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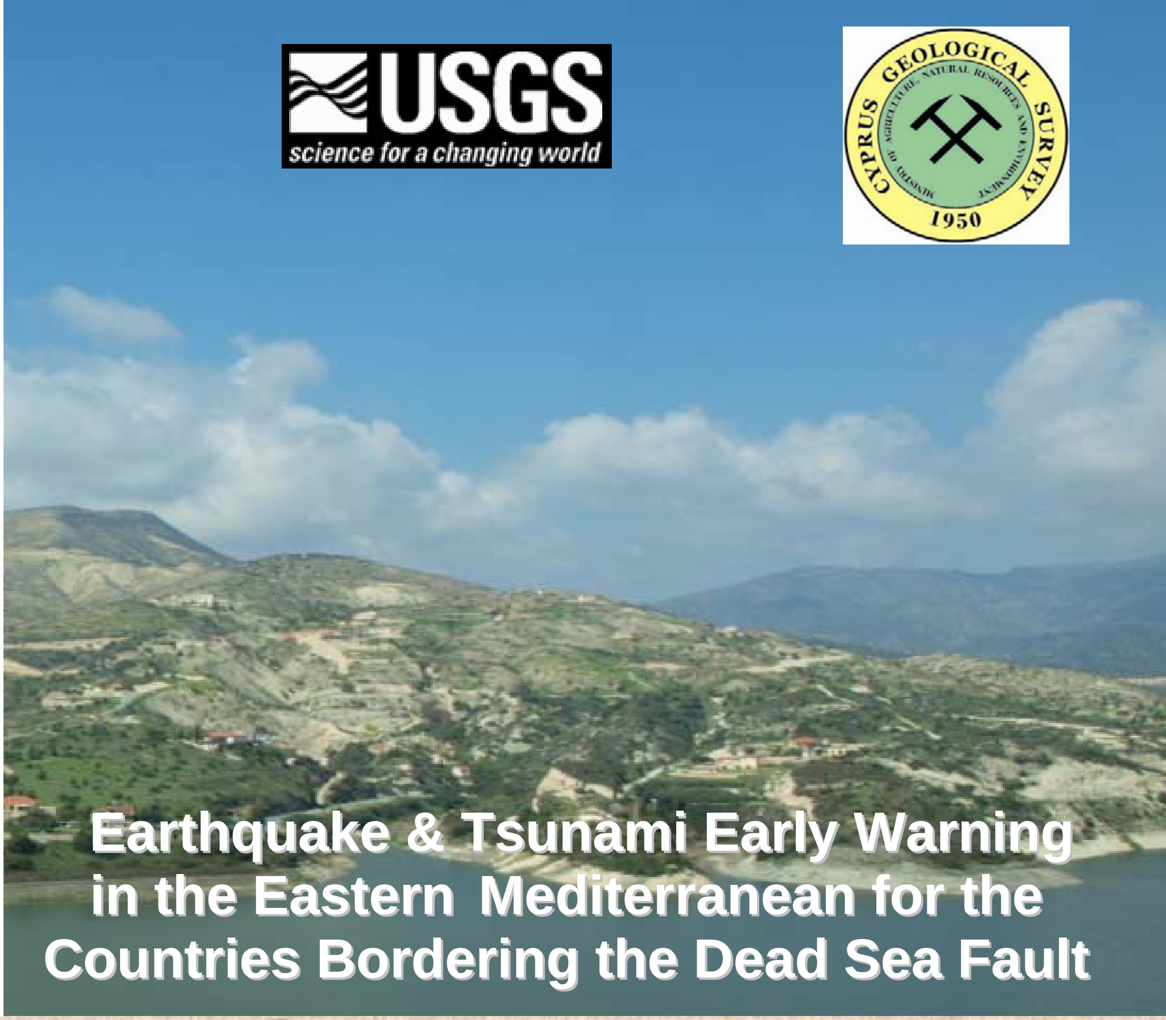

Earthquake & Tsunami Early Warning in the Eastern Mediterranean for the Countries Bordering the Dead Sea Fault

UNESCO Sub-RELEMR International Workshop

5 - 6 November 2012

Cyprus Geological Survey Department - GSD
Larnaca - Cyprus

Reducing Earthquake Losses in the Extended Mediterranean Region UNESCO-RELEMR

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Foreword

The Sub-RELEMR International Workshop on Earthquake & Tsunami Early Warning in the Eastern Mediterranean for the Countries Bordering the Dead Sea Fault, is held in Larnaca, Cyprus, from 5 to 6 November 2012 at the Palm Beach Hotel. The Workshop is an activity within the framework of the programme on Reduction of Earthquake Losses in the Extended Mediterranean Region (RELEMR). Participants of the workshop were invited to make contributions to the programme which will be included in the proceedings. The sessions of the workshop will discuss essentially tsunami early warning systems in the Eastern Mediterranean region and earthquake early warning systems from earthquakes generated by the Dead Sea Fault.

