Institute of Geodynamics
National Observatory of Athens

International Workshop

Mega Earthquakes and Tsunamis in Subduction Zones: Forecasting Approaches and Implications for Hazard Assessment

Rhodes Isl., Greece
6-8 October, 2014

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Programme

Programme

INTERNATIONAL WORKSHOP

**«MEGA EARTHQUAKES AND TSUNAMIS IN SUBDUCTION ZONES–
FORECASTING APPROACHES AND IMPLICATIONS
FOR HAZARD ASSESSMENT»**

Rhodes Isl., Greece, 6-8 Oct., 2014

Arrivals	**Sunday, 5 October 2014**
Opening	**DAY 1 - Monday, 6 October 2014** **Registration: 08:00 – 09:15** **Poster display: 08:00 – 09:15** **Welcome: 09:15 – 09:30**
Session 1	**DAY 1 - Monday, 6 October 2014** **Lessons learned from the recent cases of mega earthquakes and tsunamis** **Chair: K. Satake, A. Yalciner**
Invited Talk **09:30 – 10:00**	**Prof. Thorne LAY**, Dept. of Earth & Planetary Sciences, University of California Santa Cruz, USA **A Global Surge of Tsunamigenic Earthquake Ruptures and How We Are Quantifying Them**
10:00-10:15 **A. DZVONKOVSKAYA,** Th. HELZEL	SIGNIFICANT SURFACE CURRENT VELOCITY CHANGES MEASURED BY THE OCEAN HIGH-FREQUENCY RADAR AFTER THE GREAT 2011 JAPAN TSUNAMI
10:15-10:30 **R. MAZOVA**, B. KISELMAN, N. BARANOVA, A. RASSADIN	CATASTROPHIC CHILEAN EARTHQUAKE AND TSUNAMI ON 1 APRIL 2014. EVIDENCE FOR REALIZED PROGNOSIS
10:30-10:45 **K.-N. KATSETSIADOU,** E. ANDREADAKIS, E. LEKKAS	ISHINOMAKI TSUNAMI INTENSITY MAPPING (ITIS2012) FOR THE 9M_w TOHOKU EVENT, MARCH 11 2011, JAPAN

Programme

10:45-11:00 **G.A. PAPADOPOULOS** F. IMAMURA	EXPERIENCES FROM THE APPLICATION OF THE NEW 12-POINT TSUNAMI INTENSITY SCALE: 2001-2014
Coffee Break	**11:00 – 12:00, Poster visits & discussion**
Session 2	**DAY 1 - Monday, 6 October 2014** **Earthquake and Tsunami Forecasting** **Chair: V. Gusiakov, Th. Lay**
Invited Talk **12:00– 12:30**	**Prof. Kenji SATAKE,** Earthquake Research Institute, University of Tokyo, Tokyo, Japan **Challenges for Forecasting Size and Time for Future Great Earthquakes in Subduction Zones**
12:30-12:45 **B. FRY**, L. WALLACE, D. RHOADES, H. KAO, I. HAMLING, M. GERSTENBERGER, N. BARTLOW	INTERACTION BETWEEN SSE, EARTHQUAKES, AND SEISMIC RADIATION IN THE HIKURANGI SUBDUCTION SYSTEM
12:45-13:00 **E. CHRISTOU**, E. SCORDILIS, G. KARAKAISIS	TIME-DEPENDENT SEISMICITY ALONG THE WESTERN COAST OF CANADA
13:15-13:30 **Eleni DASKALAKI**, G.A PAPADOPOULOS, C.SIETTOS	RUPTURE ZONES OF LARGE EARTHQUAKES, LITHOSPHERIC COUPLING AND SEISMIC POTENTIAL IN THE HELLENIC ARC AND TRENCH
13:30-13:45 **A. GANAS,** P. K. ARGYRAKIS, N. C. SAGIAS	PROGRESS TOWARDS DEVELOPMENT OF THE NOANET GNSS EARLY WARNING WEB PLATFORM: PRELIMINARY RESULTS
Lunch Break	**Plaza Hotel, 13:45 – 15.30**

Programme

Session 3	**DAY 1 - Monday, 6 October 2014** **International Collaboration** **Chair: T. Aarup, W. Brenn, G.A. Papadopoulos**
15:30-16:00	Brief Introduction to international initiatives (e.g. EU, IOC/UNESCO, JGZB, EJEA etc.)
Invited Talk **16:00 – 16:30**	**Prof. Maria Ana BAPTISTA**, Portuguese Institute for Ocean and Atmosphere (IPMA), Lisbon, Portugal, Co-authored with A.C. YALCINER and the ASTARTE Team **ASTARTE: A European (FP7) Tsunami Research Project**
16:30-16:45 **G. DIAKOGIANNI**, A. FOKAEFS, G.A. PAPADOPOULOS, A. PAPAGEORGIOU	AN EXTENDED HOMOGENEOUS QUICK-LOOK TSUNAMI CATALOGUE FOR THE EUROPEAN-MEDITERRANEAN REGION
16:45-17:00 **A. PAPAGEORGIOU**, Ch. TSIMI, K. ORFANOGIANNAKI, G.A. PAPADOPOULOS, M. SACHPAZI, F. LAVIGNE, D. GRANCHER	TSUNAMI QUESTIONNAIRE SURVEY IN HERAKLION TEST SITE, CRETE ISLAND, GREECE
17:00-17:15 **B. AYTORE,** C. Z. CANKAYA, A. C. YALCINER, M. L. SUZEN, A. ZAYTSEV	HIGH RESOLUTION DATA PROCESSING AND TSUNAMI ASSESSMENT AND APPLICATIONS TO PORTS IN THE SEA OF MARMARA
Session 4 **17:15-18:00**	**DAY 1 - Monday, 6 October 2014** **Plenary Discussion on International Collaboration** **Panelists:** T. Aarup, M. Baptista, W. Brenn, V. Gusiakov, Th. Lay, K. Neville, K. Satake, A. Yalciner **Moderator:** D. Albert
Social Programme	**DAY 1 - Monday, 6 October 2014** **20:00 Welcome Reception, Plaza Hotel**

Special Session (5)	**DAY 2 - Tuesday, 7 October 2014** **Pre- and Post-Disaster Resiliance and Risk Mitigation Actions** **Conveners & Chairpersons** Dietrich ALBERT[1,2,4], Wolfgang BRENN[1,3] and Karen NEVILLE[4,5] 1. EJEA (European Japan Expert Association - http://ejea.eu/) 2. Knowledge Technologies Institute, Graz University of Technology, Austria dietrich.albert@tugraz.at; Dept. of Psychology, University of Graz, Austria dietrich.albert@uni graz.at 3. JDZB (Japanese-German Center Berlin – (http://www.jdzb.de/), wbrenn@jdzb.de 4. S–HELP-Project (Securing – Health.Emergency. Learning - www.fp7-shelp.eu/) 5. Centre for Security Management Research (CSMR), BIS, University College Cork, Ireland, KarenNeville@ucc.ie
09:00-09.15 **K. OMURA**	URBAN PLANNING FOR DISASTER RESILIENT CITIES IN CASE OF JAPAN
09.15-09:30 **N. SUGIYAMA**	STUDY ON DEVELOPMENT OF AN EVALUATION METHOD FOR CITY ENERGY RESILIENCE IN JAPAN
09:30-09:45 **V. EL MAZRAANI**	HOSPITAL PREPAREDNESS FOR DISASTERS
09:45-10:00 **C. GOUNTROMICHOU,** N. PAPADOPOULOS, K. C. STYLIANIDIS	OPERATIONAL PREPAREDNESS POLICY AND RESPONSE IN CASE OF EARTHQUAKE IN GREECE
10:00-10:15 **R. WARGER**, S. NINDL, B. JUEN	A COMPREHENSIVE GUIDELINE ON PSYCHOSOCIAL SUPPORT BEFORE, DURING AND AFTER CRISIS: A RESULT FROM THE EU-PROJECT OPSIC
10:15-10:30 **G. ZUCCARO**, M. POLESE, M. LEONE, A. GARCIA, C. AUBRECHT, M. ALMEIDA, S. NARDONE	IMPACT DAMAGE SCENARIOS FOR ALTERNATIVE DECISION MAKING THROUGH THE USE OF CRISMA TOOL

Programme

10:30-10:45 **K. NEVILLE**, A. POPE, S. WOODWORTH	INVESTIGATING THE BENEFITS OF CURRENT TOOLS IN SUPPORTING RESPONDER NEEDS
10:45-11:00 **W. HYNES**	SPATIAL INFORMATION MANAGEMENT AND GEOGRAPHIC INFORMATION SYSTEMS IN THE DELIVERY OF S-HELP DECISION SUPPORT TOOLS FOR EMERGENCY SITUATIONS
Coffee Break	**11:00 – 11:30, Poster visits/discussion**
11:30-11:45 C. RAFALOWSKI , T. **KAPLAN**	DECISION SUPPORT FOR HEALTH CARE – USERS PERSPECTIVE
11:45-12:00 **A. NUSSBAUMER**, C. M. STEINER, D. ALBERT	A PSYCHOLOGICAL FRAMEWORK FOR THE S-HELP DECISION SUPPORT SYSTEM
12:00-12:15 A. SILVA, A. RODRIGUES, D. MARQUES, C. DUARTE, **M. A. BAPTISTA** L. CARRIÇO	FINDING PEOPLE IN NATURAL DISASTERS
Lunch Break	**Plaza Hotel, 12:15 – 14:00**
Special Workshop **Open Participation for all METSZ Participants** **14:00 – 16:00**	**DAY 2 - Tuesday, 7 October 2014** **Validating End User Requirements for a Decision Support Tool for Health Emergency Management** **Hosts:** EU-FP7 "S-HELP Project" coordinator (Dr. Karen Neville, UCC-BIS) and project partners Dr. William Hynes (FAC) and Prof. Dietrich Albert (TuGraz)

Session 6	**DAY 2 - Tuesday, 7 October 2014** **Tsunami Forecasting, Hazard & Risk Assessment, Early Warning** **Chair: F. A. Audemard, M. Baptista**
Invited Talk **15:00 – 15:30**	**Dr Viacheslav K. GUSIAKOV**, Tsunami Laboratory, Inst. of Computational Mathematic and Mathematical Geophysics, Siberian Division, Russian Academy of Sciences, Novosibirsk, Russia **Largest Historical Tsunamis in the World Ocean and Their Implication for Coastal Hazard Assessment**
Key-note Lecture **15:30 – 16:00**	**Prof. Ahmet C. YALCINER**, Middle East Technical University, Dept. of Civil Engineering, Ocean Engineering Research Center, Ankara, Turkey Co-authored with A. ZAYTSEV, Ç. BILICI, S. ACAR, and B. AYTORE **Spatial and Temporal Distribution of Elevation, Current Flow Depth and Fluxes by Tsunami**
16:00 – 16:15 **F. A. AUDEMARD M.**, S. GLIMSDAL, A. F. LEAL G.	LOCAL HISTORICAL TSUNAMIS ALONG NORTH-EASTERN VENEZUELA, SOUTHERN CARIBBEAN: TECTONIC AND/OR MASS WASTING INDUCTION? FIRST MODELING RESULTS OF STRIKE-SLIP GENERATION
16:15-16:30 **G. PAGNONI**, A. ARMIGLIATO, S. TINTI	HAZARD AND RISK ASSESMENT FOR ALEXANDRIA RELATED TO TSUNAMIS GENERATED BY EARTHQUAKES IN THE EASTERN MEDITERRANEAN REGION
16:30-16:45 A. KIJKO, **A. SMIT**	NEW PROCEDURE FOR PROBABILISTIC TSUNAMI HAZARD ASSESSMENT FROM INCOMPLETE AND UNCERTAIN DATA
16:45-17:00 **A. SMIT**, G. PAPADOPOULOS, A. KIJKO	NEW PROCEDURE FOR PROBABILISTIC TSUNAMI HAZARD ASSESSMENT FROM INCOMPLETE AND UNCERTAIN DATA. AN APPLICATION TO THE MEDITERRANEAN REGION

Programme

17:00-17:15 **B. RANGUELOV**	KINEMATIC MODELING FOR THE SEISMIC AND TSUNAMI EARLY WARNING SYSTEMS – BULGARIAN EXPERIENCE
17:15-17:30 **G. A. PAPADOPOULOS** and the NEARTOWARN team	NEAR-FIELD TSUNAMI EARLY WARNING AND PREPAREDENESS IN THE MEDITERRANEAN: THE EU NEARTOWARN PROJECT
17:30 -18.00	**DAY 2 - Tuesday, 7 October 2014** **Short introduction to the field trip - Closing**
Social Programme	**DAY 2 - Tuesday, 7 October 2014** **20:00 Gala Dinner, Plaza Hotel**
Technical Programme: **Field trip**	**DAY 3 - Wednesday, 8 October 2014** **Visiting the uplifted eastern coast of Rhodes Isl. including the archaeological site of Lindos**

POSTER SESSION PROGRAMME

Instructions

All Posters should be placed on the boards in the morning of the first day of the Workshop (Monday, 6 October, 2014) from 08:00 to 09:15 and to be removed in the second day (Wednesday, 7 October, 2014) before lunch. Poster visits/discussions will be made during the coffee breaks.

