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DEPARTMENT OF DYNAMIC, TECTONIC & APPLIED GEOLOGY
LABORATORY OF NATURAL HAZARDS' PREVENTION & MANAGEMENT

LEKKAS E., ANDREADAKIS E., KOSTAKI I., KAPOURANI E.

# NEW INTEGRATED TSUNAMI INTENSITY SCALE 2012 (ITIS - 2012)

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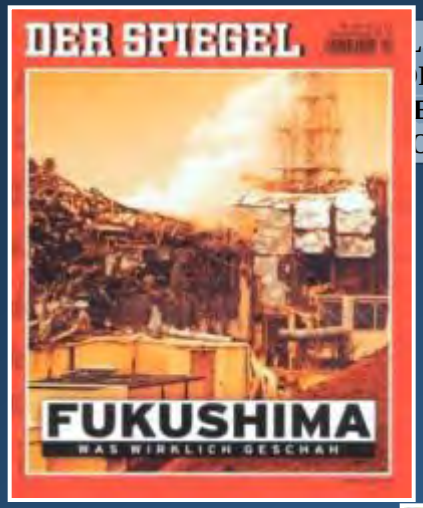
Website: www.elekkas.gr

ATHENS MARCH 2013


DER SPIEGEL
FUKUSHIMA
WAS WIRKLICH GESCHAH


PLUS: HOW IGNORANT IS AMERICA?
Newsweek
Apocalypse Now


THE TIMES OF INDIA


Board backs Mukesh, Anil braces for war
'We saw the sea coming, we all ran. But God saves little'


FRIDAY
総力取材！東日本大震災
福島第一原発の「真


stern
Das unglaubliche Volk

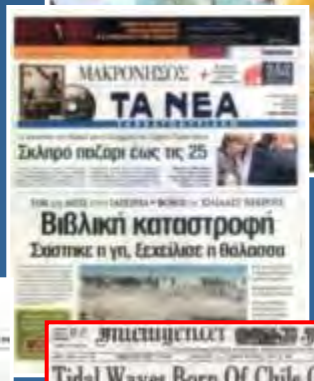

Los Angeles Times
Chileans digging for survivors


朝日新聞
M8.8 国内最大
東日本大地震 先月から地震続発


วอลสตรีทเจอร์นัล


LIBYE LA GRANDE PEUR DES REBE
Le Point
Quand le destin s'acharne sur les Japonais
La chute d'un géant


AERA


ΜΑΚΡΟΝΗΣΟΣ
TA NEA
Σκληρο παζαρι ενως τις 25
Βιβλικη καταστροφη


EL MERCURIO


The Washington Post
Operators struggle to stabilize nuclear plants


Tidal Waves Born Of Chile Quakes Spread Death And Destruction To Hawaii, Japan
Russia, U. S. Present Charges To UN Council