This document contains a compilation of abstracts of presentations, which were made available prior to the workshop. It is hoped that it will serve as a good basis for the proceedings of the workshop. We express appreciation to the authors of these abstracts.

The content of this document does not necessarily reflect the views of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Paris, 31 October 2012

Alexandros Makarigakis
Programme Specialist
Unit for Natural Disasters
UNESCO

International Workshop on
Earthquake & Tsunami Early Warning in the Eastern Mediterranean
for the Countries Bordering the Dead Sea Fault

Palm Beach Hotel, Larnaca, Cyprus
5 – 6 November 2012

Preliminary Program

Sunday, 4 November 2012

Participants arrive in Larnaca

Monday, 5 November 2012

09:00 – 09:30 Registration

Opening Ceremony

09:30 – 10:30 Opening Ceremony, Chairs:
Eleni Georgiou Morisseau, Director, Geological Survey Department
Michael Foose, USGS
Alexandros K. Makarigakis, UNESCO

10:30 – 11:00 Coffee/tea break

11:00 – 11:15 Logistical announcements

First Session

11:15 – 12:30 Contributed Papers: Chair: Mahmoud Al-Qaryouti

11:15 – 11:40 Kyriacos Hadjigeorgiou
Informing the Public

11:40 – 12:05 David Oppenhaimer
Cooperation among Regional Seismic Networks in the United States Advanced National Seismic System (ANSS)

12:05 – 12:30 Abou Elela A. Mohamed
Seismic Hazard Studies in Egypt

12:30 – 14:20 Lunch

Second Session

14:20 – 16:00 Contributed Papers: Chair: Jalal Al Dabbeek

14:20 – 14:45 Usama Zaineldeen
Tectonic Evolution in the Southern Segment of the Dead Sea Rift

14:45 – 15:10 Rami Hofstetter
Pilot Transnational Seismic Network in the Dead Sea Rift

15:10 – 15:35 Amos Salamon
Decision Criteria for Tsunami Early Warnings in the Levant

15:35 – 16:00 Rachid Jomaa and Lama Inati
Tsunami Risk off the Lebanese Coast

16:00 – 16:30 Coffee/tea break

Third Session

16:30 – 17:45 Contributed Papers: Chair: Hatem Odah

16:30 – 16:55 Sergiu Dov Rosen
Landslide Tsunami Early Warning in the NEAMTWS Context for Eastern Mediterranean, Following Strong Earthquakes at the Dead Sea Fault

16:55 – 17:20 Jalal Al Dabbeek
Slope Stability Analysis and Landsliding Studies Based on Geophysical Seismic Exploration

17:20 – 17:45 Ryad Darawcheh
Seismotectonics of the North Easternmost Part of the Mediterranean Sea: Implications for the Seismic Hazard Assessment

Tuesday, 6 November 2012

Fourth Session

09:15 – 10:30 Contributed Papers, Chair: Nurcan Meral Özel

09:15 – 09:40 Gidon Baer
Earthquake Early Warning for Israel: Recommended Implementation

09:40 – 10:05 Vladimir Pinsky
Lead time estimation for Earthquake Early Warning System in Israel Strategy

10:05 – 10:30 Ali Pinar
Earthquake Early Warning System for Istanbul and Marmara Sea Region

10:30 – 11:00 Coffee/tea break

Fifth Session

11:00 – 13:00 Keynote Presentations: Chair: Ryad Darawcheh

11:00 – 12:00 John Clinton
Building an Earthquake Early Warning System - Focus on the Seismic Network Aspects

12:00 – 13:00 Aldo Zollo
Earthquake Early Warning Methods and Feasibility Studies in Europe

13:00 – 14:30 Lunch

Sixth Session

14:30 – 16:30 Keynote Presentations: Chair: Avi Shapira

14:30 – 15:30 Richard M. Allen
Warning California: Earthquake Alerts Today

15:30 – 16:30 Nurcan Meral Özel
Tsunami Warning Center in Turkey and Eastern Mediterranean and its Connected Seas

16:30 – 17:00 Coffee/tea break

Closing session

17:00 – 17:30 Closing session: *Chairs:*
Eleni Georgiou Morisseau, Director, Geological Survey Department
Michael Foose, USGS
Alexandros K. Makarigakis, UNESCO

Wednesday, 7 November 2012

Depart Larnaca

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Informing the Public

Kyriacos Hadjigeorgiou

Cyprus Civil Defense Headquarters, Strovolos, Cyprus
Email: khadjigeorgiou@cd.moi.gov.cy

The general public needs clear information and instructions in order to be in a position to follow the recommended actions efficiently and this can be considered as one of the basic mottos of the First Responders in an emergency.

