |
| 2017.9167 | DEC | 22.7                                        | 9.3  | 2.3  | 17.2                                             | 11.6 | 7.7  |
| 2018.0000 | JAN | 21.7                                        | 9.3  | 1.9  | 17.3                                             | 11.6 | 7.7  |
| 2018.0833 | FEB | 20.7                                        | 9.3  | 1.8  | 17.7                                             | 11.5 | 7.6  |
| 2018.1667 | MAR | 19.5                                        | 9.3  | 1.8  | 18.0                                             | 11.4 | 7.6  |
| 2018.2500 | APR | 18.5                                        | 9.5  | 1.8  | 18.2                                             | 11.4 | 7.6  |
| 2018.3333 | MAY | 17.7                                        | 9.5  | 1.7  | 18.1                                             | 11.3 | 7.6  |
| 2018.4167 | JUN | 18.3                                        | 9.6  | 1.7  | 17.8                                             | 11.2 | 7.5  |
| 2018.5000 | JUL | 19.6                                        | 10.0 | 2.4  | 17.3                                             | 11.1 | 7.5  |
| 2018.5833 | AUG | 21.2                                        | 10.7 | 3.0  | 16.3                                             | 11.0 | 7.5  |
| 2018.6667 | SEP | 23.0                                        | 11.5 | 3.8  | 15.5                                             | 10.9 | 7.5  |
| 2018.7500 | OCT | 24.7                                        | 12.3 | 4.0  | 16.1                                             | 10.8 | 7.7  |
| 2018.8333 | NOV | 26.1                                        | 13.4 | 4.5  | 16.3                                             | 10.8 | 7.7  |
| 2018.9167 | DEC | 28.3                                        | 14.8 | 5.2  | 16.6                                             | 10.9 | 7.8  |
| 2019.0000 | JAN | 31.0                                        | 16.2 | 5.8  | 16.7                                             | 11.0 | 7.7  |
| 2019.0833 | FEB | 33.9                                        | 17.8 | 6.2  | 16.8                                             | 11.1 | 7.7  |
| 2019.1667 | MAR | 37.7                                        | 19.6 | 7.4  | 17.1                                             | 11.1 | 7.8  |
| 2019.2500 | APR | 42.2                                        | 21.6 | 8.3  | 17.3                                             | 11.1 | 8.0  |
| 2019.3333 | MAY | 47.1                                        | 24.0 | 8.8  | 17.3                                             | 11.2 | 8.3  |
| 2019.4167 | JUN | 51.6                                        | 26.5 | 8.8  | 17.4                                             | 11.5 | 8.6  |
| 2019.5000 | JUL | 55.2                                        | 28.8 | 9.2  | 17.6                                             | 11.7 | 9.0  |
| 2019.5833 | AUG | 57.5                                        | 31.3 | 9.3  | 17.5                                             | 12.0 | 8.8  |
| 2019.6667 | SEP | 60.1                                        | 34.0 | 10.0 | 16.9                                             | 12.2 | 8.7  |
| 2019.7500 | OCT | 67.7                                        | 37.1 | 10.8 | 16.2                                             | 12.4 | 8.9  |
| 2019.8333 | NOV | 75.3                                        | 40.0 | 11.1 | 16.0                                             | 12.5 | 9.0  |
| 2019.9167 | DEC | 82.5                                        | 42.8 | 11.2 | 16.0                                             | 12.7 | 9.0  |
| 2020.0000 | JAN | 90.4                                        | 45.8 | 12.0 | 16.1                                             | 12.9 | 8.8  |
| 2020.0833 | FEB | 99.7                                        | 48.7 | 14.2 | 16.7                                             | 13.0 | 8.4  |
| 2020.1667 | MAR | 108.9                                       | 51.4 | 14.2 | 17.1                                             | 13.0 | 8.2  |
| 2020.2500 | APR | 117.1                                       | 54.1 | 14.4 | 17.5                                             | 13.1 | 8.2  |
| 2020.3333 | MAY | 125.4                                       | 57.2 | 14.8 | 18.2                                             | 13.2 | 8.1  |
| 2020.4167 | JUN | 134.0                                       | 60.6 | 15.4 | 18.5                                             | 13.2 | 7.9  |
| 2020.5000 | JUL | 140.4                                       | 63.7 | 17.0 | 18.5                                             | 13.1 | 7.8  |
| 2020.5833 | AUG | 143.1                                       | 66.2 | 18.8 | 18.7                                             | 13.1 | 7.9  |
| 2020.6667 | SEP | 145.6                                       | 68.4 | 19.7 | 19.0                                             | 13.2 | 8.1  |
| 2020.7500 | OCT | 149.2                                       | 70.7 | 21.5 | 18.6                                             | 13.3 | 8.6  |
| 2020.8333 | NOV | 152.7                                       | 73.2 | 24.0 | 17.8                                             | 13.3 | 9.2  |
| 2020.9167 | DEC | 157.6                                       | 75.7 | 26.5 | 18.1                                             | 13.4 | 9.6  |
| 2021.0000 | JAN | 162.1                                       | 78.4 | 29.1 | 18.9                                             | 13.5 | 10.1 |
| 2021.0833 | FEB | 164.3                                       | 81.0 | 30.9 | 19.1                                             | 13.6 | 10.1 |
| 2021.1667 | MAR | 168.2                                       | 83.9 | 32.1 | 19.5                                             | 13.9 | 10.3 |
| 2021.2500 | APR | 174.2                                       | 87.3 | 34.4 | 20.5                                             | 14.1 | 10.4 |
| 2021.3333 | MAY | 178.1                                       | 90.5 | 36.7 | 20.2                                             | 14.1 | 10.6 |
| 2021.4167 | JUN | 180.7                                       | 93.2 | 38.2 | 20.4                                             | 14.1 | 10.2 |
| 2021.5000 | JUL | 184.1                                       | 96.0 | 40.9 | 20.7                                             | 14.1 | 10.2 |
| 2021.5833 | AUG | 187.5                                       | 99.0 | 43.9 | 21.1                                             | 14.2 | 9.9  |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

| TIME      |     | SUNSPOT NUMBER<br>PERCENTILE<br>( $\bar{R}$ ) |       |      | GEOMAGNETIC INDEX<br>PERCENTILE<br>( $\bar{A}_p$ ) |      |      |
|-----------|-----|-----------------------------------------------|-------|------|----------------------------------------------------|------|------|
|           |     | 95.0%                                         | 50%   | 5.0% | 95.0%                                              | 50%  | 5.0% |
| 2021.6667 | SEP | 190.8                                         | 101.8 | 45.9 | 21.4                                               | 14.2 | 9.8  |
| 2021.7500 | OCT | 193.0                                         | 104.2 | 47.3 | 21.4                                               | 14.4 | 10.5 |
| 2021.8333 | NOV | 194.0                                         | 106.2 | 47.5 | 21.6                                               | 14.5 | 10.9 |
| 2021.9167 | DEC | 193.3                                         | 108.2 | 46.7 | 21.9                                               | 14.7 | 10.9 |
| 2022.0000 | JAN | 192.9                                         | 110.4 | 46.3 | 22.4                                               | 14.9 | 11.0 |
| 2022.0833 | FEB | 195.2                                         | 112.7 | 47.8 | 22.9                                               | 15.1 | 11.2 |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum



