The Kuril Islands Tsunami of November 2006
Part I: Impact at Crescent City by distant scattering

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Abstract. A numerical model for the global tsunami computation constructed by Kowalik et al. (2005, 2007a), is applied to the tsunami of November 15, 2006 in the Northern Pacific with spatial resolution of one minute. Numerical results are compared to sea level data collected by Pacific DART buoys. The tide gauge at Crescent City (CC) recorded an initial tsunami wave of about 20 cm amplitude and a second larger energy packet arriving two hours later. The first energy input into the CC harbor was the primary (direct) wave traveling over the deep waters of the North Pacific. Interactions with submarine ridges and numerous seamounts located in the tsunami path were a larger source of tsunami energy than the direct wave. Travel time for these amplified energy fluxes is longer than for the direct wave. Prime sources for the larger fluxes at CC are interactions with Koko Guyot and Hess Rise. Tsunami waves travel next over the Mendocino Escarpment where the tsunami energy flux is concentrated due to refraction and directed towards CC. Local tsunami amplification over the shelf-break and shelf are important as well. In many locations along the North Pacific coast, the first arriving signal or forerunner, has lower amplitude than the main signal which often is delayed. Understanding this temporal distribution is important for an application to tsunami warning and prediction. As a tsunami hazard mitigation tool, we propose that along with the sea level records (which are often quite noisy) an energy flux for prediction of the delayed tsunami signals be used.

1. Introduction

On November 15, 2006 at 11:14:16 (UTC) an earthquake with moment magnitude 8.3 (http://earthquake.usgs.gov/eqcenter/recenteqww/Quakes/usvcsn.php) generated a tsunami near the Kuril Islands. Tsunamis propagated over the entire Pacific Ocean. The resulting sea level disturbance was recorded by DART buoys located in the open ocean and by many coastal tide gauges. Buoy data showed that the duration of tsunami signal while propagating away from the source was steadily increasing (with distance from source) and that often the first group of tsunami waves did not include the highest waves. Along the Japanese coast, the highest tsunami waves arrived just minutes after the initial tsunami waves arrival (largest amplitude 40 cm occurred at Hanasaki). The initial wave at Kahului (Maui) of 50 cm amplitude was followed 2 hours later by a wave of 76 cm amplitude. This pattern can be observed in many locations along the Pacific coast. The small initial tsunami of about 20 cm was barely noticed at Crescent City (CC). The highest wave of about 88 cm amplitude was recorded 2–3 hours later. No other west coast tidal stations recorded such a high wave. Large tsunamis which propagate globally can be amplified in locations remote from the source zone. The Chile (1960) and Alaska (1964) earthquakes generated tsunamis which produced unusually high waves in many distant locations. The 1960 tsunami, well recorded along the US West Coast, produced amplitudes often in excess of 1 m with the largest wave height of 1.7 m measured at CC [Landers and Lockridge, 1989]. The tsunami from the Alaska Good Friday earthquake (1964) generated wave amplitudes in excess of 1 m along the US West Coast. Again CC suffered the greatest damage due to a high wave exceeding 4 m amplitude [Wiegel, 1965]. Using the Kuril tsunami example we intend to investigate the behavior of the transoceanic tsunami and the special conditions which cause tsunami enhancement at CC. Our investigation is aimed to demonstrate that the tsunami amplification at CC is caused by both the redirection of tsunami energy over long distances of propagation and by amplification due to the local bathymetry. The effects of amplifications of the distant tsunami were studied by Hebert et al. [2001] by examining tsunami inundations observed on the Marquesas Islands. One case study considered by Hebert et al. [2001] was the 1994 Kuril tsunami. It clearly demonstrated the importance of long volcanic ridges and fracture zones in directing tsunami signals towards the distant locations and it bears strong resemblance to the November 15, 2006 tsunami. Studies of topographic transformations of tsunami signal in the open ocean due to ridges were summarized by Mei et al. [2005]. Usually, incident energy flux on a ridge is split into reflected and transmitted fluxes. The scattering of tsunami energy by bottom topography in such an approach is a function of depth of water over topographic features. In order to better understand this process Mofjeld et al. [2000] introduced a tsunami scattering index which is expressed by the ratio of the transmitted wave amplitude to that of the incident wave. One cannot exclude the possibility of a more complicated process like resonant interaction of the tsunami wave and ridge bathymetry. Snodgrass et al. [1962] demonstrated the presence of discrete spectra in waves trapped over depth discontinuities and Mei et al. [2005] showed that over a stepped
bottom ridge the discrete spectra exist as well. If an incident wave can excite these trapped modes, an amplification of the tsunami signal due to resonance will follow. The high-resolution model applied to the Indian Ocean Tsunami of 2004 [Kowalik et al., 2005, 2007a] showed a complex pattern of tsunami/bathymetry interaction. In the southern Pacific, and especially the Atlantic Ocean, tsunami wave propagation was accompanied by wave energy ducting along oceanic ridges. Travel time for these amplified energy fluxes was much longer than the travel time of the first wave. Therefore, the arrival time of these amplified waves is important for tsunami warning and prediction.

