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Original article

Evaluation of the Express Method Effectiveness in Short-Term Forecasting on the Examples of the Peruvian (2007) and the Chilean (2010, 2014 and 2015) Tsunamis

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Abstract.
Purpose. The aim of the work is to study the possibility of real-time tsunami forecasting based on the data from the deep-ocean tsunameters.
Methods and Results. The express method makes it possible to compute in advance the waveforms of the expected tsunami in the ocean, as well as near the coast. Forecasting requires seismological information on the start time and coordinates of the earthquake epicenter only, and also the data from one deep-ocean tsunameter obtained in real time. The data from the deep-ocean tsunameters closest to the tsunami sources with the duration equal to the tsunami first half-period (the first period) were used in the numerical experiments. The results of computing tsumamis for 2007–2015 agree quite well with the tsunami forms recorded at the deep-sea stations in the ocean in different directions from the source. The quality of computations in the article is comparable to the computation quality of the other authors. A tsunami forecast at the given points is possible immediately after receiving the information on passing of the tsunami first period through the deep-sea tsunameter closest to the source.
Conclusions. In contrast to the other methods, no reconstructing of a seismic source neither a giant base of synthetic mareograms is required for the express method. The express method can be used for tsunami forecasting in those areas for which other methods are not applicable (for example, there is no a database of synthetic mareograms), namely the coast of the northwestern Pacific Ocean.

Keywords: tsunami, short-term tsunami forecast, tsunami alarm, false tsunami alarms, reciprocity principle, ocean level, ocean level measurements, tsunami warning service, Pacific Ocean

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1. Introduction

The problem of operational (short-term) tsunami forecasting remains relevant, especially for the northwestern Pacific Ocean. To a greater extent, this applies to situations with false tsunami alarms. Magnitude-geographic method of tsunami forecasting, developed during the formation of warning services, nowadays remains the main one. The forecast based on this method gives a large number of false alarms.

For the Northwest Pacific, a tsunami warning is issued by the Pacific Tsunami Warning Center (PTWC) and regional centers of the Russian Tsunami Warning Service based on a magnitude criterion. The Northwest Pacific Tsunami Advisory Center, represented by the Japan Meteorological Agency (JMA), also warns of the tsunami danger, acting in accordance with the new regulation [1]. It is based on a database of preliminary computations of tsunami heights at a large number of points in the ocean from seismic sources with the most probable earthquake mechanism and various magnitudes, as well as hypocenter depths. The forecast is given for large regions and allows only a tentative assessment of the tsunami danger. The decision to declare a tsunami alarm is assigned to the regional centers. A similar approach to short-term tsunami forecasting for the Kuril Islands was proposed in [1]. The mentioned methods do not involve the use of information on the tsunami in the ocean and do not provide a reliable quantitative estimate of the expected tsunami heights. A similar approach was proposed back in 1996 [2] at the beginning of the development of hydrophysical observation systems in the ocean. Subsequently, it served as the basis for the creation of hydrophysical method [2] based on formed tsunami data in the open ocean [3–5].

When making a decision to declare a tsunami alarm, Russian tsunami warning centers are guided by a magnitude-geographical criterion and take into account the PTWC and JMA warnings, which often leads to the announcement of false tsunami alarms [6, 7]. In the present work, a false tsunami alarm is understood when an alarm is announced, but the wave heights turn out to be insignificant and do not pose danger.

Tsunami warning services do not always assess the validity of alarms according to this definition. An example is the March 25, 2020 event, when, as a result of an earthquake with a magnitude of 7.3, 220 km east of Onekotan Island (northern Kuril Islands) there was a weak tsunami [8]. A tsunami alarm was announced with the evacuation of the population, but the wave amplitude was insignificant. The tsunami center sees this alarm as justified.

The expected tsunami degree is quite difficult to estimate reliably only by the earthquake magnitude, since the ocean depth in the source area, the earthquake mechanism and its hypocenter depth are not taken into account [9]. The Russian tsunami warning service cannot detail the forecast based on the magnitude criterion due to the absence of a hydrophysical subsystem in Russia. Russia is perhaps the only country in the Pacific Ocean basin that does not have deep-sea stations for

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[1] IOC, 2019. *Users' Guide for the Northwest Pacific Tsunami Advisory Center (NWPTAC): Enhanced Products for the Pacific Tsunami Warning System*. Paris: UNESCO, 35 p. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000366546?posInSet=1&queryId=d1288da0-390e-47b1-8a51-a529b04abf93 [Accessed: 15 May 2023].

