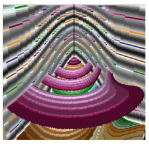
Surface Segments



Name

Surface Segments Used prior to interpreting horizons to reveal the spatial continuity, local dip magnitude and direction, local strike and internal amplitude variations of individual surfaces, as well as the stratigraphic relationships between vertically adjacent surfaces.

Description

The Stark Reality *Surface Segments* attribute is an expansion of the Surface Slice process described by Stark (1991, 1996). It is typically applied prior to interpreting seismic horizons within a 3D volume. It implements a trace-by-trace process that exposes the inherent spatial continuity (or lack thereof) of seismic horizons by producing map segments of events that intersect each Z-slice. Depending upon the user selected parameters, horizontal slices through the *Surface Segments* volume indicate the spatial variations of local dip magnitude and direction, local strike, discontinuity locations, and/or horizon amplitude variations along horizon segments. The stratigraphic relationships of vertically adjacent horizons can also be obtained from *Surface Segments* displays. All of this is obtained without the need of any data pre-processing or requiring any interpreted horizons.

The *Surface Segments* attribute assumes horizons are: 1) always on the same part of the wavelet and 2) are locally smooth and continuous. When using conventional seismic data, these assumptions are typically valid for most of the horizons we might be interested in mapping, however they are often invalid for unconformities.

The output of the *Surface Segments* plugins can be used to obtain a qualitative understanding of the geology of a survey, which can then be used to plan which horizons will be interpreted. A quantitative understanding of the geology can be obtained by using the OpendTect autotracker to extract horizons from the *Surface Segments* attribute volume. The *Surface Segments* output can also be used to identify areas where our typical assumptions break down.

If partial offset (or angle) stacks are available, *Surface Segments*, used in combination with RGB blending, provide a reconnaissance tool to locate horizon based AVO anomalies. These displays also aid in tracking events across faults, particularly if the faults are post-depositional.

If partial azimuth stacks are available, Surface Segments, used in combination with RGB blending, provide qualitative displays which indicate the amount and direction of anisotropy and it's spatial and temporal variability.

Input Parameters

The *Surface Segments* attribute is accessible from the OpendTect *Attribute Set Window* under the *Stark Reality* tab. The *Surface Segments* attribute boasts an expansive array of user modifiable parameters, however most to the parameters are not visible by default. By toggling on the *Enable Advanced Features* checkbox, additional features are made available for further

personalization. These advanced parameters will be discussed later. We will first focus on the features accessible through the default screen.

Basic Parameters

Figure 1 contains the default user interface presented when the Stark Reality *Surface Segments* attribute is selected. In this section we will discuss each of the variables in this window and how the selection of some of the methods associated with these variables exposes additional parameters.

