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# **GMS Interactive Analysis (IAN) User's Guide**

Version 1.16 (for GMS PI 16 Open Source Release)

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## **ABSTRACT**

This document is a user's manual for the Geophysical Monitoring System (GMS) Interactive Analysis (IAN) User Interface.

Andrea C. Conley, J. Mark Harris

Prepared by Sandia National Laboratories Albuquerque, New Mexico 87185 and Livermore, California 94550

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## 1. GENERAL OVERVIEW

The Geophysical Monitoring System (GMS) Interactive Analysis (IAN) User Interface (UI) is a web-based application that allows a user to access and process waveform data and station definition metadata bridged from the United States National Data Center (NDC) legacy database.

The IAN UI will primarily be used by Analysts, who process waveforms to enhance event signals while suppressing background noise. The Analysts will use the IAN UI to detect, build, refine, locate, and discriminate events.

Currently, the IAN UI has 4 displays:

- 1) Workflow – allows analysts to open, close, and view the current status of data processing intervals. A data processing interval is a discrete portion of the bridged waveform data to be processed by an analyst
- 2) IAN Map – a map of bridged station and site locations
- 3) Waveform – supports querying for and viewing of bridged waveform data for a set of stations in a time range selected via the Workflow display
- 4) Station Properties – provides detailed metadata information about a station selected in the IAN Map or Waveform display, including its channel group and channel configuration

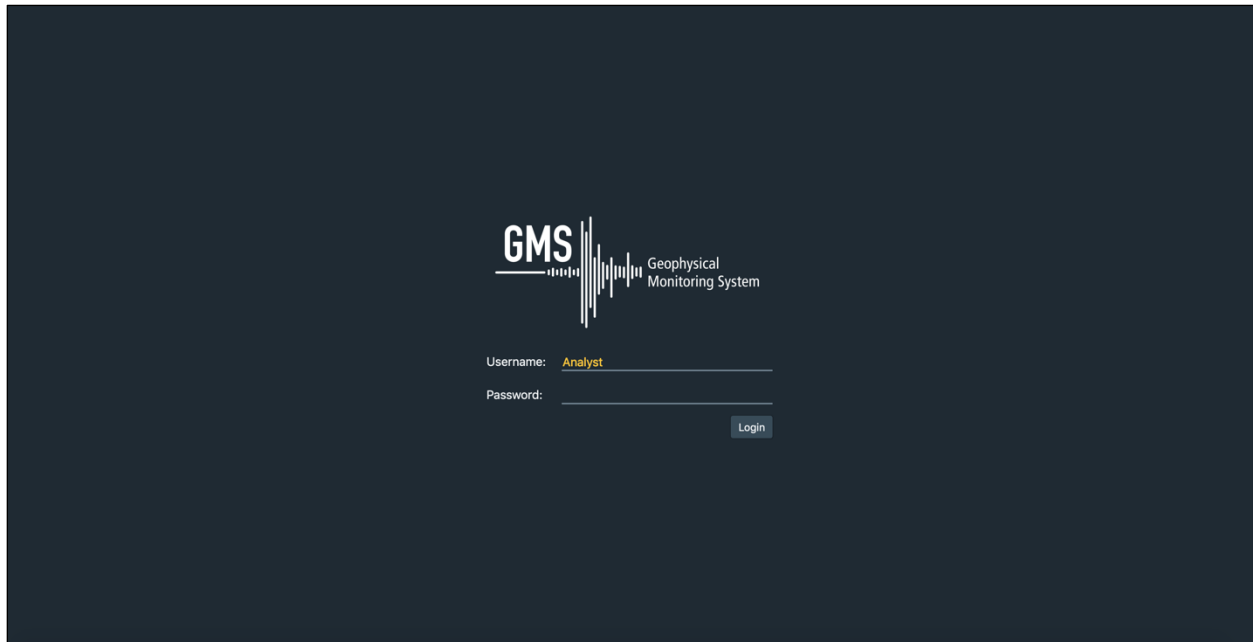
This document is an in-depth user's guide for the current version of the IAN UI, including browser requirements and an overview of each interactive display. It will periodically be updated throughout the development of the IAN UI.

## 2. BROWSER REQUIREMENTS

The UI is currently supported by Chrome (ver.  $\geq 78$ ), Firefox (ver.  $\geq 68$ ), and the open-source framework Electron (ver.  $\geq 5.0.1$ ). Docking and undocking tabs are currently not supported in Electron. The UI will also run on Apple's Safari and Microsoft's Edge but with degraded performance.

### 3. LOGIN

To log into the IAN UI, enter the appropriate URL into a supported web browser. This URL will vary depending on where GMS is installed. After entering the URL, the user will be directed to the login screen (Figure 1).

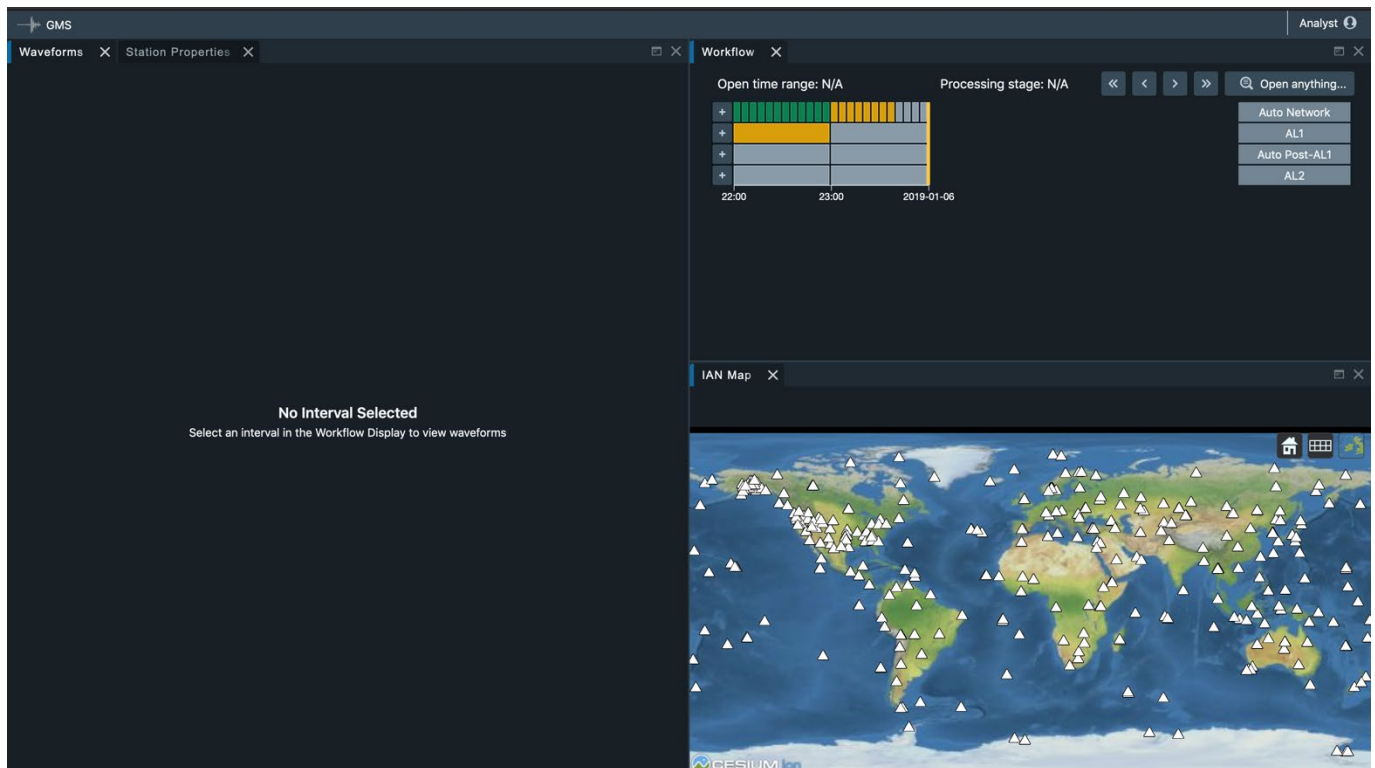


**Figure 1. Login Screen for the IAN UI.**

At the login page, users should enter any username but leave the password blank; the user will not be able to enter information into the password field. Users should not enter credential information because this information is viewable within log messages.

## 4. DEFAULT WORKSPACE LAYOUT

After logging in, the user will be taken to the default IAN UI workspace layout (Figure 2).



**Figure 2. Default Workspace Layout of the IAN UI.**

The default IAN UI workspace consists of four synchronized displays:

- Workflow (Figure 2, upper-right)
- IAN Map (Figure 2, bottom-right)
- Waveforms (Figure 2, left)
- Station Properties (Figure 2, left)
  - This display can be viewed by clicking on the corresponding tab

Initially, the Waveform and Station Properties displays are unpopulated. The IAN Map display will show the locations of all configured stations within all configured station groups available to GMS as white triangles. Available stations are configurable (see Configuration documentation). To load waveform data into the Waveform display, an interval must be selected from the Workflow display. This action will be described in detail in Section 5.2. Further, the Station Properties display will not be populated until a station is selected from the Waveform or IAN Map displays. This action will be described in Section 5.5.



The default IAN UI also includes an application-level menu button labelled with the user's username in the top-right corner (Figure 3).



**Figure 3. Application-Level Menu Button.**

The default layout and any other user-defined layout can be modified in five ways:

- 1) Displays can be moved by clicking the corresponding tab and dragging it to the desired position; this includes placing multiple displays in one window with the display tabs next to each other.
- 2) Displays can be expanded to full-screen by clicking the maximize button (i.e., box symbol) in the top-right corner of the display. Once full-screen, it can be returned to its original size by clicking the minimize button (i.e., dash symbol) at the top-right corner.
- 3) Displays can be widened horizontally or vertically by hovering the cursor over their window edge; when the window edge is highlighted blue, it can be clicked and dragged to the desired position.
- 4) An individual display can be removed from the default layout by clicking the X next to the display name or the X in the top-right corner of the window containing the display. If multiple displays share a window, clicking the X in the window's right corner will result in those displays being removed.
- 5) Once removed, individual displays can be restored to the default layout by selecting one of the following options from the application-level menu:
  - a. Select Analyst Displays from the Displays section of the application-level menu, then select one of the following display names:
    - i. IAN Map
    - ii. Station Properties
    - iii. Waveforms
    - iv. Workflow

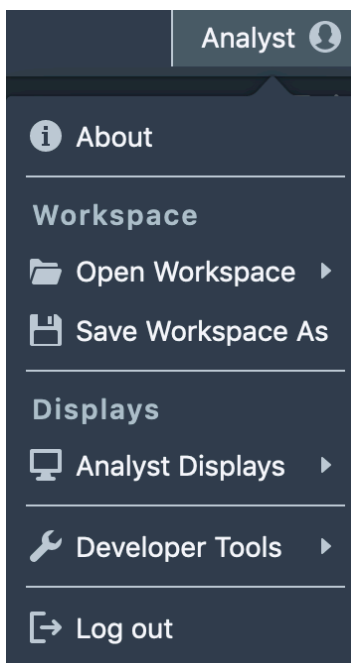
This action will be described in greater detail in Section 5.1.

- b. Select Open Workspace from the workspace section of the application-level menu, then select Analyst Displays Layout (default). This restores the workspace layout to the default layout (Figure 2) unless a personalized layout was made default by the user (see Section 5.1).

- c. Select Developer Tools, then select Clear Layout. This restores the default workspace layout (Figure 2). If another workspace layout was saved as the default (see Section 5.1), this will restore to the saved default layout.

## 5. DISPLAY INTERACTIONS

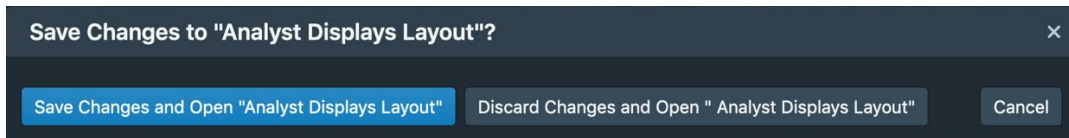
### 5.1. Application-Level Menu



**Figure 4. Application-Level Menu Options.**

Application-level menu options include:

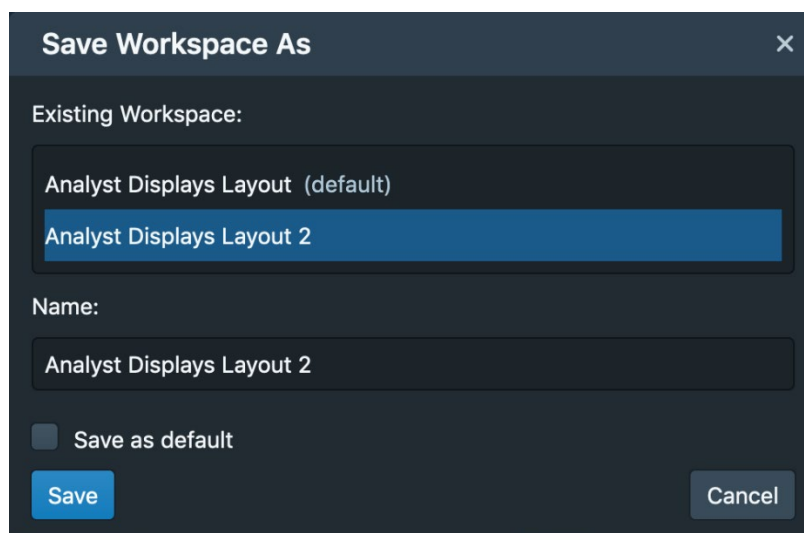
- 1) About – Displays the version of the IAN UI and its latest commit. The latest commit is used by system developers for troubleshooting.
- 2) Open Workspace – Shows the current user's available workspace layouts. Initially, only the default layout in Figure 2, titled Analyst Displays Layout, is available. More layout options are made available when the user saves them by selecting Save Workspace As. If the user makes changes to the current workspace layout and does not save it, they will be prompted to save or discard the changes when attempting to open another workspace (see Figure 5). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.