[2] Gica, E., Spillane, M.C., Titov, V.V., Chamberlin, C.D. and Newman, J.C., 2008. *Development of the Forecast Propagation Database for NOAA's Short-Term Inundation Forecast for Tsunamis (SIFT)*. Seattle, WA: Department of Commerce, 95 p.

ocean level measurement, which permit to carry out operational tsunami forecasting.

False tsunami alarms, often announced with excessive advance, although they do not cause direct losses, cause significant damage associated with stopping production in dangerous places, evacuating the population and sending ships to the open sea. Moreover, any kind of activity in the coastal strip stops for several hours. Due to the large number of false alarms, the total damage from them is comparable to the damage from the tsunami that took place. To date, the number of false alarms is at least 75% of the total number of alarms [10, 11].

The problem is to give an adequate, advance, differentiated by coastal sections forecast of the arrival times of the first, maximum tsunami waves at a given point and their amplitudes, as well as the alarm mode duration. The forecast should ensure timely evacuation of the population only at those points where a tsunami poses a real threat [6]. It is these tsunami characteristics that are listed in the definition of a tsunami forecast formulated by the UNESCO Intergovernmental Oceanographic Commission (IOC) in 2013 [3]. Based on the magnitude-geographic criterion, such a detailed forecast is impossible [7].

Currently, an effective forecasting method is based on the use of tsunami data from DART (Deep-ocean Assessment and Reporting of Tsunamis) system [4] tsunameters. The data inversion method of DART stations closest to the tsunami source makes it possible to reconstruct the tsunami source and compute tsunami waveforms at given points in the ocean or near the coast in advance.

Such methods have been developed since the late 1980s [12]. Later [3, 4], the development of the idea led to the creation of hydrophysical NOAA method, or SIFT [2, 4] method (Short-term Inundation Forecasting for Tsunamis), for forecasting [5, 13]. Based on the tsunami data in the ocean, waveforms are computed at given points in the ocean or near the coast based on a pre-computed database of synthetic mareograms with a volume of tens of Terabytes. The NOAA method has been successfully used to compute all significant tsunamis in the Pacific Ocean since 1996, including operational mode. The development of a sea-level observation network in the ocean and near the coast stimulated a number of works to improve the inversion method [14–18]. Tsunami forecasts based on inversion, the NOAA method are in line with the UNESCO IOC definition. Currently, when a tsunamigenic earthquake occurs, computations by NOAA (SIFT) method are carried out for the US West Coast, the coast of Alaska and the Aleutian Islands. To predict a tsunami, it is necessary to have a pre-computed base of synthetic mareograms covering the areas of potential tsunami sources and the areas for which the forecast is made. Otherwise, this method is not applicable.

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[3] Intergovernmental Oceanographic Commission, 2019. *Tsunami Glossary*. *Fourth Edition.* Paris: UNESCO, 46 p. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000188226 [Accessed: 15 May 2023].

[4] NOAA. *NOAA Center for Tsunami Research*. 2023. [online] Available at: http://nctr.pmel.noaa.gov/ [Accessed: 15 May 2023].

In [19, 20], a data assimilation method, combining observations and numerical modeling and not requiring information on the tsunami source, was proposed. It allows a tsunami prediction in the far zone according to the data of the DART stations closest to the source.

The Russian Far East coast is threatened not only by local tsunamis with epicenters in the Northwest Pacific Ocean from Kamchatka to Japan, but also by transoceanic tsunamis that occur off the South America coast. The 1960 Chilean tsunami, due to an earthquake with a magnitude of 9.5, caused run-ups up to 7 m high on the coasts of Kamchatka and the Kuril Islands [5]. During the February 27, 2010 event, after an earthquake with a magnitude of 8.8 off the Chile coast, a tsunami alarm was announced in the Kuril Islands, and the population was evacuated. Fortunately, after the alarm was canceled, the maximum waves with an amplitude of about 1 m, which arrived 4 hours after the first one, did not cause damage [21, 22].

The Russian tsunami warning service does not have the ability to provide an adequate detailed tsunami forecast on the Far East coast due to the lack of modern operating forecast methods. To compute local or transoceanic tsunamis in the Far East, the NOAA (SIFT) method is not applicable due to the lack of an appropriate database of synthetic mareograms.

A short-term forecast based on tsunami data in the ocean can be carried out using the original express method of short-term tsunami forecasting [6] based on the fundamental reciprocity principle. To perform the forecast, seismological information is required only on the start time and coordinates of the earthquake epicenter and information on the tsunami obtained in the ocean by one deep-ocean tsunameter.

The express method was used to simulate the 2006, 2007 and 2009 Kuril tsunami in the ocean according to the data of DART stations in different directions from the sources [6]. The possibilities of this method for the Russian Far Eastern coast using the example of the local 2020 Kuril tsunami in a near real-time mode are presented in [8].

