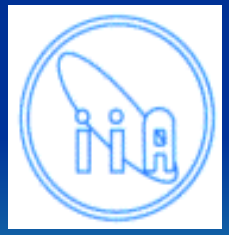
Pranams to you SUN GOD for keeping us busy in research by your activity

Periodicities in the global solar radio flux spectral indices during 2000-2004

K.R.SUBRAMANIAN



IIAP in house meeting 12th April 2007

Collaborators

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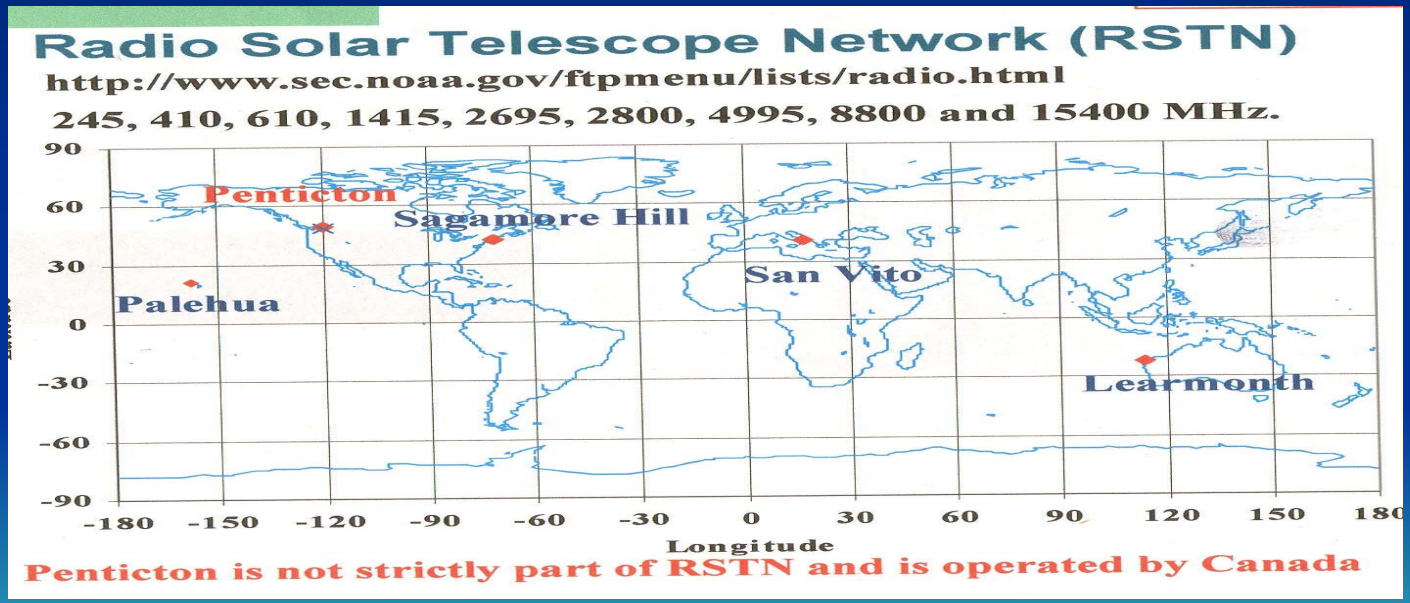
Introduction

- Solar activity covers a whole range of phenomena at all levels in the solar atmosphere and time scales ranging from seconds to minutes through months to 11 or 22 year cycle.
- Solar physicists have tried to quantify the variation of solar activity with time with many indices like Sunspot number, Sunspot area, 2800 MHz radio flux, X-ray, EUV indices, cosmic –ray fluxes etc.

- Apart from the long term 11 year solar cycle and short term 27 day periodicity due to the solar rotation, there exists mid range periodicities between 27 days and 11 years in the various features of the active Sun. At radio wavelengths, global solar radio flux at 10.7 cm had been used to quantify the solar activity.

Global Solar Radio Flux

•US Air Force Radio Solar Telescope Network (RSTN) measures the global solar radio flux from different parts of the world.



STATION	LATITUDE	LONGTUDE	CMP
SAN VITO	40.40 N	17.43 E	1200 UTC
SAGAMORE HILL	42.38 N	70.49 W	1700 UTC
PENTICTON	49.30 N	119.35 W	2000 UTC
LEARMONTH	22.13 S	114.60 E	0500 UTC
PALEHUA	21.24 N	159.06 W	2300 UTC

- The measurements of the global solar radio flux are measured with in one hour of the CMP. At Penticton site only, measurements are made 3 times with 20:00 UTC value being closest to central meridian passage. The flux measurements are made at 15400, 8800, 4995, 2800, 2695 , 1415, 610, 410 and 245 MHz. At each site the measurements of the global solar flux is measured at the same time. Solar geophysical data lists these measurements in their website. All the values from USAF are adjusted to 1AU.

