



Future Solar Activity Estimates for Use in Prediction of Space Environmental Effects On Spacecraft

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Introduction

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

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.

Observed Data

Generation of the information provided in this report begins each month with the acquisition of recently observed data. Table 1 (page 5) 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) FTP 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) gopher site and the Sunspot Index Data Center site.

The computer programs inputs used by the MSAFE 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 6) 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 5).

Future Estimates

Using these smoothed values as inputs, the program estimates the intermediate-term (months) and long-term (years) behavior of these parameters for up to 132 months into the future, initialized from the cycle 23 minimum. The cycle 23 minimum has been confirmed as May 1996 for both the $\bar{F}_{10.7}$ and \bar{R} . The cycle 23 minimum \bar{A}_p occurred in August 1997. Once the cycle 23 maximum has been established from observed $\bar{F}_{10.7}$, \bar{R} , and \bar{A}_p data, the MSAFE program will be re-initialized at the maximum for cycle 23. The results of the MSAFE model calculations (i.e. the output data) are reported in Tables 3, 4 and 5¹. Table 3 (page 11) contains the statistical estimates of $\bar{F}_{10.7}$ and \bar{A}_p values for the balance of cycle 23 and cycle 24. Table 4 (page 15) contains the statistical estimate of \bar{R} and \bar{A}_p values for the balance of cycle 23 and cycle 24. Table 5¹ (page 19) 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. Information on the characteristics of cycle 24 is 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 24) illustrate the 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 13-month Zurich smoothed 10.7-cm solar radio flux for solar cycles 23 and 24. Similarly, Figures 3 and 4 (page 25) demonstrate application of the 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 13-month Zurich smoothed relative sunspot number for solar cycles 23 and 24. Figure 5¹ (page 26) 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 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 values are the statistical evaluation of the past 22 cycles and are not influenced by the MSAFE model's performance. Cycle 24 values 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 minimum 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

¹ Table 5, Figure 5 and Figure 6 added June 2002 as requested by NASA/JSC Vehicle Integration Performance and Resources (VIPeR) team.

percentile values for the \bar{A}_p are only approximations. The mean cycle period of 11 years (132 months) is assumed for cycle 24.

Applications

General. The 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, 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-1995 Version [Justus et al., 1995], 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) [Bilitza et al., 1993] and the Fully Analytical Ionospheric Model (FAIM) [Anderson et al., 1989], and newly emerging cosmic ray models [Nymmik et al., 1996] utilize sunspot number (R) inputs. However, the statistical estimates produced by the MSAFE model provide future 13-month smoothed values of these parameters rather than the daily and 3-hourly values used in development of the models.

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 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 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 95 percentile estimates of future smoothed solar radio flux and geomagnetic index are recommended. These estimates permit statistically conservative spacecraft design and mission planning. Critical considerations such as orbital lifetime predictions should be based on the most current intermediate and long-range statistical estimates of future solar and geophysical data consistent with the critical project development decision time points prior to planned launch of the spacecraft.

Additional Information

Questions on the contents of this report may be addressed to Harold Euler (Harold.Euler@msfc.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.Suggs@msfc.nasa.gov) regarding the clarity and operational usefulness of this estimate.

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TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES

| Year | Month | Solar Flux (F_{10.7} (Series C)) | Relative Sunspot Numbers (R) | Geomagnetic Index (A_p) |
|-------------|--------------|---|---|--|
| 2001 | January | 166.6 | 95.6 | 8 |
| | February | 146.7 | 80.6 | 7 |
| | March | 177.7 | 113.5 | 20 |
| | April | 178.1 | 107.7 | 22 |
| | May | 147.9 | 96.6 | 10 |
| | June | 173.7 | 134.0 | 10 |
| | July | 131.3 | 81.8 | 9 |
| | August | 163.1 | 106.4 | 11 |
| | September | 233.8 | 150.7 | 13 |
| | October | 208.1 | 125.5 | 20 |
| | November | 212.7 | 106.5 | 16 |
| | December | 235.6 | 132.2 | 9 |
| 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 | 153.3* | 65.6* | 35* |
| | November | 140.8* | 67.2* | 28* |
| | December | 115.1* | 47.0* | 17* |

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

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

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

* Preliminary Estimates

| TABLE 2 : 13-MONTH ZURICH SMOOTHED VALUES | | | | |
|--|--------------|--|---|--|
| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
| 1990 | January | 200.3 | 150.6 | 18.6 |
| | February | 200.5 | 152.9 | 18.8 |
| | March | 198.7 | 152.0 | 18.6 |
| | April | 195.6 | 149.3 | 18.2 |
| | May | 192.4 | 147.0 | 17.6 |
| | June | 189.9 | 143.8 | 16.8 |
| | July | 190.4 | 140.6 | 16.2 |
| | August | 193.9 | 140.5 | 15.4 |
| | September | 198.3 | 142.1 | 15.0 |
| | October | 200.6 | 142.1 | 14.8 |
| | November | 201.2 | 141.7 | 14.4 |
| | December | 202.7 | 143.9 | 15.7 |
| 1991 | January | 205.5 | 147.6 | 17.4 |
| | February | 206.3 | 147.6 | 18.4 |
| | March | 205.9 | 146.6 | 19.1 |
| | April | 206.8 | 146.5 | 20.0 |
| | May | 207.1 | 145.5 | 21.7 |
| | June | 207.4 | 145.2 | 23.0 |
| | July | 207.7 | 146.3 | 23.6 |
| | August | 206.8 | 146.6 | 24.7 |
| | September | 203.9 | 144.9 | 25.0 |
| | October | 199.7 | 141.7 | 24.2 |
| | November | 195.4 | 138.1 | 24.1 |
| | December | 188.9 | 131.7 | 23.0 |
| 1992 | January | 181.8 | 123.7 | 21.1 |
| | February | 174.8 | 115.4 | 19.8 |
| | March | 168.5 | 108.2 | 19.4 |
| | April | 162.9 | 103.3 | 18.9 |
| | May | 158.9 | 100.3 | 17.5 |
| | June | 154.3 | 97.1 | 16.6 |
| | July | 146.7 | 90.7 | 16.6 |
| | August | 138.9 | 84.0 | 16.1 |
| | September | 133.8 | 79.5 | 15.9 |
| | October | 130.5 | 76.4 | 16.7 |
| | November | 128.2 | 74.4 | 16.6 |
| | December | 127.4 | 73.2 | 16.1 |

* Preliminary Estimates

| TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES | | | | |
|---|--------------|--|---|--|
| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
| 1993 | January | 125.7 | 71.4 | 16.0 |
| | February | 123.1 | 69.3 | 15.9 |
| | March | 120.7 | 66.6 | 15.3 |
| | April | 118.1 | 63.6 | 14.9 |
| | May | 114.8 | 59.9 | 14.9 |
| | June | 111.3 | 56.1 | 15.0 |
| | July | 109.6 | 54.7 | 14.9 |
| | August | 107.6 | 52.3 | 15.4 |
| | September | 103.9 | 48.4 | 16.0 |
| | October | 100.4 | 44.9 | 16.4 |
| | November | 97.5 | 41.2 | 17.4 |
| | December | 94.8 | 38.4 | 18.1 |
| 1994 | January | 92.7 | 36.6 | 18.2 |
| | February | 91.2 | 34.8 | 18.1 |
| | March | 90.2 | 34.1 | 17.8 |
| | April | 89.3 | 33.7 | 18.0 |
| | May | 88.1 | 32.5 | 18.3 |
| | June | 86.7 | 30.8 | 18.2 |
| | July | 84.5 | 28.5 | 18.1 |
| | August | 82.5 | 26.8 | 17.5 |
| | September | 81.7 | 26.6 | 16.5 |
| | October | 81.4 | 26.5 | 15.5 |
| | November | 81.2 | 26.2 | 14.7 |
| | December | 81.0 | 25.6 | 14.3 |
| 1995 | January | 80.6 | 24.2 | 14.0 |
| | February | 80.2 | 23.0 | 14.0 |
| | March | 79.9 | 22.1 | 14.0 |
| | April | 79.2 | 20.6 | 13.8 |
| | May | 78.5 | 19.2 | 13.4 |
| | June | 77.7 | 18.2 | 13.0 |
| | July | 76.9 | 17.0 | 12.6 |
| | August | 76.0 | 15.4 | 12.2 |
| | September | 74.8 | 13.4 | 11.8 |
| | October | 73.8 | 12.1 | 11.5 |
| | November | 73.2 | 11.4 | 10.8 |
| | December | 72.8 | 10.8 | 10.0 |

* Preliminary Estimates

| TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES | | | | |
|---|--------------|--|---|--|
| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
| 1996 | January | 72.4 | 10.4 | 9.7 |
| | February | 72.2 | 10.1 | 9.7 |
| | March | 72.1 | 9.7 | 9.8 |
| | April | 71.6 | 8.4 | 9.7 |
| | May | 71.4 | 8.0 | 9.5 |
| | June | 71.8 | 8.5 | 9.4 |
| | July | 72.0 | 8.4 | 9.3 |
| | August | 72.1 | 8.3 | 9.4 |
| | September | 72.3 | 8.4 | 9.3 |
| | October | 72.6 | 8.8 | 9.1 |
| | November | 73.0 | 9.8 | 9.1 |
| | December | 73.3 | 10.4 | 9.2 |
| 1997 | January | 73.4 | 10.5 | 9.3 |
| | February | 73.7 | 11.0 | 9.2 |
| | March | 75.1 | 13.5 | 8.9 |
| | April | 76.8 | 16.5 | 8.6 |
| | May | 78.4 | 18.3 | 8.6 |
| | June | 80.1 | 20.3 | 8.6 |
| | July | 81.8 | 22.6 | 8.5 |
| | August | 83.4 | 25.0 | 8.3 |
| | September | 85.7 | 28.3 | 8.4 |
| | October | 88.6 | 31.8 | 8.6 |
| | November | 91.3 | 35.0 | 9.0 |
| | December | 94.2 | 39.0 | 9.5 |
| 1998 | January | 97.5 | 43.7 | 9.9 |
| | February | 101.7 | 48.9 | 10.5 |
| | March | 105.8 | 53.4 | 11.1 |
| | April | 108.9 | 56.5 | 11.3 |
| | May | 112.0 | 59.4 | 11.6 |
| | June | 115.8 | 62.5 | 12.0 |
| | July | 120.0 | 65.5 | 12.2 |
| | August | 124.1 | 67.8 | 12.5 |
| | September | 126.8 | 69.5 | 12.7 |
| | October | 127.9 | 70.5 | 12.8 |
| | November | 130.0 | 73.0 | 12.5 |
| | December | 134.3 | 77.9 | 12.0 |

* Preliminary Estimates

| TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES | | | | |
|---|--------------|--|---|--|
| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
| 1999 | January | 139.0 | 82.6 | 11.8 |
| | February | 142.6 | 84.6 | 11.6 |
| | March | 144.0 | 83.8 | 11.8 |
| | April | 145.8 | 85.5 | 12.2 |
| | May | 149.9 | 90.5 | 12.4 |
| | June | 152.9 | 93.1 | 12.4 |
| | July | 154.4 | 94.3 | 12.6 |
| | August | 156.3 | 97.5 | 12.9 |
| | September | 161.0 | 102.3 | 12.8 |
| | October | 167.2 | 107.8 | 12.7 |
| | November | 171.5 | 111.0 | 13.1 |
| | December | 173.4 | 111.1 | 13.8 |
| 2000 | January | 175.5 | 112.9 | 14.5 |
| | February | 176.8 | 116.8 | 15.0 |
| | March | 178.4 | 119.9 | 15.0 |
| | April | 180.5 | 120.8 | 14.9 |
| | May | 180.1 | 119.0 | 15.0 |
| | June | 179.7 | 118.7 | 15.0 |
| | July | 180.2 | 119.8 | 14.7 |
| | August | 179.5 | 118.6 | 14.2 |
| | September | 177.1 | 116.3 | 14.2 |
| | October | 175.6 | 114.5 | 15.0 |
| | November | 173.8 | 112.7 | 15.1 |
| | December | 172.1 | 112.0 | 14.7 |
| 2001 | January | 168.7 | 108.7 | 14.0 |
| | February | 165.6 | 104.0 | 13.3 |
| | March | 167.8 | 104.8 | 12.8 |
| | April | 171.6 | 107.5 | 12.5 |
| | May | 174.7 | 108.6 | 12.5 |
| | June | 178.7 | 109.8 | 12.4 |
| | July | 183.8 | 111.7 | 12.4 |
| | August | 188.7 | 113.6 | 13.0 |
| | September | 191.3 | 114.1 | 12.7 |
| | October | 191.9 | 114.0 | 12.1 |
| | November | 193.6 | 115.5 | 12.0 |
| | December | 193.8 | 114.6 | 12.4 |