**Figure 5. Prompt to Save or Discard Changes.**

From the prompt, the user can choose to open a new workspace layout while either saving or discarding the changes. To save the changes, the user should select Save Changes and Open Analyst Displays Layout. To discard changes, the user should select Discard Changes and Open Analyst Displays Layout. The user can also select Cancel to return back to the current workspace layout.

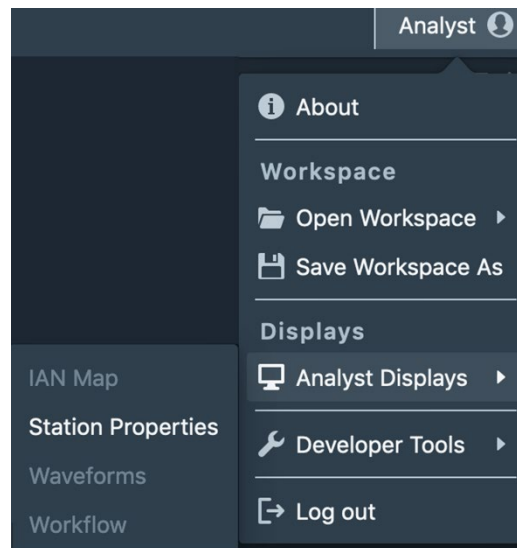
- 3) Save Workspace As –Saves a preferred UI layout (see Figure 6).



**Figure 6. Save Workspace As Menu Options.**

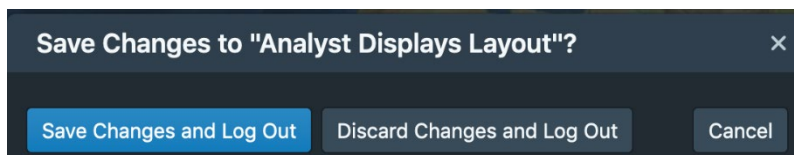
A new workspace layout can be saved under the name of an existing layout by highlighting its name in the Existing Workspace dialog box or by typing the entry in the Name field. Alternatively, the user can create a new workspace layout by typing a new entry in the name field. The user can make the new workspace layout the default by checking the Save as default option at the bottom of the context menu. Once saved, the new workspace layout can be accessed by going to Open Workspace (see bullet 2).

- 4) Analyst Displays – Adds workspace displays. Only one display instance can be open at a time. Displays already open are grayed out within the Analyst Displays submenu. For example, in Figure 7, the IAN Map display is grayed out because it is already open.



**Figure 7. Analyst Displays Menu Options.**

- 5) Developer Tools – Provides the user two options:
- a. Logs – Lets the user view searchable logs tracked in the UI (debug, info, warn, error, fatal, etc.).
  - b. Clear Layout – Resets the UI display to the default layout. This option resets the UI to the layout shown in Figure 2 if the user does not have a default custom layout.
- 6) Log Out – Logs the user out of the IAN UI. If any changes were made to the open workspace layout, the user will be prompted to save or discard the changes before logging out (see Figure 8). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.



**Figure 8. Log Out Menu Options.**

## 5.2. Workflow Display

When using the IAN display, both the GMS system and human analysts work on the available waveform data in different processing stages, where each processing stage consists of a different set of processing sequences or activities applied to the data. These stages are listed in the rightmost column of the Workflow display as shown in Figure 9 below.



**Figure 9. Workflow Display.**

Currently, the processing stages are Auto Network, AL1, Auto Post-AL1, and AL2. The processing stages Auto Network and Auto Post-AL1 are automatic processing stages performed by GMS without analyst input. Under these stages, processing sequences consisting of several processing steps (e.g., association, conflict resolution under Auto Network) are automatically applied to the data. Steps in the sequence are applied to the data one at a time and in order. The current processing sequences are shown in Appendix A and are configurable (see Configuration documentation).

The processing stages AL1 and AL2 are interactive processing stages rather than automatic. These are the stages in which an analyst can interact directly with the waveform data. These interactive stages are configured to have a list of activities for the analyst to complete. Currently, the two available activities are Event Review and Scan.

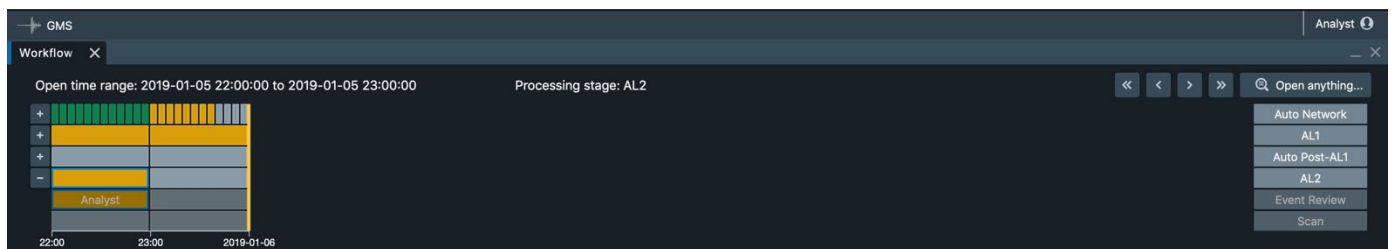
All processing stages are shown as rows stacked over a shared timeline and are further broken down into blocks of time, i.e., processing intervals, as shown in Figure 9. Each processing interval is 1 hour in duration for the AL1, Auto Post-AL1, and AL2 processing stages. The Auto Network processing stage is broken down into 5 minute intervals. These interval durations are configurable (see Configuration documentation). By default, the display will show processing intervals from the past 12 hours. Currently, only 2 hours of data are shown (see Section 6). A vertical yellow line indicates the start of a new day. For instance, in Figure 9 the Workflow Display shows intervals for the last two hours of 2019-01-05 and the vertical yellow line indicates the beginning of 2019-01-06.

To view earlier (or later) processing intervals, the user can scroll through time using the horizontal scroll bar at the bottom of the Workflow display. Alternatively, pan buttons in the toolbar at upper-right of Figure 9 can be used to jump forward or back in time. If the Workflow display is not wide enough, the pan arrow buttons will be placed under a dropdown menu shown as three vertical dots. A single arrow will jump forward or back by one day and the double arrow will jump forward or back by one week. The user can also jump forward or back in time using the keyboard. To jump forward or back by one day, press the left or right arrow keys to go back or forward, respectively. To jump forward or back one week, hold down the Shift button and press the left or right arrow to go back or forward, respectively. The length of time to jump forward or back using the pan arrows or keyboard shortcuts is configurable (see

Configuration documentation). The user cannot use any of these options to view processing intervals outside the configurable operational time period where data are made available (see Configuration documentation). For instance, because the operational time period is currently set to 2 hours of data (Section 6), the user cannot use the pan arrows to view data from the previous day or week.

To populate the UI with waveform data, the user must open a processing interval. Note that only intervals under the two interactive stages (AL1, AL2) can be used to populate the UI. To open a processing interval, the user must right click the desired processing interval and select Open Interval. When an interval is opened, the selected interval is highlighted in blue. For instance, in Figure 10 the 1 hour interval from 22:00 to 23:00 in the AL2 stage has been opened for interaction. When an interval such as the example in Figure 10 is opened, the time range and processing stage being viewed in the UI are listed at the upper-left and upper-middle of the Workflow display, respectively.

As previously mentioned, each row in the default Workflow display represents an entire processing stage, including all activities. To view intervals associated with a specific activity, the user can expand a processing stage row by clicking the plus sign to the left of the row as shown in Figure 10.

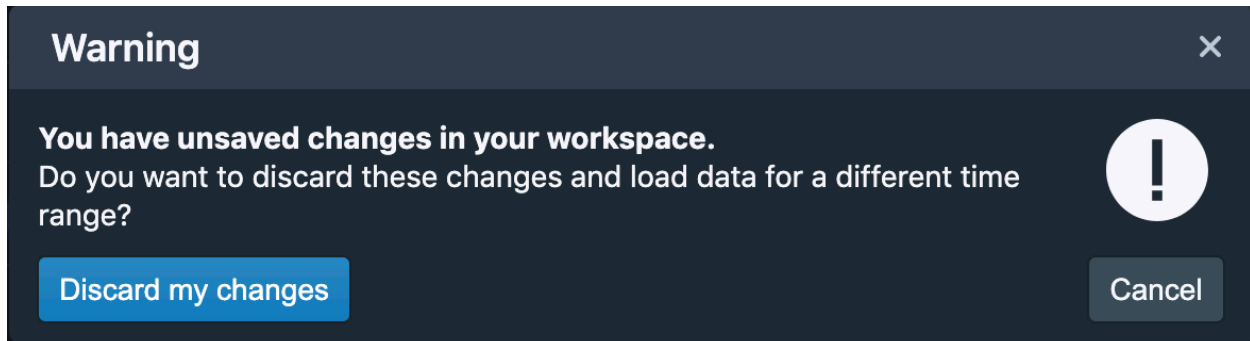


**Figure 10. Workflow Display with Processing Stage Expanded.**

The user can now see the intervals associated with Event Review and Scan processing activities. This type of expansion can also be done on automatic processing intervals to view the intervals associated with their respective processing sequences.

The user can select an interval directly from one of the unexpanded processing stage rows. When this action is done, all corresponding activity intervals within the processing stage will also be selected and highlighted in blue when expanded (see Figure 10). However, the UI will only be populated with waveforms from the first activity (Event Review in this case) when an interval from the processing stage row is opened. As an alternative, the user can open an interval corresponding to an activity. In this case, both the activity interval and the corresponding processing stage interval are highlighted. Only one interval can be opened at a

time. If the user switches to another interval without closing the current interval, the warning in Figure 11 will be shown.

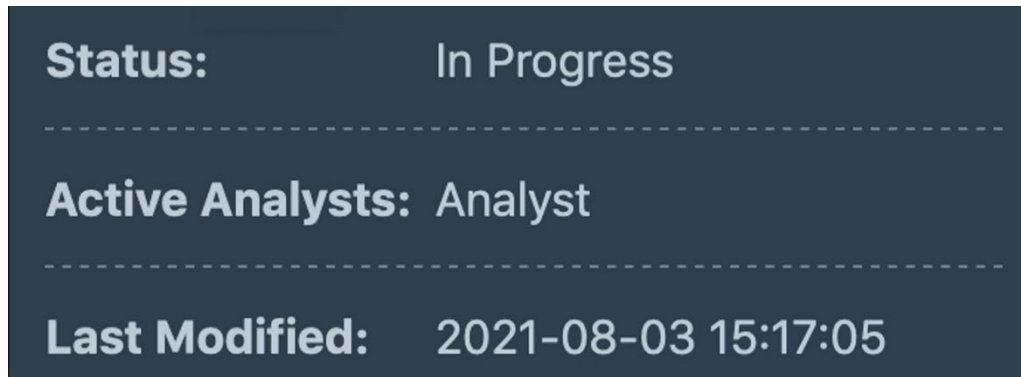


**Figure 11. Unsaved Changes to Workflow Display Warning.**

The user can either cancel to remain on the current interval or discard their changes. If the user discards their changes, the current interval will close and the newly selected interval will be opened.

In addition to being highlighted, when an interval is opened the processing stage interval and the corresponding activity interval(s) will have the user's username added to the list of active analysts for the interval. If the user is the only active analyst in the interval, their username will appear in the cell for the opened stage and activity interval(s) (e.g., Figure 10). Note that multiple users can work on the same interval(s) at the same time. When multiple analysts are working on the same interval, the interval will be labeled with the username of the first analyst to open the interval plus a count of additional active analysts. For example, Analyst + 2 indicates that along with user Analyst, two other analysts are actively analyzing the same processing interval. To view the usernames of the other analysts, hover the cursor over the processing interval activity to print out a tooltip to the screen. A union of all active analysts in all processing activities is rolled up to the list of active analysts for the corresponding processing stage and is also revealed via tooltip. As analysts open and close intervals, the user will see these changes in their Workflow display in real time.

An example interval/stage tooltip is shown in Figure 12.



**Figure 12. Workflow Display Tooltip.**

In addition to a list of active analysts, the date and time that the interval or stage was last modified as well as the interval status are also printed out in the tooltip. A description of interval status is provided later in this section.

Once an interval is opened, the Waveform display is populated with data from the station group configured (see Configuration documentation) for the opened processing activity or the first processing activity under the corresponding processing stage (e.g., Event Review under AL1). The selected interval dictates the time range of data displayed in the Waveform display. At the same time, the IAN Map display shows the locations of all station groups in GMS, with stations belonging to the open station group colored orange and stations outside the group colored white. These sync features will be described in more detail in Sections 5.3 and 5.4, respectively. With an interval opened, the user can perform analysis of the data using these populated displays.

Once the user wants to close a processing stage interval or processing activity interval, right-click the opened interval in the Workflow display and select 'Close Interval'. Note that to open the Scan activity under either AL1 or AL2, the Scan activity must be opened directly. If the user first opens the processing stage, e.g., AL1, the UI will be populated with data from the Event Review activity and Event Review data will remain in the UI even when the Event Review interval is closed by the user (see Section 6). When the interval is closed, waveforms will no longer be shown in the Waveform display and all triangle icons on the IAN Map display will revert to white.

The status of an interval is indicated in the Workflow display by interval color. For automatic processing stages, interval colors indicate the following:

- Dark Gray = Skipped; processing has been skipped by GMS
  - Skips can occur when not enough data are available
- Light gray = Not Started; processing has not begun



- Yellow = In Progress; processing is currently running
- Green = Complete; processing has finished running
- Red = Failed; an error occurred during processing

For interactive processing stages, interval colors indicate:

- Light gray = Not Started; data are available but the interval has not yet been opened by an analyst
- Yellow = In Progress; at least one analyst has opened the interval for analysis
- Orange = Not Complete; an interval has been closed but has not been marked as completed by an analyst
- Green = Complete; an analyst has marked an interval as completed

Note that the color of an individual activity interval is a shade darker than the processing stage until the user directly hovers the cursor over that interval. Then the interval color will have the same shading. The darker shading indicates that the activity interval has not been opened yet.

The status of an interactive processing stage (AL1, AL2) interval is determined via roll-up of the status of each activity in that processing stage. Currently, the available activities are Event Review and Scan. All possible roll-ups are listed in Table 1 below. Roll-ups are read from left-to-right; for example, in row 5 the combination of the *Not Started* status of Activity 1 and the *In Progress* status of Activity 2 results in an *In Progress* status for the Processing Stage.

