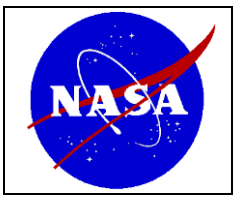

Future Solar Activity Estimates for Use in Prediction of Space Environmental Effects on Spacecraft Orbital Lifetime and Performance

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Introduction

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

Marshall Solar Activity Future Estimates (MSAFE) Model

Because no generally accepted physical solar model is available to accurately predict future solar activity, the NASA Marshall Space Flight Center (MSFC) developed a 13-month Zurich smoothed solar radio flux ($\overline{F}_{10.7}$) and geomagnetic ($\overline{A}_p$) 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 ($\overline{R}$). The 13-month Zurich smoothing technique is a running average with a 13-month kernal 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 $\overline{F}_{10.7}$, $\overline{R}$, and $\overline{A}_p$ estimates with associated statistical confidence bounds, i.e. 95 Percentile, etc.

Observed Data

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

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

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

Future Estimates

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

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

The computer program's input and output data are also depicted in graphical form. Figures 1 and 2 illustrate the inputs and application of the MSAFE model to the 10.7-cm solar radio flux. Figure 1 is a plot of monthly mean and 13-month Zurich smoothed observed 10.7-cm solar radio flux for solar cycle 23. Figure 2 is a plot of the statistical estimates of future13-month Zurich smoothed 10.7-cm solar radio flux for solar cycles 24 and 25. Similarly, Figures 3 and 4 demonstrate inputs and application of the MSAFE algorithm to sunspot number. Figure 3 is a plot of the monthly mean and 13-month Zurich smoothed observed sunspot number for solar cycle 23 and 24. Figure 4 is a plot of the statistical estimates of future13-month Zurich smoothed relative sunspot number for solar cycles 24 and 25. Figure 5[1] is a plot of monthly mean and 13-month smoothed observed Ap flux for solar

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

cycle 23 and 24. Figure 6 is a plot of the statistical estimates of future13-month Zurich smoothed 75 Percentile 10.7-cm solar radio flux for solar cycles 24 and 25.

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

Applications

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

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

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

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

Additional Information
Questions on the contents of this report may be addressed to Ron Suggs (ron.suggs@nasa.gov).

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

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TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES				
Year	**Month**	**Solar Flux ($F_{10.7}$ (Series C))**	**Relative Sunspot Numbers (R)**	**Geomagnetic Index (A_P)**
2011	January	83.4	27.3	6.0
	February	94.6	48.3	6.0
	March	115.3	78.6	8.0
	April	112.5	76.1	9.0
	May	95.8	58.2	9.0
	June	95.8	56.1	8.0
	July	94.1	64.5	8.0
	August	101.7	65.8	7.0
	September	134.5	120.1	12.0
	October	137.2	125.7	7.0
	November	153.2	139.1	5.0
	December	141.2	109.3	4.0
2012	January	134.8	94.4	7.0
	February	106.9	47.8	9.0
	March	115.7	86.6	16.0
	April	113.1	85.9	10.0
	May	121.4	96.5	7.0
	June	120.4	92	10.0
	July	137.8	100.1	14.0
	August	115.7	94.8	7.0
	September	123.0	93.7	8.0
	October	123.2	76.5	10.0
	November	121.2	87.6	7.0
	December	108.3	56.8	3.0
2013	January	127.1	96.1	5.0
	February	104.2	60.9	6.0
	March	111.3	78.3	11.0
	April	125.0	107.3	5.0
	May	131.4	120.2	10.0
	June	110.7	76.7	13.0
	July	115.6	86.2	9.0
	August	114.7	91.8	8.0
	September	102.7	54.5	5.0
	October	132.3	114.4	8.0
	November	148.8	113.9	6.0
	December	148.1	124.2	5.0

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

* Preliminary Estimates

TABLE 1: RECENT MONTHLY MEAN SOLAR ACTIVITY VALUES

Year	Month	Solar Flux ($F_{10.7}$ (Series C))	Relative Sunspot Numbers (R)	Geomagnetic Index (A_P)
2014	January	158.6	117	5.0
	February	170.3	146.1	11.0
	March	150.0	128.7	5.0
	April	144.3	112.5	8.0
	May	130.1	112.5	6.0
	June	122.4	102.9	7.0
	July	137.9	100.2	5.0
	August	124.6	106.9	8.0
	September	146.2	130	10.0
	October	153.7	90	9.0
	November	155.3	103.6	9.0
	December	158.7	112.9	11.0
2015	January	142.8	93	9.0
	February	128.9	66.7	10.0
	March	126.1	54.5	16.0
	April	129.1	78	11.0
	May	120.1	90	8.0
	June	123.2	68.3	13.0
	July	107.0	66.4	9.0
	August	105.9	64.6	14.0
	September	102.0	78.1	16.0
	October	104.0	61.7	14.0
	November	109.7*	63.2*	12.0*
	December	112.5*	57.7*	14.0*

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

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

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

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

* Preliminary Estimates

TABLE 2: 13-MONTH ZURICH SMOOTHED VALUES

Year	Month	+10.7-cm Solar Flux ($\bar{F}_{10.7}$)	++Sunspot Numbers ($\bar{R}$)	+++Geomagnetic Index ($\bar{A}_p$)
2014	January	137.4	109.3	6.8
	February	138.7	110.5	6.6
	March	140.9	114.3	6.8
	April	143.6	116.4	7.0
	May	144.8	115	7.2
	June	145.5	114.1	7.6
	July	145.3	112.6	8.0
	August	142.9	108.3	8.1
	September	140.2	101.9	8.5
	October	138.6	97.4	9.1
	November	137.5	95.0	9.3
	December	137.1	92.6	9.7
2015	January	135.9	89.8	10.1
	February	133.9	86.6	10.5
	March	131.2	82.7	11.0
	April	127.3	79.3	11.5
	May	123.4*	76.5*	11.8*
	June	119.5*	72.5*	12.0*

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

* Preliminary Estimates

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2015.5003	JUL	120.2	117.9	116.1	13.4	12.5	12.0
2015.5837	AUG	121.0	116.1	112.4	15.1	12.8	12.0
2015.6670	SEP	122.2	114.4	108.7	16.7	13.1	11.7
2015.7503	OCT	123.5	112.5	105.4	18.0	13.5	11.1
2015.8337	NOV	124.0	110.6	102.2	18.7	14.0	10.6
2015.9170	DEC	124.5	109.0	99.7	19.1	14.6	10.9
2016.0003	JAN	124.8	107.6	97.6	20.5	15.5	11.5
2016.0837	FEB	123.9	106.0	95.4	21.3	16.0	12.0
2016.1670	MAR	122.5	104.5	93.8	22.2	16.4	12.6
2016.2503	APR	121.2	103.1	91.4	22.9	16.4	12.7
2016.3337	MAY	119.1	101.6	88.5	23.0	15.9	12.2
2016.4170	JUN	119.7	100.1	86.1	23.6	15.7	11.4
2016.5003	JUL	119.9	98.7	84.8	24.3	15.5	10.7
2016.5837	AUG	118.6	97.5	83.8	24.8	15.3	10.6
2016.6670	SEP	117.6	96.4	83.1	25.1	15.2	10.6
2016.7503	OCT	116.4	95.4	82.5	25.0	14.9	10.1
2016.8337	NOV	113.9	94.5	82.1	24.2	14.3	9.5
2016.9170	DEC	111.5	93.5	81.8	23.2	13.8	9.2
2017.0003	JAN	110.0	92.3	81.0	21.9	13.5	9.0
2017.0837	FEB	109.9	91.1	79.6	20.8	13.2	8.9
2017.1670	MAR	109.7	90.1	78.5	20.3	13.3	8.9
2017.2503	APR	108.3	89.1	78.0	20.2	13.7	9.1
2017.3337	MAY	106.1	87.9	78.2	20.6	14.4	10.0
2017.4170	JUN	103.4	86.8	78.1	21.0	15.0	11.0
2017.5003	JUL	100.7	86.0	77.6	21.1	15.4	11.8
2017.5837	AUG	99.3	85.2	77.0	20.7	15.5	12.3
2017.6670	SEP	98.5	84.3	76.1	20.0	15.6	12.6
2017.7503	OCT	96.9	83.2	74.5	20.1	15.6	12.7
2017.8337	NOV	94.9	82.1	73.4	19.8	15.7	12.6
2017.9170	DEC	94.0	81.4	72.5	19.4	15.8	12.5
2018.0003	JAN	93.5	80.7	71.1	19.3	16.1	12.3
2018.0837	FEB	92.2	80.1	70.1	19.9	16.3	11.7
2018.1670	MAR	90.1	79.4	69.4	20.0	16.2	10.9
2018.2503	APR	88.6	78.7	68.8	19.7	15.9	10.6
2018.3337	MAY	87.8	78.0	68.3	19.1	15.5	10.3
2018.4170	JUN	86.7	77.4	68.2	18.3	15.1	10.1
2018.5003	JUL	85.5	76.7	68.1	18.5	15.0	10.1
2018.5837	AUG	84.4	76.1	68.0	18.8	15.0	10.0
2018.6670	SEP	83.3	75.5	67.9	19.1	14.8	9.9
2018.7503	OCT	82.2	74.9	67.8	19.0	14.5	9.7
2018.8337	NOV	81.1	74.3	67.7	18.6	14.2	9.7
2018.9170	DEC	80.1	73.7	67.6	17.7	13.6	9.4
2019.0003	JAN	79.1	73.2	67.5	16.9	13.0	9.1
2019.0837	FEB	78.2	72.7	67.4	16.0	12.4	8.8
2019.1670	MAR	77.4	72.2	67.4	15.2	11.8	8.5
2019.2503	APR	76.6	71.7	67.3	14.5	11.3	8.2
2019.3337	MAY	75.8	71.3	67.2	13.7	10.8	7.9
2019.4170	JUN	75.2	71.0	67.2	13.1	10.4	7.7
2019.5003	JUL	74.6	70.6	67.1	12.5	10.0	7.5
2019.5837	AUG	74.1	70.4	67.1	12.0	9.6	7.3

