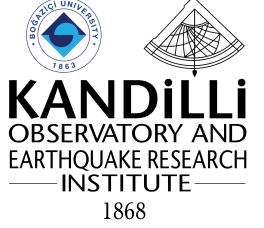




RETMC

BOĞAZIÇI UNIVERSITY

**KANDILLI OBSERVATORY
AND EARTHQUAKE RESEARCH
INSTITUTE**



**NATIONAL TSUNAMI WARNING CENTER
ICG/NEAMTWS TSUNAMI SERVICE PROVIDER
NTWC-TR / TSP-TR**

Background

KOERI, established in 1868 as the Imperial Observatory, has a long tradition of earth observation and science. From 1868 to today, the development of the Observatory and the researches conducted can be summarized into three important periods: 1868-1909-1911-1982, and from 1982 to the present: an Academic Institute. After annexed to Boğaziçi University and given an institutional academic status, Kandilli Observatory and Earthquake Research Institute (KOERI) extended its activities into various observational fields with the main emphasis oriented towards earthquake research, education and relevant observational service activities. KOERI today has evolved into a multidisciplinary earthquake research organization providing graduate education in three departments namely Earthquake Engineering, Geodesy, and Geophysics. KOERI is a unique organization in Turkey encompassing earthquake observation, research, education and application services within a single, integrated body. Besides this, the Astronomy, Meteorology and Magnetism observatories have been updated with state of art technology.

KOERI Regional Earthquake and Tsunami Monitoring Center

KOERI's Regional Earthquake and Tsunami Monitoring Center (RETMC) is 24/7 operational center comprising 176 Broadband (BB), 100 Strong Motion and 8 short-period sensors at the national level. KOERI also operates 5 sea-floor multi-instrument observation systems in the Sea of Marmara and is the National Tsunami Warning Centre for Turkey under the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG/NEAMTWS) initiative. KOERI officially declared its Interim Candidate Tsunami Service Provider Status covering Eastern Mediterranean, Aegean, Marmara and Black Seas as of 1 July 2012 to the ICG/NEAMTWS Secretariat in June 2012 and was accredited as Tsunami Service Provider (TSP) during the 13th session of ICG/NEAMTWS held in Bucharest-Romania on 26-28 September 2016.

Turkey, as a country with a history of devastating earthquakes and with a coastline of 8333 km, has been also affected by more than 100 tsunamis during the observation period over 3500 years. A possible tsunami today affecting the coastal areas of Turkey may cause considerable damage, especially considering the densely populated coastal areas, infrastructure and harbours. Coastal cities cover less than 5% of the total surface area of Turkey, but they have over 30 million inhabitants and are growing rapidly. The Marmara region around Istanbul has the highest population density of all regions. At the same time, more than 60% of the Turkish Gross National Product (GNP) is produced in the coastal strip along the northern shoreline of the Marmara Sea. Continued urbanization and tourist development will further increase exposure to tsunami hazard. Currently, the consequences of a possible tsunami are ignored in coastal management, and although strengthening of coastal management mechanisms is required for a number of reasons, tsunami hazard should be considered an important long-term issue. The determination of inundation limits for a range of credible tsunami scenarios at the coastal areas is of high importance in order to assess vulnerability and develop, coastal protection, land-use planning and evacuation plans.