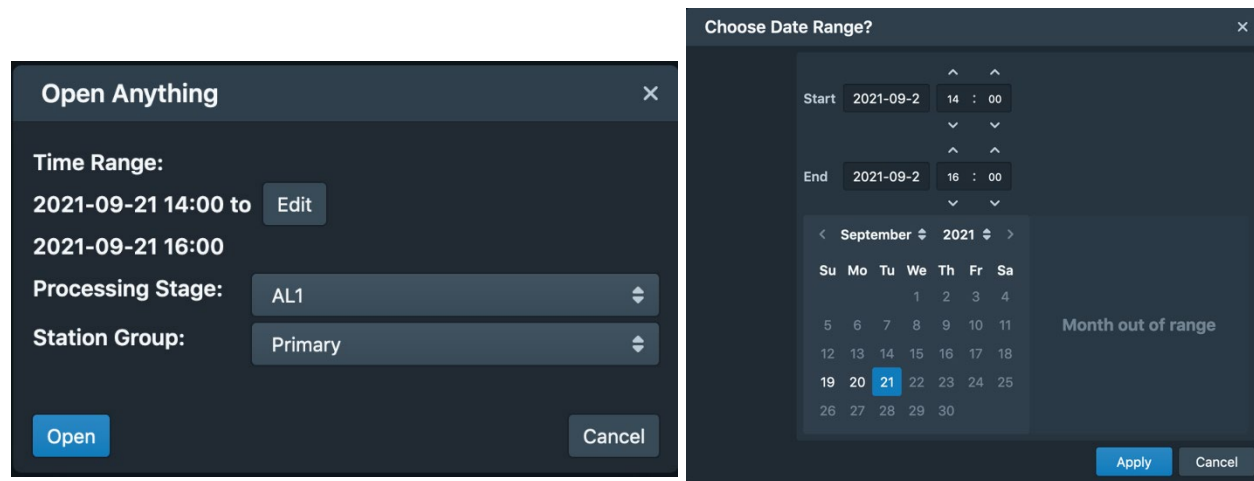
**Table 1. Status Roll-Ups of Interactive Processing Stages AL1 and AL2.**

Activity 1 (Event Review) Status	Activity 2 (Scan) Status	Processing Stage Status (Roll-up)	Notes
Not Started	Not Started	Not Started	
In Progress	In Progress	In Progress	
Not Complete	Not Complete	Not Complete	
Complete	Complete	Complete	Currently not applicable
Not Started	In Progress	In Progress	
Not Started	Not Complete	Not Complete	
In Progress	Not Complete	In Progress	
Not Started	Complete	Not Complete	Currently not applicable
In Progress	Complete	In Progress	Currently not applicable
Not Complete	Complete	Not Complete	Currently not applicable

Note that a Complete (green) status will not currently be seen in interactive processing stages because the capability to mark an interval as Complete has not yet been implemented (see

Section 6). Thus, all roll-ups involving a Complete status in Table 1 are not currently applicable. In addition to interval color, hovering over an interval to bring up a tooltip will print out interval status as seen in Figure 12.

Finally, the Open Anything option (Figure 13) accessed at the upper-right of Figure 9 will allow the user to specify a time range to be viewed, an interactive processing stage from which to load data, and a station group that will be used to populate the Waveform display. If the Workflow display is too narrow, the Open Anything option is placed in the same dropdown menu as the pan arrow buttons and will appear as a magnifying glass.



**Figure 13. The Open Anything Menu (Left) and Submenu (Right).**

The Open Anything option can only be applied to interactive processing stages (AL1, AL2) and the time range specified must be within the configured operational time period. To modify the time range, select Edit in the Open Anything menu (Figure 13, left). This action will bring up the calendar in Figure 13, right. In the calendar, dates outside the operational time period are grayed out and unavailable for selection. The length of the operational time period is determined by subtracting the duration of the operational time period from the endtime, which is defined as the current time rounded down to the nearest hour. For example, in Figure 13 (right) the operational time period is set to 48 hours. Since the current time occurs on September 21, 2021, the operational time period in Open Anything starts 48 hours earlier on September 19, 2021. Note that if a longer operational time period is configured, e.g., 45 days, the Open Anything menu will show two calendars representing the two months the operational time period spans.

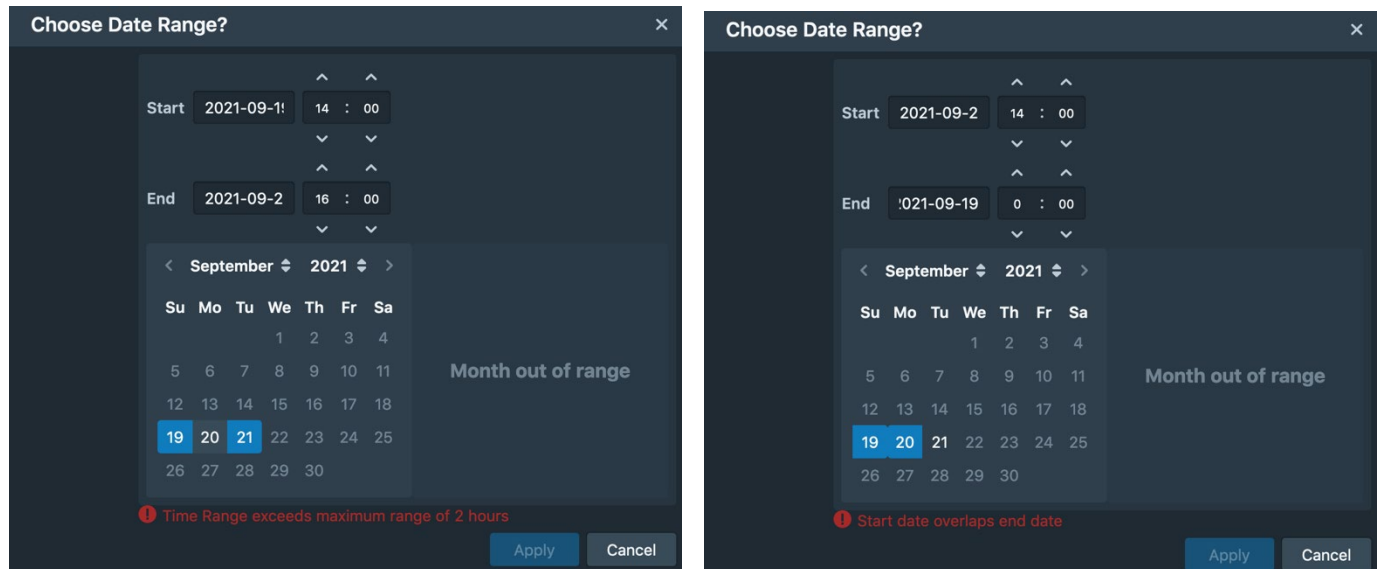
To set the time range of data to view within the operational time period, the user can either input a start and end time in the Start and End dialog boxes or select whole days by clicking a start and end date on the calendar. The Start and End dialog boxes and calendar are synced such that manual entries in the Start and End dialog boxes will cause the corresponding dates to be highlighted in blue on the calendar, with dates between the start and end dates shown in

light gray. Alternatively, selecting a start and end date with the calendar will fill the Start and End options with the corresponding start/end dates and times selected. In either case, note that a warning will be displayed and the Open button will be grayed out if the start date is set later than the end date (see Figure 14, Left).

When entering times into the Start and End options, click the Start and/or End date and type in the desired date in **YYYY-MM-DD** format. If a different format is entered, e.g., 2021:09:12 or 09-12-2021, the date will automatically be converted to the default format. If an invalid date is entered, the date will revert to the last valid date entered. Also, if the end date is set to a time prior to the start date, a warning will be displayed and the Open button will be grayed out until a valid date is entered (see Figure 14, right). The hour and minute can be set by either clicking on the hour and/or minute box and manually entering in a value or using the up and down arrows to increase or decrease the hour/minute, respectively. If an incorrect value is manually entered into the hour/minute box, the box will be highlighted in red. The user must either enter in a new value or click anywhere to have the value revert back to the last valid value entered.

When using the calendar, the user clicks on a desired start date first. This action will cause the date to be highlighted in blue. The user then clicks on another date to set the end time, which is also highlighted in blue. Any dates between the start and end dates are shown in light gray. Note that the same day can be selected as the start and end date by clicking on it twice. To select a new time range, the user can click on another desired start date and repeat the same actions as above.

By default, the time range of available data in Open Anything will be set equal to the operational time period. However, the time range can be configured to be shorter than the operational time period (see Configuration documentation). For instance, in Figure 13, the operational time period is set to 48 hours but the maximum time range of available data is 2 hours. Thus, a warning is displayed and the Open button is grayed out until a time range less than or equal to the maximum time range allowed is selected (Figure 14, left).



**Figure 14. Open Anything Menu With Time Range Warning.**

Note that currently, the time range in Open Anything will not match the interval time axis shown in the Workflow display, which displays a date from 2019 (Figure 9). This incongruity is a result of having to test the Open Anything menu, which is designed to operate based on the current time, with our currently available data from 2019. In future releases, the Workflow time axis and Open Anything menu will both show current time. Note that if the IAN UI is left open for a prolonged period of time, the endtime in Open Anything may not update to the current hour (Section 6), resulting in the Open Anything time range duration exceeding the maximum allowed operational time period duration. In this case, the user should refresh the UI to reset the Open Anything time range.

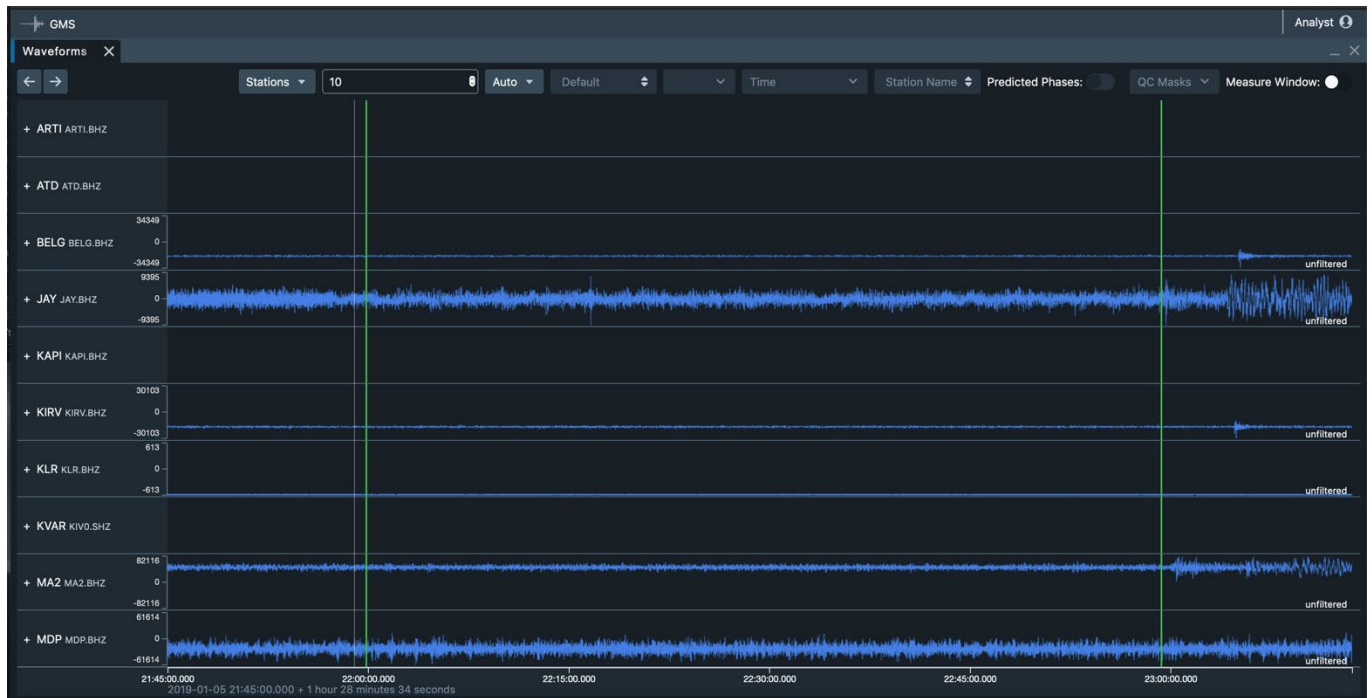
When the desired time range is selected, the user will be returned to the initial Open Anything menu (Figure 13, left). From that menu, two dropdown menus are provided to allow the user to select which interactive processing stage (AL1 or AL2) and configured station group to view in the UI. By default, the station group option will be set to the station group configured for the first activity in the processing stage. For instance, in Figure 13 the AL1 processing stage is selected and thus the station group is set to Primary, the group configured for the first activity under AL1. If the AL2 processing stage was selected instead, the station group would automatically change to the group configured for its first activity (AuxDel in this case). To view station groups other than the default group in a processing stage, the user can select any configured station group from the Station Group dropdown menu (Figure 13). For instance, the user can view data from the AuxDel station group rather than the Primary station group under the AL1 processing stage.

Once the user selects a valid time range, processing stage, and station group to view, they can click open and the waveforms corresponding to the input information will be loaded in the Waveform display (see Section 5.3) for analysis. At the same time, the station icons in the IAN Map display corresponding to the waveforms loaded into the Waveform display will be colored orange (see Section 5.4). Finally, the Open Time Range and Processing Stage categories at the top of the Workflow display (Figure 9) will update to show the time range and processing stage opened with the Open Anything menu.

Open Anything is intended for viewing purposes only. Thus, when the Open Anything option is applied, the intervals in the Workflow display corresponding to the Open Anything time range are not opened for analyst interaction and will not be marked In Progress. Note that if a processing interval is opened and the user then uses Open Anything without closing the open interval beforehand, they will be prompted to discard their changes (Figure 11). If the user discards their changes, the opened interval will be marked as Not Complete.

