A TSUNAMI FORECAST MODEL FOR MIDWAY ATOLL

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Table of Contents

List of Tables

List of Figures

viii

FOREWORD

Several Pacific Ocean Basin tsunamis have been recognized as a potential hazard to United States coastal communities since the mid-twentieth century, when multiple destructive tsunamis caused damage to the states of Hawaii, Alaska, California, Oregon, and Washington. In response to these events, the United States, under the auspices of the National Oceanic and Atmospheric Administration (NOAA), established the Pacific and Alaska Tsunami Warning Centers, dedicated to protecting United States interests from the threat posed by tsunamis. NOAA also created a tsunami research program at the Pacific Marine Environmental Laboratory (PMEL) to develop improved warning products.

The scale of destruction and unprecedented loss of life following the December 2004 Sumatra tsunami served as the catalyst to refocus efforts in the United States on reducing tsunami vulnerability of coastal communities, and on 20 December 2006, the United States Congress passed the "Tsunami Warning and Education Act" under which education and warning activities were thereafter specified and mandated. A "tsunami forecasting capability based on models and measurements, including tsunami inundation models and maps" is a central component for the protection of United States coastlines from the threat posed by tsunamis. The forecasting capability for each community described in the PMEL Tsunami Forecast Series is the result of collaboration between the National Oceanic and Atmospheric Administration office of Oceanic and Atmospheric Research, National Weather Service, National Ocean Service, National Environmental Satellite, Data, and Information Service, the University of Washington's Joint Institute for the Study of the Atmosphere and Ocean, National Science Foundation, and United States Geological Survey.

NOAA Center for Tsunami Research

A TSUNAMI FORECAST MODEL FOR MIDWAY ATOLL

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Abstract

The National Oceanic and Atmospheric Administration (NOAA) has developed a tsunami forecast model for Midway Atoll, as part of an effort to provide tsunami forecasts for United States coastal communities. Development, validation, and stability testing of the tsunami forecast model has been conducted to ensure model robustness and stability. The Midway Atoll tsunami forecast model employs the Method of Splitting Tsunami numerical code and has been validated with historical as well as synthetically generated tsunami events. A total of 12 historical events and 42 synthetic (Mw = 9.4, 7.5, and 6.2) events from different source regions were used for validation and stability testing. Results showed good agreement between observed and modeled data. The Midway Atoll forecast model has been developed so that it can simulate 4 hours of tsunami wave characteristics in approximately 16.4 minutes of CPU time.

1.0 Background and Objectives

The 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 Hawaiʻi and Alaska (Titov et al., 2005). The system is designed to efficiently provide basin-wide warning of approaching tsunami waves accurately and quickly. The system, termed Short-term Inundation Forecast of Tsunamis (SIFT), 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 SIFT 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.

Midway Atoll is a territory of the United States and is located at approximately 28.21°N latitude and 177.361°W longitude (Figure 1). It is known as Midway Atoll, Midway Island, or Midway Islands. In this report, it is referred to as Midway Atoll. Midway Atoll was discovered on 5 July 1859 by Captain N.C. Brooks of the Hawaiian Barque Gambia, who took possession in the name of the United States and named it Middlebrook Islands. There were no indigenous people on the islands (Dept. of Interior, Office of Insular Affairs, 2012).The United States of formally took possession on 28 August 1867 pursuant to the Guano Act of 1856. The islands was one of the stops for the trans-Pacific cable stretching from San Francisco to the Philippines via Honolulu, Midway Atoll, and Guam, which carried the first around-the-world message on 4 July 1903 from President Theodore Roosevelt wishing "a Happy Independence Day to the U.S., its territories, and properties (U.S. Fish and Wildlife Service, 2012).

In 1940, the U.S. Navy established a Naval Defense Sea Area and Airspace Reservation, and Middlebrook Islands became Midway Islands due to its located about halfway between the U.S. West Coast and Japan (Dept. of Interior, Office of Insular Affairs, 2012). The location of Midway Atoll was convenient for refueling trans-pacific flights and a very strategic point for the U.S. military for their warplanes and ships during the World War II, the Korean War, and the Vietnam War. The Midway Atoll is well recognized as the site of one of the most important and decisive naval battles of World War II, the Battle of Midway. On 30 September 1993, the Naval Air Facility was operationally closed and environmental cleanup was initiated. By 31 October 1996, Midway Atoll was turned over to the U.S. Fish and Wildlife Service by President Clinton through Executive Order No. 13022 and designated as Midway Atoll National Wildlife Refuge (U.S. Fish and Wildlife Service, 2012). The human population of Midway Atoll consists mostly of researchers and volunteers doing long-term scientific research on the diverse population of fish and wildlife where data gathered are critical to the conservation of its natural resources. The population of Midway Atoll consists of about 40 staff and service contractors (Central Intelligence of America, 2012).

Regardless of the role of Midway Atoll: during times of war and peace, its location, like Hawai'i, places it along the path of tsunamis that are generated in the Pacific Ocean. It is particularly close to active subduction regions of the Marianas, Japan, the Kuril Islands, and the Aleutian Islands. The potential for a destructive tsunami at Midway Atoll is of particular interest to the U.S., not only for the protection of its territory but also to serve as an early indicator of the strength of tsunamis emanating from the Marianas, Japan, the Kuril Islands, and, the West Aleutian Islands prior to arrival at Hawaii and the U.S. West Coast.

This report details the development of a tsunami forecast model for Midway Atoll. Development includes construction of a digital elevation model (DEM) based on available bathymetric and topographic data, model validation with historic events, and stability tests of the model with a suite of mega-tsunami events the originating from subduction zones in the Pacific Ocean.

2.0 Forecast Methodology

A high-resolution inundation model is used as the basis for the operational forecast model to provide an estimate of wave arrival time, wave height, and inundation immediately following tsunami generation. Tsunami forecast models are run in real time while a tsunami is propagating across the open ocean. These models are designed and tested to perform under very stringent time constraints given that time is generally the single limiting factor in saving lives and property. The goal is to maximize the amount of time that an at-risk community has to react to a tsunami threat by providing accurate information quickly.

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 Deep-ocean Assessment on Reporting for Tsunamis (DART®) observation sites, recorded sea level is ingested 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 improved tsunami source, now reflecting the transfer of energy to the fluid body, to produce boundary conditions of water elevation and flow velocities to initiate the forecast model computation.

The tsunami forecast model, based on the Method of Splitting Tsunami (MOST), emerges as the solution in the SIFT system by modeling real-time tsunamis in minutes while employing high-resolution grids constructed by the National Geophysical Data Center (NGDC) and Light Detection and Ranging (LiDAR) data obtained by U.S. Geological Survey (USGS) (Reynolds et al., 2012). Each forecast model consists of three telescoped grids with increasing spatial 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. Forecast models are generally constructed for at-risk populous coastal communities in the Pacific and Atlantic oceans, strategic locations, or U.S. coastal areas like Midway Atoll. Previous and present development of forecast models in the Pacific (Titov et al., 2005; Titov, 2009; Tang et al., 2009; Wei et al., 2008) have validated the accuracy and efficiency of the forecast models currently implemented in the SIFT system for real-time tsunami forecast. The models are also a valuable tool in hindcast research. Tang et al. (2009) provide forecast methodology details.

3.0 Model Development

The characteristics of the tsunami waves are sensitive to the nearshore bathymetry while the sub-aerial topography plays a factor in the inundation extent of the tsunami waves. Therefore, a prerequisite for a credible tsunami modeling is the availability of accurate gridded bathymetry and topographic datasets, termed DEM. Modeling of coastal communities is accomplished by development of a set of three nested grids that telescope down from a large spatial extent to a grid that finely defines the localized community. The basis for these grids is a high-resolution DEM constructed by the NGDC using best available bathymetric, topographic, and coastal shoreline data and LiDAR (Reynolds et al., 2012) data for an at-risk community. For each community, data are compiled from a variety of sources to produce a DEM referenced to Mean High Water (MHW) in the vertical and to the World Geodetic System 1984 in the horizontal (NGDC, 2012). The use of MHW as the 'zero level' for forecast results is standard. The MOST model does not include tidal fluctuations, and, since a tsunami may arrive at any stage of the tide, it is best to employ a 'worst-case' approach by assuming high tide when forecasting inundation. From these DEMs, a set of three high-resolution, 'reference' models are constructed then 'optimized' for development as a forecast model to run in an operationally specified period of time.

4

3.1 Forecast area

The location of Midway Atoll makes it vulnerable to tsunamis that are generated in the seismically active regions of the Marianas, Japan, Kuril and Aleutian trenches. As previously noted, it is strategic in terms of tsunami forecasting since it could act as a vanguard in determining the strength of tsunamis generated from these sources before they reach Hawaiʻi and the U.S. West Coast.

Figure 2 shows the reef surrounding Midway's three islands: Sand Island to the west, Eastern Island to the east, and Spit Island, which is the smallest island located at the western tip of Eastern Island. The highest elevation of each island is 11.0 m, 7.5 m, and 1.8 m, respectively. The water depth inside the reef is very shallow (Figure 3) with the reef located at approximately 10 m depth (blue line). Beyond the reef, the water depth quickly deepens to 100 m (inner black line). The current topography of Sand Island is different than it was in 1952. The southern breakwater was backfilled, adding more land area. This feature was added sometime between 1954 and 1958 as seen in the aerial photos that appear in Figure 4a taken in 1954 and 4b taken in 1956).

3.2 Historical events and data

A few historical tsunamis have resulted in significant inundation on Midway Atoll. Figure 5 shows inundation by the 4 November 1952 Kamchatka tsunami on Sand Island in the vicinity of the housing areas, with an estimated cost of damages between $0.8 and $1.0 million dollars (1952 U.S. dollars, Pararas-Carayannis, 2012). Based on NGDC's database, the tsunami amplitude at the tide gauge was 1.9 m. The more recent 11 March 2011 Tohoku tsunami, which inundated Sand Island, almost completely inundated Eastern Island, and completely inundated Spit Island is discussed in detail in Section 4.

In addition to the 1952 Kamchatka and 2011 Tohoku tsunamis, a significant number of tsunamis have propagated across the Midway Atoll, and fortunately, a majority of these events had minimal impact. Looking at available historical tide gauge data, a number of these events are used to validate the Midway Atoll forecast model. The historical tsunamis used for this forecast are 1996 Andreanof, 2001 Peru, 2003 Rat Island, 2006 Tonga, 2006 Kuril, 2007 Chile, 2007 Kuril, 2007 Peru, 2007 Solomon, 2009 Samoa, 2010 Chile, and 2011 Tohoku.

The tide gauge at Midway Atoll is located inside the northeast part of the harbor on Sand Island at 177.3611°W, 28.21167°N. It was originally established on 2 February 1947, and the present installation was established on 28 January 1989. Figure 6 shows the location inside Sand Island harbor and the housing area. The mean tidal range is 0.26 m and a diurnal range of 0.38 m. The location of the tide gauge is the point where plots of the tsunami time series will be based upon for all simulated tsunami events.

3.3 Model setup

The high-resolution DEM for Midway Atoll was developed by NGDC (Medley et al., 2009) with a grid resolution of 1/3 arc sec and coverage from 182.4300°E to 182.8399°E and 28.0900°N to 28.4200°N (Figure 3). The deepest water depth covered by the domain is 3,865 m and the highest topography elevation is 28.74 m. Both high-resolution reference and forecast models consist of three nested grids where the outermost grid (Grid A) covers the deep ocean region so as to capture the tsunami characteristics as it propagates in the deep ocean, while the innermost grid (C) covers the area outside the coral reef to capture the tsunami wave transformations in shallow waters.

The DEM for Midway Atoll was initially based on data provided by NGDC. These data indicated that the highest elevations for Sand Island, Spit Island, and Eastern Island were 26.6 m, 9.95 m, and 13 m, respectively. It was discovered, however, that the NGDC data were erroneous. As a result of the USGS conducting its first northwestern Hawaiian Islands project, new LiDAR data became available, showing the actual highest elevations for Sand Island, Spit Island, and Eastern Island to be 11 m, 1.8 m, and 7.5 m, respectively. The plot represented in Figure 3 uses the updated topographic data. The LiDAR data (obtained through personal communication, M.H. Reynolds, Pacific Island Ecosystems Research, U.S. Geological Survey, 6 January 2012) were provided to NGDC for DEM correction. Figure 7 plots the difference between the erroneous topographic data and the new LiDAR data (Reynolds et al., 2012).

The Midway Atoll forecast model was initially developed before the 11 March 2011 Tohoku tsunami and was using the erroneous topographic DEM. Extensive inundation occurred during the Tohoku 2011 tsunami and the simulated forecast model did not indicate any inundation. It was here that the topographic error was realized. Using the updated LiDAR topographic data, the forecast model was redeveloped and the post-tsunami simulation for the Tohoku 2011 tsunami and results are presented in Section 4.3.

The coverage extent of the high-resolution reference and forecast models are almost identical. Table 1 shows the details of the nested grids (A, B, and C) including the modeling parameters used. The plots of the nested grids and their contour lines are shown in Figure 8 for the forecast model. The reference model has the same extents as the forecast model but with a higher grid resolution (see Table 1). Instabilities in the grid can occur due to the existence of extreme shallow regions or steep slopes. These are stabilized by making modifications to the DEM, either by correcting the specific point manually or by smoothing a cluster of nodes if the single node causing the instability is not located.

The forecast model is an optimized version of the high-resolution inundation model. It is designed so that it can quickly provide 4 hr of simulated tsunami wave characteristics that include time series at the tide gauge. For Midway Atoll, the forecast model can simulate the tsunami wave characteristics in approximately 16.4 min (Table 1). The high-resolution reference model, on the other hand, takes about 4.5 hr to complete a simulated run of 4 hr. The forecast model was not only designed to provide a quick forecast but was

validated with historical events to check for accuracy. The high-resolution reference model was also validated with the same historical events. Table 2 lists the historical events that were used to check the accuracy of the reference and forecast models while Figure 9 plots the location of these events in relation to the location of Midway Atoll. Synthetic scenarios were also run to test the stability and reliability of the forecast model. The synthetic scenarios, using earthquake magnitudes (Mw) of 9.4, 7.5, and 6.2, are listed in Tables 3 and 4 with Figure 10 showing their locations.

4. Results and Discussions

The development of the reference and forecast models requires validation with historical events and testing for stability and reliability with synthetic scenarios. The synthetic scenario tests use cases at Mw = 9.4 (mega-tsunami event), Mw = 7.5, and Mw = 6.2 (small wave tsunami event). Validation with historical data is required to determine how well the model predicts the tsunami wave characteristics of actual events. The synthetic scenarios are applied to test whether both reference and forecast model grids will produce a stable simulation and to locate possible instabilities in the selected grids. The synthetic mega-event scenarios can also be used as a preliminary risk analysis to determine the tsunami source regions that may pose a threat to Midway Atoll. The tsunami time series at the selected tide gauge and maximum/minimum tsunami wave amplitude distribution are also compared between the reference and forecast models. This is done to verify that the tsunami wave characteristics of the lower-resolution forecast model do not significantly deviate from the reference model.

4.1 Model validation

The DEM for the high-resolution reference and forecast models is validated to determine the accuracy of the simulated tsunami characteristics upon arrival the coastal areas of Midway Atoll. This is done by comparing modeling results with recorded tide gauge data of historical events. Table 2 provides a list of the historical events used for the validation. It also contains details of the propagation unit sources (Gica et al., 2008) used for a specific event and the scaling factors applied. The scaling factors and propagation unit sources selected are based on an inversion process, which is obtained either during the actual event or from recorded DART® data. The results of the comparison are discussed in Section 4.3. Historical records show that Sand Island was flooded due to the 1952 Kamchatka tsunami (Figure 5). This historical event was not validated in the development of the Midway Atoll since no information was found on the earthquake source parameters for the event.

4.2 Model stability and reliability

The forecast model must provide a reliable forecast and should be stable enough to simulate several hours of a tsunami event. In addition to testing done with historical data as discussed in Section 4.1, reliability and stability tests were conducted by simulating

7

synthetic events emanating from different regions and at different earthquake magnitudes (Mw= 9.4, 7.5, and 6.2). Since each tsunami event is unique, tests using different earthquake magnitudes and source locations would indicate if the model developed will generate instabilities that need to be corrected. This set of tests is not exhaustive, but representative cases from select sources should be sufficient. The 42 artificial mega-tsunamis (Mw=9.4) were generated from 20 unit sources with a slip value of 30 m for each unit source. The 20 Mw=7.5 use one unit source with a slip of 1 m while the 1 Mw=6.2 is included to test the model for a no wave condition. The unit sources are obtained from the propagation database developed at NCTR (Gica et al., 2008). Tests were conducted for a total of 12 hr simulation. Sources used for synthetic events are listed in Tables 3 (mega-tsunami events) and 4 (Mw=7.5 and Mw=6.2 events).

4.3 Results of tested events

A total of 12 tide gauge records from historical events were compared with simulations using the reference and forecast models. Figures 11 – 22 compare the maximum tsunami wave amplitude distribution for the innermost grid (C) and time series at the tide gauge data for 12 historical events. Overall, the reference model has a finer distribution of the tsunami wave pattern than is present in the forecast model. This is expected since the forecast model uses a lower resolution (Table 1). However, the overall maximum tsunami wave amplitude distribution is very similar between the reference and forecast models for all 12 historical events. In general, comparison with tide gauge data shows good results but, the modeled first wave tends to arrive a bit earlier than recorded data. There are cases (e.g., 2001 Peru, 2003 Rat Island, and 2010 Chile) where the forecast model overpredicts the later waves when compared to tide gauge data and also cases (e.g., 2003 Rat Island, 2006 Kuril, 2007 Kuril, 2010 Chile, and 2011 Tohoku) where the forecast model has higher tsunami amplitude than the reference model.

The 11 March 2011 Tohoku tsunami is the first ground-truth case for Midway Atoll where NCTR has a tsunami source and inundation extent data. Figure 23a and b shows the simulated inundation extent for the forecast and reference models overlain with the field-surveyed inundation data. The data for Sand Island show that inundation in the forecast and reference models is underpredicted for the northern and western areas, predicted well for the eastern and southern areas, and overpredicted for the central area. Field data comparison to the reference and forecast models further shows that simulated inundation for Eastern Island is underpredicted, but is well matched for Spit Island, which shows complete inundation of the low-elevation island. Although the simulated inundation showed discrepancies with the field data, the model predicted the flooded area fairly well.

For the remaining four historical cases (i.e., 1946 Unimak, 1957 Andreanof, 1960 Chile, and 1994 East Kuril) where digitized tide gauge data is not available, the comparison between forecast model and reference model is very good. Figures 24 – 27 plots the maximum tsunami wave amplitude distribution and the simulated tsunami time series at the tide gauge. Similar to other historical cases, the distribution of tsunami wave amplitude pattern in the reference model, due to its higher resolution, is finer than in the

forecast model. The 1957 Andreanof event simulated significant inundation on Midway Atoll. This cannot be verified since there are no available data on surveyed inundation extent, but there is documentation of flooding at Midway Atoll (Pararas-Carayannis, 2012).

The synthetic events simulated for the forecast model show that it is both stable and reliable. Although the mega-tsunami (Mw = 9.4) tests are not exhaustive, the results can be useful in determining the tsunami source regions that may pose a threat to Midway Atoll. Plots of the maximum tsunami wave amplitude distribution and the tsunami time series at the tide gauge are shown in Figures 28 to 69. Out of 42 mega-tsunami scenarios, 5 simulated extreme inundation for Midway Atoll. These source scenarios are located in the Aleutian-Alaska and Kamchatka-Kuril subduction zones, namely at segments ACSZ 1-10, KISZ 1-10, KISZ 11-20, KISZ 21-30, and KISZ 32-41. Five other source scenarios — ACSZ 41-50, EPSZ 9-18, KISZ 42-51, KISZ 52-61, and KISZ 56-65 — simulated inundation but not as extreme as the previous cases. Three of the scenarios did not produce any inundation; these emanated from CSSZ 11-20, CSSZ 21-30, and CSSZ 31-40. The remaining 29 cases simulated only slight inundation. The most extreme inundation is from KISZ 1–10, with a simulated maximum tide gauge record slightly exceeding 5 m and only one small area of Sand Island that is not inundated. The simulated maximum tide gauge record hit slightly over 5 m. Some sources generated tsunami wave amplitudes close to 2 m with minimal tsunami inundation (e.g., ACSZ 1-10) but some cases did generate inundation (e.g., EPSZ 9-18). This variation could be attributed to the directionality of the main tsunami energy, shoaling, wave refractions, and the presence of the coral reef. As for the Mw=7.5 scenarios, Figure 70 plots the time series at the selected tide gauge warning point.

5. Summary and Conclusions

Reference and forecast models have been prepared for Midway Atoll. Both models were found to be reliable and generally showed good comparison with tide gauge data from 12 historical events and with each other. The field inundation extent for the 2011 Tohoku event also showed good comparison. It is recommended that the set of forecast model grids developed and described in this report be adopted for operational use.

The stability tests showed that both the reference and forecast models are stable for a 12 hr simulation using synthetic sources with different earthquake magnitudes (Mw = 9.4, 7.5, and 6.2) from different source regions. A total of 42 Mw =9.4 events, 20 Mw =7.5 events, and 1 Mw=6.2 event were simulated. The mega-tsunami (Mw = 9.4) events not only check the stability of the optimized forecast model, but can also provide information on which source regions represent the greatest tsunami threat to Midway Atoll. The tests conducted indicate that Midway Atoll is most susceptible to inundation from tsunami sources in the Kuril Islands, the West Aleutians, and the East Philippines.

Since providing a tsunami forecast for Midway Atoll is the main objective of this model, the DEM has been optimized to simulate 4 hr of tsunami wave characteristics in

approximately 16.4 min. The run time of 16.4 min for a 4 hr of tsunami wave exceeded the time efficiency requirement of 10 min. This is attributed to the resolution of the grid used in the forecast model. To obtain the time efficiency requirement of 10 min would require the use of a coarser grid resolution or smaller grid coverage or both. For Midway Atoll, these two options are not recommended. The atoll consists of small islands and using coarser grid resolution will result in the loss of some island features. With a large section of shallow reef area, smaller grid coverage for the C-grid is not recommended since we need to simulate the dynamics of the tsunami waves at the current grid resolution used at the C-grid level. As presented in this report, the Midway Atoll forecast model should be able to provide a reliable forecast during an event and is stable for a 12-hr simulation.

6. Acknowledgement

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Table 1. MOST setup parameters for reference and forecast models for Midway Atoll.

		Reference Model				Forecast Model			
Grid	Region	Coverage Lat. [ºN] Lon. [ºW]	Cell Size ["]	nx x ny	Time Step [sec]	Coverage Lat. [ºN] Lon. [ºW]	Cell Size ["]	nx x ny	Time Step [sec]
A	Deep Ocean	27.2000-29.2000 181.6000-183.6000	30	241 x 241	3.0	27.200-29.2000 181.6000-183.6000	60	121 x 121	6.0
B	Midway Atoll	28.0900-28.4199 182.4300-182.8399	3	493 x 397	0.4	28.0900-28.4199 182.4300-182.8399	6	247 x 199	0.6
C	Midway Atoll	28.1845-28.2889 182.5639-182.6916	2/3	690 x 565	0.2	28.1895-28.2889 182.5639-182.6916	2	230 x 180	0.6

	Reference	Forecast
Minimum offshore depth [m]	1	1
Water depth for dry land [m]	0.1	0.1
Friction coefficient [n^2]	0.0009	0.0009
CPU time for 4-hr simulation	4.5 hours	16.4 minutes

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

Table 2. Historical events used for model validation of Midway Atoll.

Event	Earthquake Date Time (UTC)	Lat. (°)	Lon. (°)	Subduction Zone	Seismic Moment Magnitude (Mw)	Tsunami Magnitude[1]	Model Tsunami Source
1946 Unimak	1946-04-01 12:28:56	52.75N	163.50W	Aleutian-Alaska-Cascadia (ACSZ)	[2]8.5	8.5	7.5 x b23 + 19.7 x b24 + 3.7 x b25
1957 Andreanof	1957-04-09 14:22:31	51.56N	173.59W	Aleutian-Alaska-Cascadia (ACSZ)	[2]8.6	8.7	31.4 x a15 + 10.6 x a16 + 12.2 x a17
1960 Chile	1960-05-22 19:11:14	38.29S	73.05W	Central-South America (CSSZ)	[3]9.5		Kanamori and Cipar (1974)
1994 East Kuril	1994-10-04 13:22:58	43.73N	147.321E	Kamchatka-Kuril-Japan-Izu-Marian-Yap (KISZ)	[2]8.3	8.1	9.0 x a20
1996 Andreanof	1996-06-10 04:04:03.4	51.10N	177.41W	Aleutian-Alaska-Cascadia (ACSZ)	[2]7.9	7.8	2.4 x a15 + 0.8 x b16
2001 Peru	2001-06-23 20:33:14	16.265S	73.641W	Central-South America (CSSZ)	[2]8.4	8.2	5.7 x a15 + 2.9 x b16 + 1.98 x a16
2003 Rat Island	2003-11-17 06:43:31.0	51.14N	177.86E	Aleutian-Alaska-Cascadia (ACSZ)	[2]7.7	7.8	2.81 x b11
2006 Tonga	2006-05-03 15:27:03.7	20.39S	173.47W	New Zealand-Kermadec-Tonga (NTSZ)	[2]8.3	8.1	4 x a12 + 0.5 x b12 + 2 x a13 + 1.5 x b13
2006 Kuril	2006-11-15 11:15:08.0	46.71N	154.33E	Kamchatka-Kuril-Japan-Izu-Marian-Yap (KISZ)	[2]8.3	8.1	4 x a12 + 0.5 x b12 + 2 x a13 + 1.5 x b13
2007 Solomon	2007-04-01 20:39:56	8.481S	156.978E	New Britain-Solomons-Vanuatu (NVSZ)	[3]8.1	8.2	12.0 x b10
2007 Peru	2007-08-15 23:40:57	13.354S	76.509W	Central-South America (CSSZ)	[2]8.0	8.1	0.9 x a61 + 1.25 x b61 + 5.6 x a62 + 6.97 x b62 + 3.5 x z62
2007 Kuril	2007-01-13 04:23:48.1	46.17N	154.80E	Kamchatka-Kuril-Japan-Izu-Marian-Yap (KISZ)	[2]8.1	7.9	-3.64 x b13
2007 Chile	2007-11-14 15:40:50	22.204S	69.869W	Central-South America (CSSZ)	[4]7.7	7.6	1.65 x z73 x
2009 Samoa	2009-09-29 17:48:10	15.509S	172.034W	New Zealand-Kermadec-Tonga (NTSZ)	[2]8.1	8.1	[5]3.96 x a34 + 3.96 x b34
2010 Chile	2010-02-27 06:35:15.4	35.95S	73.15W	Central-South America (CSSZ)	8.8 (CMT)	8.8	17.24 x a88 + 8.82 x a90 + 11.86 x b88 + 18.39 x b89 + 16.75 x b90 + 20.79 x z88 + 7.06 x z90
2011 Tohoku	2011-03-11 05:46:23.82	38.308N	142.383E	Kamchatka-Kuril-Japan-Izu-Marian-Yap (KISZ)	29.0	8.9	4.66 × b24 + 12.23 × b25 + 26.31 × a26 + 21.27 × b26 + 22.75 × a27 + 4.98 × b27

[1] Preliminary source – derived from source and deep-ocean observations [2] Centroid Moment Tensor [3] Kanamori and Cipar (1974) [4] United States Geological Survey (USGS) [5] Based on real-time forecast

Table 3. Synthetic mega-tsunamis tested for Midway Atoll.

Scenario Name	Subduction Zone	Tsunami Source (30x)
ACSZ 01-10	Aleutian-Alaska-Cascadia	A01-10, B01-10
ACSZ 11-20	Aleutian-Alaska-Cascadia	A11-20, B11-20
ACSZ 21-30	Aleutian-Alaska-Cascadia	A21-30, B21-30
ACSZ 31-40	Aleutian-Alaska-Cascadia	A31-40, B31-40
ACSZ 41-50	Aleutian-Alaska-Cascadia	A41-50, B41-50
ACSZ 46-55	Aleutian-Alaska-Cascadia	A46-55, B46-55
ACSZ 56-65	Aleutian-Alaska-Cascadia	A56-65, B56-65
CSSZ 01-10	Central-South America	A01-10, B01-10
CSSZ 11-20	Central-South America	A11-20, B11-20
CSSZ 21-30	Central-South America	A21-30, B21-30
CSSZ 31-40	Central-South America	A31-40, B31-40
CSSZ 41-50	Central-South America	A41-50, B41-50
CSSZ 51-60	Central-South America	A51-60, B51-60
CSSZ 61-70	Central-South America	A61-70, B61-70
CSSZ 71-80	Central-South America	A71-80, B71-80
CSSZ 81-90	Central-South America	A81-90, B81-90
CSSZ 91-100	Central-South America	A91-100, B91-100
CSSZ 101-110	Central-South America	A101-110, B101-110
CSSZ 106-115	Central-South America	A106-115, B106-115
NTSZ 01-10	New Zealand-Kermadec-Tonga	A01-10, B01-10
NTSZ 11-20	New Zealand-Kermadec-Tonga	A11-20, B11-20
NTSZ 21-30	New Zealand-Kermadec-Tonga	A21-30, B21-30
NTSZ 30-39	New Zealand-Kermadec-Tonga	A30-30, B30-30
NVSZ 01-10	New Britain-Solomons-Vanuatu	A01-10, B01-10
NVSZ 11-20	New Britain-Solomons-Vanuatu	A11-20, B11-20
NVSZ 28-37	New Britain-Solomons-Vanuatu	A28-37, B28-37
MOSZ 01-10	Manus OCB	A01-10, B10-10
MOSZ 08-17	Manus OCB	A08-17, B08-17
NGSZ 01-10	North New Guinea	A01-10, B01-10
NGSZ 06-15	North New Guinea	A06-15, B01-15
EPSZ 01-10	East Philippines	A01-10, B01-10
EPSZ 09-18	East Philippines	A09-18, B09-18
RNSZ 01-10	Ryukus-Kyushu-Nankai	A01-10, B01-10
RNSZ 13-22	Ryukus-Kyushu-Nankai	A13-22, B13-22
KISZ 01-10	Kamchatka-Yap-Mariana-Izu-Bonin	A01-10, B01-10
KISZ 11-20	Kamchatka-Yap-Mariana-Izu-Bonin	A11-20, B11-20
KISZ22-31	Kamchatka-Yap-Mariana-Izu-Bonin	A22-31, B22-31
KISZ 32-41	Kamchatka-Yap-Mariana-Izu-Bonin	A32-41, B32-41
KISZ 42-51	Kamchatka-Yap-Mariana-Izu-Bonin	A42-51, B42-51
KISZ 52-61	Kamchatka-Yap-Mariana-Izu-Bonin	A52-61, B52-61
KISZ 56-65	Kamchatka-Yap-Mariana-Izu-Bonin	A56-65, B56-65
KISZ 66-75	Kamchatka-Yap-Mariana-Izu-Bonin	A66-75, B66-75

Table 4. Synthetic tsunamis tested for Midway Atoll.

Scenario Name	Mw	Subduction Zone	Tsunami Source
ACSA 9	7.5	Aleutian-Alaska-Cascadia	1 x B9
ACSZ 18	7.5	Aleutian-Alaska-Cascadia	1 x B18
ACSZ 30	7.5	Aleutian-Alaska-Cascadia	1 x B18
ACSZ 50	7.5	Aleutian-Alaska-Cascadia	1 x B50
ACSZ 64	7.5	Aleutian-Alaska-Cascadia	1 x B64
CSSZ 2	7.5	Central-South America	1 x B2
CSSZ 22	7.5	Central-South America	1 x B22
CSSZ 49	7.5	Central-South America	1 x B49
CSSZ 59	7.5	Central-South America	1 x B59
CSSZ 84	7.5 and 6.2	Central-South America	1 x B84 and 0.10 x B84
EPSZ10	7.5	East Philippines	1 x B10
KISZ 8	7.5	Kamchatka-Yap-Mariana-Izu-Bonin	1 x B8
KISZ 15	7.5	Kamchatka-Yap-Mariana-Izu-Bonin	1 x B15
KISZ 27	7.5	Kamchatka-Yap-Mariana-Izu-Bonin	1 x B27
KISZ 53	7.5	Kamchatka-Yap-Mariana-Izu-Bonin	1 x B53
MOSZ 9	7.5	Manus OCB	1 x B9
NTSZ 19	7.5	New Zealand-Kermadec-Tonga	1 x B19
NTSZ 36	7.5	New Zealand-Kermadec-Tonga	1 x B36
NVSZ 23	7.5	New Britain-Solomons-Vanuatu	1 x B23
RNSZ 11	7.5	Ryukus-Kyushu-Nankai	1 x B11
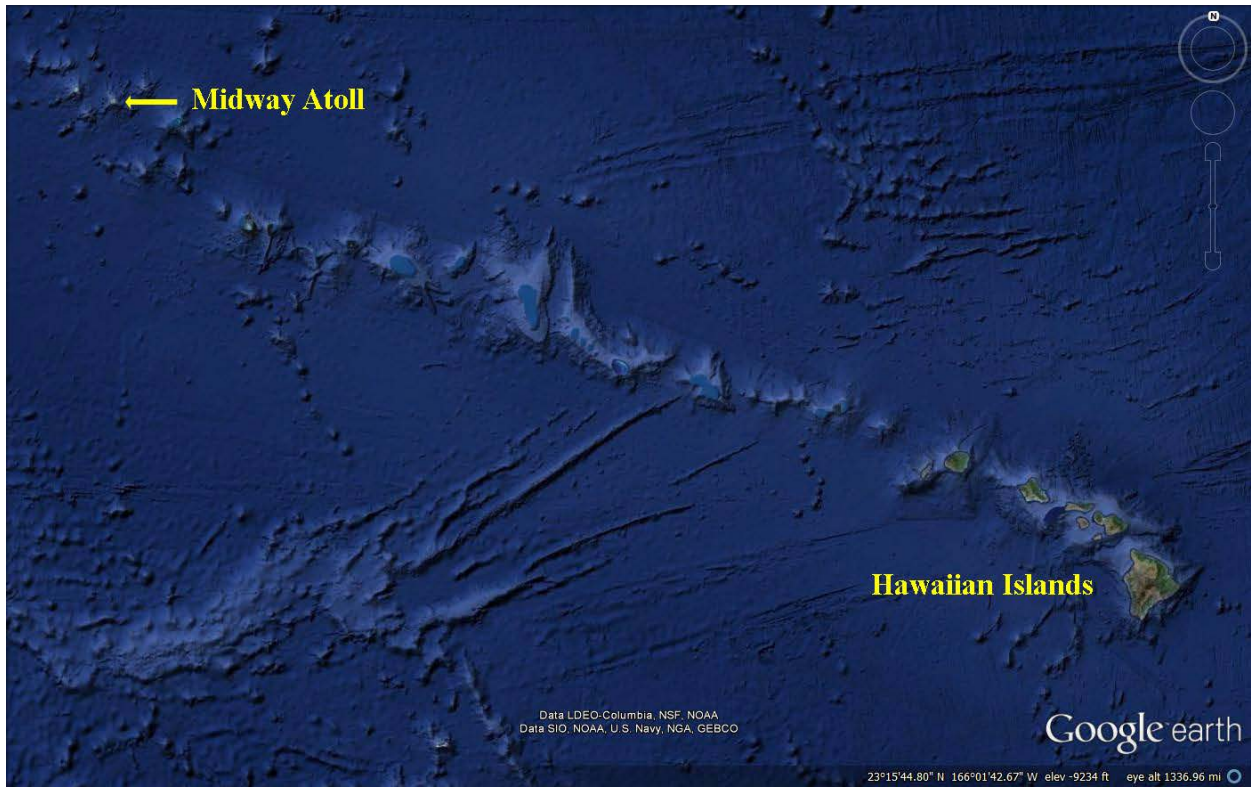
Figure 1. Location of Midway (approximately 28.21°N, 177.361°W) in relation to the Hawaiian Islands.

Figure 2. Google map image showing the coral reef of Midway Atoll.
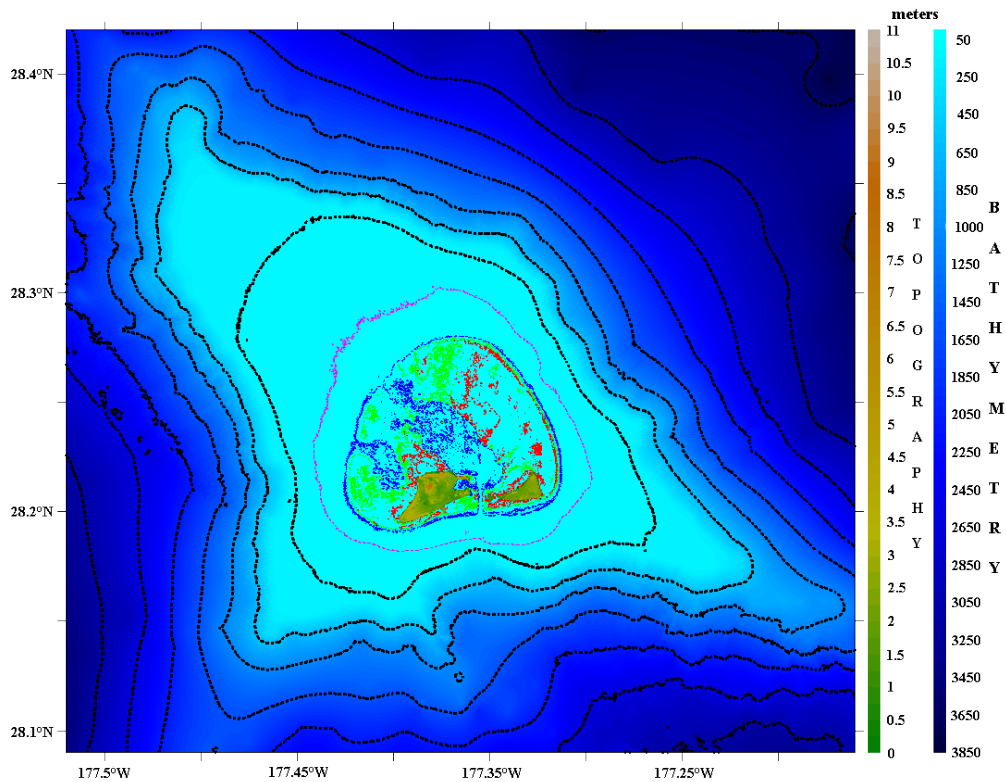
Figure 3. NGDC 1/3 arc sec DEM for Midway Atoll. Contour plot of Midway Islands; red is 1 m, green is 5 m, blue is 10 m, magenta is 50 m and black is from 100 to 4000 m with 500 m interval.

a)   1954   b) 1958
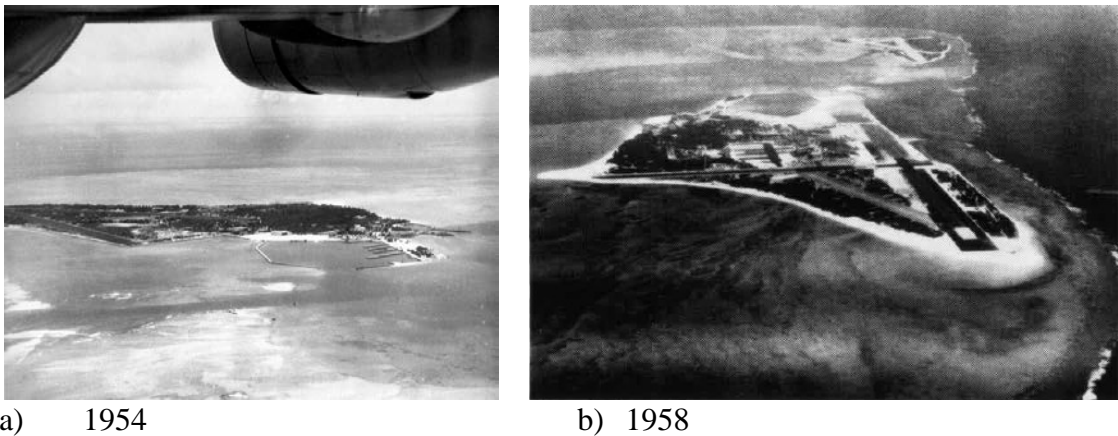
Figure 4. Aerial photo of Sand Island, Midway Atoll, a) photo taken in 1954 (source: http://www.navycthistory.com/baber_midway_intro.html) where the southern breakwater, left of photo, was directly exposed to the open ocean, b) photo taken in 1958 (source: http://commons.wikimedia.org/wiki/File:Midway_aerial_view_NAN6-58.jpg) where the southern breakwater, right of photo, was backfilled.