* Preliminary Estimates

| TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES | | | | |
|---|--------------|--|---|--|
| Year | Month | +10.7-cm Solar Flux ($\bar{F}_{10.7}$) | ++Sunspot Numbers (\bar{R}) | +++Geomagnetic Index (A_p) |
| 2002 | January | 194.6 | 113.5 | 12.7 |
| | February | 197.3 | 114.6 | 13.1 |
| | March | 195.7* | 113.3 | 12.3* |
| | April | 191.5* | 110.5 | 12.4* |
| | May | 188.0* | 108.8 | 12.5* |
| | June | 182.9* | 106.2 | 12.9* |
| | July | 176.2* | 102.7 | 13.3* |
| | August | 169.5* | 98.7 | 13.8* |
| | September | 164.1* | 94.6 | 14.5* |
| | October | 159.4* | 90.5 | 15.1* |
| | November | 154.2* | 85.2 | 15.8* |
| | December | 150.8* | 82.0 | 17.1* |
| 2003 | January | 148.1* | 80.8 | 18.2* |
| | February | 143.6* | 78.3 | 18.9* |
| | March | 138.4* | 74.0 | 19.5* |
| | April | 135.2* | 70.1* | 20.1* |
| | May | 133.4* | 67.6* | 20.9* |
| | June | 130.5* | 65.0* | 21.5* |
| | July | | | |
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| | December | | | |

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

* Preliminary Estimates

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|-------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2003.5007 | JUL | 131.3 | 128.2 | 125.8 | 22.2 | 21.8 | 20.9 |
| 2003.5840 | AUG | 130.4 | 125.9 | 121.2 | 22.9 | 22.0 | 20.6 |
| 2003.6673 | SEP | 130.8 | 123.7 | 117.5 | 23.6 | 22.2 | 20.3 |
| 2003.7507 | OCT | 131.2 | 121.4 | 113.4 | 23.8 | 22.0 | 19.9 |
| 2003.8340 | NOV | 131.0 | 118.5 | 109.0 | 23.5 | 21.4 | 19.8 |
| 2003.9173 | DEC | 129.3 | 115.8 | 105.8 | 23.1 | 20.8 | 18.7 |
| 2004.0007 | JAN | 128.6 | 113.9 | 104.4 | 23.3 | 20.5 | 18.2 |
| 2004.0840 | FEB | 127.6 | 112.6 | 103.9 | 23.4 | 20.6 | 18.3 |
| 2004.1673 | MAR | 125.1 | 111.3 | 103.4 | 23.8 | 20.3 | 17.9 |
| 2004.2507 | APR | 124.8 | 110.2 | 102.9 | 24.0 | 19.6 | 16.9 |
| 2004.3340 | MAY | 124.2 | 108.9 | 102.2 | 23.9 | 18.7 | 15.5 |
| 2004.4173 | JUN | 123.2 | 107.2 | 100.0 | 23.1 | 17.7 | 14.0 |
| 2004.5007 | JUL | 121.7 | 105.2 | 97.0 | 21.9 | 16.8 | 13.4 |
| 2004.5840 | AUG | 119.4 | 103.2 | 94.5 | 21.8 | 16.4 | 12.7 |
| 2004.6673 | SEP | 115.6 | 101.3 | 92.7 | 21.8 | 16.1 | 12.1 |
| 2004.7507 | OCT | 113.3 | 99.3 | 91.5 | 21.4 | 15.9 | 12.2 |
| 2004.8340 | NOV | 111.7 | 97.7 | 90.1 | 21.2 | 15.6 | 12.2 |
| 2004.9173 | DEC | 110.1 | 96.6 | 88.9 | 21.6 | 15.4 | 12.4 |
| 2005.0007 | JAN | 108.8 | 95.4 | 87.9 | 22.0 | 15.2 | 12.3 |
| 2005.0840 | FEB | 107.2 | 93.7 | 86.4 | 22.5 | 14.8 | 11.5 |
| 2005.1673 | MAR | 105.3 | 92.4 | 85.3 | 23.0 | 14.5 | 10.8 |
| 2005.2507 | APR | 103.4 | 91.1 | 84.2 | 24.0 | 14.6 | 10.9 |
| 2005.3340 | MAY | 101.5 | 89.8 | 83.1 | 24.7 | 14.8 | 10.7 |
| 2005.4173 | JUN | 99.7 | 88.4 | 82.1 | 25.0 | 14.9 | 10.8 |
| 2005.5007 | JUL | 97.9 | 87.2 | 81.0 | 25.1 | 14.9 | 10.8 |
| 2005.5840 | AUG | 96.0 | 85.9 | 80.0 | 24.9 | 15.1 | 10.9 |
| 2005.6673 | SEP | 94.3 | 84.6 | 79.0 | 24.1 | 15.1 | 11.0 |
| 2005.7507 | OCT | 92.5 | 83.4 | 78.0 | 23.1 | 14.9 | 11.2 |
| 2005.8340 | NOV | 90.8 | 82.2 | 77.0 | 22.3 | 14.7 | 11.2 |
| 2005.9173 | DEC | 89.2 | 81.0 | 76.1 | 21.6 | 14.6 | 10.6 |
| 2006.0007 | JAN | 87.6 | 79.9 | 75.2 | 20.9 | 14.4 | 10.2 |
| 2006.0840 | FEB | 86.0 | 78.8 | 74.3 | 20.1 | 14.3 | 10.1 |
| 2006.1673 | MAR | 84.6 | 77.8 | 73.5 | 19.3 | 14.0 | 10.3 |
| 2006.2507 | APR | 83.1 | 76.8 | 72.7 | 18.3 | 13.7 | 10.1 |
| 2006.3340 | MAY | 81.8 | 75.8 | 71.9 | 17.1 | 13.5 | 10.3 |
| 2006.4173 | JUN | 80.5 | 74.9 | 71.2 | 17.3 | 13.5 | 10.2 |
| 2006.5007 | JUL | 79.4 | 74.1 | 70.5 | 17.3 | 13.4 | 10.1 |
| 2006.5840 | AUG | 78.3 | 73.3 | 69.9 | 16.8 | 13.3 | 10.1 |
| 2006.6673 | SEP | 77.3 | 72.6 | 69.3 | 16.0 | 13.1 | 9.6 |
| 2006.7507 | OCT | 76.4 | 72.0 | 68.8 | 15.6 | 13.3 | 9.1 |
| 2006.8340 | NOV | 75.6 | 71.4 | 68.3 | 15.8 | 13.4 | 8.5 |
| 2006.9173 | DEC | 74.9 | 70.9 | 67.9 | 16.0 | 13.5 | 8.5 |
| 2007.0007 | JAN | 74.3 | 70.5 | 67.6 | 16.7 | 13.8 | 8.8 |
| 2007.0840 | FEB | 73.8 | 70.2 | 67.3 | 17.2 | 14.0 | 9.1 |
| 2007.1673 | MAR | 73.5 | 70.0 | 67.2 | 17.2 | 13.8 | 9.0 |
| 2007.2507 | APR | 73.3 | 69.8 | 67.0 | 17.4 | 13.6 | 8.8 |
| 2007.3340 | MAY | 73.2 | 69.8 | 67.0 | 17.6 | 13.3 | 8.4 |
| 2007.4173 | JUN | 73.4 | 69.9 | 67.1 | 17.2 | 12.8 | 8.1 |
| 2007.5007 | JUL | 74.0 | 70.3 | 67.3 | 16.8 | 12.3 | 7.9 |
| 2007.5840 | AUG | 74.8 | 70.7 | 67.4 | 16.1 | 11.9 | 7.8 |
| 2007.6673 | SEP | 75.7 | 71.0 | 67.5 | 15.5 | 11.6 | 7.7 |
| 2007.7507 | OCT | 76.7 | 71.5 | 67.6 | 14.9 | 11.2 | 7.6 |

* Program Initialized from established Cycle 23 smoothed 10.7-cm solar flux minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2007.8340 | NOV | 78.3 | 72.0 | 67.9 | 14.2 | 10.8 | 7.5 | | |
| 2007.9173 | DEC | 79.6 | 72.7 | 68.1 | 13.7 | 10.5 | 7.4 | | |
| 2008.0007 | JAN | 81.1 | 73.3 | 68.2 | 13.1 | 10.2 | 7.3 | | |
| 2008.0840 | FEB | 83.4 | 74.2 | 68.2 | 12.6 | 9.9 | 7.2 | | |
| 2008.1673 | MAR | 86.5 | 75.1 | 68.3 | 12.2 | 9.6 | 7.1 | | |
| 2008.2507 | APR | 91.3 | 76.3 | 68.3 | 11.8 | 9.4 | 7.0 | | |
| 2008.3340 | MAY | 95.8 | 77.7 | 68.3 | 11.5 | 9.2 | 7.0 | | |
| 2008.4173 | JUN | 99.3 | 79.1 | 68.6 | 11.3 | 9.1 | 6.9 | | |
| 2008.5007 | JUL | 104.6 | 80.8 | 68.6 | 11.1 | 9.0 | 6.9 | | |
| 2008.5840 | AUG | 110.7 | 82.8 | 68.7 | 11.1 | 9.0 | 6.9 | | |
| 2008.6673 | SEP | 116.6 | 84.9 | 68.9 | 11.3 | 9.1 | 6.9 | | |
| 2008.7507 | OCT | 124.0 | 87.2 | 68.9 | 11.6 | 9.3 | 7.1 | | |
| 2008.8340 | NOV | 132.5 | 89.6 | 69.0 | 11.7 | 9.4 | 7.4 | | |
| 2008.9173 | DEC | 139.0 | 92.2 | 69.4 | 11.9 | 9.5 | 7.5 | | |
| 2009.0007 | JAN | 143.6 | 95.0 | 69.8 | 12.0 | 9.6 | 7.5 | | |
| 2009.0840 | FEB | 147.9 | 97.8 | 70.1 | 12.1 | 9.6 | 7.3 | | |
| 2009.1673 | MAR | 152.2 | 100.6 | 70.8 | 12.2 | 9.7 | 7.2 | | |
| 2009.2507 | APR | 157.0 | 103.3 | 71.2 | 12.6 | 9.8 | 7.0 | | |
| 2009.3340 | MAY | 162.1 | 106.3 | 71.4 | 12.9 | 10.1 | 6.9 | | |
| 2009.4173 | JUN | 167.2 | 109.5 | 72.1 | 13.3 | 10.5 | 7.1 | | |
| 2009.5007 | JUL | 171.5 | 112.8 | 72.7 | 13.8 | 10.8 | 7.5 | | |
| 2009.5840 | AUG | 177.3 | 115.9 | 73.3 | 14.6 | 11.1 | 7.8 | | |
| 2009.6673 | SEP | 185.2 | 119.0 | 74.0 | 15.8 | 11.4 | 7.6 | | |
| 2009.7507 | OCT | 190.2 | 122.2 | 74.3 | 16.2 | 11.6 | 7.6 | | |
| 2009.8340 | NOV | 192.8 | 125.1 | 74.6 | 16.4 | 11.7 | 7.5 | | |
| 2009.9173 | DEC | 195.4 | 127.5 | 75.0 | 16.9 | 11.9 | 7.5 | | |
| 2010.0007 | JAN | 198.3 | 129.7 | 75.3 | 18.1 | 12.2 | 7.5 | | |
| 2010.0840 | FEB | 202.9 | 131.9 | 75.5 | 19.0 | 12.6 | 7.6 | | |
| 2010.1673 | MAR | 209.1 | 134.3 | 75.5 | 19.2 | 12.8 | 7.6 | | |
| 2010.2507 | APR | 213.2 | 136.8 | 75.1 | 19.3 | 13.0 | 7.7 | | |
| 2010.3340 | MAY | 215.9 | 139.1 | 74.9 | 19.1 | 13.2 | 7.6 | | |
| 2010.4173 | JUN | 220.4 | 141.2 | 75.2 | 18.7 | 13.3 | 7.6 | | |
| 2010.5007 | JUL | 225.0 | 143.1 | 75.5 | 18.6 | 13.3 | 7.7 | | |
| 2010.5840 | AUG | 227.3 | 144.9 | 76.3 | 19.0 | 13.5 | 7.9 | | |
| 2010.6673 | SEP | 228.4 | 146.5 | 77.5 | 18.9 | 13.6 | 8.1 | | |
| 2010.7507 | OCT | 230.3 | 147.9 | 78.2 | 17.9 | 13.6 | 8.5 | | |
| 2010.8340 | NOV | 232.4 | 148.8 | 79.1 | 18.0 | 13.8 | 8.6 | | |
| 2010.9173 | DEC | 235.4 | 149.7 | 80.7 | 18.6 | 14.1 | 8.6 | | |
| 2011.0007 | JAN | 238.7 | 150.1 | 82.6 | 19.2 | 14.3 | 8.9 | | |
| 2011.0840 | FEB | 240.3 | 150.5 | 84.7 | 19.7 | 14.8 | 9.3 | | |
| 2011.1673 | MAR | 238.7 | 150.8 | 85.9 | 20.4 | 15.1 | 9.5 | | |
| 2011.2507 | APR | 236.9 | 151.0 | 86.9 | 20.4 | 15.2 | 9.5 | | |
| 2011.3340 | MAY | 238.1 | 151.2 | 88.8 | 20.4 | 15.2 | 9.7 | | |
| 2011.4173 | JUN | 238.7 | 150.6 | 90.2 | 20.6 | 15.2 | 9.9 | | |
| 2011.5007 | JUL | 236.3 | 149.2 | 92.2 | 20.9 | 15.4 | 10.4 | | |
| 2011.5840 | AUG | 232.9 | 148.1 | 93.5 | 21.3 | 15.4 | 11.0 | | |
| 2011.6673 | SEP | 229.2 | 147.5 | 94.0 | 21.3 | 15.3 | 11.6 | | |
| 2011.7507 | OCT | 227.4 | 147.4 | 95.3 | 21.5 | 15.1 | 11.2 | | |
| 2011.8340 | NOV | 227.8 | 147.4 | 95.6 | 21.7 | 15.1 | 11.1 | | |
| 2011.9173 | DEC | 227.9 | 147.1 | 95.2 | 22.1 | 15.1 | 10.6 | | |
| 2012.0007 | JAN | 226.5 | 146.7 | 95.3 | 22.9 | 15.0 | 10.1 | | |
| 2012.0840 | FEB | 224.8 | 146.3 | 96.8 | 22.6 | 14.7 | 9.8 | | |

