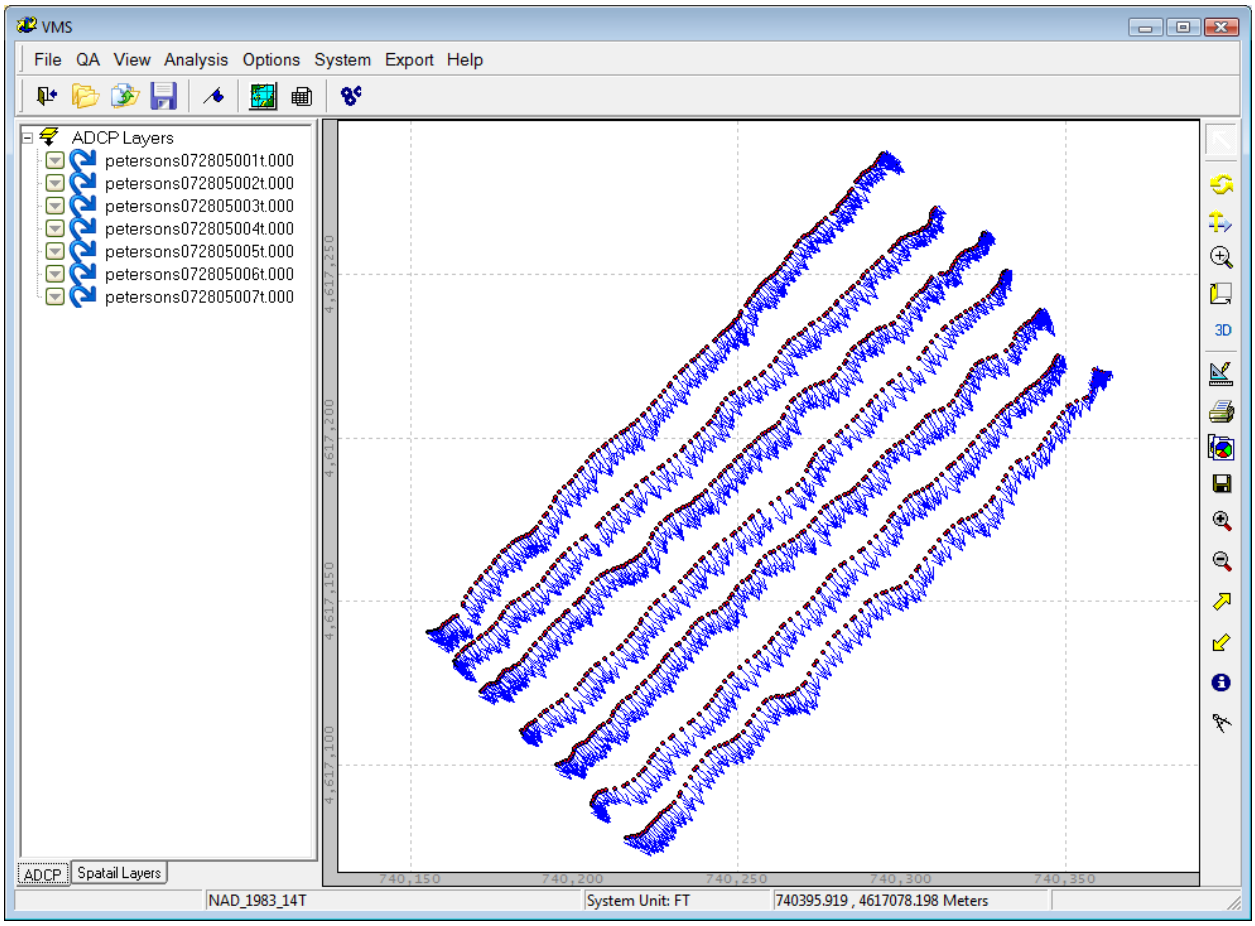
VMS

ADCP Velocity Mapping Software



A quick tutorial for using VMS

Prepared by Dongsu Kim, Marian Muste, David Mueller, and Michael Winkler

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1. Introduction

The newly developed VMS aims at providing an efficient process for quality assuring, mapping velocity vectors for visualization and facilitating comparison with physical and

numerical model results. VMS is collaboratively developed by IIHR-Hydroscience & Engineering (Dongsu Kim, Marian Muste), USGS Office of Surface Water (David Mueller), and USACE Navigation Systems Program (Michael Winkler).

VMS was designed to provide efficient and smooth work flows for processing groups of transects. The software allows to select group of files and subsequently to conduct statistical and graphical quality assurance on the files as a group and/or individually as appropriate. The software is built using Object Oriented Programming (OOP) techniques in conjunction with Borland C++ Builder (version 6). The analysis results are displayed in numerical and graphical formats. In this initial stage, VMS handles ASCII file format provided by Teledyne RD Instruments Acoustic Doppler Current Profilers (ADCP). It is anticipated that VMS will be extended to other format of input data and acoustic profilers in the near future.

This tutorial is targeted to guide beta testing of the first version of VMS.

1.1. Developing tools

Borland C++ Builder (version 6) was used as IDE for developing the graphical user interfaces and TeeChart version 7, which is add-on component of Borland C++ Builder, was used for the visualization and graphs.

1.2. Data requirements

Currently, VMS reads ADCP ASCII file (**t.000 and **ASC.TXT) with configuration file (**w.000) measured by using WinRiver I, and II. Binary files acquired from WinRiver I and II are not compatible now.

1.3. Installation and launching of VMS

The user can install VMS using the setup file (setup.exe) provided. The InstallShied Wizard will help the user to install the software. Follow each step until the user finishes installation.

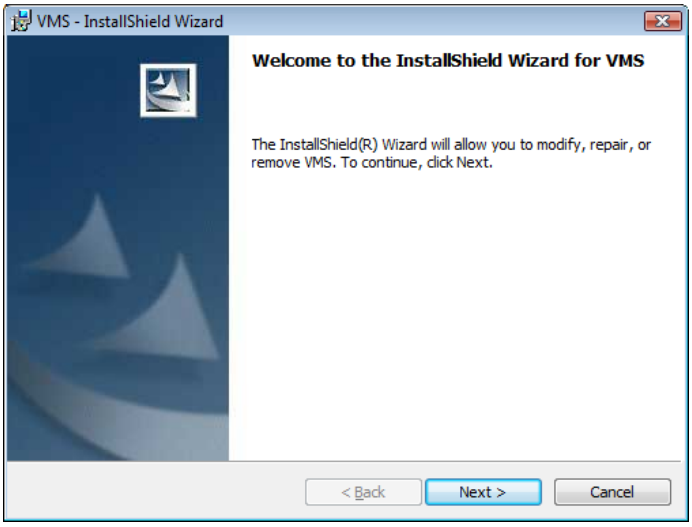


Figure 1.1. Installation of VMS

After installation of the software, launch the VMS by clicking the icon on the desktop.

Figure 1.2. Icon of VMS

The user can also launch the software from Windows Start menu (Start→All Programs→VMS→VMS.exe. In order to test latest version, replace VMS.exe in C:\Program Files\VMS folder with VMS.exe in the delivered CD. If there were no problems during installation, the following initial interface will show up.

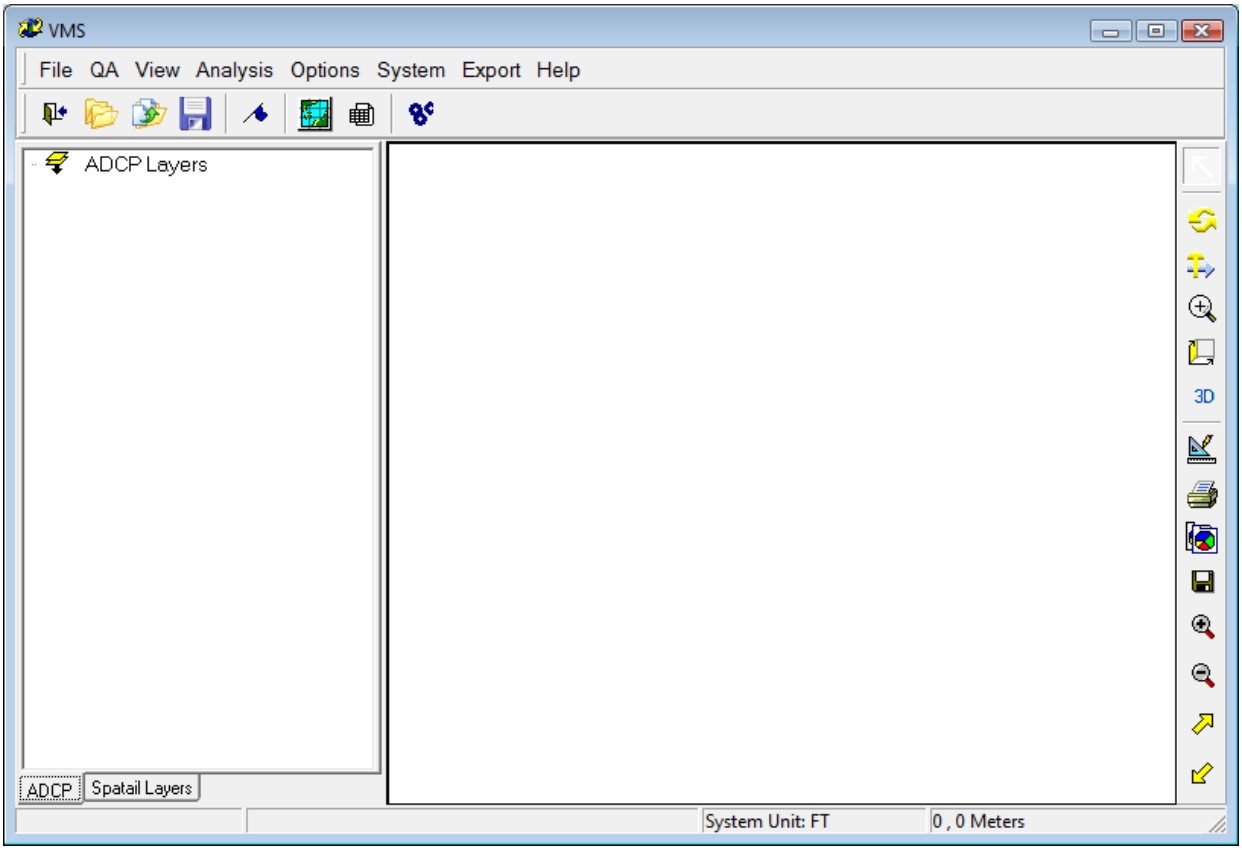


Figure 1.3. Initial interface of VMS

2. Loading ADCP files

The starting point for operating VMS is to load ADCP data. Currently, VMS should load two types of ADCP classical ASCII files from TRDI WinRiver I and II. Both files must be created by RDI WinRiver in advance. Once these files are imported, the user may begin working with data. ADCP files can be loaded under the File menu, or by clicking the correct icon as shown below. Multiple files may be selected at one time.

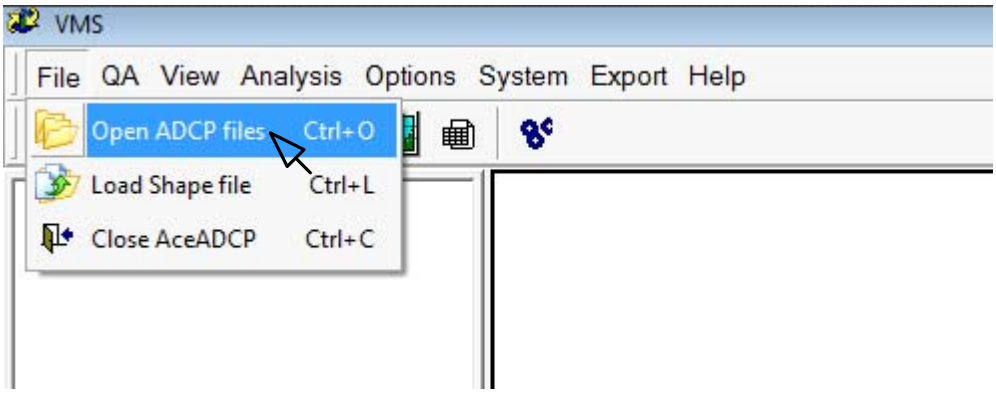


Figure 2.1. Open ADCP files from menu

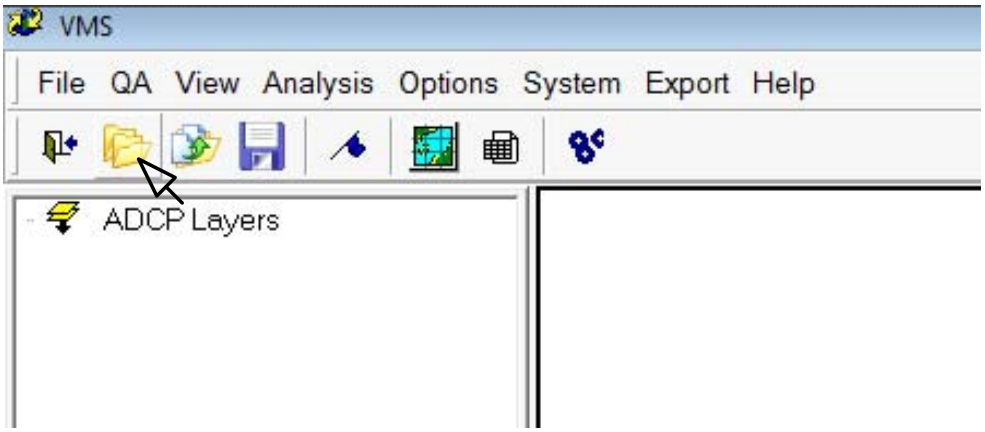


Figure 2.2. Open ADCP files from icon

To choose multiple files, hold down the 'Shift' key with and click the mouse to choose consecutive files, or hold the 'Ctrl' key while clicking the mouse to choose non-consecutive files.

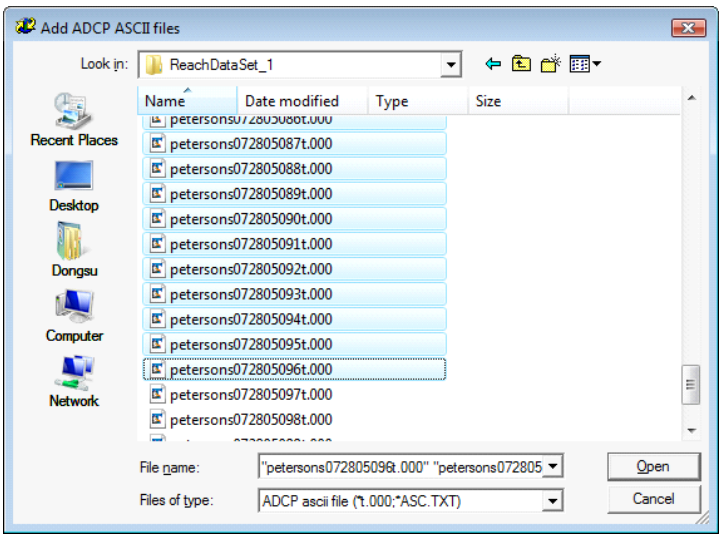


Figure 2.3. Open one or more ADCP files

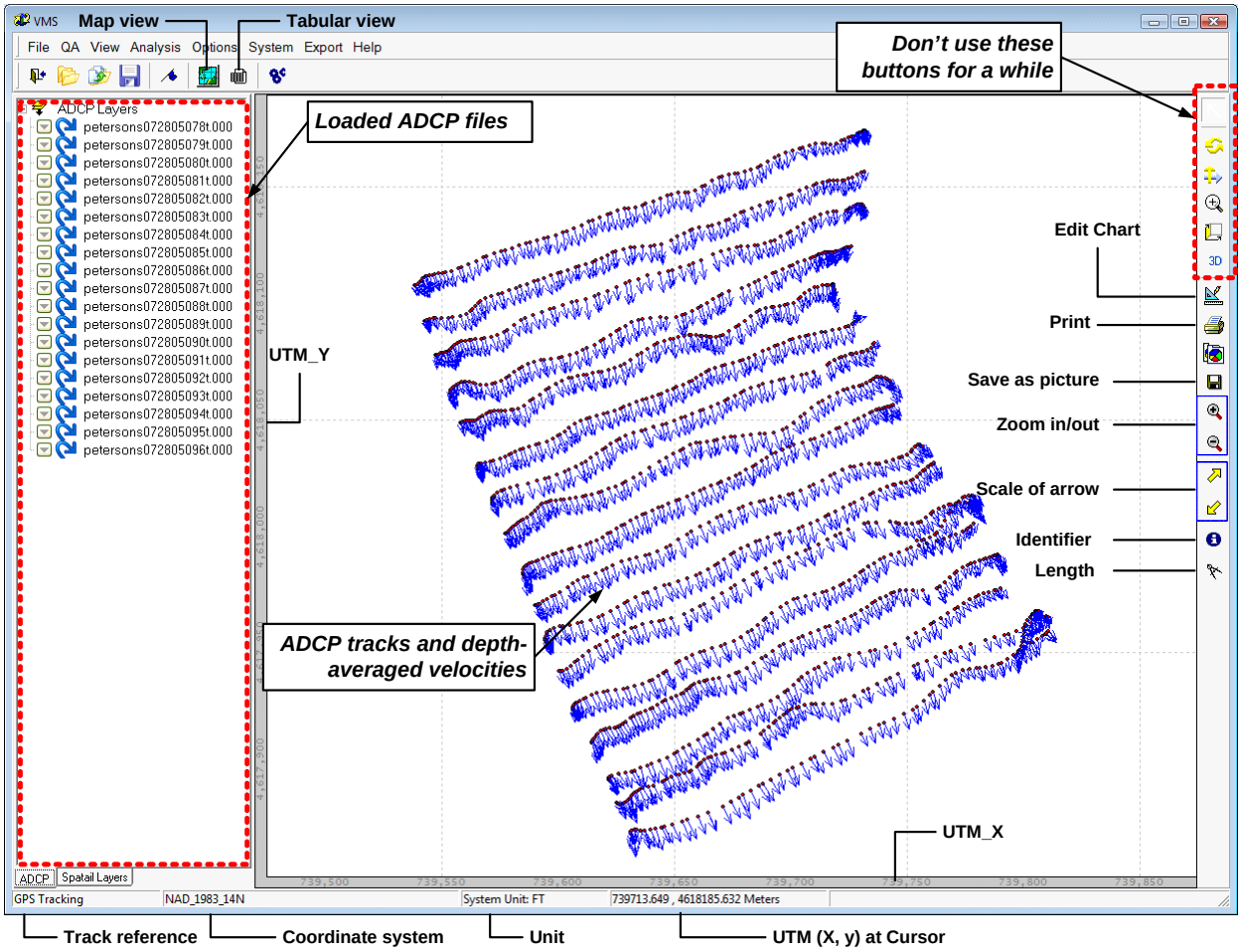


Figure 2.4. Description of main interface of VMS

As an alternative to using the zoom buttons, the user can zoom in and out with the mouse. This is accomplished by left-clicking inside the chart and dragging the mouse down to the right or up to the left to zoom in or out, respectively.

If the user clicks 'Length' icon (the last icon in the tool pane) and drags a line by left-clicking inside the chart and dragging the mouse, the length of the line appears in the bottom of the VMS. Click again this icon to deselect this function.

The user is able to identify individual transects by clicking one or multiple files with left mouse button, then corresponding transects in the map will be colored as yellow.

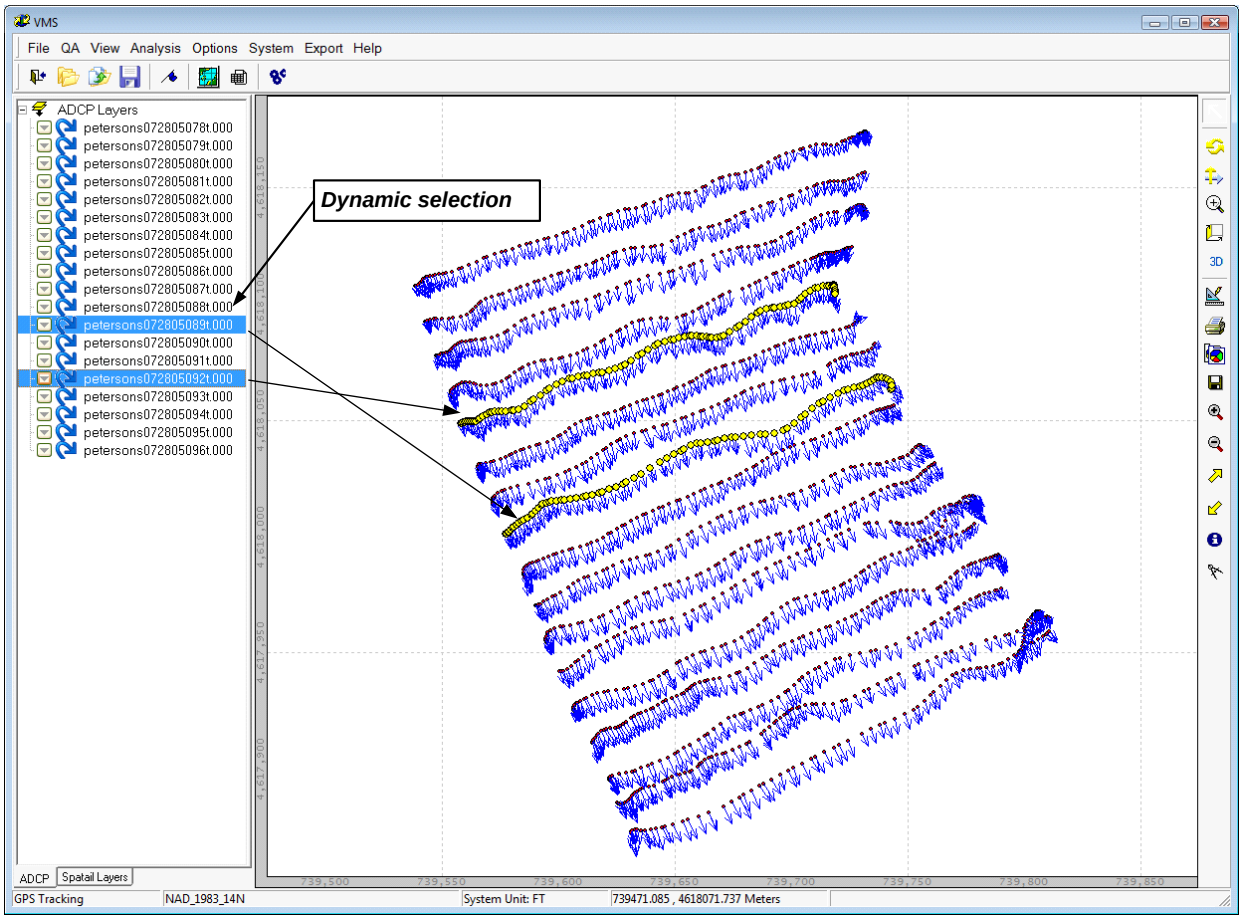


Figure 2.5. Identification of individual transects

In the ADCP file pane, if the user clicks right button of mouse, a popup menu will appear, which has several menus: Add more ADCP files, remove selected file, zoom to selected

files, clear selection, and so on. Save as shapefile and averaging selected files menu will be explained later in chapter 3, and 7.

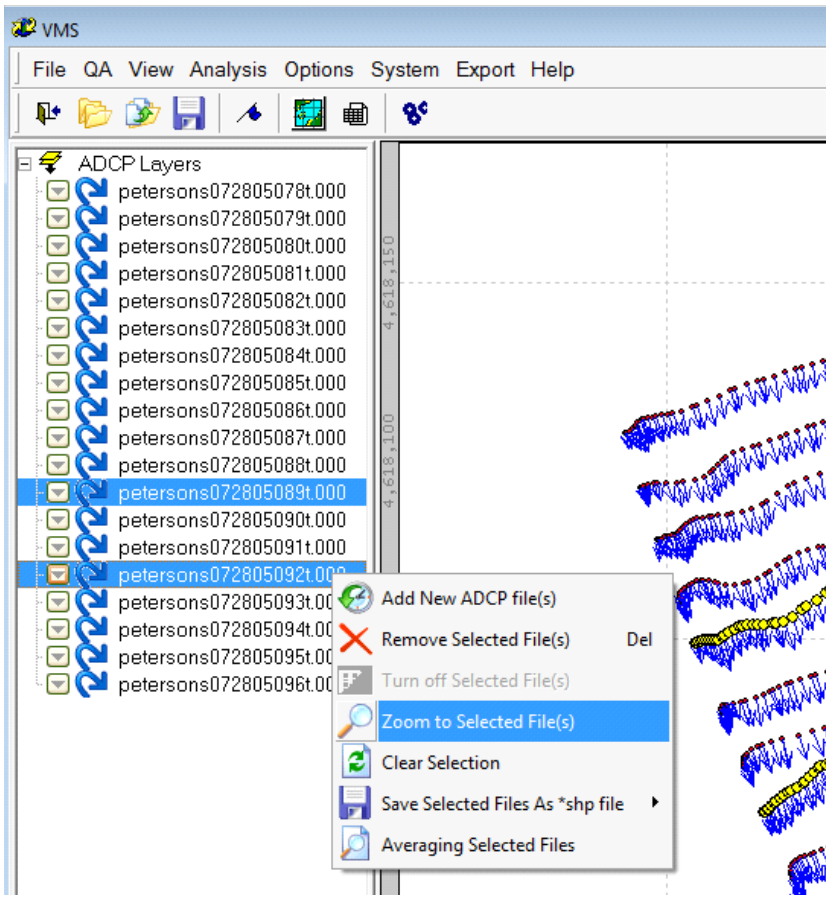


Figure 2.6. Popup menu in the file pane

3. Handling GIS files

3.1. Loading GIS shapefiles (.shp)

VMS supports loading vector-based GIS file (shapefile - *.shp) as a background of ADCP files. Any vector formats of shape file (point, line, and polygon) are applicable. Shape files can be loaded under the File menu, or by clicking the correct icon as shown below.

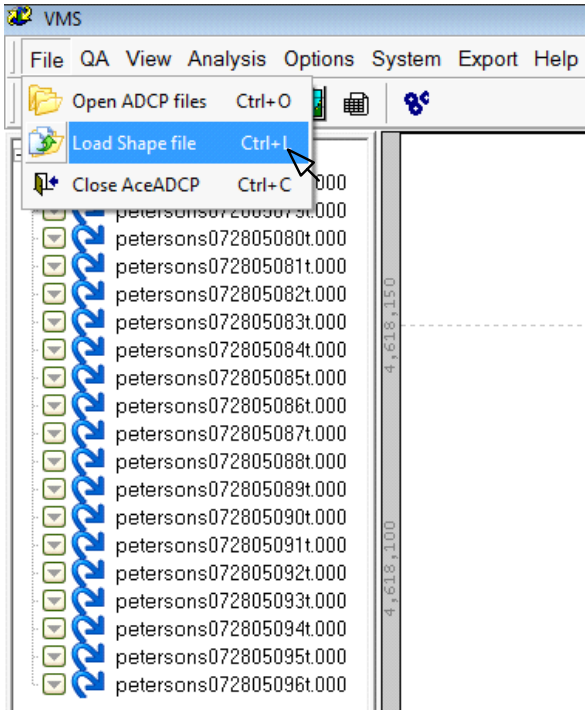


Figure 3.1. Load GIS Shapefile from menu

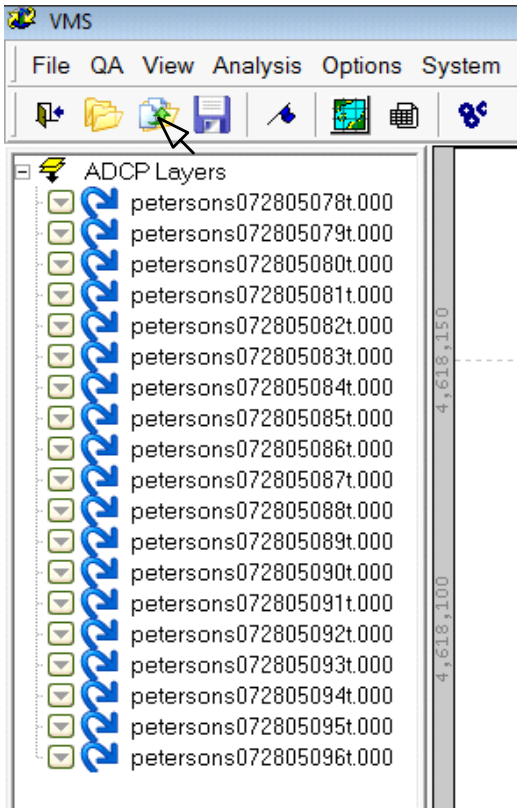


Figure 3.2. Load GIS Shapefile from Icon

Select the file that the user wants and click open. It will take some time to be loaded if the shape file is large.

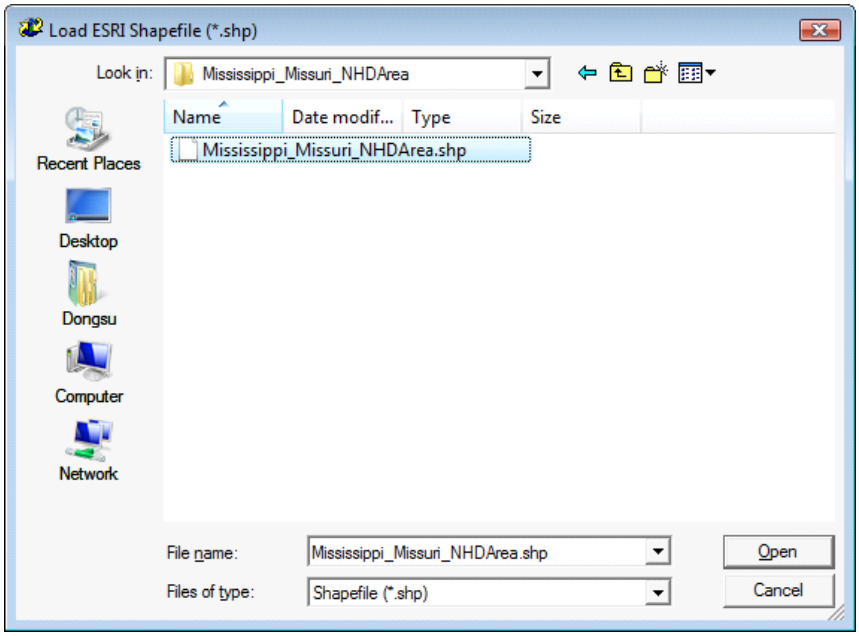


Figure 3.3. Shapefile selection window

Then the user will see the following map that display ADCP transects with the loaded GIS file.

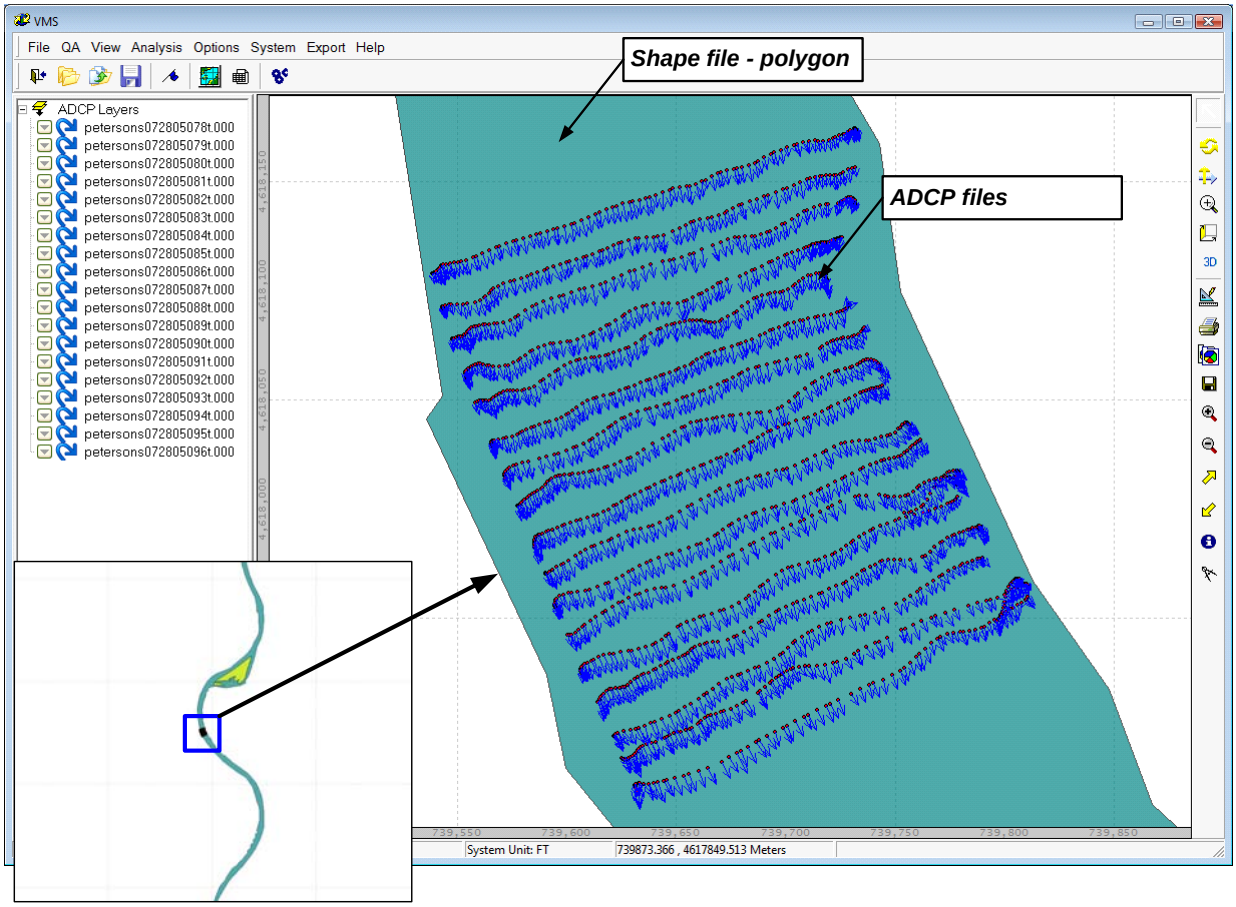


Figure 3.4. Loaded shape file as a background of ADCP transects

If the user loaded multiple GIS layers and ADCP files, they can be seen in 'Spatial Layer' tab. The user can unload GIS or ADCP layers, select them and push 'Delete' key. The user is able to zoom in and out GIS and ADCP layers using icons in the right pane as seen below.

