# The Effect of Online Sunspot Data on Visual Solar Observers

**Kristine Larsen**
*Physics and Earth Sciences, Central Connecticut State University, 1615 Stanley Street, New Britain, CT 06053; larsen@ccsu.edu*

*Presented at the 100th Spring Meeting of the AAVSO, May 22, 2011; Received June 29, 2011; revised September 13, 2011; accepted September 14, 2011*

**Abstract** Solar observing affords opportunities for amateurs and students to contribute to the AAVSO. This study explores the use of online solar data and photographs in training solar observers, and the bias effects such data can have when not used judicially.

## 1. Estimating Sunspot Activity

As noted on the AAVSO's Solar Section web page (http://www.aavso.org/solar), solar observing is one way that amateur astronomers with relatively small telescopes can (with a proper white light filter) contribute useful data. The AAVSO's Solar Section aggregates and reduces the data contributed by its observers and publishes a monthly bulletin containing the Relative American Sunspot Number $R_a$ for each day of that month (http://www.aavso.org/solar-bulletin). Since solar observing can be done during normal school hours and with modest equipment, it is an easy way to include telescopic observing in astronomy classes (both at the high school and college level) and introduce students to both the AAVSO and the collection and importance of individual astronomical observations.

There are a number of different organizations that collect and aggregate sunspot observations; each organization produces its own sunspot number or index. Each index is based on the Wolf index (developed by Rudolf Wolf in 1848), calculated as $R=10g + s$, where g is the number of sunspot groups (areas of sunspot activity) and s is the number of individual spots included in all the groups. Three commonly cited indices are the Boulder Index (computed at the NOAA Space Environment Center in Boulder, Colorado), International Index (computer by the Solar Influences Data Center in Belgium), and the aforementioned American Index (computed by the AAVSO Solar Section). Each uses data from a different set of observers/observatories, and each aggregates the data in a slightly different way. Because observers have a tendency to underreport the number of sunspots (due to differences in instrumentation, experience, and visual acuity), there will be a range of R values reported on any given day (Schaefer 1993, Foster 1997). In addition, observers will vary in the way they distinguish between different groups, and how well he or she can distinguish a pore from a sunspot (Schaefer 1993,

Schaefer 1997). In order to compensate for these differences, it has become customary to assign each observer a K-factor which is multiplied by his or her R value to correct for these differences. (For more information about the K-factor and how the AAVSO computes its values see Foster 1997, Schaefer 1997, and Feehrer 2000.) This "personal equation" is not uncommon in the aggregation and comparison of astronomical data. The term "personal equation" dates back to the nineteenth century, when astronomers discovered that their individual measurements of transit times for the same object/event differed (Schaffer 1988). Today each sunspot index uses a different technique to assign K-factors to contributing observers. The result is the values reported by each index will differ from one another.

One relatively simple way to introduce students to the concept of the sunspot cycle is through the Spaceweather website (www.spaceweather.com). This resource hosts on its main page a daily picture of the near-side of the sun from the Solar Dynamics Observatory and identifies some of the sunspot groups by number. The site also includes an overall Boulder sunspot number from the past twenty-four hours. While the Boulder index differs from $R_a$ by a significant factor (Feehrer 2000), the beginning student solar observer does not need to delve into these subtleties from the onset. Also, since the AAVSO data are released after the fifteenth of the following month, students do not have real-time access to this data. Real-time photographs and sunspot indices can be helpful for visual sunspot observers who are just beginning to learn the techniques of careful visual sunspot counts (for example, how to identify complex groups and how to carefully examine the limb of the sun), but the "power of suggestion" these data might have on an observer cannot be ignored. An observer can check his or her observations against this "standard" and may be tempted to alter their data to conform to what he or she considers to be a more reliable standard. For example, while the AAVSO Solar Section includes the SOHO website real-time image (http://sohowww.nascom.nasa.gov/data/realtime/hmi_igr/512/) as one of its recommended resources for solar observers, and recommends an observer consult such a site when one has a break in observing (in order to follow the evolution of groups), an important caveat is included within the recommendation: "DO NOT use these resources to 'scale' your own observations. Most sources available via this medium use equipment and procedures that are different from the ones you use and can be expected to achieve different results" (Beck 2010). The study described in this paper first examined the effects of the Spaceweather site on a class of college students just beginning to learn white light solar observing, and then compared the results of a more experienced solar observer (the faculty course instructor) with the Spaceweather data. In no case was biased data submitted to any agency or organization.

