

ExploreV Help

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1 General

The Acoustic Doppler Velocimeter are versatile, high-precision instruments that measure all three flow velocity components. The measurements are insensitive to water quality which allows for a wide range of applications. Velocimeters are used in laboratories, wave basins, rivers, estuaries and oceanographic research. The Velocimeter uses acoustic sensing techniques to measure flow in a remote sampling volume. The measured flow is practically undisturbed by the presence of the probe.

The Vector is a field instrument designed for measurements of rapid small scale changes in 3D velocity, used for turbulence, boundary layer measurements, surf zone measurements, and measurements in very low flow areas. The Vectrino is used in hydraulic laboratories to measure turbulence and 3D velocities in flumes and physical models. The Profiling Vectrino is a profiling version of the Vectrino with a 3 cm profiling zone. Note that Vector files (*.vec) can be imported directly into the software, while Vectrino files (*.vno) need to be converted to a *.ndv file. This is done in the Vectrino Software.

The acoustic sensor consists of one transmit transducer and three or four receive transducers. The receive transducers are mounted on short arms around the transmit transducer at 120 degree azimuth intervals, 90 degree azimuth intervals for the Vectrinos. The interception of the beams, together with the width of the transmit pulse, define the sampling volume. All receivers must be submerged to ensure correct velocity measurements. Calibration factors are determined by the speed of sound and by the angles between the transmit and receive transducers. To ensure that the correct speed of sound is used, the water temperature and salinity must be entered in the data acquisition software. The calibration angles are measured at the factory and need only be changed when a new probe is installed. Maintenance is not required unless the probe is physically damaged.



1.1 About ExploreV

ExploreV is a Windows 95 application for post processing data collected by NORTEK Velocimeters. It allows you to view, edit and analyze large data sets, to print and export results quickly and effectively and to easily create comprehensive reports on measurement studies. ExploreV integrates standard methods of statistical data treatment (univariate and cross-spectral analysis) with advanced visualization techniques (interactive views and mean velocity vector representation) and specific types of analysis (conditional quadrants analysis) in a uniform, intuitive, easy to use environment. This software is designed to facilitate the needs of most all velocimeter users and as a teaching tool on applied analysis of turbulence.

ExploreV is presently available in two versions **Lite** and **Pro**. These versions differ by their functionality. ExploreV Lite lets you edit data and calculate statistical characteristics. ExploreV Pro provides the whole functionality of the software.

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1.2 About ExploreV 1.5 Demo

ExploreV Demo lets you try the ExploreV 1.5 Lite and Pro demo versions. The data files which are supplied with the demo version are the original data files collected at small lowland river Saline Ditch, Illinois, USA.

For your convenience the demo version is also supplied with the bed.bnd file presenting a simple flow boundary and ExploreV workspace file example.avp. These files may help you to understand the mapping of mean velocity vectors.

The information in the help is marked to show you in which version the described functionality is available. Before you begin with ExploreV demo you will be asked to choose the version of the software you like to try on. To run another version you should reload the software. Use the example.avp file with the demo version Pro.

1.3 Software Support

The ExploreV user has several options open to them for support if they have registered the purchase and use of their package with NORTEK AS or NORTEK USA using the form provided with the software. The user should ensure they have available the following information before contacting the support service:

- Their registration details.
- The version number and date of their Software (in about boxes).
- The version number and date of their operating system.
- Details of the problem with data examples where possible.

Support where ever practical is given free of charge to registered end users of the software on the following conditions:

- The user has registered the package using the form provided.
- The package is the current version of the software.
- The package does not pre-date the operating system.
- There is no outstanding dispute between the user and supplier.
- The problem is resolvable by NORTEK AS or NORTEK USA and does not involve a third party.

Option 1 - WEB SITE - Check update information using the NORTEK AS or NORTEK USA Website, check for version changes, updates and important bug fix notifications before sending a communication from within the ExploreV support pages.

The web site addresses are **www.nortek-as.com** and **www.nortekUSA.com** and they can be located using a standard web browser program. To download data files the users browser must be compatible with and support the Microsoft Internet Explorer file recognition facilities.

Option 2 - TELEPHONE - Use telephone support during normal European and USA business hours from NORTEK AS

NORTEK AS: +47 6717 4500
NORTEK USA: 617-206-5750

Option 3 - FAX - Use the fax service outside normal European and USA business hours from NORTEK AS on the following telephone number

NORTEK AS: +47 6713 6770
NORTEK USA: 617-275-8955

Option 4 - EMAIL - Use email service outside normal European and USA business hours from NORTEK AS, particularly if the query involves attached data files and drawings. NORTEK AS service can read UUencoded or MIME encoded email with embedded files.

NORTEK AS :- inquiry@nortek.no
NORTEK USA :- inquiry@nortekusa.com

Option 5 - POSTAL - Use postal service for overseas queries where electronic communication is not possible or large amounts of data or drawings are involved in the query or an update is required (include original disk).

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1.4 Troubleshooting

Since the ExploreV operates on multiple data files of unlimited size there are some situations when the proper functionality of the software may be difficult. Here we list such situations.

The change of fonts and ExploreV views during processing of multiple data files. This situation does not necessarily lead to a program crash, but it makes it difficult to operate the program. It is not an ExploreV bug, it is a result of problems in Windows memory management. You can store your ExploreV session in the workspace file and then run the software again.

1.5 Literature Cited

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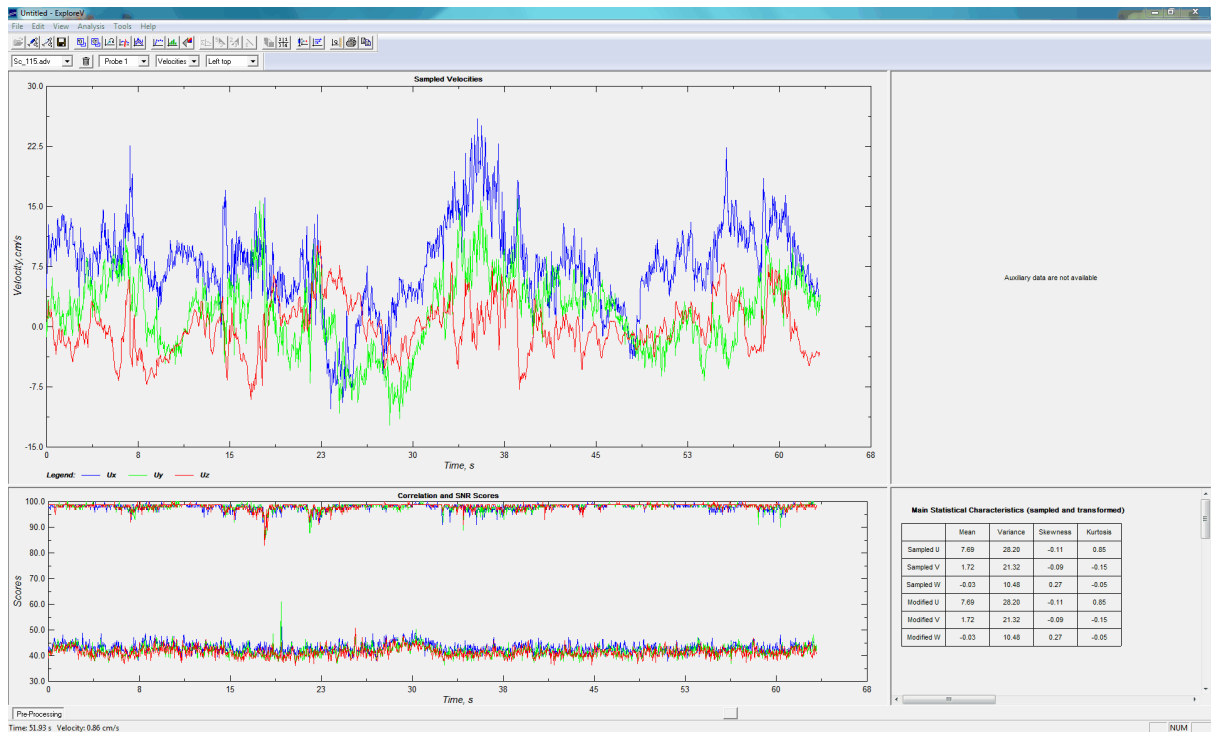
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2 ExploreV User Interface



TITLE BAR - Shows the information about selected ExploreV workspace, contains the system menu.

MENU BAR - Some of the submenus have the acceleration keys combinations.

TOOLBARS- The individual toolbars can be resized, dragged or deleted to help facilitate viewing and editing.

VIEWS - Views display the different graphs, tables and other special information. View is activated by clicking the cursor.

SPLITTER - The individual window panes (views) can be resized by dragging the divider bar between the windows.

TAB CONTROL - You can switch between different types of data analysis by selecting available tabs in this control.

STATUS BAR- It telling you about current state of data processing or provide useful information about physical values corresponding to the current cursor position.

SCROLL BARS- You can scroll the views containing tables of a large size.

2.1 Move Command

Use this command to display a four-headed arrow so you can move the active window or dialog box with the arrow keys.



Note: This command is unavailable if you maximize the window.

Shortcut

Keys: CTRL+F7

2.2 Size Command

Use this command to display a four-headed arrow so you can size the active window with the arrow keys.



After the pointer changes to the four-headed arrow:

- Press one of the DIRECTION keys (left, right, up, or down arrow key) to move the pointer to the border you want to move.
- Press a DIRECTION key to move the border.
- Press ENTER when the window is the size you want.

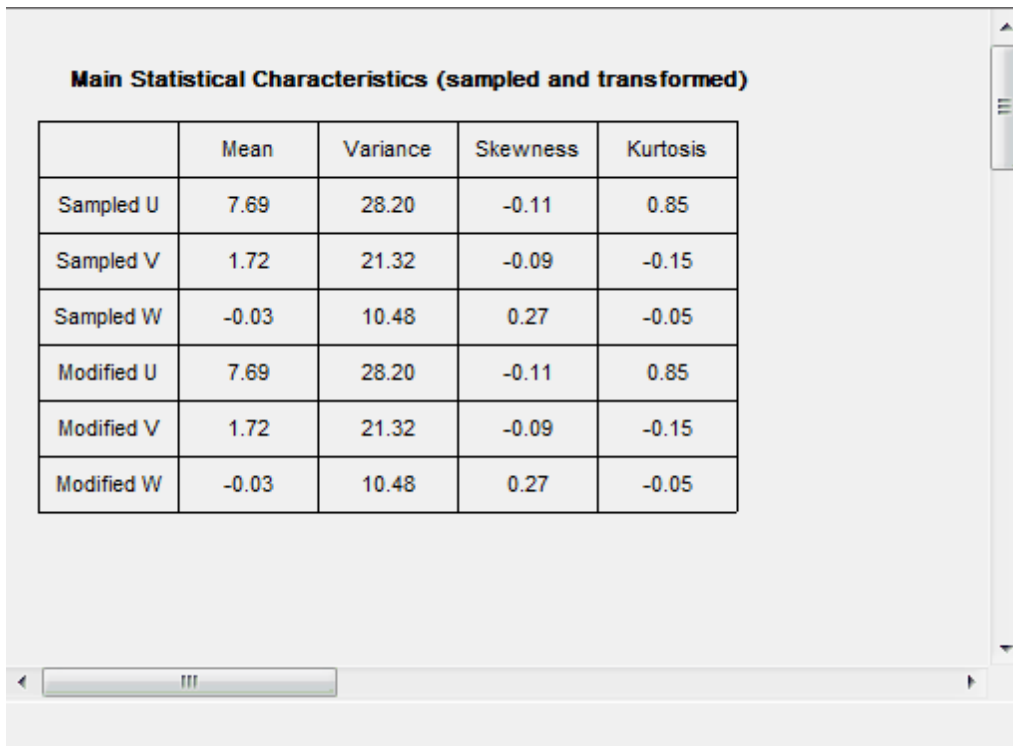
Note: This command is unavailable if you maximize the window.

Shortcut

Mouse: Drag the size bars at the corners or edges of the window.

2.3 Scroll Bars

Displayed at the right and bottom edges of the document window. The scroll boxes inside the scroll bars indicate your vertical and horizontal location in the document. You can use the mouse to scroll to other parts of the document (see figure below).



The screenshot shows a window titled "Main Statistical Characteristics (sampled and transformed)". Inside the window is a table with 5 columns: an empty header cell, "Mean", "Variance", "Skewness", and "Kurtosis". There are 6 rows of data, each representing a different variable: "Sampled U", "Sampled V", "Sampled W", "Modified U", "Modified V", and "Modified W". The values for each variable are consistent across the "Sampled" and "Modified" versions.

	Mean	Variance	Skewness	Kurtosis
Sampled U	7.69	28.20	-0.11	0.85
Sampled V	1.72	21.32	-0.09	-0.15
Sampled W	-0.03	10.48	0.27	-0.05
Modified U	7.69	28.20	-0.11	0.85
Modified V	1.72	21.32	-0.09	-0.15
Modified W	-0.03	10.48	0.27	-0.05

2.4 Title Bar

The title bar is located along the top of a window. It contains the name of the application and document. To move the window, drag the title bar. Note: You can also move dialog boxes by dragging their title bars. A title bar may contain the following elements:

- Application Control-menu button
- Document Control-menu button
- Maximize button
- Minimize button
- Name of the application
- Name of the document
- Restore button

2.5 Switch to Command

Use this command to display a list of all open applications. Use this "Task List" to switch to or close an application on the list.

Shortcut

Keys: CTRL+ESC

Dialog Box Options

When you choose the Switch To command, you will be presented with a dialog box with the following options:

Task List Select the application you want to switch to or close.

Switch To Makes the selected application active.

End Task Closes the selected application.

Cancel Closes the Task List box.

Cascade Arranges open applications so they overlap and you can see each title bar. This option does not affect applications reduced to icons.

Tile Arranges open applications into windows that do not overlap. This option does not affect applications reduced to icons.

Arrange Icons Arranges the icons of all minimized applications across the bottom of the screen.

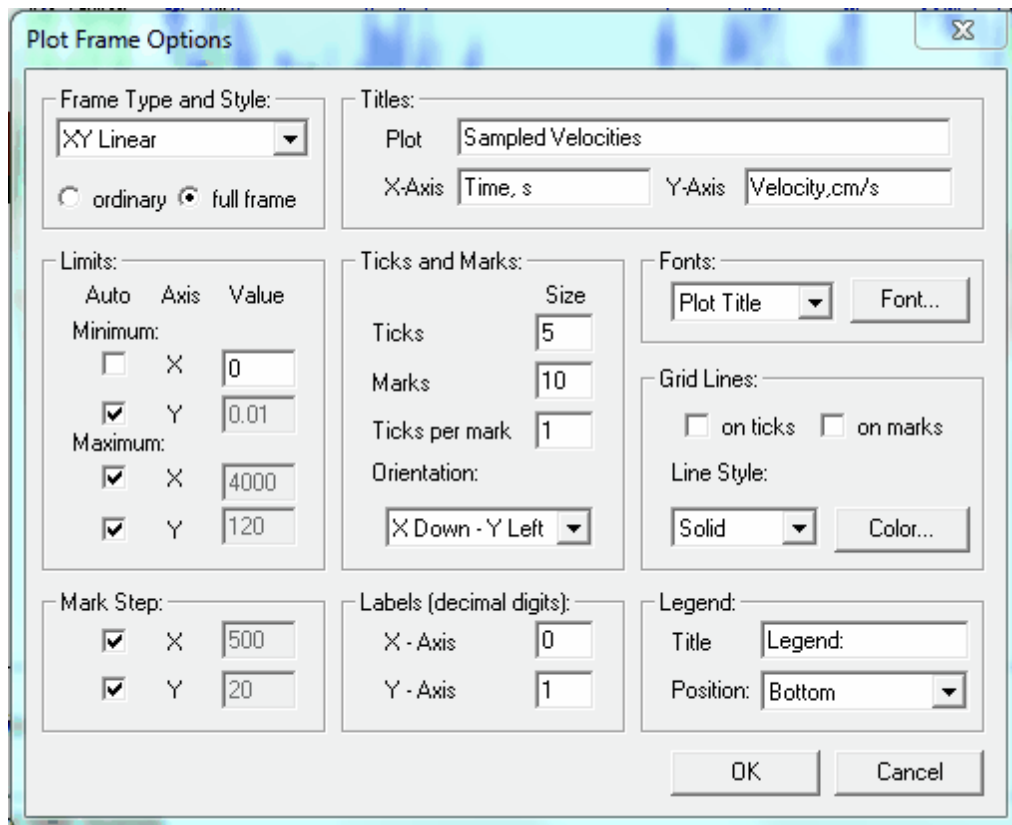
2.6 Plotting Graphics (ExploreV Lite and Pro)

ExploreV provides you with a number of tools for effective presentation of your data in graphical form. You are allowed to change the layout of your plots with the use of Plot Frame Options dialog (see figure below).

Shortcut

Mouse: Double left button click the desirable view.

Toolbar:



Frame Types

There are four types of plot frames in ExploreV:

- XY Linear both X and Y axes have linear scale
- XY Logarithmic both X and Y axes have logarithmic scale
- X Linear Y Log X axis has linear scale, Y axis has logarithmic scale
- X Log Y Linear X axis has logarithmic scale, Y axis has linear scale

Frame Style

- ordinary defines plot frame with one X and one Y axes starting at left lower plot's corner
- full frame defines plot frame with duplicated X and Y axes plotted versus generic X and Y axes.