After loading a shapefile, if ADCP velocity arrows or points are below the shape file, go to the spatial layers tab and change the order of the layer. The user is able to click a layer and drag it into a place that he/she want to move. In fact, the top layer indicates the bottom layer, so move shapefile into the top layer, then ADCP velocity arrows and points will be on the top of the shapefile layer.

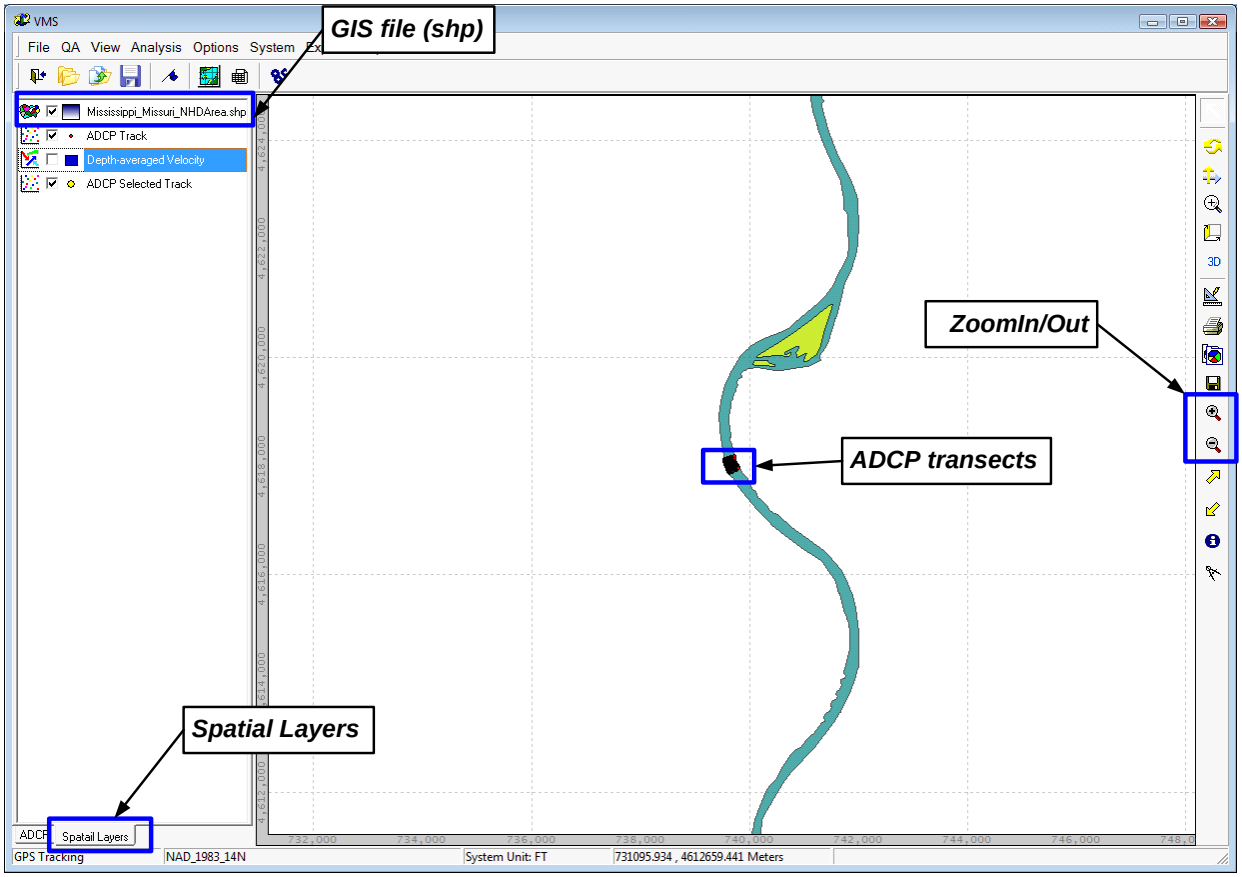


Figure 3.5. Spatial layers tab including GIS and ADCP layers

3.2. Exporting the entire or selected ADCP data to a shape file (.shp)

Under the export tab, there is an option to save the ADCP data as a GIS shapefile (.shp). The user can either select to save the ADCP Ensemble Data as a 2D shapefile or a 3D shapefile.

When ADCP data is loaded, the user may select individual or multiple files, and right click to pop-up a menu. If the user selects all ADCP file, all file will be save as shape file. Under the menu, the user can choose to save the ADCP Ensembles as 2D shapefiles or Cell data as 3D shapefiles. The user can hold ctrl when clicking on the ADCP data in the left pane to add more of the files to the current selection, thus allowing the user to select only certain ADCP ensembles for export.

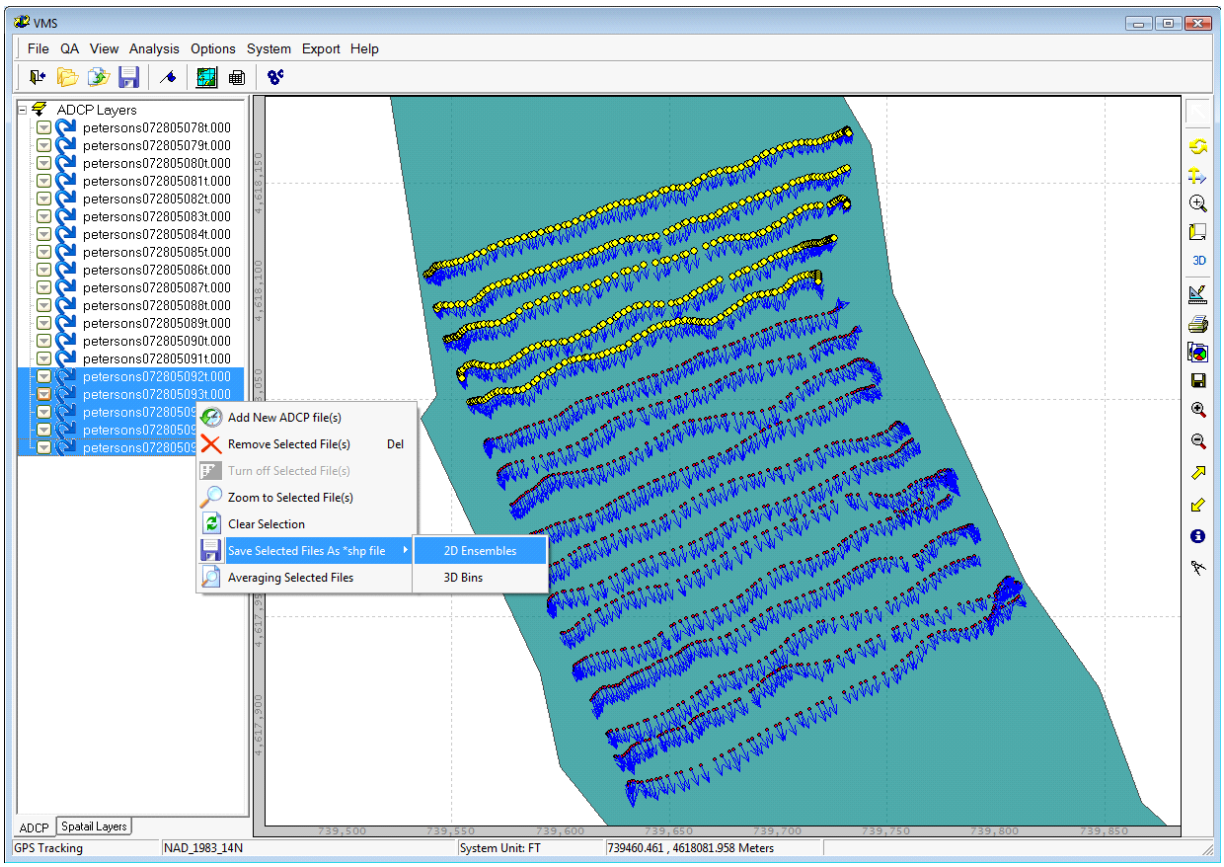


Figure 3.6. Export ADCP transects as GIS shapefile

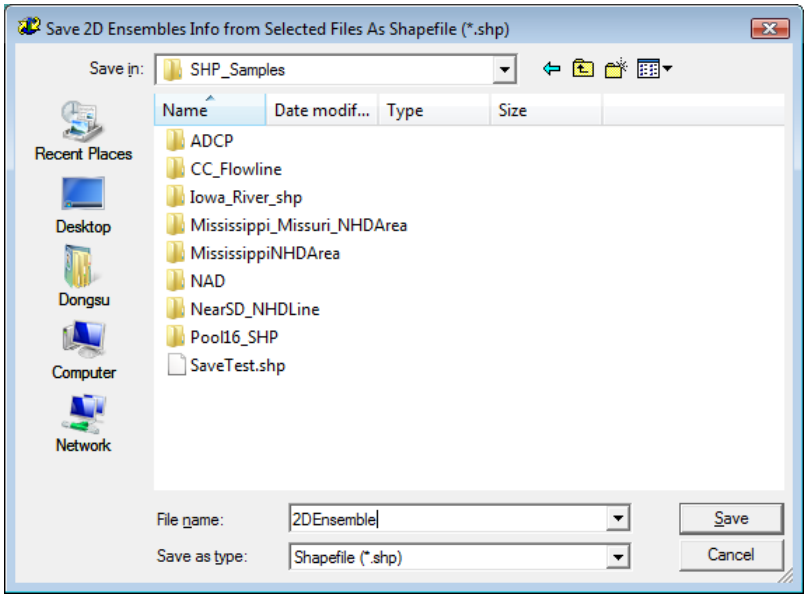
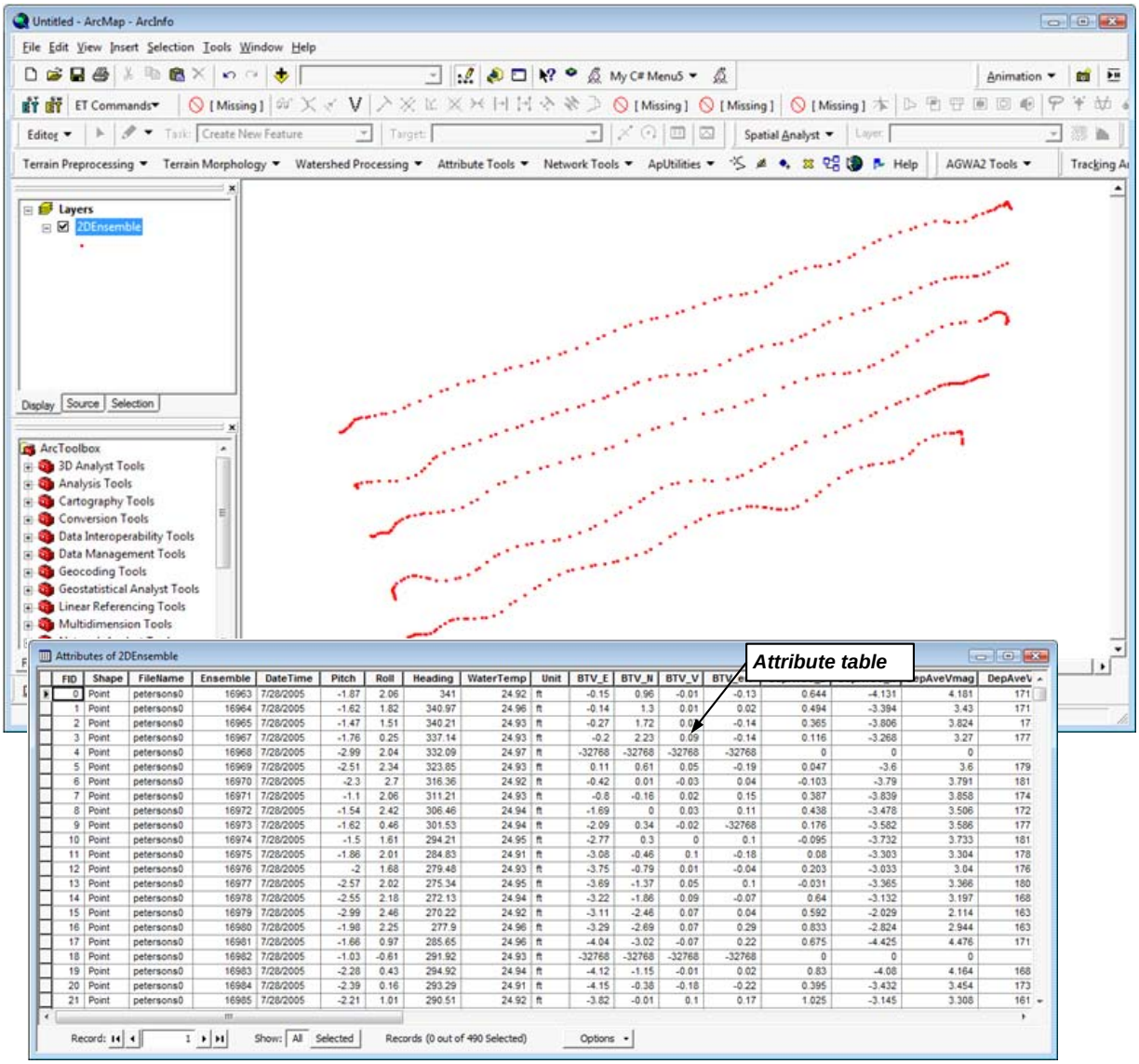


Figure 3.7. Save As shapefile dialog



FID	Shape	FileName	Ensemble	DateTime	Pitch	Roll	Heading	WaterTemp	Unit	BTV_E	BTV_N	BTV_V	BTV					DepAveVmag	DepAveV
0	Point	petersons0	16963	7/28/2005	-1.87	2.06	341	24.92	ft	-0.15	0.96	-0.01	-0.13		0.644	-4.131		4.181	171
1	Point	petersons0	16964	7/28/2005	-1.62	1.82	340.97	24.96	ft	-0.14	1.3	0.01	0.02		0.494	-3.394		3.43	171
2	Point	petersons0	16965	7/28/2005	-1.47	1.51	340.21	24.93	ft	-0.27	1.72	0.0	-0.14		0.365	-3.806		3.824	17
3	Point	petersons0	16967	7/28/2005	-1.76	0.25	337.14	24.93	ft	-0.2	2.23	0.09	-0.14		0.116	-3.268		3.27	177
4	Point	petersons0	16968	7/28/2005	-2.99	2.04	332.09	24.97	ft	-32768	-32768	-32768	-32768		0	0		0	
5	Point	petersons0	16969	7/28/2005	-2.51	2.34	323.85	24.93	ft	0.11	0.61	0.05	-0.19		0.047	-3.6		3.6	179
6	Point	petersons0	16970	7/28/2005	-2.3	2.7	316.36	24.92	ft	-0.42	0.01	-0.03	0.04		-0.103	-3.79		3.791	181
7	Point	petersons0	16971	7/28/2005	-1.1	2.06	311.21	24.93	ft	-0.8	-0.16	0.02	0.15		0.387	-3.839		3.858	174
8	Point	petersons0	16972	7/28/2005	-1.54	2.42	306.46	24.94	ft	-1.69	0	0.03	0.11		0.438	-3.478		3.506	172
9	Point	petersons0	16973	7/28/2005	-1.62	0.46	301.53	24.94	ft	-2.09	0.34	-0.02	-32768		0.176	-3.582		3.586	177
10	Point	petersons0	16974	7/28/2005	-1.5	1.61	294.21	24.95	ft	-2.77	0.3	0	0.1		-0.095	-3.732		3.733	181
11	Point	petersons0	16975	7/28/2005	-1.86	2.01	284.83	24.91	ft	-3.08	-0.46	0.1	-0.18		0.08	-3.303		3.304	178
12	Point	petersons0	16976	7/28/2005	-2	1.68	279.48	24.93	ft	-3.75	-0.79	0.01	-0.04		0.203	-3.033		3.04	176
13	Point	petersons0	16977	7/28/2005	-2.57	2.02	275.34	24.95	ft	-3.69	-1.37	0.05	0.1		-0.031	-3.365		3.366	180
14	Point	petersons0	16978	7/28/2005	-2.55	2.18	272.13	24.94	ft	-3.22	-1.86	0.09	-0.07		0.64	-3.132		3.197	168
15	Point	petersons0	16979	7/28/2005	-2.99	2.46	270.22	24.92	ft	-3.11	-2.46	0.07	0.04		0.592	-2.029		2.114	163
16	Point	petersons0	16980	7/28/2005	-1.98	2.25	277.9	24.96	ft	-3.29	-2.69	0.07	0.29		0.833	-2.824		2.944	163
17	Point	petersons0	16981	7/28/2005	-1.66	0.97	285.65	24.96	ft	-4.04	-3.02	-0.07	0.22		0.675	-4.425		4.476	171
18	Point	petersons0	16982	7/28/2005	-1.03	-0.61	291.92	24.93	ft	-32768	-32768	-32768	-32768		0	0		0	
19	Point	petersons0	16983	7/28/2005	-2.28	0.43	294.92	24.94	ft	-4.12	-1.15	-0.01	0.02		0.83	-4.08		4.164	168
20	Point	petersons0	16984	7/28/2005	-2.39	0.16	293.29	24.91	ft	-4.15	-0.38	-0.18	-0.22		0.395	-3.432		3.454	173
21	Point	petersons0	16985	7/28/2005	-2.21	1.01	290.51	24.92	ft	-3.82	-0.01	0.1	0.17		1.025	-3.145		3.308	161

Figure 3.8. Saved ADCP 2D Ensemble shape files in ESRI ArcMap

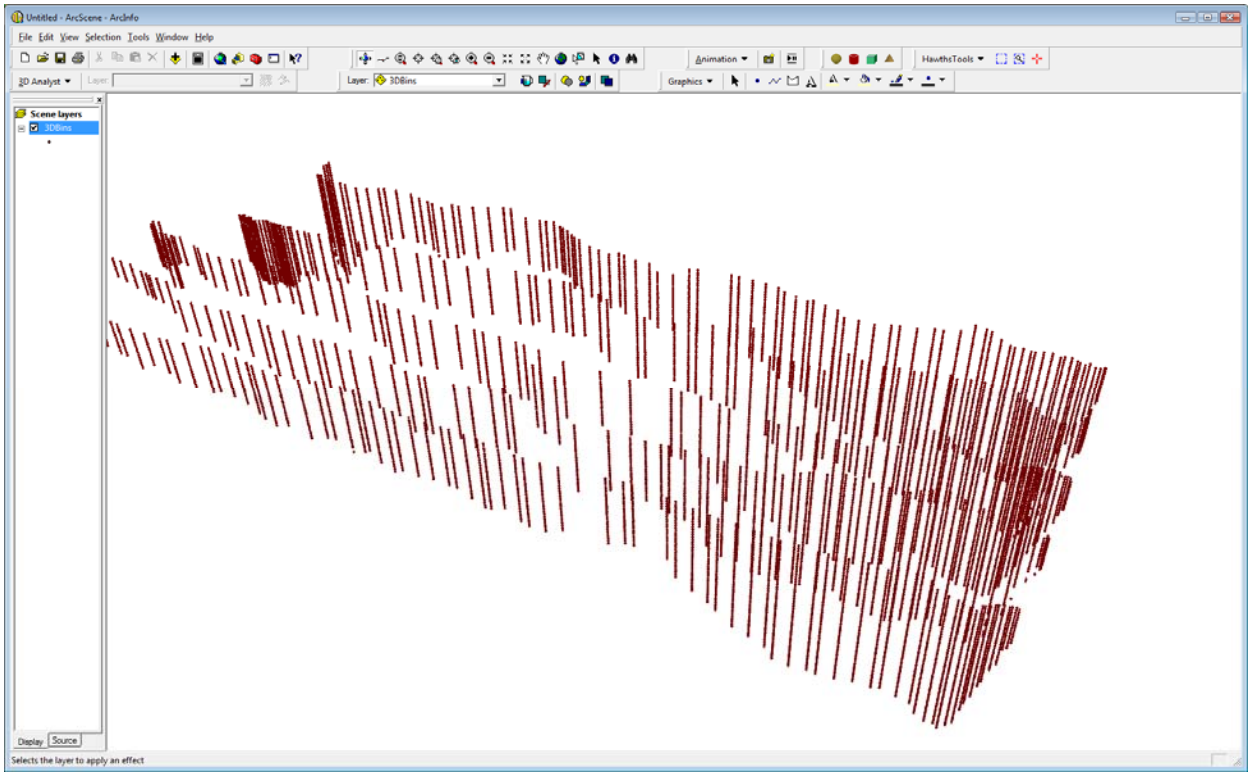


Figure 3.8. Saved ADCP 3D Bins shape files in ESRI ArcScene

4. Options

4.1. Vertical referencing – water surface elevation

VMS provides options for vertical references for the bathymetry and velocity vectors, i.e., water surface elevation. Choose 'Water Surface Elevation' under Options menu as shown below.

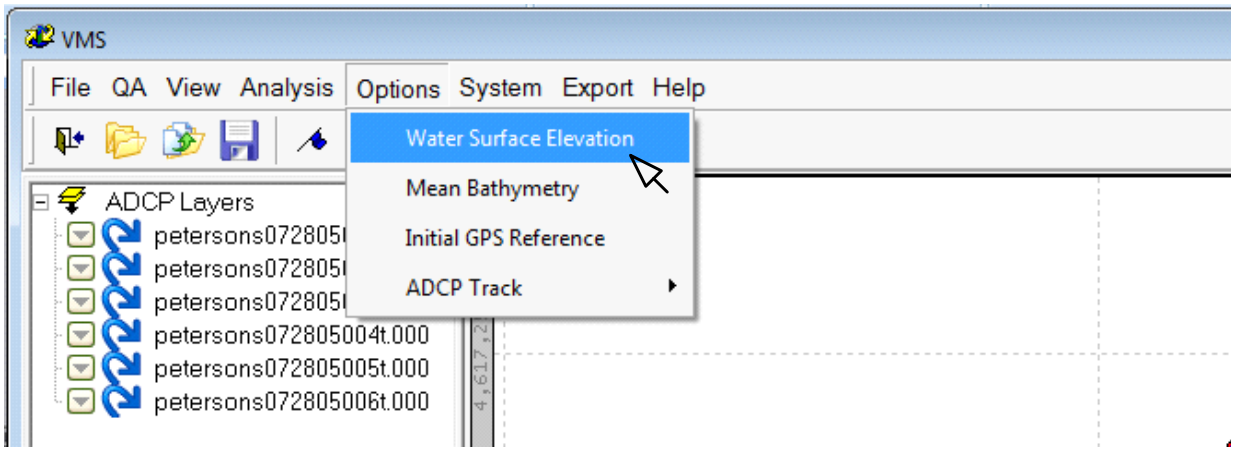


Figure 4.1. Option for vertical position

The following graphical interface will pop up. Default setting for water surface elevation of VMS is using ‘Altitude’ data from ASCII file.

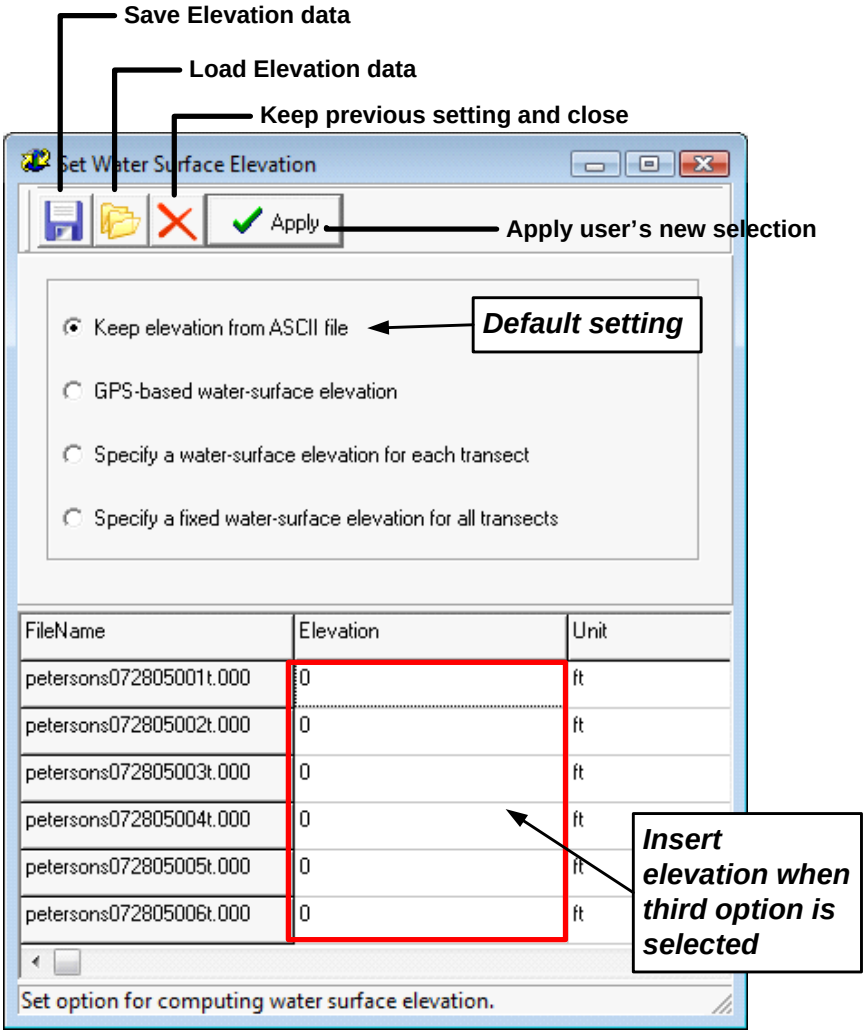


Figure 4.2. Graphical interface for vertical position

In addition, VMS provides three other options for vertical reference.

- GPS-based water-surface elevations for each transect (MSL and ellipsoid elevations).

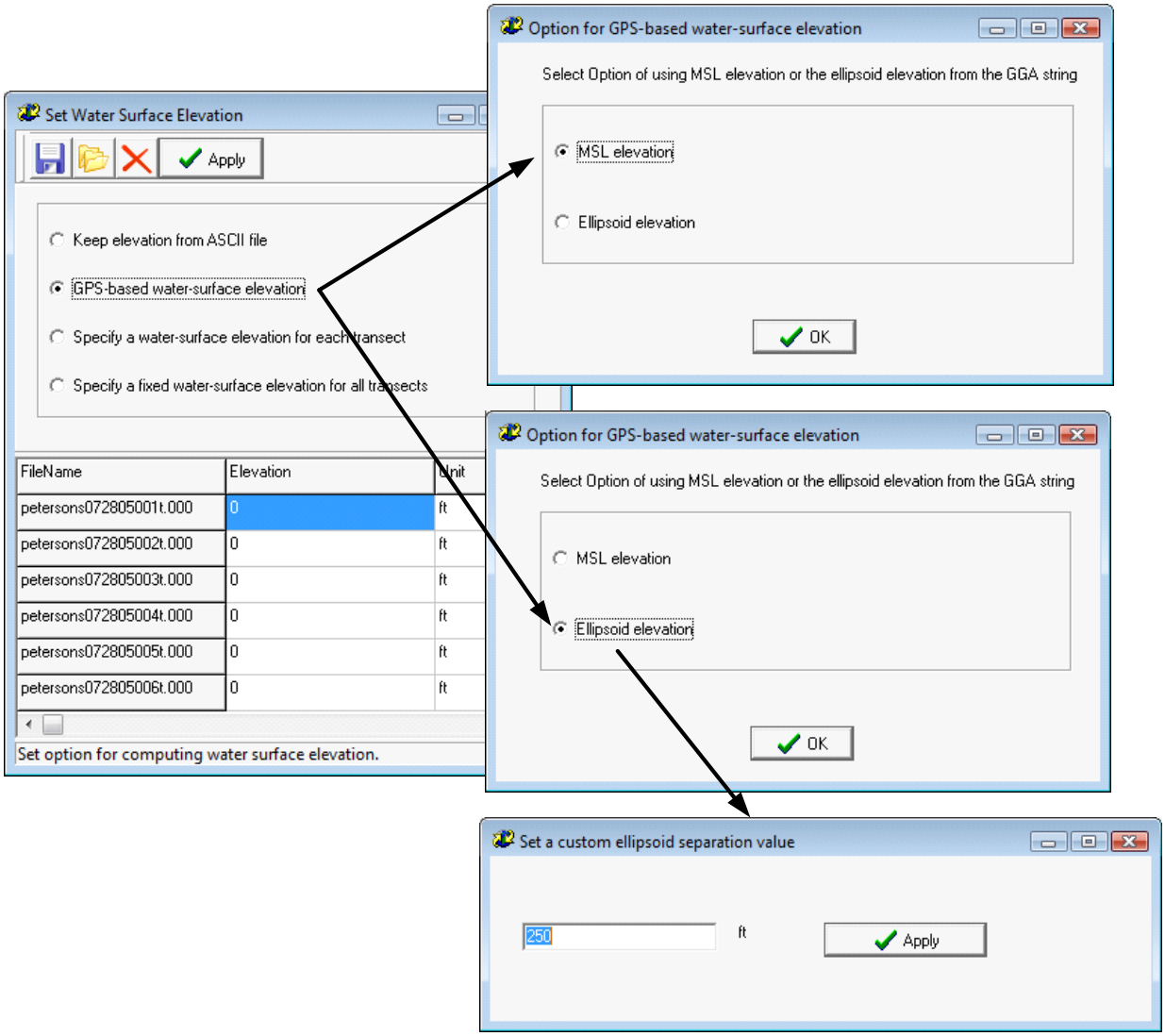


Figure 4.3. Option for GIS-based water-surface elevations for each transect

If RTK data are collected, the user will have the option of using either the MSL elevation or the ellipsoid elevation from the GGA string. If ellipsoid elevations are selected the user has the option to enter a custom ellipsoid separation value for the reach.

- Manually specify a water-surface elevation for each transect

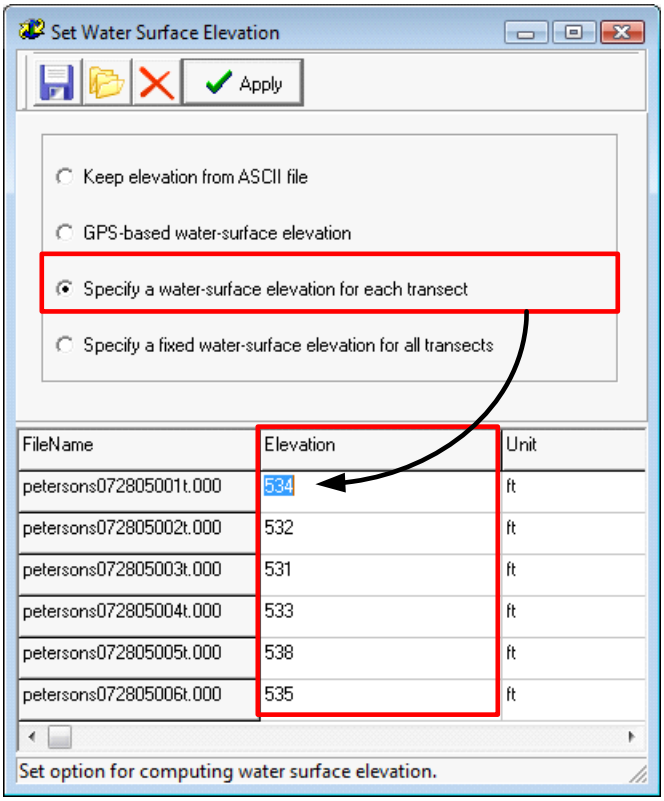


Figure 4.4. Option for specifying a water-surface for each transect

User's inputs are able to be saved and reused. Only if this option was selected, the user populates the table relating filename to water surface elevation. This table is able to be stored and reloaded for use in the future.

