Tsunami Hazard Assessment of the Strait of Juan de Fuca

Project Report

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Contents

1 Introduction

This report summarizes tsunami modeling results submitted to the Washington Geological Survey (WGS) in June, 2021, for use in the production of maximum inundation and current speed mapping products. The study region covers a portion of the Strait of Juan de Fuca from roughly Bullman Beach, WA (east of Neah Bay, WA) near longitude -124.520602 to west of Port Townsend, WA near longitude -122.805046. This region lies mainly in Clallam county with the easternmost coastline being in Jefferson county. This region connects to previous modelling projects – to the west with the outer coast modelling of 2020 and to the east with Port Townsend modelling done in house at WGS. Two earthquake sources from the Cascadia Subduction Zone and one from the Aleutian Subduction Zone were considered. Results include inundation depths and times of arrival that will be useful to coastal communities, as well as tsunami current speeds and momentum flux. GeoClaw Version 5.8.0 was used for the modeling [7].

Figure 1 shows the coastline studied, the union of the five magenta polygons in that figure. These are the "fgmax regions" where GeoClaw results are provided for each considered earthquake. An fgmax grid is a fixed grid (fg) on which is saved the maximum (max) values of model variables attained during the duration of the simulation, including the fundamental variables water depth (h) and water speed (s) derived from the velocity components ($s = \sqrt{u^2 + v^2}$), as well as other quantities of interest derived from the depth (h) and horizontal momenta (hu and hv), the quantities modelled in the shallow water equations.

Each of the regions is shown in more detail in the following figures. From west to east, the regions are named `Chito_Sekiu` (Figure 2), `Butler_Crescent` (Figure 3), `Elwha_PA` (Figure 4), `Dungeness_Sequim` (Figure 5), and `Discovery_PT` (Figure 6).

For each of these 15 sets of results (3 events on 5 regions), the quantities of interest have been provided as netCDF files on a set of points with 1/3 arcsecond (1/3") spacing in both longitude and latitude (approximately 7 m and 10 m respectively). The data format is discussed further in Appendix A.

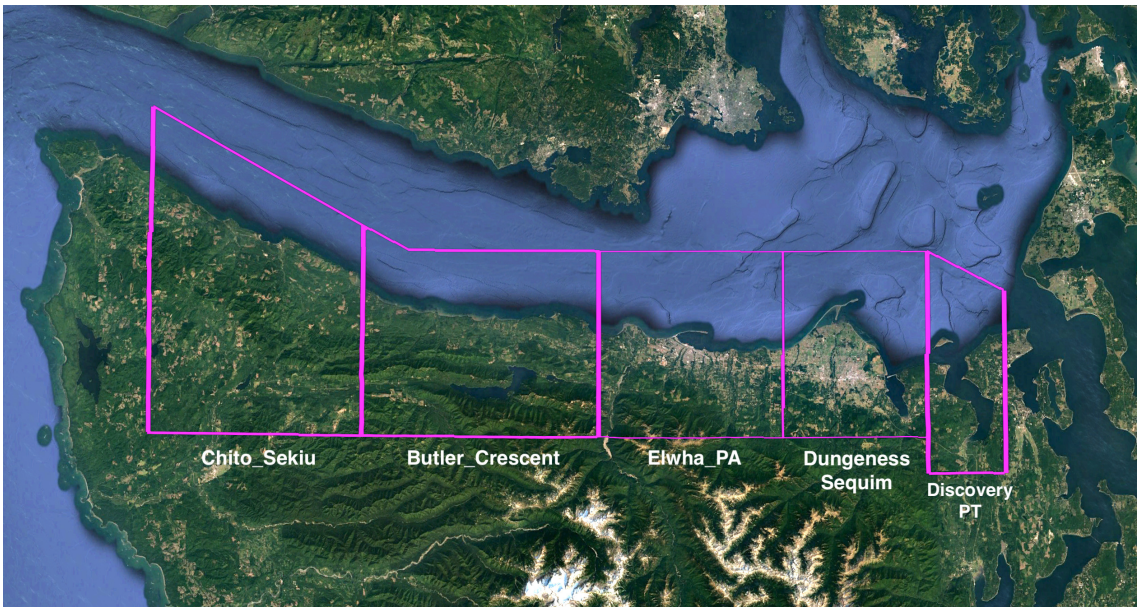


Figure 1: The magenta polygons show the five study regions considered in this project, from west to east denoted as `Chito_Sekiu`, `Butler_Crescent`, `Elwha_PA`, `Dungeness_Sequim`, and `Discovery_PT`. These are shown in more detail in the following three figures. Imagery from Google Earth.

Figure 2: The colored regions show the fgmax points in the study region denoted `Chito_Sekiu`, which extend up to 35 m elevation and some distance offshore. This region includes Chito Beach, Sekiu, Clallam Bay, and the Pysht River Valley, WA. To the region's west is Neah Bay, WA which was modelled in the `Flattery` fgmax region of the recent study [12]. Imagery from Google Earth.

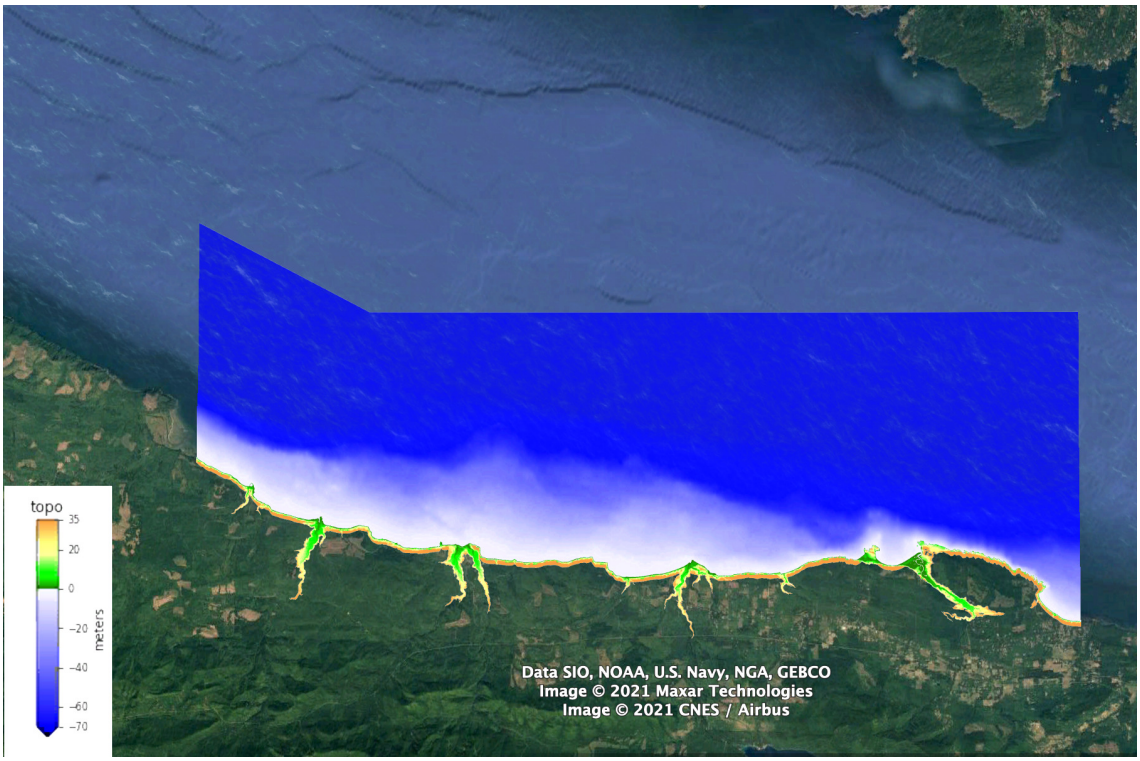


Figure 3: The colored regions show the fgmax points in the study region denoted `Butler_Crescent`, which extend up to 35 m elevation and some distance offshore. This region begins just east of Butler's Cove, WA and includes Whiskey Creek Beach, Crescent Bay, Twin Rivers Beach, Agate Bay Beach, and the Salt Creek Recreation Area, WA. Imagery from Google Earth.

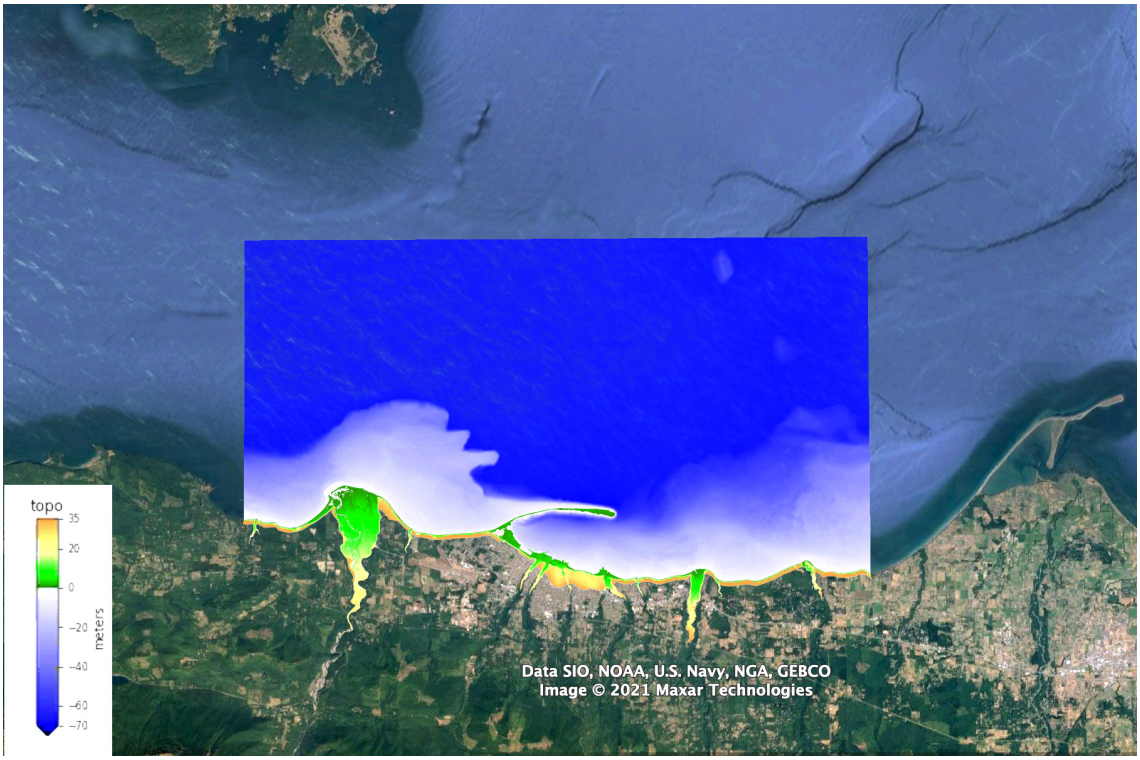


Figure 4: The colored regions show the fgmax points in the study region denoted `Elwha_PA`, which extend up to 35 m elevation and some distance offshore. This region includes the Elwha River and places of interest around Port Angeles, WA including the Coast Guard station on Ediz Hook, the Port Angleles ferry terminal and paper mill. Imagery from Google Earth.

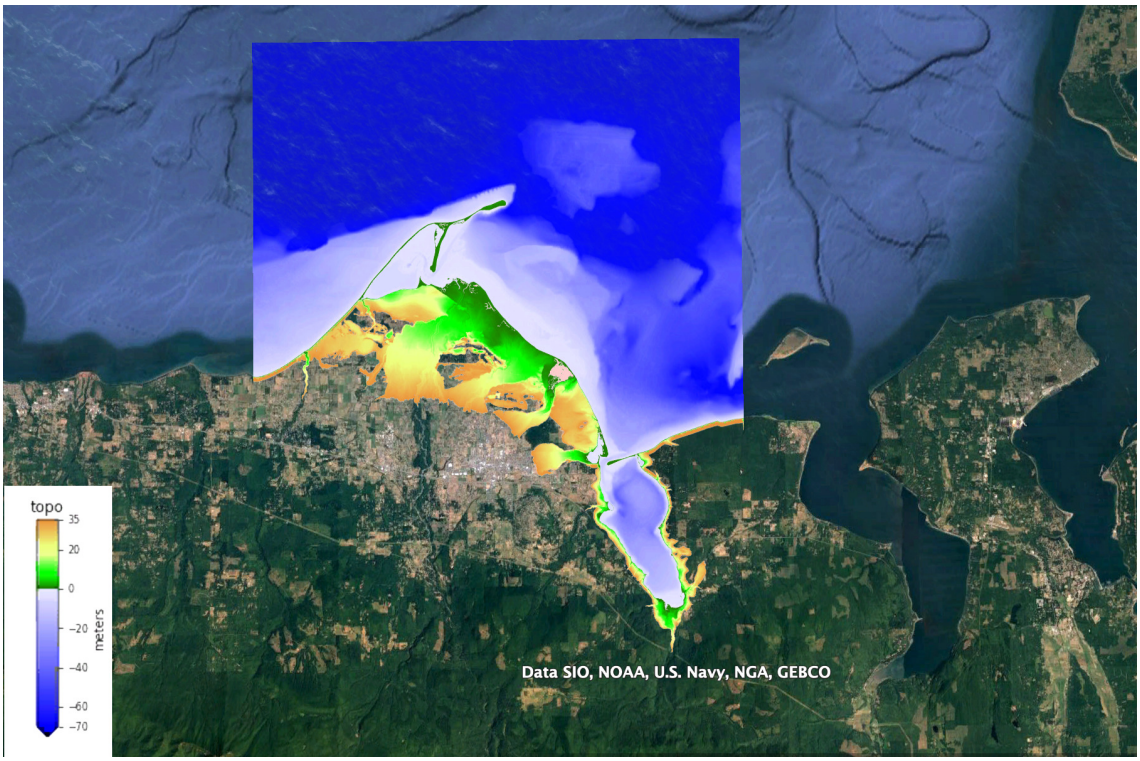


Figure 5: The colored regions show the fgmax points in the study region denoted `Dungeness_Sequim`, which extend up to 35 m elevation and some distance offshore. This region includes the Dungeness Lighthouse on Dungeness Spit, Blyn, and Sequim Bay, WA. Imagery from Google Earth.

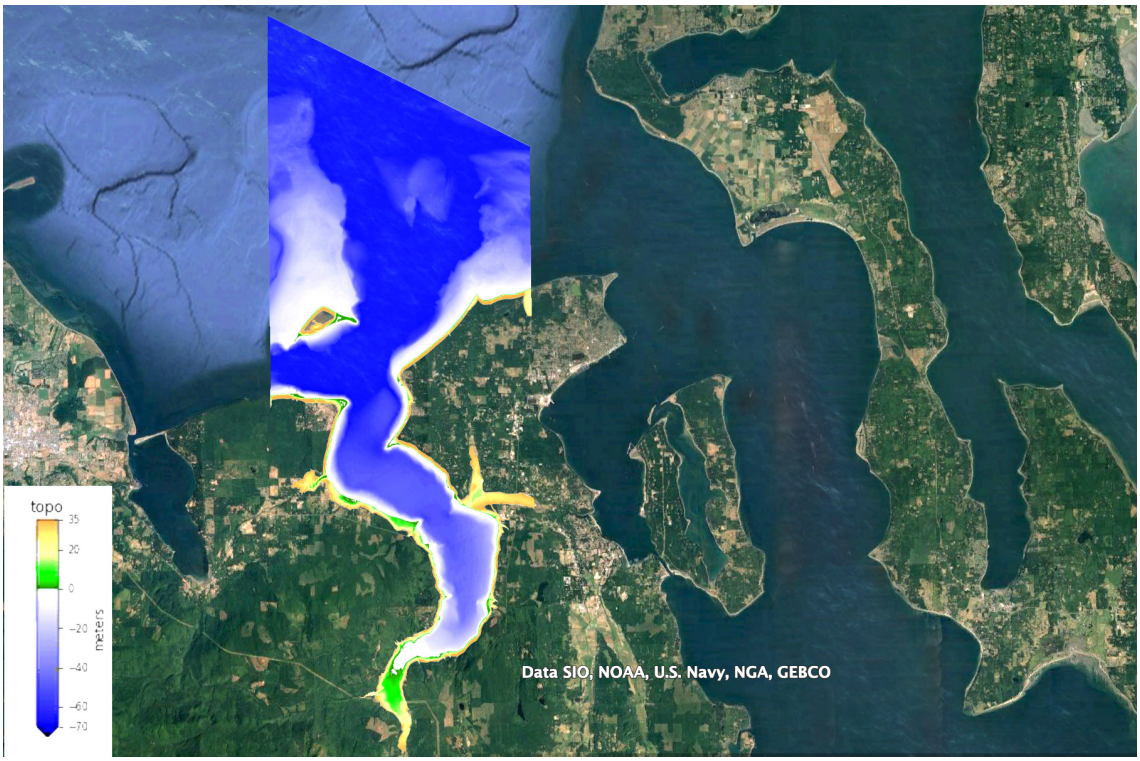


Figure 6: The colored regions show the fgmax points in the study region denoted `Discovery_PT`, which extend up to 35 m elevation and some distance offshore. This region includes Discovery Bay, WA and the marsh near its terminus where tsunami deposits can be found. To this region's east is the town of Port Townsend, WA which was modelled previously by WGS. Imagery from Google Earth.

2 Topography and Bathymetry

All DEMs and project data utilize World Geodetic System 1984 (WGS84, ESPG:4326) as the standard coordinate system for this study. The fine-resolution coastal grids are referenced to Mean High Water (MHW).

2.1 1/9 and 1/3 Arc-second DEMs

Output from the model was requested at grid points spaced 1/3" in longitude and 1/3" in latitude, with the points aligned with cell centers of the 1/3" DEM files that are available for the coastal region. (Note that 1/3" in latitude is approximately 10.3 m. At this latitude, 1/3" in longitude is approximately 6.9 m).

For this project, new DEMs were provided by NCEI covering the onshore and near shore regions along the Strait at a resolution of 1/9". These will eventually be published at [8]. We used the following pre-publication tiles:

`juan_de_fuca_mhw_g19_n48x50_w124x50_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x50_w124x25_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w124x50_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w124x25_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w124x00_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w123x75_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w123x50_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w123x25_2021v1.nc`,
`juan_de_fuca_mhw_g19_n48x25_w123x00_2021v1.nc`,

Note that the file names include the latitude and longitude of the NW corner of tile, each of which is 0.25 degrees on each side. In addition, two 1/9" tiles provided previously by NCEI for the recent modeling study of the outer coast [13] were also used, covering the region around Neah Bay and Cape Flattery:

`ncei19_n48x50_w0124x75_2020.nc`,
`ncei19_n48x25_w0124x75_2020.nc`.

Finally, we required updated topography around the terminus of Discovery Bay, which extends slightly to the south of 48N, the southern boundary of the new tiles provided by NCEI. This was provided by WGS based, using the latest lidar data in this region. They created a 1/9" DEM

`WGS_n48x00_w123x00_2020v1.nc`

that was modified only in the rectangle $[-123, -122.75, 47.91, 48]$, which includes all the topography below 35 m elevation around the terminus of Discovery Bay.

The 1/9" DEMs listed above were subsampled to create 1/3" DEMs aligned with the older 1/3" Strait of Juan de Fuca DEM from 2015 [17] and the Port Townsend DEM from 2011 [16]. The older DEMs were cropped to obtain 1/3" DEMs on the coastal regions required for this work, and then the new 1/9" DEMs were used to replace values in the regions where these overlapped. This included all regions onshore that are modeled in this study. The old DEM values remained only in some regions far from shore.

The extents of all the DEMs mentioned above are shown in Figure 7.

GeoClaw uses finite volume methods with adaptive mesh refinement, and the finest grid resolution near regions of interest was set to the desired resolution of 1/3" by 1/3". It is important to note, however, that in the finite volume formulation the given DEM files are used to construct a piecewise bilinear function interpolating at the DEM points, and averages of this function over grid cells are then used as the topography values in the numerical method. Hence a cell that is centered at a DEM point overlaps 4 bilinear functions meeting at this point and the "GeoClaw topography" used in this grid cell will depend on the DEM values at 9 neighboring points. Moreover, if there is co-seismic subsidence (or uplift) in a cell the final GeoClaw topography value in this cell (which we denote by B) will include this deformation. For these reasons we provide both B and the DEM value Z at the same point in the netCDF files of model output, along with the co-seismic deformation dZ; see Appendix A.

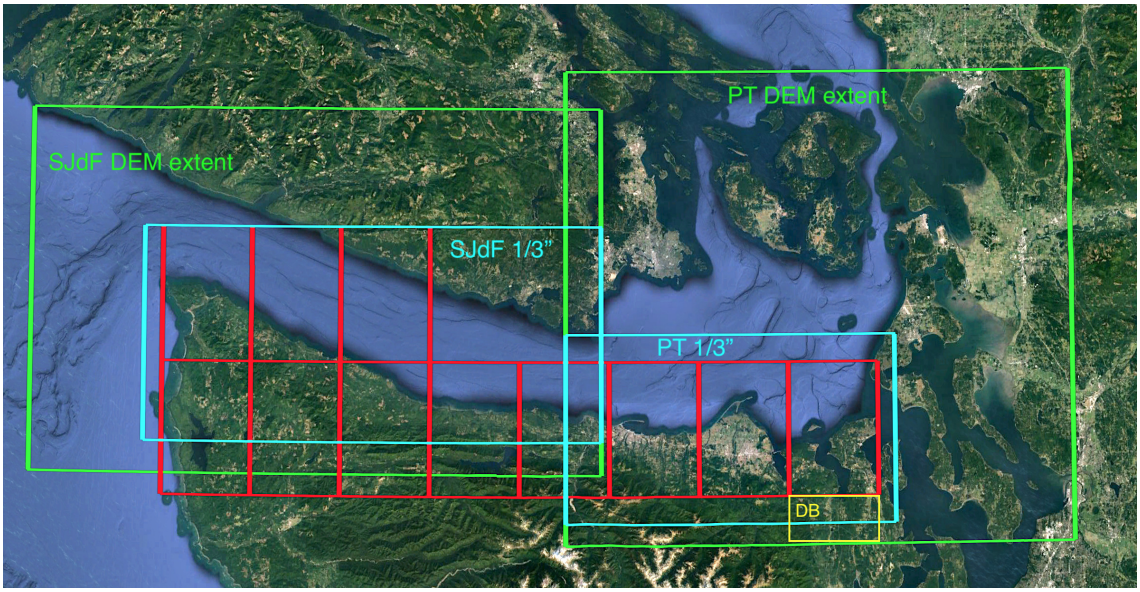


Figure 7: Green boxes show the extent of the original 1/3" DEMs for the Strait of Juan de Fuca DEM from 2015 [17] and Port Townsend from 2011 [16]. The cyan boxes are the cropped regions over which 1/3" topography is needed for the tsunami modeling, while coarsened 2" versions were used outside of these regions. The 11 red rectangles show the extents of the new 1/9" DEMs used in this study. Values from these DEMs were used to overwrite values in the cropped 1/3" DEMs and also in the 2" coarsened DEMs in order to obtain merged DEMs that include new values where available. The small yellow rectangle labeled DB shows the region where WGS provided additional new data at the terminus of Discovery Bay.

2.2 Coarser DEMs

The 1/3" Port Townsend DEM [16] and Strait of Juan de Fuca DEM [17] were coarsened to obtain 2" DEMs for use outside the regions covered by the 1/3" DEM. These DEMs are more efficient to use in GeoClaw on coarser grid levels where all the details of the 1/3" DEMs are not required. Points in the overlap regions were again replaced by values from the new 1/9" DEMs in order to obtain 2" DEMs covering larger regions that are consistent with the cropped 1/3" DEMs.

Note that the Strait of Juan de Fuca (SJdF) DEM is referenced to NAVD88 while the other 1/3" and 1/9" coastal DEMs are all referenced to MHW. The coastal areas being modeled are all covered by the newer DEMs, which are referenced to MHW, and the vertical displacement at remaining points from the original SJdF DEM is thought to be of no concern since a coarsened version of this DEM is used, and only away from the study area.

A portion of the 1/3" La Push DEM [18] was also coarsened to 2" and used to cover part of the Washington Coast to the south of Cape Flattery.

Outside of the study region, the Strait, and Puget Sound, 1-minute topography for the Pacific Ocean and outer coasts was used from the global etopo1 dataset [3]. Note that this DEM is referenced to MSL but is only used away from the coastal regions of interest, and has a resolution that does not resolve coastal features enough for the vertical datum to matter.

The extent of all of these topo files (except the 1-minute topo) are depicted in Figure 8. The five study regions are also included in this figure to show how they are covered by the topography. Note that the fgmax points selected for each magenta region as shown in Figure 2 to Figure 6 lie completely within the cyan 1/3 arc second topography regions. The SJdF 1/3" cropped DEM was used when modeling fgmax regions `Chito_Sekiu` and `Butler_Crescent`, and the PT 1/3" cropped DEM was used for the other three regions.

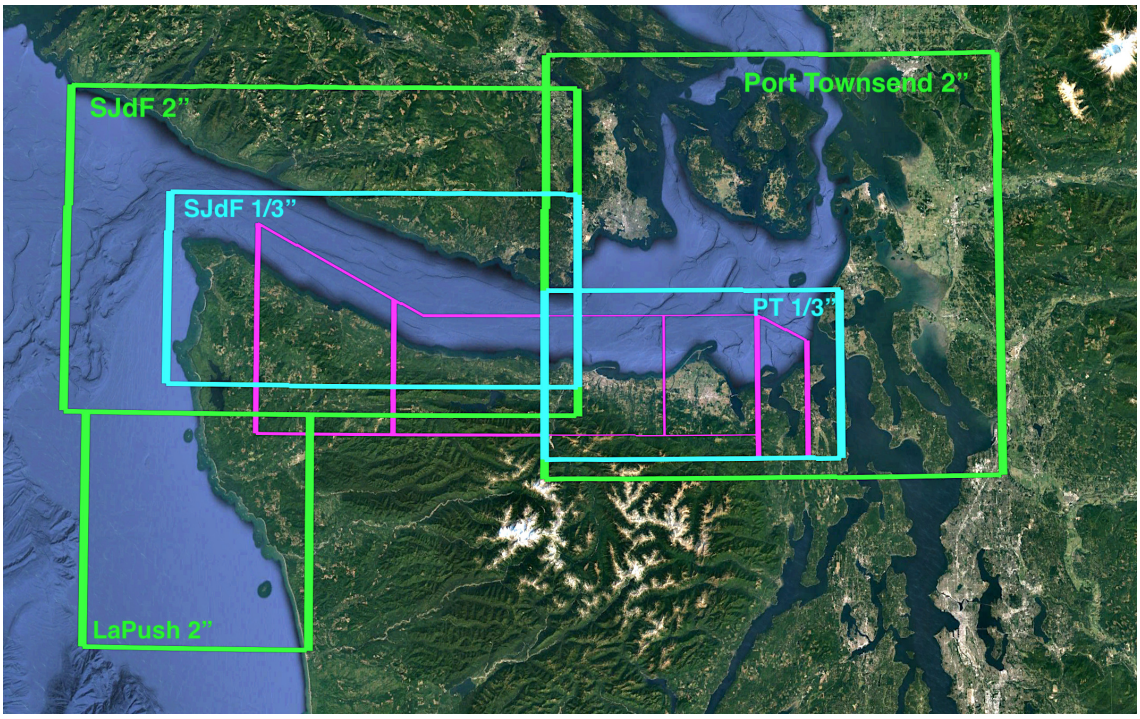


Figure 8: The topography files used for this project are shown in green and cyan. The green rectangles show the extent of three 2” topography DEMs and the cyan rectangles show the extent of the 1/3” topofiles obtained by merging several DEMs as discussed in the text. Elsewhere, 1 arcminute etopo1 topography was used. The magenta polygons of Figure 1 depicting the five study regions considered in this project are also shown. From west to east, they are denoted as `Chito_Sekiu`, `Butler_Crescent`, `Elwha_PA`, `Dungeness_Sequim`, and `Discovery_PT`. Imagery from Google Earth.

3 Earthquake Sources

Three earthquake sources were considered for this study: a Cascadia Subduction Zone (CSZ) megathurst event with moment magnitude Mw 9.0 (denoted CSZ-L1), a larger CSZ event with moment magnitude Mw 9.1 (denoted CSZ-XL1), and an Aleutian Subduction Zone event off the coast of Alaska with magnitude 9.24, denoted AKmaxWA.

3.1 Cascadia megathrust events CSZ-L1 and CSZ-XL1

The probability that an earthquake of magnitude 8 or greater will occur on the Cascadia Subduction Zone (CSZ) in the next 50 years has been estimated to be 10-14% (Petersen, et. al., 2002 [19]). The last such event occurred in 1700 (Satake, et al., 2003 [20]; Atwater, et al., 2005 [4]) and future events are expected to generate a destructive tsunami that will inundate Washington Pacific coast communities within tens of minutes after the earthquake main shock.

One potential CSZ event used in this study is the L1 scenerio developed by Witter, et al. (2013) [22]; crustal deformation for the region of interest is shown in Figure 9. The L1 source is one of 15 seismic scenarios used in a hazard assessment study of Bandon, OR, based on an analysis of data spanning 10,000 years. This scenario has been adopted by Washington State as the "maximum considered case" for many inundation modeling studies and subsequent evacuation map development; it is used because the standard engineering planning horizon is 2500 years and Witter, et al. [22] estimated that L1 has a mean recurrence period of approximately 3333 years, with the highest probability of occurrence of all events considered with magnitude Mw 9 or greater.

The original L1 source was developed for studies on the Oregon coast and was truncated at around 48N. An extension of this was developed by the NOAA Center for Tsunami Research (NCTR) group in the Pacific Marine Environment Laboratory (PMEL) in Seattle. The seafloor deformation is shown in Figure 9. As prescribed by the Washington Geological Survey (WGS), we used this extended source, the same version of the CSZ-L1 source as used in our other recent tsunami hazard assessments, [11, 1, 21, 2].

For this study a larger magnitude CSZ event was also considered, the XL1 source that was originally developed for Witter, et al. [22] as a Mw 9.1 event with a splay fault. The sea floor deformation for XL1 was essentially the same as for L1 but magnified by a multiplicative factor of approximately 1.5 at each point. For this project we started with the PMEL extension of the L1 source and magnified it by the same factor in order to obtain a version of the XL1 source that also extends north to the north. The seafloor deformation is shown in Figure 9.

Waves from the L1 or XL1 events begin hitting parts of the study region coast within a few minutes after the event (which is assumed to be instantaneous in our modeling). There is also significant subsidence of the coast from these events.

The maximum water depth and speeds recorded at the fgmax points for these CSZ events typically occurs within the first hour to two. Larger speeds are sometimes seen offshore at later times, particularly if strong vortices are generated that continue to travel around the region. At a few isolated onshore points the maximum depth is seen later, perhaps due to an accumulation of water from multiple waves.

Simulations for the CSZ events were run out to 10 hours and comparisons of fgmax results from shorter runs show that this is sufficient to capture the maxima. This is also seen at all of the synthetic gauges included in the model runs, see the plots in Section 7.

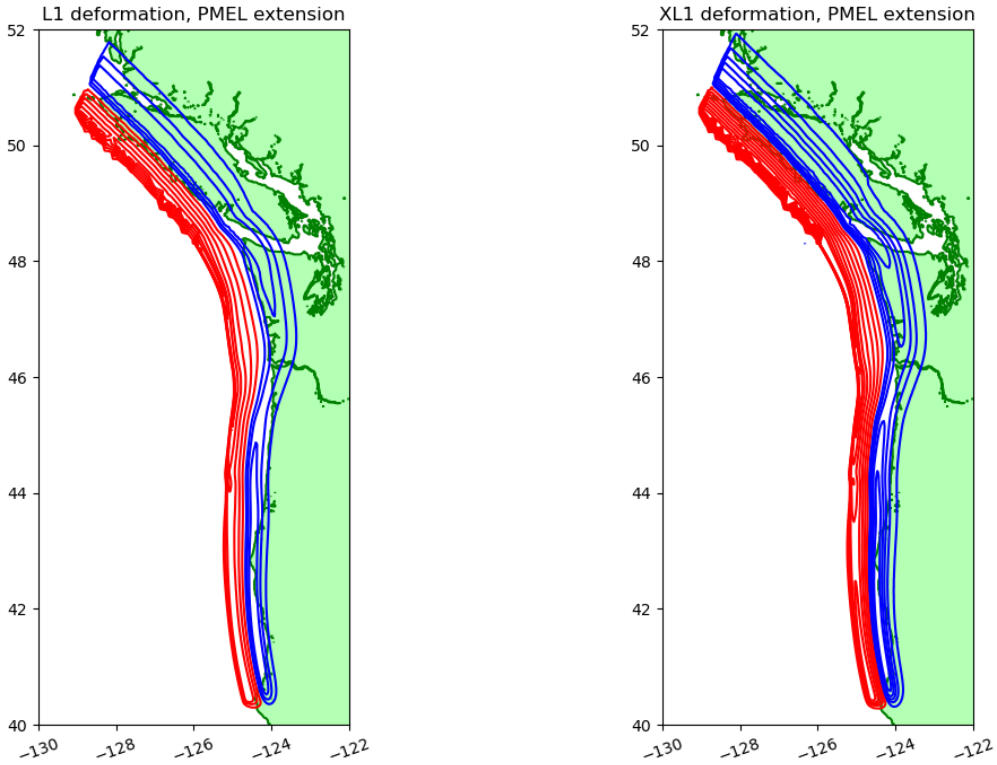


Figure 9: Left: Surface deformation of the L1 source, with maximum uplift 15.08 m and maximum subsidence −3.98 m. Right: Surface deformation of the XL1 source, with ... maximum uplift 22.62 m and maximum subsidence −5.97 m. In both plots, red contours show uplift (2 meter interval), blue contours show subsidence (1 meter interval).

3.2 Aleutian Subduction Zone event AKmaxWA

The Aleutian Subduction Zone event denoted by AKmaxWA in this study is based on a hypothetical earthquake developed by PMEL in the work reported in [6], shown in Figure 10. This source was designed to have a similar magnitude and location as the 1964 Alaska Earthquake (Mw 9.2) but to have uniform slip of 20 m specified over a set of 20 "unit source" subfaults from the NOAA SIFT database. The set of unit sources used were chosen by running tsunami simulations with all combinations subject to some constraints and choosing the set that gave the maximum impact on the Washington coast. The magnitude based on the subfault dimensions and slip (and assuming a crustal shear modulus, or rigidity, of 40 GPa) works out to Mw 9.24. Since magnitudes are generally rounded off to 1 digit in reporting them, this was viewed as a "maximal Mw 9.2" event, thus having the same magnitude as the 1964 event with maximal impact on Washington.

For more details on this source, including the subfault parameters, and related Alaska sources, see [2].

It takes more than 3 hours for the tsunami to reach the study region from the AKmaxWA source region. The maximum depth and flow speed is typically observed between 3 and 6 hours post-earthquake. Tsunami simulations for this source were run out to 12 hours of simulated time. Again the gauge results of Section 7 give confidence that this is sufficient to capture the maxima.

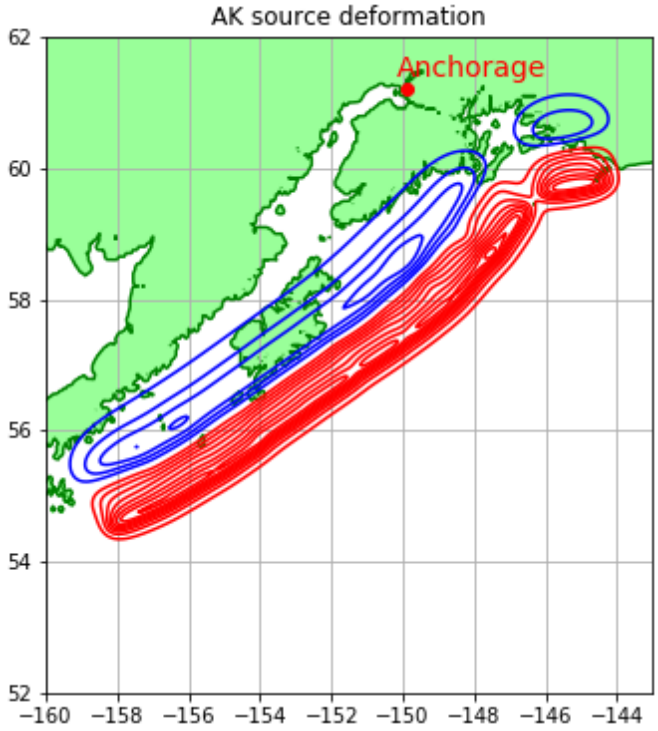


Figure 10: Surface deformation of the AKmaxWA source, with maximum uplift 9.7 m and maximum subsidence −4.9 m. Red contours show uplift, blue contours show subsidence (1 meter intervals in each case).

4 Modeling uncertainties and limitations

The simulations of tsunami generation, propagation and inundation were conducted with the GeoClaw model. This model solves the nonlinear shallow water equations, has undergone extensive verification and validation (e.g. [5, 15]), and has been accepted as a validated model by the U.S. National Tsunami Hazard Mitiga-

tion Program (NTHMP) after conducting multiple benchmark tests as part of an NTHMP benchmarking workshop [10].

Several important geophysical parameters must be set in the GeoClaw software, and some physical processes are not included in these simulations, which use the two-dimensional shallow water equations. These are discussed below along with their potential effect on the modeling results.

4.1 Tide stage and sea level rise

The simulations were conducted with the background sea level set to 0 relative to the DEMs in use, which are referenced to local MHW. This value is conservative, in the sense that the severity of inundation will generally increase with a higher background sea level. Larger tide levels do occasionally occur, but the assumption of MHW is standard practice in studies of this type. Potential sea level rise over the coming decades was not taken into account in this modeling.

The 1/3" DEMs used in this study are all referenced to MHW, meaning that $Z = 0$ corresponds to the shoreline at MHW.

4.2 Subsidence

The CSZ events have significant co-seismic subsidence at all coastal regions in this study. The subsidence is accounted for in the GeoClaw modeling, since the initial DEM provided for the region is modified by the earthquake deformation. The AKmaxWA event produces no deformation in the study region.

4.3 Structures

Buildings were not included in the simulations, the topographic DEMs provided for this study are "bare earth". The presence of structures will alter tsunami flow patterns and generally impede inland flow. To some extent the lack of structures in the model is therefore a conservative feature, in that their inclusion would generally reduce inland penetration of the tsunami wave. However, as in the case of the friction coefficient, impeding the flow can also result in deeper flow in some areas. It can also lead to higher fluid velocities, particularly in regions where the flow is channelized, such as when flowing up streets that are bounded by buildings.

4.4 Bottom friction

Mannings coefficient of friction was set to 0.025, a standard value used in tsunami modeling that corresponds to gravelly earth. This choice of 0.025 is conservative in some sense, because the presence of trees, structures and vegetation would justify the use of a larger value, which might tend to reduce the inland flow. On the other hand, larger friction values can lead to deeper flow in some areas, since the water may pile up more as it advances more slowly across the topography. A sensitivity study using other friction values has not been performed.

4.5 Tsunami modification of bathymetry and topography

Severe scouring and deposition are known to occur during a tsunami, undermining structures and altering the flow pattern of the tsunami itself. Again, this movement of material requires an expenditure of tsunami energy that tends to reduce the inland extent of inundation. On the other hand, if natural berms or ridges along the coastline (or man-made levies or dikes) are eroded by the tsunami, then some areas can experience much more extensive flooding. There is no erosion or deposition included in the simulations presented here.

5 Study regions

Figure 1 shows the portion of the coast considered, subdivided into the five polygons covering the study region. These regions will be referred to as *fgmax regions* since these are regions on which a fixed set of points is defined (independent of adaptive refinement) on which the maximum of each quantity of interest is monitored during the course of the simulation. The quantities monitored are the flow depth, flow speed, and momentum flux, along with the time at which the maximum is attained and the first arrival time of significant waves at each grid point.

Within each fgmax region, a set of fgmax points were defined as described below, the points where the maxima need to be monitored. For each tsunami source, a separate job run was then done for each region in which adaptive mesh refinement (AMR) was used to focus fine computational grids around the fgmax region. Due to the large extent of the study region and complicated coastline, it was not possible to do a single run with 1/3" resolution around all the fgmax regions. Table 1 gives an overview of the five regions.

Region label	Count	Plots and Results
`Chito_Sekiu`	4,783,174	Section 6.1
`Butler_Crescent`	5,060,684	Section 6.2
`Elwha_PA`	5,499,659	Section 6.3
`Dungeness_Sequim`	5,237,426	Section 6.4
`Discovery_PT`	2,716,950	Section 6.5
Total	23,297,893	

Table 1: The fgmax regions. The fgmax points are aligned with the DEM in the regions specified, with 1/3" spacing in longitude and latitude. The column labeled "Count" gives the number of fgmax points in each region. See Figure 2 to Figure 6 for plots of the fgmax points and Section 6 for plots of some sample results for each region.

The fgmax points lie on a grid with spacing 1/3" by 1/3" that is aligned with the DEM grids. We select only the points from the 1/3" grid that satisfy all of these conditions:

- The point lies within a specified polygon,
- The point has a topography elevation below a specified maximum $Z_{\max}$,
- There is a path of points with elevation below $Z_{\max}$ connecting the point to the coast.

In addition, any grid point in the polygon that lies within 10 grid cells of the coast is selected as an fgmax point, insuring that there is a band of fgmax points all along the coast, even in regions where the topography rises very steeply. This approach is discussed in more detail in [2]. For this project we chose $Z_{\max} = 35$ m, based on some initial simulations that showed that the XL1 event gave extreme runup values in some valleys along the Strait of Juan de Fuca.

If only onshore inundation and near shore currents need to be modeled, then one could also set a lower threshold, e.g. -60 m, and only select fgmax points within the polygons where the bathymetry elevation is both above this value and less than $Z_{\max}$. For this project we included all water points in each polygon in order to model currents farther from shore.

6 Results – Maximum flow depth and speeds

We have not attempted to produce high quality graphics of the results, since the Washington Geological Survey (WGS) is producing the maps that will be published elsewhere. However, in Figures 11–15 we provide some plots to give an indication of the sort of flooding and flow speeds observed, and for future reference if the simulations are re-run at a later date.

The maximum flow depth plots show the maximum depth of water recorded during the computation over the full simulation time of 10 hours for the CSZ events or 12 hours for AKmaxWA. This depth is shown

only in regions that were originally dry in the simulation, and those points colored green remained dry. White regions are where there was initially water, or else there were no fgmax points. In the speed plots the maximum speed is shown both in the water and for initially dry points that became wet at some point. White regions are where there were no fgmax points.

In addition to the plots shown in this report, we have also produced high-resolution png files in a form that has been embedded in kml files to facilitate viewing the input data and results on Google Earth, for example. The low resolution figures in this report cannot possibly show all the details whereas with the kml files the user can zoom in to explore the results in more detail.

These kml files can be found at [14], along with the Python code that produced them.

The raw results are contained in netCDF files posted at [14], and these can be downloaded and plotted in different ways or with different color maps, either using modifications of our Python scripts, or with sophisticated GIS tools.

For each region we point out some noteworthy aspects of the simulation results in the pages below. We give an indication of the arrival time of each tsunami in each region, as determined by inspection of the gauges at interfaces between the different fgmax regions; see Section 7.

6.1 Region `Chito_Sekiu`

Figure 2 shows the topography of the fgmax points selected in the `Chito_Sekiu` region. Figure 11 shows some sample results for this region.

Noteworthy in this region.

- The arrival of the first positive wave (5 cm above MHW) is between 22 to 37 minutes across this region from west to east for the CSZ_L1 and CSZ_XL1 events and between 3 hours and 34 minutes to 3 hours and 49 minutes for AKmaxWA.
- The AKmaxWA source inundates the Sekiu, Hoko, and Physt river valleys. The inundation is just shy of Highway 112. In the Clallam Bay area, there is flooding on shore, particularly near Fisherman's street and Frontier street and goes across Highway 112.
- The speeds were fairly low with the AKmaxWA source with the highest ones seen in Butler's cove.
- Both the CSZ_L1 and CSZ_XL1 sources produce more inundation than AKmaxWA. This inundation crosses Highway 112 in multiple places, perhaps causing impassable islands. The Clallam Bay Medical Center stays dry with CSZ_L1 but is at the edge of the inundation zone but is inundated with CSZ_XL1.
- The speeds were much higher with CSZ_L1 and CSZ_XL1 than with the far field AKmaxWA source.
- This region experiences significant subsidence with both CSZ_L1 and CSZ_XL1 but none with the AKmaxWA source. The CSZ_L1 subsidence goes from 3.632 to 2.295 meters across this region from west to east. The CSZ_XL1 subsidence is 1.5 times that of CSZ_L1.
- For the CSZ_XL1 event, the maximum speed in the Strait was very close to 2 m/s, as can be seen in the plot for Gauge 190 on page 54. Since there is a break between blue and red shades in the colormap at 2 m/s, there are bands of alternating color due to the colormap choice that are not physically significant.

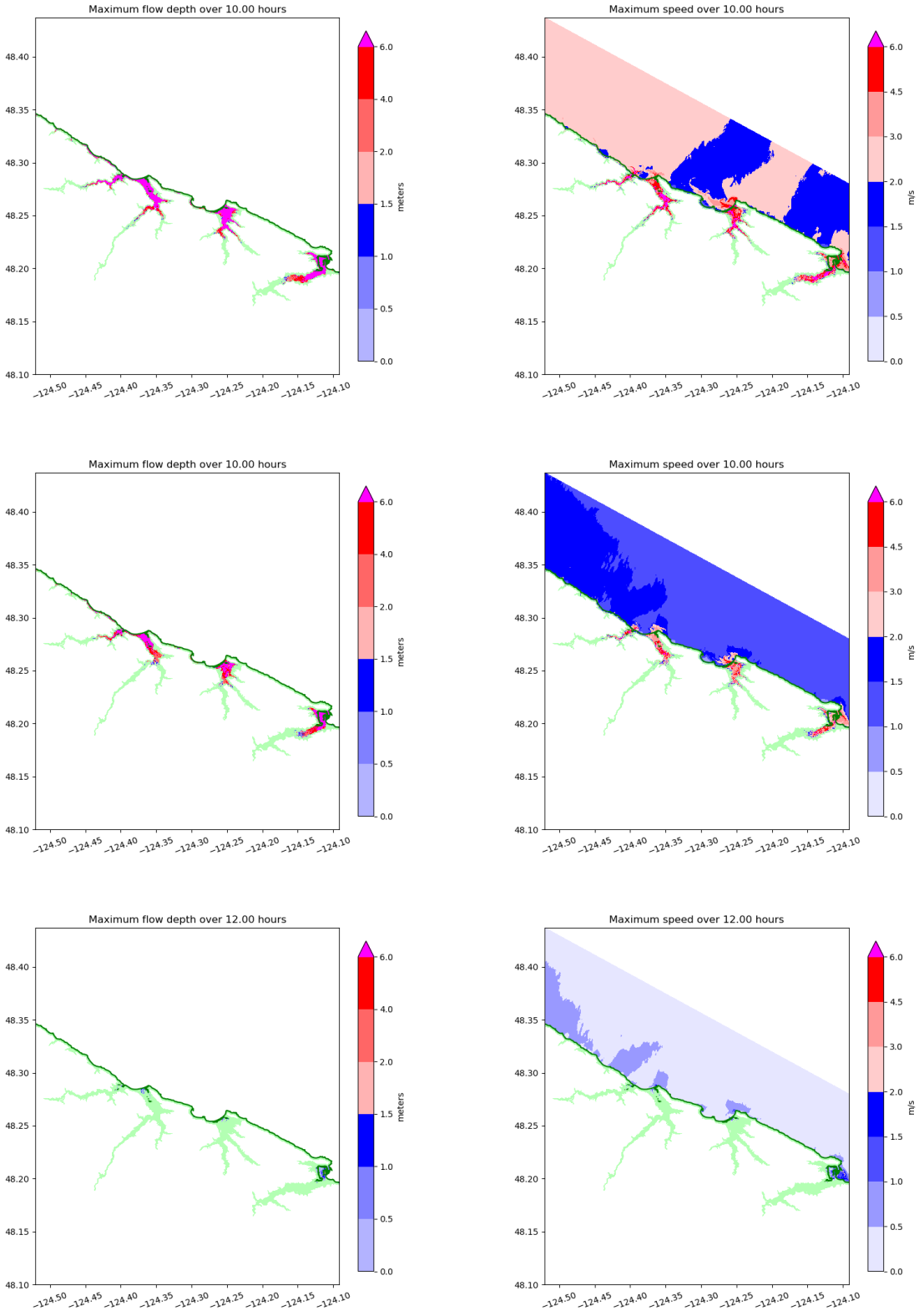


Figure 11: Sample results for the Region `Chito_Sekiu`. See the description in Section 6.1. Top: CSZ-XL1, Middle: CSZ-L1, Bottom: AKmaxWA. Plots on the left show maximum flooding depth (m) for initially-onshore points, those on the right show maximum flow speed (m/s) for all fgmax points. The fgmax points colored green remained dry in the simulation.

6.2 Region `Butler_Crescent`

Figure 3 shows the topography of the fgmax points selected in the `Butler_Crescent` region. Figure 12 shows some sample results for this region.

Noteworthy in this region.

- The arrival of the first positive wave (5 cm above MHW) is between 37 to 50 minutes across this region from west to east for the CSZ_L1 and CSZ_XL1 events and between 3 hours and 49 minutes to 4 hours and 4 minutes for AKmaxWA.
- The AKmaxWA source inundates the valleys along the Lyre River and Crescent Bay. The inundation crosses Highway 112 east of Gibson Road near longitude -124.02639, and also near longitude -123.952557, and again just east of W. Twin Road.
- Both the CSZ_L1 and CSZ_XL1 sources produce more inundation than AKmaxWA. This inundation crosses Highway 112 in multiple places for significant stretches, perhaps causing impassable islands. These stretches for CSZ_L1 are from longitude -124.028266 to -124.011991, from longitude -123.953342 to -123.948180 and from longitude -123.946971 to -123.942635. For CSZ_XL1 these stretches are from longitude -124.029211 to -124.009659, from longitude -123.954484 to -123.941702 and from longitude -123.953315 to -123.941620. The Crescent RV Park stays dry but is at the edge of the inundation zone with CSZ_L1 but is inundated with CSZ_XL1.
- The speeds for both CSZ_L1 and CSZ_XL1 were higher than those produced by AKmaxWA.
- This region experiences significant subsidence with both CSZ_L1 and CSZ_XL1 but none with the AKmaxWA source. The CSZ_L1 subsidence goes from 2.295 to 0.677 meters across this region from west to east. The CSZ_XL1 subsidence is 1.5 times that of CSZ_L1.

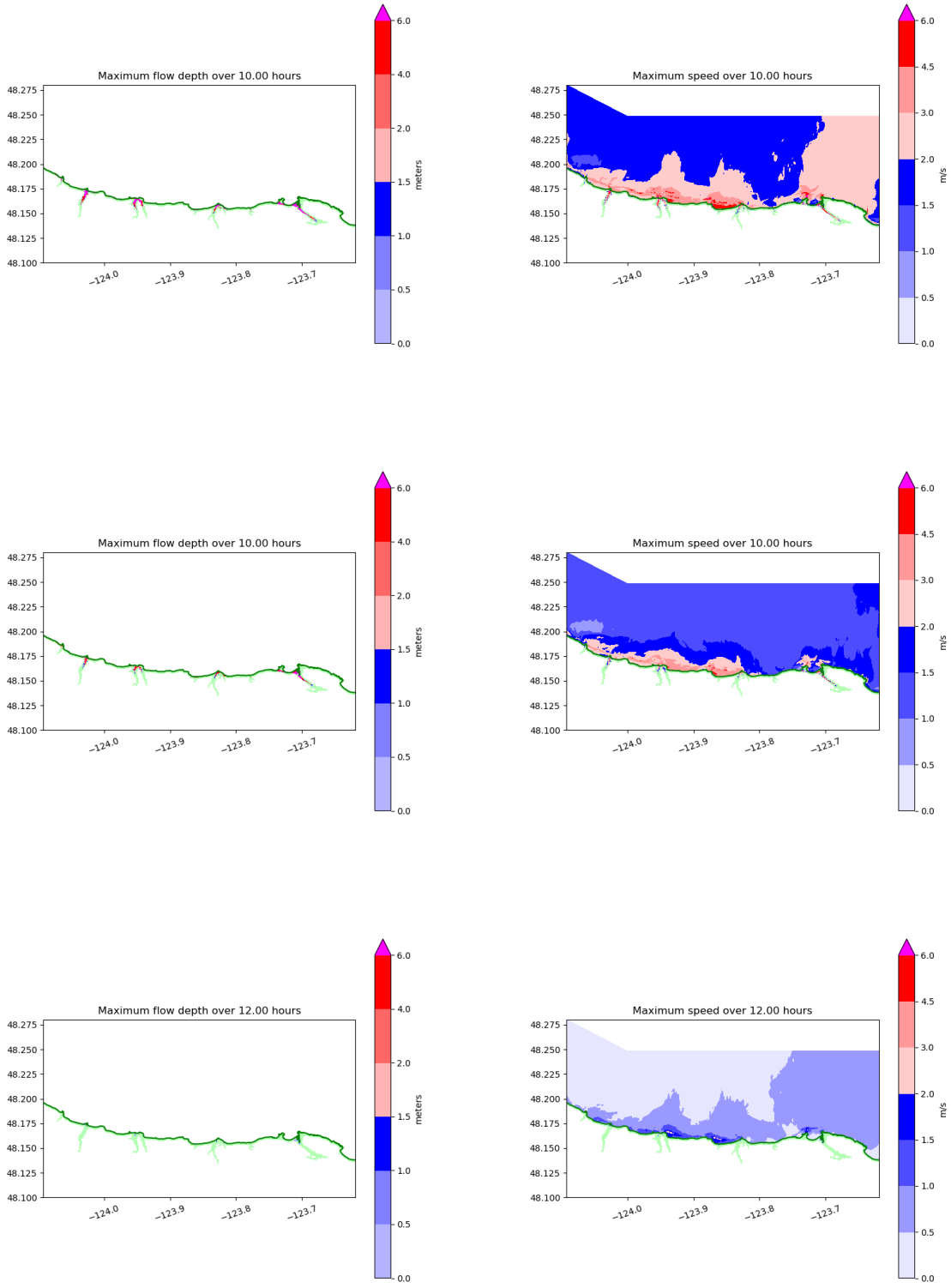


Figure 12: Sample results for the Region `Butler_Crescent`. See the description in Section 6.2. Top: CSZ-XL1, Middle: CSZ-L1, Bottom: AKmaxWA. Plots on the left show maximum flooding depth (m) for initially-onshore points, those on the right show maximum flow speed (m/s) for all fgmax points. The fgmax points colored green remained dry in the simulation.

6.3 Region `Elwha_PA`

Figure 4 shows the topography of the fgmax points selected in the `Elwha_PA` region. Figure 13 shows some sample results for this region.

Noteworthy in this region.

- The arrival of the first positive wave (5 cm above MHW) is between 50 to 66 minutes across this region from west to east for the CSZ_L1 and CSZ_XL1 events and between 4 hours and 4 minutes to 4 hours and 18 minutes for AKmaxWA.
- The AKmaxWA source inundates the land around the Lower Elwha River valley and along the waterfront in Port Angeles and Ediz Hook. The Elwha Tribal Center and Lower Elwha Clinic are not inundated. The Coast Guard Station on Ediz Hook sees some inundation.
- High speeds were produced by AKmaxWA off Ediz Hook (in the 3.5 to 4.5 m/sec range).
- The CSZ_L1 modeling is fairly consistent around Port Angeles with that published in 2018 by WGS. There are some differences between the results but they seem to be reasonable in view of the updated topography DEMs used in this study. Differences are particularly noticeable in the patterns of maximum current speed, which is known to be much more sensitive than inundation depth to changes in a model.
- Both the CSZ_L1 and CSZ_XL1 sources produce more inundation than AKmaxWA. In Port Angeles both CSZ_L1 and CSZ_XL1 inundate the Port of Port Angeles, the Port Angeles Family Medicine, and the ferry terminals. Both the Elwha Tribal Center and Lower Elwha Clinic were in the inundation zone of both these sources. The Elwha River Casino was inundated with CSZ_XL1 but not with CSZ_L1.
- The speeds for both CSZ_L1 and CSZ_XL1 were higher than those produced by AKmaxWA.
- This region experiences some subsidence with both CSZ_L1 and CSZ_XL1 but none with the AKmaxWA source. The CSZ_L1 subsidence goes from 0.677 to 0.264 meters across this region from west to east. The CSZ_XL1 subsidence is 1.5 times that of CSZ_L1.

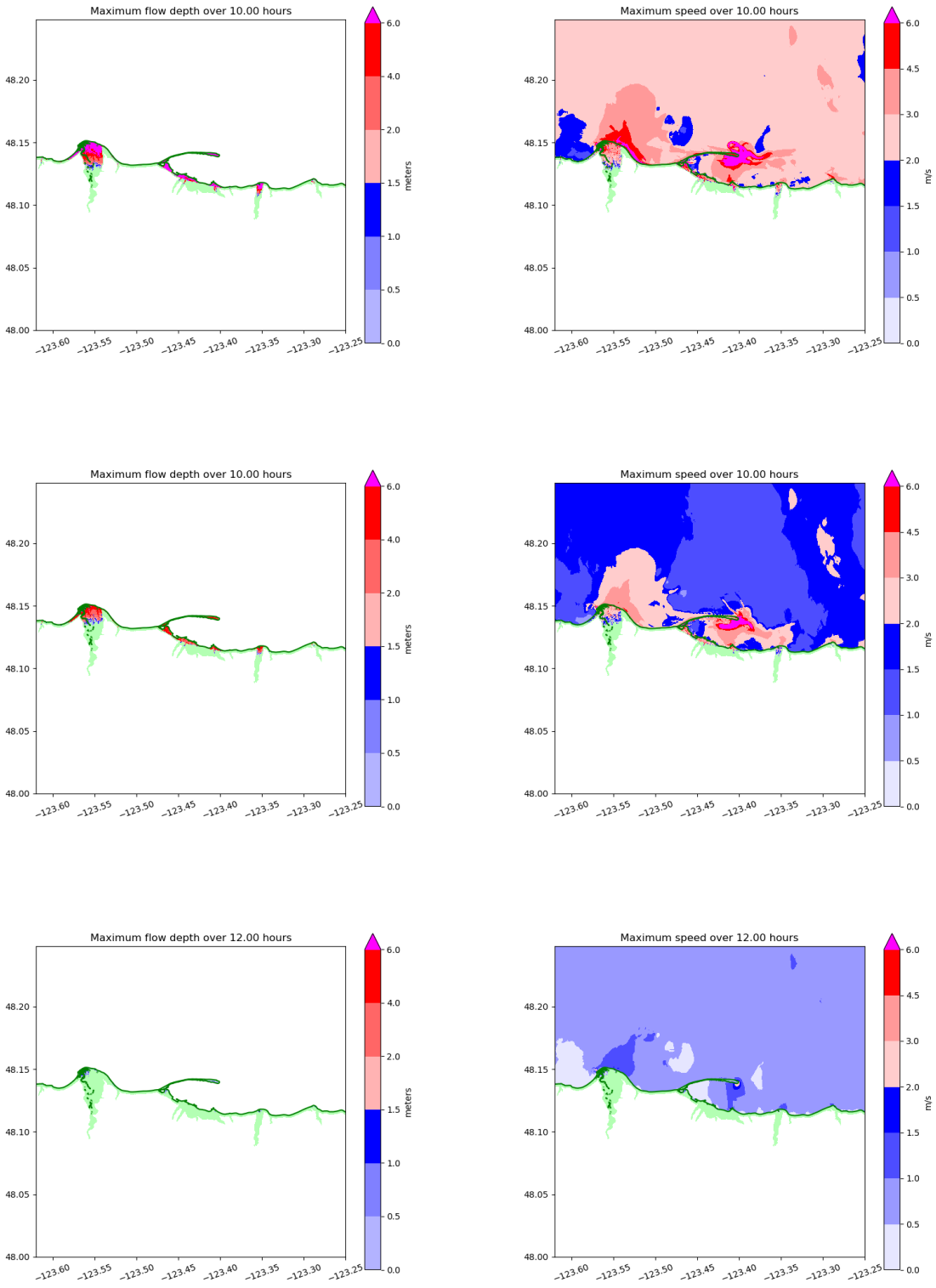


Figure 13: Sample results for the Region `Elwha_PA`. See the description in Section 6.3. Top: CSZ-XL1, Middle: CSZ-L1, Bottom: AKmaxWA. Plots on the left show maximum flooding depth (m) for initially-onshore points, those on the right show maximum flow speed (m/s) for all fgmax points. The fgmax points colored green remained dry in the simulation.

6.4 Region `Dungeness_Sequim`

Figure 5 shows the topography of the fgmax points selected in the `Dungeness_Sequim` region. Figure 14 shows some sample results for this region.

Noteworthy in this region.

- The arrival of the first positive wave (5 cm above MHW) is between 66 to 80 minutes across this region from west to east for the CSZ_L1 and CSZ_XL1 events and between 4 hours and 18 minutes to 4 hours and 29 minutes for AKmaxWA.
- The AKmaxWA source inundates some land on Dungeness Spit but the New Dungeness Lighthouse stays dry. The Flying S Airfield on Jamestown Road in Sequim to inundated to up to 0.5 meters. The other airports in the region stay dry with this source. Also the Jamestown S'Klallam Tribe land on E. Sequim Bay Rd receives no inundation; however there is inundation on land close to US 101 at the south end of Sequim Bay. The PNNL Marine Sciences Laboratory stays dry.
- There are high speeds with the AKmaxWA source off the end of Dungeness Spit and around the Dungeness National Wildlife Refuge.
- Both the CSZ_L1 and CSZ_XL1 sources produce more inundation than AKmaxWA. Both inundate the New Dungeness Lighthouse, the Flying S, and Lucilla's Roost airports. The Marine Sciences Lab and the Jamestown S'Kallam tribal land remain dry, but water now crosses US 101 at the south end of Sequim Bay. There is also high inundation of land at the entrance to Sequim Bay with both these sources.
- The speeds for both CSZ_L1 and CSZ_XL1 were higher than those produced by AKmaxWA. The entrance to Sequim Bay has very high speeds with both sources.
- This region experiences some subsidence with both CSZ_L1 and CSZ_XL1 but none with the AKmaxWA source. The CSZ_L1 subsidence goes from 0.264 to 0.132 meters across this region from west to east. The CSZ_XL1 subsidence is 1.5 times that of CSZ_L1.

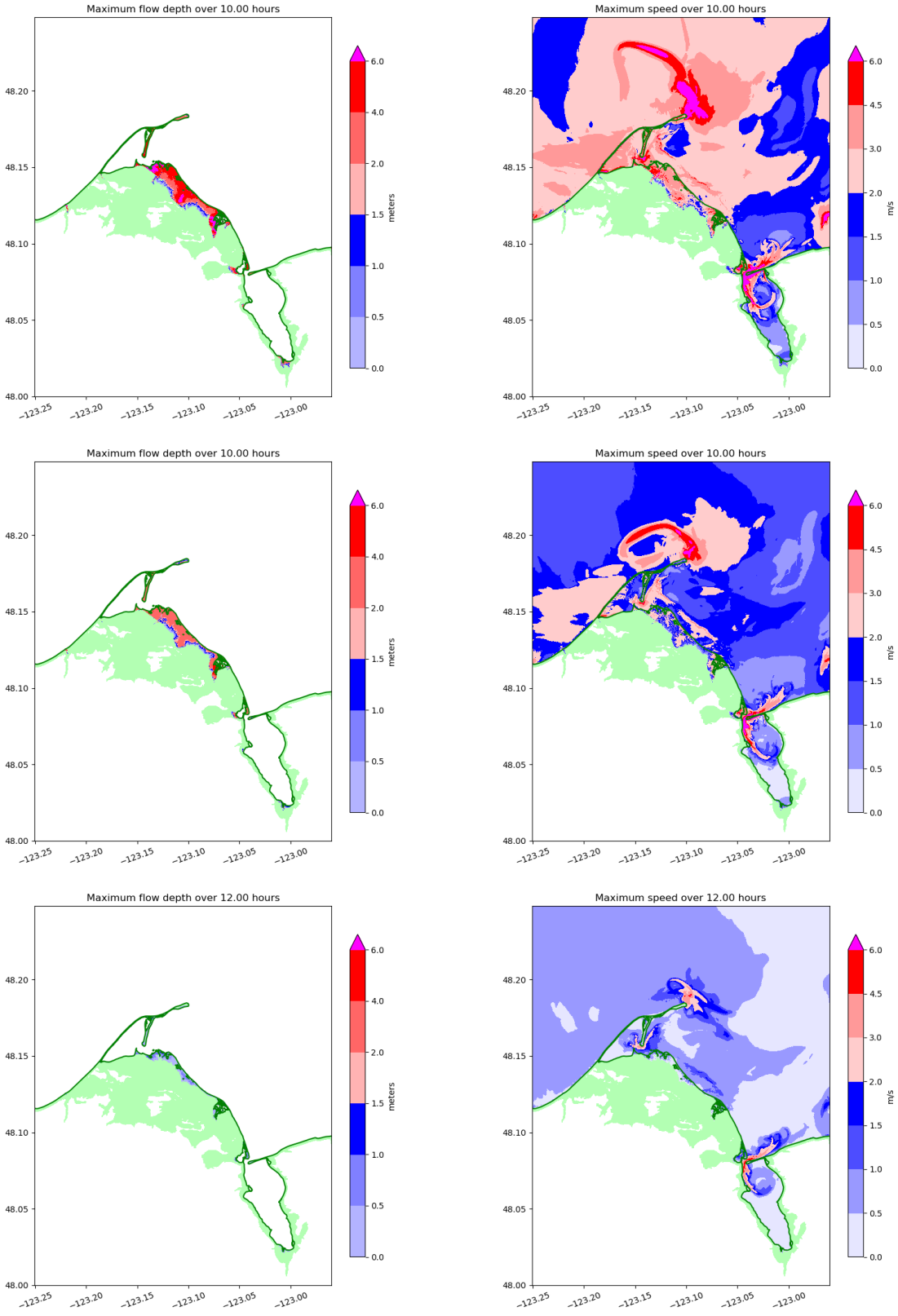


Figure 14: Sample results for the Region `Dungeness_Sequim`. See the description in Section 6.4. Top: CSZ-XL1, Middle: CSZ-L1, Bottom: AKmaxWA. Plots on the left show maximum flooding depth (m) for initially-onshore points, those on the right show maximum flow speed (m/s) for all fgmax points. The fgmax points colored green remained dry in the simulation.

6.5 Region `Discovery_PT`

Figure 6 shows the topography of the fgmax points selected in the `Discovery_PT` region. Figure 15 shows some sample results for this region.

Noteworthy in this region.