It is very important that the public should be informed that instructions should be followed only if they are issued by Official Authorities. Instructions from unofficial sources, in several cases, are wrong or misleading and can cause undue concerns and can lead to psychological and economic impact on the population.

One of the Cyprus Civil Defense's mandates is to inform the general public before, during and after the occurrence of a natural or man-made disaster or military confrontation. In order to perform this duty, Cyprus Civil Defense has installed an early warning system which covers the areas that are under the control of the Republic of Cyprus. The activation procedures of this system are included in the Contingency Action Plans prepared for every specific emergency.

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Cooperation among regional seismic networks in the United States Advanced National Seismic System (ANSS)

David Oppenheimer

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In 1998 the USGS published Circular 1188, "Requirements for an Advanced National Seismic System", which provided a conceptual framework for consolidating the many regional and specialized seismic networks operating in the USA into a national system. At the time, some regional seismic networks (RSN) were already cooperating to monitor their respective regions, but this document spurred further cooperation. Building the ANSS required willing participation from the RSNs, guidance from USGS management, and funding to implement improvements. Workshops and working groups were convened to define system priorities, technical standards, and performance requirements. Because of the diverse monitoring requirements across the country, ANSS operators subdivided monitoring operations into six regions across the nation. For example, the 14 independently operated networks operating in California organized as the California Integrated Seismic Network. RSN operators meet monthly to participate in setting ANSS policy, and the ANSS has an independent National Steering Committee comprised of professionals in the fields of engineering and seismology, State and Federal government, and emergency management. Over the past 14 years a common vision has developed that has benefitted RSNs, the emergency management community, and the public who look to the ANSS for reliable and rapid earthquake information on global and domestic earthquakes and the data to support research in earthquake engineering and seismology.

Seismic Hazard Studies in Egypt

Abou Elela A. Mohamed, M. El-Hadidy, A. Deif, K. Abou Elenean

National Research Institute of Astronomy and Geophysics (NRIAG),
Helwan, Cairo, Egypt, E-mail: amin@nriag.sci.eg

The study of earthquake activity and seismic hazard assessment of Egypt is very important due to the great and rapid spreading of large investments in national projects, especially the nuclear power plant that will be held in the northern part of Egypt. Although the number of large earthquakes documented in Egypt is low, it has experienced damaging earthquake effect through its history. The seismotectonic sitting of Egypt suggests that large earthquakes are possible particularly along the Gulf of Aqaba-Dead Sea transform, the Subduction zone along the Hellenic and Cyprean Arcs, and the Northern Red Sea triple junction point, In addition some inland significant sources as Aswan, Dahshour, and Cairo-Suez District should be considered. The seismic hazard for Egypt is calculated utilizing a probabilistic approach (for a grid of 0.5°X0.5°) within a logic-tree framework. Alternative seismogenic models and ground motion scaling relationships are selected to account for the epistemic uncertainty. Seismic hazard values on rock were calculated to create contour maps for four ground motion spectral periods and for different return periods. In addition, the uniform hazard spectra for rock sites for different 25 periods, and the probabilistic hazard curves for Cairo, and Alexandria cities are graphed. The peak ground acceleration (PGA) values were found close to the Gulf of Aqaba and it was about 220 gal for 475 year return period. While the lowest (PGA) values were detected in the western part of the western desert and it is less than 25 gal.

Tectonic evolution in the southern segment of the Dead Sea Rift

Usama Zaineldeen

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This work presents the palaeostress results obtained from fault-slip data along the eastern margins of the Dead Sea Rift (also named Dead Sea Transform) in South-western Jordan. Stress inversion of the fault-slip data was performed using an improved Right-Dieder method, followed by rotational optimisation. Fault-slip data (totaling 2773) include fault planes, striations and sense of movements, obtained from outcrops ranging in age from Neoproterozoic crystalline basement to Holocene sediments. The data were inverted to determine 88 different palaeostress tensors. Eight palaeostress tensor groups (stages) have been identified, ranging from the Late Neoproterozoic to the Holocene period, and have been correlated with the tectonic evolution of the Dead Sea Rift.