3 Menu Selections

3.1 File

ExploreV supports data files retrieved from the NORTEK Velocimeter. Even though the data may be viewed in ExploreV using several pre-processing operations, the data stored in the data file will never be changed.

3.1.1 Open Workspace

Opens an existing ExploreV Workspace. Use this command to open *.avp file. The command evokes the open file dialog box.

Shortcuts

Toolbar:



Keys:

CTRL+O

3.1.2 Save

Use this command to save the active ExploreV workspace to its current name and directory. When you save a workspace for the first time, ExploreV displays the Save As dialog box so you can name your workspace. If you want to change the name and directory of an existing workspace before you save it, choose the Save As command.

Shortcuts

Toolbar:



Keys:

CTRL+S

3.1.3 Save As

Use this command to save and name the active workspace. ExploreV displays the Save As dialog box so you can name your workspace.

To save a workspace with its existing name and directory, use the Save command.

3.1.4 Open Data File

Use this command to open a data file. The command evokes the open file dialog box. In addition to the standard file open dialog box, this one contains a data file content preview window (see figure) which displays user's and system information about the file. The content preview window is active when pointer is focused on a data file. The File Open dialog box also allows opening of a set of data files simultaneously.

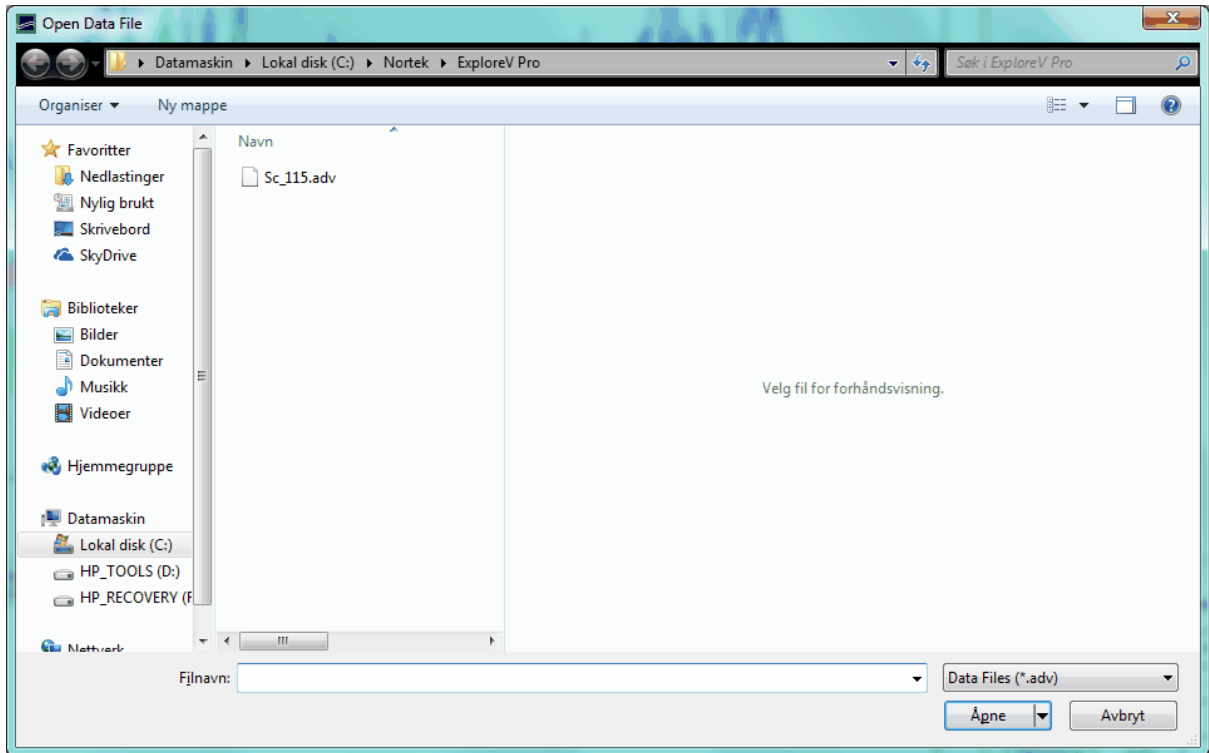
Shortcuts

Toolbar:



Keys:

CTRL+D



3.1.5 Import Vector File

Use this command to import a data file (*.vec). The command evokes the import file dialog box.

Shortcuts

Toolbar:



3.1.5.1 Import Data

The ExploreV is concerned with the following data types:

***.adv** - Normally retrieved from the NORTEK Velocimeter during data collection. Even though the data may be viewed in ExploreV using several pre-processing operations, the data stored in the data file will never be changed.

***.avp** - The files created by ExploreV as the results of data post-processing and analysis .

***.bnd** - Boundary data files that are used to show flow boundaries in vector analysis. These files can be created with the use of Grid and Boundary Editor in ExploreV.

To open a data file (or files) use menu **Open Data File** or button .

To import a data file use menu **Import Data File** or button .

To load a workspace file use menu **Open Workspace Ctrl+O** or button .

To load a boundary file use menu **Open Boundary Alt+O** or button  in Grid and Boundary Editor.

To open a Vectrino file, convert the *.vno file to a .ndv file in the Vectrino software. This is done in the Conversion dialog; just check the NDV box.

3.1.5.1.1 *.bnd

Boundary data files *.bnd are the files consisting of the boundary nodes coordinates. These files are ASCII file formats and have the simple format (see example below). These files may be created externally using any word processing software (for example Excel or Word). You can also create boundary files using Grid and Boundary Editor.

Boundary file format: Boundary file has the three columns each of which corresponds to the coordinates X,Y, Z.

X Y Z

0.1 0.1 0.2

0.1 0.3 0.5

0.1 0.25 0.3

.....
10 0.07 0.12

3.1.6 Close File

Use this command to close the selected data file. ExploreV suggests that you save changes to your document before you close it. If you close a document without saving, you lose all changes made since the last time you saved it. Before closing an untitled document, ExploreV displays the Save As dialog box and suggests that you name and save the document.

You can also close a document by using the Close icon on the document's window.

3.1.7 Export Data (ExploreV Lite and Pro)

Provides the export of data and the results of different types of analysis in ASCII tabular form.

3.1.7.1 Time Series (ExploreV Lite and Pro)

Select this submenu to export velocities u , v , w for the currently selected data file and probe. Exported velocities include only the edited, processed data (reorientation, clipping, editing and digital filtration). The dialog box Export as an ASCII File lets you define the output format of an ASCII file (see example below).

File : C:\Program Files\ExploreV\Sc_115.adv

PROBE : 1

VELOCITIES (U, V, W):

0.00 4.80 -1.25 1.07

0.04 5.99 0.58 1.08

0.08 7.33 -0.50 1.04

.....
63.36 2.61 4.08 -3.09

3.1.7.2 Stationary Analysis Results (ExploreV Pro)

This submenu exports the results of Stationarity Analysis. The data are stored in four columns for each velocity vector component. The order is u , v , w components. The order of results for each velocity component is mean, variance, skewness and kurtosis. Consequently, the export file consists of 12 columns of data. Optionally, you can add the first column with time moments corresponding to the middle position of each partition band (see example below). You can also change the format of the output ASCII file with the dialog box Export as an ASCII File.

File : C:\Program Files\ExploreV\Sc_115.adv

PROBE: 1

STATIONARITY RESULTS (Mean (U,V,W), Var.(u,v,w), Sk (u,v,w), Kr (u,v,w)) :

```
2.88 9.68 3.77 -1.17 5.31 7.07 4.51 -0.03 0.19 -0.32 -0.46 -0.94 -0.01
8.65 9.23 2.45 -1.75 7.69 12.25 6.63 0.66 0.13 0.19 1.92 -0.78 -0.26
14.41 8.72 2.87 -1.61 8.92 13.00 8.73 0.48 0.39 0.16 1.17 0.13 -0.24
20.17 6.89 1.87 -0.30 25.21 17.69 13.36 -1.08 0.01 0.26 1.56 0.08 -0.22
25.94 6.14 0.50 -0.39 24.42 23.49 11.83 -0.73 0.00 0.30 0.78 -0.38 -0.02
31.70 7.64 1.56 -0.04 34.83 27.03 11.62 -0.11 -0.05 0.16 0.64 -0.45 -0.15
37.46 7.61 1.95 -0.17 31.41 24.95 11.31 -0.09 -0.19 0.17 0.91 -0.26 -0.13
43.23 7.13 1.72 -0.29 30.66 23.26 10.15 0.02 -0.11 0.27 0.79 -0.20 0.16
48.99 7.42 1.39 -0.03 29.26 22.12 10.25 -0.04 0.03 0.21 0.87 -0.17 0.08
54.75 7.71 1.72 -0.02 28.24 21.42 10.50 -0.12 -0.09 0.27 0.86 -0.16 -0.06
```

3.1.7.3 Histograms (ExploreV Pro)

This submenu exports the velocity grades and corresponding empirical probability densities for each velocity component. The data are stored in three pairs of columns corresponding to components u , v , w . Thus, an export file consists of six columns. The format of the output file can be changed using the dialog box Export as an ASCII File.

File : C:\Program Files\ExploreV\Sc_115.adv

PROBE : 0

VELOCITY HISTOGRAMS:

```
-10.20 0.00 -12.21 0.00 -9.02 0.00
-6.59 0.01 -9.39 0.01 -7.04 0.02
-2.97 0.01 -6.57 0.03 -5.06 0.06
0.64 0.03 -3.76 0.06 -3.08 0.10
4.26 0.08 -0.94 0.07 -1.10 0.13
7.87 0.08 1.88 0.09 0.88 0.09
11.48 0.04 4.70 0.06 2.86 0.05
15.10 0.01 7.52 0.02 4.84 0.03
18.71 0.01 10.33 0.01 6.82 0.01
22.33 0.00 13.15 0.00 8.80 0.00
```

3.1.7.4 Univariate Statistics (ExploreV Lite and Pro)

This submenu exports the main univariate statistics of probability distributions for each velocity component. The statistics are mean, variance, skewness and kurtosis (see example below).

File: C:\Program Files\ExploreV\Sc_115.adv, Probe 1

Table: Univariate Statistical Characteristics

Mean

cm/s

Variance

(cm/s)²

```
Skewness Kurtosis
u 7.70 28.21 -0.116 0.855
v 1.73 21.36 -0.091 -0.155
w -0.03 10.51 0.272 -0.058
```

3.1.7.5 Univariate Spectral Analysis Results (ExploreV Pro)

This submenu exports the results of univariate spectral analysis (correlation, spectral and structure functions) to an ASCII file. Exported functions are placed into columns. The first two columns in the file are reserved for time lags and frequencies. The next three columns are the correlation function, spectral density and structure function for the **u** component. Columns for the **v** and **w** components follows (see example below). The format of the file can be changed using the dialog box Export as an ASCII File.

```
FIRST COLUMN IS TIME LAG AND SECOND IS FREQUENCY
FREQUENCY UNITS: HZ
FUNCTIONS: CORRELATION, SPECTRA, STRUCTURE (U,V,W)
0.00 0.000 0.9994 186.4550 0.0000 0.9994 133.0812 0.0000 0.9994 36.2104 0.0000
0.04 0.079 0.9269 126.3784 4.1038 0.9286 95.4897 3.0421 0.9676 30.6409 0.6746
0.08 0.158 0.8895 42.0278 6.2323 0.8986 37.2702 4.3466 0.9130 20.6271 1.8281
.....
6.28 12.500 -0.0803 0.0947 64.0814 -0.1669 0.0670 51.7546 -0.1191 0.0048 23.7456
```

3.1.7.6 Dis. Rate and Scales (ExploreV Pro)

This submenu exports the dissipation rate value, turbulence scales (integral time scales, Kolmogorov's micro-scale) and mean turbulence acceleration (see example below).

```
File: C:\Program Files\ExploreV\Sc_115.adv, Probe 1
Table: Dissipation Rate and Turbulence Scales
-----
| Dis. Rate, | Integral | Kolmogorov's | Mean Turbulent
| cm^2/s^3 | Scale, s | micro-scale, cm | Acceleration a/g
---+-----+-----+-----+-----
u | 4.33860 | 2.23 | 0.022 | 0.275
v | | 1.97 | |
w | | 0.93 | |
-----
```

3.1.7.7 Stresses Time Series (ExploreV Lite and Pro)

This submenu exports the stresses $u'v'$, $u'w'$ and $v'w'$. The stresses are placed into three columns. Optionally, the first column of the file may be used to store time moments (see example below). The dialog box Export as an ASCII File lets you define the output format of the ASCII file.

```
File : C:\Program Files\ExploreV\Sc_115.adv
PROBE : 1
STRESSES (u'v, u'w', v'w'):
0.00 8.62 -3.20 -3.28
0.04 1.95 -1.90 -1.28
0.08 0.81 -0.39 -2.39
0.12 1.22 0.97 1.80
.....
63.36 -11.98 15.54 -7.20
```

3.1.7.8 Stresses Statistics (ExploreV Lite and Pro)

This submenu exports the main statistics of velocity joint probability distributions. The statistics are mean, variance, skewness and kurtosis.

3.1.7.9 Cross-Spectral Analysis Results (ExploreV Pro)

This submenu exports the results of cross-spectral analysis (cross-correlation function, cross-spectra, coherence and phase spectra) to an ASCII file. First two columns in the file are reserved for time lags and frequencies. The next five columns are cross correlation function values for negative time lags, cross correlation function values for positive time lags, cross spectra, coherence and phase spectra for $u' - v'$ pair. Other columns are reserved for the same functions for pairs $u' - w'$ and $v' - w'$ (see example below). The format of the file can be changed using the dialog box Export as an ASCII File.

```
File : C:\Program Files\ExploreV\Sc_115.adv
PROBE : 1
CROSS-SPECTRAL CHARACTERISTICS
FIRST TWO COLUMNS ARE TIME LAGS AND THIRD IS FREQUENCY
FREQUENCY UNITS: HZ
FUNCTIONS: CROSS-SPECTRA, COHERENCE, PHASE (u'v,u'w',vw')
0.00 0.000 118.0006 4.7282 9.9220 0.5611 0.0033 0.0204 -26.8341 -89.9820 98.7163
0.04 0.079 87.1016 6.0986 2.7735 0.6287 0.0096 0.0026 -43.6937 -44.1339 0.1567
0.08 0.158 28.5058 4.2648 4.8784 0.5188 0.0210 0.0310 -56.1038 -9.2608 -87.1003
0.12 0.237 6.5298 2.7548 2.7539 0.2034 0.0325 0.0435 -22.2129 3.4302 -98.5234
.....
6.28 12.500 0.0088 0.0024 0.0075 0.0122 0.0126 0.1759 0.0000 0.0000 0.0000
```

3.1.7.10 Contribution Rates (ExploreV Pro)

This submenu exports the contribution rate values calculated in conditional quadrant analysis. The ASCII file consists of six columns. The first column is reserved for values of hole size and the other for contribution rates of events observed in quadrants 1, 2 ...5 respectively (see example below). Change the format of the file with the dialog box Export as an ASCII File.

```
File : C:\Program Files\ExploreV\Sc_115.adv
PROBE : 1
HOLE SIZE AND CONTRIBUTION RATES TO STRESSES (Quadrants: 1,2,3,4 and all):
0.00 6.18 -5.71 3.60 -3.07 0.00
0.20 6.18 -5.71 3.60 -3.07 -0.00
0.40 6.18 -5.71 3.60 -3.07 -0.00
0.60 6.18 -5.71 3.60 -3.07 -0.01
.....
19.60 5.10 -4.96 2.05 -1.82 0.63
19.80 5.10 -4.96 2.04 -1.81 0.63
```

3.1.7.11 Fractional Times (ExploreV Pro)

This submenu exports the fractional times values calculated in conditional quadrant analysis. The ASCII file consists of six columns. The first column is reserved for the values of hole size and the others for the fractional times of events observed in quadrants 1, 2 ... 5 respectively (see example below). The format of the file can be changed using the dialog box Export as an ASCII File.

```
File : C:\Program Files\ExploreV\Sc_115.adv
PROBE : 1
HOLE SIZE AND FRACTIONAL TIMES (Quadrants: 1,2,3,4 and all):
```

```
0.00 0.27 0.21 0.28 0.24 0.00
0.20 0.26 0.21 0.27 0.23 0.04
0.40 0.26 0.19 0.26 0.22 0.07
0.60 0.25 0.19 0.26 0.22 0.09
0.80 0.25 0.18 0.25 0.21 0.11
```

```
.....
19.60 0.11 0.06 0.06 0.05 0.72
19.80 0.11 0.06 0.06 0.05 0.72
```

3.1.7.12 Averaged Velocity Patterns (ExploreV Pro)

This submenu exports averaged velocity patterns, which are the results of the conditional average procedure. The ASCII consists of five columns. The first column is reserved for the time lags and others for averaged dimensionless velocities u' and w' (ejection phase) and u' and w' (sweep phase), assuming pairs of $u' - w'$ were selected for the analysis (see example below). The format of the file can be changed using the dialog box Export as an ASCII File.

```
File : C:\Program Files\ExploreV\Sc_115.adv
PROBE : 1
VELOCITY Patterns (Ejection pare, Sweep pare):
-10.00 -0.63 0.11 0.14 0.10
-9.96 -0.63 0.17 0.14 0.11
-9.92 -0.63 0.10 0.13 0.12
-9.88 -0.64 0.04 0.13 0.14
9.88 -0.48 0.31 -0.29 0.22
9.92 -0.46 0.35 -0.28 0.21
9.96 -0.45 0.29 -0.27 0.21
```

3.1.8 Print Grapics (ExploreV Lite and Pro)

3.1.8.1 Page Setup

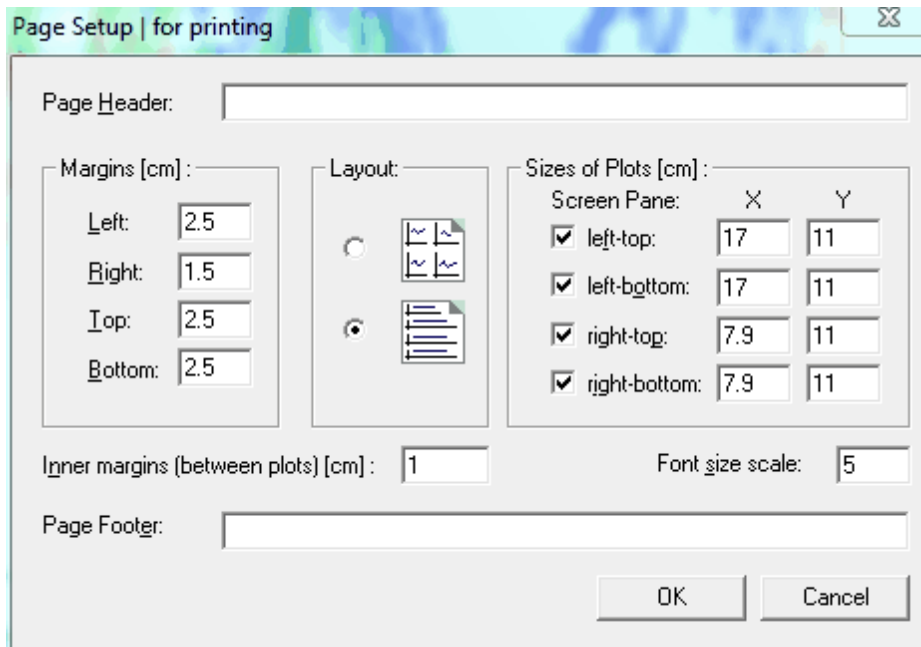
This dialog box allows you to specify the parameters of the page to print. These parameters are:

- Page header and footer;
- Margins;
- Layout style;
- Plot sizes;
- Font size scale.

