Solar magnetic sectors and spatial distribution of LDE-type flares

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Received: December 12, 1994

Abstract. We present a number of statistical tests that speak in favour of an increased (both LDE-type and impulsive) flare activity in active regions (ARs) which are located inside or along the boundaries of the solar sectors with 'reversed' magnetic polarity. Altogether 338 daily values of 32 BEARALERT regions have been analysed in terms of eight variables during the ascending phase of the 22nd solar cycle. The flare occurrence is found smallest inside the 'old' sectors and peaks inside the 'reversed' sectors and at the sectors' boundaries. Separate analyses of the data showing a lack of strong flare activity for a given day (the data subset dn, comprising 155 daily vectors), and the data pertinent to strong flare activity in a given day (the data subset df, representing 183 daily vectors) lead to the same results concerning the sectorial distribution of active regions.

Key words: Sun – global magnetic reversal – magnetic polarity sectors

1. Introduction

Large scale magnetic structures and their relation to flares as well as to the global magnetic field reversal of the Sun are studied for several years using different methods (Bumba 1976, Sýkora 1980, Gaizauskas et al. 1983, Stepanyan 1983, 1994, Banin and Yazev 1991, Ambrož 1992, Harvey 1992, Martin et al. 1992, Saniga 1992, Sýkora et al. 1994, Antalová 1994a,1994b, 1995, Zhang 1994, Pataraya and Zaqarashvili 1995, as well as references therein). The principal manifestations of the polarity reversal in the course of an 11-year solar cycle are: i) the change of the polarity of a toroidal component of magnetic field as inferred from behaviour of bipolar sunspot groups, ii) the change of the polarity of large-scale magnetic fields, including a polar reversal in the maximum of a sunspot cycle, and iii) the 'heliospheric reversal' indicated by a 22-year variation in the modulation of galactic cosmic rays (Kudela et al. 1994; Storini et al. 1995).

Contrib. Astron. Obs. Skalnaté Pleso **25**, (1994), 19–32.

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To investigate the reversal of large-scale magnetic fields we consider the sectorial distribution of proxy unipolar fields. The magnetic sectors are represented by the source surface field as modelled by Hoeksema and Scherrer (1986) as well as by Hoeksema (1991, 1992, 1993). The source surface radius is located at 2.5 solar radii (Hoeksema 1991). We suppose that a gradual change in the pattern of magnetic sectors is one of the symptoms of a global Sun's magnetic reversal. This is the main reason which motivated us to compare the flare activity of ARs located in old and reversed magnetic sectors as well as along their boundaries (Antalová 1994a, 1994b, 1995).

The purpose of this article is to shed light on a possible relation between AR-flaring and AR-locations in relation with the sectors where the process of magnetic reversal of the Sun is observed. We analyze the relation between the spatial distribution of the 32 BEARALERT regions (Zirin and Marquette 1990), characterized with 338 daily vectors and long-lasting global magnetic sectors, the latter being typical for a slow reversal of the global magnetic field during an 11-year solar cycle.

Section 2 discusses a possible connection between the locations of magnetic unipolar sectors and LDE–type flares. Section 3 contains the data and the main descriptive parameters characterizing daily values BEARALERT regions as well as the interrelations among variables investigated. In Section 4 we compare the daily values of AR-flaring in accordance with their locations in magnetic sectors and Section 5 is devoted to the analysis of the daily data, first as to AR flare-richness, and then distribution of both subsets (dn and df) according to their relation to three types of magnetic sectors (x7 = '0' (old sector), '1' (boundaries), and '2' (reversed sector)). Finally, Section 6 summarizes our findings.

