1. Welcome to the USGS Office of Surface Water Hydroacoustics podcast on “Using extrap to Determine Proper Extrapolation Methods, Part 1 – Using Extrap”. An additional webinar Part 2 – Practical Examples will provide example analyses of different measurement conditions commonly encountered in the field.

2. Part 1 – Using Extrap will cover the Purpose of extrap; the shape and distribution of velocity profiles in rivers; how profiles are averaged in WinRiver; how profiles are averaged in extrap; and then provide a detailed description of the extrap interface and how to use it.

3. The purpose for extrap is to provide the user a technically correct and efficient method to visually determine the best extrapolation method to use for computing discharge in the unmeasured top and bottom portions of an ADCP discharge measurement. One of the keys here is efficient; extrap should be faster, more accurate, and easier to use than completing the analysis using WinRiver or RiverSurveyor.

4. The distribution of velocity in a channel cross section is dependent on the roughness of the bed and bank and also the shape and width to depth ratio of the channel. This diagram from Chow’s Open Channel textbook shows the velocity distribution in several different channel shapes. [CLICK] for the narrower and deeper channels you can see that the region of maximum velocity is located below the water surface [CLICK] [CLICK] [CLICK] this would result in a velocity profile that tends to bend back near the top as shown hear. This bend back is not due to wind or density currents but simply the channel shape. For wider and shallower cross sections [CLICK] the velocity profile [CLICK] follows the more typical logarithmic or power curve.

5. In addition to the shape of the cross section, the roughness of the streambed can also have a significant impact on the shape of the velocity profile. This graph plots the normalized depth and velocity for three velocity profiles with different values or relative roughness. The relative roughness is computed as the depth of flow divided by the height of the roughness so that the smaller the relative roughness the greater the actual roughness and hence the drag on the flowing water. [CLICK] The curve with the smoothest bed shows greater velocity nearer the bed and a steeper profile than the curves with greater roughness. [CLICK] As the bed roughness increases the drag on the water increases and the velocity near the bed decreases while the velocity near the surface increases. [CLICK] Therefore, as the roughness increases the velocity profile will tend to become flatter.

6. When using WinRiver the recommended process was to average ensembles together to reduce the effects of instrument noise and turbulence so that the shape of the velocity or discharge profile could be evaluated more accurately. However, WinRiver simply averaged data in the same depth cell across multiple ensembles. Typically we suggested using about 10 ensembles in the average. [CLICK] [CLICK] If we look at two portions [CLICK] [CLICK] of this cross section each representing about 10 ensembles we can illustrate the potential problem in using this technique. [CLICK] [CLICK] Averaging the cells at the surface doesn’t illustrate the problem very well and actually seems like a reasonable thing to do. However, if we look near the bed in an

area were the depth is changing [CLICK] we can see that by averaging across constant depths we average data very near the streambed that would have a lower velocity, with data further from the streambed that would naturally have a greater velocity [CLICK] rather than with data in the same relative proximity to the bed [CLICK] [CLICK]. The result can be a distorted velocity profile.

7. Extrap uses only normalized or relative values of velocity, discharge, and depth. Use of normalized velocity and discharge [CLICK] for each ensemble allows all data from the cross section to be plotted together and the use of normalized depth accounts for the changes in the depth of flow. [CLICK] Extrap then computes the median values for 5% depth increments. [CLICK]The horizontal whiskers are added to the median values to show the spread of 50% of the data in each increment.

8. Extrap supports the PD0 binary data collected with Rio Grande, StreamPro, and RiverRay ADCP's from Teledyne RD Instruments and the Matlab output data from SonTek/YSI RiverSurveyor M9 and S5 ADCPS. The draft of the instrument is not stored in the PD0 file, so when loading a PD0 file the user must select the units for the draft and enter the draft of the instrument. The units and draft are stored in the Matlab output from RiverSurveyor Live and thus, do not have to entered manually in extrap.