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2019.6670	SEP	73.7	70.1	67.0	11.6	9.3	7.2
2019.7503	OCT	73.5	70.0	67.0	11.3	9.1	7.0
2019.8337	NOV	73.3	69.9	67.0	11.1	9.0	7.0
2019.9170	DEC	73.2	69.9	67.0	11.1	9.0	6.9
2020.0003	JAN	73.3	70.0	67.0	11.3	9.0	6.9
2020.0837	FEB	74.0	70.3	67.1	11.6	9.2	7.1
2020.1670	MAR	74.8	70.7	67.2	11.7	9.3	7.4
2020.2503	APR	75.6	71.0	67.2	11.9	9.4	7.5
2020.3337	MAY	76.7	71.5	67.4	12.0	9.5	7.5
2020.4170	JUN	78.2	72.0	67.5	12.1	9.6	7.3
2020.5003	JUL	79.6	72.6	67.6	12.2	9.7	7.2
2020.5837	AUG	81.0	73.3	67.8	12.5	9.9	7.1
2020.6670	SEP	83.3	74.1	67.9	12.8	10.1	7.0
2020.7503	OCT	86.3	75.1	68.0	13.2	10.5	7.2
2020.8337	NOV	91.0	76.3	68.3	13.7	10.8	7.6
2020.9170	DEC	95.4	77.7	68.4	14.5	11.1	7.9
2021.0003	JAN	98.8	79.2	68.4	15.7	11.4	7.7
2021.0837	FEB	103.9	80.9	68.4	16.1	11.6	7.7
2021.1670	MAR	109.8	82.9	68.4	16.3	11.8	7.6
2021.2503	APR	115.6	85.1	68.3	16.8	12.0	7.6
2021.3337	MAY	122.9	87.3	68.6	18.0	12.3	7.6
2021.4170	JUN	131.3	89.9	68.7	18.9	12.6	7.7
2021.5003	JUL	137.8	92.6	68.9	19.1	12.7	7.7
2021.5837	AUG	142.5	95.4	69.2	19.2	12.9	7.8
2021.6670	SEP	146.9	98.2	69.2	19.0	13.1	7.7
2021.7503	OCT	151.3	101.0	69.5	18.6	13.1	7.7
2021.8337	NOV	156.2	103.9	69.9	18.5	13.2	7.8
2021.9170	DEC	161.5	107.0	70.6	18.9	13.4	8.0
2022.0003	JAN	166.8	110.1	70.9	18.8	13.5	8.2
2022.0837	FEB	171.3	113.2	71.3	17.8	13.5	8.6
2022.1670	MAR	177.2	116.5	71.5	17.9	13.7	8.7
2022.2503	APR	184.7	119.7	72.1	18.5	13.9	8.7
2022.3337	MAY	189.7	122.9	72.9	19.1	14.2	9.0
2022.4170	JUN	192.2	125.7	73.3	19.6	14.6	9.4
2022.5003	JUL	194.8	128.2	74.1	20.3	14.9	9.6
2022.5837	AUG	197.9	130.5	74.7	20.3	15.1	9.6
2022.6670	SEP	202.4	132.6	75.1	20.3	15.1	9.8
2022.7503	OCT	208.5	135.1	75.6	20.5	15.2	10.0
2022.8337	NOV	212.6	137.7	75.9	20.8	15.4	10.5
2022.9170	DEC	215.4	140.3	76.1	21.2	15.4	11.1
2023.0003	JAN	219.9	142.4	76.1	21.3	15.3	11.6
2023.0837	FEB	224.3	144.3	76.0	21.4	15.1	11.3
2023.1670	MAR	226.4	146.0	76.1	21.6	15.0	11.2
2023.2503	APR	227.3	147.7	76.6	22.0	15.0	10.7
2023.3337	MAY	229.2	149.0	76.9	22.8	14.9	10.2
2023.4170	JUN	231.4	149.9	77.6	22.5	14.7	9.9
2023.5003	JUL	234.2	150.8	78.9	21.3	14.5	10.1
2023.5837	AUG	237.3	151.2	79.7	20.6	14.3	10.1
2023.6670	SEP	238.6	151.4	80.6	20.1	14.2	10.3
2023.7503	OCT	236.8	151.7	82.2	19.6	14.1	10.6
2023.8337	NOV	234.8	151.9	83.8	19.5	14.0	10.6

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2023.9170	DEC	235.8	152.0	85.6	19.3	14.0	10.5
2024.0003	JAN	236.3	151.2	86.4	19.1	14.2	10.5
2024.0837	FEB	234.1	149.7	87.8	18.9	14.6	10.5
2024.1670	MAR	230.9	148.7	89.5	18.9	14.7	10.3
2024.2503	APR	227.3	148.4	90.7	19.5	14.6	9.8
2024.3337	MAY	225.6	148.5	93.0	20.4	14.7	10.2
2024.4170	JUN	226.0	148.9	94.2	22.0	15.0	10.7
2024.5003	JUL	226.2	149.0	95.5	23.4	15.3	10.7
2024.5837	AUG	225.0	148.7	95.8	24.0	15.4	10.9
2024.6670	SEP	223.5	148.1	95.4	25.1	15.7	11.1
2024.7503	OCT	223.0	147.5	95.4	25.6	15.9	11.3
2024.8337	NOV	223.0	147.3	96.9	24.9	15.9	11.5
2024.9170	DEC	222.6	147.2	97.7	24.8	15.9	11.7
2025.0003	JAN	221.7	146.4	97.2	23.9	15.8	11.9
2025.0837	FEB	219.4	145.1	96.4	22.1	15.8	11.8
2025.1670	MAR	216.2	143.5	96.3	22.4	15.9	12.0
2025.2503	APR	213.5	141.8	96.8	23.1	16.0	11.8
2025.3337	MAY	210.9	140.1	96.3	23.1	16.0	11.1
2025.4170	JUN	207.5	138.8	95.5	22.6	16.0	10.8
2025.5003	JUL	206.4	137.4	96.1	22.0	15.8	10.8
2025.5837	AUG	204.4	135.6	97.1	21.9	15.8	10.8
2025.6670	SEP	201.0	133.7	96.2	22.7	16.1	10.8
2025.7503	OCT	197.5	132.2	94.5	23.7	16.5	10.8
2025.8337	NOV	195.1	130.9	93.8	23.9	16.7	10.8
2025.9170	DEC	193.0	129.5	93.6	23.9	17.0	10.7
2026.0003	JAN	189.1	127.8	91.7	23.9	17.1	10.6
2026.0837	FEB	184.5	125.9	88.3	23.5	17.2	10.3
2026.1670	MAR	180.1	124.6	87.9	22.5	17.2	10.5
2026.2503	APR	176.3	123.5	88.7	22.7	17.2	10.7
2026.3337	MAY	174.0	122.3	87.3	23.0	17.4	11.4
2026.4170	JUN	172.1	121.0	86.3	23.1	17.6	11.9
2026.5003	JUL	167.8	119.3	85.7	22.5	17.8	12.0
2026.5837	AUG	161.4	117.4	84.8	21.7	17.6	12.1
2026.6670	SEP	155.5	115.6	83.6	21.2	17.4	12.3
2026.7503	OCT	151.9	113.7	82.5	21.7	17.0	12.5
2026.8337	NOV	149.6	111.7	82.1	21.7	16.9	13.3
2026.9170	DEC	147.1	110.0	82.1	22.1	16.9	13.1
2027.0003	JAN	144.1	108.6	82.0	22.6	17.0	12.8
2027.0837	FEB	141.1	107.0	80.9	22.3	16.8	13.1
2027.1670	MAR	137.5	105.5	80.5	22.4	16.5	12.7
2027.2503	APR	133.8	104.0	80.6	22.7	16.2	12.5
2027.3337	MAY	129.6	102.5	80.0	22.9	15.8	12.1
2027.4170	JUN	123.6	100.9	79.1	23.5	15.6	11.2
2027.5003	JUL	119.4	99.4	77.7	24.1	15.4	10.5
2027.5837	AUG	118.6	98.2	75.6	24.8	15.3	10.7
2027.6670	SEP	118.7	97.1	74.5	25.3	15.3	10.8
2027.7503	OCT	119.2	96.1	74.0	25.6	15.3	10.6
2027.8337	NOV	119.6	95.2	73.6	25.4	15.3	10.8
2027.9170	DEC	118.8	94.2	73.4	24.9	15.2	11.0
2028.0003	JAN	117.4	92.9	73.0	24.0	15.0	11.1
2028.0837	FEB	115.8	91.7	72.7	23.0	14.9	11.3