Amplification of the tsunami signal at CC during the events of 1960 and 1964 was investigated by assuming distant or local enhancement. Mader and Bernard [1993] and Bernard et al. [1994] modeled the Aleutian Island (Unimak Island) tsunami of April 1946 and the March 1964 tsunami generated in the Gulf of Alaska, concluding that directionality of the tsunami source was the primary cause of the tsunami enhancement. On the other hand the amplification was frequently studied assuming that either local (harbor) geometry or shelf and coastal geometry has natural periods in the tsunami range of periods [Roberts, and Kauper, 1964; Keulegan, Harrison and Mathews, 1969]. The interaction of the tsunami wave with the shelf geometry often results in the trapping and amplification of the tsunami energy. Gonzalez et al. [1995] suggested that the high amplitude tsunami waves generated by the 25 April 1992 Cape Mendocino earthquake at CC were induced by the coastal trapped edge wave. An analytical solution of tsunami obliquely incident on a continental slope derived by Koshimura et al. [1999] confirms existence of the amplification of the edge waves and possibility of a resonance in the period range of tsunamis. New observations of tsunamis at the coast of Japan by Yanuma and Tsuji [1998] indicate that the shelf trapped edge wave strongly interact with the fundamental mode of a nearby harbor.

2. Source Function

The generation mechanism for the Kuril Islands tsunami model is the static sea floor uplift caused by abrupt slip at the plate interface. Actual sea floor uplift has a complicated structure composed of many blocks motion (Lobkowsky et al., 2002) but often it is considered as one continuous block (Okada [1985]). Permanent, vertical sea floor displacement is computed using the static dislocation formulae from Okada [1985]. Inputs to these formulae are parameters defining the fault plane geometry: depth (13 km), strike (215°), dip (15°), slip (92°), length (240 km), and width (80 km) as well as seismic moment (Mo = 3.5×10^28 dyne cm) and rigidity (4.2×10^{11} dyne cm^{-2}).

The bottom displacement used in computation is given in a rectangular region 45°N–49°N and 152°E–156°E, see Figure 1.

3. Distribution of Maximum Amplitude

To study tsunamis, the vertically averaged equations of motion and continuity are formulated in spherical polar coordinates [Gill, 1982]. Dissipation is described by the nonlinear bottom friction term with non-dimensional coefficient \( r = 0.003 \). The solution of this set of equations is advanced in time by the two-time-level numerical scheme. For the spatial derivatives the second order of approximation is constructed [Imamura, 1996; Mader, 2004; Kowalik et al., 2005, 2007a]. The full description of the numerical model is
given in [Kowalik et al., 2005]. A special numerical scheme is developed for the nonlinear terms in the equations of motion and continuity based on the higher order upwind-downwind approach. The spatial grid step of numerical computation was 1 one arcminute and the time step was set to 2 s. The total number of grid points was close to 100 million. A small spatial step is important as the short-period waves can be obliterated during large distances of propagation when using larger spatial steps. The integration domain extends from 80°S to 69°N and from 120°E to 70°W. The boundaries include both wet and dry points. At coastal (dry points) the normal velocity is set to zero. New dry and wet points may be generated through the runup/rundown) algorithm. At wet points on domain boundaries, the radiation condition established by Reid and Bodine [1968] is used. Model computations using the tsunami source (Figure 1) were made for 20 hours of propagation, allowing the tsunami signal to cross the entire Pacific Ocean. During computation the maximum tsunami amplitude in every grid point was recorded. The plot of maximum amplitude in the Pacific Ocean is shown in Figure 2.

![Maximum amplitude in the Pacific.](image)

Figure 2. Maximum modeled tsunami amplitude in the Pacific.