The Nation
CATASTROPHE


アサヒグラフ
東北関東大震災
2011.3.11
大津波と原発


法制报
为"中国式出行"破题
2012 十大典型刑事案例

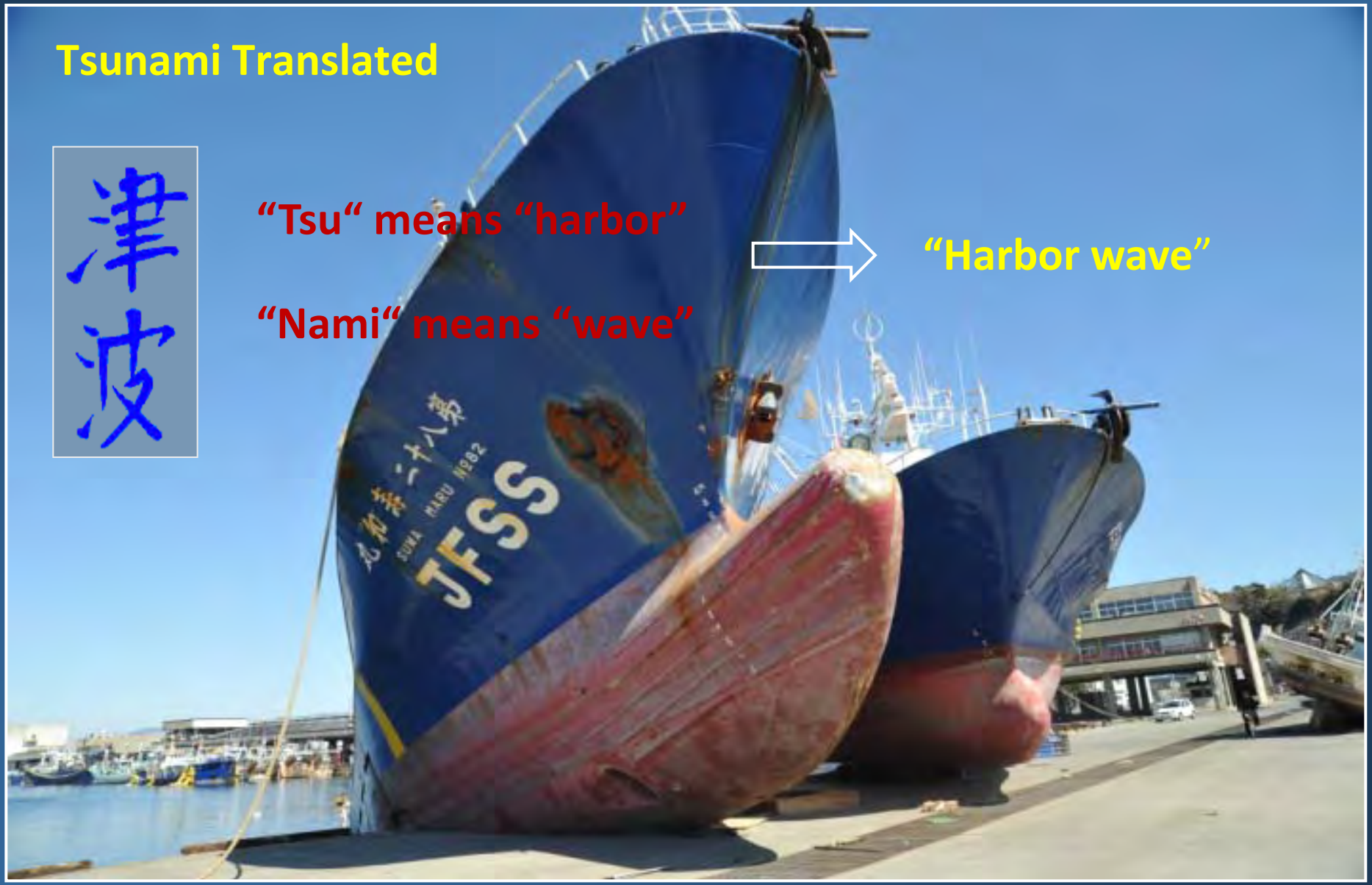
# Tsunami Translated

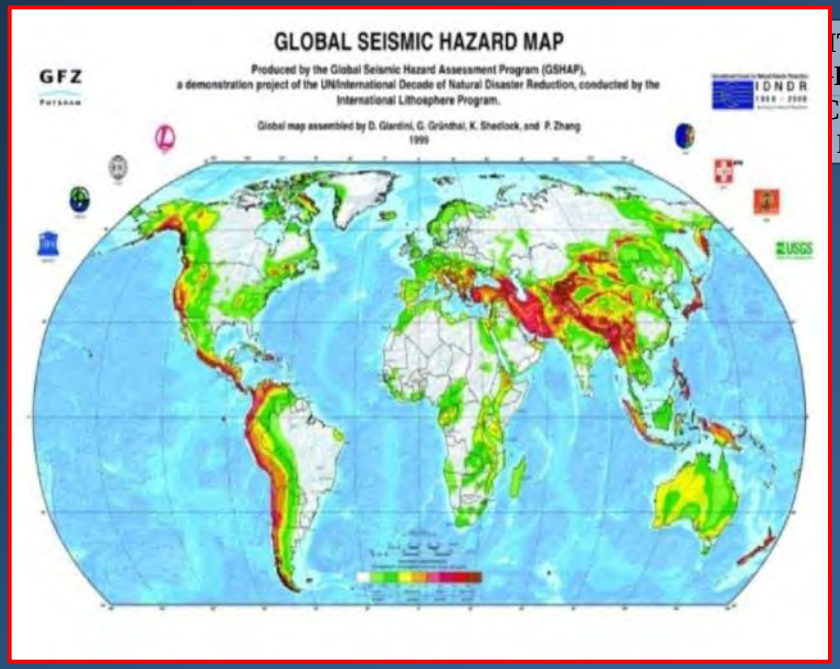
津波

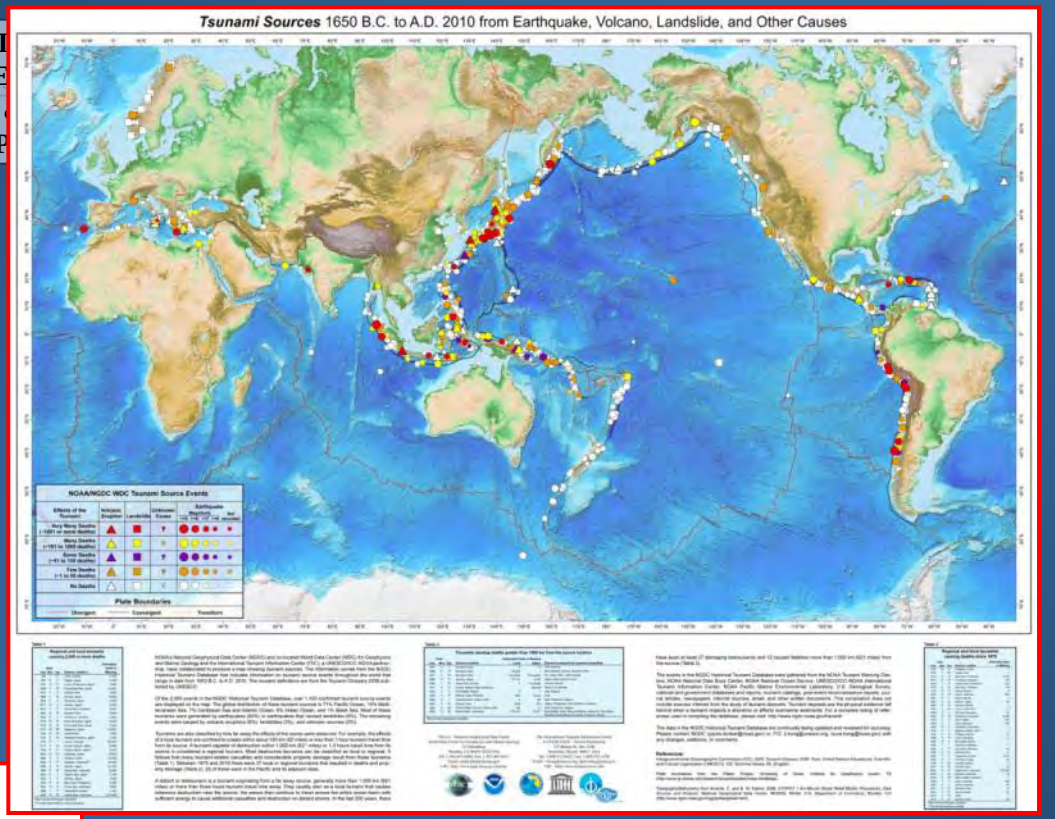
"Tsu" means "harbor"

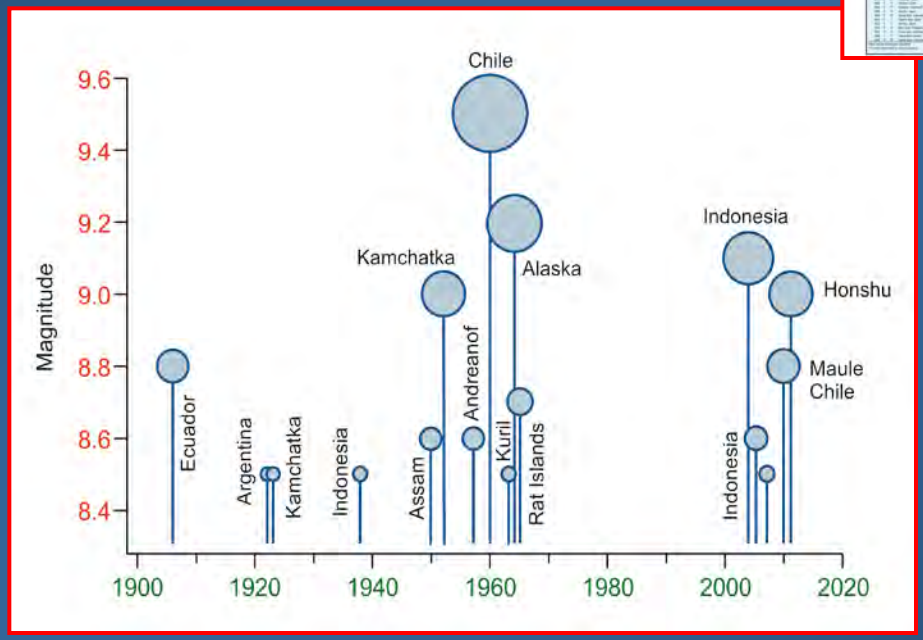
"Nami" means "wave"

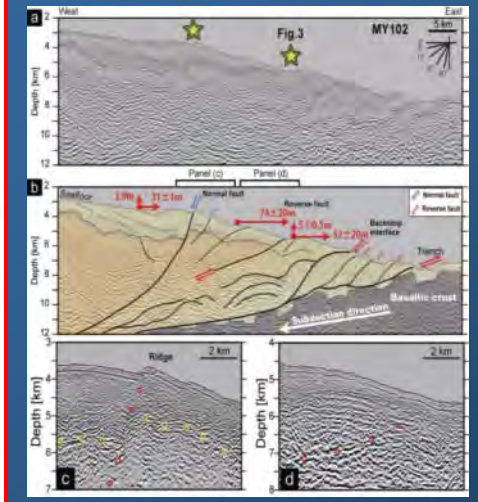
→ "Harbor wave"

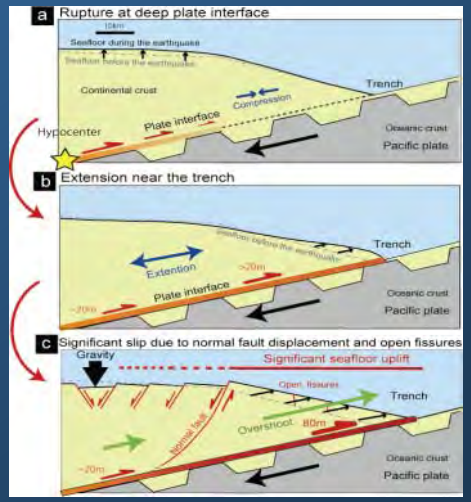





TSUJI, T. et al., 2012

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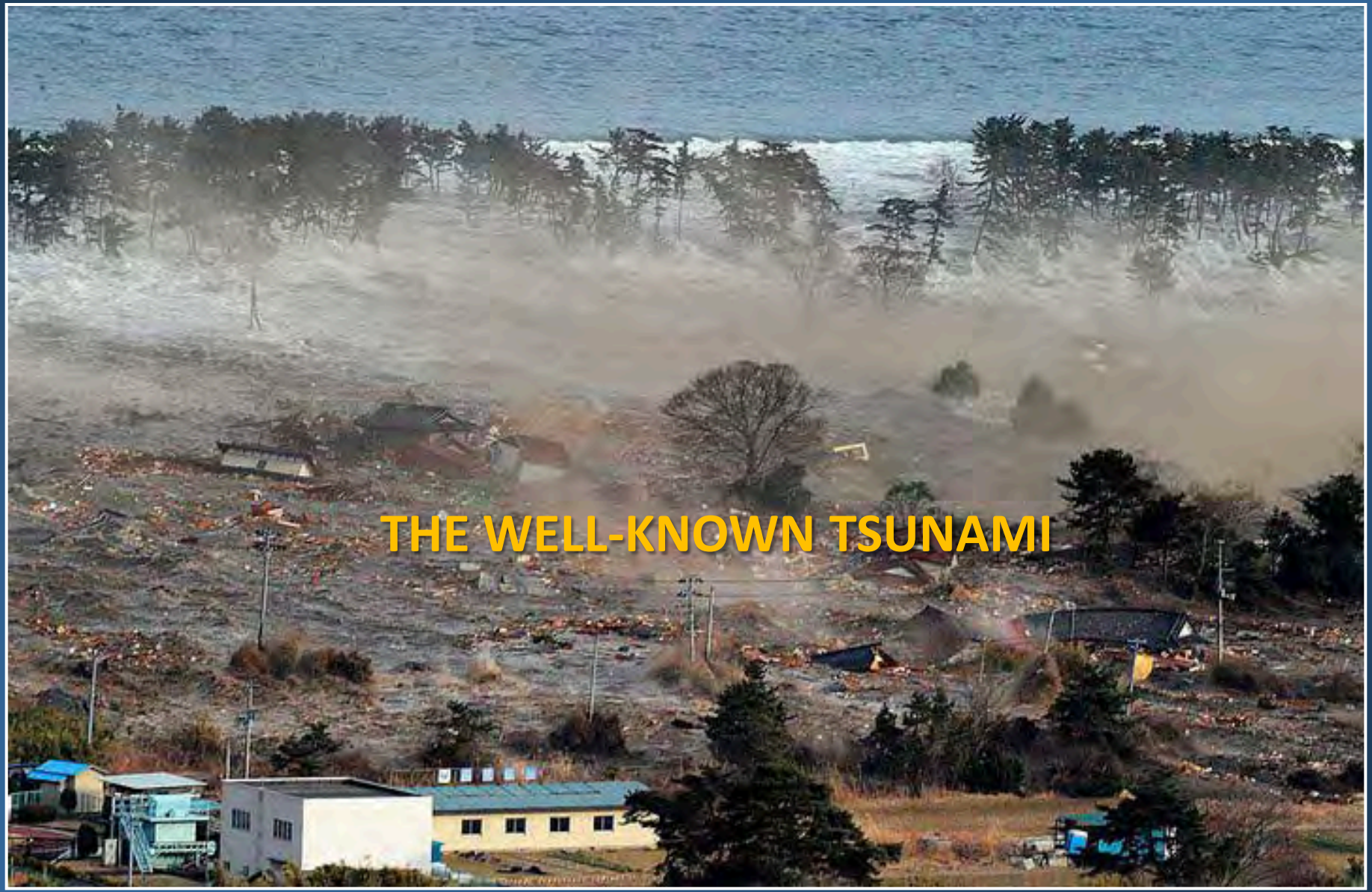


