A Tsunami Forecast Model for Unalaska, Alaska

Yong Wei

Abstract

NOAA's next-generation tsunami forecast system will rely on a series of community forecast models designed to provide inundation and current velocities following tsunami generation. This report addresses the development, validation, stability testing of the tsunami forecast model for Unalaska, a port serving the nation's most productive fishing ground and home to 4,000 residents. The forecast mode, with 50-60 m spatial resolution in the vicinity of the port, can simulate four hours of a tsunami event in about ten minutes of computation using the Method of Splitting Tsunami (MOST) model. In this study, a reference model employing higher grid resolution up to ~ 10 m is also developed to provide model reference for the forecast model. Both the forecast model and the reference model are validated over a number of historical events for which tide gage records at Unalaska provide ground truth. The stability of the forecast model is evaluated using 43 synthetic scenarios generated from all predetermined subduction zones of the Pacific Basin at the magnitude level M_w 9.3.

1. Background and Objectives

The National Oceanic and Atmospheric Administration (NOAA) Center for Tsunami

Research (NCTR) at the NOAA Pacific Marine Environmental Laboratory (PMEL) has developed a tsunami forecasting capability for operational use by NOAA's two Tsunami Warning Centers located in Hawaii and Alaska (Titov *et al.*, 2005). The system is designed to provide basin-wide warning of approaching tsunami waves quickly and accurately. This forecast system combines real-time tsunami event data with numerical models to produce estimates of tsunami wave arrival times and amplitudes at a coastal community of interest. The forecast system integrates several key components: deep-ocean observations of tsunamis in real time, a basin-wide pre-computed propagation database of water level and flow velocities based on potential seismic unit sources, an inversion algorithm to refine the tsunami source based on deep-ocean observations during an event, and high-resolution tsunami forecast models.

The city of Unalaska is the 11th largest city in the U.S. state of Alaska and encompasses Unalaska Island, on which the town center and industrial docks are located, and the smaller Amaknak Island, home to the International Port of Dutch Harbor and the regional Dutch Harbor airport. The two islands are connected by the low-lying South Channel Bridge. A regional map of the two islands of Unalaska and connecting South Channel Bridge are shown in **Figure 1**. Unalaska Bay opens towards the Bering Sea to the North. A higher resolution aerial view of the southern portion of Amaknak Island, connected to Unalaska Island by the low-lying South Channel Bridge across the channel south of Captains Bay, is also shown.

In terms of population, Unalaska is home to over 4,000 permanent residents and its population is known to seasonally increase to as large as 10,000 at the height of the fishing season when fishing and crab boats descend upon the Port of Dutch Harbor and processing facilities are fully staffed and operational. So important is the fishing industry to the local economy that the name Dutch Harbor is often used interchangeably with Unalaska to refer to the community. Its strategic position near the center of the nation's most productive fishing grounds and Unimak Pass on a major shipping lane makes Dutch Harbor the number one fishing port in the nation with commercial fishing, fish processing plants, fleet services, and shipping activities responsible for the regions employment and economy. Again due to strategic location, the harbor is the hub of the transshipment of cargo between Pacific Rim trading partners (http://unalaska-ak.us/).

Alaska has a greater earthquake and tsunami potential than any other state because of its proximity to one of the most seismically active regions in the world. The Alaskan-Aleutian Subduction Zone, where the Pacific Plate is subducting under the North America Plate, has the potential to generate both local and basin-wide tsunamis that threaten coastal communities in Alaska and the Pacific Basin. Distant and local earthquakes along the subduction zones in the Pacific account for 80% of the origins of tsunamis that have impacted Alaskan coastlines. Historically, local tsunamis such as the 1946 Unimak and 1957 Andreanov events have caused higher impact to Unalaska than distant tsunamis. Two segments of the nearby subduction zone deserve special attention. The Shumagin gap is a segment of the Alaskan-Aleutian arc that has not ruptured in a great earthquake since at least 1899-1903 (Davies et al, 1981), and accordingly may have a high seismic potential. Estabrook and Boyd (1992) reported a M7.4 earthquake in the

Shumagin Islands on 31 May 1917. To the west of the 1946 rupture area is the 200-km-long Unalaska seismic gap (House et al., 1981), which has not generated an earthquake in about as long and holds a similar capability. Davis et al. (1981) discussed about the 1948 M7.5 earthquake in Shumagin Gap, but stated that it was small and did not fill the gap. They also predicted that the Shumagin Gap is capable of producing an M8.2 quake if a rupture occurs along the full length of 250 km of the gap. Boyd and Jacob (1986) suggested a major seismicity gap exists for events of magnitudes greater than 4.6 in the forearc region near Unalaska Island. Davis *et al*. (1981) described as a "worst scenario" that an earthquake nucleated in the Shumagin Gap could also rupture the Unalaska Gap with resultant magnitude up to Mw 9.0. A tsunami induced by such an earthquake could be devastating for many communities not only on the Alaska-Aleutian coasts, including Unalaska, but also in the far field along Hawaiian Island coasts and the United States west coast.

In tsunami hazards mapping of Alaskan coastal communities, Unalaska falls within the zone of highest tsunami potential (Suleimani *et al.,* 2002). The Tsunami Hazard Map of Unalaska, developed by Data Directions Consulting Group and shown in **Figure 2**, defines the Tsunami Safe Zone as areas above 50 ft (~15m) in elevation. This map also shows the tsunami evacuation routes developed and reviewed by local emergency management officials.

The main objective of this work is to develop a tsunami forecast model for Unalaska to react to a tsunami threat by providing accurate information quickly to emergency managers and other officials responsible for the community and infrastructure within the SIFT framework. This, as has been demonstrated for other communities over the past several years, can provide timely and appropriate information. For a local event, there is a great use of this study by providing a first tsunami damage assessment in order to send limited resources to the impacted areas. For medium and far-field tsunamis, the forecast model can maximize the length of time that the community has to react to the potential tsunami threat. When severe impacts are likely the forecast can guide the emergency response; but where only a weak tsunami is indicated a warning cancellation can reduce the expense and loss of public confidence that would result from a false alarm. An additional goal is minimization of false alarms that ultimately erode system credibility with the resident and fishing populations. Discussion of the details of the individual components of the Unalaska forecast model, including the development of grids using bathymetry and topography, model validation using historical tsunami cases, model stability and robustness, sensitivity testing using synthetic tsunami events, the basic model setup, and model parameters are provided in this report. It should be noted that this report is not focused on development of the maximum credible scenarios, and should not be considered as a tsunami hazard assessment study. An interested reader may consult other studies for the worst-case scenarios at Unalaska.

2. Forecast Methodology

In NOAA's forecast system, an inundation model is used as the basis for development of a tsunami forecast model to operationally provide an estimate of wave arrival time, height, and inundation at a coastal community following tsunami generation. All tsunami forecast models are to run in real time while a tsunami is propagating across the open ocean. Before its implementation in the forecast system, a forecast model needs to be designed and tested to perform under stringent time constraints, given that time is generally the single limiting factor in saving lives and property.

The general tsunami forecast model is used in the tsunami inundation and forecasting system to provide real-time tsunami forecasts at selected coastal communities. A general tsunami forecast model runs in minutes while employing high-resolution grids constructed by the National Geophysical Data Center. The tsunami forecast models are based on a numerical model named the Method of Splitting Tsunamis (MOST), a suite of numerical simulation codes capable of simulating three processes of tsunami evolution: earthquake, transoceanic propagation, and inundation of dry land (Titov and Gonzalez, 1997). The MOST model has been extensively tested against a number of laboratory experiments and benchmarks and was successfully used for simulations of many historical tsunami events (Synolakis *et al.*, 2008). Titov and González (1997) describe the technical aspects of forecast model development, stability, testing, and robustness, and Tang *et al*. (2009) provides detailed forecast methodology.

A basin-wide database of pre-computed water elevations and flow velocities for unit sources covering worldwide subduction zones has been generated to expedite forecasts (Gica *et al.*, 2008). As the tsunami wave propagates across the ocean and successively reaches tsunameter observation sites, recorded sea level is assimilated into the tsunami forecast application in near real-time and incorporated into an inversion algorithm to produce an improved estimate of the tsunami source. A linear combination of the pre-computed database is then performed based on this tsunami source, now reflecting the transfer of energy to the fluid body, to produce synthetic boundary conditions of water elevation and flow velocities to initiate the forecast model computation.

Accurate forecasting of the tsunami impact on a coastal community largely relies on the accuracies of bathymetry and topography and the numerical computation. The high spatial and temporal grid resolution necessary for modeling accuracy poses a challenge in the run-time requirement for real-time forecasts. A forecast model usually consists of three telescoped grids with increasing spatial resolution in the finest grid, and temporal resolution for simulation of wave inundation onto dry land. The forecast model utilizes the most recent bathymetry and topography available to reproduce the correct wave dynamics during the inundation computation. Most of the forecast models, including the Unalaska forecast model, are constructed for at-risk populous coastal communities in the Pacific and Atlantic Oceans. All of these forecast models need to be validated for their accuracy and efficiency before their implementation in NOAA's real-time tsunami forecast system (Titov *et al*., 2005; Tang *et al*., 2008; Wei *et al*., 2008; Titov, 2009; Tang *et al*., 2009). Tang *et al*. (2009) provide detailed procedures and examples of development and validation of a forecast model.

3. Model Development

A tsunami forecast model using MOST usually consists of three nested grids, referred to as A, B, and C-grids, that employ increasing spatial resolutions. Tsunami wave dynamics offshore are predicted using a low-resolution A grid, while the wave dynamics in shallow, near-shore area is computed in C grid, where the model results are compared with observations at tide gauges for historical tsunamis. The procedure of model development begins with development of a large spatial extent merged with bathymetric topographic grids at high resolution, referred to as a reference model. The grids are then optimized by sub-sampling to coarsen the resolution to achieve a 4 to 10 hr simulation of tsunami waves within 10 min of wall-clock time. This optimized model The basis for these grids is a high-resolution digital elevation model constructed by the National Geophysical Data Center and NCTR using all available bathymetric, topographic, and shoreline data to reproduce the wave dynamics during the inundation computation for an at-risk community. For each community, data are compiled from a variety of sources to produce a digital elevation model referenced to Mean High Water in the vertical and to the World Geodetic System 1984 in the horizontal (http://ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html). From these digital elevation models, a set of three high-resolution, "reference" elevation grids are constructed for development of a high-resolution reference model from which an 'optimized' model is constructed to run in an operationally specified period of time. The operationally developed model is referred to as the optimized tsunami forecast model or forecast model for brevity.

3.1 Forecast Area

The city of Unalaska is the major city and port facility of the Aleutian Islands. It lies on the north side of the island of the same name, approximately 1300 km southwest of Anchorage. The remainder of the island is sparcely populated. The airport and much of the dock facilities are in Dutch Harbor on Amaknak Island within Iliuliuk Bay (Figure 1). Unalaska Island lies approximately 170 km from the Alaska-Aleutian

Trench where the Pacific Plate, subducting beneath the North America Plate, has historically been the source of numerous earthquake-generated tsunamis. Although located on the north side of the island, the deep waters of the Bering Sea, and numerous passes through the Aleutian Chain, make the population and infrastructure vulnerable to both local and remote events.

Tsunami forecast models coupled with deep-ocean observations play an important role in protecting vulnerable communities, including Unalaska, by providing timely forecasts of tsunami impacts on Alaska's seismically active, populated coastlines. **Figure 3** shows the locations of 15 historical tsunamigenic earthquakes in the Pacific and the proximity of the DART systems along with the location of the 100- by 50-km unit sources as defined in the Pacific Marine Environmental Laboratory (PMEL) tsunami propagation database.

3.2 Historical tsunamis in Unalaska and water level at tide station

Historical tsunamis have had a devastating impact on the Alaskan coastline. Lander (1996), in a comprehensive study of tsunamis affecting Alaska between 1737 and 1996, documented 100 tsunami events that affected Alaskan coastlines between 1737 and 1996, including 43 from distant sources, 31 from local sources, 14 landslide-generated, 10 volcanic-generated, and 2 meteorologically-induced tsunamis. Table 1 provides the earthquake magnitudes of 30 of these events. Figure 3 shows the locations of the epicenters of the events to be used for model validations in this study. It should be noted that locations of epicenters are not provided in **Figure 1** for events of unknown source

There have been 122 fatalities due to tsunamis in Alaska since 1900. Between 1940 and 1970, the five destructive tsunamis, 1946 Unimak, 1952 Kamchatka, 1957 Andreanov, 1960 Chile, and 1964 Alaska, represented an era of tsunami hazards and led to intensive efforts in tsunami monitoring and modeling. These events were recorded by tide gages throughout the Pacific and provided valuable datasets for tsunami research since then (U.S. Coast and Geodetic Survey, 1952, Berkman et al., 1960, Spaeth et al, 1964). The 1946 Unimak tsunami caused five fatalities and the 1964 Prince William Sound event resulted in 106 fatalities and $84 million in damages. Since 1996, 12 distant and two local tsunamis have been observed at tide stations in Alaska, including the devastating Dec. 26, 2004 Sumatra tsunami (NOAA/WDC Historical Tsunami Database at NGDC). No tsunami-related damages or fatalities have been reported in Alaska since 1996. However, 10 Pacific events since 2006 provided rich water level data at both deep-ocean tsunameters and coastal tide gages for model validation.

The National Ocean Service (NOS) tide station at Unalaska has recorded a numbers of historical tsunamis since it was first established in 1955 and then moved to its present installation in 1989. The tide station, shown in both **Figures 1 and 4**, is located at the head of Iliuliuk Bay on the Unalaska-Island-side of the channel. The mean tidal range in the vicinity is approximately 0.9m and the diurnal range is 1.1m. The mean sea level has been continuously dropping at a rate of 6.44 mm/yr since 1957 (http://tidesandcurrents.noaa.gov/stationhome.html?id=9462620).

The 10 November, 1938 Alaska Peninsula tsunami of magnitude M_w 8.3 is the earliest documented event with an maximum wave amplitude of 10 cm (Lander, 1996). **Table 2** shows the observed maximum wave amplitude at the Unalaska tide station for 27 tsunami events since 1938. The maximum wave amplitude reported to date at the tide gage is approximately 0.7 m, during both the 1957 Andreanof and 1960 Chilean tsunamis. None of the listed tsunamis caused serious damage or flooding in Unalaska. In contrast, the 1946 Unimak tsunami generated a tsunami in Dutch Harbor that damaged several small boat landings and pilings, although, interestingly, this tsunami was not recorded at the Unalaska tide station (Lander, 1996).

3.3 Digital Elevation Models in Alaska

Accurate bathymetry and topography in offshore and coastal regions play the key role, globally and locally, in tsunami generation, propagation and inundation. A number of global bathymetric and topographic datasets are available for public-domain research. Marks and Smith (2006) conducted an evaluation on six publicly available global bathymetry grids: DBDB2 (Digital Bathymetric Data Base by Naval Research Laboratory), ETOPO2 (Earth Topography by National geophysical Data Center), GEBCO (Genercal Bathymetric Charts of the Oceans by British Oceanographic Data Center), GINA (Geographic Information Network of Alaska), Smith and Sandwell (1997) and S2004. They concluded that the original Smith and Sandwell grid might be the best source among these global bathymetric grids. Subsequently, they developed a new 1-min global topography grid S2004 that combines the Smith and Sandwell below 1000m depth and equatorward of 72° and GEBCO grids in shallow water and polar region. NOAA Center for Tsunami Research (NCTR) developed a Pacific-Basin 30sec grid, derived primarily from the Smith and Sandwell grid and the SRTM30_PLUS grid, with amendments in areas where NCTR has better bathymetry. This comprehensive dataset covers the entire Pacific Ocean and part of the Arctic Ocean from E120° to W68°, and S80° to N80°.

While developing bathymetric and topographic grids for a few coastal sites, NCTR has been collaborating with National Geographic Data Center (NGDC) in the Tsunami Inundation Gridding Project since 2005 to build high-resolution digital elevation models (DEMs) for more U.S. coastal regions, and to satisfy the needs of future forecast model development in the near future.

Figure 5 shows the extent of the bathymetric and topographic grids compiled by NGDC and NCTR/PMEL for the Alaska region. The coverage, resolution and developer of each grid are described in **Table 3**. In the coarsest grid (A) of each forecast model, which covers large offshore regions and extends its boundary to deep water, a 2-min resolution is commonly used at this level to compute the dynamics of tsunami waves. The 2-min grids produced in this work primarily use the 30-sec Pacific-Basin dataset as the parental data sources, and possibly other datasets wherever they cover the domain with a grid finer than 30-sec resolution. The bathymetry and topography of the finer grid (B and C) in each forecast model makes use of the DEMs developed by NGDC as the best source, and those developed by PMEL if NGDC has not developed a grid for the area. It needs to be pointed out that the topography data of NGDC's DEM was obtained from a combination of USGS NED, NASA SRTM and OCS ENCs. The DEM thus has an estimated horizontal accuracy of 10 to 20 meters and vertical accuracy of 10-15 meters for the topographic features (Taylor et al., 2006). The lack of use of Lidar data in the DEM may cause errors in the model computation, especially when onshore flooding occurs.

It is worth noting that NGDC's DEM for Unalaska is subject to updates when more accurate data becomes available in future. The forecast model developed in this study reflects the best available DEM at the time when the model was developed.

3.4 Model setup

Figure 6 shows the coverage of data sources available and used by NGDC to develop the high-resolution grids for Unalaska/Dutch Harbor. Taylor et al. (2006) describes the detailed procedure, data sources and analysis of the Digital Elevation Model (DEM) for Unalaska/Dutch Harbor. This DEM was delivered to NCTR in 2006 and has been fully implemented for developing grids of the Unalaska reference model and forecast model.

The computational domain of the outermost grid A has an extent of 4.5° (~ 300 km) in longitudinal and 5° (~ 555 km) in latitudinal direction**. Figures 7 and 8** shows the computational domain of the A-grid for both the high resolution and forecast model grids for comparison of bathymetry resolution. **Figure 7** shows the bathymetry and topography of grid A at the grid resolution of 2 arc min and **Figure 8** at a resolution of 36-arc-sec. Both grids were interpolated from the Pacific 30-arc-sec dataset. The 36-arc-sec grid contains more details than the 2-arc-min grid in general and thus is chosen for the A-grid for reference forecast model computation. The red frame in each plot indicates the coverage of the B-grid shown superimposed over the A-grid domain of the plot.

The southern part of the domain lies mainly in the Pacific, dominated by water depth of thousands of meters. The relatively flat sea bottom of the south and southwest with 5,000 m water depth allows smooth transition of the linear boundary conditions from propagation run into grid A. The Aleutian trench, indicated by the dark band running parallel to the coast offshore in **Figure 7 and 8**, creates a steep gradient of water depth between 7,000 m and less than 100 m. In contrast, the water is about 2,000-m deep in the northwest of the domain where the Bering Sea is located and then drops to only tens of meters to the east boundary. The exception is north of Unalaska Bay, where the water depth changes gradually from 2,000 m to 1,000 m from west to east while the waterway is rapidly narrowed. This feature makes Unalaska potentially more sensitive to tsunami waves from the west, such as Kamchatka, Kuril and Western Aleutians.

The computational extent of middle B-grid is 1.295° (~ 85km) in longitudinal and 0.845° (~ 94km) in latitudinal direction**. Figure 9 and 10** shows the computational domain of the B-grid for both the high resolution and forecast model grids for comparison of bathymetry resolution. **Figure 9** shows the bathymetry and topography of grid B at the higher grid resolution of 6-arc-sec and **Figure 10** at the Unalaska forecast model resolution of 18-arc-sec for model runs covering the same domain. Both grids were interpolated from the Dutch Harbor 1-arc-sec dataset. The red frame in each plot indicates the coverage of the C-grid shown superimposed over the B-grid domain of the plot.

The southern boundary of grid B is constrained to a water depth of 100 m, as no denser bathymetric data were available further south at the time of grid development. After a gradual change from 100 m to 50 m, the bathymetry becomes complicated by jagged coastlines, narrowed channels and scattered islands as it approaches Unalaska Bay from the Pacific. While the surrounding water depth generally becomes shallower than 100 m from 1,000 m, Unalaska Bay connects to the Bering Sea by a 200-meter-deep channel in the western part of the bay.

Figure 11 and 12 shows the computational domain of the finest grid C with an extent of 0.24° (~ 16 km) in longitudinal and 0.15° (~ 17 km) in latitudinal direction. The red-cross symbol indicates the location of NOS tide gage used as the forecast model warning point. **Figure 11** shows the bathymetry and topography of grid C with a grid resolution of 3 arc sec (~ 54 m) in x and 2 arc sec (~ 62 m) in y. **Figure 12** is a plot of the same domain in higher grid resolution for reference inundation model runs, ½ arc (~ 9 m) in longitudinal direction and 1/3 arc sec (~ 10 m) in latitudinal direction. Both high resolution and forecast model grids were interpolated from the 1-arc-sec dataset, as no higher-resolution grid data were available for Dutch Harbor at the time of grid development.

The contour lines and color pattern in **Figure 11 and 12** indicate a complicated bathymetry and coastline inside Unalaska Bay. Transected by deep channel, the western half of Unalaska Bay is generally deeper than the eastern half. The entire bay basically consists of three regional lobes: Nateekin Bay in the west, Captains Bay in the southwest, and Iliuliuk Bay in eastern most regional lobe. While the deep channel ends at the two lobes in the west, Iliuliuk Bay lies atop the sloping bathymetry in the east, with the water depth dredged to 30 to 35 m inside Dutch Harbor and vicinity. Iliuliuk Bay is connected with Captains Bay through a narrow channel between Unalaska Island and Amaknak Island.

The model setup and input parameters for the Unalaska forecast model and reference model are provided in **Table 4**. The three telescoping grids of referenced model cover exactly the same domain as the forecast model, but with finer grids, to provide unbiased modeling references in terms of initial and boundary conditions. Grid C of the reference model employs a 10-m grid size, which results in 36-time-larger spatial step, 5-time-larger in temporal step and thus 180-time more intensive in computational efforts when comparing with grid C of the forecast model with an approximate grid size of 60 m. Considering the same situation in grids A and B, a single run of the reference model takes approximately 40 hours for a 4-hour simulation, while the forecast model runs in 10 minutes.

4. Results and Discussion

4.1 Model validation

The 14 historical events listed in **Table 1** and shown in **Figure 3** were used for validation of the Unalaska, Alaska tsunami forecast model. For each event, observations were compared with their modeled counterparts. The 1946 Unimak event generated a destructive transoceanic tsunami that became the milestone event for the United States to establish a Pacific-wide tsunami warning and forecast system. After 1946, four other destructive tsunamis, the 1952 Kamchatka, the 1957 Andreanov, the 1960 Chile and the 1964 Alaska, have led to intensive efforts for monitoring and modeling of tsunamis. These events were recorded by tide gages throughout the Pacific and have since provided valuable datasets for tsunami research (U.S. Coast and Geodetic Survey, 1952; Berkman *et al*., 1960; Spaeth *et al*, 1964). In the early 1990s, the implementation of the high-quality bottom pressure recorder (BPR) in the deep ocean symbolized the beginning of the modern observation of tsunami waves. This was consolidated in 1998 by the project of Deep-ocean Assessment and Reporting of Tsunamis (DART) (Gonzalez *et al.,* 1998).

The DART system of observations has played a critical role in defining the tsunami source and has provided accurate real-time tsunami forecast for U.S. coastlines since the array was tested in the 1990s and modernized in 2001 (Eble and Gonzalez, 1991, Titov *et al.,* 2003). Previous studies have shown successful applications of NOAA's experimental tsunami forecast system that constrain the tsunami source from the real-time tsunameter measurements, which is subsequently used to provide real-time propagation and coastal inundation forecasts (Titov *et al*., 2003; Wei *et al*., 2008; Tang *et al*., 2009; Titov, 2009). These real-time inversions of the tsunami source have shown a forecast accuracy up to 90% of the tsunami waveforms at distant coastline (Wei *et al.,* 2008). Seven of such validated events were used to validate the Unalaska forecast model, including the 27 February 2010, 3 May 2006 Tonga, 15 November 2006 Kuril, 13 January 2007 Kuril, 1 April 2007 Solomon, and 15 August 2007 Peru.

Figures 13 to 26 are plots of the maximum water elevation and the maximum flow speed of the innermost C-grid computed from both the forecast and reference models for 14 historical events. The complex bathymetry and jagged coastline inside the Unalaska Bay result in areas with different features of wave field. First, the higher water elevation in Liuliuk Bay, Captain Bay and Nakeetin Bay than any other areas delineates the amplification of tsunami waves as they enter narrow or shallow water. With a wide and deep entrance, Nateekin Bay allows incoming waves to retreat easily back into Unalaska Bay during the rundown process. In contrast, the Captain Bay is enclosed with narrow and shallow access that exceptionally slows down the withdrawal of water, which in turn leads to increase of water elevation inside the bay. Liuliuk Bay/Dutch Harbor, on the other hand, is also featured with a shallow entrance that induces the same phenomenon as in Captains Bay. Second, essentially there are two major high-flow-speed zones in Unalaska Bay, one at the entrance of Liuliuk Bay and one lying in the area surrounded by the entrance of Captains Bay, Amaknak Island and the small islet to the west of Amaknak Island. The highest flow speed is seen at the entrance of Captains Bay. The third notable phenomenon is a tsunami entering Unalaska Bay from the west after crossing the Bering Sea, such as for the 2007 Kuril, 2006 Kuril, 2003 Hokkaido, 1996 Andreanov, and 1994 Kuril, evemts, all of which caused higher water elevation in Captains Bay than that in Liuliuk Bay. This is probably due to the incoming wave energy from the Bering Sea, rather than climbing up the slope to reach Liuliuk Bay, finds an easier way into the Captains Bay through the deep channel connecting Captains Bay and the Bering Sea. However, for those tsunami waves coming in from the east of Unalaska, such as 2006 Tonga, 1960 Chile, and 1946 Unimak, a higher water elevation is induced in Liuliuk Bay than in Captains Bay, implying that wave propagation follows its easiest and fastest path.

Also shown in Figure 10 to 23 is the time series comparison with observation at the tide gage within 12 hours after the tsunami arrival at Unalaksa. A cursory look shows excellent agreement between the modeling results and observations for most of the historical events in spite of background noise. All events show good agreement up to 6 hours after the wave arrival except for the events for which the tsunami sources are still in debate, meaning the developed forecast model is accurate and valid in computing tsunami waves on the Unalaska coastline. The results computed by the referenced model using high-resolution grids provide a more accurate computation of the wave field and, more importantly, provide reference for the computational accuracy of the forecast model.

The results computed by the reference model are similar to those computed by the forecast model, particularly for the first couple of waves. The right panel of **Figure 27** shows that the cross correlation between forecast model and the reference model is almost 1 without time delay for most of the historical events. **Figure 27** also shows evaluation of the cross correlation between the forecast model and reference model, forecast model and observation, and reference model and observation. **Table 4** summarizes the error estimation of the computational results by forecast model and reference model compared to the noise-to-signal ratio of the tide-gage observation. These results are plotted in **Figure 28**, showing that, for most of the historical events used in this work, the noise level is much more dominant than the estimated error computed by either forecast model or reference model, indicating a valid numerical simulation of the maximum wave height for most events. The two exceptions are the 1994 Kuril and 2001 Peru events, where the noise-to-signal ratio is slightly smaller than the estimated error. However, the cross correlations of these two events are respectively 0.64 and 0.81, suggesting the computational results are still highly correlated to the observations although the models underestimate the maximum tsunami amplitude for both events. These results, overall, provide confidence that the forecast and reference models are producing highly comparable results. The difference of wave amplitude, wave period and phase is nearly negligible for the first couple of tsunami waves in every case. The difference in wave amplitude and phase starts to show up in the following several later waves, which one can expect when the local effects become more dominant as grids of the reference model contain more bathymetric and topographic features. However, bearing the expected error due to difference in grid resolution, it is recognized with confidence that forecast model results represent those of the reference model while saving 99.5% of the computing effort.

Table 5 lists the maximum tsunami runup and maximum water elevation at the tide station computed by both forecast model and referenced model. The computational results of three tsunami events, 1946 Unimak, 1960 Chile and 1964 Alaska produce limited impact to the southern portion of Captains Bay but not in Dutch Harbor. A time series of observations 4 hours before and after the waves arrived at Unalaska tide gage show the level of tsunami interference from the background noise inherent in the location. Another noticeable computational result in **Table 5** is the variation of maximum water elevation at tide station demonstrates the same tendency, although smaller value, with that of the maximum tsunami height. This suggests the forecast time series at the Unalaska tide station may be a good indication of the maximum tsunami height for the region.

4.2 Model stability testing using synthetic mega tsunamis

Model stability of the forecast model was verified using synthetic extreme events of M_w 9.3 generated in a representative region of every subduction zone in the Pacific Basin. Each scenario imitates an equivalent or greater event of the 2004 Indian tsunami, which was the cause of tragedy and devastation not before seen on such a scale. Coastlines of the Indian Ocean were impacted with a death toll of hundreds of thousands people, most of which inhabited the low-lying island of Sumatra, Indonesia. Each synthetic tsunami source consists of 20 unit sources, covering a rupture area of 1000 km by 100 km, with an average 25.0-m slip for an M_w 9.3 event, as listed in **Table 7**. These scenarios are used to examine the stability of the developed forecast model under the strike of large waves generated by mega tsunamis from all directions.

Among all synthetic scenarios tested in this study, the maximum computed water elevation at the tide station ranges from 0.06 m to 3 m. **Figures 29 to 49** show that the modeled wave amplitude and flow speed for all synthetic mega scenarios are stable without singularities or spreading instability. Thus, the Unalaska forecast model is robust and expected to provide Unalaska critical information during a tsunami event once implemented into the operational forecast system.

Among all synthetic scenarios, those originated from Aleutians, ACSZ 6-15, ACSZ 16-25, and ACSZ 22-31 (scenarios 5, 6 and 7 in Table 7), cause the most severe impact in Unalaska. The same level of tsunami magnitude in the KISZ source regions can generate distant tsunamis striking Unalaska harder than those originated in east of Alaska-Cascadia Source Zone. The funneled bathymetry directs the waves, after crossing the Bering Sea from the west, to Unalaska Bay. It shows the important role of the directionality in determining the tsunami impact at the destination. The maximum water elevation induced by tsunamis from the west of Unalaska is in general greater than from the east. Other outstanding source regions in the east Pacific lie in the South American and South Chile Subduction Zones, which are also able to have a significant impact on Unalaska even though they are located the furthest away. As Titov *et al* (1999) pointed out, the amplitude of the propagating tsunami varies significantly not only by its source location and cylindrical spreading, but also the directionality of the tsunami waves.

In the synthetic scenarios, the tsunami inundation mainly occurs at two locations, Liuliuk Bay/Dutch Harbor and the southern tip Captains Bay. The steep coastline of Liuliuk Bay only allows high-amplitude waves to inundate this area, while the low land elevation, 0.1 to 0.2 m, at the southern tip of the Captains Bay make it the most vulnerable place when tsunamis strike the Unalaska Bay. Most of the study cases show that the maximum water elevation at the tide station is a good indication of the maximum tsunami height and the maximum runup as all three quantities follow the same tendency. The relationship between tsunami runup and tide gage observations depends on multiple factors, including the complexity of the local bathymetry and topography, the wave characteristics, and the directionality of the tsunami.

5. Summary and Conclusions

A tsunami forecast model was developed for the community of Unalaska, Alaska, the most populous community in the Alaska Aleutian Islands, for operational use in NOAA's tsunami forecast system to provide real-time modeling forecast of water elevations. runup, and inundation along the Unalaska coastline. The forecast model employs grids as fine as 54 m and can accomplish a 4-hour simulation after tsunami arrival at a deep ocean observation system in 10 minutes of CPU time. A high-resolution reference model was developed in parallel with the Unalaska tsunami forecast model to provide a basis for evaluation of forecast model performance.

Model validation using 14 historical tsunami events. For each event, model results were compared with observations recorded at the Unalaska tide station. The modeling results at Unalaska showed excellent agreement with observations for most of the historical events modeled. Validation shows that of all historical events modeled, only the 1946 Unimak tsunami caused significant damage to the Unalaska coastline. The error estimations of the modeling results are mostly within the range of the noise level, indicating that modeling results agree well with the observations for most events. Results of 43 M_w 9.3 synthetic mega events, including events generating 6-m-high waves along Unalaska's coastline lend confidence in the stability of the model.

6. Acknowledgments

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List of Tables

Earthquake / Seismic				Model		
Event	**USGS Date Time (UTC) Epicenter**	**CMT Date Time (UTC) Centroid**	**Magnitude Mw**	**Tsunami Magnitude[1]**	**Subduction Zone**	**Tsunami Source**
1946 Unimak	01 Apr 12:28:56 52.75ºN 163.50ºW	01 Apr 12:28:56 53.32ºN 163.19ºW	[2]8.5	8.5	Aleutian-Alaska-Cascadia (ACSZ)	7.5 × b23 + 19.7 × b24 + 3.7 × b25
1960 Chile	22 May 19:11:14 [3]38.29ºS 73.05ºW	22 May 19:11:14 38.50ºS 74.50ºW	[3]9.5		Central-South America (CSSZ)	Tang *et al.* (2006)
1964 Alaska	28 Mar 03:36:00 [3]61.02ºN 147.65ºW	28 Mar 03:36:14 61.10ºN 147.50ºW	[3]9.2	9.0	Aleutian-Alaska-Cascadia (ACSZ)	Tang *et al.* (2006)
1994 East Kuril	04 Oct 13:22:58 43.73ºN 147.321ºE	04 Oct 13:23:28.5 43.60ºN 147.63ºE	[3]8.3	8.1	Kamchatka-Kuril-Japan-Izu-Mariana-Yap (KISZ)	9.0 × a20
1996 Andreanov	10 Jun 04:03:35 51.56ºN 175.39ºW	10 Jun 04:04:03.4 51.10ºN 177.410ºW	[5]7.9	7.8	Aleutian-Alaska-Cascadia (ACSZ)	2.40 × a15 + 0.80 × b16
2001 Peru	23 Jun 20:33:14 16.265ºS 73.641ºW	23 Jun 20:34:23.3 17.28ºS 72.71ºW	[5]8.4	8.2	Central-South America (CSSZ)	5.7 × a15 + 2.9 × b16 + 1.98 × a16
2003 Rat Island	17 Nov 06:43:07 51.13ºN 178.74ºE	17 Nov 06:43:31.0 51.14ºN 177.86ºE	[5]7.7	7.8	Aleutian-Alaska-Cascadia (ACSZ)	[4]2.81 × b11
2006 Tonga	03 May 15:26:39 20.13ºS 174.161ºW	03 May 15:27:03.7 20.39ºS 173.47ºW	[5]8.0	8.0	New Zealand-Kermadec-Tonga (NTSZ)	6.6 × b29
2006 Kuril	15 Nov 11:14:16 46.607ºN 153.230ºE	15 Nov 11:15:08 46.71ºN 154.33ºE	[5]8.3	8.1	Kamchatka-Kuril-Japan-Izu-Mariana-Yap (KISZ)	[6]4 × a12 + 0.5 × b12 + 2 × a13 + 1.5 × b13
2007 Kuril	13 Jan 04:23:20 46.272ºN 154.455ºE	13 Jan 04:23:48.1 46.17ºN 154.80ºE	[5]8.1	7.9	Kamchatka-Kuril-Japan-Izu-Mariana-Yap (KISZ)	-3.82 × b13
2007 Solomon	01 Apr 20:39:56 8.481ºS 156.978ºE	01 Apr 20:40:38.9 7.76ºS 156.34ºE	[4]8.1	8.2	New Britain-Solomons-Vanuatu (NVSZ)	12.0 × b10
2007 Peru	15 Aug 23:40:57 13.354ºS 76.509ºW	15 Aug 23:41:57.9 13.73ºS 77.04ºW	[5]8.0	8.1	Central-South America (CSSZ)	0.9 × a61 + 1.25 × b61 + 5.6 × a62 + 6.97 × b62 + 3.5 × z62
2007 Chile	14 Nov 15:40:50 22.204ºS 69.869ºW	14 Nov 15:41:11.2 22.64ºS 70.62ºW	[4]7.7	7.6	Central-South America (CSSZ)	z75 × 1.65
2010 Chile	27 Feb 06:34:14 35.909ºS 72.733ºW	27 Feb 06:35:15.4 35.95ºS 73.15ºW	[5]8.8	8.8	Central-South America (CSSZ)	[1]a88 × 17.24 + a90 × 8.82 + b88 × 11.86 + b89 × 18.39 + b90 × 16.75 + z88 × 20.78 - z90 × 7.06

[1] Preliminary source – derived from source and deep-ocean observations
[2] López and Okal (2006)

Tsunami Event	Time	M_w	Source of M_w	Max Amp (cm)
Alaska	1938. 11. 10	8.2	USGS	~ 5
Alaska	1946. 04. 01	8.5	Inversion	-
Hokkaido	1952. 03. 04	8.1	Lander, 1996	~ 5
Kamchatka	1952. 11. 04	9.0	USGS	~ 60
Kamchatka	1956. 03. 30	7.4	Lander, 1996	~ 10
Aleutian	1957. 03. 09	8.6	USGS	~ 70
Chile	1960. 05. 22	9.5	USGS	~ 70
Alaska	1964. 03. 28	9.0	Inversion	~ 40
Rat Island	1965. 02. 04	8.7	USGS	~ 24
Unimak	1965. 07. 02	7.0	Lander, 1996	~ 8
Honshu	1968. 05. 16	7.9	Lander, 1996	~ 5
Kamcha.	1971. 12. 15	7.8	Lander, 1996	~ 4
Aleutian	1986. 05. 07	7.9	USGS	~ 12
Bering	1991. 02. 21	6.5	Lander, 1996	~ 30
Kuril	1994. 10. 04	8.2	Lander, 1996	~ 8
Chile	1995. 07. 30	7.8	Lander, 1996	~ 8
Alutian	1996. 06. 10	7.9	USGS	~ 5
Kamcha.	1997. 12. 05	7.8	USGS	~ 8
Peru	2001. 06. 23	8.2	Inversion	~ 12
Hokkaido	2003. 09. 25	8.0	Inversion	~ 4
Rat Island	2003. 11. 17	8.0	Inversion	~ 3
Sumatra	2004. 12. 26	9.1	USGS	~ 14
Tonga	2006. 05. 03	8.1	Inversion	~ 4
Kuril	2006. 11. 15	8.1	Inversion	~ 4
Kuril	2007. 01. 13	7.9	Inversion	~ 6
Solomon	2007. 04. 01	8.2	Inversion	~ 5
Peru	2007. 08. 15	8.0	Inversion	~10
Samoa	2009. 09. 29	8.0	Inversion	-
Chile	2010. 02. 27	8.8	USGS	~ 19

Table 2. Observed maximum wave amplitude at Unalaska tide station for historical tsunami events.

	Datasets	Coverage	Resolution	Developer
1	Pacific 30”	E120 –W68 S80 – N80	30”	NCTR/PMEL
2	AK SouthCentral 2’	W169 – W140 N52 – N62	2’	NCTR/PMEL
3	AK SouthCentral 24”	W156 – W147 N55 – N62	24”	NCTR/PMEL
4	Dutch Harbor 1”	W167.2001 – W165.9001 N53.4999 – N54.3499	1”	NGDC
5	Sand Point 3”	W161.0004 – W 159.7966 N54.6996 – N55.7004	3”	NGDC
6	Sand Point 1/3”	W161 – W159.8 N55.05 – N55.7	1/3”	NGDC
7	Kodiak 8”	W153.0023 – W152.0022 N56.9992 – N57.9993	8”	NCTR/PMEL
8	Kodiak 3”	W152.6518 – W152.2681 N57.5852 – N57.9267	3”	NCTR/PMEL
9	Kodiak 1”	W152.6247 – W152.31 N57.6545 – N57.8418	1”	NCTR/PMEL
10	Homer 1”	W151.5585 – W151.3666 N59.5837 – N59.6674	1”	NCTR/PMEL
11	Seward 8”	W150 – W149 N59.5 – N60.1667	8”	PMEL
12	Seward 3”	W149.5 – W149.2504 N59.9756 – N60.1667	3”	PMEL
13	Seward 1”	W149.4667 – W149.3083 N60.0748 – N60.1583	1”	PMEL
14	Yakutat 9”	W141.0 – W138.5 N59.0 – N60.5	9”	PMEL
15	Yakutat 3”	W140.0 – W139.5 N59.3333 – N59.7333	3”	PMEL
16	Yakutat 1”	W139.9333 – W139.6 N59.4333 – N59.5867	1”	PMEL
17	Sitka 9”	W136.3333 – W135.0008 N56.6667 – N57.3342	9”	PMEL
18	Sitka 3”	W135.6 – W135.1333 N56.9 – N57.1667	3”	PMEL
19	Sitka 1”	W135.4022 – W135.2267 N57.0 – N 57.1333	1”	PMEL

Table 3. Bathymetric and topographic grids in Alaska developed by the National Geophysical Data Center and the Pacific Marine Environmental Laboratory.

Grid	Region	Reference Model Coverage Lat. [ºN] Lon. [ºW]	Cell Size [“]	nx x ny	Time Step [sec]	Forecast Model Coverage Lat. [ºN] Lon. [ºW]	Cell Size [“]	nx x ny	Time Step [sec]
A	Central Aleurtians	50.5-55.5 169-164.5	36 × 36	451 × 501	2.4	50.5-55.5 169-164.5	120 × 120	136 × 151	8.0
B	Unalaska Island	53.5 - 54.34486 167.2 - 165.90514	6 × 6	780 × 510	0.8	53.5 - 54.34486 167.2 - 165.90514	18 × 18	260 × 170	2.0
C	City of Unalaska and Dutch Harbor	53.82 – 53.97 166.66 – 166.42	½ × 1/3	1729 × 1621	0.2	53.82 – 53.97 166.66 – 166.42	3 × 2	289 × 271	1.0
Minimum offshore depth [m]		1				1			
Water depth for dry land [m]		0.1				0.1			
Friction coefficient [n^2]		0.001225				0.001225			
CPU time for 4-hr simulation		~ 40 hours				~ 10 minutes			
Reference point at NOS tide gage		193.459167E, 53.879444N (Row number I = 144, Column number J = 164)							

Computations were performed on a single Intel Xeon processor at 3.6 GHz, Dell PowerEdge 1850.

Table 4. Model setup parameters for reference and forecast model for Unalaska, Alaska.

Event	Time (UTC)	M_w	Max Comp. Runup (m)		Max Comp. Amp. (m)		Max Obs. Amp. (m)
			FM	RM	FM	RM	
Unimak	1946.04.01	8.5	2.82	1.50	1.41	1.01	Unknown
Chile	1960.05.22	9.5	1.33	1.34	0.71	0.59	0.80
Alaska	1964.03.28	9.0	0.51	0.51	0.36	0.30	0.36
Kuril	1994.10.04	8.1	-	-	0.05	0.05	0.15
Andreanof	1996.06.10	7.8	-	-	0.06	0.06	0.07
Peru	2001.06.23	8.2	-	-	0.04	0.04	0.08
Hokkaido	2003.09.25	8.0	-	-	0.04	0.05	0.04
Tonga	2006.05.03	8.1	-	-	0.01	0.01	0.04
Kuril	2006.11.15	8.1	-	-	0.05	0.05	0.10
Kuril	2007.01.13	7.9	-	-	0.02	0.03	0.04
Solomon	2007.04.01	8.2	-	-	0.02	0.02	0.05
Peru	2008.08.15	8.0	-	-	0.02	0.02	0.05
Chile	2010.02.27	8.8	0.44	0.40	0.14	0.08	0.19
Japan	2011.03.11	9.0	0.56	0.47	0.39	0.34	0.36

Table 5. Summary of historical events results of computed maximum runup height, maximum computed wave amplitude at the Unalaska tide station, and the maximum observed water elevation at the Unalaska tide station. FM is an abbreviation of forecast model, and RM is an abbreviation of reference model.

Event	**Time (UTC)**	**M_w**	**Forecast Model**		**Refernce Model**		R_{noise} (%)
			E (%)	C	E (%)	C	
Chile	1960.05.22	9.5	11.5	0.22	26.8	0.14	
Alaska	1964.03.28	9.2	0.4	0.50	17.3	0.79	32
Kuril	1994.10.04	8.1	65.2	0.64	64.9	0.64	44
Andreanof	1996.06.10	7.9	18.1	0.59	18.8	0.45	39
Peru	2001.06.23	8.4	54.8	0.76	55.6	0.81	44
Hokkaido	2003.09.25	8.0	9.5	0.80	25.4	0.83	22
Tonga	2006.05.03	8.0	69.0	0.69	71.1	0.63	233
Kuril	2006.11.15	8.3	45.3	0.46	44.4	0.59	104
Kuril	2007.01.13	8.1	58.8	0.44	30.4	0.48	68
Solomon	2007.04.01	8.1	57.0	0.81	61.0	0.83	133
Peru	2007.08.15	8.1	61.0	0.77	58.0	0.47	88
Chile	2010.02.27	8.8	25.0	0.72	57.3	0.68	16.5

Table 6. Comparisons of error estimation of the modeling results with noise level at Unalaska tide gage for historical events, where E is the model/data error computed by $(\eta_{model} - \eta_{obs}) / \eta_{obs} \times 100\%$, C is the max cross correlation between model and data. R_{noise} is the signal to noise ratio calculated from A_{noise}/A_{model}, where A_{noise} and A_{model} are respectively the roo-mean-square amplitudes of 4-hour observation prior to tsunami arrival and first 4-hour tsunami signal of the model.

Table 7. Unit source combination used for synthetic mega tsunami scenarios of M_w 9.3.

