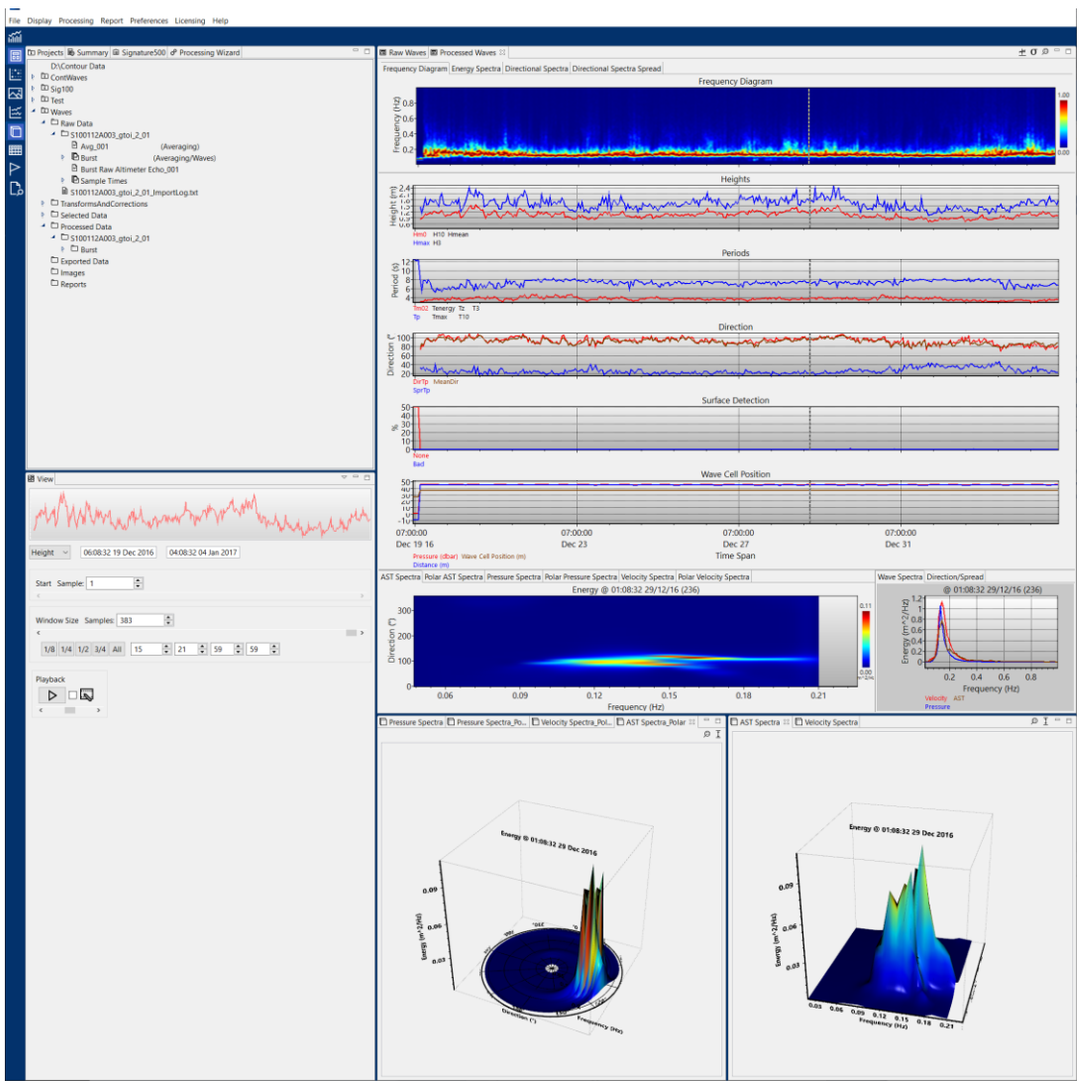
oceanillumination
CONNECTING THE DOTS

OCEAN CONTOUR

Acoustic Doppler Data Processing



SOFTWARE USERS GUIDE

2021

OCEAN CONTOUR

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Chapter 1
Introduction

Ocean Contour is a software application used to display and analyse data from acoustic Doppler current profiling systems.

Installation

PDF versions of the manual will be copied into the installation directory when the software is installed.

Ocean Contour uses a built-in Java Runtime Environment for its execution environment.

Windows

To install the software, double click on the Contour_setup.exe executable contained in the zip file. This will install the application into the given installation directory and create a shortcut to the application on the desktop. Double clicking on the shortcut will start the application.

When first running the application, please ensure that the application is allowed to access the internet. Blocking the application will prevent the automated licensing functionality from operating resulting in e-mail activation being used.

Mac OS X

To install the application, double click on the zip file to extract the OceanContour application and copy the application to the Applications directory.

Linux

Open the zip file and copy the OceanContour directory into the location from which it will be executed.

Contour has been tested using Ubuntu 16.04.04. Other releases may have compatibility problems with either the windows manager or memory settings (causing "out of memory" exceptions). On Ubuntu, it is necessary to disable the menu proxy functionality in order to get the **Preferences** menu to work. This is achieved by clearing the UBUNTU_MENUPROXY environment variable before starting Ocean Contour.

- ➔ export UBUNTU_MENUPROXY=0
- ➔ ./OceanContour

The Wayland or Broadway window manager back ends are incompatible with Ocean Contour because of known problems with JavaFX. Users should select the XOrg window manager when logging in.

Licensed Operation

Without a license, Contour acts as a data viewer, allowing data files to be opened and viewed but all processing, 3D plots, report generation, plot output and recording are disabled.

Processing operations require a license to be enabled. When purchased, a license identification number and key are provided. These should be entered using **License: Activation**.

A Basic license allows a user to do co-ordinate transforms, simplified QA/QC and averaging. A basic single user license allows a single activation to take place (i.e. it can only be used on one computer at a time).

A Professional license enables more advanced processing capabilities of the software. These include: wave processing, batch processing, processing wizard, compass re-calibration, bin mapping, subsurface mount draw-down depth correction, fish filtering (an experimental feature), report generation, 3D data plots, 2D vector (stick line) plots. A single user professional license allows up to three activations to take place so that the software can be used, for example, on both a field laptop and an office desktop computer at the same time.

Deactivating a license (**License: Deactivate**) removes the license from the computer and increases the allowed activation count by one. This, for example, allows a license to be transferred from an old computer to a new computer.

A site license allows a large number of activations. Activations are tracked and an excessive number of activations may result in the user key being changed. If this happens, contact support@oceanillumination.com for the new key.

If the computer can't connect with the automated license server, an attempt will be made to e-mail the activation request instead. Failing that (if, for example, the computer is not connected to the Internet), an activation file is created that can be copied and e-mailed to licenserequest@oceanillumination.com. A license file will then be e-mailed back that can be read using **License: Read License File**.

System Requirements

- 2 GHz x86 based host machine (minimum dual-core, quad-core recommended).
- Windows 7, Windows 8, Windows 10, Mac OS X (El Capitain and Sierra), Linux 4.x
- 8 GB of RAM (16 GB or higher recommended)
- Minimum display resolution of 1920x1080. A higher resolution is recommended.
- Approximately 325MB of disk space is required to store the application and JRE.
    - Data files and data file processing can consume many gigabytes of disk space.

Memory Usage

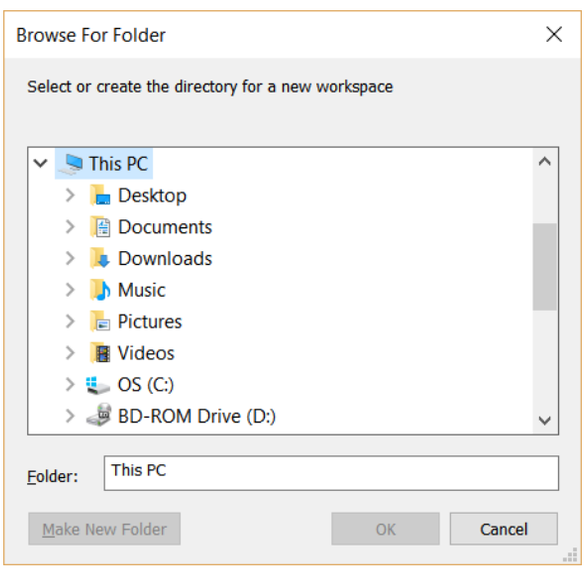
Given the large sizes of data files that may be collected, Ocean Contour can use a significant amount of memory, especially during the import phase. If the import of a data file appears to stall without any progress showing on the progress bar or a low memory or critical memory warning is shown in the view panel, the likely issue is an over allocation of memory resulting in memory being swapped to disk. A complete application crash with an out of memory log may also occur during import. If this happens, the import should be halted (and application forced to stop) and a smaller memory allocation factor selected (see the section on **Import File Sizing**).

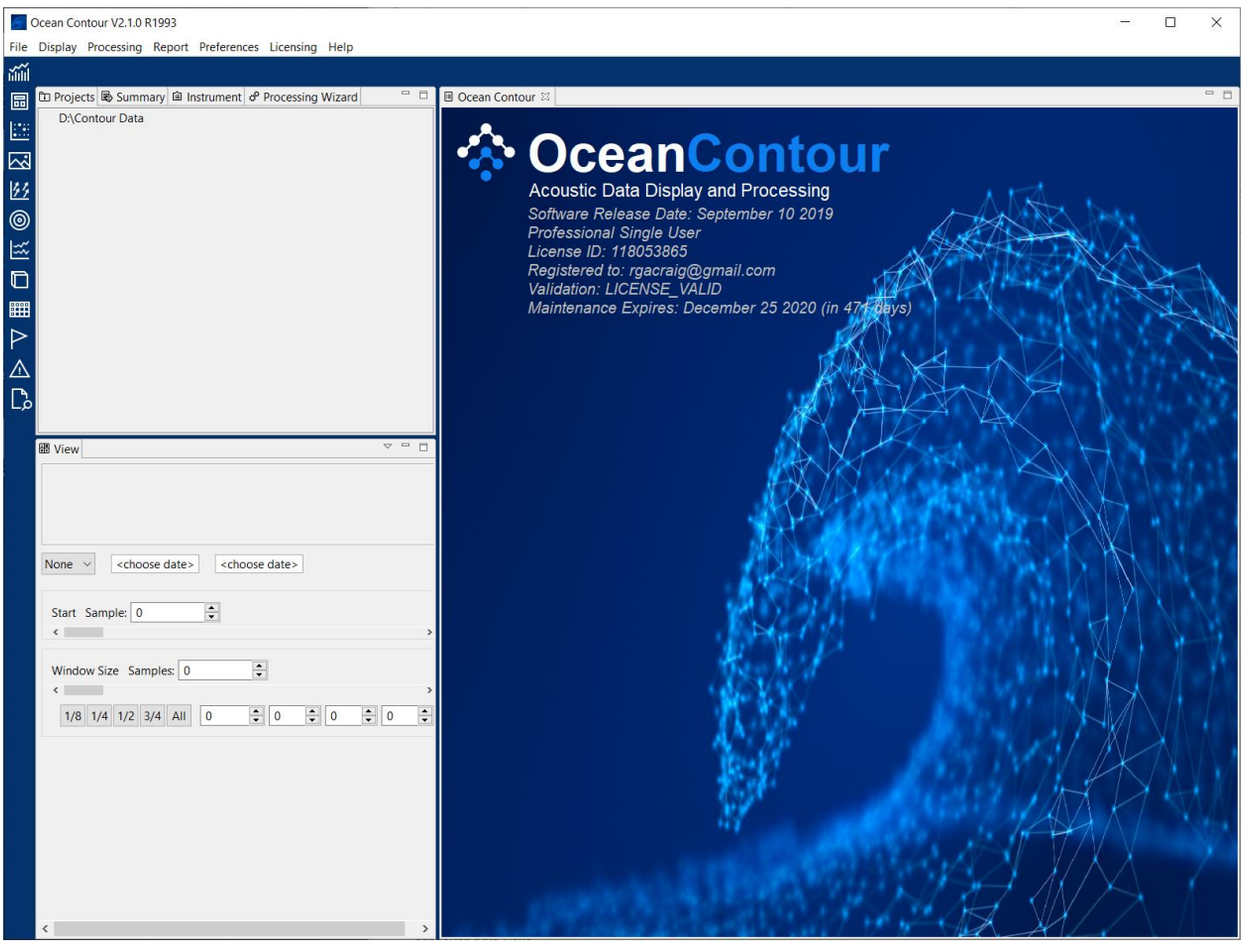
Supported File Types

Ocean Contour directly imports files created by Nortek's MIDAS software (.NTK files) and Signature AD2CP raw data files.

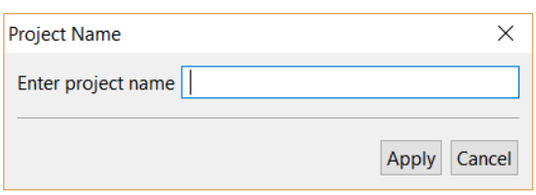
Getting Started

Double clicking on the Ocean Contour shortcut will start the application. A prompt will be displayed to select a directory for project data to be stored (the “workspace”). A new folder can be used by clicking on the “Make new Folder” button and then selecting the folder after it has been created and renamed. Ocean Contour will use this directory to store all projects and project related data. Once a folder has been selected, the application will then start.



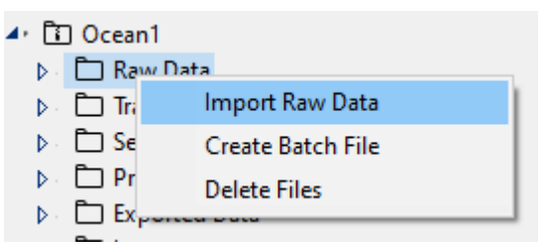


To import new data, select **File: New Project** and enter a name for a project to be created.

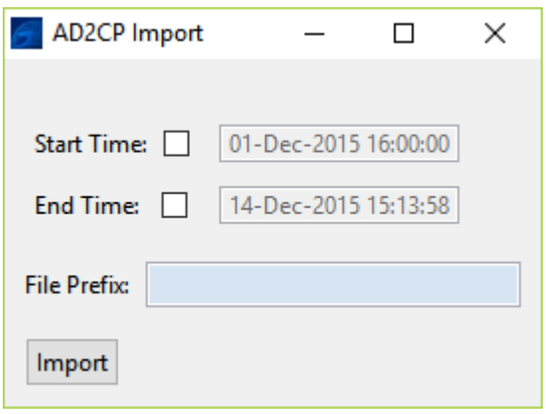


Pressing **Apply** creates the project and brings up a file selection window to choose the raw data file(s) that are to be imported into the project.

Note that after the project has been created, raw data can be imported into the project by right clicking on the **Raw Data** or top level project folder.

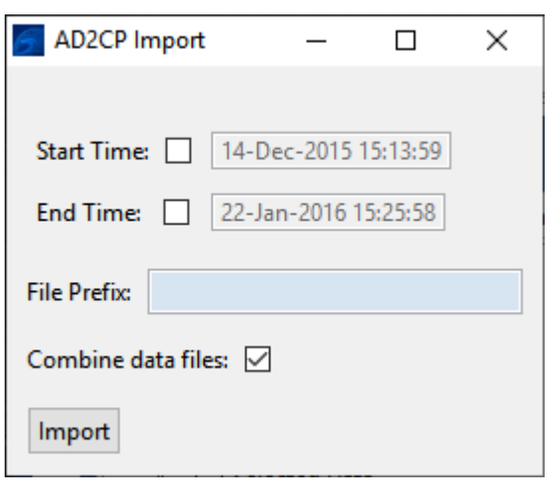


One or more raw data files can be selected for import. If multiple files are selected, the software will check for identical instrument configurations within the files. An import



screen is displayed.

If no options are selected the entire file will be imported. If either the start time or end time options are enabled, the import will start / end at the indicated time. Enabling a start or end time also allows a file prefix to be specified so that the imported files can be stored separately from a full import.



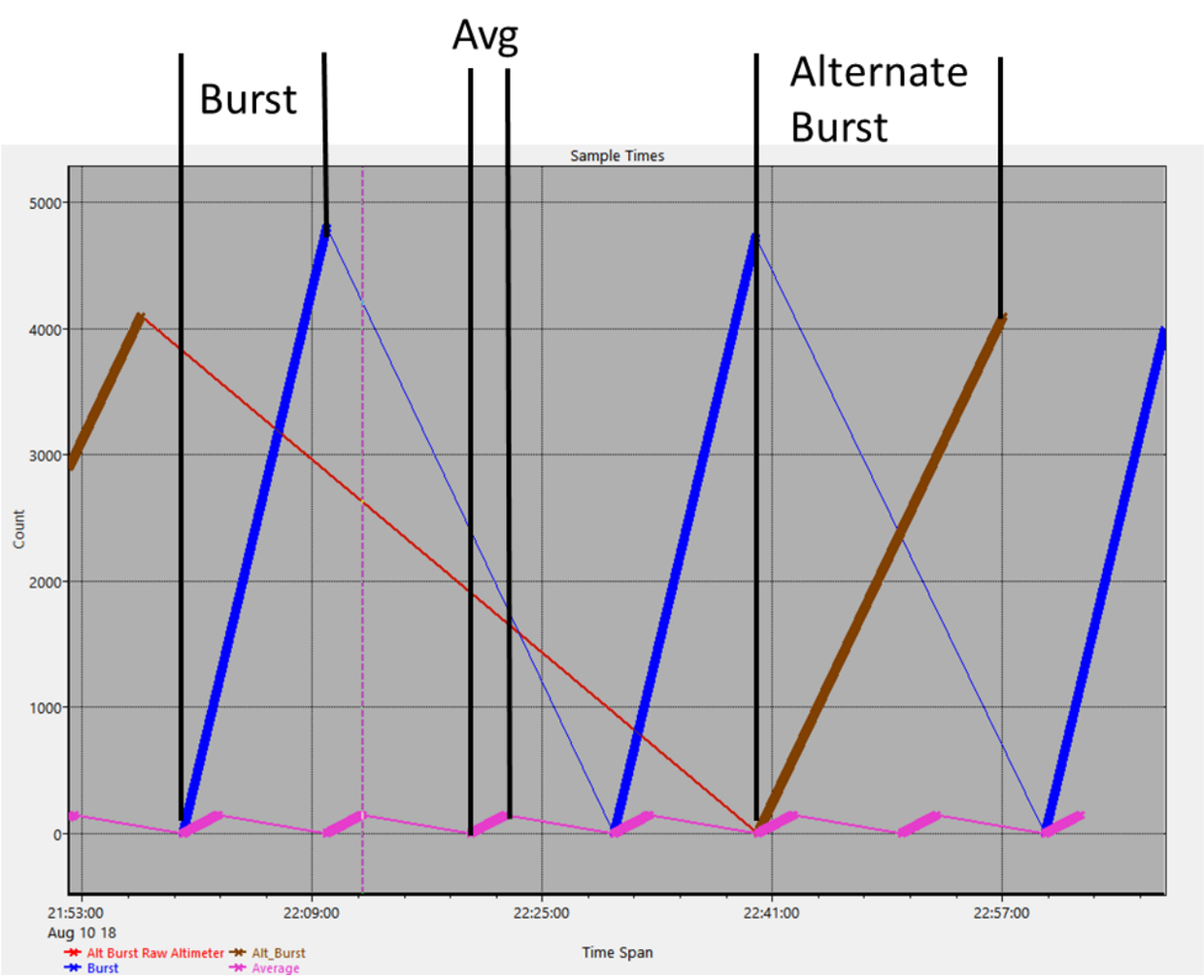
If multiple files are selected that have identical configuration and contiguous end times / start times separated by less than 12 hours, a **Combine data files** option is included. Raw files which are combined are imported as one continuous data stream, allowing continuity of processing for the entire data set.

Raw AD2CP files contain one or more *data streams.* A data stream is considered to be a collection of data records that have the same time base (i.e. sampling of the data occurs at the same absolute time and rate for all data within the data stream). For example, if the instrument has been configured to collect burst data at 16 Hz and average data at 1 Hz, two data streams are created ("Burst" and "Avg"). Data streams are stored in separate files when imported. For a complete description of all of the data

fields found in a data stream, please refer to the AD2CP System Integrator's Guide available online from Nortek.

For users interested in the overall collection timing implemented in the raw data file, a **Sample Times** data file is created as part of the import process. This data file contains all of the time stamped ensemble counts for every sample collected (data with no ensemble counts produce a count of -1). Generally speaking, data is only collected in the region where the slope of the line is positive (i.e. the ensemble count is increasing).

This data is best viewed with the plot symbol enabled to show each sample time. The plot symbol can be enabled by clicking on the appropriate line in the plot legend to toggle the display between line, line + symbol, invisible. In order for the plot symbols to appear, the number of points in the line must be less than 15000. This restriction prevents the plot drawing time from becoming too long. The number of points in each line can be reduced by zooming in on the time axis or by reducing the window size in the view panel.



In the above plot, the Avg and Alternate Avg data have been combined into a single data stream by Contour. From a configuration point of view, the Alternate Avg data starts when the alternate burst starts and completes befort the next primary burst starts.

This **Sample Times** data is foremost an educational and debugging aid. It shows how each data stream is sampled in real-time relative to the other data streams and may help to locate timing issues associated with complex data collection configurations.

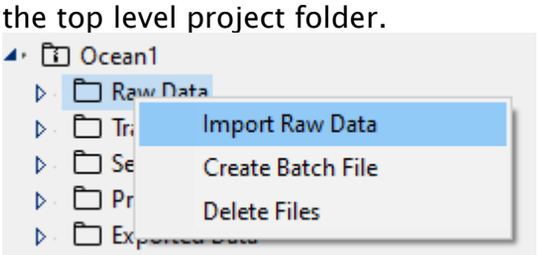
The import process creates two file types. Time series files (OCTS extension) contain the actual converted data from the import process. Depending upon the size of the raw file(s) being imported, one or more time series files may be created per data stream. If more than one time series files is created, a segment file (OCSEG extension) is created to manage all of the time series files for that data stream. Only one time series file will be stored in internal memory at any one time. The size of the time series files can be controlled by the user (see **Preferences**: **Signature Data Import**). This is important for low-end computers where large data files may become unmanageable due to CPU or memory overload. Note that end stage processing (e.g. averaging) typically stores the final processed results in a single OCTS data file.

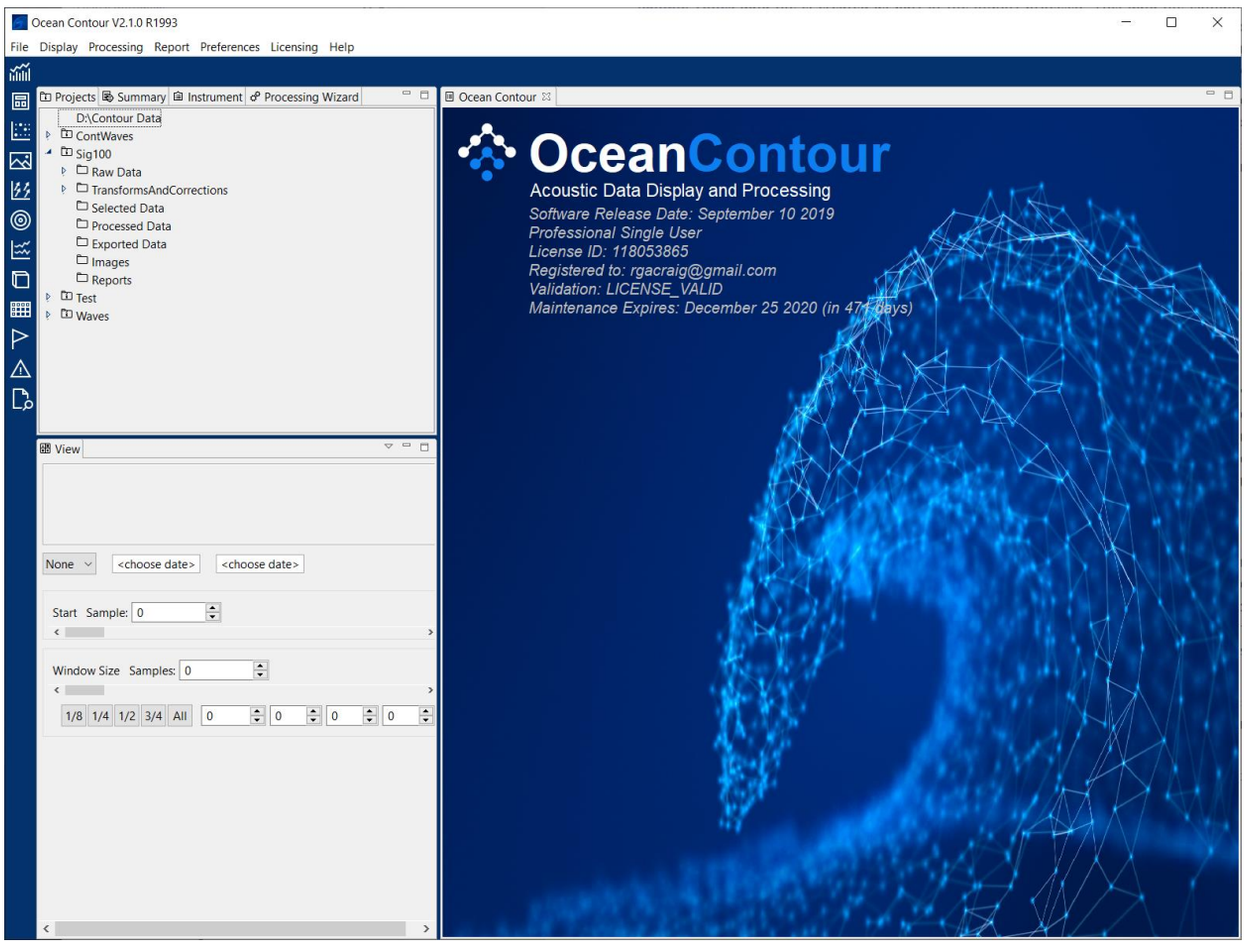
Raw AD2CP files can contain data from multiple data collection runs (either spaced in time or with different configurations). If a large time gap, a large data gap (adjustable from the **Import Preferences** menu) or an updated configuration string is found between data records in the raw file, Contour will complete writing the current import data stream and then start a new folder with a **_Cfg#** postfix added to the name. Warning messages are displayed at the end of the import process when this happens.

In addition to the imported data, a log file (xxx_ImportLog.txt). This file contains information generated during the raw data import. This include information on missing data samples, unexpected measurement gaps, which files were selected, etc.

Once the raw data import process is complete, the project is shown in the Project Navigator view along with the associated data files.

More data can be imported to the project by right-clicking on the **Raw Data** folder or the top level project folder.





