Appendix 4 – Quality Control of Index Velocity Data for SonTek™/YSI Argonauts™

The ADVMs described in this report are most often used in conjunction with electronic data loggers, which are used to transmit data for storage, retrieval, and display in USGS databases. However, most data loggers in use can only transmit and store a limited amount of the available ADVM data. Routine review of the transmitted ADVM data is necessary to provide an initial method of quality assuring the velocity data and minimizing invalid or questionable data. Procedures for reviewing those data transmitted and stored in USGS databases were discussed earlier in this report.

SonTek™/YSI ADVMs can record all available data to a built-in internal recorder. The data stored in the ADVM internal memory are useful for quality control of index velocity data in part because additional data are available (but not usually transmitted). With this in mind, procedures for reviewing data for quality control of ADVM data, especially those data stored in ADVM internal memory, are documented in this appendix. Familiarity with the manufacturer documentation is recommended for the reviewer because it can provide useful tips to aid in reviewing ADVM data.

Internally recorded ADVM data should be retrieved from the ADVM and reviewed during every site visit. A more thorough review of the data should be performed in an office setting. Typically, the easiest and most efficient way to review the internally recorded data is by means of the manufacturer software package, ViewArgonaut, using the Processing option. Data can be selected for display in the software by using the View option on the top menu and by selecting the “Select Graph Variables” option. A smaller window will open that has a number of different available selections that correspond to all internally recorded data.

The internally recorded ADVM data may be useful in determining the quality of velocity data. Determining the velocity data quality may require review of other parameter data (multi-cell data, signal amplitude, temperature, etc.) and use of the combined information from each data time series. Knowledge about the available ADVM data and how the data may be used in analyzing quality of index velocity measurements and the ability to readily differentiate good quality (valid) from poor quality (invalid) data will increase the efficiency of the review. Training, practice, and consultation with an expert will help the hydrographer develop this knowledge and ability. Figures in this appendix were re-created using data exported from ViewArgonaut software in order to more effectively illustrate quality-control concepts.

Velocity

The first step is to plot the velocity components (typically X, Y, and sometimes Z) and look for anomalies, rapid or abrupt changes, and apparent increases in standard error (noisier data). Reviewing the velocity component data (range-averaged and multi-cell X and Y velocity) can provide a good indication of velocity data validity, although sometimes additional parameter data must be reviewed in order to determine data validity. The measured index velocity data may sometimes appear acceptable after a cursory review, while the velocity data may actually be biased or completely invalid and can only be truly quality assured after reviewing more of the internally recorded data. Velocity data time series can be range-averaged, multi-cell, or both depending on the ADVM configuration.

- **X-velocity (range-averaged)**.—Look for consistent X-velocity data and correlation with stage data and (or) specific conductance data. Velocity data will have a characteristic variability (uncertainty) for the site, which is not to be confused with the variation in velocity that occurs in response to hydrologic events. A change in the uncertainty can be an indication that the instrument may have been reconfigured or may be malfunctioning, or that the measurement volume has changed or is being adversely affected by debris in one or more of the acoustic beams. An example of a change in velocity variability is illustrated in figure 4-1. At this gaging station, the ADVM was reconfigured on April 19, with the averaging interval changed from 1 minute to 10 minutes. The result of this change is a reduction in the velocity variability.

- **Y-velocity (range-averaged)**.—Y-velocity data are typically the cross-stream velocity component and should be very near to zero. A change in the magnitude of the Y-velocity may indicate that the orientation of the ADVM has changed or that some obstruction may be affecting the velocity distribution in the measured portion of the stream channel. The Y-velocity commonly changes during high velocity events or flow reversals; those changes indicate that the velocity field changes direction during these periods. Changes in the cross-stream velocity in response to flow events should be used as an indicator that the cross-stream velocity may be a significant variable that may improve the index rating and should be investigated as described in the rating analysis section of the report. For two-beam uplooker ADVMs (Argonaut™-SW), the Y-velocity

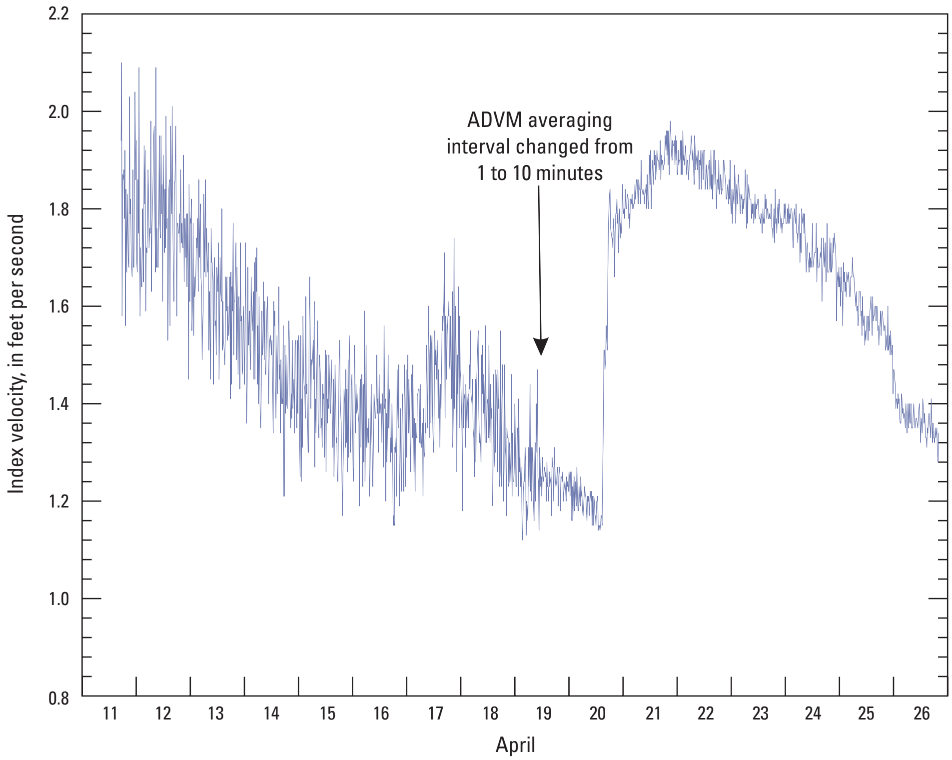

Figure 4-1. Effect of changing averaging interval on 15-minute index velocity data.

is actually the vertical velocity (see Z-Velocity discussion, below), and it should also be very near to zero and should not change with time.

- **Z-velocity (if applicable)**.—For three- or four-beam uplooker ADVMs, the Z-velocity is the up-down (vertical) velocity. Vertical velocity data should be approximately equal to zero and should not show any substantial changes over time. Large vertical velocities (greater than 10–20 percent of the X-velocity) can be an indication of turbulent velocity conditions or an improperly leveled ADVM. Changes (abrupt or gradual) can indicate a change in ADVM orientation or possible debris in the stream channel that affects the velocity distribution in the measured water volume.

- **Multi-cell velocity data**.—As many velocity cells as possible should be transmitted, routinely reviewed, and archived in the NWIS database. Currently (2011), SonTek™/YSI ADVMs are only capable of providing data via SDI-12 for the first five cells; however, data for up to 10 cells may be stored in the internal recorder. Examine each cell velocity time series for evidence of changes in the uncertainty of the velocity data compared to other velocity cells and the range-averaged velocity. A substantial change can be an indication that the measurement volume velocity is biased or being adversely affected by debris, side-lobe interference (for sidelookers), or flow disturbance in the stream cross section. Continuous review of high-quality data will allow the hydrographer to readily identify periods when velocity data is questionable or invalid.

Range-averaged X- and Y-velocity data with a 900-second measurement interval and 240-second averaging period for 10 days are shown in figure 4-2. The X-velocity data (downstream direction) have short-term and long-term variations that appear normal, with some short-term variations that are slightly greater in magnitude throughout the time series. The Y-velocity data (cross-stream direction) is relatively close to zero and a near constant value, which is desirable; however, there are some small variations at times of increasing and decreasing downstream velocity. These variations can be expected depending on the channel geometry upstream and downstream from the ADVM.