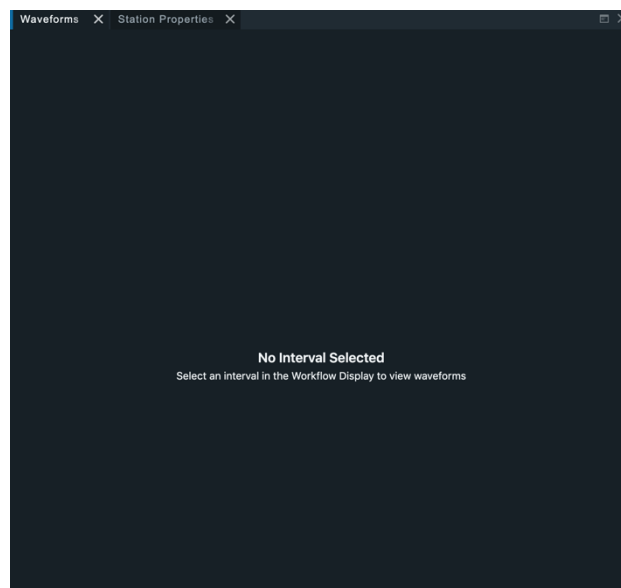
### **5.3. Waveform Display**

The Waveform display (Figure 15) provides a visual display of raw waveforms recorded at stations in a configured default station group during a specified time interval. Here a station can either represent a single station, where the station consists of only one physical site (i.e., physical installation), or an array, where the station consists of three or more physical sites. Stations can be seismic, infrasonic, or hydroacoustic.



**Figure 15. The Waveform Display.**

When initially opened, the Waveform display has no waveform data loaded. The user will be prompted to select an interval in the Workflow display (Section 5.2) as shown in Figure 16.

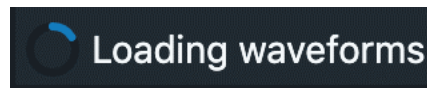


**Figure 16. Prompt to Select an Interval to Populate Waveform Display.**

When loading automatically begins, waveforms are loaded into the viewing panels in descending alphabetical order. Additional waveforms for channels not shown in the viewing

panels will not load automatically. To load and view these additional waveforms for a particular station, its viewing panel must be expanded; this action is described later in this section. Note that if a station's viewing panel is expanded before loading of the other main viewing panels is complete, the UI will prioritize populating the expanded viewing panel; upon completion, the UI will return to the default loading behavior.

During loading, a loading indicator (Figure 17) will appear at the bottom-left corner.



**Figure 17. The Waveform Loading Indicator.**

As waveforms are loaded into the display, the blue fill in the indicator to the left of "Loading waveforms" increases. The indicator disappears when all available requested waveforms for the specified time interval are loaded into the system. Note that the request for a waveform may fail during loading or the waveform data requested may not exist. In these cases, the viewing panel corresponding to that waveform will remain blank.

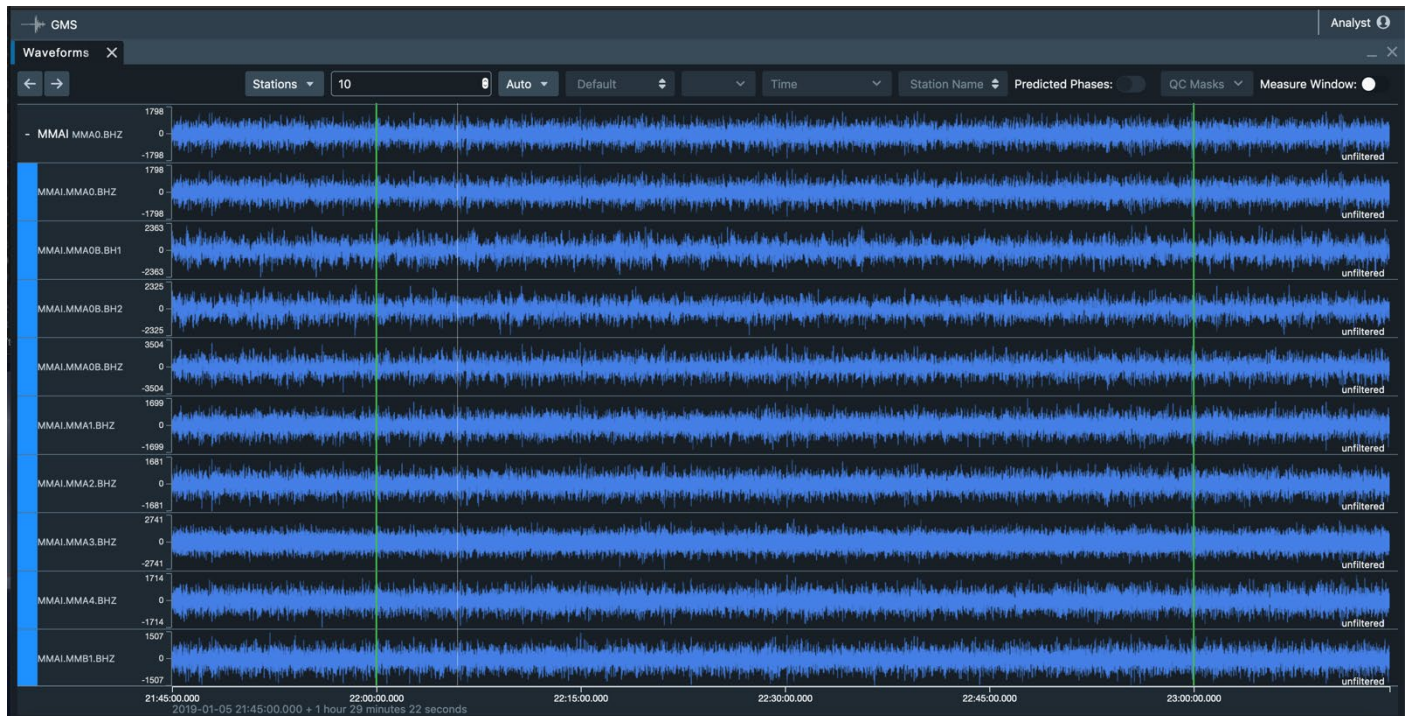
Once waveforms are loaded in, they appear in blue next to the name of their recording station. The waveform can be continuous during the specified time interval or a waveform segment associated with a signal detection or predicted phase arrival. By default, waveforms are in units of nanometers (nm) for seismic data, pascals (P) for infrasound data, and micropascals ( $\mu\text{P}$ ) for hydroacoustic data. These units reflect the multiplication of the original raw waveform counts by the calibration factor for a particular calibration period and are not configurable.

Currently, the waveform shown in the main viewing panel is recorded on the BHZ component for seismic stations, BDF component for infrasound stations, and the EDH component for hydroacoustic stations by default (Section 6). For seismic and infrasound stations, if the BHZ and BDF components are not available, waveforms from the SHZ and BDA components are shown instead. The specific site and channel used to record the waveform being displayed is shown to the right of the main station name, e.g., MMA0.BHZ for MMAI in Figure 18. Note that in future versions of the IAN UI, the beamforming capability will be enabled and a station's main viewing panel will instead show that station's beam – a single derived channel representing the sum of the raw channels seen in the expanded viewing panel described below.

To view waveforms recorded by other site/channel combinations for a particular station, the user can click the + symbol to the left of the station name and expand the viewing panel (see Figure 15). All available sites/channels will be listed in alphabetical order. Since only raw waveforms are currently shown in the Waveform display, the list of sites/channels in the expanded viewing panel will include an extra copy of the primary waveform seen in the main



viewing panel. For instance, in Figure 18 the primary waveform MMA0.BHZ is seen in the top row and again in row 2 as part of the list of sites/channels.



**Figure 18. Waveform Display for Station Array MMAI With Additional Site/Channel Combinations Shown.**

To hide the additional sites/channels again, the user can click the minus (dash) symbol that replaces the plus symbol to the left of the station name when the viewing panel is expanded (see Figure 18).

The default number of waveform viewing panels shown in the Waveform display depends on the interval opened in the Workflow display. For instance, the default number is 10 or 20 for an interval corresponding to an Event Review or Scan activity, respectively. This default number is configurable (see Configuration documentation). Panels are listed by station in alphabetical descending order. The user can scroll up or down to view the next set of waveforms in the list. To increase or reduce the number of waveforms for viewing within the Waveform display, the user can either manually enter in a number or press the arrows in the dialog box at the center-top portion of the display located between the Stations and Auto dropdown menus. When using the arrows, click the up arrow to add waveforms and the down arrow to remove waveforms. A minimum of one waveform can be viewed per screen.

The duration of the time interval being analyzed is indicated by vertical green lines, which define the start (left line) and end (right line) times of the open interval, respectively. By



default, the time interval indicated by the vertical green lines dictated by the configured time interval in the Workflow display with a 15 minute buffer of data on either side. The durations of the default time interval and the data buffer are configurable (see Configuration documentation). The total time being viewed in the display, including times outside the green lines, is shown at the bottom-left corner of Figure 15 as a date plus a time (e.g., 2019-01-05 22:45:00.000 + 1 hours 30 minutes).

The user can zoom into a specific time interval using the vertical white cursor extending from the top to the bottom of the waveform display (see Figure 15). To zoom, hold down the Ctrl key (Command on Mac) while clicking and dragging the cursor. A white window indicating the new time interval to zoom to will be shown (Figure 19).

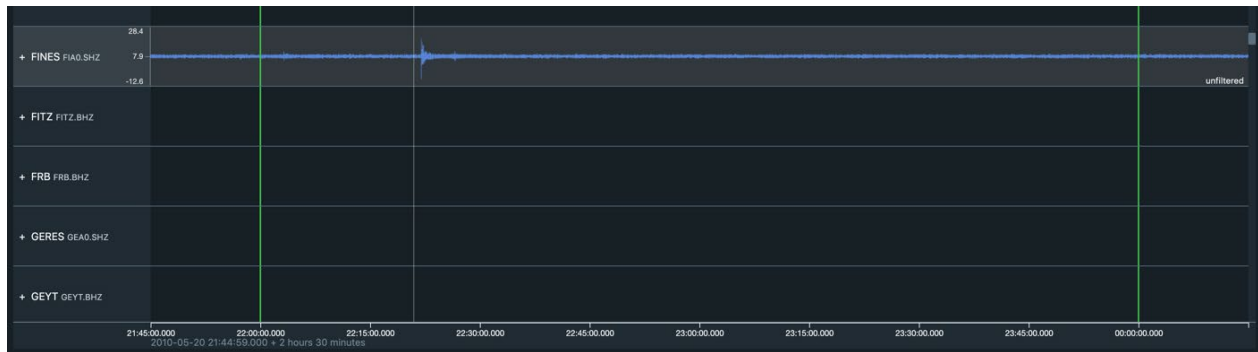


**Figure 19. Window Indicating Time Interval to Zoom Into.**

Once the desired window length is highlighted, release the Ctrl (Command) key. To zoom back out to the original window, double-click the left mouse button. Alternatively, zoom in and out by holding the Ctrl/Command key and scrolling up or down using the mouse wheel. Note that there is a limit to how far in a user can zoom. A pop-up message will be displayed in the lower-right corner of the Waveform display if the maximum zoom has been reached.

The user can also print a specific time above the cursor on the time series plot by clicking and holding the left mouse button only. By dragging the cursor across the screen while continuing to hold the left mouse button, the user can view different specific times in the series.

The Waveform display provides the ability to select a station's waveform, causing the waveform to be highlighted in white as shown in Figure 20 for station FINES. To select, the user clicks the desired station label. Note that clicking on the waveform itself will not result in selection.



**Figure 20. Waveform Display With Station FINES Selected.**

The selection feature is used to 1) synchronize station selections across displays to easily view the same data across multiple displays, 2) to populate the Station Properties display (see Section 5.5), 3) reset manual amplitude scaling, and 4) eventually, to perform signal processing operations (e.g., filtering). The selection feature is synced across the Waveform and IAN Map displays such that all stations selected in the Waveform display will be highlighted in the IAN Map display (see Section 5.4 for details). Additional site(s)/channel(s) for a station can be selected in the Waveform display by clicking the + symbol to the left of a station name, expanding the list of sites/channels, and clicking on the desired site(s)/channel(s).

In the Waveform display, multiple waveforms can be selected by holding Ctrl (Command on Mac) while clicking on the desired station labels. To select a sequence of stations, hold Shift and click on the first and last desired stations in the range. All stations in between the first and last stations will also be highlighted. Multiple sites/channels can also be selected by expanding one or more stations for viewing and performing the same actions as above. Finally, a station and all of its sites/channels can be selected by holding Alt (Option on Mac) and clicking on the station. To remove one or more selections, the user can hold Ctrl while clicking on the selected station or site/channel label. If multiple stations or sites/channels are selected and the user clicks on another station or site/channel label, that station or site/channel will be selected and all other selections will be removed. Note that the Station Properties display will not populate if multiple stations are selected or if a site/channel is selected (see Section 5.5).

### 5.3.1. Waveform Display Menus and Options

Several menus and buttons are shown at the top of the Waveform display (see Figure 15). Note that options with an asterisk are currently disabled. From left-to-right, these are:

- Pan waveforms – arrows used to pan the Waveform display to the left or right
- Stations – a dropdown menu used to select which stations to show
- A dialog box used to increase or decrease the number of waveforms displayed per screen

- A dropdown menu used to control waveform amplitude scaling
- A dropdown menu used to set the display mode\*
- A dropdown menu used to set the default phase of new signal detections\*
- A dropdown menu to align waveforms either by time or by phase\*
- A dropdown menu to change the default alphabetical ascending order of the station list\*
- A predicted phases radial button used to show or hide predicted phases\*
- A Quality Control (QC) masks dropdown menu used to show/hide categories of QC masks\*
- A button used to hide or show the Measure Window – the Measure Window allows the user to view a zoomed-in selected waveform at top of the Waveform display while simultaneously viewing multiple waveforms, including the selected waveform, at the bottom of the Waveform display.