Figure 5. Photo of inundation at Sand Island, Midway Atoll due to the 4 November 1952 Kamchatka tsunami (source: http://drgeorgepc.com/Tsunami1952.html).

a)

b)

c)

Figure 6. a) Google map image showing the location of the tide gauge in the northeastern part of the harbor in Sand Island, Midway Atoll. This is the location for all comparison between the forecast, reference and historical data, b) photo of position of the tide gauge sensor, c) photo of the tide gauge instrument housing.
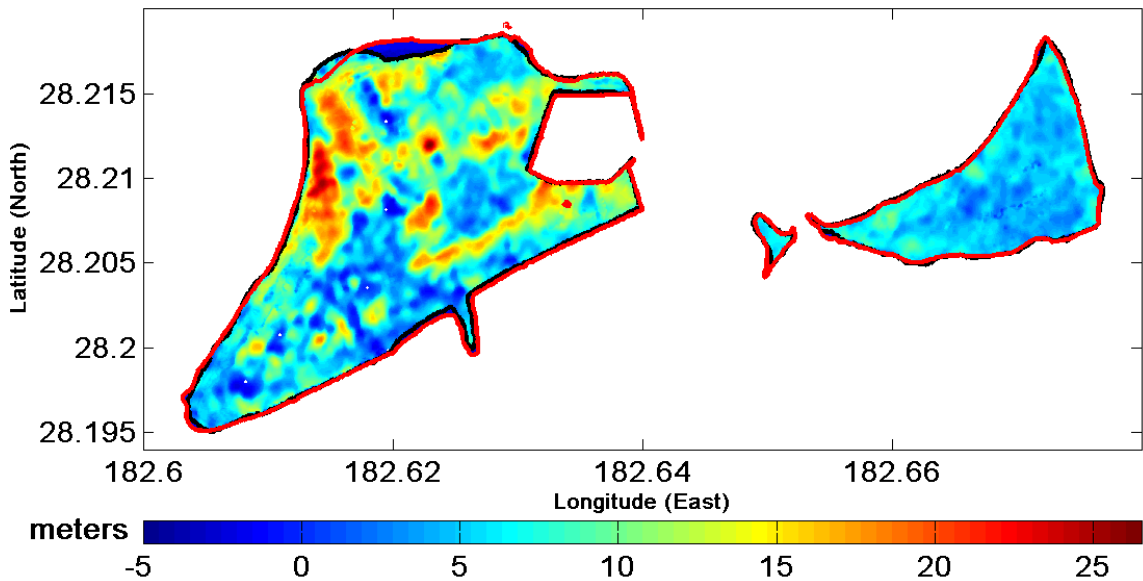
Figure 7. Difference of topographic elevation between the original erroneous topographic DEM and the LiDAR data obtained by Pacific Island Ecosystems Research Center, U.S. Geological Survey. Red line is the coastline based on LiDAR and black line is the coastline based on original erroneous topographic DEM.
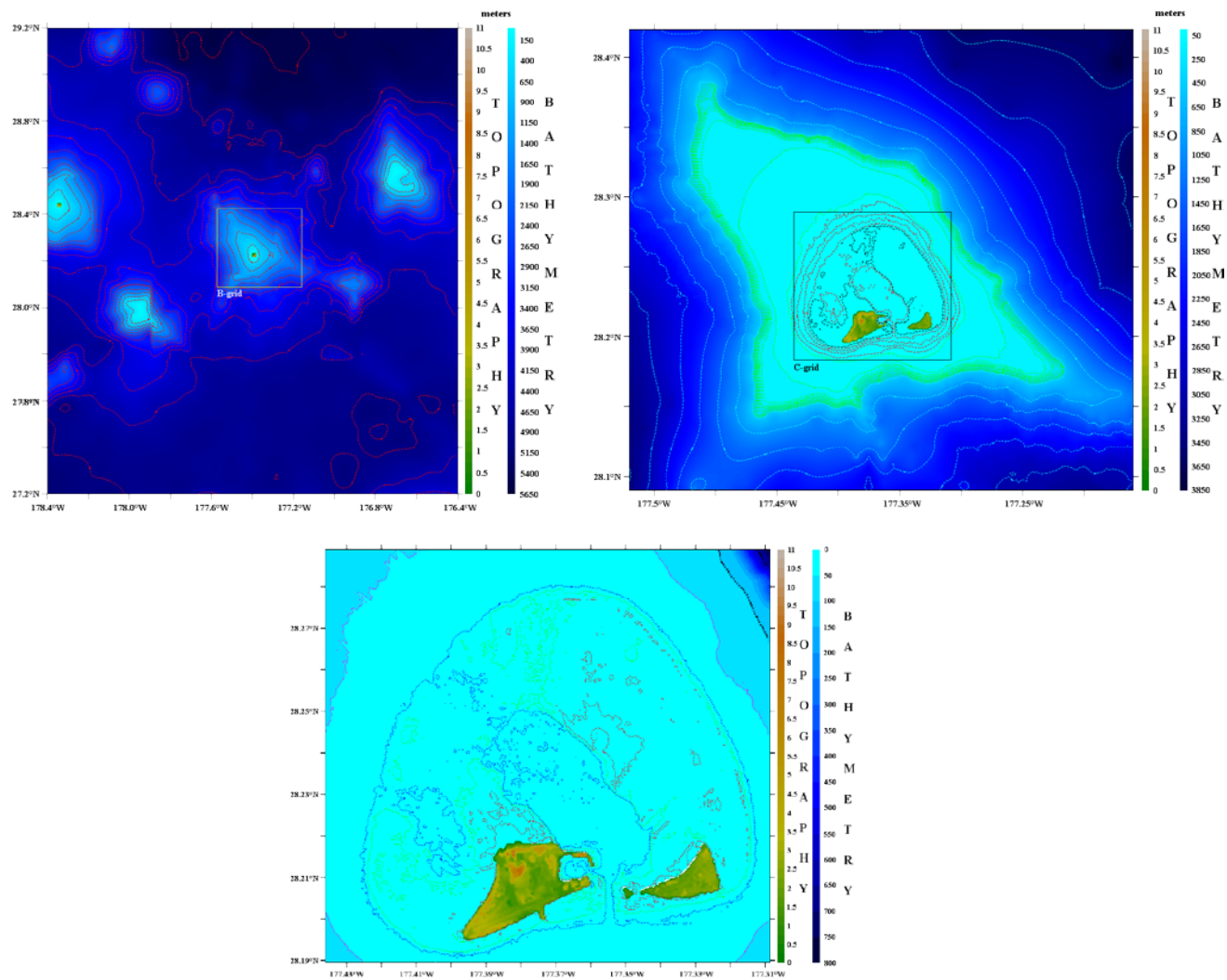
Figure 8. Domain extents of the nested grids for the forecast model; top left) grid extents of A grid, contour ranges from a depth of 500 to 5650 m with 500 m interval; top right) grid extents of B grid, black is 5 m, red ranges from 10 to 40 m with 10 m interval, green is 50 to 450 m with 50 m interval, cyan is 500 m to 4000 m with 500 m interval; bottom) grid extents of C grid, red is 1 m, green is 5 m, blue is 10 m, magenta is 50 m and black is from 100 to 4000 m with 500 m interval.
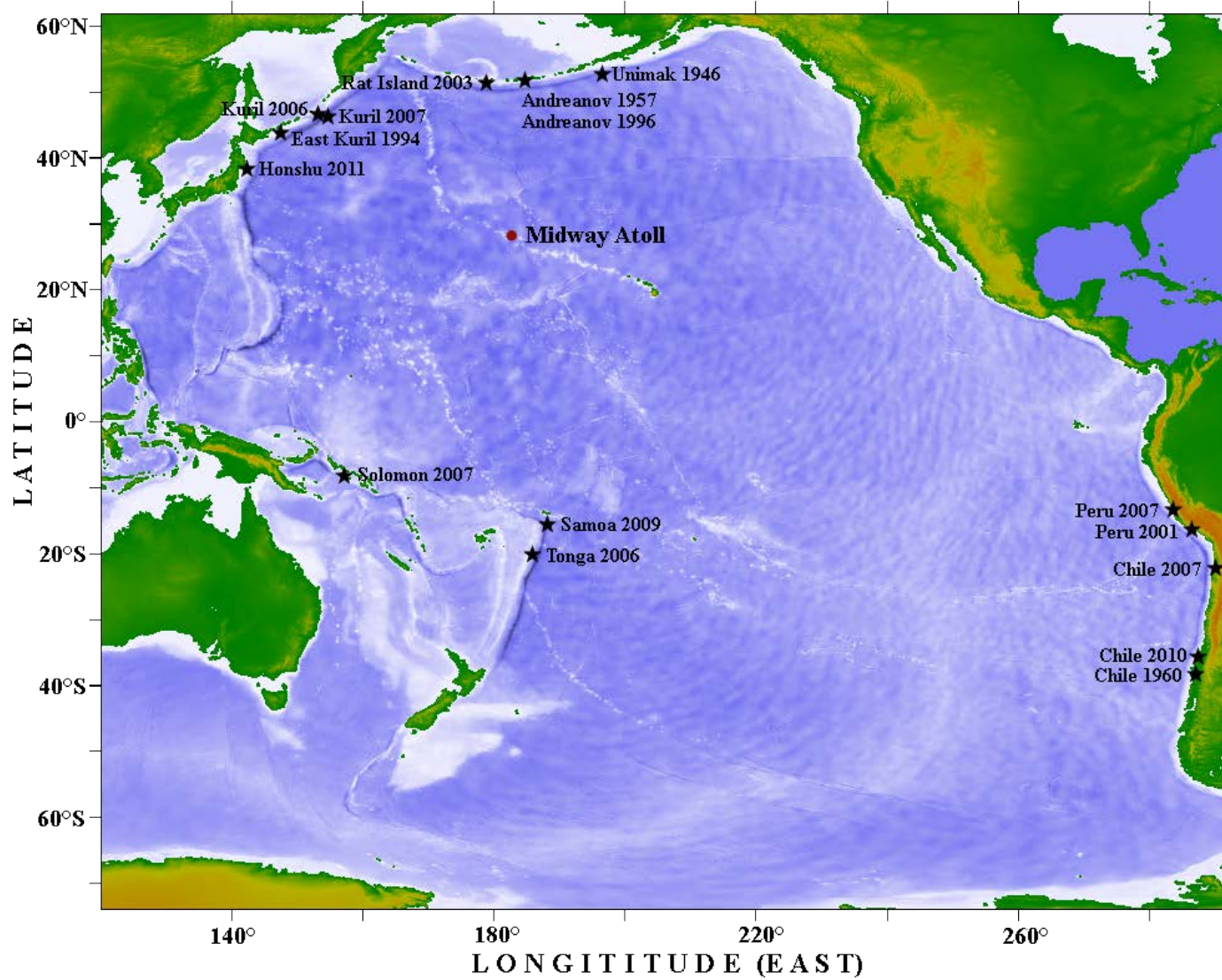
Figure 9. Location of historical events in relation to Midway Atoll.
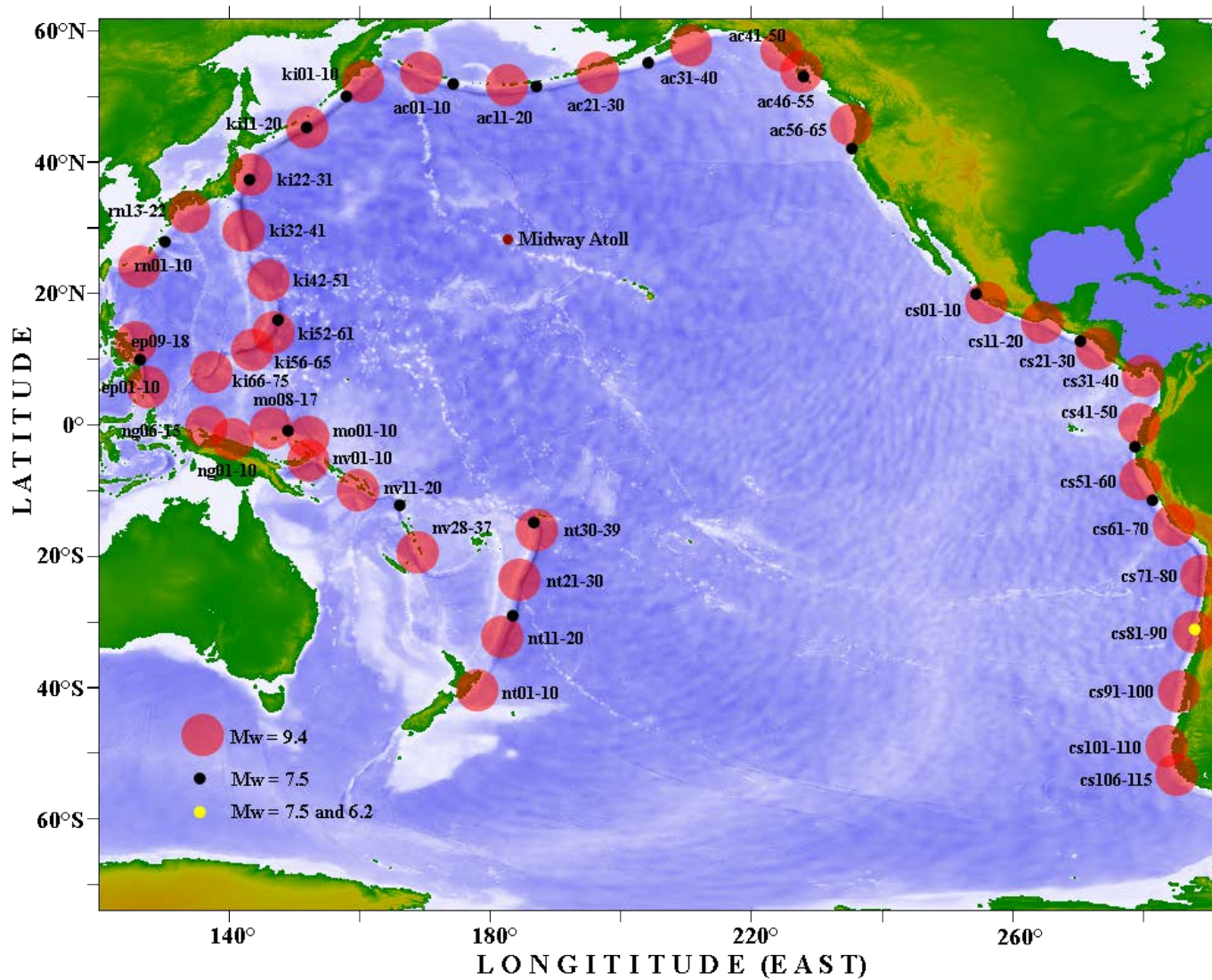
Figure 10. Location of synthetic events (Mw=9.4, 7.5, and 6.2) in relation to Midway Atoll.
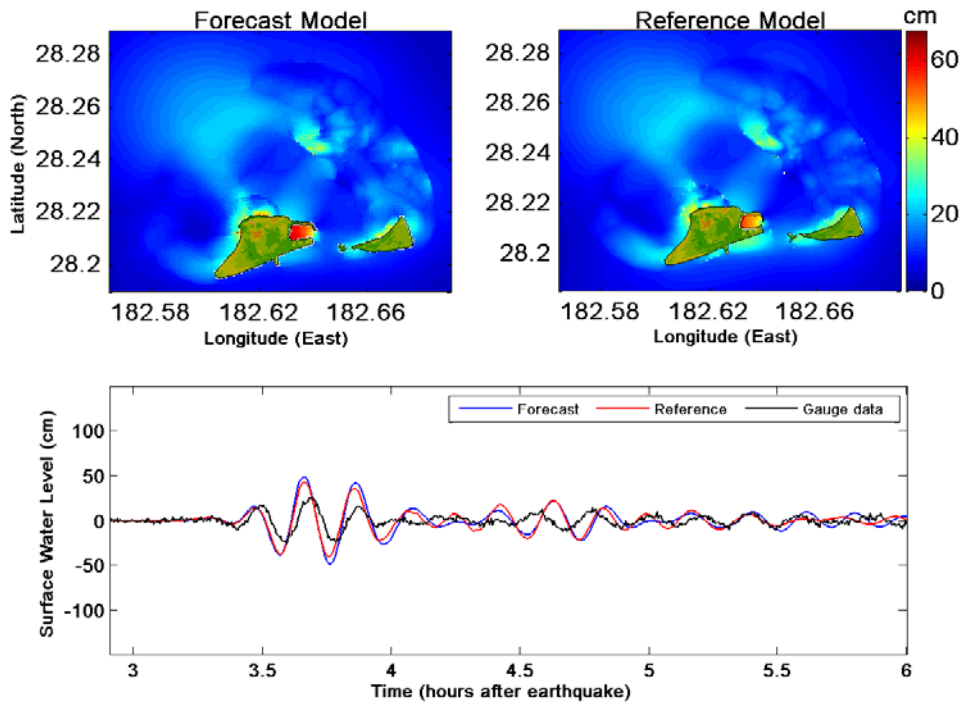
Figure 11. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 10 June 1996 Andreanof tsunami.
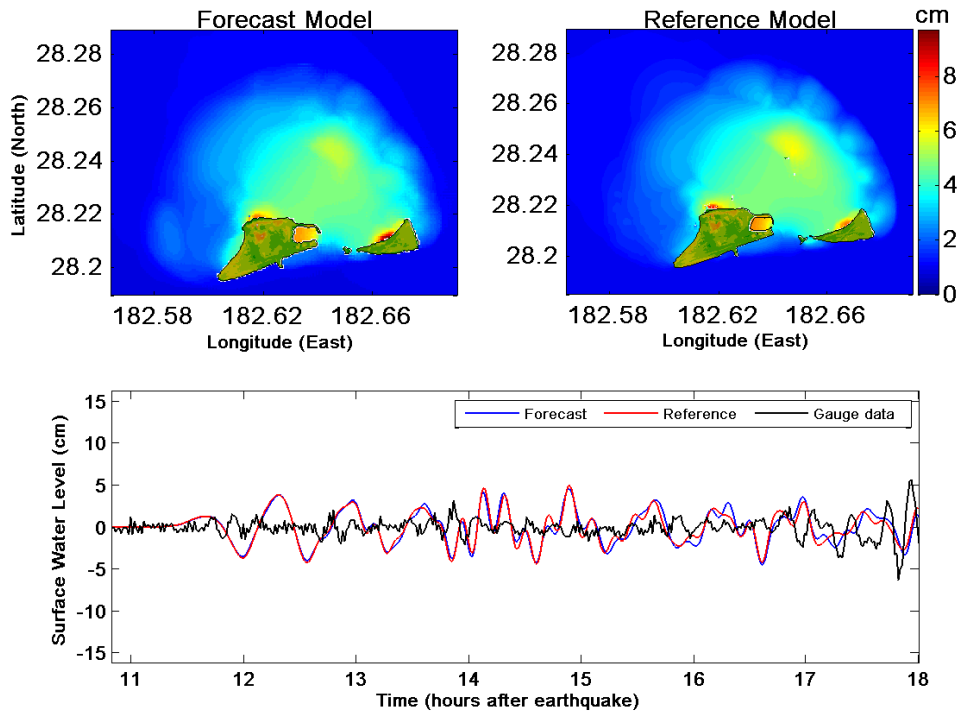
Figure 12. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 23 June 2001 Peru tsunami.
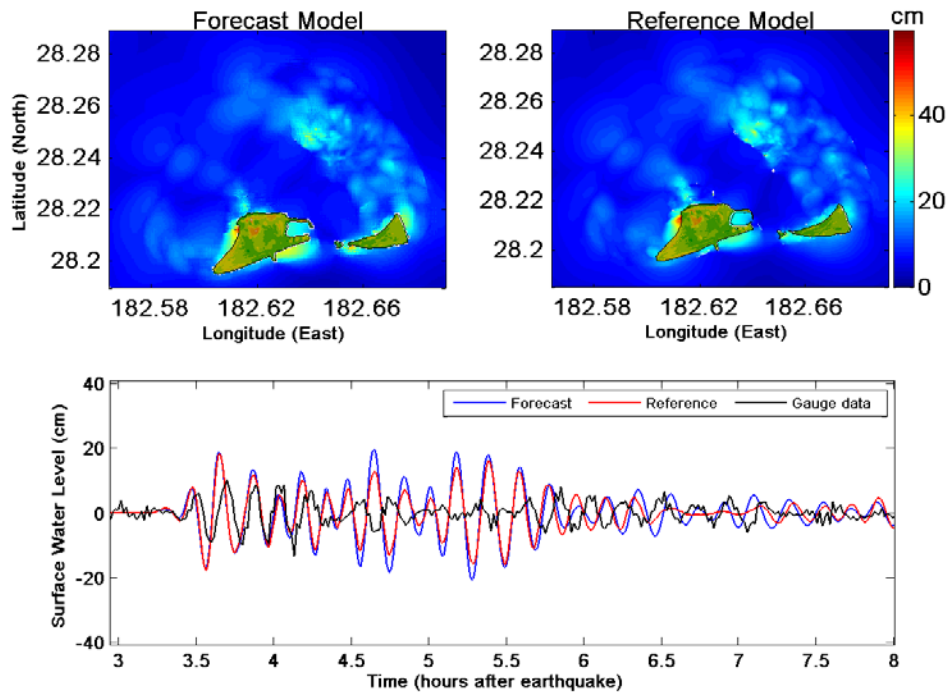
Figure 13. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 17 November 2003 Rat Island tsunami.
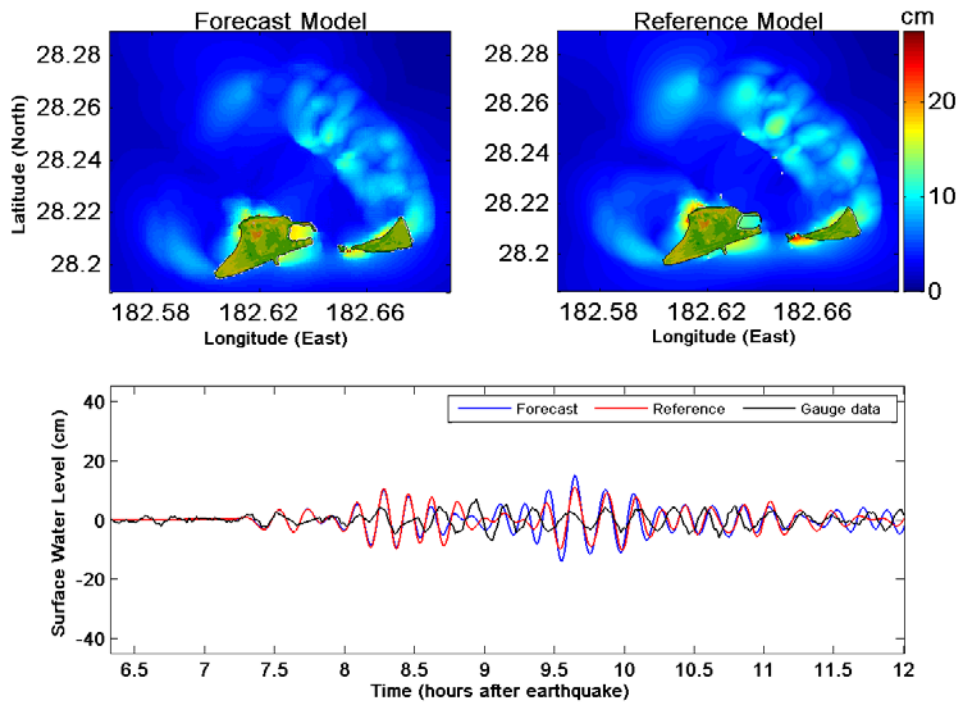
Figure 14. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 3 May 2006 Tonga tsunami.
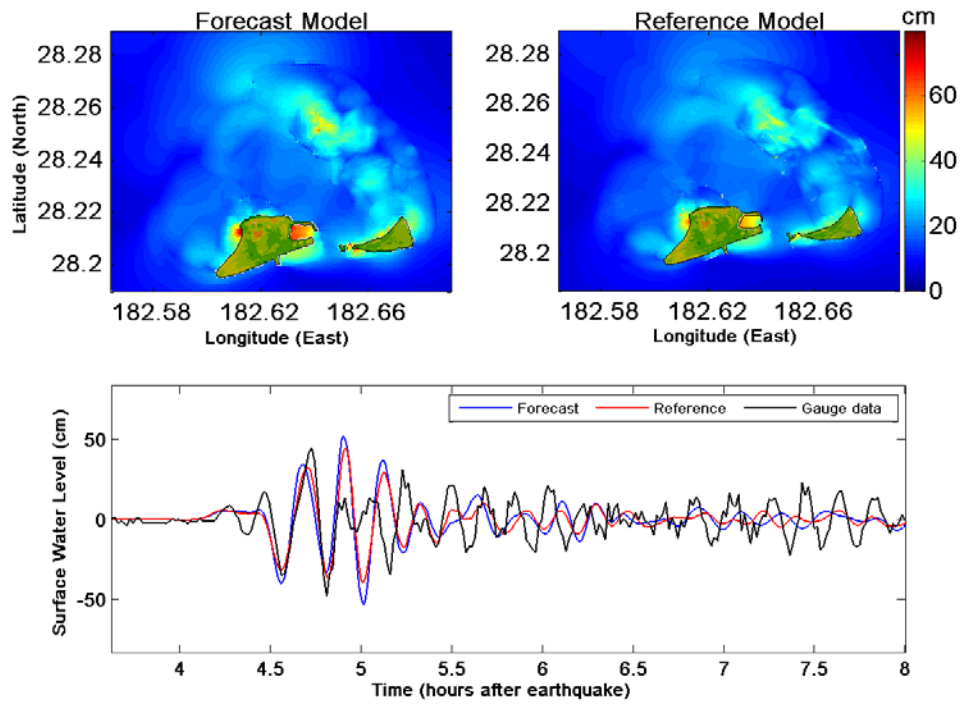
Figure 15. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 15 November 2006 Kuril tsunami.
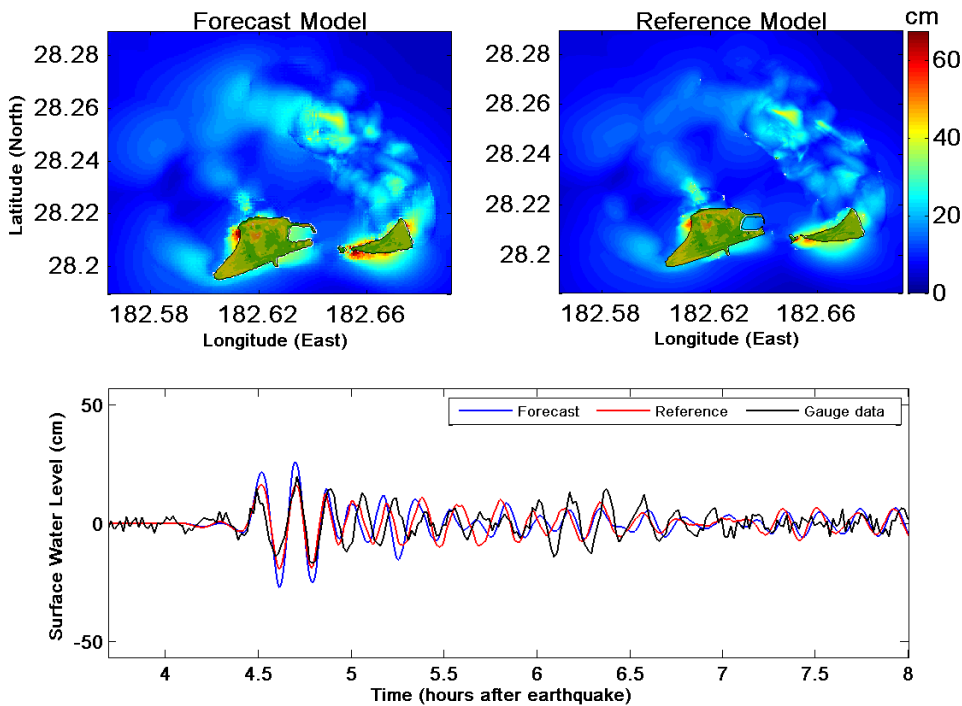
Figure 16. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 13 January 2007 Kuril tsunami.
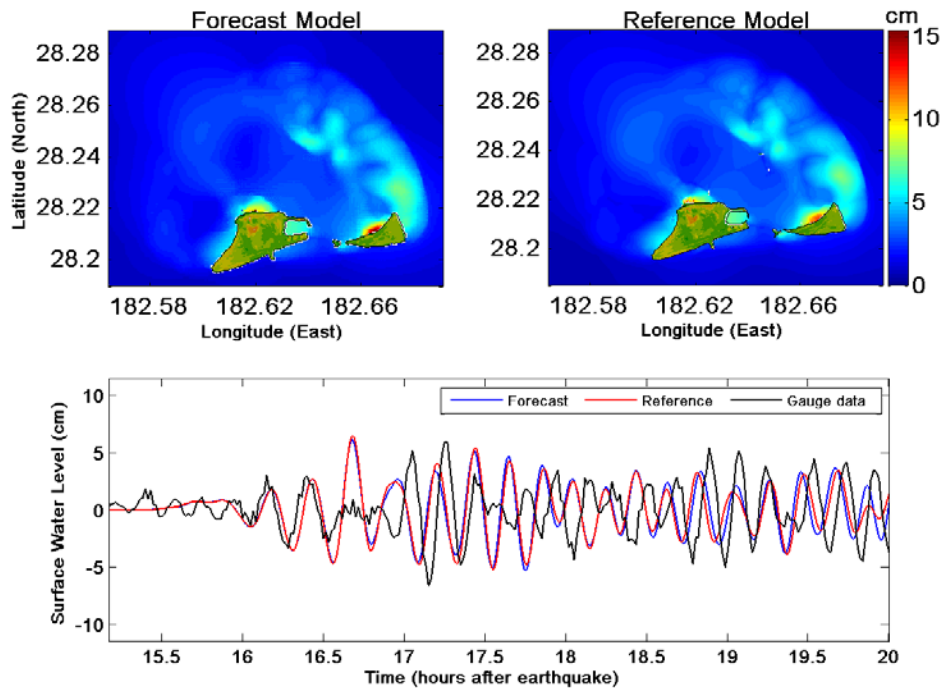
Figure 17. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 15 August 2007 Peru tsunami.
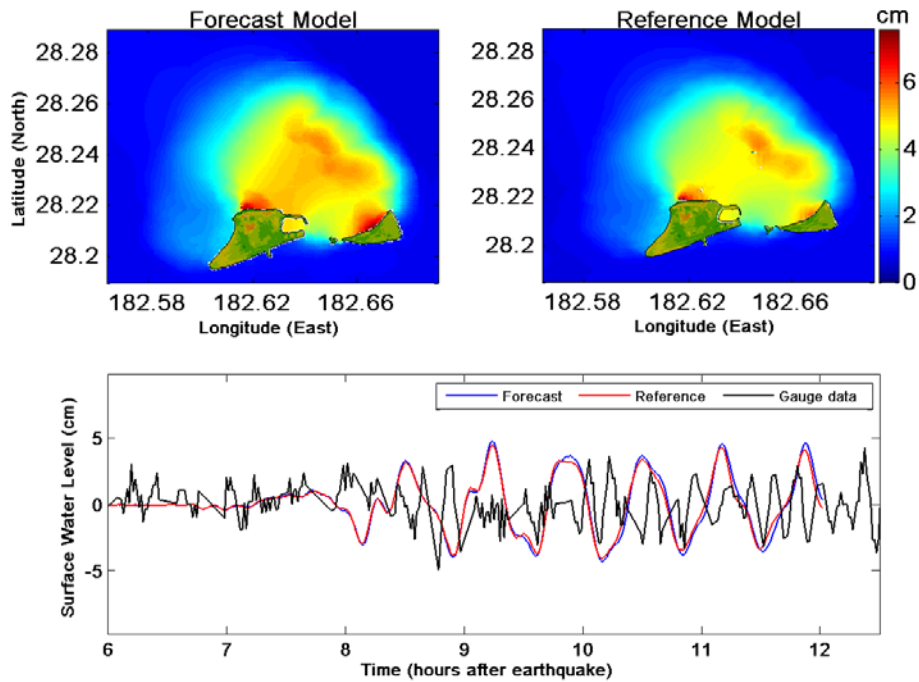
Figure 18. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 1 April 2007 Solomon tsunami.
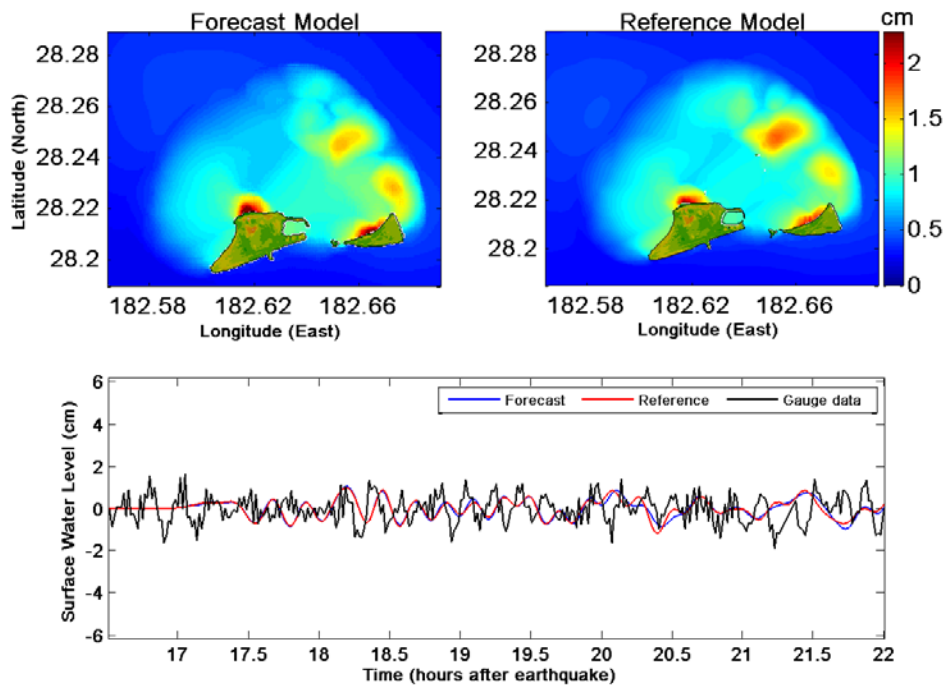
Figure 19. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 14 November 2007 Chile tsunami.
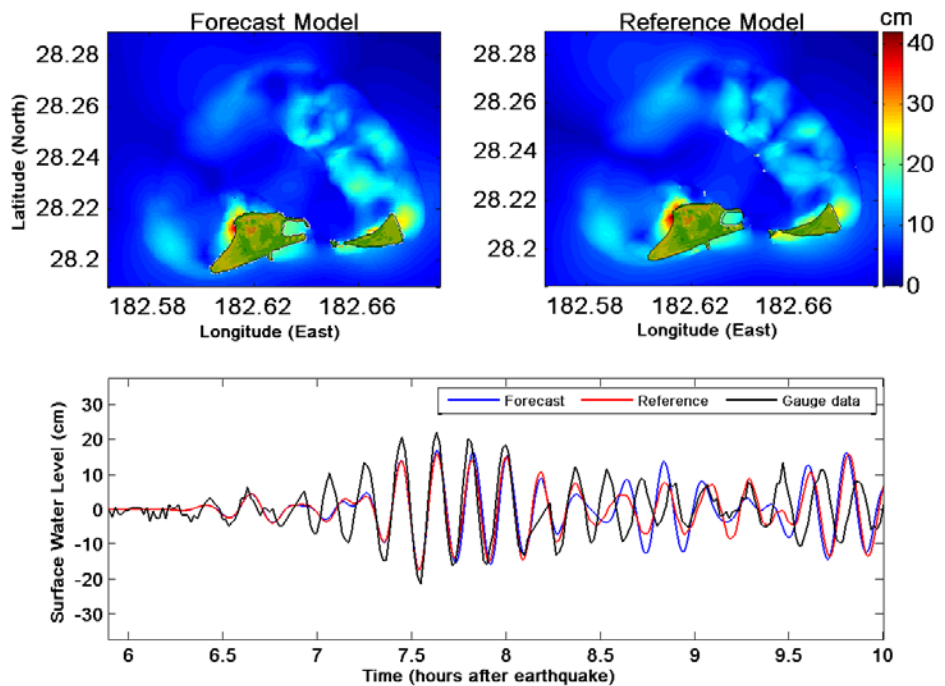
Figure 20. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 29 September 2009 Samoa tsunami.
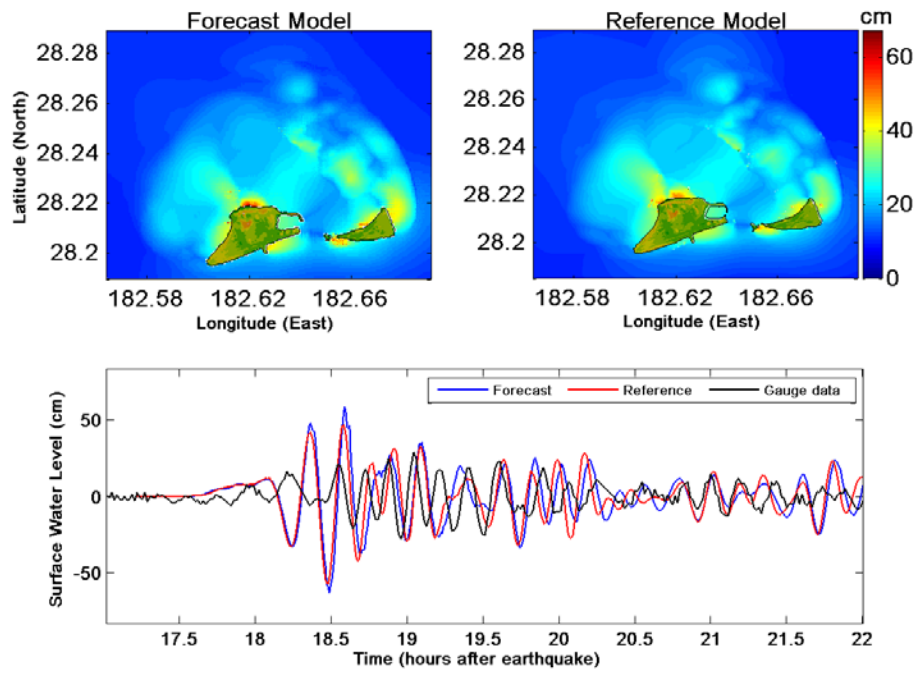
Figure 21. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 27 February 2010 Chile tsunami.
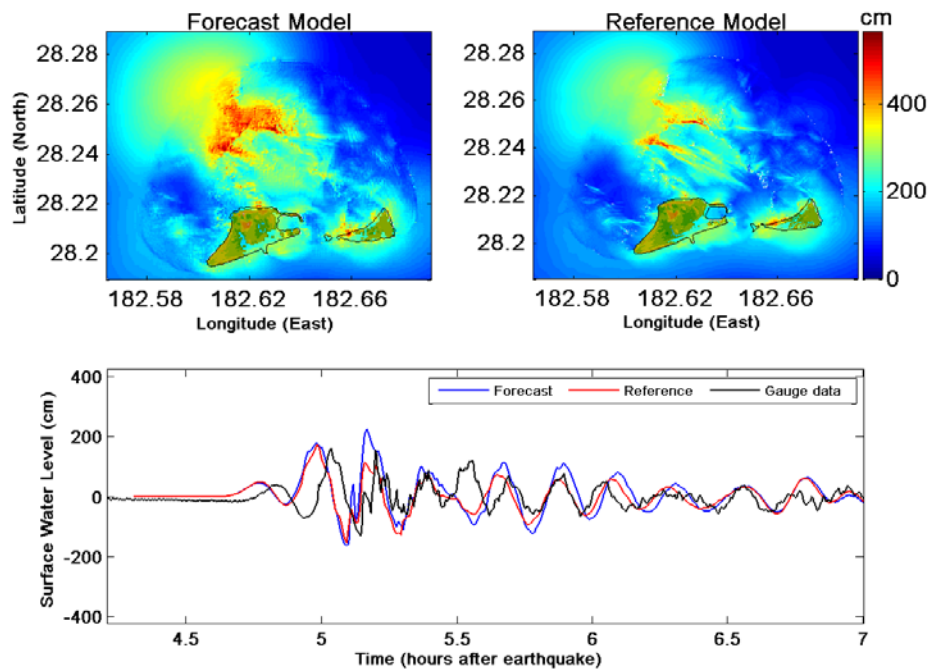
Figure 22. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 11 March 2011 Tohoku tsunami.
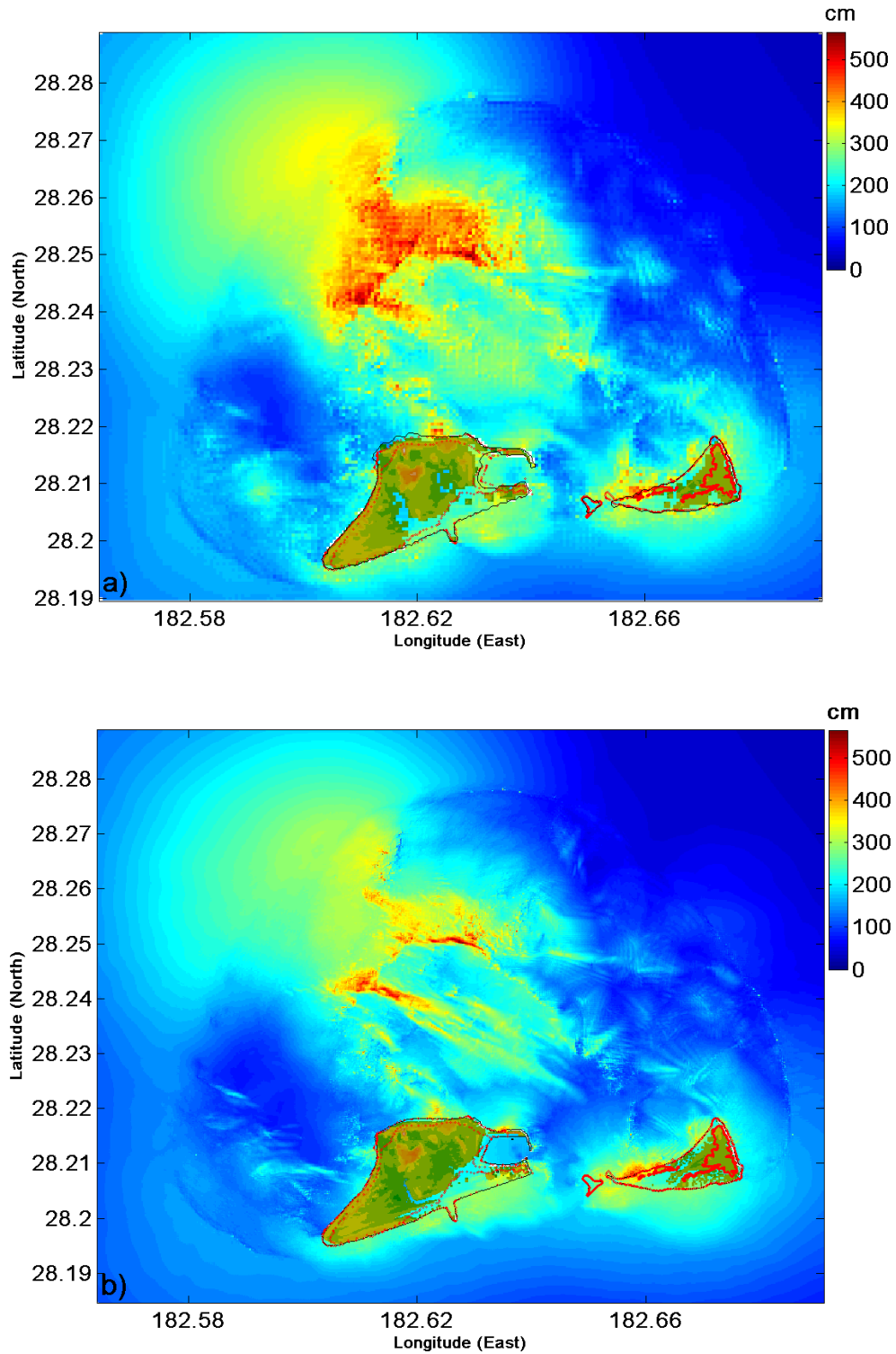
Figure 23. Comparison of simulated maximum tsunami inundation with field survey for the 11 March 2011 Tohoku tsunami; a) forecast model and b) reference model. Red dots are the measured extent of field inundation. Solid line represents the shoreline at MHW.

