Space Environment during Solar Minimum of CS-23

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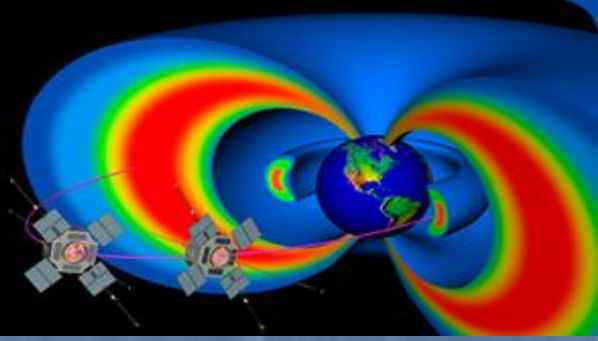
International Conference on
Radiation Belts and Space Weather

New Horizon from RBSP (Radiation Belt Storm Probes) Mission

May 29 ~ June 1, 2012 / Hotel INTERCITI, Daejeon, Korea



Outlines

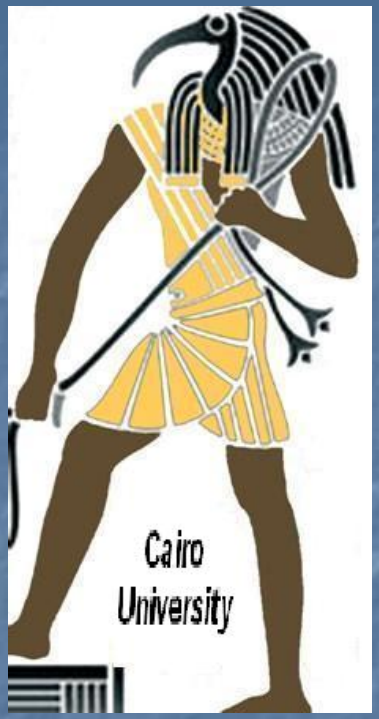
- Modern Astronomy and space science in Egypt
- Deep solar minimum between SC-23 and SC-24, and the ascending phase of SC-24 until now
- The impact and consequences of the deep solar minimum on:
  1- Heliospheric Physics
  2- Space Environment
- The notable effect of solar activates on palaeo climatic changes

Modern Astronomy in Egypt

1- In 1840 an astronomical observatory was constructed at Boulac (West Cairo). This observatory was closed in 1860 due to light pollution.

2- In 1868 another observatory was built at Abbasya east of Cairo. Closed in 1903, due to the electric tramway in Cairo.

3- Astronomical observations at Helwan started in 1903 using a 30 inch reflecting telescope, and in Katamia 1962 with 74 reflecting telescope



Kottamia Astronomical Observatory

Kottamia Observatory has been established in 1962, by Cairo University
Kottamia lies in the north eastern desert 80 Km far from Cairo.
The observatory housed a 74 reflecting telescope. The telescope was supplemented with: - A spectrograph at the Cassegrain focus
- A camera at the Newtonian focus ,

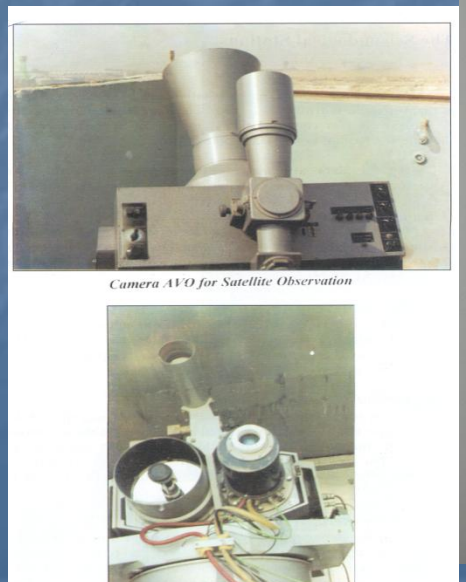
Lat: 29° 55' 48" N , Lon.: 31° 49' 30" E'
Altitude: 476 meters (msl)

Astronomy Education in Egypt

1- Modern astronomy and space science educations started in Egypt at the university level since 1926 at Department of Astronomy , Cairo University.

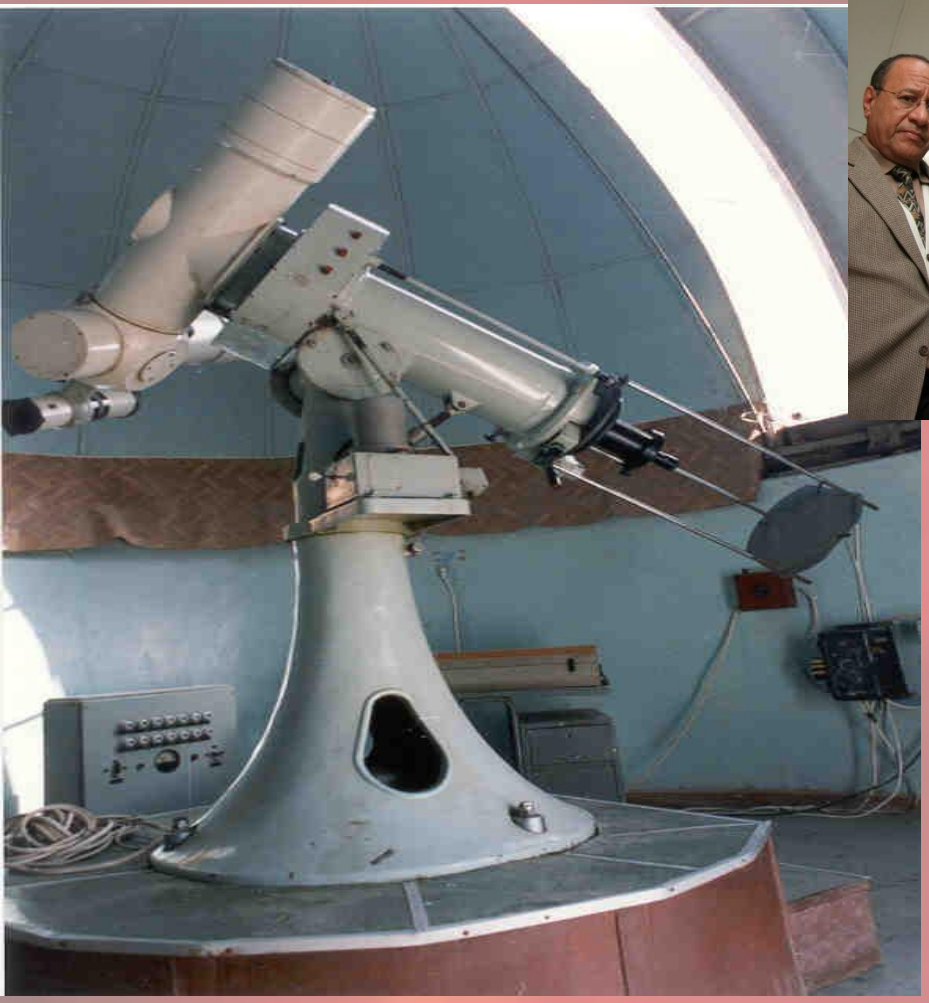
2-The University level of period 4 years, to study B.Sc. In Astronomy, the study starts from 2nd year , after Math. and Physics studies in the first year.

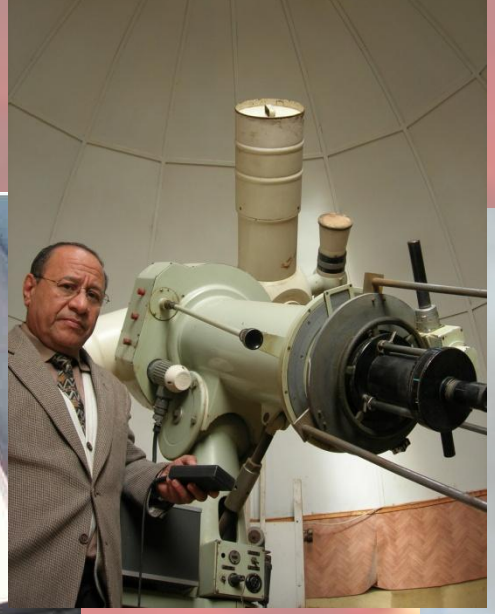
3- M. sc. , Ph.D. and D. SC. Can be awarded in Astronomy and space science.



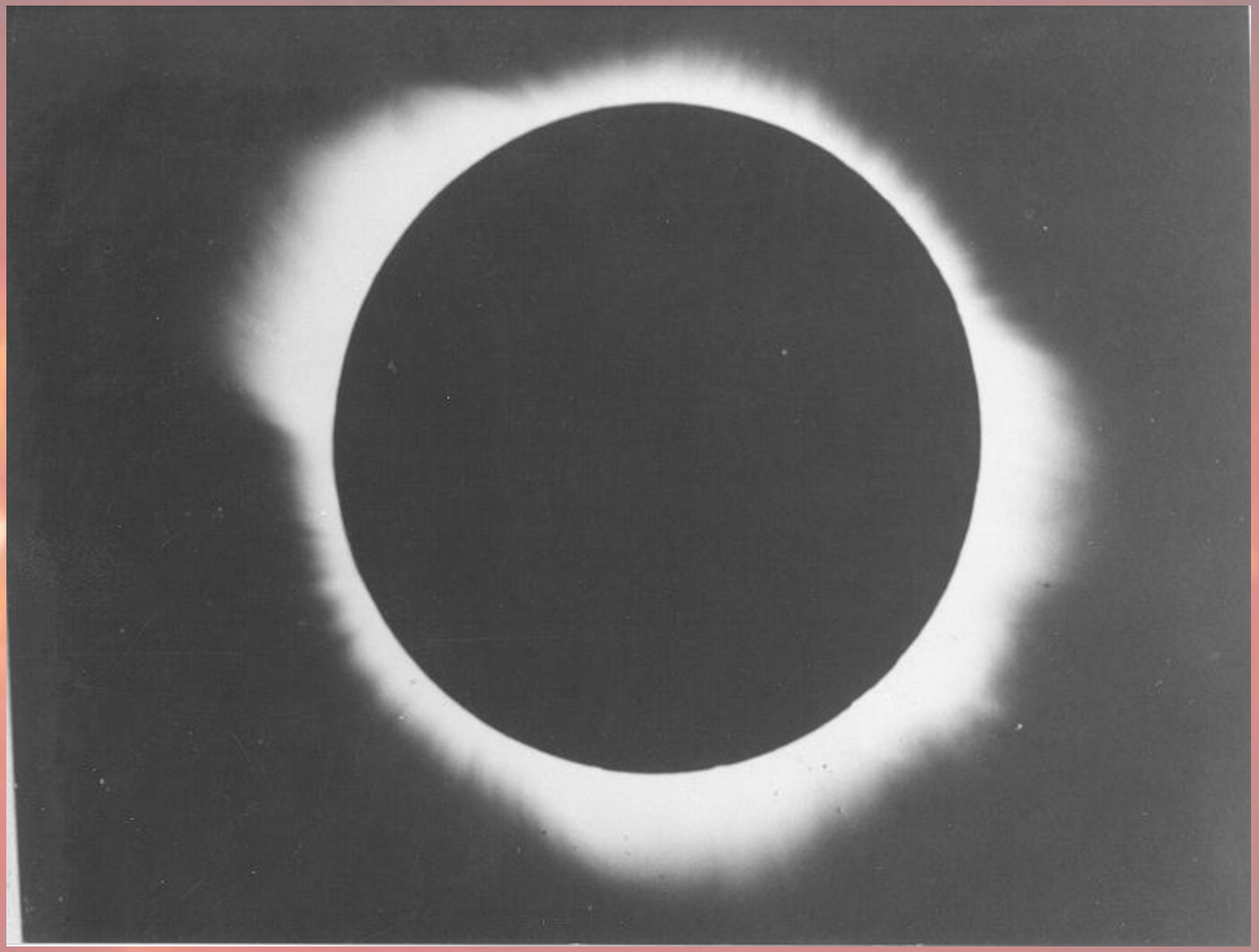
Camera AVO for Satellite Observation

أرصاد حقلية للإشعاع الشمسي





Zeiss-Coude' refractor (6 inch) in Helwan with solar and lunar Camera, and its Dome.



Solar Corona image as given during Khartoum total solar Eclipse 1952, observed by Egyptian-Frinch group.

