# ITSU-XX
# NATIONAL REPORT

## NATIONAL REPORT submitted by the Russian Federation

## BASIC INFORMATION

### ICG/ITSU National Contact:

Name: Igor P. Kuzminykh
Organization: Central Design Office for Hydrometeorological Instrument Production
Postal Address: 6, Korolev street, Obninsk, Kaluga region, 249039 Russian Federation
E-mail Address: ckb@meteo.ru
ckb@ckb.obninsk.org
Telephone Number: (+7 084 39) 6 23 03
Fax Number: (+7 084 39) 6 44 53
Cellular phone: + 7 910 912 20 17

### Primary Warning Recipient.

1. Name: Victor A. Lepekhov and
   Tatiana N. Ivelskaya
   Responsible Organization: The Sakhalin Interregional Territorial Administration for Hydrometeorology and Environmental Monitoring
   Postal Address: 78, Zapadnaya street, Youzhno-Sakhalinsk, 693000, Russian Federation
   E-mail Address: adm@shug.shln.mecom.ru
   twc@sakhalin.ru

   Emergency Telephone Number: (+7 424 2) 72 28 20
   Emergency Fax Number: (+7 424 2) 42 01 46
   Emergency Cellular phone:

2. Name: Mikhail I. Ishonin and
   Victor A. Feofanov
   Responsible Organization: The Kamchatka Interregional Territorial Administration for Hydrometeorology and Environmental Monitoring
   Postal Address: 12, Molchanova street, Petropavlovsk-Kamchatsky, 683602, Russian Federation
   E-mail Address: adm@ptug.hbrw.mecom.ru
   kammet@interkom.kamchatka.ru
   Emergency Telephone Number: (+7 415 22) 5 84 44
   Emergency Fax Number: (+7 415 22) 5 84 44
   Emergency Cellular phone:

3. Name: Boris V. Kubay
   Responsible Organization: Primorskoye Interregional Territorial Administration for Hydrometeorology and Environmental Monitoring
   Postal Address: 3, Mordovtsev street, Vladivostok, 690600, Russian Federation
   E-mail Address: head@wdwk.mecom.ru
   Emergency Telephone Number: (+7 423 2) 22 17 50, 22 20 01

Emergency Fax Number: (+7 423 2) 22 17 50, 22 77 54
Emergency Cellular phone:

## Tsunami Advisor (s).

Name: Alexander V. Frolov and
Valery A. Martyschenko
Russian Federal Service for Hydrometeorology and Environmental Monitoring
Postal Address: 12, Novovagan'kovsky street, Moscow, 123995, Russian Federation
E-mail Address: afrolov@mecom.ru
seadep@mcc.mecom.ru
Emergency Telephone Number: (+7 095) 252 24 29, (+7 095) 252 45 11
Emergency Fax Number: (+7 095) 253 94 84, 255 20 90

## Emergency Manager (s)

Ministry for Emergency Situations of Russian Federation
Emergency Telephone Numbers: (+7 095) 9263738, 9263500, 2394545.

## Local Tsunami Procedures

In case of a local tsunamigenic event, the parameters of the earthquake are identified by seismic stations (SS) of the Geophysical Service of the Russian Academy of Sciences (GS RAS). The initial tsunami warning is provided by the same seismic stations. Criteria for the warning notification are based on the magnitude, $M_s$, and the location of tsunamigenic earthquake.

At present time the GS RAS determined the magnitude criteria (magnitude threshold values for tsunami warning) to be as follows:

For areas along the coasts of Kamchatka, Kuril Islands, Okhotsk Sea and the Sea of Japan $M_s = 7{,}0$;

For areas along the coasts of Komandor Islands and Hokkaido Isl. $M_s = 7{,}5$

Tsunami warning is cancelled:

- If the tsunami has been recorded, but maximum wave heights are less than 0.5 m.
- If the tsunami warning has been declared, but tsunami signatures are absent in the data of the coastal tide gauges, the warning is cancelled 0.5-1.0 hour after the latest estimated tsunami arrival time to a settlement on the coast.

