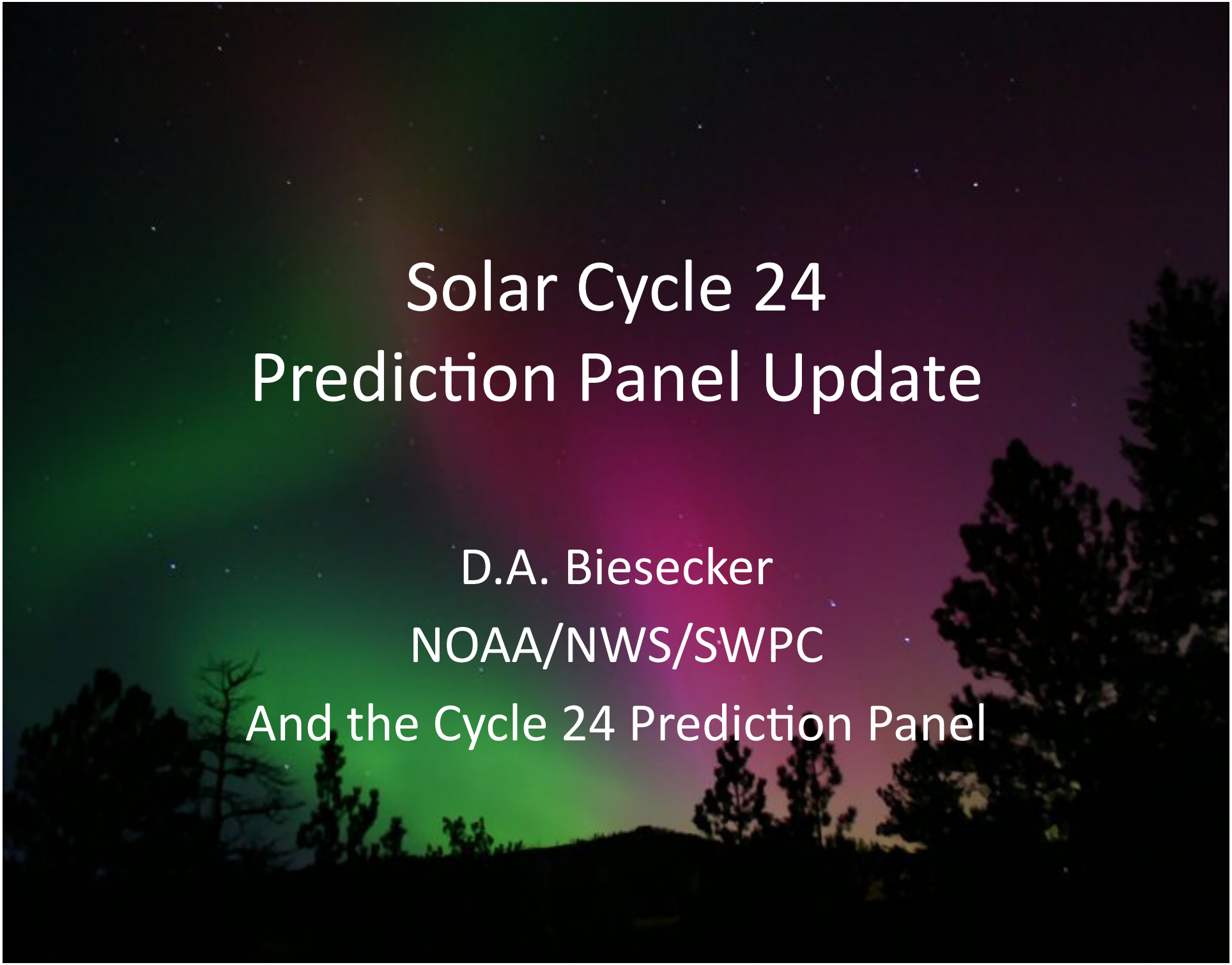


Solar Cycle 24 Prediction Panel Update

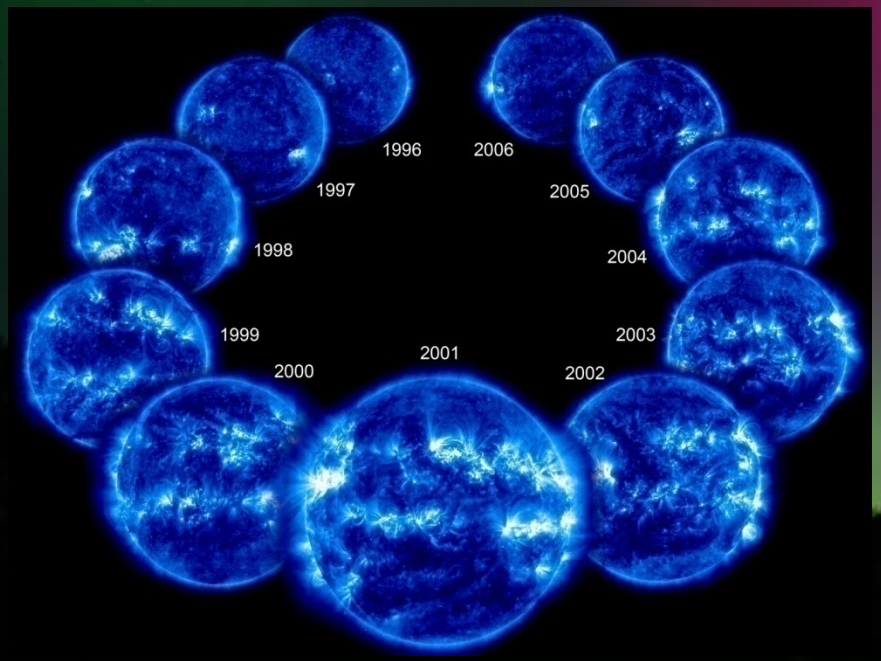
D.A. Biesecker

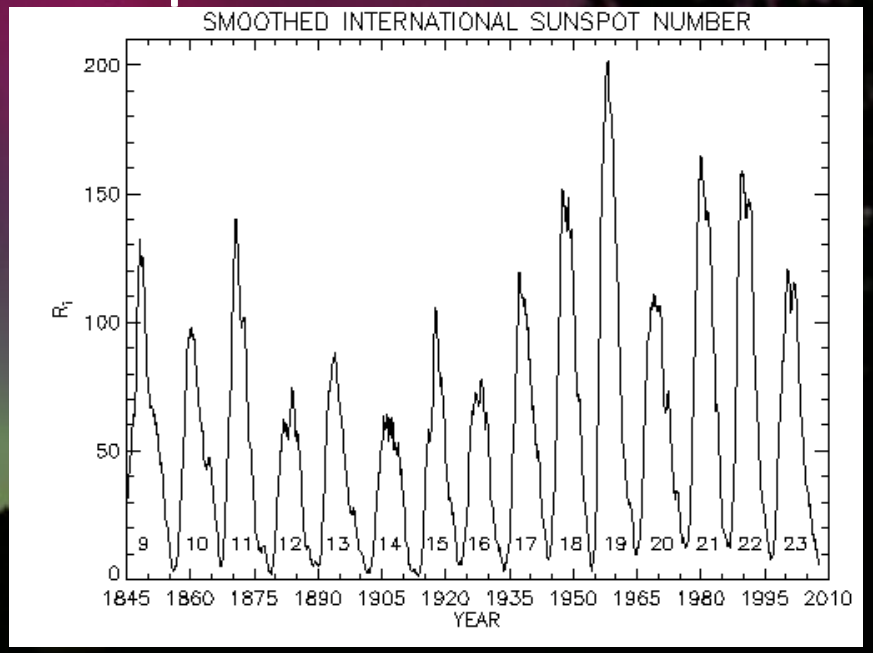
NOAA/NWS/SWPC

And the Cycle 24 Prediction Panel

Outline

- The April 2007 Solar Cycle Prediction
  - Arguments for and against
- Where is the Sun now?
- What's the latest from the panel?





