PROGNOSES AND ANOMALY OF 24TH CYCLE OF SOLAR ACTIVITY

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ABSTRACT. Development of solar activity in 24th cycle has specific peculiarity – non-monotonous increasing of solar activity on grown phase which occurs for 1/3 number of all cycles. The modification of Waldmayer's method was applied for forecasting 24th cycle which bases on a connection between maximum sunspot number and speed of increasing of activity on grown phase of cycle. If we compare 24th cycle with previous similar cycles Nos. 1, 5, 6, 9, 12, 15 and 16, we can conclude that this cycle will be weak, with maximum sunspot number W_{max} (24) = 73 ± 10 in 2014–2015, most likely – in first half of 2014. Current cycle could be considered as anomaly by three criterions: a) sharp slowdown in growth after the 30th of the month cycle, b) two-humped peak cycle with a significant predominance of the second peak height and c) the emergence of a giant sunspot with a diameter of about 170 Mm.

Key words: Sun: Solar activity – Sunspot number: Solar activity – Prognoses: Peak of 24th cycle – Anomaly.

1. Introduction

The current cycle No. 24 began in December, 2008. Some tens of forecasts of solar activity in this cycle were proposed; we will mention only some of them. According to Badalyan et al. (2001), the current cycle was expected as very weak – with the maximum averaged sunspot number on level of $W_{max} \approx 50$. The similar forecast is offered also by Svalgaard et al. (2005) – $W_{max} = 75 \pm 8$. Kane (2007), on the contrary, concluded that this cycle will be with $W_{max} = 142 \pm 24$. According to Dikpati et al. (2006), the 24th cycle will be rather powerful – on 30-50% higher, than the previous cycle No. 23. Years of cycle peak also significantly differ by different authors – from 2010 to 2014. In the present work, we use the modification of Waldmayer's method for forecasting the current cycle.

2. Method and Results

We used two working hypothesis. Our first hypothesis was following. It is necessary take into account that solar activity appears as partly determined, and partly stochastic phenomenon. We can expect that owing to stochastic component our forecasts of solar activity should be the worse the longer time interval is between the latest observational data and the forecast. In that case, the most successful forecast can be make according to latest data about the actual changes of solar activity.

Being based on this thesis as on working hypothesis, authors showed earlier that if to proceed from rise speed of activity between 20th and 32th months of development of a cycle (i.e. a little to modify Waldmayer's method), the maximum of averaged sunspot number turns out W_{max} = 120 ± 17 – as in middle cycle (Lozitsky and Efimenko, 2012).

It illustrates Fig. 1 based on data placed on site http://www.solen.info/solar/ . One can see that for the majority of cycles there is close connection between W_{max} and an increment of activity between 32th and 20th months of a cycle, $W_{32} - W_{20}$ (correlation coefficient r = 0.91 ± 0.03). Smooth curve provided in Fig. 1 is approximated by formula

$$W_{max} = 19.0 \times (W_{32} - W_{20})^{0.496} \qquad (1)$$

From (1) follows that W_{max} is approximetely proportional to scquare root from difference $W_{32} - W_{20}$. Also, one can see that the largest deviations from (1) demonstrate cycles Nos. 9, 19 and 3 (data for named cycles is pointed on Fig. 1 by corresponding numbers). If we substitute in (1) observed value $W_{32} - W_{20} = 42$ for 24th cycle then we obtain $W_{max} \approx 120$.

Similarly, the time of cycle peak was considered, and the coclusion was made that this peak should be in second half 2012 or first half 2013.

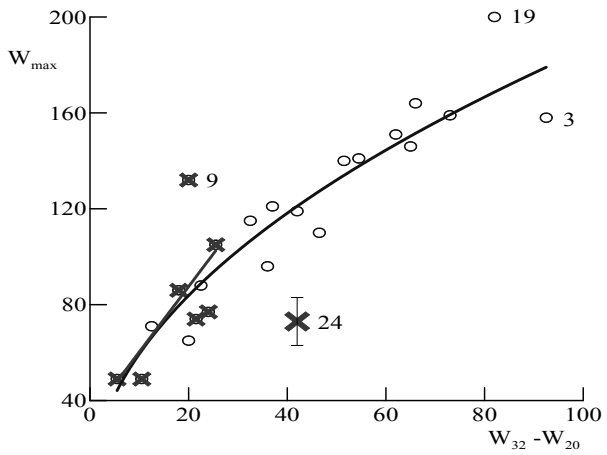

Figure 1: Maximum averages sunspot number, W_{max} , vs. speed of increasing of activity between 32th and 20th months, W_{32} - W_{20} , for 23 previous cycles (see text).

