

Monitoring Solar Activity Trends With a Simple Sunspotter

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Abstract With the Sun now in solar maximum, solar observations are a timely means to interest students and the general public in astronomy in general and variable stars in particular. The commercially produced Sunspotter is a solar projection system that allows for safer solar observations by several individuals simultaneously. Educational uses for the Sunspotter are reviewed, and the ability of the instrument to track trends in the sunspot cycle (compared to a standard telescope and the American Relative Sunspot Number (R_a)) is examined.

1. Introduction

One of the areas where students and amateur astronomers have provided a valuable service to the discipline is in the field of solar observing. For example, Elizabeth Brown led the Solar Section of the Liverpool Astronomical Society in the 1880s, and then the British Astronomical Association in the 1890s. She aggregated the sunspot counts and drawings of other amateurs for use by the Greenwich Royal Observatory and other scientists interested in the growing field of solar astronomy (Brück 2009). In the United States, Vassar College astronomy professor Maria Mitchell set her students to work at first observing and then photographing the Sun as early as 1874 (Mitchell 1890). These observations were published in *Scientific American* nearly monthly between January 1875 and January 1881.

The most commonly used protocol for reporting sunspot activity is the Wolf Number, defined in 1848 by Bern Observatory Director Rudolf Wolf as $10g+s$, where g is the number of groups of sunspots (distinct areas of sunspot activity) and s is the total number of spots. Currently there are several different sunspot indices based on the Wolf Number, including the International Index and Boulder Index. The American Index (also termed the Relative American Sunspot Number) traces its origin to World War II when there was difficulty in communicating official sunspot counts from Europe to the United States, and the AAVSO Solar Division (now Solar Section) was formed. A more detailed discussion of these different solar indices can be found in Feehrer (2000a).

The greater weight given to groups means that slight variations in the total number of spots between one observer and the next do not result in large variations in R_a . This is important because observers with different size

apertures contribute observations to the AAVSO. In addition, some observers directly observe the Sun using a filter while others project the image onto a screen. In order to compensate for these differences (and others), it has become customary to assign each observer a K-factor which is multiplied by his or her Wolf Number to correct for these differences (Feehrer 2000a). The projection method is popular with solar observers who conduct outreach, because more than one person can simultaneously view the Sun, and since no one is looking through the telescope itself there is an added layer of safety (assuming the finder scope is properly covered or removed). Identifying sunspot groups (areas of activity) is relatively straightforward when the Sun is quiet, as there are fewer sunspot groups, but becomes increasingly challenging when the Sun becomes more “crowded.” A group most often either consists of a series of small spots clustered together, or demonstrates a bipolar structure, consisting of two larger spots (generally aligned parallel with the Sun’s equator) and a variety of other spots and structures (including grayish-appearing areas called penumbra surrounding and encompassing sunspots). On average, sunspot groups extend over only a few degrees of longitude, although the largest groups can stretch over fifteen degrees of longitude or more. Information on the classification of sunspot groups (using the Zurich system) can be found on the AAVSO website (<http://www.aavso.org/zurich-classification-system-sunspot-groups>), while an exercise for older students (middle school or higher) on identifying and classifying sunspot groups is available on the NOAA website (<http://www.esrl.noaa.gov/gsd/outreach/education/sam1/Activity10.html>).

2. Using the Sunspotter to monitor R_s

The Sunspotter is a commercially produced solar projection system (available at <http://www.scientificsonline.com/sunspotter.html>). Its optical system consists of a 57-mm f/11 folded refractor that produces a 3.25-inch diameter image of the solar disk magnified 56 times (Sadler and West 2002). It is quicker to set up than a regular telescope, and the Sun is easily located by minimizing the shadow of its built-in gnomon. With the solar maximum then an estimated two years away, in late 2011 the author began observing with the Sunspotter in addition to her regular solar observing system, a 6-inch filtered SCT used at a magnification of 48 times. The goal of this experiment was to ascertain whether the Sunspotter could be effectively used in schools or long-term outreach programs to monitor the solar cycle over many months in sufficient detail to unequivocally demonstrate the trends of the American Relative Sunspot number, as published each month in the AAVSO *Solar Bulletin* (<http://www.aavso.org/solar-bulletin>).

Between October 2011 and September 2012 sixty-seven sets of data from both instruments were collected by the author. Observations with the Sunspotter were limited by time constraints, as it was only used on days on which

sufficient time could be allotted to careful observations with both instruments. On these days the Sunspotter was the first instrument used, in order to not have observations from the larger SCT bias the observer. Groups were identified and the total number of sunspots counted, then the Wolf number formula was applied ($10g+s$) to determine the sunspot activity visible with each instrument for that date. Representative results are shown in Figures 1 and 2, where the sunspot activity for the Sunspotter and telescope are compared to the published R_a value for the same date.

