# DEVELOPMENT OF 23 CYCLES ACTIVITY IN NORTHERN AND SOUTHERN HEMISPHERES OF THE SUN

M.I.Ryabov, A.L.Sukharev, S.A.Lukashuk

Odessa observatory of Radioastronomical Institute NANU
*ryabov-uran@ukr.net*

ABSTRACT. On an example of the 23rd cycle of solar activity the basic properties of its development in northern and southern hemispheres were researched (daily values of Wolf Sunspot Number – W, the daily values of Sun spots areas – Sp and daily values of flare index – FI.) Effects of application of full-scale Wavelet analysis for studying the temporary structure of formation of a solar cycle show the difference in northern and southern hemispheres. The "leading" periods (in northern hemisphere – 340 days, and in southern hemisphere – 709 days) differ. Thus, the activity period in two years is predominate in southern hemisphere. The "leading" period for the flare index for northern hemisphere is 555 days, and for southern hemisphere is 709 days. In general the basic periods W in northern hemisphere are in the range of 37-555 days, and in southern – 78-906 days, SpN (61-906 days), SpS (61-1477 days), FIN (37-555 days), FIS (23–709 days), FIS – (14-709 days) depending on the phase of solar cycle.

**Introduction**

Analysis of the data on the Wolf sunspot number – W, the total area of all groups of sunspots – Sp and Flare index – FI for each hemisphere of the Sun alone shows the distinction of forms of their activity. There is the characteristic “asymmetry of activity”. It is defined as the value of relations index values of the earth hemispheres or the magnitude of their difference. The results of earlier studies of North-South asymmetry are reflected in [1]. For its research monthly averages of various solar indices were used. The smoothed monthly values of the total area of groups of sunspots showed a significant difference in the development of the activity in the northern and southern hemispheres [2]. However, research into the nature of the North-South asymmetry most effectively on the basis of the daily values of solar indices. Examines the Wolf number of WN – northern and WS – the southern hemisphere, the total area of groups of spots-SpN and SpS, the Flare index – FIN and FIS. Data on WN and WS are only from 1992 onwards and cover only the 23rd cycle. At the same time, the SpS are presented with SpN and 1874. This paper discusses the dynamics of daily values of WN, WS, SpN, SpS, FIN, FIS with the full-scale application of wavelet analysis for 23 first-cycle activity. It is getting clear that the study of the North-South asymmetry is up-to-date and it is possible to obtain new interesting results.

**1. Wavelet-analysis**

Since explored observational data in astronomy are complex, non-stationary processes, the use of wavelet analysis allows to get more information about the variability of the data at different periods (or frequencies) than using Fourier analysis. Used in the continuous Wavelet transform based on the Morlet function. This allows you to select individual harmonic components on different time scales, track changes over time and determine the duration of their existence [3].

**2. Time – frequency wavelet spectra**

The wavelet analysis as a result of the calculations is the matrix of coefficients of the continuous Wavelet transform of surfaces in three-dimensional space. The most informative outcome of these calculations in time-frequency structure of the signal is a representation of the frequency-time. The isolines enable you to trace the changes in the intensity of wavelet transform on different scales and in time. The spectra are built in a logarithmic coordinates. The results of calculations for the WN, WS, SpN, SpS, FIN, FIS is shown in Fig. 1.

Data from table 1 mean that the “lead period” for the northern hemisphere for the WN and SpN is 340 days. In the phases maximum and slow cycle leading periods are 163 and 128 days. For Flare index FIN dominated the 555 days period. For the southern hemisphere predominate "lead period” is 709 days for indexes WS, SpS, FIS. On the slow phase the leading period is 906 days. For flare index in the northern hemisphere – FIN spacing leading periods in the interval 37-555 days and southern hemisphere of 23-709 days. The spectral power at all leading periods the southern hemisphere is systematically higher than in the northern hemisphere.

