SAND2016-3293PE

# USER INTERFACE STORYBOARDS

Enhances Signals

Brief Description

This use case describes how the Analyst processes waveforms to enhance event signals while suppressing background noise. The Analyst enhances signals using the same algorithms as pipeline processing (see 'System Enhances Signals' UC), but the Analyst has the option to select the input parameters rather than using the predefined parameters used during pipeline processing.

Overview

- The Analyst accesses the displays represented by these storyboards by opening the Analyst workspace (Analyzes Events UC), selecting data for analysis (Selects Data for Analysis UC), and selecting an event to refine (Refines Event UC).

- Alternatively, signals can be enhanced outside the context of a specific event, for example when scanning (Scans Waveforms and Unassociated Detections UC).

- Waveforms are selected for filtering, beaming, and rotating via the main waveform display (see Waveform Display UIS Component for more details).

- Filter, beaming, and rotation options are available via their respective tabs in the Analyst workspace
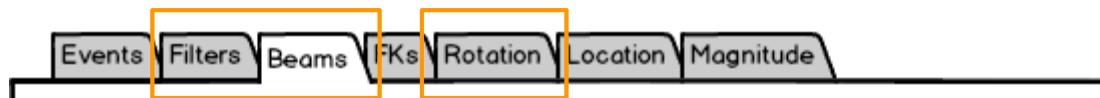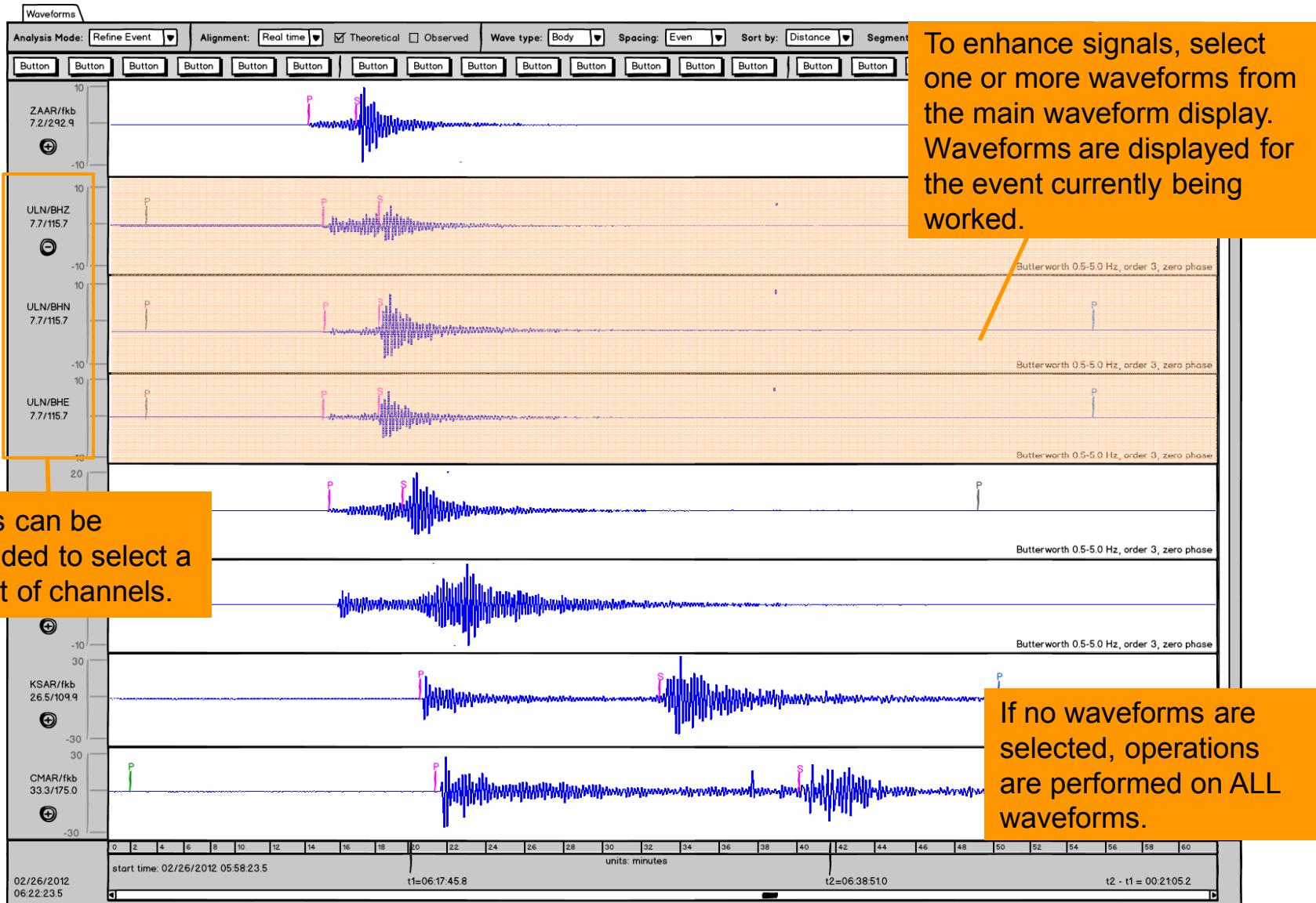
Enhances Signals: Use Case
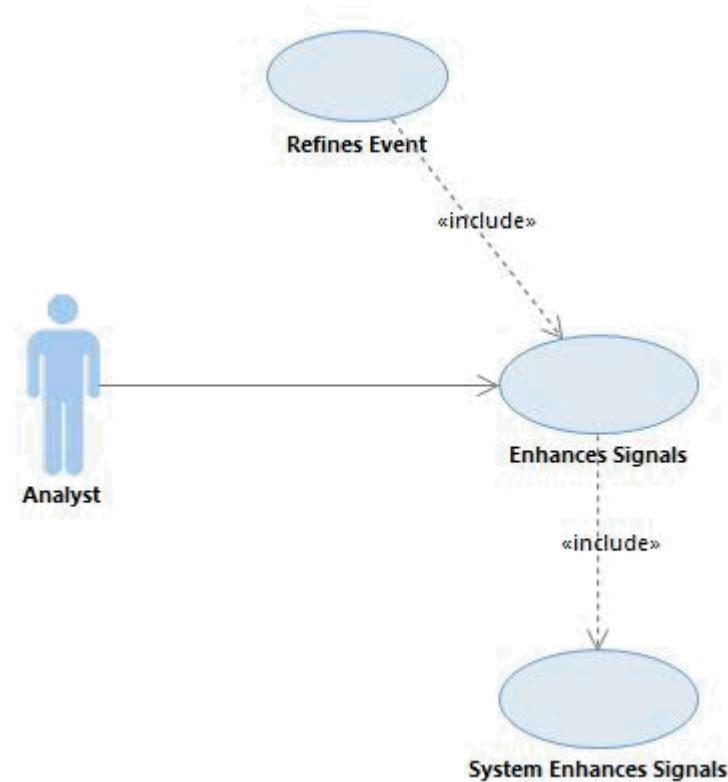
Main Flow
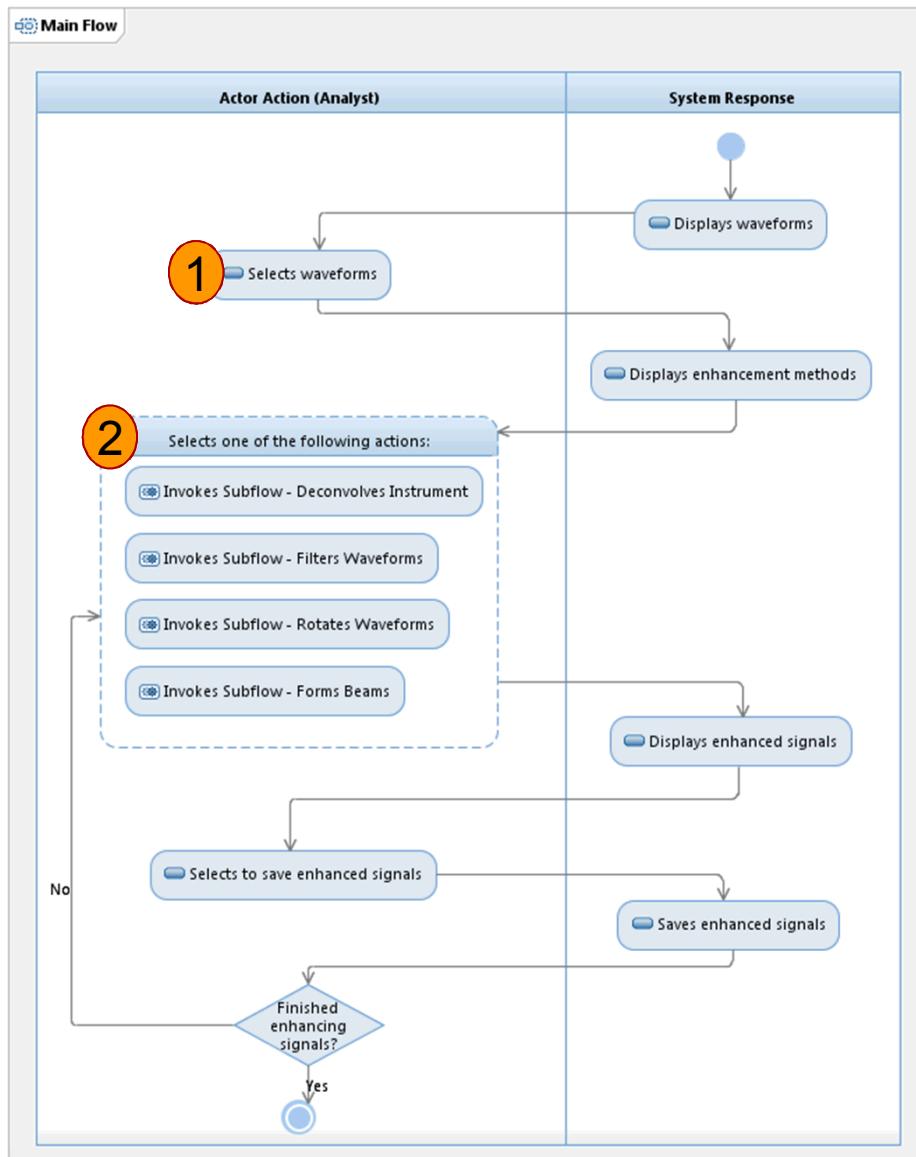
1) Selects waveforms
2) Selects enhancement method
   - Filters waveforms
   - Deconvolves instrument
   - Forms beams
   - Rotates waveforms

1) Selects waveforms

To enhance signals, select one or more waveforms from the main waveform display. Waveforms are displayed for the event currently being worked.

Arrays can be expanded to select a subset of channels.
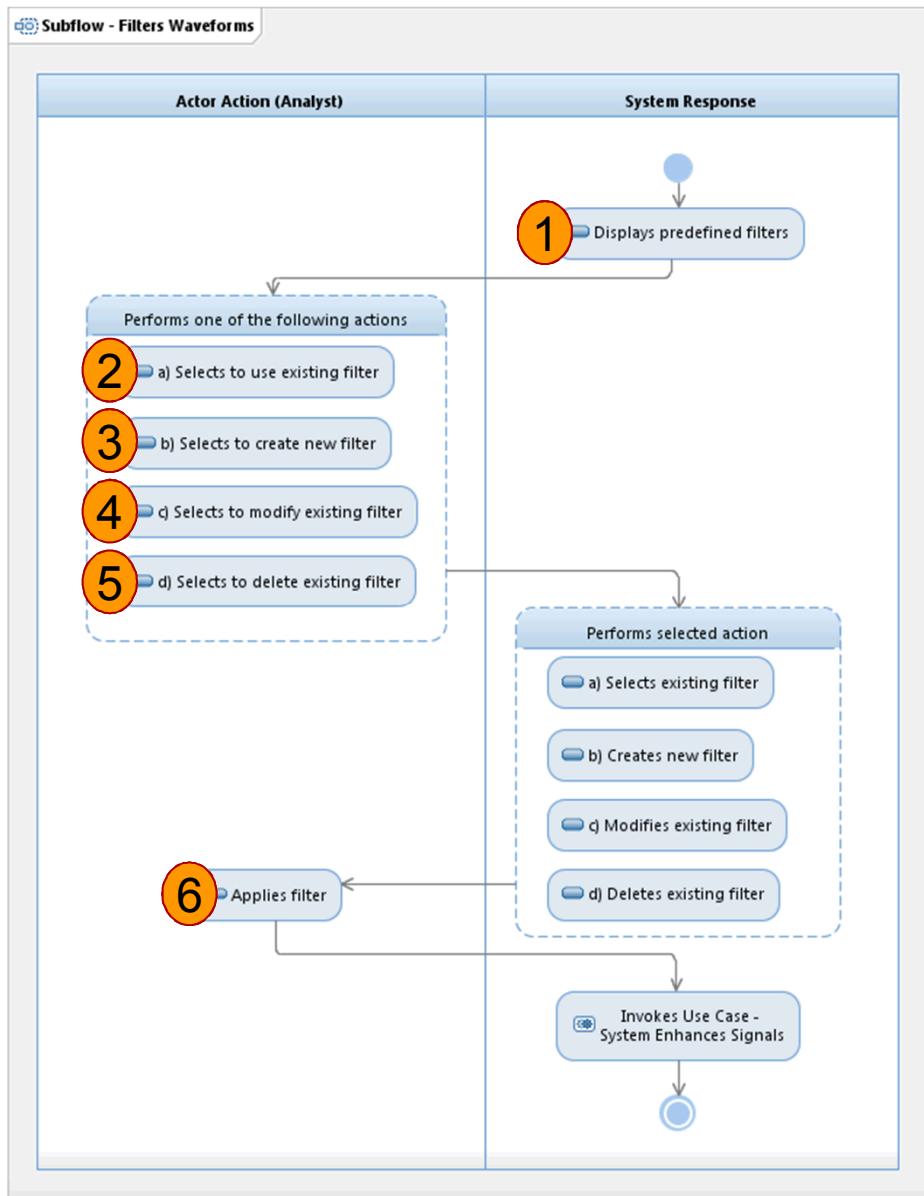
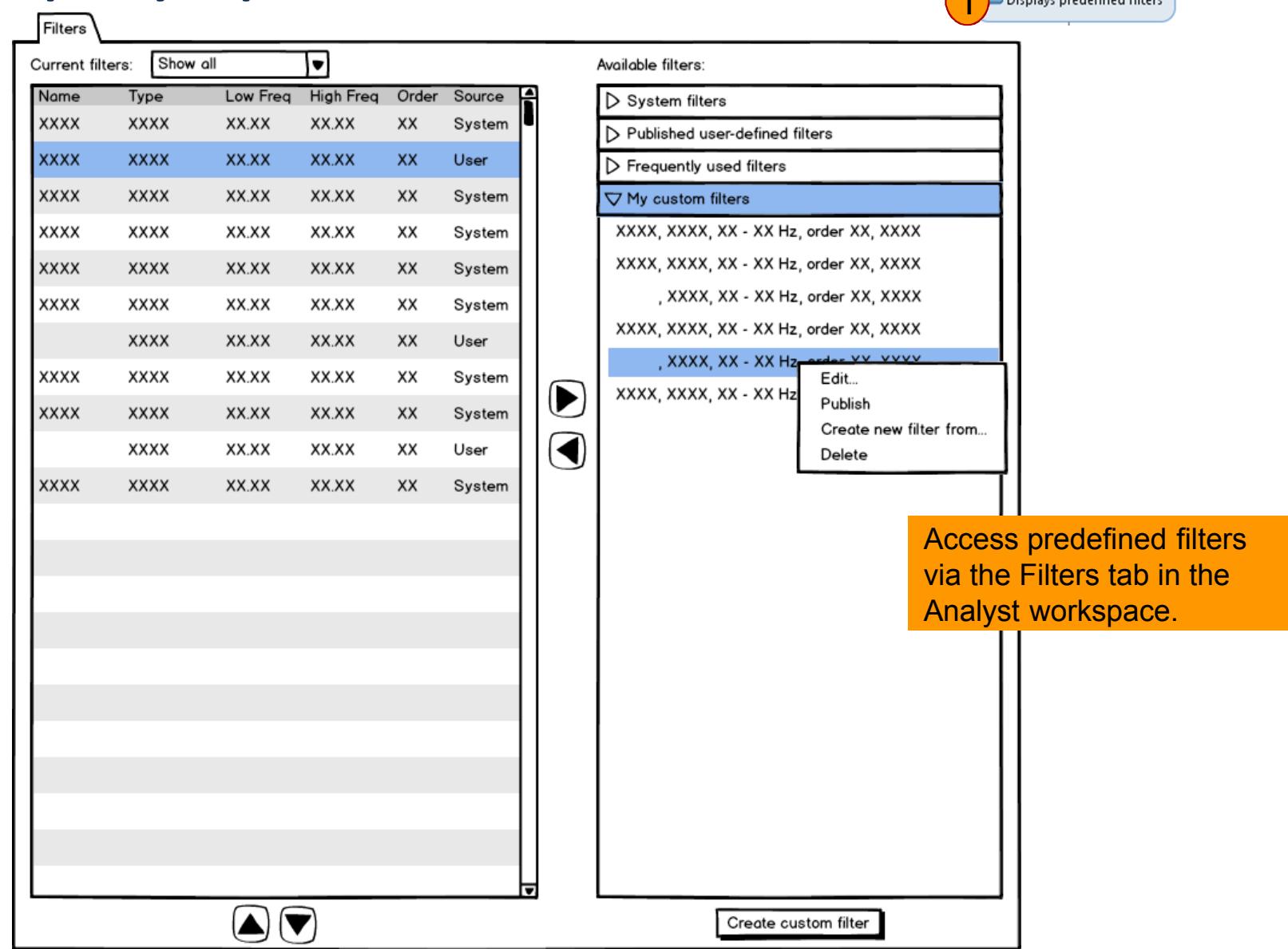If no waveforms are selected, operations are performed on ALL waveforms.

