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Tsunami
Awareness, Mitigation and Warning in the Eastern Mediterranean:
Achievements, Requirements and Challenges

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Boğaziçi University
İstanbul - TURKEY

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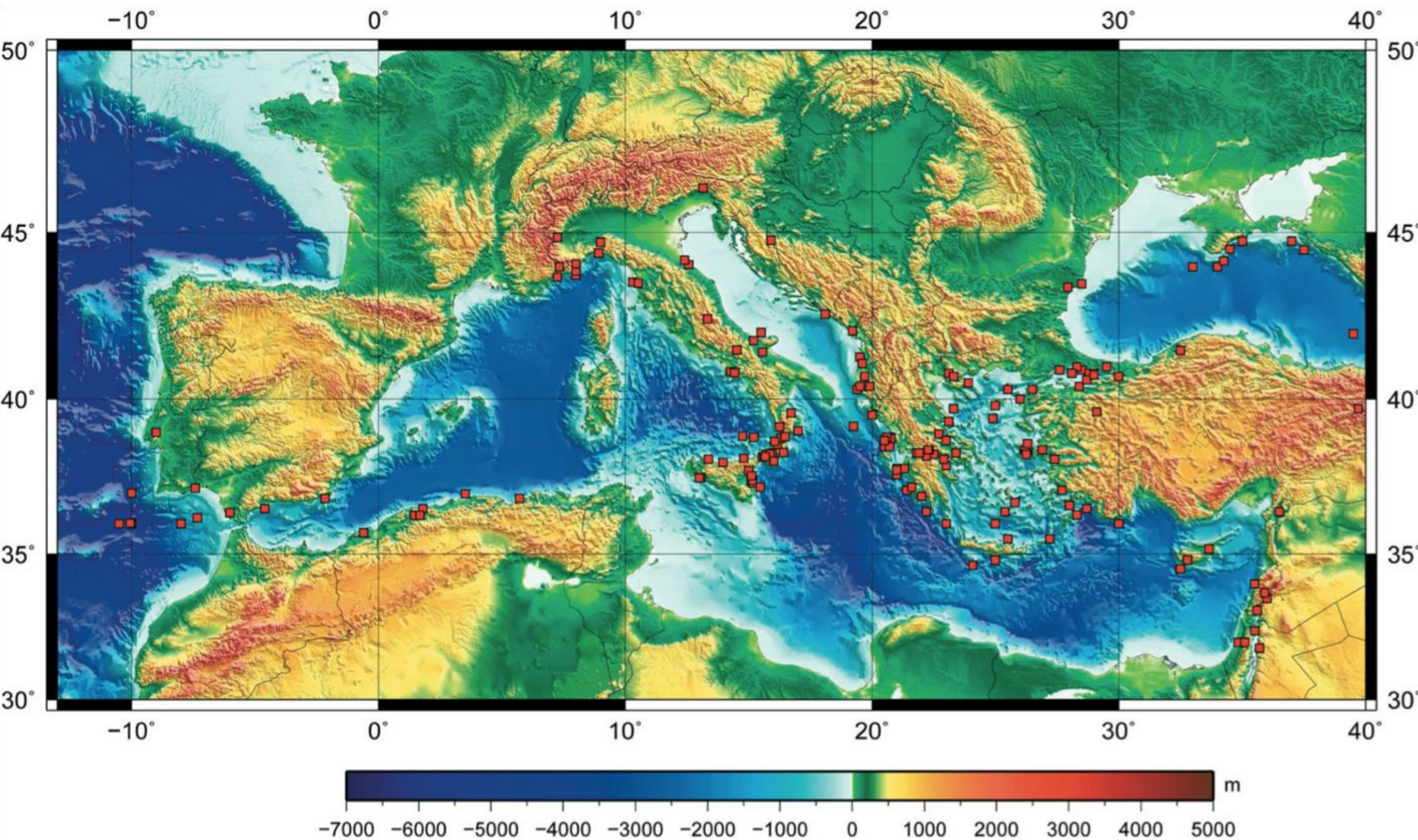
The past is the key for the present...



365 Crete

5.000-10.000 EQ+TS

1202 Syria

>30.000 EQ+TS

1303 Crete

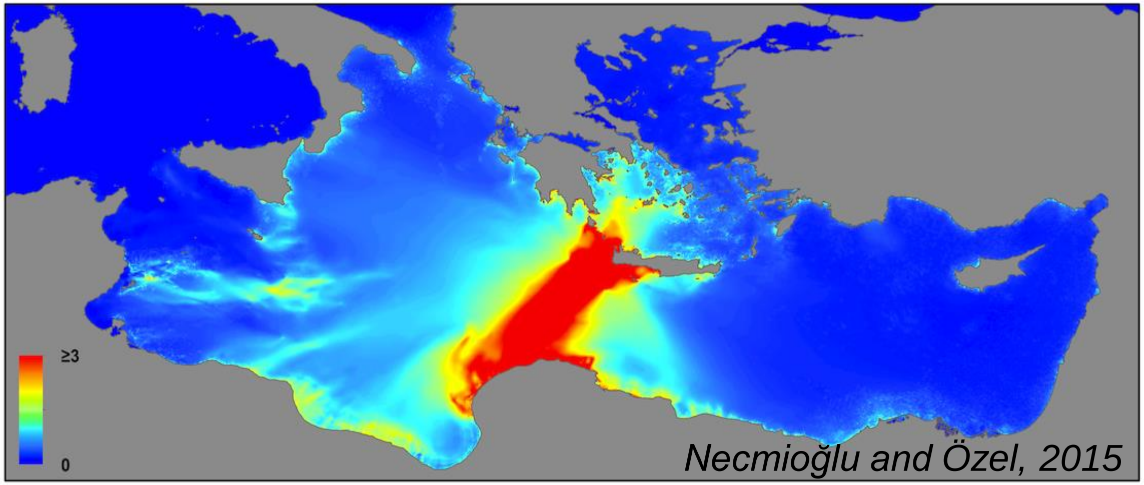
Thousands EQ+TS

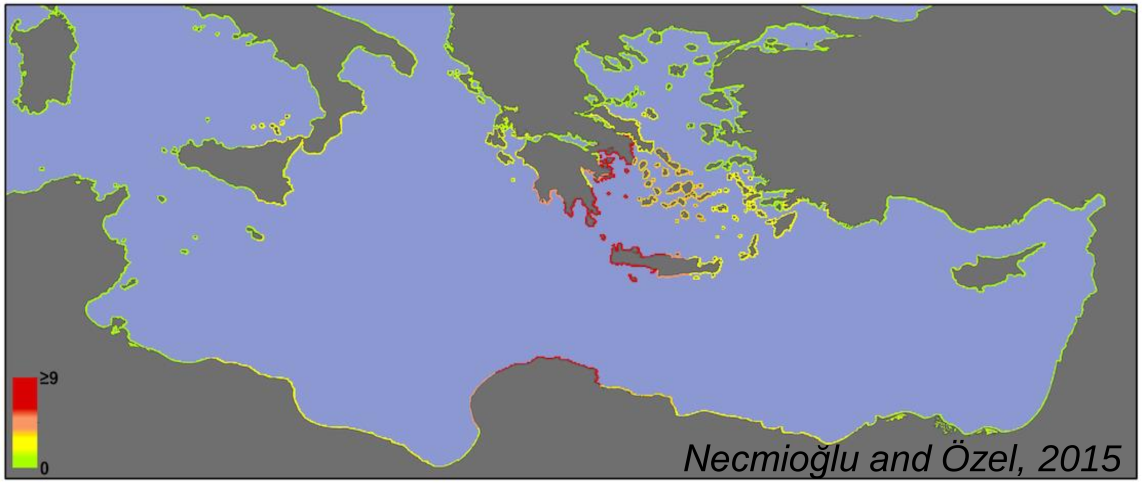
1755 Lisbon

40.000-50.000 EQ+TS

Distribution of tsunamis in the southern European Region, covering the period from 1600 BP to 2006. The most important tsunamigenic regions are in the Gulf of Cadiz, north of Algeria, southern Italy, along the Hellenic Arc, with its eastern continuation involving Cyprus and Marmara Sea. (Stefano Tinti, 2009).

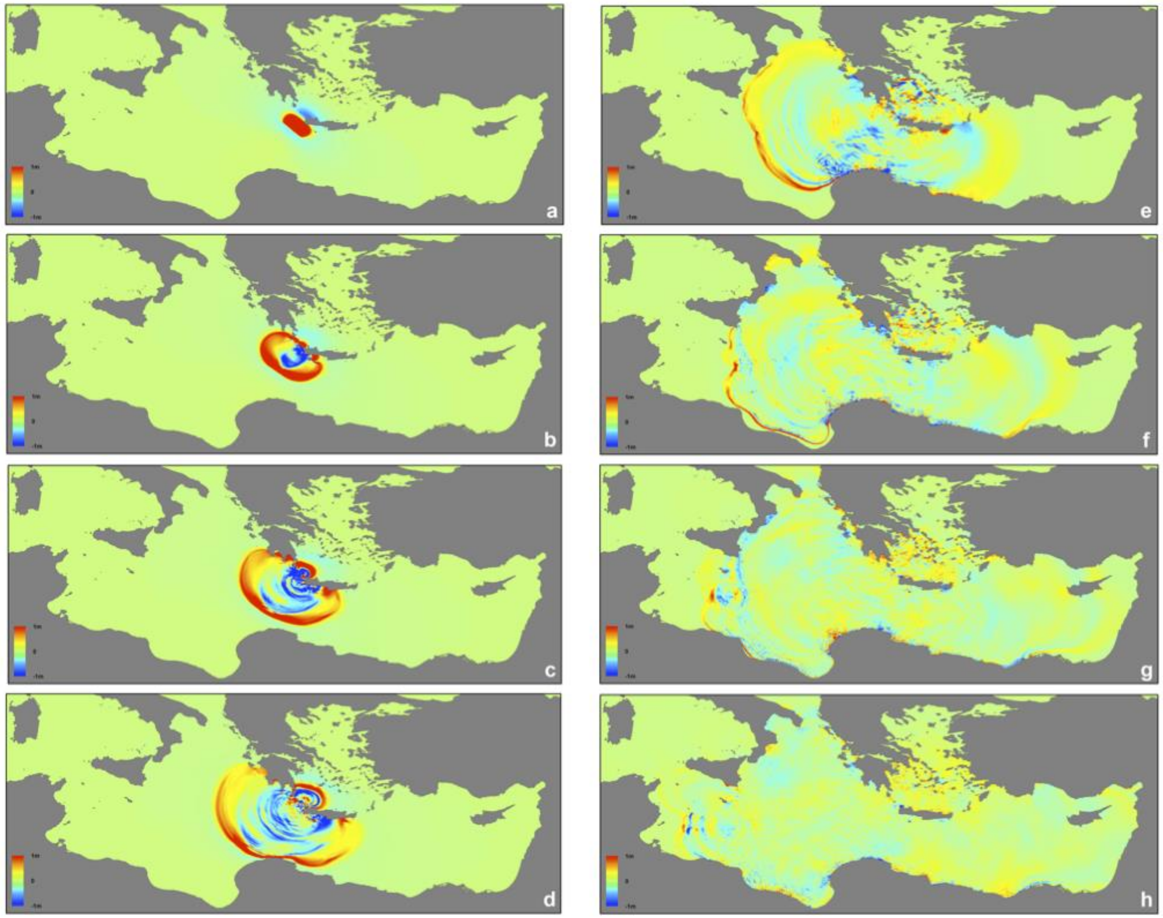
365 AD Earthquake





Mw 8.4, strike 315, dip 35, rake 90, depth 27.3km, L 120 km, W 77 km, and slip 16.7m

365 AD Earthquake



Necmioğlu and Özel, 2015

Mw 8.4, strike 315, dip 35, rake 90, depth 27.3km, L 120 km, W 77 km, and slip 16.7m

365 AD Earthquake

*…**a significant event in the Hellenic Arc affecting a large area in the Eastern Mediterranean** (Ambraseys, 2009).*

*…First the sea was driven back and then huge masses of water flowed back, **shipwrecks were found 2 km off the coastal line on the southwestern shore of Peloponnesus** near Methoni; **tsunami was observed in Asia Minor and the coast of Sicily was flooded** (Soloviev et al., 2000; Altınok et al., 2011).*

*… Shaw et al. (2008) presented evidence from field observations and radiocarbon data that **western Crete was lifted by up to 10m above sea level during the earthquake** and suggested that the earthquake occurred on a fault dipping at around 30° within the overriding plate and not on the subduction interface. Their **tsunami modeling provided open-ocean amplitudes of tsunami waves that are comparable to that of observed and modeled in the open ocean for the Sumatra 2004 tsunami.***

*… Lorito et al. (2008) argued that **up to 5m tsunami wave could be produced by the 365 AD event**.*

The tsunami in 365 AD was so devastating that the anniversary of the disaster was still commemorated annually at the end of the 6th century in Alexandria as a "day of horror".

