Update, or Lack Thereof, to the Solar Cycle 24 Prediction

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NOAA/SWPC

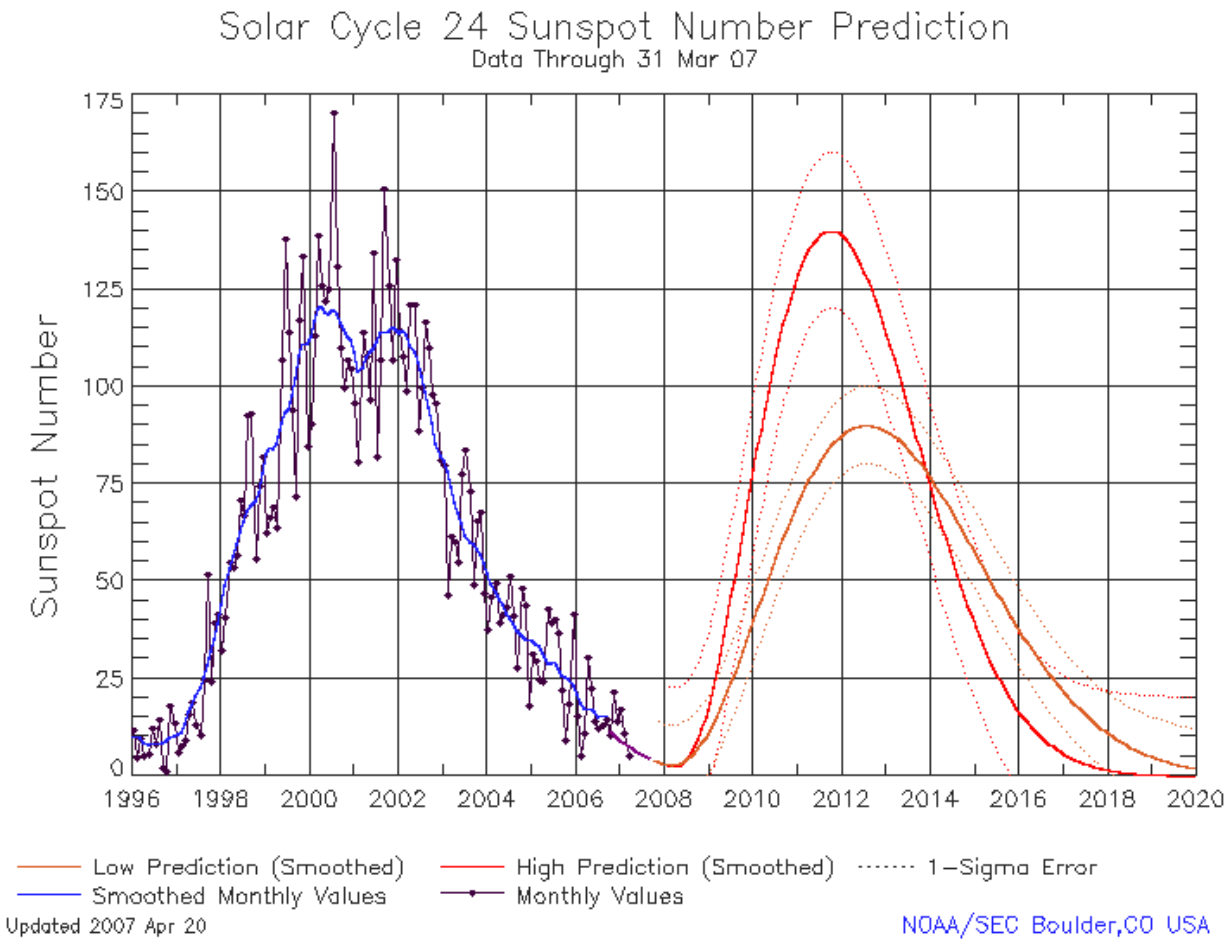
Outline

- Status of the current prediction, made in 2009
  - Is the prediction still valid?
  - What arguments drove the current prediction?
- Why has the forecast not been adjusted?
  - Because it's right…enough
- Comparison between Cycle 24 (so far) and previous solar cycles
  - Sunspots
  - Flares

The Panel

Panelist	Affiliation	Panelist	Affiliation	Panelist	Affiliation
D. Biesecker	NOAA, Chair	**M. Dikpati**	NCAR	**K. Dowdy**	USAF
D. Hathaway	NASA	**T. Hoeksema**	Stanford U.	**E. Kihn**	NOAA
H. Lundstedt	Swedish Inst. of Space Sci.	**D. Pesnell**	NASA	**M. Rast**	U. Colorado
L. Svalgaard	ETK Inc.	**R. Thompson**	IPS Australia	**R. Van der Linden**	Royal Obs. Of Belgium
J. Kunches	NOAA, ex-officio	**O.C. St. Cyr**	NASA, ex-officio		

