Sixty+ Years of Solar Microwave Flux

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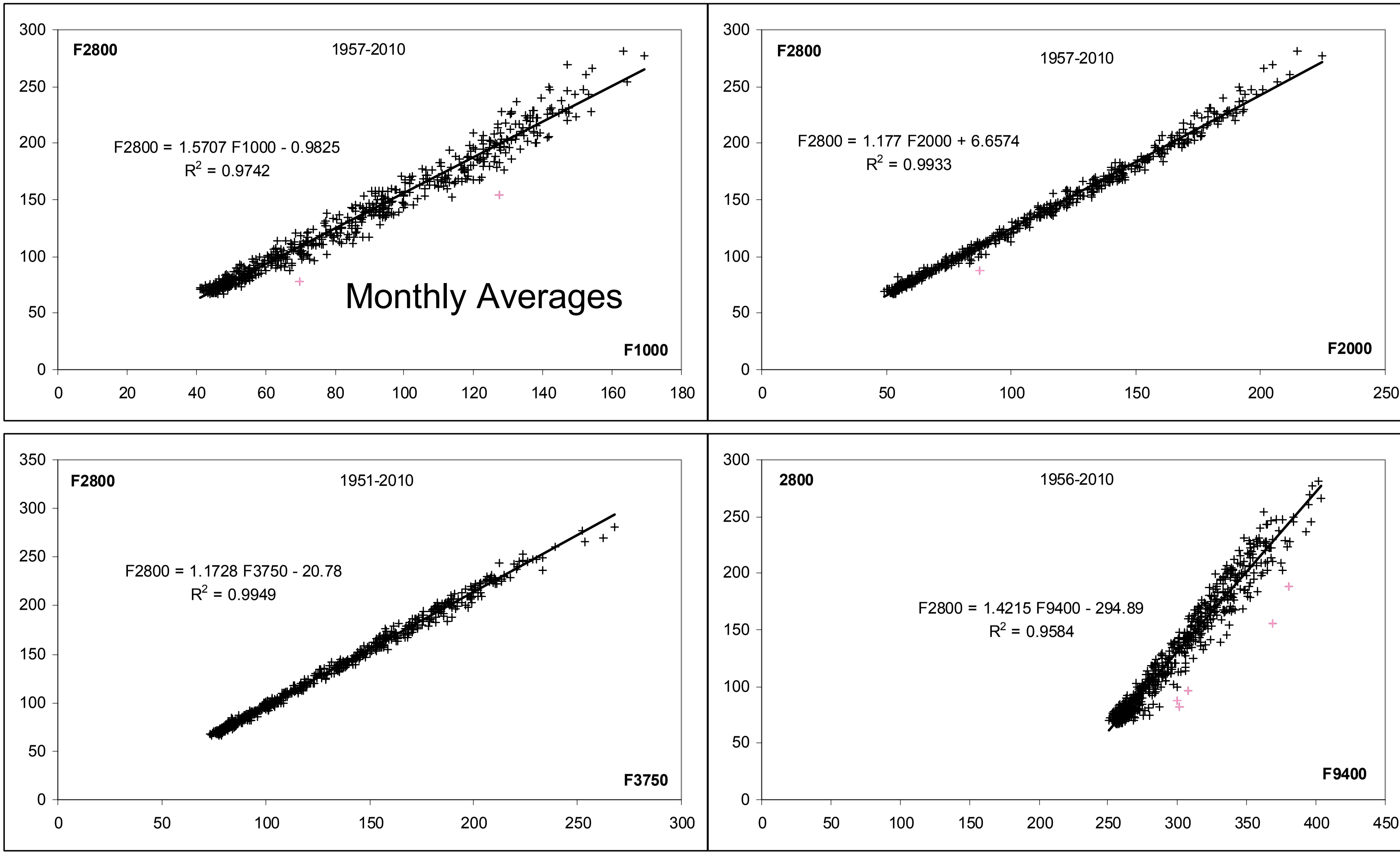
SHINE 2010, Santa Fe, NM

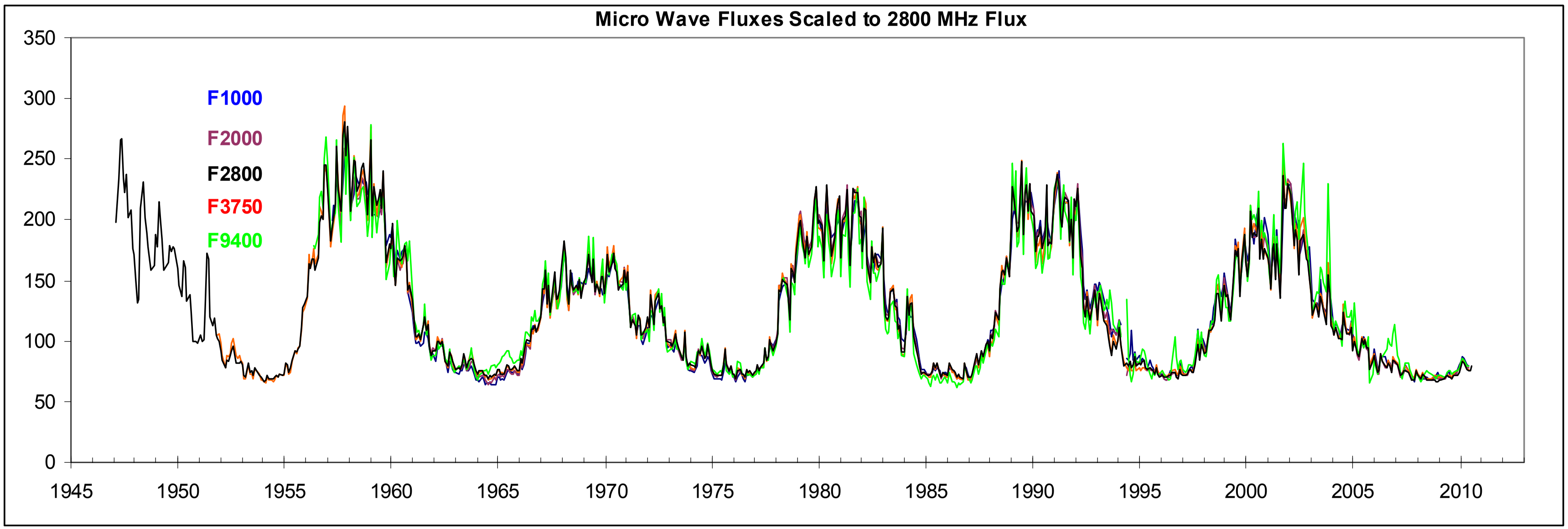
Observations and Observatories

- 1947.2-1991.5 Ottawa 2800 MHz (10.7 cm)
- 1991.5-2010.5 Penticton 2800 MHz
- 1951.8-1994.3 Toyokawa 3750 MHz (8 cm)
- 1994.4-2010.5 Nobeyama 3750 MHz
- 1957.4-1994.1 Toyokawa 2000 MHz (15 cm)
- 1994.4-2010.5 Nobeyama 2000 MHz
- 1957.2-1994.4 Toyokawa 1000 MHz (30 cm)
- 1994.4-2010.5 Nobeyama 1000 MHz
- 1956.3-1994.1 Toyokawa 9400 MHz (3.2 cm)
- 1994.4-2010.5 Nobeyama 9400 MHz

All observations are highly correlated, especially the ones [2000, 3750] flanking 2800 MHZ

