IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

JORNADA TÉCNICA SOBRE EL RIESGO DE MAREMOTOS. PROYECTO DE LA DIRECTRIZ BÁSICA DE PROTECCIÓN CIVIL ANTE EL RIESGO MAREMOTC

Aportaciones de las herramientas numéricas para la toma de decisiones en Sistemas de Alerta Temprana (SAT) y otras herramientas de apoyo

Mauricio González

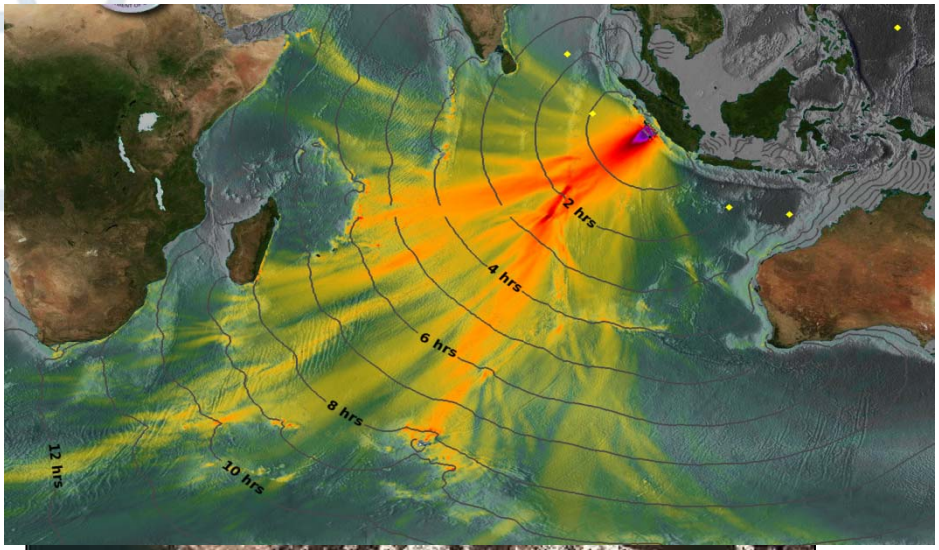
Instituto de Hidráulica Ambiental (IH Cantabria)
Universidad de Cantabria

mauricio.gonzalez@unican.es

Tragedia en Indonesia el 26 Diciembre de 2004

Mw=9.1 Tsunami de gran magnitud puede ocurrir en cualquier sitio

- **No se estaba preparado**
- **Mas de 230,000 muertos**

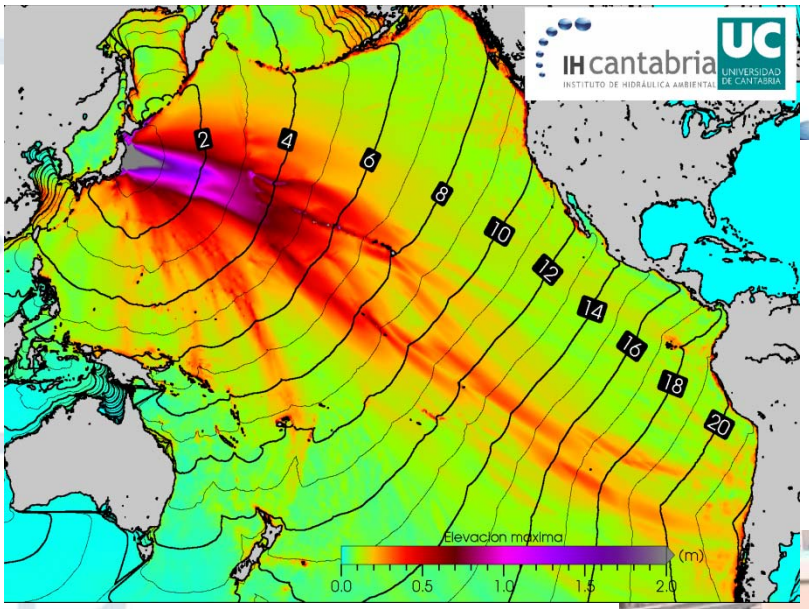


Banda Aceh-indonesia

Islas Phi Phi_Tailandia

Mw=9.0

Tragedia en Japón el 11 Marzo de 2011



- 20,000 muertos
- Uno de los país mas preparado en el mundo
- Obras diseñadas proteger población fallaron
- Debate concepto riesgo: Nivel I y Nivel II