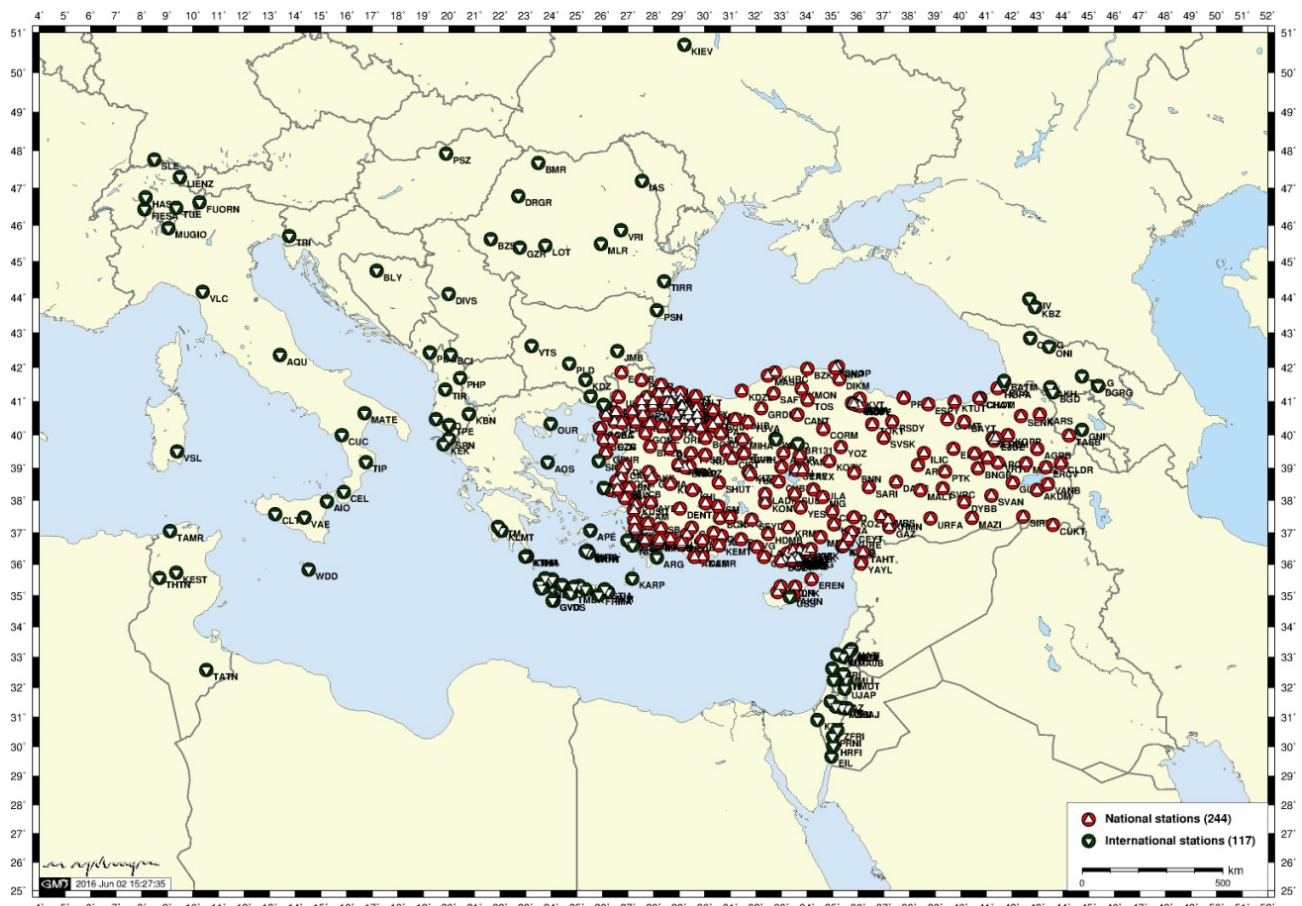


Figure 1: Distributions of regional seismic stations around Turkey available with real-time data.

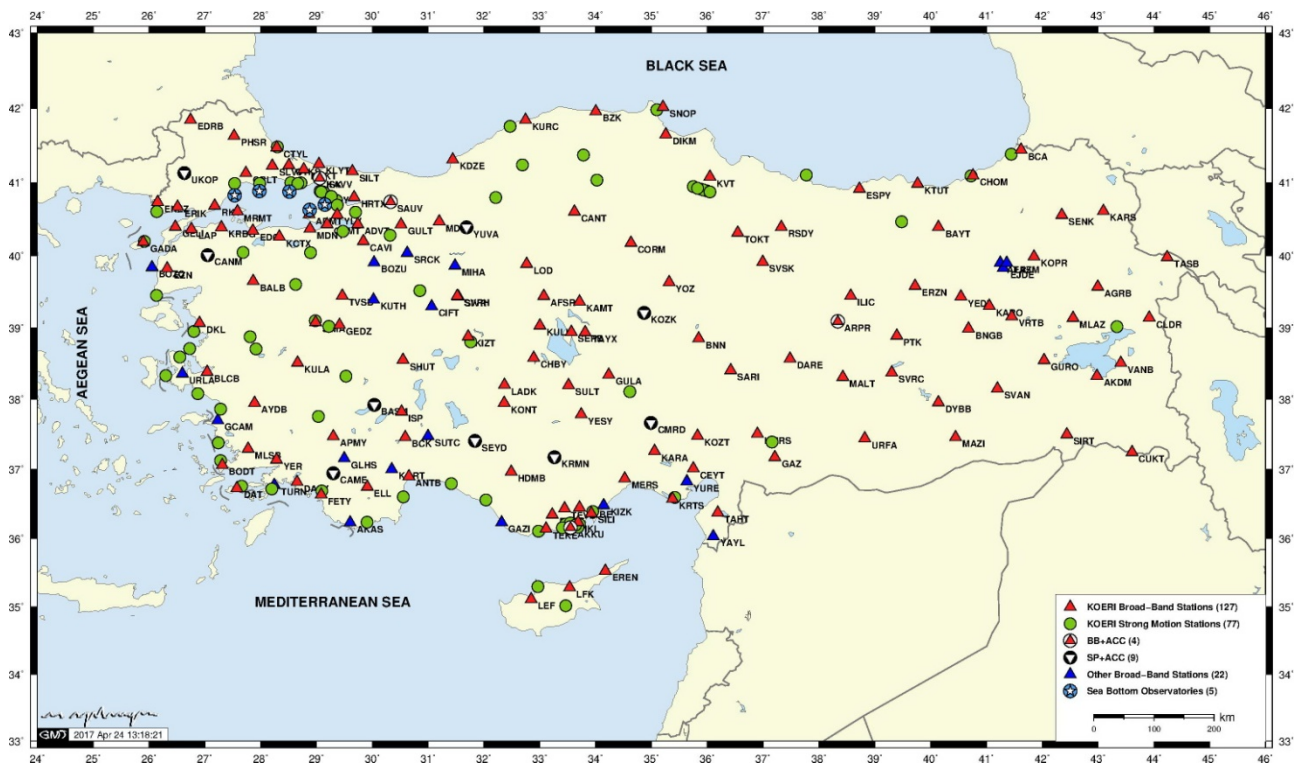


Figure 2: Seismological Network of the Regional Earthquake and Tsunami Monitoring Center of KOERI