The maximum amplitude distribution in Figure 2 shows that the tsunami traveled over the entire Pacific. The elongated tsunami source (Figure 1) directs the main lobe of wave energy towards the southern hemisphere, but strong maximum amplitudes are also observed along the shores of the North Pacific. Some of the tsunami energy propagates in a finger-like pattern, a product of wave refraction and focusing around islands/seamounts/passages chain systems. Closer examinations show that the oceanic ridges and seamounts tend to refocus tsunami energy. Our interest is in energy concentration along the Mendocino Escarpment which is directed towards Crescent City. Figure 2 also depicts the amplitude enhancement in shallow water region along the coasts and especially around the islands. Even islands located far from the source such as the Galapagos or Marquesas show quite strong tsunami amplification due to coastal energy trapping.

4. Important Stages in the Kuril Islands Tsunami Development

Although tsunami spreads over the entire Pacific, the main signal was confined to the northern hemisphere. In this domain we intend to investigate tsunami development and especially tsunami amplification in the vicinity of Crescent City (CC). The tsunami onset was
registered on November 15, 2006 at 11:14:16(UTC). The starting time in all our computations ($t = 0$) is the tsunami onset time. The model results will be compared with data recorded by DART buoys. In Figure 3 the bathymetry used in our computation (based on [GEBCO Digital Atlas, 2003]) and some locations of DART buoys are given.

Bathymetric features important in reorganizing and focusing tsunami signal towards CC are shown in Figure 3. Tsunami propagation is shown in Figure 4. The signal as generated by the source from the Figure 1 is traveling as a positive wave towards the southeast Pacific and as a negative wave into Okhotsk Sea (Figure 4 upper panel). While interacting with the Emperor Seamount Chain and with the exceptionally large Koko Guyot [Davies et al., 1972] tsunami is scattered into new directions and by interference generates a new set of waves (Figure 4 second panel from top). Further tsunami energy is trapped and dispersed by the Hess Rise (Figure 4 third panel from the top).

A complicated packet of waves arrives at CC, with the first arrival preserving the properties of the initial wave generated in the Kuril Islands trench, and a second, larger wave group arriving about 2 hours later. Differences in the wave front direction show that the two waves travel different routes. While the first wave group arrives from the north-west via the great circle route and deep Aleutian trench, the second wave group arrives from the west. This latter wave is directed towards CC by secondary sources. The comparison of the tsunami signal recorded by DART buoys and calculated by the model are given in Figure 5.

The overall amplitude recorded at DART buoy locations is of the order of a few centimeters. These are typical tsunami amplitudes for buoys anchored in deep oceanic basins far from the source zone and off the main energy lobe. The computation simulates relatively well the first cycle of wave motion and the amplitude modulation in time in all buoys. Computations for the DART buoy closest to CC (D411, located at 127°W, 39.34°N) turned out to be in satisfactory agreement with recorded sea level. To investigate tsunami signal enhancement by the Mendocino Escarpment (i.e. step-like bathymetry change) three time-series numerical results are shown in Figure 6. The numerical gauges are located along 127°W longitude at 43°20′N, 41°20′N and 39°20′N respectively. The deeper numerical gauge
Figure 4. Snapshots of Kuril tsunami development in the Northern Pacific. Large bathymetric features, like Koko Guyot and Hess Rise scatter tsunami in directions different from the incident direction. Time is given from the tsunami onset.

is situated south of the Mendocino Escarpment at a depth of 4304 m. The other two are situated north of the Mendocino Escarpment (on the step). One is facing CC (middle gauge) at a depth of 2585 m and the other just north at a depth of 2948 m.
The first wave arrivals are quite similar at all numerical gauges and they show an increasing time delay going from north to south. Thus we can conclude that the first tsunami signal arrives from the north or northwest. The largest amplitude in the second packet of waves arrives about 2 hours after the initial tsunami, and peaks at about 2.7 cm at the northern numerical gauge, 4.7 cm at the middle gauge, and 2 cm at the southern gauge.