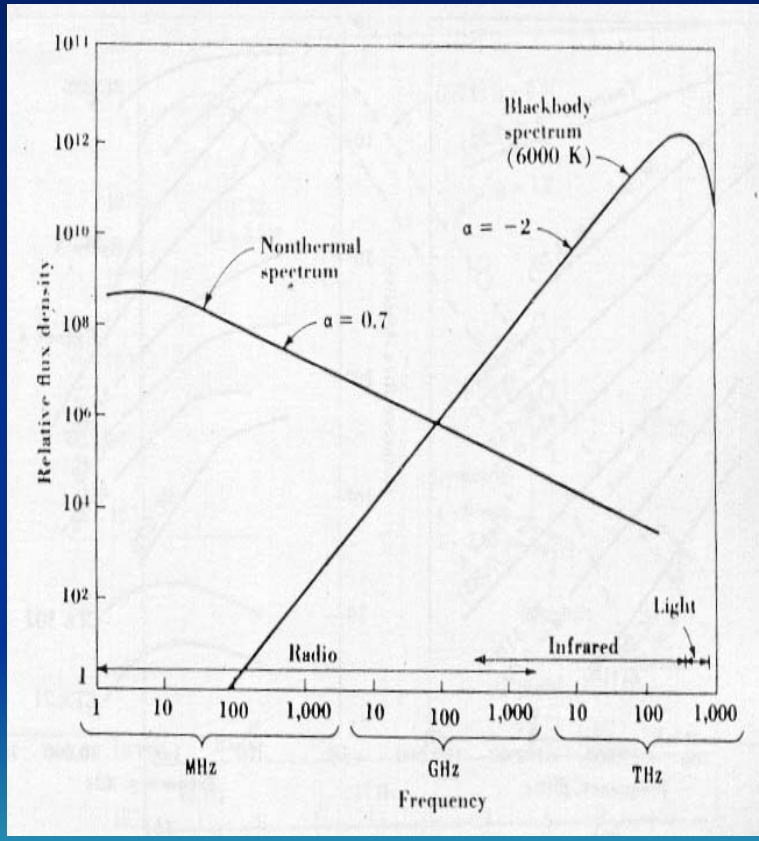
Level of Origin	Frequency (MHz)	Wavelength
Lower Chromosphere	15400 8800	1.9 cm 3.4 cm
Middle Chromosphere	4995 2695	6.0 cm 11.1 cm
Upper Chromosphere	1415 610 410	21.2 cm 49.2 cm 73.2 cm
Lower Corona	245	1.2 m
Upper corona	75 to 25 MHz	4 to 12 m

Data selection

- For the present analysis, we have used the daily solar radio flux values given by the Penticton observatory and given in the solar geophysical data published by NOAA.
- For the present study we have used only the data for the period 2000 – 2004.
- We have divided the data into 2 bands , 15400 – 1415 MHz and 610 – 245 MHz as the emission mechanism is believed to be different.
- Out of 1827 days only 1797 days of data available for the 15400 – 1415 MHz band.
- Out of 1827 days only 1754 days of data available for the 610 – 245 MHz band.

Flux density spectra

- Determination of the flux density spectra of the radio emission is important to understand their emission mechanism. Plot of the flux density against frequency gives the spectra of the source.



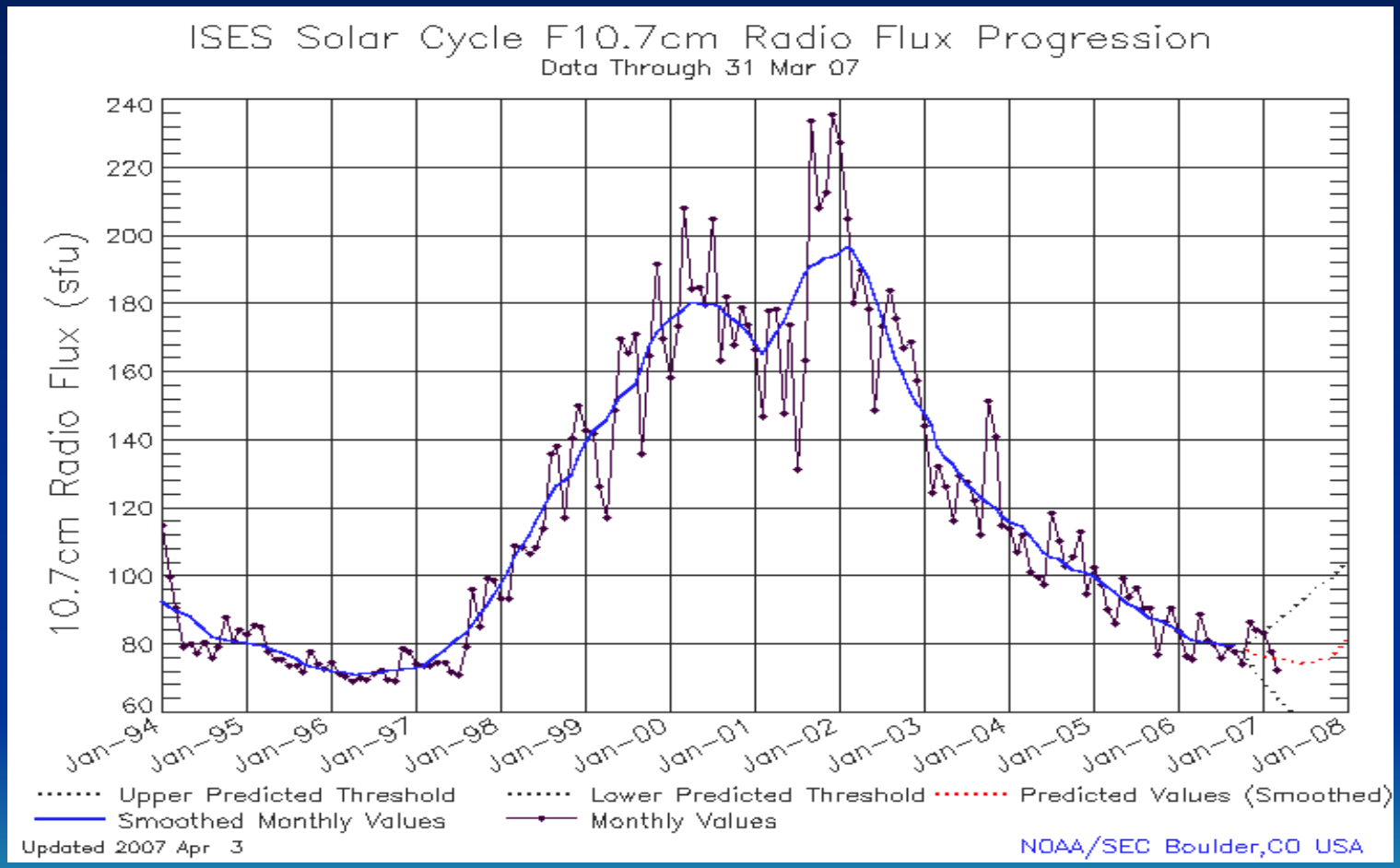
The variation of flux density with frequency can be expressed as S is proportional to f^{α} , f is the frequency of observation and α is the spectral index. From the plot of the logS vs Log f we can determine the spectral index.