29
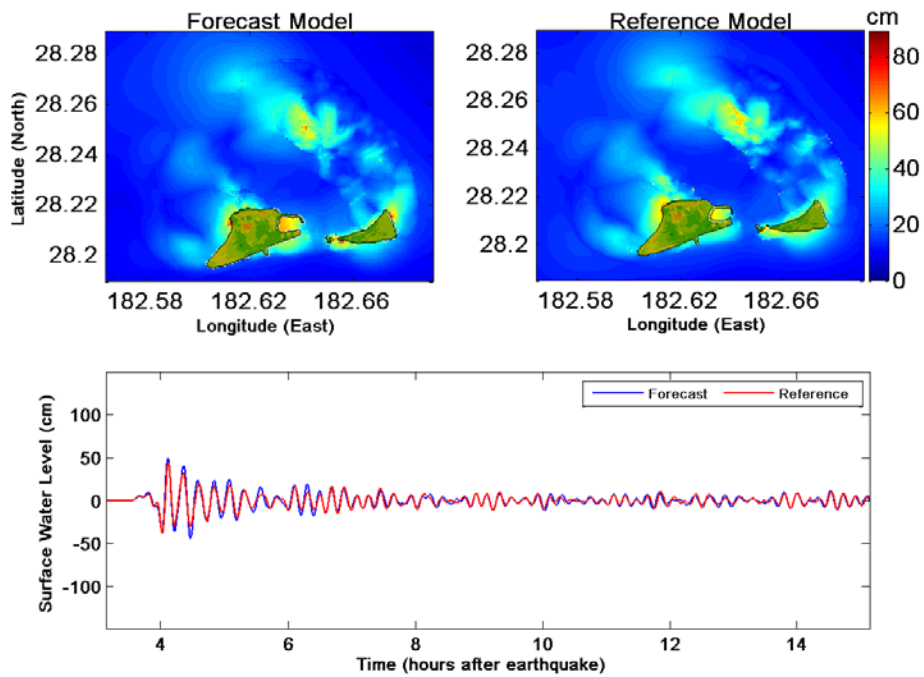
Figure 24. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 1 April 1946 Unimak tsunami.
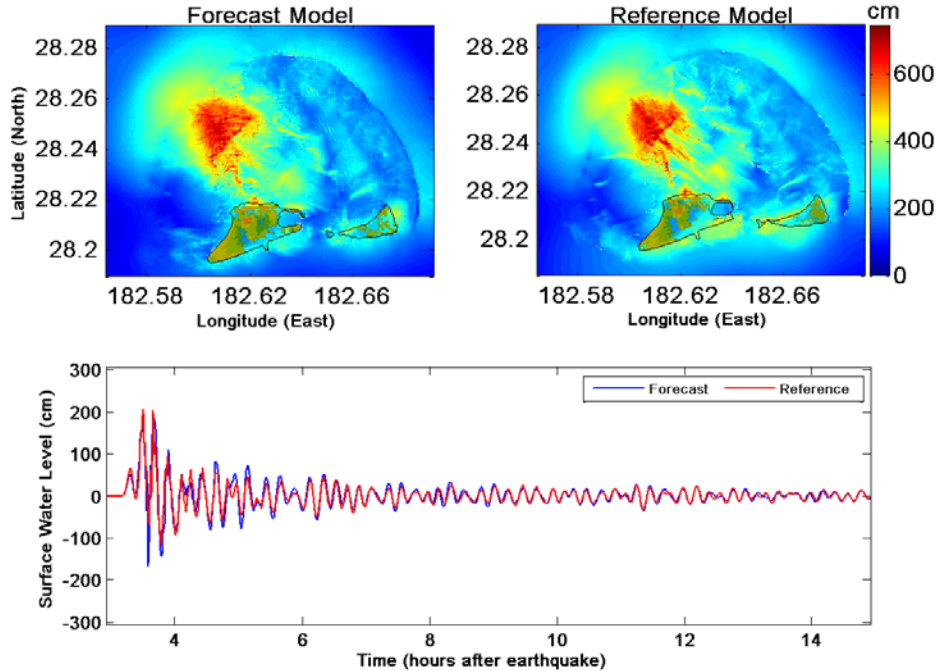
Figure 25. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 9 April 1957 Andreanof tsunami.
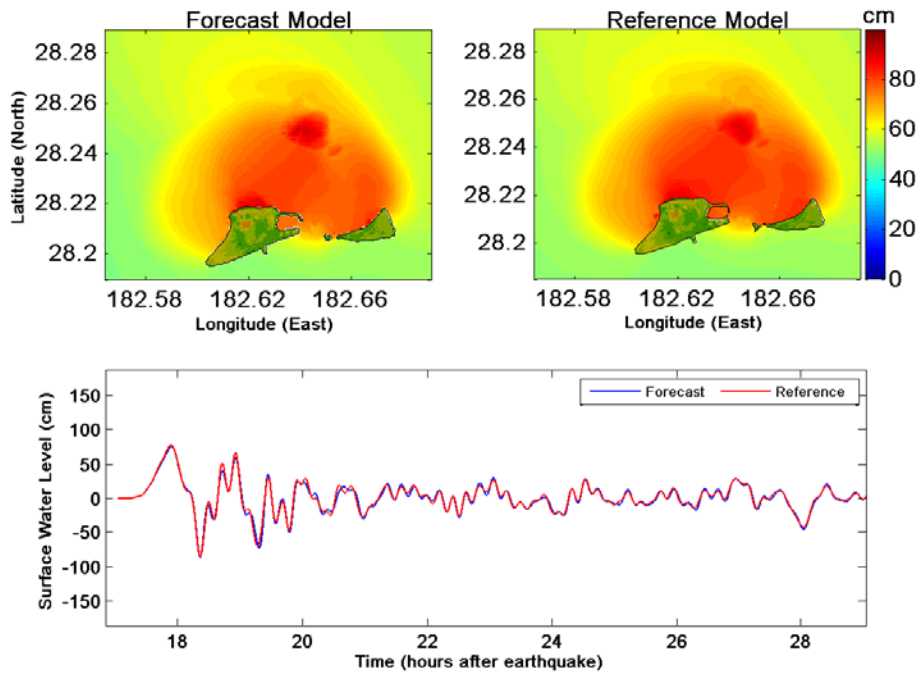
Figure 26. . Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 22 May 1960 Chile tsunami.
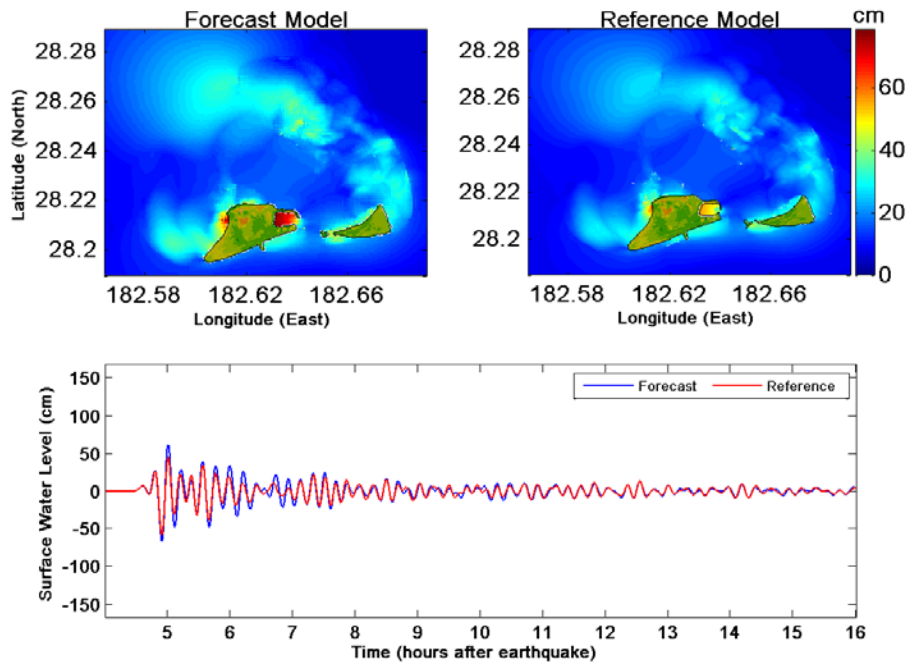
Figure 27. Comparison of maximum tsunami wave amplitude distribution (top figures) and tide gauge (bottom figure) for 4 October 1994 East Kuril tsunami.
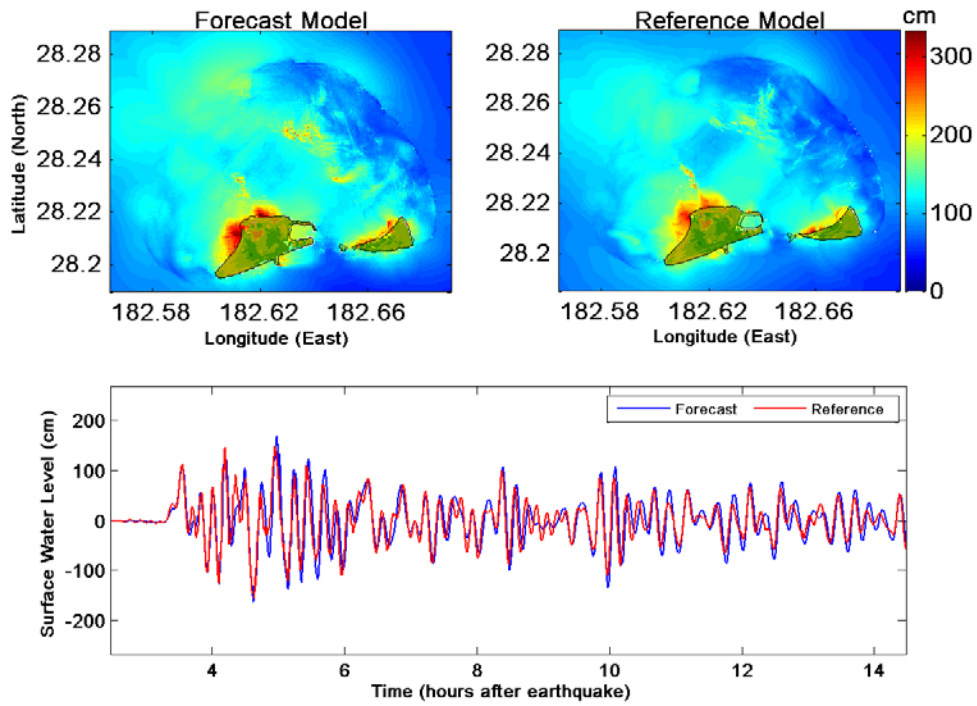
Figure 28. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 1-10ab tsunami source.
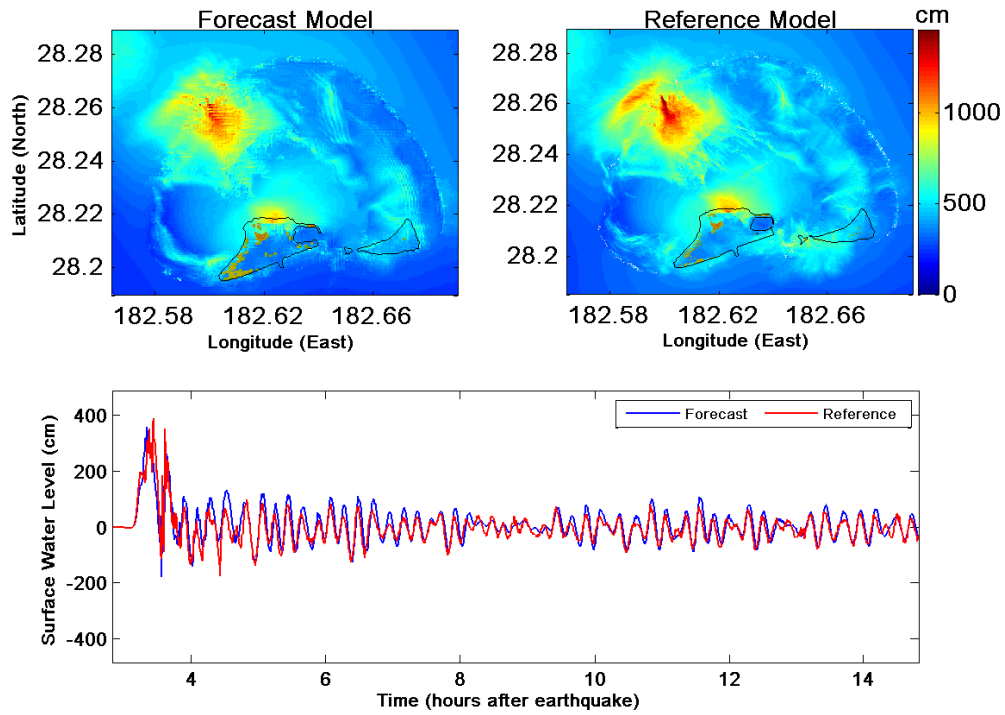
Figure 29. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 11-20 tsunami source.
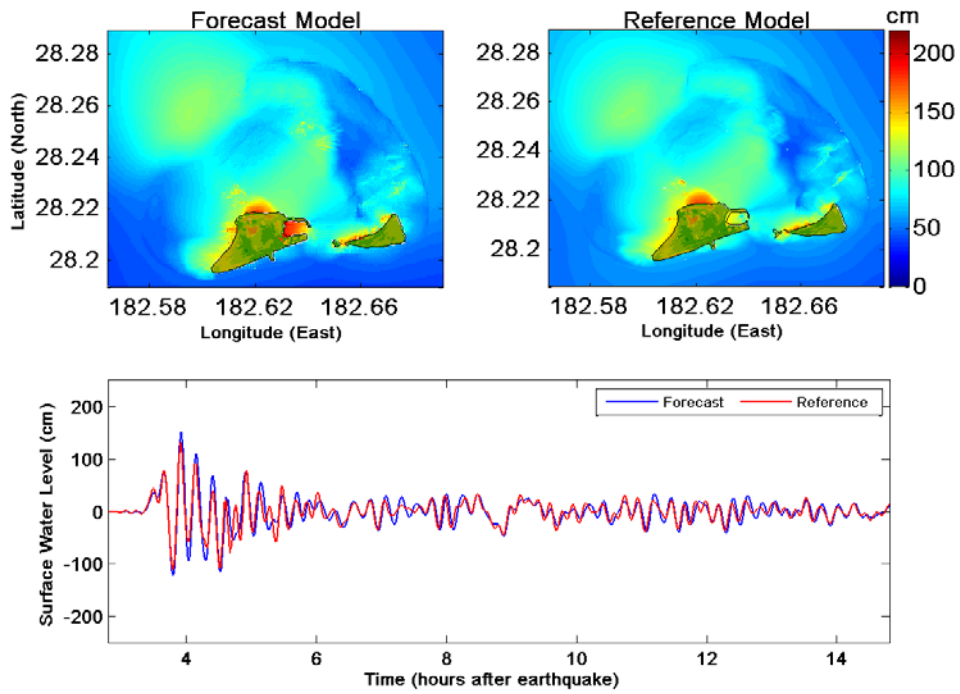
Figure 30. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 21-30 tsunami source.
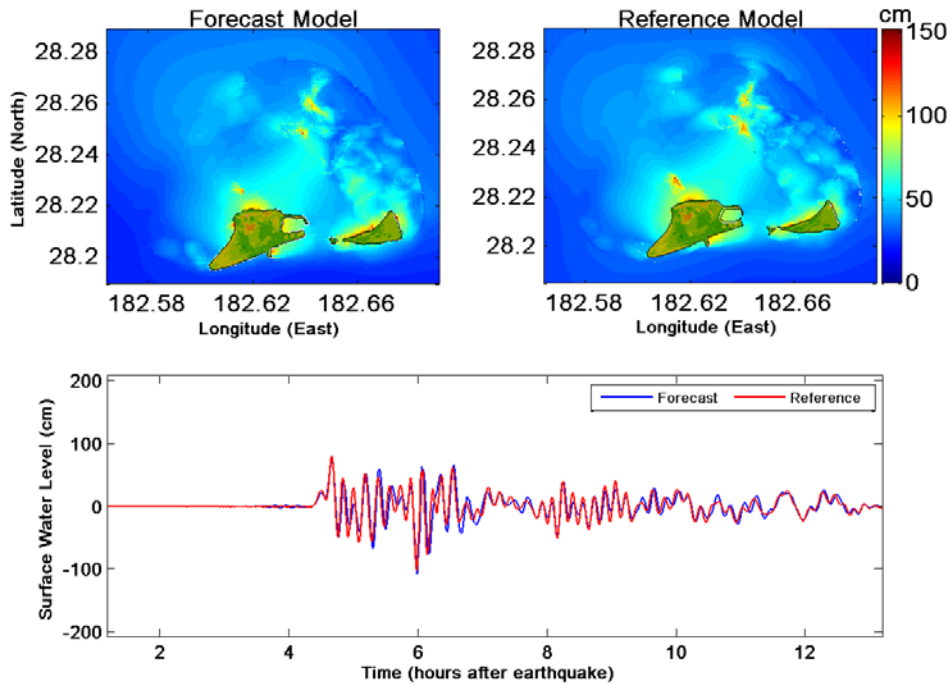
Figure 31. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 31-40 tsunami source.
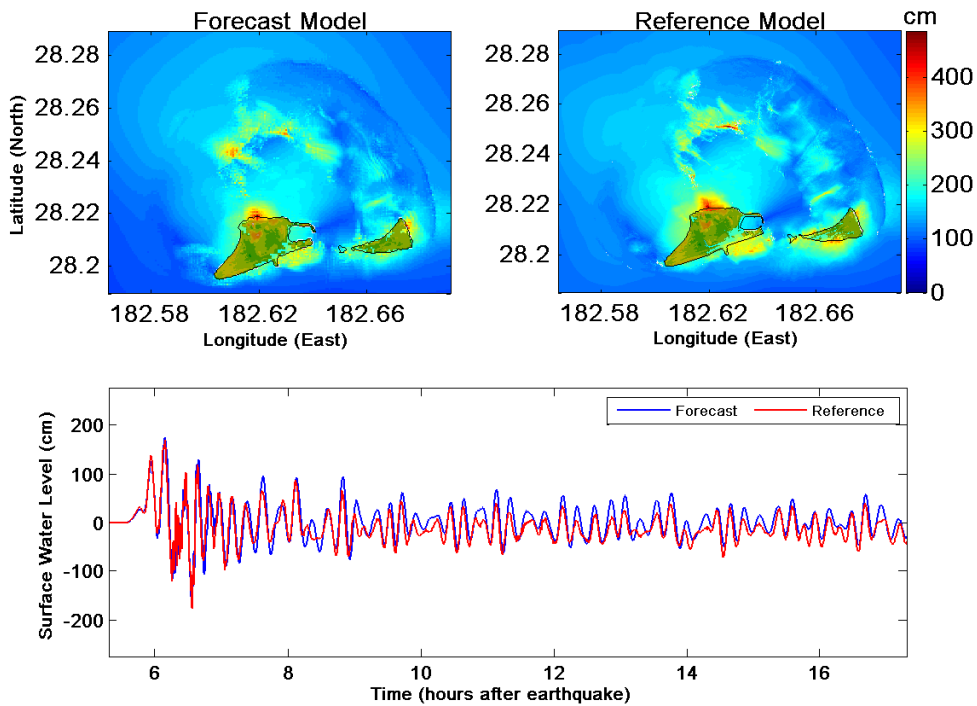
Figure 32. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 41-50 tsunami source.
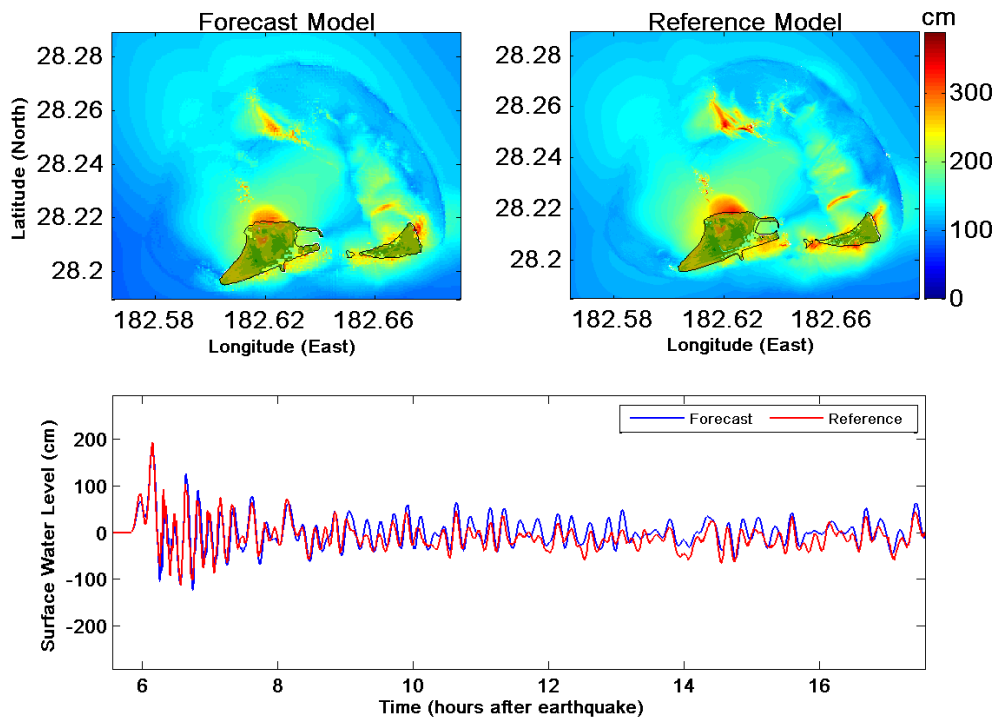
Figure 33. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 46-55 tsunami source.
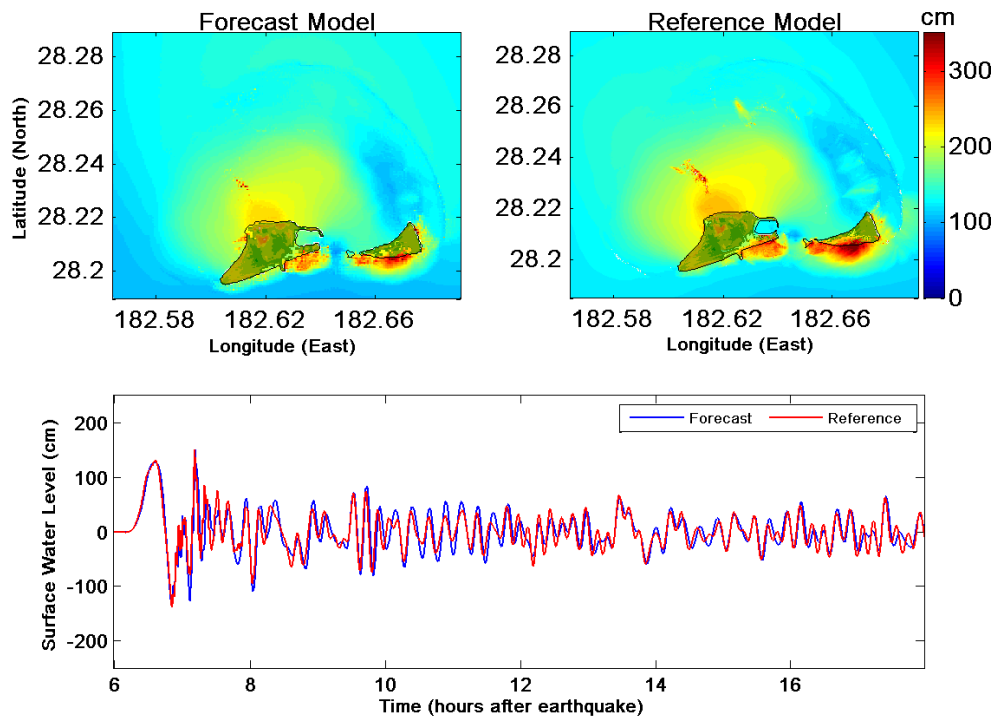
Figure 34. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for ACSZ 56-65 tsunami source.
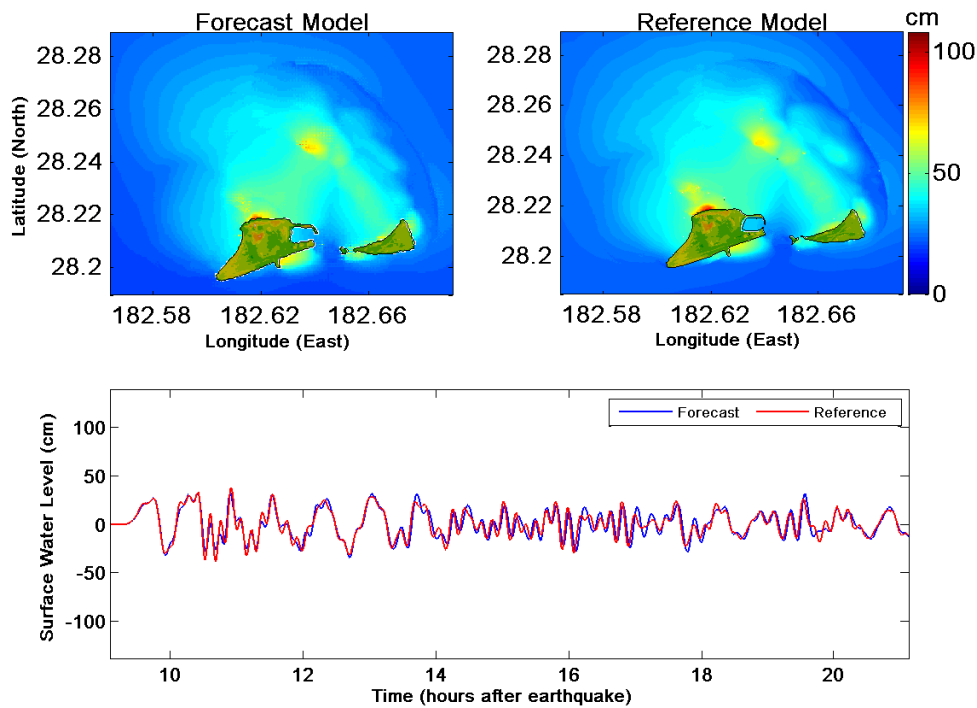
Figure 35. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 1-10 tsunami source.
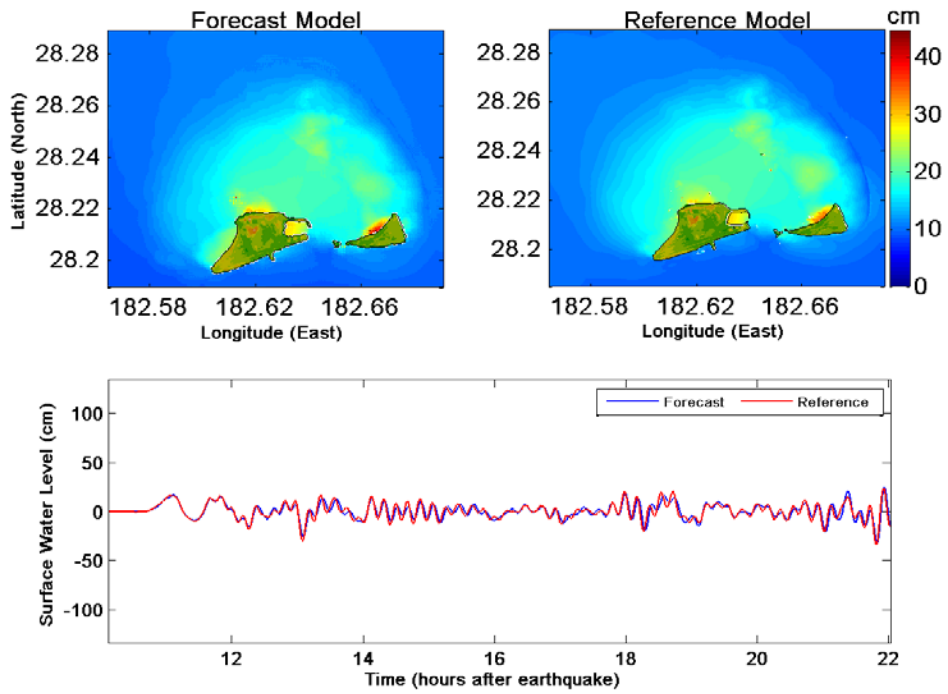
Figure 36. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 11-20 tsunami source.
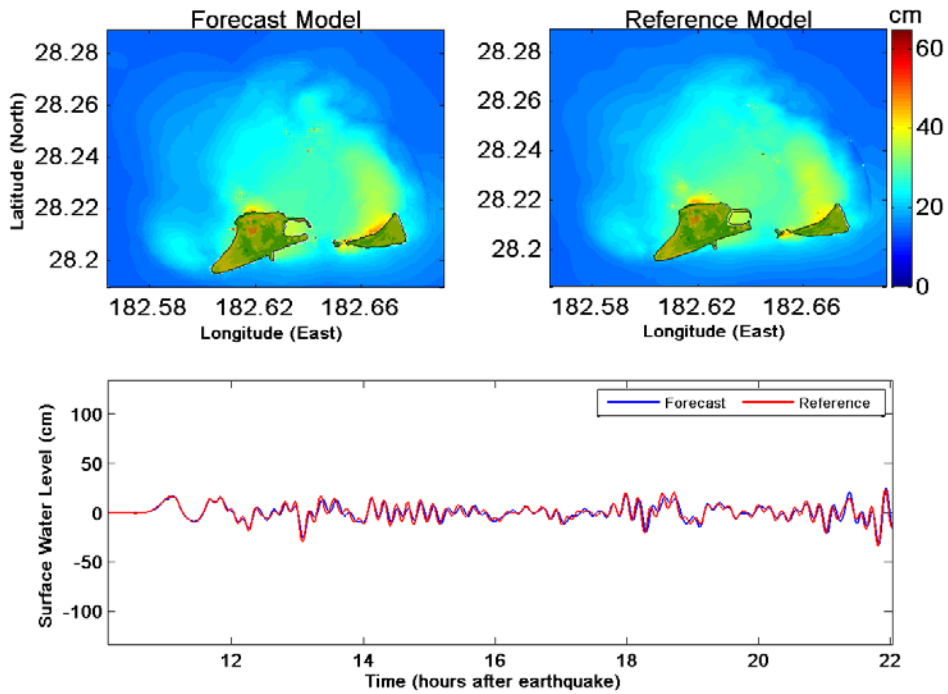
Figure 37. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 21-30 tsunami source.
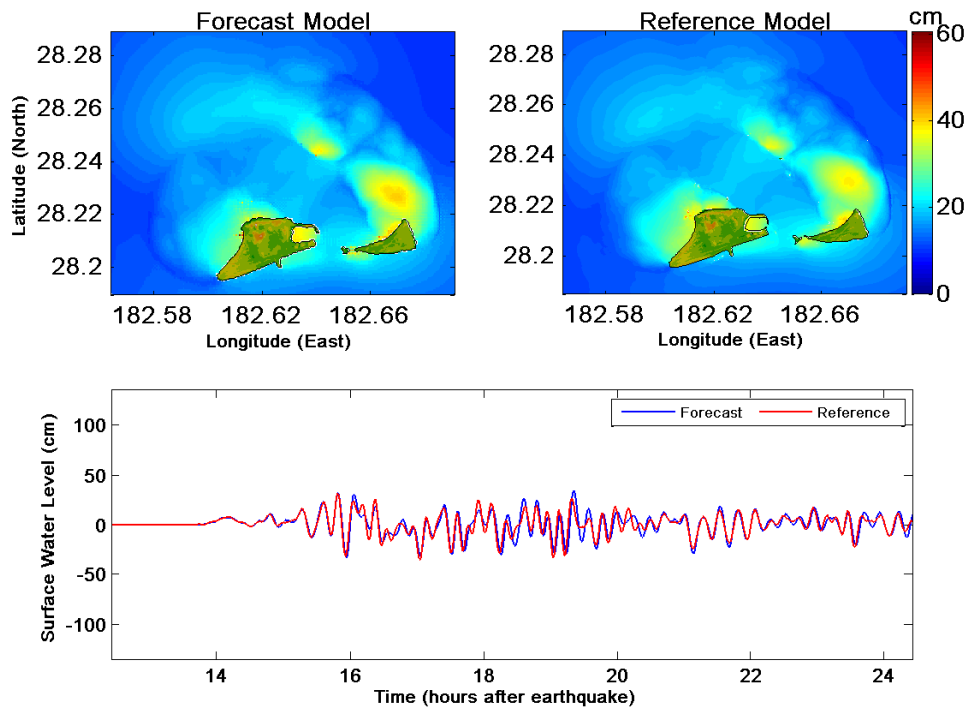
Figure 38. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSZ 31-40 tsunami source.
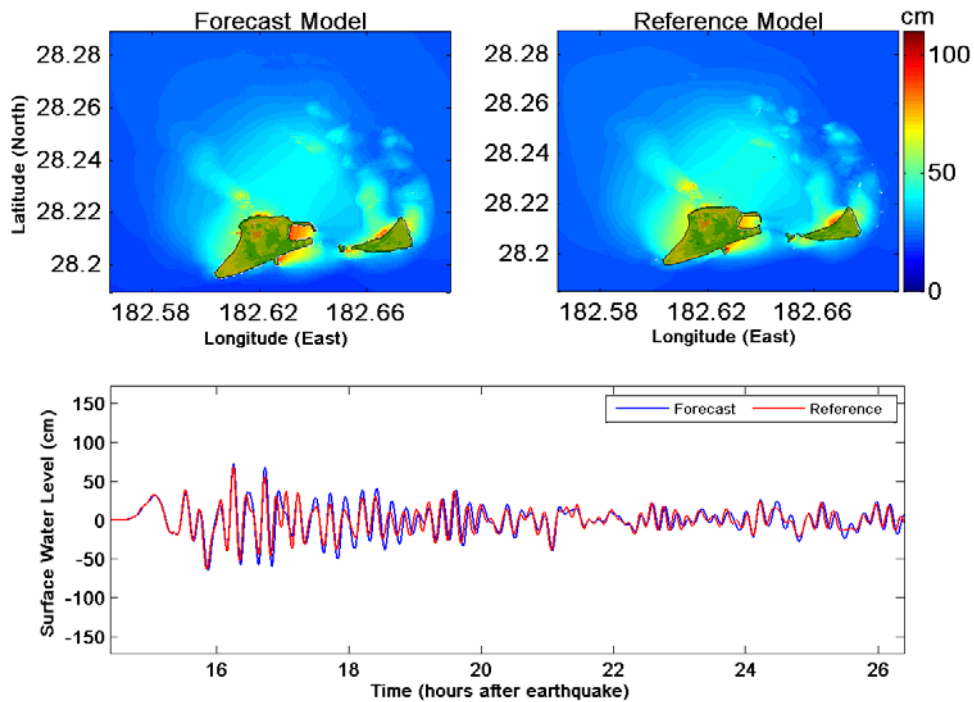
Figure 39. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 41-50 tsunami source.
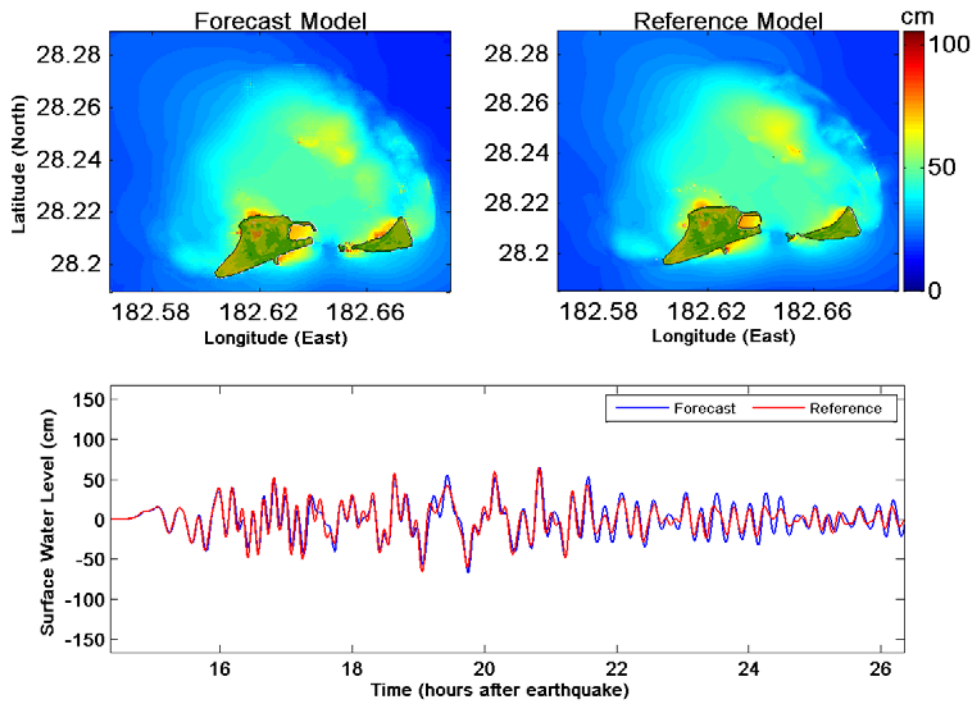
Figure 40. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 51-60 tsunami source.
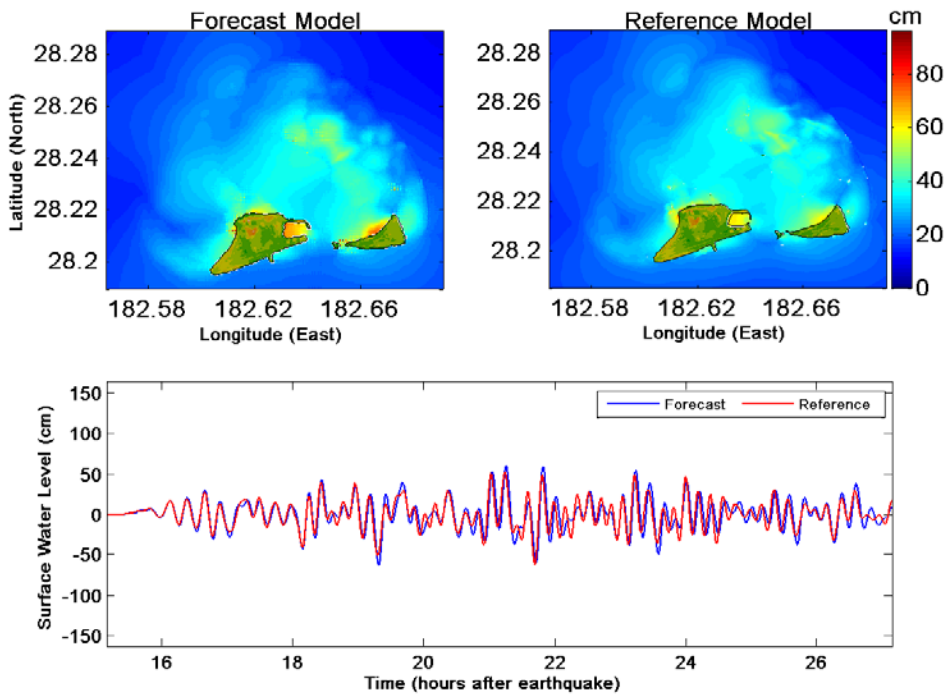
Figure 41. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 61-70 tsunami source.
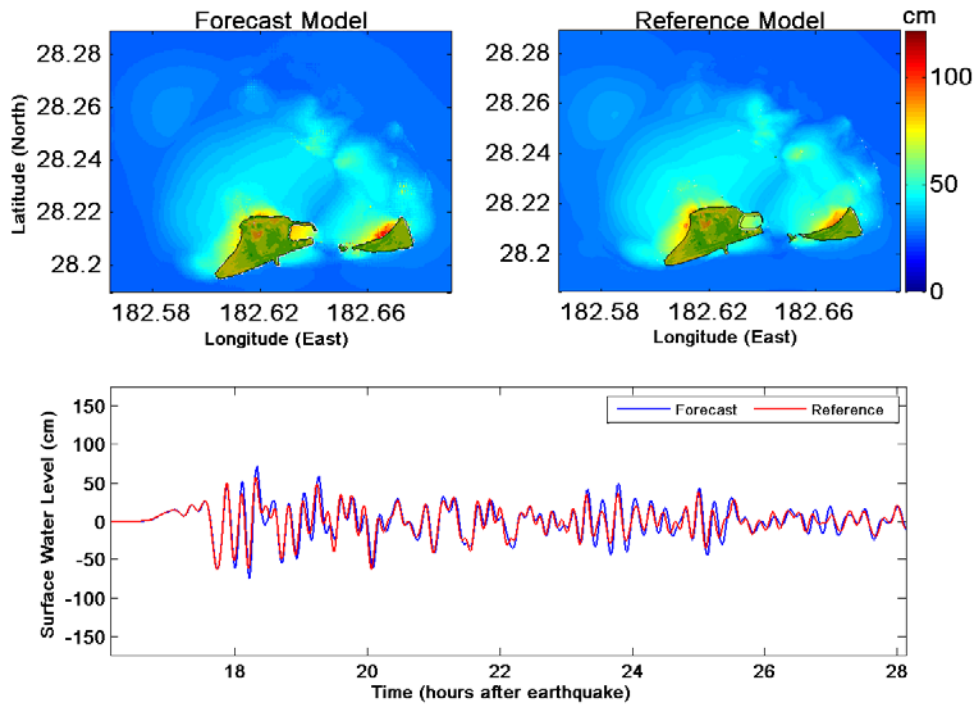
Figure 42. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 71-80 tsunami source.
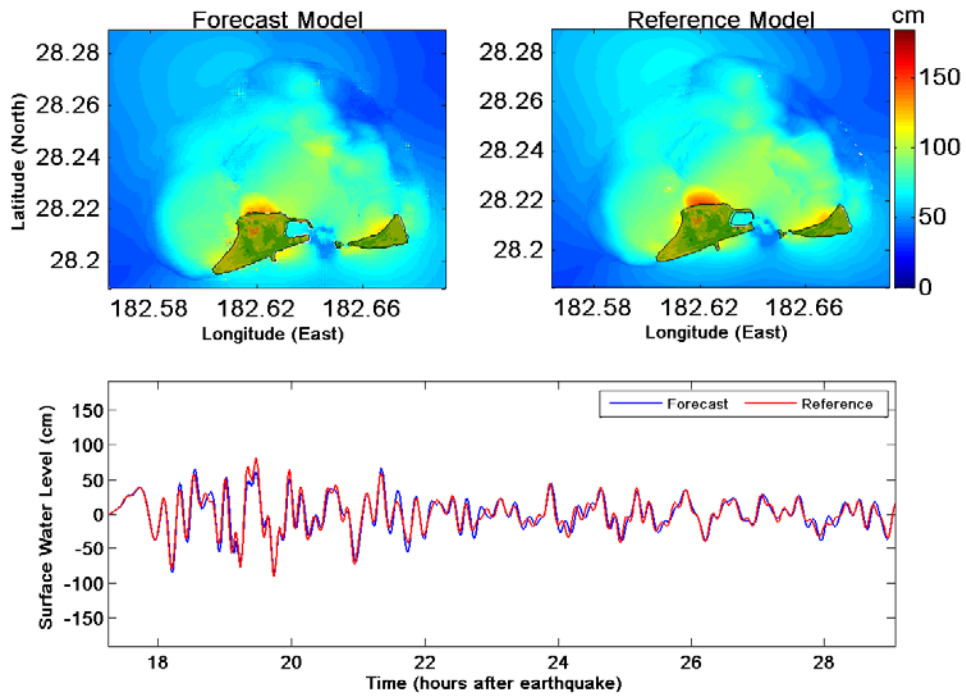
Figure 43. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 81-90 tsunami source.
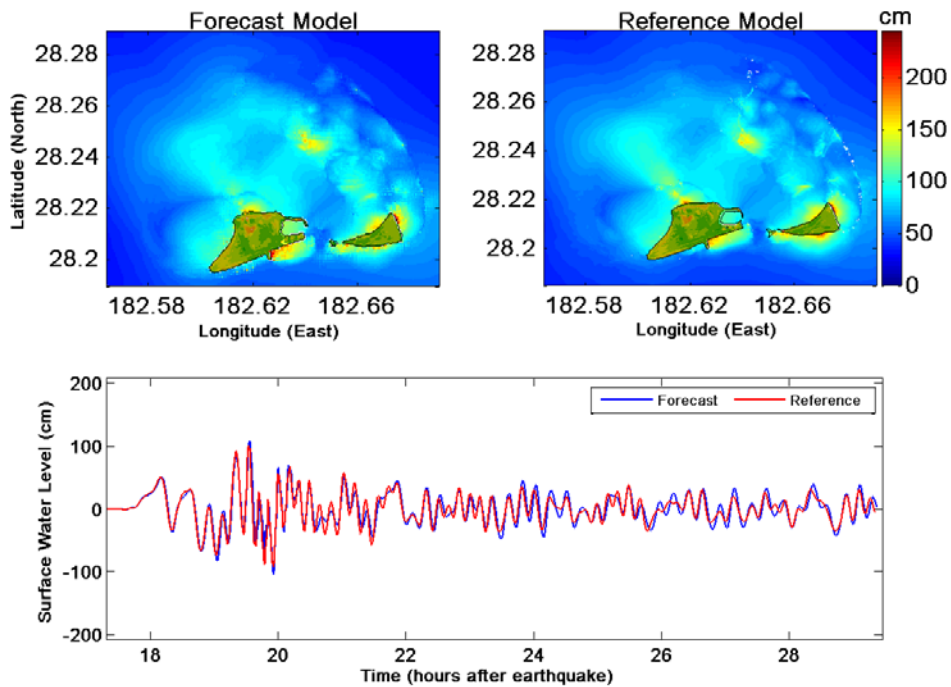
Figure 44. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 91-100 tsunami source.
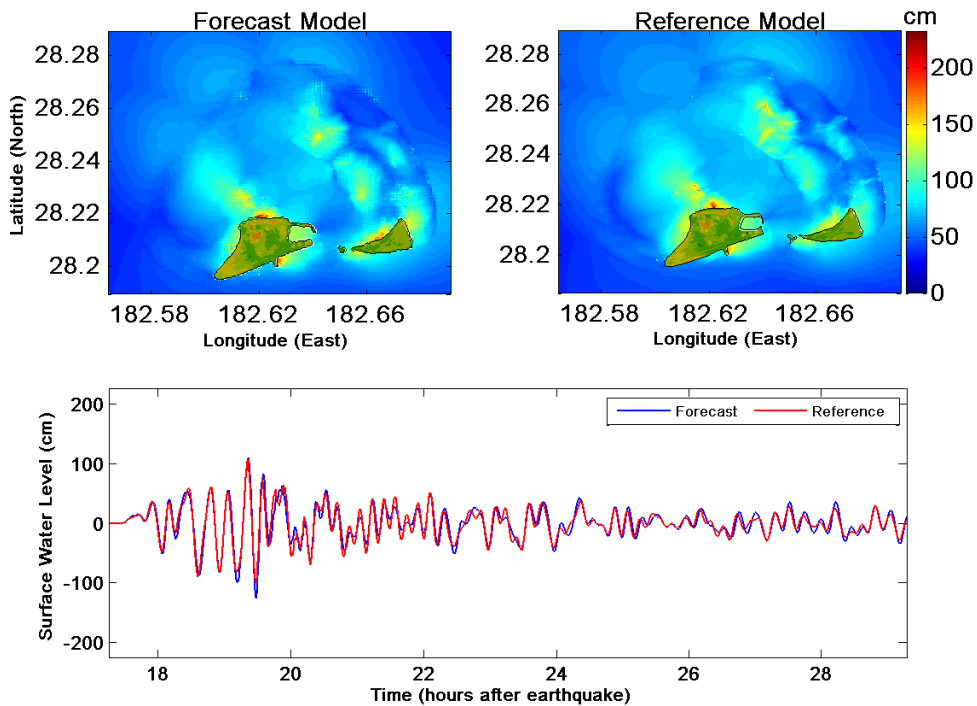
Figure 45. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 101-110 tsunami source.
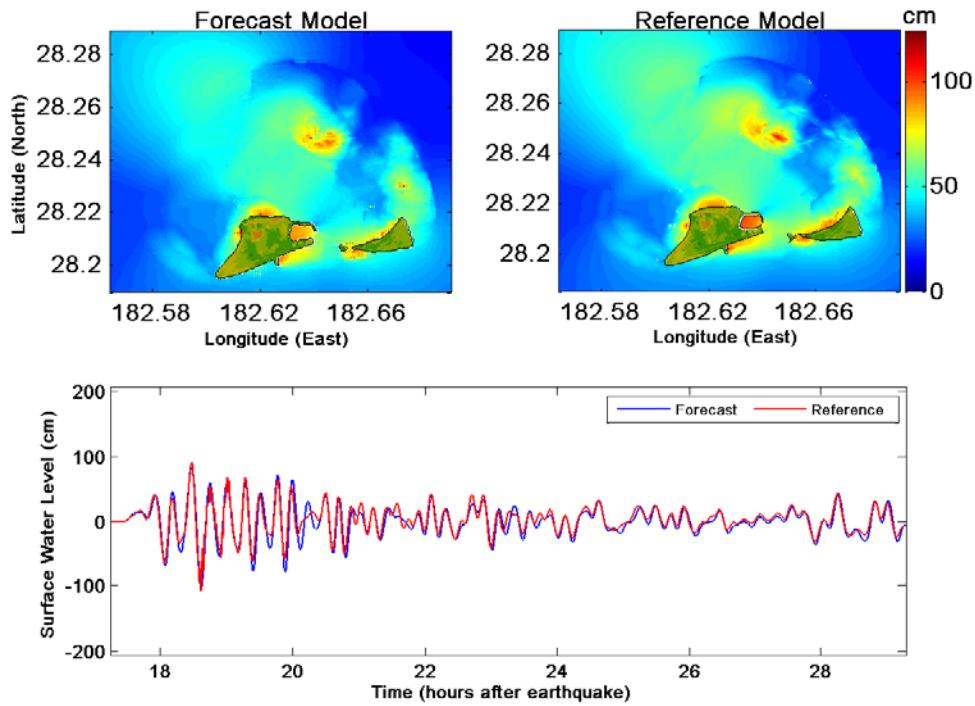
Figure 46. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for CSSZ 106-115 tsunami source.
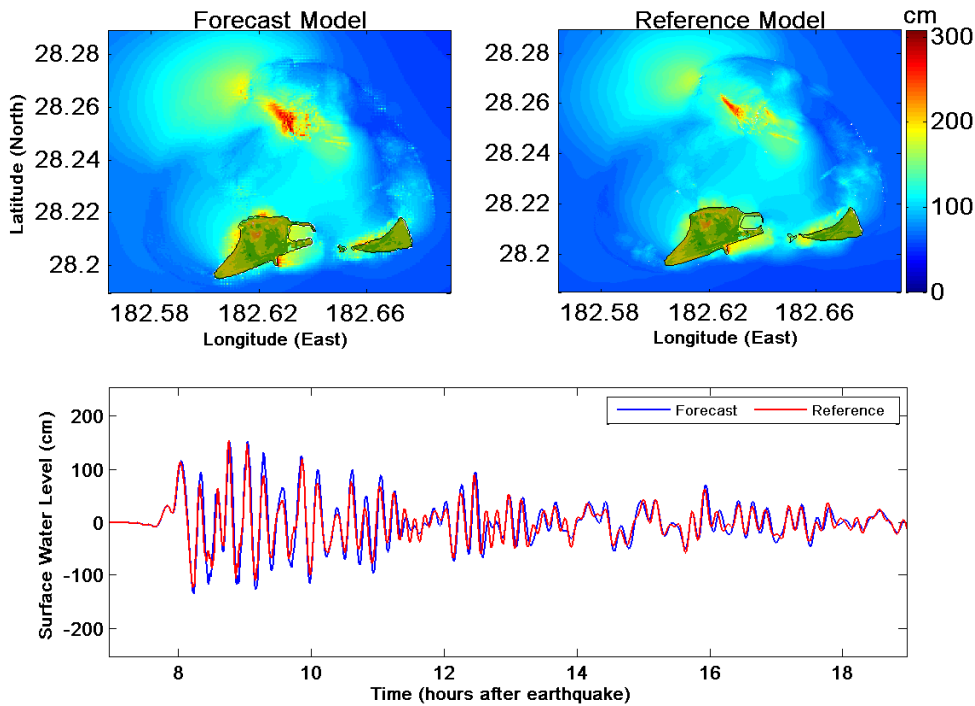
Figure 47. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for EPSZ 1-10 tsunami source.