Tsunami Wave Heights in Eastern Mediterranean

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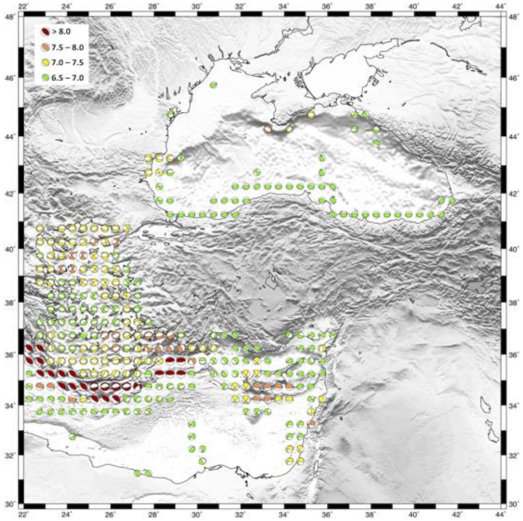

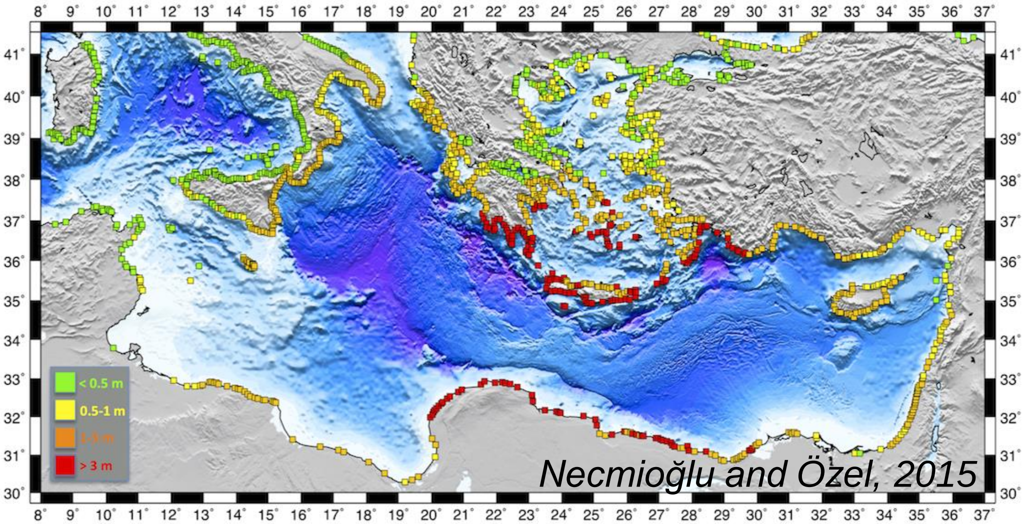

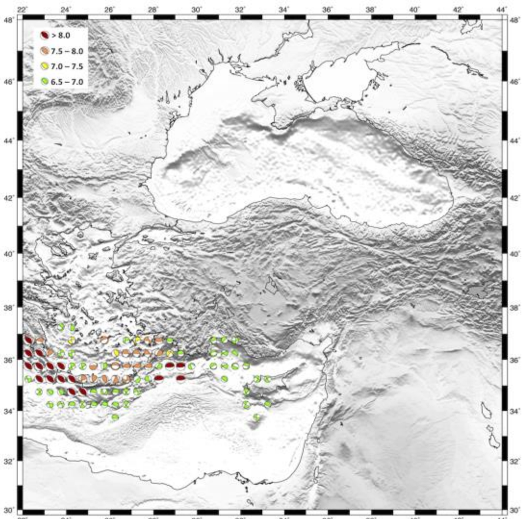

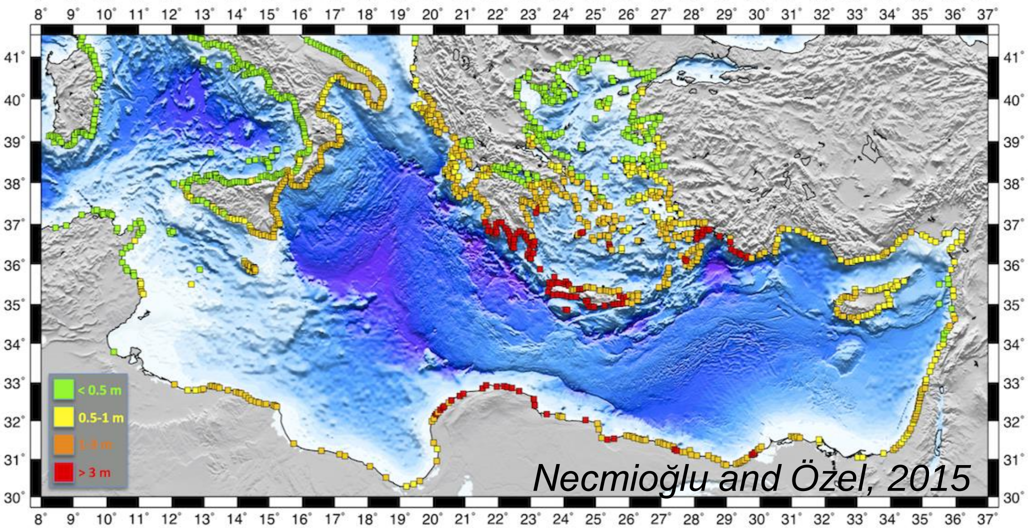

Minimum Mw for 50 cm coastal wave-height

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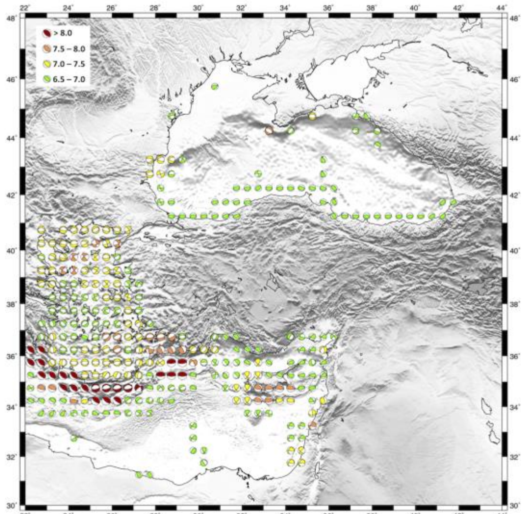

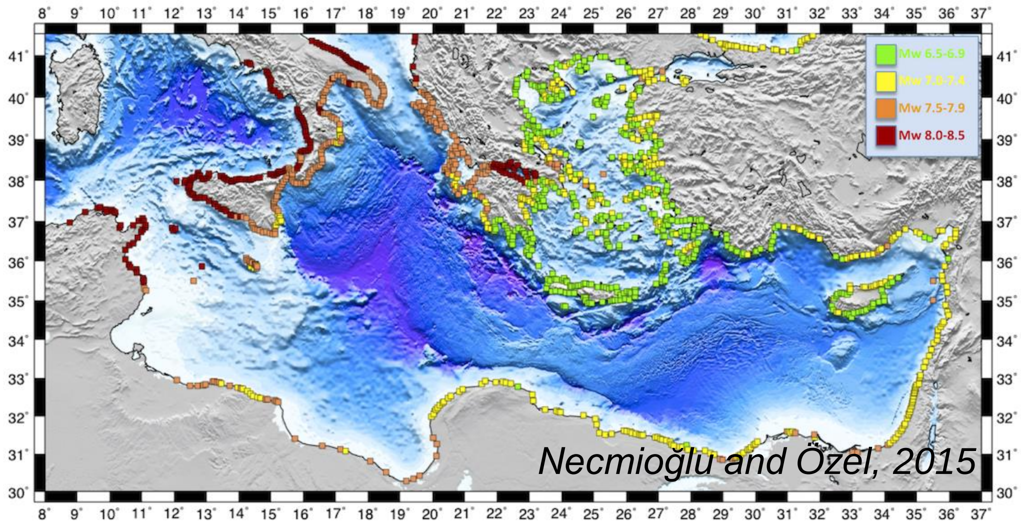

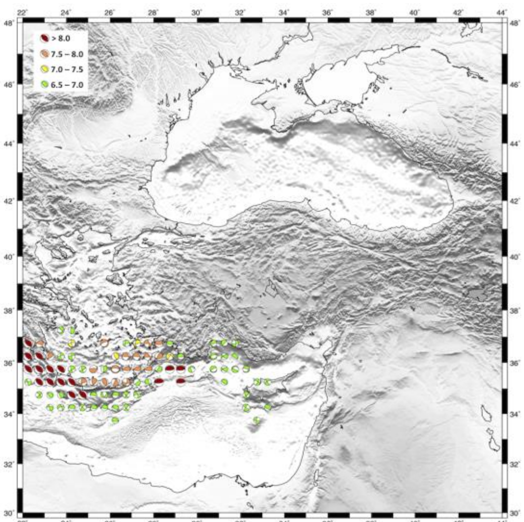

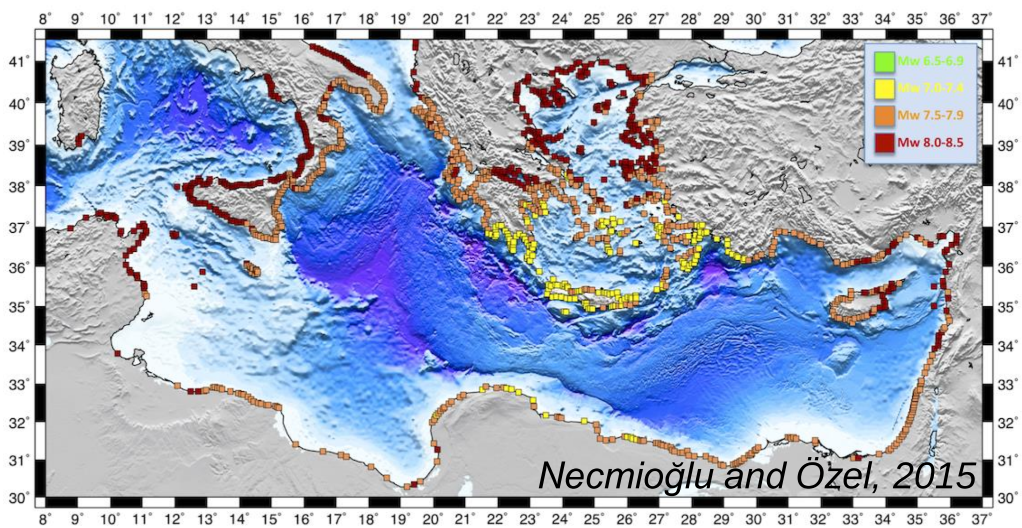

History of NEAMTWS

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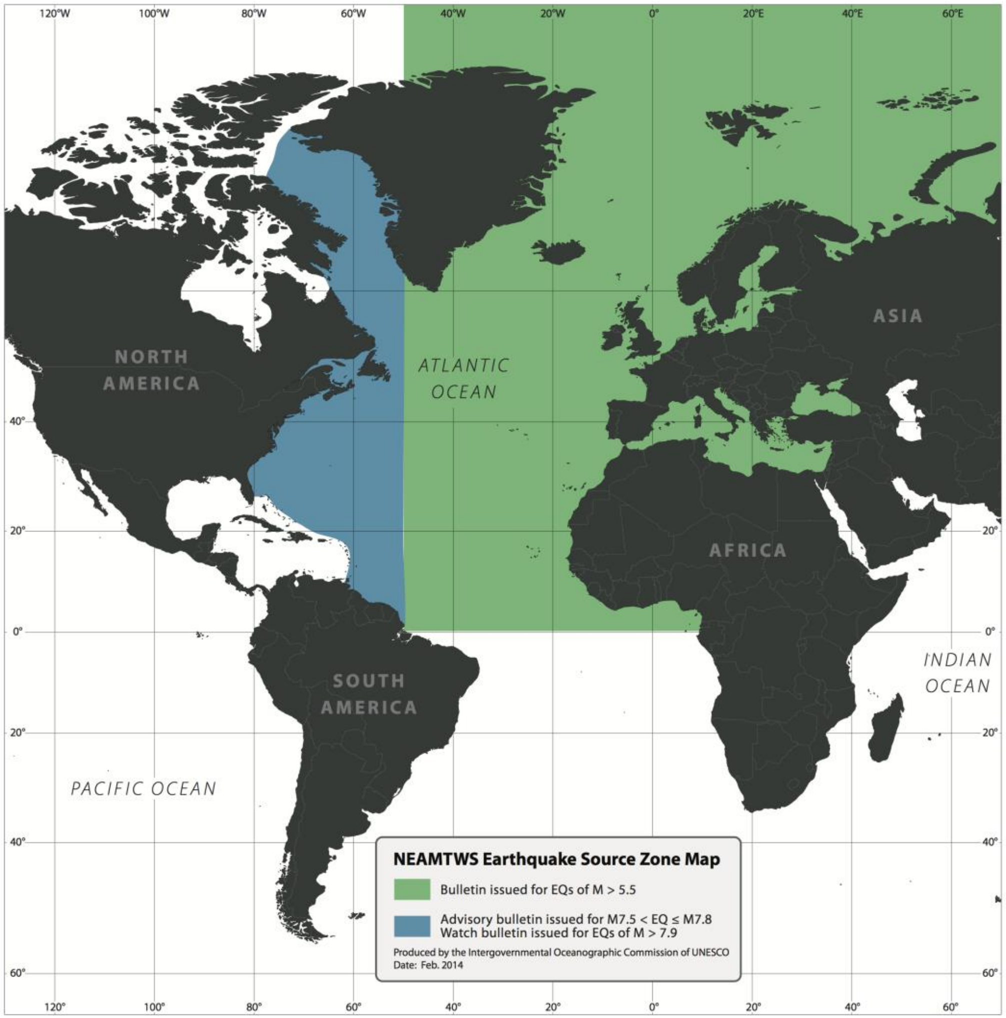
The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG/NEAMTWS) *was formed in response to the tragic tsunami on 26 December 2004, in which over 250,000 lives were lost around the Indian Ocean region.*

The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) received a mandate from the international community to coordinate the establishment of the System during the course of several international and regional meetings, including the World Conference on Disaster Reduction (Kobe, Japan, 18 – 22 January 2005), and the Phuket Ministerial Meeting on Regional Cooperation on Tsunami Early Warning Arrangements (Phuket, Thailand, 28 and 29 January 2005).

The IOC Assembly, during its twenty-third Session (21-30 June 2005), formally established the ICG/NEAMTWS through Resolution IOC-XXIII-14.

Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (NEAMTWS)



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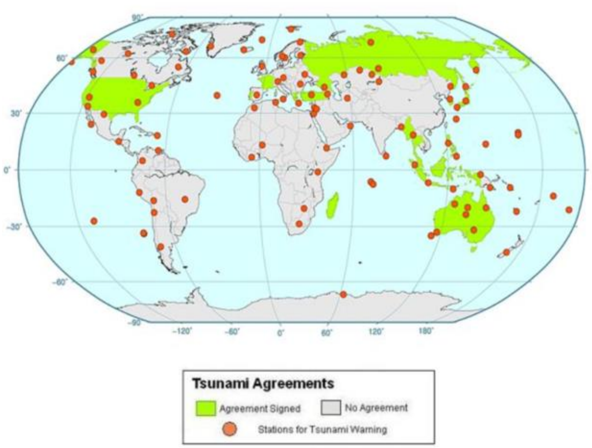
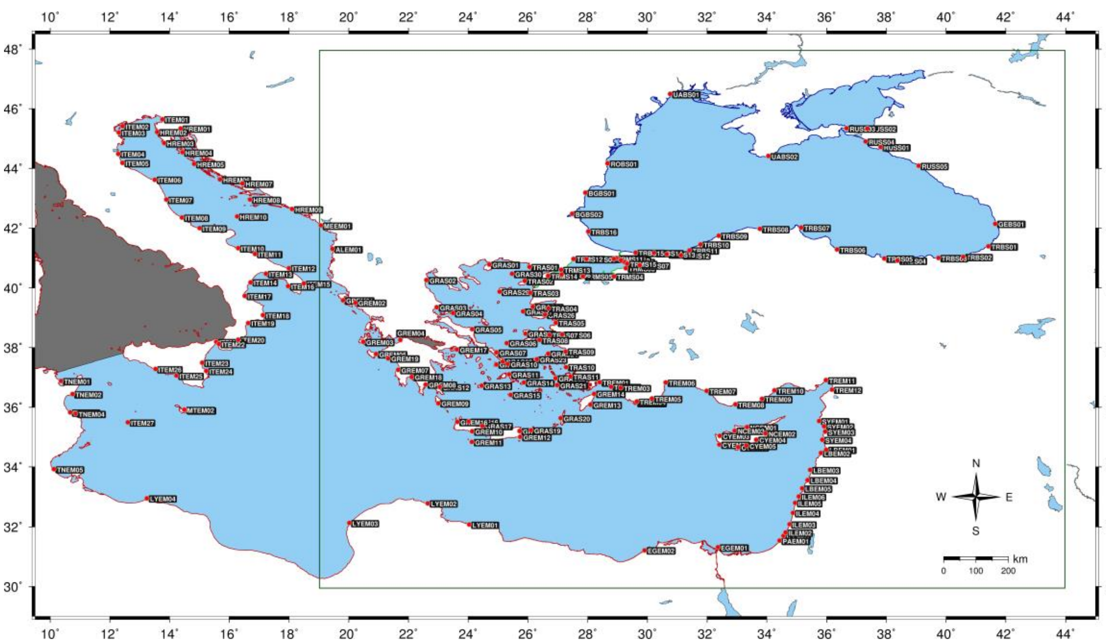
CTBTO PREPARATORY COMMISSION
COMPREHENSIVE NUCLEAR-TEST-BAN TREATY ORGANIZATION

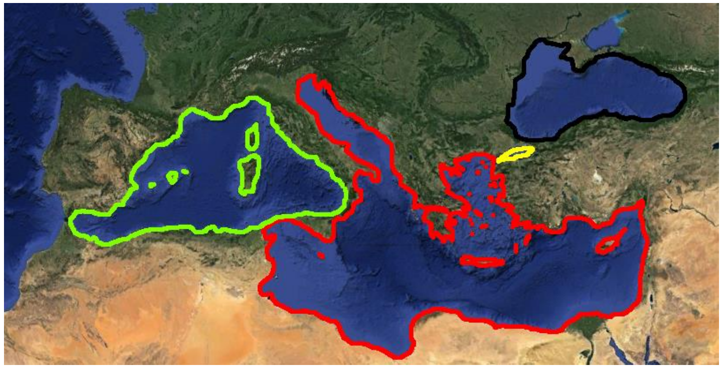


Present Status

TSP-TR is operational since 1 July 2012 under UNESCO/IOC/ICG/NEAMTWS.