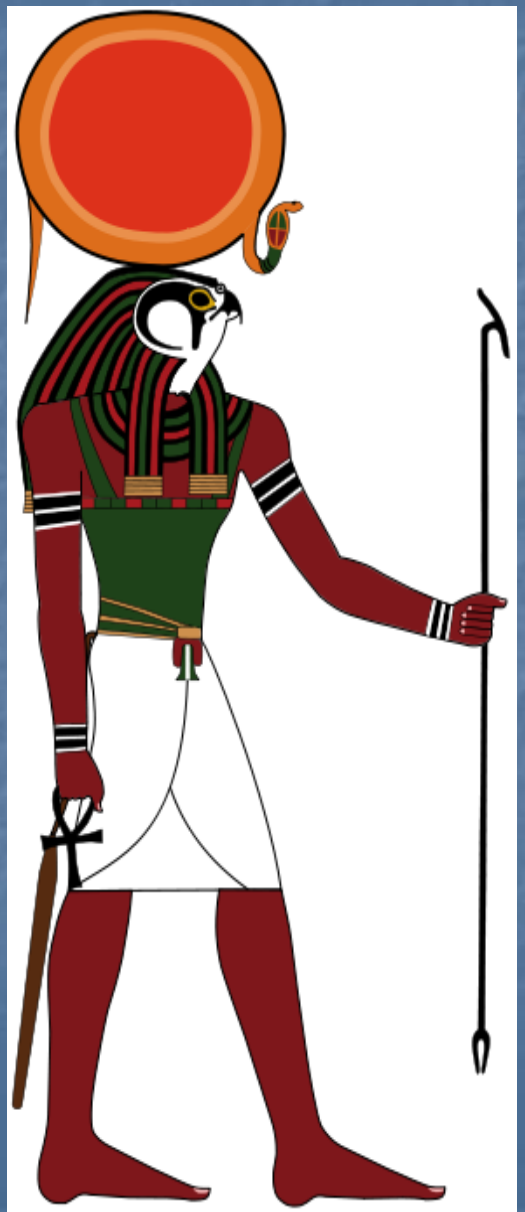
March 29, 2006 Total Eclipse Observations

By several G-B instrumental set-up , The Egyptian-French scientific group (Koutchmy S. & Hady A.) made its observations of March 29, 2006 total eclipse from El-Saloum site , in Egypt.

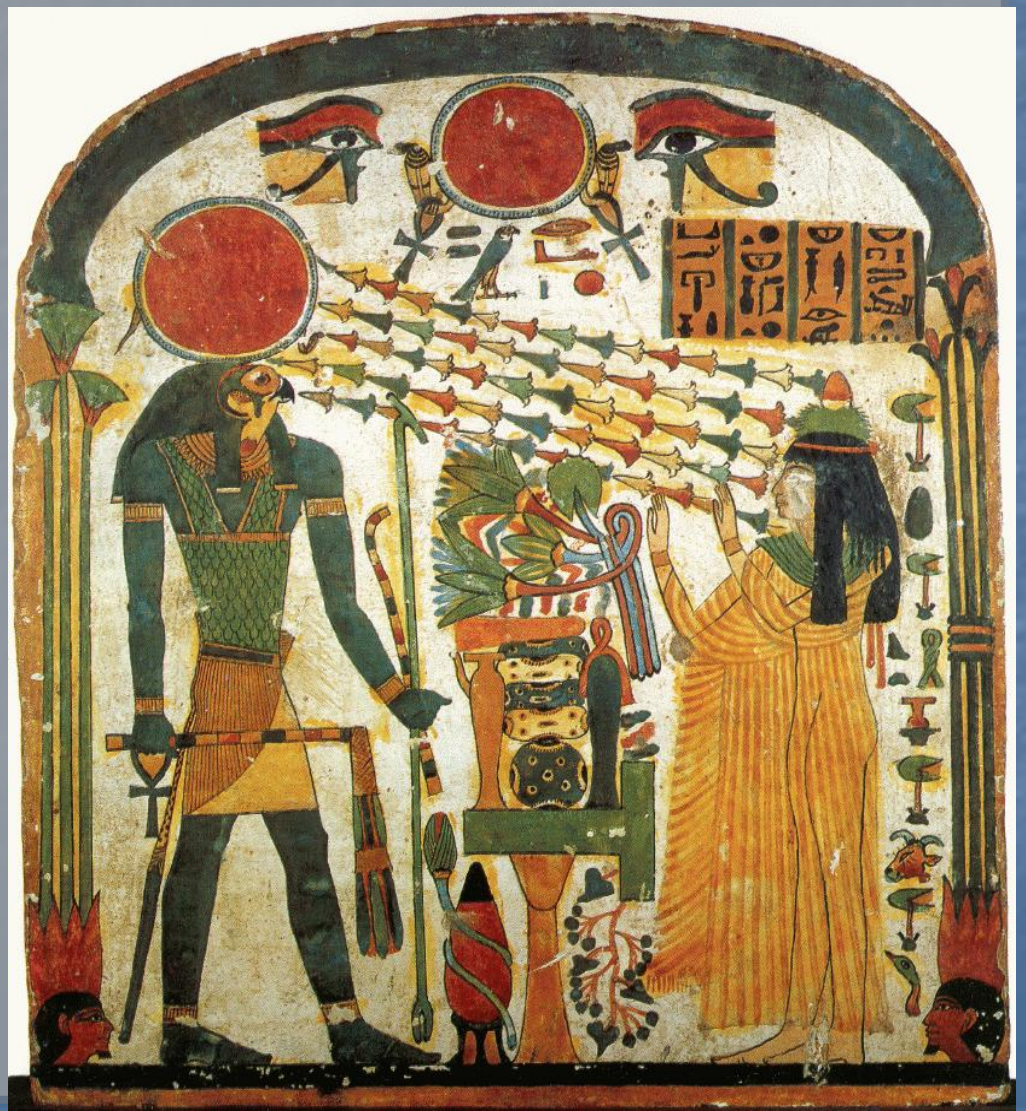
The ancient Egyptians

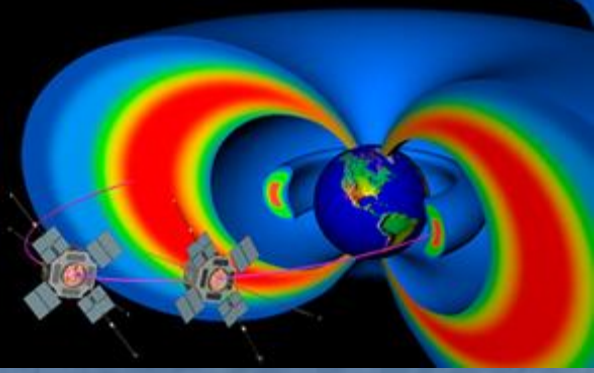
Mankind realized the Sun to be the source of all life on the Earth: The Sun is the God

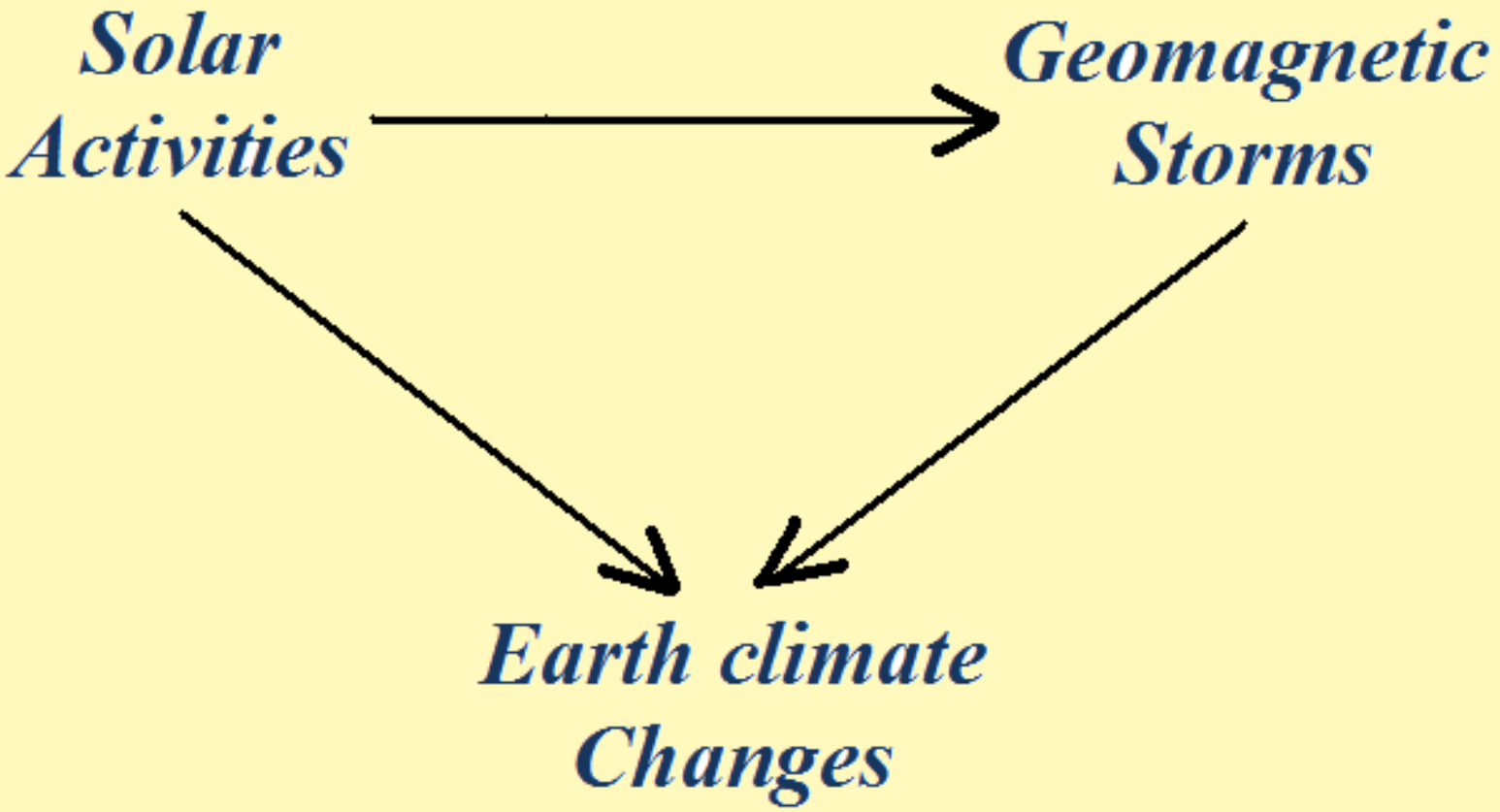
The values of the Solar activity were known since Pharaohs era



