THE STATUS OF SUNSPOT CYCLE 22 THROUGH JULY 1990

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Abstract

The performance of several indices of solar activity during the rise of cycle 22 is described. The northern hemisphere is seen as the more active hemisphere when the relative sunspot number is considered, although the southern hemisphere has spawned the greater number of strong solar x-ray flares.

1. Introduction

The current sunspot cycle, number 22 in the series which began with the minimum of the first numbered cycle in 1755, reached its initial maximum with the July 1989 smoothed-mean relative sunspot number. Although this index declined during the ensuing six months, an examination of the history of the sunspot cycle indicates that occasional periods of high activity are likely to occur through mid-1992. However, for now it is unclear if cycle 22 will develop beyond its previous peak.

Generally the maximum phase is extended for even-numbered cycles, and their intensity is almost always less than in the odd-numbered cycle which precedes them (e.g., Bray and Loughhead 1965). This has been true for the strength of cycle 22, but of course it is too early to define the time spent at maximum. If the 1989 peak does prove to be the eventual maximum, the rise-time for cycle 22 (2.83 years) will be the shortest on record, and the cycle will be the fourth strongest of all those which have occurred since the first telescopic observations by Galileo in 1610.

2. Sunspot Latitudes

In the middle of the nineteenth century, Richard Carrington discovered that sunspot groups do not erupt at random locations as a new cycle develops (Carrington 1858). Instead, Carrington found that spots emerge at high spot-latitudes (30°-35°) at the cycle's onset and progressively closer to the equator as it proceeds. By the time the cycle ends around eleven years after it began, new groups erupt near an average latitude of 7°.

When the heliographic positions of these spot clusters are plotted against time, the classic "butterfly" pattern appears. Figure 1 demonstrates this characteristic of the sunspot cycle for the ascending branch of cycle 22. The diagram is based upon data taken from *Solar-Geophysical Data* (SGD), Part I, for April 1985, when the first spots from the new cycle appeared, through April 1990, and from observations gathered by the USAF/Space Environment Services Center (SESC) network for May, June, and July 1990 (*Preliminary Report and Forecast of Solar Geophysical Data* (PRF), Nos. 766-779).

3. Radio Activity

Solar activity can also be measured according to fluctuations in the Sun's radio

emission at a wavelength of 10.7 cm (2800 MHz). Radio flux emissions originate in the higher regions of the chromosphere and lower corona, and generally parallel the sunspot index (Zirin 1988). We have taken our data from SGD after they have been adjusted to reflect an Earth-Sun distance of one Astronomical Unit, a normalizing process which is necessitated by the eccentric orbit of the Earth in its annual path around the Sun. The performance of cycle 22 as measured by monthly averages of flux emission is shown in Figure 2.

4. North-South Differences

For many years it has been apparent that solar cycles do not necessarily develop equally in the Sun's northern and southern hemispheres (e.g., Zirin 1988). The peak spot number in one hemisphere can be delayed by a year or more with respect to the opposite hemisphere and their maximum intensities often vary widely as well. During cycle 18 the southern hemisphere was more active, but recently the northern hemisphere has been dominant, a situation which has continued through the ascending phase of cycle 22. Figure 3 depicts this development during the latter portion of the rising branch. The diagram is based upon estimates of sunspot activity which were obtained by the USAF/SESC network and appear in PRF, Nos. 695-779. The values which are shown in Figure 3 have been adjusted so that they approximate the American Relative Sunspot Number. This was accomplished by multiplying the original data by 0.745, a scaling factor which resulted from a statistical comparison of the two series for an interval extending from December 1988 to June 1990. It is apparent that sunspot activity has been slightly higher, and has peaked earlier, in the northern hemisphere.

When the Sun's hemispheric activity level is measured by less traditional means, a different picture can emerge. For example, during the current cycle the Sun's southern hemisphere has been the principal source of strong x-ray flares, which we define as those with a maximum energy output at the "M"or "X" level. The x-ray events are ranked by their intensity according to a peak flux threshold, which in the case of M- and X-level flares equals or exceeds $10E^{-5}$ and $10E^{-4}$ watts/square meter, respectively. A complete description of these classifications can be found in the *SESC Descriptive Text.*

Solar x-ray flares are detected and measured by the Geostationary Operational Environmental Satellites at wavelengths between 1 and 8 Angstroms. Figure 4 shows the number of M- and X-level events which have been associated with each hemisphere according to information presented in SGD, Part II, 000.0Nos. 511-550, and provisionally in PRF, Nos. 749-779. This data set extends from the beginning of solar cycle 22 (September 1986) through July 1990. Those data which are represented by the final bar were not assigned a location in the literature, and consist of four X-level, and 144 M-level flares.