5. Why Tsunami is Amplified Along the Mendocino Escarpment – Energy Flux Approach

Observations of the Kuril Islands tsunami in Crescent City (CC) showed that the initial wave of 15–25 cm amplitude was followed about 2 hours later by a wave of 60–80 cm amplitude. Inspection of the DART buoy D411 (127°W, 39.34°N) in Figure 5 which is closest to CC, show that the sea level variations two hours after the initial wave are only slightly amplified when compared to the initial wave. It seems that amplification shown in Figure 2 takes place in the very narrow range of latitudes. To study the energy from the distant tsunami sources it is natural to introduce the energy flux vector [Kowalik et al., 2007b]. In the rectangular system of coordinates, with the x coordinate along E–W direction and y along N–S direction, the u component of velocity along x direction can be combined with the sea level (ζ) to define the E–W component of the energy flux vector e.g. [Kowalik and Murty, 1993]:

\[ E_x = \rho H u \left[ g \zeta + \frac{1}{2}(u^2 + v^2) \right]. \]  

(1)

Similarly, the N–S component of the energy flux vector is defined (with v, the velocity component along the y direction):

\[ E_y = \rho H v \left[ g \zeta + \frac{1}{2}(u^2 + v^2) \right], \]  

(2)

where: \( \rho \) is the sea water density, \( g = 9.81 \text{ms}^{-2} \) is the Earth’s gravity acceleration and \( H \) is the ocean depth. The energy flux vector for the progressive wave propagates in the direction given by the sign of the product of sea level times velocity and is perpendicular to the wave front.

Figure 5. Sea level during Kuril Tsunami of Nov. 15, 2006. Blue color: recorded by DART buoys, red color: model computation. Time is given from the tsunami onset.
To investigate the pattern of energy trapping over the Mendocino Escarpment as shown in Figure 2, the energy flux is used in two simple experiments. Three waves of 16 minutes period each and 10 cm amplitude are sent towards the west coast of North America from the open boundary located at 150°W (Figure 7a, left panel). In Figure 7a (right panel) the wave pattern 160 minutes later is shown. The energy flux vectors in these figures demonstrate the strong local amplification of energy flux during wave propagation towards CC. The wave amplitude shows a corresponding strong local amplification as well. The central latitude for the amplified wave is 41°N–42°N, while the Mendocino Escarpment is located close to 40°N. Thus the center of amplification is located in the narrow range of 1–2 degree of latitude just north from the escarpment. This result is confirmed by Figure 6 where tsunami traveling along 41°20’N shows the strongest amplification for the later arriving wave group. Experiments with various wave periods resulted in the same pattern of high amplification within a narrow latitude band just north of the Mendocino Escarpment. Obviously the energy flux pattern depicted in Figure 7a is related to the depth difference along the N–S direction when crossing the escarpment. The wave south of the escarpment travels faster than the wave on the northern side of escarpment. This difference in the phase speed causes wave refraction [Wiegel, 1965; Mei et al., 2005] resulting in steady energy amplification and focusing towards CC. The amplification shown above is related to the second wave group which as we are going to demonstrate arrives from the west. The initial wave as seen from Figure 4 arrives from the north–west and does not travel along the Mendocino Escarpment for any great distance.

In the second experiment three waves of 25 minutes period each and 10 cm amplitude are sent from the northern boundary towards the Mendocino Escarpment (Figure 7b, left panel). The wave pattern 110 minutes later is shown in Figure 7b, right panel. Tsunami waves...
cross the escarpment without amplification. The direction of wave propagation seems to play the major role in tsunami enhancement along the Mendocino Escarpment.

In the above computations according to Figure 6 we have applied shorter period (16 min) for the wave arriving from the west and longer period for the wave arriving from the north (25 min). Numerical experiments with wave periods from 10 min to 60 min confirmed that the above patterns of wave propagation are independent of the wave period.

From Figures 7, one can also appreciate an important property of the energy flux. While the wave height can change sign, the energy flux of the progressive wave is always aligned with the direction of wave front propagation. Thus the noisy behavior of the sea level is replaced by the steadier behavior of the energy flux. This property is important in our search for the energy incoming towards CC. To investigate energy flux traveling towards CC during the Kuril tsunami we consider a 5 degree box enclosing CC and calculate the energy flowing into and out of the box. The box around CC is constructed as follows. The west boundary is located at 129°W, the north boundary at 44.5°N, the south boundary at 39.5°N and the east boundary is on land. The time dependent energy flux is averaged over the length of each boundary.

**Figure 7.** a) Three waves of 10 cm amplitude and 16 minutes period travel parallel to the Mendocino Escarpment. b) Three waves of 10 cm amplitude and 25 minutes period travel from the north towards Mendocino Escarpment. Amplitude given by colors. Vectors denote energy flux.
Energy flux through the western (blue), northern (red) and southern (green) walls of a 5 degree box around Crescent City.