2. Unveiling a link between the locations of magnetic unipolar sectors and LDE–type flares?

To begin with we should stress that the concept of a boundary of the region where large-scale magnetic fields are of the same polarity is justified only above the source sourface – which lies at approximately 1.5 solar radii above the photosphere, as it is only here where such fields can be regarded as purely radial (Hoeksema 1991). On the other hand, solar flaring occurs at the heights of only some thousand kilometers above the photosphere and, hence, it seems to be unreasonable to try to link these two phenomena. It is also known that long duration SXR flares (of an LDE–type) are often associated with the type II and IV metric radio bursts, microwave richness, Solar Energetic Particle events (SEPs), and with Coronal Mass Ejections (CMEs, Krüger et al. 1989). CME being an indicator of large-scale coronal changes (Burkepile, Hundhausen and Seiden 1994, Watanabe et al. 1994). Cliver (1995) stated: "It is recognized that the long-duration component of flare emission is the by–product of a CME." Large–scale coronal changes and CMEs are located approximately at a height

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Table 1. The mean values and standard deviations obtained for eight analyzed variables of the 338 daily vectors collected in the 32 BEARALERT regions

var.	x1	x2	x3	x4	x5	x6	x7	x8
mean	2.782	1.198	0.744	1.044	1.403	0.725	1.009	1.293
st. dev.	0.438	0.714	0.892	0.605	0.641	0.717	0.791	0.576

of the source surface radius (Zhao and Hoeksema 1994). Hence, a serious connection between LDE–type flare sites (or CMEs) and Hoeksema's unipolar sectors might be envisaged.

2.1. Old and reversed sectors

Magnetic unipolar sectors having the 'correct' polarity of the current solar cycle are those showing a reverse polarity when compared with the polarity of the same solar hemisphere characterizing the minimum phase of the previous cycle (Antalová 1994a). In the 22nd cycle *the sectors of positive magnetic polarity in the northern hemisphere,* as well as those of *negative magnetic polarity in the southern hemisphere,* are the magnetic sectors of *reversed polarity.* The unreversed, or the 'old' 22nd cycle sectors, in the northern (southern) hemisphere have negative (positive) magnetic polarity.

3. ARs data description and analysis

In this paper we analyze the sample of 32 ARs which were classified, after Zirin and Marquette (1990), as BEARALERT regions from December 26, 1987 till November 18, 1989, i. e. 32 regions where the presence of flaring activity was highly probable. Hence, our analysis includes not only the genuine flaring ARs (15 cases), which were endowed with a large number of long-lasting SXR flares (of LDE-type) but also those ARs characterized by impulsive flares only. Collecting such items we obtained our data set of size 338 daily characteristics of BEARALERT regions.

The 338 daily AR characteristics (described by x1 – x8 variables) were gathered from *Solar Geophysical Data* for 32 BEARALERT regions (Zirin and Marquette 1990) observed during their passages across the solar disk. Some of ARs have complete passage (from six days before to six days after the passage across the central meridian (CM)), but some of them have only five – eleven daily values due to their life. Hence, we have collected 338 data vectors altogether. Each individual data vector comprises eight variables denoted as x1, x2, ..., x8, the latter describing daily characteristics of a given AR. The meaning of the variables is as follows:

- x1 (A) - Sunspot Group Area as published in *Solar Geophysical Data*;

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- x2 (MO) - Magnetic Orientation of the sunspot group bipole, '0' means the normal Hale orientation of an AR, '1' stands for the sequence of more than one Hale oriented bipole observed in an AR, '2' denotes the fact that the axis of bipole is tilted by around 90° to the east-west direction, and '3' groups such ARs in which the reversed bipole orientation (i. e. the fact that the following (leading) polarity lies westward (eastward) from an AR center);

- x3 (FI_{LDE}) - The Flare Index computed from all long lasting SXR (LDE–type) flares observed in given ARs in a given day. Let us recall the selection criterium of the LDE-type flares - the flare duration exceeding 2 hours above the quiet SXR GOES level. A list of LDE–type flares was prepared by ourselves (Antalová 1993), after the analysis of the daily Sun SXR profile as observed by GOES – Geostationary Operational Environmental Satellite – and published *in Solar Geophysical Data.* GOES observes the Sun continuously and is able to detect the onset, duration and SXR intensity (1 – 8 Å) of solar flares. The occurrence of LDE-type flares of different GOES classes is weighted with respect to their SXR maxima (e.g. a flare C7.9 has FI = 8 and the correspondinng FI value for an M5.1 flare is 51);

- x4 (FI_I) - The Flare Index of impulsive flares prepared in the same way as the previous one, the only difference being that in this case short lasting flares (of an impulsive-type) are only included.