The maps and related information presented here do not necessarily reflect the views and position of the United Nations, UNESCO, IOC or any affiliated Member State.

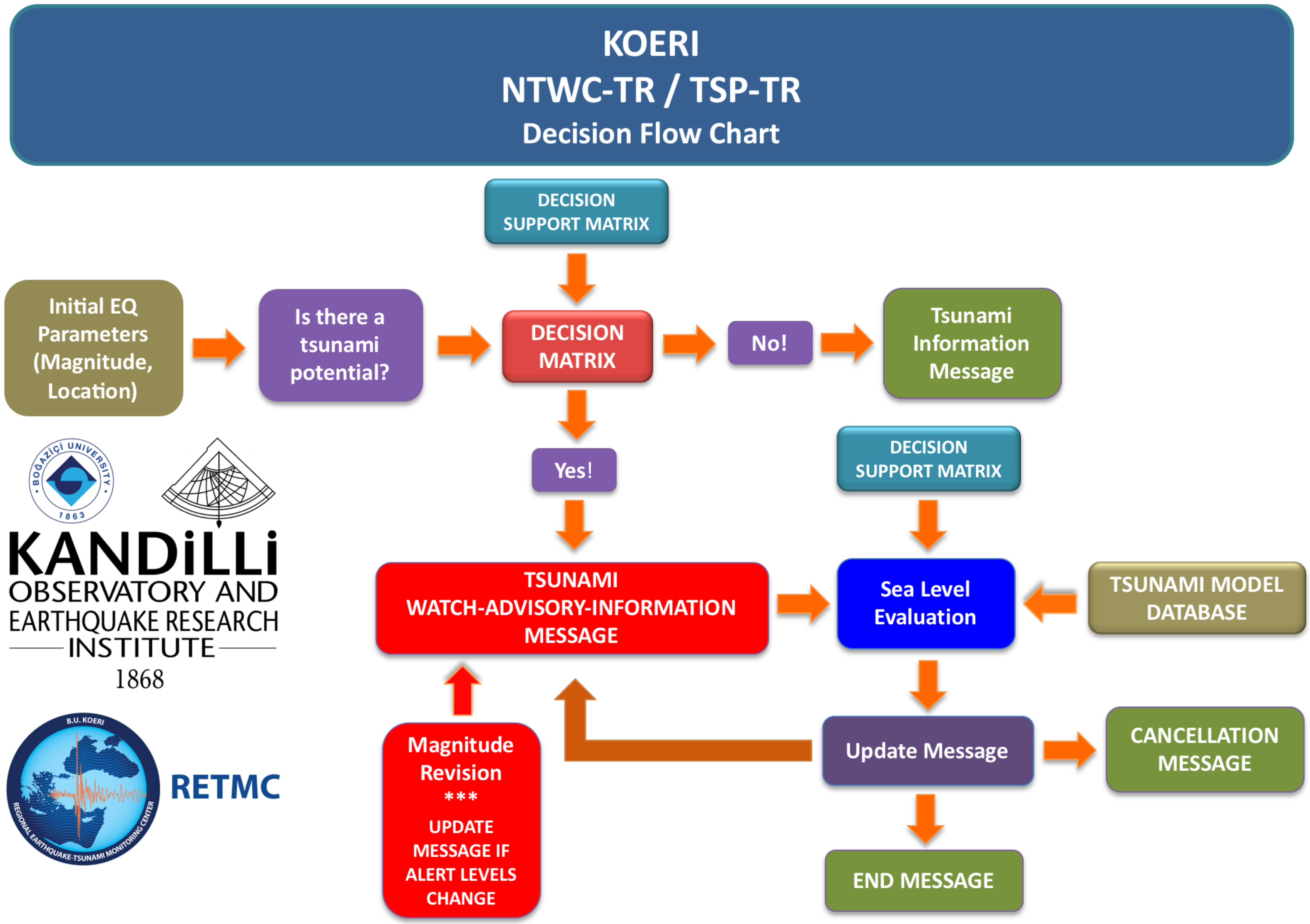


SUBSCRIBERS:

CDH (CYPRUS)
NIOF (EGYPT)
CENALT (FRANCE)
BSH (GERMANY)
DWD (GERMANY)
NOA (GREECE)
PMO (ISRAEL)
INGV (ITALY)
NCGR (LEBANON)
IPMA (PORTUGAL)
NIEP (ROMANIA)
TYPHOON (RUSSIAN FEDERATION)
DGPCE (SPAIN)
CCS (UNITED KINGDOM)
ERCC (EU)
IOC Secretariat

KANDILLI OBSERVATORY AND EARTHQUAKE RESEARCH INSTITUTE 1868 — RETMC → AFAD MINISTRY OF INTERIOR DISASTER AND EMERGENCY MANAGEMENT PRESIDENCY

Operational Concepts – Decision Support System



Operational Concepts – Decision Matrix

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TSP-TR (KOERI)

Decision Matrix for the Eastern Mediterranean, Aegean and Black Seas

Depth (km)	Epicentre Location	Earthquake Magnitude	Tsunami Potential	Type of Tsunami Message		
				Local	Regional	Basin-wide
				< 100 km	≥100 - ≤400	> 400
< 100	Offshore or close to the coast (≤ 40 km inland)	5.5 ≤ mb/Mwp ≤ 5.9	Low tsunami potential	Information	Information	Information
		6.0 ≤ Mwp ≤ 6.4	Tsunami potential	Advisory	Information	Information
	Offshore or close to the coast (≤ 100 km inland)	6.5 ≤ Mwp ≤ 6.9	Potential for a destructive tsunami	Watch	Advisory	Information
		7.0 ≤ Mwp ≤ 7.4	Potential for a destructive tsunami	Watch	Watch	Advisory
		Mwp ≥ 7.5	Potential for a destructive tsunami	Watch	Watch	Watch
	Inland (>40km and < 100km)	5.5 ≤ mb ≤ 5.9	Low tsunami potential	Information	Information	Information
		6.0 ≤ Mwp ≤ 6.4	Low tsunami potential	Information	Information	Information
≥ 100	offshore or inland (≤ 100 km)	Mwp ≥ 5.5	Low tsunami potential	Information	Information	Information

NEAMTWS Decision Support Matrix

Alert Level	Advisory	Watch
Wave Amplitude	0.2-0.5 m	> 0.5 m
Run-up	< 1m	> 1 m
Impact	Current, bore, damage in water; possible minor inundation in beaches	Watch impact + inundation of the low-lying coastal land

Other messages used in the operational context, such as (Regular) Communication Test and Tsunami Exercise Messages are not shown here.

KOERI Daily Operational Set-Up

- Day Shift (8:30-17:30) and Two Night Shift (17:30-01:00 and 01:00-08:30)
- One duty officer shift
- One stand-by Duty Officer per day shift
- One back-up Duty officer per shift
- Total number of Duty Officers: 16 – 5 of them are assigned to night shifts.

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TSUNAMI MESSAGE NUMBER 001
NEAM KOERI TSUNAMI WATCH PROVIDER
ISSUED AT 1056Z 20 SEP 2013

THIS ALERT APPLIES TO ALL COUNTRIES SUBSCRIBED TO THE SERVICES OF KOERI CTWP IN ITS MONITORING AREA.

... TSUNAMI WATCH
THIS ALERT APPLIES TO
EGYPT...GREECE...ISRAEL...LEBANON...LIBYA...PALESTINE...SYRIA...TURKEY

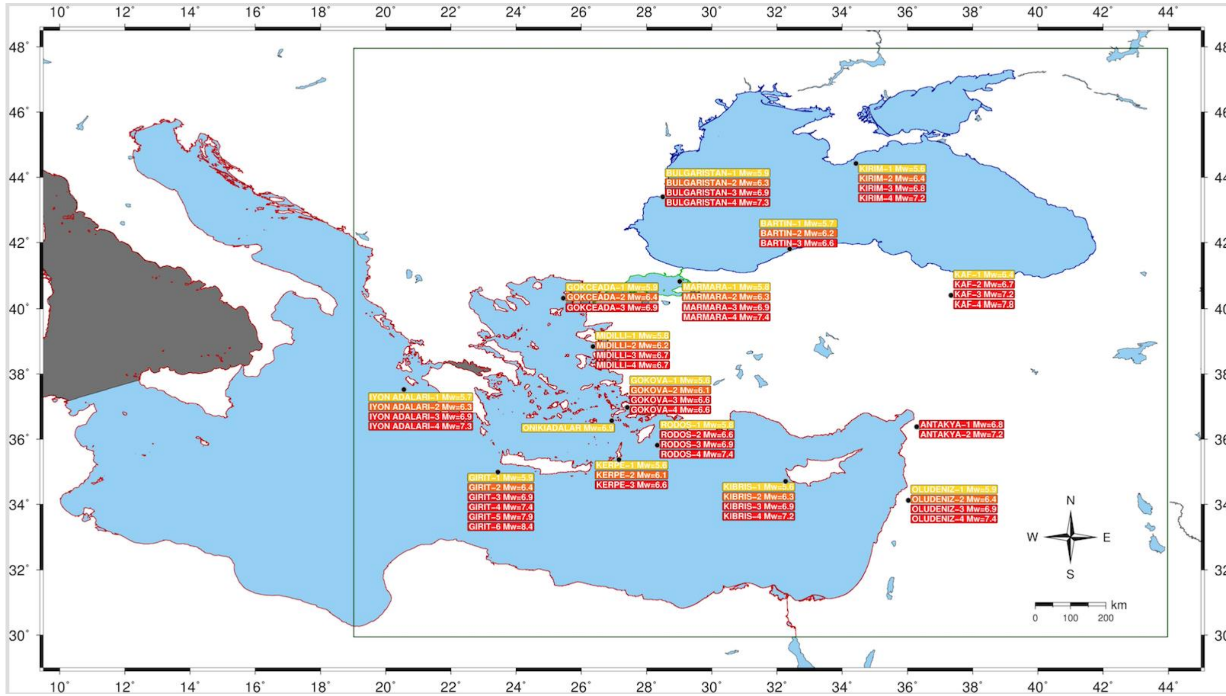
THIS MESSAGE IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

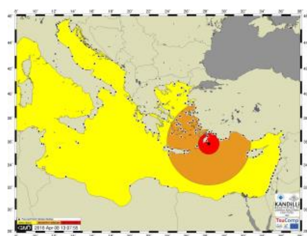
AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS
ORIGIN TIME - 0648 UTC TUE SEP 17 2013
COORDINATES - 37.86 NORTH 26.04 EAST
DEPTH - 10.0
LOCATION - TEST 34-AEGEAN SEA
MAGNITUDE - 7.3

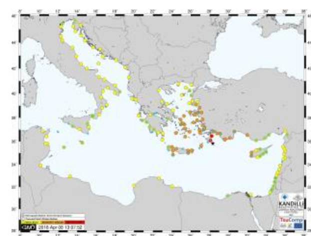
EVALUATION OF TSUNAMI WATCH
IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS MESSAGE IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A TSUNAMI THAT CAN STRIKE COASTLINES WITH A WAVE HEIGHT GREATER THAN 0.5M AND/OR CAUSE A TSUNAMI RUN-UP GREATER THAN 1M. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL DATA FROM GAUGES NEAR THE EARTHQUAKE TO DETERMINE IF A TSUNAMI WAS GENERATED AND ESTIMATE THE SEVERITY OF THE THREAT. A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE LARGEST. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY SIGNIFICANTLY ALONG A COAST DUE TO LOCAL EFFECTS. THE TIME FROM ONE TSUNAMI WAVE TO THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND THE THREAT CAN CONTINUE FOR MANY HOURS AS MULTIPLE WAVES ARRIVE.

