

## SUN AND SOLAR SYSTEM

DOI: <http://dx.doi.org/10.18524/1810-4215.2016.29.85220>

## CYCLES AND ANTI-CYCLES OF SOLAR ACTIVITY

M.I. Ryabov

Odessa observatory «URAN-4» Institute of Radioastronomy NASU, [ryabov-uran@ukr.net](mailto:ryabov-uran@ukr.net)

**ABSTRACT.** Currently representation of solar cycles on average monthly data and smoothed values on various indexes from the full solar disk is generally accepted. Such representation creates an illusion of monotone change and perceptions of simultaneity of manifestations of solar activity for all solar disc. At the same time, daily monitoring data reveal the presence of discrete properties of manifestations of solar cycle. They are associated with absence of spots on the Sun in the northern and southern hemispheres at different intervals. This phenomenon is defined as anti-cycle of solar activity. Properties of discreteness of anti-cycles are presented in this paper on "spotless days' periods". On their basis the appropriate monthly and annual data was received. The basic characteristics of the manifestations of the discreteness of activity anti-cycles had been determined. It noted the «switch effect» of the existence of the solar dynamo. It manifests itself in the rapid transition from a regime of «spotless days» to the regime of continuous generation.

### 1. Introduction

The representation of the solar cycles is limited by the data of monthly values of various indexes and their annual smoothed values. On their basis, all the main indicators of the solar cycle (data minimuma, phase rise to maximum, data maximuma, phase decline to minimum and data minimuma next cycle) (Hathaway, 2010). These data make an impression of continuity of the action of the solar dynamo for generating the magnetic fields which define the appearance of sunspots. This is clearly seen in the current views of the solar cycle (<http://www.swpc.noaa.gov/products/solar-cycle-progression>).

More significant is the physical examination of the data of daily observations  $W$  index and the average monthly of sunspot groups of indexes –  $S_p$  showing the discrete nature of the manifestation of the solar cycle (Fig.1) and the difference between the northern and southern hemispheres (Fig. 2).

Using Fourier filtering and wavelet analysis allows obtaining reliable data about the existence of maximums of solar cycles and all periods of their manifestations. Cycle maximums, their amplitudes and the period sets which form the activity cycle are different for the northern and southern hemispheres (Ryabov, 2013).

Thus the problem of asymmetry N-S manifestation of the solar cycle can be solved on the basis of separate consideration of the activity of the northern and southern hemispheres of the Sun, taking into account the

discreteness manifestations activity. Consider the observational basis for such an approach (Ryabov, 2015).

### 2. Observational data of anti- cycles activity

Discrete properties are determined by the presence of the intermittent nature of the appearance and disappearance of groups of spots, which appear in all phases of the solar cycle. Periods of spots presence on the disk form the solar activity cycle.

Periods of absence of sunspots groups can be defined as the existence of "anti-cycle" activity. The basic properties of the "anti-cycle" are defined according to the «spotless days» obtained in this work for the entire set of observations of sunspots areas of the Northern and Southern hemispheres for the period of 12-24 activity cycles.

The data in the form of «spotless days» for each year is given for the entire solar disk (<http://www.spaceweather.com>). This view is not quite correct because it does not take into account the difference in the formation of the activity of the northern and southern hemispheres of the Sun.

We have determined the annual and monthly indexes which characterize the properties of the "anti-cycles" of activity of the Northern and Southern hemispheres. It is defined as the ratio of the number of «spotless days» to the total duration of a year or a month in percentage.

Thus the value '100' (upper graph scale) indicates the complete absence of spots in the time interval of a month or a year. A value of zero means the permanent presence of spot groups in the northern or southern hemispheres. Intermediate values show the interval of time "off" of solar dynamo for generating sunspots.

In this representation, the discreteness index doesn't contain any errors because the intervals of spot absence are determined in an obvious way. Dynamics of 12-24 "anti-cycle" of the solar activity for the annual and monthly values is shown in Fig. 3-4.