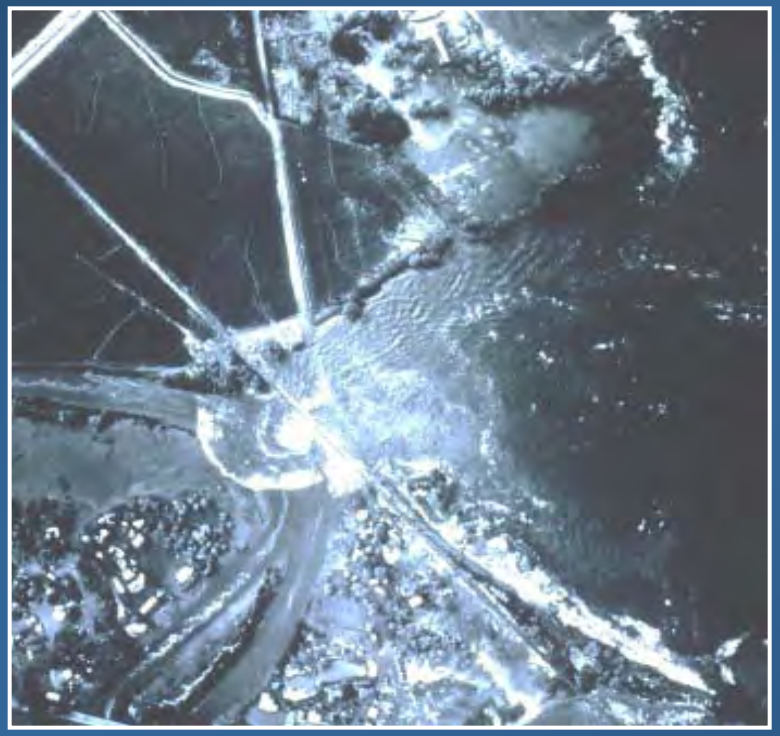


SANTORINI, MINOAN PERIONT ERUPTION 16th BC


**LISBOA 1755**

ERSITY OF ATHE
OF GEOLOGY &
ONIC & APPLIED
RDS' PREVENTIC

KAMTCHATKA 1952



ALEUTIAN ISLAND 1957

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CHILE 1960

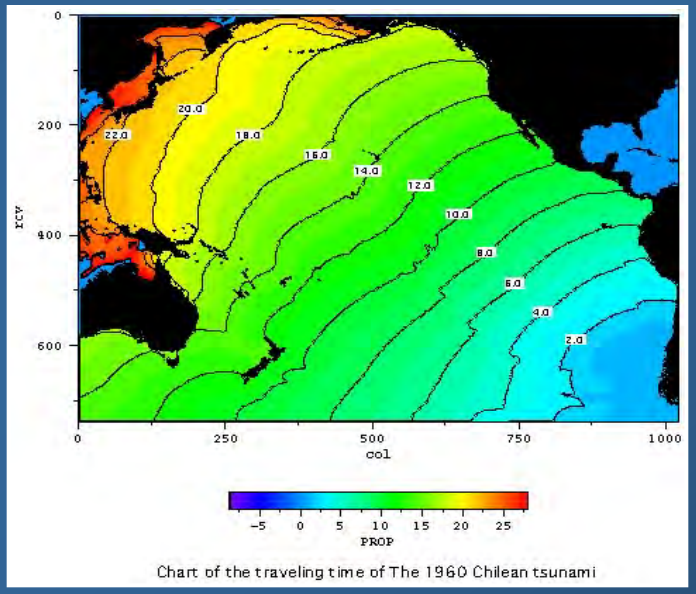
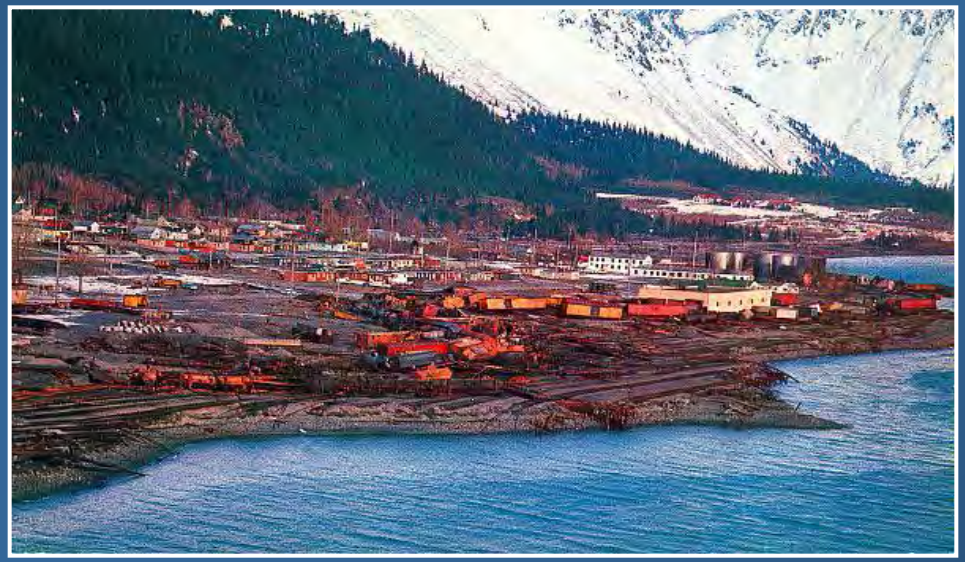
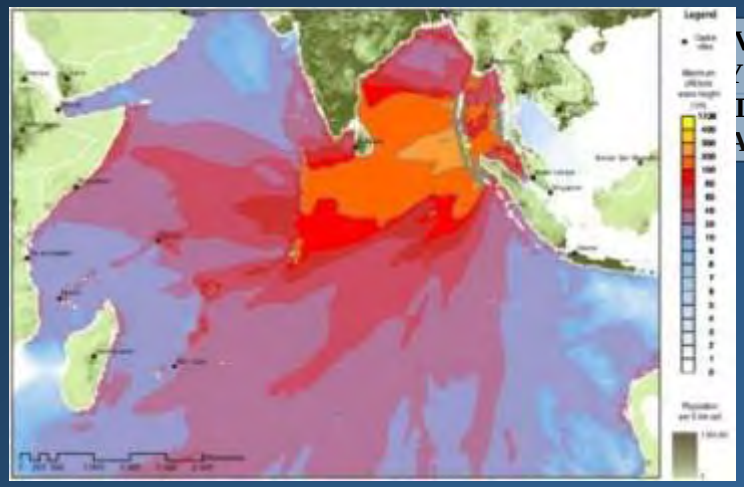



Chart of the traveling time of The 1960 Chilean tsunami

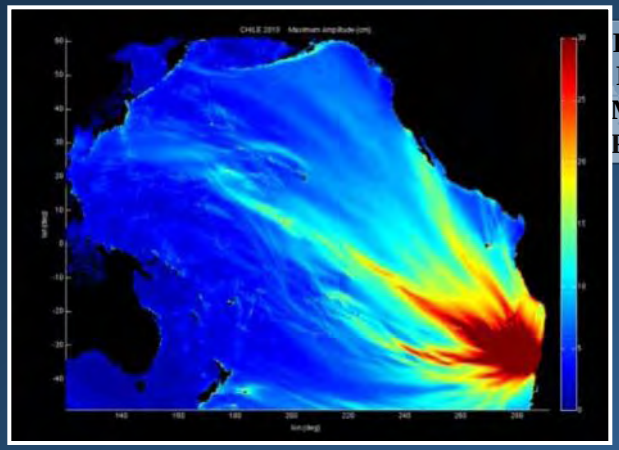
HAWAII


## ALASKA 1964

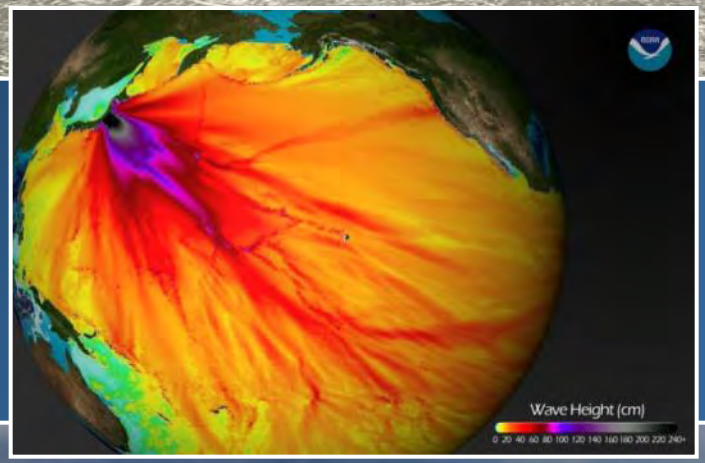




## INDIAN OCEAN 2004



## MAULE CHILE 2010




## NE JAPAN 2011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# NEW INTEGRATED TSUNAMI INTENSITY SCALE 2012 (ITIS-2012)

The structure of the new tsunami intensity scale is based on 6 categories of criteria:

A. Quantities of the Phenomenon
B. Impact on Human Environment
C. Impact on Mobile Objects
D. Impact on Infrastructure
E. Impact on the Environment
F. Impact on Structures

LEKKAS, E., ANDREADAKIS, E., KOSTAKI, I., KAPOURANI, E. (2013)

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# NEW INTEGRATED TSUNAMI INTENSITY SCALE 2012 (ITIS-2012)

| | Quantities | Impact on humans | Impact on mobile objects | Infrastructure | Environment | Structures | |
|---|---|---|---|---|---|---|---|
| I | No effect | Not felt, even under the most favourable circumstances | No effect | No effect | No effect | No damage | Not felt |
| II | No effect | Felt only by few people on board small vessels. Not being noticed onshore. | No effect | No effect | No effect | No damage | Slightly felt |
| III | No effect | Felt only by many people on board on small vessels. Being noticed by a few people onshore. | No effect | No effect | No effect | No damage | Weak |
| IV | Tsunami height of a few cm. | Felt only by all people on board on small vessels. Felt only by few people on board on large vessels and by many people onshore. | Some small vessels wiggle or move towards the coast. | No effect | No effect | No damage | Largely observed |
| V | Tsunami height of several cm to dm (0.5m). Limited onshore areas inundated. | Felt by all on board on big vessels and people onshore. Some people panic and run for higher ground. | Many small vessels get washed on the shore and many offshore collide with each other. | No effect | No effect | Damage of grade 1 to a few buildings of vulnerability class A and B | Strong |
| VI | Tsunami height of some dm (<1m). Small onshore areas are flooded. | Many people panic and run for higher ground. | Many small vessels are washed out violently or collide with each other or are overturned along the shoreline. Cars are uplifted and moved. | No effect | Marginal turbulence at coastal sediments. | Damage of grade 1 is sustained by many buildings of vulnerability class A and B; a few of class A and B suffer damage of grade 2; a few of class C suffer damage of grade 1 | Slightly damaging |