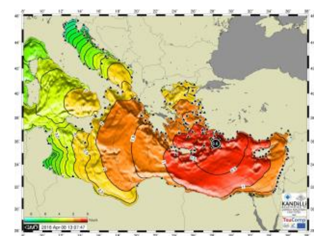
ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS WITHIN THE MONITORING AREA ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION FORECAST POINT	COORDINATES	ARRIVAL TIME	LEVEL
EGYPT-ALEXANDRIA	31.27N 29.94E	0902Z 17 SEP	WATCH
EGYPT-PORT SAID	31.31N 32.36E	1007Z 17 SEP	WATCH
GREECE-IKARIA AGIOS KIRIKO	37.61N 26.30E	0656Z 17 SEP	WATCH
GREECE-KALOGEROI	38.15N 25.29E	0656Z 17 SEP	WATCH
GREECE-CHIOS VOLLISOS	38.47N 25.92E	0700Z 17 SEP	WATCH
GREECE-MIKONOS CHORA	37.45N 25.32E	0703Z 17 SEP	WATCH
GREECE-ANDROS	37.84N 24.94E	0704Z 17 SEP	WATCH
GREECE-TINOS	37.53N 25.16E	0707Z 17 SEP	WATCH
GREECE-SIROS ERMOUPOLI	37.44N 24.95E	0716Z 17 SEP	WATCH
GREECE-KALIMNOS PANORMOS	36.97N 26.93E	0721Z 17 SEP	WATCH
GREECE-AMORGOS KATAPOLA	36.83N 25.86E	0722Z 17 SEP	WATCH
GREECE-LESVOS SIGRI	39.21N 25.84E	0724Z 17 SEP	WATCH
GREECE-EVIA KIMI	38.62N 24.11E	0726Z 17 SEP	WATCH
GREECE-NAXOS CHORA	37.11N 25.37E	0729Z 17 SEP	WATCH
GREECE-KOS KEFALOS	36.74N 26.98E	0733Z 17 SEP	WATCH
GREECE-SANTORINI ORMOS FIRA	36.42N 25.43E	0736Z 17 SEP	WATCH
GREECE-SKIATHOS	39.16N 23.49E	0743Z 17 SEP	WATCH
GREECE-KARPATHOS MESOCHORI	35.64N 27.10E	0744Z 17 SEP	WATCH
GREECE-LESVOS MOLIVOS	39.37N 26.17E	0745Z 17 SEP	WATCH
GREECE-LESVOS MITILINI	39.10N 26.57E	0747Z 17 SEP	WATCH
GREECE-LIMNOS MIRINA	39.87N 25.05E	0750Z 17 SEP	WATCH
GREECE-MILOS ADAMAS	36.72N 24.45E	0753Z 17 SEP	WATCH
GREECE-SITEIA	35.22N 26.11E	0759Z 17 SEP	WATCH
GREECE-RHODOS LINDOS	36.09N 28.09E	0759Z 17 SEP	WATCH
GREECE-AGIOS NIKOLAOS	35.21N 25.72E	0800Z 17 SEP	WATCH
GREECE-MONEMVASIA	36.68N 23.04E	0801Z 17 SEP	WATCH
GREECE-RETHIMNON	35.38N 24.47E	0802Z 17 SEP	WATCH
GREECE-RHODOS TOWN	36.46N 28.21E	0803Z 17 SEP	WATCH
GREECE-SAMOTHRAKI	40.48N 25.47E	0809Z 17 SEP	WATCH
GREECE-IERAPETRA	35.01N 25.74E	0811Z 17 SEP	WATCH
GREECE-KITHERA KAPSALI	36.14N 23.00E	0811Z 17 SEP	WATCH
GREECE-VOLOS	39.35N 22.95E	0814Z 17 SEP	WATCH
GREECE-KASTELORIZO MEGISTI	36.15N 29.59E	0819Z 17 SEP	WATCH
GREECE-GITHEION	36.77N 22.57E	0822Z 17 SEP	WATCH









TsuComp
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NEAMTWS Tsunami Exercises - NEAMWave

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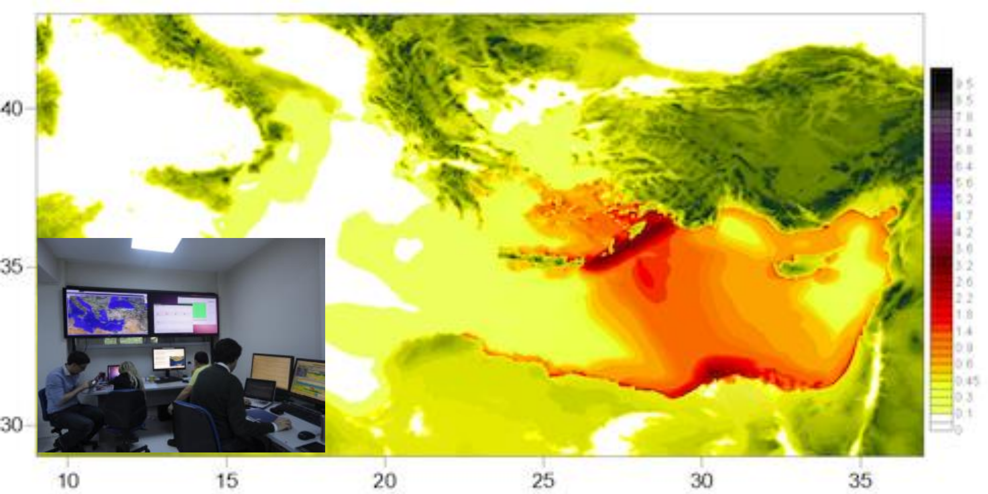
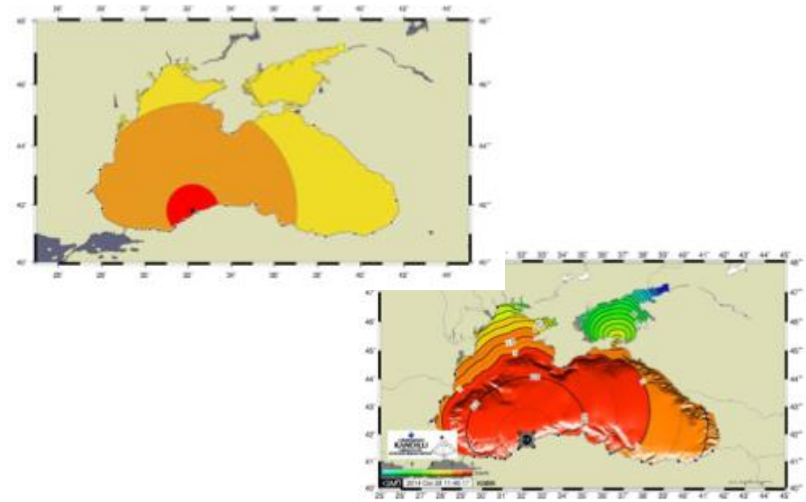
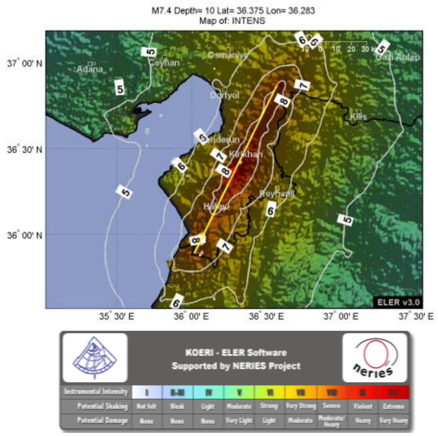
NEAMWave12

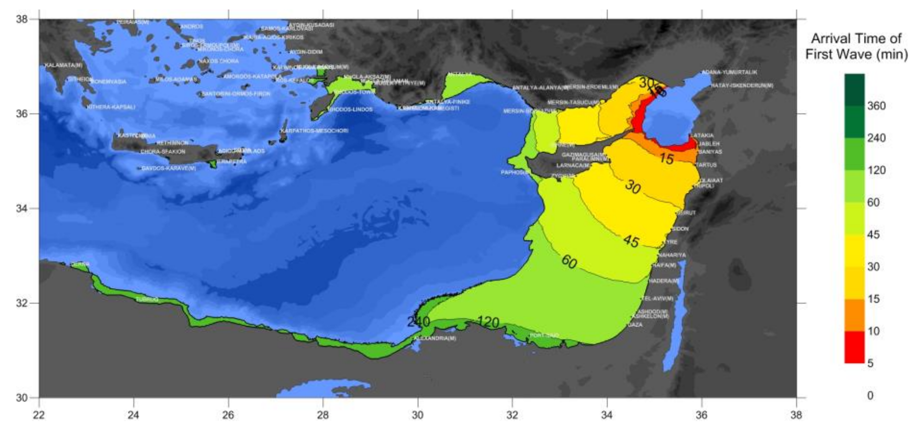


NEAMWave14

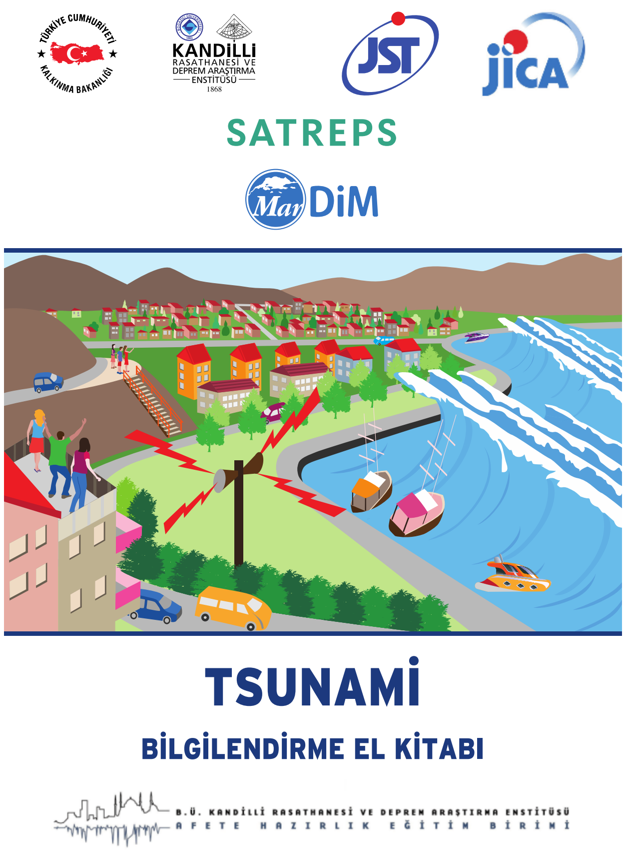


NEAMWave17



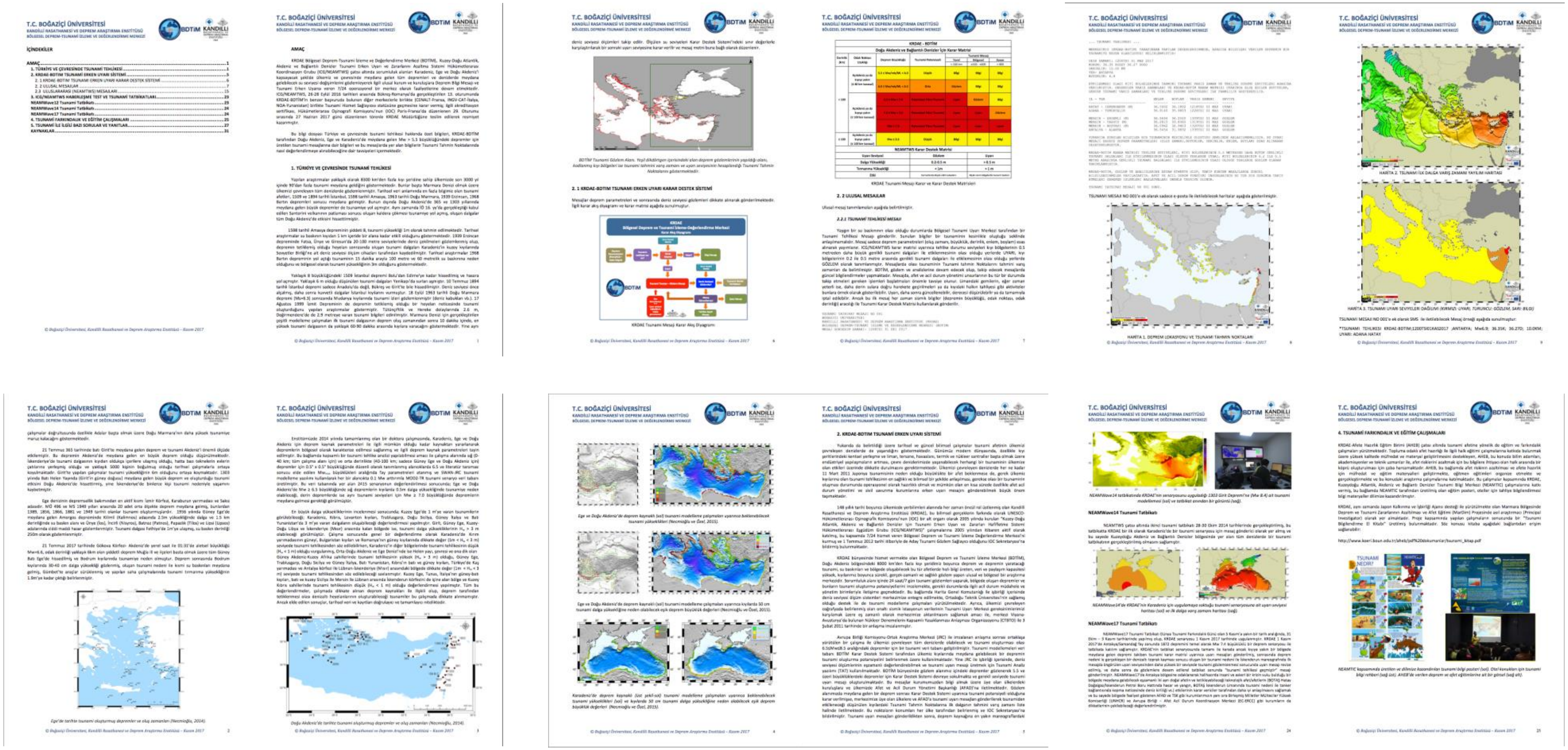


Tsunami Information Booklet



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

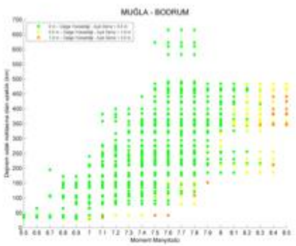
Tsunami Information Note for AFAD

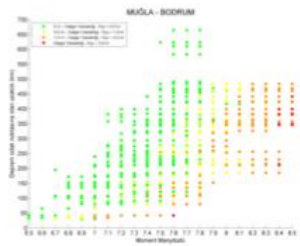


Tsunami Inundation Maps for AFAD

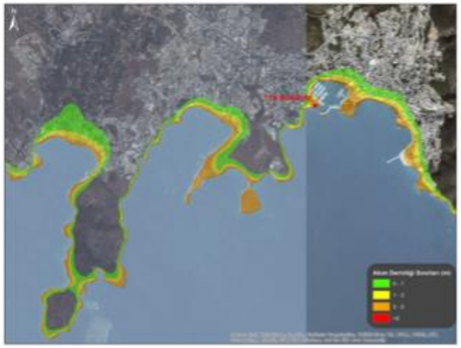
T.C. BOĞAZİÇİ ÜNİVERSİTESİ
KANDİLLİ RASATHANESİ VE DEPREM ARAŞTIRMA ENSTİTÜSÜ
BÖLGESEL DEPREM-TSUNAMİ İZLEME VE DEĞERLENDİRME MERKEZİ

MUĞLA – BODRUM





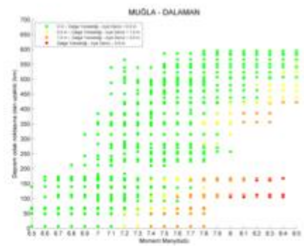
MOD2-TR Tsunami Senaryo veri tabanı uyarınca Ege ve Doğu Akdeniz'de meydana gelebilecek bir deprem için deprem büyüklüğü (Moment Büyüklüğü-Mw) ve depremin Muğla-Bodrum'dan uzaklığına bağlı olarak açık denizde (sol) ve kıyıda (sağ) beklenebilecek tahmini tsunami dalga yükseklikleri. Fethiye için tsunami tehlikesinin Mw > 7 depremler için söz konusu olabileceği düşünülmekle beraber daha küçük depremlerin tetikleyebileceği denizaltı heyelanları nedeni ile yerel tsunamiler oluşabileceği dikkate alınmalıdır.