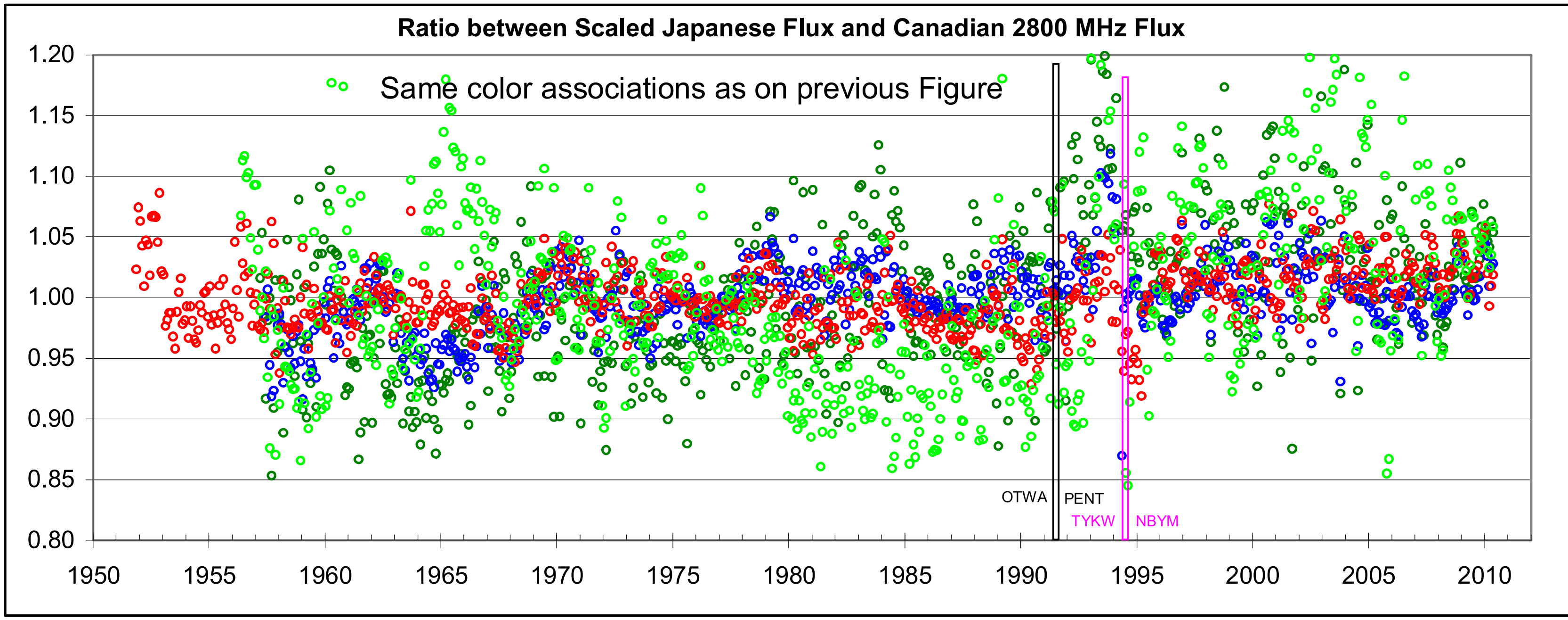


This allows us to scale all observations to 2800 MHz



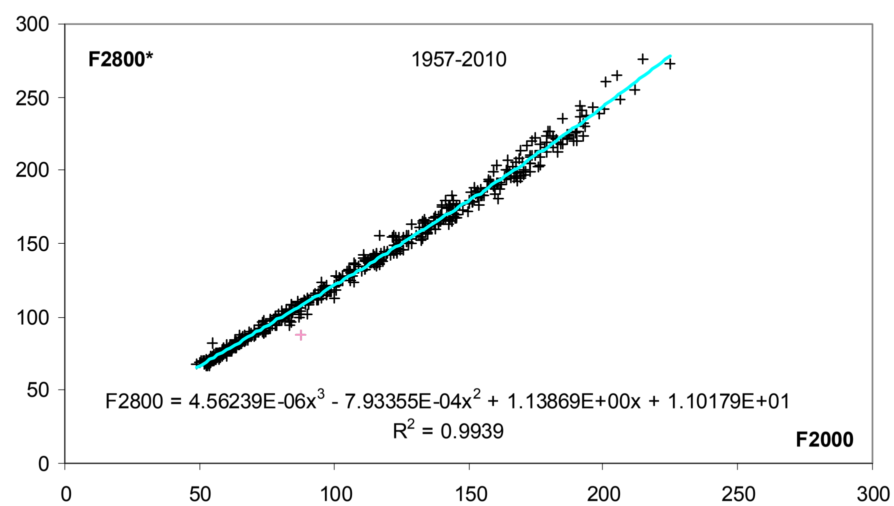
The scaled values match each other very well, except 9400 MHz where the solar activity component is rather noisy.

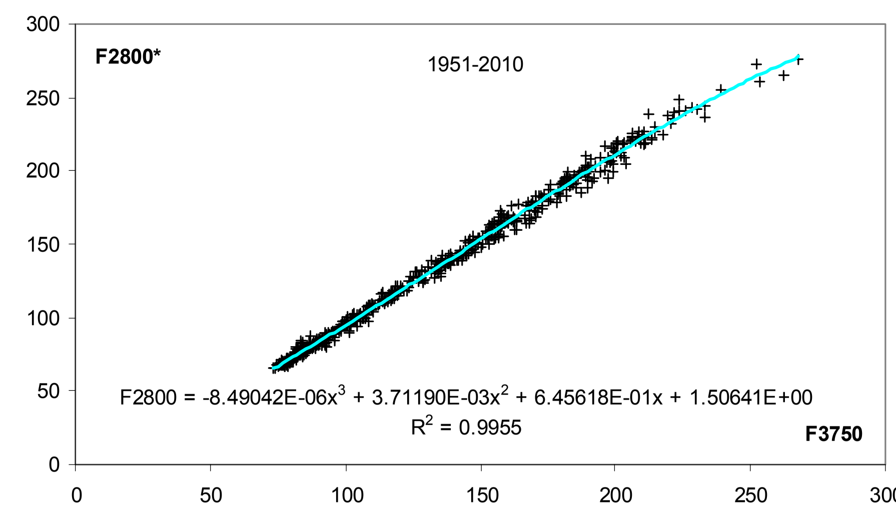
If the calibrations of the data have not changed over time, the ratios between the scaled fluxes and the 2800 MHz flux should be constant = 1