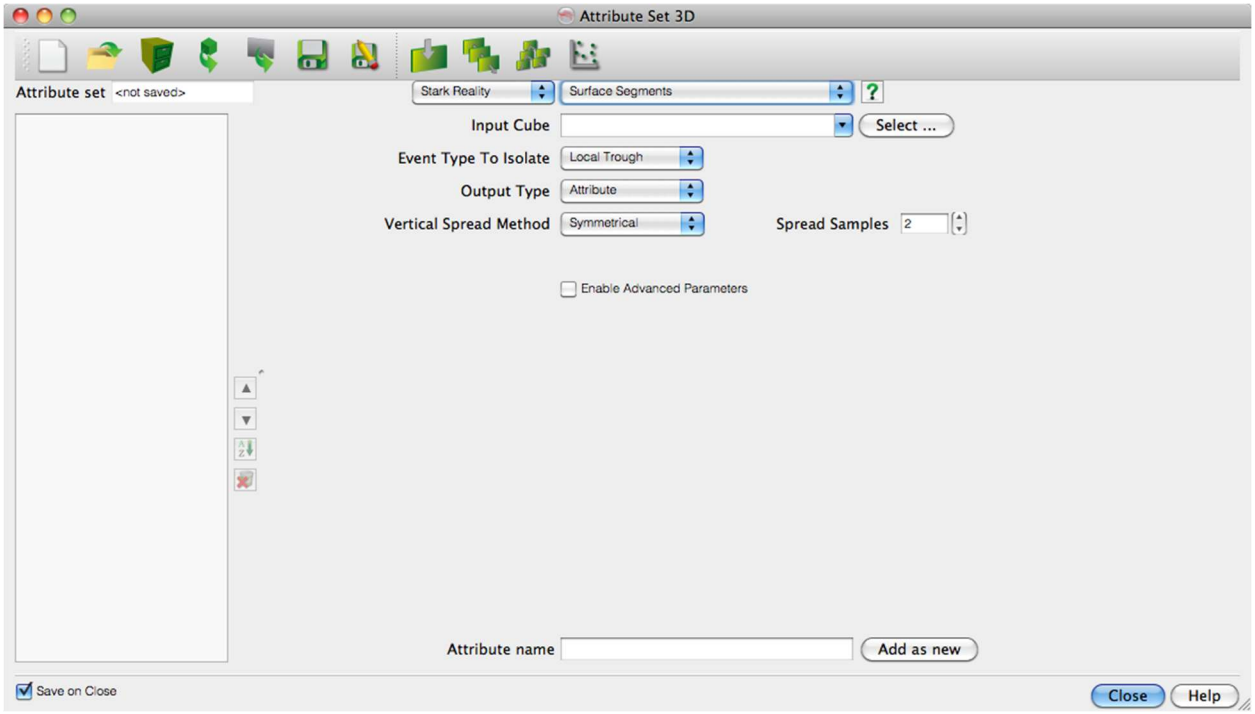


Figure 1: Default parameter screen.

Input Cube You can select any available attribute for which you wish to identify spatially continuous surfaces based on the *Event Type To Isolate*. The original seismic data is typically selected. All but the *Local Peak* and *Local Trough* of the available *Event Type To Isolate* methods assume data with a "mean value of zero (i.e. those that oscillate about zero).

Event Type To Isolate This is the part of waveform used to define the *Surface Segments*. The available event types are further defined below, and their visual representation is contained in Figure 2.

Peak A sample that is greater than zero and greater than both of the adjacent samples above and below

Trough A sample that is less than zero and less than both of the adjacent samples above and below

Local Peak A sample that is greater than both the adjacent samples above and below, regardless of its polarity

Local Trough A sample that is less than both of the adjacent samples above and below, regardless of its polarity. (Default Value)

Neg-to-Pos A sample at which the seismic attribute changes from negative to positive values. (If the *Enable Advance Parameters* checkbox is activated, selecting this option enables the *Zero Crossing Placement* option as shown in Figure 5.)

Pos-to-Neg A sample at which the seismic attribute changes from positive to negative values. (If the *Enable Advance Parameters* checkbox is activated, selecting this option enables the *Zero Crossing Placement* option as shown in Figure 5.)