MOD2-TR Tsunami Senaryo veri tabanında Muğla-Bodrum için en büyük dalga yüksekliği veren deprem senaryosu kullanılarak yapılan tsunami sayısal modellemesi uyarınca, topografik eşyükselti eğrileri esas alınarak hazırlanan en kötü (gerçekleşme olasılığı en düşük) senaryo tsunami baskın haritası. Modelleme çalışmaları 150m çözünürlüklü çalışma alanları kullanılarak yapılmış olup tsunami baskın haritaları 3m çözünürlüklü topografik veri üzerine görsellenmiştir.

T.C. BOĞAZİÇİ ÜNİVERSİTESİ
KANDİLLİ RASATHANESİ VE DEPREM ARAŞTIRMA ENSTİTÜSÜ
BÖLGESEL DEPREM-TSUNAMİ İZLEME VE DEĞERLENDİRME MERKEZİ

MUĞLA – DALAMAN



MOD2-TR Tsunami Senaryo veri tabanı uyarınca Ege ve Doğu Akdeniz'de meydana gelebilecek bir deprem için deprem büyüklüğü (Moment Büyüklüğü-Mw) ve depremin Muğla-Dalaman'dan uzaklığına bağlı olarak açık denizde (sol) ve kıyıda (sağ) beklenebilecek tahmini tsunami dalga yükseklikleri. Fethiye için tsunami tehlikesinin Mw > 7 depremler için söz konusu olabileceği düşünülmekle beraber daha küçük depremlerin tetikleyebileceği denizaltı heyelanları nedeni ile yerel tsunamiler oluşabileceği dikkate alınmalıdır.

MOD2-TR Tsunami Senaryo veri tabanında Muğla-Dalaman için en büyük dalga yüksekliği veren deprem senaryosu kullanılarak yapılan tsunami sayısal modellemesi uyarınca, topografik eşyükselti eğrileri esas alınarak hazırlanan en kötü (gerçekleşme olasılığı en düşük) senaryo tsunami baskın haritası. Modelleme çalışmaları 150m çözünürlüklü çalışma alanları kullanılarak yapılmış olup tsunami baskın haritaları 3m çözünürlüklü topografik veri üzerine görsellenmiştir.

Dr. Ceren Özer Sözdinler

WTAD Activities

Tsunami tehlikesi var mı?

Muhtemel bir İstanbul depreminde tsunami tehlikesinin Haydarpaşa limanı, Bakırköy, Maltepe gibi denize açık kıyıları olan bölgeler ile Bursa ve Yalova kıyıları için söz konusu olabileceği belirtildi

İSTANBUL (AA) - Boğaziçi Üniversitesi Kandilli Rasathanesi ve Deprem Araştırma Enstitüsünde (KRDAE) Müdürü Prof. Dr. Haluk Özener, tarih boyunca Ege, Akdeniz ve Marmara'da gerçekleşen depremlerde tsunamilerin büyük olmadığını belirterek, "Bir deprem sonucu oluşacak tsunamiler hiçbir zaman Japonya'daki gibi büyük olmayacak. 1509 ve 1894 depremleri sonrası bölgede en çok 8 metrelik tsunamiler görüldüğünü biliyoruz." dedi.

Tüm dünyada tsunami konusunda farkındalık oluşturmak için her yıl 5 Kasım'da gerçekleştirilen Dünya Tsunami Farkındalık Günü, KRDAE'de düzenlenen basın toplantısıyla ele alındı.

Toplantıda konuşan Özener, Bölgesel Tsunami Merkezi Akreditasyon Süreci ve tsunami çalışmaları hakkında bilgi verdi.

Marmara bölgesi ve İstanbul için olası depremin sürpriz olmayacağını belirten Özener, şunları kaydetti:

"1999 depremlerinden sonra gözler Marmara bölgesine ve İstanbul'a çevrildi. 1999 depremi biz bilim insanları için nasıl sürpriz değilse, bir sonraki depremin İstanbul'u etkileyeceği de sürpriz değil. Bu konuda birçok çalışma var. Çok bilinmeyenli bir denklemden bahsediyoruz. Bunu keşke çözebilsek, keşke net bir rakam, zaman verebilsek... Maalesef bugünkü teknolojilerle bu mümkün değil. Çok farklı disiplinler arası çalışma yaparak farklı senaryolar üzerine çalışıyoruz. Marmara depremi için bütün bilim insanları olacağını söylüyor. Tarihsel depremler var, bir enerji birikimi var. Olası deprem süresi geciktikçe bunun aletsel büyüklüğü artacak. Ne kadar erken olursa aletsel büyüklüğü de az olacaktır. 10 saniye sonra olacak bir depremin büyüklüğü 7 şiddetinde olacaktır. Bu 10 gün sonra da 10 yıl sonra da olabilir. Biz bilim insanları olarak olası depreme çok hazırlıklıyız."

- "Haydarpaşa Limanı için risk var"

Türkiye için tsunami ihtimalini de değerlendiren Özener, "Tarih boyunca Ege, Akdeniz ve Marmara'da gerçekleşen depremlerde tsunamiler büyük değildi. Bizim bir deprem sonucu oluşacak tsunamiler hiçbir zaman Japonya'daki gibi büyük olmayacak. 1509 ve 1894 depremleri sonrası bölgede en çok 8 metrelik tsunamiler görüldüğünü biliyoruz." dedi.

Orta Doğu Teknik Üniversitesi (ODTÜ) Mühendislik Fakültesi Öğretim Üyesi Prof. Dr. Ahmet Cevher Yalçıner, depremlerde ulaşım yolları zarar göreceği için doğal afetlerde limanların sağlam kalması gerektiğine dikkat çekerek, şöyle konuştu:

"Deprem sonrası küçük tsunamiler de olsa liman çalışamaz hale getirebilir. Limanlarda öncelikli olarak tsunami simülasyonları yapıyoruz. Haydarpaşa limanıyla ilgili yaptığımız çalışmada dalgakıranların yeterli olmadığını ve tsunaminin aşma ihtimali olduğunu gördük. Bununla ilgili hem Japonya'da hem Türkiye'de deneyler yapıldı. Dalgakıranın güçlendirilmesi yoluna gidilmesi gerekiyor."

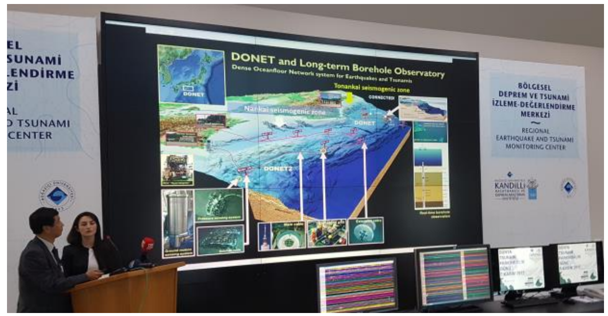
"Türkiye için tsunami için en tehlikeli bölge neresidir?" şeklindeki soru üzerine Yalçıner, "Denizdeki fayların yoğun olduğu bölgeler risklidir. Girit adasının doğusu ve batısı, Girit-Rodos adaları arası. Bu bölgelerin fay hatlarının Türkiye'ye yaklaşan bölgeleri için risk vardır. Marmara için çok yüksek dalga boyları beklenmemektedir." diye konuştu.

- Marmara'da en riskli bölgeler

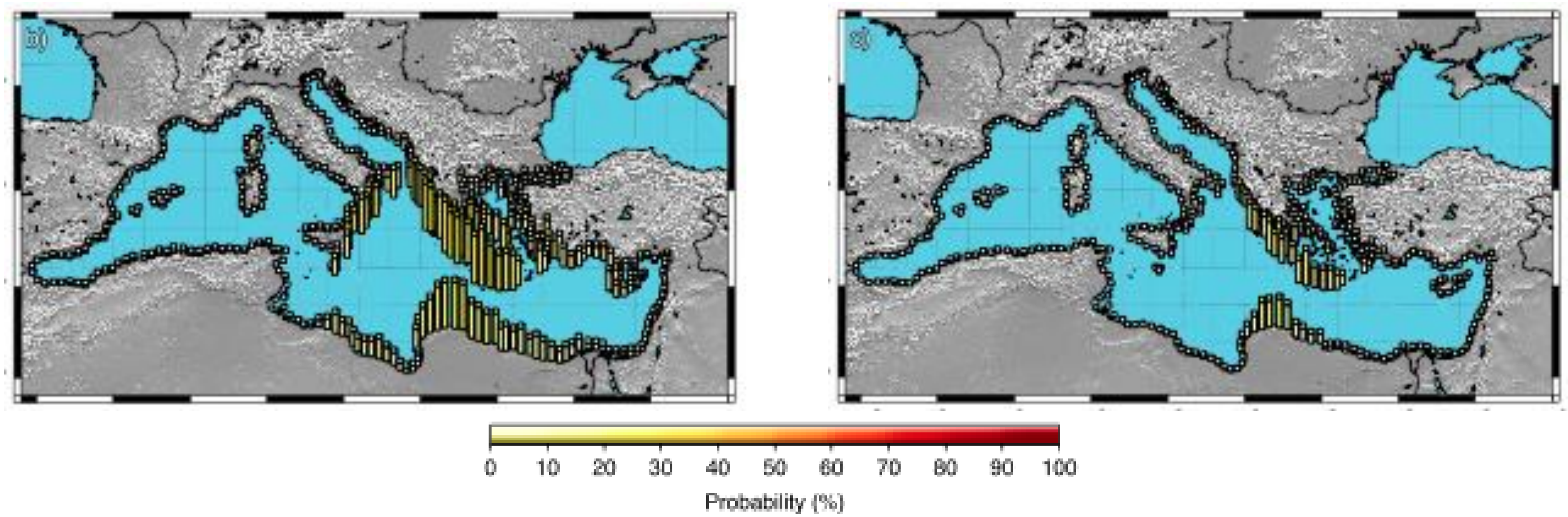
Boğaziçi Üniversitesi Öğretim Görevlisi Dr. Ceren Özer Sözdinler ise Marmara Denizi'nde tsunami için en riskli bölgelerle ilgili bilgi verdi.

Sözdinler, "Marmara için deprem nedeniyle tetiklenen deniz tabanı heyelanlarıdır. Marmara kıyısı ve İstanbul kıyılarında riskli bölgeleri belirledik. Haydarpaşa limanı, Bakırköy, Maltepe gibi denize açık kıyıları olan bölgeler ile Bursa ve Yalova kıyılarını riskli görüyoruz. Başımıza gelebilecek en kötü senaryolar üzerine çalışıyoruz." ifadelerini kullandı.

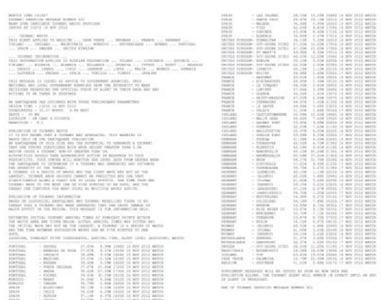
Toplantıya Japonya Uluslararası İşbirliği Ajansından Ko Goto, Kagawa Üniversitesinden Yoshuyuki Kaneda ve Japon Deniz-Yer Bilimleri ve Teknoloji Ajansından Takane Hori de katıldı.



Probability of a tsunami in the Mediterranean…



… the probability of a tsunami wave exceeding 1 m somewhere in the Mediterranean in the next 30 years is close to 100%. This underlines the urgent need for a tsunami warning system in the region (Sorensen et. al, 2012)



?

20 July 2017 Bodrum-Kos Mw 6.6 Earthquake

Turkey–Greece border in the Mediterranean Sea ruptured to a strong earthquake on July 20, 2017 at 22:31:11 UTC according to the USGS.

The epicenter was at 36.929° N and 27.414° E located 12 km to Kos in Greece and 13 km to Bodrum in Turkey.

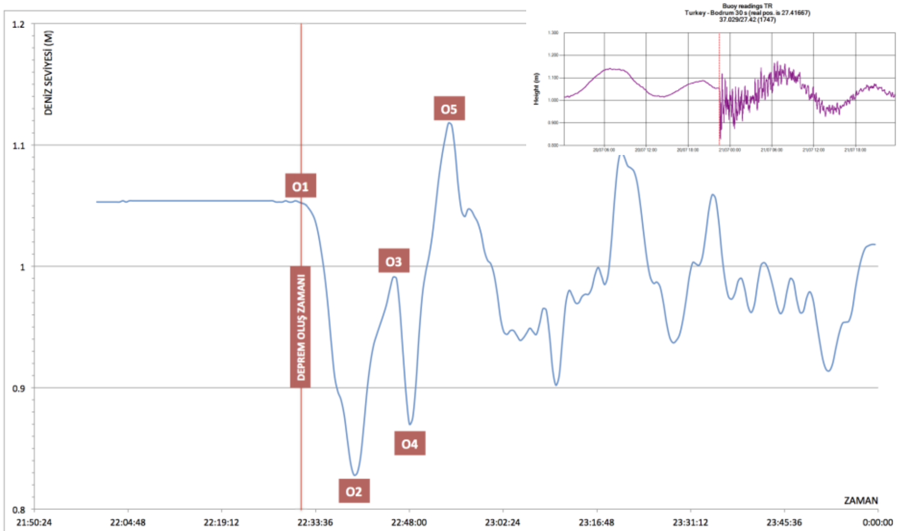
This earthquake, registering a moment magnitude (Mw) of 6.6, occurred at the depth of 7 km.

Two deaths were reported following the earthquake along with around 500 injured.

The earthquake received intense local/regional media attention as it occurred in a touristic place where many tourists, mainly from Europe, were spending their summer vacation.