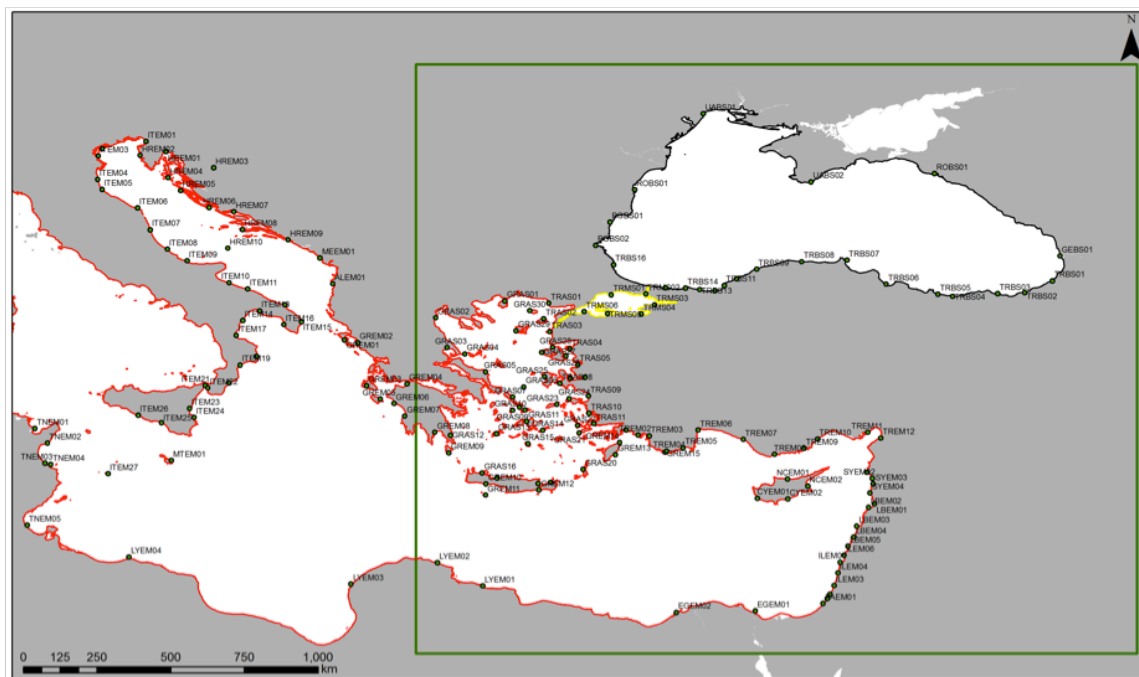


Figure 3: KOERI- Regional Earthquake and Tsunami Monitoring Center Service Area. Earthquake monitoring area is shown in green rectangle as the area monitored by KOERI to assess the tsunamigenic potential of an earthquake. whereas disseminated messages include Tsunami Forecast Points as indicated on the map.

Based on an agreement with the Disaster and Emergency Management Presidency (AFAD), data from 10 BB stations located in the Aegean and Mediterranean Coast is now transmitted in real time to KOERI. Real-time data transmission from 6 primary and 10 auxiliary stations from the International Monitoring System is in place based on an agreement concluded with the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) in 2011. In an agreement with a major Turkish GSM company, KOERI is enlarging its strong-motion network to promote real-time seismology and to extend Earthquake Early Warning system countrywide. 25 accelerometers (included in the number given above) have been purchased and installed at Base Transceiver Station Sites in coastal regions within the scope of this initiative. Data from 7 tide gauge stations operated by General Command of Mapping (GCM) is being transmitted to KOERI via satellite connection and the aim is to integrate all tide-gauge stations operated by GCM into NTWC-TR.

Duty officers of the RETMC perform internal tests of the Tsunami Warning System on a daily basis based on pre-determined set of scenarios. In addition, KOERI performs a Communication Test Exercise with other CTSPs on every Tuesday of the every first full week of each month. A collaborative agreement has been signed with the European Commission - Joint Research Centre (EC- JRC) and MOD1 & MOD2 Tsunami Scenario Databases and TAT (Tsunami Analysis Tool) are received by KOERI and user training was provided. The database and the tool are linked to SeisComp3 and currently operational. In addition KOERI finalized its work towards providing in order to develop an improved database (MOD2-TR) in a collaborative effort with EC-JRC, and also continuing its work related to the development of its own scenario database using NAMI DANCE Tsunami Simulation and Visualization Software.

In cooperation with Turkish State Meteorological Service (TSMS), KOERI has its own GTS system now and connected to GTS via its own satellite hub. The system has been successfully utilized during the First Enlarged Communication Test Exercise (NEAMTWS/ECTE1), where KOERI acted as the message provider. KOERI is providing guidance and assistance to a working group established within the AFAD on issues such as Communication and Tsunami Exercises, National Procedures and National Tsunami Response Plan. KOERI has also participated in NEAMTIC (North-Eastern Atlantic and Mediterranean Tsunami Information Centre) Project.