In the case of quiet Sun at decameter wavelengths, the radio emission shows a thermal spectrum with a spectral index of + 2.3. Radio bursts like type III shows a non thermal spectrum with a spectral index of approximately – 3.

It will be interesting to study the variation of the global solar radio flux spectral index with time and look for any periodicity.

- To our knowledge, it is the first time such a study is being made in looking for periodicities in the global radio emission using spectral indices.

10.7 cm solar flux variation

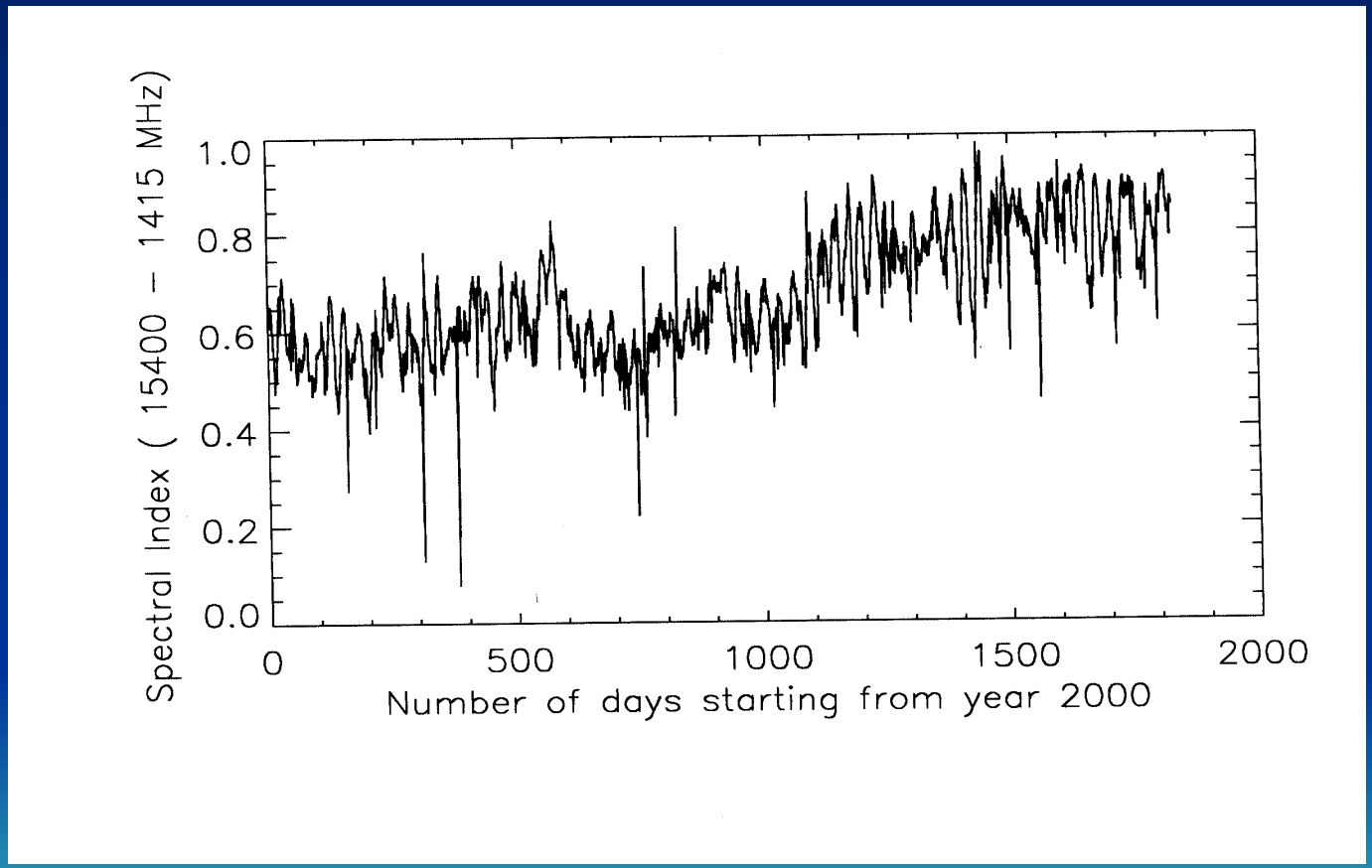


Periodogram analysis

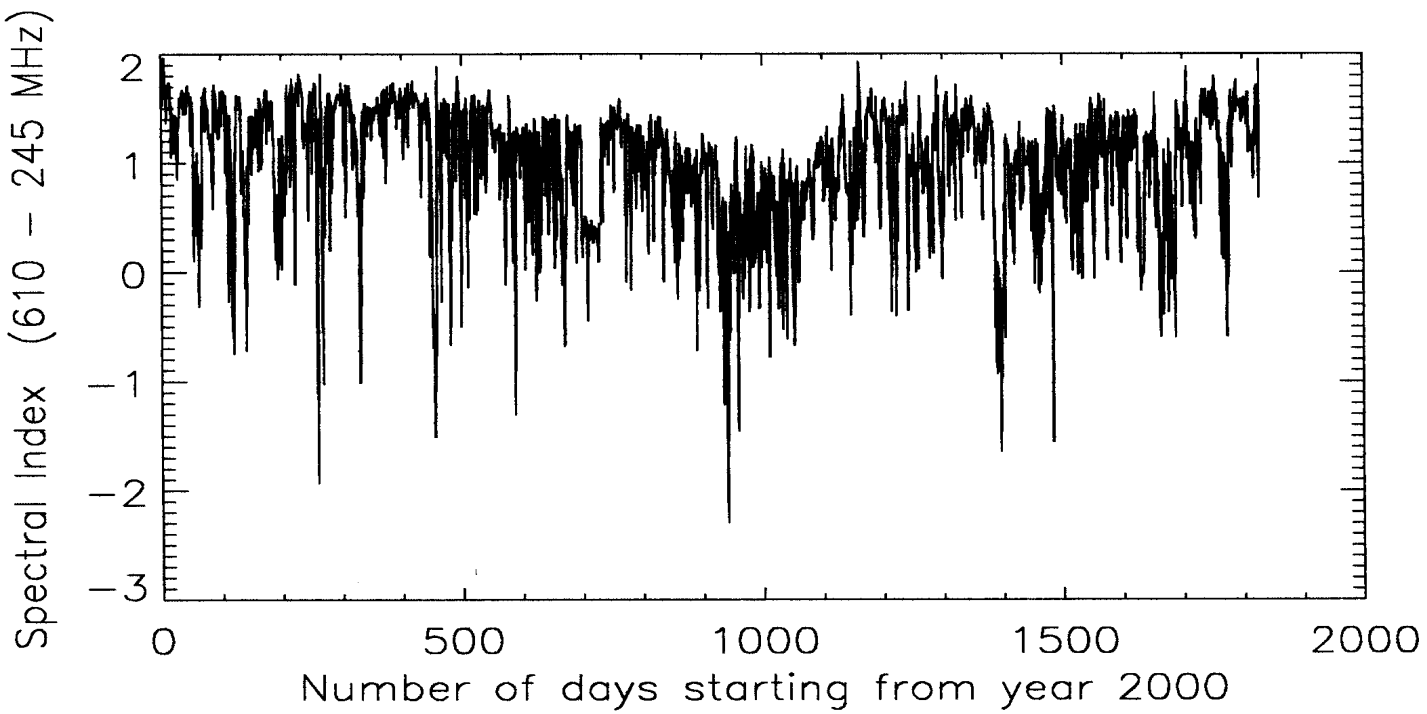
- T o study the periodicity in a regular time series $X_j = X(t_j)$ series of measurements are made at times separated by regular intervals t_j . FFT of the time series gives the spectral information.
- For irregular time series, Lomb and Scargle developed a method.
- We have used the Lomb-Scargle periodogram method to compute the power spectra of the time series data.
- This method has is useful for time series analysis of unevenly spaced data ie it can mitigate missing data problems.

- The power spectra for the spectral indices for the period 2000 – 2004 has been computed
- Out of 1827 days
- For the band 15400 – 1415 MHz the data available is for 1797 days. The time series is sampled at twice rate of 1/(1797) day ie is 12.88 nano hertz.
- For the band 610 – 245 MHz , the data is available for 1754 days. The time series is sampled at twice the rate of 1/1754 day .ie 13.197 nano hertz

