COMPARING THE MARCH 1989 SUNSPOT GROUP WITH OTHER GREAT GROUPS OF THE PAST

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Received 23 June 1989

Abstract

A large sunspot group transited the Sun's disk during March 1989. The cluster is compared according to size, appearance and intensity of related geomagnetic storm conditions with other groups which have exhibited maximum areas greater than 3000 millionths solar hemisphere.

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The great cluster of sunspots (National Oceanic and Atmospheric Administrative Region 5395; Mt. Wilson 25081) which was visible on the Sun between 6 and 19 March 1989 produced eleven X-level, and forty-eight M-level x-ray solar flares (**Solar-Geophysical Data**, May 1989). The frequency and intensity of the geomagnetic storms that resulted from this activity were among the highest ever recorded (Allen 1989). Several indices which describe the solar-terrestrial environment during March are shown graphically in **Solar-Geophysical Data** (April 1989).

The sunspot complex which generated these events is pictured in Figure 1, a photograph taken 12 March at Sacramento Peak Observatory near 4750A. Region 5395 was located in latitude thirty-four degrees north, the highest recorded location for a group of this size range (see Table I). The cluster attained a maximum area of 3583 millionths solar hemisphere on 15 March (**Solar-Geophysical Data**, May 1989) making it the ninth-largest of record according to data provided in Table I.

During its March disk passage, the region was optically classified Ekc or Fkc. At its maximum east-west growth on the 17th, the group spread across the nearly thirty degrees of longitude. Many individual sunspots could be counted within the boundaries of an essentially single, asymmetric penumbra (**PRF**, 707).

When the longitudinal extent of the largest penumbra of a group exceeds five degrees it is highly probable that both magnetic polarities exist within the same penumbra. In the case of Region 5395 opposite polarities occurred within two degrees of one another, and the group was magnetically classified beta-gamma-delta, a category noted for its high probability for flare production (**Solar-Geophysical Data** 1986). The group's magnetic polarity was normal for a sunspot cycle twenty-two group in the northern hemisphere. That is, the preceding spots, although of mixed polarity, were primarily negative.

The cluster maintained its structure and complexity during all its March transit. By its return on 2 April, the region (now numbered 5440) had simplified considerably into an area of spotless plage. However, it still managed two moderate-level flare events while rotating over the eastern limb. The area disappeared later during the April passage after producing a few tiny spots.

Although Region 5395 was large, several earlier groups have exceeded its size. Table I lists some of the characteristics for groups with maximum areas greater than 3000 millionths solar hemisphere. Since an area of 1000 millionths is equivalent to 1174 million square miles, these groups all occupied areas greater than 3.5

billion square miles. Both northern and southern hemisphere groups emerged at latitudes that averaged nineteen degrees.

Differences among results obtained with various techniques for measuring group areas are common (Waldmeier 1978). For this reason, we have generally restricted the data provided in Table I to that derived photographically at Royal Greenwich Observatory (Newton 1954; Greenwich 1955) and to that presented by Kopecky and Kotrc (1974) and Kopecky (1982). The latter two studies are also based upon the long Greenwich series which ended in 1976. After 1976 information has been taken from **Solar-Geophysical Data.**

It is customary to count each group to which a new member is assigned as a separate cluster, even though it may not actually be new. Thus, several of the groups listed in Table I are actually return transits of the same long-lasting spot complex. It is interesting that the five largest groups occurred during sunspot cycle eighteen, and that fifty percent of the remaining groups erupted during cycle seventeen.

The huge group with central meridian passage during April 1947 is the largest ever recorded. The cluster first appeared as a rather unimpressive area of small spots on 5 February. However, its growth rate was so rapid that only two days later it was large enough to be seen without optical aid (Hoge 1947). When the group reappeared on the eastern limb in early March, it had formed into one huge complex of spots. This group ranks fifth according to maximum area, and may be the largest recorded group of spots within a single penumbra. Measurements of its area range between 4554 (Newton 1954) and 4300 millionths solar hemisphere (Hoge 1947).

During its second return in April, the cluster was separated into an optically bipolar structure and attained its maximum size. Photographs of this group suggest a maximum area between 6132 (Newton 1954) and 5400 millionths solar hemisphere (Nicholson 1948). Several small flares were observed within the spot complex during its lifetime (Hoge 1947). However, no major flare activity was associated with it, and the geomagnetic field was mostly undisturbed throughout its four appearances.

The second largest of these great groups appeared in late January and February of 1946. Newton (1954) found its maximum size to be 5202 millionths, while Ellison (1946) suggested an area of 4900 millionths solar hemisphere, indicating that the group covered around six billion square miles. At maximum growth, the large follower penumbra of this bipolar group occupied an area of nearly 3800 millionths (Nicholson and Hickox 1946). Thus, the trailing portion of this group was larger by itself than the entire March 1989 region. Until the arrival of the March 1947 group, this was the largest single cluster ever recorded.