For SonTek™/YSI ADVMs, the hydrographer can select the velocity coordinate system for displaying the velocity data in the manufacturer's software. Typically, the velocity coordinate systems consist of beam (velocity towards or away from the transducer faces), XYZ (velocity oriented to the body of the ADVM), or ENU (velocity oriented to magnetic or geographic North) if the ADVM is equipped with a compass. For two-beam sidelooker or uplooker ADVMs (Argonaut™-SL and -SW), plotting the velocity data in beam coordinates can be a useful tool when aligning the ADVMs as described in the instrument installation section of the report. When a two-beam ADVM is properly aligned, the beam-coordinate velocity data should look like a mirror image. Misalignment of the ADVM, non-uniform velocity streamlines, or acoustic beam interference can usually be determined with beam-coordinate velocity plots.

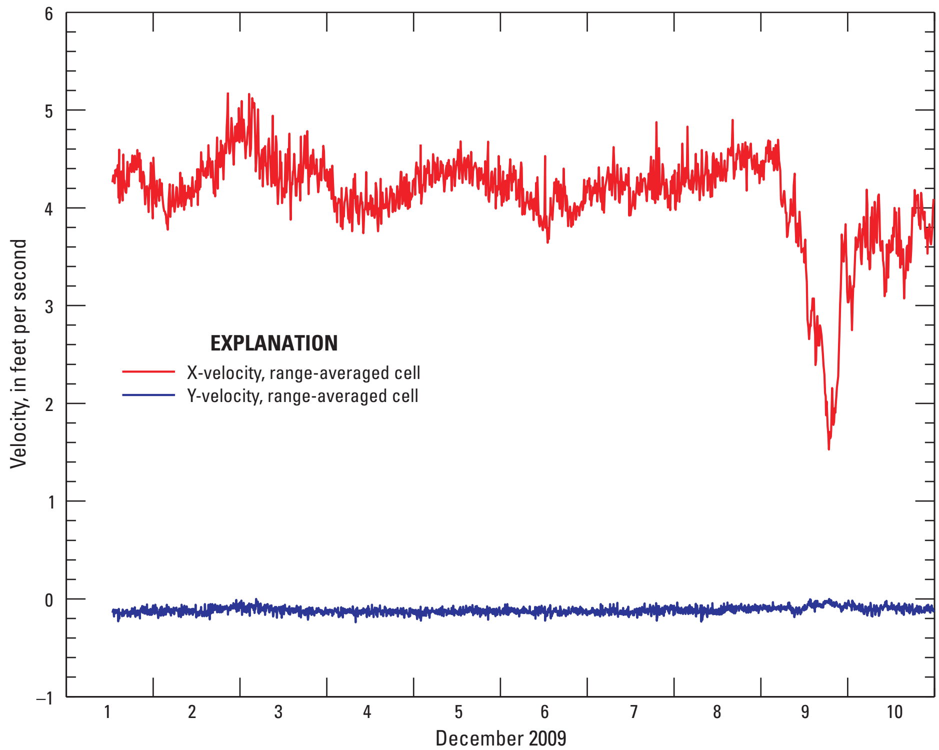

Figure 4-2. Range-averaged velocity time series plot of X velocity and Y velocity with ADVM sidelooker properly aligned with streamflow and normal velocity fluctuations.

The range-averaged beam velocity data for the same site and time period as in figure 4-2 are shown in figure 4-3. ADVMs measure velocity towards or away from the acoustic transducers and then use beam geometry (transducer angle and orientation) and (or) magnetic compass measurements to convert the beam velocity to another coordinate system. Beam 1 and beam 2 velocity data show nearly equal magnitude and opposite sign (a mirror image), indicating that the ADVM is optimally aligned with the velocity streamlines. If the beam velocity data show substantial differences either in magnitude or shape, this indicates that the ADVM is not properly aligned and the acoustic beams are not measuring homogenous velocity streamlines or may be oriented closer to perpendicular to the velocity streamlines. As an acoustic beam is oriented closer to perpendicular to the velocity streamlines, that beam velocity data will be closer to zero magnitude and will bias the measured index velocity.

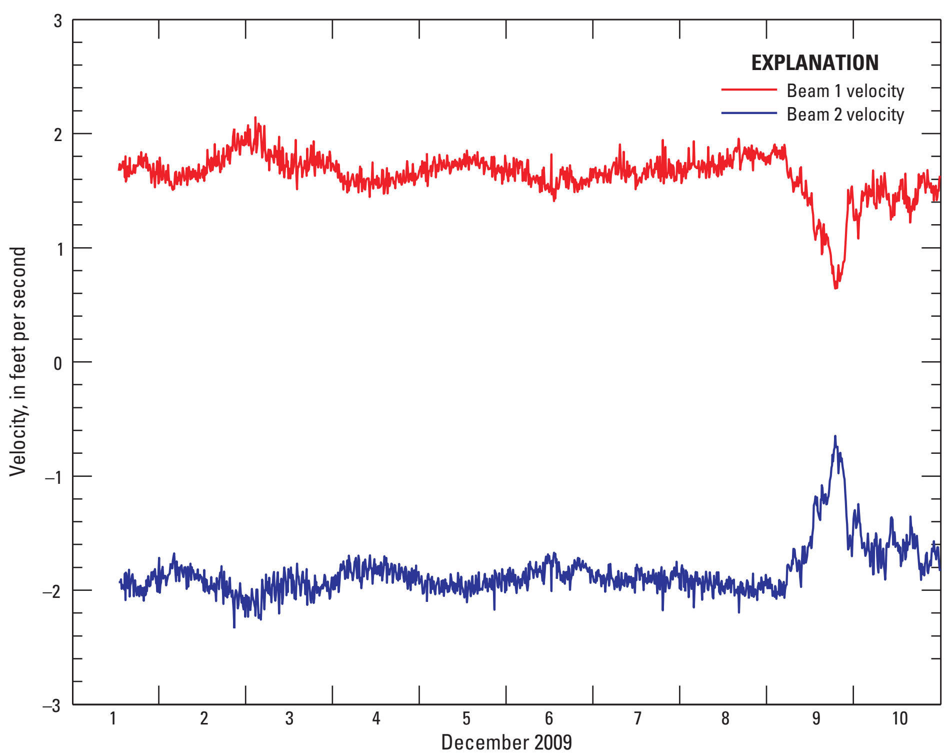

Figure 4-3. Time series velocity plot of beam 1 velocity and beam 2 velocity with ADVM sidelooker properly aligned with streamflow and normal velocity fluctuations.

The multi-cell X- and Y-velocity data for five cells for the same site and time period as figures 4-2 and 4-3 are shown in figure 4-4. Multi-cell data for cells 1, 3, 5, 7, and 9 indicate that all of the cells have the same response as the range-averaged cell (fig. 4-2), with cell 1 velocity data being 0.1 to 0.5 ft/s less than velocity data for cells 3, 5, 7, and 9 most of the time. However, the velocities are almost the same magnitude during the latter part of the time period that corresponds with a substantial decrease in velocity. Because cell 1 is likely closer to a bank or structure, the velocity measured in cell 1 is likely affected by the channel bank or the structure where the ADVM is mounted, and the range-averaged measurement volume should be adjusted to exclude the range corresponding to cell 1 (increase the blanking distance). The multi-cell velocity data are slightly noisier than the range-averaged data, but it is normal to have greater velocity variation for ADVMs when measuring with a smaller cell size. The Y-velocity multi-cell data are essentially the same as the range-averaged Y-velocity, which should be expected. If one or more of the multi-cell velocity values were different, that would be an indication that there may be changes in the velocity streamlines across the channel, and this should be carefully evaluated to ensure that the measurement of skewed velocity streamlines will not adversely affect the index rating.