- The arrival of the first positive wave (5 cm above MHW) is between 1 hour and 20 minutes to 1 hour and 28 minutes across this region from west to east for the CSZ_L1 and CSZ_XL1 events and between 4 hours and 29 minutes to 4 hours and 37 minutes for AKmaxWA.
- Diamond Point airstrip stays dry for all three events.
- The AKmaxWA source inundates land south of Discovery Bay and US 101. This is of praticular interest as there is a first hand account of flooding at a house during the 1964 Alaska tsunami in these lands told to Carrie Garrison-Laney. Previous modeling did not confirm this for another version of the Alaska 1964 source using older topography. Now we have better lidar data at Discovery Bay's terminus and across US 101 provided to us by WGS for this 2021 modeling. AKmaxWA is thought to be a stronger source than the actual 1964 Alaska source, so it would be interesting to model the best version of the 1964 Alaska source using WGS's new lidar topography to see if inundation would occur at this house, as it does for AKmaxWA. Another intriguing idea is to now search for tsunami deposits south of both Discovery Bay and US 101, particularly near the house.
- There are significant speeds with the AKmaxWA source at the south end of Discovery Bay and the lands across Highway 101 south of Discovery Bay.
- Both the CSZ_L1 and CSZ_XL1 sources produce more inundation than AKmaxWA. The inundation for CSZ_L1 goes south of Discovery Bay and US 101 to latitude 47.97 and that for CSZ_XL1 goes to latitude 47.966.
- The speeds for both CSZ_L1 and CSZ_XL1 were higher than those produced by AKmaxWA in the marshy areas at Discovery Bay's terminus and across US 101 south of Discovery Bay.
- This region experiences very little subsidence with both CSZ_L1 and CSZ_XL1 but none with the AKmaxWA source. The CSZ_L1 subsidence goes from 0.132 to 0.018 meters across this region from west to east. The CSZ_XL1 subsidence is 1.5 times that of CSZ_L1.

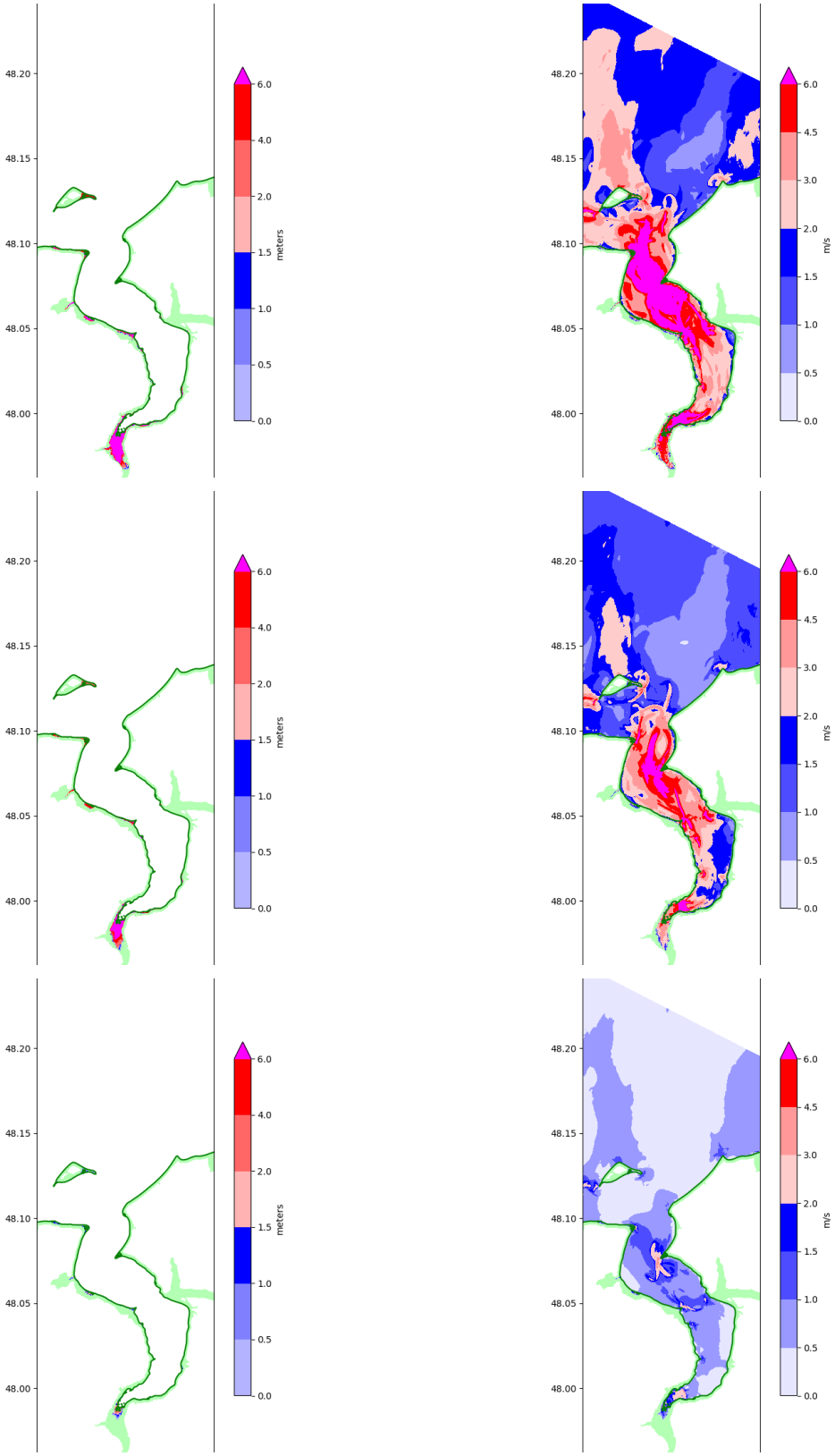


Figure 15: Sample results for the Region `Discovery_PT`. See the description in Section 6.5. Top: CSZ-XL1, Middle: CSZ-L1, Bottom: AKmaxWA. Plots on the left show maximum flooding depth (m) for initially-onshore points, those on the right show maximum flow speed (m/s) for all fgmax points. The fgmax points colored green remained dry in the simulation.

7 Results – Gauge output

Figures 16–20 show the location of the simulated gauges used to capture time series of the flow depth / surface elevation and of the current velocity over the course of each simulation, as specified by WGS and summarized in Tables 2 and 3. All of the gauges (except gauges 1 to 4) fall within at least one of the 1/3" by 1/3" *fgmax regions* listed in Table 1, and the time series for these were calculated from the run in each fgmax region containing the gauge. Most were only in one region, but Gauges 190, 191, and 192 were placed in the overlap between `Chito_Sekiu` and `Butler_Crescent`. Gauges 290, 291, and 292 were in the overlap between `Butler_Crescent` and `Elwha_PA`. Gauges 390, 391, and 392 were in the overlap between `Elwha_PA` and `Dungeness_Sequim` and Gauges 490, 491, and 492 were in the overlap between `Dungeness_Sequim` and `Discovery_PT`. Comparisons at these gauges were used to confirm consistency between the different runs, and plots are provided in Appendix C below. Gauges 1 to 4 were the same gauges used in the Flattery region for the 2020 modeling and were included here to make comparisons with our results. These four gauges were 2" resolution and were just west of the `Chito_Sekiu` region.

Gauges 1–4 were used only to compare against the results reported in the 2020 Tsunami Hazard Assessment of the Northwestern Coast of Washington [12]. In that work these gauges are found in the fgmax region labelled `Flattery` and gauge plots can be found there for simulations in which the surrounding region was refined to 1/3". In the present work, these gauges were simulated in the runs for fgmax region `Chito_Sekiu`, but they are not in the region refined fully to 1/3". We did confirm that the results are nevertheless consistent with the previous simulations. These gauge plots are not included here.

The figures starting on page 37 show time series output from the remaining synthetic gauges. For each gauge, the figures show the surface elevation and speed, for each of the three events. The speed is shown both as a time series of speed $\sqrt{u^2 + v^2}$ vs. time, and also in the u–v plane as the red curve in the lower right plot for each event. This plot allows one to see how the E–W component u of the speed compares to the N–S component v, and for some gauge locations shows a strong dominant direction of the current. At other gauges the speed is less strongly one-dimensional.

Note that the vertical scale for each surface elevation and speed plot varies between locations and events in order to clearly show the results, and is set by the maximum amplitude in each case.

Examining these gauges gives an indication that the run times chosen for these simulations were sufficiently long to capture the maximum depth and speed at each point.

No.	Longitude	Latitude	Location	Region
1	-124.60000000	48.41000000	Water North of Neah Bay	CS
2	-124.53083333	48.34907407	Bullman Beach	CS
3	-124.54648148	48.35324074	Snow Ck Resort Beach	CS
4	-124.53203704	48.34833333	Rt 112 near Bullman Beach	CS
90	-124.52027778	48.34620370	Land between Flattery and Chito_Sekiu	CS
91	-124.52027778	48.37657407	Off shore between Flattery and Chito_Sekiu	CS
92	-124.52027778	48.42759259	Middle Strait between Flattery and Chito_Sekiu	CS
101	-124.42833333	48.30518519	Chito Beach Resort	CS
102	-124.28175926	48.26101852	Callam Bay	CS
103	-124.30101852	48.26277778	Rice and Front St Sekiu	CS
104	-124.39444444	48.28916667	Sekiu River Entrance	CS
105	-124.37314815	48.28546296	Offshore Vista Dr	CS
106	-124.36416667	48.28759259	Hoko River Entrance	CS
107	-124.29851852	48.26425926	Olsens Marina	CS
108	-124.28148148	48.25787037	Clallam Bay Marina east	CS
109	-124.28416667	48.25861111	Clallam Bay Marina west	CS
110	-124.26740741	48.25462963	Clallam Bay State Park	CS
111	-124.25342593	48.26027778	Offshore Salt Air St	CS
112	-124.10768519	48.20388889	Pysht River Entrance	CS
113	-124.21462963	48.25259259	Slip Point Beach 426	CS
114	-124.33490741	48.27583333	Sekiu Point Beach 427	CS
190	-124.09166667	48.19638889	Land between Chito_Sekiu and Butler_Crescent	CS
191	-124.09166667	48.20592593	Off shore between Chito_Sekiu and Butler_Crescent	CS
192	-124.09166667	48.27703704	Middle Strait between Chito_Sekiu and Butler_Crescent	CS
201	-124.06333333	48.18611111	Mr Jim Road end	BC
202	-123.78166667	48.15537037	Whiskey Creek Beach	BC
203	-123.71166667	48.15944444	Crescent Beach RV Park	BC
204	-123.71750000	48.16296296	Crescent Bay	BC
205	-124.03925926	48.17555556	Pillar Point Beach 424	BC
206	-124.00787037	48.17212963	Twin Rivers Beach 423	BC
207	-123.94870370	48.16574074	Twin Rivers Beach 423a	BC
208	-123.91555556	48.15962963	Twin Rivers Beach 422	BC
209	-123.83250000	48.15787037	Low Point Community Beach	BC
210	-123.79731481	48.15620370	Agate Bay Beach 421	BC
211	-123.76138889	48.16018519	Agate Bay Beach 420	BC
212	-123.69777778	48.16583333	Salt Creek Recreation Area	BC
213	-123.63935185	48.14462963	Freshwater Bay Boat Launch	BC
290	-123.61962963	48.13824074	Land between Butler_Crescent and Elwha_PA	BC
291	-123.61962963	48.19500000	Off shore between Butler_Crescent and Elwha_PA	BC
292	-123.61962963	48.24500000	Middle Strait between Butler_Crescent and Elwha_PA	BC

Table 2: Location of synthetic gauges, see also the maps in Figures 16–20. For each gauge we indicate in column "Region" which of the runs is used to compute the best gauge output. The notation CS, BC, EP, DS, and DP are used in this column to denote Chito_Sekiu, Butler_Crescent, Elwha_PA, Dungeness_Sequim, and Discovery_PT, respectively.

No.	Longitude	Latitude	Location	Region
301	-123.54851852	48.14425926	Lower Elwha Health Clinic	EP
302	-123.41092593	48.14027778	Coast Guard Station, Ediz Hook	EP
303	-123.39805556	48.13916667	water East of Ediz Hook	EP
304	-123.42861111	48.12222222	water by PA ferry terminal	EP
305	-123.58166667	48.13759259	Freshwater Bay Beach	EP
306	-123.56953704	48.14824074	Elwha River Entrance	EP
307	-123.56259259	48.13981481	Elwha River lower	EP
308	-123.55935185	48.12787037	Elwha River middle	EP
309	-123.55435185	48.12120370	Elwha River upper	EP
310	-123.54824074	48.14981481	Beach N of Lower Elwha Clinic	EP
311	-123.53351852	48.14388889	Dry Creek Beach	EP
312	-123.46842593	48.13546296	Port Angeles Paper Mill	EP
313	-123.41370370	48.13944444	Port Angeles USCG Station	EP
314	-123.43055556	48.12203704	Port Angeles Ferry Terminal	EP
315	-123.45259259	48.12629630	Port Angeles Boat Haven Entrance	EP
316	-123.45055556	48.12444444	Port Angeles Boat Haven east	EP
317	-123.45657407	48.12685185	Port Angeles Boat Haven west	EP
318	-123.45370370	48.12509259	Port Angeles Boat Haven south	EP
319	-123.35407407	48.11759259	Offshore Four Seasons Ranch	EP
320	-123.29379630	48.11981481	West Green Point	EP
390	-123.25037037	48.11574074	Land between `Elwha_PA` and `Dungeness_Sequim`	EP
391	-123.25037037	48.15796296	Off shore between `Elwha_PA` and `Dungeness_Sequim`	EP
392	-123.25037037	48.24518519	Middle Strait between `Elwha_PA` and `Dungeness_Sequim`	EP
401	-123.11018519	48.18175926	Dungeness Lighthouse	DS
402	-123.00611111	48.02231481	Blyn	DS
403	-123.04370370	48.07935185	Entrance Sequim Bay	DS
404	-123.03888889	48.06277778	Sequim Bay Marina	DS
405	-123.08722222	48.12796296	Cemetery Rd-Jamestown Rd	DS
406	-123.18444444	48.15064815	Dungeness Spit west	DS
407	-123.14472222	48.15212963	Dungeness Bay Boat Launch	DS
408	-123.11629630	48.15157407	Offshore Brandt Point	DS
490	-122.96027778	48.09759259	Land between `Dungeness_Sequim` and `Discovery_PT`	DS
491	-122.96027778	48.11685185	Off shore between `Dungeness_Sequim` and `Discovery_PT`	DS
492	-122.96027778	48.23203704	Middle Strait between `Dungeness_Sequim` and `Discovery_PT`	DS
501	-122.86185185	48.00824074	WorldMark, Discovery Bay	DP
502	-122.88944444	47.98870370	River south side Hwy 101 end of Discovery Bay	DP
503	-122.88824074	47.99027778	Marsh north side Hwy 101 end of Discovery Bay	DP
504	-122.89120370	48.07675926	Beckett Point Rd, Discovery Bay	DP
505	-122.82962963	48.04842593	Adelma Beach, Discovery Bay	DP
506	-122.91472222	48.09472222	Offshore Diamond Point	DP
507	-122.88444444	48.10166667	Cape George Marina Entrance	DP
508	-122.88398148	48.10657407	Offshore Cape George	DP
509	-122.92083333	48.12620370	Protection Island	DP
510	-122.92009259	48.12805556	Protection Island dock	DP
590	-122.80518519	48.13879630	Beach between `Discovery_PT` and previous PT project	DP
591	-122.80518519	48.16212963	Off shore between `Discovery_PT` and previous PT project	DP
592	-122.80518519	48.19370370	Middle Strait between `Discovery_PT` and previous PT project	DP

Table 3: Location of synthetic gauges, see also the maps in Figures 16–20. For each gauge we indicate in column "Region" which of the runs is used to compute the best gauge output. The notation CS, BC, EP, DS, and DP are used in this column to denote `Chito_Sekiu`, `Butler_Crescent`, `Elwha_PA`, `Dungeness_Sequim`, and `Discovery_PT`, respectively.

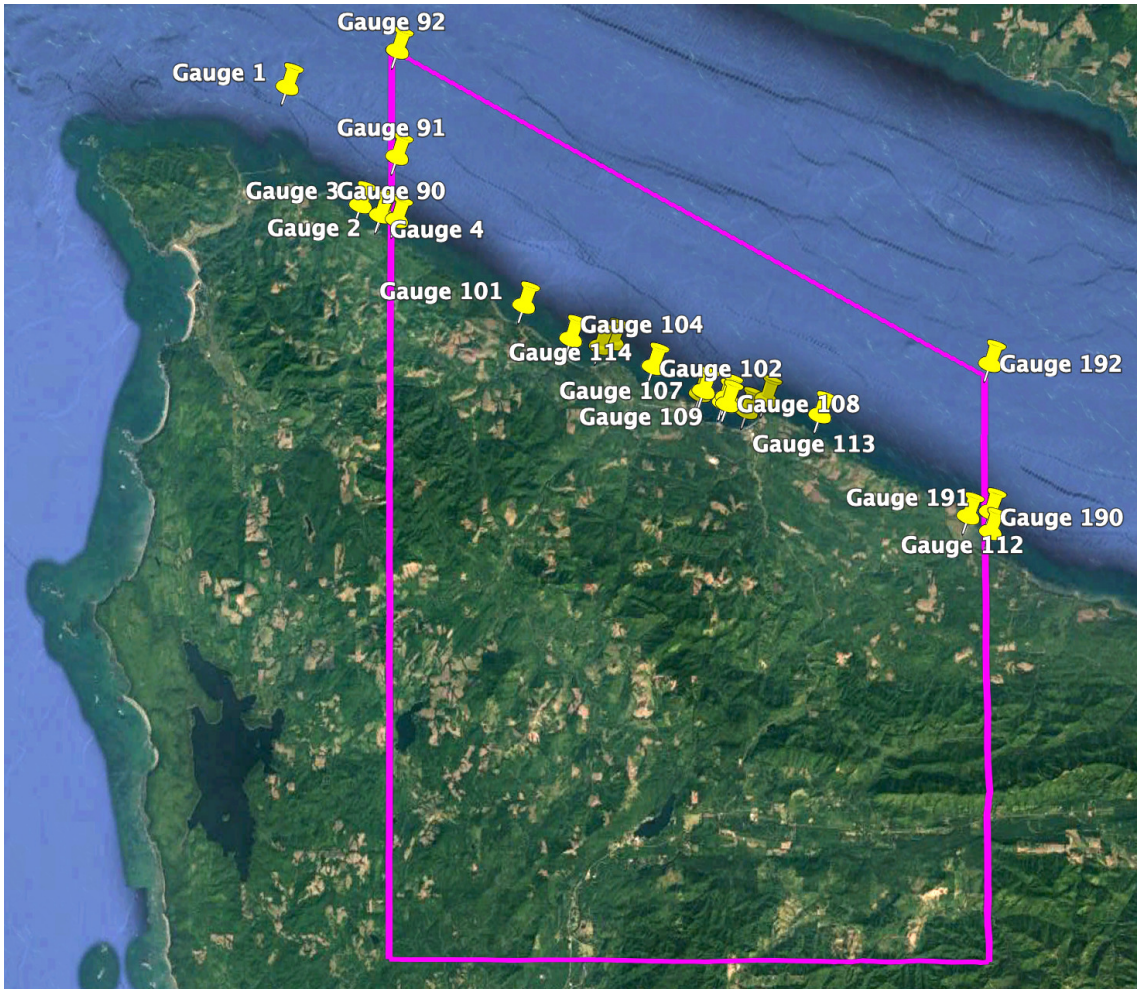


Figure 16: Synthetic gauge locations used in the `Chito_Sekiu` fgmax region. Imagery from Google Earth.

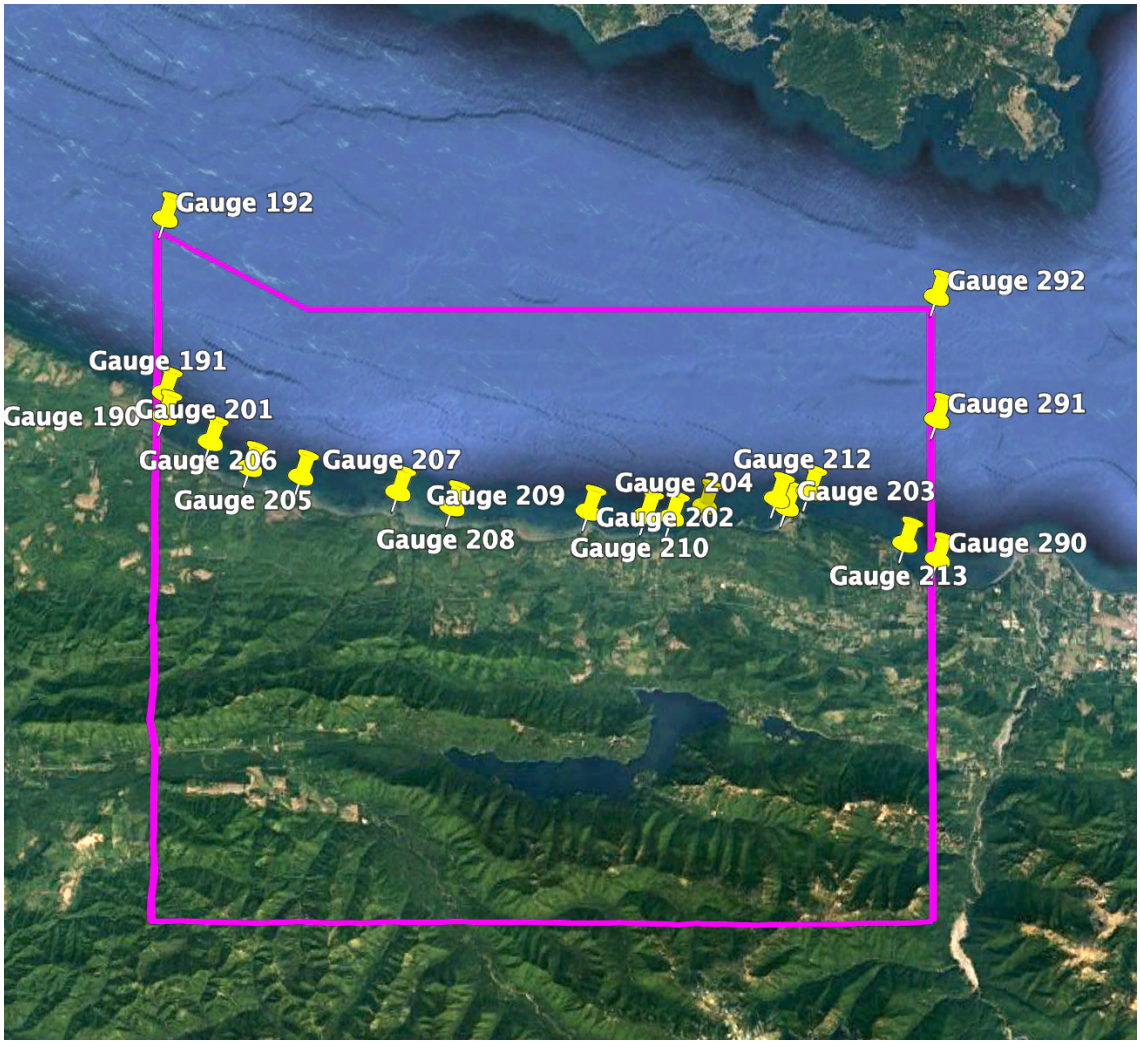


Figure 17: Synthetic gauge locations used in the `Butler_Crescent` fgmax region. Imagery from Google Earth.

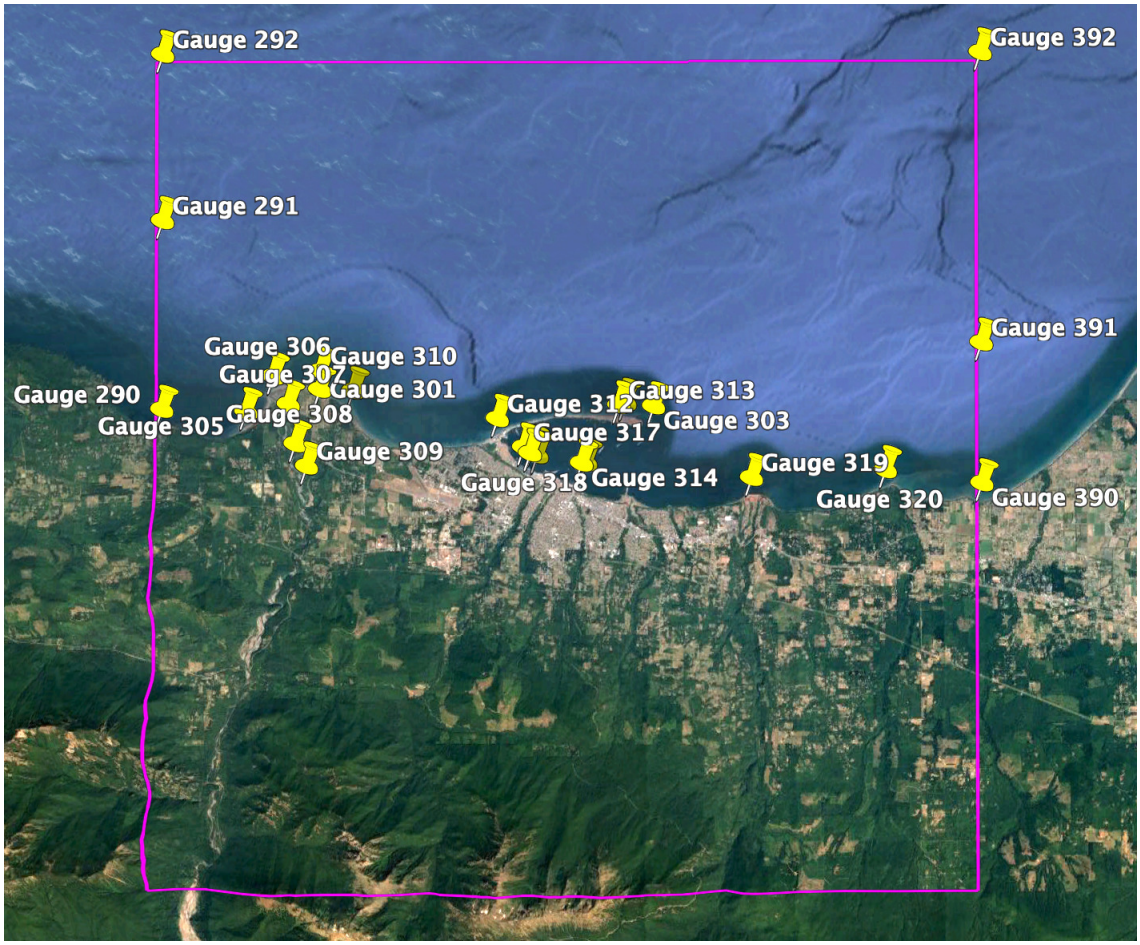


Figure 18: Synthetic gauge locations used in the `Elwha_PA` fgmax region. Imagery from Google Earth.

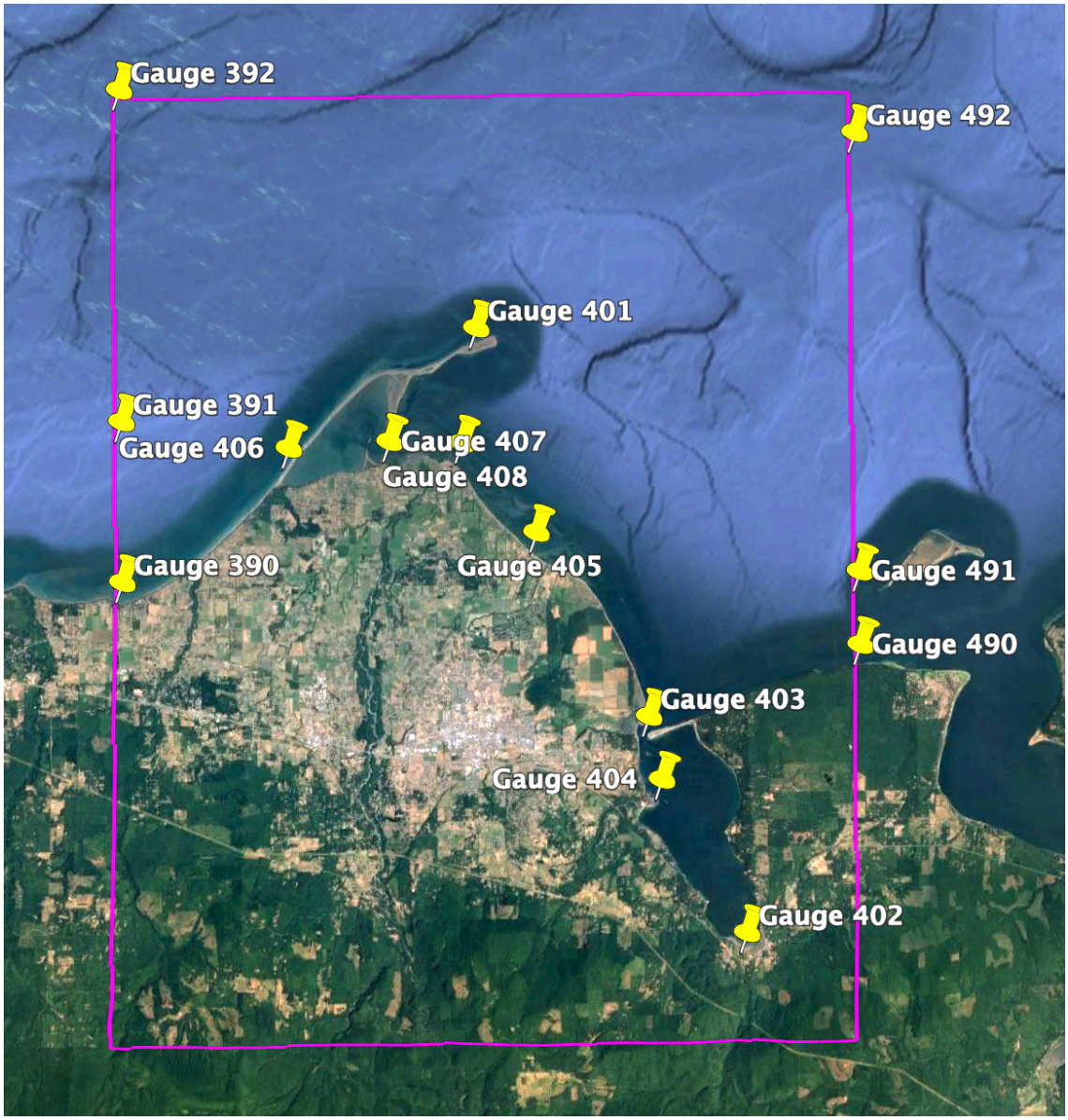


Figure 19: Synthetic gauge locations used in the `Dungeness_Sequim` fgmax region. Imagery from Google Earth.

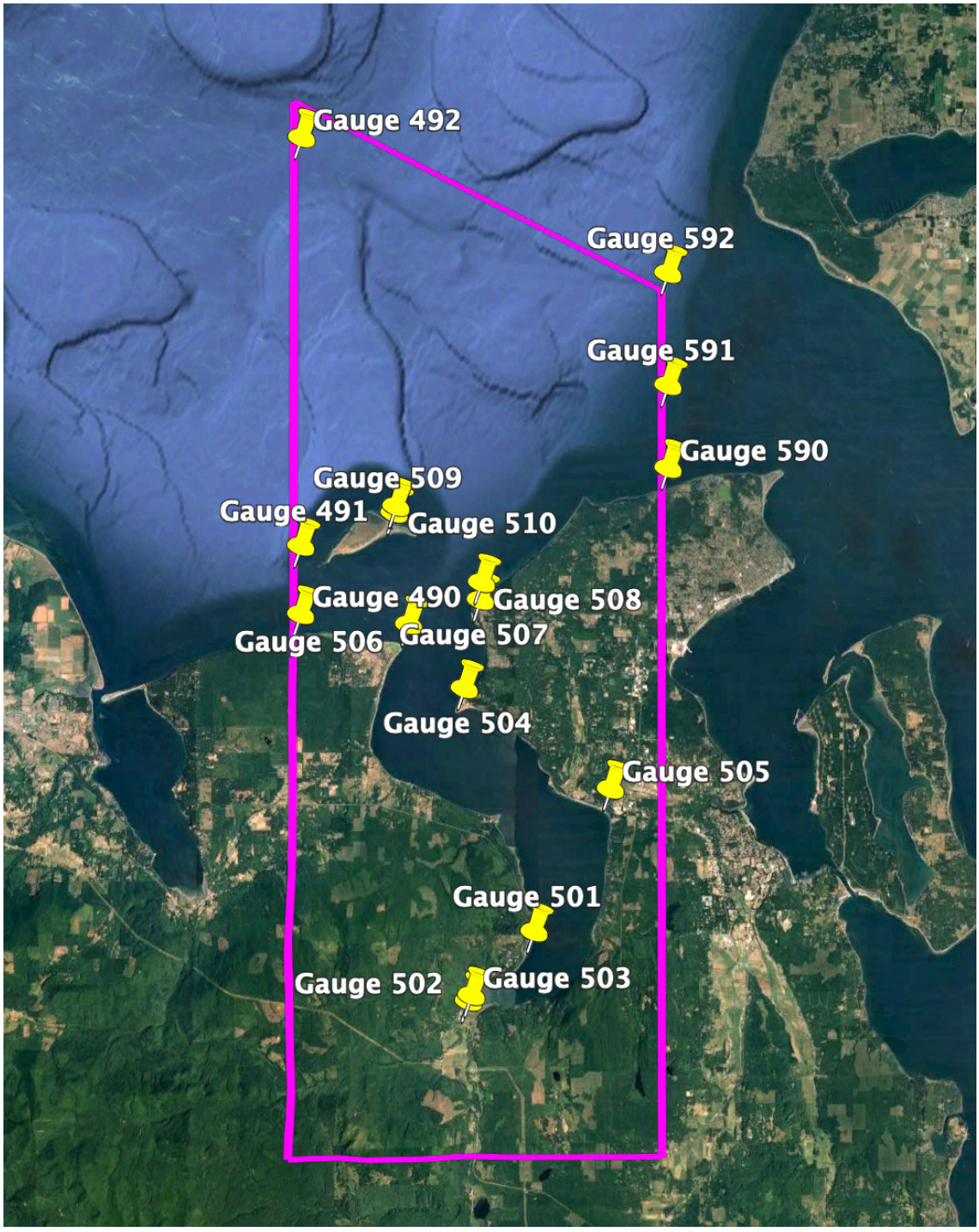
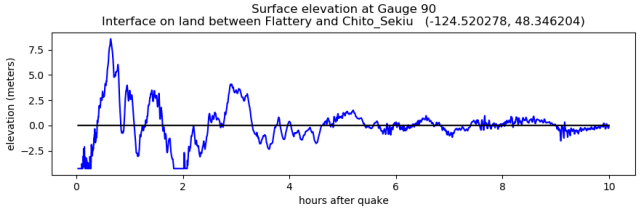


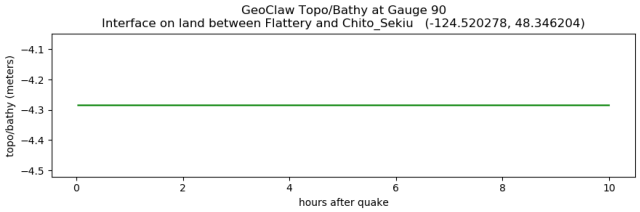
Figure 20: Synthetic gauge locations used in the `Discovery_PT` fgmax region. Imagery from Google Earth.

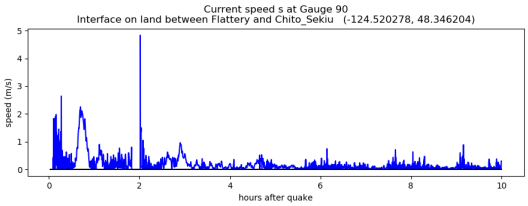
Gauge 90: Interface on land between Flattery and Chito_Sekiu.

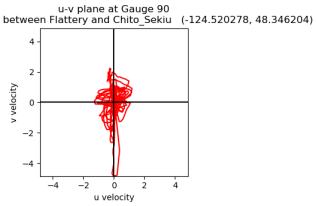
Computed on region Chito_Sekiu.

CSZ XL1 event:

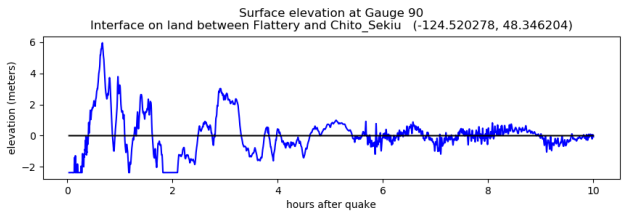


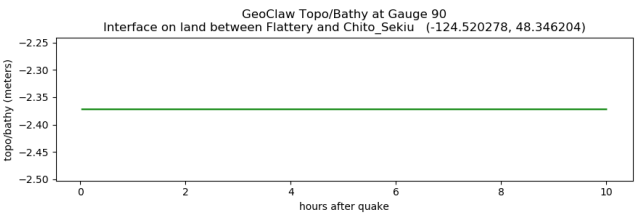


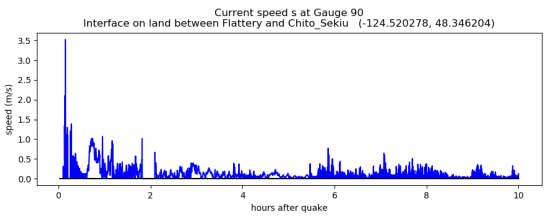


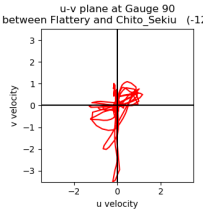


CSZ L1 event:

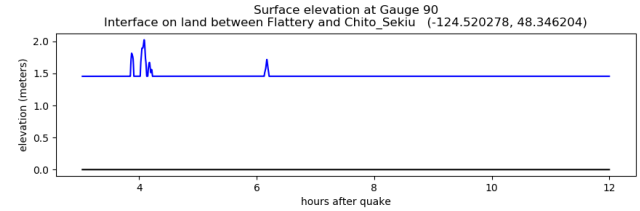


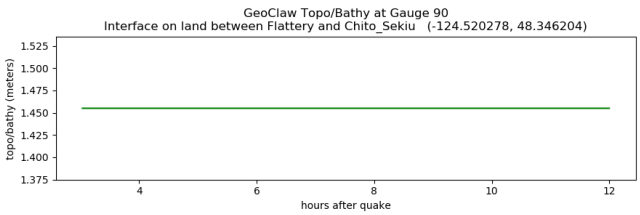


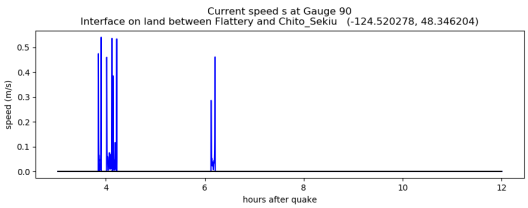


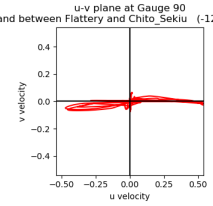


AKmaxWA event:





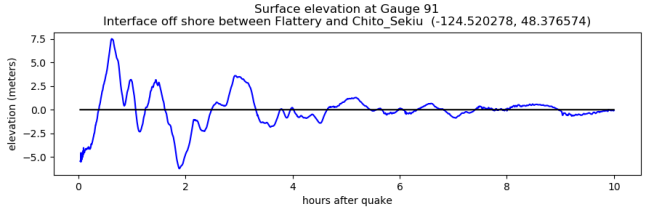


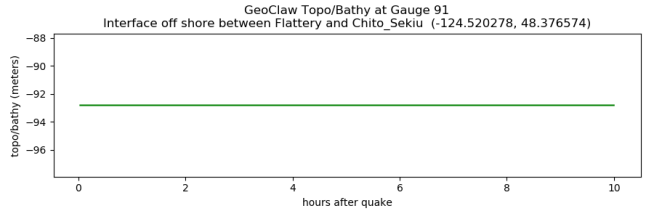


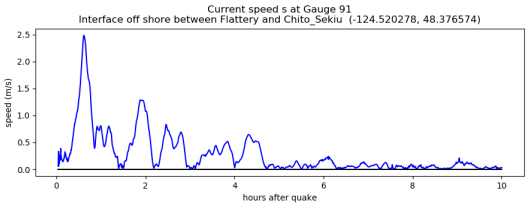
Gauge 91: Interface off shore between Flattery and `Chito_Sekiu`.

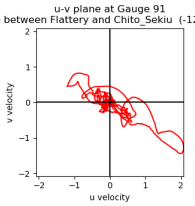
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

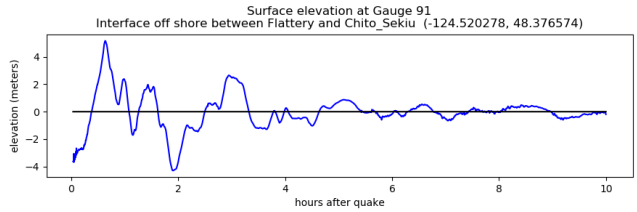


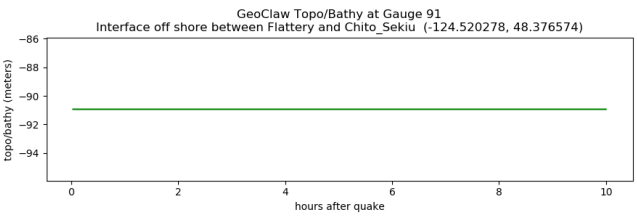


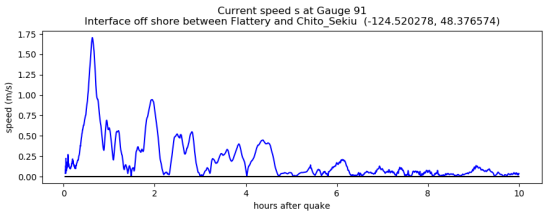


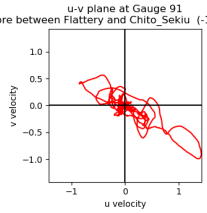


CSZ L1 event:

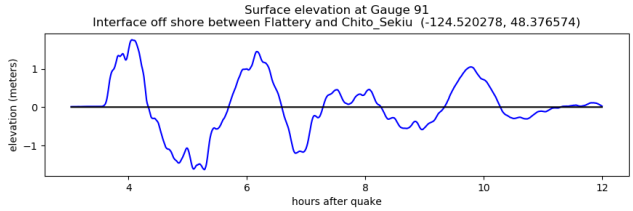


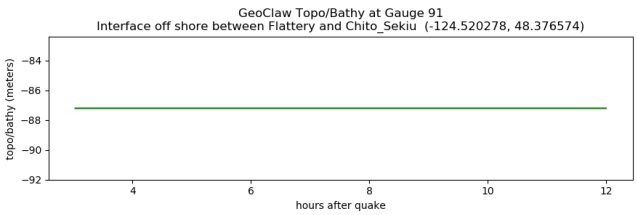


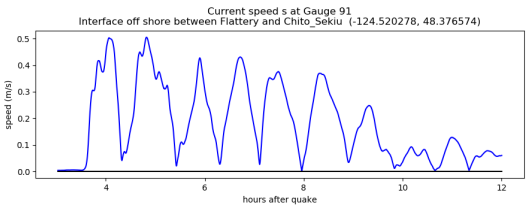


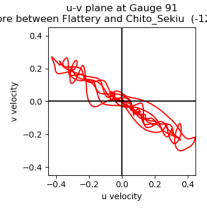


AKmaxWA event:





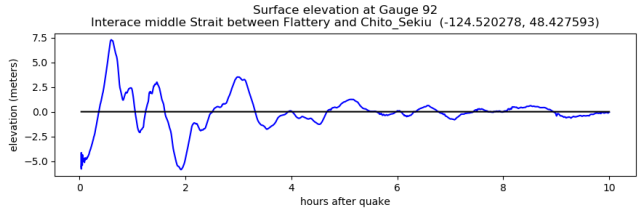


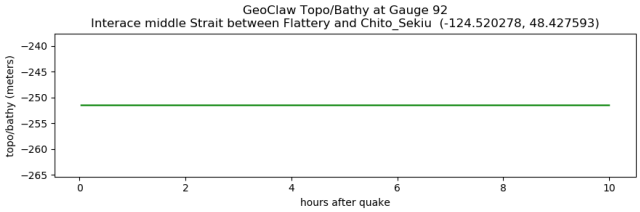


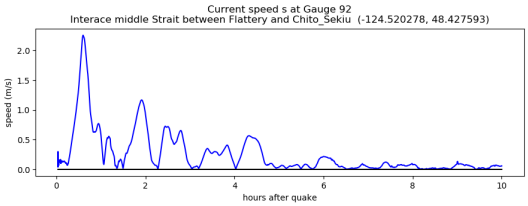
Gauge 92: Interface middle Strait between Flattery and `Chito_Sekiu`.

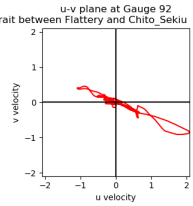
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

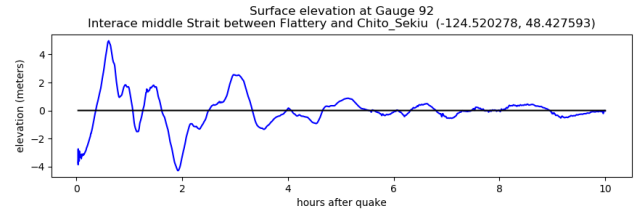


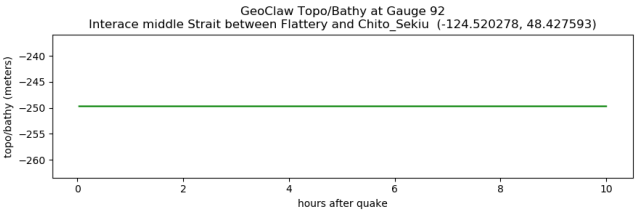


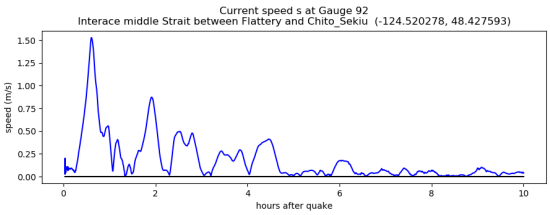


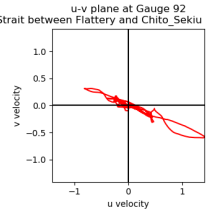


CSZ L1 event:

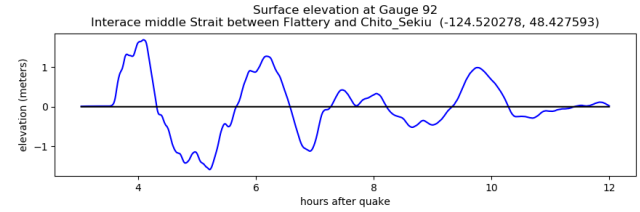


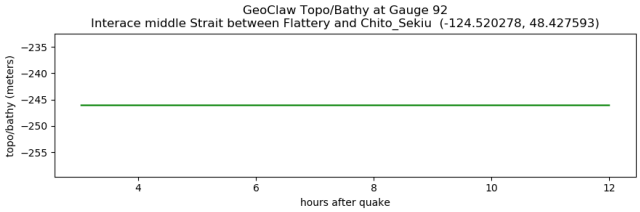


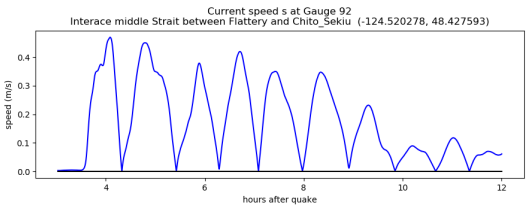


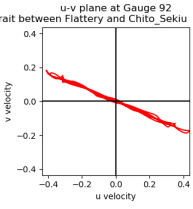


AKmaxWA event:





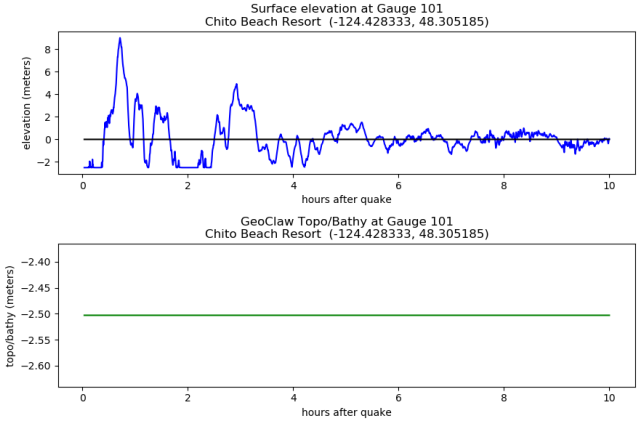


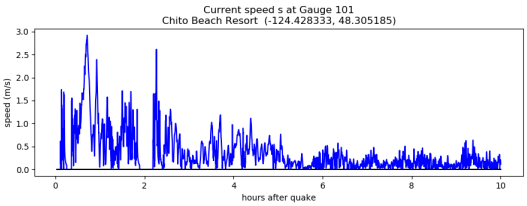


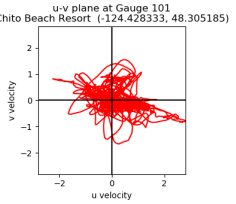
Gauge 101: Chito Beach Resort.

Computed on region `Chito_Sekiu`.

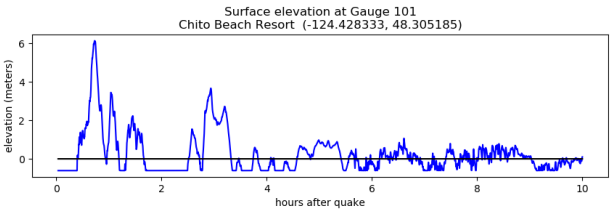
CSZ XL1 event:

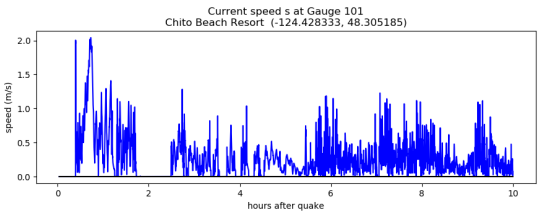


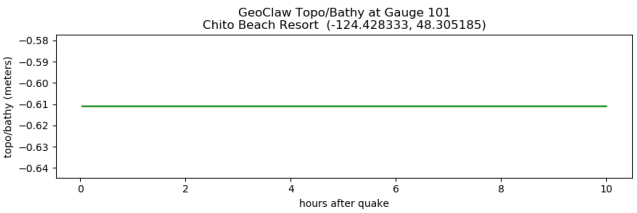


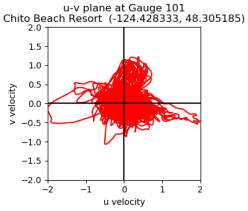


CSZ L1 event:

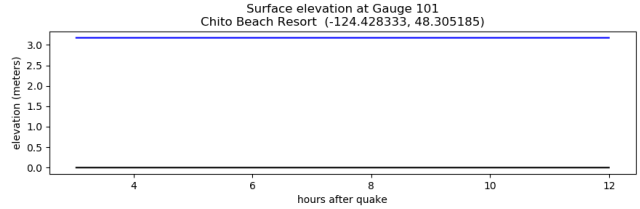


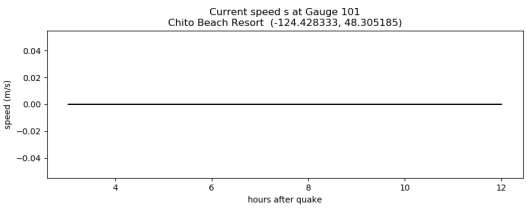


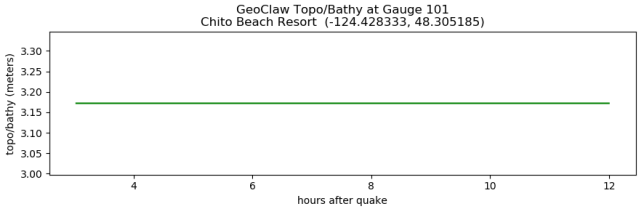


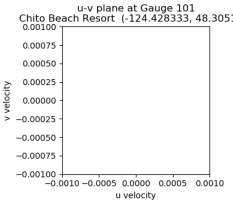


AKmaxWA event:





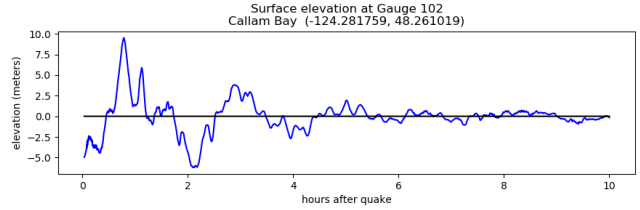


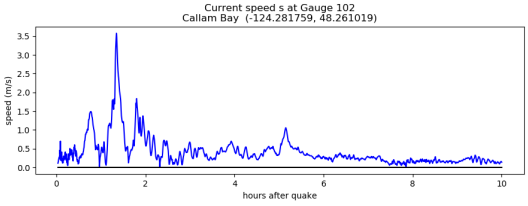


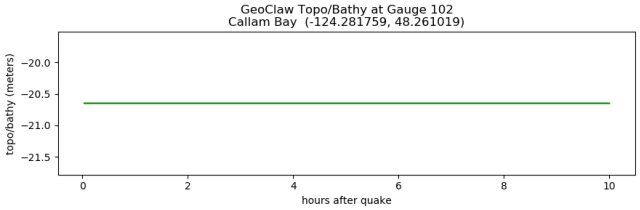
Gauge 102: Callam Bay.

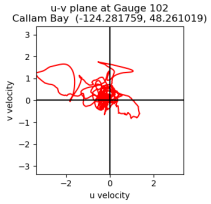
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

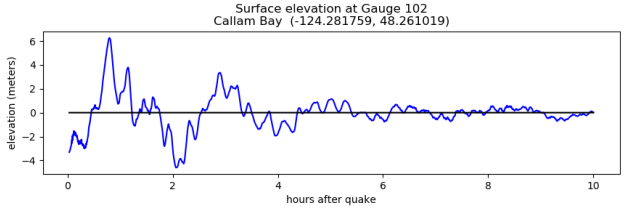


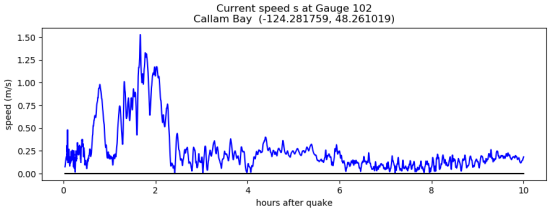


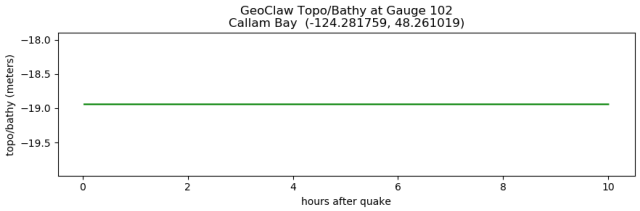


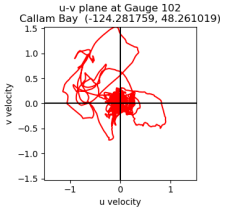


CSZ L1 event:

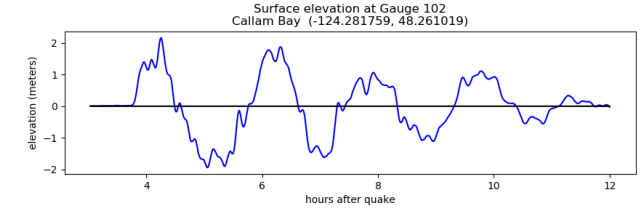


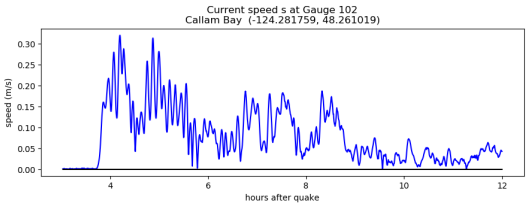


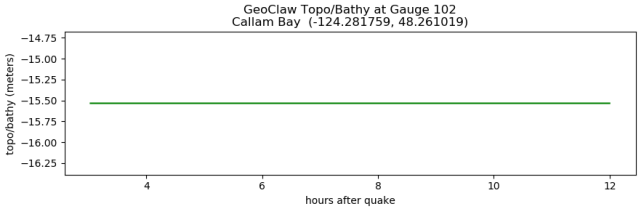


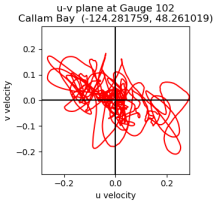


AKmaxWA event:





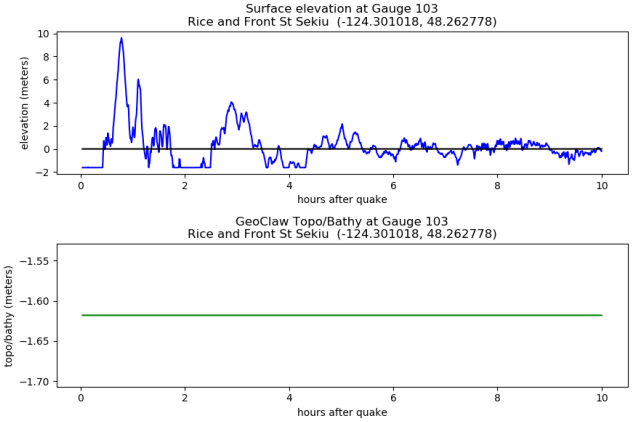


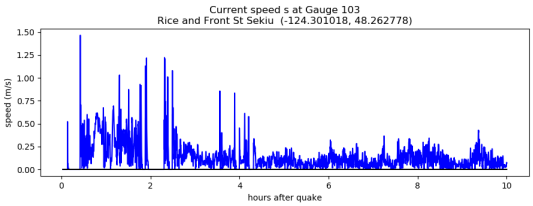


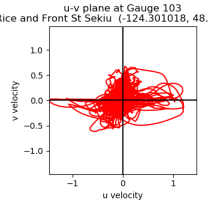
Gauge 103: Rice and Front St Sekiu.

Computed on region `Chito_Sekiu`.

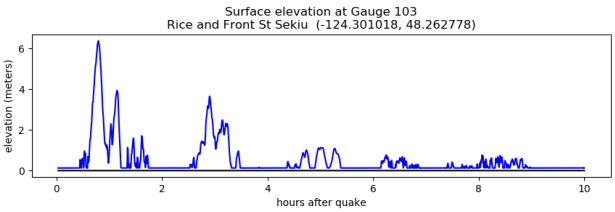
CSZ XL1 event:

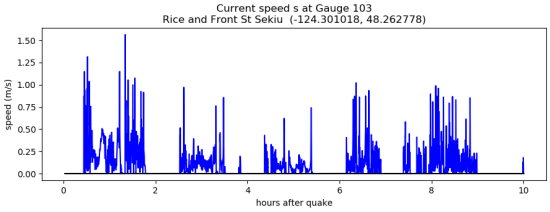


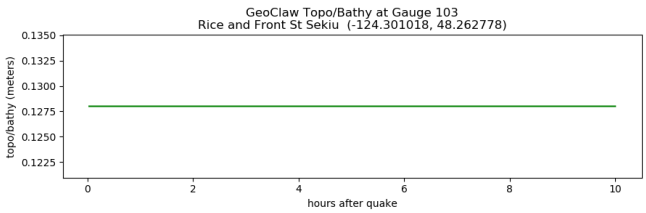


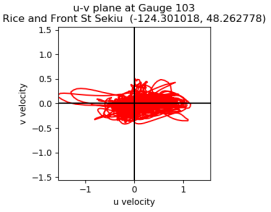


CSZ L1 event:

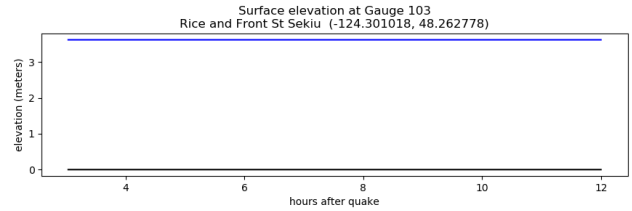


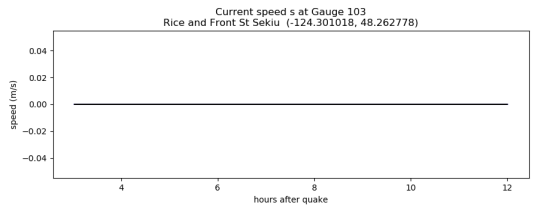


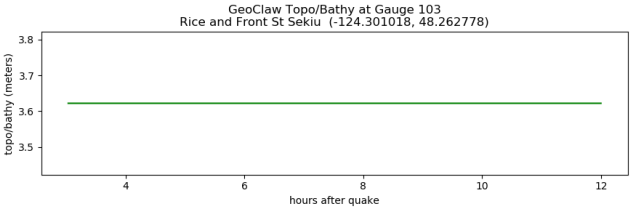


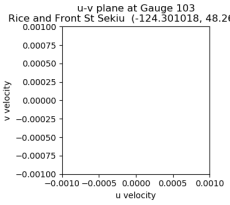


AKmaxWA event:





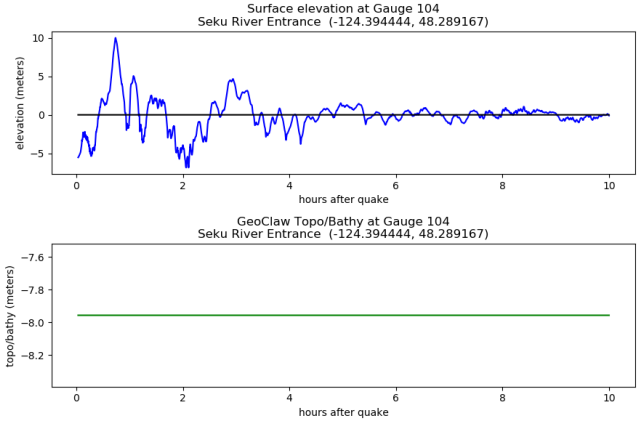


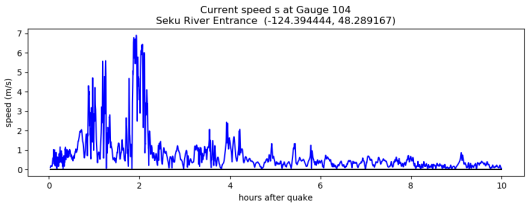


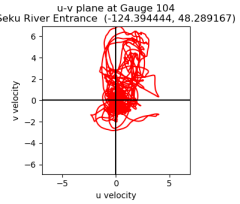
Gauge 104: Sekiu River Entrance.

Computed on region `Chito_Sekiu`.

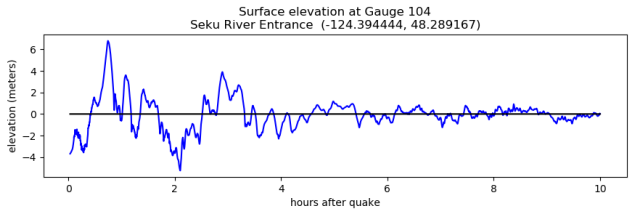
CSZ XL1 event:

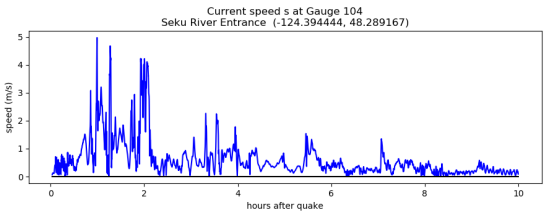


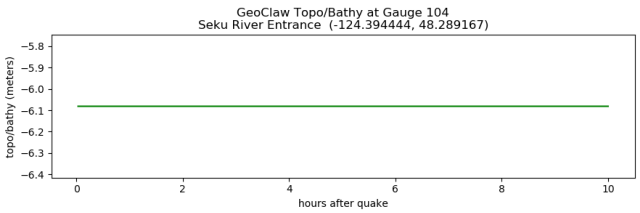


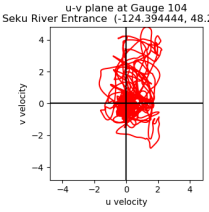


CSZ L1 event:

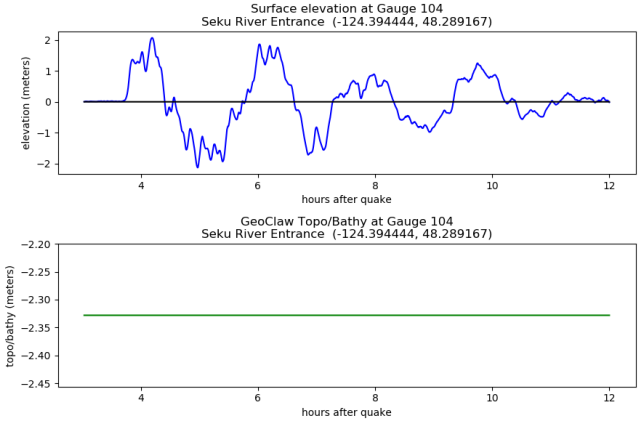


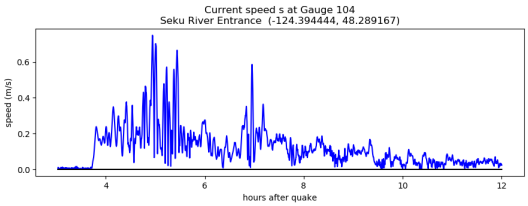


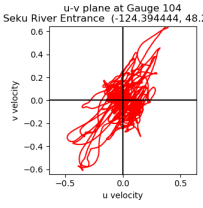




AKmaxWA event:



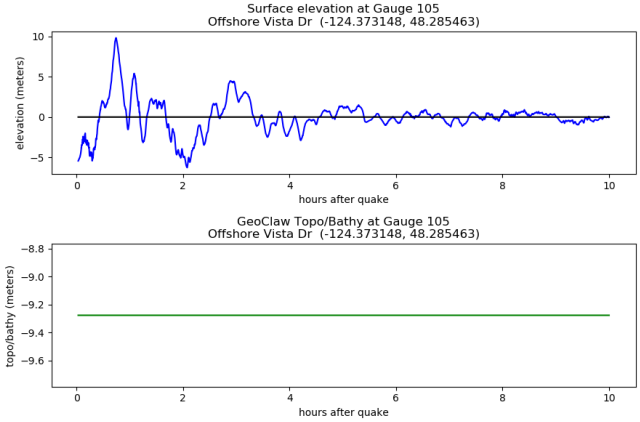


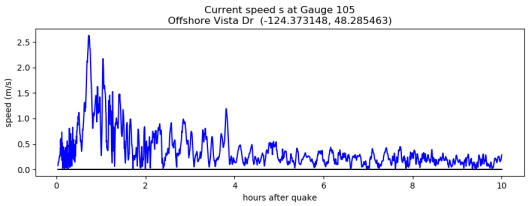


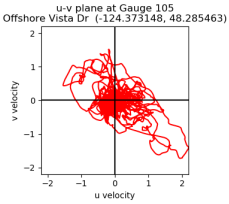
Gauge 105: Offshore Vista Dr.

Computed on region `Chito_Sekiu`.