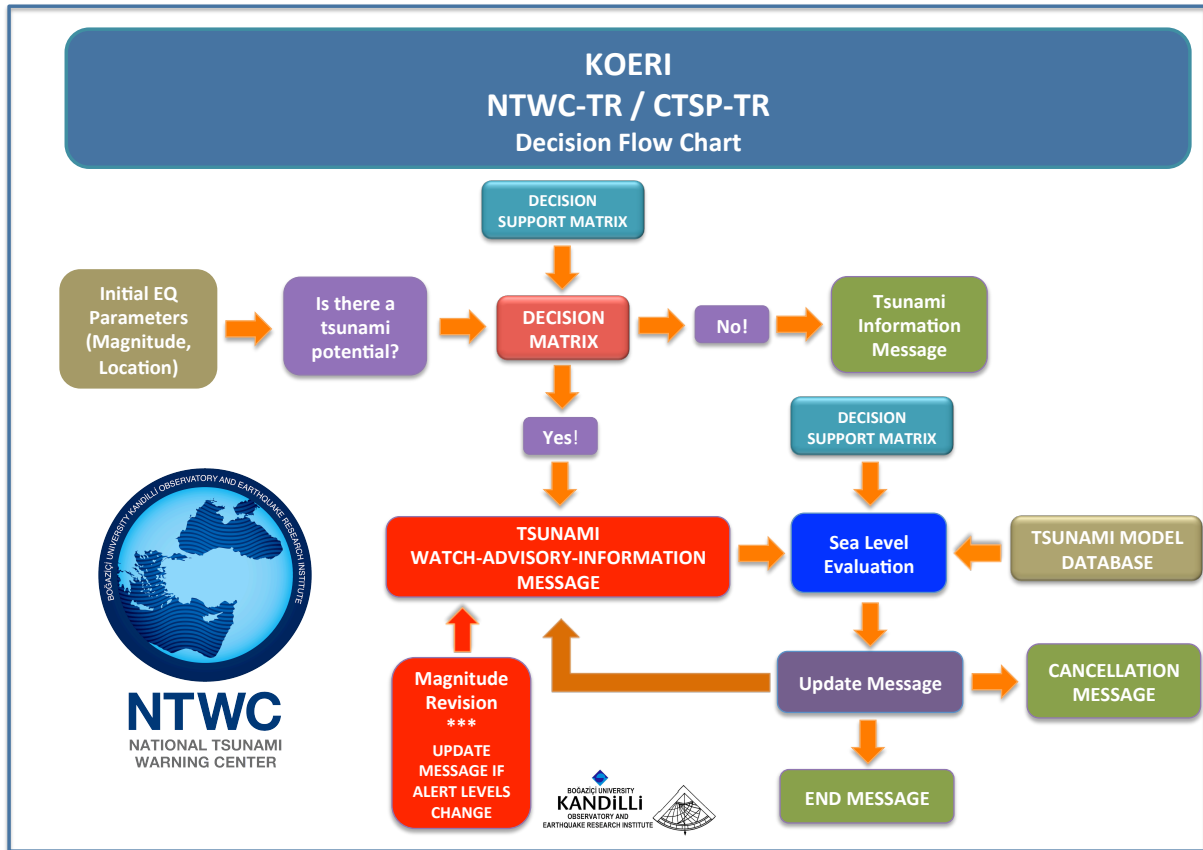


Figure 4: Concept of Operations at NTWC/TSP-TR

CTSP-TR (KOERI)						
Decision Matrix for the Eastern Mediterranean, Aegean and Black Seas						
Depth (km)	Epicentre Location	Earthquake Magnitude	Tsunami Potential	Type of Tsunami Message		
				Local < 100 km	Regional ≥100 - ≤400	Basin-wide > 400
< 100	Offshore or close to the coast (≤ 40 km inland)	5.5 ≤ Mw < 6.0	Low tsunami potential	Information	Information	Information
		6.0 ≤ Mw < 6.5	Tsunami potential	Advisory	Information	Information
	Offshore or close to the coast (≤ 100 km inland)	6.5 ≤ Mw < 7.0	Potential for a destructive tsunami	Watch	Advisory	Information
		7.0 ≤ Mw < 7.5	Potential for a destructive tsunami	Watch	Watch	Advisory
		Mw ≥ 7.5	Potential for a destructive tsunami	Watch	Watch	Watch
≥ 100	offshore or inland (≤ 100 km)	Mw ≥ 5.5	Low tsunami potential	Information	Information	Information
NEAMTWS Decision Support Matrix						
Alert Level		Advisory		Watch		
Wave Amplitude		0.2-0.5 m		> 0.5 m		
Run-up		< 1m		> 1 m		
Impact		Current, bore, damage in water; possible minor inundation in beaches		Watch impact + inundation of the low-lying coastal land		
Other messages used in the operational context, such as (Regular) Communication Test and Tsunami Exercise Messages are not shown here.						