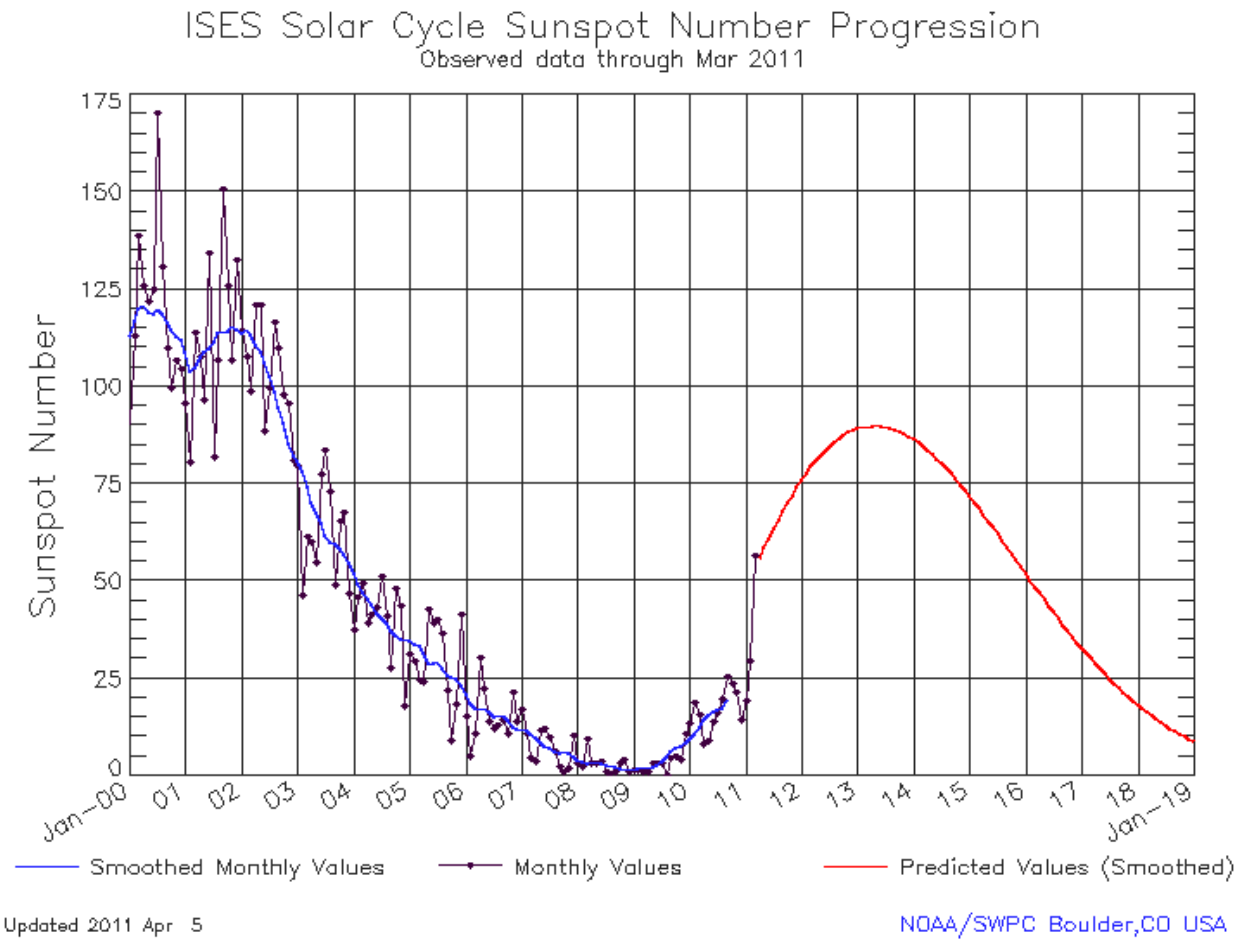
Remember all that craziness from 2008? What were they thinking?



What the ‘Official’ Panel ‘Officially’ Predicted

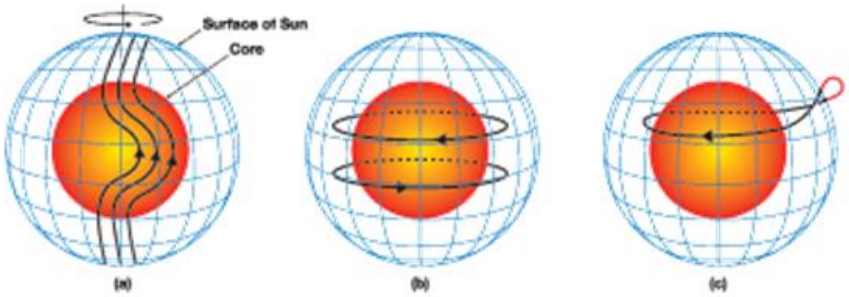
- Updated prediction released in May, 2009
  - Solar Minimum would occur in December, 2008
    - Remember, we only had smoothed data through October, 2008
  - Solar Maximum will occur in May, 2013
  - Solar Maximum will reach a peak SSN of 90
    - Average maximum is 114