The earthquakes of 2007–2015 near the western coast of South America and the tsunamis that followed, as expected, aroused great interest among researchers. The use of the data on these tsunamis provides a good opportunity to test the validity of various direct calculation models and operational tsunami forecasts based on actual data. The works devoted to specific events in 2007–2015 are discussed below. They use the ideas underlying the NOAA method. There are no known works, except for the works of the author, in which the express method ideas used in this work would be used.

The present paper is aimed at studying the possibility of operational tsunami forecasting, modeling the process of tsunami forecasting under real-time conditions and, on the basis of this, demonstrating the capabilities of the express method of short-term tsunami forecast. On the examples of transoceanic 2007 Peruvian, 2010,

[5] NOAA. *NOAA National Centers for Environmental Information*. 2023. [online] Available at: https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-search [Accessed: 15 May 2023].

2014 and 2015 Chilean tsunamis it has been shown that, based on limited data on the earthquake (only the epicenter coordinates and the earthquake onset time) and with the availability of information from deep-sea tsunameters, the short-term tsunami forecast is possible.

2. Express method for operational tsunami forecasting

The practical application of the method (express method) of short-term tsunami forecasting described in [6] is as follows.

The estimated relation follows from the well-known fundamental reciprocity principle, which is valid for tsunami type waves, provided that the shapes of the wave sources are similar:

$$\zeta\ (A,s) = \zeta\ (M,s) \cdot \frac{\eta\ (A,s)}{\eta\ (M,s)}.$$

Here M is the point in the ocean where the ocean level is measured at, A is the point in the ocean or near the coast which the forecast is made for. The $\zeta(A,s)$ and $\zeta(M,s)$ functions refer to one tsunami, the $\eta(M,s)$ and $\eta(A,s)$ functions refer to another tsunami whose source shape is similar to that of the first one, and the source epicenters coincide.

All functions included in the estimated relation are images of the integral Laplace transform (s is the parameter of the Laplace transform).

This relation allows to compute the expected tsunami (function $\zeta(A,s)$) waveform at any A point of the coast using the ocean level data at M (function $\zeta(M,s)$) point using the transfer function (ratio on the right side of the equality).

In the online mode, in a matter of minutes, the earthquake epicenter coordinates are reliably determined. When determining the magnitude of an earthquake, errors are possible, often significant ones [23]. Other information about the earthquake mechanism is often missing. Therefore, the main assumption is made. The estimate relation is approximately valid if the transfer function is formed using an auxiliary solution to the problem of wave propagation from the initial elevation of the free surface. The initial disturbance is a circular elevation of the free surface with the center coinciding with the earthquake epicenter.

Since the forecast is made using data about the formed tsunami in the ocean, the earthquake mechanism does not play a role. These data implicitly contain information on the tsunami generation process, including the influence of additional factors, such as subsea landslides. Possible errors in determining the earthquake magnitude do not affect the forecast result, since this characteristic is not used in the computations.

The transfer function is formed in real time after obtaining information on the earthquake epicenter coordinates. To form it, the $\eta(M,s)$ and $\eta(A,s)$ functions (waveforms at M and A points) are computed from an auxiliary source [6].

[6] Korolev, Yu.P., 2017. The Short-Term Tsunami Forecast in the Pacific Ocean. *Geosystems of Transition Zones*, 1(2), pp. 3-17 (in Russian).

The inverse numerical Laplace transform completes the problem solution. The result is the expected tsunami waveform at a given point *A*.

3. Numerical experiment set–up

For each event, the ocean level was computed at the given locations of the DART system stations from an auxiliary axially symmetric source. In all numerical experiments, the source center coincided with the earthquake epicenter, the source diameter was 100 km, and the maximum amplitude was 10 m. The transfer functions were formed for each given forecast point in accordance with the estimate relation. To comply with the operational regime conditions in numerical experiments, the duration of the station records in accordance with which the forecast was made, was chosen to be equal to the duration of the first half-period (first period) of the tsunami at the corresponding station. The forecast efficiency was estimated for the near (tsunami propagation time less than 4 hours) and far zones (propagation more than 4 hours).

To confirm the applied method efficiency, the computed waveforms were compared with those recorded at DART stations in the ocean [7, 8]. Due to the approximate nature of the express method, the result obtained does not imply a perfect match with the real tsunami waveform. In this work, the criterion for the adequacy of the forecast is the answer the question: is it possible, based on the results of computations, to assess the degree of tsunami danger to make a decision on declaring an alarm by warning services.

The tasks of the work did not include tsunami computations near the coasts.

4. Results

The design scheme of numerical experiments is shown in Fig. 1, which shows the positions of the DART system stations and the earthquake epicenters. When modeling tsunami propagation in the Pacific Ocean, global bathymetry [24, 25] was used. The computations were carried out in spherical coordinates on a difference grid with the 5 km step at the latitude of the equator.

