

Hydroacoustics UPDATE:

Determining Mean Velocity for Stationary Profiles using WinRiver

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INTRODUCTION

A stationary water velocity profile is collected by holding the ADCP in a specific location for a specified time and then averaging the data to obtain a mean velocity profile or a depth-integrated mean velocity at that location. WinRiver 10.06 can provide two mean water velocities for data collected in this manner. The two values are numerically valid based on the approach used to obtain them but neither value properly reflects the depth-integrated water velocity for the mean profile. Neither the two methods provided in WinRiver, nor the third method recommended herein, account for the velocity in the unmeasured area at the top and bottom of the profile. The error associated with ignoring the unmeasured areas should be less than 5%, if the depth to the top of the first bin is less than 40% of the total depth, based on a logarithmic velocity profile.

The purpose of this Hydroacoustics Update is to explain how the two values of the mean water velocity are computed in WinRiver and to describe the correct method for computing the mean water velocity for a set of velocity profiles when using WinRiver.

EXAMPLE OF THREE MEAN VALUES

The difference between the two mean water velocities calculated in WinRiver and the correct method, described herein, can be easily illustrated if we assume a vertical velocity profile comprised of five measurement ensembles, some of which have missing or bad data (Table 1). To simplify the example, a single component of the velocity will be used rather than both components (east-west and north-south) of the velocity vector. The theoretical mean velocity is simply the mean of the numbers 1 through 8 or 4.5. This is the mean value that should be computed as the mean of the measured data. One method for computing the mean velocity is to compute the mean for all of the valid velocities for all depth cells and all ensembles. In this example that would result in a mean of 4.6. WinRiver uses this method to compute the water speed reported in the Discharge History Tabular View (F12). Another method would be to compute the mean velocity in each measured profile or ensemble and then compute the mean of the mean profiles or ensembles. The result of this example is a mean of 4.63. This value is close to the first method but not identical. This method is used in

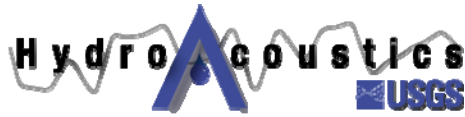


Table 1. Example of different methods for computing the mean velocity of five profile measurements with missing data.

Correct Velocity	Measured Velocities for 5 Profiles					Mean Profile	
	1	2	3	4	5		
1	1	1	1	1	1	1	
2	2		2	2		2	
3	3		3		3	3	
4			4	4	4	4	
5	5	5		5	5	5	
6		6	6	6		6	
7	7	7	7		7	7	
8	8	8	8	8	8	8	
Profile Mean	4.50	4.33	5.40	4.43	4.33	4.67	4.50
Mean of Profiles						4.63	
Mean of All Bins						4.60	

WinRiver to compute the water speed reported in the Composite Tabular View, when all ensembles are averaged together.

The correct mean velocity is obtained by computing the mean velocity profile and then computing the mean velocity from the mean profile. Using this method, the mean velocity in each bin of the profile is computed and then the mean velocity of the profile is computed from the mean velocity in each bin. For the example shown in table 1, the result when using this method is 4.5. WinRiver does not compute this value directly but it can be computed from the Velocity Tabular window if all of the ensembles averaged together.

APPLICATION TO WINRIVER

Figure 1, shows a screen capture of a stationary measurement using WinRiver. Note the bottom reference has been set to “none” and therefore, the data will not be affected by a moving bed. Figure 2 shows the difference in the water speed reported in the Composite Tabular window (with all ensembles averaged together) and the flow speed reported in the Discharge History Tabular window. The difference is small and could be assumed to be rounding error, but in fact, it is directly the result of the approach used to compute the average, as described above. Figure 3 is a screen capture of the Velocity Tabular window with all ensembles averaged together. This represents the mean velocity profile for that location. The mean velocity is computed by computing the mean east velocity component and the mean north velocity component and then computing the magnitude of the velocity by taking the square root of the sum of the squares of the components.

$$|\bar{V}| = \sqrt{\left(\frac{\sum V_e}{n}\right)^2 + \left(\frac{\sum V_n}{n}\right)^2} \quad (1)$$

where

$|\bar{V}|$ is the mean water speed;

V_e is the east component of the water velocity in each bin;

V_n is the north component of the water velocity in each bin; and

n is the number of bins with valid water velocity components.

For the stationary measurement illustrated in Figures 1-3, the mean water speed compute using equation 1, is 1.104.