Scenario	Source Zone	Tsunami Source
ACSZ 1-10	Aleutian-Alaska-Cascadia	A1-A10, B61B10
ACSZ 11-20	Aleutian-Alaska-Cascadia	A11-20, B11-20
ACSZ 21-30	Aleutian-Alaska-Cascadia	A21-A30, B21-B30
ACSZ 31-40	Aleutian-Alaska-Cascadia	A31-A40, B31-B25
ACSZ 41-50	Aleutian-Alaska-Cascadia	A41-A50, B41-B50
ACSZ 46-55	Aleutian-Alaska-Cascadia	A46-A55, B46-B55
ACSZ 56-65	Aleutian-Alaska-Cascadia	A56-A65, B56-B65
CSSZ 1-10	Central and South America	A1-A10, B1-B10
CSSZ 5-14	Central and South America	A5-A14, B5-B14
CSSZ 15-24	Central and South America	A15-A24, B15-B24
CSSZ 25-34	Central and South America	A25-A34, B25-B34
CESZ 1-10	Columbia Ecuador	A1-A10, B1-B10
CESZ 7 - 16	Columbia Ecuador	A7-A16, A7-A16
SASZ 1 - 10	South America	A1-A10, B1-B10
SASZ 11 – 20	South America	A11-A20, B11-B20
SASZ 21 – 30	South America	A21-A30, B21-B30
SASZ 31 - 40	South America	A31-A40, B31-B40
SASZ 40 - 49	South America	A40-A49, B40-B49
SCSZ 1 - 10	South Chile	A1-10, B1-10
SCSZ 6 -15	South Chile	A6-15, B6-15
NGSZ 2-11	North New Guinea	A2-A11, B2-B11
KISZ 1-10	Kamchatka-Yap-Mariana-Izu-Bonin	A1-A10, B1-B10
KISZ 8-17	Kamchatka-Yap-Mariana-Izu-Bonin	A8-A17, B8-B17
KISZ 13 - 22	Kamchatka-Yap-Mariana-Izu-Bonin	A13-22, B13-22
KISZ 22 - 31	Kamchatka-Yap-Mariana-Izu-Bonin	A22-31, B22-31
KISZ 30 - 39	Kamchatka-Yap-Mariana-Izu-Bonin	A30-39, B30-39
KISZ 40 - 49	Kamchatka-Yap-Mariana-Izu-Bonin	A40-49, B40-49
KISZ 50 - 59	Kamchatka-Yap-Mariana-Izu-Bonin	A50-59, B50-59
KISZ 57 - 66	Kamchatka-Yap-Mariana-Izu-Bonin	A57-66, B57-66
RNSZ 1-10	Ryukus-Kyushu-Nankai	A1-10, B1-10
RNSZ 13 - 22	Ryukus-Kyushu-Nankai	A13-22, B13-22
NVSZ 1 - 10	New Britain-Solomons-Vanuatu	A1-10, B1-10
NVSZ 11 - 20	New Britain-Solomons-Vanuatu	A11-20, B11-20
NVSZ 23 - 32	New Britain-Solomons-Vanuatu	A23-32, B23-32
NVSZ 28 – 37	New Britain-Solomons-Vanuatu	A28-37, B28-37
EPSZ 1 - 10	East Philippines	A1-10, B1-10
EPSZ 6 – 15	East Philippines	A6-15, B6-15
MOSZ 1 - 10	ManusOCB	A1-10, B1-10
MOSZ 8 - 17	ManusOCB	A8-17, B8-17
NTSZ 4 - 13	New Zealand-Kermadec-Tonga	A4-13, B4-13
NTSZ 14 - 23	New Zealand-Kermadec-Tonga	A14-23, B14-23
NTSZ 24 - 33	New Zealand-Kermadec-Tonga	A24-33, B24-33
NTSZ 30 - 39	New Zealand-Kermadec-Tonga	A30-39, B30-39

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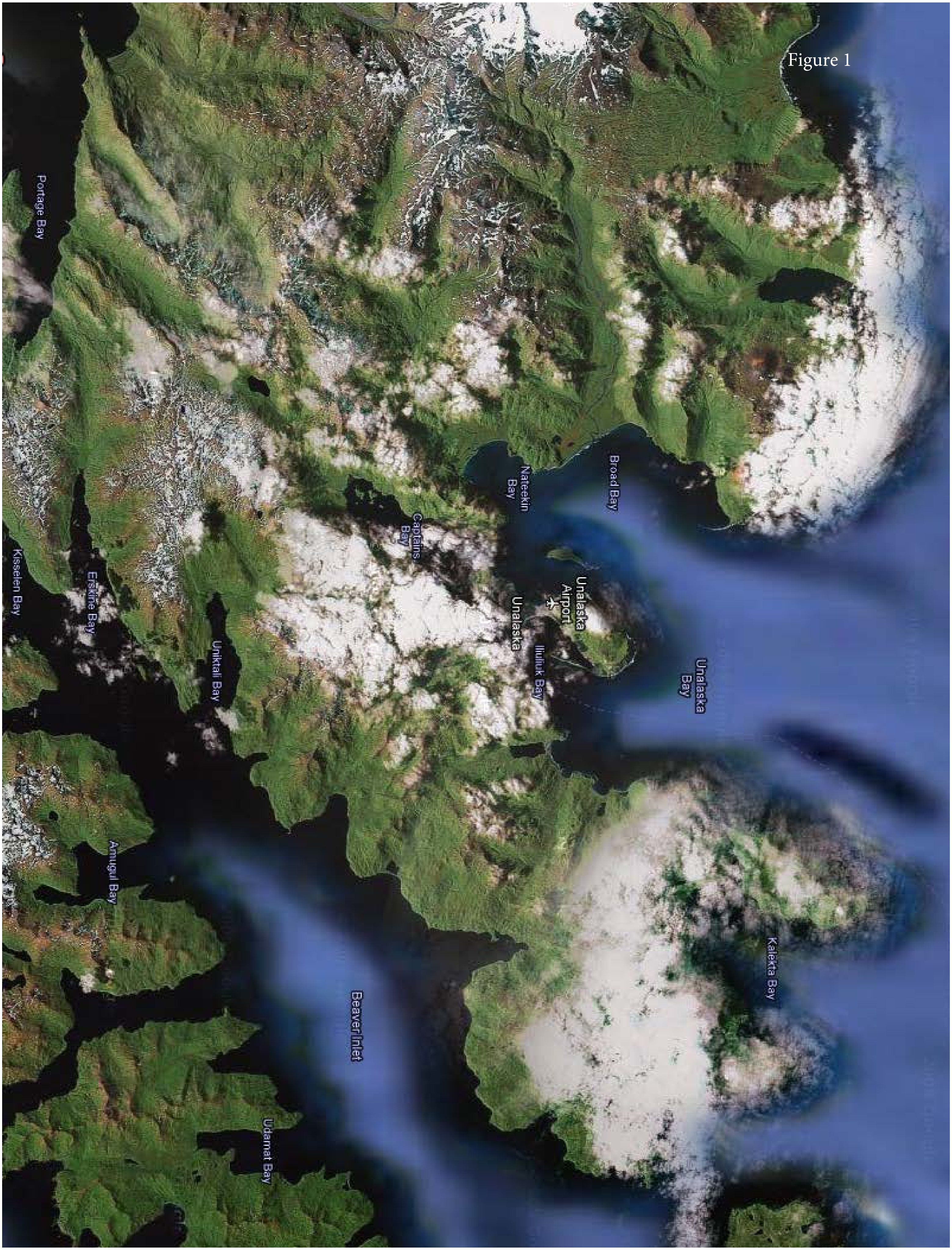
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Broad Bay
Captains Bay
Unalaska Airport
Unalaska
Iliuliuk Bay
Unalaska Bay
Kisselen Bay
Erskine Bay
Uniktali Bay
Amugul Bay
Beaver Inlet
Kalekta Bay
Udamat Bay

Figure 1

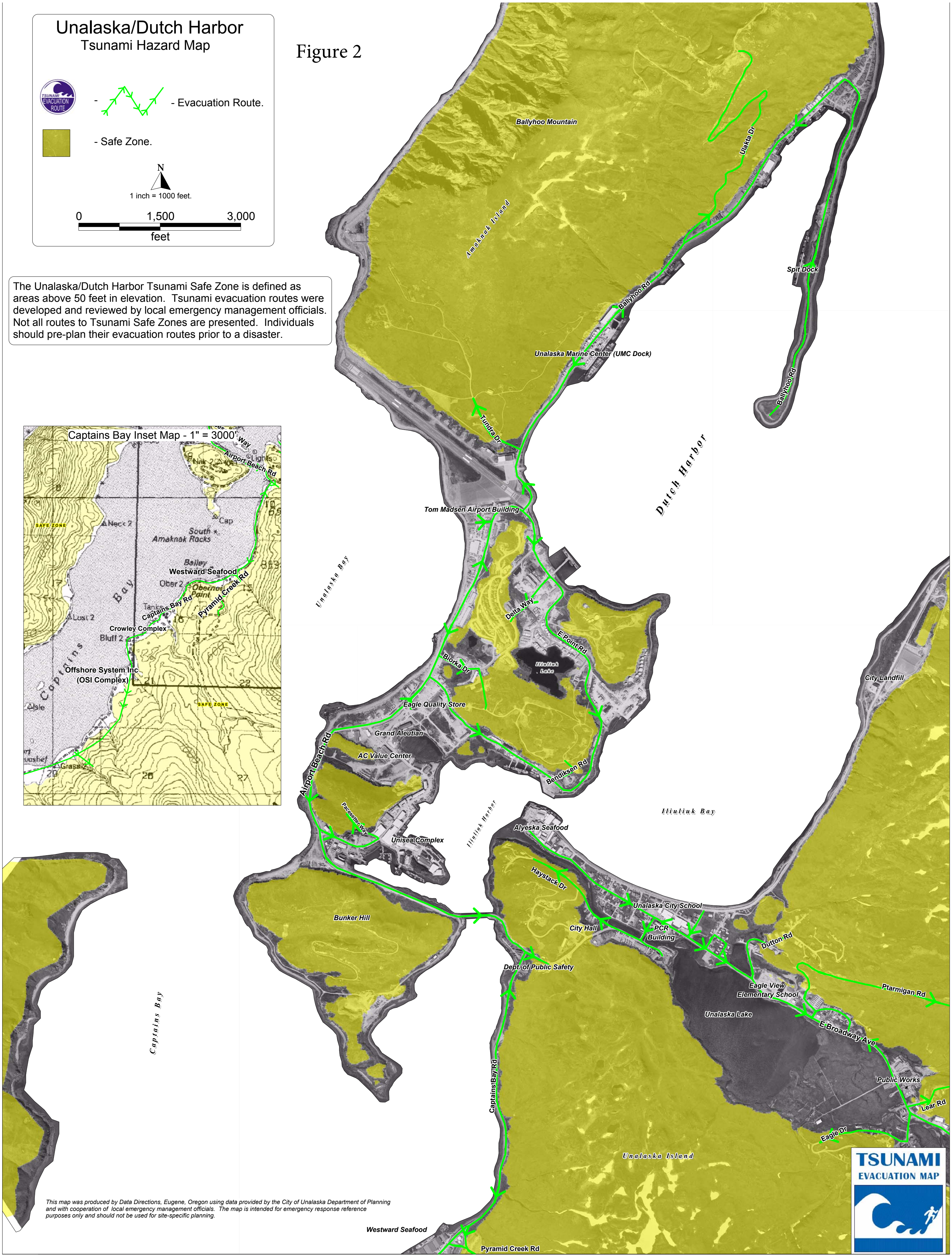
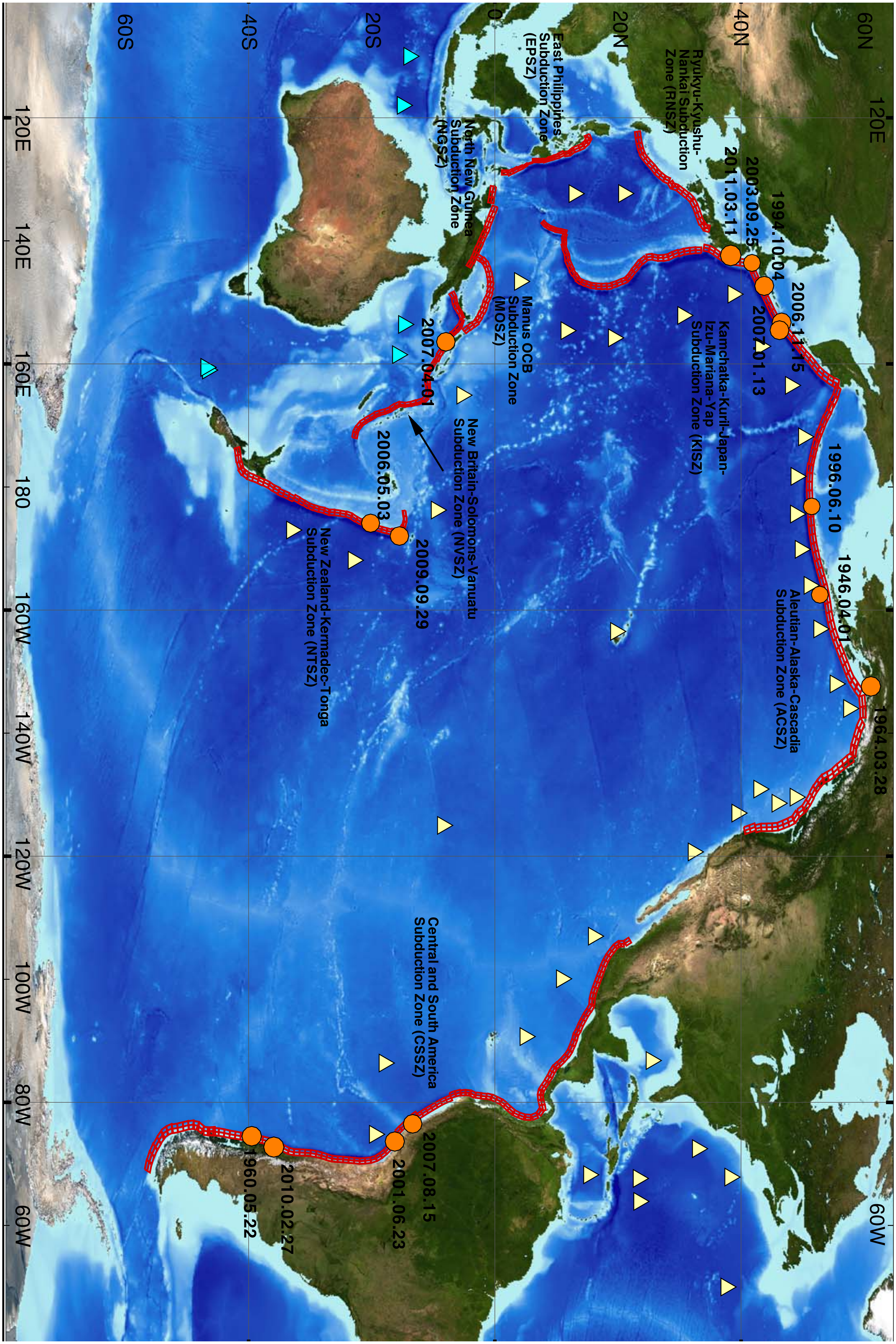

Unalaska/Dutch Harbor
Tsunami Hazard Map
TSUNAMI EVACUATION ROUTE
- Evacuation Route.
- Safe Zone.
N
1 inch = 1000 feet.
0 1,500 3,000
feet
The Unalaska/Dutch Harbor Tsunami Safe Zone is defined as areas above 50 feet in elevation. Tsunami evacuation routes were developed and reviewed by local emergency management officials. Not all routes to Tsunami Safe Zones are presented. Individuals should pre-plan their evacuation routes prior to a disaster.
Captains Bay Inset Map - 1" = 3000'
Airport Beach Rd
SAFE ZONE
South Amaknak Rocks
Westward Seafood
Pyramid Creek Rd
Captains Bay Rd
Crowley Complex
Offshore System Inc (OSI Complex)
Captains Bay
Ballyhoo Mountain
Amaknak Island
Ulakta Dr
Spit Dock
Ballyhoo Rd
Unalaska Marine Center (UMC Dock)
Tundra Dr
Dutch Harbor
Tom Madsen Airport Building
Unalaska Bay
Delta Way
E Point Rd
Biorka Dr
Iliuliuk Lake
City Landfill
Eagle Quality Store
Grand Aleutian
AC Value Center
Airport Beach Rd
Bendiksen Rd
Iliuliuk Bay
Pacesetter Way
Unisea Complex
Iliuliuk Harbor
Alyeska Seafood
Haystack Dr
Unalaska City School
Bunker Hill
City Hall
PCR Building
Dutton Rd
Dept. of Public Safety
Ptarmigan Rd
Eagle View Elementary School
Unalaska Lake
E Broadway Ave
Captains Bay
Captains Bay Rd
Public Works
Lear Rd
Eagle Dr
Unalaska Island
TSUNAMI EVACUATION MAP
This map was produced by Data Directions, Eugene, Oregon using data provided by the City of Unalaska Department of Planning and with cooperation of local emergency management officials. The map is intended for emergency response reference purposes only and should not be used for site-specific planning.
Westward Seafood
Pyramid Creek Rd
Figure 2

Figure 3



60N
40N
20N
0
20S
40S
60S
120E
140E
160E
180
160W
140W
120W
100W
80W
60W
Ryukyu-Kyushu-Nankai Subduction Zone (RNSZ)
East Philippines Subduction Zone (EPSZ)
North New Guinea Subduction Zone (NGSZ)
Manus OCB Subduction Zone (MOSZ)
Kamchatka-Kuril-Japan-Izu-Mariana-Yap Subduction Zone (KISZ)
New Britain-Solomons-Vanuatu Subduction Zone (NVSZ)
New Zealand-Kermadec-Tonga Subduction Zone (NTSZ)
Aleutian-Alaska-Cascadia Subduction Zone (ACSZ)
Central and South America Subduction Zone (CSSZ)
2011.03.11
2003.09.25
1994.10.04
2006.11.15
2007.01.13
2007.04.01
2006.05.03
2009.09.29
1996.06.10
1946.04.01
1964.03.28
2007.08.15
2001.06.23
2010.02.27
1960.05.22

Figure 4


Unalaska Tide Gauge
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 DigitalGlobe
Google

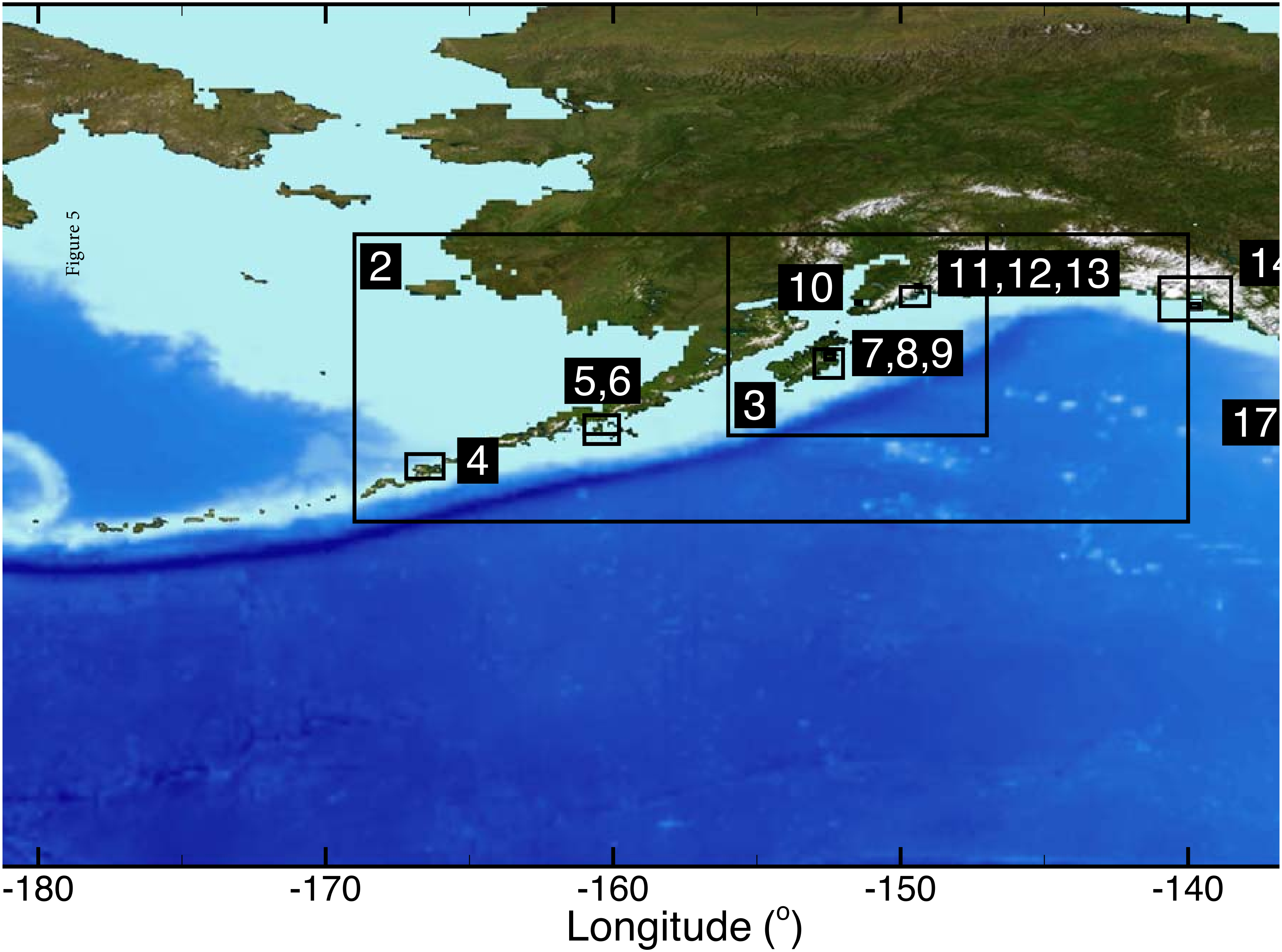
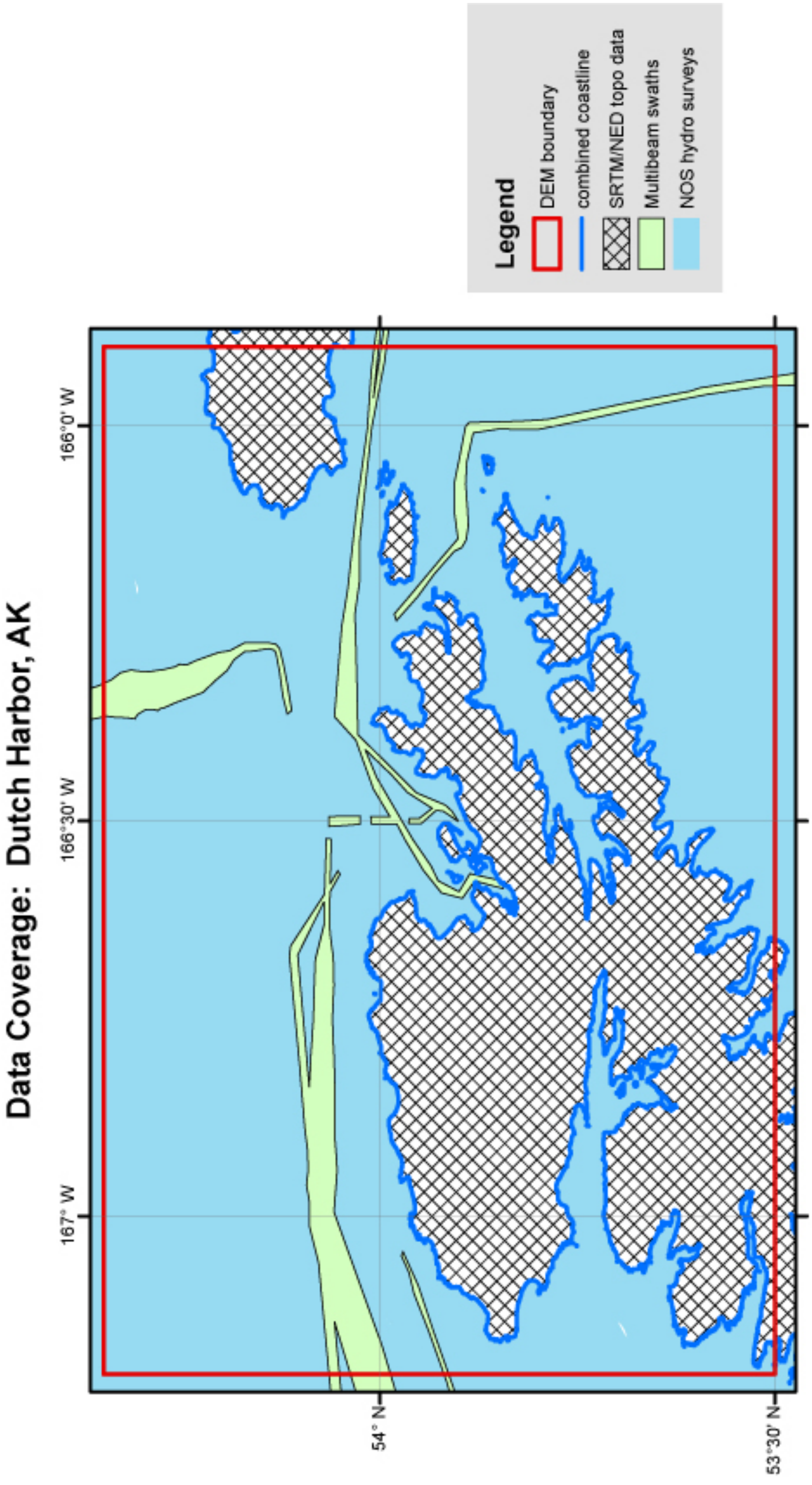


Figure 5

Figure 6


Data Coverage: Dutch Harbor, AK
Legend
DEM boundary
combined coastline
SRTM/NED topo data
Multibeam swaths
NOS hydro surveys
166°0' W
166°30' W
167° W
54° N
53°30' N

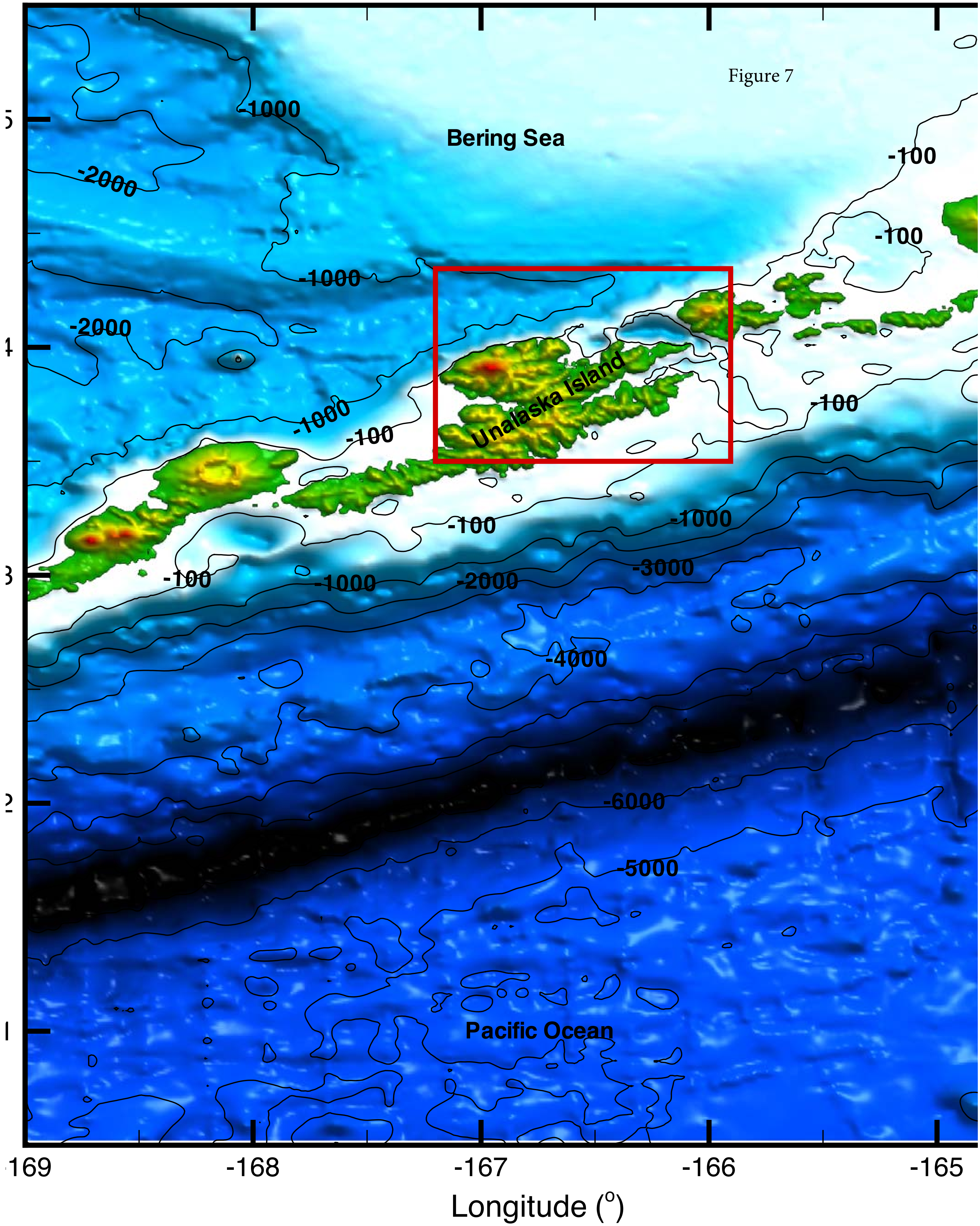

Bering Sea
Unalaska Island
Pacific Ocean
-100
-1000
-2000
-3000
-4000
-5000
-6000
-169
-168
-167
-166
-165
Longitude (°)

Figure 7

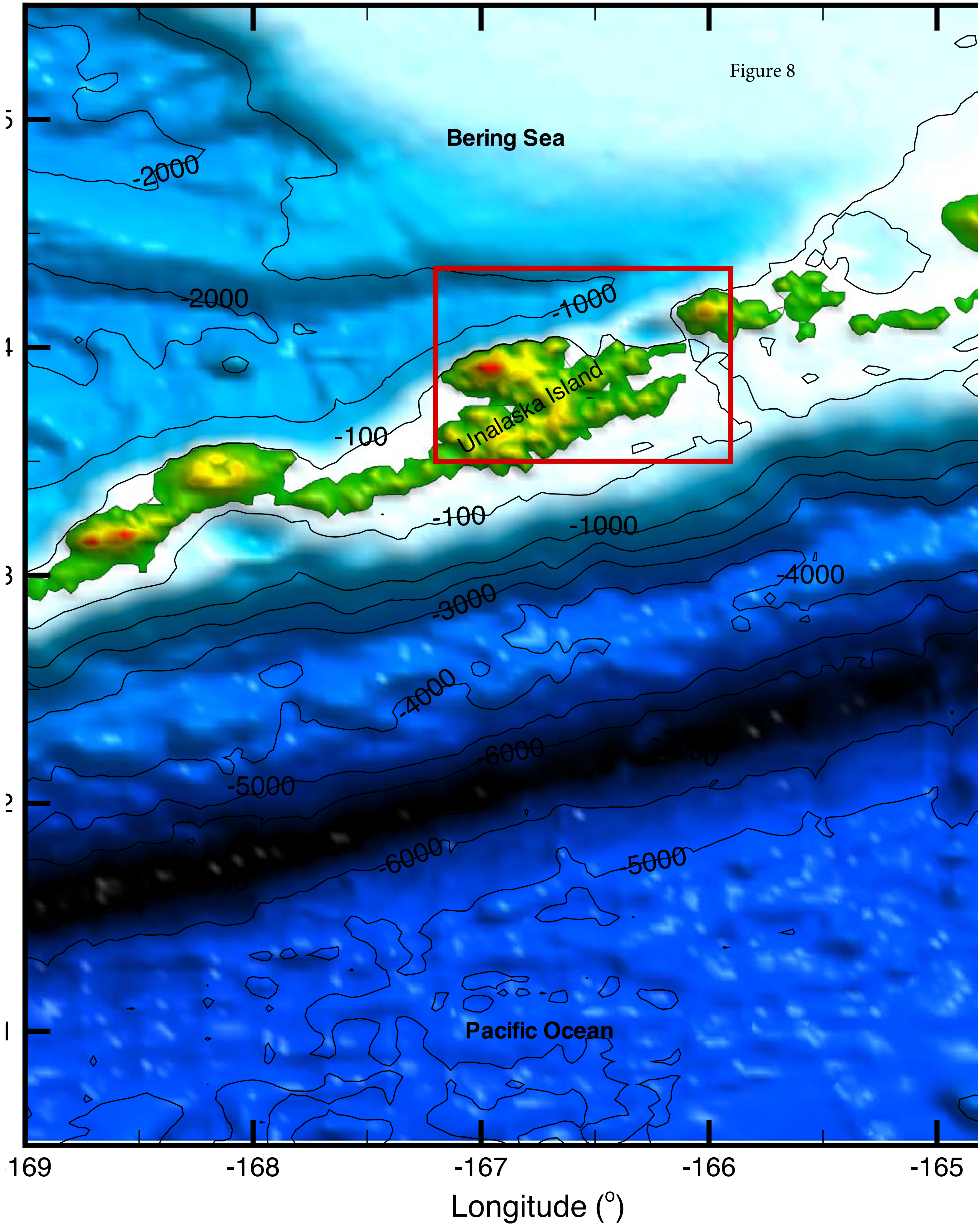


Figure 8
Bering Sea
-2000
-2000
-1000
Unalaska Island
-100
-100
-1000
-4000
-3000
-4000
-6000
-5000
-6000
-5000
Pacific Ocean
-169
-168
-167
-166
-165
Longitude (°)

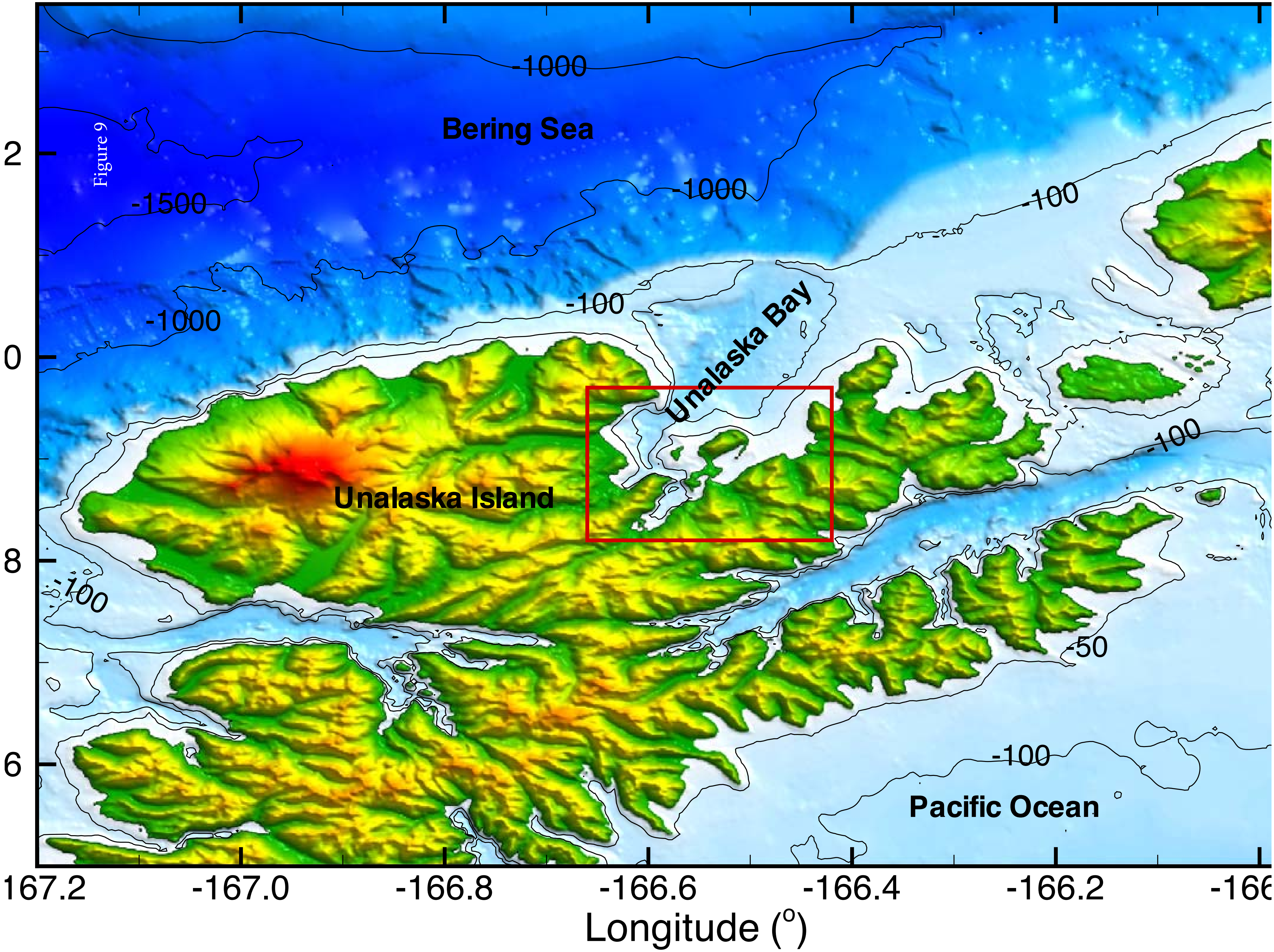


Figure 9
Bering Sea
-1000
-1500
-1000
-1000
-100
-100
-100
Unalaska Bay
Unalaska Island
-100
-50
-100
Pacific Ocean
2
0
8
6
167.2
-167.0
-166.8
-166.6
-166.4
-166.2
Longitude (°)

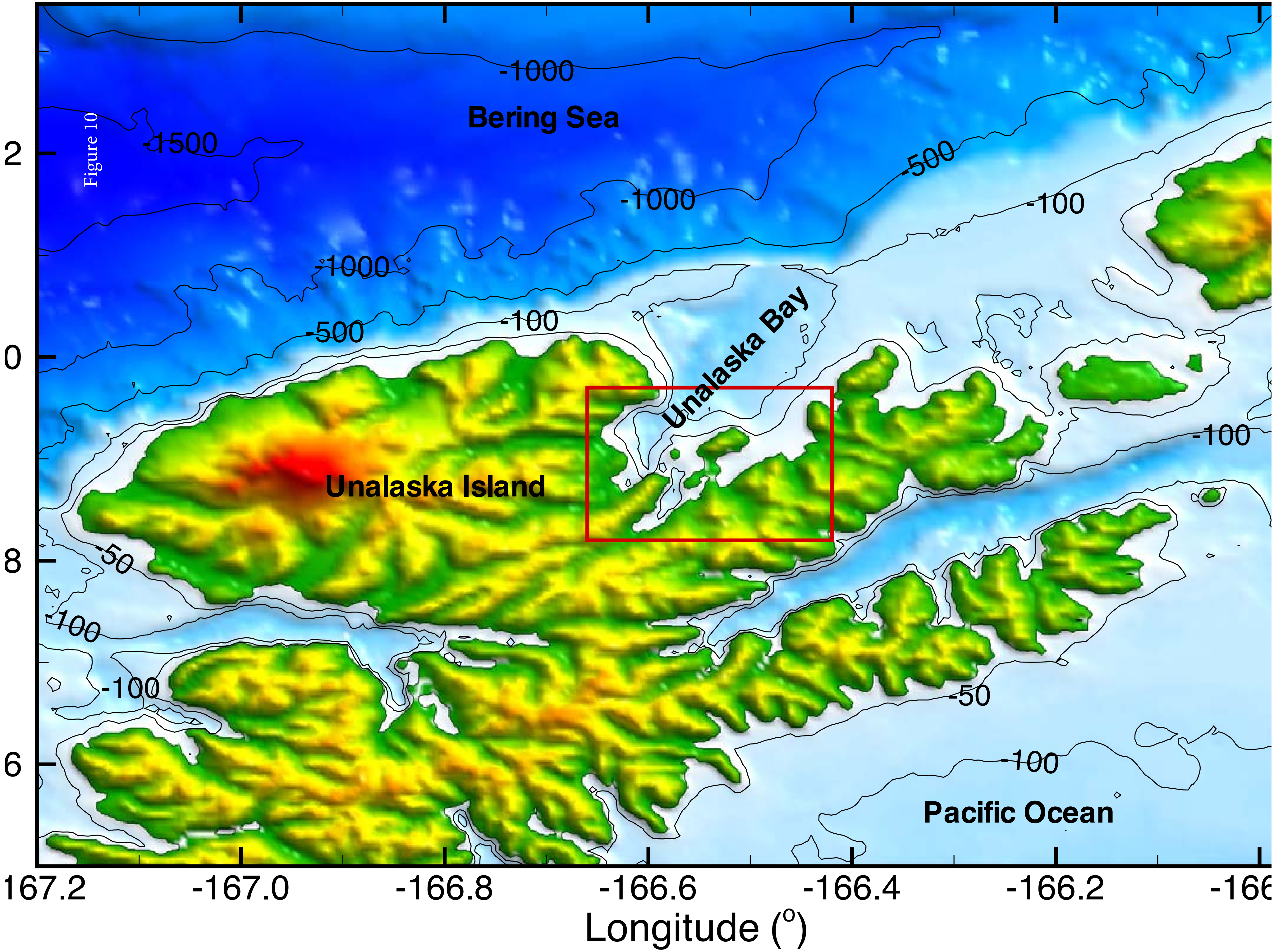


Figure 10
Bering Sea
Unalaska Island
Unalaska Bay
Pacific Ocean
-1500
-1000
-1000
-1000
-500
-500
-100
-100
-100
-100
-100
-100
-50
-50
2
0
8
6
167.2
-167.0
-166.8
-166.6
-166.4
-166.2
Longitude (°)

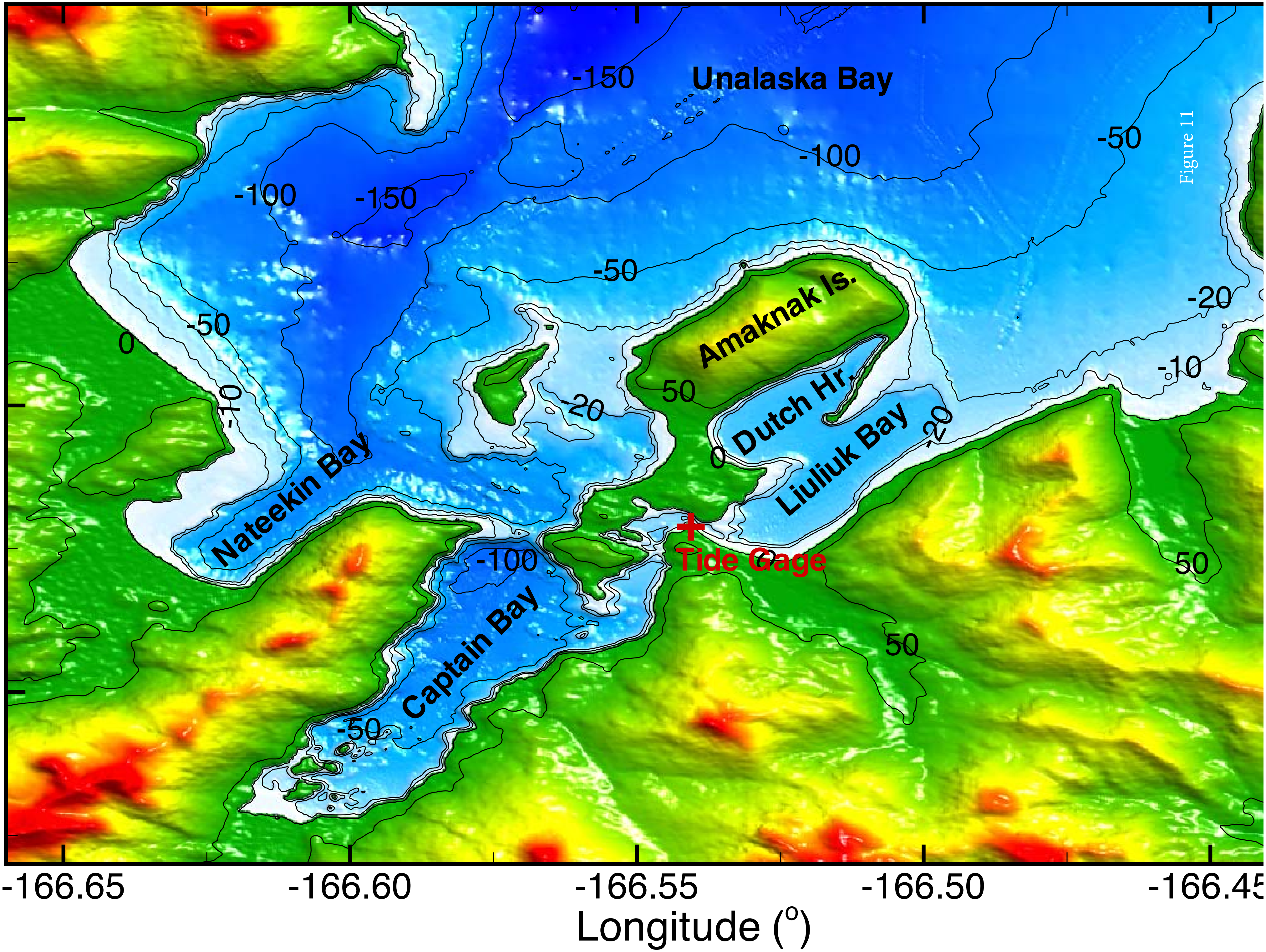
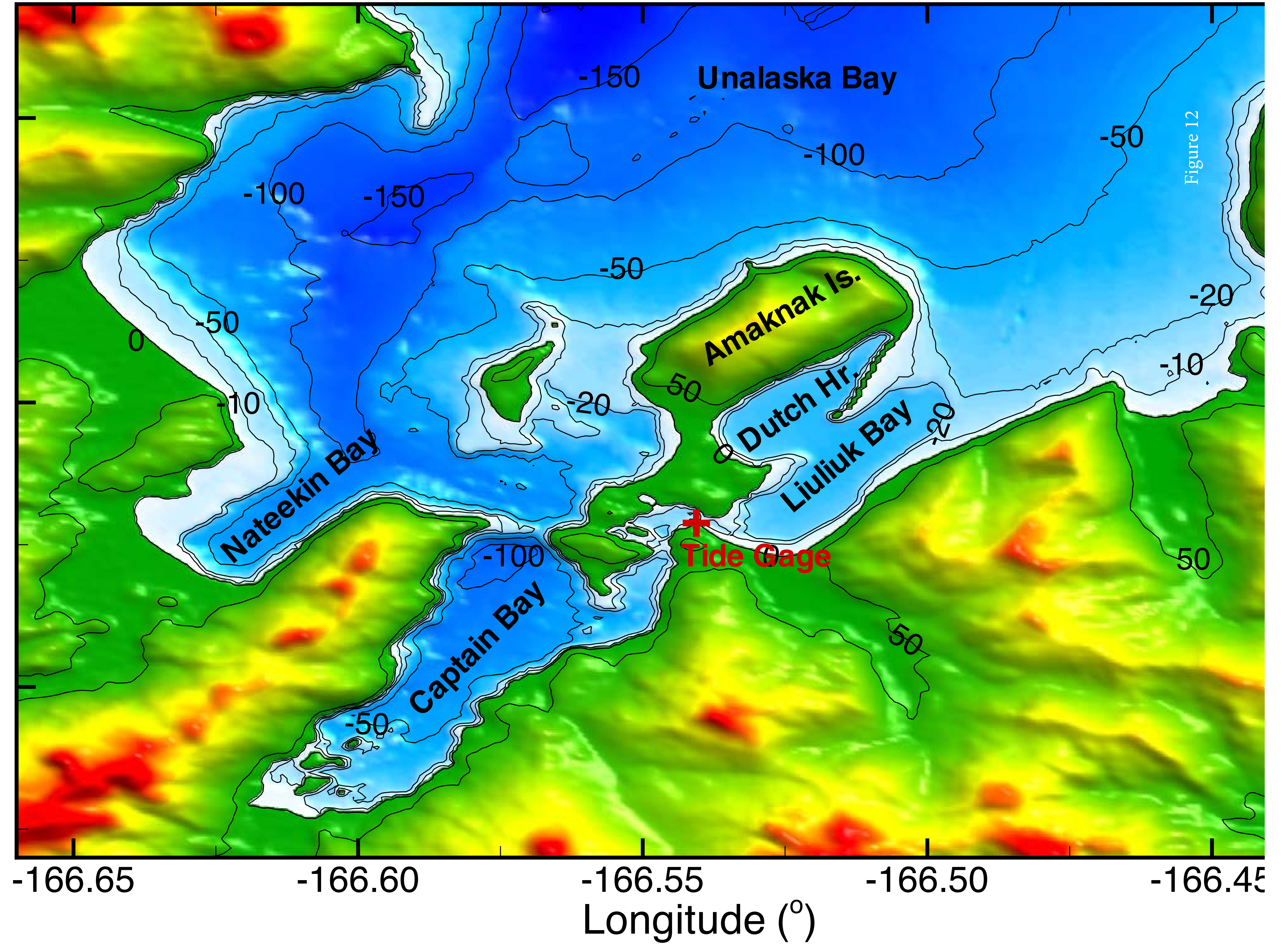

Unalaska Bay
Amaknak Is.
Dutch Hr.
Liuliuk Bay
Nateekin Bay
Captain Bay
Tide Gage
-166.65
-166.60
-166.55
-166.50
Longitude (°)

Figure 11


Unalaska Bay
Nateekin Bay
Captain Bay
Amaknak Is.
Dutch Hr.
Liuliuk Bay
Tide Gage
-150
-150
-100
-100
-100
-50
-50
-50
-50
-20
-20
-20
-10
-10
0
0
50
50
50
-166.65
-166.60
-166.55
-166.50
-166.45
Longitude (°)
Figure 12

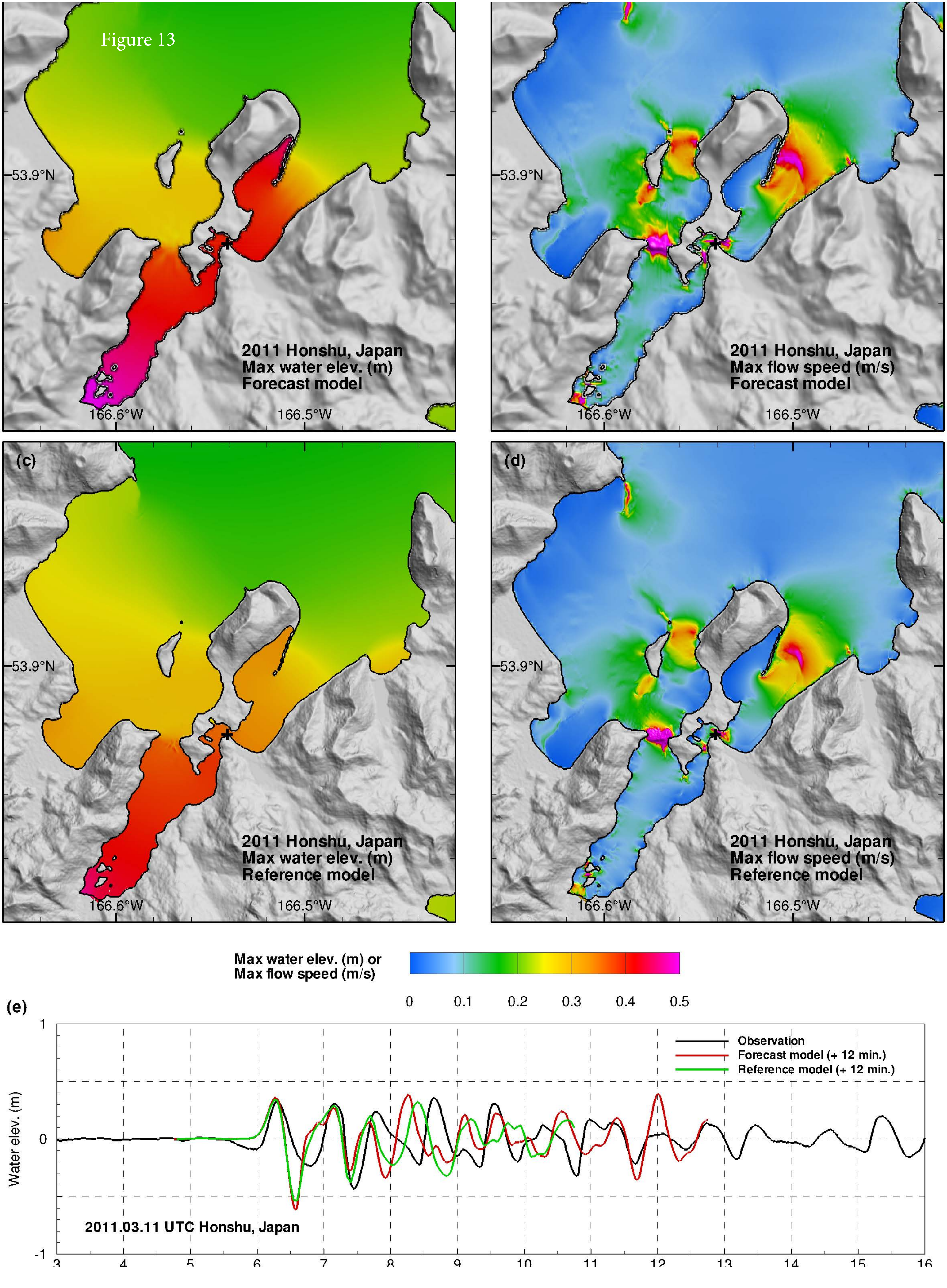


Figure 13
53.9°N
166.6°W
166.5°W
2011 Honshu, Japan
Max water elev. (m)
Forecast model
2011 Honshu, Japan
Max flow speed (m/s)
Forecast model
(c)
(d)
2011 Honshu, Japan
Max water elev. (m)
Reference model
2011 Honshu, Japan
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
(e)
Water elev. (m)
Observation
Forecast model (+ 12 min.)
Reference model (+ 12 min.)
2011.03.11 UTC Honshu, Japan
1
0
-1
3
4
5
6
7
8
9
10
11
12
13
14
15
16