Subflow: Filters Waveforms

1) Displays predefined filters
2) Selects to use existing filter
3) Selects to create new filter
4) Selects to modify existing filter
5) Selects to delete existing filter
6) Applies filter

1) Displays predefined filters

1) Displays predefined filters

The 'Current filters' list on the left is an Analyst-defined list of filters available to be applied to waveforms. For each filter, the list shows:
- Name of the filter (optional)
- Filter type (e.g., Butterworth, Pseudo Correlation…)
- Low and high frequency
- Order
- Source (System or User)

The 'Current filters' list determines the order when hotkeys are used to toggle through filters from the main waveform display.

Use the up and down arrows to reorder the filters in the 'Current filters' list.

1) Displays predefined filters

Filters

Current filters: Show all ▼

Name	Type	Low Freq	High Freq	Order	Source
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System

▶
◀

Available filters:

▷ System filters
▷ Published user-defined filters
▷ Frequently used filters
▽ My custom filters
   XXXX, XXXX, XX - XX Hz, order XX, XXXX
   XXXX, XXXX, XX - XX Hz, order XX, XXXX
        , XXXX, XX - XX Hz, order XX, XXXX
   XXXX, XXXX, XX - XX Hz, order XX, XXXX
        , XXXX, XX - XX Hz, order XX, XXXX
   XXXX, XXXX, XX - XX Hz

   Edit...
   Publish
   Create new filter from...
   Delete

Use the left and right arrows to add or remove filters from the 'Current filters' list.
Adding a filter to the 'Current filters' list does not remove it from the 'Available filters' list.

All available filters are shown on the right. Available filters include:
- All predefined system filters
- All user-defined filters that have been published by other Analysts
- A list of the current user's frequently used filters
- A list of all of the current user's custom filters

Create custom filter

2) Selects to use existing filter
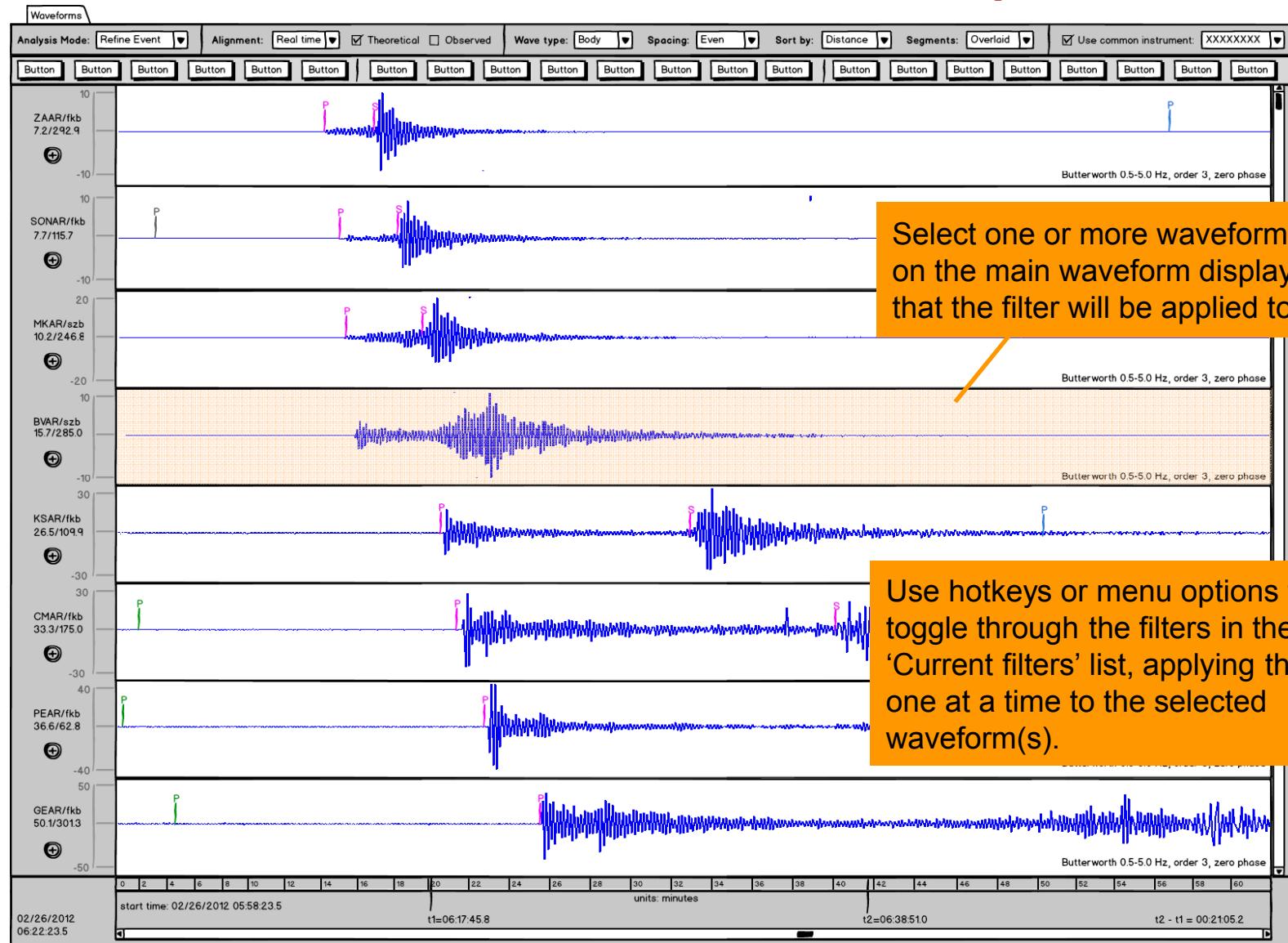
Select one or more waveforms on the main waveform display that the filter will be applied to.

Use hotkeys or menu options to toggle through the filters in the 'Current filters' list, applying them one at a time to the selected waveform(s).

2) Selects to use existing filter

If the 'Current filters' list is long, use the options in the drop-down list to locate the filter of interest more quickly

Drop-down list options:
- Show all
- System filters
- User-defined filters
- Frequently used filters
- My custom filters

Alternatively, on the Filters tab, double-click on a filter in the 'Current filters' list to apply that filter to currently selected waveform(s).

3) Selects to create new filter

Filters

Current filters: Show all ▼

Name	Type	Low Freq	High Freq	Order	Source
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System

Available filters:

▷ System filters
▷ Published user-defined filters
▷ Frequently used filters
▽ My custom filters
 XXXX, XXXX, XX - XX Hz, order XX, X
 XXXX, XXXX, XX - XX Hz, order XX, X
 , XXXX, XX - XX Hz, order XX, X
 XXXX, XXXX, XX - XX Hz, order XX, XXXX
 , XXXX, XX - XX Hz, order XX, XXXX
 XXXX, XXXX, XX - XX Hz

Edit...
Publish
Create new filter from...
Delete

To make a copy of an existing filter, right-click on the existing filter and select "Create new filter from…" A new filter entry is added to the 'My custom filters' list and can then be edited.

To create a new custom filter from scratch, press the "Create custom filter" button
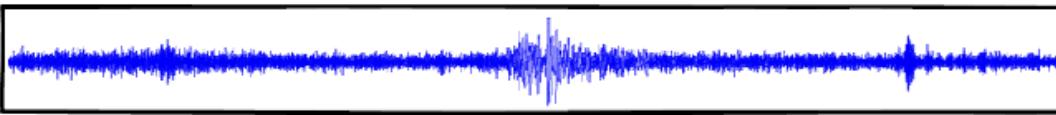
Create custom filter
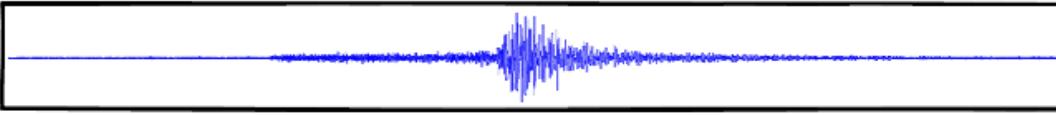
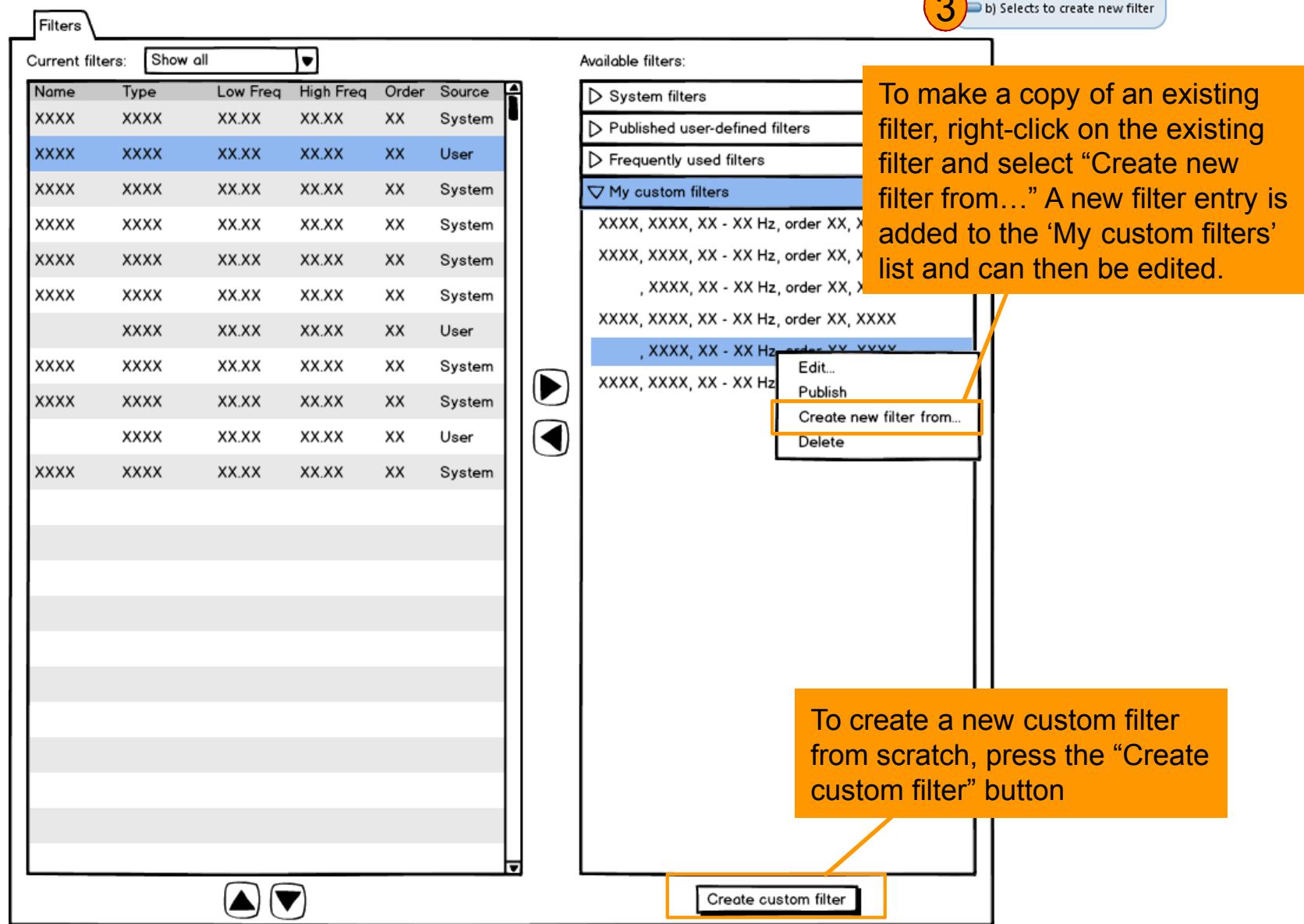# 3) Selects to create new filter

3 ⊂ b) Selects to create new filter

To create a new custom filter, optionally enter a name and description for the new filter

Select a filter type, which populates the parameters area accordingly.

Filter types include:
- Butterworth
- Pseudo Correlation
- Phase Match
- Autoregressive
- Deconvolution
- FIR
- IIR
- Cascading

Edit parameter values to define the filter.

Choose FIR or IIR in the filter type list to enter direct coefficients for a filter designed outside of the System.

3) Selects to create new filter

Custom filter

Filter name: `XXXX`

Description: `XXXXXXXXXXXXXXXXXXXX`

Filter type: `Butterworth ▼`

Low frequency (Hz): `XX.XX`

High frequency (Hz): `XX.XX`

Number of poles: `XX`

Filter pass: `Band pass ▼`

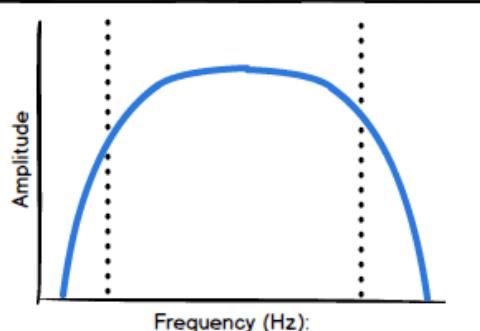Filter causality: `Causal ▼`

Amplitude

Frequency (Hz):

Raw waveform:
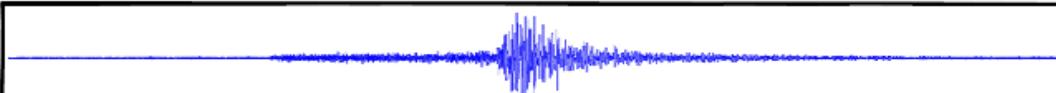
Filtered waveform:

`Save filter` `Cancel`

As filter parameters change, compare the original waveform with the filtered version

Save the filter to your custom filters list

3) Selects to create new filter

Custom filter

Filter name: XXXX

Description: XXXXXXXXXXXXXXXXXXXX

Filter type: Cascading

Name	Type	Low Freq	High Freq	Order	Source
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User

Add   Delete

Raw waveform:

Filtered waveform:

Save filter   Cancel

To create a cascading filter, choose "Cascading" from the filter type list. Use the up and down arrows and the Add and Delete buttons to create an ordered list of existing saved filters. The filtered waveform will reflect the result of applying the selected filters in the defined order.

Save the cascading filter in the same way as other filter types. The cascading filter is then available in your custom filters list.

3) Selects to create new filter

Analysts can make their custom filters available to other Analysts by publishing them. To publish a custom filter, right-click on it in the list and select 'Publish.'

4) Selects to modify existing filter

4) Selects to modify existing filter
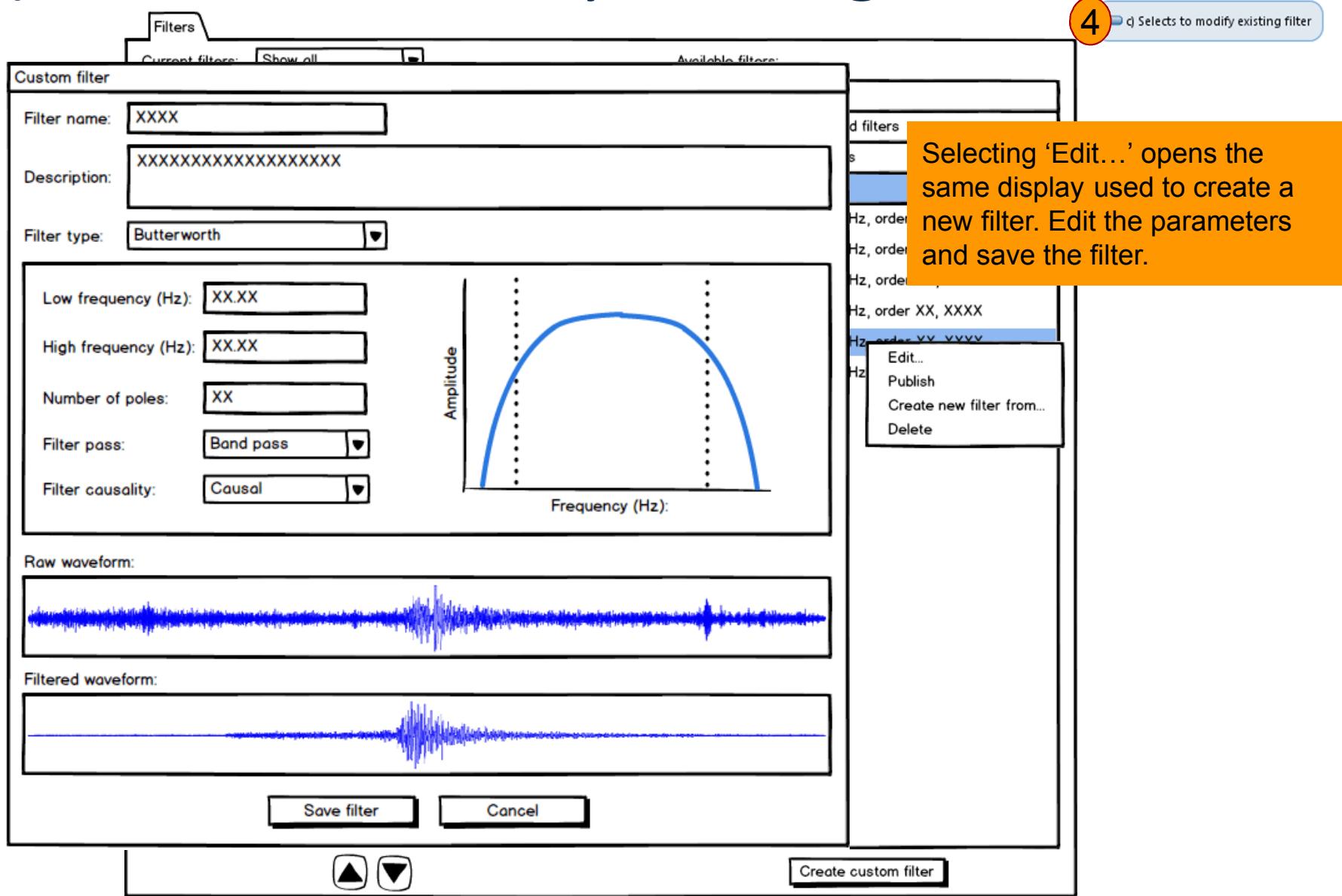
Filters

Current filters: Show all ▼

Available filters:

Custom filter

Filter name: XXXX

Description: XXXXXXXXXXXXXXXXXXX

Filter type: Butterworth ▼

Low frequency (Hz): XX.XX

High frequency (Hz): XX.XX

Number of poles: XX

Filter pass: Band pass ▼

Filter causality: Causal ▼

Amplitude

Frequency (Hz):

Raw waveform:

Filtered waveform:

Save filter   Cancel

d filters

s

Hz, order
Hz, order
Hz, order
Hz, order
Hz, order XX, XXXX
Hz, order XX, XXXX
Hz

Edit…
Publish
Create new filter from…
Delete

Create custom filter

Selecting 'Edit…' opens the same display used to create a new filter. Edit the parameters and save the filter.