The new palaeostress data evidence a general clockwise rotation with time of the SHmax axis from an E-W trend in the Cretaceous to a N-S trend in the Pleistocene. Two stages can be distinguished in this rotation. The older one marks the change of the SHmax axis from E-W to NW- SE (about 50o rotation), and took place in the Miocene. The second one illustrates the changes of the SHmax axis from NW-SE to NNW-SSE to N-S (38o rotation), taking place during the Pleistocene (the last 6 Ma). The data also show the appearance of E-W extension in the Late Pleistocene, superimposed on the Dead Sea Stress Field. It therefore suggest that the Dead Sea Rift system formed in a combination of strike-slip and dip-slip movements.

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Pilot Transnational Seismic Network in the Dead Sea Rift

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We present the creation of a cooperative pilot transnational seismic network by the countries surrounding the Dead Sea Rift. Joining and linking of seismic networks, which belong to different organizations or nations is a new tendency in the world. It provides better coverage of a seismic zone, often crossed by departmental or political boundaries and thus yields more accurate source location, better data to compute high resolution seismic tomography, more reliable hazard assessment etc. This linkage became possible over the last decade on a large scale due to low cost Internet technology. The initiative in this proposal is devoted to creation of such a network in the Dead Sea Rift, separating Jordan and Israel seismic networks and including, a future Palestinian seismic network located within the zone. Joining and standardizing seismic waveform information of the networks will provide new high quality data regarding this major tectonic feature and ultimately better understanding of the processes involved and thus reduction of seismic hazard in this highly populated area.

Decision Criteria for Tsunami Early Warnings in the Levant

Amos Salamon

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The set of criteria formulated by the IGC/NEAMTWS (Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas, 2009, 2010) determined the threshold conditions for issuing a warning message as soon as a potential tsunamigenic earthquake occurs. The criteria, also known as a 'Decision Matrix', focused mainly on regional and basin-wide tsunamis, yet most of the historical tsunamis that hit the Levant are considered local and as such might have been missed by that matrix.

Understanding the tsunamigenic framework of the eastern Mediterranean helped us to modify the proposed matrix according to the typical conditions in the Levant, where tsunamis followed on-land earthquakes (along the Dead Sea Transform) further than 30 km away from the coast, most probably due to seismogenic submarine landslides. The matrix was calibrated to suit the maximal distance (100 km) and minimal magnitude (M~ 6) of the assumed epicenter and magnitude of those continental tsunamigenic earthquakes.

Since the majority of the tsunamis in the Levant are expected to originate from local M>6 earthquakes, the first warning signal will be the strong shaking. Therefore, prior and in parallel to the establishing of a sophisticated warning system, people should be taught to protect themselves from a tsunami by moving away from the sea as soon as they feel the strong shaking. The second natural warning signal, although may not always appear, is a drop in the sea level and retreat of the water.

For tsunamis generated by remote earthquakes that may not be strongly felt, the warning system is a must. Alerting for tsunamis resulting from volcanic activity and spontaneous submarine slumps cannot be considered until a real-time monitoring of the sea is introduced into the system.

Tsunami Risk off the Lebanese Coast

Rachid Jomaa and Lama Inati

National Centre for Geophysical Research, National Council for Scientific Research, Beirut, Lebanon

Tsunami risk along the shores of Lebanon is present in the local popular culture since Antiquity. Many tsunamigenic events are listed in our historical catalog.

We present possible propagation scenarios for the 551 AD local event and the basin wide 1856 Hellenic arc event and their effects on the Lebanese coast.

We use the NEAMTWS matrix to estimate Lebanon's exposure to the tsunami threat and finally we report about current tsunami modeling related activities and our needs in the field of oceanography.

Landslide Tsunami Early Warning in the NEAMTWS Context for Eastern Mediterranean, Following Strong Earthquakes at the Dead Sea Fault

Sergiu Dov Rosen[1, 2]

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This paper presents a proposed approach for providing tsunami early warning (TEW) from potential landslide tsunami waves which can be generated on the Eastern Mediterranean shelf following a strong earthquake at the Dead Sea Fault. Following the disaster induced by the Indian Ocean earthquake and tsunami on 26 December 2004, the Intergovernmental Oceanographic Commission (IOC) of UNESCO found out that the Mediterranean ranks second in the number of tsunami events which occurred worldwide in the history and up to now.