Information on ocean level from DART system stations was taken from the web-page [7].

4.1. *2007 Peruvian tsunami*

An earthquake (magnitude M 8.0) with an epicenter at 13°23′10″ S, 76°36′11″ W occurred off the Peru coast on August 15, 2007 at 23:40:58 UTC. The resulting tsunami [5] caused flooding of the coastal area closest to the source up to 10 meters high.

The station closest to the source, which registered the tsunami, was the DART *32401* station located south of the earthquake epicenter [7] (Fig. 1).

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[7] National Data Buoy Center. *Station List*. 2023. [online] Available at: https://ndbc.noaa.gov/to_station.shtml [Accessed: 18 May 2023].

[8] NOAA National Centers for Environmental Information. *Recent/Significant Tsunami Events*. 2023. [online] Available at: https://www.ngdc.noaa.gov/hazard/recenttsunamis-table.shtml [Accessed: 15 May 2023].

As applied to the 2007 event, the influence of the source characteristics on the computed tsunami amplitudes was studied in [26]. The source was reconstructed from the surface and body seismic waves, as well as from DART *32401* tsunami data using synthetic mareograms.

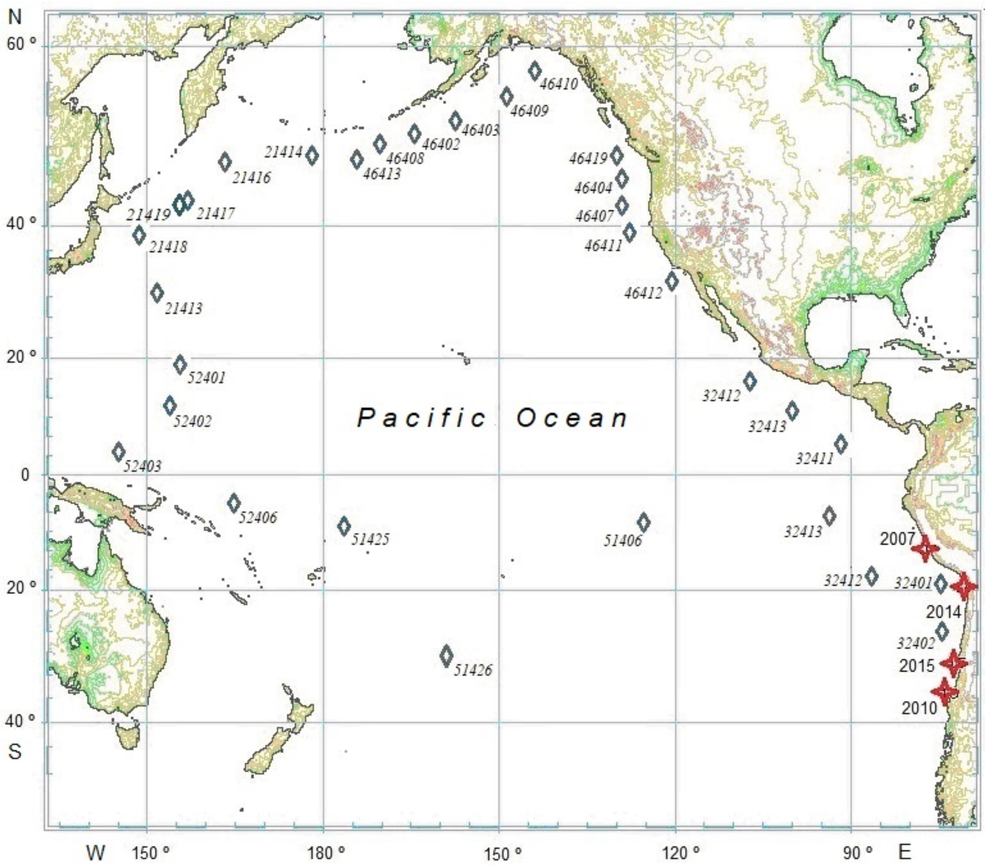


Fig. 1. Location of the DART stations (diamonds) and earthquake epicenters (red four-pointed stars) in the Pacific Ocean

In [27], according to the DART *32401* station data, using synthetic mareograms, the tsunami of 2007 was computed for points in the ocean and near settlements. The results of the experimental real-time tsunami forecast showed that the applied NOAA method could be successfully applied in the operational mode. A good agreement between the computed and actual data was obtained both in the ocean and on coastal tide gauges.

In this work, to compute the tsunami in the ocean, the data from the DART *32401* station with a duration of 30 min (the first period of the wave) from 51st to 81st min after the earthquake (the area marked with black lines in Fig. 2, *top left*) was used.