- x5 (FI_T) - The Total (i.e., x3 + x4) Flare Index of an active region;

- x6 (CHR) - The Relation of an AR to environmental Coronal Holes (CHs): here '0' denotes no existence of any CH close to a given AR, '1' indicates that there is an old solar cycle polarity CH in the vicinity of an AR (CHs of both polar or equatorial type), '2' reveals that a new solar cycle polarity CH (of an equatorial type) is present in the surrounding of an AR, and, finaly, '3' implies the existence of a *polar* CH the vicinity of an AR, whose polarity is identical with that of a new cycle.

- x7 (S) Solar Sectors: '0' shows the location of an AR in an old cycle magnetic polarity sector, '1' – along the sector's boundary, and '2' - when AR is located in the sector with a new cycle polarity (Reversed Sector – RS).

- x8 (FIL) - Association of ARs with H-alpha Filaments: '0' denotes the class when no H-alpha filament is present in an AR, '1' represents an open filament structure with respect to the AR's environment, and '2' indicates a closed filamental cell around an active region.

Because of strong skewness of the original variable distributions of the variables of continuous type x1, x3, x4 and x5 the latter were reduced to a logarithmic scale ($\log_{10}x$). Although four of the variables – x2, x6, x7 and x8 – are of a

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Table 2. The correlation matrix estimated for x1–x8 variables characterizing 338 daily vectors of 32 BEARALERT regions (Zirin and Marquette 1990) where the presence of flaring activity was highly probable. Hence, our analysis includes not only the genuine flaring ARs (15 cases), which were endowed with a large number of long-lasting SXR flares (of LDE-type) but also those ARs characterized by impulsive flares only.

	x1	x2	x3	x4	x5	x6	x7	x8
x1 (A)	1.00							
x2 (MO)	0.33	1.00						
x3 (FI_{LDE})	0.48	0.17	1.00					
x4 (FI_I)	0.46	0.00	0.25	1.00				
x5 (FI_T)	0.58	0.18	0.78	0.71	1.00			
x6 (CHR)	0.00	0.24	0.00	0.00	0.00	1.00		
x7 (S)	0.28	0.47	0.18	0.16	0.23	0.12	1.00	
x8 (FIL)	0.25	0.21	0.22	0.18	0.24	0.00	0.00	1.00

discrete type, our intention is to obtain a general view on the interrelations among the AR characteristics analyzed.

The corresponding equation for the computation of a correlation coefficient r between the variables y and z looks like

$$r = \frac{C}{sd_y sd_z} \tag{1}$$

where

$$C = \frac{1}{n}\sum_{i=1}^{n}(y_i - m_y)(z_i - m_z) \tag{2}$$

C being called the covariance and y_i (z_i), m_y (m_z) and sd_y (sd_z) are the daily value, mean value and standard deviation of a given variable y (z), respectively; to prevent the reader from confusion we use in the last two equation the variable y and z representing x1, x2, ..., x8.

Table 1 presents the mean values and standard deviations of analyzed variables obtained for the data sample of 338 data vectors. The mean values are computed from daily values of all BEARALERT active regions and not only from proper flaring ARs, so large values of standard deviations are expected. For the given sample size (338 daily vectors) and for the significance level $\alpha = 0.05$ the critical value of the correlation coefficient is found to be $r_{crit}(0.05) = 0.11$ which implies that for the cases when an obtained correlation coefficient r is greater than the above-given critical value (0.11) we should reject the null hypothesis (i.e. that there is no correlation between the appropriate variables). Table 2 collects the estimates of the correlation matrix with r values put zero when the estimated r values were < 0.11.Table 2 includes not only the genuine flaring ARs (15 cases), but all 32 BEARALERT ARs. As one can see from Table 2 the sectorial structure (x7, S) of the large-scale magnetic field is in a

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Table 3. 'u1' test: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located in old polarity sectors (x7 = 0, n = 104) with those situated along the boundaries of the sectors (x7 = 1, n = 127). A statistically significant 'u1' test (marked with a lowercase 's') was found for all but one (x6) case.