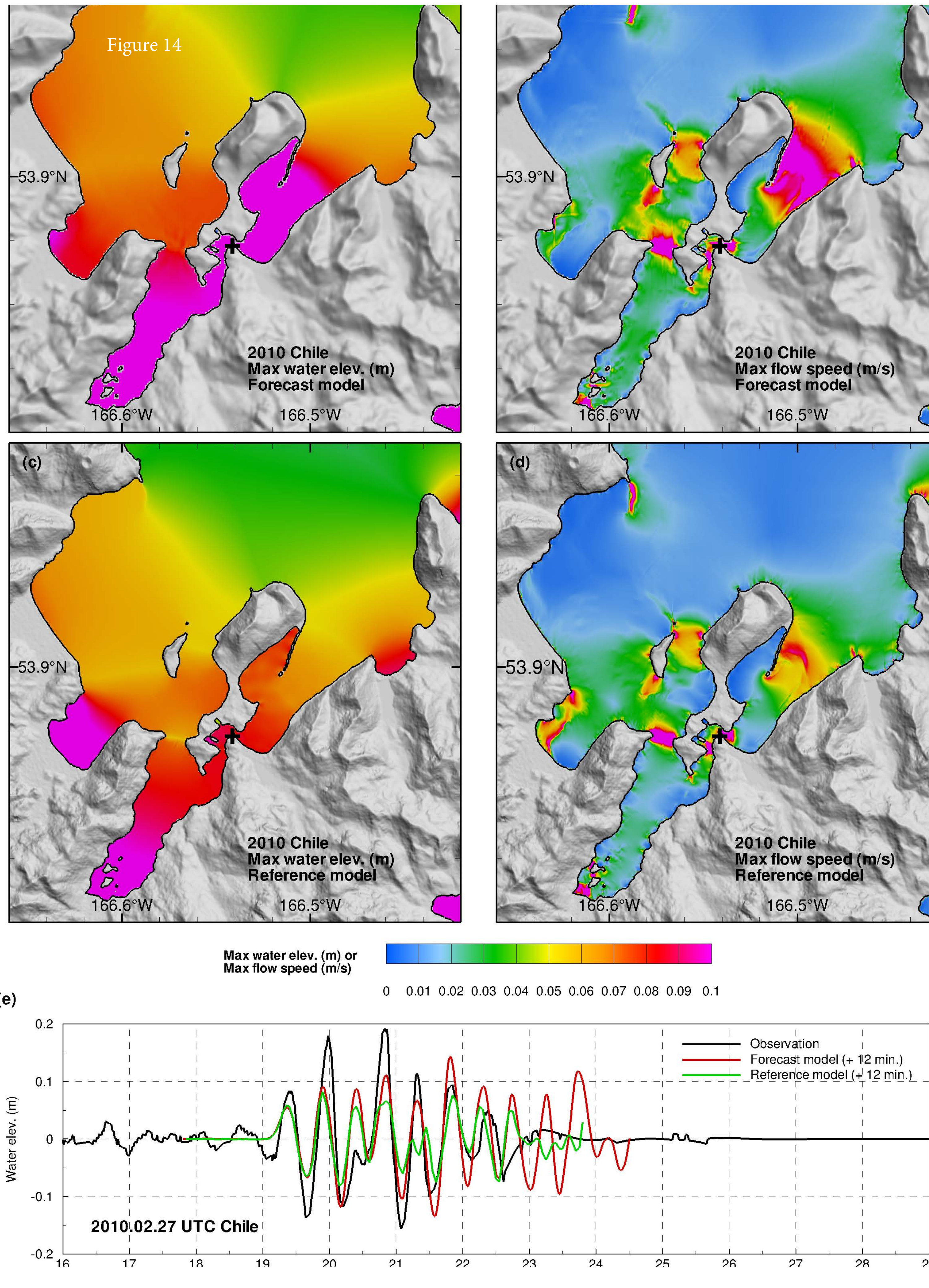
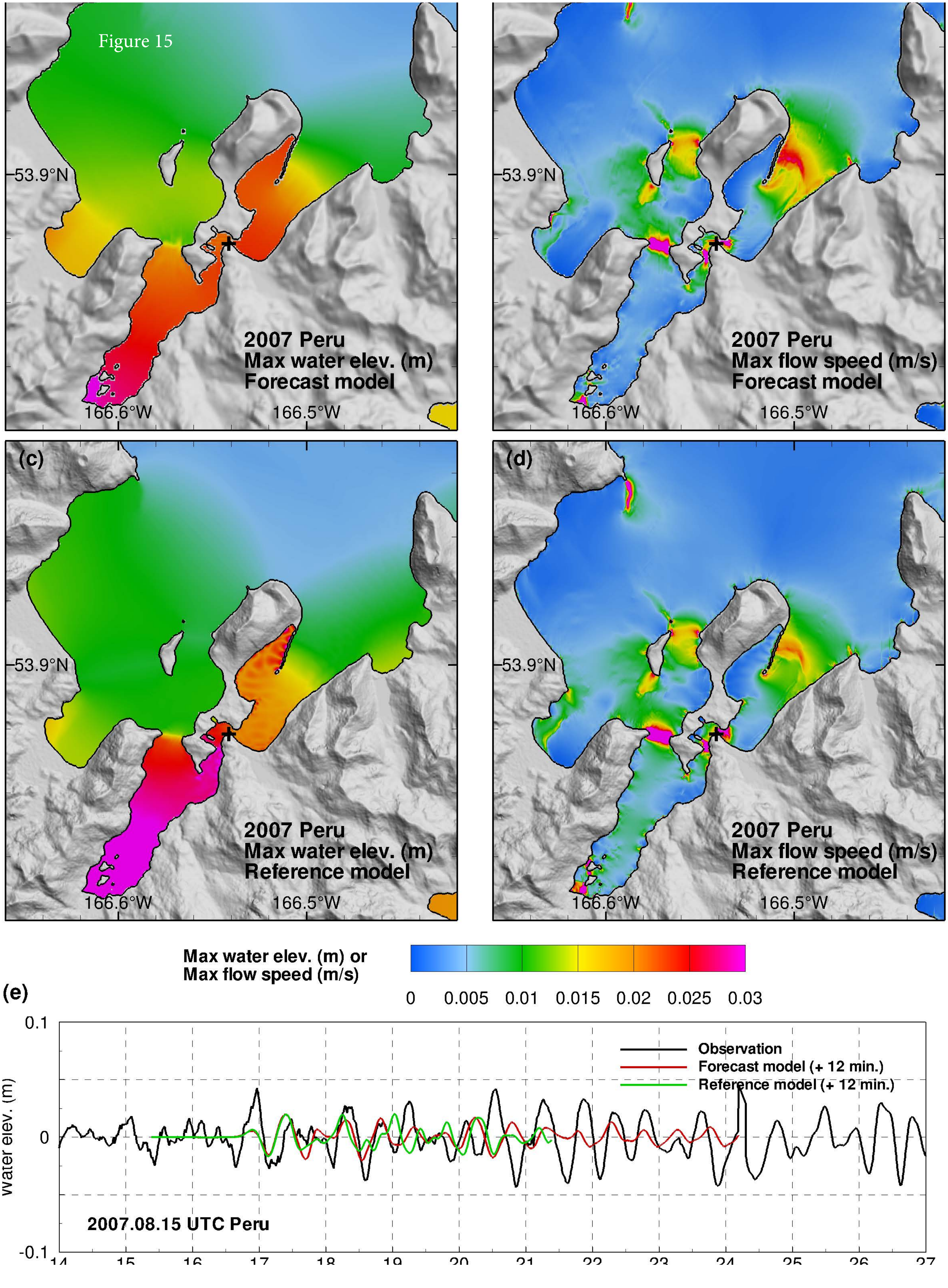


Figure 14
2010 Chile
Max water elev. (m)
Forecast model
166.6°W
166.5°W
53.9°N
2010 Chile
Max flow speed (m/s)
Forecast model
(c)
2010 Chile
Max water elev. (m)
Reference model
(d)
2010 Chile
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
(e)
Water elev. (m)
Observation
Forecast model (+ 12 min.)
Reference model (+ 12 min.)
2010.02.27 UTC Chile
0.2 0.1 0 -0.1 -0.2
16 17 18 19 20 21 22 23 24 25 26 27 28 29

Figure 15



2007 Peru
Max water elev. (m)
Forecast model
53.9°N
166.6°W
166.5°W
2007 Peru
Max flow speed (m/s)
Forecast model
(c)
2007 Peru
Max water elev. (m)
Reference model
(d)
2007 Peru
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.005
0.01
0.015
0.02
0.025
0.03
(e)
Water elev. (m)
0.1
0
-0.1
Observation
Forecast model (+ 12 min.)
Reference model (+ 12 min.)
2007.08.15 UTC Peru

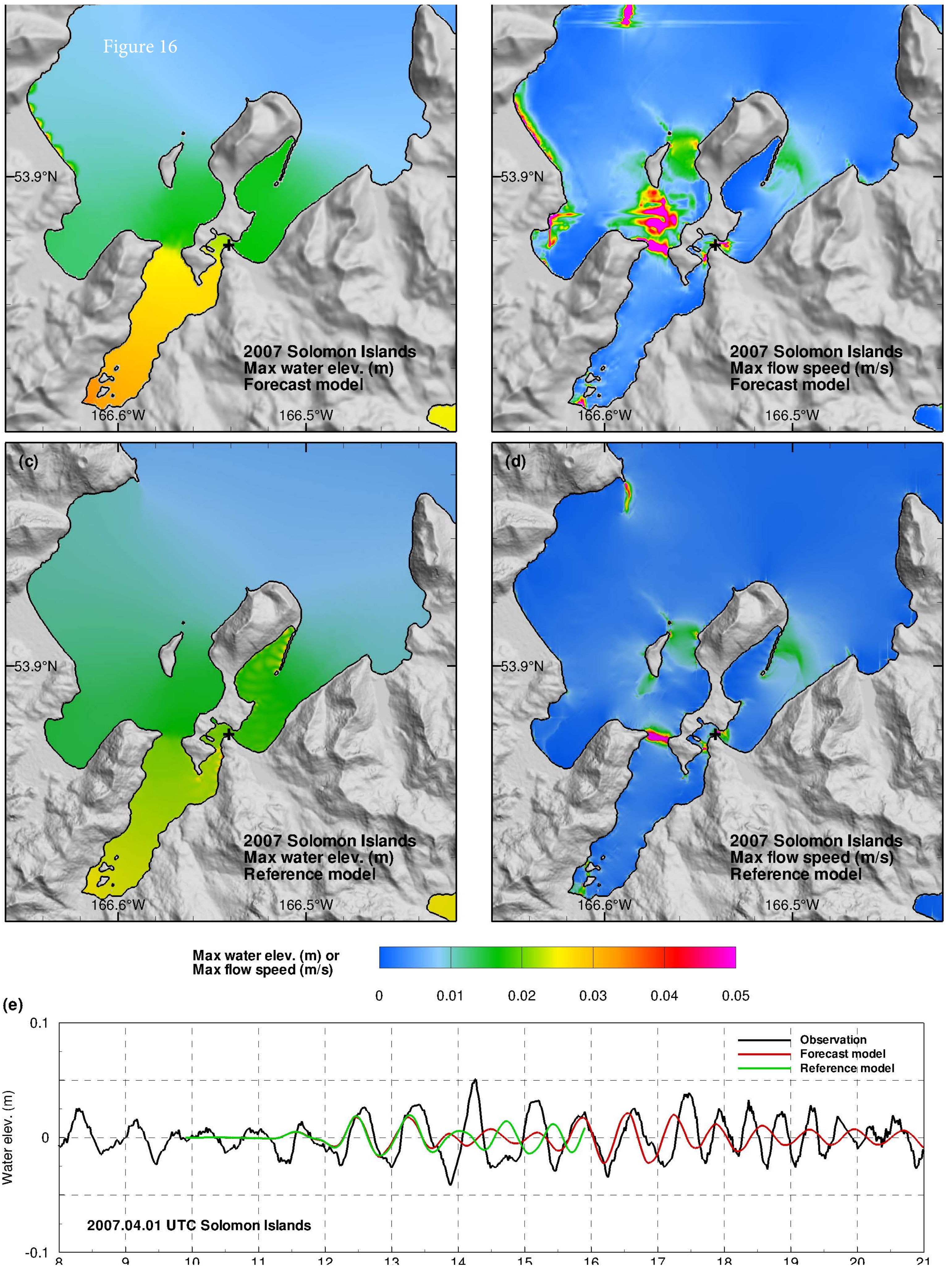


Figure 16
(c)
(d)
(e)
53.9°N
166.6°W
166.5°W
2007 Solomon Islands
Max water elev. (m)
Forecast model
2007 Solomon Islands
Max flow speed (m/s)
Forecast model
2007 Solomon Islands
Max water elev. (m)
Reference model
2007 Solomon Islands
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.01
0.02
0.03
0.04
0.05
Water elev. (m)
0.1
0
-0.1
Observation
Forecast model
Reference model
2007.04.01 UTC Solomon Islands
8
9
10
11
12
13
14
15
16
17
18
19
20
21

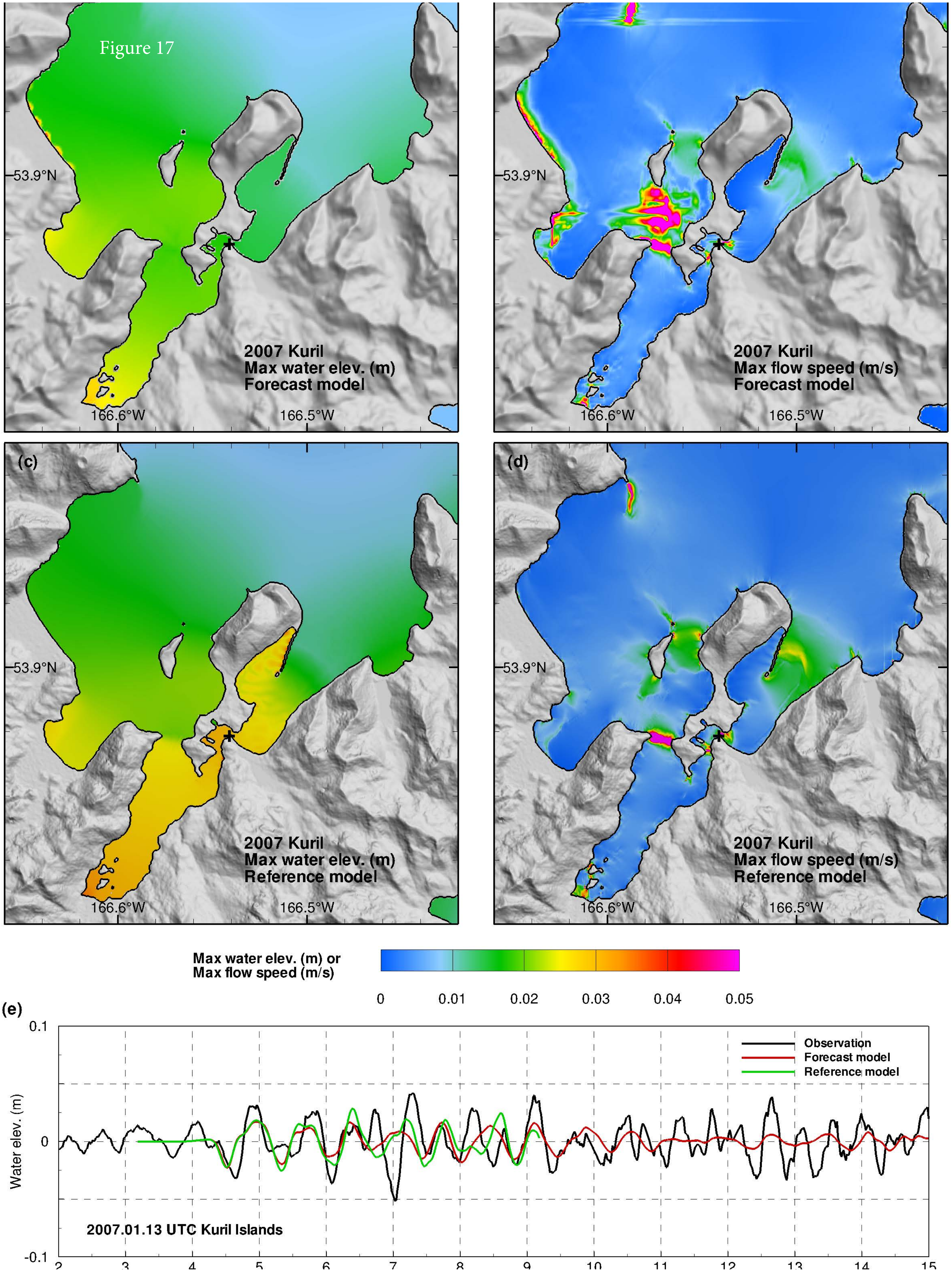
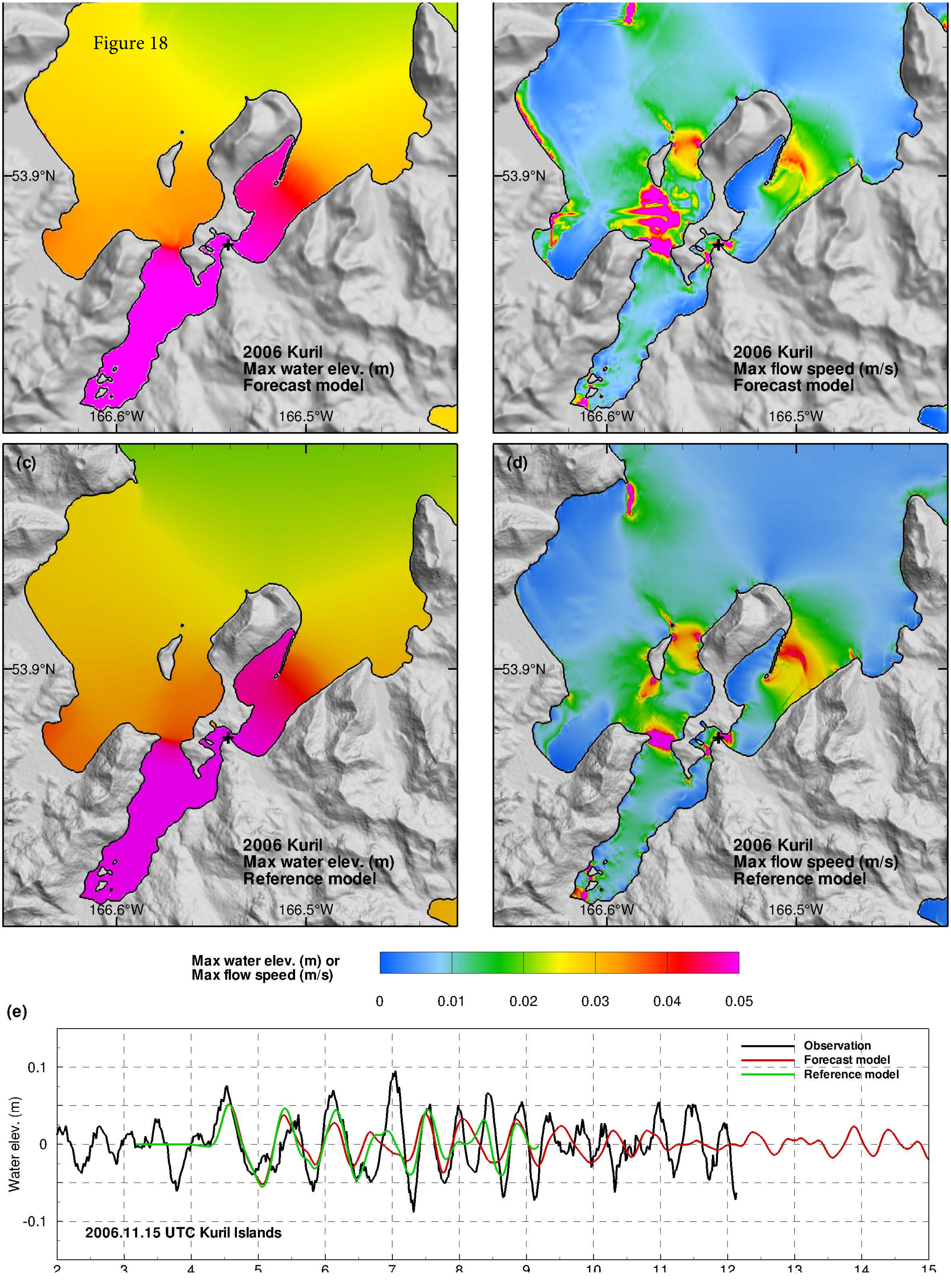


Figure 17
53.9°N
166.6°W
166.5°W
2007 Kuril
Max water elev. (m)
Forecast model
2007 Kuril
Max flow speed (m/s)
Forecast model
(c)
2007 Kuril
Max water elev. (m)
Reference model
(d)
2007 Kuril
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.01
0.02
0.03
0.04
0.05
(e)
Water elev. (m)
0.1
0
-0.1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Observation
Forecast model
Reference model
2007.01.13 UTC Kuril Islands

Figure 18



53.9°N
166.6°W
166.5°W
2006 Kuril
Max water elev. (m)
Forecast model
2006 Kuril
Max flow speed (m/s)
Forecast model
(c)
2006 Kuril
Max water elev. (m)
Reference model
(d)
2006 Kuril
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.01
0.02
0.03
0.04
0.05
(e)
Observation
Forecast model
Reference model
Water elev. (m)
0.1
0
-0.1
2006.11.15 UTC Kuril Islands
2
3
4
5
6
7
8
9
10
11
12
13
14
15

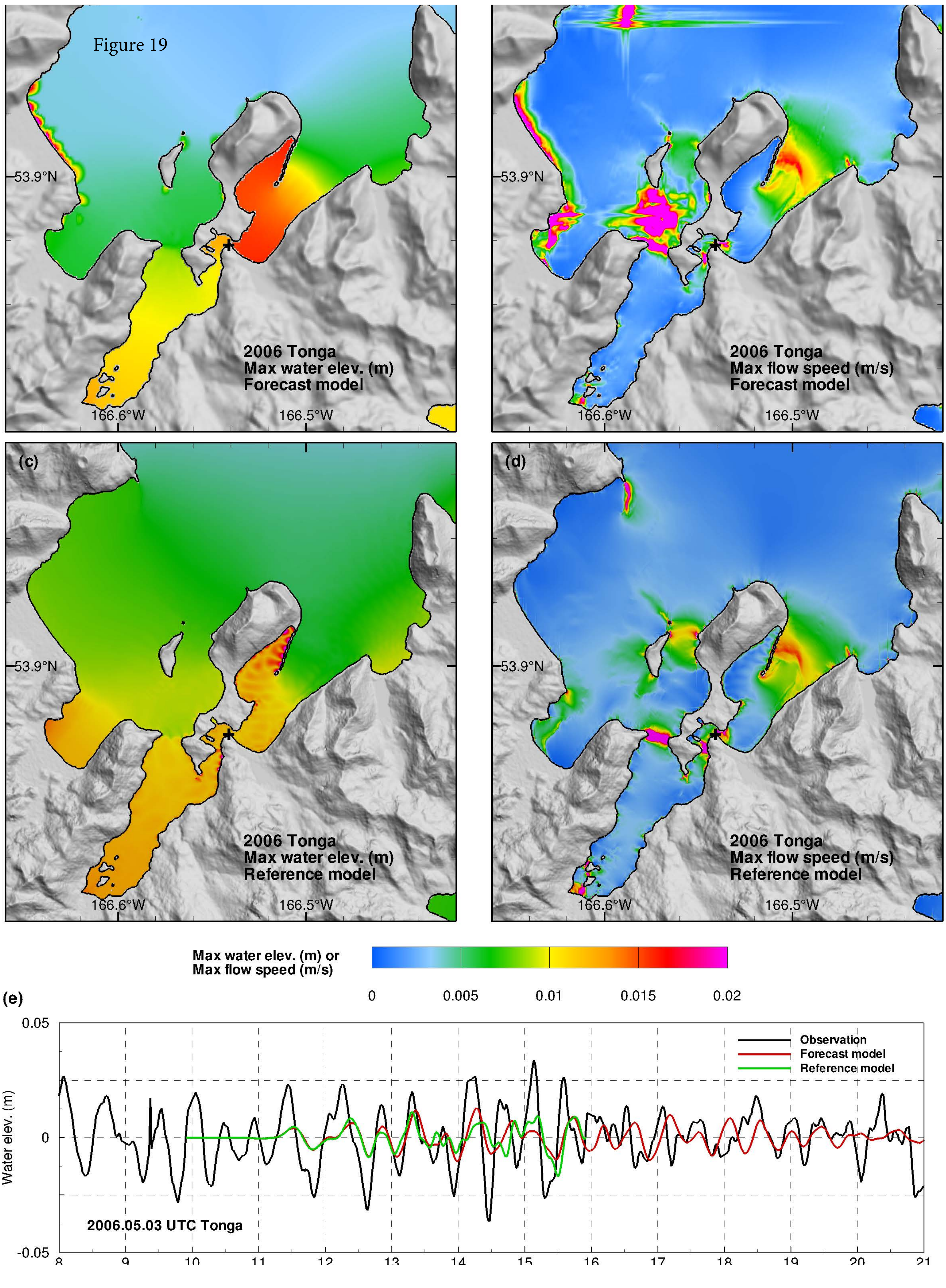


Figure 19
2006 Tonga
Max water elev. (m)
Forecast model
2006 Tonga
Max flow speed (m/s)
Forecast model
(c)
2006 Tonga
Max water elev. (m)
Reference model
(d)
2006 Tonga
Max flow speed (m/s)
Reference model
53.9°N
166.6°W
166.5°W
Max water elev. (m) or
Max flow speed (m/s)
0
0.005
0.01
0.015
0.02
(e)
Observation
Forecast model
Reference model
Water elev. (m)
2006.05.03 UTC Tonga
0.05
0
-0.05
8
9
10
11
12
13
14
15
16
17
18
19
20
21

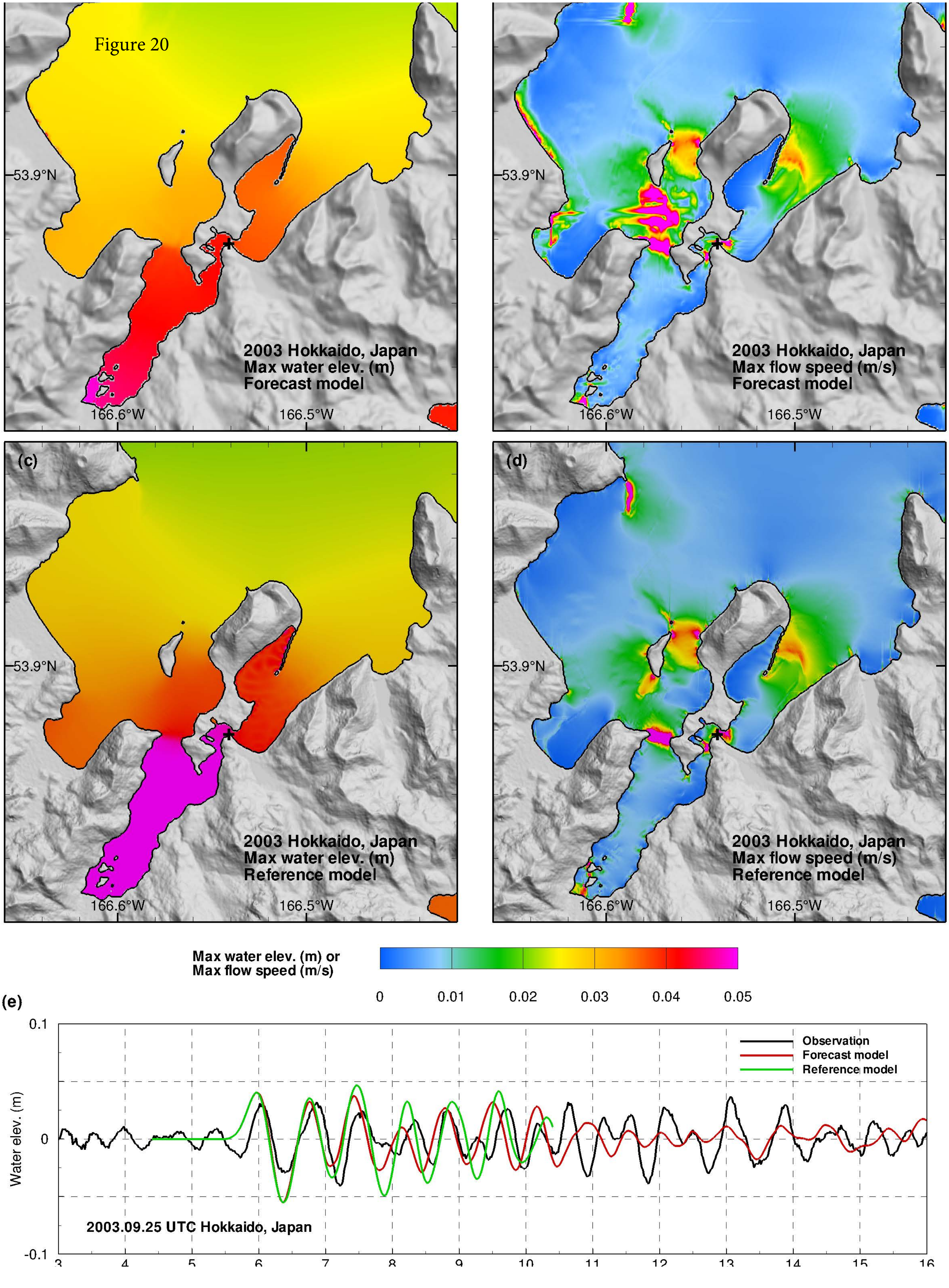

(c)
(d)
(e)
53.9°N
166.6°W
166.5°W
2003 Hokkaido, Japan
Max water elev. (m)
Forecast model
2003 Hokkaido, Japan
Max flow speed (m/s)
Forecast model
2003 Hokkaido, Japan
Max water elev. (m)
Reference model
2003 Hokkaido, Japan
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.01
0.02
0.03
0.04
0.05
Observation
Forecast model
Reference model
Water elev. (m)
0.1
0
-0.1
3
4
5
6
7
8
9
10
11
12
13
14
15
16
2003.09.25 UTC Hokkaido, Japan

Figure 20

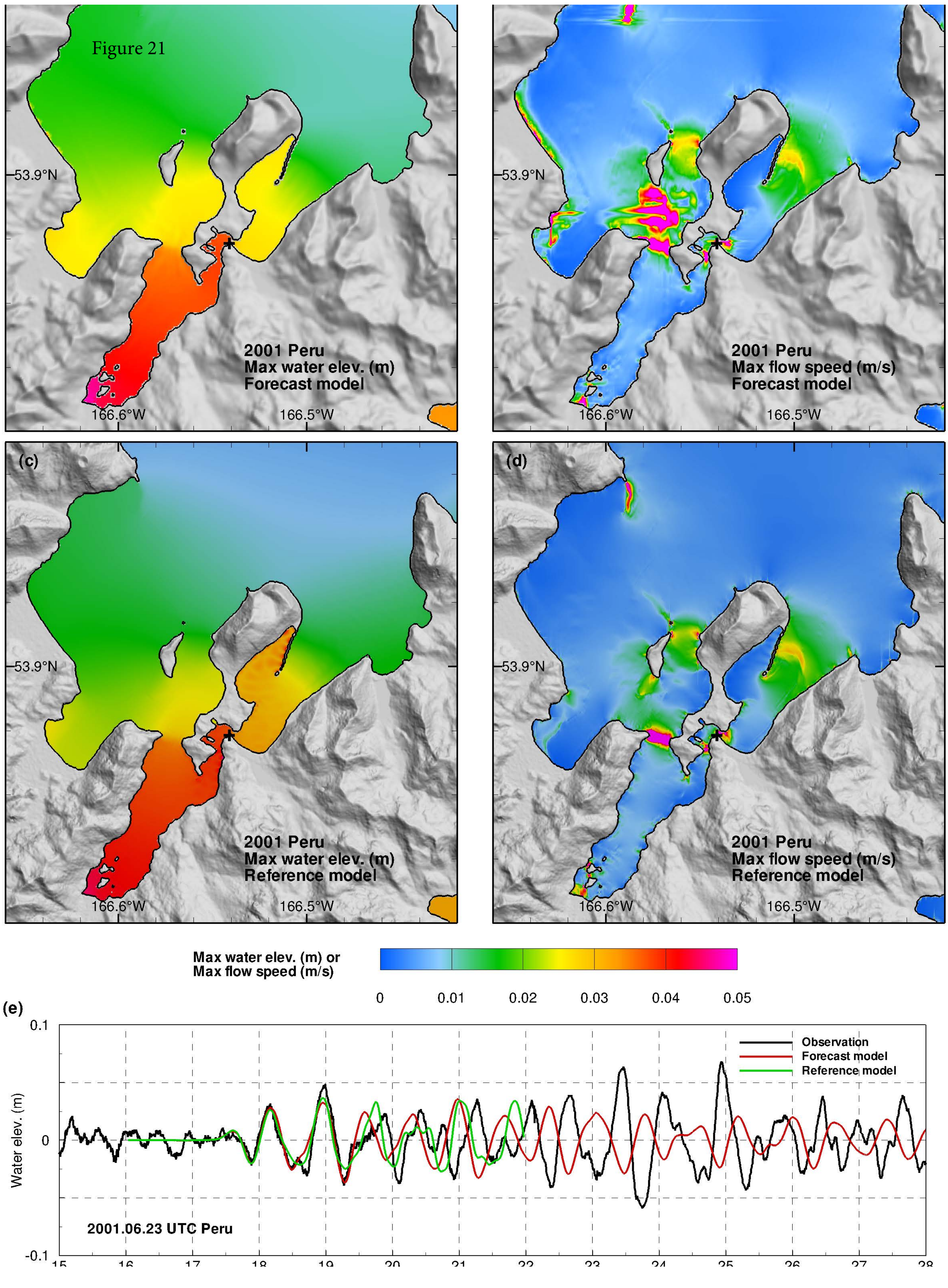


Figure 21
-53.9°N
2001 Peru
Max water elev. (m)
Forecast model
166.6°W
166.5°W
Max flow speed (m/s)
(c)
(d)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0
0.01
0.02
0.03
0.04
0.05
(e)
0.1
0
-0.1
Water elev. (m)
Observation
Forecast model
Reference model
2001.06.23 UTC Peru
15
16
17
18
19
20
21
22
23
24
25
26
27
28

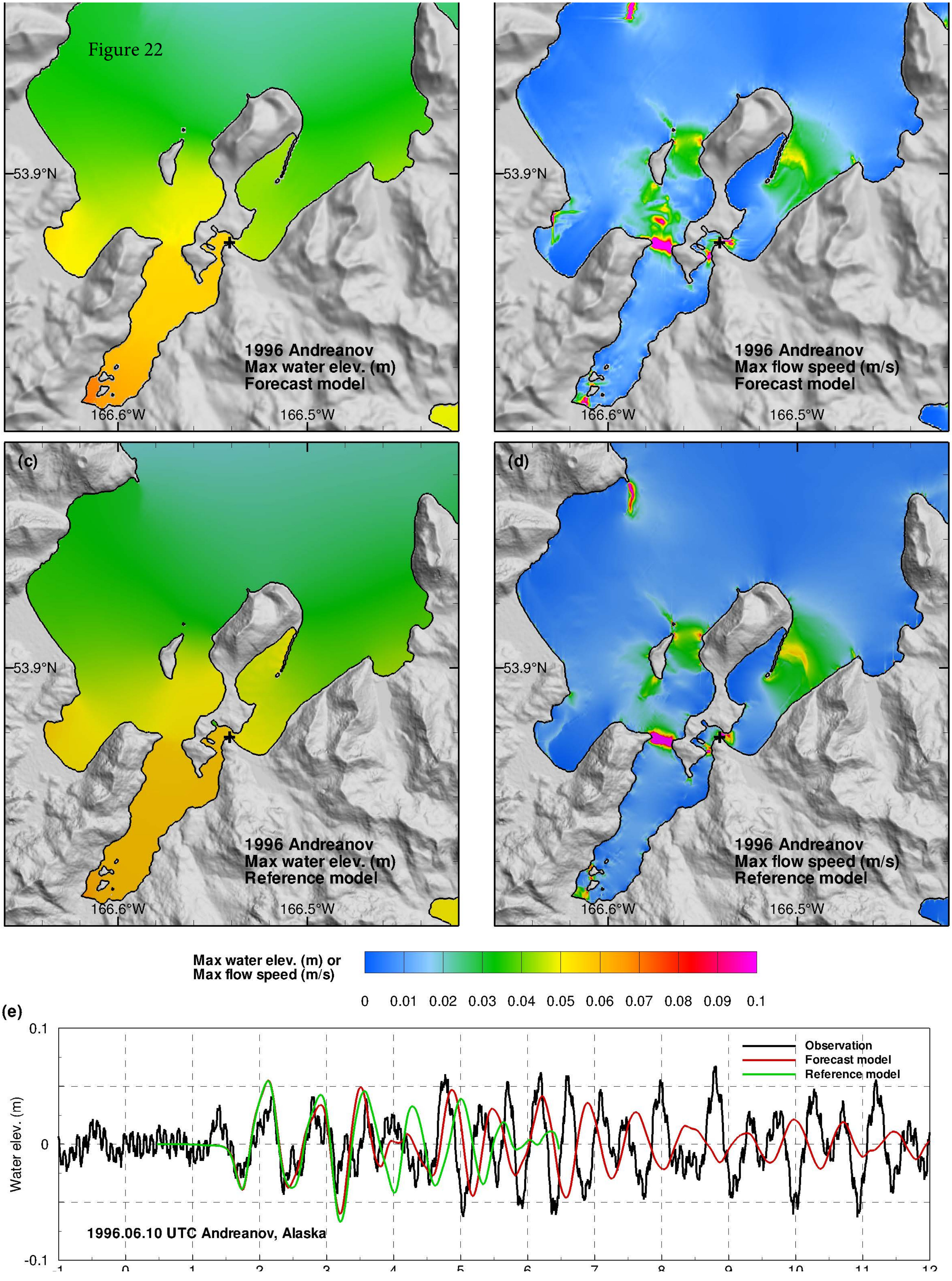


Figure 22
53.9°N
166.6°W
166.5°W
1996 Andreanov
Max water elev. (m)
Forecast model
1996 Andreanov
Max flow speed (m/s)
Forecast model
(c)
1996 Andreanov
Max water elev. (m)
Reference model
(d)
1996 Andreanov
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
(e)
Water elev. (m)
0.1
0
-0.1
Observation
Forecast model
Reference model
1996.06.10 UTC Andreanov, Alaska

Figure 23

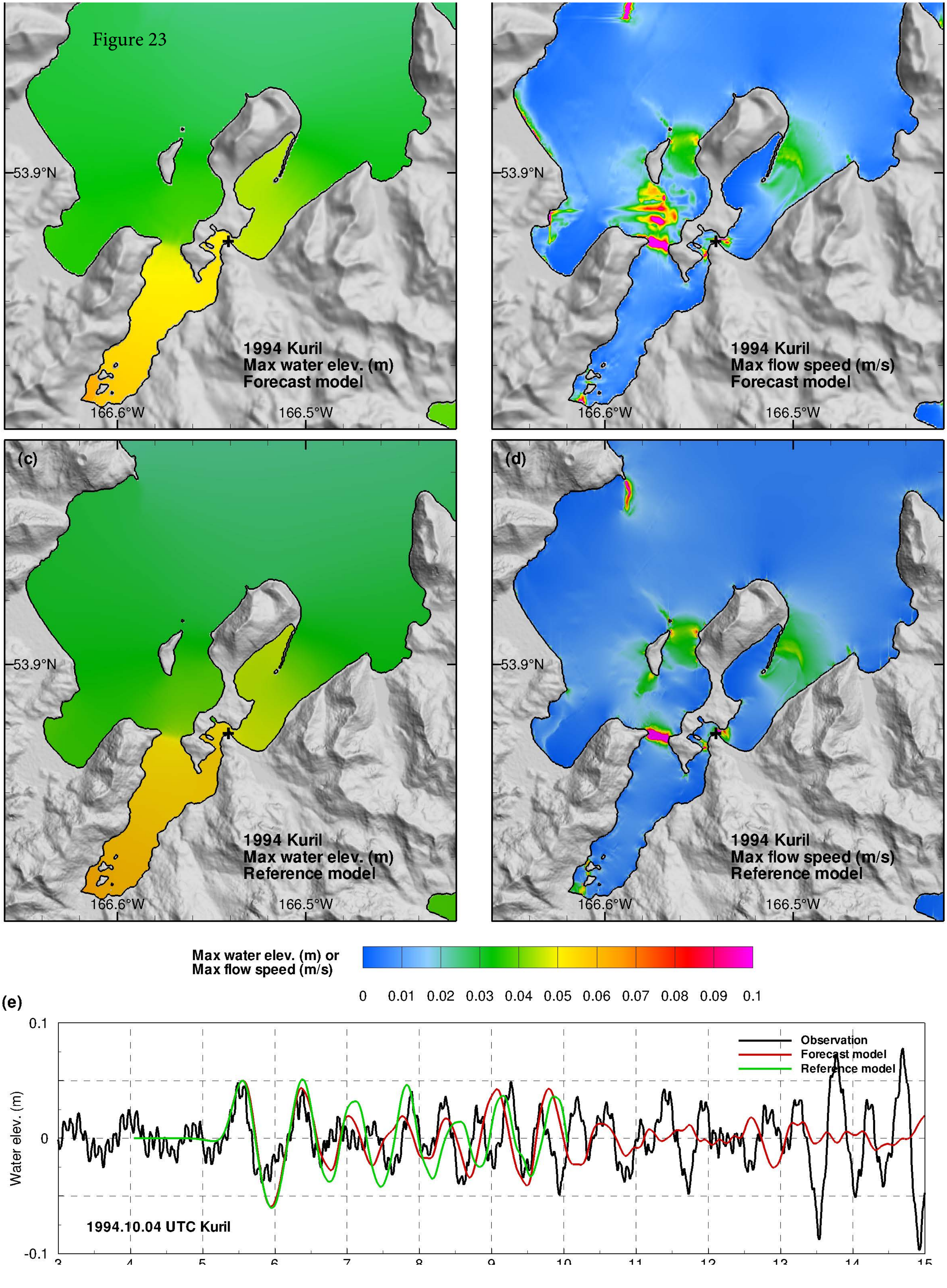
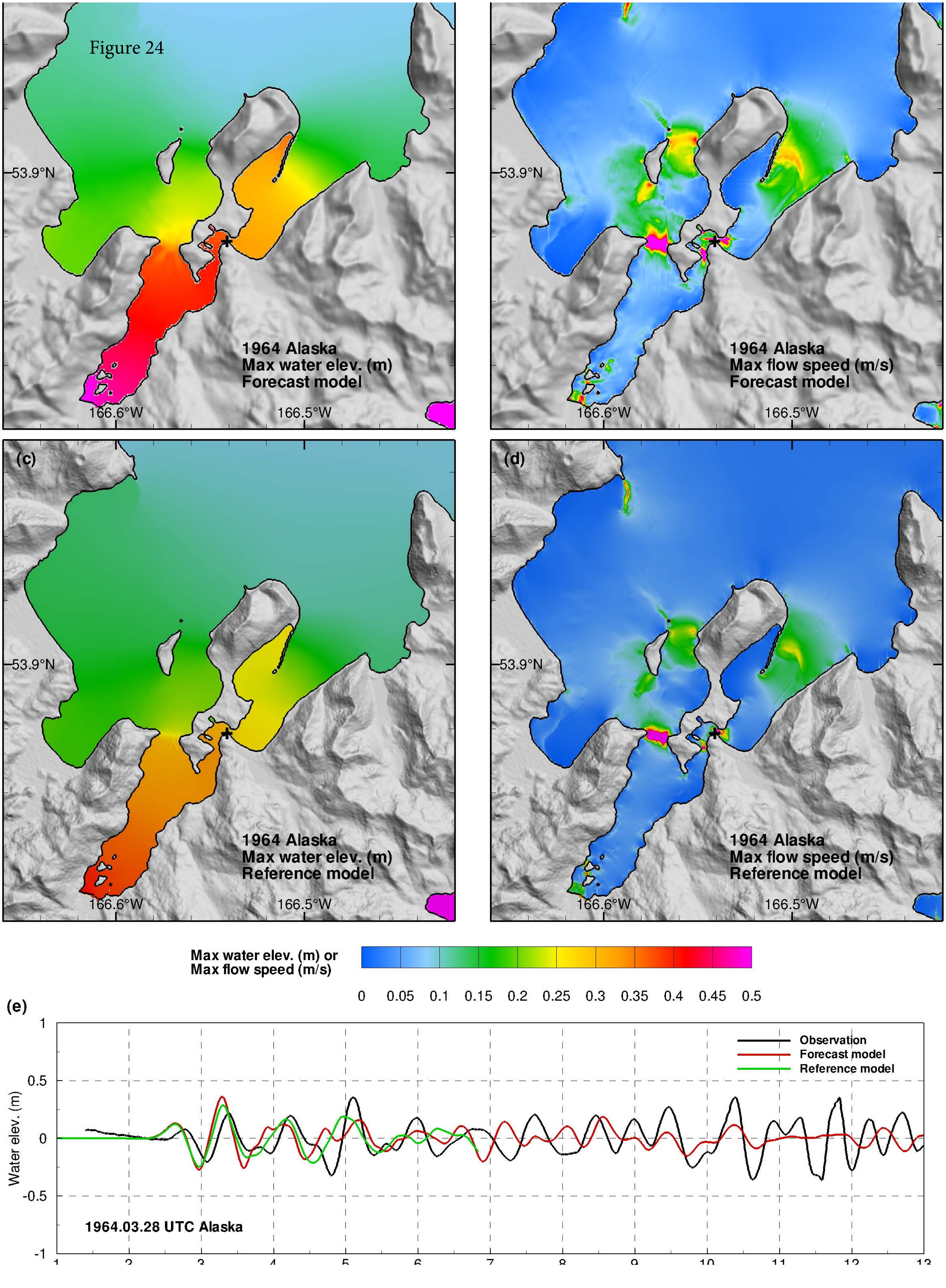

53.9°N
1994 Kuril
Max water elev. (m)
Forecast model
166.6°W
166.5°W
1994 Kuril
Max flow speed (m/s)
Forecast model
(c)
1994 Kuril
Max water elev. (m)
Reference model
(d)
1994 Kuril
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
(e)
Water elev. (m)
Observation
Forecast model
Reference model
1994.10.04 UTC Kuril

Figure 24



53.9°N
166.6°W
166.5°W
1964 Alaska
Max water elev. (m)
Forecast model
Max flow speed (m/s)
Forecast model
(c)
1964 Alaska
Max water elev. (m)
Reference model
(d)
1964 Alaska
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.05 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5
(e)
Water elev. (m)
1
0.5
0
-0.5
-1
Observation
Forecast model
Reference model
1964.03.28 UTC Alaska

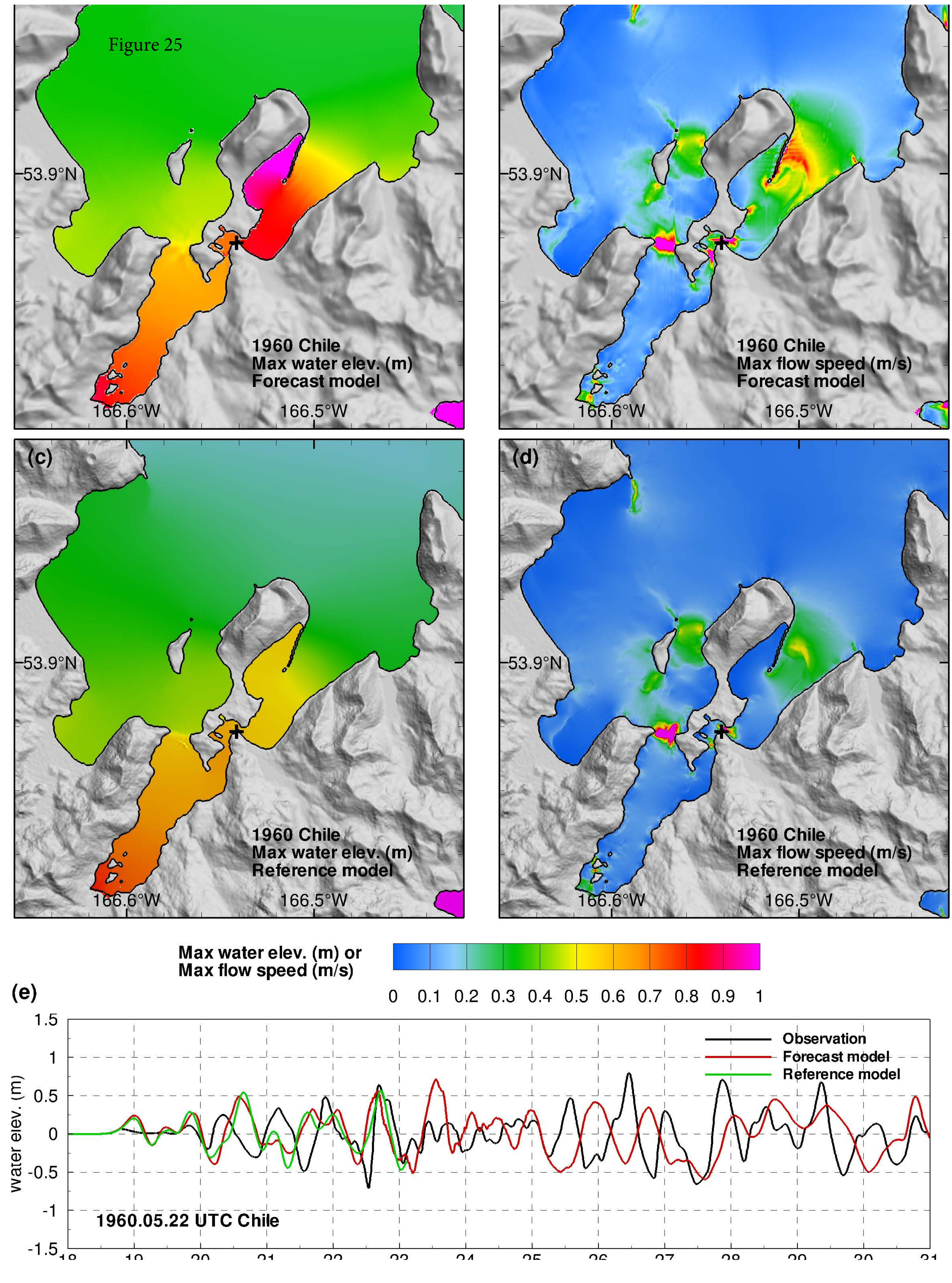


Figure 25
-53.9°N
1960 Chile
Max water elev. (m)
Forecast model
166.6°W
166.5°W
1960 Chile
Max flow speed (m/s)
Forecast model
(c)
(d)
1960 Chile
Max water elev. (m)
Reference model
1960 Chile
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
(e)
Water elev. (m)
Observation
Forecast model
Reference model
1960.05.22 UTC Chile