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2028.1670	MAR	113.7	90.7	71.9	22.5	15.0	11.2
2028.2503	APR	110.2	89.6	71.4	22.1	15.1	11.1
2028.3337	MAY	105.8	88.4	71.0	21.8	15.2	11.2
2028.4170	JUN	103.2	87.3	70.7	21.4	15.3	11.4
2028.5003	JUL	101.6	86.5	70.4	20.7	15.2	11.5
2028.5837	AUG	100.2	85.6	70.5	19.9	14.9	11.3
2028.6670	SEP	98.1	84.7	70.3	20.0	14.7	11.1
2028.7503	OCT	96.6	83.5	69.8	20.1	14.6	10.8
2028.8337	NOV	94.6	82.4	69.6	19.9	14.3	10.1
2028.9170	DEC	93.5	81.7	69.5	19.5	14.2	9.6
2029.0003	JAN	93.2	81.0	69.4	19.0	14.1	9.1
2029.0837	FEB	92.3	80.3	69.3	18.3	14.1	8.6
2029.1670	MAR	91.3	79.6	69.1	17.3	14.0	8.0
2029.2503	APR	90.5	78.9	68.8	17.4	13.8	7.5
2029.3337	MAY	89.7	78.2	68.5	17.5	13.7	7.6
2029.4170	JUN	88.7	77.5	68.3	17.6	13.7	7.8
2029.5003	JUL	87.7	77.0	68.4	17.5	13.6	8.3
2029.5837	AUG	86.9	76.5	68.4	17.7	13.5	8.6
2029.6670	SEP	85.5	75.9	68.5	18.1	13.4	8.5
2029.7503	OCT	84.1	75.4	68.4	17.9	13.2	8.6
2029.8337	NOV	82.2	74.9	68.4	17.6	12.9	8.5
2029.9170	DEC	79.9	74.2	68.3	17.3	12.6	8.5
2030.0003	JAN	78.4	73.5	68.0	16.3	12.2	8.4
2030.0837	FEB	77.5	72.8	67.8	14.8	11.8	8.4
2030.1670	MAR	77.0	72.3	67.6	13.8	11.4	8.3
2030.2503	APR	76.9	72.0	67.6	13.9	11.0	8.2
2030.3337	MAY	76.6	71.6	67.5	13.6	10.6	8.2
2030.4170	JUN	76.5	71.2	67.2	13.2	10.3	7.9
2030.5003	JUL	76.1	70.9	67.1	12.9	9.9	7.4
2030.5837	AUG	75.1	70.6	67.1	12.6	9.7	7.1
2030.6670	SEP	74.2	70.3	67.0	11.9	9.5	7.3
2030.7503	OCT	74.0	70.1	67.0	11.4	9.4	7.1

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

TIME		SUNSPOT NUMBER ($\bar{R}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2015.5003	JUL	75.8	71.0	67.2	13.4	12.5	12.0
2015.5837	AUG	79.4	69.8	63.0	15.1	12.8	12.0
2015.6670	SEP	82.2	68.1	58.3	16.7	13.1	11.7
2015.7503	OCT	84.4	65.7	53.2	18.0	13.5	11.1
2015.8337	NOV	84.6	63.7	49.7	18.7	14.0	10.6
2015.9170	DEC	84.0	61.5	46.3	19.1	14.6	10.9
2016.0003	JAN	84.0	59.3	42.2	20.5	15.5	11.5
2016.0837	FEB	85.7	58.1	39.2	21.3	16.0	12.0
2016.1670	MAR	87.5	56.3	34.8	22.2	16.4	12.6
2016.2503	APR	86.8	54.1	30.3	22.9	16.4	12.7
2016.3337	MAY	87.0	52.5	26.3	23.0	15.9	12.2
2016.4170	JUN	89.1	51.6	23.8	23.6	15.7	11.4
2016.5003	JUL	88.1	50.1	22.6	24.3	15.5	10.7
2016.5837	AUG	87.4	48.0	21.7	24.8	15.3	10.6
2016.6670	SEP	85.1	46.1	19.1	25.1	15.2	10.6
2016.7503	OCT	80.7	43.8	17.5	25.0	14.9	10.1
2016.8337	NOV	76.3	41.5	16.3	24.2	14.3	9.5
2016.9170	DEC	73.1	39.2	15.6	23.2	13.8	9.2
2017.0003	JAN	73.8	37.4	13.9	21.9	13.5	9.0
2017.0837	FEB	74.9	36.5	11.9	20.8	13.2	8.9
2017.1670	MAR	73.0	35.2	10.5	20.3	13.3	8.9
2017.2503	APR	69.9	33.8	10.7	20.2	13.7	9.1
2017.3337	MAY	65.5	32.2	11.8	20.6	14.4	10.0
2017.4170	JUN	62.1	30.8	12.1	21.0	15.0	11.0
2017.5003	JUL	60.8	29.6	10.9	21.1	15.4	11.8
2017.5837	AUG	59.1	28.3	9.5	20.7	15.5	12.3
2017.6670	SEP	55.7	27.0	7.4	20.0	15.6	12.6
2017.7503	OCT	53.1	25.7	5.1	20.1	15.6	12.7
2017.8337	NOV	52.8	25.5	4.2	19.8	15.7	12.6
2017.9170	DEC	52.8	25.3	1.2	19.4	15.8	12.5
2018.0003	JAN	50.4	24.3	-1.8	19.3	16.1	12.3
2018.0837	FEB	46.5	23.4	-3.6	19.9	16.3	11.7
2018.1670	MAR	43.2	22.4	-4.4	20.0	16.2	10.9
2018.2503	APR	42.5	21.2	-5.3	19.7	15.9	10.6
2018.3337	MAY	40.7	20.4	-4.9	19.1	15.5	10.3
2018.4170	JUN	38.9	19.5	-4.5	18.3	15.1	10.1
2018.5003	JUL	37.1	18.6	-4.1	18.5	15.0	10.1
2018.5837	AUG	35.4	17.8	-3.8	18.8	15.0	10.0
2018.6670	SEP	33.7	17.0	-3.4	19.1	14.8	9.9
2018.7503	OCT	32.0	16.2	-3.0	19.0	14.5	9.7
2018.8337	NOV	30.4	15.4	-2.6	18.6	14.2	9.7
2018.9170	DEC	28.8	14.6	-2.3	17.7	13.6	9.4
2019.0003	JAN	27.4	13.9	-2.0	16.9	13.0	9.1
2019.0837	FEB	26.0	13.2	-1.7	16.0	12.4	8.8
2019.1670	MAR	24.7	12.6	-1.4	15.2	11.8	8.5
2019.2503	APR	23.5	12.0	-1.1	14.5	11.3	8.2
2019.3337	MAY	22.3	11.5	-0.9	13.7	10.8	7.9
2019.4170	JUN	21.4	11.0	-0.6	13.1	10.4	7.7
2019.5003	JUL	20.5	10.6	-0.4	12.5	10.0	7.5

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

TIME		SUNSPOT NUMBER ($\bar{R}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2019.5837	AUG	19.8	10.3	-0.3	12.0	9.6	7.3
2019.6670	SEP	19.2	10.0	-0.2	11.6	9.3	7.2
2019.7503	OCT	18.8	9.8	-0.1	11.3	9.1	7.0
2019.8337	NOV	18.5	9.6	0.0	11.1	9.0	7.0
2019.9170	DEC	18.4	9.6	0.0	11.1	9.0	6.9
2020.0003	JAN	19.4	10.3	0.7	11.3	9.0	6.9
2020.0837	FEB	21.3	11.4	1.5	11.6	9.2	7.1
2020.1670	MAR	23.0	12.4	2.1	11.7	9.3	7.4
2020.2503	APR	25.6	13.4	2.8	11.9	9.4	7.5
2020.3337	MAY	28.5	14.7	3.2	12.0	9.5	7.5
2020.4170	JUN	33.4	16.2	3.9	12.1	9.6	7.3
2020.5003	JUL	37.0	17.8	5.0	12.2	9.7	7.2
2020.5837	AUG	40.7	19.5	5.4	12.5	9.9	7.1
2020.6670	SEP	46.2	21.6	5.5	12.8	10.1	7.0
2020.7503	OCT	53.3	23.9	5.8	13.2	10.5	7.2
2020.8337	NOV	63.8	26.8	5.8	13.7	10.8	7.6
2020.9170	DEC	72.8	30.1	5.9	14.5	11.1	7.9
2021.0003	JAN	79.8	33.3	7.0	15.7	11.4	7.7
2021.0837	FEB	90.0	37.0	7.1	16.1	11.6	7.7
2021.1670	MAR	101.3	41.0	7.1	16.3	11.8	7.6
2021.2503	APR	111.5	45.0	7.9	16.8	12.0	7.6
2021.3337	MAY	123.8	49.3	8.1	18.0	12.3	7.6
2021.4170	JUN	138.5	54.4	8.6	18.9	12.6	7.7
2021.5003	JUL	148.6	59.6	9.7	19.1	12.7	7.7
2021.5837	AUG	155.6	65.1	11.4	19.2	12.9	7.8
2021.6670	SEP	162.7	70.7	12.9	19.0	13.1	7.7
2021.7503	OCT	170.5	76.0	15.2	18.6	13.1	7.7
2021.8337	NOV	179.3	81.2	16.4	18.5	13.2	7.8
2021.9170	DEC	188.6	86.5	16.5	18.9	13.4	8.0
2022.0003	JAN	197.4	92.3	18.8	18.8	13.5	8.2
2022.0837	FEB	205.1	98.1	20.6	17.8	13.5	8.6
2022.1670	MAR	213.1	103.9	22.3	17.9	13.7	8.7
2022.2503	APR	217.8	109.7	24.3	18.5	13.9	8.7
2022.3337	MAY	224.3	115.1	25.1	19.1	14.2	9.0
2022.4170	JUN	225.7	119.9	26.1	19.6	14.6	9.4
2022.5003	JUL	226.2	124.5	27.1	20.3	14.9	9.6
2022.5837	AUG	231.6	128.4	27.8	20.3	15.1	9.6
2022.6670	SEP	234.1	131.7	28.6	20.3	15.1	9.8
2022.7503	OCT	236.5	135.4	28.5	20.5	15.2	10.0
2022.8337	NOV	239.8	139.1	27.9	20.8	15.4	10.5
2022.9170	DEC	242.1	142.9	27.3	21.2	15.4	11.1
2023.0003	JAN	248.6	146.3	28.1	21.3	15.3	11.6
2023.0837	FEB	256.1	149.3	29.0	21.4	15.1	11.3
2023.1670	MAR	261.0	152.2	31.1	21.6	15.0	11.2
2023.2503	APR	265.2	155.6	34.4	22.0	15.0	10.7
2023.3337	MAY	269.9	158.3	36.3	22.8	14.9	10.2
2023.4170	JUN	273.3	160.2	38.5	22.5	14.7	9.9
2023.5003	JUL	275.4	161.5	42.4	21.3	14.5	10.1
2023.5837	AUG	276.6	161.7	46.7	20.6	14.3	10.1
2023.6670	SEP	278.0	162.3	51.3	20.1	14.2	10.3