Figure 5: KOERI Decision Matrix

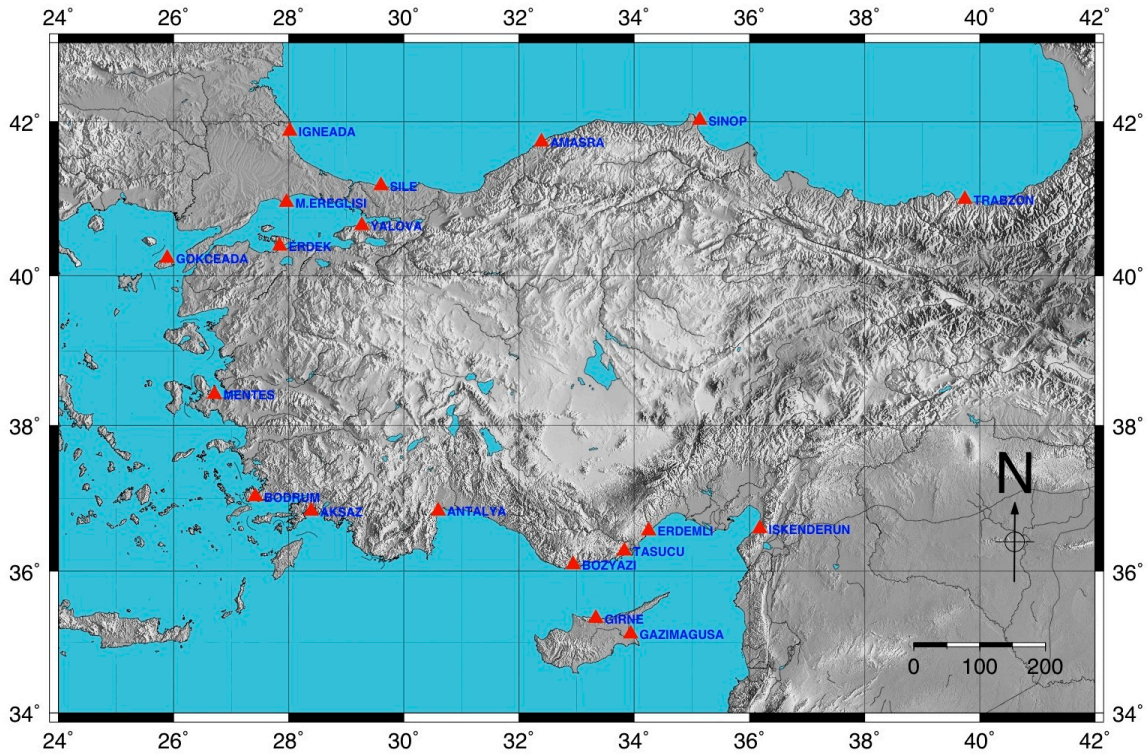


Figure 6: Map of sea-level stations in Turkey operated by General Command of Mapping. Currently, real-time data is available from Sinop, Marmara Ereğlisi, Gökçeada, Bodrum, Bozyazı, Erdemli and Iskenderun. Integration of the remaining stations are expected to be finalized by 2020.

KOERI's Experience in ICG/NEAMTWS Communication Test and Tsunami Exercises

The (Candidate) Tsunami Service Providers (C/TSP), National Tsunami Warning Centres (NTWC) and Tsunami Warning Focal Points (TWFP) must keep a high level of readiness so as to be able to act efficiently and effectively to provide watch (C/TSP) and warnings (NTWC/TWFP) for the public's safety during fast-onset and rapidly-evolving natural disasters like the tsunamis. To maintain this high state of operational readiness, and especially for infrequent events such as tsunamis, tsunami watch/warning centres and emergency agencies must regularly practice their response procedures to ensure that vital communication links work seamlessly, and that agencies and response personnel know the roles that they will need to play during an actual event. Initial Communication Test Exercises were planned, conducted and evaluated by the ICG/NEAMTWS Task Team on Communication Test Exercises (TT-CTE) in June and September 2010. The communication links used were limited to e-mail and fax. Despite the small-scale and limitations, these two first Communication Test Exercises provided the required capacity building that opened the way to the first Enlarged Communication Test.

The scope of these exercises was limited to the Candidate Tsunami Service Providers at this time (Greece, France, Portugal and Turkey), in order to make a thorough evaluation on the procedures to broadcast and receive the tsunami messages. All participants found the exercises useful and the few anomalies detected demonstrated the need for a regular schedule of CTEs. All participants performed an extended set of activities at their institutions to prepare them for the exercises. A set of technical recommendations and suggestions were elaborated that need to be addressed in future exercises. The NEAMTWS is mature for an extended Communication Test Exercise. KOERI was the Message Provider at the 1st Enlarged Communication Test Exercise (ECTE1) in 2011 with the involvement of all the Tsunami Warning Focal Points (TWFP) with 139 end-users in 31 countries of the NEAM region. The second NEAMTWS Communication Test Exercise was conducted on 22 May 2012, where CENALT (France) acted as the Message Provider. KOERI successfully participated also in the CTE2 (22 May 2012, CENALT as the Message Provider) and CTE3 (1 October 2013, NOA as the Message Provider).



Figure 7: Map showing participants of ECTE1 (left), CTE2 (middle) and CTE3 (right)

KOERI has also successfully participated in NEAMWave12, the first Tsunami Exercise in NEAM region, as a Candidate Tsunami Service Provider with a scenario based on Mw=8.4 worst-case interpretation of the 8 August 1303 Crete and Dodecanese Islands earthquake resulting in destructive inundation in the Eastern Mediterranean. 12 messages were disseminated within a 3-hour time-frame to the relevant end-users in total, where four dedicated messages were sent to the NEAMTWS Member States via e-mail, fax and GTS targeting the subscribers of the KOERI Scenario in terms of scenario affected areas. Besides the NEAMTWS messages, KOERI has also sent messages in Turkish to the Disaster and Emergency Management Presidency of Turkey (AFAD). AFAD and other selected internal end-users were also provided with the messages produced by the TRIDEC Natural Crisis Management System, currently being developed within the same titled EC-FP7 Project, where end-users were also provided with hazard maps. In addition, KOERI has also monitored IPMA (Instituto Português do Mar e da Atmosfera, Portugal) Scenario through the unique system-to-system communication capabilities of TRIDEC. The final evaluation of the exercise indicates that the messages were disseminated successfully and both KOERI and AFAD benefited from the exercise considerably, where the NEAMTWS Tsunami Warning Chain System has been tested to a full scale for the first time.