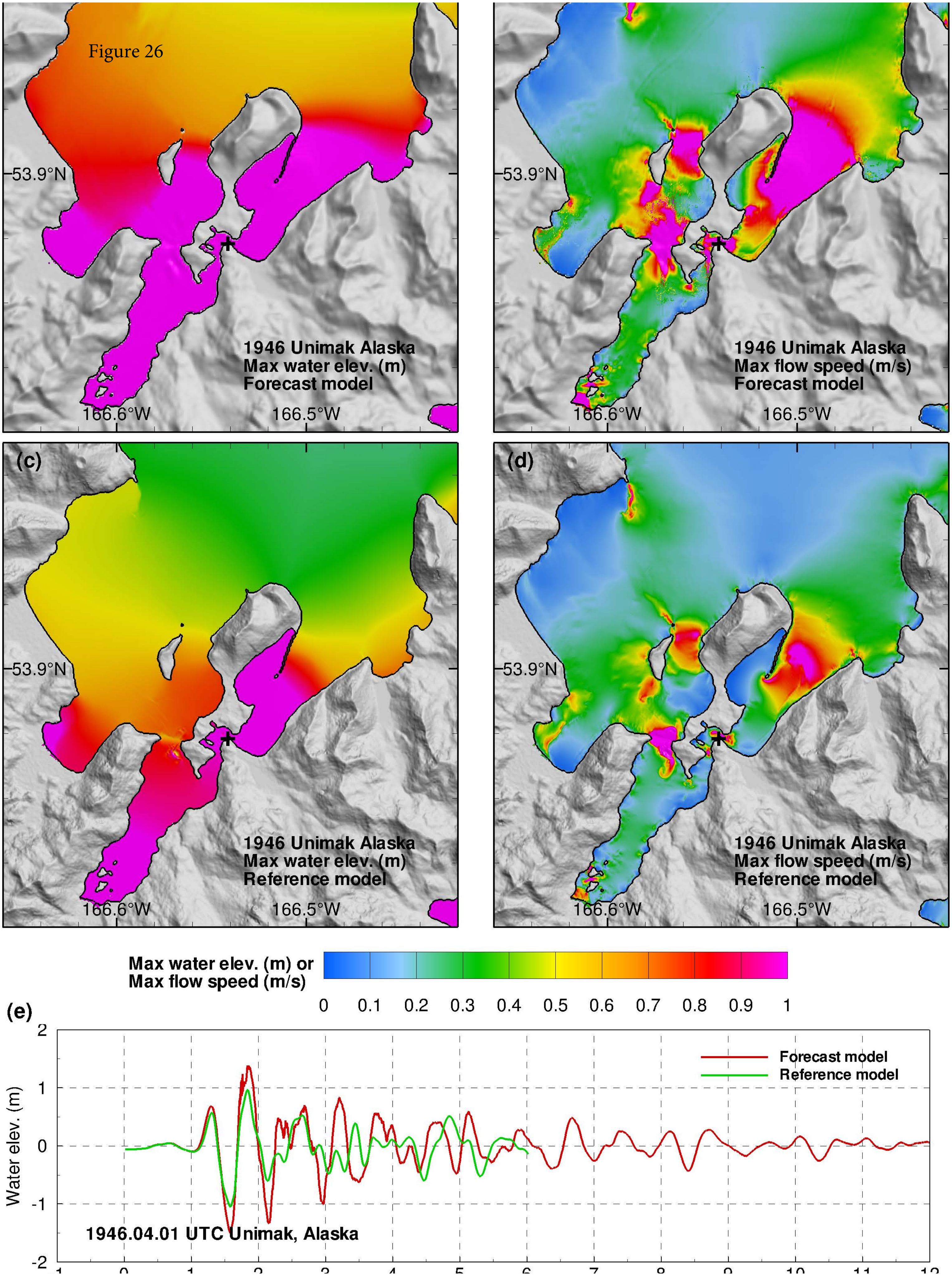
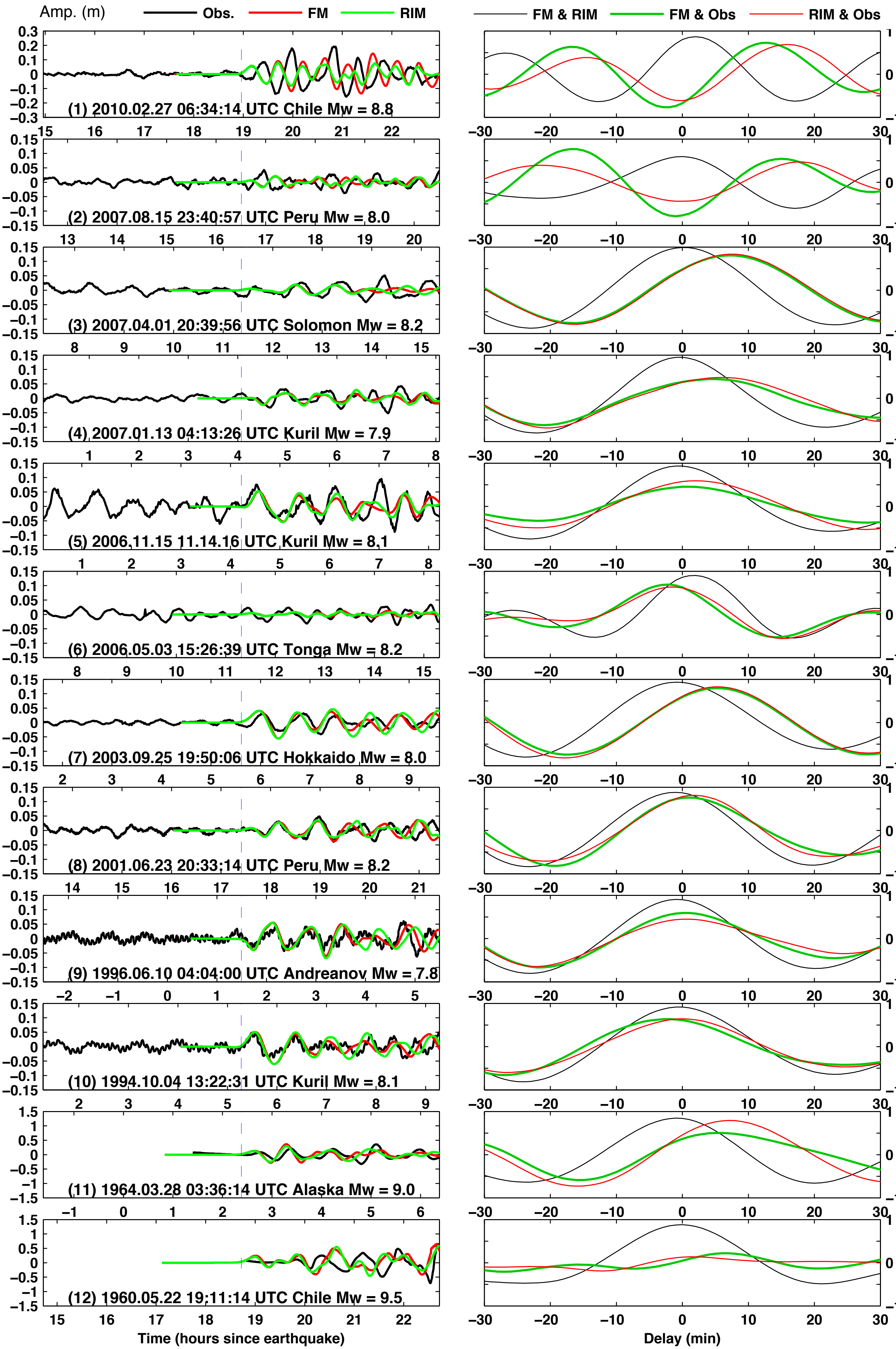


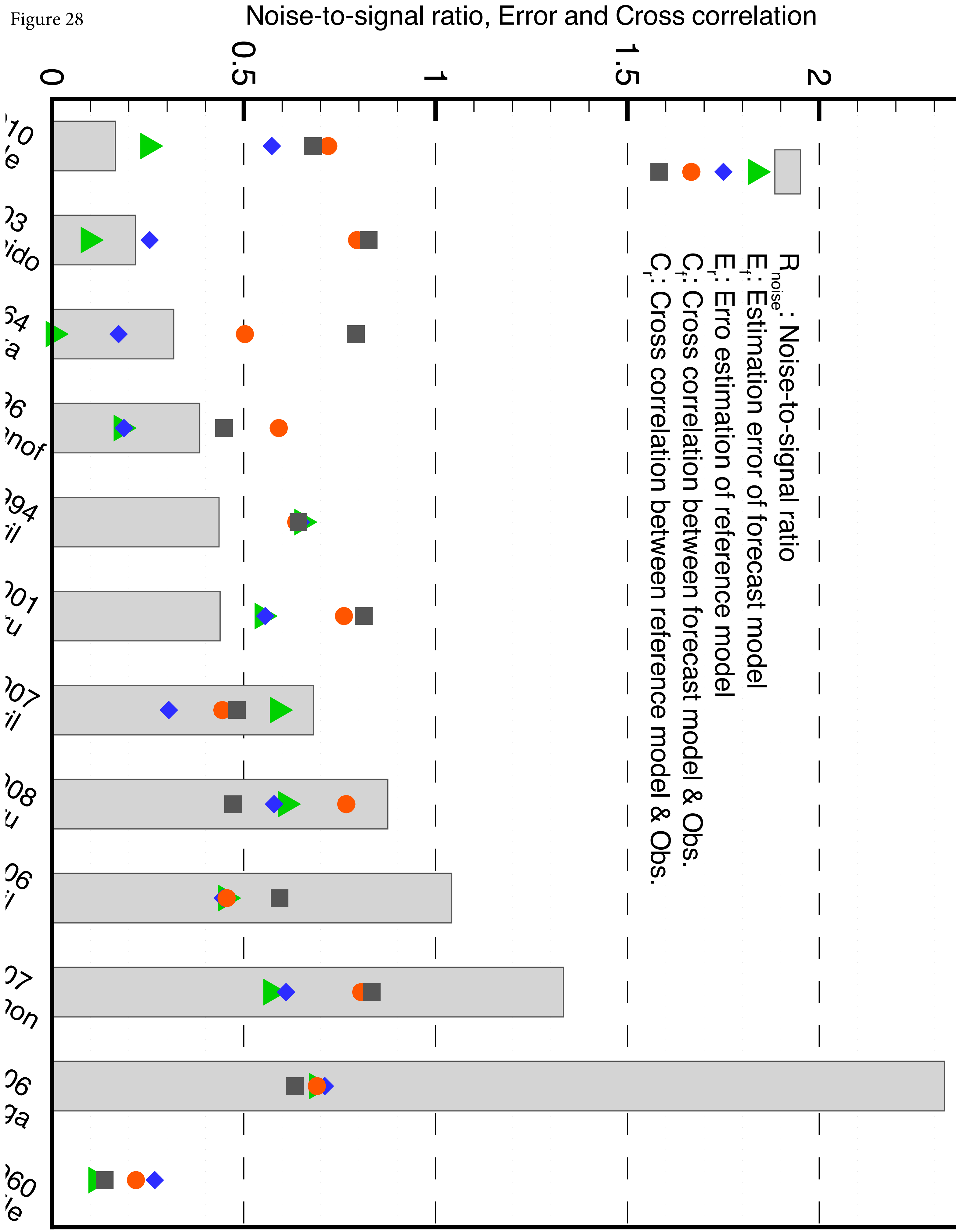
Figure 26
53.9°N
166.6°W
166.5°W
1946 Unimak Alaska
Max water elev. (m)
Forecast model
1946 Unimak Alaska
Max flow speed (m/s)
Forecast model
(c)
1946 Unimak Alaska
Max water elev. (m)
Reference model
(d)
1946 Unimak Alaska
Max flow speed (m/s)
Reference model
Max water elev. (m) or
Max flow speed (m/s)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
(e)
Water elev. (m)
Forecast model
Reference model
1946.04.01 UTC Unimak, Alaska

Figure 27



Amp. (m)
Obs.
FM
RIM
FM & RIM
FM & Obs
RIM & Obs
(1) 2010.02.27 06:34:14 UTC Chile Mw = 8.8
(2) 2007.08.15 23:40:57 UTC Peru Mw = 8.0
(3) 2007.04.01 20:39:56 UTC Solomon Mw = 8.2
(4) 2007.01.13 04:13:26 UTC Kuril Mw = 7.9
(5) 2006.11.15 11.14.16 UTC Kuril Mw = 8.1
(6) 2006.05.03 15:26:39 UTC Tonga Mw = 8.2
(7) 2003.09.25 19:50:06 UTC Hokkaido Mw = 8.0
(8) 2001.06.23 20:33:14 UTC Peru Mw = 8.2
(9) 1996.06.10 04:04:00 UTC Andreanov Mw = 7.8
(10) 1994.10.04 13:22:31 UTC Kuril Mw = 8.1
(11) 1964.03.28 03:36:14 UTC Alaska Mw = 9.0
(12) 1960.05.22 19:11:14 UTC Chile Mw = 9.5
Time (hours since earthquake)
Delay (min)

Figure 28


Noise-to-signal ratio, Error and Cross correlation
0
0.5
1
1.5
2
R_{noise}: Noise-to-signal ratio
E_f: Estimation error of forecast model
E_r: Erro estimation of reference model
C_f: Cross correlation between forecast model & Obs.
C_r: Cross correlation between reference model & Obs.

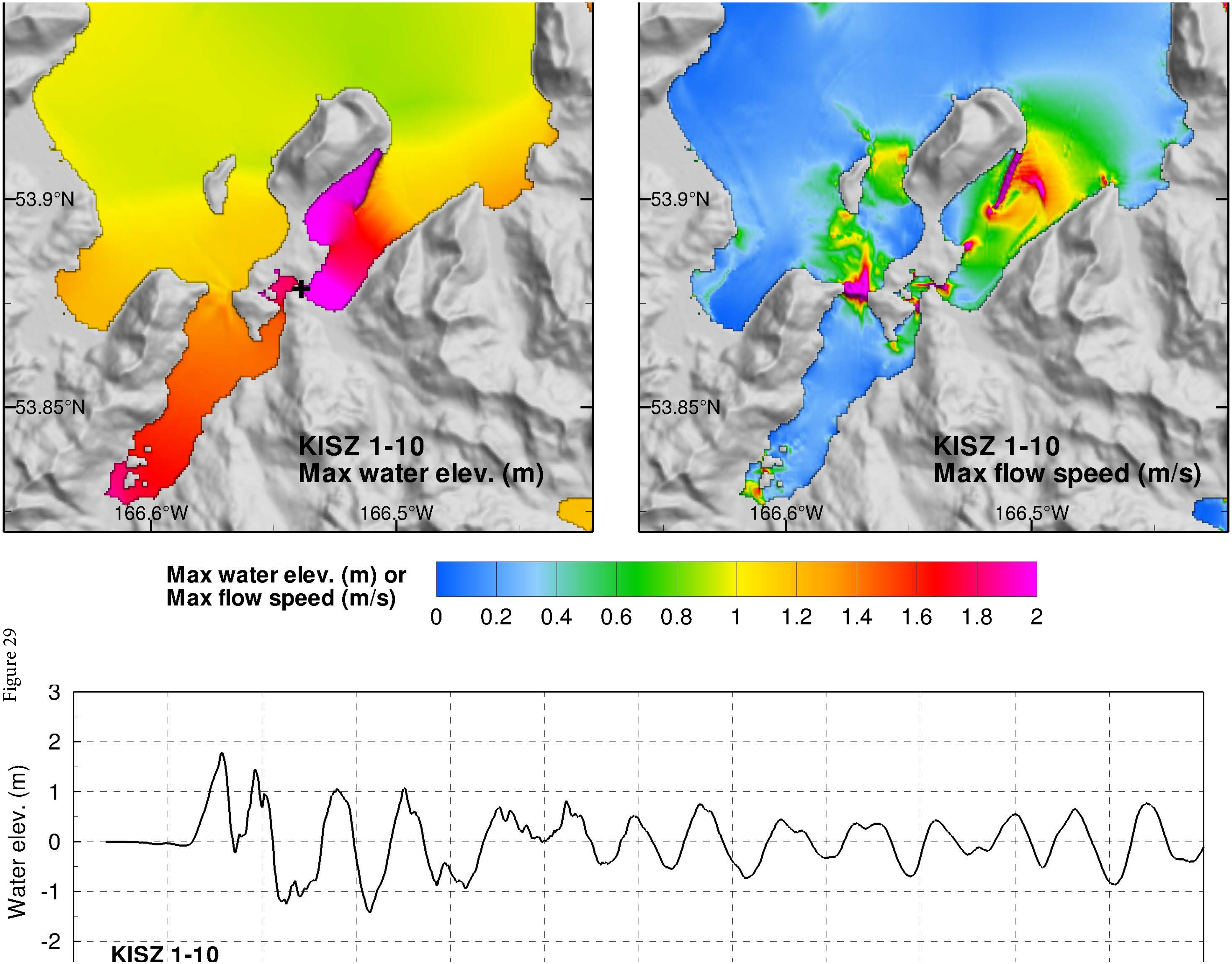
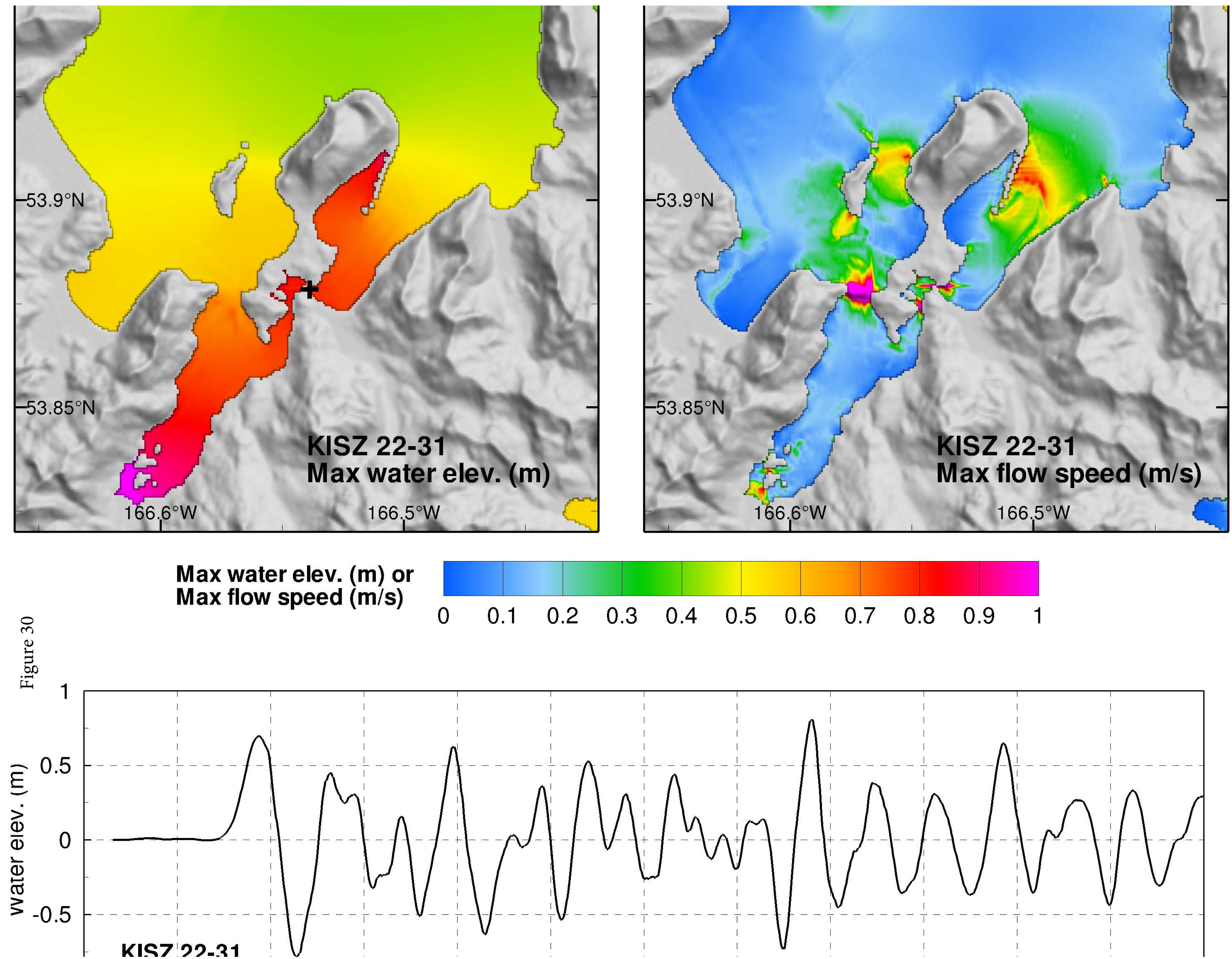

53.9°N
53.85°N
166.6°W
166.5°W
KISZ 1-10
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
KISZ 1-10
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Water elev. (m)
3
2
1
0
-1
-2
KISZ 1-10

Figure 29

Figure 30



53.9°N
53.85°N
166.6°W
166.5°W
KISZ 22-31
Max water elev. (m)
KISZ 22-31
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
-0.5
0
0.5
1
KISZ 22-31

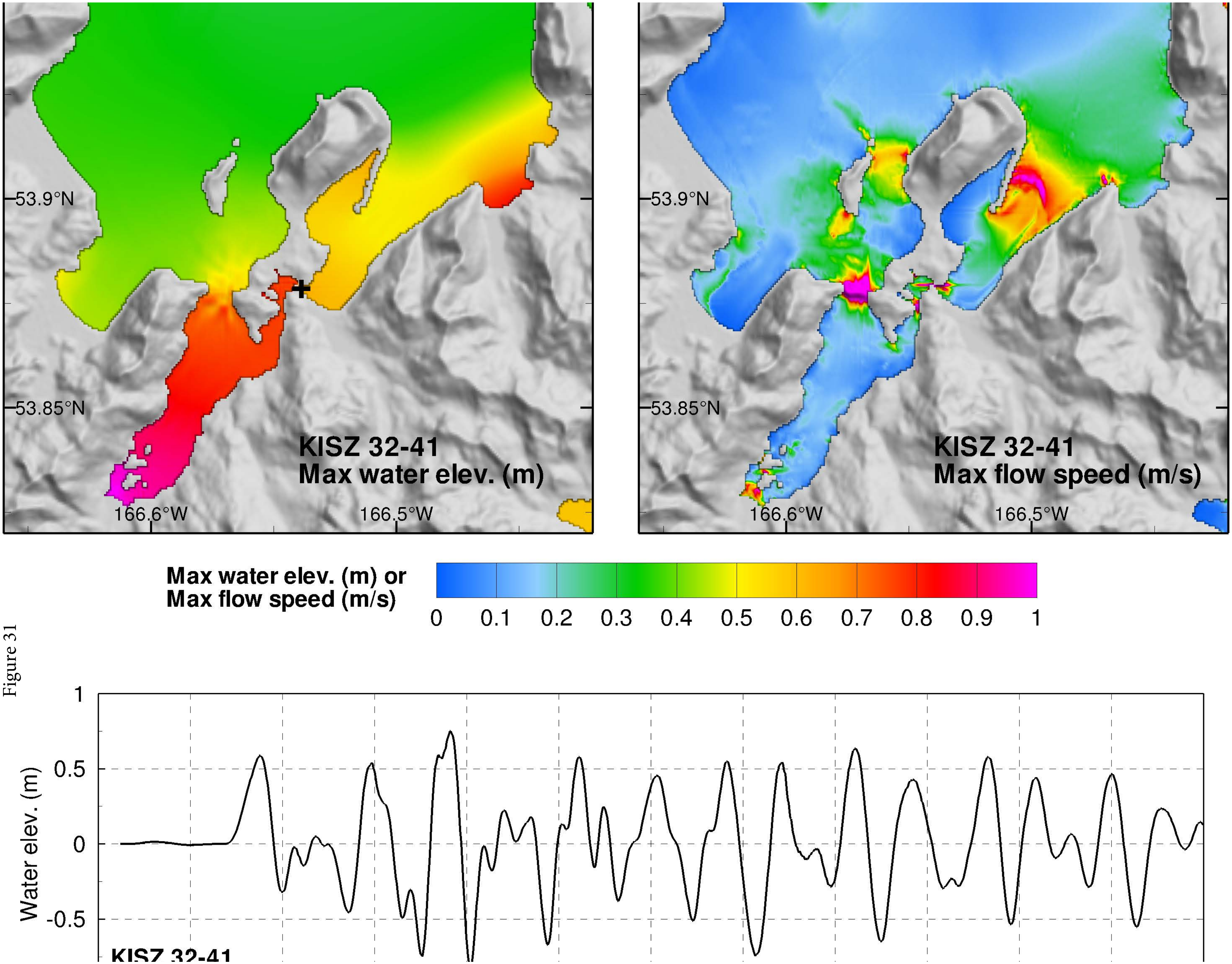

53.9°N
53.85°N
166.6°W
166.5°W
KISZ 32-41
Max water elev. (m)
KISZ 32-41
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Water elev. (m)
1
0.5
0
-0.5
KISZ 32-41

Figure 31

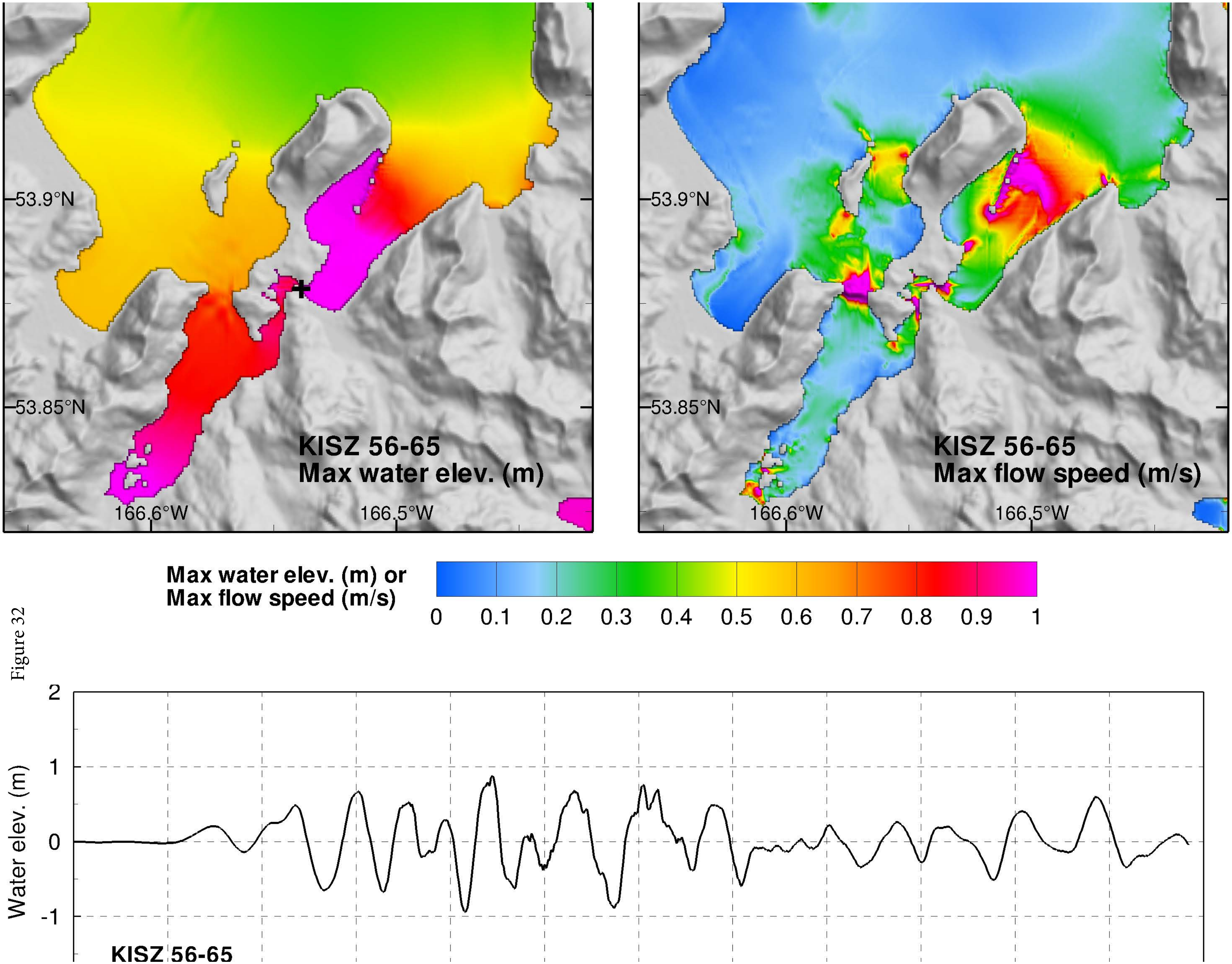

53.9°N
53.85°N
166.6°W
166.5°W
KISZ 56-65
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
KISZ 56-65
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
2
1
0
-1
KISZ 56-65

Figure 32

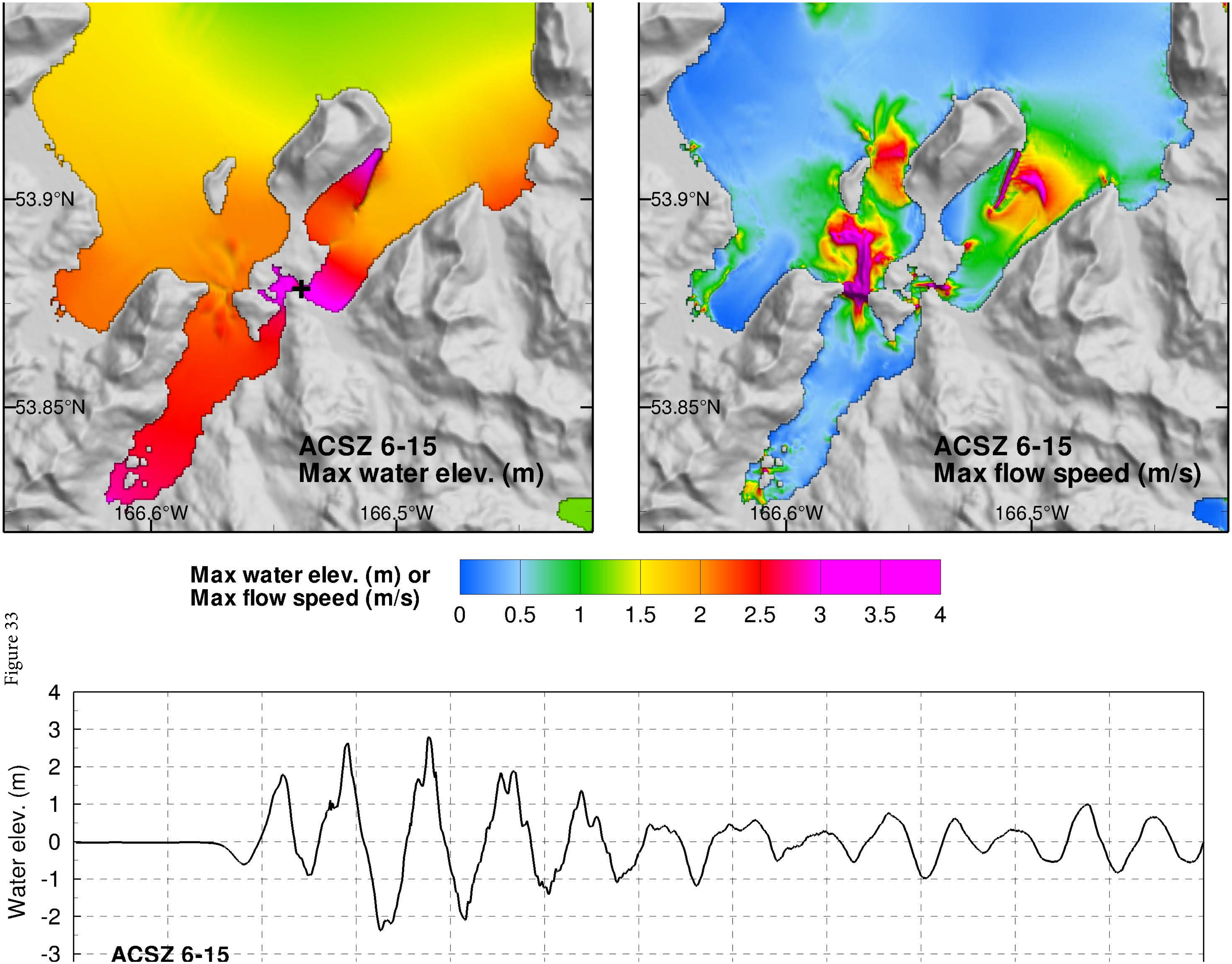

53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 6-15
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 6-15
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
Water elev. (m)
4
3
2
1
0
-1
-2
-3
ACSZ 6-15

Figure 33

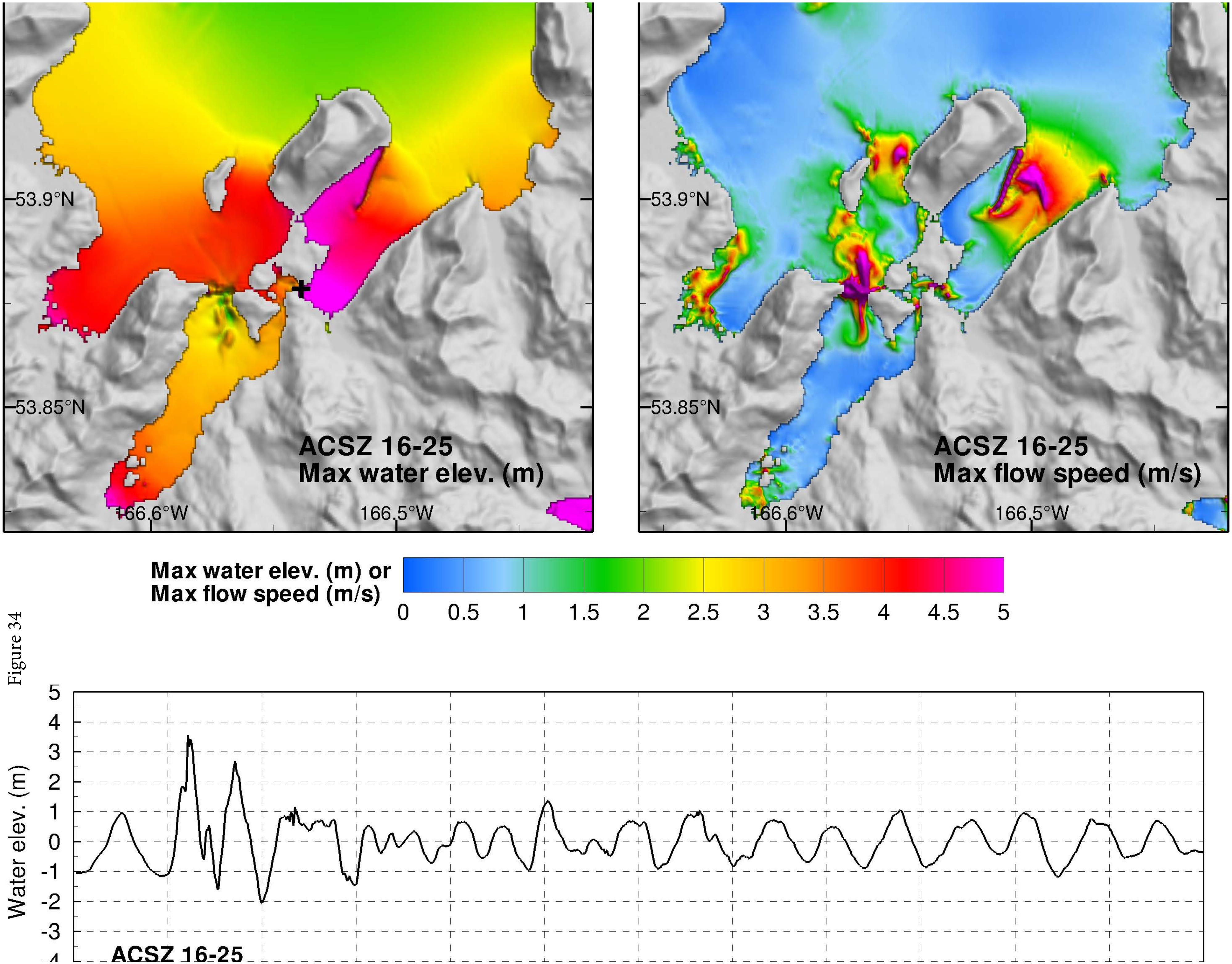

53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 16-25
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 16-25
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Water elev. (m)
5
4
3
2
1
0
-1
-2
-3
ACSZ 16-25

Figure 34

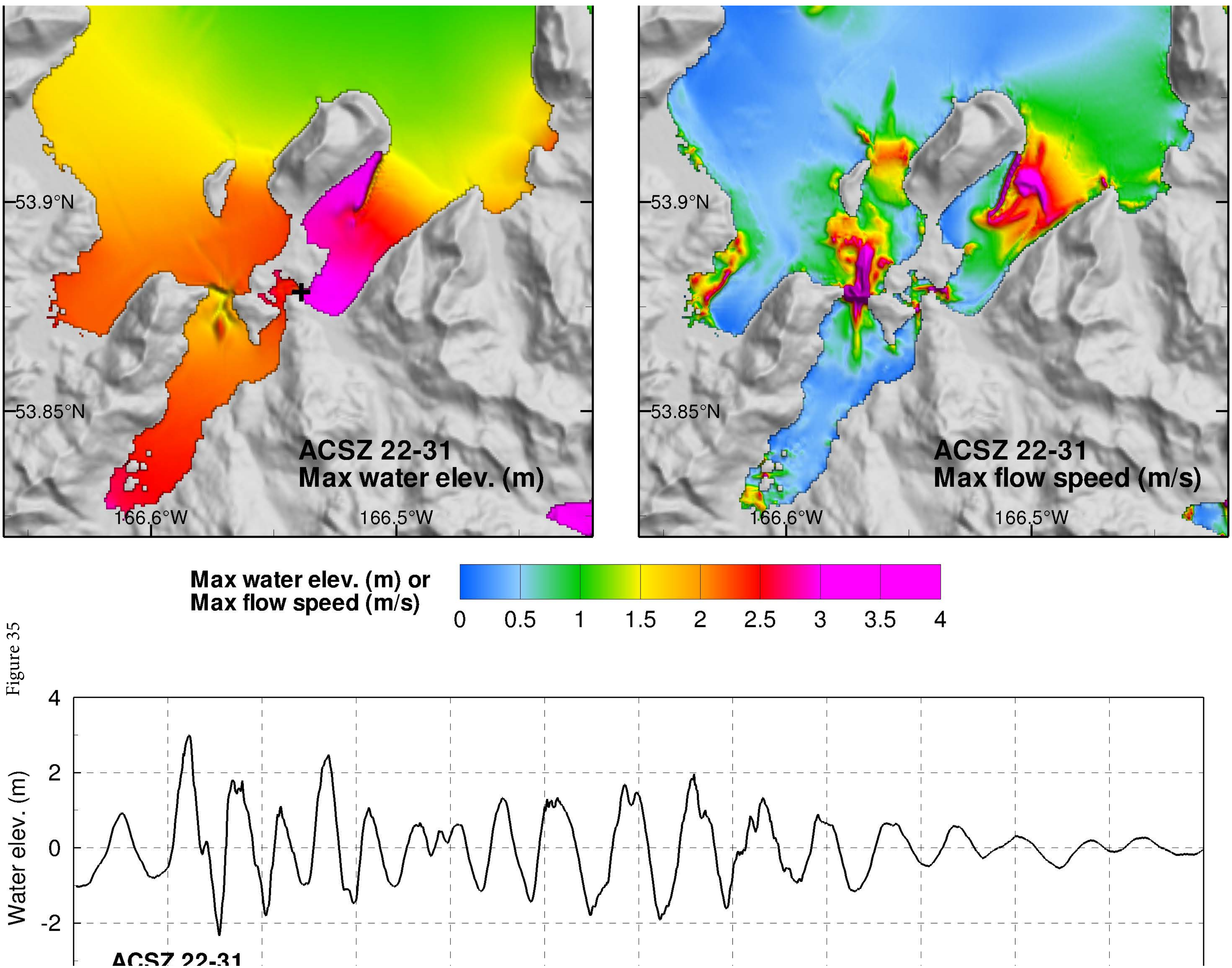
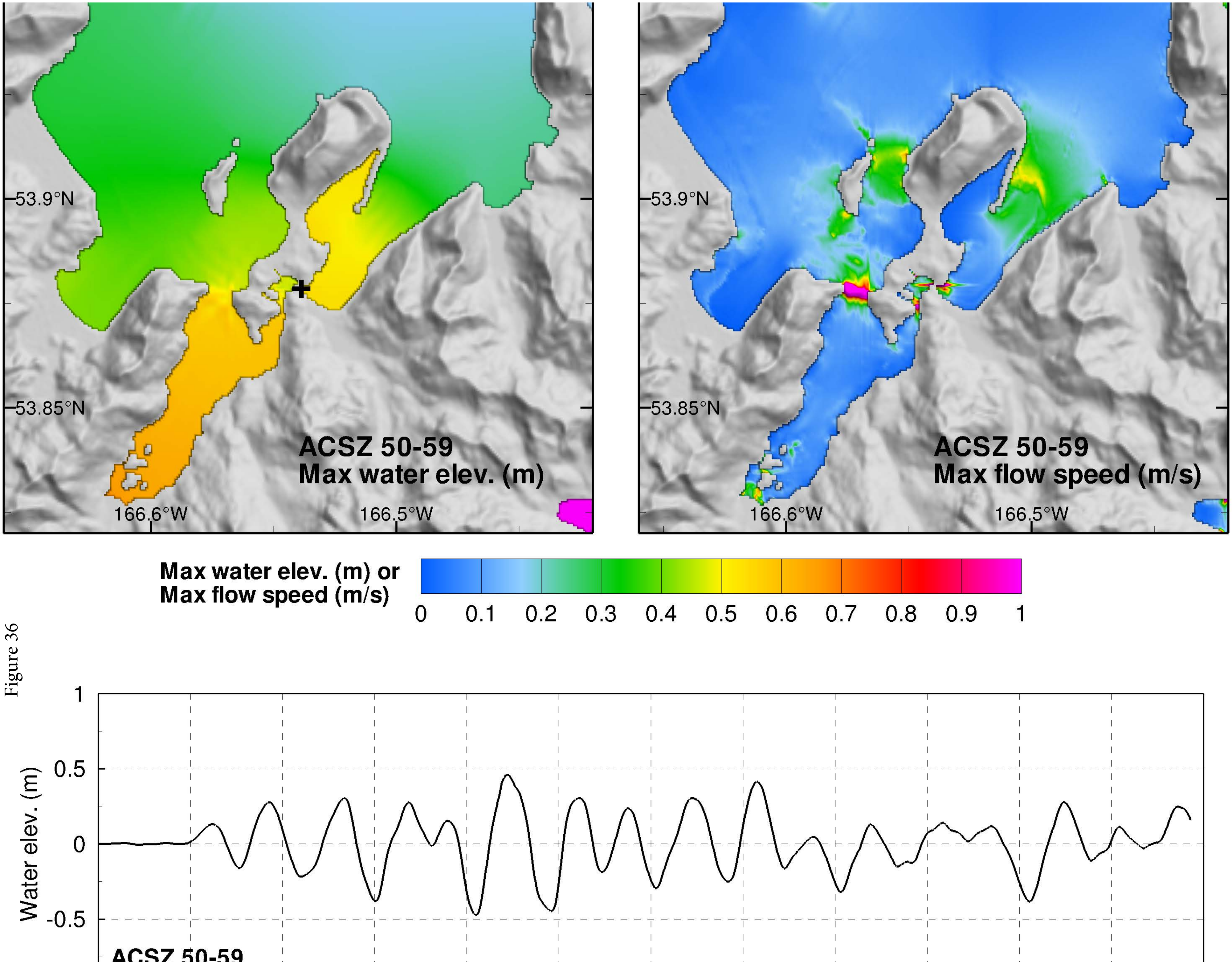

53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 22-31
Max water elev. (m)
ACSZ 22-31
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.5
1
1.5
2
2.5
3
3.5
4
Water elev. (m)
-2
0
2
4
ACSZ 22-31

Figure 35

Figure 36



53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 50-59
Max water elev. (m)
ACSZ 50-59
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
-0.5
0.5
ACSZ 50-59

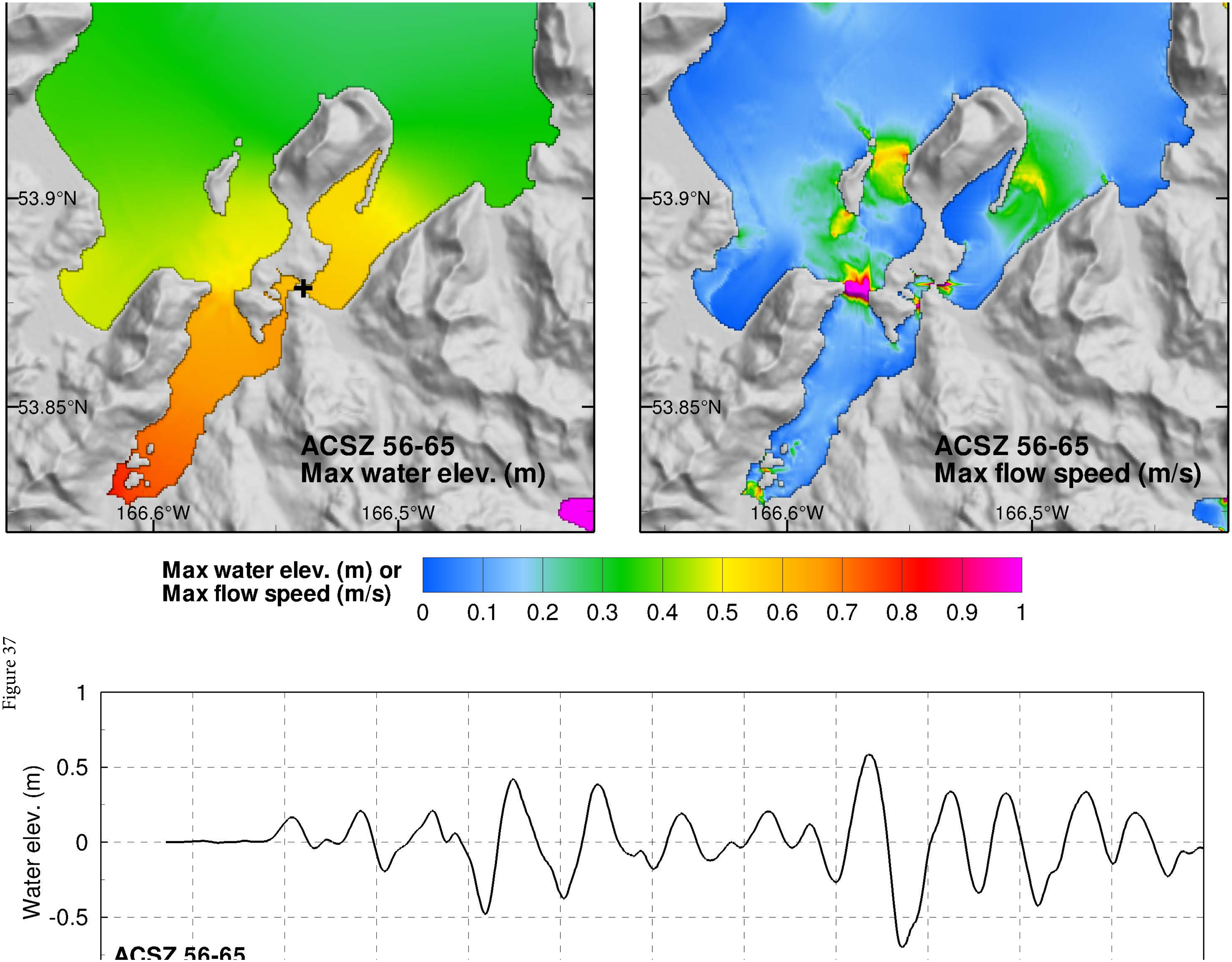

53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 56-65
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
ACSZ 56-65
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
1
0.5
0
-0.5
ACSZ 56-65

Figure 37

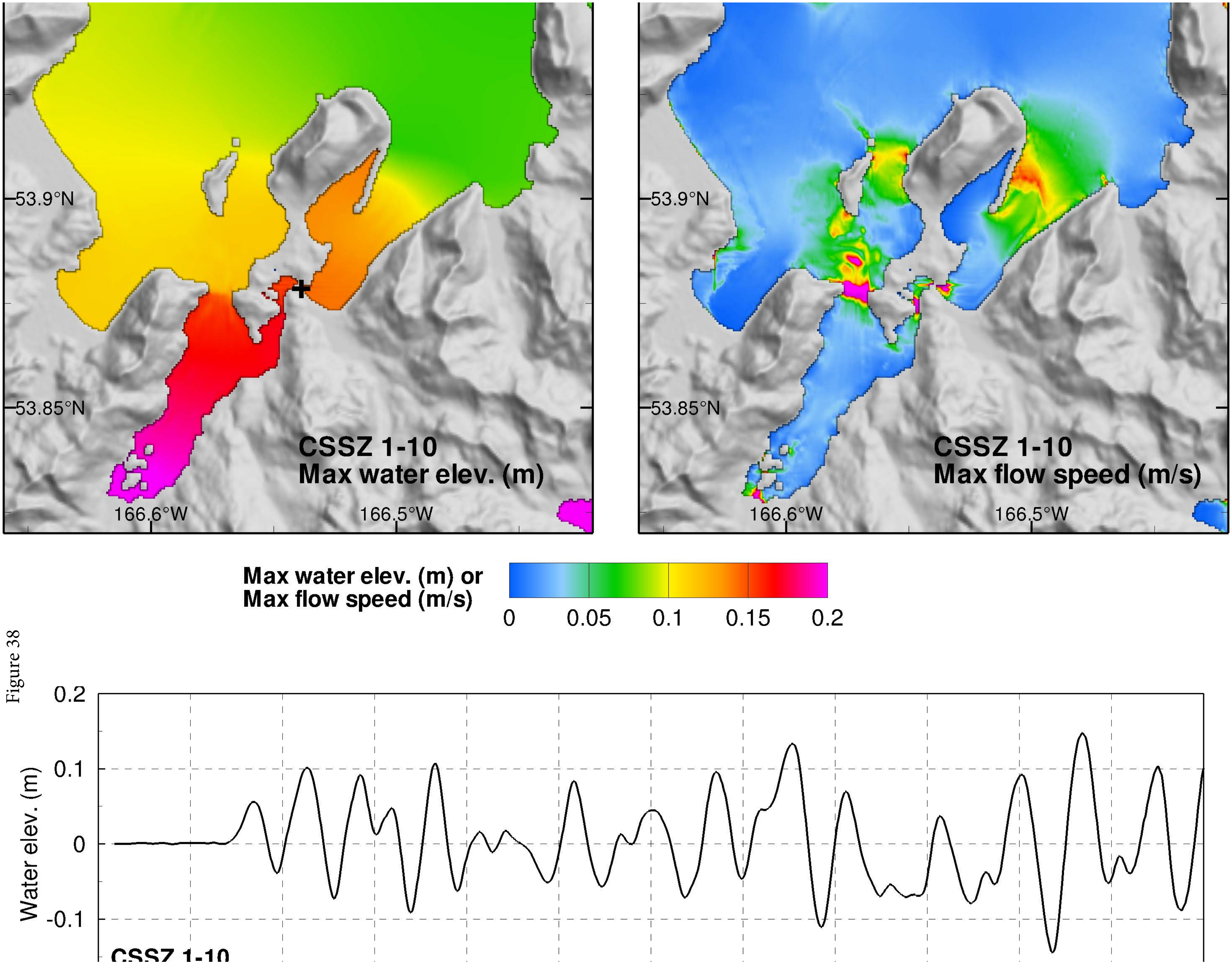

53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 1-10
Max water elev. (m)
CSSZ 1-10
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.05
0.1
0.15
0.2
Water elev. (m)
-0.1
0
0.1
0.2
CSSZ 1-10

