Bulgarian Academy of Sciences. Space Research and Technology Institute.
Aerospace Research in Bulgaria. 31, 2019, Sofia

DOI: https://doi.org/10.3897/arb.v31.e02

TRANSFORMATION OF THE CHARACTERISTICS OF QUASI-BIENNIAL OSCILLATION IN A NEW VERSION OF THE SERIES OF WOLF (RELATIVE SUNSPOT) NUMBERS

Igor Shibaev

IZMIRAN, Troitsk, Russia
e-mail: ishib@izmiran.ru

Keywords: *Wolf number, Quasi-biennial oscillations, Earth ionosphere.*

Abstract

With the introduction from June 2015 of a new methodology for estimation of Wolf numbers W (или WSN — Wolf sunspot number), this series was corrected from January 1749 to May 2015, i.e. a new version of the series WSN was proposed. The greatest transformation affected the cycles of a statistically reliable part of the series (since, 1849), which was clearly reflected in their amplitude correction and, accordingly, in the long-period component of the series, determining the epoch of maximum/minimum solar activity.

The quasi-biennial oscillations available in the solar magnetic field and in the total flux of its radiation also manifest themselves in a number of parameters of the Earth ionosphere and evaluation of their transformation degree is of high significance. This article compares the characteristics of the frequency interval of the quasi-biennial oscillations of both versions of a series.

Introduction

The influence of the Sun, through solar-terrestrial relations, on the climate and a human determines the traditional interest in the solar activity indices. The Zurich series of average monthly Wolf numbers (W) is the most representative one and is widely used in various applications. Since June 2015 with the introduction of a new methodology for estimation of Wolf numbers, this series was corrected from January 1749 to May 2015 (http://sidc.oma.be), i.e. a new version of the Wolf sunspot number (WSN) series was proposed. It is to be recalled that the series of average monthly Wolf numbers includes a series of regular instrumental observations from 1849 to the present day is a reliable series, and a series of restored values from 1749 to 1849. The greatest transformation affected the cycles of a statistically reliable part of the series (since 1849), which was clearly reflected in their amplitude correction and, accordingly, in the long-period component of the series, determining the epoch of maximum/minimum solar activity [1].

The quasi-biennial oscillations available in the solar magnetic field and in the total flux of its radiation [2] also manifest themselves in a number of parameters of the Earth ionosphere and evaluation of their transformation degree is of high significance. This paper compares the frequency interval of the quasi-biennial oscillations of both versions of a series. Officially, "quasi-biennial oscillations" enrich the spectra of the series and provide the cycles with an individual look. Their parameters can also perform diagnostic functions, i.e., in the representation of the "envelope curve-instantaneous frequency" signal («A(t) – F(t)»), one can judge the nature of a process by the degree of smoothness of these variables [3]. This is well illustrated by the example of WSN series in the transition to the Wolfer system in 1894.

Initial data

An overview of both versions of a series of Wolf (W_{new} – the new version, W_{old} – the old version) numbers and their relationship W_{new}/W_{old} is presented in Fig. 1. It is apparent that the reliable part of the series since 1849 has been transformed to the most extent. This will affect the long-period component of the W_{new} series with which the manifestation of the epoch of maximum/minimum solar activity is usually associated. Comparison of cycles in the old and new versions of the Wolf number series and analysis of their long-period components are conducted in the work [1]. Note that the periods of T_{new} = 131 years and T_{old} = 149 years were obtained with the sinus approximation of the long-period components.

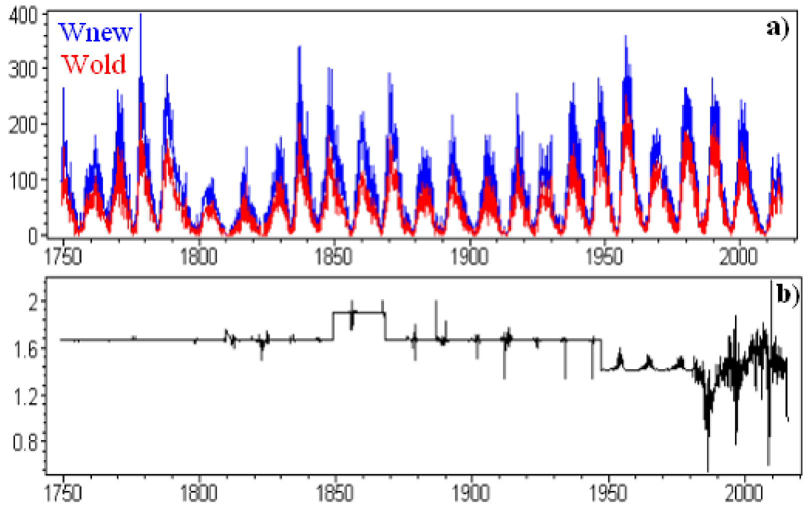

Fig. 1. (a) – an overview of W_{new}, W_{old}; (b) – relationship W_{new}/W_{old}. Axis OX – date

