SonTek RiverSurveyor and CastAway-CTD Integration

Sound Speed Profiles Increase Acoustic Measurement Accuracy

Background - Sound Speed and Acoustic Measurements

Underwater acoustic measurements, particularly acoustic depth range measurements, are dependent on information about the speed of sound in the water to collect accurate data. Sound can travel through the water at different speeds based on changes in temperature, salinity and density (Table 1). For example, sound will travel faster in hot salty water and travel slower in cold fresh water.

The water in almost every lake, river, estuary and ocean is stratified into different layers. Temperature conditions in one layer may be notably different from conditions in another layer (Fig. 1). As sound transitions from one layer to the next it will also refract and change direction.

These changes in sound speed and direction throughout the water column cause errors in acoustic depth measurements. Depth measurement errors are generally largest in deeper rivers or in estuaries where water temperature and salinity at the surface can vary significantly from the water beneath it. For more detailed information about how temperature and salinity affect depth calculations refer to Sontek Technical Note: Range, Velocity, Sound Speed and Snell's Law.

	Change	Effect on Sound Speed
Temperature	1° C	4.0 m/s
Salinity	1 PSU	1.4 m/s
Depth	1 PSU	1.7 m/s

Table 1. Temperature, salinity and depth changes and corresponding influence on the speed of sound.

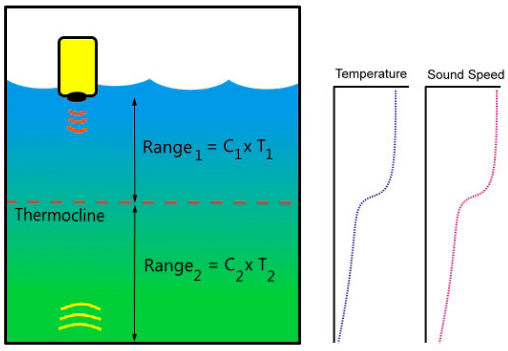

Figure 1. Diagram of a stratified water column.

Similar to acoustic current measurement systems, hydrographic surveying instruments (i.e. multibeam echosounders, side scan sonar) measure the time it takes a sound pulse to travel from the instrument to the seafloor to calculate distance. Hydrographic surveyors apply sound speed corrections to their data to reduce depth measurement errors induced by sound speed variability. To measure sound speed surveyors use a CTD (Conductivity, Temperature, Depth) sensor to collect a vertical sound speed profile during a hydrographic survey. The sound speed correction is then applied to the acoustic sounding data yielding more accurate depth measurements. These sound speed corrections can also be applied to ADCP measurements to improve their accuracy.

Application to ADCP measurements

While it has been common practice for hydrographic surveyors to apply sound speed corrections to bathymetric data, corrections have not commonly been applied to ADCP data for two primary reasons. First, the advantage of higher accuracy measurements has been overshadowed by the complexity of applying corrections and velocity measurements are impacted less by sound speed than depth measurements. In many environments sound speed corrections will only slightly improve ADCP measurement accuracy; however there are environments such as estuaries where corrections will significantly increase accuracy. With growing requirements for highly accurate flow measurements in our rivers and oceans and with more ADCP data being used for measurements other than velocity such as discharge and bathymetry, the need for applying sound speed corrections to ADCP data is increasing.

Sound speed corrections improve the accuracy of ADCP discharge calculations by increasing the accuracy of the river cross-sectional area. Accurate sound speed measurements at the ADCP transducer are important for

velocity measurement accuracy. The fast response CastAway thermistor eliminates the need for waiting for the ADCP thermistor to equilibrate to water temperature and ensures accurate water temperature at the transducer face which is important in velocity calculations.

CastAway-CTD and RiverSurveyor Integration

The CastAway is a small sophisticated CTD that provides a turnkey solution for applying sound speed corrections to RiverSurveyor measurements by integrating seamlessly with RiverSurveyor Live 3.0 and RiverSurveyor Stationary Live 2.0. Collecting sound speed profiles is simple with the CastAway:

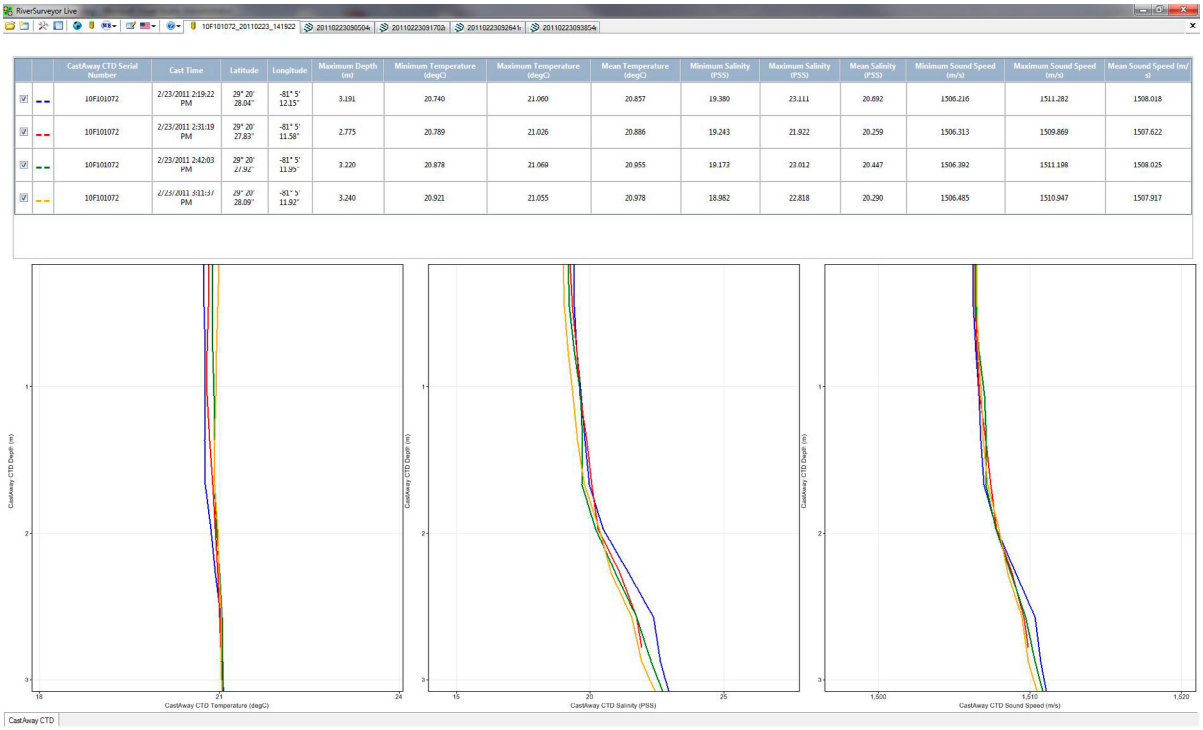

Figure 2. Screen capture from the RiverSurveyor software of the CTD summary information tab.

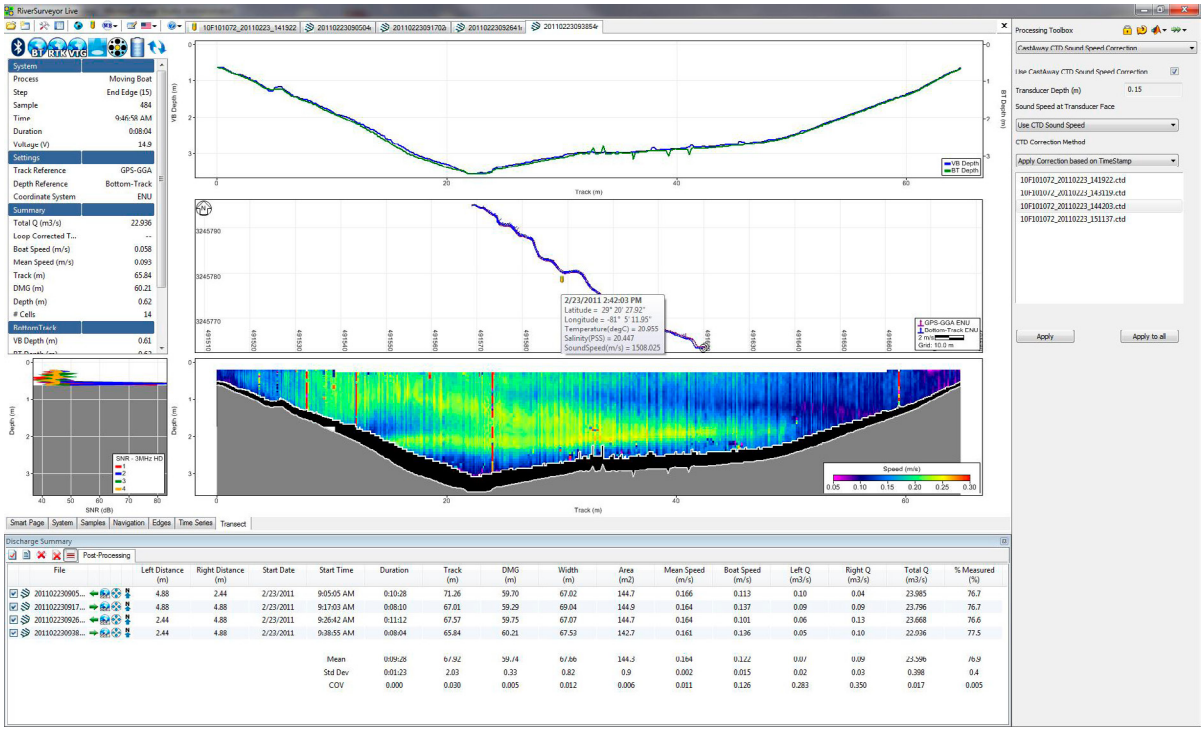

Figure 3. Screen capture of the RiverSurveyor software showing the sound speed correction side bar and the location of the selected CTD profile on the center transect plot.

it can be lowered by hand, requires no preprogramming, and after a cast automatically transfers data to your PC. A built in GPS marks the location and timestamp of the sound speed profile and also allows the software to automatically select which profile to apply to the discharge calculation. In the software, there is also a summary page that displays temperature, salinity and sound speed information from the CTD (Fig. 2).

The moving boat software also adds a marker of the CTD profile location to the ADCP transect plot (Fig. 3). There are two options for applying the CastAway sound speed correction to a discharge calculation, using ADCP surface temperature data and CastAway surface salinity, or using the full CastAway temperature and salinity profile. After applying the sound speed correction you can instantly review the impact of the correction on the discharge calculation.

Summary

Using CTD measurements to apply sound speed corrections to ADCP data helps to further improve ADCP measurement accuracy. ADCP discharge measurements in rivers with large cross-sectional profiles and areas with high stratification such as estuaries will benefit the most from sound speed corrections. The fast response thermistor of the CastAway also ensures accurate temperature data required for all velocity measurements. The CastAway-CTD and RiverSurveyor integration is a user-friendly way to apply sound speed corrections to ADCP measurements and increase ADCP measurement accuracy.

References

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