List of poster presentations

Gülşen AKAN, Mustafa SOFTA, **Mehmet Erkan KARAMAN** and Mehmet TURAN
ACTIVE TECTONIC AND HISTORICAL SEISMICITY OF KUMLUCA-DEMRE PLAIN (Antalya-Turkey)

Stefan Florin BALAN, Bogdan Felix APOSTOL, Delia TELEAGA and Dragos TOMA
CASE STUDIES OF HAZARD ASSESMENT FOR BUCHAREST METROPOLITAN AREA

Natalia BARANOVA, Boris BARANOV, Leopold LOBKOVSKY and Raissa MAZOVA
NEW APPROACH TO THE ANALYSIS OF STRONGEST EARTHQUAKE TOHOKU 2011

Aggeliki BARBEROPOULOU and Finn SCHEELE
TOWARDS DEVELOPING A HAZARD ASSESSMENT METHODOLOGY OF HISTORICAL TSUNAMI EVENTS

Halil BOLUK, **Mehmet Erkan KARAMAN** and Ergun TURKER
ESTIMATING STRESS ACCUMULATION ON PALEO-FAULTS WITH 4D ANALYSIS OF GEOPHYSICAL MEASUREMENTS

Stefano TINTI, Alberto ARMIGLIATO and **Gianluca PAGNON**I
TSUNAMI WARNING IN COMPLEX TECTONIC ENVIRONMENTS: POSSIBLE STRATEGIES FOR THE EASTERN HELLENIC ARC

Alexandr RASSADIN, Broneslav Kiselman and Raissa MAZOVA
THE STUDY OF WAVE ENERGY DISTRIBUTION AT TSUNAMI WAVE PROPAGATION IN OKHOTSK SEA BASIN

Dimitra SALMANIDOU, Frederic DIAS, Aggeliki GEORGIOPOULOU and Serge GUILLAS
NUMERICAL SIMULATION OF A SUBMARINE LANDSLIDE AND TSUNAMI GENERATION AT THE ROCKALL TROUGH, NE ATLANTIC

Kaliopi CHOCLAKI, **Filippos VALLIANATOS** and George MICHAS
SCALING PROPERTIES OF WORLDWIDE STRONG SEISMICITY IN VIEW OF NON-EXTENSIVE STATISTICAL PHYSICS

A. LÓPEZ – VENEGAS, U.-T. BRINK
ESTIMATING THE NORTHEASTERN CARIBBEAN MEGA EARTHQUAKE SEISMIC POTENTIAL FROM CONTINUOUS GPS OBSERVATIONS IN PUERTO RICO AND THE VIRGIN ISLANDS

Abstracts

ACTIVE TECTONIC AND HISTORICAL SEISMICITY OF KUMLUCA-DEMRE PLAIN (ANTALYA-TURKEY)

Gülşen AKAN[1], Mustafa SOFTA[2], Mehmet Erkan KARAMAN[3] and Mehmet TURAN[4]

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To the south of the Teke Peninsula, the northward-moving African Plate is subducting below the southwest-moving Anatolian-Aegean block. This movement generates large, deep subduction-zone earthquakes below the peninsula and shallower but equally damaging earthquakes along the transcurrent fault system (Pliny-Strabo transform) bordering the eastern edge of Rhodes Island and Kumluca-Demre encircles. On the other hand, Fethiye-Burdur Fault Zone where a large stress has caused significant damage has also affected this region. Local faults in the region such as; Finike Fault and Myra Fault have important roles on tectonics of the region. Immediately south of the peninsula lies the Kumluca-Demre Plain, an SW-NE trending tectonic trough (half graben) defined by major high angle normal faults that border the Andriake Bay, the southwestern edge of the Teke peninsula and the south of Myra Theatre. On the other hand, The Finike Fault which has a NW-SE trend is a strike slip fault. It surfaces from Mediterranean Sea towards to the land in the west of Finike and continues towards north after passing through the area between the plain and mountainous. All of these faults have an important role in the formation of the Kumluca-Demre Plain. Demre and surrounding area have many ancient cities, such as; Rhodiapolis, Gagai, Tlos, Tremendai, Myra, Aperlai, Kekova etc. These ancient cities are quite influenced by the earthquakes in the historical period. As a result, these cities have been completely damaged or abandoned. Also there are historical records on tsunami occurrence during some of these earthquakes. Active tectonic and seismicity of the region has an important role on the destruction and damaged of these ancient cities. The beginning of the seventh century, (M=7) earthquake, which completely destroyed the Kumluca-Demre and vicinity, is the most recent in a long history of damaging shocks in the surrounds of Myra. Besides, 530-529 AD earthquake had caused to heavily damage and tsunami in this region. In this study, we tried to give information about the historical seismicity and active tectonic features of Kumluca-Demre Plain.

SPECIAL SESSION

PRE- AND POST-DISASTER RESILIANCE AND RISK MITIGRATION ACTIONS

Dietrich ALBERT[1,2,4], Wolfgang BRENN[1,3] and Karen NEVILLE[4,5]

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Although many disasters and catastrophes are not avoidable, the consequences can be reduced by appropriately managing preparedness, response and recovery. Thus the aim of this Special Session is to present and to discuss different measures and topics for pre- and post-activities to improve the handling of disasters and catastrophes.

The first part of the session focuses on structural aspects at different institutional, organizational and individual levels for preventing and managing disasters and their consequences - like urban planning for disaster resilient cities (Omura), a policy model for energy resilience (Sugiyama), hospital preparedness (Mazraani), operational preparedness (Gountromichou et al.), and guidelines on psychosocial support (Warger et al.).

The second part of the session addresses procedural and organisational aspects of handling disasters and their consequences, especially supporting complex decision processes on different levels and with multiple methods – like general models of decision making with different scenarios (Zuccaro), benefitting from different tools (Neville et al.), using appropriate input information (Hynes), taking into account end user needs (Rafalowski & Kaplan), and grounding decision making on a psychological decision framework (Nussbaumer et al.).

A plenary discussion will focus on the scientific basis and the final impact of the presented ideas and projects.

LOCAL HISTORICAL TSUNAMIS ALONG NORTHEASTERN VENEZUELA, SOUTHERN CARIBBEAN: TECTONIC AND/OR MASS WASTING INDUCTION? FIRST MODELING RESULTS OF STRIKE-SLIP GENERATION

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From the evaluation of the accounts by primary sources (eye witnesses), tsunami inundations along the eastern coast of Venezuela after local offshore earthquakes have been reported only during 5 earthquakes:1-IX-1530, 15-VII-1853, 29-X-1900, 17-I-1929 and 9-VII-1997. All but the 1900 shock affected the Cumaná city, and the offshore right-lateral strike-slip El Pilar fault (EPF) has been held responsible for the 4 other events. The 1900 AD tsunami waves were reported along most of the Ensenada de Barcelona coast (W of Cumaná) and Los Roques Archipelago, being this quake attributed to the San Sebastián fault (SSF) segment running offshore Cabo Codera. The 1530 and 1853 earthquakes were produced by the Cariaco trough segment of the EPF west of Cumaná, within a restricted over-1000-m-deep marine pull-apart basin on the SSF-EPF right-lateral releasing step-over, whereas the 1929 and 1997 events occurred on the EPF segment east of Cumaná, inside the shallower Cariaco gulf. Several authors have interpreted all those four tsunamis as the result of major submarine sliding inside the steep-walled trough. First-hand accounts by locals about the abnormal waves during the Cariaco 1997 event, as well as the identification of coastal sliding at the Manzanares river mouth at Cumaná, support this thesis at least for the two latest events, because of the small size of the tsunami-affected area. In addition, recent monitoring (CARIACO Project) has recorded turbidite currents in the Cariaco trough and the Manzanares canyon during the Cariaco Mw 6.9 earthquake and a smaller Mw. 5.2 August 2008 event. However, the 1900 tsunami, and the 1530 and 1853 tsunamis by extension, appears to result from right-lateral tectonic slip along the Cariaco trough walls.

The first striking conclusion from this historical evaluation is that inundation for all these earthquakes are reported at river mouths or settlements on their mouths: Paparo, Tuy, Neverí, Manzanares. This leads to interpret the occurrence of riverbore when both waters (tsunami wave and river flow) encounter at river mouths, rising river level and flooding over banks. In addition, this implies that reported wave height of at least 5-6 m (1530 and 1853) and 10 m (1990) are highly debatable, and highly improbable for some cases. For instance, taking into account the flat-lying phisiography of the Ensenada de Barcelona coastlands, the time of occurrence still at full darkness (4:45.5:00 am local time) of the 1900 tsunami and a lucky survivor in such condition reporting a 10-m-high wave at Paparo, we would believe that those waves would more likely range in the order of 2 to 3 m, which are in fact high enough to inundate areas lying behind a coastal sand barrier with a mean elevation of 1.2-1.7 m in height and be highly channelized along the lowermost stretches of the mentioned rivers.

Preliminary results of piston-like numerical modeling of tsunami waves, in order to reproduce a horizontal slip of few (up to 3) meters on a strike-slip fault bounding a very narrow and deep pull-apart basin, such as the case of the EPF and SSF at the south and north edges of the Cariaco trough respectively, show that maximum sea surface elevation is in the order of only 20 to 30 cm, with NO vertical tectonic component of motion modeled. Future modeling will incorporate some normal component of slip on the through-bounding faults.

This is a contribution to Project FONACIT 2013000361 (2013-2016) and past projects FONACIT-ECOS Nord PI-2003000090 and PI-2009000818.

HIGH RESOLUTION DATA PROCESSING AND TSUNAMI ASSESSMENT AND APPLICATIONS TO PORTS IN THE SEA OF MARMARA

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The resilience of ports and harbors against marine hazards, especially any effects caused by tsunamis is an important issue in the success of disaster management and post disaster activities. The vulnerable nature of ports requires detailed assessment, serious preparedness and strong mitigation strategies for significant reduction of the loss of life and property. High resolution data processing and tsunami assessment for ports is very substantial solution to achieve these objectives.

Throughout history, Marmara coasts are affected by more than 30 tsunamis in the last two millenniums. Istanbul located on the coast of Marmara is the highest populated city and center of all economic activities in Turkey. Therefore, many ports are located in the region. Some of these ports are selected as the case studies for tsunami analysis. Main concern of this study is to use high resolution topographic data and best available bathymetry maps and data. Therefore detailed database are meticulously created for selected ports to acquire detailed inundation maps.

A tsunami simulation and visualization code NAMIDANCE is applied to obtain inundation maps and create simulations. By using these maps and simulations in selected ports, evacuation plans are determined and motion of tsunami waves inside the ports are observed. Addition to these, resilience of the marine structures and possible ways of reducing the effects of tsunami waves is discussed.

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CASE STUDIES OF HAZARD ASSESMENT FOR BUCHAREST METROPOLITAN AREA

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Bucharest, the capital of Romania, with more than 2 million inhabitants, is considered after Istanbul the second-most earthquake-endangered metropolis in Europe. It is identified as a natural disaster hotspot by a global study of the World Bank and the Columbia University (Dilley et al., 2005). Four major earthquakes with moment-magnitudes between 6.9 and 7.7 hit Bucharest in the last 65 years. The most recent destructive earthquake of 4th March 1977, with a moment magnitude of 7.4, caused about 1.500 casualties in the capital alone. All disastrous earthquakes are generated at intermediate depth, within a small epicentral area - the Vrancea region - about 150 km northeast of Bucharest. Thick unconsolidated sedimentary layers in the area of Bucharest amplify the arriving seismic shear-waves causing severe destruction. Thus, disaster prevention and mitigation of earthquake effects is an issue of highest priority for Bucharest and its population.

Several national and international research programs were done in the past to understand the causes for the Vrancea seismicity, to study the seismic wave propagation in the region and to assess seismic hazard for Bucharest and other communities.