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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |       | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|-------|---------------------------------|------|------|
|           |     | 75.0%                            | 50%   | 5.0%  | 95.0%                           | 50%  | 5.0% |
| 2004.6667 | SEP | 103.5                            | 103.1 | 101.5 | 14.4                            | 13.8 | 13.1 |
| 2004.7500 | OCT | 101.9                            | 100.6 | 96.3  | 15.0                            | 13.9 | 12.6 |
| 2004.8333 | NOV | 100.0                            | 98.2  | 91.4  | 15.9                            | 13.8 | 11.8 |
| 2004.9167 | DEC | 98.4                             | 96.2  | 88.6  | 16.3                            | 13.7 | 11.0 |
| 2005.0000 | JAN | 96.0                             | 94.5  | 86.7  | 16.6                            | 13.6 | 10.3 |
| 2005.0833 | FEB | 95.1                             | 92.9  | 84.0  | 16.8                            | 13.4 | 9.7  |
| 2005.1667 | MAR | 94.2                             | 91.7  | 82.3  | 16.6                            | 13.3 | 9.7  |
| 2005.2500 | APR | 93.8                             | 90.5  | 81.0  | 16.3                            | 13.1 | 10.0 |
| 2005.3333 | MAY | 92.0                             | 89.2  | 80.1  | 16.0                            | 12.9 | 9.8  |
| 2005.4167 | JUN | 90.7                             | 88.0  | 79.2  | 15.5                            | 12.5 | 9.7  |
| 2005.5000 | JUL | 89.5                             | 87.0  | 78.6  | 15.2                            | 12.2 | 9.2  |
| 2005.5833 | AUG | 88.4                             | 86.0  | 78.1  | 14.5                            | 11.7 | 8.2  |
| 2005.6667 | SEP | 87.2                             | 84.9  | 78.0  | 14.9                            | 11.2 | 7.4  |
| 2005.7500 | OCT | 86.1                             | 83.8  | 77.7  | 16.0                            | 11.1 | 7.0  |
| 2005.8333 | NOV | 85.1                             | 82.8  | 77.3  | 17.0                            | 10.9 | 6.8  |
| 2005.9167 | DEC | 84.3                             | 81.9  | 76.6  | 17.4                            | 10.7 | 6.4  |
| 2006.0000 | JAN | 83.0                             | 81.1  | 75.4  | 17.3                            | 10.5 | 6.1  |
| 2006.0833 | FEB | 81.7                             | 80.4  | 74.5  | 16.8                            | 10.2 | 5.9  |
| 2006.1667 | MAR | 80.7                             | 79.7  | 73.9  | 16.7                            | 9.8  | 5.5  |
| 2006.2500 | APR | 79.7                             | 79.1  | 73.3  | 17.1                            | 9.7  | 5.5  |
| 2006.3333 | MAY | 78.9                             | 78.3  | 72.5  | 17.2                            | 9.7  | 5.5  |
| 2006.4167 | JUN | 78.3                             | 77.3  | 71.5  | 17.2                            | 9.8  | 5.7  |
| 2006.5000 | JUL | 78.0                             | 76.5  | 71.0  | 17.0                            | 9.8  | 6.0  |
| 2006.5833 | AUG | 77.1                             | 75.7  | 70.9  | 16.1                            | 9.8  | 6.3  |
| 2006.6667 | SEP | 76.7                             | 75.0  | 70.7  | 15.2                            | 9.8  | 6.5  |
| 2006.7500 | OCT | 75.7                             | 74.4  | 70.2  | 14.3                            | 9.8  | 6.6  |
| 2006.8333 | NOV | 74.8                             | 73.8  | 69.9  | 14.6                            | 9.9  | 6.7  |
| 2006.9167 | DEC | 74.4                             | 73.5  | 69.8  | 15.1                            | 10.0 | 6.8  |
| 2007.0000 | JAN | 74.4                             | 73.1  | 69.7  | 15.6                            | 10.2 | 7.0  |
| 2007.0833 | FEB | 74.0                             | 72.8  | 69.3  | 15.9                            | 10.3 | 7.4  |
| 2007.1667 | MAR | 73.9                             | 72.5  | 68.6  | 16.3                            | 10.4 | 7.4  |
| 2007.2500 | APR | 73.8                             | 72.4  | 67.9  | 16.8                            | 10.4 | 7.4  |
| 2007.3333 | MAY | 73.5                             | 72.3  | 67.2  | 17.1                            | 10.4 | 7.4  |
| 2007.4167 | JUN | 73.2                             | 72.4  | 66.6  | 17.1                            | 10.5 | 7.4  |
| 2007.5000 | JUL | 73.0                             | 72.6  | 66.3  | 16.9                            | 10.4 | 7.4  |
| 2007.5833 | AUG | 73.5                             | 73.1  | 66.2  | 16.4                            | 10.4 | 7.3  |
| 2007.6667 | SEP | 74.2                             | 73.7  | 66.0  | 15.5                            | 10.3 | 7.3  |
| 2007.7500 | OCT | 75.2                             | 74.3  | 65.6  | 14.1                            | 10.2 | 7.4  |
| 2007.8333 | NOV | 76.4                             | 75.1  | 65.4  | 14.6                            | 10.1 | 7.6  |
| 2007.9167 | DEC | 77.5                             | 75.9  | 65.1  | 14.7                            | 9.9  | 7.5  |
| 2008.0000 | JAN | 79.1                             | 76.9  | 65.1  | 15.2                            | 10.1 | 7.7  |
| 2008.0833 | FEB | 80.8                             | 78.0  | 64.9  | 15.5                            | 10.4 | 7.6  |
| 2008.1667 | MAR | 82.5                             | 78.9  | 64.3  | 15.7                            | 10.5 | 7.6  |
| 2008.2500 | APR | 84.9                             | 80.2  | 64.4  | 16.0                            | 10.5 | 7.7  |
| 2008.3333 | MAY | 87.4                             | 81.9  | 65.0  | 16.2                            | 10.5 | 7.9  |
| 2008.4167 | JUN | 89.6                             | 84.0  | 65.6  | 16.3                            | 10.7 | 8.2  |
| 2008.5000 | JUL | 91.5                             | 86.2  | 66.4  | 16.5                            | 11.0 | 8.5  |
| 2008.5833 | AUG | 93.3                             | 88.6  | 67.6  | 16.8                            | 11.3 | 8.7  |
| 2008.6667 | SEP | 94.9                             | 91.2  | 69.1  | 17.0                            | 11.7 | 8.6  |
| 2008.7500 | OCT | 98.3                             | 93.8  | 70.8  | 16.6                            | 12.0 | 8.6  |
| 2008.8333 | NOV | 101.7                            | 96.6  | 71.9  | 15.7                            | 12.1 | 8.7  |
| 2008.9167 | DEC | 105.0                            | 99.5  | 73.2  | 14.9                            | 11.9 | 8.6  |
| 2009.0000 | JAN | 108.2                            | 102.5 | 75.0  | 14.6                            | 12.0 | 8.5  |
| 2009.0833 | FEB | 111.7                            | 105.7 | 76.7  | 14.3                            | 12.1 | 8.3  |
| 2009.1667 | MAR | 116.5                            | 109.4 | 79.1  | 14.3                            | 12.0 | 7.9  |
| 2009.2500 | APR | 121.3                            | 113.5 | 82.0  | 14.1                            | 12.0 | 7.6  |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