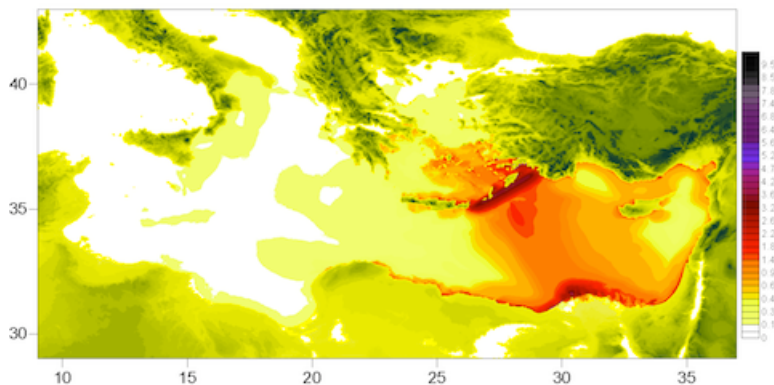


Figure 8: Maximum wave height distribution of the Mw=8.4 worst-case interpretation of the 1303 Crete and Dodecanese Islands earthquake used in NEAMWave12 by KOERI (left) and KOERI's Operations Room during the Exercise (right)

NEAMWave 14, as the second Tsunami Exercise in NEAM, was held on 28-30 October 2014. NEAMWave14 involved the simulation of the assessment of a tsunami, based on an earthquake-driven scenario followed by alert message dissemination by Tsunami ServiceProviders-CTSP (Phase A) and continued with the simulation of the Tsunami Warning Focal Points/National Tsunami Warning Centres (TWFP/NTWC) and Civil Protection Authorities (CPA) actions (Phase B), as soon as the message produced in Phase A has been received. Different from the tsunami exercise in 2012, NEAMWave14 also included Phase C which covered the simulation of activation of the Union Civil Protection Mechanism at international level as soon as the message produced in Phase A has been received by the European Commission Emergency Response and Coordination Centre (ERCC). In NEAMWave14, KOERI acted as the Message Provider for a Black Sea Scenario, where Black Sea was covered for the first time in a NEAMTWS Tsunami Exercise.

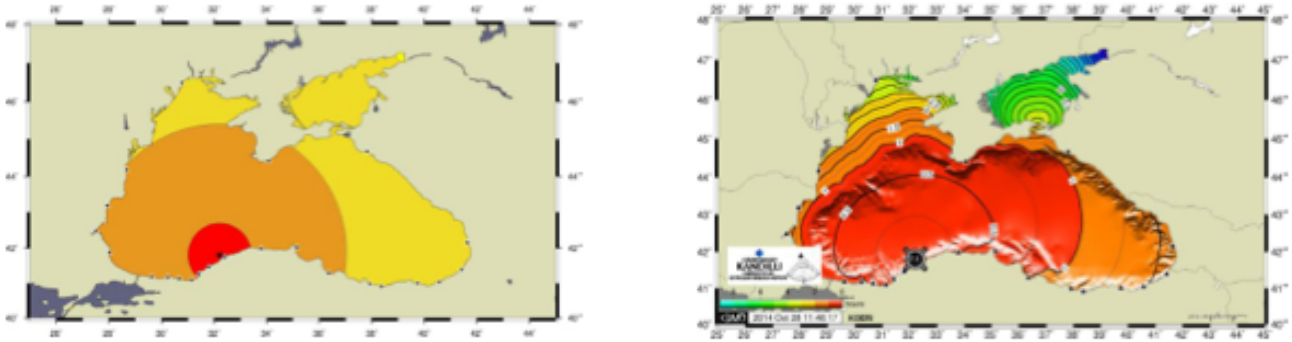
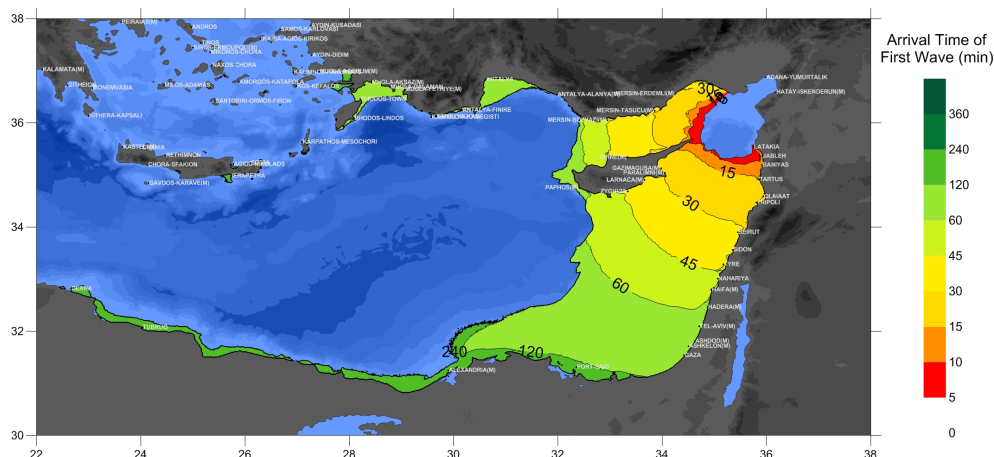


Figure 9: Distance Based Tsunami Alert Map (left) and Tsunami Travel Time Map disseminated to Turkish CPA in NEAMWave14 (right).