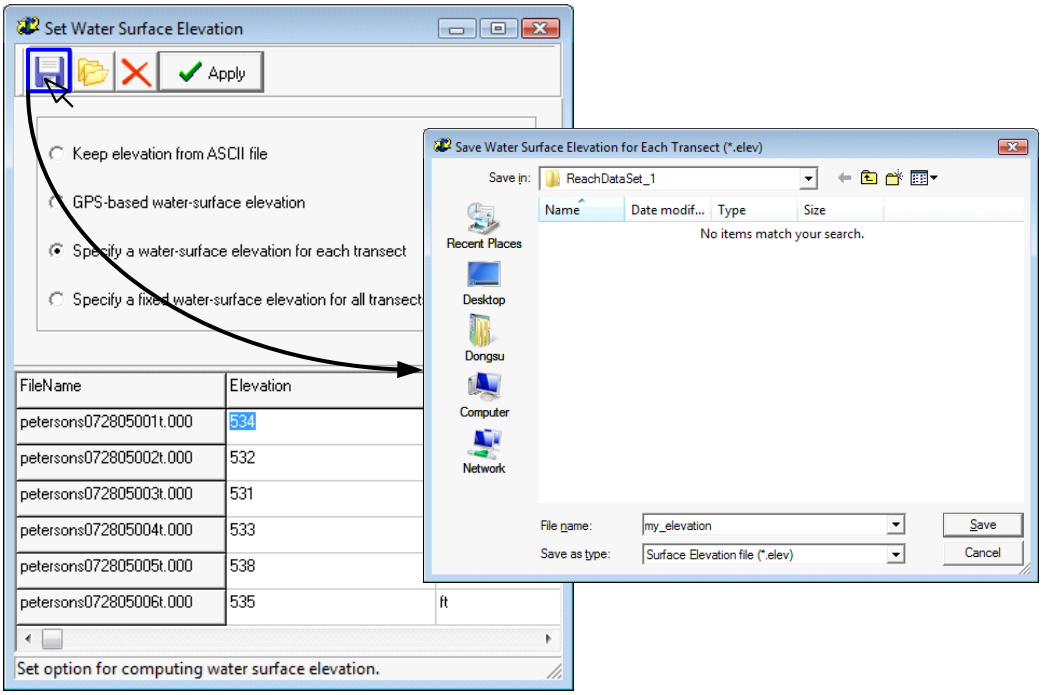


Figure 4.5. Saving the user-populated elevation for each transect

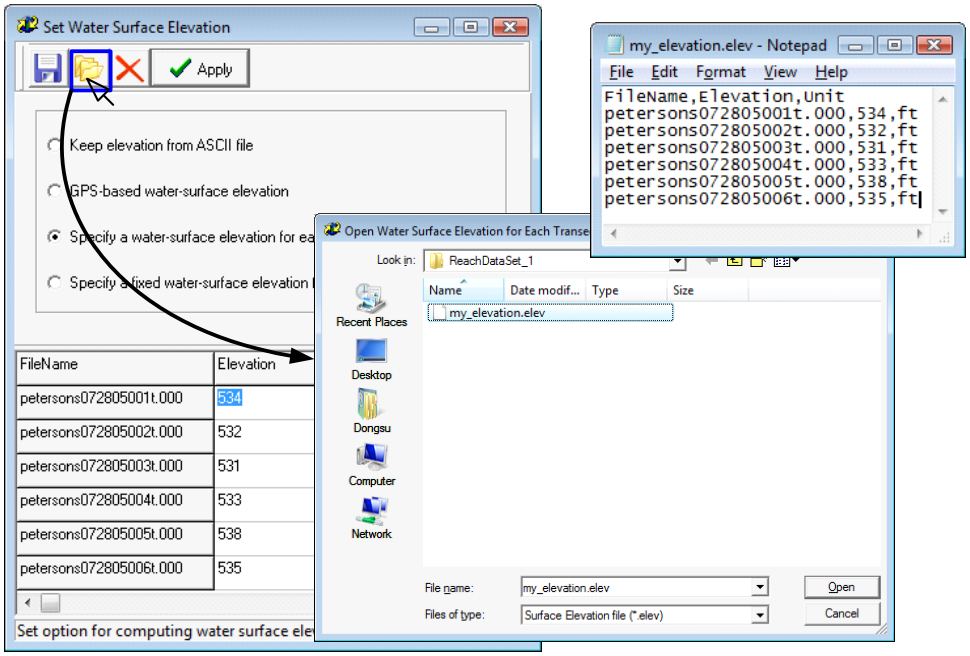


Figure 4.6. Reloading the user-populated elevation for each transect

- Specify a fixed water-surface elevation for all transects.

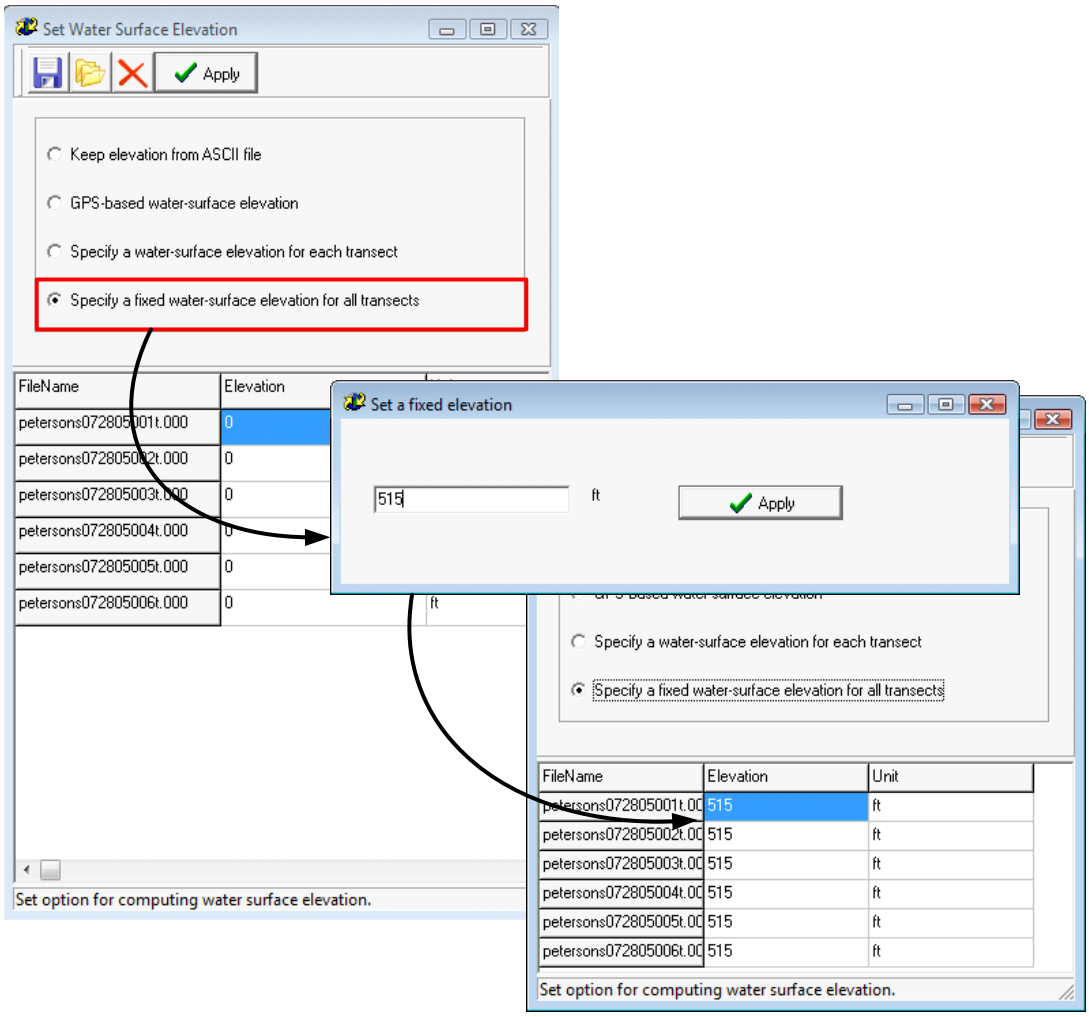


Figure 4.7. Option for specifying a fixed water-surface elevation for all transects

4.2. Horizontal referencing

When ASCII file does not contain GPS data, initial positions entered by the user for the starting position of each transect can be used as a surrogate way to georeference the measurements, where bottom tracking is used to compute subsequent positions. The initial positions (latitude/longitude) are able to be entered in a table displaying all of the filenames to be processed. Once entered, the table is able to be saved and reloaded without the user having to reenter the initial positions. If initial positions are used the software should provide a facility to enter these positions or read from a file the

positions for each transect to be processed. When GPS is used, a georeferenced coordinate is computed in UTM.

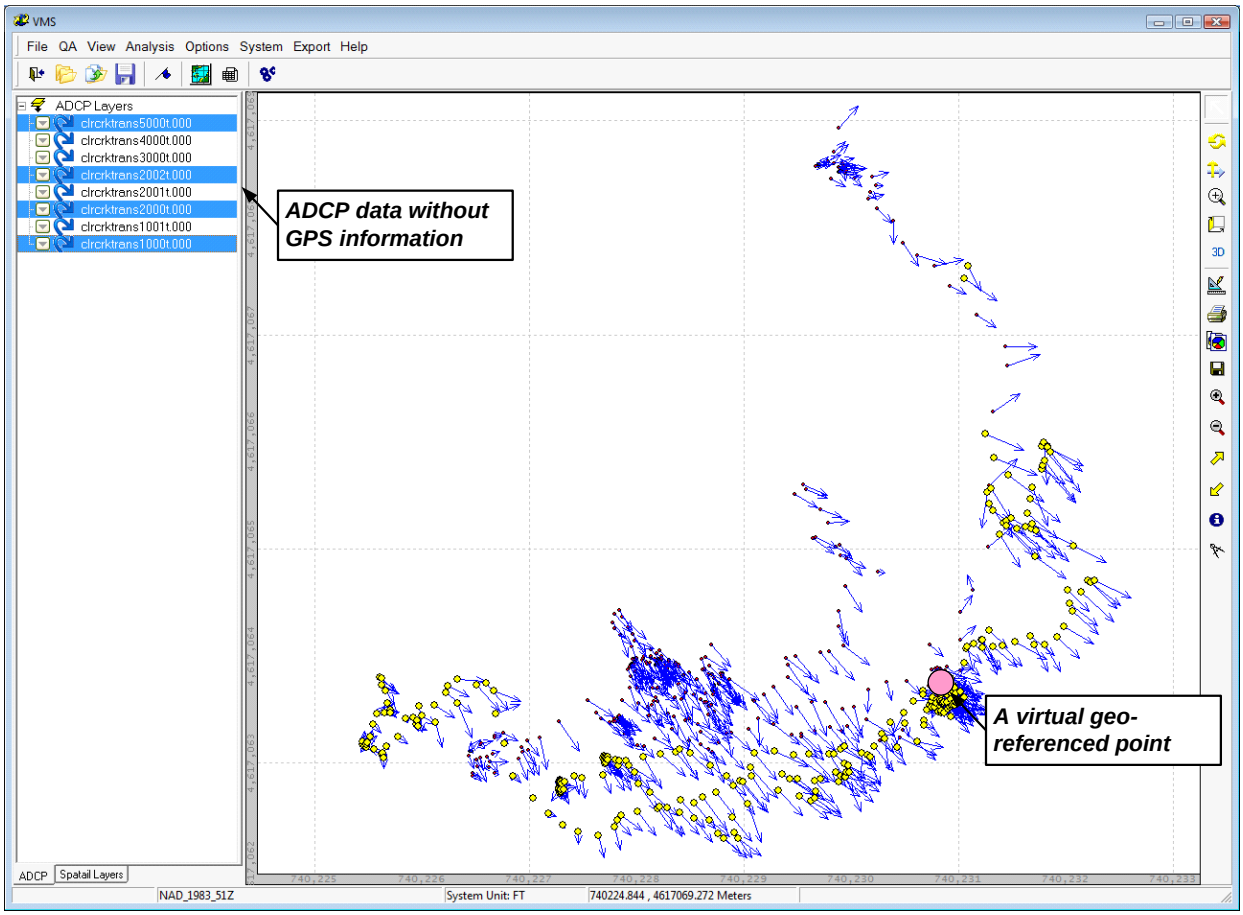


Figure 4.8. Multiple transect ADCP StreamPro files without having GPS information

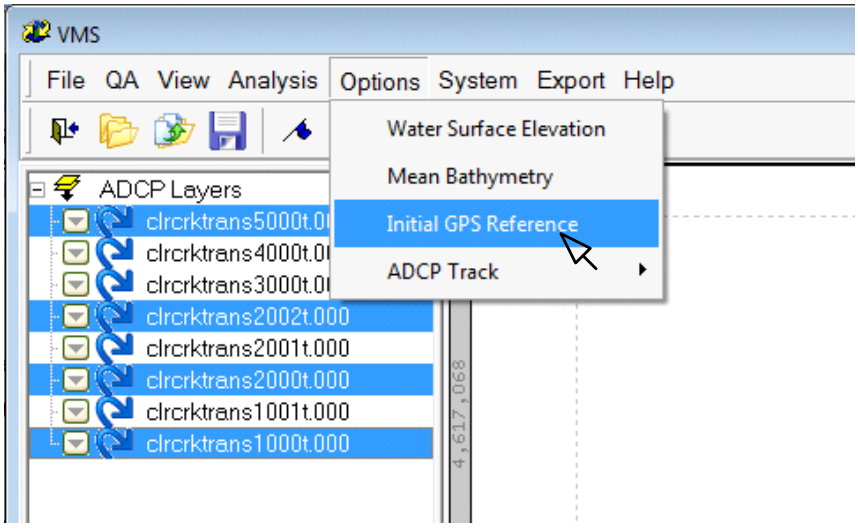


Figure 4.9. Option for setting initial GPS reference data

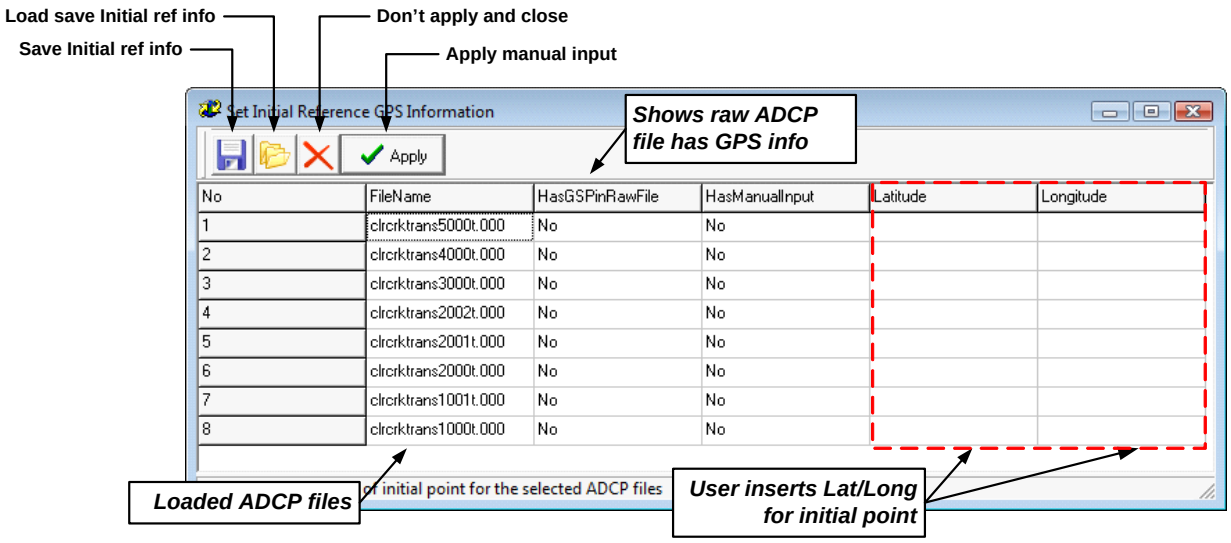


Figure 4.10. Graphical interface to populate initial GPS points of multiple transects

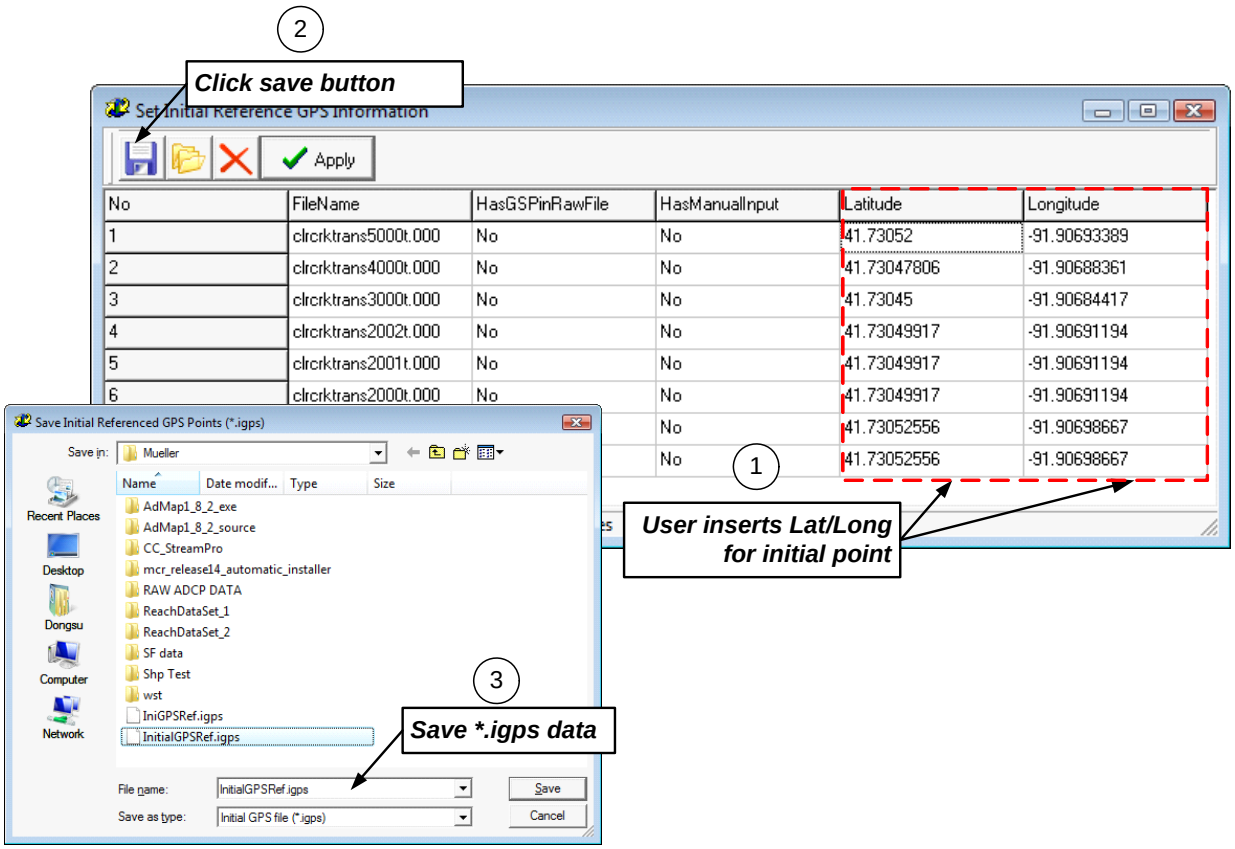


Figure 4.11. Saving the user-populated initial GPS points for each transect

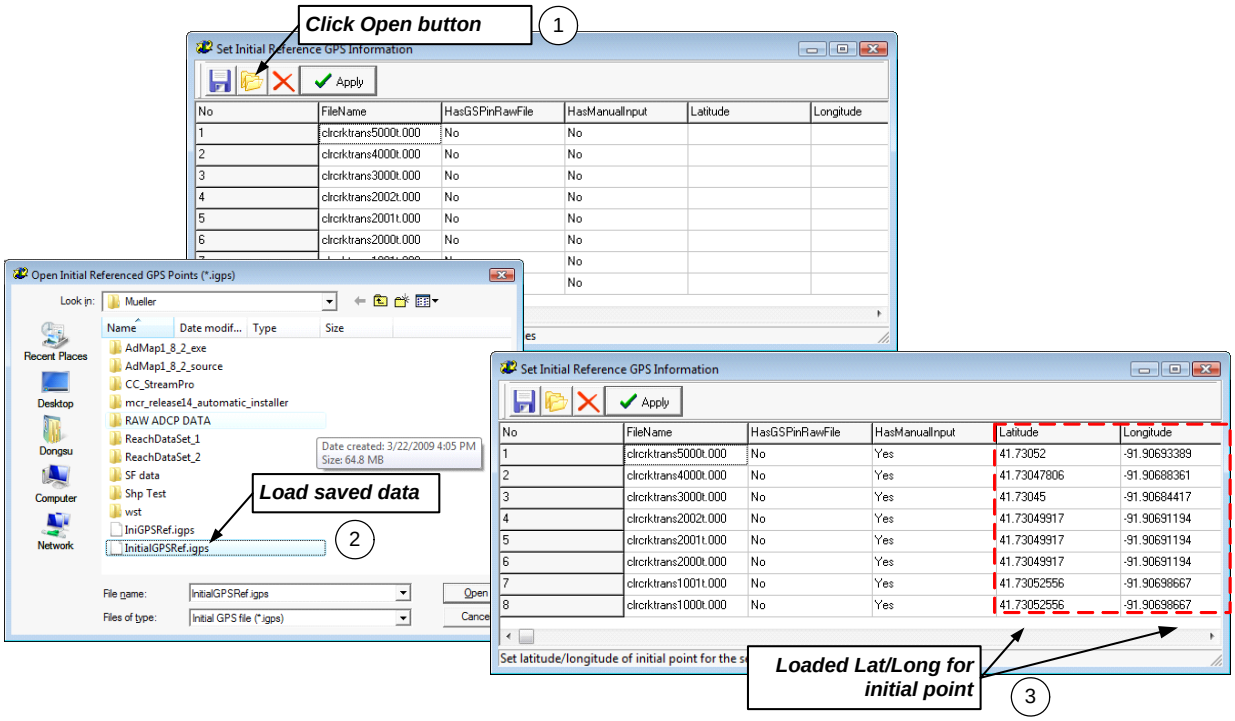


Figure 4.12. Reloading the user-populated initial GPS points for each transect

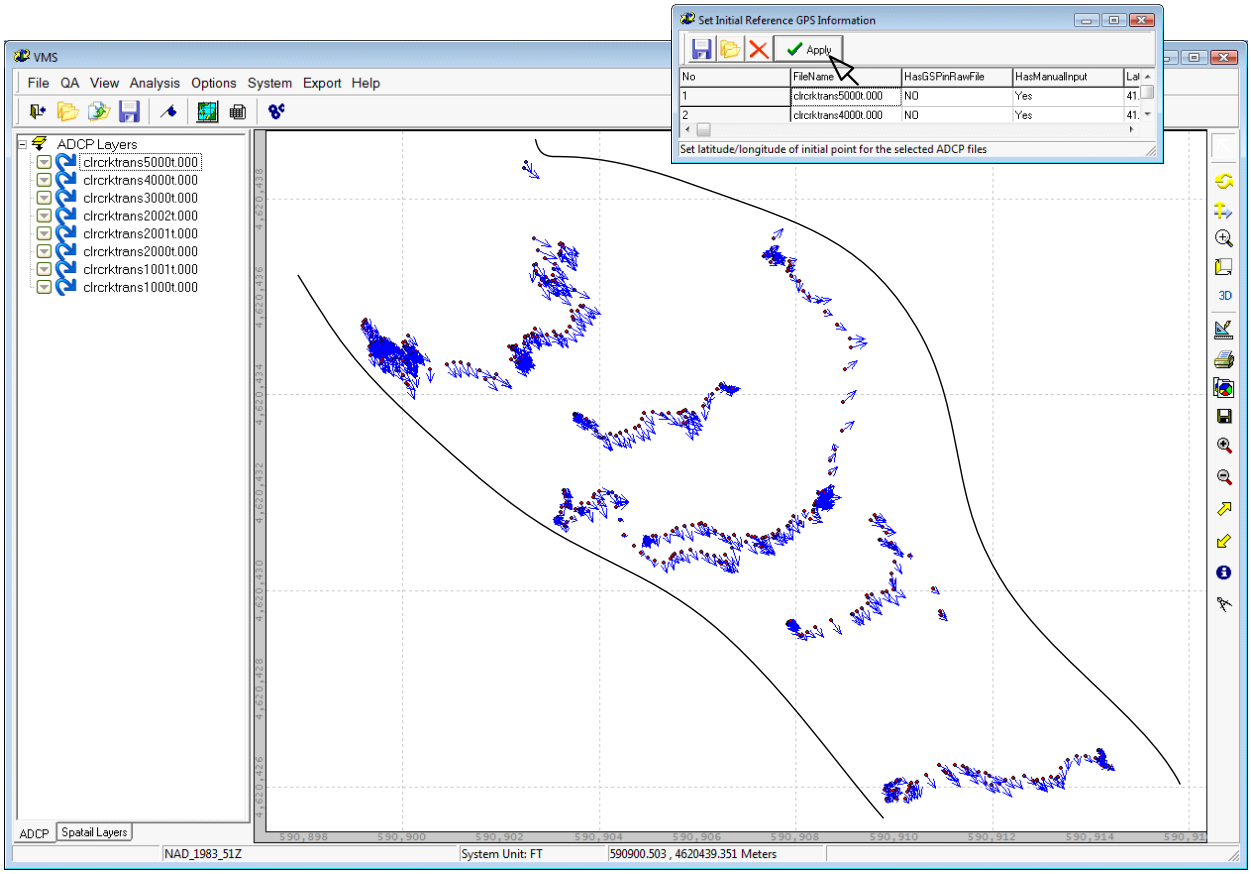


Figure 4.13. Applying initial GPS points for each transect

4.3. Boat Tracking referencing

The user is able to select boat tracking references by either GPS or Bottom Tracking. Default setting is GPS tracking, but the user can change it into Bottom tracking as shown below. If there are no GPS data for the ADCP dataset, there will be no difference between GPS and Bottom tracking, since GPS locations will be assigned by following bottom tracking.

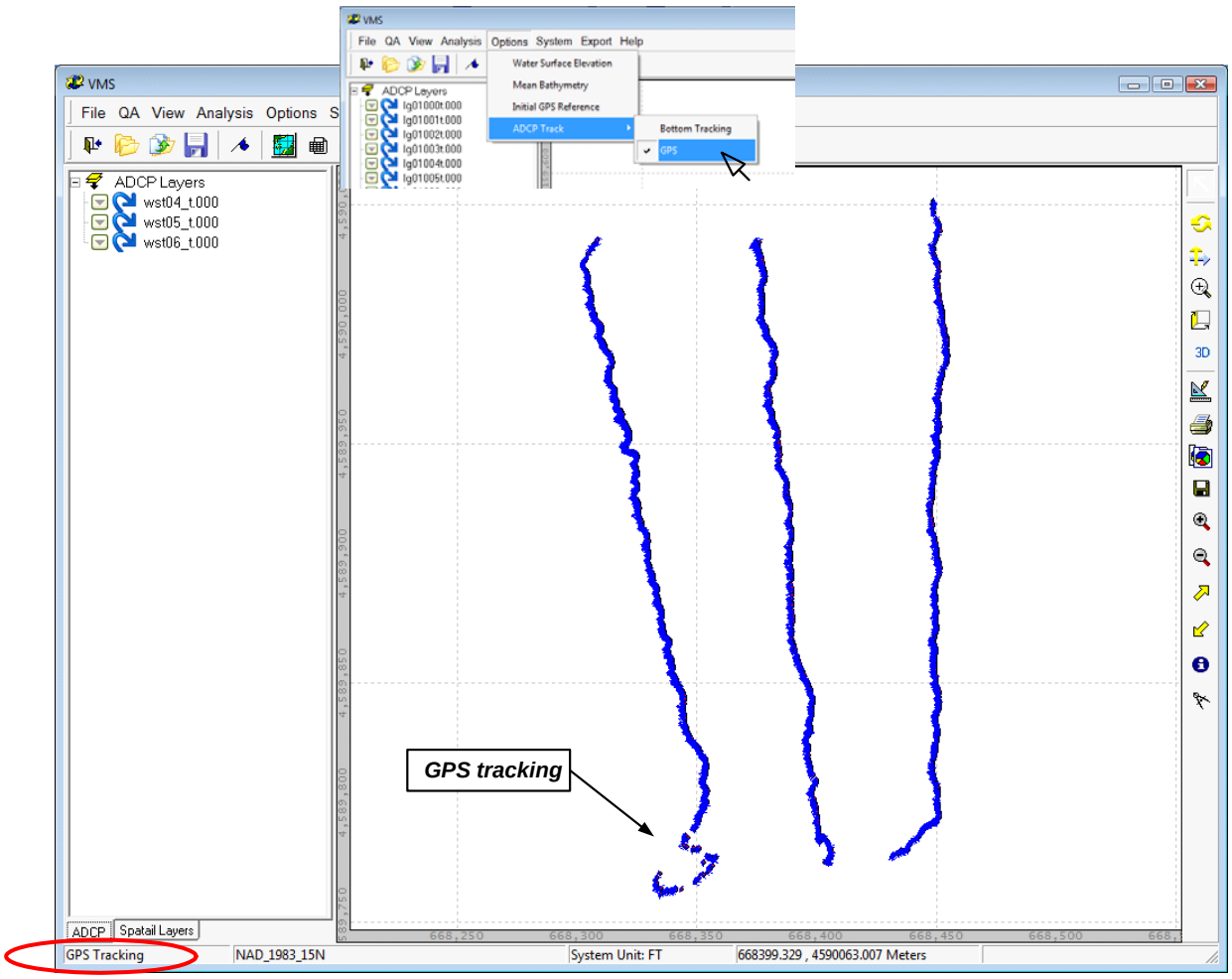


Figure 4.14. Representation of the boat tracking based on GPS

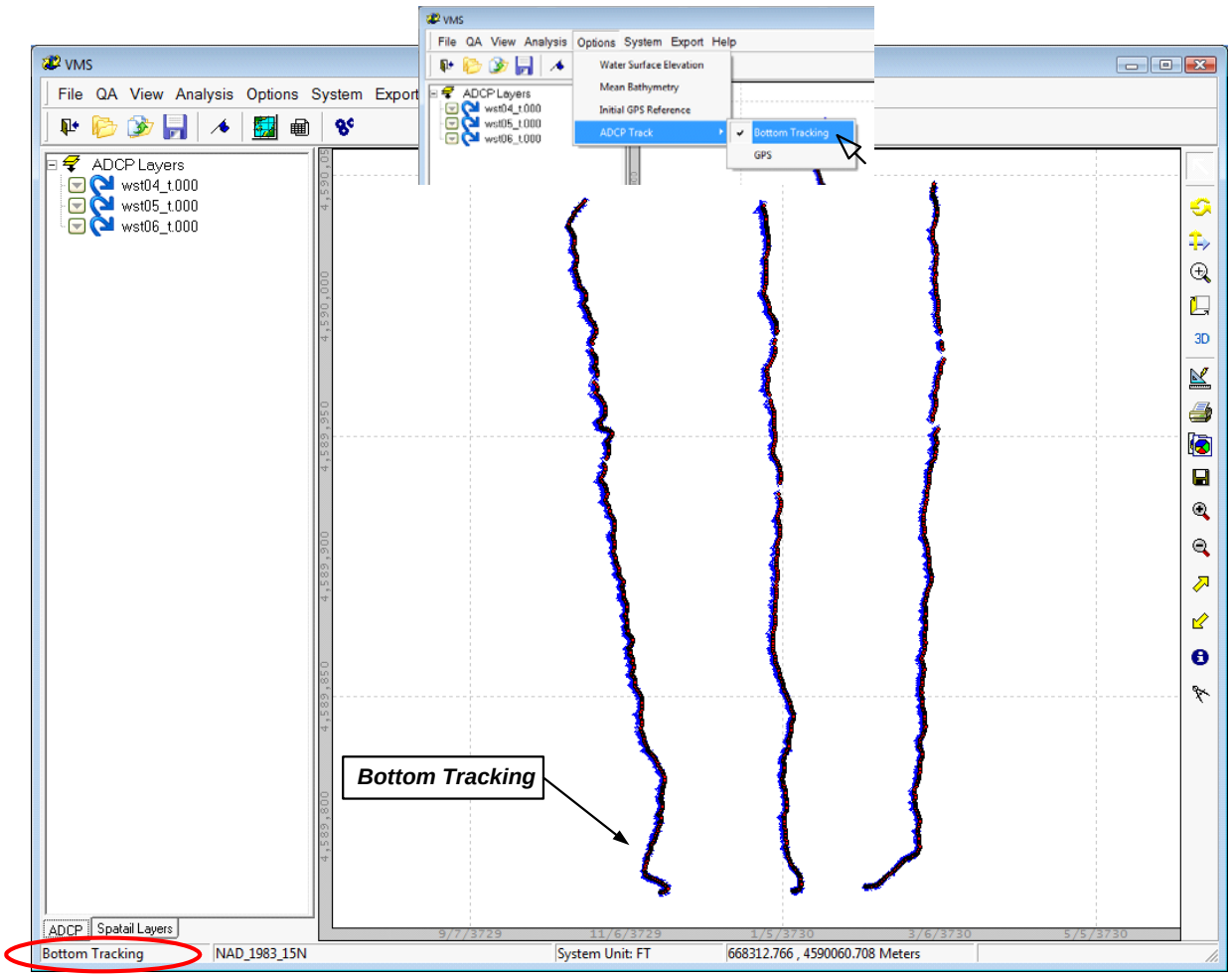


Figure 4.15. Representation of the boat tracking based on Bottom tracking

4.4. Unit

The user can select either English or SI unit system to show values. It is set via the Units option under the System menu as show below.