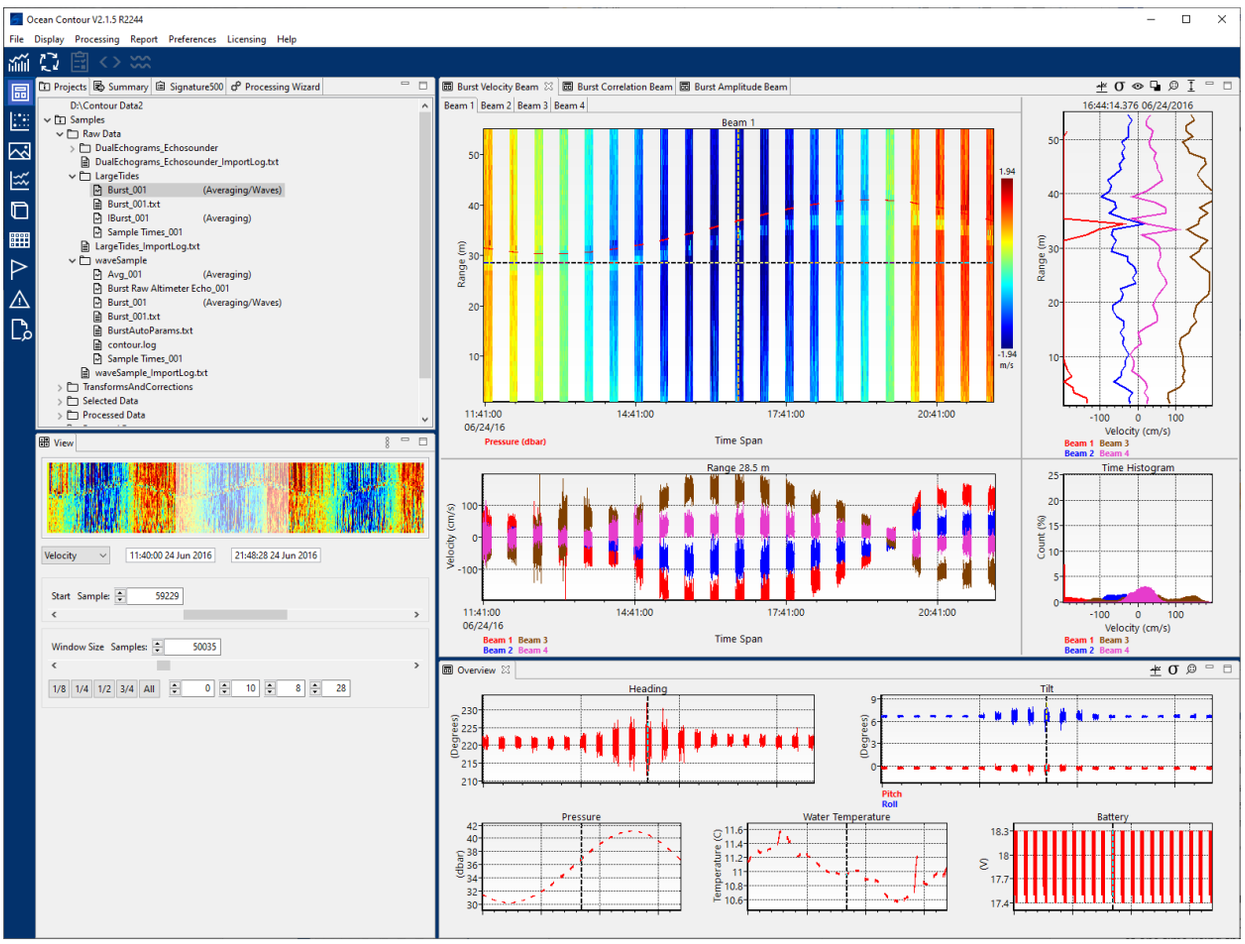
Right clicking on a data file allows the data to be exported to Matlab or NetCDF format. Exported data is saved in the **Exported Data** folder.

Data is saved in sub-folders named using the import file name so multiple file imports will produce multiple sub-folders in the raw data folder. A flat file system (individual files saved using the name of the raw file) can be created by disabling the **Signature Data Import: Create data subfolders** option in the **Preferences** menu.

In addition to the file name, end stage processing capabilties for each file are displayed (Averaging or Waves). These capabilities are dependent upon the licensed featuers in the software and the contents of the data file.

Data files are opened by double clicking on the icon. Both time series files and segment files can be opened within Ocean Contour. Opening a segment file opens the first time series file in the collection. It is then possible to advance through the remaining files by using the **File Segment Selector** in the **View Settings** window.

The default view shown when a file is opened is the **Data Overview.** This shows contour images for all of the profiled data as well as profile plots, time series plots, time series histograms and other pertinent time series information (such as batteries and heading/tilt if present). The horizontal / vertical cursor in the images are used to control the cell / time slot displayed in the time or profile plots.



The Profile Display Controls  control the display view. These buttons: turn on/off the dashed cursor lines and statistical information on the line plots; remove any zoom factor (expands scales to the full window); and control the colour scale and axis plot limits for the plots displayed. Zooming the image (by either double clicking on the axis and setting the limits or clicking on the axis and using the mouse wheel) will cause a zoom in all of the displayed data, making it easy to view a single event in all data frames.

The window of data displayed within the data file (as shown by the highlighted area in the overview image) is controlled by the View Settings panel (bottom left). Moving the Start Time slider changes the start time position of the window and changing the Time Span slider changes the length of time used for the window display.

Multiple data views (including the instrument configuration settings) can be displayed at one time using the Display menu.

The Processing menu (or associated toolbar buttons ) is used to transition between processing perspectives. Current perspectives include Display, Velocity Transforms and Correction, Echo Correction, Data Selection, Averaging and Wave Processing. Note that Contour enforces a sequential workflow

where all steps must be completed in order. The highlighted toolbar icons indicate the next processing step that may be completed in the sequence. For example, to enable the averaging stage, the transforms / corrections stage and data selection stage must be completed first. Wave processing and transforms / corrections can be done immediately from the raw data file.

The **Report** option is used to create Microsoft Word™, PowerPoint™ reports or PNG image files using the data currently displayed in the **Display** perspective. Report files are saved in the **Reports** or **Images** folder.

The **Preference** option provides a means of changing default software settings (e.g. import file sizes).

The **Licensing** menu contains options for updating and requesting licenses.

The **Help** menu contains options for support, displaying the user manual, release notes, log files, and application version.

Time Series Files versus Segment Files

Data files are opened by double clicking on them. As noted, there are potentially two types of data files created upon import. Time series files (OCTS extension) contain the time series data. Only one time series file will be stored in internal memory at any one time. Depending upon the size of the raw file(s) being imported, one or more time series files may be created per data stream. If more than one time series files is created, a segment file (OCSEG extension) is created to manage all of the time series files for that data stream.

When working with data, in almost all cases, users should be working with the segment file if one is created. To open the segment file, double click on the segment file. This will open and display the first time series file in the data series. Other file segments can be displayed using the File Segment selection in the View panel.

It is important to note that the segment file acts as a container for all of the associated time series files. Processing is carried out consecutively on **all** the time series files in the segment file. The final stage of processing (e.g. averaging or wave parameter analysis) also usually reduces the data volume enough to fit within a single time series file. This allows the entire processed data set to be loaded into internal memoety and viewed. Note that this is *not* the same as “Batch Processing” in which data from different time series are processed using the same processing stages and parameters. For example, batch processing of individual time series files will not combine the results of contiguous time series files into a single data file when completed.

While each individual time series file can be opened by expanding the segment file view and double clicking on them, this is rarely done (or needed) in practice.

Chapter 2
Detailed Description

Main Menu Options

File

New Project

Creates a new project in the workspace

Add Existing Projects

Searches the current workspace for projects which were removed from the workspace but not deleted from disk. These projects can then be added back into the workspace view.

Recent Workspaces

Allows one of the last five most recently used workspaces to be opened. This provides a quick way to navigate between multiple workspaces. The currently opened workspace is displayed at the top of the Projects tab.

Change Workspace

Open a workspace not in the list of recent workspace.

Create Workspace

Creates a new workspace on the disk.

Close All Files

Closes all opened data files and removes them from internal memory.

Quit

Exits the application.

Display

Show

Selects the type of data view to be displayed. The options available will vary depending upon the active perspective. The Display perspective contains all possible views for a given data file. Show options are also presented in the Display toolbar on the left of the application. Views operate in "toggle" mode with the first click showing the view and the next click erasing it.

Select Data

Presents a list of all data elements that are contained within the currently opened data file. Un-ticking an element will prevent that data from being shown in an associated view. This selection is preserved so that the same data will be shown for a given data file every time that data file is opened.
This option is also presented in the Display toolbar.

Processing

This menu shows the available processing perspectives available for the currently opened data file, duplicating the functionality of the processing selection toolbar. It also contains an option to hide the processing toolbar, providing more vertical space for data views.

Note that processing stages must be completed sequentially. Only one processing stage is enabled at a time. The other possible stages for the data selected are shown, but are disabled. Completing and saving the data for the currently enabled stage automatically advances to the next stage.

Report

Creates Microsoft Word™, Power Point™ reports or image files using all currently displayed data view in the display mode. This option is only available in the Display Perspective.

Preferences

Default application settings including file sizing, plot parameters, 3D image parameters, exported image sizing, etc.

Licensing

Activate License

Sends hardware information to the license server for auto-generation of a suitable license key. Activating a license reduces the available activation count by one. If the server cannot be contacted, an e-mail activation request will be generated.

Deactivate License

Sends a deactivation request to the license server and deletes the license from the system. Deactivating a license increases the available license count by one allowing it to be transferred to a separate machine. If the server cannot be contacted, an e-mail deactivation request will be generated.

Read License

Reads the license file attached to an e-mail activation response.

Help

User Manual

This displays the software manual (this manual) in PDF format.

Guided Walk Through

Displays a slide deck showing an example processing session.

Release Notes

Displays the release notes for the current software.

Check for Updates

Checks the on-line software catalogue to see if new versions of the software are available.

Send Support File

Sends a support request e-mail to support@oceanillumination.com which includes relevant debug information.

Log Files

Displays run time log files for the application. These may useful for resolving any software bugs that may be encountered.

Clear Log Files

Clears the contents of the currently opened log files.

About

Displays build and license information for the application.

Display Perspective

The display perspective is used for general viewing of data and report generation. It consists of a number of panels, some of which are duplicated in other perspectives.

Data Display

The Data Display toolbar contains push button access to operations contained in the main Display menu. The contents of the toolbar is perspective dependent (not all perspectives support all views). Multiple pushes of the buttons toggle that particular data view on and off. Views which have been detached from the main application window will not toggle on and off.

Display an overview of the data in the file (profile data and selected ancillary plots).

 Display two-dimensional profile views (velocity, amplitude, etc.).

 Display two-dimensional contour image of profile views

 Display two dimensional vector image

 Display a rose plot of the maximum and mean speed data

 Display ancillary data plots (battery, water temperature, pressure, etc.)

 Display three dimensional profile view

 Display text view of the ancillary data changes as the vertical marker in the profile view is moved.

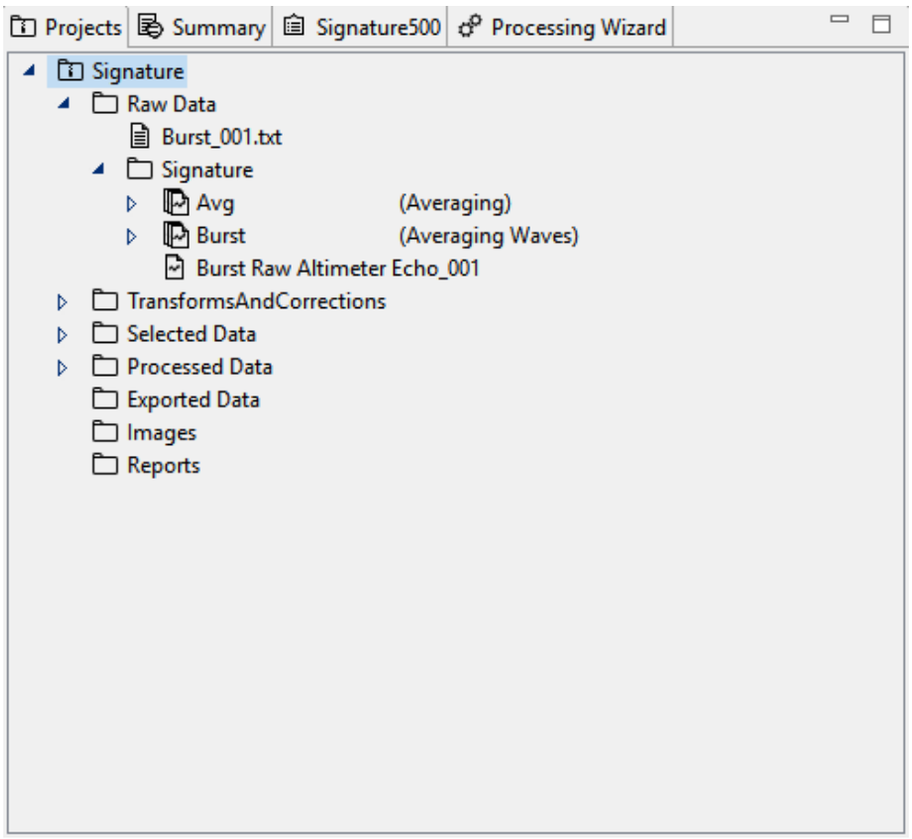
 Display status plot information

 Display error plot information

 Select data elements in data stream to display

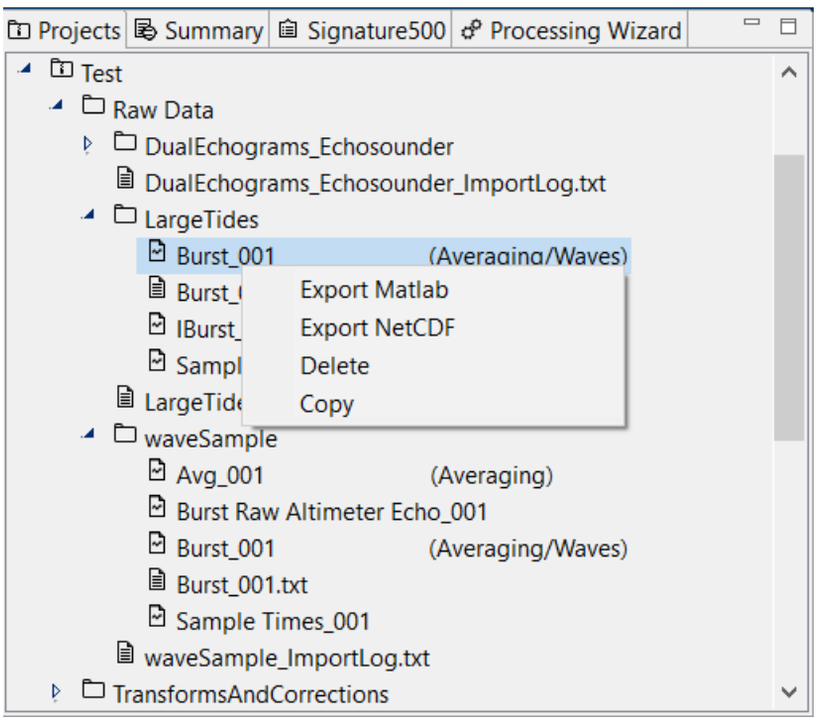
Project Panel

The Project Panel shows all of the projects within a workspace and all of the related files within the project.

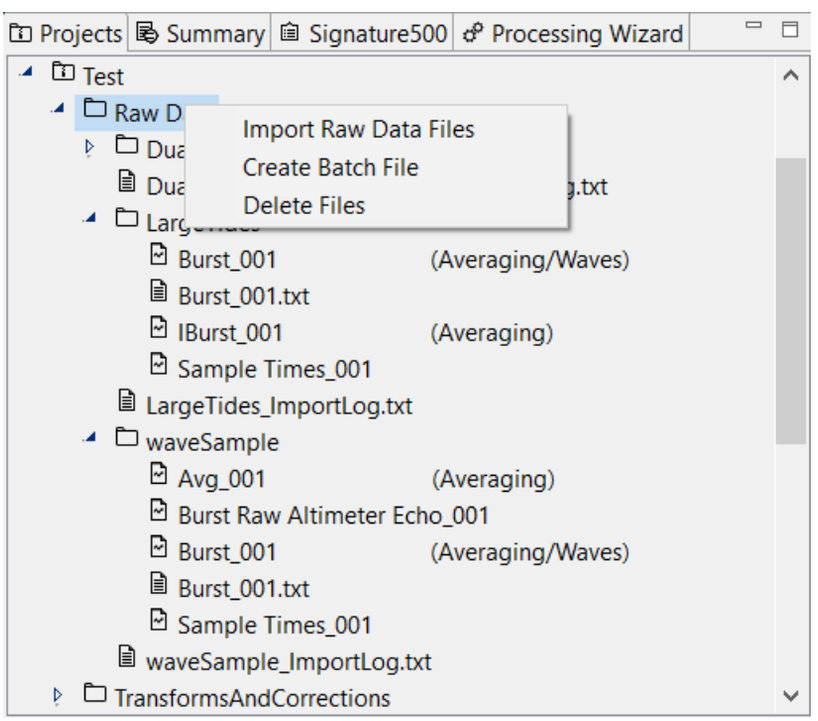


Files can be opened by double clicking (Contour files are opened in the application, other file are opened by the operating system). Right clicking on a file brings up file export or delete options.

Right clicking on the project allows the project to be removed (hidden), renamed or deleted. It also offers a **Create New Project** option and a **Refresh** option which re-reads the directory and shows files that may have been added to the project outside of the application. Multiple projects can be selected at one time for removal / deletion.



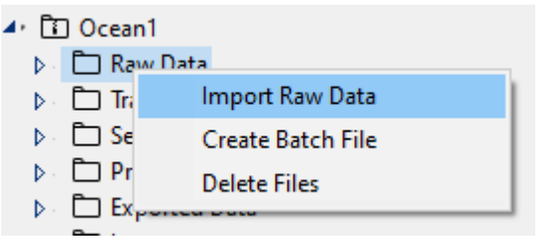
Right clicking on the Raw Data folder brings up options for importing a raw data file, deleting all files in the raw data directory, or creating a batch processing file.



Raw Data Import

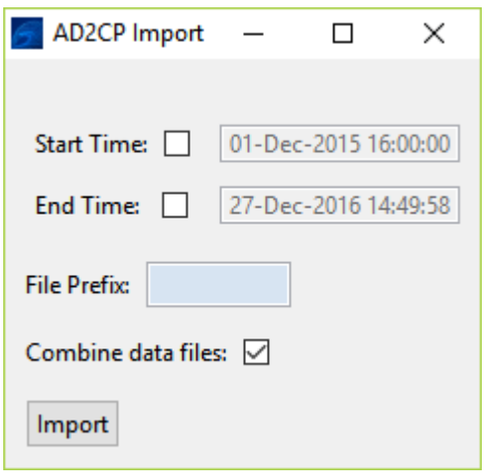
The raw data import process reads the raw data, checks it for consistency (e.g. missing data records) and converts it into the appropriate OCTS + OCSEG files for use by Ocean Contour. Ocean Contour currently imports files created by Nortek Scientific's MIDAS data collection software software (NTK files) and raw Signature AD2CP files.

Raw data can be imported by right clicking on either the **Raw Data** or top level project folder.



When importing Signature series data files, an import menu is displayed that allows the start and end times for import to be entered. This provides a means for importing a section of the raw data rather than the whole data file; useful, for example, for discarding data before the instrument was placed in the water and after it was retrieved. The times can also be used for producing subsets of data that contain events of interest (such as a storm). If a start or end time is enabled, a file prefix should also be entered. The prefix will be pre-pended to the file in order to distinguish it from other imported data files from the same raw data.

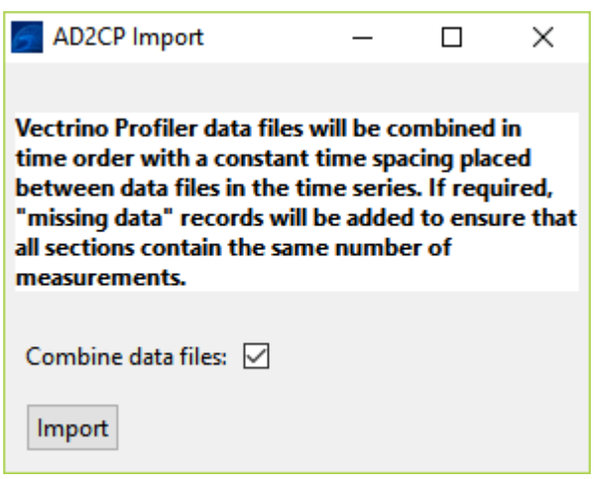
Raw AD2CP files can contain data from multiple data collection runs (either spaced in time or with different configurations). If a large time gap, a large data gap or an updated configuration string is found between data records in the raw file, Contour will complete writing the current import data stream and then start a new folder with a **_Cfg#** postfix added to the name. Warning messages are displayed at the end of the import process when this happens. The length of time / data gap size can be changed by adjusting the **Preferences: Signature Data Import: Split on Missing Measurement Interval Count** value. The default setting is to split the import if 5 measurement intervals are missing (this count is in hours if the data is acquired continuously). A hard limit of 24 hours is also applied to prevent the creation of large data files with no data in them.



Multiple files can be selected at one time for importing. For Signature series data files, when multiple files are selected the instrument configuration for the files are checked and files with the same configuration which are contiguous in time are grouped together (in time order). In this case, an option to "Combine data files" will be displayed. If this option is selected, the imported data will be grouped together to produce a series of contiguous data files that will be treated as a single unit by Ocean Contour.

When importing multiple NTK data files, if files with the same configuration are found, an option to "Combine data files" will also be shown.

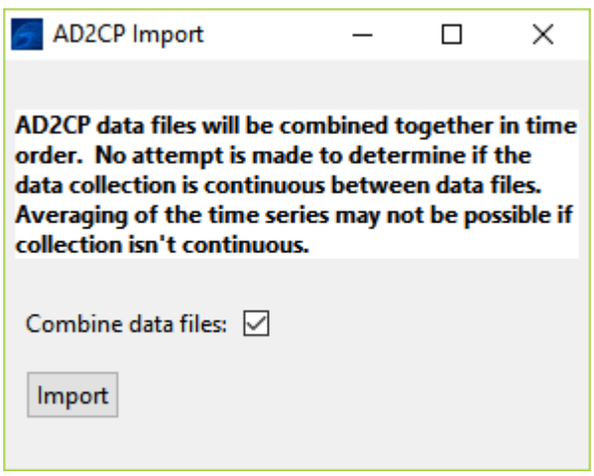
For Vectrino Profiler data, the following is displayed:



In many cases, Vectrino Profiler data is taken at either separate locations or heights at a location. Each data run is meant to correspond to a measurement of the conditions at that location. Importing multiple data files into a single data set is convenient in that it lets all the files be processed in an identical manner in one session. The import process also makes sure that all files have the same number of data records by adding "missing records" as required. Note that the data is treated as a single time series and

data displays do *not* account for the different positioning (in either location or height) of the individual data files.

For AD2CP NTK data files, the following is displayed:



AD2CP data files have absolute time stamps and those time stamps are used to sort the data files during import and for displaying the data.

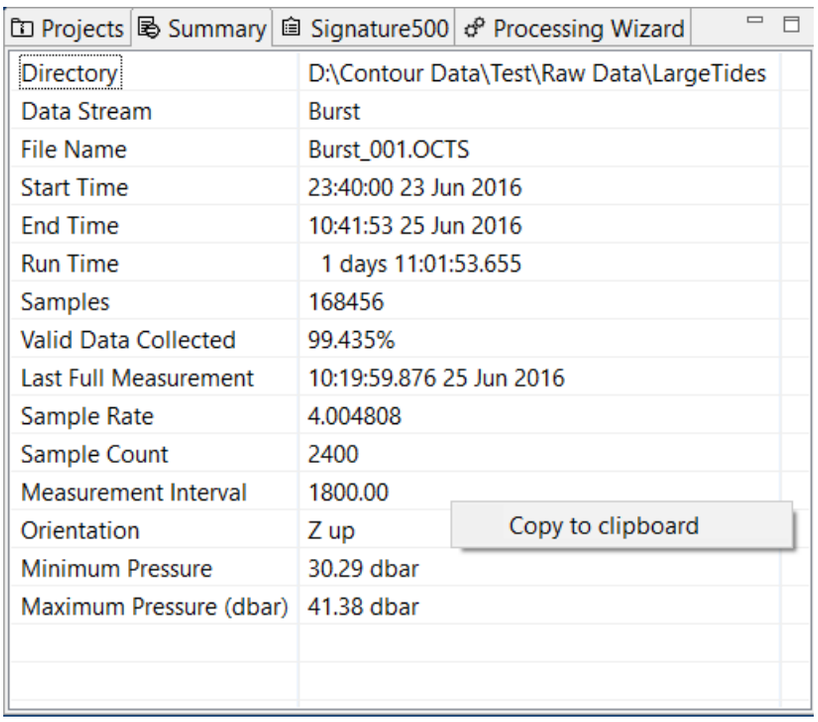
Import File Sizing

The size of the time series files should be correlated with the processing capabilities / physical memory available on the host computer. The default options assume that 8GB of RAM combined with a reasonably fast processor are in use. Displaying large files on a machine with less memory / under-powered CPU may result in significant slow-downs in operation or possible an application crash during import. In order to correct this behaviour, the **Preferences: Signature Data Import** menu option should be used to reduce the size of the OCTS file. The sizing factor can be chosen based upon the responsiveness of the system. Increasing the sizing factor results in larger OCTS file, meaning that more data can be made visible at one time at the expense of requiring longer times to process / display individual files. Decreasing the sizing factor results in smaller OCTS files, meaning that it takes less time to process / display the file but at the expense of more OCTS files being created with a smaller time window of data displayed per file.

Data Summary (Display)

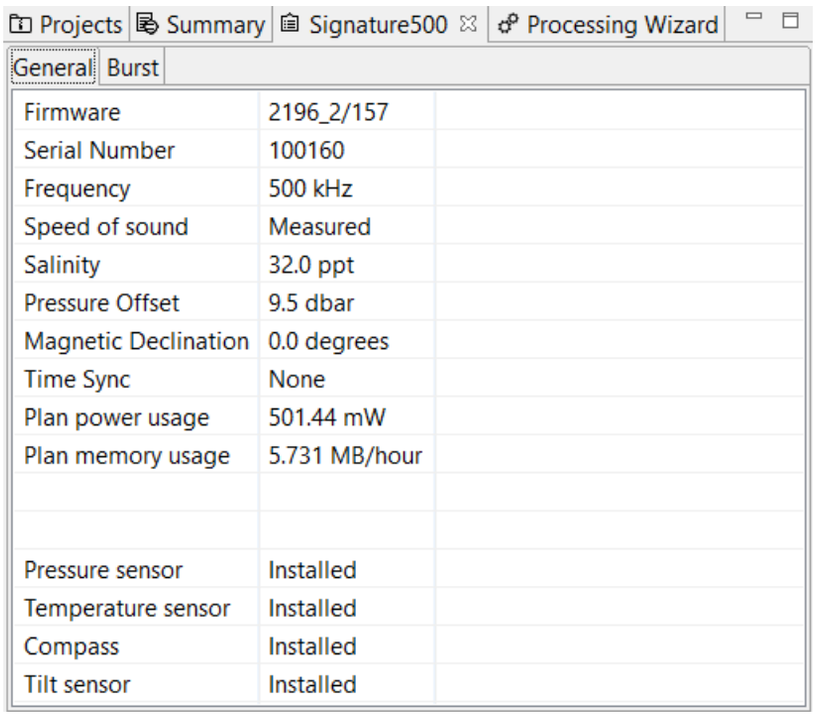
Provides detailed information about the data contained in the currently opened file.