Costa española

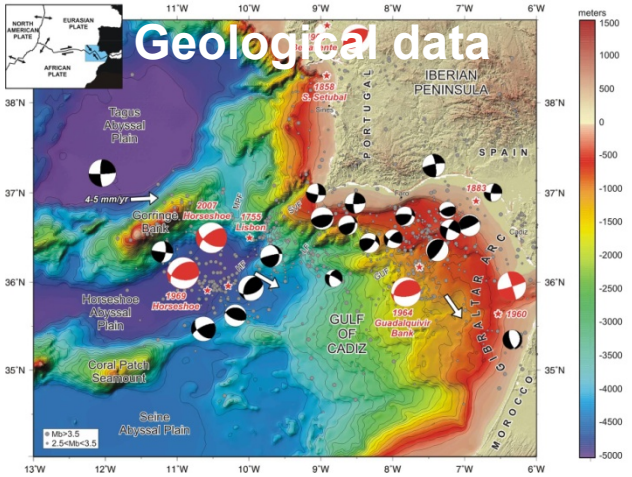
- **Golfo de Cádiz:**
  Zona expuesta a tsunamis poco frecuentes pero de gran magnitud, con inundaciones devastadoras y gran impacto en la población

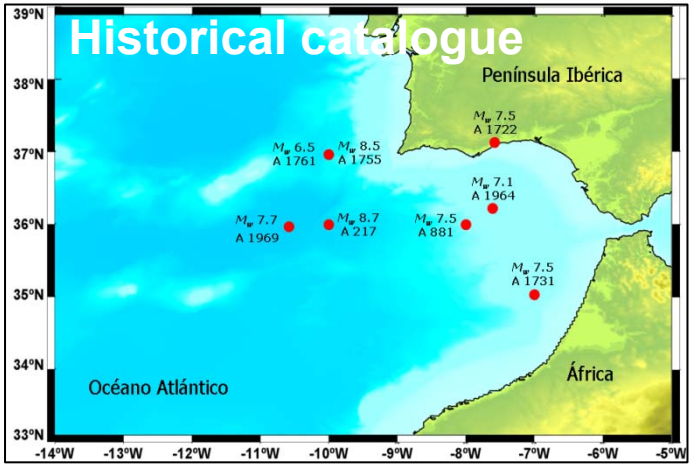
- **Islas Baleares:**
  frecuencia mayor de tsunamis de menor amplitud, que pueden causar inundaciones y daños importantes en el interior de los puertos

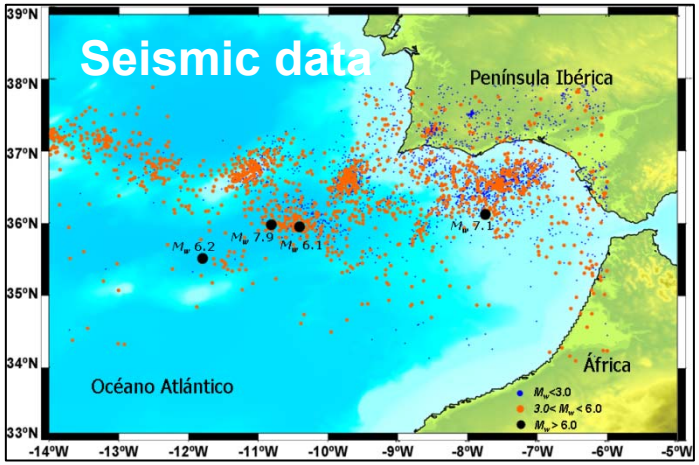
IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