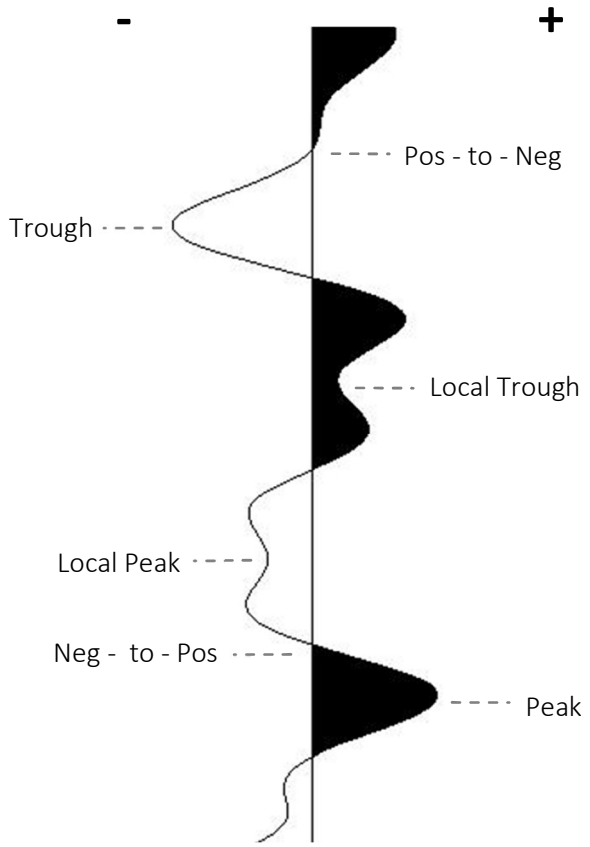


Figure 2: Visual depiction of *Event Type To Isolate* options.

Zero Crossing Placement This parameter is only available when *Event Type To Isolate* is either *Neg-to-Pos* or *Pos-to-Neg* and the *Enable Advance Parameters* checkbox is activated. This parameter determines which of the two samples that straddle a zero crossing is used to store the zero crossing value. See Figure 3 for a visual depiction of these options.

Minimum Sample with minimum absolute value regardless of polarity or vertical location

Positive Sample with positive amplitude value

Negative Sample with negative amplitude value

Shallow Shallowest of the two samples

Deep Deepest of the two samples. (Default Value)

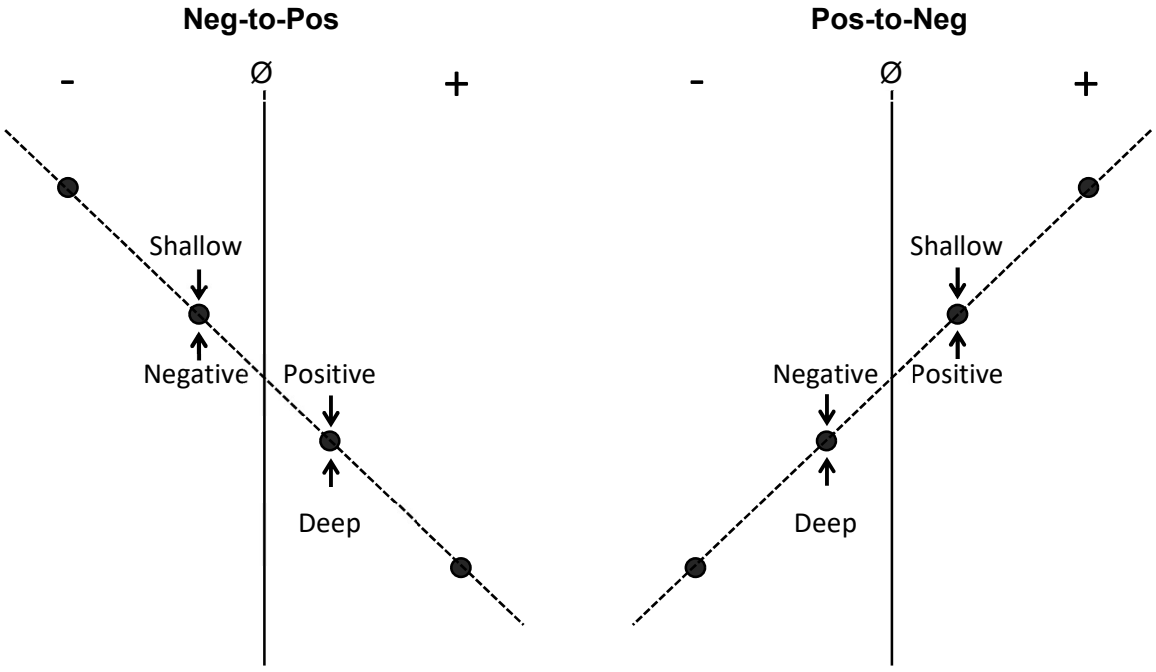


Figure 3: Visual depiction of *Zero Crossing Placement* options.

Output Type How the Surface Segments are represented in the output trace.