The Background

- Charged with determining the official prediction for Solar Cycle 24 for NOAA, NASA, and the International Space Environment Service (ISES)
  - Time and intensity of solar cycle 24
    - Sunspot number
    - F10.7
- Panel chaired by NOAA, funded by NASA
  - Previous panels met in 1989 and 1996
- International membership
- The panel has 12 voting members
  - Only 11 voted on these predictions

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		

Predicting Cycle 24

The Third Official Prediction Panel

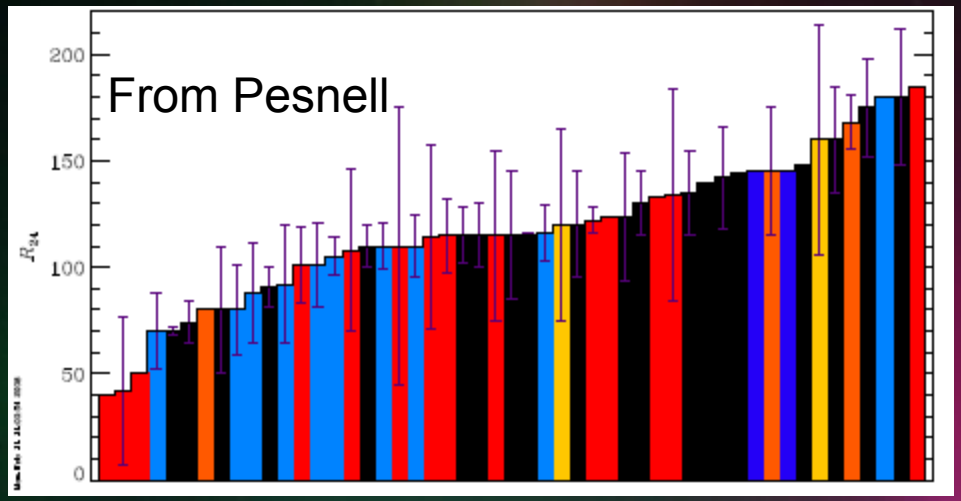


Table 2: Summary of Predictions for Solar Cycle 24

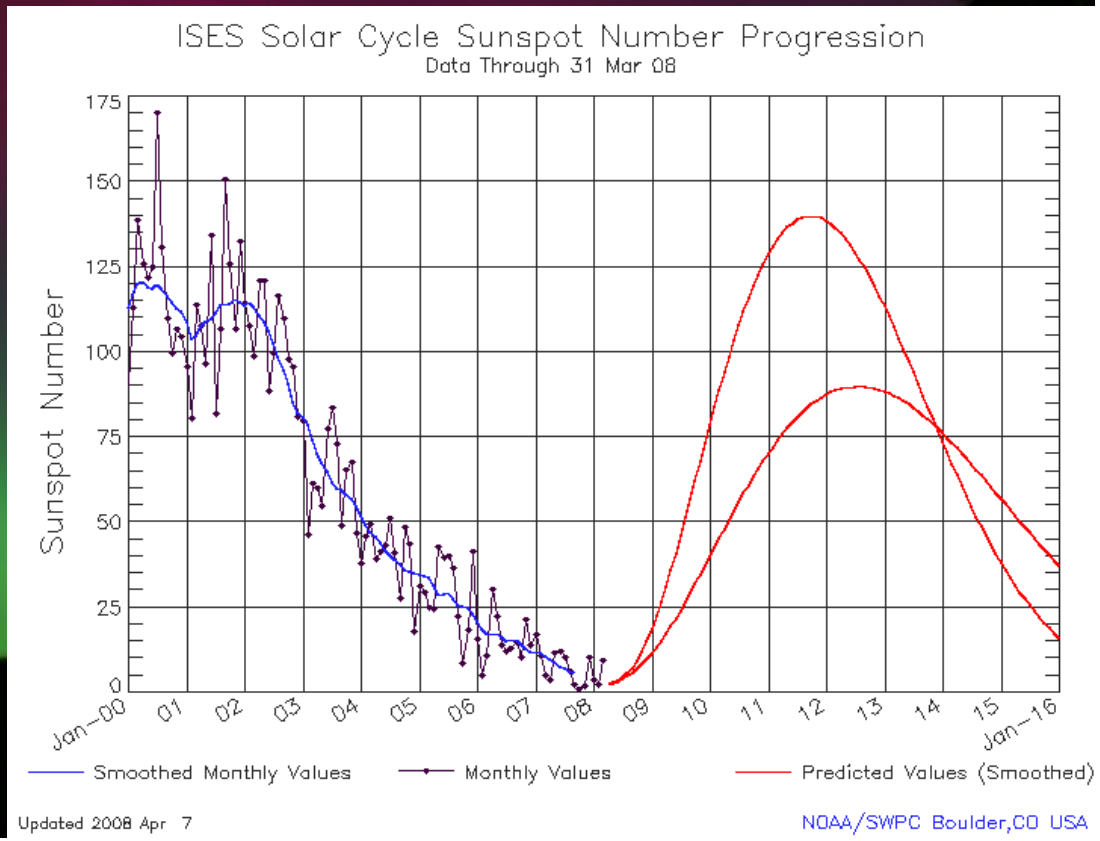
Category	Number	Average	Range
Combined	51	118 ± 34	40–185
Climatology (C)	14	107 ± 40	40–185
Recent Climatology (R)	2	140 ± 30	120–160
Physics-based Models (B)	3	131 ± 45	80–168
Spectral (S)	10	105 ± 30	70–180
Neural Network (N)	2	145	145–145
Precursor (P)	20	124 ± 30	70–180

- Climatology and Recent Climatology
- Spectral and Neural Network
- Precursor
- Physics Based

April 2007 Panel Prediction

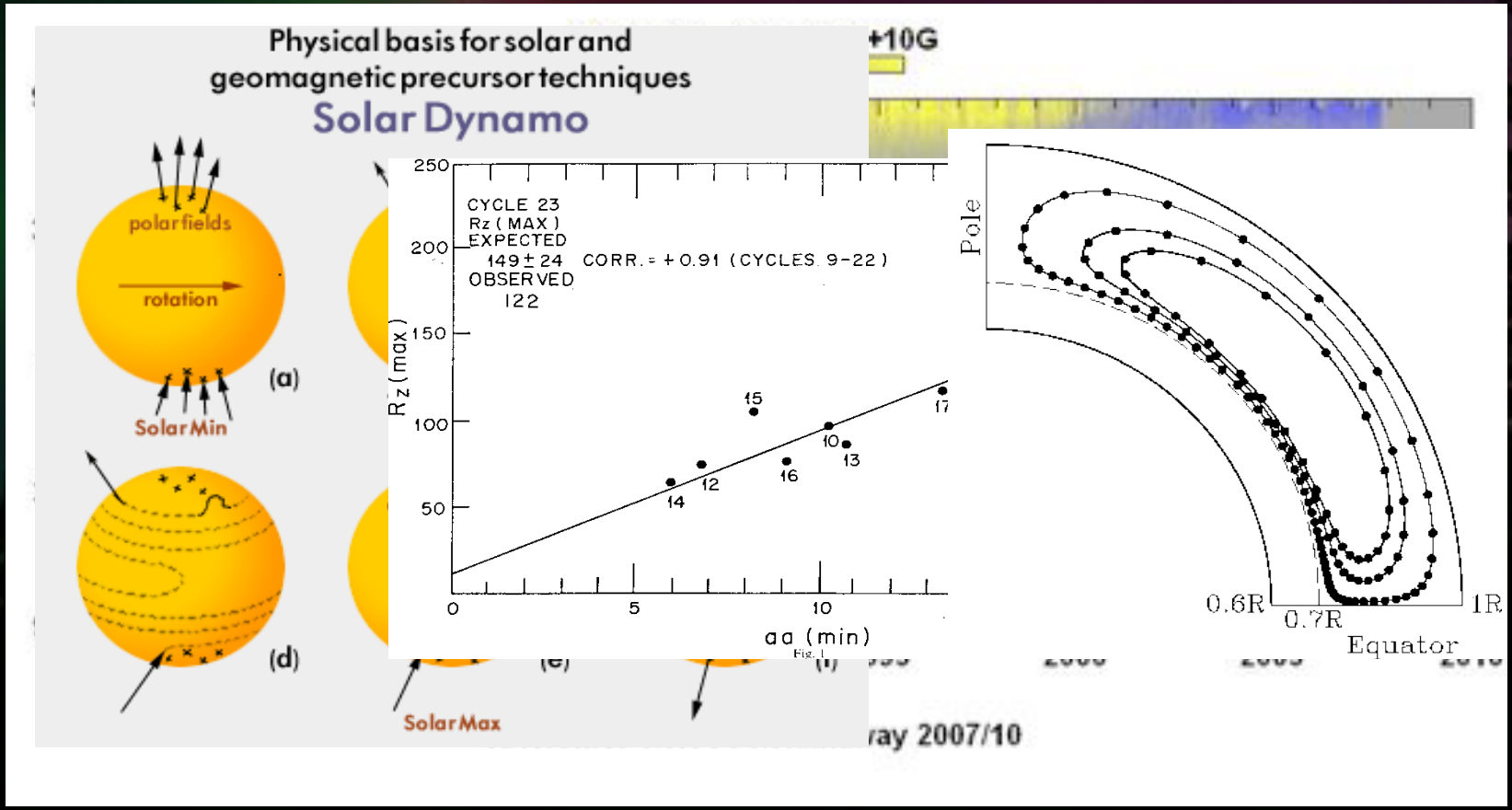
- Solar Minimum will be in March, 2008
- Cycle 24 will be small
  - R_i = 90
  - August, 2012