The IOC General Assembly decided in June 2005 to establish a tsunami early-warning and mitigation system and an associated intergovernmental coordination group for tsunamis in the northeastern Atlantic, the Mediterranean and connected seas. The IOC member states appointed delegates to the Intergovernmental Coordination Group (ICG), which met in Rome in November 2005 and decided to develop and operate a Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (NEAMTWS), similar to those established earlier for the Indian Ocean and for the Caribbean and to the initial one in the Pacific. Since then the TEW developed slowly but in summer 2012 three National Tsunami Warning Centers in France, Turkey and Greece declared that they are ready to serve as Candidate Tsunami Watch Providers for those other states wishing to receive their alerts.

As tsunami waves are mostly generated due to strong earthquakes, but not all strong earthquakes generate tsunamis, the TEW consists of two major elements: (a) a seismic network, to enable location of the earthquake and its major characteristics (magnitude, location, depth) and (b) tsunami waves detection network, consisting mainly of tide gauges monitoring the water surface fluctuation complemented by sea bottom mounted pressure sensors with underwater to buoy and satellite communication (e.g. Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy systems) as well as other potential detection means like GPS buoys. However, the international NEAMTWS is being developed with the main purpose to be able to detect tsunami waves induced by tectonic plates earthquakes with regional to basin wide impact, because other types of tsunamis such as by volcanic lava eruptions or by submarine landslides are very difficult to detect seismically, unless seismometers are located at the site of or near the submarine landslide.

In addition, submarine landslide induced tsunamis are considered of a more local impact, being left so far to the responsibility of each member state. In spite of this approach, the Eastern margins of the Mediterranean Sea witnessed in the last 3000 years some 21 tsunami events, 10 of which Salamon et al. (2007) concluded that were most probably due to submarine landslides on the shelf of the eastern Mediterranean coasts of Israel, Northeastern Egypt, Lebanon and Syria, following strong earthquakes at the Dead Sea

Fault. Numerical simulations carried out by Galanti et al. (2009) of landslide tsunamis off the Mediterranean coast of Israel indicated that the impact of such landslides tsunamis would be not just local, but that they can impact neighboring countries in the Southeastern Mediterranean such as Egypt, Cyprus, Turkey, Lebanon and Syria. Furthermore, the author detected an additional potential submarine landslide tsunami site, off the Nile delta vis-à-vis the Suez Canal. This location is at author's estimate under continuous scouring of the sea bottom by the much saltier and increased inflow from the Red Sea via the Suez Canal, following the deepening and widening of the Canal since the 1990's. This might lead to increasing instability with time, which can be triggered by a Dead Sea Fault strong earthquake to generate a submarine landslide and consequently a tsunami in the Southeastern Mediterranean.

To be able to provide TEW also from landslide tsunamis in this region, two complementary tools are proposed to be implemented: (a) A High Frequency (HF) Radar system network, based on a number of stations of the WERA multi antenna system which has proven capabilities to detect tsunamis at the shelf edge providing a warning time of some 6 to 20 minutes for the local shelf and about 30 to 60 min for neighboring countries, and (b) in situ low latency tsunami detection at local tide gauge stations of the NEAMTWS network installed by the IOLR on the Israeli coast and at a number of foreign sites (e.g. Cyprus) with financial support provided by the Science Commission for the Mediterranean (CIESM), as CIESM contribution to the MedGLOSS sea level monitoring network for the NEAMTWS. Details will be provided in the presentation.

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Slope Stability Analysis and Landsliding Studies based on Geophysical Seismic Exploration

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Generally, local site effects (landslides, liquefaction, amplification and faulting systems) play an important role in the intensity of earthquakes. Thus, Earthquake-resistant design of new structures and evaluating the seismic vulnerability of existing buildings take into account their response to site ground motions. Geophysical studies of seismic activity in Palestine, deep seismic sounding, paleoseismic excavation, and instrumental earthquake studies of half a century demonstrate that damaging earthquakes occurred along the Dead Sea Transform fault. The topography, geomorphology and geology of the West Bank have been the main reasons behind several sizeable landslides that occurred around ten years ago in different parts of the West Bank. Also, it has been shown that Palestine suffered from several landslides during historical earthquakes.

Landslides are rock, earth, or debris flows on slopes due to gravity, and they can occur on any terrain given the right conditions of soil, moisture, and the angle of slope. Landslides can be triggered by rains, floods, earthquakes, and other natural causes as well as human-made causes, such as grading, terrain cutting and filling, excessive development, etc. Because the factors affecting landslides can be geophysical or human-made, they can occur in developed areas, undeveloped areas, or any area where the terrain was altered for roads, houses, utilities, buildings, and even for lawns in one's backyard.

To investigate landslides one should do field studies (including geophysical seismic study), laboratory studies and slope stability analysis. It is important that the field and laboratory investigations be supplemented by field measurements so that the behavior of a slope can be checked and corrective measures be taken in times. The first step in landslides analysis is the collection of available information geological, hydrological, topographical, and soil maps.