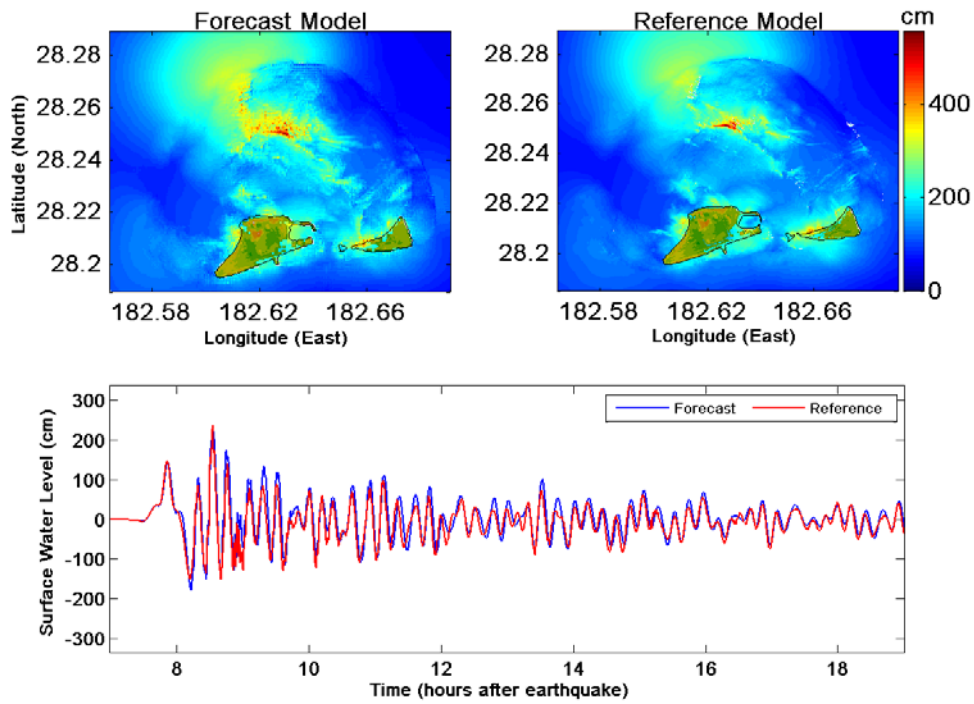
Figure 48. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for EPSZ 9-18 tsunami source.
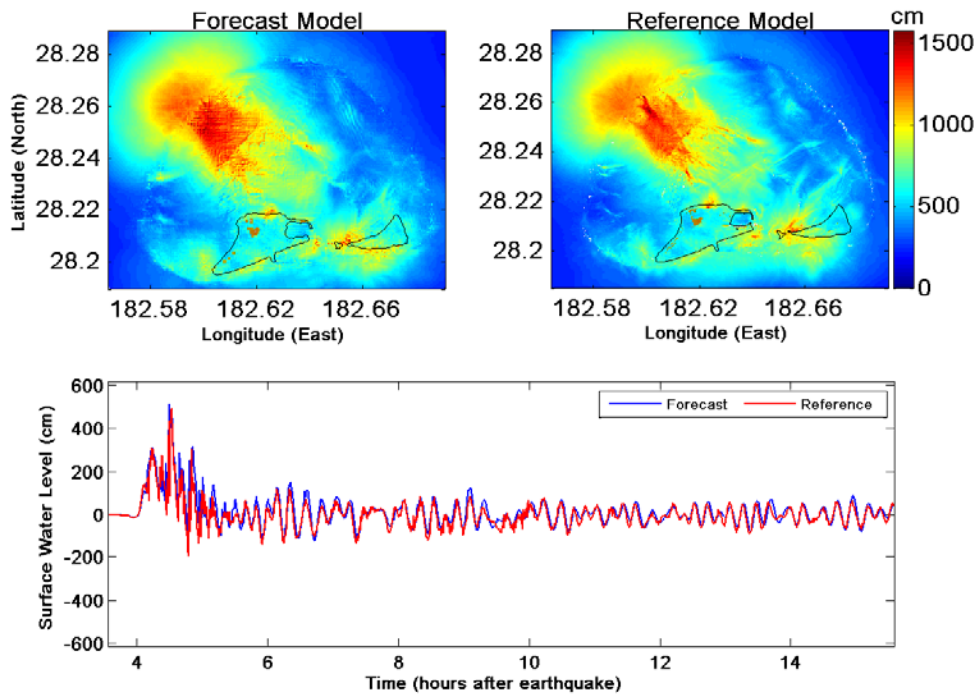
Figure 49. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 1-10 tsunami source.
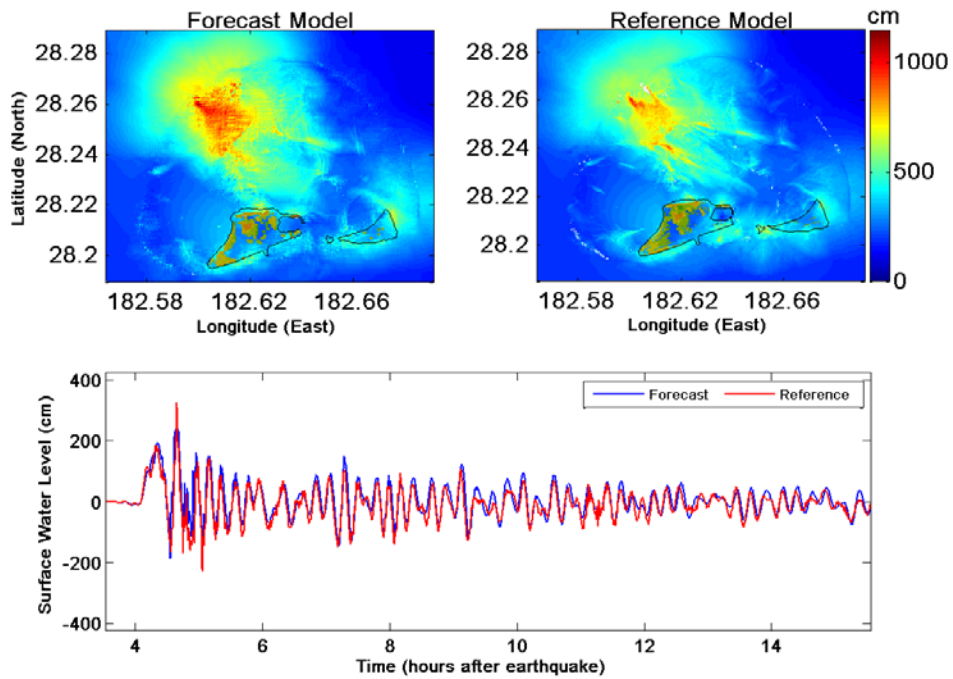
Figure 50. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 11-20 tsunami source.
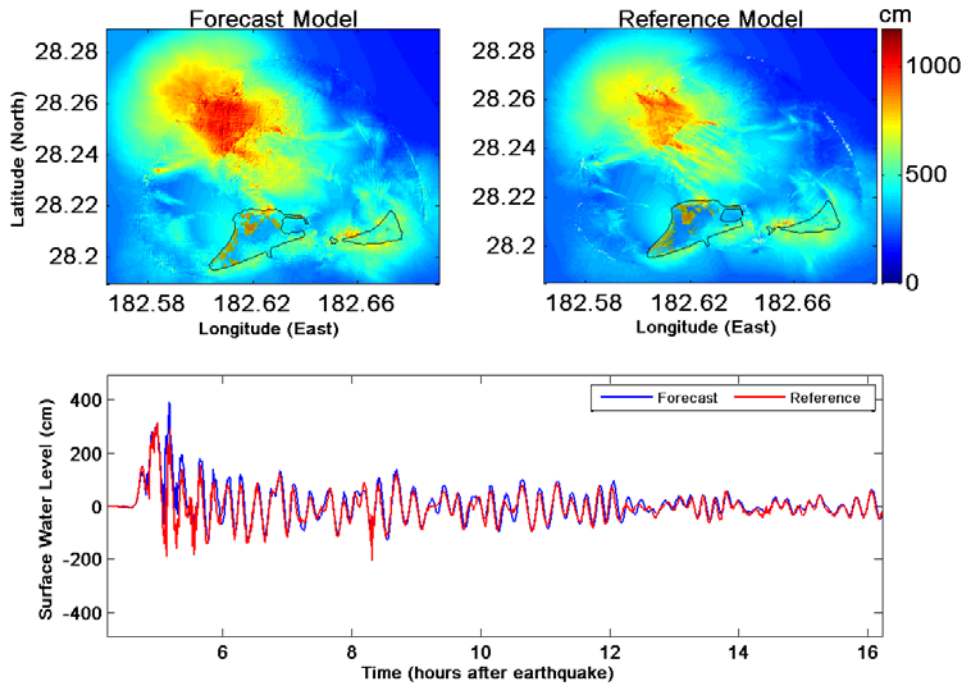
Figure 51. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 22-31 tsunami source.
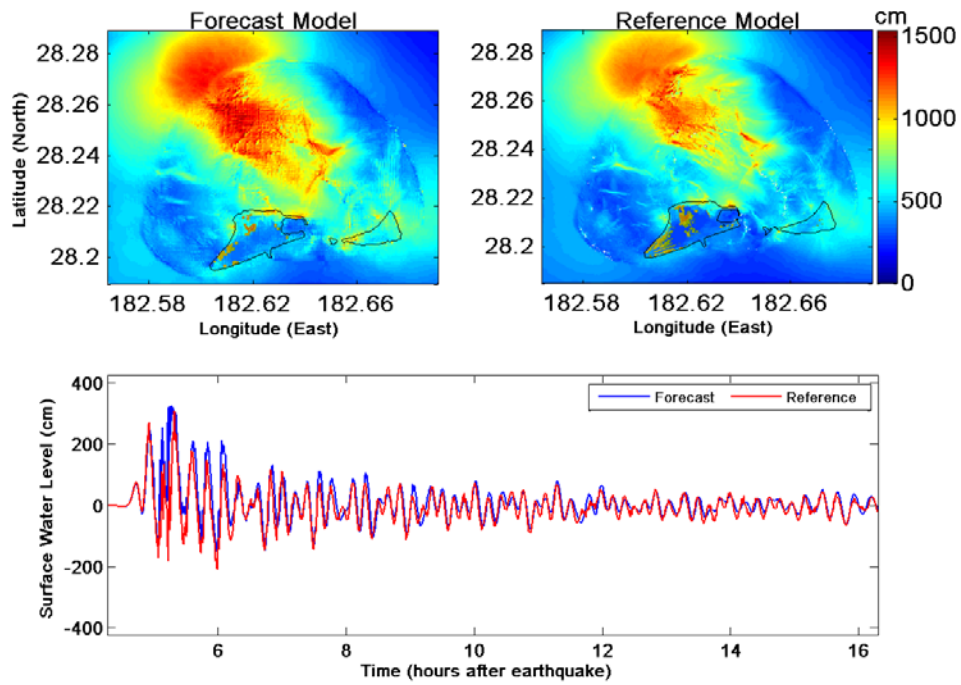
Figure 52. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 32-41 tsunami source.
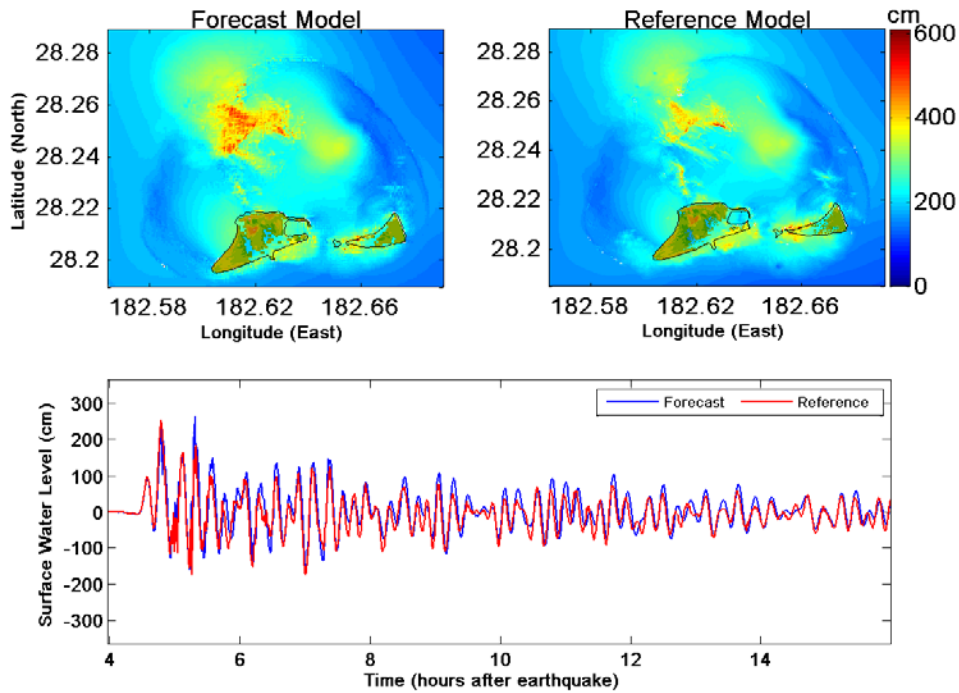
Figure 53. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 42-51 tsunami source.
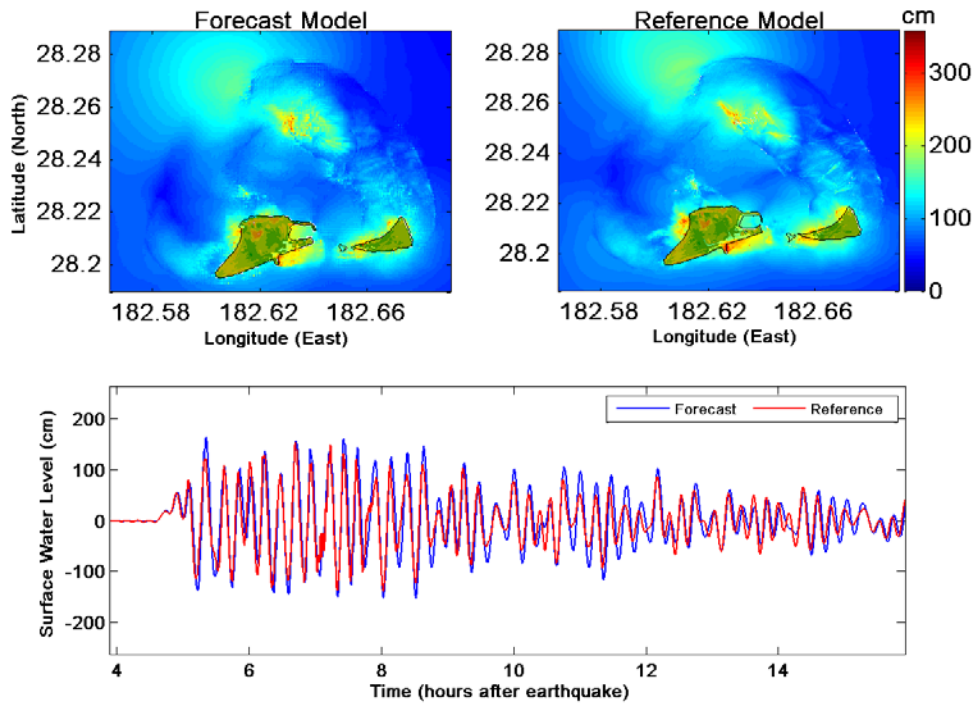
Figure 54. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 52-61 tsunami source.
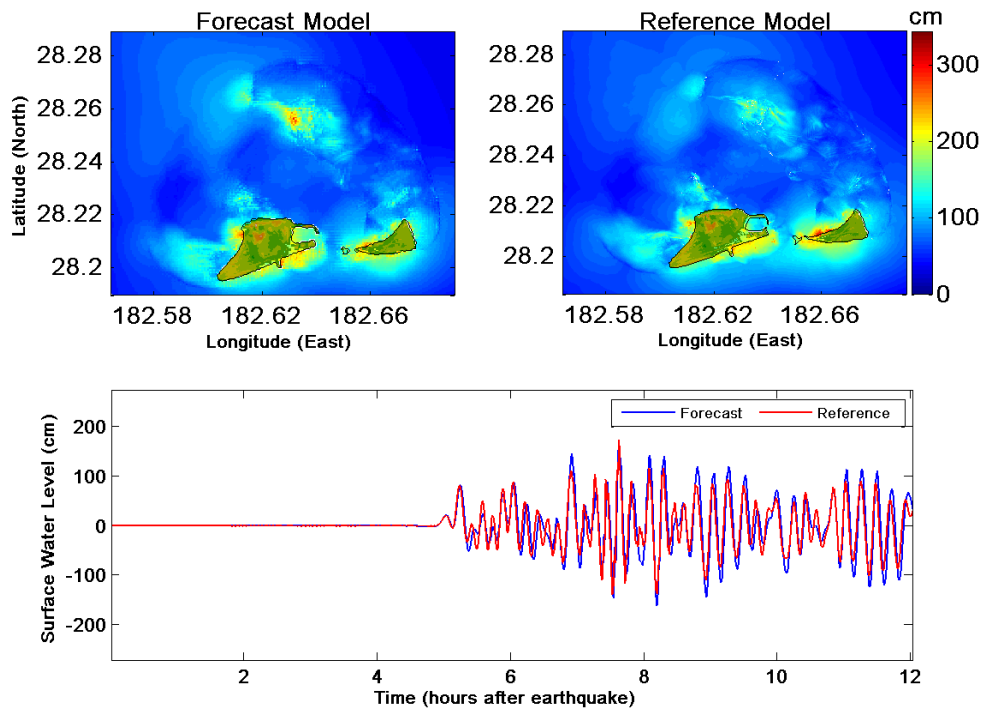
Figure 55. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 56-65 tsunami source.
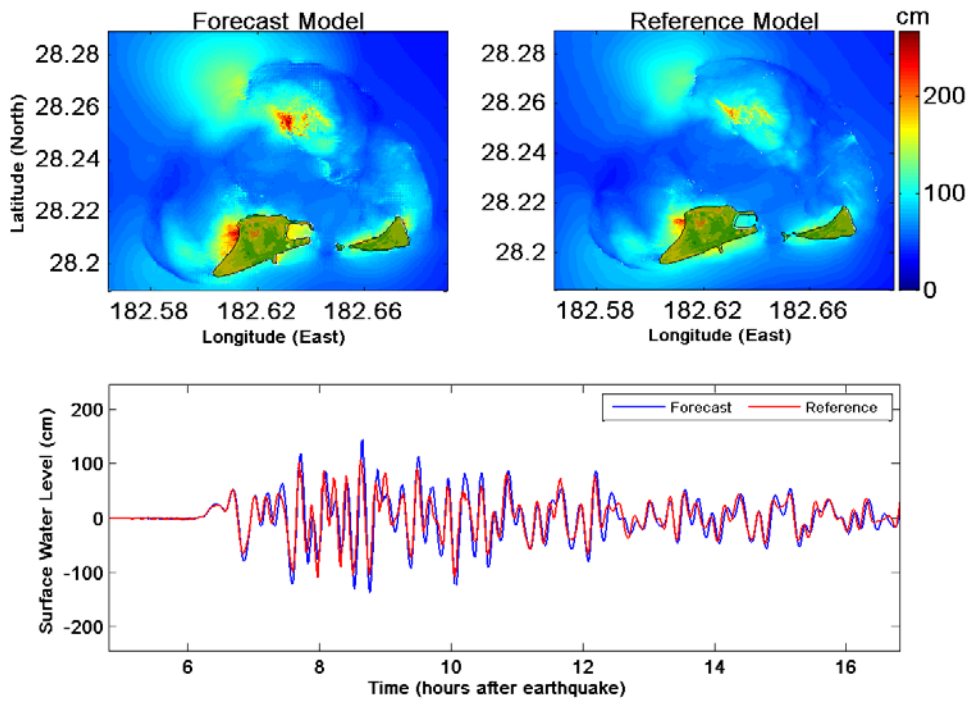
Figure 56. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for KISZ 66-75 tsunami source.
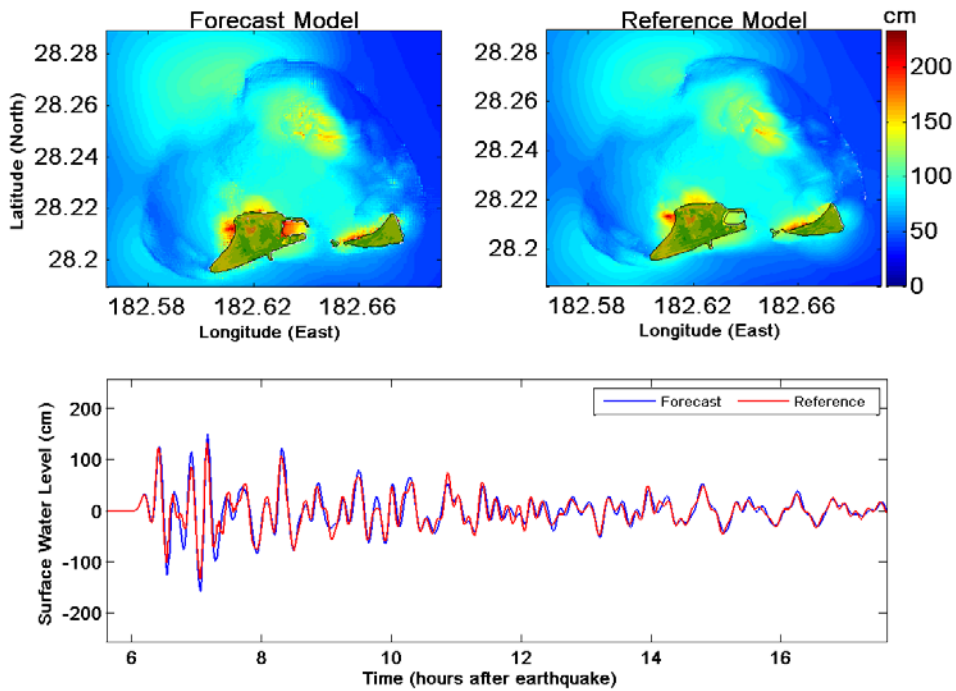
Figure 57. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for MOSZ 1-10 tsunami source.
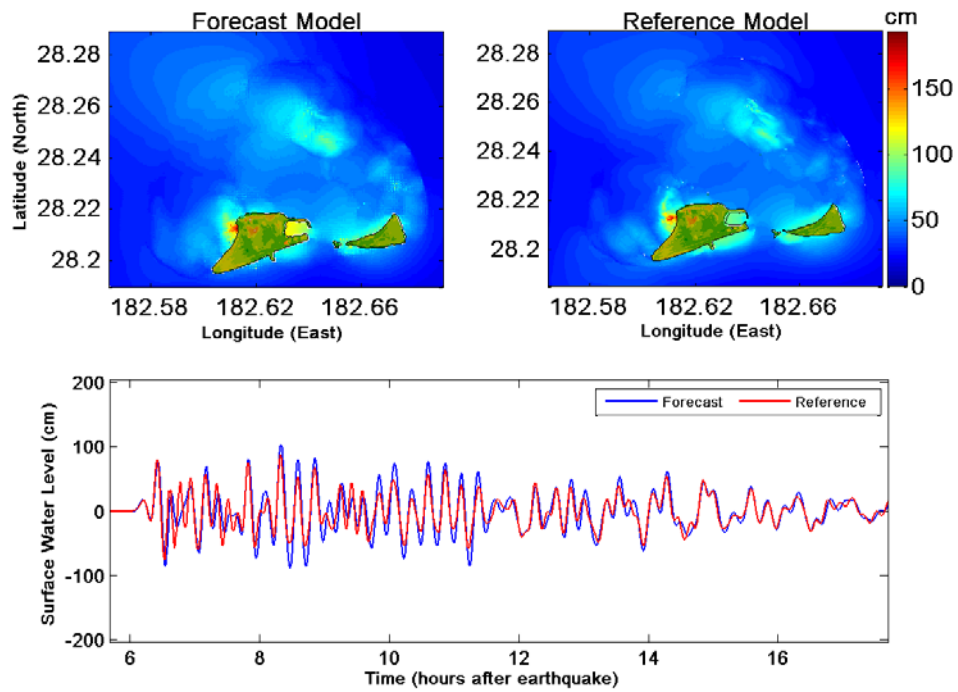
Figure 58. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for MOSZ 8-17 tsunami source.
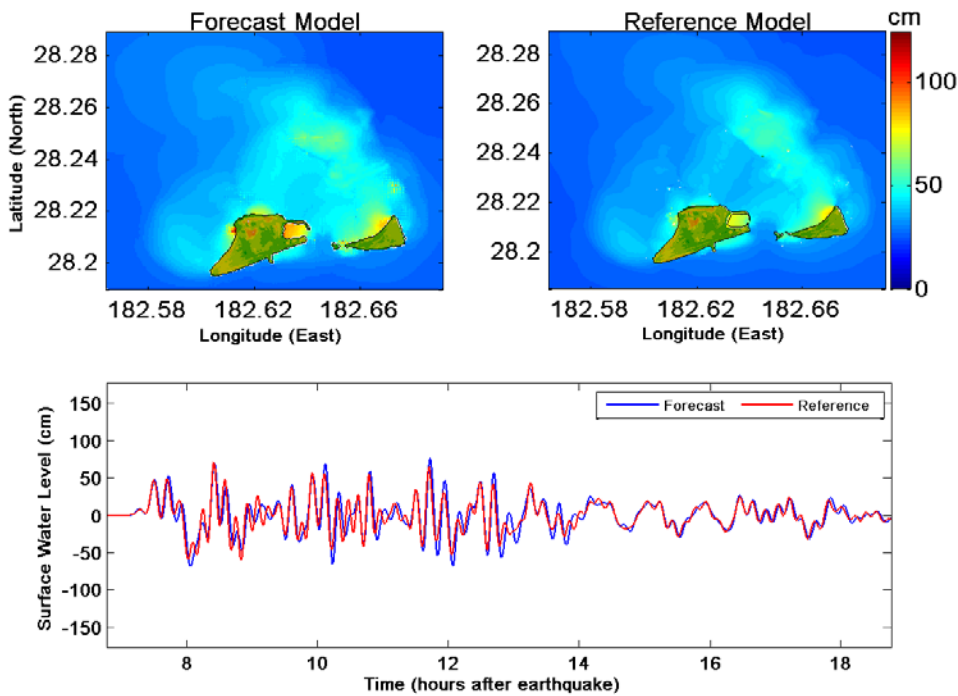
Figure 59. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NGSZ 1-10 tsunami source.
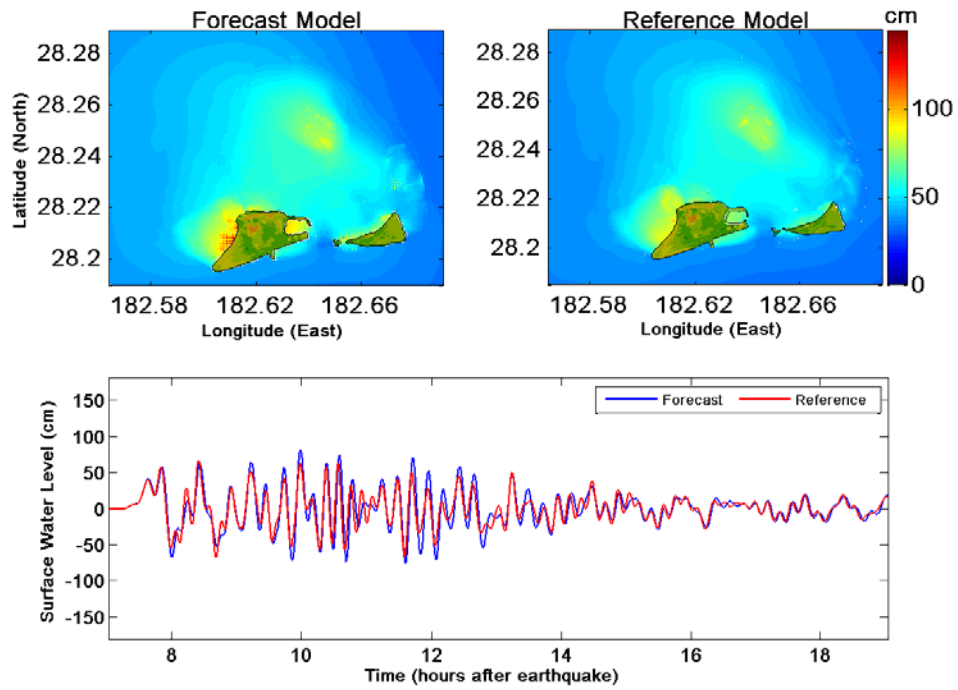
Figure 60. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NGSZ 6-15 tsunami source.
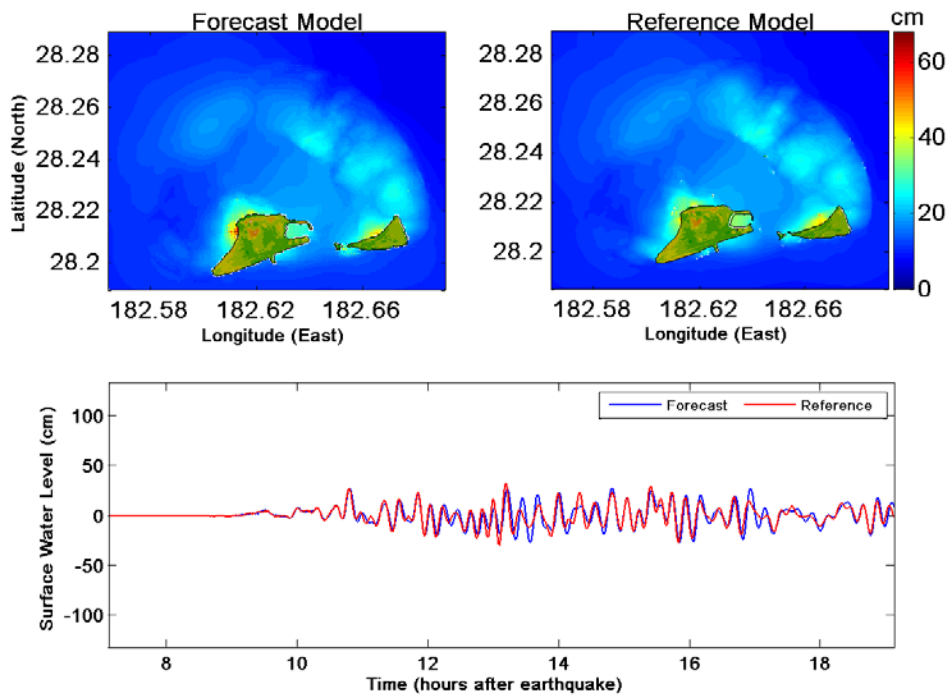
Figure 61. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NTSZ 1-10 tsunami source.
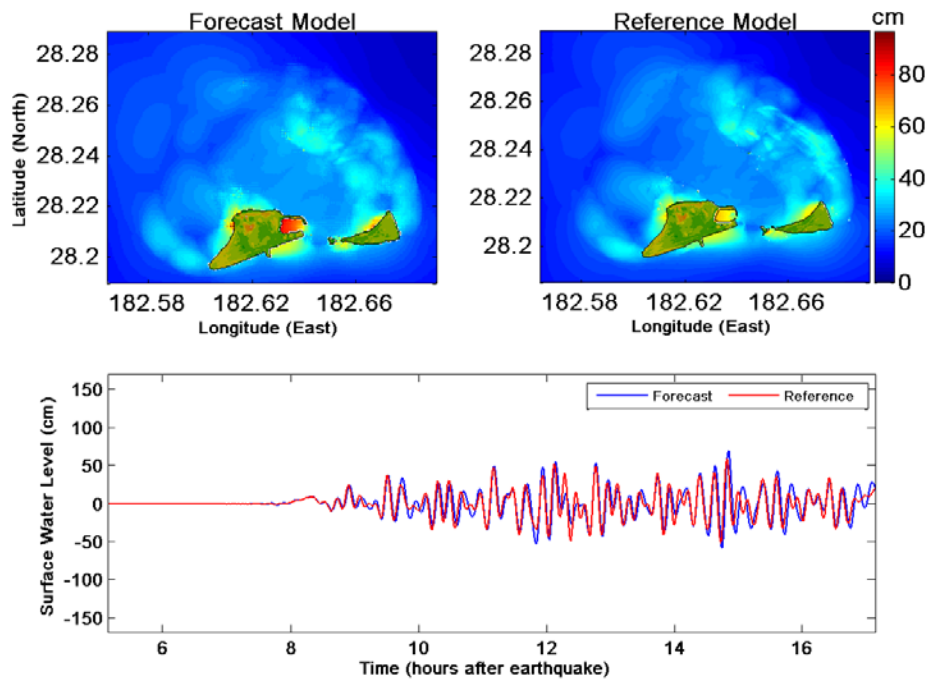
Figure 62. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NTSZ 11-20 tsunami source.
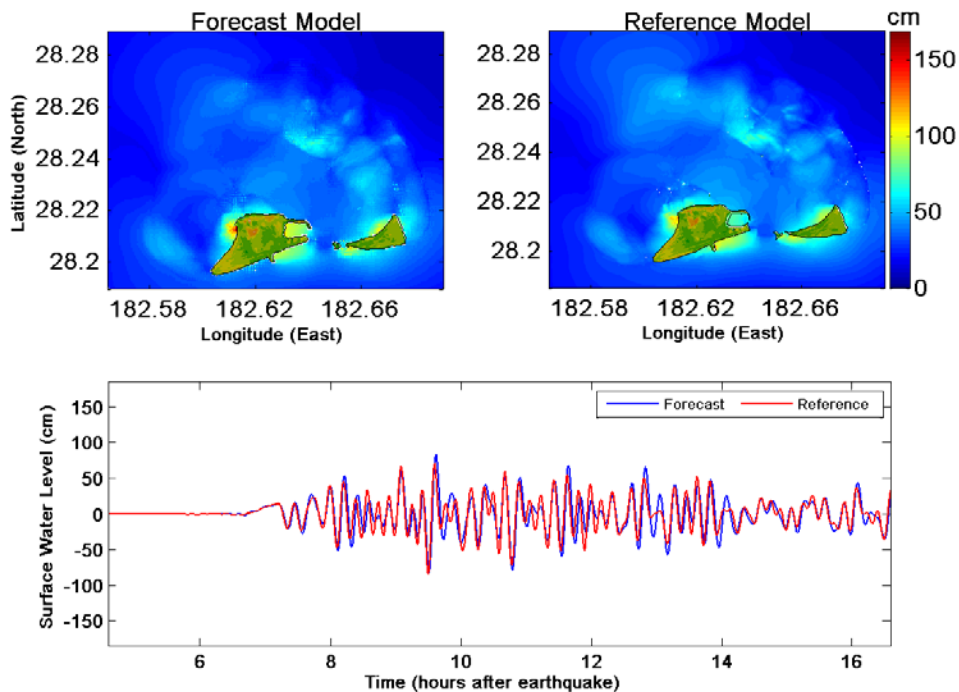
Figure 63. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NTSZ 21-30 tsunami source.
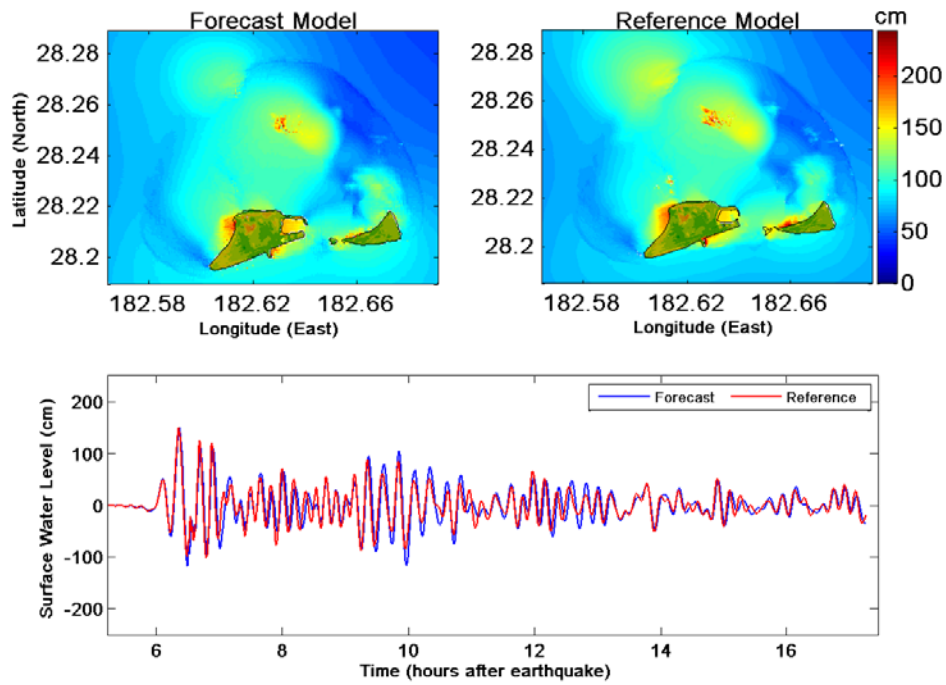
Figure 64. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NTSZ 30-39 tsunami source.
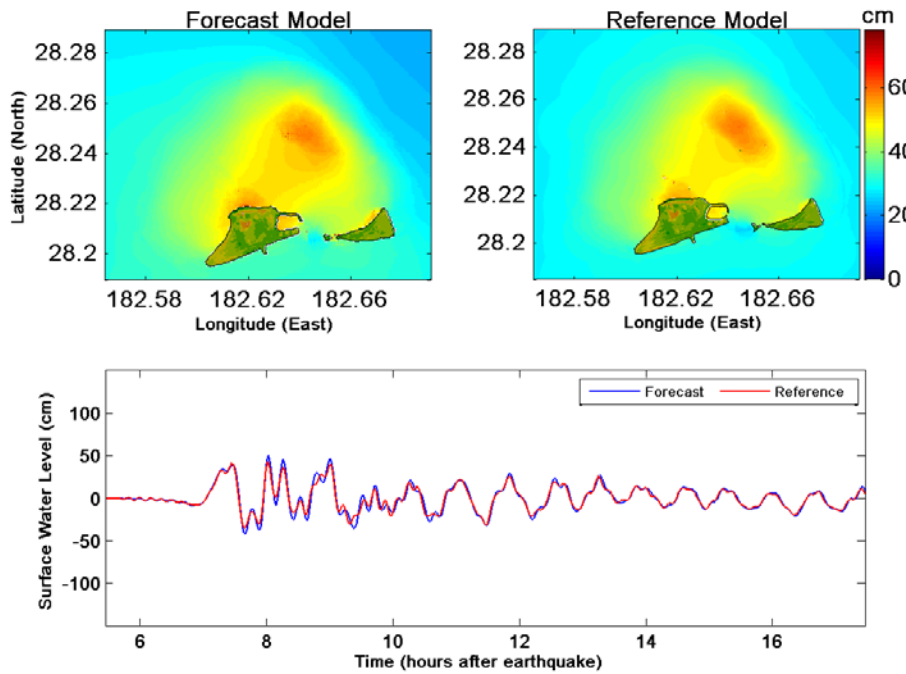
Figure 65. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NVSZ 1-10 tsunami source.
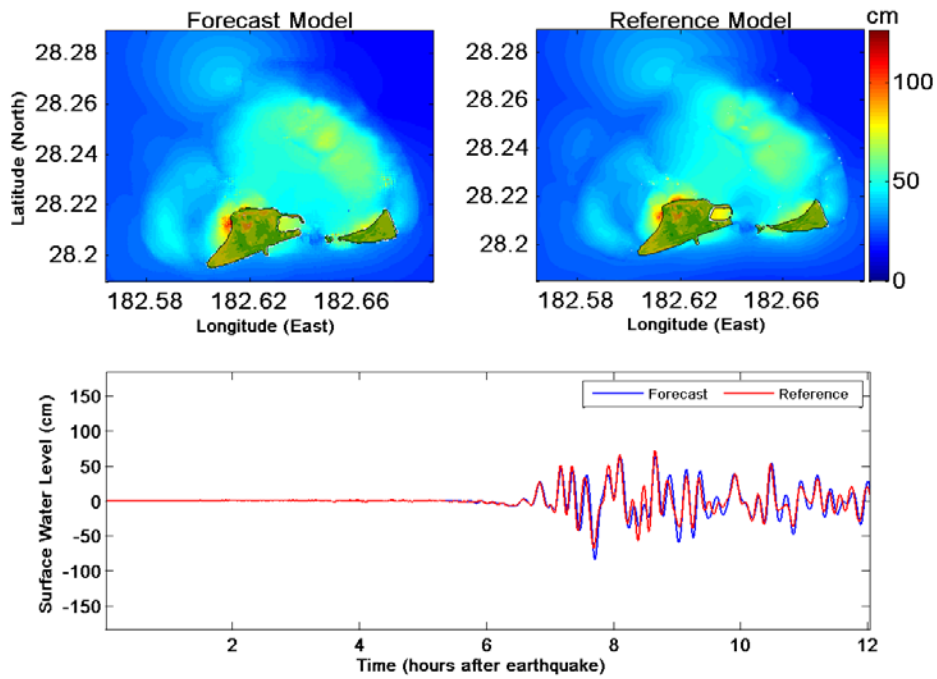
Figure 66. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NVSZ 11-20 tsunami source.
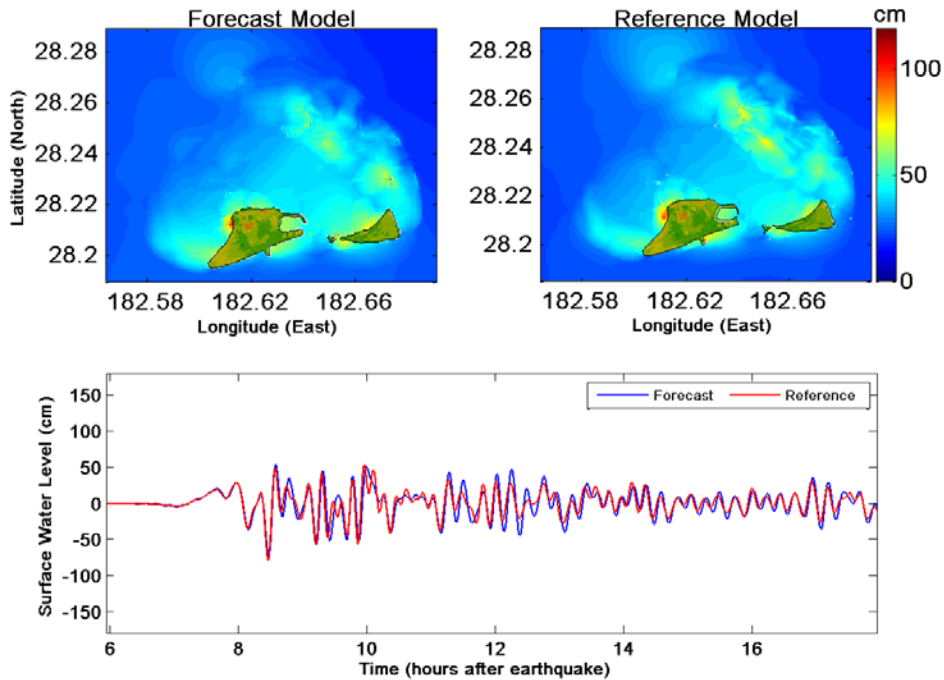
Figure 67. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for NVSZ 28-37 tsunami source.
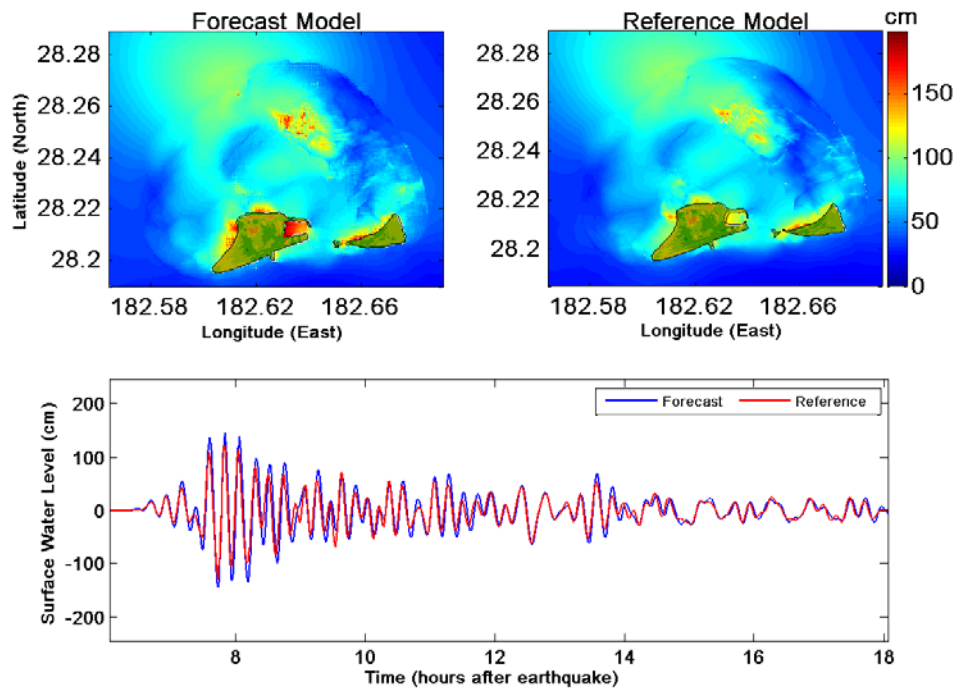
Figure 68. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for RNSZ 1-10 tsunami source.
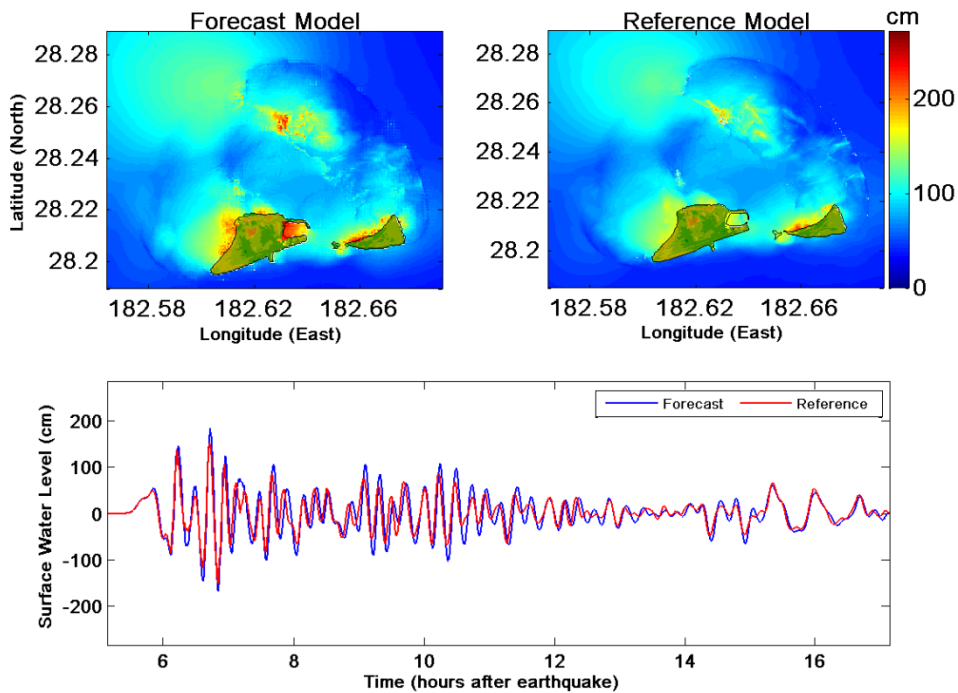
Figure 69. Maximum tsunami wave amplitude distribution (top figures) for synthetic mega-tsunami, Mw = 9.4 and tide gauge (bottom figure) for RNSZ 13-22 tsunami source.
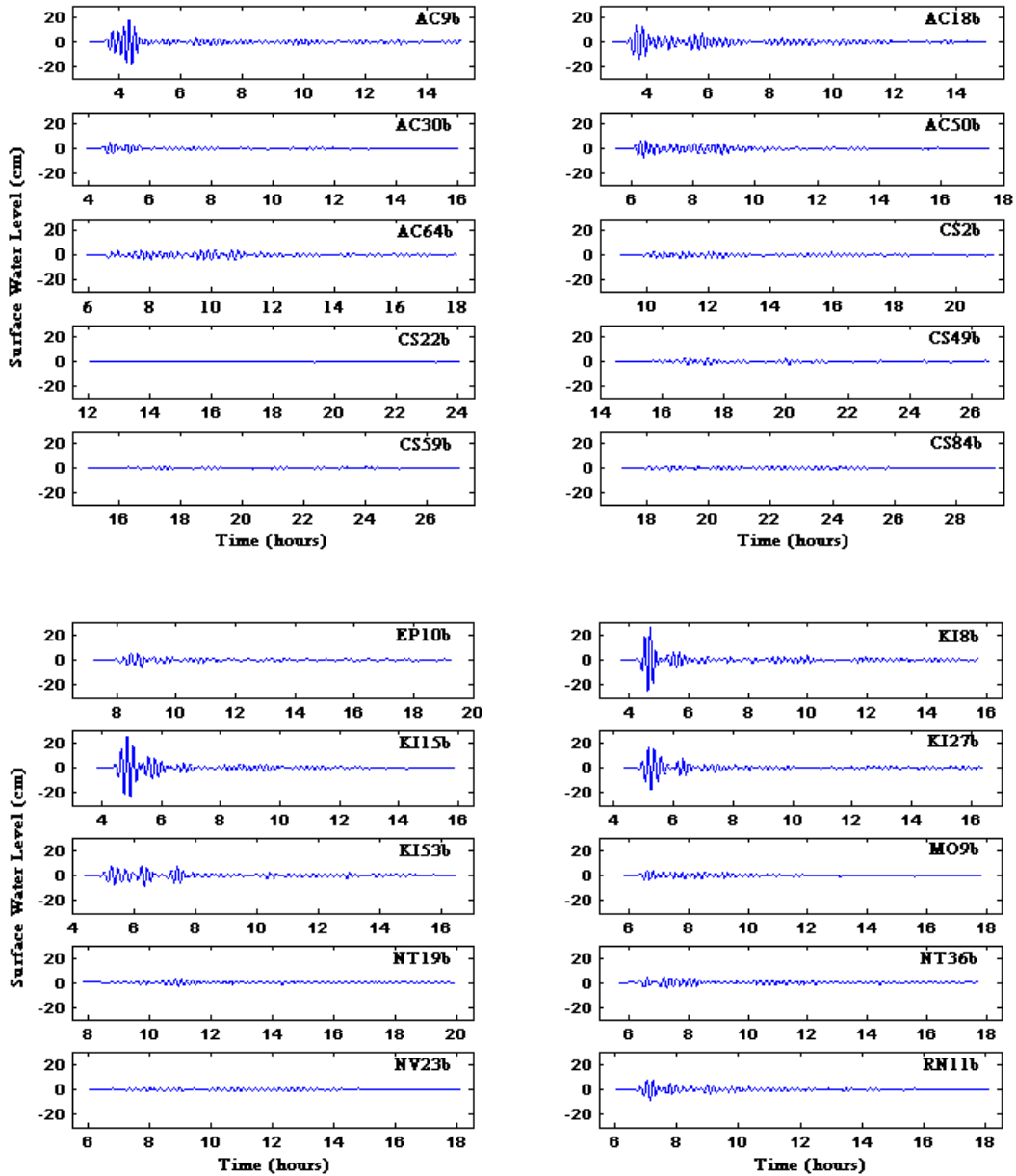
Figure 70. Simulated tsunami time series for the 20 synthetic Mw = 7.5 events. Vertical scale is fixed to reflect the scale of the arriving tsunami waves at tide gauge from different source regions.