  or
- Cycle 24 will be large
  - R_i = 140
  - October, 2011
- The panel is split



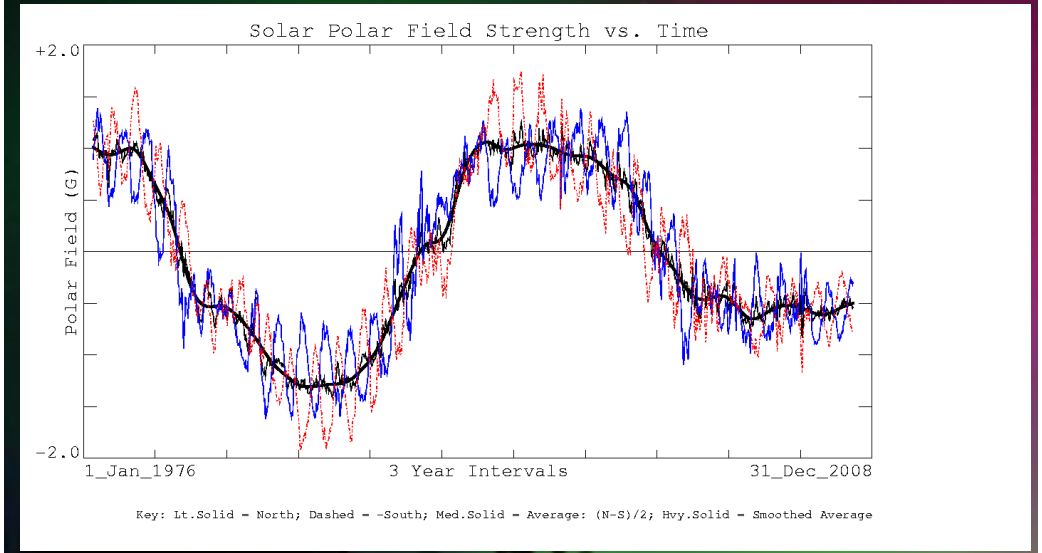
Why the Split?

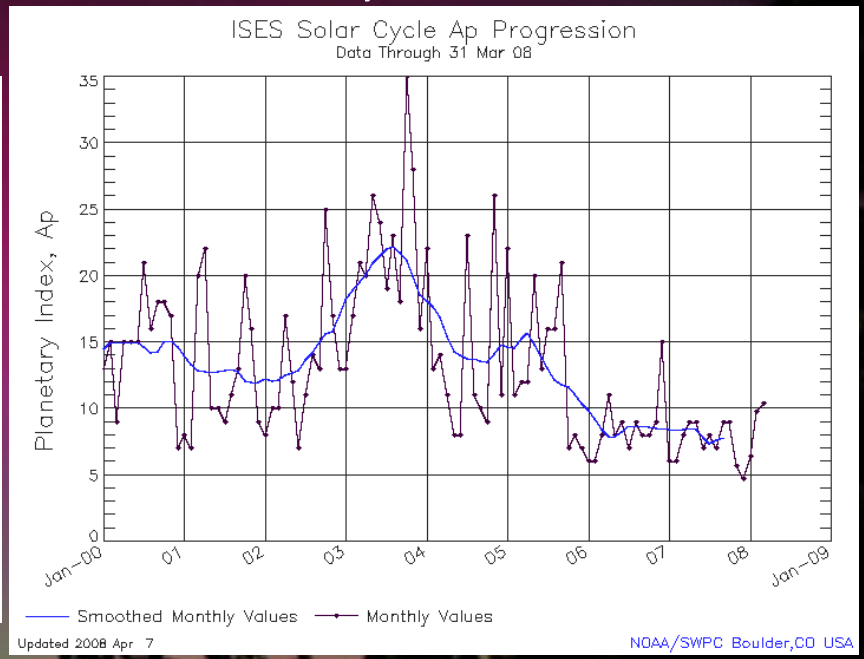
- The Sun recycles its magnetic fields in 1 solar cycle
- The Sun recycles its magnetic fields in 2-3 solar cycles



What would change things?

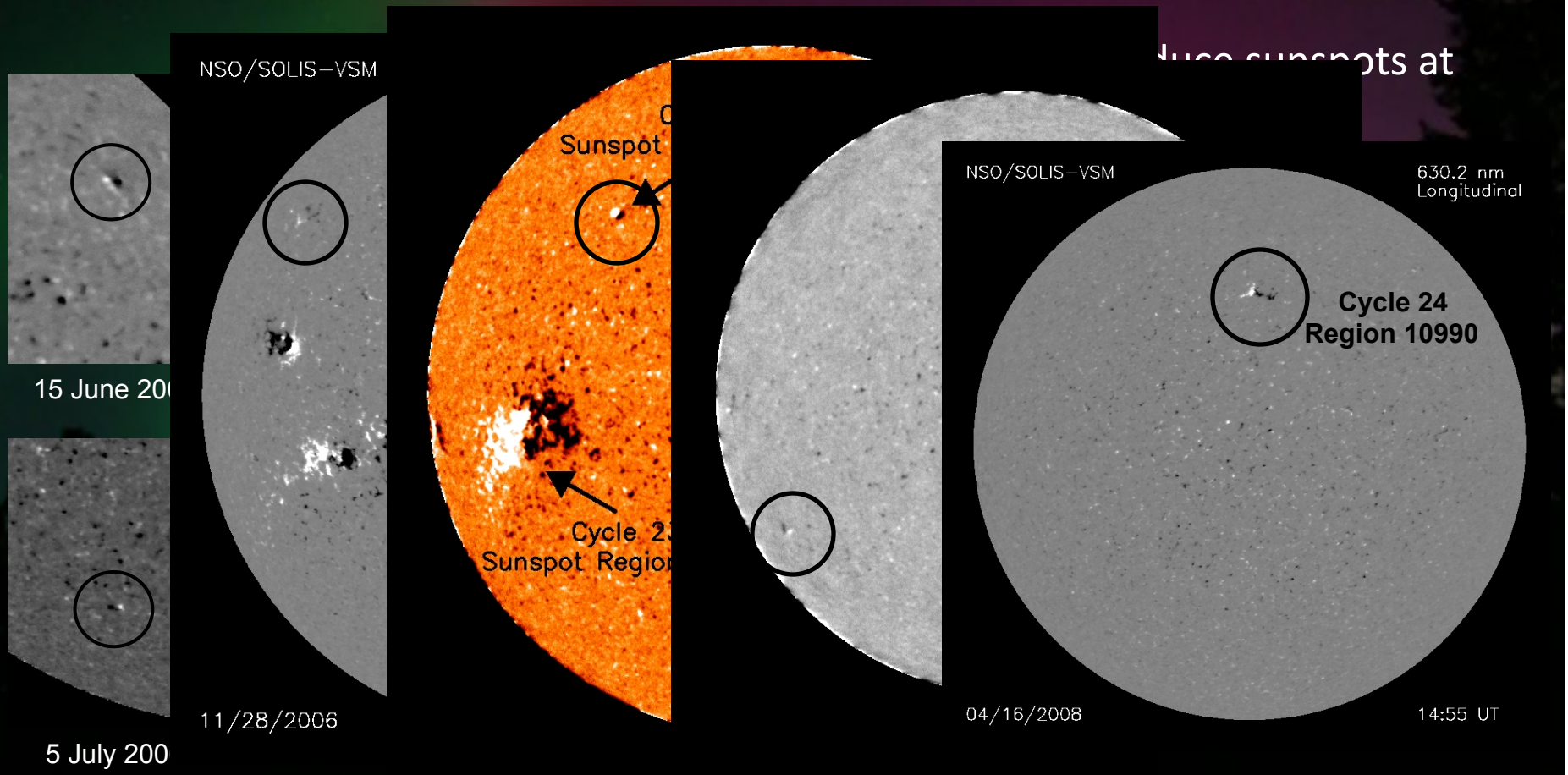
- Would small cycle proponents concede?
  - What they said one year ago
    - If the polar field strength increases → increased Cycle 24
    - If geomagnetic activity increases → increased Cycle 24