The contents of the data summary table can be copied to the clipboard by right-clicking on the table



Instrument Configuration

Shows the instrument family and configuration used during data collection.

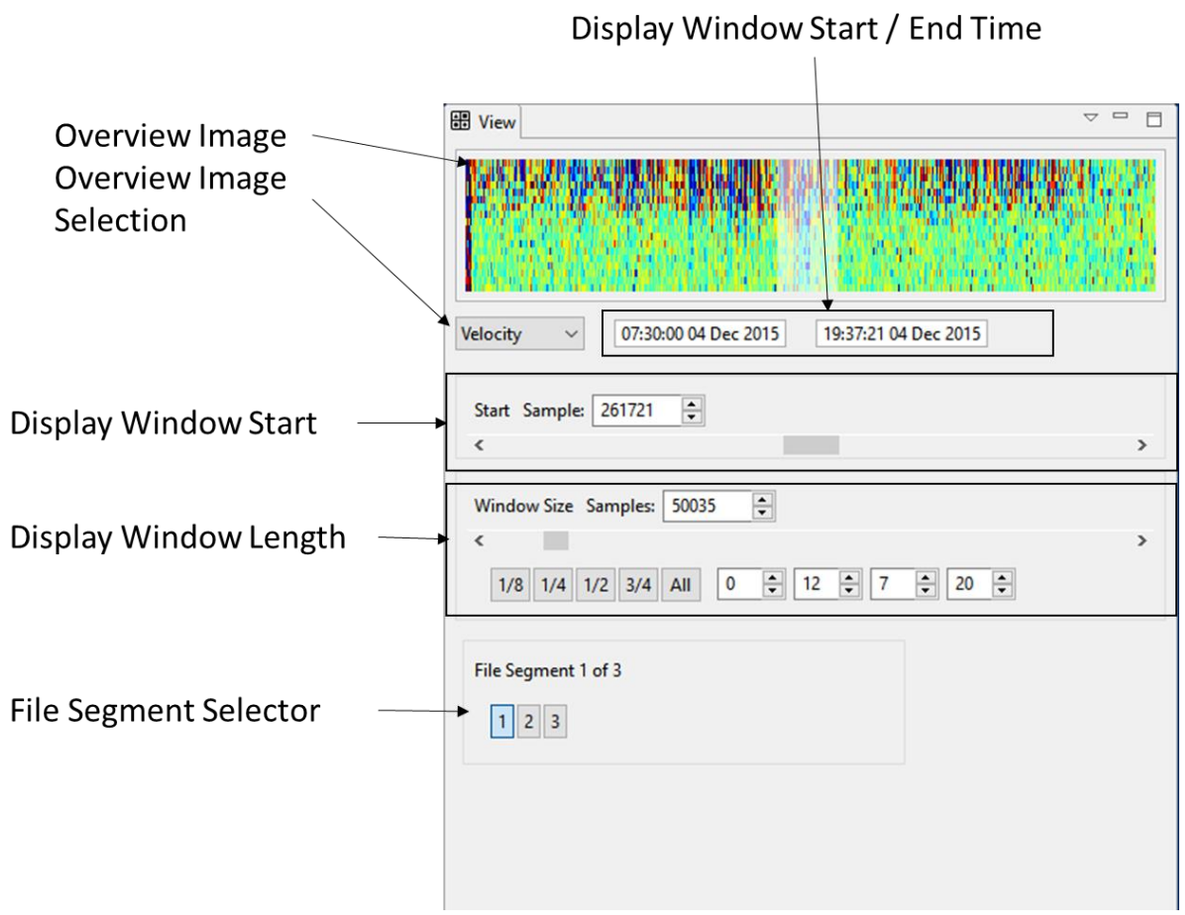


View Settings Panel

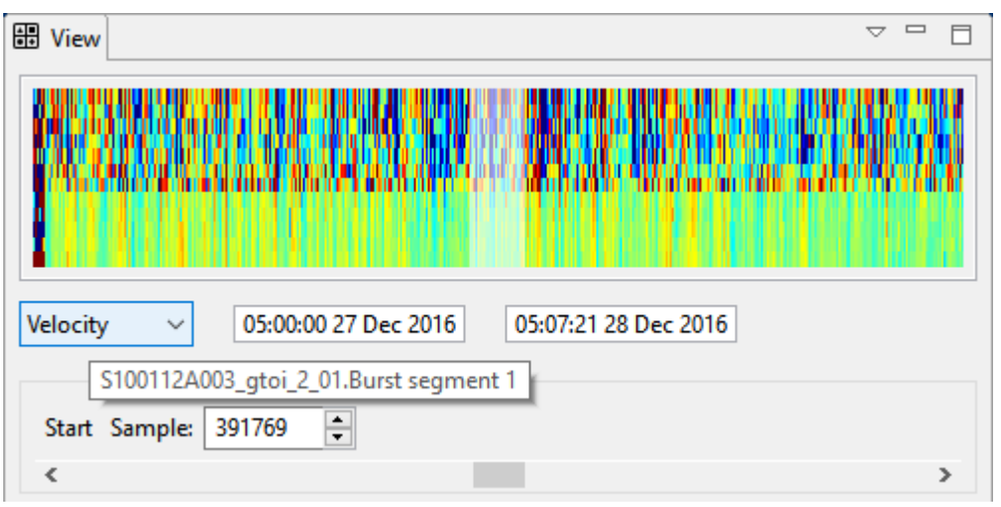
The View Settings panel shows an overview image of the data file currently opened with the current data window highlighted and provides tools to position the data window within the OCTS file. The available image selection choice is dependent upon the type of data in the file.

The start / end time parameters can be modified to change the start / end time of the data view. The Start Time slider controls the start position of the window and the length slider / buttons / inputs control the length of data (in time). If a segment file has been opened, the Data Segment buttons can be used to move between the individual time series files referenced by the segment file.

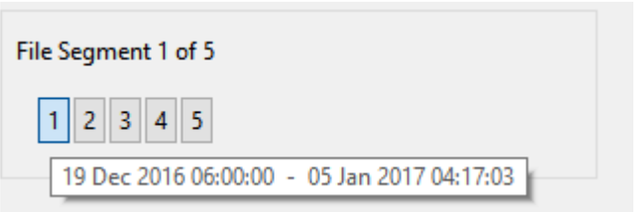
If the amount of memory used approaches the amount of physical memory available in the computer, the application may become unresponsive. If this should happen, a memory warning messages will be displayed. The user should then reduce the sizing factor used (in the **Preferences: Signature Data Import** menu) and re-import the data to correct this.



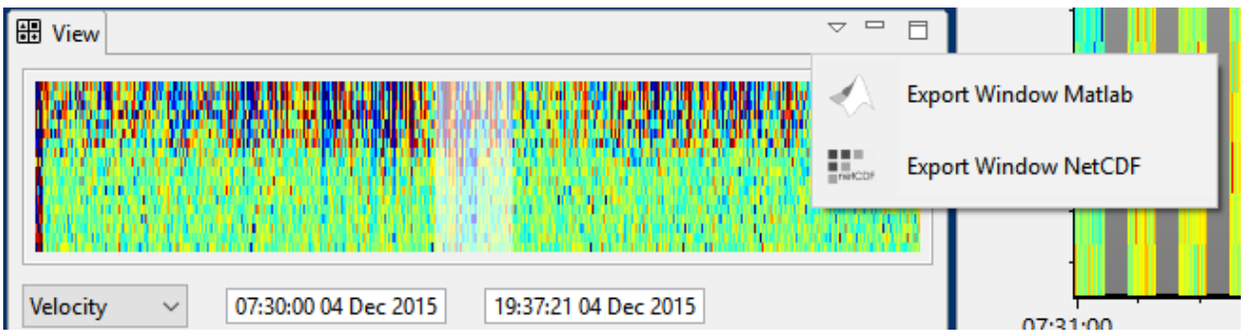
Hovering over the **Overview Image Selector** shows the currently loaded data file.



Hovering over the segment selector shows the start / end times for that segment.



The View menu can be used to export the current displayed data window to a Matlab or NetCDF file. The export options are only available in the Display perspective. When a processed data file is being viewed, an option to export the displayed data window to a text file is also present.



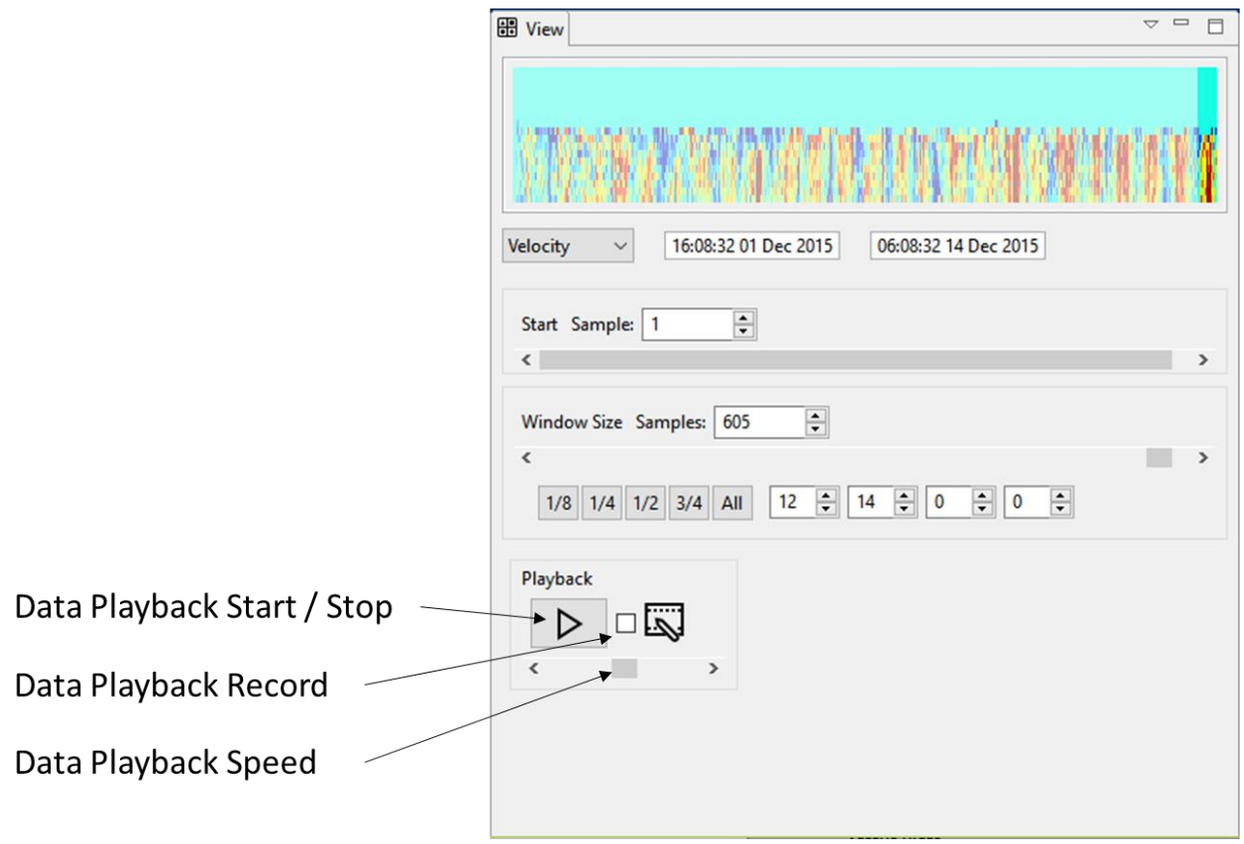
Data File Playback and Recording

The View Settings panel for processed data files also includes a data playback control. The playback control is used to automatically scroll the data window through time. The rate of playback is controlled by the slider below the playback button. The record checkbox is used to create animated AVI files of the playback as it occurs. Only data displays fully visible at the start of playback will be recorded (data views not visible can be detached into separate windows to make them visible for recording). The animated AVI files are stored under sub-folders in the **Images** directory. The image size and frame rate are controlled from the main menu **Preferences: Image Export** selection. Only continuous data files (ones with consistent timing between data points) can be played back.

When starting a recording, the display window length should be set to a relatively small value. The window is advanced at a rate that is proportional to the size of the window, so a large window will not advance very many frames before completion.

For file playback in Windows, an application such as Apple's QuickTime™ is recommended. The native playback application in Windows appears to skip data frames when a low frame rate is used (although decreasing the application window size seems to help improve this situation).

When recording 3D images, the images are expanded to the given size when recording starts. Do not change the window sizes during recording as this will also affect the size of the images saved in the movie.



Processing Stages

Each processing stage contains a separate view called a “perspective” or “stage”. The perspective includes a parameter panel (containing the associated adjustable parameters for the stage), a data display panel, a view settings panel and operations toolbar. Processing stages are designed to be executed **in order** with each stage requiring that the preceding stages be completed first. The processing toolbar highlights the stages which may be executed at the current time. The data views displayed in a processing stage correspond to the data contained in the currently open OCTS file.

The parameters can be adjusted by the user as required or read in from a text file via the **Read Parameters** tool button. The format and contents of the file is dependent upon the perspective.

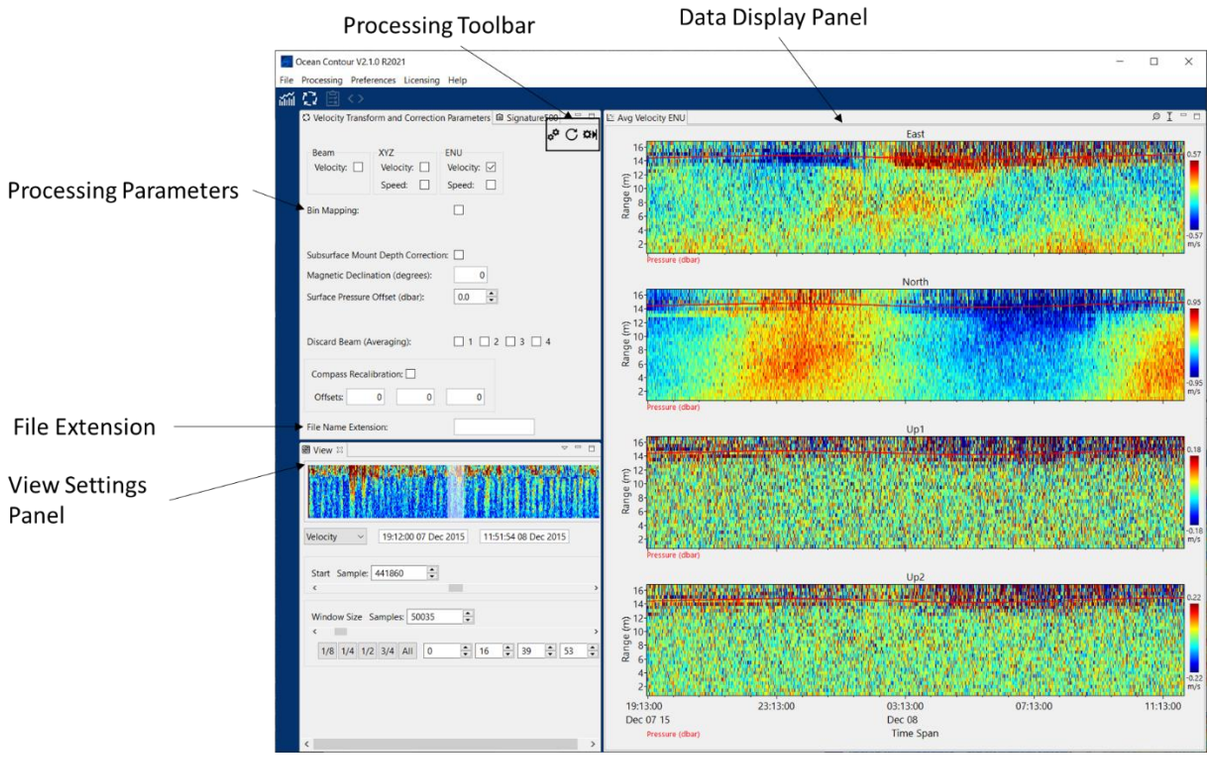
If a perspective can take a significant amount of time for processing, a reprocessing button will be shown. This button will reprocess the in-memory data using the new parameter set. Changing a parameter will enable this button. After reprocessing with the current parameters, the button is disabled.

Once the parameters have been adjusted as required, the data is saved by using the Save and Advance button. Saving the data will initiate processing of all of the associated data files as well as the creation and storage of a text file containing the parameter settings. Once the processing has been complete, Contour automatically advances to the next processing stage. Opening a data file that has a pre-existing parameter file will result in the parameters being automatically read from that file.

Once the data has been processed and saved, the application automatically switches to the next processing stage and the current processing stage is removed from the toolbar. To change a parameter after the processing has completed, the previous stage data file must be opened from the Display perspective.

If it is desirable to save the results of different processing parameters, the File Name Extension input field is provided to identify the file and prevent the results from previous parameter settings from being overwritten. This extension is added on to the stage identifier extension, allowing each stage to maintain a trail of how the file was processed.

Velocity Transforms and Correction



Data containing velocity measurements are collected using a single co-ordinate system. This processing stage is used to calculate other co-ordinate systems as well as correct the data before proceeding to the next stage.

This follow up processing stage can be either the Data Selection stage or Wave Processing stage (if licensed).

Depending upon the instrument, the following co-ordinate systems are available:

Beam: Raw beam co-ordinates

XYZ Velocity: Velocity along X, Y, Z for three beams systems or X, Y, Z1, Z2 for four beams systems.

XYZ Speed: Calculates the XYZ velocity in polar co-ordinates (magnitude of the XYZ velocity and a direction angle). The **XYZ Velocity** option must also be selected when speed is included.

ENU Velocity: Velocity in East, North and Up directions for three beams system or East, North, Up1 and Up2 for four beam systems.

ENU Speed: Calculates the ENU velocity in polar co-ordinates (magnitude of the ENU velocity and a direction angle). The **ENU Velocity** option must also be selected when speed is included.

Data can also be corrected for the following conditions:

Bin Mapping: Data collected from instruments that have been mounted with a significant tilt usually require data cell re-positioning to account for differences in the vertical bin-depth of the raw beam co-ordinate data before the conversion ENU co-ordinates. This option enables the bin mapping processing. Enabling bin mapping disables the XYZ co-ordinate conversion (since it is no longer possible to calculate with the re-mapped bins) and wave processing operations.

Fish Filter Threshold: Fish filtering uses amplitude comparison amongst beams to find spikes in a single beam that are likely due to fish (see below). These spikes can then be marked for removal from the data. This option is only shown when bin mapping is enabled. If bin mapping is not used, fish filtering is carried out in the Data Selection stage. The fish filtering algorithm is derived from Observing Fine-scale Oceanic Velocity Structure with an Autonomous Nortek Acoustic Doppler Current Profiler", Andrey Y. Shcherbina, Eric A. D'Asaro, Sven Nylund

(https://journals.ametsoc.org/doi/full/10.1175/JTECH-D-17-0108.1)

Fish filtering is considered experimental at this point and feedback about its effectiveness is welcome.

Subsurface Mount Depth Correction: The depth of subsurface buoy mounts may vary depending upon current direction and strength. This depth variation (draw down) can be significant, especially in areas that have strong tides. This option uses the pressure data to adjust the cells depths for each single ping profile so that a constant depth is maintained. Upon completion, the range axis is converted into absolute depth using the corrected pressure values (From "Algorithms for computation of fundamental properties of seawater", 1983. UNESCO Tech. Pap. in Mar. Sci., No. 44, 53 pp. Eqn 25, p26. UNESCO 1983. Latitude is 45 degrees north). Enabling depth correction disables wave processing operations.

Magnetic Declination: This is the compass correction to be applied to the heading to account for magnetic declination. If the instrument already has a magnetic declination included, the instrument setting will be removed before this new declination value is applied.

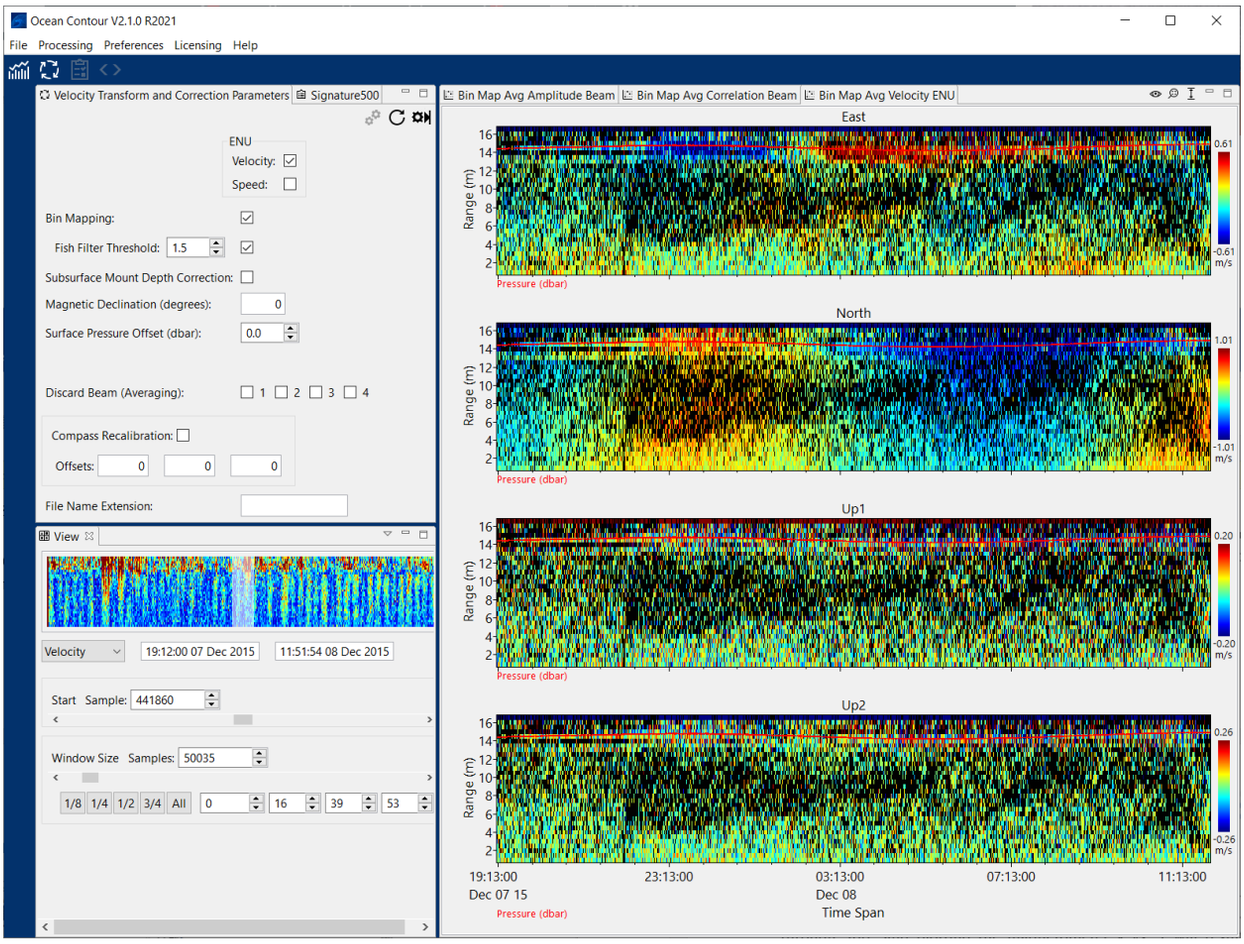
Surface Pressure Offset: Sets the offset used to adjust the pressure data to account for atmospheric pressure at the surface.

Speed of Sound: When an incorrect fixed speed of sound (i.e. the speed of sound wasn't measured) is used during data collection this option corrects the measured

velocities by multiplying them by the ratio (**`new speed/old speed`**). This option will not be visible if the speed of sound was measured.

Discard Beam (Averaging): Allows the user to discard a beam and use a three beam solution for calculating ENU / XYZ. This option can be used to remove an unusable beam (e.g. obstructed path, faulty transducer). This option is intended for averaging data. Discarding a beam disables wave processing (the wave processing module has its own beam discard option). This option is only available on four beam Signature series instruments.

Bin Mapping and Fish Filtering



The process of bin mapping causes a shift in cell locations within a beam relative to the surrounding beams. This means that the fish filter algorithm (which relies on the comparisons between unshifted cells) will not be as effective after bin mapping is performed. For that reason, when bin mapping data, the ability to do fish filtering is offered before the bin mapping is carried out. In this case, the data masking is accomplished by changing the correlation of the "bad" cell to a value of zero and using the correlation filter in the Data Selection stage to produce the rejection mask.

Fish filtering is currently considered experimental and feedback about its effectiveness is welcome.

Compass Recalibration

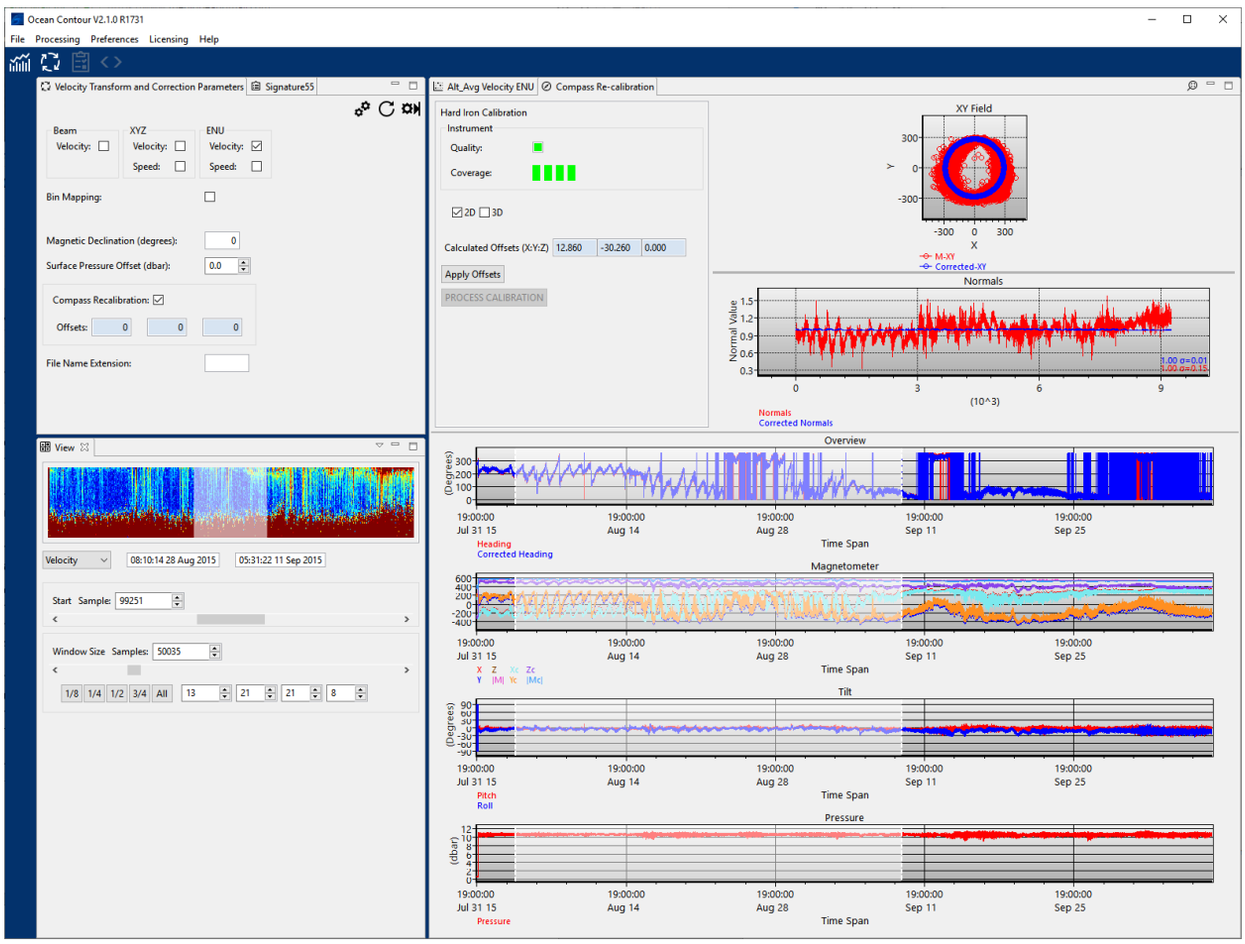
Ferromagnetic / magnetic materials surrounding the instrument will cause distortions in the magnetic field sensed by the internal magnetometers resulting in errors in the headings produced by the compass. With no distortions, rotating the instrument through 360° and plotting the magnetometer X vs. Y will result in a circle centred around (0, 0). Hard iron (material which produces its own magnetic field) will produce a circle which is offset from the centre. The compass calibration procedure calculates these offsets. The offsets can then be used to remove the hard iron effects when calculating the compass heading.

