CORRECTION OF MEAN VALUES OF RE-ESTABLISHED CYCLES WITH RESPECT TO THE CERTAIN PART OF WOLF NUMBER SERIES (VERSION V.1)

Shibaev I.G.

IZMIRAN, Troitsk, Russia

КОРРЕКЦИЯ СРЕДНИХ ЗНАЧЕНИЙ ВОССТАНОВЛЕННЫХ ЦИКЛОВ ПО ХАРАКТЕРИСТИКАМ ДОСТОВЕРНОЙ ЧАСТИ РЯДА ЧИСЕЛ ВОЛЬФА ВЕРСИИ V.1

Шибяев И.Г.

ИЗМИРАН, Троицк, Россия

Работа опирается на цюрихский ряд среднемесячных чисел Вольфа W ($W = W_{rest} \cup W_{tool}$), который включает восстановленный ряд W_{rest} (с 1749 г. по 1849 г.) и ряд достоверных данных W_{tool} (регулярные инструментальные наблюдения с 1849 г. по настоящее время). Многие исследователи используют ряд чисел Вольфа (или опирающиеся на него показания) с учетом восстановленных данных. Но при объединении отрывочных данных с различной плотностью наблюдений, амплитудным разрешением и масштабированием искажаются, естественно, локальные характеристики регистрируемого процесса и взаимосвязь временных фрагментов разного масштаба. Всё это проявилось при формировании восстановленного ряда W_{rest} [1, Fig.2], но на это обращают мало внимания, хотя влияние этих факторов не оценивалось.

Другие авторы, считая эти данные ненадежными, опираются только на достоверный ряд W_{tool} . При этом «повисают» понятия (структуры) сформированные с опорой хотя бы на часть восстановленных данных. Цикл Гляйсберга [2] – яркий пример тому, т. к. понятие «цикл Гляйсберга» возникло из анализа небольшого объема данных, имеющих различную степень достоверности, и с ключевой ролью циклов $V \div VII$ (минимум Дальтона) из восстановленного ряда. Отмеченный в работе [3] рост периода цикла Гляйсберга с увеличением доли достоверных данных хорошо это иллюстрирует.

В этой работе представлены варианты групповой коррекции средних значений циклов $I \div IX$. Так как при сопоставлении протяженных фрагментов локальные невязки данных играют меньшую роль, то опираясь на интегральные оценки этих фрагментов (без детализации их «сложной» истории формирования) мы получаем более взвешенные интервальные оценки. Параметры интервалов (групп циклов) достоверного ряда служат основой коррекции. Приведенный сценарий связывает согласование параметров восстановленного ряда с коррекцией минимума Дальтона, что должно отразиться в характеристиках цикла Гляйсберга.

DOI: 10.31725/0552-5829-2021-313-316

1. Introduction

The paper considers the Zurich series of monthly averaged sunspot numbers W ($W = W_{rest} \cup W_{tool}$), which includes the restored W_{rest} series (from 1749 to 1849) and W_{tool} , a series of reliable Wolf numbers (regular instrumental observations from 1849 to the present). Many researchers use a series of Wolf

numbers (or readings based on it) taking into account the recovered data. When combining fragmentary data with different density of observations, amplitude resolution and scaling, the local characteristics of the recorded process and the consistency of time fragments of different scales (for example, the structure of the cycles and their relationship) are distorted.

All this manifested itself during the formation of the restored Wrest series [1, Fig.2], but little attention is paid to this, although the influence of these factors has not been evaluated.

Other authors, considering these data unreliable, rely only on the reliable Wtool series. At the same time, concepts (structures) "hang" generated based on at least part of the recovered data. The Gleisberg cycle [2] is a vivid example of this, since the concept of the "Gleisberg cycle" arose from the analysis of a small amount of data with varying degrees of reliability, and with the key role of cycles $5 \div 7$ (Dalton minimum) from the reconstructed series. The growth of the Gleisberg cycle period [3] with an increase in the proportion of reliable data illustrates this well.

An earlier paper by the author [4] has provided a detailed analysis of the W series (from 1749 to 2005); a 150-year harmonic specific for the certain part of the series has been distinguished there. Comparison of spectral components and the analysis of their smoothness has demonstrated essential differences in their behaviour for Wrest and Wtool (discordant characteristics of the series). Statistic characteristics of $1 \div 9$ and $10 \div 23$ cycle groups, which correspond to the re-established and certain series, also differ. With that, the rate of distortion grows while receding into the past, and characteristics of a time domain adjacent to 1849, which is the $8 \div 9$ cycles domain, are less distorted.

One may get some overview of the 8 and 9 cycles "quality" by estimating the correlation relationship between the growth twig T_m and the cycle maximum W_m for two variants of sample comparison: $(1 \div 9)$ & $(10 \div 23)$; $(1 \div 7)$ & $(8 \div 23)$. For small samples and without the normal distribution of study values, the Shihate criterion is deemed to be more effective. In the first instance, with a confidence figure of $\alpha = 0.95$, the correlation between T_m and W_m for both cycle groups is recognised as negative. In the second instance, for $1 \div 7$ cycles, this relationship actually disappears, whereas for $8 \div 23$ cycles it remains but subsides. Hence, 8 and 9 cycles improve the quality of the Wrest series and disimprove it for Wtool one. Additionally, cycles 1, 5 and 7 have abnormally long growth branches – more than half of the cycle. Moreover, the series' interval estimations have demonstrated the inconsistency of parameters of the Wrest series [5].