The cancellation of the tsunami warning is made by the Tsunami Warning Centers (TWC) of the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) in Youzhno-Sakhalinsk, Vladivostok and Petropavlovsk-Kamchatsky.

## Distant Tsunami Procedures

The tsunami warning for distant tsunamigenic events is provided by the Tsunami Centers in Youzhno-Sakhalinsk and Petropavlovsk-Kamchatsky.

After receiving information and corresponding parameters of a major distant earthquake from the GS RAS, foreign seismic stations and the Pacific Tsunami Warning Center (PTWC) the following actions are carried out:

- Estimation of tsunami threat for the Russian coast based on the magnitude-geographical criterion.
- Calculation of the tsunami arrival times to specific coastal sites.

- Sending "Warning and Watch" messages to the coastal hydrometeorological stations; activating tide gauge monitoring and witness observations of sea level changes near the coast.
- A situation analysis based on the entire set of information, including information on actual tsunami tide gauge observations from the Pacific Tsunami Warning Center (PTWC) and other foreign centers.
- Final decision about the actual tsunami threat for the Russian coast, declaring (if necessary) a Tsunami Warning.
- Transmitting tsunami warning emergency messages via communication channels according to the rules of notification to local and central authorities, all sectors of the population at risk and to foreign tsunami warning centers.

More precise definition of tsunami parameters and threat for the Russian coast are based on information about recorded tsunami wave heights coming from stations located near the source area or between the source area and the Russian coast, as well as on other information coming from the foreign centers.

During the period between the XIX (2003) and XX (2005) ITSU assemblies, a situation analysis was carried out each time PTWC provided a tsunami warning for the Pacific Ocean. These analyses, in particular, included examination of the tide gauge data from Russian and foreign stations.

## National Sea Level Network

Hydrometeorological stations (HMS) located along the Russian coast of the Pacific Ocean and marginal seas carry out sea level observations. Part of the stations do not have automatic instrumentation for monitoring sea level variations. Sea level data from the four HMS (Severo-Kurilsk, Youzhno-Kurilsk, Ust-Kamchatsk and Nikol'skoye, Bering Isl.) are transmitted for the international exchange.

The automatic tsunami/tide system at Severo-Kurilsk (Paramushir Island) was re-established by the PTWC in co-operation with Youzhno-Sakhalinsk Tsunami Center in August, 2004. The station provides critical information on tsunamis generated in the Kuril Islands and the Kamchatka Region. This tide gauge perfectly recorded the Sumatra tsunami of 26 December 2004.

## Information on Tsunami occurrence

On September 25, 2003 an earthquake with magnitude $M_s$ = 8.3 (SS Youzhno-Sakhalinsk) occurred at 19:51 UTC offshore of Hokkaido Island in the region of the Japan Trench (41.7ºN, 144.2ºE). This earthquake (known as "Tokachi-Oki Earthquake") generated tsunami waves recorded by analogue tide gauges located on the coast of the South Kuril Islands. At Malokurilsk (Shikotan Island) maximum wave height was 78 cm (unfortunately, tide-gauge data were obtained only 3 hours after the estimated tsunami arrival time because of stoppage of the tide gauge clock.) The maximum recorded wave height at Youzhno-Kurilsk (Kunashir Island) was 13 cm, but near Youzhno-Kurilsk eyewitnesses reported 50 cm tsunami waves. Tsunami warnings were declared for this event 11 minutes after the main shock by the TWS centers in Youzhno-Sakhalinsk and were cancelled after the first information came from the Japanese tide gauges located on the coast of Hokkaido close to the source area.