Especially in Bucharest, high-quality seismic data were acquired during the URS (URban Seismology) Project from October 2003 to August 2004. Within this project 32 state-of-the-art broadband stations were continuously recording in the metropolitan area of Bucharest (Ritter et al., 2005). This unique dataset provides important information on the seismic amplitude variation across the area.

Other investigations were done on a NATO project: 10 new boreholes including complete lithological profiles and about 250 recovered core samples for geotechnical analysis; 10 downhole measurements for vp and vs profiles; 400 geotechnical analyses of samples from 6 Quaternary layers; Spectral amplification curves for the 10 sites; Improved vs30 map. Investigation of seismological measurements across the city.

Another important element in hazard evaluation of Bucharest zone is a modern ground acceleration observation network which has been upgraded in the last years to 15 stations with easy handling data (accelerations/velocities easy to transform in displacements). A dense measurement network is needed in order to identify seismic events and compute correlation functions between the measured ground deformation and a seismic movement.

Thus, the need of a "Seismic Movement Monitoring Service" (SMMS) arose. The test sites for SMMS will be the city of Bucharest, well-known as one of the capitals with the highest seismic risk in the world. We are now working on starting this kind of service. All this is done in the framework of project: Spaceborne Multiple Aperture Interferometry and Sequential Patterns Extraction Techniques for Accurate Directional Ground and Infrastructure Stability Measurements.

All these data mentioned above is necessary for an interdisciplinary approach, where Synthetic Aperture Radar Interferometry data and processing techniques will be integrated into the current monitoring system of the zone and into the seismological knowledge with the purpose of improving the input to existing structural stability and seismic models leading to their refinement. The results will be used for an improvement of the microzonation map of the city and mitigation of seismic risk.

ASTARTE: A EUROPEAN (FP7) TSUNAMI RESEARCH PROJECT

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ASTARTE (Assessment STrategy And Risk Reduction for Tsunamis in Europe), is a 36-month FP7 project that aims to develop a comprehensive strategy to assess and mitigate tsunami impact and develop guidelines for structural and societal resilience in the North East Atlantic, and Mediterranean (NEAM) region including adjacent seas. In this direction, improvement in preparedness of coastal populations and, ultimately, to help saving lives and asset take place in the ultimate goals of ASTARTE.

The main objectives are: Assessing long term recurrence of tsunamis; (ii) Improving the identification of tsunami generation mechanisms; (iii) Developing new computational tools for hazard assessment; (iv) Ameliorate the understanding of tsunami interactions with coastal structures; (v) Enhance tsunami detection capabilities, forecast and early warning skills in the NEAM region; (vi) Establishing new approaches to quantify vulnerability and risk and to identify the key components of tsunami resilience and their implementation in the NEAM region.

ASTARTE consists of 10 work packages (WPs). Following WP1, which is devoted to Project coordination and management, WPs 2-5 focus on tsunami recurrence, generation mechanisms, modeling and coastal impacts. WPs 6-8 focus on detection and communication infrastructures, early warning and forecast and risk assessment. These WPs open into WP9, which aims at building tsunami resilient societies in Europe, and WP10, which is devoted to the dissemination and exploitation of results. ASTARTE includes 9 test sites in the Mediterranean and Northeast Atlantic in 8 different countries.

ASTARTE will result in: (i) an improved knowledge on tsunami generation involving novel empirical data and statistical analyses so that the long-term recurrence and associated hazards of large events in sensitive areas of the NEAM could be established; (ii) the development of numerical techniques for tsunami simulation concentrating in real-time codes and novel statistical emulations, and (iii) refined methods for the assessment of tsunami hazard, vulnerability and risk.

ASTARTE consortium includes 22 institutions of the NEAM region and 4 institutions from Japan and US.

This project is funded by Grant 603839, 7th FP (ENV.2013.6.4-3 ENV.2013.6.4-3): ASTARTE - Assessment, STrategy And Risk Reduction for Tsunamis in Europe.

NEW APPROACH TO THE ANALYSIS OF STRONGEST EARTHQUAKE TOHOKU 2011

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In the history of Japan there are known large number of strong earthquakes and tsunami, however, earthquake in Tohoku 11 March 2011 is a rare giant having no recorded precedents. During earthquake rupture displacements on interplate fault which delineates north-eastern Japan and subducting under it Pacific plate, were continued near 150 sec, in result of which eastern coast of Japan shifted to the east up to 5 m and lowered nearly to 1 m, and sea bottom raised to 5 m in average. The coasts of Honsu and Hokkaido islands were attacked by tsunami waves with height in 3 to 15 m. [Kanamori, Yomogida, 2011]. Before, strongest earthquakes in the region of Sanriku occurred at various sections of the subduction zone. Among them two types of seismic events can be distinguished [Lay, Kanamori, 2011]. To first type there are related two events of earthquake and tsunami: 1896 ($M_w = 8.2$) and 1933 ($M_w = 8.4$). Both of them arose close to the upper edge of subduction zone and induced catastrophic tsunami waves at Sanriku coast with height up to 30 m. The second type of seismic events is constituted by all other earthquakes of XX century with $M_w \geq 8$ which occurred close to beach, induced strong quakes at the land but not produced such intensive tsunami as earthquakes of first type. Comparing now earthquake Tohoku 11 March 2011 with its predecessors near the Sanriku coast, it can be said that it represent typical example of complicated event, collected itself the features of earthquakes of both considered above types. The process of rupture spreading in the source of this event occurs on cascade mechanism what was difficult to foresee and estimate of seismic danger. The study of data from the array of mobile stations demonstrated that strong quakes at Honsu island mainly came from deep half of fault where overall shift was much less than in upper section of the fault. But huge displacements at low depth, which took place in 50-90 sec after beginning of earthquake, probably, have led to repeated rupture of central, deep section of the fault, what increases entire scale and energy of earthquake. The displacements close to the Japan Trench were anomalously large; on the average they was near 40 m at upper 100-km part of mega-trust and reached maximum in 60-80 m close to the trench [Ito et al., 2011; Lay et al., 2011]. Proceed from the geophysical model of faults and using theory of elastic dislocations for calculation of sea bottom rising [Lobkovsky et.al, 2004], it is possible to accurately enough estimate initial wave height in the source. Elaborated by us model of interaction of oceanic lithosphere and island-arc blocks in subduction zone with taking into account of incomplete (partial) stress discharge at realization of seismic process and further accumulation of elastic energy, permits to account for appearance of strongest mega-earthquakes such as catastrophic earthquake with source in Japan Trench in March 2011. The results of carried out numerical simulation of possible processes in seismic source at given earthquake and generation of tsunami waves are well consistent with recorded and observation data.

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TOWARDS DEVELOPING A HAZARD ASSESSMENT METHODOLOGY OF HISTORICAL TSUNAMI EVENTS

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Tsunamis may affect immediately or within few hours of impact the natural, built and social environments but their effects may well be felt in the future for many years. The immediate effect of the disasters (direct damages) is our primary focus and is easier to quantify. The indirect effects are longer-term and also affect recovery.

Following a catastrophic event a detailed damage and loss assessment is necessary to avoid losing important information. Documenting the direct effects has become more sophisticated with the availability of various types of sensors and new technologies, but also more tedious and complicated.

For example, Remote Sensing products (RS; Satellite or other data such as drone) can be processed to give precise flood extent and damage. Other data collections such as those from post-tsunami field surveys can also compliment RS products and help calibrate tsunami inundation models. Such data sets can provide information for the development of layers in the production of detailed post-disaster maps. The latter can be done for new events but for older events such detail of information is lacking. Post-disaster assessments for historical events are either scarce or contain limited information. A good source of information on past significant events is tsunami historical databases.

In this study we are assessing ways to examine tsunami impacts by utilizing data from older events while maintaining independence from physical parameters of both the tsunami source and resulting waves which are largely unknown. As such, we have applied a tsunami intensity scale to historical events, in order to examine its applicability in hazard assessments and its future as a tool in planning and preparedness. We hope these results may be used towards developing a well-defined methodology to produce hazard maps and refine numerical models for past tsunami events for which the tsunami sources are largely unknown.

ESTIMATING STRESS ACCUMULATION ON PALEO-FAULTS WITH 4D ANALYSIS OF GEOPHYSICAL MESUREMENTS

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Stress accumulation in deep of crust is occurring because of tectonic movements, magmatic intrusion, weight of geological units etc. Rocks in crust can bear stress within limits of faulting or folding, after that limits, rocks drain off accumulated stress. If rocks treats as an elastic material, folding can be formed else if rocks treats as a plastic material faulting can be formed. Accumulated stress prefers the weakest zone of crust to pop out this stress, generally paleo-faults.

After and before these faulting or folding, accumulated stress changes a lot of physical properties of rocks, for example porosity, permeability and water content. Changing of resistivity of rocks is expected because of relationship between these physical properties and resistivity. Resistivity of rocks is interconnected with two main parameters: existence and rate of materials having low electrical resistivity (etc. metals, ions) and connection of rocks ingredient (etc. porosity, permeability).

Regarding to all of these information it is clear that, stress accumulation can be analysed by investigating changing of resistivity under a continuous stress with time in three dimensional environment. In this study there environment will be modelled with a sandbox test mechanism and special geophysical equipment and relationship of resistivity anomalies and formed stress areas and faults analysed in four dimensional by the help of a computer and specific software.

SCALING PROPERTIES OF WORLDWIDE STRONG SEISMICITY IN VIEW OF NON-EXTENSIVE STATISTICAL PHYSICS

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The collective properties of earthquakes has to be studied within a statistical physics frame which is necessary to understand the collective properties of earthquakes. A significant attempt is given in a series of works (Main 1996; Rundle et al., 2003) where classic statistical physics are used to describe seismicity. Then a natural question arises. What type of statistical physics is appropriate to commonly describe effects large earthquakes?

An answer to the previous question could be non-extensive statistical physics (NESP), originally introduced by Tsallis (1988). The latter is strongly supported by the fact that this type of statistical mechanics is the appropriate methodological tool to describe entities with (multi) fractal distributions of their elements and where long-range interactions or intermittency are important, as in fracturing phenomena and earthquakes. NESP has found many applications in nonlinear dynamical systems including earthquakes (Tsallis, 2009). In a series of recent publications, it has been shown that the collective properties of the earthquake and fault populations from the laboratory scale (Vallianatos et al., 2011; Vallianatos et al., 2012), to local (Michas et al., 2013; Vallianatos et al., 2013), regional (Papadakis et al., 2013) and global scale (Vallianatos and Sammonds, 2013) can well reproduced by means of NESP.

In the present work we study the distribution of worldwide shallow strong seismic events occurred from 1981 to 2011 extracted from the CMT catalog, with magnitude equal or greater than Mw 5.0. Our analysis based on the subdivision of the Earth surface into seismic zones that are homogeneous with regards to seismic activity and orientation of the predominant stress field. To this direction we use the Flinn-Engdahl regionalization (Flinn and Engdahl, 1965), which consists of 50 seismic zones as modified by Lombardi and Marzocchi (2007), where grouped the 50 FE zones into larger tectonically homogeneous ones, utilizing the cumulative moment tensor method. As a result Lombardi and Marzocchi (2007), limit the initial 50 regions to 39 ones, in which we apply the non- extensive statistical physics approach. We analyze the magnitude-frequency distribution along with the interevent time distribution between successive earthquakes using the

Tsallis entropy approach in each of the seismic zones defined by Lombardi and Marzocchi (2007) confirming the importance of long-range interactions as supported by the NESP formulation of magnitude-frequency distribution and the existence of a power–law approximation in the distribution of the interevent times. We present strong evidence on temporal clustering of seismic activity in each of the tectonic zones analyzed.

This research has been co-funded by the European Union (European Social Fund) and Greek national resources under the framework of the "THALES Program: SEISMO FEAR HELLARC" project of the "Education & Lifelong Learning" Operational Programme.

TIME DEPENDENT SEISMICITY ALONG THE WESTERN COAST OF CANADA

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Decelerating generation of intermediate magnitude earthquakes (preshocks) in a narrow region (seismogenic region) and accelerating generation of relatively larger such earthquakes in a broader region (critical region) has been proposed as an appropriate model for intermediate-term earthquake prediction.

We examined the seismic activity which preceded the Mw=7.7 (October 28, 2012) thrust event that occurred off the west coast of Haida Gwaii, Canada (formerly the Queen Charlotte Islands), by applying the decelerating-accelerating seismic strain model (D-AS model). We found that this mainshock was preceded with a pronounced accelerating seismic sequence with the time to the mainshock, as well as with an equally easily identifiable decelerating seismic sequence. Both precursory seismic sequences occurred in different space, time and magnitude windows.