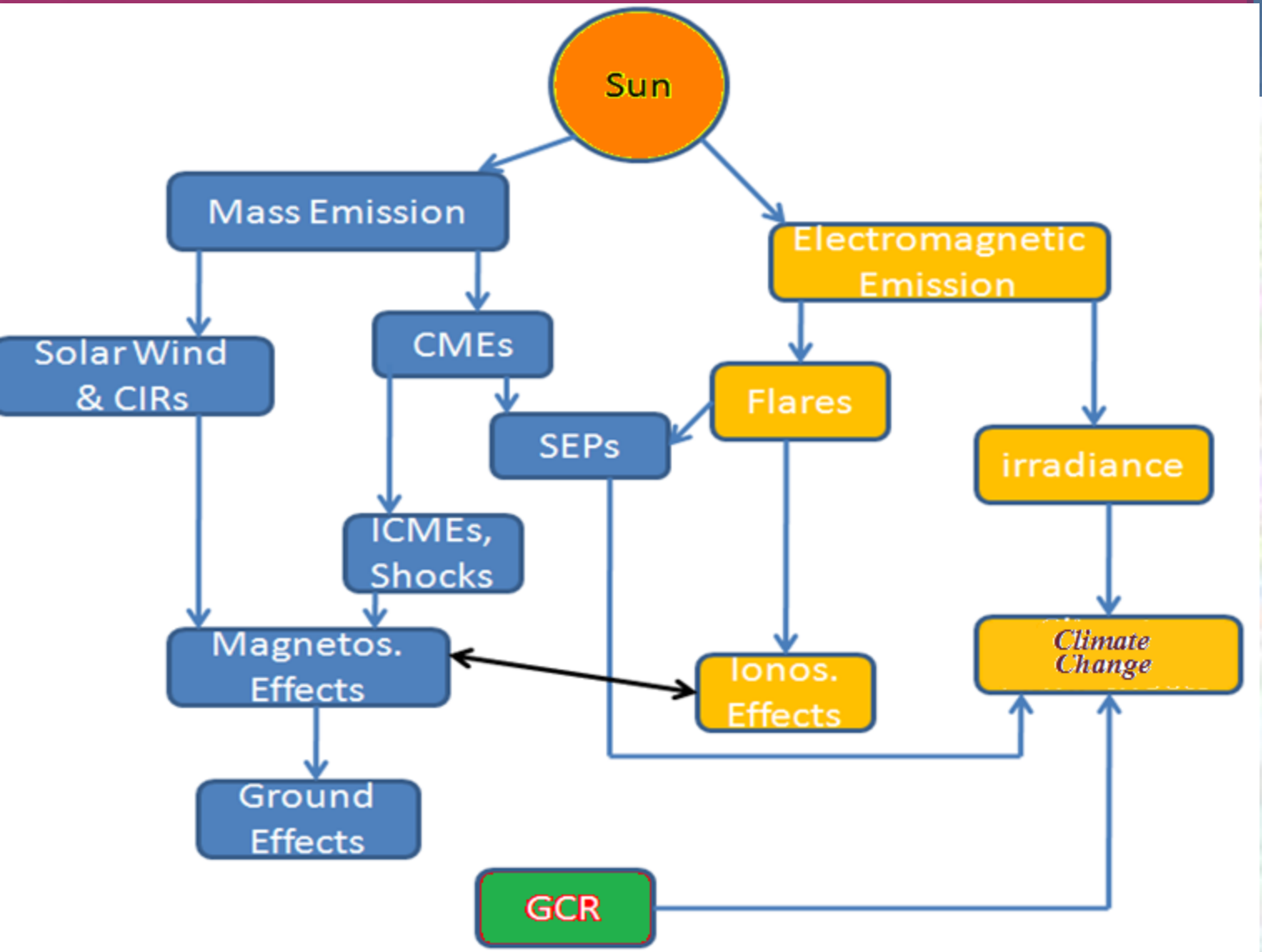
Starting from the beginning of the life






Solar Activities
Geomagnetic Storms
Earth climate Changes

Solar activity & Consequences



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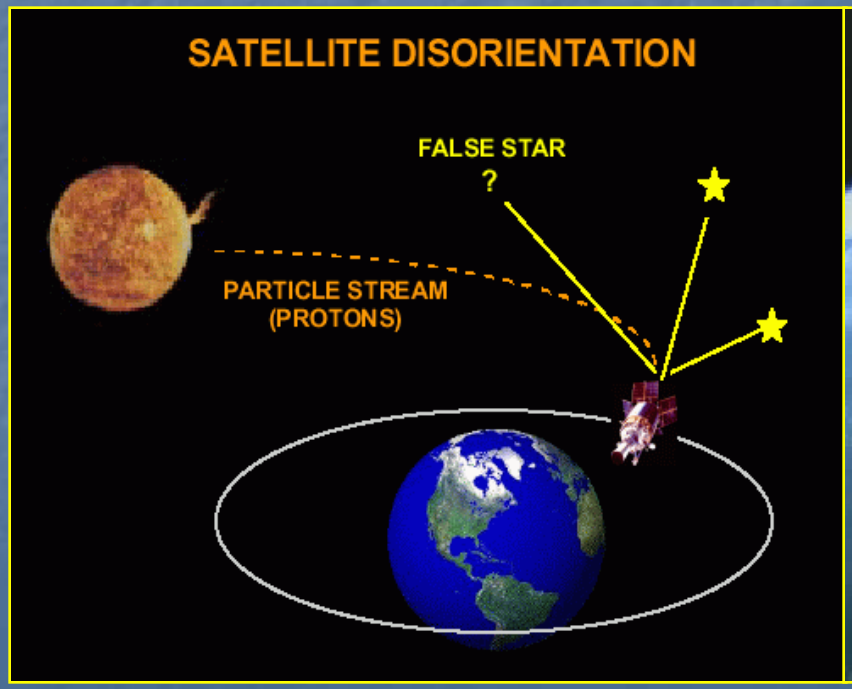
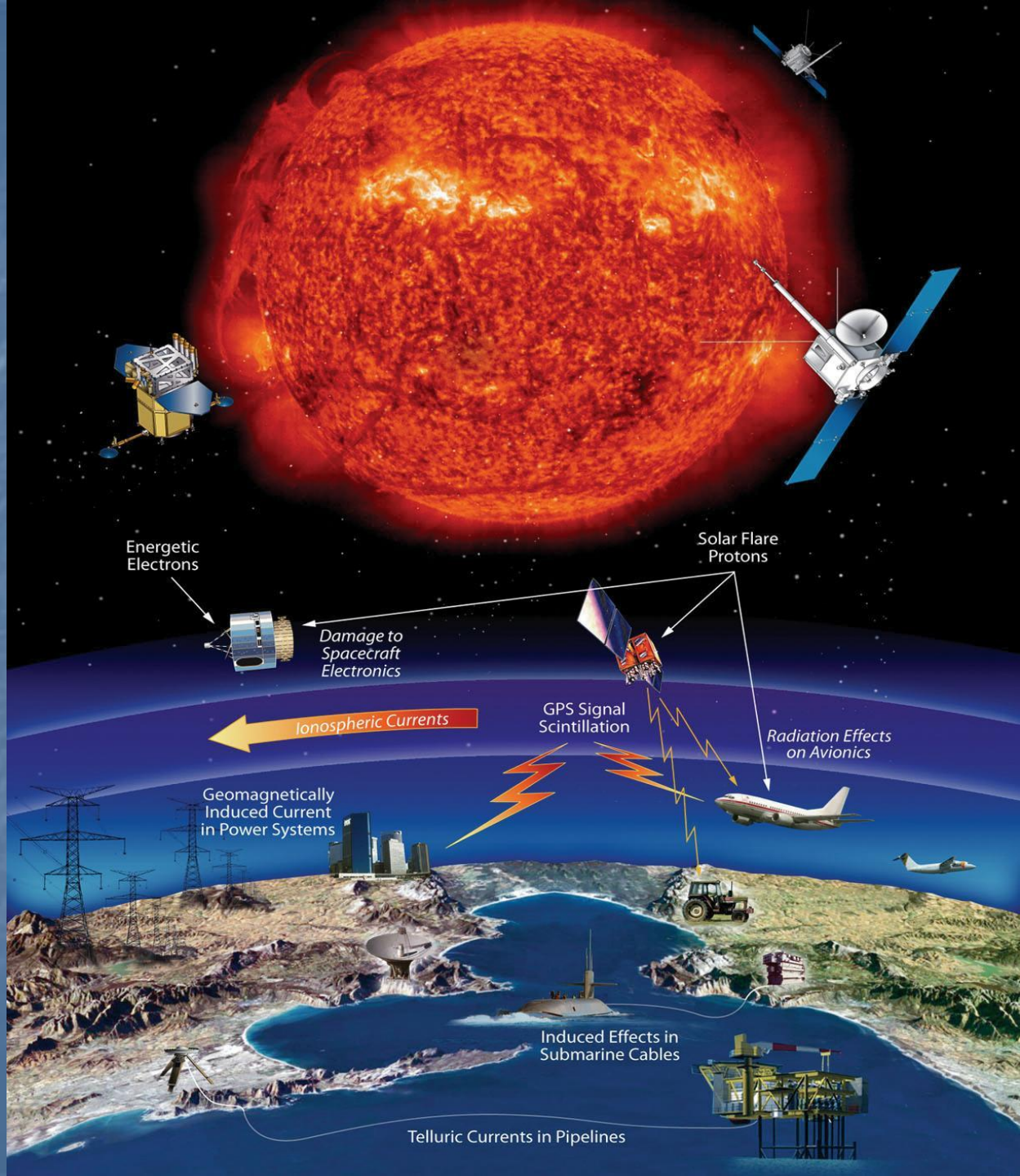
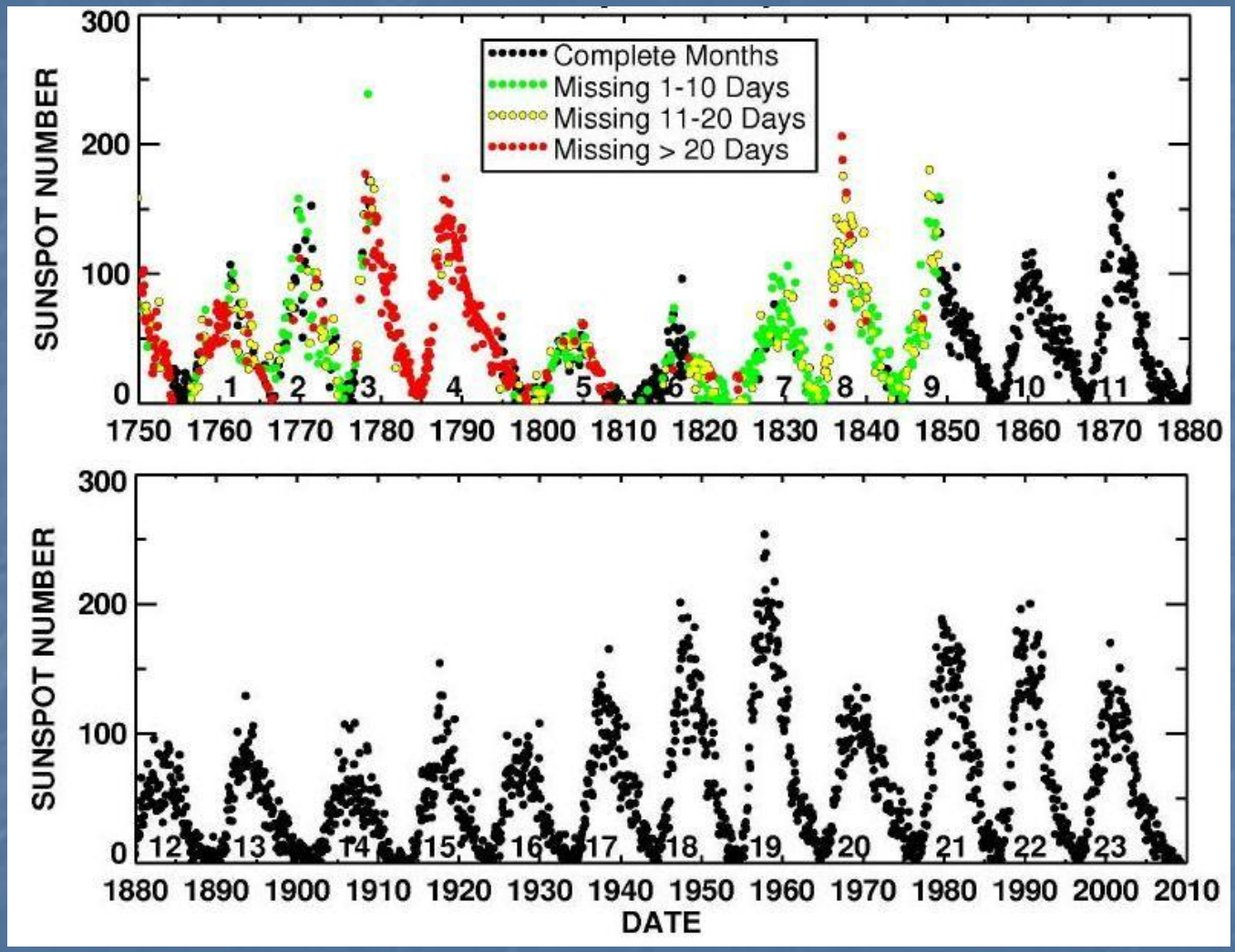
Space Weather :
Effects On Orbiting Spacecraft