The presented results demonstrate a good agreement with the registration data. The quality of the computations allows adequate estimation of the degree of expected tsunami danger. It is comparable with the quality of the computations obtained in [26, 27] and on NOAA web page [4].

The good coincidence of the computed and recorded waveforms is observed both in the far (the wave run is more than 4 hours) and in the near (the wave run is less than 4 hours) zones. In the 2007 event, as well as in subsequent events, the energy emission from the source is nonisotropic [4]. The use of the express method of tsunami forecasting, which uses a circular source to make transfer functions, gives quite adequate results both in the far and in the near zones, regardless of the direction from the source.

The creation of transfer functions (computation of waveforms from an auxiliary circular source) can begin after receiving information about the start time and coordinates of the earthquake epicenter.

The forecast in the near zone can be given immediately after obtaining information on the passing of the first tsunami period through the DART *32401* station, i.e. 81 min after the earthquake, in the far one – as the transfer function is created, but no later than 1.5 - 2 hours after the start of auxiliary computations.

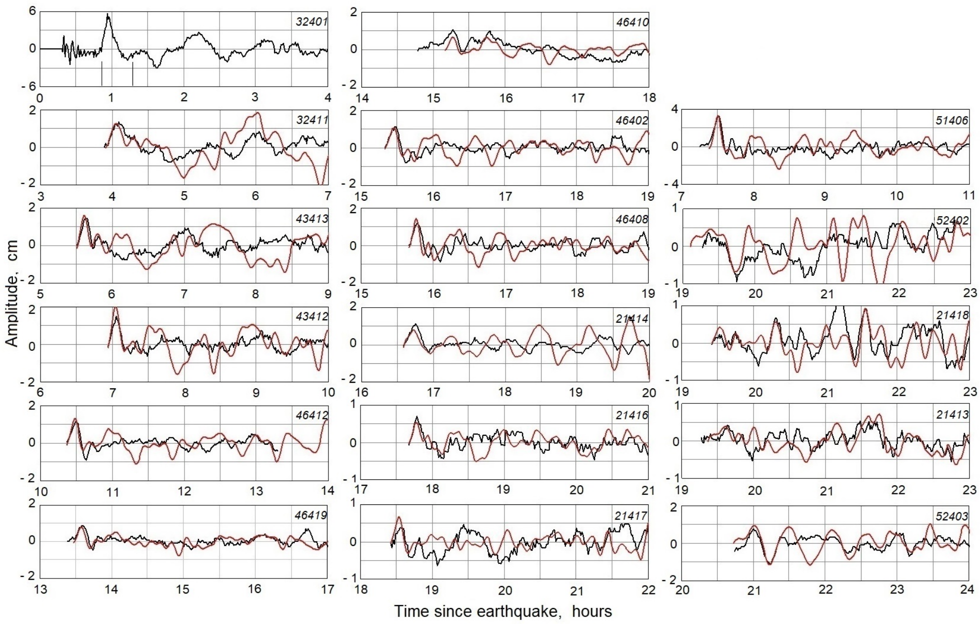


Fig. 2. Waveforms of the 2007 Peruvian tsunami: the recorded (black line) and computed (red line) ones based on the DART *32401* data for the DART stations located north of the tsunami source, along the US West Coast (*left*), along the Aleutian Islands to Kamchatka (*middle*) and to the west of the earthquake epicenter (*right*). Here and in the following figures, the DART station number is shown at the top right of each graph

4.2. *2010 Chilean tsunami*

On February 27, 2010 at 06:34:12 UTC, an earthquake (M 8.8) occurred off the coast of Chile with an epicenter at 36°07′19″ S, 72°53′53″ W (see Fig. 1).

The resulting tsunami [5] caused flooding of the coastal areas of Chile closest to the source up to 29 meters high.

The computations of the 2010 tsunami in [28] were carried out based on initial disturbances in the tsunami source, reconstructed from the data of DART stations and other data. It is shown that a real-time tsunami forecast off the Japan coast is possible from the data of DART stations closest to the sources off the Chile coast.

In the present paper, this tsunami computation was carried out according to the data from the DART *32412* station [7], located to the northwest of the source (Fig. 1), with a duration of 62 min, starting from 180th to 242nd min after the earthquake onset (Fig. 3, *top left*). The tsunami waveform at this station is characterized by an initial negative phase.

The computation results are shown in Fig. 3. As in the previous case, the calculated waveforms are in good agreement with the registered ones by DART stations [7].