|           |     | 75.0%                            | 50%   | 5.0% | 95.0%                           | 50%  | 5.0% |
| 2009.3333 | MAY | 126.3                            | 117.9 | 86.1 | 14.6                            | 12.1 | 7.6  |
| 2009.4167 | JUN | 131.9                            | 122.5 | 90.3 | 14.6                            | 12.1 | 7.5  |
| 2009.5000 | JUL | 138.0                            | 126.9 | 94.5 | 15.1                            | 12.3 | 7.7  |
| 2009.5833 | AUG | 142.9                            | 130.7 | 98.6 | 15.6                            | 12.4 | 7.9  |
| 2009.6667 | SEP | 146.8                            | 133.0 | 98.7 | 16.2                            | 12.6 | 8.2  |
| 2009.7500 | OCT | 150.7                            | 135.4 | 98.8 | 16.7                            | 12.8 | 8.4  |
| 2009.8333 | NOV | 154.6                            | 137.7 | 98.9 | 17.2                            | 13.0 | 8.6  |
| 2009.9167 | DEC | 158.3                            | 140.0 | 99.0 | 17.6                            | 13.2 | 8.9  |
| 2010.0000 | JAN | 162.0                            | 142.3 | 99.1 | 18.1                            | 13.4 | 9.1  |
| 2010.0833 | FEB | 165.6                            | 144.4 | 99.2 | 18.6                            | 13.5 | 9.3  |
| 2010.1667 | MAR | 169.1                            | 146.5 | 99.3 | 19.0                            | 13.7 | 9.5  |
| 2010.2500 | APR | 172.4                            | 148.6 | 99.3 | 19.4                            | 13.9 | 9.7  |
| 2010.3333 | MAY | 175.5                            | 150.5 | 99.4 | 19.8                            | 14.0 | 9.8  |
| 2010.4167 | JUN | 178.4                            | 152.2 | 99.5 | 20.2                            | 14.1 | 10.0 |
| 2010.5000 | JUL | 181.2                            | 153.9 | 99.6 | 20.5                            | 14.3 | 10.2 |
| 2010.5833 | AUG | 183.6                            | 155.4 | 99.6 | 20.8                            | 14.4 | 10.3 |
| 2010.6667 | SEP | 185.9                            | 156.7 | 99.7 | 21.1                            | 14.5 | 10.4 |
| 2010.7500 | OCT | 187.8                            | 157.9 | 99.8 | 21.3                            | 14.6 | 10.5 |
| 2010.8333 | NOV | 189.4                            | 158.9 | 99.8 | 21.5                            | 14.6 | 10.6 |
| 2010.9167 | DEC | 190.7                            | 159.7 | 99.8 | 21.7                            | 14.7 | 10.7 |
| 2011.0000 | JAN | 191.7                            | 160.3 | 99.9 | 21.8                            | 14.7 | 10.8 |
| 2011.0833 | FEB | 192.3                            | 160.6 | 99.9 | 21.9                            | 14.8 | 10.8 |
| 2011.1667 | MAR | 192.5                            | 160.8 | 99.9 | 21.9                            | 14.8 | 10.8 |
| 2011.2500 | APR | 193.5                            | 159.8 | 98.5 | 20.6                            | 14.9 | 11.5 |
| 2011.3333 | MAY | 192.2                            | 157.8 | 97.8 | 20.2                            | 15.0 | 11.8 |
| 2011.4167 | JUN | 189.2                            | 156.1 | 96.7 | 19.7                            | 15.1 | 11.7 |
| 2011.5000 | JUL | 184.9                            | 154.9 | 95.4 | 19.4                            | 15.3 | 11.9 |
| 2011.5833 | AUG | 180.2                            | 153.6 | 93.8 | 19.2                            | 15.6 | 12.1 |
| 2011.6667 | SEP | 177.5                            | 152.2 | 92.6 | 19.0                            | 15.7 | 11.6 |
| 2011.7500 | OCT | 175.8                            | 150.5 | 91.8 | 19.0                            | 15.7 | 10.9 |
| 2011.8333 | NOV | 175.4                            | 149.0 | 91.2 | 18.9                            | 15.7 | 10.8 |
| 2011.9167 | DEC | 173.4                            | 147.3 | 90.3 | 19.0                            | 15.7 | 10.8 |
| 2012.0000 | JAN | 169.3                            | 145.5 | 89.3 | 19.2                            | 15.8 | 10.8 |
| 2012.0833 | FEB | 166.2                            | 143.3 | 88.6 | 19.8                            | 15.9 | 10.8 |
| 2012.1667 | MAR | 165.9                            | 141.5 | 87.7 | 20.4                            | 16.1 | 10.9 |
| 2012.2500 | APR | 163.7                            | 140.1 | 86.2 | 21.4                            | 16.3 | 10.8 |
| 2012.3333 | MAY | 160.6                            | 139.0 | 85.4 | 21.9                            | 16.5 | 10.7 |
| 2012.4167 | JUN | 159.8                            | 137.8 | 84.9 | 21.6                            | 16.6 | 10.6 |
| 2012.5000 | JUL | 158.8                            | 136.3 | 84.0 | 21.3                            | 16.4 | 10.3 |
| 2012.5833 | AUG | 156.3                            | 135.1 | 82.7 | 21.8                            | 16.5 | 10.3 |
| 2012.6667 | SEP | 153.6                            | 133.9 | 81.3 | 23.1                            | 16.7 | 10.4 |
| 2012.7500 | OCT | 152.4                            | 132.6 | 80.4 | 23.3                            | 16.9 | 10.9 |
| 2012.8333 | NOV | 151.6                            | 131.0 | 79.8 | 22.7                            | 17.0 | 11.7 |
| 2012.9167 | DEC | 151.1                            | 129.4 | 79.1 | 22.6                            | 17.0 | 11.8 |
| 2013.0000 | JAN | 149.3                            | 128.0 | 78.4 | 22.7                            | 16.9 | 11.9 |
| 2013.0833 | FEB | 146.2                            | 126.8 | 77.5 | 23.2                            | 17.1 | 12.0 |
| 2013.1667 | MAR | 144.8                            | 125.7 | 76.5 | 23.9                            | 17.3 | 12.1 |
| 2013.2500 | APR | 144.9                            | 124.2 | 75.5 | 23.9                            | 17.2 | 12.5 |
| 2013.3333 | MAY | 143.0                            | 122.2 | 74.6 | 23.9                            | 17.1 | 13.3 |
| 2013.4167 | JUN | 139.7                            | 120.3 | 73.6 | 23.3                            | 17.0 | 13.7 |
| 2013.5000 | JUL | 135.8                            | 118.7 | 72.7 | 21.6                            | 16.8 | 13.3 |
| 2013.5833 | AUG | 135.2                            | 117.4 | 72.3 | 21.8                            | 16.6 | 12.8 |
| 2013.6667 | SEP | 133.5                            | 116.1 | 72.0 | 21.8                            | 16.4 | 12.7 |
| 2013.7500 | OCT | 132.8                            | 114.5 | 71.6 | 21.5                            | 16.4 | 12.5 |
| 2013.8333 | NOV | 130.9                            | 112.8 | 71.4 | 21.1                            | 16.4 | 12.4 |
| 2013.9167 | DEC | 128.9                            | 111.0 | 71.5 | 20.5                            | 16.4 | 12.2 |
| 2014.0000 | JAN | 125.9                            | 109.0 | 71.4 | 19.9                            | 16.1 | 11.9 |
| 2014.0833 | FEB | 124.1                            | 107.1 | 71.2 | 20.1                            | 16.0 | 11.9 |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