Figure 38

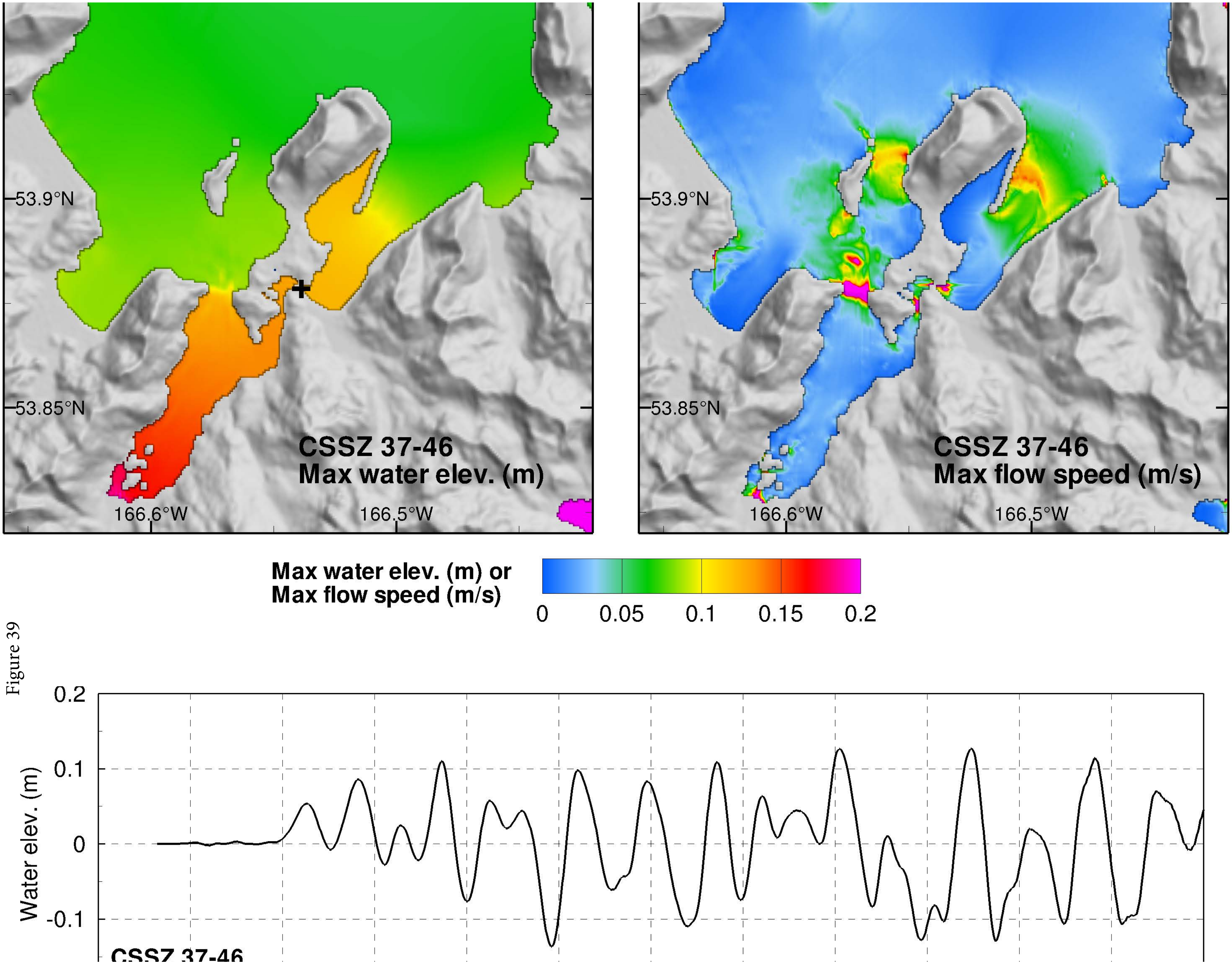
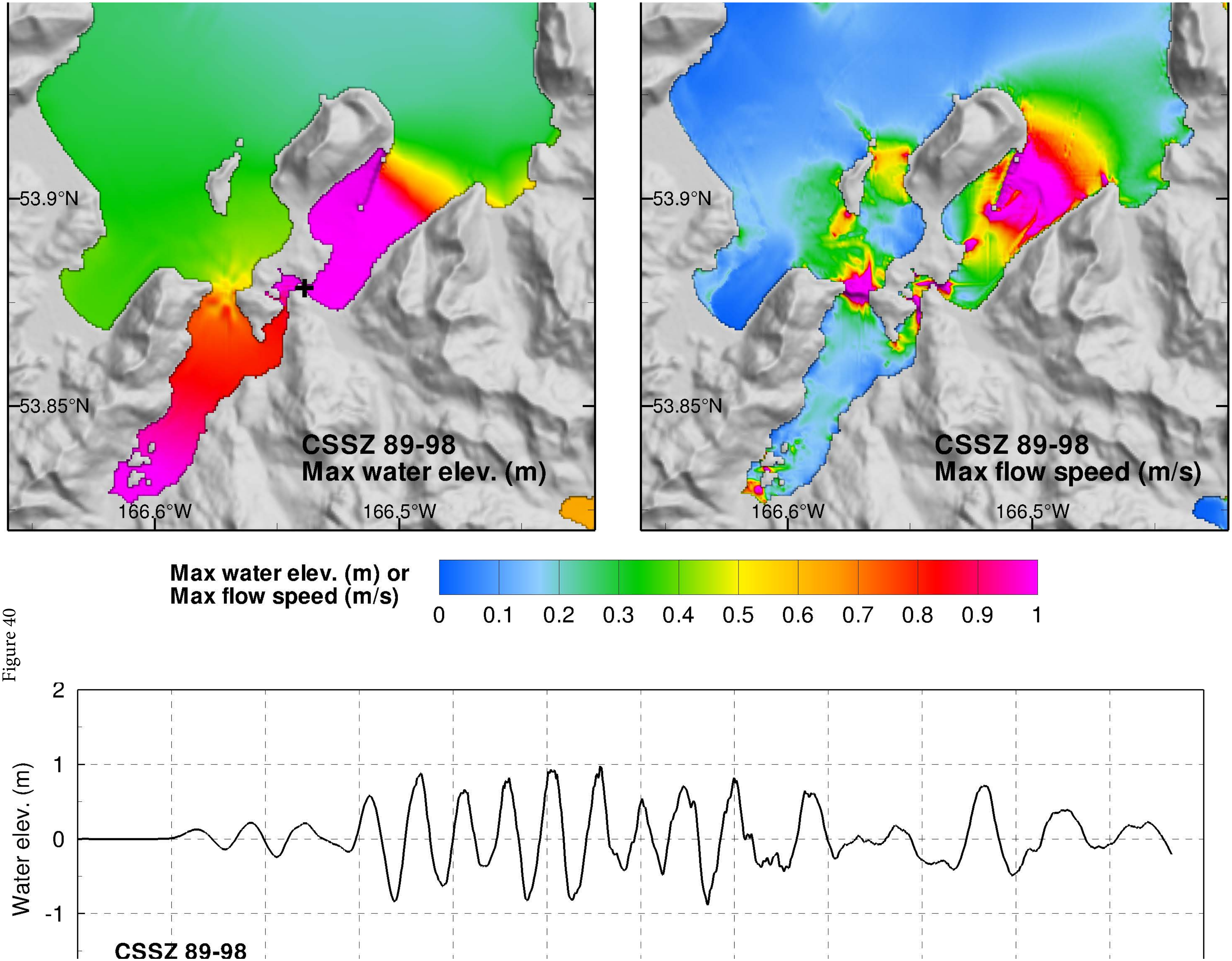

53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 37-46
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 37-46
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.05
0.1
0.15
0.2
Water elev. (m)
0.2
0.1
0
-0.1
CSSZ 37-46

Figure 39

Figure 40



53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 89-98
Max water elev. (m)
53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 89-98
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
2
1
0
-1
CSSZ 89-98

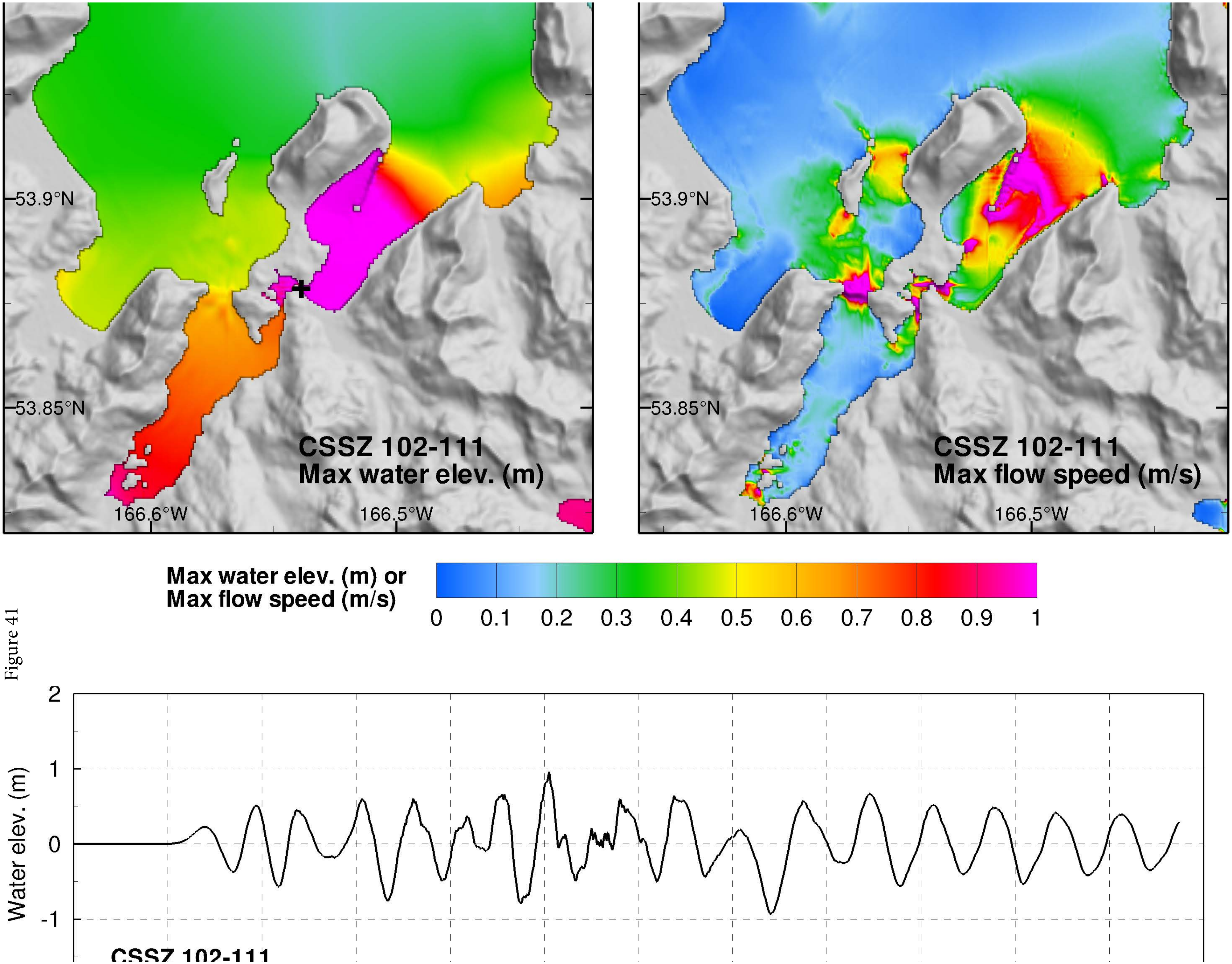
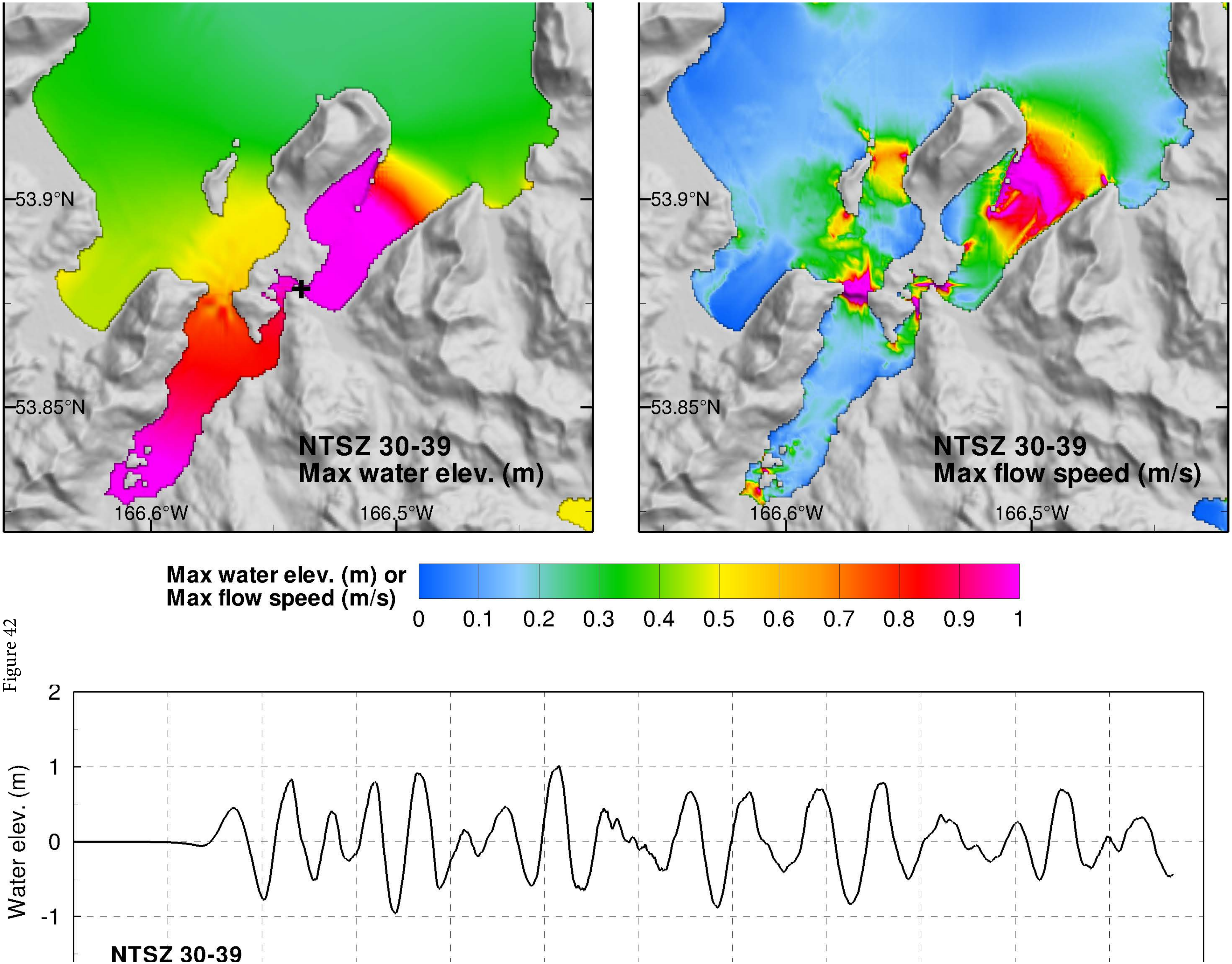

53.9°N
53.85°N
166.6°W
166.5°W
CSSZ 102-111
Max water elev. (m)
CSSZ 102-111
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
2
1
0
-1
CSSZ 102-111

Figure 41



53.9°N
53.85°N
166.6°W
166.5°W
NTSZ 30-39
Max water elev. (m)
NTSZ 30-39
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
2
1
0
-1
NTSZ 30-39

Figure 42

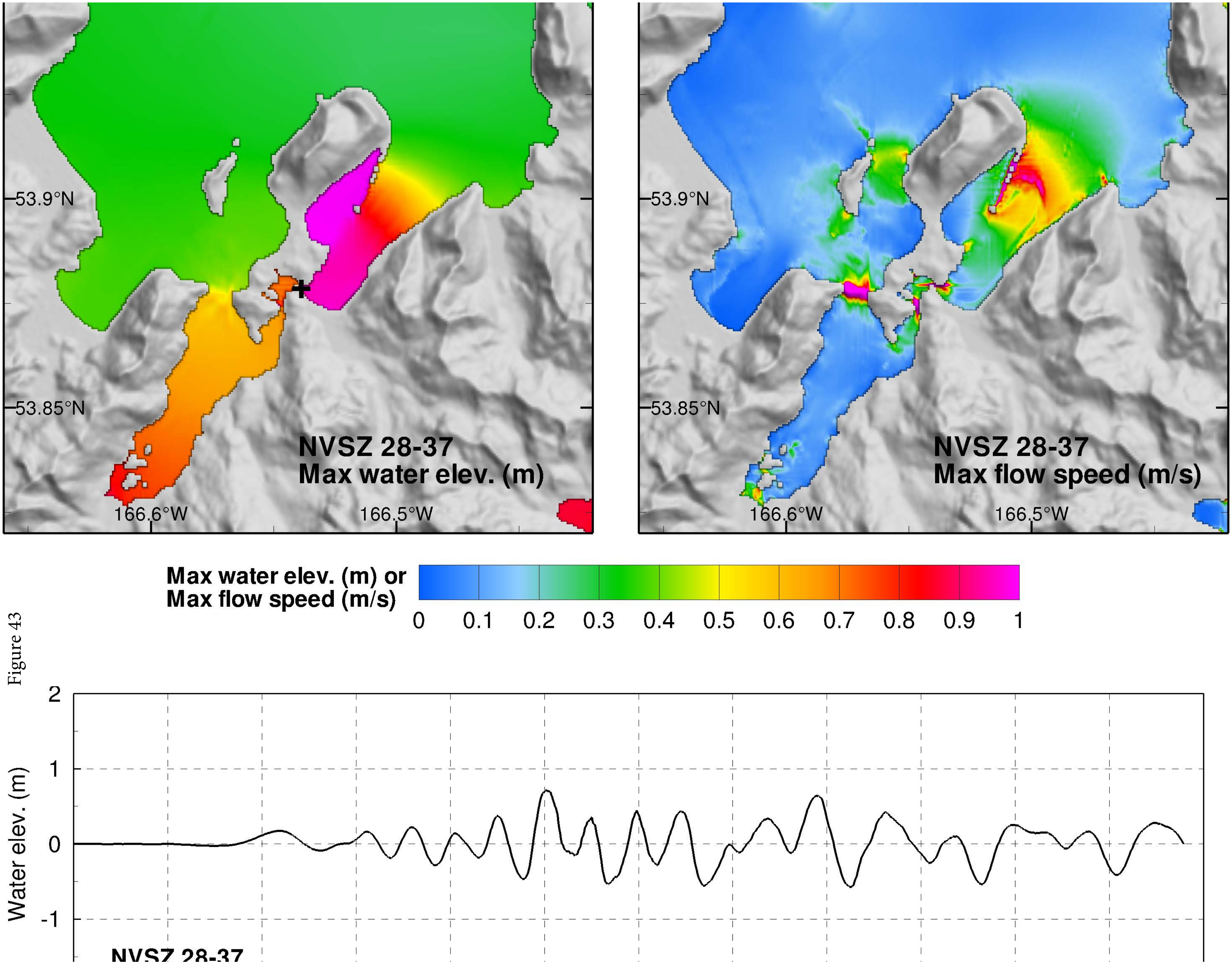
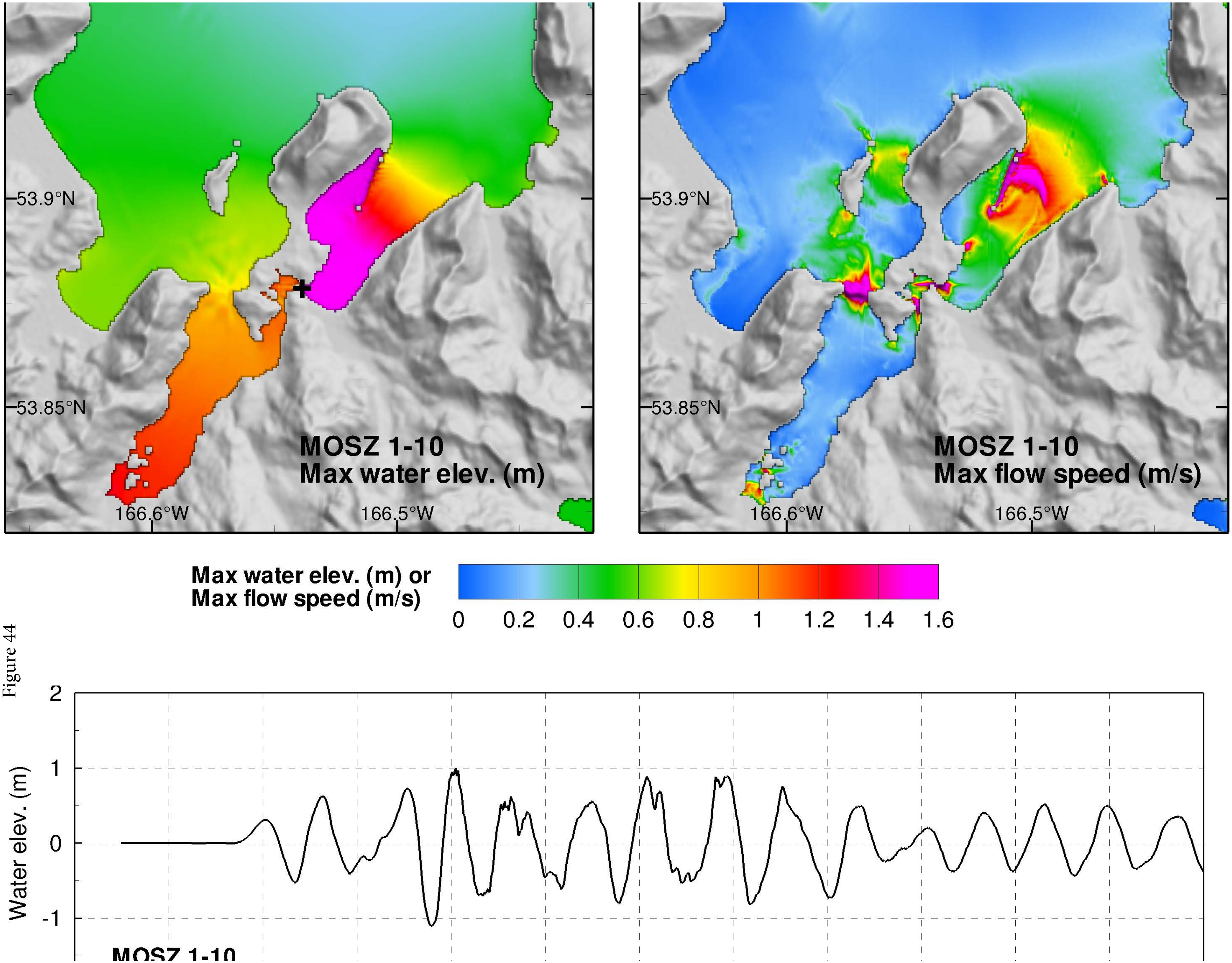

53.9°N
53.85°N
166.6°W
166.5°W
NVSZ 28-37
Max water elev. (m)
NVSZ 28-37
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Water elev. (m)
2
1
0
-1
NVSZ 28-37

Figure 43

Figure 44


53.9°N
53.85°N
166.6°W
166.5°W
MOSZ 1-10
Max water elev. (m)
MOSZ 1-10
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Water elev. (m)
2
1
0
-1
MOSZ 1-10

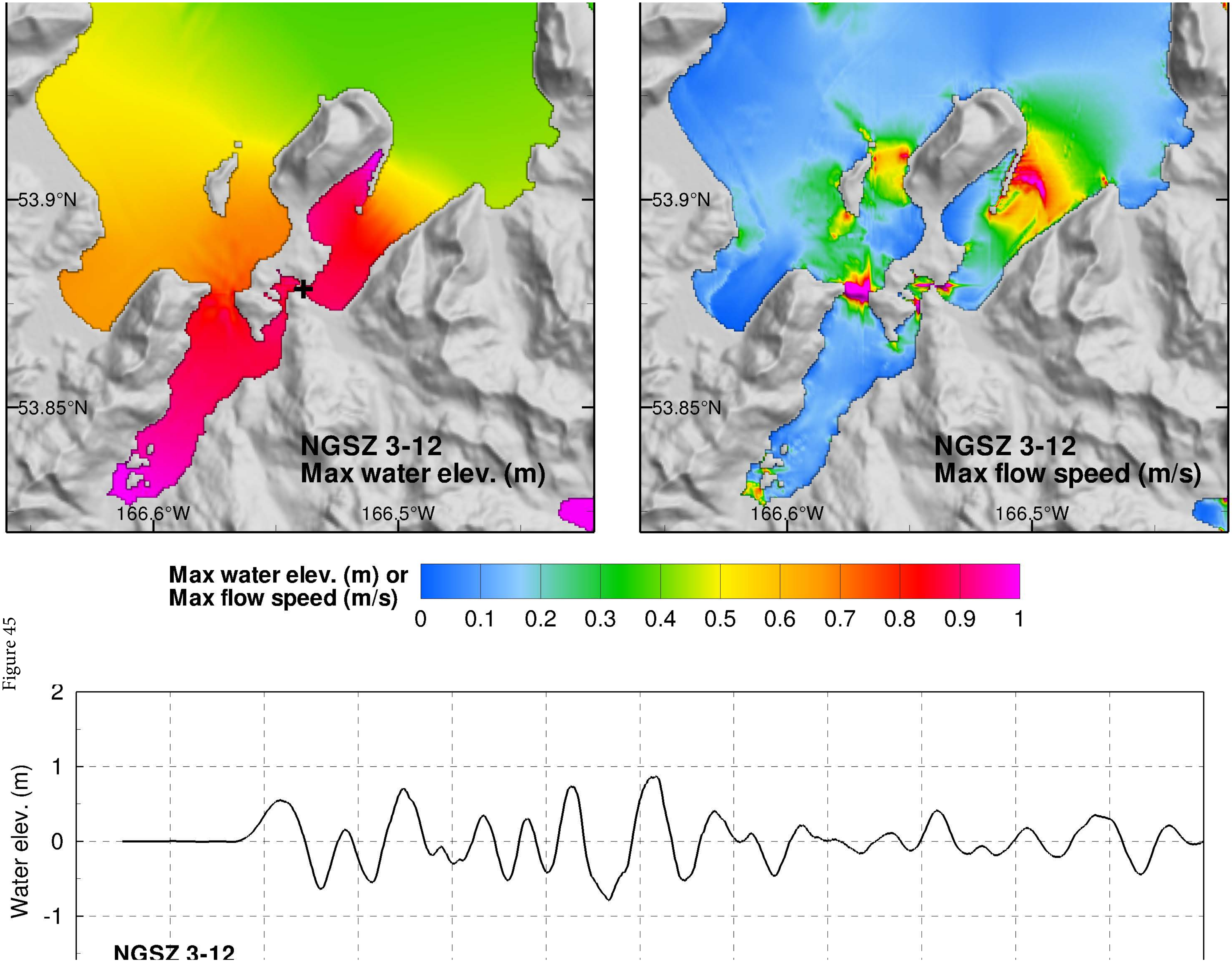
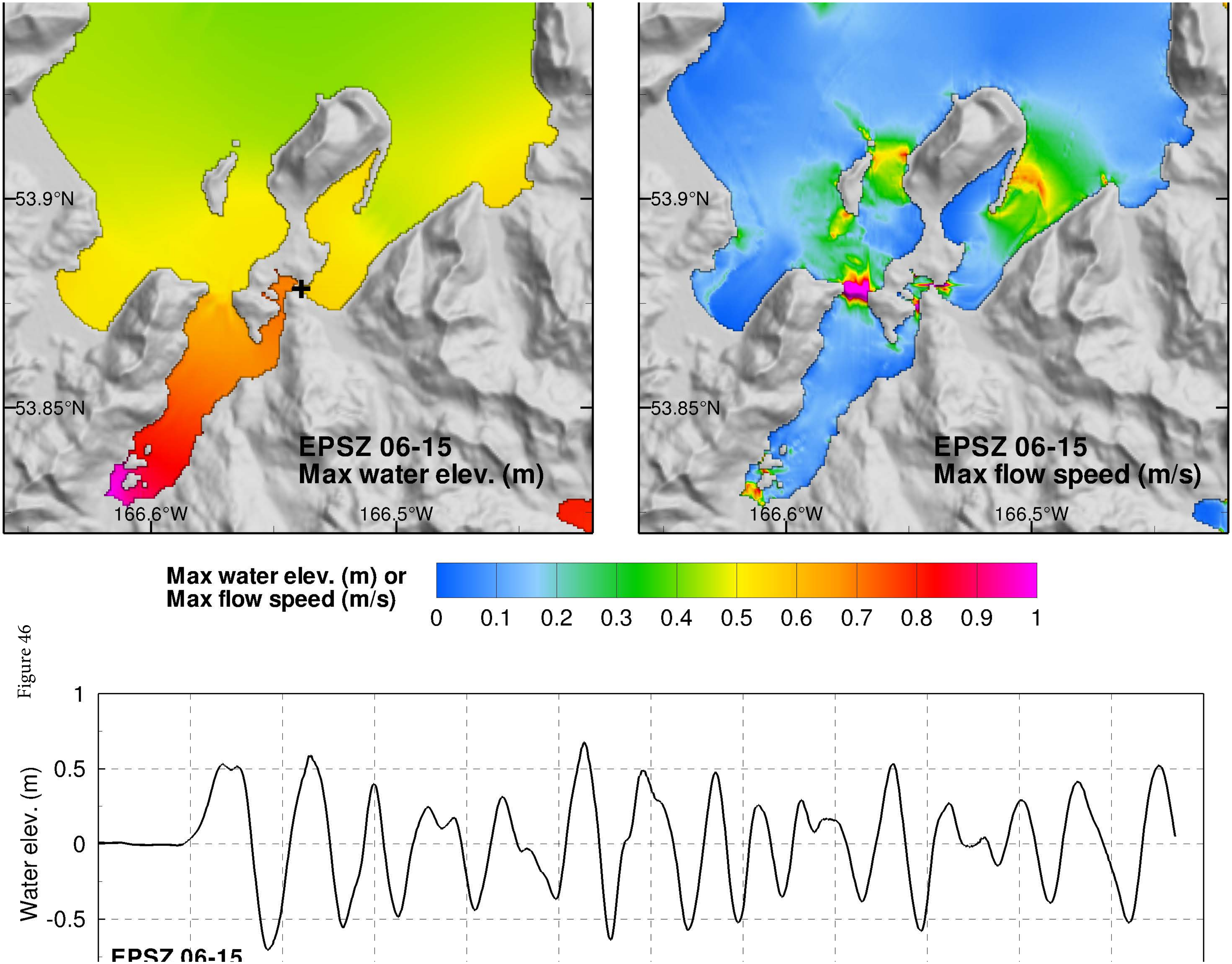

53.9°N
53.85°N
166.6°W
166.5°W
NGSZ 3-12
Max water elev. (m)
NGSZ 3-12
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
2
1
0
-1
NGSZ 3-12

Figure 45

Figure 46


53.9°N
53.85°N
166.6°W
166.5°W
EPSZ 06-15
Max water elev. (m)
EPSZ 06-15
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Water elev. (m)
1
0.5
0
-0.5
EPSZ 06-15

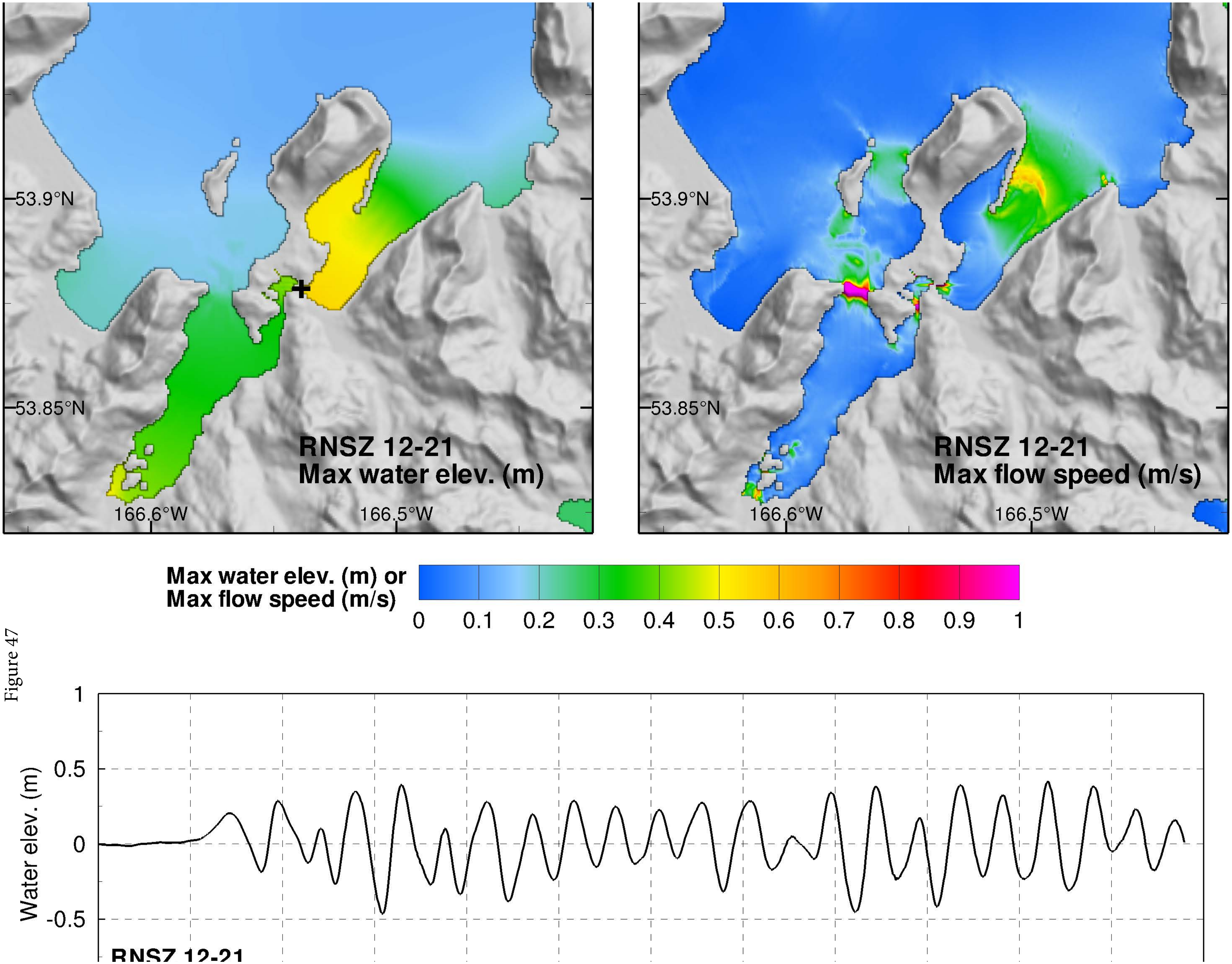

53.9°N
53.85°N
166.6°W
166.5°W
RNSZ 12-21
Max water elev. (m)
RNSZ 12-21
Max flow speed (m/s)
Max water elev. (m) or
Max flow speed (m/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (m)
-0.5
0
0.5
1
RNSZ 12-21

Figure 47

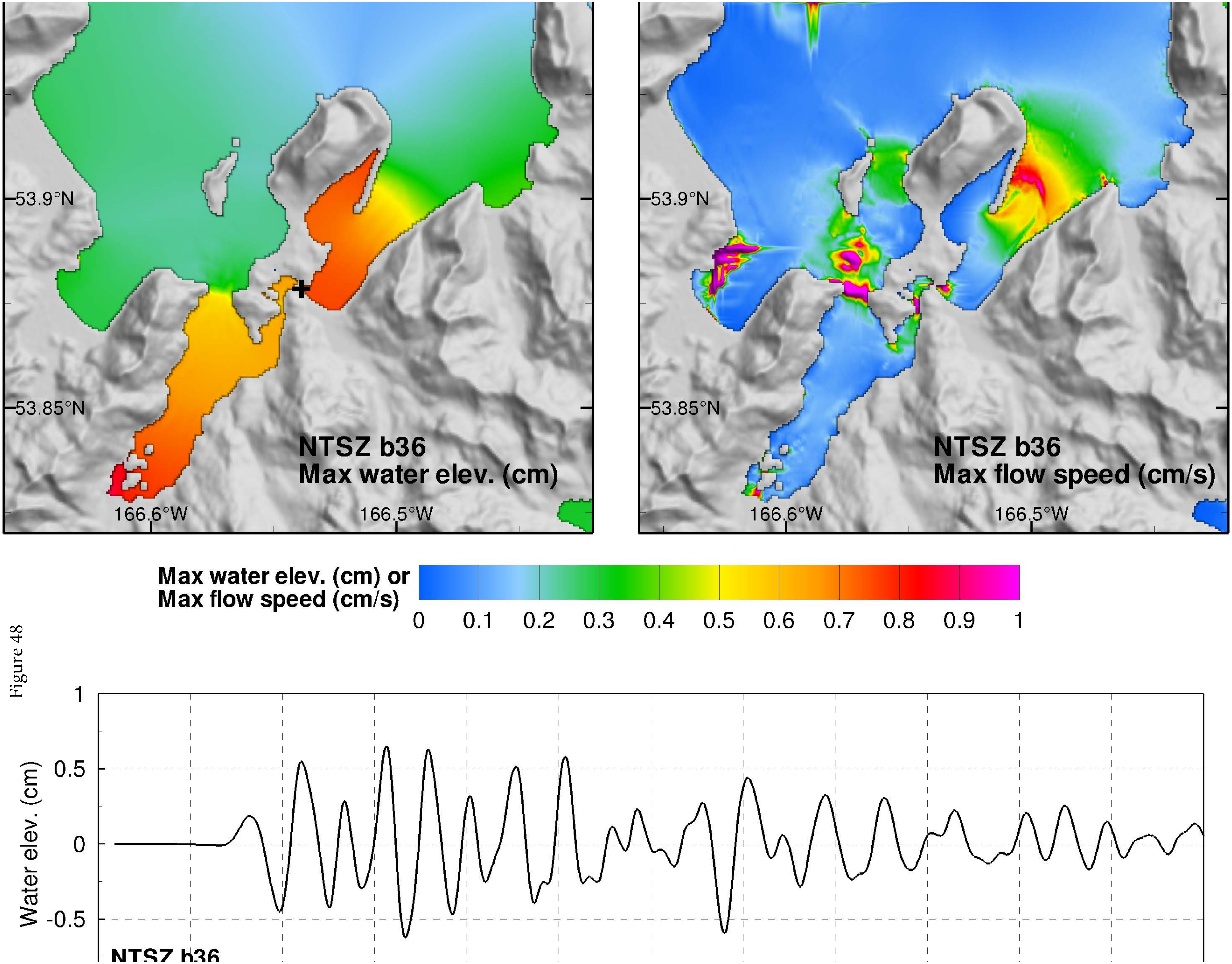

53.9°N
53.85°N
166.6°W
166.5°W
NTSZ b36
Max water elev. (cm)
NTSZ b36
Max flow speed (cm/s)
Max water elev. (cm) or
Max flow speed (cm/s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Water elev. (cm)
-0.5
0.5
NTSZ b36

Figure 48

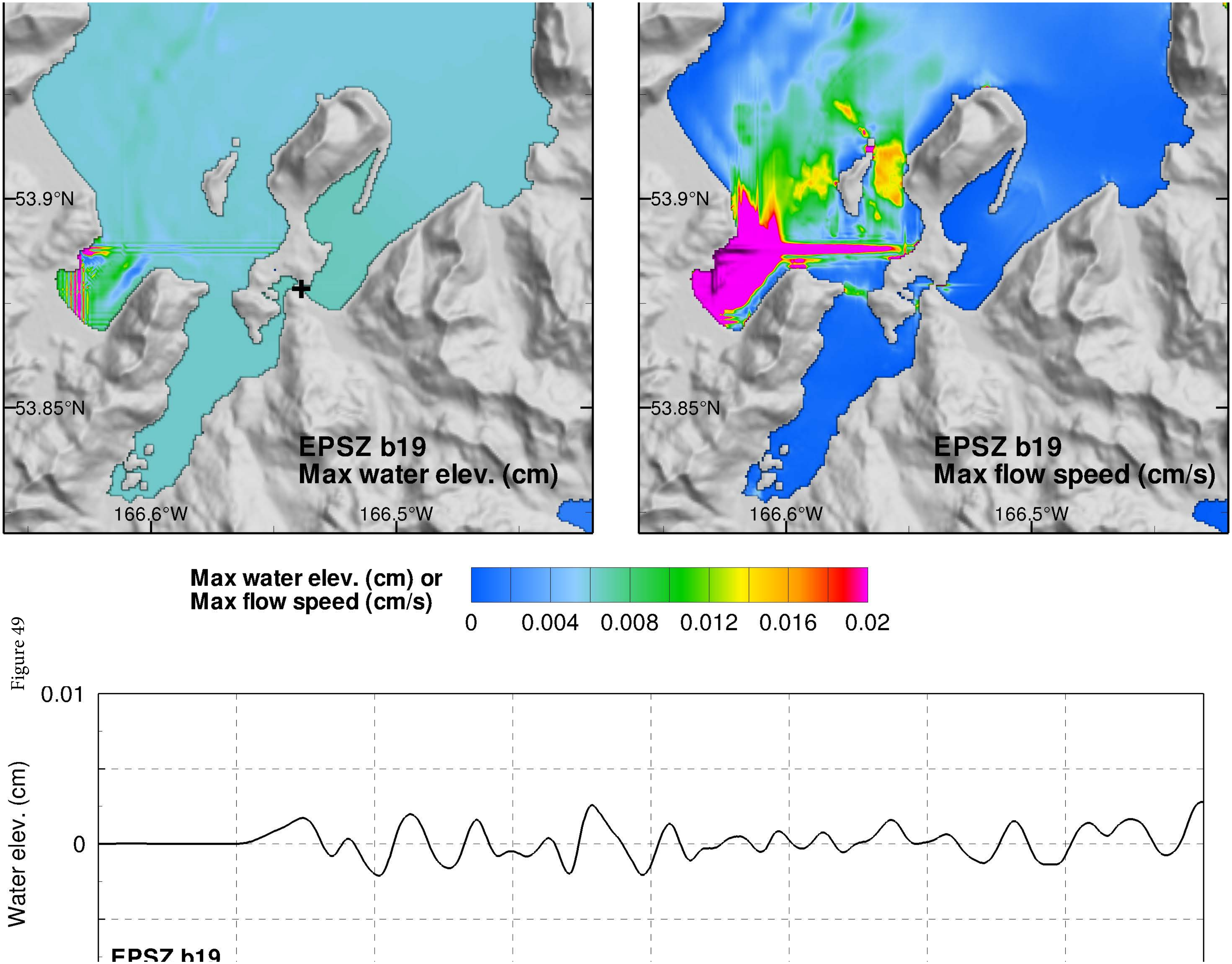

53.9°N
53.85°N
166.6°W
166.5°W
EPSZ b19
Max water elev. (cm)
EPSZ b19
Max flow speed (cm/s)
Max water elev. (cm) or
Max flow speed (cm/s)
0
0.004
0.008
0.012
0.016
0.02
0.01
0
Water elev. (cm)
EPSZ b19

Figure 49

Appendix A.

Development of the Unalaska, Alaska, tsunami forecast model occurred prior to parameter changes that were made to reflect modifications to the MOST model code. As a result, the input file for running both the optimized tsunami forecast model and the high-resolution reference inundation model in MOST have been updated accordingly. Appendix A1 and A2 provide the updated files for Unalaska, Alaska.

A1. Reference model *.in file for Unalaska, Alaska

```
0.001    Minimum amplitude of input offshore wave (m)
1.0  Input minimum depth for offshore (m)
0.1  Input "dry land" depth for inundation (m)
0.001225 Input friction coefficient (n**2)
1    let a and b run up
300.0    blowup limit
0.2  input time step (sec)
108000   input amount of steps
12   Compute "A" arrays every n-th time step, n=
4    COmpute "B" arrays every n-th time step, n=
120  Input number of steps between snapshots
0    ...Starting from
1    ...saveing grid every n-th node, n=
```

A2. Forecast model *.in file for Unalaska, Alaska

```
0.001    Minimum amplitude of input offshore wave (m)
1.0  Input minimum depth for offshore (m)
0.1  Input "dry land" depth for inundation (m)
0.001225 Input friction coefficient (n**2)
1    let a and b run up
300.0    blowup limit
1.0  input time step (sec)
28800    input amount of steps
8    Compute "A" arrays every n-th time step, n=
2    COmpute "B" arrays every n-th time step, n=
32   Input number of steps between snapshots
0    ...Starting from
1    ...saveing grid every n-th node, n=
```

Appendix B. Propagation database:
Pacific Ocean Unit Sources

These propagation source details reflect the database as of February 2013, and there may have been updates in the earthquake source parameters after this date.

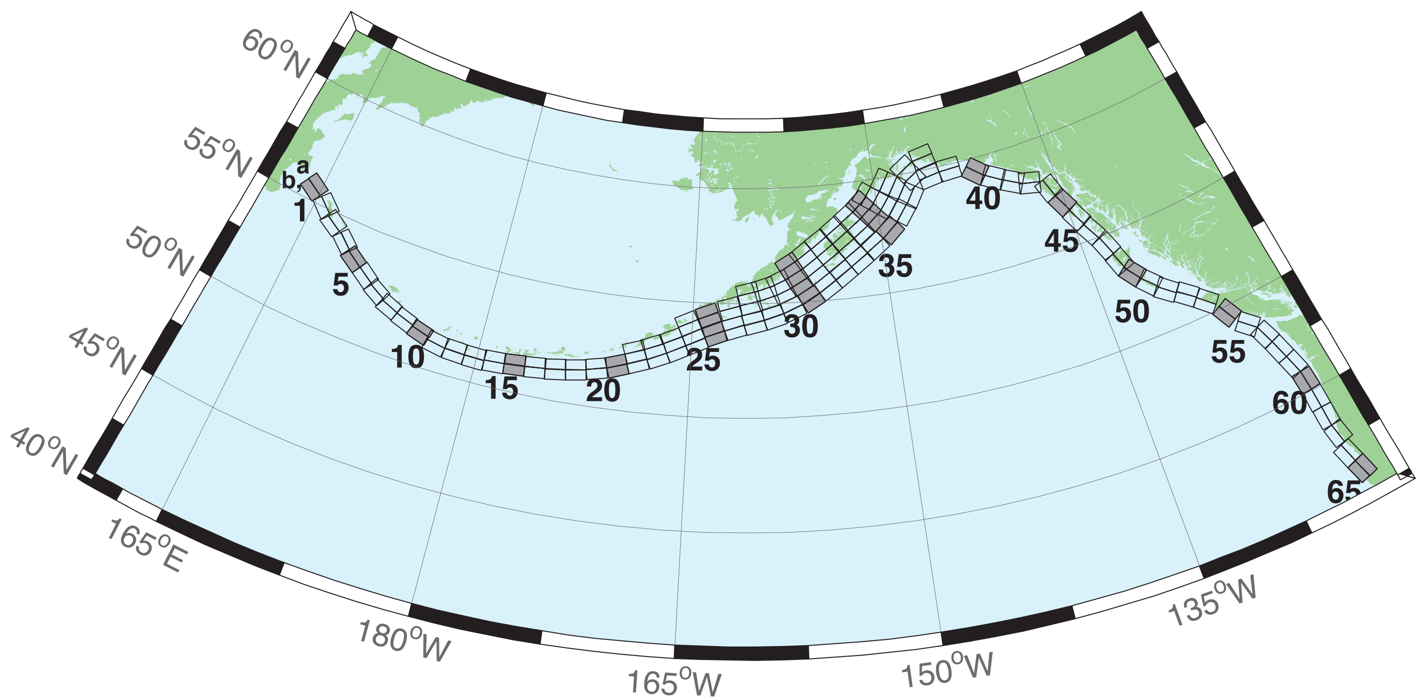


Figure B.1: Aleutian–Alaska–Cascadia Subduction Zone unit sources.