* Program Initialized from established Cycle 23 smoothed 10.7-cm solar flux minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2012.1673 | MAR | 224.3 | 145.7 | 97.5 | 21.4 | 14.4 | 10.0 |
| 2012.2507 | APR | 224.2 | 145.2 | 97.1 | 20.7 | 14.3 | 10.0 |
| 2012.3340 | MAY | 223.6 | 144.8 | 96.3 | 20.1 | 14.2 | 10.2 |
| 2012.4173 | JUN | 222.6 | 144.0 | 96.3 | 19.7 | 14.1 | 10.5 |
| 2012.5007 | JUL | 220.3 | 143.0 | 96.8 | 19.6 | 14.1 | 10.5 |
| 2012.5840 | AUG | 216.8 | 141.4 | 95.9 | 19.4 | 14.1 | 10.4 |
| 2012.6673 | SEP | 213.9 | 139.8 | 95.4 | 19.2 | 14.4 | 10.4 |
| 2012.7507 | OCT | 211.1 | 138.6 | 96.2 | 19.0 | 14.7 | 10.4 |
| 2012.8340 | NOV | 207.6 | 137.6 | 97.2 | 19.0 | 14.9 | 10.2 |
| 2012.9173 | DEC | 206.6 | 136.3 | 96.2 | 19.5 | 14.8 | 9.8 |
| 2013.0007 | JAN | 204.5 | 134.6 | 94.6 | 20.5 | 14.9 | 10.1 |
| 2013.0840 | FEB | 201.1 | 132.8 | 93.9 | 22.1 | 15.3 | 10.6 |
| 2013.1673 | MAR | 197.5 | 131.4 | 93.6 | 23.5 | 15.6 | 10.6 |
| 2013.2507 | APR | 195.2 | 130.3 | 91.9 | 24.1 | 15.8 | 10.8 |
| 2013.3340 | MAY | 193.4 | 128.9 | 88.5 | 25.3 | 16.1 | 10.9 |
| 2013.4173 | JUN | 189.6 | 127.1 | 87.7 | 25.8 | 16.3 | 11.1 |
| 2013.5007 | JUL | 185.1 | 125.5 | 88.8 | 25.0 | 16.3 | 11.4 |
| 2013.5840 | AUG | 180.7 | 124.2 | 88.3 | 24.9 | 16.2 | 11.6 |
| 2013.6673 | SEP | 176.8 | 123.1 | 87.0 | 24.1 | 16.2 | 11.7 |
| 2013.7507 | OCT | 174.6 | 122.0 | 86.0 | 22.2 | 16.1 | 11.7 |
| 2013.8340 | NOV | 172.7 | 120.8 | 85.7 | 22.5 | 16.2 | 11.9 |
| 2013.9173 | DEC | 168.6 | 119.2 | 84.8 | 23.2 | 16.3 | 11.7 |
| 2014.0007 | JAN | 162.0 | 117.2 | 83.5 | 23.3 | 16.3 | 10.9 |
| 2014.0840 | FEB | 156.1 | 115.4 | 82.5 | 22.8 | 16.1 | 10.6 |
| 2014.1673 | MAR | 152.5 | 113.5 | 81.9 | 22.1 | 15.9 | 10.7 |
| 2014.2507 | APR | 150.3 | 111.5 | 81.9 | 22.0 | 15.9 | 10.7 |
| 2014.3340 | MAY | 148.0 | 109.8 | 81.6 | 22.9 | 16.1 | 10.6 |
| 2014.4173 | JUN | 145.1 | 108.3 | 80.4 | 23.8 | 16.4 | 10.7 |
| 2014.5007 | JUL | 142.0 | 106.9 | 80.5 | 24.0 | 16.6 | 10.7 |
| 2014.5840 | AUG | 138.4 | 105.4 | 80.2 | 24.0 | 16.8 | 10.6 |
| 2014.6673 | SEP | 134.5 | 103.9 | 79.5 | 24.0 | 16.9 | 10.5 |
| 2014.7507 | OCT | 130.1 | 102.4 | 79.0 | 23.6 | 16.9 | 10.2 |
| 2014.8340 | NOV | 124.1 | 100.8 | 78.2 | 22.7 | 16.9 | 10.3 |
| 2014.9173 | DEC | 119.1 | 99.3 | 77.1 | 22.9 | 16.8 | 10.5 |
| 2015.0007 | JAN | 118.2 | 98.0 | 75.4 | 23.1 | 16.9 | 11.3 |
| 2015.0840 | FEB | 118.7 | 96.9 | 74.3 | 23.2 | 17.2 | 11.8 |
| 2015.1673 | MAR | 119.3 | 95.9 | 73.6 | 22.6 | 17.3 | 11.9 |
| 2015.2507 | APR | 119.6 | 95.0 | 72.8 | 21.6 | 17.2 | 12.1 |
| 2015.3340 | MAY | 118.8 | 94.0 | 71.8 | 21.3 | 17.1 | 12.2 |
| 2015.4173 | JUN | 117.4 | 92.9 | 71.3 | 21.8 | 16.9 | 12.4 |
| 2015.5007 | JUL | 116.0 | 91.8 | 70.8 | 21.8 | 16.7 | 13.2 |
| 2015.5840 | AUG | 113.9 | 90.7 | 70.4 | 22.2 | 16.8 | 13.0 |
| 2015.6673 | SEP | 110.2 | 89.5 | 70.3 | 22.6 | 16.9 | 12.7 |
| 2015.7507 | OCT | 105.1 | 88.2 | 70.4 | 22.4 | 16.9 | 13.0 |
| 2015.8340 | NOV | 102.7 | 87.3 | 70.2 | 22.4 | 16.7 | 12.7 |
| 2015.9173 | DEC | 101.7 | 86.6 | 70.1 | 22.8 | 16.5 | 12.4 |
| 2016.0007 | JAN | 100.2 | 85.8 | 70.2 | 23.0 | 16.1 | 12.0 |
| 2016.0840 | FEB | 98.1 | 84.7 | 70.1 | 23.6 | 15.8 | 11.1 |
| 2016.1673 | MAR | 96.3 | 83.6 | 70.3 | 24.2 | 15.6 | 10.4 |
| 2016.2507 | APR | 94.5 | 82.5 | 69.8 | 25.0 | 15.5 | 10.5 |
| 2016.3340 | MAY | 93.4 | 81.8 | 69.6 | 25.5 | 15.5 | 10.6 |
| 2016.4173 | JUN | 92.1 | 81.0 | 69.4 | 25.7 | 15.5 | 10.5 |

* Program Initialized from established Cycle 23 smoothed 10.7-cm solar flux minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2016.5007 | JUL | 91.7 | 80.3 | 69.3 | 25.6 | 15.4 | 10.6 |
| 2016.5840 | AUG | 91.1 | 79.5 | 69.0 | 25.0 | 15.3 | 10.9 |
| 2016.6673 | SEP | 90.5 | 78.8 | 68.7 | 24.1 | 15.1 | 11.0 |
| 2016.7507 | OCT | 89.8 | 78.1 | 68.4 | 23.1 | 14.9 | 11.2 |
| 2016.8340 | NOV | 88.9 | 77.5 | 68.3 | 22.6 | 15.0 | 11.1 |
| 2016.9173 | DEC | 88.0 | 77.0 | 68.3 | 22.2 | 15.2 | 11.0 |
| 2017.0007 | JAN | 87.1 | 76.4 | 68.2 | 21.9 | 15.4 | 11.1 |
| 2017.0840 | FEB | 85.8 | 75.9 | 68.0 | 21.5 | 15.5 | 11.3 |
| 2017.1673 | MAR | 84.4 | 75.4 | 67.7 | 20.8 | 15.5 | 11.4 |
| 2017.2507 | APR | 82.3 | 74.8 | 67.5 | 20.0 | 15.3 | 11.4 |
| 2017.3340 | MAY | 79.9 | 74.2 | 67.6 | 20.1 | 15.1 | 11.7 |
| 2017.4173 | JUN | 78.4 | 73.5 | 67.4 | 20.2 | 14.9 | 11.9 |
| 2017.5007 | JUL | 77.5 | 72.9 | 67.3 | 19.9 | 14.7 | 11.6 |
| 2017.5840 | AUG | 77.0 | 72.4 | 67.2 | 19.5 | 14.6 | 11.5 |
| 2017.6673 | SEP | 76.9 | 72.0 | 67.2 | 19.0 | 14.6 | 11.1 |
| 2017.7507 | OCT | 76.7 | 71.6 | 67.2 | 18.2 | 14.6 | 10.6 |
| 2017.8340 | NOV | 76.5 | 71.3 | 67.1 | 17.3 | 14.5 | 9.8 |
| 2017.9173 | DEC | 76.2 | 71.0 | 67.1 | 17.4 | 14.4 | 9.4 |
| 2018.0007 | JAN | 75.2 | 70.7 | 67.0 | 17.5 | 14.3 | 9.3 |
| 2018.0840 | FEB | 74.2 | 70.4 | 67.0 | 17.6 | 14.2 | 9.3 |
| 2018.1673 | MAR | 74.0 | 70.1 | 67.0 | 17.6 | 14.1 | 9.3 |

* Program Initialized from established Cycle 23 smoothed 10.7-cm solar flux minimum