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

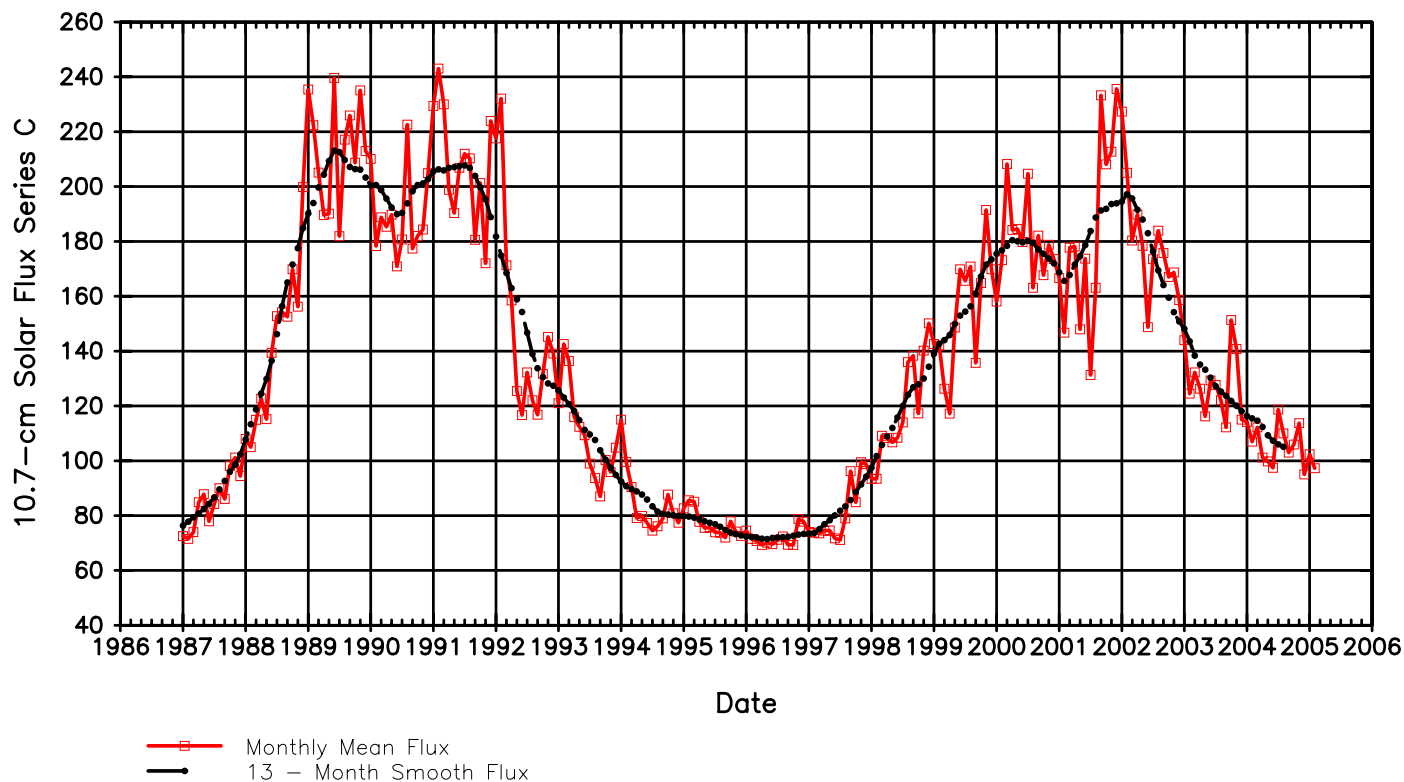
| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
|           |     | 75.0%                            | 50%   | 5.0% | 95.0%                           | 50%  | 5.0% |
| 2014.1667 | MAR | 122.0                            | 105.4 | 70.9 | 21.6                            | 15.9 | 11.7 |
| 2014.2500 | APR | 119.0                            | 104.0 | 70.7 | 23.2                            | 15.8 | 11.7 |
| 2014.3333 | MAY | 118.6                            | 102.7 | 70.5 | 24.0                            | 15.8 | 11.5 |
| 2014.4167 | JUN | 116.9                            | 101.3 | 70.7 | 25.1                            | 15.7 | 11.3 |
| 2014.5000 | JUL | 115.8                            | 100.1 | 71.1 | 25.8                            | 15.7 | 11.3 |
| 2014.5833 | AUG | 115.7                            | 98.8  | 71.2 | 25.0                            | 15.6 | 10.8 |
| 2014.6667 | SEP | 116.6                            | 97.6  | 71.4 | 25.0                            | 15.6 | 10.3 |
| 2014.7500 | OCT | 114.5                            | 96.5  | 71.2 | 24.1                            | 15.7 | 10.7 |
| 2014.8333 | NOV | 111.2                            | 95.2  | 70.7 | 22.2                            | 15.7 | 10.8 |
| 2014.9167 | DEC | 109.4                            | 94.0  | 70.3 | 21.4                            | 15.6 | 10.8 |
| 2015.0000 | JAN | 108.2                            | 93.2  | 70.0 | 21.7                            | 15.8 | 11.0 |
| 2015.0833 | FEB | 106.7                            | 92.5  | 69.6 | 22.4                            | 16.0 | 11.2 |
| 2015.1667 | MAR | 104.8                            | 91.5  | 69.2 | 22.6                            | 16.0 | 11.2 |
| 2015.2500 | APR | 102.8                            | 90.4  | 69.0 | 22.5                            | 16.1 | 11.0 |
| 2015.3333 | MAY | 101.2                            | 89.3  | 68.7 | 22.7                            | 16.3 | 11.0 |
| 2015.4167 | JUN | 99.4                             | 88.2  | 68.2 | 22.9                            | 16.6 | 11.3 |
| 2015.5000 | JUL | 97.8                             | 87.0  | 68.0 | 23.4                            | 16.8 | 11.2 |
| 2015.5833 | AUG | 96.1                             | 85.9  | 67.8 | 24.1                            | 16.9 | 11.2 |
| 2015.6667 | SEP | 94.5                             | 84.8  | 67.7 | 24.8                            | 17.0 | 11.8 |
| 2015.7500 | OCT | 93.1                             | 83.7  | 67.6 | 25.4                            | 16.9 | 12.2 |
| 2015.8333 | NOV | 92.0                             | 82.8  | 67.6 | 25.6                            | 16.7 | 12.1 |
| 2015.9167 | DEC | 90.9                             | 81.8  | 67.5 | 25.4                            | 16.4 | 12.0 |
| 2016.0000 | JAN | 90.0                             | 80.9  | 67.3 | 24.7                            | 16.0 | 12.2 |
| 2016.0833 | FEB | 89.1                             | 80.2  | 67.2 | 23.6                            | 15.6 | 12.3 |
| 2016.1667 | MAR | 88.6                             | 79.6  | 67.2 | 22.8                            | 15.2 | 12.2 |
| 2016.2500 | APR | 87.4                             | 78.9  | 67.2 | 22.4                            | 14.9 | 11.8 |
| 2016.3333 | MAY | 86.0                             | 78.4  | 67.2 | 21.9                            | 14.6 | 11.2 |
| 2016.4167 | JUN | 85.4                             | 77.9  | 67.1 | 21.6                            | 14.2 | 10.7 |
| 2016.5000 | JUL | 84.6                             | 77.3  | 67.1 | 20.9                            | 13.8 | 10.0 |
| 2016.5833 | AUG | 83.4                             | 76.8  | 67.0 | 20.0                            | 13.4 | 9.4  |
| 2016.6667 | SEP | 82.1                             | 76.2  | 67.0 | 18.7                            | 13.1 | 9.0  |
| 2016.7500 | OCT | 81.0                             | 75.7  | 67.0 | 18.2                            | 12.8 | 8.5  |
| 2016.8333 | NOV | 80.1                             | 75.2  | 67.0 | 18.7                            | 12.6 | 8.0  |
| 2016.9167 | DEC | 78.9                             | 74.9  | 67.1 | 18.7                            | 12.5 | 7.8  |
| 2017.0000 | JAN | 78.2                             | 74.6  | 67.3 | 18.4                            | 12.4 | 7.4  |
| 2017.0833 | FEB | 77.7                             | 74.2  | 67.4 | 18.4                            | 12.2 | 7.0  |
| 2017.1667 | MAR | 76.9                             | 73.9  | 67.5 | 18.8                            | 12.1 | 6.6  |
| 2017.2500 | APR | 76.0                             | 73.6  | 67.6 | 18.9                            | 12.0 | 6.5  |
| 2017.3333 | MAY | 75.4                             | 73.1  | 67.7 | 18.8                            | 12.0 | 6.4  |
| 2017.4167 | JUN | 75.0                             | 72.7  | 67.7 | 18.4                            | 11.9 | 6.6  |
| 2017.5000 | JUL | 75.0                             | 72.3  | 68.0 | 17.5                            | 11.8 | 6.9  |
| 2017.5833 | AUG | 75.2                             | 72.1  | 68.0 | 16.5                            | 11.7 | 7.2  |
| 2017.6667 | SEP | 74.8                             | 71.9  | 68.0 | 16.3                            | 11.6 | 7.4  |
| 2017.7500 | OCT | 73.9                             | 71.7  | 68.0 | 16.6                            | 11.6 | 7.5  |
| 2017.8333 | NOV | 73.8                             | 71.6  | 67.9 | 16.9                            | 11.6 | 7.5  |
| 2017.9167 | DEC | 73.6                             | 71.7  | 67.9 | 17.2                            | 11.6 | 7.7  |
| 2018.0000 | JAN | 73.2                             | 71.8  | 67.7 | 17.3                            | 11.6 | 7.7  |
| 2018.0833 | FEB | 73.2                             | 72.0  | 67.6 | 17.7                            | 11.5 | 7.6  |
| 2018.1667 | MAR | 73.6                             | 72.3  | 67.7 | 18.0                            | 11.4 | 7.6  |
| 2018.2500 | APR | 73.6                             | 72.6  | 67.6 | 18.2                            | 11.4 | 7.6  |
| 2018.3333 | MAY | 74.0                             | 73.0  | 67.6 | 18.1                            | 11.3 | 7.6  |
| 2018.4167 | JUN | 74.0                             | 73.4  | 67.7 | 17.8                            | 11.2 | 7.5  |
| 2018.5000 | JUL | 74.6                             | 74.1  | 67.9 | 17.3                            | 11.1 | 7.5  |
| 2018.5833 | AUG | 75.6                             | 75.0  | 68.1 | 16.3                            | 11.0 | 7.5  |
| 2018.6667 | SEP | 77.0                             | 76.1  | 68.5 | 15.5                            | 10.9 | 7.5  |
| 2018.7500 | OCT | 78.5                             | 77.2  | 68.6 | 16.1                            | 10.8 | 7.7  |
| 2018.8333 | NOV | 80.3                             | 78.2  | 68.8 | 16.3                            | 10.8 | 7.7  |
| 2018.9167 | DEC | 82.4                             | 79.5  | 69.1 | 16.6                            | 10.9 | 7.8  |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