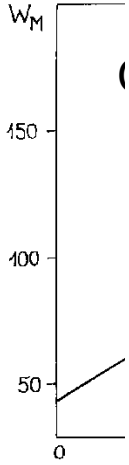
What that prediction looks like



Geomagnetic Precursors

- **Utilize information from the declining phase of a cycle or from solar minimum to predict the intensity of the subsequent maximum**
  - Based in dynamo theory, whereby poloidal field of cycle N is converted into toroidal field of cycle N+1
- **Historically, these techniques have provided the best skill at predicting the solar cycle.**





Prediction Method	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	RMS
Mean Cycle	-94.8	-9.1	-53.5	-48.6	-10.1	53.7
Secular Trend	-91.6	8.7	-36.2	-25.3	17.8	46.3
Gleissberg Cycle	-80.4	18.5	-51.6	-51.1	-9.6	49.4
Even-Odd	-59.3		-22.3		61.1	50.8
Amplitude-Period	-74.1	0.3	-61.2	-25.3	9.7	44.7
Maximum-Minimum	-83.9	21.6	-22.9	-15.0	1.8	40.6
Ohl's Method	-55.4	19.1	21.8	4.4	22.2	29.7
Feynmann's Method	-42.8	9.6	26.9	3.6	41.1	29.5
Thompson's Method	-17.8	8.7	-26.5	-13.6	40.1	24.1

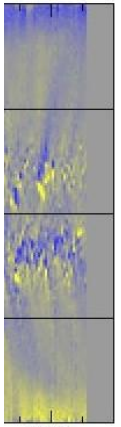
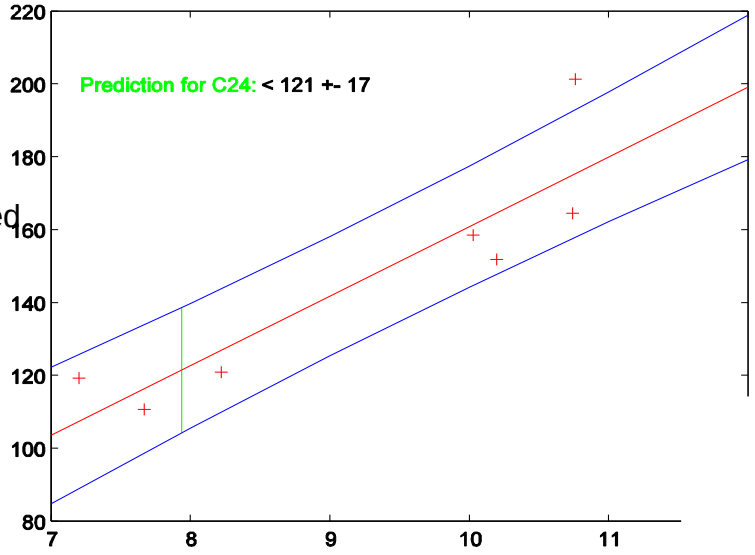


Figure 1 ... in the maximum of the next 11-year cycle.