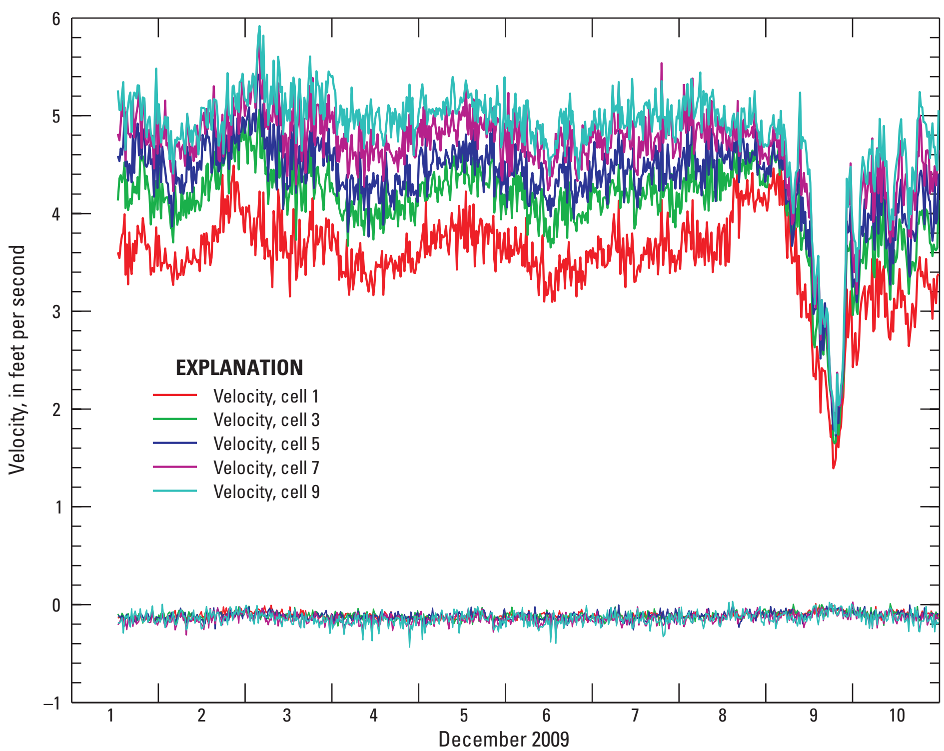

Figure 4-4. Multi-cell X- and Y-velocity time series data for cells 1, 3, 5, 7, and 9.

Velocity Standard Error

Velocity standard error is the standard deviation of the velocity measurements from each acoustic ping divided by the square root of the number of pings averaged together during the averaging period (SonTek™/YSI, 2009). Plot the range-averaged measurement volume velocity standard error and the multi-cell standard error. Make sure all y-axis scales have the same range to enable easy identification of differences in magnitude. Velocity standard error should not vary substantially over time, but may increase slightly as velocity increases due to increased turbulence in the river or stream at higher velocity. The multi-cell velocity standard error time series are useful when viewed simultaneously with multi-cell velocity data. Again, increases in an individual measurement cell compared with other multi-cells can indicate the possibility that the multi-cell is located in a more turbulent region, may be affected by side-lobe interference, or could be measuring velocity affected by boundaries or structures.

Figure 4-5*A* shows the range-averaged velocity standard error for downstream velocity (X-velocity) and the cross-stream velocity (Y-velocity) for the same site and time period shown in figures 4-2 to 4-4. The data is relatively constant throughout the period shown with a few short periods where the standard error data spikes to between 0.02 and 0.04 ft/s. Those small changes alert the hydrographer that something is different during those periods. Overall, the standard error data for the range-averaged velocity looks relatively good for the 10-day period shown.

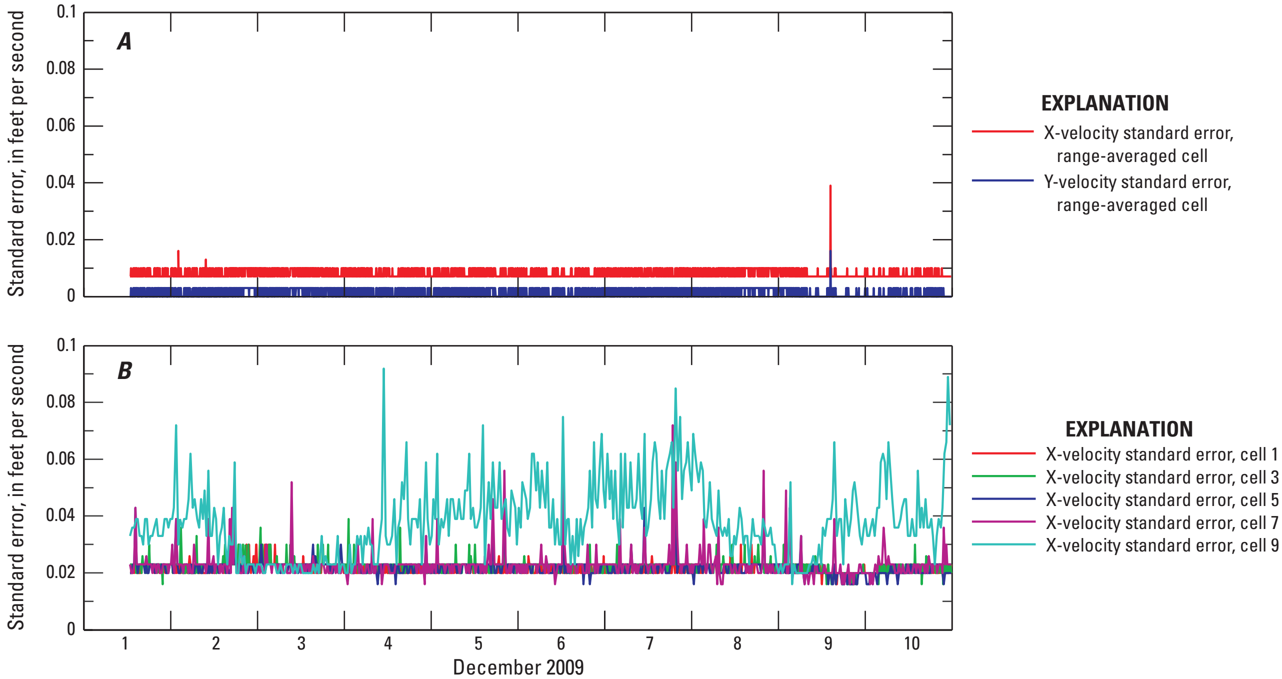

Figure 4-5. Time series of (*A*) range-averaged velocity standard error and (*B*) velocity standard error for multi-cell data.

SonTek™/YSI ADVMs used for index velocity measurement should be configured to collect multi-cell data that overlap the range-averaged measurement volume. Review the multi-cell velocity standard error for each data period and look for indications that can further help determine the quality of the data during deployment periods. Although it is recommended that all multi-cell data be reviewed, for this example, only 5 of the 10 multi-cells are shown and discussed. Figure 4-5*B* shows the standard error for five of the velocity multi-cells (cell 1, 3, 5, 7, and 9) for the same site and 10-day period used in previous examples. The data indicate that the velocity standard error for cells 1, 3, 5, and 7 are relatively constant at about 0.02 ft/s, but the standard error for cell 9 is substantially greater than that for the other cells, ranging from 0.02 to 0.08 ft/s. Because the range-averaged cell and multi-cells 1 through 9 are measuring the same volume of water, and cell 9 shows increased standard error, the range-averaged cell velocity data are likely biased and of poorer quality than the range-averaged data alone would suggest. For this station, the index velocity range-averaged measurement volume should be configured to coincide spatially with cells 2 through 7 (assuming that cell 8 had the same increases in standard error as cell 9).

Signal Amplitude, Instrument Noise Level, and Signal-to-Noise Ratio

The beam signal amplitudes and the instrument noise level provide information about the return signals from the acoustic pulses emitted by the ADVM, the internal instrument noise, and the relative noise in the water at the site. The signal amplitudes are recorded in counts (1 count = 0.43 decibels), with higher counts corresponding to stronger return acoustic signals. Plot and review all of the beam signal amplitudes (signal amplitudes) and instrument noise level (noise level) time-series data. Rescale the left and right y-axes so that they both have the same range. The signal amplitude data will likely show variations over time, and these variations may be normal for a stream, but also may indicate data-quality problems. Look for abrupt changes and low values (counts) in the signal amplitude data and try to understand the causes of variations in the data. Abrupt changes may be related to changes in the scatterers in the water or may be an indication of problems with the acoustic signal. Spikes or rapid increases can be normal, but may also indicate that one or more of the acoustic beams or side lobes are striking a surface or object and increasing the signal amplitudes. Signal amplitude increases should be investigated for correlation with other available data such as water level, temperature, or velocity. The signal amplitudes should be substantially greater than the noise level. While signal amplitudes will vary over time, depending on backscatter concentration, the noise-level data should remain relatively constant for each time period and vary by no more than two or three counts (SonTek™/YSI, 2009). Changes in the noise level can be an indication that the acoustic signal is degraded, site characteristics have changed, ADVM electronics are degrading, or the communication/power cable is damaged or degrading.