Earthquake Impact

Bodrum Mareograph Readings



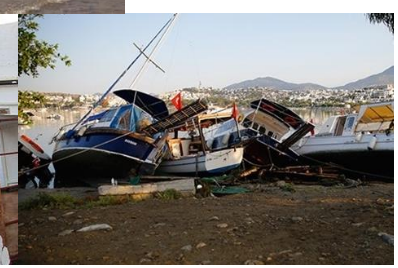
	VALUE OBSERVED (M)	ARRIVAL TIME
1. Reading (O1)	1,05	22:31
2. Reading (O2)	0,83	22:39
3. Reading (O3)	0,99	22:45
4. Reading (O4)	0,87	22:48
5. Reading (O5)	1,12	22:54
Max-Min (O5-O2)	0,29	
Wave Height [(Max-Min)/2]	0,15	22:54
Period (tO5-tO3)	9	22:54



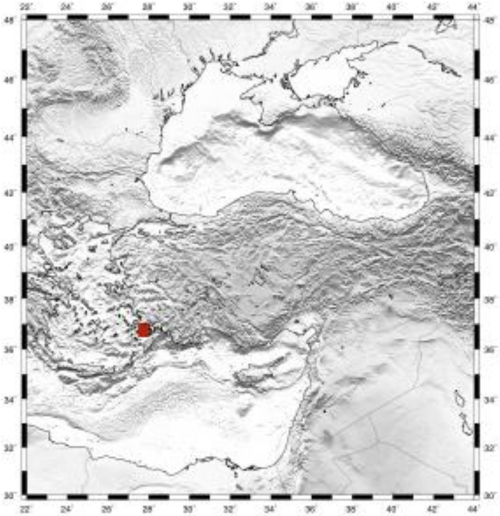
Dogan et al., 2019

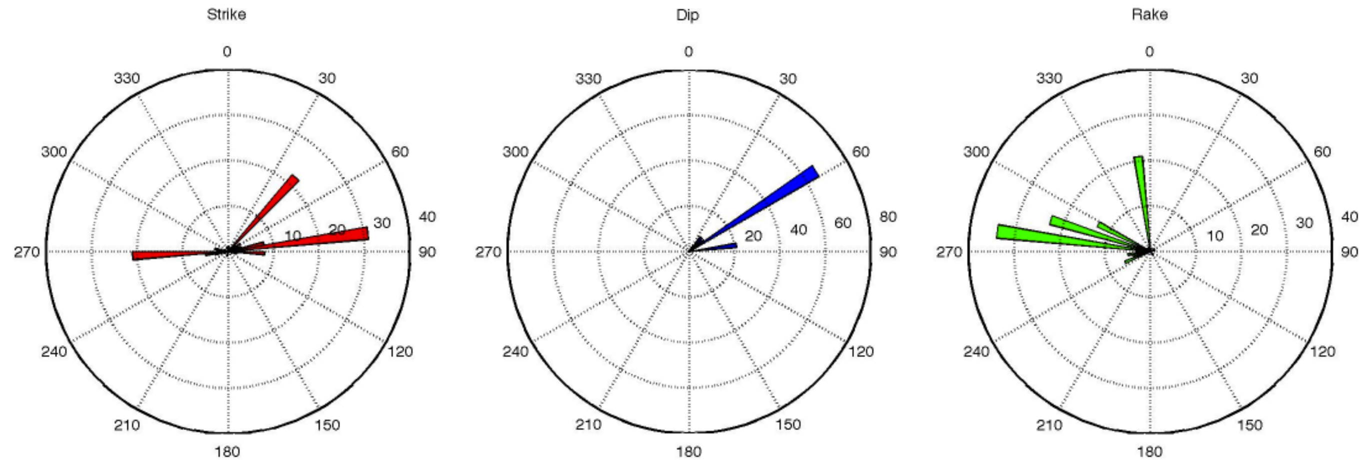






It could have been worst…





Mw(max) 7.1 L=84 km W=15 km S=2m D=10 km (Necmioglu O., 2014; Necmioglu and Ozel, 2015)

TFP	ID	Lon	Lat	HmaxCoarse	DepthCoarse	EPILat	EPILon	EPIDepth	Mag	Distance	Hmax(GL)
Bodrum	33273	27,420834	37,020832	0,09	46,00	36,75	27,25	5	6,5	34	0,23
Bodrum	33273	27,420834	37,020832	0,14	46,00	36,75	27,25	5	6,6	34	0,36
Bodrum	33273	27,420834	37,020832	0,20	46,00	36,75	27,25	5	6,7	34	0,52
Bodrum	33273	27,420834	37,020832	0,26	46,00	36,75	27,25	5	6,8	34	0,68
Bodrum	33273	27,420834	37,020832	0,36	46,00	36,75	27,25	5	6,9	34	0,94
Bodrum	33273	27,420834	37,020832	0,51	46,00	36,75	27,25	5	7	34	1,33
Bodrum	33273	27,420834	37,020832	1,02	46,00	36,75	27,25	5	7,1	34	2,66

It could have been worst…

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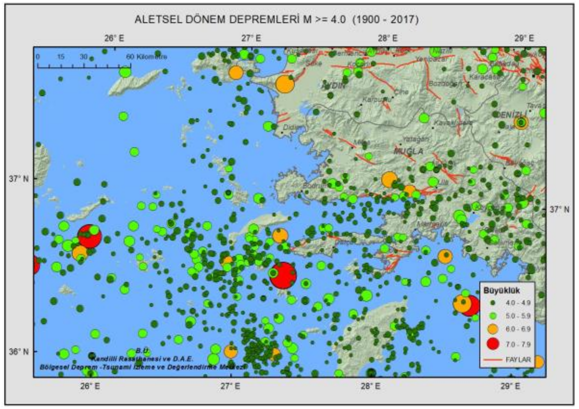
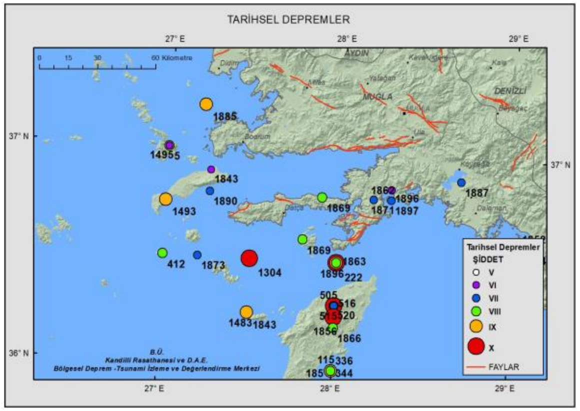
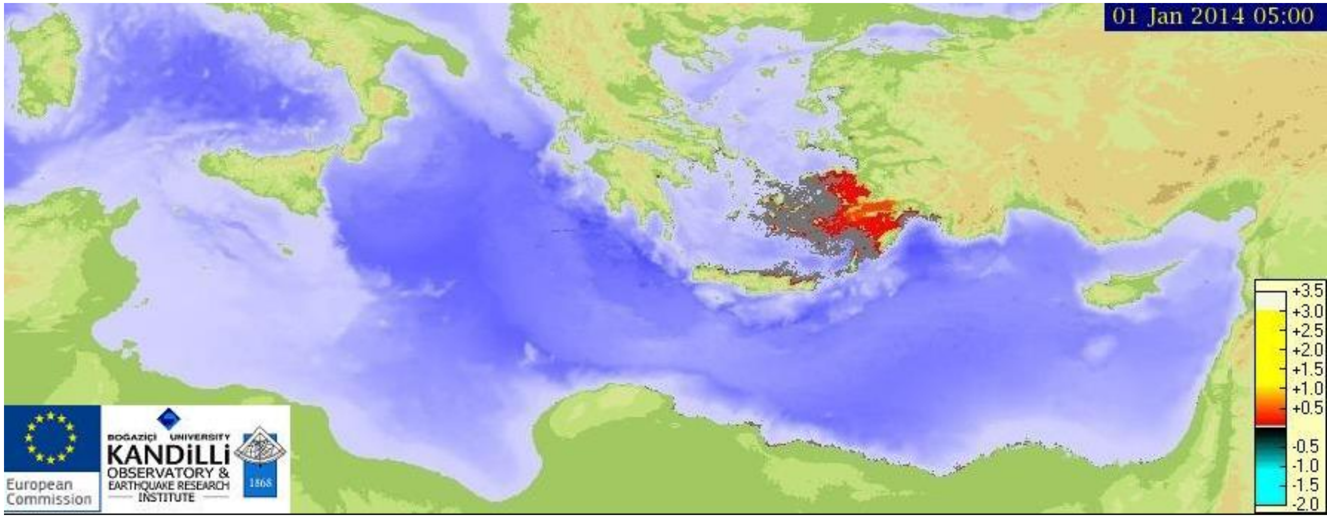


Simulated maximum tsunami wave heights for the closest Mw 6.6 (top) and Mw 7.1 (bottom) earthquakes (Necmioglu, O., 2014)

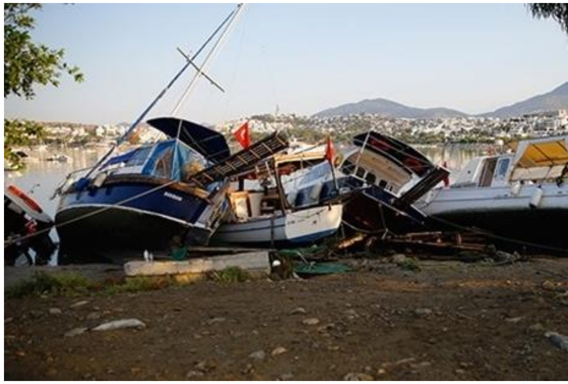




TSP Performance

	CAT-INGV	KOERI-RETMC	NOA/HL-NTWC	EMSC	USGS
Origin time (UTC)	22:31	22:31	22:31	22:31:11	22:31:11
Magnitude	Mw 6.8	Mw 6.6	ML 6.4[a]	Mw 6.6[b]	Mw 6.6
Depth (km)	10	11	10	2	7
Lat (°N)	36.90	36.96	36.95[c]	36.96	36.929[e]
Lon (°E)	27.46E	27.51	27.42[d]	27.45	27.414

Various TSPs within ICG/NEAMTWS	CAT-INGV	KOERI-RETMC	NOA/HL-NTWC
WATCH Message time (h: min, UTC)	22:41	22:50	22:49
Time interval after the origin time (min)	10	19	18
ONGOING message time (h: min, UTC)	01:02	23:32	01:53
END message time (h: min, UTC)	01:46	01:30	02:37



Boundary Conditions of Near-Field Tsunami Warning

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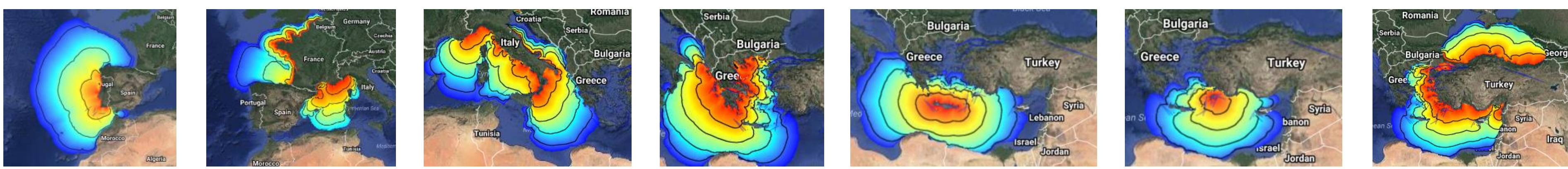
$$T_{\mathrm{TR}} > t_{\mathrm{SD}} + t_{\mathrm{TD}} + t_{\mathrm{ST}} + t_{\mathrm{WT}} + t_{\mathrm{EV}}$$

< 3 min

t_{SD}	time needed for the determination of the earthquake focal parameters
t_{TD}	time needed for the tsunami decision-making
t_{ST}	time needed for the transmission of the earthquake information and of the result of tsunami decision to the operational center of the civil protection
t_{WT}	time needed to transmit warning information from the civil protection to the population
t_{EV}	time to respond for real evacuation

Effective Warning ∝ $t_{WT} + t_{EV}$

Papadopoulos and Fokaefs (2013)



NearToWarn

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Prototype Local Tsunami Warning System in Bodrum

Necmioğlu *Earth, Planets and Space* (2016) 68:13
DOI 10.1186/s40623-016-0388-2

Earth, Planets and Space
a SpringerOpen Journal

TECHNICAL REPORT Open Access

Design and challenges for a tsunami early warning system in the Marmara Sea

Öcal Necmioğlu

BODRUM PROTOTYPE TSUNAMI EARLY WARNING SYSTEM

SGM-SL MULTI-HAZARD INTEGRATED OBSERVATION SYSTEM

EW PARAMETERS DERIVED FROM SGM DATA

↓

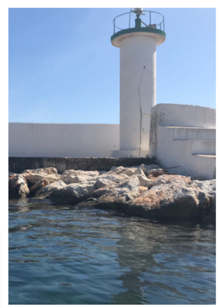
TSUNAMI ALERT ABOVE A THRESHOLD

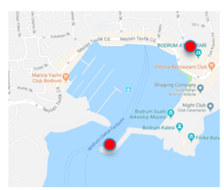
↓

SEA LEVEL EVALUATION → CANCELLATION MESSAGE

↓

END MESSAGE

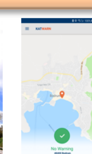




COMMUNICATION INFRASTRUCTURE

SIRENS | CELL BROADCASTING | SMS

E-MAIL | MOBILE PHONE APPLICATIONS



MESSAGE DISSEMINATION

MUNICIPALITY | LOCAL DISASTER AND EMERGENCY MANAGEMENT AUTHORITY

PUBLIC

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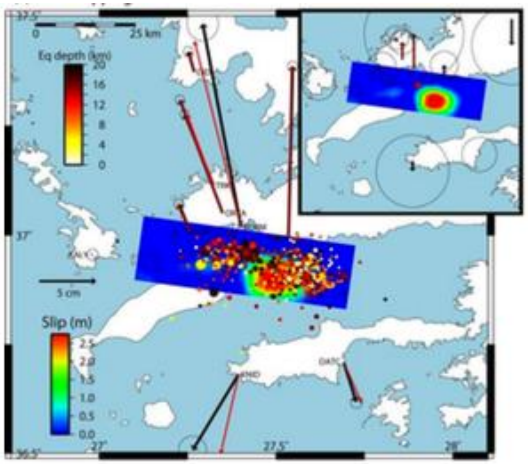
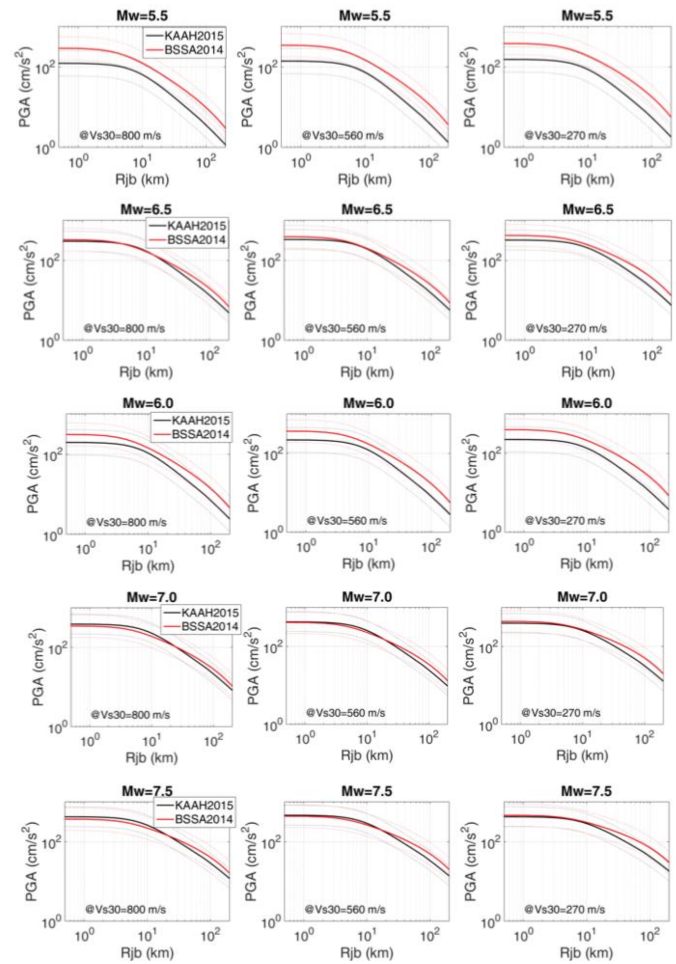
JRC EUROPEAN COMMISSION

