DISTRIBUTION OF FLARE ACTIVITY ON THE SOLAR DISK IN THE YEARS 1937 - 1976

Š. Knoška
Astronomical Institute, Slovak Academy of Sciences
059 60 Tatranská Lomnica, Czechoslovakia

Received 28 September 1984

ABSTRACT. The asymmetry of flare activity on the solar disk is studied in the paper. For this purpose, the flare index was employed, and the variation of the asymmetry is compared with the solar activity variation of the 11-year cycle. No unique relationship was found between the asymmetry of flare activity and the 11-year cycle of solar activity in the interval studied.

РАСПРЕДЕЛЕНИЕ ВСПЫШЕЧНОЙ АКТИВНОСТИ НА СОЛНЕЧНОМ ДИСКЕ В 1937 - 1976. В статье изучена асимметрия вспышечной активности на солнечном диске. Асимметрия изучается при помощи вспышечного индекса и его изменения в сравнении с ходом 11-летнего цикла солнечной активности. В статье неподтвердилась однозначная связь асимметрии вспышечной активности и 11-летнего цикла солнечной активности.

ROZDELENIE ERUPČNEJ AKTIVITY NA SLNEČNOM DISKU V ROKOCH 1937 -1976. V článku je študovaná asymetria erupčnej aktivity na slnečnom disku. Asymetria je študovaná pomocou erupčného indexu a jej chod je porovnaný s priebehom 11-ročného cyklu slnečnej aktivity. Za sledované obdobie sa nepotvrdila jednoznačná súvislosť chodu asymetrie erupčnej aktivity a 11-ročného cyklu slnečnej aktivity.

1. INTRODUCTION

Long-term observations of flare occurrence on the solar disk indicate

that their occurrence in the northern and southern (but also in the eastern and western) part of the solar disk is not uniform, and that more flares occur in one or the other part of the disk in particular intervals. This phenomenon is referred to as asymmetry. Asymmetry can be observed in all manifestations of solar activity.

The problem of asymmetry is encountered in the papers of a large number of authors, e.g. Maunder (1890, 1904), Newton and Milson (1955), Bell (1962), Pajdušáková (1966), Waldmeier (1966), Dodson and Hedeman (1972), Roy (1977). In most of these studied, the principal attention was devoted to the asymmetry in the occurence of sunspots (number, groups, area, etc.) and its relation to the phase of the 11-year cycle of solar activity. In general, however, it may be claimed that direct dependence of the asymmetry on the phase of the 11-year cycle of solar activity has not been proved uniquely for all cycles studied.

Other authors studied the asymmetry of other manifestations of solar activity: Waldmeier (1971) - faculae, the monochromatic and K-corona; Howard (1974) - occurrence of local magnetic fields; Hansen (1975) - prominences; Rušín (1980) - the corona.

The problem of the time variations of the E-W asymmetry of flare activity in dependence on the phase of the 11-year cycle of solar activity was studied by Letfus and Růžičková-Topolová (1980). These authors based their study on the number of flares which occurred on the solar disk. Růžičková-Topolová (1974) studied the E-W and N-S asymmetries of large solar flares (importance ≥ 2), based on their numbers.

In the present paper, the N-S and E-W asymmetries of flare activity are investigated with the aid of the flare index introduced by Kleczek (1952).

2. DATA USED AND METHOD OF THEIR PROCESSING

The basic material used to study the asymmetry of flare activity is the flare index (q), introduced by Kleczek (1952). This diurnal flare index takes into account the duration (t in minutes), the importance (i) and position of all flares on the solar disk. It is determined by the relation

$$q = i.t \qquad (1)$$

and, as the final result, it provides a very good idea of the overall energy emitted during a flare. The flare index was adopted from the papers of Kleczek (1952, 1953), Knoška and Letfus, Catalogue of activity of chromospheric flares 1950 - 1965, and Knoška and Petrášek (1984). In these papers, the flare index was determined for every day in longitudinal zones of 30° separately for the northern and southern hemisphere. The sums of the flare index for the northern (q_N) and southern (q_S) part of the solar disk were calculated from the catalogues for the period 1936 to 1976, as well as for the eastern (q_E) and western (q_W) part (Tab. 1).