The individual signal amplitudes for each beam should have similar magnitudes and patterns. Signal amplitudes for a beam that are substantially different from other beam signal amplitude(s) or beam signal amplitudes having a different pattern than other beams, may indicate that a beam or beams (depending on the ADVM) are affected by debris in the measurement volume or faulty electronics. If beam signal amplitude anomalies are present in the data, it may indicate poor quality velocity data. Depending on the ADVM manufacturer and model, the signal amplitude data can be displayed differently. SonTek™/YSI Argonaut™ ADVMs record the signal amplitude time series for the range-averaged measurement volume as the average of the signal amplitudes from the beginning to the end of the measurement volume, the average signal amplitude for each multi-cell, and the average beam instrument noise level. The averaged value for the measurement volume may appear to be reasonable even when a portion of the measured volume (multi-cell data) may have signal amplitudes that are at or near the ADVM instrument noise level. If the range-averaged signal amplitudes are reasonable values and the cell end is changing over time, then it is likely that the signal amplitudes are not of sufficient magnitude somewhere in the measurement volume. If the signal amplitudes are not of sufficient magnitude anywhere in the range-averaged measurement volume, the measurement volume cell end will be automatically reduced to maintain adequate signal amplitudes throughout the entire measurement volume. The change in cell end may adversely affect the index rating and possibly degrade the quality of computed discharge.

Reviewing signal-to-noise ratio (SNR) data is not really necessary if the beam signal amplitudes and the instrument noise level are reviewed. The SNR data are calculated by using the signal amplitude, subtracting the instrument noise data, and converting the resulting value to decibels. Reviewing the signal amplitudes and noise levels will provide more information than reviewing the SNR data.

Figure 4-6*A* shows signal amplitudes and instrument noise levels for a 90-day data period for a sidelooker ADVM. The signal amplitudes are relatively high, but are normal for this stream because it has relatively high suspended-sediment concentrations. The time series show increased amplitudes at the beginning and later in the time series, both of which correspond to increases in velocity (not shown). In addition to the larger increases, there are periodic fluctuations in the signal amplitudes for most of the data period. After reviewing other available data, the battery voltage time series correlates well with the periodic fluctuations that are seen in signal amplitude data, which is expected. Changes in available power for the ADVM, such as a solar panel powered battery that increases voltage during the day and decreases at night, can cause changes in the transmitted acoustic energy and therefore cause corresponding changes in the signal amplitude data. The instrument noise data is relatively unchanging except for a short period near the end of the time series that corresponds with constantly changing roll data, which could be an indication that the mount has loosened. Essentially, the data seem to be of good quality and do not provide any indication that the index velocity data quality is substantially affected, with the exception of the elevated noise-level data near the end of the record.

Figure 4-6*B* shows signal amplitude and instrument noise-level data for a different ADVM during a 27-day data period. The signal amplitude data indicate numerous abrupt changes in magnitude that do not seem reasonable. For some of the abrupt changes in signal amplitudes, there are substantial increases in instrument noise, which is further indication that something could be occurring that degrades the velocity data quality. Additional review of ADVM data revealed that substantial changes in the cell end correspond with the abrupt changes in signal amplitudes but not with the increases in instrument noise. The increases in the noise-level data might be related to ice break up and increased noise in the water because this site is subject to ice formation.

Range-Averaged Cell End

The ADVM range-averaged measurement volume is configured using the cell-begin and cell-end commands; however, the cell end can change automatically. This behavior is expected and necessary for up-looking ADVMs, but is undesirable for sidelooking ADVMs used for index velocity measurement. The range-averaged cell-end data should be plotted and reviewed for changes with time. If the system is an uplooker ADVM, the cell end should change over time as the water depth changes. If the system is a sidelooker ADVM, the cell end should not change. If the sidelooker ADVM cell end changes over time, this may alter the index rating and degrade the quality of computed discharge. If the sidelooker cell end does change over time, determine the cause for the change or changes. It may be necessary to reduce the cell end in order to maintain a constant cell-end value throughout every deployment.

An up-looking ADVM cell-end change is desired so that the ADVM always measures the same proportion of the water column as the water depth changes. Depending on the Argonaut™ model, SW or XR, the cell end is adjusted automatically by either the vertical acoustic level (SW) or the non-vented pressure sensor (XR). The vertical level or pressure measurements should be plotted and compared with the cell end to verify that both measurements are reasonable and responding to changes in streamflow depth.

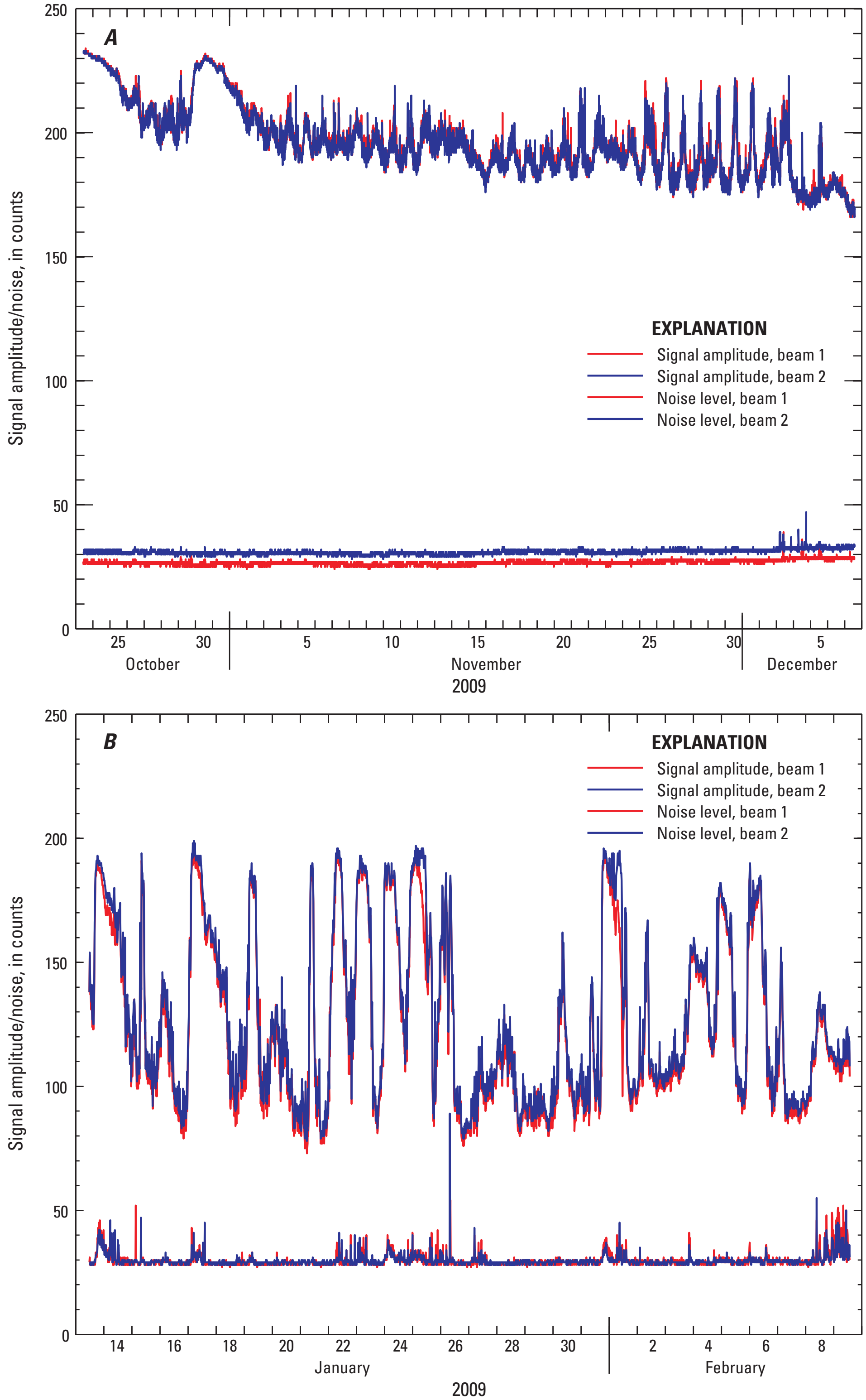

Figure 4-6. Time series data with (*A*) relatively high, yet normal, signal amplitude and noise level and (*B*) unusual signal amplitude and unusual noise level.