5) Selects to delete existing filter

Filters

Current filters: Show all ▼

Name	Type	Low Freq	High Freq	Order	Source
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System
XXXX	XXXX	XX.XX	XX.XX	XX	System
	XXXX	XX.XX	XX.XX	XX	User
XXXX	XXXX	XX.XX	XX.XX	XX	System

Available filters:

▷ System filters
▷ Published user-defined filters
▷ Frequently used filters
▽ My custom filters
　XXXX, XXXX, XX - XX Hz, order XX,
　XXXX, XXXX, XX - XX Hz, order XX,
　　, XXXX, XX - XX Hz, order XX,
　XXXX, XXXX, XX - XX Hz, order XX,
　　, XXXX, XX - XX Hz, order XX
　XXXX, XXXX, XX - XX Hz

- Edit...
- Publish
- Create new filter from...
- Delete

Create custom filter

To delete an existing filter, right-click on that filter in the list and select 'Delete.' Only custom filters built by the current user can be deleted.

Deleting a filter removes it from the list, but filter information is maintained to support historic data.

6) Applies filter

The selected filter is applied to the selected waveform(s). A label indicates which filter has been applied.

Subflow: Deconvolves Instrument
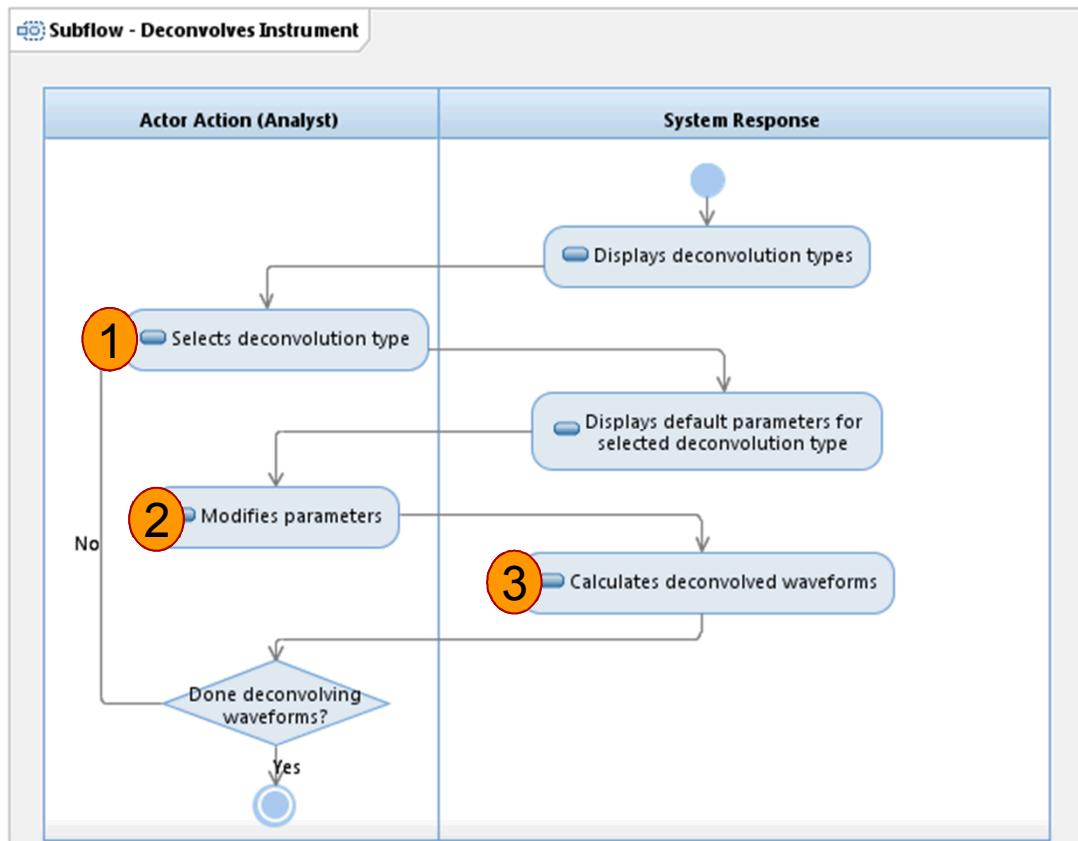
1) Selects deconvolution type
2) Modifies parameters
3) Calculates deconvolved waveforms
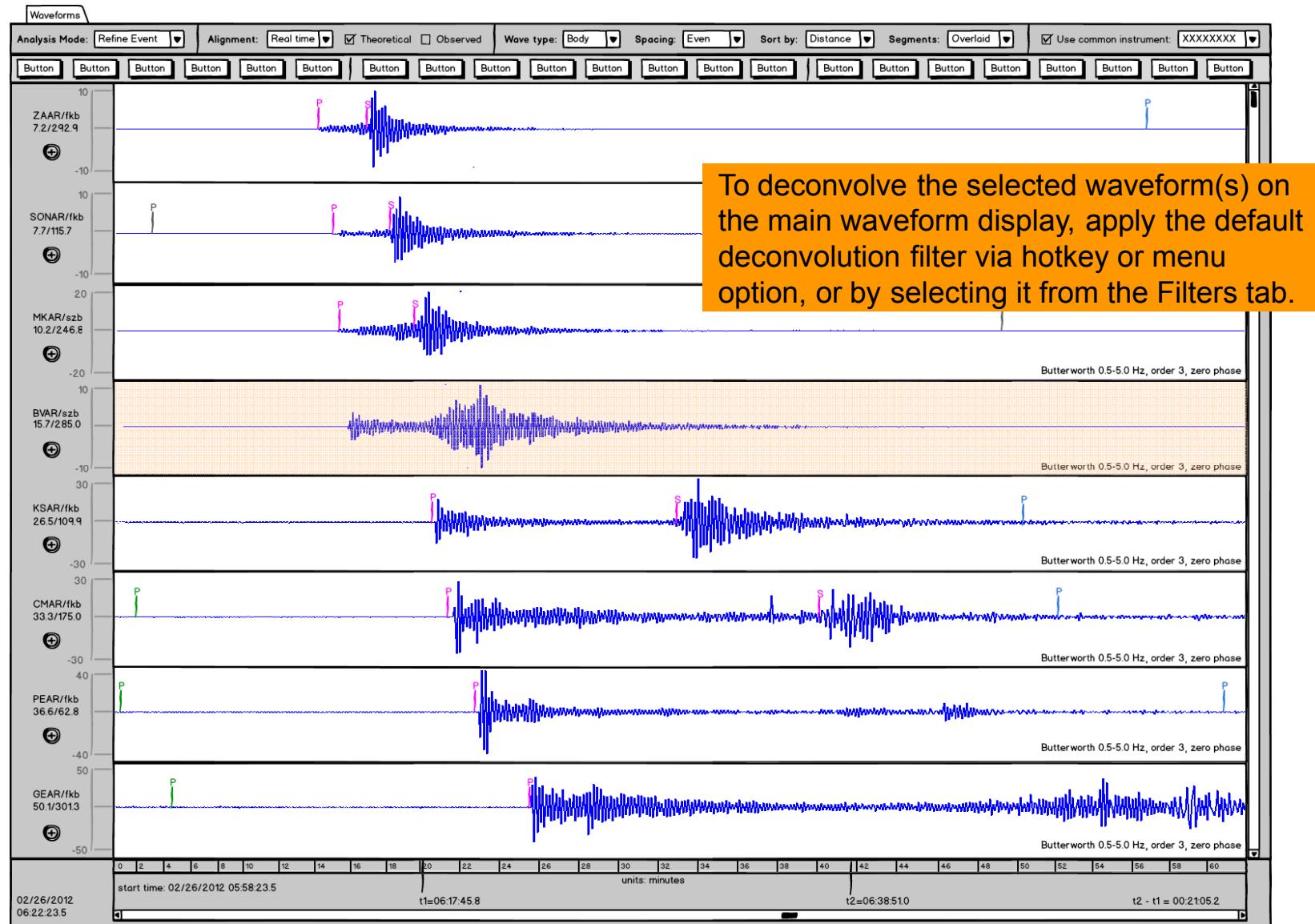
Note: Deconvolution can also be performed automatically with no Analyst interaction (e.g., for moment tensor or coda mag calculations).

1) Select deconvolution type

Deconvolution parameters are configured via a Deconvolution filter.
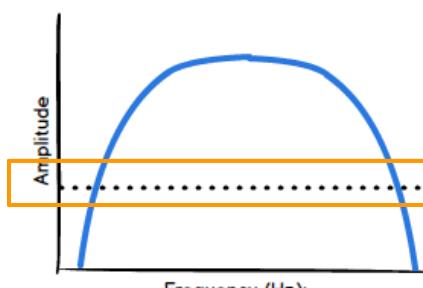
A default Deconvolution filter for the frequency domain is available via the Filters tab in the Analyst workspace.

2) Modifies parameters

To deconvolve the selected waveform(s) on the main waveform display, apply the default deconvolution filter via hotkey or menu option, or by selecting it from the Filters tab.
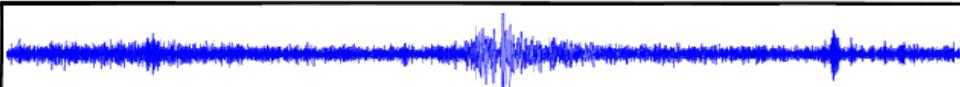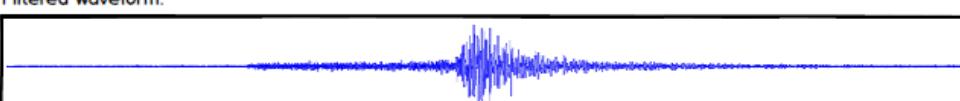
2) Modifies parameters

The Analyst can modify Deconvolution filter parameters by creating a custom Deconvolution filter.

The water level can be modified by dragging the dotted line up or down, or by typing a value into the text field.

The custom filter can then be saved and applied to the selected waveform(s).

3) Calculates deconvolved waveforms

The Deconvolution filter is applied to the selected waveform(s). A label indicates which filter has been applied.
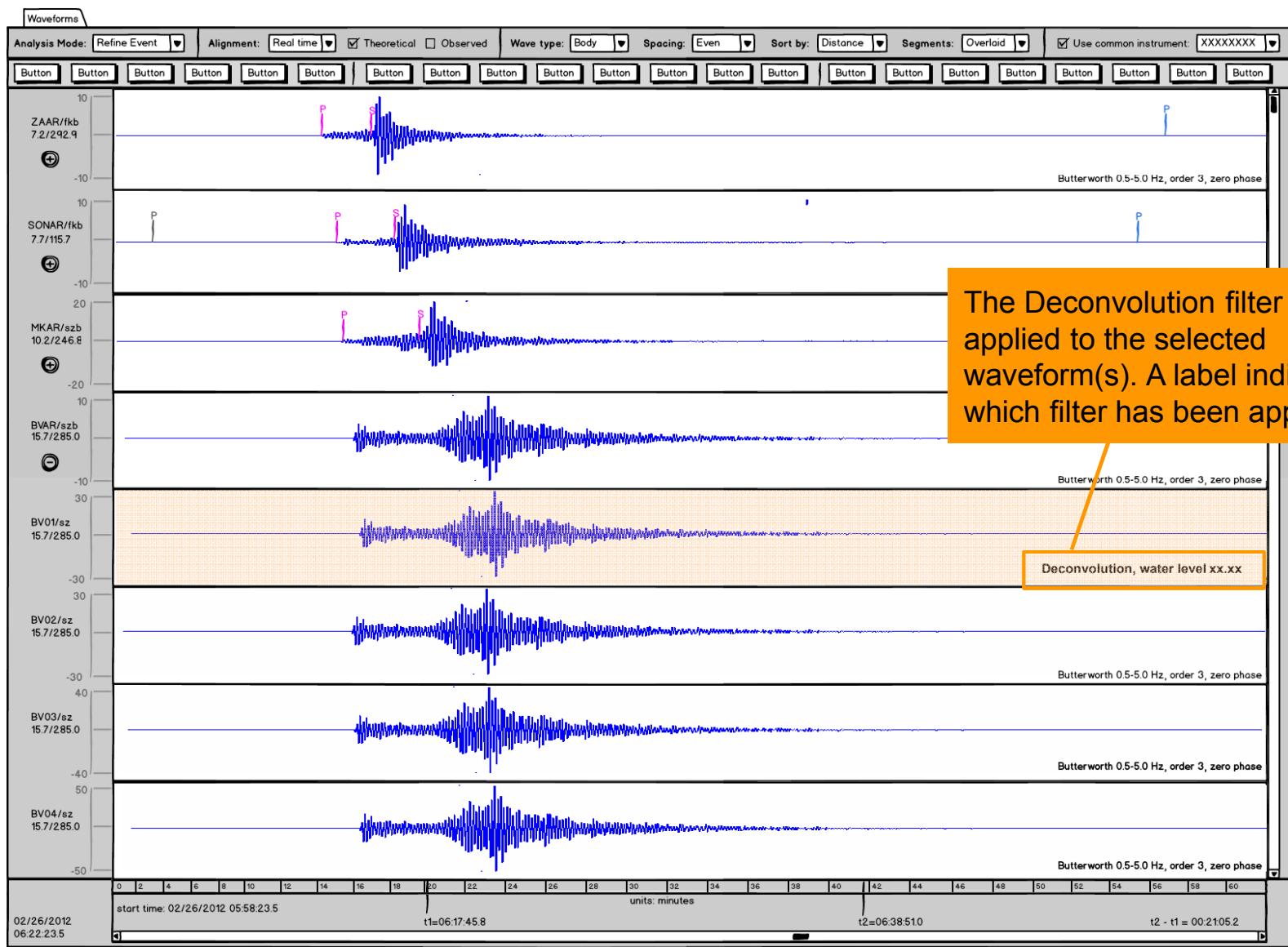
Subflow: Forms Beams
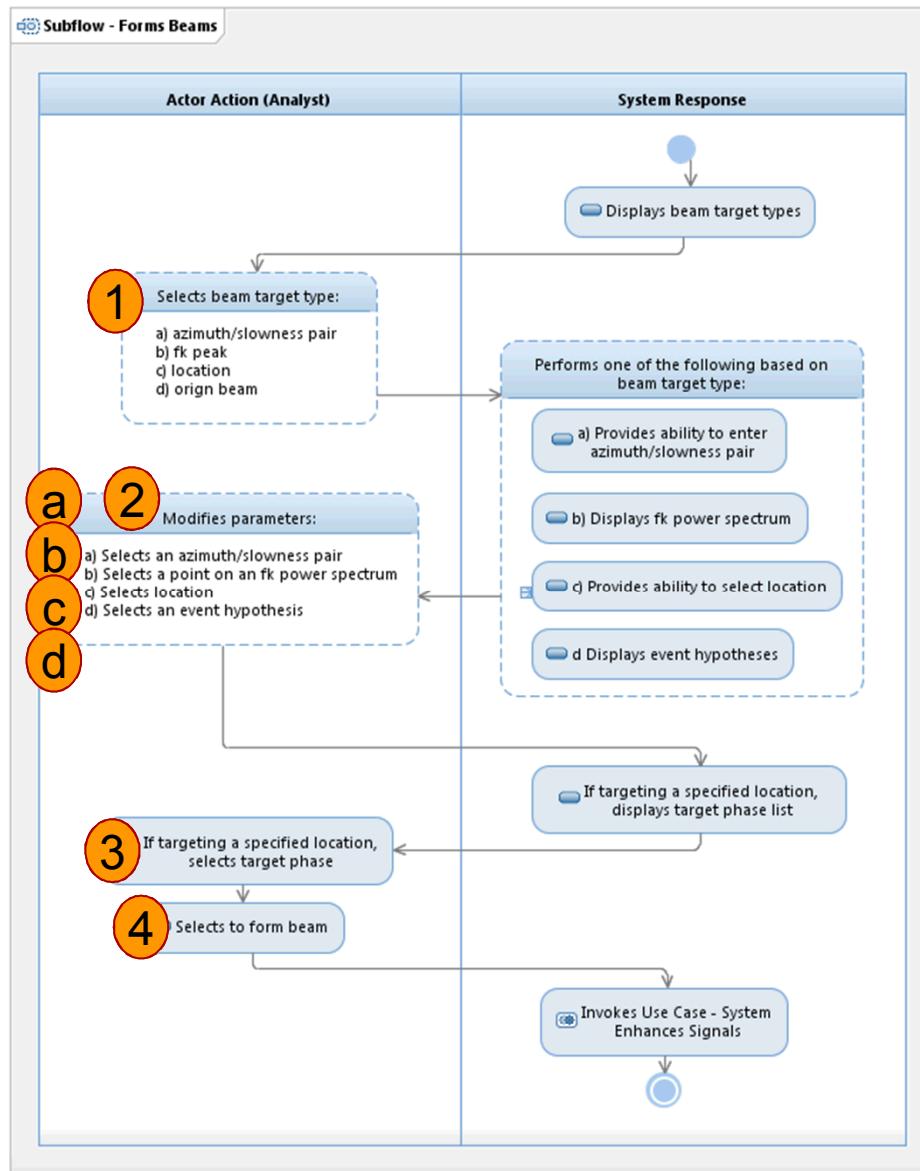
1) Selects beam target type
2) Modifies parameters
   a) Selects an azimuth/slowness pair
   b) Selects a point on an FK power spectrum
   c) Selects location
   d) Selects an event hypothesis
3) If targeting a specified location, selects target phase
4) Selects to form beam

1d) Selects beam target type

1

Selects beam target type:

a) azimuth/slowness pair
b) fk peak
c) location
d) orign beam

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An origin beam is formed for selected waveform(s) by invoking a menu option or hotkey from the main waveform display.