Figure 5 compares the Sun's monthly output of M- and X-level flares and the number of Grouped Solar Flares (SGD, 550) with the smoothed monthly-mean American Relative Sunspot Number, during the ascent of the current cycle. When flares are "grouped," all recorded flares, rather than only x-ray events, are included in the totals. Flares which are observed by more than one station are counted as one event. Smoothed monthly-mean sunspot numbers have been reduced from data which were obtained by the AAVSO Solar Division's international sunspot observer network (*AAVSO Solar Bulletin*, 1987-90).

We note the appearance of a pronounced increase in the numbers of both M/X level and grouped flares on a time scale which varies between two and four months. As one would expect, this phenomenon is also reflected in the (unsmoothed) monthly sunspot number, although not with the degree of regularity which is displayed by the other indices. One explanation for this effect would relate the variation to the return of solar

longitudes which are particularly active at intervals of two or more synodic rotations.

References

AAVSO Solar Bulletin, **43**, No. 3 - **46**, No. 7, ed. P. O. Taylor, AAVSO, Cambridge, MA.

Bray, R. J., and Loughhead, R. E. 1965, *Sunspots*, John Wiley and Sons Inc., New York, NY.

Carrington, R. 1858, *Mon. Not. Roy. Astron. Soc.*, **19**, 1.

Preliminary Report and Forecast of Solar Geophysical Data, 1987, Descriptive Text, Space Environment Services Center, Boulder, CO 80303 USA.

Preliminary Report and Forecast of Solar Geophysical Data, Nos. 695-779, Space Environment Services Center, Boulder, CO.

Solar-Geophysical Data, Parts I and II, Nos. 511-550, ed. H. Coffey, National Oceanic and Atmospheric Administration, Boulder, CO.

Zirin, H. 1988, *Astrophysics of the Sun*, Cambridge University Press, Cambridge.