Figure 4-7*A* shows a sidelooker range-averaged measurement volume cell-end time series where the cell end remains constant (desirable). Figure 4-7*B* shows the range-averaged measurement volume cell end that is from the same 27-day time series shown in figure 4-6*B*. The cell end in figure 4-7*B* is constantly changing, which would ultimately result in an unstable index rating. The range-averaged measurement volume for this ADVM/site should be reduced such that the cell end does not change over time. Based on examination of this short time period, the cell end should be set to no greater than 200 feet. The multi-cell data should also be reviewed to make sure the measurement volume is optimized for the conditions at the site as described in the Configuration section of the report.

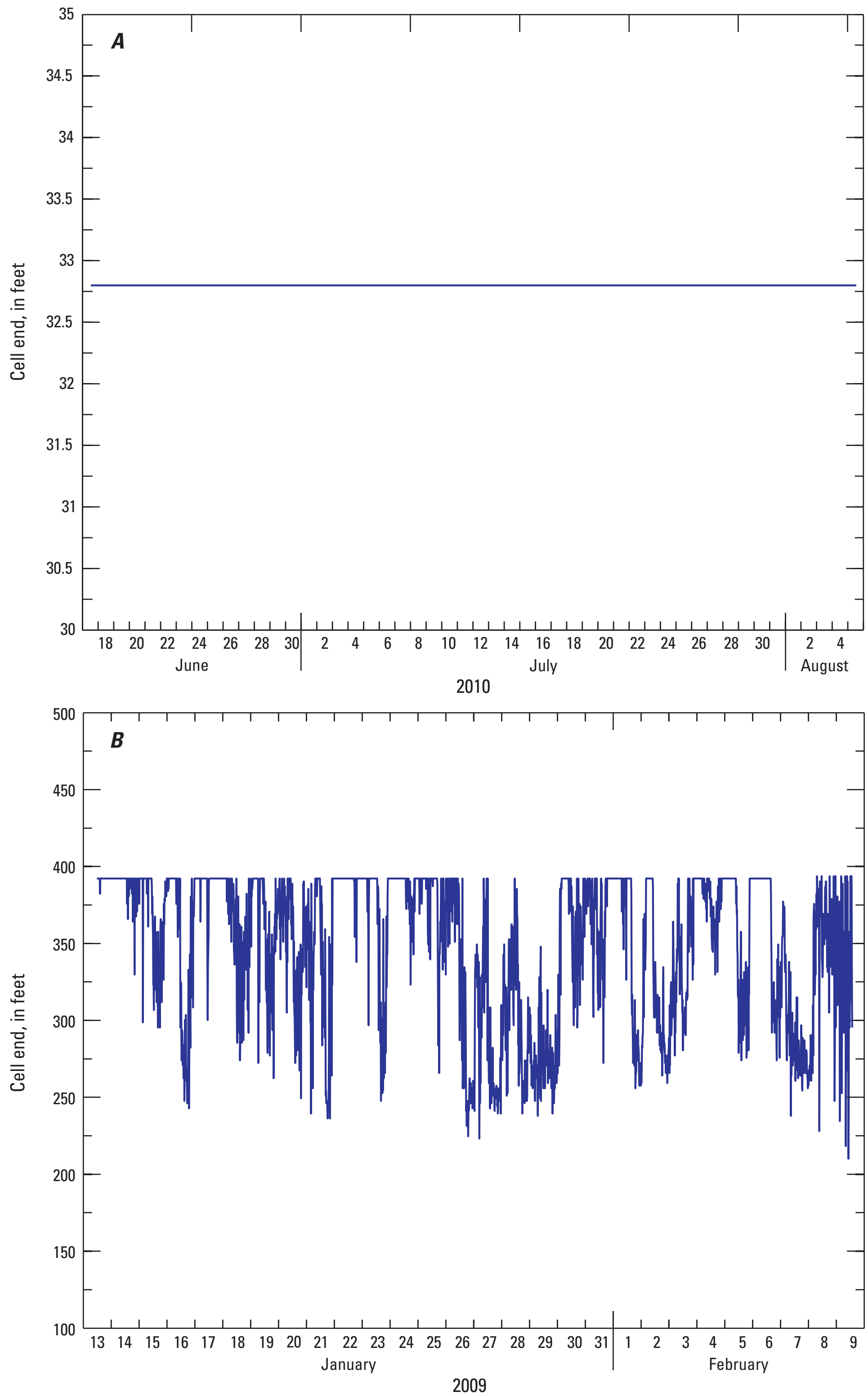

Figure 4-7. Sidelooker ADVM range-averaged measurement volume time-series data with (*A*) no change in cell end and (*B*) substantial changes in cell end.

Figure 4-8*A* shows an Argonaut™-SW uplooker ADVM cell end and acoustic water-depth time-series plot that is considered correct and normal. The left and right y-axes have been rescaled to the same range in order to easily compare the cell-end distance and the water depth. The plot shows that the cell end adequately follows the changes in water depth and therefore should not adversely affect the velocity data quality. The cell-end data has steps, and the water-depth data is a continuous line because the cell end data are recorded in increments of 0.1 meter (0.3 feet).

