Changes in Solar Behaviour
Before and During Cycle 23, and
into the Extended Minimum

Ken Tapping

ken.tapping@nrc-cnrc.gc.ca
F10.7 Flux Monthly Means

Year


Adjusted Flux in sfu

18 19 20 21 22 23 24
What Is F10.7?

\[ F_{10.7} = 10^{22} \frac{2k}{\lambda^2} \left( \sum_i (T_i - T_0)\Omega_i + \Omega_0 T_0 \right) \]

\[ T = \alpha T_{chrom} + (1 - \alpha)T_{cor} \]
One-Year Running Mean for F10.7 and Sunspot Number

![Diagram showing F10.7 and Sunspot Number over time.](image)

\[ \bar{x}_i = \frac{1}{365} \sum_{j=i-182}^{i+182} x_j \]
Mean F107 v Mean Sunspot Number

$F_{10.7} = 0.448 N_S \left(2 - \exp(-0.027N_S)\right) + 66$

Cycle 23
\[ F_{10.7}(\text{proxy}) = 0.448 N_S (2 - \exp(-0.027 N_S)) + 66 \]

\[ \xi = \frac{F_{10.7}(\text{observed}) - F_{10.7}(\text{proxy})}{F_{10.7}(\text{observed})} \]
Cycle 23 was Different. Will Cycle 24 be?

\[ \xi = \frac{F_{10.7}(\text{observed}) - F_{10.7}(\text{proxy})}{F_{10.7}(\text{observed})} \]
Changes in Behaviour in Earlier Cycles?
Other Indices

proxy = \( f(\text{sunspot \_ number}) \)

\[ \xi = \frac{\text{observed} - \text{proxy}}{\text{observed}} \]
Has It Happened Before?

Annual Means

Chart 5

Year

Sunspot Number (1735-1835)

Year

Sunspot Number (1947-2047)

1735 1745 1755 1765 1775 1785 1795 1805 1815 1825 1835


180 160 140 120 100 80 60 40 20 0

180 160 140 120 100 80 60 40 20 0

Red line: 1750-1850
Blue line: 1947-2047
Conclusions

- In Cycle 23 the relationship between coronal/chromospheric activity and photospheric activity changed.
- Indications are that in Cycle 24 so far the deviation from “standard behaviour” is continuing or perhaps increasing.
- The next cycle is probably going to be a weak one. Could this be a precursor to a series of weak cycles?
- There are indications in earlier cycles of a changing behaviour.
- Use of one index as a proxy for another index or some other solar parameter, may not always be reliable, because the relationships between different indices can change.
- On the other hand, changing relationships between proxies may provide a very high resolution detector of deviations from “standard behaviour”.
- Weird solar behaviour should be good for solar and space weather funding.
Next Generation Solar Flux Monitor

- Multiple operating wavelengths provides indices for different levels in the solar atmosphere and separation of emission components.
- High time resolution and broad frequency coverage for burst recording.
- Dual polarization

Antenna under test, March, 2010