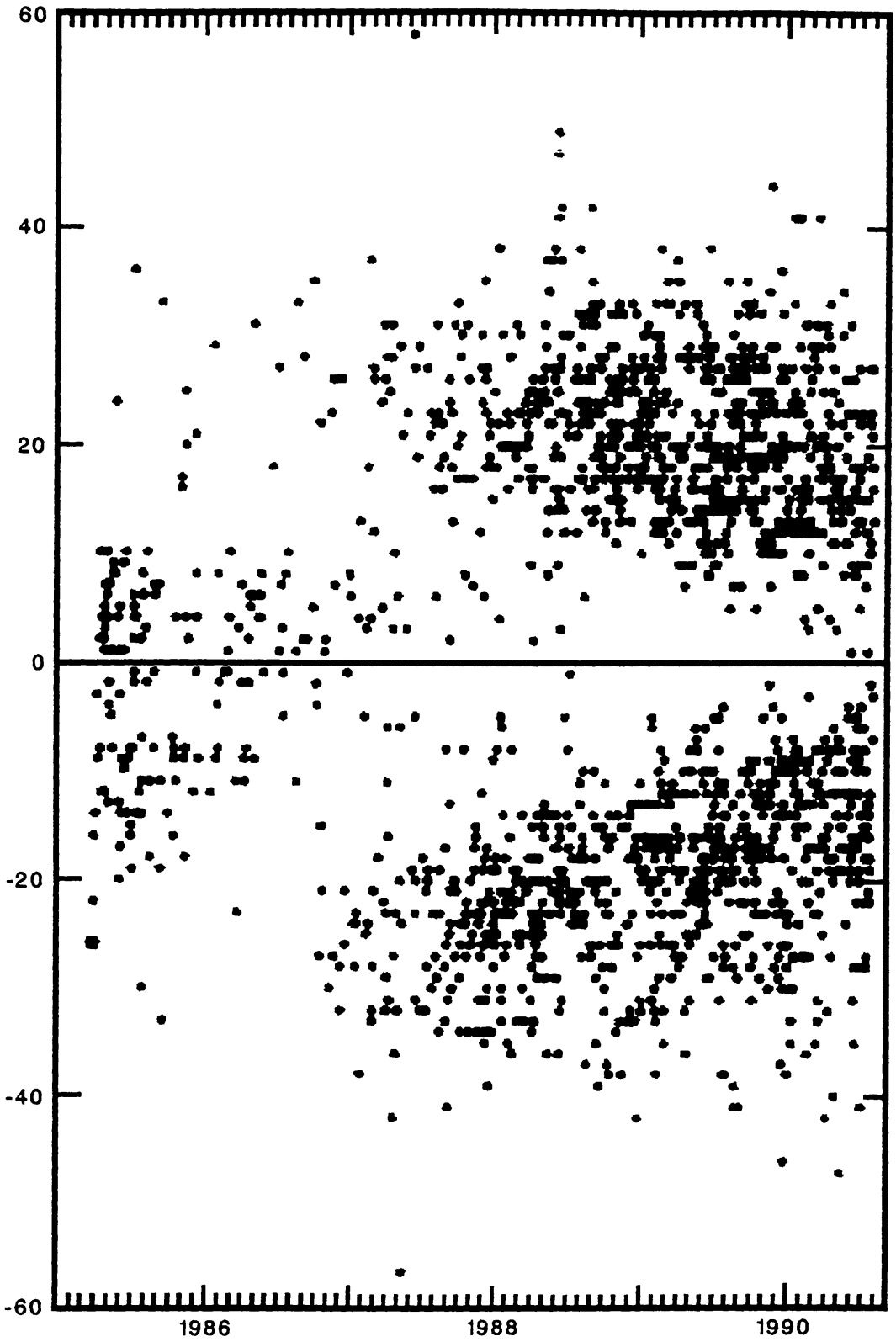

Figure 1. This version of the "butterfly diagram" shows the initial positions of sunspot groups which emerged between April 1985, when the first groups from cycle 22 appeared, and July 1990.

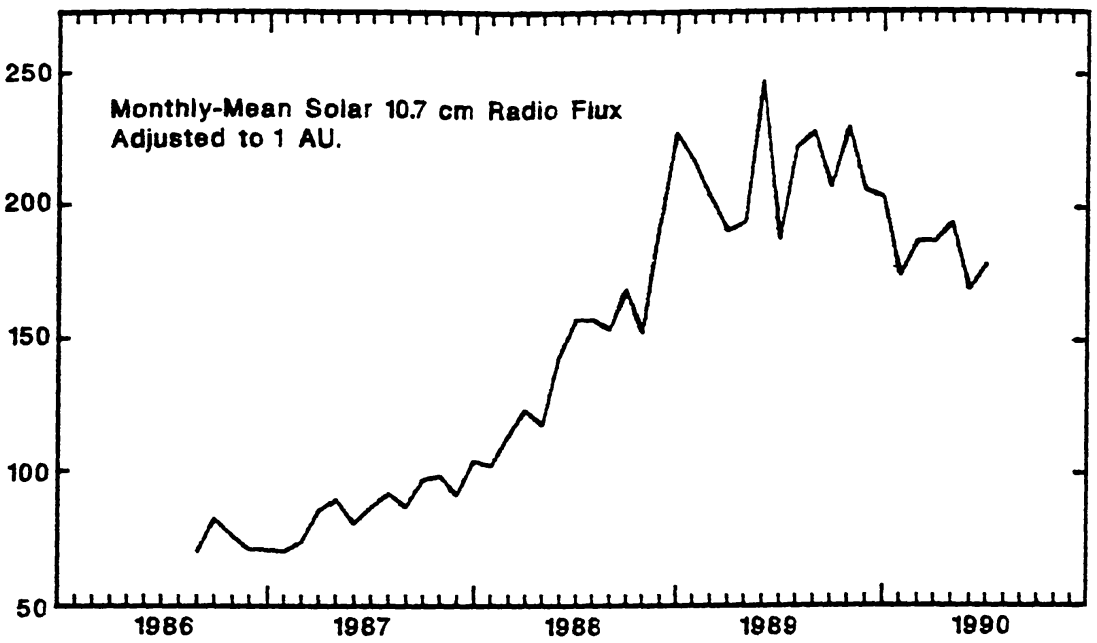

Figure 2. The solar cycle can also be measured by changes in the emission of radio flux at a wavelength of 10.7 cm (2800 MHz). The diagram is a plot of this activity between September 1986 and July 1990, after adjustment for annual variations in the distance between the Sun and Earth.