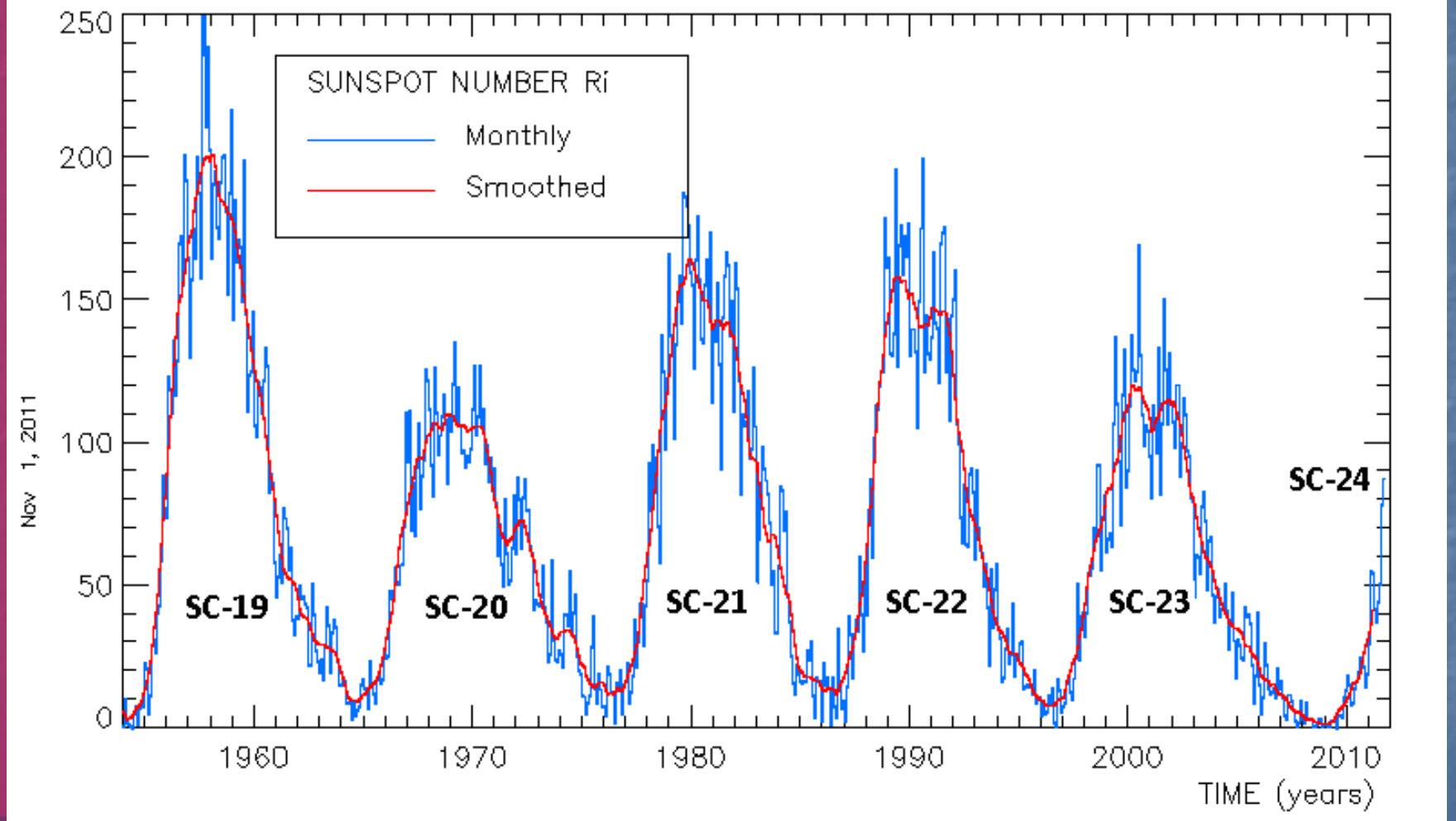
Changes in the ionosphere during geomagnetic storms interfere with high-frequency radio communications and Global Positioning System (GPS) navigation.



The Sunspot Cycle

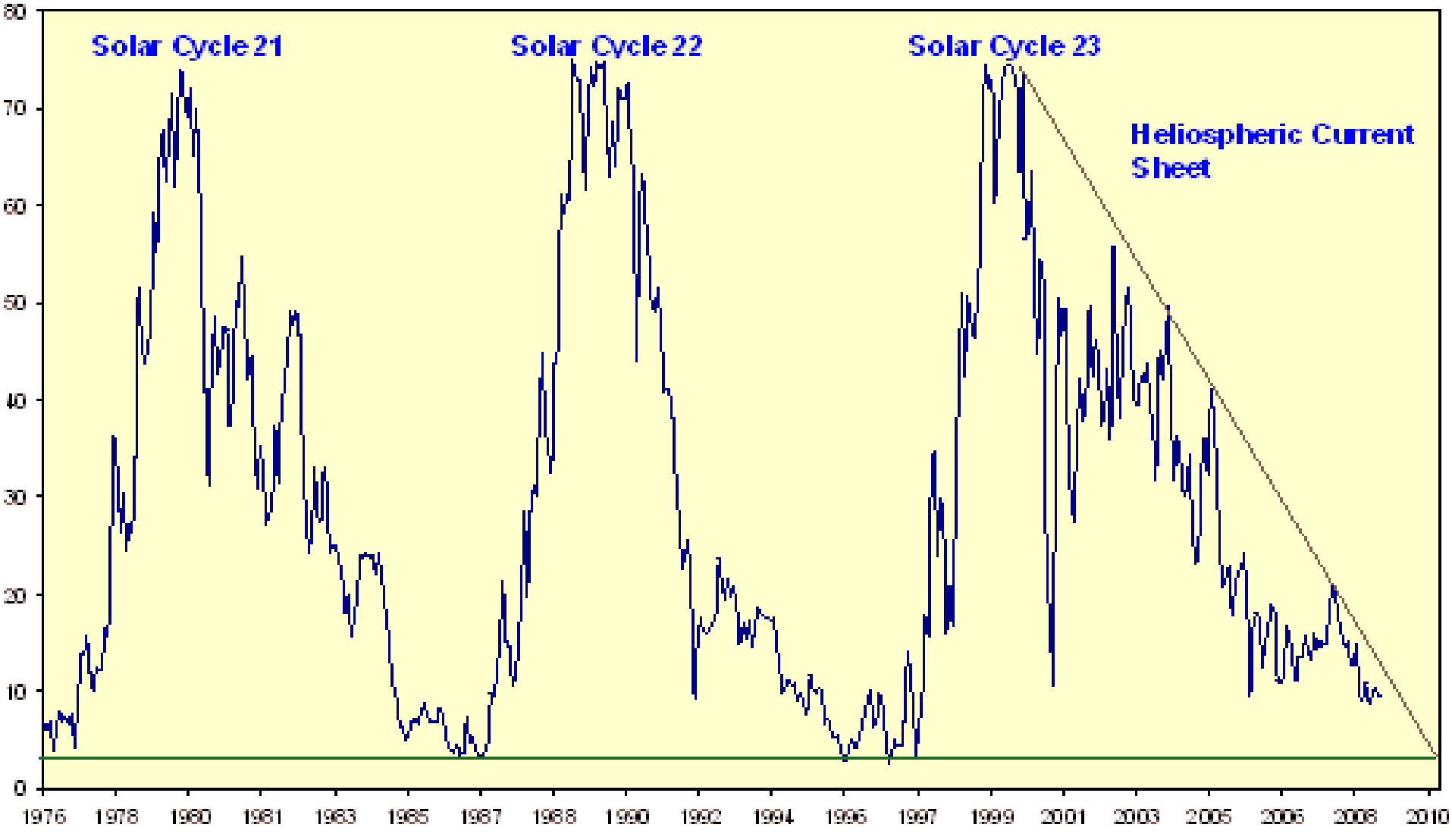


The average cycle lasts 131±14 months and has a smoothed sunspot number maximum of 114±40.



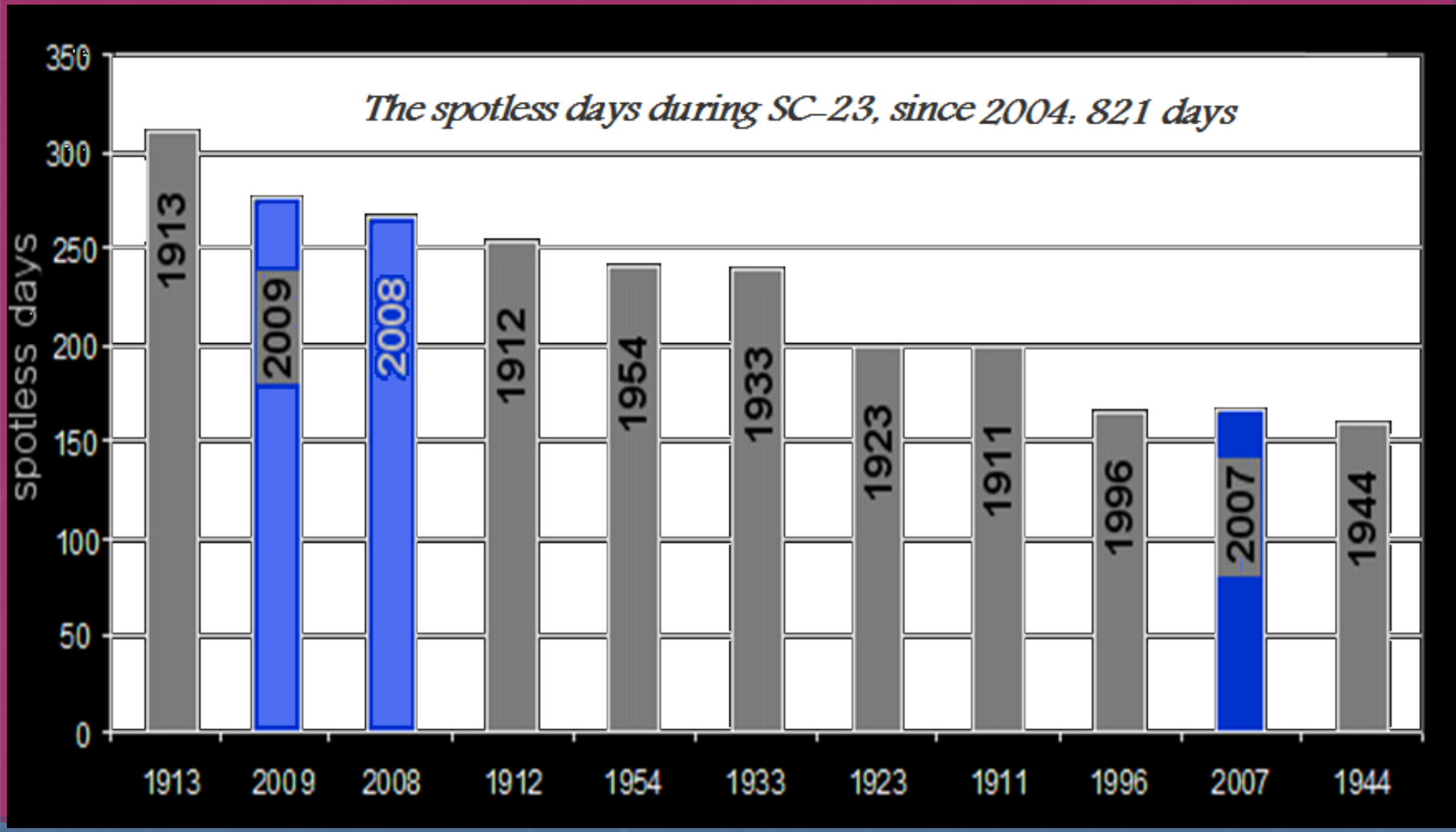
The monthly and monthly smoothed sunspot numbers are plotted for the present cycle and the four latest cycles

Deep Solar Minimum of Cycle 23



Cycle 21,22, 23 and its decline phase phase

Deep Solar Minimum of SC-23



Sunspot counts for spotless years during the last 100 years. The years 2007, 2008, 2009 are the years of minimum of solar cycle 23 (spotless days 841 days)

Table 1 Monthly and yearly means of sunspot numbers of solar cycle23, 24

Year 2001: Yearly Means: 110.58
Monthly mean: 95.6 80.6 113.5 107.7 96.6 134.0 81.8 106.4 150.7 125.5 106.5 132.2

Year 2003: Yearly Means: 63.57
Monthly mean: 79.7 46.0 61.1 60.0 54.6 77.4 83.3 72.7 48.7 65.5 67.3 46.5

Year 2006: Yearly Means: 15.16
Monthly mean: 15.3 4.9 10.6 30.2 22.3 13.9 12.2 12.9 14.4 10.4 21.5 13.6

Year 2007: Yearly Means: 7.5
Monthly mean: 16.8 10.7 4.5 3.4 11.7 12.1 9.7 6.0 2.4 0.9 1.7 10.1
Spotless Days 149 of 365 days (41% spotless days)

Year 2008: Yearly Means: 2.85
Monthly mean: 3.3 2.1 9.3 2.9 3.2 3.4 0.8 0.5 1.1 2.9 4.1 0.8
potless Days 266 of 366 days (73% spotless days)

Year 2009: Yearly Means: 3.1, Start of Solar cycle 24, Jan. 2009)
Monthly mean: 1.5 1.4 0.7 0.8 2.9 2.9 3.2 0.0 4.3 4.6 4.2 10.6
Spotless Days 260 of 365 days (71% spotless days)

Year 2010: Yearly Means: 16.6
Monthly mean: 13.1 18.6 15.4 7.9 8.8 13.5 16.1 19.6 25.2 23.5 21.6 14.4 (Dec.)
Spotless Days 51 of 365 days (14% spotless days)

Year 2011
Monthly mean: 18.8 29.6 55.8 54.4 41.6 37.0 43.9 50.6 78.0 88.0 96.7 73.0 73.0 (Dec.)
2011 Spotless days 2 days

Total spotless days Since 2004: 821 days (Typical Solar Min: 486 days)

Year 2012, monthly mean 58.3(Jan) 33.1(Feb) 64.2 Mar) 55.2(Apr) 55.2(May)