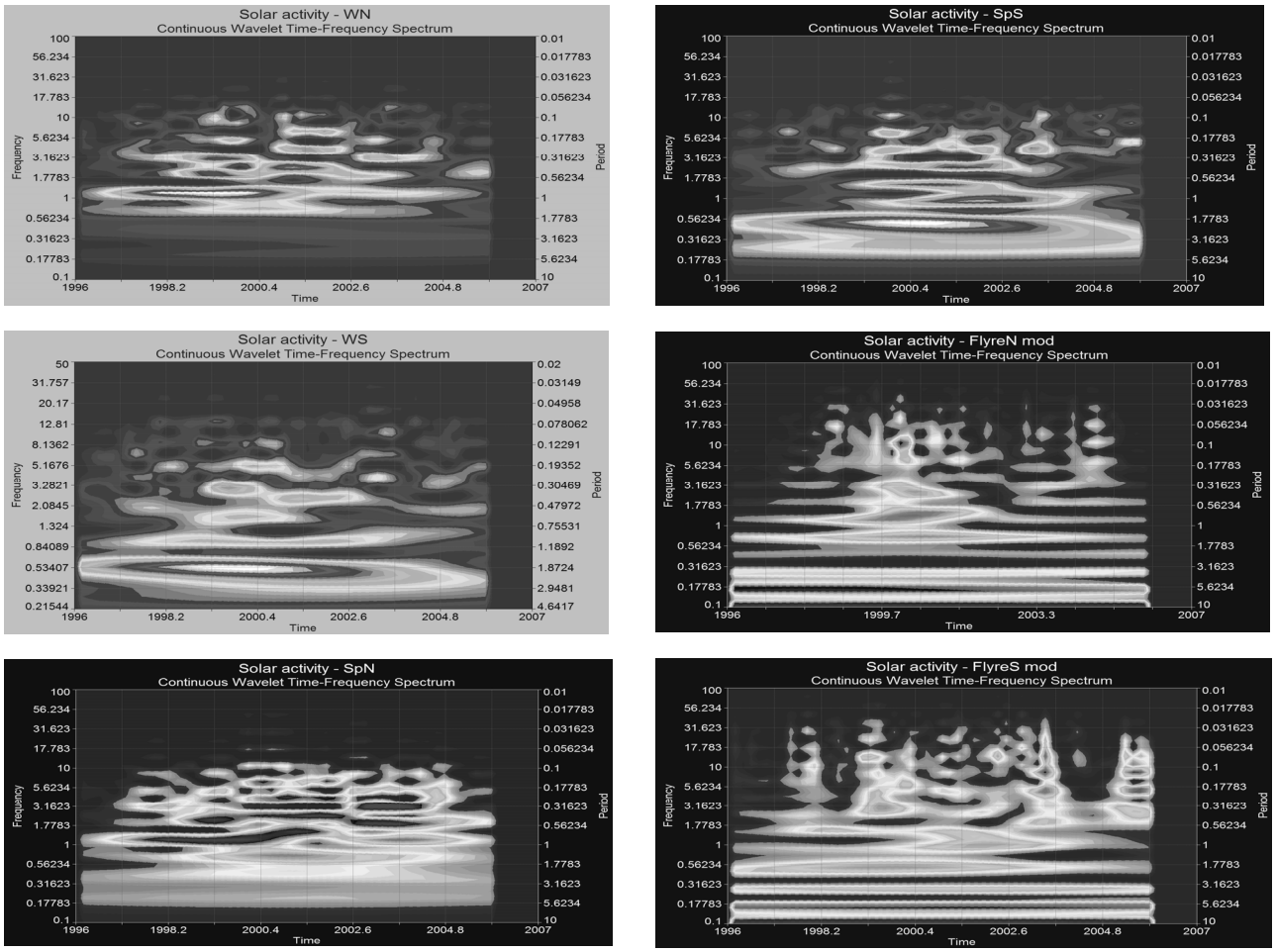


Figure 1: Wavelet spectra for WS WN indexes, SpN, SpS, FIN, FIS (on the horizontal axis, the vertical-years-period and frequency). The "leading periods" are determined on the basis of wavelet Spectra. They show the maximum spectral power. The results are shown in Table 1.