The results given in Figure 8 show two distinct pulses of energy crossing the western face of the box towards CC. Within the second pulse, two maxima occur separated by 20 minutes time interval. Energy appears to have a period of about 6–15 minutes. The periodicity of the energy flux of the progressive waves is different from the sea level oscillation, as its period of propagation is two times shorter than that of the sea level or velocity [Henry and Foreman, 2001]. It is interesting to see that there is very little reflected energy coming back across the faces of the box. This must mean that most of the incident energy is dissipated by the near shore bottom friction.

Nearly the entire energy flux enters the box through the western wall. Although the first wave group propagates from the northwest (see Figure 4), the front of these waves becomes nearly parallel to the shore due to refraction (see Figure 4 and 7b).

Energy flux through faces of the box around CC can be easily applied to pinpoint the source of the second wave packet. First we simply remove from the bathymetry the Hess Rise (see Figure 3) by setting it to the depth of 5000 m. Next, the Koko Guyot is removed in the same manner. In Figure 9 the energy flux crossing the western wall is plotted; in the upper panel the Hess Rise is removed but the Koko Guyot stays unchanged and in the lower panel the Koko Guyot has been removed while the Hess Rise remains unchanged. For comparison the energy flux across the western face from Figure 8 is also given.

The absence of Koko Guyot resulted in a restructuring of the energy flux through the western face of the box in such a way that the first maximum in the second wave group practically disappeared (Figure 9 lower panel). The second maximum in this later wave group, as the upper panel shows, is related to the Hess Rise. The absence of the Hess Rise leads to energy amplification from the Koko Guyot as the Hess Rise did not scatter any longer the energy send by Koko Guyot towards CC. We can also conclude from Figure 9 that the first group of waves to arrive at CC must travel a route unobstructed by either Koko Guyot or the Hess Rise.

The immense influence of the Koko Guyot on tsunami signal scattering is due to its size and strong contrast be-
between shallow and deep waters. It rises from the depth of 4750 m to within 250 m of the ocean surface Davies et al. [1972]. To further identify Koko Guyot as an important bathymetric feature, we plot in Figure 10 the energy flux vectors immediately following passage of the main energy lobe past Koko. Note the new wave front radiating from this secondary source. The Hess Rise is an elongated plateau, located to the east from Koko Guyot, with a few smaller subdomains which generally parallel the Mendocino Escarpment [GEBCO Digital Atlas, 2003]. Although it rises from the deep ocean plain to just 1500 m below the surface, it extends 1000 km in the E-W direction. The Hess Rise ridge like structure tends to enhance tsunami scattered from Koko Guyot and directs it towards Mendocino Escarpment, see Figure 10.

6. Spatial Resolution

The latter experiments show that the strength of the second group of waves arriving at Crescent City (CC) depend strongly on bottom topography. Therefore it is important to investigate whether the numerical bottom bathymetry changes resulting from different spatial resolutions will change the predicted tsunami amplitude and phase. The influence of the magnitude of the spatial step used in the numerical model is investigated by computing the Kuril Islands tsunami generated by the same source function but with two different space steps, namely 1 and 2 arcminutes. The comparison is made for the two DART buoy locations: D413 and D411, see Figure 3.

We can glean from Figure 11 that the initial signals at D413 (close to the source) and at D411 (far from the source) are unchanged when computed with either spatial resolution. Later waves however show phase and amplitude differences for the two space steps. Waves which follow the initial signal show differences in amplitude and phase for the computations with the different space step. These secondary waves are generated by various bathymetric features through scattering and refocusing of the initial signal. Obviously the differences in signal between the two computations originate from the different bathymetric resolutions. Small differences in bathymetry between 1 and 2 arcminutes spatial resolutions underline the importance of high resolution bathymetry in reproducing tsunami by numerical-hydrodynamical models.
7. Discussions and Conclusions

The sea level recorded in the wake of Kuril Islands tsunami of November 15, 2006 by the West Coast tidal stations and by the open ocean DART buoys show strong tsunami signal enhancement by the shallowing bathymetry (http://wcatwc.arh.noaa.gov/previous.events/11.15.2006/11-15-06.html). In a few locations along California shoreline the peak tsunami wave range leaped over 1m (Arena Cove, 118 cm; Port San Luis, 115 cm), but again the highest range of 176 cm occurred at Crescent City (CC).