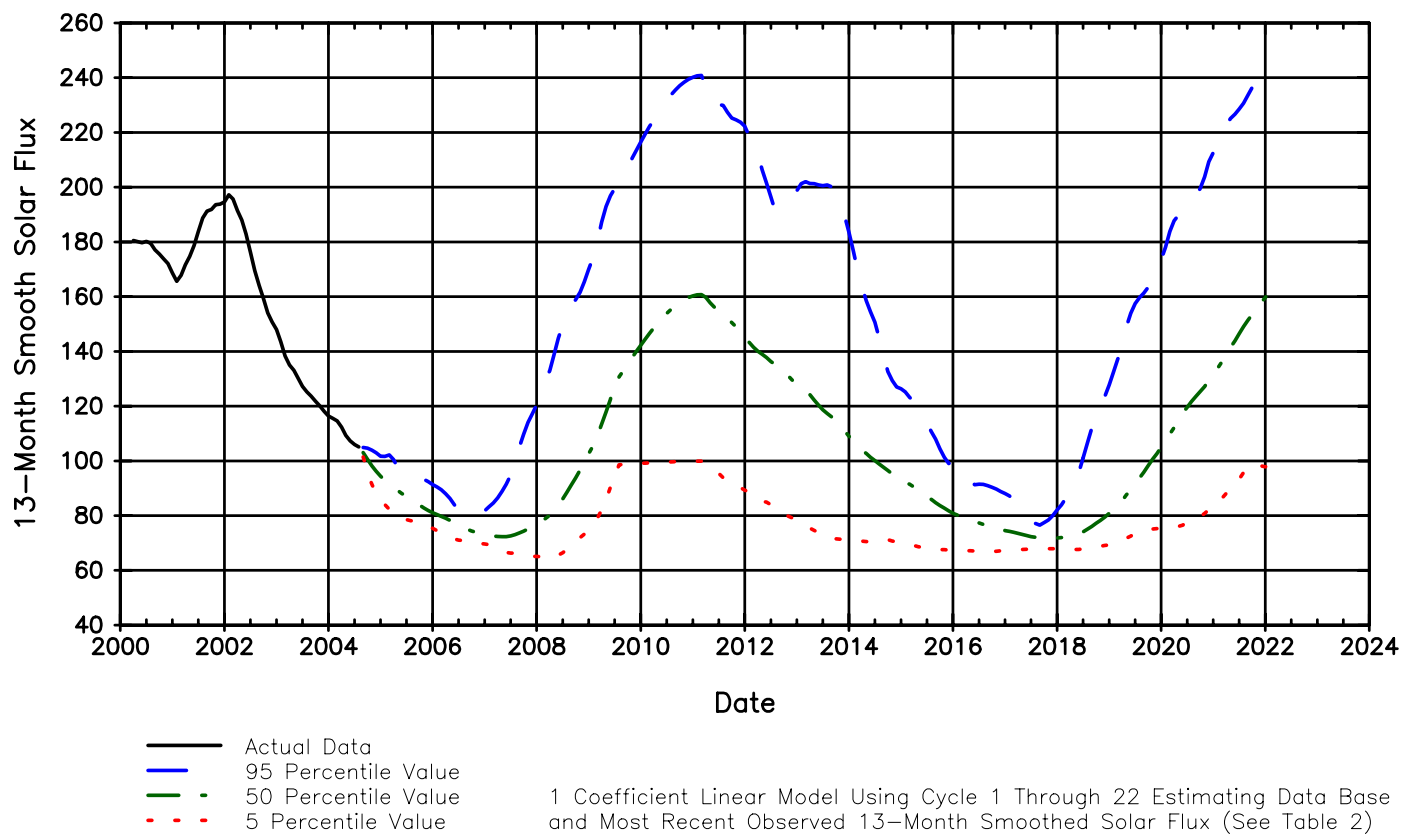
**TABLE 5 ESTIMATES OF 13-MONTH SMOOTHED  $F_{10.7}^*$  AND  $A_p$  FOR  
BALANCE OF CYCLE 23 AND CYCLE 24**