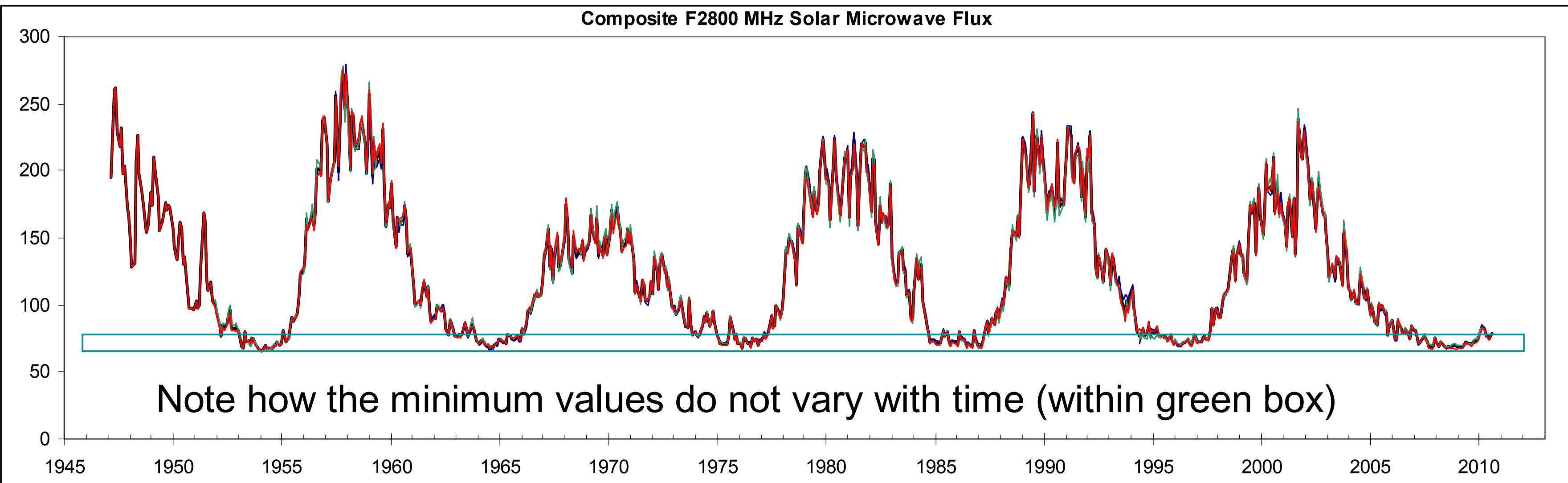


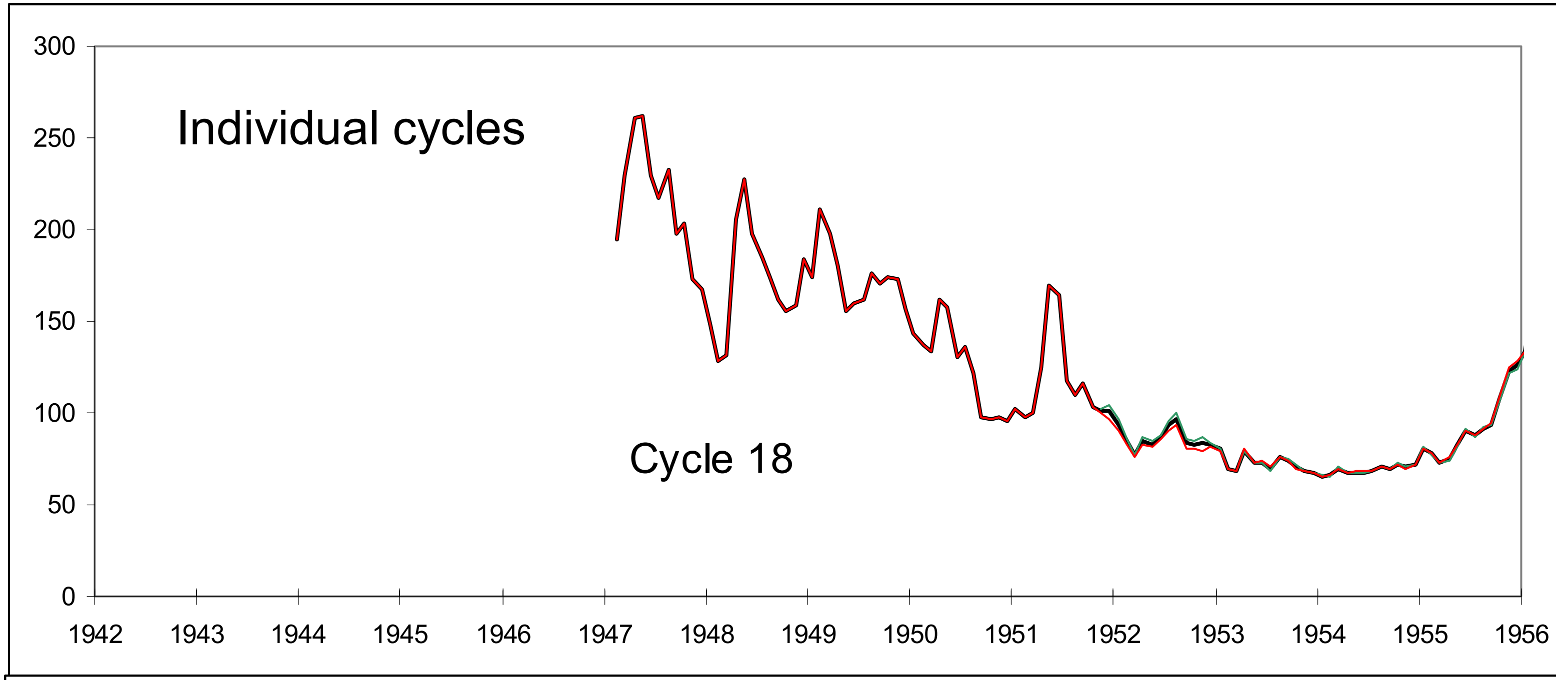
Within the scatter, the ratios appear to be lower than 1 before 1991 and higher thereafter. We interpret that as a 2% downward jump in Pentiction compared to Ottawa. We therefore reduce the Ottawa 2800 MHz flux by 2%.

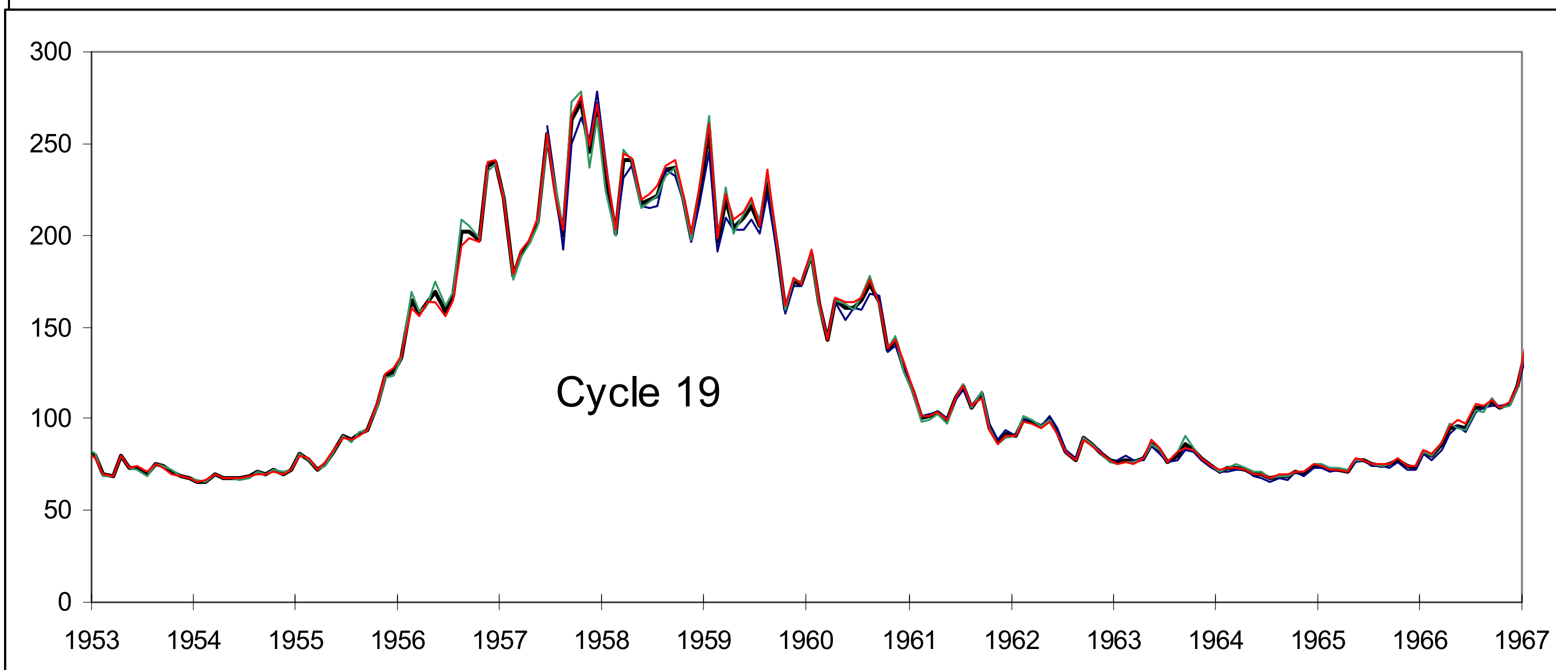
After the correction, we rescale 2000 and 3750 MHz again to 2800 MHz, and construct a composite