The default page header is the full path name of the data file and the probe name. There are two styles of page layout in ExploreV:

- Chess board;
- Stack.

You can define vertical and horizontal sizes for plots. Note that these sizes specify the whole layout of the plot rather than size for each plot's axis. Plot axes are defined automatically based on the current font size, presence and style of legend. The page header and footer are aligned to the center of the page.



3.1.8.2 Print

Use this command to print a graphic. This command presents a Print dialog box, where you may specify the range of pages to be printed, the number of copies, the destination printer, and other printer setup options.

Shortcuts

Toolbar: 
 Keys: CTRL+P

Print dialog box

The following options allow you to specify how the document should be printed:

Printer: This is the active printer and printer connection. Choose the Setup option to change the printer and printer connection.

Setup: Displays a Print Setup dialog box, so you can select a printer and printer connection.

Print Range: Specify the pages you want to print:

All: Prints the entire document.

Selection: Prints the currently selected text.

Pages: Prints the range of pages you specify in the From and To boxes.

Copies: Specify the number of copies you want to print for the above page range.

Collate Copies: Prints copies in page number order, instead of separated multiple copies of each page.

Print Quality: Select the quality of the printing. Generally, lower quality printing takes less time to

produce.

Print Progress Dialog

The Printing dialog box is shown during the time that ExploreV is sending output to the printer. The page number indicates the progress of the printing. To abort printing, choose Cancel.

3.1.8.3 Print Preview

Use this command to display the active document as it would appear when printed. When you choose this command, the main window will be replaced with a print preview window in which one or two pages will be displayed in their printed format. The print preview toolbar offers you options to view either one or two pages at a time; move back and forth through the document; zoom in and out of pages; and initiate a print job.

Print Preview toolbar (ExploreV Lite and Pro)

The print preview toolbar offers you the following options:

Print: Bring up the print dialog box, to start a print job.

Next Page: Preview the next printed page.

Prev Page: Preview the previous printed page.

One Page / Two Page: Preview one or two printed pages at a time.

Zoom In: Take a closer look at the printed page.

Zoom Out: Take a larger look at the printed page.

Close: Return from print preview to the editing window.

3.1.8.4 Print Setup

Use this command to select a printer and a printer connection. This command presents a Print Setup dialog box, where you specify the printer and its connection.

Print Setup dialog box (ExploreV Lite and Pro)

The following options allow you to select the destination printer and its connection.

Printer: Select the printer you want to use. Choose the Default Printer; or choose the Specific Printer option and select one of the current installed printers shown in the box. You install printers and configure ports using the Windows Control Panel.

Orientation: Choose Portrait or Landscape.

Paper Size: Select the size of paper that the document is to be printed on.

Paper Source: Some printers offer multiple trays for different paper sources. Specify the tray here.

Options: Displays a dialog box where you can make additional choices about printing, specific to the type of printer you have selected.

Network...: Choose this button to connect to a network location, assigning it a new drive letter.

3.1.9 Bitmap Copy

Plots can be copied to the clipboard (bitmap) and pasted into other applications.

3.1.10 Recent File

Opens a recent used ExploreV Workspace. Use the numbers and filenames listed to open the last four workspaces you closed. Choose the number that corresponds with the workspace you want to open.

3.1.11 Exit

Use this command to end your ExploreV session. You can also use the Close command on the application Control menu. Explore prompts you to save documents with unsaved changes.

Shortcuts

Keys: ALT+F4


3.2 Edit

This menu lets you edit sampled time series. It allows you to clean up communication errors, remove trends and low frequency fluctuations and change orientation of the sampling volume.

3.2.1 Reset Time Series (ExploreV Lite and Pro)

This menu cancels all previous changes (clipping, editing, reorienting and digital filtration) performed on sampled time series, SNR and correlation scores for current probe. The screen will be redrawn after this command.

Shortcuts:

Toolbar: 

See also Zoom and Clipping

3.2.2 Zoom and Clipping (ExploreV Lite and Pro)

This menu allows you to zoom the time series parts and simultaneously select a portion for further analysis. To zoom a part of time series move the cursor to the left (start) position. Press and hold the left mouse button while moving the cursor to the right (finish) position. A rectangle will indicate the zooming area. When left mouse button is released, all the views will be redrawn. Zooming affects the correlation and SNR plots; they also will be zoomed with the same limits.

Shortcuts:

Toolbar: 

See also Reset Time Series

3.2.3 Coordinate System (ExploreV Lite and Pro)

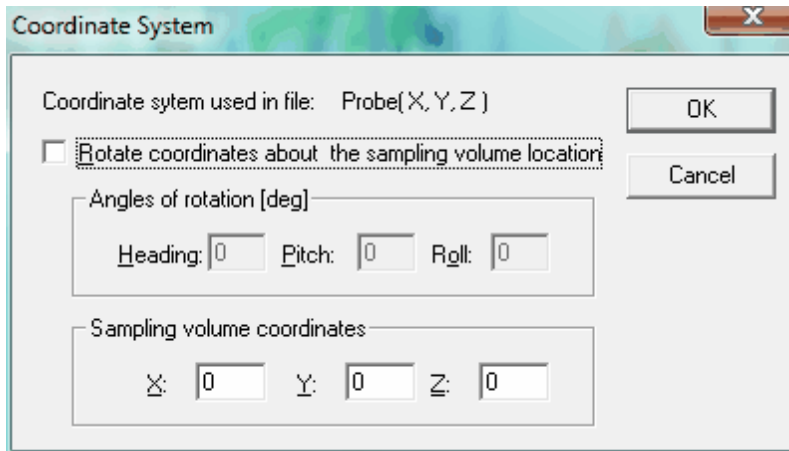
This menu shows the dialog box Change Orientation.

Shortcuts:

Toolbar:



The dialog box Coordinate System allows you to specify the probe orientation and physical coordinates of the probe sampling volume on a measuring grid. These coordinates are used to view the mean velocity vectors. It is also possible to change these coordinates from the Grid Editor.

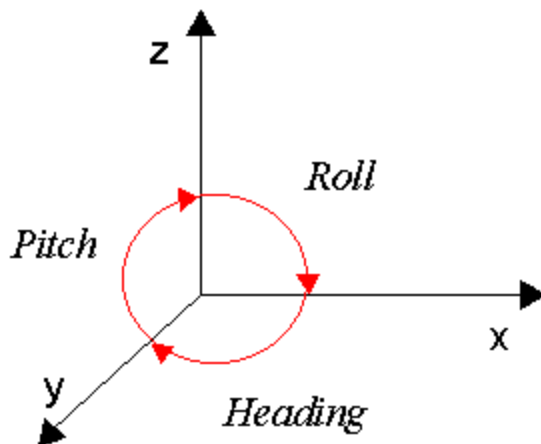


For more information on changing the probe orientation see Change Probe Orientation. See also Reset Time Series

3.2.3.1 Change Probe Orientation

Sometimes you might need to transform the orientation of your sampling volume. Such situations occur when it is necessary to change the local probe's orientation into a global coordinate system defined for multiple measuring grids. ExploreV supplies you with a simple tool to perform these transformations.

The definition of the coordinate system used in ExploreV is presented below



The transformation affects each sample of the time series in accordance with

$$C = \sqrt{V_i^2 + V_j^2}, \quad \alpha = \arctg\left(\frac{V_j}{V_i}\right),$$

$$V_i^t = C \cos(\alpha + \varphi), \quad V_j^t = C \sin(\alpha + \varphi), \quad i = j = x, y, z$$

Here V_i, V_j are velocities in the old coordinate system and V_i^t, V_j^t are velocities in the new coordinate system, φ is the angle of rotation (heading, pitch or roll respectively).

3.2.4 Editing Time Series (ExploreV Lite and Pro)

This menu shows the dialog box Edit Time Series.

Shortcuts:

Toolbar:



See also topics Methods of Editing Time Series, Reset Time Series

3.2.4.1 Editing Time Series Dialog

This dialog box allows you to specify parameters for cleaning time series (see figure).

ExploreV allows you to treat the data with low correlation or SNR scores, spikes and relatively high velocities (bad samples) with the following options:

- 1) linearly interpolate the bad sample between neighbouring values;
- 2) remove bad samples from the time series.

In the first case (interpolation) the treated data may be used to perform spectral analyses. If the bad data are removed from the time series it can be only used to calculate the statistical characteristics and stresses.

Editing Time Series

Bad samples treatment:

Interpolate linearly between neighbouring (i-1, i+1) samples

Remove bad sample from the time series

Criteria to identify the bad samples:

Correlation Score Threshold:

Average Correlation:

Minimum Correlation:

Signal to Noise Ratio Threshold:

Average SNR value:

Minimum SNR value:

Velocity Threshold:

Clean up $|V_{x,y,z}| >$ Sigma $V_{x,y,z}$

Spike Filter:

Acceleration Threshold: g

OK Cancel

For more information see Methods of Time Series Editing.

3.2.4.2 Methods of Editing Time Series

ExploreV provides the user with three methods to exclude rough errors in time series associated with velocity sampling:

- Correlation Score Threshold;
- Signal to Noise Ratio Threshold;
- Velocity Threshold;
- Spikes Filtering.

Correlation Score Threshold replaces velocity values for which the correlation scores are lower than the threshold value. The user can optionally specify averaged threshold values for all three components or minimum correlation values among all three components. Values to replace the bad samples are linearly interpolated or excluded from the time series according to the selected option.

Signal to Noise (snr) Ratio method finds segments with snr lower than the specified threshold, then replaces the velocity values with linearly interpolated values. The user may choose threshold values or minimum snr values for all three components individually. Values to replace the bad samples are calculated in the same manner as for the correlation score threshold method or excluded from the time series according to the selected option.

Velocity Threshold method lets you replace the samples in which the magnitude exceeds the defined threshold. The threshold value is expressed as a multiplied of the standard deviation of each velocity component. Values to replace bad samples are calculated in the same manner as for the correlation score threshold method or excluded from the time series according to the selected option.

Spike Filtering method detects bad samples using an acceleration threshold value. This threshold is specified as a multiplies of the gravity acceleration g . The procedure for calculating the local acceleration is based on the simple formulae:

$$a_{ij} = \frac{V_{ij} - V_{i-1j}}{dt}$$

Here i is the sample number and $j = x, y, z$ and dt is the sampling rate. For each successive triplets of samples, two accelerations are calculated

$$a_{1j} = \frac{V_{ij} - V_{i-1j}}{dt} \quad \text{and} \quad a_{2j} = \frac{V_{i+1j} - V_{ij}}{dt}$$

The change of the sign in accelerations indicates the presence of the spike while its magnitude A_i is calculated according to the expression

$$A_i = \sqrt{\sum_{j=1}^{j=3} (a_{1j} - a_{2j})^2}$$

3.2.5 Digital Filtration (ExploreV Lite and Pro)

This menu shows the dialog box Digital Filtration | Parameters. With this dialog box you can construct various digital filters with different shapes, performance and specification.

Shortcuts:

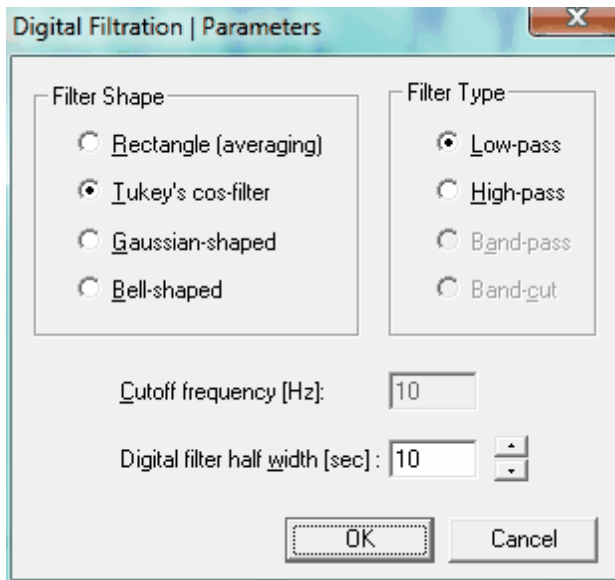
Toolbar:



See also topic Digital Filtration, Reset Time Series

3.2.5.1 Digital Filtration | Parameters Dialog

This dialog box lets you specify the filter shape, type and size (see figure). If you accept the parameters, digital filtration starts immediately. When calculations are done, the transformed time series are displayed immediately.



For more information on digital filtration see Digital Filtration.

3.2.5.2 Digital Filtration

Digital filtration uses a linear transformation of the time series according to

$$V(t) = \sum_{l=-\infty}^{\infty} h_k V(t+l)$$

Here h is a weighting function or digital filter. The digital filters are generally used to:

- Smooth the data or exclude high frequency fluctuations;
- Exclude the low frequency trends from time series;
- Subdivide the time series to a certain number of frequency components.

There are three types of digital filters in ExploreV: **low-pass**, **high-pass** and **band-pass**. The low-pass filter removes the high frequency components from the time series. The high-pass filter leaves only high frequency components in the time series. Band-pass filtration allows you remove both low and high frequency components. All filters available in ExploreV are presented in the following Table.

Filter Type	Title	Expression
Low-pass or high-pass	Gaussian curve	$h_k = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{k^2}{2\sigma^2}\right), k \leq M$ $h_k = 0, k > M$
Low-pass or high-pass	Tukey's filter	$h_k = \frac{1 + \cos\left(\frac{2\pi k}{2M+1}\right)}{2M+1}, k \leq M$ $h_k = 0, k > M$
Band-pass	Bell-shaped	$h_k = \frac{\sqrt{2}}{M} \exp\left(-\frac{\pi k^2}{2M^2}\right) \cos\left(\frac{2\pi k}{M}\right), k \leq M$ $h_k = 0, k > M$

Here M is the half width of the filter.

3.3 View

The View menu offers the following commands:

Toolbar Shows or hides the toolbar.
 Status Bar Shows or hides the status bar.

3.3.1 Toolbar

Use this command to display and hide the Toolbar, which includes buttons for some of the most common commands in ExploreV, such as File Open. A check mark appears next to the menu item when the Toolbar is displayed.



The toolbar is displayed across the top of the application window, below the menu bar. The toolbar provides quick mouse access to many tools used in ExploreV;



Open an existing ExploreV workspace. ExploreV displays the Open dialog box, in which you can locate and open the desired file.



Open an existing data file. ExploreV display the Open Data File dialog box, in which you can locate, preview and open the desired file or a group of files.



Import Vector file. ExploreV display the Import Data File dialog box, in which you can locate, preview and import the desired file or a group of files



Save the active ExploreV workspace or template with its current name. If you have not named the workspace, ExploreV displays the Save As dialog box.



Reset time series.



















Zoom and clip time series.



Change coordinate system (probe's orientation and sampling volume coordinates).



Edit time series. Remove communication errors and replace bad samples with interpolated values.