Attribute Value of input trace at location of event types (Default Value)

Sample Number Vertical sample numbers at which desired *Event Type To Isolate* attribute occurs. By default the *Sample Number* is wrapped to fall in the range of 1 to 25 by using a *Sample Wrap* value of 25. *Sample Wrap* is one of the *Advanced Parameters* the user can modify. (See Figure 5.)

Constant Each event is represented with a constant value as dictated by *Event Type To Isolate* and the following table:

2	if *Peak*
4	if *Trough*
8	if *Local Peak*
16	if *Local Trough*
32	if *Neg-to-Pos* zero crossing
64	if *Pos-to-Neg* zero crossing

Vertical Spread Method Determines how each identified *Event Type To Isolate* is distributed to vertically adjacent samples on the output trace using the method specified by *Output Type.*

None No spreading is performed. Output values only occur at the samples at which an *Event Type To Isolate* is found (when *None* is selected, the *Spread Samples* input field is no longer visible)

Symmetrical Output values are placed symmetrically about each sample containing an *Event Type To Isolate*. The *Spread Samples* parameter determines the number of samples, both above and below, that the events are spread. (Default Value)

Asymmetrical Output samples are placed asymmetrically about each sample containing an *Event Type To Isolate*. The *Spread Samples Up* parameter determines the number of samples above, while the *Spread Samples Down* parameter determines the number of samples below that the events are spread. (When *Asymmetrical* is selected, the *Spread Samples* parameter is no longer visible.)

Fill Up All output samples between two samples containing an *Event Type To Isolate* are filled with the value associated with the deeper event.

Fill Down All output samples between two samples containing an *Event Type To Isolate* are filled with the values associated with the shallower event.

Fill Up w/ Gap Similar to *Fill Up*, but the sample below each sample containing an *Event Type To Isolate* will be set to the *Background Value*, to produce a vertical gap.

Fill Down w/ Gap Similar to *Fill Up*, but the sample above each sample containing an *Event Type To Isolate* will be set to the *Background Value*, to produce a vertical gap.

Spread Samples Default value 2, only available when *Vertical Spread Method* is *Symmetrical*.

Spread Samples Up Default value 2, only available when *Vertical Spread Method* is *Asymmetrical*.

Spread Samples Down Default value 2, only available when *Vertical Spread Method* is *Asymmetrical*.

NOTE: When either *Pos-to-Neg* or *Neg-to-Pos* event types are selected, and *Output Type* is *Attribute*, then the output value is actually the difference in the attribute values of the two samples that define the zero crossing rather than the attribute value of either of the samples. A *Pos-to-Neg* event type will always have a negative attribute value while a *Neg-to-Pos* will always have a positive attribute value.

Advanced Parameters

In this section we will describe the advanced parameters that are available to the user. Figure 4 illustrates the default user interface when the *Enable Advanced Parameters* check box is selected. Figure 5 illustrates the user interface when parameters are selected to expose most (but not quite all) of the available parameters.