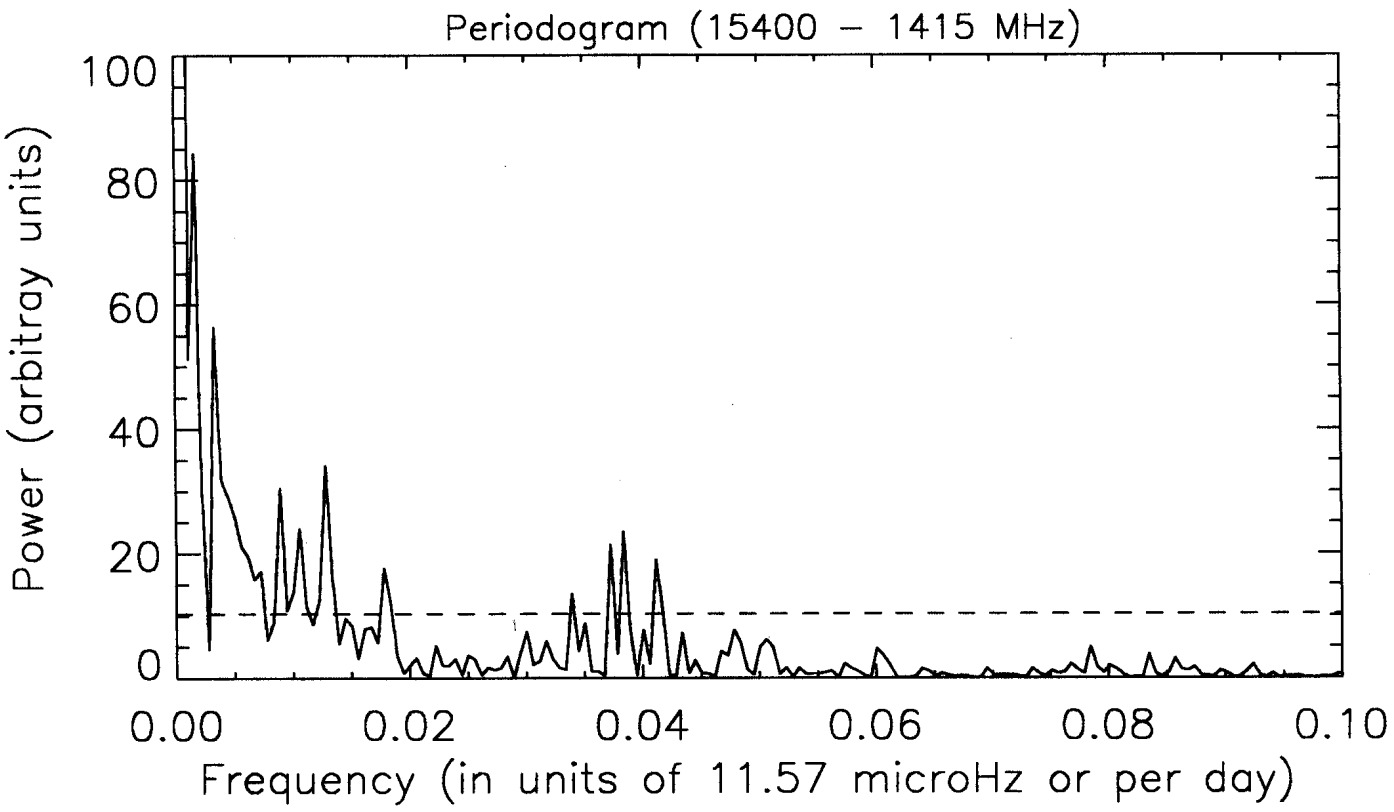
Variation of Spectral index 15400 – 1415 MHz



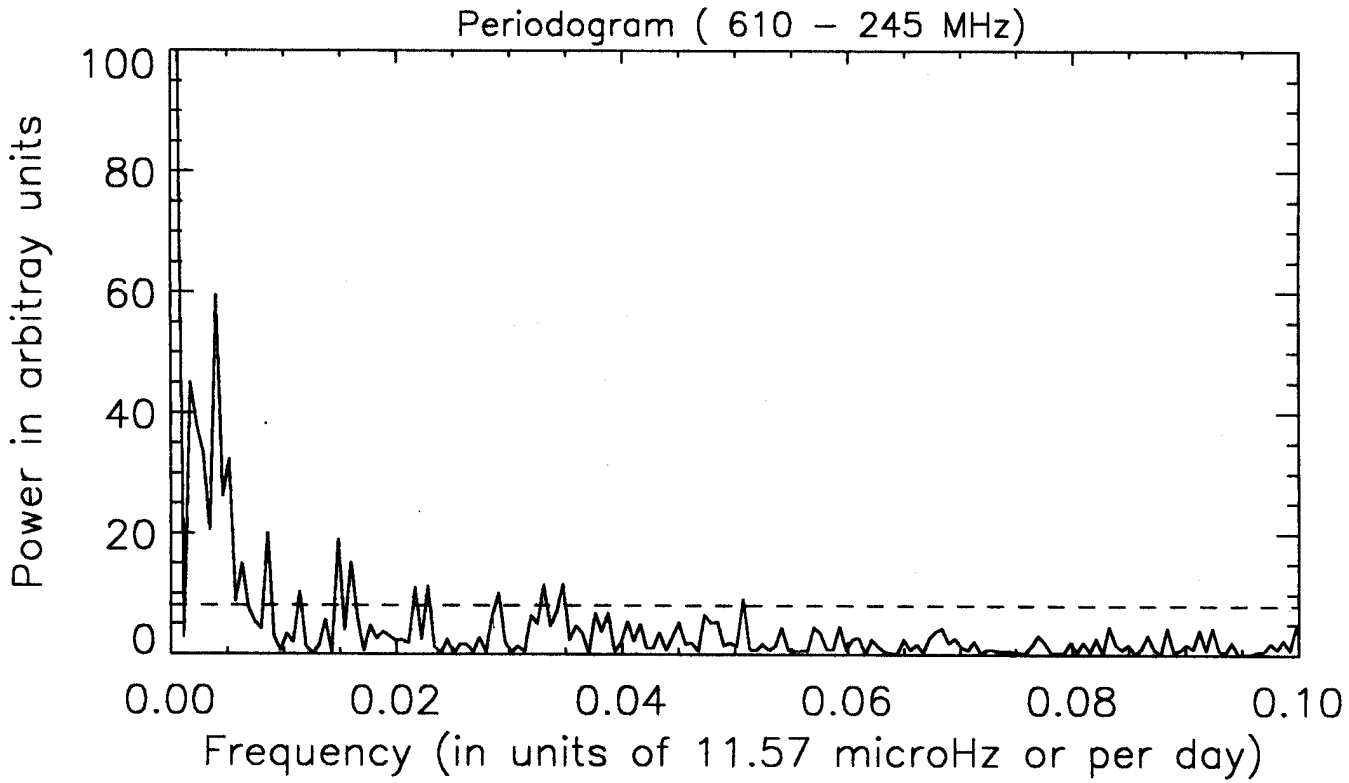
Variation of spectral index (610 – 245 MHz)