Table 2 Monthly and yearly mean flare index of solar full disk of cycle 23

Year 2001 is the maximum solar activates of cycle 23

Yearly Mean = 6.80

Monthly Means: 2.76 1.25 7.65 10.20 2.89 4.86 1.84 6.38 11.77 9.50 10.95 11.39

Year 2003 is the year of starting decline phase of cycle 23

Yearly Mean = 3.46

Monthly means: 2.69 1.55 3.33 2.62 4.35 4.54 2.55 1.59 0.77 12.11 4.53 0.68

Year 2006 is the year of staring solar minimum of cycle 23

Yearly Mean = 0.54

Monthly means: 0.03 0.00 0.11 0.53 0.03 0.01 0.28 0.14 0.19 0.05 0. 4.89

Year 2007, continuous of minimum of cycle 23

Yearly Mean = 0.47

Monthly Mean: 0.49 0.01 0.01 0.02 0.24 1.53 1.16 0.21 0.00 0.00 0.01 1.88

Year 2008, continuation of minimum of cycle 23

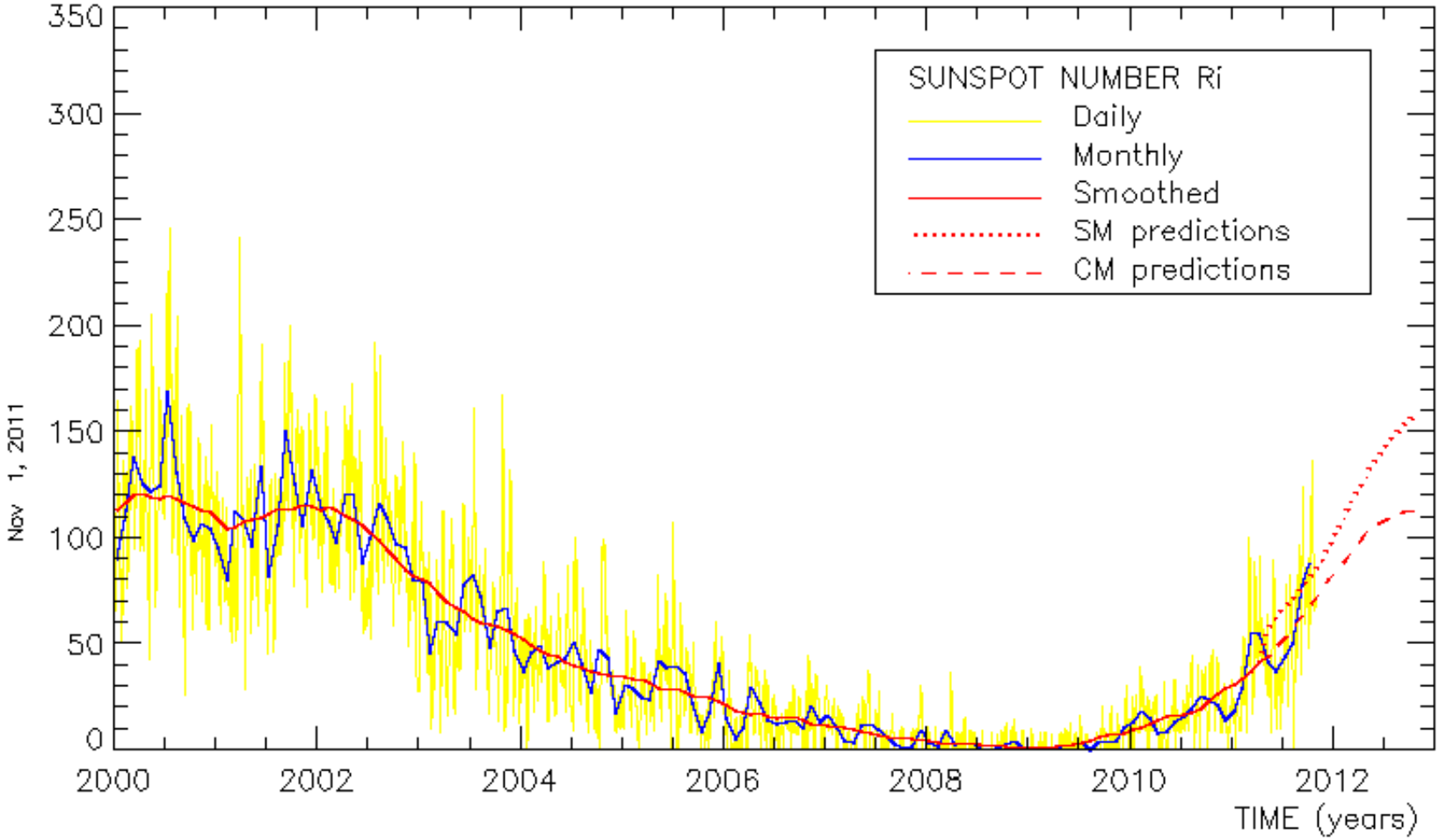
Yearly Mean = 0.03

Monthly Means: 0.05 0.00 0.20 0.06 0.00 0.00 0.00 0.00 0.00 0.00 0.03 0.00

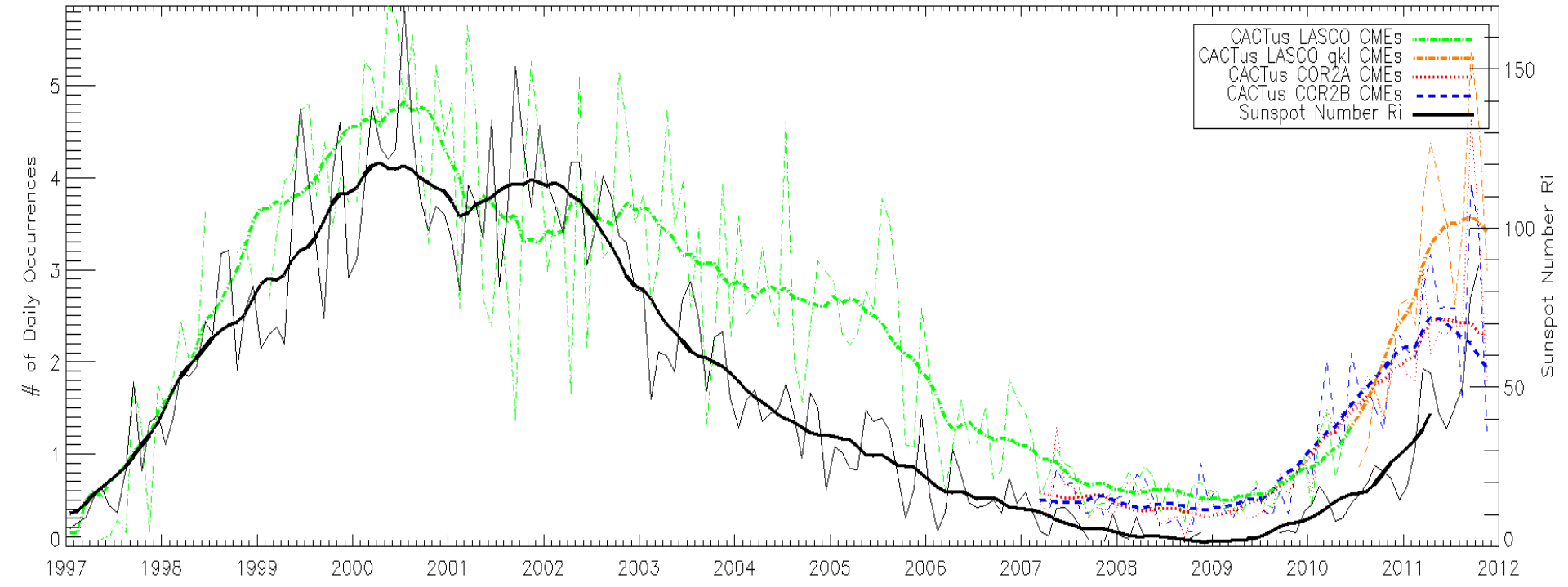
Year 2009, continuation of minimum of cycle 23

Yearly Mean= 0.027

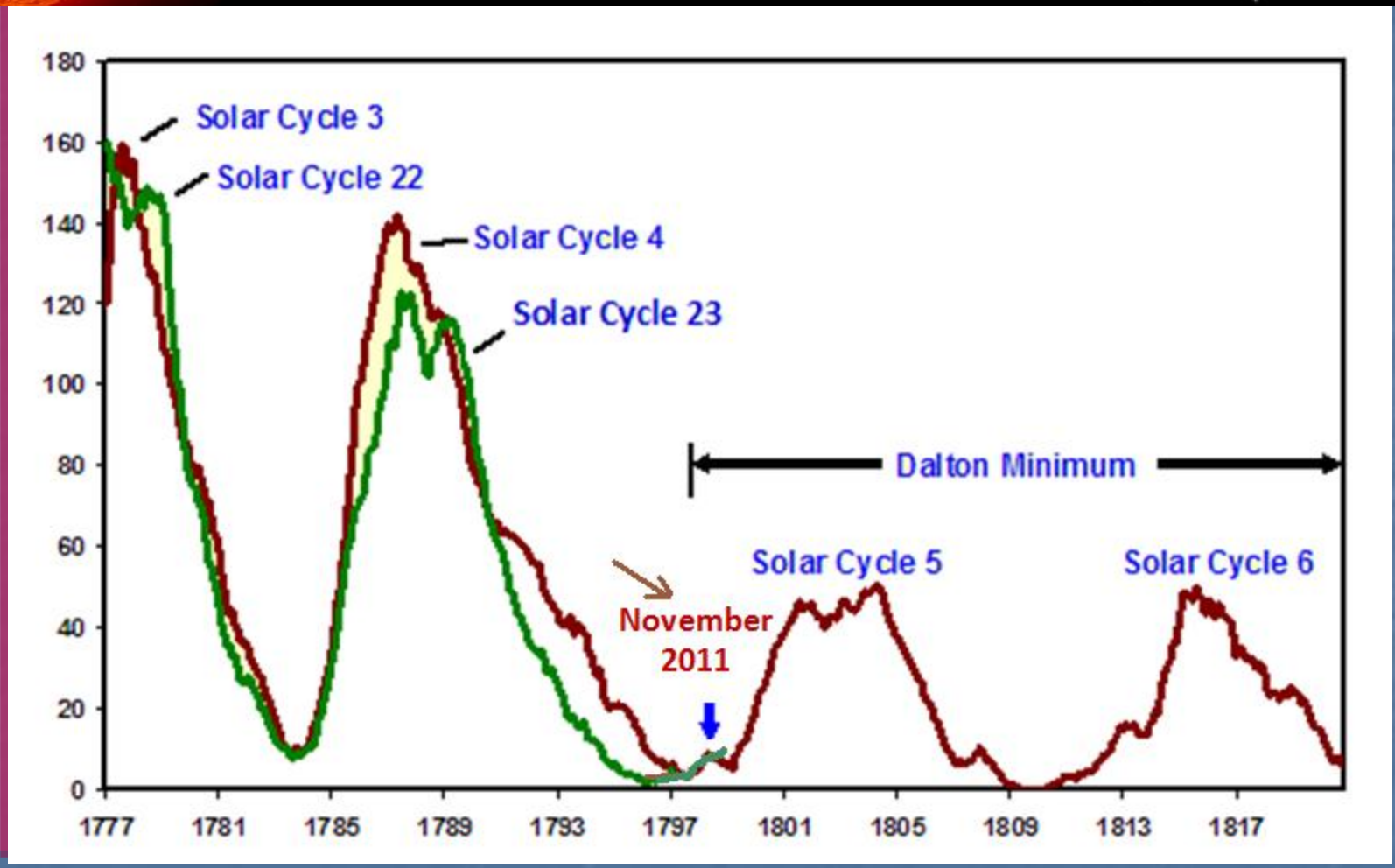
Monthly Means: 0.04 0.00 0.03 0.06 0.00 0.00 0.00 0.00 0.00 0.00 **0.03** **0.20**



The daily, monthly and monthly smoothed sunspot numbers for the past 12 years, and predictions for 12 months ahead.



CME's activity from SoHO and from Stereo coronagraphs



Dalton minimum era and the Solar Cycle 22 and 23 are overlaid on solar cycle 3 and 4 above to show similarity.Solar Cycle 24 suggested to be like Cycle 5.

Predictions of SC-24

The techniques were used to predict the **amplitude of a cycle** during the time near and **before sunspot minimum**, depends on **the level of activity at sunspot minimum, and the size of the previous cycles, etc.**

We used 3 methods for solar cycles predictions based on patterns:

1- the first method depend on the Waldmeier Lows which state that a- the higher the maximum, the shorter the time of rise, b- the higher the maximum, the longer the time of fall, c- the higher the maximum, the stronger the sunspot activity 5 years after the maximum, d- the higher the maximum, the higher the descent area.