2d) Selects an event hypotheses

The event hypothesis is assumed to be the event that is currently being worked.

3) If targeting a specified location, selects target phase

Invoking beam processing via hotkey from the main waveform display assumes first P as the target phase. To select a different target phase, invoke a modified hotkey and then select a phase from the resulting popup list.

4) Selects to form beam

The new beam or beam segment is displayed below the original waveform for comparison.

The label next to the station indicates the type of beam that was formed.

1) Selects beam target type

1 Selects beam target type:

a) azimuth/slowness pair
b) fk peak
c) location
d) orign beam

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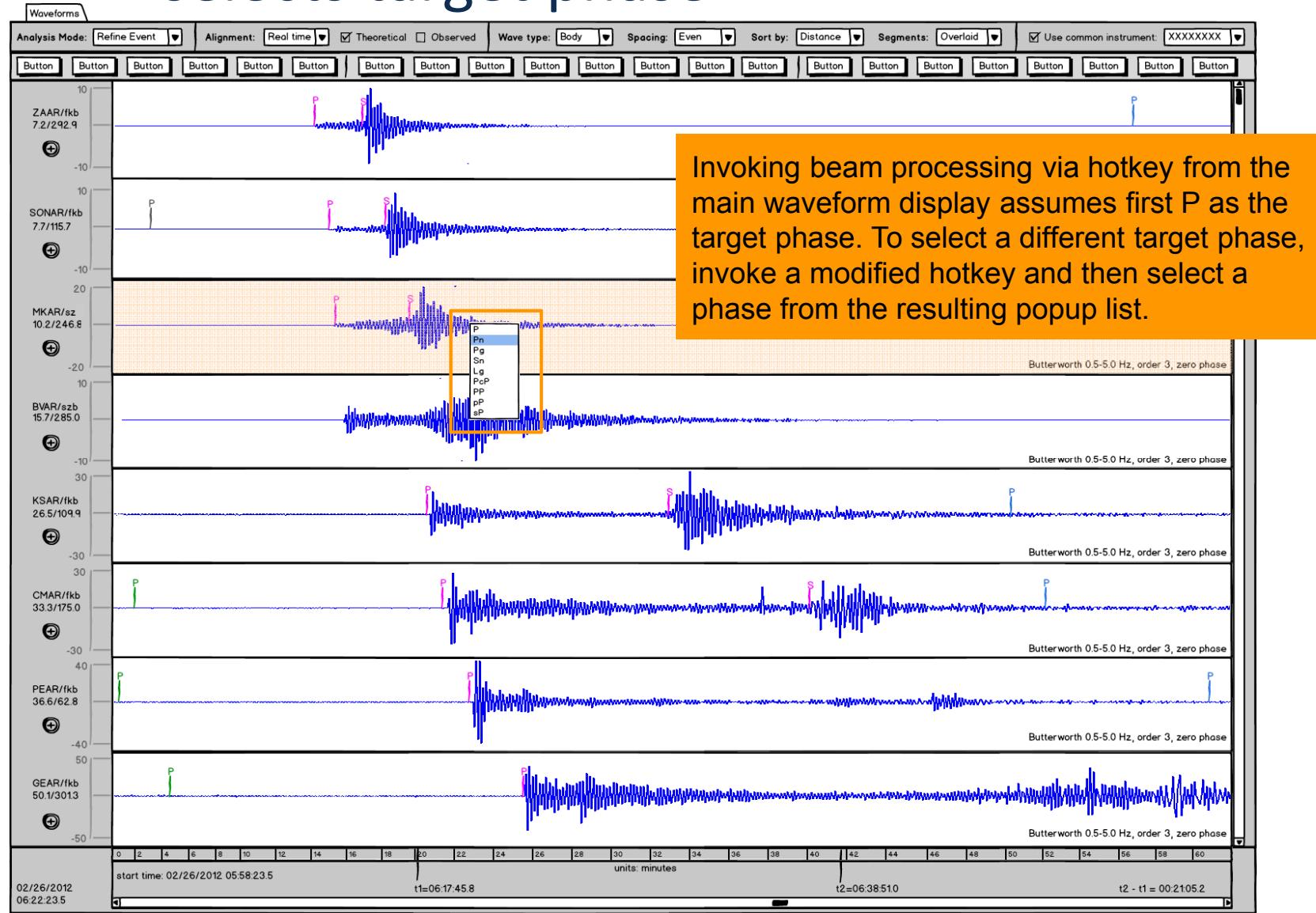
The remaining three beam target types are invoked from the Beams tab in the Analyst Workspace:

2a) Azimuth/slowness pair
2b) FK peak
2c) Location

1) Selects beam target type

1 — Selects beam target type:
a) azimuth/slowness pair
b) fk peak
c) location
d) orign beam

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Beams

Station: XXXX   [Show array configuration]   Phase: [P ▼]

Low frequency: [XX.XX]   Latitude: [XX.XX]

High frequency: [XX.XX]   Longitude: [XX.XX]

	Current	Selected
Azimuth	YYYY	XXXX
Slowness	ZZZZ	XXXX

☐ Normalize channels

FK window length

Start time: [XX/XX/XXXX XX:XX:XX]

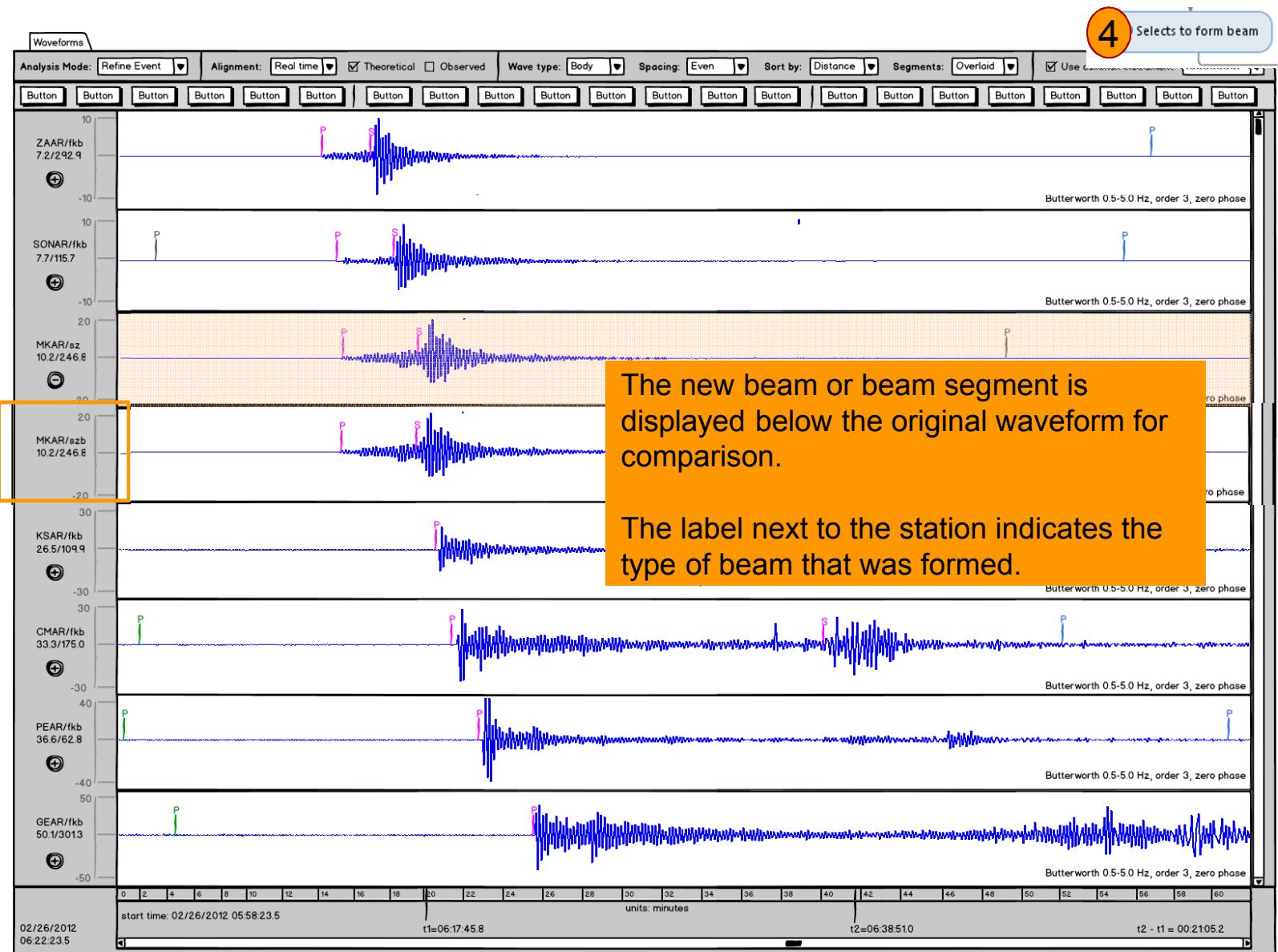End time: [XX/XX/XXXX XX:XX:XX]

Sy (Seconds/Degree) vs Sx (Seconds/Degree)

Channel: [XXXX ▼]   P   S

Fstat:

Azimuth:

Slowness:

[Create beam segment]   [Create conti...]

Map

Selecting the Beams tab automatically displays a beams-specific layer on the standard Map component. Information on this Map layer will automatically update as parameters are modified on the Beams tab.

33

2a) Selects an azimuth/slowness pair

a 2 Modifies parameters:

a) Selects an azimuth/slowness pair
b) Selects a point on an fk power spectrum
c) Selects location
d) Selects an event hypothesis

Enter an azimuth/slowness pair. The FK peak and map update accordingly.

2b) Selects a point on an FK power spectrum

b 2 Modifies parameters:

a) Selects an azimuth/slowness pair
b) Selects a point on an fk power spectrum
c) Selects location
d) Selects an event hypothesis

Hovering the mouse over the FK power spectrum updates the Current azimuth/slowness pair. Clicking on a point in the FK power spectrum updates the Selected pair.

Select a point on the FK power spectrum. The azimuth/slowness pair and map update accordingly.

35

2b) Selects a point on an FK power spectrum

b 2 Modifies parameters:

a) Selects an azimuth/slowness pair
b) Selects a point on an fk power spectrum
c) Selects location
d) Selects an event hypothesis

Update the low and high frequency values as needed.

Examine channel waveforms, and adjust the beam length or FK window by dragging the time windows on the channel waveform or by updating the start/end times in the text fields.

Signal detections are shown on the channel waveforms and can be edited as needed. Edits in this display will be reflected in the main waveform display.

2b) Selects a point on an FK power spectrum

Displays the physical layout of array elements. Layout is displayed in the standard map component, which automatically zooms to an appropriate scale.

Normalize channel amplitudes

View changes in Fstat, azimuth, and slowness over the same time range as the signal

b 2 Modifies parameters:

a) Selects an azimuth/slowness pair
b) Selects a point on an fk power spectrum
c) Selects location
d) Selects an event hypothesis

2c) Selects location

c 2 Modifies parameters:
a) Selects an azimuth/slowness pair
b) Selects a point on an fk power spectrum
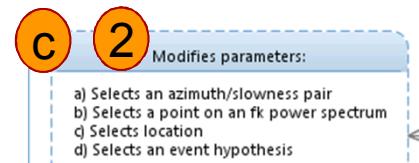c) Selects location
d) Selects an event hypothesis

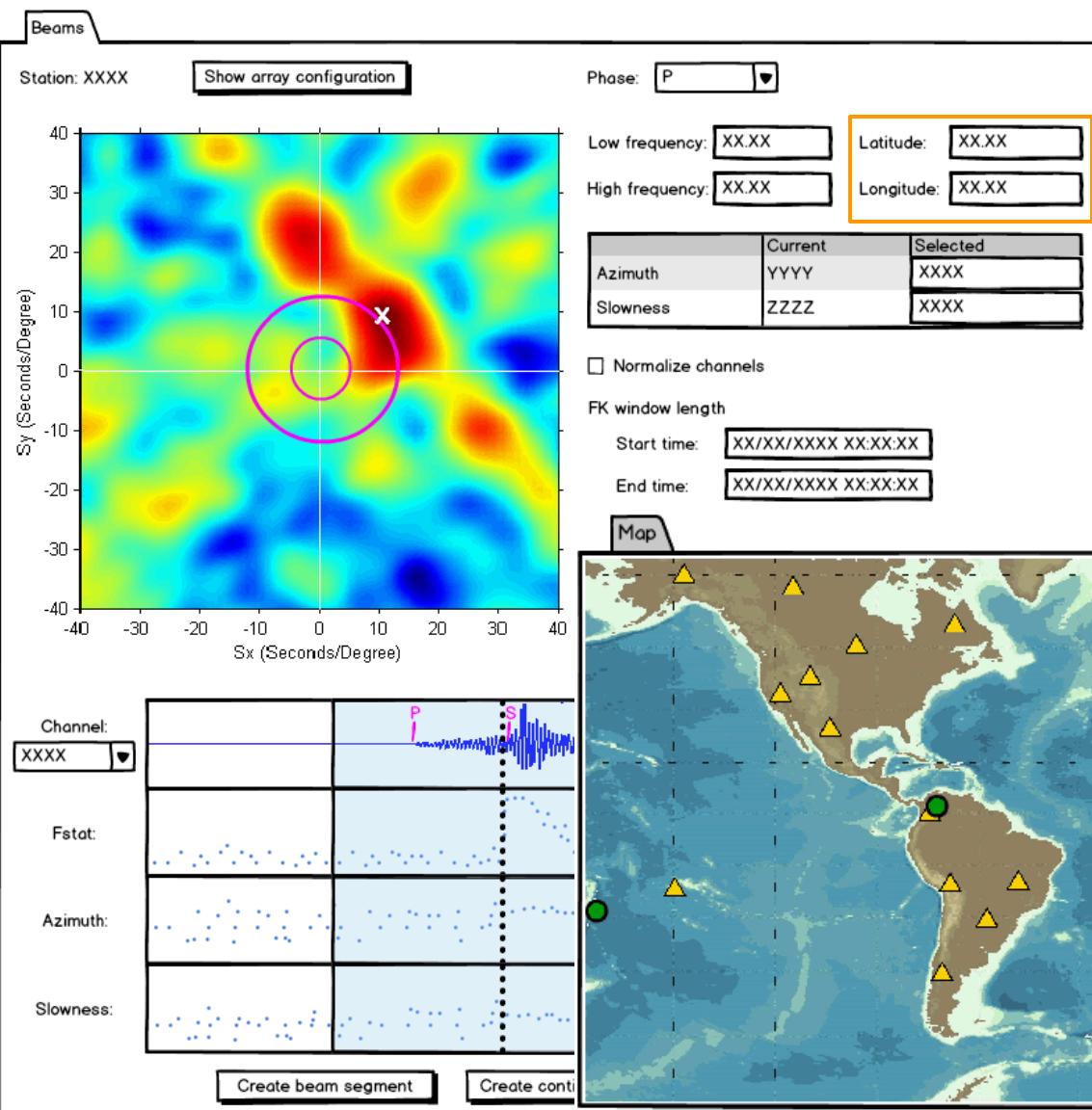Select a location by clicking on a point on the map. The current station is highlighted in orange. Events are color-coded using the same color scheme as the main waveform display (Magenta = current event).

Alternatively, type in a latitude and longitude to select a point on the map.

3) If targeting a specified location, selects target phase

On the Beams tab, select a target phase from the drop-down list.

First P is selected by default.

4) Selects to form beam

Press 'Create beam segment' to form the beam and add it to the main waveform display. Alternatively, press 'Create continuous beam' to form a virtual origin beam.

4) Selects to form beam

The new beam or beam segment is displayed below the original waveform for comparison.