Periodogram for high band data



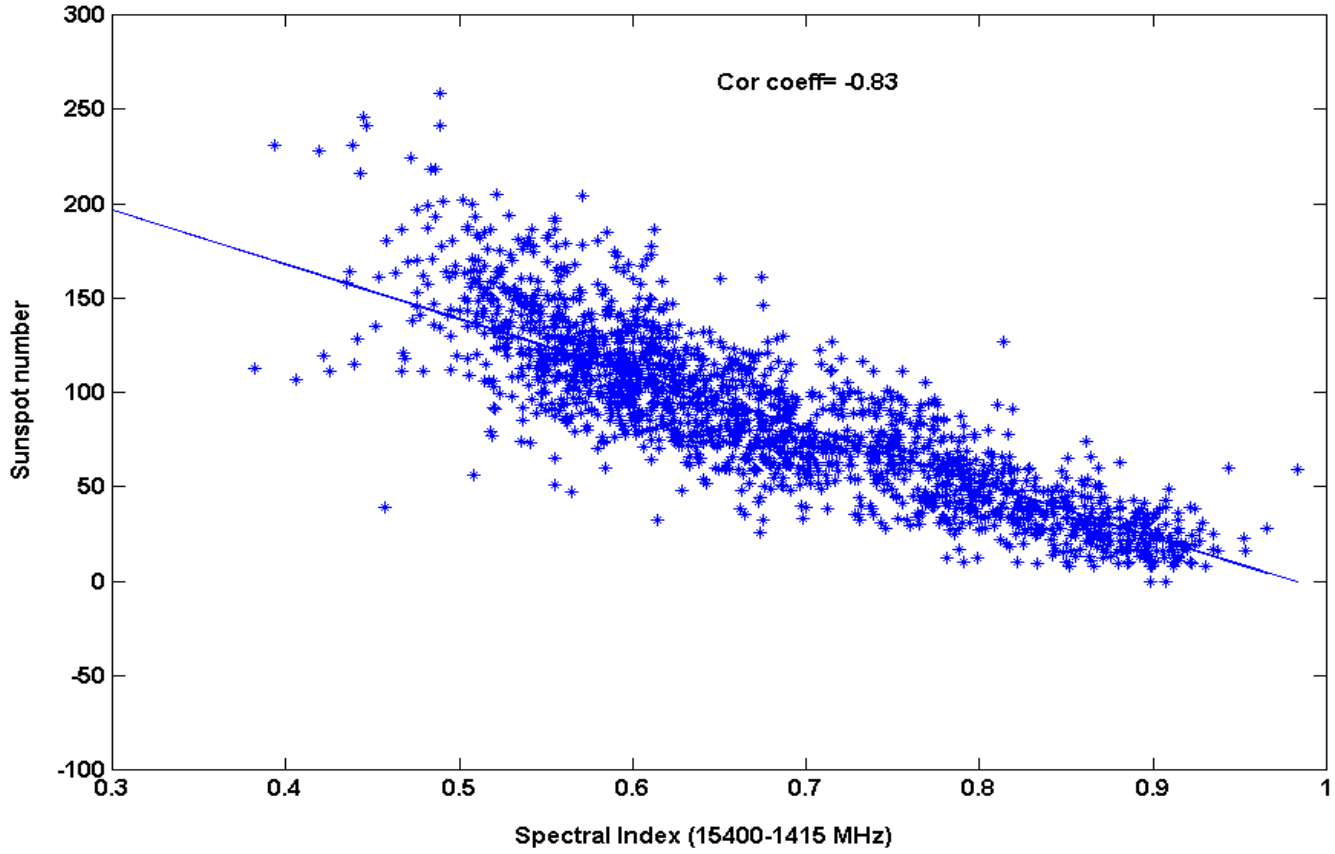
Periodogram for the low band



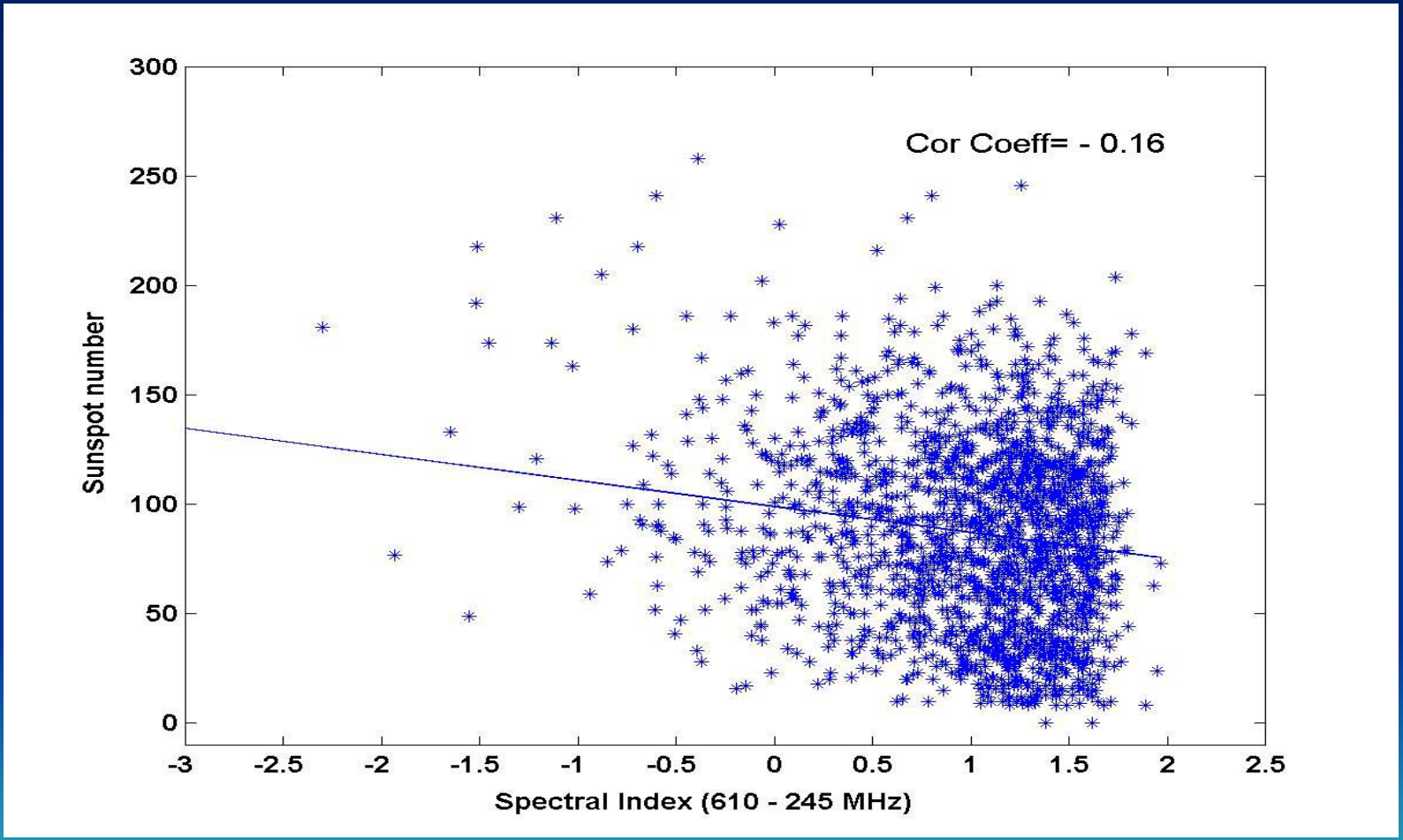
Significant periods above 99% confidence levels

15400 – 1415 MHz	610 – 245 MHz
300 days	250 days