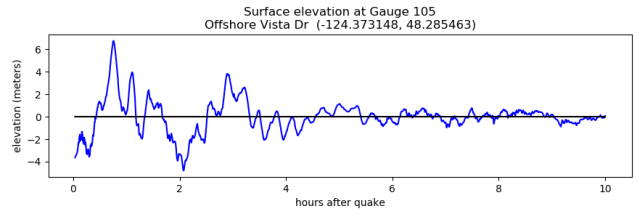
CSZ XL1 event:

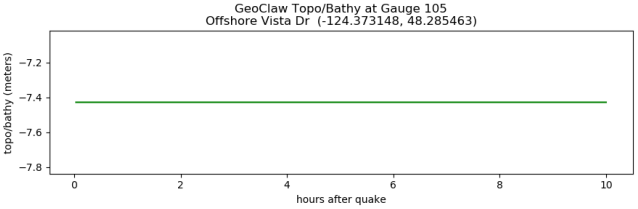


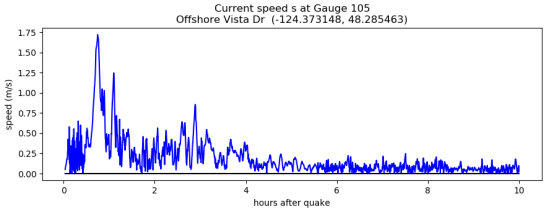


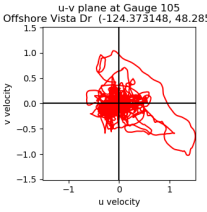


CSZ L1 event:

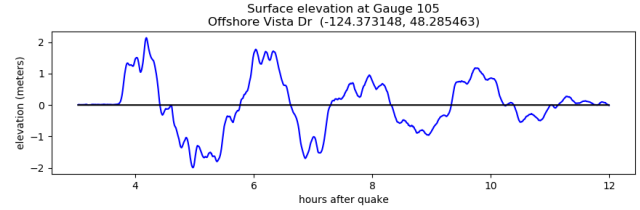


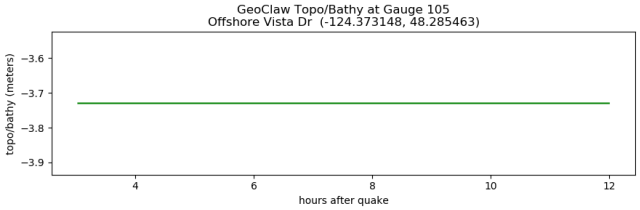


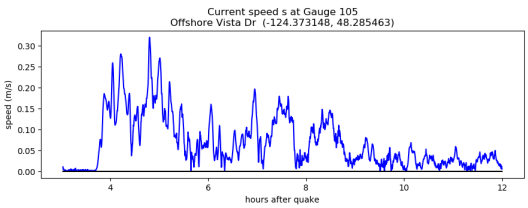


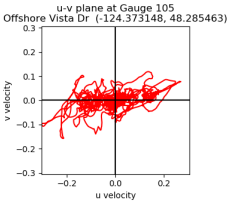


AKmaxWA event:





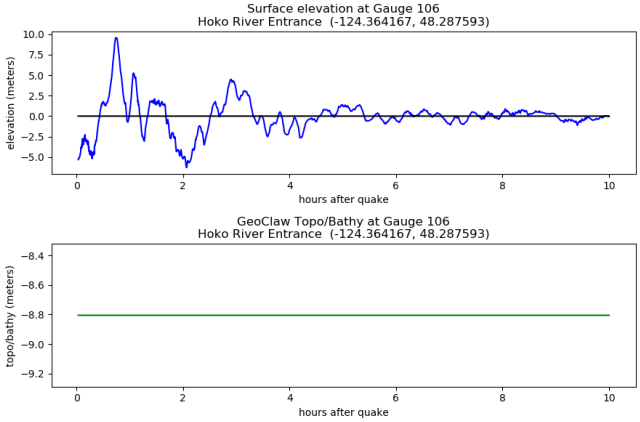


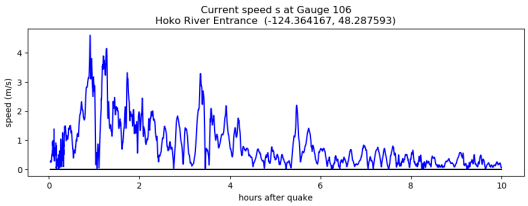


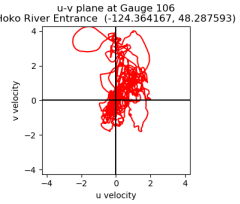
Gauge 106: Hoko River Entrance.

Computed on region `Chito_Sekiu`.

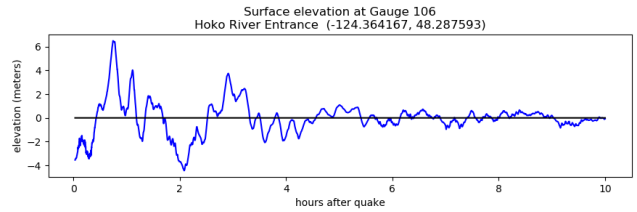
CSZ XL1 event:

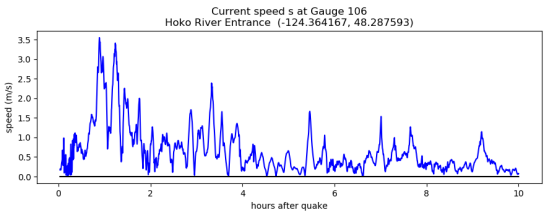


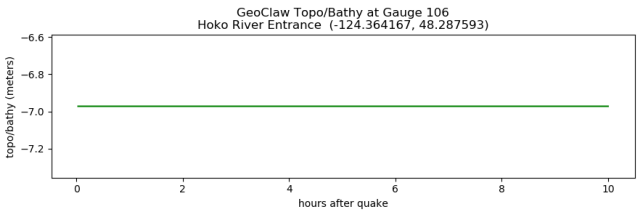


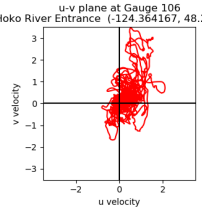


CSZ L1 event:

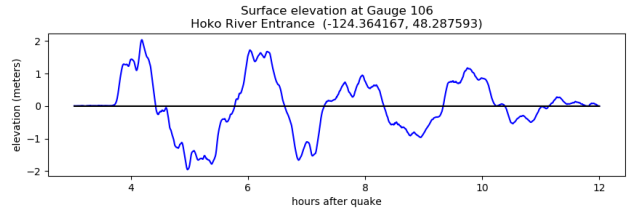


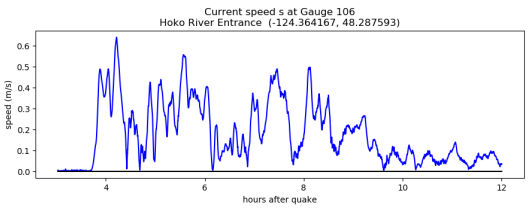


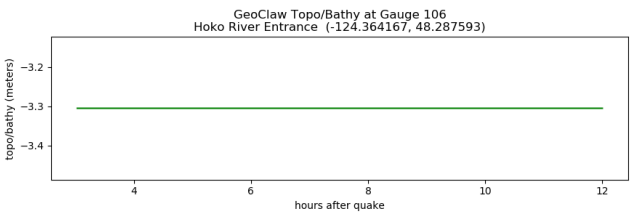


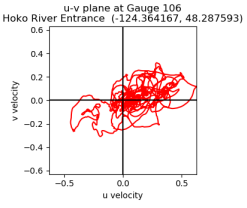


AKmaxWA event:





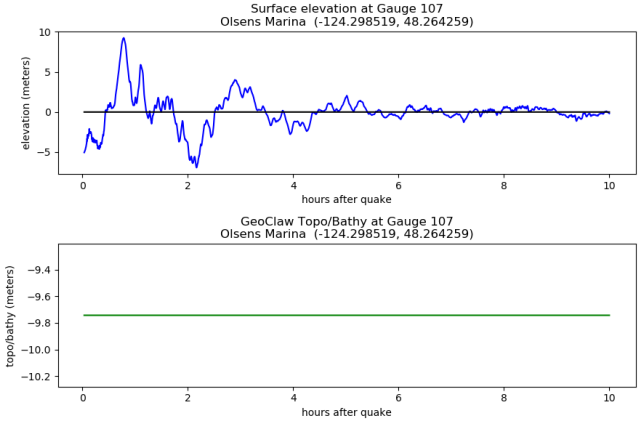


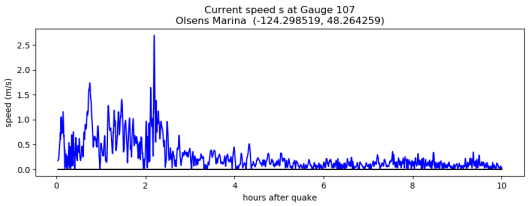


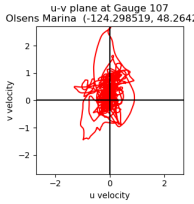
Gauge 107: Olsens Marina.

Computed on region `Chito_Sekiu`.

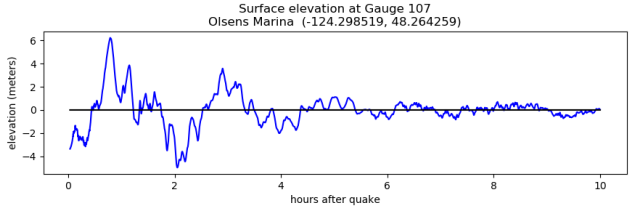
CSZ XL1 event:

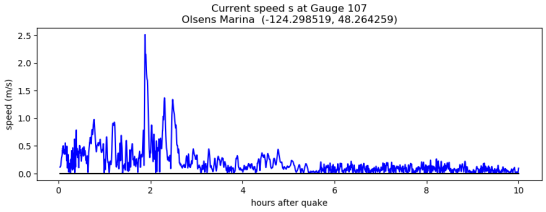


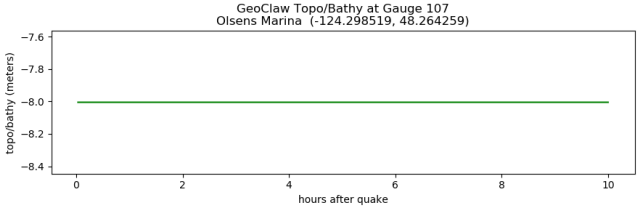


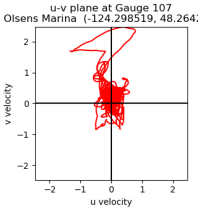


CSZ L1 event:

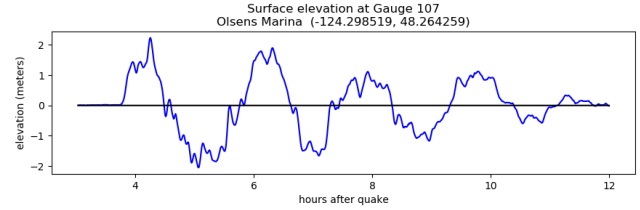


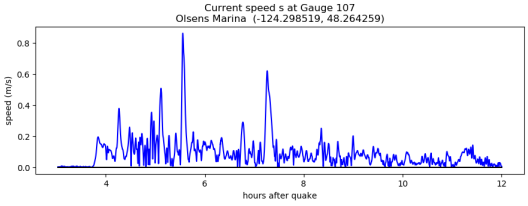


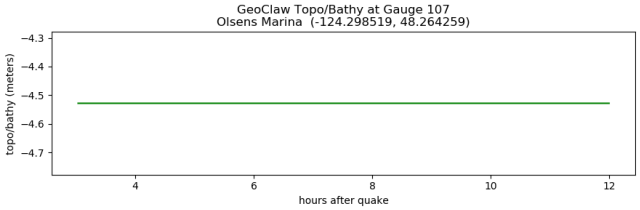


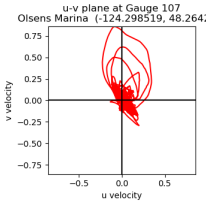


AKmaxWA event:





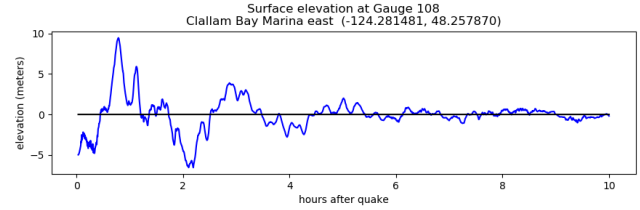


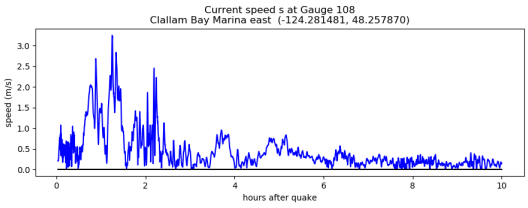


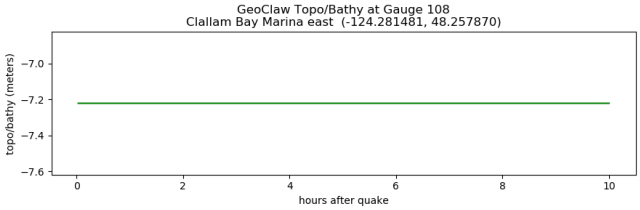
Gauge 108: Clallam Bay Marina east.

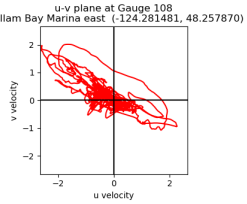
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

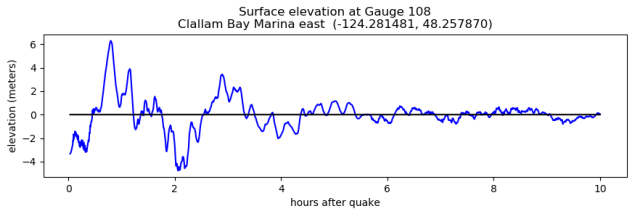


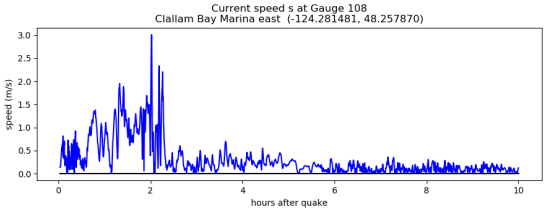


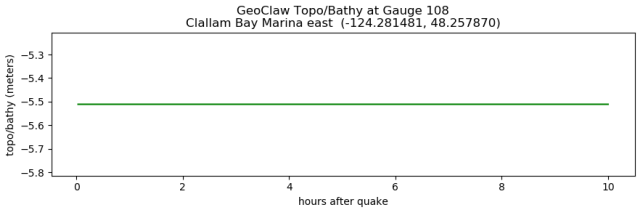


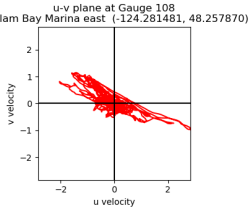


CSZ L1 event:

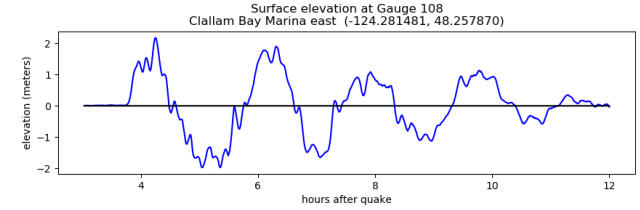


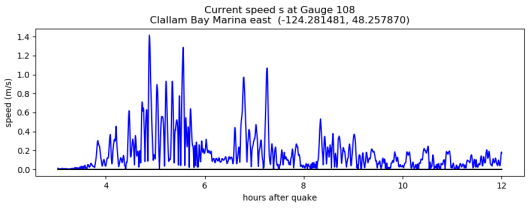


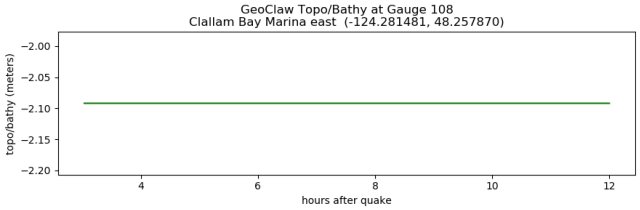


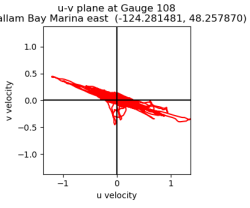


AKmaxWA event:





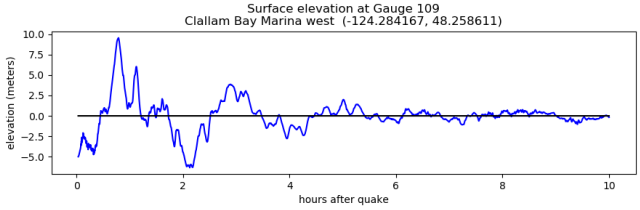


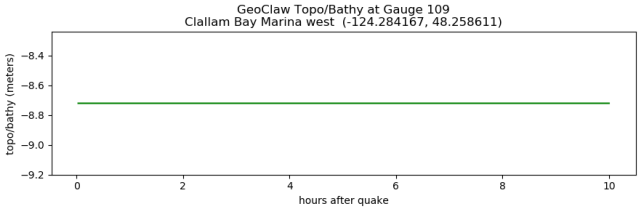


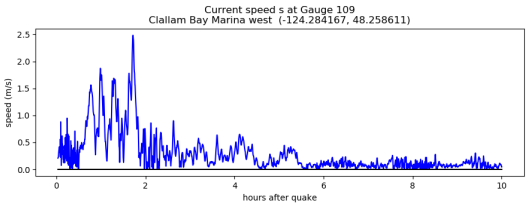
Gauge 109: Clallam Bay Marina west.

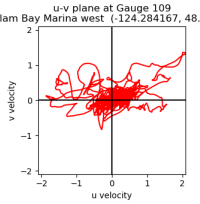
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

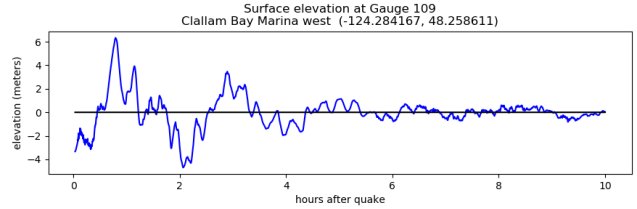


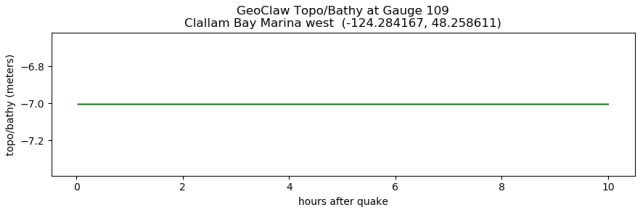


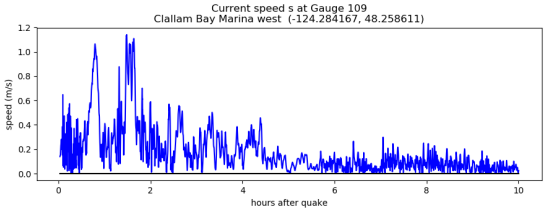


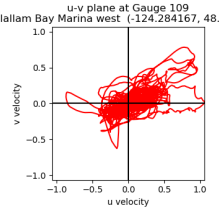


CSZ L1 event:

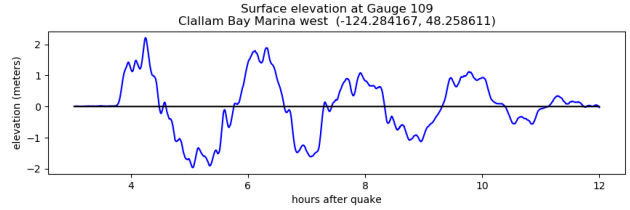


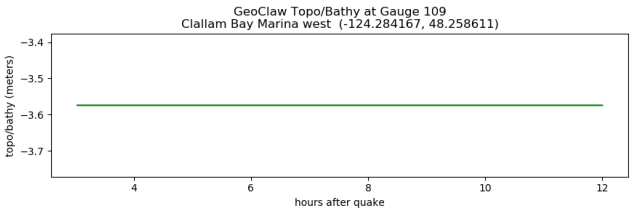


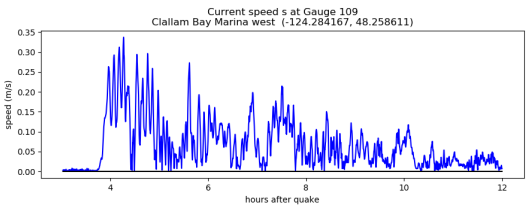


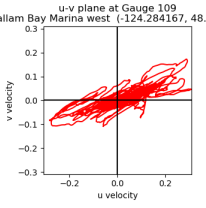


AKmaxWA event:





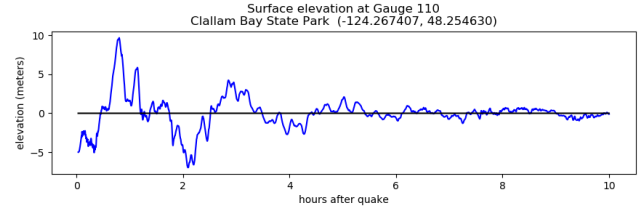


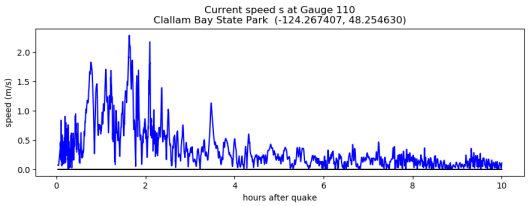


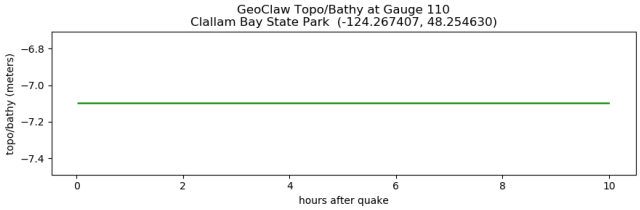
Gauge 110: Clallam Bay State Park.

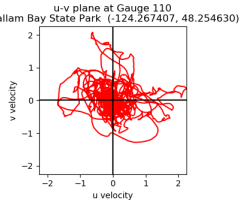
Computed on region `Chito_Sekiu`.

CSZ XL1 event:

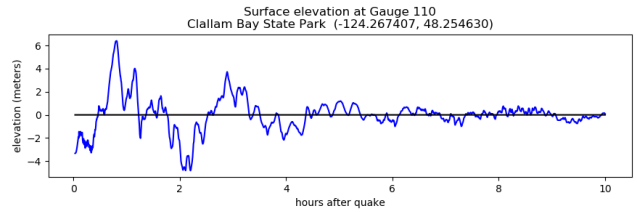


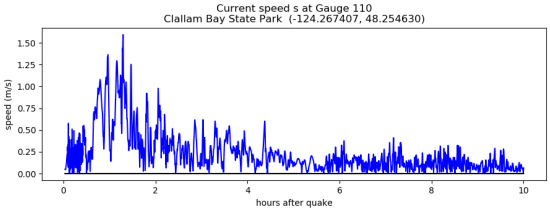


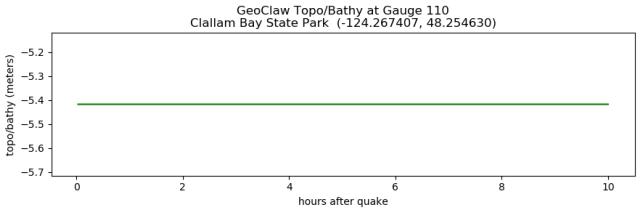


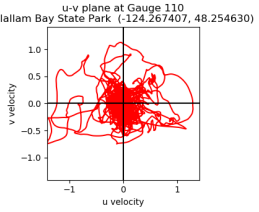


CSZ L1 event:

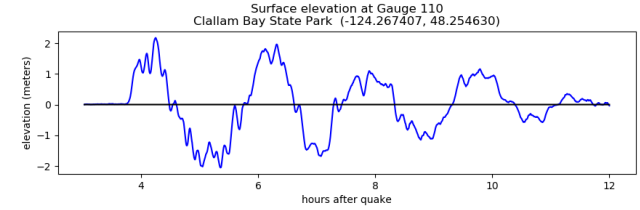


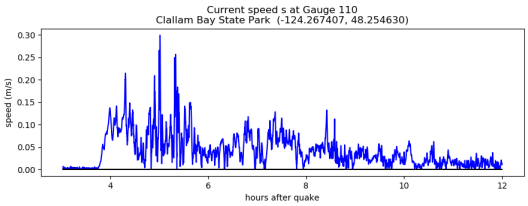


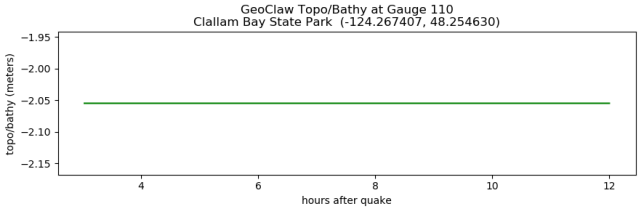


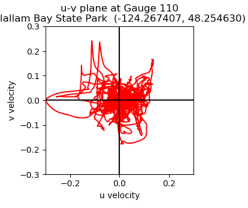


AKmaxWA event:





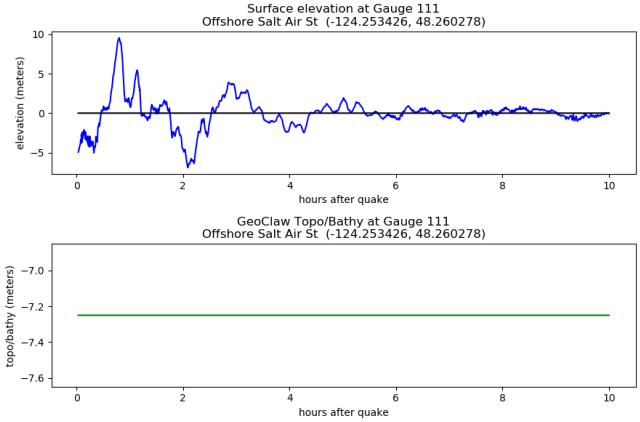


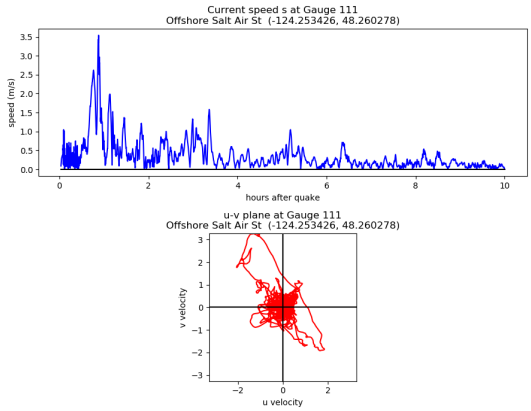


Gauge 111: Offshore Salt Air St.

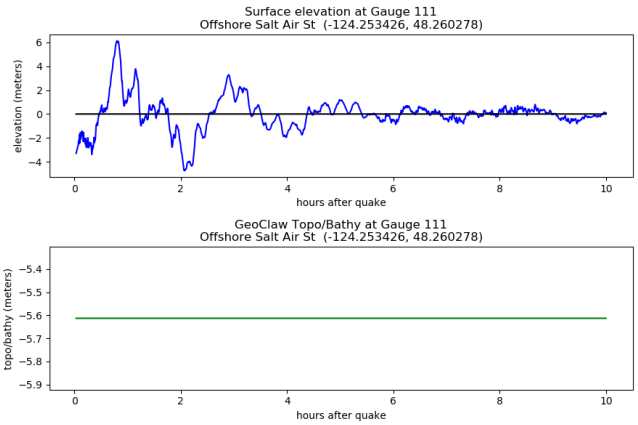
Computed on region `Chito_Sekiu`.

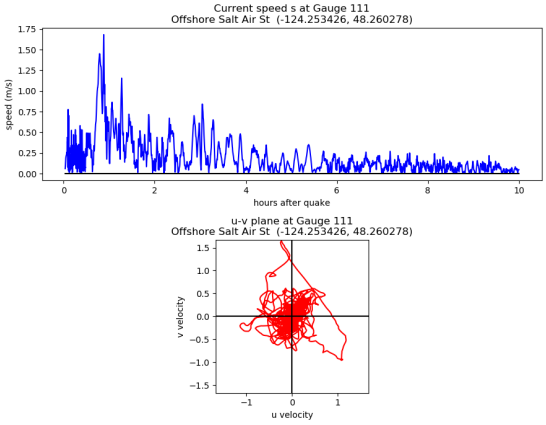
CSZ XL1 event:



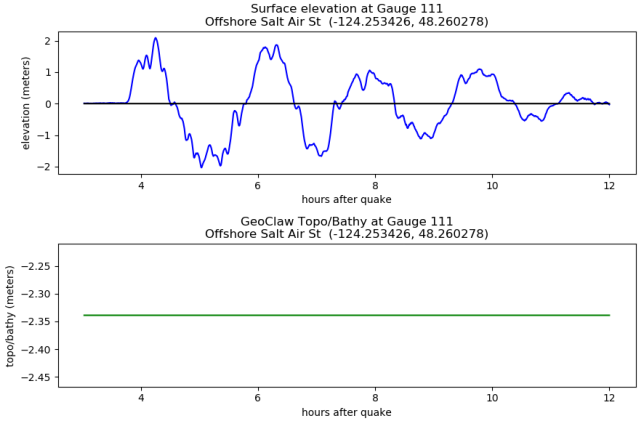


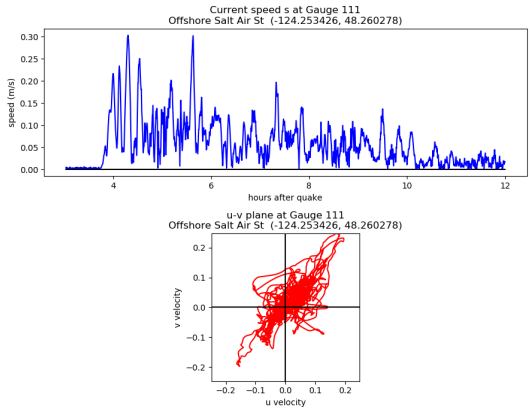
CSZ L1 event:





AKmaxWA event:

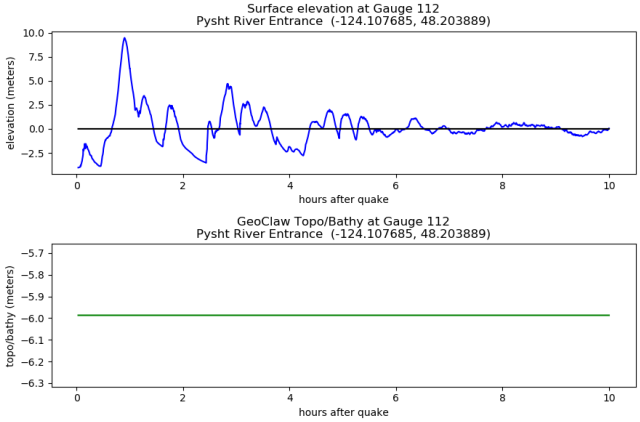


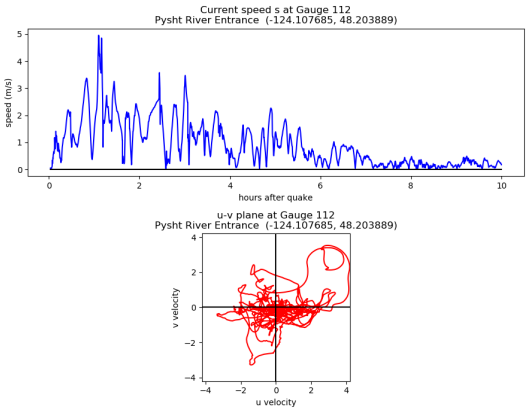


Gauge 112: Pysht River Entrance.

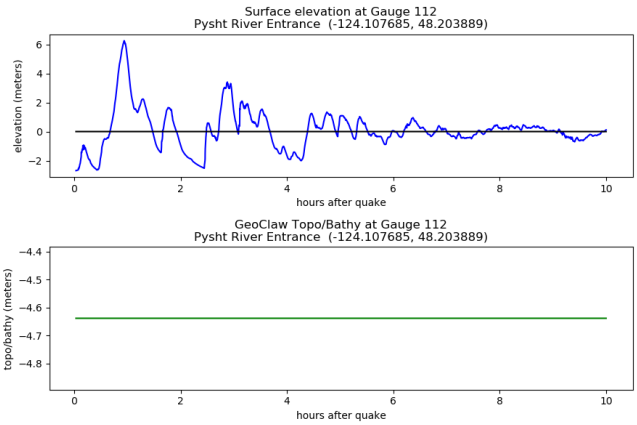
Computed on region `Chito_Sekiu`.

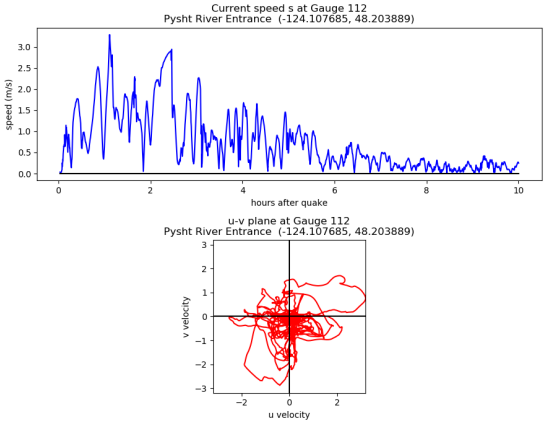
CSZ XL1 event:



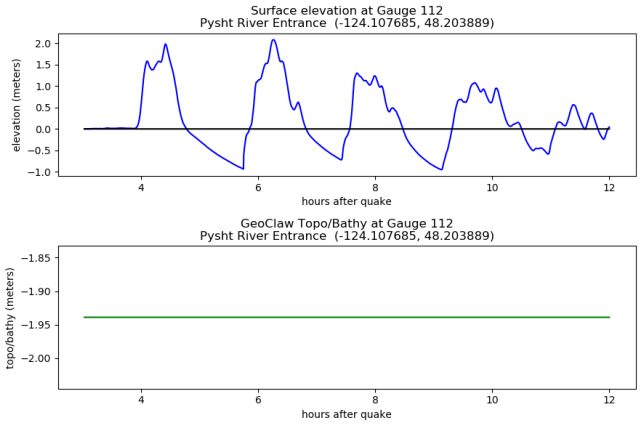


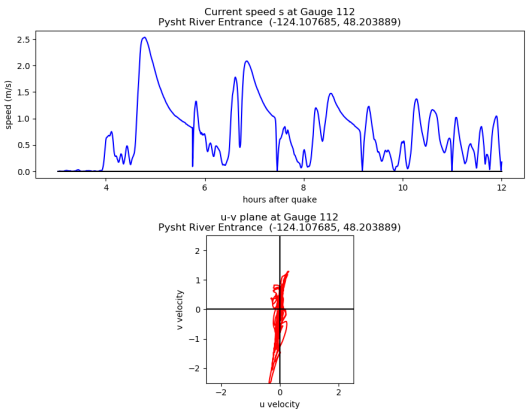
CSZ L1 event:





AKmaxWA event:

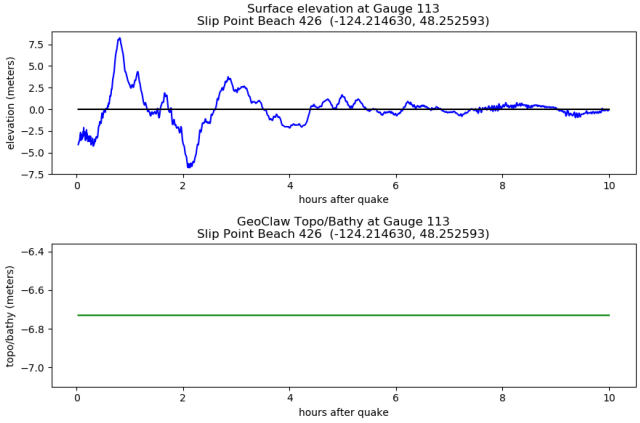


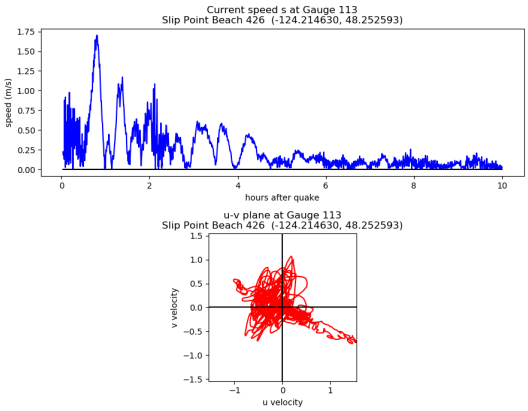


Gauge 113: Slip Point Beach 426.

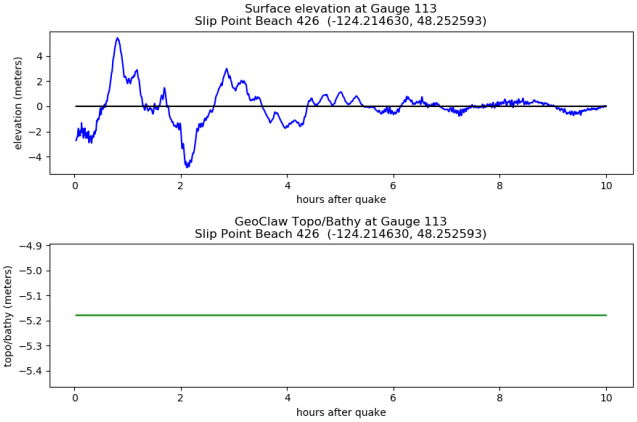
Computed on region `Chito_Sekiu`.

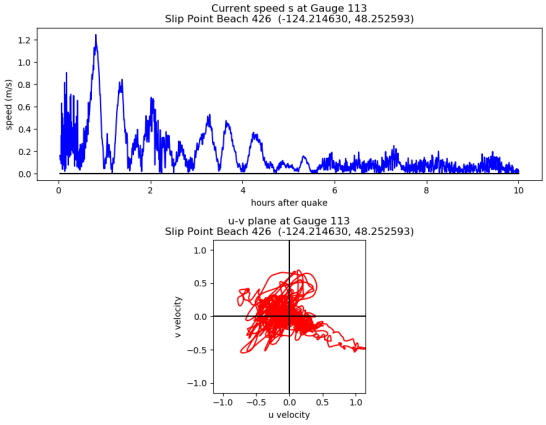
CSZ XL1 event:



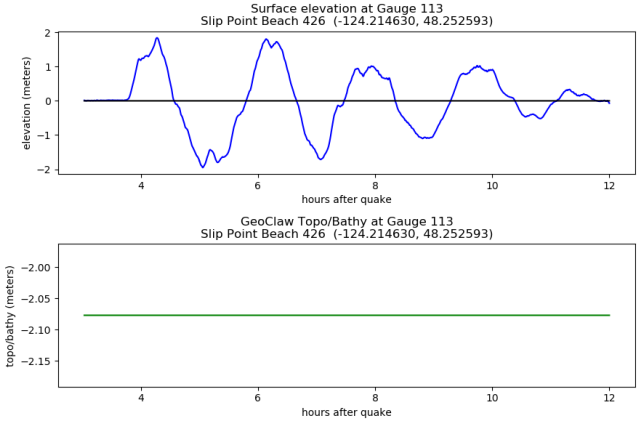


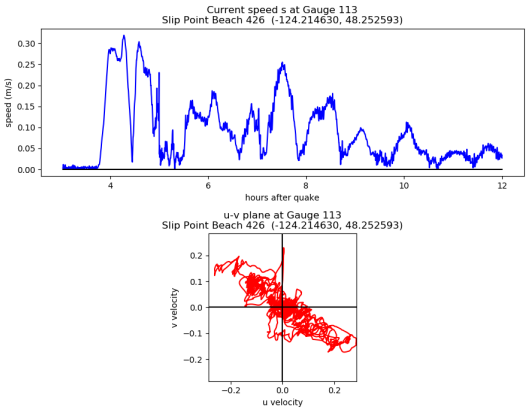
CSZ L1 event:





AKmaxWA event:

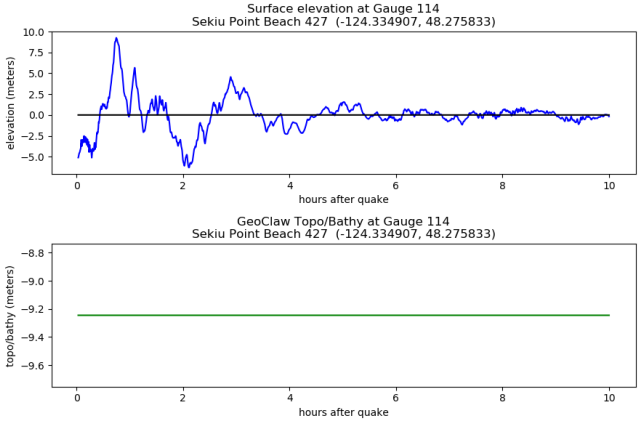


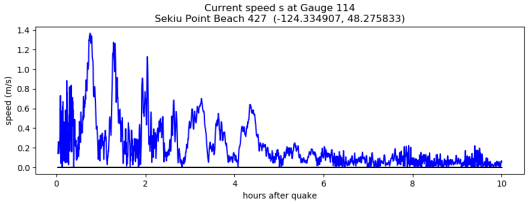


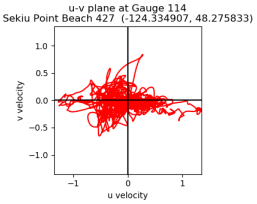
Gauge 114: Slip Point Beach 427.

Computed on region `Chito_Sekiu`.

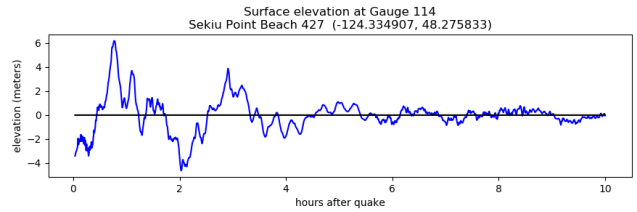
CSZ XL1 event:

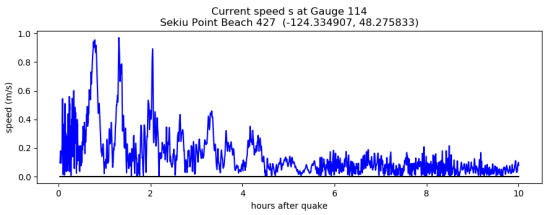


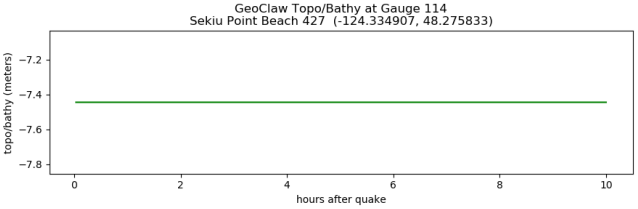


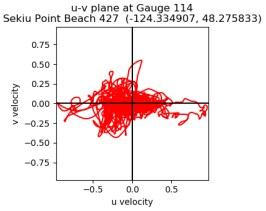


CSZ L1 event:

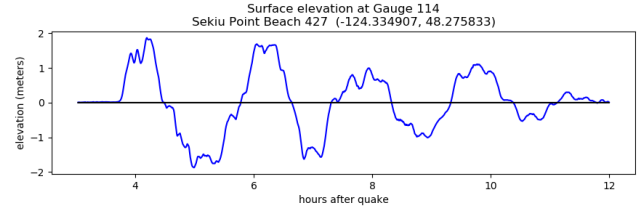


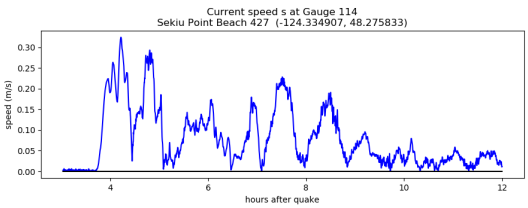


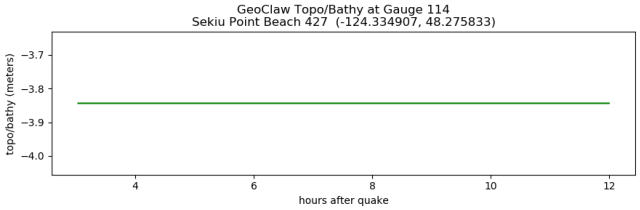


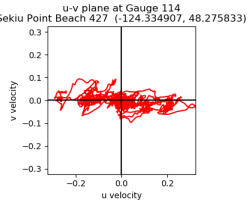


AKmaxWA event:





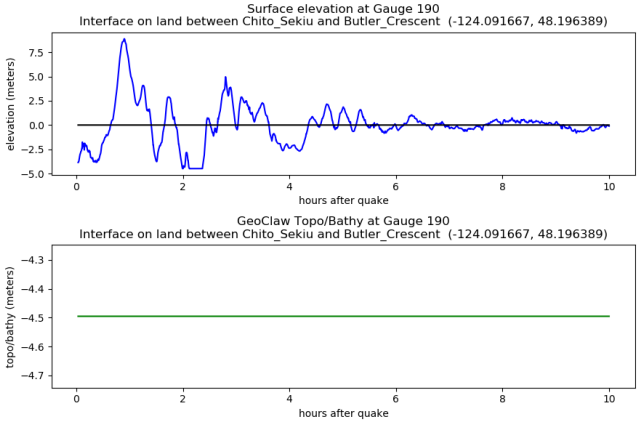


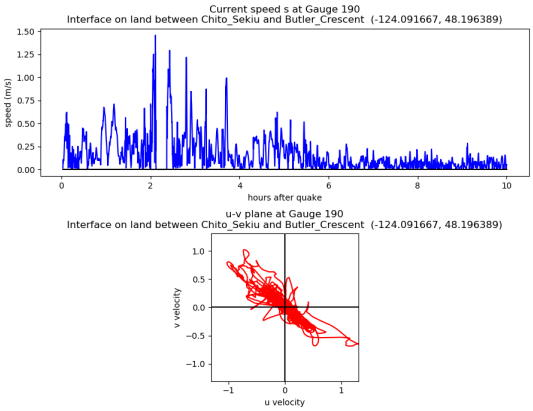


Gauge 190: Interface on land between Chito_Sekiu and Butler_Crescent.

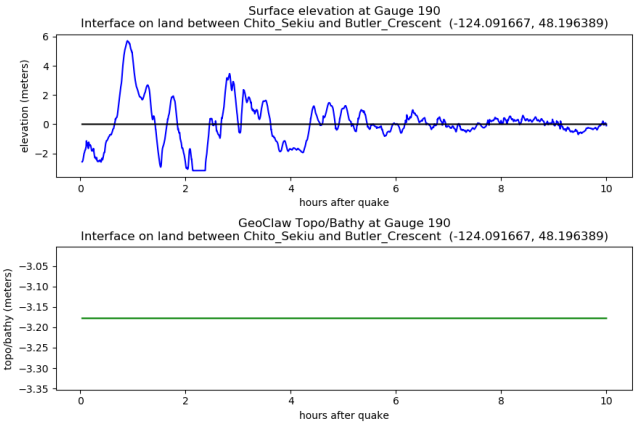
Computed on region Chito_Sekiu.

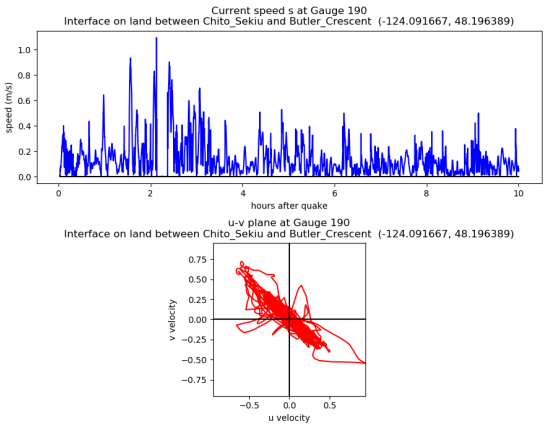
CSZ XL1 event:



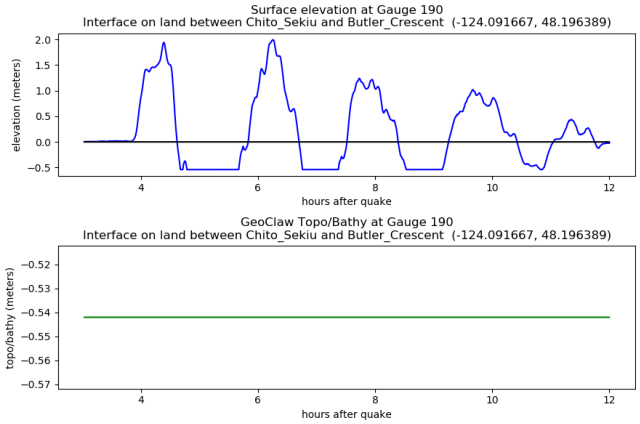


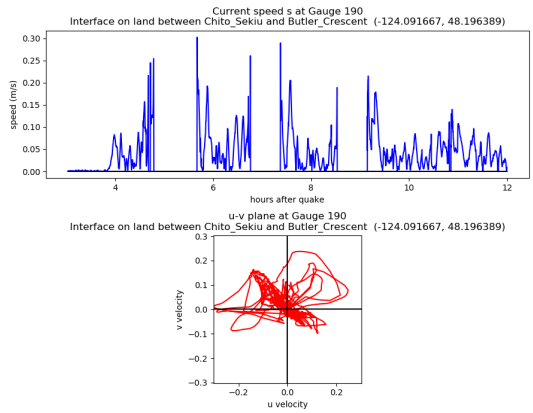
CSZ L1 event:





AKmaxWA event:

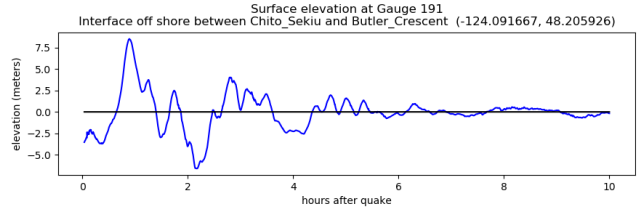


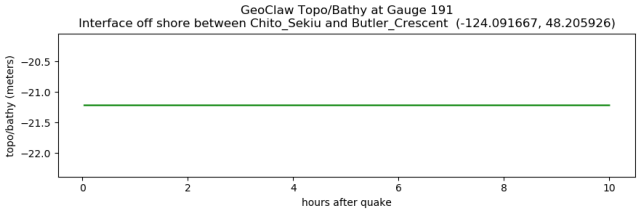


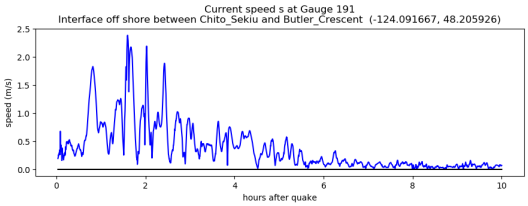
Gauge 191: Interface off shore between Chito_Sekiu and Butler_Crescent.

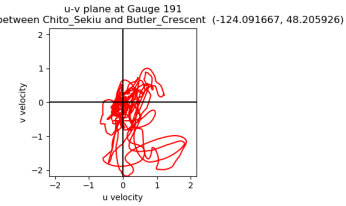
Computed on region Chito_Sekiu.

CSZ XL1 event:

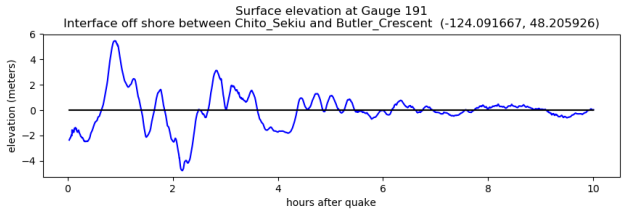


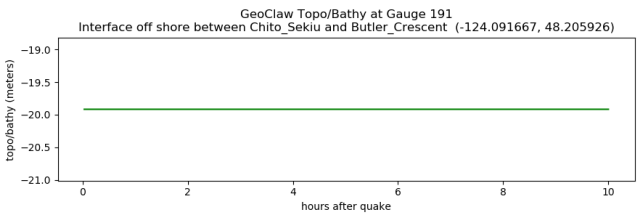


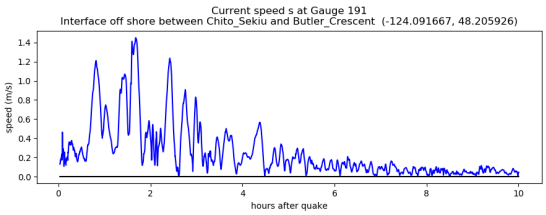


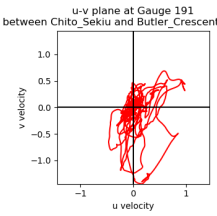


CSZ L1 event:

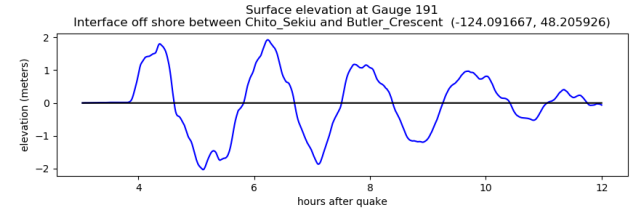


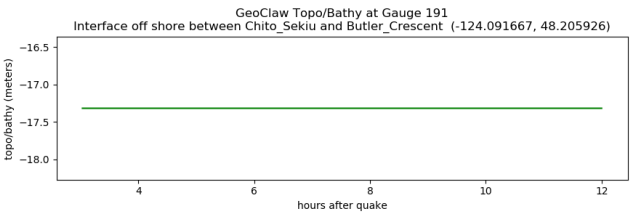


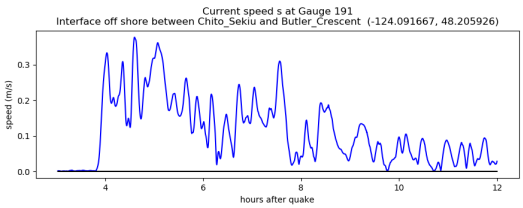


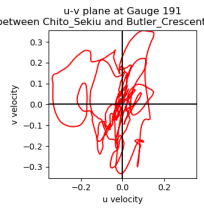


AKmaxWA event:





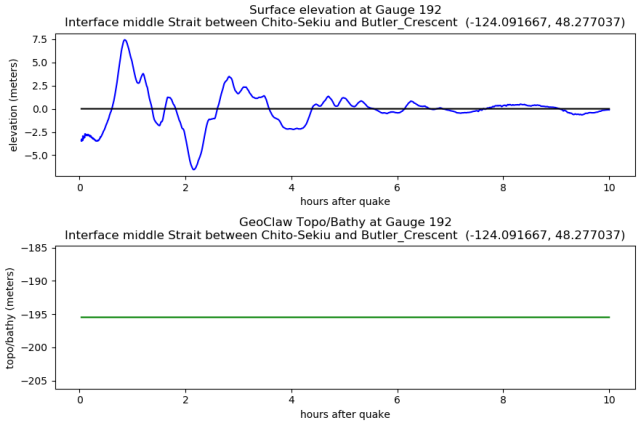


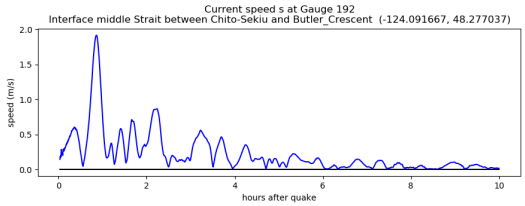


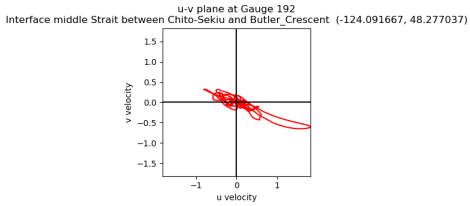
Gauge 192: Interface middle Strait between Chito_Sekiu and Butler_Crescent.

Computed on region Chito_Sekiu.

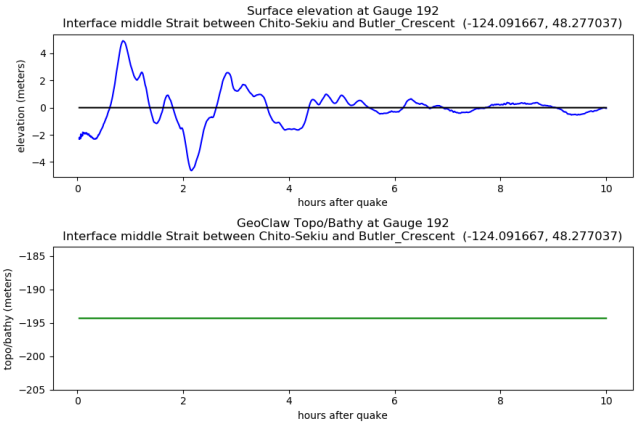
CSZ XL1 event:

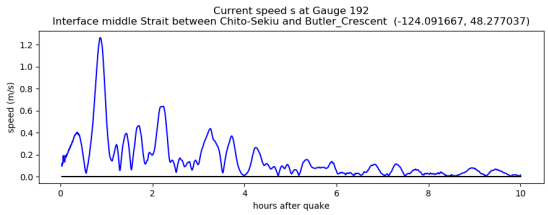


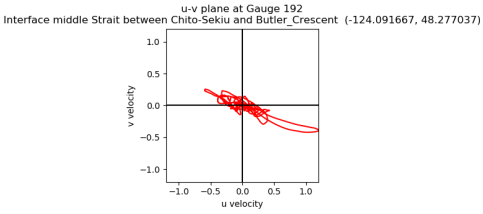




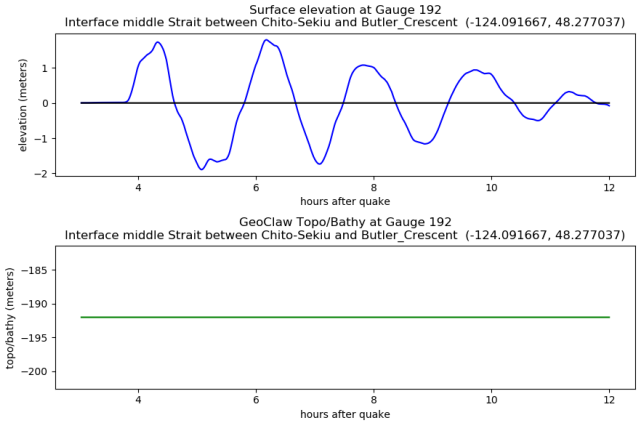
CSZ L1 event:

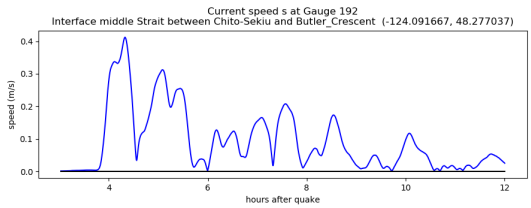


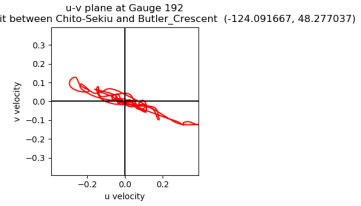




AKmaxWA event:



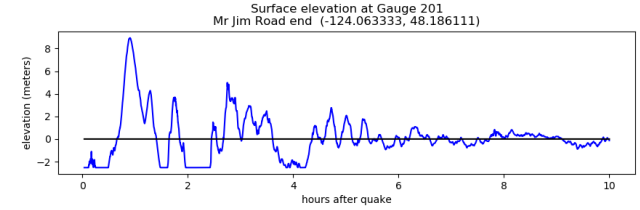


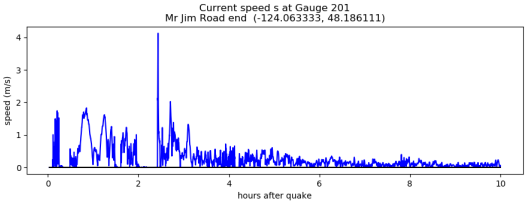


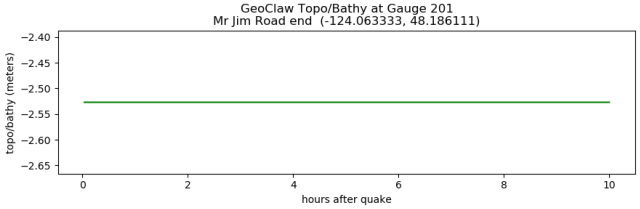
Gauge 201: Mr Jim Road end.

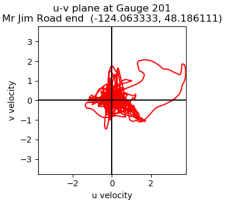
Computed on region `Butler_Crescent`.

CSZ XL1 event:

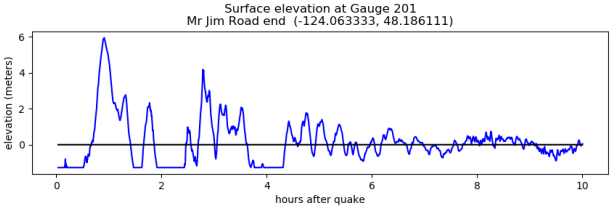


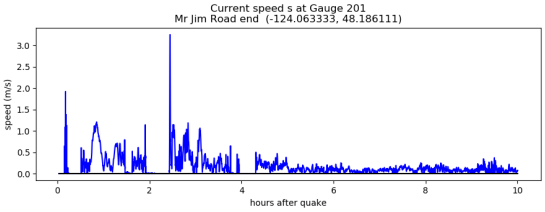


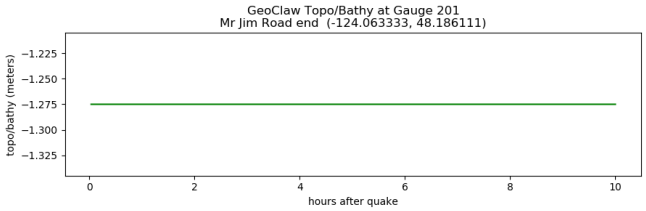


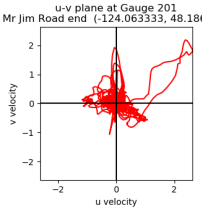


CSZ L1 event:

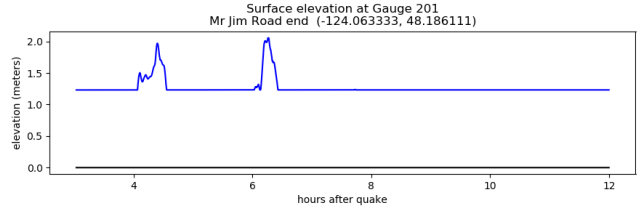


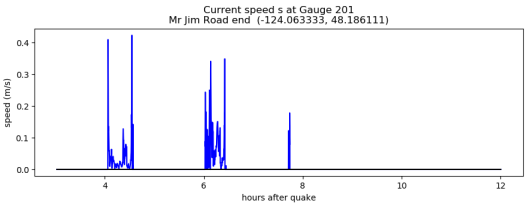


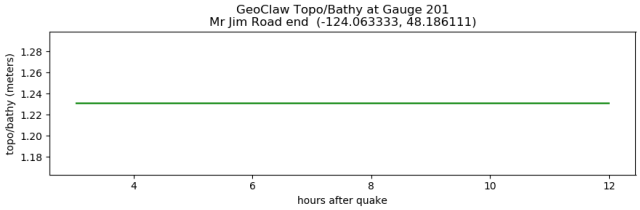


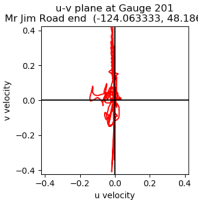


AKmaxWA event:





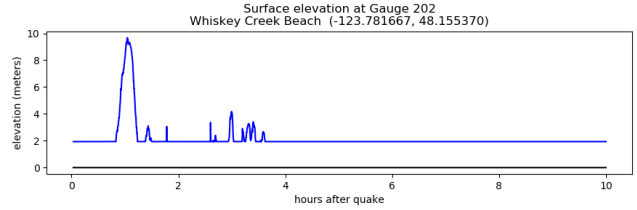


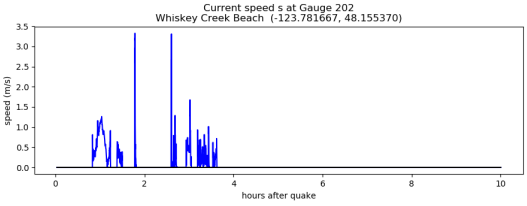


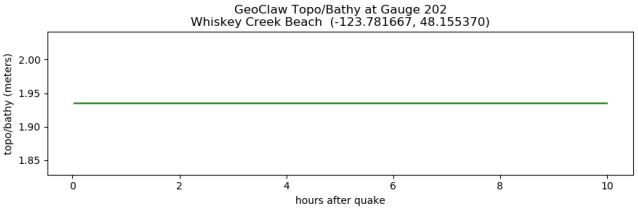
Gauge 202: Whiskey Creek Beach.

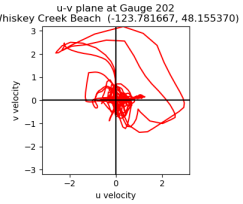
Computed on region `Butler_Crescent`.