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

| TIME | | SUNSPOT NUMBER PERCENTILE | | | \bar{R} 5.0% | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p 5.0% |
|-----------|-----|------------------------------|------|------|-------------------|---------------------------------|------|------|---------------------|
| | | 95.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2003.5007 | JUL | 66.7 | 63.4 | 60.1 | 22.2 | 21.8 | 20.9 | | |
| 2003.5840 | AUG | 67.2 | 61.6 | 55.1 | 22.9 | 22.0 | 20.6 | | |
| 2003.6673 | SEP | 67.5 | 59.8 | 51.3 | 23.6 | 22.2 | 20.3 | | |
| 2003.7507 | OCT | 68.5 | 57.9 | 47.7 | 23.8 | 22.0 | 19.9 | | |
| 2003.8340 | NOV | 69.0 | 55.9 | 44.0 | 23.5 | 21.4 | 19.8 | | |
| 2003.9173 | DEC | 67.9 | 53.7 | 41.7 | 23.1 | 20.8 | 18.7 | | |
| 2004.0007 | JAN | 67.6 | 51.7 | 41.1 | 23.3 | 20.5 | 18.2 | | |
| 2004.0840 | FEB | 66.5 | 50.4 | 40.3 | 23.4 | 20.6 | 18.3 | | |
| 2004.1673 | MAR | 63.8 | 49.2 | 39.5 | 23.8 | 20.3 | 17.9 | | |
| 2004.2507 | APR | 61.5 | 48.0 | 38.7 | 24.0 | 19.6 | 16.9 | | |
| 2004.3340 | MAY | 60.0 | 46.5 | 37.7 | 23.9 | 18.7 | 15.5 | | |
| 2004.4173 | JUN | 59.9 | 44.8 | 35.6 | 23.1 | 17.7 | 14.0 | | |
| 2004.5007 | JUL | 59.7 | 43.1 | 32.3 | 21.9 | 16.8 | 13.4 | | |
| 2004.5840 | AUG | 59.1 | 41.4 | 29.6 | 21.8 | 16.4 | 12.7 | | |
| 2004.6673 | SEP | 58.0 | 39.8 | 28.3 | 21.8 | 16.1 | 12.1 | | |
| 2004.7507 | OCT | 56.4 | 38.1 | 27.5 | 21.4 | 15.9 | 12.2 | | |
| 2004.8340 | NOV | 55.2 | 36.7 | 26.2 | 21.2 | 15.6 | 12.2 | | |
| 2004.9173 | DEC | 53.7 | 35.8 | 25.0 | 21.6 | 15.4 | 12.4 | | |
| 2005.0007 | JAN | 52.5 | 34.7 | 24.1 | 22.0 | 15.2 | 12.3 | | |
| 2005.0840 | FEB | 51.3 | 33.3 | 22.7 | 22.5 | 14.8 | 11.5 | | |
| 2005.1673 | MAR | 49.1 | 31.6 | 19.7 | 23.0 | 14.5 | 10.8 | | |
| 2005.2507 | APR | 46.5 | 30.1 | 17.0 | 24.0 | 14.6 | 10.9 | | |
| 2005.3340 | MAY | 44.5 | 29.0 | 15.2 | 24.7 | 14.8 | 10.7 | | |
| 2005.4173 | JUN | 42.8 | 27.8 | 12.4 | 25.0 | 14.9 | 10.8 | | |
| 2005.5007 | JUL | 40.5 | 26.7 | 10.5 | 25.1 | 14.9 | 10.8 | | |
| 2005.5840 | AUG | 38.4 | 25.6 | 9.7 | 24.9 | 15.1 | 10.9 | | |
| 2005.6673 | SEP | 36.8 | 24.6 | 8.9 | 24.1 | 15.1 | 11.0 | | |
| 2005.7507 | OCT | 35.0 | 23.2 | 8.2 | 23.1 | 14.9 | 11.2 | | |
| 2005.8340 | NOV | 33.2 | 21.9 | 7.6 | 22.3 | 14.7 | 11.2 | | |
| 2005.9173 | DEC | 31.4 | 20.5 | 6.9 | 21.6 | 14.6 | 10.6 | | |
| 2006.0007 | JAN | 29.6 | 19.1 | 6.3 | 20.9 | 14.4 | 10.2 | | |
| 2006.0840 | FEB | 27.8 | 17.8 | 5.6 | 20.1 | 14.3 | 10.1 | | |
| 2006.1673 | MAR | 26.1 | 16.5 | 5.0 | 19.3 | 14.0 | 10.3 | | |
| 2006.2507 | APR | 24.5 | 15.2 | 4.4 | 18.3 | 13.7 | 10.1 | | |
| 2006.3340 | MAY | 22.9 | 14.0 | 3.9 | 17.1 | 13.5 | 10.3 | | |
| 2006.4173 | JUN | 21.4 | 12.9 | 3.3 | 17.3 | 13.5 | 10.2 | | |
| 2006.5007 | JUL | 20.0 | 11.8 | 2.8 | 17.3 | 13.4 | 10.1 | | |
| 2006.5840 | AUG | 18.6 | 10.8 | 2.3 | 16.8 | 13.3 | 10.1 | | |
| 2006.6673 | SEP | 17.4 | 9.9 | 1.9 | 16.0 | 13.1 | 9.6 | | |
| 2006.7507 | OCT | 16.3 | 9.0 | 1.5 | 15.6 | 13.3 | 9.1 | | |
| 2006.8340 | NOV | 15.3 | 8.2 | 1.1 | 15.8 | 13.4 | 8.5 | | |
| 2006.9173 | DEC | 14.4 | 7.6 | 0.8 | 16.0 | 13.5 | 8.5 | | |
| 2007.0007 | JAN | 13.7 | 7.0 | 0.5 | 16.7 | 13.8 | 8.8 | | |
| 2007.0840 | FEB | 13.1 | 6.6 | 0.3 | 17.2 | 14.0 | 9.1 | | |
| 2007.1673 | MAR | 12.6 | 6.2 | 0.1 | 17.2 | 13.8 | 9.0 | | |
| 2007.2507 | APR | 12.4 | 6.0 | 0.0 | 17.4 | 13.6 | 8.8 | | |
| 2007.3340 | MAY | 12.3 | 6.0 | 0.0 | 17.6 | 13.3 | 8.4 | | |
| 2007.4173 | JUN | 12.9 | 6.3 | 0.4 | 17.2 | 12.8 | 8.1 | | |
| 2007.5007 | JUL | 14.3 | 6.9 | 0.7 | 16.8 | 12.3 | 7.9 | | |
| 2007.5840 | AUG | 15.5 | 7.6 | 1.0 | 16.1 | 11.9 | 7.8 | | |
| 2007.6673 | SEP | 16.7 | 8.2 | 1.5 | 15.5 | 11.6 | 7.7 | | |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | SUNSPOT NUMBER PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|------------------------------|-------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2007.7507 | OCT | 18.1 | 9.0 | 1.7 | 14.9 | 11.2 | 7.6 |
| 2007.8340 | NOV | 20.6 | 9.9 | 2.2 | 14.2 | 10.8 | 7.5 |
| 2007.9173 | DEC | 22.9 | 10.9 | 2.7 | 13.7 | 10.5 | 7.4 |
| 2008.0007 | JAN | 25.0 | 12.0 | 2.9 | 13.1 | 10.2 | 7.3 |
| 2008.0840 | FEB | 28.3 | 13.2 | 3.1 | 12.6 | 9.9 | 7.2 |
| 2008.1673 | MAR | 32.2 | 14.6 | 3.3 | 12.2 | 9.6 | 7.1 |
| 2008.2507 | APR | 38.3 | 16.3 | 3.3 | 11.8 | 9.4 | 7.0 |
| 2008.3340 | MAY | 43.7 | 18.3 | 3.3 | 11.5 | 9.2 | 7.0 |
| 2008.4173 | JUN | 47.9 | 20.4 | 4.0 | 11.3 | 9.1 | 6.9 |
| 2008.5007 | JUL | 53.9 | 22.6 | 4.2 | 11.1 | 9.0 | 6.9 |
| 2008.5840 | AUG | 60.9 | 25.0 | 4.3 | 11.1 | 9.0 | 6.9 |
| 2008.6673 | SEP | 67.5 | 27.6 | 4.8 | 11.3 | 9.1 | 6.9 |
| 2008.7507 | OCT | 75.1 | 30.2 | 4.6 | 11.6 | 9.3 | 7.1 |
| 2008.8340 | NOV | 83.9 | 33.0 | 4.8 | 11.7 | 9.4 | 7.4 |
| 2008.9173 | DEC | 90.9 | 36.2 | 5.6 | 11.9 | 9.5 | 7.5 |
| 2009.0007 | JAN | 96.0 | 39.9 | 6.6 | 12.0 | 9.6 | 7.5 |
| 2009.0840 | FEB | 100.8 | 43.5 | 7.3 | 12.1 | 9.6 | 7.3 |
| 2009.1673 | MAR | 105.5 | 46.9 | 8.6 | 12.2 | 9.7 | 7.2 |
| 2009.2507 | APR | 110.7 | 50.3 | 9.5 | 12.6 | 9.8 | 7.0 |
| 2009.3340 | MAY | 116.4 | 53.7 | 9.6 | 12.9 | 10.1 | 6.9 |
| 2009.4173 | JUN | 121.8 | 57.4 | 11.1 | 13.3 | 10.5 | 7.1 |
| 2009.5007 | JUL | 126.2 | 61.0 | 12.2 | 13.8 | 10.8 | 7.5 |
| 2009.5840 | AUG | 134.2 | 64.5 | 13.2 | 14.6 | 11.1 | 7.8 |
| 2009.6673 | SEP | 141.9 | 67.7 | 14.4 | 15.8 | 11.4 | 7.6 |
| 2009.7507 | OCT | 146.6 | 71.2 | 14.9 | 16.2 | 11.6 | 7.6 |
| 2009.8340 | NOV | 148.6 | 74.6 | 15.4 | 16.4 | 11.7 | 7.5 |
| 2009.9173 | DEC | 151.8 | 77.4 | 16.0 | 16.9 | 11.9 | 7.5 |
| 2010.0007 | JAN | 155.5 | 79.8 | 16.4 | 18.1 | 12.2 | 7.5 |
| 2010.0840 | FEB | 159.3 | 81.9 | 16.7 | 19.0 | 12.6 | 7.6 |
| 2010.1673 | MAR | 164.8 | 84.2 | 16.6 | 19.2 | 12.8 | 7.6 |
| 2010.2507 | APR | 168.2 | 86.5 | 16.1 | 19.3 | 13.0 | 7.7 |
| 2010.3340 | MAY | 169.9 | 88.9 | 15.7 | 19.1 | 13.2 | 7.6 |
| 2010.4173 | JUN | 173.9 | 91.1 | 16.1 | 18.7 | 13.3 | 7.6 |
| 2010.5007 | JUL | 178.8 | 93.2 | 16.6 | 18.6 | 13.3 | 7.7 |
| 2010.5840 | AUG | 181.8 | 95.2 | 17.7 | 19.0 | 13.5 | 7.9 |
| 2010.6673 | SEP | 183.9 | 97.4 | 19.5 | 18.9 | 13.6 | 8.1 |
| 2010.7507 | OCT | 186.7 | 99.4 | 20.7 | 17.9 | 13.6 | 8.5 |
| 2010.8340 | NOV | 189.2 | 100.7 | 22.0 | 18.0 | 13.8 | 8.6 |
| 2010.9173 | DEC | 191.5 | 101.6 | 24.3 | 18.6 | 14.1 | 8.6 |
| 2011.0007 | JAN | 192.9 | 101.8 | 27.0 | 19.2 | 14.3 | 8.9 |
| 2011.0840 | FEB | 194.3 | 102.2 | 29.8 | 19.7 | 14.8 | 9.3 |
| 2011.1673 | MAR | 194.4 | 103.0 | 31.5 | 20.4 | 15.1 | 9.5 |
| 2011.2507 | APR | 193.8 | 103.6 | 32.8 | 20.4 | 15.2 | 9.5 |
| 2011.3340 | MAY | 195.2 | 104.2 | 35.3 | 20.4 | 15.2 | 9.7 |
| 2011.4173 | JUN | 195.8 | 103.7 | 37.1 | 20.6 | 15.2 | 9.9 |
| 2011.5007 | JUL | 192.6 | 102.3 | 39.5 | 20.9 | 15.4 | 10.4 |
| 2011.5840 | AUG | 188.0 | 101.0 | 41.2 | 21.3 | 15.4 | 11.0 |
| 2011.6673 | SEP | 183.4 | 100.2 | 41.9 | 21.3 | 15.3 | 11.6 |
| 2011.7507 | OCT | 181.2 | 100.0 | 43.4 | 21.5 | 15.1 | 11.2 |
| 2011.8340 | NOV | 180.5 | 99.8 | 43.7 | 21.7 | 15.1 | 11.1 |
| 2011.9173 | DEC | 179.4 | 99.1 | 43.2 | 22.1 | 15.1 | 10.6 |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | SUNSPOT NUMBER PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|------------------------------|------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2012.0007 | JAN | 178.2 | 98.5 | 43.3 | 22.9 | 15.0 | 10.1 |
| 2012.0840 | FEB | 176.8 | 98.0 | 45.1 | 22.6 | 14.7 | 9.8 |
| 2012.1673 | MAR | 176.1 | 97.4 | 46.0 | 21.4 | 14.4 | 10.0 |
| 2012.2507 | APR | 175.0 | 96.8 | 45.4 | 20.7 | 14.3 | 10.0 |
| 2012.3340 | MAY | 173.8 | 95.9 | 44.6 | 20.1 | 14.2 | 10.2 |
| 2012.4173 | JUN | 172.1 | 94.9 | 44.5 | 19.7 | 14.1 | 10.5 |
| 2012.5007 | JUL | 169.5 | 93.7 | 45.1 | 19.6 | 14.1 | 10.5 |
| 2012.5840 | AUG | 165.3 | 92.0 | 44.1 | 19.4 | 14.1 | 10.4 |
| 2012.6673 | SEP | 162.0 | 90.2 | 43.4 | 19.2 | 14.4 | 10.4 |
| 2012.7507 | OCT | 158.7 | 88.8 | 44.4 | 19.0 | 14.7 | 10.4 |
| 2012.8340 | NOV | 154.4 | 87.7 | 45.5 | 19.0 | 14.9 | 10.2 |
| 2012.9173 | DEC | 150.8 | 86.3 | 44.5 | 19.5 | 14.8 | 9.8 |
| 2013.0007 | JAN | 146.5 | 84.6 | 42.5 | 20.5 | 14.9 | 10.1 |