This forecast was not come true. The main cause of this failture is that the approximation presented by formula (1)

is suitable for cycles with monotonous curve of grown phase. But, as it was observed after 32th month of current cycle, this cycle has namely non-monotonous grown phase. In particular, after 32th month the development of solar activity slowed down. In fact, following two years after 32th month the sunspot number was almost the same - in range of 58–67 units. But later solar activity increased, in general, monotonically and this increasing is in progress till 64th month. This is obvious evidence that 24th cycle has non-monotonous grown phase. Among 23 previous cycles, number of similar cycles was 7 (approximately 1/3), namely Nos. 1, 5, 6, 9, 12, 15 and 16.

Second our working hypothesis was following. For more exact forecast, we should compare the cycles with non-monotonous grown phase only.

Figure 2 presents the comparison of W_{max} vs. W_{52}, i.e. sunspot number on 52th month. In fact, W_{52} is averaged by 4,33 years speed of increasing of solar activity which well averages local temporal changes of sunspot number.

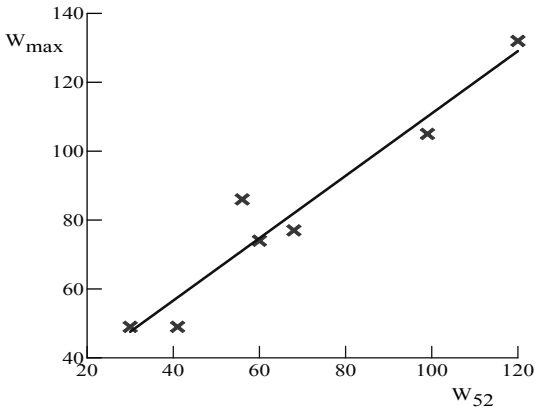

Figure 2: Maximum averages sunspot number, W_{max}, vs. sunspot number on 52th month, W_{52} , for cycles with non-monotonous increasing of solar activity on grown phase.

As it follows from Fig. 2, dependence W_{max} vs. W_{52} is enough close and almost linear. It has not any sizable deviations from linear trend that allow to prognose the peak of current cycle with confidence. So long as for 24th cycle W_{52} = 58, we obtain by this method: W_{max} (24) = 73±10. Time of peak – likely, first half of 2014.

3. Anomaly Cycle

There are three evidences that current cycle is anomaly.

Firstly, corresponding value W_{max} (24) = 73±10 on Fig. 1 has practically the same largest deviation from averaged curve (1) as cycle No. 9. However, data for cycles Nos. 9 and 24 are located on opposite sides of this curve. This means that cycle No. 9 had sharp increasing of solar activity before the maximum, whereas cycle No.24 has, on the contrary, sizable slowing down. In this connection, current cycly can be considered as cycle with destroyed peak. It is interesting to note that all 'irregular' cycles (with non-monotonous grown phase) excluding No.9 were weak. Such cycles are pointed on Fig. 1 by crosses. As it follows from this Figure, forecast of W_{max} via $W_{32} - W_{20}$ for such cycles is unreliable.

Secondly, current cycle should have two splitted peaks, and second peak is expected to be higher than the first. In fact, two or three past cycles had such peculiarity, namely Nos. 5, 12 and perhaps 16.

Let us illustrate this anomaly using number data. Denote $W_2 - W_1$ second maximum height difference relative to the first, and through $T_2 - T_1$- time (in months) between the first and second maximum. Comparison from this point of view cycles Nos. 5, 12, 16 and 24 is given in Table 1.

Table 1: Some characteristics of cycles 5, 12,16 and 24

No. of cycle	$W_2 - W_1$	$T_2 - T_1$
5	4	31
12	11	24
16	5	17
24	≥15	≥26

From Table 1 follows, that current cycle has the largest difference $W_2 - W_1$ and second (from all named cycles) time interval $T_2 - T_1$ between splitted peaks.

Thirdly, namely in the current cycle a giant sunspot had occurred in October 2014 (Fig. 3). Similar sunspots with penumbra diameter of 150-170 Mm were observed in cycles Nos. 17, 18 and 22. It was shown that such sunspots present a unique separate statistical ensemble of especially large spots (Babij et al, 2011). Strictly speaking, the existence of such an ensemble is determined not only by the diameter of sunspots, but by the index of integral distribution in the range of 50-90 Mm. Authors plan to do this study in the future.

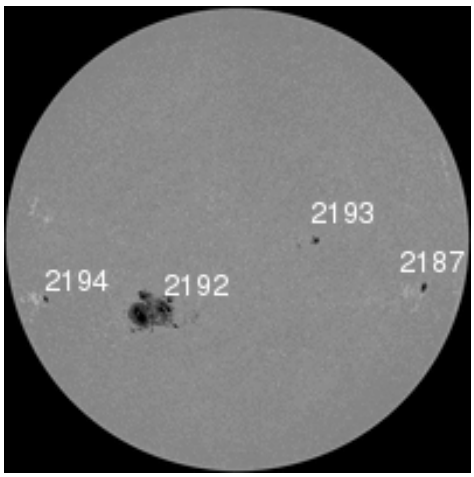

Figure 3: Sun's image in white light observed 22 October 2014 using SDO/HMI (http://spaceweather.com/).

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