138 days	194 days
112 days	159 days
94 days	116 days
78 days	88 days
56 days	62 days
29 days	46 days
26 days	34 days
24 days	28 days

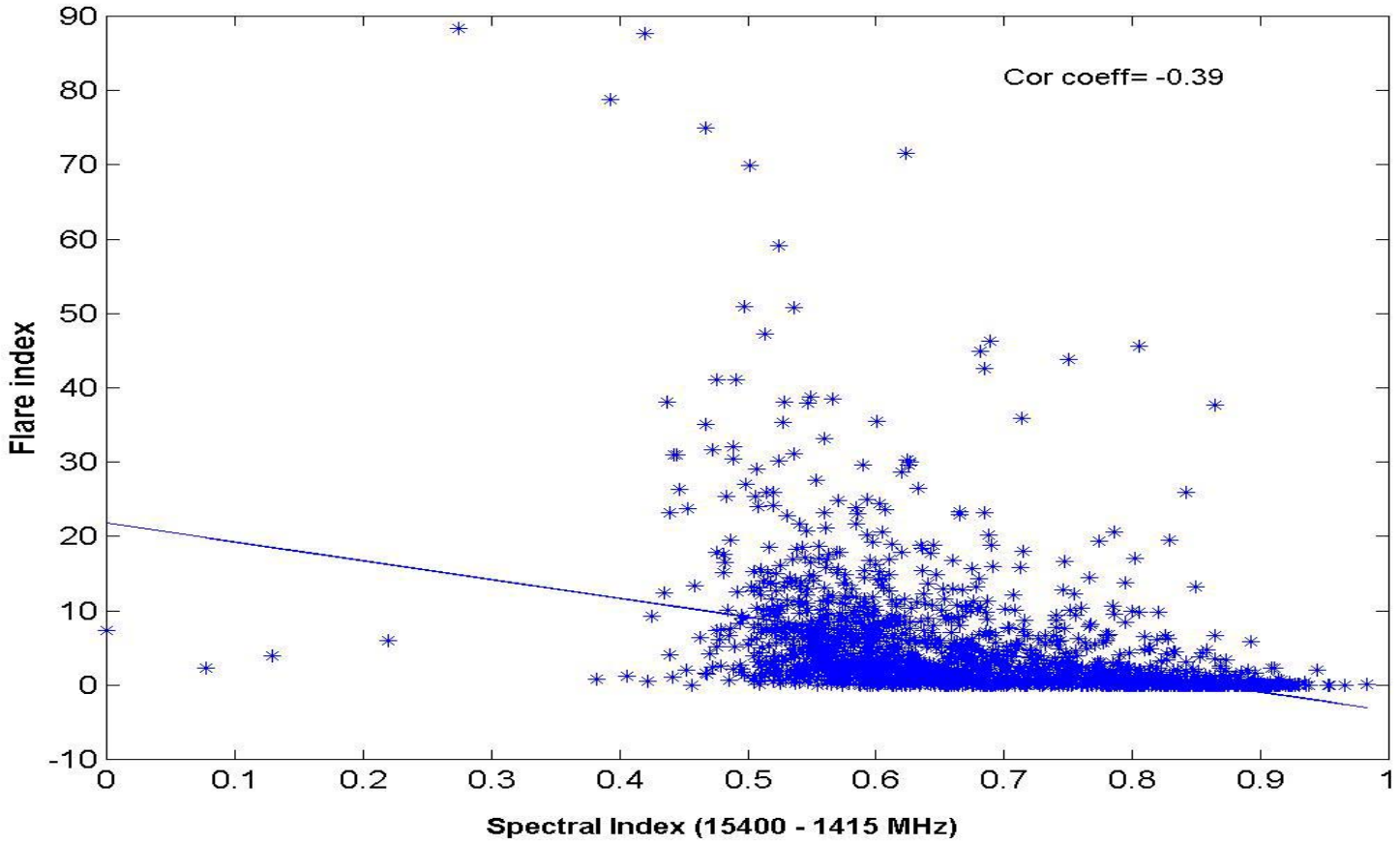
Correlation between the SI (15400 – 1415 MHz) and the sunspot number