Table 1

Rok	q_N	q_S	A_{NS}	q_E	q_W	A_{EW}
1936	12137	15854	-0,13	15241	12750	+0,09
1937	28997	12267	+0,40	20453	20811	-0,01
1938	21175	21630	-0,01	20742	22063	-0,03
1939	15540	23083	-0,20	17862	20761	-0,08
1940	8219	9660	-0,08	8635	9244	-0,03
1941	11137	6123	+0,29	10518	6745	+0,22
1942	4920	5188	-0,03	4084	6024	-0,19
1943	7255	959	+0,77	2478	2467	+0,00
1944	508	1474	-0,49	946	1036	-0,04
1945	1239	4487	-0,57	3332	2394	+0,16
1946	15647	5438	+0,48	12718	8367	+0,21
1947	15991	18072	-0,06	19431	14632	+0,14
1948	14134	14368	-0,01	14374	14128	+0,01
1949	18587	21250	-0,07	19682	19230	+0,01
1950	12590	5324	+0,40	9868	8046	+0,10
1951	7107	5808	+0,10	7079	8836	-0,11
1952	2603	3635	-0,16	3347	2891	+0,07
1953	2392	1287	+0,30	1889	1790	+0,03
1954	183	300	-0,24	381	102	+0,58
1955	5793	5603	+0,02	6740	4656	+0,18
1956	38827	36881	+0,02	42640	33068	+0,13
1957	68811	71537	-0,01	66818	73530	-0,04
1958	67925	82770	-0,09	76835	73860	+0,01
1959	98026	26559	+0,57	66098	58487	+0,06
1960	65489	26647	+0,42	45089	47047	-0,02
1961	25876	14542	+0,28	20167	20251	-0,00
1962	16060	8145	+0,33	12334	11871	+0,02
1963	20118	3521	+0,70	13673	9966	+0,16
1964	7161	1397	+0,67	3522	5036	-0,18
1965	16300	2024	+0,78	9973	8351	+0,09
1966	40725	2204	+0,90	22305	20704	+0,04
1967	46642	19520	+0,41	33553	32609	+0,01
1968	20903	18047	+0,07	20848	18102	+0,07
1969	32331	13831	+0,40	24149	22013	+0,40
1970	33554	18153	+0,30	25928	25779	+0,00
1971	8648	9360	-0,04	8817	9191	-0,02
1972	9421	12175	-0,13	12565	9031	+0,16
1973	6971	7849	-0,06	6919	7901	-0,07
1974	4609	9603	-0,35	5124	9088	-0,28
1975	2494	1175	+0,36	1457	2212	-0,20
1976	2830	4093	-0,18	3728	3195	+0,08

The N-S asymmetry for each year was determined using the relation

$$A_{NS} = (q_N - q_S)/(q_N + q_S) \; ; \qquad (2)$$

the values are given in Tab. 1.

The annual values of the E-W asymmetry of the flare index were calculated in very much the same way using an analogous relation,

$$A_{EW} = (q_E - q_W)/(q_E + q_W) \; , \qquad (3)$$

and are given in Tab. 1.

Using Eqs (2) and (3), the asymmetry of flare activity was determined for part of cycle 17 and for cycles 18, 19 and 20. The time variation of the asymmetry index A was compared with the pattern of the 11-year cycle of solar activity shown in Fig. 1. This pattern is illustrated with the aid of