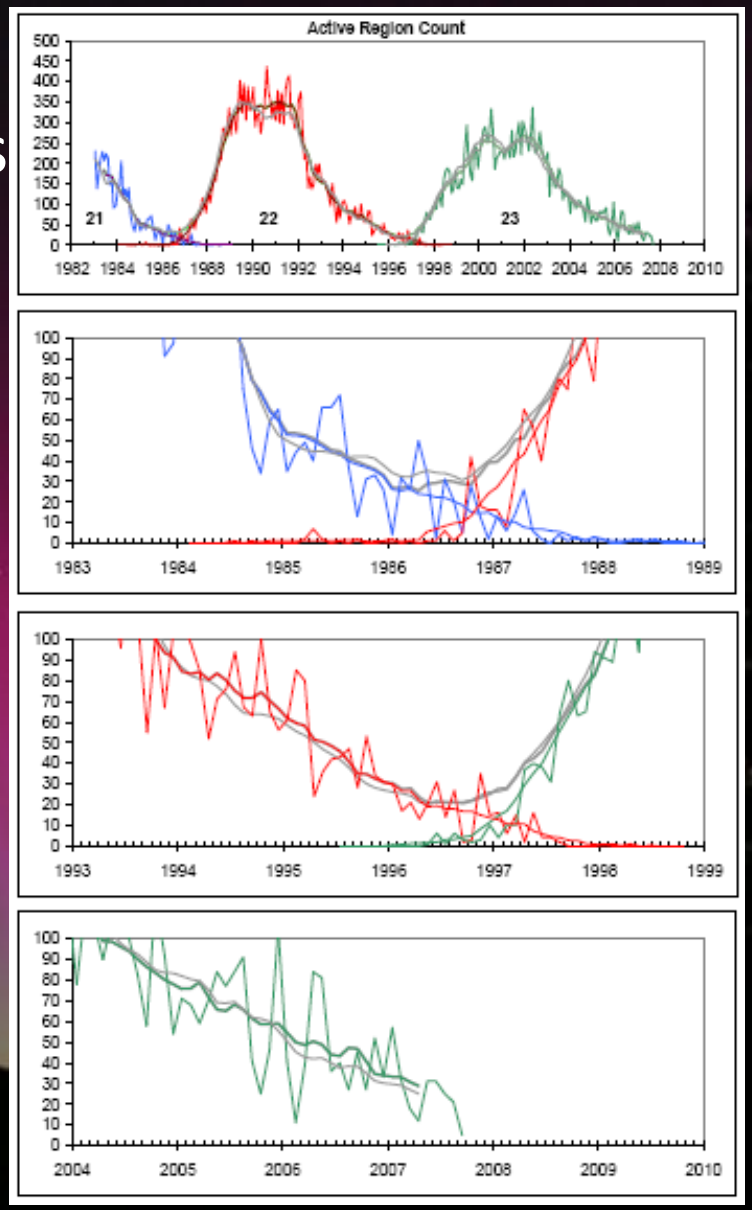
What would change things?

- Would big cycle proponents concede?
  - What they said one year ago



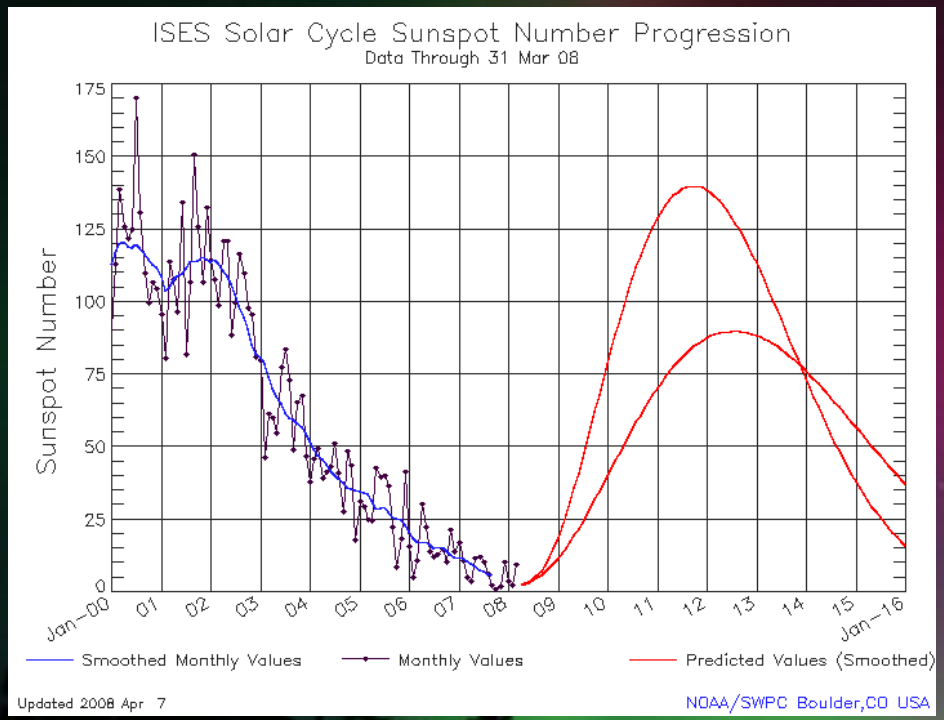
What has the Sun done?

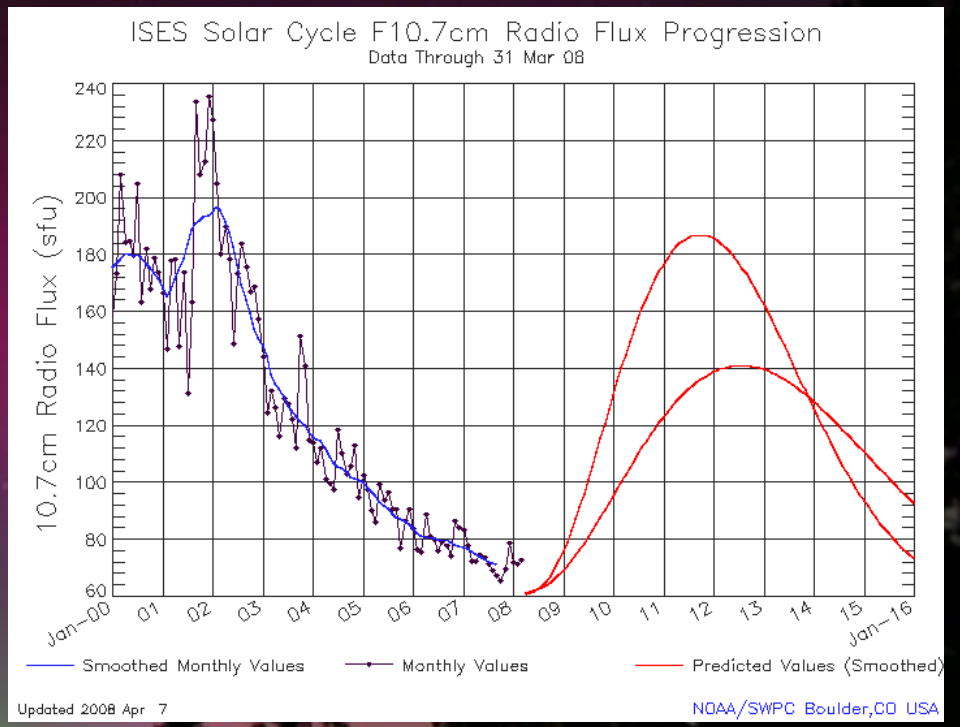
- We're seeing new cycle spots
  - Old Cycle and New cycle spots coexist
  - Old cycle at low latitudes
  - New cycle at high latitudes



What has the Sun done?

- Have we reached minimum yet?

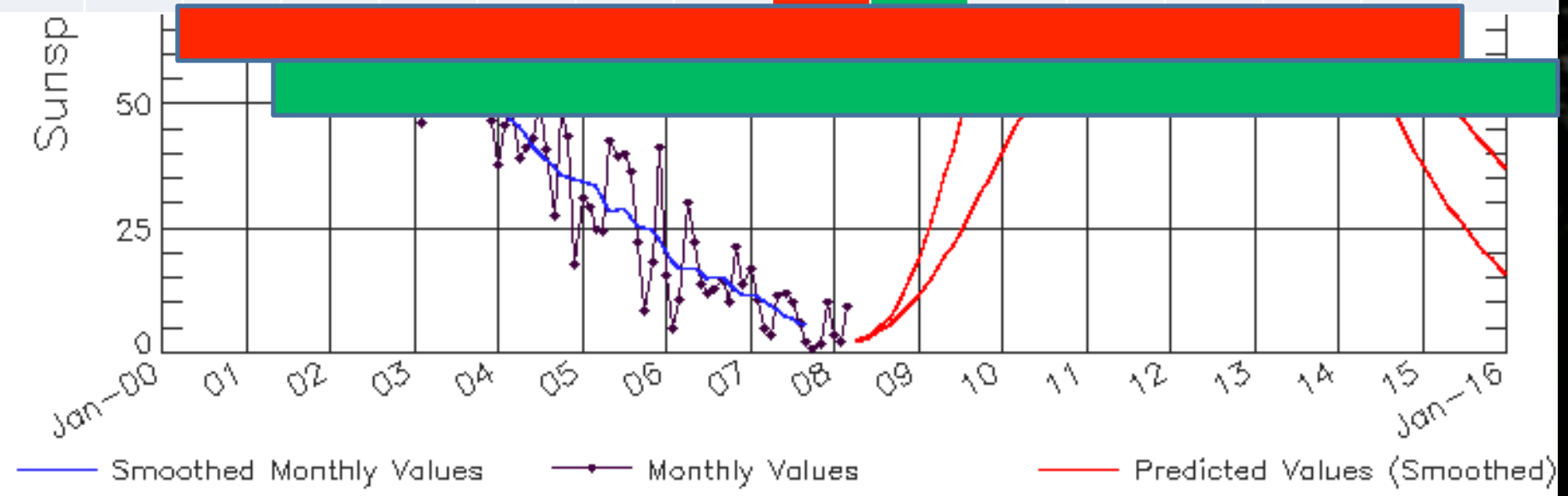




What will happen?