The second tsunami event recorded on the coast of Russia was the catastrophic Sumatra tsunami that occurred on December 26, 2004 in the Indian Ocean ($M_w$ = 9.3). The Severo-Kurilsk

tsunami station located on Paramushir Island, Northern Kurils, clearly recorded tsunami waves associated with this event. There were two trains of waves that came to the station. The first train with a maximum trough-to-crest wave height of 25.5 cm arrived at the station on December 27 at 13:30 GMT, i.e. about 35hrs 30min after the main shock. Typical periods of the waves in this first train were about 50 min. The second train (with maximum wave heights of 29 cm and periods of about 40 min) arrived at 18:15 GMT (in 41hrs 15min). The train structure and long ringing of tsunami oscillations (2-3 days) indicate that the incoming waves propagated by different tracks and probably experienced significant influence of wave reflection from the continental coastlines. It is noteworthy that the station at Severo-Kurilsk was one of the most distant stations to record this tsunami. Analogue tide gauges at Youzhno-Kurilsk (Kunashir Island) and Malokurilsk (Shikotan Island) apparently also recorded the tsunami but the corresponding signal was not clear. The digital tsunami station at Ust-Kamchatsk did not record the tsunami, apparently because this station was too far away from the source and sheltered from the arriving waves.

## SUMMARY

Tsunami monitoring, prediction and warning for the Pacific coasts of Russia now are provided by the Tsunami Warning System (TWS) centers of ROSHYDROMET in Youzhno-Sakhalinsk and Petropavlovsk-Kamchatsky working in close cooperation with regional structures of Ministry for Emergency Situations and Ministry for Communications and Information of Russian Federation, seismic stations of the GS RAS and local hydrometeorological stations of ROSHYDROMET. The Russian TWS centers efficiently cooperate with the TWS centers of other countries. The Russian Tsunami Warning System is an important part of the International Tsunami Warning System for the Pacific (ITSU), operating under the umbrella of the UNESCO Intergovernmental Oceanographic Commission (IOC). The Russian subsystem as a whole and the Russian TWS centers are guided by regulations and instructions at the federal and local level.

The divisions involved in the TWS provide twenty-four hours operation, including continuous monitoring of seismicity and sea level variations, situation analysis, declaring and canceling Tsunami Watches and Warnings, preparation and relaying of appropriate signals and messages in accordance with the established procedure.

In case of a local tsunamigenic event, the tsunami alarm is declared by the seismic stations of the GS RAS based on magnitude-geographical criterion (the magnitude threshold value for tsunami warning is $M_S = 7.0$ for local earthquakes). The tsunami warning is cancelled by the TWS centers of ROSHYDROMET.

For distant tsunamigenic events, the tsunami alarm is declared by the TWS centers of ROSHYDROMET based on information from Russian and foreign seismic stations, information from PTWC, as well as sea level variations from tide gauges located near the source area and far-field stations located between the source region and the Russian coast. The TWS centers in Youzhno-Sakhalinsk and Petropavlovsk-Kamchatsky (ROSHYDROMET) are responsible for canceling the tsunami warning.

During the intersessional period (2003-2005), two tsunami events have been recorded at the Russian coast: (1) The Hokkaido (Tokachi-Oki) tsunami of September 25, 2003 ($M_S = 8.3$) recorded by analogue tide gauges at Malokurilsk (Shikotan Island) and Youzhno-Kurilsk (Kunashir Island); and (2) the Sumatra tsunami in the Indian Ocean of December 26, 2004 ($M_W = 9.3$) recorded by the tsunami station at Severo-Kurilsk (Paramushir Island). The maximum recorded tsunami height at the Russian coast was 78 cm for the first event and 29 cm for the second event. A Tsunami Warning was declared for the first event for the coasts of Kuril Islands and the Pacific coast of Kamchatka. It

was an alarm that was cancelled after information came from the Japanese tide gauges located in the vicinity of the source.

The catastrophic tsunamis of the last decade initiated, during the intersession period (2003-2005), an upgrade of the existing Russian Tsunami Warning System (TWS). In particular, the tide gauge network has been partially upgraded; two digital tsunami recorders with 2-minute sampling interval have been established in Severo-Kurilsk and Ust-Kamchatsk and equipped with a new telemetry system transmitting sea level data to the TWS centers and PTWC. (Unfortunately, at present time the Ust-Kamchatsk- tsunami recorder is not working).