At minimuma 19 cycle (1964 year) of the Northern hemisphere anti-cycle showed a quick transition from the complete absence of spots (100%) to their continued existence (0%). At the same time the southern hemisphere anti-cycle demonstrates the quasi-periodic changes in the duration of time intervals of absence of sunspots range of 20-60% (Fig. 5).

In the decay phase of cycle 19 (1962 year), the anti-cycle of the Northern hemisphere demonstrates continued rise of activity from 80% to 0% (June).

Condition of low activity to 80% Northern hemisphere again comes in two months.

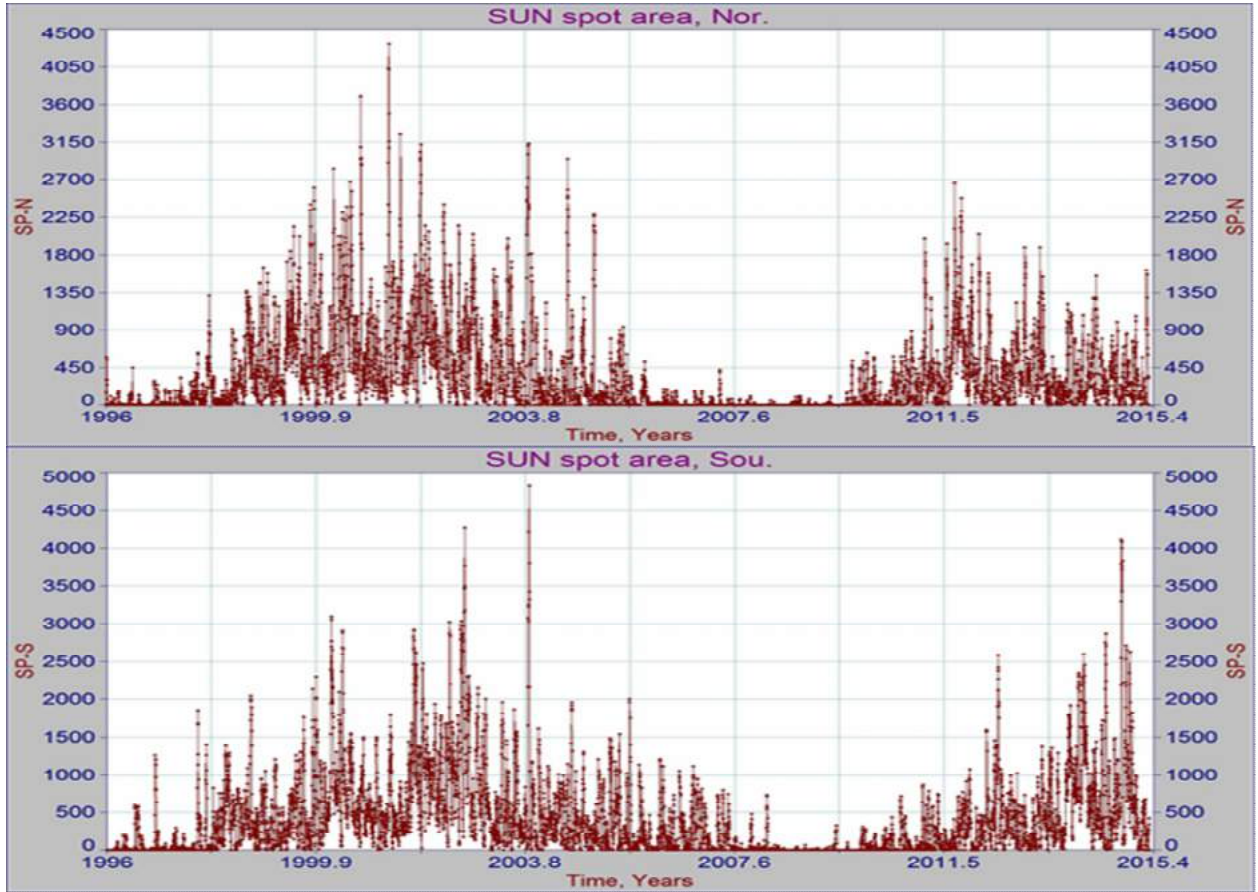


Figure 1: Daily values of the total area of sunspot groups- Sp of 23-24 cycles for the northern and southern hemispheres of the Sun.