- Did the panel get it wrong? Was minimum in September 2007?
  - The panel error bar was 6 months, which allows Sep 07

Jan 2007	Feb 2007	Mar 2007	Apr 2007	May 2007	Jun 2007	Jul 2007	Aug 2007	Sep 2007	Oct 2007	Nov 2007	Dec 2007	Jan 2008	Feb 2008	Mar 2008	Apr 2008
16.8	10.7	4.5	3.4	11.7	12.1	9.7	6.0	2.4	0.9	1.7	10.1	3.4	2.1	9.3	2.9
11.9	11.5	10.7	9.9	8.7	7.7	7.0	6.0	5.9	6.0						



Updated 2008 Apr 7

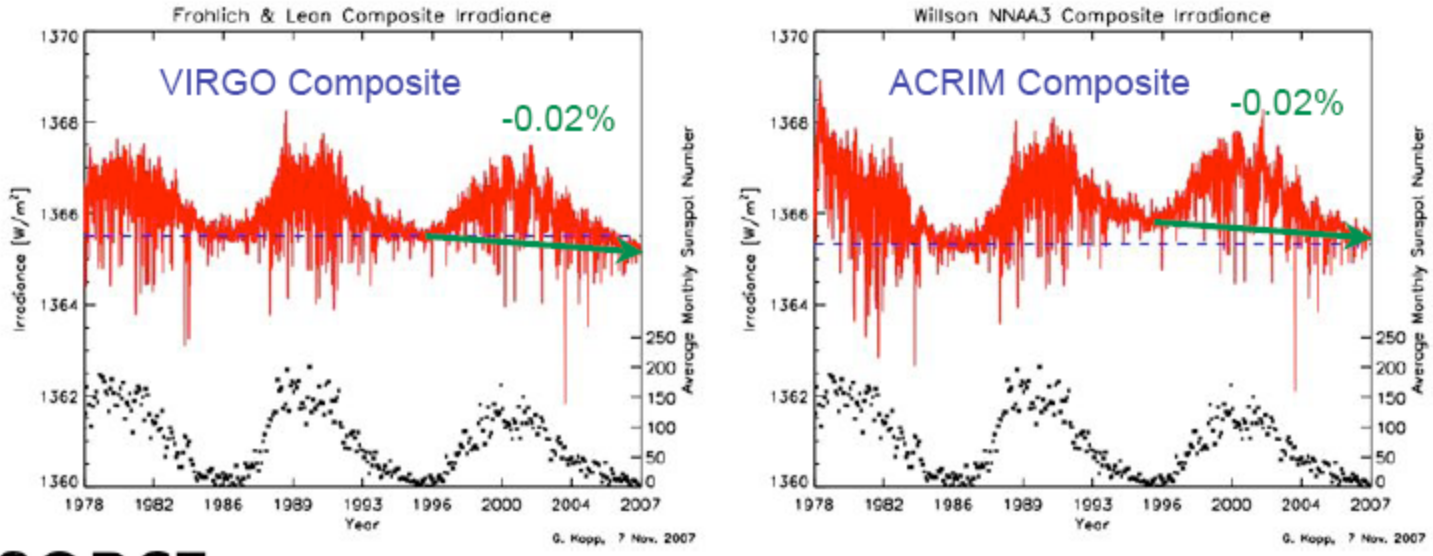
NOAA/SWPC Boulder,CO USA

T. Woods SORCE 2008

TSI Recent Decline - Is Modern Maximum Over?

- Downward trend of the TSI by 0.02% from last cycle minimum
  - SOHO VIRGO (single instrument) has been measuring TSI since 1996
    - SORCE TIM agrees well with VIRGO trend since SORCE launch in 2003
  - ACRIM composite (multiple instruments) has same trend
  - Lower TSI (if confirmed) implies a new natural cooling for climate change

Steven Dewitte's and Claus Fröhlich's talks (Tue AM) will provide more details about long-term TSI results

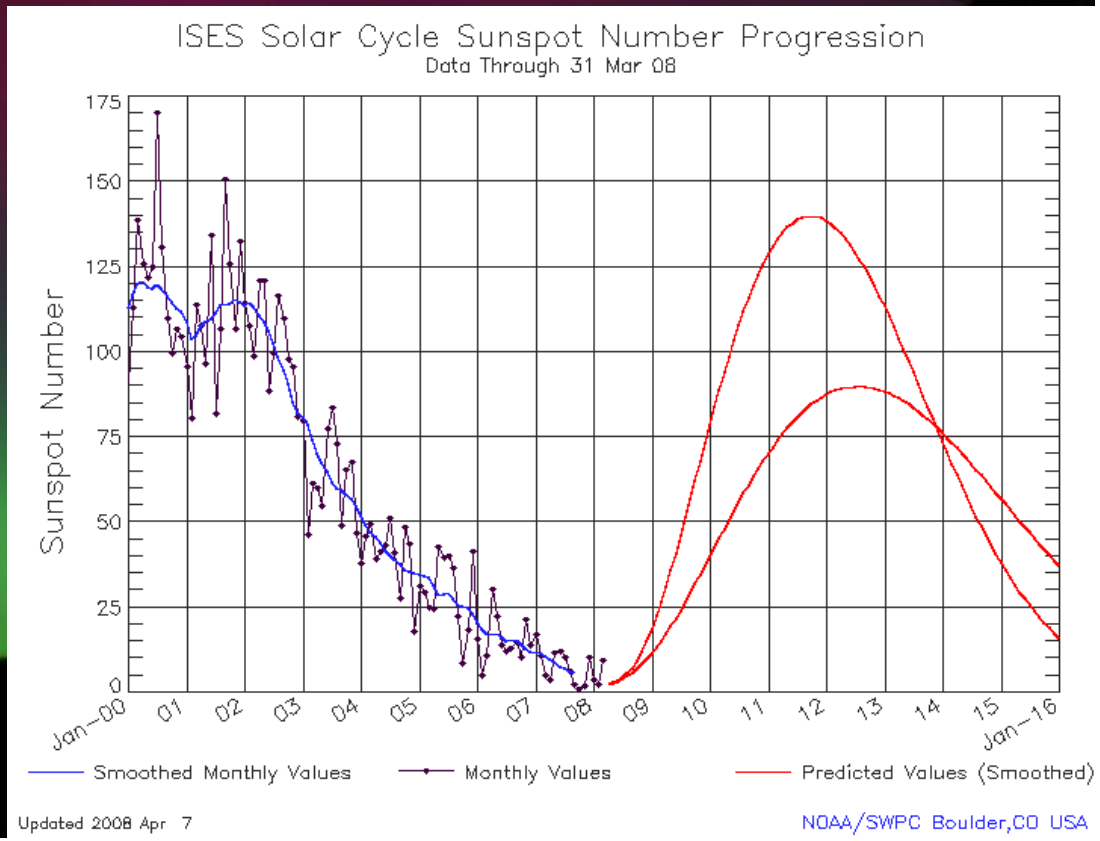


Summary

- Solar Minimum will be in March, 2008
  - Re-affirmed by panel in March, 2008
- Cycle 24 will be small
  - R_i = 90
  - August, 2012