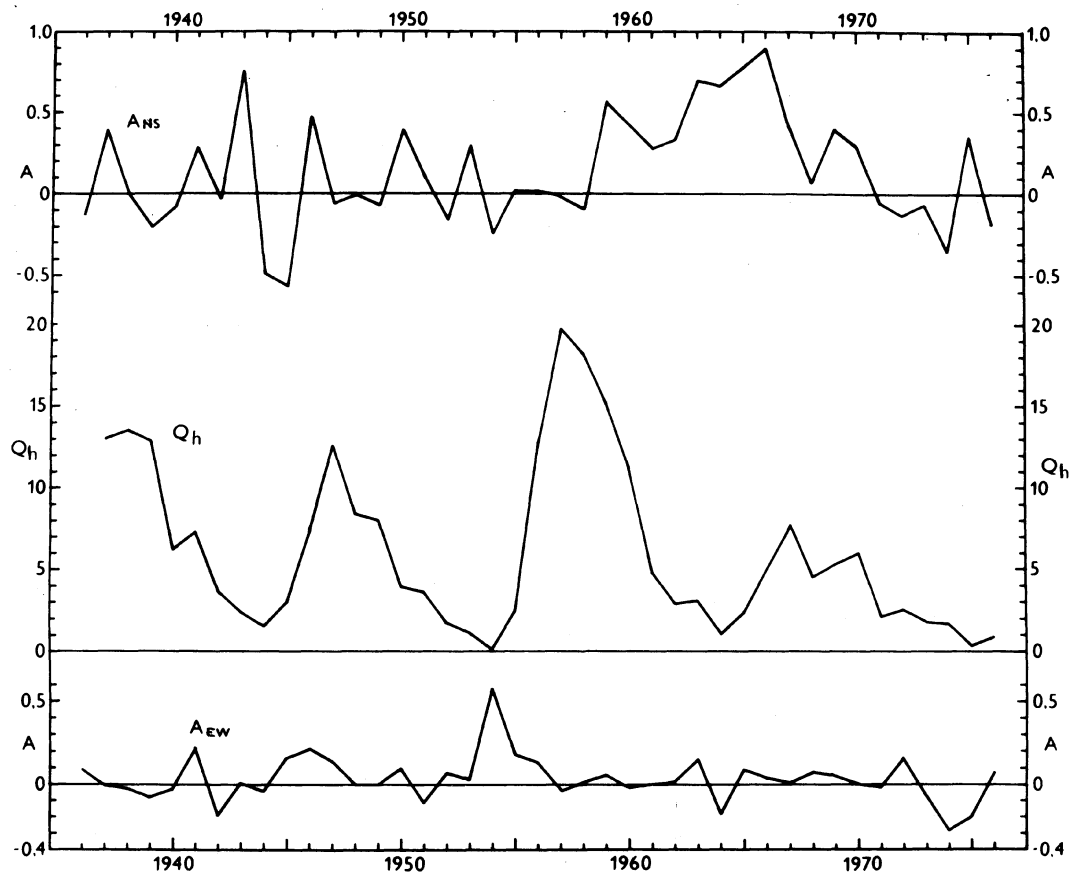

Fig. 1. Asymmetry index A_{NS}, upper curve, asymmetry index A_{EW}, lower curve, and annual average hourly values of the index of flare activity Q_h, middle curve.

annual mean hourly values of the flare index Q_h, determined from Eq. (4):

$$Q_h = \Sigma q / \Sigma t_p \ , \qquad (4)$$

where Σq is the total annual sum of the flare index (q) for the whole disk and Σt_p is the aggregate time of observation per year in hours. The time variation of the mean hourly flare index Q_h correlates very well with the time variation of the mean values of the Zurich relative sunspot number, as can been seen in Fig. 2.

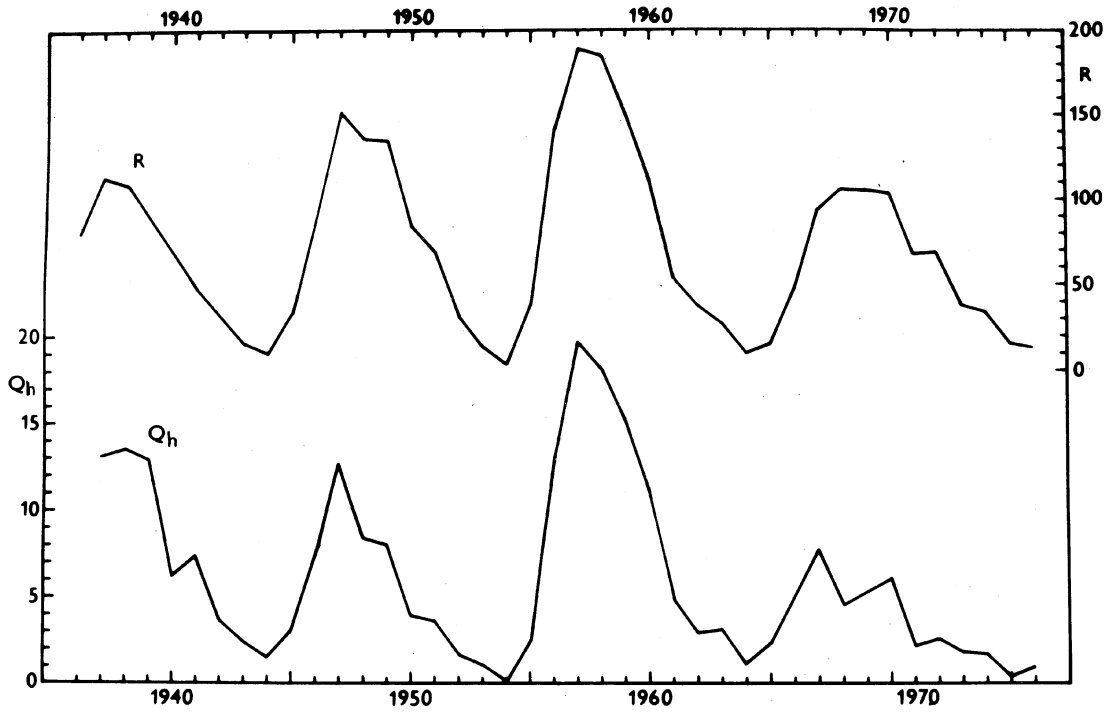

Fig. 2. Flare index Q_h , lover curve, and relative sunspot number R, upper curve.