Table 1.

| | **WN** | | **WS** | | **SpN** | | **SpS** | | **FIN** | | **FIS** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Год** | **Per** | **Power** | **Per** | **Power** | **Per** | **Power** | **Per** | **Power** | **Per** | **Power** | **Per** | **Power** |
| **1996** | **340** | 1,8E+04 | **709** | 4,3E+04 | **340** | 3,9E+06 | **709** | 1,9E+07 | **555** | 4,8E+02 | **709** | 5,8E+02 |
| **1997** | **340** | 5,4E+04 | **709** | 6,9E+04 | **340** | 1,2E+07 | **709** | 3,3E+07 | **555** | 7,9E+02 | **709** | 8,2E+02 |
| **1998** | **340** | 8,4E+04 | **709** | 9,0E+04 | **340** | 2,0E+07 | **709** | 4,8E+07 | **555** | 1,1E+03 | **709** | 9,8E+02 |
| **1999** | **340** | 8,5E+04 | **709** | 9,9E+04 | **340** | 2,0E+07 | **709** | 5,8E+07 | **266** | 2,4E+03 | **128** | 1,0E+03 |
| **2000** | **340** | 7,2E+04 | **709** | 9,8E+04 | **266** | 1,8E+07 | **709** | 6,0E+07 | **37** | 3,5E+03 | **709** | 1,0E+03 |
| **2001** | **163** | 5,4E+04 | **709** | 9,1E+04 | **163** | 2,0E+07 | **709** | 5,8E+07 | **266** | 2,3E+03 | **709** | 9,1E+02 |
| **2002** | **163** | 3,4E+04 | **709** | 7,0E+04 | **163** | 1,9E+07 | **709** | 4,8E+07 | **555** | 8,9E+02 | **23** | 8,6E+02 |
| **2003** | **128** | 1,6E+04 | **709** | 4,4E+04 | **128** | **2,4E+07** | **709** | 3,1E+07 | **555** | 5,9E+02 | **29** | 1,3E+03 |
| **2004** | **340** | 1,2E+04 | **906** | 2,5E+04 | **128** | 1,4E+07 | **906** | 2,3E+07 | **61** | 6,3E+02 | **128** | 4,1E+02 |
| **2005** | **163** | 9,5E+03 | **906** | 1,7E+04 | **163** | 4,6E+06 | **906** | 1,5E+07 | **555** | 2,6E+02 | **78** | 1,2E+03 |