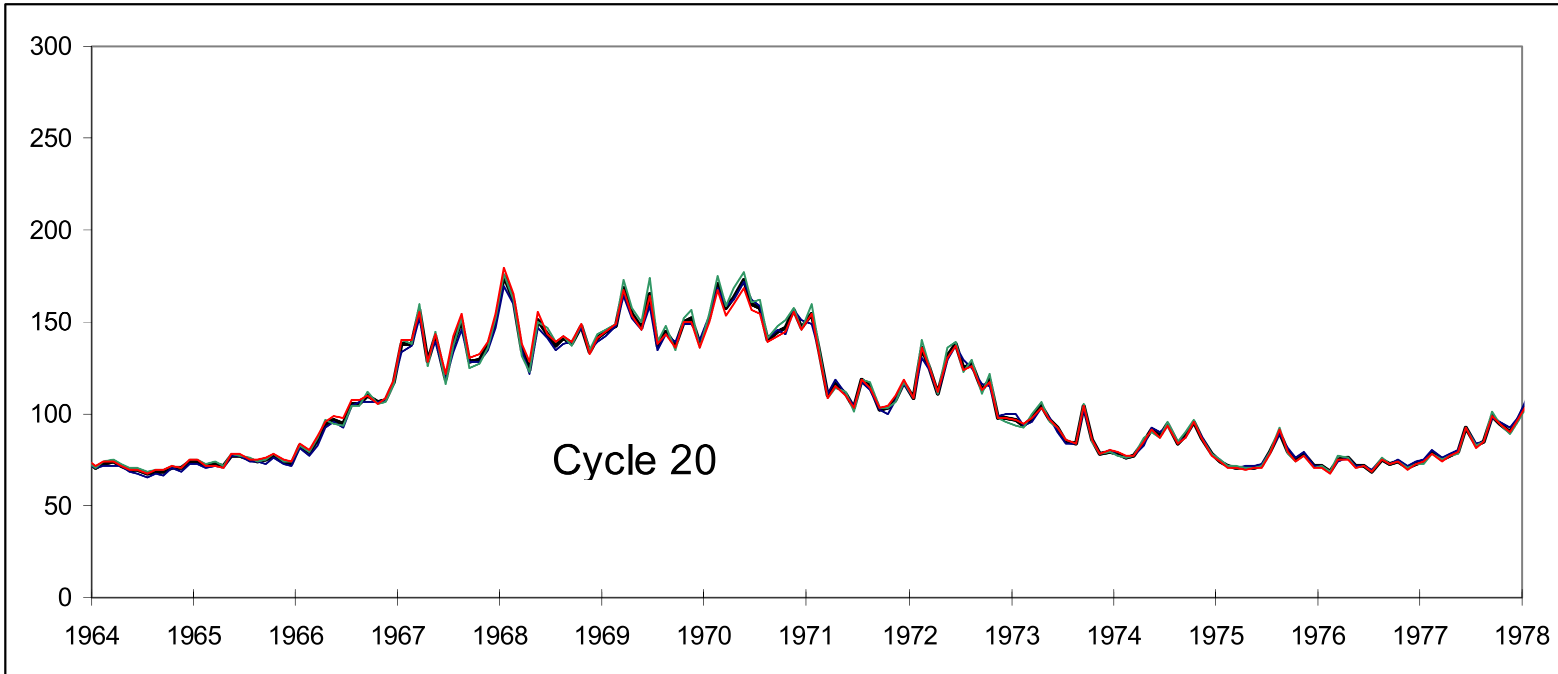


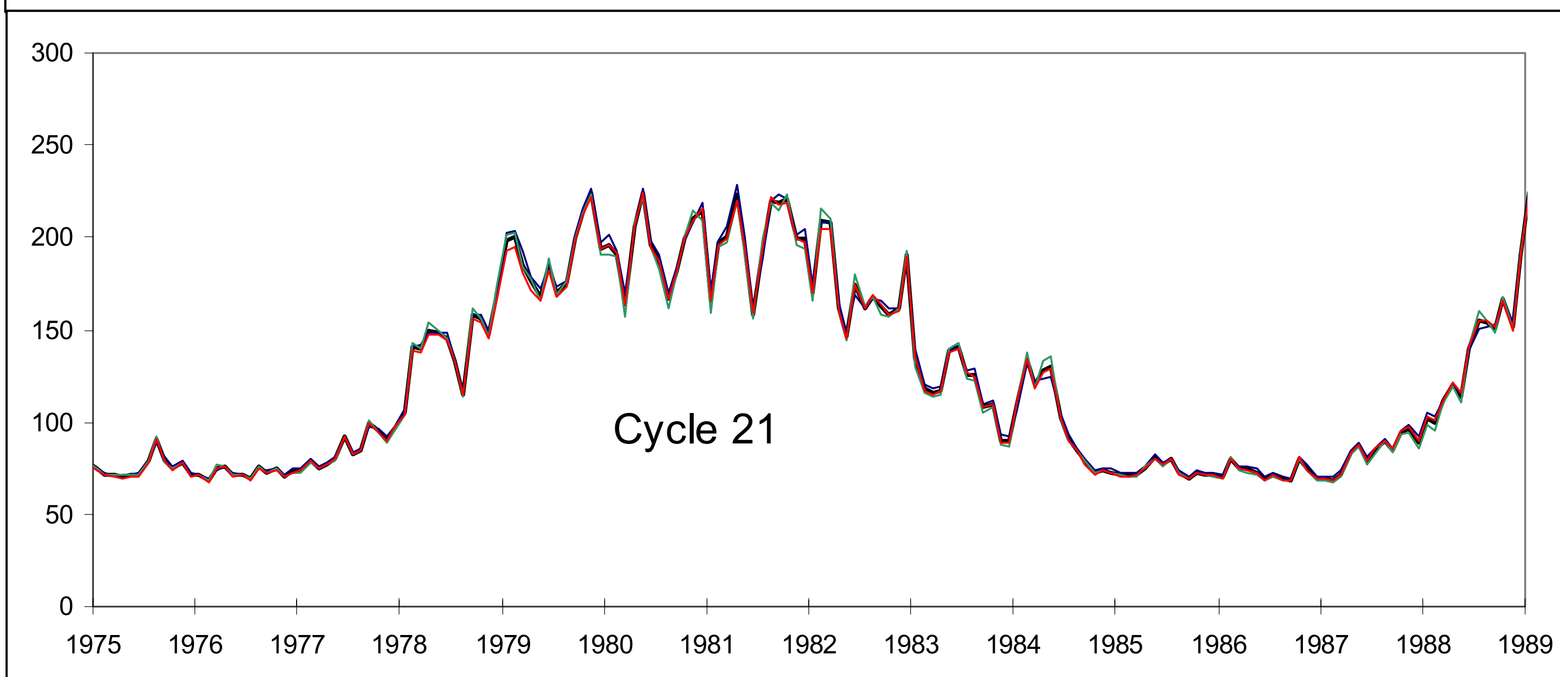


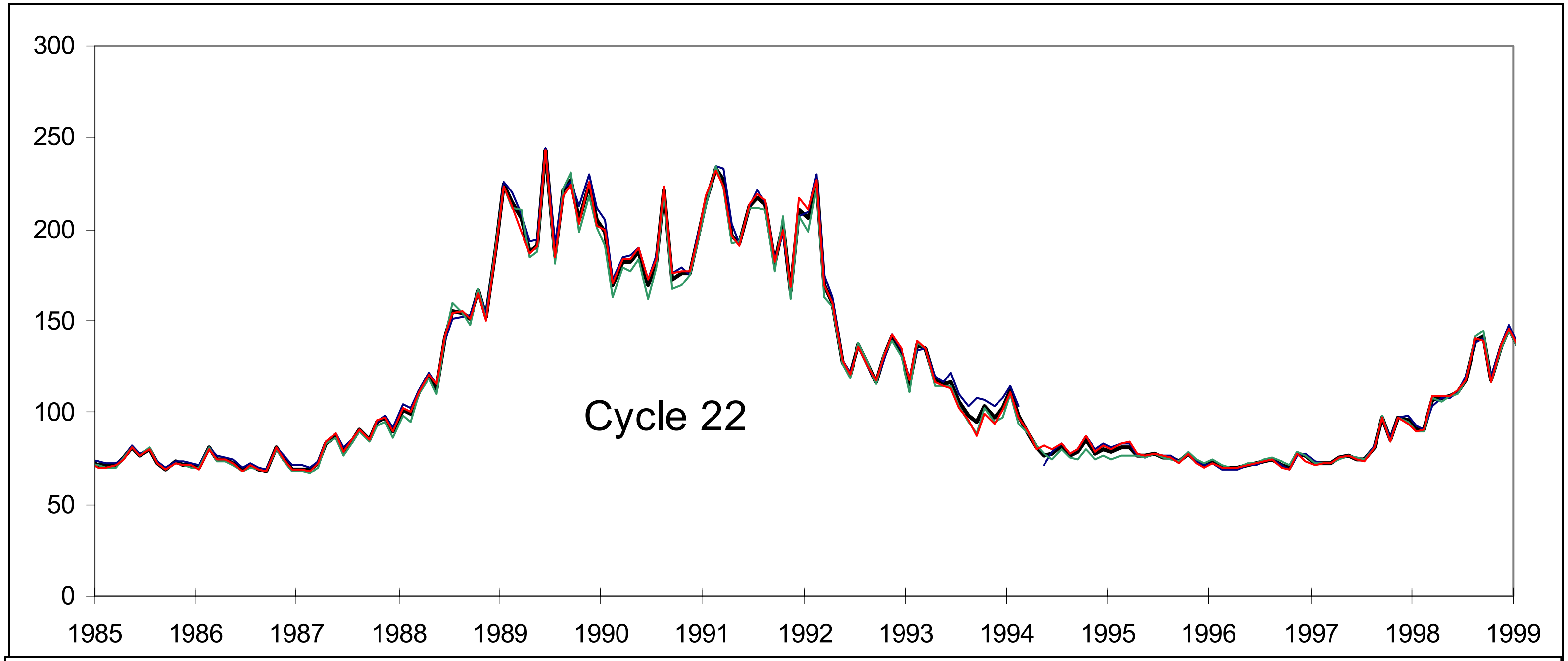


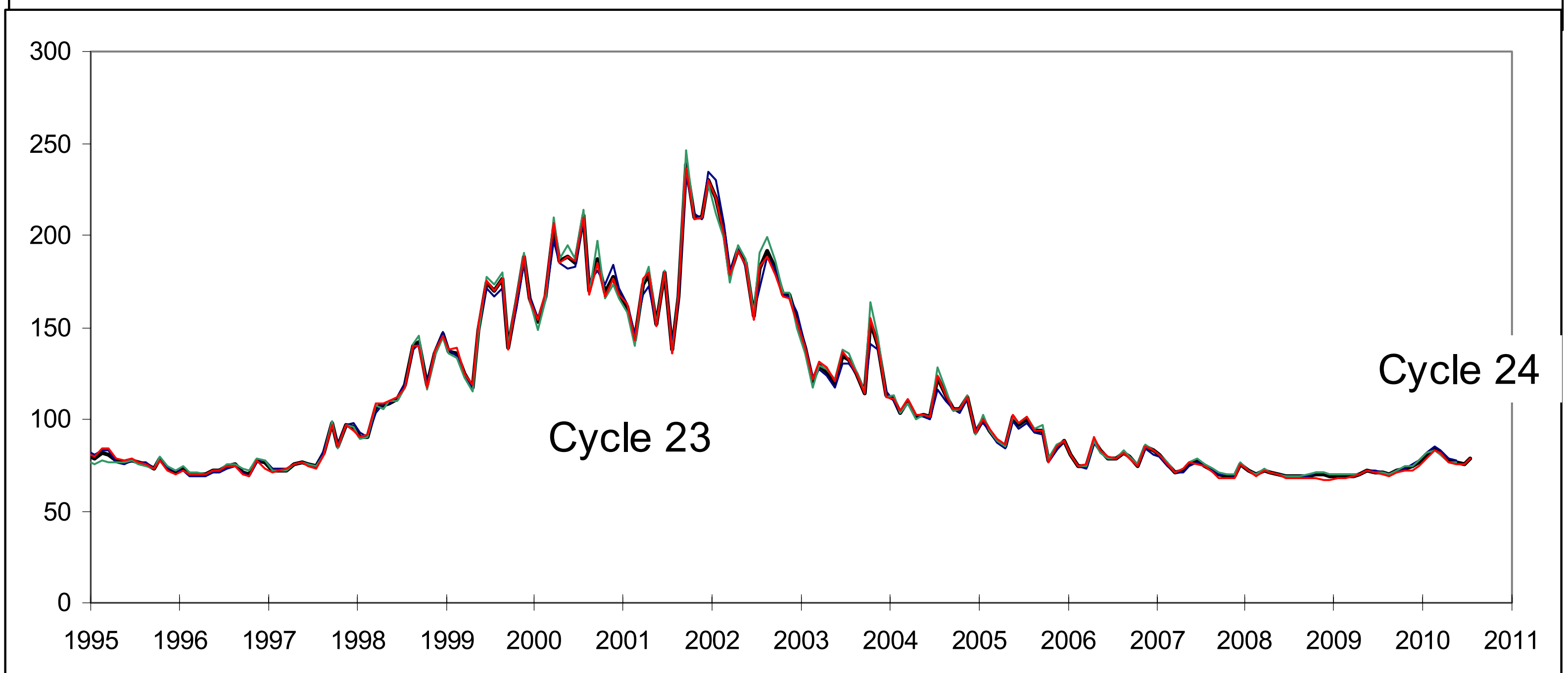

Individual cycles
Cycle 18
300
250
200
150
100
50
0
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956


Cycle 19
300
250
200
150
100
50
0
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967