As expected, observations with the SCT typically resulted in higher Wolf numbers, as small spots were more difficult to view (partially due to lower contrast) with the Sunspotter. Groups consisting of a single small spot were sometimes missed, resulting in a difference in one fewer group being reported with the Sunspotter, and therefore a Wolf Number that was 11 lower than that obtained with the SCT. It was also sometimes difficult to count the numbers of spots in crowded groups with the Sunspotter, also resulting in lower Wolf numbers. However, despite these difficulties, Figures 1 and 2 demonstrate that the Sunspotter does track the overall trends in R_a . Therefore, the Sunspotter system would be useful in a school or long-term outreach program to safely monitor solar activity and allow children and others to compare their observations to those of seasoned amateur astronomers.

3. Additional uses of the Sunspotter in education and outreach

The Sunspotter is not inexpensive; therefore, in order to justify the expense there need to be additional pedagogical and outreach uses besides sunspot counts and monitoring trends in sunspot activity. Fortunately there are a number of different types of both short-term and long-term activities that can be completed using this equipment. For example, the built-in gnomon used to align the Sunspotter can be utilized as a mini-sundial to show the movement of shadows (and the changing angle of the Sun) over an hour. The rotation of the Earth can also be demonstrated by watching the Sun's image drift out of the field of view. Over several consecutive days changes can be seen in individual sunspot groups, and the rotation rate of the Sun can be measured. During the course of a season (or longer) the changing angle of the Sun at noon can be noted by keeping track of changes in the vertical angle the Sunspotter must be set at in its cradle. Sadler and West's manual (2002) for the Sunspotter describes a number of these activities, and George Roberts (2013) has produced a website with downloadable templates and Stonyhurst grids for detailed sunspot observations (<http://gr5.org/sunspotter/>).

Another argument in favor of including the Sunspotter in science education and outreach is that the types of activities listed above align with state and school district science standards. For example, the Connecticut Grade 6–8 Core Scientific Inquiry, Literacy, and Numeracy Standards include the ability

of students to “use appropriate tools and techniques to make observations and gather data; use mathematical operations to analyze and interpret data; identify and present relationships between variables in appropriate graphs; [and] draw conclusions and identify sources of error” (CT DOE 2011). Grade 1 students are expected to be able to “describe the apparent movement of the Sun across the sky and the changes in the length and direction of shadows during the day” while Grade 5 students are expected to “describe the uses of different instruments, such as eye glasses, magnifiers, periscopes and telescopes, to enhance our vision” (CT DOE 2011). Science standards for other states can often be readily found online through a simple Google search, and in general are fairly consistent from state to state in terms of overall content. The Sunspotter also aligns with the National Research Council’s Standards and the AAAS Benchmarks in Astronomy (Sadler and West 2002). The recently published Next Generation Science Standards (Achieve Inc. 2013) highlight patterns involving the Sun within its progression of Earth Science standards from Kindergarten through grade 12. While younger students may have some difficulty manipulating the Sunspotter to properly align it to the Sun, students in Grades 5 and higher should have little difficulty (especially considering that this will, of course, be done under close teacher supervision). Students who are interested in comparing their observations with the published results beyond the level of general trends can compute an “observatory constant” each month by comparing their observations with those published by the AAVSO, using a method described by Fehrer (2000b). Therefore, sunspot observations in general and those utilizing the Sunspotter in particular can play an important role in astronomy education and outreach and introduce students and the general public to the importance of amateur astronomy.

4. Conclusion

With solar maximum now upon us, this is the time to interest students and the general public in observing the nearest variable star, the Sun (Hathaway 2013). The Sunspotter is an easy-to-use commercially produced instrument designed exactly for this task, and which can be used for both one-off events as well as longer term observing programs.

References

- Achieve Inc. 2013, “Next Generation Science Standards” (<http://www.nextgenscience.org/next-generation-science-standards>), Appendix E.
- Brück, M. 2009, *Women in Early British and Irish Astronomy*, Springer, Dordrecht.
- Connecticut State Department of Education. 2011, “Prekindergarten—Grade 8 Science Curriculum Standards” (http://www.sde.ct.gov/sde/lib/sde/pdf/curriculum/science/pk8_science_curriculumstandards2011.pdf)

Feehrer, C. E. 2000a, “Dances with Wolf’s” (<http://www.aavso.org/dances-wolfs-short-history-sunspot-indices#american>).