An attempt was also made to identify such seismic strain patterns which may also be related to the generation of probably ensuing strong mainshocks along the western coast of Canada.

RUPTURE ZONES OF LARGE EARTHQUAKES, LITHOSPHERIC COUPLING AND SEISMIC POTENTIAL IN THE HELLENIC ARC AND TRENCH

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The subduction zone along the Hellenic Arc and Trench (HAT) system is the most active in the entire Mediterranean region producing shallow, interplate and intermediate-depth earthquakes. Instrumental seismicity records indicate that large earthquakes of M ~7.5 were generated in the last century or so. Very large historical earthquakes with assigning magnitudes up to about 8.0 or more ruptured the western and eastern segments of HAT in AD 365 and 1303, respectively. Both earthquakes produced large tsunamis that propagated to remote coastal zones of the entire east Mediterranean basin. To investigate the current seismic potential along the HAT, we compiled a historical earthquake catalogue for the last centuries and mapped the lateral distribution of rupture zones of large earthquakes (M over 7). Our analysis shows that the segments ruptured by the 365 and 1303 earthquakes very likely are strongly coupled, failing to rupture by large earthquakes in last centuries. This result implies that big earthquakes possibly are under preparation in the western and eastern segments of the arc. The generation of large earthquakes and their repeat times depend on the degree of lithospheric decoupling (or coupling) which is possible to calculate from the plate motion rate and the seismic slip rate. From the recent seismicity we determined certain segments along the plate interface in HAT and for each segment both the plate motion and the seismic slip rates were calculated. The degree of decoupling has been used as a measure of the seismic potential accumulated in each HAT segment. We control the results by comparing the instrumental seismicity rate with the historical one and discus earthquake forecasting consequences.

AN EXTENDED HOMOGENEOUS QUICK-LOOK TSUNAMI CATALOGUE FOR THE EUROPEAN-MEDITTERRANEAN REGION

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The tsunami catalogue in the European and Mediterranean region has been systematically revised since the beginning of 1990's through several research initiatives, mainly the EU projects GITEC, GITEC-TWO and TRANSFER with the contribution of many scientists from several institutes. However, the research in this field is still ongoing for the main reason that new historical tsunami events are revealed and/or event parameters are revised by new techniques or on the basis of new observational data. The compilation of a tsunami catalogue being as much complete, homogeneous and accurate is of importance for tsunami hazard and risk assessment studies which are major issues in the current EUFP7 ASTARTE tsunami research project. In this paper an effort has been made to improve existing catalogues with the addition of new historical events in the Mediterranean and associated seas (Marmara Sea, Black Sea, Azov Sea, SW Iberia) but also in the NE Atlantic and the North Sea, the revision in earthquake and tsunami parameters as well as the assignment of reliability score for each tsunami event. The assignment of tsunami intensity to each event has been made by applying the 12-point Papadopoulos-Imamura (2001) scale for reasons of homogeneity and with the aim to describe better the intensity level, with respect to previous intensity assignments based on 6-point scales. The main progress achieved is the production of a new extended, quick-look, unified tsunami catalogue of increased completeness and homogeneity. The entire European-Mediterranean region is covered by the new catalogue. This research is a contribution to the EU-FP7 tsunami research project ASTARTE (Assessment, Strategy And Risk Reduction for Tsunamis in Europe), grant agreement no: 603839, 2013-10-30.

SIGNIFICANT SURFACE CURRENT VELOCITY CHANGES MEASURED BY THE OCEAN HIGH-FREQUENCY RADAR AFTER THE GREAT 2011 JAPAN TSUNAMI

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The ocean high-frequency (HF) radar, which is based on electromagnetic wave propagation along the salty and good conducting ocean surface, provides a unique capability for continuously monitoring large areas of ocean. This type of radar is usually operated at a radio frequency between 3 and 30 MHz to provide a grid coverage of ocean surface that could extend more than 250 km off the coast. These large ranges are of high interest for many interesting applications such as research in oceanography, vessel detection and tracking, search and rescue, transport and distribution of pollutants, etc. These radar systems recently became an operational tool for coastal monitoring worldwide.

The HF radar system WERA (**W**av**E** **RA**dar) was originally designed at the University of Hamburg; nowadays it is completely manufactured by the Helzel Messtechnik company in Germany. The WERA system is operated as a low-power ocean radar providing simultaneous measurements and mapping of surface current velocity and direction, wind parameters, ocean wave height and directional spectrum. The WERA system is based on a modular design that can be easily installed at the coast and adapted to the requirements of an actual application.

One of the WERA systems was in operation on March 11, 2011, when the Great 2011 Japan tsunami waves hit the Chilean coast after 22 hours of propagation time throughout the Pacific Ocean. The radar was located near Rumena, Chile, and supplied ocean surface monitoring in that region. The radar measurements were recording during several hours while tsunami wave train was arriving at the coast. Bragg-resonant backscattering by ocean waves with a half of the electromagnetic radar wavelength allows measuring the ocean surface current velocity using space-time processing. The ocean surface current field changes due to a tsunami event were evaluated using the measured HF radar backscatter spectra. The unique chance to observe a natural tsunami event by means of WERA radar showed that such radars are capable to measure tsunami surface current velocity with a resolution of a few cm/s. Significant deviations in ocean current measurements were observed by the radar system at distances up to 40 km off the coast. It was also observed that as soon as the tsunami waves were moving into shallower water, the surface velocity was increasing. To identify a tsunami induced signature in a measured current field, a moving-average filtering technique to remove regional surface currents was used. After applying this technique the unique tsunami wave train was clearly seen in radar measurements. Furthermore, it was compared with water level measurements by the tide gauge located 50 km to the south from the radar site. The tsunami wave periodicity was estimated for measurement data. It showed agreement estimating two tsunami wave periods of 14 min and 32 min for both tide gauge and radar measurements.

Installed along the coastal regions at tsunami risk the ocean HF radars can contribute to tsunami early warning systems. If these radar systems would have been already installed at the coast, it is just an additional software package to enable real-time support for tsunami detection and its monitoring.

HOSPITAL PREPAREDNESS FOR DISASTERS

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Hospitals around the world, providing primary, secondary or tertiary health care may have to receive massive influx of victims in/due to various traumatic or non-traumatic circumstances.

These/Such events can occur quite unexpectedly at any time.

Healthcare facilities need be organized in a way to be “transformed” within minutes to be able to admit, treat and discharge a number of victims exceeding the original capacity of the hospitals.

Recent crisis situations encountered in Lebanon were mainly due to terrorist acts. This situation has highlighted the need to rely on structured mechanisms for crisis/disaster management especially that the absence of such management systems would have catastrophic consequences on the social level.

Bahman Hospital is a private non-profit health care institution located in Haret Hreik, a southern suburb of Beirut. Bahman Hospital has a capacity of 170 beds, an Emergency Room capacity of 25 admissions and the “transformed” hospital can admit up to 50 victims. A disaster plan was developed in 2002, and updated on regular basis.

The process is divided into three parts: pre-disaster, per disaster and post disaster. This process and its monitoring will be presented in more detail.

INTERACTION BETWEEN SSE, EARTHQUAKES, AND SEISMIC RADIATION IN THE HIKURANGI SUBDUCTION SYSTEM

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In the foreseeable future, we intend to incorporate geodetic and seismological constraints into both scenario based and probabilistic seismic hazard for New Zealand, including megathrust rupture. We are also investigating inclusion of GPS strain models into hybrid models based on earthquake catalogues. By mathematically combining GPS based information with smoothed seismicity models or earthquake clustering models we can capture different scales of the seismic process and improve the forecasting ability. In this talk, we will present an example from 2013 to highlight current research that is directed toward these two goals. We will focus on the southern Hikurangi margin, where GPS inversion identifies a strong degree of interseismic coupling updip from a large slow slip (SSE) event that occurred during 2013. The deep (30-50 km) long-term Kapiti SSE that began in January 2013 is equivalent to an Mw7.1 earthquake. Previous Kapiti SSEs occurred in 2003 and 2008. The 2013 event activated tremor-like energy release in at least two discrete regions around the SSE. We use an energy scanning approach (Kao and Shan, 2004; Liao et al., 2012) to search continuous data from 2013 for areas around the SSE that emitted seismic radiation, either from tectonic tremor or long-duration (~>20-50s) clustering. By using an energy-based approach, we forestall many catalogue-related issues including the ambiguous distinction between tremor and attenuated microseisms. We locate these events within a 3D model that encompasses the plate interface from the trench to aseismic depths. We map increased seismic energy release updip from the SSE with morphology 'interlocking' with an embayment of the SSE. We suggest that these results map a large-scale asperity on the plate interface. We further suggest that this type of mapping can be used to quantify the evolution of stress transfer from the SSE to the locked region, providing an a priori model for deterministic modeling of megathrust rupture. We will also present a complex interaction of this SSE and an M6.3 local earthquake which was possibly triggered by the SSE and subsequently hinders its process. To aid in PSHA, future work will also be directed at using calculated stress perturbations from both the SSE and mapped areas of seismic radiation to test the usefulness of incorporating these effects into forecast models such as EEPAS or ETAS.

PROGRESS TOWARDS DEVELOPMENT OF THE NOANET GNSS EARLY WARNING WEB PLATFORM: PRELIMINARY RESULTS

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The prevention and mitigation of geohazards requires the use of early warning systems. Space-geodetic techniques and dedicated satellite missions are crucial tools in the determination of geophysical parameters (e.g. precise and rapid determination of earthquake magnitudes as well as improved modeling of tsunami waves) and monitoring of faults, landslides etc. Since 2006 NOA (National Observatory of Athens) has developed a National GNSS ground network, NOANET (www.gein.noa.gr/gps.html). NOANET can provide valuable data (1-s observations) for warning systems because of the development of real-time processing techniques, such as PPP. The PPP (Precise Point Positioning) approach is able to obtain cm-level accuracy of the GNSS receiver and is independent of other reference stations which can be a large advantage for a warning service. In addition, the continued improvement of algorithms which minimize the errors sources like ionosphere, troposphere, clocks etc. has made PPP a reliable method to measure large earthquake displacement and develop platforms for early warning systems. In this work we use the BKG BNC processing engine, Python and web programming (HTML, Google API) tools towards the development of a web platform that monitors GNSS station positions along the Hellenic Arc in real time.

SPECIAL SESSION

OPERATIONAL PREPAREDNESS POLICY AND RESPONSE IN CASE OF EARTHQUAKE IN GREECE

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Working towards an earthquake mitigation policy in Greece, for the thirty operating years of Earthquake Planning and Protection Organization (E.P.P.O.), a successful shifting from a seismic disaster-resistant community to a resilient community has been achieved (UN/ISDR, 2005).

Basically one of the main strategic E.P.P.O.'s priority actions is related to the operational preparedness policy and consequently to response in case of disastrous events. Essential components of this policy are: enhancement of organizational capacities, capabilities, coordination, activation of local participation, as well as consistency and constant earthquake operational planning at every level of administration.

The objectives of this national policy are focusing on the improvement of interoperability in disaster management, i.e. procedures, common language among involved actors, legislation and systems, and in a rational management of the consequences for ensuring effectiveness, efficiency and coherent response to the disaster. Among the main initiatives for implementing and controlling the effectiveness of this policy are the following:

- organizing periodical workshops and meetings at local and regional level with the responsible stakeholders covering specialized earthquake management related issues,
- contacting pilot simulation exercises (table-top and field) at all administrative levels and
- updating of guidelines and procedures for emergency management taking into account the accumulative experience, aftermaths and best practices of past events in Greece.

E.P.P.O. is continuously monitoring through research (questionnaires, debriefing meetings) the preparedness level of the communities and attempts to improve it, in the sense of a sustainable seismic mitigation framework. Implementing priority actions in the whole country (at regional and local level), E.P.P.O. is able to comment in three major topics: a) Seismic risk Management Planning, b) Communication Planning and c) Institutional Issues. Accordingly it has been proposed a clear coordination scheme within the new administrative bodies (Municipalities, Regional Unit - Region and Decentralized Administration) with emphasis of resolving the co-responsibilities and clarifying the thresholds as regards to the time of undertaking activities per level of management. However, the essential idea is remaining the same, the strengthening of local communities to be able to cope with the expected disaster through constant operational planning and become more effective and more efficient the response system in a rational manner.