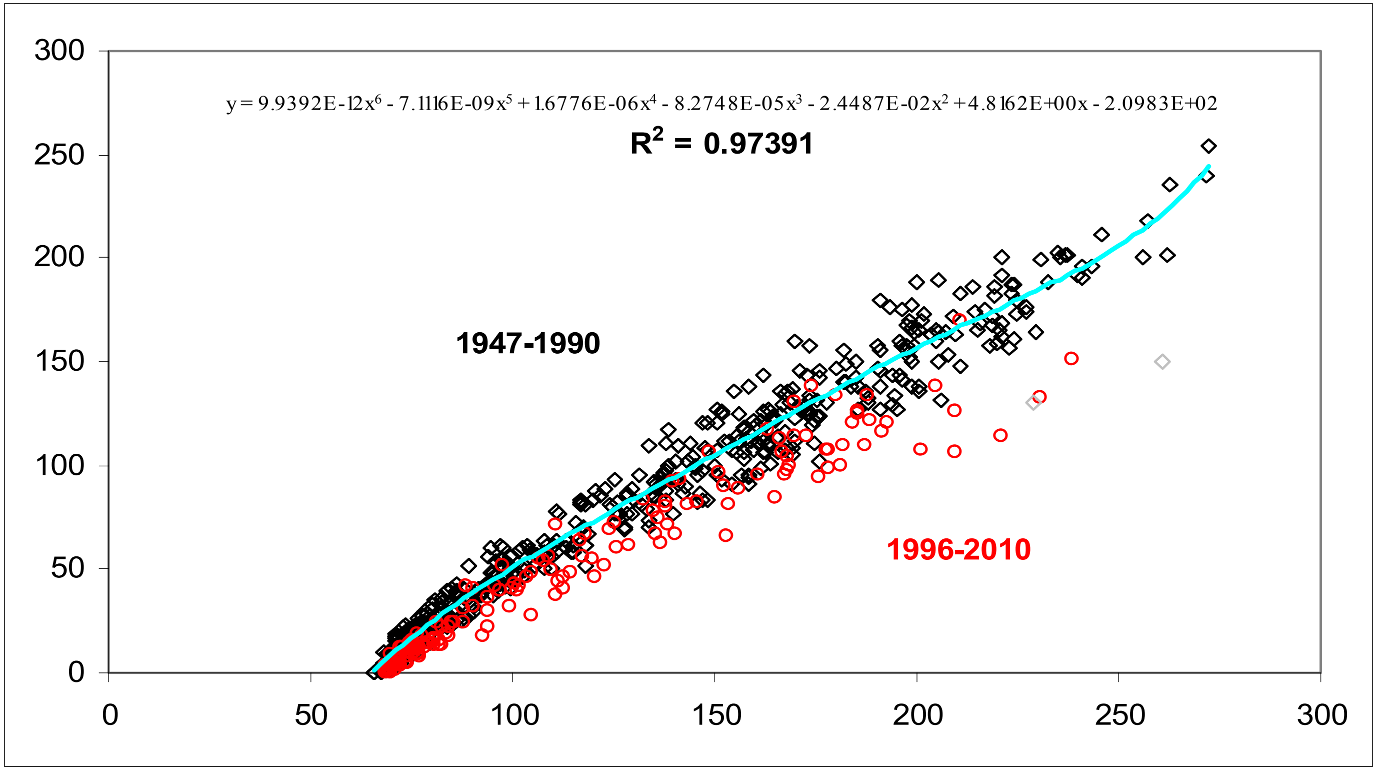

Cycle 20
300
250
200
150
100
50
0
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978

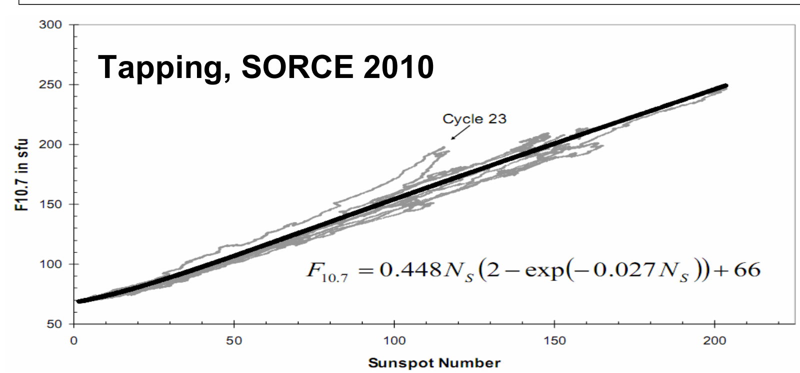

Cycle 21
300
250
200
150
100
50
0
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989


300
250
200
150
100
50
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
Cycle 22


300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
Cycle 23
Cycle 24

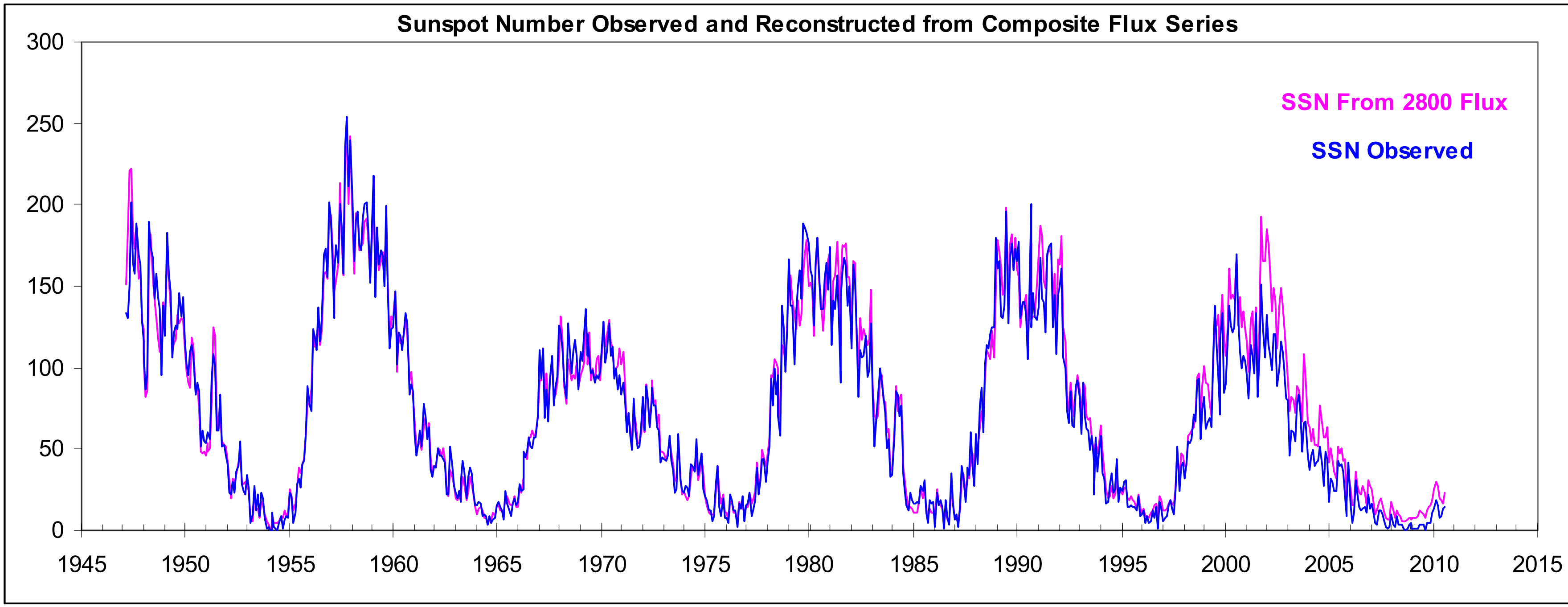
There is a well-known, strong [slightly non-linear] relationship between the solar flux and the sunspot number (black diamonds). This relationship seems to have changed in solar cycle 23 (red circles).