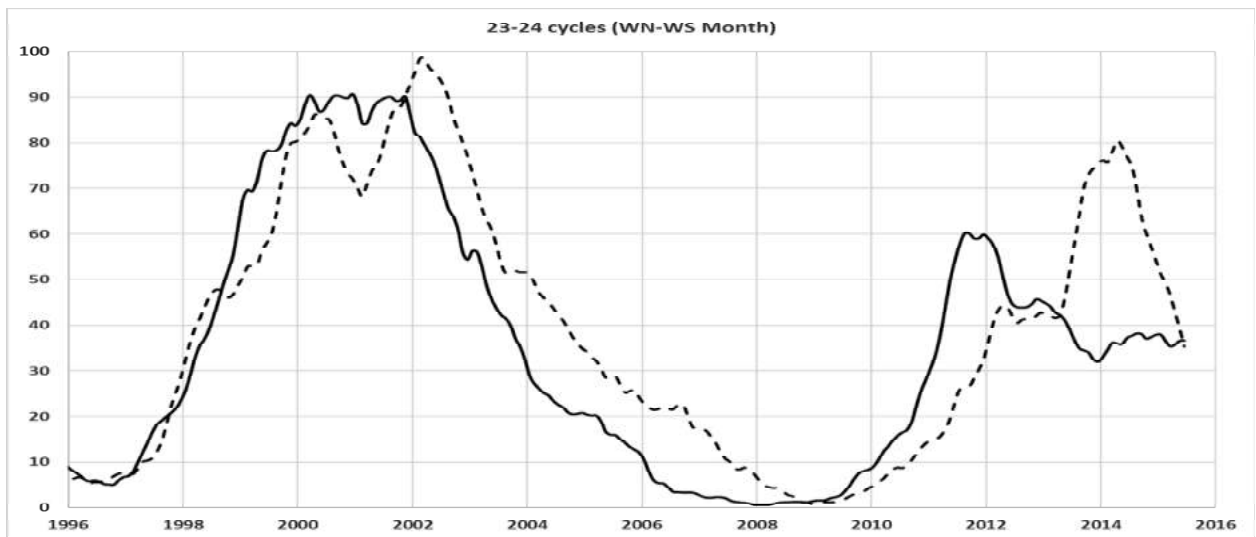


Figure 2: The average monthly Wolf number for 23-24 North and South solar cycles.