Table B.1: Earthquake parameters for Aleutian–Alaska–Cascadia Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
acsz–1a	Aleutian–Alaska–Cascadia	164.7994	55.9606	299	17	19.61
acsz–1b	Aleutian–Alaska–Cascadia	164.4310	55.5849	299	17	5
acsz–2a	Aleutian–Alaska–Cascadia	166.3418	55.4016	310.2	17	19.61
acsz–2b	Aleutian–Alaska–Cascadia	165.8578	55.0734	310.2	17	5
acsz–3a	Aleutian–Alaska–Cascadia	167.2939	54.8919	300.2	23.36	24.82
acsz–3b	Aleutian–Alaska–Cascadia	166.9362	54.5356	300.2	23.36	5
acsz–4a	Aleutian–Alaska–Cascadia	168.7131	54.2852	310.2	38.51	25.33
acsz–4b	Aleutian–Alaska–Cascadia	168.3269	54.0168	310.2	24	5
acsz–5a	Aleutian–Alaska–Cascadia	169.7447	53.7808	302.8	37.02	23.54
acsz–5b	Aleutian–Alaska–Cascadia	169.4185	53.4793	302.8	21.77	5
acsz–6a	Aleutian–Alaska–Cascadia	171.0144	53.3054	303.2	35.31	22.92
acsz–6b	Aleutian–Alaska–Cascadia	170.6813	52.9986	303.2	21	5
acsz–7a	Aleutian–Alaska–Cascadia	172.1500	52.8528	298.2	35.56	20.16
acsz–7b	Aleutian–Alaska–Cascadia	171.8665	52.5307	298.2	17.65	5
acsz–8a	Aleutian–Alaska–Cascadia	173.2726	52.4579	290.8	37.92	20.35
acsz–8b	Aleutian–Alaska–Cascadia	173.0681	52.1266	290.8	17.88	5
acsz–9a	Aleutian–Alaska–Cascadia	174.5866	52.1434	289	39.09	21.05
acsz–9b	Aleutian–Alaska–Cascadia	174.4027	51.8138	289	18.73	5
acsz–10a	Aleutian–Alaska–Cascadia	175.8784	51.8526	286.1	40.51	20.87
acsz–10b	Aleutian–Alaska–Cascadia	175.7265	51.5245	286.1	18.51	5
acsz–11a	Aleutian–Alaska–Cascadia	177.1140	51.6488	280	15	17.94
acsz–11b	Aleutian–Alaska–Cascadia	176.9937	51.2215	280	15	5
acsz–12a	Aleutian–Alaska–Cascadia	178.4500	51.5690	273	15	17.94
acsz–12b	Aleutian–Alaska–Cascadia	178.4130	51.1200	273	15	5
acsz–13a	Aleutian–Alaska–Cascadia	179.8550	51.5340	271	15	17.94
acsz–13b	Aleutian–Alaska–Cascadia	179.8420	51.0850	271	15	5
acsz–14a	Aleutian–Alaska–Cascadia	181.2340	51.5780	267	15	17.94
acsz–14b	Aleutian–Alaska–Cascadia	181.2720	51.1290	267	15	5
acsz–15a	Aleutian–Alaska–Cascadia	182.6380	51.6470	265	15	17.94
acsz–15b	Aleutian–Alaska–Cascadia	182.7000	51.2000	265	15	5
acsz–16a	Aleutian–Alaska–Cascadia	184.0550	51.7250	264	15	17.94
acsz–16b	Aleutian–Alaska–Cascadia	184.1280	51.2780	264	15	5
acsz–17a	Aleutian–Alaska–Cascadia	185.4560	51.8170	262	15	17.94
acsz–17b	Aleutian–Alaska–Cascadia	185.5560	51.3720	262	15	5
acsz–18a	Aleutian–Alaska–Cascadia	186.8680	51.9410	261	15	17.94
acsz–18b	Aleutian–Alaska–Cascadia	186.9810	51.4970	261	15	5
acsz–19a	Aleutian–Alaska–Cascadia	188.2430	52.1280	257	15	17.94
acsz–19b	Aleutian–Alaska–Cascadia	188.4060	51.6900	257	15	5
acsz–20a	Aleutian–Alaska–Cascadia	189.5810	52.3550	251	15	17.94
acsz–20b	Aleutian–Alaska–Cascadia	189.8180	51.9300	251	15	5
acsz–21a	Aleutian–Alaska–Cascadia	190.9570	52.6470	251	15	17.94
acsz–21b	Aleutian–Alaska–Cascadia	191.1960	52.2220	251	15	5
acsz–21z	Aleutian–Alaska–Cascadia	190.7399	53.0443	250.8	15	30.88
acsz–22a	Aleutian–Alaska–Cascadia	192.2940	52.9430	247	15	17.94
acsz–22b	Aleutian–Alaska–Cascadia	192.5820	52.5300	247	15	5
acsz–22z	Aleutian–Alaska–Cascadia	192.0074	53.3347	247.8	15	30.88
acsz–23a	Aleutian–Alaska–Cascadia	193.6270	53.3070	245	15	17.94
acsz–23b	Aleutian–Alaska–Cascadia	193.9410	52.9000	245	15	5
acsz–23z	Aleutian–Alaska–Cascadia	193.2991	53.6768	244.6	15	30.88
acsz–24a	Aleutian–Alaska–Cascadia	194.9740	53.6870	245	15	17.94
acsz–24b	Aleutian–Alaska–Cascadia	195.2910	53.2800	245	15	5
acsz–24y	Aleutian–Alaska–Cascadia	194.3645	54.4604	244.4	15	43.82
acsz–24z	Aleutian–Alaska–Cascadia	194.6793	54.0674	244.6	15	30.88

Continued on next page

Table B.1 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
acsz–25a	Aleutian–Alaska–Cascadia	196.4340	54.0760	250	15	17.94
acsz–25b	Aleutian–Alaska–Cascadia	196.6930	53.6543	250	15	5
acsz–25y	Aleutian–Alaska–Cascadia	195.9009	54.8572	247.9	15	43.82
acsz–25z	Aleutian–Alaska–Cascadia	196.1761	54.4536	248.1	15	30.88
acsz–26a	Aleutian–Alaska–Cascadia	197.8970	54.3600	253	15	17.94
acsz–26b	Aleutian–Alaska–Cascadia	198.1200	53.9300	253	15	5
acsz–26y	Aleutian–Alaska–Cascadia	197.5498	55.1934	253.1	15	43.82
acsz–26z	Aleutian–Alaska–Cascadia	197.7620	54.7770	253.3	15	30.88
acsz–27a	Aleutian–Alaska–Cascadia	199.4340	54.5960	256	15	17.94
acsz–27b	Aleutian–Alaska–Cascadia	199.6200	54.1600	256	15	5
acsz–27x	Aleutian–Alaska–Cascadia	198.9736	55.8631	256.5	15	56.24
acsz–27y	Aleutian–Alaska–Cascadia	199.1454	55.4401	256.6	15	43.82
acsz–27z	Aleutian–Alaska–Cascadia	199.3135	55.0170	256.8	15	30.88
acsz–28a	Aleutian–Alaska–Cascadia	200.8820	54.8300	253	15	17.94
acsz–28b	Aleutian–Alaska–Cascadia	201.1080	54.4000	253	15	5
acsz–28x	Aleutian–Alaska–Cascadia	200.1929	56.0559	252.5	15	56.24
acsz–28y	Aleutian–Alaska–Cascadia	200.4167	55.6406	252.7	15	43.82
acsz–28z	Aleutian–Alaska–Cascadia	200.6360	55.2249	252.9	15	30.88
acsz–29a	Aleutian–Alaska–Cascadia	202.2610	55.1330	247	15	17.94
acsz–29b	Aleutian–Alaska–Cascadia	202.5650	54.7200	247	15	5
acsz–29x	Aleutian–Alaska–Cascadia	201.2606	56.2861	245.7	15	56.24
acsz–29y	Aleutian–Alaska–Cascadia	201.5733	55.8888	246	15	43.82
acsz–29z	Aleutian–Alaska–Cascadia	201.8797	55.4908	246.2	15	30.88
acsz–30a	Aleutian–Alaska–Cascadia	203.6040	55.5090	240	15	17.94
acsz–30b	Aleutian–Alaska–Cascadia	203.9970	55.1200	240	15	5
acsz–30w	Aleutian–Alaska–Cascadia	201.9901	56.9855	239.5	15	69.12
acsz–30x	Aleutian–Alaska–Cascadia	202.3851	56.6094	239.8	15	56.24
acsz–30y	Aleutian–Alaska–Cascadia	202.7724	56.2320	240.2	15	43.82
acsz–30z	Aleutian–Alaska–Cascadia	203.1521	55.8534	240.5	15	30.88
acsz–31a	Aleutian–Alaska–Cascadia	204.8950	55.9700	236	15	17.94
acsz–31b	Aleutian–Alaska–Cascadia	205.3400	55.5980	236	15	5
acsz–31w	Aleutian–Alaska–Cascadia	203.0825	57.3740	234.5	15	69.12
acsz–31x	Aleutian–Alaska–Cascadia	203.5408	57.0182	234.9	15	56.24
acsz–31y	Aleutian–Alaska–Cascadia	203.9904	56.6607	235.3	15	43.82
acsz–31z	Aleutian–Alaska–Cascadia	204.4315	56.3016	235.7	15	30.88
acsz–32a	Aleutian–Alaska–Cascadia	206.2080	56.4730	236	15	17.94
acsz–32b	Aleutian–Alaska–Cascadia	206.6580	56.1000	236	15	5
acsz–32w	Aleutian–Alaska–Cascadia	204.4129	57.8908	234.3	15	69.12
acsz–32x	Aleutian–Alaska–Cascadia	204.8802	57.5358	234.7	15	56.24
acsz–32y	Aleutian–Alaska–Cascadia	205.3385	57.1792	235.1	15	43.82
acsz–32z	Aleutian–Alaska–Cascadia	205.7880	56.8210	235.5	15	30.88
acsz–33a	Aleutian–Alaska–Cascadia	207.5370	56.9750	236	15	17.94
acsz–33b	Aleutian–Alaska–Cascadia	207.9930	56.6030	236	15	5
acsz–33w	Aleutian–Alaska–Cascadia	205.7126	58.3917	234.2	15	69.12
acsz–33x	Aleutian–Alaska–Cascadia	206.1873	58.0371	234.6	15	56.24
acsz–33y	Aleutian–Alaska–Cascadia	206.6527	57.6808	235	15	43.82
acsz–33z	Aleutian–Alaska–Cascadia	207.1091	57.3227	235.4	15	30.88
acsz–34a	Aleutian–Alaska–Cascadia	208.9371	57.5124	236	15	17.94
acsz–34b	Aleutian–Alaska–Cascadia	209.4000	57.1400	236	15	5
acsz–34w	Aleutian–Alaska–Cascadia	206.9772	58.8804	233.5	15	69.12
acsz–34x	Aleutian–Alaska–Cascadia	207.4677	58.5291	233.9	15	56.24
acsz–34y	Aleutian–Alaska–Cascadia	207.9485	58.1760	234.3	15	43.82
acsz–34z	Aleutian–Alaska–Cascadia	208.4198	57.8213	234.7	15	30.88
acsz–35a	Aleutian–Alaska–Cascadia	210.2597	58.0441	230	15	17.94
acsz–35b	Aleutian–Alaska–Cascadia	210.8000	57.7000	230	15	5

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Table B.1 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
acsz–35w	Aleutian–Alaska–Cascadia	208.0204	59.3199	228.8	15	69.12
acsz–35x	Aleutian–Alaska–Cascadia	208.5715	58.9906	229.3	15	56.24
acsz–35y	Aleutian–Alaska–Cascadia	209.1122	58.6590	229.7	15	43.82
acsz–35z	Aleutian–Alaska–Cascadia	209.6425	58.3252	230.2	15	30.88
acsz–36a	Aleutian–Alaska–Cascadia	211.3249	58.6565	218	15	17.94
acsz–36b	Aleutian–Alaska–Cascadia	212.0000	58.3800	218	15	5
acsz–36w	Aleutian–Alaska–Cascadia	208.5003	59.5894	215.6	15	69.12
acsz–36x	Aleutian–Alaska–Cascadia	209.1909	59.3342	216.2	15	56.24
acsz–36y	Aleutian–Alaska–Cascadia	209.8711	59.0753	216.8	15	43.82
acsz–36z	Aleutian–Alaska–Cascadia	210.5412	58.8129	217.3	15	30.88
acsz–37a	Aleutian–Alaska–Cascadia	212.2505	59.2720	213.7	15	17.94
acsz–37b	Aleutian–Alaska–Cascadia	212.9519	59.0312	213.7	15	5
acsz–37x	Aleutian–Alaska–Cascadia	210.1726	60.0644	213	15	56.24
acsz–37y	Aleutian–Alaska–Cascadia	210.8955	59.8251	213.7	15	43.82
acsz–37z	Aleutian–Alaska–Cascadia	211.6079	59.5820	214.3	15	30.88
acsz–38a	Aleutian–Alaska–Cascadia	214.6555	60.1351	260.1	0	15
acsz–38b	Aleutian–Alaska–Cascadia	214.8088	59.6927	260.1	0	15
acsz–38y	Aleutian–Alaska–Cascadia	214.3737	60.9838	259	0	15
acsz–38z	Aleutian–Alaska–Cascadia	214.5362	60.5429	259	0	15
acsz–39a	Aleutian–Alaska–Cascadia	216.5607	60.2480	267	0	15
acsz–39b	Aleutian–Alaska–Cascadia	216.6068	59.7994	267	0	15
acsz–40a	Aleutian–Alaska–Cascadia	219.3069	59.7574	310.9	0	15
acsz–40b	Aleutian–Alaska–Cascadia	218.7288	59.4180	310.9	0	15
acsz–41a	Aleutian–Alaska–Cascadia	220.4832	59.3390	300.7	0	15
acsz–41b	Aleutian–Alaska–Cascadia	220.0382	58.9529	300.7	0	15
acsz–42a	Aleutian–Alaska–Cascadia	221.8835	58.9310	298.9	0	15
acsz–42b	Aleutian–Alaska–Cascadia	221.4671	58.5379	298.9	0	15
acsz–43a	Aleutian–Alaska–Cascadia	222.9711	58.6934	282.3	0	15
acsz–43b	Aleutian–Alaska–Cascadia	222.7887	58.2546	282.3	0	15
acsz–44a	Aleutian–Alaska–Cascadia	224.9379	57.9054	340.9	12	11.09
acsz–44b	Aleutian–Alaska–Cascadia	224.1596	57.7617	340.9	7	5
acsz–45a	Aleutian–Alaska–Cascadia	225.4994	57.1634	334.1	12	11.09
acsz–45b	Aleutian–Alaska–Cascadia	224.7740	56.9718	334.1	7	5
acsz–46a	Aleutian–Alaska–Cascadia	226.1459	56.3552	334.1	12	11.09
acsz–46b	Aleutian–Alaska–Cascadia	225.4358	56.1636	334.1	7	5
acsz–47a	Aleutian–Alaska–Cascadia	226.7731	55.5830	332.3	12	11.09
acsz–47b	Aleutian–Alaska–Cascadia	226.0887	55.3785	332.3	7	5
acsz–48a	Aleutian–Alaska–Cascadia	227.4799	54.6763	339.4	12	11.09
acsz–48b	Aleutian–Alaska–Cascadia	226.7713	54.5217	339.4	7	5
acsz–49a	Aleutian–Alaska–Cascadia	227.9482	53.8155	341.2	12	11.09
acsz–49b	Aleutian–Alaska–Cascadia	227.2462	53.6737	341.2	7	5
acsz–50a	Aleutian–Alaska–Cascadia	228.3970	53.2509	324.5	12	11.09
acsz–50b	Aleutian–Alaska–Cascadia	227.8027	52.9958	324.5	7	5
acsz–51a	Aleutian–Alaska–Cascadia	229.1844	52.6297	318.4	12	11.09
acsz–51b	Aleutian–Alaska–Cascadia	228.6470	52.3378	318.4	7	5
acsz–52a	Aleutian–Alaska–Cascadia	230.0306	52.0768	310.9	12	11.09
acsz–52b	Aleutian–Alaska–Cascadia	229.5665	51.7445	310.9	7	5
acsz–53a	Aleutian–Alaska–Cascadia	231.1735	51.5258	310.9	12	11.09
acsz–53b	Aleutian–Alaska–Cascadia	230.7150	51.1935	310.9	7	5
acsz–54a	Aleutian–Alaska–Cascadia	232.2453	50.8809	314.1	12	11.09
acsz–54b	Aleutian–Alaska–Cascadia	231.7639	50.5655	314.1	7	5
acsz–55a	Aleutian–Alaska–Cascadia	233.3066	49.9032	333.7	12	11.09
acsz–55b	Aleutian–Alaska–Cascadia	232.6975	49.7086	333.7	7	5
acsz–56a	Aleutian–Alaska–Cascadia	234.0588	49.1702	315	11	12.82
acsz–56b	Aleutian–Alaska–Cascadia	233.5849	48.8584	315	9	5

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Table B.1 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
acsz–57a	Aleutian–Alaska–Cascadia	234.9041	48.2596	341	11	12.82
acsz–57b	Aleutian–Alaska–Cascadia	234.2797	48.1161	341	9	5
acsz–58a	Aleutian–Alaska–Cascadia	235.3021	47.3812	344	11	12.82
acsz–58b	Aleutian–Alaska–Cascadia	234.6776	47.2597	344	9	5
acsz–59a	Aleutian–Alaska–Cascadia	235.6432	46.5082	345	11	12.82
acsz–59b	Aleutian–Alaska–Cascadia	235.0257	46.3941	345	9	5
acsz–60a	Aleutian–Alaska–Cascadia	235.8640	45.5429	356	11	12.82
acsz–60b	Aleutian–Alaska–Cascadia	235.2363	45.5121	356	9	5
acsz–61a	Aleutian–Alaska–Cascadia	235.9106	44.6227	359	11	12.82
acsz–61b	Aleutian–Alaska–Cascadia	235.2913	44.6150	359	9	5
acsz–62a	Aleutian–Alaska–Cascadia	235.9229	43.7245	359	11	12.82
acsz–62b	Aleutian–Alaska–Cascadia	235.3130	43.7168	359	9	5
acsz–63a	Aleutian–Alaska–Cascadia	236.0220	42.9020	350	11	12.82
acsz–63b	Aleutian–Alaska–Cascadia	235.4300	42.8254	350	9	5
acsz–64a	Aleutian–Alaska–Cascadia	235.9638	41.9818	345	11	12.82
acsz–64b	Aleutian–Alaska–Cascadia	235.3919	41.8677	345	9	5
acsz–65a	Aleutian–Alaska–Cascadia	236.2643	41.1141	345	11	12.82
acsz–65b	Aleutian–Alaska–Cascadia	235.7000	41.0000	345	9	5
acsz–238a	Aleutian–Alaska–Cascadia	213.2878	59.8406	236.8	15	17.94
acsz–238y	Aleutian–Alaska–Cascadia	212.3424	60.5664	236.8	15	43.82
acsz–238z	Aleutian–Alaska–Cascadia	212.8119	60.2035	236.8	15	30.88

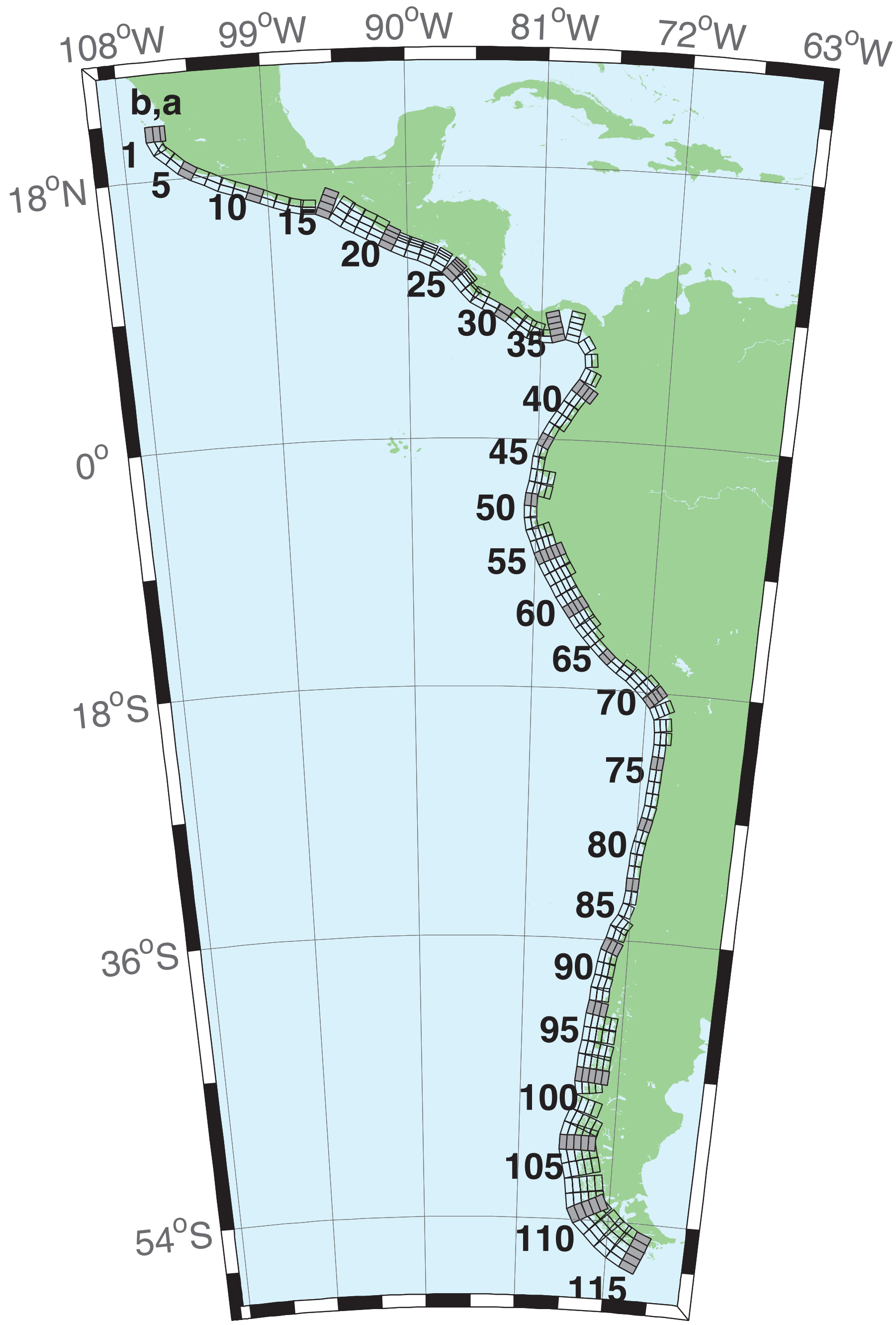

Figure B.2: Central and South America Subduction Zone unit sources.

Table B.2: Earthquake parameters for Central and South America Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–1a	Central and South America	254.4573	20.8170	359	19	15.4
cssz–1b	Central and South America	254.0035	20.8094	359	12	5
cssz–1z	Central and South America	254.7664	20.8222	359	50	31.67
cssz–2a	Central and South America	254.5765	20.2806	336.8	19	15.4
cssz–2b	Central and South America	254.1607	20.1130	336.8	12	5
cssz–3a	Central and South America	254.8789	19.8923	310.6	18.31	15.27
cssz–3b	Central and South America	254.5841	19.5685	310.6	11.85	5
cssz–4a	Central and South America	255.6167	19.2649	313.4	17.62	15.12
cssz–4b	Central and South America	255.3056	18.9537	313.4	11.68	5
cssz–5a	Central and South America	256.2240	18.8148	302.7	16.92	15
cssz–5b	Central and South America	255.9790	18.4532	302.7	11.54	5
cssz–6a	Central and South America	256.9425	18.4383	295.1	16.23	14.87
cssz–6b	Central and South America	256.7495	18.0479	295.1	11.38	5
cssz–7a	Central and South America	257.8137	18.0339	296.9	15.54	14.74
cssz–7b	Central and South America	257.6079	17.6480	296.9	11.23	5
cssz–8a	Central and South America	258.5779	17.7151	290.4	14.85	14.61
cssz–8b	Central and South America	258.4191	17.3082	290.4	11.08	5
cssz–9a	Central and South America	259.4578	17.4024	290.5	14.15	14.47
cssz–9b	Central and South America	259.2983	16.9944	290.5	10.92	5
cssz–10a	Central and South America	260.3385	17.0861	290.8	13.46	14.34
cssz–10b	Central and South America	260.1768	16.6776	290.8	10.77	5
cssz–11a	Central and South America	261.2255	16.7554	291.8	12.77	14.21
cssz–11b	Central and South America	261.0556	16.3487	291.8	10.62	5
cssz–12a	Central and South America	262.0561	16.4603	288.9	12.08	14.08
cssz–12b	Central and South America	261.9082	16.0447	288.9	10.46	5
cssz–13a	Central and South America	262.8638	16.2381	283.2	11.38	13.95
cssz–13b	Central and South America	262.7593	15.8094	283.2	10.31	5
cssz–14a	Central and South America	263.6066	16.1435	272.1	10.69	13.81
cssz–14b	Central and South America	263.5901	15.7024	272.1	10.15	5
cssz–15a	Central and South America	264.8259	15.8829	293	10	13.68
cssz–15b	Central and South America	264.6462	15.4758	293	10	5
cssz–15y	Central and South America	265.1865	16.6971	293	10	31.05
cssz–15z	Central and South America	265.0060	16.2900	293	10	22.36
cssz–16a	Central and South America	265.7928	15.3507	304.9	15	15.82
cssz–16b	Central and South America	265.5353	14.9951	304.9	12.5	5
cssz–16y	Central and South America	266.3092	16.0619	304.9	15	41.7
cssz–16z	Central and South America	266.0508	15.7063	304.9	15	28.76
cssz–17a	Central and South America	266.4947	14.9019	299.5	20	17.94
cssz–17b	Central and South America	266.2797	14.5346	299.5	15	5
cssz–17y	Central and South America	266.9259	15.6365	299.5	20	52.14
cssz–17z	Central and South America	266.7101	15.2692	299.5	20	35.04
cssz–18a	Central and South America	267.2827	14.4768	298	21.5	17.94
cssz–18b	Central and South America	267.0802	14.1078	298	15	5
cssz–18y	Central and South America	267.6888	15.2148	298	21.5	54.59
cssz–18z	Central and South America	267.4856	14.8458	298	21.5	36.27
cssz–19a	Central and South America	268.0919	14.0560	297.6	23	17.94
cssz–19b	Central and South America	267.8943	13.6897	297.6	15	5
cssz–19y	Central and South America	268.4880	14.7886	297.6	23	57.01
cssz–19z	Central and South America	268.2898	14.4223	297.6	23	37.48
cssz–20a	Central and South America	268.8929	13.6558	296.2	24	17.94
cssz–20b	Central and South America	268.7064	13.2877	296.2	15	5
cssz–20y	Central and South America	269.1796	14.2206	296.2	45.5	73.94
cssz–20z	Central and South America	269.0362	13.9382	296.2	45.5	38.28

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Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–21a	Central and South America	269.6797	13.3031	292.6	25	17.94
cssz–21b	Central and South America	269.5187	12.9274	292.6	15	5
cssz–21x	Central and South America	269.8797	13.7690	292.6	68	131.8
cssz–21y	Central and South America	269.8130	13.6137	292.6	68	85.43
cssz–21z	Central and South America	269.7463	13.4584	292.6	68	39.07
cssz–22a	Central and South America	270.4823	13.0079	288.6	25	17.94
cssz–22b	Central and South America	270.3492	12.6221	288.6	15	5
cssz–22x	Central and South America	270.6476	13.4864	288.6	68	131.8
cssz–22y	Central and South America	270.5925	13.3269	288.6	68	85.43
cssz–22z	Central and South America	270.5374	13.1674	288.6	68	39.07
cssz–23a	Central and South America	271.3961	12.6734	292.4	25	17.94
cssz–23b	Central and South America	271.2369	12.2972	292.4	15	5
cssz–23x	Central and South America	271.5938	13.1399	292.4	68	131.8
cssz–23y	Central and South America	271.5279	12.9844	292.4	68	85.43
cssz–23z	Central and South America	271.4620	12.8289	292.4	68	39.07
cssz–24a	Central and South America	272.3203	12.2251	300.2	25	17.94
cssz–24b	Central and South America	272.1107	11.8734	300.2	15	5
cssz–24x	Central and South America	272.5917	12.6799	300.2	67	131.1
cssz–24y	Central and South America	272.5012	12.5283	300.2	67	85.1
cssz–24z	Central and South America	272.4107	12.3767	300.2	67	39.07
cssz–25a	Central and South America	273.2075	11.5684	313.8	25	17.94
cssz–25b	Central and South America	272.9200	11.2746	313.8	15	5
cssz–25x	Central and South America	273.5950	11.9641	313.8	66	130.4
cssz–25y	Central and South America	273.4658	11.8322	313.8	66	84.75
cssz–25z	Central and South America	273.3366	11.7003	313.8	66	39.07
cssz–26a	Central and South America	273.8943	10.8402	320.4	25	17.94
cssz–26b	Central and South America	273.5750	10.5808	320.4	15	5
cssz–26x	Central and South America	274.3246	11.1894	320.4	66	130.4
cssz–26y	Central and South America	274.1811	11.0730	320.4	66	84.75
cssz–26z	Central and South America	274.0377	10.9566	320.4	66	39.07
cssz–27a	Central and South America	274.4569	10.2177	316.1	25	17.94
cssz–27b	Central and South America	274.1590	9.9354	316.1	15	5
cssz–27z	Central and South America	274.5907	10.3444	316.1	66	39.07
cssz–28a	Central and South America	274.9586	9.8695	297.1	22	14.54
cssz–28b	Central and South America	274.7661	9.4988	297.1	11	5
cssz–28z	Central and South America	275.1118	10.1643	297.1	42.5	33.27
cssz–29a	Central and South America	275.7686	9.4789	296.6	19	11.09
cssz–29b	Central and South America	275.5759	9.0992	296.6	7	5
cssz–30a	Central and South America	276.6346	8.9973	302.2	19	9.36
cssz–30b	Central and South America	276.4053	8.6381	302.2	5	5
cssz–31a	Central and South America	277.4554	8.4152	309.1	19	7.62
cssz–31b	Central and South America	277.1851	8.0854	309.1	3	5
cssz–31z	Central and South America	277.7260	8.7450	309.1	19	23.9
cssz–32a	Central and South America	278.1112	7.9425	303	18.67	8.49
cssz–32b	Central and South America	277.8775	7.5855	303	4	5
cssz–32z	Central and South America	278.3407	8.2927	303	21.67	24.49
cssz–33a	Central and South America	278.7082	7.6620	287.6	18.33	10.23
cssz–33b	Central and South America	278.5785	7.2555	287.6	6	5
cssz–33z	Central and South America	278.8328	8.0522	287.6	24.33	25.95
cssz–34a	Central and South America	279.3184	7.5592	269.5	18	17.94
cssz–34b	Central and South America	279.3223	7.1320	269.5	15	5
cssz–35a	Central and South America	280.0039	7.6543	255.9	17.67	14.54
cssz–35b	Central and South America	280.1090	7.2392	255.9	11	5
cssz–35x	Central and South America	279.7156	8.7898	255.9	29.67	79.22
cssz–35y	Central and South America	279.8118	8.4113	255.9	29.67	54.47

Continued on next page

Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–35z	Central and South America	279.9079	8.0328	255.9	29.67	29.72
cssz–36a	Central and South America	281.2882	7.6778	282.5	17.33	11.09
cssz–36b	Central and South America	281.1948	7.2592	282.5	7	5
cssz–36x	Central and South America	281.5368	8.7896	282.5	32.33	79.47
cssz–36y	Central and South America	281.4539	8.4190	282.5	32.33	52.73
cssz–36z	Central and South America	281.3710	8.0484	282.5	32.33	25.99
cssz–37a	Central and South America	282.5252	6.8289	326.9	17	10.23
cssz–37b	Central and South America	282.1629	6.5944	326.9	6	5
cssz–38a	Central and South America	282.9469	5.5973	355.4	17	10.23
cssz–38b	Central and South America	282.5167	5.5626	355.4	6	5
cssz–39a	Central and South America	282.7236	4.3108	24.13	17	10.23
cssz–39b	Central and South America	282.3305	4.4864	24.13	6	5
cssz–39z	Central and South America	283.0603	4.1604	24.13	35	24.85
cssz–40a	Central and South America	282.1940	3.3863	35.28	17	10.23
cssz–40b	Central and South America	281.8427	3.6344	35.28	6	5
cssz–40y	Central and South America	282.7956	2.9613	35.28	35	53.52
cssz–40z	Central and South America	282.4948	3.1738	35.28	35	24.85
cssz–41a	Central and South America	281.6890	2.6611	34.27	17	10.23
cssz–41b	Central and South America	281.3336	2.9030	34.27	6	5
cssz–41z	Central and South America	281.9933	2.4539	34.27	35	24.85
cssz–42a	Central and South America	281.2266	1.9444	31.29	17	10.23
cssz–42b	Central and South America	280.8593	2.1675	31.29	6	5
cssz–42z	Central and South America	281.5411	1.7533	31.29	35	24.85
cssz–43a	Central and South America	280.7297	1.1593	33.3	17	10.23
cssz–43b	Central and South America	280.3706	1.3951	33.3	6	5
cssz–43z	Central and South America	281.0373	0.9573	33.3	35	24.85
cssz–44a	Central and South America	280.3018	0.4491	28.8	17	10.23
cssz–44b	Central and South America	279.9254	0.6560	28.8	6	5
cssz–45a	Central and South America	279.9083	-0.3259	26.91	10	8.49
cssz–45b	Central and South America	279.5139	-0.1257	26.91	4	5
cssz–46a	Central and South America	279.6461	-0.9975	15.76	10	8.49
cssz–46b	Central and South America	279.2203	-0.8774	15.76	4	5
cssz–47a	Central and South America	279.4972	-1.7407	6.9	10	8.49
cssz–47b	Central and South America	279.0579	-1.6876	6.9	4	5
cssz–48a	Central and South America	279.3695	-2.6622	8.96	10	8.49
cssz–48b	Central and South America	278.9321	-2.5933	8.96	4	5
cssz–48y	Central and South America	280.2444	-2.8000	8.96	10	25.85
cssz–48z	Central and South America	279.8070	-2.7311	8.96	10	17.17
cssz–49a	Central and South America	279.1852	-3.6070	13.15	10	8.49
cssz–49b	Central and South America	278.7536	-3.5064	13.15	4	5
cssz–49y	Central and South America	280.0486	-3.8082	13.15	10	25.85
cssz–49z	Central and South America	279.6169	-3.7076	13.15	10	17.17
cssz–50a	Central and South America	279.0652	-4.3635	4.78	10.33	9.64
cssz–50b	Central and South America	278.6235	-4.3267	4.78	5.33	5
cssz–51a	Central and South America	279.0349	-5.1773	359.4	10.67	10.81
cssz–51b	Central and South America	278.5915	-5.1817	359.4	6.67	5
cssz–52a	Central and South America	279.1047	-5.9196	349.8	11	11.96
cssz–52b	Central and South America	278.6685	-5.9981	349.8	8	5
cssz–53a	Central and South America	279.3044	-6.6242	339.2	10.25	11.74
cssz–53b	Central and South America	278.8884	-6.7811	339.2	7.75	5
cssz–53y	Central and South America	280.1024	-6.3232	339.2	19.25	37.12
cssz–53z	Central and South America	279.7035	-6.4737	339.2	19.25	20.64
cssz–54a	Central and South America	279.6256	-7.4907	340.8	9.5	11.53
cssz–54b	Central and South America	279.2036	-7.6365	340.8	7.5	5
cssz–54y	Central and South America	280.4267	-7.2137	340.8	20.5	37.29

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Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–54z	Central and South America	280.0262	-7.3522	340.8	20.5	19.78
cssz–55a	Central and South America	279.9348	-8.2452	335.4	8.75	11.74
cssz–55b	Central and South America	279.5269	-8.4301	335.4	7.75	5
cssz–55x	Central and South America	281.0837	-7.7238	335.4	21.75	56.4
cssz–55y	Central and South America	280.7009	-7.8976	335.4	21.75	37.88
cssz–55z	Central and South America	280.3180	-8.0714	335.4	21.75	19.35
cssz–56a	Central and South America	280.3172	-8.9958	331.6	8	11.09
cssz–56b	Central and South America	279.9209	-9.2072	331.6	7	5
cssz–56x	Central and South America	281.4212	-8.4063	331.6	23	57.13
cssz–56y	Central and South America	281.0534	-8.6028	331.6	23	37.59
cssz–56z	Central and South America	280.6854	-8.7993	331.6	23	18.05
cssz–57a	Central and South America	280.7492	-9.7356	328.7	8.6	10.75
cssz–57b	Central and South America	280.3640	-9.9663	328.7	6.6	5
cssz–57x	Central and South America	281.8205	-9.0933	328.7	23.4	57.94
cssz–57y	Central and South America	281.4636	-9.3074	328.7	23.4	38.08
cssz–57z	Central and South America	281.1065	-9.5215	328.7	23.4	18.22
cssz–58a	Central and South America	281.2275	-10.5350	330.5	9.2	10.4
cssz–58b	Central and South America	280.8348	-10.7532	330.5	6.2	5
cssz–58y	Central and South America	281.9548	-10.1306	330.5	23.8	38.57
cssz–58z	Central and South America	281.5913	-10.3328	330.5	23.8	18.39
cssz–59a	Central and South America	281.6735	-11.2430	326.2	9.8	10.05
cssz–59b	Central and South America	281.2982	-11.4890	326.2	5.8	5
cssz–59y	Central and South America	282.3675	-10.7876	326.2	24.2	39.06
cssz–59z	Central and South America	282.0206	-11.0153	326.2	24.2	18.56
cssz–60a	Central and South America	282.1864	-11.9946	326.5	10.4	9.71
cssz–60b	Central and South America	281.8096	-12.2384	326.5	5.4	5
cssz–60y	Central and South America	282.8821	-11.5438	326.5	24.6	39.55
cssz–60z	Central and South America	282.5344	-11.7692	326.5	24.6	18.73
cssz–61a	Central and South America	282.6944	-12.7263	325.5	11	9.36
cssz–61b	Central and South America	282.3218	-12.9762	325.5	5	5
cssz–61y	Central and South America	283.3814	-12.2649	325.5	25	40.03
cssz–61z	Central and South America	283.0381	-12.4956	325.5	25	18.9
cssz–62a	Central and South America	283.1980	-13.3556	319	11	9.79
cssz–62b	Central and South America	282.8560	-13.6451	319	5.5	5
cssz–62y	Central and South America	283.8178	-12.8300	319	27	42.03
cssz–62z	Central and South America	283.5081	-13.0928	319	27	19.33
cssz–63a	Central and South America	283.8032	-14.0147	317.9	11	10.23
cssz–63b	Central and South America	283.4661	-14.3106	317.9	6	5
cssz–63z	Central and South America	284.1032	-13.7511	317.9	29	19.77
cssz–64a	Central and South America	284.4144	-14.6482	315.7	13	11.96
cssz–64b	Central and South America	284.0905	-14.9540	315.7	8	5
cssz–65a	Central and South America	285.0493	-15.2554	313.2	15	13.68
cssz–65b	Central and South America	284.7411	-15.5715	313.2	10	5
cssz–66a	Central and South America	285.6954	-15.7816	307.7	14.5	13.68
cssz–66b	Central and South America	285.4190	-16.1258	307.7	10	5
cssz–67a	Central and South America	286.4127	-16.2781	304.3	14	13.68
cssz–67b	Central and South America	286.1566	-16.6381	304.3	10	5
cssz–67z	Central and South America	286.6552	-15.9365	304.3	23	25.78
cssz–68a	Central and South America	287.2481	-16.9016	311.8	14	13.68
cssz–68b	Central and South America	286.9442	-17.2264	311.8	10	5
cssz–68z	Central and South America	287.5291	-16.6007	311.8	26	25.78
cssz–69a	Central and South America	287.9724	-17.5502	314.9	14	13.68
cssz–69b	Central and South America	287.6496	-17.8590	314.9	10	5
cssz–69y	Central and South America	288.5530	-16.9934	314.9	29	50.02
cssz–69z	Central and South America	288.2629	-17.2718	314.9	29	25.78

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Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–70a	Central and South America	288.6731	-18.2747	320.4	14	13.25
cssz–70b	Central and South America	288.3193	-18.5527	320.4	9.5	5
cssz–70y	Central and South America	289.3032	-17.7785	320.4	30	50.35
cssz–70z	Central and South America	288.9884	-18.0266	320.4	30	25.35
cssz–71a	Central and South America	289.3089	-19.1854	333.2	14	12.82
cssz–71b	Central and South America	288.8968	-19.3820	333.2	9	5
cssz–71y	Central and South America	290.0357	-18.8382	333.2	31	50.67
cssz–71z	Central and South America	289.6725	-19.0118	333.2	31	24.92
cssz–72a	Central and South America	289.6857	-20.3117	352.4	14	12.54
cssz–72b	Central and South America	289.2250	-20.3694	352.4	8.67	5
cssz–72z	Central and South America	290.0882	-20.2613	352.4	32	24.63
cssz–73a	Central and South America	289.7731	-21.3061	358.9	14	12.24
cssz–73b	Central and South America	289.3053	-21.3142	358.9	8.33	5
cssz–73z	Central and South America	290.1768	-21.2991	358.9	33	24.34
cssz–74a	Central and South America	289.7610	-22.2671	3.06	14	11.96
cssz–74b	Central and South America	289.2909	-22.2438	3.06	8	5
cssz–75a	Central and South America	289.6982	-23.1903	4.83	14.09	11.96
cssz–75b	Central and South America	289.2261	-23.1536	4.83	8	5
cssz–76a	Central and South America	289.6237	-24.0831	4.67	14.18	11.96
cssz–76b	Central and South America	289.1484	-24.0476	4.67	8	5
cssz–77a	Central and South America	289.5538	-24.9729	4.3	14.27	11.96
cssz–77b	Central and South America	289.0750	-24.9403	4.3	8	5
cssz–78a	Central and South America	289.4904	-25.8621	3.86	14.36	11.96
cssz–78b	Central and South America	289.0081	-25.8328	3.86	8	5
cssz–79a	Central and South America	289.3491	-26.8644	11.34	14.45	11.96
cssz–79b	Central and South America	288.8712	-26.7789	11.34	8	5
cssz–80a	Central and South America	289.1231	-27.7826	14.16	14.54	11.96
cssz–80b	Central and South America	288.6469	-27.6762	14.16	8	5
cssz–81a	Central and South America	288.8943	-28.6409	13.19	14.63	11.96
cssz–81b	Central and South America	288.4124	-28.5417	13.19	8	5
cssz–82a	Central and South America	288.7113	-29.4680	9.68	14.72	11.96
cssz–82b	Central and South America	288.2196	-29.3950	9.68	8	5
cssz–83a	Central and South America	288.5944	-30.2923	5.36	14.81	11.96
cssz–83b	Central and South America	288.0938	-30.2517	5.36	8	5
cssz–84a	Central and South America	288.5223	-31.1639	3.8	14.9	11.96
cssz–84b	Central and South America	288.0163	-31.1351	3.8	8	5
cssz–85a	Central and South America	288.4748	-32.0416	2.55	15	11.96
cssz–85b	Central and South America	287.9635	-32.0223	2.55	8	5
cssz–86a	Central and South America	288.3901	-33.0041	7.01	15	11.96
cssz–86b	Central and South America	287.8768	-32.9512	7.01	8	5
cssz–87a	Central and South America	288.1050	-34.0583	19.4	15	11.96
cssz–87b	Central and South America	287.6115	-33.9142	19.4	8	5
cssz–88a	Central and South America	287.5309	-35.0437	32.81	15	11.96
cssz–88b	Central and South America	287.0862	-34.8086	32.81	8	5
cssz–88z	Central and South America	287.9308	-35.2545	32.81	30	24.9
cssz–89a	Central and South America	287.2380	-35.5993	14.52	16.67	11.96
cssz–89b	Central and South America	286.7261	-35.4914	14.52	8	5
cssz–89z	Central and South America	287.7014	-35.6968	14.52	30	26.3
cssz–90a	Central and South America	286.8442	-36.5645	22.64	18.33	11.96
cssz–90b	Central and South America	286.3548	-36.4004	22.64	8	5
cssz–90z	Central and South America	287.2916	-36.7142	22.64	30	27.68
cssz–91a	Central and South America	286.5925	-37.2488	10.9	20	11.96
cssz–91b	Central and South America	286.0721	-37.1690	10.9	8	5
cssz–91z	Central and South America	287.0726	-37.3224	10.9	30	29.06
cssz–92a	Central and South America	286.4254	-38.0945	8.23	20	11.96

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Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–92b	Central and South America	285.8948	-38.0341	8.23	8	5
cssz–92z	Central and South America	286.9303	-38.1520	8.23	26.67	29.06
cssz–93a	Central and South America	286.2047	-39.0535	13.46	20	11.96
cssz–93b	Central and South America	285.6765	-38.9553	13.46	8	5
cssz–93z	Central and South America	286.7216	-39.1495	13.46	23.33	29.06
cssz–94a	Central and South America	286.0772	-39.7883	3.4	20	11.96
cssz–94b	Central and South America	285.5290	-39.7633	3.4	8	5
cssz–94z	Central and South America	286.6255	-39.8133	3.4	20	29.06
cssz–95a	Central and South America	285.9426	-40.7760	9.84	20	11.96
cssz–95b	Central and South America	285.3937	-40.7039	9.84	8	5
cssz–95z	Central and South America	286.4921	-40.8481	9.84	20	29.06
cssz–96a	Central and South America	285.7839	-41.6303	7.6	20	11.96
cssz–96b	Central and South America	285.2245	-41.5745	7.6	8	5
cssz–96x	Central and South America	287.4652	-41.7977	7.6	20	63.26
cssz–96y	Central and South America	286.9043	-41.7419	7.6	20	46.16
cssz–96z	Central and South America	286.3439	-41.6861	7.6	20	29.06
cssz–97a	Central and South America	285.6695	-42.4882	5.3	20	11.96
cssz–97b	Central and South America	285.0998	-42.4492	5.3	8	5
cssz–97x	Central and South America	287.3809	-42.6052	5.3	20	63.26
cssz–97y	Central and South America	286.8101	-42.5662	5.3	20	46.16
cssz–97z	Central and South America	286.2396	-42.5272	5.3	20	29.06
cssz–98a	Central and South America	285.5035	-43.4553	10.53	20	11.96
cssz–98b	Central and South America	284.9322	-43.3782	10.53	8	5
cssz–98x	Central and South America	287.2218	-43.6866	10.53	20	63.26
cssz–98y	Central and South America	286.6483	-43.6095	10.53	20	46.16
cssz–98z	Central and South America	286.0755	-43.5324	10.53	20	29.06
cssz–99a	Central and South America	285.3700	-44.2595	4.86	20	11.96
cssz–99b	Central and South America	284.7830	-44.2237	4.86	8	5
cssz–99x	Central and South America	287.1332	-44.3669	4.86	20	63.26
cssz–99y	Central and South America	286.5451	-44.3311	4.86	20	46.16
cssz–99z	Central and South America	285.9574	-44.2953	4.86	20	29.06
cssz–100a	Central and South America	285.2713	-45.1664	5.68	20	11.96
cssz–100b	Central and South America	284.6758	-45.1246	5.68	8	5
cssz–100x	Central and South America	287.0603	-45.2918	5.68	20	63.26
cssz–100y	Central and South America	286.4635	-45.2500	5.68	20	46.16
cssz–100z	Central and South America	285.8672	-45.2082	5.68	20	29.06
cssz–101a	Central and South America	285.3080	-45.8607	352.6	20	9.36
cssz–101b	Central and South America	284.7067	-45.9152	352.6	5	5
cssz–101y	Central and South America	286.5089	-45.7517	352.6	20	43.56
cssz–101z	Central and South America	285.9088	-45.8062	352.6	20	26.46
cssz–102a	Central and South America	285.2028	-47.1185	17.72	5	9.36
cssz–102b	Central and South America	284.5772	-46.9823	17.72	5	5
cssz–102y	Central and South America	286.4588	-47.3909	17.72	5	18.07
cssz–102z	Central and South America	285.8300	-47.2547	17.72	5	13.72
cssz–103a	Central and South America	284.7075	-48.0396	23.37	7.5	11.53
cssz–103b	Central and South America	284.0972	-47.8630	23.37	7.5	5
cssz–103x	Central and South America	286.5511	-48.5694	23.37	7.5	31.11
cssz–103y	Central and South America	285.9344	-48.3928	23.37	7.5	24.58
cssz–103z	Central and South America	285.3199	-48.2162	23.37	7.5	18.05
cssz–104a	Central and South America	284.3440	-48.7597	14.87	10	13.68
cssz–104b	Central and South America	283.6962	-48.6462	14.87	10	5
cssz–104x	Central and South America	286.2962	-49.1002	14.87	10	39.73
cssz–104y	Central and South America	285.6440	-48.9867	14.87	10	31.05
cssz–104z	Central and South America	284.9933	-48.8732	14.87	10	22.36
cssz–105a	Central and South America	284.2312	-49.4198	0.25	9.67	13.4

Continued on next page

Table B.2 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
cssz–105b	Central and South America	283.5518	-49.4179	0.25	9.67	5
cssz–105x	Central and South America	286.2718	-49.4255	0.25	9.67	38.59
cssz–105y	Central and South America	285.5908	-49.4236	0.25	9.67	30.2
cssz–105z	Central and South America	284.9114	-49.4217	0.25	9.67	21.8
cssz–106a	Central and South America	284.3730	-50.1117	347.5	9.25	13.04
cssz–106b	Central and South America	283.6974	-50.2077	347.5	9.25	5
cssz–106x	Central and South America	286.3916	-49.8238	347.5	9.25	37.15
cssz–106y	Central and South America	285.7201	-49.9198	347.5	9.25	29.11
cssz–106z	Central and South America	285.0472	-50.0157	347.5	9.25	21.07
cssz–107a	Central and South America	284.7130	-50.9714	346.5	9	12.82
cssz–107b	Central and South America	284.0273	-51.0751	346.5	9	5
cssz–107x	Central and South America	286.7611	-50.6603	346.5	9	36.29
cssz–107y	Central and South America	286.0799	-50.7640	346.5	9	28.47
cssz–107z	Central and South America	285.3972	-50.8677	346.5	9	20.64
cssz–108a	Central and South America	285.0378	-51.9370	352	8.67	12.54
cssz–108b	Central and South America	284.3241	-51.9987	352	8.67	5
cssz–108x	Central and South America	287.1729	-51.7519	352	8.67	35.15
cssz–108y	Central and South America	286.4622	-51.8136	352	8.67	27.61
cssz–108z	Central and South America	285.7505	-51.8753	352	8.67	20.07
cssz–109a	Central and South America	285.2635	-52.8439	353.1	8.33	12.24
cssz–109b	Central and South America	284.5326	-52.8974	353.1	8.33	5
cssz–109x	Central and South America	287.4508	-52.6834	353.1	8.33	33.97
cssz–109y	Central and South America	286.7226	-52.7369	353.1	8.33	26.73
cssz–109z	Central and South America	285.9935	-52.7904	353.1	8.33	19.49
cssz–110a	Central and South America	285.5705	-53.4139	334.2	8	11.96
cssz–110b	Central and South America	284.8972	-53.6076	334.2	8	5
cssz–110x	Central and South America	287.5724	-52.8328	334.2	8	32.83
cssz–110y	Central and South America	286.9081	-53.0265	334.2	8	25.88
cssz–110z	Central and South America	286.2408	-53.2202	334.2	8	18.92
cssz–111a	Central and South America	286.1627	-53.8749	313.8	8	11.96
cssz–111b	Central and South America	285.6382	-54.1958	313.8	8	5
cssz–111x	Central and South America	287.7124	-52.9122	313.8	8	32.83
cssz–111y	Central and South America	287.1997	-53.2331	313.8	8	25.88
cssz–111z	Central and South America	286.6832	-53.5540	313.8	8	18.92
cssz–112a	Central and South America	287.3287	-54.5394	316.4	8	11.96
cssz–112b	Central and South America	286.7715	-54.8462	316.4	8	5
cssz–112x	Central and South America	288.9756	-53.6190	316.4	8	32.83
cssz–112y	Central and South America	288.4307	-53.9258	316.4	8	25.88
cssz–112z	Central and South America	287.8817	-54.2326	316.4	8	18.92
cssz–113a	Central and South America	288.3409	-55.0480	307.6	8	11.96
cssz–113b	Central and South America	287.8647	-55.4002	307.6	8	5
cssz–113x	Central and South America	289.7450	-53.9914	307.6	8	32.83
cssz–113y	Central and South America	289.2810	-54.3436	307.6	8	25.88
cssz–113z	Central and South America	288.8130	-54.6958	307.6	8	18.92
cssz–114a	Central and South America	289.5342	-55.5026	301.5	8	11.96
cssz–114b	Central and South America	289.1221	-55.8819	301.5	8	5
cssz–114x	Central and South America	290.7472	-54.3647	301.5	8	32.83
cssz–114y	Central and South America	290.3467	-54.7440	301.5	8	25.88
cssz–114z	Central and South America	289.9424	-55.1233	301.5	8	18.92
cssz–115a	Central and South America	290.7682	-55.8485	292.7	8	11.96
cssz–115b	Central and South America	290.4608	-56.2588	292.7	8	5
cssz–115x	Central and South America	291.6714	-54.6176	292.7	8	32.83
cssz–115y	Central and South America	291.3734	-55.0279	292.7	8	25.88
cssz–115z	Central and South America	291.0724	-55.4382	292.7	8	18.92

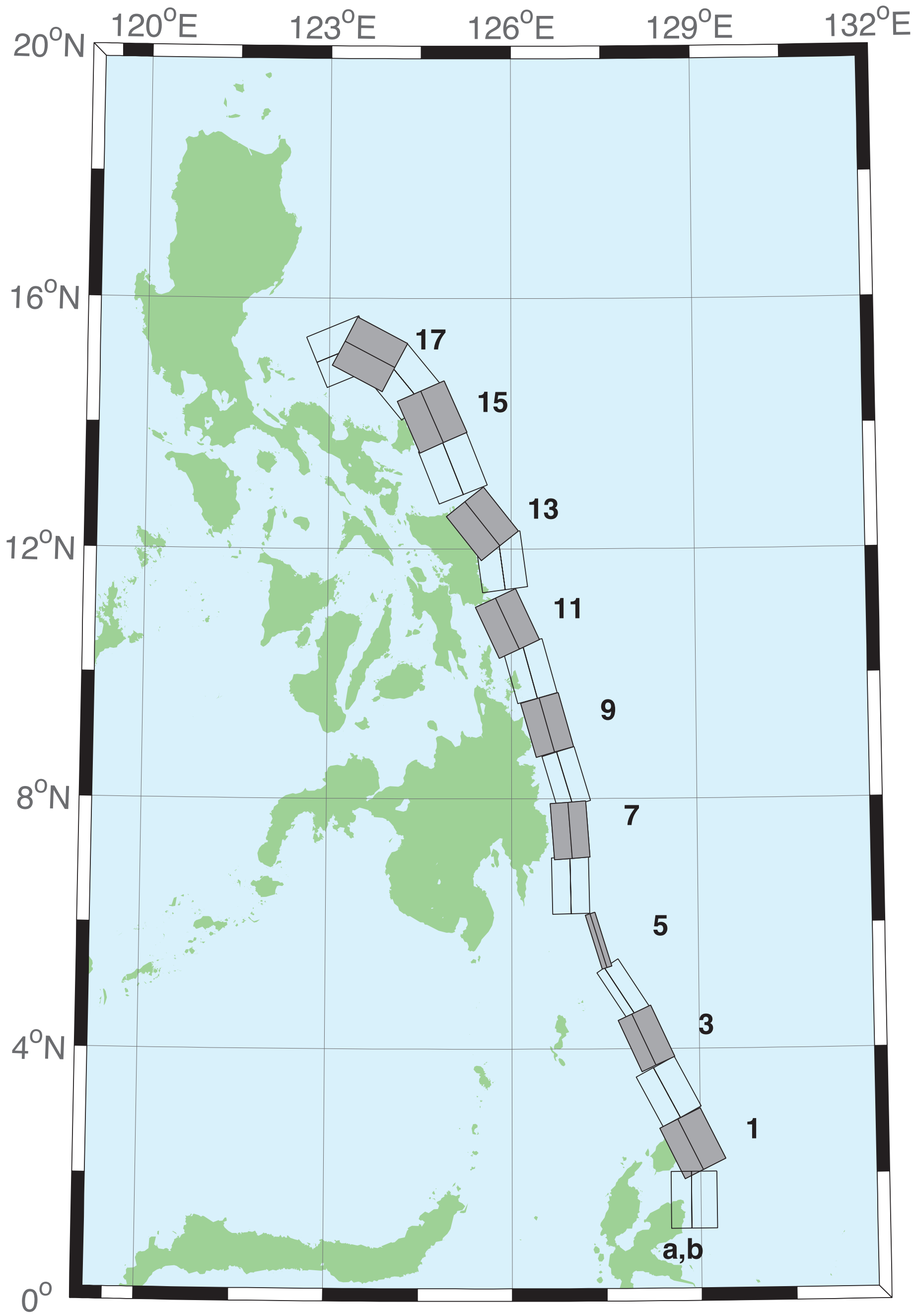

Figure B.3: Eastern Philippines Subduction Zone unit sources.