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| | Quantities | Impact on humans | Impact on mobile objects | Infrastructure | Environment | Structures | |
|---|---|---|---|---|---|---|---|
| VII | Tsunami height or tsunami flow depth usually higher than 1m . Small onshore areas are flooded. | All people panic and run for higher ground. | Many small vessels suffer damage. Bigger vessels are shaken violently or collide with each other. All cars are carried away. | Few makeshift facilities on coastline are washed away. | Garbage - debris at parts of the shoreline. Limited erosion - deposition of sand and pebble at coastal areas. | Many buildings of vulnerability class A suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class B suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class C sustain damage of grade 2. A few buildings of vulnerability class D sustain damage of grade 1. | Damaging |
| VIII | Tsunami height higher than 2m. Limited onshore areas are flooded. Limited inundation along coastline. | All people run for higher ground. Many are washed away. | Many small vessels suffer damage. Bigger vessels are washed out or collide with each other. Heavy objects are moved. Cars are washed away. | Many makeshift facilities along the coastline are washed away. | Erosion and garbage - debris along the shoreline. Some bushes or trees are uprooted and get carried away in small distance. | Many buildings of vulnerability class A suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class B suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class C suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class D sustain damage of grade 2. | Heavily damaging |
| IX | Tsunami height of a few m (<5). Wide areas are inundated along the shoreline. Tsunami run up of some m, whereas inundation depth reaches some hundreds of m, depending on coastal morphology. | Many people are washed away. | Most vessels are destroyed or sunk. Many bigger vessels are washed out and some are destroyed. Cars are being washed away. Fires break along the shore. | Most makeshift facilities along the coastline are washed away. Little damage on offshore backfilling. | Depending on the topography and the kind of coastal formations, limited coastal profile changes with erosion and material deposition takes place. Garbage - debris deposition along the shoreline. Uprooting of bushes and some trees. | Many buildings of vulnerability class A sustain damage of grade 5. Many buildings of vulnerability class B suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class C suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class D suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class E sustain damage of grade 2. | Destructive |
| X | Tsunami height of many m (<7). Tsunami run up reaches or exceeds 10 m, whereas inundation depth reaches some hundreds of m, depending on coastal morphology. | General panic. Most people are washed away. | Most big vessels are washed out and many are destroyed due to impact on the shoreline and buildings. Cars overturn and are washed away. | Few damage on quays and port facilities. Damage on objects at port facilities. Small failures on antierrosional works on the shoreline. | Depending on the profile of offshore and onshore area, notable changes at the coastal profile take place due to erosion and deposition. Trees are uprooted and washed away, small boulders move. Extensive pollution from oil and chemicals. Fires break. | Most buildings of vulnerability class A sustain damage of grade 5. Many buildings of vulnerability class B sustain damage of grade 5. Many buildings of vulnerability class C suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class D suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class E suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class F sustain damage of grade 2. | Very destructive |

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| | Quantities | Impact on humans | Impact on mobile objects | Infrastructure | Environment | Structures | |
|---|---|---|---|---|---|---|---|
| XI | Tsunami height of many m (<10m). Tsunami run up exceeds 15 m, whereas inundation depth exceeds 1km, depending on coastal morphology. | Extensive human loss. | Extensive fires break. Heavy objects are washed away. Extensive erosion. Boats are washed off for hundreds of m onshore. Most cars are washed away or destroyed. | Breakwaters are damaged. Failures at anti-erosion works on the shoreline. Damage on the roads near the coastline. Great damage at onshore lifelines. Damage on cranes and other port facilities. Tanks on port facilities are moved. Rail lines suffer damage. Many riprap boulders are detached and moved. Some industrial facilities are damaged. | Depending on the profile of offshore and onshore area and probable uplift or subsidence, changes at the coastal profile take place due to erosion deposition and deep erosion. Many trees are uprooted and washed away, small boulders are washed away. Great pollution from oil and chemicals. Many fires break. | Most buildings of vulnerability class B sustain damage of grade 5. Most buildings of vulnerability class C suffer damage of grade 4; many of grade 5. Many buildings of vulnerability class D suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class E suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class F suffer damage of grade 2; a few of grade 3. | Devastating |
| XII | Tsunami height exceeds 10m. Run up reaches many tens of m and inundation some km. Areas of some tens km² are inundated. | Extended human loss in wide areas. | Boats are moved in high altitude. Cars, trains etc are washed away or destroyed. | Great damage in all port works such as jetties, marine breakwaters, port facilities, cranes, onshore lifelines. Riprap blocks are detached and moved in great distances. | Depending on the profile of offshore and onshore area and probable uplift or subsidence, extended changes at the coastal profile take place in wide areas, due to erosion deposition and deep erosion. Great changes on coastline topography. Almost all trees are uprooted and washed away. Big boulders are washed away on great distance. Massive pollution from oil and chemicals. Extensive fires break | All buildings of vulnerability class A, B and practically all of vulnerability class C are destroyed. Most buildings of vulnerability class D, E and F are destroyed. The earthquake effects have reached the maximum conceivable effects. | Completely devastating |

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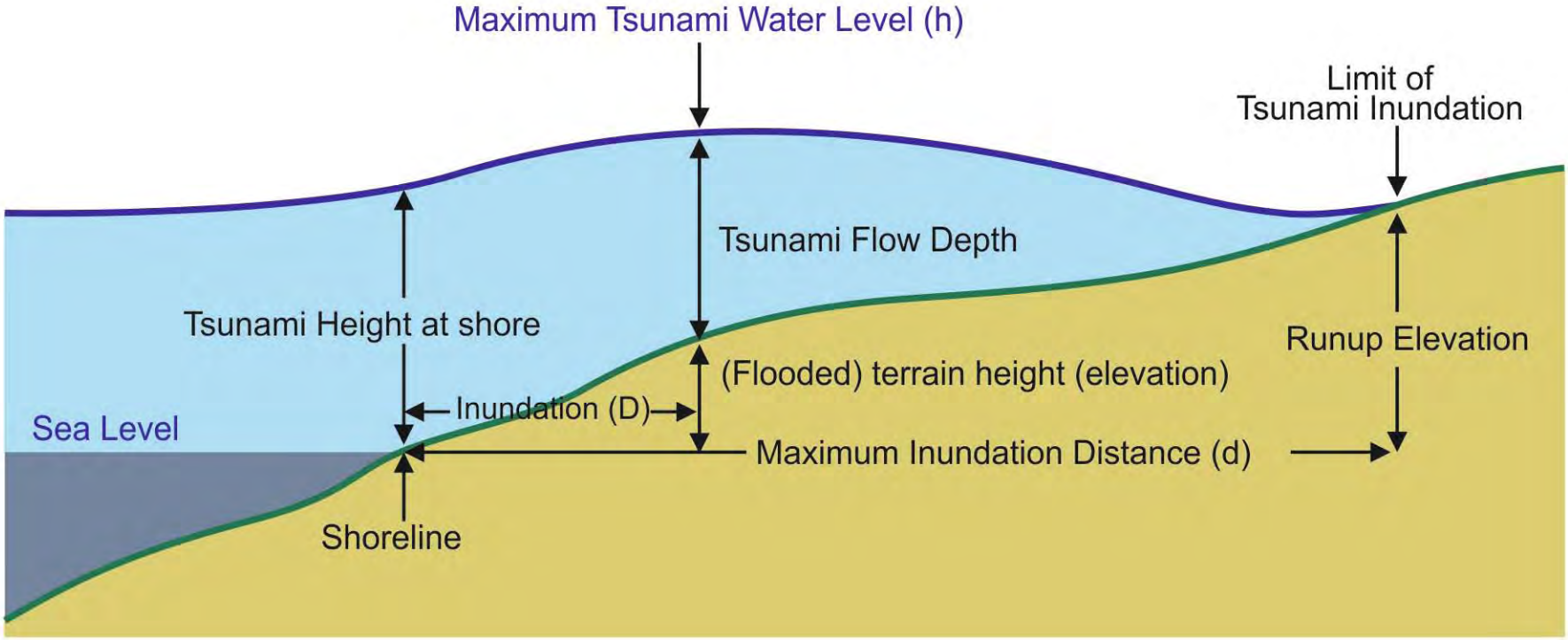
# A. Quantities of the Phenomenon




The anatomy and the main characteristics of Tsunami Waves

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# A. QUANTITIES OF THE PHENOMENON

| | | |
|---|---|---|
| I | No effect | Not felt |
| II | No effect | Slightly felt |
| III | No effect | Weak |
| IV | Tsunami height of a few cm. | Largely observed |
| V | Tsunami height of several cm to dm (0.5m). Limited onshore areas inundated. | Strong |
| VI | Tsunami height of some dm (<1m). Small onshore areas are flooded. | Slightly damaging |
| VII | Tsunami height usually higher than 1m . Small onshore areas are flooded. | Damaging |
| VIII | Tsunami height higher than 2m. Limited onshore areas are flooded. Limited inundation along coastline. | Heavily damaging |
| IX | Tsunami height of a few m (<5). Wide areas are inundated along the shoreline. Tsunami run up of some m, whereas inundation depth reaches some hundreds of m, depending on coastal morphology. | Destructive |
| X | Tsunami height of many m (<7). Tsunami run up reaches or exceeds 10 m, whereas inundation depth reaches some hundreds of m, depending on coastal morphology. | Very destructive |
| XI | Tsunami height of many m (<10m). Tsunami run up exceeds 15 m, whereas inundation depth exceeds 1km, depending on coastal morphology. | Devastating |
| XII | Tsunami height exceeds 10m. Run up reaches many tens of m and inundation some km. Areas of some tens $km^2$ are inundated. | Completely devastating |