In paper [3], based on the spectrum nature, row $W(=W_{old})$ is divided into five spectral intervals with the following time periods in years: P1 [24 < T], P2 [6.8 < T < 24], P3 [4.26 < T < 6.8], P4 [1.66 < T < 4.26], and P5 [T<1.66]. Fig. 2 demonstrates an overview of the spectrum with assigned intervals. Recall the role of P1 – P5 components of W series. The sum of the long-period component of P1 and P2 (vicinities of the fundamental harmonic f*, T* = 1/f* ~ 131 months) reflects the main time and amplitude characteristics of the cycles. Row P3 adjusts the branches of growth and decline. Component P4 transforms the smooth relief of cycles by means of "quasi-biennial oscillations", local maxima appear and the main maximum can shift, i.e. cycles become more individual. The high-frequency residue P5 includes the annual and 155-d harmonics.

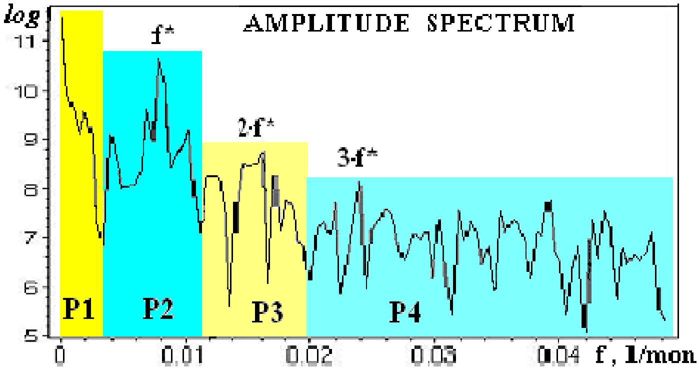

Fig. 2. Spectrum W_{old}, axis OX – inverse months

Each of the components P2 – P4 can be described by the $A(t) \times EXP[j \times \Theta(t)]$ - type template, and the Hilbert transformation [4] can be used to specify the time dependencies A(t), Θ(t). This enables to describe the signal with a slowly varying "envelope" and "instantaneous frequency" («A(t) – F(t)»).

"Quasi-biennial oscillations"

Let us demonstrate this approach by comparing the characteristics of the quasi-biennial oscillations (P4 ≥ 1.66 < T < 4.26) of the Greenwich series of areas S and a series of Wolf numbers $W(= W_{old})$ within the time interval 1874 ÷ 1976. The temporal dynamics of the "instantaneous" frequencies of these series is displayed at the top of Fig. 3, at the bottom – the dynamics of the envelopes and the date – along the OX axis. One can see the close dynamics of all the parameters of quasi-biennial oscillations of the series under consideration until 1975, and further there are known problems in the registration of a series of areas. Note the moment of transition to the Wolfer system in 1894 for the Wolf numbers (indicated by a rectangle). The continuity of the "instantaneous" frequency F[P4(W)] is broken and the envelope amplitude of the Wolf numbers A[P4(W)] is transformed, the smoothness of these parameters (F[P4(S)], A[P4(S)]) in a number of areas is maintained. In a number of cases, a change in the ratio of the amplitudes of the envelopes can be noted, but the nature of the temporal dynamics, as a rule, coincides.

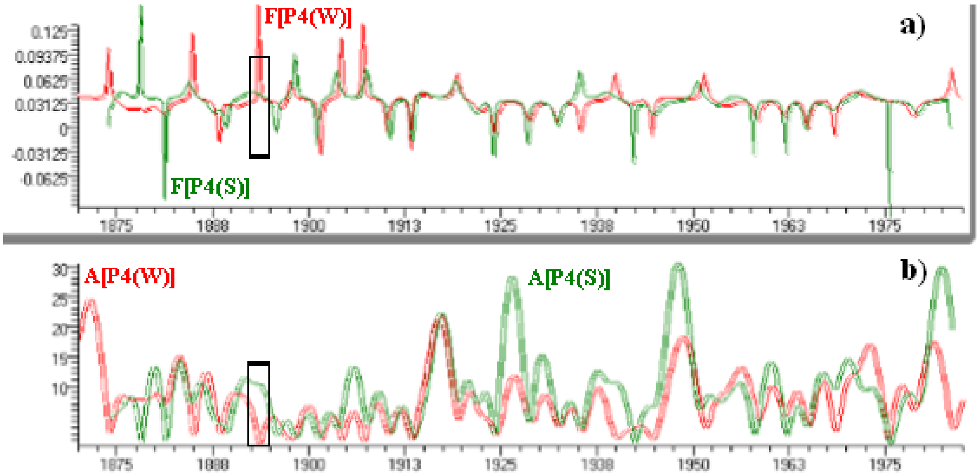

Fig. 3. Review of the parameters of quasi-biennial oscillations:
(a) – the "instantaneous" frequencies of W (F[P4(W)]) and S (F[P4(S)]);
(b) – the envelope amplitude of W (A[P4(W)]) and S (A[P4(S)])