	Filter time series using digital filters.
	Perform stationarity analysis of time series.
	Show univariate velocity distributions (histograms).
	Calculate univariate spectral functions (auto-covariance, auto-spectra and structure functions).
	Integrate correlation functions and calculate integral scales of turbulence.
	Place rectangle with $-5/3$ slope on a spectral density plot.
	Place rectangle with $2/3$ slope on a structure functions plot.
	Extract dissipation rate from spectra or structure functions.
	Calculate cross-spectral functions (cross-covariance, cross-spectra, coherence and phase functions).
	Calculate contribution rate, fractional time functions and conditionally averaged velocity patterns.
	Activate Grid and Boundary Editor.
	Show velocity vectors.
	Edit the frame options for a selected plot.
	Print
	Copy
<input type="text" value="Sc_115.adv"/>	Select a data file.
	Close selected data file.
<input type="text" value="Probe 1"/>	Select a probe.
<input type="text" value="Velocities"/>	Physical Values. Choose between velocities and stresses.
<input type="text" value="Left top"/>	Active View

3.3.2 Status Bar

Use this command to display and hide the Status Bar, which describes the action to be executed by the selected menu item or depressed toolbar button, and keyboard latch state. A check mark appears next to the menu item when the Status Bar is displayed.



The status bar is displayed at the bottom of the ExploreV window.

The left area of the status bar describes actions of menu items as you use the arrow keys to navigate through menus. This area similarly shows messages that describe the actions of toolbar buttons as you depress them, before releasing them. If after viewing the description of the toolbar button command you wish not to execute the command, then release the mouse button while the pointer is off the toolbar button. The right areas of the status bar indicate which of the following keys are latched down:

Indicator Description

CAP The Caps Lock key is latched down.
 NUM The Num Lock key is latched down.
 SCRL The Scroll Lock key is latched down.

3.4 Analysis (ExploreV Pro)

This menu lets you perform the analysis of time series.

3.4.1 Stationary Analysis (ExploreV Pro)

This menu shows the dialog box Stationarity Analysis | Parameters

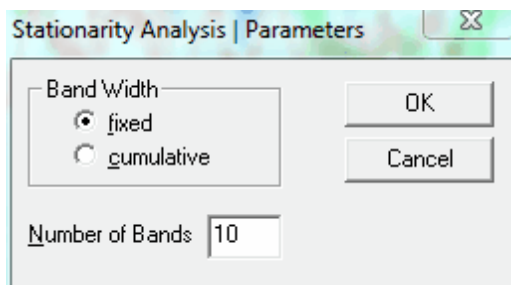
Shortcuts:

Toolbars: 

See also topic Stationarity Analysis of Time Series

3.4.1.1 Stationary Analysis | Parameters Dialog

This dialog box lets you specify the parameters for stationarity analysis (see figure). The two parameters are the type of the band and the total number of bands (for explanations see Stationarity Analysis of Time Series. Accepting parameters means that the calculations start immediately. When calculations are done, a new tab, Stationarity Analysis, appears in the Tab Control and the screen will be redrawn using functions of stationarity analysis.



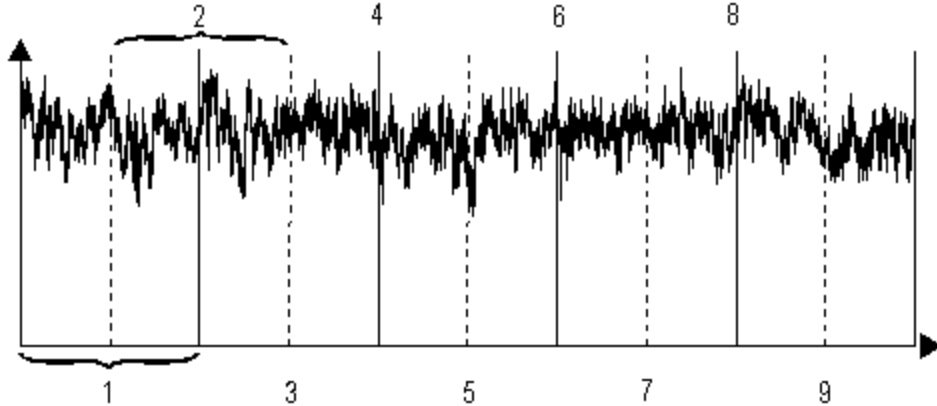
For more information about this analysis see topic Stationarity Analysis of Time Series

3.4.1.2 Stationarity Analysis of Time Series

The goals of stationarity analysis are:

- 1) to explore the presence of trends or low frequency fluctuations in the time series;
- 2) to estimate the accuracy for computed characteristics (mean, variance, skewness and kurtosis).

To perform stationarity analysis, the time series has to be divided into n parts, or bands, of equal length. Each band overlaps its neighboring bands (see figure).



For each band the mean, variance, skewness and kurtosis are calculated if the parameter Band Width is specified as **fixed**. The plots of mean, variance, skewness and kurtosis versus time will indicate, for this case, trends or low frequency fluctuations in the time series. If the parameter Band Width is specified as **cumulative**, then each individual band width is considered as a sum of all previous bands. After calculating the main statistical characteristics for growing bands, the plots will show how the accuracy of the estimates for the main statistical characteristics depend on the time series length. If time series is lengthy enough then the functions on plots will quickly approach their stable values.

The results of stationarity analysis may be used to estimate the flow accelerations due to low frequency fluctuations of the mean velocity field. These accelerations can be calculated as

$$A_x = \frac{\Delta \overline{V}_x}{\Delta t}; \quad A_y = \frac{\Delta \overline{V}_y}{\Delta t}; \quad A_z = \frac{\Delta \overline{V}_z}{\Delta t}$$

Here $\Delta \overline{V}_x$, $\Delta \overline{V}_y$, $\Delta \overline{V}_z$ are the differences between successive bands and Δt is the band's width.

3.4.2 Distributions (ExploreV Pro)

This menu shows the dialog box Univariate Distributions | Histogram Parameters.

Shortcuts:

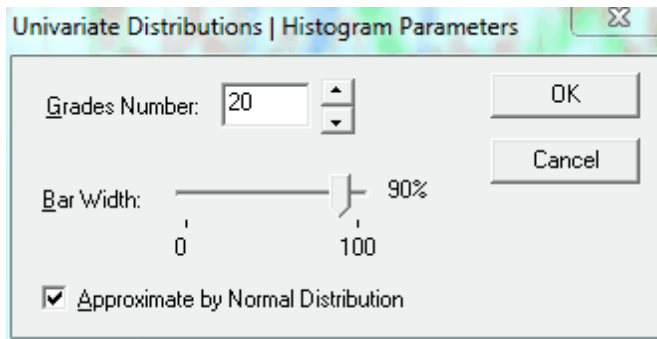
Toolbar:



See also Statistical Characteristics and Probability Density Distributions.

3.4.2.1 Distributions | Histogram Parameters Dialog

This dialog box lets you perform calculations of univariate probability density distributions. You may specify the histogram presentation bar width and select a Gaussian probability density function to fit the histogram.



For more information on univariate distributions see Univariate Statistical Characteristics and Probability Density Distributions.

3.4.2.2 Statistical Characteristics and Probability Density Distributions

The univariate statistical characteristics are mean, variance, skewness and kurtosis defined for individual time series of the velocity vector component.

Mean Velocity

The mean velocity

$$\bar{V}_j = \int_{-\infty}^{+\infty} V_j \rho(V_j) dV_j \approx \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T V_j(t) dt \approx \frac{1}{N} \sum_{i=1}^N V_{ij}, i=1,2,\dots,N, j = x,y,z$$

Here: j is a reference to one of the actual velocity vector component, ρ is a probability density, T is a period of time N is a time series length (total number of samplings).

Velocity Variance

Velocity variance is

$$\overline{V_j^2} = \int_{-\infty}^{+\infty} (V_j - \bar{V}_j) \rho(V_j) dV_j \approx \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T (V_j - \bar{V}_j)^2 dt \approx \frac{1}{N} \sum_{i=1}^N (V_{ij} - \bar{V}_j)^2$$

The square root of variance is the standard deviation.

Skewness

Skewness is

$$Sk_j = \left(\overline{V_j^2} \right)^{-3/2} \int_{-\infty}^{+\infty} (V_j - \bar{V}_j)^3 \rho(V_j) dV_j \approx \left(\overline{V_j^2} \right)^{-3/2} \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T (V_j - \bar{V}_j)^3 dt$$

$$\approx \left(\overline{V_j^2} \right)^{-3/2} \frac{1}{N} \sum_{i=1}^N (V_{ij} - \bar{V}_j)^3$$

Skewness characterizes the shape of the probability density function. The skewness also shows the relative contribution of positive and negative velocity fluctuations to the formation of the velocity pattern.

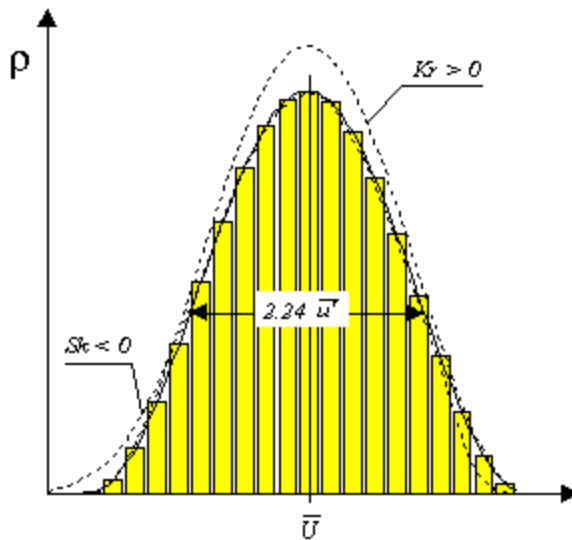
Kurtosis

Kurtosis is

$$K_{r_j} = \left(\overline{V^2_j} \right)^{-2} \int_{-\infty}^{+\infty} (V_j - \bar{V}_j)^4 \rho(V_j) dV_j - 3 \approx \left(\overline{V^2_j} \right)^{-2} \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T (V_j - \bar{V}_j)^4 dt - 3$$

$$\approx \left(\overline{V^2_j} \right)^{-2} \frac{1}{N} \sum_{i=1}^N (V_{\bar{v}} - \bar{V}_j)^4 - 3$$

Statistical characteristics represent the shape of the probability density function and characterize the difference between normal and measured distributions. The following figure compares the empirical probability density distribution (histogram) with a normal distribution (solid line). Dashed lines and arrows illustrate the meaning of the main statistical characteristics.



3.4.3 Spectral Analysis (ExploreV Pro)

This menu shows the dialog box Spectral Analysis | Parameters.

Shortcuts:

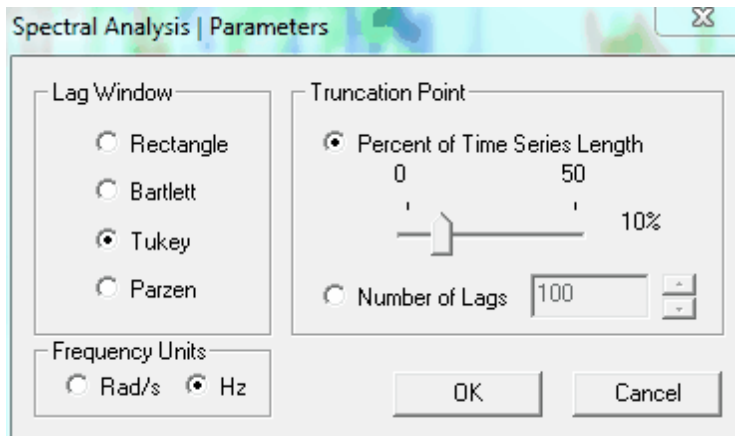
Toolbar:



See also Statistical Functions, Univariate Spectral Analysis and Univariate Spectral Analysis Calculations and Operations

3.4.3.1 Spectral Analysis | Parameters Dialog

With the help of this dialog box you can specify the parameters of univariate spectral analysis. The parameters are Lag Window, Frequency Units and Truncation Point (see figure).



For more information on this analysis see Statistical Functions, Univariate Spectral Analysis and Univariate Spectral Analysis Calculations and Operations

3.4.3.2 Statistical Functions

Auto-covariation function

The auto-covariation function is calculated using

$$Cov_j(\tau) \approx \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T (V_j(t+\tau) - \bar{V}_j)(V_j(t) - \bar{V}_j) dt \approx \frac{1}{N-K} \sum_{i=1}^{N-K} (V_{i+\tau} - \bar{V}_j)(V_i - \bar{V}_j)$$

$i = 1, 2, 3 \dots N, j = x, y, z$

Here τ is time lag, N is total number of samples and K is the maximum lag or **truncation point**. Auto-correlation function $R(\tau)$ is auto-covariation function normalized by variance of time series.

Spectrum

ExploreV calculates the power spectrum using the Fourier Transformation of the auto-covariance function (**Jenkins and Watts, 1968**). Spectrum calculated as

$$S_j(\omega) = \frac{2}{\pi} \int_0^{\infty} Cov_j(\tau) \cos \omega \tau d\tau$$

Here omega is a cyclical frequency. In practical statistical analysis, the spectrum should be smoothed with weighting functions called **correlation windows**. The following Table gives equations for the four commonly used correlation windows available in ExploreV (**Jenkins and Watts, 1968**)

Correlation window	Expression
Rectangle	$constant = 1$
Bartlett's	$1 - \frac{\tau}{\tau_{max}}$
Tukey's	$\frac{1}{2} \left(1 + \cos \frac{\pi \tau}{\tau_{max}} \right)$
Parzen's	$\begin{cases} 1 - 6 \left(\frac{\tau}{\tau_{max}} \right)^2 + 6 \left(\frac{\tau}{\tau_{max}} \right)^3 & \tau \leq \frac{\tau_{max}}{2} \\ 2 \left(1 - \frac{\tau}{\tau_{max}} \right) \frac{\tau_{max}}{2} & \frac{\tau_{max}}{2} < \tau \leq \tau_{max} \end{cases}$

The discrete analog of the equation for spectra calculations used in ExploreV is

$$S_j \left(\frac{\pi \tau k}{\tau_{max} \Delta t} \right) \approx \frac{\Delta t}{\pi} \left[Cov_j(0) + 2 \sum_{\tau=1}^{\tau_{max}-1} Cov_j(\tau) Cw(\tau) \cos \frac{\pi \tau k}{\tau_{max}} \right], 0 \leq k \leq \tau_{max}$$

Here Cw is a correlation window.

Structure function

The structure function is defined as:

$$D_j(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \left[(V_j(t+\tau) - \bar{V}_j)(V_j(t) - \bar{V}_j) \right]^2 dt \approx \frac{1}{N-K} \sum_{i=1}^{N-K} \left(V_{\psi}(t+\tau) - \bar{V}_j \right) \left(V_{\psi}(t) - \bar{V}_j \right)$$

Univariate Spectral Analysis (ExploreV Pro)

The main goals of univariate spectral analysis are:

- 1) to extract the characteristic scales of turbulence;
- 2) to explore the applicability of the local isotropy hypothesis and presence of Kolmogorov's internal subrange in the power spectra;
- 3) to estimate the dissipation rate.

The characteristic scales of turbulence are

$$T_i = \int_0^{\infty} R_i(\tau) d\tau \quad \text{integral time scale;}$$

$$L_i = \overline{U} \int_0^{\infty} R_i(\tau) d\tau \quad \text{integral spatial scale;}$$

$$\ell_i = \left[\int_0^{\infty} S_{ii}(\omega) \omega^2 d\omega \right]^{-2}, \quad S_{ii}(\omega) = S_i(\omega) / \overline{u_i^2} \quad \text{turbulence microscale;}$$

$$\eta_o = \left(\frac{\nu^3}{\varepsilon} \right)^{1/4} \quad \text{Kolmogorov's internal turbulence scale}$$

Here ν is the cinematic viscosity and ε is the dissipation rate

The dissipation rate is the rate at which energy is lost from the velocity field.

$$\overline{\varepsilon} = \frac{\nu}{2} \sum_i \sum_j \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right)^2$$

The dissipation rate is evaluated using the local isotropy theory of Kolmogorov-Obukhov. According to the theory, the dissipation rate can be calculated from equations (**Monin and Yaglom, 1971**)

$$S(\omega) = C_1 \frac{\overline{\varepsilon}^{-2/3}}{\omega^{5/3}} \overline{U}^{1/3} \omega^{-5/3}$$

$$D(\tau) = C_2 \frac{\overline{\varepsilon}^{-2/3}}{\tau^{3/2}} \overline{U}^{1/3} \tau^{3/2}$$

These equations use the observed values of spectral density and structure function within the inertial subrange of the spectrum. Inertial subrange is the frequency band of the spectrum within which the turbulence is isotropic and spectral density obeys to Kolmogorov's -5/3 law.

