

# The size of the Carrington Event sunspot group

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The size of the sunspot group that produced the white-light solar flare observed by Carrington and Hodgson in 1859 is measured and compared with the size of sunspot groups since 1874.

On 1859 Sept 1, Richard Carrington and Richard Hodgson independently observed one of the first documented white-light solar flares.<sup>1,2</sup> The recording of this flare and the subsequent magnetic disturbances and aurorae is well known and documented; for example, see King (2009) and Hayakawa *et al.* (2019).<sup>3,4</sup> But how large was the sunspot group that produced this flare and how does its size compare with other recorded sunspot groups?

Figure 1 shows Carrington's drawing for the day of the white-light flare (from Hayakawa *et al.*, 2019) after being modified (background removal and conversion to a mask, coloured red) and input into the author's *Helio Viewer* software.<sup>5</sup> Various heliographic parameters are shown in the left panel for the time of Carrington's drawing. Superimposed are Carrington's latitude and longitude of various individual sunspots for his group number 520 (green crosses).<sup>6</sup> Note that Carrington's longitude values have been corrected by  $-7.99^\circ$ .<sup>7,8</sup> *Helio Viewer* calculates the area of each red-mask pixel, corrected for foreshortening, within a user-specified rectangle.<sup>9</sup>

The area within the blue box is calculated to be 3,100 millionths of the Sun's visible hemisphere (MSH). Although the small sunspot above the box was included as part of the main group by Carrington, it would nowadays be marked as a separate group, being more than  $5^\circ$  in latitude from the sunspots within the box (the mean heliographic position of the main group is at  $18^\circ\text{N}/96^\circ$  while the sunspot above the box is at  $28^\circ\text{N}/107^\circ$ ).

A group area of 3,100 MSH is just over half the 6,132 MSH area of the largest recorded sunspot group, which occurred on

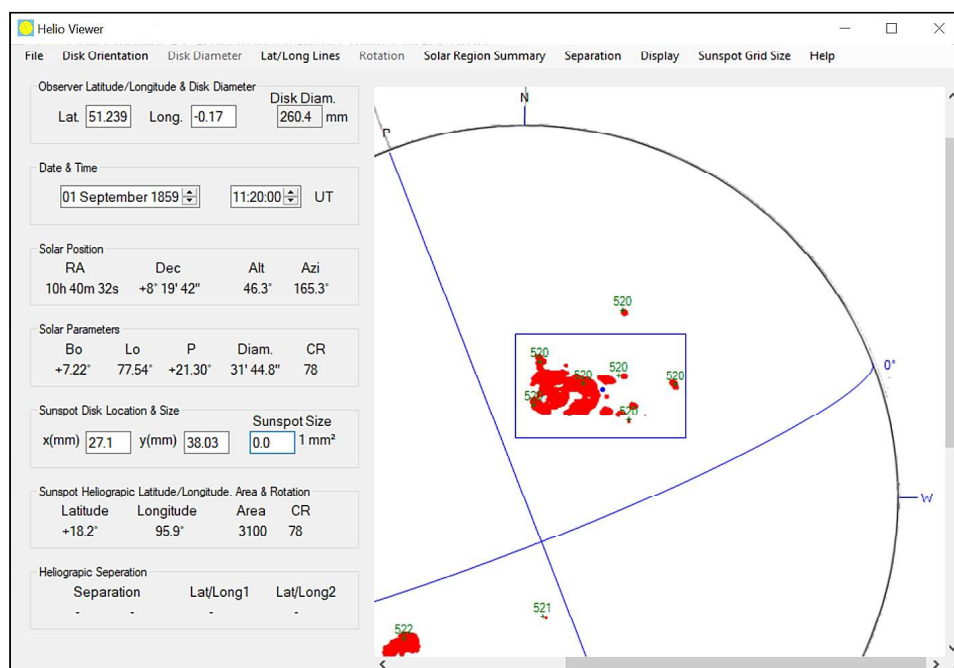


Figure 1. Area measurement of the Carrington Event sunspot group, shown in the *Helio Viewer* software.

1947 Apr 8. It would also be in 24th place if it were included in a list of the largest groups recorded since 1874 (Table 1).<sup>10</sup>

Thus, the Carrington and Hodgson white-light flare did not occur in the very largest of the recorded sunspot groups but in a group that was, for example, smaller than the largest group from the last solar cycle: AR 12192 on 2014 Oct 24 at 4,419 MSH. If sunspot group area were the only factor in the generation of white-light flares, there would have been many more instances of Carrington and Hodgson's disruptive event since 1859.

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Table 1. Largest recorded sunspot groups

|    | Group | Date        | Area (MSH) |
|----|-------|-------------|------------|
| 1  | 14886 | 1947 Apr 08 | 6132       |
| 2  | 14417 | 1946 Feb 07 | 5202       |
| 3  | 16763 | 1951 May 19 | 4865       |
| 4  | 14585 | 1946 Jul 29 | 4720       |
| 5  | 14851 | 1947 Mar 12 | 4554       |
| 6  | 12192 | 2014 Oct 24 | 4419       |
| 7  | 5395  | 1989 Mar 14 | 4201       |
| 8  | 6368  | 1990 Nov 16 | 3872       |
| 9  | 9861  | 1926 Jan 19 | 3716       |
| 10 | 12673 | 1938 Jan 21 | 3627       |
| 11 | 7977  | 1917 Feb 14 | 3590       |
| 12 | 10486 | 2003 Nov 01 | 3388       |
| 13 | 9393  | 2001 Mar 29 | 3387       |
| 14 | 12902 | 1938 Jul 20 | 3379       |
| 15 | 12553 | 1937 Oct 05 | 3340       |
| 16 | 5441  | 1905 Feb 02 | 3339       |
| 17 | 12455 | 1937 Jul 28 | 3303       |
| 18 | 4474  | 1984 Apr 26 | 3274       |
| 19 | 6555  | 1991 Mar 23 | 3257       |
| 20 | 5528  | 1989 Jun 16 | 3249       |
| 21 | 6850  | 1991 Oct 27 | 3234       |
| 22 | 21482 | 1968 Feb 01 | 3202       |
| 23 | 8181  | 1917 Aug 09 | 3178       |
| 24 | 520   | 1859 Sep 01 | 3100       |

The group numbers are Greenwich numbers prior to 1977, National Oceanic and Atmospheric Administration (NOAA) numbers since the start of 1977, and Carrington’s group number, 520.

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ADDED IN PROOF:

The great sunspot group of 2024 May, AR 13364, achieved a peak area of 3400 MSH thus demoting Carrington’s group 520 to 25th place in Table 1.

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