LARGEST HISTORICAL TSUNAMIS IN THE WORLD OCEAN AND THEIR IMPLICATION FOR COASTAL HAZARD ASSESSMENT

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The global tsunami catalog of tsunamis contains nearly 2250 historical events that occurred in the World Ocean since 2000 BC to present. Many of them were highly destructive and some resulted in numerous fatalities, but in most cases their impact was limited to the nearest coast. Only a small number of historically known tsunamis were powerful enough to produce a damage and fatalities far outside the source area. They form a group of the so-called trans-oceanic tsunamis which are characterized by large run-up heights (up to 40–50 m) near the source and the ability to cross the entire oceanic basin and to cause an essential damage to its opposite coast (at distances up to 10 000 km). This ability is a result of several factors, the main of them being an increased directivity of energy radiation by an extended earthquake source and increased wavelengths as compared to regional and local tsunamis. An additional factor is the contribution of waveguide effects to the energy redistribution during the wave propagation along oceanic underwater ridges. Another key feature of trans-oceanic tsunamis is their ability to induce dangerous oscillations on the coasts of marginal seas, which are largely protected by island arcs from the impact of even the strongest regional tsunamis.

Among all historical tsunamigenic events the trans-oceanic tsunamis represent only a small fraction (less than 1%), however they are responsible for more than half the total tsunami fatalities and a considerable part of the overall tsunami damage.

The source of all known trans-oceanic tsunamis is subduction mega-earthquakes with magnitude 9.0 or higher having a return period from 200-300 years to 1000-1200 years. This paper presents a list of 15 trans-oceanic tsunamis identified so far in historical catalogs with their basic source parameters, near-field and far-field impact effects and their generation and propagation features. Among them there is one event (365 AD Crete tsunami) that formally cannot be called "trans-oceanic" since it occurred in the Mediterranean Sea, however, due to its physical nature and the scale of destructions it fully deserves to be included in this list.

During many years seismologists believed that mega-quakes of M9 class can occur only in some particular places of subduction zones, having some specific geological features (e.g. the younger age and an increased subduction rate), however, the occurrence of the December 26, 2004 Sumatra earthquake in Indonesia and especially, the March 11, 2011 Tohoku earthquake in Japan questioned this idea. The presently prevailing point of view is that all the subduction zones should be considered as possible areas for the occurrence of M9 mega-earthquakes. The only reason for the absence of such events in some of them seems to be an insufficient length of instrumental and historical catalogs, which in most regions are significantly shorter than the expected recurrence period of mega-earthquakes. For the tsunami hazard assessment problem recognizing this fact means radically revising the existing approaches to the coastal tsunamizoning, especially in the part related to the assessment of 500-year and 1000-year flooding. Finally, we discuss possible changes in methodology of tsunamizoning when the occurrence of mega-earthquakes on the nearest section of subduction zone is taken into account.

SPECIAL WORKSHOP: VALIDATING END USER REQUIREMENTS FOR A DECISION SUPPORT TOOL FOR HEALTH EMERGENCY MANAGEMENT

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The S-HELP project (Securing - Health.Emergency.Learning.Planning) is developing a decision support system (DSS) that will support decision makers in preparing for, responding to and recovering from major emergency incidents. The S-HELP DSS will bring major benefits to emergency healthcare management, from learning and preparing for emergency incidents and analysing threats, to post evaluation, reporting and logistics management. It will provide a unique mechanism to assist stakeholders and end users to work together for co-ordinated, effective, evidence based decisions at all stages of EM including before an incident takes place, during the incident, immediately following an incident, and later post incident stages involving evaluation and the communication of information to the public. It is intended that the DSS will bridge the gap between current constraints and optimal capabilities, being cognisant of the complex and dynamic Health Services in emergency situations.

In developing the DSS, a comprehensive analysis of stakeholder and end user needs (e.g. data, tools, practices and standards, training, process models for building collective knowledge bases, resources) in all three phases of an emergency situation (preparedness, response and recovery) is being undertaken through a combination of desk top research and consultation with key stakeholders and end users.

The initial findings on stakeholder and end user needs and requirements for a DSS to support decision making for emergency management will be presented at the Special Workshop on Validating End User Requirements for a Decision Support Tool for Health Emergency Management. Workshop participants will be invited to further contribute to the requirements identification process and to share their views on the requirements identified to date.

SPATIAL INFORMATION MANAGEMENT AND GEOGRAPHIC INFORMATION SYSTEMS IN THE DELIVERY OF S-HELP DECISION SUPPORT TOOLS FOR EMERGENCY SITUATIONS

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Access to reliable and up-to-date information is fundamental in assessing risks, planning for hazards, responding effectively to incidents, deploying resources and assisting communities recover in emergency situations. In helping to identify, model and analyse situations and problems, the value of the information and the effectiveness of the decision-support tools being developed by the S-HELP project (*Securing - Health.Emergency.Learning.Planning*) are closely related to the quality and completeness of such information (i.e. data) and the manner in which it is handled and made available for analysis.

The key challenge for effective spatial information management during emergencies is the capacity to manage, utilise and share spatial data and information effectively across organisations and borders. Prerequisites for a sustainable and integrated information management solution involve the acquisition, processing and dissemination of data and information within a collaborative framework which combines leadership, people, technology, applications and data to ensure that tools and procedures are in place to maintain and transform data into meaningful information products, capable of supporting core emergency operations and decision-making processes in a timely manner.

The power of spatial or geographic information systems rests in their capability to overlay different layers of information from the same location, and to then derive conclusions about spatial relationships within and between the layers to support decision-making and planning. However, the full spectrum of activities pertaining to the handling of data, from ownership to metadata compilation, from quality, standardisation and lifecycle control, to access and dissemination form part of the overall infrastructure S-HELP is developing to support emergency management.

This presentation will provide insight on how Future Analytics Consulting is implementing best practices in spatial information management for the development of S-HELP's decision support tools.

THE INTERDISCIPLINARY SCIENCE OF EARTHQUAKE PRECURSORS: CHALLENGES AND OPPORTUNITIES

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The science of Earthquake precursors and the associated issues of predictability and forecasting are now more generally accepted. However, agreements on specific methods and techniques need to be pursued by the science communities in scientific frameworks. What I call the science of Earthquake Predictability has at least as good potential as climate change predictability and at par with weather forecasting.

New capabilities in monitoring from both space and ground, coupled with advances in data analysis and theory, provide opportunities as well as challenges. One scientific discipline by itself cannot solve the associated complex issues. What will be needed are international, multidisciplinary and interdisciplinary collaborations, coupled with new training and degree programs at universities working together.

A good theoretical start would be to better understand the energies involved in the EQ preparation and in actual events in terms of existing models. On the space front, science communities should propose specific space missions as the global change communities did several years ago.

ISHINOMAKI TSUNAMI INTENSITY MAPPING ($ITIS_{2012}$) FOR THE 9MW TOHOKU EVENT, MARCH 11 2011, JAPAN

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The study applies the Integrated Tsunami Intensity Scale ($ITIS_{2012}$, Lekkas et al 2013) criteria to map the tsunami intensities distribution in the broader Ishinomaki area, for the 9Mw March 11, 2011 event offshore Tohoku, Japan. Reports, satellite imagery and published point and zone data were taken into account to rank the impact of the tsunami in each of the six criteria categories of the ITI Scale. Impact of all categories was mapped on city blocks, point measurements, findings etc, so that thematic impact maps were first created. Then intensity values were assigned, depending on the impact for each category to produce thematic tsunami intensity maps (layers). Most of the criteria result in a mosaic of intensities, which is in many cases due to lack of data, depending on the land use zoning. The complementary function of the criteria is evident in the final map. Two different methodologies of criteria combination were used for the production of a final map. A land-use-based weighted overlay was applied integrating the layers of the criteria, resulting in a final map that rather shows damage assessment or total impact of the tsunami on Ishinomaki area. The second final map was produced using the cell statistics "max" function, so that the maximum grade throughout the layers was selected for each pixel. This map showed an excellent zoning filling in any gaps due to lack of information in some layers and areas with maximum intensity data from the others and it is the tsunami intensity map of the area. It was made very clear though, that field data, especially during the first hours or days after such an event, are extremely useful for the intensity assessment. Once restoration works begin, it is difficult to estimate impact for some categories, especially when the area has been hit by both earthquake and tsunami.

NEW PROCEDURE FOR PROBABILISTIC TSUNAMI HAZARD ASSESSMENT FROM INCOMPLETE AND UNCERTAIN DATA

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The 26 December 2004 Sumatra and 11 March 2011 Japan mega earthquakes and tsunamis once again focused the world's attention on the devastating impact that tsunamis can have on infrastructure, economic stability and the quality of the life. Tsunamis are a natural phenomenon with a low probability of occurring but have a high impact when it does occur. Observed tsunamis are normally very few and far between. Many events are known only through investigations of deposits and historical narratives. Many tsunami-threatened coastal areas therefore have long palaeo- and historic records available containing information of the largest and catastrophic tsunami occurrences. Traditional probabilistic tsunami hazard analysis procedures require observations spanning hundreds of years but are not always capable of accommodating this type of datasets as well as the associated uncertainty regarding location and intensity of individual events. During this presentation, we will introduce a new technique for probabilistic tsunami hazard analysis which permits the assessment of the key tsunami distribution parameters in the case when the catalogue consists of the palaeo, historic as well as the most recent, instrumentally recorded ('"complete") tsunami events. Subsequently the tsunami risk (damages) to infrastructure can be assessed.

A GLOBAL SURGE OF TSUNAMIGENIC EARTHQUAKE RUPTURES AND HOW WE ARE QUANTIFYING THEM

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During the past decade from December 2004 to present 18 great ($M_w \geq 8.0$) earthquakes occurred globally (~1.8 per year), compared to 71 from 1900 to mid-2004 (~0.68 per year), yielding an effective rate increase of 265%. Six events had $M_w \geq 8.5$, larger than any prior event since the 1965 Rat Islands earthquake. Substantial tsunami were generated for two-thirds of these events, as well as for several additional M_w 7.8-7.9 thrust-faulting events that ruptured at very shallow depths. While this overall surge of activity has not been demonstrated to be causally linked, regional spatio-temporal clustering is clearly evident for great events along the Sumatra, Kuril and Samoa subduction zones, and longer-range interactions have been established for global seismicity at lower magnitudes following some of the events. This recent decade of high great earthquake activity coincided with vastly expanded global networks of seismometers, GPS stations, tsunami gauges, and new satellite imaging capabilities such as GRACE, InSAR, and LandSAT interferometry. Individual events such as the March 11, 2011, Tohoku, Japan M_w 9.0 earthquake produced more ground motion and tsunami recordings than available for all great earthquakes of the last century collectively, enabling unprecedented analyses of precursory, co-seismic and post-seismic processes around the megathrust environments where most of these events have occurred. Joint inversion and modeling of the diverse data sets exploit complementary sensitivity of the signals to different aspects of the earthquake processes. Major advances have been achieved in quantifying frictional locking and strain accumulation prior to some great events and relating it to coseismic slip heterogeneity. Many surprising aspects of these well-quantified earthquakes have been manifested, associated with rupture dimensions, tectonic location, compound faulting, triggering interactions, aftershock complexity, and depth-varying seismic radiation characteristics. The lessons learned from quantification of recent tsunamigenic earthquakes hold implications for tsunami hazards from future great earthquakes around the world.

ESTIMATING THE NORTHEASTERN CARIBBEAN MEGA EARTHQUAKE SEISMIC POTENTIAL FROM CONTINUOUS GPS OBSERVATIONS IN PUERTO RICO AND THE VIRGIN ISLANDS

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Tectonics of the northeastern Caribbean region features a highly oblique convergence where the North American plate subducts beneath the Caribbean plate at a rate of approximately 2 mm/yr. The northeastern corner of the Caribbean is characterized by the east-west trending Puerto Rico Trench (PRT), north of Puerto Rico, followed by a southward curvature towards the Lesser Antilles Trench. Therefore, having in consideration that the motion of the Caribbean Plate is towards N70E, oblique collision results along the PRT, whereas full frontal collision occurs along the Lesser Antilles Arc. Puerto Rico and the Virgin Islands is home to approximately 4 Million people and the fact that the largest significant event was more than 95 years ago may result in a devastating situation. Continuously operating Global Positioning System (cGPS) sites along the Northeastern Caribbean have been used to evaluate strain accumulation within the Puerto Rico and the Virgin Islands forearc and thus assess the potential for mega-earthquakes in this region. Using only the horizontal components of 10 cGPS sites we believe that the PRT is unable to generate mega-earthquakes because the northward motion appears deficient in trench-normal thrust accumulation. However, this does not indicate that smaller, but equally damaging events may occur as it has occurred with the recently M_w6.4 January 13, 2014 event. Our conclusions, based on a maximum of 5 years of cGPS data is at most preliminary, however, the data suggests the Bahamas bank is still impeding Caribbean's plate motion and that obstacle is observed at the PRT by the decrease in westward motion rates of sites within the PRVI region with distance from the trench.