The "Waldmeier Laws in the Mathematical Form

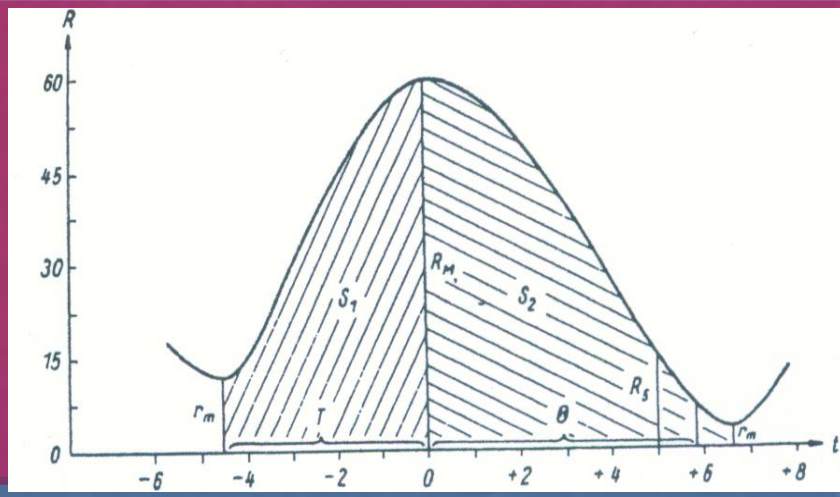
For even-numbered Cycles

$$\log \overline{R}_{max} = (2.69 \pm 0.09) - (0.17 \pm 0.02)T$$

For odd numbered Cycles

$$\log \overline{R}_{max} = (2.48 \pm 0.10) - (0.10 \pm 0.02)T$$

T is the mean Cycle length



Sunspot Curve of the 11-Year cycle (Schematic)

2- Second method depend on that the value of the geomagnetic ***aa*** **index at its minimum which related to the sunspot number during the ensuing maximum**.(by Ohl and Ohl, 1979) and by **J. Feynman,** She separates the geomagnetic *aa* index into two components: one in **phase with and proportional** to the sunspot number, the other component is then **the remaining signal**.

3-Third method is due to **Richard Thompson** [*Solar Physics* **148**, 383 (1993)]. He found a relationship between the number of days during a sunspot cycle in which the geomagnetic field was "disturbed" and the amplitude of the next sunspot maximum. His method has the advantage of giving a **prediction for the size** of the next sunspot maximum before sunspot minimum.

Solar Cycle 24 Prediction

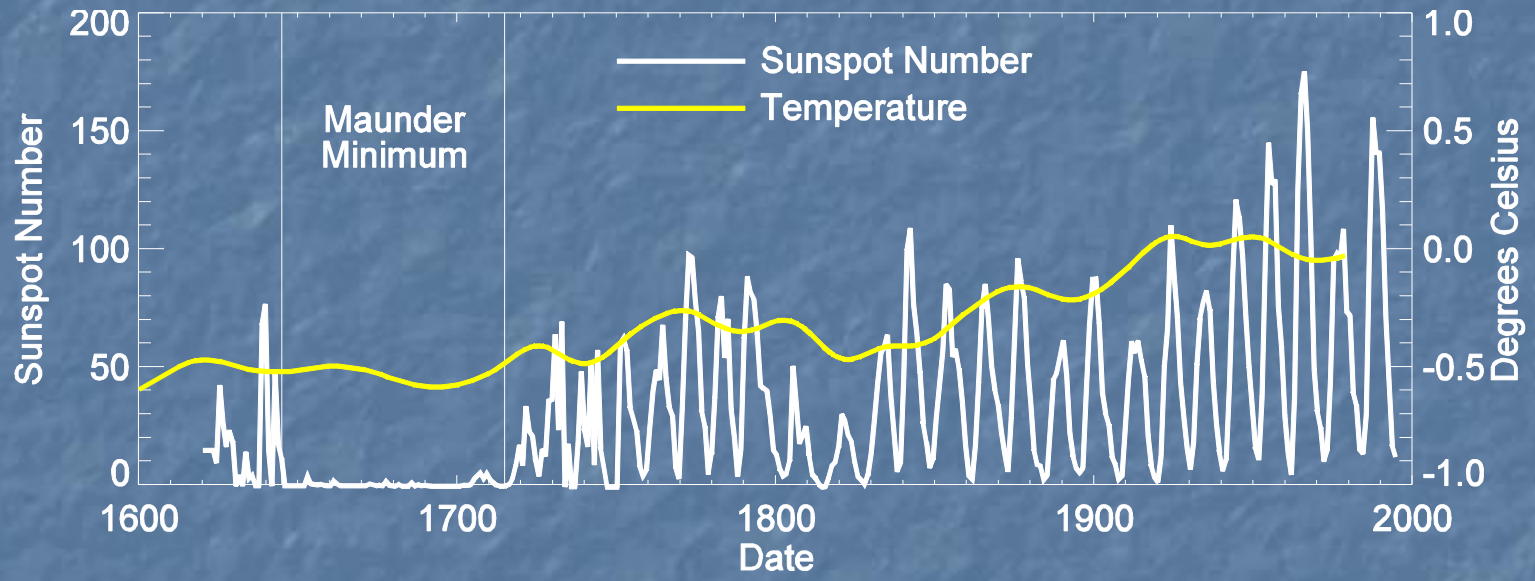
Cycle No	SC Start Year	SC Start Mth	SC Max Year	SC Max Mth	Max SSN	Length Years	Rise Max.	Max to End
24	2009	May	2013	Jan	105	11.7	3.9 Yr	7.8 Yr

Table 4 Minimum and maximum of sunspot in the series of solar cycles

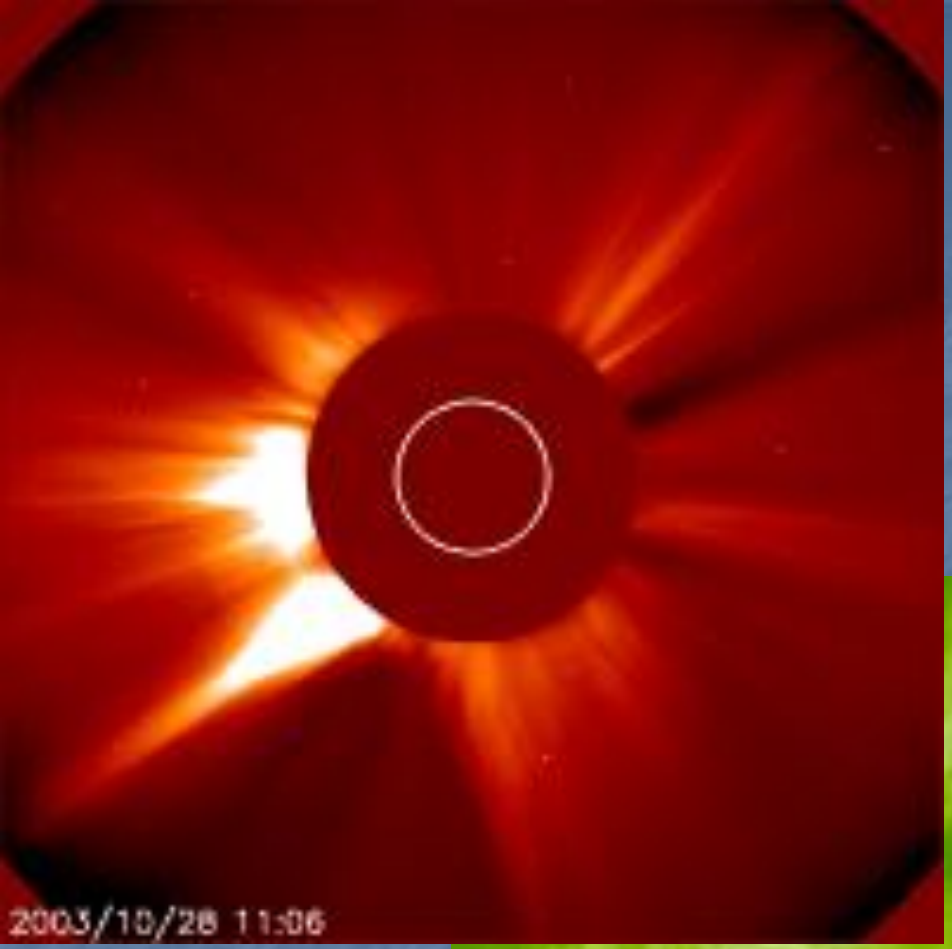
Sunspot Cycle Number	Year of Min	Smallest Smoothed monthly mean	Year of Max	Largest Smoothed Monthly Mean	Rise to Max (Yrs)	Fall to Min (Yrs)	Cycle (Yrs)
1	1755.2	8.4	1761.5	86.5	6.3	5.0	11.3
2	1766.5	11.2	1769.7	115.8	3.2	5.8	9.0
3	1775.5	7.2	1778.4	158.5	2.9	6.3	9.2
4	1784.7	9.5	1788.1	141.2	3.4	10.2	13.6
5	1798.3	3.2	1805.2	49.2	6.9	5.4	12.3
6	1810.6	0.0	1816.4	48.7	5.8	6.9	12.7
7	1823.3	0.1	1829.9	71.7	6.6	4.0	10.6
8	1833.9	7.3	1837.2	146.9	3.3	6.3	9.6
9	1843.5	10.5	1848.1	131.6	4.6	7.9	12.5
10	1856.0	3.2	1860.1	97.9	4.1	7.1	11.2
11	1867.2	5.2	1870.6	140.5	3.4	8.3	11.7
12	1878.9	2.2	1883.9	74.6	5.0	5.7	10.7
13	1889.6	5.0	1894.1	87.9	4.5	7.6	12.1
14	1901.7	2.6	1907.0	64.2	5.3	6.6	11.9
15	1913.6	1.5	1917.6	105.4	4.0	6.0	10.0
16	1923.6	5.6	1928.4	78.1	4.8	5.4	10.2
17	1933.8	3.4	1937.4	119.2	3.6	6.8	10.4
18	1944.2	7.7	1947.5	151.8	3.3	6.8	10.1
19	1954.3	3.4	1957.9	201.3	3.6	7.0	10.6
20	1964.9	9.6	1968.9	110.6	4.0	7.6	11.6
21	1976.5	12.2	1979.9	164.5	3.4	6.9	10.3
22	1986.8	12.3	1989.6	158.5	2.8	6.8	9.7
23	1996.4	8.0	2000.3	120.8	4.0	10.0	13.5
Author's estimation of cycle 24							
24	2009.4	9.0	2013.2	105.0	4.3	7.8	12.1
Mean Cycle Values:		6.1		113.2	4.7	6.3	11.0

Total Irradiance and Climate

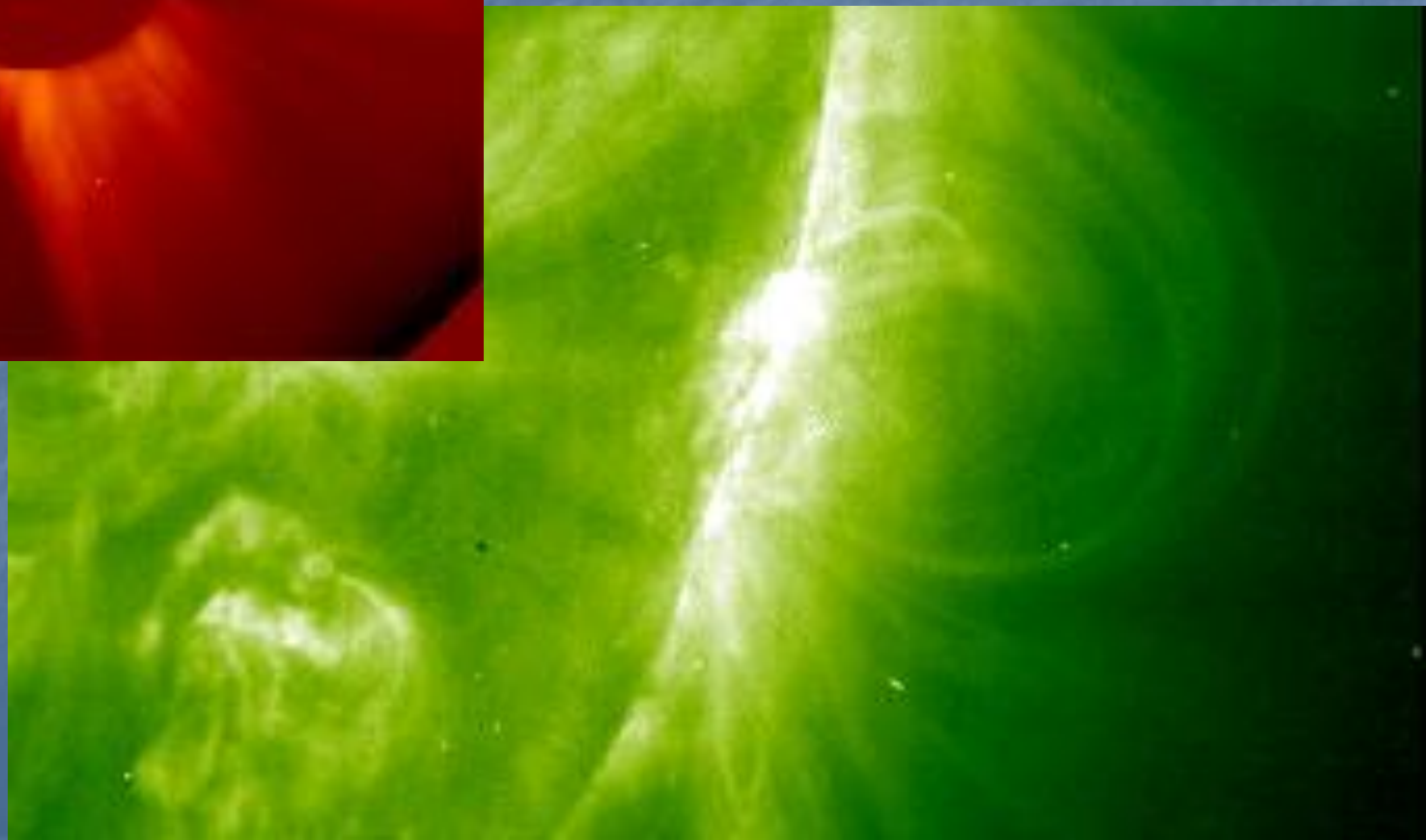
The 0.1% change in the Total Solar Irradiance seen over the last three solar cycles only produces a 0.1° C temperature change in climate models. However, the Sun seems to have a bigger impact.