53

Appendix A

Development of the Midway Atoll 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 Midway Atoll.

A1. Reference model *.in file for Midway Atoll

0.0	Minimum amplitude of input offshore wave (m)
1	Input minimum depth for offshore (m)
0.1	Input "dry land" depth for inundation (m)
0.0009	Input friction coefficient (n**2)
1	A & B-grid runup flag (0=disallow, 1=allow runup)
300.0	Blow-up limit (maximum eta before blow-up)
0.2	Input time step (sec)
216000	Input number of steps
15	Compute "A" arrays every n^{th} time step, n=
2	Compute "B" arrays every n^{th} time step, n=
150	Input number of steps between snapshots
1	...Starting from
1	...Saving grid every n^{th} node, n=1

A2. Forecast model *.in file for Midway Atoll

0.005	Minimum amplitude of input offshore wave (m)
1	Input minimum depth for offshore (m)
0.1	Input "dry land" depth for inundation (m)
0.0009	Input friction coefficient (n**2)
1	A & B-grid runup flag (0=disallow, 1=allow runup)
300	Blow-up limit (maximum eta before blow-up)
0.6	Input time step (sec)
72000	Input number of steps
10	Compute "A" arrays every n^{th} time step, n=
1	Compute "B" arrays every n^{th} time step, n=
50	Input number of steps between snapshots
1	...Starting from
1	...Saving grid every n^{th} node, n=1

Appendix B

Propagation source details reflect the database as of January 29, 2013 and there may have been updates in the earthquake source parameters after this date. The development of Midway Atoll forecast inundation model uses the propagation database as of January 29, 2013.
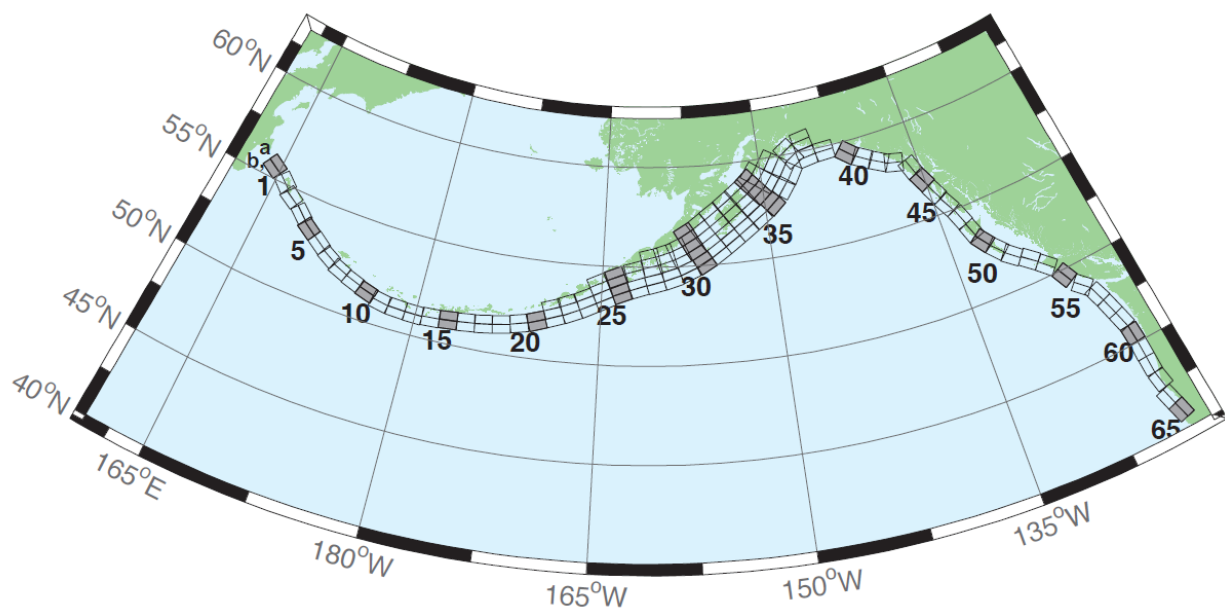
Figure B.1. Aleutian-Alaska-Cascadia Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-01a	Aleutian-Alaska-Cascadia	164.7994	55.9606	17.00	299.00	19.61
acsz-01b	Aleutian-Alaska-Cascadia	164.4310	55.5849	17.00	299.00	5.00
acsz-02a	Aleutian-Alaska-Cascadia	166.3418	55.4016	17.00	310.17	19.61
acsz-02b	Aleutian-Alaska-Cascadia	165.8578	55.0734	17.00	310.17	5.00
acsz-03a	Aleutian-Alaska-Cascadia	167.2939	54.8919	23.36	300.22	24.82
acsz-03b	Aleutian-Alaska-Cascadia	166.9362	54.5356	23.36	300.22	5.00
acsz-04a	Aleutian-Alaska-Cascadia	168.7131	54.2852	38.51	310.21	25.33
acsz-04b	Aleutian-Alaska-Cascadia	168.3269	54.0168	24.00	310.21	5.00
acsz-05a	Aleutian-Alaska-Cascadia	169.7447	53.7808	37.02	302.77	23.54
acsz-05b	Aleutian-Alaska-Cascadia	169.4185	53.4793	21.77	302.77	5.00
acsz-06a	Aleutian-Alaska-Cascadia	171.0144	53.3054	35.31	303.16	22.92
acsz-06b	Aleutian-Alaska-Cascadia	170.6813	52.9986	21.00	303.16	5.00
acsz-07a	Aleutian-Alaska-Cascadia	172.1500	52.8528	35.56	298.16	20.16
acsz-07b	Aleutian-Alaska-Cascadia	171.8665	52.5307	17.65	298.16	5.00
acsz-08a	Aleutian-Alaska-Cascadia	173.2726	52.4579	37.92	290.75	20.35
acsz-08b	Aleutian-Alaska-Cascadia	173.0681	52.1266	17.88	290.75	5.00
acsz-09a	Aleutian-Alaska-Cascadia	174.5866	52.1434	39.09	289.03	21.05
acsz-09b	Aleutian-Alaska-Cascadia	174.4027	51.8138	18.73	289.03	5.00
acsz-10a	Aleutian-Alaska-Cascadia	175.8784	51.8526	40.51	286.07	20.87
acsz-10b	Aleutian-Alaska-Cascadia	175.7265	51.5245	18.51	286.07	5.00
acsz-11a	Aleutian-Alaska-Cascadia	177.1140	51.6488	15.00	280.00	17.94
acsz-11b	Aleutian-Alaska-Cascadia	176.9937	51.2215	15.00	280.00	5.00
acsz-12a	Aleutian-Alaska-Cascadia	178.4500	51.5690	15.00	273.00	17.94
acsz-12b	Aleutian-Alaska-Cascadia	178.4130	51.1200	15.00	273.00	5.00
acsz-13a	Aleutian-Alaska-Cascadia	179.8550	51.5340	15.00	271.00	17.94
acsz-13b	Aleutian-Alaska-Cascadia	179.8420	51.0850	15.00	271.00	5.00
acsz-14a	Aleutian-Alaska-Cascadia	181.2340	51.5780	15.00	267.00	17.94
acsz-14b	Aleutian-Alaska-Cascadia	181.2720	51.1290	15.00	267.00	5.00
acsz-15a	Aleutian-Alaska-Cascadia	182.6380	51.6470	15.00	265.00	17.94
acsz-15b	Aleutian-Alaska-Cascadia	182.7000	51.2000	15.00	265.00	5.00
acsz-16a	Aleutian-Alaska-Cascadia	184.0550	51.7250	15.00	264.00	17.94
acsz-16b	Aleutian-Alaska-Cascadia	184.1280	51.2780	15.00	264.00	5.00
acsz-17a	Aleutian-Alaska-Cascadia	185.4560	51.8170	15.00	262.00	17.94
acsz-17b	Aleutian-Alaska-Cascadia	185.5560	51.3720	15.00	262.00	5.00

Table B.1. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-18a	Aleutian-Alaska-Cascadia	186.8680	51.9410	15.00	261.00	17.94
acsz-18b	Aleutian-Alaska-Cascadia	186.9810	51.4970	15.00	261.00	5.00
acsz-19a	Aleutian-Alaska-Cascadia	188.2430	52.1280	15.00	257.00	17.94
acsz-19b	Aleutian-Alaska-Cascadia	188.4060	51.6900	15.00	257.00	5.00
acsz-20a	Aleutian-Alaska-Cascadia	189.5810	52.3550	15.00	251.00	17.94
acsz-20b	Aleutian-Alaska-Cascadia	189.8180	51.9300	15.00	251.00	5.00
acsz-21a	Aleutian-Alaska-Cascadia	190.9570	52.6470	15.00	251.00	17.94
acsz-21b	Aleutian-Alaska-Cascadia	191.1960	52.2220	15.00	251.00	5.00
acsz-21z	Aleutian-Alaska-Cascadia	190.7399	53.0443	15.00	250.79	30.88
acsz-22a	Aleutian-Alaska-Cascadia	192.2940	52.9430	15.00	247.00	17.94
acsz-22b	Aleutian-Alaska-Cascadia	192.5820	52.5300	15.00	247.00	5.00
acsz-22z	Aleutian-Alaska-Cascadia	192.0074	53.3347	15.00	247.82	30.88
acsz-23a	Aleutian-Alaska-Cascadia	193.6270	53.3070	15.00	245.00	17.94
acsz-23b	Aleutian-Alaska-Cascadia	193.9410	52.9000	15.00	245.00	5.00
acsz-23z	Aleutian-Alaska-Cascadia	193.2991	53.6768	15.00	244.58	30.88
acsz-24a	Aleutian-Alaska-Cascadia	194.9740	53.6870	15.00	245.00	17.94
acsz-24b	Aleutian-Alaska-Cascadia	195.2910	53.2800	15.00	245.00	5.00
acsz-24y	Aleutian-Alaska-Cascadia	194.3645	54.4604	15.00	244.38	43.82
acsz-24z	Aleutian-Alaska-Cascadia	194.6793	54.0674	15.00	244.64	30.88
acsz-25a	Aleutian-Alaska-Cascadia	196.4340	54.0760	15.00	250.00	17.94
acsz-25b	Aleutian-Alaska-Cascadia	196.6930	53.6543	15.00	250.00	5.00
acsz-25y	Aleutian-Alaska-Cascadia	195.9009	54.8572	15.00	247.90	43.82
acsz-25z	Aleutian-Alaska-Cascadia	196.1761	54.4536	15.00	248.12	30.88
acsz-26a	Aleutian-Alaska-Cascadia	197.8970	54.3600	15.00	253.00	17.94
acsz-26b	Aleutian-Alaska-Cascadia	198.1200	53.9300	15.00	253.00	5.00
acsz-26y	Aleutian-Alaska-Cascadia	197.5498	55.1934	15.00	253.11	43.82
acsz-26z	Aleutian-Alaska-Cascadia	197.7620	54.7770	15.00	253.28	30.88
acsz-27a	Aleutian-Alaska-Cascadia	199.4340	54.5960	15.00	256.00	17.94
acsz-27b	Aleutian-Alaska-Cascadia	199.6200	54.1600	15.00	256.00	5.00
acsz-27x	Aleutian-Alaska-Cascadia	198.9736	55.8631	15.00	256.47	56.24
acsz-27y	Aleutian-Alaska-Cascadia	199.1454	55.4401	15.00	256.62	43.82
acsz-27z	Aleutian-Alaska-Cascadia	199.3135	55.0170	15.00	256.76	30.88
acsz-28a	Aleutian-Alaska-Cascadia	200.8820	54.8300	15.00	253.00	17.94
acsz-28b	Aleutian-Alaska-Cascadia	201.1080	54.4000	15.00	253.00	5.00

Table B.1. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-28x	Aleutian-Alaska-Cascadia	200.1929	56.0559	15.00	252.55	56.24
acsz-28y	Aleutian-Alaska-Cascadia	200.4167	55.6406	15.00	252.74	43.82
acsz-28z	Aleutian-Alaska-Cascadia	200.6360	55.2249	15.00	252.92	30.88
acsz-29a	Aleutian-Alaska-Cascadia	202.2610	55.1330	15.00	247.00	17.94
acsz-29b	Aleutian-Alaska-Cascadia	202.5650	54.7200	15.00	247.00	5.00
acsz-29x	Aleutian-Alaska-Cascadia	201.2606	56.2861	15.00	245.70	56.24
acsz-29y	Aleutian-Alaska-Cascadia	201.5733	55.8888	15.00	245.96	43.82
acsz-29z	Aleutian-Alaska-Cascadia	201.8797	55.4908	15.00	246.21	30.88
acsz-30a	Aleutian-Alaska-Cascadia	203.6040	55.5090	15.00	240.00	17.94
acsz-30b	Aleutian-Alaska-Cascadia	203.9970	55.1200	15.00	240.00	5.00
acsz-30w	Aleutian-Alaska-Cascadia	201.9901	56.9855	15.00	239.52	69.12
acsz-30x	Aleutian-Alaska-Cascadia	202.3851	56.6094	15.00	239.85	56.24
acsz-30y	Aleutian-Alaska-Cascadia	202.7724	56.2320	15.00	240.17	43.82
acsz-30z	Aleutian-Alaska-Cascadia	203.1521	55.8534	15.00	240.49	30.88
acsz-31a	Aleutian-Alaska-Cascadia	204.8950	55.9700	15.00	236.00	17.94
acsz-31b	Aleutian-Alaska-Cascadia	205.3400	55.5980	15.00	236.00	5.00
acsz-31w	Aleutian-Alaska-Cascadia	203.0825	57.3740	15.00	234.54	69.12
acsz-31x	Aleutian-Alaska-Cascadia	203.5408	57.0182	15.00	234.93	56.24
acsz-31y	Aleutian-Alaska-Cascadia	203.9904	56.6607	15.00	235.30	43.82
acsz-31z	Aleutian-Alaska-Cascadia	204.4315	56.3016	15.00	235.67	30.88
acsz-32a	Aleutian-Alaska-Cascadia	206.2080	56.4730	15.00	236.00	17.94
acsz-32b	Aleutian-Alaska-Cascadia	206.6580	56.1000	15.00	236.00	5.00
acsz-32w	Aleutian-Alaska-Cascadia	204.4129	57.8908	15.00	234.32	69.12
acsz-32x	Aleutian-Alaska-Cascadia	204.8802	57.5358	15.00	234.72	56.24
acsz-32y	Aleutian-Alaska-Cascadia	205.3385	57.1792	15.00	235.10	43.82
acsz-32z	Aleutian-Alaska-Cascadia	205.7880	56.8210	15.00	235.48	30.88
acsz-33a	Aleutian-Alaska-Cascadia	207.5370	56.9750	15.00	236.00	17.94
acsz-33b	Aleutian-Alaska-Cascadia	207.9930	56.6030	15.00	236.00	5.00
acsz-33w	Aleutian-Alaska-Cascadia	205.7126	58.3917	15.00	234.24	69.12
acsz-33x	Aleutian-Alaska-Cascadia	206.1873	58.0371	15.00	234.64	56.24
acsz-33y	Aleutian-Alaska-Cascadia	206.6527	57.6808	15.00	235.03	43.82
acsz-33z	Aleutian-Alaska-Cascadia	207.1091	57.3227	15.00	235.41	30.88
acsz-34a	Aleutian-Alaska-Cascadia	208.9371	57.5124	15.00	236.00	17.94
acsz-34b	Aleutian-Alaska-Cascadia	209.4000	57.1400	15.00	236.00	5.00

Table B.1. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-34w	Aleutian-Alaska-Cascadia	206.9772	58.8804	15.00	233.47	69.12
acsz-34x	Aleutian-Alaska-Cascadia	207.4677	58.5291	15.00	233.88	56.24
acsz-34y	Aleutian-Alaska-Cascadia	207.9485	58.1760	15.00	234.29	43.82
acsz-34z	Aleutian-Alaska-Cascadia	208.4198	57.8213	15.00	234.69	30.88
acsz-35a	Aleutian-Alaska-Cascadia	210.2597	58.0441	15.00	230.00	17.94
acsz-35b	Aleutian-Alaska-Cascadia	210.8000	57.7000	15.00	230.00	5.00
acsz-35w	Aleutian-Alaska-Cascadia	208.0204	59.3199	15.00	228.81	69.12
acsz-35x	Aleutian-Alaska-Cascadia	208.5715	58.9906	15.00	229.29	56.24
acsz-35y	Aleutian-Alaska-Cascadia	209.1122	58.6590	15.00	229.75	43.82
acsz-35z	Aleutian-Alaska-Cascadia	209.6425	58.3252	15.00	230.20	30.88
acsz-36a	Aleutian-Alaska-Cascadia	211.3249	58.6565	15.00	218.00	17.94
acsz-36b	Aleutian-Alaska-Cascadia	212.0000	58.3800	15.00	218.00	5.00
acsz-36w	Aleutian-Alaska-Cascadia	208.5003	59.5894	15.00	215.59	69.12
acsz-36x	Aleutian-Alaska-Cascadia	209.1909	59.3342	15.00	216.18	56.24
acsz-36y	Aleutian-Alaska-Cascadia	209.8711	59.0753	15.00	216.76	43.82
acsz-36z	Aleutian-Alaska-Cascadia	210.5412	58.8129	15.00	217.33	30.88
acsz-37a	Aleutian-Alaska-Cascadia	212.2505	59.2720	15.00	213.71	17.94
acsz-37b	Aleutian-Alaska-Cascadia	212.9519	59.0312	15.00	213.71	5.00
acsz-37x	Aleutian-Alaska-Cascadia	210.1726	60.0644	15.00	213.04	56.24
acsz-37y	Aleutian-Alaska-Cascadia	210.8955	59.8251	15.00	213.66	43.82
acsz-37z	Aleutian-Alaska-Cascadia	211.6079	59.5820	15.00	214.27	30.88
acsz-38a	Aleutian-Alaska-Cascadia	214.6555	60.1351	0.00	260.08	15.00
acsz-38b	Aleutian-Alaska-Cascadia	214.8088	59.6927	0.00	260.08	15.00
acsz-38y	Aleutian-Alaska-Cascadia	214.3737	60.9838	0.00	259.03	15.00
acsz-38z	Aleutian-Alaska-Cascadia	214.5362	60.5429	0.00	259.03	15.00
acsz-39a	Aleutian-Alaska-Cascadia	216.5607	60.2480	0.00	267.04	15.00
acsz-39b	Aleutian-Alaska-Cascadia	216.6068	59.7994	0.00	267.04	15.00
acsz-40a	Aleutian-Alaska-Cascadia	219.3069	59.7574	0.00	310.91	15.00
acsz-40b	Aleutian-Alaska-Cascadia	218.7288	59.4180	0.00	310.91	15.00
acsz-41a	Aleutian-Alaska-Cascadia	220.4832	59.3390	0.00	300.73	15.00
acsz-41b	Aleutian-Alaska-Cascadia	220.0382	58.9529	0.00	300.73	15.00
acsz-42a	Aleutian-Alaska-Cascadia	221.8835	58.9310	0.00	298.94	15.00
acsz-42b	Aleutian-Alaska-Cascadia	221.4671	58.5379	0.00	298.94	15.00
acsz-43a	Aleutian-Alaska-Cascadia	222.9711	58.6934	0.00	282.34	15.00

Table B.1. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-43b	Aleutian-Alaska-Cascadia	222.7887	58.2546	0.00	282.34	15.00
acsz-44a	Aleutian-Alaska-Cascadia	224.9379	57.9054	12.00	340.91	11.09
acsz-44b	Aleutian-Alaska-Cascadia	224.1596	57.7617	7.00	340.91	5.00
acsz-45a	Aleutian-Alaska-Cascadia	225.4994	57.1634	12.00	334.15	11.09
acsz-45b	Aleutian-Alaska-Cascadia	224.7740	56.9718	7.00	334.15	5.00
acsz-46a	Aleutian-Alaska-Cascadia	226.1459	56.3552	12.00	334.15	11.09
acsz-46b	Aleutian-Alaska-Cascadia	225.4358	56.1636	7.00	334.15	5.00
acsz-47a	Aleutian-Alaska-Cascadia	226.7731	55.5830	12.00	332.26	11.09
acsz-47b	Aleutian-Alaska-Cascadia	226.0887	55.3785	7.00	332.26	5.00
acsz-48a	Aleutian-Alaska-Cascadia	227.4799	54.6763	12.00	339.40	11.09
acsz-48b	Aleutian-Alaska-Cascadia	226.7713	54.5217	7.00	339.40	5.00
acsz-49a	Aleutian-Alaska-Cascadia	227.9482	53.8155	12.00	341.17	11.09
acsz-49b	Aleutian-Alaska-Cascadia	227.2462	53.6737	7.00	341.17	5.00
acsz-50a	Aleutian-Alaska-Cascadia	228.3970	53.2509	12.00	324.51	11.09
acsz-50b	Aleutian-Alaska-Cascadia	227.8027	52.9958	7.00	324.51	5.00
acsz-51a	Aleutian-Alaska-Cascadia	229.1844	52.6297	12.00	318.36	11.09
acsz-51b	Aleutian-Alaska-Cascadia	228.6470	52.3378	7.00	318.36	5.00
acsz-52a	Aleutian-Alaska-Cascadia	230.0306	52.0768	12.00	310.85	11.09
acsz-52b	Aleutian-Alaska-Cascadia	229.5665	51.7445	7.00	310.85	5.00
acsz-53a	Aleutian-Alaska-Cascadia	231.1735	51.5258	12.00	310.85	11.09
acsz-53b	Aleutian-Alaska-Cascadia	230.7150	51.1935	7.00	310.85	5.00
acsz-54a	Aleutian-Alaska-Cascadia	232.2453	50.8809	12.00	314.11	11.09
acsz-54b	Aleutian-Alaska-Cascadia	231.7639	50.5655	7.00	314.11	5.00
acsz-55a	Aleutian-Alaska-Cascadia	233.3066	49.9032	12.00	333.71	11.09
acsz-55b	Aleutian-Alaska-Cascadia	232.6975	49.7086	7.00	333.71	5.00
acsz-56a	Aleutian-Alaska-Cascadia	234.0588	49.1702	11.00	315.00	12.82
acsz-56b	Aleutian-Alaska-Cascadia	233.5849	48.8584	9.00	315.00	5.00
acsz-57a	Aleutian-Alaska-Cascadia	234.9041	48.2596	11.00	341.00	12.82
acsz-57b	Aleutian-Alaska-Cascadia	234.2797	48.1161	9.00	341.00	5.00
acsz-58a	Aleutian-Alaska-Cascadia	235.3021	47.3812	11.00	344.00	12.82
acsz-58b	Aleutian-Alaska-Cascadia	234.6776	47.2597	9.00	344.00	5.00
acsz-59a	Aleutian-Alaska-Cascadia	235.6432	46.5082	11.00	345.00	12.82
acsz-59b	Aleutian-Alaska-Cascadia	235.0257	46.3941	9.00	345.00	5.00
acsz-60a	Aleutian-Alaska-Cascadia	235.8640	45.5429	11.00	356.00	12.82

Table B.1. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
acsz-60b	Aleutian-Alaska-Cascadia	235.2363	45.5122	9.00	356.00	5.00
acsz-61a	Aleutian-Alaska-Cascadia	235.9106	44.6227	11.00	359.00	12.82
acsz-61b	Aleutian-Alaska-Cascadia	235.2913	44.6150	9.00	359.00	5.00
acsz-62a	Aleutian-Alaska-Cascadia	235.9229	43.7245	11.00	359.00	12.82
acsz-62b	Aleutian-Alaska-Cascadia	235.3130	43.7168	9.00	359.00	5.00
acsz-63a	Aleutian-Alaska-Cascadia	236.0220	42.9020	11.00	350.00	12.82
acsz-63b	Aleutian-Alaska-Cascadia	235.4300	42.8254	9.00	350.00	5.00
acsz-64a	Aleutian-Alaska-Cascadia	235.9638	41.9818	11.00	345.00	12.82
acsz-64b	Aleutian-Alaska-Cascadia	235.3919	41.8677	9.00	345.00	5.00
acsz-65a	Aleutian-Alaska-Cascadia	236.2643	41.1141	11.00	345.00	12.82
acsz-65b	Aleutian-Alaska-Cascadia	235.7000	41.0000	9.00	345.00	5.00
acsz-238a	Aleutian-Alaska-Cascadia	213.2878	59.8406	15.00	236.83	17.94
acsz-238y	Aleutian-Alaska-Cascadia	212.3424	60.5664	15.00	236.83	43.82
acsz-238z	Aleutian-Alaska-Cascadia	212.8119	60.2035	15.00	236.83	30.88
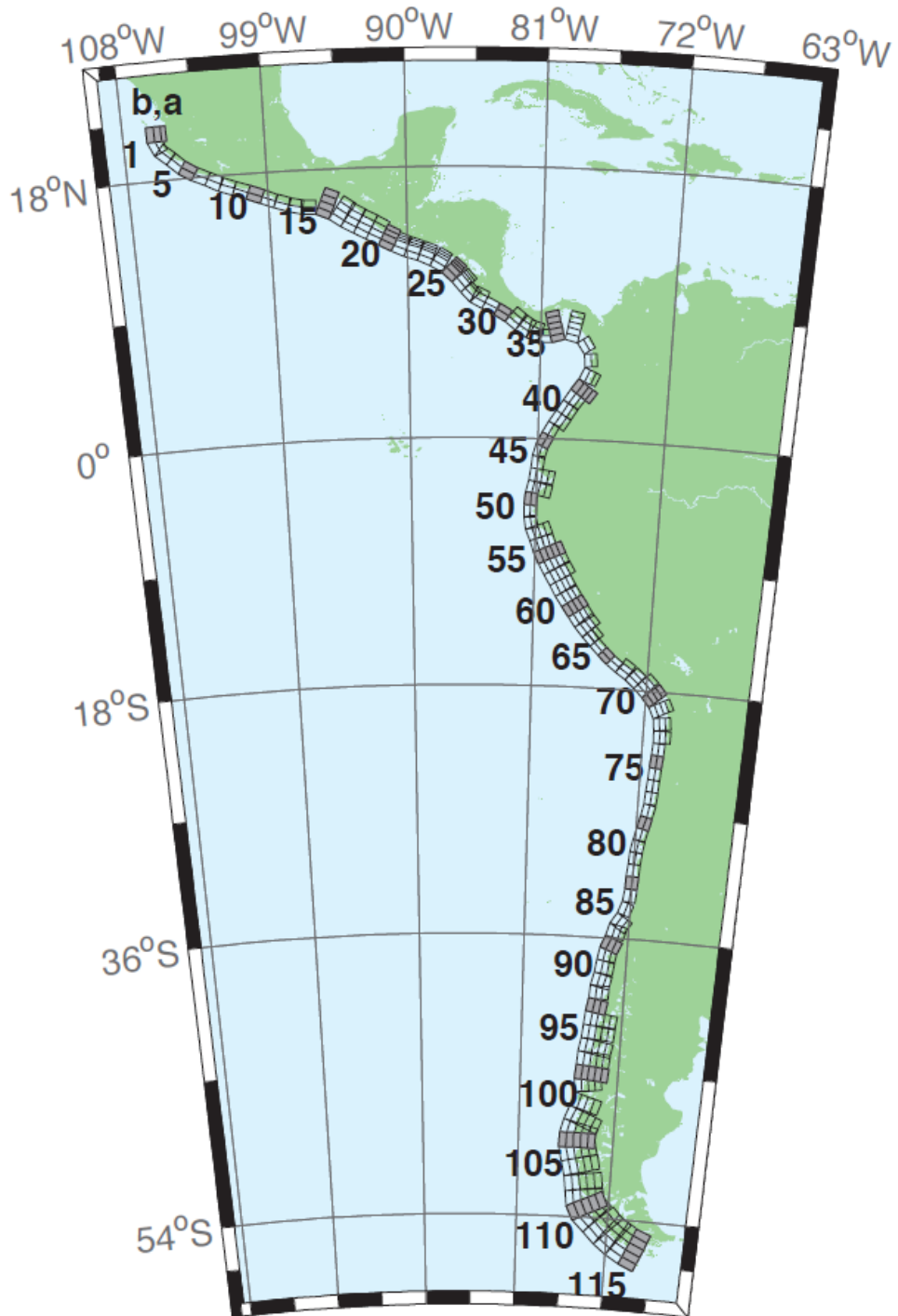
Figure B.2. Central and South America Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-01a	Central and South America	254.4573	20.8170	19.00	358.97	15.40
cssz-01b	Central and South America	254.0035	20.8094	12.00	358.97	5.00
cssz-01z	Central and South America	254.7664	20.8222	50.00	358.97	31.67
cssz-02a	Central and South America	254.5765	20.2806	19.00	336.76	15.40
cssz-02b	Central and South America	254.1607	20.1130	12.00	336.76	5.00
cssz-03a	Central and South America	254.8789	19.8923	18.31	310.60	15.27
cssz-03b	Central and South America	254.5841	19.5685	11.85	310.60	5.00
cssz-04a	Central and South America	255.6167	19.2649	17.62	313.37	15.12
cssz-04b	Central and South America	255.3056	18.9537	11.68	313.37	5.00
cssz-05a	Central and South America	256.2240	18.8148	16.92	302.70	15.00
cssz-05b	Central and South America	255.9790	18.4532	11.54	302.70	5.00
cssz-06a	Central and South America	256.9425	18.4383	16.23	295.15	14.87
cssz-06b	Central and South America	256.7495	18.0479	11.38	295.15	5.00
cssz-07a	Central and South America	257.8137	18.0339	15.54	296.91	14.74
cssz-07b	Central and South America	257.6079	17.6480	11.23	296.91	5.00
cssz-08a	Central and South America	258.5779	17.7151	14.85	290.42	14.61
cssz-08b	Central and South America	258.4191	17.3082	11.08	290.42	5.00
cssz-09a	Central and South America	259.4578	17.4024	14.15	290.48	14.47
cssz-09b	Central and South America	259.2983	16.9944	10.92	290.48	5.00
cssz-10a	Central and South America	260.3385	17.0861	13.46	290.75	14.34
cssz-10b	Central and South America	260.1768	16.6776	10.77	290.75	5.00
cssz-11a	Central and South America	261.2255	16.7554	12.77	291.82	14.21
cssz-11b	Central and South America	261.0556	16.3487	10.62	291.82	5.00
cssz-12a	Central and South America	262.0561	16.4603	12.08	288.86	14.08
cssz-12b	Central and South America	261.9082	16.0447	10.46	288.86	5.00
cssz-13a	Central and South America	262.8638	16.2381	11.38	283.18	13.95
cssz-13b	Central and South America	262.7593	15.8094	10.31	283.18	5.00
cssz-14a	Central and South America	263.6066	16.1435	10.69	272.06	13.81
cssz-14b	Central and South America	263.5901	15.7024	10.15	272.06	5.00
cssz-15a	Central and South America	264.8259	15.8829	10.00	293.03	13.68
cssz-15b	Central and South America	264.6462	15.4758	10.00	293.03	5.00
cssz-15y	Central and South America	265.1865	16.6971	10.00	293.03	31.05
cssz-15z	Central and South America	265.0060	16.2900	10.00	293.03	22.36

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-16a	Central and South America	265.7928	15.3507	15.00	304.95	15.82
cssz-16b	Central and South America	265.5353	14.9951	12.50	304.95	5.00
cssz-16y	Central and South America	266.3092	16.0619	15.00	304.95	41.70
cssz-16z	Central and South America	266.0508	15.7063	15.00	304.95	28.76
cssz-17a	Central and South America	266.4947	14.9019	20.00	299.52	17.94
cssz-17b	Central and South America	266.2797	14.5346	15.00	299.52	5.00
cssz-17y	Central and South America	266.9259	15.6365	20.00	299.52	52.14
cssz-17z	Central and South America	266.7101	15.2692	20.00	299.52	35.04
cssz-18a	Central and South America	267.2827	14.4768	21.50	298.01	17.94
cssz-18b	Central and South America	267.0802	14.1078	15.00	298.01	5.00
cssz-18y	Central and South America	267.6888	15.2148	21.50	298.01	54.59
cssz-18z	Central and South America	267.4856	14.8458	21.50	298.01	36.27
cssz-19a	Central and South America	268.0919	14.0560	23.00	297.64	17.94
cssz-19b	Central and South America	267.8943	13.6897	15.00	297.64	5.00
cssz-19y	Central and South America	268.4880	14.7886	23.00	297.64	57.01
cssz-19z	Central and South America	268.2898	14.4223	23.00	297.64	37.48
cssz-20a	Central and South America	268.8929	13.6558	24.00	296.23	17.94
cssz-20b	Central and South America	268.7064	13.2877	15.00	296.23	5.00
cssz-20y	Central and South America	269.1796	14.2206	45.50	296.23	73.94
cssz-20z	Central and South America	269.0362	13.9382	45.50	296.23	38.28
cssz-21a	Central and South America	269.6797	13.3031	25.00	292.65	17.94
cssz-21b	Central and South America	269.5187	12.9274	15.00	292.65	5.00
cssz-21x	Central and South America	269.8797	13.7690	68.00	292.65	131.79
cssz-21y	Central and South America	269.8130	13.6137	68.00	292.65	85.43
cssz-21z	Central and South America	269.7463	13.4584	68.00	292.65	39.07
cssz-22a	Central and South America	270.4823	13.0079	25.00	288.59	17.94
cssz-22b	Central and South America	270.3492	12.6221	15.00	288.59	5.00
cssz-22x	Central and South America	270.6476	13.4864	68.00	288.59	131.79
cssz-22y	Central and South America	270.5925	13.3269	68.00	288.59	85.43
cssz-22z	Central and South America	270.5374	13.1674	68.00	288.59	39.07
cssz-23a	Central and South America	271.3961	12.6734	25.00	292.45	17.94
cssz-23b	Central and South America	271.2369	12.2972	15.00	292.45	5.00
cssz-23x	Central and South America	271.5938	13.1399	68.00	292.45	131.79