The subsurface geology determined by seismic studies is extremely important for the development of urban areas. The shallow upper part of the rock formation section is the most significant part for civil infrastructures. The seismic refraction technique is considered an accurate geophysical method to investigate the shallow geological structures of an area. During the past decades, the seismic parameters obtained by a refraction survey have been widely used in cases of site investigation as indicators of rock mass quality. These parameters are of great importance in land use management of various civil engineering purposes (Primary velocity Vp, shear wave velocity Vs and Soil profiles).

Several landslides occurred in Palestine during 2012 in which geophysical seismic explorations were used for slope stability analysis and landslides studies. Four major landslides are focused on, namely, Al Bathan – Nablus main road landslides, Nablus District, A'arrabeh landslides, Jenin District, Kufur Qalil landslides, Nablus District and Beit A'oor, Ramallah District.

In order to better understand the causes of landslides and slope instability in the above mentioned areas, it is important to describe soil strata, soil properties and the geotechnical conditions of these sites. These parameters and conditions at the study areas were found from the seismic geophysical investigation by using seismograph 24 channels, trial pits, lab tests and eye observations. Then, slope stability analysis using software GeoStudio2007 was carried out for several conditions along the critical sections in the studied areas to figure out the minimum factor of safety and comparing to the acceptable limits. In general, the factor of safety for slope required for any temporary structures is 1.3 and that for permanent structures it is 1.8.

During the presentation in the Workshop, these four major landslides which occurred in Palestine during 2012 will be focused on and results of slope stability analysis and landslides studies will be presented. Based on these analysis and studies the factor of safety found, it is clear that these sites suffer slope instability and hence, landslides may occur at any moment. Furthermore, soil properties may be changed at these sites due to weather conditions, such as, rainfall or snow fall or / and these sites will be affected by relative strong earthquakes. This will reduce the factor of safety and landslides may occur.

In general, several recommendations were suggested to overcome slope instability in sites were landslides occurred. Such recommendations are to reduce the weights at the top of slopes, increase and install weights at the bottom (toe) of the slope, flatten the slope, methods to drain the slope and the site around landslides, increase stability by planting trees on the slope.

It is found out as planning strategy; land use policy should be done for Palestine, especially, for sites of high slopes and those of which they have previously landslides.

Seismotectonics of the North Easternmost Part of the Mediterranean Sea: Implications for the Seismic Hazard Assessment

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The north easternmost Mediterranean Sea represents the meeting region of three small tectonic plates namely Arabian, Sinai and Anatolian. This means that there are different plate boundaries with regional fault systems located at the bottom of the northern easternmost part of the Mediterranean Sea and on land near the coast e.g. the Dead Sea transform fault system and the subduction-collision Cyprian Arc. In this work, we examine the tectonic setting and seismic activity in the region. Although the earthquakes and related tsunamis have been the most damaging natural geological hazards affecting the eastern Mediterranean coasts throughout the recorded history of the region, the picture of the instrumental seismicity is low-to-moderate seismic activity; the earthquake of 11 May 2012 with mb 5.5 was the most recent event. It is believed that a tsunamigenic environment is available in the region, which can produce tsunamigenic earthquakes. Therefore, more investigation including bathymetry should be done in order to reduce the tsunamigenic hazard in the region.

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Earthquake Early Warning for Israel: Recommended Implementation Strategy

Gidon Baer

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(On behalf of the International Advisory Committee on Earthquake Early Warning in Israel)
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The Government of Israel has decided on June 7th, 2012, to establish an Earthquake Early Warning System (EEWS) for Israel. Recommendations for this system were prepared by an International Advisory Committee on Earthquake Early Warning that was formed by the Earth and Marine Research Administration (EMRA) of Israel, and met in Israel from September 9th to 14th, 2012. The committee consisted of three international and five Israeli members. This presentation will summarize the recommendations of the committee.