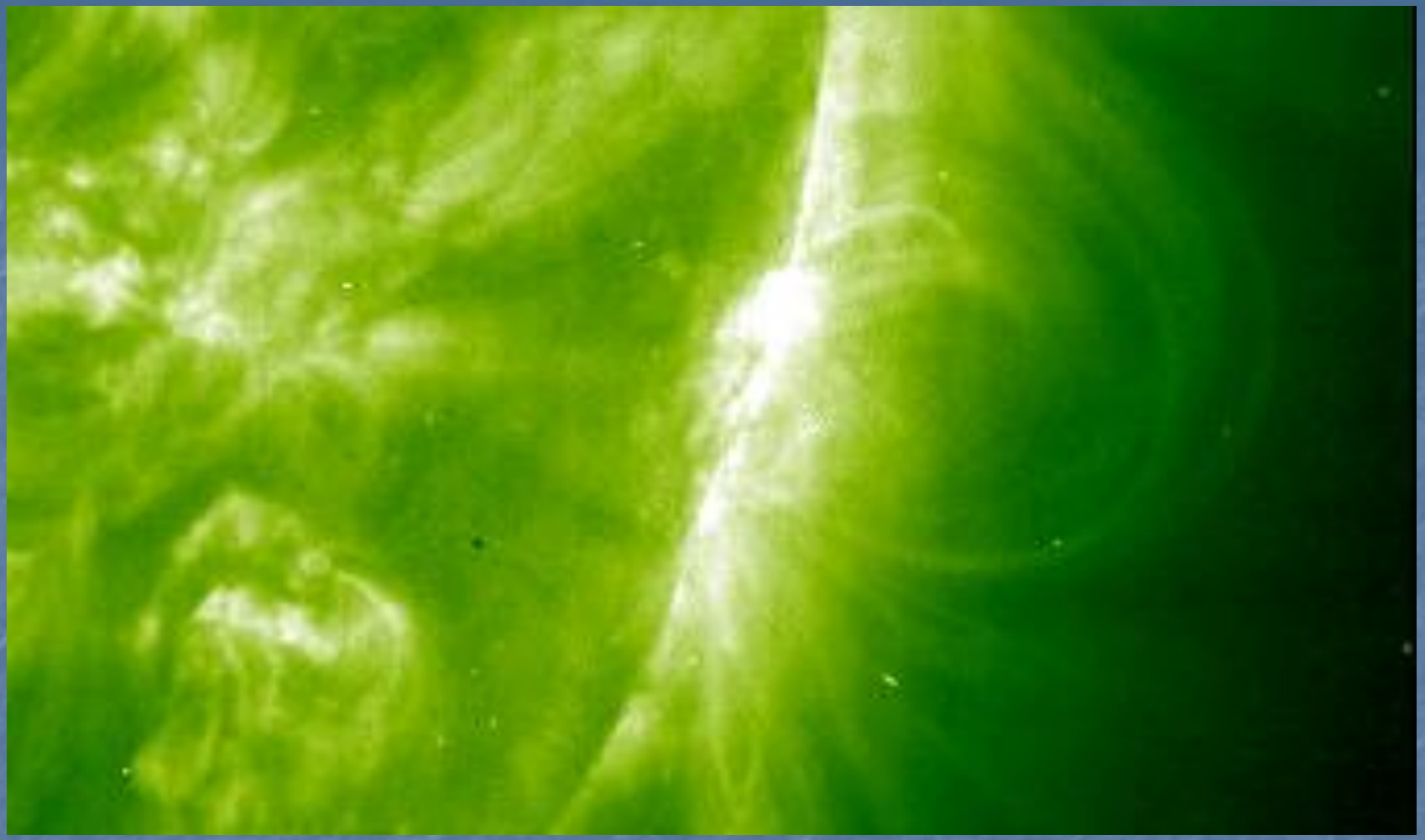


Two other mechanisms (besides direct forcing by the Total Solar Irradiance variations) are under study: 1) solar ultraviolet and extreme ultraviolet variability and 2) Cosmic Ray modulation on cloud cover.



SoHo observations of Halloween storms (28 October 2003), the most eruptive storm observed in history, during cycle 23





Movies of regions 10486

SoHo EIT X-Ray Flare (X28/3B) Nov 4, 2003

SC-23

Date	Middle Latitude --Fredericksburg--- A	--K-indices---	Estimated -----Planetary --- A	--K-indices--
20000714	33	3 3 3 3 3 6 6 4	35	4 3 4 4 4 6 5 4
20000715	148	3 3 3 3 6 8 9 9	152	4 4 5 5 6 9 9 9
20001108	14	1 3 4 4 3 3 1 2	15	2 3 4 4 3 3 1 3
20001109	10	3 1 1 1 3 3 2 3	11	3 1 1 1 3 3 3 3
20010924	5	3 2 1 1 1 1 1 1	6	3 1 1 2 2 2 2 1
20010925	17	1 2 2 0 3 0 4 6	18	1 2 2 1 1 2 5 6
20011104	4	0 0 2 3 1 2 1 0	7	0 0 2 3 3 3 2 1
20011105	12	0 0 1 2 4 3 4 3	13	0 0 1 2 3 4 5 4
20011122	8	1 2 2 2 2 2 3 2	8	1 2 2 3 2 2 3 2
20011123	11	2 1 2 2 3 4 1 3	12	3 2 2 2 3 3 3 3
20020421	4	1 1 1 1 1 1 2 2	7	3 2 2 1 2 2 2 3
20031028	15	2 4 3 3 2 3 3 3	20	3 4 4 4 3 4 3 4
20031029	199	3 3 9 6 7 7 9 9	189	4 3 9 8 7 7 9 8
20031030	144	7 5 4 4 4 6 9 9	162	8 7 6 5 5 8 9 9
20031031	73	8 7 6 4 5 3 3 3	93	8 7 7 6 6 5 4 4
20031101	16	5 4 3 1 2 2 1 3	21	4 5 4 3 3 3 3 3
20031102	11	3 3 2 2 2 3 3 2	18	3 4 3 3 3 4 4 3
20031103	15	4 2 1 1 5 2 2 3	10	3 3 2 3 2 3 2 3
20031104	20	2 2 5 5 2 2 4 2	31	3 2 5 7 3 3 4 3

Daily Geomagnetic data of most eruptive days during the Peak and declining phase of Solar cycle 23 ,

Magnetic flux measured by GEOS – note that the instrument sensors are not capable to register values exceeding 327.11 Nano tesla. The solar source region must have had strong magnetic field intensity and high speed to compress the earth's magnetosphere.

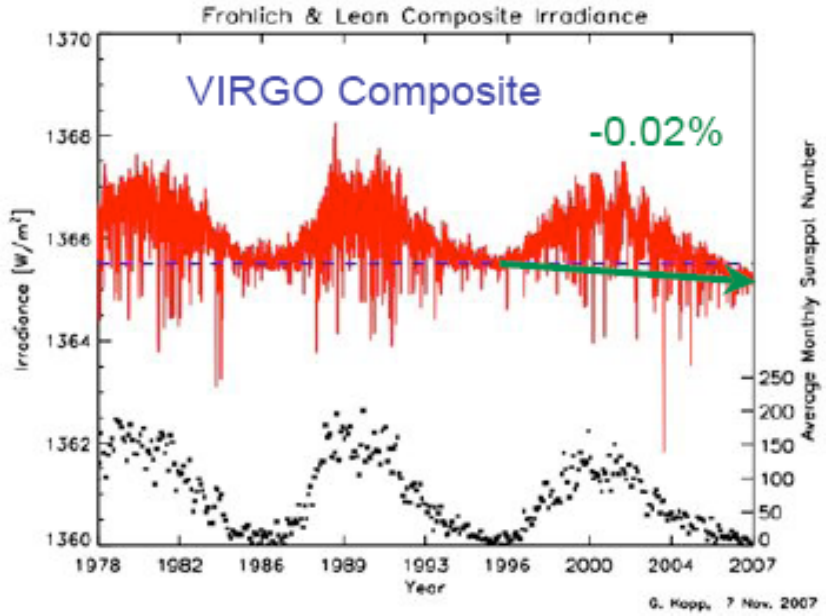
Date / UT	---- Magnetic Flux (Nanotesla)--- North -word HP	Earth -word HE	East -word HN	Total HT
2000 07 14 /17 00	169.00	35.40	2.67	172.69
2000 11 07 /19 12	178.00	22.60	-3.80	179.47
2001 09 24 /00 15	143.00	11.80	25.00	145.65
2001 11 14 /17 25	117.00	15.90	18.30	119.49
2002 04 21 /17 50	122.00	50.80	-3.91	132.21
2003 10 28 /12 15	**327.11**	**327.11**	**327.11**	**327.11**
2003 11 02 /11 05	**327.11**	**327.11**	**327.11**	**327.11**
2003 11 04 /22 25	**327.11**	**327.11**	**327.11**	**327.11**
2003 11 18 /01 16	**327.11**	**327.11**	**327.11**	**327.11**
2004 01 01 /00 00	110.00	11.50	22.30	112.83

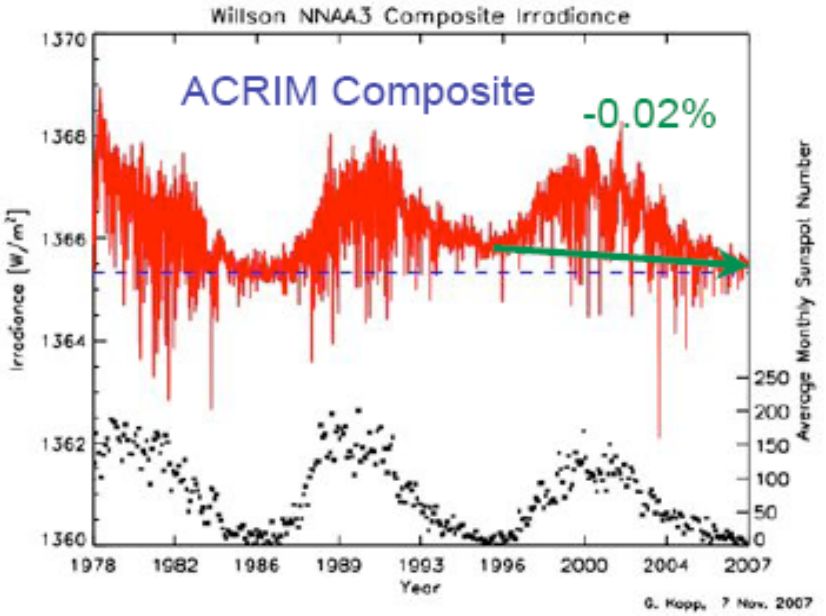
Magnetic flux during the most disturbed days in the Peak and decline phases of cycle 23.