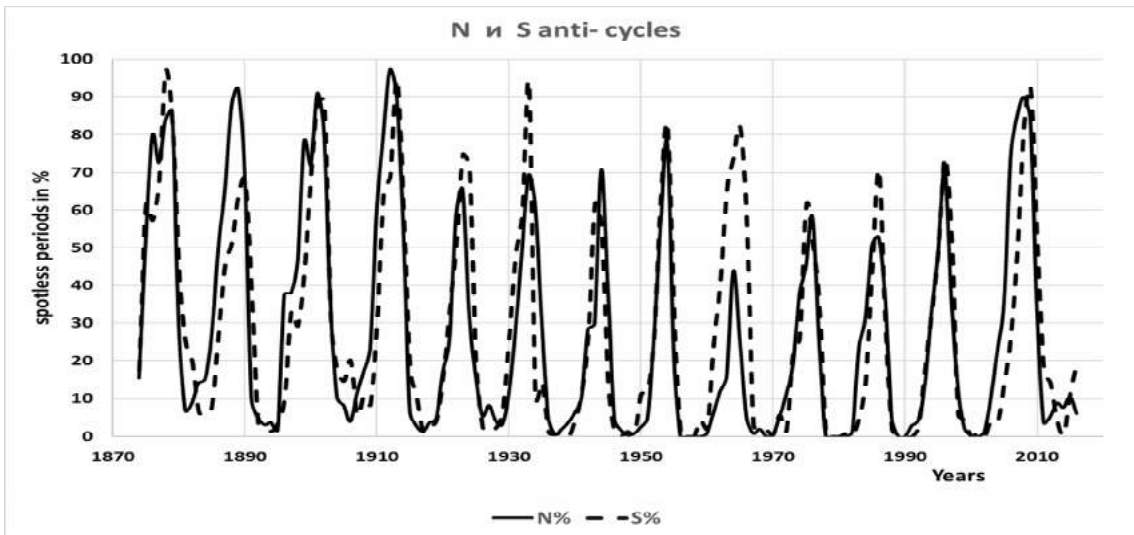


Figure 3: The annual index changes of discreteness of "anti-cycles" of the Northern and Southern hemispheres of the Sun.

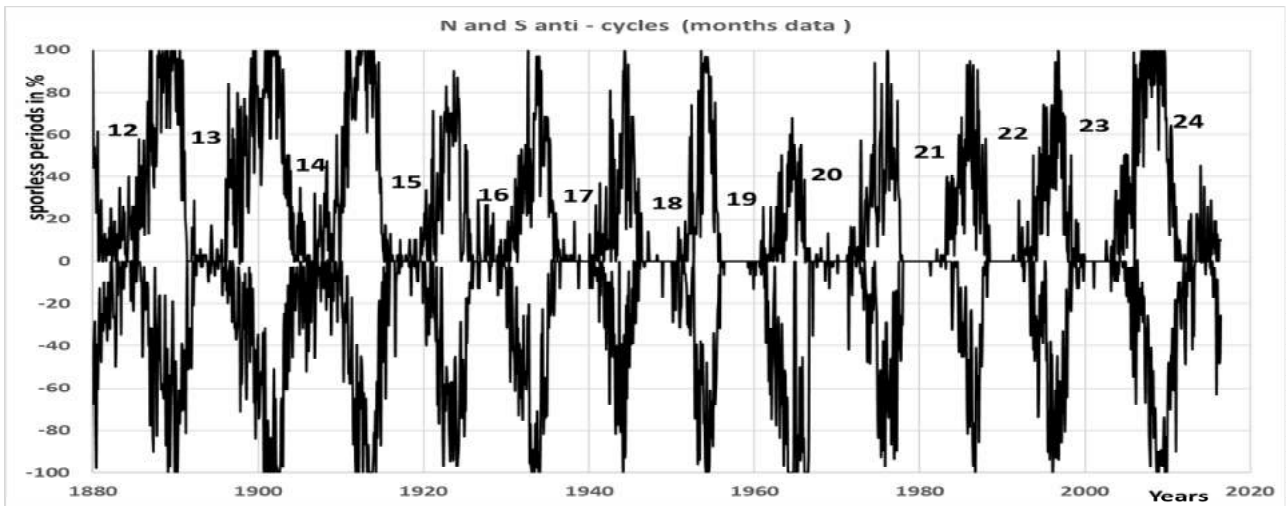


Figure 4: Monthly changes in the discreteness index of "anti-cycles" of the Northern and Southern hemispheres of the Sun (For the data separation the discrete index of the southern hemisphere is indicated with conditional negative values).

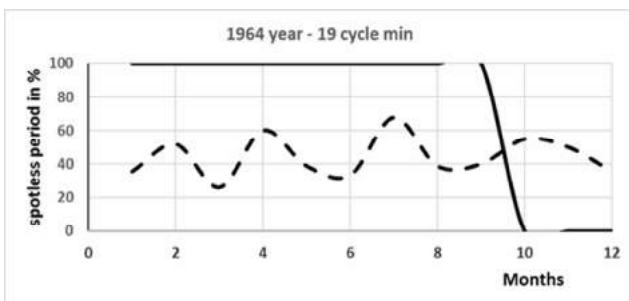


Figure 5: Anti-cycles Northern and Southern solar activity in 1964 years (19 cycle).