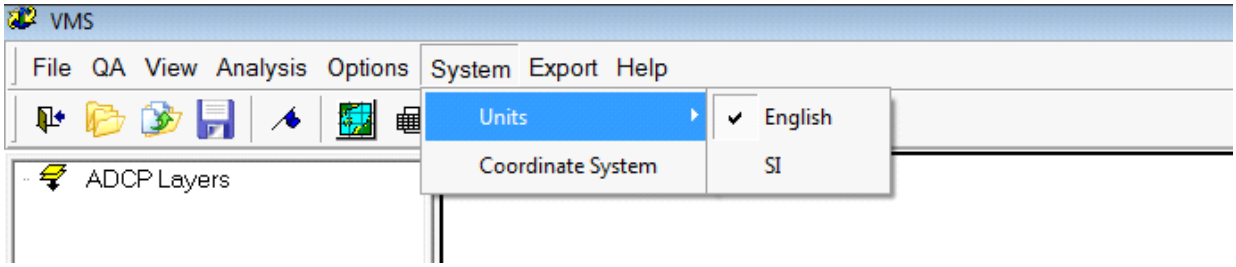


Figure 4.16. Change unit of the software

4.5. Geo-referenced coordinate system

The geo-referenced coordinate system of VMS will default to UTM NAD (North America Datum). If a shape file is loaded first that also has a projection (.prj) file associated, the shape file's coordinate system will be used. However, upon loading an ADCP file, the ADCP data will trump the shape file's coordinate system, which the ADCP files are set by default to UTM NAD. UTM zone number (e.g., 15N) will be automatically calculated. If the user loads multiple ADCP files and some of them across UTM zone, then zone number calculated from first GPS available point of first file will be forced to be zone number of others. After loading ADCP or shape file, the user is able to identify coordinate system in the bottom of the software as shown below.

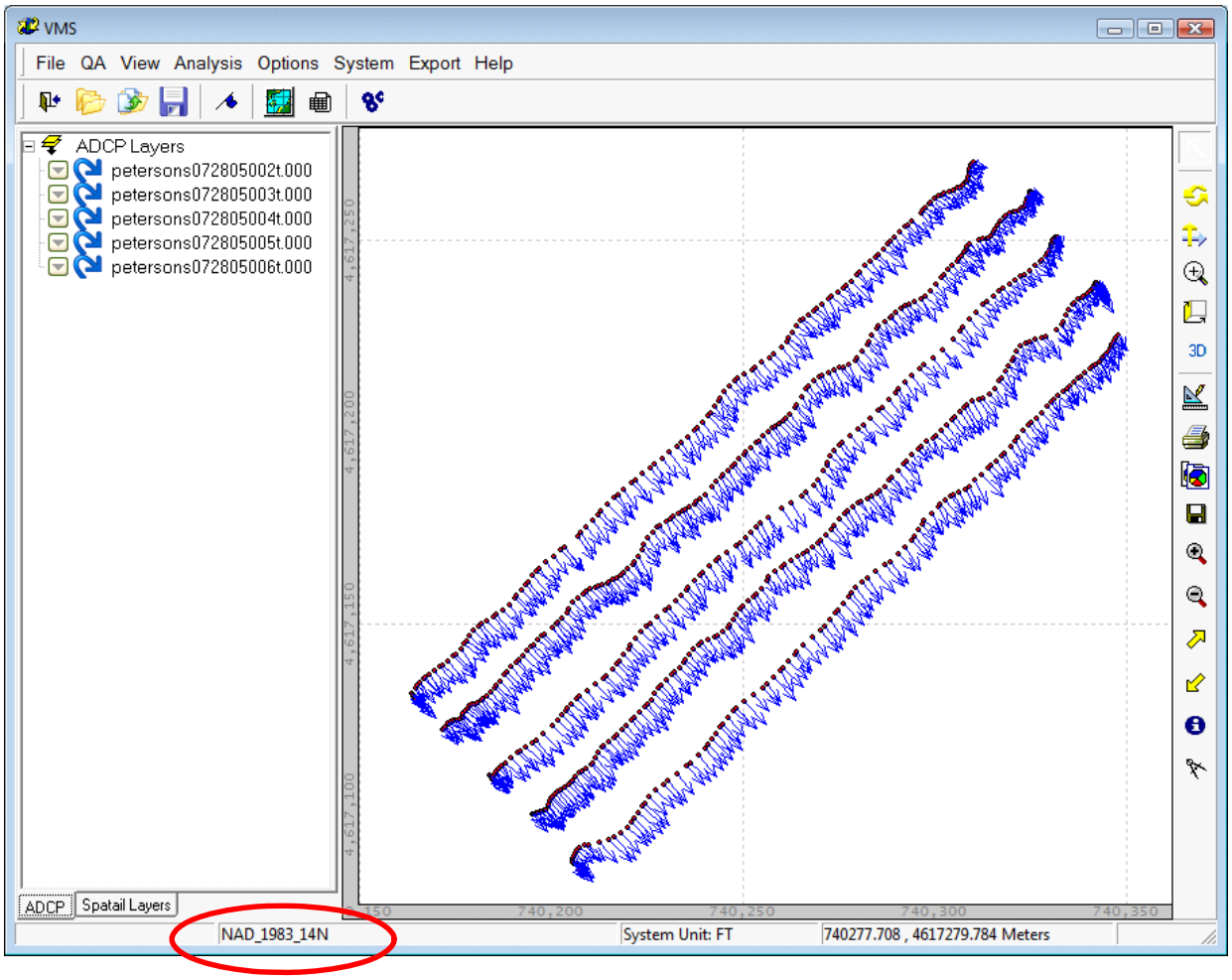


Figure 4.17. Identification of geo-referenced coordinate system

Finally, there is a way to set the coordinate system, where the users are in full control. ADCP or shape file loading will never interfere if the user sets the coordinate

system himself. It is set via the Coordinate System option under the System menu as shown below. This allows the user to set either UTM or Geographic coordinate systems, and affiliated zone data.

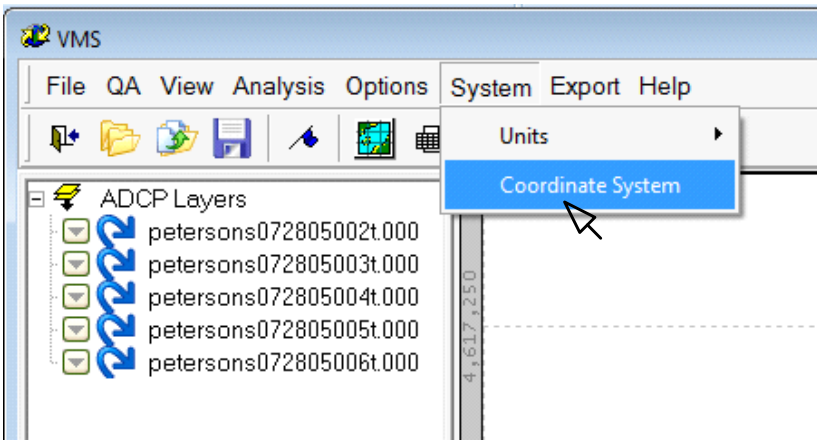


Figure 4.18. Option for changing geo-referenced coordinate system

The following interface shows up by updating current coordinate system.

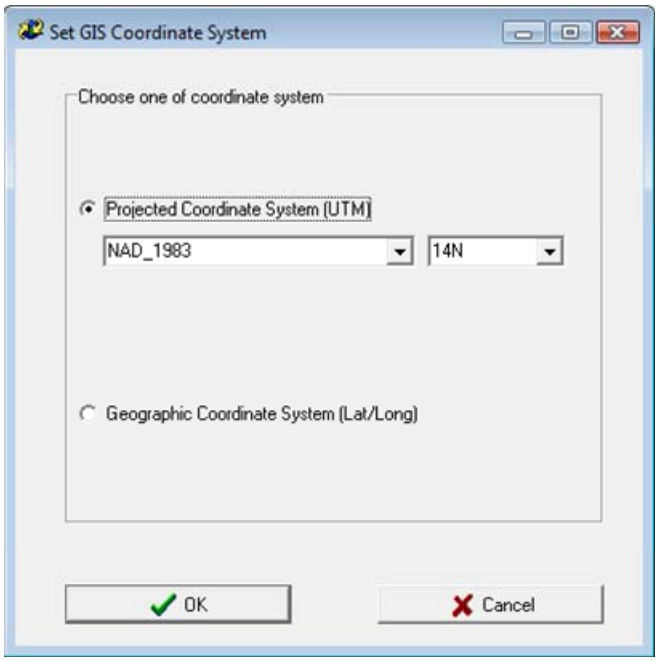


Figure 4.19. Interface showing current geo-referenced coordinate system

VMS supports two UTM coordinate systems (NAD1983 and NAD1927) and Geographic Coordinate System (Lat/Long). The users are allowed to change UTM coordinate system and zone number or select Geographic Coordinate System. If the user clicks 'OK', then a selected coordinate system will be applied to whole ADCP and shape files.

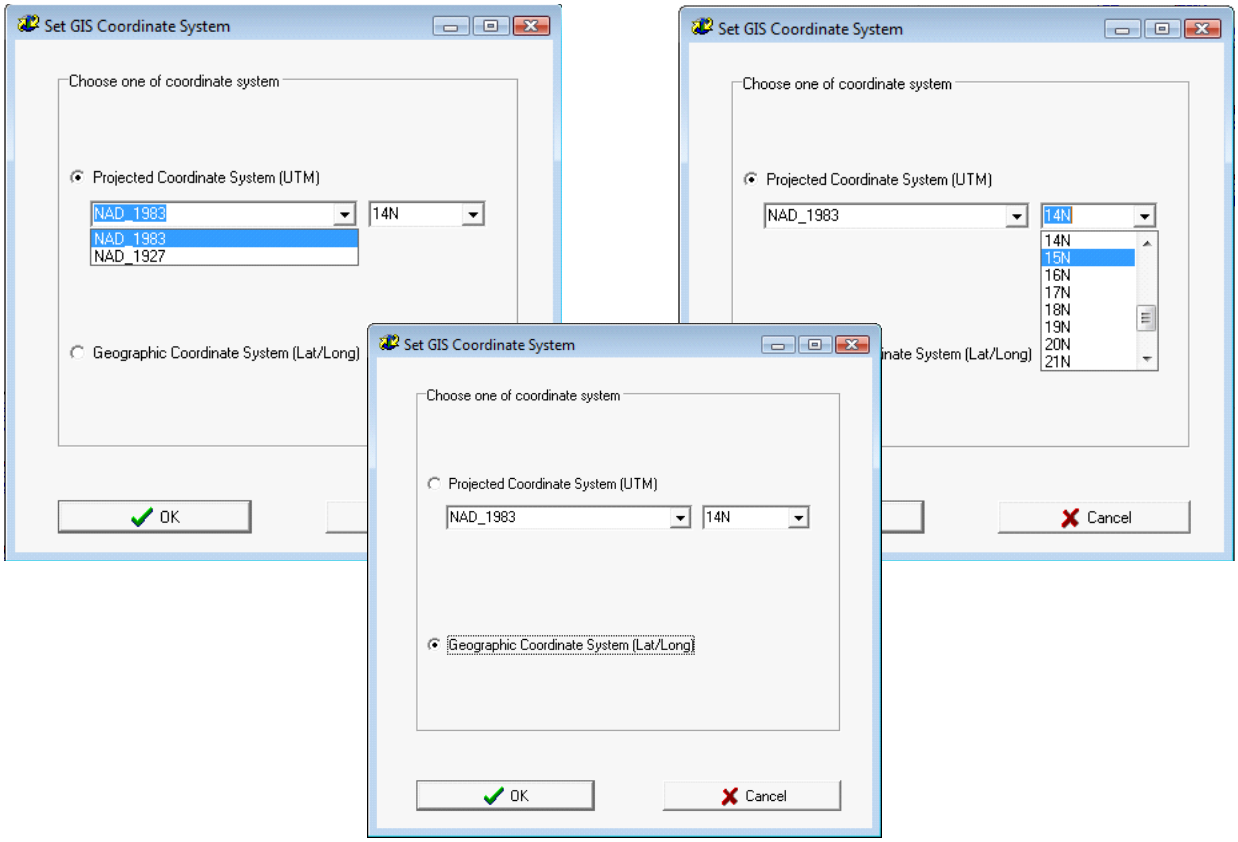


Figure 4.20. Changing coordinate system

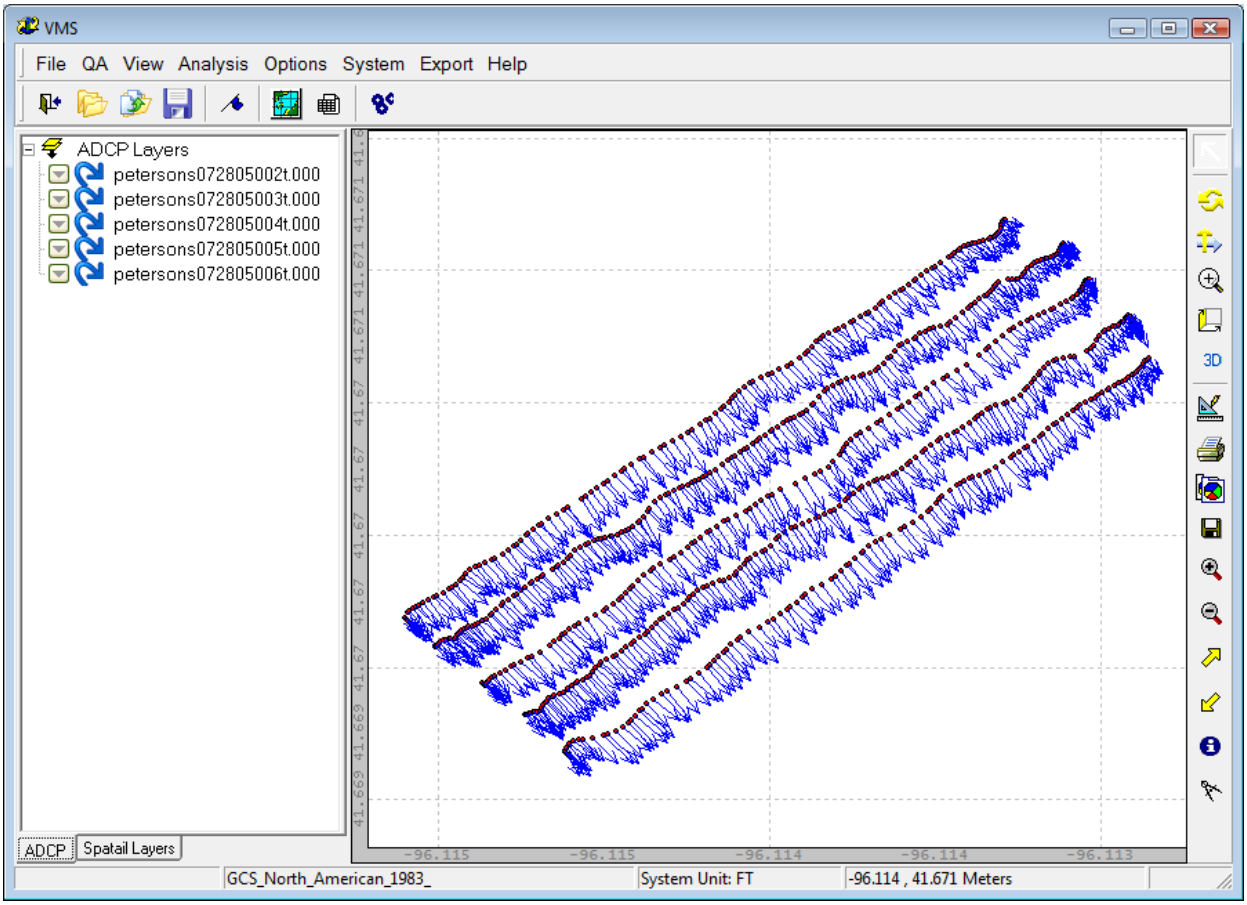


Figure 4.21. Representation of transects in geographic coordinate system (latitude/longitude)

5. Quality Assurance

One of major functions of VMS is to support quality assurance of the collected data. This quality assurance in VMS can be done on a transect by transect basis and the appropriate extrapolation techniques and filter thresholds can be applied. Moreover, the many of the data filters can be automated to provide a more efficient and consistent approach to quality assurance. Currently, the following filters are implemented: Error Velocity, Beam Depths, and Boat Speed.

All filters provide a graphical representation of the filter and the option to apply or not apply the filter. Allowing the user to change the parameters of a filter could be possible, and reasonable default values are provided if the user attempts to change the parameters.

The interface for quality assurance allows the user to quickly click through the transects and ensembles in a transect as necessary.

The provided summary report of automated filter results would help the user determine how much manual effort will be needed to quality assure the data. Depending on the type of data being processed, discharge for each transect is provided as a quality indicator and a table/graphic of the discharge for each transect are presented in a manner that the user could identify irregularities.

VMS provides an additional interface for the quality assurance. After loading single or multiple ADCP files, click flag button as described in Figure 5.1 to open QA interface.

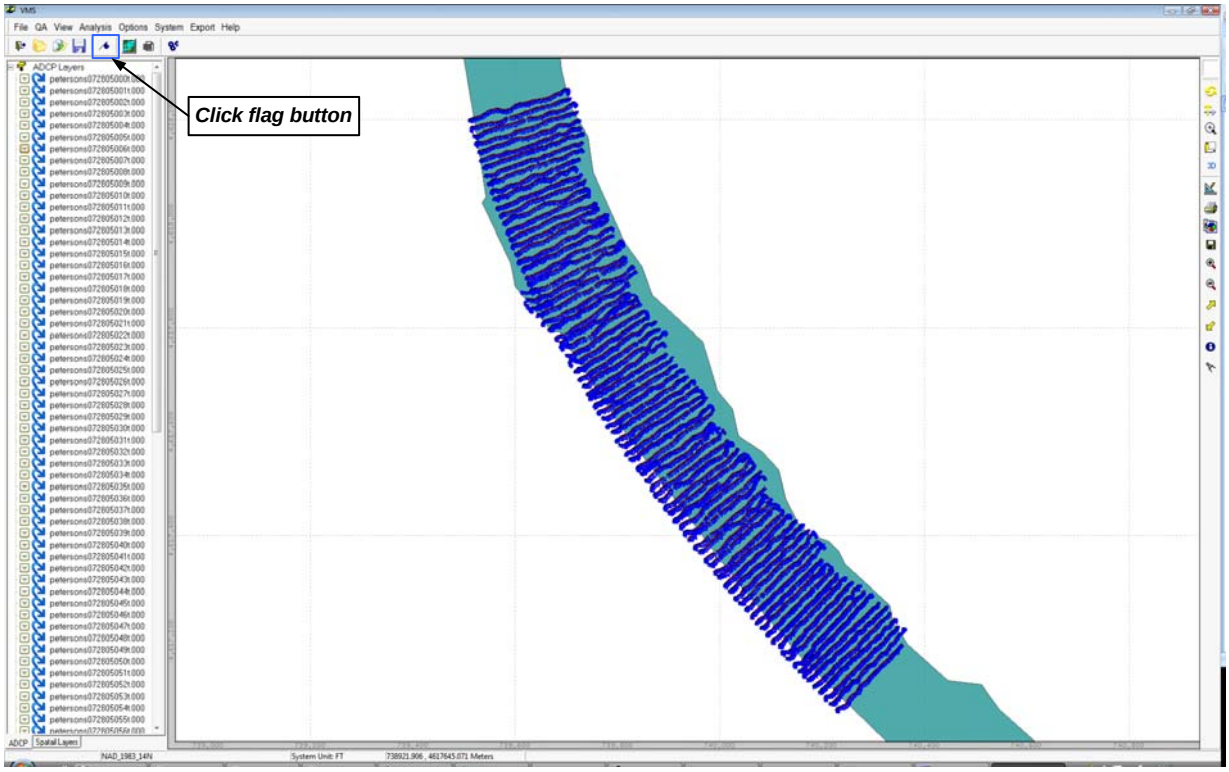


Figure 5.1. Button for quality assurance interface

An interface named “Quality Assurance Setup” will appear as illustrated in Figure 4.2. This interface handles all loaded ADCP files (not just for the selected files), and file names are displayed in the left file pane.

The initial interface (named ‘Discharge Info’ tab) shows discharge for each file in graphic/tabular format. If the user click one of files in the file pane or table (with blue color), the corresponding discharge displayed in the chart will be colored as red. Discharge table provides two discharges for each file: discharge recorded in the ASCII file (Qraw) with rectangle symbol in the chart and computed discharge (Qfilter) with cross symbol in the chart by reflecting changes after applying filters, where discharge calculation algorithm using flow and bottom tracking velocity was applied. Initially, both Qraw and Qfilter are identical, since any filter was not applied yet. But Qfilter will be altered after applying filters later on, and the user can check this out. The file pane will appear every interface, so that the user can quickly explorer filtering results by clicking file name or key up and down. If the user just click ‘Apply Filter(s)’ button without further customizing parameters of individual filters, the default filtering parameters will be automatically applied. If the user wants to skip applying any filter, ‘Don’t Apply Any Filters’ button should be clicked. The users are also allowed to deselect file(s) in the file pane by un-checking checkbox. And specific filters for all files can be selectable (see the bottom pane). For example, if the user deselects Error Velocity Filter, this filter will not be applied for any files though this filter was selected in the individual file filter setup.

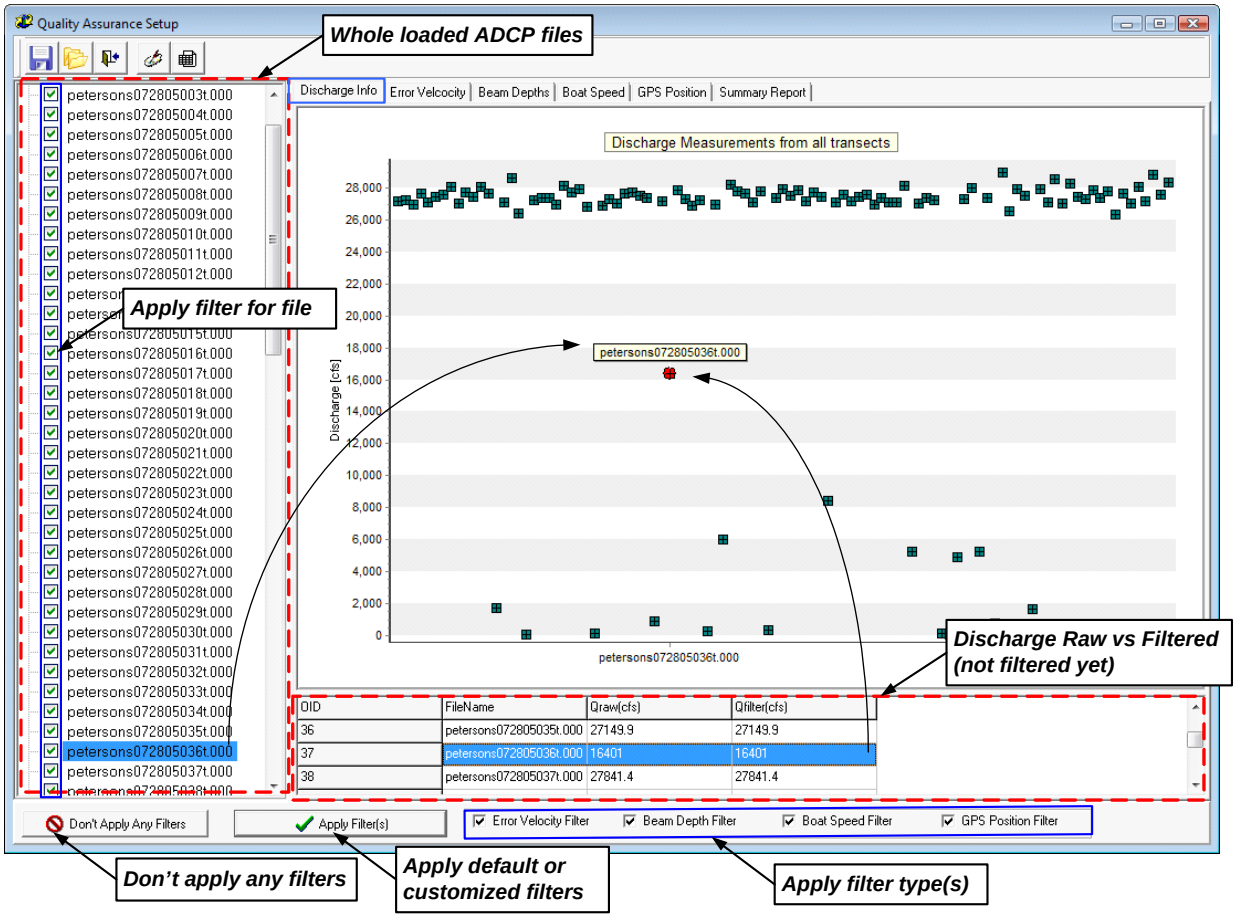


Figure 5.2. Initial interface of quality assurance interface.

5.1. Error velocity filter

Assuming that the error velocity have a Gaussian distribution, VMS computes the standard deviation of all error velocities in the transect, removes data outside a given times (4 as default) of the standard deviation and repeats this process using the remaining data until no additional data are removed. The user is able to see this interface by clicking 'Error Velocity' tab above the chart, and the following interface will show up.

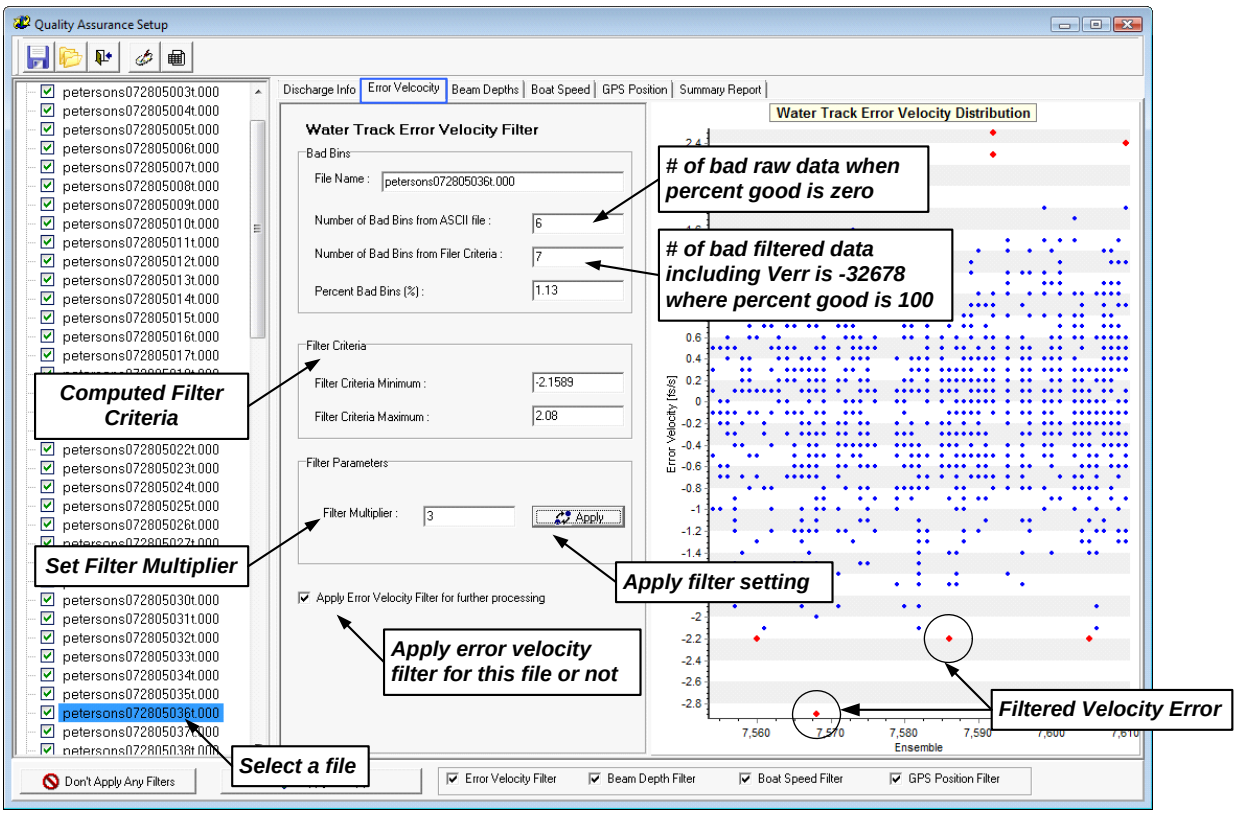


Figure 5.3. An interface for the velocity error filter

Whenever, this interface shows up, default or customized filtering parameters are automatically applied for a selected file (with blue color in the file pane) and the results are displayed in the chart, where the red colored dots are the filtered error velocity. The interface reports the number of bad bins originated from ASCII file where percent good is zero, and the number of bad bins after applying velocity error filter, which additionally filters data that has -32678 as velocity error but percent good is 100. Therefore, though there are no red dots in the chart, the interface might report a number for the bad bins after applying filter criteria. When the error velocity was filtered, other relevant velocity component such as eastern, northern, and vertical velocity would be changed as bad (-32678) data, and will not be used in computing discharge, but will be interpolated instead.

The filter criteria (minimum and maximum) is internally computed and reported, depending on filter multiplier. The user can change this filter multiplier and click 'Apply' button, then will be able to see computed filter criteria, subsequently the number of bad

bins from filter criteria and red dots in the chart. If the user deselects ‘Apply Error Velocity Filter for further processing’ checkbox, this filtered results will not be applied when the user finally click ‘Apply Filter’ in the bottom pane.

When the user explorers files and chooses filter criteria, each customized filter setup will be saved in memory and be updated when the user returns to the file that the user have already customized.

If the user goes back to ‘Discharge Info’ tab after applying velocity error filter, he/she will see the filtered discharge (Qfilter) in the table and chart was changed.