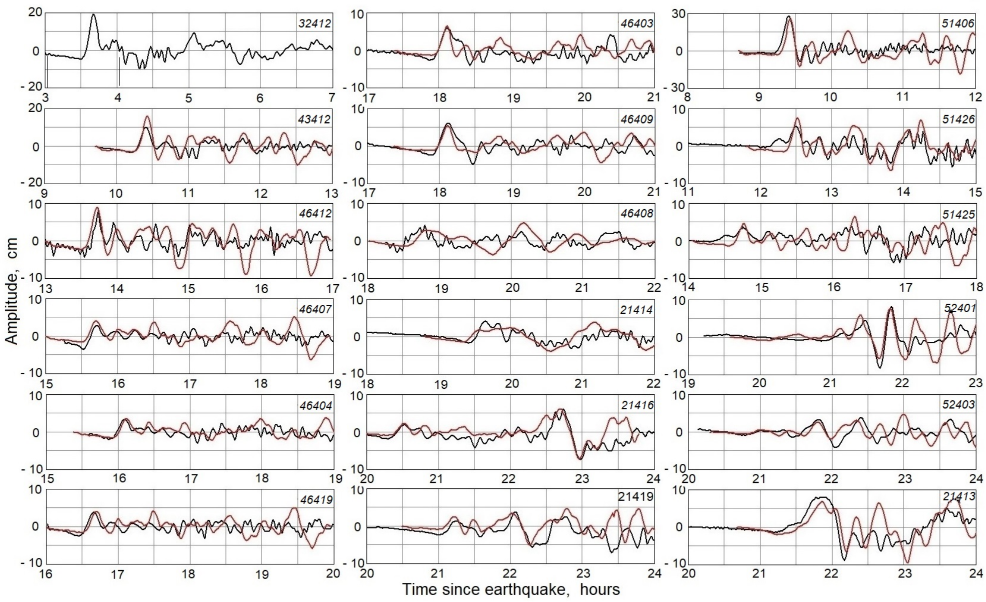


Fig. 3. Waveforms of the 2010 Chilean tsunami: the recorded (black line) and computed (red line) ones based on the DART *32412* data for the DART stations located north of the tsunami source, along the US West Coast (*left*), along the Aleutian Islands up to the Kuril Islands (*middle*) and to the west of the earthquake epicenter (*right*)

The computed waveforms in most cases show the tsunami arrival, starting with an ocean level decrease in accordance with the waveform at DART *32412* station. The quality of the computations makes it possible to adequately assess the degree of expected tsunami danger and is comparable to the quality of the calculations in [28].

The forecast can be given immediately after obtaining the information on the passing of the first tsunami period through the DART 32412 station, i.e. 242 min after the earthquake.

4.3. *2014 Chilean tsunami*

An earthquake (M 8.2) occurred on April 1, 2014 at 23:46:46 UTC off the northern coast of Chile with an epicenter at 19°38′31″ S, 70°49′01″ W (Fig. 1). On the coast of Chile, Ecuador and Costa Rica, a tsunami alert was declared and the population was evacuated from dangerous territories. The tsunami caused flooding of the Chilean coastline, closest to the source, up to 4 meters high [5].

In [29], using the data of three DART stations, the slip (forms of bottom displacement) distribution in the source zone was obtained. Waveforms were computed using nonlinear shallow water equations from this perturbation. A good agreement between the computed waveforms and the data of tide gauges along the Chile coast was obtained. The 2014 tsunami was also studied in [30, 31]. For its modeling, a single rectangular fault with a uniform shear was taken as a source. A good agreement between the computed and recorded waveforms by DART stations was obtained. The possibility of using the applied technique for short-term tsunami forecasting was not discussed.

In this work the DART *32401* station data from the closest to the tsunami source, located to the west, were taken as reference ones (Fig. 4, *top left*). On their basis the forecast was made. The station data were used from 17th to 36th min from the beginning of the earthquake, which lasted 19 min (the first period of the wave).

