The Properties of Solar Cycle 24 and Their Connection with Common Relationships of Cycles 19–23

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Abstract. A set of properties of solar activity cycle 24 is considered on the base of the data of Kislovodsk Mountain Astronomical Station. Some of those properties are in connection with common relationships of previous cycles.

1. Introduction
The Sun observations data set in white light at the Kislovodsk Station (GAS GAO RAN) embrace the period from 1954 until the present including complete cycles 19–23 and the beginning of cycle 24. The set of GAS GAO RAN observations is continuous [7] and in good correlation with data sets of other observatories [1]. The data archive is on the site www.solarstation.ru and represented by the daily summaries. The summaries contain following information: date and time of observations; number of each group by Kislovodsk classification; coordinates of each group (latitude, Carrington longitude, \( r/R \)); group area and area of maximal spot in group; quantity of sunspots in each group. Thus the Kislovodsk data set is to a certain extent unique, because among all the solar observatories it is the only one that contains simultaneously all the above-listed parameters.

The cycle terms in accordance with NGDC/NOAA data are following: 19: 04.1954–09.1964; 20: 10.1964–05.1976; 21: 06.1976–08.1986; 22: 09.1986–04.1996; 23: 05.1996–12.2008; 24: from 01.2009 up to 06.2013 inclusive.

2. The low activity of the cycle 24
Before the beginning of the current cycle there was dramatic discussion concerning its power. As is well known, the odd cycle 23 was weaker than previous one that is violation of the Gnevyshev – Ohl rule [3], [4], [5]. In this regard, the predictions of the power of cycle 24 had to confirm or disprove various propositions relative to the dynamo theory. There was opinions about both the high [2] and the low [9] activity of cycle 24. Now, almost half of the cycle, it became clear that the latter viewpoint is correct.

In [6] it was shown that the initial phase of cycle 24 has very low activity, the northern hemisphere is more active than the southern one. All these conclusions remain actual until the present. Mean area of sunspots for the first 4.5 years of cycle 24 is 602 millionth of solar hemisphere (msh), mean Wolf number is 57.5. The northern hemisphere surpasses the southern...
one at 1.59 times by the area and at 1.49 times by the Wolf number, mean spot latitude in the north is approximately two degrees less than in the south. Moreover, activity for the last about 2 years came, in fact, to a plateau (figures 1 & 2).

Figure 1. Mean annual sunspot areas of cycle 24.

Figure 2. Mean annual Wolf number of cycle 24.

3. The low amount of very-large-scale sunspots
The current cycle is inferior to all previous ones by relative number of groups at which the area of the maximum spot exceeds 800 msh. It is remarkable that the leader by this parameter is not cycle 19 (the most powerful of all), but cycle 22. The relative quantity of such groups by cycles is given in Figure 3, the same dependence by years is in Figure 4 (mean annual areas of sunspot groups are given in overlapping by a dotted line).

Figure 3. Mean relative amount of very-large-scale sunspots by cycles.

Figure 4. Mean relative yearly amount of very-large-scale sunspots.

4. The low duration of group life
The actual solar cycle has the least mean duration of group life among all the Kislovodsk cycles. This parameter is in good correlation with mean areas of sunspot groups (Figure 5) and in even more correlation with mean areas of maximal spots in groups (Figure 6). Cycle 22 is the leader by mean duration of group life, but it was cycle 22 that has maximal amount of very-large-scale sunspots as follows from the previous paragraph. This result is expected because the more the sunspots the more its life time.
5. The great amount of short-lived groups and single sunspots
The present cycle is the leader both by the relative amount of short-lived groups (namely, the groups which have life time less than one day) and by the relative amount of single sunspots (i.e. groups which consist of the only sunspot). Figure 7 shows the relative amount of short-lived groups, Figure 8 presents the relative amount of single sunspots. Both dependencies has the identical view with pronounced growth trend from the beginning of cycle 22. In Figure 9 is given the growth trend of single sunspots by years. Both parameters are in good correlation (Figure 10). This can be explained by the fact that the short-lived groups are, as a rule, single sunspots (the opposite is generally incorrect).

6. Common relationships of sunspot groups for Kislovodsk cycles
Cycle 24 is the leader by a set of many parameters. Namely, it has: 1) the least mean amount of sunspots in a group; 2) the least mean amount of both sunspots and groups per day; 3) the least mean ratio of the Wolf number to the group amount; 4) the greatest mean ratio of the maximal spot area in group to the total group area (calculated as the sum of all maximal spots areas through the cycle divided by the total sum of sunspot areas). But in all these aspects cycle 24 continues the relationships that began from cycle 19. These relationships are given in Figures 11–18. Figure 11 shows the mean amount of sunspots in a group by years including trend line, in Figure 12 is the same dependence by cycles [8]. In Figures 13 and 14 are given the mean amounts of sunspots and groups per day respectively. Figure 15 presents the mean ratio
of the Wolf number to the group amount. In Figure 16 is given the mean ratio of the maximal spot area in group to the total group area.

It is remarkable that the average size of an individual sunspot (calculated as the sum of all sunspot areas through the cycle divided by the total number of sunspots) is practically constant for each cycle except cycle 20 (Figure 17). On the other hand, the average size of an individual group (calculated by the same manner) is in direct dependence with cycle power (i.e. with mean areas of sunspot groups) (Figure 18).

The foregoing dependencies as well as the growth of short-lived groups and single sunspots demonstrate the tendency of sunspot groups to “break up”. In other words, from cycle to cycle the relative number of groups with high amount of small spots decreases and the the relative number of groups with low amount of small spots (many of them are single and/or short-lived) increases.

7. Conclusions
Cycle 24 has the least relative amount of very-large-scale sunspots and the least mean group life time. On the other hand, it is the leader by the relative amount of short-lived groups and single sunspots. The mean amount of sunspots in a group and the average size of an individual group are the least among all the Kislovodsk cycles. Besides, it has the least mean amount of both
sunspots and groups per day. All these parameters are in correction with previous Kislovodsk cycles.

Cycles 19–24 are characterized by the tendency of decreasing the mean amount of sunspots in a group and increasing the relative amount of groups consisting of small number of sunspots. This phenomenon can be characterized as “crushing” of sunspot groups.
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