For a two-dimensional compass re-calibration to be effective, the instrument data file must contain enough variation in heading to provide a good estimate of the center of the circle. If the instrument was rotated in all three dimensions (tilt and roll directions as well as heading) then a 3D re-calibration may also be possible.

In operation, the data selection window is moved to encompass a region that has sufficient variation in the heading. The **PROCESS CALIBRATION** button is enabled (and the calibration data cleared) each time the selection region is moved. The position of the window should be moved to produce a green quality indicator, preferably with all green coverage bars (the coverage bars are used to indicate the number of points in each quadrant for a 2D re-calibration and the number of points in each octant for a 3D re-calibration). The recalibration processing must be run every time the selection region has been changed. Once a good quality calibration has been achieved, the **Apply Offsets** button is used to transfer the offsets to the parameter panel of the **Transforms and Corrections** view. The offset values can also be entered manually if they are available from a previous re-calibration.

In the 2D view the XY field shows the measured and corrected points. A good quality calibration results in a constant value for the **Corrected Normals** plot line. The effects of the offsets on the heading are also shown in the **Heading** and **Magnetometer** plots.

In the 3D view, red cubes are drawn for each data point. The last collected point is yellow and double the size of the other points. As the instrument is rotated, the octant for the collected data point is automatically rotated into view. Once sufficient points for the quadrant have been collected, the octant turns green. The current fitted sphere is also drawn at regular intervals. This sphere may vary greatly in size and location when starting out but will stabilize after sufficient data has been collected. Viewing controls for the 3D plot are shown by clicking the mouse on the 3D plot (to give it focus) and pressing Ctrl-H or by clicking both mouse buttons simultaneously when the cursor is on the plot.


Ocean Contour V2.1.0 R1731
File Processing Preferences Licensing Help
Velocity Transform and Correction Parameters
Signature55
Beam
Velocity:
XYZ
Velocity:
Speed:
ENU
Velocity:
Speed:
Bin Mapping:
Magnetic Declination (degrees):
0
Surface Pressure Offset (dbar):
0.0
Compass Recalibration:
Offsets:
0
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0
File Name Extension:
Alt_Avg Velocity ENU
Compass Re-calibration
Hard Iron Calibration
Instrument
Quality:
Coverage:
2D
3D
Calculated Offsets (X:Y:Z)
12.860
-30.260
0.000
Apply Offsets
PROCESS CALIBRATION
XY Field
M-XY
Corrected-XY
Normals
Normal Value
(10^3)
Normals
Corrected Normals
View
Velocity
08:10:14 28 Aug 2015
05:31:22 11 Sep 2015
Start Sample:
99251
Window Size Samples:
50035
1/8
1/4
1/2
3/4
All
13
21
21
8
Overview
(Degrees)
Heading
Corrected Heading
Magnetometer
Time Span
Tilt
Pitch
Roll
Pressure
(dbar)
Jul 31 15
Aug 14
Aug 28
Sep 11
Sep 25

Echo Amplitude Correction and Transform Perspectives

Echo amplitude data experiences amplitude absorption with range that should be fixed to produce accurate amplitude profiles. The following formulae are used to correct for the absorption and remove noise:

TS: Target Strength (dB)

Sv: Volume Scattering (dB)

Nt: user supplied noise threshold (dB)

α: absorption

c: Speed of sound

λ: wavelength = c / frequency

k: wave number = $2 * \pi / \lambda$

r: Transducer radius

ψ: theoretical equivalent beam angle ($10 \log_{10}(5.78/(k * r)^2$ dB)

R: Range

G_{cal}: user supplied calibration gain

PL: the configured power level

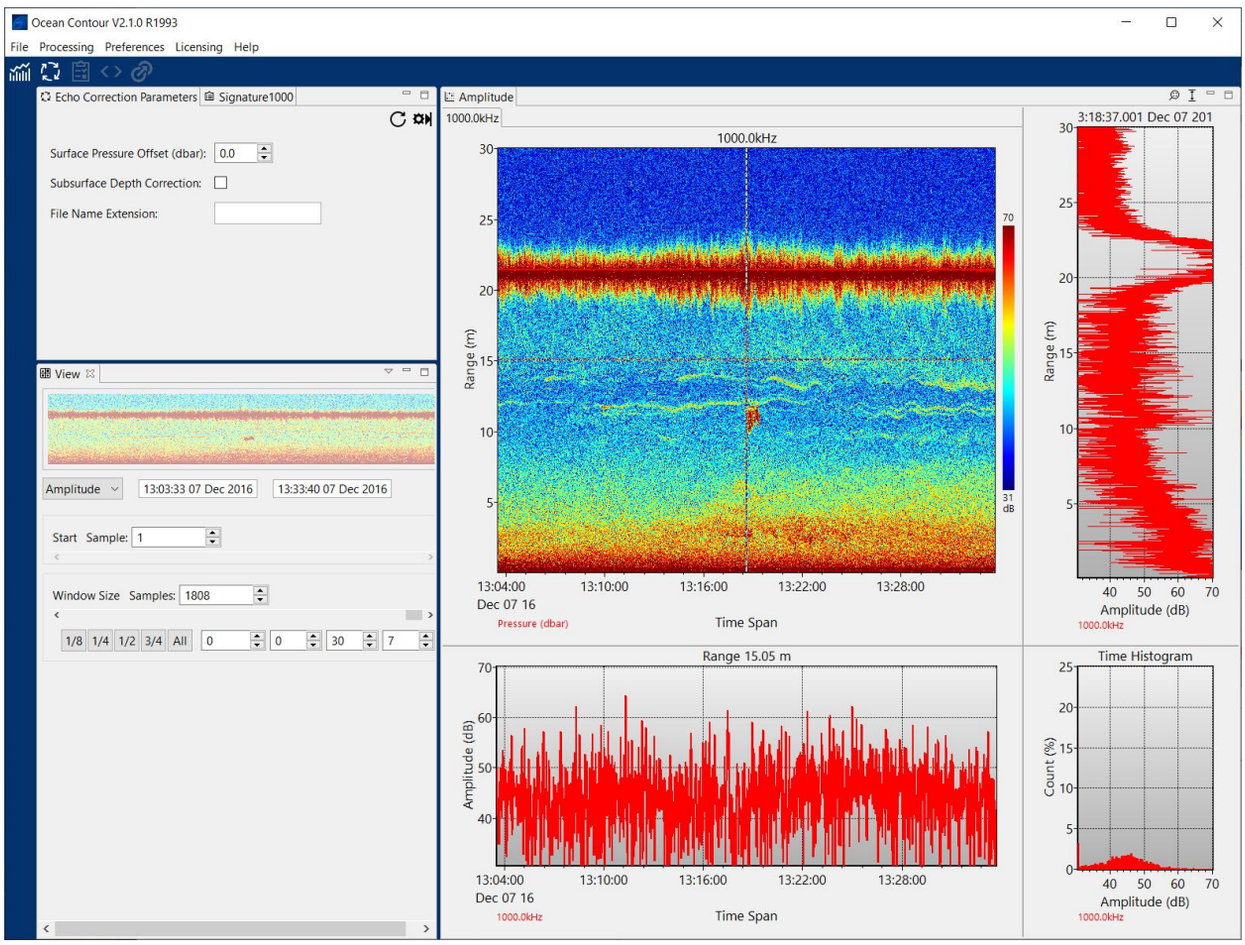
Pr: measured echo amplitude (dB)

τ: transmit pulse length

$$TS = 10 \log_{10}(10^{(Pr/10)} - 10^{(Nt/10)}) + 40 \log_{10}(R) + 2\alpha R + PL + G_{cal}$$

$$Sv = 10 \log_{10}(10^{(Pr/10)} - 10^{(Nt/10)}) + 20 \log_{10}(R) + 2\alpha R + PL + G_{cal} - 10 \log_{10}(c\tau/2) - \psi$$

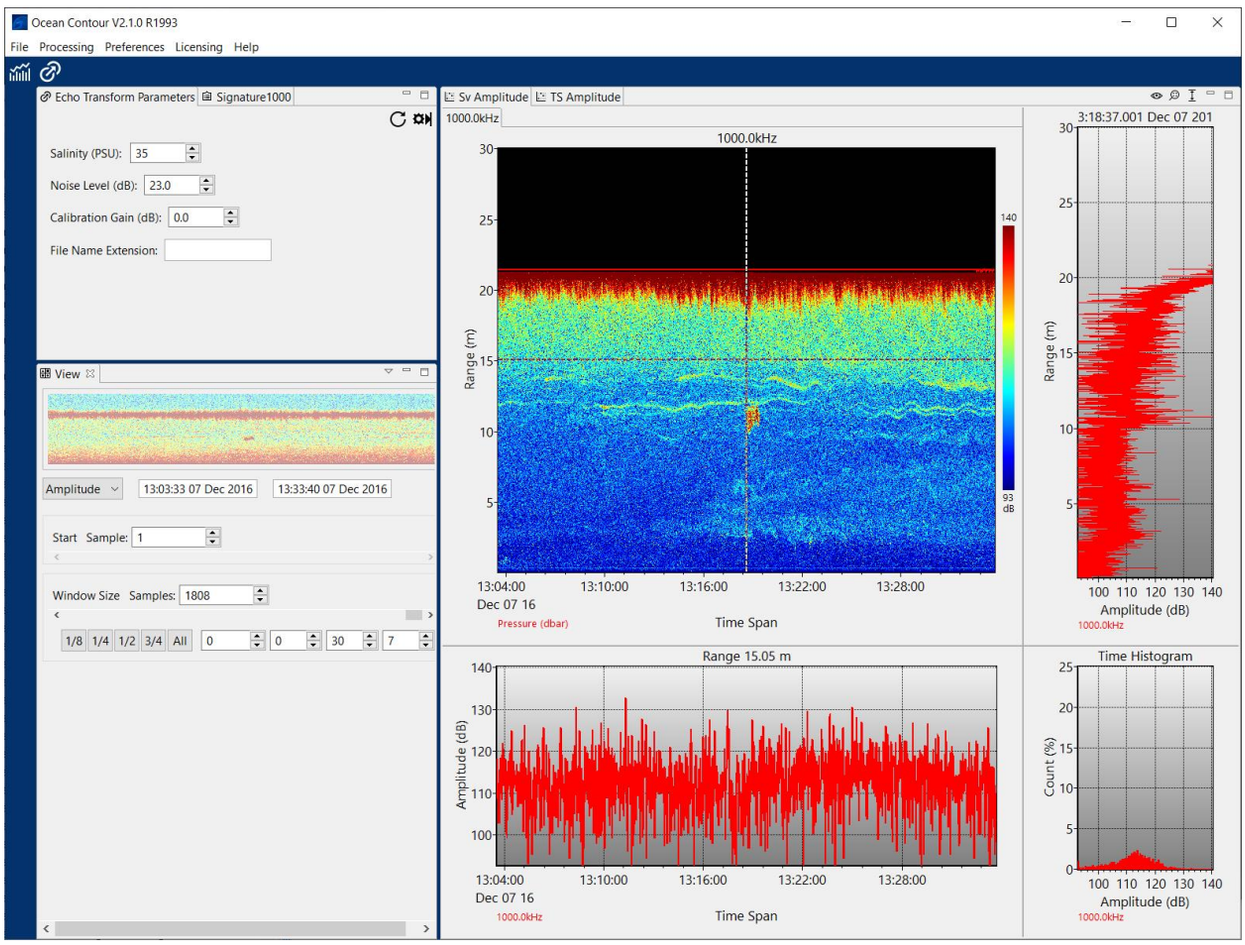
Averaging of echo data must be done linearly (i.e. the data must be converted from the dB scale back to linear and averaged before being converted back to the dB scale). This means that the averaging must be carried out before the transformation from raw to TS and Sv formats. The echo processing has been broken up into two separate stages, Echo Correction and Echo Transform (with Data Selection and Averaging stages in between) to accommodate for this.



Echo Correction Stage

Surface Pressure Offset: Sets the offset used to adjust the pressure data to account for atmospheric pressure at the surface.

Subsurface Mount Depth Correction: The depth of subsurface buoy mounts may vary depending upon current direction and strength. This depth variation (draw down) can be significant, especially in areas that have strong tides. This option uses the pressure data to adjust the cells depths for each single ping profile so that a constant depth is maintained. Upon completion, the range axis is converted into absolute depth using the corrected pressure values.



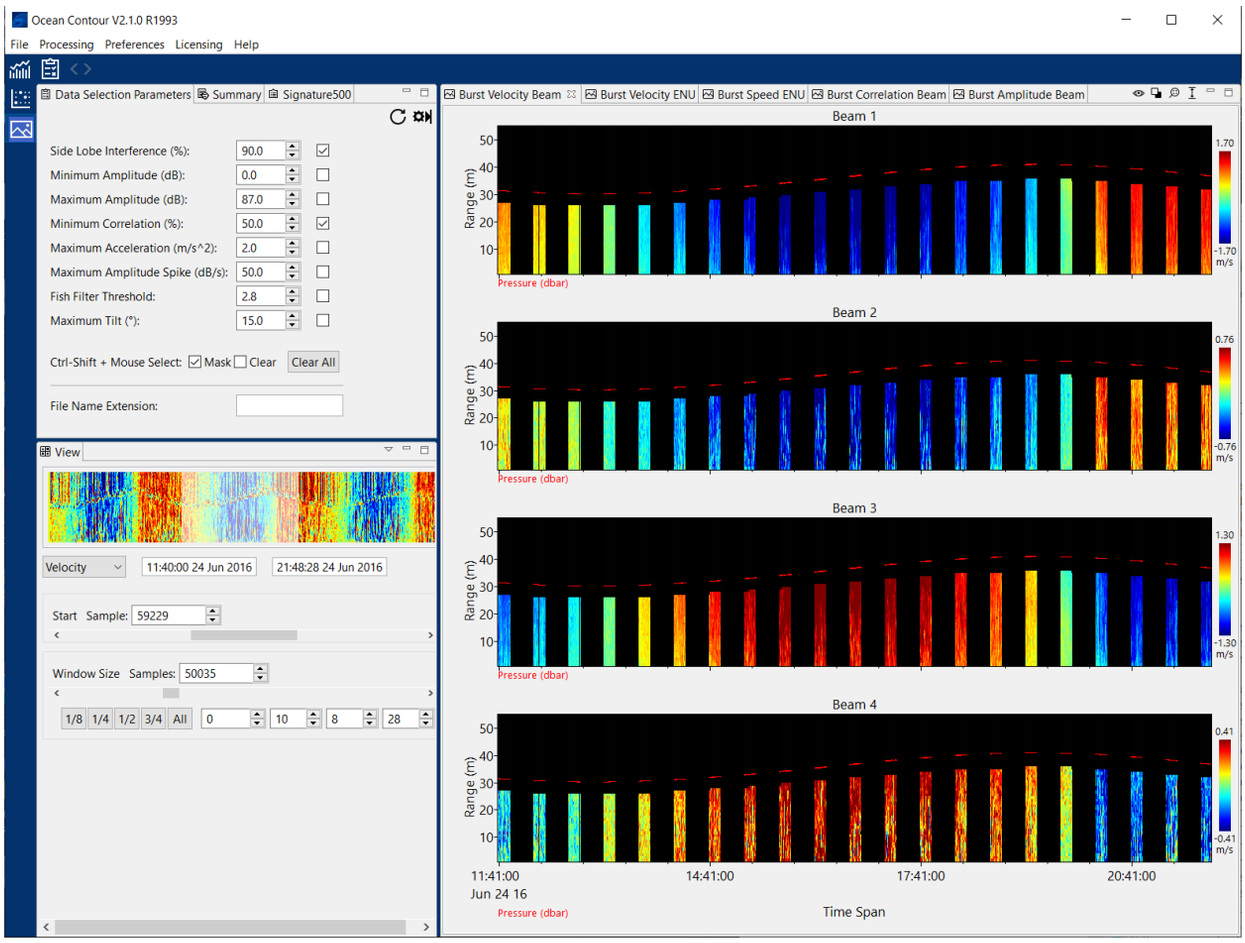
Echo Processing Stage

Salinity: Salinity to be used in speed of sound calculations (in Practical Salinity Units)

Noise Level: Estimated background noise to be subtracted from the initial amplitude data.

Calibration Gain: User supplied calibration gain as determined from calibration procedure.

Data Selection



The Data Selection stage is used to identify areas of bad data for removal from later processing stages.

Side Lobe Interference: Reflection of beam side lobes from the water surface (for an upwards facing instrument) can result in an interference region in the profiled data. This option uses the pressure sensor reading to determine the surface location and then masks out the upper region within a certain percent of the surface. The percentage selected is dependent upon beam geometry. While this can be tuned as required, the correct percentage is initially set within the raw data file when the data is imported. If the pressure sensor offset was not properly offset to account for atmospheric pressure at the time of the experiment, the offset should be applied in the Corrections stage.

Minimum Amplitude: Insufficient signal is often an indication of poor quality data. When the stage is first opened, this field is set to be the minimum amplitude found in the amplitude data. An appropriate threshold is both instrument and environment specific.

Maximum Amplitude: Large amplitude returns may be produced by a bounday material in the signal path. When the stage is first opened, this field is set to be the maximum

amplitude found in the amplitude data. An appropriate threshold is both instrument and environment specific.

Minimum Correlation: Poor correlation values indicate bad quality data. The appropriate threshold is instrument dependent. For Signature series instruments, a typical minimum correlation of 50% should be used as a threshold. For the Vectrino Profiler a much higher limit (typically 90%) is more suitable, although a lower threshold may be more appropriate for turbulent flows.

Maximum Acceleration: The rate of change of current can be used to flag non-physical current changes. Acoustic Doppler data is often subject to spikes in the velocity measurement. Adjusting the acceleration threshold allows these spikes to be removed from the data.

Maximum Amplitude Spike: The rate of change of amplitude can be used to flag problem areas in the data (e.g. interference with another instrument). Adjusting the amplitude spike threshold allows these spikes to be removed from the data.

Fish Filter Threshold: Masks based on spike detection in each beam when compared to the mean values of the other beams. The threshold is a unitless value used for comparison (i.e. not and amplitude value). See "Observing Fine-scale Oceanic Velocity Structure with an Autonomous Nortek Acoustic Doppler Current Profiler" Shcherbina / D'Asaro / Nylund (https://doi.org/10.1175/JTECH-D-17-0108.1).

Maximum Tilt: Enabling this option will remove a complete profile if the absolute value of the tilt or roll is larger than the threshold. This option will not be shown if the instrument doiesn't contain a tilt sensor.

User Selection: Users with a more intimate knowledge of the expected data characteristics may want to choose areas that appear to contain bad data. When an individual OCTS file is opened, bad data areas can be masked by the user using CTRL-SHIFT + the primary mouse button to open a rubber band rectangle to enclose an area of known-bad data. The user selection can be either masked or cleared. Clearing an area will not clear data masked for other reasons. Note that this setting will only appear when a single OCTS file (not a segment file) is opened.

The Data Selection time series / segment files are saved in the Selected Data directory with .DSEL extension.

A configuration file is automatically created and stored in the Selected Data directory when the masked data is saved.

The summary panel also shown in the Data Selection view details the percentage of data (in the currently time series file) that have been removed by each filter parameter.

After saving data, the application advances to the Averaging stage.

Data Mask Interpretation

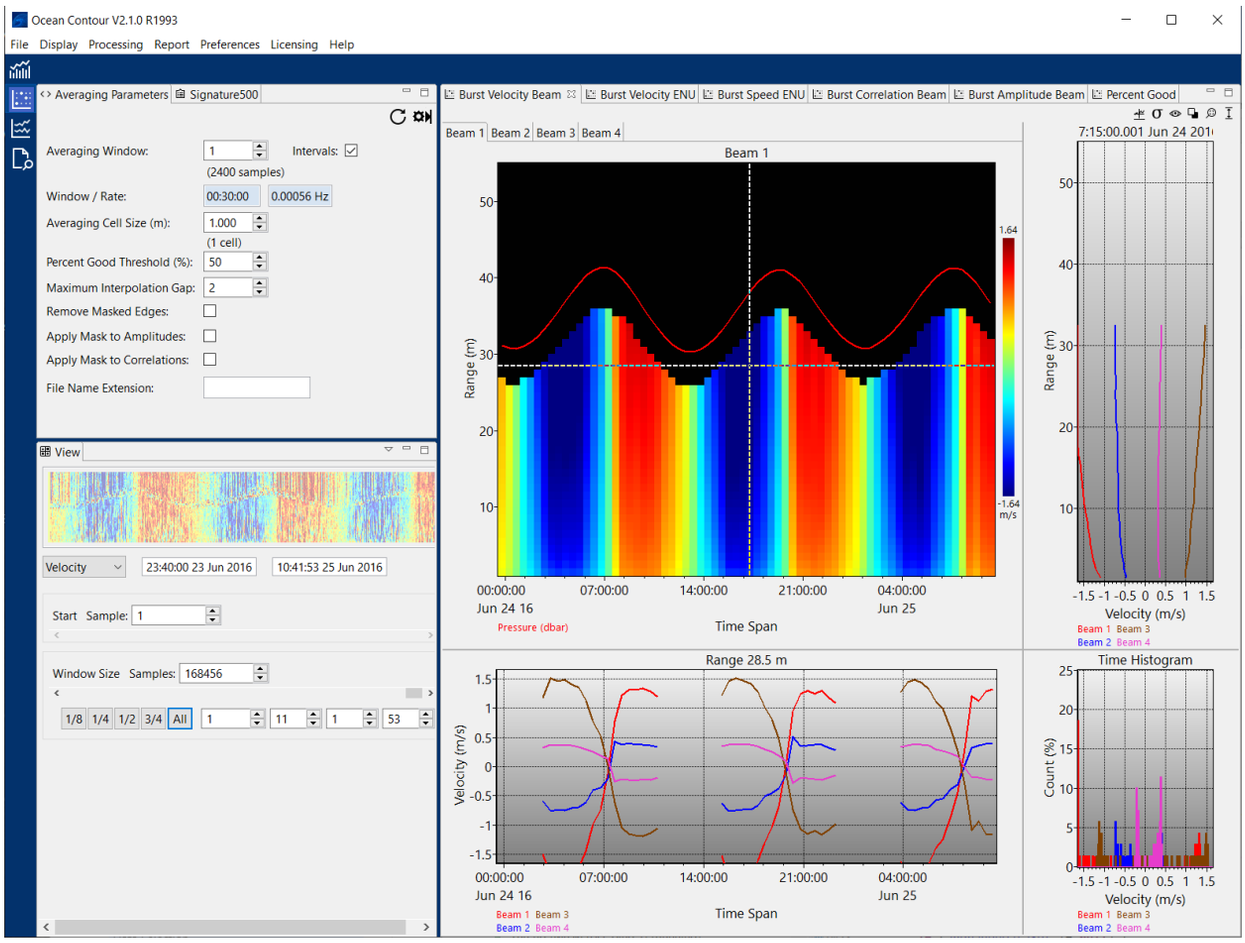
Exported data should use the data mask array as an overlay on the relevant cell data to determine if a particular cell is valid or not.

The exported data mask values consist of bitwise OR'd values representing the reason(s) why the cell is masked.

0 – Data is valid (not masked)
1 (bit 0) – Masked by user
2 (bit 1) – Amplitude threshold (minimum / maximum thresholds)
4 (bit 2) – Correlation threshold
8 (bit 3) – Pressure threshold
16 (bit 4) – Acceleration threshold (spike)
32 (bit 5) – Sidelobe
64 (bit 6) – Percent good threshold
128 (bit 7) – Missing data
256 (bit 8) – Bin map masked
512 (bit 9) – Tilt threshold (non DVL) or DVL invalid
1024 (bit 10) – Invalid data (because of processing or as part of import)
2048 (bit 11) – Amplitude spike threshold

The 4 remaining bits are reserved for internal use and should be ignored (note that the internal usage can result in these bits getting set resulting in negative numbers for exported mask values).

Averaging Perspective



The averaging stage averages data together to produce a lower sample rate / reduced noise data set. For instruments which collect data in discrete measurement intervals (e.g. collect 10 minutes of data every 30 minutes), the data may be averaged together within the measurement interval (e.g. reducing the 10 minutes to a smaller number while maintaing the 30 minute separation) or over one or more measurement intervals (e.g. producing a single averaged profile every 30 minutes), effectively producing a data set with a constant sample rate.

Averaging Window: For instruments with discrete measurement intervals, the user can select how many intervals of data are averaged together to produce a single measurement (see **Intervals** below). For continuously collected data, the user can select how many individual samples are averaged together. The corresponding averaged **Window** and **Rate** are updated to match the selected value.

Intervals: If checked, this means that the **Averaging Window** is in measurement intervals. The sample count corresponding to the number of selected intervals is also displayed.

If not checked, the Averaging Window is in single samples and the data set produced will continue to have the same measurement interval, but with fewer samples per interval. Note that in this case, if the number of samples in the measurement interval is not an integral multiple of the Averaging Window samples selected, then the averaging algorithm simply discards the remaining data within the measurement interval.

If, for example, the data has a measurement interval of one hour and that data was collected for 20 minutes at 16 Hz during that one hour period then this would correspond to 20*16*60 = 19200 raw measurements per measurement interval.

Intervals enabled means average an integral number of "measurement interval" measurements (i.e. N * 19200) to produce a "continuous" data set (so entering 1 will result in a single average of 19200 measurements every hour; 2 will result in a single average of 38400 measurements every 2 hours; etc.).