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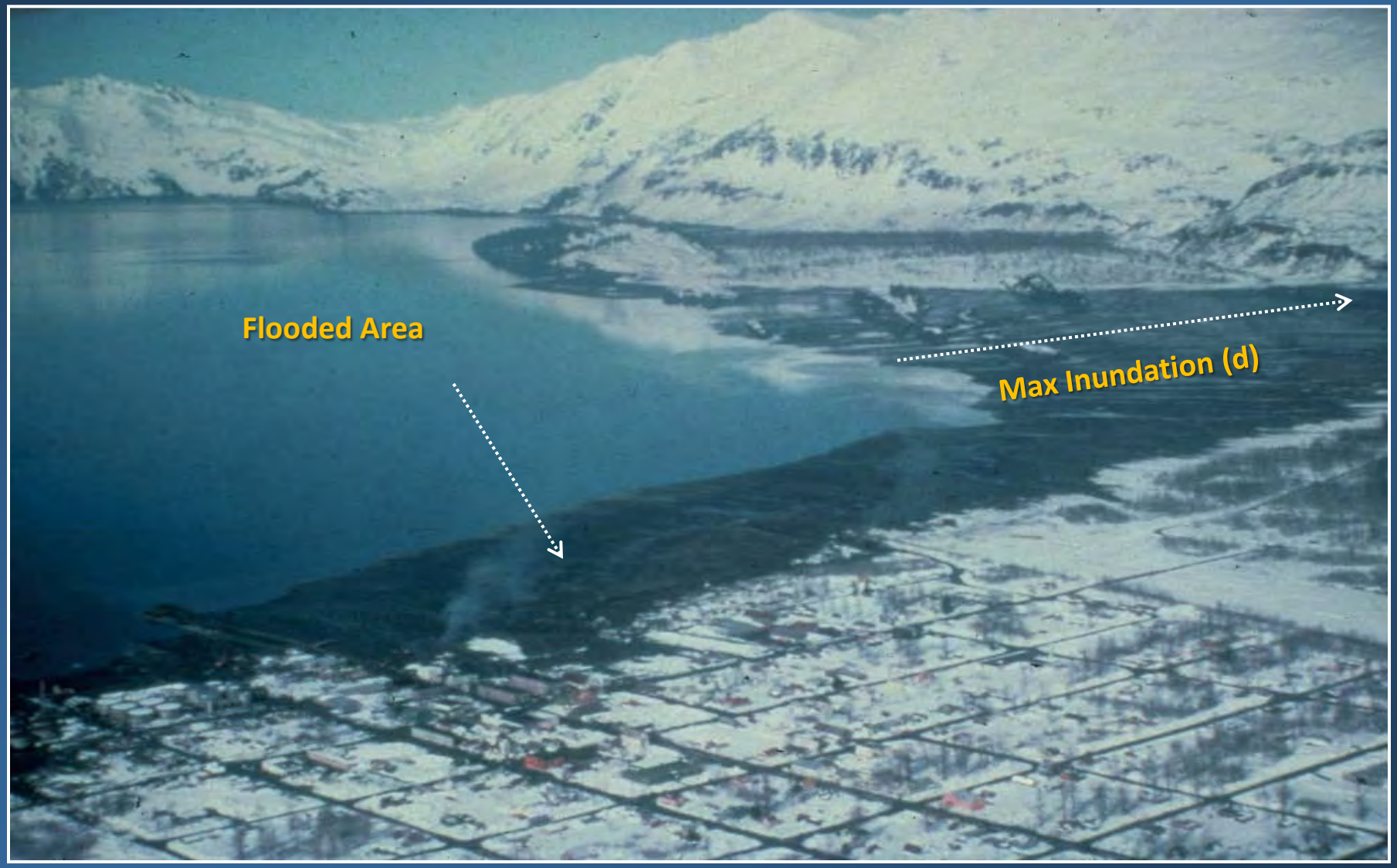
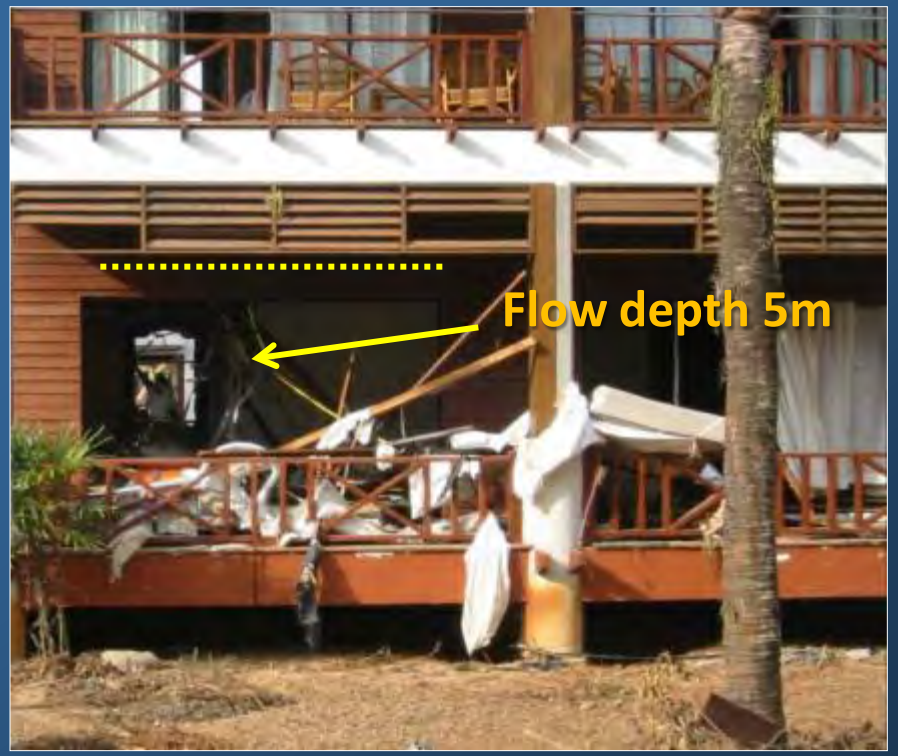



VALDEZ, ALASKA 1964

# KHAO LAK, INDIAN OCEAN 2004





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**ONAGAWA, NE JAPAN 2011**


ONAGAWA, NE JAPAN 2011

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OGATSU, NE JAPAN 2011

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# B. Impact on Human Environment

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# B. IMPACT ON HUMAN ENVIRONMENT

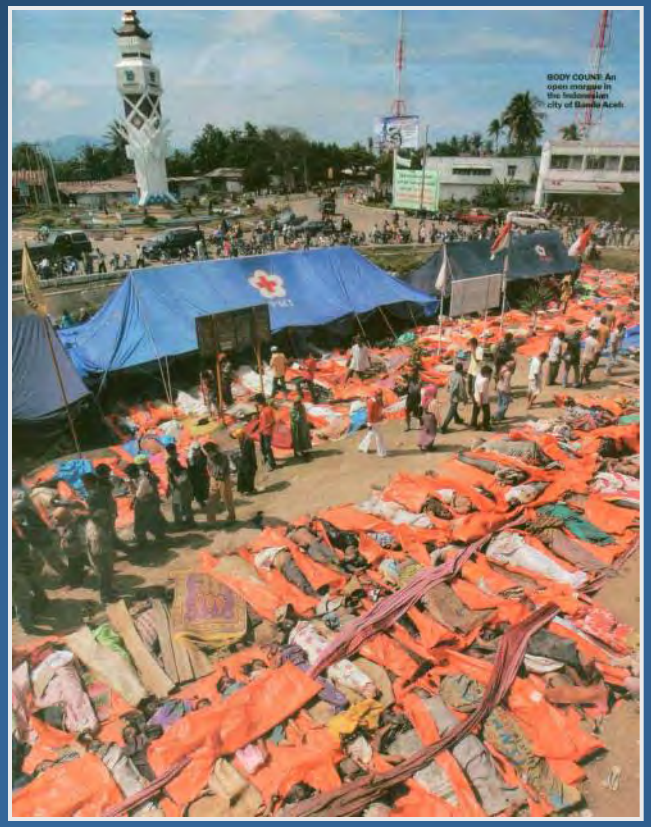
| | | |
|---|---|---|
| I | Not felt, even under the most favourable circumstances | Not felt |
| II | Felt only by few people on board small vessels. Not being noticed onshore. | Slightly felt |
| III | Felt only by many people on board on small vessels. Being noticed by a few people onshore. | Weak |
| IV | Felt only by all people on board on small vessels. Felt only by few people on board on large vessels and by many people onshore. | Largely observed |
| V | Felt by all on board on big vessels and people onshore. Some people panic and run for higher ground. | Strong |
| VI | Many people panic and run for higher ground. | Slightly damaging |
| VII | All people panic and run for higher ground. | Damaging |
| VIII | All people run for higher ground. Many are washed away. | Heavily damaging |
| IX | Many people are washed away. | Destructive |
| X | General panic. Most people are washed away. | Very destructive |
| XI | Extensive human loss. | Devastating |
| XII | Extended human loss in wide areas. | Completely devastating |


NE JAPAN 2011:

**NE JAPAN 2011:**

**XI ITIS 2012 : Extensive human loss**


## XII ITIS 2012 : Extensive human loss in wide areas (NE JAPAN 2011)




## XII ITIS 2012 : Extensive human loss in wide areas (INDIAN OCEAN 2004)

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# C. Impact on Mobile Objects