| 2013.0840 | FEB | 142.9 | 83.1 | 41.6 | 22.1 | 15.3 | 10.6 |
| 2013.1673 | MAR | 142.2 | 81.9 | 41.3 | 23.5 | 15.6 | 10.6 |
| 2013.2507 | APR | 138.9 | 80.6 | 39.2 | 24.1 | 15.8 | 10.8 |
| 2013.3340 | MAY | 136.8 | 79.1 | 34.9 | 25.3 | 16.1 | 10.9 |
| 2013.4173 | JUN | 135.9 | 77.3 | 33.9 | 25.8 | 16.3 | 11.1 |
| 2013.5007 | JUL | 132.9 | 75.6 | 35.4 | 25.0 | 16.3 | 11.4 |
| 2013.5840 | AUG | 129.3 | 74.2 | 34.8 | 24.9 | 16.2 | 11.6 |
| 2013.6673 | SEP | 125.3 | 73.1 | 33.1 | 24.1 | 16.2 | 11.7 |
| 2013.7507 | OCT | 121.0 | 71.9 | 31.9 | 22.2 | 16.1 | 11.7 |
| 2013.8340 | NOV | 117.5 | 70.5 | 31.3 | 22.5 | 16.2 | 11.9 |
| 2013.9173 | DEC | 115.3 | 68.8 | 30.2 | 23.2 | 16.3 | 11.7 |
| 2014.0007 | JAN | 111.4 | 66.9 | 28.4 | 23.3 | 16.3 | 10.9 |
| 2014.0840 | FEB | 104.9 | 64.9 | 27.0 | 22.8 | 16.1 | 10.6 |
| 2014.1673 | MAR | 98.0 | 62.6 | 26.2 | 22.1 | 15.9 | 10.7 |
| 2014.2507 | APR | 94.1 | 60.4 | 26.3 | 22.0 | 15.9 | 10.7 |
| 2014.3340 | MAY | 93.1 | 58.6 | 25.8 | 22.9 | 16.1 | 10.6 |
| 2014.4173 | JUN | 92.2 | 57.1 | 24.2 | 23.8 | 16.4 | 10.7 |
| 2014.5007 | JUL | 89.9 | 55.6 | 24.3 | 24.0 | 16.6 | 10.7 |
| 2014.5840 | AUG | 87.6 | 54.1 | 23.9 | 24.0 | 16.8 | 10.6 |
| 2014.6673 | SEP | 83.8 | 52.4 | 22.9 | 24.0 | 16.9 | 10.5 |
| 2014.7507 | OCT | 80.3 | 50.7 | 22.1 | 23.6 | 16.9 | 10.2 |
| 2014.8340 | NOV | 76.6 | 49.0 | 20.9 | 22.7 | 16.9 | 10.3 |
| 2014.9173 | DEC | 71.1 | 47.1 | 19.3 | 22.9 | 16.8 | 10.5 |
| 2015.0007 | JAN | 69.8 | 45.4 | 16.8 | 23.1 | 16.9 | 11.3 |
| 2015.0840 | FEB | 70.3 | 44.2 | 14.9 | 23.2 | 17.2 | 11.8 |
| 2015.1673 | MAR | 69.9 | 42.9 | 13.8 | 22.6 | 17.3 | 11.9 |
| 2015.2507 | APR | 69.7 | 41.8 | 12.3 | 21.6 | 17.2 | 12.1 |
| 2015.3340 | MAY | 68.9 | 40.4 | 10.5 | 21.3 | 17.1 | 12.2 |
| 2015.4173 | JUN | 66.9 | 38.9 | 9.5 | 21.8 | 16.9 | 12.4 |
| 2015.5007 | JUL | 64.3 | 37.4 | 8.7 | 21.8 | 16.7 | 13.2 |
| 2015.5840 | AUG | 61.0 | 36.1 | 7.8 | 22.2 | 16.8 | 13.0 |
| 2015.6673 | SEP | 56.5 | 34.7 | 7.6 | 22.6 | 16.9 | 12.7 |
| 2015.7507 | OCT | 52.1 | 33.2 | 7.7 | 22.4 | 16.9 | 13.0 |
| 2015.8340 | NOV | 48.9 | 32.1 | 7.4 | 22.4 | 16.7 | 12.7 |
| 2015.9173 | DEC | 49.9 | 31.3 | 7.2 | 22.8 | 16.5 | 12.4 |
| 2016.0007 | JAN | 49.1 | 30.3 | 7.3 | 23.0 | 16.1 | 12.0 |
| 2016.0840 | FEB | 46.6 | 29.0 | 7.2 | 23.6 | 15.8 | 11.1 |
| 2016.1673 | MAR | 44.5 | 27.6 | 7.7 | 24.2 | 15.6 | 10.4 |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | SUNSPOT NUMBER PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|------------------------------|------|------|---------------------------------|------|------|
| | | 95.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2016.2507 | APR | 42.4 | 26.3 | 6.6 | 25.0 | 15.5 | 10.5 |
| 2016.3340 | MAY | 41.1 | 25.4 | 6.2 | 25.5 | 15.5 | 10.6 |
| 2016.4173 | JUN | 39.5 | 24.4 | 5.8 | 25.7 | 15.5 | 10.5 |
| 2016.5007 | JUL | 38.9 | 23.5 | 5.4 | 25.6 | 15.4 | 10.6 |
| 2016.5840 | AUG | 38.3 | 22.5 | 4.9 | 25.0 | 15.3 | 10.9 |
| 2016.6673 | SEP | 37.9 | 21.6 | 4.3 | 24.1 | 15.1 | 11.0 |
| 2016.7507 | OCT | 37.1 | 20.6 | 3.5 | 23.1 | 14.9 | 11.2 |
| 2016.8340 | NOV | 36.1 | 19.7 | 3.4 | 22.6 | 15.0 | 11.1 |
| 2016.9173 | DEC | 34.9 | 19.0 | 3.3 | 22.2 | 15.2 | 11.0 |
| 2017.0007 | JAN | 33.5 | 18.1 | 3.1 | 21.9 | 15.4 | 11.1 |
| 2017.0840 | FEB | 31.8 | 17.1 | 2.5 | 21.5 | 15.5 | 11.3 |
| 2017.1673 | MAR | 29.9 | 16.2 | 1.9 | 20.8 | 15.5 | 11.4 |
| 2017.2507 | APR | 27.1 | 15.3 | 1.4 | 20.0 | 15.3 | 11.4 |
| 2017.3340 | MAY | 24.6 | 14.3 | 1.4 | 20.1 | 15.1 | 11.7 |
| 2017.4173 | JUN | 22.2 | 13.1 | 1.2 | 20.2 | 14.9 | 11.9 |
| 2017.5007 | JUL | 20.3 | 12.0 | 0.8 | 19.9 | 14.7 | 11.6 |
| 2017.5840 | AUG | 19.2 | 11.1 | 0.5 | 19.5 | 14.6 | 11.5 |
| 2017.6673 | SEP | 19.0 | 10.3 | 0.4 | 19.0 | 14.6 | 11.1 |
| 2017.7507 | OCT | 18.6 | 9.5 | 0.4 | 18.2 | 14.6 | 10.6 |
| 2017.8340 | NOV | 18.2 | 8.8 | 0.3 | 17.3 | 14.5 | 9.8 |
| 2017.9173 | DEC | 16.8 | 8.3 | 0.2 | 17.4 | 14.4 | 9.4 |
| 2018.0007 | JAN | 15.9 | 7.8 | 0.1 | 17.5 | 14.3 | 9.3 |
| 2018.0840 | FEB | 15.9 | 7.3 | 0.0 | 17.6 | 14.2 | 9.3 |
| 2018.1673 | MAR | 15.1 | 6.8 | 0.0 | 17.6 | 14.1 | 9.3 |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|-------|-------|---------------------------------|------|------|
| | | 75.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2003.5007 | JUL | 129.0 | 128.2 | 125.8 | 22.2 | 21.8 | 20.9 |
| 2003.5840 | AUG | 127.0 | 125.9 | 121.2 | 22.9 | 22.0 | 20.6 |
| 2003.6673 | SEP | 125.3 | 123.7 | 117.5 | 23.6 | 22.2 | 20.3 |
| 2003.7507 | OCT | 123.8 | 121.4 | 113.4 | 23.8 | 22.0 | 19.9 |
| 2003.8340 | NOV | 121.9 | 118.5 | 109.0 | 23.5 | 21.4 | 19.8 |
| 2003.9173 | DEC | 119.7 | 115.8 | 105.8 | 23.1 | 20.8 | 18.7 |
| 2004.0007 | JAN | 118.4 | 113.9 | 104.4 | 23.3 | 20.5 | 18.2 |
| 2004.0840 | FEB | 117.3 | 112.6 | 103.9 | 23.4 | 20.6 | 18.3 |
| 2004.1673 | MAR | 115.5 | 111.3 | 103.4 | 23.8 | 20.3 | 17.9 |
| 2004.2507 | APR | 114.7 | 110.2 | 102.9 | 24.0 | 19.6 | 16.9 |
| 2004.3340 | MAY | 113.2 | 108.9 | 102.2 | 23.9 | 18.7 | 15.5 |
| 2004.4173 | JUN | 111.5 | 107.2 | 100.0 | 23.1 | 17.7 | 14.0 |
| 2004.5007 | JUL | 109.4 | 105.2 | 97.0 | 21.9 | 16.8 | 13.4 |
| 2004.5840 | AUG | 107.1 | 103.2 | 94.5 | 21.8 | 16.4 | 12.7 |
| 2004.6673 | SEP | 105.5 | 101.3 | 92.7 | 21.8 | 16.1 | 12.1 |
| 2004.7507 | OCT | 104.9 | 99.3 | 91.5 | 21.4 | 15.9 | 12.2 |
| 2004.8340 | NOV | 103.8 | 97.7 | 90.1 | 21.2 | 15.6 | 12.2 |
| 2004.9173 | DEC | 101.1 | 96.6 | 88.9 | 21.6 | 15.4 | 12.4 |
| 2005.0007 | JAN | 99.2 | 95.4 | 87.9 | 22.0 | 15.2 | 12.3 |
| 2005.0840 | FEB | 96.8 | 93.7 | 86.4 | 22.5 | 14.8 | 11.5 |
| 2005.1673 | MAR | 95.4 | 92.4 | 85.3 | 23.0 | 14.5 | 10.8 |
| 2005.2507 | APR | 94.0 | 91.1 | 84.2 | 24.0 | 14.6 | 10.9 |
| 2005.3340 | MAY | 92.6 | 89.8 | 83.1 | 24.7 | 14.8 | 10.7 |
| 2005.4173 | JUN | 91.2 | 88.4 | 82.1 | 25.0 | 14.9 | 10.8 |
| 2005.5007 | JUL | 89.8 | 87.2 | 81.0 | 25.1 | 14.9 | 10.8 |
| 2005.5840 | AUG | 88.5 | 85.9 | 80.0 | 24.9 | 15.1 | 10.9 |
| 2005.6673 | SEP | 87.2 | 84.6 | 79.0 | 24.1 | 15.1 | 11.0 |
| 2005.7507 | OCT | 85.9 | 83.4 | 78.0 | 23.1 | 14.9 | 11.2 |
| 2005.8340 | NOV | 84.6 | 82.2 | 77.0 | 22.3 | 14.7 | 11.2 |
| 2005.9173 | DEC | 83.4 | 81.0 | 76.1 | 21.6 | 14.6 | 10.6 |
| 2006.0007 | JAN | 82.2 | 79.9 | 75.2 | 20.9 | 14.4 | 10.2 |
| 2006.0840 | FEB | 81.0 | 78.8 | 74.3 | 20.1 | 14.3 | 10.1 |
| 2006.1673 | MAR | 79.9 | 77.8 | 73.5 | 19.3 | 14.0 | 10.3 |
| 2006.2507 | APR | 78.8 | 76.8 | 72.7 | 18.3 | 13.7 | 10.1 |
| 2006.3340 | MAY | 77.8 | 75.8 | 71.9 | 17.1 | 13.5 | 10.3 |
| 2006.4173 | JUN | 76.9 | 74.9 | 71.2 | 17.3 | 13.5 | 10.2 |
| 2006.5007 | JUL | 76.0 | 74.1 | 70.5 | 17.3 | 13.4 | 10.1 |
| 2006.5840 | AUG | 75.2 | 73.3 | 69.9 | 16.8 | 13.3 | 10.1 |
| 2006.6673 | SEP | 74.4 | 72.6 | 69.3 | 16.0 | 13.1 | 9.6 |
| 2006.7507 | OCT | 73.8 | 72.0 | 68.8 | 15.6 | 13.3 | 9.1 |
| 2006.8340 | NOV | 73.2 | 71.4 | 68.3 | 15.8 | 13.4 | 8.5 |
| 2006.9173 | DEC | 72.7 | 70.9 | 67.9 | 16.0 | 13.5 | 8.5 |
| 2007.0007 | JAN | 72.2 | 70.5 | 67.6 | 16.7 | 13.8 | 8.8 |
| 2007.0840 | FEB | 71.9 | 70.2 | 67.3 | 17.2 | 14.0 | 9.1 |
| 2007.1673 | MAR | 71.6 | 70.0 | 67.2 | 17.2 | 13.8 | 9.0 |
| 2007.2507 | APR | 71.5 | 69.8 | 67.0 | 17.4 | 13.6 | 8.8 |
| 2007.3340 | MAY | 71.4 | 69.8 | 67.0 | 17.6 | 13.3 | 8.4 |
| 2007.4173 | JUN | 71.6 | 69.9 | 67.1 | 17.2 | 12.8 | 8.1 |
| 2007.5007 | JUL | 72.2 | 70.3 | 67.3 | 16.8 | 12.3 | 7.9 |
| 2007.5840 | AUG | 73.0 | 70.7 | 67.4 | 16.1 | 11.9 | 7.8 |
| 2007.6673 | SEP | 73.0 | 71.0 | 67.5 | 15.5 | 11.6 | 7.7 |
| 2007.7507 | OCT | 73.1 | 71.5 | 67.6 | 14.9 | 11.2 | 7.6 |
| 2007.8340 | NOV | 73.7 | 72.0 | 67.9 | 14.2 | 10.8 | 7.5 |
| 2007.9173 | DEC | 74.4 | 72.7 | 68.1 | 13.7 | 10.5 | 7.4 |
| 2008.0007 | JAN | 75.5 | 73.3 | 68.2 | 13.1 | 10.2 | 7.3 |
| 2008.0840 | FEB | 77.1 | 74.2 | 68.2 | 12.6 | 9.9 | 7.2 |
| 2008.1673 | MAR | 78.6 | 75.1 | 68.3 | 12.2 | 9.6 | 7.1 |
| 2008.2507 | APR | 80.4 | 76.3 | 68.3 | 11.8 | 9.4 | 7.0 |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2008.3340 | MAY | 82.8 | 77.7 | 68.3 | 11.5 | 9.2 | 7.0 | | |