3. THE N-S ASYMMETRY OF THE FLARE INDEX

The time variation of the index of N-S asymmetry (A_{NS}) for the period 1936 - 1976 being investigated is represented by the upper curve in Fig. 1. One can see at first glance that the behaviour of the asymmetry is not conspicuously regular, and that it can be divided into two different intervals. The first interval covers the years 1936 - 1958 and the second the years 1959 - 1976.

In the first interval, the N-S asymmetry fluctuates and displays considerable variation tending towards positive values. A relatively large posi-

tive asymmetry begins to appear in 1958 and lasts until 1971. In the years 1971 to 1974, the asymmetry is negative with a relatively small amplitude, and, after that, the asymmetry appears to fluctuate again; however, the period being studied ends there. Generally speaking, it may be said that the positive asymmetry of flare activity on the solar disk predominates during the whole period involved.

The comparison of the time variation of the N-S asymmetry of flare activity with the phase of the 11-year cycle of solar activity seems to indicate that the positive asymmetry has a tendency to appear in the neighbourhood of the maximum and descending branch of the cycle, whereas the negative in the neighbourhood of the minimum; however, this is not unique.

4. THE E-W ASYMMETRY OF THE FLARE INDEX

The time variation of the index of E-W asymmetry (A_{EW}) for the period 1936 - 1976 is represented by the lower curve in Fig. 1. The curve clearly shows that the E-W asymmetry of flare activity is small on the whole. The values of the amplitudes oscillate about zero, however, it seems that, on the average, the asymmetry is positive. At the time of low activity, around the minimum between cycle 17 and 18 and also between cycle 18 and 19, an enhanced positive asymmetry can be observed, whereas the asymmetry was negative in the neighbourhood of the minimum after cycle 20.

In comparing the time variation of the E-W asymmetry of flare activity with the phase of the 11-year cycle (Fig. 1) no unique relationship between the two patterns was found.

5. CONCLUSION

In studying the asymmetry of the flare index for the period 1936 to 1976, no unique relationship was found between the time variation of the flare activity and the phase of the 11-year cycle of solar activity, either for the N-S or for the E-W asymmetry. This conclusion supports the opinion that each individual 11-year cycle of solar activity displays individual behaviour as a separate element independent of the other cycles, which was pointed out by Kopecký (1981).

REFERENCES

Bell, B.: 1962, Smithsonian Contr. Astrophys. 5, 187.
Dodson, H. W., Hedeman, E. R.: 1972, in The Solar-Terrestrial Physics 1970 (Ed. E. R. Deyer), D. Reidel Publ. Co., Dordrecht-Holland, p. 151.
Hansen, R. T., Hansen, S. F.: 1975, Solar Phys. 44, 225.
Howard, R.: 1974, Solar Phys. 38, 59.

Kleczek, J.: 1952, Publ. Inst. Centr. Astron., No. 22, Prague.
- : 1953, Publ. Obs. Astrophys. Acad. Tchécosl. Sci. Ondřejov, No. 24, Prague.
Knoška, Š., Letfus, V.: Catalogue of Activity of the Solar Flares 1950 - 1965 (unpublished).
Knoška, Š., Petrášek, J.: 1984, Contr. Astron. Obs. Skalnaté Pleso 12, 165.
Kopecký, M.: 1981, Phys. Solariter. 16, 33.
Letfus, V., Růžičková-Topolová, B.: 1980, Bull. Astron. Inst. Czechosl. 31, 232.
Maunder, E. W.: 1890, Monthly Notices Roy. Astron. Soc. 50, 251.
- : 1904, Monthly Notices Roy. Astron. Soc. 64, 747.
Newton, H. W., Milson, A. S.: 1955, Monthly Notices Roy. Astron. Soc. 115, 398.
Pajdušáková, L.: 1966, Contr. Astron. Obs. Skalnaté Pleso 3, 6.
Roy, J. R.: 1977, Solar Phys. 52, 53.
Rušín, V.: 1980, Bull. Astron. Inst. Czechosl. 31, 9.
Růžičková-Topolová, B.: 1974, Bull. Inst. Astron. Czechosl. 25, 345.
Waldmeier, M.: 1966, in The Proccedings of the Meeting on Sunspots (Eds. G. Righini, G. Barbera), Firenze, p. 41.
- : 1971, Solar Phys. 20, 332.