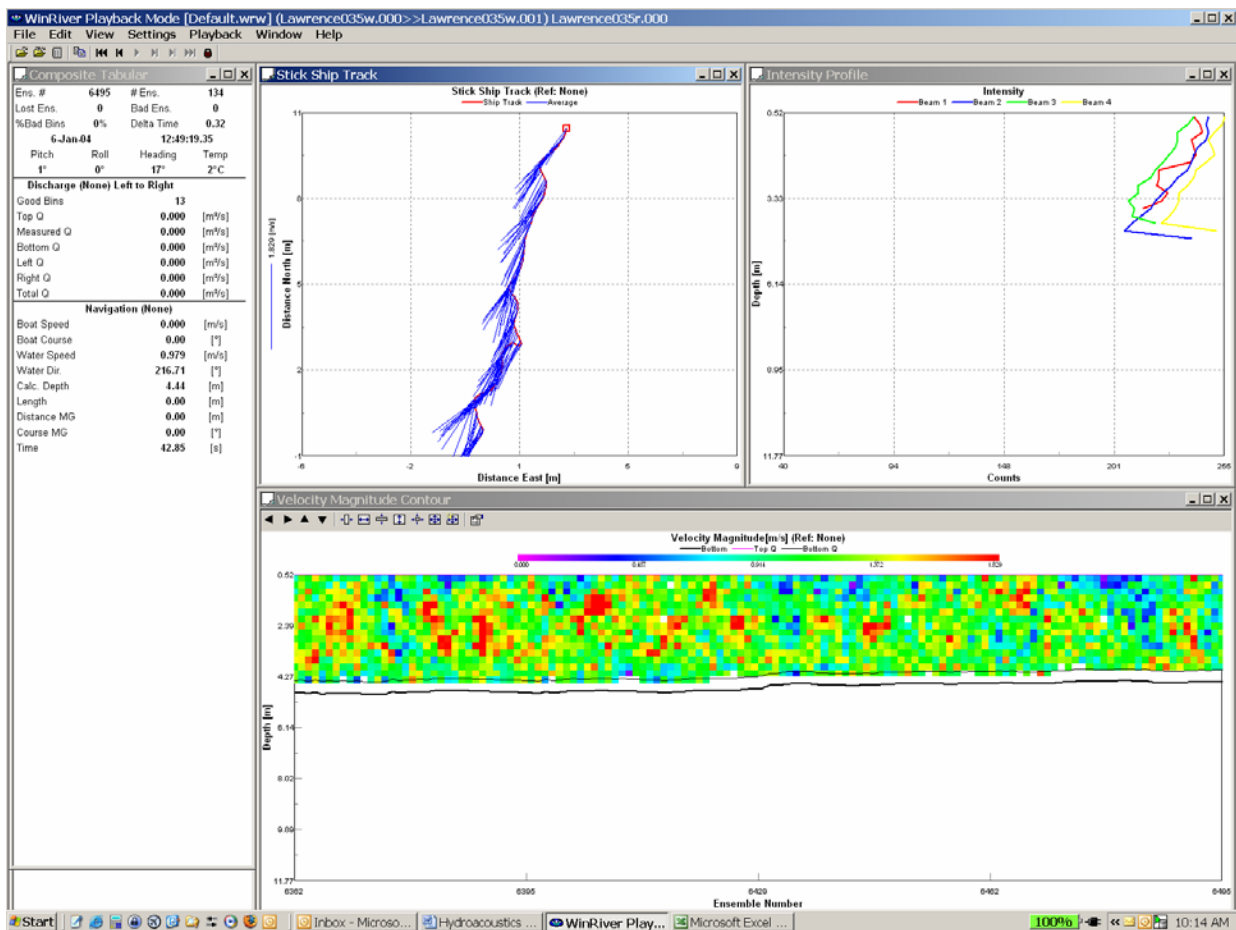


Figure 1. WinRiver screen capture of a stationary velocity profile measurement.