| 2008.4173 | JUN | 85.8 | 79.1 | 68.6 | 11.3 | 9.1 | 6.9 | | |
| 2008.5007 | JUL | 88.3 | 80.8 | 68.6 | 11.1 | 9.0 | 6.9 | | |
| 2008.5840 | AUG | 91.6 | 82.8 | 68.7 | 11.1 | 9.0 | 6.9 | | |
| 2008.6673 | SEP | 95.3 | 84.9 | 68.9 | 11.3 | 9.1 | 6.9 | | |
| 2008.7507 | OCT | 98.0 | 87.2 | 68.9 | 11.6 | 9.3 | 7.1 | | |
| 2008.8340 | NOV | 99.9 | 89.6 | 69.0 | 11.7 | 9.4 | 7.4 | | |
| 2008.9173 | DEC | 104.0 | 92.2 | 69.4 | 11.9 | 9.5 | 7.5 | | |
| 2009.0007 | JAN | 107.7 | 95.0 | 69.8 | 12.0 | 9.6 | 7.5 | | |
| 2009.0840 | FEB | 111.6 | 97.8 | 70.1 | 12.1 | 9.6 | 7.3 | | |
| 2009.1673 | MAR | 116.0 | 100.6 | 70.8 | 12.2 | 9.7 | 7.2 | | |
| 2009.2507 | APR | 118.5 | 103.3 | 71.2 | 12.6 | 9.8 | 7.0 | | |
| 2009.3340 | MAY | 119.9 | 106.3 | 71.4 | 12.9 | 10.1 | 6.9 | | |
| 2009.4173 | JUN | 123.2 | 109.5 | 72.1 | 13.3 | 10.5 | 7.1 | | |
| 2009.5007 | JUL | 128.2 | 112.8 | 72.7 | 13.8 | 10.8 | 7.5 | | |
| 2009.5840 | AUG | 132.8 | 115.9 | 73.3 | 14.6 | 11.1 | 7.8 | | |
| 2009.6673 | SEP | 136.2 | 119.0 | 74.0 | 15.8 | 11.4 | 7.6 | | |
| 2009.7507 | OCT | 141.6 | 122.2 | 74.3 | 16.2 | 11.6 | 7.6 | | |
| 2009.8340 | NOV | 148.4 | 125.1 | 74.6 | 16.4 | 11.7 | 7.5 | | |
| 2009.9173 | DEC | 153.1 | 127.5 | 75.0 | 16.9 | 11.9 | 7.5 | | |
| 2010.0007 | JAN | 158.1 | 129.7 | 75.3 | 18.1 | 12.2 | 7.5 | | |
| 2010.0840 | FEB | 163.8 | 131.9 | 75.5 | 19.0 | 12.6 | 7.6 | | |
| 2010.1673 | MAR | 169.7 | 134.3 | 75.5 | 19.2 | 12.8 | 7.6 | | |
| 2010.2507 | APR | 175.0 | 136.8 | 75.1 | 19.3 | 13.0 | 7.7 | | |
| 2010.3340 | MAY | 180.6 | 139.1 | 74.9 | 19.1 | 13.2 | 7.6 | | |
| 2010.4173 | JUN | 183.7 | 141.2 | 75.2 | 18.7 | 13.3 | 7.6 | | |
| 2010.5007 | JUL | 186.3 | 143.1 | 75.5 | 18.6 | 13.3 | 7.7 | | |
| 2010.5840 | AUG | 187.1 | 144.9 | 76.3 | 19.0 | 13.5 | 7.9 | | |
| 2010.6673 | SEP | 186.9 | 146.5 | 77.5 | 18.9 | 13.6 | 8.1 | | |
| 2010.7507 | OCT | 186.1 | 147.9 | 78.2 | 17.9 | 13.6 | 8.5 | | |
| 2010.8340 | NOV | 186.2 | 148.8 | 79.1 | 18.0 | 13.8 | 8.6 | | |
| 2010.9173 | DEC | 188.5 | 149.7 | 80.7 | 18.6 | 14.1 | 8.6 | | |
| 2011.0007 | JAN | 191.5 | 150.1 | 82.6 | 19.2 | 14.3 | 8.9 | | |
| 2011.0840 | FEB | 192.9 | 150.5 | 84.7 | 19.7 | 14.8 | 9.3 | | |
| 2011.1673 | MAR | 193.3 | 150.8 | 85.9 | 20.4 | 15.1 | 9.5 | | |
| 2011.2507 | APR | 193.1 | 151.0 | 86.9 | 20.4 | 15.2 | 9.5 | | |
| 2011.3340 | MAY | 191.2 | 151.2 | 88.8 | 20.4 | 15.2 | 9.7 | | |
| 2011.4173 | JUN | 187.8 | 150.6 | 90.2 | 20.6 | 15.2 | 9.9 | | |
| 2011.5007 | JUL | 183.4 | 149.2 | 92.2 | 20.9 | 15.4 | 10.4 | | |
| 2011.5840 | AUG | 179.2 | 148.1 | 93.5 | 21.3 | 15.4 | 11.0 | | |
| 2011.6673 | SEP | 176.3 | 147.5 | 94.0 | 21.3 | 15.3 | 11.6 | | |
| 2011.7507 | OCT | 174.7 | 147.4 | 95.3 | 21.5 | 15.1 | 11.2 | | |
| 2011.8340 | NOV | 174.3 | 147.4 | 95.6 | 21.7 | 15.1 | 11.1 | | |
| 2011.9173 | DEC | 173.5 | 147.1 | 95.2 | 22.1 | 15.1 | 10.6 | | |
| 2012.0007 | JAN | 171.4 | 146.7 | 95.3 | 22.9 | 15.0 | 10.1 | | |
| 2012.0840 | FEB | 169.8 | 146.3 | 96.8 | 22.6 | 14.7 | 9.8 | | |
| 2012.1673 | MAR | 166.5 | 145.7 | 97.5 | 21.4 | 14.4 | 10.0 | | |
| 2012.2507 | APR | 161.9 | 145.2 | 97.1 | 20.7 | 14.3 | 10.0 | | |
| 2012.3340 | MAY | 159.6 | 144.8 | 96.3 | 20.1 | 14.2 | 10.2 | | |
| 2012.4173 | JUN | 157.4 | 144.0 | 96.3 | 19.7 | 14.1 | 10.5 | | |
| 2012.5007 | JUL | 156.1 | 143.0 | 96.8 | 19.6 | 14.1 | 10.5 | | |
| 2012.5840 | AUG | 155.3 | 141.4 | 95.9 | 19.4 | 14.1 | 10.4 | | |
| 2012.6673 | SEP | 154.4 | 139.8 | 95.4 | 19.2 | 14.4 | 10.4 | | |
| 2012.7507 | OCT | 152.7 | 138.6 | 96.2 | 19.0 | 14.7 | 10.4 | | |
| 2012.8340 | NOV | 151.2 | 137.6 | 97.2 | 19.0 | 14.9 | 10.2 | | |
| 2012.9173 | DEC | 149.2 | 136.3 | 96.2 | 19.5 | 14.8 | 9.8 | | |
| 2013.0007 | JAN | 145.8 | 134.6 | 94.6 | 20.5 | 14.9 | 10.1 | | |
| 2013.0840 | FEB | 143.0 | 132.8 | 93.9 | 22.1 | 15.3 | 10.6 | | |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | $\bar{F}_{10.7}$ | GEOMAGNETIC INDEX PERCENTILE | | | \bar{A}_p |
|-----------|-----|----------------------------------|-------|------|------------------|---------------------------------|------|------|-------------|
| | | 75.0% | 50% | 5.0% | | 95.0% | 50% | 5.0% | |
| 2013.1673 | MAR | 140.7 | 131.4 | 93.6 | 23.5 | 15.6 | 10.6 | | |
| 2013.2507 | APR | 137.8 | 130.3 | 91.9 | 24.1 | 15.8 | 10.8 | | |
| 2013.3340 | MAY | 135.9 | 128.9 | 88.5 | 25.3 | 16.1 | 10.9 | | |
| 2013.4173 | JUN | 135.0 | 127.1 | 87.7 | 25.8 | 16.3 | 11.1 | | |
| 2013.5007 | JUL | 135.0 | 125.5 | 88.8 | 25.0 | 16.3 | 11.4 | | |
| 2013.5840 | AUG | 134.2 | 124.2 | 88.3 | 24.9 | 16.2 | 11.6 | | |
| 2013.6673 | SEP | 134.9 | 123.1 | 87.0 | 24.1 | 16.2 | 11.7 | | |
| 2013.7507 | OCT | 134.1 | 122.0 | 86.0 | 22.2 | 16.1 | 11.7 | | |
| 2013.8340 | NOV | 133.2 | 120.8 | 85.7 | 22.5 | 16.2 | 11.9 | | |
| 2013.9173 | DEC | 131.8 | 119.2 | 84.8 | 23.2 | 16.3 | 11.7 | | |
| 2014.0007 | JAN | 130.0 | 117.2 | 83.5 | 23.3 | 16.3 | 10.9 | | |
| 2014.0840 | FEB | 127.6 | 115.4 | 82.5 | 22.8 | 16.1 | 10.6 | | |
| 2014.1673 | MAR | 126.9 | 113.5 | 81.9 | 22.1 | 15.9 | 10.7 | | |
| 2014.2507 | APR | 126.3 | 111.5 | 81.9 | 22.0 | 15.9 | 10.7 | | |
| 2014.3340 | MAY | 124.2 | 109.8 | 81.6 | 22.9 | 16.1 | 10.6 | | |
| 2014.4173 | JUN | 122.6 | 108.3 | 80.4 | 23.8 | 16.4 | 10.7 | | |
| 2014.5007 | JUL | 121.3 | 106.9 | 80.5 | 24.0 | 16.6 | 10.7 | | |
| 2014.5840 | AUG | 118.9 | 105.4 | 80.2 | 24.0 | 16.8 | 10.6 | | |
| 2014.6673 | SEP | 116.5 | 103.9 | 79.5 | 24.0 | 16.9 | 10.5 | | |
| 2014.7507 | OCT | 115.5 | 102.4 | 79.0 | 23.6 | 16.9 | 10.2 | | |
| 2014.8340 | NOV | 114.2 | 100.8 | 78.2 | 22.7 | 16.9 | 10.3 | | |
| 2014.9173 | DEC | 112.1 | 99.3 | 77.1 | 22.9 | 16.8 | 10.5 | | |
| 2015.0007 | JAN | 108.6 | 98.0 | 75.4 | 23.1 | 16.9 | 11.3 | | |
| 2015.0840 | FEB | 106.6 | 96.9 | 74.3 | 23.2 | 17.2 | 11.8 | | |
| 2015.1673 | MAR | 105.3 | 95.9 | 73.6 | 22.6 | 17.3 | 11.9 | | |
| 2015.2507 | APR | 104.5 | 95.0 | 72.8 | 21.6 | 17.2 | 12.1 | | |
| 2015.3340 | MAY | 102.6 | 94.0 | 71.8 | 21.3 | 17.1 | 12.2 | | |
| 2015.4173 | JUN | 100.8 | 92.9 | 71.3 | 21.8 | 16.9 | 12.4 | | |
| 2015.5007 | JUL | 99.3 | 91.8 | 70.8 | 21.8 | 16.7 | 13.2 | | |
| 2015.5840 | AUG | 98.4 | 90.7 | 70.4 | 22.2 | 16.8 | 13.0 | | |
| 2015.6673 | SEP | 98.4 | 89.5 | 70.3 | 22.6 | 16.9 | 12.7 | | |
| 2015.7507 | OCT | 98.1 | 88.2 | 70.4 | 22.4 | 16.9 | 13.0 | | |
| 2015.8340 | NOV | 97.5 | 87.3 | 70.2 | 22.4 | 16.7 | 12.7 | | |
| 2015.9173 | DEC | 96.0 | 86.6 | 70.1 | 22.8 | 16.5 | 12.4 | | |
| 2016.0007 | JAN | 95.0 | 85.8 | 70.2 | 23.0 | 16.1 | 12.0 | | |
| 2016.0840 | FEB | 93.5 | 84.7 | 70.1 | 23.6 | 15.8 | 11.1 | | |
| 2016.1673 | MAR | 91.1 | 83.6 | 70.3 | 24.2 | 15.6 | 10.4 | | |
| 2016.2507 | APR | 89.8 | 82.5 | 69.8 | 25.0 | 15.5 | 10.5 | | |
| 2016.3340 | MAY | 88.4 | 81.8 | 69.6 | 25.5 | 15.5 | 10.6 | | |
| 2016.4173 | JUN | 86.8 | 81.0 | 69.4 | 25.7 | 15.5 | 10.5 | | |
| 2016.5007 | JUL | 86.1 | 80.3 | 69.3 | 25.6 | 15.4 | 10.6 | | |
| 2016.5840 | AUG | 85.4 | 79.5 | 69.0 | 25.0 | 15.3 | 10.9 | | |
| 2016.6673 | SEP | 84.3 | 78.8 | 68.7 | 24.1 | 15.1 | 11.0 | | |
| 2016.7507 | OCT | 83.0 | 78.1 | 68.4 | 23.1 | 14.9 | 11.2 | | |
| 2016.8340 | NOV | 81.9 | 77.5 | 68.3 | 22.6 | 15.0 | 11.1 | | |
| 2016.9173 | DEC | 81.3 | 77.0 | 68.3 | 22.2 | 15.2 | 11.0 | | |
| 2017.0007 | JAN | 81.0 | 76.4 | 68.2 | 21.9 | 15.4 | 11.1 | | |
| 2017.0840 | FEB | 80.0 | 75.9 | 68.0 | 21.5 | 15.5 | 11.3 | | |
| 2017.1673 | MAR | 79.5 | 75.4 | 67.7 | 20.8 | 15.5 | 11.4 | | |
| 2017.2507 | APR | 78.2 | 74.8 | 67.5 | 20.0 | 15.3 | 11.4 | | |
| 2017.3340 | MAY | 77.4 | 74.2 | 67.6 | 20.1 | 15.1 | 11.7 | | |
| 2017.4173 | JUN | 76.8 | 73.5 | 67.4 | 20.2 | 14.9 | 11.9 | | |
| 2017.5007 | JUL | 75.9 | 72.9 | 67.3 | 19.9 | 14.7 | 11.6 | | |
| 2017.5840 | AUG | 75.6 | 72.4 | 67.2 | 19.5 | 14.6 | 11.5 | | |
| 2017.6673 | SEP | 74.8 | 72.0 | 67.2 | 19.0 | 14.6 | 11.1 | | |
| 2017.7507 | OCT | 73.7 | 71.6 | 67.2 | 18.2 | 14.6 | 10.6 | | |
| 2017.8340 | NOV | 73.5 | 71.3 | 67.1 | 17.3 | 14.5 | 9.8 | | |
| 2017.9173 | DEC | 72.6 | 71.0 | 67.1 | 17.4 | 14.4 | 9.4 | | |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