Intervals disabled averages together single raw measurements to produce a different sampling rate for the measurement interval than the original one. So, for example, if 4 is entered, then a measurement interval containing 19200/4 = 4800 averaged measurements is produced (i.e. a sample rate of 4 Hz over the 20 minute collection time). The measurement interval is timing preserved, but the effective sampling rate is reduced. In terms of discarding data, take, for example, 1500 sample averaging. It would produce (19200/1500) = 12.8 => 12 averaged samples in the sample interval with the remaining (0.8*1500) = 1200 raw measurement samples being discarded.

Averaging Cell Size: The desired cell size achieved by averaging together cells within the profile. The profile length will be truncated if the last cell contains less than half of the number of cells being averaged together.

Percent Good Threshold: The number of "good samples" per average is tracked during the data averaging process (good samples being those that haven't been flagged as "bad"). The final averaged sample can be marked as "good" or "bad" depending upon what percentage of the unaveraged data was actually included in the average. This percentage (the **Percent Good Threshold**) can be adjusted by the user to select the threshold at which data should be considered valid. Data containing less than this percentage of good data is masked. "Good" data is data that has passed the data selection stage (i.e. hasn't been masked out). Note that when comparing Contour results with the Signature series AVGD data files, the only "good" criteria used by the instrument firmware is that the measurement correlation has to be > 50%.

Measurement Interpolation Gap: Bad data can be replaced by data interpolated between two known good data points in time. The length of time for which interpolation is reasonable is specified by the **Measurement Interpolation Gap**. This is

the gap (in averaged samples over which interpolation can be used to replace bad data values. The interpolated data remains masked to indicate that the data was originally bad.

Remove Fully Masked Edges on Save: Data towards the end of the profile which has been marked as bad for all time slots or data at the start or end of the time series which has been marked as bad for all profile slots can be removed from the data set if desired by selecting this option.

Apply Mask to Amplitude / Correlation: Whether or not the mask will be used to automatically remove masked data from the amplitude / correlation averages. Not using the mask may be desirable if an overall view of the data quality (including bad data) is required.

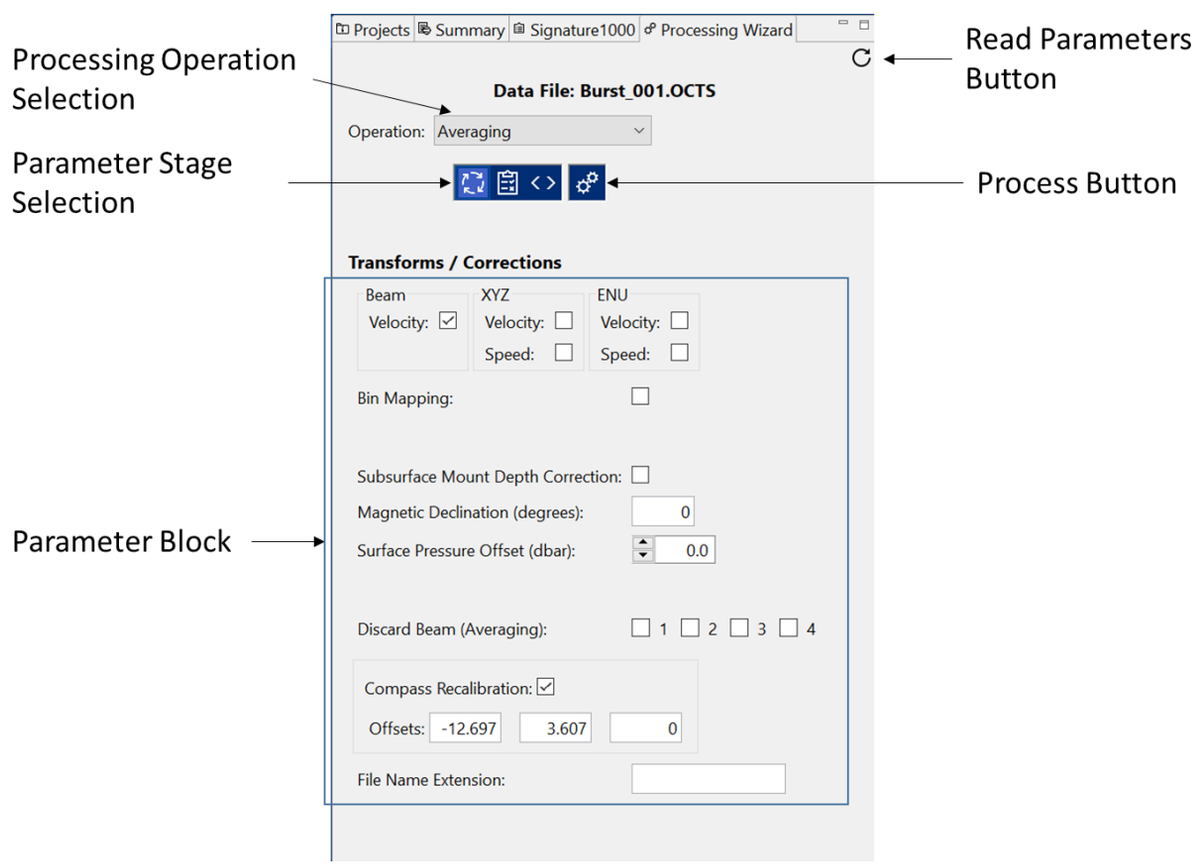
The averaged data time series is stored in the Processed Data folder with the extension .AVER. After the data is saved, the averaged time series is automatically opened in the Display perspective.

A configuration file is automatically created and stored in the Processed Data directory when the averaged data is saved.

Chapter 3
General Operation

Processing Wizard

The processing wizard (visible as a tab in the **Display** perspective) can be used to automate the processing of data.



Use of the wizard assumes that the parameters for each processing stage are known beforehand. The overall processing operation is selected, the parameters for each processing stage are filled in (using the stage selection toolbar) and the processing

button is clicked to initiate processing. All processing stages are then completed sequentially.

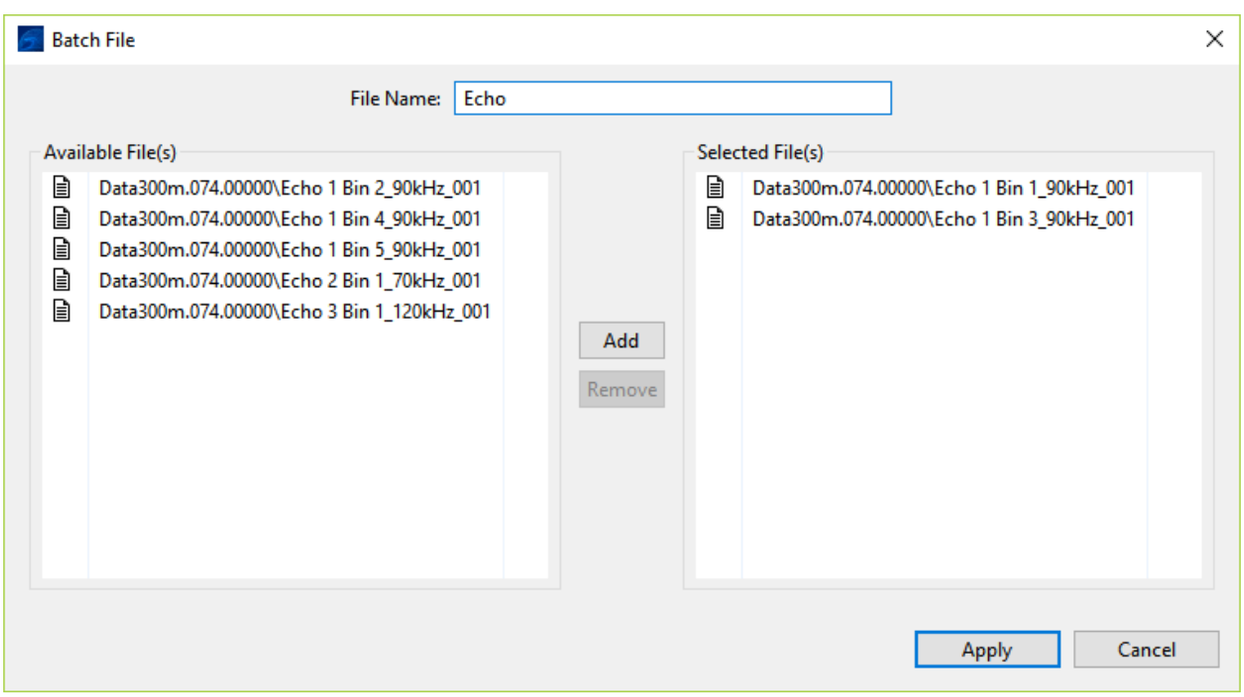
The processing wizard acts on the currently opened data file unless a batch file has been selected (see below).

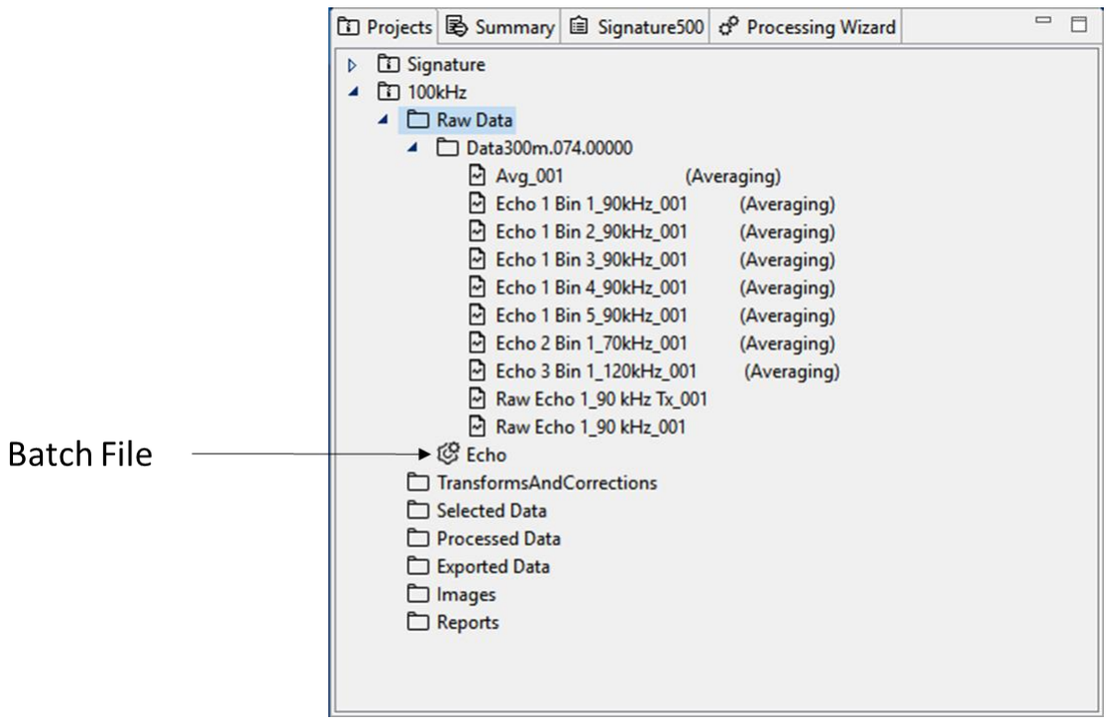
Creating and Using Batch Processing Files

Batch processing files allow multiple data streams to be processed in one sitting. Right clicking on a raw data directory brings up the **Create Batch File** option. The first file selected is examined and all other data files which are incompatible with its processing capabilities are removed from the Available File(s) list. Data files must be from the same instrument family, be of the same data type, support the same processing modes and have the same measurement intervals in order to be included in a batch processing file.

This operation creates and saves an .OCBAT file in the raw data directory  . Double clicking on this file switches the view to the **Processing Wizard** tab for subsequent processing. Initiating processing on a batch file will result in each data stream in the batch file being fully processed using the wizard's processing parameters. The processing parameters are written into a unified parameter file that has the same name as the batch file (with a .txt extension).

The processing parameters can be read from the batch parameter file using the **Read Parameters** button



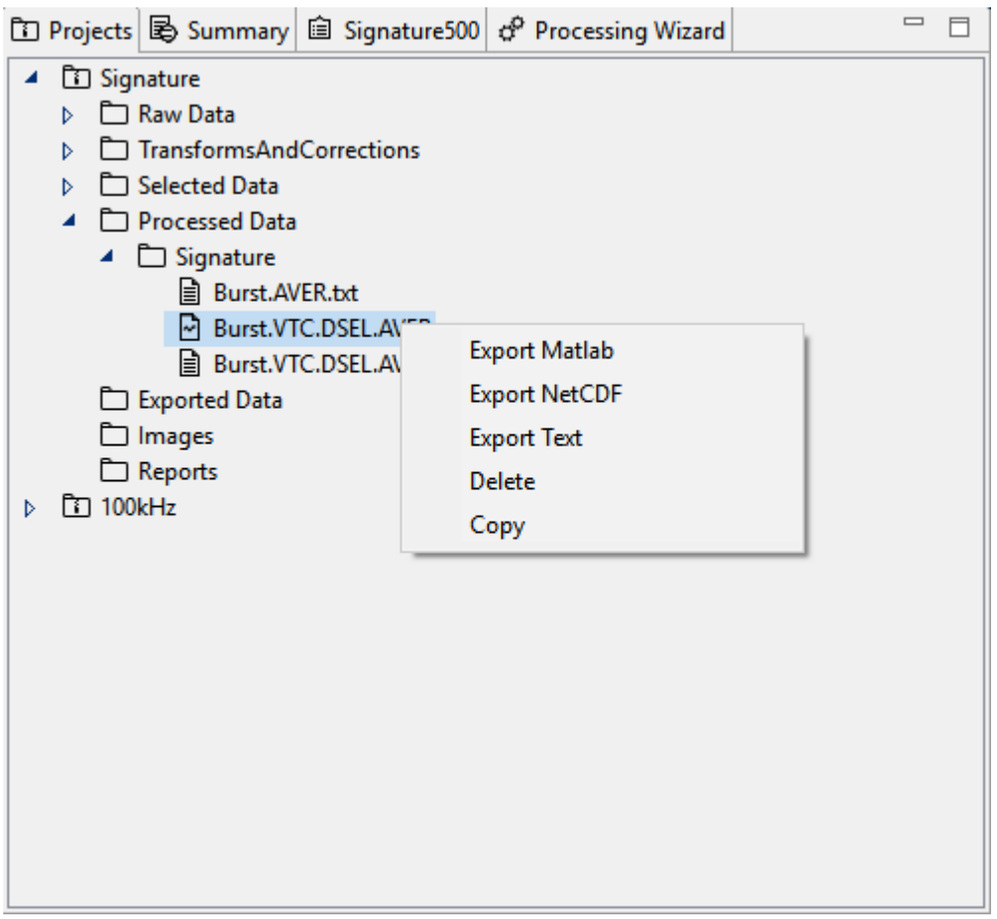


Exporting Data

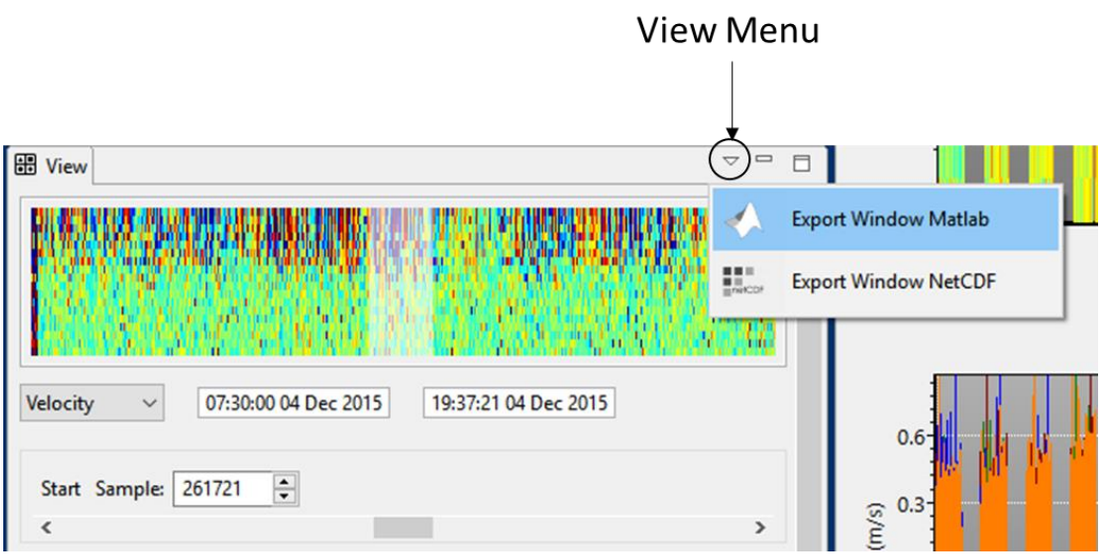
Data files can be fully exported to NetCDF or Matlab by right clicking on the data file in the project navigator view.

Right clicking on a processed data file will also dispaly an option to export the data to a text file. The export creates a **.hdr** file, which contain configuration information and comments about the data fields exported, and a **.dat** file which contains data. Array values are named and delimited by brackets [ ] to indicate rows. Given that text export can result in large output files, an option to select the data frames that will be exported is presented when a single data file is selected to be exported.

In addition to the Contour text export, averaged data files and waves data files can also be exported to a file compatible with Nortek's Signatures Waves / Signature Viewer software.



A subsection of the data file (corresponding to the data displayed in the view window) can be exported using the View Menu option in the View Settings panel. An option for exporting to text is also presented when a processed data file is being viewed.



Supported Data Views

Data Overview

This displays a combination of 2D profiles and selected ancillary data and status plots for raw data files. Processed data files have overview displays that are based on the data in the file. By default, the x-axes on the ancillary data plots shown in the overview don't display labelling in order to save vertical screen space. X-axis labelling can be enabled by checking the **Preferences: Profile Views: X-Axis Labels on Overview Plots** setting.

2D Profiles

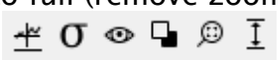
This is a combination of contour images, profile plot, time series plot and time series histogram that is first shown when a data file is opened. Vertical and horizontal cursors in the contour plots are used to select individual time series and profiles which are subsequently displayed in the time series and profiles plots. The time series histogram is also updated. For upwards facing instruments with pressure sensors, a line corresponding to the pressure sensor reading is also displayed (in units of dbar as opposed to meters for the Y axis).

The vertical cursor can be moved by dragging with the mouse or by clicking on the graph (to give it focus) and using the **Up Arrow** or **Down Arrow** to move one slot. **Shift-Up Arrow** or **Shift-Down Arrow** moves by 10 slots.

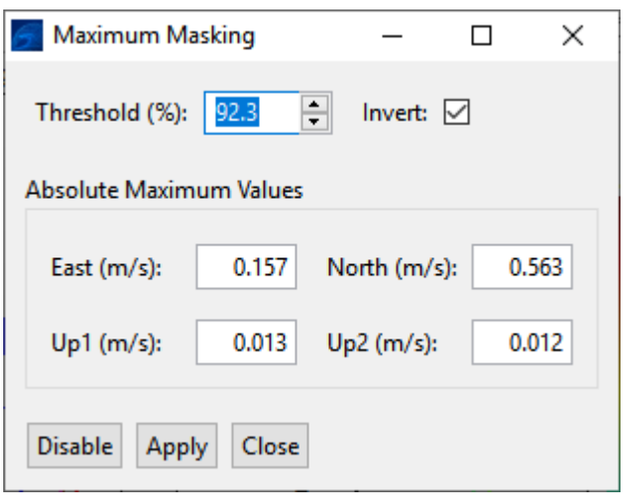
The horizontal cursor can be moved by dragging with the mouse or by clicking on the graph with the mouse (to give it focus) and using **Left Arrow** or **Right Arrow** to move one slot. **Shift-Right Arrow** or **Shift-Left Arrow** moves 10 slots.

Zooming in / out on the contour images will zoom in / out on all of the 2D profile views (and plots). Zooming performed on the time series / profiles plots will only operate on that plot.

Display Control Buttons

The Display Control Buttons at the top right of each tab allow the cursor to be turned on/off, statistics to be turned on / off, the mask overlay (if present) to be enabled / disabled, value mask, expand to full (remove zoom), and adjustment of the limits used to scale the graphs / colours. 

The maximum mask  creates a white threshold mask based upon user supplied values. The percentage value allows the user to keep the same limit while adjust the threshold as required. The mask can be set to mask all values less than the threshold or inverted to mask all values greater than the threshold. The **Apply** button is used to update the mask with the currently set parameters. Enabling the maximum mask disables any previously displayed mask.



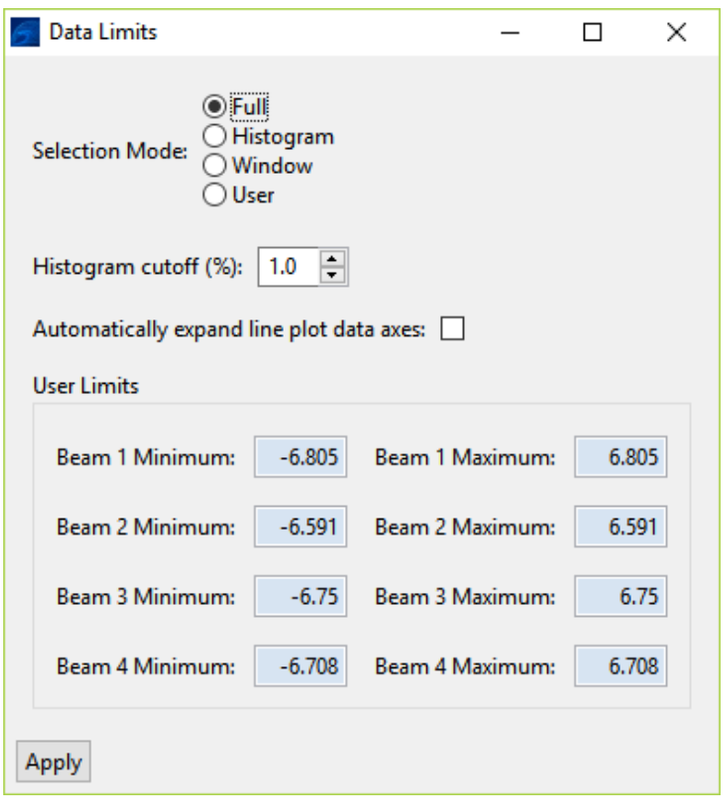
For velocity measurements, the mask thresholding is done using the absolute value of the data rather than a simple comparison threshold.

Scaling limits  can be selected based on all of the data in the data set (Full), on a histogram of the data (with a selectable tail cut-off to get the maximum / minimum values), on the data in the selected data window (from the View panel) or manually entered by the user. The option to have line plot data axes expand to cover the

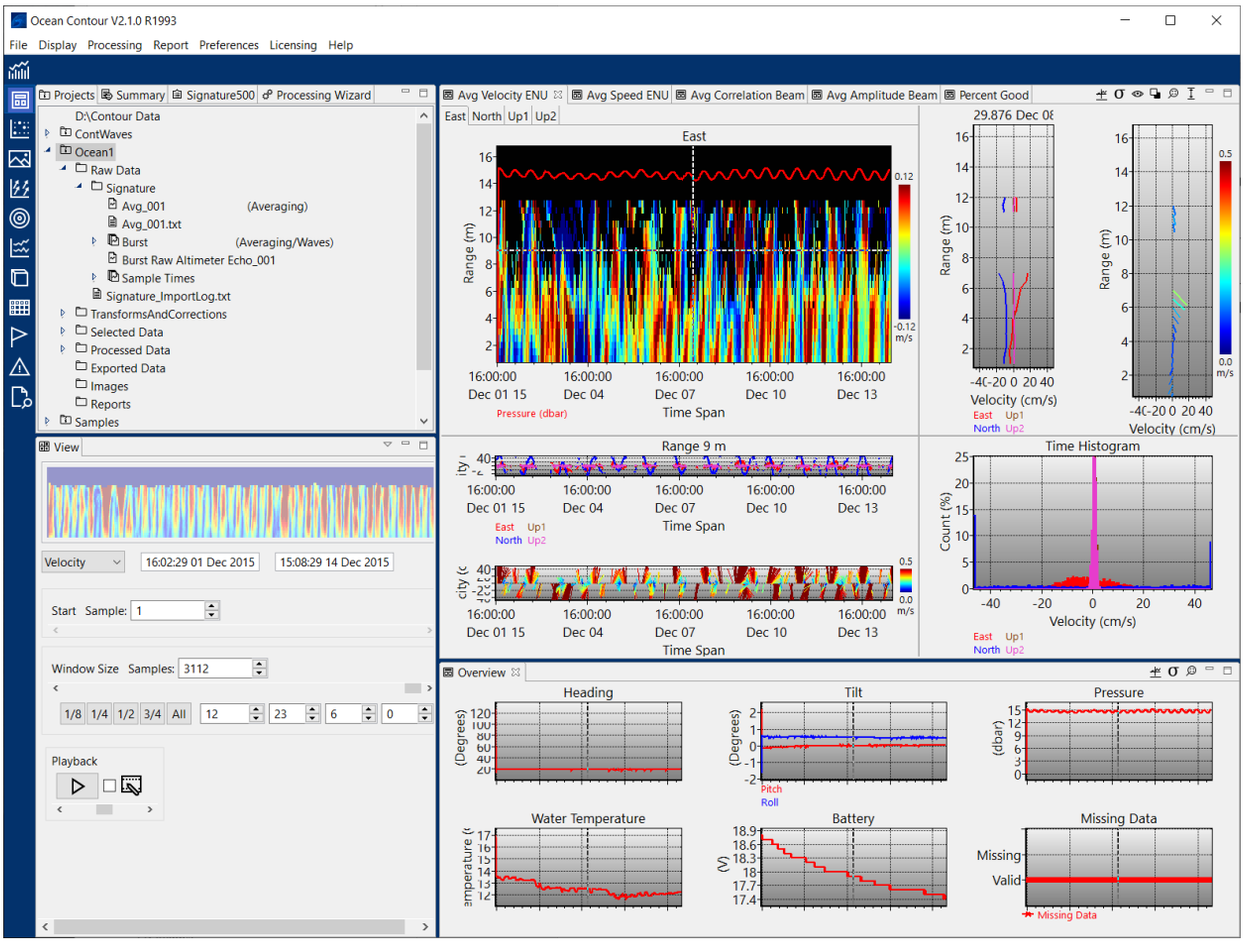
displayed data is also presented (i.e. the axis limits will grow if data larger than the limits is displayed but they won't contract).

Each co-ordinate axis / beam has its scales selected individually, so the colour scales will not be identical for all contour images in a tab.

Once selected, limits are "sticky" in that they persist for a particular data frame. Closing / re-opening the file will read in the last limits settings and apply them to that data.