CSZ XL1 event:

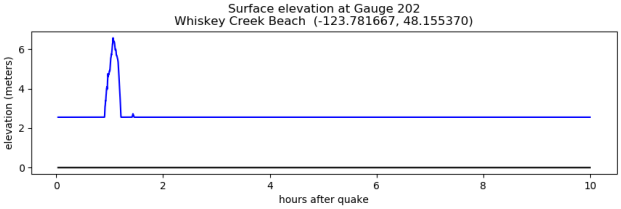


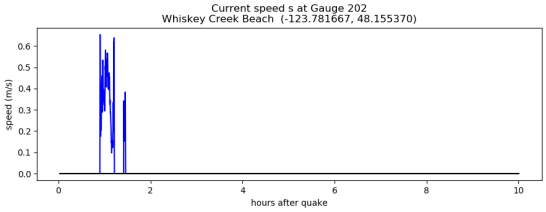


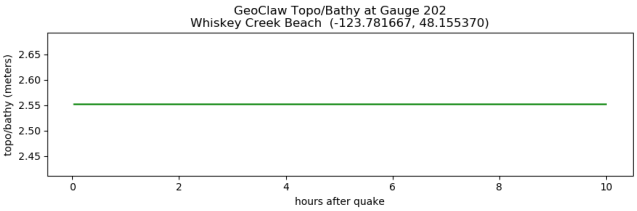


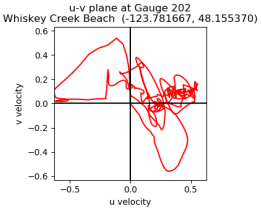


CSZ L1 event:

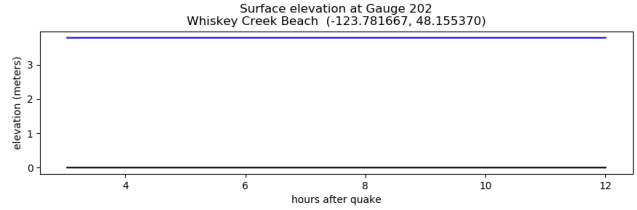


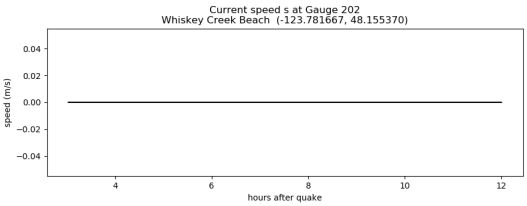


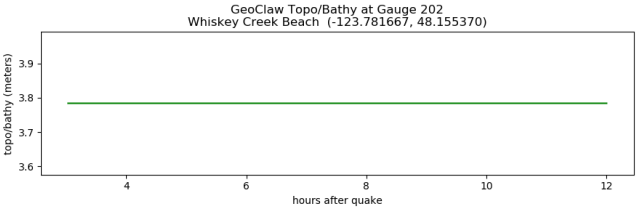


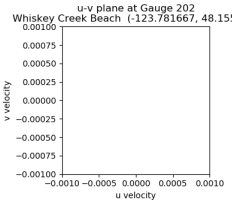


AKmaxWA event:





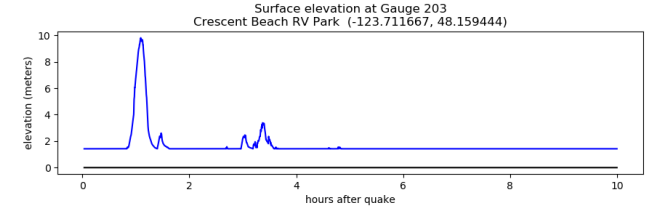


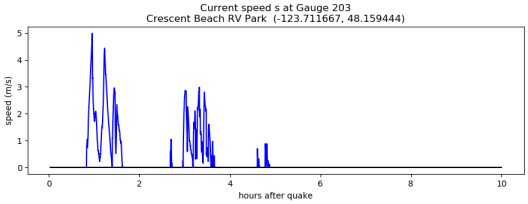


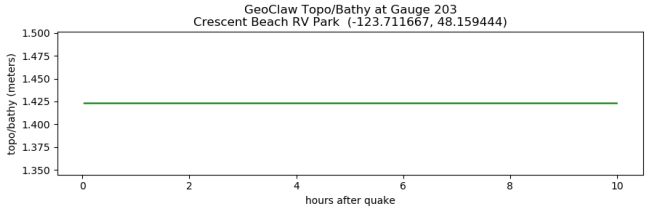
Gauge 203: Crescent Beach RV Park.

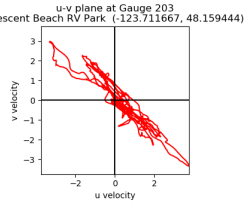
Computed on region `Butler_Crescent`.

CSZ XL1 event:

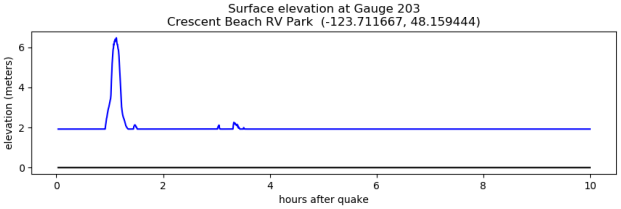


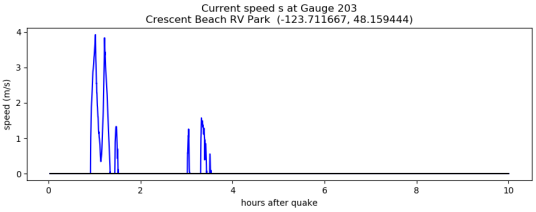


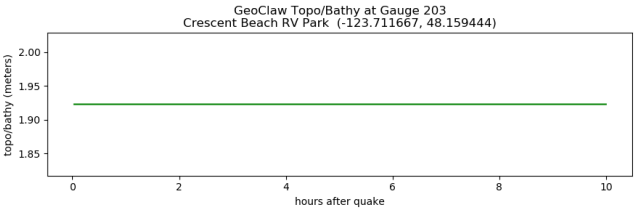


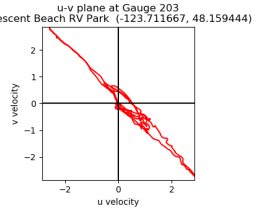


CSZ L1 event:

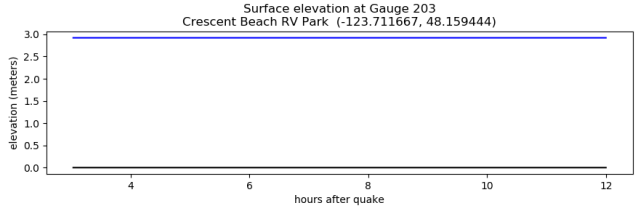


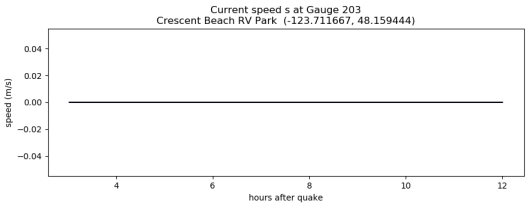


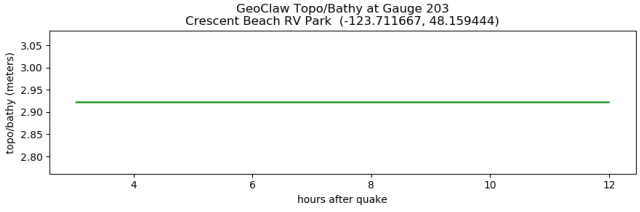


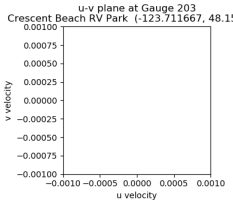


AKmaxWA event:





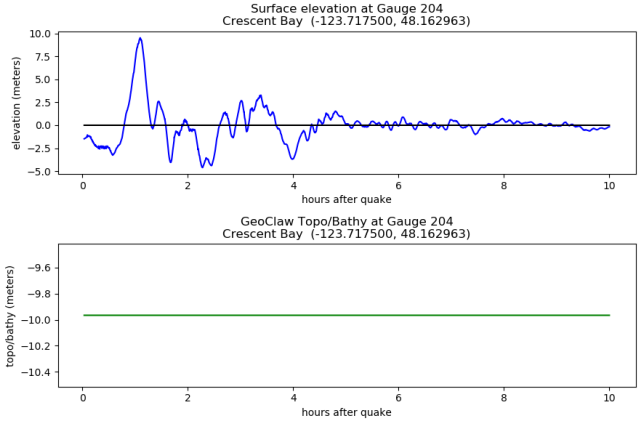


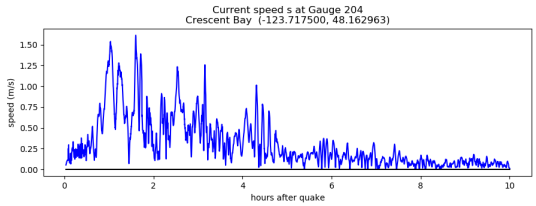


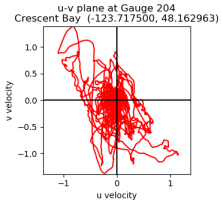
Gauge 204: Crescent Bay.

Computed on region `Butler_Crescent`.

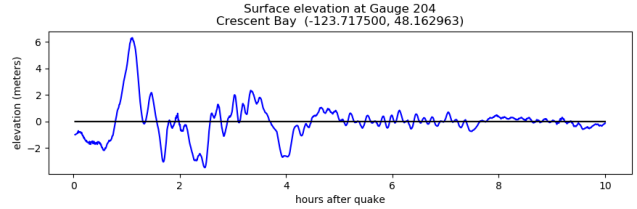
CSZ XL1 event:

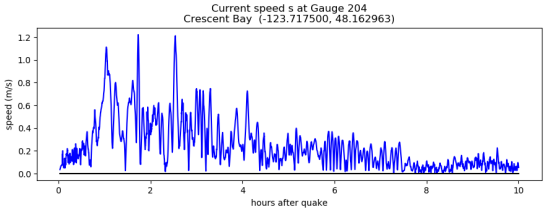


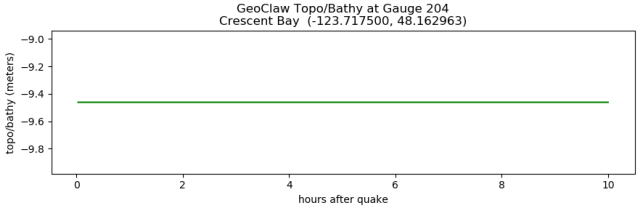


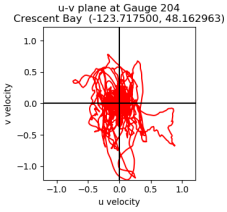


CSZ L1 event:

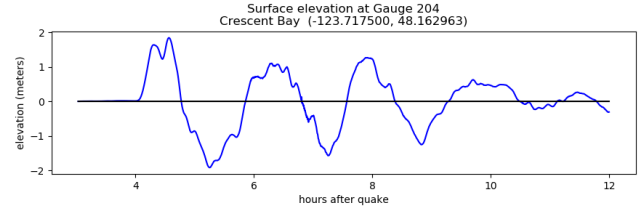


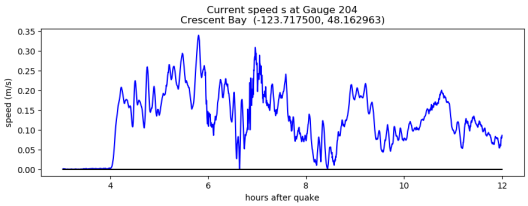


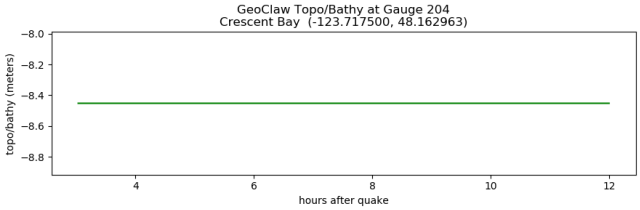


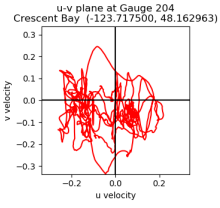


AKmaxWA event:





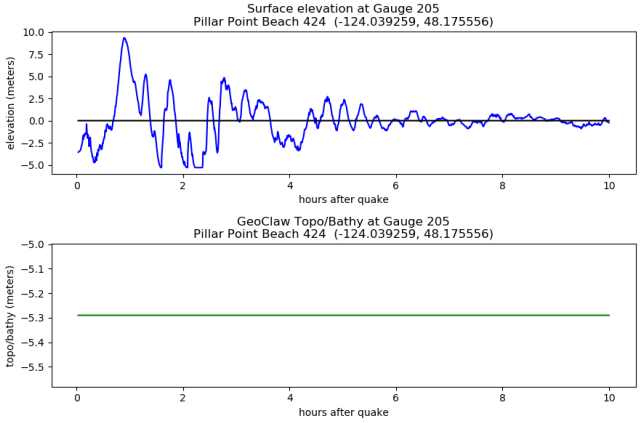


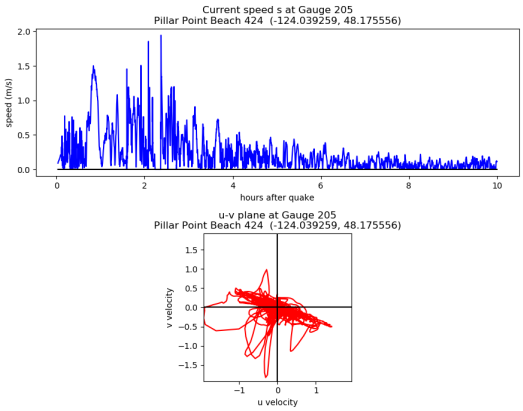


Gauge 205: Pillar Point Beach 424.

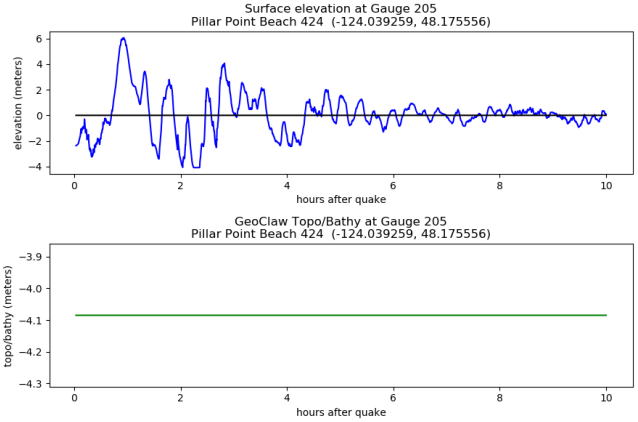
Computed on region `Butler_Crescent`.

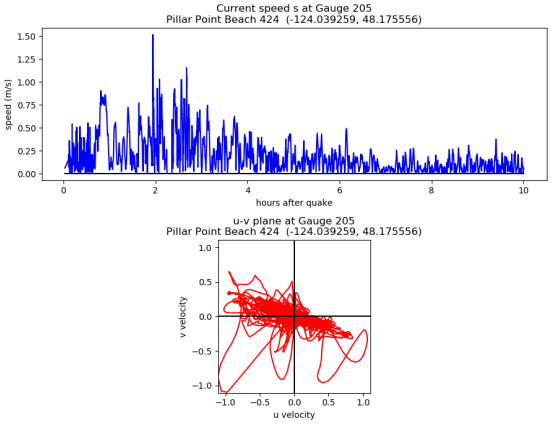
CSZ XL1 event:



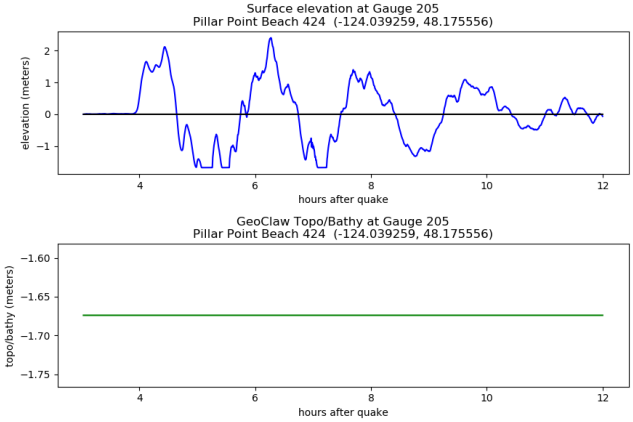


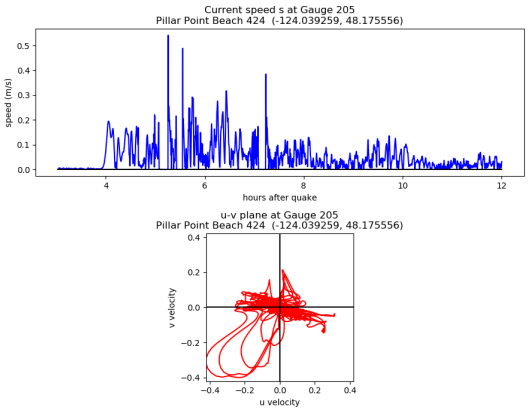
CSZ L1 event:





AKmaxWA event:

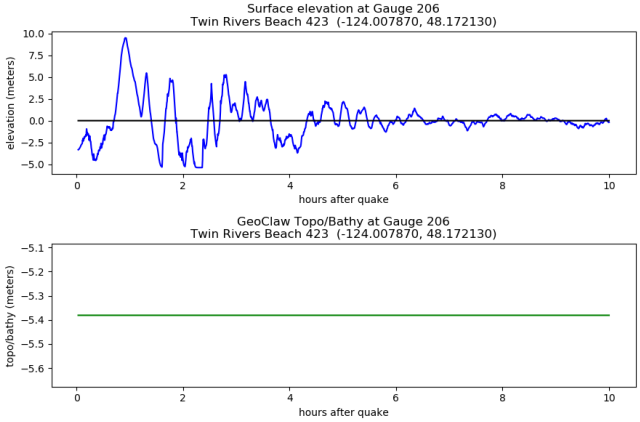


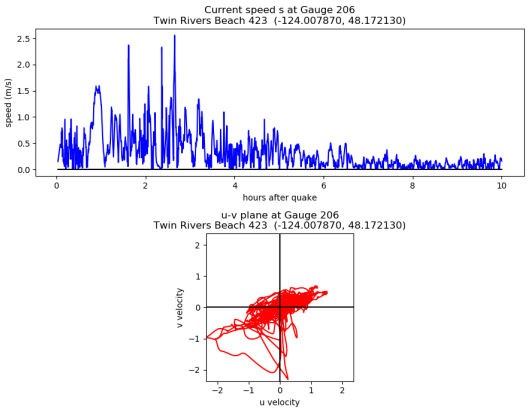


Gauge 206: Twin Rivers Beach 423.

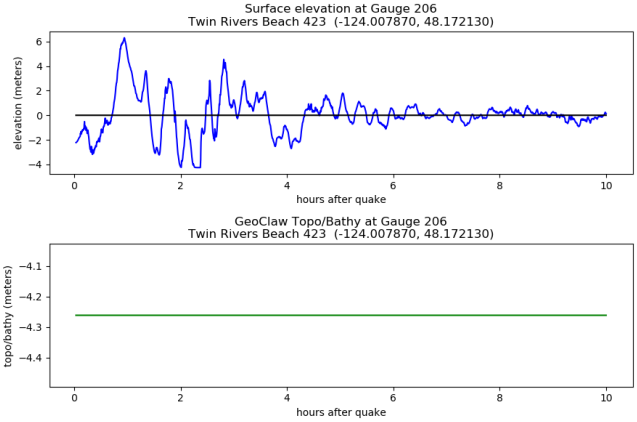
Computed on region `Butler_Crescent`.

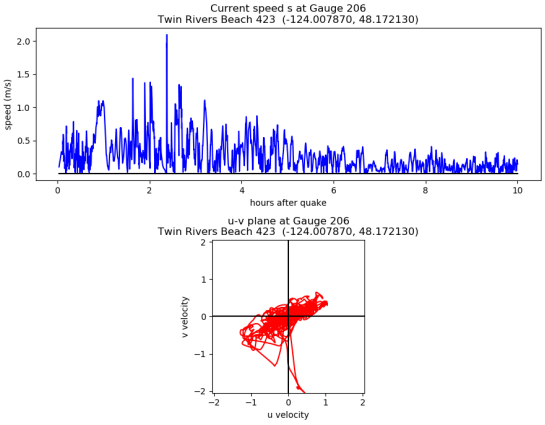
CSZ XL1 event:



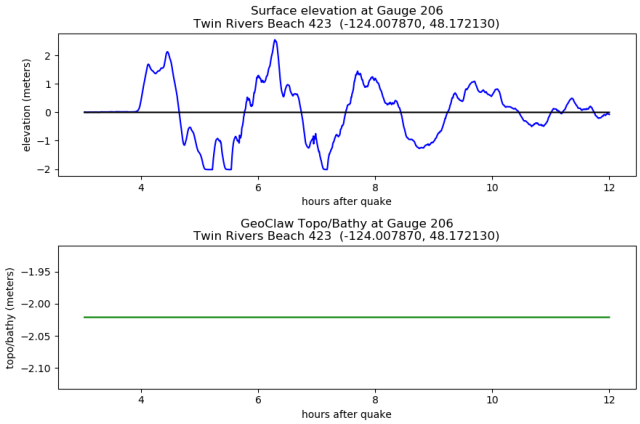


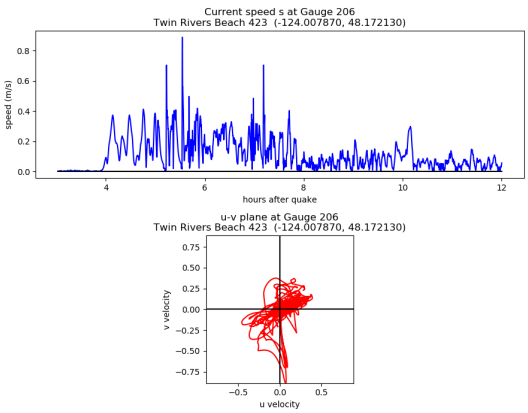
CSZ L1 event:





AKmaxWA event:

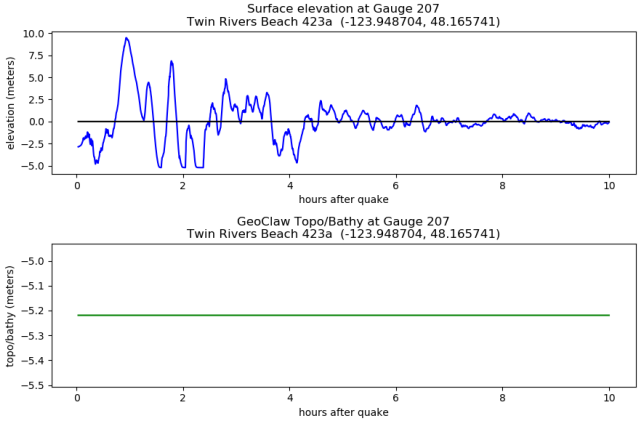


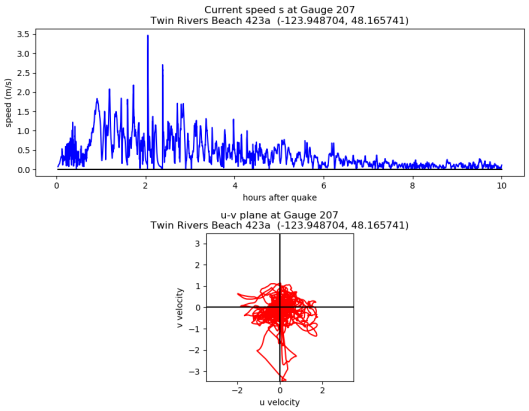


Gauge 207: Twin Rivers Beach 423a.

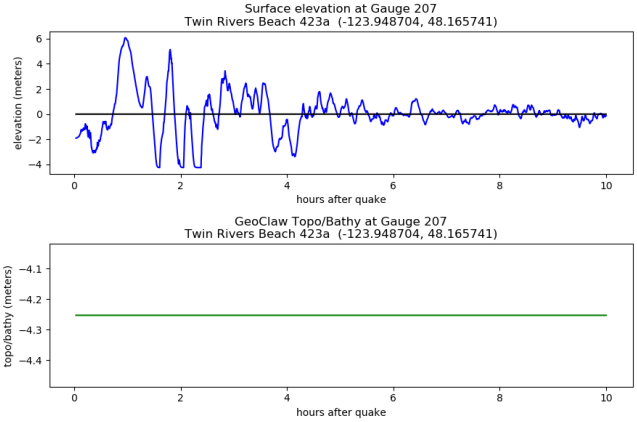
Computed on region `Butler_Crescent`.

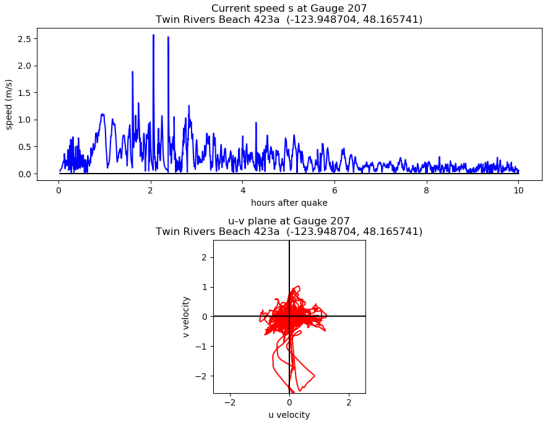
CSZ XL1 event:



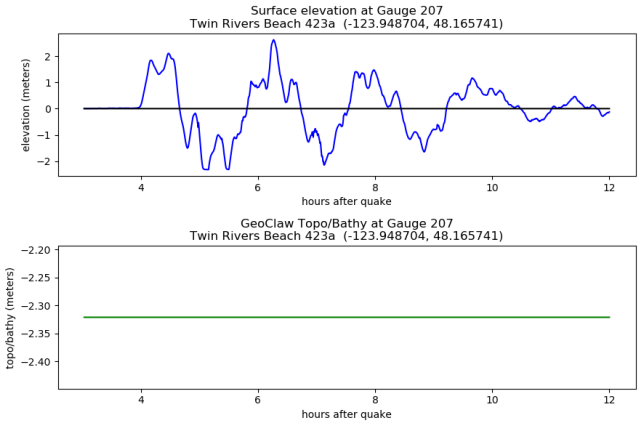


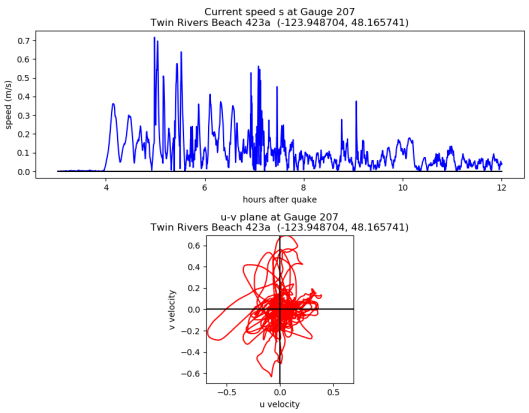
CSZ L1 event:





AKmaxWA event:

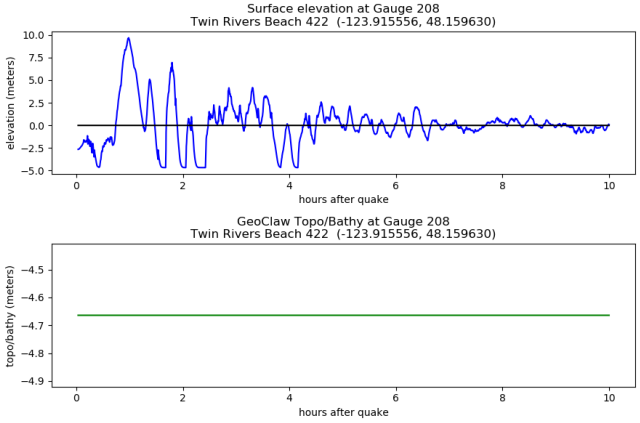


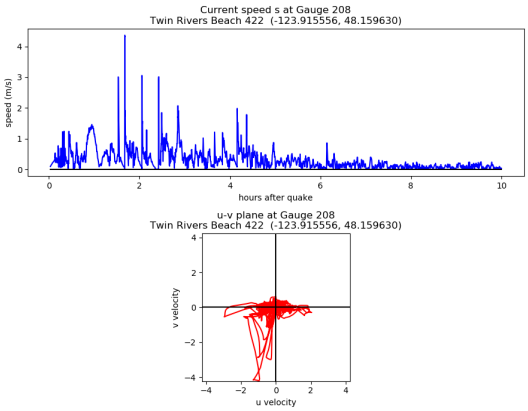


Gauge 208: Twin Rivers Beach 422.

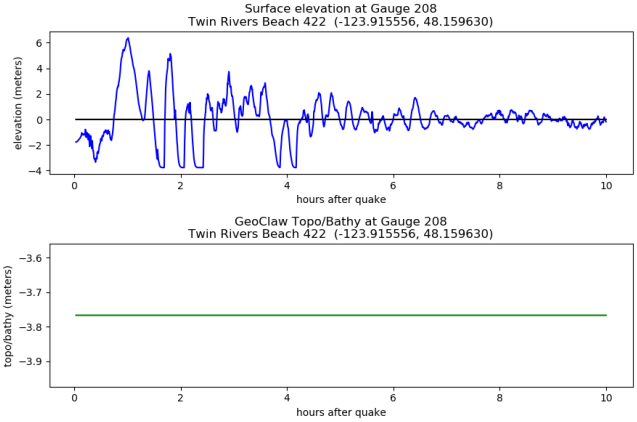
Computed on region `Butler_Crescent`.

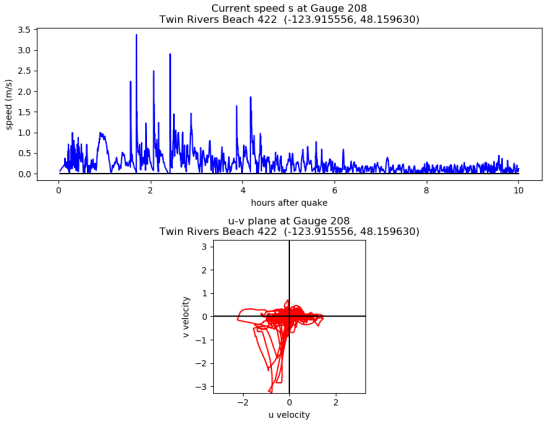
CSZ XL1 event:



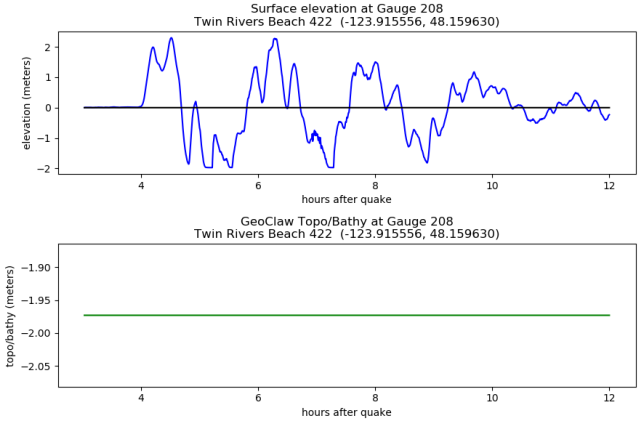


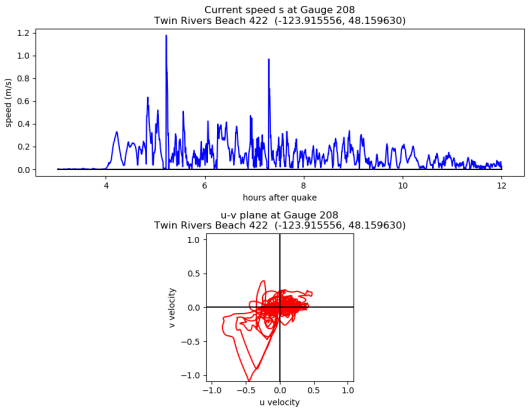
CSZ L1 event:





AKmaxWA event:

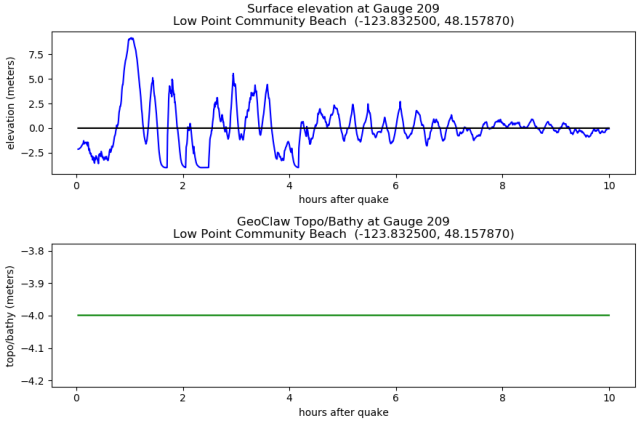


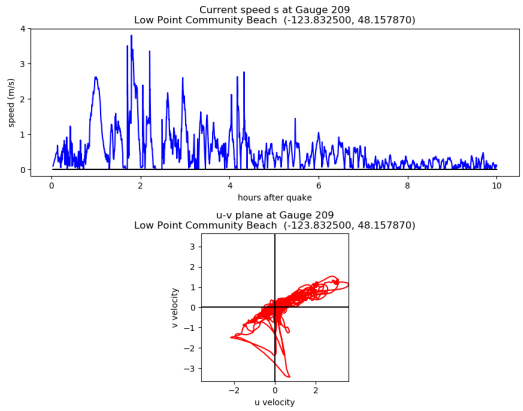


Gauge 209: Low Point Community Beach.

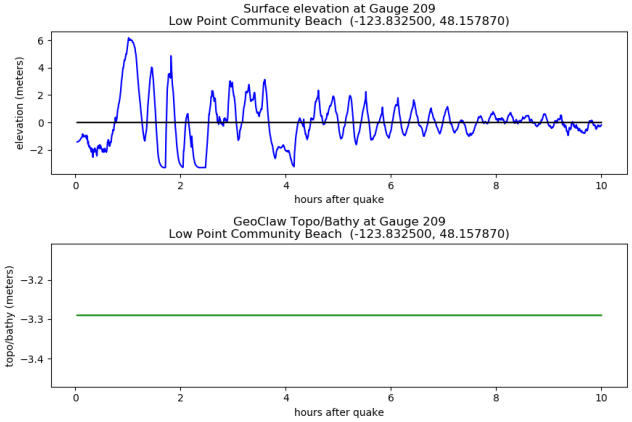
Computed on region `Butler_Crescent`.

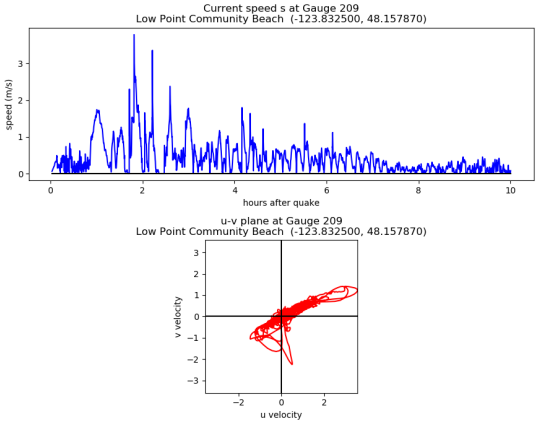
CSZ XL1 event:



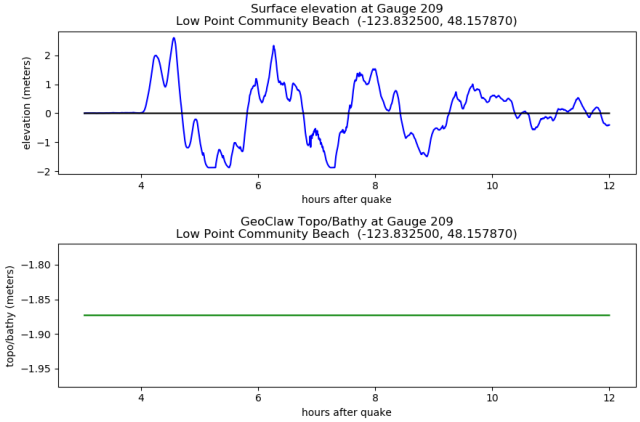


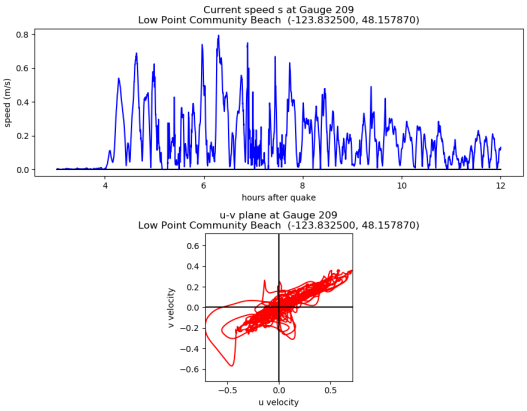
CSZ L1 event:





AKmaxWA event:

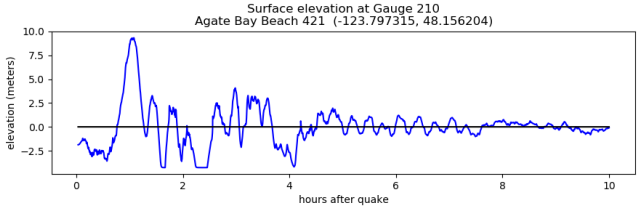


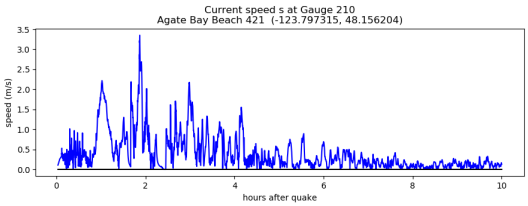


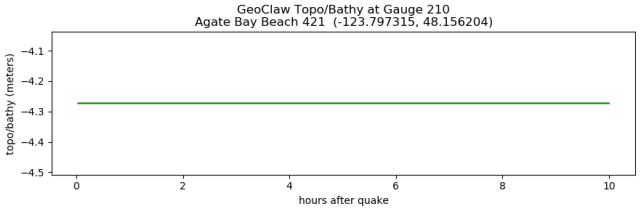
Gauge 210: Agate Bay Beach 421.

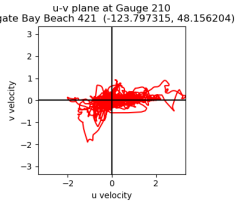
Computed on region `Butler_Crescent`.

CSZ XL1 event:

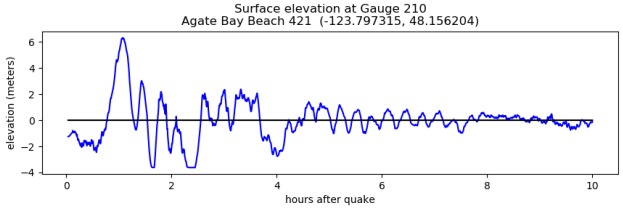


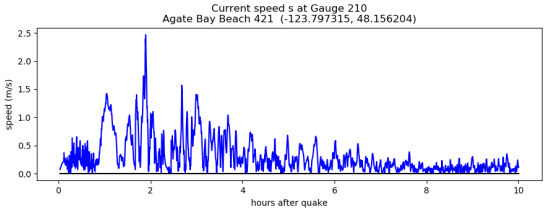


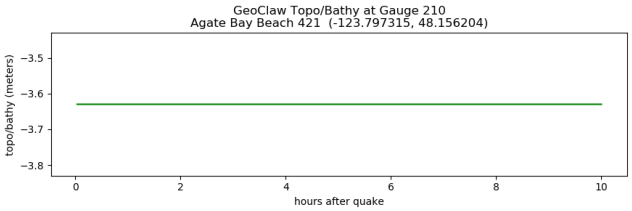


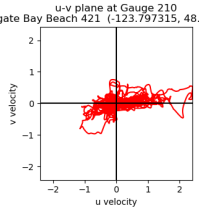


CSZ L1 event:

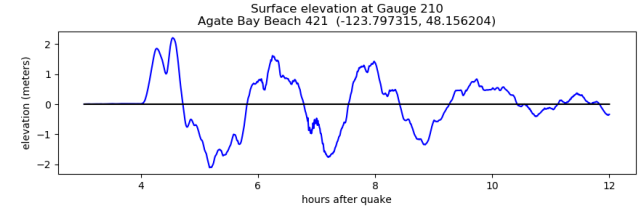


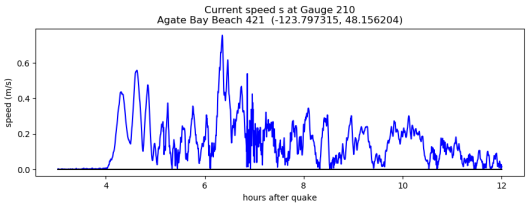


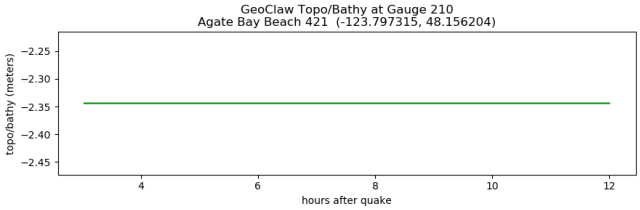


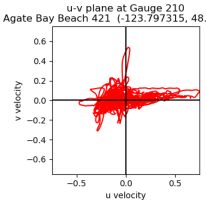


AKmaxWA event:





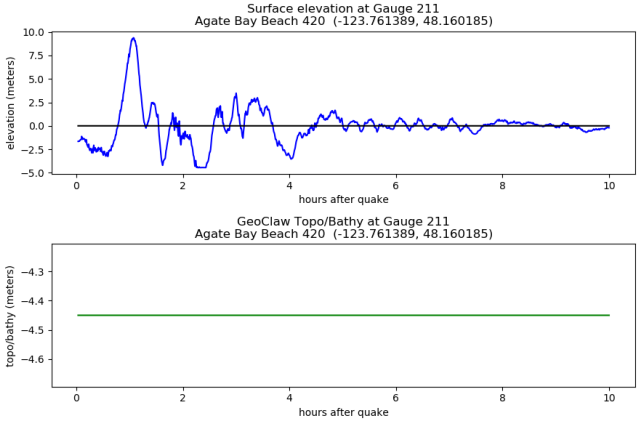


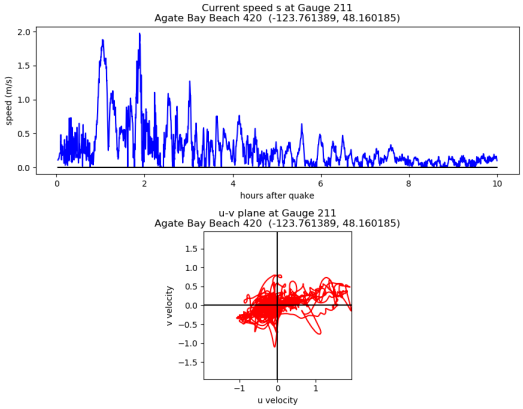


Gauge 211: Agate Bay Beach 420.

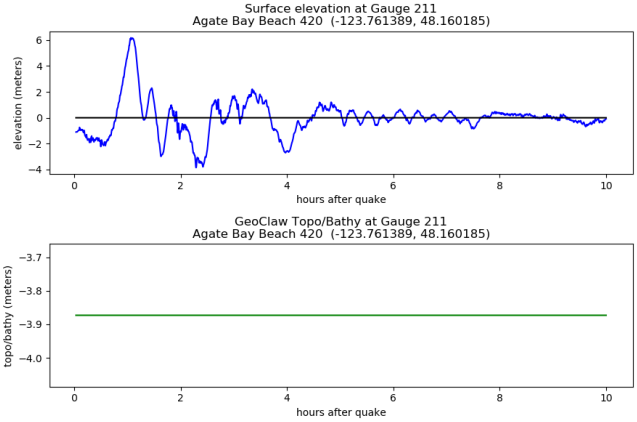
Computed on region `Butler_Crescent`.

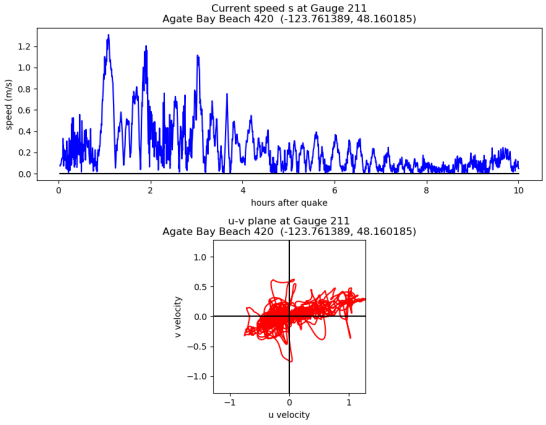
CSZ XL1 event:



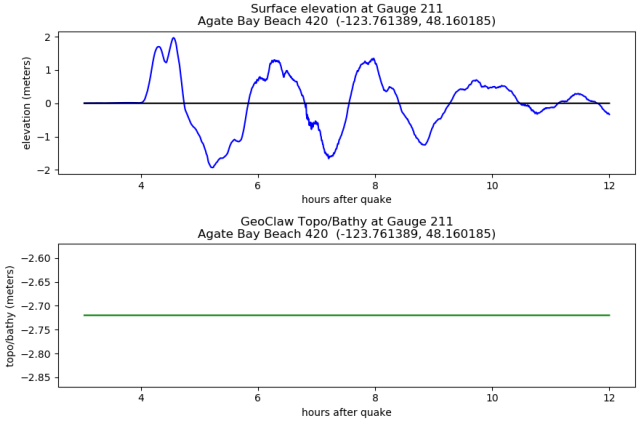


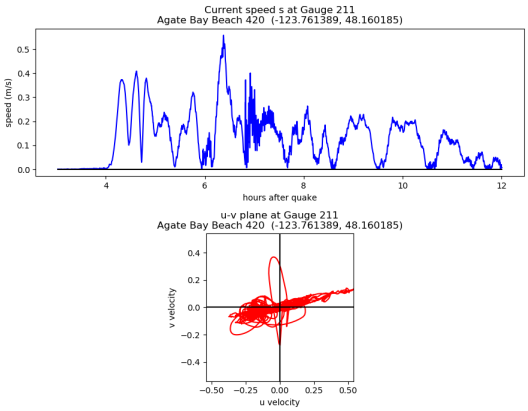
CSZ L1 event:





AKmaxWA event:

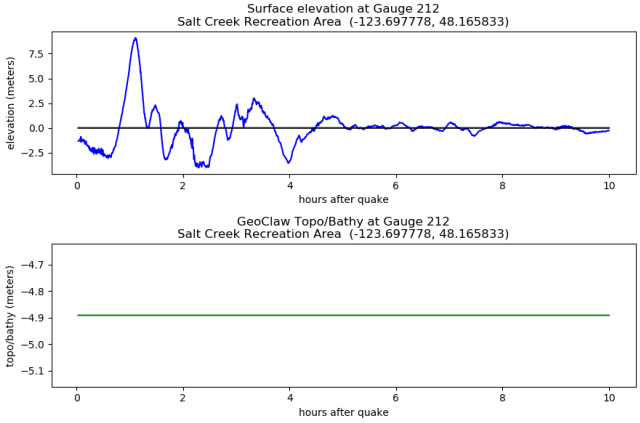


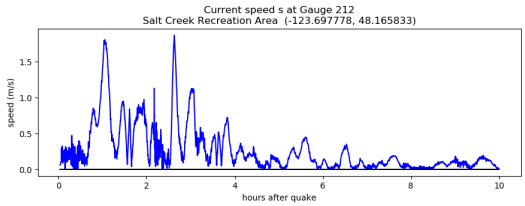


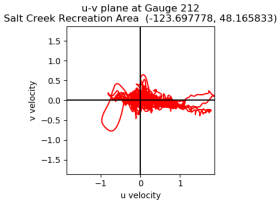
Gauge 212: Salt Creek Recreation Area.

Computed on region `Butler_Crescent`.

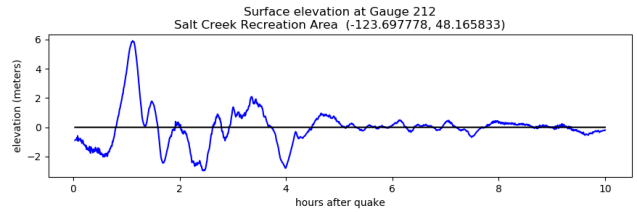
CSZ XL1 event:

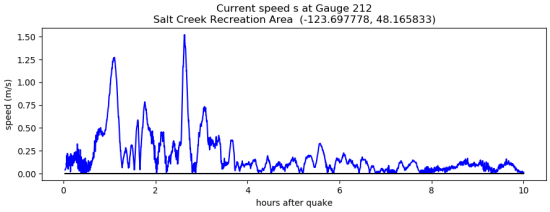


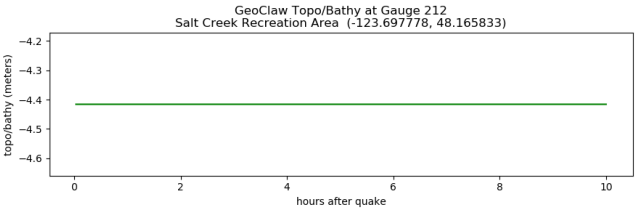


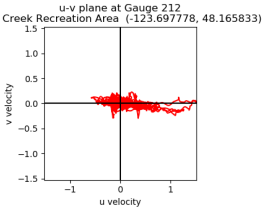


CSZ L1 event:

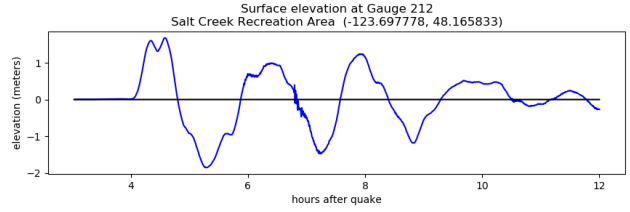


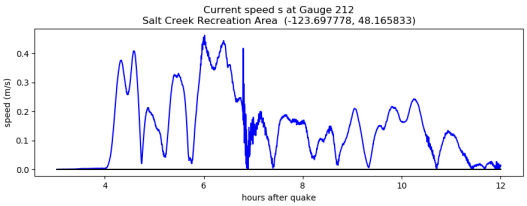


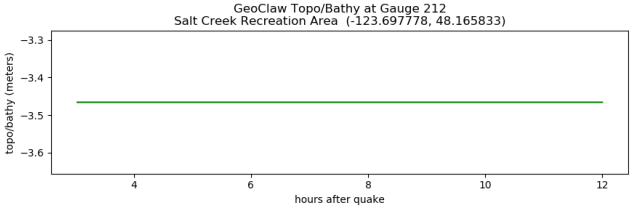


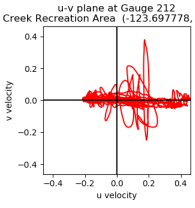


AKmaxWA event:





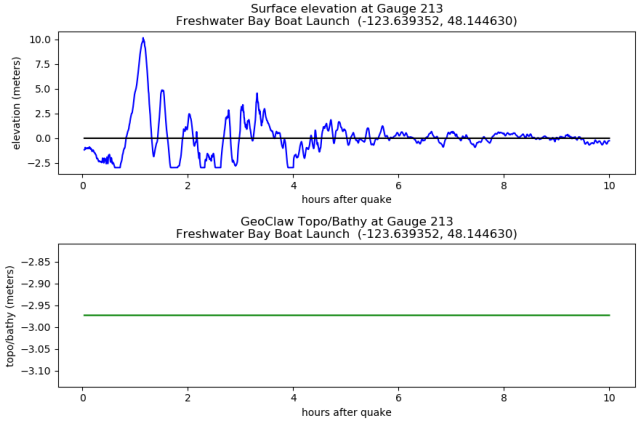


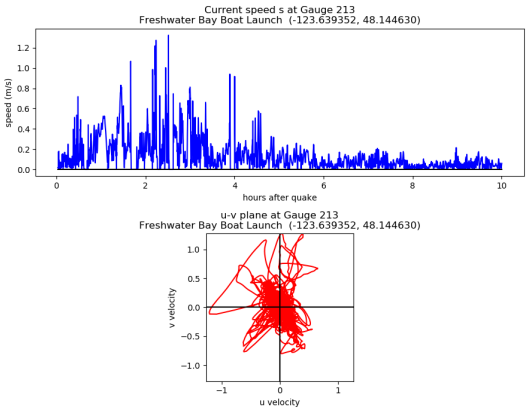


Gauge 213: Freshwater Bay Boat Launch.

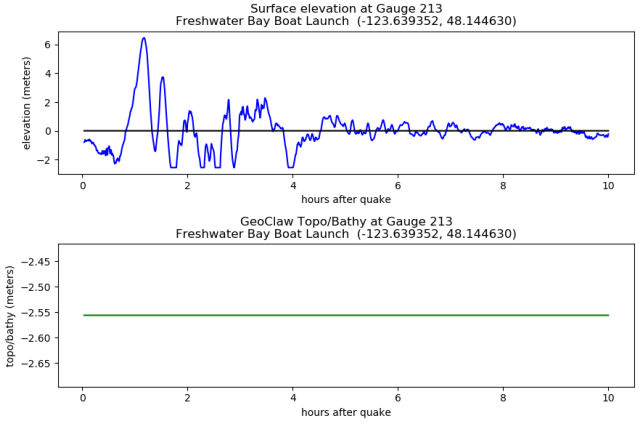
Computed on region `Butler_Crescent`.

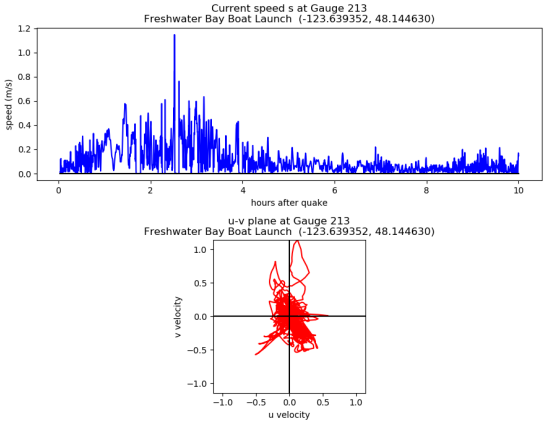
CSZ XL1 event:



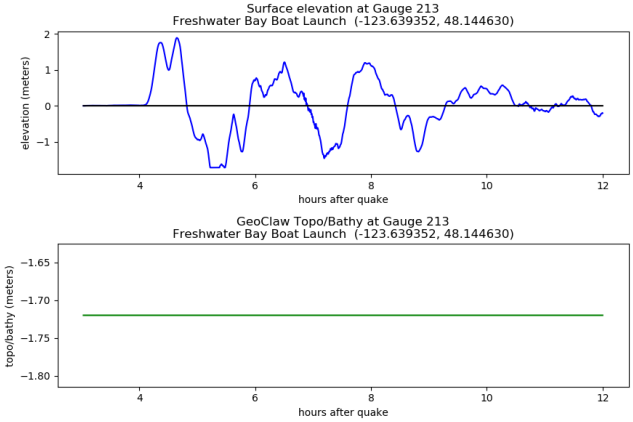


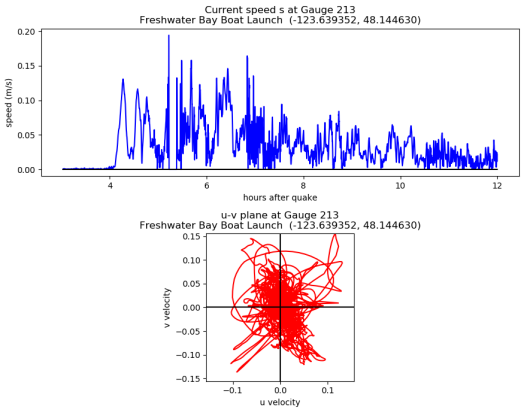
CSZ L1 event:





AKmaxWA event:

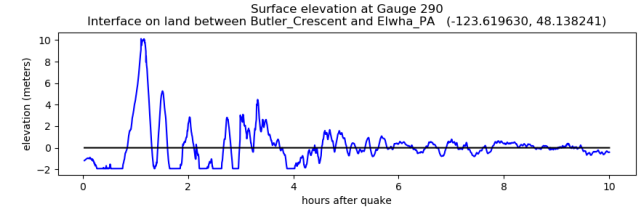


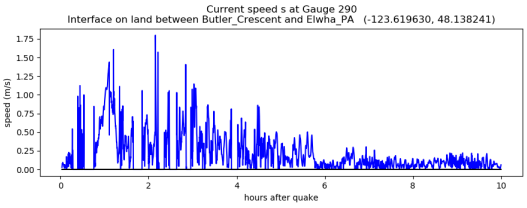


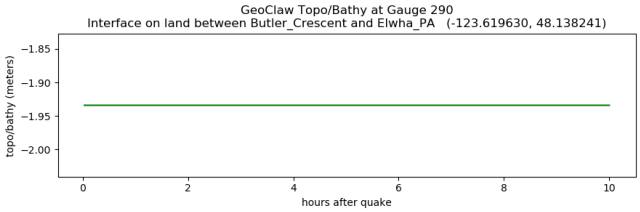
Gauge 290: Interface on land between Butler_Crescent and Elwha_PA.

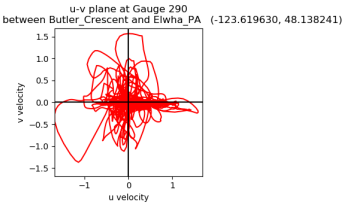
Computed on region Butler_Crescent.

CSZ XL1 event:

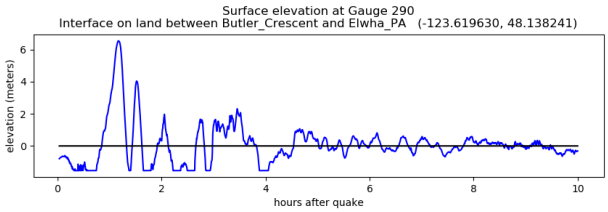


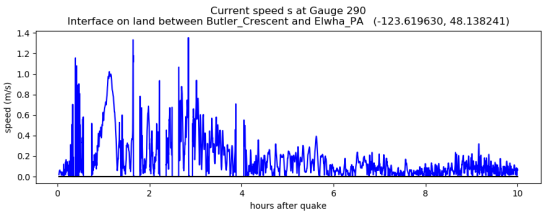


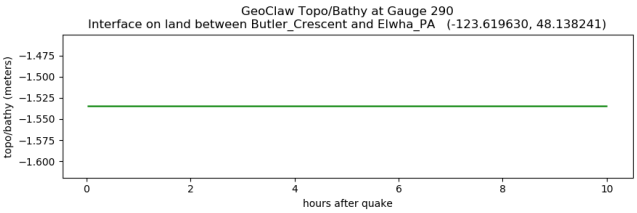


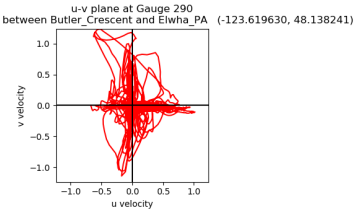


CSZ L1 event:

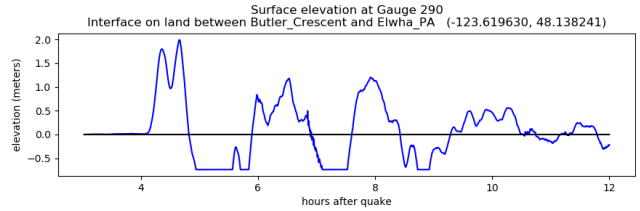


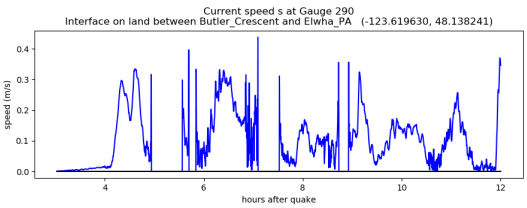


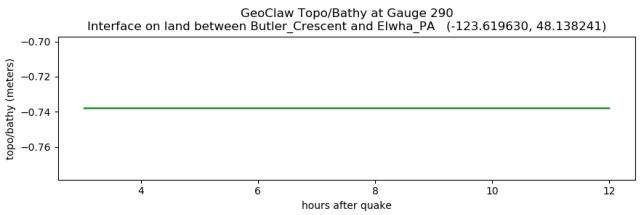


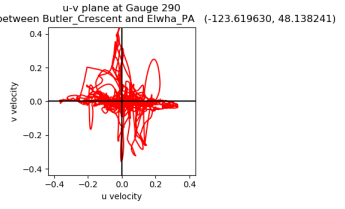


AKmaxWA event:





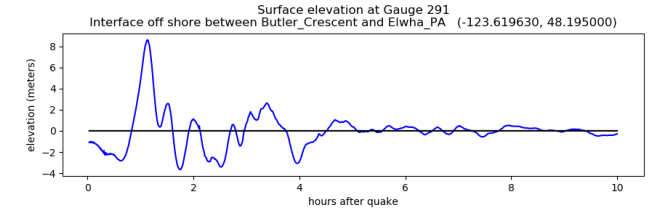


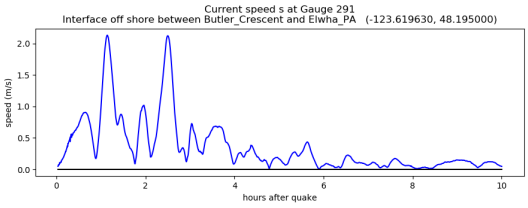


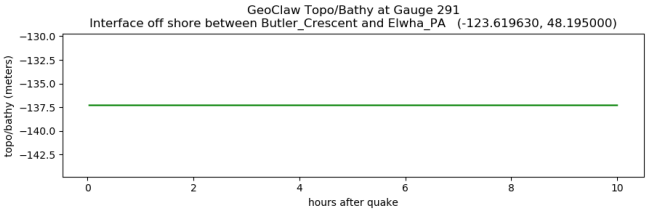
Gauge 291: Interface off shore between Butler_Crescent and Elwha_PA.

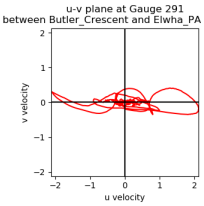
Computed on region Butler_Crescent.

CSZ XL1 event:

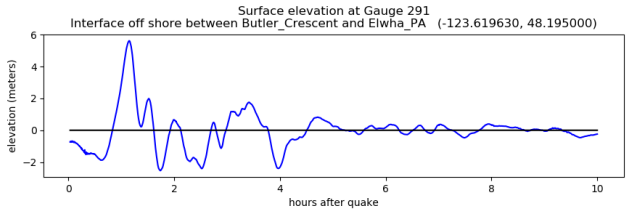


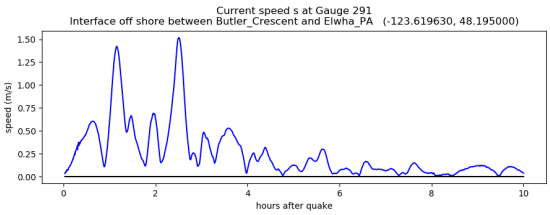


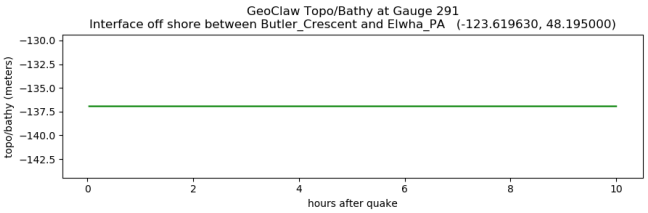


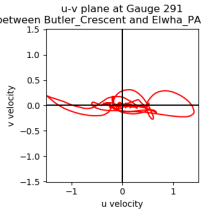


CSZ L1 event:

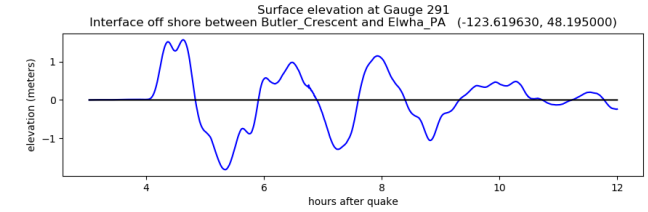


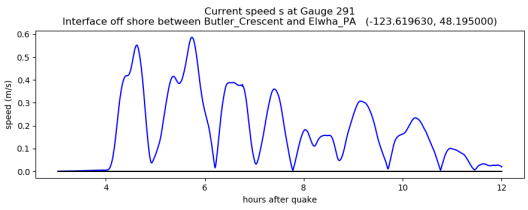


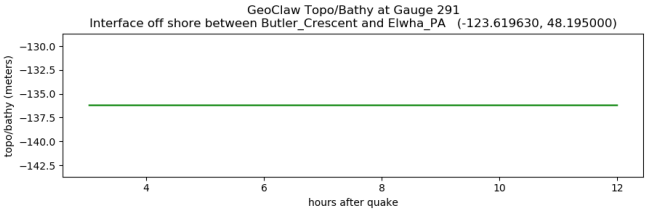


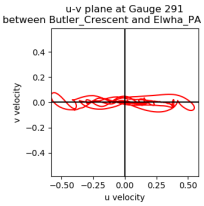


AKmaxWA event:





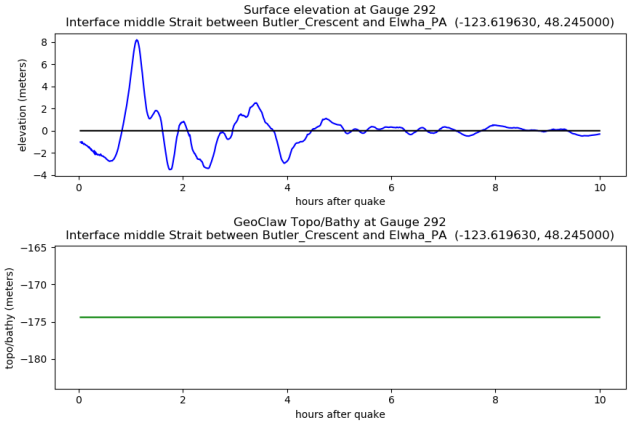


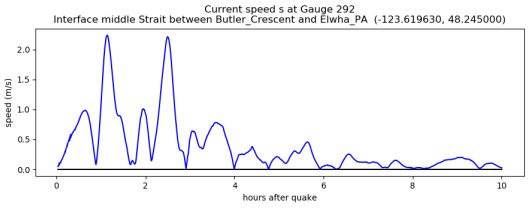


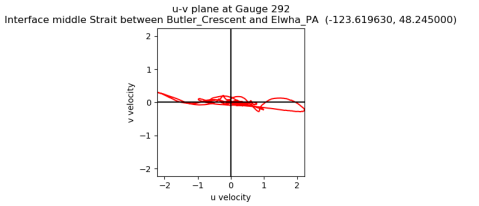
Gauge 292: Interface middle Strait between Butler_Crescent and Elwha_PA.

Computed on region Butler_Crescent.