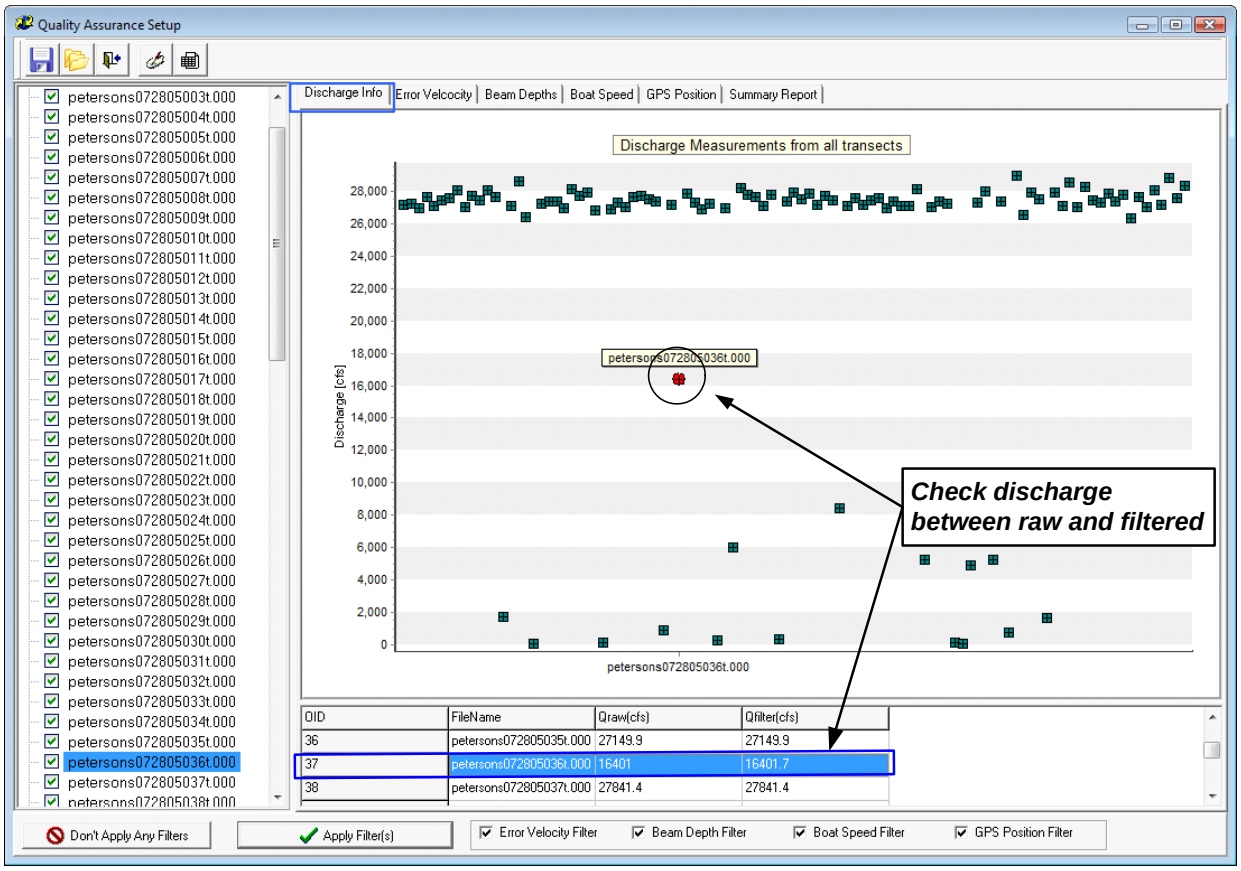


Figure 5.4. Discharge changed after applying filter

5.2. Beam depths filter

The beam depths are filtered individually by using a smooth with a moving window with the window size depending on data on both sides of the point being evaluated. This interface will be showed up as illustrated in Figure after the user click 'Beam Depth' tab.

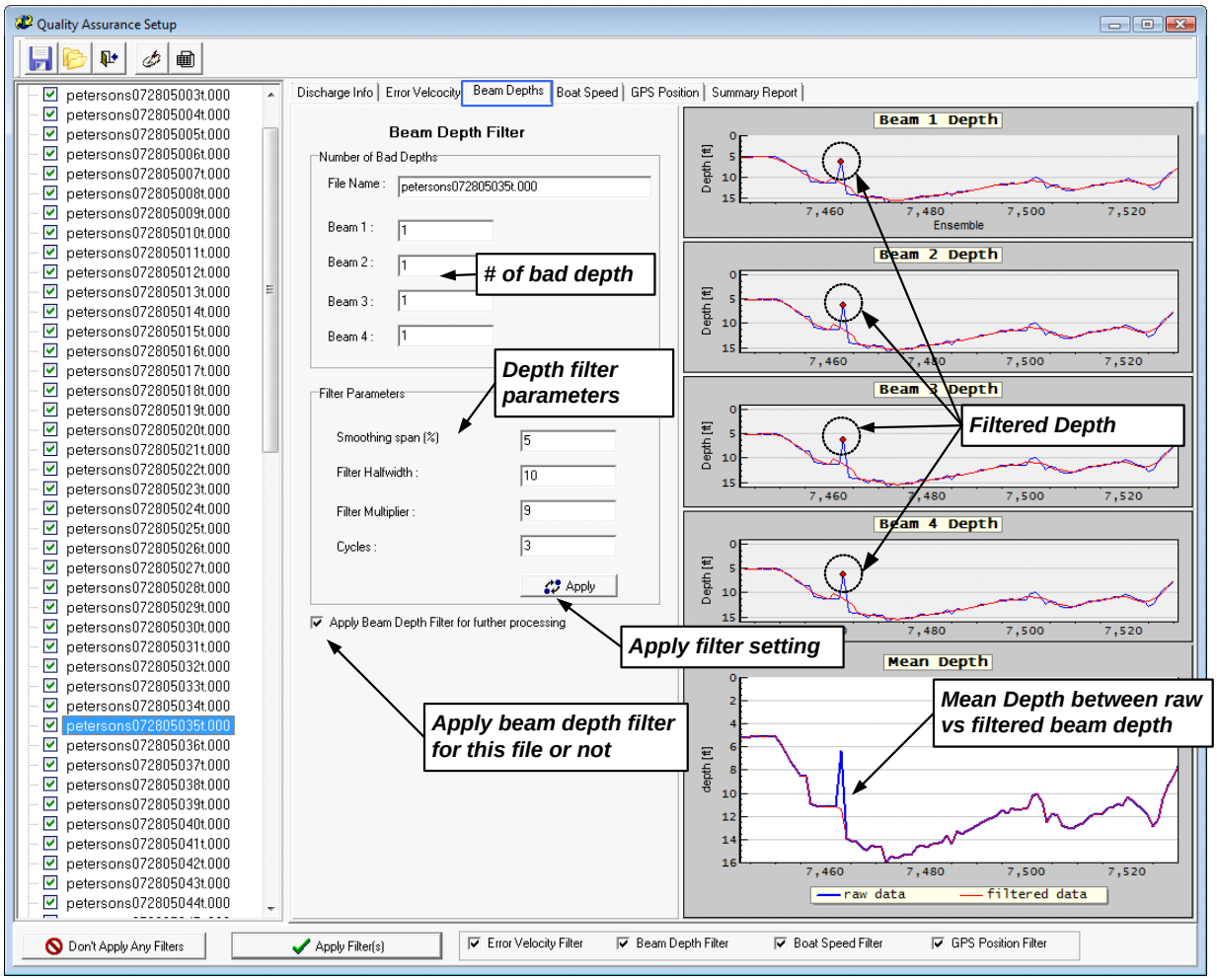


Figure 5.5. An interface for the beam depth filter

The interface for the beam depth filter reports filtered beam depth as displayed in the charts, which depend on filter parameters such as smoothing span, filter half width (smoothing window size), multiplier (criteria), and cycles (number of repeated filter algorithm). The red lines in the charts (Beam 1 ~4 Depth) indicate smoothed lines. In applying smoothing, zero depth was not included as input dataset, but eliminated as default. Mean depth chart shows mean depth based on raw and filtered beam depth by simple averaging, where zero depth was not included for calculating raw mean beam depth. Filtered mean depth only differs from raw mean depth, when filtered beam

depths exist where they are replaced with corresponding smoothed beam depth. The results after applying this filter for discharge was not implemented yet, so the user cannot see how this filter affects discharge.

5.3. Boat speed filter

This filter used an approach similar to beam depths, applying a smooth and a moving window with a window size dependent on surrounding data. Currently, boat speed based on the bottom tracking is applicable for this filter. Click 'Boat Speed' tab, and the user will see the following interface.

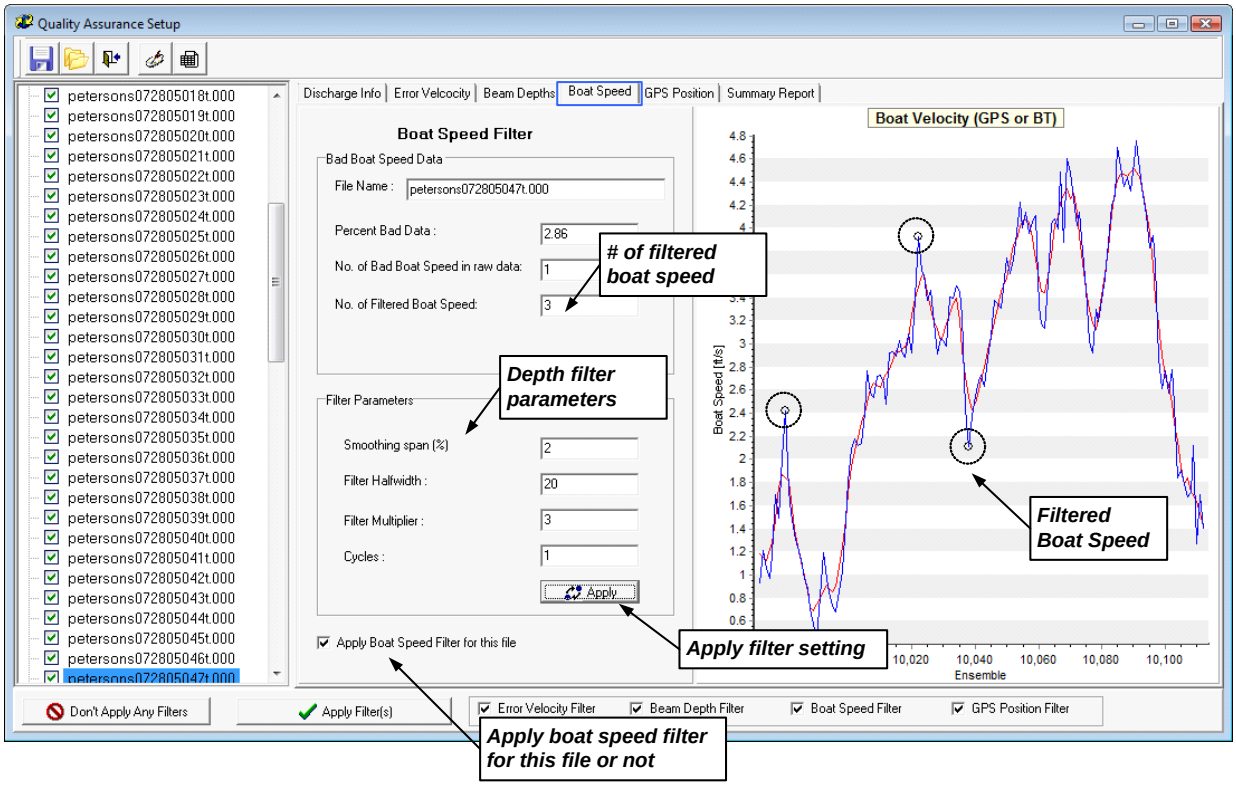


Figure 5.6. An interface for the boat speed filter

The results after applying this filter for discharge was also not implemented yet, so the user cannot see how this filter affects discharge.

5.4. GPS position

** This interface was implemented yet, so more rigorous idea will be needed.

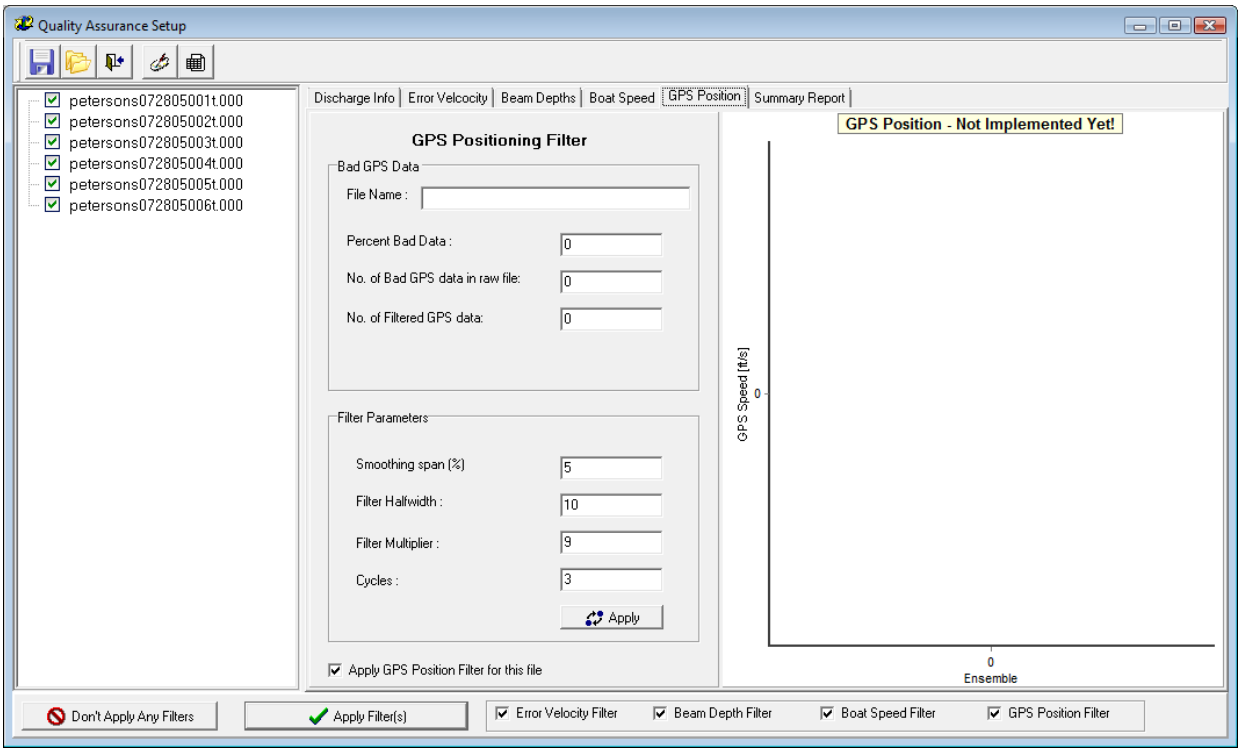
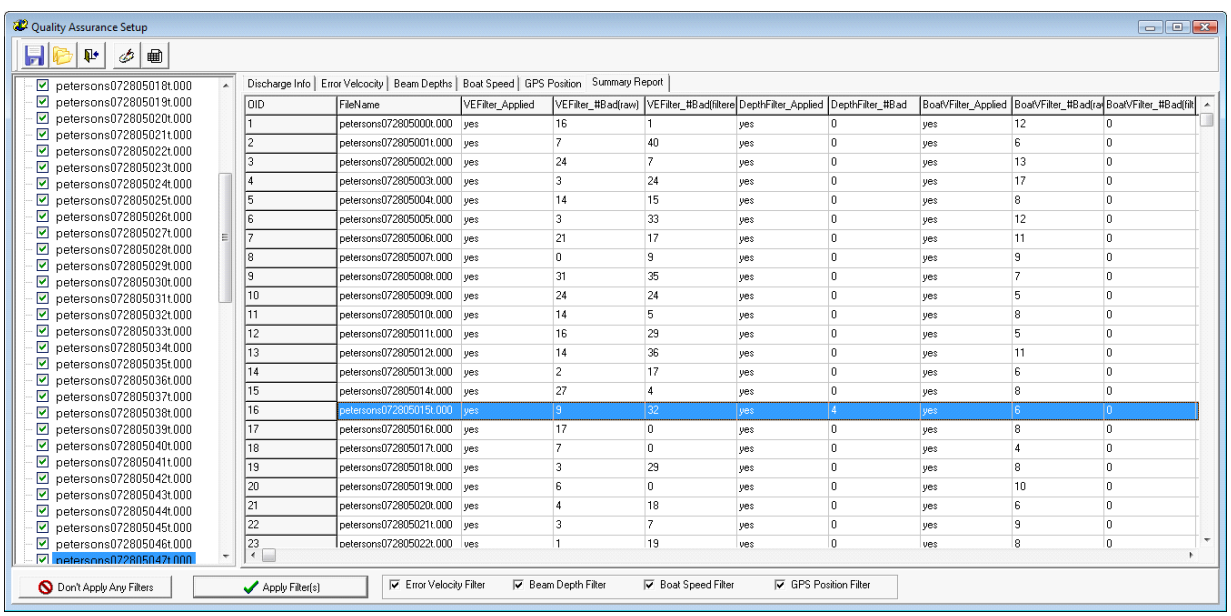


Figure 5.7. An interface for the GPS positioning filter

5.5. Summary report



OID	FileName	VEFilter_Applied	VEFilter_#Bad(raw)	VEFilter_#Bad(filtere	DepthFilter_Applied	DepthFilter_#Bad	BoatVFilter_Applied	BoatVFilter_#Bad(raw	BoatVFilter_#Bad(filt
1	petersons072805000t.000	yes	16	1	yes	0	yes	12	0
2	petersons072805001t.000	yes	7	40	yes	0	yes	6	0
3	petersons072805002t.000	yes	24	7	yes	0	yes	13	0
4	petersons072805003t.000	yes	3	24	yes	0	yes	17	0
5	petersons072805004t.000	yes	14	15	yes	0	yes	8	0
6	petersons072805005t.000	yes	3	33	yes	0	yes	12	0
7	petersons072805006t.000	yes	21	17	yes	0	yes	11	0
8	petersons072805007t.000	yes	0	9	yes	0	yes	9	0
9	petersons072805008t.000	yes	31	35	yes	0	yes	7	0
10	petersons072805009t.000	yes	24	24	yes	0	yes	5	0
11	petersons072805010t.000	yes	14	5	yes	0	yes	8	0
12	petersons072805011t.000	yes	16	29	yes	0	yes	5	0
13	petersons072805012t.000	yes	14	36	yes	0	yes	11	0
14	petersons072805013t.000	yes	2	17	yes	0	yes	6	0
15	petersons072805014t.000	yes	27	4	yes	0	yes	8	0
16	petersons072805015t.000	yes	9	32	yes	4	yes	6	0
17	petersons072805016t.000	yes	17	0	yes	0	yes	8	0
18	petersons072805017t.000	yes	7	0	yes	0	yes	4	0
19	petersons072805018t.000	yes	3	29	yes	0	yes	8	0
20	petersons072805019t.000	yes	6	0	yes	0	yes	10	0
21	petersons072805020t.000	yes	4	18	yes	0	yes	6	0
22	petersons072805021t.000	yes	3	7	yes	0	yes	9	0
23	petersons072805022t.000	yes	1	19	yes	0	yes	8	0

Figure 5.8. An interface for summary report

5.6. Save and reload filter setup file

The customized filter setup is able to be saved and reloaded without the user having to reenter filter setup. When the user load setup file, VMS compares file names in the file pane with file name in the reloaded setup file, and updates filter setup of only existing files. If file name is not in the setup file, VMS uses default filter setup. So, the user might be able to keep updating archive of filter setup, that file can be broadly used for the user group. However, saving function is still not smart enough to do selective archiving, so that the user should have to save filter setup individually and manually combine them into a single 'mater' filter setup file.

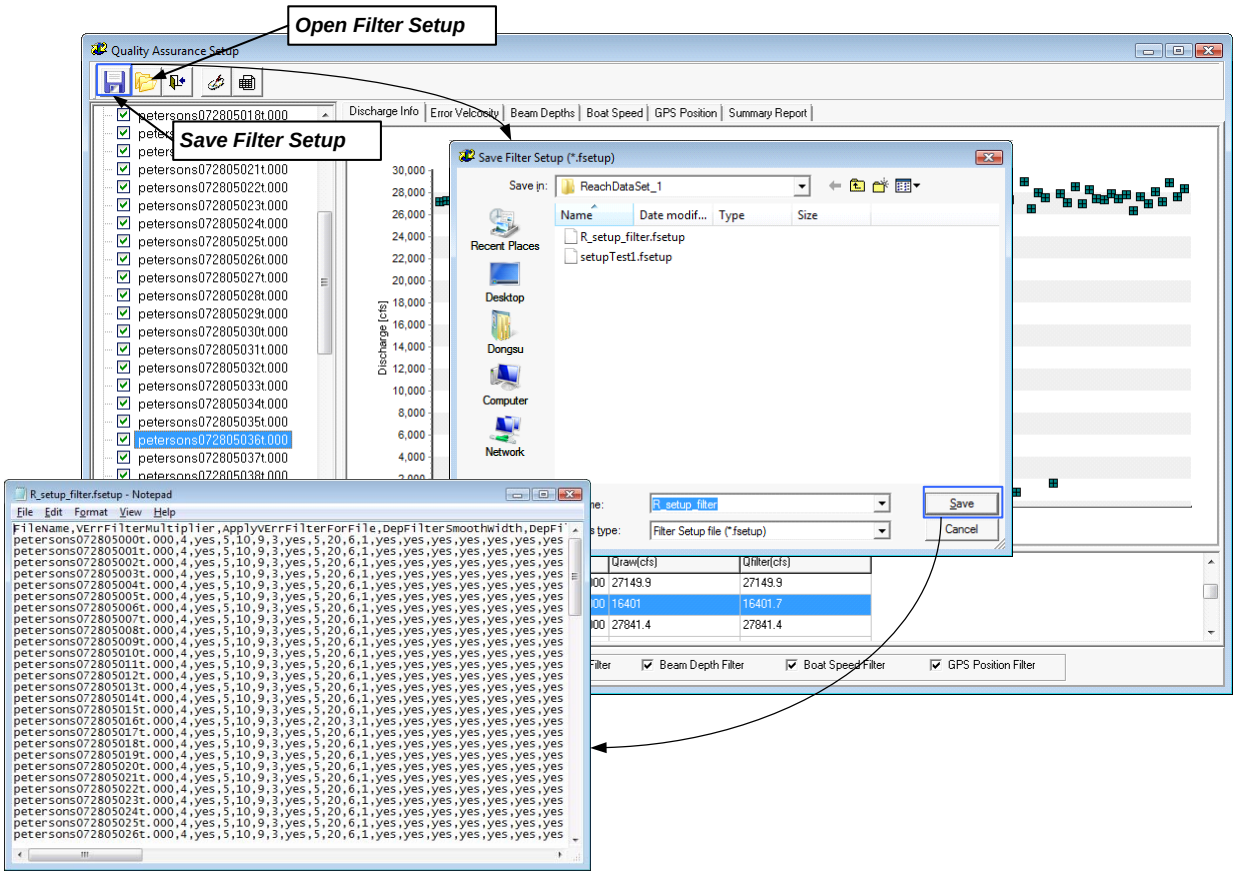


Figure 5.9. Save and reload filter setup

5.7. Notes

- The user should have to keep in mind that the filtered results will not be actually applied to the data before clicking ‘Apply Filter’ button in the bottom pane after the user finish the filter setup.
- In the Filter interface, ADCP files cannot be removed from VMS, but those files should be removed in the main interface.

6. Transect Information

VMS provides a graphical the user interface that would display each transect and allow the user to select a transect by either selecting the transect from a list. Once a transect is selected and attached button is clicked, it could be examined in more detail with other interface including graphic (color contour plot of velocities, vertical and horizontal view, animation, and ship track) or tabular displays. The graphical interface could include both 2-D and 3-D representations of the data.

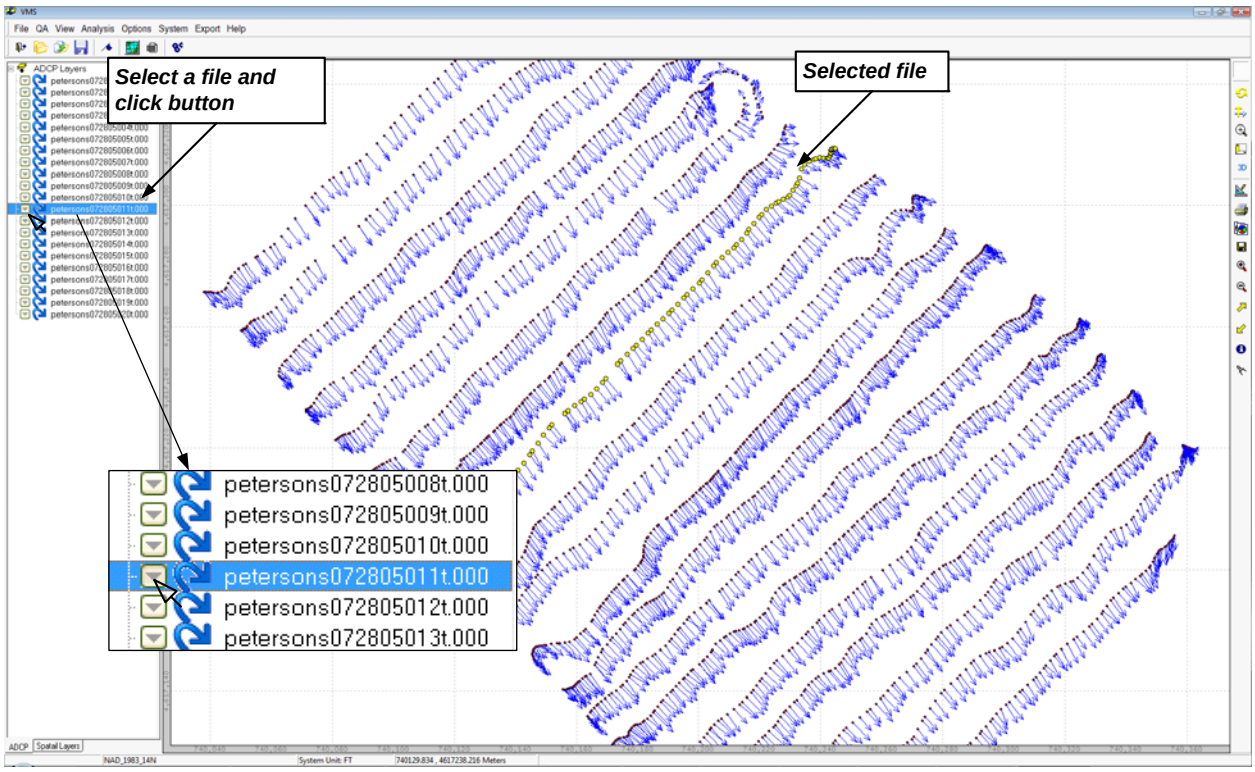


Figure 6.1. Select a transect in the file pane and click attached button to examine details

6.1. Tabular view

Once the button is clicked, a new interface will show up including file name on the top of the window. And 'Summary' table in the 'Tabular' tab will be activated as fault. This table provides summarized information that is similar to summary file provided by WinRiver I.

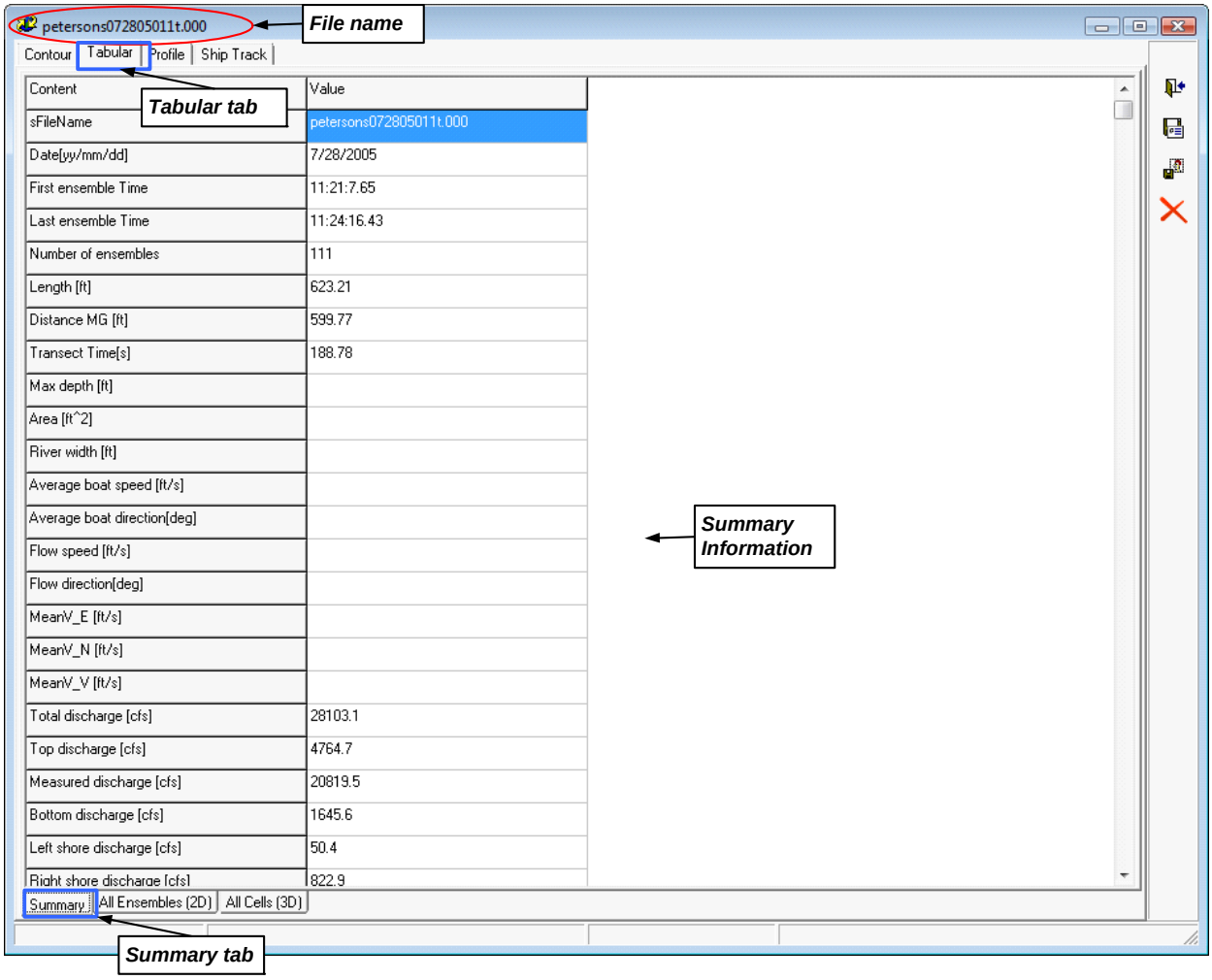
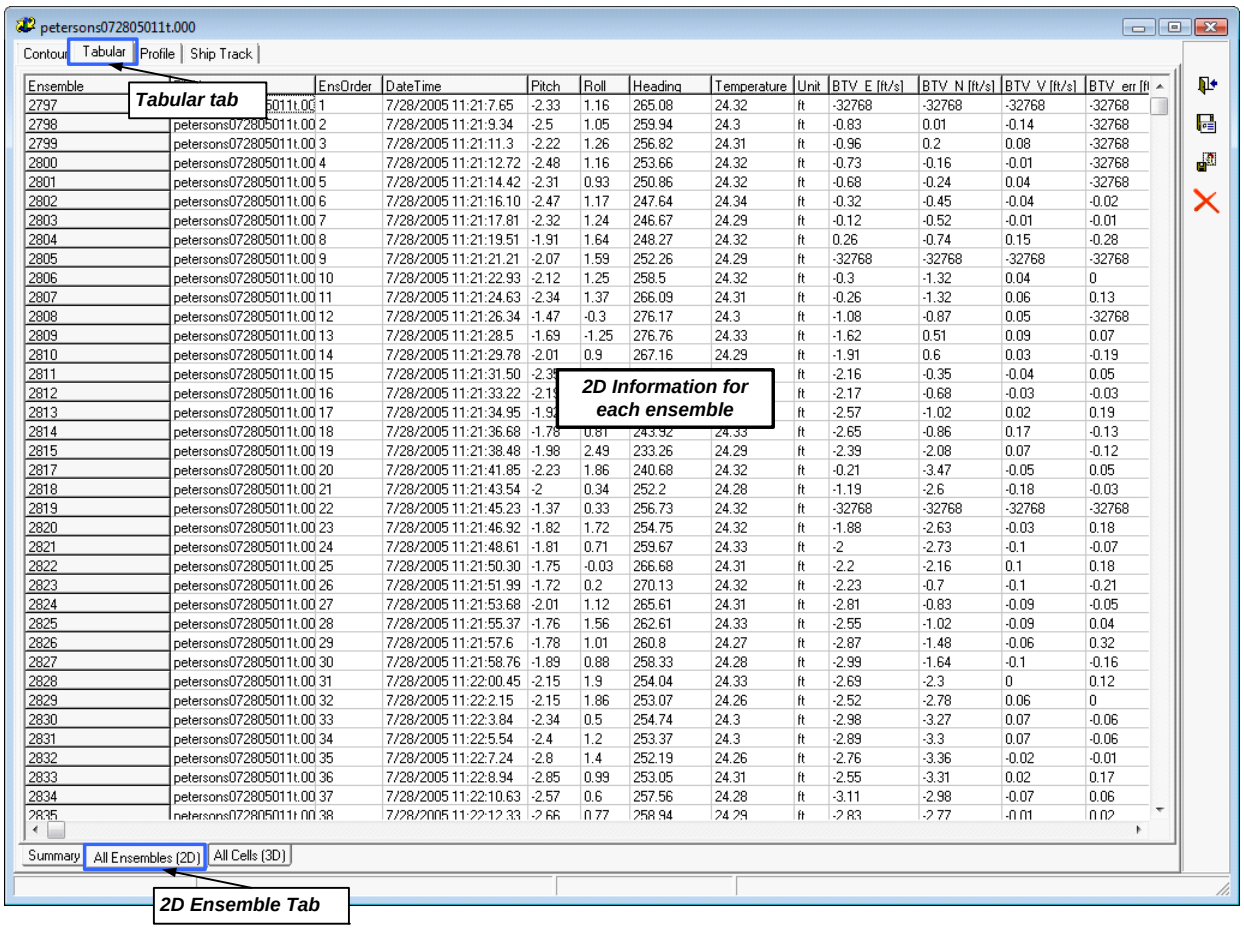