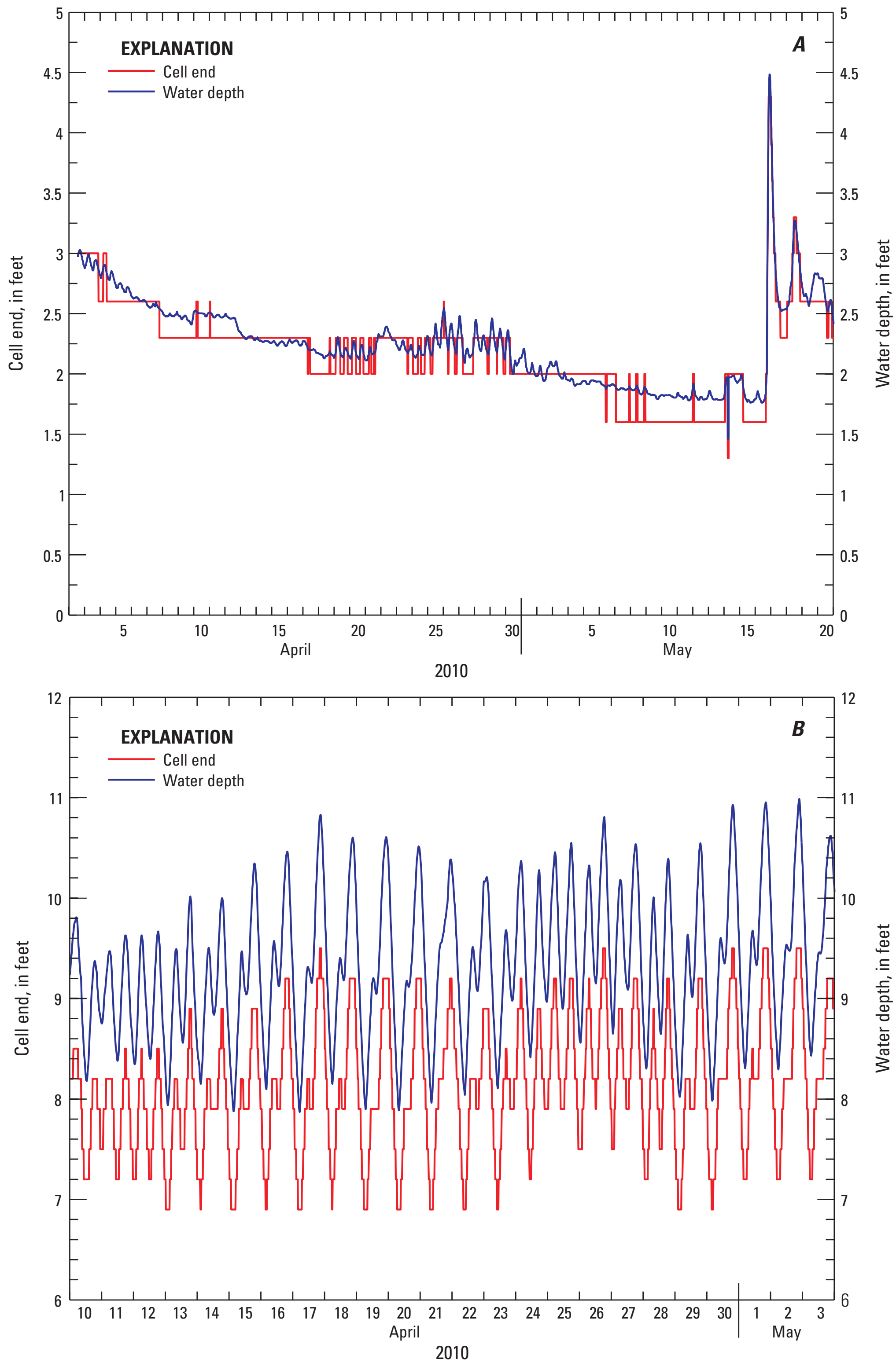

Figure 4-8. Uplooker range-averaged measurement volume and water-depth time-series data for (*A*) Argonaut™-SW and for (*B*) Argonaut™-XR.

Figure 4-8*B* shows an Argonaut™-XR uplooker ADVM range-averaged measurement volume (red) and non-vented pressure depth (blue) time series that is considered correct and normal. When using SI units of measurement, the pressure data is reported in decibars (dbars), which is approximately equal to meters in freshwater, thus making it easy to compare pressure data to the cell end, which is reported in meters. The pressure data depths are greater than the cell-end ranges, and the offset is desirable in order to prevent the cell end from extending past the water surface if there are substantial changes in atmospheric pressure which could bias the measured velocity data.

Temperature

The ADVM temperature sensor is used to estimate the speed of sound, which is required to compute an accurate velocity and to accurately set the cell-end distance for sidelookers. Temperature time series should reflect natural daily and seasonal variations. Typically when the temperature sensor fails, the data values are obviously erroneous; however, on occasion, the errors may be less obvious. If the temperature time series does not change at all (flat line), it is a strong indication that the sensor has failed. Routine field comparisons between an independent temperature sensor and the ADVM temperature should reduce the possibility that velocity data will be biased due to errors in ADVM temperature sensor measurements.

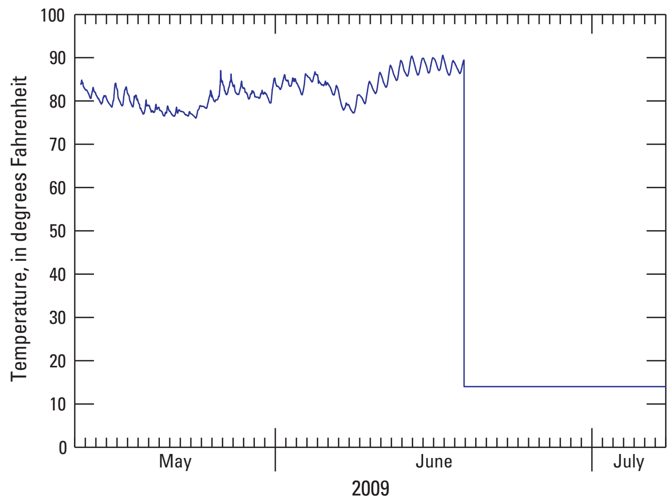

Figure 4-9. ADVM temperature time-series data with periods of valid and invalid data.

Figure 4-9 shows an ADVM temperature time-series plot that appears normal for approximately one-half of the time series, but then abruptly changes to an unrealistic value (14 degrees Fahrenheit) for the remainder of the deployment. A malfunctioning temperature sensor will often change to an unrealistic value and then remain constant over time, although it may be possible for the temperature sensor to malfunction more subtly. Therefore, it is important to routinely verify that the ADVM temperature sensor is operating properly by means of independent water temperature measurements during every station visit per USGS policy (U.S. Geological Survey, 2010). The velocity data and the cell end for sidelookers will be affected by a malfunctioning or failed temperature sensor. When the temperature sensor malfunctions, the ADVM should be replaced as soon as possible. It may be possible to adjust the velocity data if an independent temperature sensor is at the site; however, the cell-end change caused by an erroneous speed of sound computation cannot be corrected. The quality of the velocity data is therefore affected, and the data may have to be identified as estimated or poor quality for the period of the temperature sensor failure.

Pressure

If the ADVM has a pressure sensor, pressure data should be reviewed to ensure that the pressure data changes according to changes in the water level and that the pressure values are reasonable for the depth of the ADVM. This can be critical for Argonaut™-XR ADVMs using the dynamic-range adjustment feature because the water-column cell end is set based on the pressure-sensor data. A malfunction of the pressure sensor or an erroneous pressure reading can result in invalid velocity data. The ADVMs currently available (2011) all use non-vented pressure sensors that require the hydrographer to “zero” the pressure sensor in the air prior to deployment in order to correct for changes in local atmospheric pressure (altitude). When using a non-vented pressure sensor to determine a water level, a nearby quality-controlled barometric pressure senor will be required to correct for changes in local atmospheric pressure.

Most sidelooking ADVMs are equipped with a non-vented pressure sensor that is used to make a coarse depth measurement. This coarse depth measurement is used to identify a range for a valid acoustic water-level measurement. If the pressure sensor is not zeroed properly at the site, or if the pressure sensor malfunctions, there is an increased chance for invalid acoustic water-level measurements.

Figure 4-10 shows ADVM pressure-sensor time-series data for a period when the pressure sensor was working at the beginning of the deployment period, but failing soon after the hydrographer left the station. For a sidelooking ADVM, the acoustic water-level measurements might be erroneous during the time that the pressure sensor failed. For an up-looking Argonaut™-XR, the cell-end data would be improperly set, resulting in biased velocity data that will have to be marked as estimated and may have to be deleted.

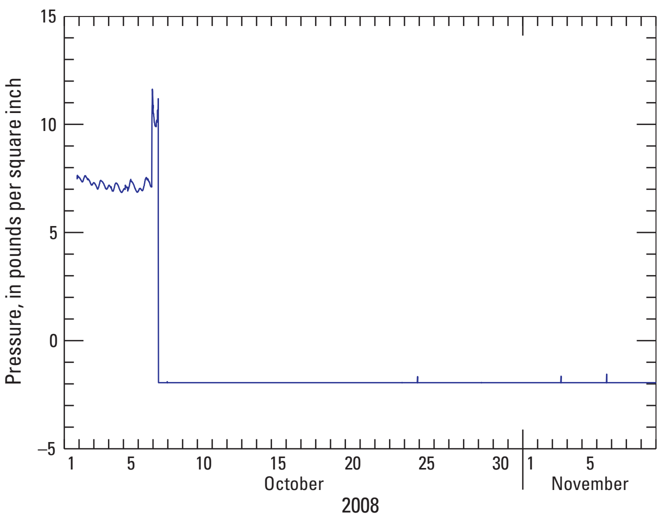

Figure 4-10. ADVM pressure-sensor time-series data with periods of valid and invalid data.

Internal Diagnostic Beam Checks

The Argonaut™ series of ADVMs enables an additional quality-assurance test—an automatically recorded, averaged beam check. By default, the Argonaut™ ADVMs measure the signal amplitude profile data every 100 measurements. The diagnostic beam checks should be reviewed on a routine basis using the manufacturer's software. The diagnostic beam checks are viewed by clicking on the "Diag" button on the tool bar at the top of the ViewArgonaut Processing window, selecting View from the menu across the top of the window, then moving the cursor over the "View Diagnostic Data" option, or by holding the Ctrl key and simultaneously pressing the "D" key. The automatic diagnostic beam checks look like an averaged beam check that is routinely recorded during every site visit, except the individual pings cannot be displayed; only the average of the pings and a profile plot of signal amplitudes over the entire range of the ADVM are displayed. The number of pings averaged together is a function of the averaging period. These automatic beam checks can indicate inadequate signal amplitude above the instrument noise that may adversely affect the measurement volume range (cell end) even though the signal amplitude time-series data values are greater than the noise-level values. As described previously, the signal amplitude or SNR time-series data are the average value for the entire measurement volume, which can be misleading because signal amplitudes at the farther ranges may be lower than desired, while the average amplitude for the entire measurement volume is within an acceptable range (greater than the noise level). The automatic diagnostic beam checks can reveal periods when the velocity data quality may be questionable and possibly provide information on how to identify and possibly prevent the decreases in quality.