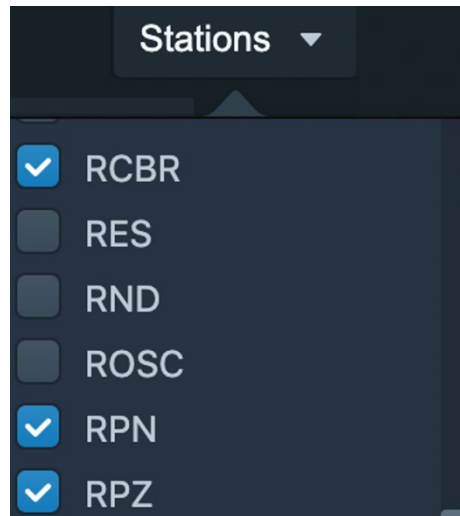
Note that depending on the width of the display, one or more of these menu options may be placed under a dropdown menu indicated by three vertical dots.

Currently, only the pan waveforms arrows, Stations dropdown menu, per screen dialog box, amplitude scale dropdown menu, and Measure Window button are functional. The remaining menus and buttons functionality is currently disabled (see Section 6). They will be made functional in future updates.

The per screen dialog box was described earlier in this section. Thus, we will begin by describing the behavior of the pan waveforms arrows. When the user clicks on either the left or right panning arrow, all waveforms in the Waveform display will be panned to the left or right, respectively. If the user pans beyond the boundaries of the time interval being analyzed (indicated by the vertical green lines), the system will automatically request and load data available from either before or after the time interval. As data loads, the waveform loading indicator will appear in the bottom-left corner of the Waveform display until data loading is complete (see Figure 17). As an alternative to the pan waveforms arrows, the user can also hold down the Ctrl button (Command on Mac) and press the left or right arrow to pan left or right, respectively.

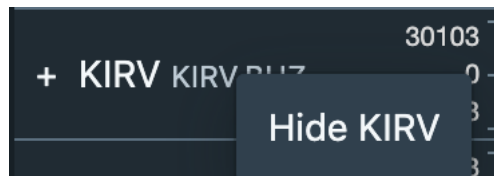
The Stations menu allows the user to view stations outside of the configured station group for the open interval and also remove stations from the Waveform Display. By default, all stations in an interval's configured station group are shown. Checked stations are shown on the Waveform display, unchecked stations are hidden. Users can add a station to the Waveform display by clicking on the box next to the station name which will automatically retrieve the waveform data for display. The icon color of an added station will update from white to orange

in the IAN Map display (see Section 5.4). To remove stations from the Waveform display, the user unchecks each undesired station as shown in Figure 21 where stations RES, RND, and ROSC have been removed. The icon color of a removed station will update from orange to white in the IAN Map display (see Section 5.4). Stations are added or removed in descending alphabetical order.



**Figure 21. Stations Dropdown Menu.**

Alternatively, stations can be removed by right-clicking the station name within the station label and selecting the option to hide that station as shown in Figure 22.

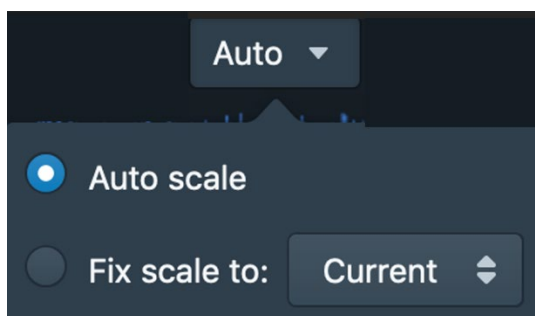


**Figure 22. Example of Option to Hide a Single Waveform.**

Note that in the Waveform display the Stations dropdown menu (Figure 21) must be used to add a station back to the display. Alternatively, a station can be added using the IAN Map display by right-clicking the station's icon and selecting Show STATION on Waveform Display (see Section 5.4 for details). Changes to station visibility are maintained until the analyst workspace is closed or a new time range is opened.

To quickly find a particular station in the Stations dropdown menu, the user can enter in the first few letters of the station name into Search input to filter the station list. Once the user has finished adding or removing stations, clicking on the Stations button once again or anywhere else on the display will remove the dropdown menu.

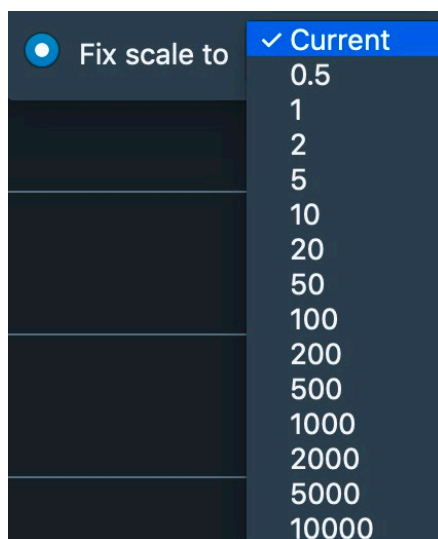
The scale dropdown menu provides two options for waveform amplitude scaling as shown in Figure 23.



**Figure 23. Auto Scale Dropdown Menu.**

The default option, 'Auto scale', causes the amplitude of each waveform to be automatically scaled such that the minimum and maximum y-axis values are equal to the absolute maximum value of the waveform amplitude currently on screen. For instance, if the waveform station YAK has a maximum amplitude of 52027, the y-axis will range from -52027 to 52027, centered around zero. This scale will be adjusted as the user pans and/or zooms. If the maximum amplitude of the YAK waveform on screen is now 21475 after panning, the y-axis will now range from -21475 to 21475. A small buffer is provided above and below the maximum and minimum amplitudes to improve viewing. This buffer is not configurable.

If the 'Fix scale to' option is selected, the amplitude will remain fixed to one of the scale options shown in the dropdown menu in Figure 24.

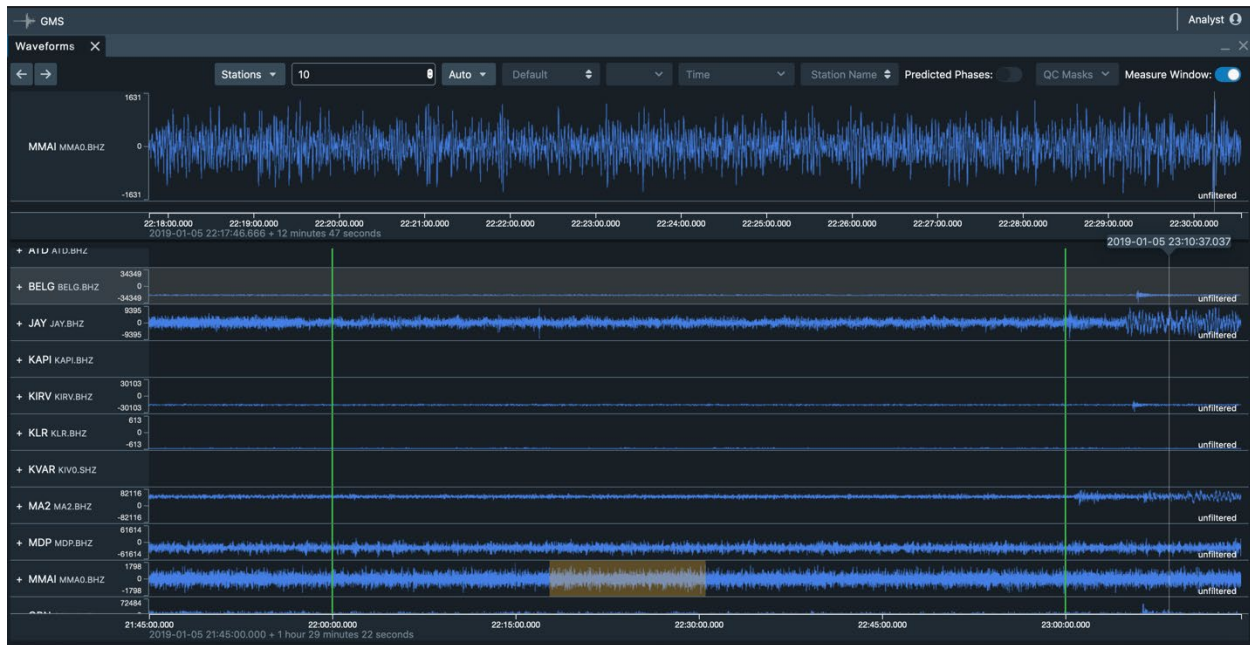


**Figure 24. Fix Scale Y-Axis Range Options.**

If the user selects 'Current', the amplitude scale will be frozen to whatever scale was currently on screen during the time of selection. For example, if the Current option was selected when the maximum amplitude on screen was 30000, the amplitude will range from -30000 to 30000. Otherwise, the amplitude can manually be set to range to a desired scale, e.g., from -0.5 to 0.5 if the 0.5 option is selected. When the 'fix scale to' amplitude option is selected, the y-axis scale is not adjusted when the user pans or zooms. The available scale values are configurable and currently range from 0.5 to 10000 as shown in Figure 24.

The user can also manually scale a waveform by holding down the S key, then left-clicking and dragging while the cursor is over the waveform to be scaled. Drag down to reduce amplitude and drag up to increase amplitude. Manual rescaling will override any previously applied scaling option. Manual scaling can be applied to as many waveforms as desired by performing the above actions on each waveform. When the user pans, zooms, or selects a different option from the amplitude scale dropdown menu, the manual scale will revert back to the option selected in the amplitude scale dropdown menu (Figure 23). A scaled waveform's amplitude can be reset to the previously applied scaling option by selecting the station and holding Alt + S (Option + S on Mac). Additionally, users can revert all manually scaled channels back to their previous amplitude scale by holding the Alt + Shift + S keys (Option + Shift + S on Mac) anywhere in the display.

Finally, the Measure Window button at the upper right of the Waveform display (Figure 15) provides the ability to simultaneously view a zoomed in, detailed view of a desired waveform while still viewing that waveform in the original Waveform display, as seen in Figure 25.



**Figure 25. Waveform Display with Measure Window Option On for Station MMAI.**

To view the Measure Window for a particular waveform, the user must hold Alt (Option on Mac) and left-click and drag over the portion of the waveform to be viewed. The waveform does not have to be formally selected and highlighted (see Section 5.3). For instance, in Figure 25 station BELG is selected but the Measure Window was placed on station MMAI's waveform. Note that only one waveform may have a Measure Window at a time. These actions can also be applied to waveforms recorded by other sites/channels for a station when its viewing panel is expanded (see Section 5.3, Figure 10).

The selected area will be highlighted in gold as shown for station MMAI in Figure 25. Once the interval for the Measure Window is selected, its position will not be affected by panning, zooming, or scaling. The user can move the Measure Window by left-clicking the window then holding and dragging the window left or right to the desired position. The selected waveform segment can now be viewed in detail in the top window and the Measure Window button will be in the on-position (Figure 25). The y-axis range in the Measure Window will be calculated for the selected window. The Measure Window acts as its own waveform panel in the Waveform Display, such that scaling options and zooming (described in Section 5.3, see Figure 19) update the waveform the same as they would for regular panels within the Waveform Display. Panning and zooming in the Waveform Display will not update the Measure Window scale.

To stop showing the Measure Window for a station, the user must 1) create another window using the same actions described above, either on the same waveform or a different waveform, or 2) click the Measure Window button so that it is in the off position (circle to the left, not

highlighted in blue). In the first case, the Measure Window is populated with the newly selected waveform segment. In the second case, the Measure Window is removed and the display returns to the same view as seen in the default display (Figure 15).

Finally, while the user can turn on the Measure Window without selecting any waveform segment for viewing via the radial button, they will be prompted to select a waveform segment (Figure 26).

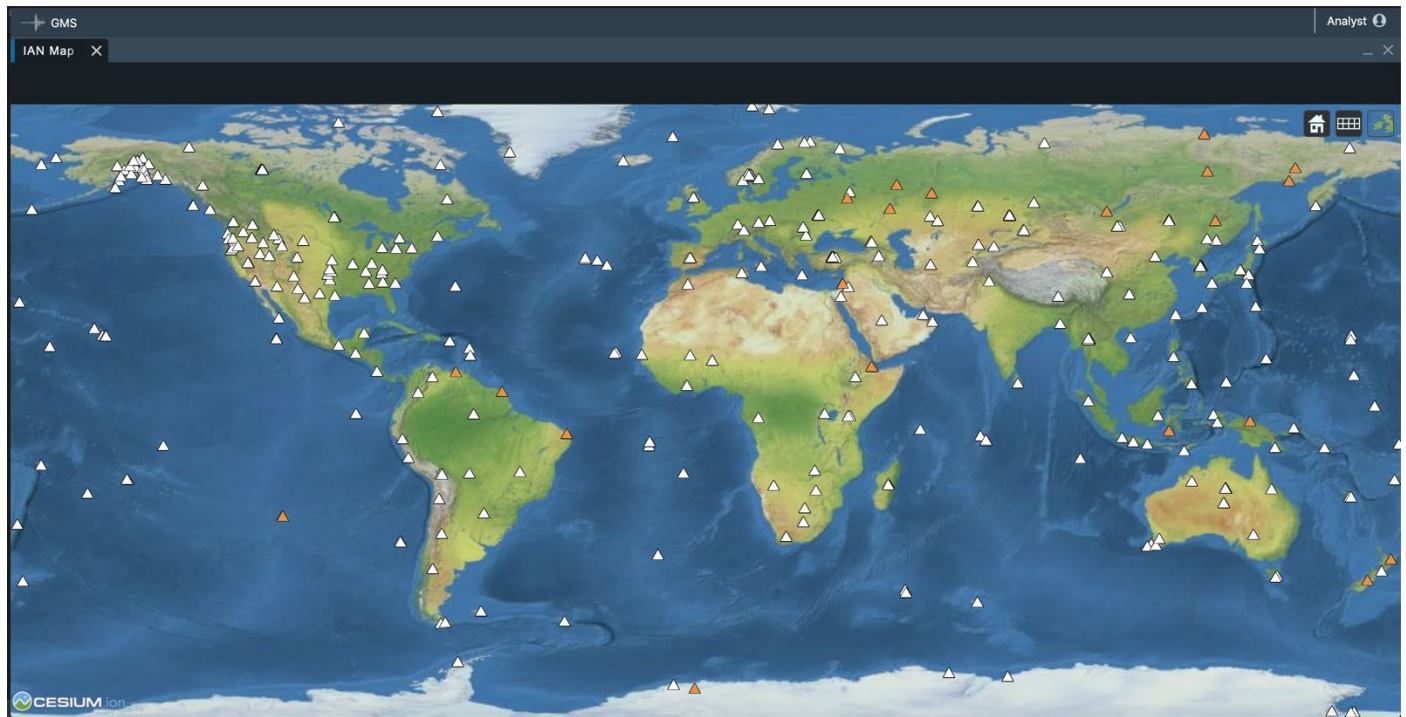


**Figure 26. Measure Window with no Waveform Data Selected.**

## 5.4. IAN Map Display

The IAN Map display (Figure 27) provides a map showing the locations of all stations in the configured station groups available to GMS. Each station is represented as a triangle icon. All available configured stations within the configured set of station groups in GMS are displayed on the map at all times. Once an interval is selected in the Workflow display (Section 5.2), station definitions are updated to reflect the time range of the open interval and all stations currently loaded in the Waveform display will be shown in orange, see Figure 27. Note that the orange icon color is unrelated to the orange color indicating a Not Complete status in the Workflow display (Section 5.2). Stations not currently shown in the Waveform display are shown in white (Figure 27).