Phase A covers the simulation of a tsunami assessment triggered by an earthquake scenario, tsunami alert message dissemination by CTSP and the message reception and evaluation by Tsunami Warning Focal Points (TWFP). Each CTSP selected one single earthquake scenario and computed the corresponding prescheduled tsunami assessment. The schedule of events list followed by KOERI includes the dissemination of 5 messages at the 5th, 15th, 60nd, 110th and 180th minutes of the event, respectively. In addition to the NEAMTWS messages, KOERI has disseminated 5 Turkish alert messages to the Disaster and Emergency Management Presidency of Turkey (AFAD) as the authorized CPA in Turkey, where the first message included enhanced products such as Tsunami Travel Map, Tsunami Forecast Point Alert Level Map and Distance Based Tsunami Alert Maps. In NEAMWave14, KOERI also disseminated tsunami exercise message via SMS to the subscribed recipients. In NEAMWave14, KOERI disseminated the tsunami alert messages to the recipients from the countries of Bulgaria, Belgium, Cape Verde, Croatia, Cyprus, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Ireland, Israel, Italy, Lebanon, Malta, Monaco, Netherlands, Poland, Portugal, Romania, Russian Federation, Slovenia, Spain, Sweden, Syria, Turkey, Ukraine and United Kingdom. The messages were sent to 92 recipients via email, 87 recipients via fax and 65 recipients via sms using KOERI’s in-house developed back-up Tsunami Message Dissemination Tool “TWS_Messenger”. In addition to the countries listed above, KOERI also disseminated tsunami alert messages within NEAMWAVE14 to Intergovernmental Oceanographic Commission (IOC) via fax and Monitoring and Information Centre (MIC) both via fax and email.

NEAMWave17, the third tsunami exercise of NEAMTWS, will be conducted during 31 October – 3 November 2017. KOERI scenario for the NEAMWave17, which will be conducted on 1 November 2017, is based on a Mw 7.4 inland earthquake in Hatay Province of Turkey, that would trigger a submarine landslide generating a tsunami which would mainly impact Iskenderun Bay, but also leading to tsunami impact in Latakia, and observations in southern Turkey, Levantine coast and Cyprus. The main aim is to simulate a multi-hazard natural disaster in a region where there is an on-going humanitarian crisis to allow Phase B and Phase C participants to consider respective actions. As of March 2017, more than 35.000 Syrian refugees are sheltered by the Turkish CPA AFAD in Hatay Province only and the scenario is expected to allow AFAD to exercise their post-disaster recovery and management activities in a broader context. It is also envisaged that corresponding UNHCR and ERCC activities could also be simulated based on this scenario.



Arrival times of first wave in the KOERI M7.4 Samandag scenario during NEAMWave17

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Tsunami Education and Awareness Raising Activities

Besides the Communication Test and Tsunami Exercises KOERI has participated in, as briefly described in Chapter 3, KOERI also has a committed program in tsunami education and awareness raising activities. Disaster Preparedness Education Unit (DPEU) of KOERI has been contributing to the preparation of the community to a destructive earthquake through increased disaster awareness, local preparedness, first response organization and skills across the country. DPEU is already involved in developing, supervising and evaluating training programs on disaster risk management; preparation and dissemination of training materials such as booklets, forms, presentations, videos and CD's; creation of a pool of trainers within KOERI; providing training programs at the national level in cooperation with other agencies if necessary; organizing national and international seminars, workshop and public activities. DPEU earthquake training packages are Basic Disaster Awareness, Community Disaster Volunteers, Nonstructural Risk Mitigation and Structural Awareness for Seismic Safety. Since the beginning of the regional services of the KOERI-RETMC, DPEUs experience and know-how on earthquake awareness, preparedness and mitigation is being used to reach the same level of maturity concerning the tsunami hazard education and awareness raising activities.

In this spirit, KOERI has participated in NEAMTIC (North-Eastern Atlantic and Mediterranean Tsunami Information Centre) Project on a self-funded base for the translation of selected material in Turkish, as follows: educational poster, website/virtual library interface, coastal inundation online course, of good and guidelines/poster on hotel evacuation practices compendium.