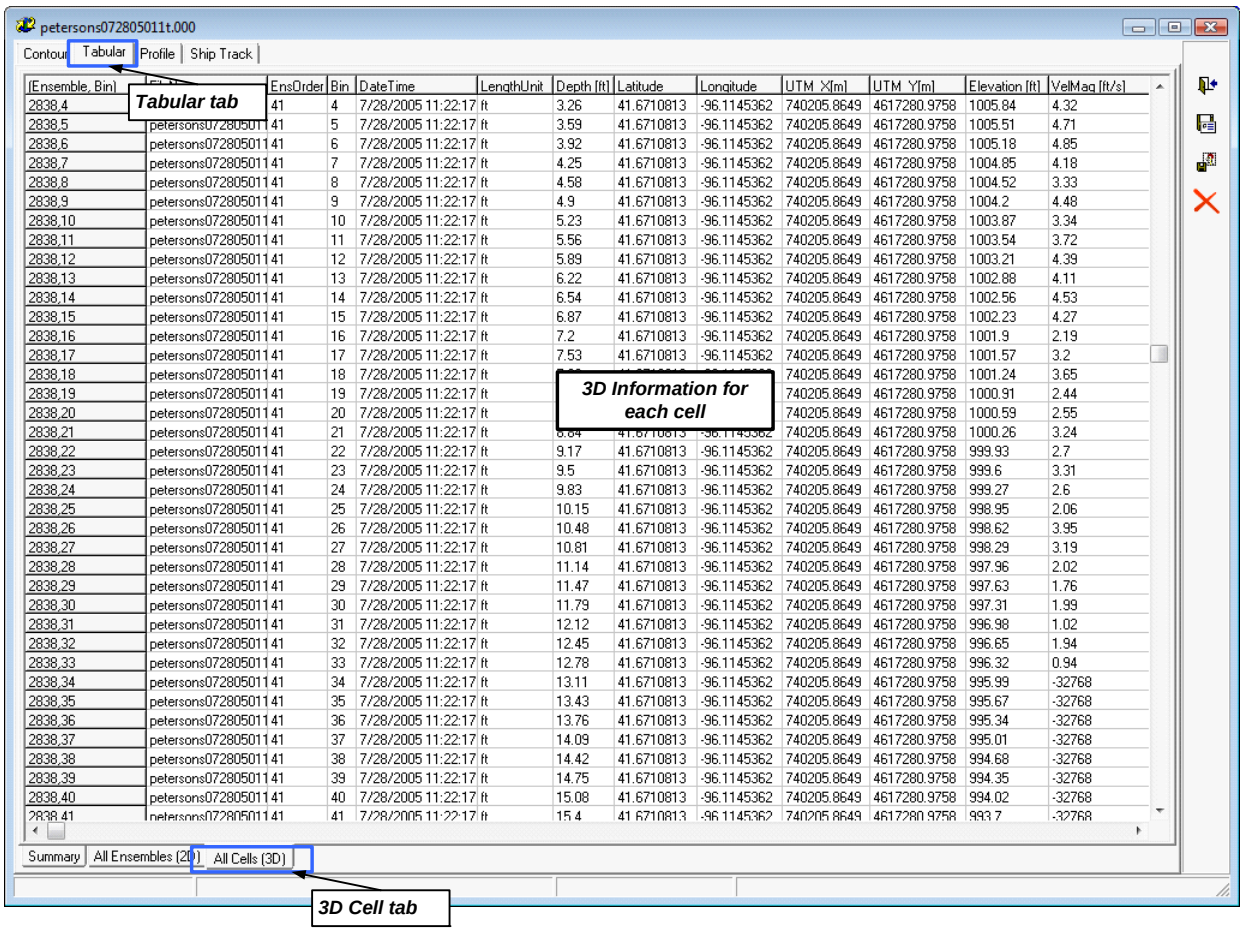
Figure 6.2. Summary table for a transect

Under the Tabular tab, there are two other subsets of Tabular tab: All Ensembles (2D) and All Cells (3D) tables as illustrated in Figure 6.3 and 6.4, respectively. All Ensembles (2D) table includes information recorded in header part of each ensemble from ASCII file, such as time, BT velocity, and latitude/longitude, and processed data such as depth averaged velocity components. All 3D Cells (3D) table includes information recorded in body part of each ensemble from ASCII file such as velocity components at bins.



Ensemble		EnsOrder	DateTime	Pitch	Roll	Heading	Temperature	Unit	BTV_E [ft/s]	BTV_N [ft/s]	BTV_V [ft/s]	BTV_err [ft
2797	5011t.00	1	7/28/2005 11:21:7.65	-2.33	1.16	265.08	24.32	ft	-32768	-32768	-32768	-32768
2798	petersons072805011t.00	2	7/28/2005 11:21:9.34	-2.5	1.05	259.94	24.3	ft	-0.83	0.01	-0.14	-32768
2799	petersons072805011t.00	3	7/28/2005 11:21:11.3	-2.22	1.26	256.82	24.31	ft	-0.96	0.2	0.08	-32768
2800	petersons072805011t.00	4	7/28/2005 11:21:12.72	-2.48	1.16	253.66	24.32	ft	-0.73	-0.16	-0.01	-32768
2801	petersons072805011t.00	5	7/28/2005 11:21:14.42	-2.31	0.93	250.86	24.32	ft	-0.68	-0.24	0.04	-32768
2802	petersons072805011t.00	6	7/28/2005 11:21:16.10	-2.47	1.17	247.64	24.34	ft	-0.32	-0.45	-0.04	-0.02
2803	petersons072805011t.00	7	7/28/2005 11:21:17.81	-2.32	1.24	246.67	24.29	ft	-0.12	-0.52	-0.01	-0.01
2804	petersons072805011t.00	8	7/28/2005 11:21:19.51	-1.91	1.64	248.27	24.32	ft	0.26	-0.74	0.15	-0.28
2805	petersons072805011t.00	9	7/28/2005 11:21:21.21	-2.07	1.59	252.26	24.29	ft	-32768	-32768	-32768	-32768
2806	petersons072805011t.00	10	7/28/2005 11:21:22.93	-2.12	1.25	258.5	24.32	ft	-0.3	-1.32	0.04	0
2807	petersons072805011t.00	11	7/28/2005 11:21:24.63	-2.34	1.37	266.09	24.31	ft	-0.26	-1.32	0.06	0.13
2808	petersons072805011t.00	12	7/28/2005 11:21:26.34	-1.47	-0.3	276.17	24.3	ft	-1.08	-0.87	0.05	-32768
2809	petersons072805011t.00	13	7/28/2005 11:21:28.5	-1.69	-1.25	276.76	24.33	ft	-1.62	0.51	0.09	0.07
2810	petersons072805011t.00	14	7/28/2005 11:21:29.78	-2.01	0.9	267.16	24.29	ft	-1.91	0.6	0.03	-0.19
2811	petersons072805011t.00	15	7/28/2005 11:21:31.50	-2.3				ft	-2.16	-0.35	-0.04	0.05
2812	petersons072805011t.00	16	7/28/2005 11:21:33.22	-2.1				ft	-2.17	-0.68	-0.03	-0.03
2813	petersons072805011t.00	17	7/28/2005 11:21:34.95	-1.9				ft	-2.57	-1.02	0.02	0.19
2814	petersons072805011t.00	18	7/28/2005 11:21:36.68	-1.78	0.81	243.32	24.33	ft	-2.65	-0.86	0.17	-0.13
2815	petersons072805011t.00	19	7/28/2005 11:21:38.48	-1.98	2.49	233.26	24.29	ft	-2.39	-2.08	0.07	-0.12
2817	petersons072805011t.00	20	7/28/2005 11:21:41.85	-2.23	1.86	240.68	24.32	ft	-0.21	-3.47	-0.05	0.05
2818	petersons072805011t.00	21	7/28/2005 11:21:43.54	-2	0.34	252.2	24.28	ft	-1.19	-2.6	-0.18	-0.03
2819	petersons072805011t.00	22	7/28/2005 11:21:45.23	-1.37	0.33	256.73	24.32	ft	-32768	-32768	-32768	-32768
2820	petersons072805011t.00	23	7/28/2005 11:21:46.92	-1.82	1.72	254.75	24.32	ft	-1.88	-2.63	-0.03	0.18
2821	petersons072805011t.00	24	7/28/2005 11:21:48.61	-1.81	0.71	259.67	24.33	ft	-2	-2.73	-0.1	-0.07
2822	petersons072805011t.00	25	7/28/2005 11:21:50.30	-1.75	-0.03	266.68	24.31	ft	-2.2	-2.16	0.1	0.18
2823	petersons072805011t.00	26	7/28/2005 11:21:51.99	-1.72	0.2	270.13	24.32	ft	-2.23	-0.7	-0.1	-0.21
2824	petersons072805011t.00	27	7/28/2005 11:21:53.68	-2.01	1.12	265.61	24.31	ft	-2.81	-0.83	-0.09	-0.05
2825	petersons072805011t.00	28	7/28/2005 11:21:55.37	-1.76	1.56	262.61	24.33	ft	-2.55	-1.02	-0.09	0.04
2826	petersons072805011t.00	29	7/28/2005 11:21:57.6	-1.78	1.01	260.8	24.27	ft	-2.87	-1.48	-0.06	0.32
2827	petersons072805011t.00	30	7/28/2005 11:21:58.76	-1.89	0.88	258.33	24.28	ft	-2.99	-1.64	-0.1	-0.16
2828	petersons072805011t.00	31	7/28/2005 11:22:00.45	-2.15	1.9	254.04	24.33	ft	-2.69	-2.3	0	0.12
2829	petersons072805011t.00	32	7/28/2005 11:22:2.15	-2.15	1.86	253.07	24.26	ft	-2.52	-2.78	0.06	0
2830	petersons072805011t.00	33	7/28/2005 11:22:3.84	-2.34	0.5	254.74	24.3	ft	-2.98	-3.27	0.07	-0.06
2831	petersons072805011t.00	34	7/28/2005 11:22:5.54	-2.4	1.2	253.37	24.3	ft	-2.89	-3.3	0.07	-0.06
2832	petersons072805011t.00	35	7/28/2005 11:22:7.24	-2.8	1.4	252.19	24.26	ft	-2.76	-3.36	-0.02	-0.01
2833	petersons072805011t.00	36	7/28/2005 11:22:8.94	-2.85	0.99	253.05	24.31	ft	-2.55	-3.31	0.02	0.17
2834	petersons072805011t.00	37	7/28/2005 11:22:10.63	-2.57	0.6	257.56	24.28	ft	-3.11	-2.98	-0.07	0.06
2835	petersons072805011t.00	38	7/28/2005 11:22:12.33	-2.66	0.77	258.94	24.29	ft	-2.83	-2.77	-0.01	0.02

Figure 6.3. All Ensembles (2D) table for a transect



[Ensemble, Bin]		EnsOrder	Bin	DateTime	LengthUnit	Depth [ft]	Latitude	Longitude	UTM_X[m]	UTM_Y[m]	Elevation [ft]	VelMag [ft/s]
2838,4		41	4	7/28/2005 11:22:17	ft	3.26	41.6710813	-96.1145362	740205.8649	4617280.9758	1005.84	4.32
2838,5	petersons072805011	41	5	7/28/2005 11:22:17	ft	3.59	41.6710813	-96.1145362	740205.8649	4617280.9758	1005.51	4.71
2838,6	petersons072805011	41	6	7/28/2005 11:22:17	ft	3.92	41.6710813	-96.1145362	740205.8649	4617280.9758	1005.18	4.85
2838,7	petersons072805011	41	7	7/28/2005 11:22:17	ft	4.25	41.6710813	-96.1145362	740205.8649	4617280.9758	1004.85	4.18
2838,8	petersons072805011	41	8	7/28/2005 11:22:17	ft	4.58	41.6710813	-96.1145362	740205.8649	4617280.9758	1004.52	3.33
2838,9	petersons072805011	41	9	7/28/2005 11:22:17	ft	4.9	41.6710813	-96.1145362	740205.8649	4617280.9758	1004.2	4.48
2838,10	petersons072805011	41	10	7/28/2005 11:22:17	ft	5.23	41.6710813	-96.1145362	740205.8649	4617280.9758	1003.87	3.34
2838,11	petersons072805011	41	11	7/28/2005 11:22:17	ft	5.56	41.6710813	-96.1145362	740205.8649	4617280.9758	1003.54	3.72
2838,12	petersons072805011	41	12	7/28/2005 11:22:17	ft	5.89	41.6710813	-96.1145362	740205.8649	4617280.9758	1003.21	4.39
2838,13	petersons072805011	41	13	7/28/2005 11:22:17	ft	6.22	41.6710813	-96.1145362	740205.8649	4617280.9758	1002.88	4.11
2838,14	petersons072805011	41	14	7/28/2005 11:22:17	ft	6.54	41.6710813	-96.1145362	740205.8649	4617280.9758	1002.56	4.53
2838,15	petersons072805011	41	15	7/28/2005 11:22:17	ft	6.87	41.6710813	-96.1145362	740205.8649	4617280.9758	1002.23	4.27
2838,16	petersons072805011	41	16	7/28/2005 11:22:17	ft	7.2	41.6710813	-96.1145362	740205.8649	4617280.9758	1001.9	2.19
2838,17	petersons072805011	41	17	7/28/2005 11:22:17	ft	7.53	41.6710813	-96.1145362	740205.8649	4617280.9758	1001.57	3.2
2838,18	petersons072805011	41	18	7/28/2005 11:22:17	ft				740205.8649	4617280.9758	1001.24	3.65
2838,19	petersons072805011	41	19	7/28/2005 11:22:17	ft				740205.8649	4617280.9758	1000.91	2.44
2838,20	petersons072805011	41	20	7/28/2005 11:22:17	ft				740205.8649	4617280.9758	1000.59	2.55
2838,21	petersons072805011	41	21	7/28/2005 11:22:17	ft	8.84	41.6710813	-96.1145362	740205.8649	4617280.9758	1000.26	3.24
2838,22	petersons072805011	41	22	7/28/2005 11:22:17	ft	9.17	41.6710813	-96.1145362	740205.8649	4617280.9758	999.93	2.7
2838,23	petersons072805011	41	23	7/28/2005 11:22:17	ft	9.5	41.6710813	-96.1145362	740205.8649	4617280.9758	999.6	3.31
2838,24	petersons072805011	41	24	7/28/2005 11:22:17	ft	9.83	41.6710813	-96.1145362	740205.8649	4617280.9758	999.27	2.6
2838,25	petersons072805011	41	25	7/28/2005 11:22:17	ft	10.15	41.6710813	-96.1145362	740205.8649	4617280.9758	998.95	2.06
2838,26	petersons072805011	41	26	7/28/2005 11:22:17	ft	10.48	41.6710813	-96.1145362	740205.8649	4617280.9758	998.62	3.95
2838,27	petersons072805011	41	27	7/28/2005 11:22:17	ft	10.81	41.6710813	-96.1145362	740205.8649	4617280.9758	998.29	3.19
2838,28	petersons072805011	41	28	7/28/2005 11:22:17	ft	11.14	41.6710813	-96.1145362	740205.8649	4617280.9758	997.96	2.02
2838,29	petersons072805011	41	29	7/28/2005 11:22:17	ft	11.47	41.6710813	-96.1145362	740205.8649	4617280.9758	997.63	1.76
2838,30	petersons072805011	41	30	7/28/2005 11:22:17	ft	11.79	41.6710813	-96.1145362	740205.8649	4617280.9758	997.31	1.99
2838,31	petersons072805011	41	31	7/28/2005 11:22:17	ft	12.12	41.6710813	-96.1145362	740205.8649	4617280.9758	996.98	1.02
2838,32	petersons072805011	41	32	7/28/2005 11:22:17	ft	12.45	41.6710813	-96.1145362	740205.8649	4617280.9758	996.65	1.94
2838,33	petersons072805011	41	33	7/28/2005 11:22:17	ft	12.78	41.6710813	-96.1145362	740205.8649	4617280.9758	996.32	0.94
2838,34	petersons072805011	41	34	7/28/2005 11:22:17	ft	13.11	41.6710813	-96.1145362	740205.8649	4617280.9758	995.99	-32768
2838,35	petersons072805011	41	35	7/28/2005 11:22:17	ft	13.43	41.6710813	-96.1145362	740205.8649	4617280.9758	995.67	-32768
2838,36	petersons072805011	41	36	7/28/2005 11:22:17	ft	13.76	41.6710813	-96.1145362	740205.8649	4617280.9758	995.34	-32768
2838,37	petersons072805011	41	37	7/28/2005 11:22:17	ft	14.09	41.6710813	-96.1145362	740205.8649	4617280.9758	995.01	-32768
2838,38	petersons072805011	41	38	7/28/2005 11:22:17	ft	14.42	41.6710813	-96.1145362	740205.8649	4617280.9758	994.68	-32768
2838,39	petersons072805011	41	39	7/28/2005 11:22:17	ft	14.75	41.6710813	-96.1145362	740205.8649	4617280.9758	994.35	-32768
2838,40	petersons072805011	41	40	7/28/2005 11:22:17	ft	15.08	41.6710813	-96.1145362	740205.8649	4617280.9758	994.02	-32768
2838,41	petersons072805011	41	41	7/28/2005 11:22:17	ft	15.4	41.6710813	-96.1145362	740205.8649	4617280.9758	993.7	-32768

Figure 6.4. All Cells (3D) table for a transect

6.2. Contour plot

If the user clicks Contour tab in the upper part of the interface, the colored contour plot for the velocity magnitude will show up (see Figure 6.5). At this time, only velocity magnitude was used, not including other parameters like velocity component/ intensity.

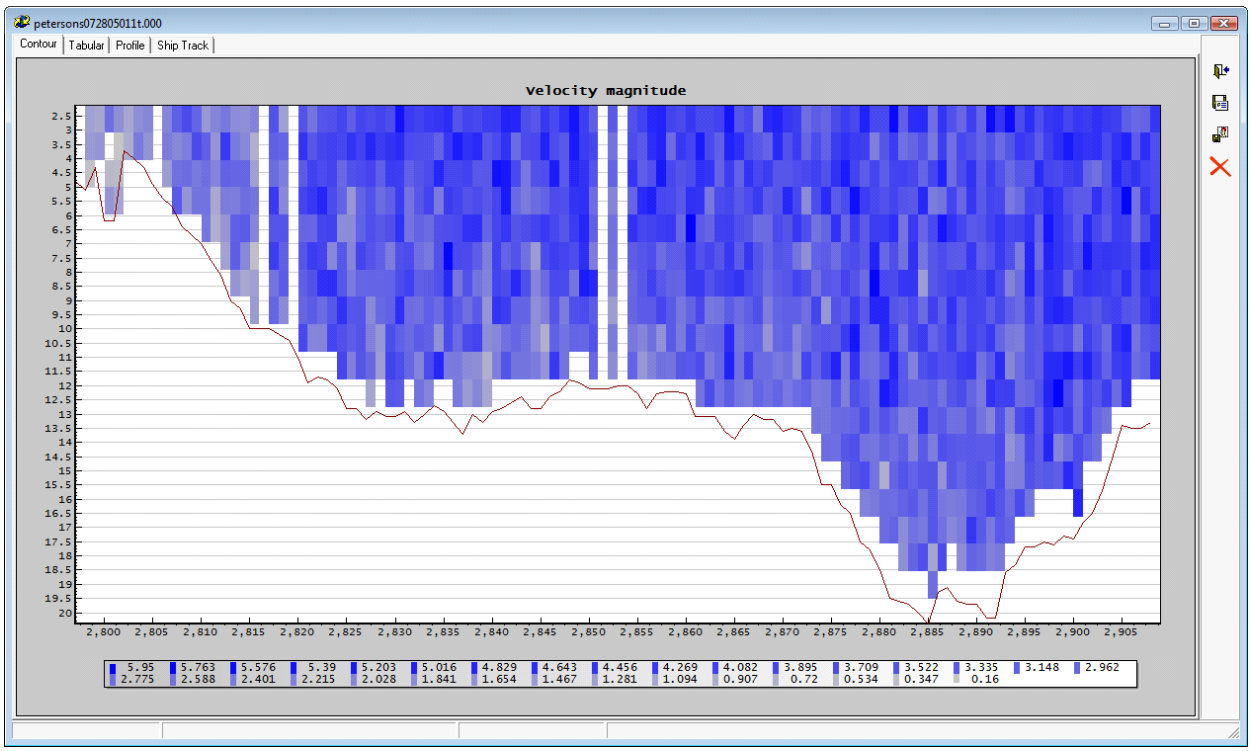


Figure 6.5. Contour plot of velocity magnitude

6.3. Velocity profile

VMS provides two different types of velocity profile: vertical and horizontal. First, the vertical profile at each ensemble can be examined in the Vertical tab. Along the ship track, the user is able to move forward and backward to see velocity data in tabular and 3D graphical format. When the user starts the animation, dynamic variation of the 3D velocity in the transect can be visualized.

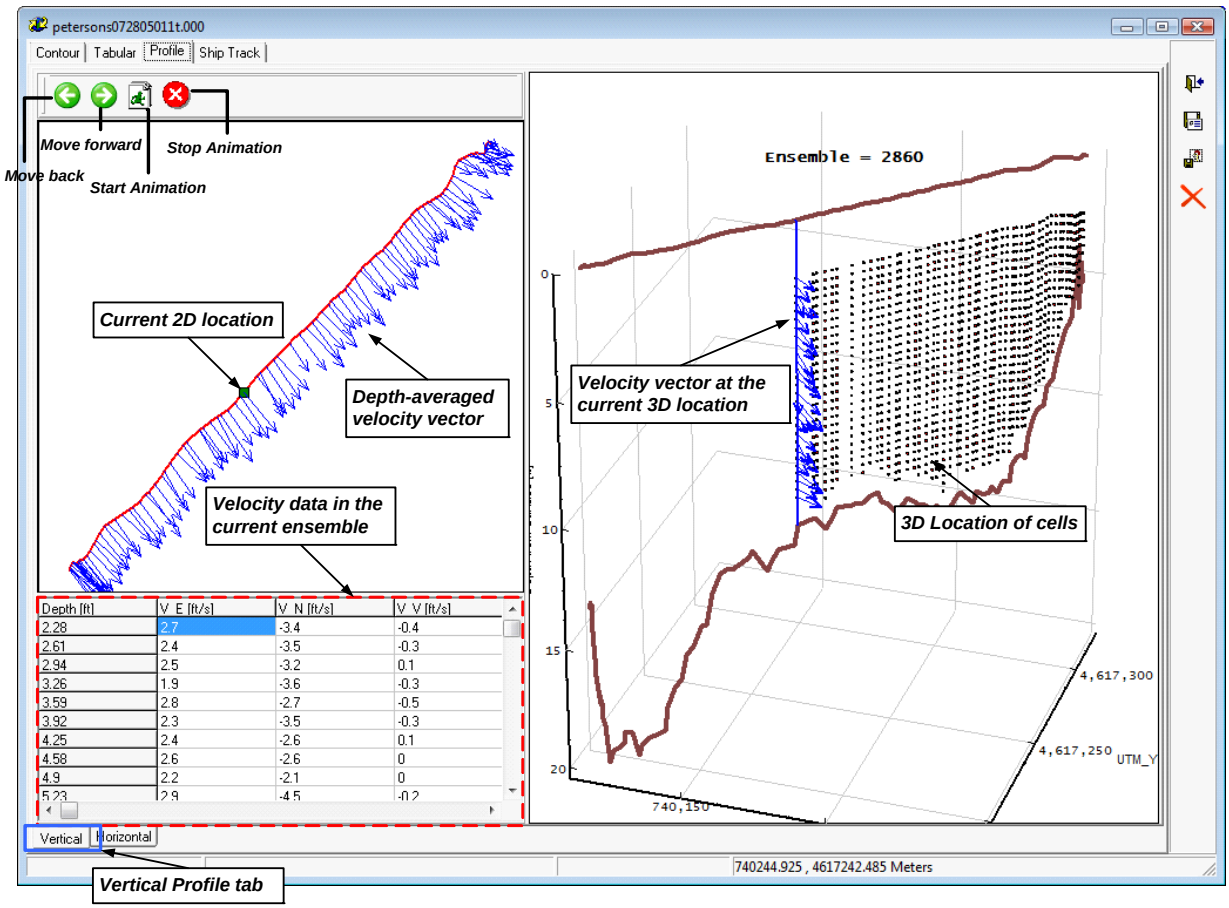


Figure 6.6. vertical velocity profile

Second, the horizontal profile can be represented in the depth-averaged (Figure 6.7), nearest surface (Figure 6.8), nearest bottom (Figure 6.9), and layers (Figure 6.10). To rotate the chart in 3D the user should left-click and drag the cursor around inside the chart. In order to zoom in and out click the “Edit Chart” button located to the right of the chart and select the 3D tab. Under this tab the zoom slider will be visible and allow for this manipulation.