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# C. IMPACT ON MOBILE OBJECTS

| | | |
|---|---|---|
| I | No effect | Not felt |
| II | No effect | Slightly felt |
| III | No effect | Weak |
| IV | Some small vessels wiggle or move towards the coast. | Largely observed |
| V | Many small vessels get washed on the shore and many offshore collide with each other. | Strong |
| VI | Many small vessels are washed out violently or collide with each other or are overturned along the shoreline. Cars are uplifted and moved. | Slightly damaging |
| VII | Many small vessels suffer damage. Bigger vessels are shaken violently or collide with each other. All cars are carried away. | Damaging |
| VIII | Many small vessels suffer damage. Bigger vessels are washed out or collide with each other. Heavy objects are moved. Cars are washed away. | Heavily damaging |
| IX | Most vessels are destroyed or sunk. Many bigger vessels are washed out and some are destroyed. Cars are being washed away. Fires break along the shore. | Destructive |
| X | Most big vessels are washed out and many are destroyed due to impact on the shoreline and buildings. Cars overturn and are washed away. | Very destructive |
| XI | Extensive fires break. Heavy objects are washed away. Extensive erosion. Boats are washed off for hundreds of m onshore. Most cars are washed away or destroyed. | Devastating |
| XII | Boats are moved in high altitude. Cars, trains etc are washed away or destroyed. | Completely devastating |


E140°54'27.36"
E140°54'53.28"
N36°56'22.56"
USGS
Google


JFSS


USGS
Google

Cars are carried away (NE JAPAN 2011)

**X** Most big vessels are washed out and many are destroyed due to impact on the shoreline and buildings. Cars overturn and are washed away. **Very destructive**

**XI** Most cars are washed away or destroyed. **Devastating**

**XII** Boats are moved in high altitude.

**Completely devastating**


**XII** Boats are moved in high altitude. Cars, trains etc are washed away or destroyed.

**Completely devastating**

**XII** Boats are moved in high altitude. Cars, trains etc are washed away or destroyed.

**Completely devastating**


## ONAGAWA, NE JAPAN 2011


**XII** Boats are moved in high altitude.

**Completely devastating**

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# D. Impact on Infrastructure

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# D. IMPACT ON INFRASTRUCTURE

| | | |
|---|---|---|
| I | No effect | Not felt |
| II | No effect | Slightly felt |
| III | No effect | Weak |
| IV | No effect | Largely observed |
| V | No effect | Strong |
| VI | No effect | Slightly damaging |
| VII | Few makeshift facilities on coastline are washed away. | Damaging |
| VIII | Many makeshift facilities along the coastline are washed away. | Heavily damaging |
| IX | Most makeshift facilities along the coastline are washed away. Little damage on offshore backfilling. | Destructive |
| X | Few damage on quays and port facilities. Damage on objects at port facilities. Small failures on antierrosional works on the shoreline. | Very destructive |
| XI | Breakwaters are damaged. Failures at anti-erosion works on the shoreline. Damage on the roads near the coastline. Great damage at onshore lifelines. Damage on cranes and other port facilities. Tanks on port facilities are moved. Rail lines suffer damage. Many riprap boulders are detached and moved. Some industrial facilities are damaged. | Devastating |
| XII | Great damage in all port works such as jetties, marine breakwaters, port facilities, cranes, onshore lifelines. Riprap blocks are detached and moved in great distances. | Completely devastating |

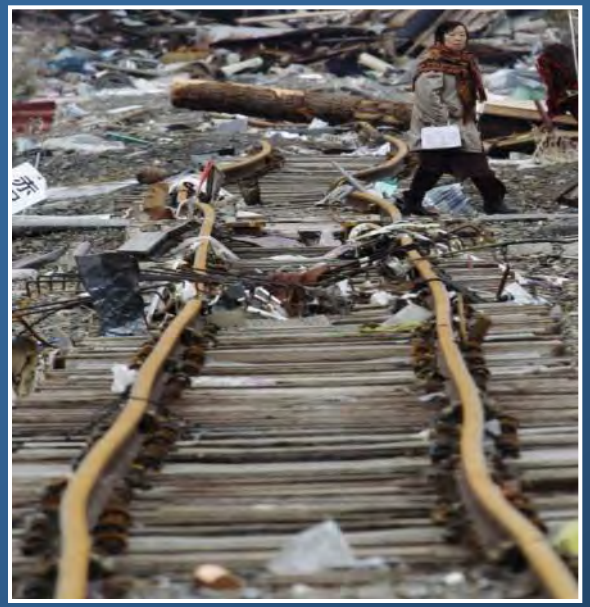

## X ITIS 2012 : Damage on quays and port facilities (THAILAND 2004, NE JAPAN 2011).

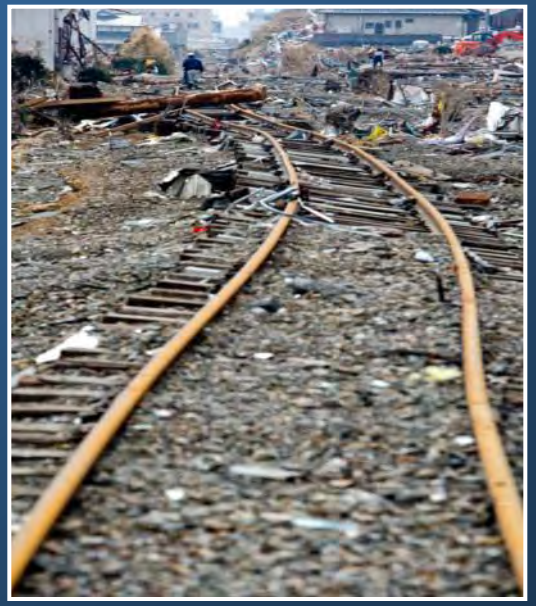
**X ITIS 2012 : Damage on objects at port facilities**

**IX ITIS 2012 : Ripraps are detached and/or moved**



**XII ITIS 2012 : Railway tracks damage, (NE JAPAN 2011).**

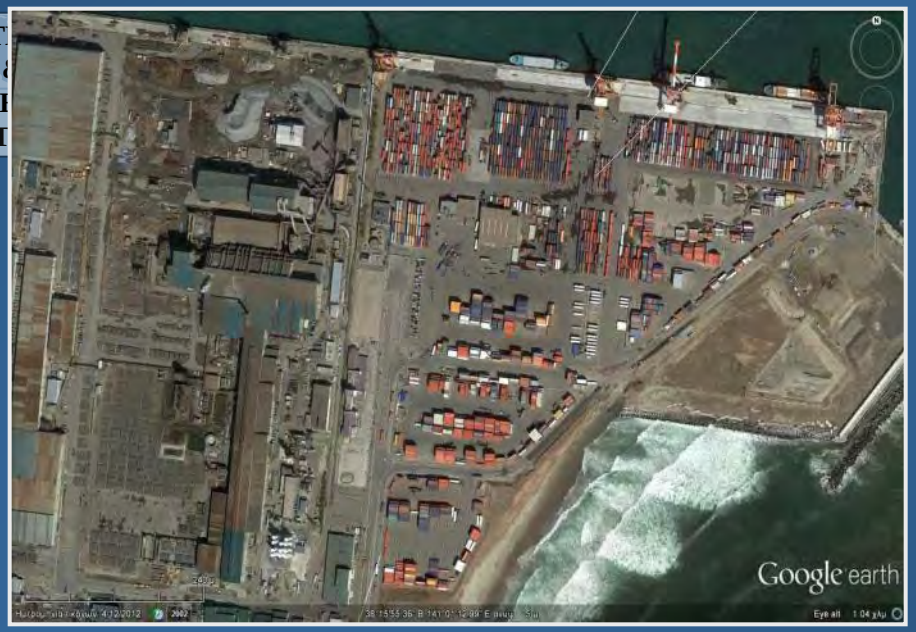




**XII ITIS 2012 : Damage on roads near the coastline, (THAILAND 2004, NE JAPAN 2011).**

XII ITIS 2012 : Failure on antierrosional works on the shoreline.

XII ITIS 2012 : Tanks on port facilities are moved


## XI ITIS 2012 : Some Industrial facilities are damaged, (NE JAPAN, 2011 )




| | | |
|---|---|---|
| **XII** | Great damage in all port works. such as jetties, marine breakwaters, port facilities, cranes, onshore lifelines. | **Completely devastating** |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# E. Impact on the Environment

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# E. IMPACT ON THE ENVIRONMENT

| | | |
|---|---|---|
| I | No effect | Not felt |
| II | No effect | Slightly felt |
| III | No effect | Weak |
| IV | No effect | Largely observed |
| V | No effect | Strong |
| VI | Marginal turbulence at coastal sediments. | Slightly damaging |
| VII | Garbage - debris at parts of the shoreline. Limited erosion - deposition of sand and pebble at coastal areas. | Damaging |
| VIII | Erosion and garbage - debris along the shoreline. Some bushes or trees are uprooted and get carried away in small distance. | Heavily damaging |
| IX | Depending on the topography and the kind of coastal formations, limited coastal profile changes with erosion and material deposition takes place. Garbage - debris deposition along the shoreline. Uprooting of bushes and some trees. | Destructive |
| X | Depending on the profile of offshore and onshore area, notable changes at the coastal profile take place due to erosion and deposition. Trees are uprooted and washed away, small boulders move. Extensive pollution from oil and chemicals. Fires break. | Very destructive |
| XI | Depending on the profile of offshore and onshore area and probable uplift or subsidence, changes at the coastal profile take place due to erosion deposition and deep erosion. Many trees are uprooted and washed away, small boulders are washed away. Great pollution from oil and chemicals. Many fires break. | Devastating |
| XII | Depending on the profile of offshore and onshore area and probable uplift or subsidence, extended changes at the coastal profile take place in wide areas, due to erosion deposition and deep erosion. Great changes on coastline topography. Almost all trees are uprooted and washed away. Big boulders are washed away on great distance. Massive pollution from oil and chemicals. Extensive fires break. | Completely devastating |

| | | |
|---|---|---|
| IX | Depending on the topography and the kind of coastal formations, limited coastal profile changes with erosion and material deposition take place. Garbage - debris deposition along the shoreline. Bushes and some trees are uprooted | Destructive |