The group changed little during this disk passage, and on its return measured nearly thirty-six degrees in length (220,000 miles) although its structure had simplified to a considerable extent (Nicholson and Hickox 1946). During its initial transit, this spot complex produced several large flares. Their cumulative effect resulted in an extended period of major geomagnetic storm conditions (Newton 1946a).

Before the appearance of this group, the largest to be recorded had erupted during January 1926 (Mulders 1947). However, its area was nearly fifty percent smaller than the 1946 spot complex.

Another very large sunspot group erupted during May 1951. The active area that contained this group may have produced spots as early as February. Since the cluster made its last appearance in July, one hundred forty-five days later, this group may be the longest-lasting spot complex on record. No significant geomagnetic storms have been associated with this cluster (Nicholson 1952).

The sunspot group which transited the disk between 19 July and 2 August 1946 was similar in appearance to Region 5395. However, this region produced only one great flare, on 25 July (Newton 1946b). The event lasted nearly three hours, causing severe communications disruptions within a few minutes of its maximum (Nicholson 1946). An associated geomagnetic storm began on 27 July but ended that same day, and the group began to decay shortly thereafter. According to Newton (1954) this cluster ranks fourth among the largest groups ever observed.

On the average, great sunspot groups do not occur in concert with peaks of the smoothed relative sunspot number. For those listed in Table I, the average occurrences are for 0.9 years before, and 2.0 years after, sunspot maximum. These values are in good agreement with results determined previously by H. W. Newton of Royal Greenwich Observatory, for fifty-four groups with areas over 1500 millionths solar hemisphere (Newton 1954).

Likewise, the strongest flares usually occur one or more years after sunspot maximum. Harold Zirin has suggested one explanation for this apparent contradiction (Zirin 1988). Zirin feels that the lag may be related to the moderately-sized instruments that are employed in the determination of the relative sunspot number. If this is correct, a peak sunspot number derived from observations made with very powerful telescopes with all spots resolved, could coincide with the maximum number of great flares.

We leave it to others to rank the flare activity of Region 5395 compared with that of previous groups. However, it seems obvious that the high level of March activity will place the region among the greatest flare producers since the discovery of this phenomenon by Carrington and Hodgson in 1859.

We wish to thank Thomas A. Cragg of the Anglo-Australian Observatory, New South Wales, for suggesting the topic of this short paper. We are also indebted to AAVSO Solar Division/American Sunspot Program collaborator Thomas G. Compton for supplying the superb photograph of Region 5395, through the courtesy of Dr. Donald F. Neidig, National Solar Observatory at Sacramento Peak. Data used in this study for years after 1976 were provided by WDC-A for Solar-Terrestrial Physics, NOAA E/GC2, 325 Broadway, Boulder, CO 80303, USA.

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TABLE I

Sunspot Groups with Maximum Areas Greater than 3000 Millionths Solar Hemisphere Recorded Between 1874.0 and 1989.3

Year	CMP	Area[1] Mean	Max	Latitude	Sunspot Maximum ±	Intense[2] Geomag. Storms
1947.3	April	5520	6132	-24	-0.2 years	No
1946.2	February	4779	5202	+26	-1.3	Yes
1951.4	May	3743	4865	+13	+3.9	No
1946.6	July	3958	4720	+22	-0.9	Yes
1947.3	March	3637	4554	-23	-0.2	No
1926.1	January	3285	3716	+21	-2.3	Yes
1938.1	January	2955	3627	+17	+0.7	Yes
1917.2	February	2176	3590	-16	-0.4	No
1989.3[3]	March	2735	3583	+34	---	Yes
1938.6	July	2122	3379	-12	+1.2	No
1937.8	October	2661	3340	+ 9	-0.4	No
1905.2	February	2801	3339	-15	-1.8	No
1937.6	July	2589	3303	+31	-0.2	No
1968.1	January	2383	3202	+13	-0.8	No
1917.7	August	2389	3178	+16	+0.1	Yes
1941.8	September	1862	3088	+12	+4.4	Yes
1939.8	September	1751	3054	-14	+2.4	No
1892.2	February	2638	3038	-28	-1.9	Yes
1938.8	October	2654	3003	+17	+1.4	No

Notes

[1]Areas are expressed in millionths of the solar hemisphere and are corrected for foreshortening. Mean areas are averages of daily measurements obtained when the group was within eighty degrees of the central meridian.

[2]Intense geomagnetic storms are those with D at least sixty minutes, or 300 γ in H or Z (Newton 1954; **Solar-Geophysical Data** 1986).

[3]**Solar-Geophysical Data** (May 1989). Mean and maximum areas are averages determined from information supplied by the eight NOAA/USAF astronomical stations.

Figure 1. The great sunspot group of March 1989. North is to the top of this photograph taken 12 March at the National Solar Observatory at Sacramento Peak, at 4275 Angstroms.