Feehrer, C. E. 2000b, “Accuracy and Consistency in the Production of the American Sunspot Number (Ra): Addendum” (<http://www.aavso.org/accuracy-and-consistency-production-american-sunspot-number-ra>).

Hathaway, D. H. 2013, “Solar Cycle Prediction” (<http://solarscience.msfc.nasa.gov/predict.shtml>).

Mitchell, H. 1890, *Proc. Amer. Acad. Arts Sci.*, **25**, 331.

Roberts, G. 2013, “Sunspotter Telescope Measure Sunspots and Measure Rotation of Sun” (<http://gr5.org/sunspotter/>).

Sadler, P., and West, M. L. 2002, *A Manual for the Care and Use of the Sunspotter*, Contact Learning Technologies, Inc., Somerville, MA.

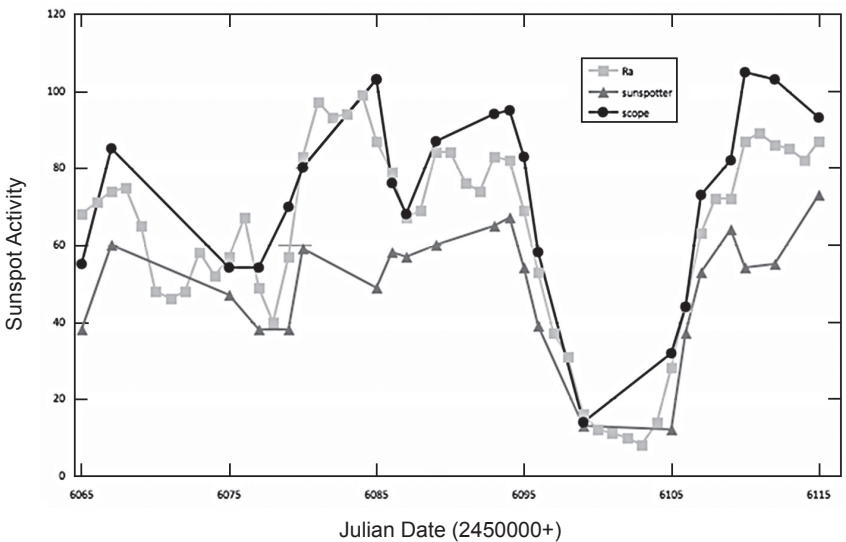


Figure 1. Sunspot activity as measured by the SCT, Sunspotter, and published R_a for May–July 2012.

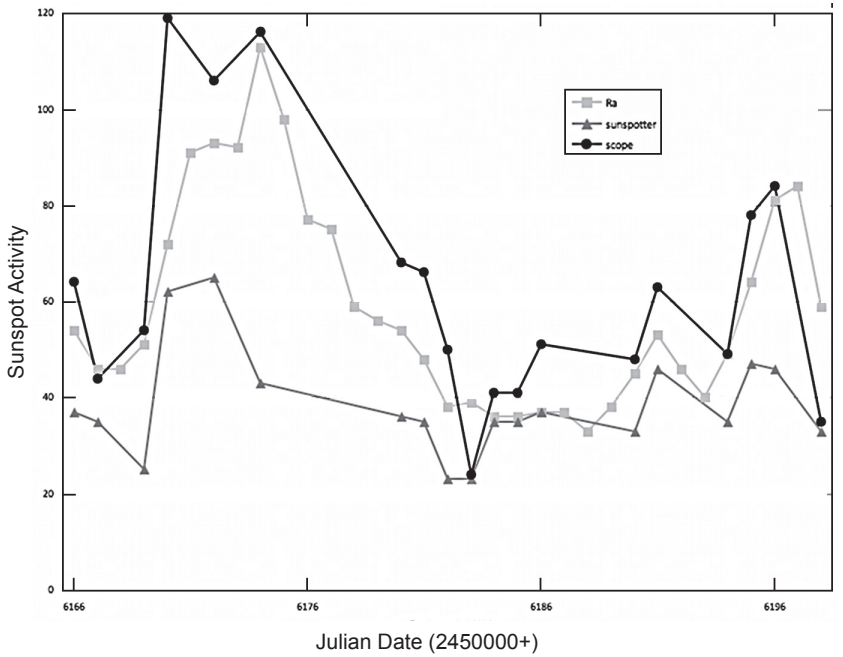


Figure 2. Sunspot activity as measured by the SCT, Sunspotter, and published R_a for August–September 2012.