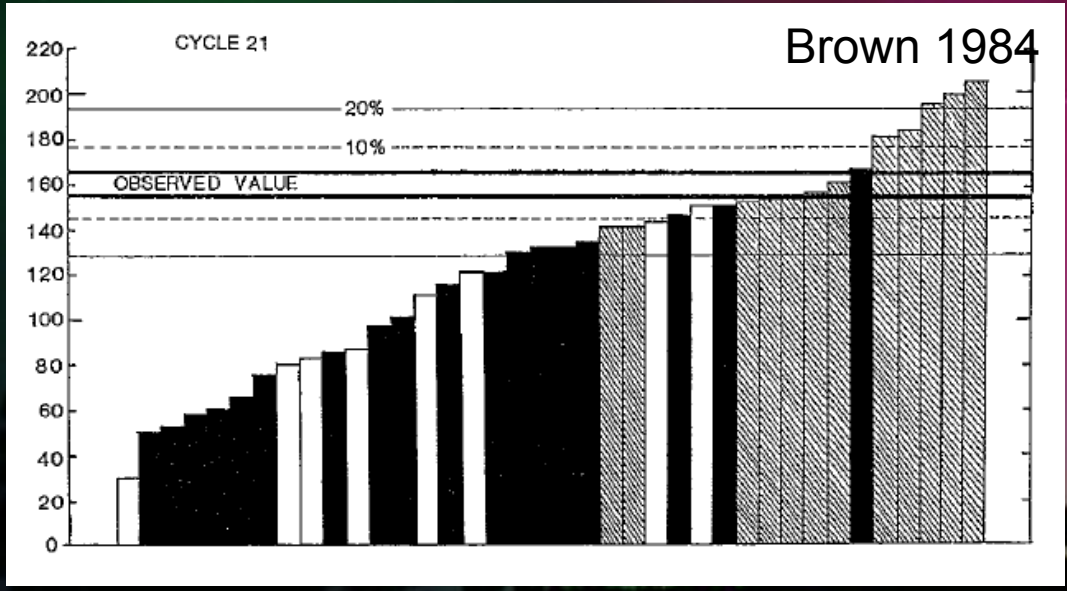
  or
- Cycle 24 will be large
  - R_i = 140
  - October, 2011

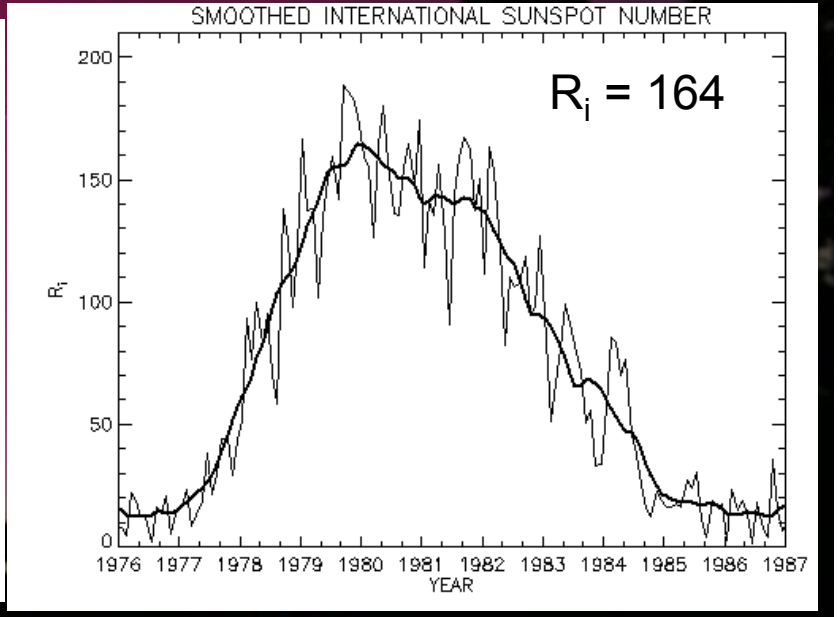
- The panel is still split



Predicting Cycle 21

- 1979 Boulder, CO – STP Workshop
  - 18 Statistical Predictions – solid bars
  - 12 Precursor Predictions - shaded bars
  - 8 Other methods - unfilled



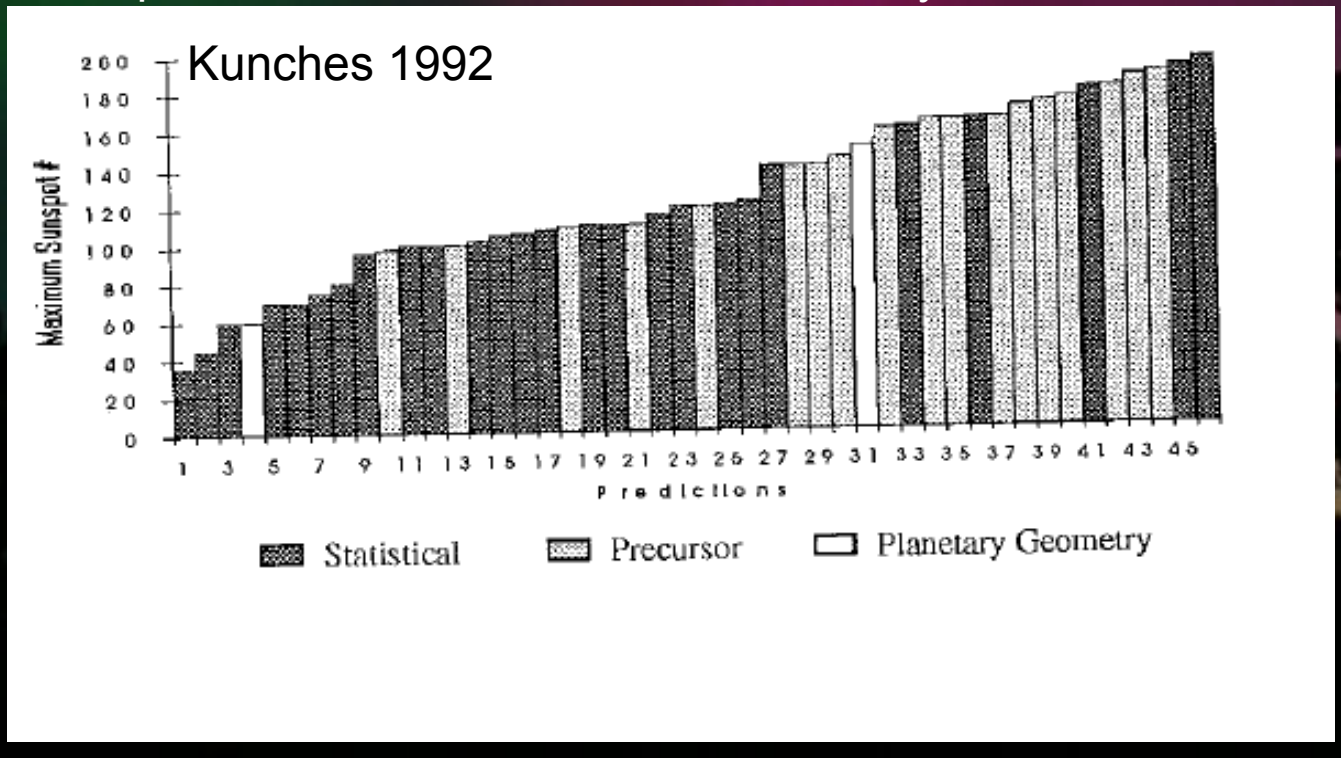


Predicting Cycle 22

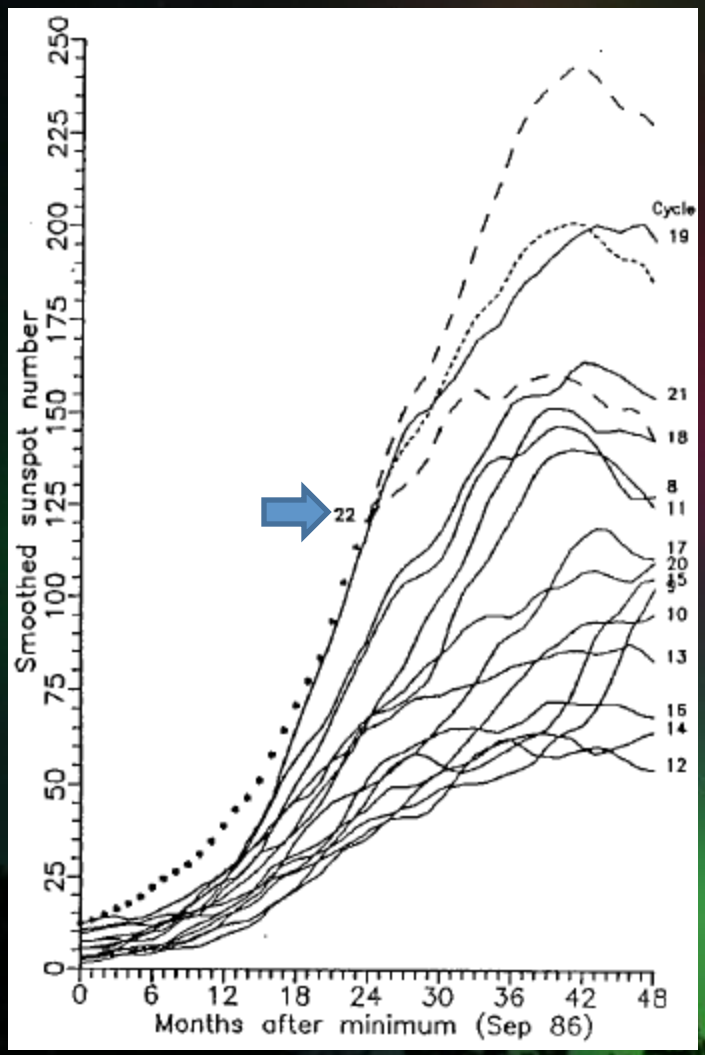
- 1984 Meudon – STP Workshop
  - "At the outset, it was agreed that there have not been any startling new developments in prediction techniques over the intervening five years."