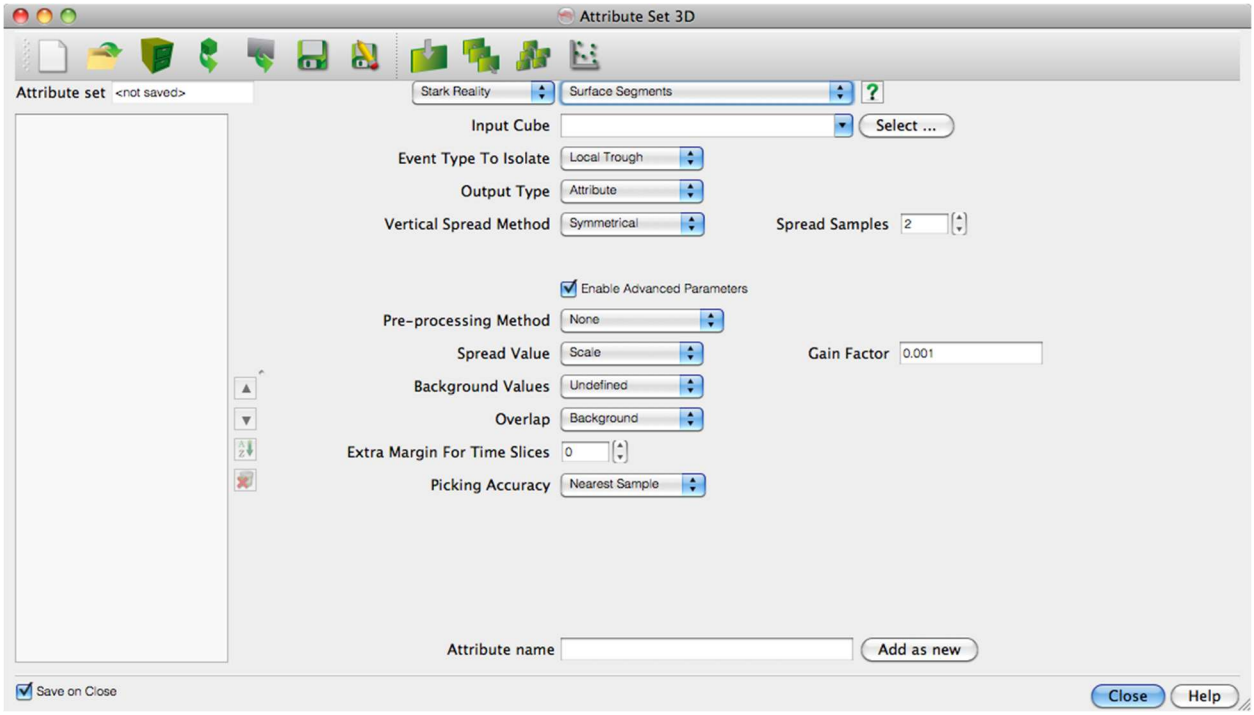


Figure 4: User interface depicting parameters available by default when *Enable Advanced Parameters* is first selected.

Pre-Processing Method Method applied to data trace prior to isolation of event types.

None No processing conducted prior to generation of *Surface Segments*. (Default Value)

First Difference Output(idx) = Input(idx) - Input(idx-1)

Gapped Difference Output(idx) = Input(idx+1) - Input(idx-1)

Spread Value Determines how the output type values are adjusted when spread to vertically adjacent to samples. NOTE: use of *Scale* with the default values will typically produce output that can be used with the OpendTect autotracker to extract horizons to the nearest sample from the *Surface Segments* attribute volume. Generally, this will not produce a visible amplitude variation across the spread samples.

Copy Spread value for output data will be equivalent to that of input data.

Scale Output Amplitude = Input Amplitude * (1 + (Delta Sample * Gain Factor)) (Default Value)

Modify Output Amplitude = Input Amplitude + (Delta Sample * Gain Factor))

NOTE: "*Delta Sample*" is always a negative value and represents the number of samples away from the sample containing the actual event (e.g., peak, trough, etc.)

Gain Factor User defined floating point number used to modify the *Output Type* values when spread to vertically adjacent samples as defined above. (Default value is 0.001)

Background Values Determines how each output trace is initialized. In general, samples with this value either do not have an *Event Type To Isolate* at this sample, or within plus or minus the number of samples as defined by *Spread Samples*, or within *Spread Samples Up* and *Spread Samples Down*, whichever is used. However, if *Overlap* uses the same value as the *Background Value*, then it could mean there is not a unique *Event Type To Isolate* at sample locations containing this *Background Value*.

Undefined Initializes the output trace to the OpendTect undefined amplitude value (Default Value)

Zero Initializes the output trace to zero

User Defined Initialize the output trace to the value the user provides for the *User Defined Background* parameter

User Defined Background Only visible when the *User Defined* method for the *Background Values* parameter is selected. The user is to provide a floating point number which will be used to initialize the output trace prior to finding and spreading the *Event Type To Isolate*. (Default value is 0.0)

Overlap Determines how samples are represented when the vertical spread method results in two or more events falling on the same output sample. The following options are available.