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-23y	Central and South America	271.5279	12.9844	68.00	292.45	85.43
cssz-23z	Central and South America	271.4620	12.8289	68.00	292.45	39.07
cssz-24a	Central and South America	272.3203	12.2251	25.00	300.23	17.94
cssz-24b	Central and South America	272.1107	11.8734	15.00	300.23	5.00
cssz-24x	Central and South America	272.5917	12.6799	67.00	300.23	131.12
cssz-24y	Central and South America	272.5012	12.5283	67.00	300.23	85.10
cssz-24z	Central and South America	272.4107	12.3767	67.00	300.23	39.07
cssz-25a	Central and South America	273.2075	11.5684	25.00	313.80	17.94
cssz-25b	Central and South America	272.9200	11.2746	15.00	313.80	5.00
cssz-25x	Central and South America	273.5950	11.9641	66.00	313.80	130.43
cssz-25y	Central and South America	273.4658	11.8322	66.00	313.80	84.75
cssz-25z	Central and South America	273.3366	11.7003	66.00	313.80	39.07
cssz-26a	Central and South America	273.8943	10.8402	25.00	320.42	17.94
cssz-26b	Central and South America	273.5750	10.5808	15.00	320.42	5.00
cssz-26x	Central and South America	274.3246	11.1894	66.00	320.42	130.43
cssz-26y	Central and South America	274.1811	11.0730	66.00	320.42	84.75
cssz-26z	Central and South America	274.0377	10.9566	66.00	320.42	39.07
cssz-27a	Central and South America	274.4569	10.2177	25.00	316.10	17.94
cssz-27b	Central and South America	274.1590	9.9354	15.00	316.10	5.00
cssz-27z	Central and South America	274.5907	10.3444	66.00	316.10	39.07
cssz-28a	Central and South America	274.9586	9.8695	22.00	297.10	14.54
cssz-28b	Central and South America	274.7661	9.4988	11.00	297.10	5.00
cssz-28z	Central and South America	275.1118	10.1643	42.50	297.10	33.27
cssz-29a	Central and South America	275.7686	9.4789	19.00	296.60	11.09
cssz-29b	Central and South America	275.5759	9.0992	7.00	296.60	5.00
cssz-30a	Central and South America	276.6346	8.9973	19.00	302.25	9.36
cssz-30b	Central and South America	276.4053	8.6381	5.00	302.25	5.00
cssz-31a	Central and South America	277.4554	8.4152	19.00	309.05	7.62
cssz-31b	Central and South America	277.1851	8.0854	3.00	309.05	5.00
cssz-31z	Central and South America	277.7260	8.7450	19.00	309.05	23.90
cssz-32a	Central and South America	278.1112	7.9425	18.67	302.97	8.49
cssz-32b	Central and South America	277.8775	7.5855	4.00	302.97	5.00
cssz-32z	Central and South America	278.3407	8.2927	21.67	302.97	24.49

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-33a	Central and South America	278.7082	7.6620	18.33	287.56	10.23
cssz-33b	Central and South America	278.5785	7.2555	6.00	287.56	5.00
cssz-33z	Central and South America	278.8328	8.0522	24.33	287.56	25.95
cssz-34a	Central and South America	279.3184	7.5592	18.00	269.48	17.94
cssz-34b	Central and South America	279.3223	7.1320	15.00	269.48	5.00
cssz-35a	Central and South America	280.0039	7.6543	17.67	255.90	14.54
cssz-35b	Central and South America	280.1090	7.2392	11.00	255.90	5.00
cssz-35x	Central and South America	279.7156	8.7898	29.67	255.90	79.22
cssz-35y	Central and South America	279.8118	8.4113	29.67	255.90	54.47
cssz-35z	Central and South America	279.9079	8.0328	29.67	255.90	29.72
cssz-36a	Central and South America	281.2882	7.6778	17.33	282.48	11.09
cssz-36b	Central and South America	281.1948	7.2592	7.00	282.48	5.00
cssz-36x	Central and South America	281.5368	8.7896	32.33	282.48	79.47
cssz-36y	Central and South America	281.4539	8.4190	32.33	282.48	52.73
cssz-36z	Central and South America	281.3710	8.0484	32.33	282.48	25.99
cssz-37a	Central and South America	282.5252	6.8289	17.00	326.91	10.23
cssz-37b	Central and South America	282.1629	6.5944	6.00	326.91	5.00
cssz-38a	Central and South America	282.9469	5.5973	17.00	355.37	10.23
cssz-38b	Central and South America	282.5167	5.5626	6.00	355.37	5.00
cssz-39a	Central and South America	282.7236	4.3108	17.00	24.13	10.23
cssz-39b	Central and South America	282.3305	4.4864	6.00	24.13	5.00
cssz-39z	Central and South America	283.0603	4.1604	35.00	24.13	24.85
cssz-40a	Central and South America	282.1940	3.3863	17.00	35.28	10.23
cssz-40b	Central and South America	281.8427	3.6344	6.00	35.28	5.00
cssz-40y	Central and South America	282.7956	2.9613	35.00	35.28	53.52
cssz-40z	Central and South America	282.4948	3.1738	35.00	35.28	24.85
cssz-41a	Central and South America	281.6890	2.6611	17.00	34.27	10.23
cssz-41b	Central and South America	281.3336	2.9030	6.00	34.27	5.00
cssz-41z	Central and South America	281.9933	2.4539	35.00	34.27	24.85
cssz-42a	Central and South America	281.2266	1.9444	17.00	31.29	10.23
cssz-42b	Central and South America	280.8593	2.1675	6.00	31.29	5.00
cssz-42z	Central and South America	281.5411	1.7533	35.00	31.29	24.85
cssz-43a	Central and South America	280.7297	1.1593	17.00	33.30	10.23

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-43b	Central and South America	280.3706	1.3951	6.00	33.30	5.00
cssz-43z	Central and South America	281.0373	0.9573	35.00	33.30	24.85
cssz-44a	Central and South America	280.3018	0.4491	17.00	28.80	10.23
cssz-44b	Central and South America	279.9254	0.6560	6.00	28.80	5.00
cssz-45a	Central and South America	279.9083	-0.3259	10.00	26.91	8.49
cssz-45b	Central and South America	279.5139	-0.1257	4.00	26.91	5.00
cssz-46a	Central and South America	279.6461	-0.9975	10.00	15.76	8.49
cssz-46b	Central and South America	279.2203	-0.8774	4.00	15.76	5.00
cssz-47a	Central and South America	279.4972	-1.7407	10.00	6.90	8.49
cssz-47b	Central and South America	279.0579	-1.6876	4.00	6.90	5.00
cssz-48a	Central and South America	279.3695	-2.6622	10.00	8.96	8.49
cssz-48b	Central and South America	278.9321	-2.5933	4.00	8.96	5.00
cssz-48y	Central and South America	280.2444	-2.8000	10.00	8.96	25.85
cssz-48z	Central and South America	279.8070	-2.7311	10.00	8.96	17.17
cssz-49a	Central and South America	279.1852	-3.6070	10.00	13.15	8.49
cssz-49b	Central and South America	278.7536	-3.5064	4.00	13.15	5.00
cssz-49y	Central and South America	280.0486	-3.8082	10.00	13.15	25.85
cssz-49z	Central and South America	279.6169	-3.7076	10.00	13.15	17.17
cssz-50a	Central and South America	279.0652	-4.3635	10.33	4.78	9.64
cssz-50b	Central and South America	278.6235	-4.3267	5.33	4.78	5.00
cssz-51a	Central and South America	279.0349	-5.1773	10.67	359.43	10.81
cssz-51b	Central and South America	278.5915	-5.1817	6.67	359.43	5.00
cssz-52a	Central and South America	279.1047	-5.9196	11.00	349.75	11.96
cssz-52b	Central and South America	278.6685	-5.9981	8.00	349.75	5.00
cssz-53a	Central and South America	279.3044	-6.6242	10.25	339.21	11.74
cssz-53b	Central and South America	278.8884	-6.7811	7.75	339.21	5.00
cssz-53y	Central and South America	280.1024	-6.3232	19.25	339.21	37.12
cssz-53z	Central and South America	279.7035	-6.4737	19.25	339.21	20.64
cssz-54a	Central and South America	279.6256	-7.4907	9.50	340.78	11.53
cssz-54b	Central and South America	279.2036	-7.6365	7.50	340.78	5.00
cssz-54y	Central and South America	280.4267	-7.2137	20.50	340.78	37.29
cssz-54z	Central and South America	280.0262	-7.3522	20.50	340.78	19.78
cssz-55a	Central and South America	279.9348	-8.2452	8.75	335.38	11.74

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-55b	Central and South America	279.5269	-8.4301	7.75	335.38	5.00
cssz-55x	Central and South America	281.0837	-7.7238	21.75	335.38	56.40
cssz-55y	Central and South America	280.7009	-7.8976	21.75	335.38	37.88
cssz-55z	Central and South America	280.3180	-8.0714	21.75	335.38	19.35
cssz-56a	Central and South America	280.3172	-8.9958	8.00	331.62	11.09
cssz-56b	Central and South America	279.9209	-9.2072	7.00	331.62	5.00
cssz-56x	Central and South America	281.4212	-8.4063	23.00	331.62	57.13
cssz-56y	Central and South America	281.0534	-8.6028	23.00	331.62	37.59
cssz-56z	Central and South America	280.6854	-8.7993	23.00	331.62	18.05
cssz-57a	Central and South America	280.7492	-9.7356	8.60	328.71	10.75
cssz-57b	Central and South America	280.3640	-9.9663	6.60	328.71	5.00
cssz-57x	Central and South America	281.8205	-9.0933	23.40	328.71	57.94
cssz-57y	Central and South America	281.4636	-9.3074	23.40	328.71	38.08
cssz-57z	Central and South America	281.1065	-9.5215	23.40	328.71	18.22
cssz-58a	Central and South America	281.2275	-10.5350	9.20	330.52	10.40
cssz-58b	Central and South America	280.8348	-10.7532	6.20	330.52	5.00
cssz-58y	Central and South America	281.9548	-10.1306	23.80	330.52	38.57
cssz-58z	Central and South America	281.5913	-10.3328	23.80	330.52	18.39
cssz-59a	Central and South America	281.6735	-11.2430	9.80	326.24	10.05
cssz-59b	Central and South America	281.2982	-11.4890	5.80	326.24	5.00
cssz-59y	Central and South America	282.3675	-10.7876	24.20	326.24	39.06
cssz-59z	Central and South America	282.0206	-11.0153	24.20	326.24	18.56
cssz-60a	Central and South America	282.1864	-11.9946	10.40	326.50	9.71
cssz-60b	Central and South America	281.8096	-12.2384	5.40	326.50	5.00
cssz-60y	Central and South America	282.8821	-11.5438	24.60	326.50	39.55
cssz-60z	Central and South America	282.5344	-11.7692	24.60	326.50	18.73
cssz-61a	Central and South America	282.6944	-12.7263	11.00	325.47	9.36
cssz-61b	Central and South America	282.3218	-12.9762	5.00	325.47	5.00
cssz-61y	Central and South America	283.3814	-12.2649	25.00	325.47	40.03
cssz-61z	Central and South America	283.0381	-12.4956	25.00	325.47	18.90
cssz-62a	Central and South America	283.1980	-13.3556	11.00	318.96	9.79
cssz-62b	Central and South America	282.8560	-13.6451	5.50	318.96	5.00
cssz-62y	Central and South America	283.8178	-12.8300	27.00	318.96	42.03

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-62z	Central and South America	283.5081	-13.0928	27.00	318.96	19.33
cssz-63a	Central and South America	283.8032	-14.0147	11.00	317.85	10.23
cssz-63b	Central and South America	283.4661	-14.3106	6.00	317.85	5.00
cssz-63z	Central and South America	284.1032	-13.7511	29.00	317.85	19.77
cssz-64a	Central and South America	284.4144	-14.6482	13.00	315.68	11.96
cssz-64b	Central and South America	284.0905	-14.9540	8.00	315.68	5.00
cssz-65a	Central and South America	285.0493	-15.2554	15.00	313.23	13.68
cssz-65b	Central and South America	284.7411	-15.5715	10.00	313.23	5.00
cssz-66a	Central and South America	285.6954	-15.7816	14.50	307.67	13.68
cssz-66b	Central and South America	285.4190	-16.1258	10.00	307.67	5.00
cssz-67a	Central and South America	286.4127	-16.2781	14.00	304.30	13.68
cssz-67b	Central and South America	286.1566	-16.6381	10.00	304.30	5.00
cssz-67z	Central and South America	286.6552	-15.9365	23.00	304.30	25.78
cssz-68a	Central and South America	287.2481	-16.9016	14.00	311.81	13.68
cssz-68b	Central and South America	286.9442	-17.2264	10.00	311.81	5.00
cssz-68z	Central and South America	287.5291	-16.6007	26.00	311.81	25.78
cssz-69a	Central and South America	287.9724	-17.5502	14.00	314.88	13.68
cssz-69b	Central and South America	287.6496	-17.8590	10.00	314.88	5.00
cssz-69y	Central and South America	288.5530	-16.9934	29.00	314.88	50.02
cssz-69z	Central and South America	288.2629	-17.2718	29.00	314.88	25.78
cssz-70a	Central and South America	288.6731	-18.2747	14.00	320.37	13.25
cssz-70b	Central and South America	288.3193	-18.5527	9.50	320.37	5.00
cssz-70y	Central and South America	289.3032	-17.7785	30.00	320.37	50.35
cssz-70z	Central and South America	288.9884	-18.0266	30.00	320.37	25.35
cssz-71a	Central and South America	289.3089	-19.1854	14.00	333.19	12.82
cssz-71b	Central and South America	288.8968	-19.3820	9.00	333.19	5.00
cssz-71y	Central and South America	290.0357	-18.8382	31.00	333.19	50.67
cssz-71z	Central and South America	289.6725	-19.0118	31.00	333.19	24.92
cssz-72a	Central and South America	289.6857	-20.3117	14.00	352.39	12.54
cssz-72b	Central and South America	289.2250	-20.3694	8.67	352.39	5.00
cssz-72z	Central and South America	290.0882	-20.2613	32.00	352.39	24.63
cssz-73a	Central and South America	289.7731	-21.3061	14.00	358.94	12.24
cssz-73b	Central and South America	289.3053	-21.3142	8.33	358.94	5.00

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-73z	Central and South America	290.1768	-21.2991	33.00	358.94	24.34
cssz-74a	Central and South America	289.7610	-22.2671	14.00	3.06	11.96
cssz-74b	Central and South America	289.2909	-22.2438	8.00	3.06	5.00
cssz-75a	Central and South America	289.6982	-23.1903	14.09	4.83	11.96
cssz-75b	Central and South America	289.2261	-23.1536	8.00	4.83	5.00
cssz-76a	Central and South America	289.6237	-24.0831	14.18	4.67	11.96
cssz-76b	Central and South America	289.1484	-24.0476	8.00	4.67	5.00
cssz-77a	Central and South America	289.5538	-24.9729	14.27	4.30	11.96
cssz-77b	Central and South America	289.0750	-24.9403	8.00	4.30	5.00
cssz-78a	Central and South America	289.4904	-25.8621	14.36	3.86	11.96
cssz-78b	Central and South America	289.0081	-25.8328	8.00	3.86	5.00
cssz-79a	Central and South America	289.3491	-26.8644	14.45	11.34	11.96
cssz-79b	Central and South America	288.8712	-26.7789	8.00	11.34	5.00
cssz-80a	Central and South America	289.1231	-27.7826	14.54	14.16	11.96
cssz-80b	Central and South America	288.6469	-27.6762	8.00	14.16	5.00
cssz-81a	Central and South America	288.8943	-28.6409	14.63	13.19	11.96
cssz-81b	Central and South America	288.4124	-28.5417	8.00	13.19	5.00
cssz-82a	Central and South America	288.7113	-29.4680	14.72	9.68	11.96
cssz-82b	Central and South America	288.2196	-29.3950	8.00	9.68	5.00
cssz-83a	Central and South America	288.5944	-30.2923	14.81	5.36	11.96
cssz-83b	Central and South America	288.0938	-30.2517	8.00	5.36	5.00
cssz-84a	Central and South America	288.5223	-31.1639	14.90	3.80	11.96
cssz-84b	Central and South America	288.0163	-31.1351	8.00	3.80	5.00
cssz-85a	Central and South America	288.4748	-32.0416	15.00	2.55	11.96
cssz-85b	Central and South America	287.9635	-32.0223	8.00	2.55	5.00
cssz-86a	Central and South America	288.3901	-33.0041	15.00	7.01	11.96
cssz-86b	Central and South America	287.8768	-32.9512	8.00	7.01	5.00
cssz-87a	Central and South America	288.1050	-34.0583	15.00	19.40	11.96
cssz-87b	Central and South America	287.6115	-33.9142	8.00	19.40	5.00
cssz-88a	Central and South America	287.5309	-35.0437	15.00	32.81	11.96
cssz-88b	Central and South America	287.0862	-34.8086	8.00	32.81	5.00
cssz-88z	Central and South America	287.9308	-35.2545	30.00	32.81	24.90
cssz-89a	Central and South America	287.2380	-35.5993	16.67	14.52	11.96

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-89b	Central and South America	286.7261	-35.4914	8.00	14.52	5.00
cssz-89z	Central and South America	287.7014	-35.6968	30.00	14.52	26.30
cssz-90a	Central and South America	286.8442	-36.5645	18.33	22.64	11.96
cssz-90b	Central and South America	286.3548	-36.4004	8.00	22.64	5.00
cssz-90z	Central and South America	287.2916	-36.7142	30.00	22.64	27.68
cssz-91a	Central and South America	286.5925	-37.2488	20.00	10.90	11.96
cssz-91b	Central and South America	286.0721	-37.1690	8.00	10.90	5.00
cssz-91z	Central and South America	287.0726	-37.3224	30.00	10.90	29.06
cssz-92a	Central and South America	286.4254	-38.0945	20.00	8.23	11.96
cssz-92b	Central and South America	285.8948	-38.0341	8.00	8.23	5.00
cssz-92z	Central and South America	286.9303	-38.1520	26.67	8.23	29.06
cssz-93a	Central and South America	286.2047	-39.0535	20.00	13.46	11.96
cssz-93b	Central and South America	285.6765	-38.9553	8.00	13.46	5.00
cssz-93z	Central and South America	286.7216	-39.1495	23.33	13.46	29.06
cssz-94a	Central and South America	286.0772	-39.7883	20.00	3.40	11.96
cssz-94b	Central and South America	285.5290	-39.7633	8.00	3.40	5.00
cssz-94z	Central and South America	286.6255	-39.8133	20.00	3.40	29.06
cssz-95a	Central and South America	285.9426	-40.7760	20.00	9.84	11.96
cssz-95b	Central and South America	285.3937	-40.7039	8.00	9.84	5.00
cssz-95z	Central and South America	286.4921	-40.8481	20.00	9.84	29.06
cssz-96a	Central and South America	285.7839	-41.6303	20.00	7.60	11.96
cssz-96b	Central and South America	285.2245	-41.5745	8.00	7.60	5.00
cssz-96x	Central and South America	287.4652	-41.7977	20.00	7.60	63.26
cssz-96y	Central and South America	286.9043	-41.7419	20.00	7.60	46.16
cssz-96z	Central and South America	286.3439	-41.6861	20.00	7.60	29.06
cssz-97a	Central and South America	285.6695	-42.4882	20.00	5.30	11.96
cssz-97b	Central and South America	285.0998	-42.4492	8.00	5.30	5.00
cssz-97x	Central and South America	287.3809	-42.6052	20.00	5.30	63.26
cssz-97y	Central and South America	286.8101	-42.5662	20.00	5.30	46.16
cssz-97z	Central and South America	286.2396	-42.5272	20.00	5.30	29.06
cssz-98a	Central and South America	285.5035	-43.4553	20.00	10.53	11.96
cssz-98b	Central and South America	284.9322	-43.3782	8.00	10.53	5.00
cssz-98x	Central and South America	287.2218	-43.6866	20.00	10.53	63.26

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-98y	Central and South America	286.6483	-43.6095	20.00	10.53	46.16
cssz-98z	Central and South America	286.0755	-43.5324	20.00	10.53	29.06
cssz-99a	Central and South America	285.3700	-44.2595	20.00	4.86	11.96
cssz-99b	Central and South America	284.7830	-44.2237	8.00	4.86	5.00
cssz-99x	Central and South America	287.1332	-44.3669	20.00	4.86	63.26
cssz-99y	Central and South America	286.5451	-44.3311	20.00	4.86	46.16
cssz-99z	Central and South America	285.9574	-44.2953	20.00	4.86	29.06
cssz-100a	Central and South America	285.2713	-45.1664	20.00	5.68	11.96
cssz-100b	Central and South America	284.6758	-45.1246	8.00	5.68	5.00
cssz-100x	Central and South America	287.0603	-45.2918	20.00	5.68	63.26
cssz-100y	Central and South America	286.4635	-45.2500	20.00	5.68	46.16
cssz-100z	Central and South America	285.8672	-45.2082	20.00	5.68	29.06
cssz-101a	Central and South America	285.3080	-45.8607	20.00	352.58	9.36
cssz-101b	Central and South America	284.7067	-45.9152	5.00	352.58	5.00
cssz-101y	Central and South America	286.5089	-45.7517	20.00	352.58	43.56
cssz-101z	Central and South America	285.9088	-45.8062	20.00	352.58	26.46
cssz-102a	Central and South America	285.2028	-47.1185	5.00	17.72	9.36
cssz-102b	Central and South America	284.5772	-46.9823	5.00	17.72	5.00
cssz-102y	Central and South America	286.4588	-47.3909	5.00	17.72	18.07
cssz-102z	Central and South America	285.8300	-47.2547	5.00	17.72	13.72
cssz-103a	Central and South America	284.7075	-48.0396	7.50	23.37	11.53
cssz-103b	Central and South America	284.0972	-47.8630	7.50	23.37	5.00
cssz-103x	Central and South America	286.5511	-48.5694	7.50	23.37	31.11
cssz-103y	Central and South America	285.9344	-48.3928	7.50	23.37	24.58
cssz-103z	Central and South America	285.3199	-48.2162	7.50	23.37	18.05
cssz-104a	Central and South America	284.3440	-48.7597	10.00	14.87	13.68
cssz-104b	Central and South America	283.6962	-48.6462	10.00	14.87	5.00
cssz-104x	Central and South America	286.2962	-49.1002	10.00	14.87	39.73
cssz-104y	Central and South America	285.6440	-48.9867	10.00	14.87	31.05
cssz-104z	Central and South America	284.9933	-48.8732	10.00	14.87	22.36
cssz-105a	Central and South America	284.2312	-49.4198	9.67	0.25	13.40
cssz-105b	Central and South America	283.5518	-49.4179	9.67	0.25	5.00
cssz-105x	Central and South America	286.2718	-49.4255	9.67	0.25	38.59

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-105y	Central and South America	285.5908	-49.4236	9.67	0.25	30.20
cssz-105z	Central and South America	284.9114	-49.4217	9.67	0.25	21.80
cssz-106a	Central and South America	284.3730	-50.1117	9.25	347.50	13.04
cssz-106b	Central and South America	283.6974	-50.2077	9.25	347.50	5.00
cssz-106x	Central and South America	286.3916	-49.8238	9.25	347.50	37.15
cssz-106y	Central and South America	285.7201	-49.9198	9.25	347.50	29.11
cssz-106z	Central and South America	285.0472	-50.0157	9.25	347.50	21.07
cssz-107a	Central and South America	284.7130	-50.9714	9.00	346.48	12.82
cssz-107b	Central and South America	284.0273	-51.0751	9.00	346.48	5.00
cssz-107x	Central and South America	286.7611	-50.6603	9.00	346.48	36.29
cssz-107y	Central and South America	286.0799	-50.7640	9.00	346.48	28.47
cssz-107z	Central and South America	285.3972	-50.8677	9.00	346.48	20.64
cssz-108a	Central and South America	285.0378	-51.9370	8.67	352.01	12.54
cssz-108b	Central and South America	284.3241	-51.9987	8.67	352.01	5.00
cssz-108x	Central and South America	287.1729	-51.7519	8.67	352.01	35.15
cssz-108y	Central and South America	286.4622	-51.8136	8.67	352.01	27.61
cssz-108z	Central and South America	285.7505	-51.8753	8.67	352.01	20.07
cssz-109a	Central and South America	285.2635	-52.8439	8.33	353.08	12.24
cssz-109b	Central and South America	284.5326	-52.8974	8.33	353.08	5.00
cssz-109x	Central and South America	287.4508	-52.6834	8.33	353.08	33.97
cssz-109y	Central and South America	286.7226	-52.7369	8.33	353.08	26.73
cssz-109z	Central and South America	285.9935	-52.7904	8.33	353.08	19.49
cssz-110a	Central and South America	285.5705	-53.4139	8.00	334.19	11.96
cssz-110b	Central and South America	284.8972	-53.6076	8.00	334.19	5.00
cssz-110x	Central and South America	287.5724	-52.8328	8.00	334.19	32.83
cssz-110y	Central and South America	286.9081	-53.0265	8.00	334.19	25.88
cssz-110z	Central and South America	286.2408	-53.2202	8.00	334.19	18.92
cssz-111a	Central and South America	286.1627	-53.8749	8.00	313.83	11.96
cssz-111b	Central and South America	285.6382	-54.1958	8.00	313.83	5.00
cssz-111x	Central and South America	287.7124	-52.9122	8.00	313.83	32.83
cssz-111y	Central and South America	287.1997	-53.2331	8.00	313.83	25.88
cssz-111z	Central and South America	286.6832	-53.5540	8.00	313.83	18.92
cssz-112a	Central and South America	287.3287	-54.5394	8.00	316.39	11.96

Table B.2. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
cssz-112b	Central and South America	286.7715	-54.8462	8.00	316.39	5.00
cssz-112x	Central and South America	288.9756	-53.6190	8.00	316.39	32.83
cssz-112y	Central and South America	288.4307	-53.9258	8.00	316.39	25.88
cssz-112z	Central and South America	287.8817	-54.2326	8.00	316.39	18.92
cssz-113a	Central and South America	288.3409	-55.0480	8.00	307.64	11.96
cssz-113b	Central and South America	287.8647	-55.4002	8.00	307.64	5.00
cssz-113x	Central and South America	289.7450	-53.9914	8.00	307.64	32.83
cssz-113y	Central and South America	289.2810	-54.3436	8.00	307.64	25.88
cssz-113z	Central and South America	288.8130	-54.6958	8.00	307.64	18.92
cssz-114a	Central and South America	289.5342	-55.5026	8.00	301.48	11.96
cssz-114b	Central and South America	289.1221	-55.8819	8.00	301.48	5.00
cssz-114x	Central and South America	290.7472	-54.3647	8.00	301.48	32.83
cssz-114y	Central and South America	290.3467	-54.7440	8.00	301.48	25.88
cssz-114z	Central and South America	289.9424	-55.1233	8.00	301.48	18.92
cssz-115a	Central and South America	290.7682	-55.8485	8.00	292.70	11.96
cssz-115b	Central and South America	290.4608	-56.2588	8.00	292.70	5.00
cssz-115x	Central and South America	291.6714	-54.6176	8.00	292.70	32.83
cssz-115y	Central and South America	291.3734	-55.0279	8.00	292.70	25.88
cssz-115z	Central and South America	291.0724	-55.4382	8.00	292.70	18.92
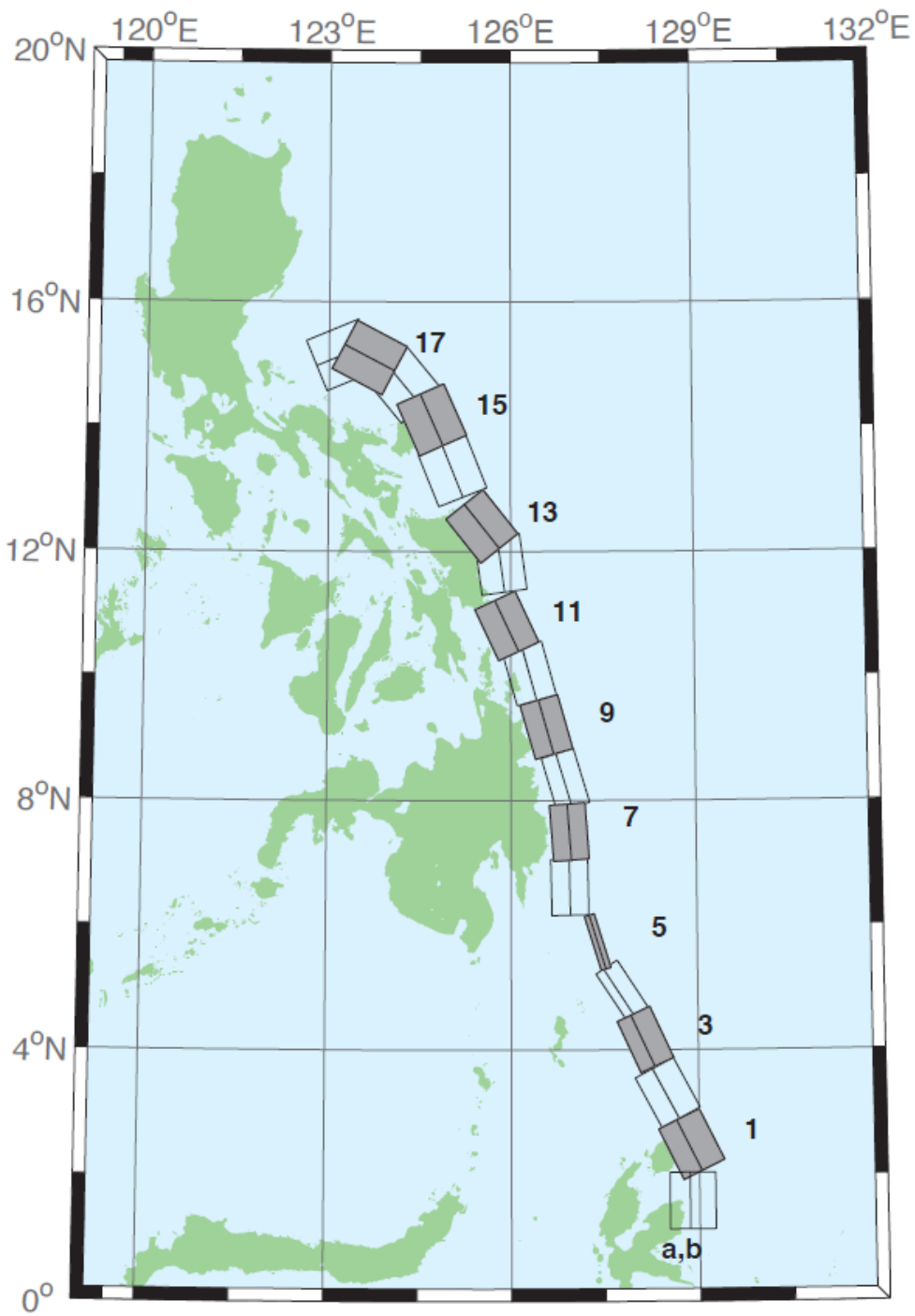
Figure B.3. East Philippines Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
epsz-00a	East Philippines	128.5264	1.5930	44.00	180.00	26.92
epsz-00b	East Philippines	128.8496	1.5930	26.00	180.00	5.00
epsz-01a	East Philippines	128.5521	2.3289	44.20	153.61	27.62
epsz-01b	East Philippines	128.8408	2.4720	26.90	153.61	5.00
epsz-02a	East Philippines	128.1943	3.1508	45.90	151.93	32.44
epsz-02b	East Philippines	128.4706	3.2979	32.80	151.93	5.35
epsz-03a	East Philippines	127.8899	4.0428	57.30	155.22	40.22
epsz-03b	East Philippines	128.1108	4.1445	42.70	155.22	6.31
epsz-04a	East Philippines	127.6120	4.8371	71.40	146.84	48.25
epsz-04b	East Philippines	127.7324	4.9155	54.80	146.84	7.39
epsz-05a	East Philippines	127.3173	5.7040	79.90	162.87	57.40
epsz-05b	East Philippines	127.3930	5.7272	79.40	162.87	8.25
epsz-06a	East Philippines	126.6488	6.6027	48.60	178.89	45.09
epsz-06b	East Philippines	126.9478	6.6085	48.60	178.89	7.58
epsz-07a	East Philippines	126.6578	7.4711	50.70	175.76	45.52
epsz-07b	East Philippines	126.9439	7.4921	50.70	175.76	6.83
epsz-08a	East Philippines	126.6227	8.2456	56.70	163.31	45.60
epsz-08b	East Philippines	126.8614	8.3164	48.90	163.31	7.92
epsz-09a	East Philippines	126.2751	9.0961	47.00	164.09	43.59
epsz-09b	East Philippines	126.5735	9.1801	44.90	164.09	8.30
epsz-10a	East Philippines	125.9798	9.9559	43.10	164.46	42.25
epsz-10b	East Philippines	126.3007	10.0438	43.10	164.46	8.09
epsz-11a	East Philippines	125.6079	10.6557	37.80	154.97	38.29
epsz-11b	East Philippines	125.9353	10.8059	37.80	154.97	7.64
epsz-12a	East Philippines	125.4697	11.7452	36.00	172.14	37.01
epsz-12b	East Philippines	125.8374	11.7949	36.00	172.14	7.62
epsz-13a	East Philippines	125.2238	12.1670	32.40	141.53	33.87
epsz-13b	East Philippines	125.5278	12.4029	32.40	141.53	7.08
epsz-14a	East Philippines	124.6476	13.1365	23.00	158.23	25.92
epsz-14b	East Philippines	125.0421	13.2898	23.00	158.23	6.38
epsz-15a	East Philippines	124.3107	13.9453	24.10	156.12	26.51
epsz-15b	East Philippines	124.6973	14.1113	24.10	156.12	6.09
epsz-16a	East Philippines	123.8998	14.4025	19.50	140.32	21.69

Table B.3. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
epsz-16b	East Philippines	124.2366	14.6728	19.50	140.32	5.00
epsz-17a	East Philippines	123.4604	14.7222	15.30	117.58	18.19
epsz-17b	East Philippines	123.6682	15.1062	15.30	117.58	5.00
epsz-18a	East Philippines	123.3946	14.7462	15.00	67.40	17.94
epsz-18b	East Philippines	123.2219	15.1467	15.00	67.40	5.00
epsz-19a	East Philippines	121.3638	15.7400	15.00	189.63	17.94
epsz-19b	East Philippines	121.8082	15.6674	15.00	189.63	5.00
epsz-20a	East Philippines	121.6833	16.7930	15.00	203.26	17.94
epsz-20b	East Philippines	122.0994	16.6216	15.00	203.26	5.00
epsz-21a	East Philippines	121.8279	17.3742	15.00	184.19	17.94
epsz-21b	East Philippines	122.2814	17.3425	15.00	184.19	5.00
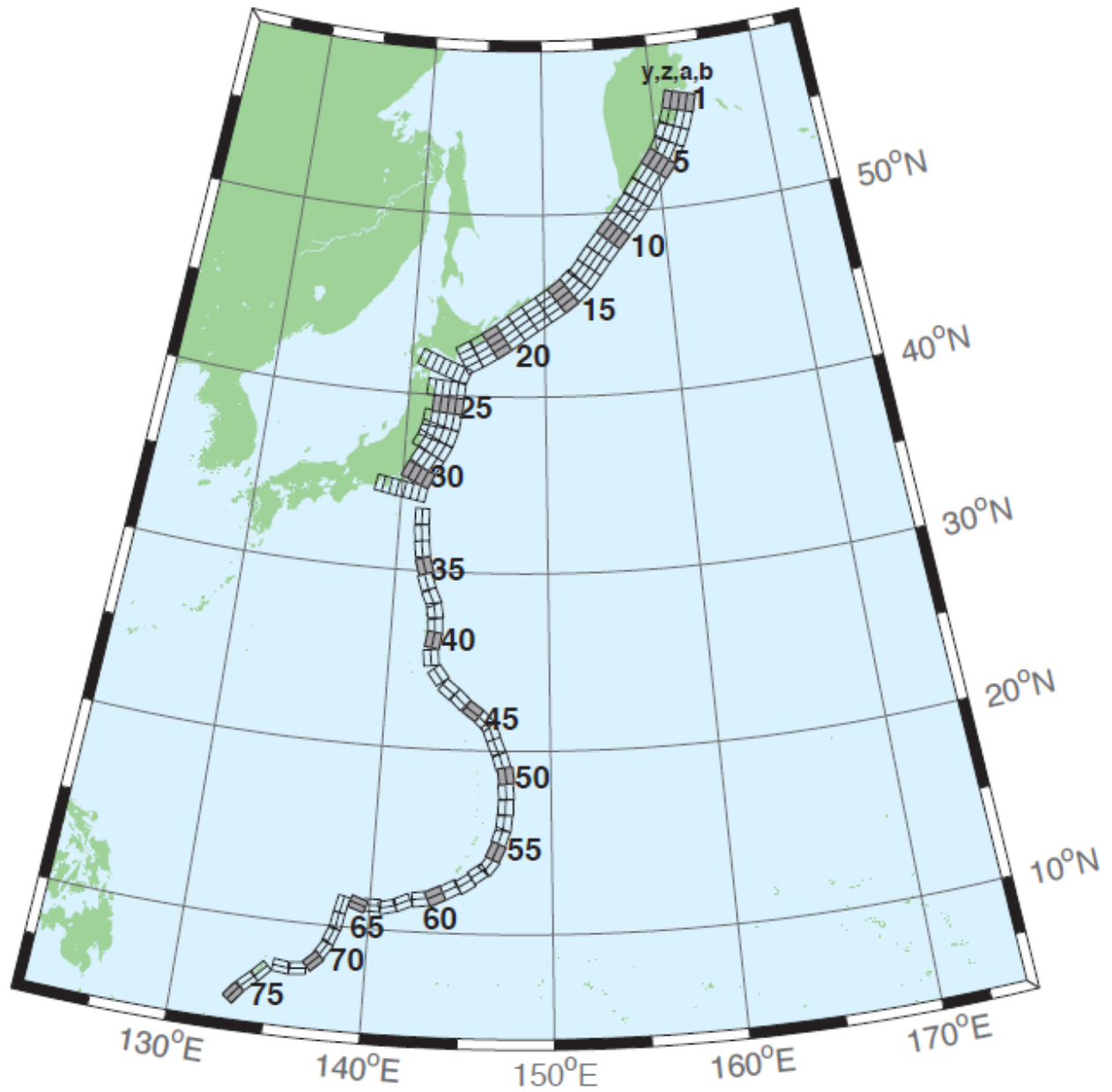
Figure B.4. Kamchatka-Kuril-Japan-Izu-Mariana-Yap Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-00a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.8200	56.3667	29.00	194.41	26.13
kisz-00b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	163.5057	56.2677	25.00	195.00	5.00
kisz-00z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.1309	56.4618	29.00	193.84	50.37
kisz-01a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.4318	55.5017	29.00	195.00	26.13
kisz-01b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	163.1000	55.4000	25.00	195.00	5.00
kisz-01y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.0884	55.7050	29.00	195.00	74.61
kisz-01z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.7610	55.6033	29.00	195.00	50.37
kisz-02a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.9883	54.6784	29.00	200.00	26.13
kisz-02b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.6247	54.5440	25.00	200.00	5.00
kisz-02y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.7072	54.9471	29.00	200.00	74.61
kisz-02z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.3488	54.8127	29.00	200.00	50.37
kisz-03a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.4385	53.8714	29.00	204.00	26.13
kisz-03b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	162.0449	53.7116	25.00	204.00	5.00
kisz-03y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.2164	54.1910	29.00	204.00	74.61
kisz-03z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.8286	54.0312	29.00	204.00	50.37
kisz-04a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.7926	53.1087	29.00	210.00	26.13
kisz-04b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	161.3568	52.9123	25.00	210.00	5.00

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-04y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.6539	53.5015	29.00	210.00	74.61
kisz-04z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.2246	53.3051	29.00	210.00	50.37
kisz-05a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.0211	52.4113	29.00	218.00	26.13
kisz-05b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	160.5258	52.1694	25.00	218.00	5.00
kisz-05y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.0005	52.8950	29.00	218.00	74.61
kisz-05z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.5122	52.6531	29.00	218.00	50.37
kisz-06a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.1272	51.7034	29.00	218.00	26.13
kisz-06b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	159.6241	51.4615	25.00	218.00	5.00
kisz-06y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.1228	52.1871	29.00	218.00	74.61
kisz-06z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.6263	51.9452	29.00	218.00	50.37
kisz-07a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.2625	50.9549	29.00	214.00	26.13
kisz-07b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	158.7771	50.7352	25.00	214.00	5.00
kisz-07y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.2236	51.3942	29.00	214.00	74.61
kisz-07z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.7443	51.1745	29.00	214.00	50.37
kisz-08a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.4712	50.2459	31.00	218.00	27.70
kisz-08b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.9433	50.0089	27.00	218.00	5.00
kisz-08y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.5176	50.7199	31.00	218.00	79.20

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-08z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.9956	50.4829	31.00	218.00	53.45
kisz-09a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.6114	49.5584	31.00	220.00	27.70
kisz-09b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	157.0638	49.3109	27.00	220.00	5.00
kisz-09y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.6974	50.0533	31.00	220.00	79.20
kisz-09z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.1556	49.8058	31.00	220.00	53.45
kisz-10a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.7294	48.8804	31.00	221.00	27.70
kisz-10b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.1690	48.6278	27.00	221.00	5.00
kisz-10y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.8413	49.3856	31.00	221.00	79.20
kisz-10z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2865	49.1330	31.00	221.00	53.45
kisz-11a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.8489	48.1821	31.00	219.00	27.70
kisz-11b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2955	47.9398	27.00	219.00	5.00
kisz-11c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	156.0358	47.5375	57.89	39.00	4.60
kisz-11y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.9472	48.6667	31.00	219.00	79.20
kisz-11z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.3991	48.4244	31.00	219.00	53.45
kisz-12a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.9994	47.4729	31.00	217.00	27.70
kisz-12b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.4701	47.2320	27.00	217.00	5.00
kisz-12c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	155.2207	46.8473	57.89	37.00	4.60

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-12y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.0856	47.9363	31.00	217.00	79.20
kisz-12z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.5435	47.7046	31.00	217.00	53.45
kisz-13a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.2239	46.7564	31.00	218.00	27.70
kisz-13b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.6648	46.5194	27.00	218.00	5.00
kisz-13c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	154.3957	46.1258	57.89	38.00	4.60
kisz-13y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.3343	47.2304	31.00	218.00	79.20
kisz-13z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.7801	46.9934	31.00	218.00	53.45
kisz-14a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.3657	46.1515	23.00	225.00	24.54
kisz-14b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	152.7855	45.8591	23.00	225.00	5.00
kisz-14c	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	153.4468	45.3976	57.89	45.00	4.60
kisz-14y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.5172	46.7362	23.00	225.00	63.62
kisz-14z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.9426	46.4438	23.00	225.00	44.08
kisz-15a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.4663	45.5963	25.00	233.00	23.73
kisz-15b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.8144	45.2712	22.00	233.00	5.00
kisz-15y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.7619	46.2465	25.00	233.00	65.99
kisz-15z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	151.1151	45.9214	25.00	233.00	44.86
kisz-16a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.4572	45.0977	25.00	237.00	23.73

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-16b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.7694	44.7563	22.00	237.00	5.00
kisz-16y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.8253	45.7804	25.00	237.00	65.99
kisz-16z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	150.1422	45.4390	25.00	237.00	44.86
kisz-17a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.3989	44.6084	25.00	237.00	23.73
kisz-17b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.7085	44.2670	22.00	237.00	5.00
kisz-17y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.7723	45.2912	25.00	237.00	65.99
kisz-17z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	149.0865	44.9498	25.00	237.00	44.86
kisz-18a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.3454	44.0982	25.00	235.00	23.73
kisz-18b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.6687	43.7647	22.00	235.00	5.00
kisz-18y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.6915	44.7651	25.00	235.00	65.99
kisz-18z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	148.0194	44.4316	25.00	235.00	44.86
kisz-19a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3262	43.5619	25.00	233.00	23.73
kisz-19b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.6625	43.2368	22.00	233.00	5.00
kisz-19y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6463	44.2121	25.00	233.00	65.99
kisz-19z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9872	43.8870	25.00	233.00	44.86
kisz-20a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.3513	43.0633	25.00	237.00	23.73
kisz-20b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6531	42.7219	22.00	237.00	5.00

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-20y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.7410	43.7461	25.00	237.00	65.99
kisz-20z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.0470	43.4047	25.00	237.00	44.86
kisz-21a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.3331	42.5948	25.00	239.00	23.73
kisz-21b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6163	42.2459	22.00	239.00	5.00
kisz-21y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.7603	43.2927	25.00	239.00	65.99
kisz-21z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.0475	42.9438	25.00	239.00	44.86
kisz-22a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.3041	42.1631	25.00	242.00	23.73
kisz-22b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.5605	41.8037	22.00	242.00	5.00
kisz-22y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.7854	42.8819	25.00	242.00	65.99
kisz-22z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.0455	42.5225	25.00	242.00	44.86
kisz-23a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.2863	41.3335	21.00	202.00	21.28
kisz-23b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.8028	41.1764	19.00	202.00	5.00
kisz-23v	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.6816	42.1189	21.00	202.00	110.87
kisz-23w	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.2050	41.9618	21.00	202.00	92.95
kisz-23x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.7273	41.8047	21.00	202.00	75.04
kisz-23y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2482	41.6476	21.00	202.00	57.12
kisz-23z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7679	41.4905	21.00	202.00	39.20

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-24a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.9795	40.3490	21.00	185.00	21.28
kisz-24b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5273	40.3125	19.00	185.00	5.00
kisz-24x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.3339	40.4587	21.00	185.00	75.04
kisz-24y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8827	40.4221	21.00	185.00	57.12
kisz-24z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.4312	40.3856	21.00	185.00	39.20
kisz-25a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.8839	39.4541	21.00	185.00	21.28
kisz-25b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.4246	39.4176	19.00	185.00	5.00
kisz-25y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8012	39.5272	21.00	185.00	57.12
kisz-25z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.3426	39.4907	21.00	185.00	39.20
kisz-26a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7622	38.5837	21.00	188.00	21.28
kisz-26b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.2930	38.5254	19.00	188.00	5.00
kisz-26x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1667	38.7588	21.00	188.00	75.04
kisz-26y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6990	38.7004	21.00	188.00	57.12
kisz-26z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2308	38.6421	21.00	188.00	39.20
kisz-27a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.5320	37.7830	21.00	198.00	21.28
kisz-27b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.0357	37.6534	19.00	198.00	5.00
kisz-27x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0142	38.1717	21.00	198.00	75.04

Table B.4. continued.