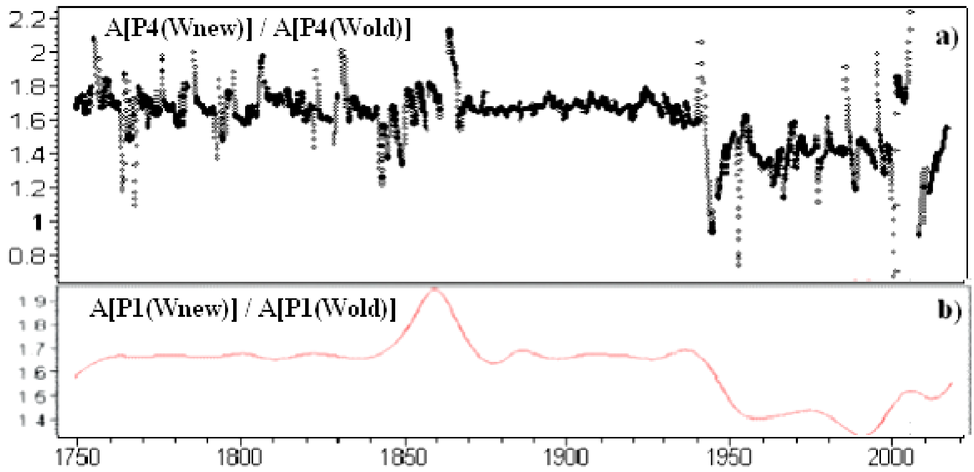

Fig. 4. (a) – relationship A[P4(W_{new})]/A[P4(W_{old})]; (b) – relationship A[P1(W_{new})]/A[P1(W_{old})]. Axis OX – date.

Let us apply this approach when comparing the quasi-biennial oscillations of the new and old versions of the series of Wolf numbers. Fig. 4a represents the amplitude ratio of the envelopes of “quasi-biennial oscillations” W_{new} and W_{old}, which is compared (Fig. 4b) with the ratio of the long-period components of these series [1]. In accordance with the W_{new}/W_{old} values ratio (Fig. 1), there are four areas with different conversion factors:
I – a series of restored values from 1749 to 1849;
II – from the beginning of a reliable series, part of cycle 9, and before the beginning of cycle 11;
III – interval with cycles 11 ÷ 17;
IV – the interval from cycle 18 and to the end is characterized by the most complex transformation.

When comparing the “quasi-biennial oscillations” W_{new} and W_{old}, it can be seen that there is the most stable connection between them only on the interval **III**. On the **II** interval we have a growing trend in contrast to the proportionality of W_{new} and W_{old}. The remaining intervals are characterized by a variety of all situations. We also note that the new version retains the “effect” associated with the transition to the Wolfer system.

Conclusion

The nature of transformation of the quasi-biennial oscillations and the long-period component of the series of Wolf numbers (1749 ÷ 2015) is quite different. Actually, old artefacts were added with new ones in the transformed series. A real assessment of the proposed method to count Wolf numbers can be obtained by comparing both versions of a series and a number of areas starting from June 2015.

References

1. Shibaev, A. The characteristics of old and new versions of month Wolf numbers range and there uniformity are compared. In: Proceedings of 12th Scientific Conference with International Participation "Space, Ecology, Safety" SES’2016, Sofia, Bulgaria, 2017, 73–76.
2. Ivanov-Holodnyj, G. S., V. S. Chertoprud. Kvazidvuhletnie variacii polnogo potoka izluchenija Solnca: ih projavlenie v variacijah stratosfernogo vetra i skorosti vrashhenija Zemli. Solnechno-zemnaja fizika. 2008, 12, 2, 291–92. (in Russian)
3. Shibaev, I. G. Estimation of the Reconstructed Part of the Wolf Series and the Possibility of Its Correction. Solar System Research, 2008, 42, 1, 63–72. DOI: 10.1134/S0038094608010073.
4. Bendant, J., A. Pirsol. Random Data. Analysis and Measurement Procedures, John Wiley & Sons, Inc., NY, 1986.

ТРАНСФОРМАЦИЯ ХАРАКТЕРИСТИК КВАЗИДВУХЛЕТНИХ ВАРИАЦИЙ В НОВОЙ ВЕРСИИ РЯДА ЧИСЕЛ ВОЛЬФА

И. Шибаев

Резюме

С введением с июня 2015 г. новой методики оценки чисел Вольфа W (или WSN — Wolf Sunspot Number) проведена коррекция этого ряда с января 1749 г. по май 2015 г., т.е. предложена новая версия ряда WSN. Наибольшая трансформация коснулась циклов достоверной части ряда с 1849 г., что явно отразилось в их амплитудной коррекции и, соответственно, длиннопериодной компоненте ряда, определяющей эпохи максимума/минимума солнечной активности.

Квазидвухлетние вариации, присутствующие в магнитном поле Солнца и в полном потоке его излучения, также проявляются в ряде параметров ионосферы Земли и важно оценить степень их трансформации при таком переходе. Данная работа сопоставляет характеристики частотного интервала квазидвухлетних вариаций обеих версий ряда.