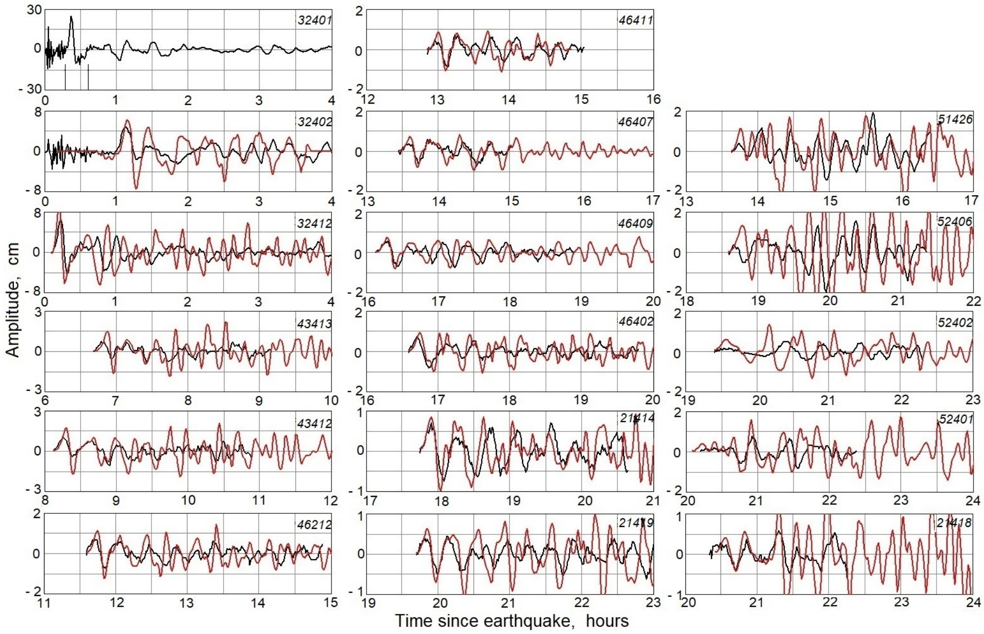
The computation results (retrospective forecast) demonstrate a satisfactory agreement with the registration data [7] in directions north of the source, along the US West Coast, the Aleutian Islands and near the Kuril Islands. The forecast quality is comparable to the quality of SIFT (NOAA) method computations using the data from two DART stations *32401* and *32402* [4]. In the western direction, the forecast gives overestimated amplitudes of waveforms compared to those recorded [4, 7].

The forecast in the near zone can be given immediately after receiving information on the passing of the first tsunami period through the DART *32401* station, i.e. 36 min after the earthquake, in the far one – as the transfer function is created.

4.4. *2015 Chilean tsunami*

An earthquake (M 8.3) with an epicenter at 31°34′23″ S, 71°40′26″ W off the Chile coast occurred on September 16, 2015 at 22:54:32 UTC. The resulting tsunami [5] caused flooding of the coastal area closest to the source, up to 13.6 meters high. The resulting tsunami was recorded by many DART stations. The nearest one, located to the north of the source, was the DART *32402* station [7] (see Fig. 1).

In [20], the 2015 tsunami forecasting possibility in the far zone was estimated using the method of assimilation of data from the DART stations closest to the source. The preliminary forecast could be given 1 hour after the earthquake began, i.e. after the passing of the first period of the wave through the nearest DART *32402* station. In the numerical experiment, the predicted waveforms generally agree well with real observations in the central and eastern parts of the Pacific Ocean. The real-time estimates of the 2015 Chilean tsunami using the NOAA (SIFT) method and their comparison with the data from 26 DART stations, as well as 38 coastal tide gauges, are presented in [32]. The estimates were made according to the data of the DART *32402* station closest to the source with a duration of a quarter period, a half period and a full period of the first wave. In all three cases, good agreement was observed between the computations and real data in the ocean and near the coast.

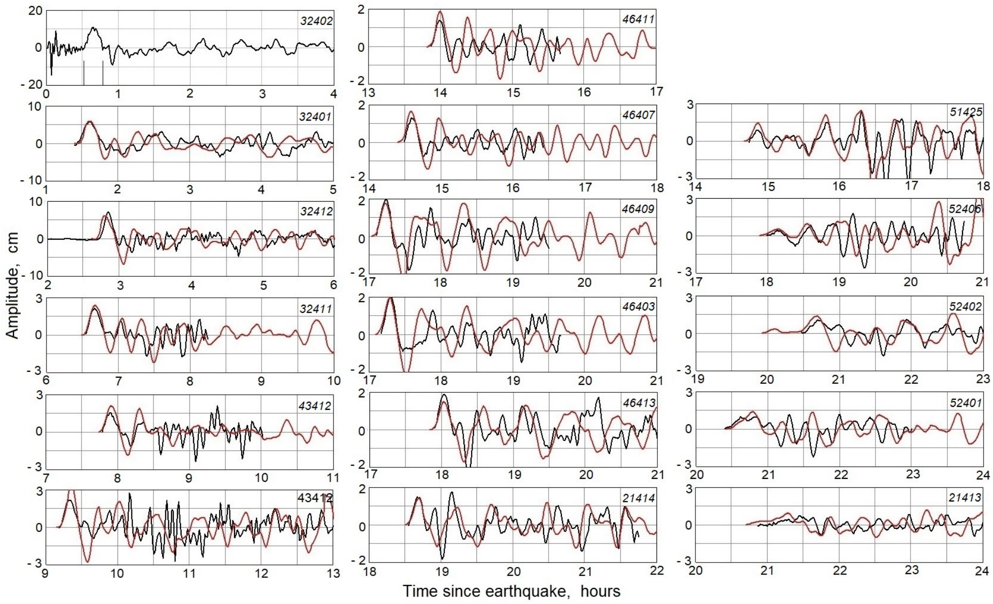


F i g. 4. Waveforms of the 2014 Chilean tsunami: the recorded (black line) and computed (red line) ones based on the DART *32401* data for the DART stations located north of the tsunami source (*left*), along the US West Coast, along the Aleutian Islands up to the Kuril Islands (*middle*) and to the west of the earthquake epicenter (*right*)