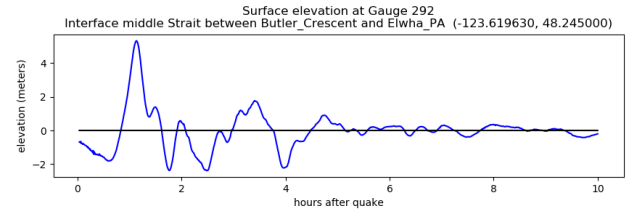
CSZ XL1 event:

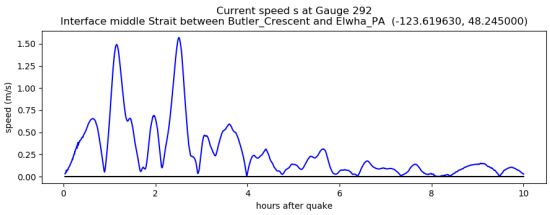


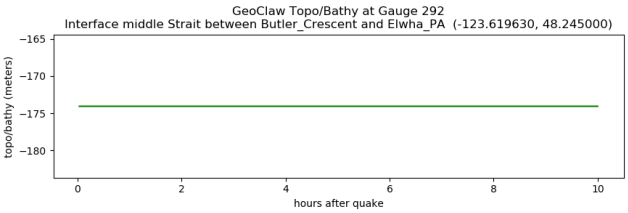


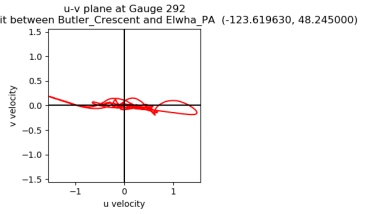


CSZ L1 event:

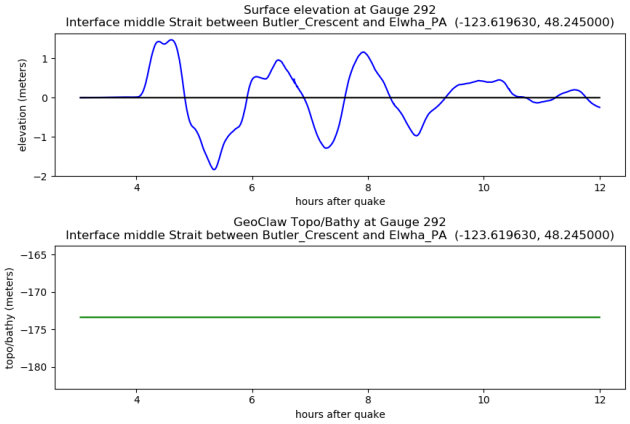


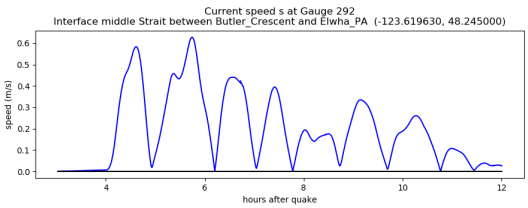


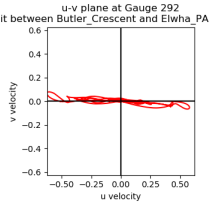




AKmaxWA event:



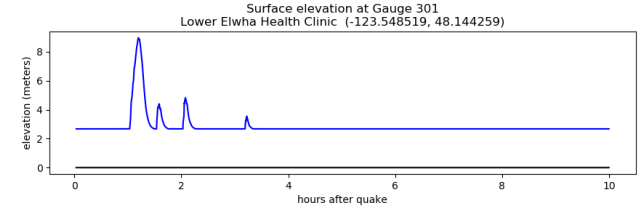


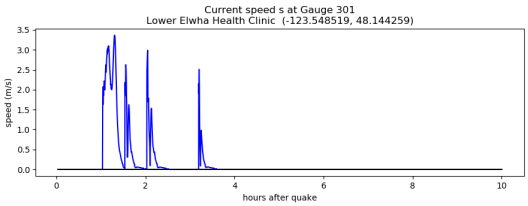


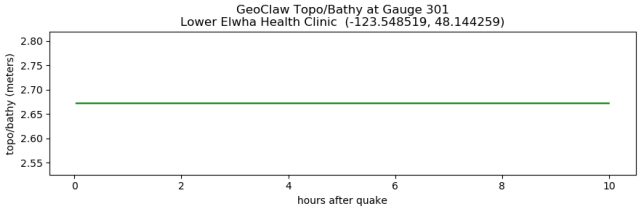
Gauge 301: Lower Elwha Health Clinic.

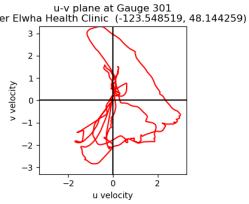
Computed on region `Elwha_PA`.

CSZ XL1 event:

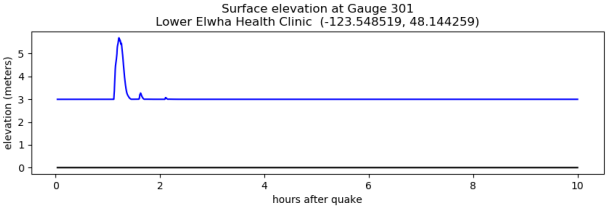


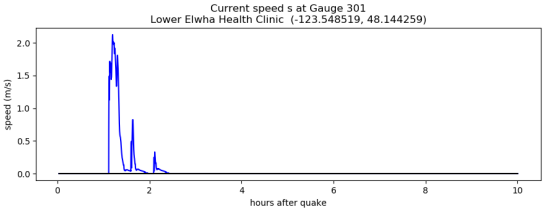


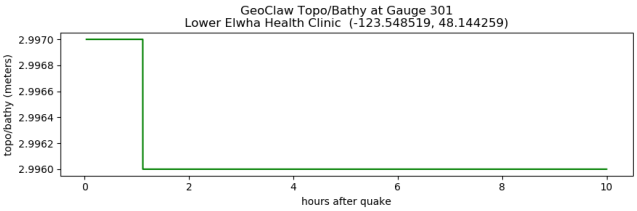


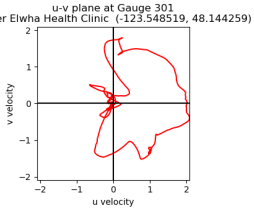


CSZ L1 event:

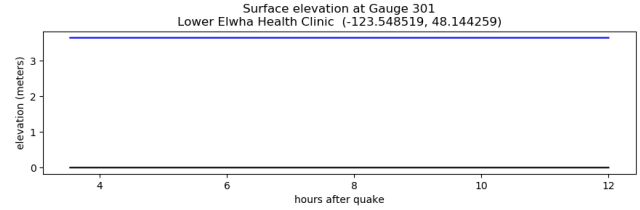


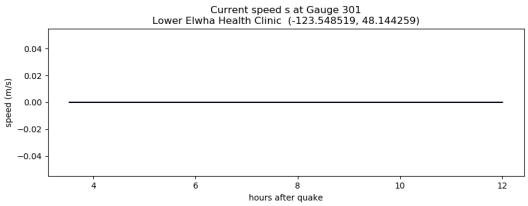


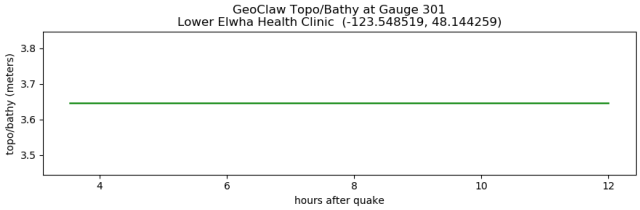


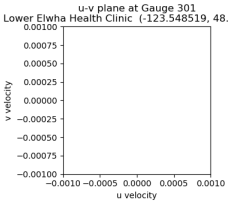


AKmaxWA event:





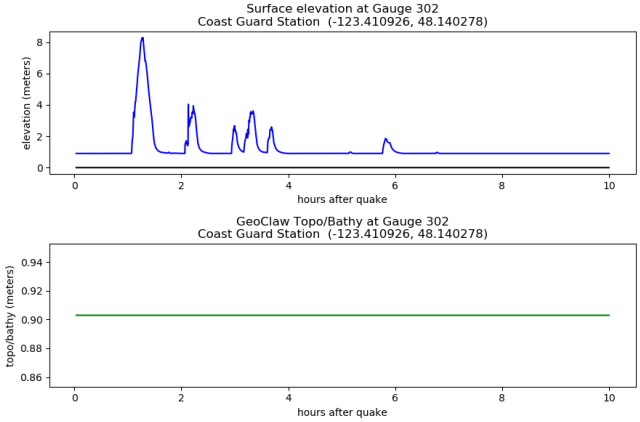


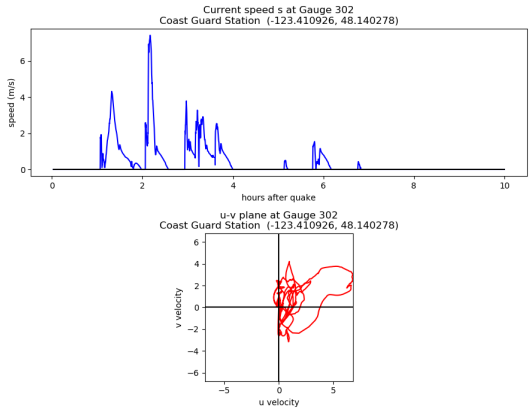


Gauge 302: Coast Guard Station, Ediz Hook.

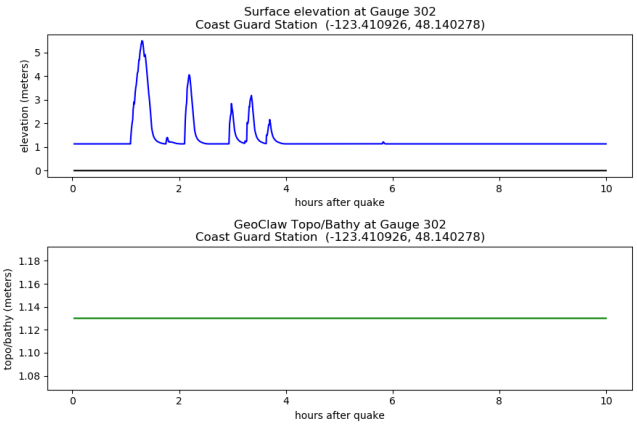
Computed on region `Elwha_PA`.

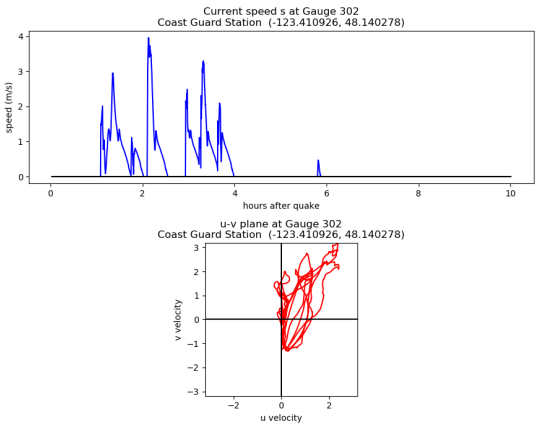
CSZ XL1 event:



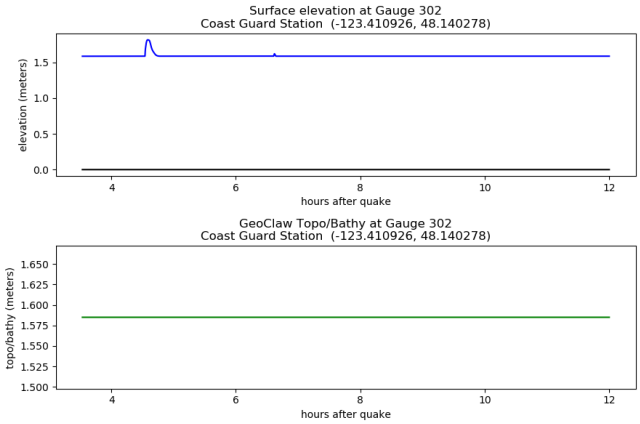


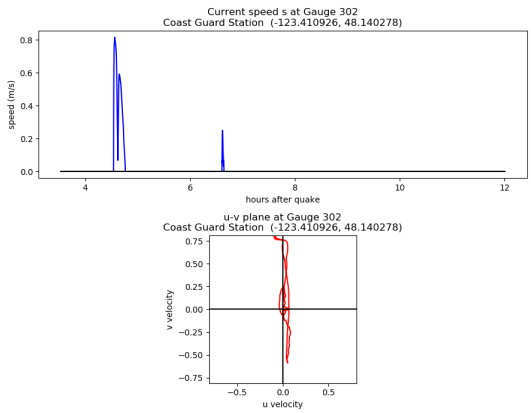
CSZ L1 event:





AKmaxWA event:

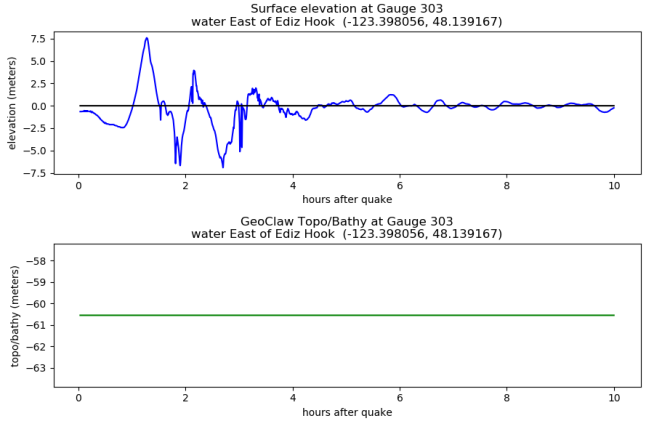


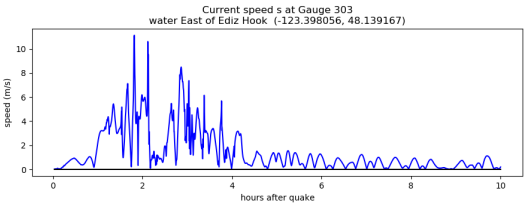


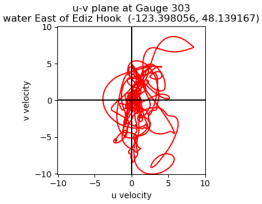
Gauge 303: Water East of Ediz Hook.

Computed on region `Elwha_PA`.

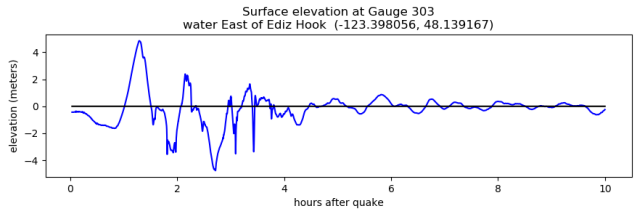
CSZ XL1 event:

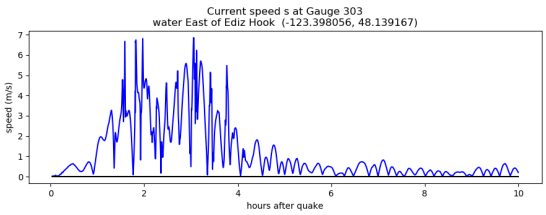


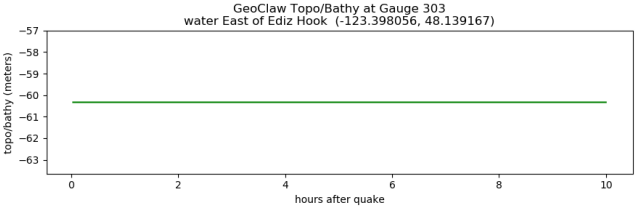


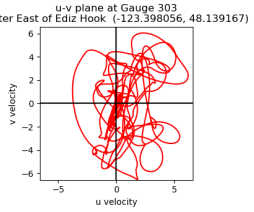


CSZ L1 event:

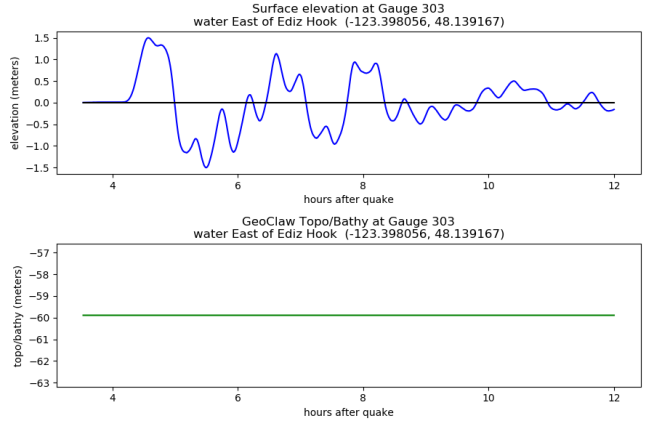


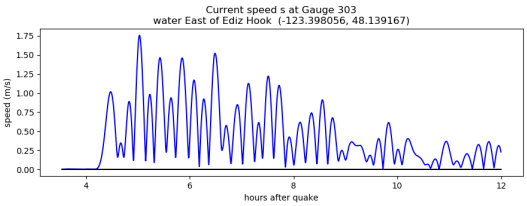


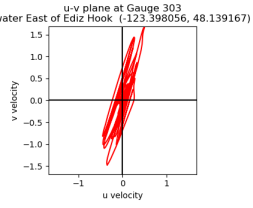




AKmaxWA event:



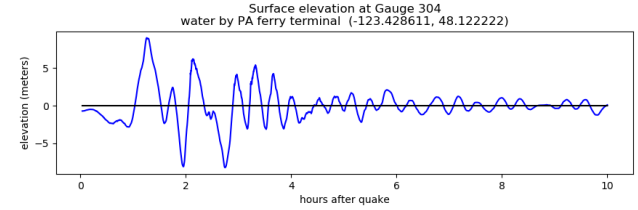


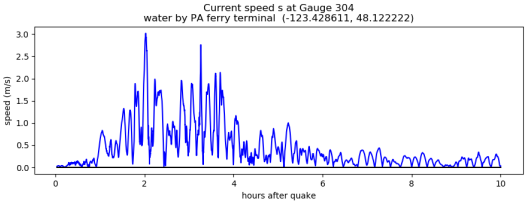


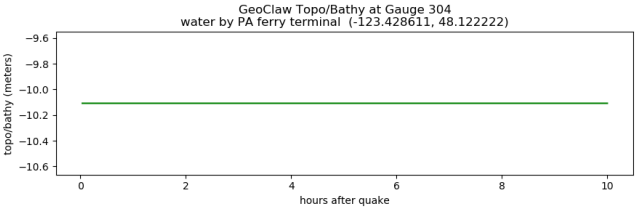
Gauge 304: Water by PA ferry terminal.

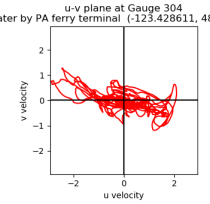
Computed on region `Elwha_PA`.

CSZ XL1 event:

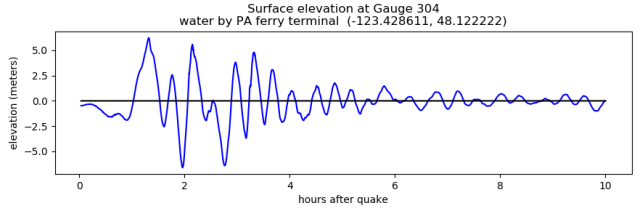


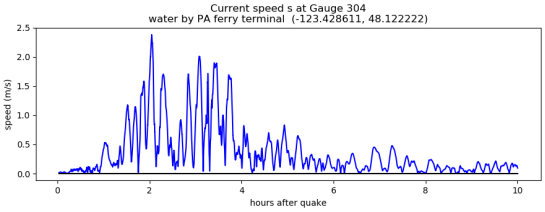


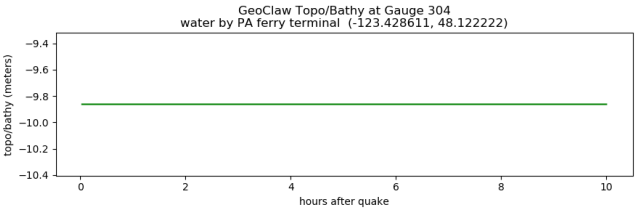


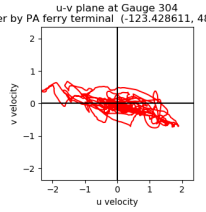


CSZ L1 event:

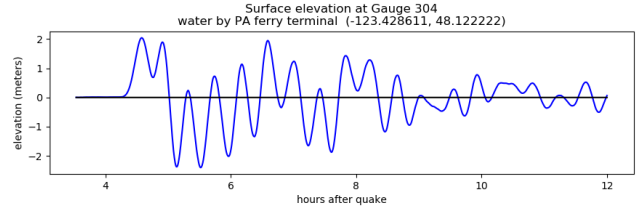


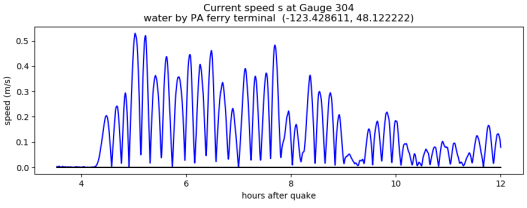


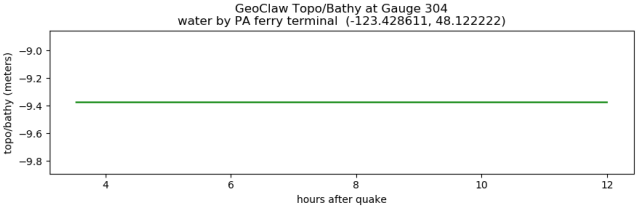


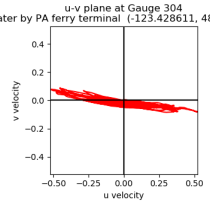


AKmaxWA event:





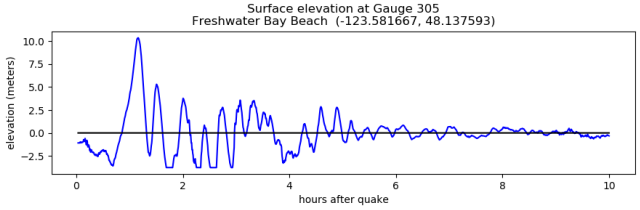


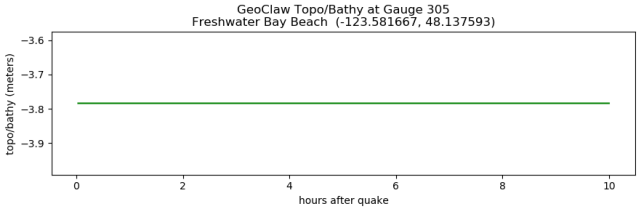


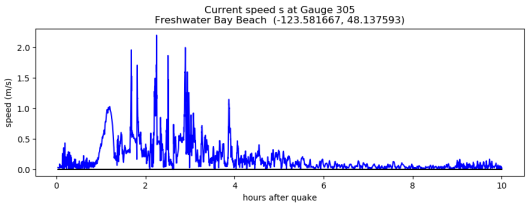
Gauge 305: Freshwater Bay Beach.

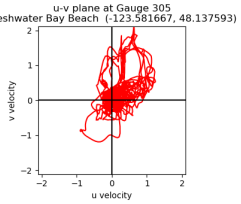
Computed on region `Elwha_PA`.

CSZ XL1 event:

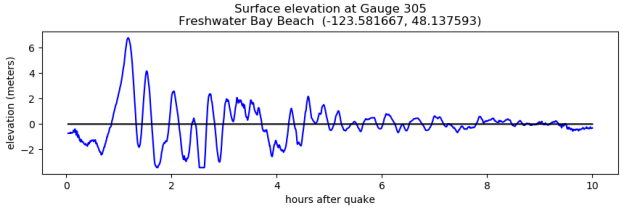


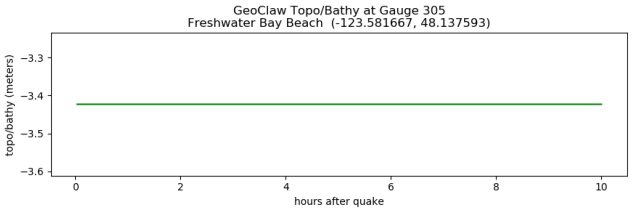


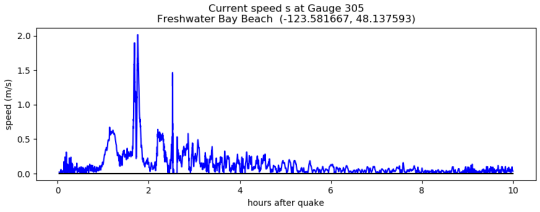


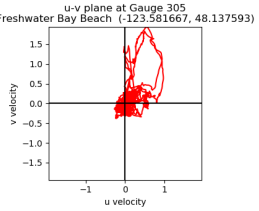


CSZ L1 event:

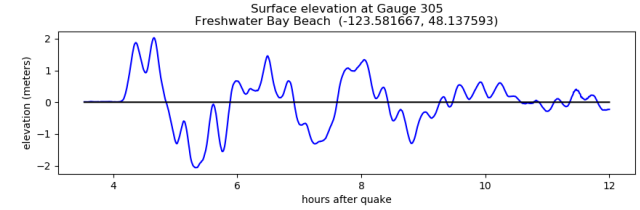


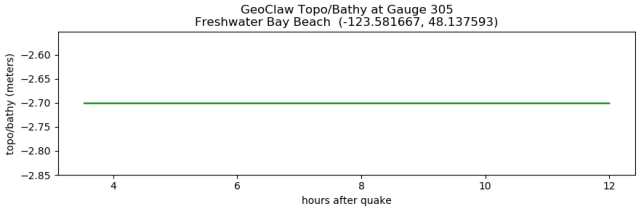


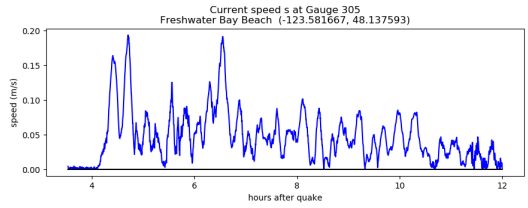


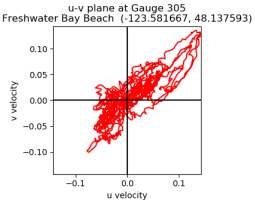


AKmaxWA event:





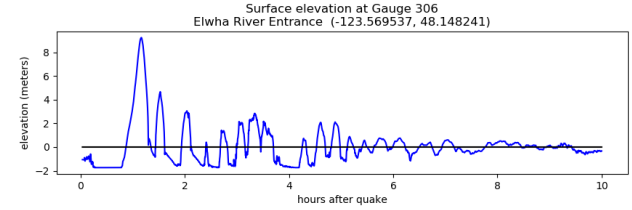


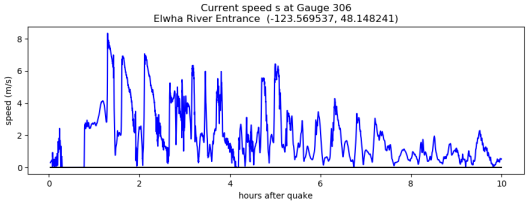


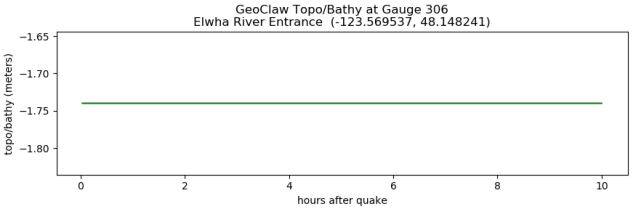
Gauge 306: Elwha River Entrance.

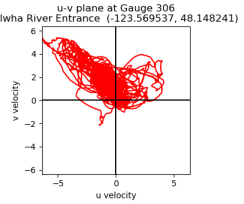
Computed on region `Elwha_PA`.

CSZ XL1 event:

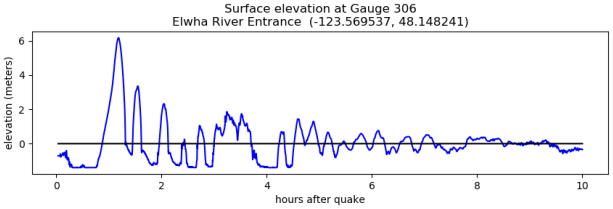


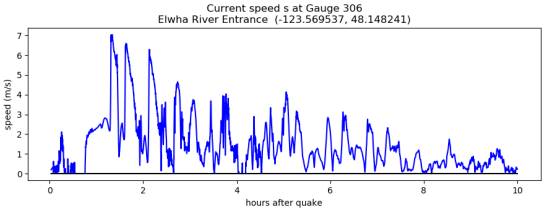


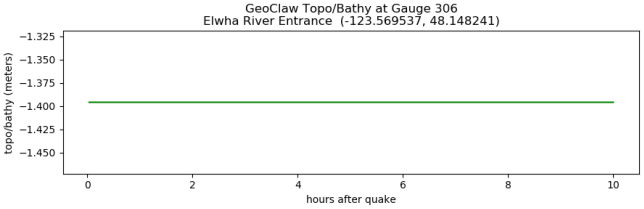


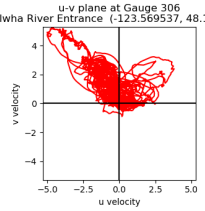


CSZ L1 event:

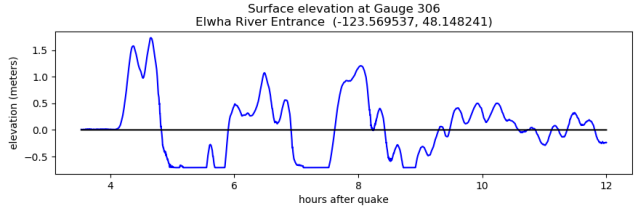


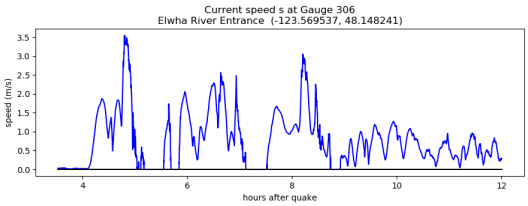


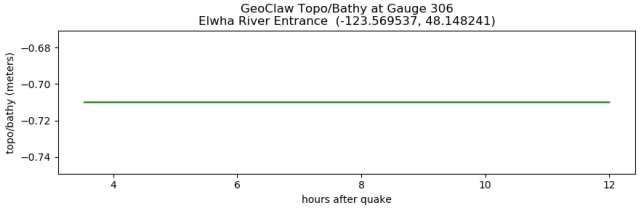


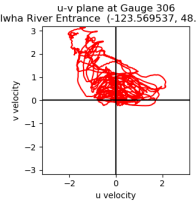


AKmaxWA event:





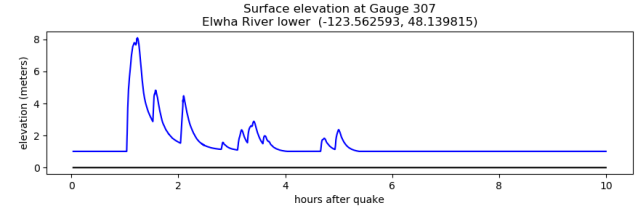


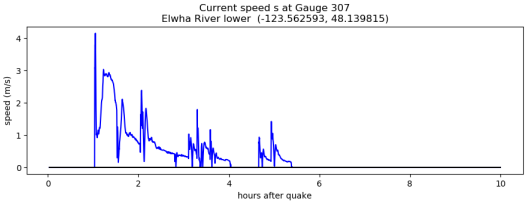


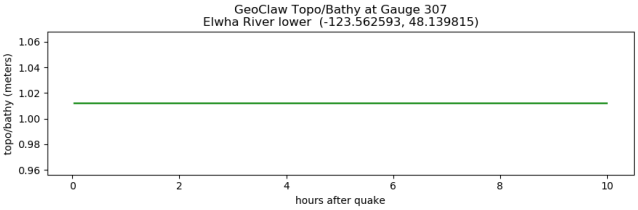
Gauge 307: Elwha River lower.

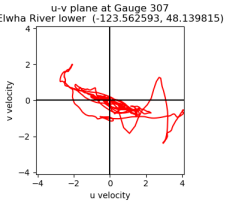
Computed on region `Elwha_PA`.

CSZ XL1 event:

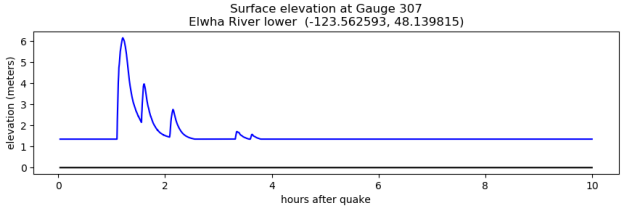


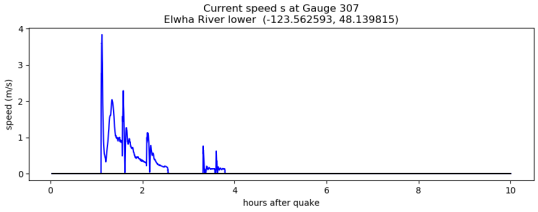


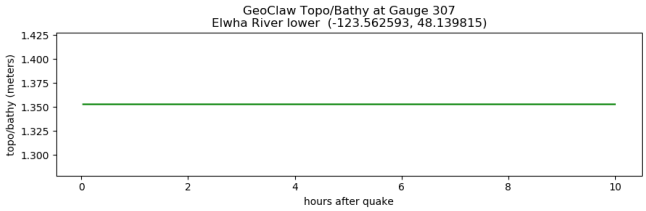


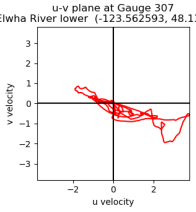


CSZ L1 event:

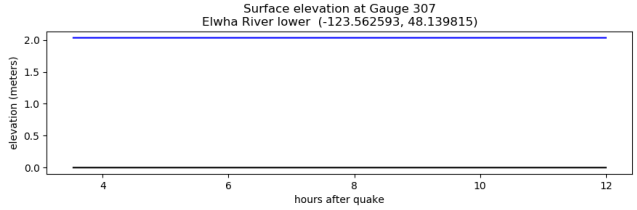


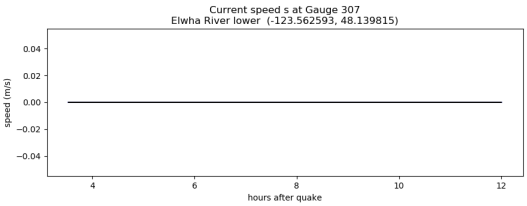


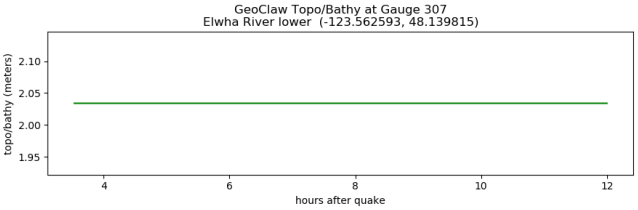


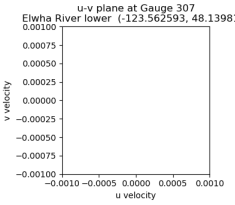


AKmaxWA event:





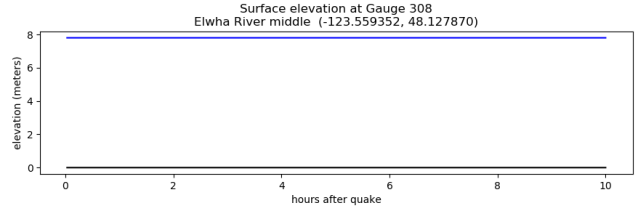


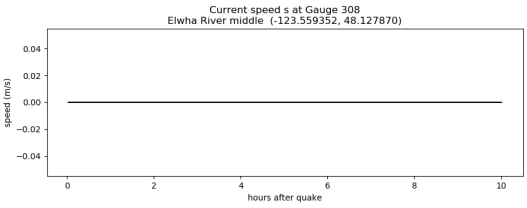


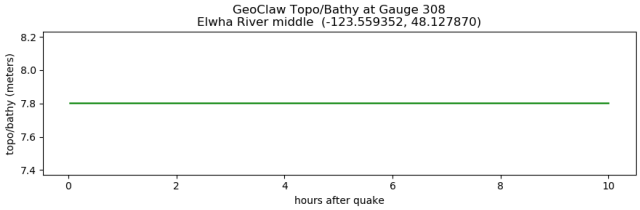
Gauge 308: Elwha River middle.

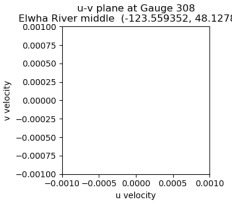
Computed on region `Elwha_PA`.

CSZ XL1 event:

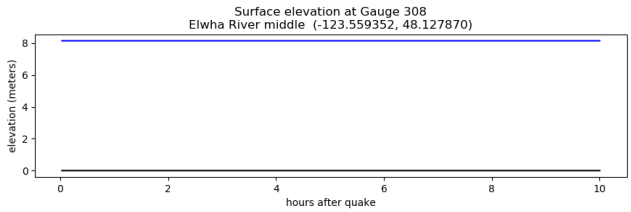


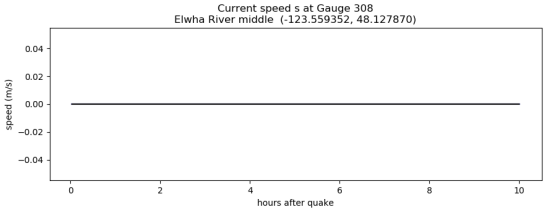


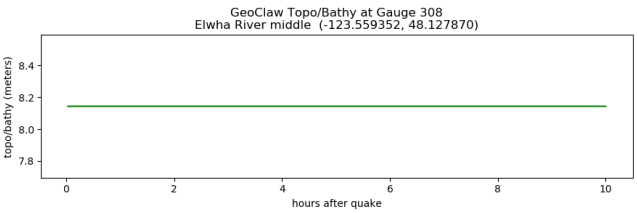


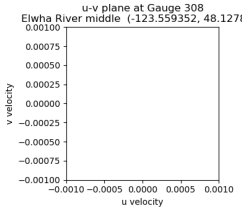


CSZ L1 event:

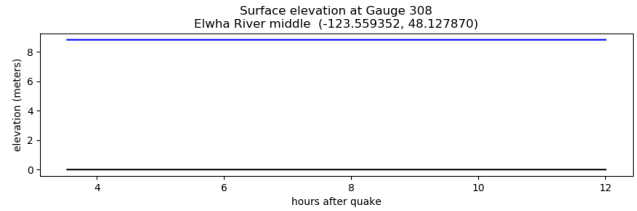


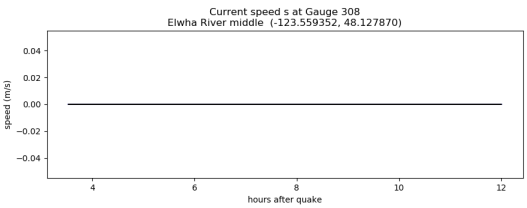


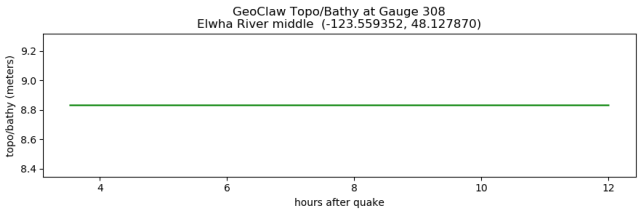


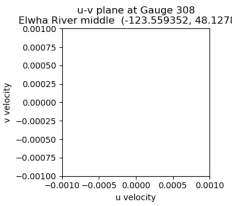


AKmaxWA event:





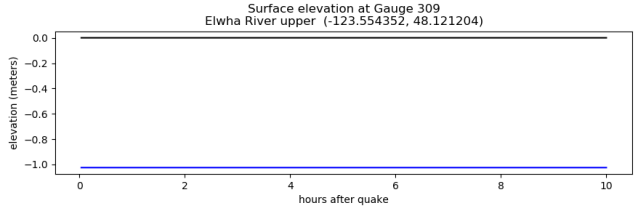


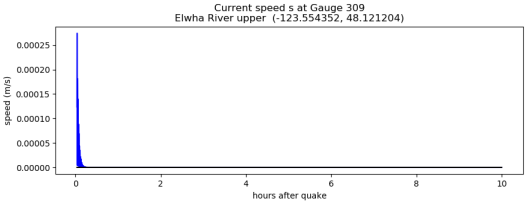


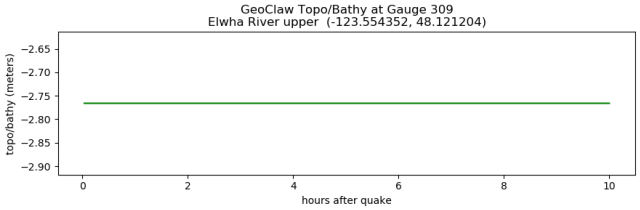
Gauge 309: Elwha River upper.

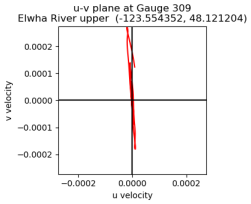
Computed on region `Elwha_PA`.

CSZ XL1 event:

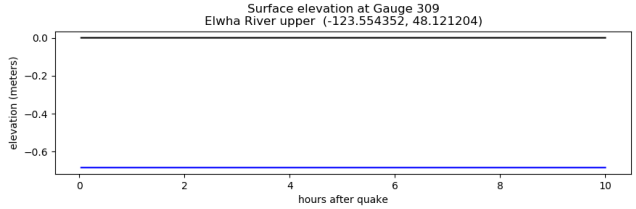


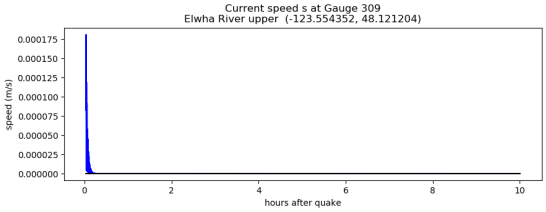


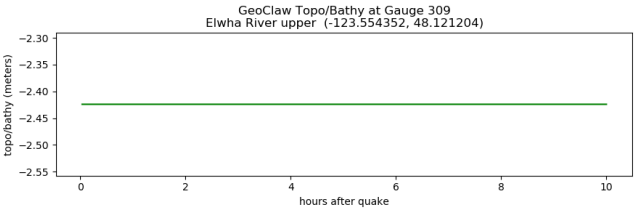


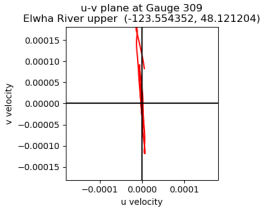


CSZ L1 event:

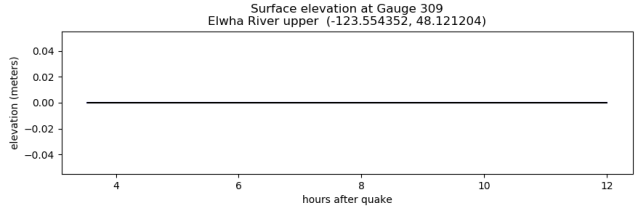


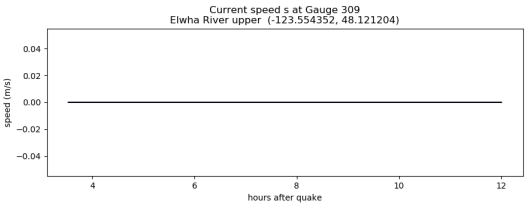


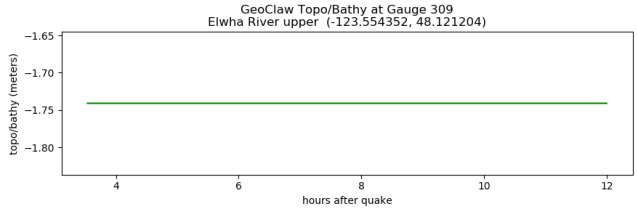


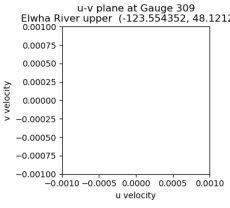


AKmaxWA event:





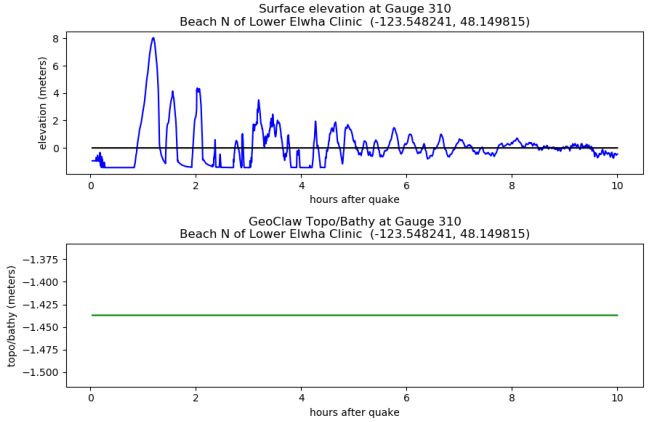


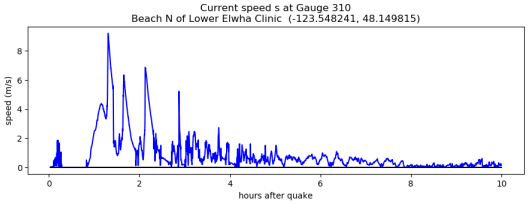


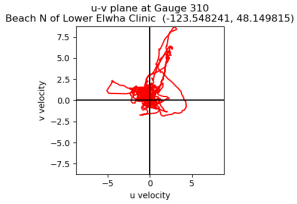
Gauge 310: Beach N of Lower Elwha Clinic.

Computed on region `Elwha_PA`.

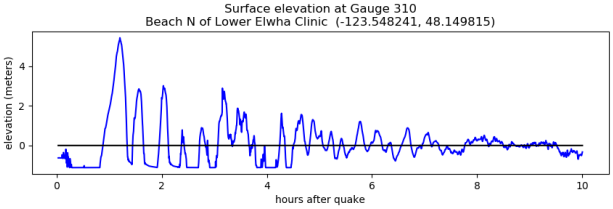
CSZ XL1 event:

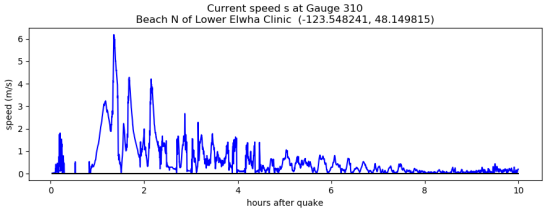


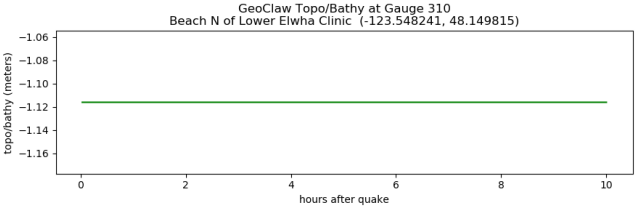


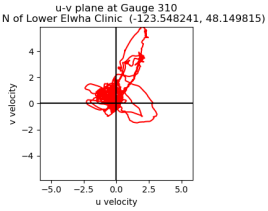


CSZ L1 event:

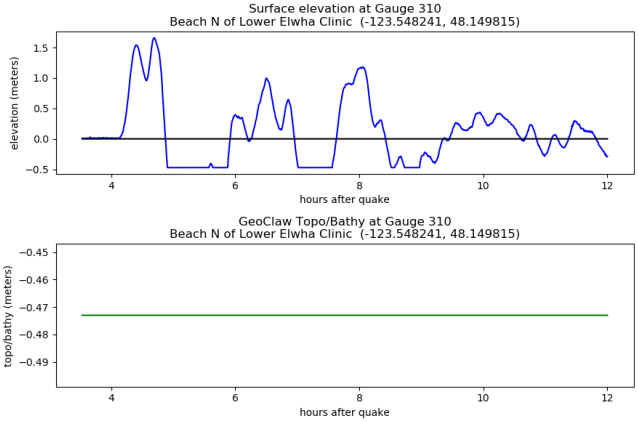


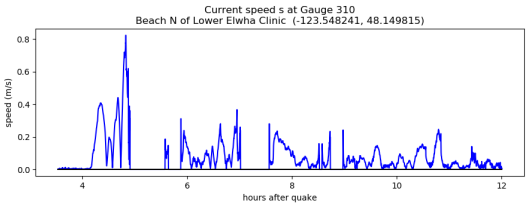


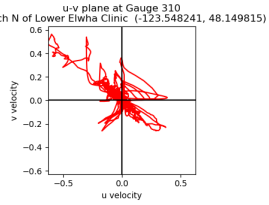




AKmaxWA event:



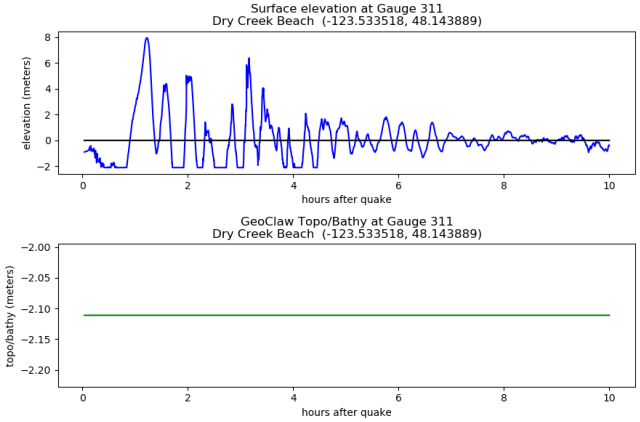


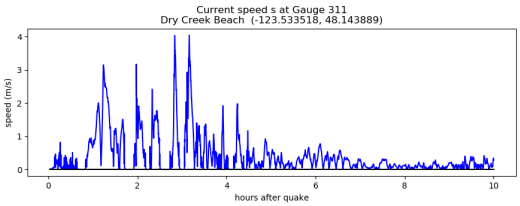


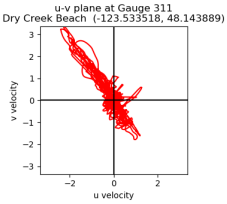
Gauge 311: Dry Creek Beach.

Computed on region `Elwha_PA`.

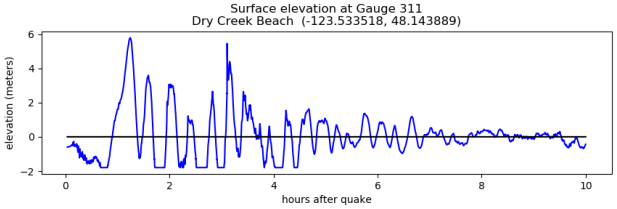
CSZ XL1 event:

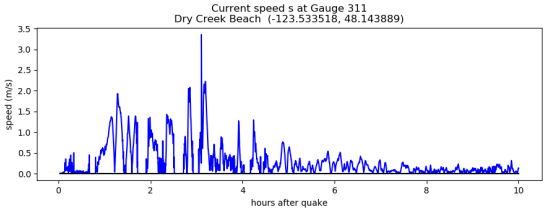


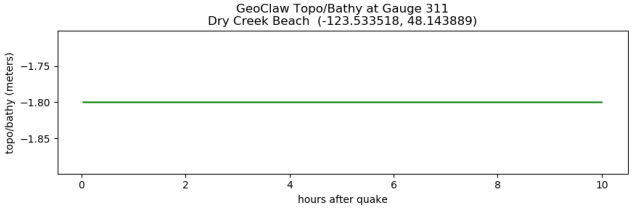


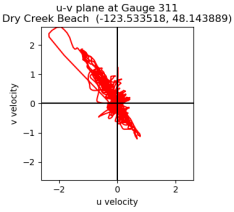


CSZ L1 event:

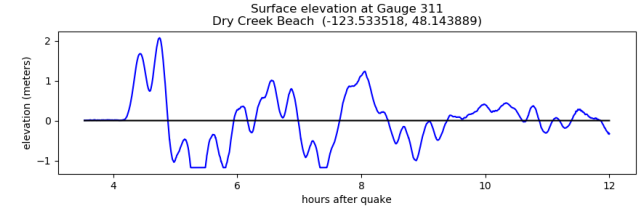


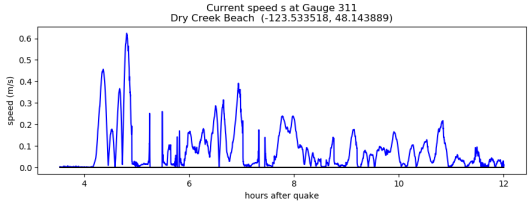


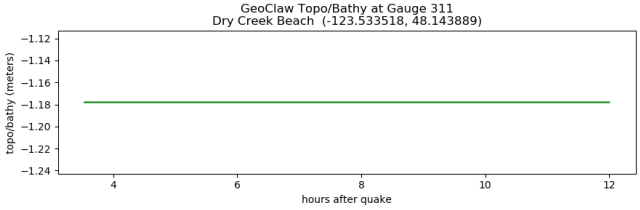


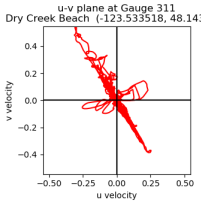


AKmaxWA event:





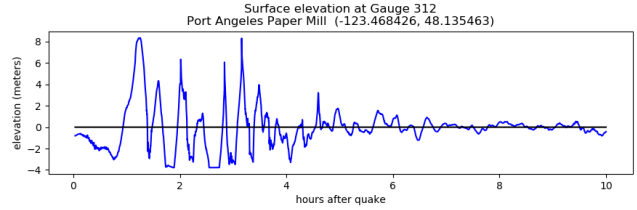


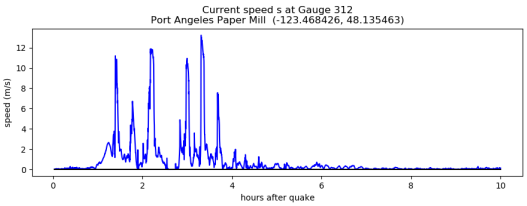


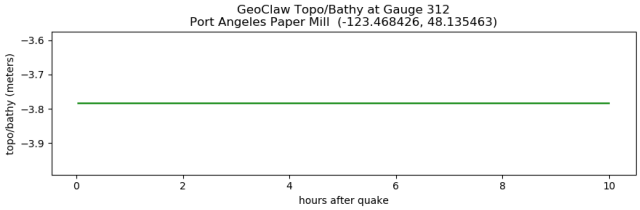
Gauge 312: Port Angeles Paper Mill.

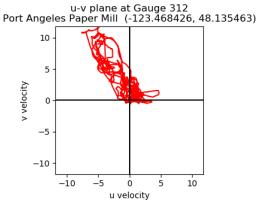
Computed on region `Elwha_PA`.

CSZ XL1 event:

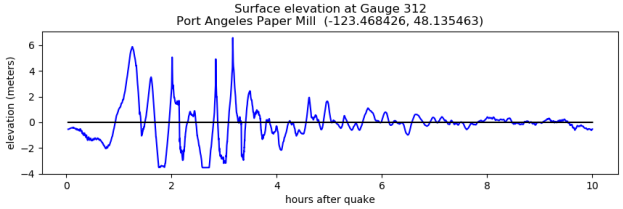


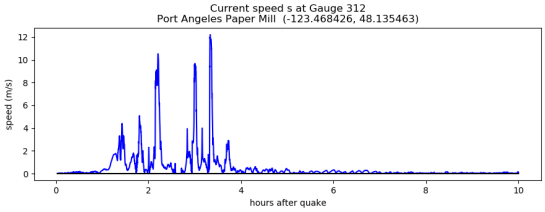


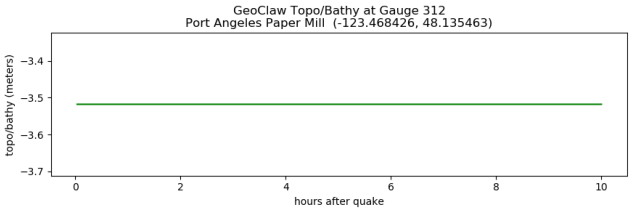


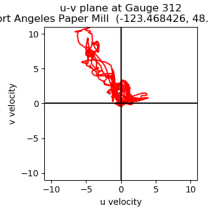


CSZ L1 event:

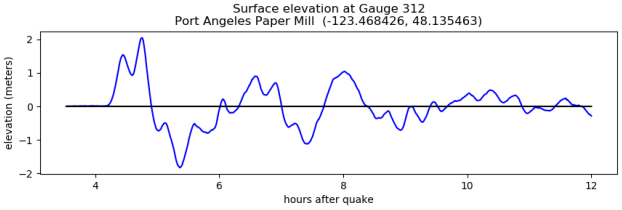


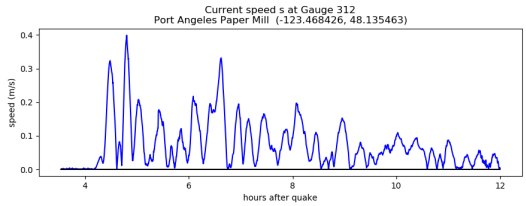


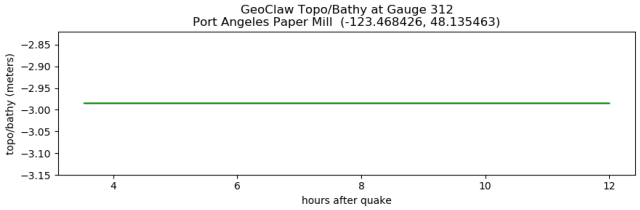


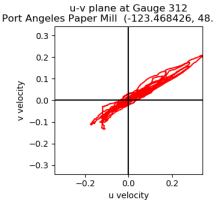


AKmaxWA event:





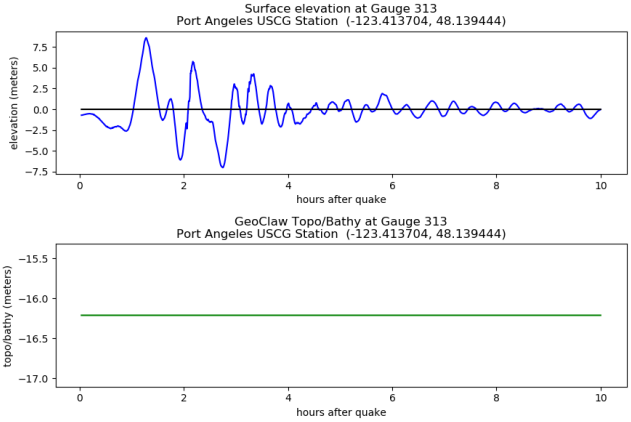


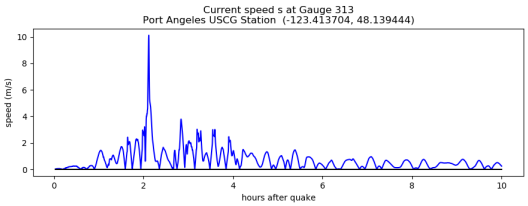


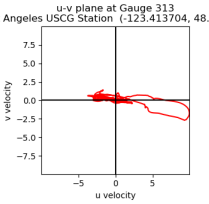
Gauge 313: Port Angeles USCG Station.

Computed on region `Elwha_PA`.

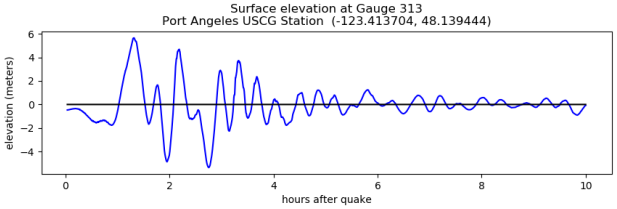
CSZ XL1 event:

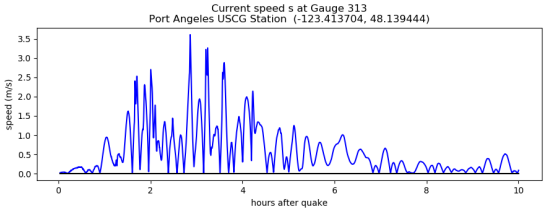


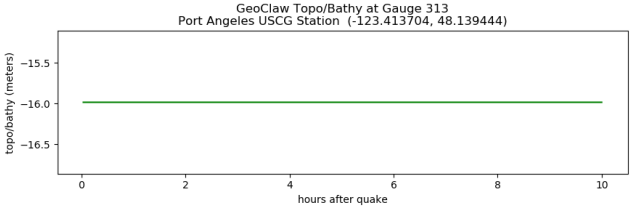


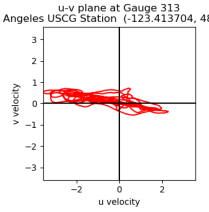


CSZ L1 event:

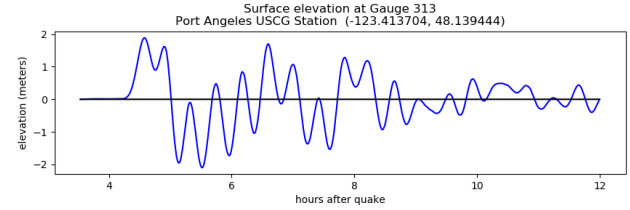


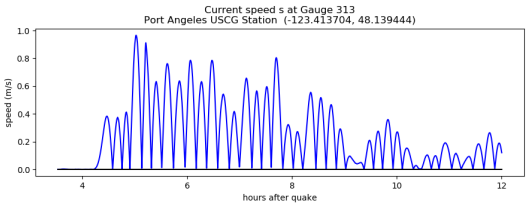


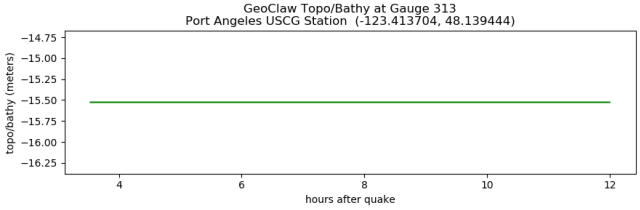


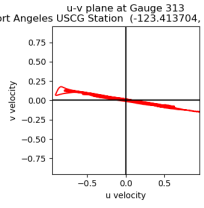


AKmaxWA event:





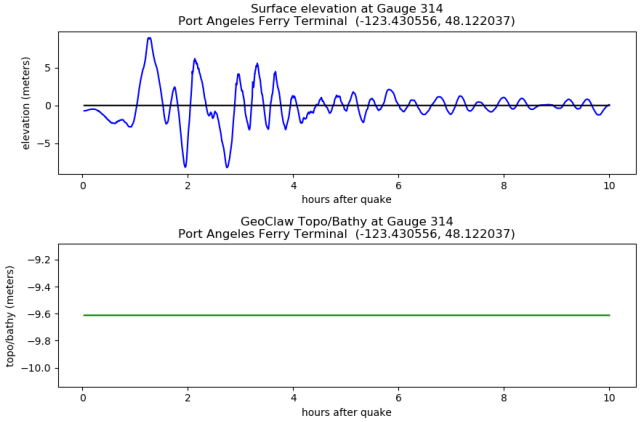


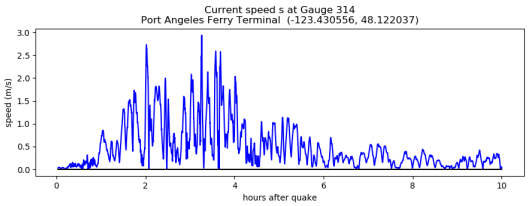


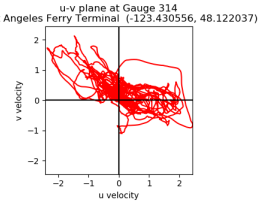
Gauge 314: Port Angeles Ferry Terminal.

Computed on region `Elwha_PA`.

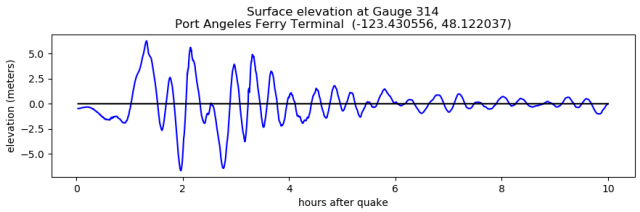
CSZ XL1 event:

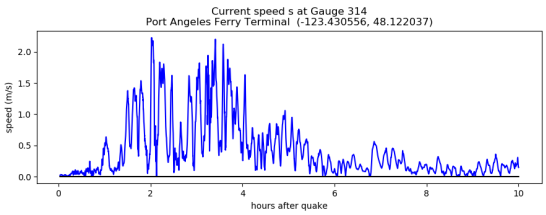


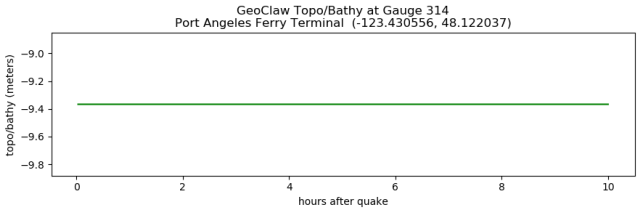


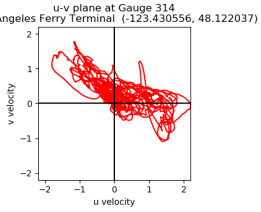


CSZ L1 event:

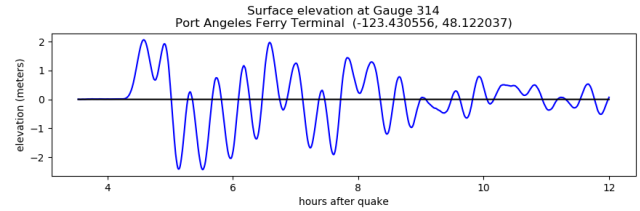


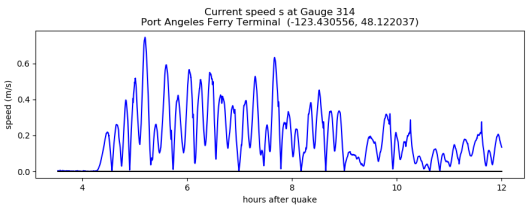


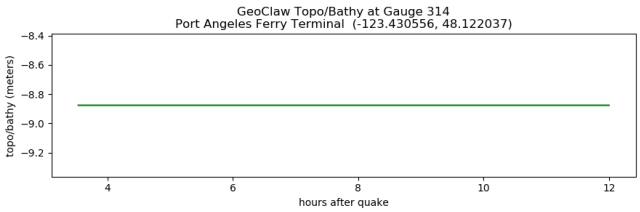


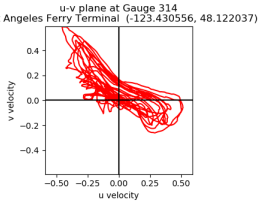


AKmaxWA event:





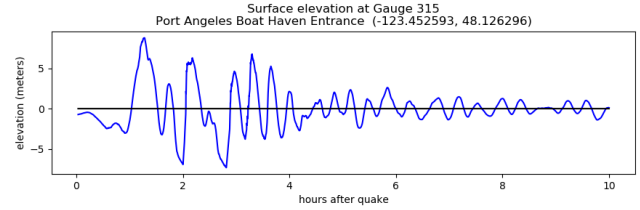


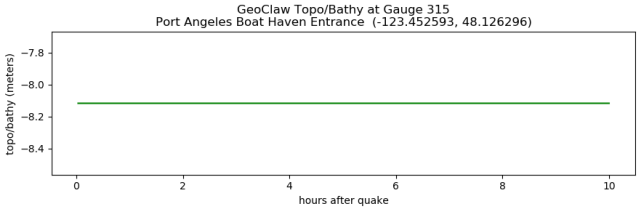


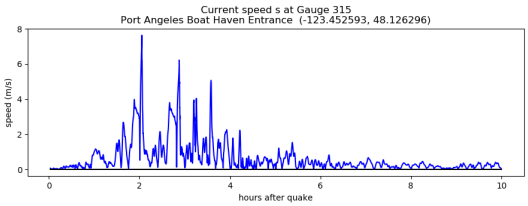
Gauge 315: Port Angeles Boat Haven Entrance.

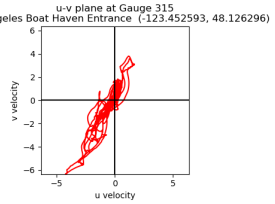
Computed on region `Elwha_PA`.