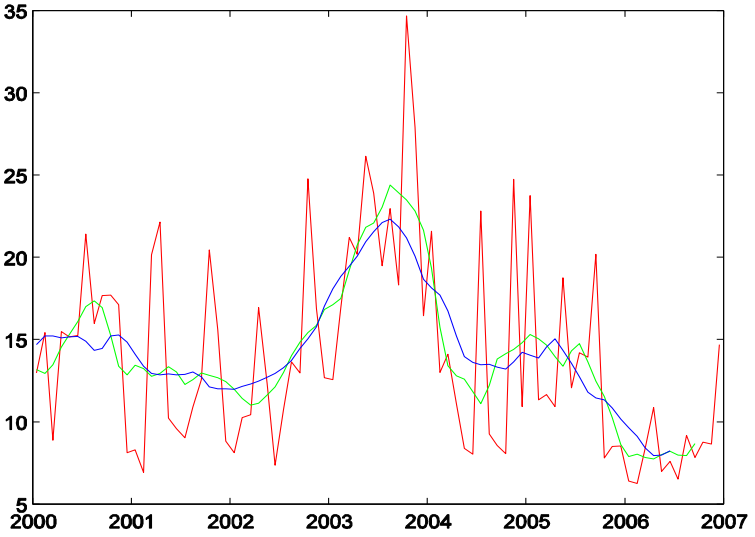
Courtesy D. Hathaway

Richard Thompson (IPS) Geomagnetic Precursor based on Ap

Peak Smoothed SSN



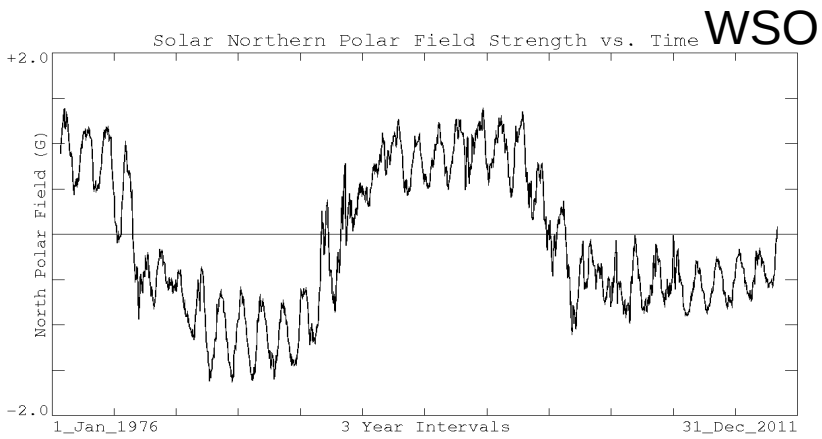
Minimum 12-month average Ap

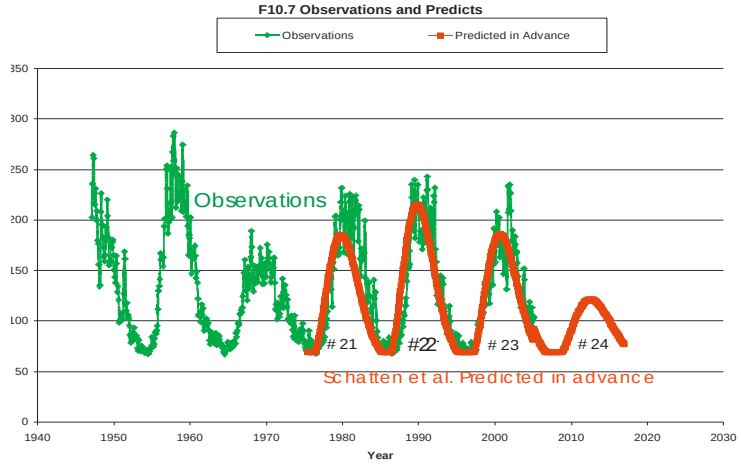


- red (monthly)
- green (6 monthly)
- blue (12 monthly)

Polar Field Precursor Methods

- A model calling for a small cycle – short recycle time
  - Skip the 'proxy' (geomagnetic disturbances)

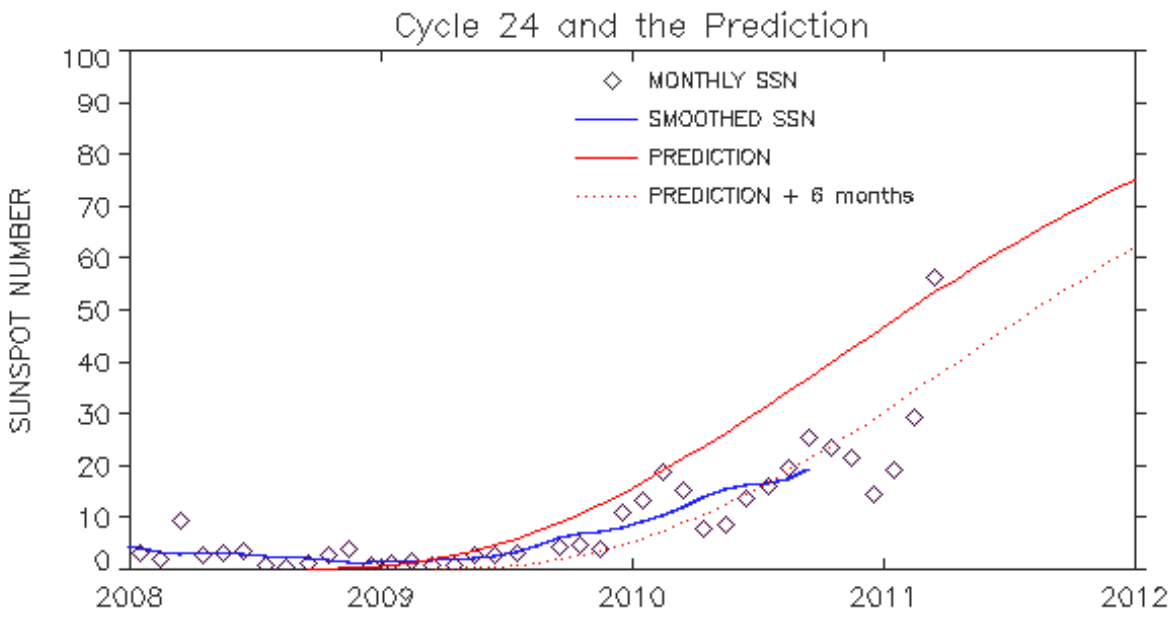




$$\mathrm{SODA} = 60 + 146\left[\left(\frac{B_{pol}}{1.28}\right)^2 + \left(\frac{\mathrm{F10.7} - 60}{146}\right)^2\right]^{1/2}$$

Schatten and Pesnell (1993)

How is the Prediction Shaping Up?