xi	x7 = 0 mean	n = 104 st.dev.	'u1'	x7 = 1 mean	n = 127 st.dev.
x1 (A)	2.58	0.49	4.94s	2.86	0.37
x2 (MO)	0.76	0.62	5.50s	1.20	0.61
x3 (FI_{LDE})	0.49	0.71	3.16s	0.83	0.92
x4 (FI_I)	0.89	0.62	2.66s	1.10	0.55
x5 (FI_T)	1.17	0.58	3.97s	1.48	0.60
x6 (CHR)	0.71	0.63	1.81	0.56	0.64
x7 (S)	0.00	0.00	0.00	1.00	0.00
x8 (FIL)	1.11	0.54	6.00s	1.52	0.50

statistically significant positive correlation with all other variables but one – the filament association (x8, FIL). The values of correlation coefficient are low but statistically significant with the significance level $\alpha = 0.05$. This is the reason that we want to look more closely at this interrelation. It is also evident that from the variables studied the highest correlation coefficient (r = 0.47) is between magnetic orientation of the sunspot group bipole (x2, MO) and x7 (S). High values of r between the flare indices (x3 – x5) are formal (x5 is the sum of x3 and x4). It should be stressed here that in the above analysis no distinction was made between df and dn subsets; this point will be discussed in detail in Section 5.

4. The sectorial distribution of 338 daily vectors

We discriminate our data set into three subsets in accordance to the values of the variable x7, i.e. to the location of ARs in the magnetic field sectors. The sample sizes of the subsets for x7 = 0, 1 and 2 are equal to 104, 127 and 107, respectively.

Tables 3–5 present the results of the comparison betwen the mean values and standard deviations of the variables x1–x8 with respect to the ARs' location in corresponding magnetic sectors and their boundaries. We use the statistic 'u' test to verify the null hypothesis that the corresponding mean values for the two compared subsets are equal to each other due to the fact that the corresponding standard deviations are very similar.

The statistics 'u' is described as:

$$u = \frac{m_y - m_z}{sd_d} \tag{3}$$

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Table 4. 'u2' test: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located along the boundaries of the sectors (x7 = 1, n = 127) with those situated in sectors of reversed polarity (x7 = 2, n = 107).

compared xi	x7 = 1 mean	n = 127 st.dev.	and 'u2'	x7 = 2 mean	n = 107 st.dev.
x1 (A)	2.86	0.37	0.39	2.88	0.40
x2 (MO)	1.20	0.61	4.90s	1.62	0.67
x3 (FI_{LDE})	0.83	0.92	0.52	0.89	0.97
x4 (FI_I)	1.10	0.55	0.41	1.13	0.63
x5 (FI_T)	1.48	0.60	0.64	1.54	0.68
x6 (CHR)	0.56	0.64	0.83	0.93	0.83
x7 (S)	1.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.52	0.50	4.25s	1.21	0.61

where

$$sd_d = \sqrt{(v_y)/n + (v_z)/n} \quad (4)$$

sd_d being the standard deviation of a variable formed as a difference 'd' between two mean values obtained for the compared two data subsets, m_y (m_z) and v_y (v_z) are the mean value and the variance of a given variable y (z), respectively ; to prevent the reader from confusion we use, like previously, in the last two equations the variables y and z representing the appropriate pair of the variables x1, x2, ..., x8. In accordance with central limit theorem, and if the null hypothese is right, the statistic 'u' has normal distribution with expected value and standard deviation equal to zero and one, respectively.
The notation exploited in Tables 3 – 11 below is as follows:

- 'u1' test – the comparison of the frequency distribution of daily vectors between a subset of ARs which are located in old sectors (x7 = 0) and that containing ARs found along the sector boundaries (x7 = 1);
- 'u2' test – the same as above when ARs are located along the sector boundaries (x7 = 1) and in the sectors of reversed polarity (x7 = 2); and
- 'u3' test – the same as above when ARs are situated in old sectors (x7 = 0) and the sectors of reversed polarity (x7 = 2);
- finally, whenever the values of 'u' are marked by the letter 's' it means statistically significant differences (with respect to the critical value of '$u'_\alpha = 1.96$ at the significance level $\alpha = 0.05$). 'u' = 1.96 is taken from the table of normal distribution, and our 'u1', 'u2', 'u3' values are computed by us and compared with this critical value. "s" marks the obtained 'u1', 'u2' and 'u3' values > 1.96, and means that the null hypothese should be rejected what

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Table 5. 'u3' test: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located in old polarity sectors (x7 = 0, n = 104) with those situated in sectors of reversed polarity (x7 = 2, n = 107).