CSZ XL1 event:

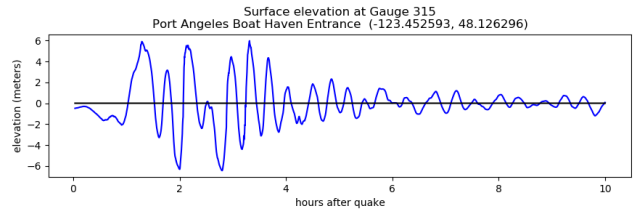


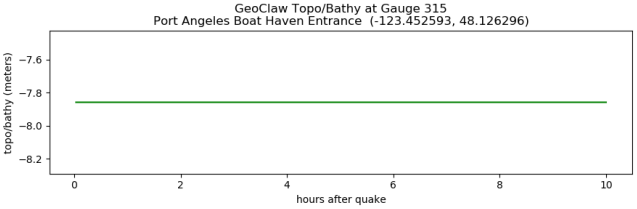


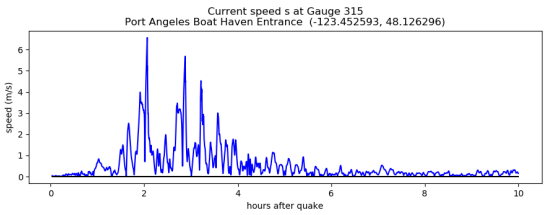


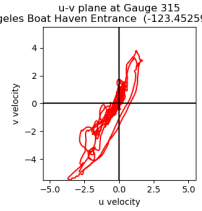


CSZ L1 event:

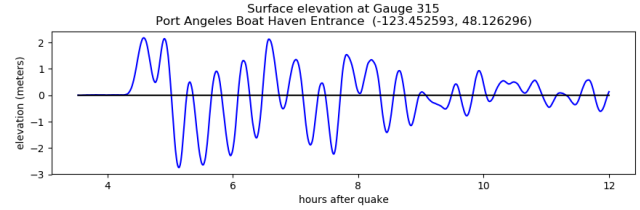


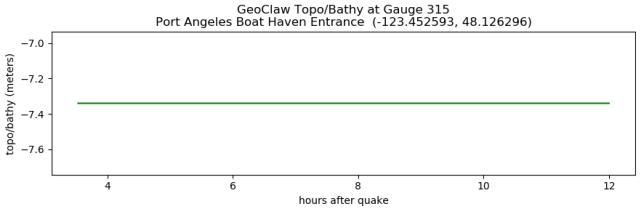


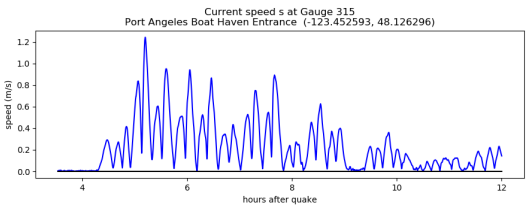


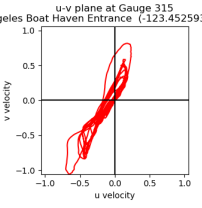


AKmaxWA event:





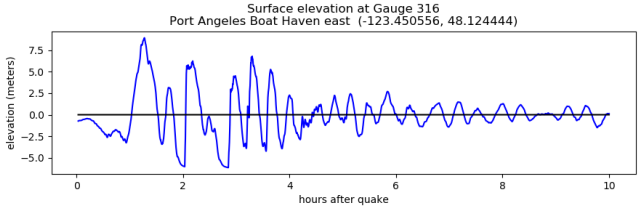


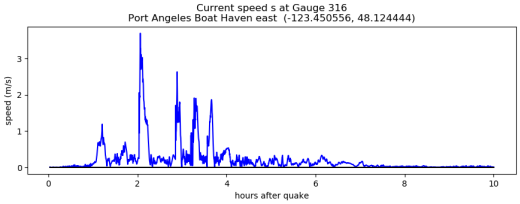


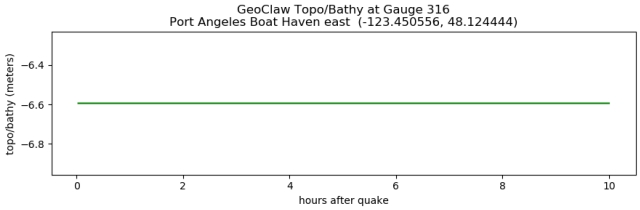
Gauge 316: Port Angeles Boat Haven east.

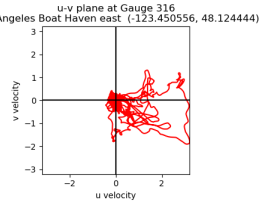
Computed on region `Elwha_PA`.

CSZ XL1 event:

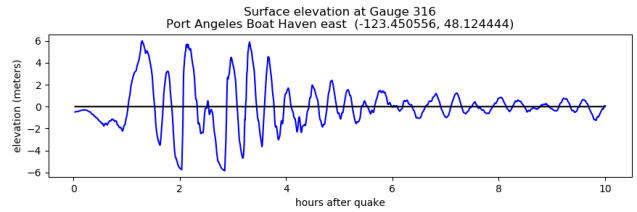


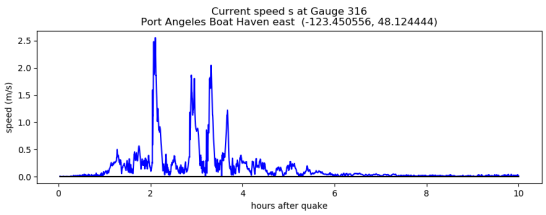


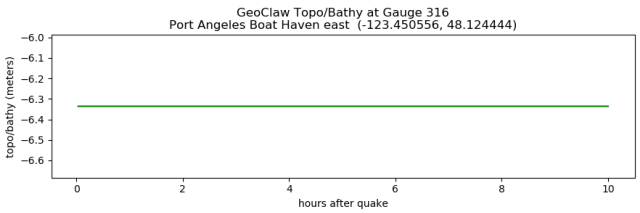


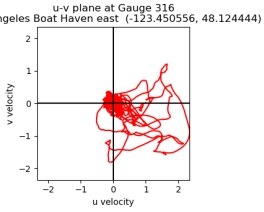


CSZ L1 event:

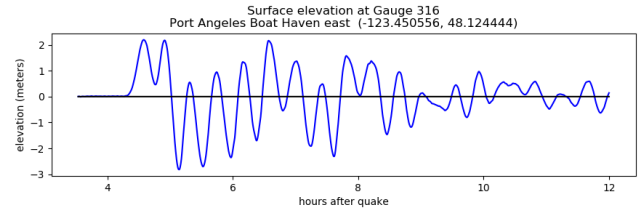


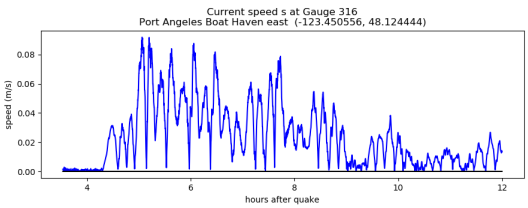


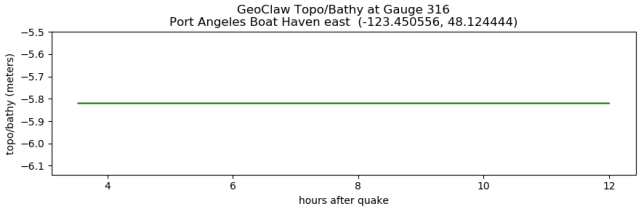


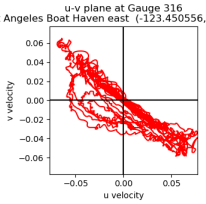


AKmaxWA event:





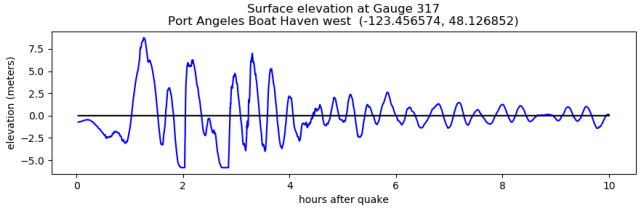


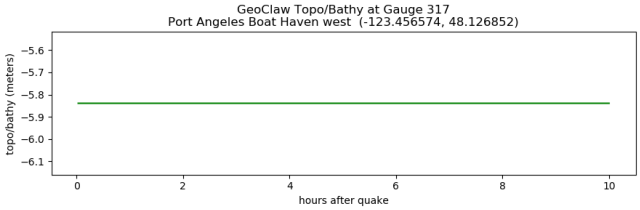


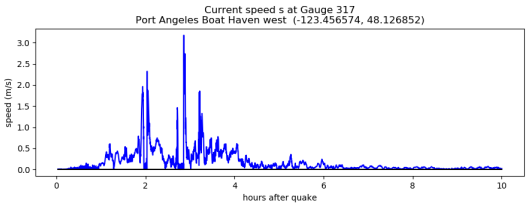
Gauge 317: Port Angeles Boat Haven west.

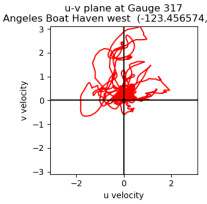
Computed on region `Elwha_PA`.

CSZ XL1 event:

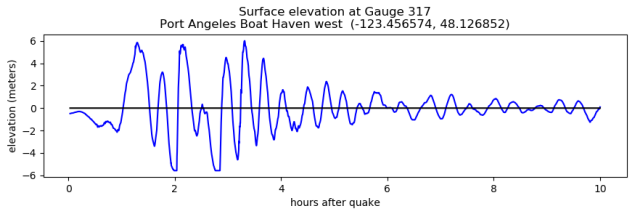


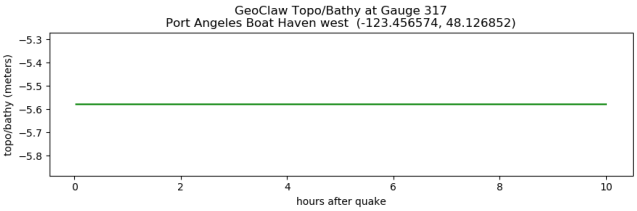


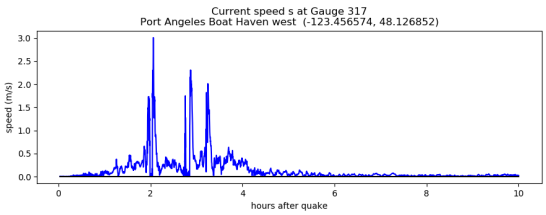


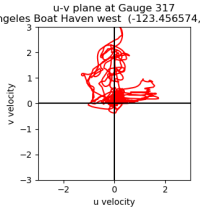


CSZ L1 event:

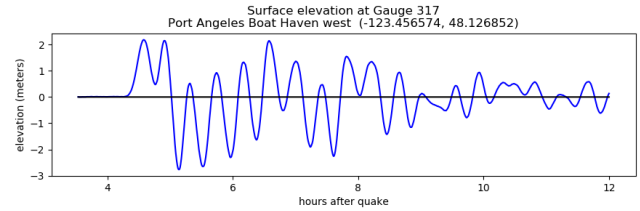


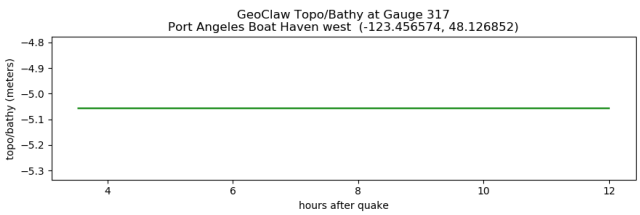


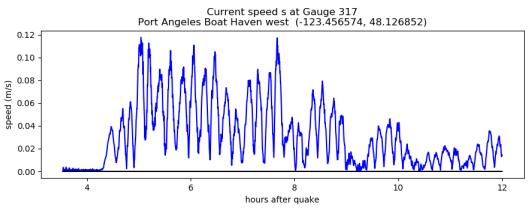


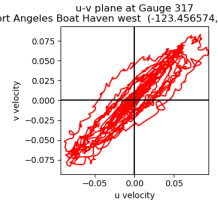


AKmaxWA event:





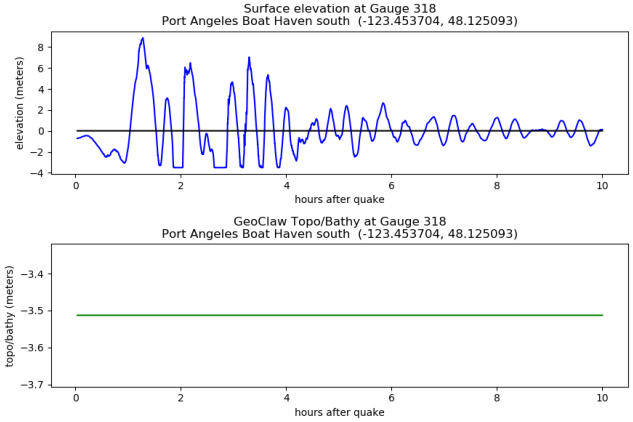


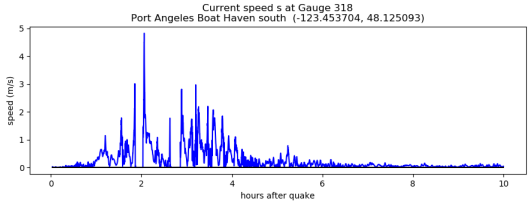


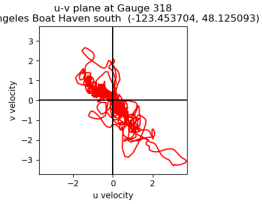
Gauge 318: Port Angeles Boat Haven south.

Computed on region `Elwha_PA`.

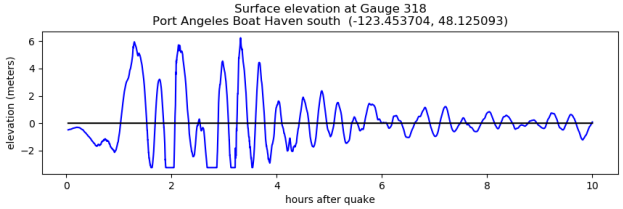
CSZ XL1 event:

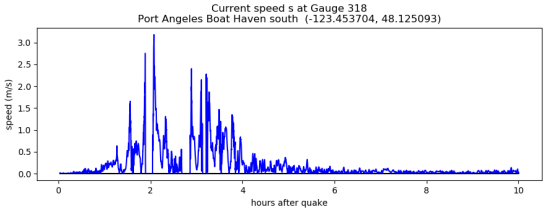


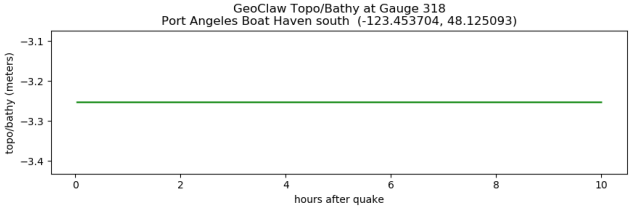


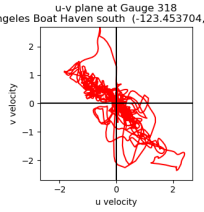


CSZ L1 event:

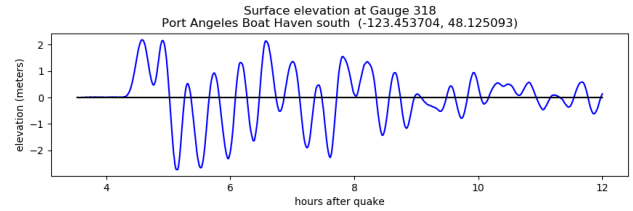


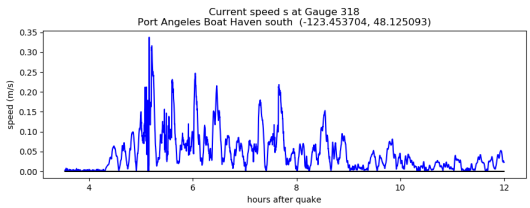


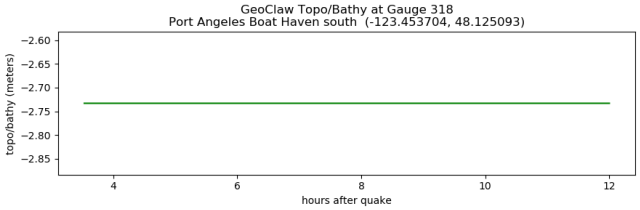


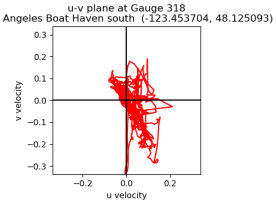


AKmaxWA event:





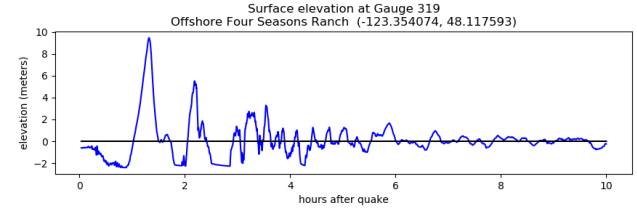


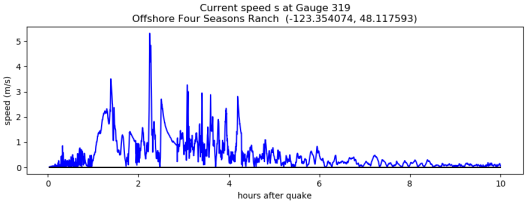


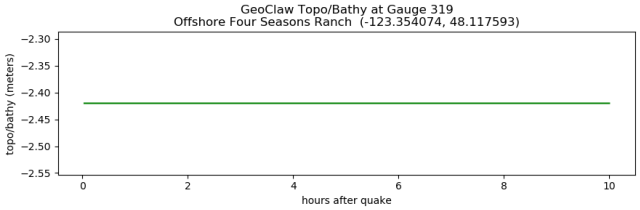
Gauge 319: Offshore Four Seasons Ranch.

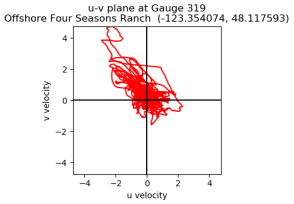
Computed on region `Elwha_PA`.

CSZ XL1 event:

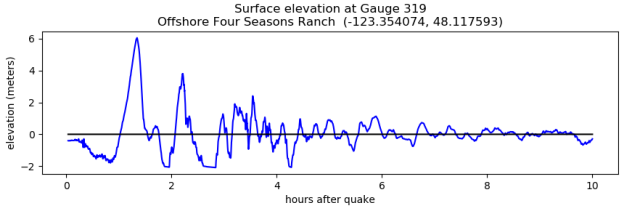


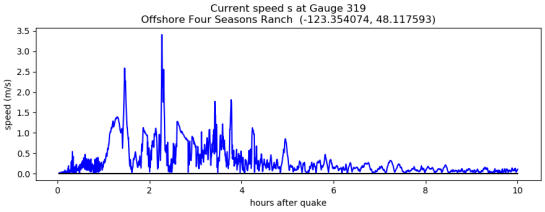


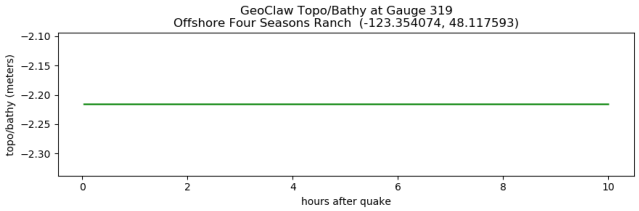


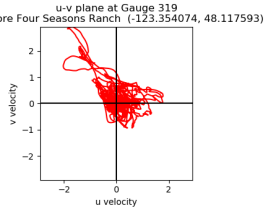


CSZ L1 event:

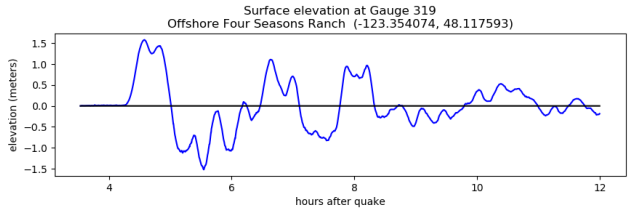


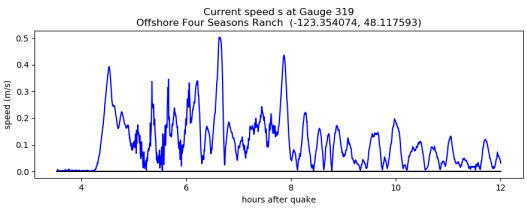


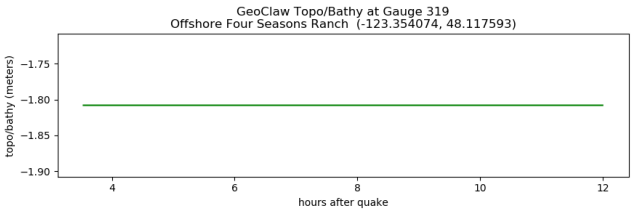


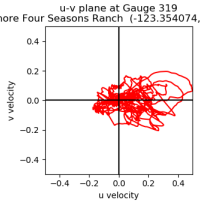


AKmaxWA event:





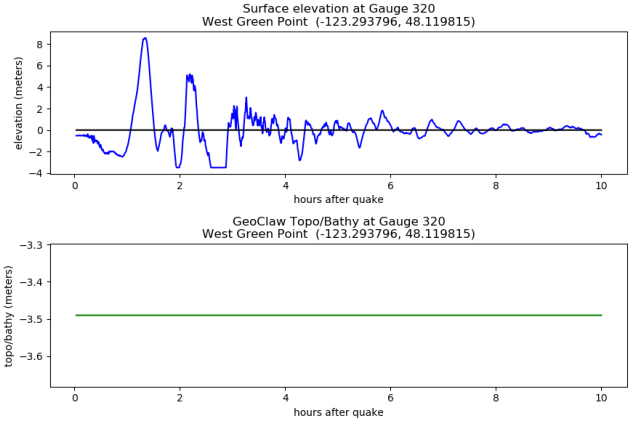


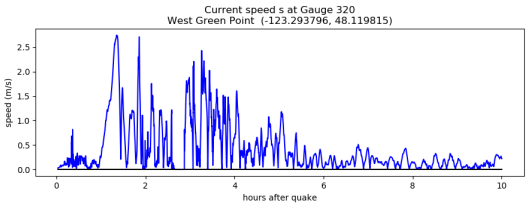


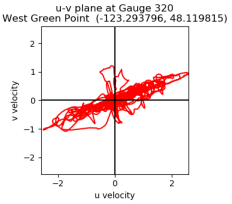
Gauge 320: West Green Point.

Computed on region `Elwha_PA`.

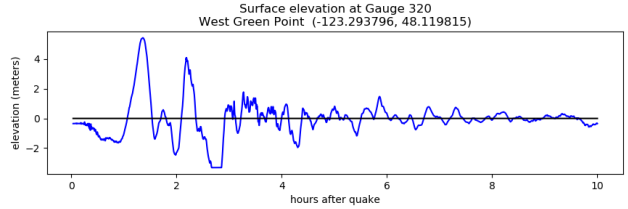
CSZ XL1 event:

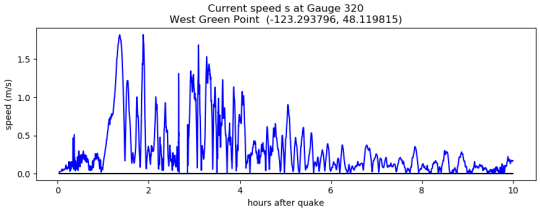


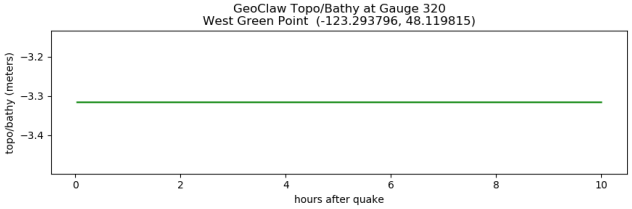


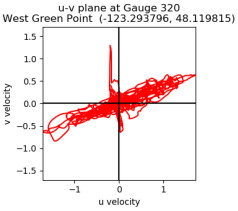


CSZ L1 event:

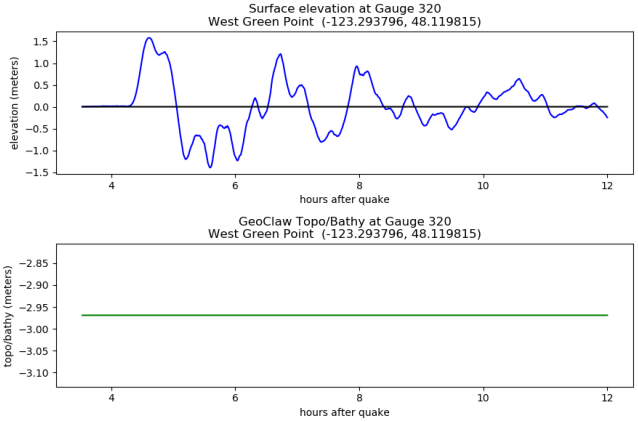


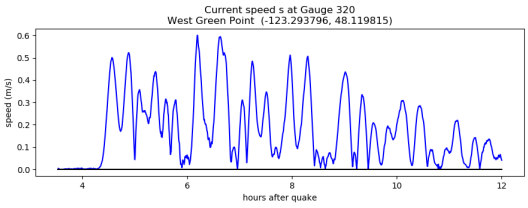


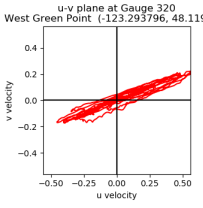




AKmaxWA event:



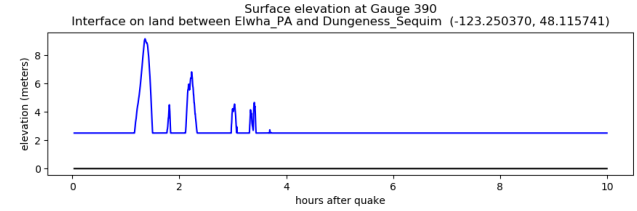


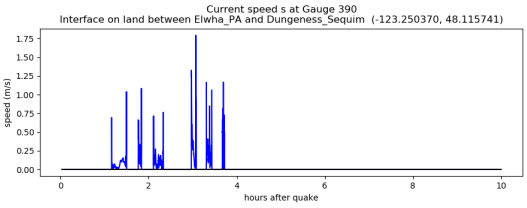


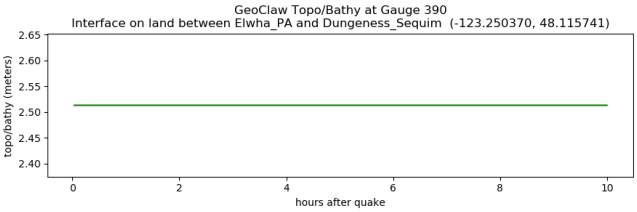
Gauge 390: Interface on land between Elwha_PA and Dungeness_Sequim.

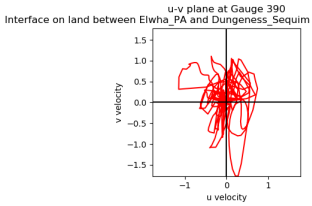
Computed on region Elwha_PA.

CSZ XL1 event:

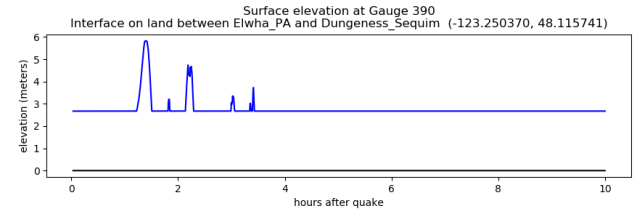


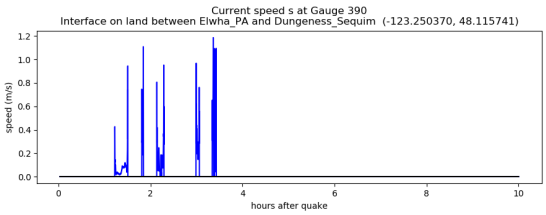


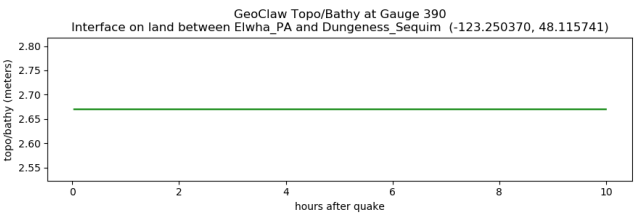


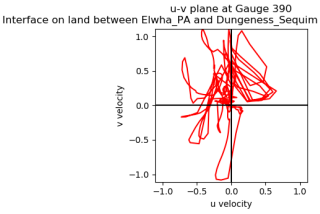


CSZ L1 event:

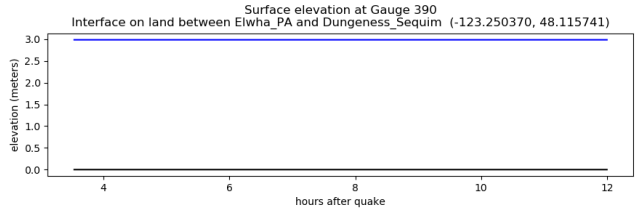


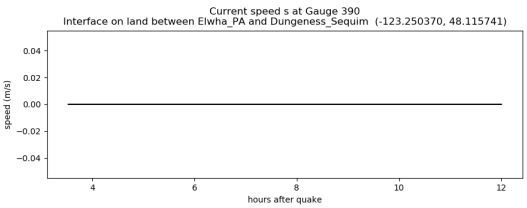


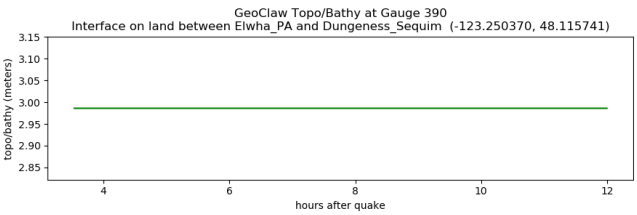


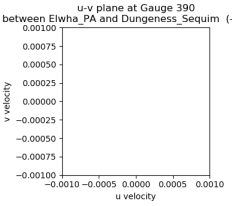


AKmaxWA event:





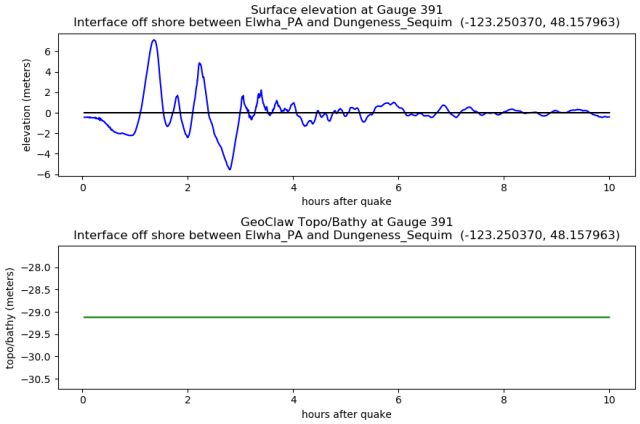


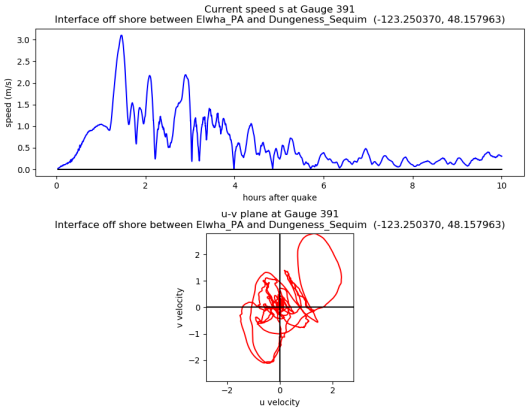


Gauge 391: Interface off shore between Elwha_PA and Dungeness_Sequim.

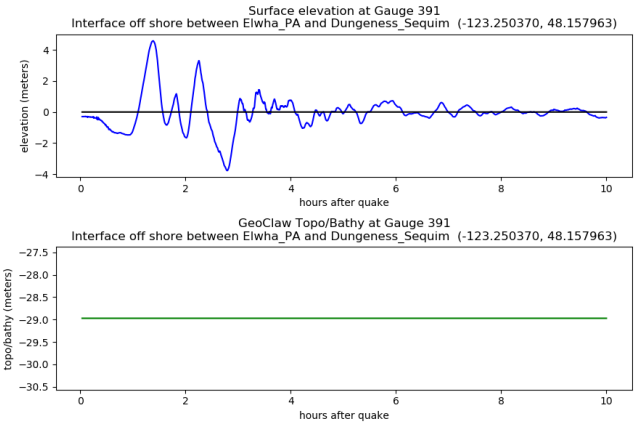
Computed on region Elwha_PA.

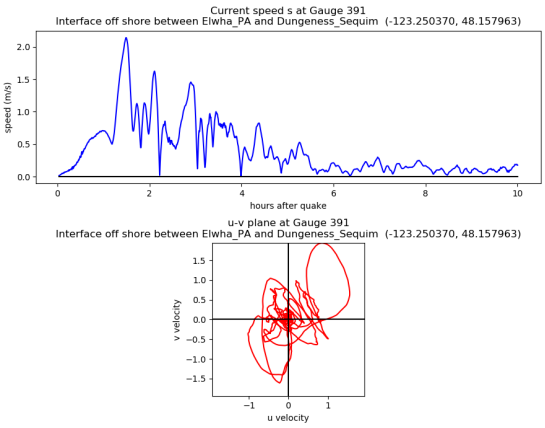
CSZ XL1 event:



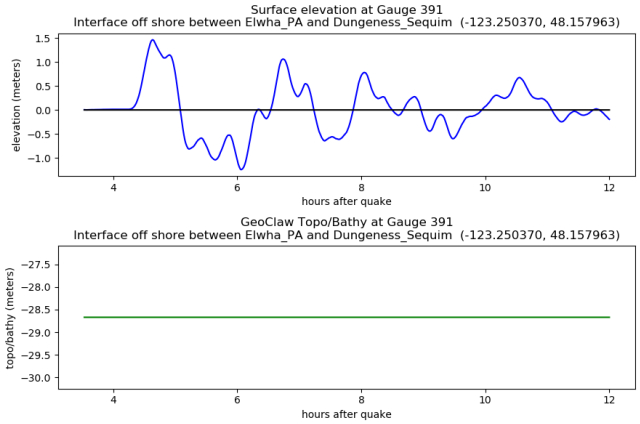


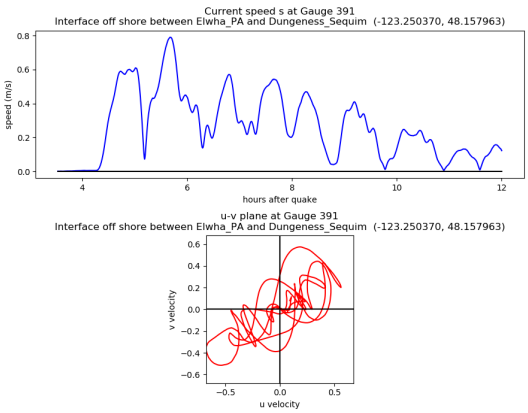
CSZ L1 event:





AKmaxWA event:

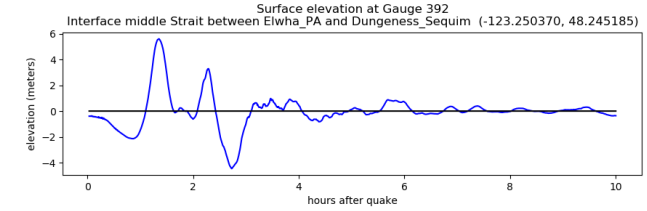


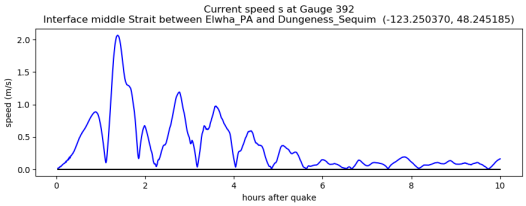


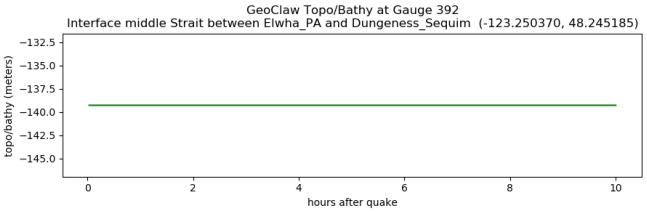
Gauge 392: Interface middle Strait between Elwha_PA and Dungeness_Sequim.

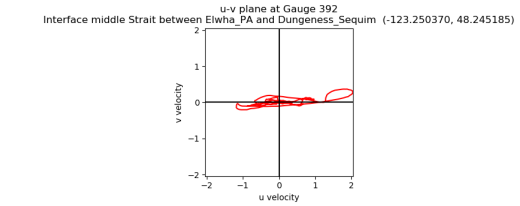
Computed on region Elwha_PA.

CSZ XL1 event:

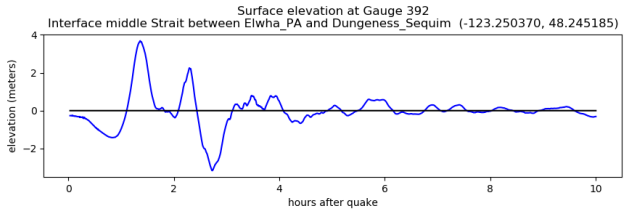


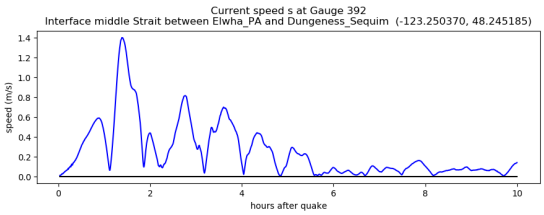


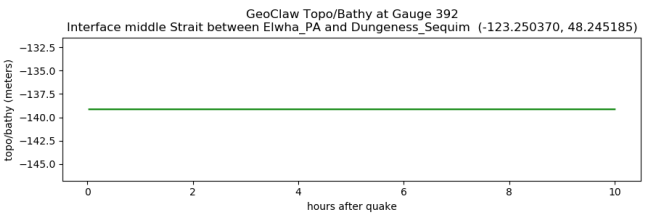


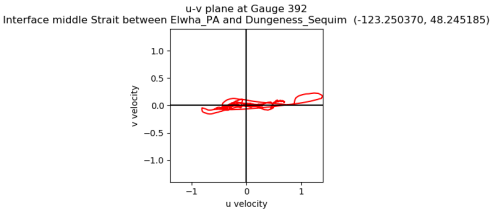


CSZ L1 event:

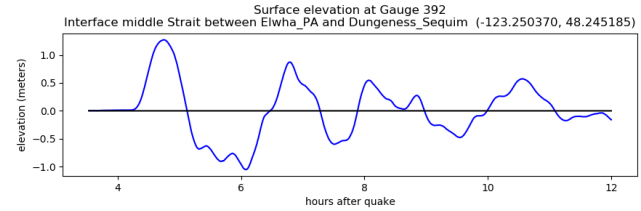


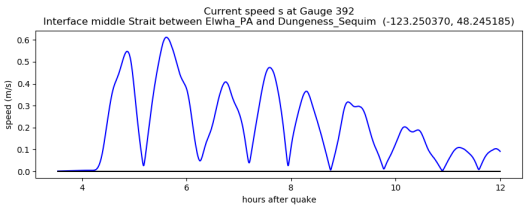


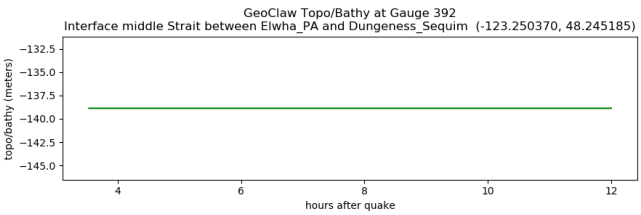


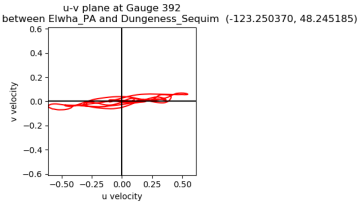


AKmaxWA event:





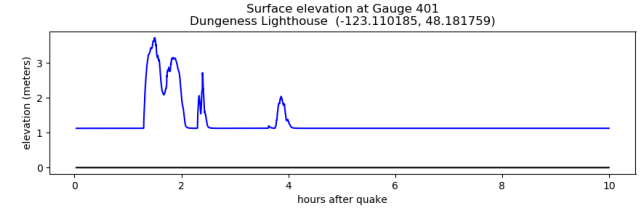


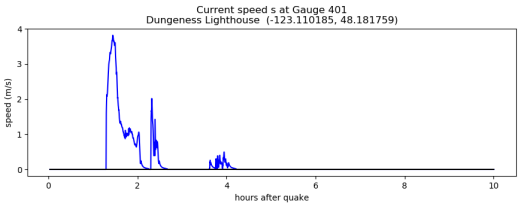


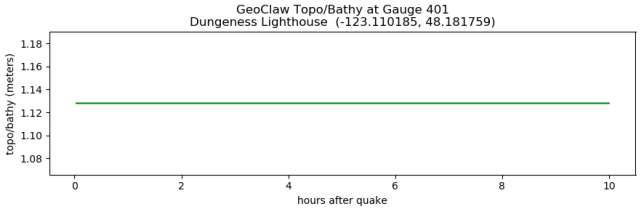
Gauge 401: Dungeness Lighthouse.

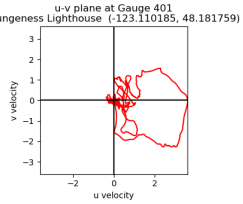
Computed on region `Dungeness_Sequim`.

CSZ XL1 event:

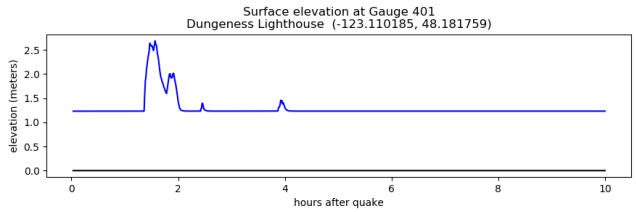


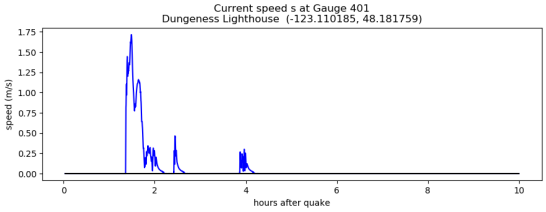


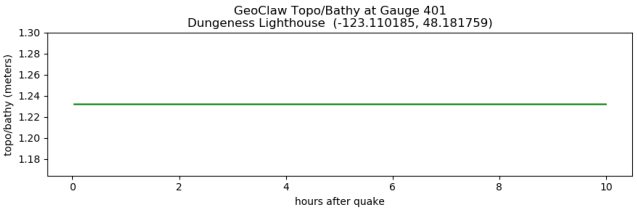


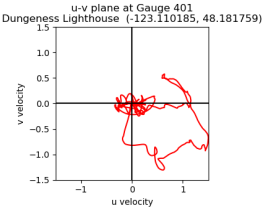


CSZ L1 event:

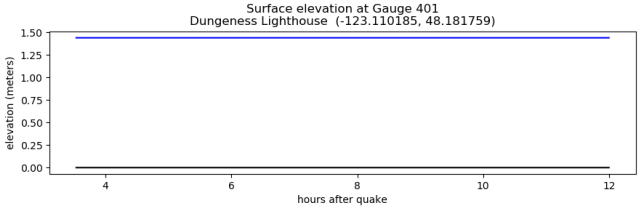


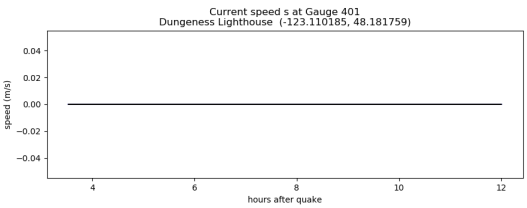


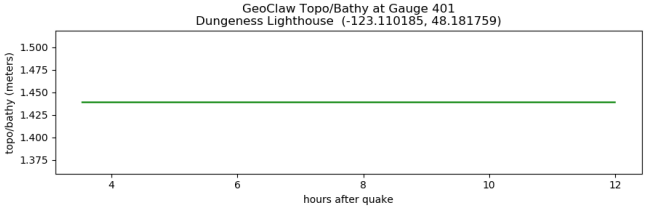


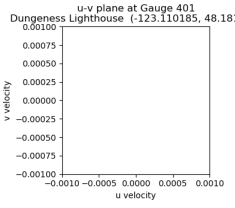


AKmaxWA event:





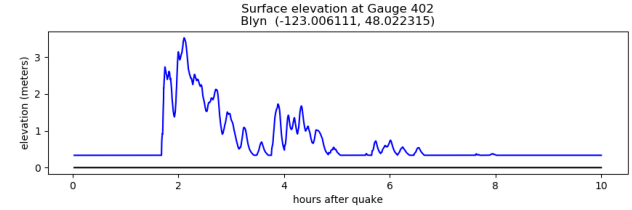


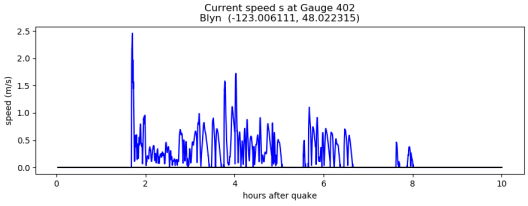


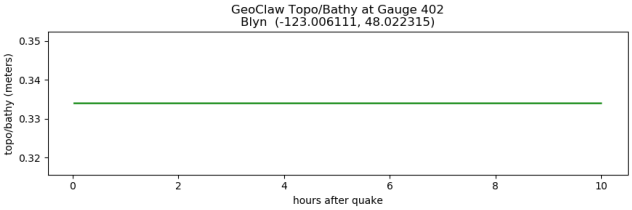
Gauge 402: Blyn.

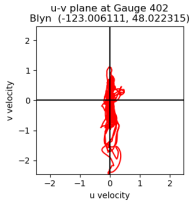
Computed on region `Dungeness_Sequim`.

CSZ XL1 event:

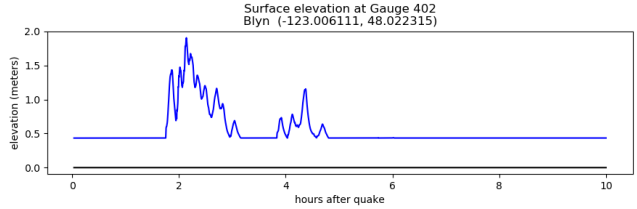


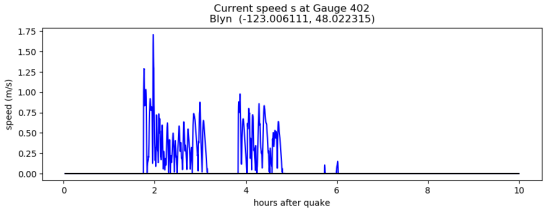


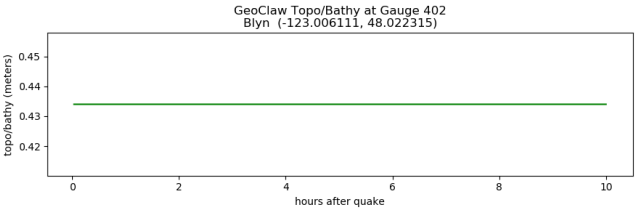


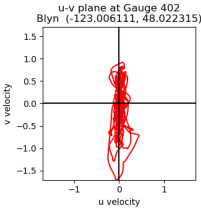


CSZ L1 event:

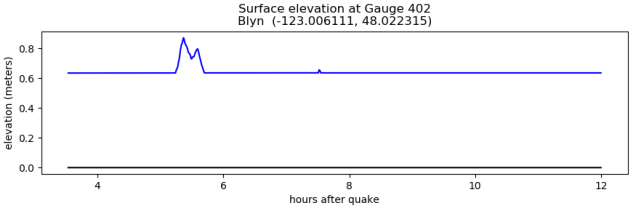


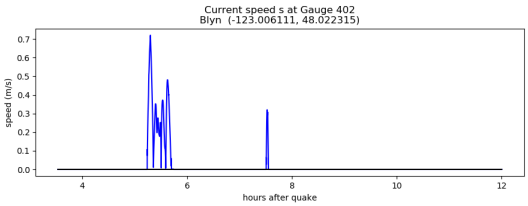


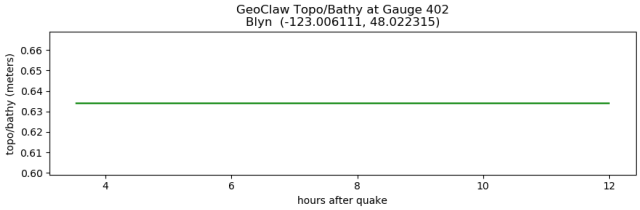


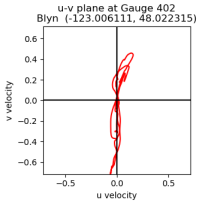


AKmaxWA event:





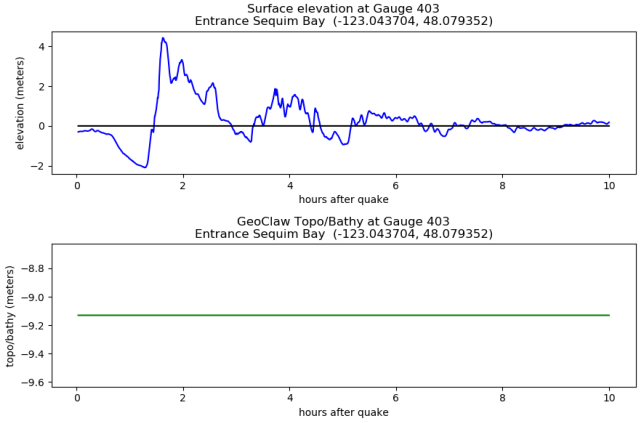


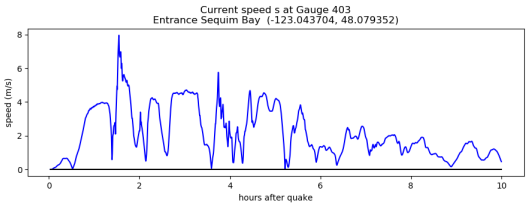


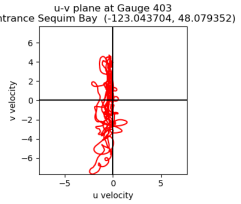
Gauge 403: Entrance Sequim Bay.

Computed on region `Dungeness_Sequim`.

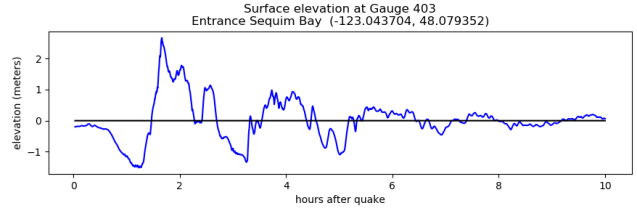
CSZ XL1 event:

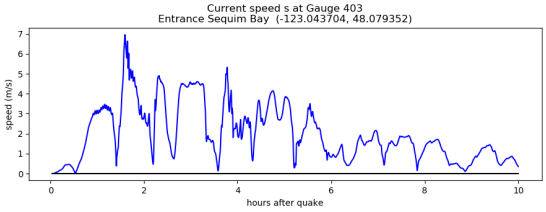


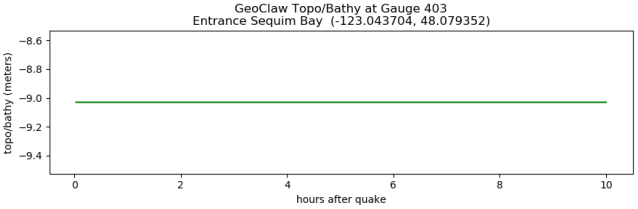


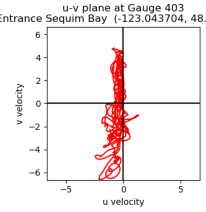


CSZ L1 event:

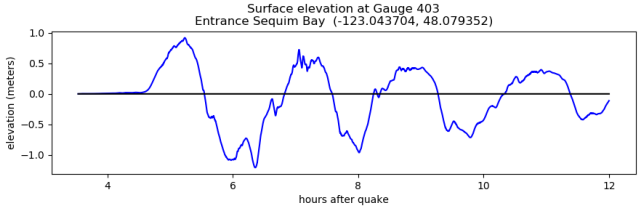


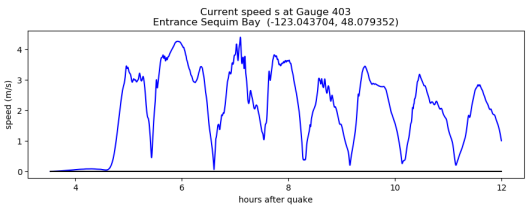


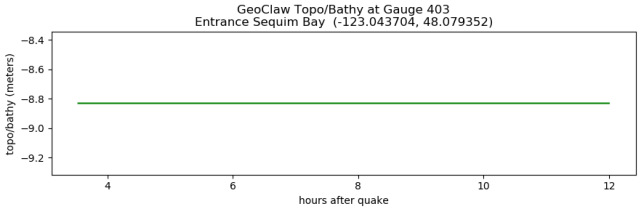


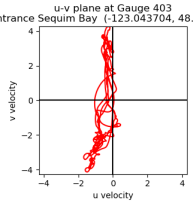


AKmaxWA event:





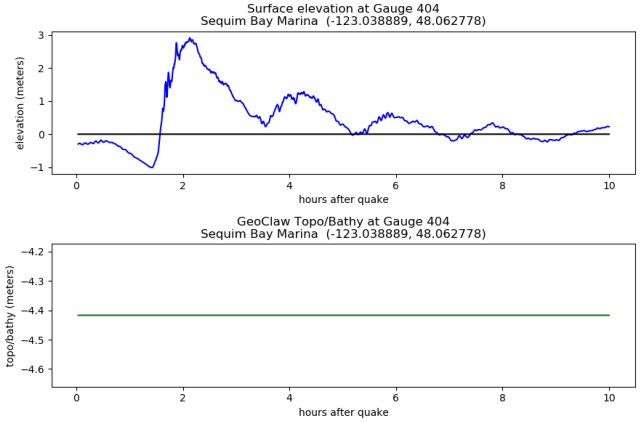


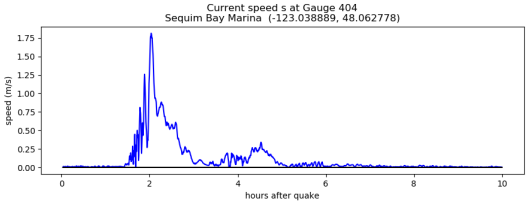


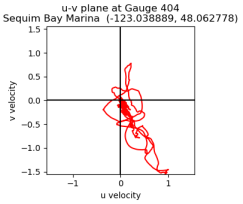
Gauge 404: Sequim Bay Marina.

Computed on region `Dungeness_Sequim`.

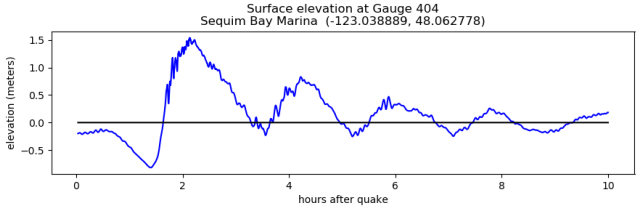
CSZ XL1 event:

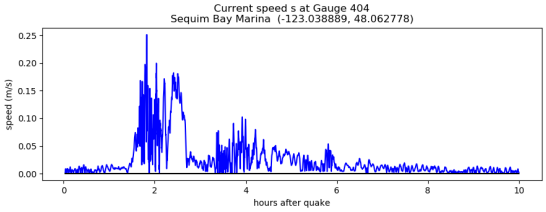


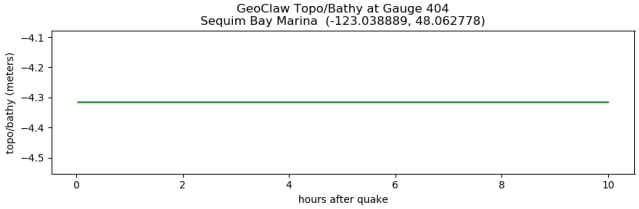


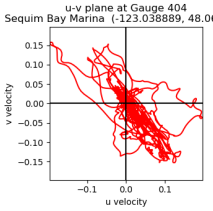


CSZ L1 event:

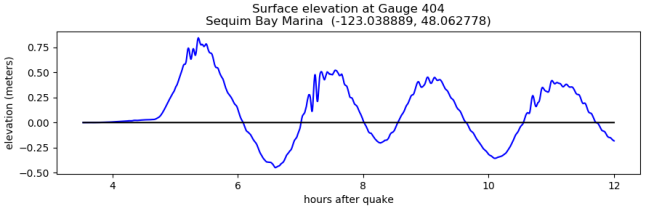


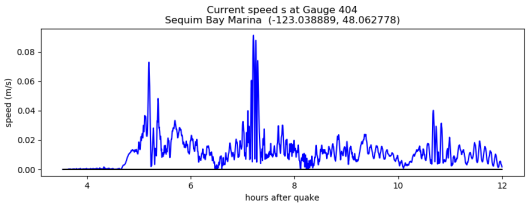


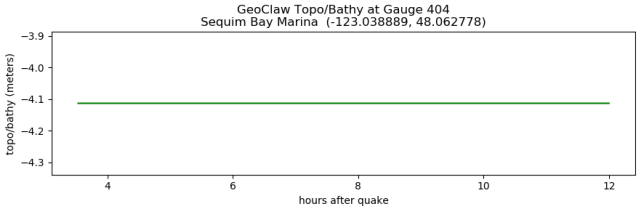


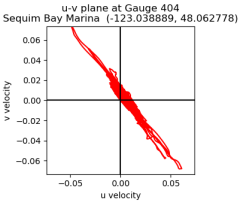


AKmaxWA event:





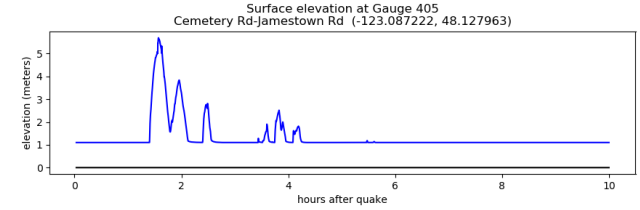


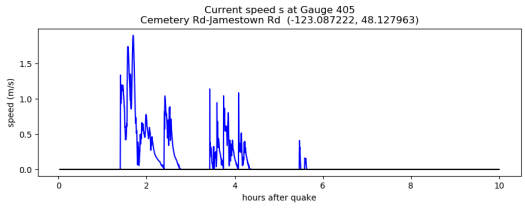


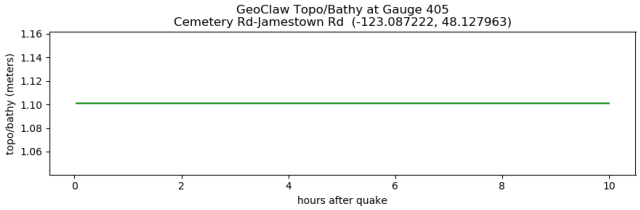
Gauge 405: Cemetery Rd-Jamestown Rd.

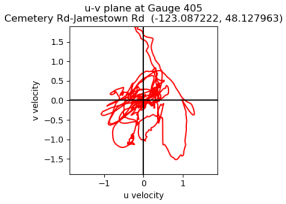
Computed on region `Dungeness_Sequim`.

CSZ XL1 event:

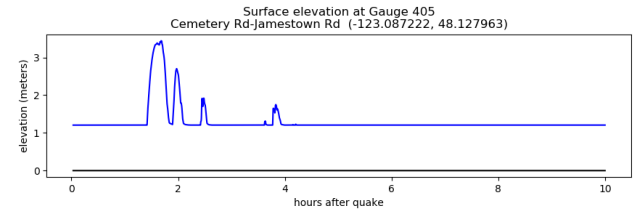


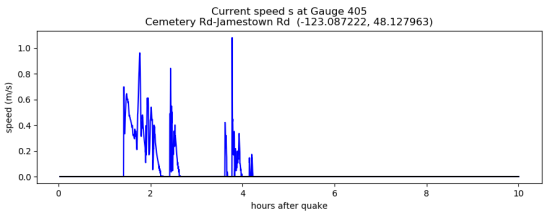


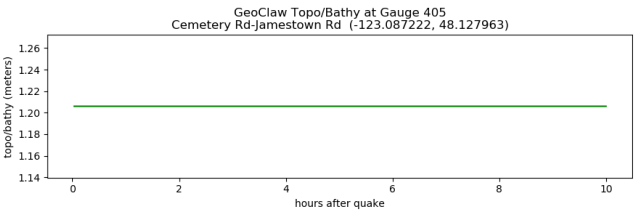


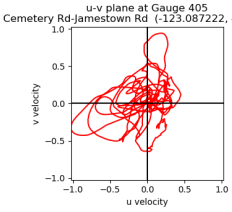


CSZ L1 event:

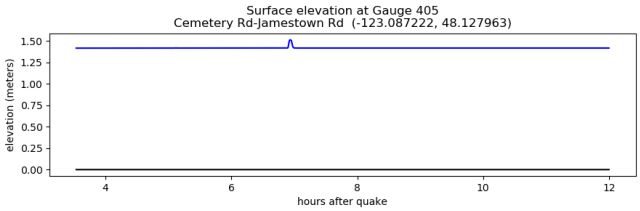


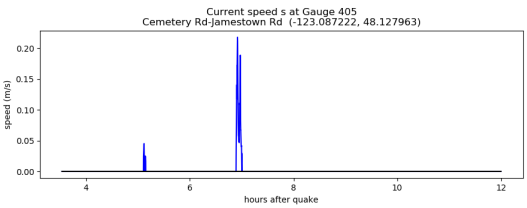


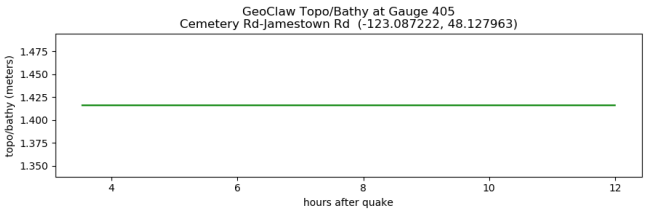


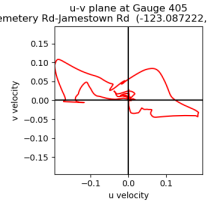


AKmaxWA event:





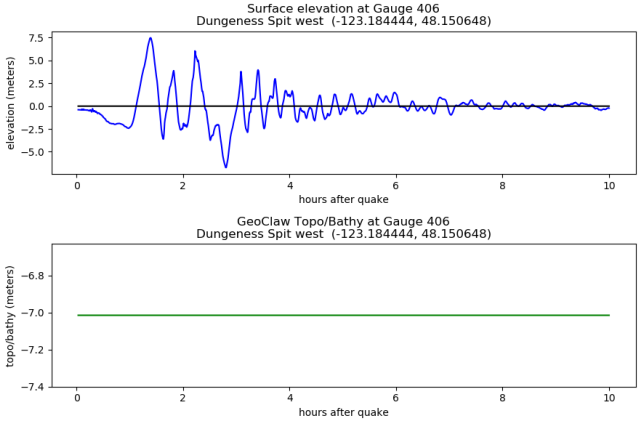


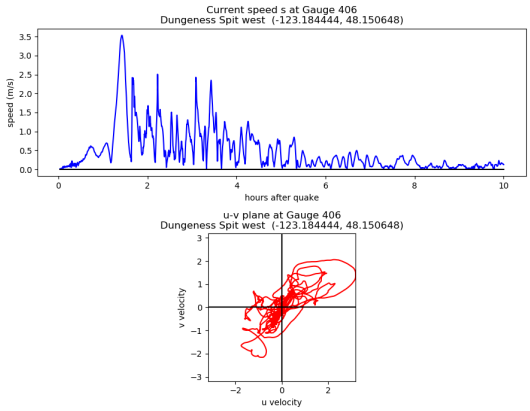


Gauge 406: Dungeness Spit west.

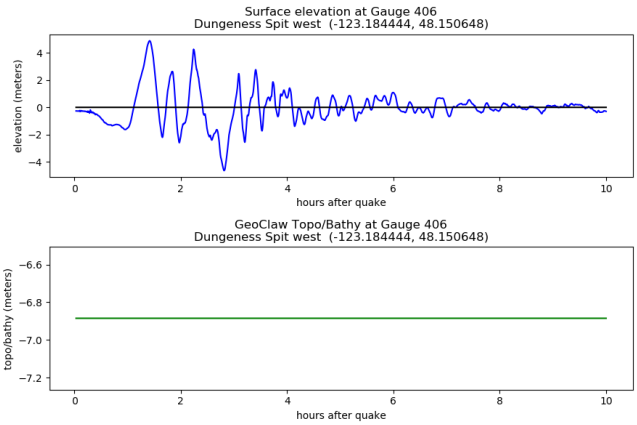
Computed on region `Dungeness_Sequim`.

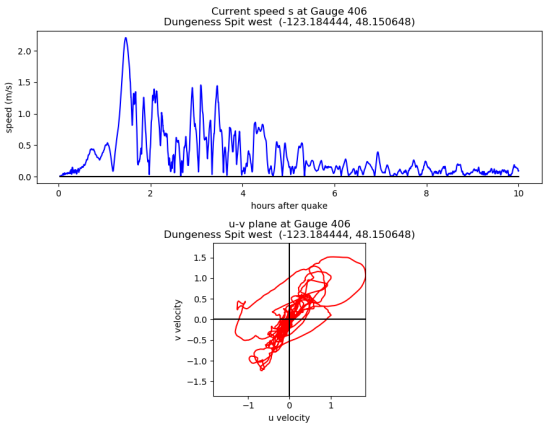
CSZ XL1 event:



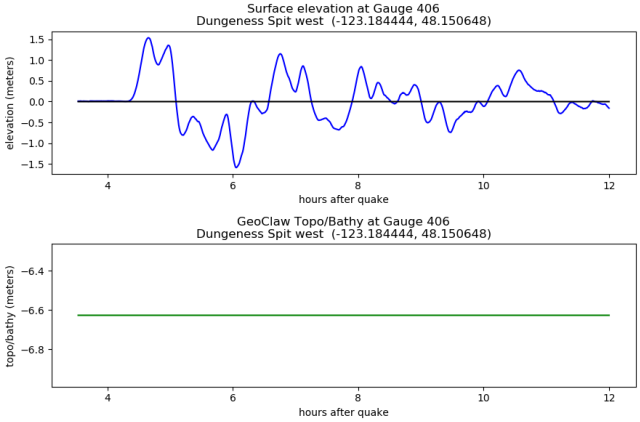


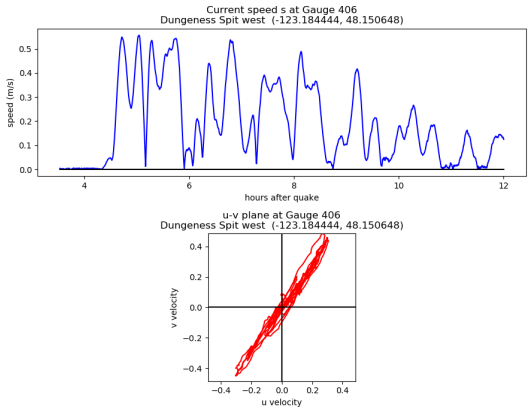
CSZ L1 event:





AKmaxWA event:

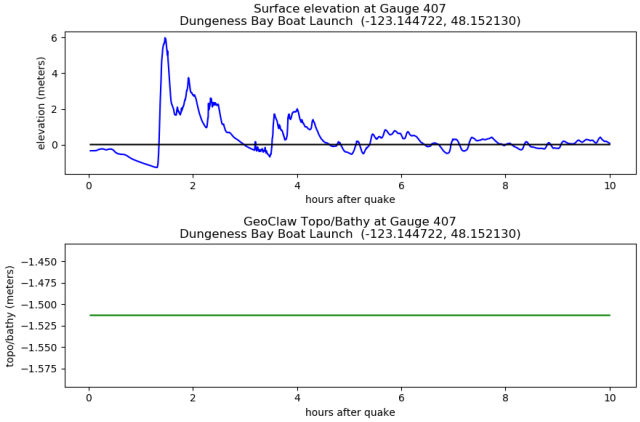


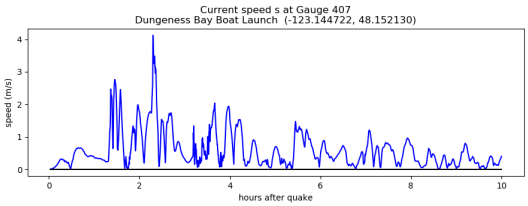


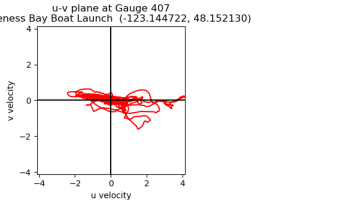
Gauge 407: Dungeness Bay Boat Launch.