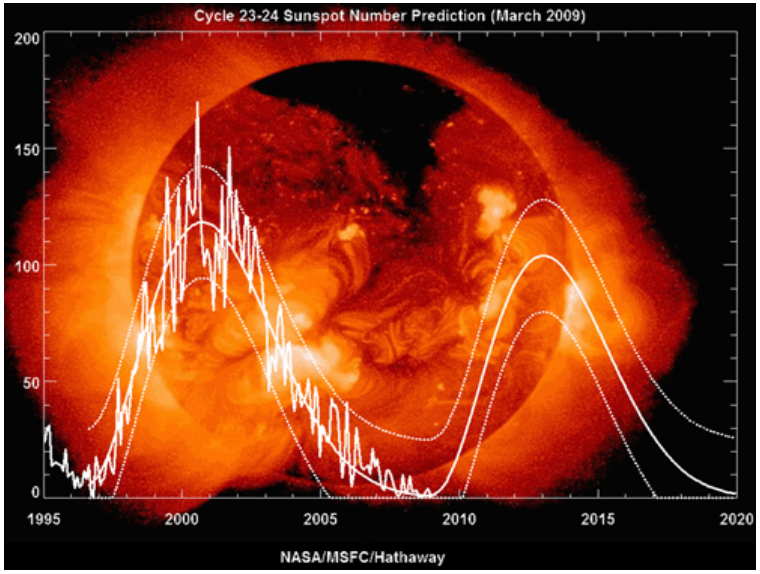
The cycle may be lagging slightly behind the prediction

- Overall, it's not far off

What is everyone else saying?

Well, some of them anyway…

- IPS
  - 90 in April 2013
- SODA
  - 82 in early 2014
- NGDC (McNish-Lincoln)
  - 76 in June/July 2013
- Hathaway
  - Geomag Precursor
  - 59 in June/July 2013



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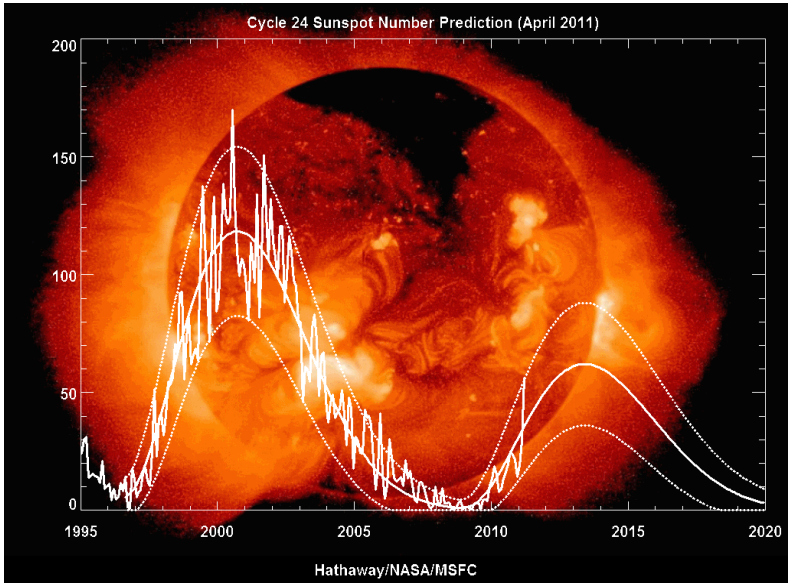
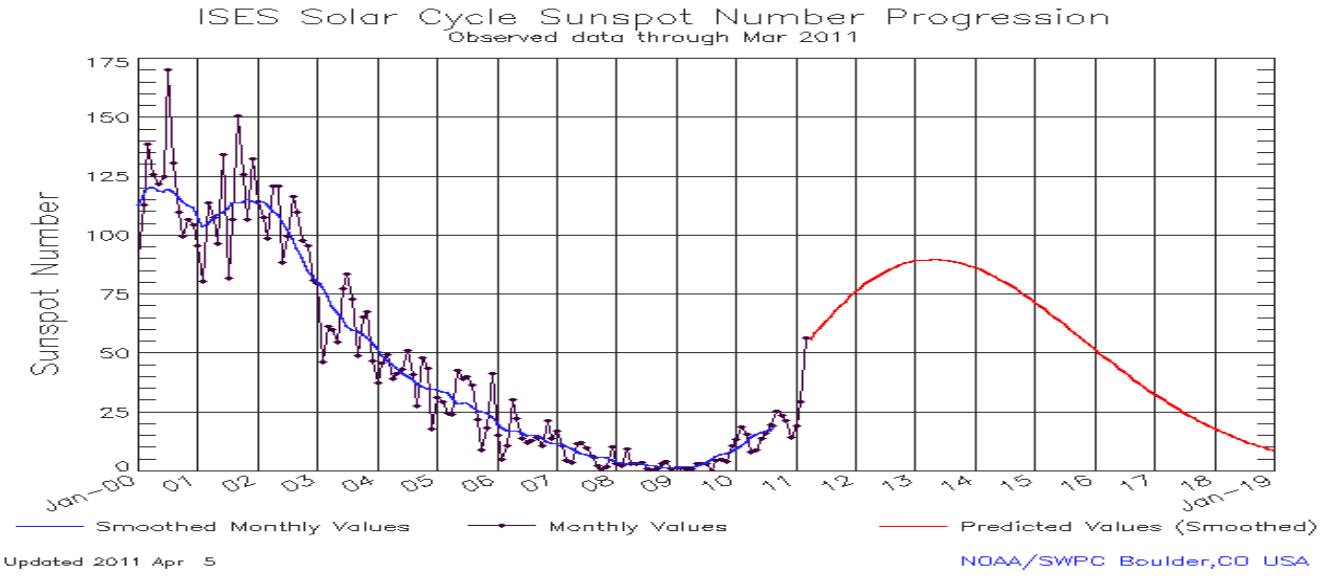