There are two types of approaches to earthquake early warning. The first is a post S-wave based threshold approach, which alerts when two or more seismic stations observe ground shaking above some strong shaking level. The advantage of this approach is simplicity and that cheap low-quality accelerometers can be used. The challenges include the fact that the first earthquake to trigger the system will be the big earthquake for which an alert is needed, so only simulated testing is possible; alerts are only generated for events close to the sensors; and there is currently no open source community supported processing system. These challenges all mean that there is no possibility of upgrade or improvements to the system in the future, without a significant investment. The second approach is the P-wave based earthquake detection. This approach uses P-waves—which travel about twice as fast as S-waves and cause little damage—to detect earthquakes, characterize the source magnitude and location, and then issue an alert based on predicted shaking. The approach requires higher quality equipment, but it allows for location specific alerts (a dynamic grid approach) and regular testing through detection of smaller (non-hazardous) earthquakes. This is the approach favored by early warning groups around the world. For this approach there is also an open source community supported software

The committee recommends a hybrid approach for Israel that invests in the necessary hardware for a P-wave based system, while also supporting an initial post S-wave based threshold approach, which can be implemented very rapidly at little additional cost. We propose the installation of high quality seismic instrumentation across Israel, with significant densification along the Dead Sea and Carmel Faults. This instrumentation consists of a mixture of accelerometers and broadband velocity instruments. These new seismic sites should be integrated into the ISN, and existing ISN stations should be upgraded to the same quality (mainly an upgrade to the telemetry system). Seismic network management software should be installed at a hub at the Seismology Division, where an open source community supported earthquake monitoring system will collect data from all seismic sites and perform real-time event characterization and alerting. A secondary back-up seismic network hub should be installed at a geographically separate location. We recommend to initially implement a post S-wave based threshold algorithm which is expected to be put into action within the tight timeline decided by the Israeli Government. A P-wave based approach should then be implemented within the next two-years. Further assessment of system performance should continue in order to further improve and optimize the algorithms, making full use of advances made by the early warning community around the world.

The committee also recommends some additional areas of development and research that do not fit into the initial two-year plan, but are believed to be important and should be pursued once the initial system as described above has been installed and is operating.

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Lead time estimation for Earthquake Early Warning System in Israel

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The Earthquake Early-warning system is being designed in Israel, so as to maximize the lead time - the difference between the moment of destructive S wave arrival and the moment of getting an alarm at a certain place – for majority of population in the country. For this purpose specific configuration of the network is proposed, where most of the stations are in the vicinity of the expected epicenter, i. e. along the Dead Sea Fault and Carmel Fault. We shall consider the lead time dependency on a mutual position of the epicenter and observer as well as on several other most important factors: network configuration, P or S triggering approach, type of processing, acquisition and communication, source depth. For the lead-time computation P and S travel times at different source depths are derived from the standard velocity model, while electronic signal latency is determined by the typical and maximum possible delays of the data-loggers, communication lines, time of processing and dissemination.

Strategy Earthquake Early Warning System for Istanbul and Marmara Sea Region

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The implementation of the earthquake early warning system (EEWS) commenced in 2001 following the devastating 1999 Izmit (Mw=7.5) and Duzce (Mw=7.2) earthquakes. At present the EEWS network consists of 10 strong motion stations located as close as possible to the Great Marmara Fault zone. At the beginning data transmission was provided with Spread Spectrum Radio Modem; now, a satellite based data transmission system is used for communication between the remote stations and the base station at KOERI. The continuous on-line data from these stations is used to provide real time warning for emerging potentially disastrous earthquakes. A simulation of Early warning times for 280 earthquakes portrays a lead time between 0-30 seconds for Istanbul metropolitan area.

Considering the complexity of fault rupture and the short fault distances, a simple and robust Early Warning algorithm, based on the exceedance of specific threshold time domain amplitude levels (band-pass filtered accelerations and the cumulative absolute velocity) is implemented.

The early warning sygnal (consisting three alarm levels) is to be communicated to the appropriate servo shut-down systems of the recipient facilities, which will automatically decide proper action based on the alarm level. Among the prospective end users of the EEW sygnal are the facilities such as Fast Train and Tube Tunnel, Istanbul Gas Distribution Corporation (IGDAS), Recently constructed tall buildings, electric power plants and so on.

The continuous upgrade of the EEWS network, the software and the hardware is going on. In addition to the present strong motion stations 10 stations will be deployed along the southern coastline of the Marmara sea. The improved station coverage will enable regional warning technique be implemented along with the present on-site warning algorithm.

Building an Earthquake Early Warning System
Focus on the seismic network aspects

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The pre-requisite of an Earthquake Early Warning system is a seismic network producing high quality seismic data with rapid transmission of information. The most robust early warning systems rely on centralised processing of waveforms. This presentation will discuss how the seismic network influences the potential for Earthquake Early Warning, with focus on the network geometry, density, station quality and communications. Beyond the seismic network, data needs to be acquired and processed with minimum delay, and messages must be delivered rapidly to the endusers. Over the last decade, researchers at ETH Zurich have been involved in building early warning systems in California and Switzerland, and building up EEW capabilities across Europe. This presentation will focus on our experience in developing Early Warning systems in Switzerland.