compared	x7 = 0	n = 104	and	x7 = 2	n = 46
xi	mean	st.dev.	'u3'	mean	st.dev.
x1 (A)	2.58	0.49	4.99s	2.88	0.40
x2(MO)	0.76	0.62	9.70s	1.62	0.67
x3(FI_{LDE})	0.49	0.71	3.46s	0.89	0.97
x4 (FI_I)	0.89	0.62	2.78s	1.13	0.63
x5 (FI_T)	1.17	0.58	4.20s	1.54	0.68
x6 (CHR)	0.71	0.63	2.20s	0.93	0.83
x7 (S)	0.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.11	0.54	1.26	1.21	0.61

we comment as statistically significant difference between the tested mean values.

Let us discuss the results of three tests separately:
In Table 3 we give the comparison of the frequency distribution obtained for the AR subsets located in old sectors (x7 = 0, n = 104) and along the sector boundaries (x7 = 1, n = 107, test 'u1'). For both AR subsets the differences are statistically significant for all but one (x6) variables. Especially high 'u1' values are obtained for the variables x1, x2 and x8. That means that, when ARs are located on the sector boundary, they are observed in average with larger areas, much more complicated magnetic configuration and with more filaments. There is obvious discrepancy in the mean values of x1 – x5 variables and, hence, statistically significant difference in all flare indices (x3–x5). This simply reflects the fact that from 1987 to 1989 the flaring of ARs located along sector boundaries was significantly higher than that of ARs situated in old magnetic sectors.

On the other hand, a negative 'u2' test (Table 4) reveals that there is practically no flaring difference between the ARs located along sector boundaries and those observed in reversed sectors. The significant differences are found only for the magnetic orientation (x2) and for the filament association (x8). The magnetic orientation is in average much more complicated when the ARs are located in sectors with reversed polarity than when they are observed on the sector boundary. However, 'u2' test show, that the flare characteristics have comparable mean values in these two subsets. As mentioned earlier, this concerns only the flaring activity in 1987–1989 BEARALERT regions. We have thus confirmed earlier findings of Bumba and Obridko (1969), Dittmer (1975), as well as McIntosh (1992), indicating that during each phase of a solar cycle flare-rich ARs are invariably seen along a global magnetic neutral line of the Sun. (Let us

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Table 6. 'ul' test in the dn subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of active regions located in old polarity sectors (x7 = 0, n = 55) with those situated along the boundaries of the sectors (x7 = 1, n = 54). The critical value u = 1.96 in dn subset, when the significance level $\alpha = 0.05$.

compared var.	x7 = 0 mean	n = 55 st.dev.	and 'ul'	x7 = 1 mean	n = 54 st.dev.
x1 (A)	2.39	0.55	3.53s	2.73	0.44
x2(MO)	0.65	0.62	4.62s	1.20	0.63
x3(FI_{LDE})	-0.05	0.00	0.00	-0.05	0.00
x4 (FI_I)	0.72	0.62	2.28s	0.98	0.56
x5 (FI_T)	0.86	0.50	2.18s	1.06	0.47
x6 (CHR)	0.62	0.62	0.25	0.65	0.62
x7 (S)	0.00	0.00	0.00	1.00	0.00
x8 (FIL)	1.05	0.36	4.67s	1.44	0.50

recall that the *global magnetic neutral line* coincides with the notion of sector boundaries adopted in this paper). Moreover, our negative 'u2' test also indicates that flare-mighty ARs are situated not only along sector boundaries, but they are also found inside of the sectors of reversed polarity. For example, in the case of an X9.8 flare of September 29, 1989, (characterized by the largest ground-level cosmic ray enhancement ever observed – Kudela et al. 1993) the parent AR – NOAA 5698 – was just situated along sector boundaries; on the other hand, the AR NOAA 6659 (endowed by the largest flares of June 1991 – McIntosh 1993, Antalová 1994) was undoubtedly present inside of an RS.