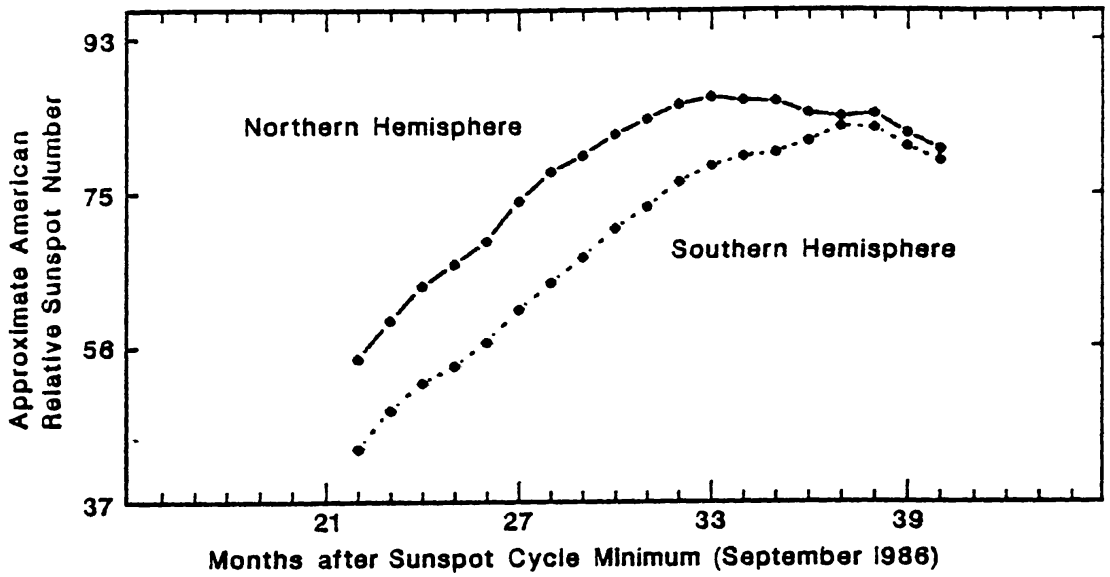

Figure 3. During the ascent of cycle 22, the northern hemisphere has been slightly more active than its southern counterpart when activity is measured by sunspot numbers. The data represented in the figure have been adjusted so that they are approximately equivalent to the American Relative Sunspot Number (see text).