In this paper, the variants of the group correction of the average values of cycles $1 \div 9$ are presented. Since local data inconsistencies play a smaller role when comparing extended fragments, relying on integral estimates of these fragments (without detailing their "complex" formation history), we obtain more weighted interval estimates. The parameters of intervals (groups of cycles) of a reliable series serve as the basis for correction.

2. The series' interval estimations via cycle groups

It is common-sensical to compare groups with the same number of cycles. In this case, nine re-established cycles 1÷9 (the G0 group) can be compared with six other groups: 10÷18, 11÷19, 12÷20, 13÷21, 14÷22, 15÷23 (G1÷G6), each of nine cycles from the certain part of the series. The integrated duration of cycles ΣT_c and area of those ΣS_q in the group are matching each group; $w = \Sigma S_q / \Sigma T_c$ shall be taken as the estimated mean value of W in the group. For the group of re-established cycles G0, these parameters equal to 1209 ($= \Sigma T_0$, months), 56713.65 ($= \Sigma S_{q0}$), 46.91 ($\sim w_0$). The classification of cycles with respect to their duration ("long" cycles with $T_c > 133$ months and "short" ones with $T_c < 133$ months) allowed for parametrisation and approximation of characteristics of certain cycles groups [5]. While projecting the "rules" obtained for G1÷G6 groups onto the G0 one, the discordance between the duration and the "energetics" of the re-established series has been determined, and the necessity for the correction of the time structure of the Wres series firstly (e.g., the relation between the "long" (N_L) and "short" cycles) has been pointed out. $N_L = 3$ ($\Sigma T_c = 1159.0$ months, which is the mean value over the G1÷G6 groups) and $N_L = 2$ correspond to more realistic scenario. One shall rely upon the relation of $w = \Sigma S_q / \Sigma T_c$ to the number of "long" cycles in the group N_L (Fig. 1), where the relationship between $\Sigma T_c(N_L)$, $\Sigma S_q(N_L)$ and N_L for groups of 9 certain cycles each were taken from the paper [5]. This relationship shall be used for the correction of mean values of cycles of the G0 group.

Fig. 1. The relation of the cycle mean value in the group to the number of "long" cycles N_L in the group.

3. Correction of mean values of re-established cycles

As is obvious, the area with $w > w_0$ corresponds to $N_L \leq 4$ values. The manifestation of the increased w value of the re-established cycles group shall be evaluated in parameters of individual cycles. The area of the most of cycles of the G0 group is greater than (or about) the mean value of 6301.52, and it is common-sensical to assign the increment of $(\Sigma S_q - \Sigma S_{q0})$ to the Dalton Minimum (which means to associate the increment with the Dalton Minimum correction). The tabulated mean values of cycles of the re-established series are presented in Fig. 2; for illustrative purposes, the average of mean values (~ 26.48) of cycles 5÷7 is shown with a solid line. By associating the increased "energetics"

of all nine cycles with these three problematic cycles, one shall obtain the increment of the $(w-w_0) \times 9/3$ mean value for each of them. The resulting mean levels for corrected mean values of cycles 5÷7 are marked with dashed lines. The level 59.15 corresponds to the $N_L = 3$ variant, which is the “weighed estimation of the G0 group length” (in fact, it invalidates the Dalton Minimum), and the formation of the maximum at the 77.15 level is possible for the $N_L = 2$ variant.

Рис. 2. Average values of cycles 1÷9; axis oX – cycle number.

4. Conclusions

When comparing extended fragments, the local data residual plays a smaller role and more balanced estimates are obtained. Classification of cycles by duration allows us to describe the relationship between the parameters of reliable cycles and to show the inconsistency of these parameters for the 1–9 cycle group. The given scenario associates the matching of parameters of the re-established series with the correction of the Dalton Minimum, which shall affect the characteristics of the Gleissberg cycle.

In conclusion, we note that a number of authors express a critical attitude to the restored series in the works of the Solar-Terrestrial Communications, Weather and Climate Symposium (1978) [6]. An attempt to balance the temporal characteristics of the W series cycles due to the “lost” cycle was undertaken in [7].

References

1. Hathaway David H. The Solar Cycle / <https://arxiv.org/pdf/1502.07020.pdf>, 2015.
2. Gleissberg W. A long-periodic Fluctuation of the Sun-spot Numbers // Observatory, 1939, V. 62, p. 158–159.
3. Shibaev, A. Connection between period of low-frequency component Wolf's numbers (WNS) and length of Wolf's numbers series // Aerospace Research in Bulgaria, 2017, V. 29, p. 5–9.
4. Shibaev I.G. Estimation of the reconstructed part of the Wolf series and the possibility of its correction // Solar System Research, 2008, V. 42, № 1, p. 63–72.
5. Shibaev I. Old and new versions of wolf sunspot numbers: consistency of characteristics for restored and instrumental parts of series / Proceedings of 15th International Scientific Conference "Space, Ecology, Safety" SES'2019. Sofia, Bulgaria, 2019, p. 37 – 41.
6. Solar-Terrestrial Influences on Weather and Climate. Proceeding of a Symposium. The Ohio State University, Columbus, Ohio, 24-28 August 1978. Dordrecht, Holland, 1979, P. 348.
7. Usoskin I.G., K. Mursula, and G.A. Kovaltsov. The lost sunspot cycle: Reanalysis of sunspot statistics // A&A, 2003, V. 403, № 2, p. 743–748.