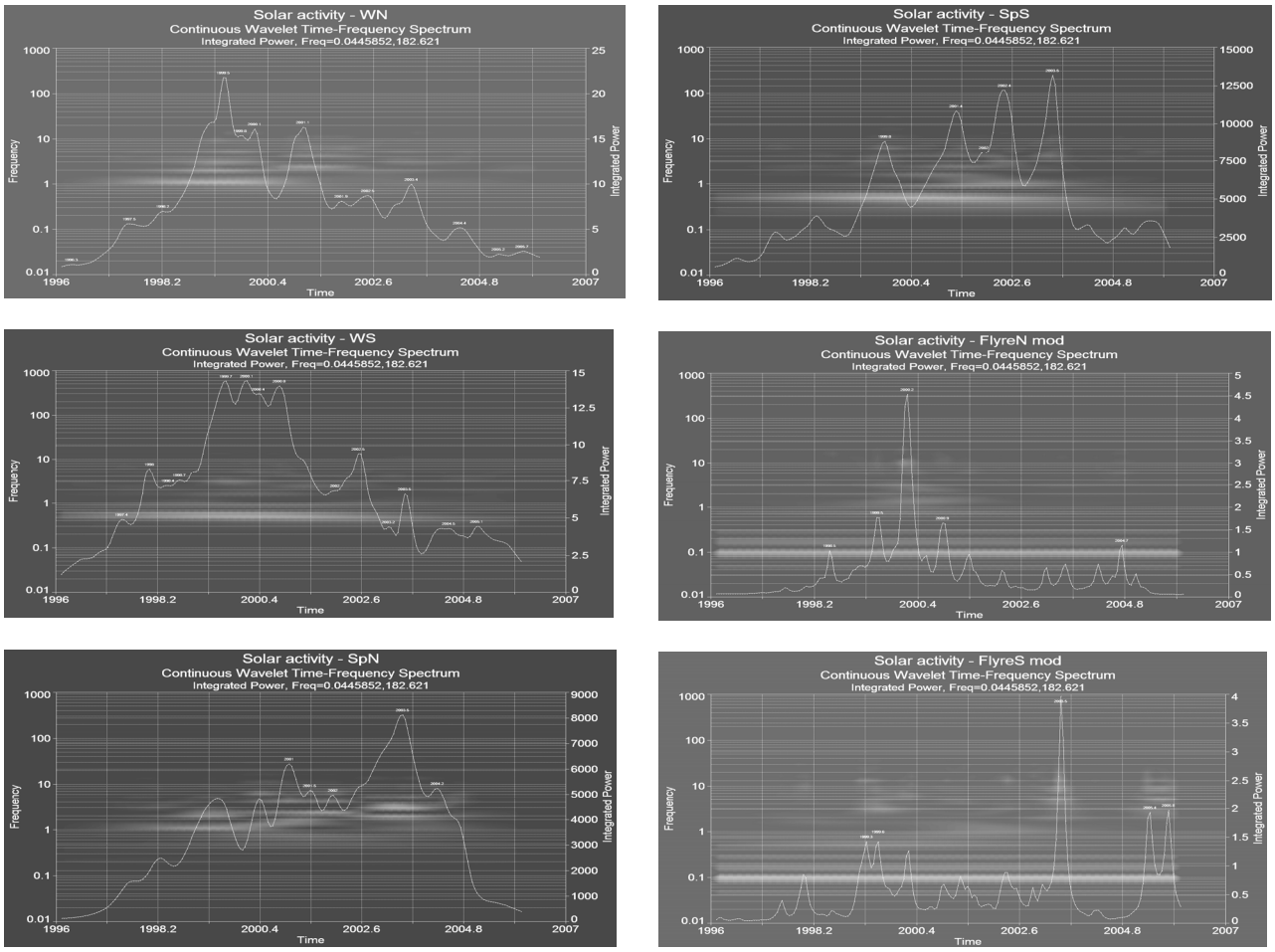


Figure. 2. The global spectrum of wavelet for indexes WN, WS, SpN, SpS, FIN, FIS (on the horizontal axis is vertical, spectral power and frequency).

### 3. Global wavelet spectra

Distribution of the total energy of the signal can be tracked using global Wavelet spectrum [4]. The integrated averaging in frequency spectrum shows the distribution of energy process on time. This type of range is required to determine the moments of greatest activity of the analyzed process that is the result of the addition of periodic processes on different time-scales.

Wavelet Spectra demonstrates global received a noticeable difference in the nature and timing of periodic processes shaping the dynamics of changes of W, Sp and FI. For each of these indices is the difference in their dynamics in the northern and southern hemispheres.

### 4. «Spectra of periods»

Wavelet transform can be more effective if you build it as a series of separate graphs "spectral power-period" for each year. This approach allows users to compare changes in periodic components of solar activity in a certain time interval with complexes activity that existed at that time. “Spectra periods” which correspond the maximums on global Wavelet spectra indicate what periodic elements contribute to the phase of increasing solar activity.

### Conclusion

The wavelet analysis of Wolf sunspots numbers, the total area of all the spots and flare index separately for the northern and southern hemisphere allows to present the development of 23$^{rd}$ solar cycle as a sum of quasi-periodic processes. These processes have different time scales in both hemispheres. Also the development of the solar cycle on generation number and total area of activity is different. The dynamics of their development has been posted in time. The result of these processes is the varying degrees of the impact of the activity of the northern and southern hemisphere, depending on the position of the Earth in orbit around the Sun and its provisions regarding the hemisphere of the current layer. A similar analysis for other solar cycles will be the subject of subsequent publications.

### References

1. Vitinskij Ju.I., Kopecky M., Kuklin G.V. *Statistics of the sunspots generation*, M.: Nauka, 1986.
2. Ryabov M., Lukashuk S.A.: 2009, *Cycles of activity on the Sun and the stars, S.-Pb.,* 121.
3. Yakovlev A.N. *Introduction to Wavelet transform. Stud. Allowance,* Publish. House of the NSTU, Novosibirsk, 2003.
4. Astafyeva N.M.: 1996, *Physics-Uspekhi (Adv. in Phys. Sci.)*, **166**, 1145.