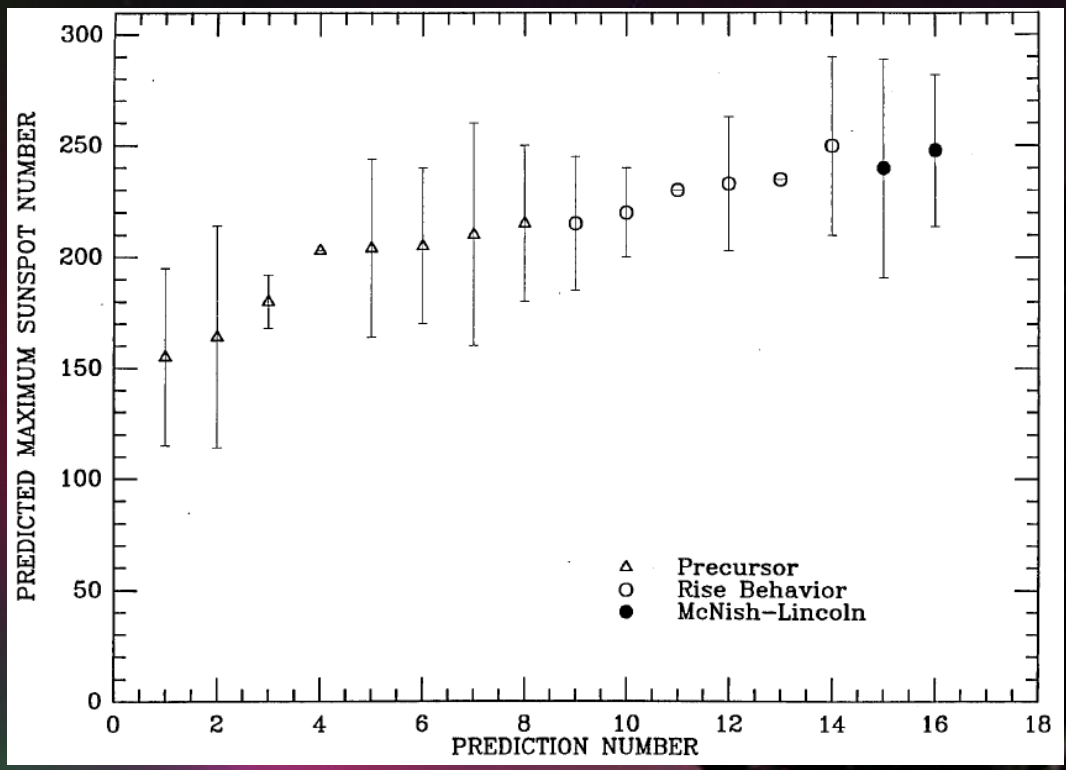
13 Statistical Methods
13 Spectral Methods

18 Precursor Methods
2 Planetary Influences



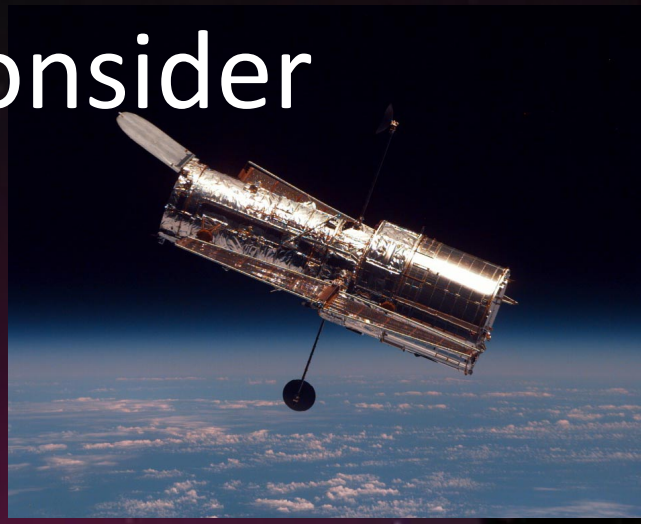
The First 'Official' Prediction



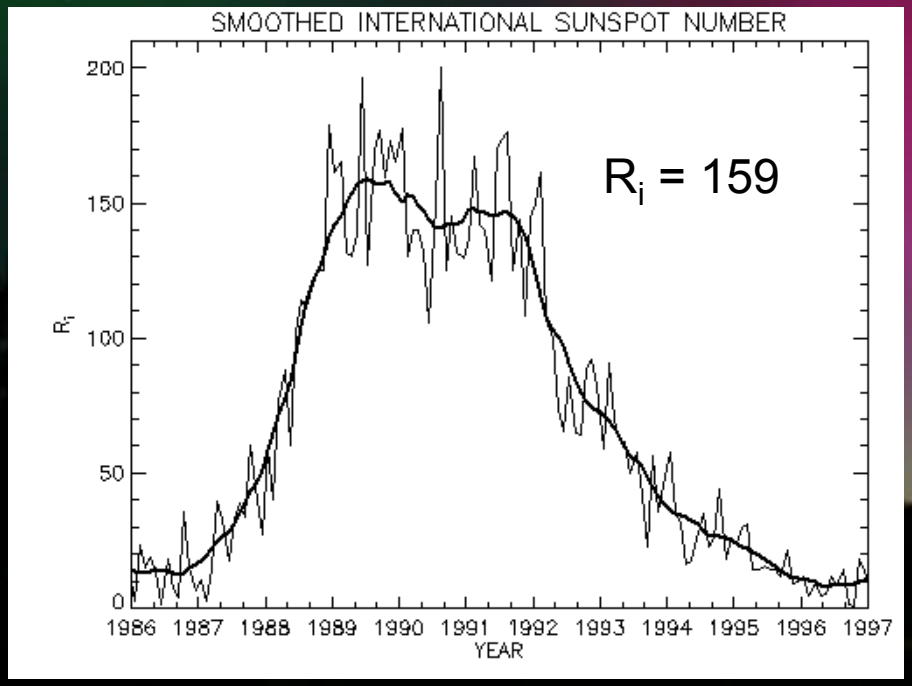


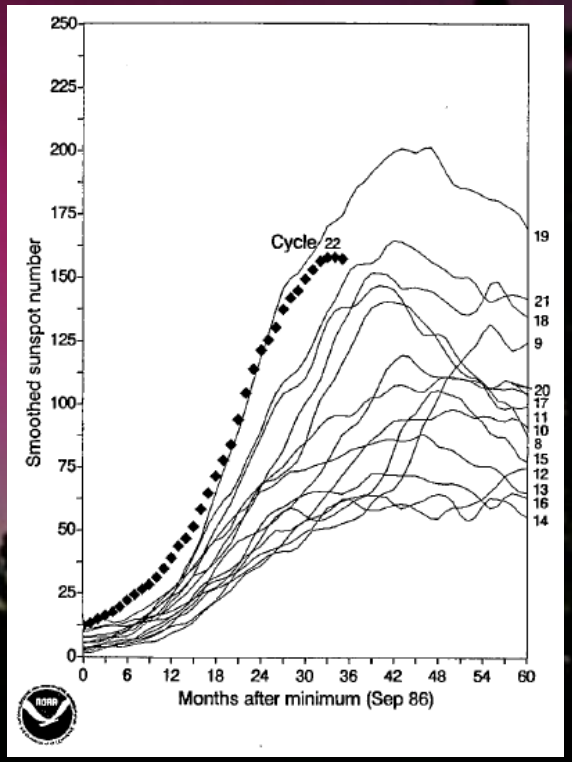
- Consensus Estimate ≈ 200
- Clearly based on precursor methods and on the observed rise behavior of Cycle 22