The label next to the station indicates the type of beam that was formed.
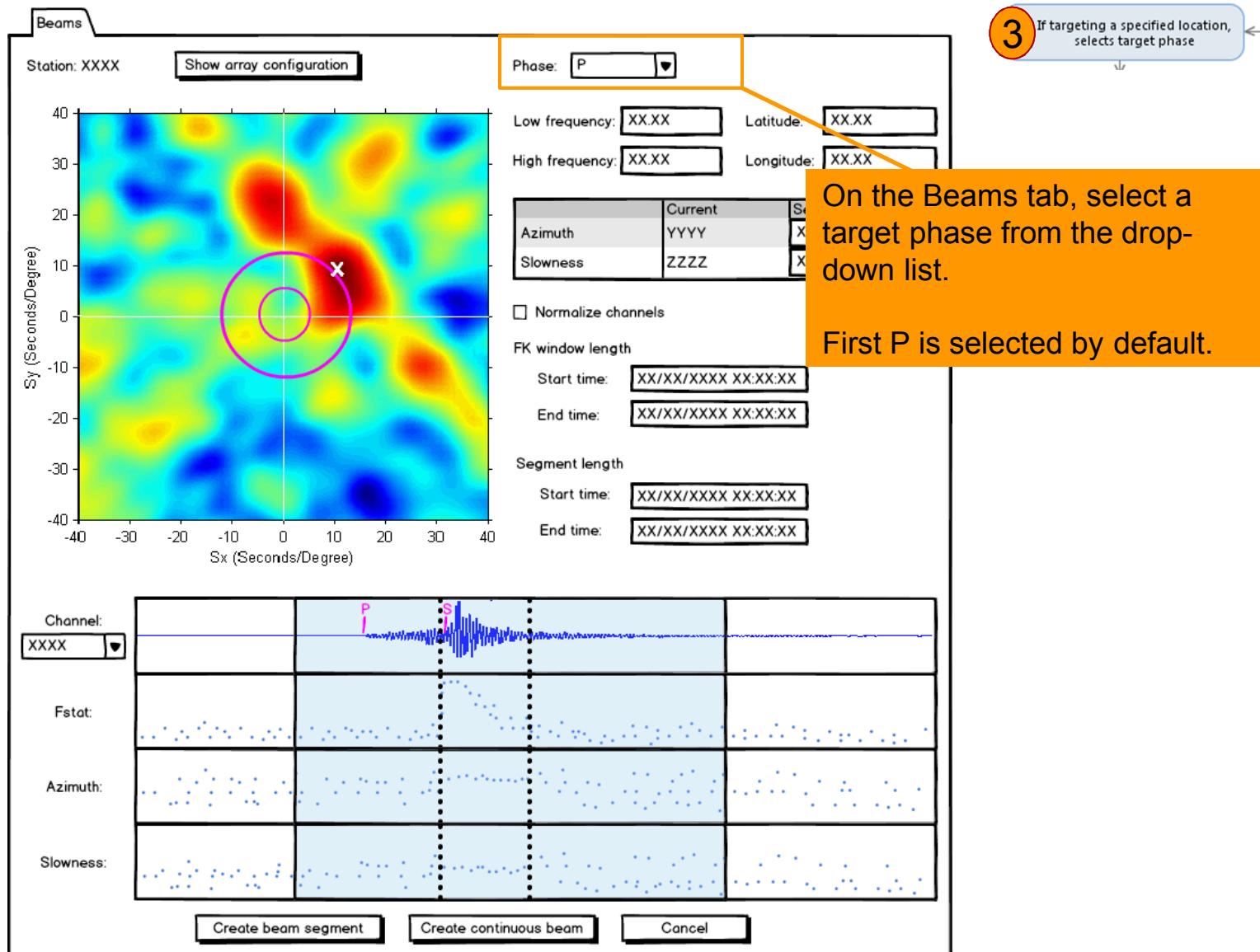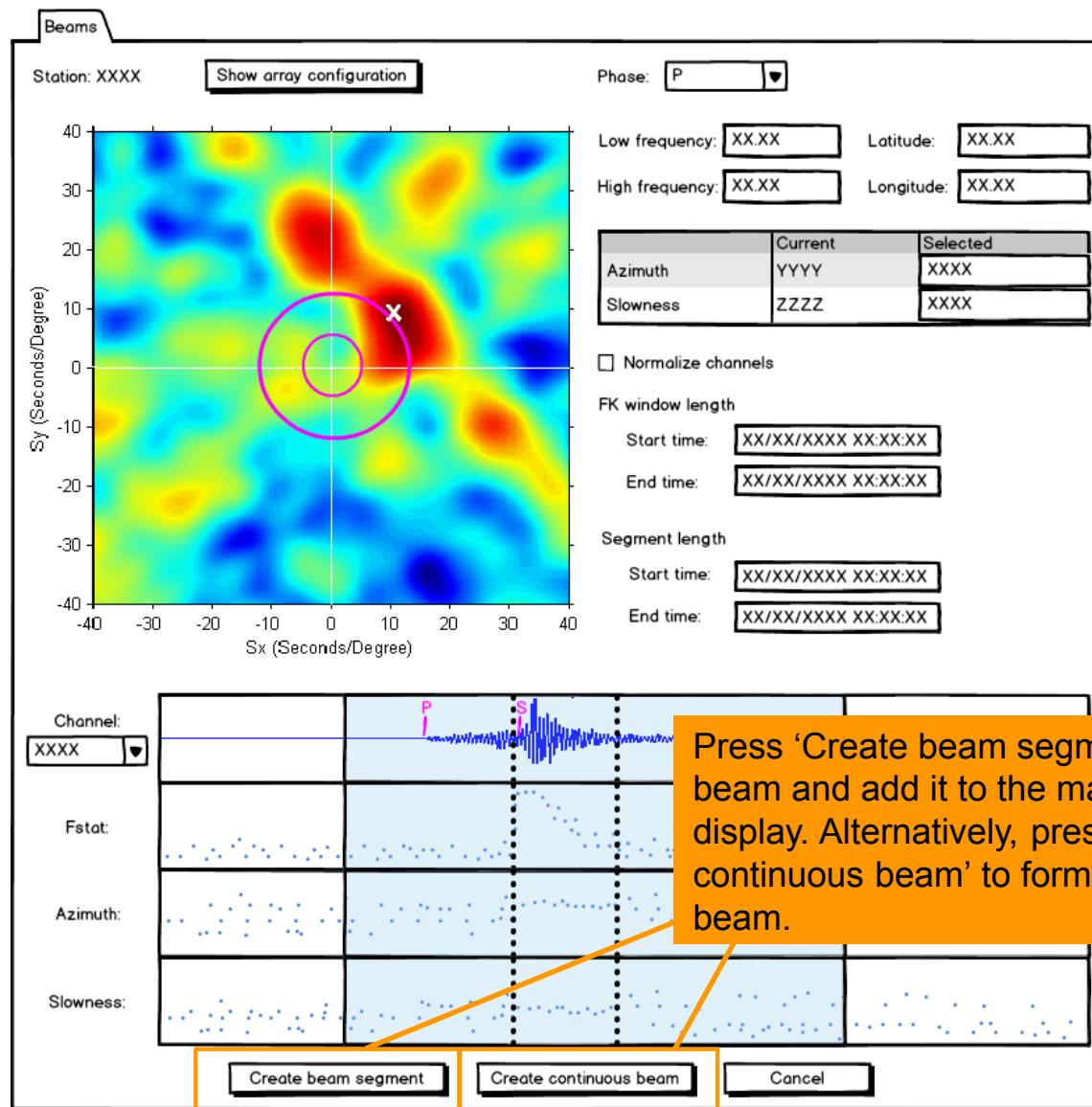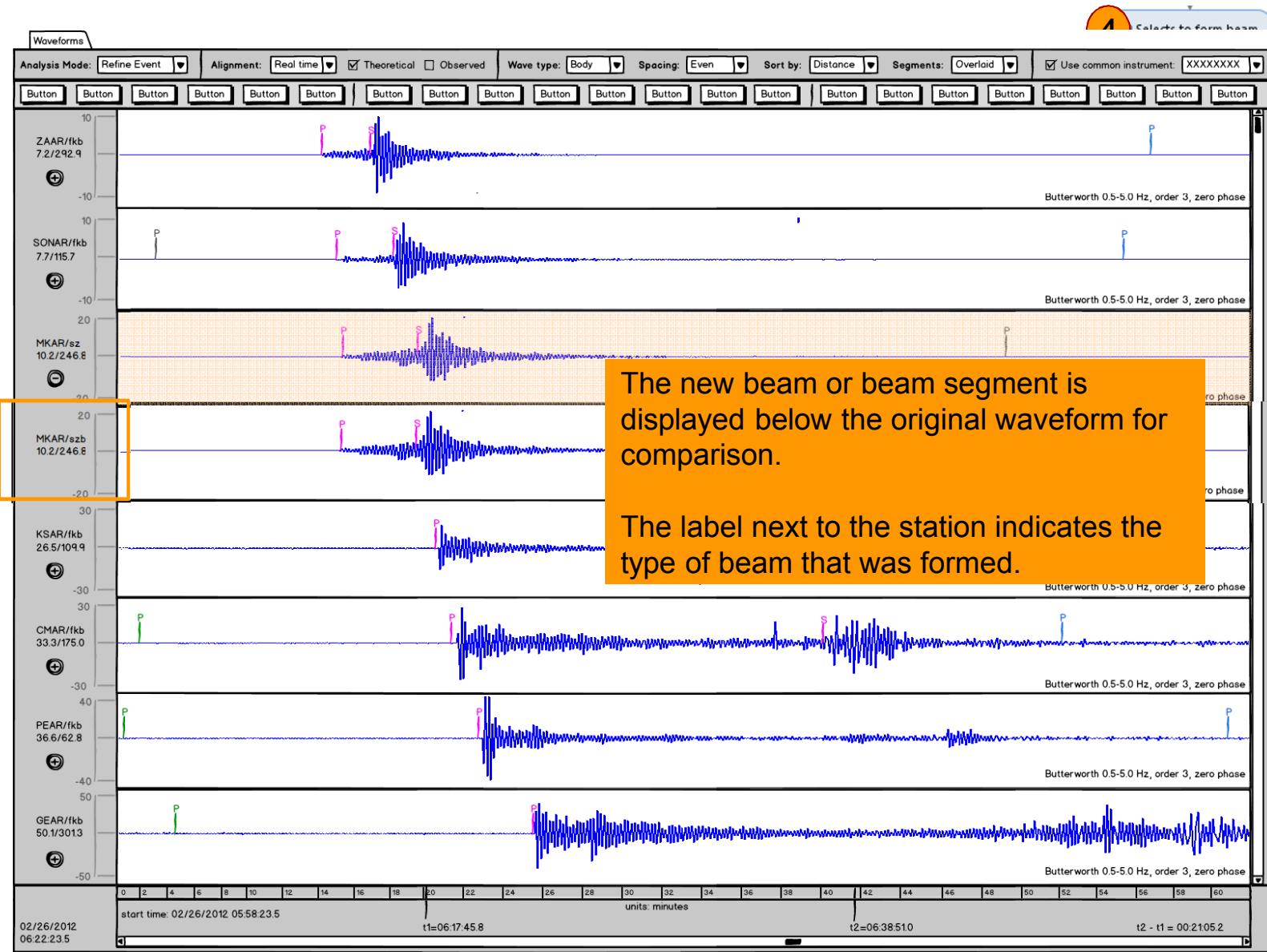
Subflow: Rotates Waveforms
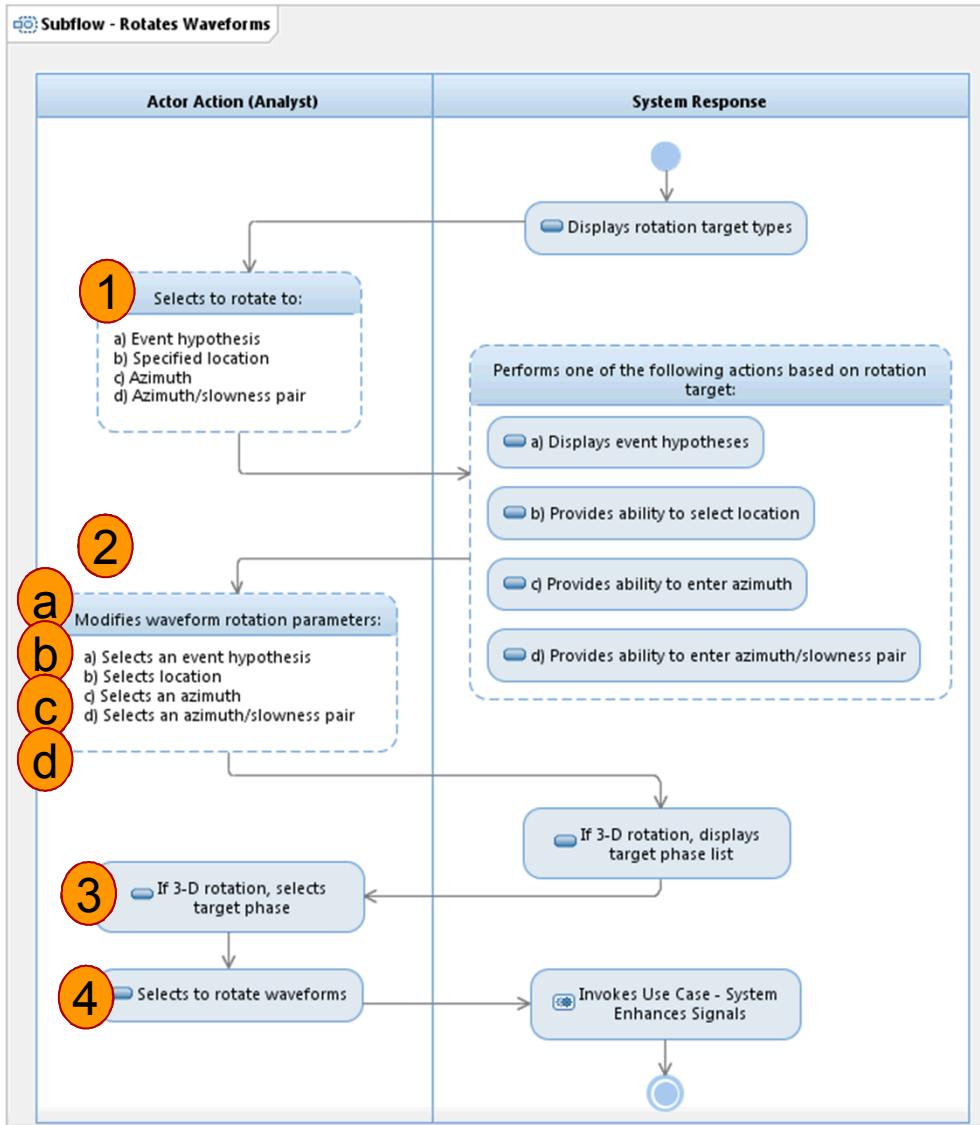
1) Selects to rotate to:
   a) Event hypothesis
   b) Specified location
   c) Azimuth
   d) Azimuth/slowness pair

2) Modifies parameters
   a) Selects an event hypothesis
   b) Selects location
   c) Selects an azimuth
   d) Selects an azimuth/slowness pair
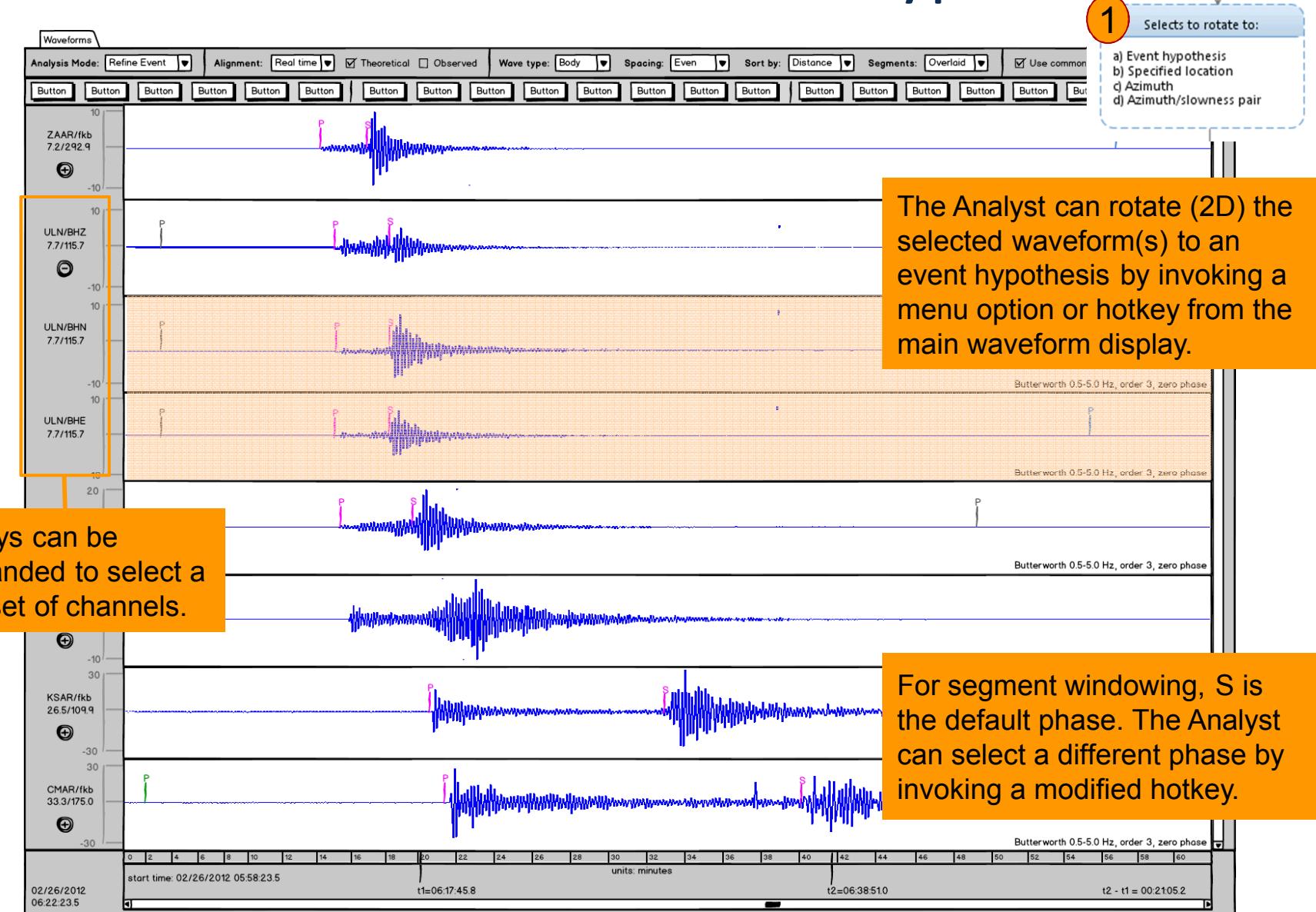
3) If 3D rotation, selects target phase

4) Selects to rotate waveforms

1) Selects to rotate to: an event hypothesis

The Analyst can rotate (2D) the selected waveform(s) to an event hypothesis by invoking a menu option or hotkey from the main waveform display.