SGM Modeling of the Bodrum-Kos EQ (KOERI)



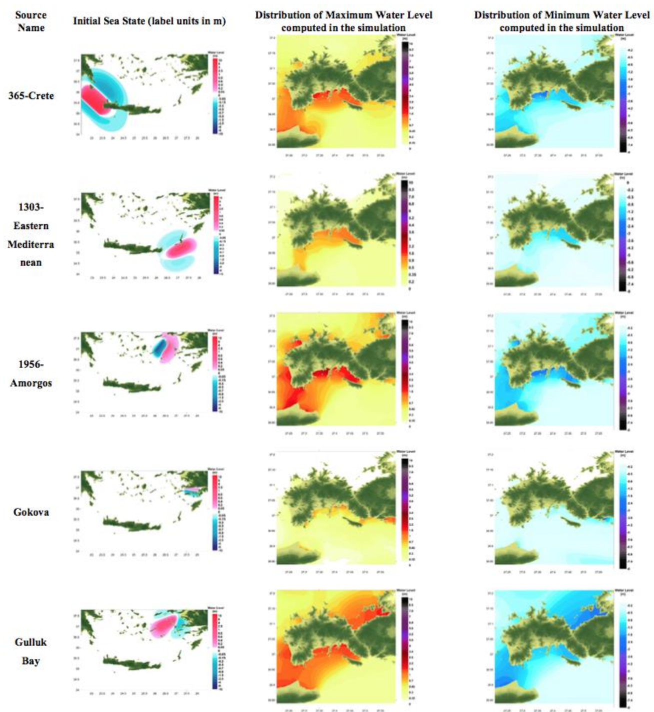
(Top) Slip distribution on the north dipping and south dipping fault by Konca et al. (2018)

(Right) PGA –Distance variations as a result of 5 magnitudes levels (Mw5.5-Mw7.5) for 3 different site conditions using 2 ground motion prediction equations (GMPE) produced/adjusted for Turkey GMPE (BSSA2014: Boore et al., 2014, KAAH2014: Kale et al., 2015). Dotted lines show the ±1 standard error (Tanırcan and Yelkenci-Necmioğlu, 2019)

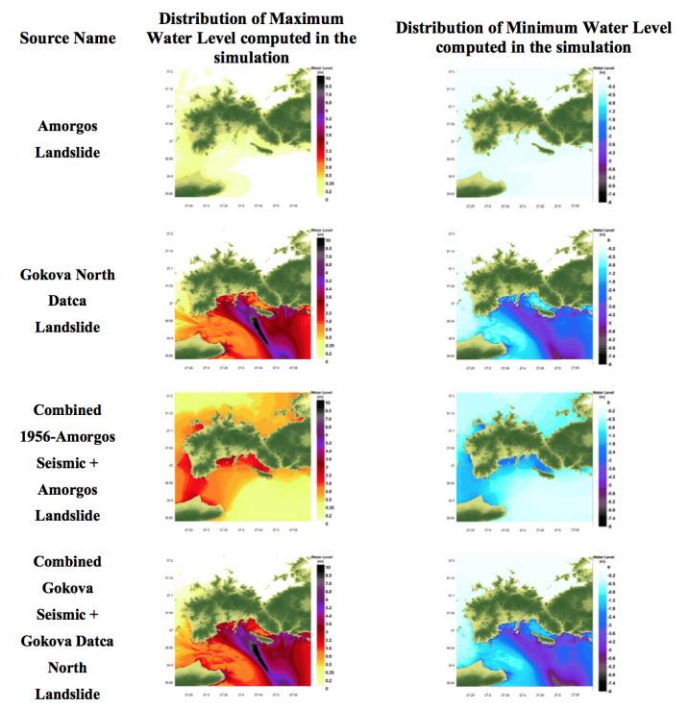


Tsunami Modeling of Largest Earthquakes in Gulf of Gokova and South Aegean (METU)

365-Crete, 1303-Eastern Mediterranean, 1956-Amorgos, Gokova and Gulluk Bay scenario earthquakes were considered. In addition, Amorgos and Gokova-North-Datca landslide landslide scenarios were considered for this study.

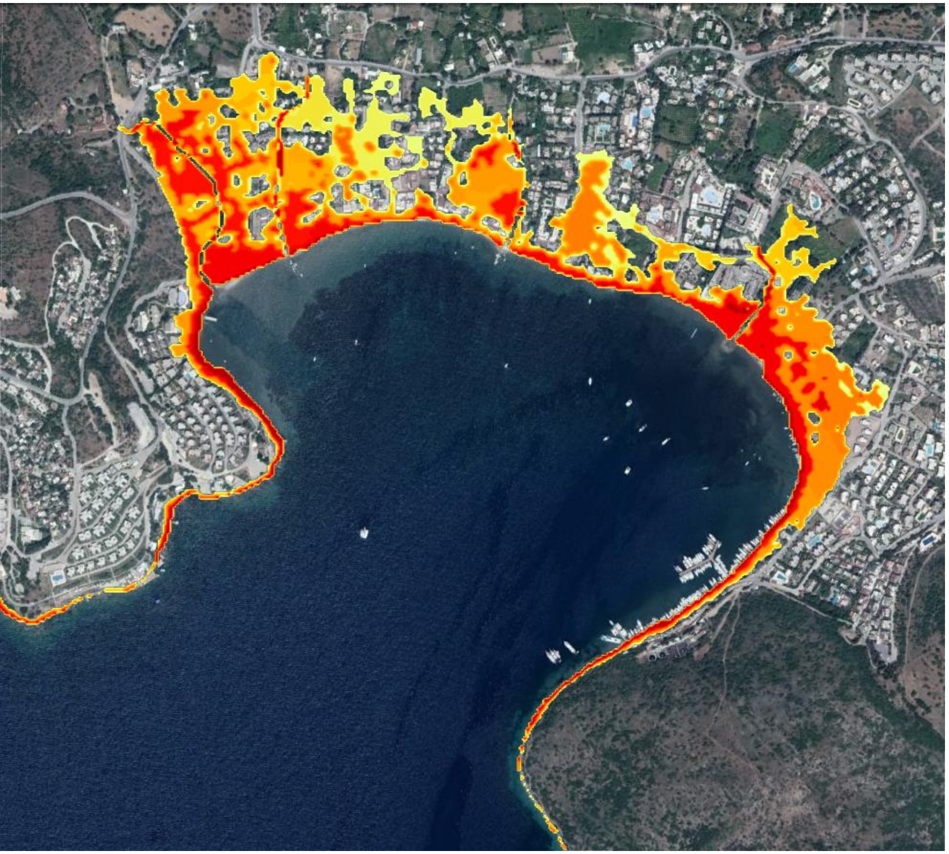


Initial Sea States and Distribution of Maximum and Minimum Water Levels for Seismic Scenarios



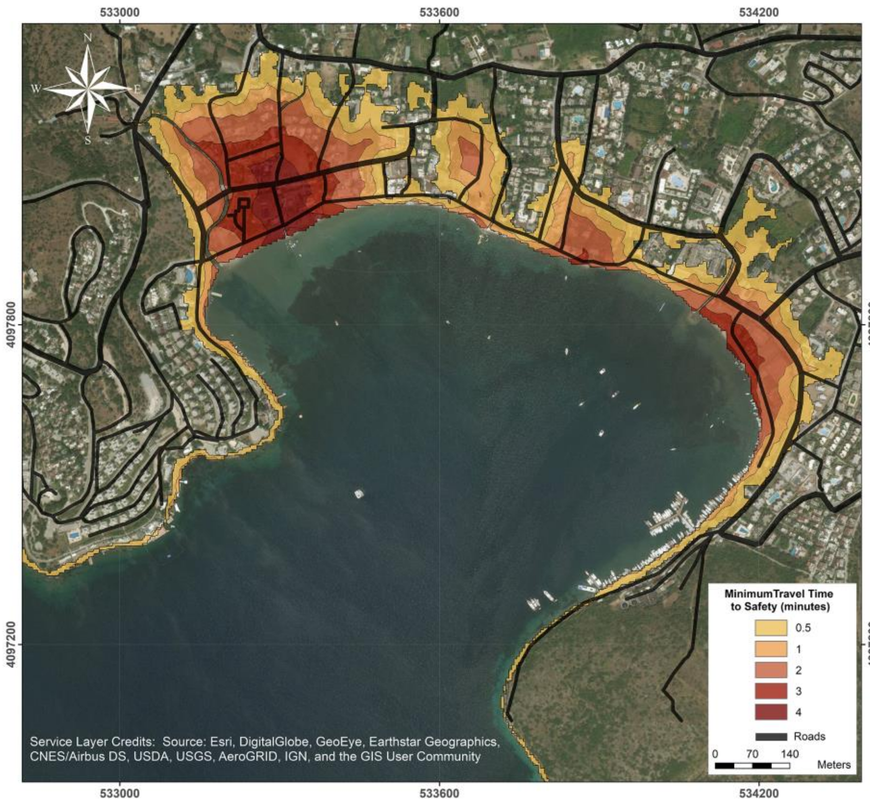
Initial Sea States and Distribution of Maximum and Minimum Water Levels for Landslide and Combined Scenarios

Tsunami Inundation and Evacuation Maps (METU)

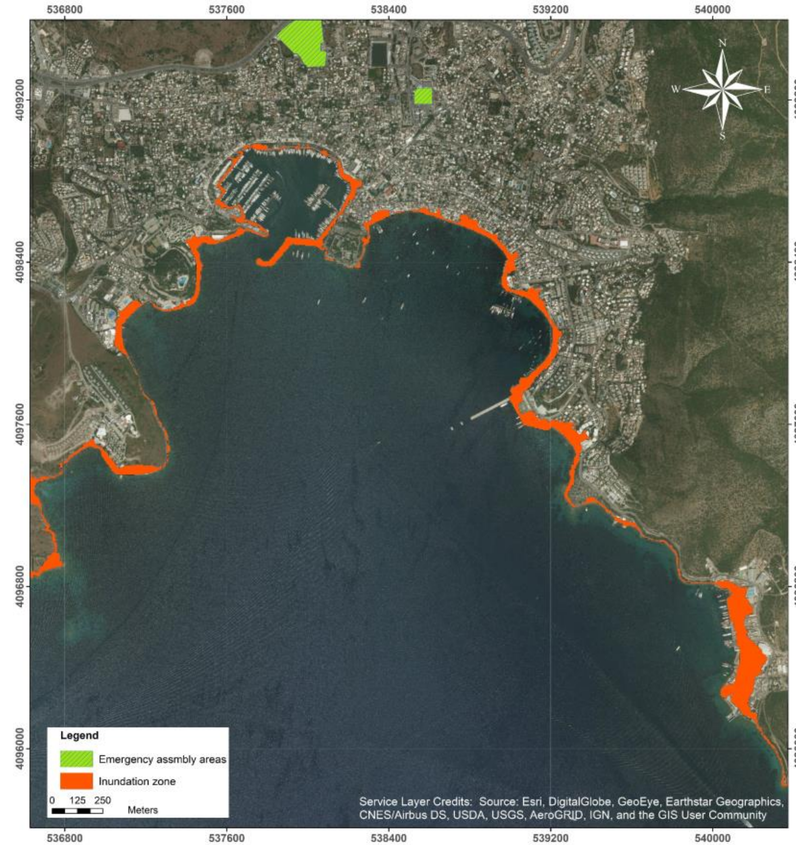


Distribution of Maximum Flow Depth in Bitez Bay due to
Left: 1956-Amorgos Scenario
Right: Combined Gokova Seismic and Gokova-North-Datca Landslide Scenario

Tsunami Inundation and Evacuation Maps (METU)



Tsunami Evacuation Walk Time Map for the coastal areas around the Bitez Bay according to the merged inundation area of Combined Gokova Seismic and Gokova-North-Datca Landslide Scenario and 1956-Amorgos Scenario



Inundation Zones and Emergency Assembly Areas in Central Bodrum

EC/JRC-KOERI-METU Last Mile - Turkey

ODTÜ METU
Joint Research Centre
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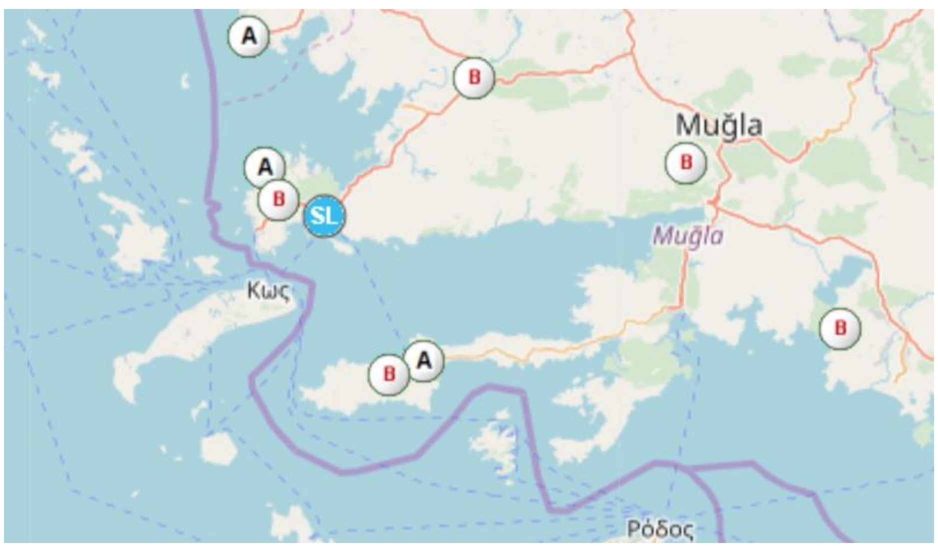
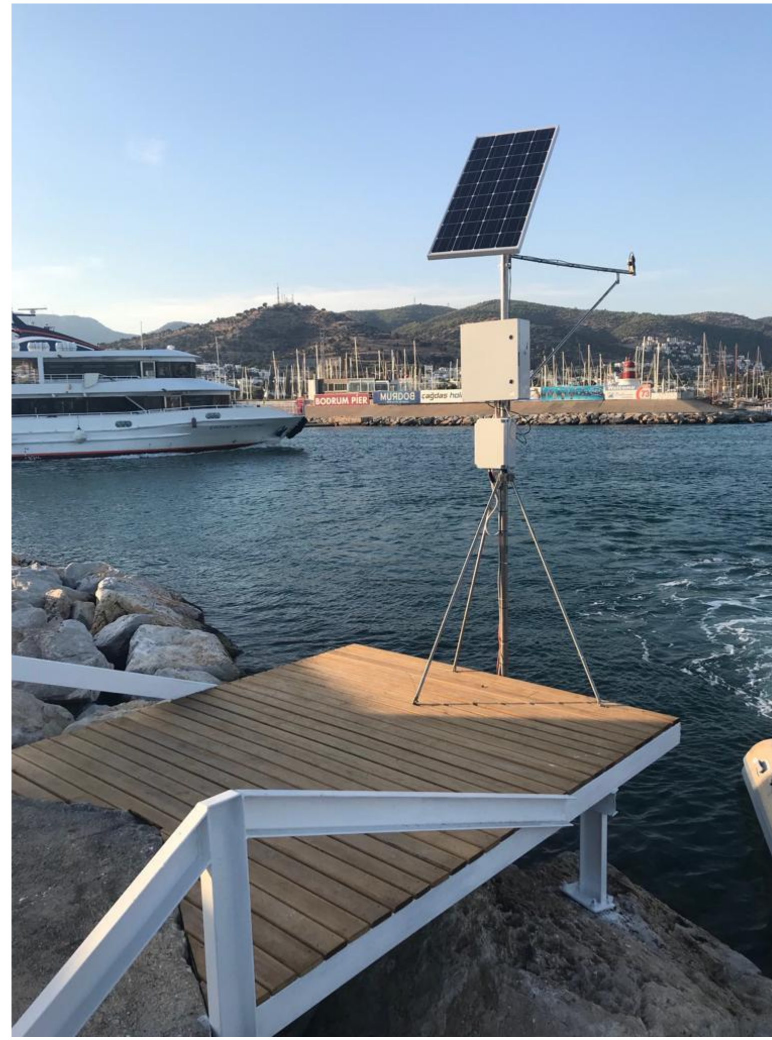
Prototype Local Tsunami Warning System (KOERI-JRC)