Same conclusion reached by others, *e.g.* Tapping (2010)

Plotting the reconstructed Sunspot Number (pink) from the composite 2800 MHz flux using the 1947-1990 relation shows the increasing discrepancy with the SIDC ‘official’ sunspot number (blue) the past ~15 years:



As the Japanese and Canadian microwave data support each other so well, we must ask: how sure are we of the calibration and stability of the sunspot number?

Some other organizations that have kept a keen eye on the Sun, making their own sunspot number series:

http://www.vds-sonne.de/gem/res/results.html

SIDC: Solar Influences Data Analysis Center, Brussels
(International sunspot numbers)

SONNE prov.: SONNE network, provisional sunspot numbers

SONNE def. : SONNE network, definitive sunspot numbers

AAVSO: American Association of Variable Star Observers - Solar Division

AKS: Arbeitskreis Sonne des Kulturbundes e.V., Germany

BAA: The British Astronomical Association - Solar Section, UK

GFOES: G.F.O.E.S. Commission "Nombre de Wolf", France

GSRSI: GruppoSole Ricerce Solari Italia, Italy

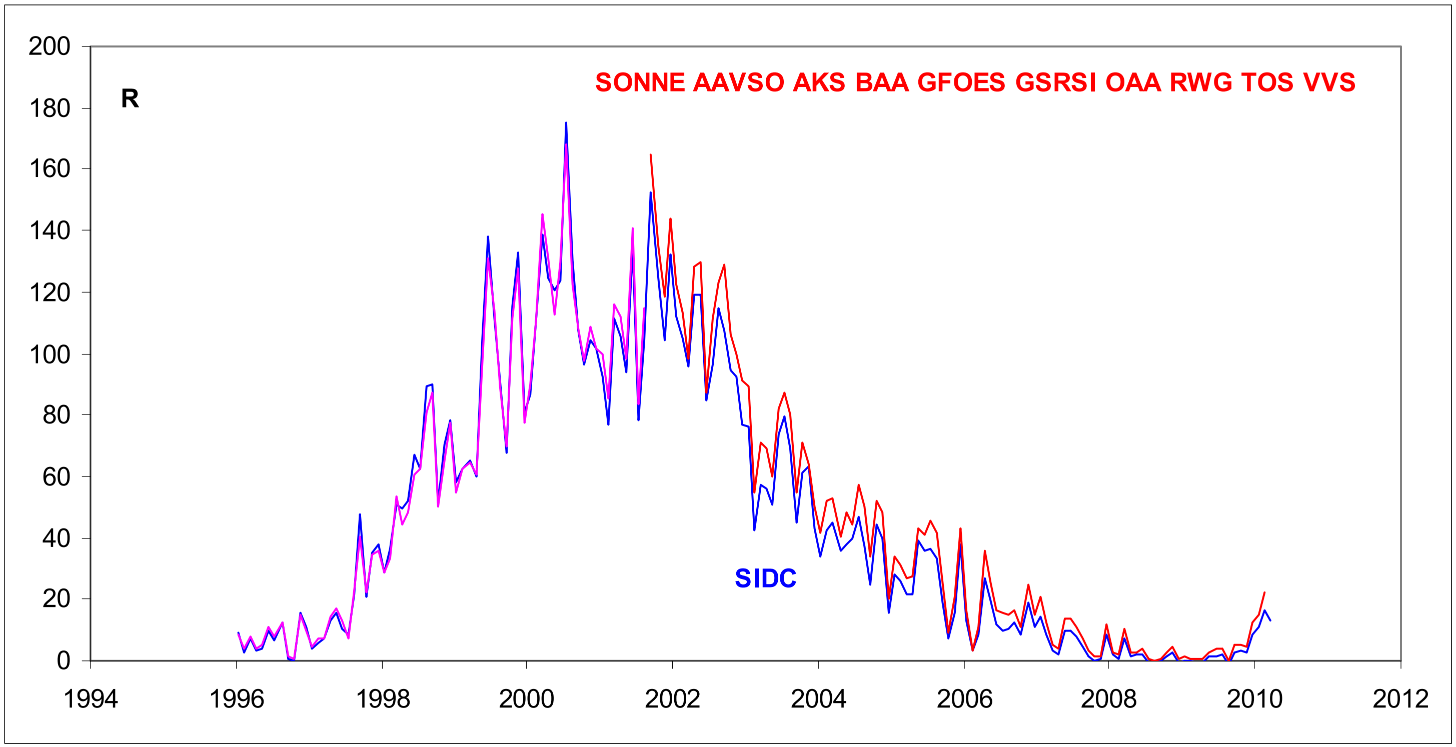
OAA: The Oriental Astronomical Association - Solar Division, Japan

RWG: Rudolf Wolf Gesellschaft - Solar Obs. Group of Swiss Astron. Society

TOS: Towarzystwo Obserwatorow Slonca - Solar Observers Society, Poland

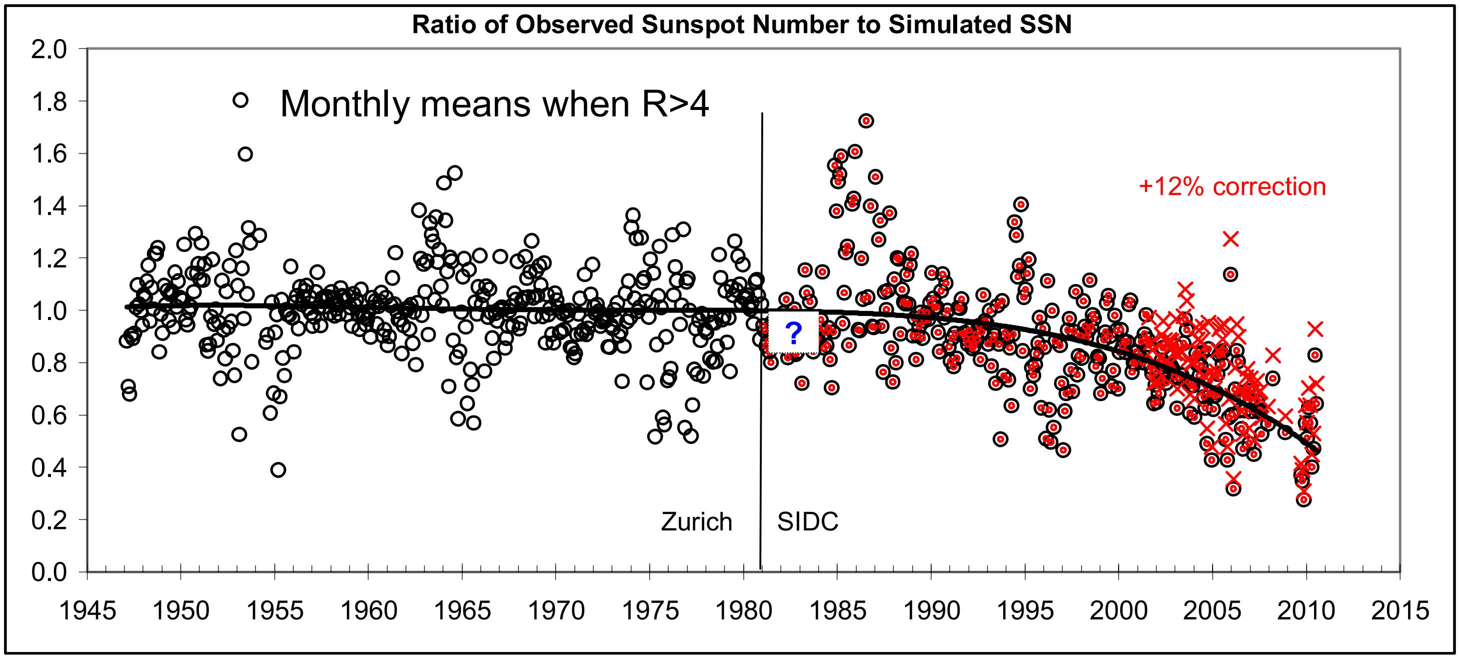
VVS: Vereniging voor Sterrenkunde, Werkgroep Zon, Belgium