Why is there a lack of an update?

- Everybody seems to now agree the cycle will be small
  - Whether it ends up being 90 or 80, shouldn't really matter.
  - We won't chase a number, unless it's clear we are 'wildly' wrong
- Should consider in the future choosing one of
  - Small, Average, Large



Cycle sizes

Small	Average	Large
48.7	98	140.3
49.2	105.2	141.2
64.2	110	146.9
71.5	114.1	151.8
74.6	115.8	158.5
78.1	119.2	158.5
86.5	120.8	163.9
87.9	131.9	201.3

Smoothed SSN
Sorted by size

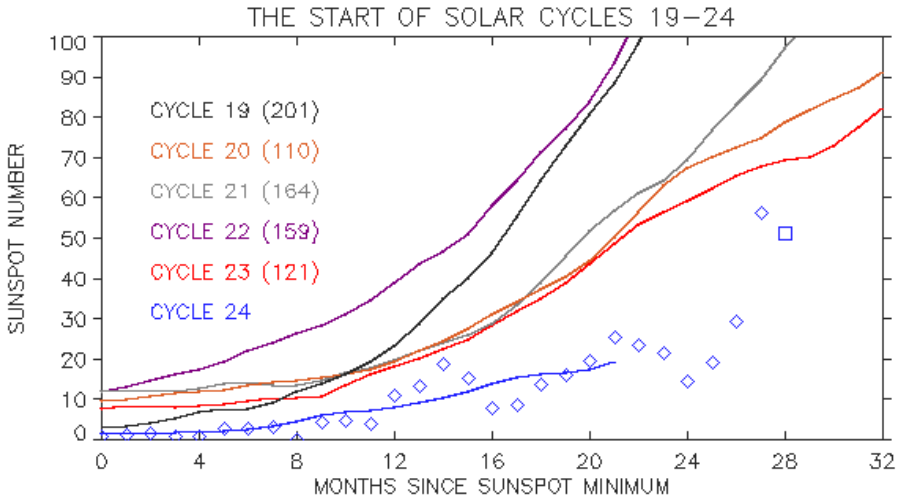
- Small <=90
- Medium >90 - <140
- Large >=140