Table 5 summarizes the results of 'u3' test, which give the same verification as the test 'ul'. Generally the values 'u3' are higher than the appropriate values 'ul', and 'u2' and it is the indirect indication that particularly in the reversed sectors large, magnetically complicated and strongly flaring ARs occure. A close inspection shows considerable difference between the two subsets of ARs in all (i. e. x1 – x6) variables. In particular, the RSs contain ARs with a larger area (x1), more complicated orientation of magnetic bipoles (x2), greater LDE–type and impulsive flaring (x3–x5), as well as with a different Coronal Hole–AR relation (x6). What is obvious, the filaments prefere the sector boundary, and there is no difference in the filament association between the old and reversed sectors.

5. The daily data division with respect to real flare activity in a given day – dn and df subsets

A total of 338 daily vectors were splitted into two subsets: i) dn subset – comprising 155 daily values selected from the whole sample of BEARALERT ARs (Zirin and Marquette 1990) by the criterion that in a given day flare activity

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Table 7. 'u2' test in the dn subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located along the boundaries of the sectors (x7 = 1, n = 54) with those situated in sectors of reversed polarity (x7 = 2, n = 46).

compared var.	x7 = 1 mean	n = 54 st.dev.	and 'u2'	x7 = 2 mean	n = 46 st.dev
x1 (A)	2.73	0.44	0.77	2.67	0.28
x2(MO)	1.20	0.63	3.01s	1.54	0.50
x3(FI_{LDE})	-0.05	0.00	0.00	-0.05	0.00
x4 (FI_I)	0.98	0.56	0.19	1.01	0.66
x5 (FI_T)	1.06	0.47	0.29	1.09	0.57
x6 (CHR)	0.65	0.62	2.25s	1.00	0.89
x7 (S)	1.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.44	0.50	3.11s	1.09	0.63

Table 8. 'u3' test in the dn subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located in old polarity sectors (x7 = 0, n = 55) with those situated in sectors of reversed polarity (x7 = 2, n = 46).

compared var.	x7 = 0 mean	n = 55 st.dev.	and 'u3'	x7 = 2 mean	n = 46 st.dev.
x1 (A)	2.39	0.55	3.30s	2.67	0.28
x2(MO)	0.65	0.62	7.99s	1.54	0.50
x3(FI_{LDE})	-0.05	0.00	0.00	-0.05	0.00
x4 (FI_I)	0.72	0.62	2.19s	1.01	0.66
x5 (FI_T)	0.86	0.50	2.16s	1.09	0.57
x6 (CHR)	0.62	0.62	2.44s	1.00	0.89
x7 (S)	0.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.05	0.36	0.31	1.09	0.63

was small (i. e., when x3 = - 0.05); ii) df subset – 183 daily values representing strong flaring in BEARALERT regions (i. e., when x3 > 0).

5.1. Sectorial distribution of 155 flare-poor daily values – dn subset

As shown in Tables 6 – 11 the two subsets (dn and df) of ARs do not differ appreciably from each other as far as their sectorial distribution is concerned. That is, 'u1' and 'u3' test are positive and 'u2' - negative, which implies that the same results hold as for the original sample. It is also worth mentioning that during the flare-poor days (i.e, dn subset), ARs located inside of RSs show a

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Table 9. 'u1' test in the df subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located in old polarity sectors (x7 = 0, n = 49) with those situated along sector boundaries (x7 = 1, n = 73).

compared	x7 = 0	n = 49	and	x7 = 1	n = 73
var.	mean	st.dev.	'u1'	mean	st.dev.
x1 (A)	2.79	0.28	3.48s	2.97	0.26
x2(MO)	0.88	0.60	2.96s	1.21	0.60
x3(FI_{LDE})	1.09	0.62	3.21s	1.48	0.69
x4 (FI_I)	1.08	0.56	1.05	1.18	0.53
x5 (FI_T)	1.52	0.47	3.08s	1.79	0.50
x6 (CHR)	0.82	0.63	2.73s	0.49	0.65
x7 (S)	0.00	0.00	0.00	1.00	0.00
x8 (FIL)	1.16	0.69	3.61s	1.58	0.50

Table 10. 'u2' test in the df subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located along the boundaries of the sectors (x7 = 1, n = 73) with those situated in sectors of reversed polarity (x7 = 2, n = 61).

compared	x7 = 1	n = 73	and	x7 = 2	n = 61
var.	mean	st.dev.	'u2'	mean	st.dev.
x1 (A)	2.97	0.26	1.35	3.05	0.39
x2(MO)	1.21	0.60	3.86s	1.67	0.77
x3(FI_{LDE})	1.48	0.69	1.06	1.60	0.68
x4 (FI_I)	1.18	0.53	0.40	1.22	0.60
x5 (FI_T)	1.79	0.50	0.84	1.87	0.56
x6 (CHR)	0.49	0.65	3.13s	0.89	0.78
x7 (S)	1.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.58	0.50	2.95s	1.30	0.59

larger spot area (x1), more magnetic complicated groups (x2) as well as greater impulsive flaring (x4 and x5 variables) when compared with the corresponding quantities for old sectors ('u3' test in Table 8).