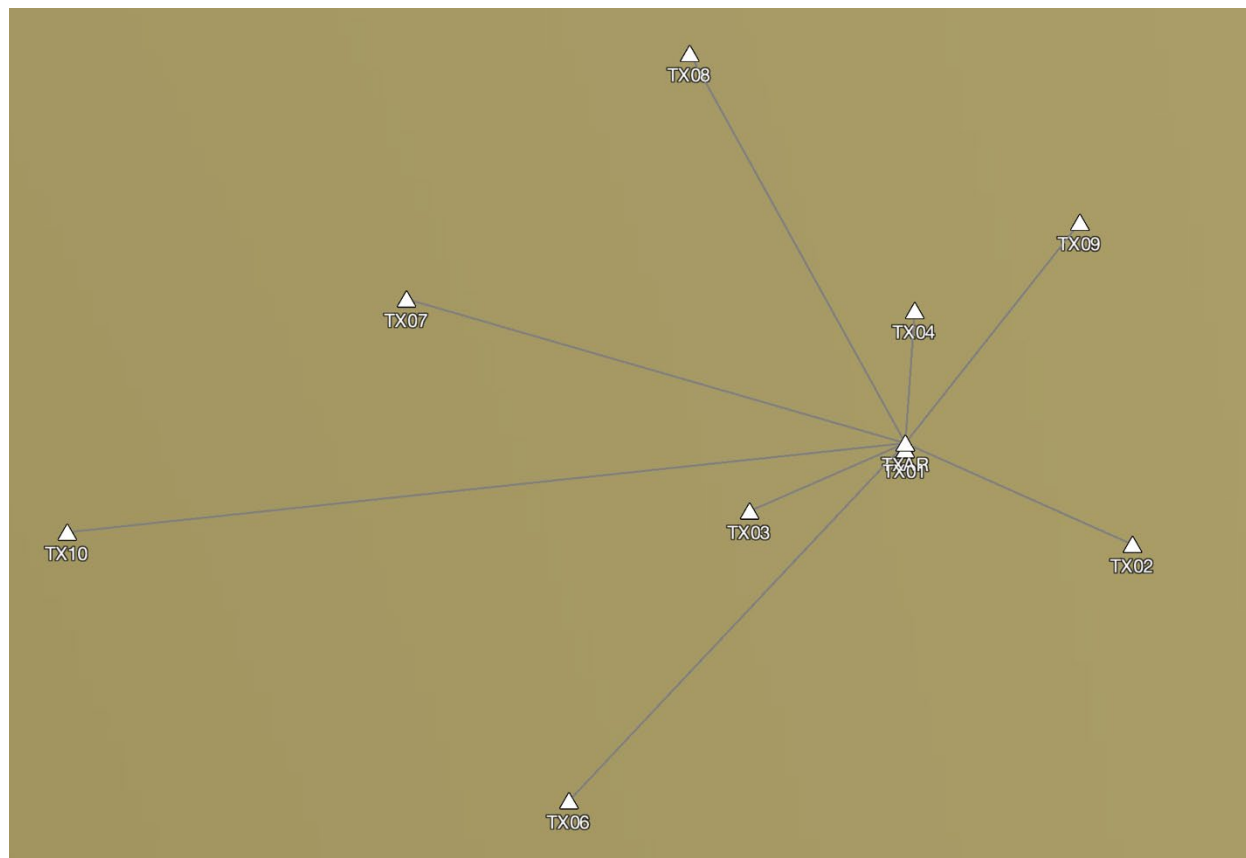




**Figure 27. The IAN Map Display.**

By default, stations are shown on a 2D projection. In this default projection, the user can click and drag to pan across the map. The user can also zoom in and out by 1) using the mouse scroll wheel (scroll up to zoom in and scroll down to zoom out) or 2) using a two-finger drag on a touch pad (drag towards yourself to zoom in, push away from yourself to zoom out). Also, the user can zoom in to a single station by double-clicking on that station. If zoomed in sufficiently, the station name will appear next to the corresponding station marker.

If a station is an array, i.e., it consists of multiple physical sites, users can zoom in on the station to view the individual sites that make up that station (e.g., TXAR in Figure 28). These sites are represented by white triangle icons. The site icons remain white if the station is part of the opened interval's configured station group; only the reference station icon will be orange. If zoomed in sufficiently, the site name will appear next to the corresponding site marker. Gray lines connecting the sites to the reference station are used to indicate that the sites are part of an array. The gray lines also allow users to visualize the array geometry. Note that the IAN Map display typically does not have sufficient resolution to resolve topographic features at this level of zoom.



**Figure 28. Map of TXAR Array Station Locations.**

Users can hover over a station and view tooltips to display basic station information. A station tooltip contains the name, latitude, longitude, elevation, and station type (single or array) for that station, while site tooltips contain the name, latitude, longitude, and elevation of that site. An example is shown in Figure 29 for the reference station TXAR.

```
Name:      TXAR
Lat:       29.334°
Lon:       -103.668°
Elevation: 0.991 km
Type:      Array
```

**Figure 29. Station Description Tooltip for Array TXAR.**

A station can be selected on the map by clicking its icon. When a station is selected, the triangle representing it will be made larger than the unselected stations, and its name will be shown and highlighted in blue. Figure 30 shows the station FINES selected. Only one station can be selected at a time on the map. To select multiple stations at once, the user must make the selections in the Waveform display (see Section 5.3).



**Figure 30. IAN Map Displays with Station FINES selected.**

Station selection is synchronized across the IAN Map, Waveform, and Station Properties displays. If the station selected in the IAN Map display is orange, i.e., the station belongs to the station group currently being shown in the Waveform display, that station will be selected in the Waveform display (see Section 5.3) and the Station Properties display will be populated with its information (see Section 5.5). If the selected station is in white, the Station Properties display will be populated with the station's information but the Waveform display will not show its waveform.

The user can add the selected station's waveform to the Waveform display by either using the Stations dropdown menu in the Waveform display (Figure 21) or right-clicking on the selected station and selecting the Show STATION on Waveform Display option as shown in Figure 31 for station FINES. When a station's waveform is added to the Waveform display, its icon will turn orange in the IAN Map display and a checkmark will appear in the Waveform display Stations dropdown menu (Figure 21). If the station's waveform is already being shown in the Waveform display, the user can perform the same actions described above to hide that station's waveform in the Waveform display (Figure 31). When a station's waveform is hidden on the Waveform display, its icon will turn white and the checkmark in the Stations dropdown menu (Figure 21) will be removed. Changes to station visibility are maintained until the analyst workspace is closed or a new time range is opened.



**Figure 31. Option to Show (left) or Hide (right) a Waveform on the Waveform Display via the IAN Map Display.**

Three buttons are provided in the upper right corner of the IAN Map display (Figure 27) as shown in Figure 32.



**Figure 32. Map Display Buttons.**

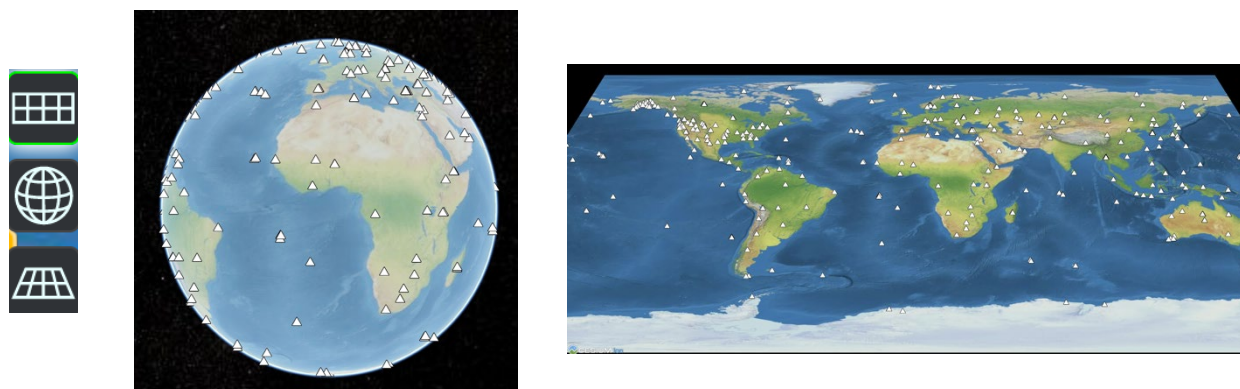
From left to right, the buttons are the View Home button, Projection button, and Imagery and Terrain button. Hovering over a button with the cursor will provide a tooltip briefly describing that button.

When the user clicks the View Home button, the map will automatically zoom out to the default map view. Note that if the map is already in the default view, clicking on the View Home button will result in no change.

When the user clicks the Projection button, a dropdown menu with alternative projections is provided (Figure 33, left). Hovering the cursor over each option in the dropdown menu will provide a tooltip briefly describing the projection. Currently, in addition to the default 2D projection, a 3D globe (Figure 33, center) and a tilted projection known as a Columbus projection (Figure 33, right) are provided. The Columbus projection will be removed in a future release.

In the 3D globe projection, click and drag to rotate the sphere; to zoom, perform the same actions described for the default 2D projection. Note that in this view, clicking the View Home button will cause the map to be automatically positioned over the Prime Meridian. In the Columbus projection, the actions to pan and zoom are identical to the 2D projection.





**Figure 33. Projection Dropdown Menu (Left), 3D Globe Projection (Center), Columbus Projection (Right).**

When a projection option is selected, the Projection button label changes to the current projection being viewed.

The Imagery and Terrain button provides a dropdown menu (Figure 34) allowing the user to select the appearance of the map and the ellipsoid to be used to define the terrain.



**Figure 34. Imagery and Terrain Dropdown Menu.**

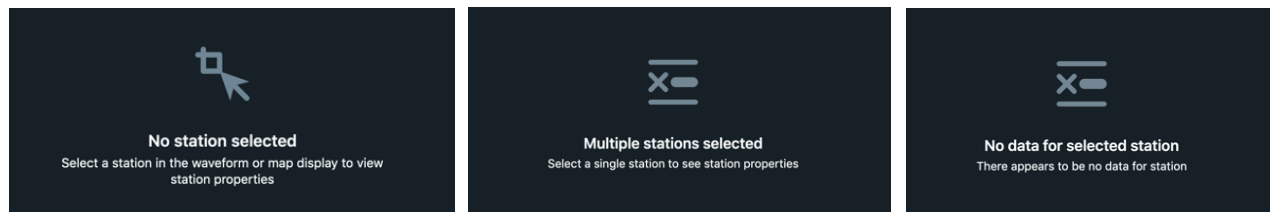
Currently, only default options are provided for imagery and terrain (see Section 6). These defaults are automatically applied to the map and cannot be changed or removed.

### 5.5. Station Properties Display

The Station Properties display allows users to view detailed metadata information about a selected station (channel group and channel configuration) in either the Map or Waveform Displays (see Sections 5.3, 5.4 for selection details) and will eventually provide information

about the station that is configured on GMS (e.g., beam definitions). It is also a helpful tool to validate that bridged information is correct.

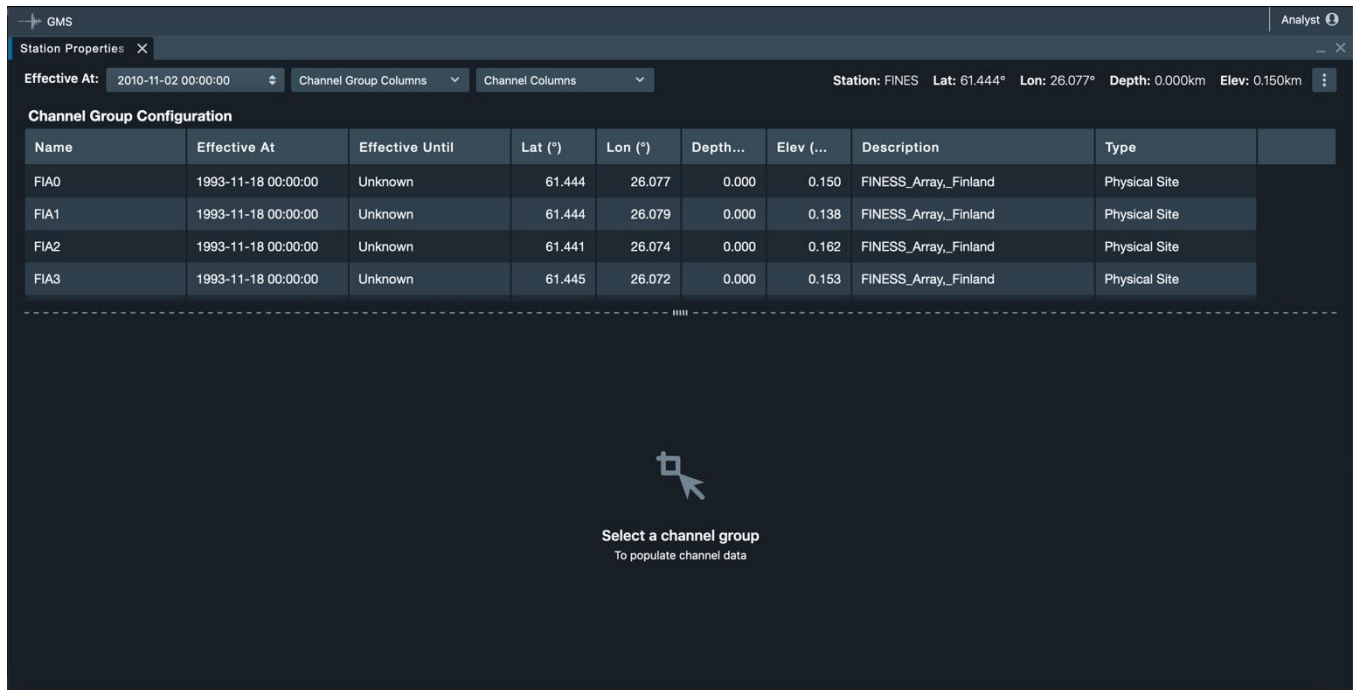
There are several cases where the Station Properties display will not be populated as shown in (Figure 35).