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

TIME		SUNSPOT NUMBER ($\bar{R}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2023.7503	OCT	277.7	163.6	53.5	19.6	14.1	10.6
2023.8337	NOV	276.5	164.4	55.6	19.5	14.0	10.6
2023.9170	DEC	277.8	165.0	59.6	19.3	14.0	10.5
2024.0003	JAN	277.3	163.6	62.2	19.1	14.2	10.5
2024.0837	FEB	271.7	161.4	66.0	18.9	14.6	10.5
2024.1670	MAR	265.1	160.1	68.7	18.9	14.7	10.3
2024.2503	APR	259.1	159.5	71.3	19.5	14.6	9.8
2024.3337	MAY	255.5	159.4	73.2	20.4	14.7	10.2
2024.4170	JUN	253.8	159.1	73.0	22.0	15.0	10.7
2024.5003	JUL	252.1	158.6	72.1	23.4	15.3	10.7
2024.5837	AUG	250.8	157.9	73.3	24.0	15.4	10.9
2024.6670	SEP	248.8	156.9	76.5	25.1	15.7	11.1
2024.7503	OCT	247.1	156.2	76.7	25.6	15.9	11.3
2024.8337	NOV	245.1	155.2	75.1	24.9	15.9	11.5
2024.9170	DEC	244.0	154.0	74.0	24.8	15.9	11.7
2025.0003	JAN	241.6	152.7	74.9	23.9	15.8	11.9
2025.0837	FEB	237.3	150.3	75.8	22.1	15.8	11.8
2025.1670	MAR	232.2	147.1	73.7	22.4	15.9	12.0
2025.2503	APR	227.9	144.2	72.9	23.1	16.0	11.8
2025.3337	MAY	223.3	142.1	74.5	23.1	16.0	11.1
2025.4170	JUN	217.2	140.1	76.2	22.6	16.0	10.8
2025.5003	JUL	212.3	137.3	74.2	22.0	15.8	10.8
2025.5837	AUG	206.6	134.3	70.9	21.9	15.8	10.8
2025.6670	SEP	202.1	132.0	69.3	22.7	16.1	10.8
2025.7503	OCT	200.6	130.4	68.8	23.7	16.5	10.8
2025.8337	NOV	195.3	128.0	65.5	23.9	16.7	10.8
2025.9170	DEC	192.5	125.1	58.4	23.9	17.0	10.7
2026.0003	JAN	190.7	122.2	56.8	23.9	17.1	10.6
2026.0837	FEB	185.9	119.5	58.9	23.5	17.2	10.3
2026.1670	MAR	180.3	117.3	57.6	22.5	17.2	10.5
2026.2503	APR	174.5	115.4	54.5	22.7	17.2	10.7
2026.3337	MAY	168.9	113.7	52.9	23.0	17.4	11.4
2026.4170	JUN	164.2	111.5	51.5	23.1	17.6	11.9
2026.5003	JUL	161.0	108.9	49.0	22.5	17.8	12.0
2026.5837	AUG	155.7	105.8	46.2	21.7	17.6	12.1
2026.6670	SEP	146.7	102.3	44.6	21.2	17.4	12.3
2026.7503	OCT	138.4	98.5	44.0	21.7	17.0	12.5
2026.8337	NOV	137.2	95.4	44.4	21.7	16.9	13.3
2026.9170	DEC	135.8	92.7	42.9	22.1	16.9	13.1
2027.0003	JAN	131.4	90.2	40.5	22.6	17.0	12.8
2027.0837	FEB	126.9	87.8	40.8	22.3	16.8	13.1
2027.1670	MAR	122.3	85.2	39.7	22.4	16.5	12.7
2027.2503	APR	116.8	82.5	37.9	22.7	16.2	12.5
2027.3337	MAY	115.9	80.0	36.5	22.9	15.8	12.1
2027.4170	JUN	116.9	77.4	34.0	23.5	15.6	11.2
2027.5003	JUL	115.4	74.6	31.6	24.1	15.4	10.5
2027.5837	AUG	114.0	71.8	27.9	24.8	15.3	10.7
2027.6670	SEP	111.6	69.9	24.8	25.3	15.3	10.8
2027.7503	OCT	107.6	67.9	22.9	25.6	15.3	10.6
2027.8337	NOV	103.7	65.9	19.9	25.4	15.3	10.8

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

TIME		SUNSPOT NUMBER ($\bar{R}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		95.0%	50%	5.0%	95.0%	50%	5.0%
2027.9170	DEC	100.5	63.7	17.4	24.9	15.2	11.0
2028.0003	JAN	99.6	61.4	15.8	24.0	15.0	11.1
2028.0837	FEB	98.6	59.2	14.5	23.0	14.9	11.3
2028.1670	MAR	95.5	57.1	13.2	22.5	15.0	11.2
2028.2503	APR	91.7	55.0	13.1	22.1	15.1	11.1
2028.3337	MAY	86.5	52.6	13.2	21.8	15.2	11.2
2028.4170	JUN	84.9	50.8	12.6	21.4	15.3	11.4
2028.5003	JUL	85.1	49.4	12.5	20.7	15.2	11.5
2028.5837	AUG	82.2	47.8	12.3	19.9	14.9	11.3
2028.6670	SEP	77.6	45.8	11.9	20.0	14.7	11.1
2028.7503	OCT	73.9	43.5	10.9	20.1	14.6	10.8
2028.8337	NOV	70.0	41.9	10.7	19.9	14.3	10.1
2028.9170	DEC	68.4	40.5	10.1	19.5	14.2	9.6
2029.0003	JAN	65.9	38.8	9.1	19.0	14.1	9.1
2029.0837	FEB	64.6	37.1	8.6	18.3	14.1	8.6
2029.1670	MAR	63.3	35.5	7.7	17.3	14.0	8.0
2029.2503	APR	62.3	34.1	6.5	17.4	13.8	7.5
2029.3337	MAY	60.9	32.4	5.9	17.5	13.7	7.6
2029.4170	JUN	59.1	30.9	5.9	17.6	13.7	7.8
2029.5003	JUL	57.0	29.5	5.5	17.5	13.6	8.3
2029.5837	AUG	54.8	28.1	5.4	17.7	13.5	8.6
2029.6670	SEP	51.8	26.5	4.3	18.1	13.4	8.5
2029.7503	OCT	48.6	25.0	3.2	17.9	13.2	8.6
2029.8337	NOV	44.1	23.7	2.7	17.6	12.9	8.5
2029.9170	DEC	38.6	22.1	2.5	17.3	12.6	8.5
2030.0003	JAN	34.9	20.3	2.1	16.3	12.2	8.4
2030.0837	FEB	33.1	18.4	1.5	14.8	11.8	8.4
2030.1670	MAR	32.1	16.8	1.1	13.8	11.4	8.3
2030.2503	APR	31.6	15.6	0.9	13.9	11.0	8.2
2030.3337	MAY	31.0	14.5	0.9	13.6	10.6	8.2
2030.4170	JUN	30.2	13.5	0.6	13.2	10.3	7.9
2030.5003	JUL	27.9	12.6	0.5	12.9	9.9	7.4
2030.5837	AUG	25.3	11.8	0.3	12.6	9.7	7.1
2030.6670	SEP	23.4	11.0	0.1	11.9	9.5	7.3
2030.7503	OCT	21.8	10.2	0.0	11.4	9.4	7.1