Figure 10. Energy flux vectors 3.5 hours (upper panel) and 4 hours (lower panel) after tsunami onset. Note radially expanding wave front centered on Koko Guyot.
The purpose of the present study was to examine and to explain amplification observed at the CC through tsunami refocusing by the distant bathymetric features. The tsunami signal at CC shows an initial wave group which was followed 2 hours later by second group of larger waves. The peculiarities in the tsunami signal attest to the scattering of the tsunami signal by various bathymetric features. The basic results from the model computations given in Figures 2 and 4 show that: 1) an amplified signal is directed towards CC, 2) it is composed of two distinct wave groups which arrive approximately from the northwest and from the west.

Comparison of the model with deep ocean DART buoys shows that the model reproduces well the first group of waves. There are differences between model and measurement with the second group—differences which often grow in time. The later arriving waves are influenced by the scattering/trapping mechanism and energy enhancement around bathymetric features as Hebert et al. [2001] demonstrated for the 1994 Kuril tsunami and Kowalik et al. [2005, 2007a]; Titov et al. [2005] for the Indian Ocean Tsunami of 2004.

Along with the primary source of tsunami, sea level uplift due to earthquake, the secondary sources due to scattering and refocusing complicate the process of tsunami propagation. The secondary ridge-amplified and seamount-scattered waves travel more slowly from the primary source and arrive later at distant coastal points. As a result, interactions between wave fronts

Figure 11. Sea level computed at two DART buoy locations. Blue: 1 arcminute spatial resolution, Red: 2 arcminutes spatial resolution.
derived from primary and secondary sources lead to difficulties in predicting the arrival time of the largest amplitude wave. These waves are important for tsunami prediction, warning and hazard mitigation.

To investigate tsunami behavior we use energy flux. We have comprehensively tested this tool to reveal various aspects of tsunami physics [Kowalik et al., 2007b] and we hope that it can serve well for tsunami prediction, warning, and hazard mitigation. Energy flux in contrast to the noisy tsunami sea level reveals uniform behavior in time and space. In addition it contains information about the directionality of the signal which is important for identification of the prominent bathymetric features as potential sources of tsunami wave refocusing. The energy flux is applied to investigate enhancement of tsunami signal and sources of the late arriving tsunami at CC. Simple numerical experiments reveal energy trapping and enhancement by the Mendocino Escarpment. These experiments define bathymetric features which scatter the tsunami signal towards CC via the Mendocino Escarpment. This escarpment seems to be efficient in delivering enhanced tsunami energy if the approaching tsunami signal travels from the west along the escarpment. To pinpoint the sources of late signals, a control box is constructed around CC and the energy flux through faces of the box is examined. The results are quite surprising, showing the key role played by two bathymetric features thousands of kilometers distant from CC (Koko Guyot and the Hess Rise) in refocusing tsunami signal towards CC. These prominent bathymetric features scattered, delayed and re-routed the tsunami signal more efficiently toward CC.

As the later arriving group of waves depends strongly on the depth contrast between shallower and deeper domains surrounding bathymetric features [Mei et al., 2005; Mofjeld et al., 2000] it is important to consider the influence of spatial resolution on the calculated results. Presently the open ocean bathymetry is resolved with 1 arcminute spatial step. Finer resolution is not available and the 1 arcminute bathymetry in many locations (especially close to Aleutian Islands) is smoothed due the lack of measurements. Two experiments with different spatial resolution have shown that the later arriving group of waves which is generated by tsunami/bathymetry interaction depends on the spatial resolution of the bathymetry. These differences cannot be explained by numerical dispersion since neither of these spatial resolutions introduce significant dispersion. Therefore, further improvement to tsunami calculations will require finer resolution of the major bathymetric features.

Our investigations are based on the long wave approach. Unique measurements of currents and sea level taken by Bricker et al. [2007] in the wake of Kuril Islands tsunami 2006 delineate periodical motion with periods less than 10 min thus pointing towards short dispersive waves. Examination of tsunami signals (Figures 5 and 11) scattered from the bathymetric features also shows stronger influence of shorter wave periods when compared with the primary tsunami signal generated by source. Similar conclusion follows from Horrillo et al. [2006] numerical experiments on interaction of dispersive and nondispersive wave trains with bathymetry; the dispersive wave trains tend to generate shorter wave periods. Therefore, the role of dispersive waves in the tsunami scattering will require further investigations.

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