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-27y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5210	38.0421	21.00	198.00	57.12
kisz-27z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0269	37.9126	21.00	198.00	39.20
kisz-28a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.1315	37.0265	21.00	208.00	21.28
kisz-28b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.5941	36.8297	19.00	208.00	5.00
kisz-28x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.7348	37.6171	21.00	208.00	75.04
kisz-28y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.2016	37.4202	21.00	208.00	57.12
kisz-28z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6671	37.2234	21.00	208.00	39.20
kisz-29a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5970	36.2640	21.00	211.00	21.28
kisz-29b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0416	36.0481	19.00	211.00	5.00
kisz-29y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.7029	36.6960	21.00	211.00	57.12
kisz-29z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1506	36.4800	21.00	211.00	39.20
kisz-30a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0553	35.4332	21.00	205.00	21.28
kisz-30b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5207	35.2560	19.00	205.00	5.00
kisz-30y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1204	35.7876	21.00	205.00	57.12
kisz-30z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.5883	35.6104	21.00	205.00	39.20
kisz-31a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.6956	34.4789	22.00	190.00	22.10
kisz-31b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1927	34.4066	20.00	190.00	5.00

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-31v	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.2025	34.8405	22.00	190.00	115.75
kisz-31w	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.7021	34.7682	22.00	190.00	97.02
kisz-31x	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.2012	34.6958	22.00	190.00	78.29
kisz-31y	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.6997	34.6235	22.00	190.00	59.56
kisz-31z	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1979	34.5512	22.00	190.00	40.83
kisz-32a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0551	33.0921	32.00	180.00	23.48
kisz-32b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5098	33.0921	21.69	180.00	5.00
kisz-33a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.0924	32.1047	27.65	173.85	20.67
kisz-33b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.5596	32.1473	18.27	173.85	5.00
kisz-34a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.1869	31.1851	25.00	172.14	18.26
kisz-34b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6585	31.2408	15.38	172.14	5.00
kisz-35a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.4154	30.1707	25.00	162.98	17.12
kisz-35b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.8662	30.2899	14.03	162.98	5.00
kisz-36a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6261	29.2740	25.73	161.68	18.71
kisz-36b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0670	29.4012	15.91	161.68	5.00
kisz-37a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.0120	28.3322	20.00	154.72	14.54
kisz-37b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.4463	28.5124	11.00	154.72	5.00

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-38a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2254	27.6946	20.00	170.27	14.54
kisz-38b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.6955	27.7659	11.00	170.27	5.00
kisz-39a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.3085	26.9127	24.23	177.23	17.42
kisz-39b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7674	26.9325	14.38	177.23	5.00
kisz-40a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.2673	26.1923	26.49	189.44	22.26
kisz-40b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7090	26.1264	20.20	189.44	5.00
kisz-41a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.1595	25.0729	22.07	173.72	19.08
kisz-41b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.6165	25.1184	16.36	173.72	5.00
kisz-42a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7641	23.8947	21.54	143.50	18.40
kisz-42b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.1321	24.1432	15.54	143.50	5.00
kisz-43a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5281	23.0423	23.02	129.21	18.77
kisz-43b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.8128	23.3626	15.99	129.21	5.00
kisz-44a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.2230	22.5240	28.24	134.63	18.56
kisz-44b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.5246	22.8056	15.74	134.63	5.00
kisz-45a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.0895	21.8866	36.73	125.83	22.79
kisz-45b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.3171	22.1785	20.84	125.83	5.00
kisz-46a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6972	21.3783	30.75	135.90	20.63

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-46b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.9954	21.6469	18.22	135.90	5.00
kisz-47a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.0406	20.9341	29.87	160.07	19.62
kisz-47b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4330	21.0669	17.00	160.07	5.00
kisz-48a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.3836	20.0690	32.75	157.96	19.68
kisz-48b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.7567	20.2108	17.07	157.96	5.00
kisz-49a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.6689	19.3123	25.07	164.48	21.41
kisz-49b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.0846	19.4212	19.16	164.48	5.00
kisz-50a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9297	18.5663	22.00	172.07	22.10
kisz-50b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3650	18.6238	20.00	172.07	5.00
kisz-51a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9495	17.7148	22.06	175.11	22.04
kisz-51b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3850	17.7503	19.93	175.11	5.00
kisz-52a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.9447	16.8869	25.51	180.00	18.61
kisz-52b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.3683	16.8869	15.79	180.00	5.00
kisz-53a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.8626	16.0669	27.39	185.18	18.41
kisz-53b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.2758	16.0309	15.56	185.18	5.00
kisz-54a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.7068	15.3883	28.12	199.05	20.91
kisz-54b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	147.0949	15.2590	18.56	199.05	5.00

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-55a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4717	14.6025	29.60	204.35	26.27
kisz-55b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.8391	14.4415	25.18	204.35	5.00
kisz-56a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.1678	13.9485	32.04	217.45	26.79
kisz-56b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	146.4789	13.7170	25.84	217.45	5.00
kisz-57a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.6515	13.5576	37.00	235.81	24.54
kisz-57b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.8586	13.2609	23.00	235.81	5.00
kisz-58a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.9648	12.9990	37.72	237.80	24.54
kisz-58b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	145.1589	12.6984	23.00	237.80	5.00
kisz-59a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.1799	12.6914	34.33	242.87	22.31
kisz-59b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	144.3531	12.3613	20.25	242.87	5.00
kisz-60a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.3687	12.3280	30.90	244.95	20.62
kisz-60b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	143.5355	11.9788	18.20	244.95	5.00
kisz-61a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7051	12.1507	35.41	261.84	25.51
kisz-61b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	142.7582	11.7883	24.22	261.84	5.00
kisz-62a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.6301	11.8447	39.86	245.69	34.35
kisz-62b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	141.7750	11.5305	35.94	245.69	5.00
kisz-63a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.8923	11.5740	42.00	256.20	38.46

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-63b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.9735	11.2498	42.00	256.20	5.00
kisz-64a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1387	11.6028	42.48	269.61	38.77
kisz-64b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	140.1410	11.2716	42.48	269.61	5.00
kisz-65a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.4595	11.5883	44.16	288.71	39.83
kisz-65b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	139.3541	11.2831	44.16	288.71	5.00
kisz-66a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.1823	11.2648	45.00	193.08	40.36
kisz-66b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.4977	11.1929	45.00	193.08	5.00
kisz-67a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.9923	10.3398	45.00	189.83	40.36
kisz-67b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.3104	10.2856	45.00	189.83	5.00
kisz-68a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.7607	9.6136	45.00	201.68	40.36
kisz-68b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	138.0599	9.4963	45.00	201.68	5.00
kisz-69a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.4537	8.8996	45.00	213.54	40.36
kisz-69b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.7215	8.7241	45.00	213.54	5.00
kisz-70a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.0191	8.2872	45.00	226.47	40.36
kisz-70b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	137.2400	8.0569	45.00	226.47	5.00
kisz-71a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	136.3863	7.9078	45.00	263.92	40.36
kisz-71b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	136.4202	7.5920	45.00	263.92	5.00
kisz-72a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	135.6310	7.9130	45.00	276.87	40.36

Table B.4. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
kisz-72b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	135.5926	7.5977	45.00	276.87	5.00
kisz-73a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	134.3296	7.4541	45.00	223.98	40.36
kisz-73b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	134.5600	7.2335	45.00	223.98	5.00
kisz-74a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.7125	6.8621	45.00	228.06	40.36
kisz-74b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.9263	6.6258	45.00	228.06	5.00
kisz-75a	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.0224	6.1221	45.00	217.68	40.36
kisz-75b	Kamchatka-Kuril-Japan-Izu-Mariana-Yap	133.2751	5.9280	45.00	217.68	5.00
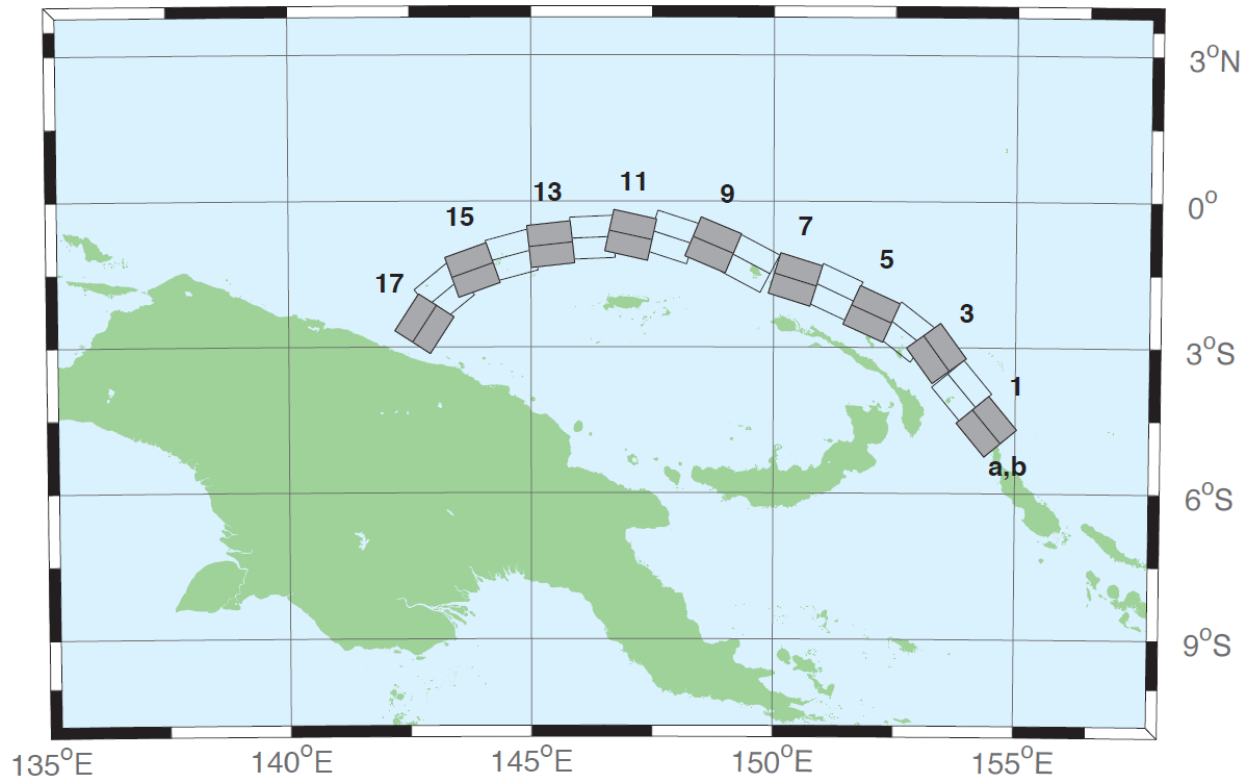
Figure B.5. Manus Oceanic Convergent Boundary Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
mosz-01a	Manus	154.0737	-4.8960	15.00	140.23	15.88
mosz-01b	Manus	154.4082	-4.6185	15.00	140.23	2.94
mosz-02a	Manus	153.5589	-4.1575	15.00	140.23	15.91
mosz-02b	Manus	153.8931	-3.8800	15.00	140.23	2.97
mosz-03a	Manus	153.0151	-3.3716	15.00	143.91	16.64
mosz-03b	Manus	153.3662	-3.1160	15.00	143.91	3.70
mosz-04a	Manus	152.4667	-3.0241	15.00	127.66	17.32
mosz-04b	Manus	152.7321	-2.6806	15.00	127.66	4.38
mosz-05a	Manus	151.8447	-2.7066	15.00	114.32	17.57
mosz-05b	Manus	152.0235	-2.3112	15.00	114.32	4.63
mosz-06a	Manus	151.0679	-2.2550	15.00	114.99	17.66
mosz-06b	Manus	151.2513	-1.8618	15.00	114.99	4.72
mosz-07a	Manus	150.3210	-2.0236	15.00	107.20	17.73
mosz-07b	Manus	150.4493	-1.6092	15.00	107.20	4.79
mosz-08a	Manus	149.3226	-1.6666	15.00	117.82	17.83
mosz-08b	Manus	149.5251	-1.2829	15.00	117.82	4.89
mosz-09a	Manus	148.5865	-1.3017	15.00	112.71	17.84
mosz-09b	Manus	148.7540	-0.9015	15.00	112.71	4.90
mosz-10a	Manus	147.7760	-1.1560	15.00	108.01	17.78
mosz-10b	Manus	147.9102	-0.7434	15.00	108.01	4.84
mosz-11a	Manus	146.9596	-1.1226	15.00	102.45	17.54
mosz-11b	Manus	147.0531	-0.6990	15.00	102.45	4.60
mosz-12a	Manus	146.2858	-1.1820	15.00	87.48	17.29
mosz-12b	Manus	146.2667	-0.7486	15.00	87.48	4.35
mosz-13a	Manus	145.4540	-1.3214	15.00	83.75	17.34
mosz-13b	Manus	145.4068	-0.8901	15.00	83.75	4.40
mosz-14a	Manus	144.7151	-1.5346	15.00	75.09	17.21
mosz-14b	Manus	144.6035	-1.1154	15.00	75.09	4.27
mosz-15a	Manus	143.9394	-1.8278	15.00	70.43	16.52
mosz-15b	Manus	143.7940	-1.4190	15.00	70.43	3.58
mosz-16a	Manus	143.4850	-2.2118	15.00	50.79	15.86
mosz-16b	Manus	143.2106	-1.8756	15.00	50.79	2.92
mosz-17a	Manus	143.1655	-2.7580	15.00	33.00	16.64
mosz-17b	Manus	142.8013	-2.5217	15.00	33.00	3.70
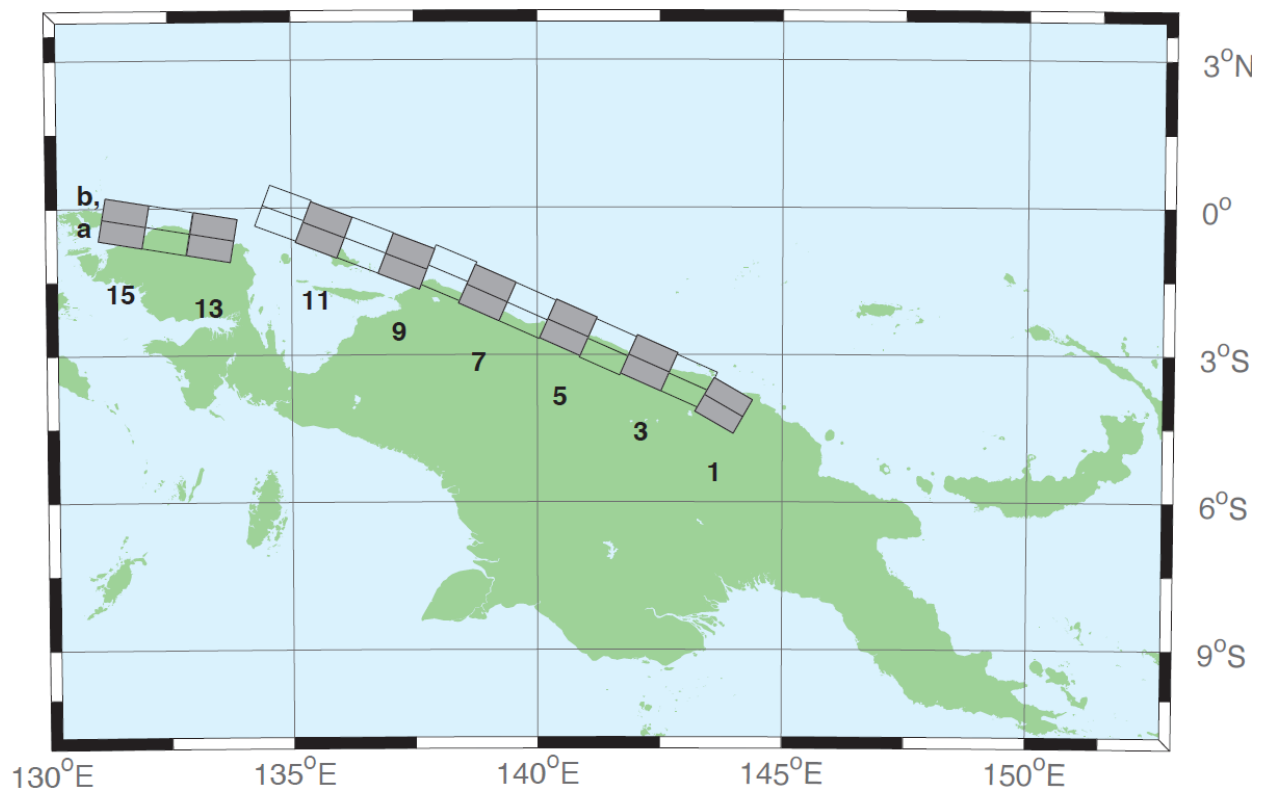
Figure B.6. New Guinea Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
ngsz-01a	New Guinea	143.6063	-4.3804	29.00	120.00	25.64
ngsz-01b	New Guinea	143.8032	-4.0402	29.00	120.00	1.40
ngsz-02a	New Guinea	142.9310	-3.9263	27.63	114.00	20.10
ngsz-02b	New Guinea	143.0932	-3.5628	21.72	114.00	1.60
ngsz-03a	New Guinea	142.1076	-3.5632	20.06	114.00	18.73
ngsz-03b	New Guinea	142.2795	-3.1778	15.94	114.00	5.00
ngsz-04a	New Guinea	141.2681	-3.2376	21.00	114.00	17.76
ngsz-04b	New Guinea	141.4389	-2.8545	14.79	114.00	5.00
ngsz-05a	New Guinea	140.4592	-2.8429	21.26	114.00	16.14
ngsz-05b	New Guinea	140.6296	-2.4605	12.87	114.00	5.00
ngsz-06a	New Guinea	139.6288	-2.4960	22.72	114.00	15.40
ngsz-06b	New Guinea	139.7974	-2.1175	12.00	114.00	5.00
ngsz-07a	New Guinea	138.8074	-2.1312	21.39	114.00	15.40
ngsz-07b	New Guinea	138.9776	-1.7491	12.00	114.00	5.00
ngsz-08a	New Guinea	138.0185	-1.7353	18.79	113.09	15.14
ngsz-08b	New Guinea	138.1853	-1.3441	11.70	113.09	5.00
ngsz-09a	New Guinea	137.1805	-1.5037	15.24	111.00	13.23
ngsz-09b	New Guinea	137.3358	-1.0991	9.47	111.00	5.00
ngsz-10a	New Guinea	136.3418	-1.1774	13.51	111.00	11.09
ngsz-10b	New Guinea	136.4983	-0.7697	7.00	111.00	5.00
ngsz-11a	New Guinea	135.4984	-0.8641	11.38	111.00	12.49
ngsz-11b	New Guinea	135.6562	-0.4530	8.62	111.00	5.00
ngsz-12a	New Guinea	134.6759	-0.5216	10.00	110.48	13.68
ngsz-12b	New Guinea	134.8307	-0.1072	10.00	110.48	5.00
ngsz-13a	New Guinea	133.3065	-1.0298	10.00	99.50	13.68
ngsz-13b	New Guinea	133.3795	-0.5935	10.00	99.50	5.00
ngsz-14a	New Guinea	132.4048	-0.8816	10.00	99.50	13.68
ngsz-14b	New Guinea	132.4778	-0.4453	10.00	99.50	5.00
ngsz-15a	New Guinea	131.5141	-0.7353	10.00	99.50	13.68
ngsz-15b	New Guinea	131.5871	-0.2990	10.00	99.50	5.00
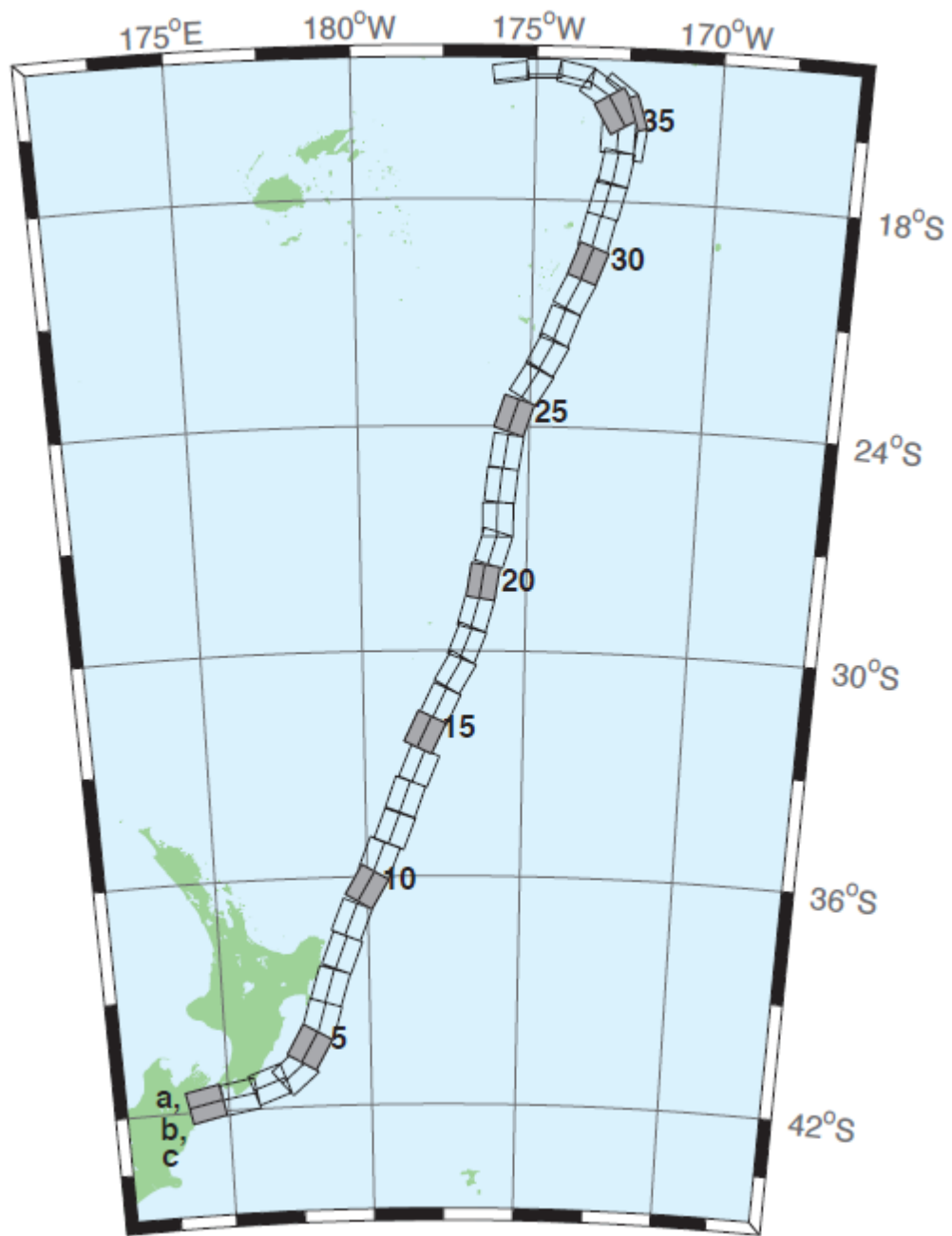
Figure B.7. New Zealand-Kermadec-Tonga Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
ntsz-01a	New Zealand-Tonga	174.0985	-41.3951	24.00	258.57	25.34
ntsz-01b	New Zealand-Tonga	174.2076	-41.7973	24.00	258.57	5.00
ntsz-02a	New Zealand-Tonga	175.3289	-41.2592	29.38	260.63	23.17
ntsz-02b	New Zealand-Tonga	175.4142	-41.6454	21.31	260.63	5.00
ntsz-03a	New Zealand-Tonga	176.2855	-40.9950	29.54	250.65	21.74
ntsz-03b	New Zealand-Tonga	176.4580	-41.3637	19.56	250.65	5.00
ntsz-04a	New Zealand-Tonga	177.0023	-40.7679	24.43	229.42	18.87
ntsz-04b	New Zealand-Tonga	177.3552	-41.0785	16.10	229.42	5.00
ntsz-05a	New Zealand-Tonga	177.4114	-40.2396	18.80	210.04	19.29
ntsz-05b	New Zealand-Tonga	177.8951	-40.4525	16.61	210.04	5.00
ntsz-06a	New Zealand-Tonga	177.8036	-39.6085	18.17	196.68	15.80
ntsz-06b	New Zealand-Tonga	178.3352	-39.7310	12.48	196.68	5.00
ntsz-07a	New Zealand-Tonga	178.1676	-38.7480	28.10	197.03	17.85
ntsz-07b	New Zealand-Tonga	178.6541	-38.8640	14.89	197.03	5.00
ntsz-08a	New Zealand-Tonga	178.6263	-37.8501	31.47	201.41	18.78
ntsz-08b	New Zealand-Tonga	179.0788	-37.9899	16.00	201.41	5.00
ntsz-09a	New Zealand-Tonga	178.9833	-36.9770	29.58	202.19	20.02
ntsz-09b	New Zealand-Tonga	179.4369	-37.1245	17.48	202.19	5.00
ntsz-10a	New Zealand-Tonga	179.5534	-36.0655	32.10	210.62	20.72
ntsz-10b	New Zealand-Tonga	179.9595	-36.2593	18.32	210.62	5.00
ntsz-11a	New Zealand-Tonga	179.9267	-35.3538	25.00	201.65	16.09
ntsz-11b	New Zealand-Tonga	180.3915	-35.5040	12.81	201.65	5.00
ntsz-12a	New Zealand-Tonga	180.4433	-34.5759	25.00	201.18	15.46
ntsz-12b	New Zealand-Tonga	180.9051	-34.7230	12.08	201.18	5.00
ntsz-13a	New Zealand-Tonga	180.7990	-33.7707	25.87	199.75	19.06
ntsz-13b	New Zealand-Tonga	181.2573	-33.9073	16.33	199.75	5.00
ntsz-14a	New Zealand-Tonga	181.2828	-32.9288	31.28	202.41	22.73
ntsz-14b	New Zealand-Tonga	181.7063	-33.0751	20.77	202.41	5.00
ntsz-15a	New Zealand-Tonga	181.4918	-32.0035	32.33	205.43	22.64
ntsz-15b	New Zealand-Tonga	181.8967	-32.1665	20.66	205.43	5.00
ntsz-16a	New Zealand-Tonga	181.9781	-31.2535	34.29	205.48	23.59
ntsz-16b	New Zealand-Tonga	182.3706	-31.4131	21.83	205.48	5.00

Table B.7. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
ntsz-17a	New Zealand-Tonga	182.4819	-30.3859	37.60	210.31	25.58
ntsz-17b	New Zealand-Tonga	182.8387	-30.5655	24.30	210.31	5.00
ntsz-18a	New Zealand-Tonga	182.8176	-29.6545	37.65	201.63	26.13
ntsz-18b	New Zealand-Tonga	183.1985	-29.7856	25.00	201.63	5.00
ntsz-19a	New Zealand-Tonga	183.0622	-28.8739	34.41	195.70	26.13
ntsz-19b	New Zealand-Tonga	183.4700	-28.9742	25.00	195.70	5.00
ntsz-20a	New Zealand-Tonga	183.2724	-28.0967	38.00	188.80	26.13
ntsz-20b	New Zealand-Tonga	183.6691	-28.1508	25.00	188.80	5.00
ntsz-21a	New Zealand-Tonga	183.5747	-27.1402	32.29	197.10	24.83
ntsz-21b	New Zealand-Tonga	183.9829	-27.2518	23.37	197.10	5.00
ntsz-22a	New Zealand-Tonga	183.6608	-26.4975	29.56	180.00	18.63
ntsz-22b	New Zealand-Tonga	184.0974	-26.4975	15.82	180.00	5.00
ntsz-23a	New Zealand-Tonga	183.7599	-25.5371	32.42	185.77	20.56
ntsz-23b	New Zealand-Tonga	184.1781	-25.5752	18.13	185.77	5.00
ntsz-24a	New Zealand-Tonga	183.9139	-24.6201	33.31	188.17	23.73
ntsz-24b	New Zealand-Tonga	184.3228	-24.6734	22.00	188.17	5.00
ntsz-25a	New Zealand-Tonga	184.1266	-23.5922	29.34	198.48	19.64
ntsz-25b	New Zealand-Tonga	184.5322	-23.7163	17.03	198.48	5.00
ntsz-26a	New Zealand-Tonga	184.6613	-22.6460	30.26	211.67	19.43
ntsz-26b	New Zealand-Tonga	185.0196	-22.8497	16.78	211.67	5.00
ntsz-27a	New Zealand-Tonga	185.0879	-21.9139	31.73	207.93	20.67
ntsz-27b	New Zealand-Tonga	185.4522	-22.0928	18.27	207.93	5.00
ntsz-28a	New Zealand-Tonga	185.4037	-21.1758	32.44	200.48	21.76
ntsz-28b	New Zealand-Tonga	185.7849	-21.3084	19.58	200.48	5.00
ntsz-29a	New Zealand-Tonga	185.8087	-20.2629	32.47	206.37	20.40
ntsz-29b	New Zealand-Tonga	186.1710	-20.4312	17.94	206.37	5.00
ntsz-30a	New Zealand-Tonga	186.1499	-19.5087	32.98	200.91	22.46
ntsz-30b	New Zealand-Tonga	186.5236	-19.6432	20.44	200.91	5.00
ntsz-31a	New Zealand-Tonga	186.3538	-18.7332	34.41	193.88	21.19
ntsz-31b	New Zealand-Tonga	186.7339	-18.8221	18.89	193.88	5.00
ntsz-32a	New Zealand-Tonga	186.5949	-17.8587	30.00	194.12	19.12
ntsz-32b	New Zealand-Tonga	186.9914	-17.9536	16.40	194.12	5.00
ntsz-33a	New Zealand-Tonga	186.8172	-17.0581	33.15	190.04	23.34

Table B.7. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
ntsz-33b	New Zealand-Tonga	187.2047	-17.1237	21.52	190.04	5.00
ntsz-34a	New Zealand-Tonga	186.7814	-16.2598	15.00	182.13	13.41
ntsz-34b	New Zealand-Tonga	187.2330	-16.2759	9.68	182.13	5.00
ntsz-34c*	New Zealand-Tonga	187.9697	-16.4956	57.06	7.62	6.57
ntsz-35a	New Zealand-Tonga	186.8000	-15.8563	15.00	149.85	12.17
ntsz-35b	New Zealand-Tonga	187.1896	-15.6384	8.24	149.85	5.00
ntsz-35c*	New Zealand-Tonga	187.8775	-15.6325	57.06	342.45	6.57
ntsz-36a	New Zealand-Tonga	186.5406	-15.3862	40.44	123.91	36.72
ntsz-36b	New Zealand-Tonga	186.7381	-15.1025	39.38	123.91	5.00
ntsz-36c*	New Zealand-Tonga	187.3791	-14.9234	57.06	307.04	6.57
ntsz-37a	New Zealand-Tonga	185.9883	-14.9861	68.94	101.95	30.99
ntsz-37b	New Zealand-Tonga	186.0229	-14.8282	31.32	101.95	5.00
ntsz-38a	New Zealand-Tonga	185.2067	-14.8259	80.00	88.40	26.13
ntsz-38b	New Zealand-Tonga	185.2044	-14.7479	25.00	88.40	5.00
ntsz-39a	New Zealand-Tonga	184.3412	-14.9409	80.00	82.55	26.13
ntsz-39b	New Zealand-Tonga	184.3307	-14.8636	25.00	82.55	5.00

*Rake angle is -90°
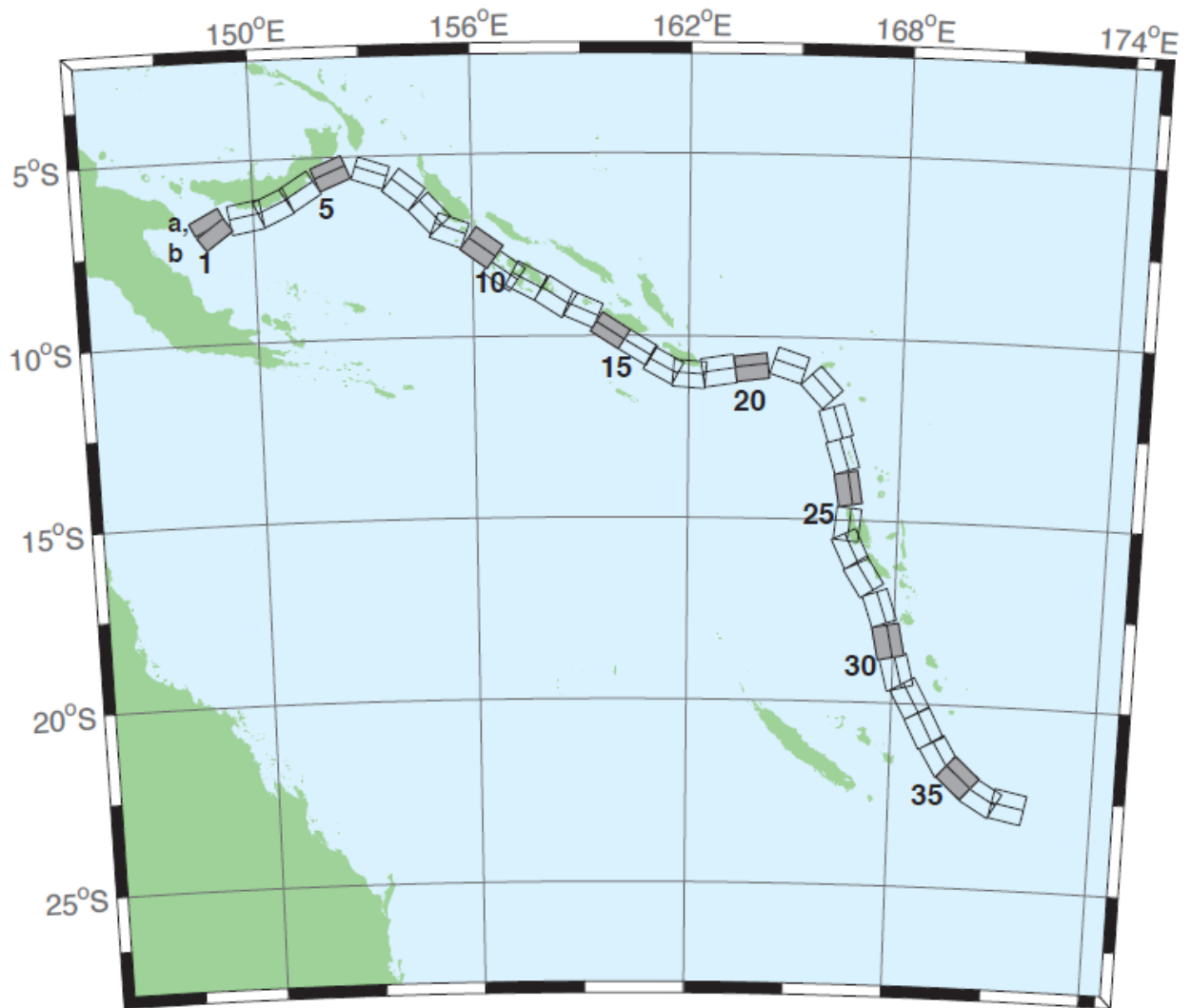
Figure B.8. New Britain-Solomons-Vanuatu Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
nvsz-01a	New Britain-Vanuatu	148.6217	-6.4616	32.34	243.15	15.69
nvsz-01b	New Britain-Vanuatu	148.7943	-6.8002	12.34	234.15	5.00
nvsz-02a	New Britain-Vanuatu	149.7218	-6.1459	35.10	260.06	16.36
nvsz-02b	New Britain-Vanuatu	149.7856	-6.5079	13.13	260.06	5.00
nvsz-03a	New Britain-Vanuatu	150.4075	-5.9659	42.35	245.69	18.59
nvsz-03b	New Britain-Vanuatu	150.5450	-6.2684	15.77	245.69	5.00
nvsz-04a	New Britain-Vanuatu	151.1095	-5.5820	42.41	238.22	23.63
nvsz-04b	New Britain-Vanuatu	151.2851	-5.8639	21.88	238.22	5.00
nvsz-05a	New Britain-Vanuatu	152.0205	-5.1305	49.22	247.73	32.39
nvsz-05b	New Britain-Vanuatu	152.1322	-5.4020	33.22	247.73	5.00
nvsz-06a	New Britain-Vanuatu	153.3450	-5.1558	53.53	288.58	33.59
nvsz-06b	New Britain-Vanuatu	153.2595	-5.4089	34.87	288.58	5.00
nvsz-07a	New Britain-Vanuatu	154.3814	-5.6308	39.72	308.27	19.18
nvsz-07b	New Britain-Vanuatu	154.1658	-5.9017	16.48	308.27	5.00
nvsz-08a	New Britain-Vanuatu	155.1097	-6.3511	45.33	317.22	22.92
nvsz-08b	New Britain-Vanuatu	154.8764	-6.5656	21.00	317.22	5.00
nvsz-09a	New Britain-Vanuatu	155.5027	-6.7430	48.75	290.51	22.92
nvsz-09b	New Britain-Vanuatu	155.3981	-7.0204	21.00	290.51	5.00
nvsz-10a	New Britain-Vanuatu	156.4742	-7.2515	36.88	305.85	27.62
nvsz-10b	New Britain-Vanuatu	156.2619	-7.5427	26.90	305.85	5.00
nvsz-11a	New Britain-Vanuatu	157.0830	-7.8830	32.97	305.36	29.72
nvsz-11b	New Britain-Vanuatu	156.8627	-8.1903	29.63	305.36	5.00
nvsz-12a	New Britain-Vanuatu	157.6537	-8.1483	37.53	297.94	28.57
nvsz-12b	New Britain-Vanuatu	157.4850	-8.4630	28.13	297.94	5.00
nvsz-13a	New Britain-Vanuatu	158.5089	-8.5953	33.62	302.73	23.02
nvsz-13b	New Britain-Vanuatu	158.3042	-8.9099	21.12	302.73	5.00
nvsz-14a	New Britain-Vanuatu	159.1872	-8.9516	38.44	293.32	34.06
nvsz-14b	New Britain-Vanuatu	159.0461	-9.2747	35.54	293.32	5.00
nvsz-15a	New Britain-Vanuatu	159.9736	-9.5993	46.69	302.76	41.38
nvsz-15b	New Britain-Vanuatu	159.8044	-9.8584	46.69	302.76	5.00
nvsz-16a	New Britain-Vanuatu	160.7343	-10.0574	46.05	300.99	41.00
nvsz-16b	New Britain-Vanuatu	160.5712	-10.3246	46.05	300.99	5.00
nvsz-17a	New Britain-Vanuatu	161.4562	-10.5241	40.12	298.37	37.22
nvsz-17b	New Britain-Vanuatu	161.2900	-10.8263	40.12	298.37	5.00

Table B.8. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
nvsz-18a	New Britain-Vanuatu	162.0467	-10.6823	40.33	274.07	29.03
nvsz-18b	New Britain-Vanuatu	162.0219	-11.0238	28.72	274.07	5.00
nvsz-19a	New Britain-Vanuatu	162.7818	-10.5645	34.25	261.27	24.14
nvsz-19b	New Britain-Vanuatu	162.8392	-10.9315	22.51	261.27	5.00
nvsz-20a	New Britain-Vanuatu	163.7222	-10.5014	50.35	262.93	26.30
nvsz-20b	New Britain-Vanuatu	163.7581	-10.7858	25.22	262.93	5.00
nvsz-21a	New Britain-Vanuatu	164.9445	-10.4183	40.31	287.89	23.30
nvsz-21b	New Britain-Vanuatu	164.8374	-10.7442	21.47	287.89	5.00
nvsz-22a	New Britain-Vanuatu	166.0261	-11.1069	42.39	317.08	20.78
nvsz-22b	New Britain-Vanuatu	165.7783	-11.3328	18.40	317.08	5.00
nvsz-23a	New Britain-Vanuatu	166.5179	-12.2260	47.95	342.37	22.43
nvsz-23b	New Britain-Vanuatu	166.2244	-12.3171	20.40	342.37	5.00
nvsz-24a	New Britain-Vanuatu	166.7236	-13.1065	47.13	342.6	28.52
nvsz-24b	New Britain-Vanuatu	166.4241	-13.1979	28.06	342.6	5.00
nvsz-25a	New Britain-Vanuatu	166.8914	-14.0785	54.10	350.28	31.16
nvsz-25b	New Britain-Vanuatu	166.6237	-14.1230	31.55	350.28	5.00
nvsz-26a	New Britain-Vanuatu	166.9200	-15.1450	50.46	365.62	29.05
nvsz-26b	New Britain-Vanuatu	166.6252	-15.1170	28.75	365.62	5.00
nvsz-27a	New Britain-Vanuatu	167.0053	-15.6308	44.74	334.23	25.46
nvsz-27b	New Britain-Vanuatu	166.7068	-15.7695	24.15	334.23	5.00
nvsz-28a	New Britain-Vanuatu	167.4074	-16.3455	41.53	327.46	22.44
nvsz-28b	New Britain-Vanuatu	167.1117	-16.5264	20.42	327.46	5.00
nvsz-29a	New Britain-Vanuatu	167.9145	-17.2807	49.10	341.16	24.12
nvsz-29b	New Britain-Vanuatu	167.6229	-17.3757	22.48	341.16	5.00
nvsz-30a	New Britain-Vanuatu	168.2220	-18.2353	44.19	348.58	23.99
nvsz-30b	New Britain-Vanuatu	167.8895	-18.2991	22.32	348.58	5.00
nvsz-31a	New Britain-Vanuatu	168.5022	-19.0510	42.20	345.59	22.26
nvsz-31b	New Britain-Vanuatu	168.1611	-19.1338	20.20	345.59	5.00
nvsz-32a	New Britain-Vanuatu	168.8775	-19.6724	42.03	331.06	21.68
nvsz-32b	New Britain-Vanuatu	168.5671	-19.8338	19.49	331.06	5.00
nvsz-33a	New Britain-Vanuatu	169.3422	-20.4892	40.25	332.91	22.40
nvsz-33b	New Britain-Vanuatu	169.0161	-20.6453	20.37	332.91	5.00
nvsz-34a	New Britain-Vanuatu	169.8304	-21.2121	39.00	329.15	22.73
nvsz-34b	New Britain-Vanuatu	169.5086	-21.3911	20.77	329.15	5.00
nvsz-35a	New Britain-Vanuatu	170.3119	-21.6945	39.00	311.89	22.13
nvsz-35b	New Britain-Vanuatu	170.0606	-21.9543	20.03	311.89	5.00

Table B.8. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
nvsz-36a	New Britain-Vanuatu	170.9487	-22.1585	39.42	300.43	23.50
nvsz-36b	New Britain-Vanuatu	170.7585	-22.4577	21.71	300.43	5.00
nvsz-37a	New Britain-Vanuatu	171.6335	-22.3087	30.00	281.26	22.10
nvsz-37b	New Britain-Vanuatu	171.5512	-22.6902	20.00	281.26	5.00
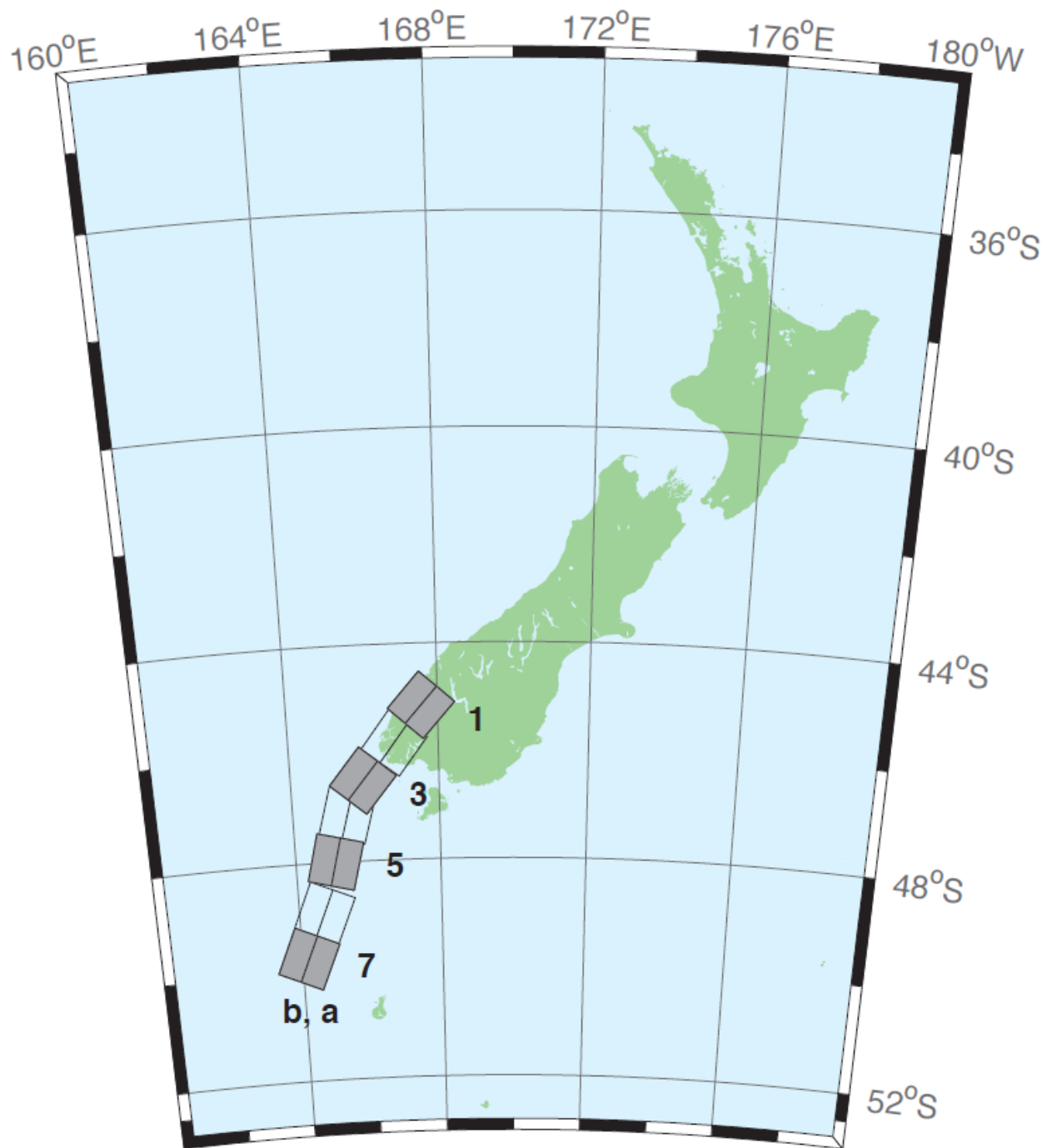
Figure B.9. New Zealand-Puyseger Zone unit sources.