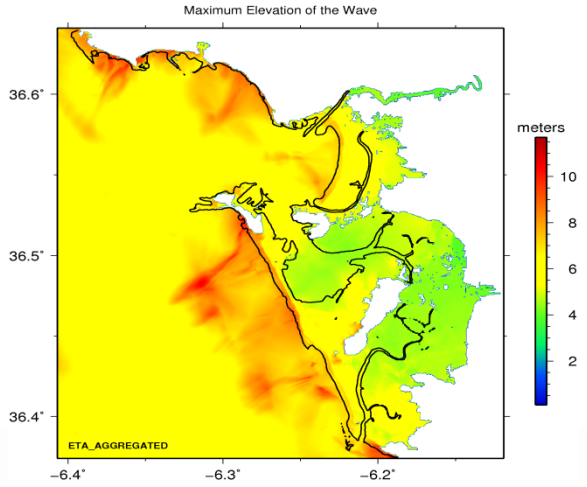
TRANSFER

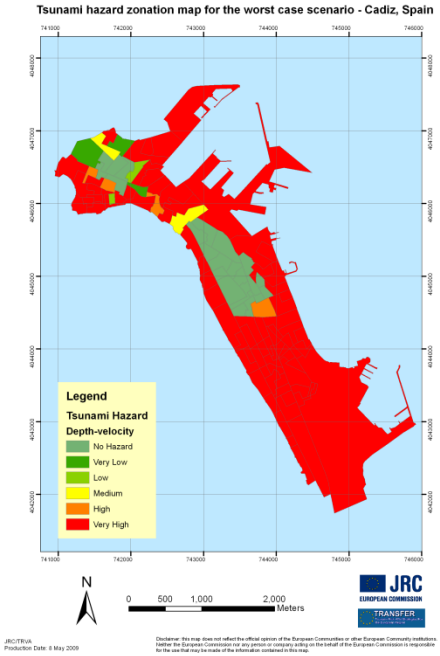
El Riesgo de tsunamis en España es ALTO









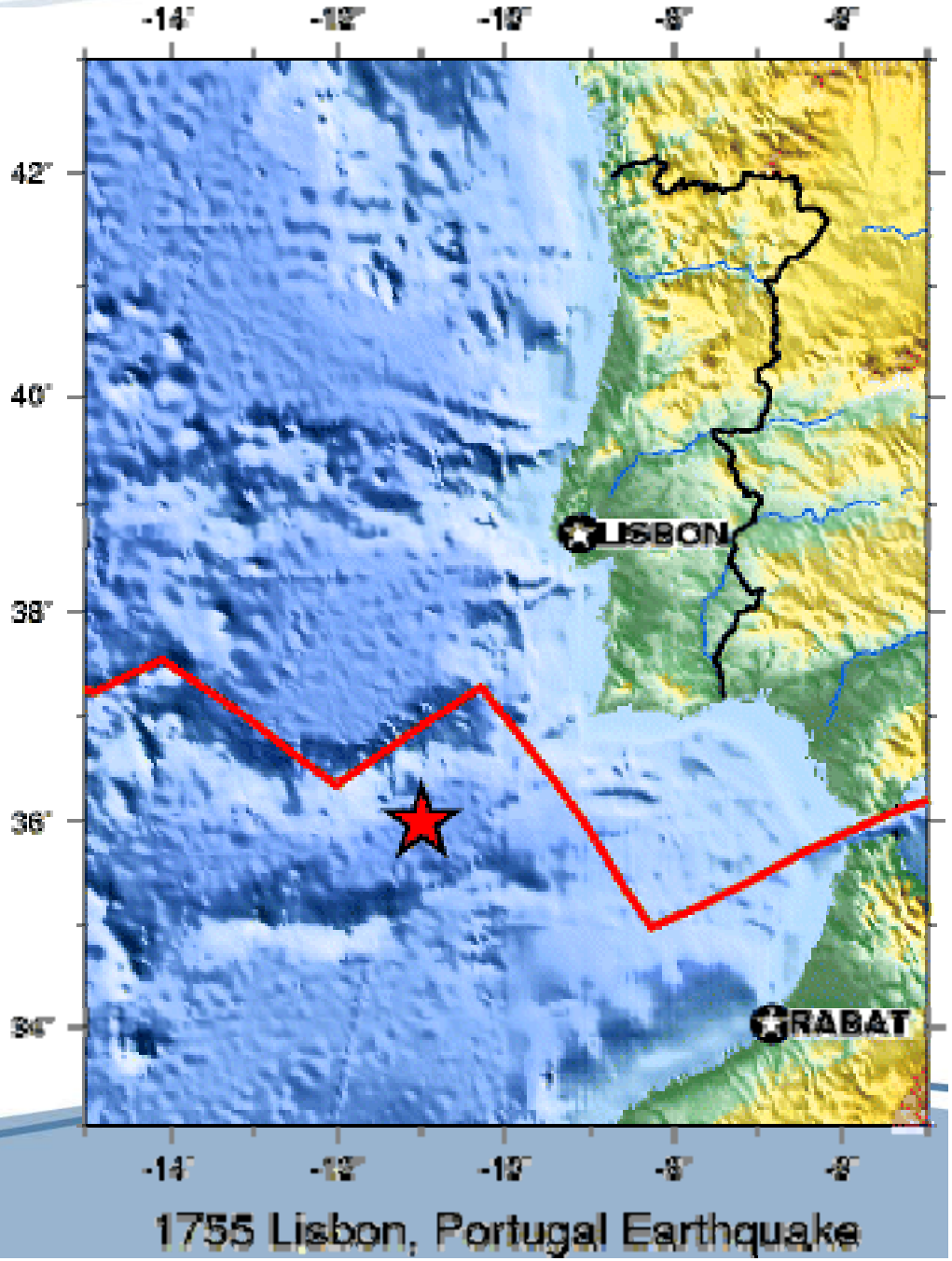


FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL

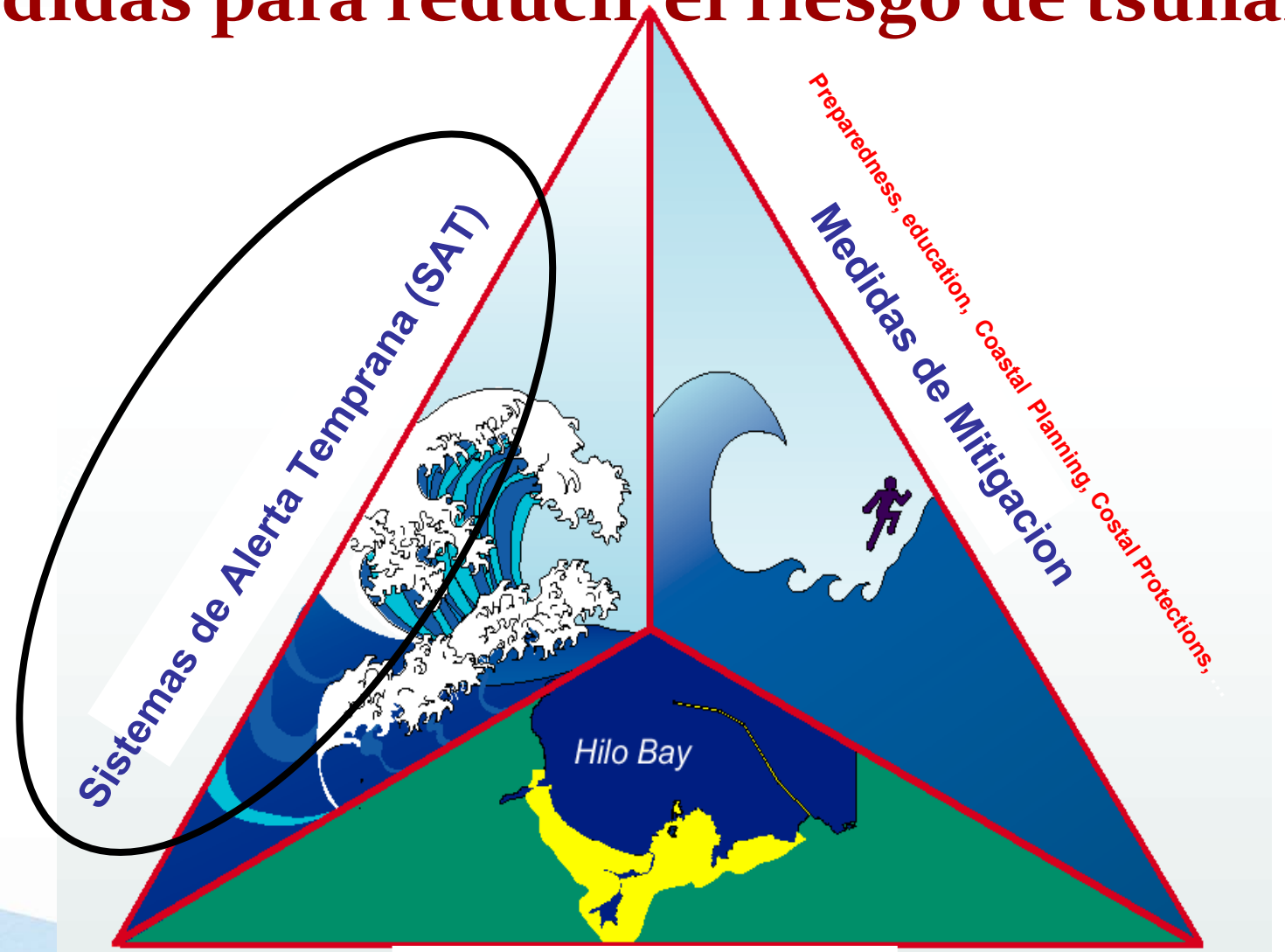
Un tsunami igual o peor que el de Lisboa 1755