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		75.0%	50%	5.0%	95.0%	50%	5.0%
2015.5003	JUL	119.0	117.9	116.1	13.4	12.5	12.0
2015.5837	AUG	118.5	116.1	112.4	15.1	12.8	12.0
2015.6670	SEP	117.2	114.4	108.7	16.7	13.1	11.7
2015.7503	OCT	115.0	112.5	105.4	18.0	13.5	11.1
2015.8337	NOV	112.2	110.6	102.2	18.7	14.0	10.6
2015.9170	DEC	111.6	109.0	99.7	19.1	14.6	10.9
2016.0003	JAN	110.3	107.6	97.6	20.5	15.5	11.5
2016.0837	FEB	110.6	106.0	95.4	21.3	16.0	12.0
2016.1670	MAR	109.9	104.5	93.8	22.2	16.4	12.6
2016.2503	APR	107.6	103.1	91.4	22.9	16.4	12.7
2016.3337	MAY	106.1	101.6	88.5	23.0	15.9	12.2
2016.4170	JUN	105.1	100.1	86.1	23.6	15.7	11.4
2016.5003	JUL	103.5	98.7	84.8	24.3	15.5	10.7
2016.5837	AUG	101.1	97.5	83.8	24.8	15.3	10.6
2016.6670	SEP	100.5	96.4	83.1	25.1	15.2	10.6
2016.7503	OCT	100.9	95.4	82.5	25.0	14.9	10.1
2016.8337	NOV	99.4	94.5	82.1	24.2	14.3	9.5
2016.9170	DEC	99.1	93.5	81.8	23.2	13.8	9.2
2017.0003	JAN	97.8	92.3	81.0	21.9	13.5	9.0
2017.0837	FEB	96.0	91.1	79.6	20.8	13.2	8.9
2017.1670	MAR	95.3	90.1	78.5	20.3	13.3	8.9
2017.2503	APR	95.2	89.1	78.0	20.2	13.7	9.1
2017.3337	MAY	93.0	87.9	78.2	20.6	14.4	10.0
2017.4170	JUN	88.9	86.8	78.1	21.0	15.0	11.0
2017.5003	JUL	87.9	86.0	77.6	21.1	15.4	11.8
2017.5837	AUG	87.5	85.2	77.0	20.7	15.5	12.3
2017.6670	SEP	87.7	84.3	76.1	20.0	15.6	12.6
2017.7503	OCT	87.4	83.2	74.5	20.1	15.6	12.7
2017.8337	NOV	86.7	82.1	73.4	19.8	15.7	12.6
2017.9170	DEC	87.3	81.4	72.5	19.4	15.8	12.5
2018.0003	JAN	87.2	80.7	71.1	19.3	16.1	12.3
2018.0837	FEB	86.0	80.1	70.1	19.9	16.3	11.7
2018.1670	MAR	84.6	79.4	69.4	20.0	16.2	10.9
2018.2503	APR	83.1	78.7	68.8	19.7	15.9	10.6
2018.3337	MAY	81.7	78.0	68.3	19.1	15.5	10.3
2018.4170	JUN	80.9	77.4	68.2	18.3	15.1	10.1
2018.5003	JUL	80.1	76.7	68.1	18.5	15.0	10.1
2018.5837	AUG	79.3	76.1	68.0	18.8	15.0	10.0
2018.6670	SEP	78.5	75.5	67.9	19.1	14.8	9.9
2018.7503	OCT	77.8	74.9	67.8	19.0	14.5	9.7
2018.8337	NOV	77.0	74.3	67.7	18.6	14.2	9.7
2018.9170	DEC	76.3	73.7	67.6	17.7	13.6	9.4
2019.0003	JAN	75.6	73.2	67.5	16.9	13.0	9.1
2019.0837	FEB	74.9	72.7	67.4	16.0	12.4	8.8
2019.1670	MAR	74.3	72.2	67.4	15.2	11.8	8.5
2019.2503	APR	73.8	71.7	67.3	14.5	11.3	8.2
2019.3337	MAY	73.2	71.3	67.2	13.7	10.8	7.9
2019.4170	JUN	72.8	71.0	67.2	13.1	10.4	7.7
2019.5003	JUL	72.4	70.6	67.1	12.5	10.0	7.5

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		75.0%	50%	5.0%	95.0%	50%	5.0%
2019.5837	AUG	72.0	70.4	67.1	12.0	9.6	7.3
2019.6670	SEP	71.8	70.1	67.0	11.6	9.3	7.2
2019.7503	OCT	71.6	70.0	67.0	11.3	9.1	7.0
2019.8337	NOV	71.4	69.9	67.0	11.1	9.0	7.0
2019.9170	DEC	71.4	69.9	67.0	11.1	9.0	6.9
2020.0003	JAN	71.9	70.0	67.0	11.3	9.0	6.9
2020.0837	FEB	72.1	70.3	67.1	11.6	9.2	7.1
2020.1670	MAR	72.8	70.7	67.2	11.7	9.3	7.4
2020.2503	APR	72.5	71.0	67.2	11.9	9.4	7.5
2020.3337	MAY	72.9	71.5	67.4	12.0	9.5	7.5
2020.4170	JUN	73.3	72.0	67.5	12.1	9.6	7.3
2020.5003	JUL	73.8	72.6	67.6	12.2	9.7	7.2
2020.5837	AUG	75.1	73.3	67.8	12.5	9.9	7.1
2020.6670	SEP	76.7	74.1	67.9	12.8	10.1	7.0
2020.7503	OCT	78.1	75.1	68.0	13.2	10.5	7.2
2020.8337	NOV	79.9	76.3	68.3	13.7	10.8	7.6
2020.9170	DEC	82.0	77.7	68.4	14.5	11.1	7.9
2021.0003	JAN	85.2	79.2	68.4	15.7	11.4	7.7
2021.0837	FEB	88.2	80.9	68.4	16.1	11.6	7.7
2021.1670	MAR	90.2	82.9	68.4	16.3	11.8	7.6
2021.2503	APR	92.2	85.1	68.3	16.8	12.0	7.6
2021.3337	MAY	95.6	87.3	68.6	18.0	12.3	7.6
2021.4170	JUN	99.1	89.9	68.7	18.9	12.6	7.7
2021.5003	JUL	103.5	92.6	68.9	19.1	12.7	7.7
2021.5837	AUG	108.5	95.4	69.2	19.2	12.9	7.8
2021.6670	SEP	112.0	98.2	69.2	19.0	13.1	7.7
2021.7503	OCT	116.5	101.0	69.5	18.6	13.1	7.7
2021.8337	NOV	120.8	103.9	69.9	18.5	13.2	7.8
2021.9170	DEC	124.1	107.0	70.6	18.9	13.4	8.0
2022.0003	JAN	126.7	110.1	70.9	18.8	13.5	8.2
2022.0837	FEB	129.2	113.2	71.3	17.8	13.5	8.6
2022.1670	MAR	133.3	116.5	71.5	17.9	13.7	8.7
2022.2503	APR	138.2	119.7	72.1	18.5	13.9	8.7
2022.3337	MAY	142.8	122.9	72.9	19.1	14.2	9.0
2022.4170	JUN	148.3	125.7	73.3	19.6	14.6	9.4
2022.5003	JUL	152.9	128.2	74.1	20.3	14.9	9.6
2022.5837	AUG	157.7	130.5	74.7	20.3	15.1	9.6
2022.6670	SEP	163.7	132.6	75.1	20.3	15.1	9.8
2022.7503	OCT	169.4	135.1	75.6	20.5	15.2	10.0
2022.8337	NOV	174.6	137.7	75.9	20.8	15.4	10.5
2022.9170	DEC	180.2	140.3	76.1	21.2	15.4	11.1
2023.0003	JAN	183.5	142.4	76.1	21.3	15.3	11.6
2023.0837	FEB	185.6	144.3	76.0	21.4	15.1	11.3
2023.1670	MAR	185.7	146.0	76.1	21.6	15.0	11.2
2023.2503	APR	185.2	147.7	76.6	22.0	15.0	10.7
2023.3337	MAY	184.2	149.0	76.9	22.8	14.9	10.2
2023.4170	JUN	184.6	149.9	77.6	22.5	14.7	9.9
2023.5003	JUL	187.3	150.8	78.9	21.3	14.5	10.1
2023.5837	AUG	190.1	151.2	79.7	20.6	14.3	10.1
2023.6670	SEP	191.7	151.4	80.6	20.1	14.2	10.3