Table B.9. Earthquake parameters for New Zealand-Puyseger Subduction Zone unit sources.

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
nzsz-01a	New Zealand-Puyseger	168.0294	-45.4368	15.00	41.50	17.94
nzsz-01b	New Zealand-Puyseger	167.5675	-45.1493	15.00	41.50	5.00
nzsz-02a	New Zealand-Puyseger	167.3256	-46.0984	15.00	37.14	17.94
nzsz-02b	New Zealand-Puyseger	166.8280	-45.8365	15.00	37.14	5.00
nzsz-03a	New Zealand-Puyseger	166.4351	-46.7897	15.00	39.53	17.94
nzsz-03b	New Zealand-Puyseger	165.9476	-46.5136	15.00	39.53	5.00
nzsz-04a	New Zealand-Puyseger	166.0968	-47.2583	15.00	15.38	17.94
nzsz-04b	New Zealand-Puyseger	165.4810	-47.1432	15.00	15.38	5.00
nzsz-05a	New Zealand-Puyseger	165.7270	-48.0951	15.00	13.94	17.94
nzsz-05b	New Zealand-Puyseger	165.0971	-47.9906	15.00	13.94	5.00
nzsz-06a	New Zealand-Puyseger	165.3168	-49.0829	15.00	22.71	17.94
nzsz-06b	New Zealand-Puyseger	164.7067	-48.9154	15.00	22.71	5.00
nzsz-07a	New Zealand-Puyseger	164.8017	-49.9193	15.00	23.25	17.94
nzsz-07b	New Zealand-Puyseger	164.1836	-49.7480	15.00	23.25	5.00
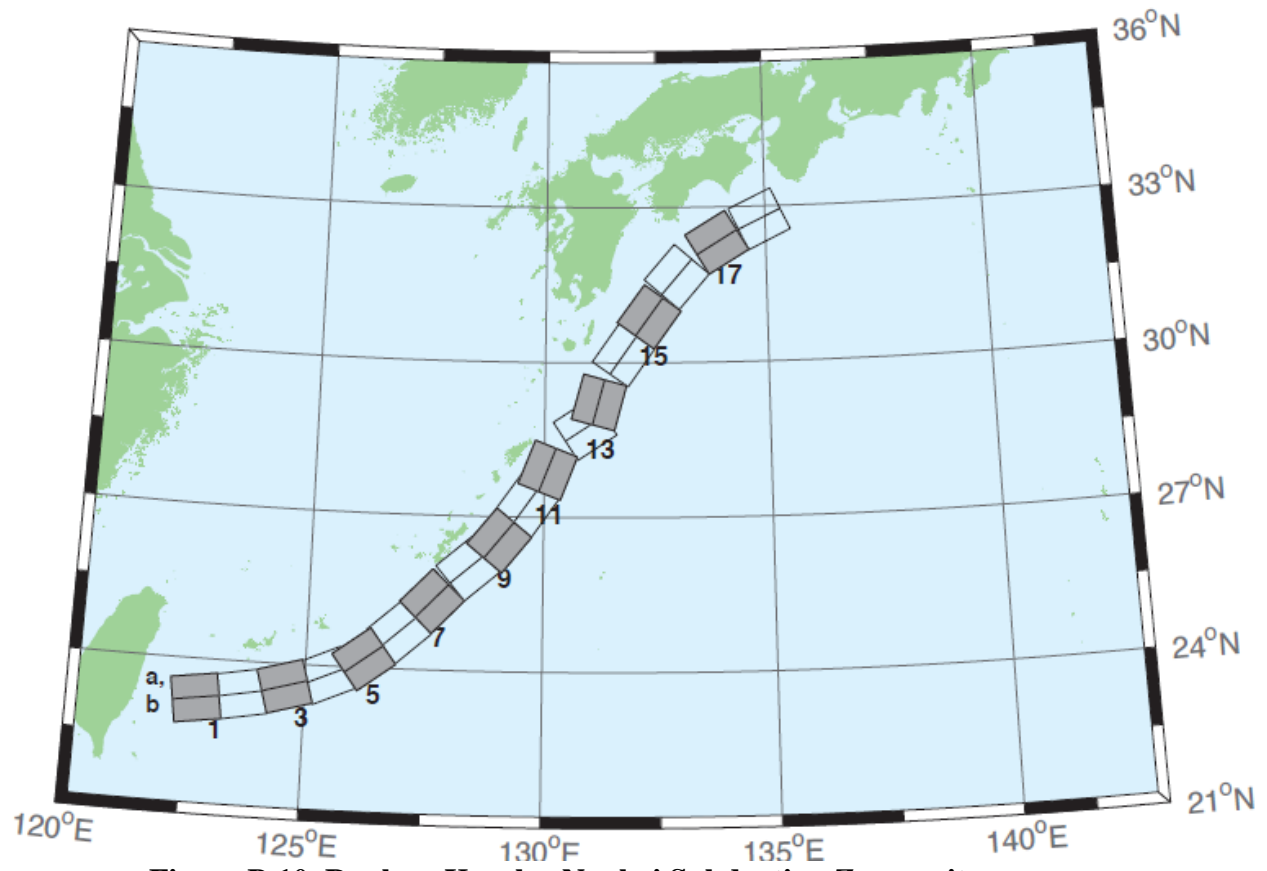
Figure B.10. Ryukyu-Kyushu-Nankai Subduction Zone unit sources.

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

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
rnsz-01a	Ryukyu-Nankai	122.6672	23.6696	14.00	262.00	11.88
rnsz-01b	Ryukyu-Nankai	122.7332	23.2380	10.00	262.00	3.20
rnsz-02a	Ryukyu-Nankai	123.5939	23.7929	18.11	259.95	12.28
rnsz-02b	Ryukyu-Nankai	123.6751	23.3725	10.00	259.95	3.60
rnsz-03a	Ryukyu-Nankai	124.4604	23.9777	19.27	254.63	14.65
rnsz-03b	Ryukyu-Nankai	124.5830	23.5689	12.18	254.63	4.10
rnsz-04a	Ryukyu-Nankai	125.2720	24.2102	18.00	246.75	20.38
rnsz-04b	Ryukyu-Nankai	125.4563	23.8177	16.00	246.75	6.60
rnsz-05a	Ryukyu-Nankai	125.9465	24.5085	18.00	233.64	20.21
rnsz-05b	Ryukyu-Nankai	126.2241	24.1645	16.00	233.64	6.43
rnsz-06a	Ryukyu-Nankai	126.6349	25.0402	17.16	228.73	19.55
rnsz-06b	Ryukyu-Nankai	126.9465	24.7176	15.16	228.73	6.47
rnsz-07a	Ryukyu-Nankai	127.2867	25.6343	15.85	224.04	17.98
rnsz-07b	Ryukyu-Nankai	127.6303	25.3339	13.56	224.04	6.26
rnsz-08a	Ryukyu-Nankai	128.0725	26.3146	14.55	229.69	14.31
rnsz-08b	Ryukyu-Nankai	128.3854	25.9831	9.64	229.69	5.94
rnsz-09a	Ryukyu-Nankai	128.6642	26.8177	15.40	219.24	12.62
rnsz-09b	Ryukyu-Nankai	129.0391	26.5438	8.00	219.24	5.66
rnsz-10a	Ryukyu-Nankai	129.2286	27.4879	17.00	215.21	12.55
rnsz-10b	Ryukyu-Nankai	129.6233	27.2402	8.16	215.21	5.45
rnsz-11a	Ryukyu-Nankai	129.6169	28.0741	17.00	201.30	12.91
rnsz-11b	Ryukyu-Nankai	130.0698	27.9181	8.80	201.30	5.26
rnsz-12a	Ryukyu-Nankai	130.6175	29.0900	16.42	236.69	13.05
rnsz-12b	Ryukyu-Nankai	130.8873	28.7299	9.57	236.69	4.74
rnsz-13a	Ryukyu-Nankai	130.7223	29.3465	20.25	195.18	15.89
rnsz-13b	Ryukyu-Nankai	131.1884	29.2362	12.98	195.18	4.66
rnsz-14a	Ryukyu-Nankai	131.3467	30.3899	22.16	215.11	19.73
rnsz-14b	Ryukyu-Nankai	131.7402	30.1507	17.48	215.11	4.71
rnsz-15a	Ryukyu-Nankai	131.9149	31.1450	15.11	216.04	16.12
rnsz-15b	Ryukyu-Nankai	132.3235	30.8899	13.46	216.04	4.48
rnsz-16a	Ryukyu-Nankai	132.5628	31.9468	10.81	220.90	10.88
rnsz-16b	Ryukyu-Nankai	132.9546	31.6579	7.19	220.90	4.62

Table B.10. continued

Segment	Description	Longitude (°)	Latitude (°)	Strike (°)	Dip (°)	Depth (km)
rnsz-17a	Ryukyu-Nankai	133.6125	32.6956	10.14	238.96	12.01
rnsz-17b	Ryukyu-Nankai	133.8823	32.3168	8.41	238.96	4.70
rnsz-18a	Ryukyu-Nankai	134.6416	33.1488	10.99	244.70	14.21
rnsz-18b	Ryukyu-Nankai	134.8656	32.7502	10.97	244.47	4.70
rnsz-19a	Ryukyu-Nankai	135.6450	33.5008	14.49	246.46	14.72
rnsz-19b	Ryukyu-Nankai	135.8523	33.1021	11.87	246.46	4.44
rnsz-20a	Ryukyu-Nankai	136.5962	33.8506	15.00	244.77	14.38
rnsz-20b	Ryukyu-Nankai	136.8179	33.4581	12.00	244.77	3.98
rnsz-21a	Ryukyu-Nankai	137.2252	34.3094	15.00	231.90	15.40
rnsz-21b	Ryukyu-Nankai	137.5480	33.9680	12.00	231.90	5.00
rnsz-22a	Ryukyu-Nankai	137.4161	34.5249	15.00	192.27	15.40
rnsz-22b	Ryukyu-Nankai	137.9301	34.4327	12.00	192.27	5.00

Appendix C. Forecast Model tests in SIFT system.

An effective forecast model must provide reliable and stable data for several hours of simulation. This is accomplished by testing the forecast model with a set of synthetic tsunami events covering a range of tsunami source locations and magnitudes. Testing is also done with selected historical tsunami events when available.

The purpose of testing the forecast model 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 similar 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 are used with tools familiar to the researcher(s) to run the Method of Splitting Tsunami (MOST) model during the forecast model development. The test results presented in this section 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 Midway Atoll tsunami forecast model that consistent results are produced irrespective of system.

C.1 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 as 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 the forecast system, 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 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.
9. Retesting the forecast models in the forecast system when reported issues have been addressed or explained.

Simulation of the synthetic models 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 32 GB memory. The processors are hex core and support hyper-threading, 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.

C.2 Results

The Midway Atoll forecast model was tested with SIFT version 3.2 with MOST v2.

The Midway Atoll forecast model was tested with four synthetic scenarios and one historical tsunami event. Test results from the forecast system and comparisons with the results obtained during the forecast model development are shown numerically in Table C.1 and graphically in Figures C.1 to C.5. The results show that the forecast model is stable and robust, with consistent and high-quality results across geographically distributed tsunami sources and mega-event tsunami magnitudes. The model run time (wall-clock time) was under 23.63 min for 6 hr of simulation time, and under 15.76 min for 4 hr. This run time is not within the 10 min run time requirement for 4 hr of simulation time and does not satisfy time efficiency requirements. This is attributed to the grid resolution used in the forecast model. Meeting the 10 min run for a 4 hr of tsunami simulation would require a coarser grid resolution or smaller grid coverage or both. Both options are not recommended since Midway Atoll consists of small islands and a coarse grid resolution might result in the loss of some island features. A smaller grid coverage is also not recommended since the C-grid coverage is such that it includes the shallow reef areas.

Four synthetic events were run on the Midway Atoll forecast model. A slip of 30 m was used rather than the standard 25 m for direct comparison purposes. The modeled scenarios were stable for all cases tested, with no instabilities or ringing. Results show that the largest modeled tsunami wave amplitude was 390 cm and originated in the Kamchatka-Yap-Mariana-Izu-Bonin (KISZ 22-31) source. Amplitudes greater than 100 cm were recorded for all test sources. The smallest signal of 107 cm was recorded at the far-field Central and South American (CSSZ 89-98) source. The largest modeled tsunami wave amplitude indicated in this section is based only from the four synthetic events (Table C.1) and does not represent the largest tsunami wave amplitude from the 42 tested during its development. Direct comparisons of output from the forecast tool with results of both the historical event (2011 Tohoku) and available development

112

synthetic events demonstrated that the wave pattern at the selected warning point was nearly identical.

Table C.1. Table of maximum and minimum amplitudes (cm) at the Midway Atoll warning point for synthetic and historical events tested using SIFT 3.2 and obtained during development.

| Scenario Name	Source Zone	Tsunami Source	α [m]	SIFT Max (cm)	Development Max (cm)	SIFT Min (cm)	Development Min (cm)
Mega-tsunami Scenarios
KISZ 22-31	Kamchatka-Yap-Mariana-Izu-Bonin	A22-A31, B22-B31	30	389.5	389.5	-133.6	-133.6
ACSZ 56-65	Aleutian-Alaska-Cascadia	A56-A65, B56-B65	30	150.7	150.4	-131.7	-131.7
CSSZ 91-100	Central and South America	A91-A100, B91-B100	30	106.7	106.7	-103.0	-103.0
NTSZ 30-39	New Zealand-Kermadec-Tonga	A30-A39, B30-B39	30	149.9	149.9	-115.9	-115.9
Historical Events
Tohoku 2011	Kamchatka-Yap-Mariana-Izu-Bonin	See Table 2		222.0	222.4	-162.8	-162.5
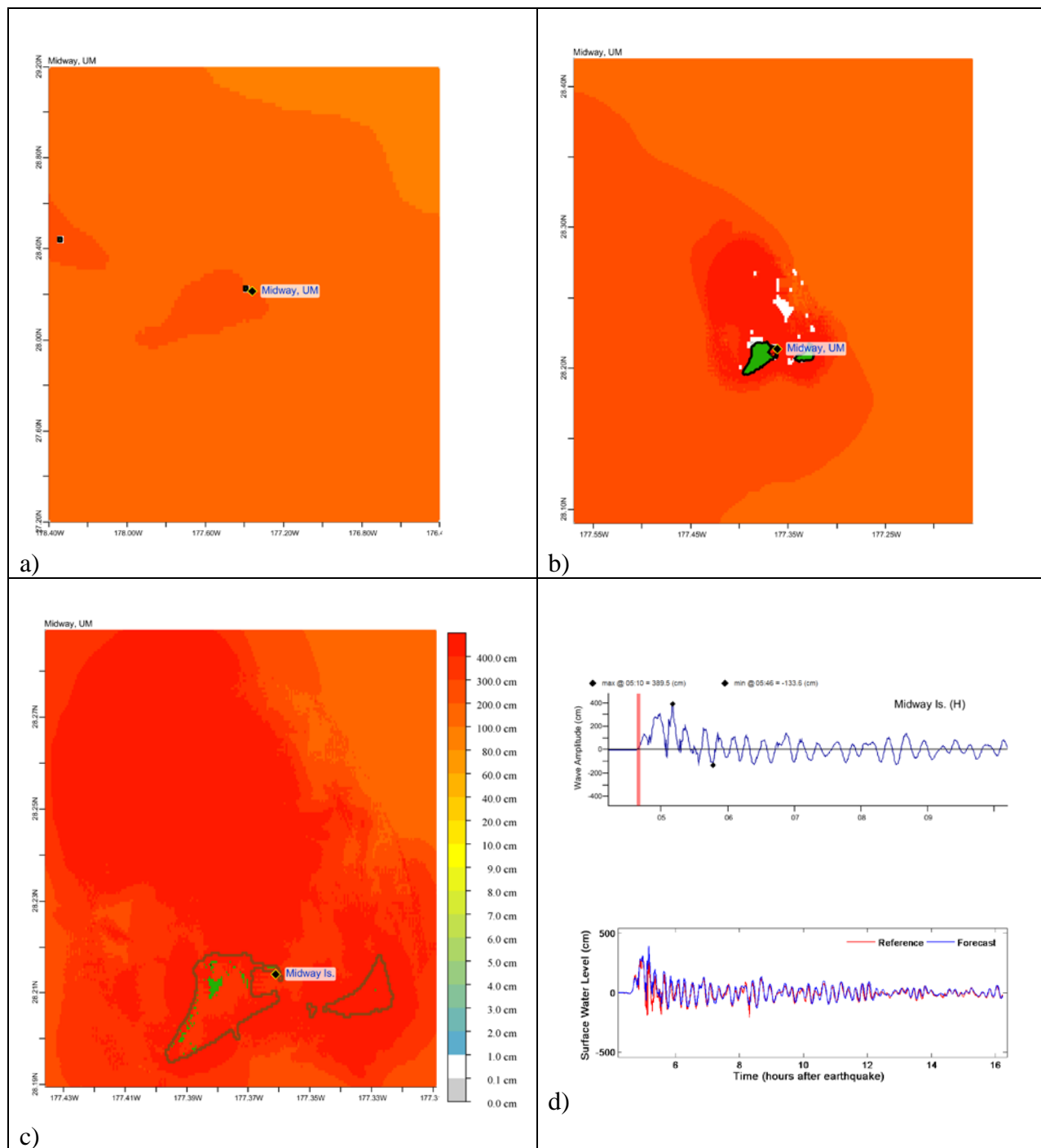
Figure C.1. Response of the Midway Atoll forecast model to synthetic scenario KISZ 22-31 (alpha=30). Maximum sea surface elevation for (a) A grid, b) B grid, c) C grid. Sea surface elevation time series at the C-grid warning point (d). The lower time series plot is the result obtained during model development and is shown for comparison with test results.
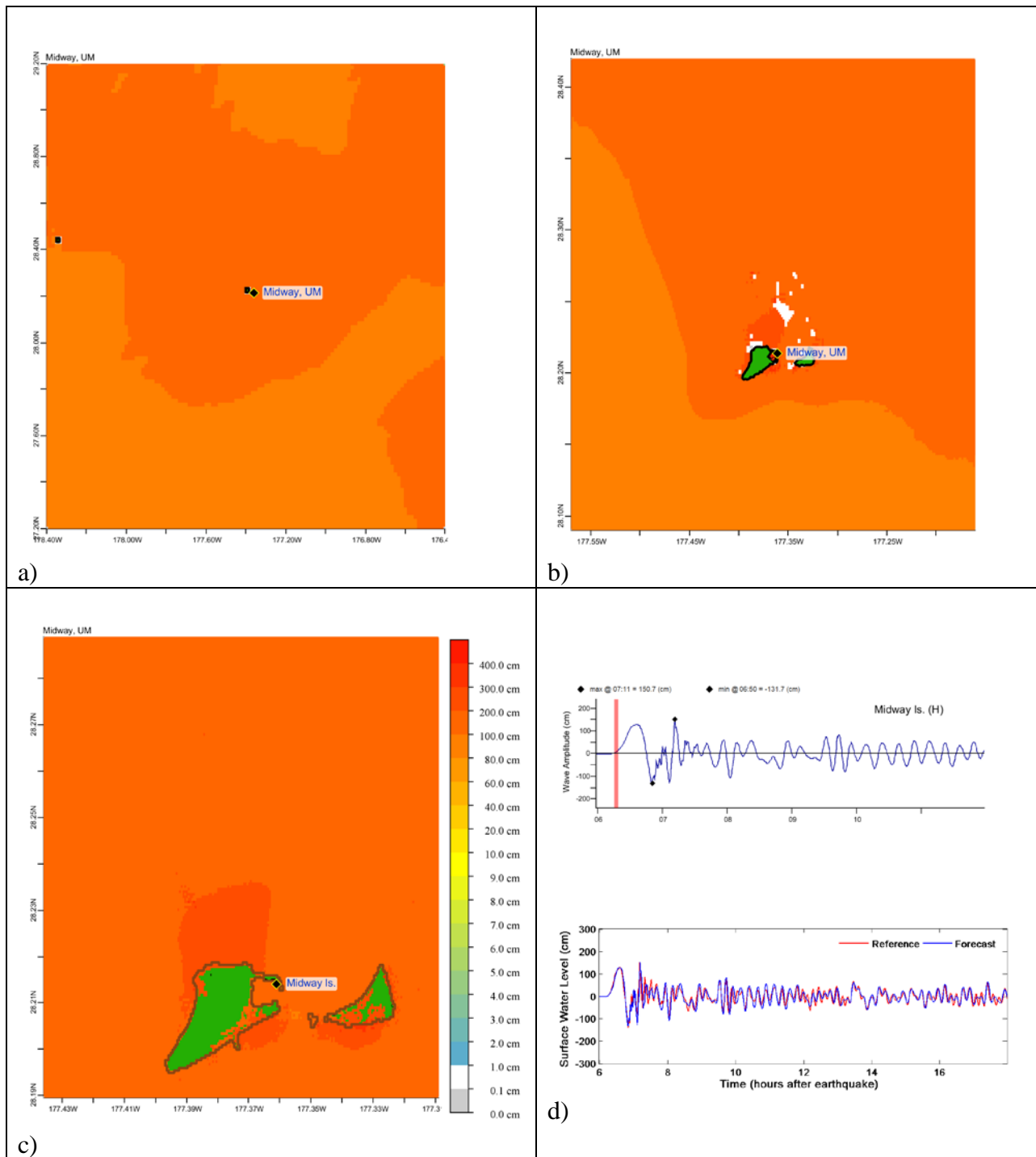
Figure C.2. Response of the Midway Atoll forecast model to synthetic scenario ACSZ 56-65 (alpha=30). Maximum sea surface elevation for (a) A grid, b) B grid, c) C grid. Sea surface elevation time series at the C-grid warning point (d). The lower time series plot is the result obtained during model development and is shown for comparison with test results.
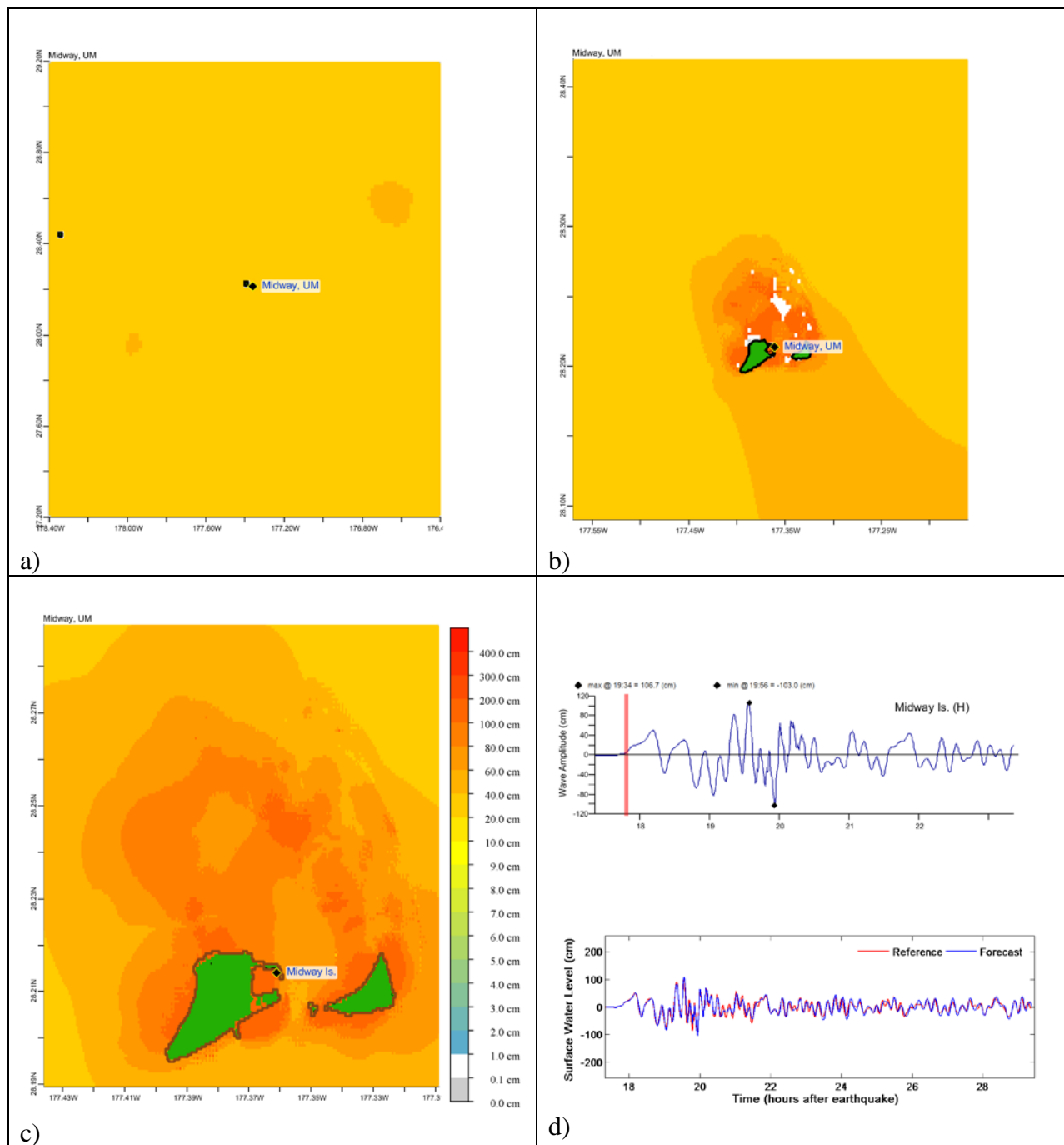
Figure C.3. Response of the Midway Atoll forecast model to synthetic scenario CSSZ 91-100 (alpha=30). Maximum sea surface elevation for (a) A grid, b) B grid, c) C grid. Sea surface elevation time series at the C-grid warning point (d). The lower time series plot is the result obtained during model development and is shown for comparison with test results.
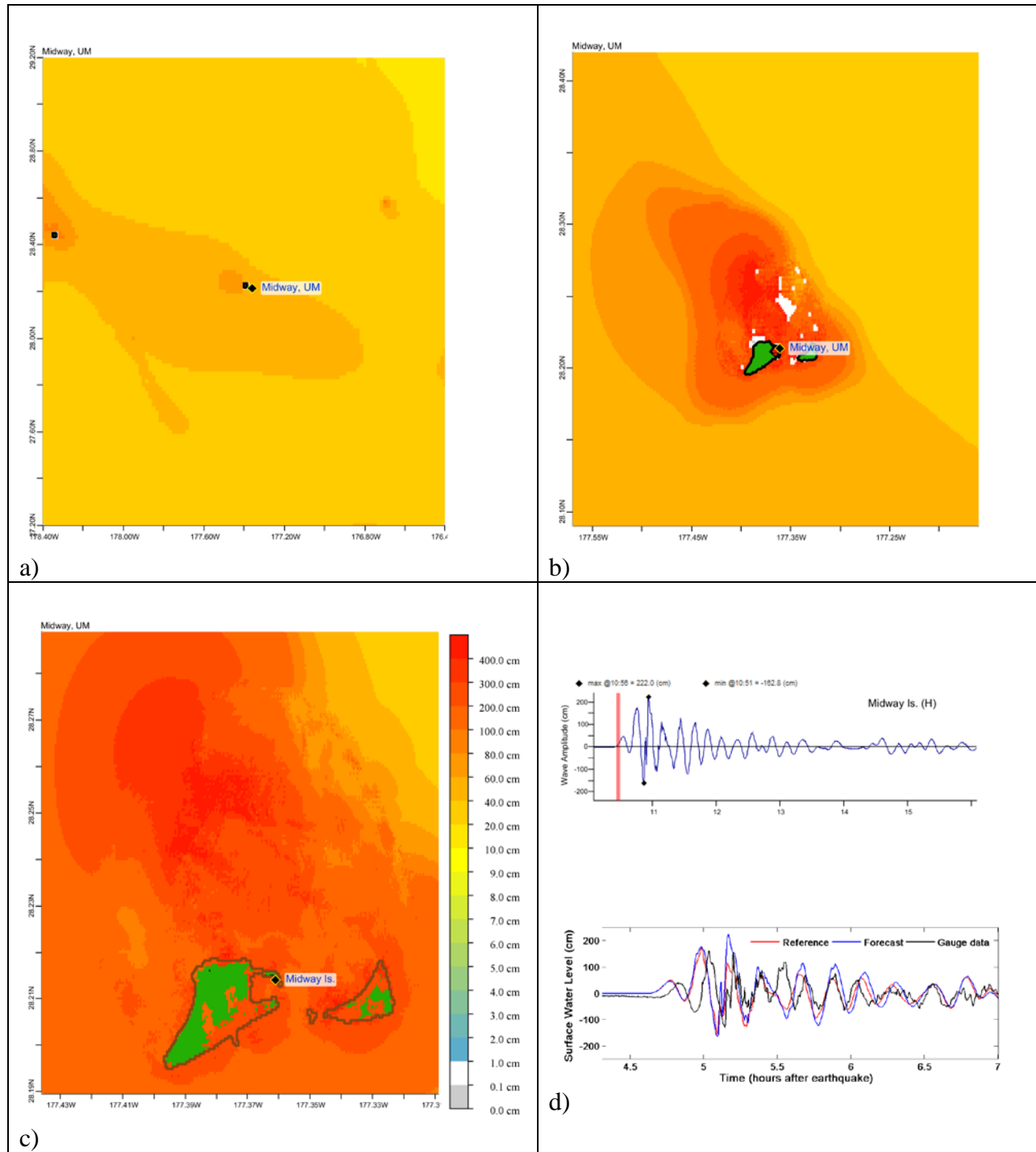
117
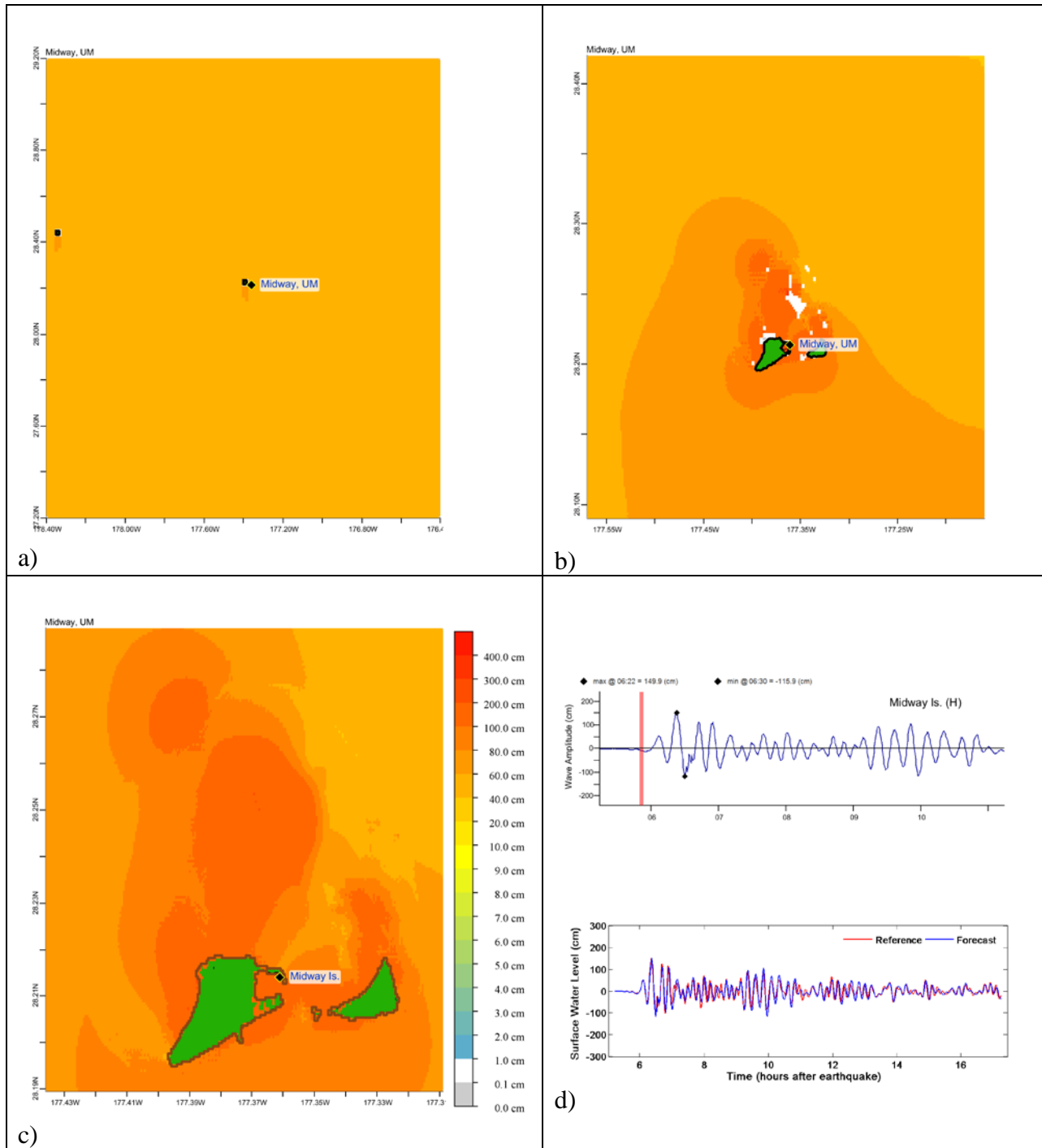
Figure C.4. Response of the Midway Atoll forecast model to synthetic scenario NTSZ 30-39 (alpha=30). Maximum sea surface elevation for (a) A grid, b) B grid, c) C grid. Sea surface elevation time series at the C-grid warning point (d). The lower time series plot is the result obtained during model development and is shown for comparison with test results.

Figure C.5. Response of the Midway Atoll forecast model to the 2011 Tohoku tsunami. Maximum sea surface elevation for (a) A grid, b) B grid, c) C grid. Sea surface elevation time series at the C-grid warning point (d). The lower time series plot is the result obtained during model development and is shown for comparison with test results.

Glossary

Arrival time The time when the first tsunami wave is observed at a particular location, typically given in local and/or universal time, but also commonly noted in minutes or hours relative to the time of the earthquake.

Bathymetry The measurement of water depth of an undisturbed body of water.

Cascadia Subduction Zone Fault that extends from Cape Mendocino in Northern California northward to mid-Vancouver Island, Canada. The fault marks the convergence boundary where the Juan de Fuca tectonic plate is being subducted under the margin of the North America plate.

Current speed The scalar rate of water motion measured as distance/time.

Current velocity Movement of water expressed as a vector quantity. Velocity is the distance of movement per time coupled with direction of motion.

Deep-ocean Assessment and Reporting of Tsunamis (DART®) Tsunami detection and transmission system that measures the pressure of an overlying column of water and detects the passage of tsunami.

Digital Elevation Model (DEM) A digital representation of bathymetry or topography based on regional survey data or satellite imagery. Data are arrays of regularly spaced elevations referenced to a map projection of the geographic coordinate system.

Epicenter The point on the surface of the earth that is directly above the focus of an earthquake.

Far-field Region outside of the source of a tsunami where no direct observations of the tsunami-generating event are evident, except for the tsunami waves themselves.

Focus The point beneath the surface of the earth where a rupture or energy release occurs due to a buildup of stress or the movement of earth's tectonic plates relative to one another.

Inundation The horizontal inland extent of land that a tsunami penetrates, generally measured perpendicularly to a shoreline.

Marigram Tide gauge recording of wave level as a function of time at a par ticular location. The instrument used for recording is termed a marigraph.

Method of Splitting Tsunami (MOST) A suite of numerical simulation codes used to provide estimates of the three processes of tsunami evolution: tsunami generation, propagation, and inundation.

Moment magnitude (M_w) The magnitude of an earthquake on a logarithmic scale in terms of the energy released. Moment magnitude is based on the size and characteristics of a fault rupture as determined from long-period seismic waves.

Near–field Region of primary tsunami impact near the source of the tsunami. The near-field is defined as the region where non-tsunami effects of the tsunami-generating event have been observed, such as earth shaking from the earthquake, visible or measured ground deformation, or other direct (non-tsunami) evidences of the source of the tsunami wave.

Propagation database A basin-wide database of pre-computed water elevations and flow velocities at uniformly spaced grid points throughout the world oceans. Values are computed from tsunamis generated by earthquakes with a fault rupture at any one of discrete 100×50 km unit sources along worldwide subduction zones.

Runup Vertical difference between the elevation of tsunami inundation and the sea level at the time of a tsunami. Runup is the elevation of the highest point of land inundated by a tsunami as measured relative to a stated datum, such as mean sea level.

Short-term Inundation Forecasting for Tsunamis (SIFT) A tsunami forecast system that integrates tsunami observations in the deep ocean with numerical models to provide an estimate of tsunami wave arrival and amplitude at specific coastal locations while a tsunami propagates across an ocean basin.

Subduction zone A submarine region of the earth's crust at which two or more tectonic plates converge to cause one plate to sink under another, overriding plate. Subduction zones are regions of high seismic activity.

Synthetic event Hypothetical events based on computer simulations or theory of possible or even likely future scenarios.

Tele–tsunami or **distant tsunami** or **far–field tsunami** Most commonly, a tsunami originating from a source greater than 1000 km away from a particular location. In some contexts, a tele-tsunami is one that propagates through deep ocean before reaching a particular location without regard to distance separation.

Tidal wave Term frequently used incorrectly as a synonym for tsunami. A tsunami is unrelated to the predictable periodic rise and fall of sea level due to the gravitational attractions of the moon and sun (see **Tide**, below).

Tide The predictable rise and fall of a body of water (ocean, sea, bay, etc.) due to the gravitational attractions of the moon and sun.

Tide gauge An instrument for measuring the rise and fall of a column of water over time at a particular location.

Travel time The time it takes for a tsunami to travel from the generating source to a particular location.

Tsunameter An oceanographic instrument used to detect and measure tsunamis in the deep ocean. Tsunami measurements are typically transmitted acoustically to a surface buoy that in turn relays them in real time to ground stations via satellite.

Tsunami A Japanese term that literally translates to "harbor wave." Tsunamis are a series of long-period shallow water waves that are generated by the sudden displacement of water due to subsea disturbances

121

such as earthquakes, submarine landslides, or volcanic eruptions. Less commonly, meteoric impact to the ocean or meteorological forcing can generate a tsunami.

Tsunami hazard assessment A systematic investigation of seismically active regions of the world oceans to determine their potential tsunami impact at a particular location. Numerical models are typically used to characterize tsunami generation, propagation, and inundation, and to quantify the risk posed to a particular community from tsunamis generated in each source region investigated.

Tsunami magnitude A number that characterizes the strength of a tsunami based on the tsunami wave amplitudes. Several different tsunami magnitude determination methods have been proposed.

Tsunami propagation The directional movement of a tsunami wave outward from the source of generation. The speed at which a tsunami propagates depends on the depth of the water column in which the wave is traveling. Tsunamis travel at a speed of 700 km/hr (450 mi/hr) over the average depth of 4000 m in the open deep Pacific Ocean.

Tsunami source Location of tsunami origin, most typically an underwater earthquake epicenter. Tsunamis are also generated by submarine landslides, underwater volcanic eruptions, or, less commonly, by meteoric impact of the ocean.

Wall-clock time The time that passes on a common clock or watch between the start and end of a model run, as distinguished from the time needed by a CPU or computer processor to complete the run, typically less than wall-clock time.

Wave amplitude The maximum vertical rise or drop of a column of water as measured from wave crest (peak) or trough to a defined mean water level state.

Wave crest or peak The highest part of a wave or maximum rise above a defined mean water level state, such as mean lower low water.

Wave height The vertical difference between the highest part of a specific wave (crest) and its corresponding lowest point (trough).

Wavelength The horizontal distance between two successive wave crests or troughs.

Wave period The length of time between the passage of two successive wave crests or troughs as measured at a fixed location.

Wave trough The lowest part of a wave or the maximum drop below a defined mean water level state, such as mean lower low water.