Amateur Observing Patterns and Their Potential Impact on Variable Star Science

Matthew R. Templeton
AAVSO, 49 Bay State Road, Cambridge, MA 02138; matthewt@aavso.org

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Abstract In this paper I highlight some trends seen in amateur observations submitted to the AAVSO over the past fifty years. Some systematic trends are noted in both the amount of data submitted and the frequency with which stars are observed. Two trends are evident: the decreasing number of days per year when individual stars are observed, and the overall decreasing number of visual observations submitted. The former is shown through an analysis of data submitted for a number of subclasses of cataclysmic variable, while the latter is generally evident across all variable star types through our overall annual totals. A decrease in nightly coverage may impact the kinds of science that can be done with AAVSO light curves. The decrease in visual observing may result in a loss of long-term coverage that impacts the usability of long-term light curves. I discuss possible impacts on the kinds of science that can be done with AAVSO data and long-term light curves, and suggest ways to address this issue.

1. Introduction

The AAVSO International Database (AID) contains over 20 million observations of thousands of individual stars. The data are a mix of both visual magnitude estimates and instrumental photometry, with visual data making up the vast majority of all data submitted prior to 1995. Instrumental observations now account for more than eighty percent of all data submitted to the AAVSO every year. Prior to 1995, most observations of variables were nightly or weekly visual observations, and the goal was to monitor these objects for phenomena that occurred on timescales from days to years. Now, a much larger fraction of data submitted consists of instrumental time-series of short-term phenomena (Figure 1). This shift in focus has drawn a number of observers away from long-term monitoring observations toward these more focused, short-term projects. It has also brought about a shift in observing method from visual to CCD; while the number of visual observers still numbers around 800 (Figure 2), the number of visual observations of all variable stars submitted per year is now about half the number submitted in the mid-1990s. When visual observers do observe, they do not do so in the numbers they once did.

The question of whether long-term visual observation of variable stars should be encouraged is an important one. Underlying this question is a more fundamental one of whether the scientific questions that long-term monitoring of variable stars can answer are ones that are still of interest to the scientific community. Any observational program must be motivated by the pursuit of valid scientific questions in order to be relevant to astronomical research. This is as true of instrumental observations as visual ones. In order to motivate a discussion of this question, I present a simple study of the daily observational coverage of cataclysmic variable stars to quantify the shift in focus from long-term monitoring to more intensive short-term observations.

2. Selection of CV data sets for examination

To examine trends in long-term coverage, we searched the AID for observations of CVs of several important subclasses. We selected stars based upon the following criteria:

- star is classified as NL or UGx;
- at least 1000 observations/500 days covered since 1961;
- observations counted: visual, and (B,V, unfiltered) CCD;
- we are not counting the total number of observations, but *the number of days they were observed at least once.*

The last bullet is critical: this study aims to address not the raw number of observations made per year, but the daily coverage of individual stars. The number of days observed per year is a better indicator of how useful a light curve will be in performing studies of long-term behavior, potentially yielding information about mean light levels, outburst frequency, and outburst duration among other things.

3. Results

There are between two and three dozen stars among each of the NL, UGSS, UGSU, and UGZ types that meet these criteria. The results for each of these four subsets are as follows:

UGSS-type—See Figure 3. Many of these stars have been observed for many decades, with the longest-observed star being SS Cygni itself (SS Cyg is one of the best-observed stars in the AID, with nearly 365 days of coverage per year). Among the twenty best-observed stars, only SS Cyg has retained a near continuous level of daily coverage. The remainder of the twenty show declines in coverage of varying degree. Coverage slowly increased through the mid- to late-1990s, and then began to decline across the board. Some declines have been dramatic (a factor of two or more), but others show less of a decline. In most cases, the onset of declines appear to be in the late 1990s to early 2000s.

UGSU-type—Most of these stars show significant declines in coverage starting in 2000, with some well-known and observed stars (like SU UMa itself) losing nearly half of their daily coverage since 2000. Others have been even more precipitous, with southern stars in particular showing losses in daily coverage of greater than fifty percent (for example: TU Men, WX Hyi, Z Cha, and OY Car). For some stars, daily coverage has declined to levels not seen since 1970.

UGZ-type—Z Cam itself is well observed but as with the UGSS stars, the UGZs show generally declining coverage in the past five to ten years. Some of the small number of stars that first came under observation in the 1970s and 1980s (for example: EM Cyg, AT Cnc, BI Ori, VW Vul, and V344 Ori) have leveled off in coverage. EM Cyg is covered for around sixty percent of the nights per year, but the more equatorial sources have coverage only about one-third of the year, while the more southerly star TT Ind is hardly observed anymore—only around twenty percent of the nights per year have at least one observation.