Oops, we better reconsider



- Withbroe and Chappell - redux
- Concern for HST re-entry prompted an April 1990 update to the 1989 official prediction
- Minority opinion: we are past maximum
- Consensus opinion: SSN ≈ 170

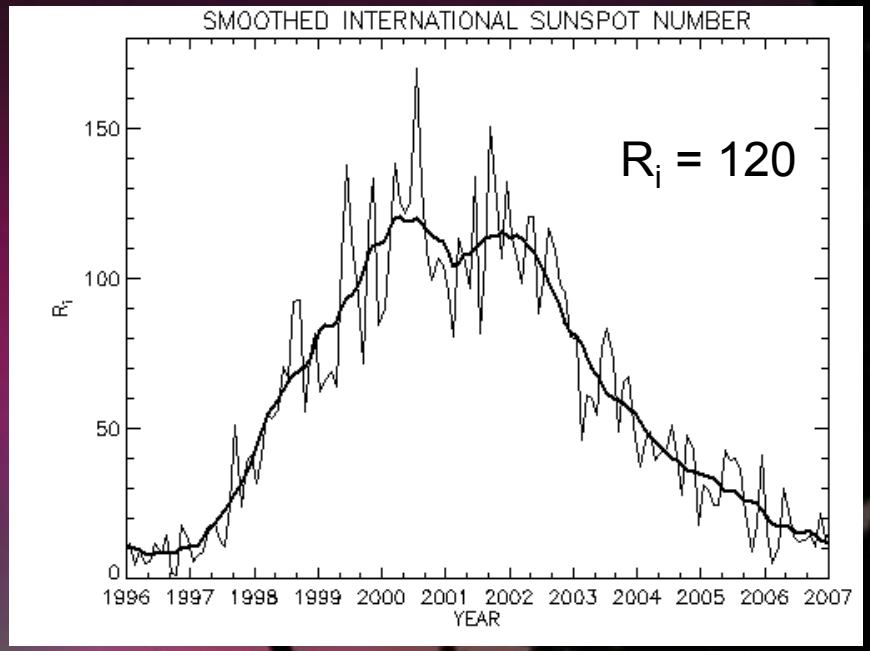




Predicting Cycle 23
The Second Official Prediction

- NOAA led panel (J.A. Joselyn) report issued 1997

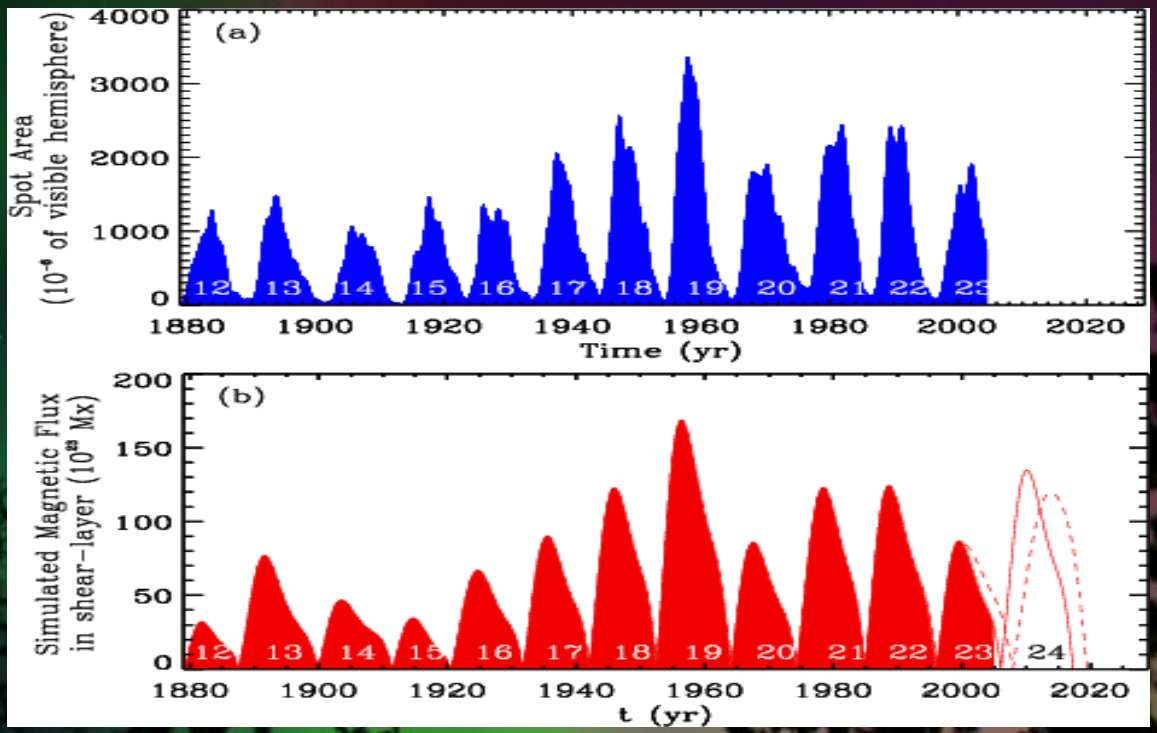
Technique	Prediction
Even/Odd Behavior	200 ± 35
Precursor	160 ± 20
Spectral	155 ± 25
Recent Climatology	155 ± 30
Neural Networks	140 ± 30
Climatology	115 ± 40
Consensus	160 ± 30



The scientific community should be encouraged to develop a fundamental understanding of the solar cycle that would provide a physical – rather than empirical – basis for prediction methods.

Flux Transport Dynamo

- Dikpati *et al* predict cycle 24 will be 30%-50% larger than cycle 23
  - Slowing of meridional flow gives smaller prediction
  - Smaller cycle begins later, peaks later



(Dikpati, de Toma & Gilman, GRL 2006)

Hathaway, Wilson and Reichman (1999)

Prediction Method Errors (Prediction-Observed)

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
Feynman'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

D. Hathaway SORCE 2008

Caveats

1. They used my data for sunspot areas – which was 20% high for cycle 20. Their prediction for cycle 20 fit the erroneous value and later cycles were also predicted accurately in spite of the error in the input data.

2. They kept the meridional flow speed constant. They allow it to change in cycle 23 and found a 10% change in the prediction. Similar variations in meridional flow speed should have occurred in the past.

3. A independent confirmation of the model is needed.

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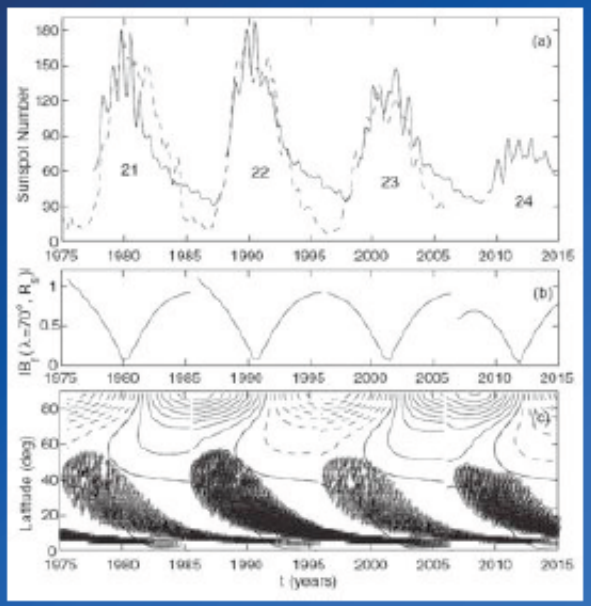
The Second Dynamo Prediction

Choudhuri, Chatterjee, & Jiang (2007) ran a similar dynamo model but one more dominated by diffusion. In an effort to assimilate real data they change the strength of the poloidal field at cycle mimimum to match the observed polar fields.



Cycle 24 Prediction ~ 75

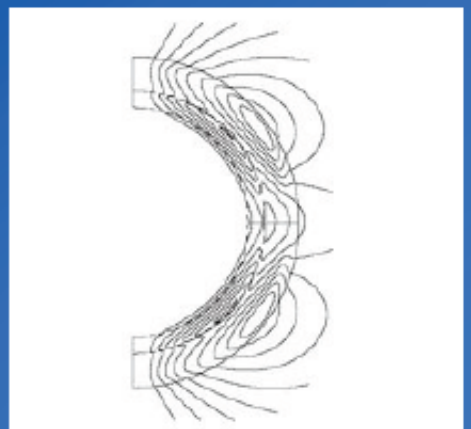


FIG. 1. A snapshot of streamlines of the poloidal field given by constant contours of $Ar\sin\theta$ just after correcting by the DM value for the poloidal field at the minimum before cycle 24. The dashed lines correspond to $r = 0.7R_\odot$ and $r = 0.8R_\odot$.