Arrays can be expanded to select a subset of channels.

For segment windowing, S is the default phase. The Analyst can select a different phase by invoking a modified hotkey.
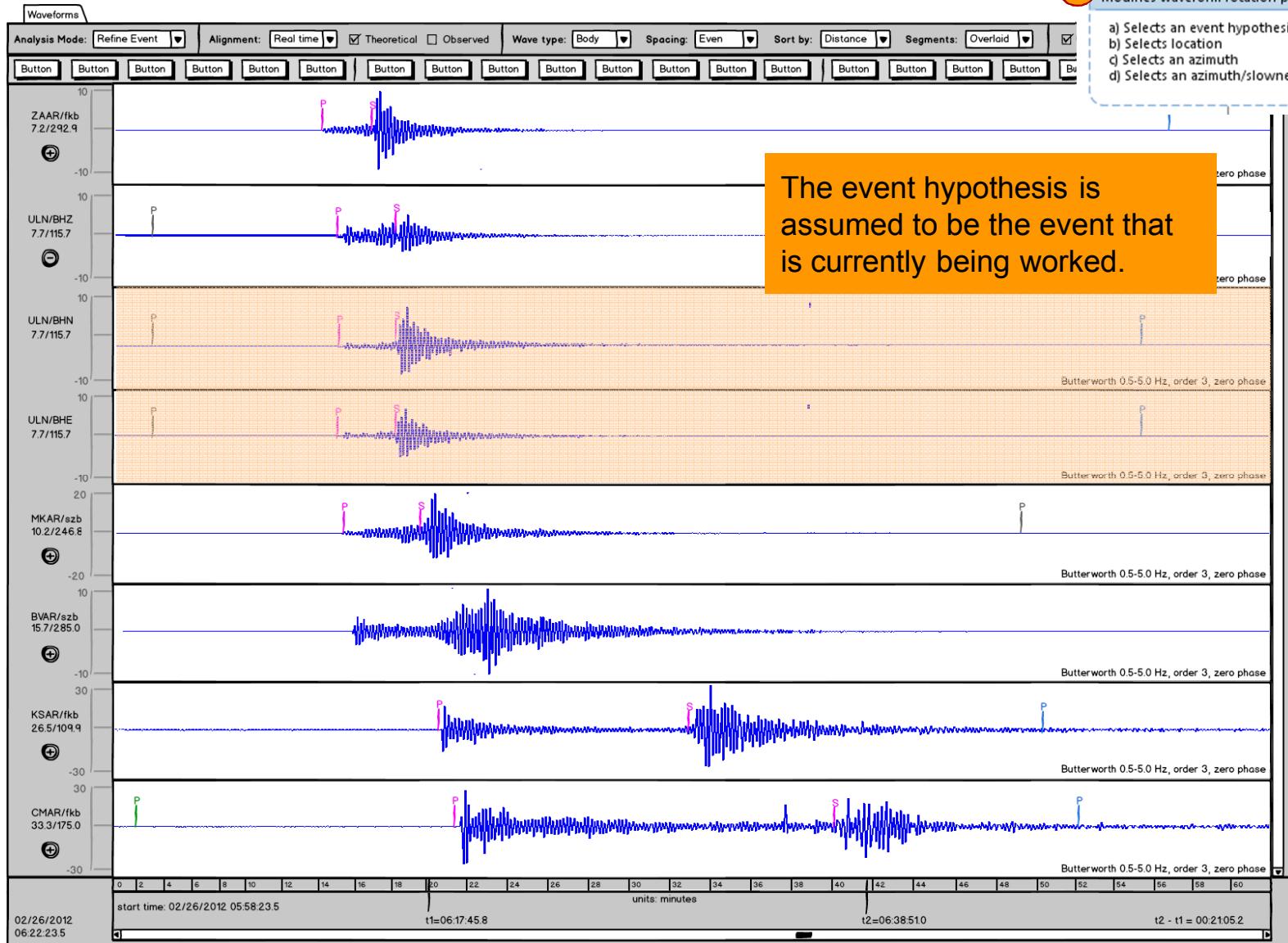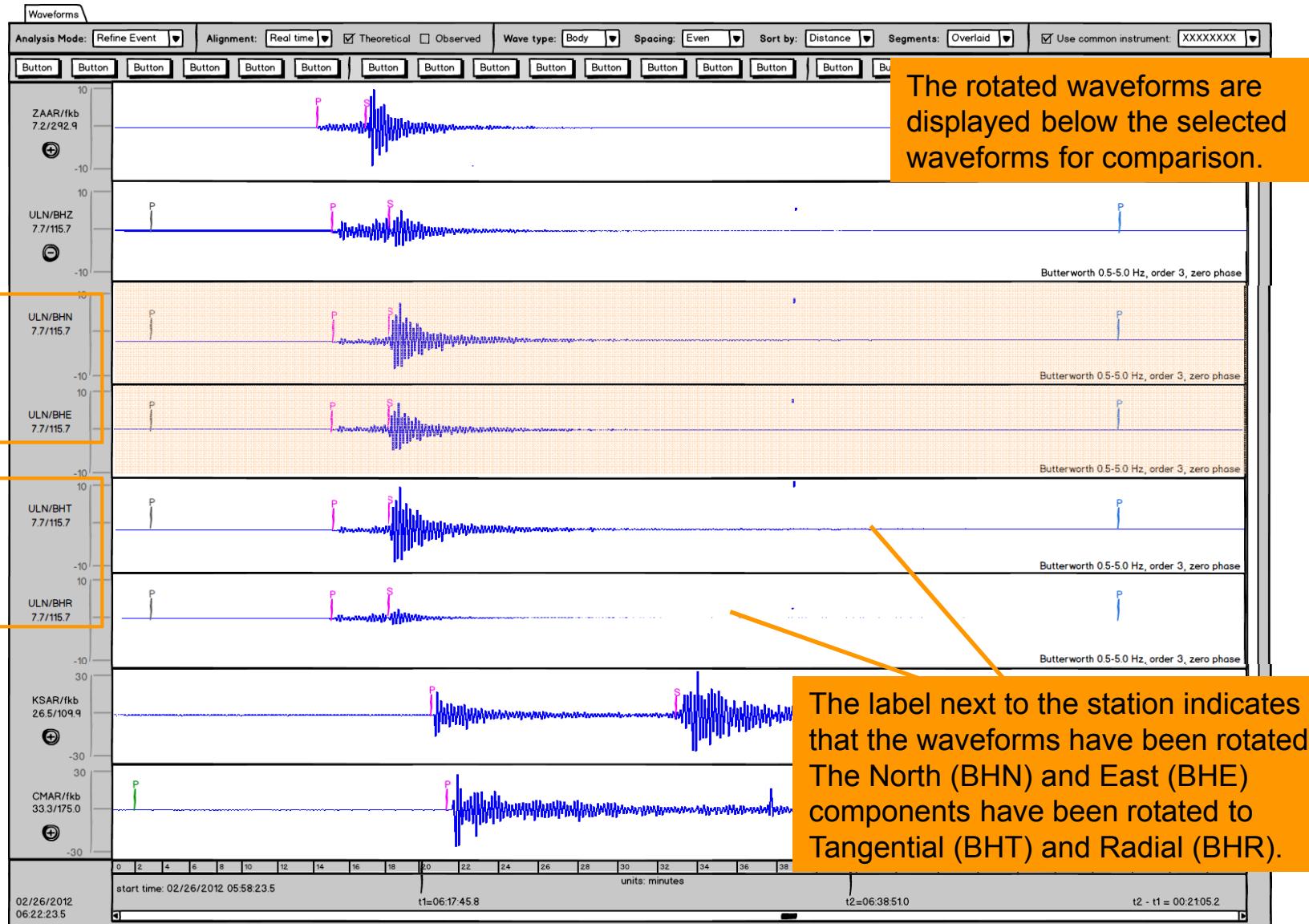
2a) Selects an event hypothesis

Modifies waveform rotation parameters:

a) Selects an event hypothesis
b) Selects location
c) Selects an azimuth
d) Selects an azimuth/slowness pair

The event hypothesis is assumed to be the event that is currently being worked.

4) Selects to rotate waveforms

The rotated waveforms are displayed below the selected waveforms for comparison.

The label next to the station indicates that the waveforms have been rotated. The North (BHN) and East (BHE) components have been rotated to Tangential (BHT) and Radial (BHR).
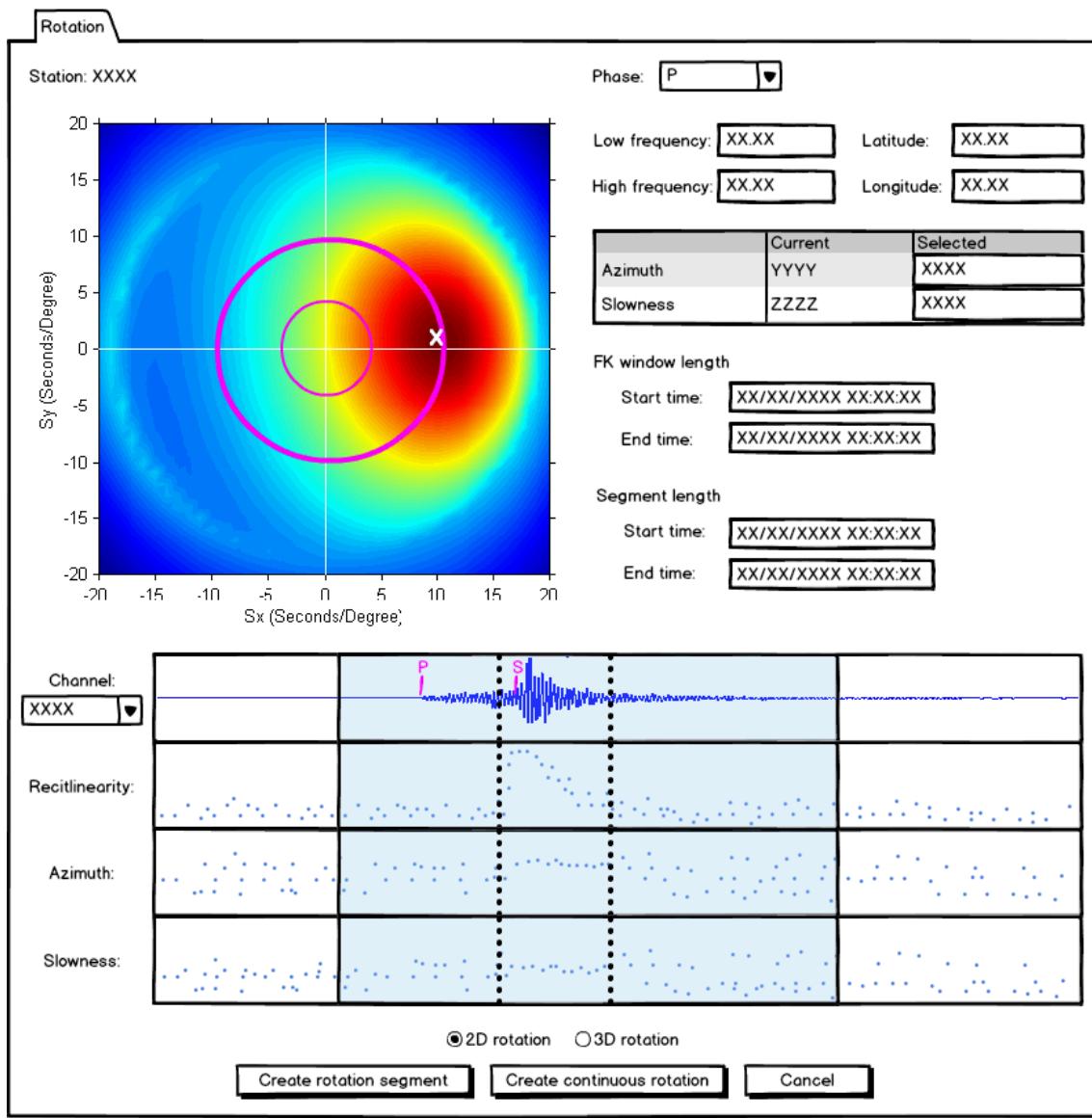
3) If 3D rotation, selects target phase
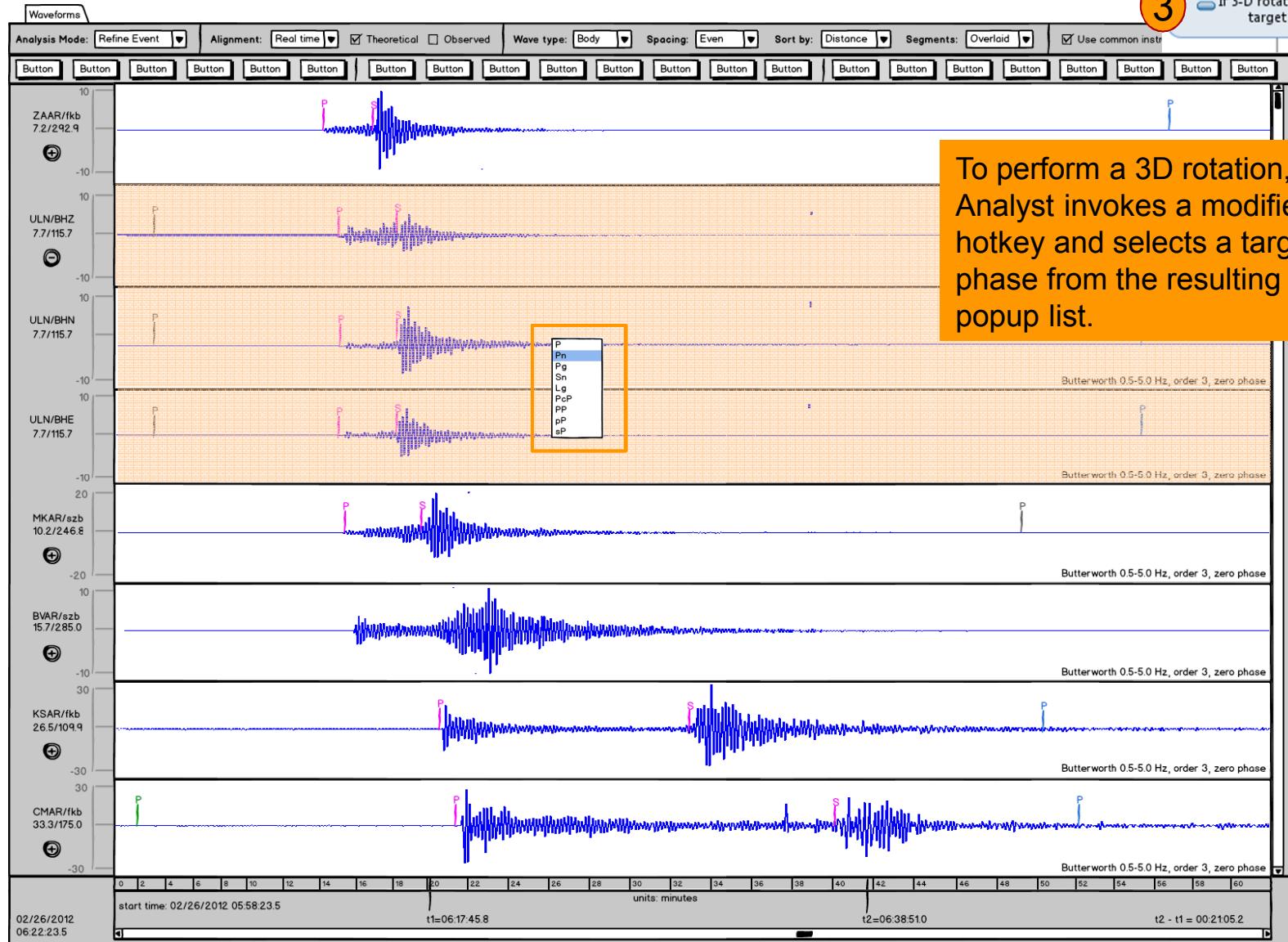
To perform a 3D rotation, the Analyst invokes a modified hotkey and selects a target phase from the resulting popup list.