Background Samples containing overlap will be assigned the same value used as the *Background Values* described above (Default Value). NOTE: Using this means that you cannot tell if a sample with the *Background Value* has 0 or 2 or more events that map (via spreading) to that sample.

Zero Samples containing overlap will be assigned a value of zero. It is best to use this option when *Output Type* is *Sample #* to make use of the specialized color tables provided with this plugin.

Undefined Samples containing overlap will be assigned the standard OpendTect "undefined" value.

User Defined Samples containing overlap will be assigned a user defined value

Sum Samples containing overlap will be assigned the sum of the values assigned to this sample

Min Samples containing overlap will be assigned the minimum of the values assigned to this sample

Max Samples containing overlap will be assigned the maximum of the values assigned to this sample

Extra Margin For Time Slices Measured in number of time samples. (Default value is 0.)

NOTE: The Surface Segment attribute is best used in a batch mode to create an attribute volume on disk and then display that attribute volume in a time slice (Z-slice) format.

This parameter is sometimes needed when interactively generating Surface Segments for a Z-slice display. In particular it is needed when using either the "*Fill Up*" or "*Fill Down*" option and the resulting Z-slice still contains "background color" pixels that are not associated with dead traces. If the *Resample* option discussed below is used, then this parameter should be incremented by about 10. It would require a very special case for this parameter to ever be set to anything above 20.

Picking Accuracy By default this routine picks the *Event Type To Isolate* to the nearest sample. For most applications this is adequate. However more refined amplitudes or arrival times are desired for some specialized applications. This parameter allows the event types to be found with sub-sample accuracy via interpolation.

Nearest Sample All arrival times and amplitudes are to the nearest seismic sample. No interpolation is used. (Default Value)

Linear This will only affect the travel time accuracy of the *Pos-to-Neg* and *Neg-to-Pos* zero crossings. It will not affect the amplitude output.

Resample This uses a Sicking (1980) interpolation method. It will affect both the time and amplitude of all of the *Event Type To Isolate*

methods. The Sicking interpolation parameters are preset by the program and not available for the user to modify.

NOTE: When an event is digitally clipped (two or more vertically adjacent samples having the same value), this implementation of the *Resample* option might find two events, whereas the *Nearest Sample* option will only find one.

Extra Samples This determines the number of extra samples the *Resample* interpolation method utilizes. A value of 9 means the time of the event will be picked to 1/10 of a sample. A value of 99 means the time of the event will be picked to 1/100 of a sample. The computation time goes up linearly with the number of extra samples. Rarely will a user want to use an *Extra Samples* value that is greater than 9. (The valid range is 1 to 99 inclusive. Default value is 9)

NOTE: When *Resample* is used, and *Event Type To Isolate* is either *Pos-to-Neg* or *Neg-to-Pos*, and *Output Type* is *Attribute*, then the output value is actually the difference in the attribute values of the two samples that define the zero crossing multiplied by (*Extra Samples* + 1) rather than the attribute value of either of the samples. A *Pos-to-Neg* event type should always have a negative attribute value while a *Neg-to-Pos* should always have a positive attribute value.