The main problem of the existing Tsunami Warning System in Russia is the lack of high-quality digital tsunami recorders incorporated into the system. Several recorders should be deployed along the coasts of the Kuril Islands, Kamchatka and the Komandor Islands. Also, it will be quite important to install open-ocean bottom pressure stations offshore from Kamchatka and the Kuril Islands. These stations will be especially important for the region of the Central Kuril Islands, a region with a large seismic gap and a high probability of the next destructive tsunamigenic earthquake (with $M_w$ =8.5-8.7). Another problem to be solved is a widely spaced network of seismic stations and out-of-date instruments that are still used in these stations.

Since the destructive Indian Ocean tsunami of 26 December 2004 a program of measures for the modernization of the National Russian TWS has been developed as part of the federal program aimed at the reduction of risks and mitigation of the consequences caused by natural disasters. The federal program is now being examined by the Government of the Russian Federation. It is to be approved and adopted in the nearest future. Measures for the improvement of the TWS include: the installation of several broad-band digital seismometers, introduction of local seismic station networks, installation of modern pressure gauges for sea level observations, reconstruction of tide gauge observation sites, designation of modern technologies for data processing at the TWS Centers, designation of the modern communication means for data exchange, development of the software for the computation of tsunami dynamic characteristics and others. The modernization of the Russian TWS will be an important achievement and will serve to increase the safety of the population along the coasts of the Pacific Ocean as a whole.

## NARRATIVE

In comparison to the previous national report, i.e. since 2003, the following basic projects and investigative works have been carried out:

(1) The modern digital tsunami/tide system at Severo-Kurilsk (Paramushir Island) was re-established by the Youzhno-Sakhalinsk Tsunami Warning Center (YS TWC) in cooperation with the Pacific Tsunami Warning Center (PTWC) in August, 2004. The efficiency of this new system was demonstrated during the catastrophic event of December 26, 2004 in the Indian Ocean. Tsunami waves from the Mw = 9.3 Sumatra earthquake propagated over 25,000 km across the Indian Ocean around the southern and eastern coasts of Australia and across the entire Pacific Ocean to be clearly recorded by the upgraded Severo-Kurilsk instrument in the region of the Northern Kuril Islands in the northwestern Pacific.

(2) The Geo-information System (GIS) "Extremum" designed by the Institute of Ministry for Emergency Situations of Russia was established in the Sakhalin Region to estimate the consequence of earthquakes in the territory of this region. A System for monitoring, laboratory checking and forecasting emergency situations, including earthquakes and tsunamis, was also created in the Sakhalin Region.

(3) The comprehensive historical tsunami database with global coverage has been created at the Novosibirsk Tsunami Laboratory within the GTDB (Global Tsunami Database) Project. This is a joint project of the IUGG Tsunami Commission (IUGG/TC) and the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU). The database covers the period from 1628 B.C. to the present and currently contains nearly 2250 historical events with 1206 of them having occurred in the Pacific, 263 in the Atlantic, 125 in the Indian Ocean and 545 in the Mediterranean region. This database also contains a new subroutine for fast calculation of the tsunami travel times for any part of the World Ocean provided with digital bathymetric data.

(4) An efficient approach has been proposed to optimize the placement of tsunami warning stations for coastal areas of the Indian and Pacific Oceans. Theoretically, for an arbitrary tsunami source this approach is based on maximizing a *safe warning time*, i.e. the time delay between the tsunami arrival time at a specified coastal site and the tsunami warning ("reference") station. This approach can be used to estimate the effectiveness of the existing Tsunami Warning System and to design a new optimum system. In particular, it is shown that warning stations located on the Nicobar or Andaman Islands would provide about a two-hour warning for the coasts of East India and Sri Lanka, while for the coasts of Thailand, Indonesia, Myanmar and Malaysia in the Indian Ocean, or for the Kuril Islands and Kamchatka in the Pacific Ocean, additional buoys or bottom pressure stations in the open ocean are critical. It is also shown that open ocean remote stations may be efficiently used to calculate exact tsunami waveforms for coastal stations based on the "reciprocity principle".