Computed on region `Dungeness_Sequim`.

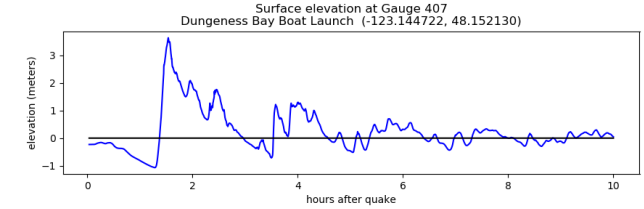
CSZ XL1 event:

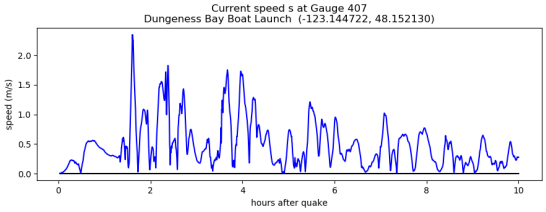


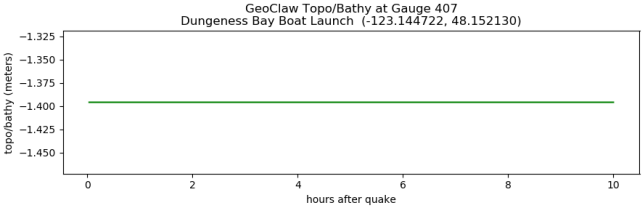


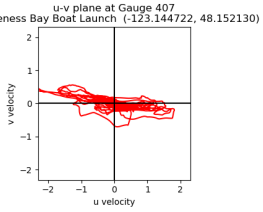


CSZ L1 event:

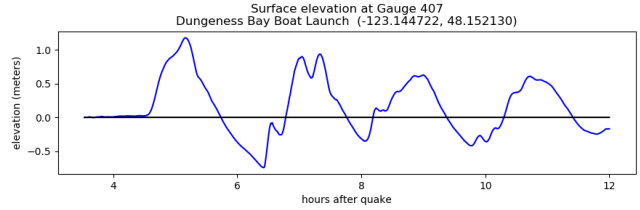


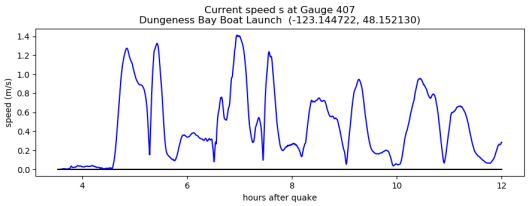


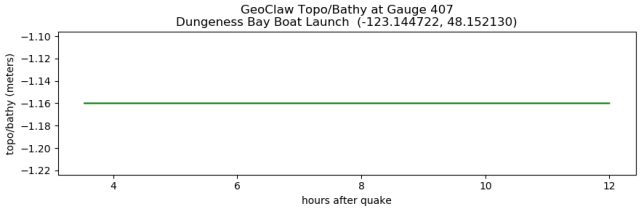


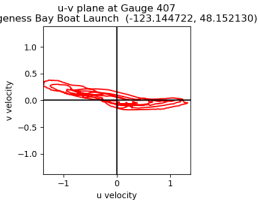


AKmaxWA event:





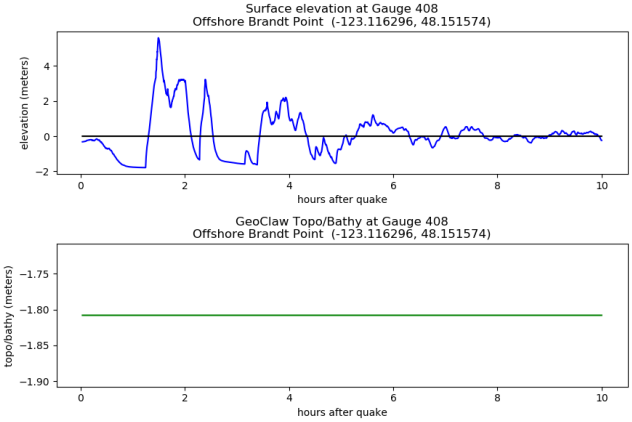


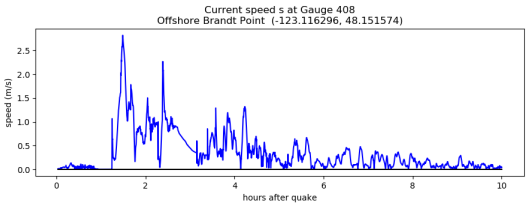


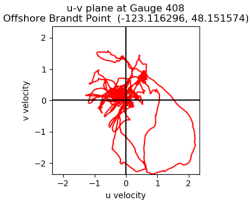
Gauge 408: Offshore Brandt Point.

Computed on region `Dungeness_Sequim`.

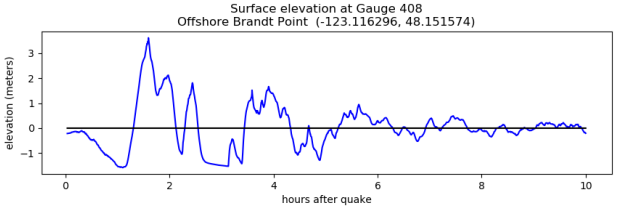
CSZ XL1 event:

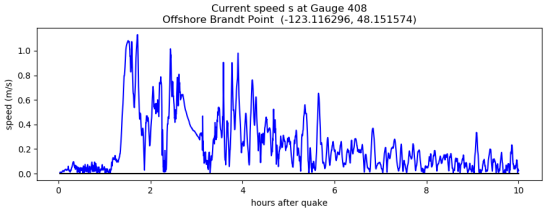


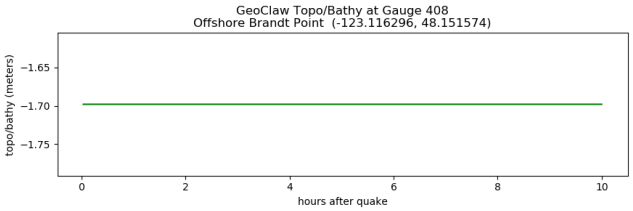


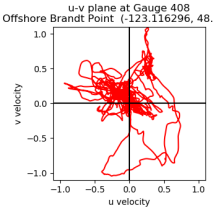


CSZ L1 event:

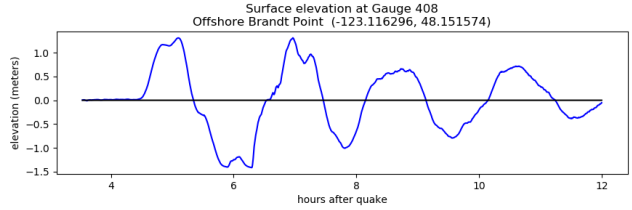


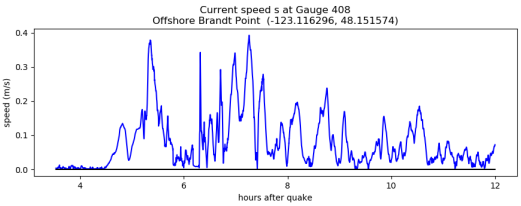


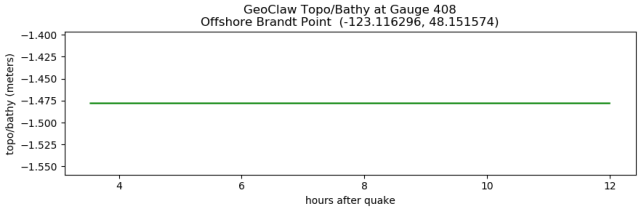


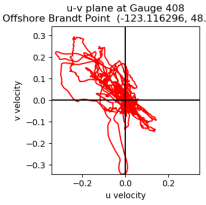


AKmaxWA event:





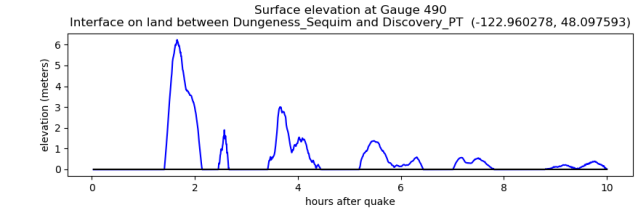


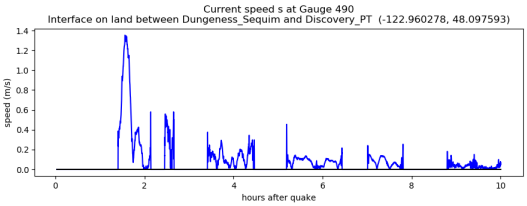


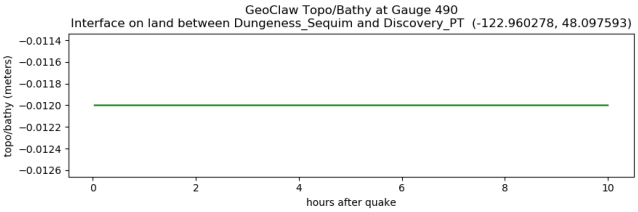
Gauge 490: Interface on land between Dungeness_Sequim and Discovery_PT.

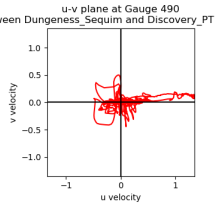
Computed on region Dungeness_Sequim.

CSZ XL1 event:

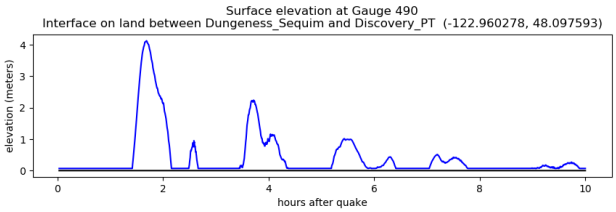


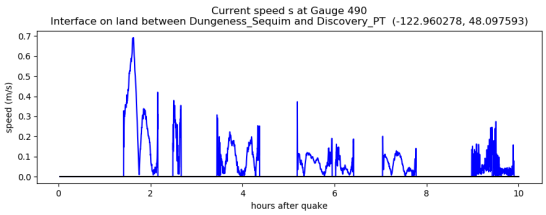


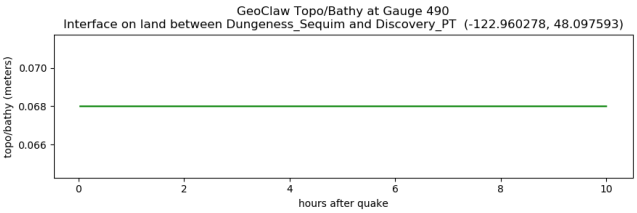


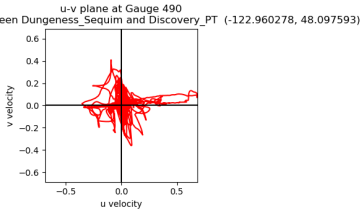


CSZ L1 event:

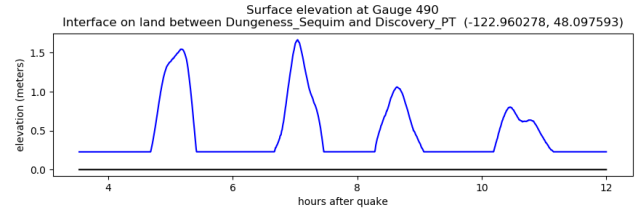


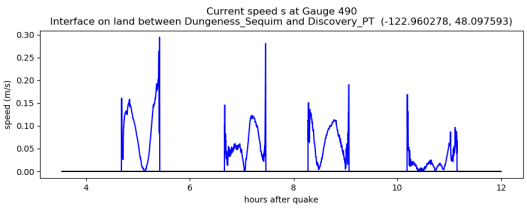


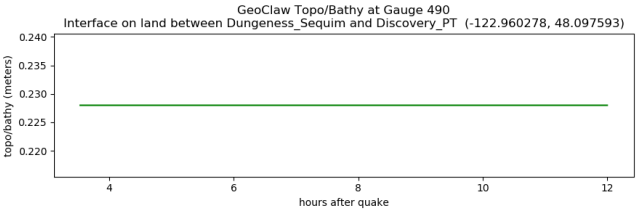


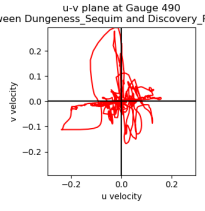


AKmaxWA event:





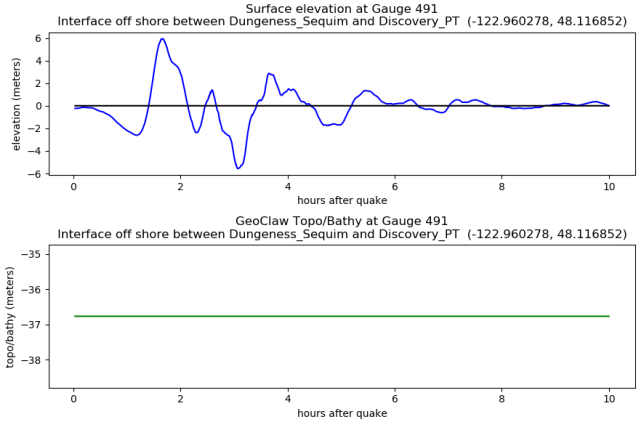


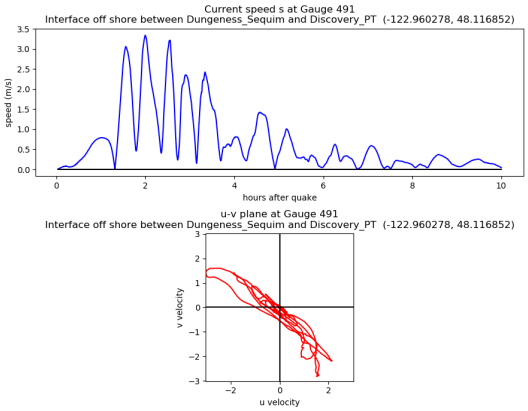


Gauge 491: Interface off shore between Dungeness_Sequim and Discovery_PT.

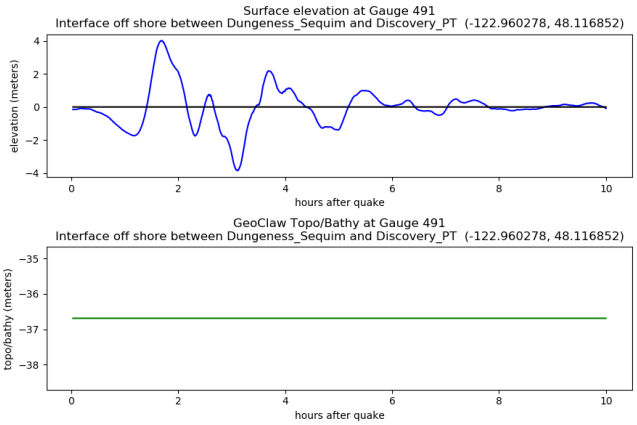
Computed on region Dungeness_Sequim.

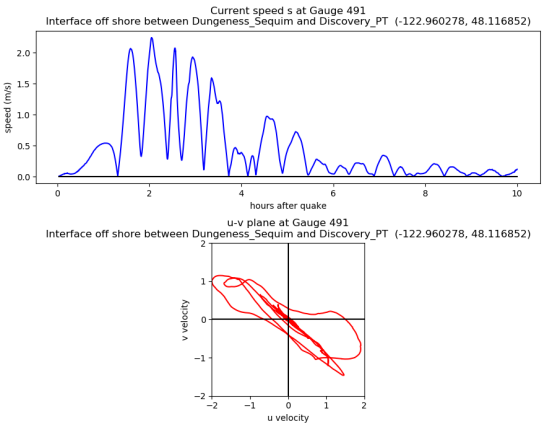
CSZ XL1 event:



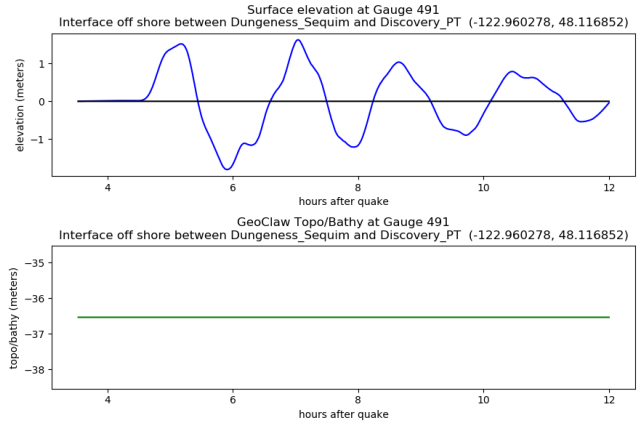


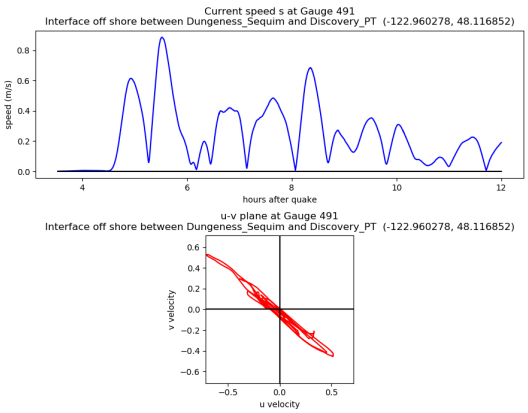
CSZ L1 event:





AKmaxWA event:

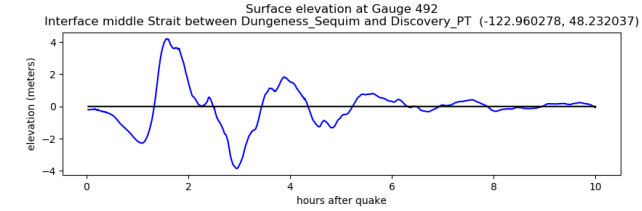


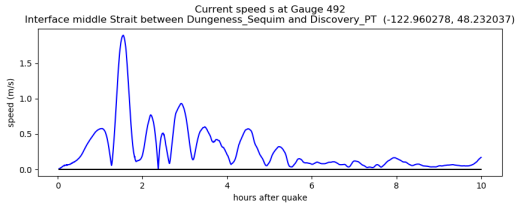


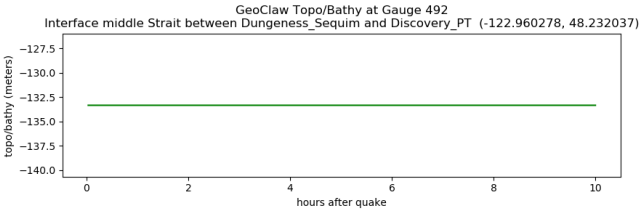
Gauge 492: Interface middle Strait between Dungeness_Sequim and Discovery_PT.

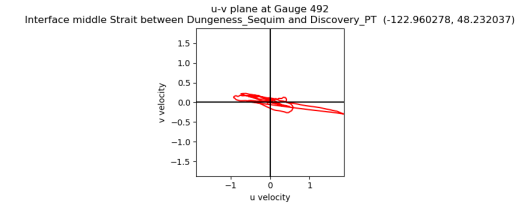
Computed on region Dungeness_Sequim.

CSZ XL1 event:

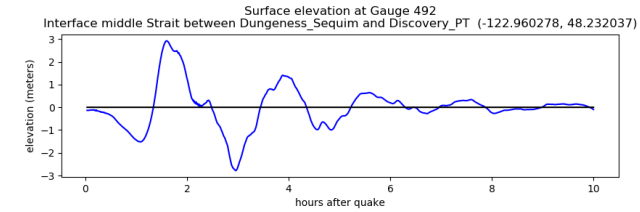


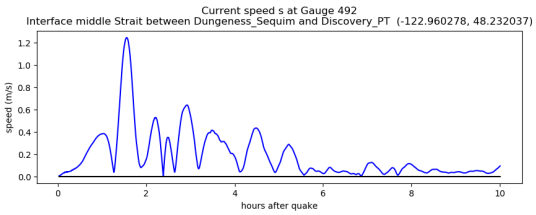


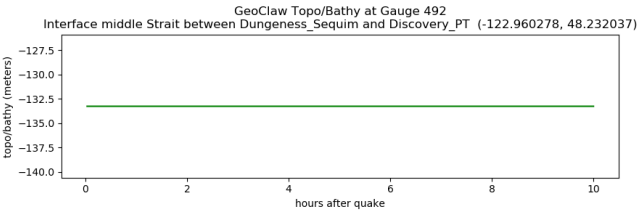


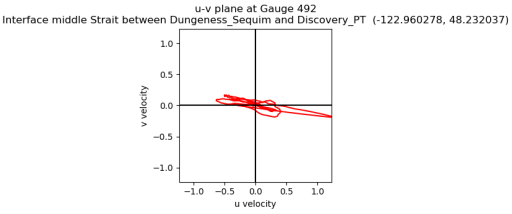


CSZ L1 event:

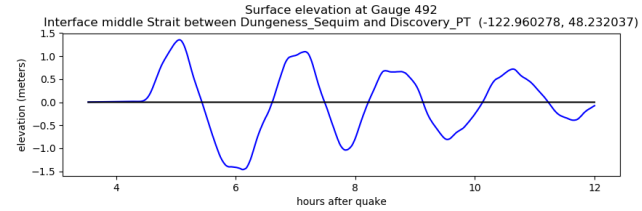


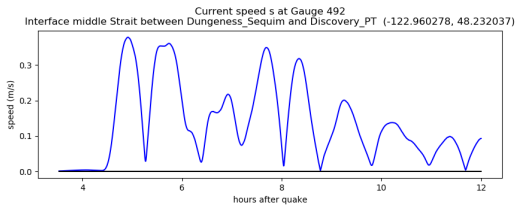


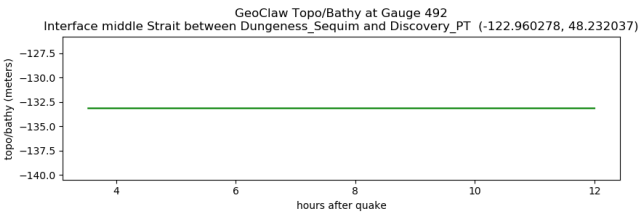


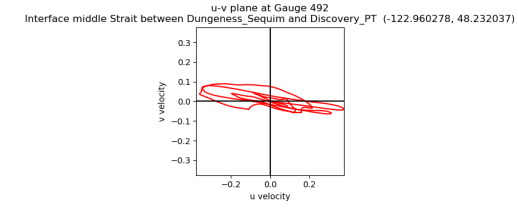


AKmaxWA event:





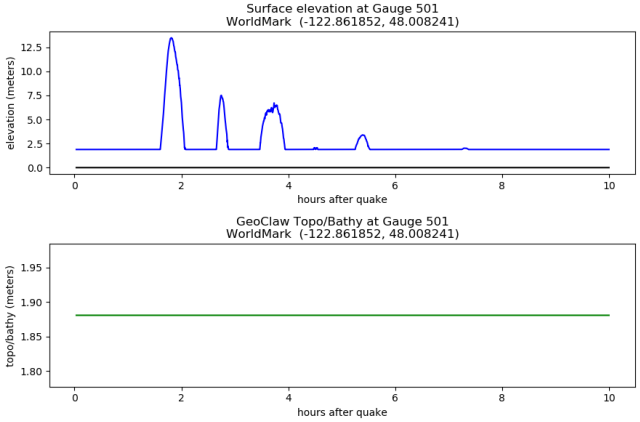


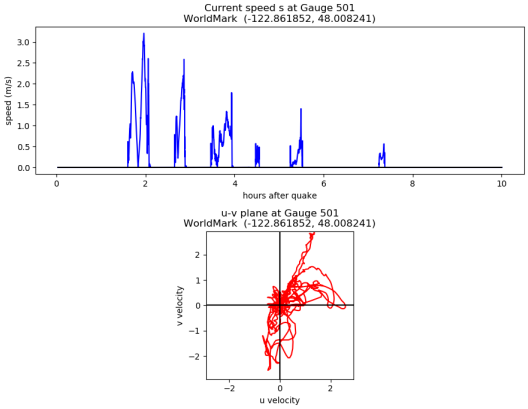


Gauge 501: WorldMark.

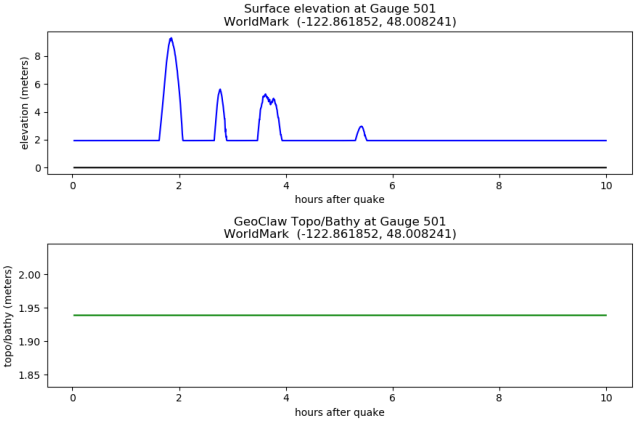
Computed on region `Discovery_PT`.

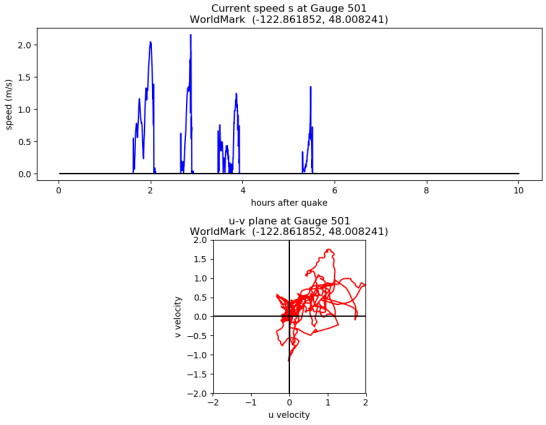
CSZ XL1 event:



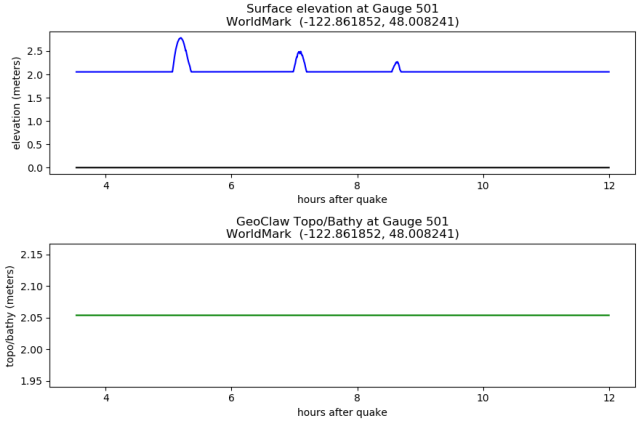


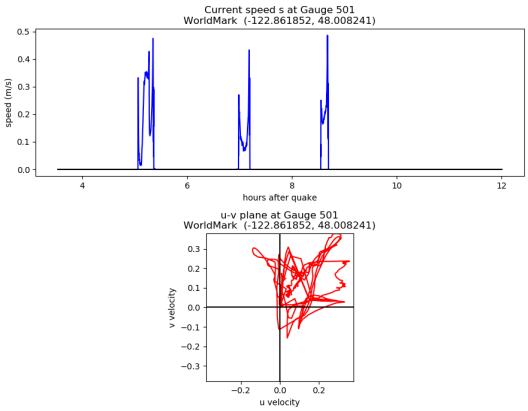
CSZ L1 event:





AKmaxWA event:

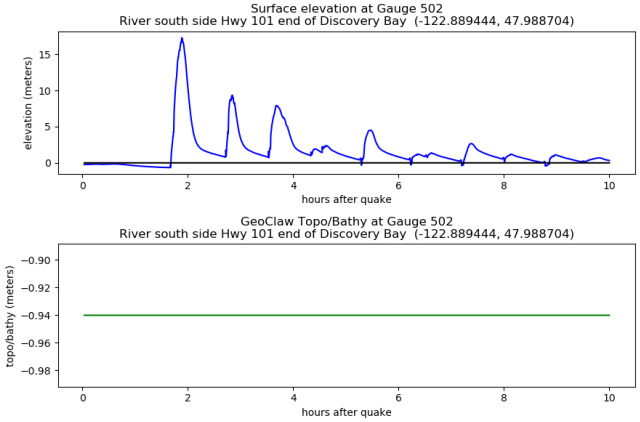


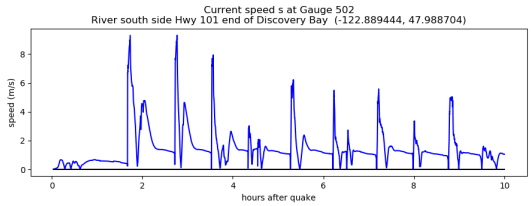


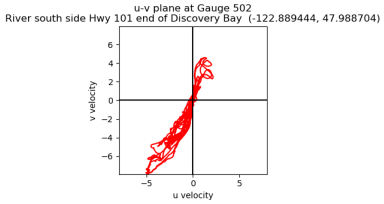
Gauge 502: River south side Hwy 101 end of Discovery Bay.

Computed on region `Discovery_PT`.

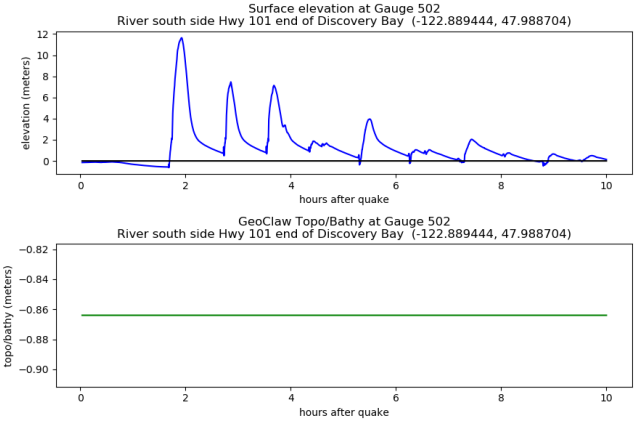
CSZ XL1 event:

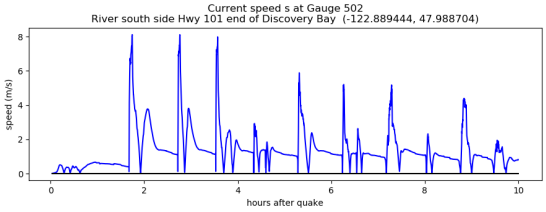


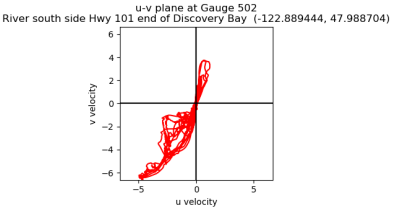




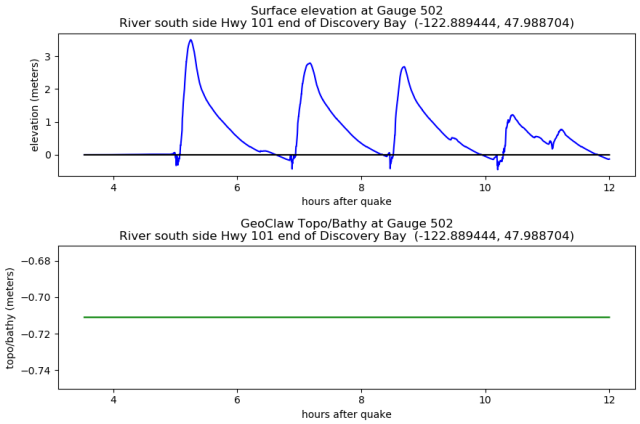
CSZ L1 event:

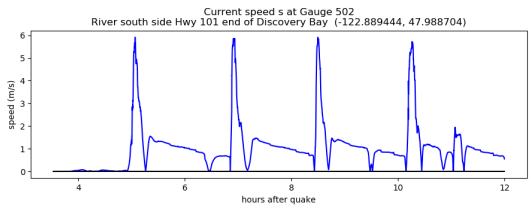


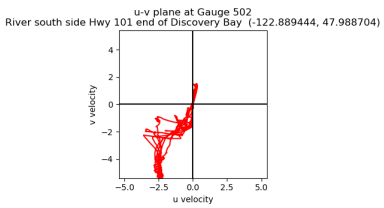




AKmaxWA event:



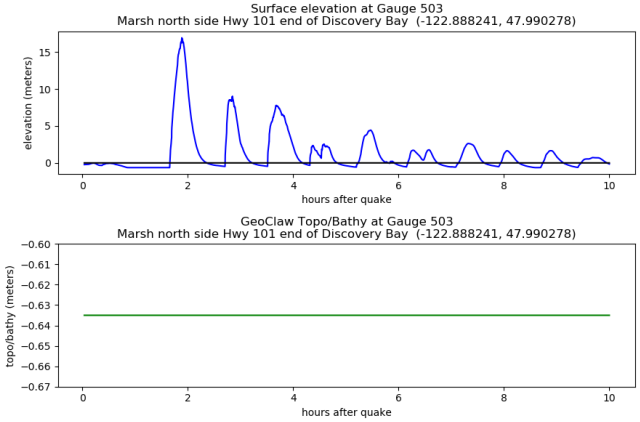


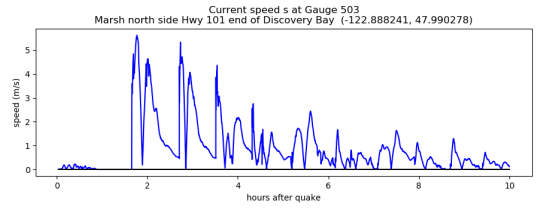


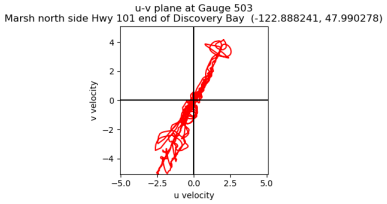
Gauge 503: Marsh north side Hwy 101 end of Discovery Bay.

Computed on region `Discovery_PT`.

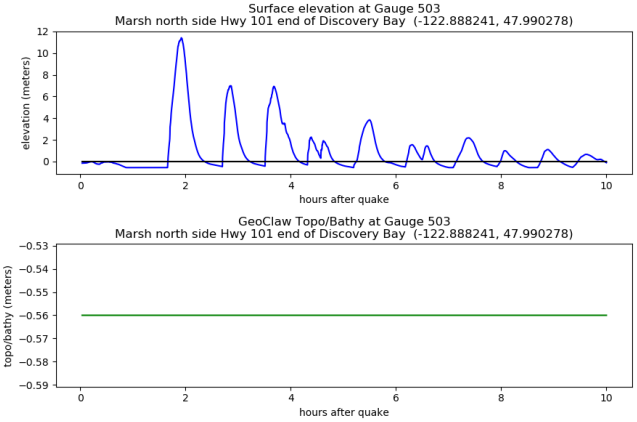
CSZ XL1 event:

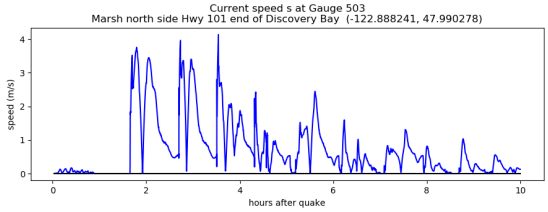


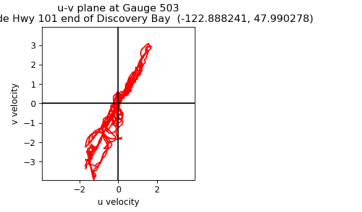




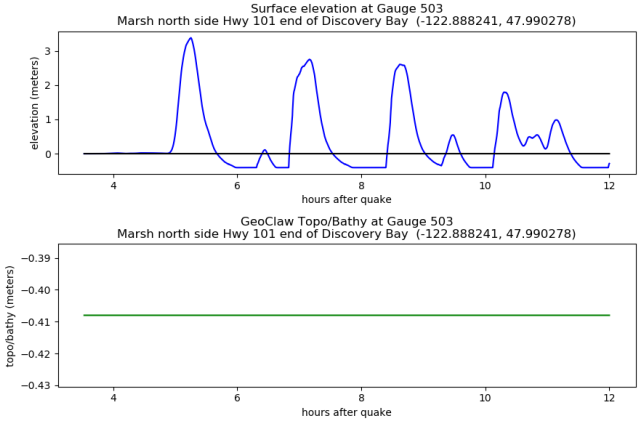
CSZ L1 event:

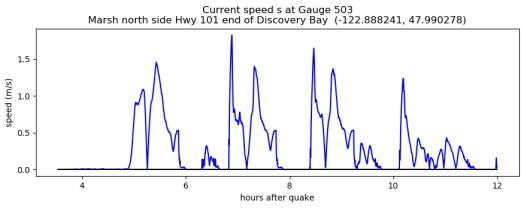


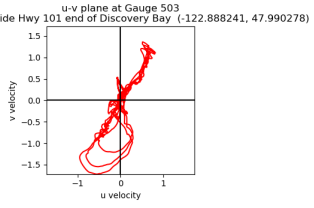




AKmaxWA event:



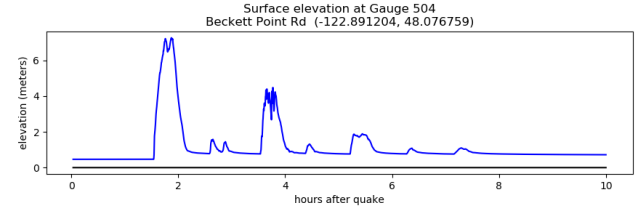


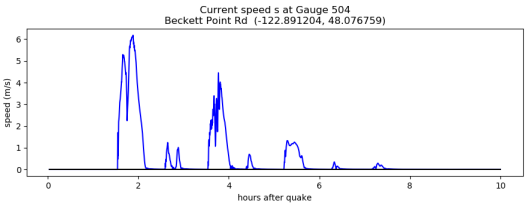


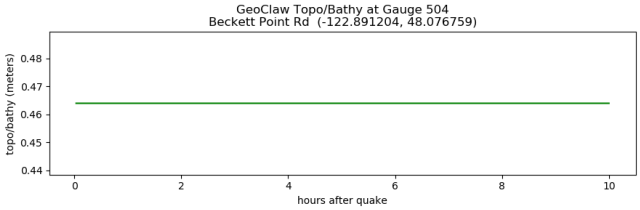
Gauge 504: Beckett Point Rd.

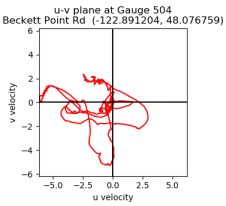
Computed on region `Discovery_PT`.

CSZ XL1 event:

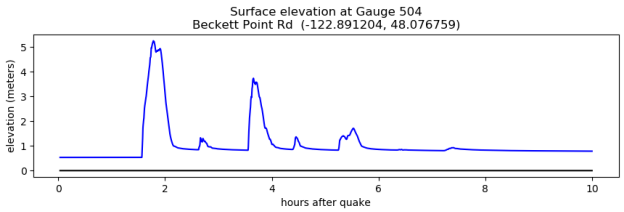


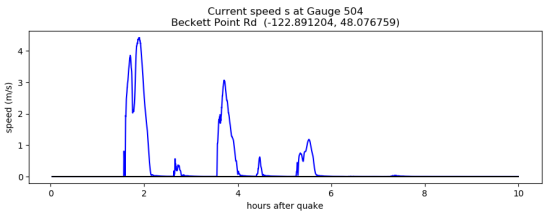


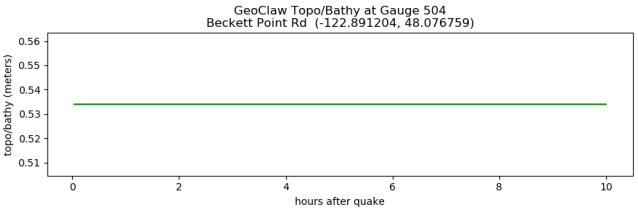


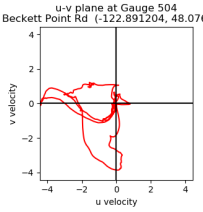


CSZ L1 event:

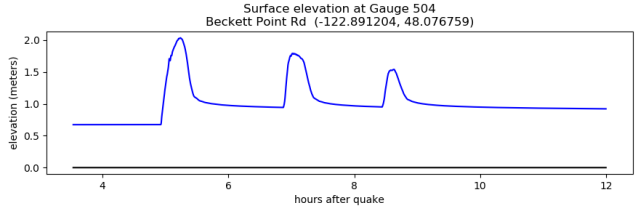


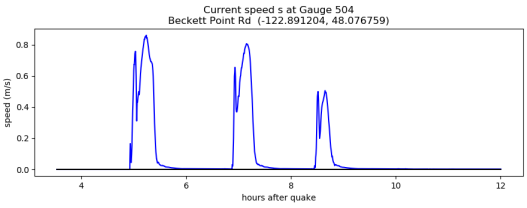


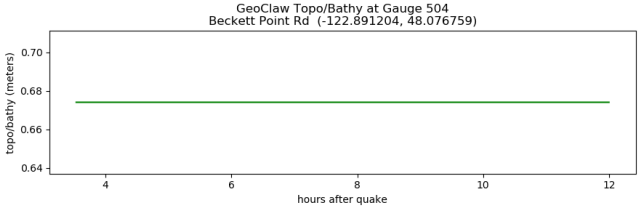


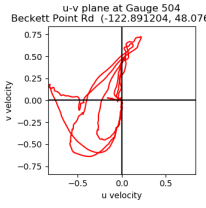


AKmaxWA event:





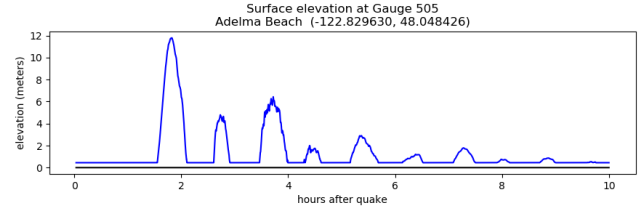


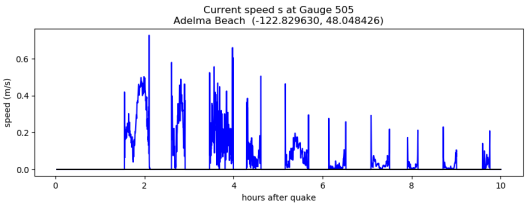


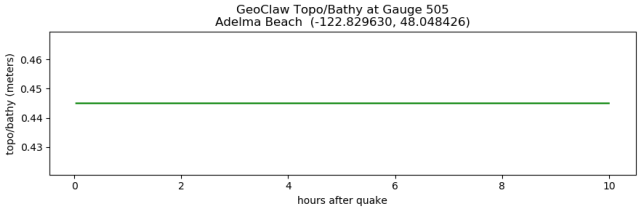
Gauge 505: Adelma Beach.

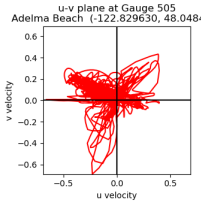
Computed on region `Discovery_PT`.

CSZ XL1 event:

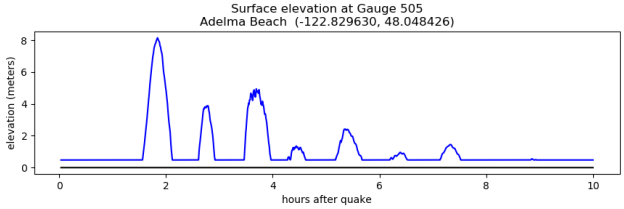


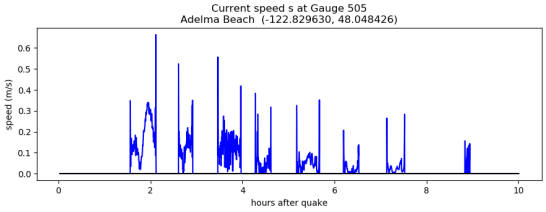


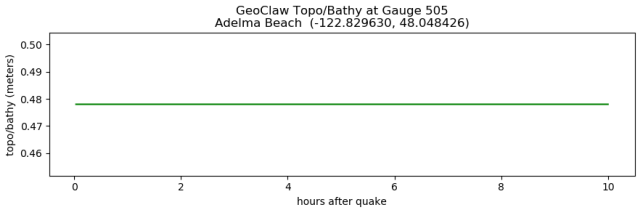


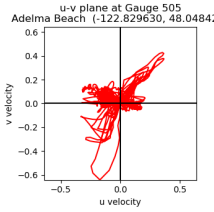


CSZ L1 event:

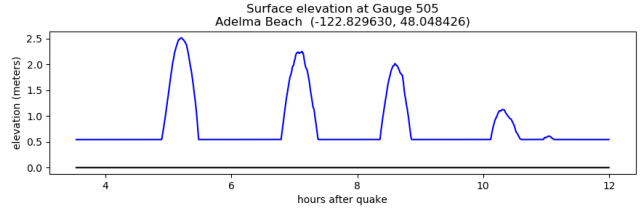


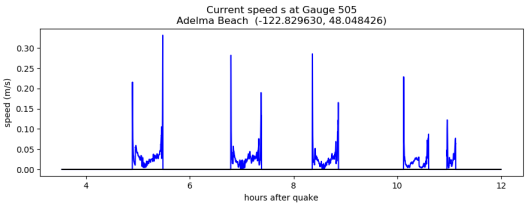


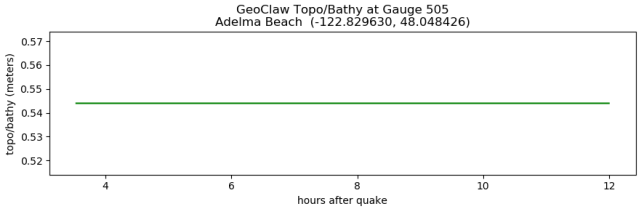


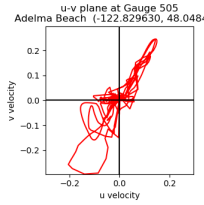


AKmaxWA event:





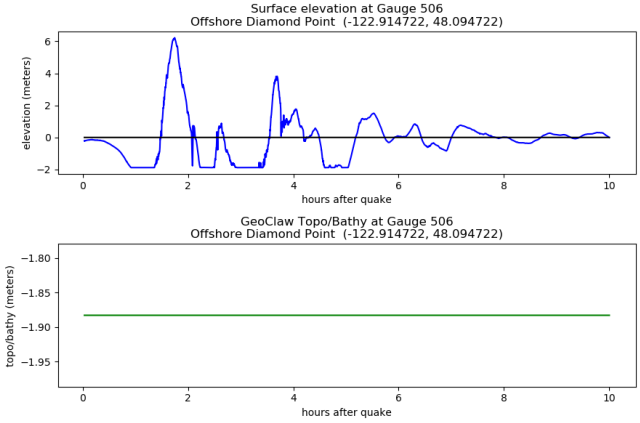


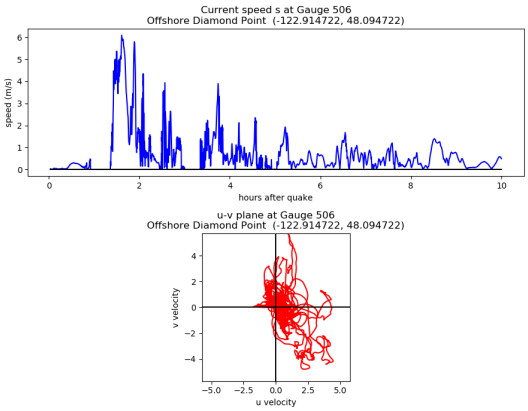


Gauge 506: Offshore Diamond Point.

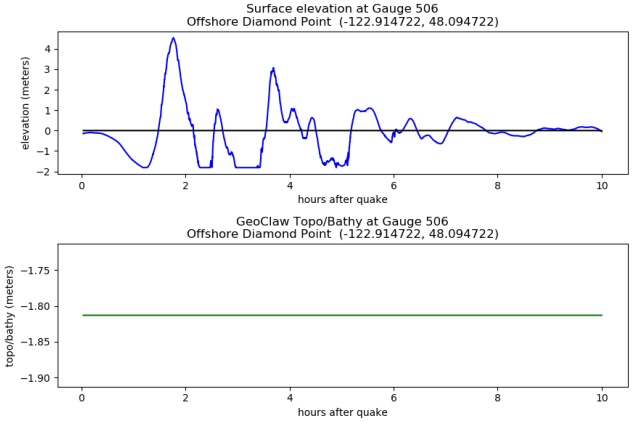
Computed on region `Discovery_PT`.

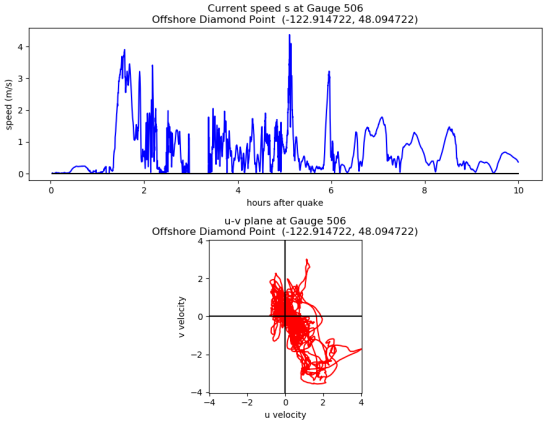
CSZ XL1 event:



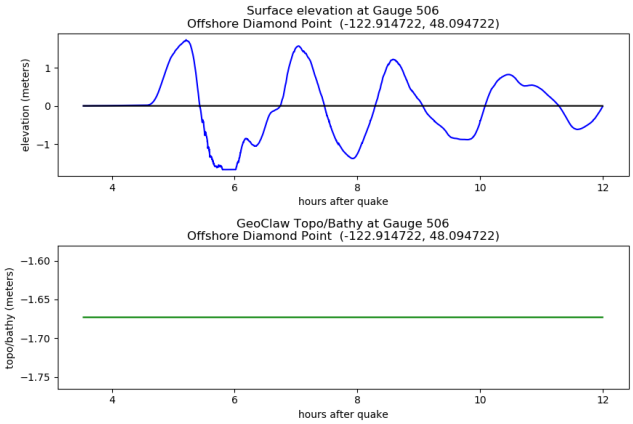


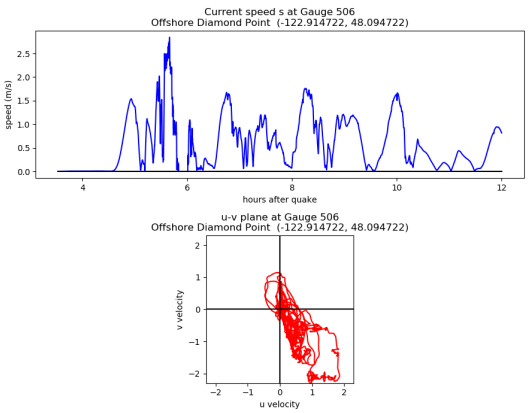
CSZ L1 event:





AKmaxWA event:

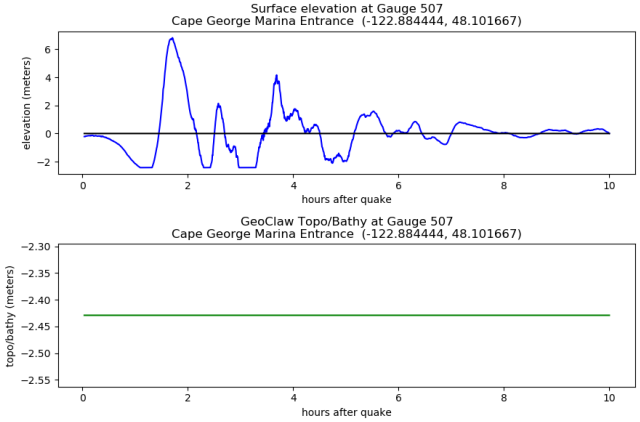


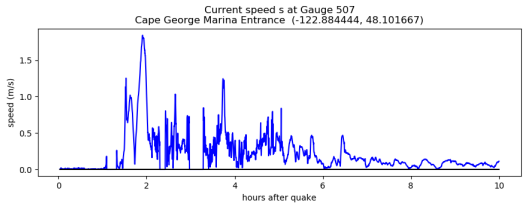


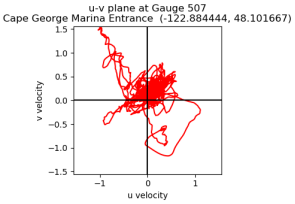
Gauge 507: Cape George Marina Entrance.

Computed on region `Discovery_PT`.

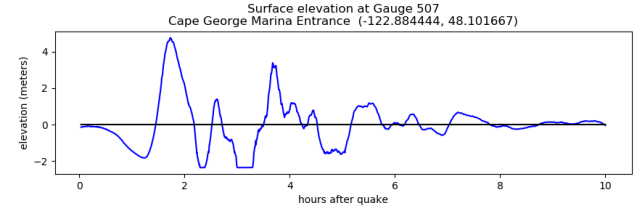
CSZ XL1 event:

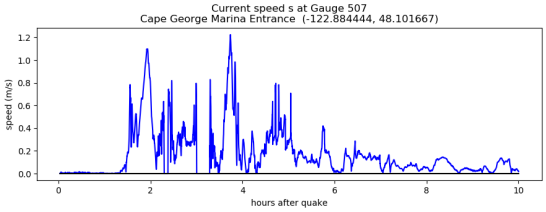


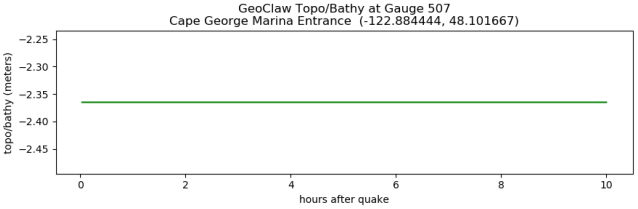


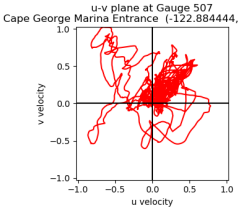


CSZ L1 event:

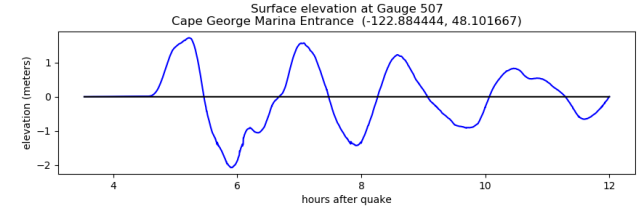


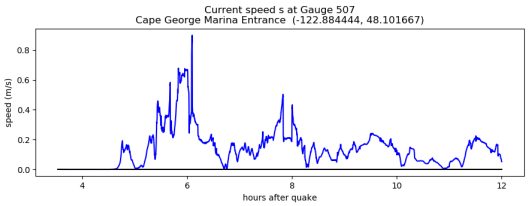


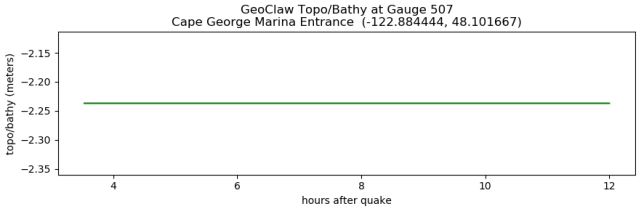


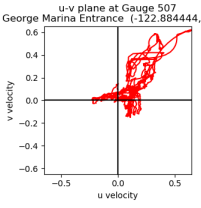


AKmaxWA event:





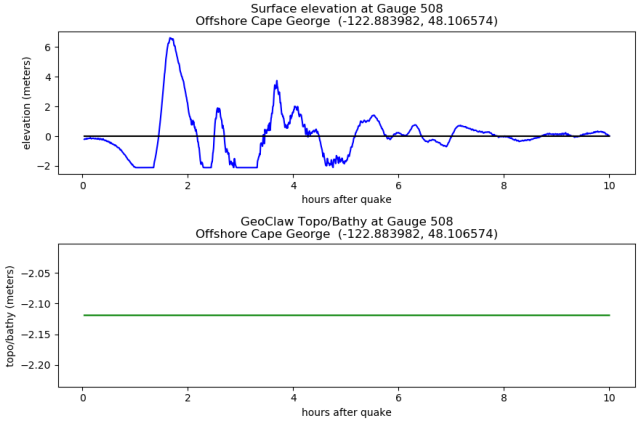


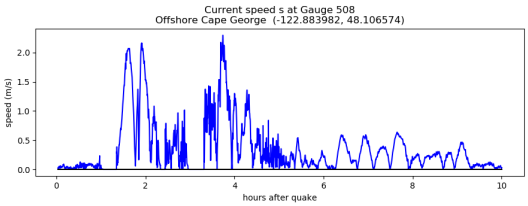


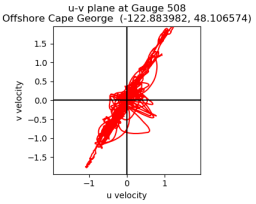
Gauge 508: Offshore Cape George.

Computed on region `Discovery_PT`.

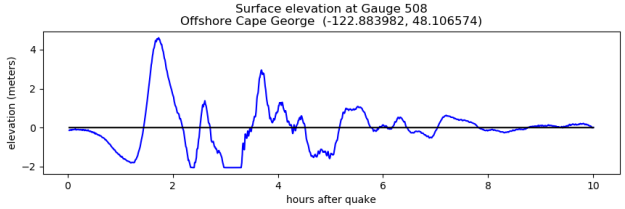
CSZ XL1 event:

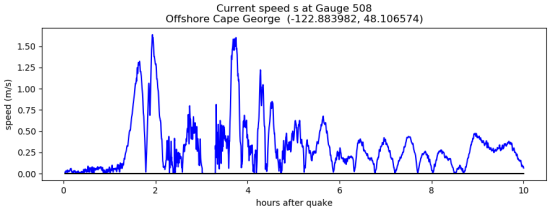


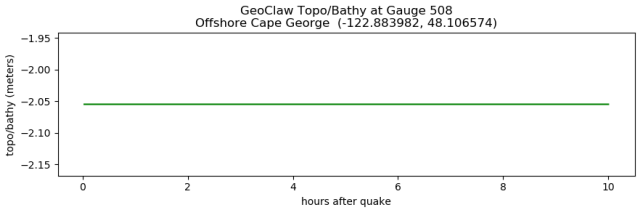


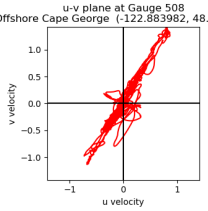


CSZ L1 event:

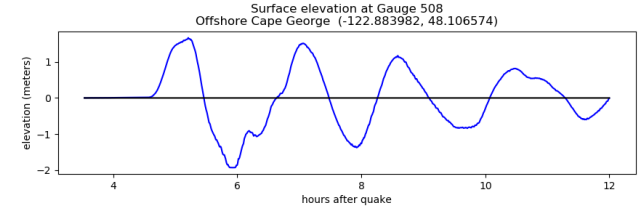


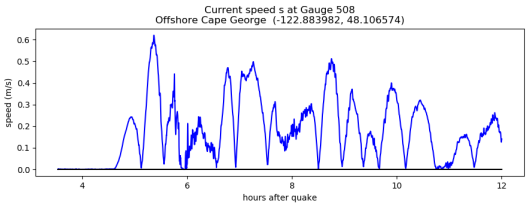


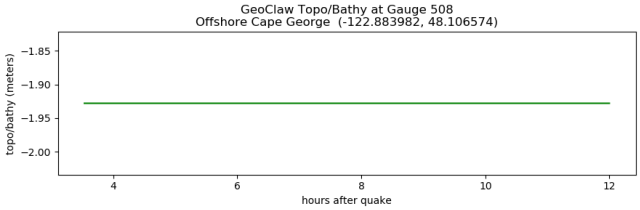


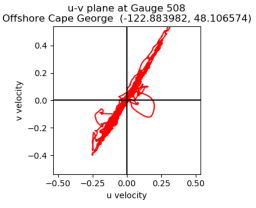


AKmaxWA event:





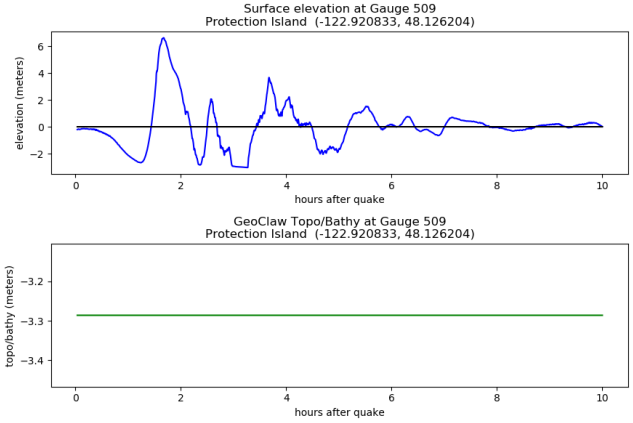


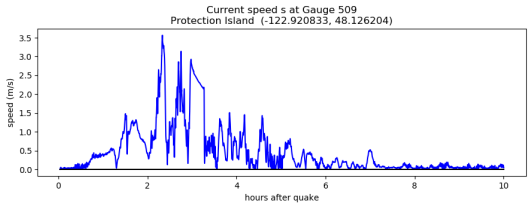


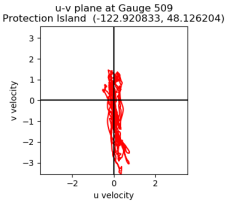
Gauge 509: Protection Island.

Computed on region `Discovery_PT`.

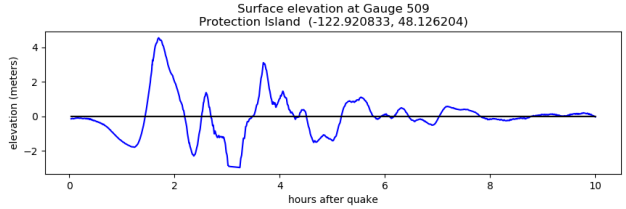
CSZ XL1 event:

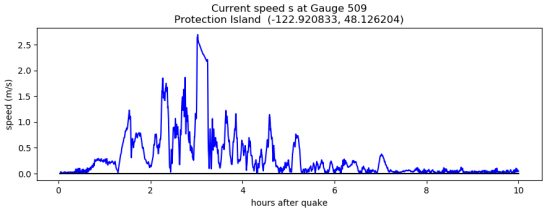


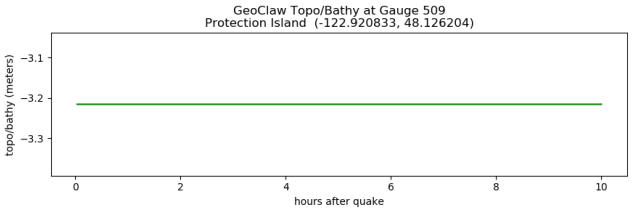


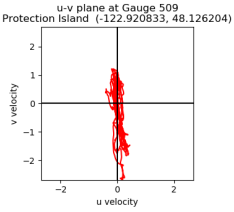


CSZ L1 event:

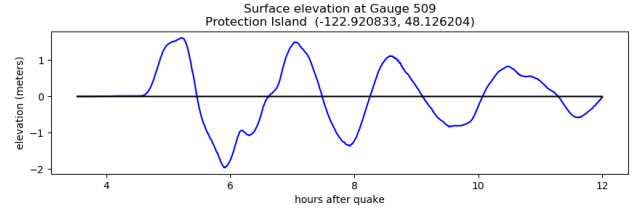


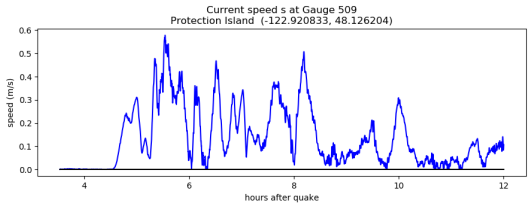


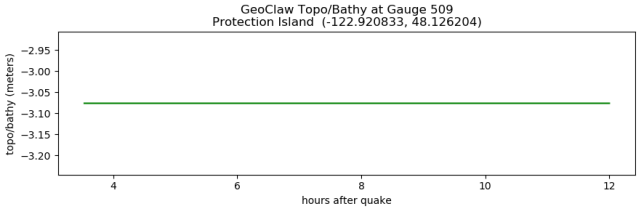


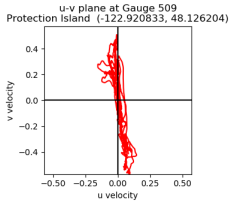


AKmaxWA event:





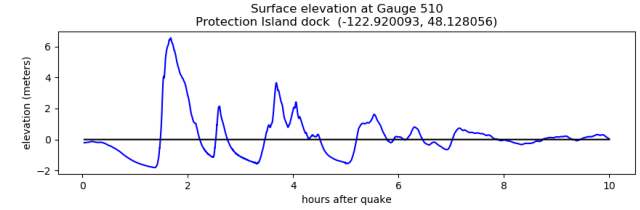


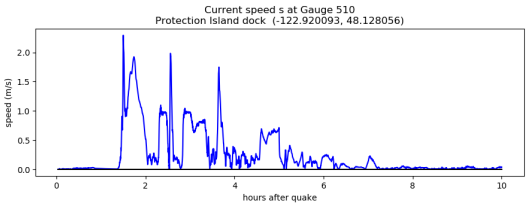


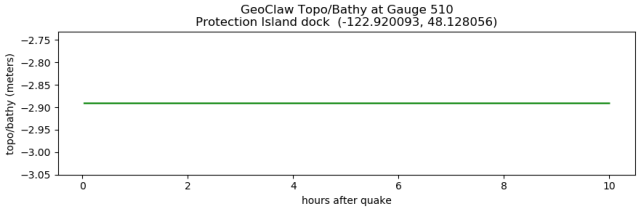
Gauge 510: Protection Island dock.