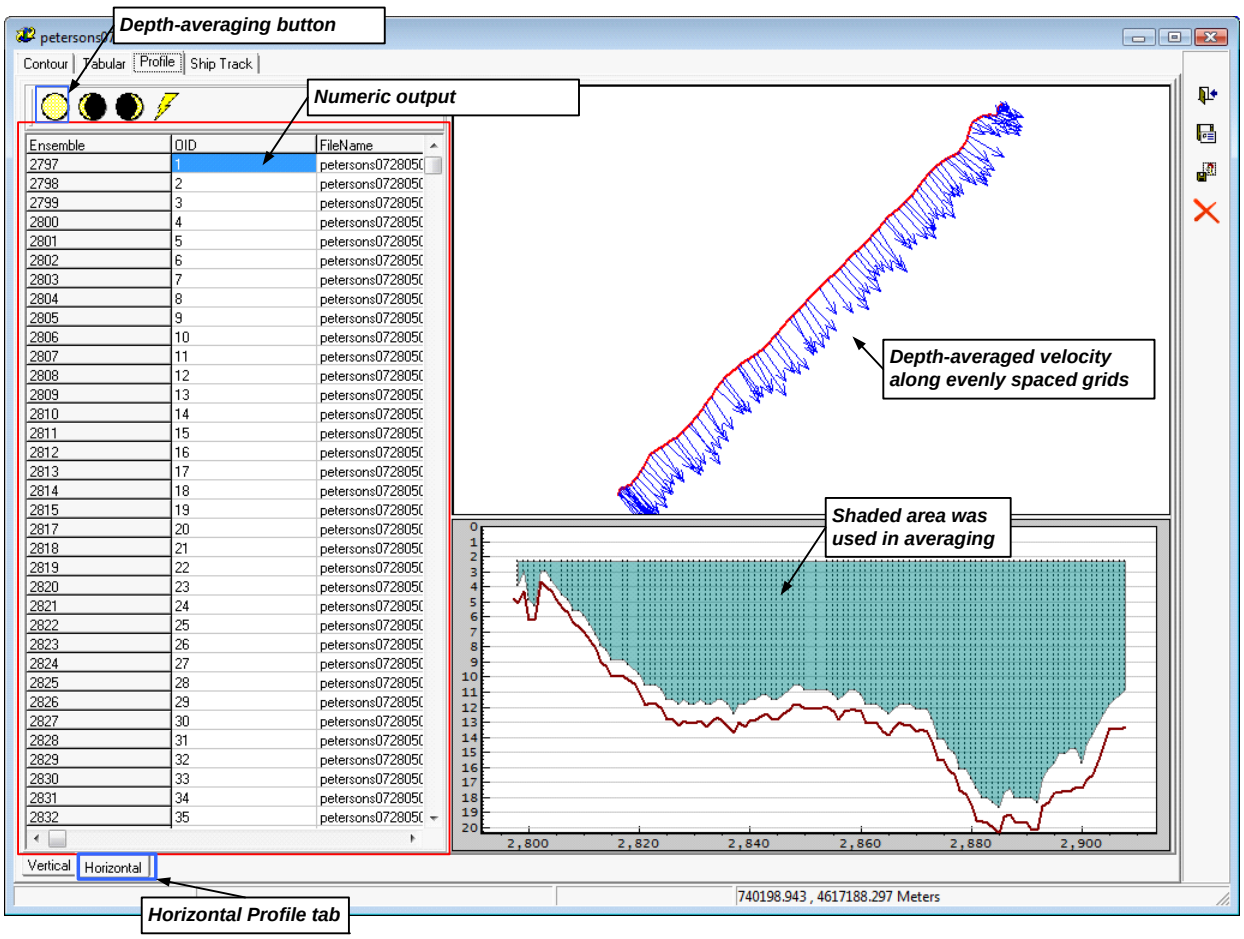


Figure 6.7. Horizontal velocity profile – depth averaged

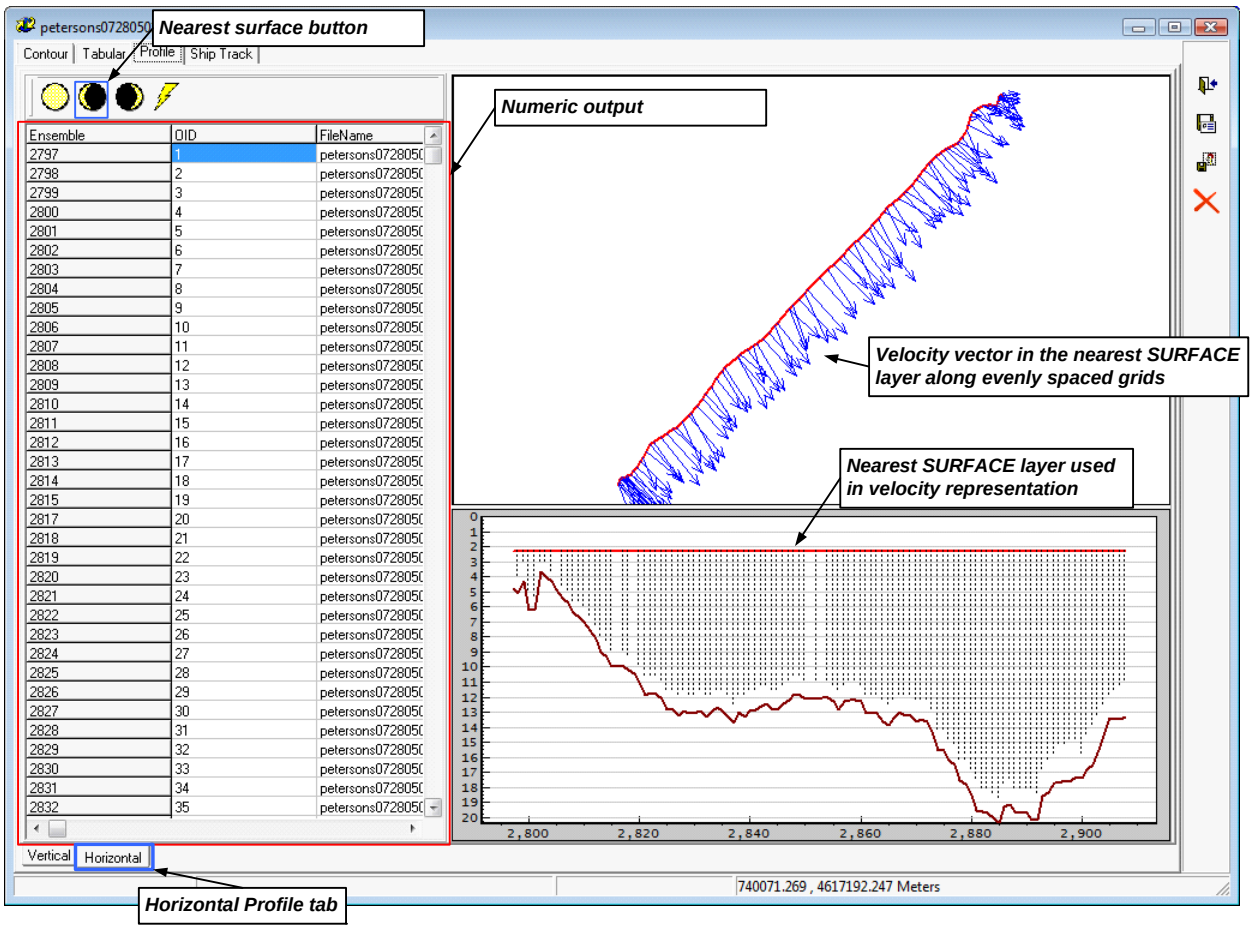


Figure 6.8. Horizontal velocity profile – nearest surface

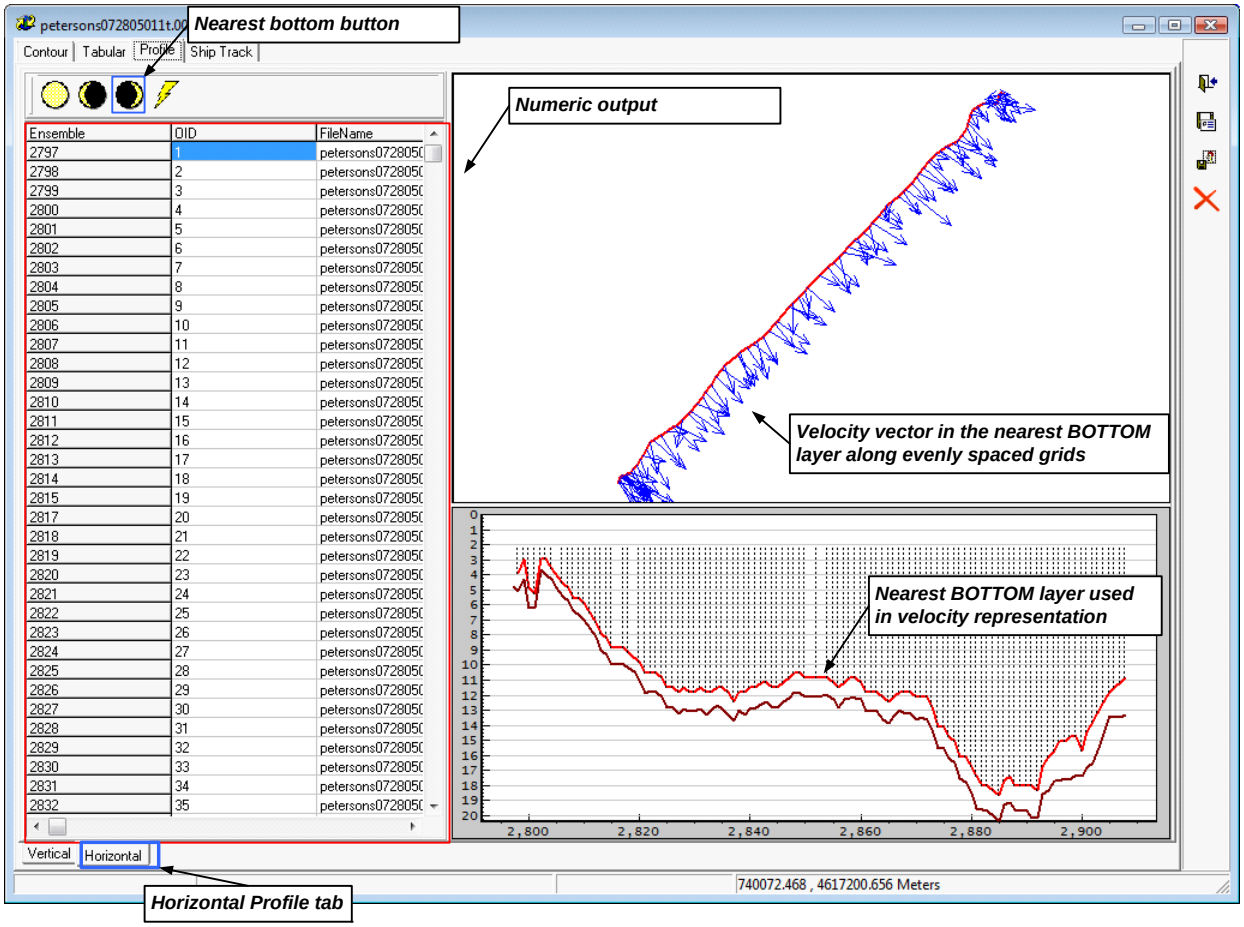


Figure 6.9. Horizontal velocity profile – nearest bottom

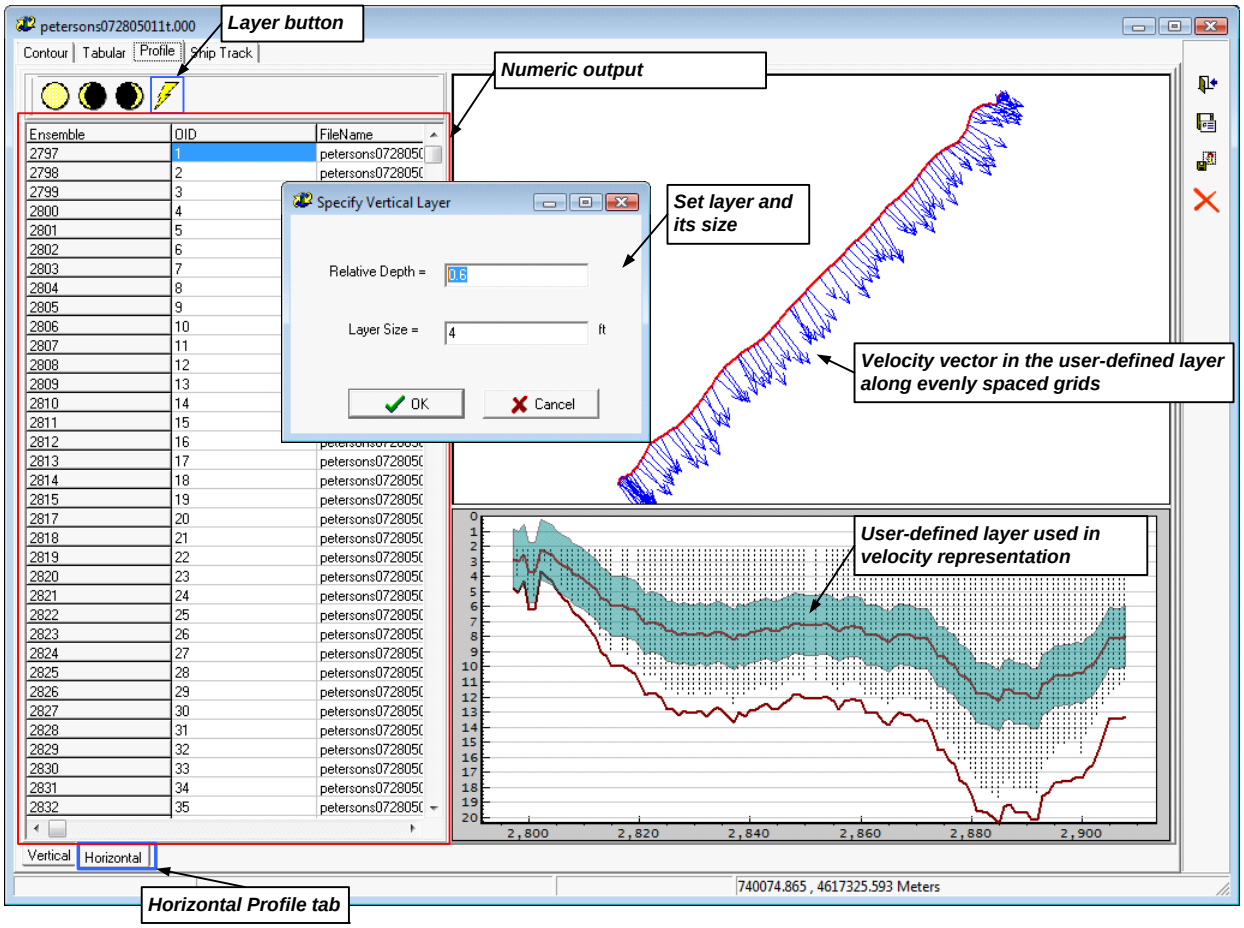
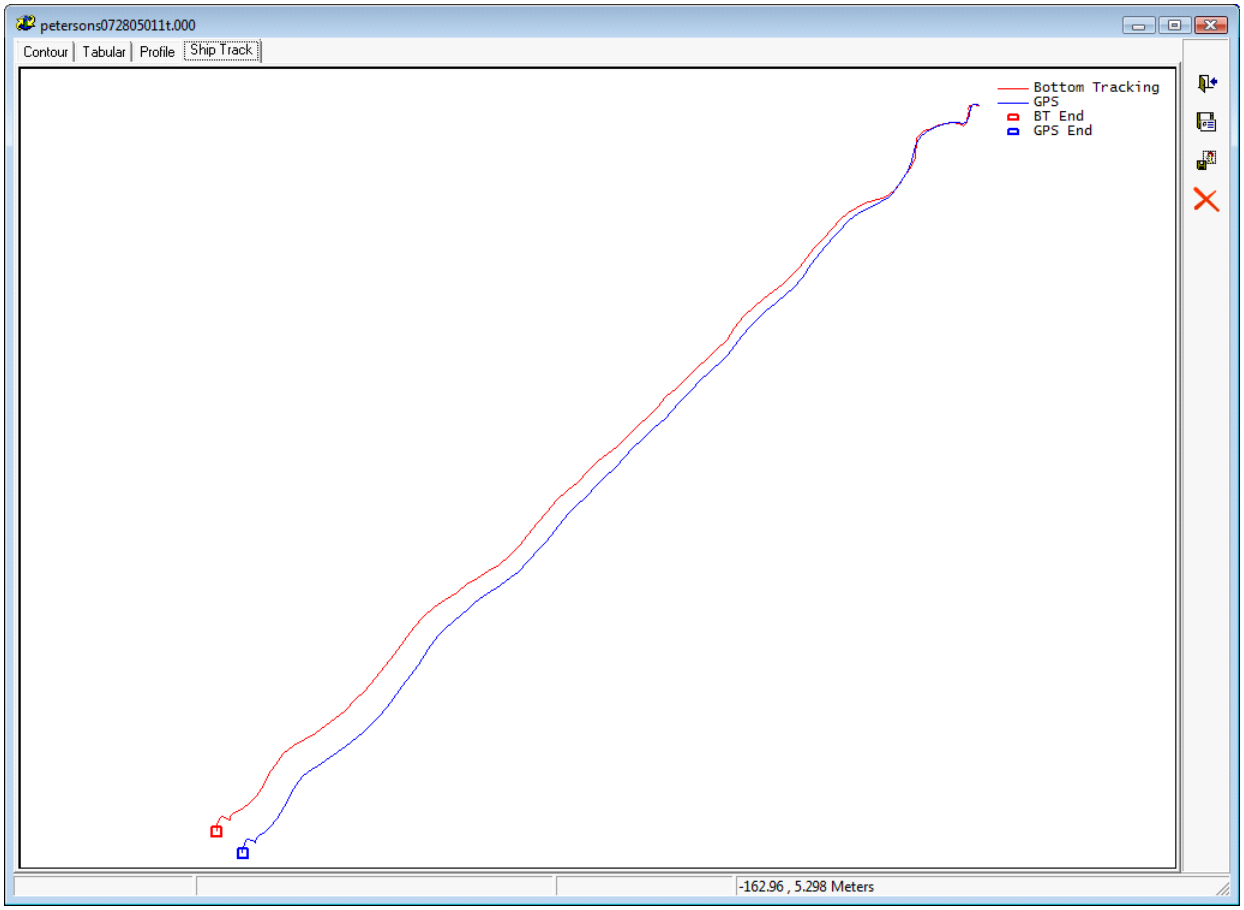


Figure 6.10. Horizontal velocity profile – layer

6.4. Ship track



7. Spatial Averaging

VMS supports horizontal averaging along transect with specified averaging step (or spacing). The horizontal spacing of the averages will be specified by the user and will be applied over the curvilinear path of the transect. In this version, VMS only provides averaging among multiple transects collected at the same cross section, which is expected to reduce the uncertainty associated with velocity averages. In general, the users collect multiple transects at the same cross section and look for horizontally and/or vertically averaged data using all of the transects in the group. The average path traveled for a group of transects is computed first to provide a method to compute a mean path. The spacing for horizontal averaging will be then applied along that mean

path and the points to be averaged will be those that fall within a user defined diameter. The depths along the mean path were averaged and smoothed, and depth at each spaced point will be taken from these depths.

7.1. Grouping of multiple transects

The starting point for performing horizontal averaging is to load the required ADCP data as illustrated as follows.

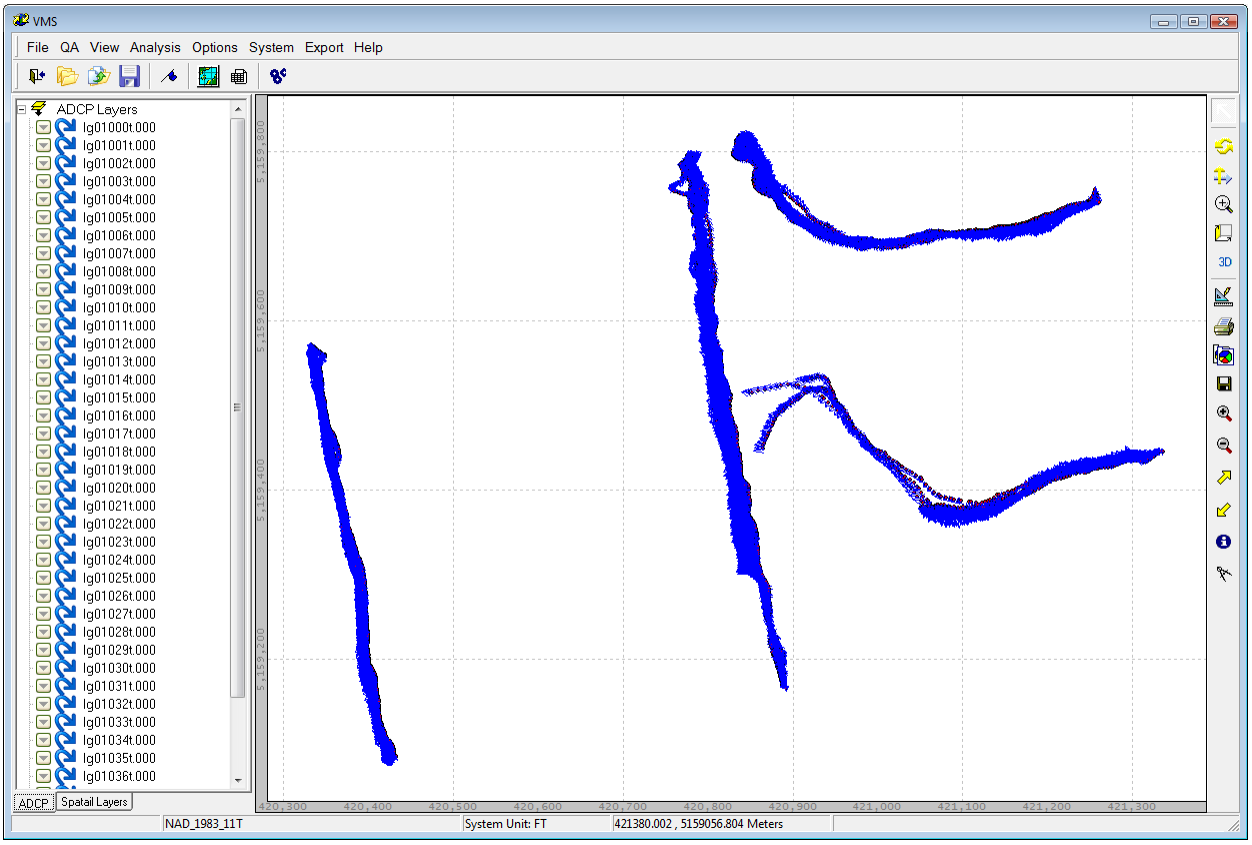


Figure 7.1. Load multiple ADCP files

Currently, only manual grouping is possible in VMS. In order to perform manual grouping the user will select transects from the side panel and indicate which group transects belong to (see yellow dots in the Figure 7.2). Because current version of VMS does not support automatic grouping, if the user uses ADCP files which are not grouped, it will not work properly. VMS conducts spatial averaging only for a single group, not for multiple groups at the same time.

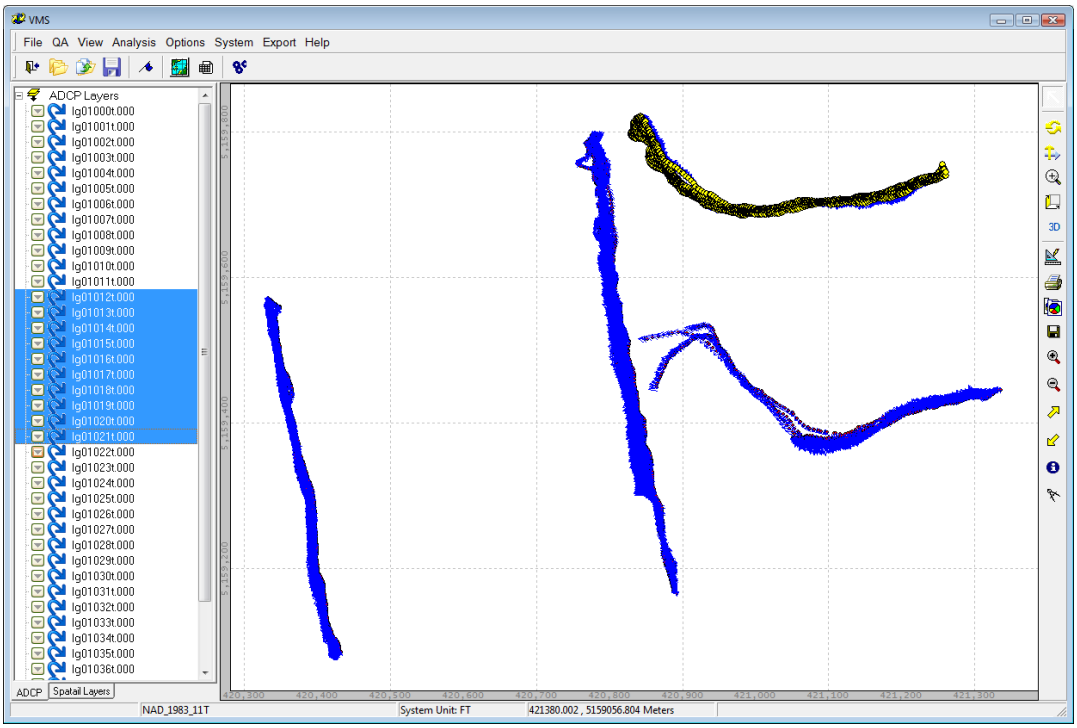


Figure 7.2. Manual grouping of multiple transects

Click right click of the mouse on the file pane, and select menu ‘Averaging Selected Files’.

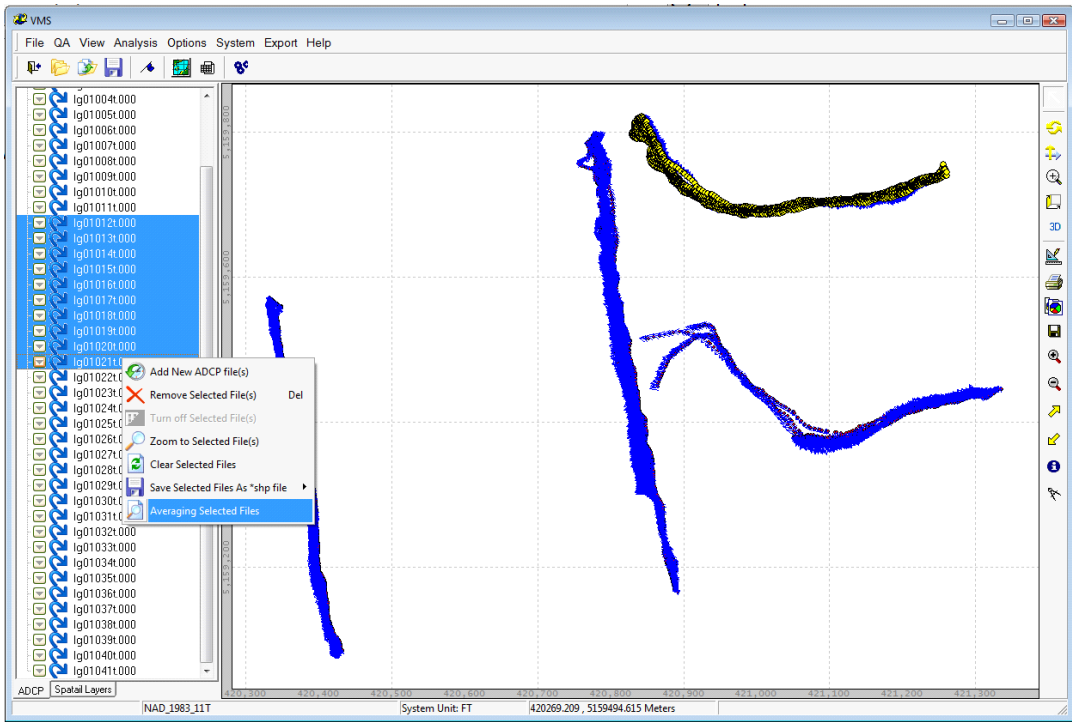


Figure 7.3. Manual grouping of multiple transects

7.2. Setup of averaging parameters and run horizontal averaging

The user will see a new interface that includes options for horizontal averaging and displays the locations of the multiple ADCP files in the map.

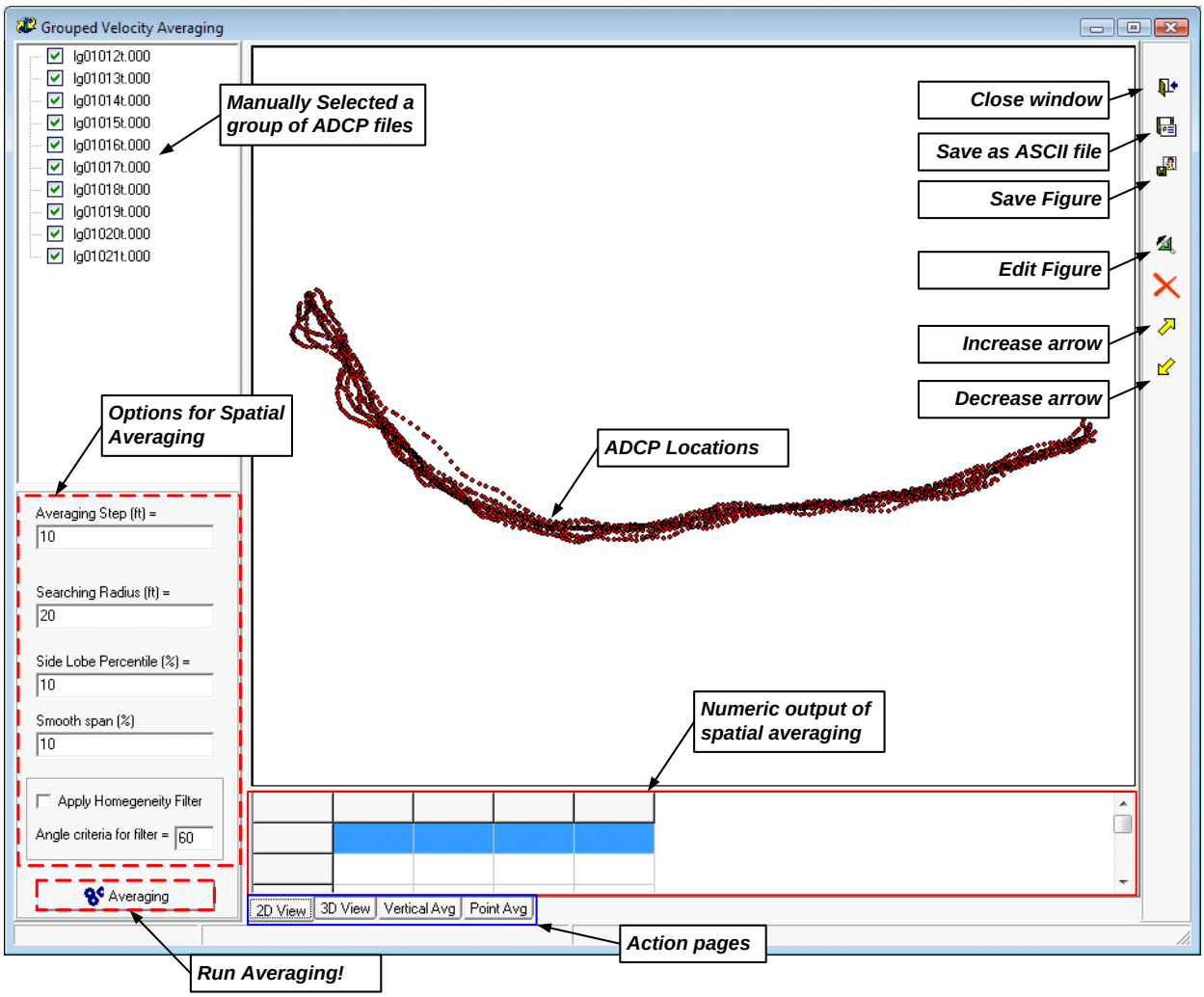


Figure 7.4. Setup horizontal averaging options

The user is able to process or reprocess the data for different purposes by changing options and averaging criteria without having to reselect the data files. VMS supports an automated approach to horizontal averaging that could avoid averaging across changes in flow distribution (see 'Apply Homogeneity Filter' option in the parameter pane). This involves developing an algorithm to identify mean flow direction within the given search areas, where velocity vectors having less than a given angle criteria are used in horizontal averaging. This approach only considers the flow distributions that were reasonably homogeneous and ensure the averages did not cross automatically identified zone boundaries.

After setting up parameters for averaging, click the 'Averaging' button.

7.3. 2D visualization of the horizontal and depth averaged velocity

Once running horizontal averaging, the interface will display the mean path, evenly spaced points, and depth averaged velocity vector after the given horizontal averaging. The table at the bottom of the interface displays the numeric values with the data in the graph.

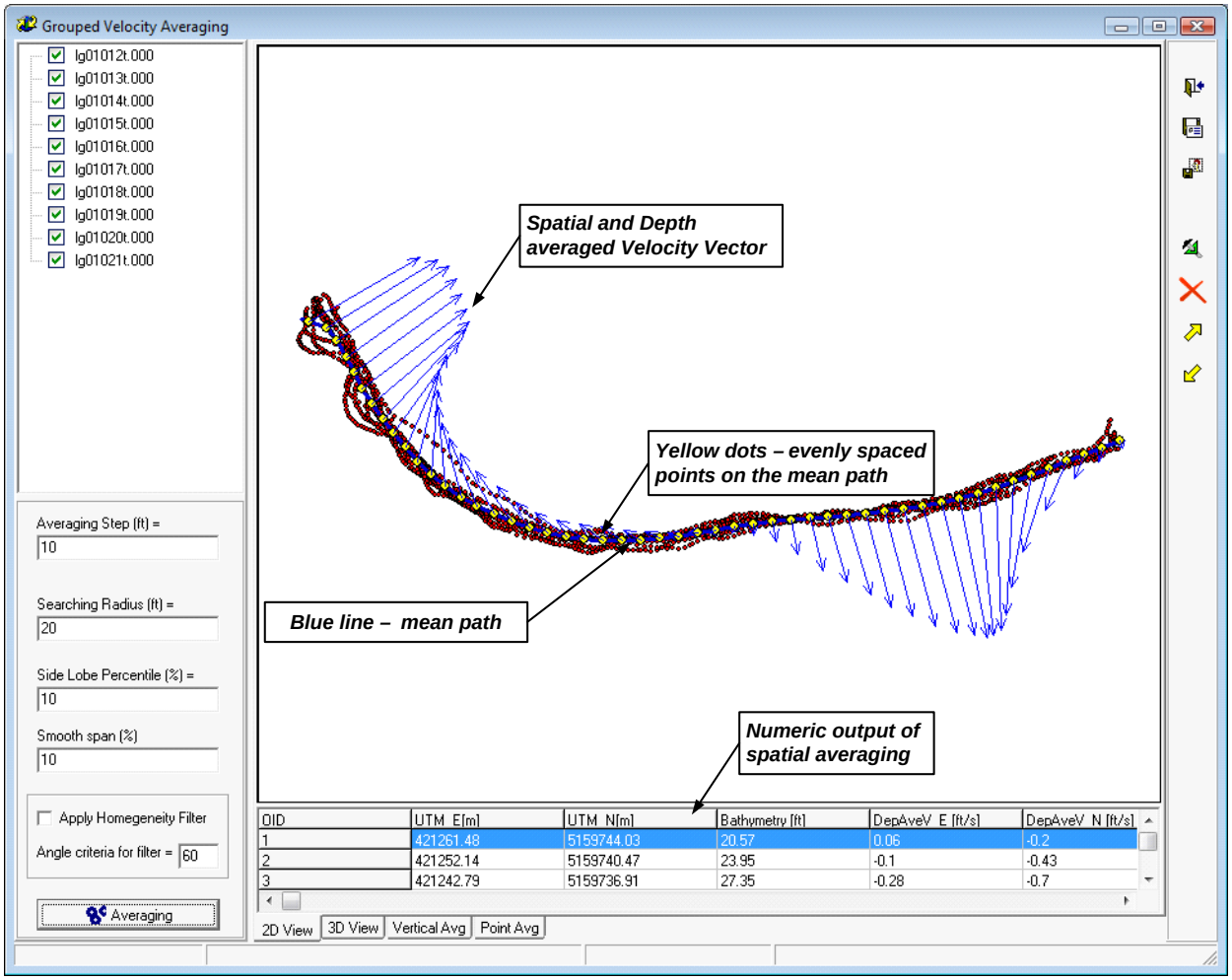


Figure 7.5. 2D visualization of averaged velocities

For better visualization, the scale of velocity arrows can be changed as follows:

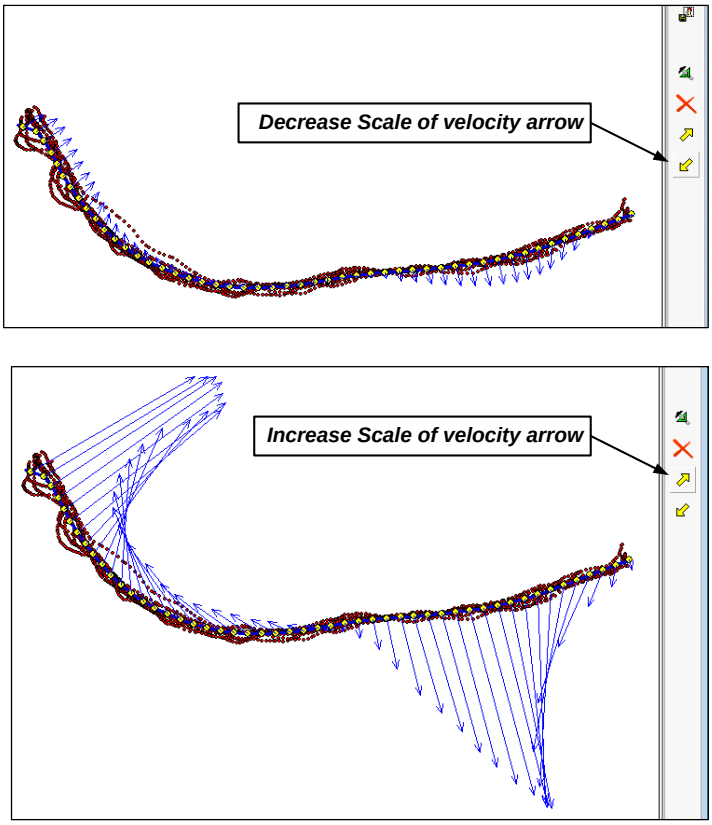


Figure 7.6. Arrangement of the size of velocity arrow

In order to identify which data in the table corresponds to the chart, the user clicks a row of the table and move up and down, and then the user will see a circled symbol is moving, which indicates the location of data as illustrated below.