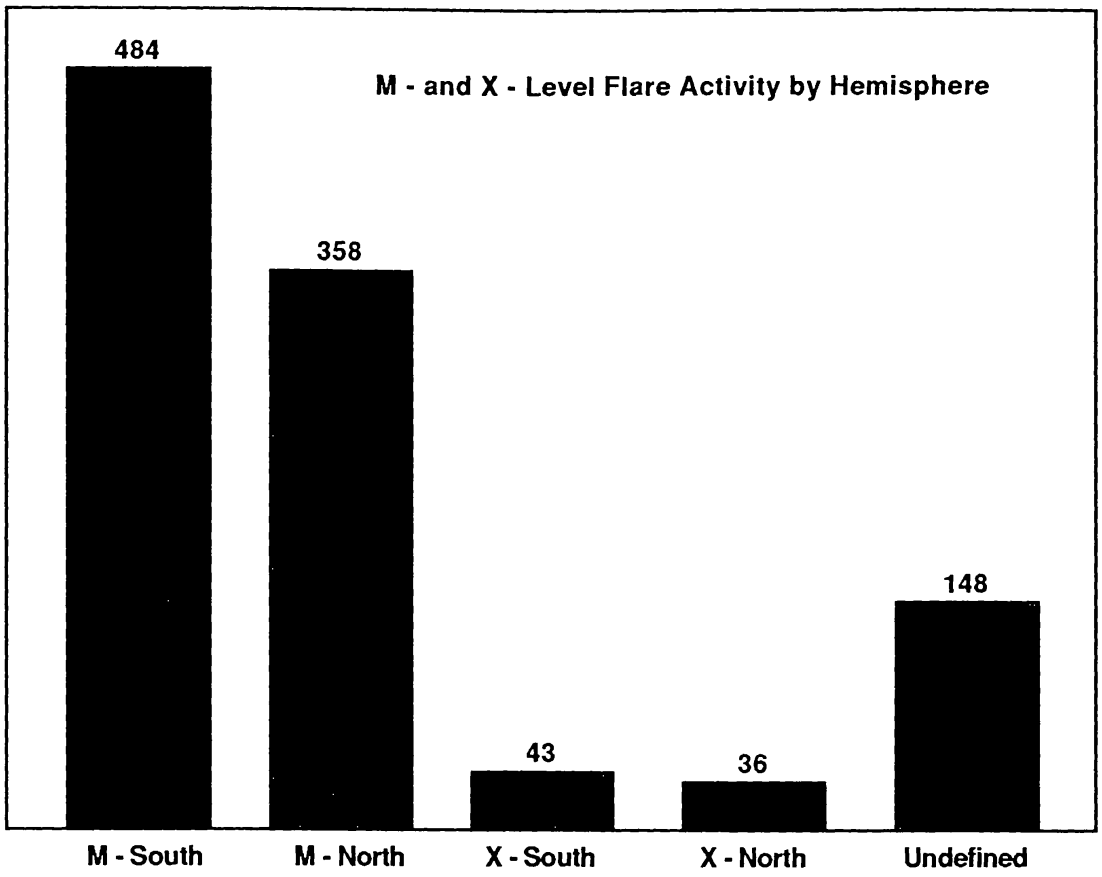

Figure 4. When solar activity during the rise of the current cycle is measured by the production of strong x-ray flares, the southern hemisphere is the more active hemisphere. Those solar flares that are represented by the final bar are optically un-correlated events which cannot be assigned a precise location.

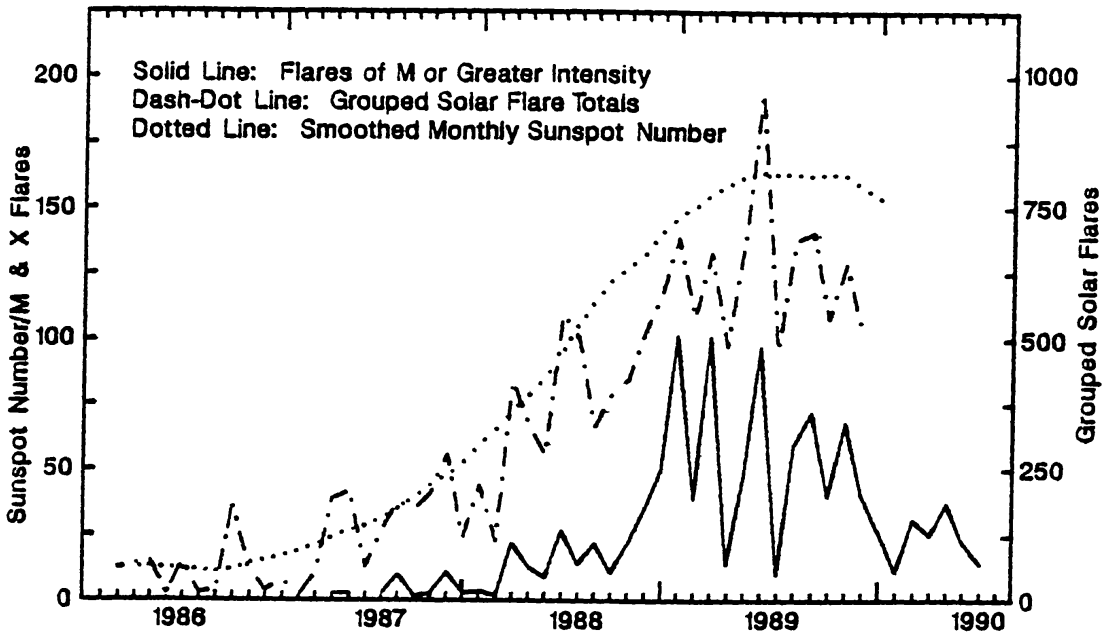

Figure 5. A comparison of solar flare activity and the smoothed-mean American Relative Sunspot Number. Monthly totals of Grouped Solar Flares include all observed flares regardless of intensity, and count events which are recorded by multiple stations as one. Note the appearance of a distinct pulse in flare activity on a time scale which varies between two and four months.