(5) Major attention has been paid to the analysis of the December 26, 2004 Indian Ocean tsunami. The records of this tsunami were collected for the entire world ocean, including the North Pacific and North Atlantic. The combination of the model simulations and the vast instrumental data for this giant tsunami provided a unique opportunity to improve our knowledge about tsunami evolution during propagation over large distances. Although no tsunami damage has been reported outside the Indian Ocean basin for this event, the provided study clearly indicated the inter-ocean potential of tsunami energy transport. A large tsunami was found to enable substantial wave energy to propagate to very distant coasts and even to different oceans by combination of source focusing and wave-guide properties of ocean bathymetry; major ocean ridges provide the main route of energy transport for a large tsunami in the far-field area. In the near-field the tsunami source configuration was found to be the main factor in the energy distribution. The good correlation between the model predictions and instrumental observations in the far-field suggest that tsunami dynamic during the offshore propagation is mostly linear.

(6) Thorough analysis of the JASON-1 and TOPEX/POSEIDON satellite altimetry data of the December 26, 2004 Indian Ocean tsunami revealed clearly the effect of surface gravity wave dispersion: the high-frequency "tail" of this tsunami propagated much slower than the low-frequency leading waves. Satellite tracks crossed the wave front nearly 2 hours after the main shock ($M_w = 9.3$); maximum tsunami heights have been found to be 0.8 m, and the basic wave length about 500 km.

(7) In analogy with seismological studies, tsunami arrival times obtained from coastal tide gauge and satellite altimetry records of the December 26, 2004 tsunami for the Indian Ocean were used to delineate the source region for the 2004 event. Findings marked out a curved 250-km wide,

1000-km long heterogeneous tsunami source region centered over the Sunda Subduction Zone, which closely matches the seismic source generated from broadband geophysical data. Imbedded in this general source region are distinct northern and southern “hot spots” which were responsible for separate groups of peak waves that inundated different sectors of the Indian Ocean.

(8) A team of Russian specialists, in cooperation with specialists from other countries, actively participated in the field survey of the Indonesian coast after the catastrophic December 26, 2004 earthquake and tsunami in the Indian Ocean. In particular, they examined the coastal zones, estimated vertical tsunami run-up and inundation on the coasts of Sumatra, Simelu and Nias islands (Indonesia). They also collected a great number of paleo samples of historical tsunamis in this region.

(9) The “keyboard model” of the great earthquakes in the subduction zones was used to demonstrate the high probability of a destructive tsunamigenic earthquake (with possible magnitude $M_w$ =8.5-8.7) in the region of the Central Kuril Islands. The results of numerical modeling indicated that such an earthquake would produce tsunami waves with maximum run-up of about 15 m on the coast of the Kuril Islands and more than 4 m on the coast of northeastern Sakhalin.

(10) Data for tsunamigenic earthquakes and observed tsunami run-up were used to estimate tsunami-risk for the coasts of Peru and northern Chile for zones bounded by 5°S to 35°S latitude. Expected tsunami wave heights for various return periods were estimated based on three different empirical relations between earthquake magnitudes and tsunamis. The average heights were 11.2 m (50 years), 13.7 m (100 years), and 15.9 m (200 years), while the maximum height values (obtained by Iida’s method) were: 13.9, 17.3, and 20.4 m, respectively. Both the “averaged” and “maximum” seismological estimates of tsunami wave heights for this region are significantly smaller than the actually observed tsunami run-up of 24 to 28 m for the major events of 1586, 1724, 1746, 1835, and 1877. Based directly on tsunami run-up data, estimated tsunami wave heights were 13 m for a 50-year return period and 25 m for a 100-year return period. According to the “seismic gap” theory, the next strong earthquake and tsunami may be expected to occur between 19°S and 28°S in the vicinity of northern Chile.