9. Demo

10. Demo

11. Let's begin looking at the extrap user interface by defining the displayed data. [CLICK] The gray dots represent the normalized discharge or depth for each depth cell in the transect plotted at the appropriate normalized depth. [CLICK] The blue squares represent the median value for data falling within the 5% increments of normalized depth. [CLICK] The blue horizontal lines or whiskers show the limit of the central 50% portion of the data used to compute the median. In statistics this is often called the interquartile range. [CLICK] The numbers in the boxes to the side of the graph indicate the number of data points in each 5% increment of normalized depth. [CLICK] The blue curve is the extrapolation fit based on the data and the user provided parameters (extrapolation method and exponent). [CLICK] The data in red show the median and interquartile ranges for 5% increments of depth where the number of points in the increment are below the threshold for the minimum number of points for a valid median point.

12. Video

13. Video

14. There are two options for the type of data to be plotted: velocity and discharge. Discharge is the product computation similar to WinRiver and RiverSurveyor but normalizes the data for each ensemble. Velocity is an option that can be used particularly for stationary measurements were the instrument doesn't move and therefore, there is little or no BT velocity for computing the

cross product. Generally there is always some ADCP movement [CLICK] but the noise associated with the BT in these situations make velocity a better choice [CLICK].

15. The extrapolation method options presented in extrap use the terminology from WinRiver. [CLICK] The top extrapolation can be either Power or Constant [CLICK] and the bottom extrapolation method can be either Power or No Slip. If No Slip is selected for the bottom extrapolation method then the top extrapolation method is automatically changed to constant because we know the bottom of the profile should have some power curve shape and if the whole profile doesn't follow a power curve necessitating the use of no slip then the top extrapolation certainly should not be a power fit based on all the data. The user can change these as necessary to help determine the best fit for their data.

16. The Set Pt Threshold sets the number of points that must be present in each 5% normalized depth increment for that data in that increment to be used in fitting the chosen extrapolation method. Changing this value will result in more or less median values plotted as red. [CLICK] [CLICK] if we change the value from 10 to 5 we see that [CLICK] the second median value from the bottom is now blue.

17. Video

18. Applying the results of extrap to WinRiver is straightforward as the terminology and options are the same. However, applying the results to RiverSurveyor Live requires some adjustment.

    [CLICK] for a Power / Power fit, power at the top and bottom the application is pretty simple. Power / Power is the default configuration for RiverSurveyor Live. [CLICK] However, to change the exponent requires that the exponent be changed for both the top and bottom extrapolation.

    For a Constant / Power situation, constant at the top and power at the bottom requires several steps. First the top extrapolation method must be changed to Constant. [Click] Then the Cells to use must be changed to "Only Use" [CLICK] and the number of cells set to 1.

    To achieve a Constant / No Slip fit requires that the same steps for setting the constant fit at the top be followed. Set [CLICK] constant, [CLICK] Only use, [CLICK] one cell. To achieve a No Slip fit at the bottom [CLICK] set the cells to use to Only Use and [CLICK] then the number of cells to 2. In shallow water where there are few depth cells only one could be used but generally you want to use at least 2.

    [CLICK] for the last two fits the exponents can also be changed for the bottom fit.

19. To apply extrap to your discharge measurements you would want to use extrap to view a sample of the transects. It is generally NOT necessary to view every transect, but you must view enough to know that the profile is consistent and follows what you would expect given the streams shape and bed roughness. Select a SINGLE best fit for the whole measurement. Don't

adjust the fit for each transect unless there is documentation to show the flow changed, in which case the data may not be consistent enough to be used as a single discharge measurement but may need to be treated as multiple measurements. When visually assessing the fit among multiple transects use optimize wisely taking into account what you know hydraulically about the cross section and consider the noise; the width of the whiskers. Although the exponent computed by optimize may change from transect to transect, the change may be within the noise of the data and may make very little change in overall discharge. Using extrap should be quick and efficient and save you time. The fit you decide is the best must be manually entered into WinRiver or RiverSurveyor Live when you process the final discharge. The podcast on “Using extrap to Determine Proper Extrapolation Methods, Part 2 – Practical Examples” will provide examples of commonly encountered situations and how to treat them using extrap.