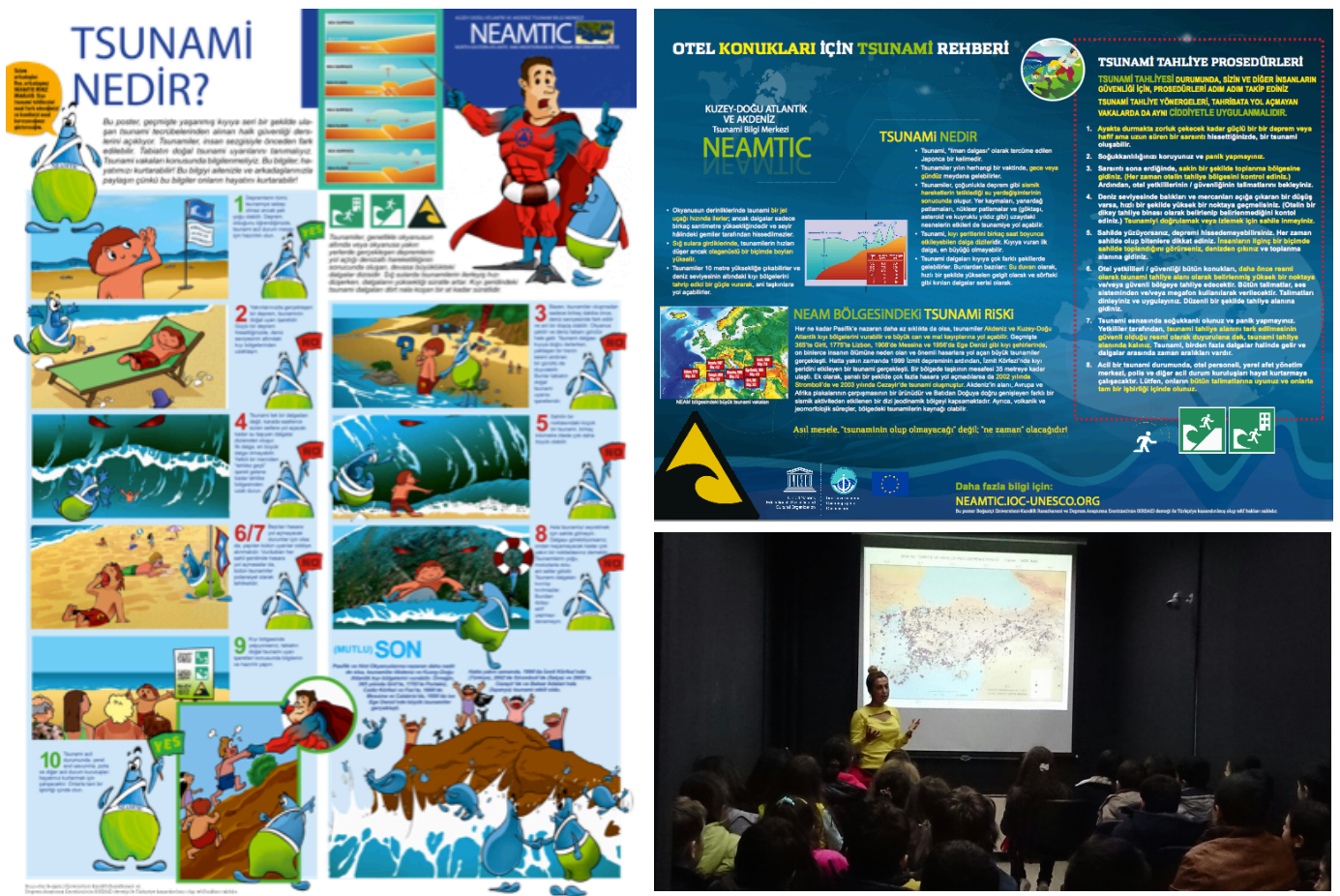


Figure 10: (left) Educational tsunami poster in Turkish. (right top) Tsunami poster on hotel evacuation in Turkish. (right bottom) A scene from the educational session at KOERI's Disaster Preparedness Education Unit.

Within the EC-FP7 Project ASTARTE and "MarDim: Earthquake And Tsunami Disaster Mitigation In The Marmara Region And Disaster Education In Turkey" project supported by JICA/SATREPS, KOERI executed an assessment of tsunami studies conducted in Turkey that includes published articles, oral and poster presentations, books and several awareness materials produced. In addition, studies around the globe have also

been evaluated, and particular emphasis was given to preparedness studies in Japan. In direct consultation with a group of Japanese experts, experiences and preparedness material produced in Japan, such as booklets, videos, animations etc., have also been studied. As a result of this, a 20 page “Tsunami Information Booklet” has been prepared, that comprises the following chapters:

- What is a tsunami and how it is generated?
- Major tsunamis around the globe
- Some earthquakes resulted in tsunamis and associated losses
- Tsunami risk in the Mediterranean
- Tsunami risk in and around Turkey
- Historical Tsunamis in Turkey
- Tsunami Early Warning Systems
- Tsunami studies in Turkey
- How can we protect ourselves from tsunami?

The booklet in Turkish language could be downloaded at the following link:

http://www.koeri.boun.edu.tr/aheb/pdf%20dokumanlar/tsunami_kitap.pdf



Figure 11: Extracts from the Tsunami Information Booklet in Turkish. (left) “What is a tsunami? How is it generated?” and (right) “How can we protect ourselves from tsunami?”

An educational short video has also been prepared in consultation with Japanese experts. To assess the effectiveness of the produced material, a pre- and post-questionnaire with 10 questions have been prepared, which comprised three sections as personal attributes, general questions and understanding tsunami. This questionnaire has been applied to pupils visiting KOERI’s Disaster Preparedness Education Unit.