| TIME      |     | 10.7-CM SOLAR FLUX<br>PERCENTILE |       |      | GEOMAGNETIC INDEX<br>PERCENTILE |      |      |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
|           |     | 75.0%                            | 50%   | 5.0% | 95.0%                           | 50%  | 5.0% |
| 2019.0000 | JAN | 84.0                             | 80.8  | 69.3 | 16.7                            | 11.0 | 7.7  |
| 2019.0833 | FEB | 85.2                             | 82.2  | 69.6 | 16.8                            | 11.1 | 7.7  |
| 2019.1667 | MAR | 86.5                             | 83.7  | 70.2 | 17.1                            | 11.1 | 7.8  |
| 2019.2500 | APR | 88.7                             | 85.5  | 71.1 | 17.3                            | 11.1 | 8.0  |
| 2019.3333 | MAY | 92.6                             | 87.6  | 71.8 | 17.3                            | 11.2 | 8.3  |
| 2019.4167 | JUN | 95.0                             | 89.7  | 72.5 | 17.4                            | 11.5 | 8.6  |
| 2019.5000 | JUL | 97.1                             | 91.8  | 73.7 | 17.6                            | 11.7 | 9.0  |
| 2019.5833 | AUG | 99.1                             | 93.8  | 74.2 | 17.5                            | 12.0 | 8.8  |
| 2019.6667 | SEP | 101.7                            | 95.8  | 74.5 | 16.9                            | 12.2 | 8.7  |
| 2019.7500 | OCT | 104.4                            | 98.2  | 74.8 | 16.2                            | 12.4 | 8.9  |
| 2019.8333 | NOV | 106.8                            | 100.6 | 75.1 | 16.0                            | 12.5 | 9.0  |
| 2019.9167 | DEC | 108.5                            | 102.6 | 75.3 | 16.0                            | 12.7 | 9.0  |
| 2020.0000 | JAN | 111.1                            | 104.9 | 75.2 | 16.1                            | 12.9 | 8.8  |
| 2020.0833 | FEB | 114.6                            | 107.3 | 75.2 | 16.7                            | 13.0 | 8.4  |
| 2020.1667 | MAR | 116.0                            | 109.8 | 75.3 | 17.1                            | 13.0 | 8.2  |
| 2020.2500 | APR | 117.8                            | 112.2 | 75.7 | 17.5                            | 13.1 | 8.2  |
| 2020.3333 | MAY | 120.4                            | 114.8 | 76.1 | 18.2                            | 13.2 | 8.1  |
| 2020.4167 | JUN | 123.7                            | 117.3 | 76.6 | 18.5                            | 13.2 | 7.9  |
| 2020.5000 | JUL | 126.4                            | 119.6 | 77.5 | 18.5                            | 13.1 | 7.8  |
| 2020.5833 | AUG | 129.8                            | 121.7 | 78.3 | 18.7                            | 13.1 | 7.9  |
| 2020.6667 | SEP | 133.4                            | 123.6 | 78.6 | 19.0                            | 13.2 | 8.1  |
| 2020.7500 | OCT | 137.0                            | 125.3 | 79.6 | 18.6                            | 13.3 | 8.6  |
| 2020.8333 | NOV | 141.7                            | 127.2 | 80.8 | 17.8                            | 13.3 | 9.2  |
| 2020.9167 | DEC | 147.0                            | 129.1 | 82.2 | 18.1                            | 13.4 | 9.6  |
| 2021.0000 | JAN | 150.9                            | 131.4 | 84.1 | 18.9                            | 13.5 | 10.1 |
| 2021.0833 | FEB | 152.9                            | 133.8 | 85.4 | 19.1                            | 13.6 | 10.1 |
| 2021.1667 | MAR | 155.0                            | 136.2 | 86.3 | 19.5                            | 13.9 | 10.3 |
| 2021.2500 | APR | 159.0                            | 138.9 | 88.1 | 20.5                            | 14.1 | 10.4 |
| 2021.3333 | MAY | 163.4                            | 141.5 | 90.0 | 20.2                            | 14.1 | 10.6 |
| 2021.4167 | JUN | 167.6                            | 143.9 | 91.1 | 20.4                            | 14.1 | 10.2 |
| 2021.5000 | JUL | 172.9                            | 146.5 | 93.3 | 20.7                            | 14.1 | 10.2 |
| 2021.5833 | AUG | 178.7                            | 149.1 | 95.7 | 21.1                            | 14.2 | 9.9  |
| 2021.6667 | SEP | 181.8                            | 151.4 | 97.5 | 21.4                            | 14.2 | 9.8  |
| 2021.7500 | OCT | 184.2                            | 153.5 | 98.7 | 21.4                            | 14.4 | 10.5 |
| 2021.8333 | NOV | 187.0                            | 155.6 | 98.8 | 21.6                            | 14.5 | 10.9 |
| 2021.9167 | DEC | 189.7                            | 157.6 | 98.2 | 21.9                            | 14.7 | 10.9 |
| 2022.0000 | JAN | 191.8                            | 159.7 | 97.8 | 22.4                            | 14.9 | 11.0 |
| 2022.0833 | FEB | 192.7                            | 161.7 | 99.1 | 22.9                            | 15.1 | 11.2 |