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

| TIME | | 10.7-CM SOLAR FLUX PERCENTILE | | | GEOMAGNETIC INDEX PERCENTILE | | |
|-----------|-----|----------------------------------|------|------|---------------------------------|------|------|
| | | 75.0% | 50% | 5.0% | 95.0% | 50% | 5.0% |
| 2018.0007 | JAN | 72.4 | 70.7 | 67.0 | 17.5 | 14.3 | 9.3 |
| 2018.0840 | FEB | 72.4 | 70.4 | 67.0 | 17.6 | 14.2 | 9.3 |
| 2018.1673 | MAR | 72.0 | 70.1 | 67.0 | 17.6 | 14.1 | 9.3 |

* Program Initialized from established Cycle 23 smoothed sunspot minimum

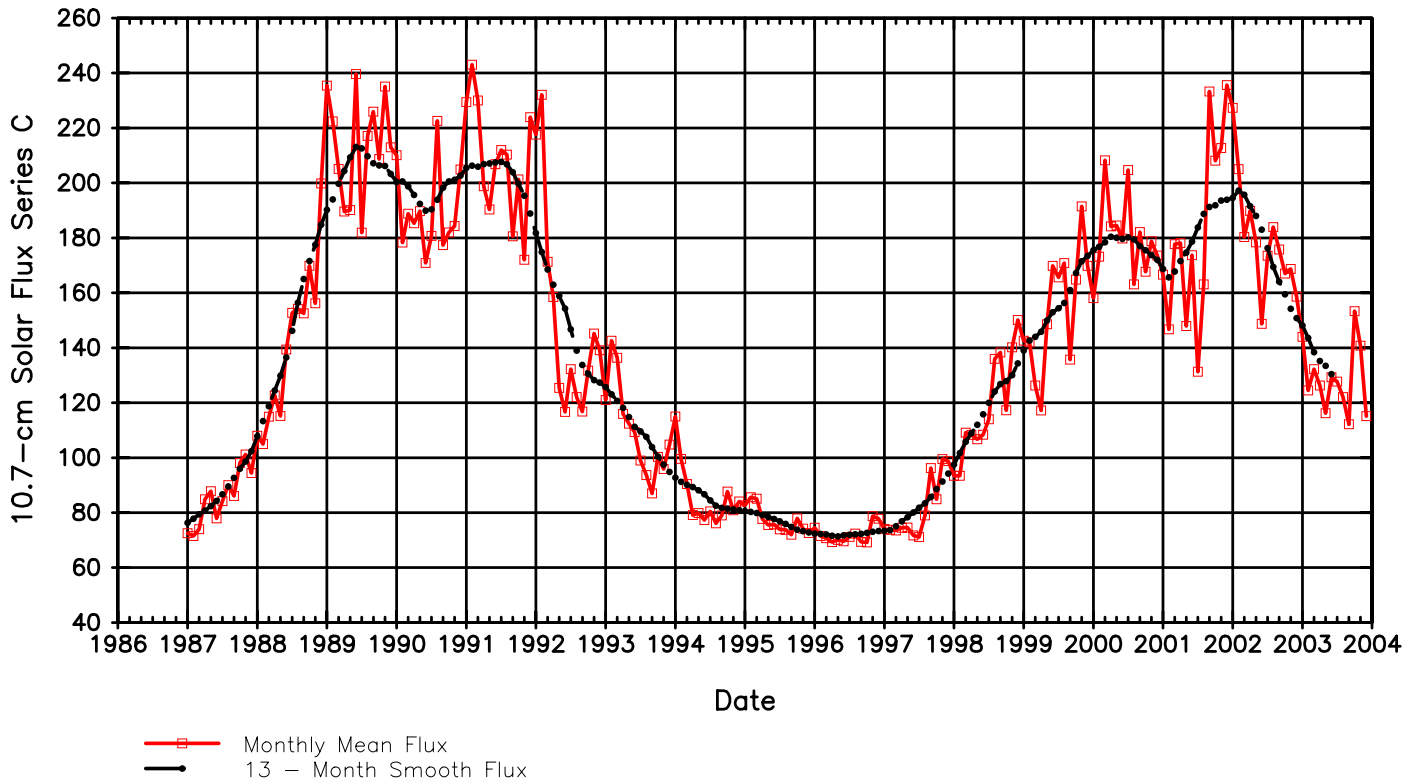


Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

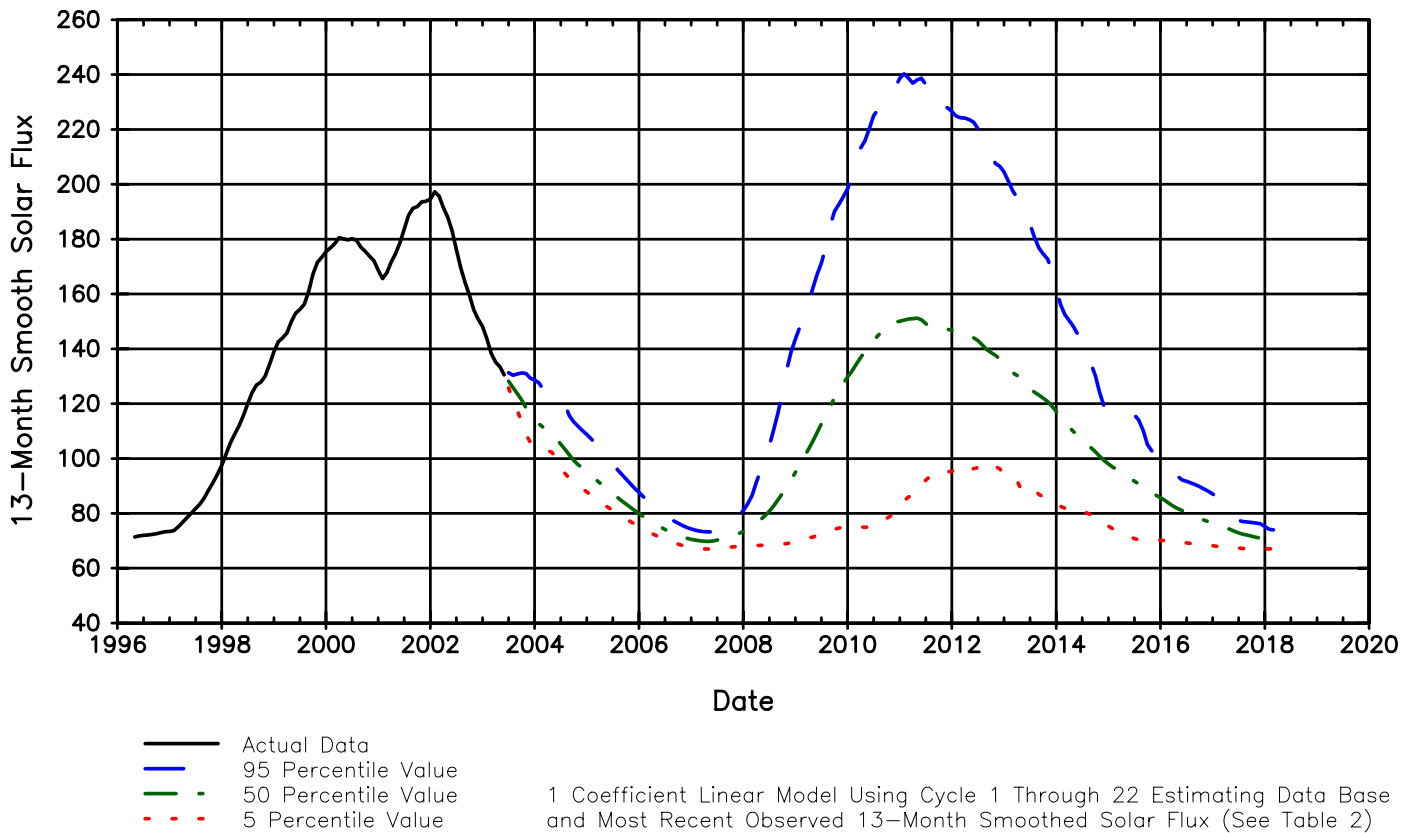


Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 23* and Cycle 24

* Program Initialized from Cycle 23 May 1996 smoothed minimum

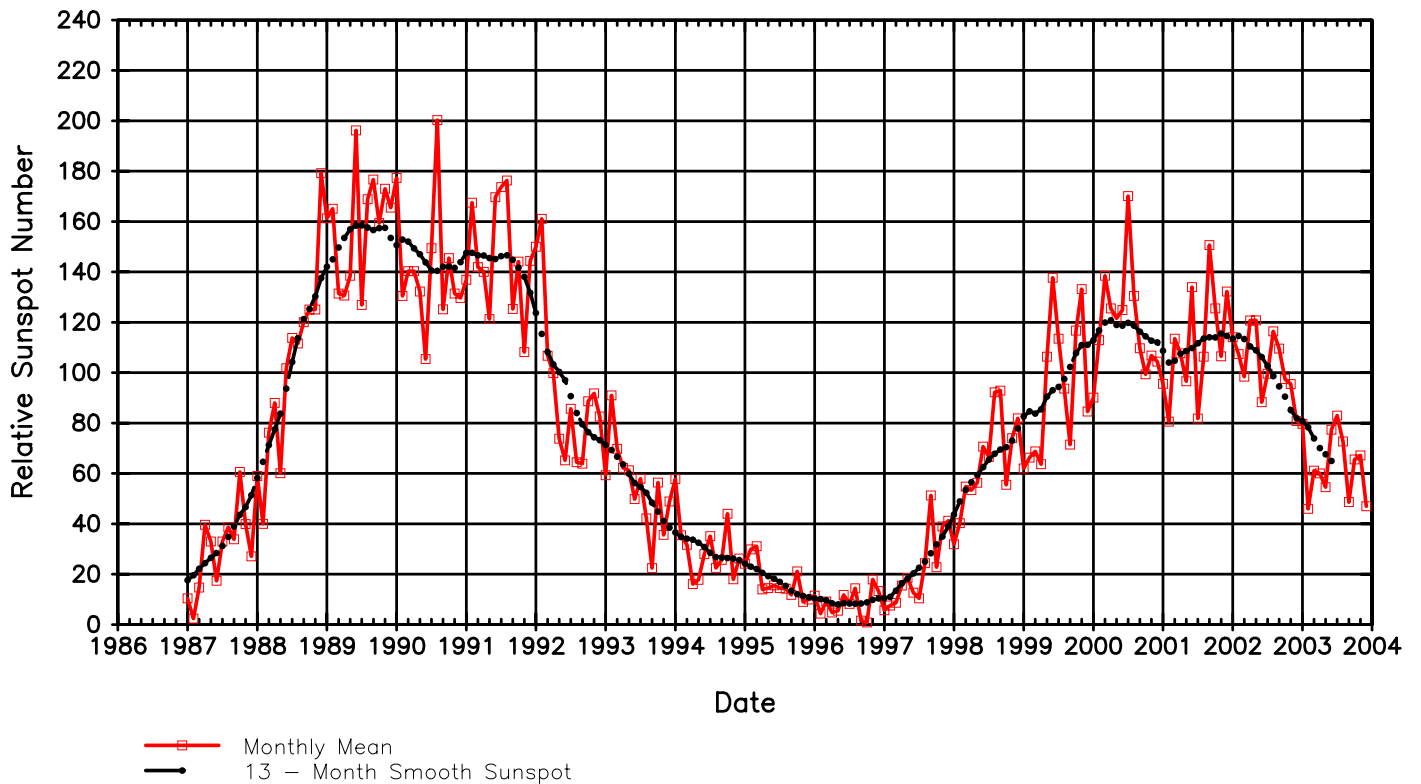


Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number

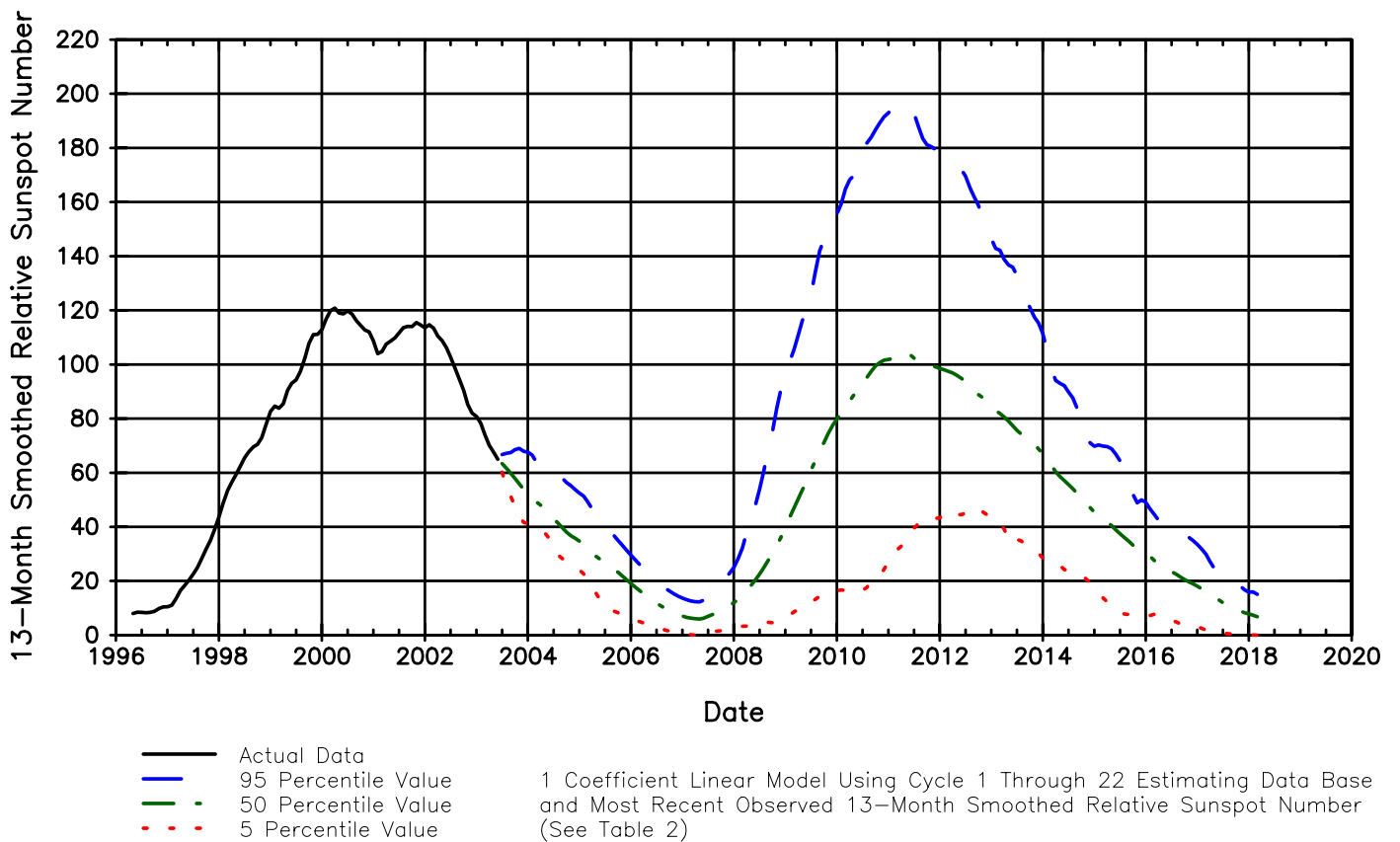


Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 23* and Cycle 24

* Program Initialized from Cycle 23 May 1996 smoothed minimum

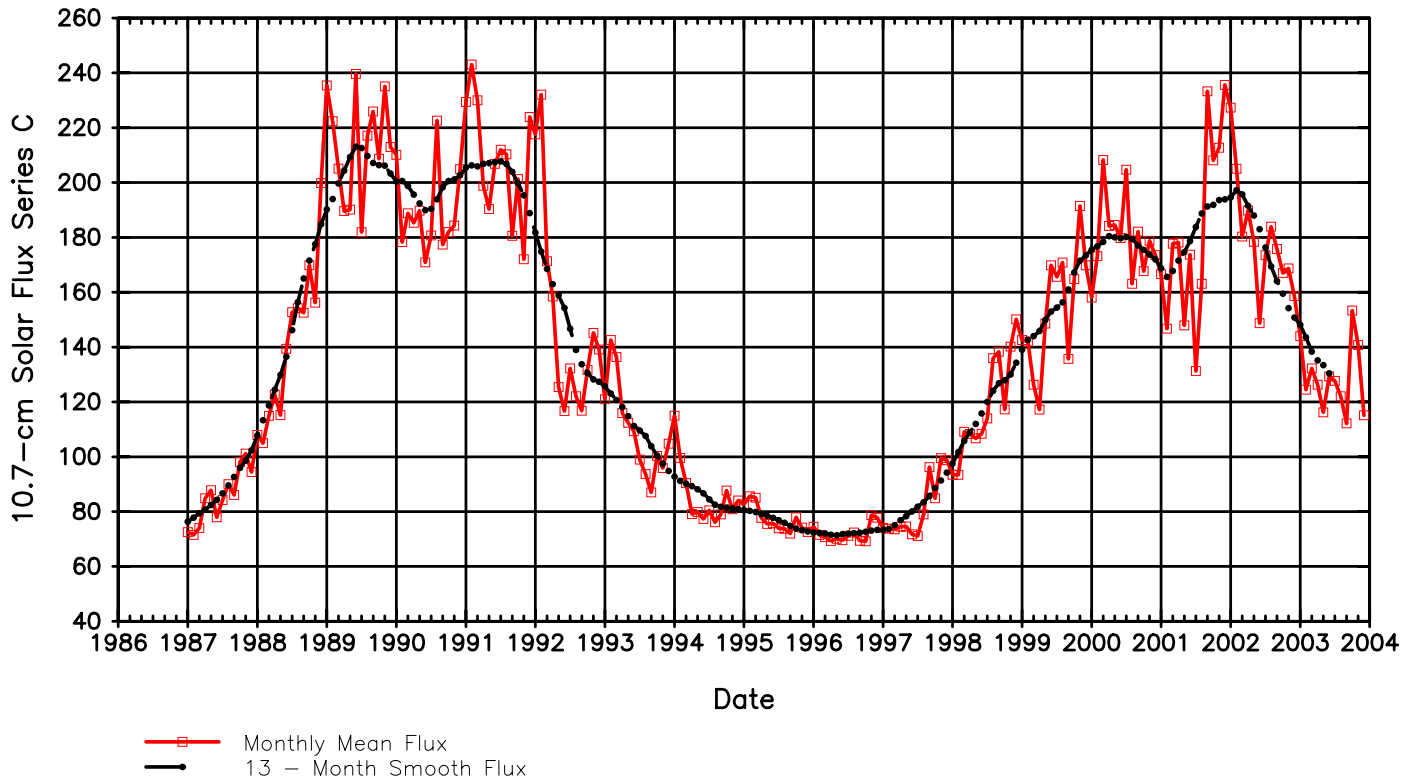


Figure 5. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

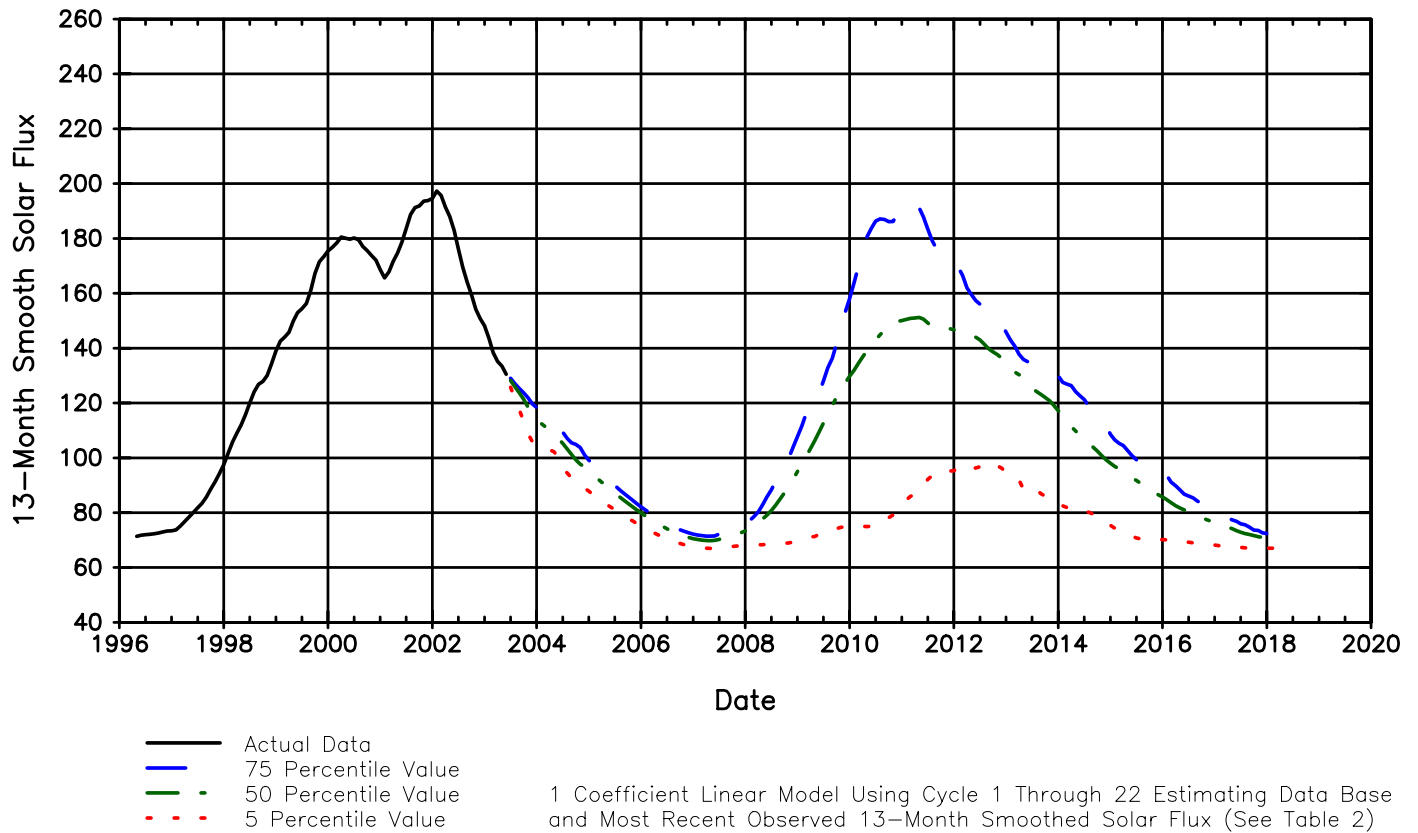


Figure 6. Estimate of 75th Percentile 13-Month Smoothed Solar Flux For Cycle 23* and Cycle 24

* Program Initialized from Cycle 23 May 1996 smoothed minimum