To explore the existence of the inertial subrange, you may apply the relationship (**Tennekes and Lumley, 1972**)

$$S_v(\omega) = S_w(\omega) = \frac{4}{3} S_u(\omega)$$

Spectral analysis also provides information on mean turbulence accelerations that can be evaluated applying Yaglom's relationship (**Monin and Yaglom, 1971**)

$$\overline{\ddot{a}} = \sum_i \overline{\left(\frac{du_i}{dt} \right)^2} = 3 \left(\frac{\overline{\varepsilon}}{\nu} \right)^{1/2}$$

3.4.3.3 Univariate Spectral Analysis Calculations and Operations

To calculate functions for univariate spectral analysis, specify parameters in the Spectral Analysis | Parameters dialog box. The parameter Lag Window allows the user to apply different correlation windows. This dialog box also lets you choose frequency units (Rad/s or Hz). The truncation point or maximum lag specifies the width of the spectral window. Thus, ExploreV provides the user with two valuable operations of spectral analysis: **window carpentry** and **window closing** (*Jenkins and Watts, 1968*).

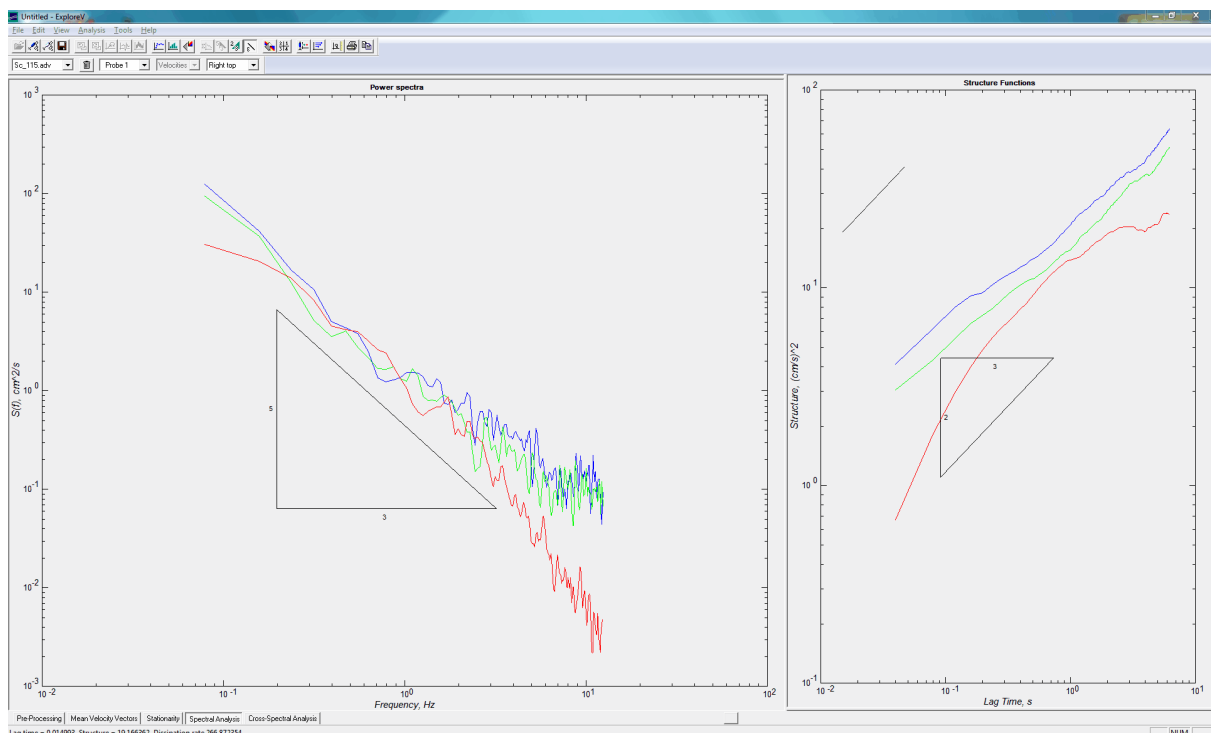
Window closing is the procedure of spectra viewing with different truncation points. The aim of window closing is to explore the detailed structure of spectra. You can specify the truncation point as a percent of the time series length or as a number of samples. Calculations start immediately when you press OK to accept the parameters. The progress bar shows the progress in calculations. When calculations are done, the correlation function, spectra and structure function plots are redrawn and the Spectral Analysis Tab appears.

To explore the existence of an inertial subrange in the spectra or structure functions, to evaluate turbulence scales and dissipation rate, use menu Tools or toolbars



There are four buttons: Draw Triangle -5/3, Draw Triangle 2/3, Extract Dissipation Rate and Integrate Function. To activate the buttons, it is necessary to left-clicking the appropriate views. For example, to enable the Draw Triangle -5/3 button, click the power spectra.

Draw Triangle -5/3 button allows you to place a triangle with -5/3 slope. You may also adjust the size of the triangle. To place the triangle, press the corresponding button of the toolbar and move the cursor to the upper left position you like. Then press and hold the left mouse button and move the cursor to the bottom right position. Use the same approach when using Draw Triangle 2/3 for structure functions. An example is shown on the following figure.



To look for isotropy, the user should visually identify the inertial subrange by comparing the slopes of power spectra or structure functions with the corresponding triangles and compare the spectra for the three different components. The level of spectral density should be approximately the same for all three components (see topic Univariate Spectral Analysis).


The button Extract Dissipation Rate enables you to estimate the dissipation rate from either power spectra or structure functions. You activate the Extract Dissipation Rate button, the cursor carries a slope line (-5/3 slope for spectra, 2/3 slope for structure functions) to the appropriate panel. Place the line into the inertial subrange to compute the dissipation rate. Click the right mouse button to deactivate the computation. When moving the slope line, you can watch the current frequency or time lag, spectral density or structure function value and corresponding value of the dissipation rate in the status string. The dissipation rate calculation used the following values for constants $C1 = 0.5$ for the spectral estimate and $C2 = 1.92$ for the structure estimate (see Univariate Spectral Analysis). For computations of dissipation rate you can use the mean velocity calculated as the magnitude of the mean velocity vector or you can specify the appropriate value manually. This gives you possibility to extract the dissipation rate from time series after high-pass filtration. Note that after high-pass filtration the mean velocity value should be set to zero. In this case you should use mean values of original series. To change the mean velocity value use menu Tools | Mean Velocity.

The Integrate Function button lets you evaluate turbulence scales (see Univariate Spectral Analysis). To obtain integral time scales and spatial scales, activate the left top view with the correlation function. Press the Integrate Function button and move the cursor to the left (start) position. Then press and hold the left button of the mouse and move the cursor to the right position. You may select the whole function or only a part. Sometimes it is convenient to estimate the scales roughly using only a part of the correlation function. Such a situation may occur when the time series consist of some quasi-periodical fluctuations. Use the same procedure to applicable to extract turbulence micro-scale from spectra. When you release the left mouse button you will be asked to accept or reject the scales.

3.4.4 Cross-Spectral Analysis (ExploreV Pro)

This menu starts the calculations of cross-spectral functions. This menu and the button are active when univariate spectral analysis is completed.

Shortcuts:

Toolbar: 

See also topic Cross-Spectral Functions.

3.4.4.1 Cross-Spectral Functions

The main goal of cross-spectral analysis is to explore the structural properties of turbulence by using the correlation between velocity vector components. Cross-spectral analysis include calculation of the cross-covariance function, cross-spectra, coherence and phase spectra.

Cross-covariance function

The cross-covariance function is defined according to

$$Cov_{jk}(\tau) \approx \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T (V_j(t+\tau) - \bar{V}_j)(V_k(t) - \bar{V}_k) dt \approx \frac{1}{N-M} \sum_{i=1}^{N-M} (V_{i+Mj} - \bar{V}_j)(V_{ik} - \bar{V}_k)$$

Cross-correlation function $R_{jk}(\tau)$ is cross-covariation function normalized by the result of multiplication of velocities standard deviations $\bar{V}'_j \bar{V}'_k$.

Cross-spectrum

ExploreV obtains the cross-spectrum by Fourier transforming the cross-covariance function (**Jenkins and Watts, 1968**)

$$S_{jk}(\omega) = \int_{-\infty}^{\infty} Cov_{jk}(\tau) \exp(-i\omega\tau) d\tau = C_{jk}(\omega) + iQ_{jk}(\omega)$$

Here $C_{jk}(\omega)$ is co-spectrum (or cos part) and $Q_{jk}(\omega)$ is quadrature spectrum (sin part).

The discrete analog of this equation is

$$C_{jk} \left(\frac{\pi m}{\tau_{\max} \Delta t} \right) \approx 2 \left[L_{jk}(0) + 2 \sum_{\tau=1}^{\tau_{\max}-1} L_{jk}(\tau) Cw(\tau) \cos \frac{\pi m \tau}{\tau_{\max}} \right], 0 \leq m \leq \tau_{\max} - 1$$

$$Q_{jk} \left(\frac{\pi m}{\tau_{\max} \Delta t} \right) \approx 4 \sum_{\tau=1}^{\tau_{\max}-1} M_{jk}(\tau) Cw(\tau) \sin \frac{\pi m \tau}{\tau_{\max}}, 1 \leq m \leq \tau_{\max} - 1$$

Here Cw is the correlation window and

$$L_{jk} = \frac{1}{2} [Cov_{jk}(\tau) + Cov_{jk}(-\tau)], 0 \leq \tau \leq \tau_{\max} - 1$$

$$M_{jk} = \frac{1}{2} [Cov_{jk}(\tau) - Cov_{jk}(-\tau)], 0 \leq \tau \leq \tau_{\max} - 1$$

Finally, we obtain the amplitude spectrum using

$$A_{jk}(\omega) = \sqrt{C_{jk}^2(\omega) + Q_{jk}^2(\omega)}$$

Coherence spectrum

The coherence spectrum of two random processes is like a correlation coefficient calculated for each frequency. Coherence shows the ratio between random noise and turbulent signal. If noise is dominant, coherence approaches zero. Coherence is calculated as

$$Ch_{jk}(\omega) = \sqrt{\frac{A_{jk}^2(\omega)}{S_j(\omega)S_k(\omega)}}$$

Phase spectrum

The phase spectrum lets you calculate the phase between harmonics of two random processes. It is defined according to

$$F_{jk}(\omega) = \arctg - \left[\frac{Q_{jk}(\omega)}{C_{jk}(\omega)} \right]$$

3.4.5 Quadrants Analysis and Averaging (ExploreV Pro)

Conditional Quadrants Analysis (Analysis Menu, ExploreV Pro)

This menu shows the dialog box Conditional Quadrants Analysis and Averaging

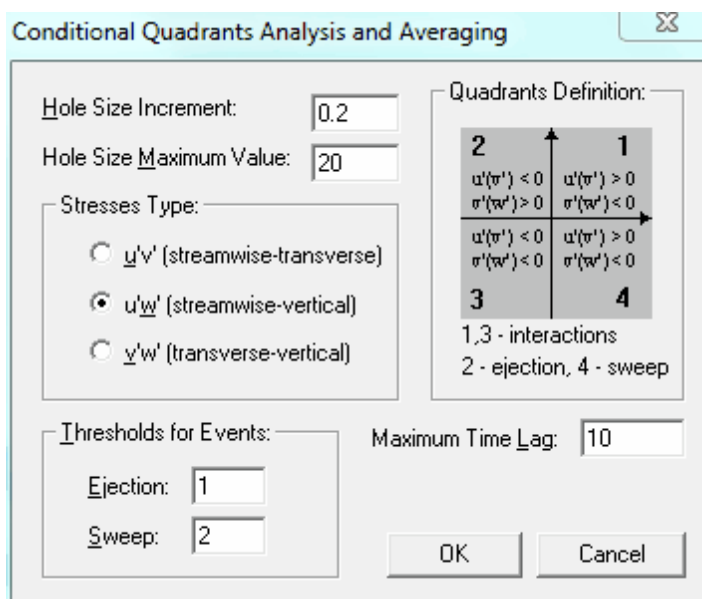
Shortcuts

Toolbar: 

See also Joint Probability Density Distributions and Conditional Quadrants Analysis and Averaging.

3.4.5.1 Conditional Quadrants Analysis and Averaging Dialog

This dialog lets you specify the parameters for **conditional quadrants analysis and averaging procedure**. The parameters are Hole Size Increment, Hole Size Maximum Value, Stresses Type, Thresholds for Ejection and Sweep and Maximum Time Lag. The default values for thresholds are 1 and 2 respectively. The authors (Nezu and Nakagawa, 1993) propose these values as the most appropriate for the general case (open channel flow, quasi-two dimensional flow). You may start the analysis with these values and later repeat the calculations with other thresholds if necessary.



Conditional Quadrants Analysis and Averaging

Hole Size Increment:

Hole Size Maximum Value:

Stresses Type:

- $u'v'$ (streamwise-transverse)
- $u'w'$ (streamwise-vertical)
- $v'w'$ (transverse-vertical)

Quadrants Definition:

2 $u'(\sigma') < 0$ $\sigma'(\omega') > 0$	1 $u'(\sigma') > 0$ $\sigma'(\omega') < 0$
3 $u'(\sigma') < 0$ $\sigma'(\omega') < 0$	4 $u'(\sigma') > 0$ $\sigma'(\omega') < 0$

1,3 - interactions
2 - ejection, 4 - sweep

Thresholds for Events:

Ejection:

Sweep:

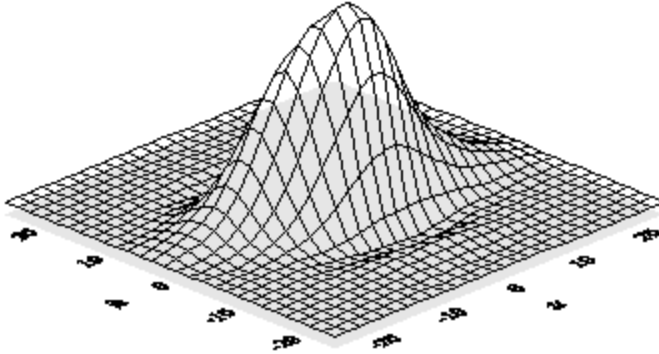
Maximum Time Lag:

OK Cancel

For more information see Joint Probability Density Distributions and Conditional Quadrants Analysis and Averaging.

3.4.5.2 Joint Probability Density Distribution

The correlation between different velocity components gives you information about the structural properties of turbulence. For example, consider the correlation of u' and w' below.

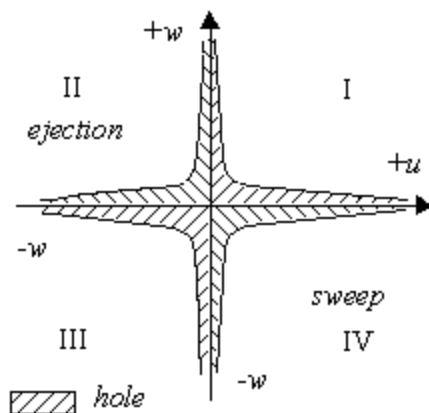


The statistical moments of joint distribution are calculated similarly as for univariate distributions (see Univariate Statistical Characteristics and Probability Density Distributions). The most valuable physical meaning of these statistical quantities is that their mean values represent the non-diagonal components of the stress tensor.

3.4.5.3 Conditional Quadrants Analysis and Averaging

The most frequently used technique to detect coherent structures in turbulent flows is the conditional average procedure based on conditional quadrants analysis (*Lu and Willmarth, 1973; Willmarth, 1975; Nezu and Nakagawa, 1993*). Conditional quadrants analysis distinguishes *ejection* and *sweep* types of motion from other types of *interactions*. This technique is usually applied to 2D flows when only streamwise and vertical components of velocity vector are considered. However, ExploreV provides the user with the possibility to decide which components to consider for this analysis. For simplicity the description of the method in this document is restricted to u and w components.

Ejection or sudden outward motion of low-speed fluid from the bed region can be associated with instantaneous large amplitude values of the joint probability in the second quadrant (see figure).



A sweep phase is the motion of high-speed fluid toward the flow bed and can be recognized by the

appearance of instantaneous large joint probability values in the fourth quadrant.

The quadrants analysis is based on the assumption that ejection and sweep motions occur when

$|V_x' V_z'| > H \overline{V_x' V_z'}$, where H is a threshold level. The latter is introduced to distinguish between signals of interest (ejection and sweeps) and other interactions. Quantitatively, ejection and sweep can be characterized by their contribution rate RS_q to the Reynolds stress and by their fractional time T_q

$$RS_q(H) = \int_H^{\infty} \rho_q(\varphi) d\varphi, \quad \text{quadrants } q = 2 \text{ and } 4$$

$$RS_q(H) = \int_{-\infty}^{-H} \rho_q(\varphi) d\varphi, \quad \text{quadrants } q = 1 \text{ and } 3$$

$$T_q(H) = \int_H^{\infty} \rho_q(\varphi) d\varphi, \quad \text{quadrants } q = 2 \text{ and } 4$$

$$T_q(H) = \int_{-\infty}^{-H} \rho_q(\varphi) d\varphi, \quad \text{quadrants } q = 1 \text{ and } 3$$

where φ denotes the instantaneous dimensionless Reynolds stress $\varphi = V_x' V_z' / \overline{V_x' V_z'}$ and $\rho_q(\varphi)$ is probability density function.