**Figure 35. The Station Properties Display With (Left) No Station Selected, (Center) Multiple Stations Selected, and (Right) No Data For Selected Station.**

First, a station must be selected in the Waveform display (Section 5.3) or IAN Map display (Section 5.4) to populate the Station Properties display. If no station is selected, the user will be prompted to choose a station (Figure 35, left). Only one station may be selected at a time. Note that choosing an additional site/channel from a station's expanded viewing panel, e.g., MMAI.MMA0B.BH1 in Figure 18, will not populate the Station Properties display. Second, if multiple stations are selected in the Waveform or IAN Maps displays, the user will be prompted to select just one station as shown in Figure 35, center. Finally, if no data are available for the selected station, the user will be warned as shown in in Figure 35, right. In this case the user should select a different station.

Once a station with data is selected, the Station Properties display will be populated with information for all channel group configurations, as shown in Figure 36.



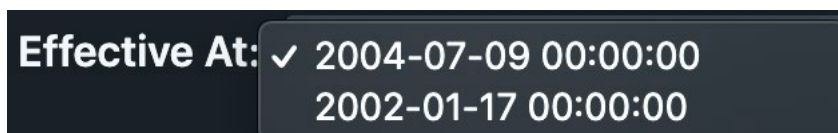
**Figure 36. Station Properties Display With Top Panel Populated.**

At the top of the display, the following information is shown from left-to-right:

- Effective At – a dropdown menu listing several dates on which to view the station’s particular configuration on that date
- Channel Group Columns – a dropdown menu used to select which columns in the Channel Group Configuration table to view
- Channel Columns – a dropdown menu used to select which columns in the Channel Configuration table to view
- Station – name of station being viewed
- Lat, Lon – latitude and longitude of station in degrees
- Depth – depth of station burial in km
- Elev – elevation of station in km
- Description – a comment describing the station
- Type – type of station being viewed; station type can be single or array

A tooltip providing a brief description of each dropdown menu and station information entry can be brought up by hovering the cursor over the desired menu or entry.

The Effective At dropdown menu is shown in Figure 37 below.

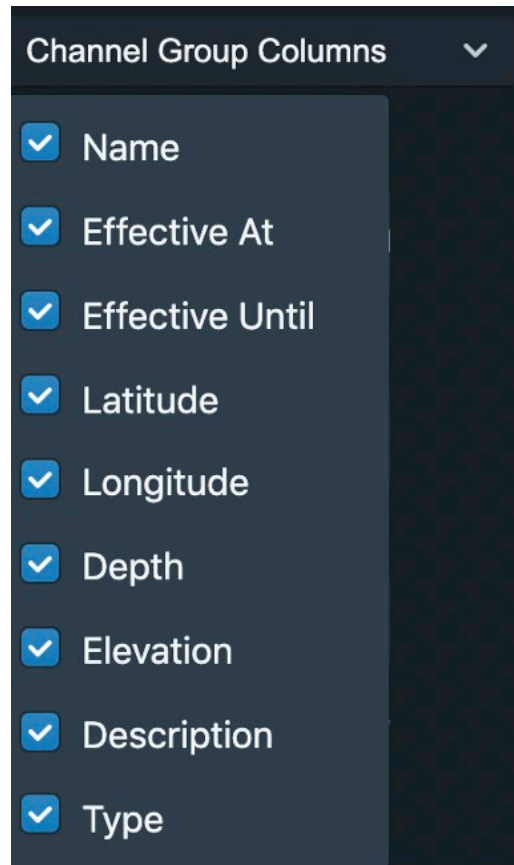


**Figure 37. Effective At Dropdown Menu.**

Each date in the dropdown menu represents an ordered collection of effective times where the selected station and/or any of its aggregated objects (i.e., channel groups, channels, responses) changed within the configured operational time range. By default, the corresponding metadata with the latest effective time is displayed. Different dates will update the metadata shown in the Channel Group and Channel Configuration tables to the configuration that was effective at the corresponding time. By default, the channel group effective at the given time is populated in the Channel Group Configuration table.

The Channel Group Columns dropdown menu (Figure 38) allows the user to select which columns to view in the Channel Group Configuration panel. By default, all columns will be checked for viewing. The user can uncheck any undesired columns to customize the table. The order in which the columns are listed is the order in which they appear in the Channel Group Configuration panel.





**Figure 38. Channel Group Columns Dropdown Menu.**

Finally, the Channel Columns dropdown menu is the same as the Channel Group Columns dropdown menu, but for columns in the Channel Configuration panel. It will be described later in this section.

Directly beneath the station information described above, the Channel Group Configuration panel is populated with every active channel group during the respective effective time. From left-to-right, the following information is shown:

- Name – name of the channel group configuration
- Effective At – the beginning date at which the channel group configuration was active
- Effective Until – the end date after which the channel group configuration was active; will be Unknown if the channel group configuration is currently active
- Lat, Lon – latitude and longitude of the site corresponding to the channel group configuration in degrees
- Depth – depth of burial in km for the site corresponding to the channel group configuration

- Elev – elevation of station in km for the site corresponding to the channel group configuration
- Description – a comment describing the channel group configuration
- Type – type of channel group configuration

Note that the channel group configuration type listed in the type column can be either 1) a Processing Group or 2) a Physical Site. A processing group is a collection of raw channels used together to perform some kind of desired automatic or interactive data processing (e.g. beaming) while a physical site is a collection of raw channels corresponding to sites with physical locations. In the case of physical sites, the number of channel group configurations will depend on the station type, with a single station having just one channel group configuration and an array having multiple channel group configurations, one for each physical site that makes up the array. If a channel group configuration type is a physical site, the channel group configuration will have the same name as the physical site.

To view information on every channel in a particular channel group configuration, the user can click the channel group of interest, which will highlight the selected row in blue (see Figure 39). This action will populate the Channel Configuration panel as shown in Figure 39. The Channel Configuration panel is populated with the channels that were effective for that channel group during the given effective time.

The screenshot shows the GMS Station Properties window. The top panel, 'Channel Group Configuration', displays a table with columns: Name, Effective At, Effective Until, Lat (°), Lon (°), Depth..., Elev (...), Description, and Type. The bottom panel, 'Channel Configuration', displays a table with columns: Name, Effective At, Effective Until, Lat (°), Lon (°), Depth..., Elev (...), Samp..., Units, Horiz ..., Vert A..., and Calib Factor (s).

Name	Effective At	Effective Until	Lat (°)	Lon (°)	Depth...	Elev (...)	Description	Type
FIA0	1993-11-18 00:00:00	Unknown	61.444	26.077	0.000	0.150	FINES_Array_Finland	Physical Site
FIA1	1993-11-18 00:00:00	Unknown	61.444	26.079	0.000	0.138	FINES_Array_Finland	Physical Site
FIA2	1993-11-18 00:00:00	Unknown	61.441	26.074	0.000	0.162	FINES_Array_Finland	Physical Site
FIA3	1993-11-18 00:00:00	Unknown	61.445	26.072	0.000	0.153	FINES_Array_Finland	Physical Site

Name	Effective At	Effective Until	Lat (°)	Lon (°)	Depth...	Elev (...)	Samp...	Units	Horiz ...	Vert A...	Calib Factor (s)
FINES.FIA0.SHE	2007-09-25 00:00:00	Unknown	61.444	26.077	0.000	0.150	40	Nanome...	90	90	Unknown
FINES.FIA0.SHN	2007-09-25 00:00:00	Unknown	61.444	26.077	0.000	0.150	40	Nanome...	0	90	Unknown
FINES.FIA0.SHZ	2007-09-25 00:00:00	Unknown	61.444	26.077	0.000	0.150	40	Nanome...	-1	0	Unknown

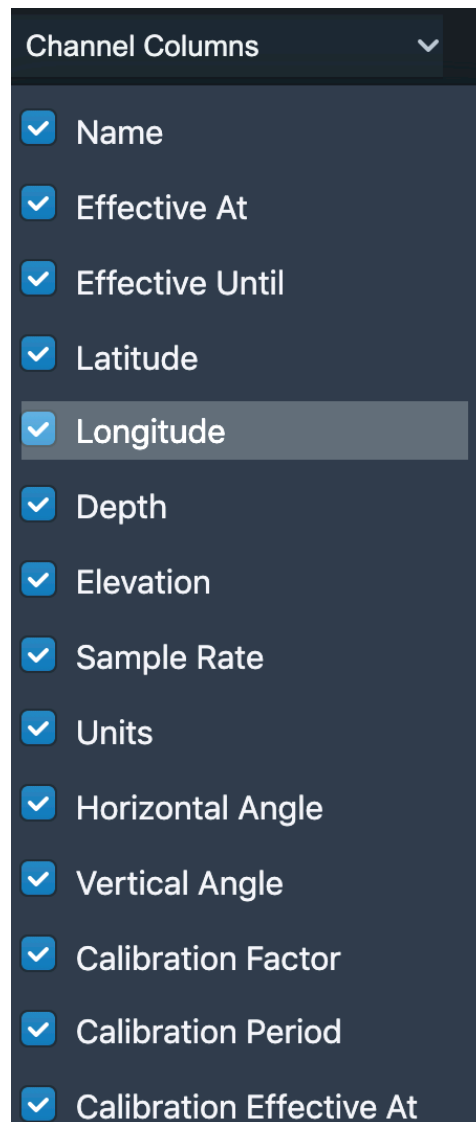
Figure 39. Station Properties Display With Top and Bottom Panel Populated.

When populated, the channel configuration columns from left-to-right are:

- Effective At – the beginning date when the channel had the particular configuration being viewed
- Effective Until – the enddate when the channel configuration was no longer effective, either because it was no longer needed or it was superseded by a new configuration. If the configuration is still currently available, Effective Until will be listed as Unknown
- Lat, Lon – latitude and longitude of the channel in degrees
- Depth – depth of burial for that channel in km
- Elev – elevation of the channel in km
- Sample Rate – nominal sample rate in Hz
- Units – the units reported by the specific channel
- Horiz Angle – channel orientation horizontal angle in degrees; the horizontal orientation of the instrument in the horizontal plane measured clockwise from North
- Vert Angle – channel orientation vertical angle in degrees; measures the angle between the sensitive axis of the instrument and the outward pointing vertical direction
- Calib Factor – a calibration factor (in sec) used to multiply the original raw waveforms recorded by the station to convert them to physical units. This factor converts a waveform from unitless counts to units of nanometers (nm) for seismic data, pascals (P) for infrasound data, and micropascals ( $\mu\text{P}$ ) for hydroacoustic data to the waveforms. These units are not configurable.
- Calib Period – the period in seconds at which the calibration factor is valid
- Calib Effective At – the starttime from which the reported calibration factor became the effective version
- Calib Time Shift – calibration time shift in seconds, used as a correction factor for clock errors at the channel
- Calib Std Dev – standard deviation of the calibration factor
- North/East/Vert Displacement – north/east/vertical displacement or position of the channel relative to the reference station
- Description – a comment describing the channel
- Data Type – channel data type, currently can be seismic, hydroacoustic, or infrasound

- **Band Type** – channel band type, corresponds to the first character in a channel name (e.g. B for broadband). Specifies the general sample rate and response band of the instrument. A list of potential band types is given in Appendix B
- **Instrument Type** – channel instrument type, corresponds to the second character in a channel name (e.g., H for high gain seismometer). Specifies the instrument type to which the sensor belongs to. A list of available instrument types can be found in Appendix B
- **Orientation Code** – channel orientation code, corresponds to the last character in a channel name (e.g., Z for vertical). Indicates the directionality of the sensor measurement. Note that for instruments other than seismometers, orientation code is used for instrument-specific purposes other than direction. A list of available orientation codes and their usage can be found in Appendix B
- **Orientation Type** – channel orientation type, description of specific sensor corresponding to the orientation code. For instance, when band type is E (extremely short period), instrument type is D (pressure), and orientation code is H (Hydrophone), Orientation Type will be listed as Hydrophone. Table B3 in Appendix B can be used to determine what Orientation Type will be for a given channel
- **Calib ID** – calibration response ID
- **FAP Resp ID** – frequency amplitude response ID

By default, all of the above columns except Data Type, Band Type, Instrument Type, Orientation Code, and Orientation Type will be shown. To add or remove columns from viewing, the user can check/uncheck any column using the Channel Columns dropdown menu in Figure 40 to customize the Channel Columns panel. The order in which the columns are listed is the order in which they appear in the panel.



**Figure 40. Channel Columns Dropdown Menu.**

Due to the number of columns in the Channel Configuration panel, the user will have to scroll down to add or remove some columns. Note that the Channel Columns are configurable (see Configuration documentation).

When the default number of columns is shown, the user will typically not be able view all columns at once. Instead, the user must scroll the panel towards the right or left using the scroll bar at the bottom of the panel.

### 5.5.1. Station Properties Display Workspace Layout

The fully populated Station Properties display shown in Figure 39 represents its default layout. In addition to the layout options described in Section 4, the Channel Group Configuration and Channel Configuration panels in Figure 39 can be further modified in six ways:

- 1) The columns' position can be rearranged by clicking anywhere in the column title cell and dragging the column to the desired position.
- 2) Column width can be modified by hovering over a column title edge until a double-arrow symbol appears. Then the user can click and drag the column edge to the desired width.
- 3) Columns can be sorted alphanumerically, ascending or descending, by clicking to the right of each column title. This action will bring up an arrow symbol (Figure 41) to the right of the column title that indicates whether the column is ascending or descending.