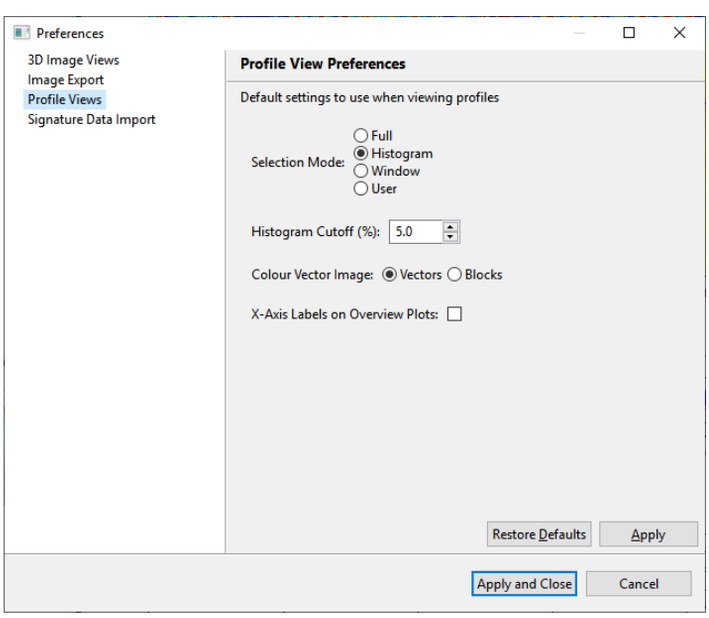


Processed data files in ENU or XYZ co-ordinates also include stick image plots of the associated current.

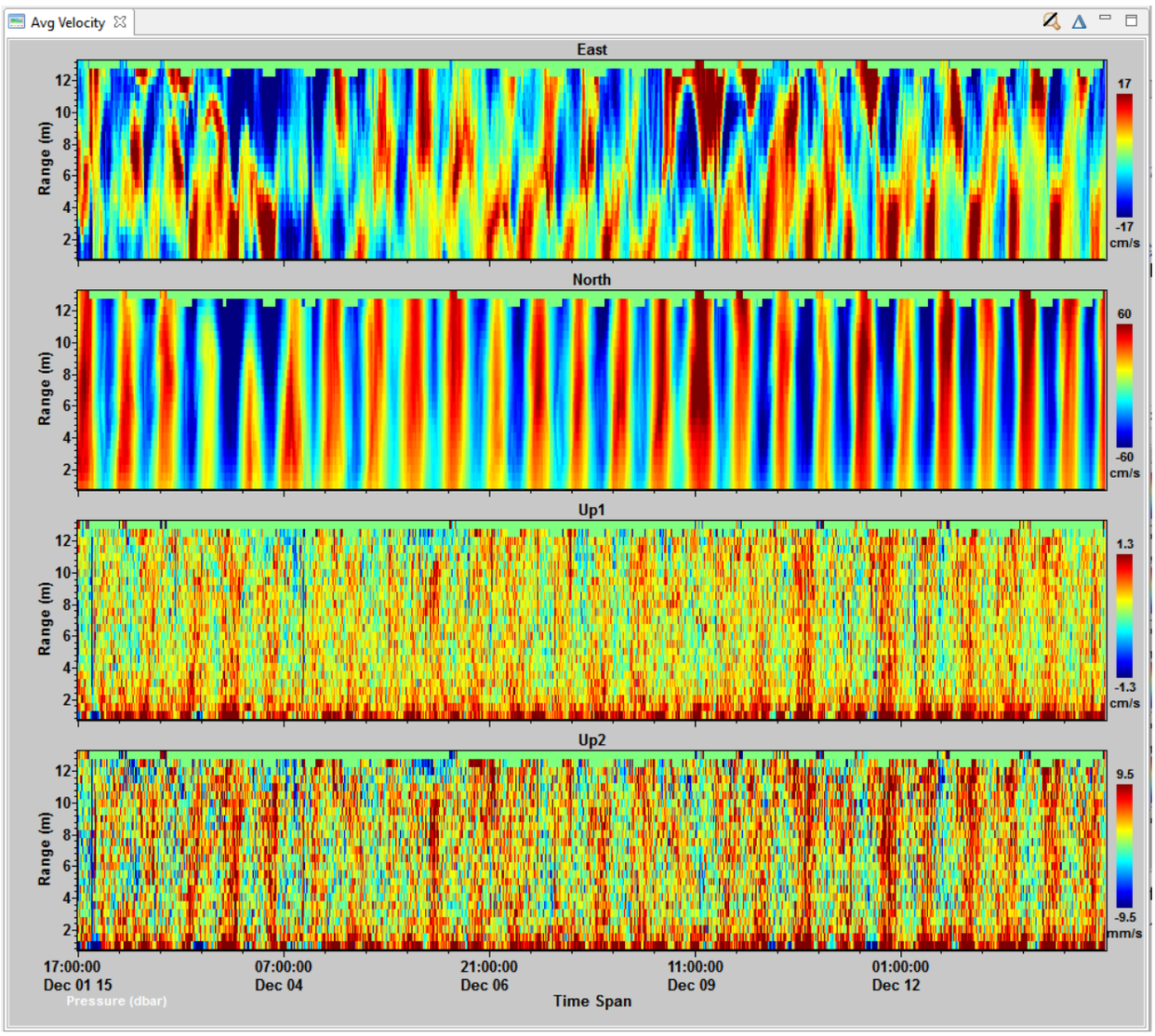


Profile View Preferences

The default scaling mode for the profile views can be chosen using the **Preferences: Profile Views** menu option. This default is applied to all the views which display contour images (2D Images and 2D Vector Images). These preferences apply to data that hasn't had the limits set by the user.



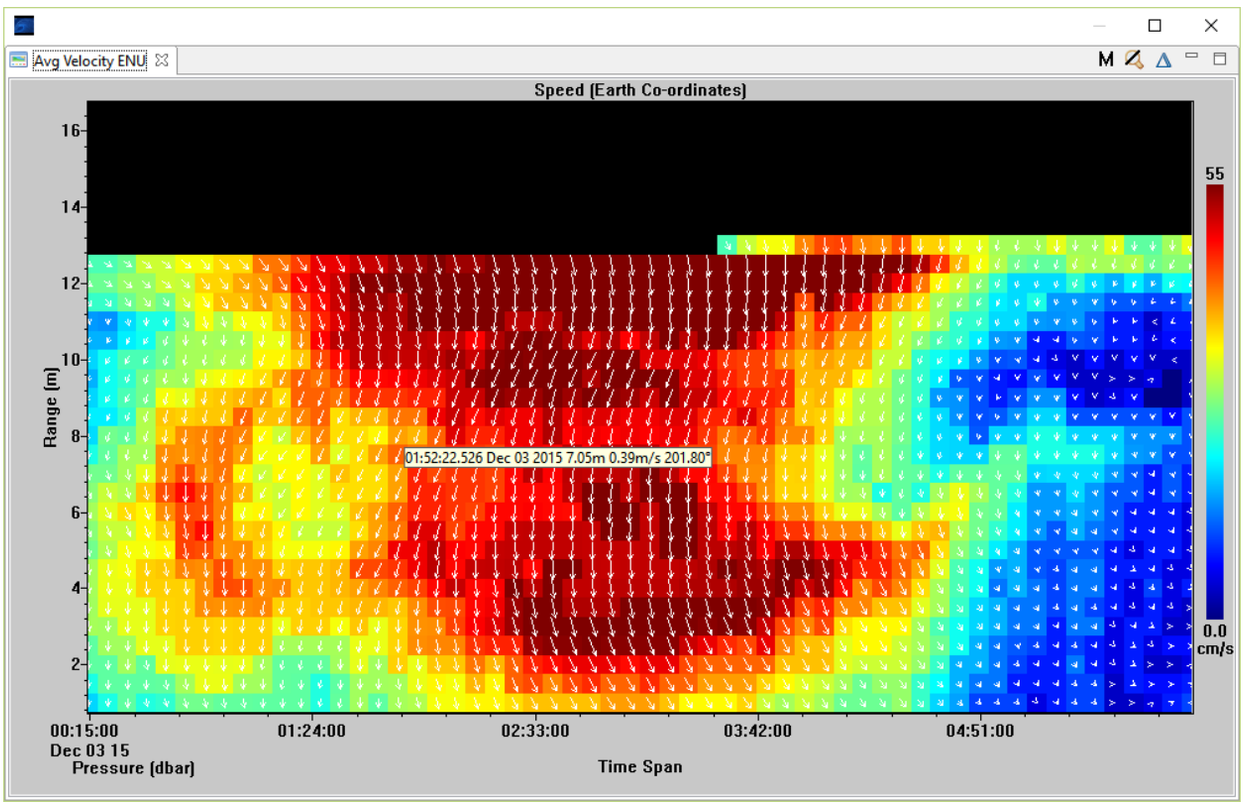
2D Images



This view shows only the contour images for all of the co-ordinate axes / beams for the data stream displayed. For upwards facing instruments with pressure sensors, the pressure reading (in dbar) is also displayed.

2D Vector Images

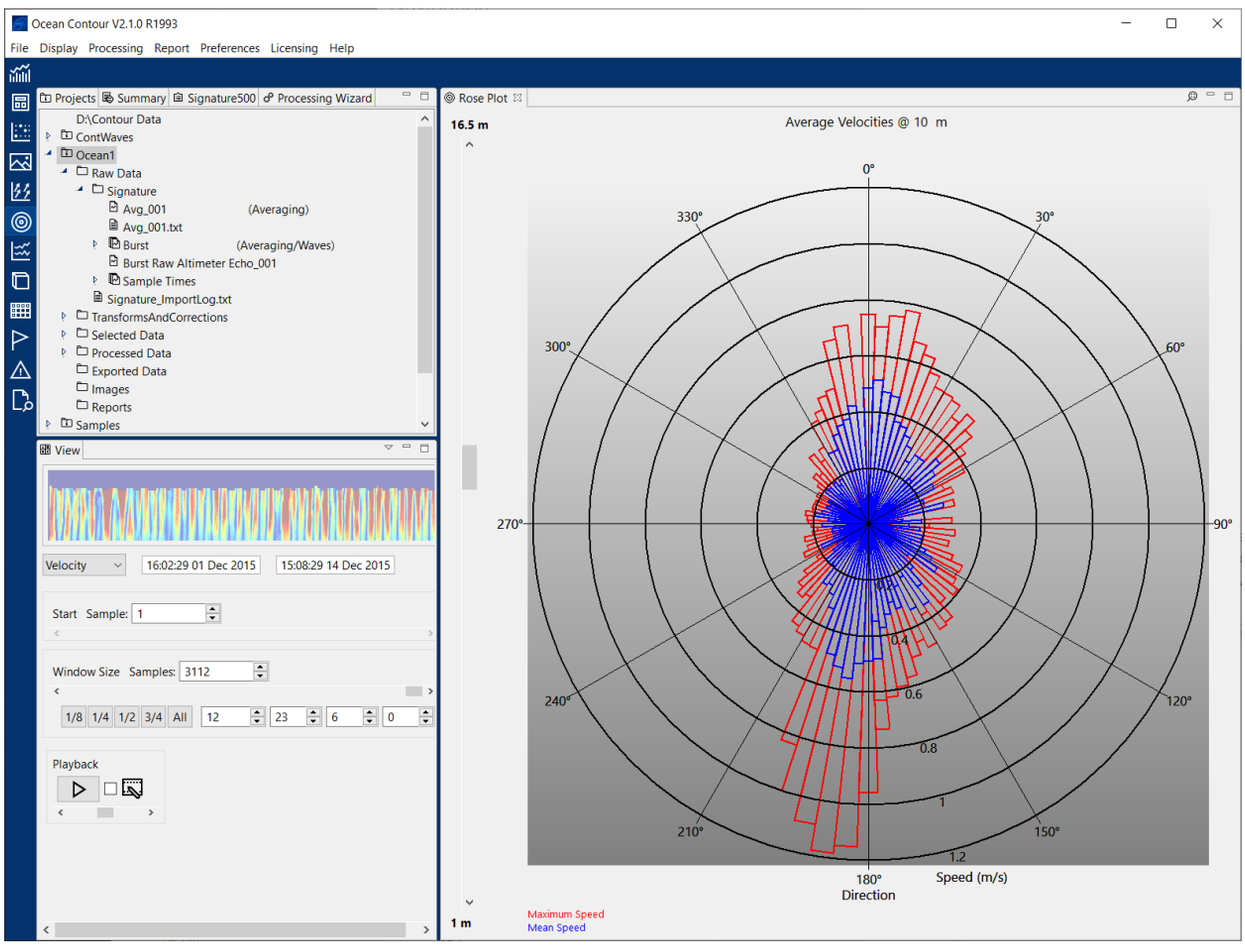
This view is only available for East/North/Up (ENU) co-ordinate system velocity data that has already been processed (e.g. averaged). In addition to being able to change the colour scaling limits as in the contour image plots, the colouring can also be chosen to apply to either the block representing the velocity (leaving the vector white) or the vector (leaving the block transparent). The vector image calculation performs averaging at the given zoom level to determine the value / direction of the velocity vector. Images with a large number of points averaged together will look uniform in colour / direction so it is important to either zoom in to an appropriate level or choose the smallest data window (using the View Settings Panel) to get the highest resolution information. The image can be displayed as coloured block format (as below) or as coloured vectors on a white background by changing the "Colour Vector Image" setting in the Profile View Preferences.



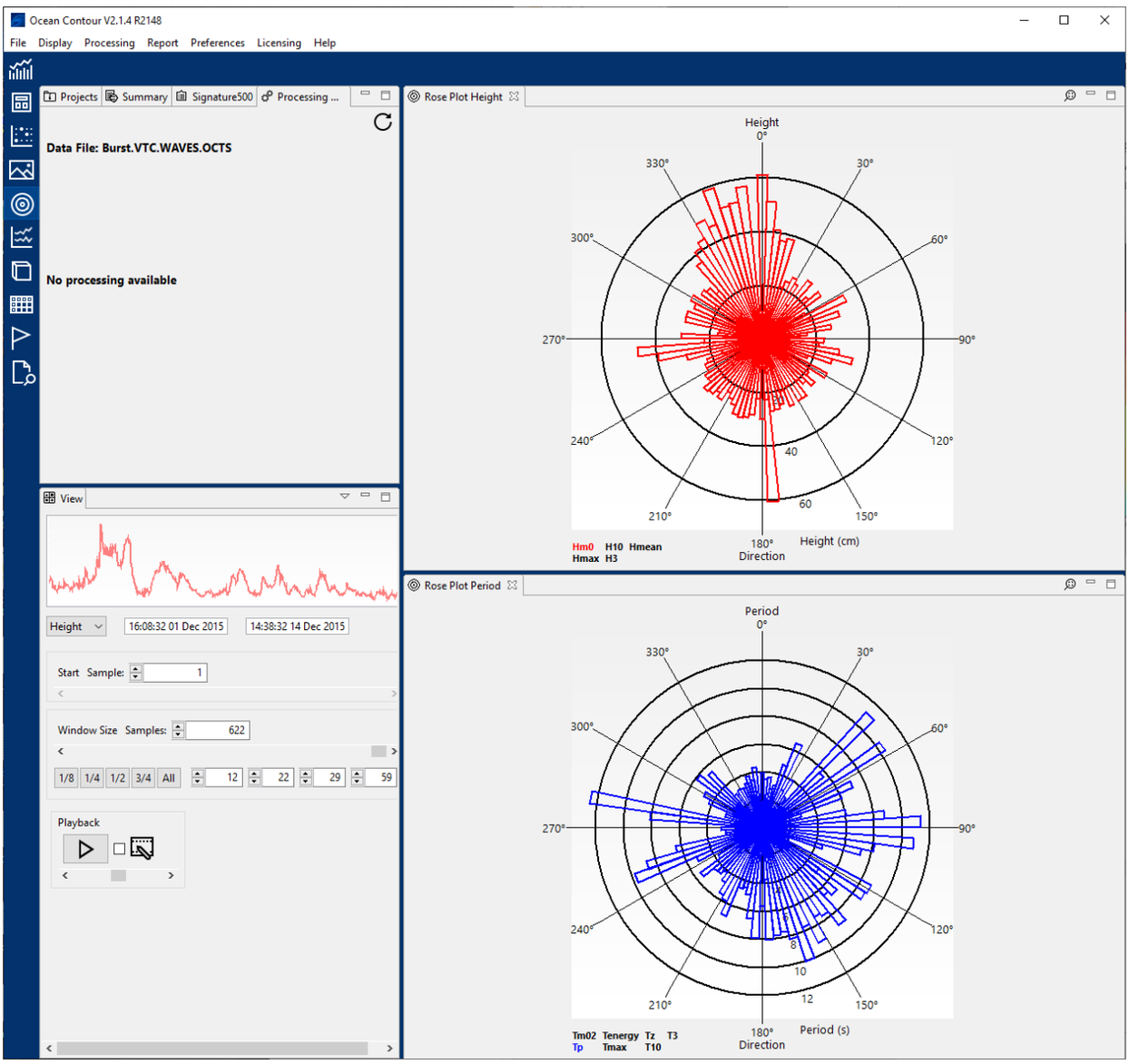
Rose Plots

This view is provided for averaged East/North/Up (ENU) co-ordinate system velocity data and for processed wave data.

Velocity rose plots are calculated per cell over the displayed window. The cell is selected by moving the slider located to the left of the plot.

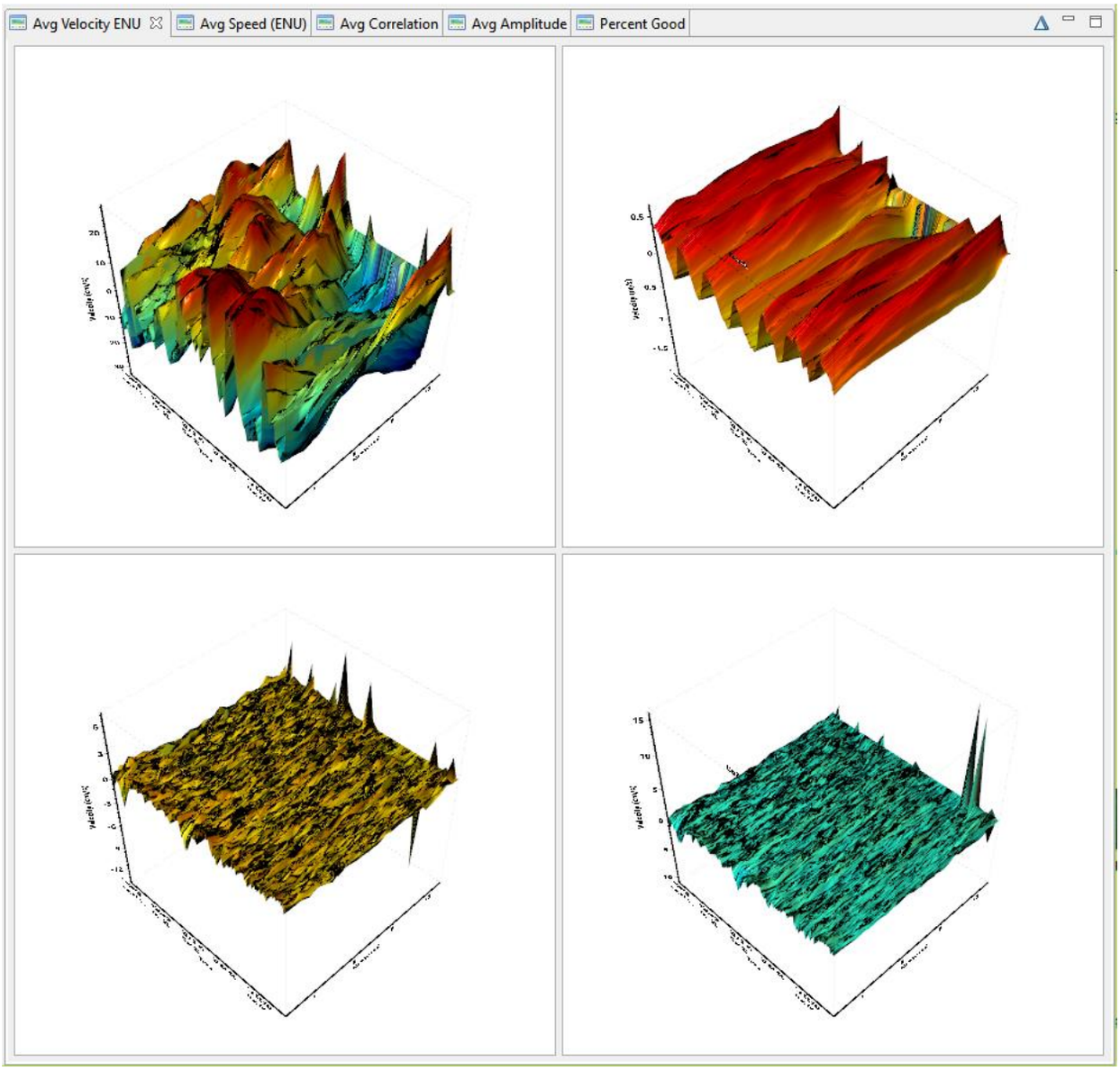


Wave data rose plots are also calculated over the displayed data window.

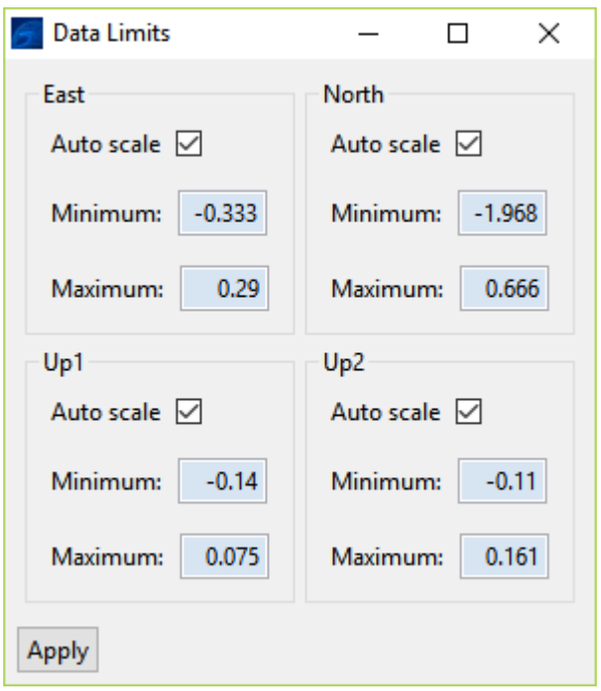


3D Images

Three-dimensional surface images can be drawn using profiling data. The images can be rotated and moved in space using a combination of the mouse (to rotate) and other keyboard commands (ALT-H in the plot window will show the help menu). A cursor is also available for examining specific data points in the image.



The data limits for the Z-data automatically scale by default (i.e. they are set to be the minimum / maximum of the data being drawn). The image may be compressed using averaging for large point counts (see below). If a fixed scale is desired, the limits can be adjusted using the data limit menu option. Fixed scale limits should be considered when recording 3D image movies.



Colour Scales

Right clicking on the image brings up the colour scale menu for the image.

Jet: A linearly graded colour scale similar to the jet colour map in MATLAB.

Log Jet: A logarithmically graded colour scale using the jet colours.

HSV: A graded colour scale using hue / saturation / value which wraps the hue value from 0 to 360 degrees over the data limits.

Grey: A linearly graded scaled from black for the minimum data value to white for the maximum data value.

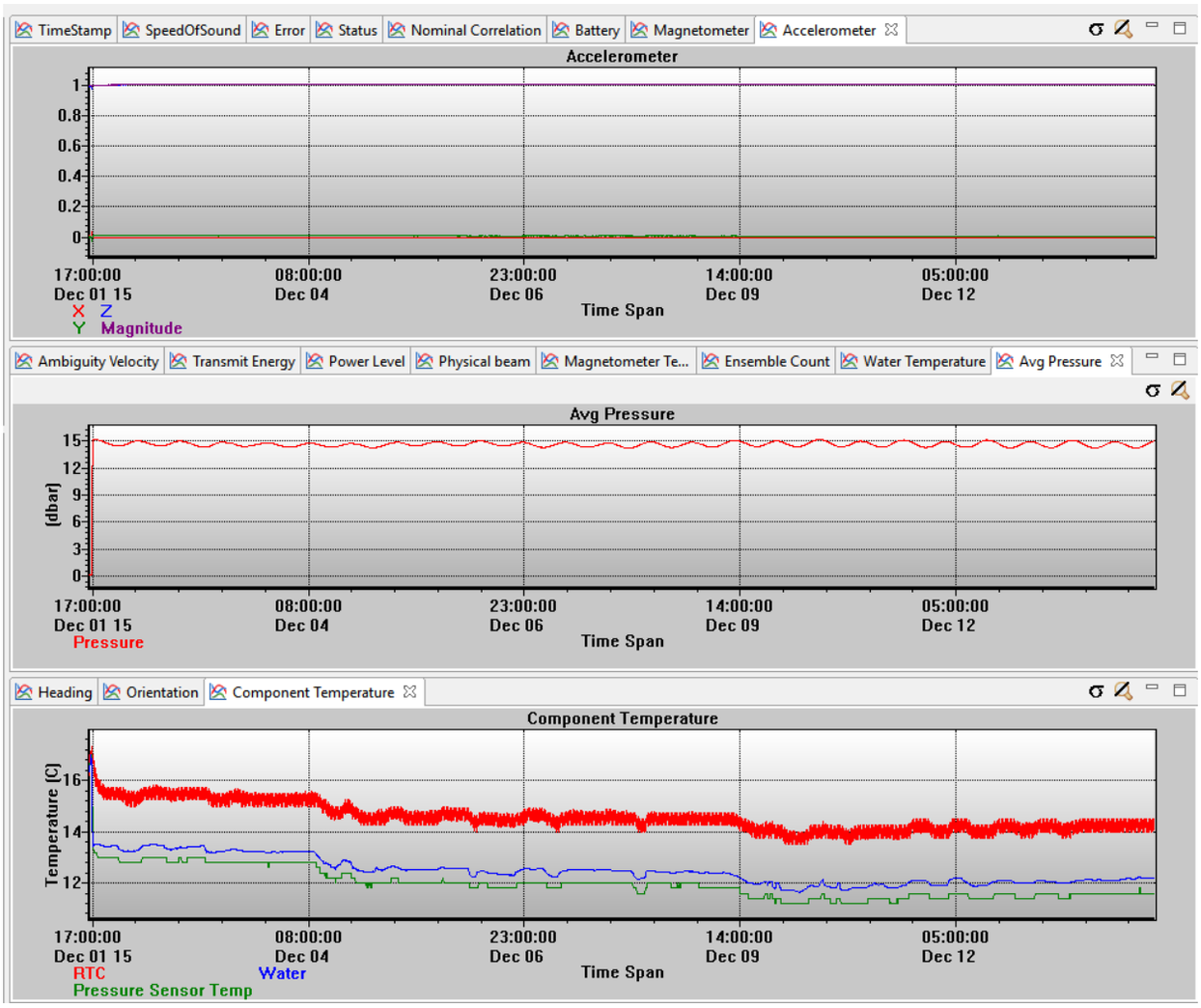
Log Grey: A logarithmically graded scale from black for the minimum data value to white for the maximum data value.