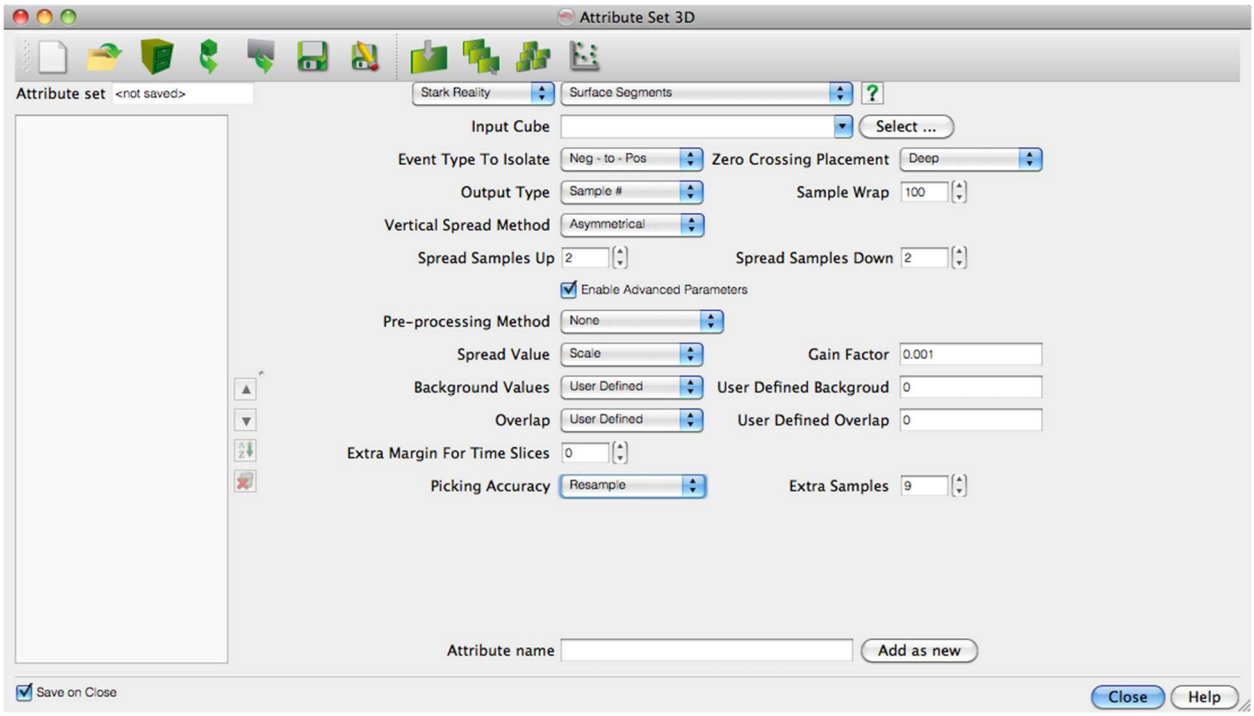


Figure 5: User interface with most of the available parameters exposed

Sample Wrap This parameter is only visible when *Output Type* is *Sample Number* and *Enable Advanced Parameters* is selected. It is provided to allow better use of the available display colors. To avoid wrapping, this parameter can be set to either 1, or 0. (Default value is 25)

Usage Comments

Surface Segments attributes are best displayed as *Z-slices*. It is also best to use the *Processing/Create Seismic Output/Attribute/Single Attribute* option to create a *Stored Cube*. Displaying a *Z-Slice* from a *Stored Cube* is much faster than interactively calculating the attributes. If possible, you should preload the *Surface Segments* attribute volumes.

Surface Segments are best displayed as "*Classification Volumes*". This is accomplished by right clicking on the displayed *Line* or *Z-Slice* number in the *Tree Scene* and selecting *Display/Properties/Texture/Classification*.

When using *Color Blend* displays of *Trough Surface Segments*, the color bar of each color needs to be *Flipped*. If the near stack is placed on the red channel, mid stack on the green, and the far stack on the blue, then the resulting hues can be used to provide a qualitative interpretation of the relative AVO behavior of each event. The "colors" can be used to help distinguish an event from its neighbors and can be very useful in correlating across post-depositional faults. Cyan to Blue hue events indicate relative increases in amplitude with offset (angle), while Yellow to Red hue events indicate relative decreases in amplitude with offset (angle). Pure colors (Red, Yellow, Green, Cyan, Blue or Magenta) normally indicate that one of the partial stacks does not have a corresponding event at the particular sample. There are many potential causes for this. Residual moveout it the most common cause. It could also be caused by using the "Undefined" value to represent "Event Overlaps". The most geologically interesting cause would be a polarity change of an event.