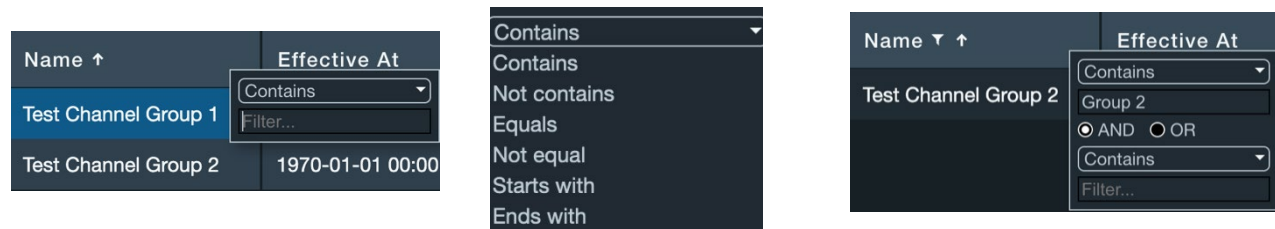
**Figure 41. Sorting Arrow and Bar Symbol Used to Pull Up a Filter Menu for All Station Properties Display Columns.**

The arrow symbol will only be visible in the column being sorted. By default, columns are sorted ascending (arrow points up). To change to descending, click once anywhere in the column title, except on the bar menu button (far right of Figure 41) which is used to open the filter menu (bullet 5).

- 4) Columns can be added or removed using the Channel Group Columns and/or Channel Columns dropdown menus (see Section 5.5).
- 5) Rows can be filtered to show one or more desired values by hovering to the far right of a desired column title to bring up a bar menu button (Figure 41, far right).

When this button is clicked, it will bring up a filter menu (Figure 42, center). When a value is entered into the filter field, the menu expands giving the option to apply another AND/OR filter (Figure 42, right) with its own filtering options (Figure 42, center). This option can be used once. Once the values are entered, click anywhere in the display to hide the filter. A funnel shaped symbol will appear to the right of the column title, indicating a filter is in place. To remove the applied filter, bring up the filter menu once more and delete the entered value(s).

- 6) The size of the Channel Group and Channel Configuration panels can be adjusted by clicking and dragging the horizontal dotted line between the panels up or down.



**Figure 42. Filter Application (Left), Available Filter Options (Center), Menu Expansion for Applying Another AND/OR Filter (Right).**

## 6. CURRENT LIMITATIONS

Intervals cannot be marked as Complete (see Section 5.2).

The Scan activity must be opened directly by right-clicking one of its intervals in the Workflow display. If the user first opens the processing stage, e.g., AL1, the UI will be populated with data from the Event Review activity and Event Review data will remain in the UI even when the Event Review interval is closed by the user. At the same time, the Workflow display will show the processing stage and Scan interval as In Progress and the Event Review interval as Not Complete (see Section 5.2).

Only 2 hours of data are available in the Workflow display (see Section 5.2).

The time range in the Open Anything menu will not match the interval time axis shown in the Workflow display, which displays a date from 2019. This incongruity is a result of having to test the Open Anything menu, which is designed to operate based on the current time, with our currently available data from 2019 (see Section 5.2).

If the IAN UI is left open for a prolonged period of time, the endtime in Open Anything may not update to the current hour, resulting in a time range duration exceeding the maximum allowed operational time range. In this case, the user should refresh the UI to reset the Open Anything time range (see Section 5.2).

Currently, the waveform shown in a station's main viewing panel in the Waveform display is recorded on the BHZ component for seismic stations, BDF component for infrasound stations, and the EDH component for hydroacoustic stations by default. For seismic and infrasound stations, if the BHZ and BDF components are not available, waveforms from the SHZ and BDA components are shown instead. In future releases the beamforming capability will be enabled and the IAN UI will show a station's beam in the main viewing panel (see Section 5.3).

With the exception of the per screen option, panning arrows, Stations dropdown menu, scale dropdown menu, and measure window option, all menu options shown at the top of the Waveform display are disabled and are shown in gray (see Section 5.3 and Figure 15).

In the IAN Map display (Section 5.4), only the default imagery and terrain options (Natural Earth and WGS84, respectively) can be used.



## Appendix A. Automatic Processing Sequences

The steps performed in the current Auto Network and Auto-Post AL1 stage processing sequences are shown in Table A1. These steps can be configured (see Configuration documentation).

**Table A1. List of Processing Steps in Automatic Processing Sequences under Auto Network and Auto-Post AL1 Stages.**

Auto Network Sequence	Auto-Post AL1 Sequence
Partial Processing (covers all station processing)	Origin Beam SP
Association	Origin Beam LP
Conflict Resolution	Recall
Origin Beam SP	Arrival Beam SP
Arrival Beam SP	Detection LP
	Recall LP
	Magnitude
	Hydro EDP
	HAE

## Appendix B. Band, Instrument, and Orientation Codes

The following tables provide a list of band codes, instrument codes, and orientation codes that may be available in GMS. These codes were originally listed in the [SEED manual](#). Channel names will consist of band code + instrument code + orientation code, e.g., B(roadband) + H(igh gain seismometer) + Z(vertical component) or BHZ. Note that not all bands, instruments, and orientations listed below are available at this time.

**Table B1. List of band codes, their band type, range of sample rates in Hz, and corner period in seconds.**

Band Code	Band Type	Sample Rate (Hz)	Corner Period (sec)
F	...	$\geq 1000$ to $< 5000$	$\geq 10$ sec
G	...	$\geq 1000$ to $< 5000$	$< 10$ sec
D	...	$\geq 250$ to $< 1000$	$< 10$ sec
C	...	$\geq 250$ to $< 1000$	$\geq 10$ sec
E	Extremely Short Period	$\geq 80$ to $< 250$	$< 10$ sec
S	Short Period	$\geq 10$ to $< 80$	$< 10$ sec
H	High Broadband	$\geq 80$ to $< 250$	$\geq 10$ sec
B	Broadband	$\geq 10$ to $< 80$	$\geq 10$ sec
M	Mid Period	$> 1$ to $< 10$	
L	Long Period	$\approx 1$	
V	Very Long Period	$\approx 0.1$	
U	Ultra Long Period	$\approx 0.01$	
R	Extremely Long Period	$\geq 0.0001$ to $< 0.001$	

P	On the order of 0.1 to 1 day	$\geq 0.00001$ to $< 0.0001$	
T	On the order of 1 to 10 days	$\geq 0.000001$ to $< 0.00001$	
Q	Greater than 10 days	$< 0.000001$	
A	Administrative Instrument Channel (e.g. State of Health)	variable	NA
O	Opaque Instrument Channel	variable	NA

**Table B2. List of instruments, their corresponding instrument codes, and instrument description.**

Instrument	Instrument Code	Description
Seismometer	H	High Gain Seismometer
	L	Low Gain Seismometer
	G	Gravimeter
	M	Mass Position Seismometer
	N (L,G)*	Accelerometer  *Note: Historically, some channels from accelerometers have used instrumentation codes of <b>L</b> and <b>G</b> . The use of <b>N</b> is the FDSN convention defined in August 2000.
Rotational Sensor	J	Measures solid-body rotations about an axis. Units may be in displacement (radians), velocity (radians/sec) or acceleration (radians/sec <sup>2</sup> )
Tilt Meter	A	Measures tilt from the horizontal plane. Azimuth is typical N/S or E/W

Instrument	Instrument Code	Description
Creep Meter	B	Measures the absolute movement between two sides of a fault.
Calibration Input	C	Usually only used for seismometers or other magnetic coil instruments. This signal monitors the input signal to the coil to be used in the response evaluation.
Pressure	D	A barometer or micro barometer that measures pressure. This includes infrasonic and hydrophone measurements.
Electronic Test Point	E	Used to monitor circuitry inside a recording system, local power, or seismometer. Usually for supply or line voltages.
Magnetometer	F	Measures the magnetic field where the instrument is sitting.
Humidity	I	Absolute or relative measurements of the humidity.
Temperature	K	Measurement of the temperature at some location.
Water Current	O	Measures the velocity of water in a given direction.
Geophone	P	Very short period seismometer with a natural frequency of 5-10 Hz or higher.
Electric Potential	Q	Measures the electric potential between two points.
Rainfall	R	Measures total rainfall, or an amount per sampling interval.
Linear Strain	S	Very sensitive displacement measuring device.
Tide	T	Depth of water at the monitoring site.
Bolometer	U	Infrared instrument used to evaluate average cloud cover.
Volumetric Strain	V	Unknown
Wind	W	Wind vector or velocity.
Derived/Generated	X	Time series derived from observational data or entirely generated by a computer seismogram.
Non-specific Instrument	Y	Used for instruments not covered but the SEED format.
Synthesized Beam	Z	Used when forming beams from the individual elements of an array.

**Table B3. List of instruments, their corresponding instrument codes, orientation codes, type, and orientation code description.**

Instrument	Instrument Code	Orientation Code(s)	Type	Description
Seismometer, Rotational Sensor, or Derived/Generated	H, L, G, M, N  J  X	Z, N, E	Geophysical	Traditional (Z=Vertical, N=North-South, E=East-West) within 5 degrees
		A, B, C		Triaxial (along the edges of a cube turned up on a corner)
		T, R		For formed beams (T=Transverse, R=Radial)
		1, 2, 3		Orthogonal, but non-traditional, components
		U, V, W		Optional components
Tilt Meter	A	N, E	Geophysical	Traditional
Calibration Input	C	A, B, C, D	Unspecified	Different letters used to differentiate between different calibration sources for the same device. Meaning is device- specific.
		blank		if there is only one calibrator for the device
		Z, N, E		If present, matches calibration channel to traditional channel
Pressure	D	O	Weather <i>or</i>	Outside

Instrument	Instrument Code	Orientation Code(s)	Type	Description
			State-of-Health	
		I		Inside
		D		Down hole
		F		Infrasound
		H		Hydrophone
		U		Underground
Electronic Test Point	E	varies	State-of-Health	Different values depending on device vendor.
Magnetometer	F	Z, N, E	Geophysical	Traditional (Z=Vertical, N=North-South, E=East-West) within 5 degrees
Humidity or Temperature	I K	O	Weather <i>or</i> State-of-Health	Outside environment
		I		Inside building
		D		Down hole
		1, 2, 3, 4		Cabinet sources
		all other letters		Different values depending on device vendor.
Geophone	P	Z, N, E	Geophysical	Traditional (Z=Vertical, N=North-South, E=East-West) within 5 degrees
Linear Strain	S	Z, N, E		Traditional (Z=Vertical, N=North-South, E=East-West) within 5 degrees
Tide	T	Z		Always vertical
Wind	W	S	Weather	Wind speed

Instrument	Instrument Code	Orientation Code(s)	Type	Description
		D		Wind direct vector relative to geographic north
Creep Meter, Electric Potential, Water Current, Volumetric Strain	B Q O V	Unknown	Geophysical	
Rainfall, Bolometer	R U	Unknown	Weather	
Non-Specific	Y	varies		Different values depending on instrument and vendor.

## Appendix C. Hot Keys and User Interactions

The following tables list hot keys and user interactions available for each display. When available, the display buttons the hot keys/user interactions are referencing and alternate hot keys/user interactions are also listed.

### Appendix C.1. Workflow Display

Operation	Hot Key/User Interaction	Display Buttons	Alternate	Notes
Pan forward/back ONE DAY	Arrow Left/Right	Single Arrow		Functionality can't be fully exercised due to limited data (see Section 5.2)
Pan forward/back ONE WEEK	Shift + Arrow Left/Right	Double Arrow		Functionality can't be fully exercised due to limited data (see Section 5.2)
Scroll forward/back	Shift + Scroll Wheel	Mouse Drag Horizontal Bar		Functionality can't be fully exercised due to limited data (see Section 5.2)



**Appendix C.2. Waveforms Display**

Operation	Hot Key/User Interaction	Display Buttons	Alternate	Notes
Zoom in	(Ctrl/Cmd + Click) Mouse Drag		(Ctrl/Cmd + Scroll Wheel)	Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Zoom Out	Double Click		(Ctrl/Cmd + Scroll Wheel)	
Print Time to Screen	Click + Hold			
Pan Left/Right	Ctrl/Cmd + Arrow Left/Right	Single Arrow		Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Select Range of Channels	Shift + Click on Channel Label			
Select Parent Channel and All Children	Alt/Option + Click on Parent			Use Alt on Windows, Option on Mac
Modify (Add to or Remove From) Current Channel Selection	Ctrl/Cmd + Click on Channel Label			Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Select Range of Parent Channels and All of Their Children	Shift + Alt/Option + Click on Parent			Use Alt on Windows, Option on Mac
Open Menu to Hide a Station	Right Click on Station Label		Ctrl + Click	

Manual Amplitude Scaling	S + Click drag Up/Down			
Undo Manual Amplitude Scaling for Individual Channel	Alt/Option + S			Use Alt on Windows, Option on Mac
Reset All Transient Amplitude Scaling for All Waveforms (Resets Manual Scaling or Scale to Selected to Persistent Toolbar Operation)	Alt/Option + Shift + S			Use Alt on Windows, Option on Mac
Scale All Waveform Amplitudes to Selected Waveform's Amplitude	Ctrl + Shift + S			
View Waveform in Measure Window	(Alt/Option + Click) Mouse Drag			Use Alt on Windows, Option on Mac
Move Measure Window	Click + Drag			

**Appendix C.3. IAN Map Display**

Operation	Hot Key	Display Buttons	Alternate	Notes
Zoom In/Out	Scroll Wheel		Two-Finger Drag on TouchPad	
Zoom Into Single Station	Double Click Station Icon			
Pan Left/Right (2D Projections)	Click + Drag			
Rotate (3D Projection)	Click + Drag			
Add/Hide Station in Waveforms Display	Right Click on Station Icon			

**Appendix C.4. Station Properties Display**

Operation	Hot Key/User Interaction	Display Buttons	Alternate	Notes
Freeze Table Column in Place	Click + Drag to Far-Left + Hold			Hold until a thumbtack symbol appears, then release.
Unfreeze Table Column	Click + Drag to Right			Release when column is in desired position.