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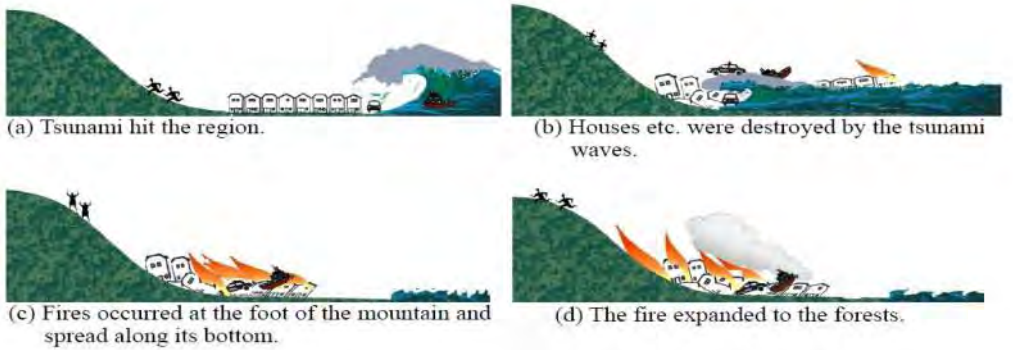
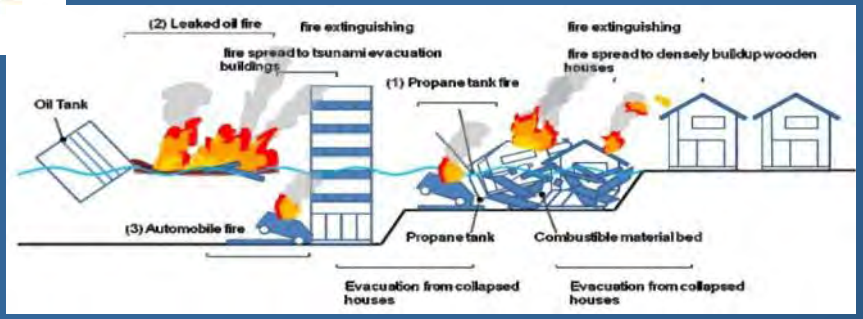
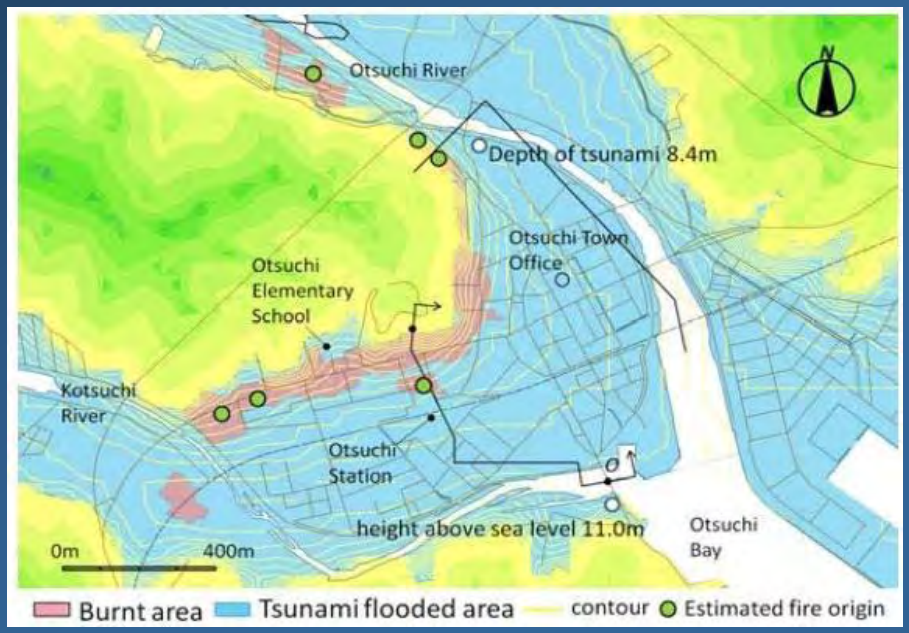
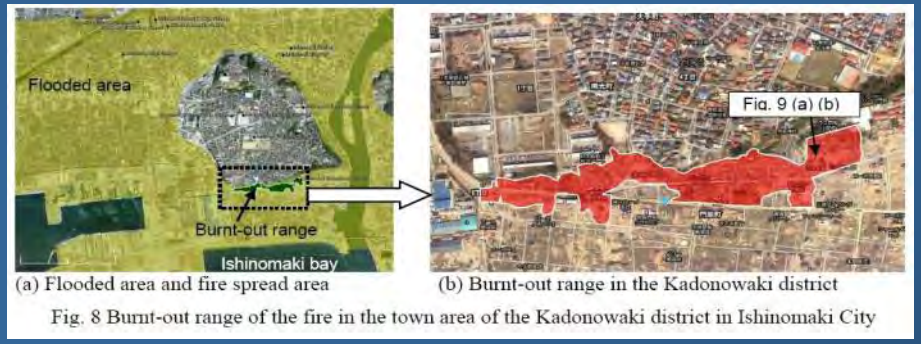
**IVIRONMENT**
**OGY**
**ANAGEMENT**



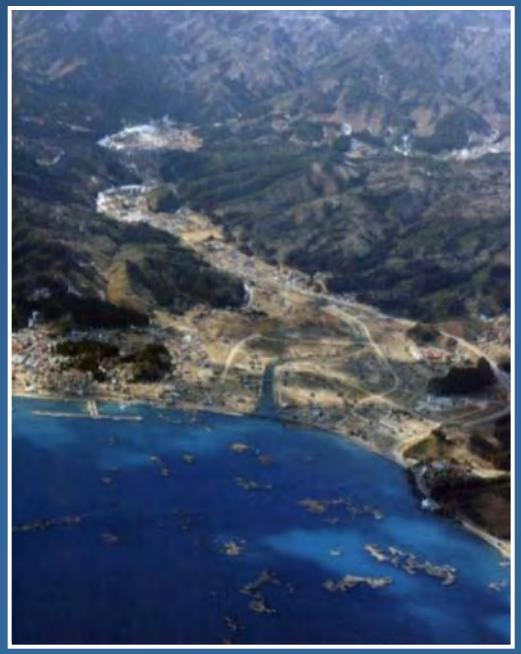



(a) Flooded area and fire spread area
(b) Burnt-out range in the Kadonowaki district

Fig. 8 Burnt-out range of the fire in the town area of the Kadonowaki district in Ishinomaki City

YAMADA, T. HIROI, U & SAKAMOTO, N., 2012



**XII ITIS 2012 : Massive oil and chemicals pollution, (NE JAPAN 2011).**

## XII ITIS 2012 : Garbage - debris deposition, (ONAGAWA, NE JAPAN 2011)

XII ITIS 2012 : Great changes on coastline topography, (BANDA AJEK & PHI PHI ISLAND, INDIAN OCEAN 2004).

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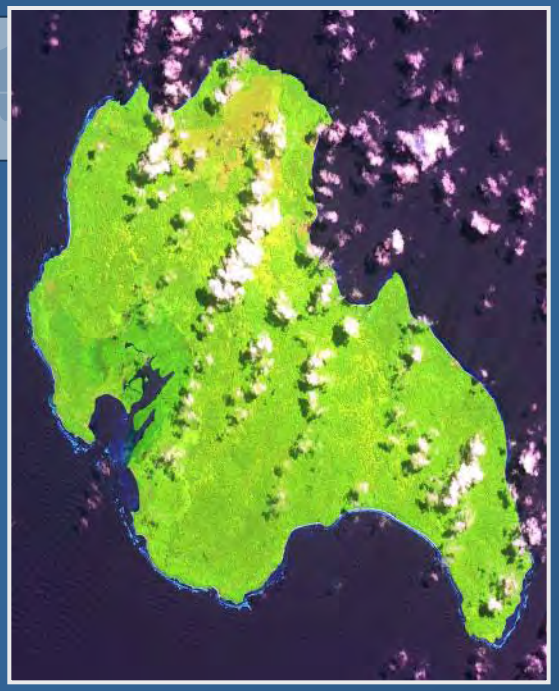
## XII ITIS 2012 : Great changes on coastline topography, (NE JAPAN 2011)

XII ITIS 2012 : Great changes on coastline topography, (THAILAND, 2004)

XII ITIS 2012 : Great changes on coastline topography, (NW SUMATRA 2004, NE JAPAN 2011, ADAMON ISLAND INDIAN OCEAN 2004)

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# F. Impact on Structures

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# F. IMPACT ON STRUCTURES

| | | |
|---|---|---|
| I | No damage | Not felt |
| II | No damage | Slightly felt |
| III | No damage | Weak |
| IV | No damage | Largely observed |
| V | Damage of grade 1 to a few buildings of vulnerability class A and B | Strong |
| VI | Damage of grade 1 is sustained by many buildings of vulnerability class A and B; a few of class A and B suffer damage of grade 2; a few of class C suffer damage of grade 1 | Slightly damaging |
| VII | Many buildings of vulnerability class A suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class B suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class C sustain damage of grade 2. A few buildings of vulnerability class D sustain damage of grade 1. | Damaging |
| VIII | Many buildings of vulnerability class A suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class B suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class C suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class D sustain damage of grade 2. | Heavily damaging |
| IX | Many buildings of vulnerability class A sustain damage of grade 5. Many buildings of vulnerability class B suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class C suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class D suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class E sustain damage of grade 2. | Destructive |
| X | Most buildings of vulnerability class A sustain damage of grade 5. Many buildings of vulnerability class B sustain damage of grade 5. Many buildings of vulnerability class C suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class D suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class E suffer damage of grade 2; a few of grade 3. A few buildings of vulnerability class F sustain damage of grade 2. | Very destructive |
| XI | Most buildings of vulnerability class B sustain damage of grade 5. Most buildings of vulnerability class C suffer damage of grade 4; many of grade 5. Many buildings of vulnerability class D suffer damage of grade 4; a few of grade 5. Many buildings of vulnerability class E suffer damage of grade 3; a few of grade 4. Many buildings of vulnerability class F suffer damage of grade 2; a few of grade 3. | Devastating |
| XII | All buildings of vulnerability class A, B and practically all of vulnerability class C are destroyed. Most buildings of vulnerability class D, E and F are destroyed. The earthquake effects have reached the maximum conceivable effects. | Completely devastating |