CATASTROPHIC CHILEAN EARTHQUAKE AND TSUNAMI ON 1 APRIL 2014. EVIDENCE FOR REALIZED PROGNOSIS

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In present work, catastrophic seismic event at northern coast of Chile on 1 April 2014 to north of Iquique city with magnitude 8.2 as well as generated by it tsunami is analyzed. It is noted that such event was predicted in the paper [1] in which there were analyzed all the strongest tsunamigenic earthquakes with sources near the Chilean coast. Analysis of catastrophic earthquakes and tsunami in given region, localization of sources of historical earthquakes and character of generated by them tsunami waves permit authors to do a conclusion about possibility of repeat of catastrophic earthquake similar to that with magnitude 8.5, occurred on 13 August 1868 in the region of the South Peru. The source of this earthquake was elongated to the northern coast of Chile, near Arica city, and induced the great tsunami – “Arica’s tsunami”. The epicenter of earthquake was less than 100 km out of shoreline and located at terrace of deep-sea trench. Almost in all coastal points, where the tsunami was recorded, it was begun with run down of sea water from the beach, then wave train was followed, in which train second wave was most destructive [1,2]. Tsunami waves generated by this earthquake reached maximal run up height up to 21 m. Survived eyewitnesses described this event as follows: “From the ocean side, with thunder-like noise, tremendous wall of phosphorescent and foaming sea water had rushed” or “Ocean had rushed to the beach in the form of terrible wave … carried ships at its crest.” In a 10 years, in the same region, with source near northern coast of Chile, it occurs destructive earthquake with magnitude 8.8, which was accompanied by catastrophic tsunami. In literature, this tsunami is cited as “Iquique’s tsunami”. Tsunami with wave height more than 15 meters are appeared at northern coast of Chile, in the region of Arica approximately once a 140 years. Thus, analysis performed in [1] demonstrated that in the beginning of 21 century (2008-2018) the catastrophic event similar above described can occur. The earthquake and tsunami near Arica city in April 2014 are within this time interval. It can be considered as supporting evidence for preliminary prognosis made by authors in 1999. In present work, analysis of spectral characteristics of wave fields obtained at numerical simulation of given event is performed.

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INVERTIGATING THE BENEFITS OF CURRENT TOOLS IN SUPPORTING RESPONDER NEEDS

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Damage to health infrastructure, demand for medical attention, displacement and major outbreaks all place a strain on health services. Preparedness, response and recovery capabilities of health services will directly impact society's ability to 'bounce back' to become more resilient to such devastating shocks. One of the objectives of the S-HELP (*Securing - Health.Emergency.Learning.Planning*) project is to investigate the challenges facing multi-agency coordination, the characteristics of commercially available tools in addressing these issues and as a result current decision support systems (DSS) in managing emergencies.

Vendor solutions, do not fully address first responder challenges such as: response under time pressure, lack of data, human factors (cognition, emotions, interpersonal relationships), the activation of social service for recovery (public mental health), trust-building across groups, definitions or conflicts in incidents and debriefs. The tools analysed incorporate very basic decision support. The most common failure of these tools is information overload and inflexibility. Information overload, although most frequently tied to an individuals' degree of cognitive overload, can also occur at the intra-organisational level as the sheer volume of information made available is just too much and leads to an organisations' inability to search/find and use the information when needed. Tools selected for information sharing and coordination across agencies is due primarily to the expected value the agency expects. A lack of understanding of organisational information requirements and end user interface design can reduce the expected group value of the system and prevent effective use. As a result a significant effort must be made to ensure that increased inter-agency integration does not lead to voluminous amounts of irrelevant information and overload the organisations. S-HELP DSS will go beyond a mere technical only solution to ensure the effective ownership, sharing and coordination. It will be designed so as to ensure flexibility, minimise information overload and cognitive absorption to ensure system and information quality, two aspects concerned with emergency response DSS success

The initial findings of the project will be presented. These provide a rich foundation for future research on the design of incident/emergency management decision support (DS) tools. The development of a tool-set is proposed which will enhance the protection of public health across borders. The solution will bring benefits to emergency healthcare management, from learning and preparing for emergency incidents and analysing threats, to post evaluation, reporting and logistics management. It will provide a unique mechanism to assist stakeholders and end users to work together for co-ordinated, effective, evidence based decisions at all stages of emergency management including before an incident takes place, during the incident, immediately following an incident, and later post incident stages involving evaluation and the communication of information to the public.

A PSYCHOLOGICAL FRAMEWORK FOR THE S-HELP DECISION SUPPORT SYSTEM

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This presentation addresses the psychological framework that is being developed in the context of the S-HELP project. This project aims at creating a solution approach and system to support the decision making process in emergency situation, in order to improve healthcare preparedness, response and recovery. Based on end-user needs and requirements the developed system will support decision makers on operational, tactical, and strategic level. Furthermore, the system will incorporate interoperability features, risk communication mechanisms, ethical considerations, and psychological findings. Moreover a training methodology will be developed to improve the quality of taken decisions in combination with the S-HELP system.

The psychological framework is one of the core components of the S-HELP system and approach. It informs the system development, the training methodology, and the project evaluation. The central component is the self-regulated decision making process. It is based on the concept of self-regulation that stimulates and supports meta-cognition. Including planning and reflection activities in the decision making process the quality and accuracy of taken decisions should be improved. In addition to the self-regulated decision making process three further components are part of the psychological framework. The first component is the competence model that describes the abilities to make decisions. It consists of two types of competences, which are meta-competences addressing the decision making in general, as well as operational competences targeting the specific knowledge in the field where decisions have to be made. The application of this model is mainly seen in the training methodology. The second component is the information processing and perception concept. Using perception psychology findings, a concept is being developed how information should be presented, so that it is most effective for decision makers in emergency situations. The application of this concept results in guidelines for the user interface design of the decision support system. The third component targets the psychological states and traits of the decision makers. Mainly emotional arousal and stress are relevant states that influence the decision making process. Solutions how to deal with such factors influence both user interface design and training.

Empirical studies will be conducted to prove and adapt the psychological framework. These studies will include the developed system, the training methodology, and the end users. They should give insight in the effectiveness and usefulness of the overall psychological framework and its components.

URBAN PLANNING FOR DISASTER RESILIENT CITIES IN CASE OF JAPAN

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In the modern history of Japan, many cities and regions were seriously damaged by gigantic natural disaster such as earthquake, typhoon, tsunami etc. After the East Japan Mega Earthquake, resilience is one of the important keywords to promote urban and regional planning in Japan.

In this presentation at first the relationship between planning and three mega earthquakes, namely the Kanto Mega Earthquake in 1923, Hanshin Mega Earthquake in 1995 and East Japan Mega Earthquake in 2011, is briefly reviewed. Each mega earthquake brought not only innovative ideas and measures of planning, but also additional problems and challenging task.

Secondly the situation, efforts and problems in cities and regions in Tohoku region after the East Japan Great Earthquake are presented. Japanese society is entering to aging society and decreasing society. Planning task for damaged area is especially symbolic and challenging task in the age of demographic change.

Thirdly as a resent planning for resilient city the case of Tokyo metropolitan government (TMG) is presented. Tokyo is assumed to be attacked by large scale epicentral earthquake. TMG announced urgent programs of disaster prevention: ten-year project to advance fire resistance in close-set wooden housing areas. In this presentation the background of close-set wooden housing area problems is reviewed. Then the possibility and limitation of this program are discussed.

As conclusion it is pointed out that for resilient planning both improvement of physical environment and participation and involvement of neighborhood community is essential.

HAZARD AND RISK ASSESMENT FOR ALEXANDRIA RELATED TO TSUNAMIS GENERATED BY EARTHQUAKES IN THE EASTERN MEDITERRANEAN REGION

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Alexandria is the second biggest city in Egypt as regards population, is a key economic area in northern Africa and has developed a very important tourist industry. Historical catalogues indicate that it was severely affected by a number of tsunami events.

In this paper we present the results of a study of tsunami hazard and vulnerability through methods developed over the last 10 years within European projects centered of tsunamis in the European region: SCHEMA, TRANSFER and ASTARTE.

The hazard assessment is carried out by means of the Worst-case Credible Tsunami Scenario Analysis (WCTSA) and is based only on tsunamis generated by earthquakes, including the two strongest earthquakes that hit the eastern part of the Mediterranean Sea in historic times, namely the 365 A.D. and the 1303 events.

The tsunami scenarios are provided by using a code that implements a finite difference numerical method, called UBO-TSUFD, developed and maintained by the tsunami research team of the University of Bologna. This code solves the nonlinear Navier-Stokes equations in the shallow-water approximation and calculates inundation. The results obtained by the different scenarios are aggregated to provide the maximum inundation.

The tsunami vulnerability and damage to buildings are calculated by means of a method developed in the frame of the EU-FP6 project SCHEMA. The damage level of buildings is computed through a damage matrix taking into account the vulnerability class of the structure and the maximum value of the inundation water column resulting from tsunami modelling.

The largest values of run-up heights found for the aggregate scenario do not exceed 5 m. Due to the topography of the coast, the inundation area is estimated to be larger in the western sector of the province of Alexandria, in particular to the west of the port of Dekhila, in the districts of El Almeriyah and El Dekhila that have had a big development over the last decade with a significant increase of population. The result of our study is that thousands of residential buildings can be affected by tsunami inundation though only a few can be damaged substantially, with the involvement of some 175,000-316,000 people.

EXPERIENCES FROM THE APPLICATION OF THE NEW 12-POINT TSUNAMI INTENSITY SCALE: 2001-2014

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The quantification of tsunamis is a puzzling issue since no standard magnitude scales have been established so far. Therefore, intensity is a proxy for measuring the size of tsunami events. From the 1920's up to 1960's several 6-point tsunami intensity scales were proposed mainly in Europe, Japan and Russia. To contribute substantially to this critical issue, in 2001 the authors of this paper proposed a new 12-point tsunami intensity scale in analogy to 12-point seismic intensity scales and by following the next principles: (a) independency from any tsunami physical parameter, dependency only on the tsunami effects; (b) sensitivity, that is incorporation of an adequate number of levels (or points) in order to describe even small differences in tsunami effects; (c) detailed description of each intensity level by taking into account all possible tsunami impact on the human and natural environment, the vulnerability of buildings and other engineered structures. The new scale is arranged according to the tsunami effects on humans and on nature, on objects and property, e.g. vessels of variable size, and on damage to buildings and other engineered structures. Since 2001, particularly after the 2004 Indian Ocean big tsunami, the so-called Papadopoulos-Imamura scale was applied for intensity assignement of both modern and historical tsunamis, in tsunami statistics and hazard assessment studies, in mapping the spatial distribution of tsunami damage as well as in comparative studies regarding intensity scales of other natural phenomena. The interest about the quantification of tsunamis increases and, therefore, further applications are raising, such as risk assessment approaches, e.g. the development of future damage scenarios in terms of tsunami intensity distributions and the repeat times of certain tsunami intensity levels.

NEAR-FIELD TSUNAMI EARLY WARNING AND PREPAREDENESS IN THE MEDITERRANEAN: THE EU NEARTOWARN PROJECT

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The Mediterranean Sea region is characterized by near-field tsunamis (travel times less than 30 min.). An efficient end-to-end warning system should fulfill the condition that the time needed from earthquake detection to evacuation is less than the arrival time of the first wave, which is a very hard task in the Mediterranean. The project NEARTOWARN, supported by the EU DG-ECHO prevention programme (2012-2013) focused, among others, to the establish of a pilot near-field seismic and tsunami early warning system in Rhodes island, SE Aegean Sea, Greece, with the purpose to meet needs for local earthquakes (epicentral distance up to ~100 km) and tsunamis but applicable in other coastal zones of the Mediterranean and beyond. To minimize emergency time in less than 30 sec, seismic alert devices (SED's) make the core component of alerting. SED's are activated and send alerting signals as soon as a P-phase of seismic wave is detected in the near-field domain and for a predetermined threshold of ground motion. Then, emergency starts while SED's activate remotely other devices, such as computers with data bases of pre-calculated tsunami simulations, surveillance cameras etc. The system is completed with tide-gauges, simulated tsunami scenarios and emergency planning supported by a Geographical Management System. Rhodes island in Dodecanese, Greece, has been selected as a test-area for the development of the prototype system. To promote the future development of such local systems in other coastal zones of the Mediterranean the NEARTOWARN partners review current status of early warning systems, produce digital inventories of wave travel times from several tsunami sources to a number of forecasting points, standardize data bases for pre-simulated tsunami scenarios and optimize triggering thresholds for the SED alerting networks. A local system such as the one developed by NEARTOWARN is expected to function in synergy with national and regional warning systems such as the one coordinated NEAMTWS.