Earthquake Early Warning Methods and Feasibility Studies in Europe

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An earthquake early warning system (EEWS) is a real-time, modern monitoring infrastructure that is able to provide an automatic notification of the potential damaging effects of an impending earthquake, through rapid telemetry and processing of data from dense instrument arrays deployed in the source region of the event of concern and/or surrounding the target infrastructure. Such a system allows mitigating actions to be taken before strong shaking and can significantly shorten the time necessary for emergency response and the recovery of critical facilities such as roads, hospitals and communication lines.

EEWSs have experienced a sudden improvement and a wide diffusion in many active seismic regions of the world in the last three decades [e.g. Allen et al., 2009]. They are operating in Japan, Taiwan, Mexico and California. Many other systems are under development and testing in other regions of the world such as Italy, Turkey, Romania, Switzerland and China.

Most of developed EEWS are conceived as either “regional” (network-based) or “on-site” (stand-alone) systems (Kanamori,2005). A “regional” EEWS is based on a dense sensor network covering a portion or the entirety of an area that is threatened by earthquakes. The relevant source parameters (event location and magnitude) are estimated from the early portion of recorded P-signals and are used to predict, with a quantified confidence, a ground motion intensity measure at a distant site where a target structure to protect is located. An “on-site” EEWS consists of a single sensor or an array of sensors deployed in the proximity of the target structure that is to be alerted, and whose measurements of peak amplitude and/or predominant period on the initial P-wave motion are used to predict the ensuing peak ground motion (mainly related to the arrival of S and surface waves) at the same site.

During the last decade the European Union (EU) has largely invested in research and technological development of early warning systems for earthquakes and tsunamis through a series of research projects (SAFER, TRANSFER, SEAHELLARC, NERIES). The last of these projects , REAKT (Strategies and tools for Real Time EArthquake RisK ReducTion), is still in progress and one of its main objectives is the experimentation and application of Early Warning to several industries, infrastructures, and structures of strategic interest deployed in high seismic risk, EU countries.

After reviewing the basic principles, observations and methods for earthquake Early Warning actually used worldwide, the presentation will overview the various EW applications in Europe and their present state-of-the-art.

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Warning California: Earthquake Alerts Today

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The California Integrated Seismic Network (CISN.org) has been developing an earthquake early warning capability since 2006. Today three independent algorithms are detecting earthquakes in realtime, and feeding alerts to an aggregator which then issues alerts. This demonstration system is now delivering alerts to a group of test users including private and public institutions from the corporate and government sectors. This talk will summarize the approach that has been taken to develop an earthquake earning capability in the state, the process of identifying users, and how these institutions are using (or are planning to use) the alerts.

Tsunami Warning Center in Turkey and Eastern Mediterranean and its Connected Seas

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KOERI has been involved in the activities of Tsunami Warning System in the North-eastern Atlantic, the Mediterranean and connected seas region (ICG/NEAMTWS) since its formal establishment by the IOC Assembly in 2005. NTWC-TR is integrated into the 24/7 operational National Earthquake Monitoring Center (NEMC) and KOERI has declared its Interim Operational Status as the Candidate Tsunami Watch Provider as of 1 July 2012. The system relies on seismic observations supported with a Decision Support System based on the operational guidelines established by the ICG/NEAMTWS. The components of the Decision Support System are pre-calculated tsunami scenario database and Tsunami Analysis Tool, both provided by EC-JRC, message dissemination systems and sea-level observations. KOERI's seismic network comprises 118 BB and 35 strong motion instruments and data from 10 BB stations located in the Aegean and Mediterranean Coast are being transmitted to KOERI based on an agreement with the Disaster and Emergency Management Presidency (DEMP). 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 have been installed at Base Transceiver Station Sites in coastal regions within the scope of this initiative. In addition, 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 Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) in March 2011. Six tide gauge stations operated by General Command of Mapping (GCM) are transmitting data to KOERI using satellite connection. 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) and the Second Communication Test Exercise (CTE2). Further improvement of the Tsunami Warning System at the NTWC-TR will be accomplished through KOERI's participation in the FP-7 Project TRIDEC focusing on new technologies for real-time intelligent earth information management to be used in Tsunami Early Warning Systems. KOERI is hosting the co-chair position of the ICG/NEAMTWS Task Team on Communication Test and Tsunami Exercises responsible for the planning, preparation, conduct and evaluation of the first Tsunami Exercise in the Euro-Mediterranean Region NEAMWave12, which will take place during 27-28 November 2012, in which KOERI will also act as the Message Provider.

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Reducing Earthquake Losses in the Extended Mediterranean Region
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