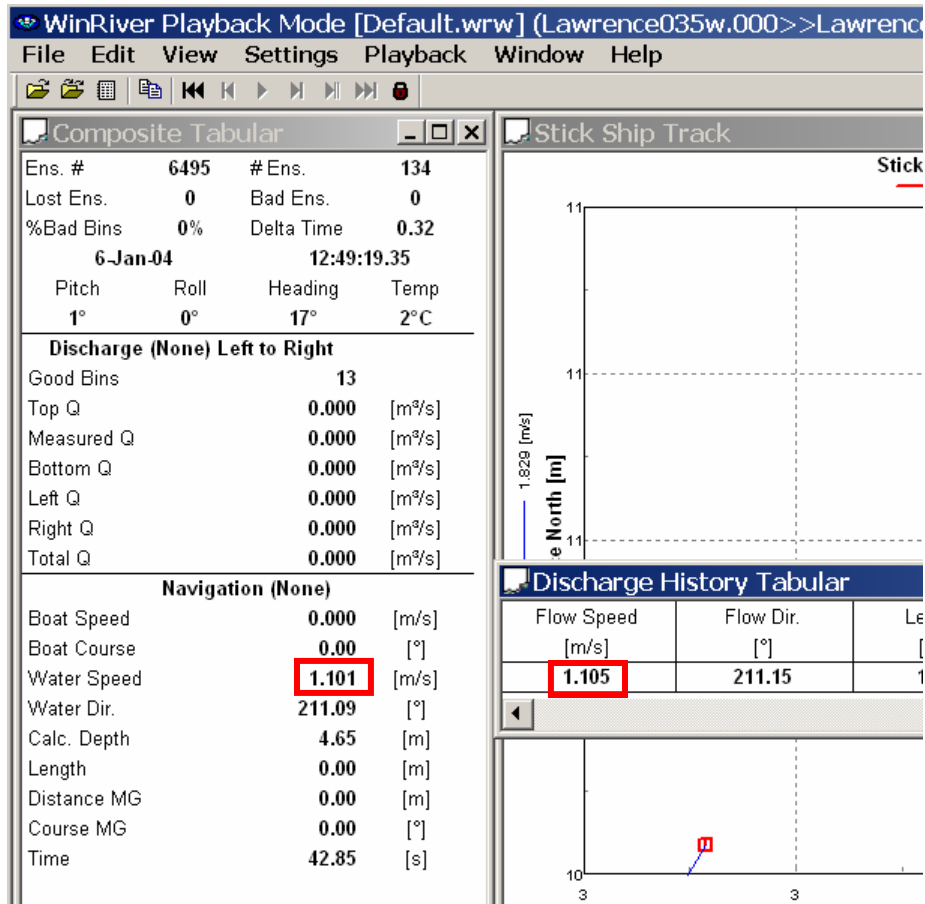


Figure 2. Screen capture of WinRiver showing difference in water speed in the Composite Tabular window and flow speed in the Discharge History Tabular window when all ensembles are averaged.

Depth [m]	Velocity [m/s] (Ref. None)				%	Discharge [m ³ /s]
	East	North	Up	Error		
0.64	-0.427	-0.780	-0.017	0.036	100	0.000
0.89	-0.481	-0.823	-0.014	0.019	99	0.000
1.14	-0.536	-0.871	-0.026	0.055	100	0.000
1.39	-0.566	-0.917	-0.026	0.089	100	0.000
1.64	-0.561	-0.992	-0.023	0.150	100	0.000
1.89	-0.596	-0.977	-0.017	0.137	100	0.000
2.14	-0.657	-1.009	-0.027	0.084	98	0.000
2.39	-0.658	-1.012	-0.029	0.105	100	0.000
2.64	-0.609	-1.000	-0.025	0.094	100	0.000
2.89	-0.543	-1.006	-0.018	0.116	100	0.000
3.14	-0.589	-1.006	-0.025	0.109	100	0.000
3.39	-0.649	-0.987	-0.028	0.083	100	0.000
3.64	-0.579	-0.975	-0.023	0.074	100	0.000
3.89	-0.559	-0.932	-0.017	0.066	98	0.000
4.14	-0.501	-0.917	-0.015	0.036	77	0.000
4.39	-0.404	-0.880	0.006	0.068	40	Bad
4.64	Bad	Bad	Bad	Bad	0	Bad
4.89	Bad	Bad	Bad	Bad	0	Bad
5.14	Bad	Bad	Bad	Bad	0	Bad
5.39	Bad	Bad	Bad	Bad	0	Bad
5.64	Bad	Bad	Bad	Bad	0	Bad
5.89	Bad	Bad	Bad	Bad	0	Bad
6.14	Bad	Bad	Bad	Bad	0	Bad
6.39	Bad	Bad	Bad	Bad	0	Bad

Figure 3. Screen capture of WinRiver Velocity Tabular window with all ensembles averaged.

SUMMARY

Computing the correct mean water velocity for stationary profiles collected in WinRiver requires some computation by the user. WinRiver computes two mean water velocities one in the Composite Tabular window and one in the Discharge History Tabular window, but neither value correctly represents the mean water velocity for a stationary profile. The mean water velocity for a stationary profile must be computed by averaging all of the ensembles for each bin together and computing the mean water speed from the mean velocity components in each bin displayed in the Velocity Tabular window.