(11) The catastrophic tsunamis of the last decade generated a new interest in the 1883 Krakatau volcanic eruption tsunami, the first known global tsunami with wave heights of 40 m near the source area and significant oscillations reported in the Indian, Atlantic and Pacific oceans. The 35 records available for this tsunami were digitized with a time step of 2 min and carefully processed. De-tided digital records were used to re-determine the observed tsunami characteristics (wave heights and periods). The results of this analysis have been compared with the results of a numerical simulation of the Krakatau tsunami wave propagation based on the shallow-water theory and ETOPE2 bathymetry.

(12) A thorough re-examination was also done of the largest Atlantic Ocean tsunami of the XX century, associated with a $M$ = 7.2 earthquake of November 18, 1929 that occurred at the southern edge of the Grand Banks, 280 km south of Newfoundland. The earthquake triggered a large submarine slope failure (200 $km^3$); tsunami waves generated by this failure killed 28 people in Canada and crossed the Atlantic to be recorded on the coasts of Portugal and the Azores Island. A viscous shallow-water model was used to simulate this slide-generated

tsunami. The preliminary results of the numerical modeling are encouraging with computed and observed tsunami characteristics are in reasonable agreement.

(13) Comparative characteristics of tsunami wave heights along the Russian coast of the Sea of Japan associated with historical and hypothetical sources have been examined. The hypothetical sources were selected to be localized along the western coast of Japan. Distribution of wave heights along the coast was calculated based on a shallow-water numerical model. It was found that, independent of the source location, calculated tsunami wave heights are small at some local sites and, therefore, tsunami risk is small for these selected sites.

(14) Field surveys were provided on the coasts of Les Saintes Islands (Lesser Antilles) to estimate wave run-ups and other wave characteristics of a weak tsunami generated by a moderate earthquake ($M_s$ =6.1; $M_w$ =6.3) of November 21, 2004, that occurred in Dominica Passage separating Guadelupe and Dominica Islands. Clear tsunami signatures with maximum amplitudes +70 cm and –80 cm have been found.

(15) Special hydrographic experiments were performed in August - September of 2003 and 2004 in Youzhno-Kurilsk Bay (Kunashir Island) by the Institute of Marine Geology and Geophysics (Youzhno-Sakhalinsk) to study waves processes in the tsunami frequency band. These experiments gave important information about resonant properties of the bay and estimates of tsunami risk in various coastal segments of the bay.

(16) It is shown that acoustic signals (AS) appearing at the critical stage of a submarine earthquake may be efficiently used for early tsunami warning. Increasing micro-crack density generates AS with frequencies in the range 10-100 Hz. These signals decay quite slowly in water media and propagate for long distances. The data from a receiving array of precise hydro-acoustic hydrophones offshore from Kamchatka was used to analyze local Kamchatka earthquakes. Two types of acoustic signals have been detected: (1) *micro-earthquakes* and (2) seismic rumble, which appears just before the main shock.

(17) Several field surveys of historical tsunami signatures and paleotsunami traces were provided on the coasts of the Kuril Islands and Kamchatka. The expedition materials significantly enlarged the temporal extent of historical tsunami events for 10000 years and considerably increased the catalogue of tsunami for the Pacific coast of Russia. In particular, for the region of the Lesser Kuril Islands 15 major tsunami events have been identified in paleotsunami deposits. The return period for tsunamis with wave heights 5-8 m was found to be 500 years for this region.

(18) The International Symposium **“***Topical Problems of Island and Coast Seismology (ICS-2005)***”** was organized in Youzhno-Sakhalinsk, Russia on June 5-8, 2005. The Symposium was devoted to the 10-year memorial of the catastrophic 1995 Neftegorsk Earthquake in Sakhalin Island and to recent progress in the interrelation fields of seismology and geodynamics of active continental margins. The main topics of the symposium were the problems of earthquake prediction, timely earthquake and tsunami warnings, and mitigation of the natural hazards.

**Date: August 25, 2005**

**Name: I.P. Kuzminykh**