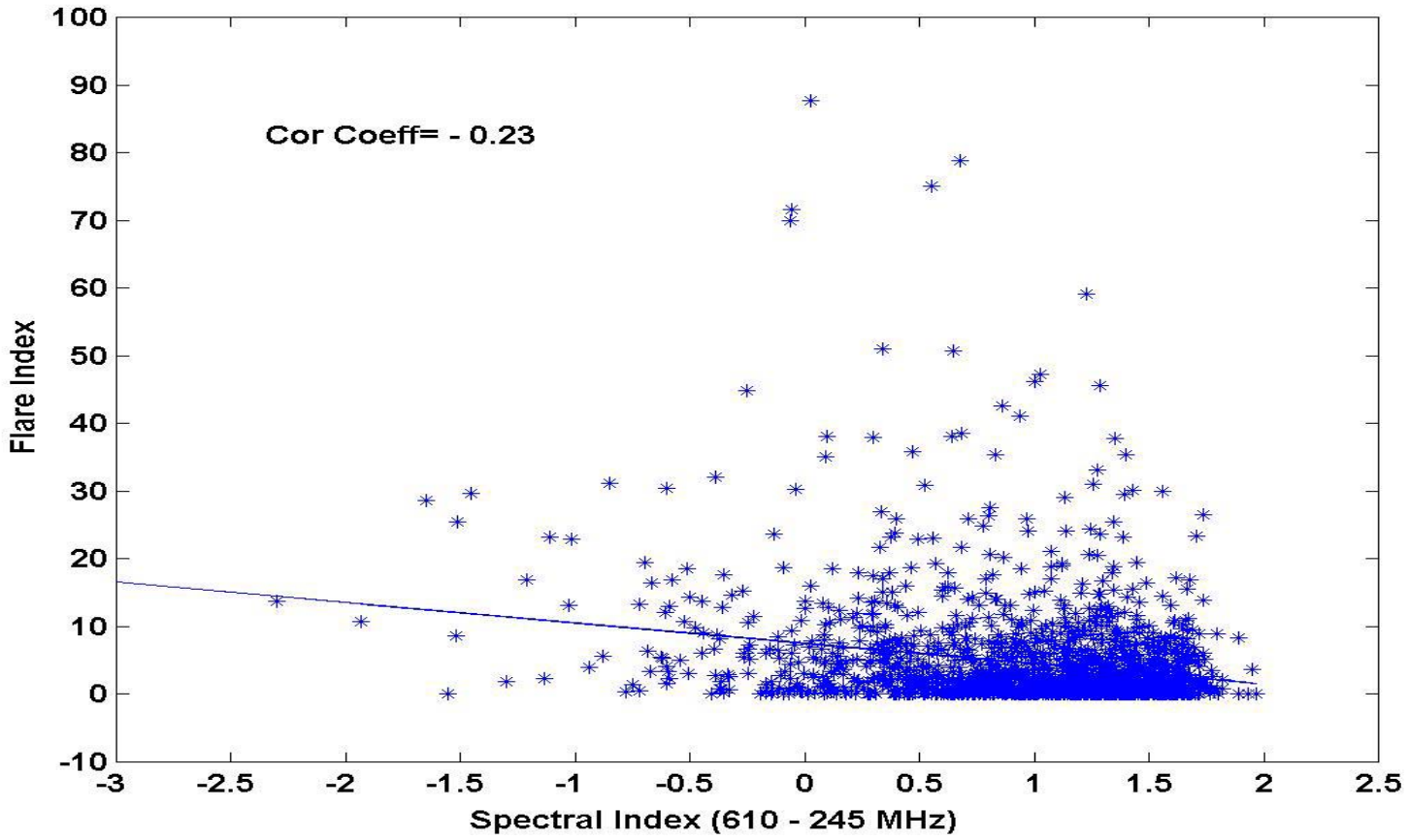
Correlation between the SI(610 – 245 MHz) and the sunspot number



Correlation between the SI(15400 – 1415 MHz) and the flare index



Correlation between the SI (610 – 245 MHz) and the flare index



Conclusions

- We have studied the periodicities in the spectral indices of the Global solar radio flux in the band 15400 – 1415 MHz and 610 – 245 MHz.
- The SI in the band 15400 – 1415 MHz is well correlated with the sunspot number suggesting that the radio emission is closely associated with sunspot activity and not the flare activity.

- The SI in the band 610 - 245 MHz show only a weak correlation both with the sunspot number and flare index.

- Power spectral analysis of sunspot numbers during cycle 23 by several authors show periodicities of 175 133 113, 104, 84, 63 and 27 days some of which in close values are seen in our analysis.

- It was suggested by Lean and Brueckner that periodicity in the range of 120 – 200 days are caused by emerging magnetic flux from active regions.

Future work

- It is planned to extend the data analysis for all the years of the 23rd cycle.
- Correlate the SI with other solar activity indices.
- Periodogram analysis of these activity and compare with spectral indices variation