3D Image View Preferences

For large data point counts, the 3D image processing compresses the data size using averaging to produce a point count which is reasonable given the available screen area and the processing power of the computer. The maximum number of data points in the X/Y dimensions can be adjusted using the **Preferences: 3D Image Views** menu option. Using a smaller point count will reduce the processing power required to draw and manipulate the images

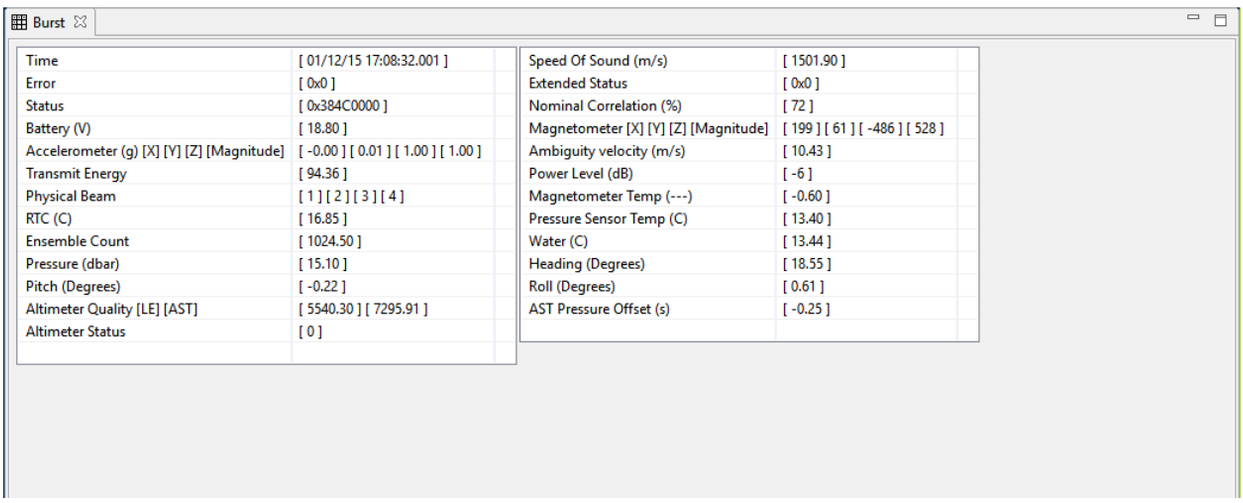
Ancillary Plots

This view displays time series plots for all ancillary data collected along with the profile data (e.g. temperature, heading, orientation, etc.). Zooming in on the time axis of these plots will result in the time axes for all displayed data being zoomed by the same amount. This allows easy viewing of data around a particular event in the data stream.



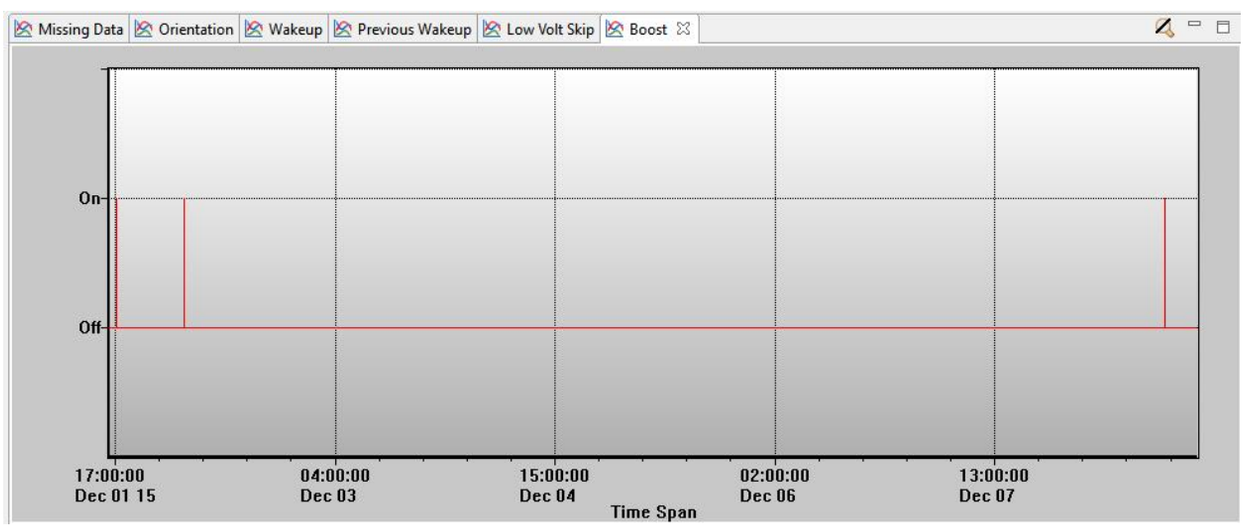
Ancillary Text

Ancillary text shows the same data as would be shown with the ancillary plots, but in text format. The vertical cursor in the 2D Profile contour image is used to select the profile data displayed by the text view.



Status Plots

Each data stream may have one or more operational states associated with it. This view displays time series of the known states for the instrument. In addition to the instrument states, a missing data state (showing where data records were inserted to accommodate for missing data points) is also shown.



Error Plots

Each data stream may have one or more error states associated with it. This view displays time series for the known error states for the instrument

Report Generation

Generating a report results in the creation of a document using all of the data currently being displayed. For Word and PowerPoint documents selecting a pre-existing document for output will result in the generated report being appended to the document using the document styling in the document. If a new document has to be created, the template documents in the installation directory are used to determine the document styling. In addition to data images, a Word document report also produces chapters containing configuration information for the instrument and processing used to produce the images. For image output, the image files produced are stored in a user selected sub-folder in the **Images** folder of the project. The default size of the images can be changed using the **Preferences: Image Export** menu.

Graphing Operations

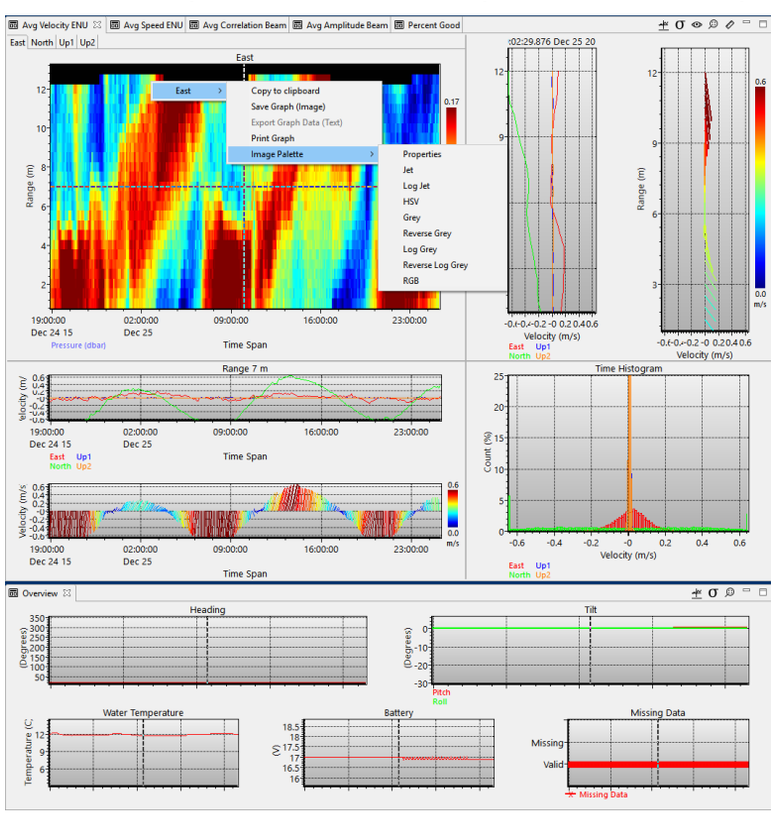
Within a single graph, hovering the cursor over the data area of the graph will bring up a display showing the graph values corresponding to the mouse location within the window. Holding down SHIFT key in a line plot while hovering will cause the mouse to snap to the nearest data point and display the corresponding values.

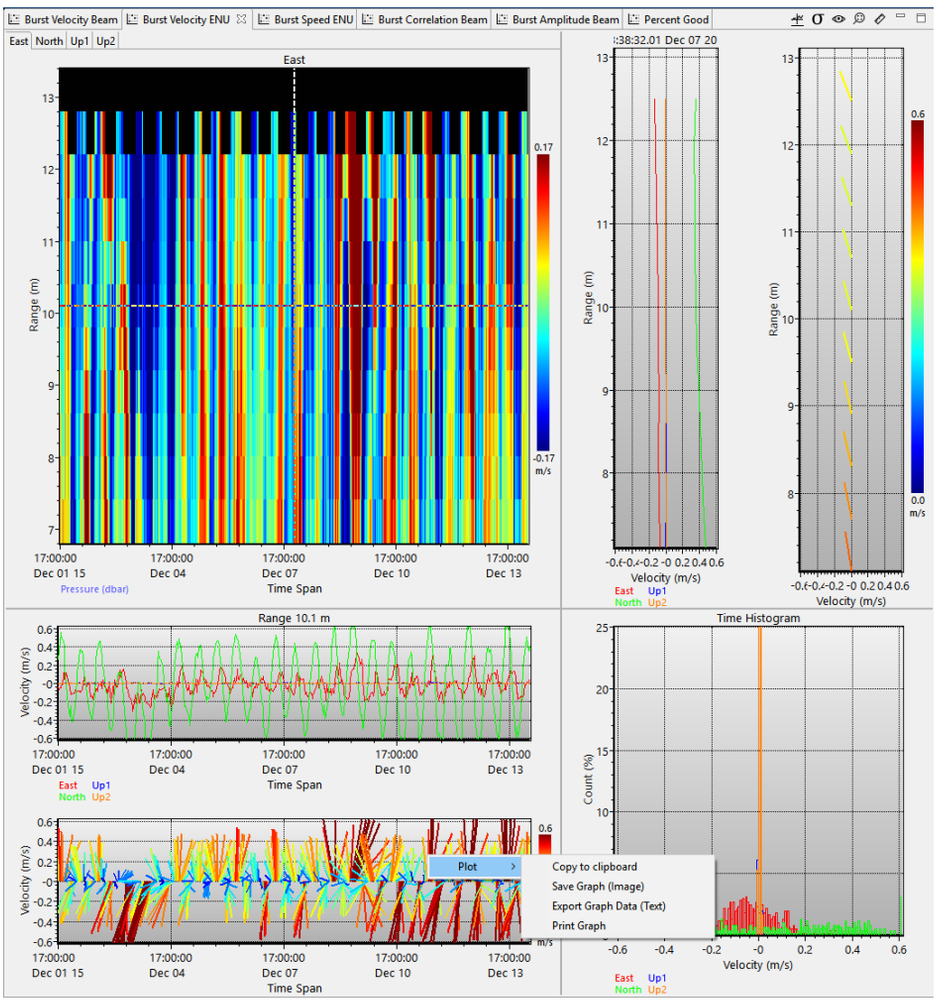
2D plots can be zoomed by double clicking on the appropriate axis, bringing up a menu allowing the limits to be entered or by hovering the mouse over the axis and using the mouse wheel. When using the mouse wheel, the location of the mouse will be used as the centre point for the zoom. If the mouse is positioned in the data view, then both axes will be zoomed with the mouse wheel. Finally, a zoom-in area can be selected by holding down CTRL plus the left mouse button and pulling the rubber band box created over the desired zoom area.

Zooming is restricted to prevent zooming in too far in (less than a few points being displayed) or out too far (outside of the actual data limits).

Graph Pop-up Menu

Right clicking on the plot window area brings up the plot window pop-up menu. This menu allows specific actions to be performed on the plots.





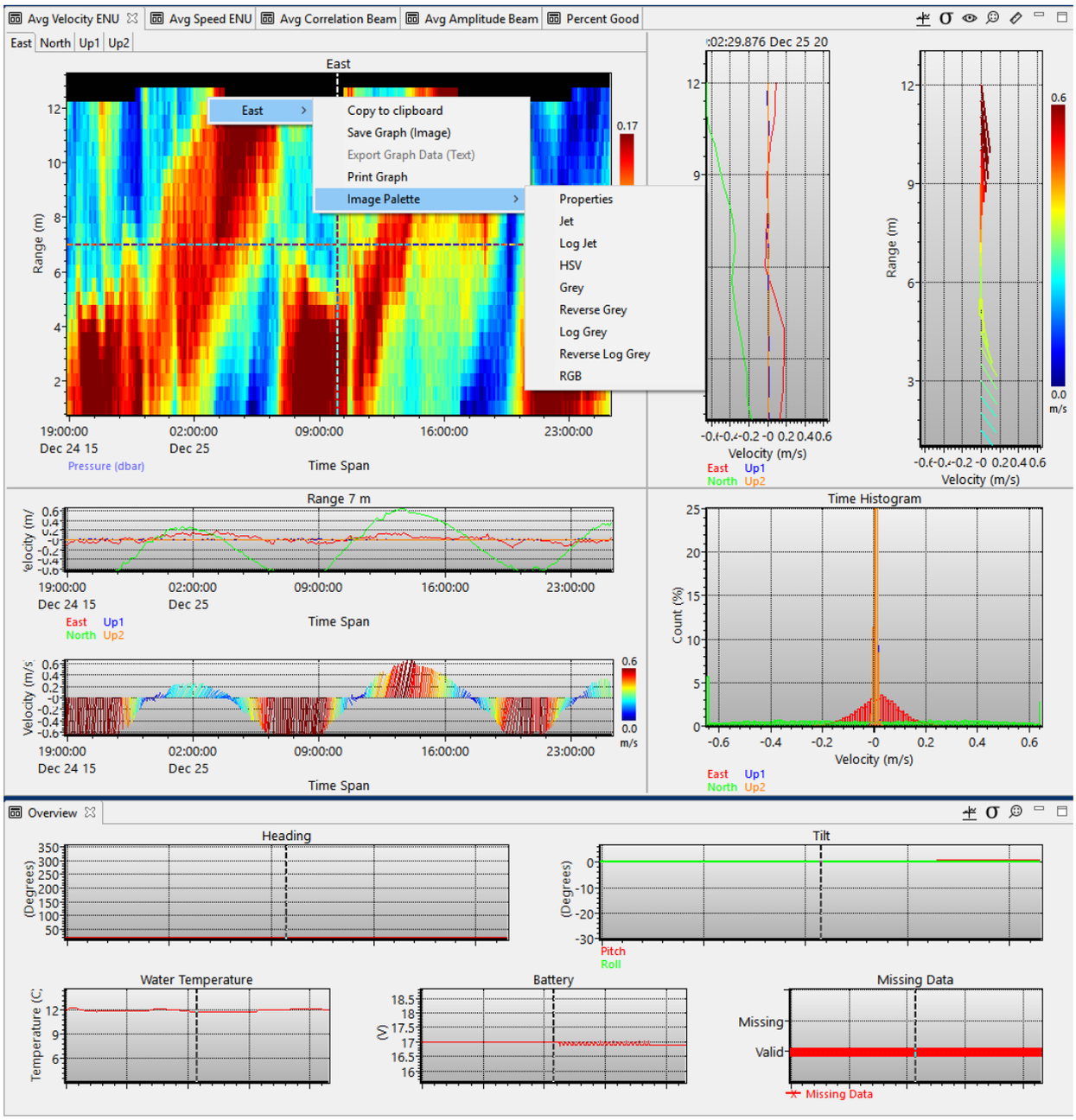
Each window has a separate entry in the pop-up menu (activated by right clicking on the data portion of the graph).

Copy to Clipboard: Saves a copy to the clipboard ready for a paste operation.

Save Graph (Image): Saves the plot to disk as an image file

Export Graph (Text): Exports the data used to create the graph into an ASCII file.

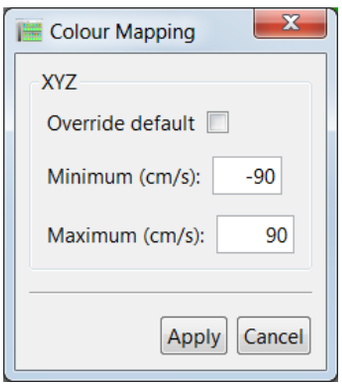
Print Graph: Prints the graph.



Imaging plot windows include an **Image Palette** option for altering the colour palette used to display the image data. The palette menu can also be brought up by double clicking on a colour bar in the image.

The following options are supported for the image palette:

Properties: Adjusts colour map data limits. This let you adjust the scaling used to convert the minimum data value to the bottom of the colour map and the maximum data value to the top of the colour map. If **Override default** is not checked, then the default limits are used instead of the user limits.



Jet: A graded colour scale similar to the jet colour map in MATLAB.

HSV: A graded colour scale using hue / saturation / value which wraps the hue value from 0 to 360 degrees over the data limits.

Grey: A linearly graded scaled from black for the minimum data value to white for the maximum data value.

Reverse Grey: A linearly graded scaled from white for the minimum data value to black for the maximum data value.

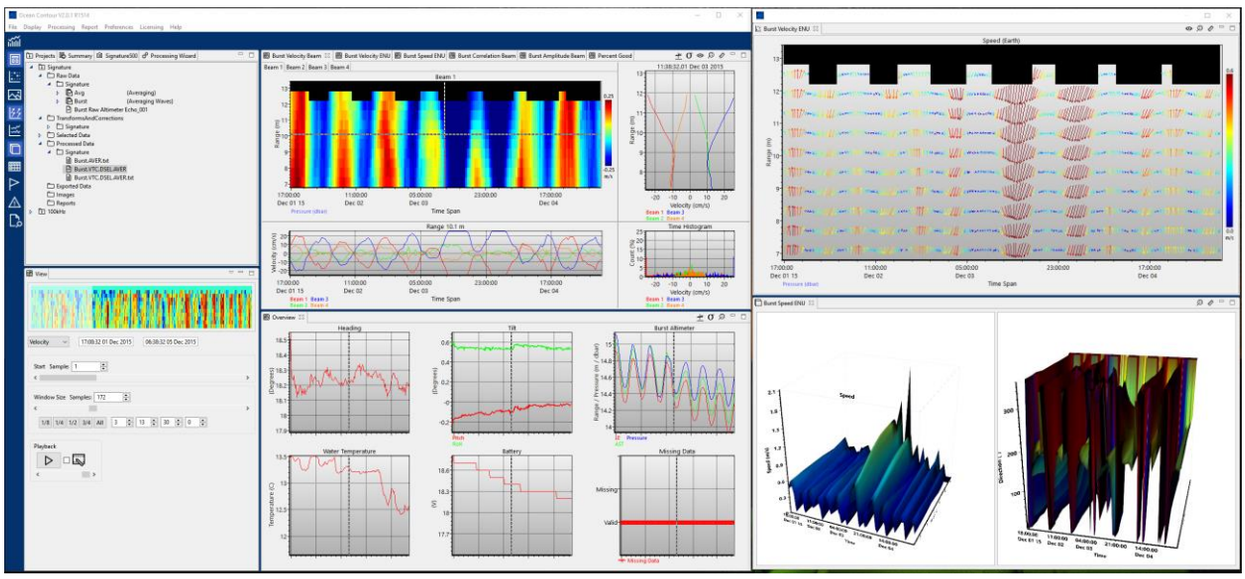
Log Grey: A logarithmically graded scaled from black for the minimum data value to white for the maximum data value.

Reverse Log Grey: A logarithmically graded scaled from white for the minimum data value to black for the maximum data value.

RGB: A graded red scale for low data values, a graded green scale for median data values and a graded blue scale for high data values.

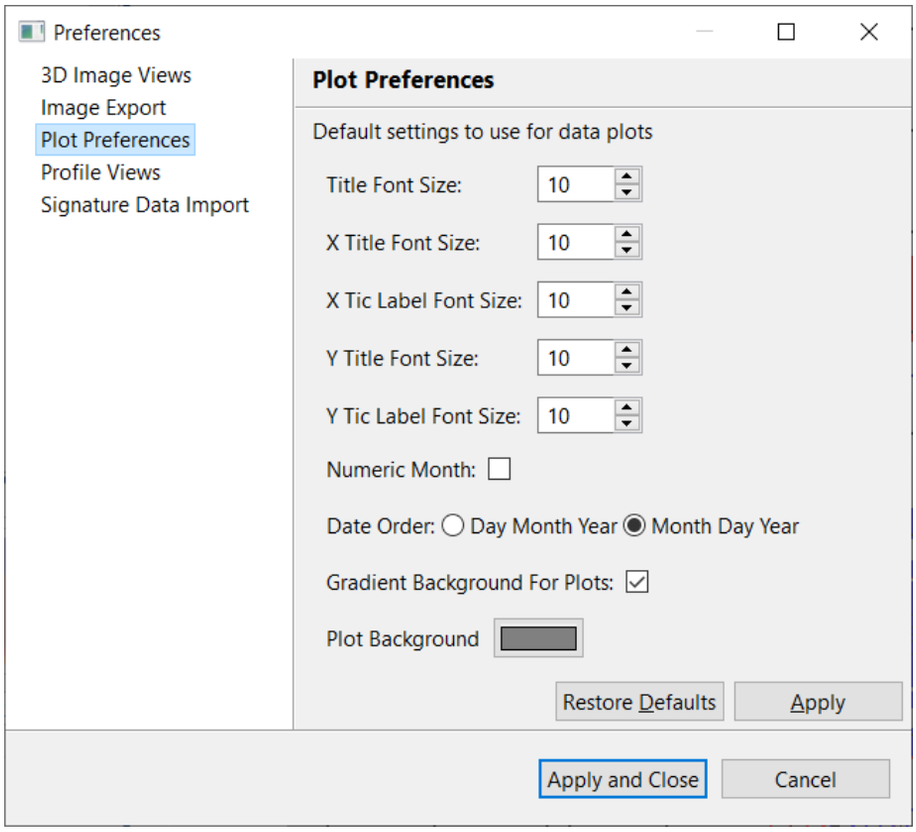
Windowing Drag and Drop Operations

Display windows are organized into “tabs” (individual display views) and “stacks” (grouped display views). A tab can be undocked from a stack by dragging the tab out of the current stack. Other tabs can be dragged into this newly created stack window to create a custom data view. This ability to undock / re-dock data view provides a means of maximizing the screen real-estate. Right clicking on the tab title lets you close individual data views within a stack.



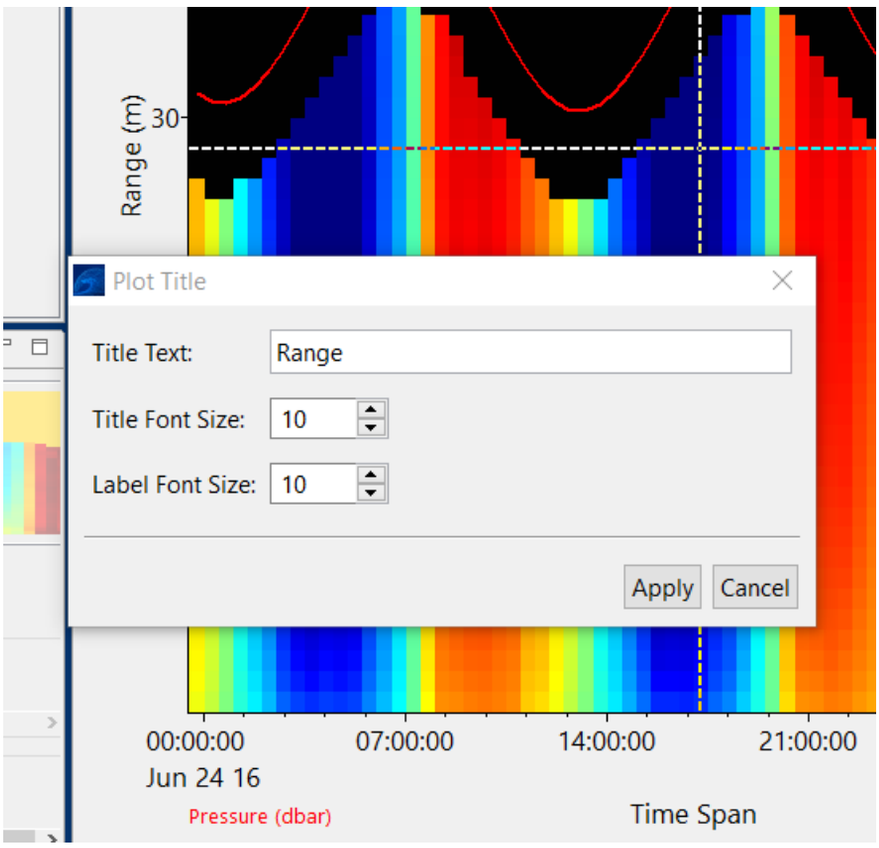
Plot Preferences

Default aspects of the plots produced by Contour can be set using the Plot Preferences menu. These include the font sizes used for various text elements of the plot, whether or not a numeric or text month display is used, the order of the day and month in the date and the background colour used for the plot window.



Changing Plot Text

Double clicking on the main plot title or axes titles pops up a dialog box allowing the font and title text to be changed. This change is not persistent. If the graph is removed and re-drawn, the default settings are used.

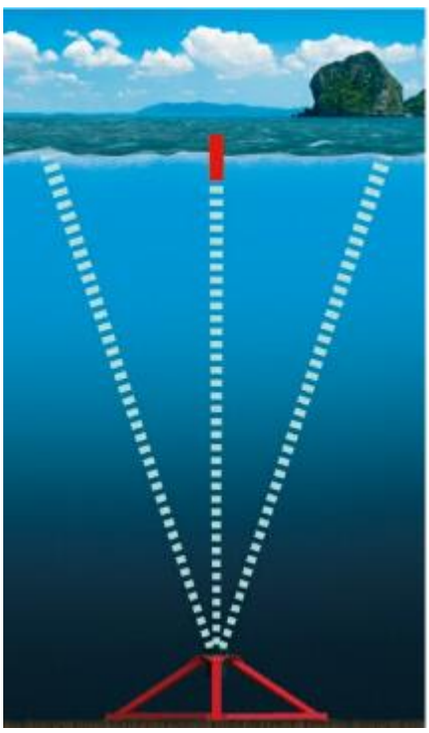


Chapter 4
Wave Processing

Waves

All bodies of water experience waves. These may range from long waves, such as tides to tiny wavelets generated by the wind's drag on the water surface. There is considerable variability in the distribution of energy for waves with periods from 12 hours to 0.5 seconds. A significant contribution of this energy is found in the band from 0.5 to 30 seconds, commonly referred to as wind waves. These are the waves engineers and scientists are primarily interested in when they discuss wave measurements. Measuring these waves accurately often comes down to how complete the measurement method covers this band.

Wind waves are random and may vary in both time and space, and this variability makes characterizing waves non-trivial. Waves begin both small in height and short in length, created by local winds, and grow as a function of wind strength, duration of wind, and distance. As a result, the wave environment at a particular location is composed of a combination of local wind waves from a sea breeze and long waves (swell) generated by storm events hundreds or thousands of kilometers away. The local sea state, then, is composed of waves with different amplitudes, periods, and directions.



Sampling area of the Signature while measuring waves

When using the Signature series to measure waves, the instrument is configured to sample a number of samples at a certain sample rate every measurement interval. One may view the Signature's measurements as two separate operations which permits the ability to estimate Directional and Non-Directional wave parameters:

1. The four beams slanted off to the side measure wave generated orbital velocities. Each beam measures a truncated profile - or one sufficiently capturing the orbital velocities. From the recorded profile one may select a level below the surface where the measurements form an array projected from the Signature to just below the surface. Managing the fact that orbital velocities attenuate exponentially with depth means that the data used for wave processing are the ones that are measured close to the surface, while ensuring that there is no contamination from the surface either directly from the cells touching the surface or indirectly from side lobes. This can be managed by adaptively positioning the cells just below the surface by a fraction of the measured depth; 10% of the depth has proven to provide a good signal response without contamination.