Figure 4-11 shows a series of automatic diagnostic beam checks (diagnostic checks) during one deployment period. In the ViewArgonaut software, the display for each diagnostic check has two plots. The signal amplitudes and noise level are displayed in the top plot, and the lower plot shows the signal-to-noise ratio data. Because the signal amplitude provides more information when coupled with the noise-level data, only the upper plot for each diagnostic check will be discussed here. The diagnostic checks were re-created using data exported from ViewArgonaut software and only show the data from the upper plot. The first two diagnostic checks (figs. 4-11*A* and *B*) show normal responses for signal amplitudes with an increase in signal amplitudes at about 24 feet (possibly side-lobe interference) and a strong return signal return at about 30 feet (possibly the far bank or a strong reflector in the cross section). The signal amplitudes also show separation beginning at about 16 to 18 feet that may indicate side-lobe interference. The theoretical decay line is shown as a curved gray line and provides a guide as to how the signal amplitudes should decrease with range under certain conditions. The noise level is shown as a horizontal gray line and is about 30 counts, which is typical for Argonaut™ ADVMs. The cell begin and cell end for the range-averaged measurement volume are shown as vertical dashed lines. In this example (fig. 4-11), the ADVM has been configured to begin the range-averaged measurement volume at approximately 6 feet and end the measurement volume at 16 feet. Figures 4-11*C* and *D* show two more diagnostic checks later in the same deployment. These plots clearly indicate that some type of obstruction has moved into the ADVM measurement volume that may adversely affect the velocity data quality. The information provided by the diagnostic checks alone may not be enough information to determine the quality of the velocity data. The velocity data for this period of unusual diagnostic checks may be valid, but must be verified using the other data available for review. Another diagnostic check made after the previous two checks shows that the obstruction in the measurement volume is no longer there and provides some evidence that the velocity data may be of better quality during this period (fig. 4-11*E*).

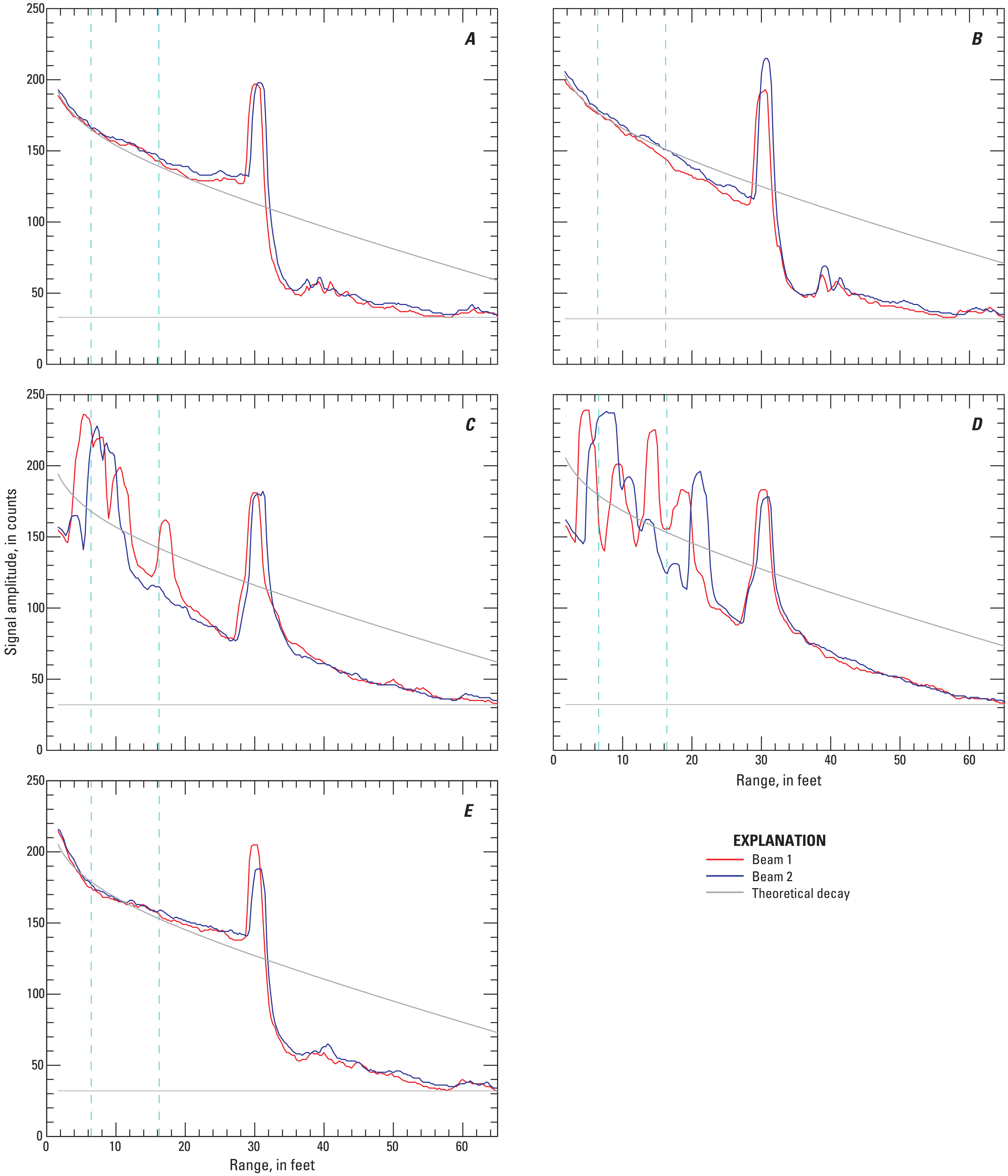

Figure 4-11. Sequential internal diagnostic beam checks that exhibit a normal response (*A*, *B*, *E*) and an abnormal response (*C*, *D*).

Figure 4-12 shows ADVM diagnostic checks for a different station and deployment period than shown in figure 4-11. Figure 4-12*A* shows the signal amplitudes diverging from the theoretical decay curve; however, the shape of the plotted signal amplitutde data is similar for both beams. Of some concern is that the signal amplitudes near the cell end (approximately 340 feet) are very close to the instrument noise at that range and the signal amplitudes level out and diverge before the cell end. Figure 4-12*B* shows another diagnostic check for the same station at a later date during the deployment and indicates that the signal amplitudes have decreased even further, resulting in the cell end being automatically reduced to about 240 feet, which is a change of approximately 100 feet from the previous diagnostic check. With this observation, the hydrographer should plot and review the cell-end time-series data to determine the validity of the range-averaged velocity data during this period due to the changing size of the measurement volume.