Conditional-average procedure

You may apply the conditional-average procedure to evaluate periods of ejection and sweep motions. Considering an arbitrary signal $q(t)$, the conditional-average procedure can be described as

$$\langle q(t) \rangle = \frac{\int_0^T q(t+\tau) I(t) dt}{\int_0^T I(t) dt}$$

where $I(t)$ is the detection function for ejection:

$$I_e(t) = \begin{cases} 1 & \text{for } V_x'(t) < 0 \text{ and } V_z'(t) > 0 \\ 0 & \text{otherwise} \end{cases}$$

and for sweep:

$$I_s(t) = \begin{cases} 1 & \text{for } V_x'(t) > 0 \text{ and } V_z'(t) < 0 \\ 0 & \text{otherwise} \end{cases}$$

3.4.6 Vectors of Mean Velocities (ExploreV Pro)

This menu shows the dialog box Vectors of Mean Velocities | View Parameters

Shortcuts

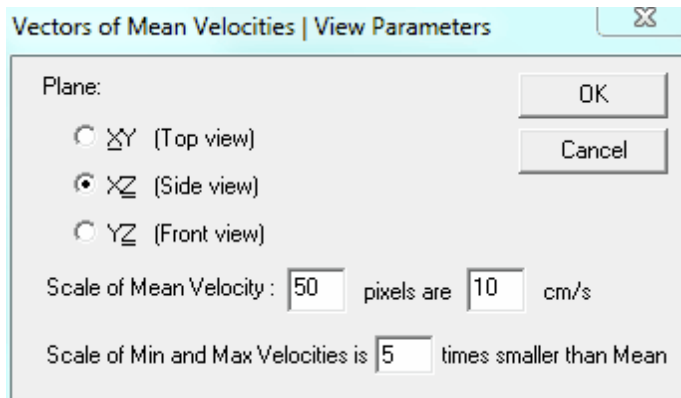
Toolbar:



See also Vectors of Mean Velocity, Grid and Boundary Editor.

3.4.6.1 Vectors of Mean Velocities | View Parameters Dialog

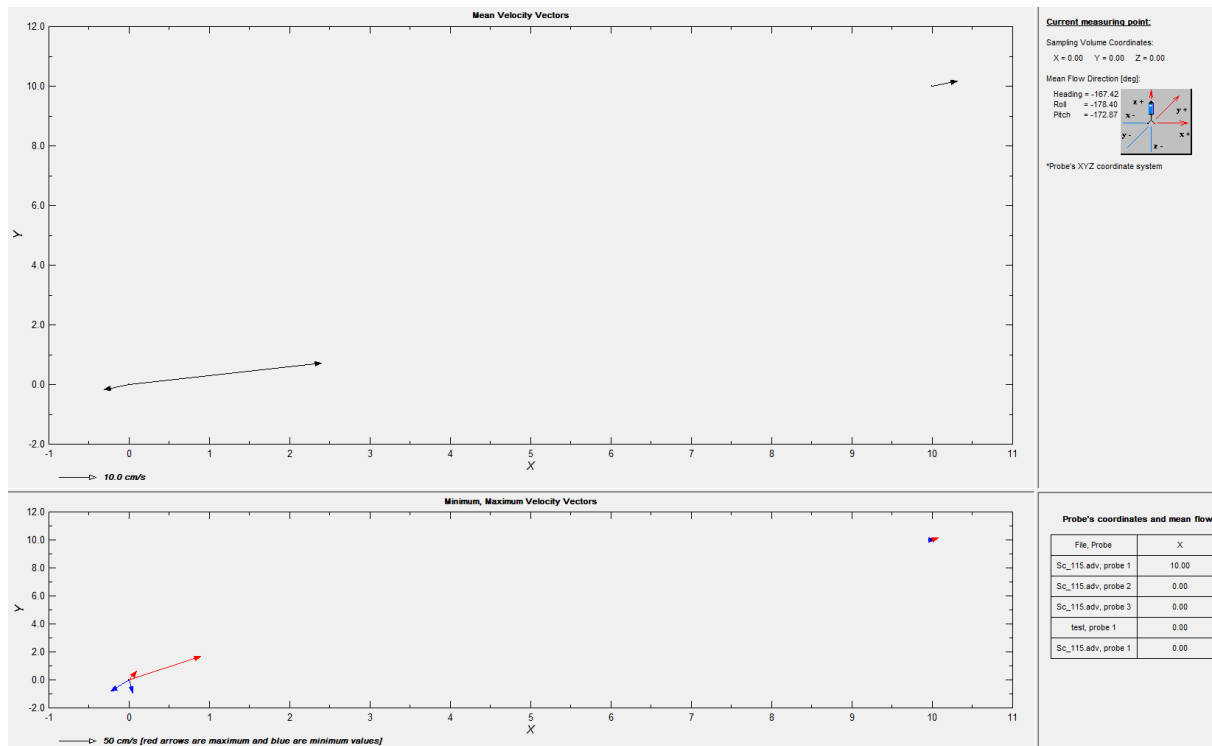
With the help of this dialog box you can specify the parameters to show the vectors of mean velocities. The parameters are Plane, Velocity Scale and Ratio of Scale for minimum and maximum values (see figure).



For more information on this analysis see topics Vectors of Mean Velocity, Grid And Boundary Editor.

3.4.6.2 Vectors of Mean Velocities

Multiple velocimeters (or repetitive sampling by one probe) can be used to map the velocity field in 3-D space. ExploreV lets you to plot mean velocity vectors, its maximum and minimum values and flow's boundaries (see figure below).



You should specify coordinates for each probe's sampling volume and if necessary flow boundaries to view the mean velocity vectors in the layout of your measuring domain. Use the dialog box Change Orientation or the Grid Editor tool to specify the probe's coordinates. You may create or browse flow boundaries in the Grid Editor.

The left-top view displays the mean velocity vectors. The left-bottom view shows the minimum and maximum vectors and the right-top shows the coordinates and the direction of mean velocity vector for a current probe. The table in the right-bottom view presents the information on coordinates and directions for all probes available in current ExploreV session.

3.5 Tools

3.5.1 Extract Scales

The Integrate Function tool lets you evaluate turbulence scales (see Univariate Spectral Analysis). To obtain integral time scales and spatial scales, activate the left top view with the correlation function. Press the Integrate Function button and move the cursor to the left (start) position. Then press and hold the left button of the mouse and move the cursor to the right position. You may select the whole function or only a part. Sometimes it is convenient to estimate the scales roughly using only a part of the correlation function. Such a situation may occur when the time series consist of some quasi-periodical fluctuations. Use the same procedure to applicable to extract turbulence micro-scale from spectra. When you release the left mouse button you will be asked to accept or reject the scales.

Shortcuts:

Toolbar:



See also Univariate Spectral Analysis Calculations and Operations.

3.5.2 Draw Triangle -5/3

Draw Triangle -5/3 tool allows you to place a triangle with -5/3 slope into spectral functions plot. You may also adjust the size of the triangle. To place the triangle, press the corresponding button of the toolbar and move the cursor to the upper left position you like. Then press and hold the left mouse button and move the cursor to the bottom right position. Use the same approach when using Draw Triangle 2/3 for structure functions.

Shortcuts:

Toolbar:



See also Univariate Spectral Analysis Calculations and Operations.

3.5.3 Draw Triangle 2/3

Draw Triangle 2/3 tool allows you to place a triangle with 2/3 slope into structure function plot. You may also adjust the size of the triangle. To place the triangle, press the corresponding button of the toolbar and move the cursor to the upper right position you like. Then press and hold the left mouse button and move the cursor to the bottom right position. Use the same approach when using Draw Triangle -5/3 for spectral functions.

Shortcuts:

Toolbar:



See also Univariate Spectral Analysis Calculations and Operations.

3.5.4 Extract Dissipation Rate

The Extract Dissipation Rate tool enables you to estimate the dissipation rate from either power spectra or structure functions. You activate the Extract Dissipation Rate button, the cursor carries a slope line (-5/3 slope for spectra, 2/3 slope for structure functions) to the appropriate panel. Place the line into the inertial subrange to compute the dissipation rate. Click the right mouse button to deactivate the computation. When moving the slope line, you can watch the current frequency or time lag, spectral density or structure function value and corresponding value of the dissipation rate in the status string. The dissipation rate calculation used the following values for constants $C1 = 0.5$ for the spectral estimate and $C2 = 1.92$ for the structure estimate (see Univariate Spectral Analysis). The mean velocity is calculated as the magnitude of the mean velocity vector.

Shortcuts:

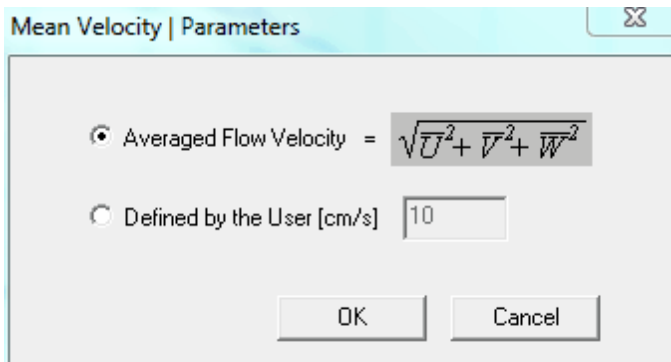
Toolbar:



See also Univariate Spectral Analysis Calculations and Operations.

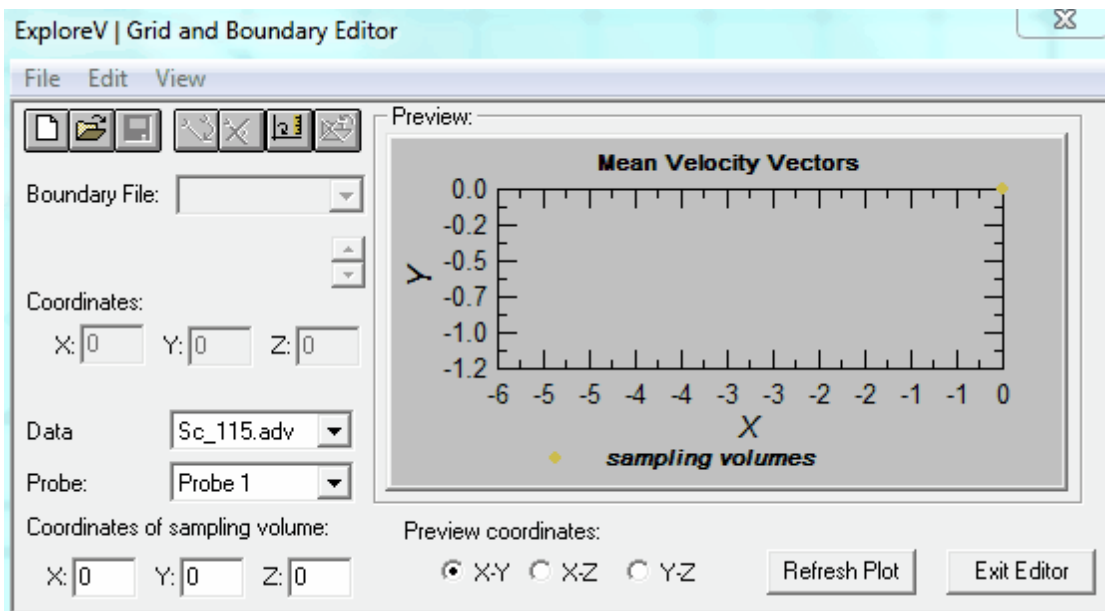
3.5.5 Mean Velocity (ExploreV Pro)

This dialog box lets you specify the mean velocity value for computations of dissipation rate values (see figure below). You can specify the mean velocity value to be automatically computed as a mean value of the velocity vector or you can manually enter the desired value.




3.5.6 Grid and Boundries Editor (ExploreV Lite and Pro)

Grid and Boundary Editor lets you to browse or create flow's boundaries data files, edit and preview measuring grid layout and specify sampling volume coordinates for probes (see figure below).





Commands:


New boundary - creates a new boundary file (*.bnd). Shortcuts: Alt+N 


Open boundary - opens a boundary data file (*.bnd). Shortcuts: Alt+O 

Save - saves a boundary data file (*.bnd) 

Close Boundary - closes the boundary file (*.bnd) 

Add Node - adds the boundary node 

Remove Node - removes selected node from boundary file 

Frame Options - lets you to change plot frame options 

3.5.6.1 Add Node Dialog

This simple dialog box lets you manually enter the node's coordinates.

3.5.7 Simulate Time Series

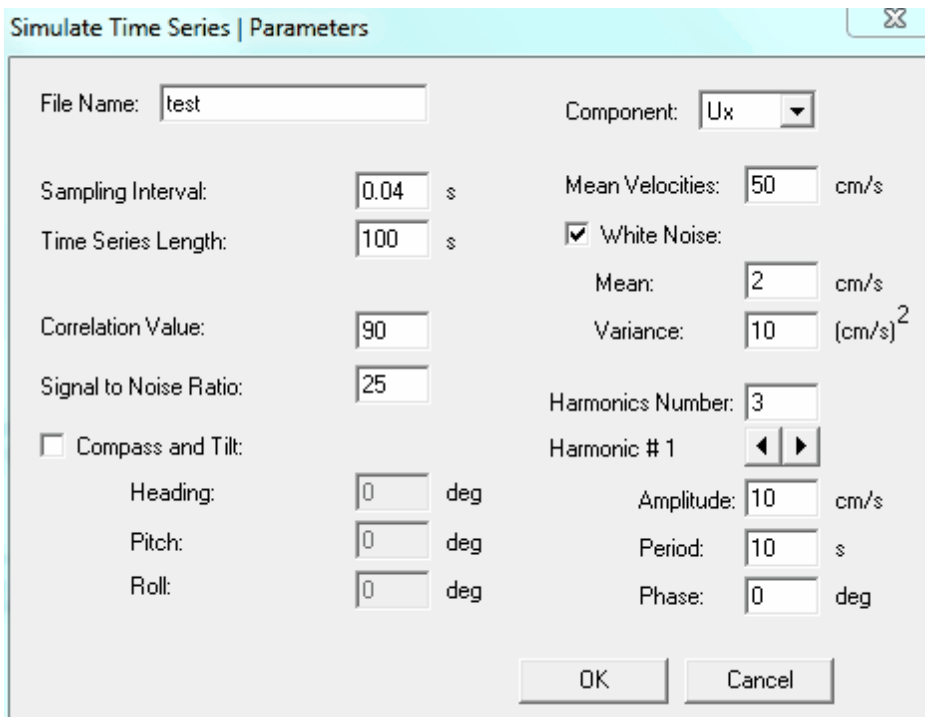
ExploreV lets you try out the methods of analysis with the help of simulated time series. Simulation tools allows the user to create artificial time series with known properties and then explore these properties applying the methods of ExploreV. This menu shows the dialog box Simulate Time Series | Parameters.

See also Time Series Simulation.

3.5.7.1 Simulate Time Series | Parameters Dialog

This dialog box allows the user to specify the parameters for artificial time series (see figure). The artificial time series is similar to the data file and therefore it consists of sampled velocities, correlation and SNR scores, compass and tilt data (optionally).

The user can define the number of harmonics and parameters for each harmonic. To change between harmonics use the spin control. To change the velocity component use the combo box "component".



Simulate Time Series | Parameters

File Name: Component:

Sampling Interval: s Mean Velocities: cm/s

Time Series Length: s White Noise:

Correlation Value: Mean: cm/s

Signal to Noise Ratio: Variance: (cm/s)²

Compass and Tilt: Harmonics Number:

Heading: deg Harmonic # 1:

Pitch: deg Amplitude: cm/s

Roll: deg Period: s

Phase: deg

See also Time Series Simulation.

3.5.7.2 Time Series Simulation

The artificial time series can be created as a sum of n harmonics with various amplitudes, periods and phases with addition of white noise.

$$V_{ij} = \bar{V}_j + \sum_{k=1}^{k=N} A_k \sin \left(\frac{2\pi i}{T_k} + \phi_k \right) + \text{white noise}$$

Here \bar{V} is mean velocity, A_k is amplitude T_k is period and ϕ_k is phase. Index k refers to a number of harmonics and j to a velocity vector component.

The value of white noise is calculated as a Gaussian random value with specified mean and variance.

Spectral analysis allows you to find the specific frequencies defined by the user as $1/T_k$ considering the picks in spectra, periods in correlation and structure functions. Phase shifts between components lets the user simulate coherent structures (ejection and sweep) and explore them with cross-spectral analysis and conditional quadrants analysis. Addition of white noise into the time series makes the series more realistic and allows you to see the effect of noise on the deterministic signals.

3.6 Help

The Help menu offers the following commands, which provide you assistance with this application:

Help Topics	Offers you an index to topics on which you can get help.
About ExploreV	Displays the version number of this application.

3.6.1 Help Topics

Offers you an index to topics on which you can get help. From the opening screen, you can jump to step-by-step instructions for using ExploreV and various types of reference information. Once you open Help, you can click the Contents button whenever you want to return to the opening screen.

3.6.2 About ExploreV

Use this command to display the copyright notice and version number of your copy of ExploreV.

4 Example of Application

The post-processing of data file recorded on River Spree in Germany (*Sukhodolov et al., 1998*) is chosen as an example herein. The data file is Sp_10.adv (vertical 4, $z/h = 0.37$, 21/05/1996, see *Sukhodolov et al., 1998*). Note that the sampling volume was installed with the heading 180 degree therefore streamwise component was negative.

Figure 1 The sampled time series and their correlation/SNR scores. Note that streamwise velocity component is negative and consists of three well defined spikes (between 120-160s, 200-240s, 280-320s).