2. The fifth, vertical beam works as an altimeter and measure the distance to the surface directly. It traces the surface wave profile as it passes through its field of view. The Signature series instruments have a relatively large, fixed altimeter window, which is defined in processing depending on the pressure sensor (calculated per ping). Wave processing will select a suitable wave cell per wave burst, so it will change depending on the tidal conditions.

A cleanup step is iteratively performed on the raw time series and if the cumulative number of false and no detects exceeds 10% of the total number of samples in the ensemble, the ensemble is considered corrupt and discarded.

The resulting time series of the raw measurements is not particularly useful from a practical standpoint, and therefore needs to be processed to yield parameters that can broadly, yet accurately, characterize the sea state.

The resulting wave parameters into the two categories introduced above; Non-Directional Parameters (Wave Height) and Directional Parameters (Wave Direction).

Non-Directional parameters covers parameters that do not depend on the direction of the waves, and comprise:

Peak period (Tp), Mean period (Tm02), Mean zero-crossing period (Tz), Mean 1/3 Period (T3), Mean 1/10 Period (T10) and Maximum Period (Tmax)

Significant wave height (Hm0), Mean 1/3 and 1/10 height (H3 and H10), Maximum height (Hmax), Mean height (Hmean),

Directional parameters include Peak direction (DirTp), Directional spread (SprTp) and Mean direction (Mdir). Direction is always reported as where the waves are coming from.

Acoustic Surface Tracking

The Acoustic Surface Tracking (AST) is basically echo-ranging to the surface with the vertically oriented transducer (altimeter). The approach used to detect the surface is relatively simple. It can be broken down into the following sequence of steps.

1) Transmit a relatively short pulse

2) Specify a receive window covering the range of all possible wave heights

3) Discretize the receive window into multiple cells (~5 cm)

4) Apply a match filter over series of cells to locate the maximum peak, which is the surface

5) Use quadratic interpolation to precisely estimate surface location.

Non-Directional Limitations

The wave resolution from the altimeter measurements is dependent on deployment depth. The diameter, or the "footprint" of the area ensonified by the altimeter increases as the distance from the surface increases. When the diameter of this footprint becomes similar in size to a wavelength, then the structure of the waveform (crest and trough) cannot be well resolved. There is an average of the distance over the waveform and thus a "smearing" of the true features. A "cut off" frequency is assumed when the

footprint diameter is equivalent to half a wavelength. The relationship is plotted in the figures below.

➔ Example: The Signature250 is to be deployed with a distance to the surface of 80m, and the footprint on the surface from the altimeter beam will be 80*tan(2.2). The minimum wavelength needs to be twice this footprint (~6.15m). The equation that relates wave length (L) to wave period (T) is L = gT^2/2π. Using this equation the minimum wave period measurable at 80 m depth is ~2m.

Directional Limitations

The directional limitation lies within the relationship between the wavelength and separation distance of the measurement cells. The shortest period wave is limited by the rule that an unambiguous direction estimate may only be made for waves that have a wavelength that is twice the separation of the closest cells.

Given that the distance between the measurement cells increases with distance from the instrument, the spatial separation of the cells depends on the depth of the instrument.

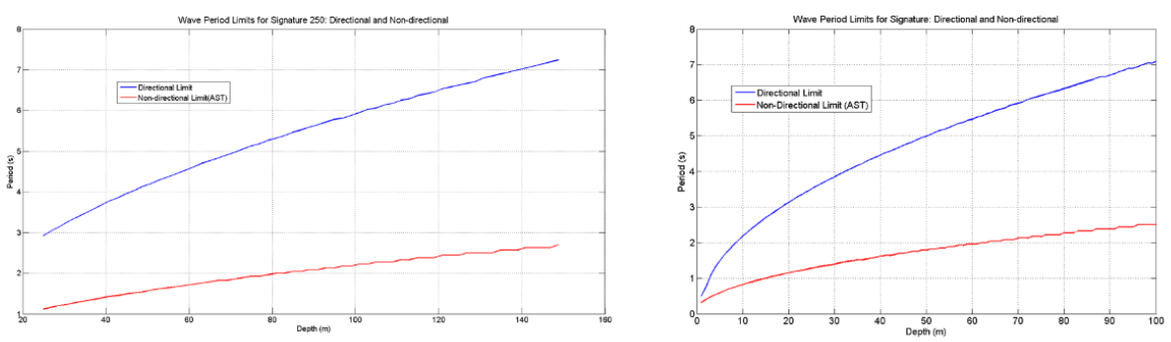
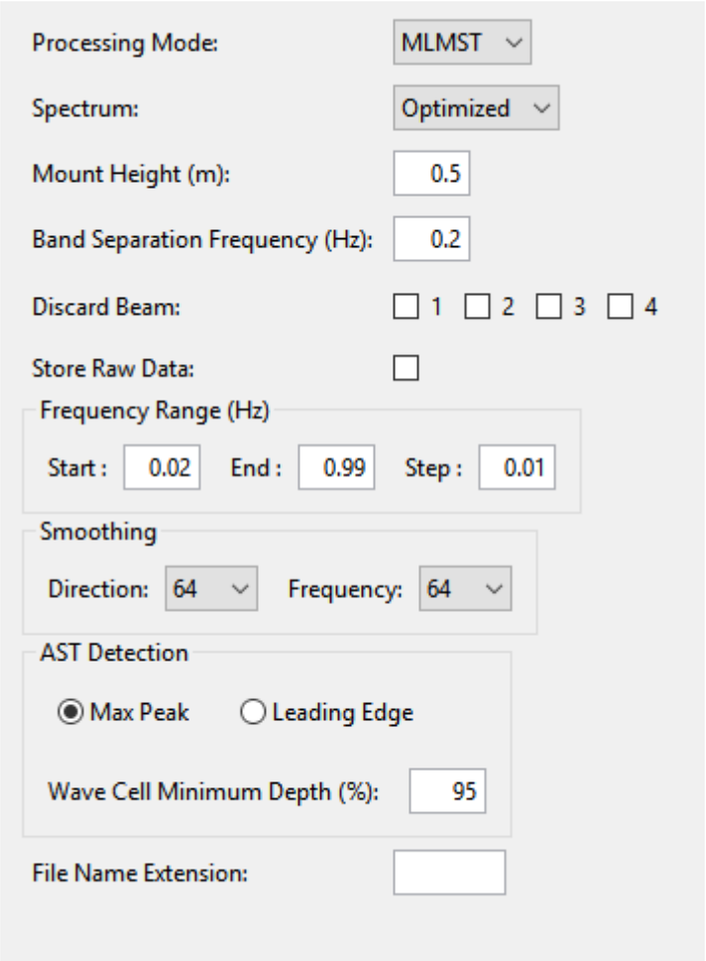


Figure 4.2: Shows the directional and non-directional limitations for different instrument depths and different wave periods. To the right: Signature250. Left: Signature1000 and Signature500.

One perceived solution is to position the measurement cells closer to the instrument such that the spatial separation is reduced and consequently the frequency at which this ambiguity occurs is higher. Unfortunately, moving the measurement cell further down in the water column means that the orbital velocity signal may disappear. The result is that there is no performance gain by drawing the cells in closer to the instrument.

Wave Processing Parameters



(NOTE: If the magnetic declination needs to be altered, this must be done in the Transforms and Corrections section before the wave processing is started.)

Processing Mode: This is the algorithm used for the directional wave processing. MLMST is the default. This is the Maximum Likelihood Method with Surface Tracking. This is a special type of array processing that is well suited for Signature wave measurements.

The MLM method is the same but without surface tracking, and is used for data that does not have AST.

The PUV method is suited for instruments that collect this special “triple point” type of measurement. This includes the Aquadopp, Aquadopp Profiler, and the Vector.

The SUV method is a special method that is a hybrid between the PUV and AST. It is particularly well suited for deployments on a subsurface buoy. The method may be used for bottom mounted deployments even if data was collected without the SUV mode turned on in the deployment configurations. The method is also better suited

(than MLM) for deployments where the waves are exposed to large mean currents. Mean currents can present a Doppler shift on the wave field and introduce error in the directional and non-directional estimates if not corrected; The SUV method does not require this correction.

Spectrum: This chooses the type of spectrum used to calculate the wave parameters (Pressure, Velocity, AST or Optimized). "Optimized" is the default. This setting will choose the AST spectrum where possible and one of the other types depending on depth otherwise.

Mounting Height: The distance from the instruments head (the pressure sensor location) to the sea floor; this is used to calculate the transfer functions used for the pressure and velocity. Transfer functions for the velocity and pressure measurements are used when estimate standard wave parameters.

Band Separation Frequency: The band separation frequency distinguishes sea and swell estimates. The sea estimates are from wave activity generated by local conditions, while the swell estimates are from far away sources like tides. Sea and swell tend to have different directions in addition to different periods. The estimates for the non-directional parameters of height and period are based on the energy density spectra and the directional estimates are based on the Fourier coefficients; peak estimate uses the specific frequency of the peak energy in the band while the mean estimate uses the energy weighted Fourier coefficients for the calculation.
Significant wave height is a wave estimate that is based on the integrated energy density over a band. This means that the wave heights calculated for the swell and sea cannot simple be added together in order to get the total significant wave height reported.
The separation frequency is different between oceans. For example, in the Mediterranean, waves typically separate around 3 seconds, while in the Pacific they separate around 7 seconds.

Discard Beam: Allows the user to discard a beam and use a three beam solution instead. This option can be used to remove an unusable beam (e.g. obstructed path, faulty transducer). This option is only available on four beam Signature series instruments.

Store Raw Data: If desired the raw data used to calculate the wave parameters can be stored along with the wave data. Note that this setting can add significantly to the size of the data file, which may cause issues on machines with lower amounts of RAM available. The raw data includes, for each sample, the beam velocities, amplitudes and correlations, the pressure, surface distance, wave cell position, pitch, heading and roll.

Direction (Smoothing): Specifies how much averaging is used for each discrete direction in the spectra.

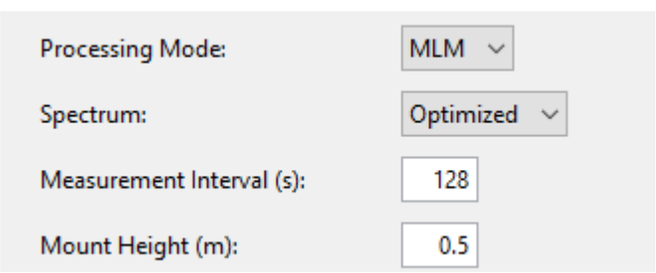
Frequency (Smoothing): Specifies how much averaging is used for each discrete frequency of the spectra. More specifically, the number here specifies how many FFT bins are used at each frequency. The greater the number of bins, the smoother the spectra will appear; conversely, the lower the number of bins, the more the spectra will appear to be "spikey". The number of bins specified does not change the total energy, but may change the distribution of energy slightly.

Frequency Range: This sets the frequency range of the non-directional (energy) spectra. This will also be the limit for the directional spectra. If the user selects an upper frequency that is out of range, then the software will use the Nyquist limit (sampling frequency/2) as the upper frequency. The lower limit is set to 0.02 Hz by default. The smallest frequency step is 0.005 Hz, but is set to 0.01 as a default.

AST Detection: Specifies the algorithm to use for the acoustic surface tracking. **Max peak** uses the maximum peak in the surface echo intensity to determine the surface while **Leading edge** detects where the edge of the surface echo intensity profile.

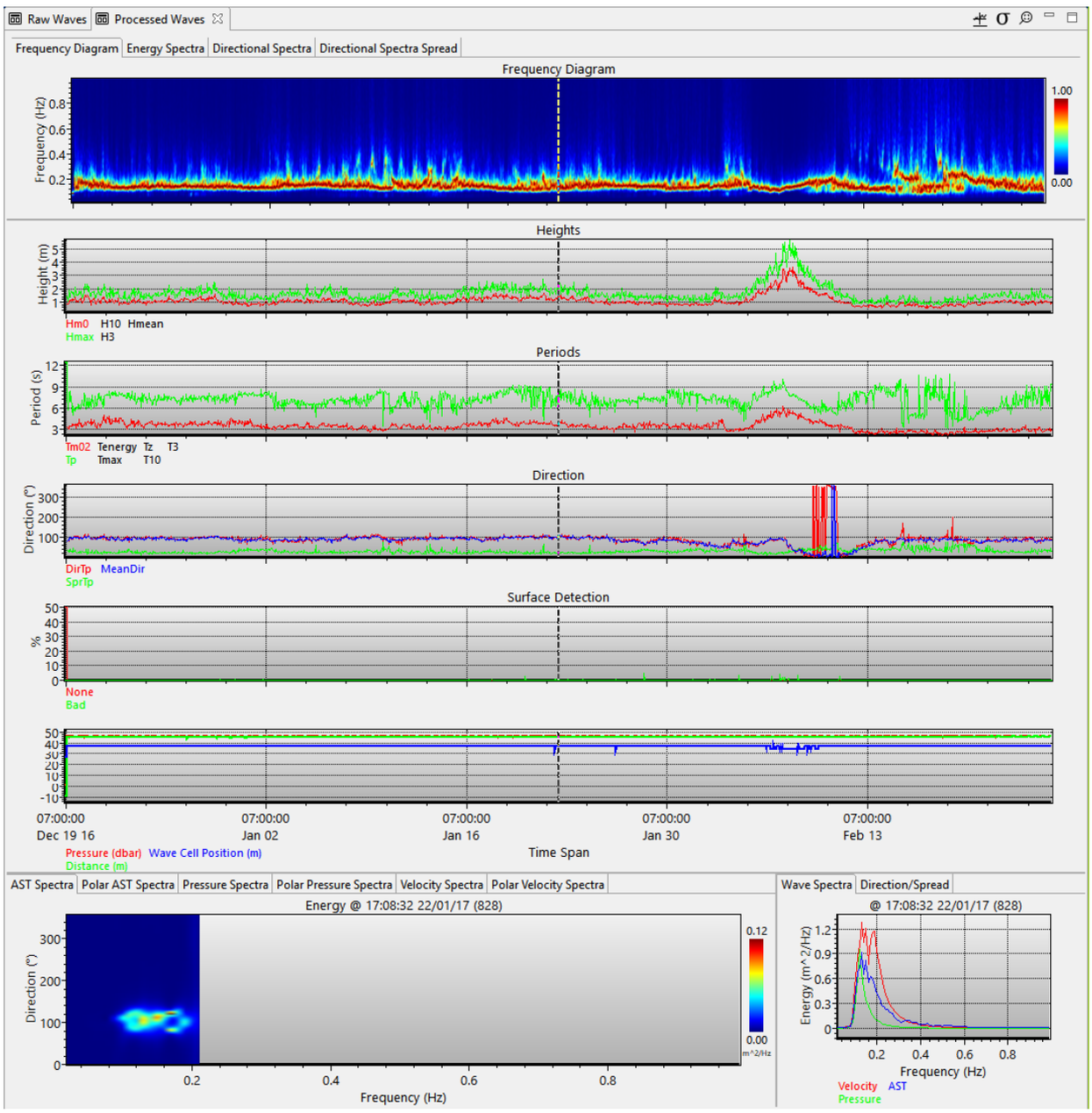
Wave Cell Minimum Depth: The position of the wave cell in the water column expressed as a percentage of the water depth.

Measurement Interval: This parameter is presented when the data set is continuously collected (i.e. no gaps between the data bursts). The measurement interval is the desired time interval (in seconds) that is used for the wave processing calculations. Internal minimum / maximum values will be applied to this parameter as required.

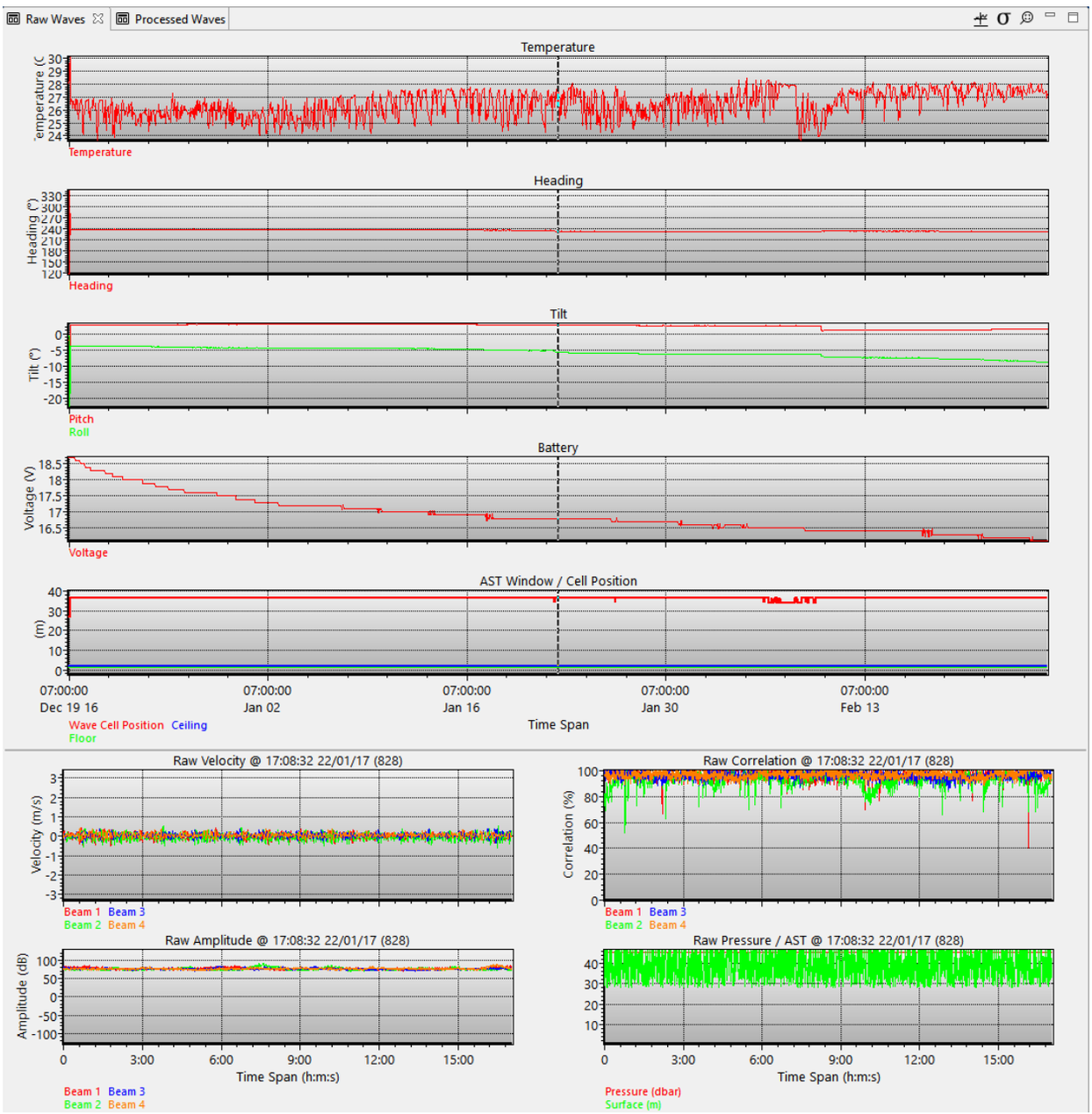


Wave Data

Data Overview



The vertical cursors in the images and waves data plots control which the time slot used to display the AST / Pressure / Velocity spectra at the bottom. The time stamps for each data record are calculated from the mid-point of the burst data time period used. Note that Signature Waves uses the start of the burst time period as a time stamp.



The vertical cursors in the top plots are used to determine the time slots for the raw, single ping used in calculating the wave parameters displayed in the bottom plots.

Spectra based estimates

Instruments that are outfitted with Acoustic Surface Tracking (AST) should use the “Optimized” setting as the primary spectra unless there are specific reasons not to do so. This setting selects the AST spectra when available and reverts to pressure or velocity if the AST calculation fails.

The user may also choose pressure or velocity energy spectra estimates.

Time series based estimates

Time series based estimates are only available with AST. Time series estimates utilize the "zero-crossing" technique to identify individual waves in a time record. The method defines a mean value and wave start and finish when the time series crosses this mean value. Standard statistical wave parameters are produced.

Spectra Type

This is the spectra that was used to estimate the non-directional parameters of height and period. For a PUV instrument this is always pressure. For the AWAC it may be the Pressure, Velocity, or the AST, which is 0, 1, or 3, respectively.

Significant Wave Height (*Hm0*)

This is the classic estimate sometimes referred to as Hs. It is calculated from the energy spectrum; $Hmo = 4\sqrt{\sum M_0}$.

Mean 1/3 Wave Height (*H3*)

This is the mean of the 1/3 largest waves in a record. It is a time series based estimate. Typically this value is 5% larger than *Hmo*, yet variations can be greater or smaller. Note: AST only.

Mean 1/10 Wave Height (*H10*)

This is the mean of the 1/10 largest waves in a record. It is a time series based estimate when AST is available. When AST is not available, then this estimate may simply be presented as a linear extrapolation of *Hmo*, whereby $H10 = 1.27Hm0$. Note: AST only.

Maximum Wave Height (*Hmax*)

This is the largest wave in a record. It is a time series based estimate when AST is available. When AST is not available, then this estimate may simply be presented as a linear extrapolation of *Hmo*, whereby $Hmax = 1.67Hm0$. Note: AST only.

Mean Wave Height (*Hmean*)

This is the mean value of all waves in a record. It is a time series based estimate when AST is available. When AST is not available, then this estimate is marked as an invalid value.

Mean Period (*Tm02*)

This is the average period for all the waves in the burst and it is calculated from the energy spectrum according to the first and second moment of the energy spectrum: $Tm02 = \Sigma(M0/M02)$ The value is reported in seconds.

Peak Period (*Tpeak*)

This is the period of the waves corresponding to the peak frequency for the wave spectrum. The value is reported in seconds.

Mean Zero-crossing Period (*Tz*)

This is the mean period calculated from the zero-crossing technique. It is calculated as the mean of all the periods in the wave burst. The value is reported in seconds.

Mean Zero-crossing Period (*T3*)

This is the mean period associated with the 1/3 largest waves (*H3*) in a record, where the period is calculated from the zero-crossing technique. The value is reported in seconds.

Mean Zero-crossing Period (*T10*)

This is the mean period associated with the 1/10 largest waves (*H10*) in a record, where the period is calculated from the zero-crossing technique. The value is reported in seconds.

Mean Zero-crossing Period (*Tmax*)

This is the mean period associated with the largest wave (*Hmax*) in a record, where the period is calculated from the zero-crossing technique. The value is reported in seconds.

Peak Direction (*TpDir*)

This is the direction of the wave corresponding to the peak period. The direction is reported as “from” and is reported in degrees.

Directional Spread (*Spr1*)

The directional spread is a measure of the directional variance. The estimate is calculated for the peak frequency. The value is reported in degrees.

Main Direction (*Mdir*)

This value is a weighted average of all the directions in the wave spectrum. It is weighted according to the energy at each frequency. The direction is reported as “from” and is reported in degrees.

Unidirectivity Index

This is a measure of how much of the wave energy over the full spectrum is from a single direction. Values range from 0.0 to 1.0, and a value of 1.0 indicates the energy is from one primary direction. Wave spectra with peak energy at several directions or frequencies will lead to lower values.

Mean Pressure

The mean pressure is calculated over the duration of the burst, and provides estimate of the depth. The value is reported in decibars. In fresh water, 1 dbar=1meter of water. This means that if one assumes this value is depth in meters then the estimate reported for instruments deployed in saltwater will overestimate the depth by 2.5% (for seawater density = 1025 kg/m3).

Mean AST distance

This is the mean distance of all AST estimates in a burst, after the time series has been quality controlled and de-spiked. Distance is reported in meters.

Number of No Detects

This is a count the number of pings that did not detect the surface. Note: AST only.

Number of Bad Detects

This is a count the number of pings that detect something in the water column but data analysis indicated that it was outside the normal boundaries to be the surface. Bad detects or Outliers is a value that is 4*(Standard Deviation of the time series). Note: AST only.

Number of Zero-Crossings

The number of uniquely identified waves in a wave burst that was used for all time series based estimates (*H3, H10, Hmax, Hmean, T3, T10, Tmax, Tz*).

Current direction (wave cell)

This is an estimate of the current direction as estimated from the wave measurement cell. All data recorded during the wave burst is used for this estimate. Estimates are reported as degrees.

Current speed (wave cell)

This is an estimate of the current speed as estimated from the wave measurement cell. All data recorded during the wave burst is used for this estimate. Estimates are reported as meters/second.

Error Codes

The error code is the sum of the bit codes for all the quality control checks of the data.

No Pressure (000 0001): This would appear if the pressure is too low, and indicates that the instrument was most likely out of the water or unreasonably close to the surface.

Low Pressure (0000 0010): No dynamic pressure detected in the time series, and suggests that the waves were not measurable (constant pressure). This would occur if the instrument was deployed at a depth that is too deep to measure the waves or simply that there were no measurable waves.

Low Amplitude (0000 0100): The amplitude of the Doppler signal was too low to measure the orbital velocity.

White Noise Test (0000 1000): This test is to determine if the estimated wave energy spectrum is purely white noise. Such a spectrum does not contain information about the surface waves.

Unreasonable Estimate (0001 0000): If it appears that there is an unreasonable wave parameter estimate then the burst is flagged as bad.

$H_s > 20$ meters

Tm02 > 35 seconds or Tm02 < 0.5 seconds

$T_p > 50$ seconds or $T_p < 0.5$ seconds

Never Processed (0010 0000): The wave processing cleans up some corrupt data (i.e. checksum errors) however if number of bad points exceeds 10% of the burst data, then the data is not processed and it is tagged with this error message. Usually this error message suggests that the wave burst was incomplete or damaged

AST Out of Bounds (0100 0000): Since many of the AST estimates are based on the zero-crossing, there is a check to make certain none of these estimates are unreasonable. Estimates are limited as follows:

$H_3 < 20$ meters

$H_{10} < 25$ meters

$H_{max} < 35$ meters

0.5 seconds $< T_{mean} <$ 35 seconds

$T_{peak} < 30$ seconds

Direction for Peak Period Out of Bounds (1000 0000): This limit is applicable for directional estimation using the Maximum Likelihood Method. As we move up in frequency the wavelength decreases and at some wavelength there is a limit associated with the array separation distance that can unambiguously resolve wave directions. A check is performed to see if the wavelength associated with the peak period is too small to resolve the wave direction at this frequency.

No Pressure Peak Found (0001 0000 0000): This indicates that there was no pressure peak found in the spectrum. Waves probably did not exist in spectrum (too high frequency).

Close to clipping (0010 0000 0000): This indicates if the surface track is close to reaching the extent of its range. Such a situation would clip the crest of the waves an underestimate the wave height estimates. A fast value of 0.25 meters has been chosen to indicate this situation.

High AST Data Loss (0100 0000 0000): This indicates that the too many points were lost during the data clean-up or de-spiking steps. The level at which the data loss in the AST time series is considered excessive is 10% of the data.

Excessive tilt (1000 0000 0000): This indicates that the too much tilt and almost exclusively effects the AST measurements, unless it is extreme. The test is 10 degrees from vertical.

Chapter 5
Further Information and Help

Contact Information

If you need more information, support or other assistance, you are always welcome to contact us by e-mail.

info@oceanillumination.com
support@oceanillumination.com

A support request can also be initiated via the **Help: Send Support File** menu option.

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JTransforms

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