Novalikes and UGWZ-types—It is difficult to make any blanket assessments of their long-term coverage. Few of these stars have been extensively observed for many decades, although UZ Boo (UGWZ) appears to receive consistent coverage for about seventy-five percent of the nights per year. Coverage of UGWZ stars with marginally predictable recurrence times may decline outside of expected outburst windows; WZ Sge itself is now only observed about 125 nights per year, about the same as in 1980. Among the novalikes only V Sge has good coverage throughout the fifty-year span of this study, and the vast majority of these objects were discovered within the past fifty years. Observations of these sources peaked in the 1990s, probably due to the interest generated from space-based X-ray observations in the 1970s–1990s. TT Ari has had consistent coverage of about 200 nights per year since the mid-1980s, around the time it returned from its previous deep fade (circa 1985).

4. Overall trends

Most of the objects under consideration here have shown some decline in coverage since the 1990s when interest in cataclysmic variables first peaked. While the trends show declines in the number of days covered, many of these stars also show declines in the number of observations made per year, despite the consistent increase in the total number of observations of all variable stars made per year. Figure 4 shows the number of observations submitted per year for six well-known dwarf novae. Although the totals for individual stars are occasionally punctuated by years with substantial time-series data, in general the number of observations per year per star is declining.

5. Time-Series versus long-term monitoring

The annual total of all observations submitted to the AAVSO includes several hundred thousand data points of time-series observations of a small number of stars. Often, these observations are of interest to that particular observer during a small window of time (for example: a study of an eclipsing binary or outbursting cataclysmic variable). In such cases, the total number of submitted data points is large, but the time-span of the data is very small—often days, weeks, or months—and the star may not be observed again. While the overall number of observations being submitted to the AAVSO is increasing, the coverage and quality of our long-term light curves is not keeping pace with this increase. For many important stars, coverage is in decline.

6. The roles of amateur monitoring and robotic surveys

There are several robotic surveys in existence whose purpose is to conduct nightly monitoring of the visible night sky. Surveys like the All-Sky Automated Survey (ASAS; Pojmański 2002), the Northern Sky Variability Survey (NSVS; Wozniak *et al.* 2004), and the Catalina Real-Time Transient Survey (CRTS; Drake *et al.* 2009) provide a possible means for overcoming the declining numbers of amateur observations of stars with long-term light curves. As of today there is no universally agreed-upon process by which survey data are guaranteed to remain publicly available beyond the lifetime of the individual project, and thus the long-term survivability of robotic survey data is unclear. It is not difficult to ensure that such data be preserved.

There is clearly room for both human and robotic observation of variable stars, and the benefits of both methods are numerous. They should be considered as complementary rather than conflicting. The variable star community needs to address both the declining long-term coverage by the amateur community, and the organized care and maintenance of large and valuable databases created by robotic surveys. Without such a discussion, there is a chance that the scientific value of long-term light curves such as those held by the AAVSO will no longer grow with time.

References

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Pojmański, G. 2002, *Acta Astron.*, **52**, 397.
Wozniak, P. R., *et al.* 2004, *Astron. J.*, **127**, 2436.

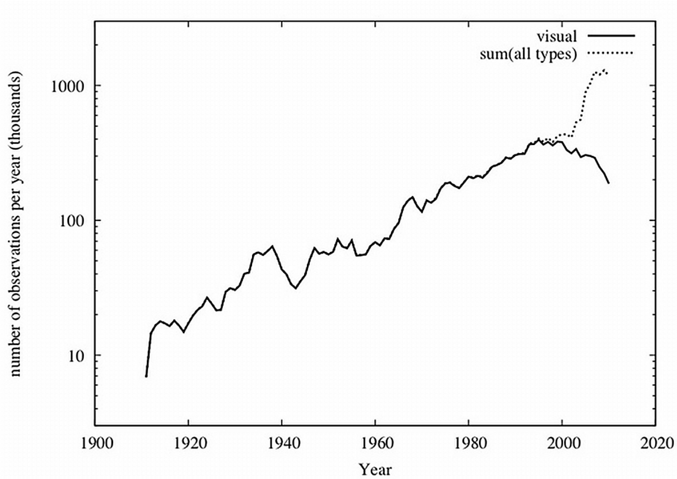

Figure 1. The number of observations per year found in the AAVSO International Database (AID): solid line, visual data; dotted line, all data. These numbers include data from the AFOEV and RASNZ. Beginning around the year 2000, CCD observations became the majority of observations submitted per year. The number of visual observations has been in decline since its historical maximum in 1995.

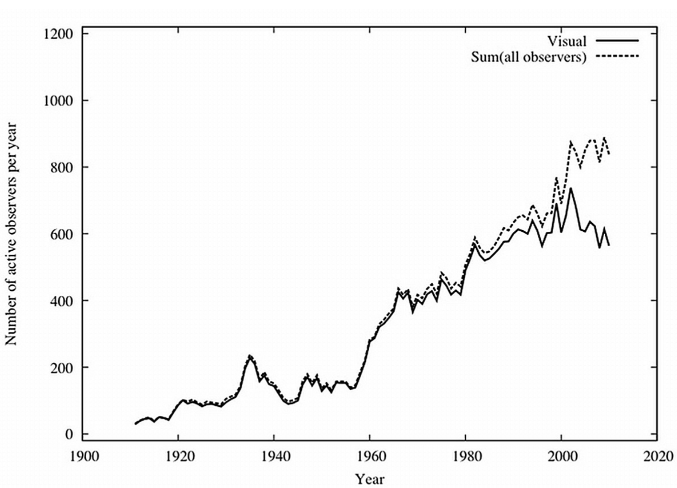

Figure 2. The number of observers whose data are submitted to the AID per year: solid line, visual data; dotted line, all data. Visual observers—including those who also observe with a CCD part of the time—still represent a majority of observers. Recent trends suggest the number of observers is holding steady or declining slightly.