TSUNAMI QUESTIONNAIRE SURVEY IN HERAKLION TEST SITE, CRETE ISLAND, GREECE

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The Heraklion city (Crete Island, Greece) has been chosen as one of the test-sites for the EU-FP7ASTARTE tsunami project. Heraklion is the biggest city in Crete Isl. and the fourth biggest in Greece with a population of about 170,000 which, however, during the summer vacation period nearly doubles. In the past, Herakleion was hit by strong, destructive tsunamis such as the ones of AD 8 August 1303, 10 October 1650 and 9 July 1956. The first and the third were caused by large tectonic earthquakes associated with the eastern segment of the Hellenic Arc the first and with the back-arc area the third. The one of 1650 was associated with the eruption of the Columbo volcano in the Santorini volcanic complex. One of the activities scheduled for WP9 of ASTARTE project, which aims at building tsunami resilient societies in Europe, is dedicated to organize questionnaire surveys among the populations of the several ASTARTE test-sites. Although the questionnaire is comprised by more than 50 questions, the central concept is to better understand what people know about tsunamis and if they are ready to cope with risks associated with future tsunami occurrences. In Herakleion the survey was conducted during tourism peak season of July 2014, thus questionnaires were collected by both local people and tourists representing a variety of countries. We attempted to keep balance between males and females, while the age ranged from 15 to 65. Totally, 113 persons were interviewed of which 62 were females and 51 males. From the point of view of origin, 58 out of 113 were local people and residents, 22 were Greek tourists and 29 foreign tourists. Generally, the questionnaire consists of four parts. In the first, people were asked about their relation with the area of Heraklion. In the second part, the questions considered the knowledge that people have on tsunamis as a natural, hazardous phenomenon. More precisely, people were asked questions like what a tsunami is, if Heraklion could be affected by a tsunami, how a tsunami is created etc. In the third part of the survey, people were asked questions regarding evacuation practices in case of a tsunami. In the last part, personal data, such as nationality, age, education level and more were collected. To analyse the replies received we used the statistical software SPSS. Preliminary results are really interesting showing that most people have only a general idea about the phenomenon of tsunamis while that they don't feel sure about what to do or to avoid in case of a tsunami. This research is a contribution to the EU-FP7 tsunami research project ASTARTE (Assessment, Strategy And Risk Reduction for Tsunamis in Europe), grant agreement no: 603839, 2013-10-30.

SPECIAL SESSION

DECISION SUPPORT FOR HEALTH CARE – USERS PERSPECTIVE

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Health care systems prepare for 2 major types of emergencies – those who are primarily health related and impact the society (e.g. H1N1 outbreak, Ebola outbreak), and emergencies who impact the society, while health is one of sectors impacted (e.g. earthquakes and tsunami, but also civil unrest). Both types of emergencies require close cooperation between health care practioners and the "Crisis management community". This cooperation is the first challenge for the S-HELP project, as these are different types of organizations, being the health-care in most of the country a "business", with very little "hierarchy" and great variation in the degree authorities have real power over the providers.

As S-HELP objective is to design a decision support system to support health care system in their preparedness and response to emergency situations, the following aspects are considered essential components of the system:

1. Scenarios – not as a "fortune teller" but validated and detailed as a preparedness tool.
2. Information sharing tools – health care systems, mainly public health have tools that are used on daily basis. Information generated on those tools needs to be exported to "general users" in a manner that is understood to none medical professionals. In the same manner information generated by the crisis management system, needs to be imported into health care information systems to be analysed (e.g. the size, composition and concentration of a toxic plume). As these systems contain patient data, data protection is a key element.
3. Risk communications – health care emergencies tend to create "dooms day" perception by the none experts. Experts using "high professional terminology" tend to make the situation worst. Tools to tailor the information to the different audience and the different media tools (including social media) are essential. One of the key issues to be addressed is the phase (built in in medical tests) between clinical suspicions (starting point for action) to the verification of the suspicion by the appropriate test.
4. Procedures and the appropriate equipment – Some health care emergencies, though dramatic are rare (e.g. the Polonium exposure in the UK 2006). Effi-

cient response requires a large data base including procedures (algorithms for clinical investigation, contact tracing, testing, hospitalization, decontamination) and the needed equipment to fulfil those tasks (including specifications and standards to allow fast procurement).

5. Knowledge management – personnel as to be trained in the use of the system, but never the less in response to the different scenarios. These training should take place in the preparedness, but also during the emergency phase, to ensure high level of knowledge of responders as well as updates and flow of the relevant information. The system should support the identification of lessons from trainings / simulations / operations and their incorporation into the system (lessons learned).

This project has received funding from the Union's seventh framework programme, for research, technological development and demonstration under grant agreement No.607865.

KINEMATIC MODELING FOR THE SEISMIC AND TSUNAMI EARLY WARNING SYSTEMS – BULGARIAN EXPERIENCE

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The seismic early warning systems (SEWS) and tsunami early warning systems (TEWS) are the world innovative product. Heavy subduction earthquakes and tsunamis occurred in Japan (2011), Sumatra (2004), Chile (2010, 2014), Solomon Islands (2014), etc. These earthquakes and the following tsunamis demonstrated clearly the need of Seismic and Tsunami Early Warning systems especially for the subduction zones – the generators of almost all mega earthquakes and tsunamis. All kinematic models about SEWS are based on the fundamental physical property of the seismic waves propagation: the P-waves (with lower amplitudes and smaller destructive potential) travel approximately 1.71 times faster then the S waves (with larger amplitudes and much more destructive potential, due to the medium particles movement, perpendicular to the wave ray propagation). Up to now – only Japan has fully operative and effective SEWS introduced in operation in 2007. Its efficiency was demonstrated during the M9 earthquake on 11th March, 2011.

All TEWS are based on the time differences between the propagation velocity of the seismic and the tsunami waves. The differences of their velocities are in the range of 102 to 104 of seconds.

During the last years SEWS and TEWS have been on focus in Bulgaria. Many projects related to this issue have been executed. Several very peculiar cases and kinematic models have been developed in two directions:

- The SEWS about two typical cases – Vrancea and Pernik town (M5.8) seismic sources
- The TEWS about a case of the tsunami sources located near the Bulgarian Black Sea coast.
- A combination of TEWS and SEWS kinematic models calculated for Venice.

The kinematic models about seismic and tsunami early warning systems are developed using the standard methodology of the travel times for seismic S and P waves as well as for the tsunamis travel times.

For both types the travel times of the P, S, and S-P seismic waves are calculated. These calculations can be used by the local authorities, decision makers and other responsible institutions (like Civil Defense, Administrations, etc.) for the development of a SEWS providing resilience of the infrastructure and population in case of strong earthquake occurring anywhere.

Several models of the travel times of tsunamis propagation trough the Adriatic Sea have been used. The travel tames from some seismogenic sources in the Black Sea also show the time limitations for the warning issue. Both needed complex hardware for the effective operation. The decision matrix is suggested using all available hardware for the marine hazards observations.

Some practical considerations are presented about the organization of a SEWS and TEWS, using the existing seismic networks or creation the own infrastructure of these early warning systems.

THE STUDY OF WAVE ENERGY DISTRIBUTION AT TSUNAMI WAVE PROPAGATION IN OKHOTSK SEA BASIN

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It is well known that up to 30 September 2006 in Kurile island arc, there was large enough “seismic gap” located in between Bussole and Kruzenshtern straits. The danger of existence of so extensive seismic gap required its intensive study. After performed sea expedition “Kurile-2005”, numerical simulation of possible tsunamigenic earthquakes with hypothetic seismic sources, located in the region of this gap, had changed to that with sources of complicated structure. And these computations gave well preliminary prognosis of earthquake occurring in 2006-2007 (30 September 2006 with M = 7.1, 15 November 2006 with M = 8.3, and 13 January 2007 with M = 8.1) (see, e.g. [1-3]). After realization of three strong earthquakes, two of which were tsunamigenic ones, with localization of sources in south-eastern part of “seismic gap”, most dangerous, in present time, is a right part of “seismic gap”. In addition, since Bussole anf Kruzenshtern straits can be considered as secondary sources, generating wave field in Okhotsk Sea basin, then it is interesting to consider local sources with the same length placed before Bussole strait as well as Kruzenshern one. In such case, to obtain sharp directivity diagram from such sources, processes of wave generation by each source are considered independently. The wave energy distribution in Okhotsk Sea basin was estimated with using of amplitude spectrum, which permit to estimate amplification or damping of wave field in any point. To realize given study, the wavelet-analysis was also performed. Numerical simulation of generation of tsunami by two independent sources had permitted to make detailed estimations on wave energy distribution in Okhotsk Sea basin and estimate possible catastrophic consequences from earthquake with localization of the source directly in right part of “seismic gap” in the Central Kuriles.

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NUMERICAL SIMULATION OF A SUBMARINE LANDSLIDE AND TSUNAMI GENERATION AT THE ROCKALL TROUGH, NE ATLANTIC

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Submarine failures of large volumes constitute the major tsunamigenic source in the Atlantic Ocean giving rise to hazardous events of large magnitude. A high-resolution multibeam mapping of the seabed offshore Ireland has revealed evidence of a large submarine failure on the eastern flank of the Rockall Bank, in the NE Atlantic. The Rockall Bank Slide Complex (RBSC), also referred to as the Rockall Bank Mass Flow in the past, spreads over a large area on the seabed of the Rockall Trough. Based on a generous and conservative approach for the reconstruction of the pre-slide space morphology, the volume of the missing sediments was calculated between 265 and 765km^3, respectively. The excessively large volumes of the landslide deposits have raised questions for the tsunamigenic potential of the landslide in the area and the subsequent effect of a landslide tsunami on the northwest coast of Ireland.

As a result, numerical simulations of the underwater landslide are performed in order to understand the magnitude of the geohazard it might pose. In this study, the landslide movement is modelled for the first hours of the motion which are often considered to be the most critical for tsunami generation. The sliding material is computed as a solid block moving over the slope. The tsunami wave generation and propagation in the ocean is modelled with the use of a nonlinear shallow water equation solver, VOLNA. The numerical model uses a finite volume scheme and can accurately reconstruct the complete life cycle of a tsunami. The study also aims to highlight the uncertainty that underpins geophysical processes and the importance of the landslide characteristics for the tsunami wave generation.

CHALLENGES FOR FORECASTING SIZE AND TIME FOR FUTURE GREAT EARTHQUAKES IN SUBDUCTION ZONES

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The 2004 Sumatra-Andaman earthquake (M 9.1) and the 2011 Tohoku earthquake (M 9.0) were surprises to seismologists, because giant earthquakes occurred in unexpected locations. Such giant earthquakes are infrequent, hence a global perspective is important. The maximum size of subduction-zone earthquakes was once considered to be related to the age of subducting plate and plate convergence rate, but recent studies do not seem to support a simple relationship. Any subduction zone in the world may produce an M~9 giant earthquake. Matsuzawa (2014, J. Disaster Res.) recently proposed that we should prepare for an M~10 earthquake, while the maximum size of an earthquake on the earth could be M~11.

Estimation of probable maximum earthquake size is needed to assess earthquake and tsunami hazard and risks, as well as tsunami warning at the initial stage. The Japan Meteorological Agency, following the lessons from the 2011 tsunami, introduced a new initial warning based on the possible maximum earthquake size if growing earthquake size in the first few minutes is observed.

The Earthquake Research Committee of the Japanese government has made long-term forecast of large earthquakes. On the basis of earthquake recurrence (M~7.5 earthquakes with average interval of 37 years) off Miyagi prefecture, near the epicenter of the 2011 Tohoku earthquake, the ERC estimated the probability of a great (M~8) earthquake occurring between 2010 and 2040 was 99 %. The long-term forecast failed to predict the size (M) of the Tohoku earthquake.

The ERC recently revised the long-term forecast for the Nankai and Sagami troughs. For the Nankai trough, while the 30 year probability (60–70 %) is similar to the previous estimate, they noted the size can be M 8 to 9, considering the maximum area of seismogenic zone and variability of past earthquakes. For the Sagami trough, the earthquake size may be M 7.9 to 8.6, but the 30 year probability is 0–50 %. The Central Disaster Management Council assumed an M 9.1 event for the Nankai trough but an M~7 earthquake for the Sagami trough for assessments of earthquake and tsunami damage. The Nuclear Regulation Authority assigned probable maximum earthquake magnitude of 9.6 for the Nankai trough.