Bodrum Tsunami Exercise

An awareness seminar in a primary school and a preparedness seminar in a coastal hotel, both in Bodrum-Turkey, were organized on 4 November 2019. ***A table-top tsunami exercise was organised in Bodrum-Turkey on 5 November 2019, coordinated by the Mugla City Disaster and Emergency Management Presidency (Mugla AFAD), supported by the District Governorship of Bodrum, Municipality of Bodrum, KOERI, METU, Bodrum Port Authority and various NGOs****, as part of the pilot project "Last Mile Turkey" activities, funded and supported by the EC-JRC.*

The exercise was based on the 20 July 2017 Mw 6.6 Bodrum-Kos earthquake and provided an opportunity to assess the added values of various activities undertaken since the 2017 earthquake, such as dedicated meetings with the local stakeholders on ***tsunami hazard-risk-awareness-readiness, preparation of tsunami inundation and evacuation maps and installation of pilot local tsunami early warning system (triggered by the strong ground motion generated from an earthquake recorded by two seismic devices and complemented with a sea-level observation device) in the Bodrum Marina, all being tested currently as part of the pilot project "Last Mile Turkey".***

After the exercise, a press conference was organised in Bodrum-Turkey targeting further tsunami awareness in the region. A national press-release concerning these activities was issued by the Boğaziçi University.

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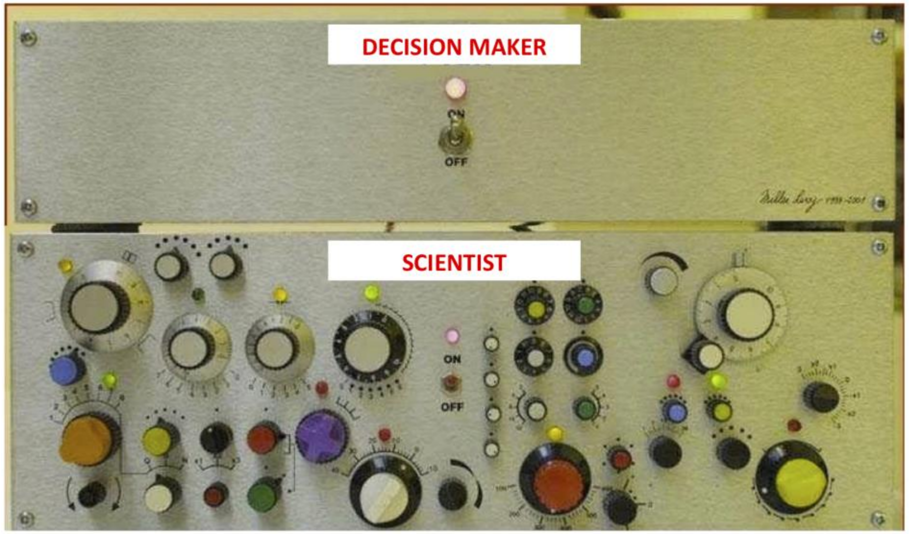
The Bitter Truth

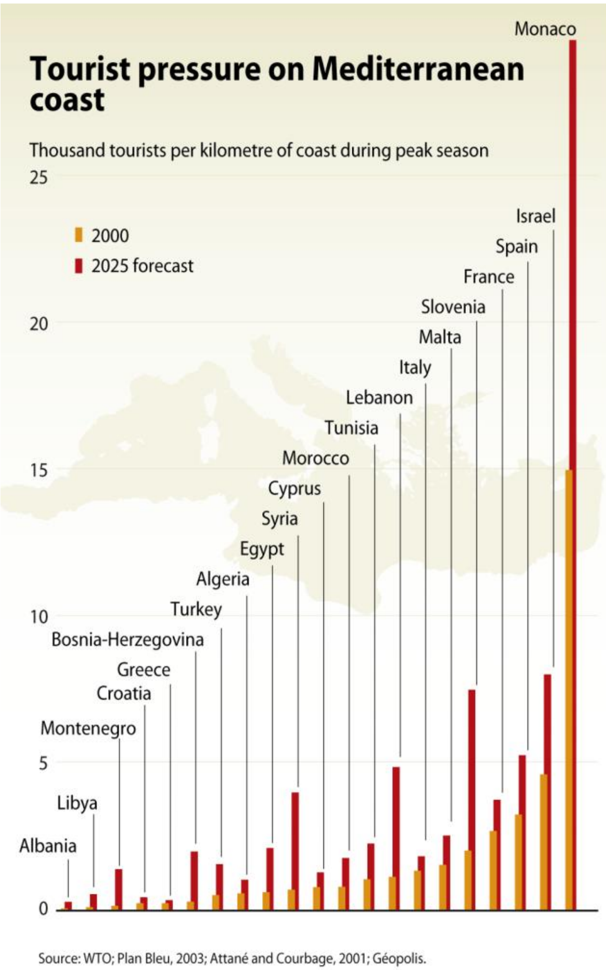


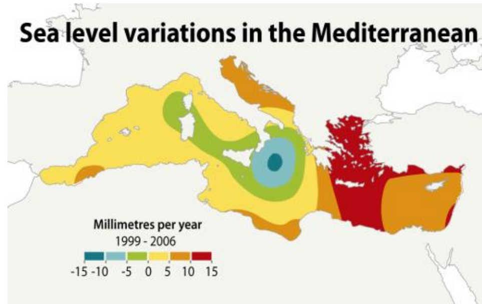
… the effectiveness of any tsunami early warning depends purely on the awareness and preparedness of the civil protection authorities and the public…

Bodrum-Kos event demonstrated the need for further efforts in the downstream components of NEAMTWS, such as further integration of Civil Protection Authorities (CPAs) and promoting education and preparedness programs for the people at risk, as a strategic priority for the NEAMTWS.

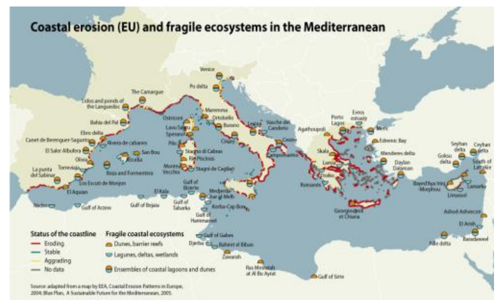
It showed also that local capacity building progra ms in coordination with municipalities, CPAs, TSPs, Ministries of Education, and other relevant stakeholders targeting development of inundation and evacuation maps, CPAs Standard Operating Procedures, local monitoring and Tsunami Early Warning Systems, local education programs and multi-hazard (earthquakes and tsunamis) exercises, should be promoted.

Other factors…



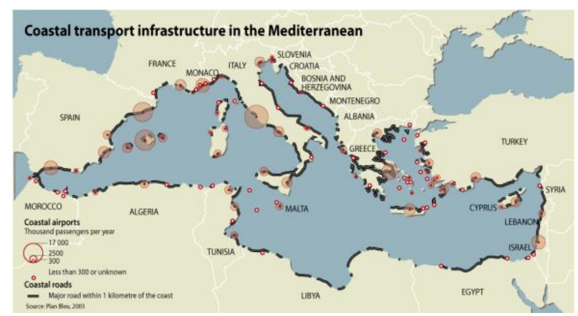


Sea-level rise…



Coastal erosion…

Coastal Infrastructure development…



source: www.grida.no

KANDİLLİ OBSERVATORY AND EARTHQUAKE RESEARCH INSTITUTE 1868

Port and Harbour Threats

2011 Japan Tsunami

- *350 ports suffered some damage*
- *18,000+ fishing boats out of operation*

P. Lynett (2014)

An issue for force protection?

- Two American nuclear submarines in Guam’s Apra Harbor were knocked from their moorings by the strength of the tsunami from the March 11 earthquake in Japan.

- **At approximately 8 p.m. the nuclear submarines USS Houston and USS Corpus Christi mooring lines broke free from the pier at Alpha Wharf because of the tsunami.**

- It took tugboats 5-6 hours to get the subs moored back to the wharf.

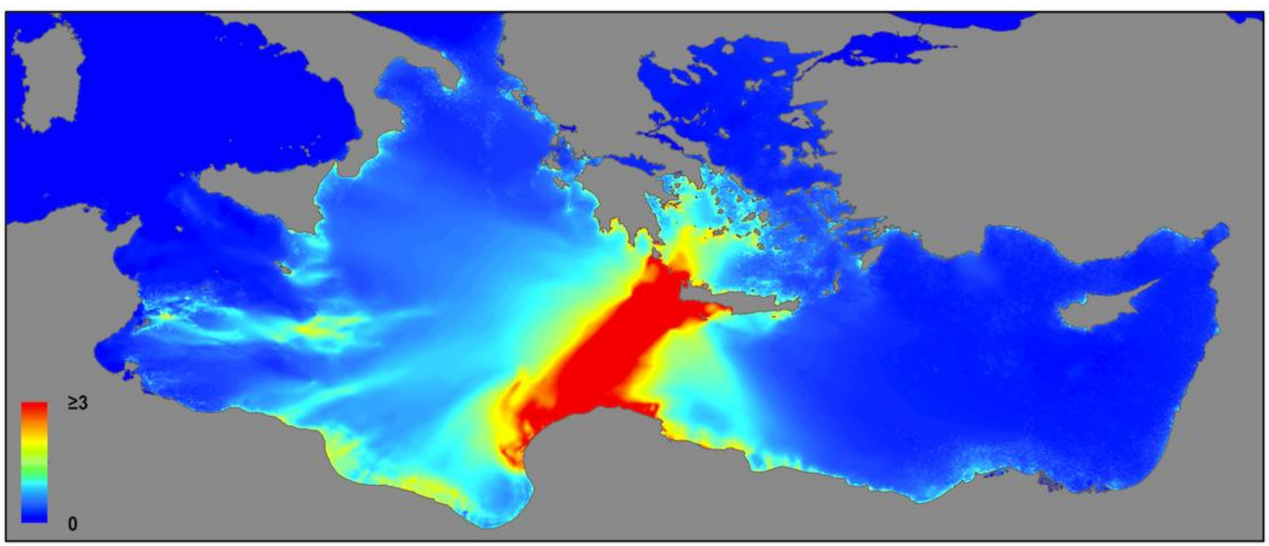
USS Houston

40 cm wave height!

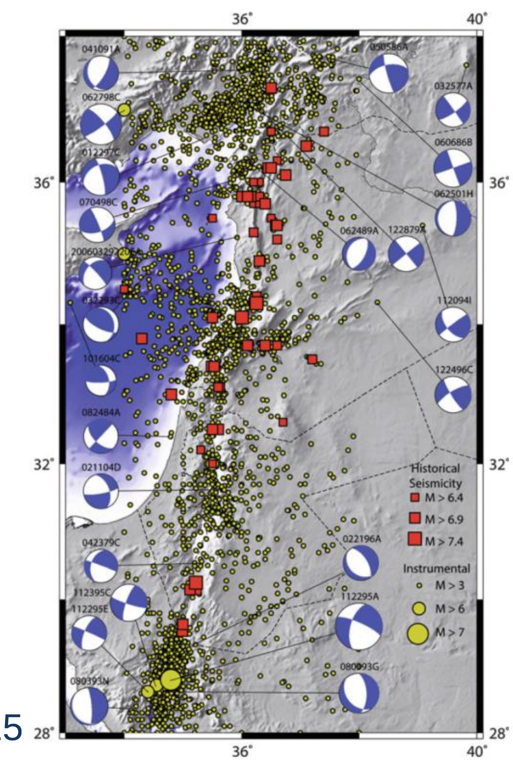
Remember Kursk!

What if there would be a tsunami tomorrow?

A tsunami in the Eastern Mediterranean triggered by an earthquake in Hellenic Arc (Mw > 8) or Dead Sea Fault (Mw > 7) should also be considered as a potential threat to Global Security due to the humanitarian crisis it may generate and the political instability it could trigger as a result of the catastrophe generated by the earthquake and tsunami!



Necmioğlu and Özel, 2015



Meghraoui, 2015

Thank you…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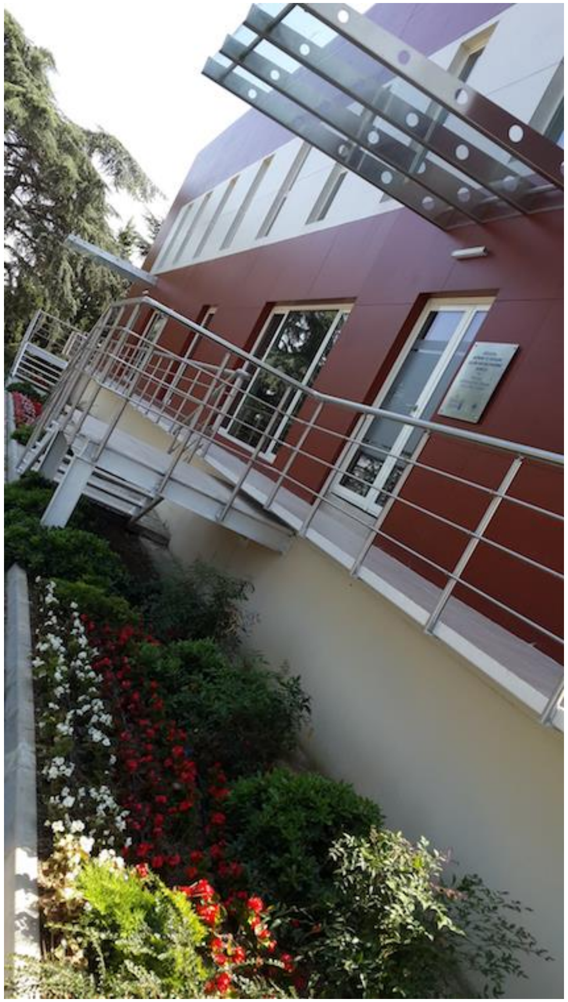


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ENSTİTÜSÜ