**2. Introducing Students to Sunspot Observing**

In the middle of the Fall 2010 semester, twelve students in ESCI 278 (Observational Astronomy) at Central Connecticut State University were taught how to solar observe with a 6-inch *f*/1 1525 mm Schmidt-Cassegrain telescope, Thousand Oaks glass filter, and 35mm *f*/1 eyepiece. Students had been using other telescopes for night observing for six weeks beforehand and were therefore familiar with basic telescope usage and observing techniques. Solar activity was very low during this time; therefore, the instructor consulted the Spaceweather website before each sunny class period and observations were made only on days on which there were sunspots to observe. Each student individually observed the sun, drew a sketch, and estimated his or her observed sunspot number R=10g + s. Afterwards each student checked his or her sketch against the Spaceweather.com picture, observed a second time and drew a second sketch, noting if he or she could see all the areas of activity visible on the website. Students were aware of the fact that the posted R on the website was the previous day's data, and therefore concentrated on the actual photograph (which was on average several hours old).

There were 37 sets of before/after observations. In 19 cases the students could not see additional activity after viewing the photograph, while in 13 instances students were able to view additional activity afterwards. Sample comments from this latter group of observations include the following:

> "Without looking at the internet I observed two elliptical shaped sunspots making a group. After looking online I noticed that with the two sunspots I saw above are several more smaller spots but I couldn't divide them in the scope."

> "After I could see more spots in the lower group—about 2 more. Also, I could see one more spot in the higher group."

> "After looking at the computer I see a few more in the center."

> "For some reason after looking at the computer I was able to see two 'sets' of spots with a multitude of spots to be seen the second time. However, the spots seemed to be perforated."

> "When I observed I could not see anything. Image was fuzzy, could see a minimum of four spots (went back to look after seeing computer)."

Consulting the online photograph was therefore successful in prompting the students to both look more carefully at the groups they had seen in order to

count small spots and look at all areas of the sun more carefully to pick up small spots/groups. In the case of one student, it also reinforced an important lesson of observing in general: "One of the pieces of 'dirt' (on the eyepiece) turned out to be a group of sunspots."

Several student comments also raised important red flags, including the following (made by two different students):

> "After I think I might see one. But I'm not sure. It's hard for me to see anything. I could be making it up again."

> "I still can't see anything, including the one I made up before. The image seemed shakier than before."

The fact that students had (apparently) included spots in their logbooks that they had not seen speaks directly to the admonition of the AAVSO website and raises questions as to whether students felt they would either be graded lower or otherwise displease the instructor if they could not see spots (although they had been unequivocally advised otherwise). The honesty of the students is laudable, but reflects one of the dangers in utilizing such photographs or standardized data when instructing beginning observers—the tendency toward bias is powerful. Although students were often and firmly admonished never to change their original observation based on what their classmates saw, or what they saw on the website, this was clearly not followed. Even if the Spaceweather site was not used in this study, it is suggested that general peer pressure would have been sufficient to tempt some students to "make it up." While keeping one's observations secret from one's classmates may have stopped this, the need to improve one's technique (and attention to detail), and the ability to do this by sharing and consulting other sources, outweighs the downfalls *if* the students do not attempt to submit their data until they are confident enough in their own abilities to avoid such biases.

Even after viewing the Spaceweather picture, some of the students still could not see activity that his or her classmates could see, leading to some frustration (and possibly explaining the previously noted instances of "making spots up"). One student in particular—a science major—had difficulties on all four dates:

> "There were, supposedly, other sunspots found besides the ones I saw but I was unable to find them even after I saw their position online."