In this work, the computation was carried out using the data from the DART *32402* station for a duration of 16 min (the first half-period of the wave) from 31st to 47th min after the earthquake (Fig. 5, *top left*).

The computation results are shown in Fig. 5. The results demonstrate a fairly good agreement with the registration data [7]. The quality of the computations is comparable to the quality of the computations presented in [20, 32] and on the web page [4].

The forecasts for the stations in the near zone can be given 47 min after the earthquake, for more distant ones – as auxiliary computations are carried out.



F i g. 5. Waveforms of the 2015 Chilean tsunami: the recorded (black line) and computed (red line) ones based on the DART *32402* data for the DART stations located north of the tsunami source (*left*), along the US West Coast, along the Aleutian Islands up to Kamchatka (*middle*) and to the west of the earthquake epicenter (*right*)

5. Discussion

Modeling of the process of operational tsunami forecasting consisted in performing the computations in a near real-time mode. The creation of transfer functions (computation of waveforms from an auxiliary circular source) begins after receiving information on the start time and coordinates of the earthquake epicenter (10 minutes after the earthquake start).

The computation process on an Intel Core i5-2450M CPU @ 2.50GHz laptop on a difference grid with 5 km step in the Pacific Ocean to the most distant points from the source with a tsunami run of more than 20 hours takes about 1.5 hours. The creation of the transfer function, individual for each point, can be carried out in the process of computing the waveforms. For the near zone (with tsunami travel times less than 4 hours), the forecast can be made immediately after obtaining information on the registration of the first half-period (first period) of the tsunami by the DART station closest to the source. The duration of the auxiliary solution waveform for a given point should be equal to the required duration of the forecasted wave. For the far zone, the forecast is given as auxiliary computations are carried out. The times of forecast making at points in the ocean for the researched tsunamis are given in Sections 4.1 – 4.4.

The whole process of forecast making consists of the sequential application of three programs, which does not allow to use the express method practically during the event.

The use of fast computing technologies [33] and the nested grid technique for creating transfer functions will make it possible to forecast tsunami for any given point near the coast immediately after receiving information about the passing of the first half-period (first period) of a tsunami through the DART station closest to the source, both for transoceanic and local tsunamis.

In all considered events, energy radiation from the sources is not isotropic [4]. Nevertheless, despite the approximate nature (the use of a circular wave source in the auxiliary problem for constructing the transfer function), the express method gives quite adequate results in all directions from the tsunami source. It gives opportunity of rapid estimation of the tsunami hazard degree at given points with sufficient accuracy for practical use. The computed waveforms, as a rule, are in good agreement with the recorded tsunami waveforms by DART stations in all directions from the source. The results show a good agreement with the registration data. The quality of the computations is comparable to the quality of the computations of other authors.

6. Conclusion

Modeling of the operational forecast process for the 2007 Peruvian, 2010, 2014 and 2015 Chilean tsunamis was carried out according to the tsunami data from the DART stations closest to the source using the express method of the short-term tsunami forecast. The express method consists of the computation transfer functions, with the help of which, according to the ocean level data of DART stations, a tsunami forecast is carried out at given points. The transfer functions are created based on the results of computing the waveforms from the auxiliary axially symmetric initial elevation of the free surface with the center coinciding with the earthquake epicenter. The use of waveforms from an auxiliary circular source without any assumptions about the structure and mechanism of an earthquake is quite justified under the operational mode for cases of local tsunamis.

The express method, unlike others, does not require the reconstruction of a seismic source and a giant base of synthetic mareograms. Making forecast requires only the start time and coordinates of the earthquake epicenter from the seismic subsystem and real time data of one deep-ocean tsunameter obtained from the hydrophysical subsystem.

The express method fully satisfies the definition of a tsunami forecast formulated by the UNESCO IOC.

The express method can be used to forecast tsunamis in those areas where other methods are not applicable (for example, there are no bases of synthetic mareograms). Such areas are the northwestern Pacific Ocean coasts.

The creation of a short-term tsunami forecast complex based on the express method will improve the quality of the forecast by reducing the number of false alarms.

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