\* Program Initialized from established Cycle 23 Smoothed Sunspot maximum

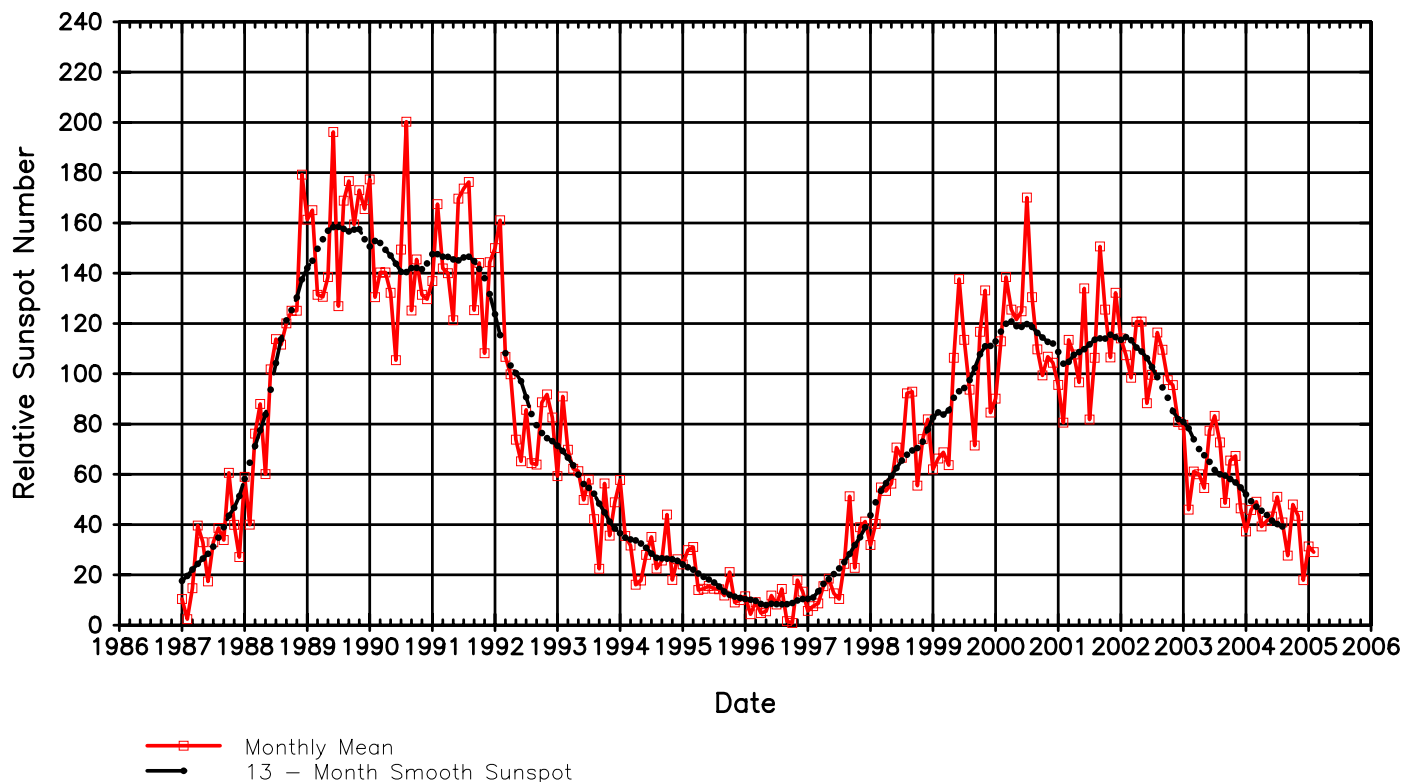


**Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux**

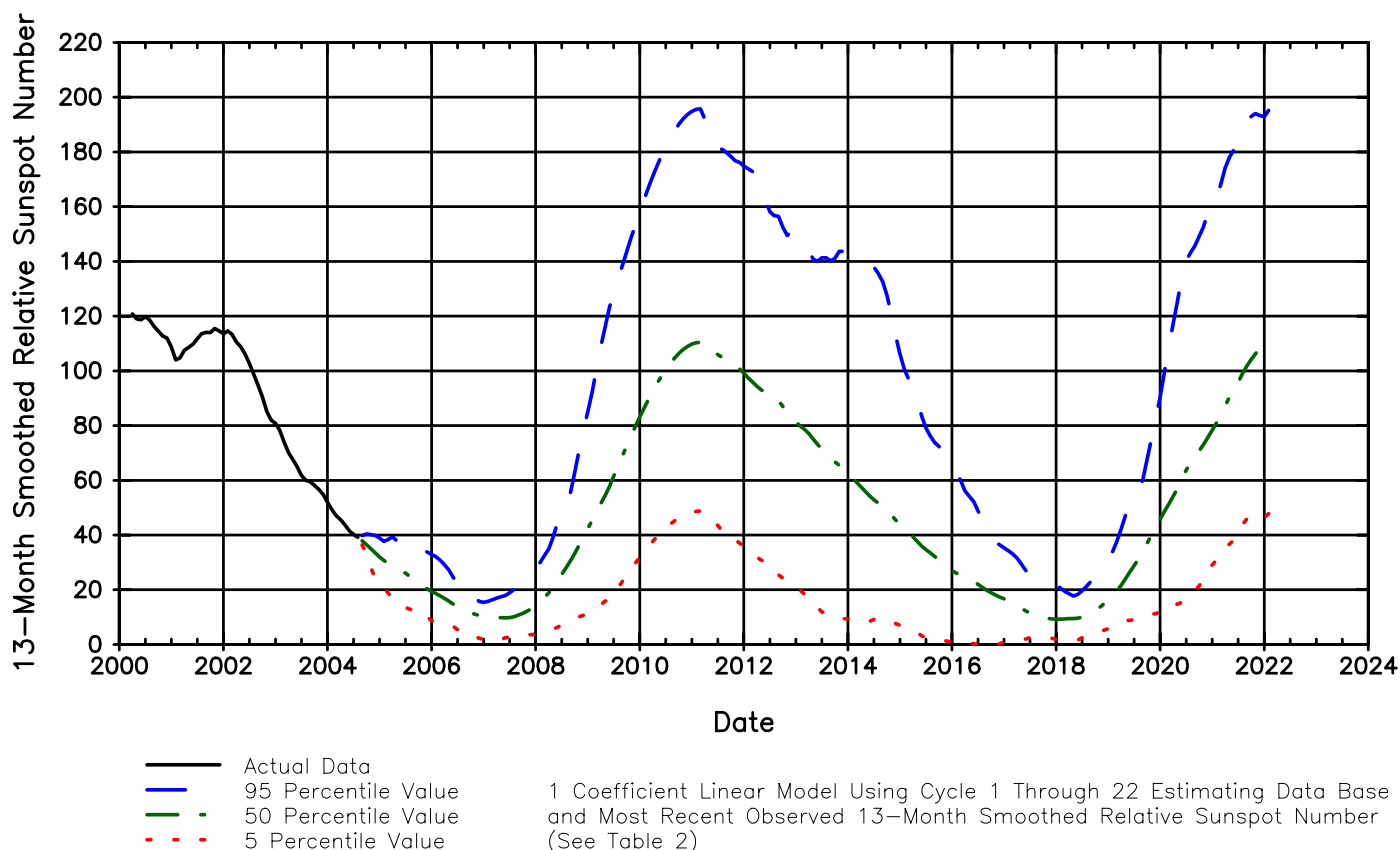


**Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 23\* and Cycle 24**

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum

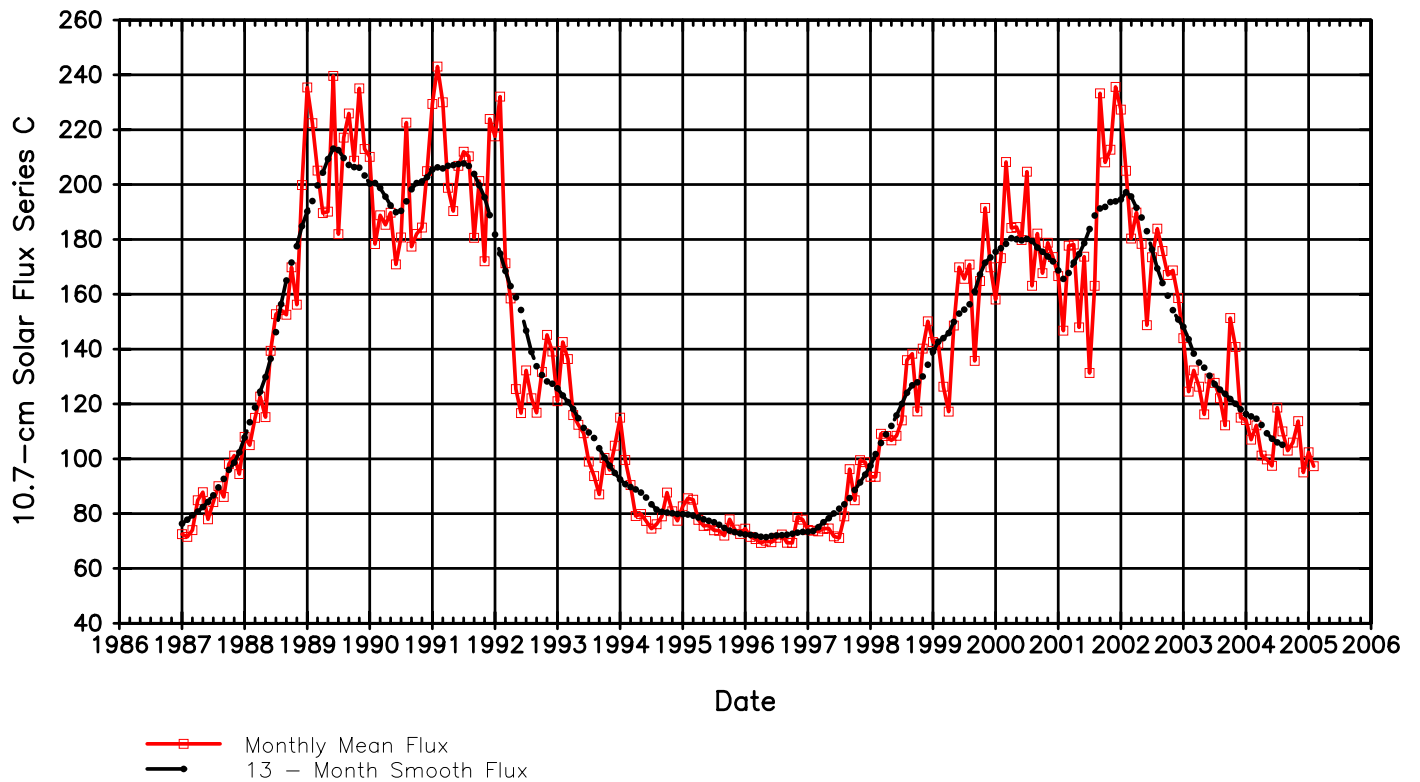


**Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number**

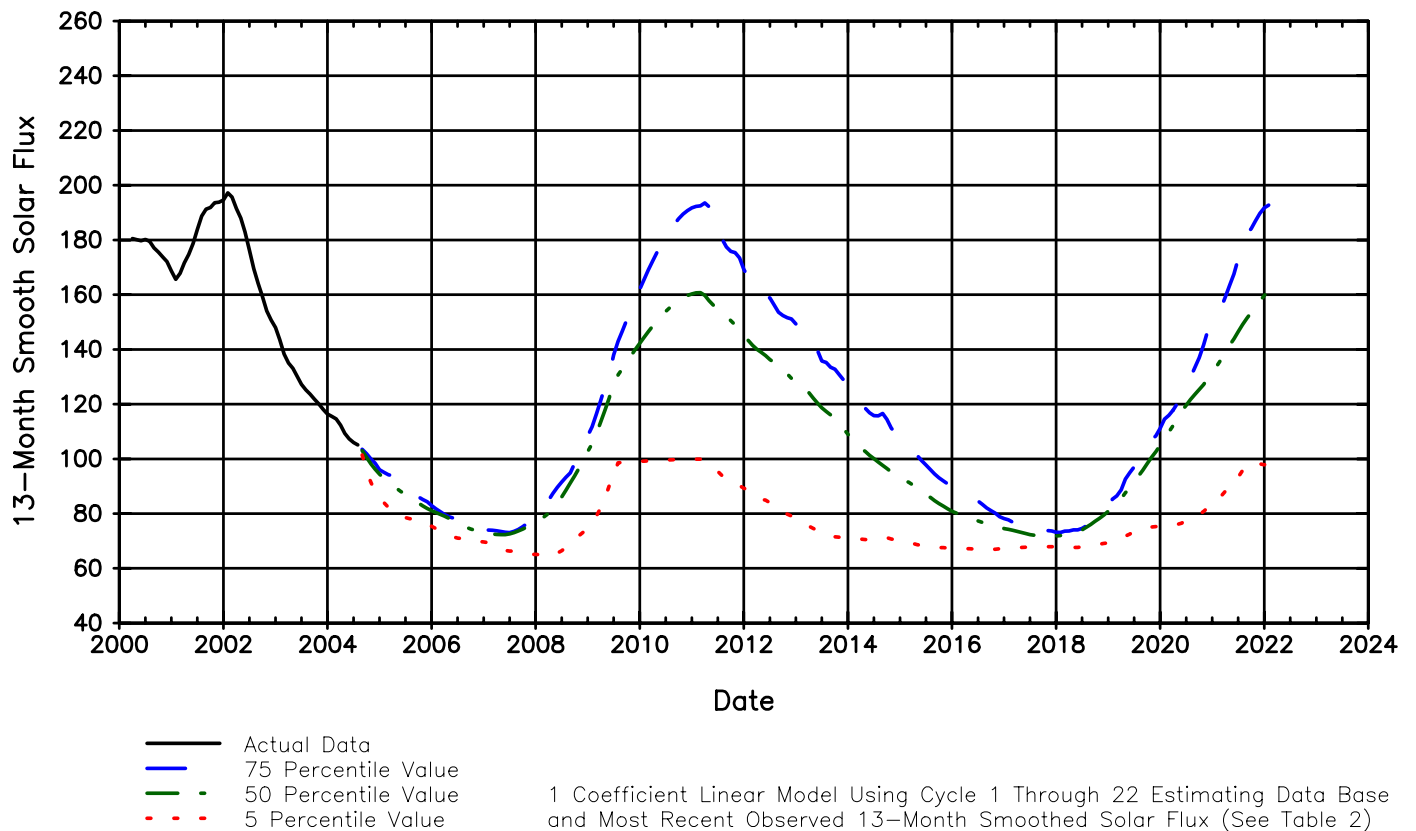


**Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 23\* and Cycle 24**

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum



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



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

\* Program Initialized from established Cycle 23 Sunspot Smoothed maximum