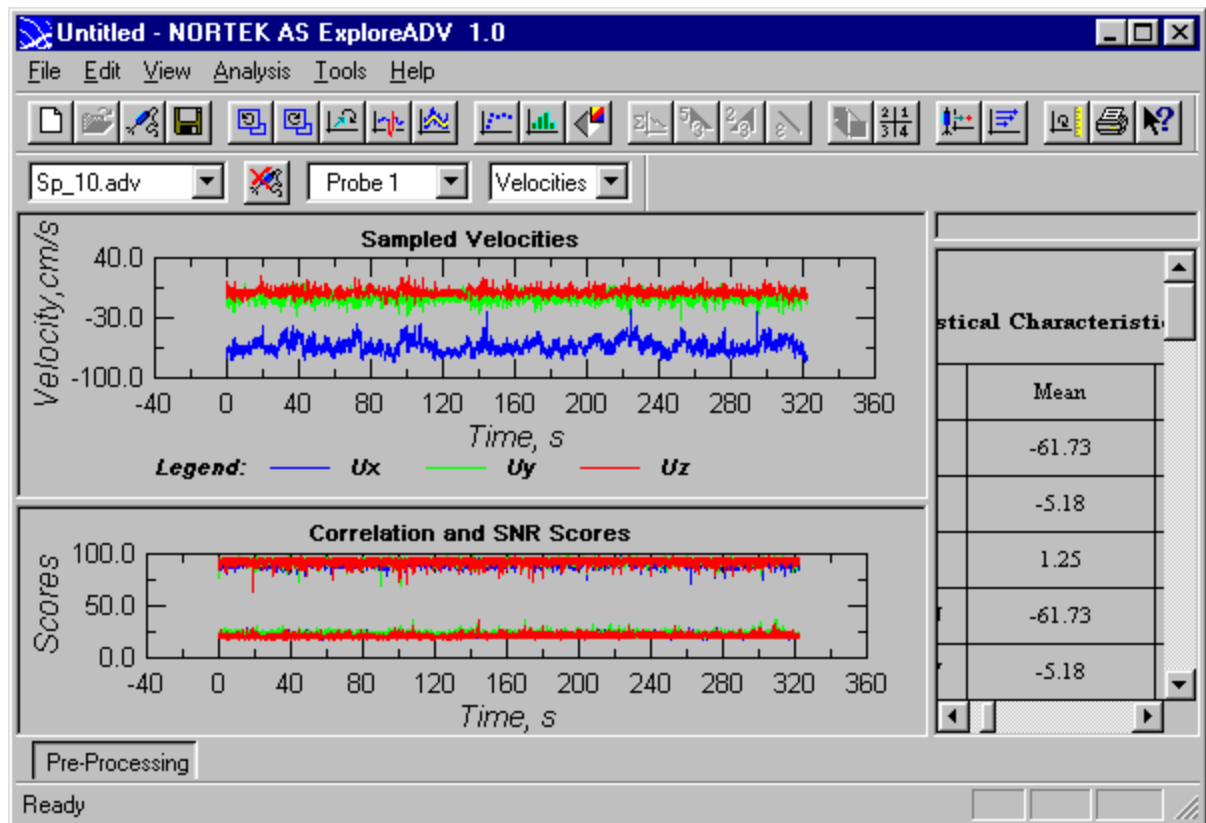


Figure 2 The time series shown here are edited (spike filter with the threshold 0.8g), rotated (heading 180 degree) and zoomed (clipped) on the interval 40-280s.

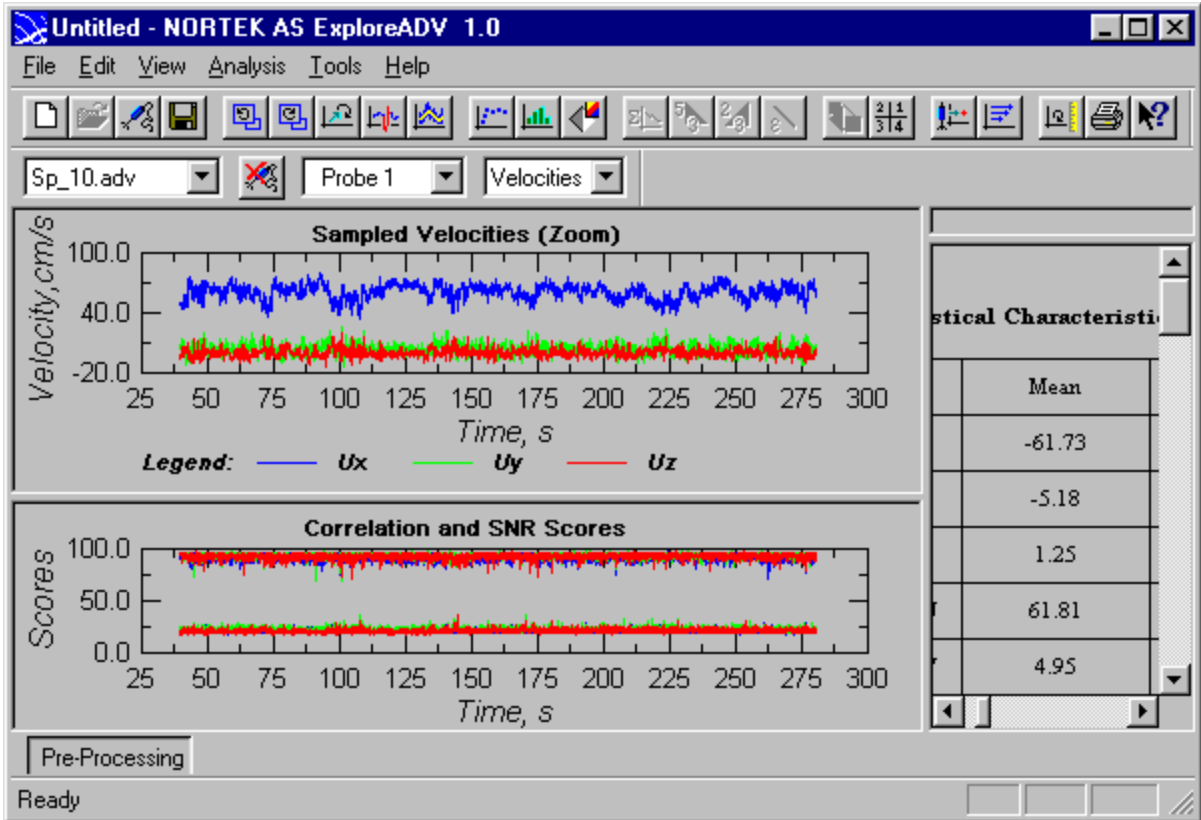


Figure 3 This figure shows the stationarity analysis results. You can see that all functions approach their saturation values when the time series length is about 180s long. Since the length of series is 220s we can conclude that series are lengthy enough for accurate calculations even high order statistics.

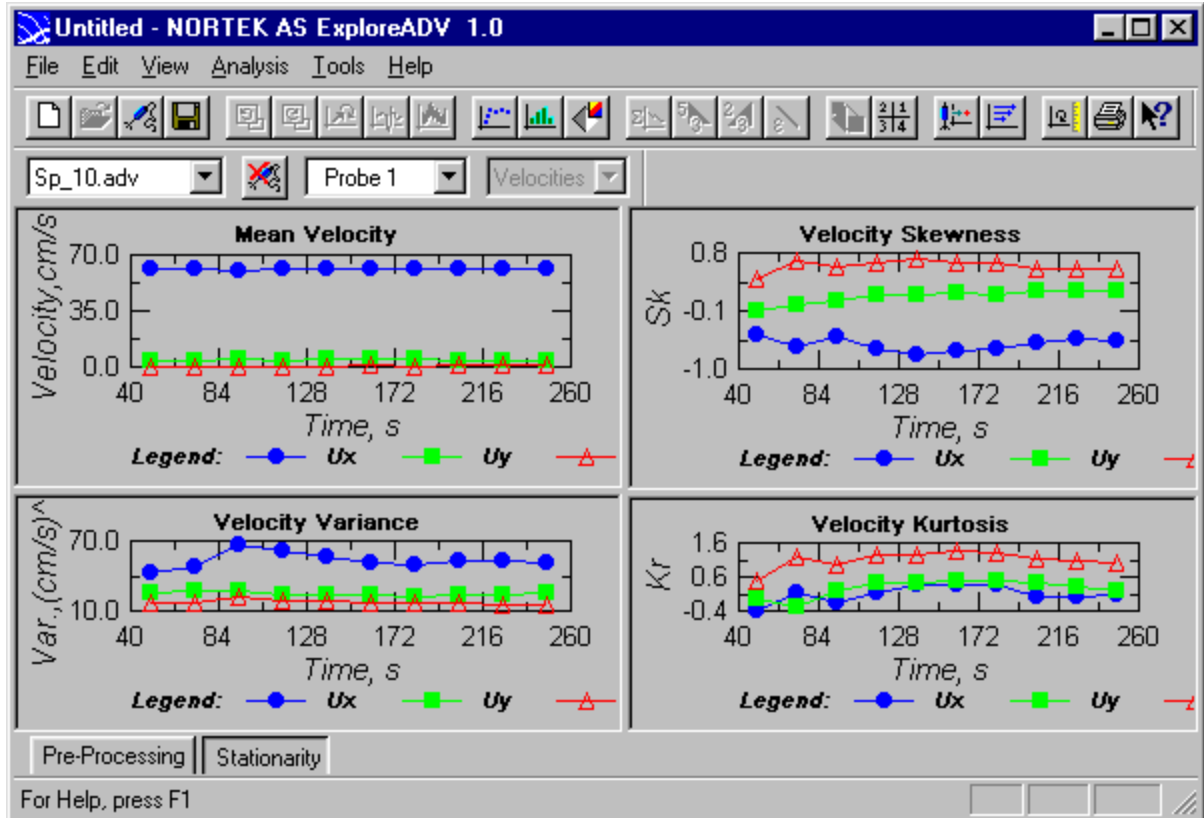


Figure 4 Analysis of univariate distributions and their comparison with gaussian curves is shown here.

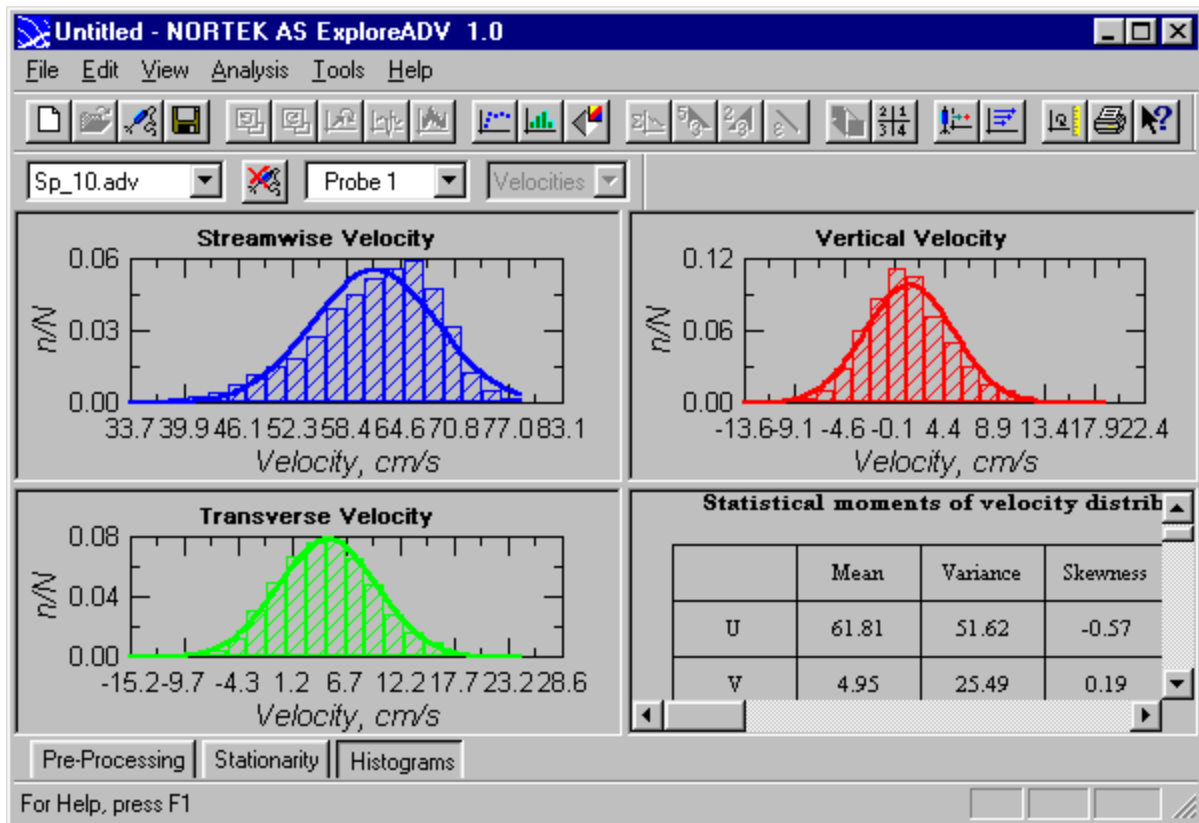


Figure 5 This figure illustrates the spectral analysis procedure. You can see the triangles with $-5/3$ and $2/3$ slopes on spectra and structure functions plots. We can assume about turbulence anisotropy for frequencies higher than 0.3 Hz.

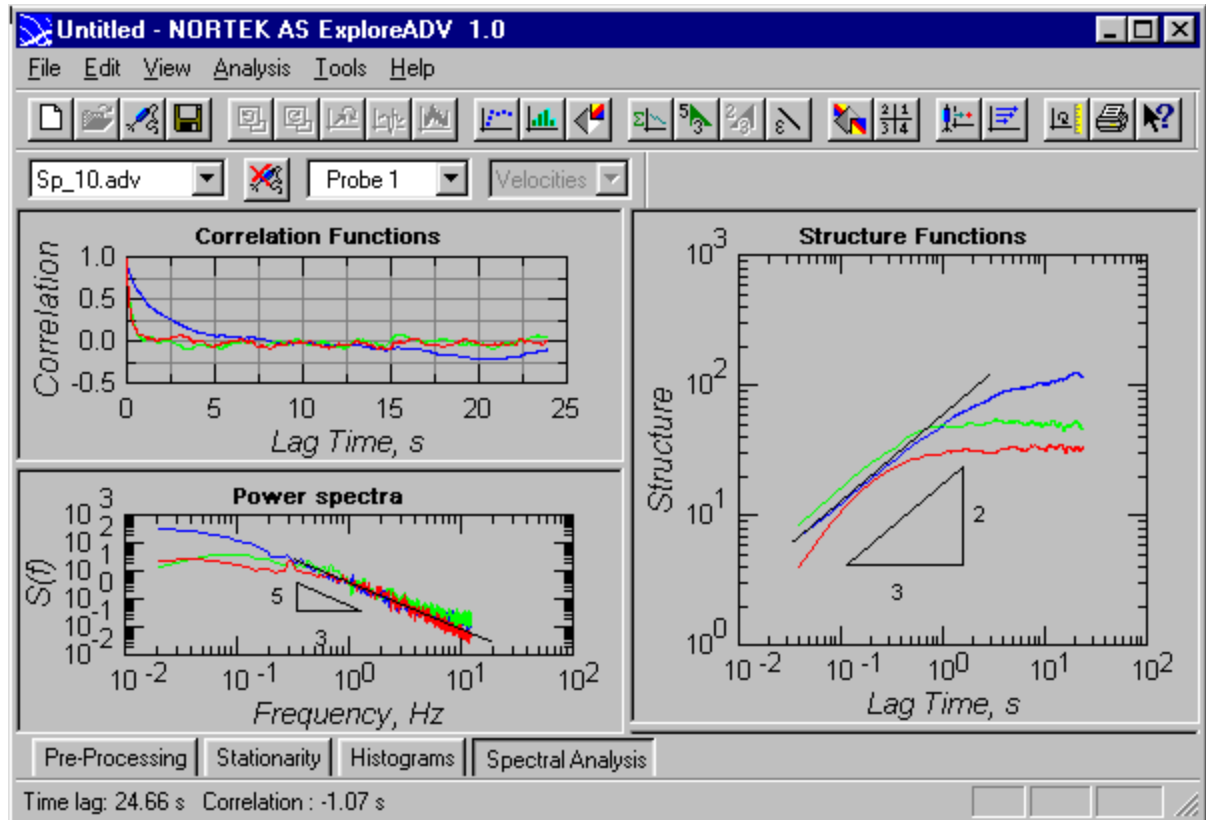


Figure 6 The results of cross-spectral analysis are presented in this figure. Cross-correlation function indicates the relatively high correlation between streamwise and vertical velocity components. The coherence function also has maximum value at 0.3Hz that corresponds to the spatial scale about 1.8 m (the river depth is 1.66m). The phase difference between streamwise and vertical velocities at 0.3 Hz is 180 degrees. Note that phase shift 180 degrees is typical for ejection and sweep events (see Quadrants Analysis and Averaging).