5.2. The Sectorial Distribution of 183 flare-rich daily values - df subset

In Tables 9–11 the sectorial distribution of the flare-rich daily values is given (df subset). Since the results for this subset are almost identical to those of previous one this can be taken as an indirect verification that all the results obtained are reliable.

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Table 11. 'u3' test in the df subset: comparison of the mean values and the corresponding standard deviations of x1 to x8 between the subsets of ARs located in old polarity sectors (x7 = 0, n = 49) with those situated in sectors of reversed polarity (x7 = 2, n = 61).

compared var.	x7 = 0 mean	n = 49 st.dev.	and 'u3'	x7 = 2 mean	n = 61 st.dev.
x1 (A)	2.79	0.28	3.95s	3.05	0.39
x2(MO)	0.88	0.60	6.09s	1.67	0.77
x3(FI_{LDE})	1.09	0.62	4.11s	1.60	0.68
x4 (FI_I)	1.08	0.56	1.32	1.22	0.60
x5 (FI_T)	1.52	0.47	3.61s	1.87	0.56
x6 (CHR)	0.82	0.63	0.51	0.89	0.78
x7 (S)	0.00	0.00	0.00	2.00	0.00
x8 (FIL)	1.16	0.69	1.07	1.30	0.59

6. Results and Discussion

We have performed a thorough analysis of the sectorial distribution of 32 BEAR-ALERT regions based on the synoptic magnetic maps of modelled source surface fields (Hoeksema 1993). Using the sample of 338 daily values we have arrived at the following results:

1. a general trend of x1–x8 correlation coefficients was found as illustrated in Table 2. The x7 and other xi variables are possitively and significantly correlated;

2. 'u2' tests for all subsets reveal that the *sector boundaries* have the same flaring significance as the *reversed sectors* and that the differences between them are unsignificant. It is, therefore, very probable that there are mainly sector boundaries which are a preferable location of flare-rich ARs during the greater part of a solar cycle;

3. 'u1' and 'u3' tests show significant differences for of flare indices (x3–x5 variables) and for all studied subsets. It means that *old polarity sector ARs* have significantly smaller flaring than ARs observed in *reversed polarity sectors*, or ARs located *along* sector boundaries; slightly rephrased this also means that AR-flaring depends on a sectorial distribution of ARs.

4. 183 flare-richest days (df subset) of the BEARALERT regions observed from 1987 to 1989 years were found to be related to the sectorial distribution because of smaller occurrence of flaring days in ARs located in old sectors (49 cases) when compared with that along sector boundaries (73 cases) or in reversed sectors (61 cases). The presence of a global magnetic reversal process in a given reversed magnetic sector of the Sun seems to be important for

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the development of magnetically complicated and therefore flare-rich sunspot complexes. We suspect that the flare-ability to recognize the large-scale magnetic changes reflecting the global magnetic field reversal process is linked to unbalanced, large-scale magnetic patterns rather than to pulse-like local emergence of an AR magnetic flux. But the question arises why it is related to RS only, when the same unbalanced polarity patterns are also observed in old sectors. Apparent difference between RSs and old sectors is caused by their opposite magnetic polarity, and this obviously play an important role in the interaction of these fields with the local magnetic field of an AR; however, at present this question remains open.

5. The situation for dn subset is completely different because here we have an inhomogenous subset and the 'quiet days' of flare-rich ARs are mixed together with the daily values of genuinely flare-poor ARs.

Acknowledgements. This work has been supported under a Grant 2/506/1995 by the Slovak Academy of Sciences as well as under a Grant 2/P304/02304 of the Polish Committee for Scientific Research.

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