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		75.0%	50%	5.0%	95.0%	50%	5.0%
2023.7503	OCT	191.8	151.7	82.2	19.6	14.1	10.6
2023.8337	NOV	191.4	151.9	83.8	19.5	14.0	10.6
2023.9170	DEC	189.8	152.0	85.6	19.3	14.0	10.5
2024.0003	JAN	186.5	151.2	86.4	19.1	14.2	10.5
2024.0837	FEB	182.2	149.7	87.8	18.9	14.6	10.5
2024.1670	MAR	177.4	148.7	89.5	18.9	14.7	10.3
2024.2503	APR	173.9	148.4	90.7	19.5	14.6	9.8
2024.3337	MAY	177.0	148.5	93.0	20.4	14.7	10.2
2024.4170	JUN	176.6	148.9	94.2	22.0	15.0	10.7
2024.5003	JUL	173.8	149.0	95.5	23.4	15.3	10.7
2024.5837	AUG	172.7	148.7	95.8	24.0	15.4	10.9
2024.6670	SEP	171.7	148.1	95.4	25.1	15.7	11.1
2024.7503	OCT	170.6	147.5	95.4	25.6	15.9	11.3
2024.8337	NOV	167.1	147.3	96.9	24.9	15.9	11.5
2024.9170	DEC	163.8	147.2	97.7	24.8	15.9	11.7
2025.0003	JAN	161.2	146.4	97.2	23.9	15.8	11.9
2025.0837	FEB	158.7	145.1	96.4	22.1	15.8	11.8
2025.1670	MAR	155.9	143.5	96.3	22.4	15.9	12.0
2025.2503	APR	155.7	141.8	96.8	23.1	16.0	11.8
2025.3337	MAY	156.4	140.1	96.3	23.1	16.0	11.1
2025.4170	JUN	154.9	138.8	95.5	22.6	16.0	10.8
2025.5003	JUL	151.2	137.4	96.1	22.0	15.8	10.8
2025.5837	AUG	147.1	135.6	97.1	21.9	15.8	10.8
2025.6670	SEP	144.2	133.7	96.2	22.7	16.1	10.8
2025.7503	OCT	144.9	132.2	94.5	23.7	16.5	10.8
2025.8337	NOV	142.3	130.9	93.8	23.9	16.7	10.8
2025.9170	DEC	137.0	129.5	93.6	23.9	17.0	10.7
2026.0003	JAN	134.3	127.8	91.7	23.9	17.1	10.6
2026.0837	FEB	134.9	125.9	88.3	23.5	17.2	10.3
2026.1670	MAR	134.0	124.6	87.9	22.5	17.2	10.5
2026.2503	APR	134.3	123.5	88.7	22.7	17.2	10.7
2026.3337	MAY	132.9	122.3	87.3	23.0	17.4	11.4
2026.4170	JUN	131.5	121.0	86.3	23.1	17.6	11.9
2026.5003	JUL	130.4	119.3	85.7	22.5	17.8	12.0
2026.5837	AUG	129.7	117.4	84.8	21.7	17.6	12.1
2026.6670	SEP	126.8	115.6	83.6	21.2	17.4	12.3
2026.7503	OCT	125.7	113.7	82.5	21.7	17.0	12.5
2026.8337	NOV	125.9	111.7	82.1	21.7	16.9	13.3
2026.9170	DEC	124.1	110.0	82.1	22.1	16.9	13.1
2027.0003	JAN	122.4	108.6	82.0	22.6	17.0	12.8
2027.0837	FEB	120.8	107.0	80.9	22.3	16.8	13.1
2027.1670	MAR	118.9	105.5	80.5	22.4	16.5	12.7
2027.2503	APR	116.4	104.0	80.6	22.7	16.2	12.5
2027.3337	MAY	115.2	102.5	80.0	22.9	15.8	12.1
2027.4170	JUN	114.2	100.9	79.1	23.5	15.6	11.2
2027.5003	JUL	111.9	99.4	77.7	24.1	15.4	10.5
2027.5837	AUG	108.1	98.2	75.6	24.8	15.3	10.7
2027.6670	SEP	106.6	97.1	74.5	25.3	15.3	10.8
2027.7503	OCT	105.0	96.1	74.0	25.6	15.3	10.6
2027.8337	NOV	104.3	95.2	73.6	25.4	15.3	10.8

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

TIME		10.7-CM SOLAR FLUX ($\bar{F}_{10.7}$) PERCENTILE			GEOMAGNETIC INDEX ($\bar{A}_p$) PERCENTILE		
		75.0%	50%	5.0%	95.0%	50%	5.0%
2027.9170	DEC	102.5	94.2	73.4	24.9	15.2	11.0
2028.0003	JAN	100.8	92.9	73.0	24.0	15.0	11.1
2028.0837	FEB	99.1	91.7	72.7	23.0	14.9	11.3
2028.1670	MAR	98.3	90.7	71.9	22.5	15.0	11.2
2028.2503	APR	98.3	89.6	71.4	22.1	15.1	11.1
2028.3337	MAY	97.9	88.4	71.0	21.8	15.2	11.2
2028.4170	JUN	97.0	87.3	70.7	21.4	15.3	11.4
2028.5003	JUL	95.7	86.5	70.4	20.7	15.2	11.5
2028.5837	AUG	95.0	85.6	70.5	19.9	14.9	11.3
2028.6670	SEP	93.3	84.7	70.3	20.0	14.7	11.1
2028.7503	OCT	91.0	83.5	69.8	20.1	14.6	10.8
2028.8337	NOV	89.6	82.4	69.6	19.9	14.3	10.1
2028.9170	DEC	88.2	81.7	69.5	19.5	14.2	9.6
2029.0003	JAN	86.7	81.0	69.4	19.0	14.1	9.1
2029.0837	FEB	86.0	80.3	69.3	18.3	14.1	8.6
2029.1670	MAR	85.4	79.6	69.1	17.3	14.0	8.0
2029.2503	APR	84.3	78.9	68.8	17.4	13.8	7.5
2029.3337	MAY	82.9	78.2	68.5	17.5	13.7	7.6
2029.4170	JUN	81.8	77.5	68.3	17.6	13.7	7.8
2029.5003	JUL	81.3	77.0	68.4	17.5	13.6	8.3
2029.5837	AUG	81.0	76.5	68.4	17.7	13.5	8.6
2029.6670	SEP	80.8	75.9	68.5	18.1	13.4	8.5
2029.7503	OCT	79.4	75.4	68.4	17.9	13.2	8.6
2029.8337	NOV	78.0	74.9	68.4	17.6	12.9	8.5
2029.9170	DEC	77.4	74.2	68.3	17.3	12.6	8.5
2030.0003	JAN	76.8	73.5	68.0	16.3	12.2	8.4
2030.0837	FEB	75.8	72.8	67.8	14.8	11.8	8.4
2030.1670	MAR	75.6	72.3	67.6	13.8	11.4	8.3
2030.2503	APR	74.6	72.0	67.6	13.9	11.0	8.2
2030.3337	MAY	73.4	71.6	67.5	13.6	10.6	8.2
2030.4170	JUN	73.5	71.2	67.2	13.2	10.3	7.9
2030.5003	JUL	72.6	70.9	67.1	12.9	9.9	7.4
2030.5837	AUG	72.3	70.6	67.1	12.6	9.7	7.1
2030.6670	SEP	72.2	70.3	67.0	11.9	9.5	7.3
2030.7503	OCT	71.9	70.1	67.0	11.4	9.4	7.1