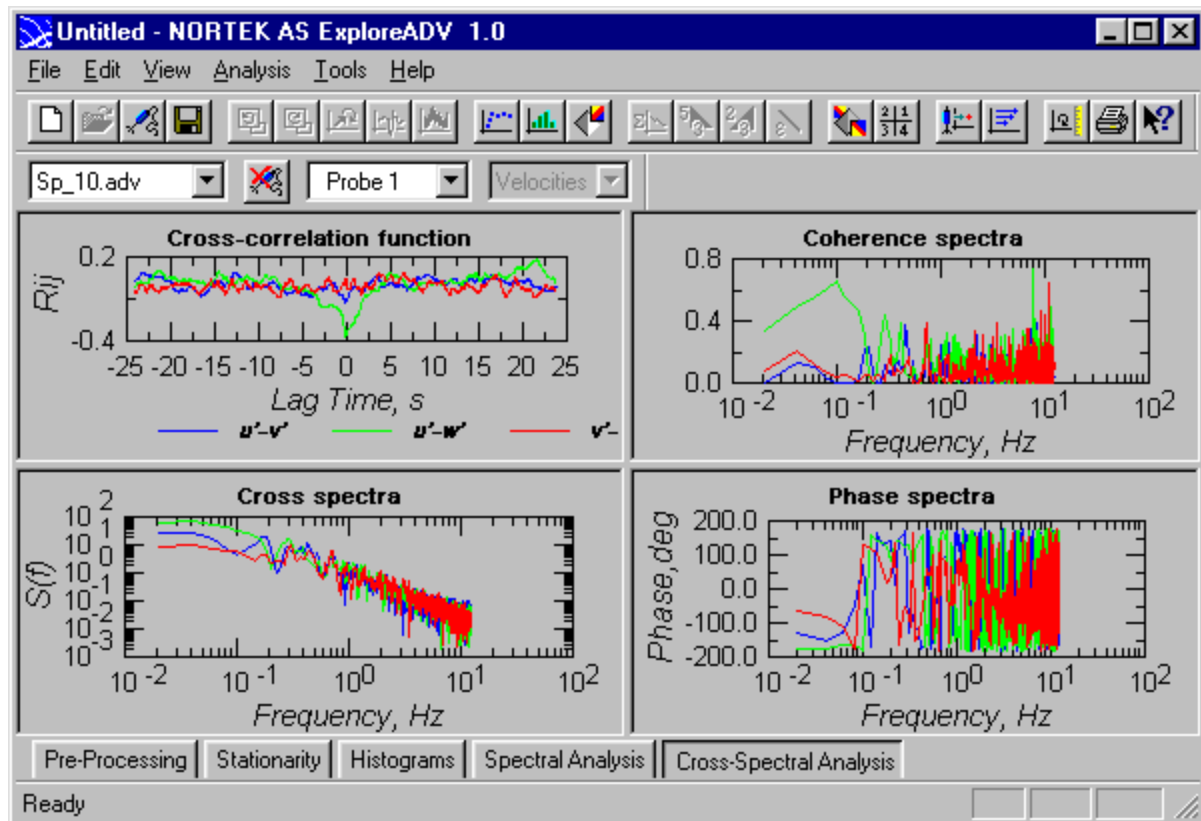


Figure 7 Figure shows some results of conditional quadrants analysis and averaging procedure. The contribution rates plot indicates the dominance of the second and fourth quadrants or ejection/sweep events. The spatial scale of sweep is 1.5-1.7 m, that is in good agreement with the results of cross-analysis.

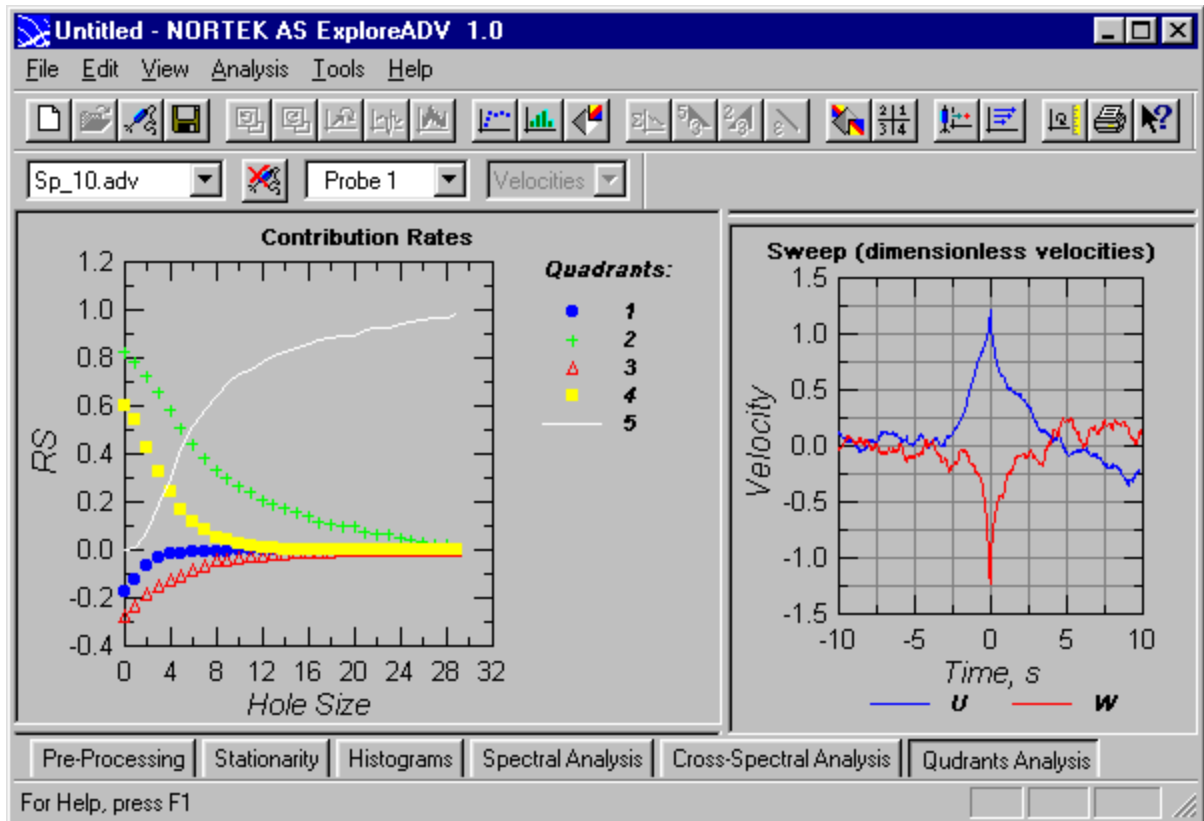


Figure 8 The river's cross section and mean velocity vector (note that cross-section is just an example and the river depths on figure does not correspond to the Spree river depth).

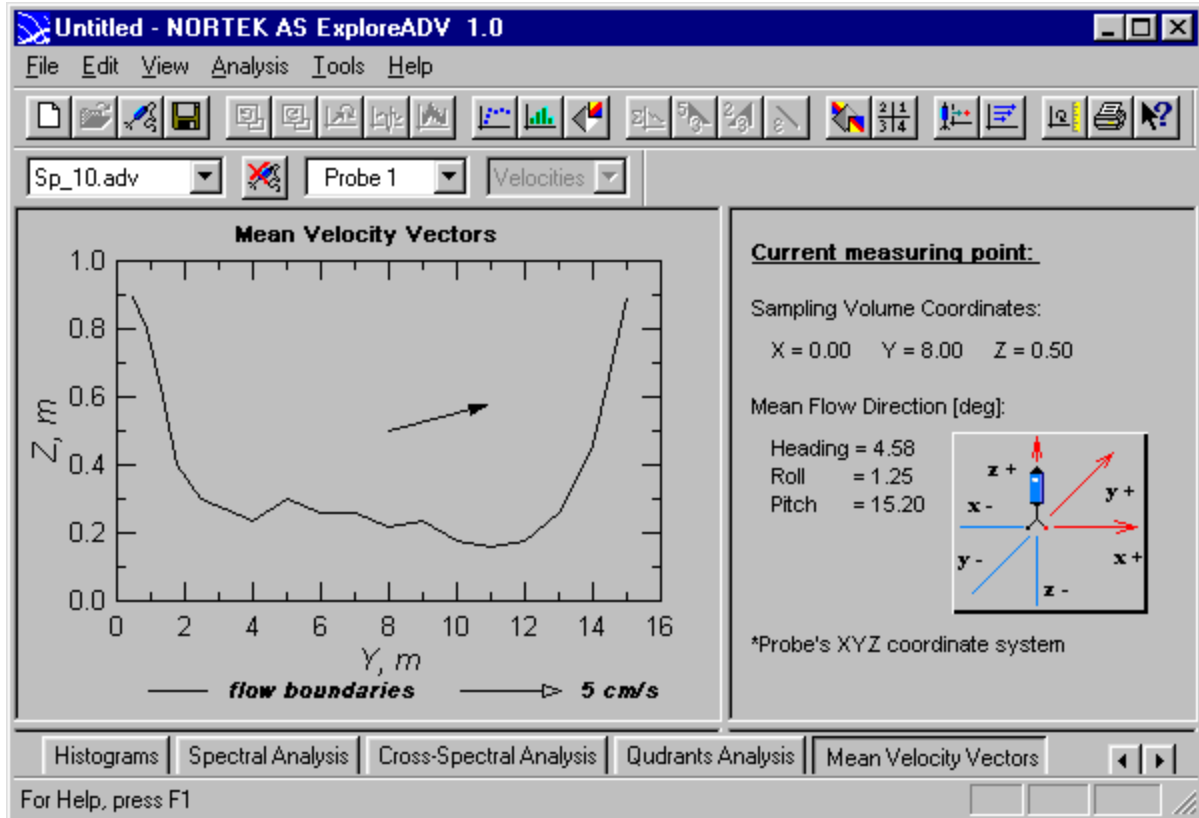


Figure 9 The filtered time series (Tukey's low-pass filter with 1s half width is applied).

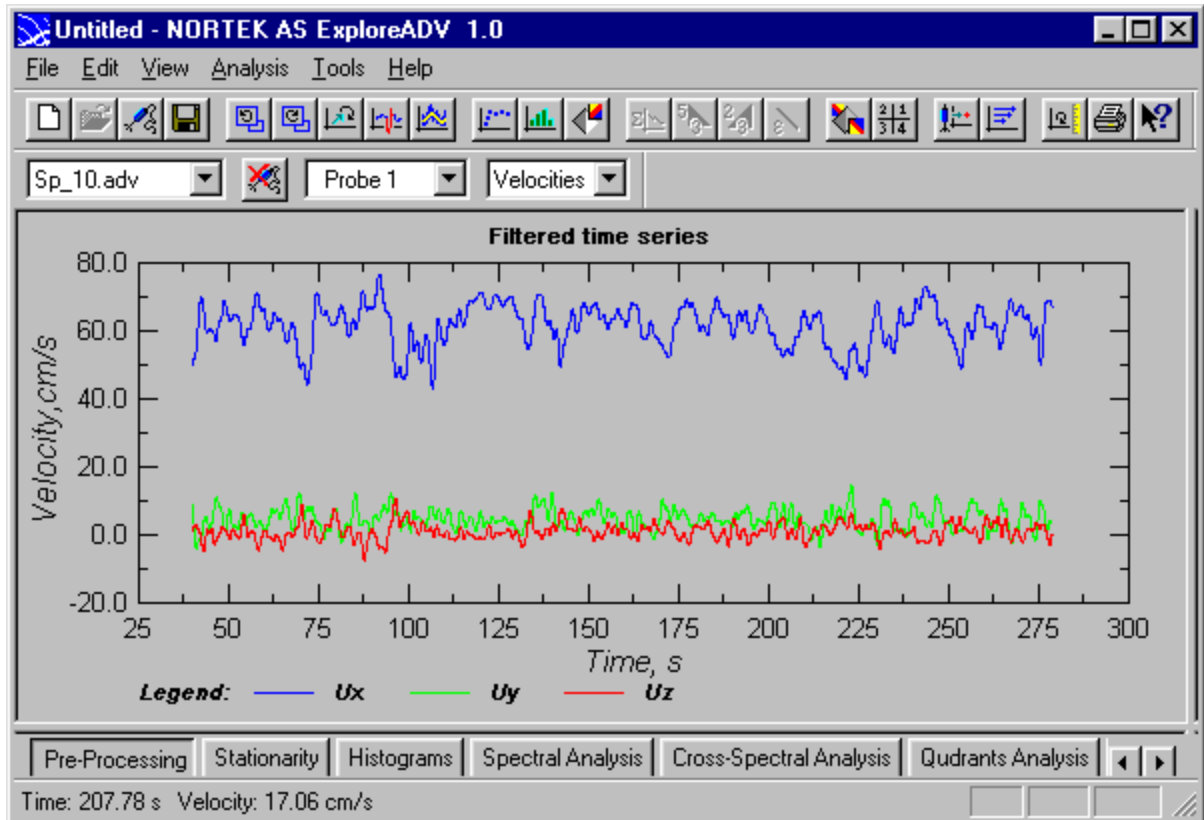
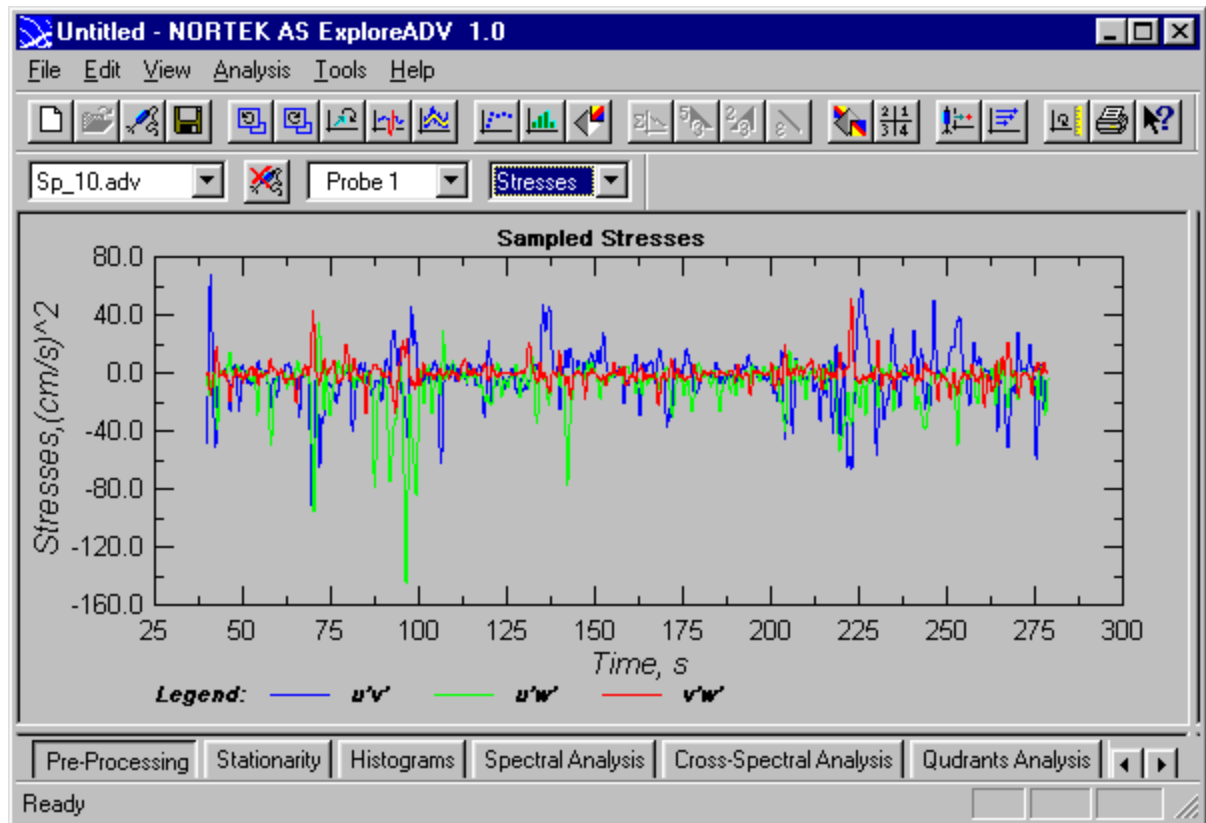


Figure 10 Stresses time series (filtered data).

5 Tips of field mounting

5.1 Tripod for Small and Medium Rivers

This tripod is designed for flows with depth smaller than 2.0 m. Contains an elevating element with a bubble level for probe's orienting. Prevents the probe from flow induced vibration. Enables precise positioning of the device.

Designed by Dr. A. Sukhodolov, Nortek AS (*Sukhodolov et al., 1998*).



5.2 Platform for Small Rivers

This platform is designed for flows with depth smaller than 0.7m. Contains an elevating element with a bubble level for probe's orienting. Prevents the probe from flow induced vibration. Enables precise positioning of the device.

Designed by Dr. A. Sukhodolov, Nortek AS.



5.3 Wading Rod for Small Rivers

Wading Rod for Small Rivers

This wading rod is designed for flows with depth smaller than 0.7m and velocity lower than 1m/s. Horizontally can be oriented with tag lines and vertically with a bubble level.

Designed by Prof. Bruce L. Rhoads, University of Illinois at Urbana-Champaign.



5.4 Universal Platform for Medium and Large Rivers

Universal Platform for Medium and Large Rivers

This platform is designed for flows with depth smaller than 7.0 m. Floating elements enables the device to be easily moved on the water surface. Contains an elevating element with a bubble level for probe's orienting. Prevents the probe from flow induced vibration. Enables precise positioning of the device.

Designed by Dr. A. Sukhodolov, Nortek AS.