All these series can be successfully scaled to SIDC before August 2001



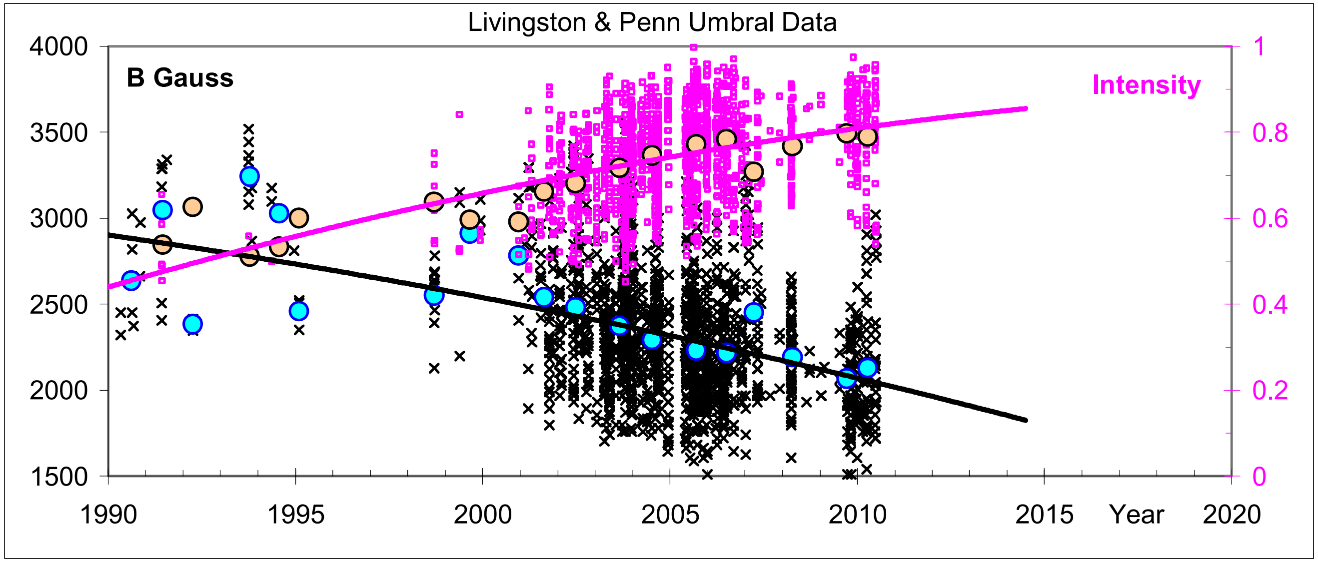
But the same scaling relation yields a sunspot number after that time that is systematically 12% higher than SIDC's. Did all these organizations somehow change their procedures and/or or observer cadre? Or did SIDC?

It seems that we increasingly see ‘fewer spots’ for the same amount of microwave flux. We can quantify that by the ratio between observed spots and expected spots from the pre-1991 relationship:

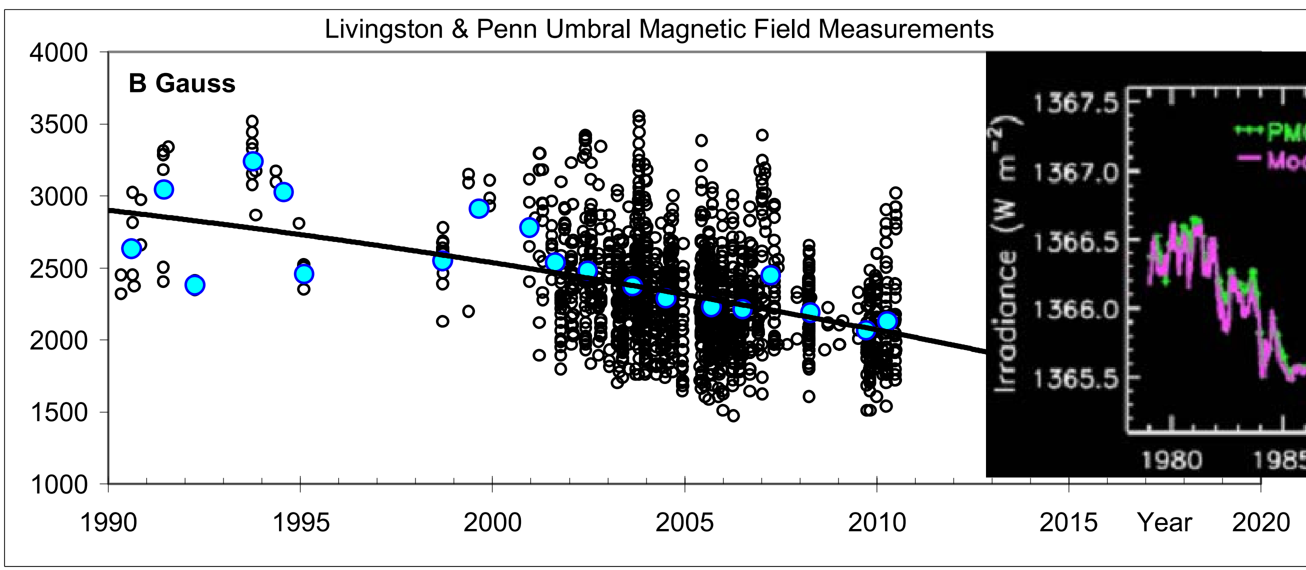


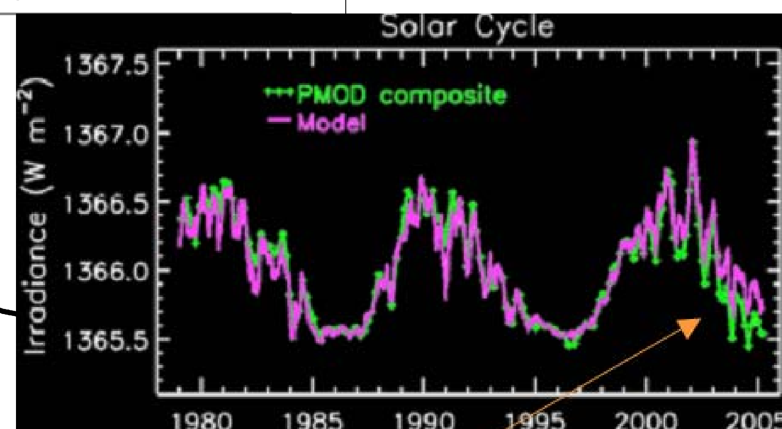
Adding 12% [assuming that SIDC has a problem in August 2001] does not materially alter this conclusion (red crosses).

Are there other indications of lesser visibility of sunspots?



Livingston and Penn report a decrease of magnetic field strength and hence decrease in contrast (less dark) with the surrounding photosphere.





Is this discrepancy another one?