SPECIAL SESSION

FINDING PEOPLE IN NATURAL DISASTERS

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When disasters (like earthquakes, hurricanes or tsunamis) hit populated areas, members of the affected communities often offer themselves to help in the field. While they may not have the necessary knowledge to provide first aid to victims in every situation, these volunteers know the geography and have a better sense of which people are missing. They can be valuable actors in emergency operations, providing immediate response and collecting information useful to other stakeholders, like civil defence efforts. They can report changes in the field, which people need help, etc. In areas that become isolated, local volunteers are sometimes the primary emergency responders for extended periods of time.

However, at those sites in the immediate aftermath of events, accurate information about the location and status of potential victims is often hard to collect, even for locals. Moreover, the communication infrastructure fails or is overloaded, hindering the dissemination of information, amongst volunteers, victims and volunteers and volunteers and professional rescuers. Technology, that could play a major role here, is crippled and tools that empower local volunteers are still uncommon.

We propose FIND (Finding Inaccessible people in Natural Disasters), a system that tackles the challenge of providing a source of actionable information to volunteer responders. It comprehends four main components. A smartphone application automatically gathers location and aliveness activity information from people's smartphones, which then tries to disseminate in a peer-to-peer, ad-hoc network. This network requires no infrastructure, relying solely in availability of neighbouring smartphones. Still, provided the adequate conditions, quite possible in the aforementioned scenarios, it provides the means to disseminate the information through very large areas. A second component, a tablet application, provides a visualization map where volunteers can directly track the data provided by the victims' smartphones. Besides the location, it shows aggregation and history of the victims' aliveness data thus informing the volunteers about the people's conditions in his/her vicinity. This component uses the same peer-to-peer, ad-hoc network, but it extends it by actively searching for any available infrastructured network. Upon success it uploads data to the third component, a server, which functions as a central repository, managing the data collected from all victims' smartphones and all volunteers' tablets. The last component is a web application, also providing a larger visualization map, which allows rescuers to access the server's data, thus allowing them to coordinate actions over the real information gathered in different locations.

Two studies have been conducted to preliminarily validate the solution. The first assesses the comprehension that users may have of the mapping tool. The second evaluates the efficiency of the tablet tool in rescuing operations, particularly considering the decisions people make when faced with the aliveness data.

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NEW PROCEDURE FOR PROBABILISTIC TSUNAMI HAZARD ASSESSMENT FROM INCOMPLETE AND UNCERTAIN DATA. AN APPLICATION TO THE MEDITERRANEAN REGION

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A new procedure for probabilistic tsunami hazard and risk assessment is proposed. The new approach is capable of utilizing palaeo, historical (largest only) and instrumentally recorded (“complete”) tsunami catalogues. The key tsunami distribution parameters including the coastline characteristic, maximum possible tsunami intensity or equivalently, the maximum runup are estimated through the application of the maximum likelihood method. The procedure is applied to a tsunami catalogue of the whole Mediterranean region, as well as to selected tsunamigenic zones of the region and in particular the Hellenic Arc and Trench system where the extreme, devastating earthquakes/tsunamis of AD 365 (M~8.3) and 1303 (M~8) respectively ruptured the western and eastern segments of the Arc.

STUDY ON DEVELOPMENT OF AN EVALUATION METHOD FOR CITY ENERGY RESILIENCE IN JAPAN

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After the Great East Japan Earthquake in 2011, developing or redeveloping cities for resilience, such as reducing damage from natural disasters and creating self-sustaining energy systems, has become an urgent issue. Moreover, the damage caused by climate change, such as floods, landslides triggered by heavy rain, and health hazards from heat waves, becomes obvious. In 2013, the Japanese government set up the Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry and the Fundamental Plan for National Resilience. In this way, there is a pressing need to establish the environmental resilience policy to cope with the environmental risks caused by anthropogenic climate change and large-scale natural disasters. This presentation focuses on the energy resilience for cities.

What is "energy resilience?" It could be said that it is the ability of a city's energy system to cope with the various risks associated with climate change and natural disasters. The measures taken by the energy sector for energy resilience can be divided into 3 categories: 1) Precaution, 2) Adaptation, and 3) Transformation. The Precaution measures are to strengthen the energy network in the city. The Adaptation measures are to quickly recover the system after it has been damaged. Finally, the Transformation measures are to convert the network to a decentralized system.

We developed and set up three indicators to evaluate a city's energy resilience measures. The first is "resilience value," the cost at which damages could be averted from systematic risks by implementing the resilience measure. The second is "CO_2 emission reductions," the amount of CO_2 emissions reduced by implementing the resilience measure. The third is "amount of capital investment for resilience," the amount of capital investment to develop or re-develop the resilience measure. We then estimated each resilience measure (Prevention, Adaptation, and Transformation) for Nagoya with the three energy resilience indicators, using the data from The Great East Japan Earthquake.

The result was that, more so than Prevention and Adaptation, Transformation results in a lower cost along with greater emission reductions, making it the most valid of the three measures. Specifically, transforming the energy system from a centralized to a decentralized one (transformation to distributed energy system) is important not only for mitigation, but also for adaptation. It could also be said that Transformation is one of the measures for building national resilience in the energy sector.

Further, we are going to develop an energy resilience policy skill enhancement program for energy resilience, which will support municipal energy policy to show the evaluation through resilience indicators and attempt a feasibility study of resilience measures for the municipality. This study was supported by The Environment Research and Technology Development Fund (1-1304) of the Ministry of the Environment, Japan.

TSUNAMI WARNING IN COMPLEX TECTONIC ENVIRONMENTS: POSSIBLE STRATEGIES FOR THE EASTERN HELLENIC ARC

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The development of suitable strategies for tsunami early warning in the different world oceans and basins has become one of the most important and active topics in tsunami research after the 2004 Boxing Day tsunami, and received further impulse after the 11 March 2011 Tohoku-Oki event. Through the years, researchers realized that simple tools as the Decision Matrixes (DMs), which are presently implemented in several decision support systems, cannot completely account for the numerous variables involved in tsunami generation in different tectonic and geomorphological environments. For a given earthquake magnitude, the focal mechanism and the rupture history, including the final slip distribution, of the parent earthquake play a key role in the possible tsunami generation and in the ensuing tsunami propagation. The Mediterranean Sea provides an excellent example of a basin where tools more sophisticated than the simple DMs might be developed and included in the warning system architecture. These tools must cope with the very different tsunamigenic sources that are found in the Mediterranean, with the different styles of faulting that several tectonically active regions can exhibit, and with the fact that sources are usually placed very close to the coastlines, hence reducing the time within which the tsunami warning system must react. We move from the experience matured by our team in the frame of the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-East Atlantic, the Mediterranean and connected seas (ICG/NEAMTWS), of the completed EU-funded projects DEWS, TRIDEC and NearToWarn and of the ongoing EU FP7 project called ASTARTE (Grant 603839, 7th FP, l ENV.2013.6.4-3), to illustrate some theoretical examples of tsunamis generated by earthquakes taking place along the eastern sector of the Hellenic Arc, that is the portion ranging from southern Crete to Rhodes and south-western Turkey. Starting from few different reference magnitudes and hypocentral locations, we compute the static deformation produced by different faulting styles for the same earthquake (strike-slip, thrust, normal faulting). From the vertical component of the seafloor deformation, taken to coincide with the tsunami initial condition, we simulate numerically the ensuing tsunami, producing fields of maximum water elevation along the coasts of Crete, Rhodes and other major islands found along the eastern Hellenic Arc. Our main goal is to

stress the importance of a timely determination of the faulting style, for example by means of the presently installed GPS networks of Greece and Turkey, to assess properly the tsunamigenic potential of the earthquake and hence to enhance the efficiency and reliability of the tsunami warning systems today under implementation in the eastern Mediterranean region.

SPECIAL SESSION

A COMPREHENSIVE GUIDELINE ON PSYCHOSOCIAL SUPPORT BEFORE, DURING AND AFTER CRISIS: A RESULT FROM THE EU-PROJECT OPSIC

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Disasters (e.g. airplane accidents, earthquakes, flooding and terrorist attacks) have the potential of seriously affecting entire populations as well as nations. This might result in long-term psychosocial consequences for the most vulnerable groups in the population as well as for the helpers. Therefore, it is vital to gain a quick overview on requirements for prevention and intervention before, during and after disasters in order to provide best possible support.

There are already large numbers of excellent guidelines on psychosocial support in disasters. One main intention of the EU-project *Operationalising Psychosocial Support In Crisis* (OPSIC) (funded by the European Union Seventh Framework Programme) was directed at merging this knowledge on psychosocial support in disasters and crises into one comprehensive guideline. The main aim was not to create an additional guideline, but to filter the main recommendations on psychosocial support and to interlink existing guidelines for practical use.

The construction of the comprehensive guideline included various steps. After searching and mapping European and International guidelines on psychosocial support, main recommendations were extracted from these guidelines. The main recommendations in these guidelines provided the basis for the comprehensive guideline. Additionally, best practice examples (Amsterdam Medical Centre) and a meta-analysis on the long-term effect of psychosocial support after disaster (University of Zagreb) complemented the comprehensive guideline. The comprehensive guideline covers important aspects of psychosocial support before, during and after crisis and takes ethical, cultural and gender aspects into account. Different levels (policy, deliverable design and practice), as well as disaster phases, target groups and types of disasters were included in the guideline.

In our talk we will give a short and practically oriented overview of recommendations for each phase of the disaster on the level of intervention design and/or practice.

The comprehensive guideline was constructed by the University of Innsbruck, the University of Zagreb and the Amsterdam Medical Center in close collaboration with the other OPSIC partners (DRC, TNO, IMPACT, MDA, TRIPITCH, SAMUR, CRISMART). More information on the OPSIC project can be found on the website http://opsic.eu/.

SPATIAL AND TEMPORAL DISTRIBUTION OF ELEVATION, CURRENT, FLOW DEPTH AND FLUXES BY TSUNAMI

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Better assessment of the effects of marine hazards needs to clearly identify the motion of water during inundation. The main parameters of the wave motion at the shallow and inundation areas are water elevation, current velocities and fluxes. This study is focused on the spatial and temporal change of these parameters at coastal areas under the long wave action. As for the case studies, different coastal towns at Southwest of Anatolia are selected. The selected towns are Gulluk bay, Bodrum peninsula, Fethiye, Marmaris and Antalya.

The numerical model NAMI DANCE, which is developed for the simulation and visualization of tsunamis and long waves is used as the computational tool. The code has the capability of solving nonlinear form of shallow water equations with friction in nested domains. The model computes time histories of all necessary main parameters of long wave (distributions of water level, current velocities, flow depth, discharge and momentum fluxes, inundation length and height) in the study area.

For each site the inundation maps due to selected tsunami events are developed. The spatial and temporal distributions of water elevations, current velocities, discharge and momentum fluxes are plotted, compared and discussed in regard to hazard analysis. Addition to these, resilience of the marine facilities and possible ways of reducing the effects of tsunami waves are also discussed.

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IMPACT DAMAGE SCENARIOS FOR ALTERNATIVE DECISION MAKING THROUGH THE USE OF CRISMA TOOL

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CRISMA project (Modelling crisis management for improved action and preparedness. EU FP7 Security Integration Project, 2012-2015) focuses on large scale crisis scenarios with immediate and extended human, structural, societal and economic impacts.

The aim is to provide a framework of methodologies and tools to support decision making either at national level, either when the extent of the crisis requires multi-organisational and multi-national cooperation, including humanitarian aid.

The simulation-based decision support system shall facilitate simulation and modelling of realistic crisis scenarios, possible response actions, and the impacts of crisis depending on both external factors driving the crisis development and various actions of the emergency management process. Reference crisis scenarios and selected timelines for a wide range of pilot cases (electricity outage in the far north of Finland, coastal submersion in France, accidental chemical pollution, earthquake and forest fire in Italy, Mass Casualty Incident in Germany) are stored in a repository accessible through the CRISMA platform allowing different kind of simulations to be performed also for resource management training purposes.

In particular, the Italy use case is referred to the 2009 seismic crisis in L'Aquila, with 309 victims, more than 1,500 injured and more than 10 billion euro of estimated damages on buildings and infrastructure. Reference scenarios also include possible cascading effects, thus allowing a dynamic representation of hazard scenarios that can be varied through the selection of different "crisis paths" on a given event timeline, also involving alternative decision making choices. Scenarios can be compared in terms of expected impacts (on people, buildings and infrastructure), thus allowing an assessment of alternative long term planning or short term response strategies.

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