Puede ocurrir en cualquier momento!!!

Por lo tanto, hay que estar preparados…..

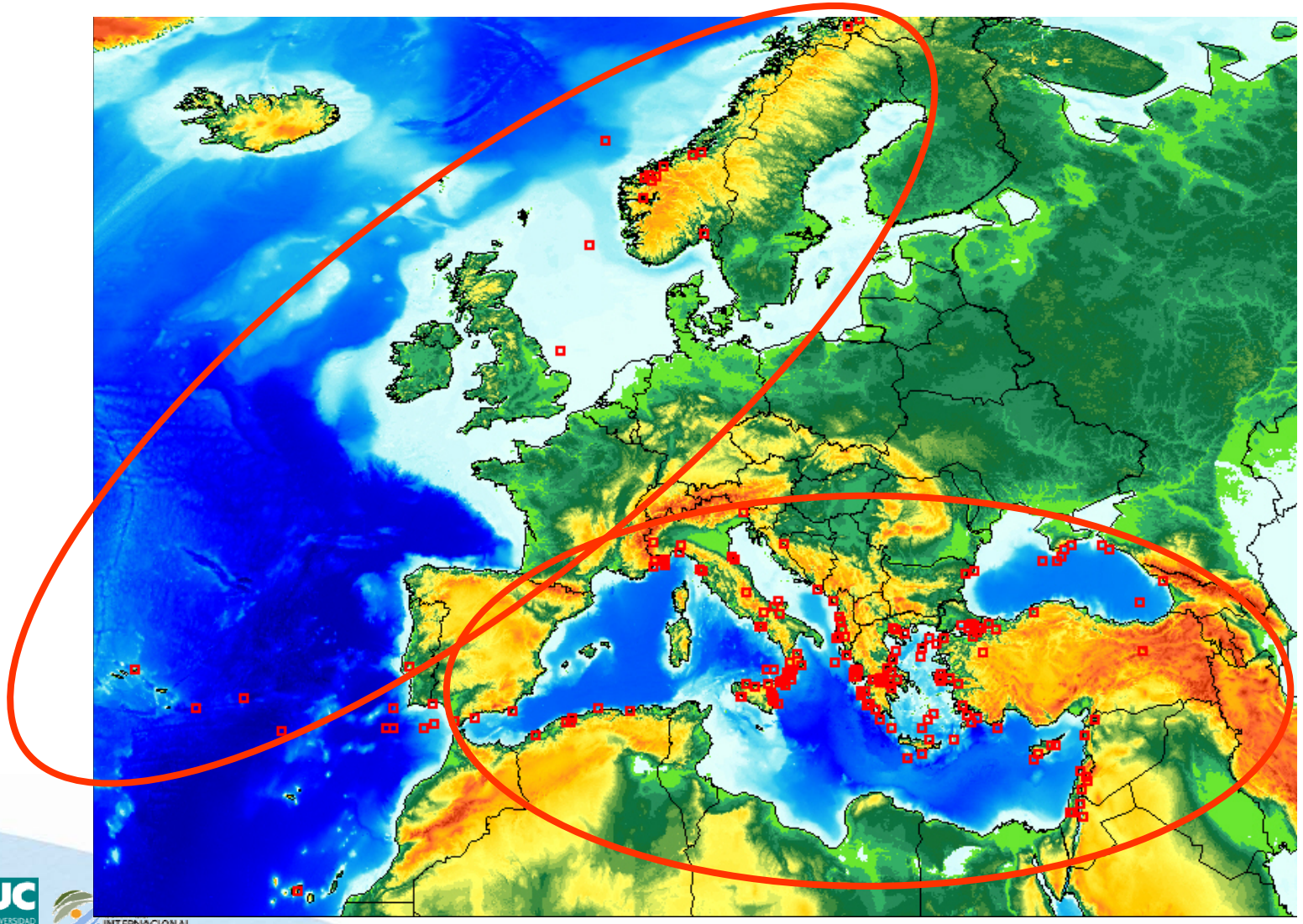


Medidas para reducir el riesgo de tsunamis