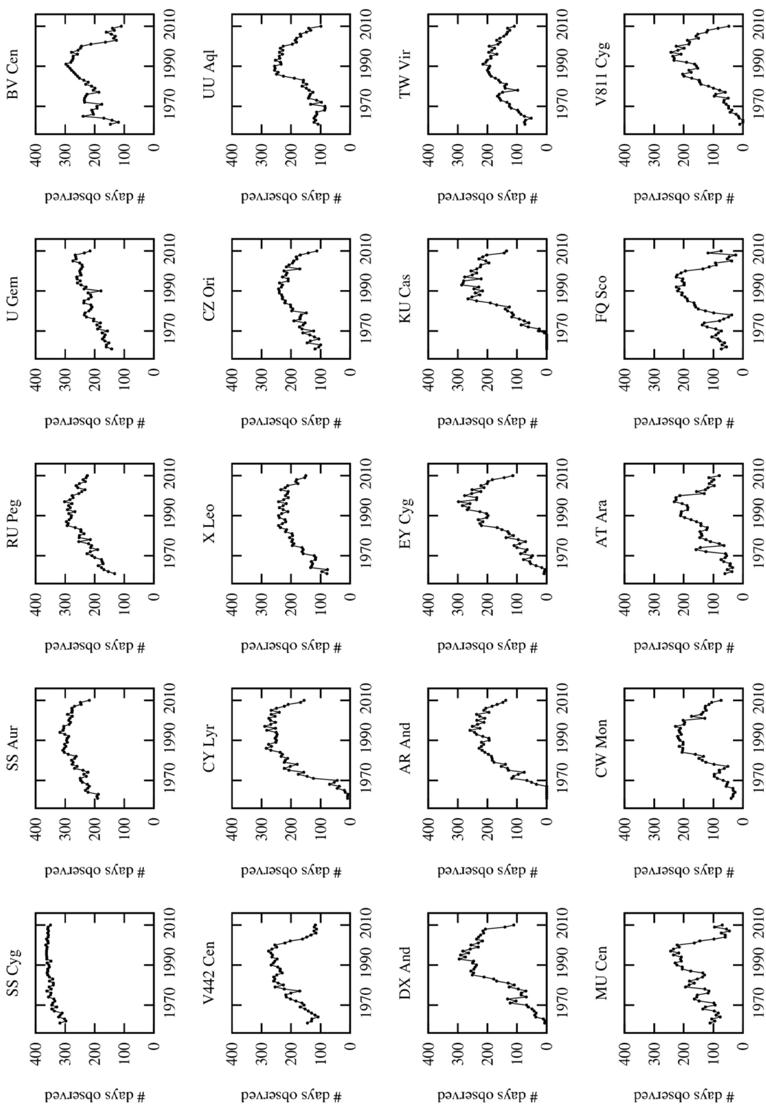

Figure 3. Daily coverage: The twenty best-observed dwarf novae of type UGSS (SS Cyg-type).

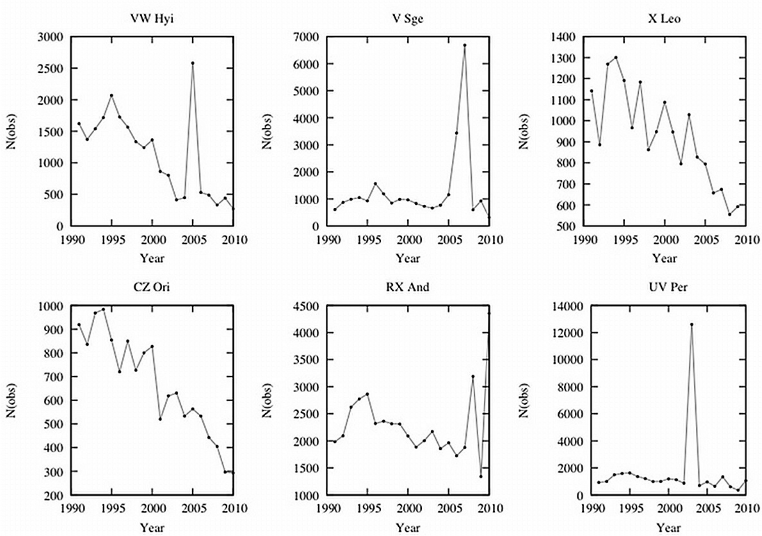

Figure 4. Yearly totals for six dwarf novae, 1991–2010. Coverage of these stars is declining, with some declines (especially CZ Ori, X Leo, and VW Hyi) being especially dramatic. With fewer observations and fewer days per year, it becomes increasingly difficult to study long-term changes in these stars.