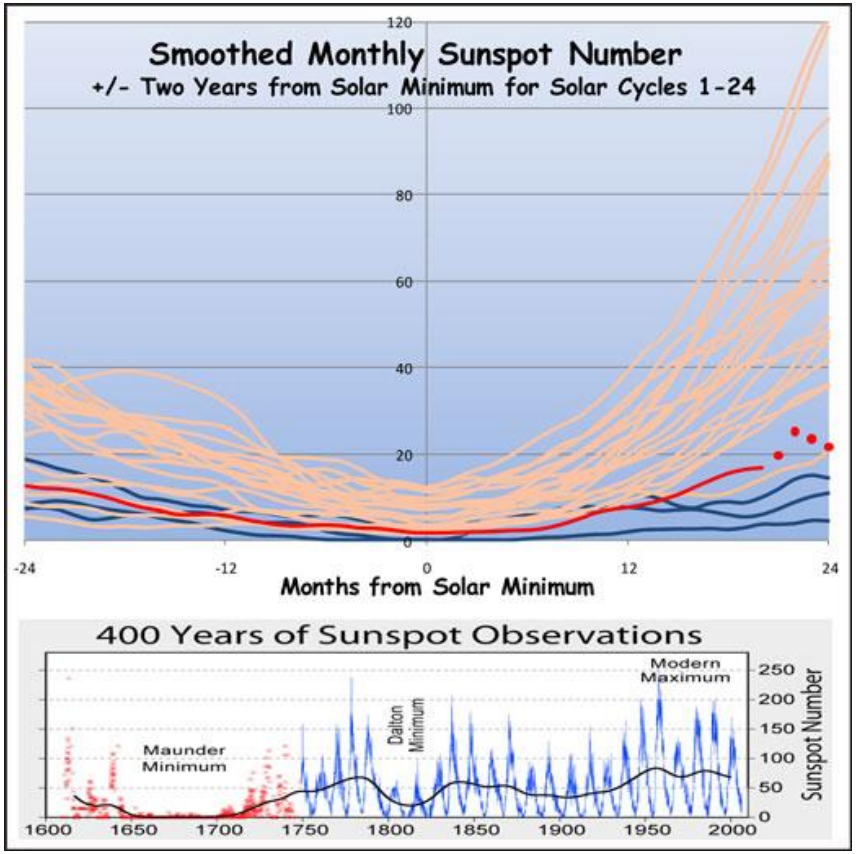
- Something for the next panel to consider

How does Cycle 24 Compare?

Clearly cycle 24 started from a lower SSN and is rising slower than recent cycles

This is exactly what we expect for a prediction of a small cycle

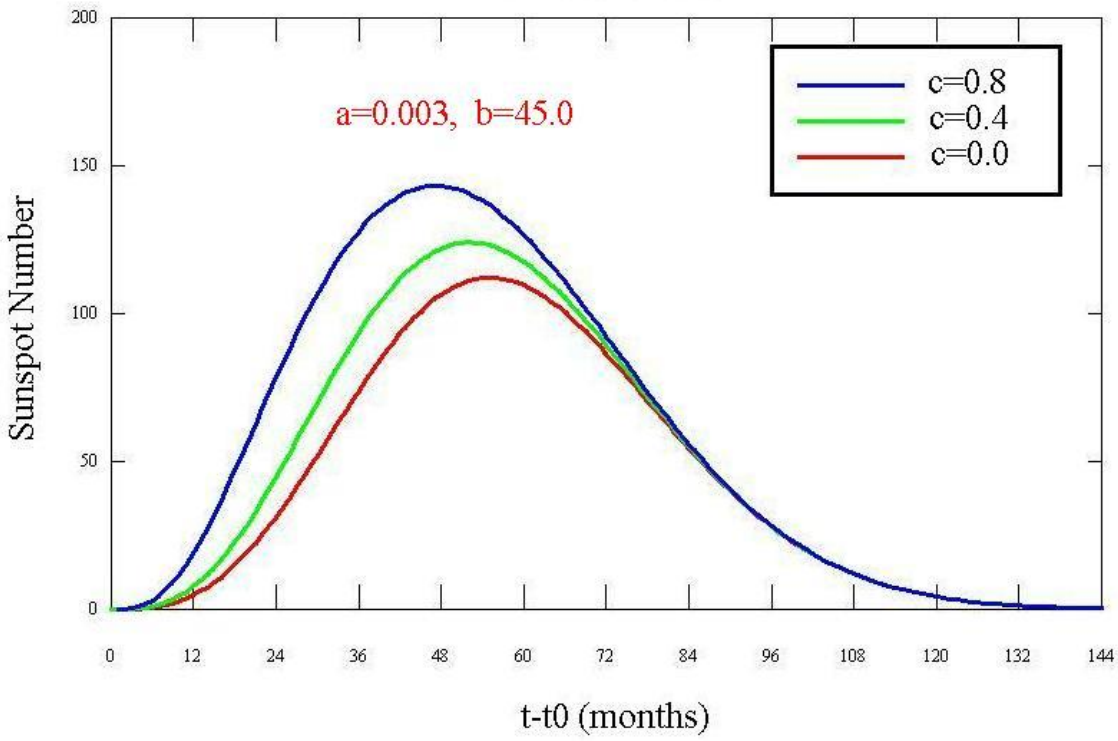




A Functional Form for the Cycle

Fitting the cycle to a functional form with amplitude *a*, starting time t_0, width *b*, and asymmetry *c*, provides a prediction for the current cycle and can account for systematic changes in cycle shape.

$$f(t;a,t_0,b,c) = \frac{a(t-t_0)^3}{\exp\left[(t-t_0)^2/b^2\right]-c}$$



Solar Activity at the Start of the Cycle (Months 1-27)