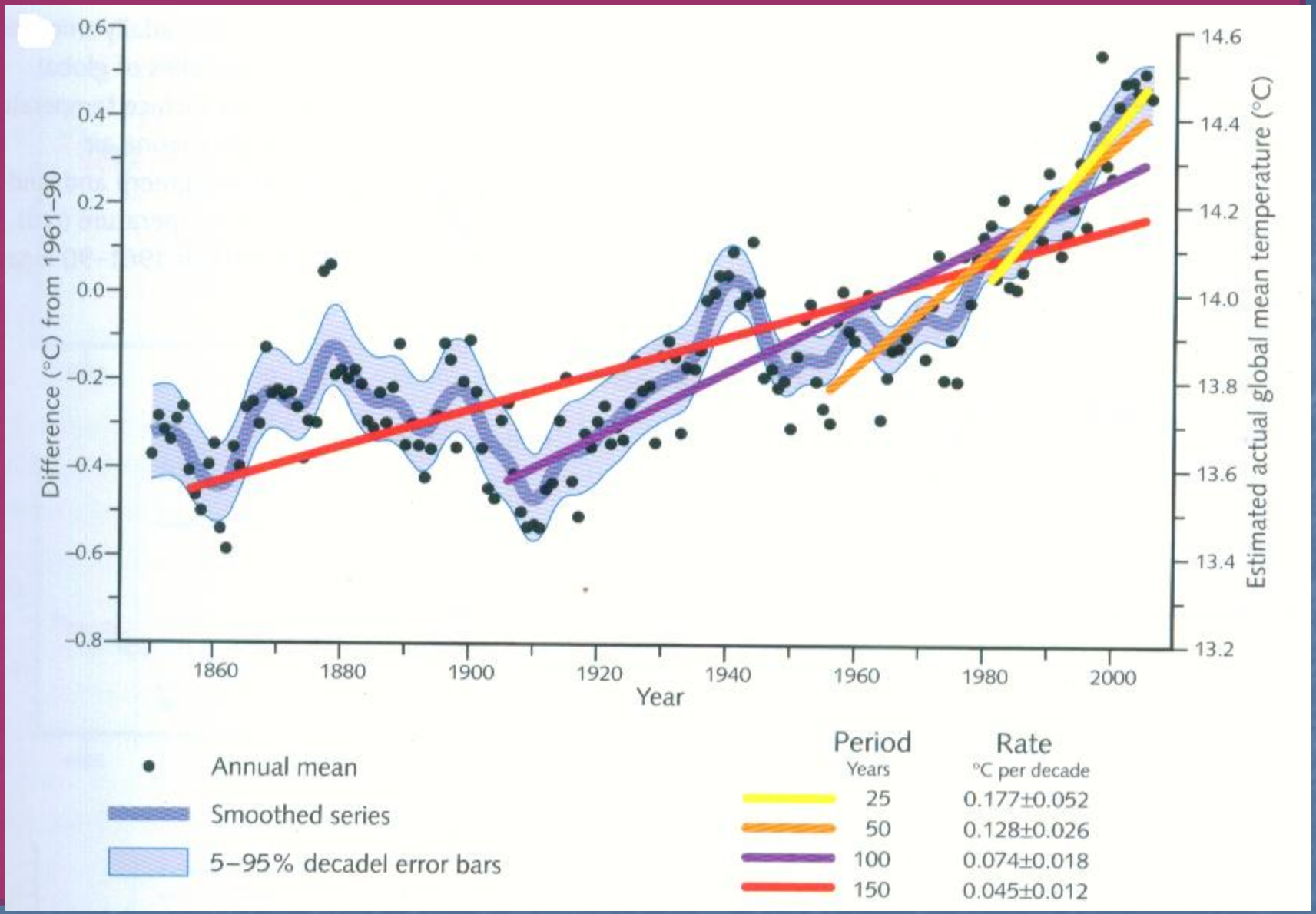
TSI Recent Decline - Is Modern Maximum Over?

- 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

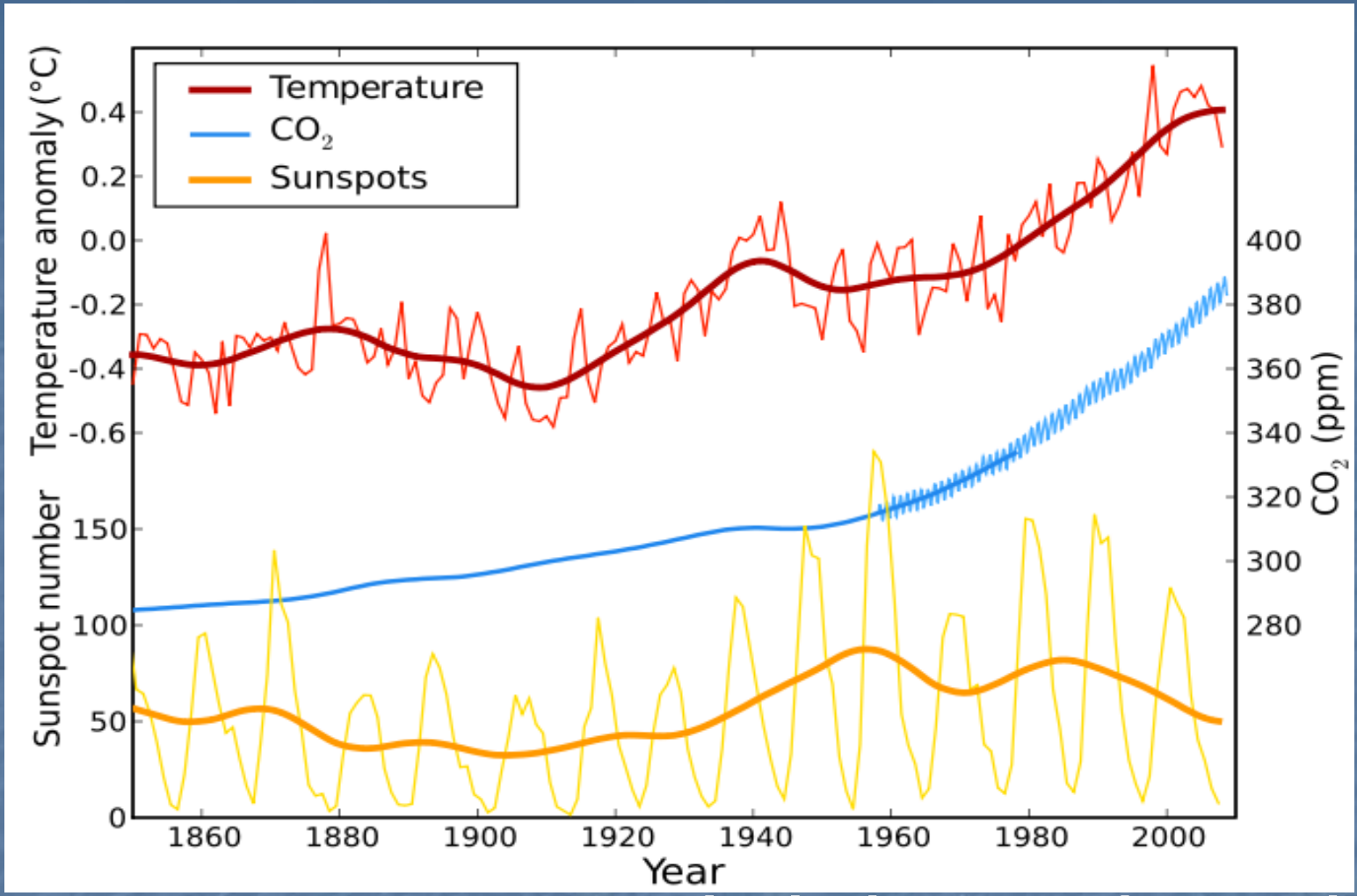
Steven Dewitte's and Claus Fröhlich's talks (Tue AM) will provide more details about long-term TSI results





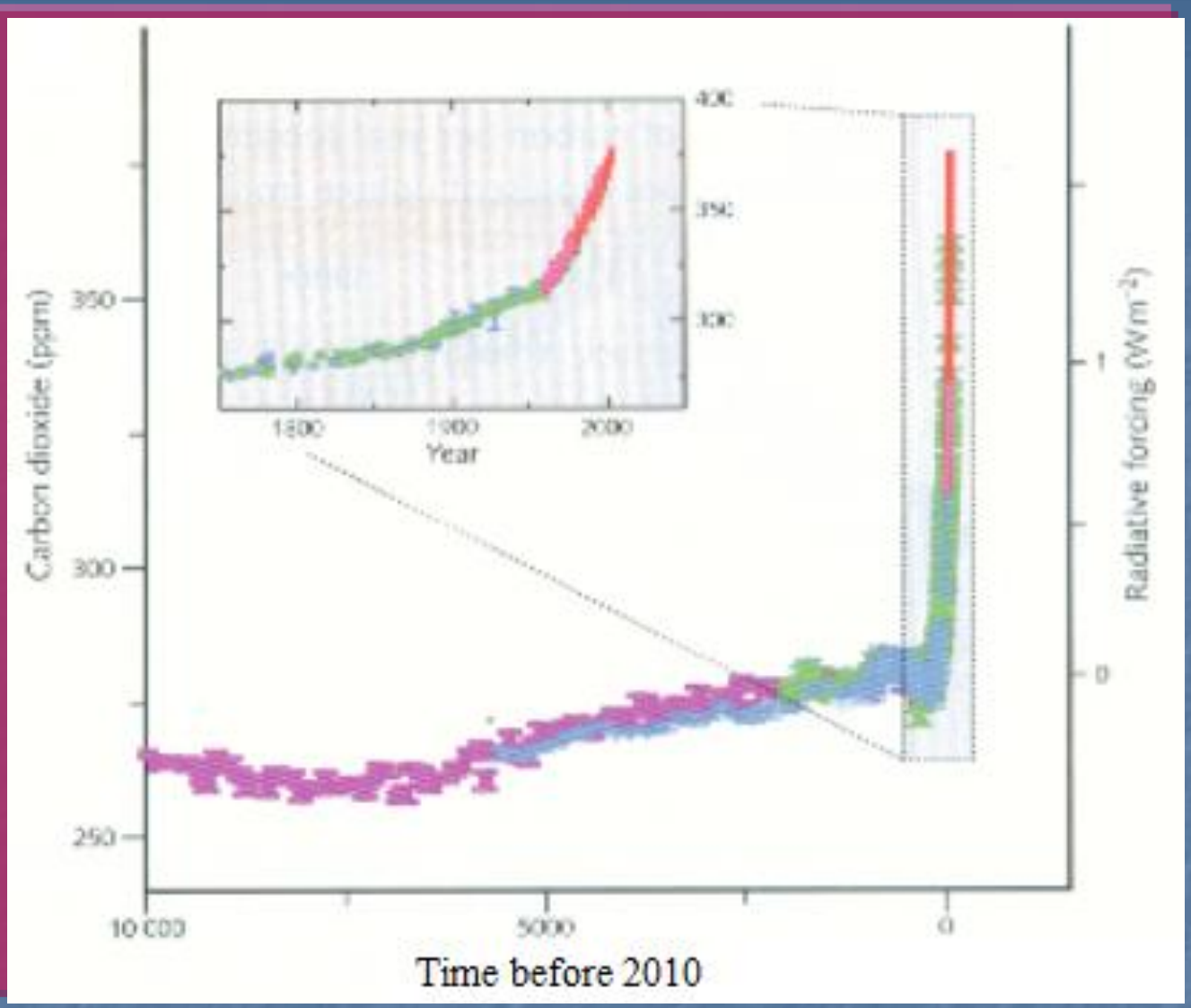


Global Temperature Changes during the last 150 years , the Solar Activity decrease and the Global Temperature increase



Temperature, Co_2 concentration in the troposphere, and sunspots variations starting year 1850 until now

Then :The solar activities have had notable effect on palaeoclimatic changes. Contemporary solar activities are so weak and hence expected to cause global cooling. Prevalent global warming, caused by building-up of green-house gases in the atmosphere, seems to exceed this solar effect



Atmospheric Carbon Dioxide concentration over the last 10,000 Years (symbols with different colors for different studies). The atmospheric sample (red lines). Forongs Show on right-hand axis

Conclusion

-The deep solar minimum and the failure of the forecasting of the SC-23, SC-24 means that we need more advanced models for Solar Cycle prediction.

-The minimum of solar activity during the solar cycle 23 have notable effects on the space environments and climatic changes

-The electromagnetic emissions at the different bands during the deep solar minimum are less than in the time of maximum solar activities.

-The Geomagnetic indices are increased after the high energetic flare released, after 1-2 days from the start of the solar flares, due to the coronal mass ejection and geomagnetic storms occurrence

- Solar activities have had notable effect on palaeoclimatic changes. Now solar activity are so weak and hence expected to cause global cooling, but the green-house gases in the troposphere, seems to exceed this solar effect now.


THANK YOU