Table B.3: Earthquake parameters for Eastern Philippines Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
epsz–1a	Eastern Philippines	128.5521	2.3289	153.6	44.2	27.62
epsz–1b	Eastern Philippines	128.8408	2.4720	153.6	26.9	5
epsz–2a	Eastern Philippines	128.1943	3.1508	151.9	45.9	32.44
epsz–2b	Eastern Philippines	128.4706	3.2979	151.9	32.8	5.35
epsz–3a	Eastern Philippines	127.8899	4.0428	155.2	57.3	40.22
epsz–3b	Eastern Philippines	128.1108	4.1445	155.2	42.7	6.31
epsz–4a	Eastern Philippines	127.6120	4.8371	146.8	71.4	48.25
epsz–4b	Eastern Philippines	127.7324	4.9155	146.8	54.8	7.39
epsz–5a	Eastern Philippines	127.3173	5.7040	162.9	79.9	57.4
epsz–5b	Eastern Philippines	127.3930	5.7272	162.9	79.4	8.25
epsz–6a	Eastern Philippines	126.6488	6.6027	178.9	48.6	45.09
epsz–6b	Eastern Philippines	126.9478	6.6085	178.9	48.6	7.58
epsz–7a	Eastern Philippines	126.6578	7.4711	175.8	50.7	45.52
epsz–7b	Eastern Philippines	126.9439	7.4921	175.8	50.7	6.83
epsz–8a	Eastern Philippines	126.6227	8.2456	163.3	56.7	45.6
epsz–8b	Eastern Philippines	126.8614	8.3164	163.3	48.9	7.92
epsz–9a	Eastern Philippines	126.2751	9.0961	164.1	47	43.59
epsz–9b	Eastern Philippines	126.5735	9.1801	164.1	44.9	8.3
epsz–10a	Eastern Philippines	125.9798	9.9559	164.5	43.1	42.25
epsz–10b	Eastern Philippines	126.3007	10.0438	164.5	43.1	8.09
epsz–11a	Eastern Philippines	125.6079	10.6557	155	37.8	38.29
epsz–11b	Eastern Philippines	125.9353	10.8059	155	37.8	7.64
epsz–12a	Eastern Philippines	125.4697	11.7452	172.1	36	37.01
epsz–12b	Eastern Philippines	125.8374	11.7949	172.1	36	7.62
epsz–13a	Eastern Philippines	125.2238	12.1670	141.5	32.4	33.87
epsz–13b	Eastern Philippines	125.5278	12.4029	141.5	32.4	7.08
epsz–14a	Eastern Philippines	124.6476	13.1365	158.2	23	25.92
epsz–14b	Eastern Philippines	125.0421	13.2898	158.2	23	6.38
epsz–15a	Eastern Philippines	124.3107	13.9453	156.1	24.1	26.51
epsz–15b	Eastern Philippines	124.6973	14.1113	156.1	24.1	6.09
epsz–16a	Eastern Philippines	123.8998	14.4025	140.3	19.5	21.69
epsz–16b	Eastern Philippines	124.2366	14.6728	140.3	19.5	5
epsz–17a	Eastern Philippines	123.4604	14.7222	117.6	15.3	18.19
epsz–17b	Eastern Philippines	123.6682	15.1062	117.6	15.3	5
epsz–18a	Eastern Philippines	123.3946	14.7462	67.4	15	17.94
epsz–18b	Eastern Philippines	123.2219	15.1467	67.4	15	5
epsz–19a	Eastern Philippines	121.3638	15.7400	189.6	15	17.94
epsz–19b	Eastern Philippines	121.8082	15.6674	189.6	15	5
epsz–20a	Eastern Philippines	121.6833	16.7930	203.3	15	17.94
epsz–20b	Eastern Philippines	122.0994	16.6216	203.3	15	5
epsz–21a	Eastern Philippines	121.8279	17.3742	184.2	15	17.94
epsz–21b	Eastern Philippines	122.2814	17.3425	184.2	15	5

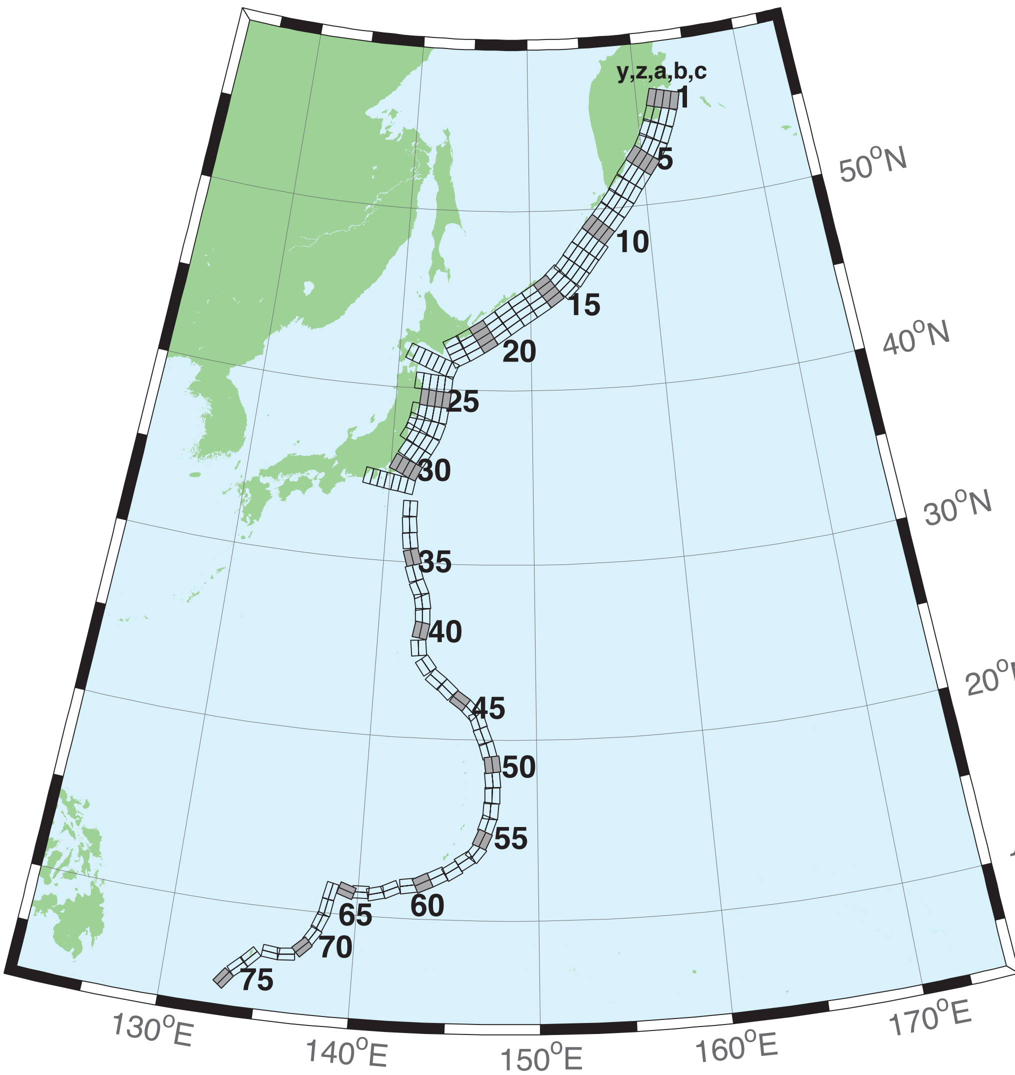

Figure B.4: Kamchatka-Kuril-Japan-Izu-Mariana-Yap Subduction Zone unit sources.

Table B.4: Earthquake parameters for Kamchatka-Kuril-Japan-Izu-Mariana-Yap Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
kisz–1a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.4318	55.5017	195	29	26.13
kisz–1b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	163.1000	55.4000	195	25	5
kisz–1y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.0884	55.7050	195	29	74.61
kisz–1z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.7610	55.6033	195	29	50.37
kisz–2a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.9883	54.6784	200	29	26.13
kisz–2b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.6247	54.5440	200	25	5
kisz–2y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.7072	54.9471	200	29	74.61
kisz–2z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.3488	54.8127	200	29	50.37
kisz–3a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.4385	53.8714	204	29	26.13
kisz–3b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.0449	53.7116	204	25	5
kisz–3y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.2164	54.1910	204	29	74.61
kisz–3z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.8286	54.0312	204	29	50.37
kisz–4a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.7926	53.1087	210	29	26.13
kisz–4b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.3568	52.9123	210	25	5
kisz–4y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.6539	53.5015	210	29	74.61
kisz–4z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.2246	53.3051	210	29	50.37
kisz–5a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.0211	52.4113	218	29	26.13
kisz–5b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.5258	52.1694	218	25	5
kisz–5y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.0005	52.8950	218	29	74.61
kisz–5z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.5122	52.6531	218	29	50.37
kisz–6a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.1272	51.7034	218	29	26.13
kisz–6b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.6241	51.4615	218	25	5
kisz–6y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.1228	52.1871	218	29	74.61
kisz–6z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.6263	51.9452	218	29	50.37
kisz–7a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.2625	50.9549	214	29	26.13
kisz–7b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.7771	50.7352	214	25	5
kisz–7y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.2236	51.3942	214	29	74.61
kisz–7z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.7443	51.1745	214	29	50.37
kisz–8a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.4712	50.2459	218	31	27.7
kisz–8b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.9433	50.0089	218	27	5
kisz–8y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.5176	50.7199	218	31	79.2
kisz–8z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.9956	50.4829	218	31	53.45
kisz–9a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.6114	49.5583	220	31	27.7
kisz–9b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.0638	49.3109	220	27	5
kisz–9y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.6974	50.0533	220	31	79.2
kisz–9z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.1556	49.8058	220	31	53.45
kisz–10a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.7294	48.8804	221	31	27.7
kisz–10b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.1690	48.6278	221	27	5
kisz–10y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.8413	49.3856	221	31	79.2
kisz–10z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2865	49.1330	221	31	53.45
kisz–11a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.8489	48.1821	219	31	27.7
kisz–11b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2955	47.9398	219	27	5
kisz–11y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.9472	48.6667	219	31	79.2
kisz–11z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.3991	48.4244	219	31	53.45
kisz–11c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.0358	47.5374	39	57.89	4.602
kisz–12a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.9994	47.4729	217	31	27.7
kisz–12b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.4701	47.2320	217	27	5
kisz–12y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.0856	47.9363	217	31	79.2
kisz–12z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.5435	47.7046	217	31	53.45
kisz–12c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2208	46.8473	37	57.89	4.602
kisz–13a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.2239	46.7564	218	31	27.7
kisz–13b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.6648	46.5194	218	27	5

Continued on next page

Table B.4 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
kisz–13y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.3343	47.2304	218	31	79.2
kisz–13z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.7801	46.9934	218	31	53.45
kisz–13c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.3957	46.1257	38	57.89	4.602
kisz–14a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.3657	46.1514	225	23	24.54
kisz–14b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.7855	45.8591	225	23	5
kisz–14y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.5172	46.7362	225	23	63.62
kisz–14z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.9426	46.4438	225	23	44.08
kisz–14c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.4468	45.3976	45	57.89	4.602
kisz–15a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.4663	45.5963	233	25	23.73
kisz–15b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.8144	45.2712	233	22	5
kisz–15y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.7619	46.2465	233	25	65.99
kisz–15z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.1151	45.9214	233	25	44.86
kisz–16a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.4572	45.0977	237	25	23.73
kisz–16b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.7694	44.7563	237	22	5
kisz–16y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.8253	45.7804	237	25	65.99
kisz–16z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.1422	45.4390	237	25	44.86
kisz–17a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.3989	44.6084	237	25	23.73
kisz–17b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.7085	44.2670	237	22	5
kisz–17y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.7723	45.2912	237	25	65.99
kisz–17z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.0865	44.9498	237	25	44.86
kisz–18a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.3454	44.0982	235	25	23.73
kisz–18b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.6687	43.7647	235	22	5
kisz–18y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.6915	44.7651	235	25	65.99
kisz–18z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.0194	44.4316	235	25	44.86
kisz–19a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3262	43.5619	233	25	23.73
kisz–19b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.6625	43.2368	233	22	5
kisz–19y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6463	44.2121	233	25	65.99
kisz–19z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9872	43.8870	233	25	44.86
kisz–20a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.3513	43.0633	237	25	23.73
kisz–20b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6531	42.7219	237	22	5
kisz–20y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.7410	43.7461	237	25	65.99
kisz–20z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.0470	43.4047	237	25	44.86
kisz–21a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.3331	42.5948	239	25	23.73
kisz–21b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6163	42.2459	239	22	5
kisz–21y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.7603	43.2927	239	25	65.99
kisz–21z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.0475	42.9438	239	25	44.86
kisz–22a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.3041	42.1631	242	25	23.73
kisz–22b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.5605	41.8037	242	22	5
kisz–22y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.7854	42.8819	242	25	65.99
kisz–22z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.0455	42.5225	242	25	44.86
kisz–23a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.2863	41.3335	202	21	21.28
kisz–23b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.8028	41.1764	202	19	5
kisz–23v	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.6816	42.1189	202	21	110.9
kisz–23w	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.2050	41.9618	202	21	92.95
kisz–23x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.7273	41.8047	202	21	75.04
kisz–23y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2482	41.6476	202	21	57.12
kisz–23z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7679	41.4905	202	21	39.2
kisz–24a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.9795	40.3490	185	21	21.28
kisz–24b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5273	40.3125	185	19	5
kisz–24x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.3339	40.4587	185	21	75.04
kisz–24y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8827	40.4221	185	21	57.12
kisz–24z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.4312	40.3856	185	21	39.2
kisz–25a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.8839	39.4541	185	21	21.28
kisz–25b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.4246	39.4176	185	19	5
kisz–25y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8012	39.5272	185	21	57.12

Continued on next page

Table B.4 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
kisz–25z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.3426	39.4907	185	21	39.2
kisz–26a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7622	38.5837	188	21	21.28
kisz–26b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.2930	38.5254	188	19	5
kisz–26x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1667	38.7588	188	21	75.04
kisz–26y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6990	38.7004	188	21	57.12
kisz–26z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2308	38.6421	188	21	39.2
kisz–27a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.5320	37.7830	198	21	21.28
kisz–27b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.0357	37.6534	198	19	5
kisz–27x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0142	38.1717	198	21	75.04
kisz–27y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5210	38.0421	198	21	57.12
kisz–27z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0269	37.9126	198	21	39.2
kisz–28a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.1315	37.0265	208	21	21.28
kisz–28b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.5941	36.8297	208	19	5
kisz–28x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.7348	37.6171	208	21	75.04
kisz–28y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.2016	37.4202	208	21	57.12
kisz–28z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6671	37.2234	208	21	39.2
kisz–29a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5970	36.2640	211	21	21.28
kisz–29b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0416	36.0481	211	19	5
kisz–29y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.7029	36.6960	211	21	57.12
kisz–29z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1506	36.4800	211	21	39.2
kisz–30a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0553	35.4332	205	21	21.28
kisz–30b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5207	35.2560	205	19	5
kisz–30y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1204	35.7876	205	21	57.12
kisz–30z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.5883	35.6104	205	21	39.2
kisz–31a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.6956	34.4789	190	22	22.1
kisz–31b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1927	34.4066	190	20	5
kisz–31v	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.2025	34.8405	190	22	115.8
kisz–31w	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.7021	34.7682	190	22	97.02
kisz–31x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.2012	34.6958	190	22	78.29
kisz–31y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.6997	34.6235	190	22	59.56
kisz–31z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1979	34.5512	190	22	40.83
kisz–32a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0551	33.0921	180	32	23.48
kisz–32b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5098	33.0921	180	21.69	5
kisz–33a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0924	32.1047	173.8	27.65	20.67
kisz–33b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5596	32.1473	173.8	18.27	5
kisz–34a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1869	31.1851	172.1	25	18.26
kisz–34b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6585	31.2408	172.1	15.38	5
kisz–35a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.4154	30.1707	163	25	17.12
kisz–35b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8662	30.2899	163	14.03	5
kisz–36a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6261	29.2740	161.7	25.73	18.71
kisz–36b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0670	29.4012	161.7	15.91	5
kisz–37a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0120	28.3322	154.7	20	14.54
kisz–37b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.4463	28.5124	154.7	11	5
kisz–38a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2254	27.6946	170.3	20	14.54
kisz–38b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.6955	27.7659	170.3	11	5
kisz–39a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.3085	26.9127	177.2	24.23	17.42
kisz–39b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7674	26.9325	177.2	14.38	5
kisz–40a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2673	26.1923	189.4	26.49	22.26
kisz–40b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7090	26.1264	189.4	20.2	5
kisz–41a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.1595	25.0729	173.7	22.07	19.08
kisz–41b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.6165	25.1184	173.7	16.36	5
kisz–42a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7641	23.8947	143.5	21.54	18.4
kisz–42b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.1321	24.1432	143.5	15.54	5
kisz–43a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5281	23.0423	129.2	23.02	18.77
kisz–43b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.8128	23.3626	129.2	15.99	5

Continued on next page

Table B.4 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
kisz–44a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.2230	22.5240	134.6	28.24	18.56
kisz–44b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.5246	22.8056	134.6	15.74	5
kisz–45a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.0895	21.8866	125.8	36.73	22.79
kisz–45b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.3171	22.1785	125.8	20.84	5
kisz–46a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6972	21.3783	135.9	30.75	20.63
kisz–46b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.9954	21.6469	135.9	18.22	5
kisz–47a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.0406	20.9341	160.1	29.87	19.62
kisz–47b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4330	21.0669	160.1	17	5
kisz–48a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.3836	20.0690	158	32.75	19.68
kisz–48b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.7567	20.2108	158	17.07	5
kisz–49a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6689	19.3123	164.5	25.07	21.41
kisz–49b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.0846	19.4212	164.5	19.16	5
kisz–50a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9297	18.5663	172.1	22	22.1
kisz–50b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3650	18.6238	172.1	20	5
kisz–51a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9495	17.7148	175.1	22.06	22.04
kisz–51b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3850	17.7503	175.1	19.93	5
kisz–52a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9447	16.8869	180	25.51	18.61
kisz–52b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3683	16.8869	180	15.79	5
kisz–53a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.8626	16.0669	185.2	27.39	18.41
kisz–53b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.2758	16.0309	185.2	15.56	5
kisz–54a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.7068	15.3883	199.1	28.12	20.91
kisz–54b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.0949	15.2590	199.1	18.56	5
kisz–55a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4717	14.6025	204.3	29.6	26.27
kisz–55b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.8391	14.4415	204.3	25.18	5
kisz–56a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.1678	13.9485	217.4	32.04	26.79
kisz–56b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4789	13.7170	217.4	25.84	5
kisz–57a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6515	13.5576	235.8	37	24.54
kisz–57b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.8586	13.2609	235.8	23	5
kisz–58a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.9648	12.9990	237.8	37.72	24.54
kisz–58b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.1589	12.6984	237.8	23	5
kisz–59a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.1799	12.6914	242.9	34.33	22.31
kisz–59b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.3531	12.3613	242.9	20.25	5
kisz–60a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.3687	12.3280	244.9	30.9	20.62
kisz–60b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5355	11.9788	244.9	18.2	5
kisz–61a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7051	12.1507	261.8	35.41	25.51
kisz–61b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7582	11.7883	261.8	24.22	5
kisz–62a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6301	11.8447	245.7	39.86	34.35
kisz–62b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.7750	11.5305	245.7	35.94	5
kisz–63a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.8923	11.5740	256.2	42	38.46
kisz–63b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.9735	11.2498	256.2	42	5
kisz–64a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1387	11.6028	269.6	42.48	38.77
kisz–64b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1410	11.2716	269.6	42.48	5
kisz–65a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.4595	11.5883	288.7	44.16	39.83
kisz–65b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.3541	11.2831	288.7	44.16	5
kisz–66a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.1823	11.2648	193.1	45	40.36
kisz–66b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.4977	11.1929	193.1	45	5
kisz–67a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.9923	10.3398	189.8	45	40.36
kisz–67b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.3104	10.2856	189.8	45	5
kisz–68a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.7607	9.6136	201.7	45	40.36
kisz–68b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.0599	9.4963	201.7	45	5
kisz–69a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.4537	8.8996	213.5	45	40.36
kisz–69b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.7215	8.7241	213.5	45	5
kisz–70a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.0191	8.2872	226.5	45	40.36
kisz–70b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.2400	8.0569	226.5	45	5
kisz–71a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	136.3863	7.9078	263.9	45	40.36

Continued on next page

Table B.4 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
kisz–71b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	136.4202	7.5920	263.9	45	5
kisz–72a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	135.6310	7.9130	276.9	45	40.36
kisz–72b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	135.5926	7.5977	276.9	45	5
kisz–73a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	134.3296	7.4541	224	45	40.36
kisz–73b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	134.5600	7.2335	224	45	5
kisz–74a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.7125	6.8621	228.1	45	40.36
kisz–74b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.9263	6.6258	228.1	45	5
kisz–75a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.0224	6.1221	217.7	45	40.36
kisz–75b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.2751	5.9280	217.7	45	5

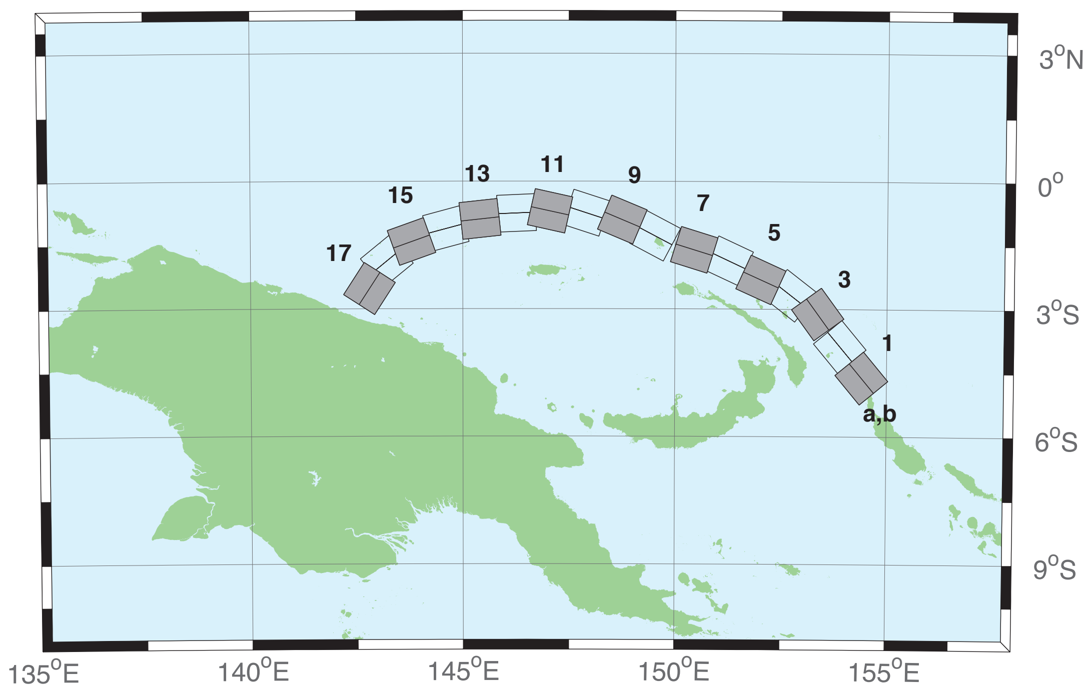

Figure B.5: Manus–Oceanic Convergent Boundary Subduction Zone unit sources.

Table B.5: Earthquake parameters for Manus–Oceanic Convergent Boundary Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
mosz–1a	Manus	154.0737	-4.8960	140.2	15	15.88
mosz–1b	Manus	154.4082	-4.6185	140.2	15	2.94
mosz–2a	Manus	153.5589	-4.1575	140.2	15	15.91
mosz–2b	Manus	153.8931	-3.8800	140.2	15	2.97
mosz–3a	Manus	153.0151	-3.3716	143.9	15	16.64
mosz–3b	Manus	153.3662	-3.1160	143.9	15	3.7
mosz–4a	Manus	152.4667	-3.0241	127.7	15	17.32
mosz–4b	Manus	152.7321	-2.6806	127.7	15	4.38
mosz–5a	Manus	151.8447	-2.7066	114.3	15	17.57
mosz–5b	Manus	152.0235	-2.3112	114.3	15	4.63
mosz–6a	Manus	151.0679	-2.2550	115	15	17.66
mosz–6b	Manus	151.2513	-1.8618	115	15	4.72
mosz–7a	Manus	150.3210	-2.0236	107.2	15	17.73
mosz–7b	Manus	150.4493	-1.6092	107.2	15	4.79
mosz–8a	Manus	149.3226	-1.6666	117.8	15	17.83
mosz–8b	Manus	149.5251	-1.2829	117.8	15	4.89
mosz–9a	Manus	148.5865	-1.3017	112.7	15	17.84
mosz–9b	Manus	148.7540	-0.9015	112.7	15	4.9
mosz–10a	Manus	147.7760	-1.1560	108	15	17.78
mosz–10b	Manus	147.9102	-0.7434	108	15	4.84
mosz–11a	Manus	146.9596	-1.1226	102.5	15	17.54
mosz–11b	Manus	147.0531	-0.6990	102.5	15	4.6
mosz–12a	Manus	146.2858	-1.1820	87.48	15	17.29
mosz–12b	Manus	146.2667	-0.7486	87.48	15	4.35
mosz–13a	Manus	145.4540	-1.3214	83.75	15	17.34
mosz–13b	Manus	145.4068	-0.8901	83.75	15	4.4
mosz–14a	Manus	144.7151	-1.5346	75.09	15	17.21
mosz–14b	Manus	144.6035	-1.1154	75.09	15	4.27
mosz–15a	Manus	143.9394	-1.8278	70.43	15	16.52
mosz–15b	Manus	143.7940	-1.4190	70.43	15	3.58
mosz–16a	Manus	143.4850	-2.2118	50.79	15	15.86
mosz–16b	Manus	143.2106	-1.8756	50.79	15	2.92
mosz–17a	Manus	143.1655	-2.7580	33	15	16.64
mosz–17b	Manus	142.8013	-2.5217	33	15	3.7

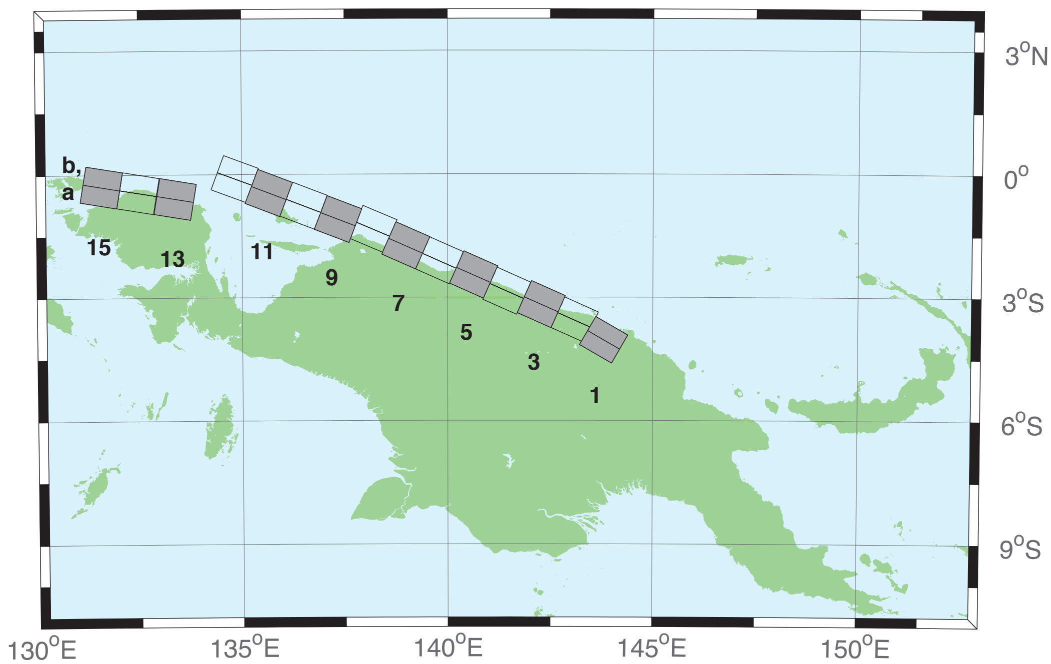

Figure B.6: New Guinea Subduction Zone unit sources.

Table B.6: Earthquake parameters for New Guinea Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
ngsz–1a	New Guinea	143.6063	-4.3804	120	29	25.64
ngsz–1b	New Guinea	143.8032	-4.0402	120	29	1.4
ngsz–2a	New Guinea	142.9310	-3.9263	114	27.63	20.1
ngsz–2b	New Guinea	143.0932	-3.5628	114	21.72	1.6
ngsz–3a	New Guinea	142.1076	-3.5632	114	20.06	18.73
ngsz–3b	New Guinea	142.2795	-3.1778	114	15.94	5
ngsz–4a	New Guinea	141.2681	-3.2376	114	21	17.76
ngsz–4b	New Guinea	141.4389	-2.8545	114	14.79	5
ngsz–5a	New Guinea	140.4592	-2.8429	114	21.26	16.14
ngsz–5b	New Guinea	140.6296	-2.4605	114	12.87	5
ngsz–6a	New Guinea	139.6288	-2.4960	114	22.72	15.4
ngsz–6b	New Guinea	139.7974	-2.1175	114	12	5
ngsz–7a	New Guinea	138.8074	-2.1312	114	21.39	15.4
ngsz–7b	New Guinea	138.9776	-1.7491	114	12	5
ngsz–8a	New Guinea	138.0185	-1.7353	113.1	18.79	15.14
ngsz–8b	New Guinea	138.1853	-1.3441	113.1	11.7	5
ngsz–9a	New Guinea	137.1805	-1.5037	111	15.24	13.23
ngsz–9b	New Guinea	137.3358	-1.0991	111	9.47	5
ngsz–10a	New Guinea	136.3418	-1.1774	111	13.51	11.09
ngsz–10b	New Guinea	136.4983	-0.7697	111	7	5
ngsz–11a	New Guinea	135.4984	-0.8641	111	11.38	12.49
ngsz–11b	New Guinea	135.6562	-0.4530	111	8.62	5
ngsz–12a	New Guinea	134.6759	-0.5216	110.5	10	13.68
ngsz–12b	New Guinea	134.8307	-0.1072	110.5	10	5
ngsz–13a	New Guinea	133.3065	-1.0298	99.5	10	13.68
ngsz–13b	New Guinea	133.3795	-0.5935	99.5	10	5
ngsz–14a	New Guinea	132.4048	-0.8816	99.5	10	13.68
ngsz–14b	New Guinea	132.4778	-0.4453	99.5	10	5
ngsz–15a	New Guinea	131.5141	-0.7353	99.5	10	13.68
ngsz–15b	New Guinea	131.5871	-0.2990	99.5	10	5

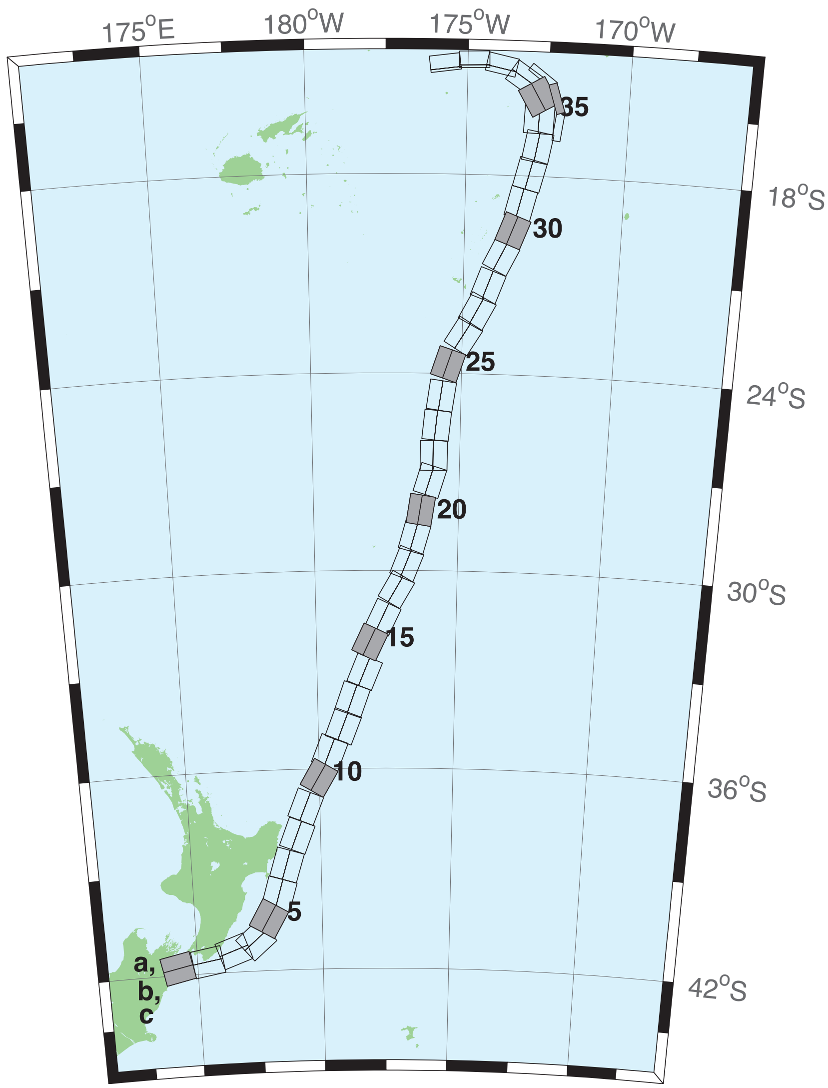

Figure B.7: New Zealand–Kermadec–Tonga Subduction Zone unit sources.

Table B.7: Earthquake parameters for New Zealand–Kermadec–Tonga Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
ntsz–1a	New Zealand–Tonga	174.0985	-41.3951	258.6	24	25.34
ntsz–1b	New Zealand–Tonga	174.2076	-41.7973	258.6	24	5
ntsz–2a	New Zealand–Tonga	175.3289	-41.2592	260.6	29.38	23.17
ntsz–2b	New Zealand–Tonga	175.4142	-41.6454	260.6	21.31	5
ntsz–3a	New Zealand–Tonga	176.2855	-40.9950	250.7	29.54	21.74
ntsz–3b	New Zealand–Tonga	176.4580	-41.3637	250.7	19.56	5
ntsz–4a	New Zealand–Tonga	177.0023	-40.7679	229.4	24.43	18.87
ntsz–4b	New Zealand–Tonga	177.3552	-41.0785	229.4	16.1	5
ntsz–5a	New Zealand–Tonga	177.4114	-40.2396	210	18.8	19.29
ntsz–5b	New Zealand–Tonga	177.8951	-40.4525	210	16.61	5
ntsz–6a	New Zealand–Tonga	177.8036	-39.6085	196.7	18.17	15.8
ntsz–6b	New Zealand–Tonga	178.3352	-39.7310	196.7	12.48	5
ntsz–7a	New Zealand–Tonga	178.1676	-38.7480	197	28.1	17.85
ntsz–7b	New Zealand–Tonga	178.6541	-38.8640	197	14.89	5
ntsz–8a	New Zealand–Tonga	178.6263	-37.8501	201.4	31.47	18.78
ntsz–8b	New Zealand–Tonga	179.0788	-37.9899	201.4	16	5
ntsz–9a	New Zealand–Tonga	178.9833	-36.9770	202.2	29.58	20.02
ntsz–9b	New Zealand–Tonga	179.4369	-37.1245	202.2	17.48	5
ntsz–10a	New Zealand–Tonga	179.5534	-36.0655	210.6	32.1	20.72
ntsz–10b	New Zealand–Tonga	179.9595	-36.2593	210.6	18.32	5
ntsz–11a	New Zealand–Tonga	179.9267	-35.3538	201.7	25	16.09
ntsz–11b	New Zealand–Tonga	180.3915	-35.5040	201.7	12.81	5
ntsz–12a	New Zealand–Tonga	180.4433	-34.5759	201.2	25	15.46
ntsz–12b	New Zealand–Tonga	180.9051	-34.7230	201.2	12.08	5
ntsz–13a	New Zealand–Tonga	180.7990	-33.7707	199.8	25.87	19.06
ntsz–13b	New Zealand–Tonga	181.2573	-33.9073	199.8	16.33	5
ntsz–14a	New Zealand–Tonga	181.2828	-32.9288	202.4	31.28	22.73
ntsz–14b	New Zealand–Tonga	181.7063	-33.0751	202.4	20.77	5
ntsz–15a	New Zealand–Tonga	181.4918	-32.0035	205.4	32.33	22.64
ntsz–15b	New Zealand–Tonga	181.8967	-32.1665	205.4	20.66	5
ntsz–16a	New Zealand–Tonga	181.9781	-31.2535	205.5	34.29	23.59
ntsz–16b	New Zealand–Tonga	182.3706	-31.4131	205.5	21.83	5
ntsz–17a	New Zealand–Tonga	182.4819	-30.3859	210.3	37.6	25.58
ntsz–17b	New Zealand–Tonga	182.8387	-30.5655	210.3	24.3	5
ntsz–18a	New Zealand–Tonga	182.8176	-29.6545	201.6	37.65	26.13
ntsz–18b	New Zealand–Tonga	183.1985	-29.7856	201.6	25	5
ntsz–19a	New Zealand–Tonga	183.0622	-28.8739	195.7	34.41	26.13
ntsz–19b	New Zealand–Tonga	183.4700	-28.9742	195.7	25	5
ntsz–20a	New Zealand–Tonga	183.2724	-28.0967	188.8	38	26.13
ntsz–20b	New Zealand–Tonga	183.6691	-28.1508	188.8	25	5
ntsz–21a	New Zealand–Tonga	183.5747	-27.1402	197.1	32.29	24.83
ntsz–21b	New Zealand–Tonga	183.9829	-27.2518	197.1	23.37	5
ntsz–22a	New Zealand–Tonga	183.6608	-26.4975	180	29.56	18.63
ntsz–22b	New Zealand–Tonga	184.0974	-26.4975	180	15.82	5
ntsz–23a	New Zealand–Tonga	183.7599	-25.5371	185.8	32.42	20.56
ntsz–23b	New Zealand–Tonga	184.1781	-25.5752	185.8	18.13	5
ntsz–24a	New Zealand–Tonga	183.9139	-24.6201	188.2	33.31	23.73
ntsz–24b	New Zealand–Tonga	184.3228	-24.6734	188.2	22	5
ntsz–25a	New Zealand–Tonga	184.1266	-23.5922	198.5	29.34	19.64
ntsz–25b	New Zealand–Tonga	184.5322	-23.7163	198.5	17.03	5
ntsz–26a	New Zealand–Tonga	184.6613	-22.6460	211.7	30.26	19.43
ntsz–26b	New Zealand–Tonga	185.0196	-22.8497	211.7	16.78	5
ntsz–27a	New Zealand–Tonga	185.0879	-21.9139	207.9	31.73	20.67

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Table B.7 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
ntsz–27b	New Zealand–Tonga	185.4522	-22.0928	207.9	18.27	5
ntsz–28a	New Zealand–Tonga	185.4037	-21.1758	200.5	32.44	21.76
ntsz–28b	New Zealand–Tonga	185.7849	-21.3084	200.5	19.58	5
ntsz–29a	New Zealand–Tonga	185.8087	-20.2629	206.4	32.47	20.4
ntsz–29b	New Zealand–Tonga	186.1710	-20.4312	206.4	17.94	5
ntsz–30a	New Zealand–Tonga	186.1499	-19.5087	200.9	32.98	22.46
ntsz–30b	New Zealand–Tonga	186.5236	-19.6432	200.9	20.44	5
ntsz–31a	New Zealand–Tonga	186.3538	-18.7332	193.9	34.41	21.19
ntsz–31b	New Zealand–Tonga	186.7339	-18.8221	193.9	18.89	5
ntsz–32a	New Zealand–Tonga	186.5949	-17.8587	194.1	30	19.12
ntsz–32b	New Zealand–Tonga	186.9914	-17.9536	194.1	16.4	5
ntsz–33a	New Zealand–Tonga	186.8172	-17.0581	190	33.15	23.34
ntsz–33b	New Zealand–Tonga	187.2047	-17.1237	190	21.52	5
ntsz–34a	New Zealand–Tonga	186.7814	-16.2598	182.1	15	13.41
ntsz–34b	New Zealand–Tonga	187.2330	-16.2759	182.1	9.68	5
ntsz–34c	New Zealand–Tonga	187.9697	-16.4956	7.62	57.06	6.571
ntsz–35a	New Zealand–Tonga	186.8000	-15.8563	149.8	15	12.17
ntsz–35b	New Zealand–Tonga	187.1896	-15.6384	149.8	8.24	5
ntsz–35c	New Zealand–Tonga	187.8776	-15.6325	342.4	57.06	6.571
ntsz–36a	New Zealand–Tonga	186.5406	-15.3862	123.9	40.44	36.72
ntsz–36b	New Zealand–Tonga	186.7381	-15.1025	123.9	39.38	5
ntsz–36c	New Zealand–Tonga	187.3791	-14.9234	307	57.06	6.571
ntsz–37a	New Zealand–Tonga	185.9883	-14.9861	102	68.94	30.99
ntsz–37b	New Zealand–Tonga	186.0229	-14.8282	102	31.32	5
ntsz–38a	New Zealand–Tonga	185.2067	-14.8259	88.4	80	26.13
ntsz–38b	New Zealand–Tonga	185.2044	-14.7479	88.4	25	5
ntsz–39a	New Zealand–Tonga	184.3412	-14.9409	82.55	80	26.13
ntsz–39b	New Zealand–Tonga	184.3307	-14.8636	82.55	25	5

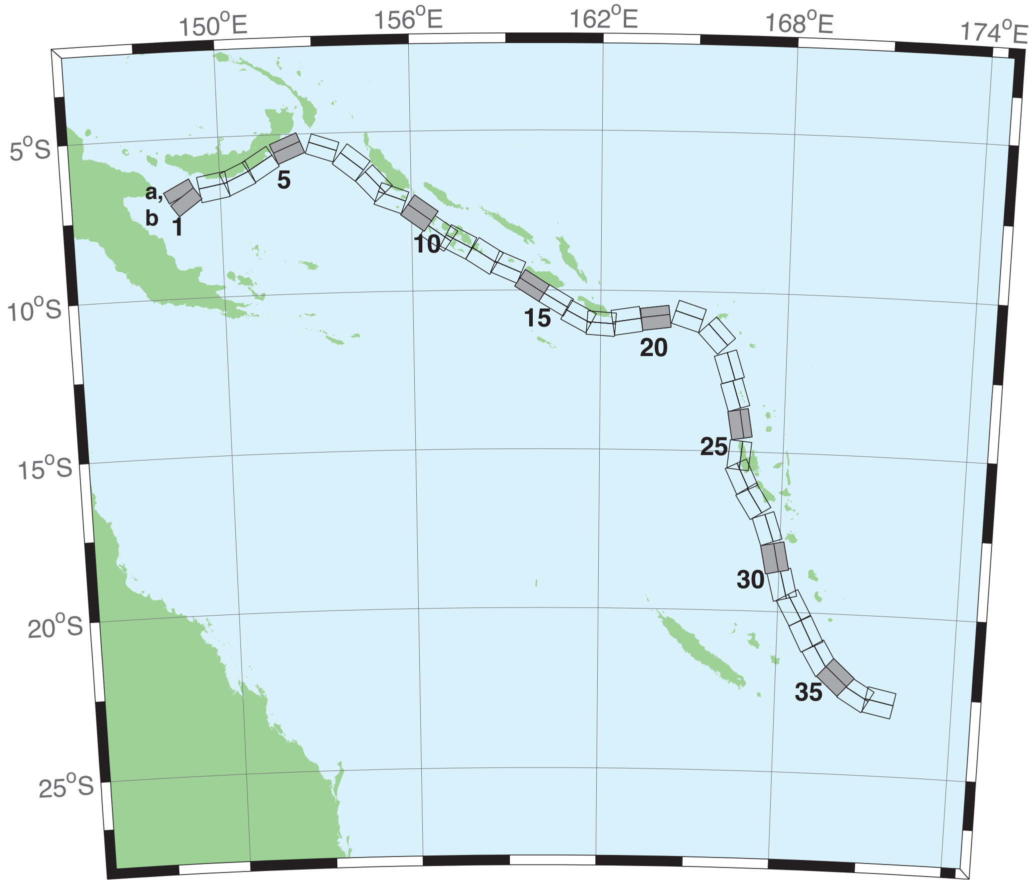

Figure B.8: New Britain–Solomons–Vanuatu Zone unit sources.