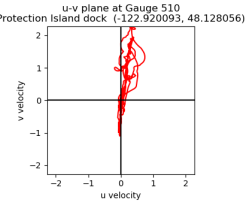
Computed on region `Discovery_PT`.

CSZ XL1 event:

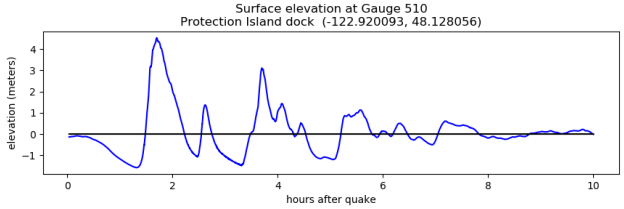


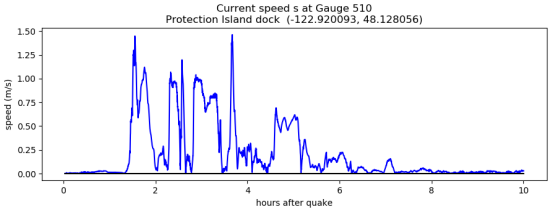


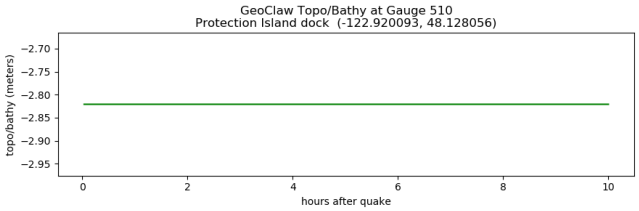


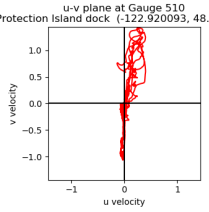


CSZ L1 event:

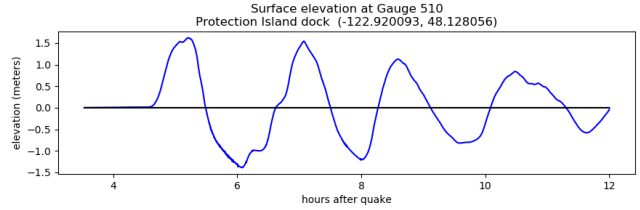


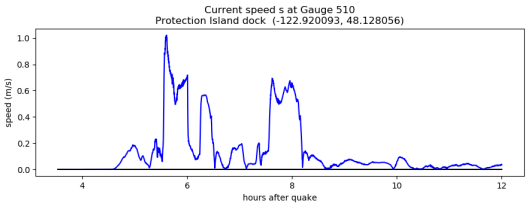


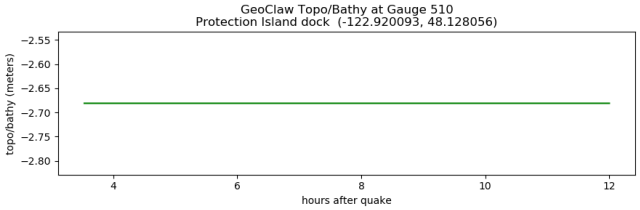


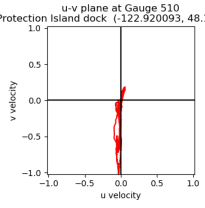


AKmaxWA event:





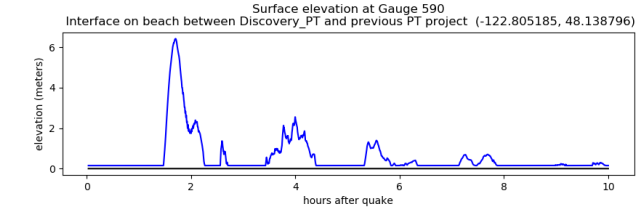


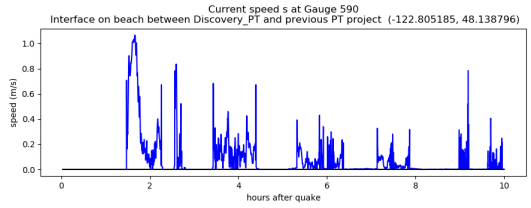


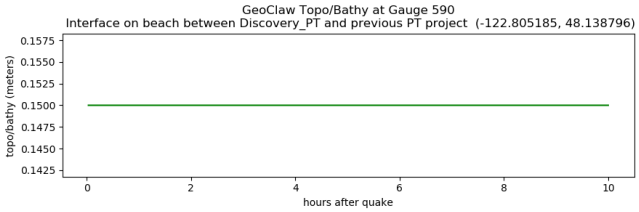
Gauge 590: Interface on beach between Discovery_PT and previous PT project.

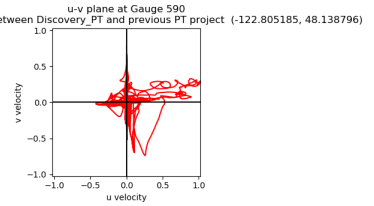
Computed on region Discovery_PT.

CSZ XL1 event:

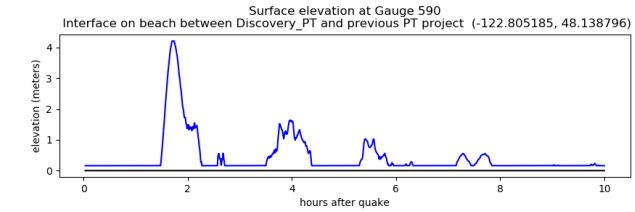


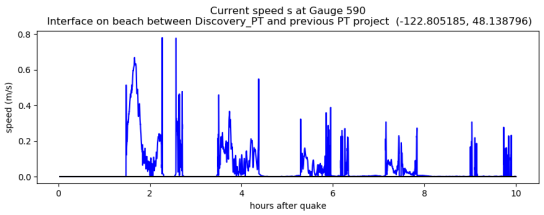


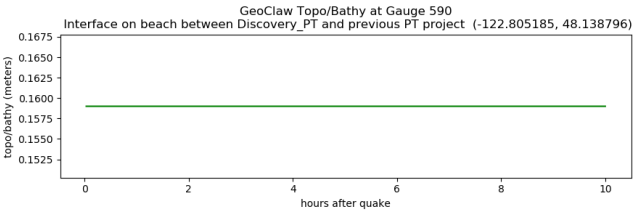


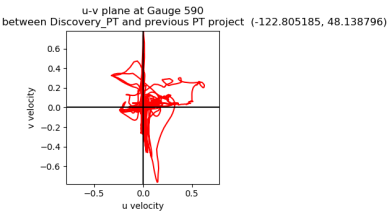


CSZ L1 event:

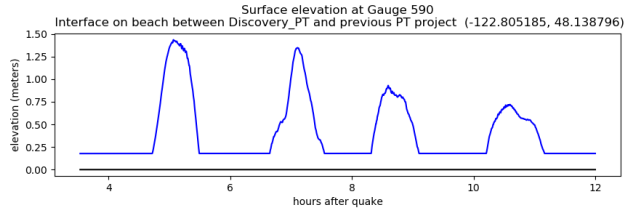


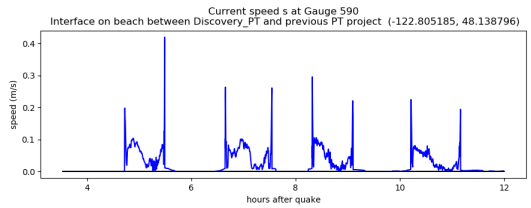


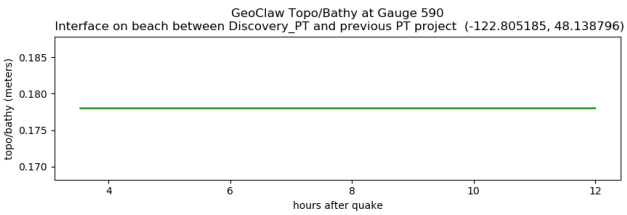


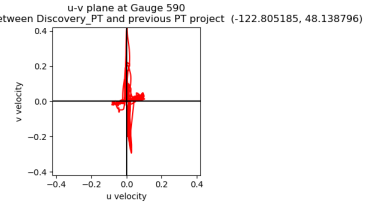


AKmaxWA event:





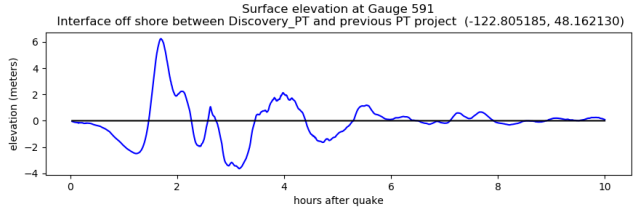


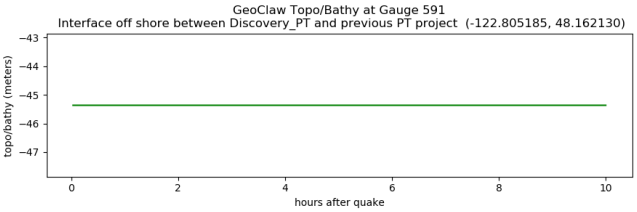


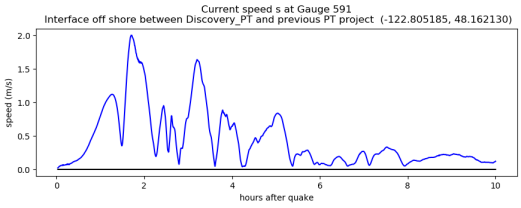
Gauge 591: Interface off shore between `Discovery_PT` and previous PT project.

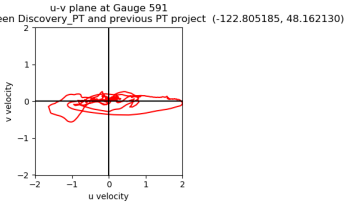
Computed on region `Discovery_PT`.

CSZ XL1 event:

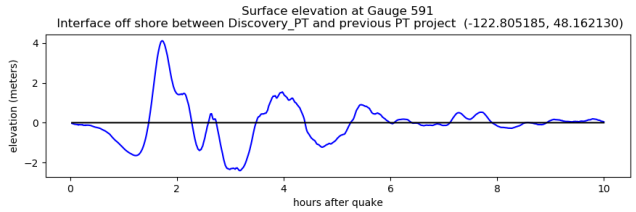


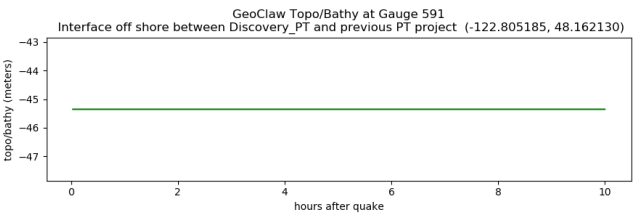


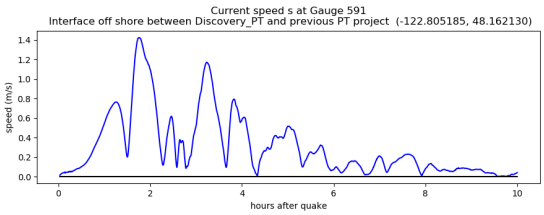


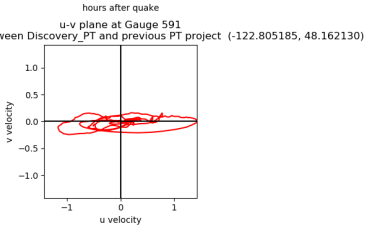


CSZ L1 event:

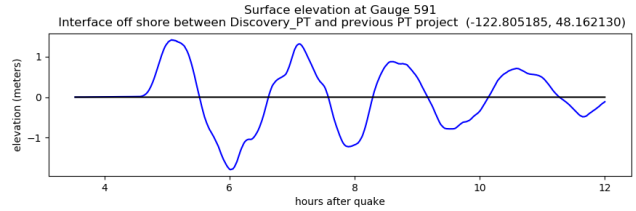


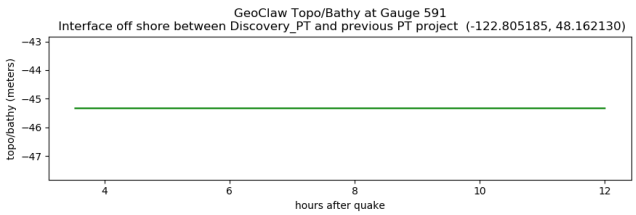


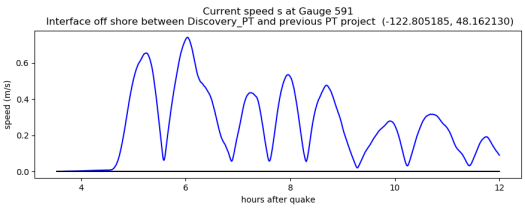


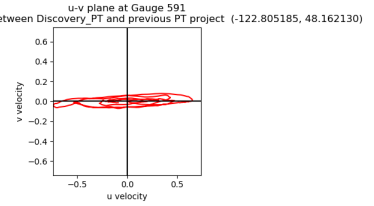


AKmaxWA event:





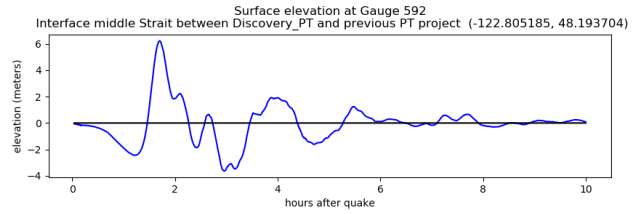


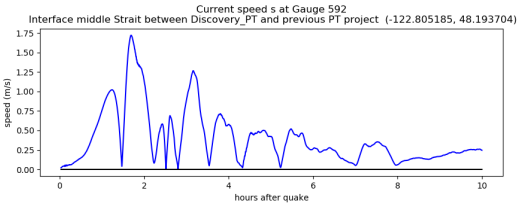


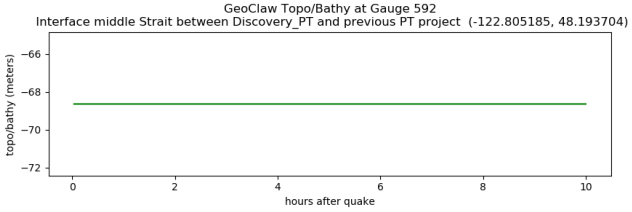
Gauge 592: Interface middle Strait between Discovery_PT and previous PT project.

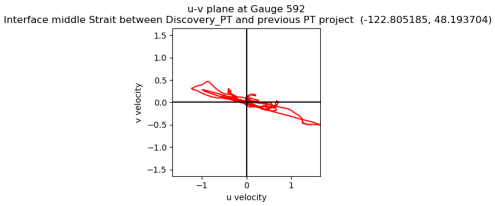
Computed on region Discovery_PT.

CSZ XL1 event:

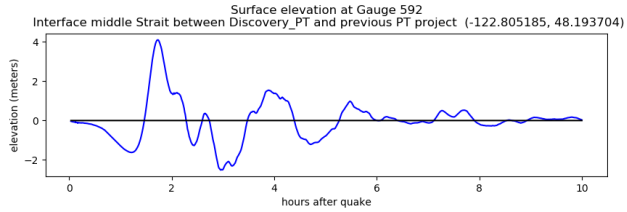


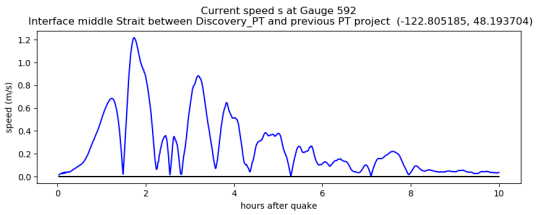


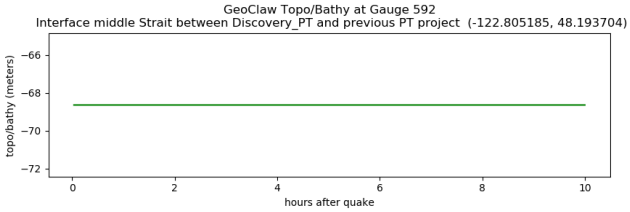


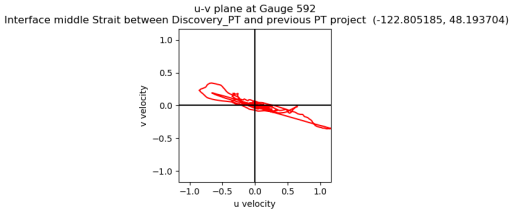


CSZ L1 event:

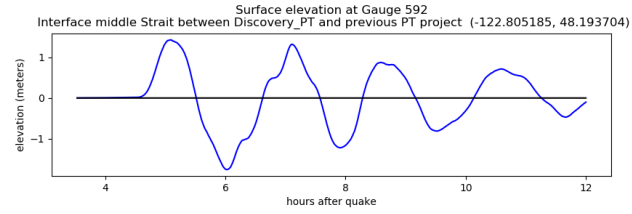


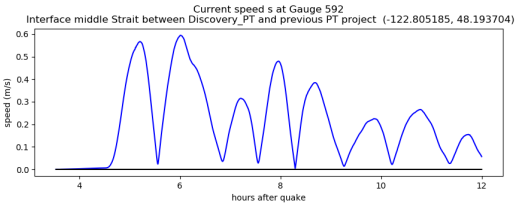


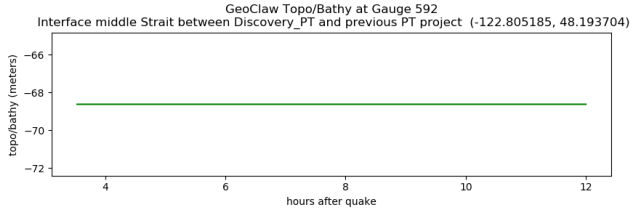


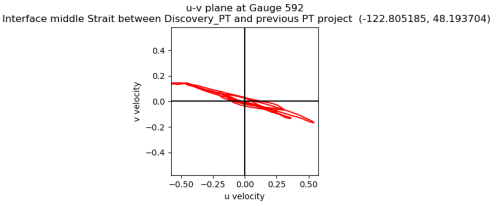


AKmaxWA event:









Appendices

A Data format

The deliverables described here are currently available on the Supplementary Materials website [14], which also contains additional materials and the code used to produce input data, run GeoClaw, postprocess output, and produce the plots shown in this paper and on the website. The permanently archived version is available by request from the Washington State Geological Survey.

A.1 fgmax values

For each earthquake source, output data is provided in a set of netCDF files, one for each of the regions associated with the source as listed in Table 1 and shown in Sections 6.1 through 6.5. There are five regions for each of 3 tsunami sources, so a total of 15 netCDF files are provided with results. The netCDF files archived have names of the form `REGION_EVENT_results.nc` where `REGION` is replaced by the fgmax region on which it was computed, and `EVENT` is replaced by the event (one of `CSZ_XL1, CSZ_L1, AK`). The AK event is also referred to as AKmaxWA.

The netCDF files contain the field variables described below. Some are generated before the GeoClaw run as part of the input, and are independent of the tsunami source event, depending only on the fgmax region. Others are generated after the run from the fgmax output. Note that all variables are stored on two-dimensional uniform grids as defined by the `lon` and `lat` arrays. Only the points on this grid where `fgmax_point == 1` are used as fgmax points and only at these points is fgmax output available.

Values created as part of the GeoClaw input:

`lon`: longitude, x (degrees),
`lat`: latitude, y (degrees),
`Z`: topography value Z from the DEM, relative to MHW (m),
`fgmax_point`: 1 if this point is used as an fgmax point, 0 otherwise.

Note that for this project, no points were forced to be dry and so no `force_dry_init` arrays were specified.

Values created based on the GeoClaw output:

`dz`: Co-seismic surface deformation interpolated to each point (m),
`B`: post-seismic topography value B from GeoClaw at gauge location (m),
`h`: maximum depth of water over simulation (m),
`s`: maximum speed over simulation (m/s),
`hss`: maximum momentum flux hs^2 over simulation (m^3/s^2),
`hmin`: minimum depth of water over simulation (m),
`arrival_time`: apparent arrival time of tsunami (s),

In addition, the netCDF files contain the following metadata values:

`tfinal`: Final time of GeoClaw simulation (seconds),
`history`: Record of times data was added to file,
`outdir`: Location of output directory where data was found,
`run_finished`: Date and time run finished,

Recall that the fgmax points are exactly aligned with the 1/3" DEM points. The finest level computational finite volume grid is also aligned so that cell centers are exactly at the fgmax points, and Z in the netCDF file is the value from the DEM at this point. However, the topography value B used in a grid cell in GeoClaw is obtained by integrating a piecewise bilinear function that interpolates the 1/3" DEM, and so B does not exactly equal Z initially. Moreover, B is the value after any co-seismic deformation associated with the event.

A.2 Gauge time series

The gauge time series was captured from each simulation every time step, but was then interpolated to 5 second increments to create the time series stored in the netCDF file for each gauge. The gauges were generally turned on only after the finest level computational grids were introduced around the fgmax region, and so time series do not start at $t = 0$ in general. All gauges except gauges 1 to 4 were all within some fgmax region and so the finest computational grid around the gauge had a resolution of 1/3". The time step then depends on the maximum depth over this region (since GeoClaw requires computing with a time step satisfying the CFL condition), but in general was less than 1 second. Gauges 1 to 4 were west of the `Chito_Sekiu` fgmax region but are the same gauges 1 to 4 used in the 2020 modeling of the Flattery region. We included them here to compare water coming into the Strait (gauge 1) and results closer to the western edge of the `Chito_Sekiu` region to the 2020 modeling. These gauges had resolution of 2", and the results were found to be consistent with the 2020 modeling.

The netCDF files archived have names of the form `REGION_EVENT_gauge00000.nc` where `REGION` is replaced by the fgmax region on which it was computed, `EVENT` is replaced by the event (one of `CSZ_XL1, CSZ_L1, AK`), and `00000` is replaced by the gauge number. The AK event is also referred to as AKmaxWA.

The netCDF files contain the following field variables:

`times`: time (seconds post-quake),
`zGeo`: post-seismic topography value B from GeoClaw at gauge location (m),
`h`: depth of water at gauge in simulation (m),
`u`: E/W velocity u at gauge (m/s),
`v`: N/S velocity v at gauge (m/s),
`level`: AMR refinement level at gauge at this time.

In addition, the netCDF files contain the following metadata values:

`history`: Record of times data was added to file,
`outdir`: Location of output directory where data was found,
`run_finished`: Date and time run finished,

B Modeling Details and GeoClaw Modifications

GeoClaw Version 5.8.0 was used for the modeling. This open source software is distributed as part of Clawpack, and is available from [7].

For this project no custom Fortran code used, and GeoClaw from the archived Version 5.8.0 of Clawpack was used.

Each individual run in a `Runs/LOC/EVENT` directory is controlled by a `setrun.py` and an auxiliary `params.py` file in that directory.

Python scripts and/or Jupyter notebooks were used to:

- Download, merge, and/or subsample topography DEMs and create topofiles in the format needed for GeoClaw,
- Create input files specifying fgmax points,
- Create ruled rectangles around the fgmax regions to guide AMR,
- Postprocess fgmax and gauge results to make plots and produce `.nc` and/or `.csv` files of the results.

These codes are all included in the archive `2021_SJdF_L1_XL1_AKmaxWA_code.tar.gz` available on request from the Washington State Geological Survey (WGS), and described more fully in the `README` file available in that archive and on the non-archival website [14].

C Gauge comparisons

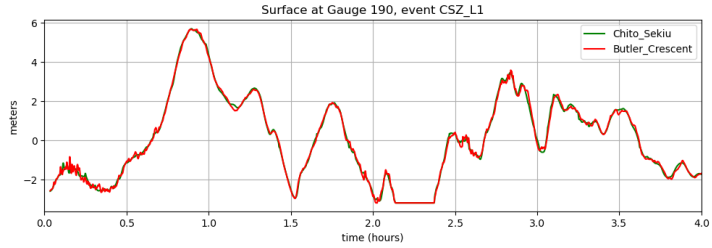
In this appendix we present a few comparisons of time series at key gauges, as a test that the different runs for different fgmax regions are consistent with one another.

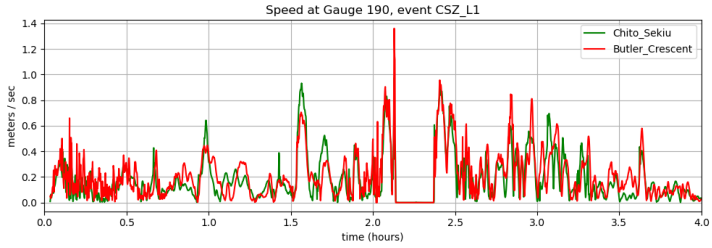
- Gauges 190, 191, and 192 are on the beach, offshore, and in the middle of the Strait in the `Chito_Sekiu` / `Butler_Crescent` overlap region, respectively.
- Gauges 290, 291, and 292 are on the beach, offshore, and in the middle of the Strait in the `Butler_Crescent` / `Elwha_PA` overlap region, respectively.
- Gauges 390, 391, and 392 are on the beach, offshore, and in the middle of the Strait in the `Elwha_PA` / `Dungeness_Sequim` overlap region, respectively.
- Gauges 490, 491, and 492 are on the beach, offshore, and in the middle of the Strait in the `Dungeness_Sequim` / `Discovery_PT` overlap region, respectively.

In these plots we focus on the first 4 hours for the CSZ events and from $t = 3.5$ to 7.5 hours for the AKmaxWA event in order to better see the differences between the results obtained in the two different simulations. In all cases the maximum values of elevation and speed occurs at these gauges during these time windows. (Also in general the maximum everywhere occurs over these time windows except at a few isolated locations.)

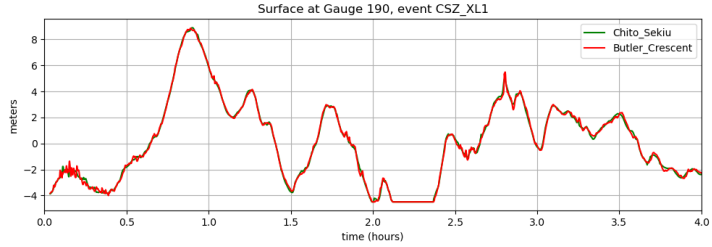
C.1 Gauge 190 in Chito_Sekiu / Butler_Crescent Overlap

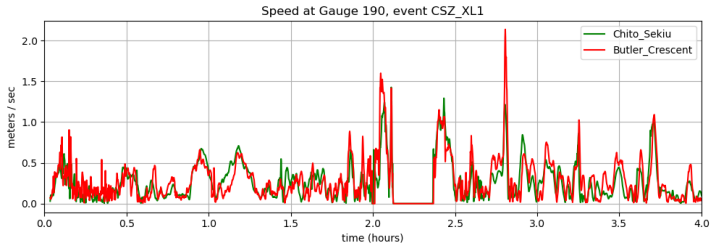
CSZ L1 event:



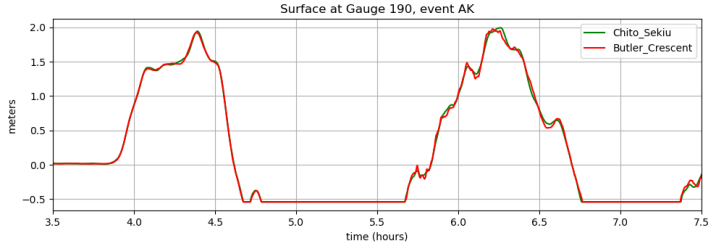


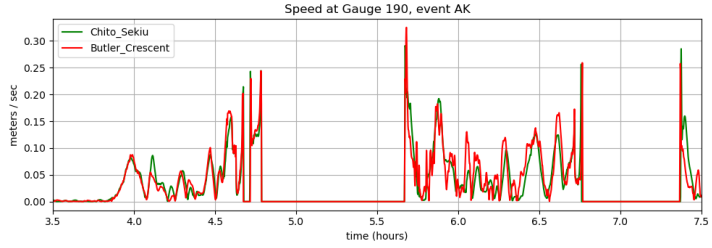
CSZ XL1 event:





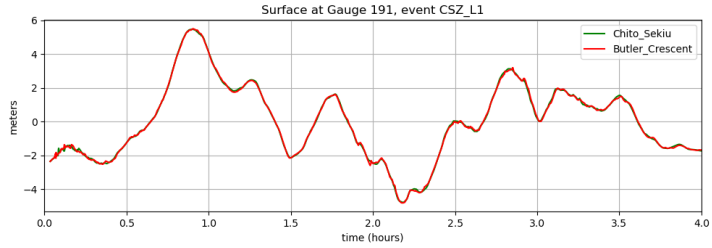
AKmaxWA event:

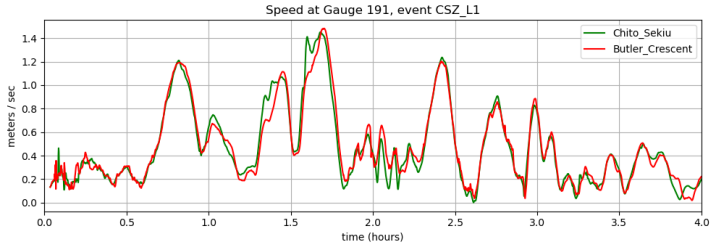




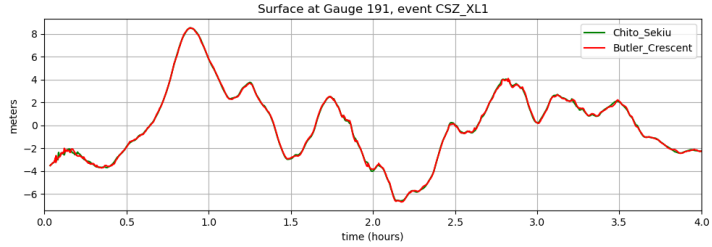
C.2 Gauge 191 in Chito_Sekiu / Butler_Crescent Overlap

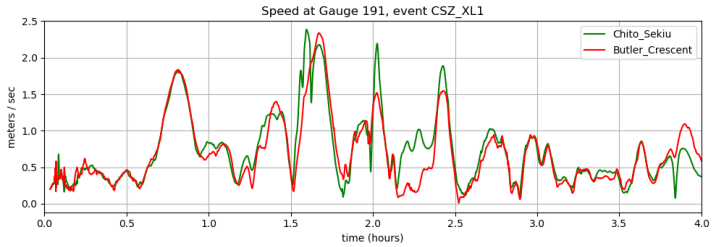
CSZ L1 event:



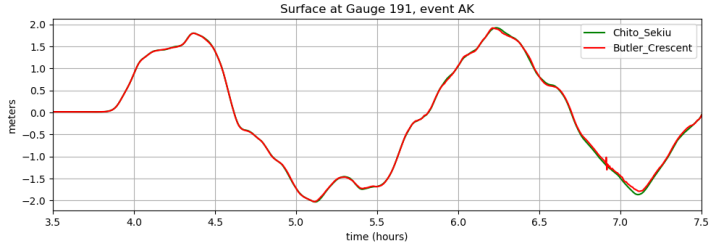


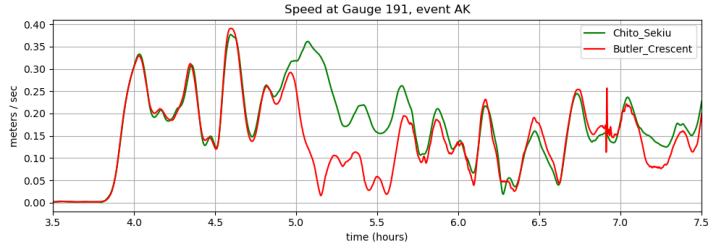
CSZ XL1 event:





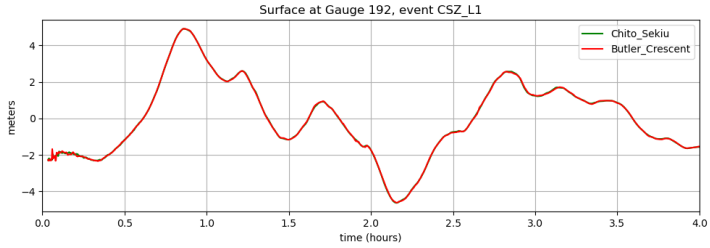
AKmaxWA event:

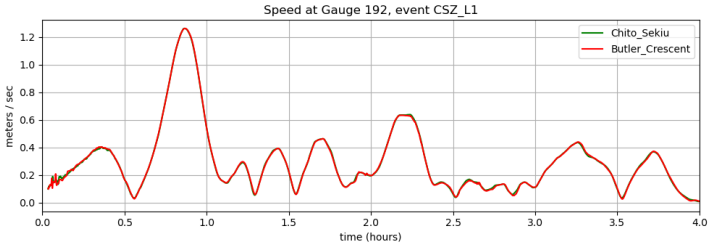




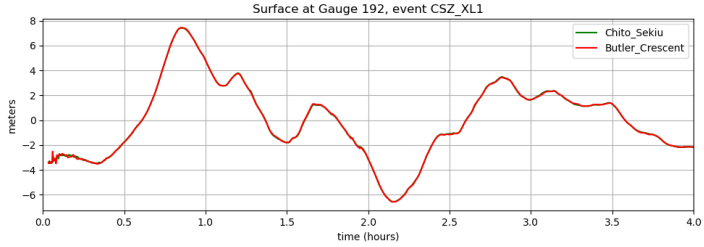
C.3 Gauge 192 in Chito_Sekiu / Butler_Crescent Overlap

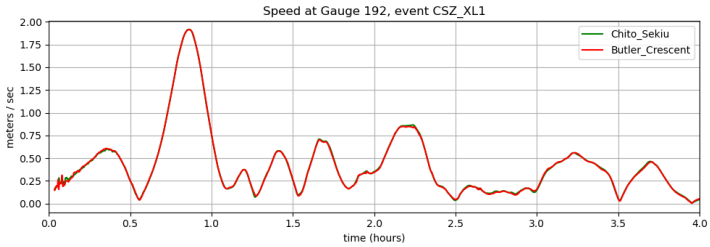
CSZ L1 event:



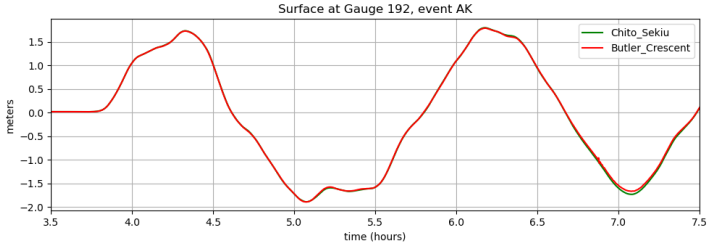


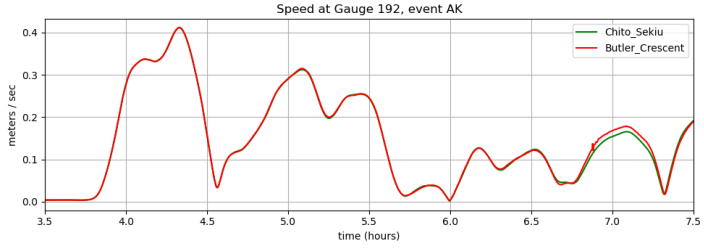
CSZ XL1 event:





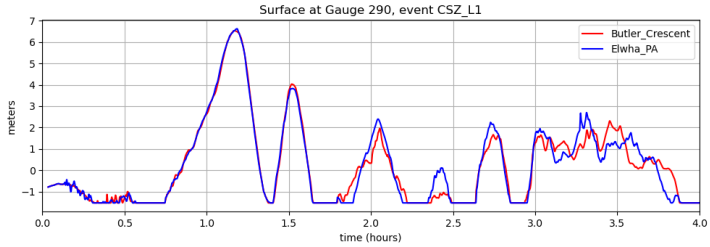
AKmaxWA event:

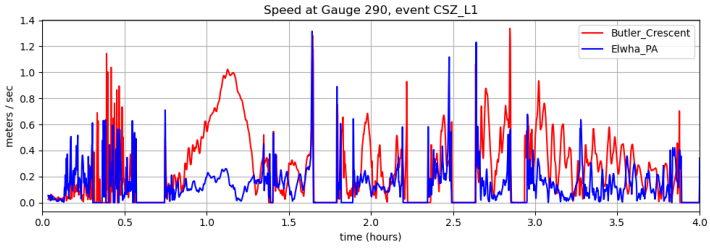




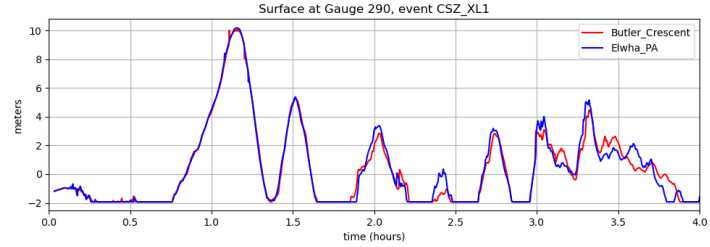
C.4 Gauge 290 in Butler_Crescent / Elwha_PA Overlap

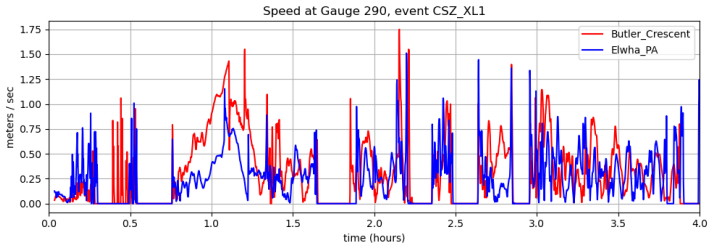
CSZ L1 event:



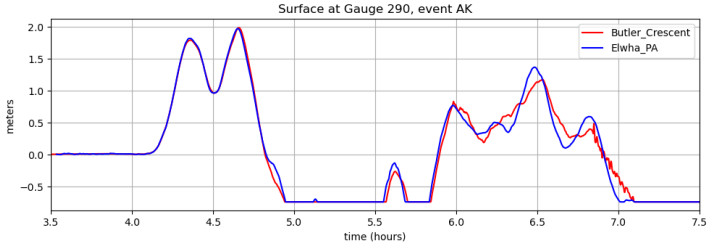


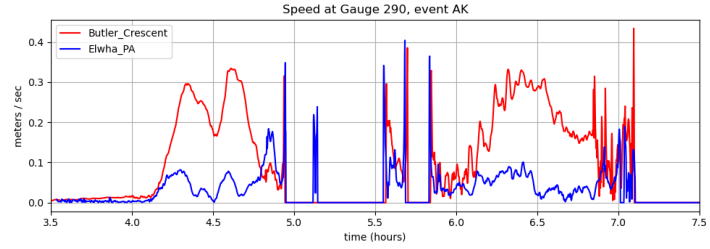
CSZ XL1 event:





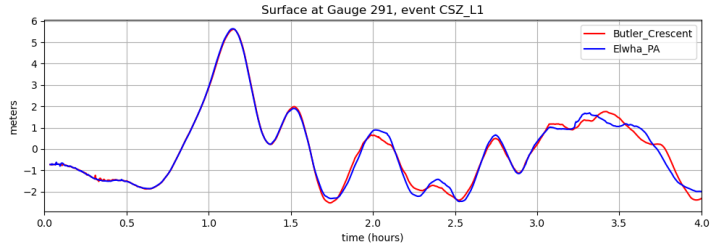
AKmaxWA event:

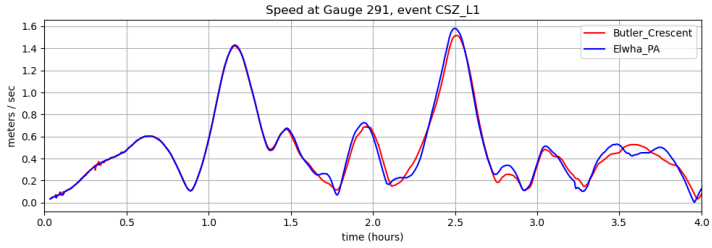




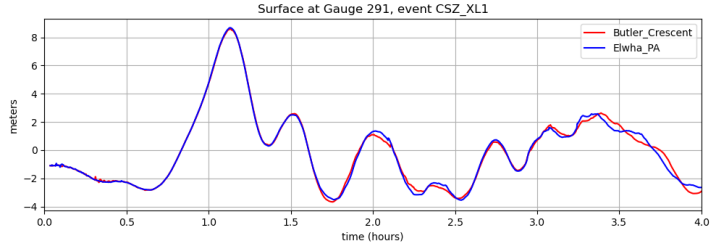
C.5 Gauge 291 in Butler_Crescent / Elwha_PA Overlap

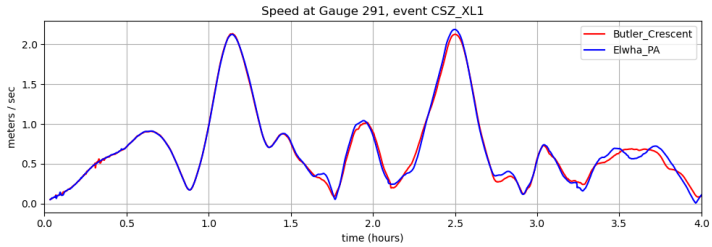
CSZ L1 event:



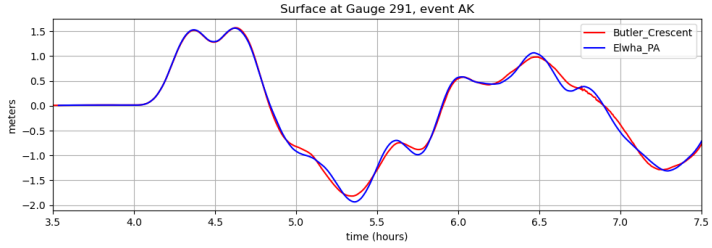


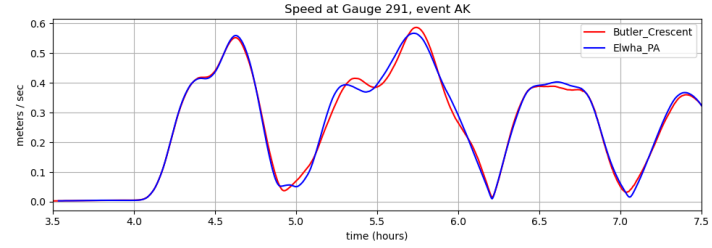
CSZ XL1 event:





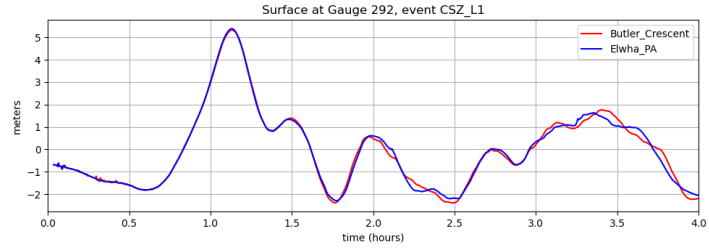
AKmaxWA event:

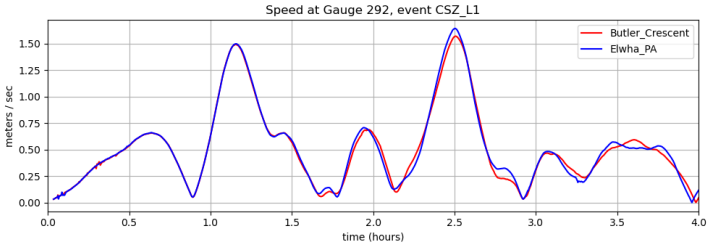




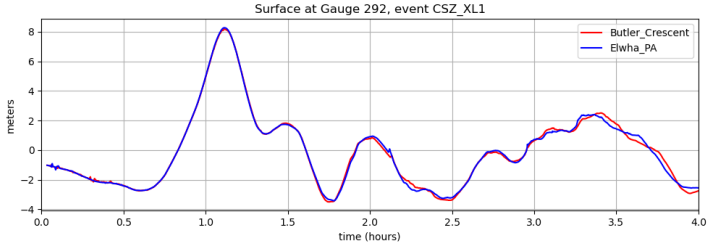
C.6 Gauge 292 in Butler_Crescent / Elwha_PA Overlap

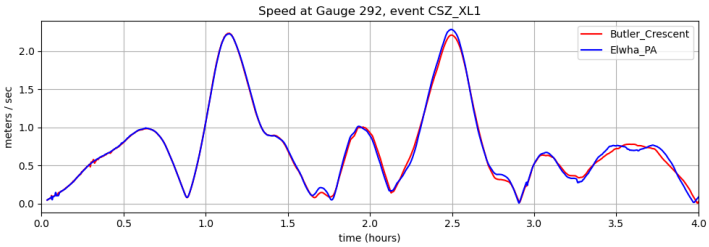
CSZ L1 event:



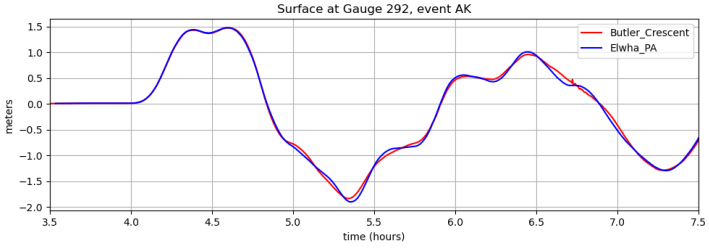


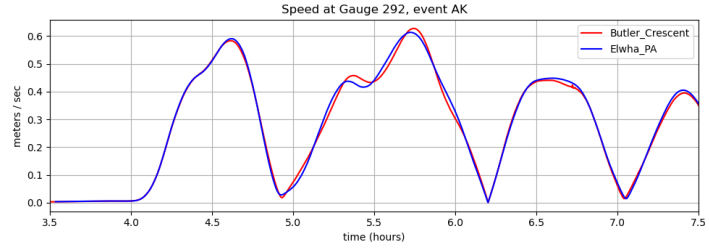
CSZ XL1 event:





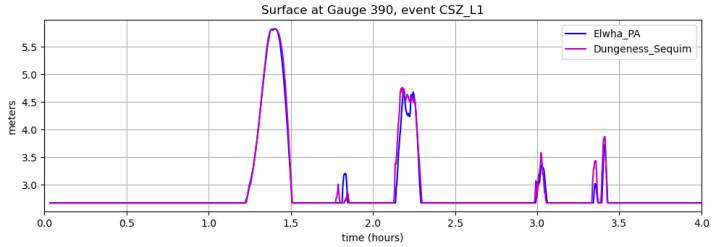
AKmaxWA event:

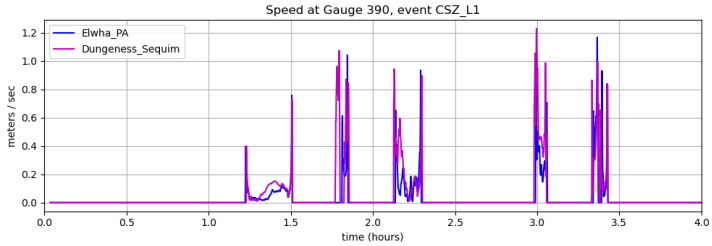




C.7 Gauge 390 in Elwha_PA / Dungeness_Sequim Overlap

CSZ L1 event:





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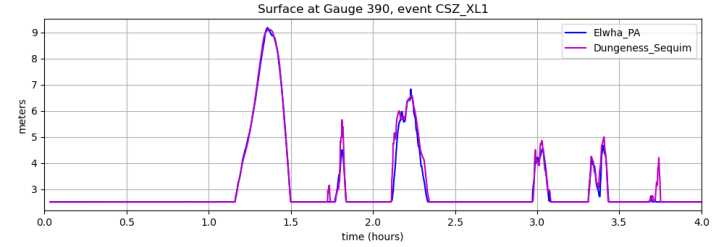

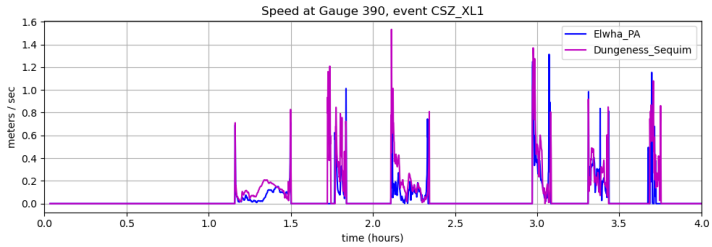

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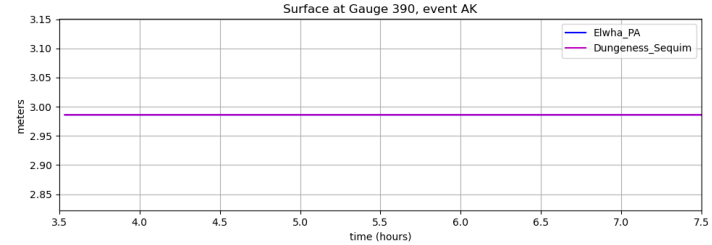
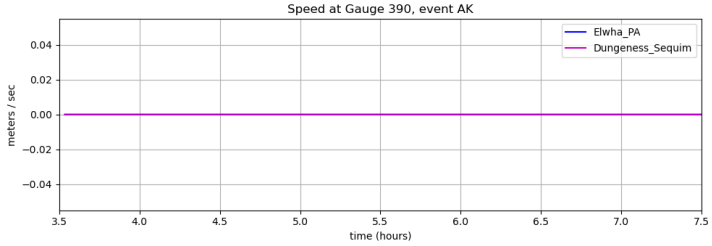
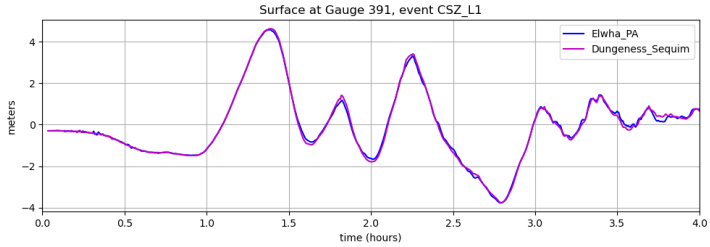
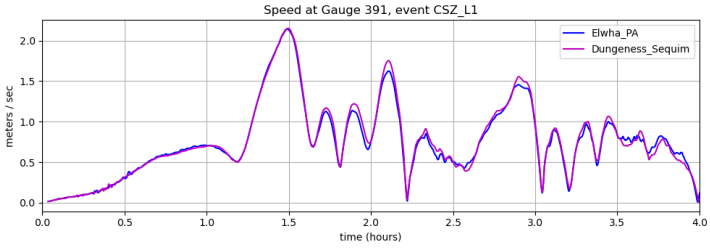




C.8 Gauge 391 in Elwha_PA / Dungeness_Sequim Overlap

CSZ L1 event:





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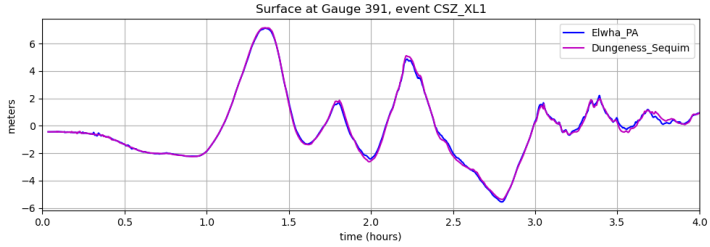

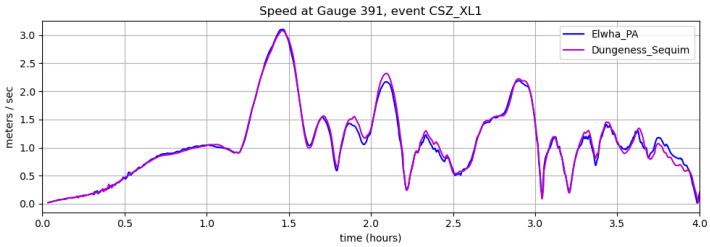

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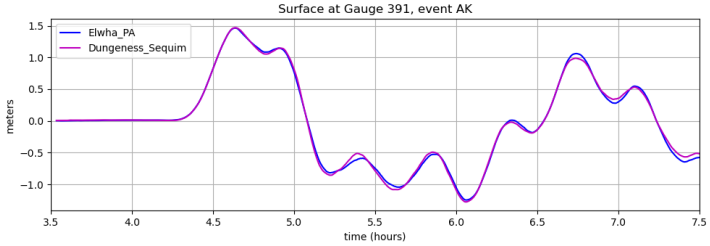
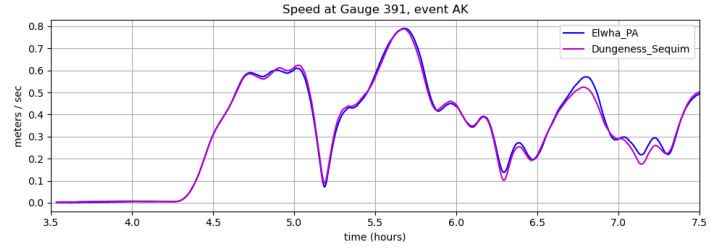
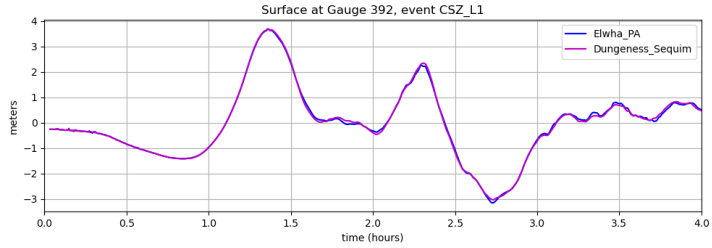
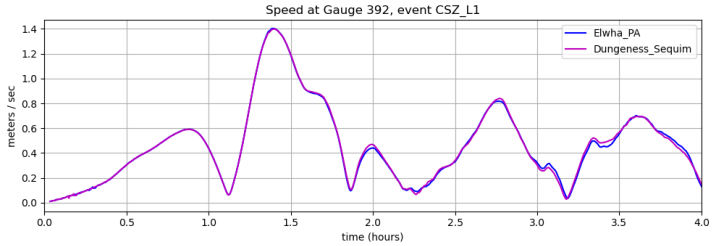




C.9 Gauge 392 in Elwha_PA / Dungeness_Sequim Overlap

CSZ L1 event:





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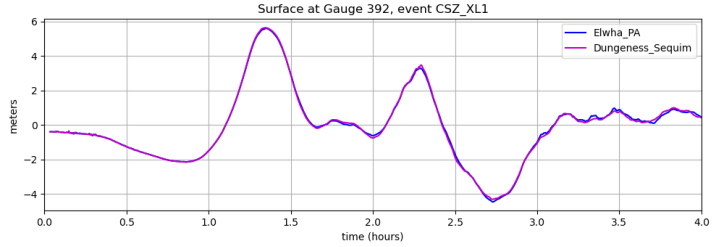

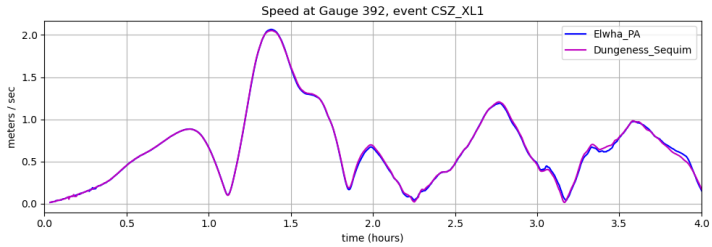

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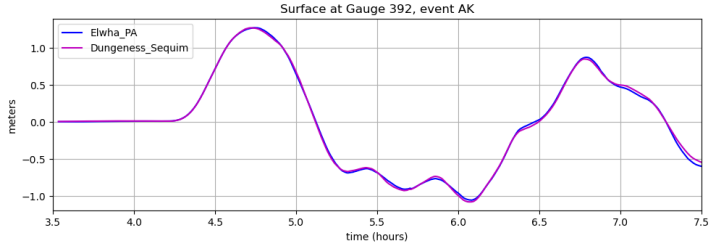
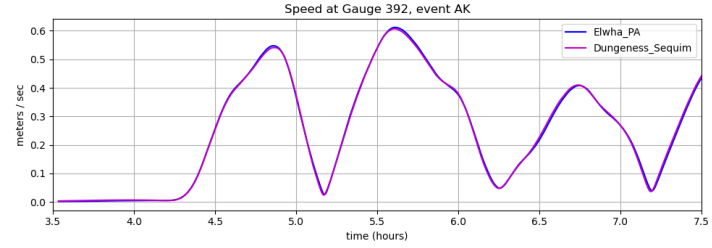
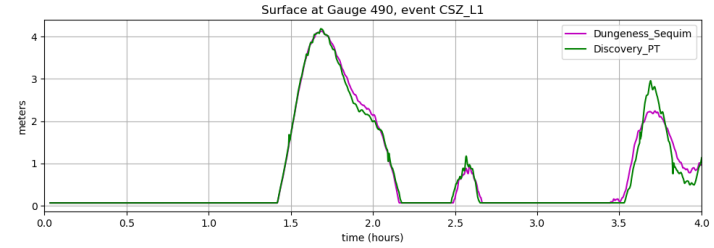
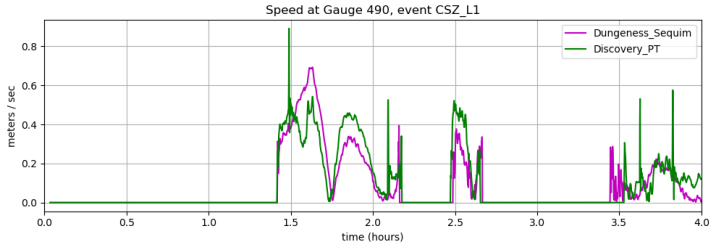




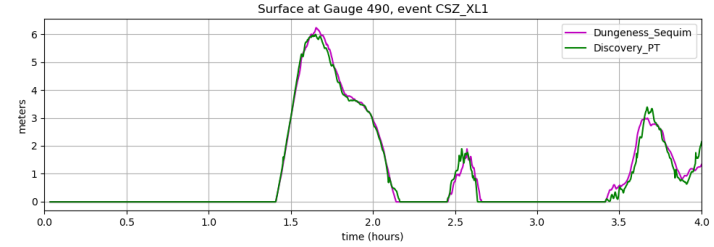
C.10 Gauge 490 in Dungeness_Sequim / Discovery_PT Overlap

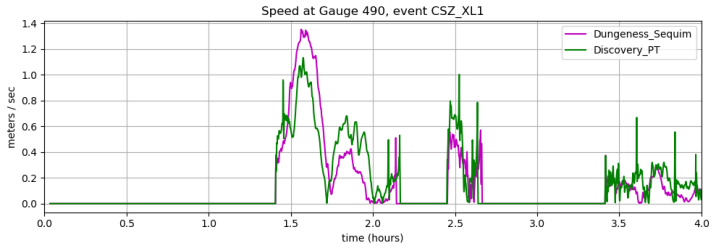
CSZ L1 event:



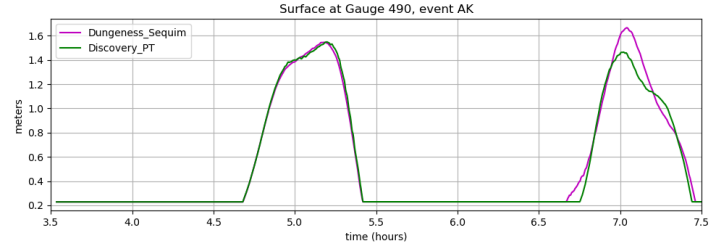


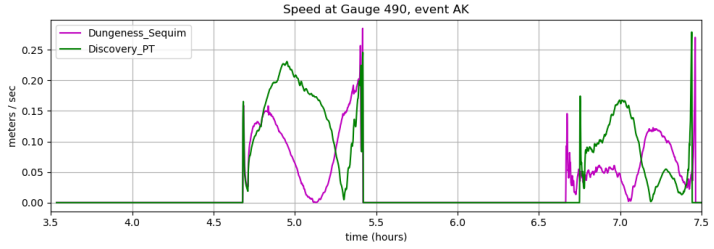
CSZ XL1 event:





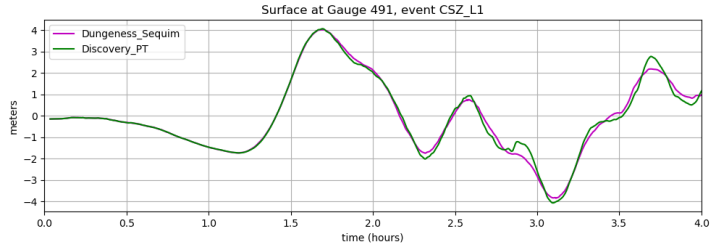
AKmaxWA event:

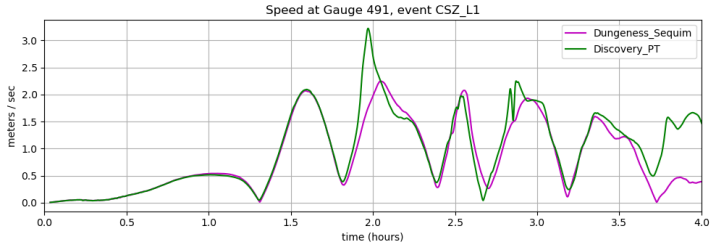




C.11 Gauge 491 in Dungeness_Sequim / Discovery_PT Overlap

CSZ L1 event:





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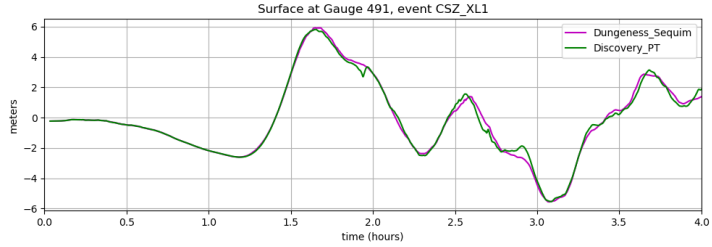
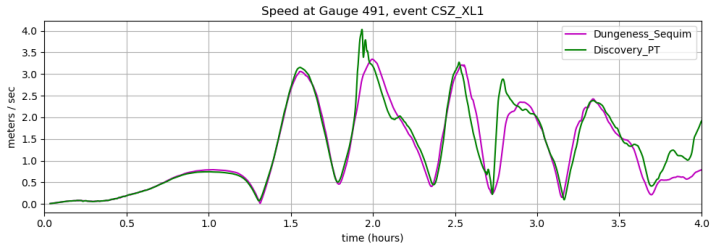
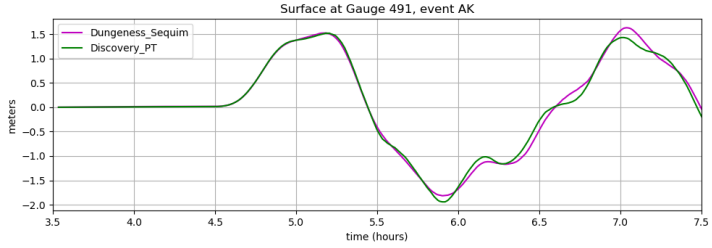
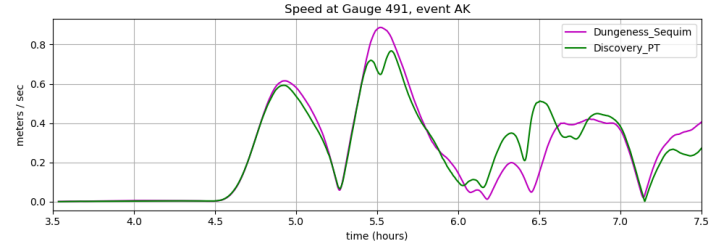




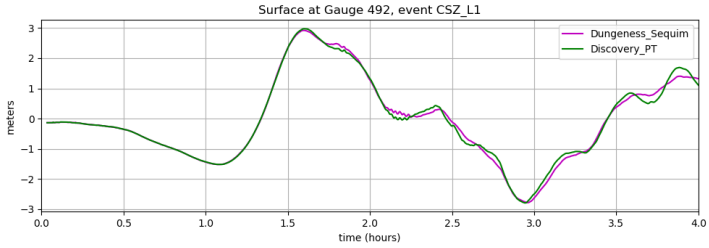
AKmaxWA event:

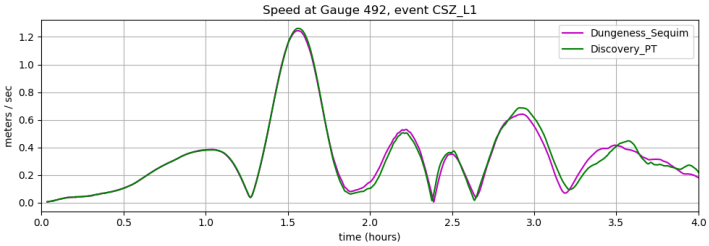




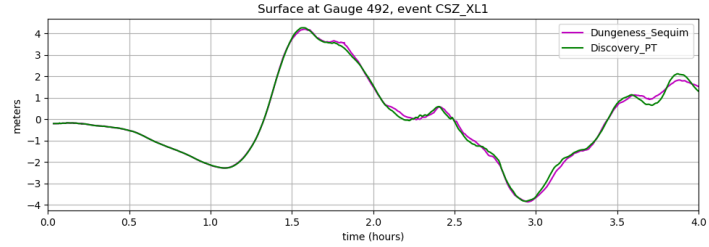
C.12 Gauge 492 in Dungeness_Sequim / Discovery_PT Overlap

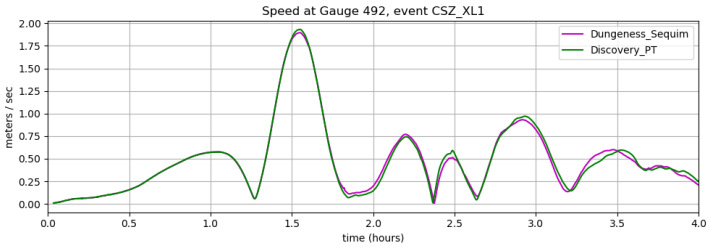
CSZ L1 event:



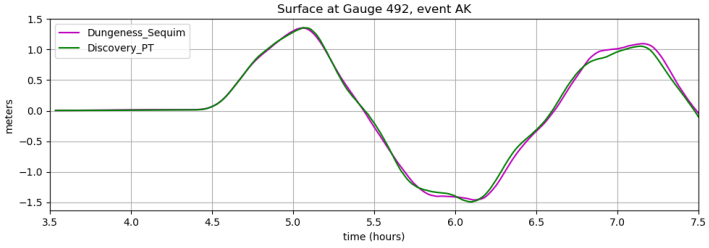


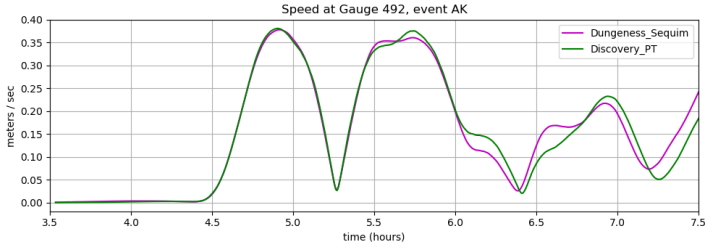
CSZ XL1 event:





AKmaxWA event:





Acknowledgments

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Data availability

The computer code and input data used in this study, along with selected GeoClaw fgmax grid and gauge output, has been archived and is available on request from the Washington State Geological Survey (WGS). Much of this data and the resulting GeoClaw output is also available on the non-archival website [14].

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