CYCLE	27 month total SSN	GOES M flares	M Flares / SSN	GOES X flares	X Flares / SSN
21	1292	183	0.14	18	0.014
22	1769	318	0.18	20	0.011
23	1122	131	0.12	17	0.015
24	337	37	0.11	1	0.003

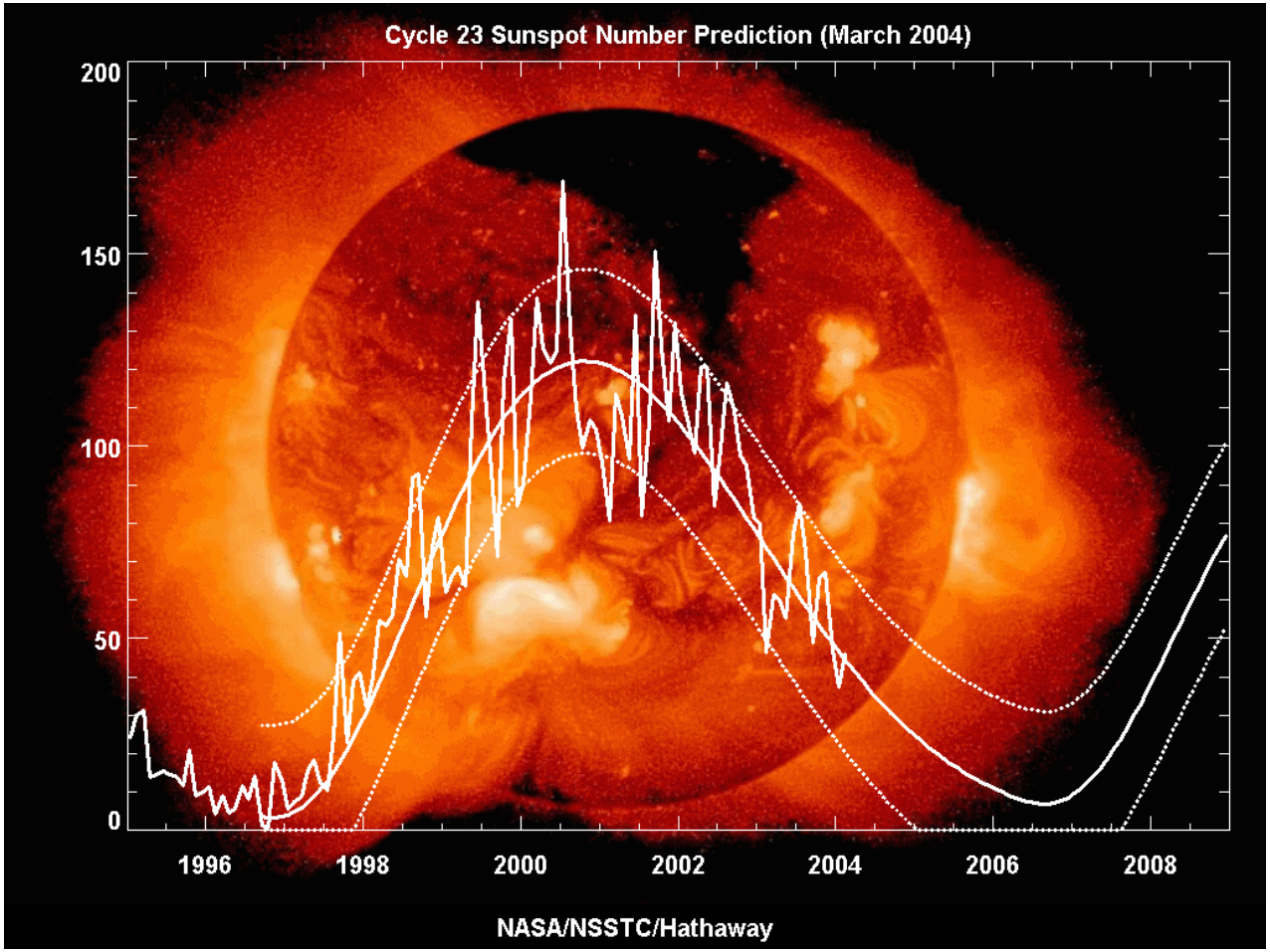
WHERE ARE ALL THE X-FLARES?

Otherwise, this cycle looks normal compared to recent, larger cycles

Summary

- The Solar Cycle Prediction remains on track
  - Peak of 90 in May, 2013
  - Or close enough to not go chasing a number
- Seems that everyone now agrees the cycle will be smaller than average
- The official prediction should be seen as guidance
  - Below average, average, above average
- The solar flare rate is consistent with recent solar cycles

One final movie



Accurate Predictions by 30 Months

Asymmetry is constant (c=0.71) and width varies with amplitude. The remaining two parameters, amplitude and starting time, can be accurately determined by about 30 months from the start of the cycle.