> "I was not able to make out any spots today even though there was at least one spot other people found. I was only able to see the yellow sun."

> "This whole semester I have had trouble with noting the sunspots. It was hard to see with my glasses and sun shining at me but it would also be difficult for me to focus clearly on the sun so I could see the spots. The spot on the top left is only a smudge on the eyepiece."

This particular student also had issues with some night observations as well, and began wearing her contact lenses to class near the end of the semester (after the solar observing had concluded) in order to help with her observations (with some success). It would be interesting to explore whether the use of glasses versus contact lenses affects the acuity of solar observers (although astigmatism should be compensated for by refocusing the telescope).

The general conclusions of this portion of the study are as follows:

1) Integrating Spaceweather.com's real-time sun pictures can aid students in taking care to look more carefully when solar observing.

2) Beginning observers can be tempted to "invent" sunspots if they know they are missing something that others can see. Students must be reminded on numerous occasions of the ethics involved in contributing individual data to collecting organizations.

3) By sharing their observations and noting the differences, students came to an understanding of the importance of the K-factor in solar data aggregation.

For a future extension of this study, it would be interesting to explore whether using the posted sunspot counts (posted on the next day) and the labeling of certain sunspot groups by number on the posted photo aid students in identifying individual groups in times of higher solar activity (as suggested by the AAVSO Guidelines for Solar Observers (http://www.aavso.org/solar-guidelines)).

**3. Online Sunspot Counts as an Aid for Experienced Sunspot Observers**

In the second portion of this study, the faculty instructor used the same equipment to observe the sun ten times (approximately once a week) from March 1 through May 1. The separation between observations was selected to avoid bias from previous observations. In each case, the Spaceweather.com photograph was consulted after the initial observation and a second observation was then commenced to note if additional activity could be seen. The observer's results were consistent with the AAVSO sunspot index $R_a$ published in the following month (Howe 2011) and were (as expected) generally significantly lower than the Boulder index reported on the Spaceweather website. The most important outcome was the fact that in all cases, any additional activity visible

in the photograph but not seen in the initial observation was not seen in a second observation, confirming that the observer was consistently observing to the limits of her instrumentation, eyesight, and seeing (Schaefer 1993). The conclusion of this portion of the study is that Spaceweather.com and other similar websites are valuable to more seasoned observers as well as beginners in order to make sure one is taking care to view all spots visible to his or her limitations and not rushing through an observation or being sloppy. Again, the AAVSO's admonition to avoid bias is key. One can consult a website after concluding one's observation; if sunspots are found to be missing, one should never add to his or her data afterwards. If differences in the number of areas of sunspot activity had been found by the author in this study, those observations would not have been sent to the AAVSO, but instead used as practice. Similarly, the students in the first portion of this study did not submit their data to the AAVSO, and the consultations with the Spaceweather site were done to aid the students in improving his or her own ability, with the goal to become a competent solar observer.

## 4. Conclusion

In conclusion, both the AAVSO Solar Section's inclusion of such websites in its recommended resources for observers and the accompanying admonition are confirmed as appropriate (and necessary) for beginning observers and their more seasoned colleagues who wish to improve their solar observing technique. However, in order to prevent bias, these sources of information should be used for training purposes only, and in no case should an observer's report to the AAVSO (or any other organization) be anything other than his or her individual observations.

## References

Beck, S. J. 2010, http://www.aavso.org/solar-guidelines

Feehrer, C. E. 2000 http://www.aavso.org/dances-wolfs-short-history-sunspot-indices

Foster, G. 1997, *J. Amer. Assoc. Var. Star Obs.,* **26**, 50.

Howe, R. 2011, *Solar Bulletin*, **67**, Nos. 3, 4, 5.

Schaefer, B. 1993, *Astrophys. J.,* **411**, 909.

Schaefer, B. 1997, *J. Amer. Assoc. Var. Star Obs.,* **26**, 40.

Schaffer, S. 1988, *Science in Context,* **2**, 115.

Spaceweather.com 2009, http://www.spaceweather.com/glossary/sunspotnumber.html