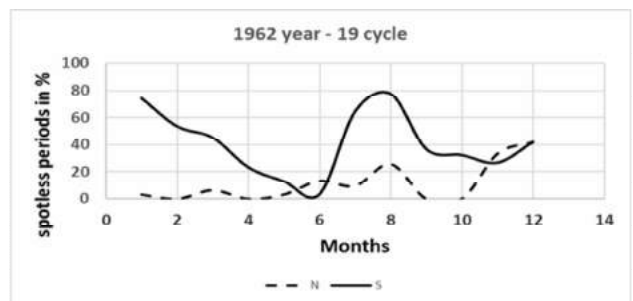


Figure 6: Anti-cycles Northern and Southern solar activity in 1962 years (19 cycle – decline to minimum).



Figure 7: Anti-cycles Northern and Southern solar activity in 1966 years (20 cycle – rise to maximum)

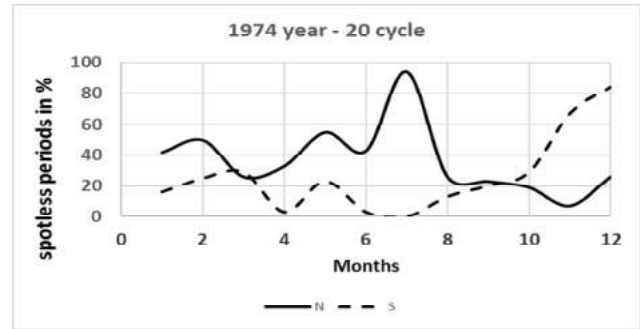


Figure 8: Anti-cycles Northern and Southern solar activity in 1974 years (20 cycle – decline to minimum)

At the same time the anti-cycle of the Southern Hemisphere showing minor deviations from the mode of existence of permanent exist sunspots (0% level) (Fig. 6).

Changes to the anti-cycles of the northern and southern hemispheres of the Sun in some years and in different phases of the solar cycle. Demonstrates manifestation «switch effect» in the solar dynamo. It manifests itself in the rapid transition from a regime of prolonged absence of sunspots to the regime of continuous generation (Fig. 5, Fig. 7).

In the rise phase of the cycle 20 (1966 year) anti-cycles of the Northern and Southern hemispheres show the same ratio as their activity in 1962 year (minimum 19 cycle) (Fig. 7).

Condition activity Northern and Southern hemispheres of the Sun during the decline to minimum 20 cycle activity (1974 years) varied widely from month to month.

However, the Southern hemisphere there has also been more active and showed no correlation with the activity of the Northern hemisphere (Fig. 8).

### 3. Conclusion

On the basis of the obtained results on presentation of the discreteness index of "anti-cycles" of the northern and southern hemispheres of the Sun a number of definite conclusions can be done.

According to the annual index values there are significant differences in the dynamics of the "anti-cycles"

in different hemispheres, including the value of the amplitude and time of the beginning and the end. And for the weaker cycles the activity duration in maximum is short.

Particular interest is the 19<sup>th</sup> cycle in which the maximum activity is provided by the abnormally high activity of the northern hemisphere. While the southern hemisphere sharply reduced its activity forming an intense and long-lasting "anti-cycle".

According to the monthly values of discrete indexes we can see that the change of sunspot regime happens within one month. During this time a complete disappearance may happen, and then the sudden appearance of groups of alternate spots in the northern and southern hemispheres.

Thus the discrete index of anti-cycles of the northern and southern hemispheres shows interesting features that are important in understanding the operation of the solar dynamo. In the continuation of this work by means of wavelet analysis the main periods of forming an "anti-cycle" of the solar activity will be identified.

### References

- Hathaway David H.: 2010, *Living Rev. Solar Phys.*, **7**, 1.
- Ryabov M.I. et al.: 2013, *Odessa Astron. Publ.*, **26**, 276.
- Ryabov M.I.: 2015, *Geomagnetism and Aeronomy*, **55**, 1089.