1) Selects to rotate to:

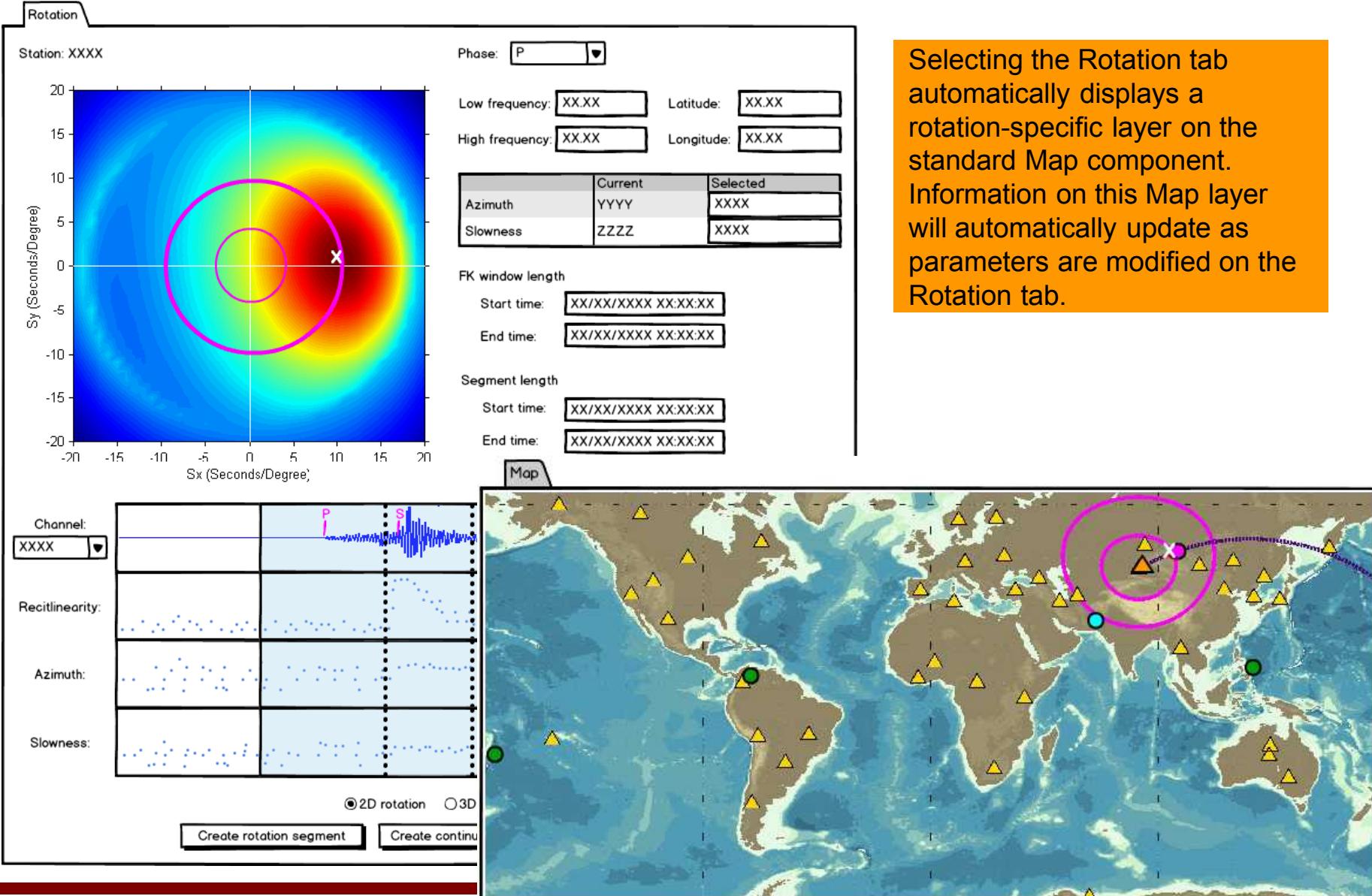The remaining three rotation options are invoked from the Rotation tab in the Analyst Workspace:

1b) Specified location
1c) Azimuth
1d) Azimuth/slowness pair

1) Selects to rotate to:

1 Selects beam target type:

a) azimuth/slowness pair
b) fk peak
c) location
d) orign beam

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Selecting the Rotation tab automatically displays a rotation-specific layer on the standard Map component. Information on this Map layer will automatically update as parameters are modified on the Rotation tab.

Rotation

Station: XXXX

Phase: P

Low frequency: XX.XX   Latitude: XX.XX
High frequency: XX.XX   Longitude: XX.XX

	Current	Selected
Azimuth	YYYY	XXXX
Slowness	ZZZZ	XXXX

FK window length
  Start time: XX/XX/XXXX XX:XX:XX
  End time: XX/XX/XXXX XX:XX:XX

Segment length
  Start time: XX/XX/XXXX XX:XX:XX
  End time: XX/XX/XXXX XX:XX:XX

Channel: XXXX

Recitlinearity:

Azimuth:

Slowness:

○ 2D rotation   ○ 3D

Create rotation segment   Create continu...

Map

2b) Selects specified location

2 b

Modifies waveform rotation parameters:
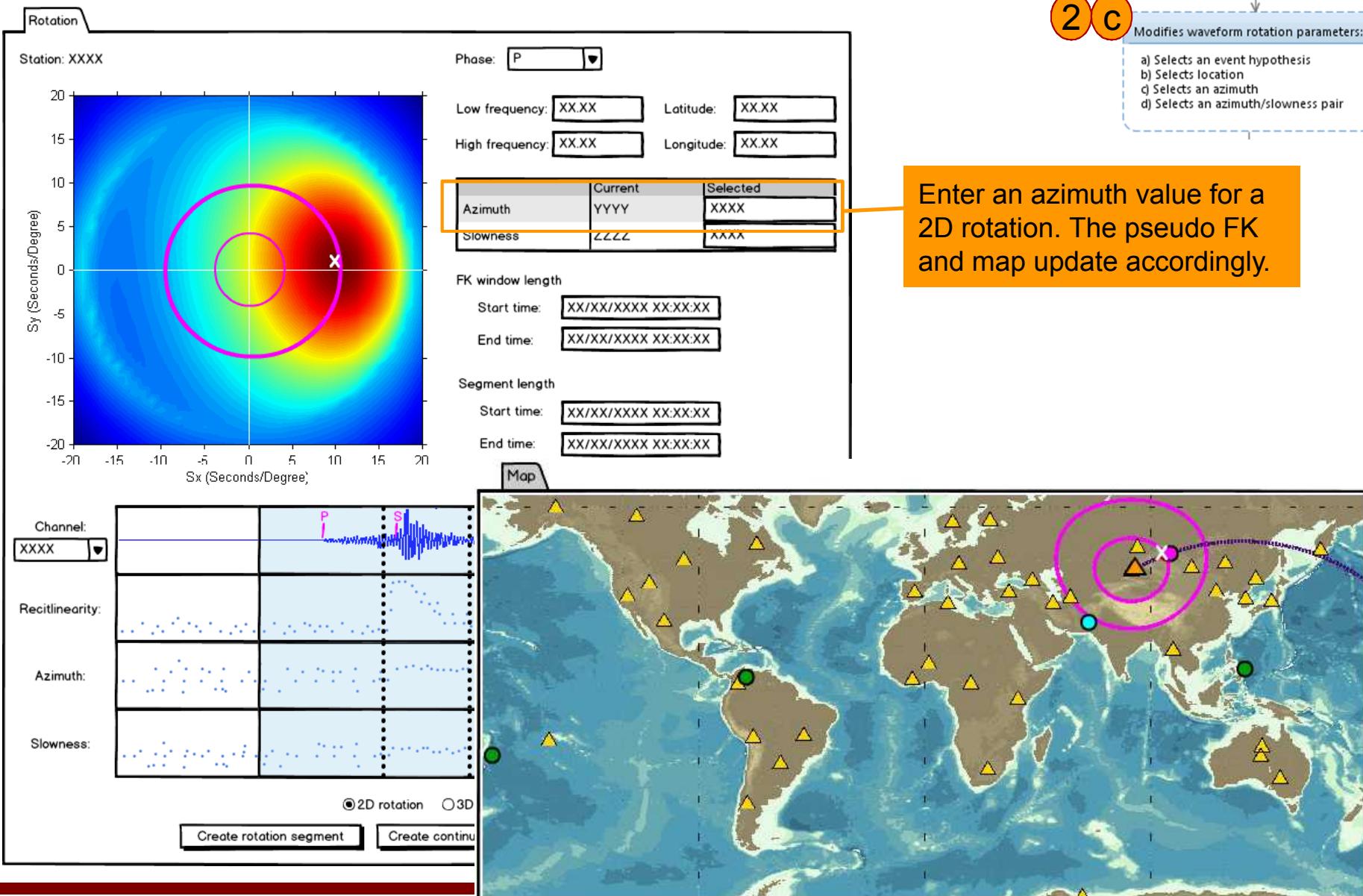
a) Selects an event hypothesis
b) Selects location
c) Selects an azimuth
d) Selects an azimuth/slowness pair
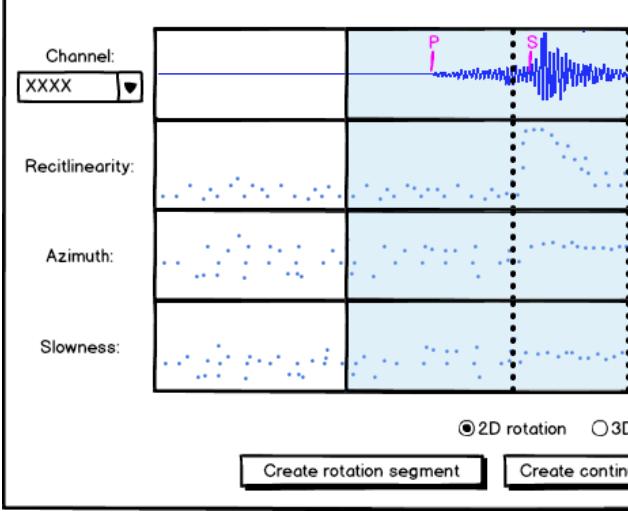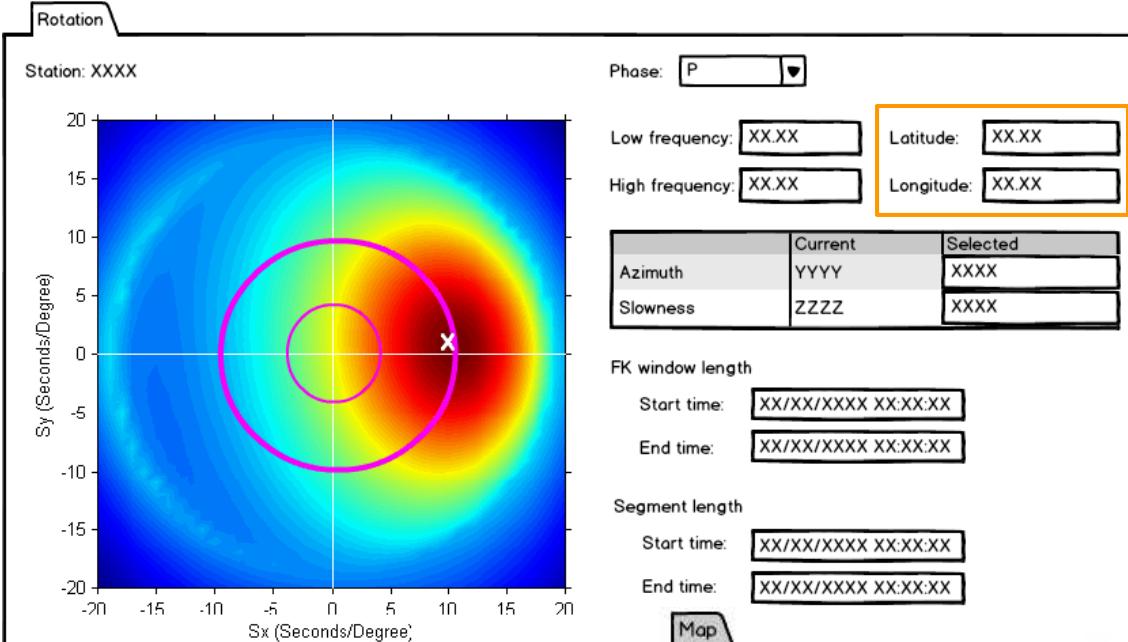
Select a location by clicking on a point on the map. The current station is highlighted in orange. Events are color-coded using the same color scheme as the main waveform display (Magenta = current event).

Alternatively, type in a latitude and longitude to select a point on the map.

2c) Selects an azimuth

Enter an azimuth value for a 2D rotation. The pseudo FK and map update accordingly.

2d) Selects an azimuth/slowness pair

Enter an azimuth/slowness pair for a 3D rotation. The pseudo FK and map update accordingly.

2 d

Modifies waveform rotation parameters:

a) Selects an event hypothesis
b) Selects location
c) Selects an azimuth
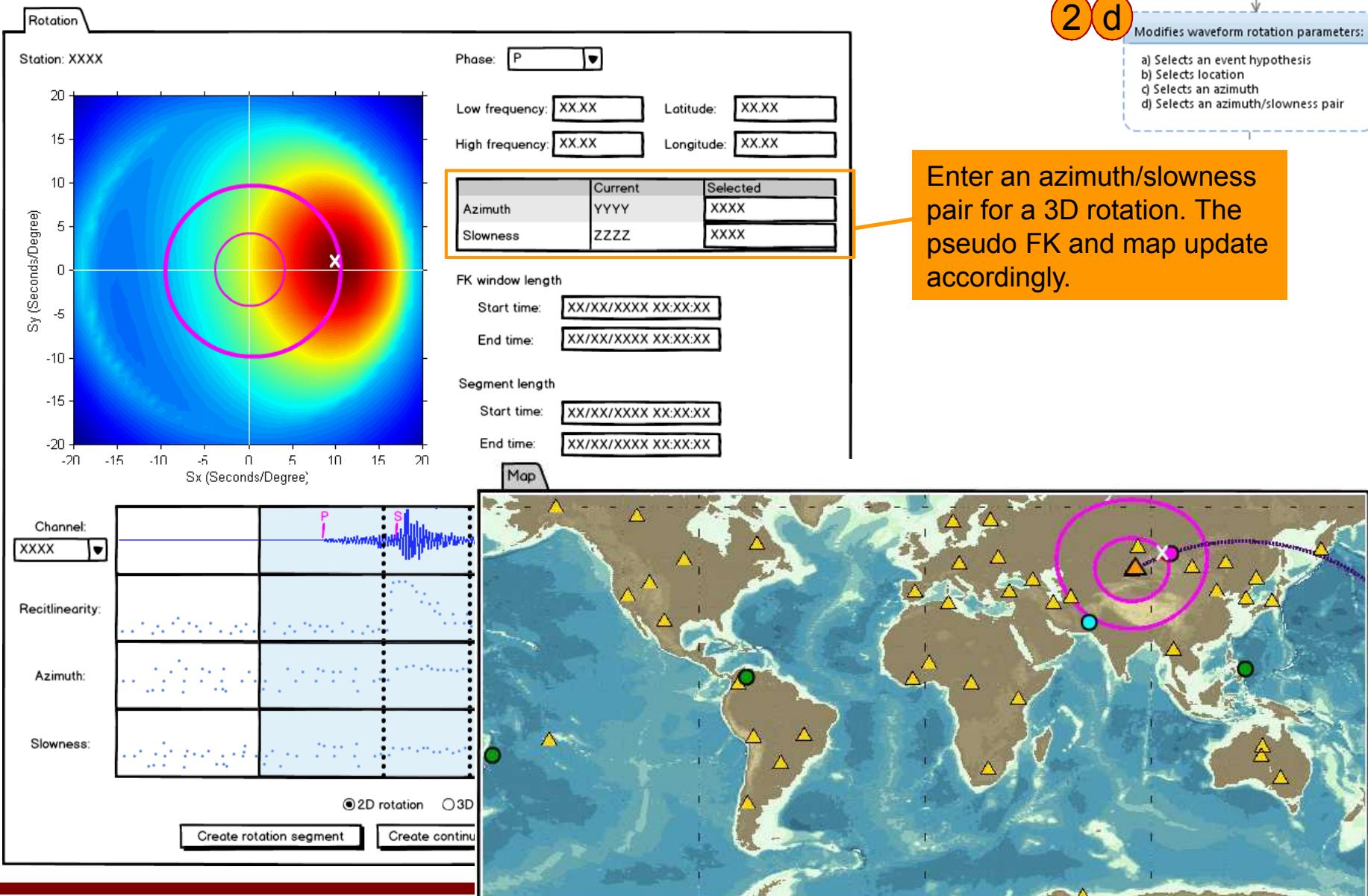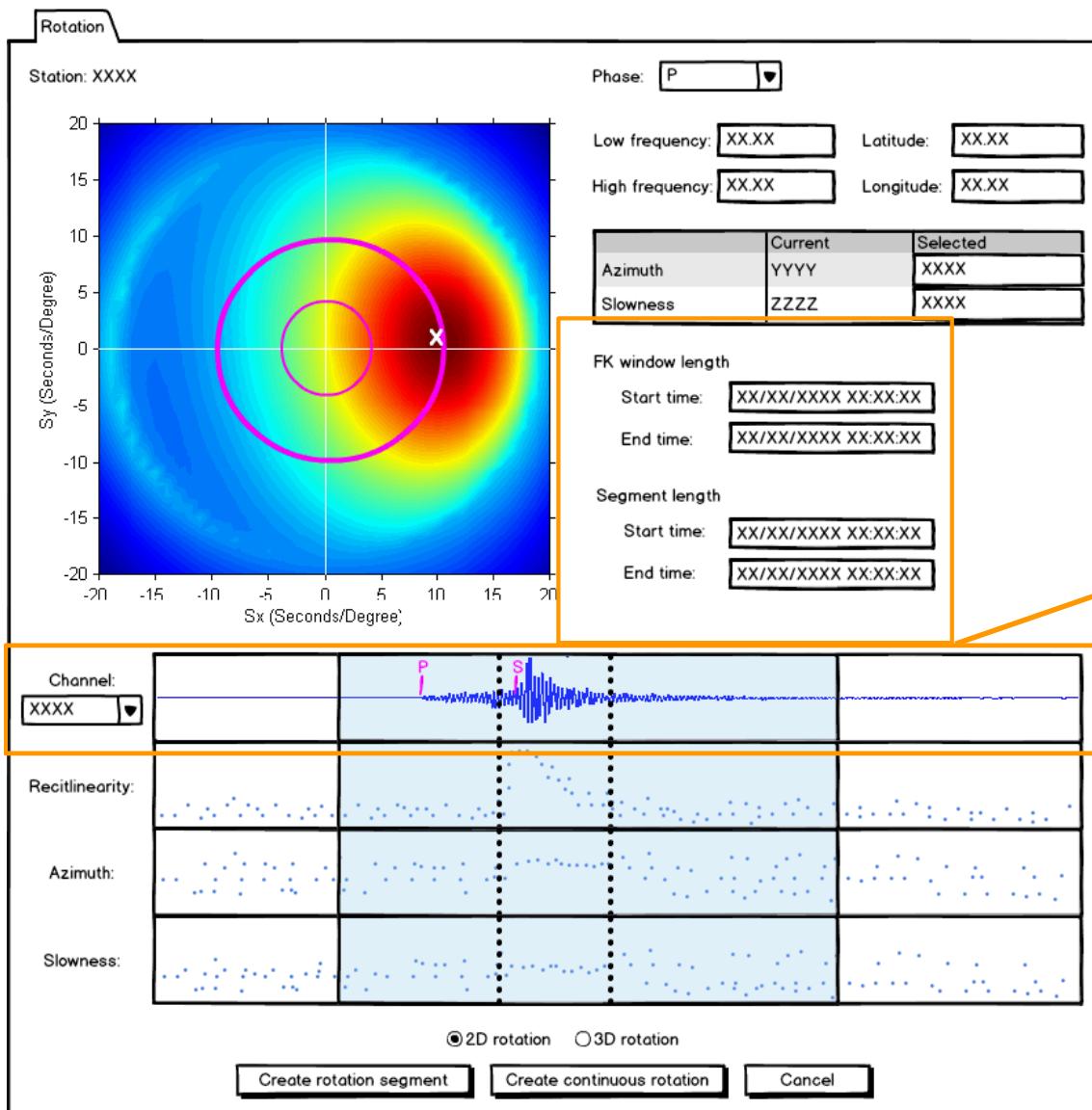d) Selects an azimuth/slowness pair