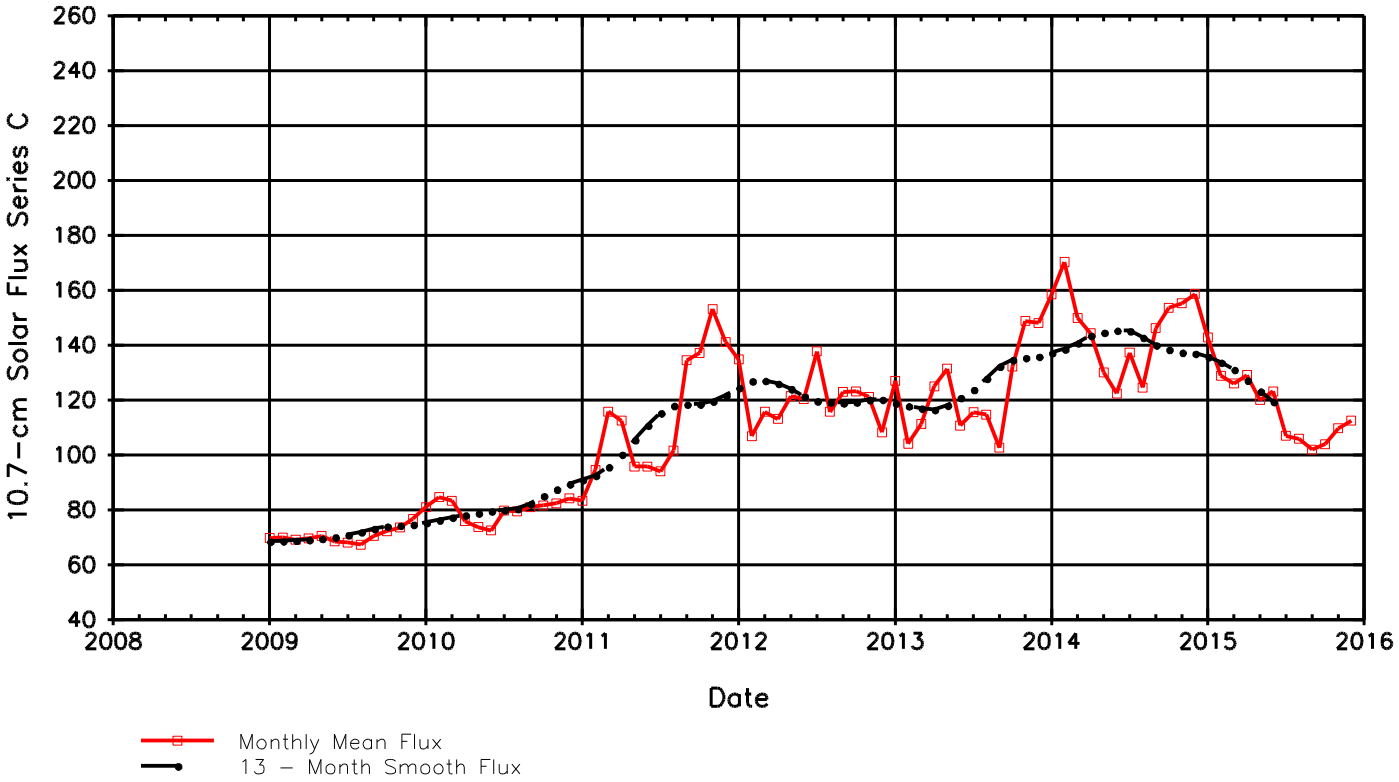

Figure 1. Plot of Recent Monthly Mean and 13-Month Smoothed Solar Flux

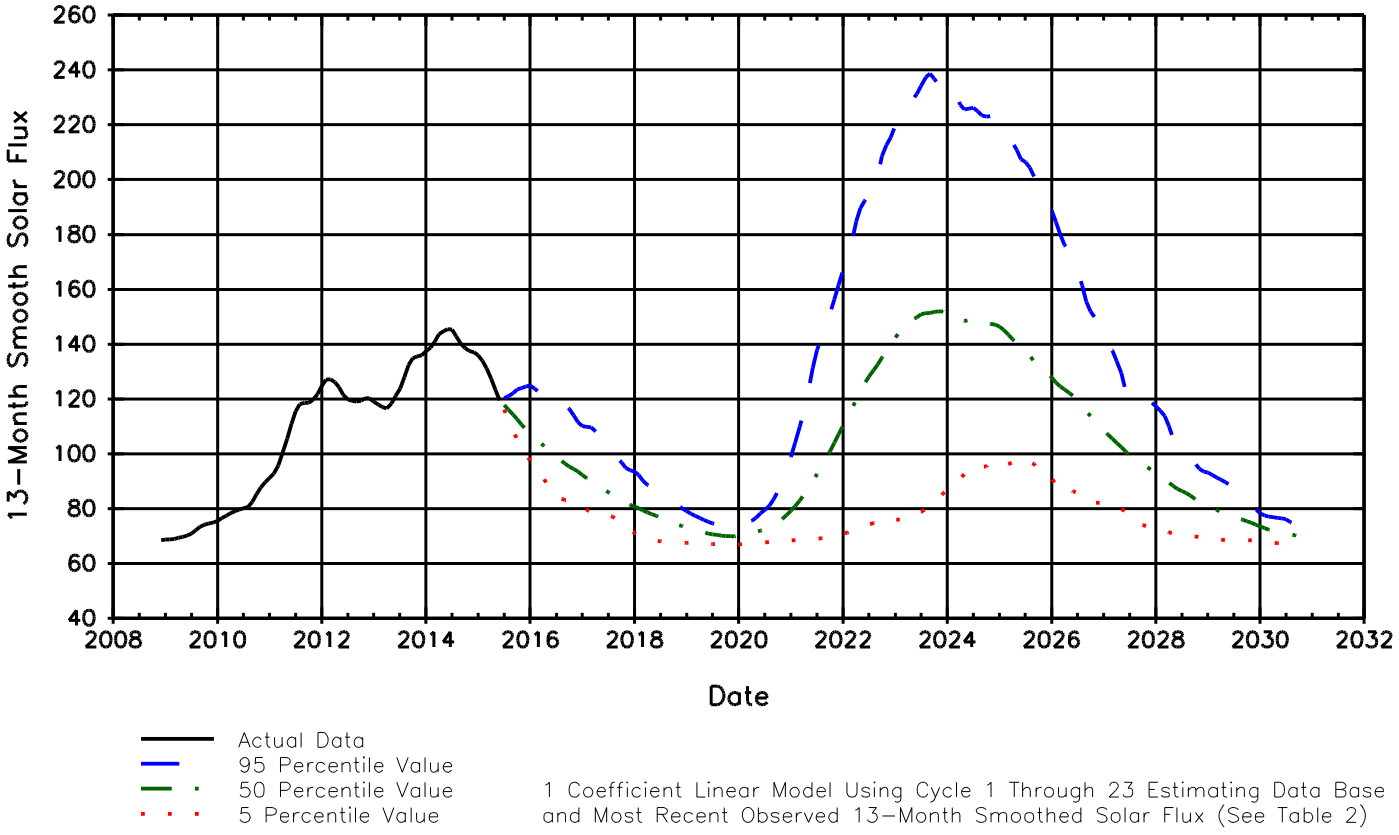

Figure 2. Estimate of 13-Month Smoothed Solar Flux For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24

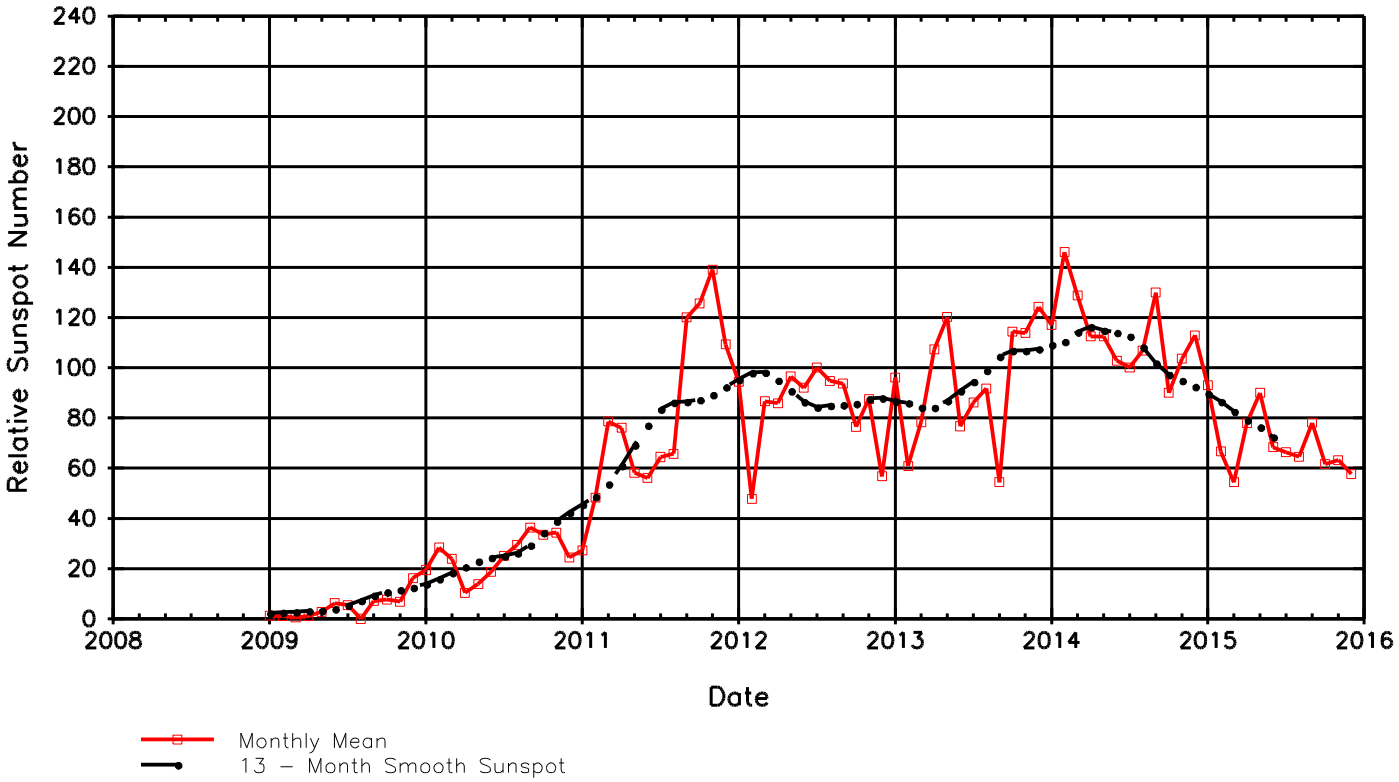

Figure 3. Plot of Recent Monthly Mean and 13-Month Smoothed Relative Sunspot Number