Two special *Color Tables* have been generated to use with *Surface Segments* created with *Sample #* as the *Output Type*. If you utilize the display and *Surface Segments* parameters denoted below, and the results are displayed as "*Classification Volumes*", then, when using these color tables:

- a red value will denote locations where "*Overlap*" has occurred,
- each color will represent one (original or resampled) data sample, and
- light to dark within each hue will indicate the down dip direction

Color Scale Name	Display Minimum	Display Maximum	User Defined Overlap	Sample Wrap	Picking Accuracy	Extra Samples
SRI Contours 5x10	0	50	0	50	Nearest Sample	0
SRI Contours 5x10	0.8	10.8	0	50	Resample	4
SRI Contours 5x10	0.9	5.9	0	50	Resample	9
SRI Contours 5x5	0	25	0	25	Nearest Sample	0
SRI Contours 5x5	0.8	5.8	0	25	Resample	4

Figure 6 below explains some of the information that is contained within *Surface Segments* created with *Sample #* as the *Output Type* using a color table mentioned above. In addition to what is describe in this figure, the local thickness of the color bands represents the local dip magnitude. The thinner the color band, the steeper the dip.

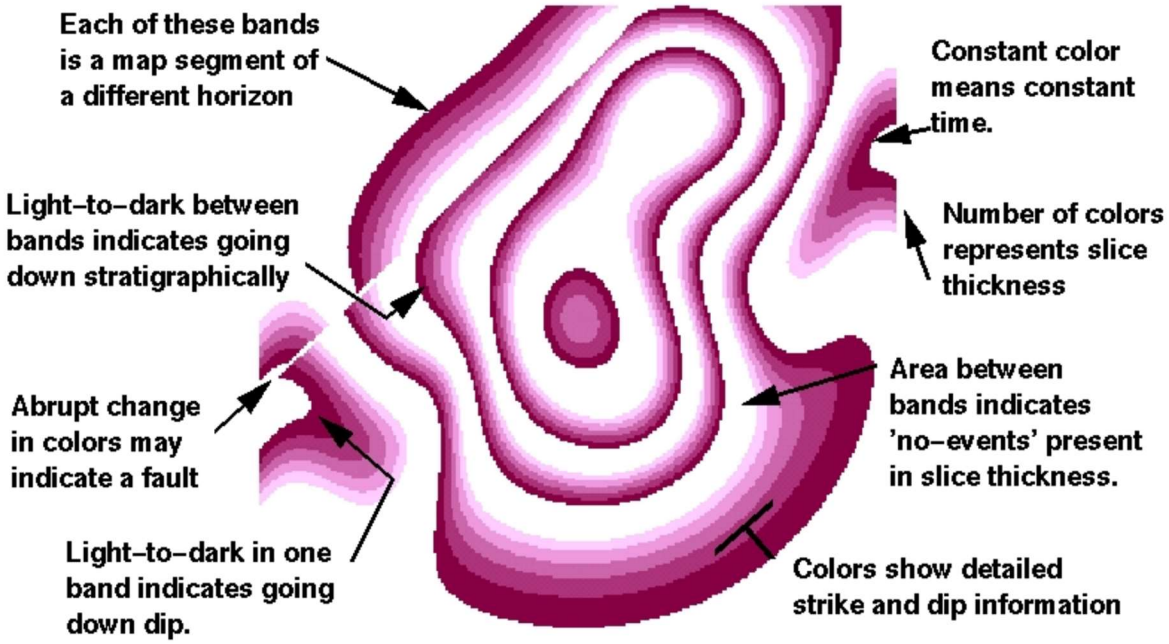


Figure 6: Some of the information available from *Sample # Surface Segments* (After Stark, 1986)

References

Sicking, C.J., 1980, Sampling requirements for reflection seismograms in geophysical data acquisition: PhD dissertation, University of Texas at Austin

Stark, Tracy, 1991, Surface slices: Interpretation using surface segments instead of line segments*:* 61st Annual International Meeting, SEG, Expanded Abstracts, 259-262.

Stark, Tracy J., 1996, Interpreter's corner - Surface slice generation and interpretation: A review: The Leading Edge, **15**, 818-819.