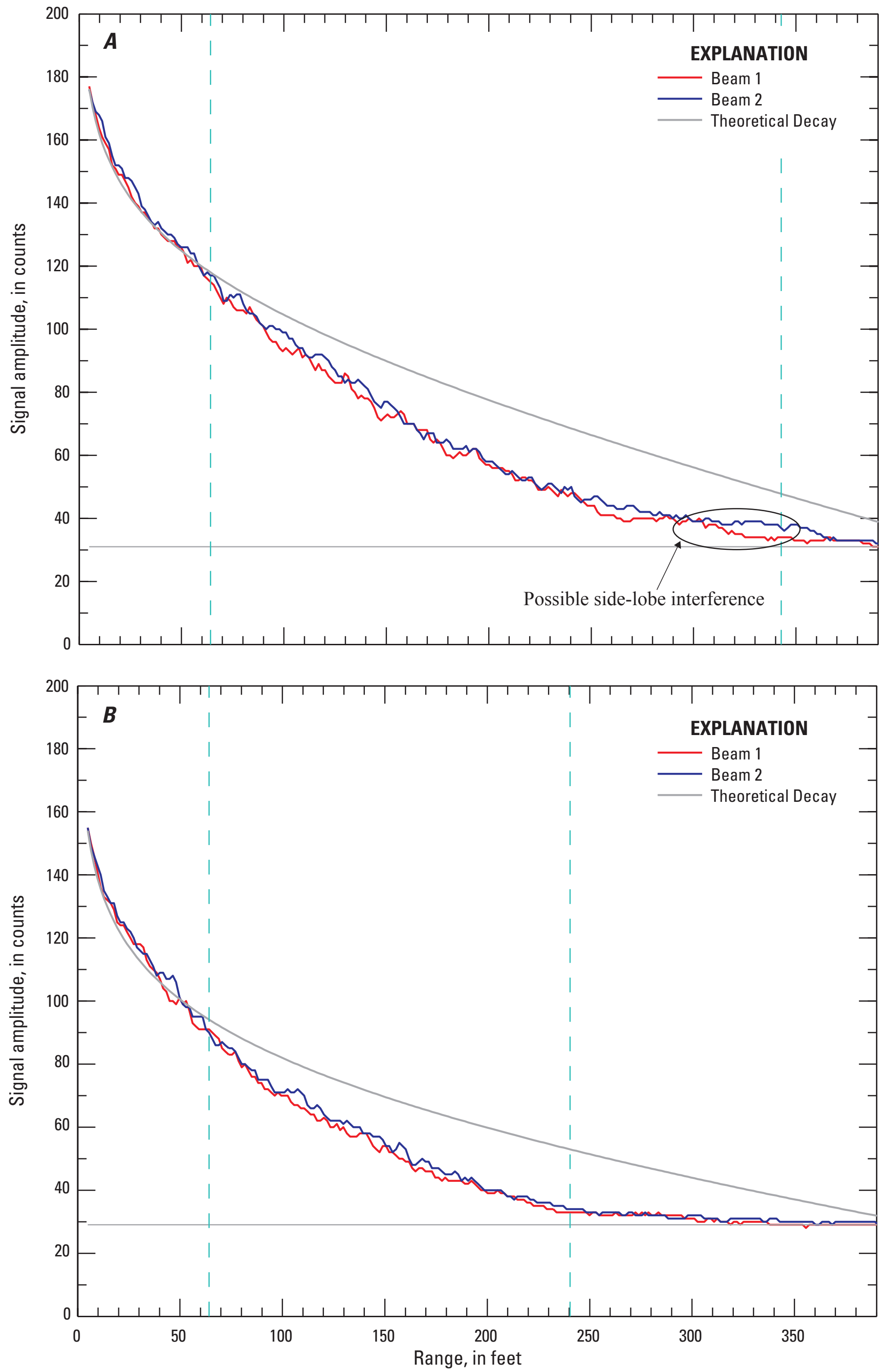

Figure 4-12. Changes in signal amplitude and cell end from Argonaut™-SL internal diagnostic beam checks from the same deployment.

Pitch, Roll, and Heading

Many ADVMs are equipped with an internal compass that can provide information concerning the ADVM orientation. Substantial changes over time in pitch, roll, or heading may indicate instrument movement. Pitch, roll, and heading should not change substantially (greater than 2 degrees) over time, and the values should be included in the station description for documentation purposes and should be checked during routine station visits. Sometimes changes can be caused by malfunctioning electronics, so further investigation of other data and a physical inspection of the ADVM may be required to determine if the ADVM has changed position or if the compass electronics have malfunctioned. The pitch and roll sensors in the ADVM are typically accurate to plus or minus 1 or 2 degrees, so the ADVM should be installed using a bubble level. The pitch and roll sensors should be sampled when the ADVM orientation can be verified with a bubble level, and the values should be recorded on the ADVM Installation and Set-up Form or the Site Visit Form and transferred to the station description. The ADVM should then be lowered and fastened into its desired location and position, and the heading, pitch, and roll sensors should be sampled again. Any differences between the readings at the surface and at the desired location should be noted and may indicate that the ADVM mounting structure is not level, thus requiring the ADVM orientation to be adjusted.

Figure 4-13 shows time series plots for pitch and roll and heading for an ADVM equipped with a compass. Figure 4-13*A* shows a normal time series with little or no change during the deployment period. The values for pitch and roll are about –1 degree, indicating that the ADVM is approximately level. These values (–1 degree) are within the accuracy of the commonly used pitch-roll sensors. The pitch and roll data should not show changes or drift over time. Figure 4-13*B* shows the heading data for the same ADVM and time period as shown in figure 4-13*A*. The heading data shows a slight increase over time of about 2 degrees. This increase may or may not indicate that the ADVM is rotating, but the position of the ADVM should be checked to ensure that it has not moved or cannot move. This small change in heading (approximately 2 degrees) may also be related to the compass error or the presence of ferrous metals near the ADVM. Therefore, when evaluating the heading data, consider that the compass can be affected by ferrous objects or materials near or around the ADVM.

Summary

Routine review of the transmitted ADVM data is necessary to provide quality-assured velocity data and minimize invalid or questionable data. The data stored in the ADVM internal memory are useful for quality control of index velocity data, in part because additional data are available but not usually transmitted. Internally recorded ADVM data should be retrieved from the ADVM and reviewed during every site visit, and a more thorough review of the data should be performed in an office setting. Awareness of the available ADVM data, use of the data for analyzing index velocity measurement quality, and the ability to readily differentiate valid data from invalid data can increase the efficiency of the review.

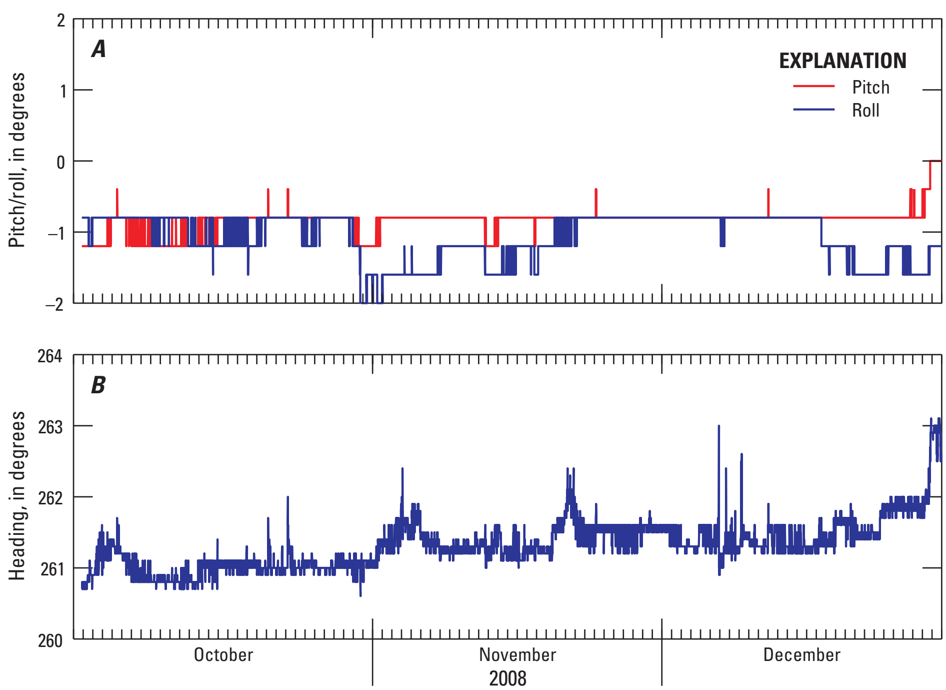

Figure 4-13. (*A*) Pitch and roll and (*B*) heading data time series.

References Cited

SonTek™/YSI, 2009, Argonaut™-SL System Manual Firmware Version 12.0, San Diego, CA, SonTek™/YSI Corporation, 316 p.

U.S. Geological Survey, 2010, Independent water temperature measurement for hydroacoustic measurements: U.S. Geological Survey, Office of Surface Water Technical Memorandum 2010.07, accessed April 18, 2011, at *http://water.usgs.gov/admin/memo/SW/sw10.07.html.*