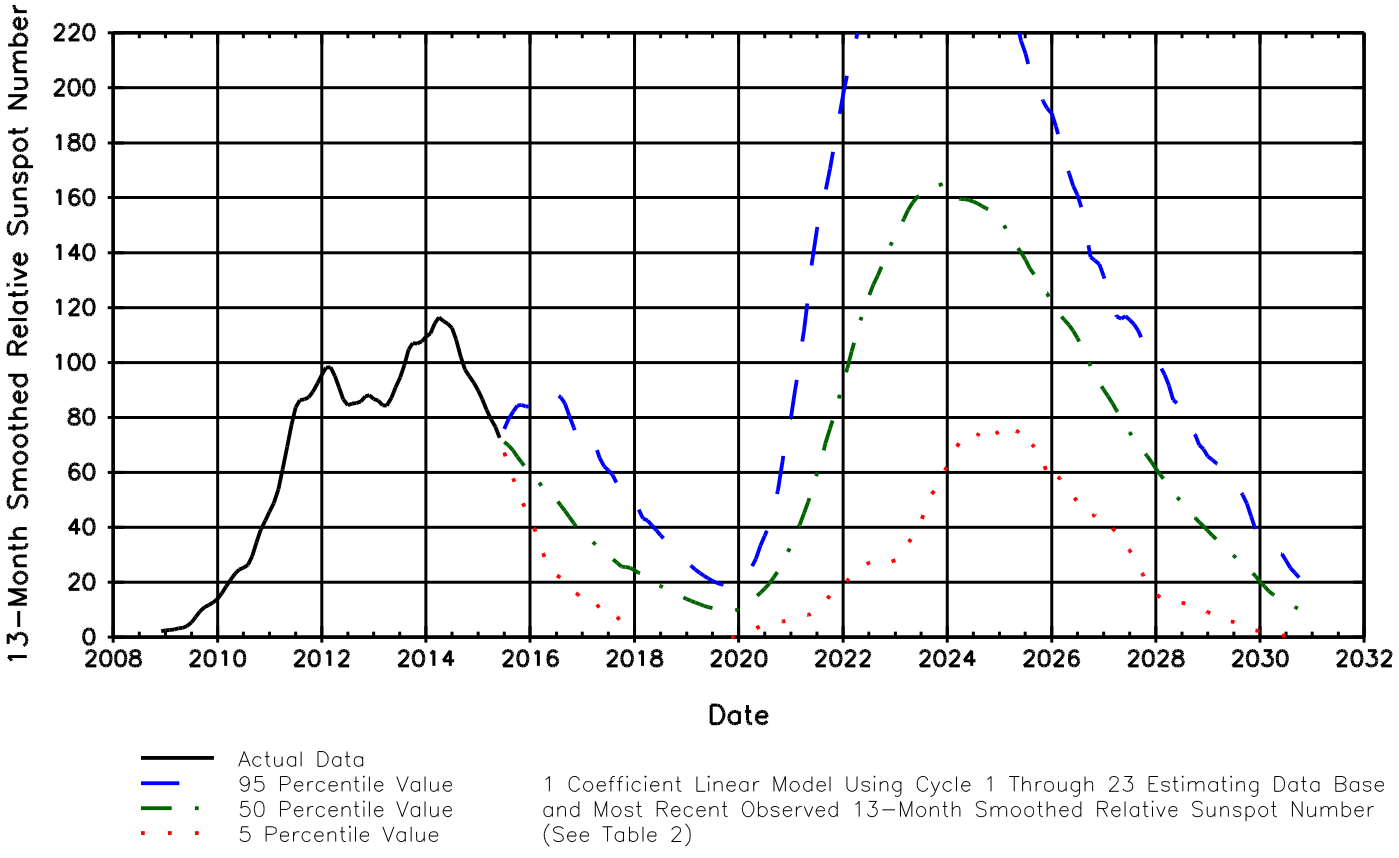

Figure 4. Estimate of 13-Month Smoothed Sunspot Number For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24

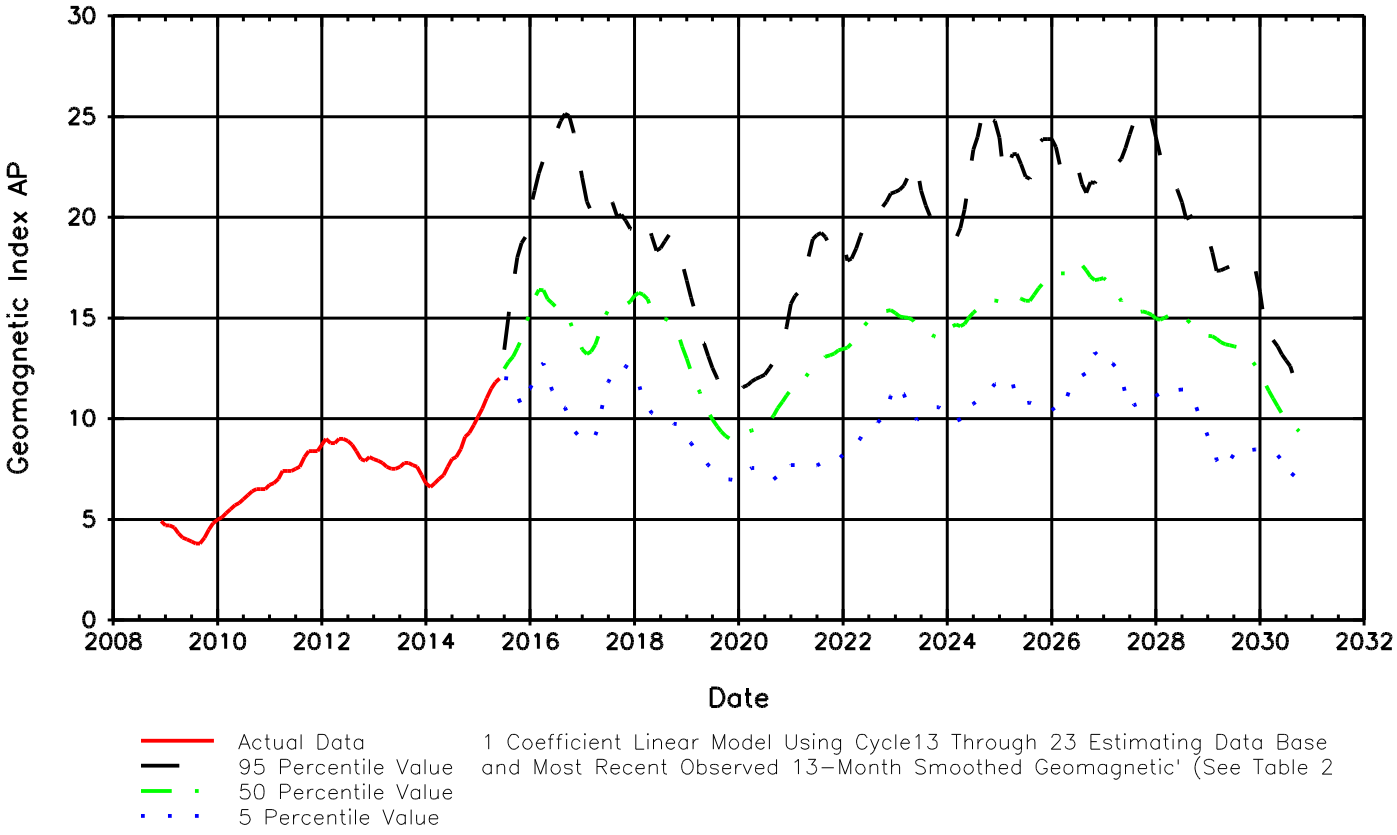

Figure 5. Estimate of 13-Month Smoothed Ap For Cycle 24* and Cycle 25

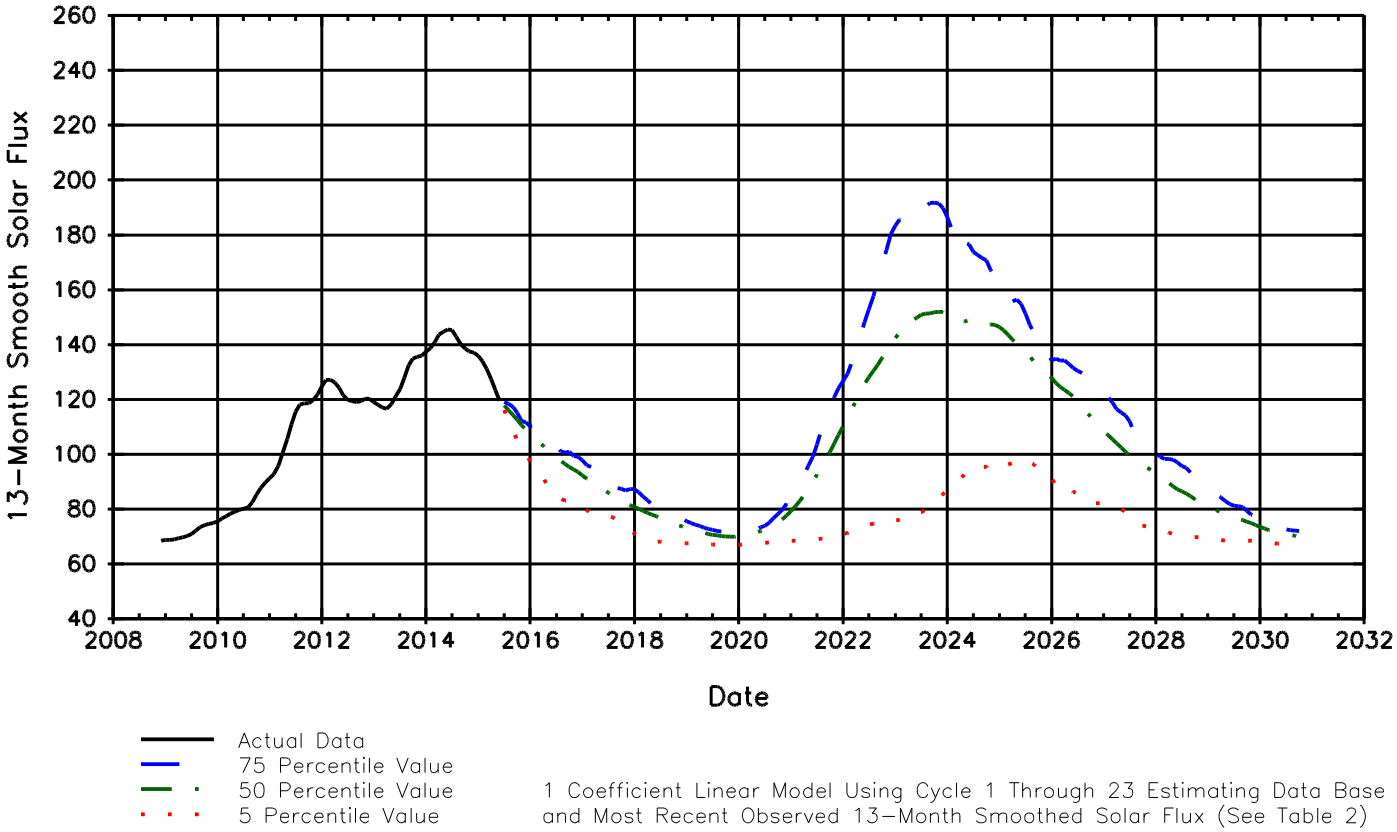

Figure 6. Estimate of 75th Percentile 13-Month Smoothed Solar Flux For Cycle 24* and Cycle 25

* Program initialized from the start of Cycle 24