2d) Selects an azimuth/slowness pair

Modifies waveform rotation parameters:

a) Selects an event hypothesis
b) Selects location
c) Selects an azimuth
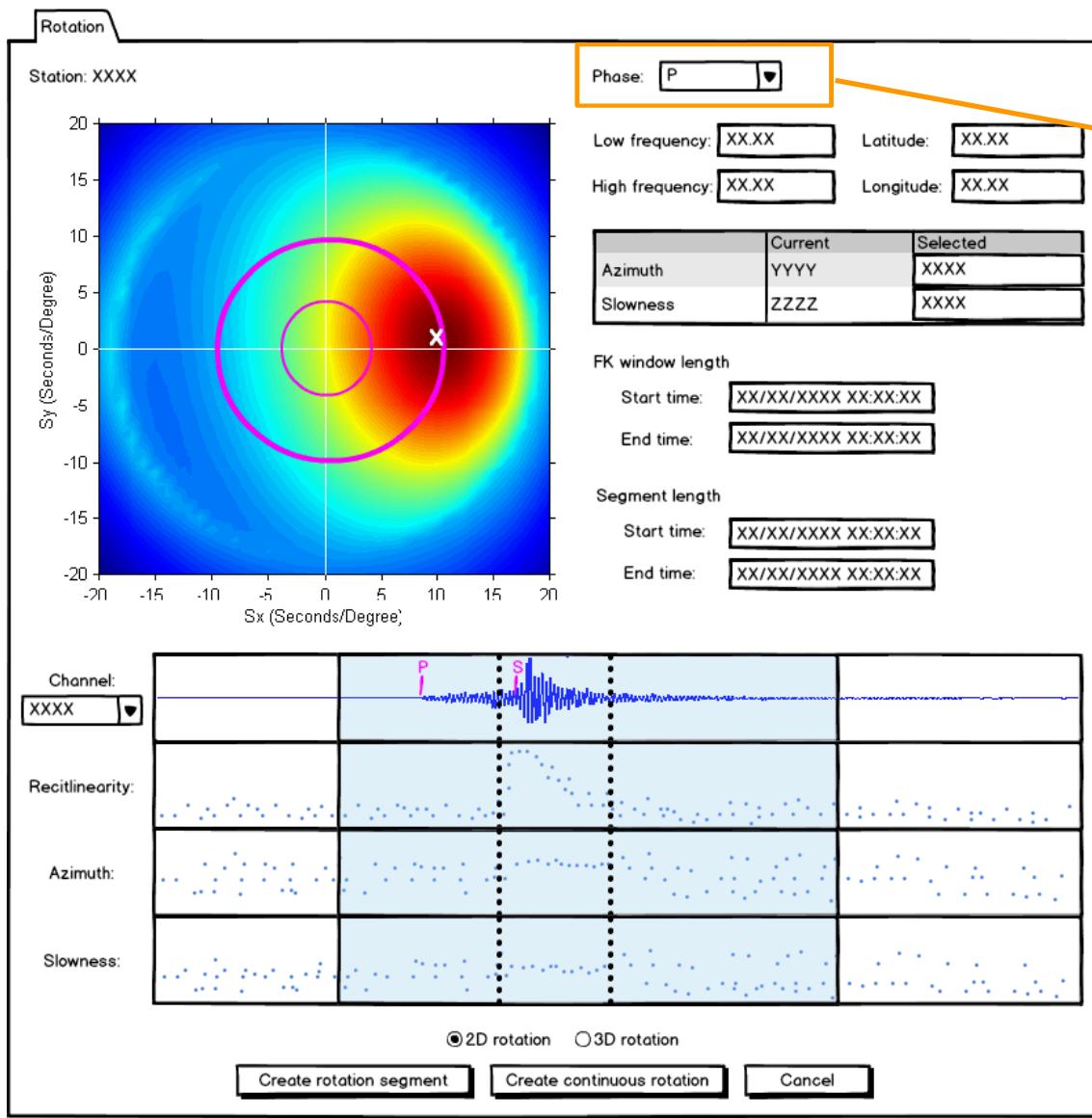d) Selects an azimuth/slowness pair

Examine channel waveforms, and adjust the pseudo FK window or segment length by dragging the time windows in the channel waveform or by updating the start/end times in the text fields.

Signal detections are shown on the channel waveforms and can be edited as needed. Edits in this display will be reflected in the main waveform display.
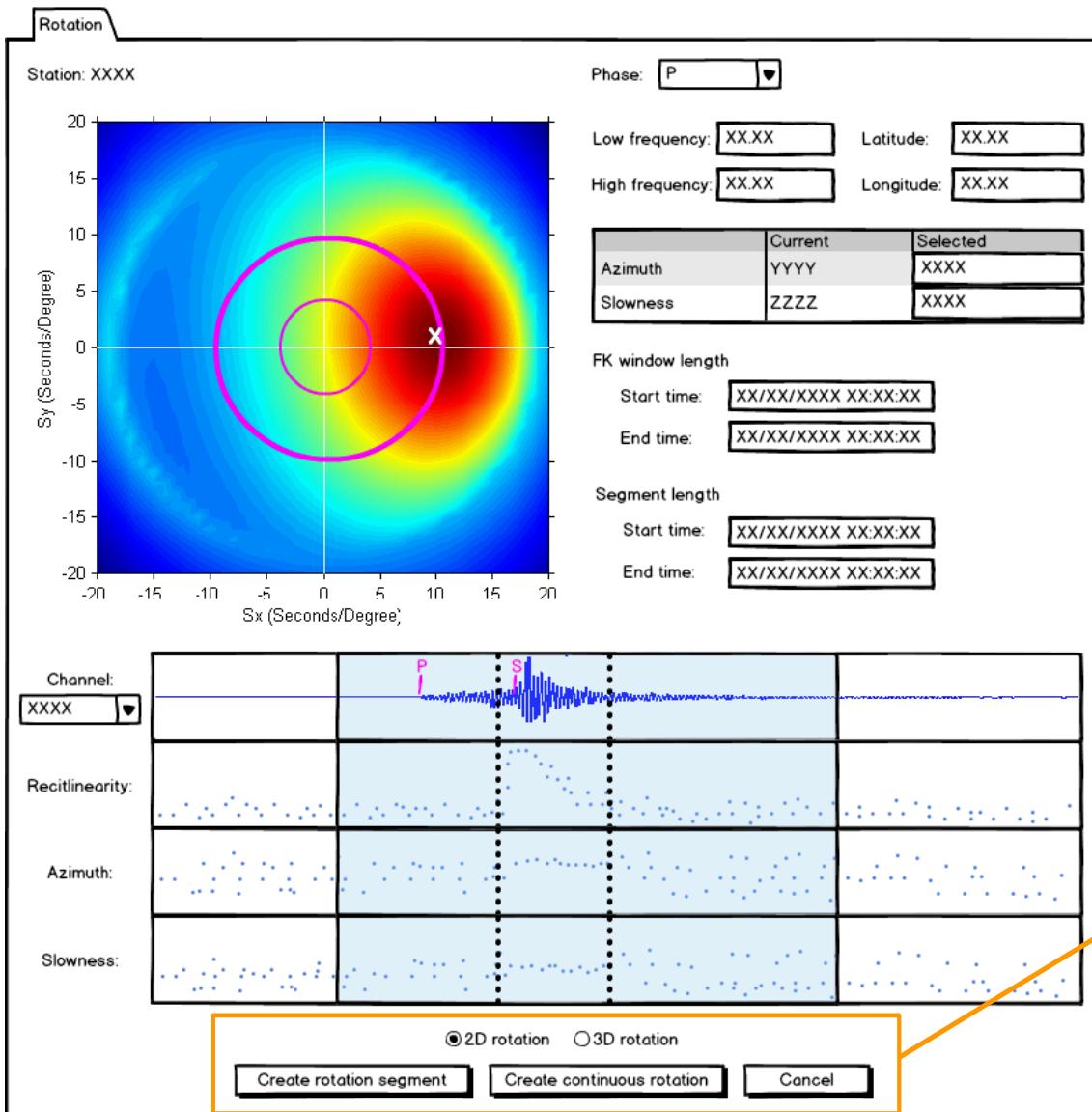
3) If 3D rotation, selects target phase

3 — If 3-D rotation, selects target phase

Rotation

Station: XXXX

Phase: P ▼

Low frequency: XX.XX   Latitude: XX.XX

High frequency: XX.XX   Longitude: XX.XX

	Current	Selected
Azimuth	YYYY	XXXX
Slowness	ZZZZ	XXXX

FK window length

Start time: XX/XX/XXXX XX:XX:XX

End time: XX/XX/XXXX XX:XX:XX

Segment length

Start time: XX/XX/XXXX XX:XX:XX

End time: XX/XX/XXXX XX:XX:XX

For a 3D rotation, select a target phase from the drop-down list. First P is selected by default.

Sy (Seconds/Degree) vs Sx (Seconds/Degree)

Channel: XXXX ▼

Recitlinearity:

Azimuth:

Slowness:

○ 2D rotation   ○ 3D rotation

Create rotation segment   Create continuous rotation   Cancel
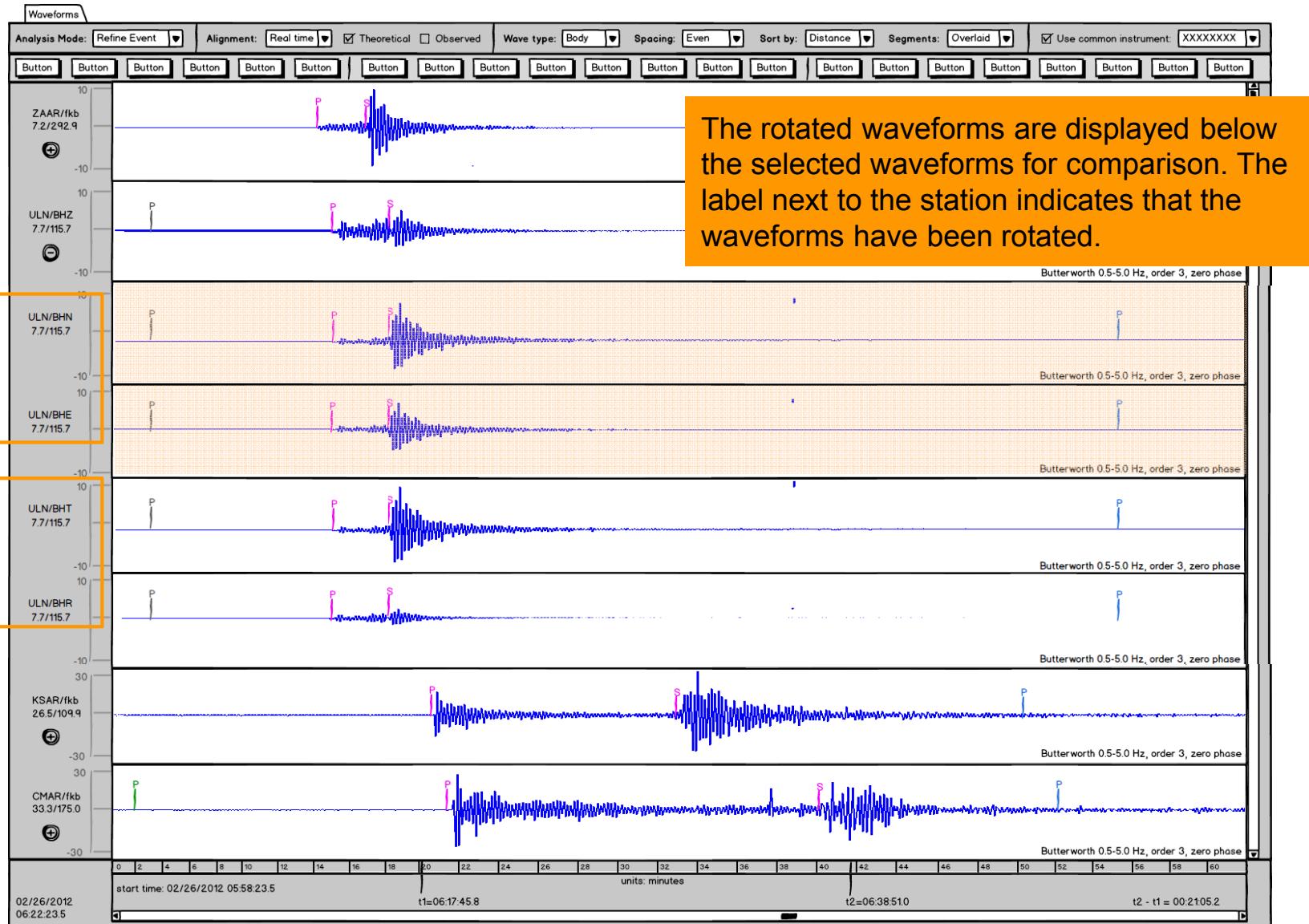
4) Selects to rotate waveforms

Select a radio button for either 2D or 3D rotation.

Press 'Create rotation segment' or 'Create continuous rotation' to rotate the selected waveforms.
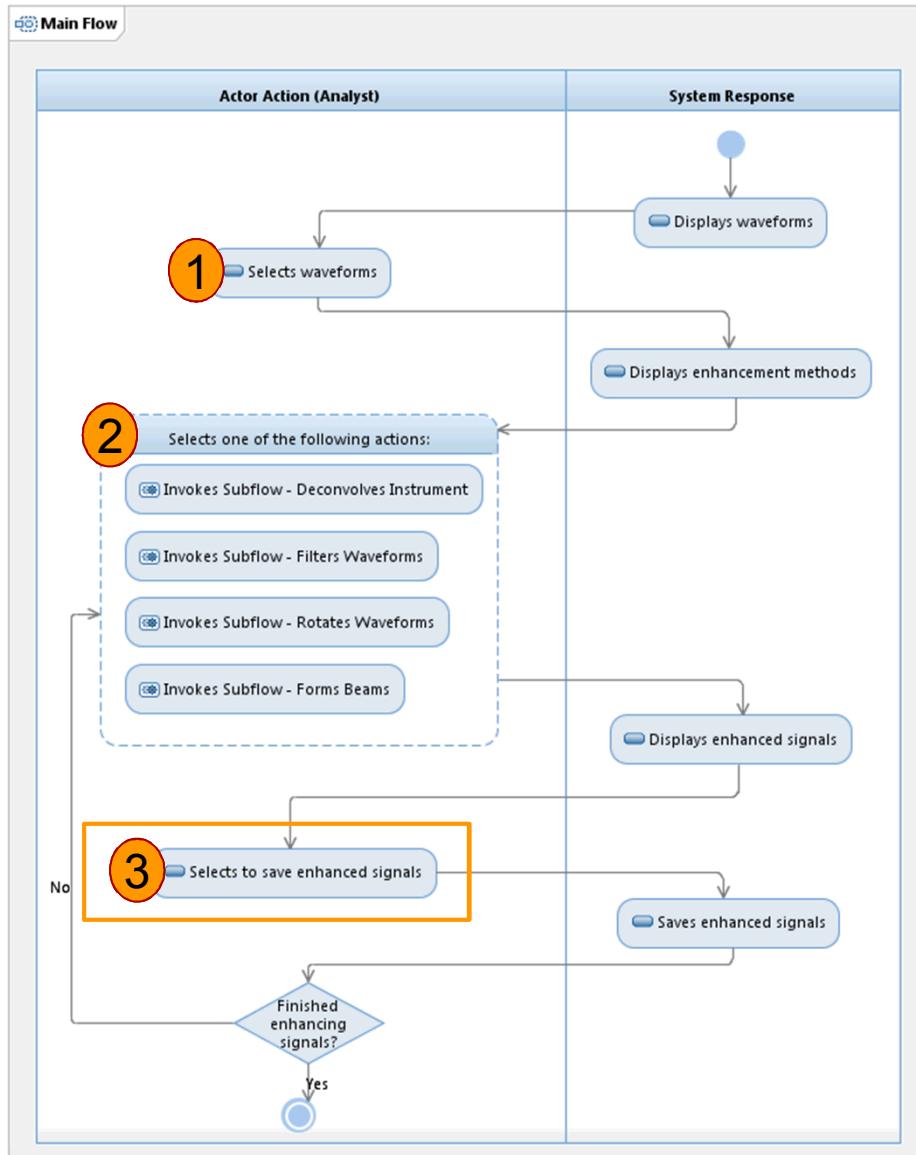
4) Selects to rotate waveforms

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The rotated waveforms are displayed below the selected waveforms for comparison. The label next to the station indicates that the waveforms have been rotated.

Main Flow

1) Selects waveforms
2) Selects enhancement method
3) Selects to save enhanced signals

- *For associated signal detections, enhanced signals are saved with the current event*
- *For unassociated signal detections, enhanced signals can be saved at any time*

Notes

- For both rotating and beaming, the standard operation can be performed entirely from the main waveform display. The Rotating and Beaming tabs allow beaming and rotation to be performed via additional methods.