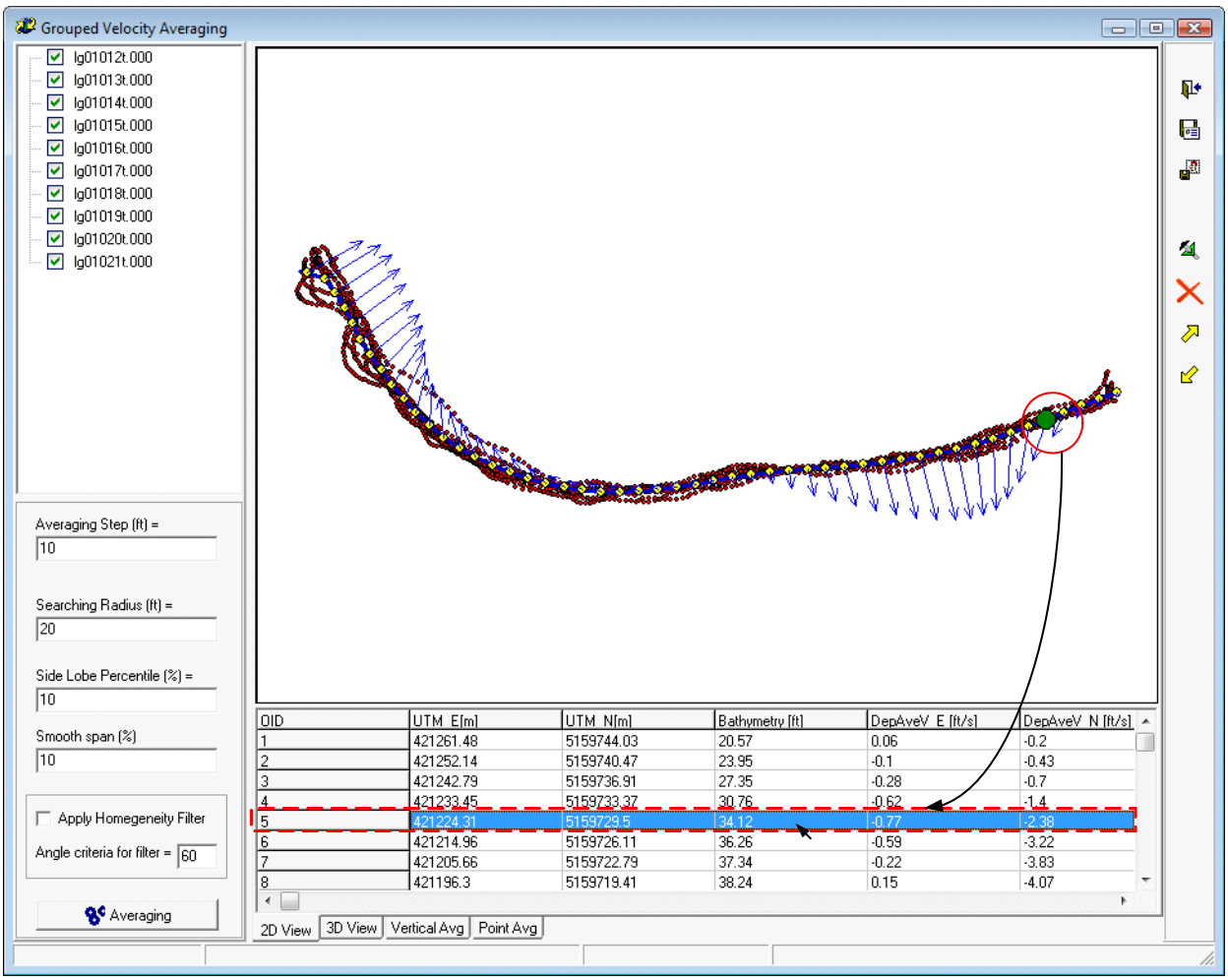


Figure 7.7. Identification of velocity data and its location

7.4. 3D visualization of the horizontal velocity

If the user clicks the ‘3D View’ tab located in the bottom of the interface, the following 3D graph will show up to allow detailed visualization of 3D velocity vectors. By holding the left mouse button over the chart and moving the cursor around the user can manipulate the viewing angle to allow for a visual inspection of the vector field.

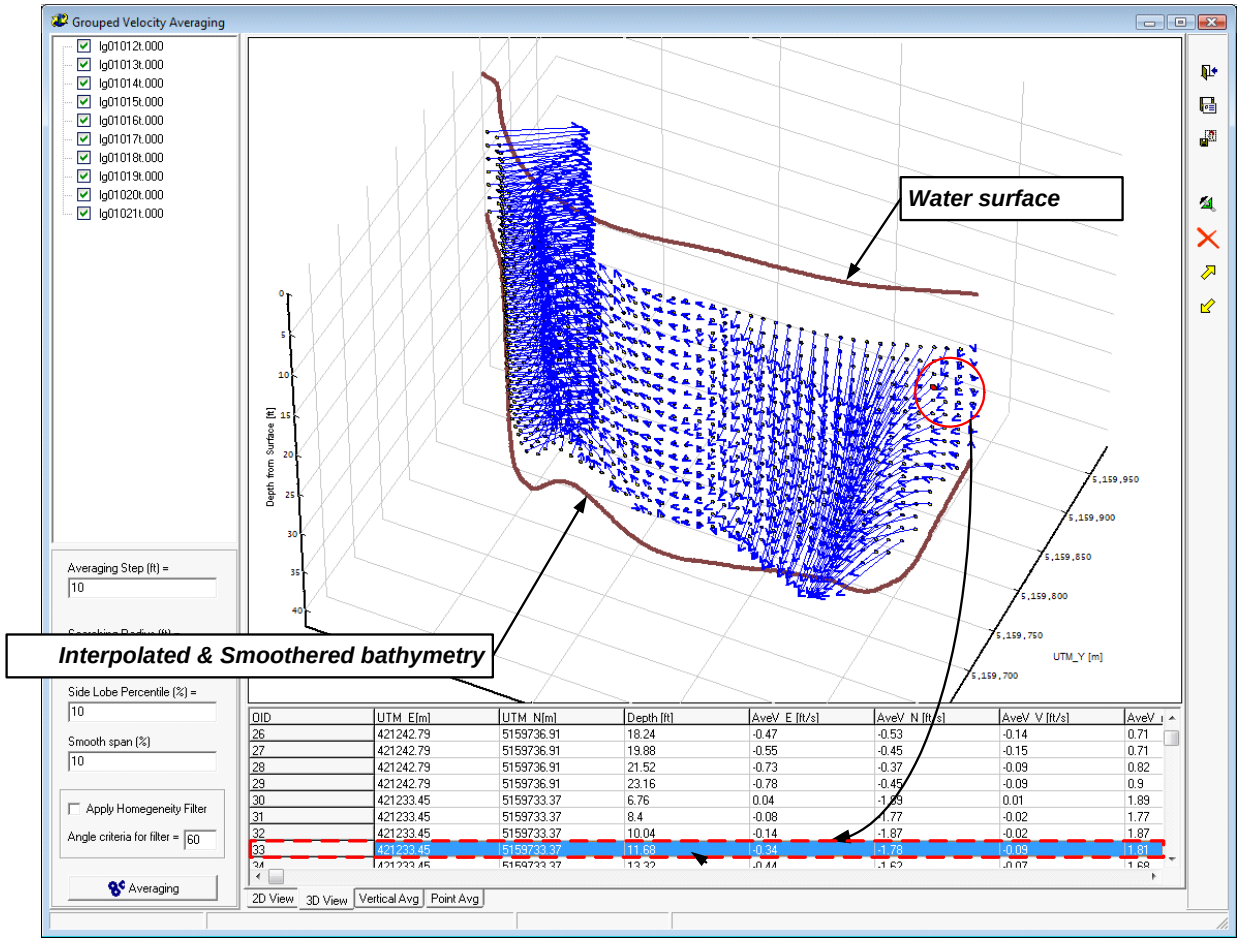


Figure 7.8. 3D visualization of averaged velocities

7.5. Vertical averaging of horizontal averaged velocity

Vertical averaging will only be applied after horizontal averaging has been completed.

a. Depth averaged without accounting for unmeasured area

The unmeasured areas at the top and the bottom of the profile or at the edges of the stream will be accounted for in the depth averages.

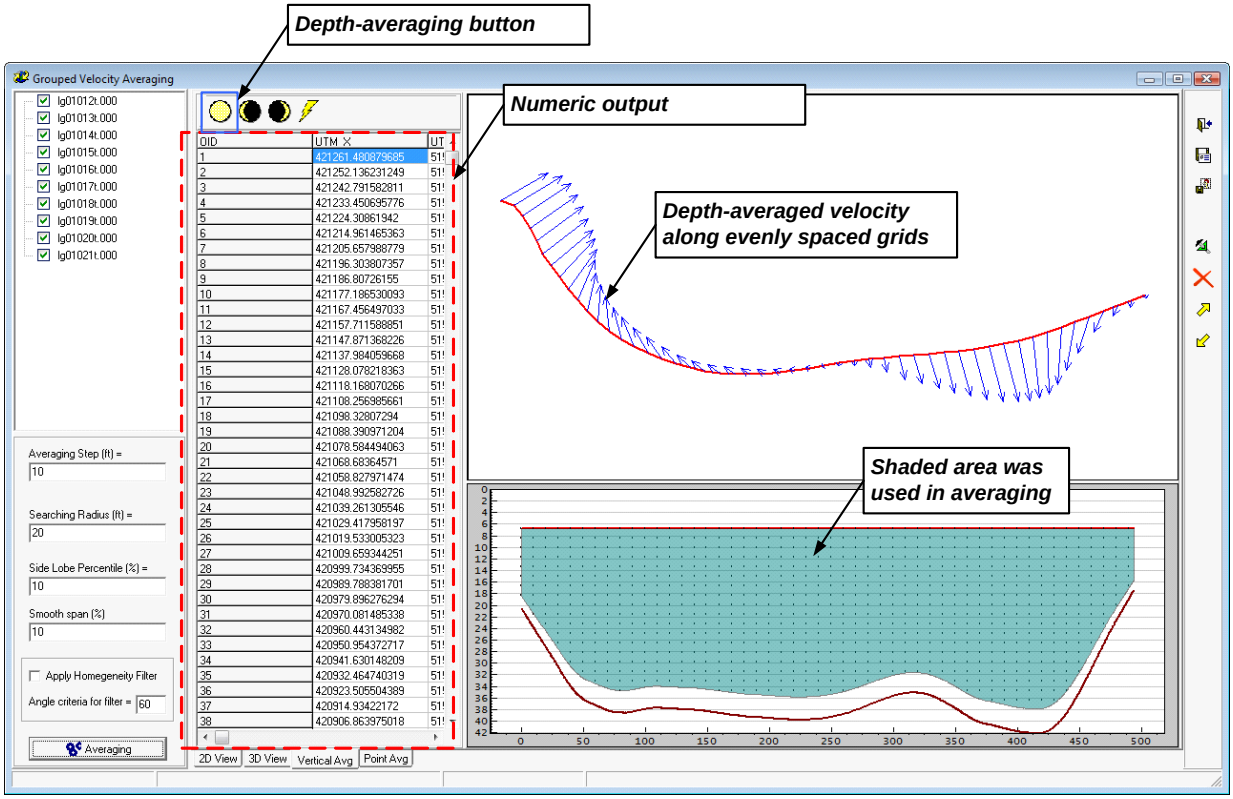


Figure 7.9. Depth averaged without accounting for unmeasured area

b. Nearest surface

This layer will be the velocity in the upper most depth cell of each profile or averaged profile, independent of depth cell size and location.

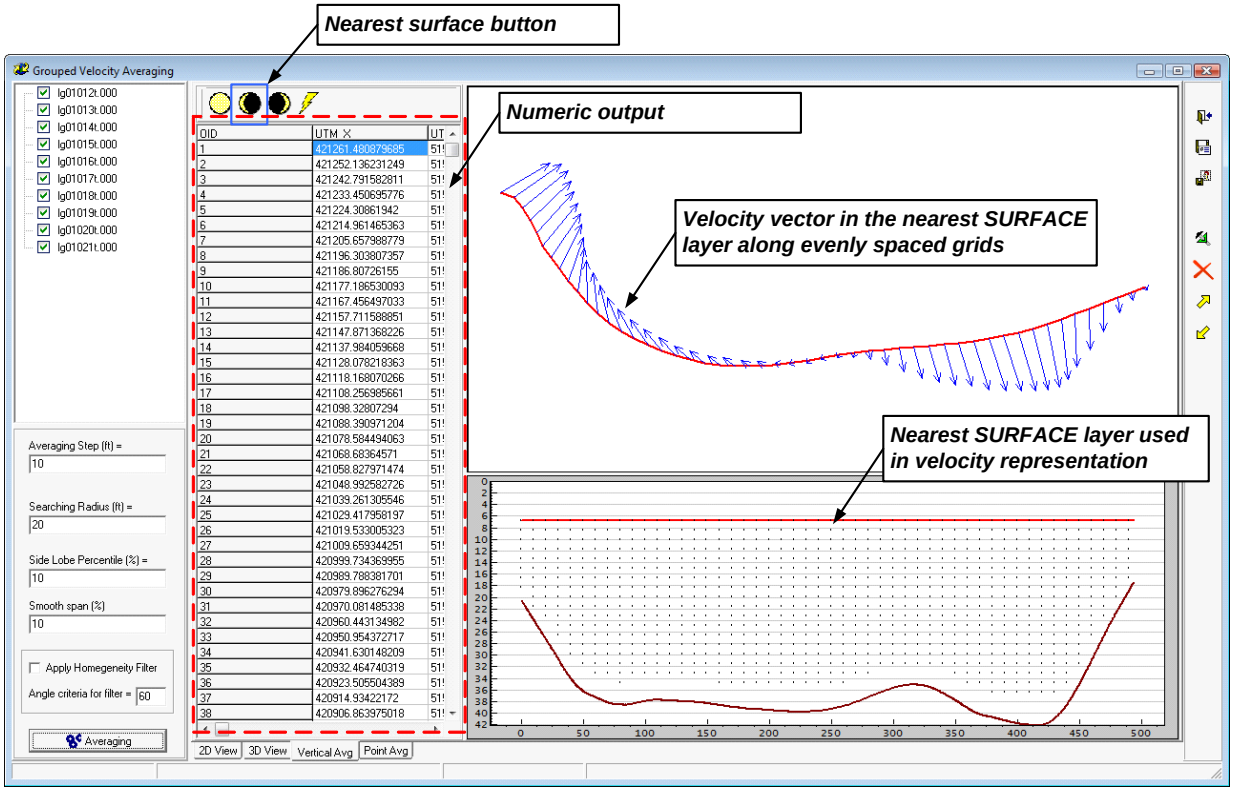


Figure 7.10. Velocity distribution along the nearest surface

c. *Nearest bed*

This layer will be the velocity in the lower most depth cell of each profile or averaged profile, independent of depth cell size and location.

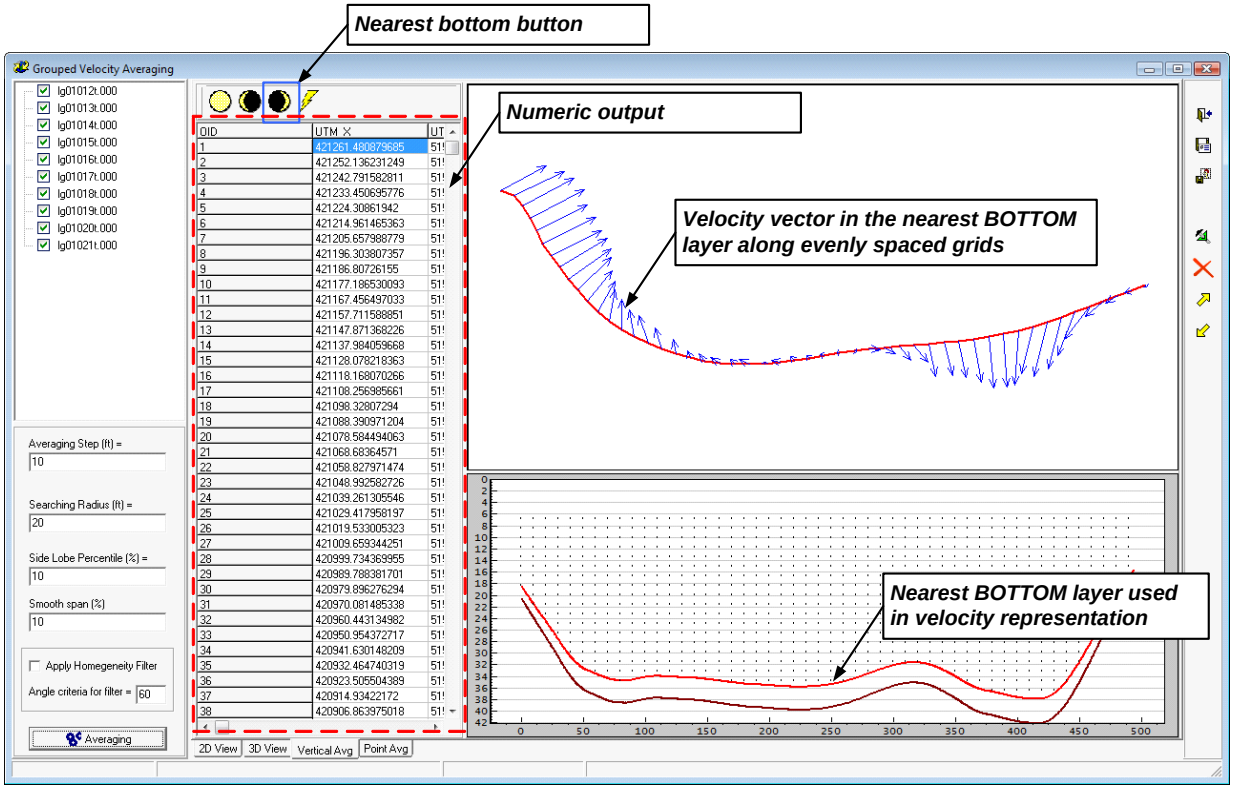


Figure 7.11. Velocity distribution along the nearest bed

d. Layers

The averaging at a layer as a relative depth and layer size can be conducted. Relative depth would allow the user to specify a layer at 0.6 depth of profile from the surface. The layer size should always be a specified size and not relative.

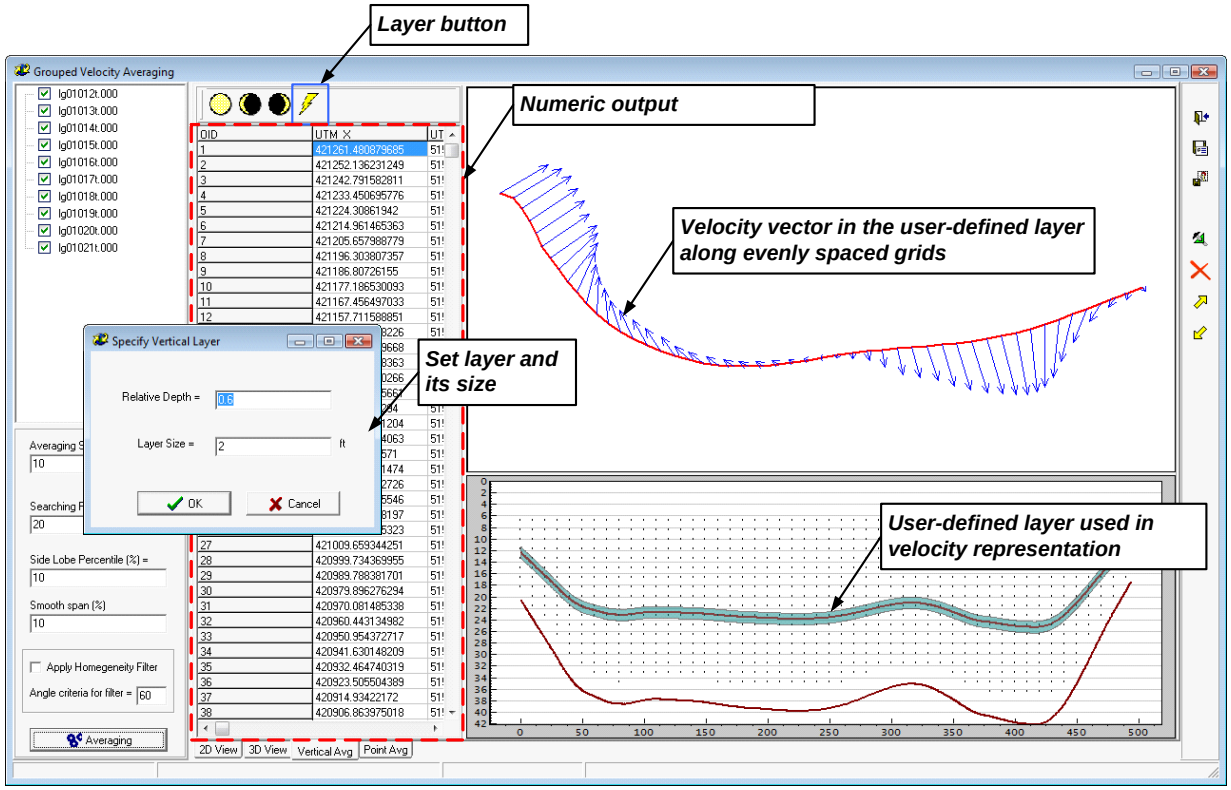


Figure 7.12. Velocity distribution along a specified vertical layer

7.6. Averaging onto specified points (grids)

VMS also supports the ability to do averaging based on a user-supplied ASCII text file containing UTM points. This would allow the same points to be averaged from different data sets.

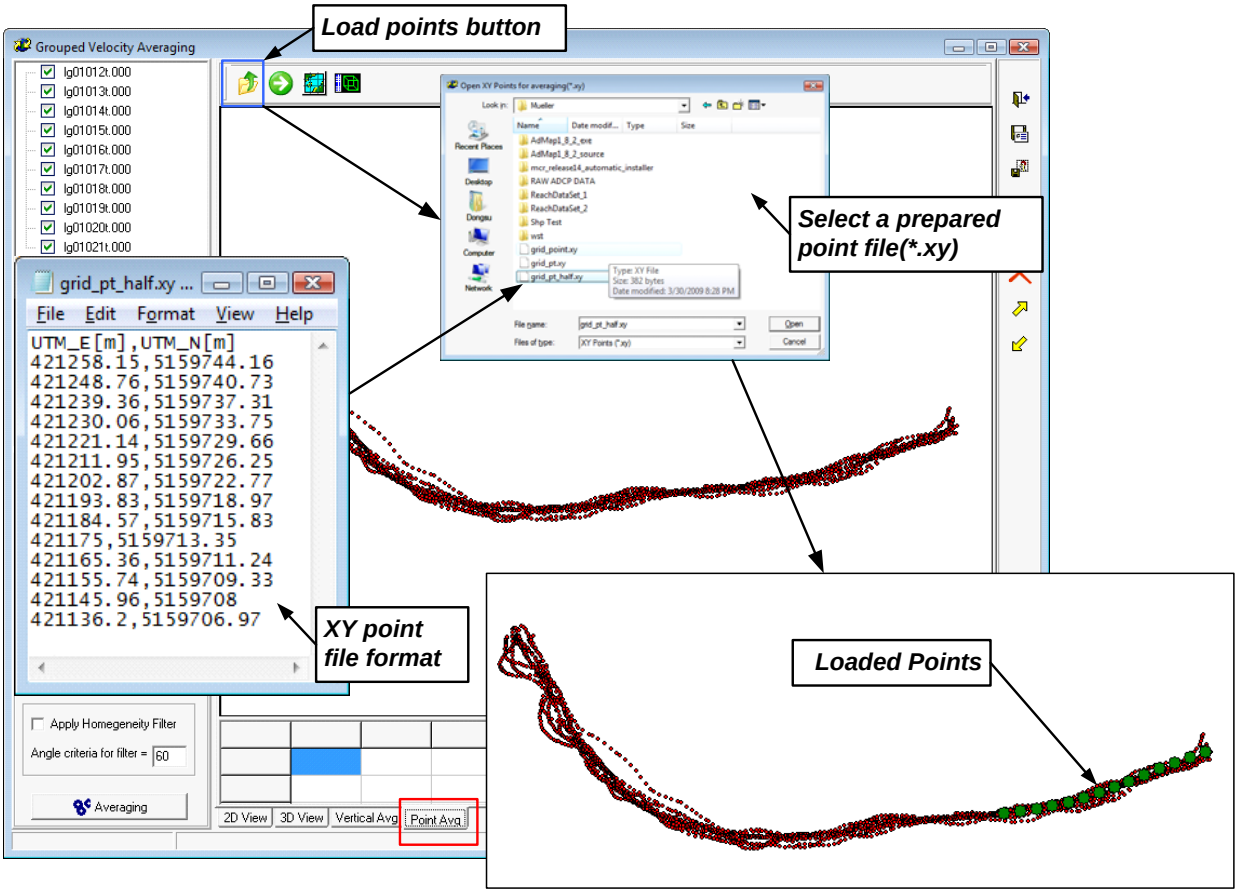


Figure 7.13. Loading of the user specified UTM points

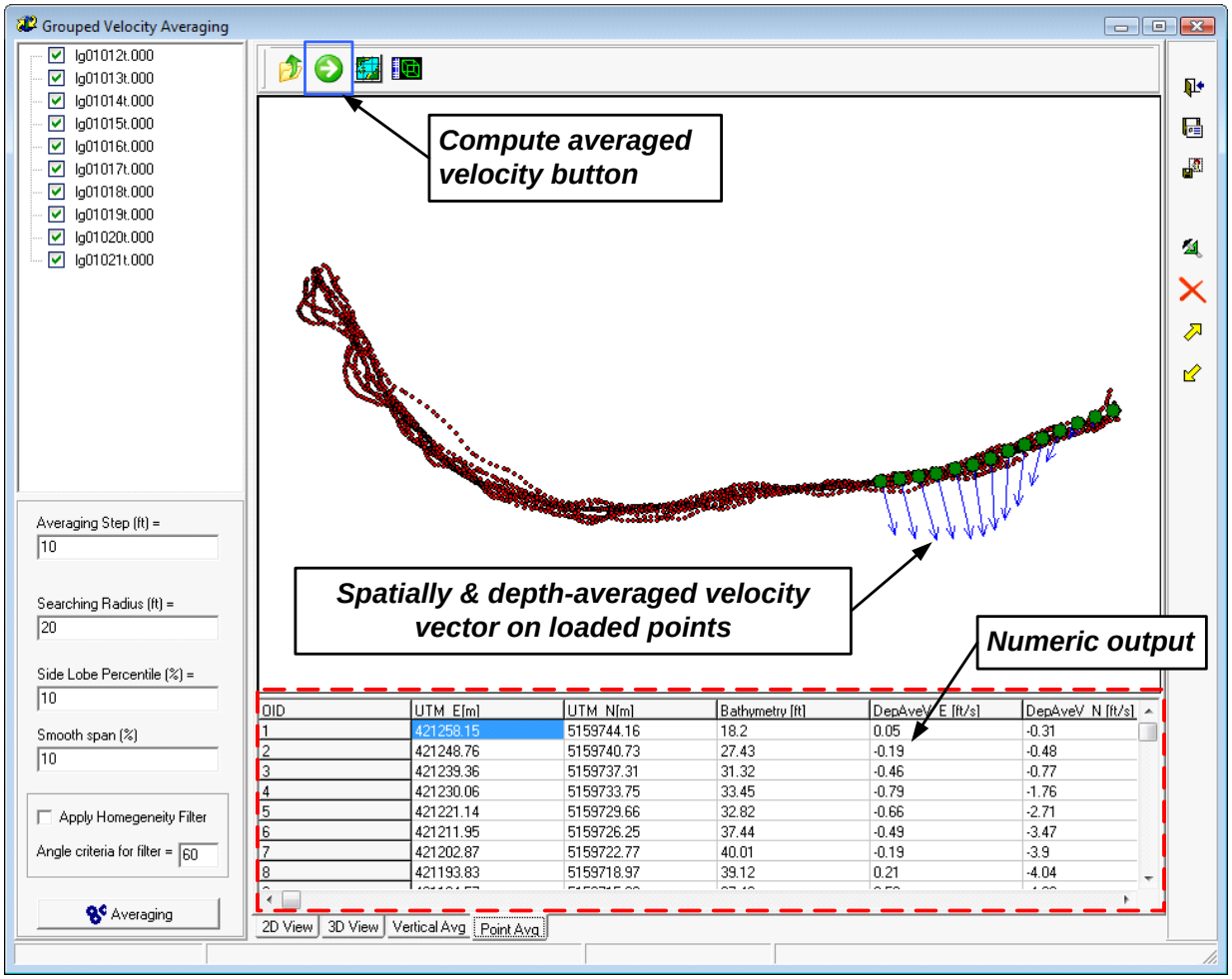


Figure 7.14. Conduct averaging on the user specified UTM points

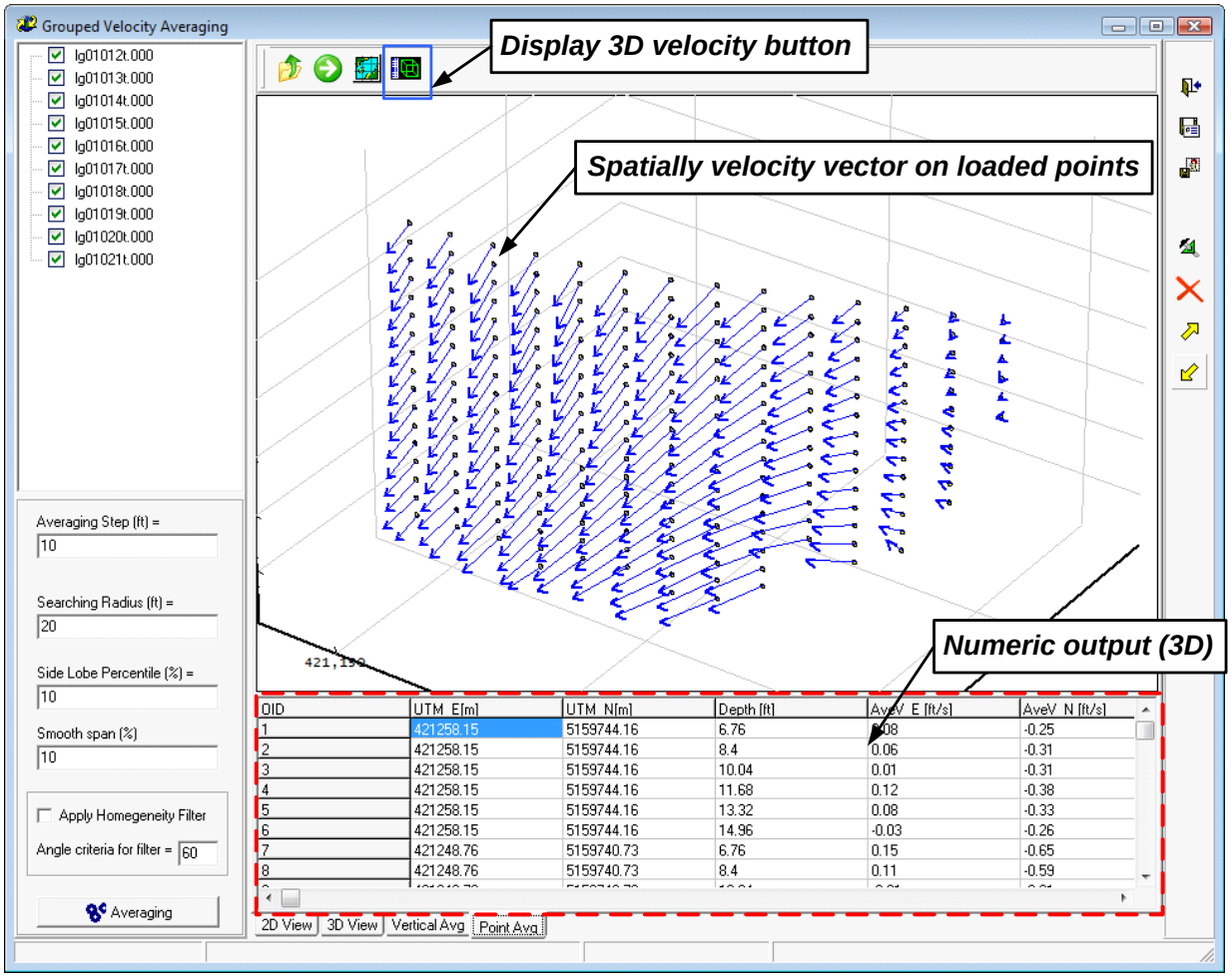


Figure 7.15. 3D view of averaging on the user specified UTM points