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| CLASSIFICATION OF DAMAGE TO TIMBER STRUCTURES | CLASSIFICATION OF DAMAGE TO STEEL STRUCTURES | CLASSIFICATION OF DAMAGE TO MASONRY STRUCTURES | CLASSIFICATION OF DAMAGE TO BUILDINGS OF R.C. |
|---|---|---|---|
| **Grade 1 - Slight damage**<br>Perimetrical imprints of water level. Slight abrasions. Light objects overturn. | **Grade 1 - Slight damage**<br>Perimetrical imprints of water level. Slight abrasions. Light objects overturn. | **Grade 1 - Slight damage**<br>Perimetrical imprints of water level. Slight abrasions on walls. Light objects overturn outwards. | **Grade 1 - Slight damage**<br>Perimetrical imprints of water level. Slight abrasions on walls. Light objects overturn outwards. |
| **Grade 2 - Moderate damage**<br>Extensive external abrasions. Windows break. Decorative elements detachment. | **Grade 2 - Moderate damage**<br>Extensive external abrasions. Windows break. Decorative elements detachment. | **Grade 2 - Moderate damage**<br>External erosion Extensive external abrasions. Windows break. Decorative elements detachment. | **Grade 2 - Moderate damage**<br>Extensive perimetrical abrasions. Windows break. Decorative elements detachment. |
| **Grade 3 - Heavy damage**<br>Walls fracture, roof damage. Doors break. Small deformations. | **Grade 3 - Heavy damage**<br>Deformation and detachment of frame elements. Doors break. | **Grade 3 - Heavy damage**<br>Partial wall collapse. Roof damage, tiles are detached, or extensive wall damage from object impact.Doors and shutters break. | **Grade 3 - Heavy damage**<br>Masonry wall damage. Masonry wall damage due to object impact. |
| **Grade 4 - Very heavy damage**<br>Extensive fracture on walls and roof. Detachment and small movement of the construction. | **Grade 4 - Very heavy damage**<br>Extensive detachment of wall elements. Load bearing structure exposure. | **Grade 4 - Very heavy damage**<br>Partial building collapse. Partial - total roof collapse. | **Grade 4 - Very heavy damage**<br>Extensive damage on masonry walls, masonry walls blow up. Reinforced masonry walls suffer damage. Load bearing elements are destroyed, few building collapses. |
| **Grade 5 - Destruction**<br>Total fracture and collapse of the construction. Detachments of all the construction and transport at sufficient distance. | **Grade 5 - Destruction**<br>Extensive load bearing structure deformation. Buildings are possible to be detached and carried away at great distances. | **Grade 5 - Destruction**<br>Total collapses of most of the buildings. Debris is carried away. Buildings disappear. Buildings are uprooted. | **Grade 5 - Destruction**<br>Total destruction of most of buildings. Construction elements are carried away. |

## TIMBER STRUCTURES

**Grade 3 - Heavy damage.**
Walls fracture, roof damage. Doors break. Small deformations.

**Grade 4 - Very heavy damage.**
Extensive fracture on walls and roof. Detachment and small movement of the construction.

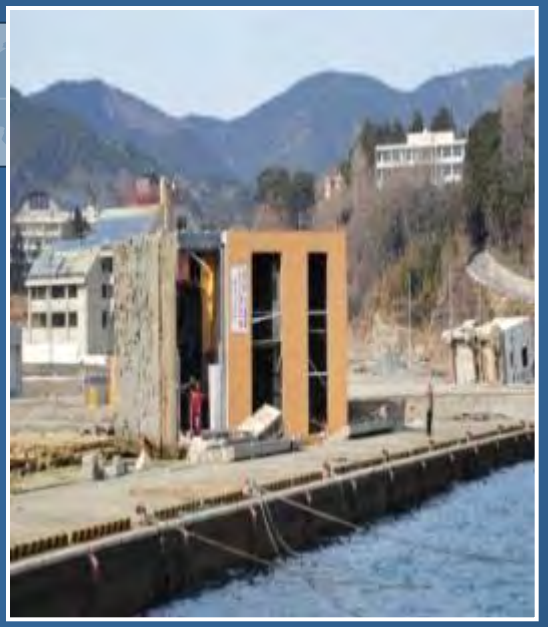
**Grade 5 – Destruction.**

Total fracture and collapse of the construction. Detachments of all the construction and transport at sufficient distance.

## TIMBER STRUCTURES

**Grade 4 - Very heavy damage.**
Extensive damage on masonry walls, masonry walls blow up. Reinforced masonry walls suffer damage. Load bearing elements are destroyed.

## R.C. BUILDINGS



## R.C. BUILDINGS

**Grade 5 – Destruction.**

Total destruction of most of buildings. Construction elements are carried away.

## STEEL STRUCTURE

**Grade 2 - Moderate damage.**

Extensive external abrasions. Windows break. Decorative elements detachment.

## STEEL STRUCTURE

**Grade 3 - Heavy damage.**
Deformation and detachment of frame elements. Doors break.

## STEEL STRUCTURE

**Grade 4 - Very heavy damage.**
Extensive detachment of wall elements. Load bearing structure exposure.

## STEEL STRUCTURE

**Grade 5 – Destruction.**

Extensive load bearing structure deformation. Buildings detached and carried away at great distances.

## STEEL STRUCTURE

**Grade 5 – Destruction.**

Extensive load bearing structure deformation. Buildings detached and carried away at great distances.

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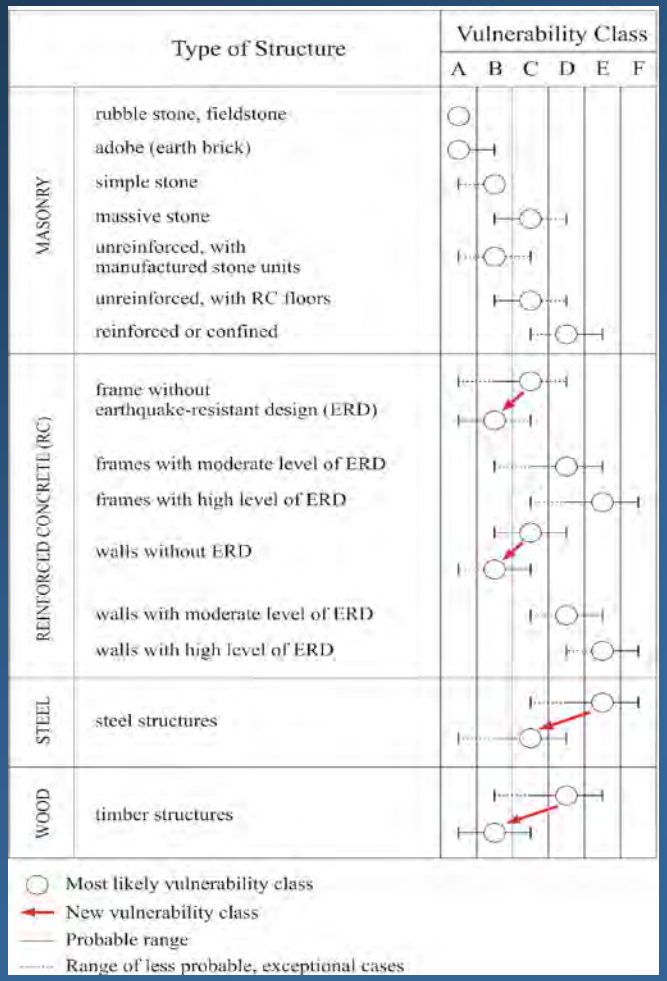


Vulnerability Table. Differentiation of structure (building) into vulnerability classes based on the EMS-1998 (Grünthal, 1998). Modifications to the Vulnerability Class for certain types of structures are shown.

| | | MAXIMUM GRADE OF DAMAGE BY VULNERABILITY CLASS | | | | | |
|---|---|---|---|---|---|---|---|
| ITIS$_{2012}$ | TSUNAMI HEIGHT / TSUNAMI FLOW DEPTH | A | B | C | D | E | F |
| I | - | | | | | | |
| II | - | | | | | | |
| III | - | | | | | | |
| IV | <0,5 | | | | | | |
| V | 0,5-1 | 1 | 1 | | | | |
| VI | <1 | 2 | 2 | 1 | | | |
| VII | 1-2 | 4 | 3 | 2 | 1 | | |
| VIII | 2-5 | 5 | 4 | 3 | 2 | | |
| IX | 5-7 | 5 | 5 | 4 | 3 | 2 | |
| X | 7-10 | 5 | 5 | 5 | 4 | 3 | 2 |
| XI | <10 | 5 | 5 | 5 | 4 | 4 | 3 |
| XII | >10 | | | | 5 | 5 | 5 |

Relationship between tsunami height and damage grading of on-land structures and buildings

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# NEW INTEGRATED TSUNAMI INTENSITY SCALE 2012 (ITIS-2012)

**The main characteristics of the new tsunami intensity scale are:**

- **The scale is based on 6 different criteria, more than any other existing scale and offers horizontal correlation between criteria in every intensity grade.**
- **There is a gradual increase of the intensity grades, which is observable in all 6 criteria categories with clear boundaries between grades, at the same time.**
- **Quantities are easily measured. Objective criteria are more than subjective criteria.**
- **Evidence and grading is based at fieldwork data and particular damage types and not in theoretical data.**
- **The new intensity scale is fully compatible with EMS 1998 and ESI 2007 .**
- **Covers a wide span of land use type areas, such as agricultural, natural, ports, and a variety of different infrastructure and protection facilities/works.**
- **Application of the scale and area microzonation in smaller areas is easier via the use of remote sensing techniques.**
- **A 12-grade scale is more accurate and does not saturate, as 6-grade scales.**

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