Table B.8: Earthquake parameters for New Britain–Solomons–Vanuatu Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
nvsz–1a	New Britain–Vanuatu	148.6217	-6.4616	243.2	32.34	15.69
nvsz–1b	New Britain–Vanuatu	148.7943	-6.8002	234.2	12.34	5
nvsz–2a	New Britain–Vanuatu	149.7218	-6.1459	260.1	35.1	16.36
nvsz–2b	New Britain–Vanuatu	149.7856	-6.5079	260.1	13.13	5
nvsz–3a	New Britain–Vanuatu	150.4075	-5.9659	245.7	42.35	18.59
nvsz–3b	New Britain–Vanuatu	150.5450	-6.2684	245.7	15.77	5
nvsz–4a	New Britain–Vanuatu	151.1095	-5.5820	238.2	42.41	23.63
nvsz–4b	New Britain–Vanuatu	151.2851	-5.8639	238.2	21.88	5
nvsz–5a	New Britain–Vanuatu	152.0205	-5.1305	247.7	49.22	32.39
nvsz–5b	New Britain–Vanuatu	152.1322	-5.4020	247.7	33.22	5
nvsz–6a	New Britain–Vanuatu	153.3450	-5.1558	288.6	53.53	33.59
nvsz–6b	New Britain–Vanuatu	153.2595	-5.4089	288.6	34.87	5
nvsz–7a	New Britain–Vanuatu	154.3814	-5.6308	308.3	39.72	19.18
nvsz–7b	New Britain–Vanuatu	154.1658	-5.9017	308.3	16.48	5
nvsz–8a	New Britain–Vanuatu	155.1097	-6.3511	317.2	45.33	22.92
nvsz–8b	New Britain–Vanuatu	154.8764	-6.5656	317.2	21	5
nvsz–9a	New Britain–Vanuatu	155.5027	-6.7430	290.5	48.75	22.92
nvsz–9b	New Britain–Vanuatu	155.3981	-7.0204	290.5	21	5
nvsz–10a	New Britain–Vanuatu	156.4742	-7.2515	305.9	36.88	27.62
nvsz–10b	New Britain–Vanuatu	156.2619	-7.5427	305.9	26.9	5
nvsz–11a	New Britain–Vanuatu	157.0830	-7.8830	305.4	32.97	29.72
nvsz–11b	New Britain–Vanuatu	156.8627	-8.1903	305.4	29.63	5
nvsz–12a	New Britain–Vanuatu	157.6537	-8.1483	297.9	37.53	28.57
nvsz–12b	New Britain–Vanuatu	157.4850	-8.4630	297.9	28.13	5
nvsz–13a	New Britain–Vanuatu	158.5089	-8.5953	302.7	33.62	23.02
nvsz–13b	New Britain–Vanuatu	158.3042	-8.9099	302.7	21.12	5
nvsz–14a	New Britain–Vanuatu	159.1872	-8.9516	293.3	38.44	34.06
nvsz–14b	New Britain–Vanuatu	159.0461	-9.2747	293.3	35.54	5
nvsz–15a	New Britain–Vanuatu	159.9736	-9.5993	302.8	46.69	41.38
nvsz–15b	New Britain–Vanuatu	159.8044	-9.8584	302.8	46.69	5
nvsz–16a	New Britain–Vanuatu	160.7343	-10.0574	301	46.05	41
nvsz–16b	New Britain–Vanuatu	160.5712	-10.3246	301	46.05	5
nvsz–17a	New Britain–Vanuatu	161.4562	-10.5241	298.4	40.12	37.22
nvsz–17b	New Britain–Vanuatu	161.2900	-10.8263	298.4	40.12	5
nvsz–18a	New Britain–Vanuatu	162.0467	-10.6823	274.1	40.33	29.03
nvsz–18b	New Britain–Vanuatu	162.0219	-11.0238	274.1	28.72	5
nvsz–19a	New Britain–Vanuatu	162.7818	-10.5645	261.3	34.25	24.14
nvsz–19b	New Britain–Vanuatu	162.8392	-10.9315	261.3	22.51	5
nvsz–20a	New Britain–Vanuatu	163.7222	-10.5014	262.9	50.35	26.3
nvsz–20b	New Britain–Vanuatu	163.7581	-10.7858	262.9	25.22	5
nvsz–21a	New Britain–Vanuatu	164.9445	-10.4183	287.9	40.31	23.3
nvsz–21b	New Britain–Vanuatu	164.8374	-10.7442	287.9	21.47	5
nvsz–22a	New Britain–Vanuatu	166.0261	-11.1069	317.1	42.39	20.78
nvsz–22b	New Britain–Vanuatu	165.7783	-11.3328	317.1	18.4	5
nvsz–23a	New Britain–Vanuatu	166.5179	-12.2260	342.4	47.95	22.43
nvsz–23b	New Britain–Vanuatu	166.2244	-12.3171	342.4	20.4	5
nvsz–24a	New Britain–Vanuatu	166.7236	-13.1065	342.6	47.13	28.52
nvsz–24b	New Britain–Vanuatu	166.4241	-13.1979	342.6	28.06	5
nvsz–25a	New Britain–Vanuatu	166.8914	-14.0785	350.3	54.1	31.16
nvsz–25b	New Britain–Vanuatu	166.6237	-14.1230	350.3	31.55	5
nvsz–26a	New Britain–Vanuatu	166.9200	-15.1450	365.6	50.46	29.05
nvsz–26b	New Britain–Vanuatu	166.6252	-15.1170	365.6	28.75	5
nvsz–27a	New Britain–Vanuatu	167.0053	-15.6308	334.2	44.74	25.46

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Table B.8 – continued

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
nvsz–27b	New Britain–Vanuatu	166.7068	-15.7695	334.2	24.15	5
nvsz–28a	New Britain–Vanuatu	167.4074	-16.3455	327.5	41.53	22.44
nvsz–28b	New Britain–Vanuatu	167.1117	-16.5264	327.5	20.42	5
nvsz–29a	New Britain–Vanuatu	167.9145	-17.2807	341.2	49.1	24.12
nvsz–29b	New Britain–Vanuatu	167.6229	-17.3757	341.2	22.48	5
nvsz–30a	New Britain–Vanuatu	168.2220	-18.2353	348.6	44.19	23.99
nvsz–30b	New Britain–Vanuatu	167.8895	-18.2991	348.6	22.32	5
nvsz–31a	New Britain–Vanuatu	168.5022	-19.0510	345.6	42.2	22.26
nvsz–31b	New Britain–Vanuatu	168.1611	-19.1338	345.6	20.2	5
nvsz–32a	New Britain–Vanuatu	168.8775	-19.6724	331.1	42.03	21.68
nvsz–32b	New Britain–Vanuatu	168.5671	-19.8338	331.1	19.49	5
nvsz–33a	New Britain–Vanuatu	169.3422	-20.4892	332.9	40.25	22.4
nvsz–33b	New Britain–Vanuatu	169.0161	-20.6453	332.9	20.37	5
nvsz–34a	New Britain–Vanuatu	169.8304	-21.2121	329.1	39	22.73
nvsz–34b	New Britain–Vanuatu	169.5086	-21.3911	329.1	20.77	5
nvsz–35a	New Britain–Vanuatu	170.3119	-21.6945	311.9	39	22.13
nvsz–35b	New Britain–Vanuatu	170.0606	-21.9543	311.9	20.03	5
nvsz–36a	New Britain–Vanuatu	170.9487	-22.1585	300.4	39.42	23.5
nvsz–36b	New Britain–Vanuatu	170.7585	-22.4577	300.4	21.71	5
nvsz–37a	New Britain–Vanuatu	171.6335	-22.3087	281.3	30	22.1
nvsz–37b	New Britain–Vanuatu	171.5512	-22.6902	281.3	20	5

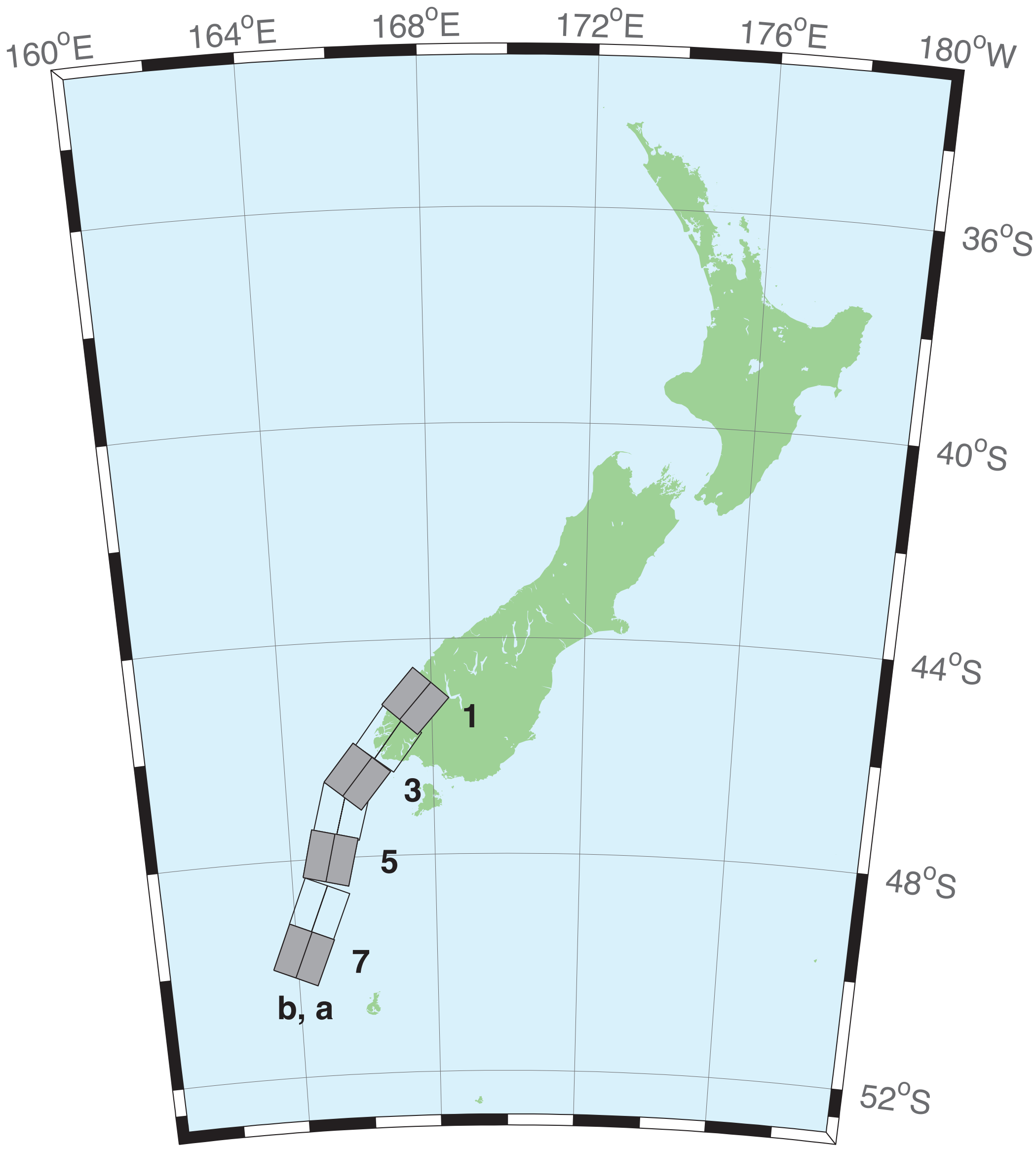

Figure B.9: New Zealand–Puysegur Zone unit sources.

Table B.9: Earthquake parameters for New Zealand–Puysegur Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
nzsz–1a	New Zealand–Puysegur	168.0294	-45.4368	41.5	15	17.94
nzsz–1b	New Zealand–Puysegur	167.5675	-45.1493	41.5	15	5
nzsz–2a	New Zealand–Puysegur	167.3256	-46.0984	37.14	15	17.94
nzsz–2b	New Zealand–Puysegur	166.8280	-45.8365	37.14	15	5
nzsz–3a	New Zealand–Puysegur	166.4351	-46.7897	39.53	15	17.94
nzsz–3b	New Zealand–Puysegur	165.9476	-46.5136	39.53	15	5
nzsz–4a	New Zealand–Puysegur	166.0968	-47.2583	15.38	15	17.94
nzsz–4b	New Zealand–Puysegur	165.4810	-47.1432	15.38	15	5
nzsz–5a	New Zealand–Puysegur	165.7270	-48.0951	13.94	15	17.94
nzsz–5b	New Zealand–Puysegur	165.0971	-47.9906	13.94	15	5
nzsz–6a	New Zealand–Puysegur	165.3168	-49.0829	22.71	15	17.94
nzsz–6b	New Zealand–Puysegur	164.7067	-48.9154	22.71	15	5
nzsz–7a	New Zealand–Puysegur	164.8017	-49.9193	23.25	15	17.94
nzsz–7b	New Zealand–Puysegur	164.1836	-49.7480	23.25	15	5

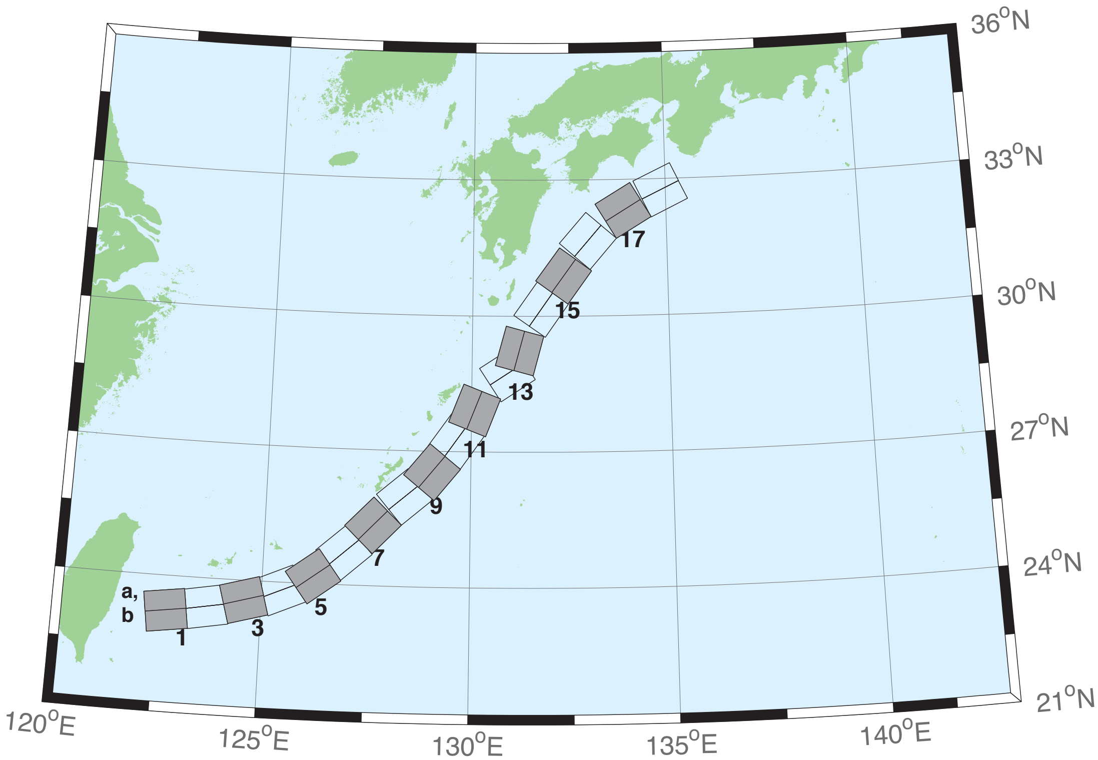

Figure B.10: Ryukyu–Kyushu–Nankai Zone unit sources.

Table B.10: Earthquake parameters for Ryukyu–Kyushu–Nankai Subduction Zone unit sources.

Segment	Description	Longitude(°E)	Latitude(°N)	Strike(°)	Dip(°)	Depth (km)
rnsz–1a	Ryukyu–Nankai	122.6672	23.6696	262	14	11.88
rnsz–1b	Ryukyu–Nankai	122.7332	23.2380	262	10	3.2
rnsz–2a	Ryukyu–Nankai	123.5939	23.7929	259.9	18.11	12.28
rnsz–2b	Ryukyu–Nankai	123.6751	23.3725	259.9	10	3.6
rnsz–3a	Ryukyu–Nankai	124.4604	23.9777	254.6	19.27	14.65
rnsz–3b	Ryukyu–Nankai	124.5830	23.5689	254.6	12.18	4.1
rnsz–4a	Ryukyu–Nankai	125.2720	24.2102	246.8	18	20.38
rnsz–4b	Ryukyu–Nankai	125.4563	23.8177	246.8	16	6.6
rnsz–5a	Ryukyu–Nankai	125.9465	24.5085	233.6	18	20.21
rnsz–5b	Ryukyu–Nankai	126.2241	24.1645	233.6	16	6.43
rnsz–6a	Ryukyu–Nankai	126.6349	25.0402	228.7	17.16	19.55
rnsz–6b	Ryukyu–Nankai	126.9465	24.7176	228.7	15.16	6.47
rnsz–7a	Ryukyu–Nankai	127.2867	25.6343	224	15.85	17.98
rnsz–7b	Ryukyu–Nankai	127.6303	25.3339	224	13.56	6.26
rnsz–8a	Ryukyu–Nankai	128.0725	26.3146	229.7	14.55	14.31
rnsz–8b	Ryukyu–Nankai	128.3854	25.9831	229.7	9.64	5.94
rnsz–9a	Ryukyu–Nankai	128.6642	26.8177	219.2	15.4	12.62
rnsz–9b	Ryukyu–Nankai	129.0391	26.5438	219.2	8	5.66
rnsz–10a	Ryukyu–Nankai	129.2286	27.4879	215.2	17	12.55
rnsz–10b	Ryukyu–Nankai	129.6233	27.2402	215.2	8.16	5.45
rnsz–11a	Ryukyu–Nankai	129.6169	28.0741	201.3	17	12.91
rnsz–11b	Ryukyu–Nankai	130.0698	27.9181	201.3	8.8	5.26
rnsz–12a	Ryukyu–Nankai	130.6175	29.0900	236.7	16.42	13.05
rnsz–12b	Ryukyu–Nankai	130.8873	28.7299	236.7	9.57	4.74
rnsz–13a	Ryukyu–Nankai	130.7223	29.3465	195.2	20.25	15.89
rnsz–13b	Ryukyu–Nankai	131.1884	29.2362	195.2	12.98	4.66
rnsz–14a	Ryukyu–Nankai	131.3467	30.3899	215.1	22.16	19.73
rnsz–14b	Ryukyu–Nankai	131.7402	30.1507	215.1	17.48	4.71
rnsz–15a	Ryukyu–Nankai	131.9149	31.1450	216	15.11	16.12
rnsz–15b	Ryukyu–Nankai	132.3235	30.8899	216	13.46	4.48
rnsz–16a	Ryukyu–Nankai	132.5628	31.9468	220.9	10.81	10.88
rnsz–16b	Ryukyu–Nankai	132.9546	31.6579	220.9	7.19	4.62
rnsz–17a	Ryukyu–Nankai	133.6125	32.6956	239	10.14	12.01
rnsz–17b	Ryukyu–Nankai	133.8823	32.3168	239	8.41	4.7
rnsz–18a	Ryukyu–Nankai	134.6416	33.1488	244.7	10.99	14.21
rnsz–18b	Ryukyu–Nankai	134.8656	32.7502	244.5	10.97	4.7
rnsz–19a	Ryukyu–Nankai	135.6450	33.5008	246.5	14.49	14.72
rnsz–19b	Ryukyu–Nankai	135.8523	33.1021	246.5	11.87	4.44
rnsz–20a	Ryukyu–Nankai	136.5962	33.8506	244.8	15	14.38
rnsz–20b	Ryukyu–Nankai	136.8179	33.4581	244.8	12	3.98
rnsz–21a	Ryukyu–Nankai	137.2252	34.3094	231.9	15	15.4
rnsz–21b	Ryukyu–Nankai	137.5480	33.9680	231.9	12	5
rnsz–22a	Ryukyu–Nankai	137.4161	34.5249	192.3	15	15.4
rnsz–22b	Ryukyu–Nankai	137.9301	34.4327	192.3	12	5

Appendix C. SIFT testing results

Lindsey Wright, Yong Wei Yong Wei

1.0 PURPOSE

Forecast models are tested with synthetic tsunami events covering a range of tsunami source locations and magnitudes ranging from mega-events to micro-events. Testing is also done with selected historical tsunami events when available.

The purpose of forecast model testing is three-fold. The first objective is to assure that the results obtained with NOAA's tsunami forecast system, which has been released to the Tsunami Warning Centers for operational use, are identical to those obtained by the researcher during the development of the forecast model. The second objective is to test the forecast model for consistency, accuracy, time efficiency, and quality of results over a range of possible tsunami locations and magnitudes. The third objective is to identify bugs and issues in need of resolution by the researcher who developed the Forecast Model or by the forecast software development team before the next version release to NOAA's two Tsunami Warning Centers.

Local hardware and software applications, and tools familiar to the researcher(s), are used to run the Method of Splitting Tsunamis (MOST) model during the forecast model development. The test results presented in this report lend confidence that the model performs as developed and produces the same results when initiated within the forecast application in an operational setting as those produced by the researcher during the forecast model development. The test results assure those who rely on the Unalaska tsunami forecast model that consistent results are produced irrespective of system.

2.0 TESTING PROCEDURE

The general procedure for forecast model testing is to run a set of synthetic tsunami scenarios and a selected set of historical tsunami events through the forecast system application and compare the results with those obtained by the researcher during the forecast model development and presented in the Tsunami Forecast Model Report. Specific steps taken to test the model include:

1. Identification of testing scenarios, including the standard set of synthetic events, appropriate historical events, and customized synthetic scenarios that may have been used by the researcher(s) in developing the forecast model.
2. Creation of new events to represent customized synthetic scenarios used by the researcher(s) in developing the forecast model, if any.
3. Submission of test model runs with SIFT, and export of the results from A, B, and C grids, along with time series.
4. Recording applicable metadata, including the specific version of the forecast system used for testing.
5. Examination of SIFT forecast model results for instabilities in both time series and plot results.
6. Comparison of forecast model results obtained through the forecast system with those obtained during the forecast model development.
7. Summarization of results with specific mention of quality, consistency, and time efficiency.
8. Reporting of issues identified to modeler and forecast software development team.

Retesting the forecast models in the forecast system when reported issues have been addressed or explained.
Synthetic model runs were tested on a DELL PowerEdge R510 computer equipped with two Xeon E5670 processors at 2.93 Ghz, each with 12 MBytes of cache and 32GB memory. The processors are hex core and support hyperthreading, resulting in the computer performing as a 24 processor core machine. Additionally, the testing computer supports 10 Gigabit Ethernet for fast network connections. This computer configuration is similar or the same as the configurations of the computers installed at the Tsunami Warning Centers so the compute times should only vary slightly.

Results

The Unalaska forecast model was tested with NOAA's tsunami forecast system version 3.1, the current version installed at the NOAA Tsunami Warning Centers.

The Unalaska, Alaska forecast model was tested with twenty three synthetic scenarios and two historical tsunami events. Test results from the forecast system and comparisons with the results obtained during the forecast model development are shown numerically in Table 2 and graphically in Figures 1 to 25 The results show that the forecast model is stable and robust, with consistent and high quality results across geographically distributed tsunami sources and tsunami magnitudes from micro-events to mega-events. The model run time (wall clock time) was 15.95 minutes for 7.99 hours of simulation time, and 7.96 minutes for 4.0 hours. This run time is within the 10 minute run time for 4 hours of simulation time and satisfies time efficiency requirements.

The standard suite of synthetic events was run on the Unalaska forecast model. The modeled scenarios were stable for all cases tested, with no instabilities or ringing. Results show that the largest modeled height was 385.1 cm and originated in the Aleutian-Alaska-Cascadia (ACSZ 16-25) source. Additionally, large (282.2-306 cm) amplitudes were recorded using the overlapping and adjacent Aleutian-Alaska-Cascadia (ACSZ 22-31 and 6-15) sources. Amplitudes greater than 100 cm were recorded at the Kamchatka-Yap-Mariana-Izu-Bonin (KISZ 1-10), Manus OCB (MOSZ 1-10) and the New Zealand-Kermadec-Tonga (NTSZ 30-39) sources. The smallest signals of 12.8 cm and 13.5 cm were recorded at the far field Central and South American (CSSZ 1-10 and 37-46) sources. Small scale events (Mw =7.5) and the micro events tested were also stable. Direct comparisons of output from the forecast tool with development results of both the historical events and synthetic events demonstrated that the wave pattern were similar in shape, pattern and amplitude. However, in a few cases, the maximum amplitudes obtained during forecast model development of Unalaska were higher than the maximum amplitudes obtained using the forecast software. This is mostly due to a change of the computational spatial time step in C grid from 1.2 sec to 1.0 sec in the most recent version of Unalaska forecast model that is currently implemented in the forecast system.

Scenario Name	Source Zone	Tsunami Source	α [m]	SIFT Max (cm)	Development Max (cm)	SIFT Min (cm)	Development Min (cm)
Mega-tsunami Scenarios							
KISZ 1-10	Kamchatka-Yap-Mariana-Izu-Bonin	A1-A10, B1-B10	25	180.4	178.2	-145.0	-142.6
KISZ 22-31	Kamchatka-Yap-Mariana-Izu-Bonin	A22-A31, B22-B31	25	81.1	80.7	-79.1	-78.6
KISZ 32-41	Kamchatka-Yap-Mariana-Izu-Bonin	A32-A41, B32-B41	25	75.2	75.3	-83.1	-83.1
KISZ 56-65	Kamchatka-Yap-Mariana-Izu-Bonin	A56-A65, B56-B65	25	89.7	87.4	-95.8	-94.2
ACSZ 6-15	Aleutian-Alaska-Cascadia	A6-A15, B6-B15	25	282.2	279.8	-237.1	-238
ASCZ 16-25	Aleutian-Alaska-Cascadia	A16-A25, B16-B25	25	385.1	355.4	-204.8	-205.9
ASCZ 22-31	Aleutian-Alaska-Cascadia	A22-A31, B22-B31	25	306.1	298.4	-230.8	-234
ASCZ 50-59	Aleutian-Alaska-Cascadia	A50-A59, B50-B59	25	47.5	46.3	-47.2	-47.3
ASCZ 56-65	Aleutian-Alaska-Cascadia	A56-A65, B56-B65	25	57.8	58.5	-69.6	-70.2
CSSZ 1-10	Central and South America	A1-A10, B1-B10	25	13.5	14.8	-11.3	-14.5
CSSZ 37-46	Central and South America	A37-A46, B37-B46	25	12.8	12.7	-13.9	-13.7
CSSZ 89-98	Central and South America	A89-A98, B89-B98	25	99.8	97.6	-88.6	-88.7
CSSZ 102-111	Central and South America	A102-A111, B102-B111	25	95.3	95.9	-93.9	-93.1
NTSZ 30-39	New Zealand-Kermadec-Tonga	A30-A39, B30-B39	25	103.5	101.4	-95.3	-96.1

37		B37					
MOSZ 1-10	ManusOCB	A1-A10, B1-B10	25	106.8	100.0	-112	-111
NGSZ 3-12	North New Guinea	A3-A12, B3-B12	25	87.0	86.8	-77.8	-78.8
EPSZ 6-15	East Philippines	A6-A15, B6-B15	25	66.9	67.8	-71.2	-70.5
RNSZ 12-21	Ryukus-Kyushu-Nankai	A12-A21, B12-B21	25	40.2	41.9	-47.0	-46.4
Mw 7.5 Scenarios							
NTSZ B36	New Zealand-Kermadec-Tonga	B36	1	0.7	0.7	-0.6	-0.6
Micro-tsunami Scenarios							
EPSZ B19	East Philippines	B19	0.04	0.01	0.01	-0.01	-0.01
RNSZ B14	Ryukus-Kyushu-Nankai	B14	0.03	0.01	n/a	-0.01	n/a
ACSZ B6	Aleutian-Alaska-Cascadia	B6	0.02	0.06	n/a	-0.07	n/a
Historical Events							
2006 Kuril	n/a	n/a	n/a	8.1	n/a	-8.1	n/a
2007 Kuril	n/a	n/a	n/a	2.5	n/a	-3.3	n/a

Table 1. Table of maximum and minimum amplitudes (cm) at the Unalaska, Alaska warning point for synthetic and historical events tested using SIFT 3.1 and obtained during development.

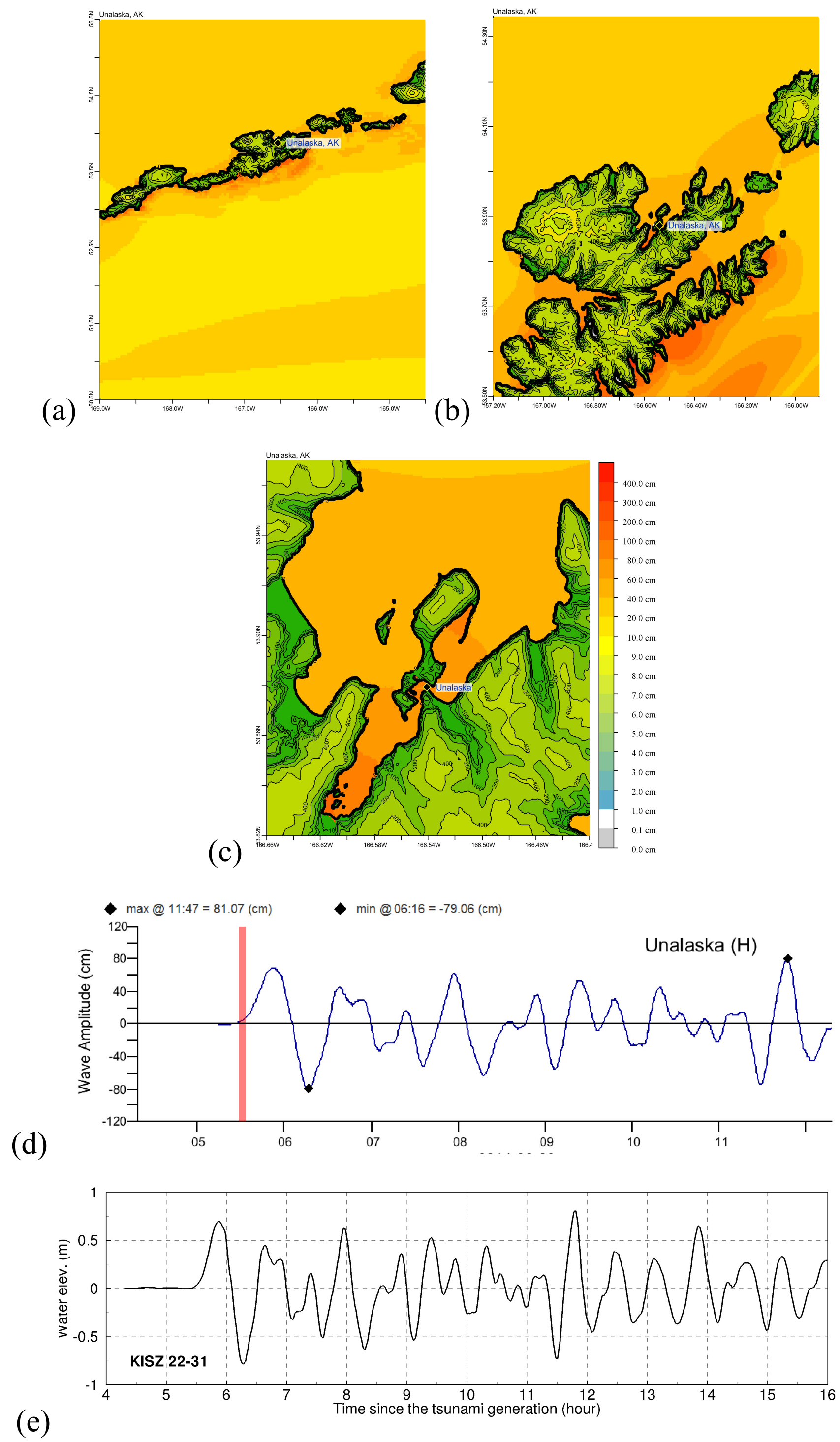

Figure 1: Response of the Unalaska forecast model to synthetic scenario KISZ 22- (alpha=25). Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The compu time series obtained during model development and is shown for comparison wit test results in (d).

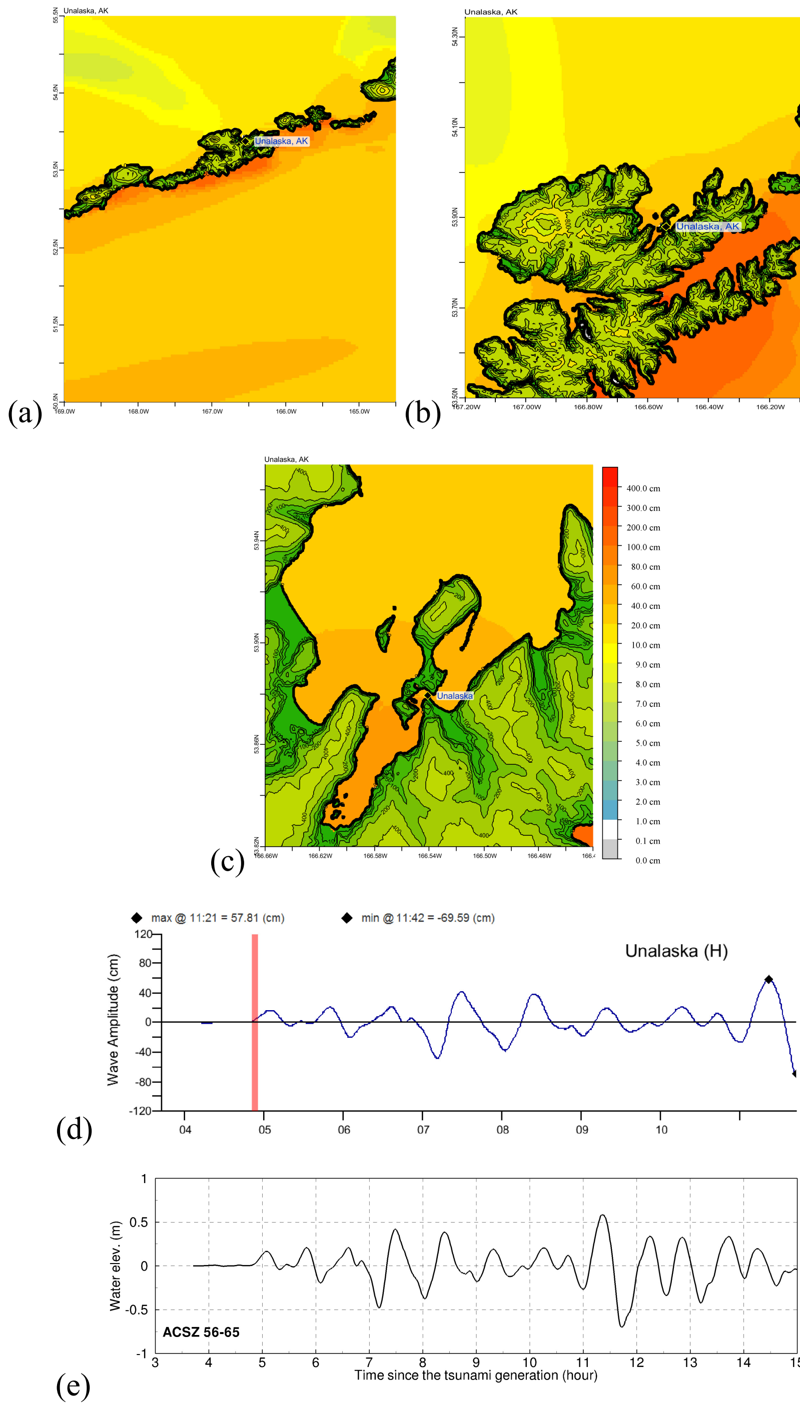

Figure 2: Response of the Unalaska forecast model to synthetic scenario ACSZ 56-65 (alpha=25). Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The computed time series obtained during model development and is shown for comparison with test results in (d).

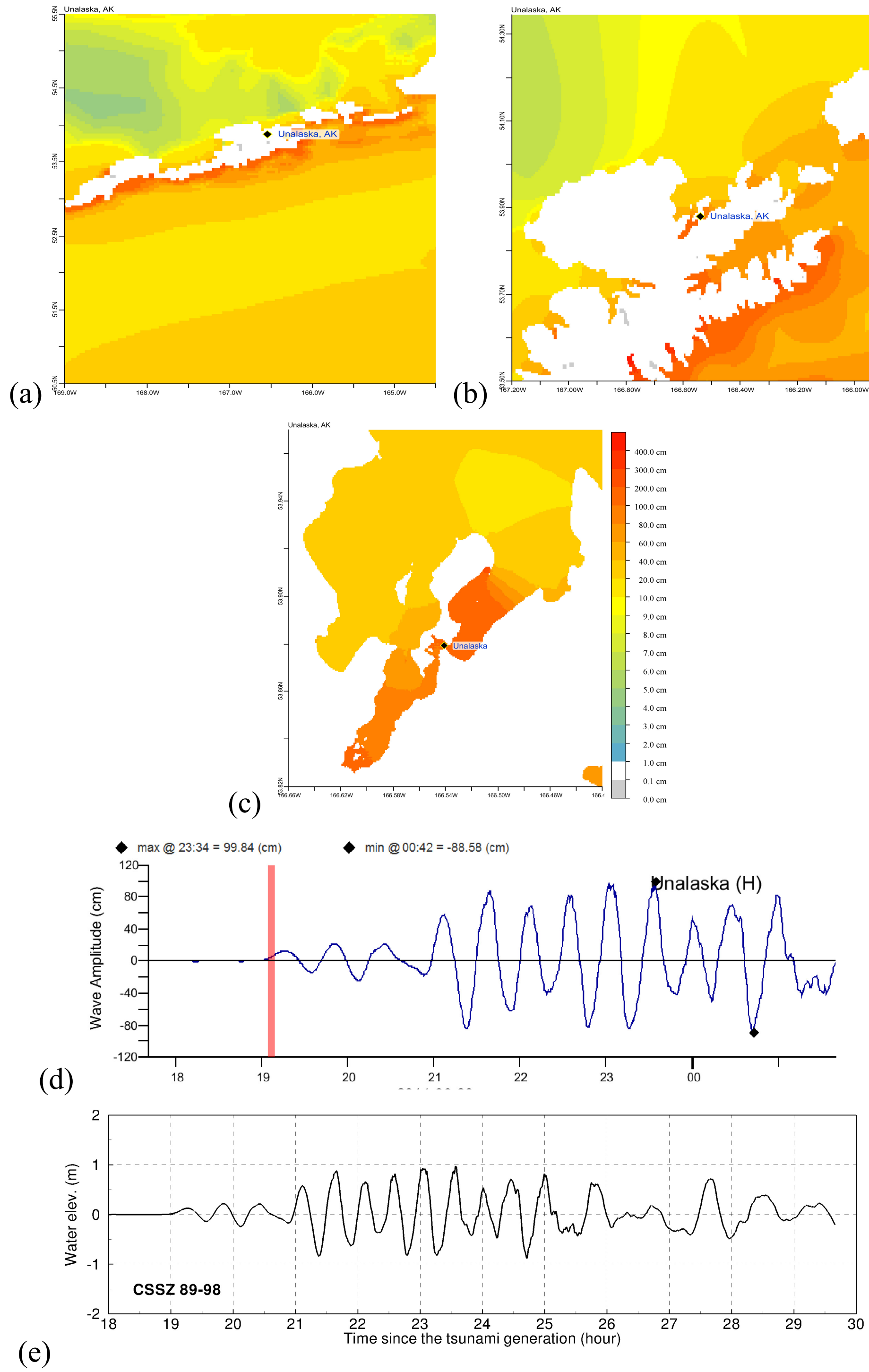

Figure 3: Response of the Unalaska forecast model to synthetic scenario CSSZ 89-98(alpha=25). Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The computed time series obtained during model development and is shown for comparison with test results in (d).

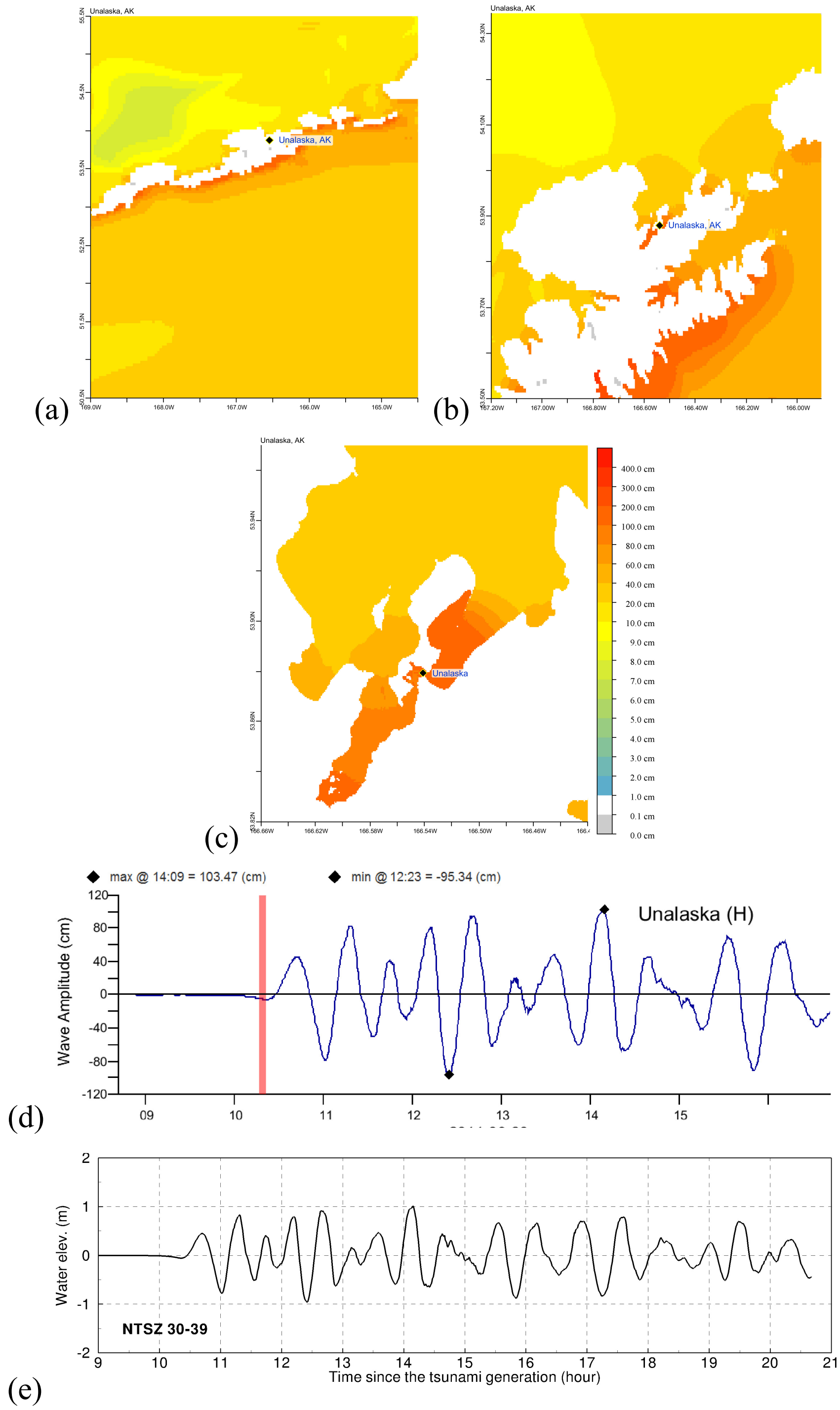

Figure 4: Response of the Unalaska forecast model to synthetic scenario NTSZ 30-39 (alpha=25). Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The computed time series obtained during model development and is shown for comparison with test results in (d).

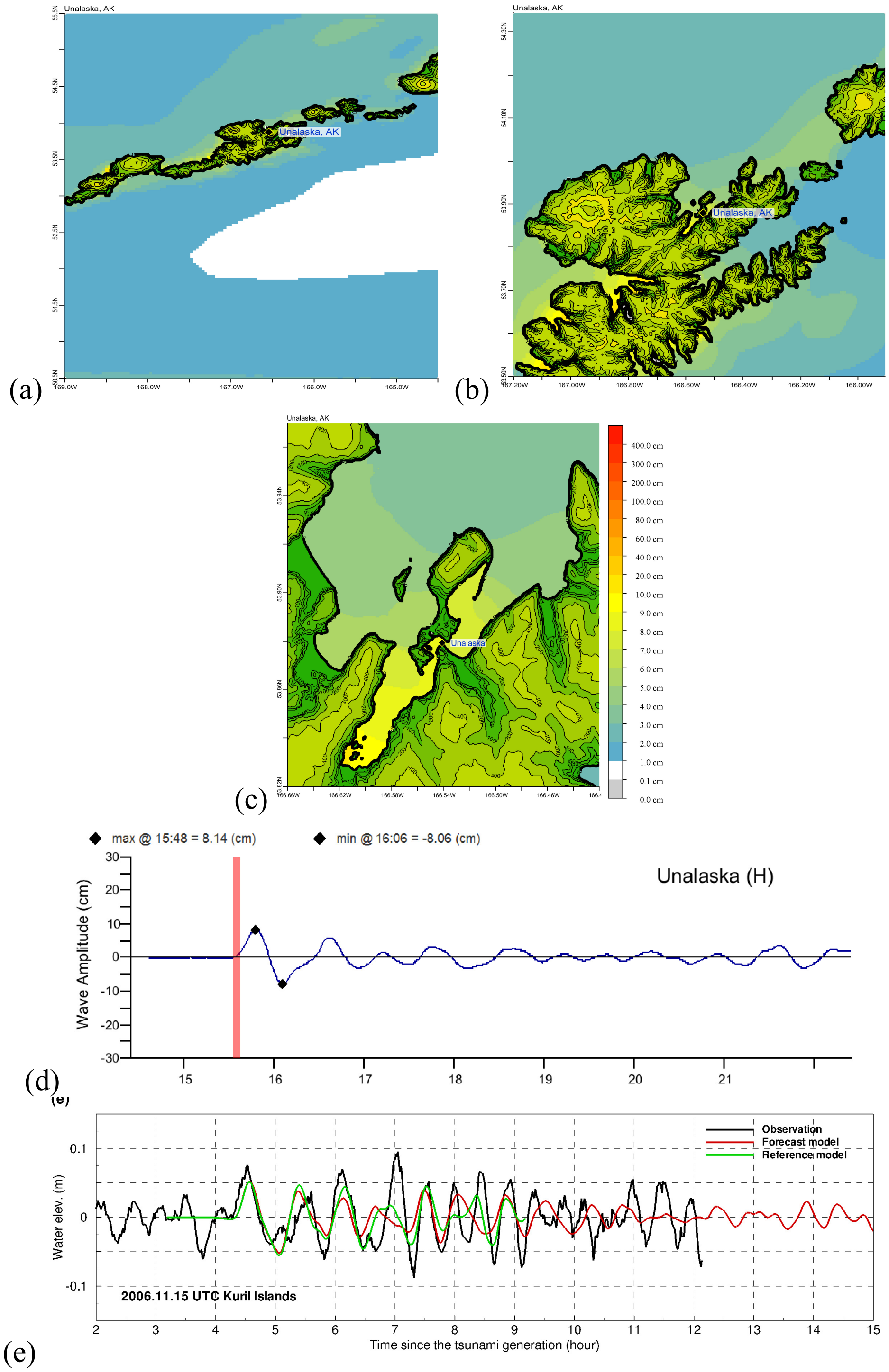

Figure 5: Response of the Unalaska forecast model to the 2006 Kuril tsunami. Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The computed time series obtained during model development and is shown for comparison with test results in (d).

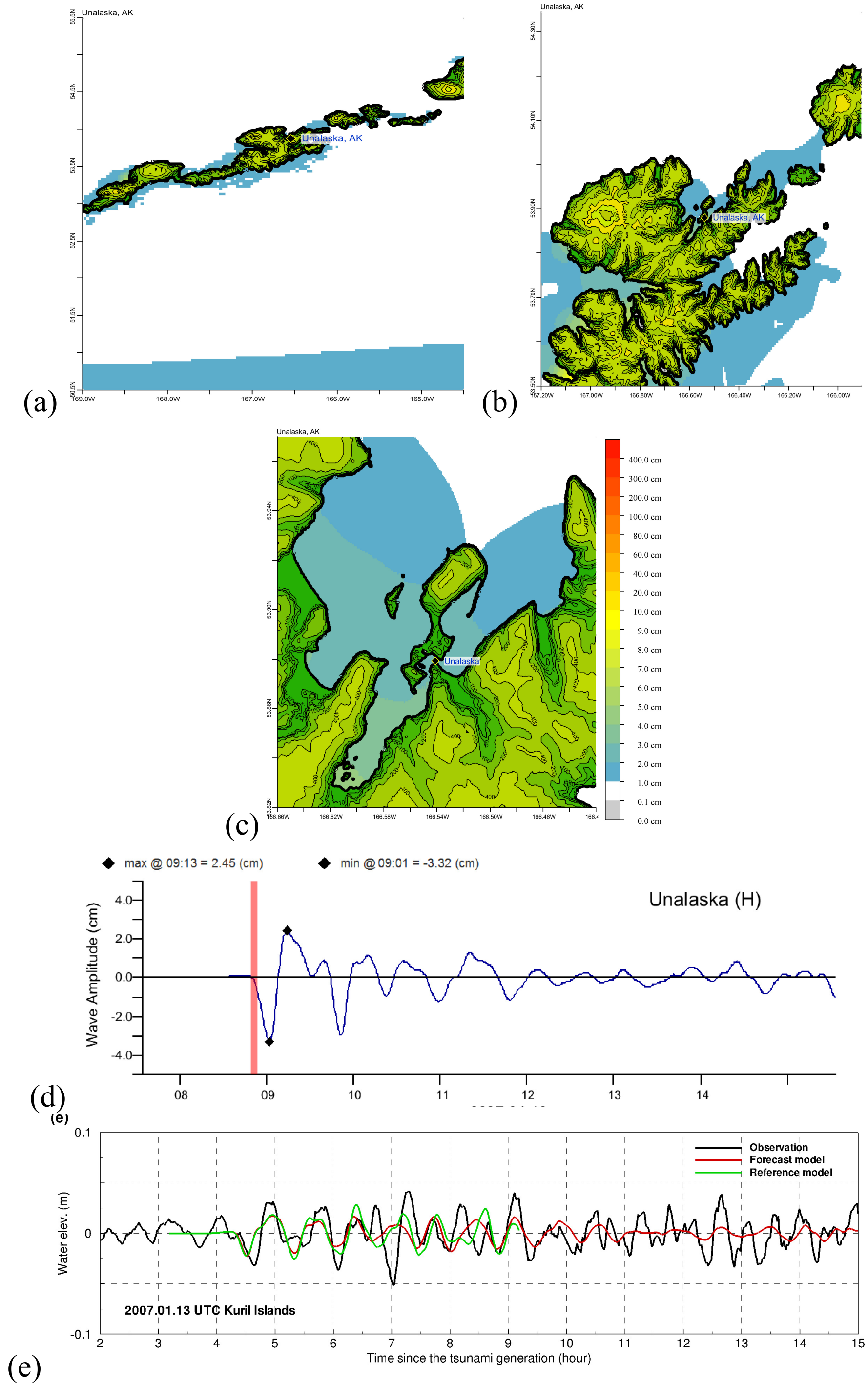

Figure 6: Response of the Unalaska forecast model to the 2007 Kuril tsunami. Maximum sea surface elevation for (a) A-grid, b) B-grid, c) C-grid. (d) SIFT time series of sea surface elevation at the C-grid warning point; (e) The computed time series obtained during model development and is shown for comparison with test results in (d).