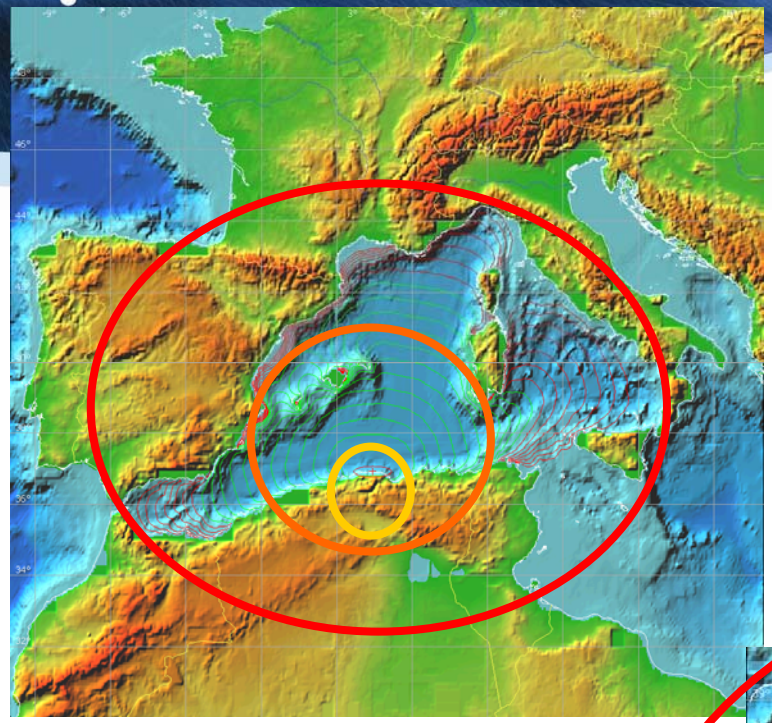


Sistema de Alerta Regional (NEAMTWS)

North-eastern Atlantic and Mediterranean region

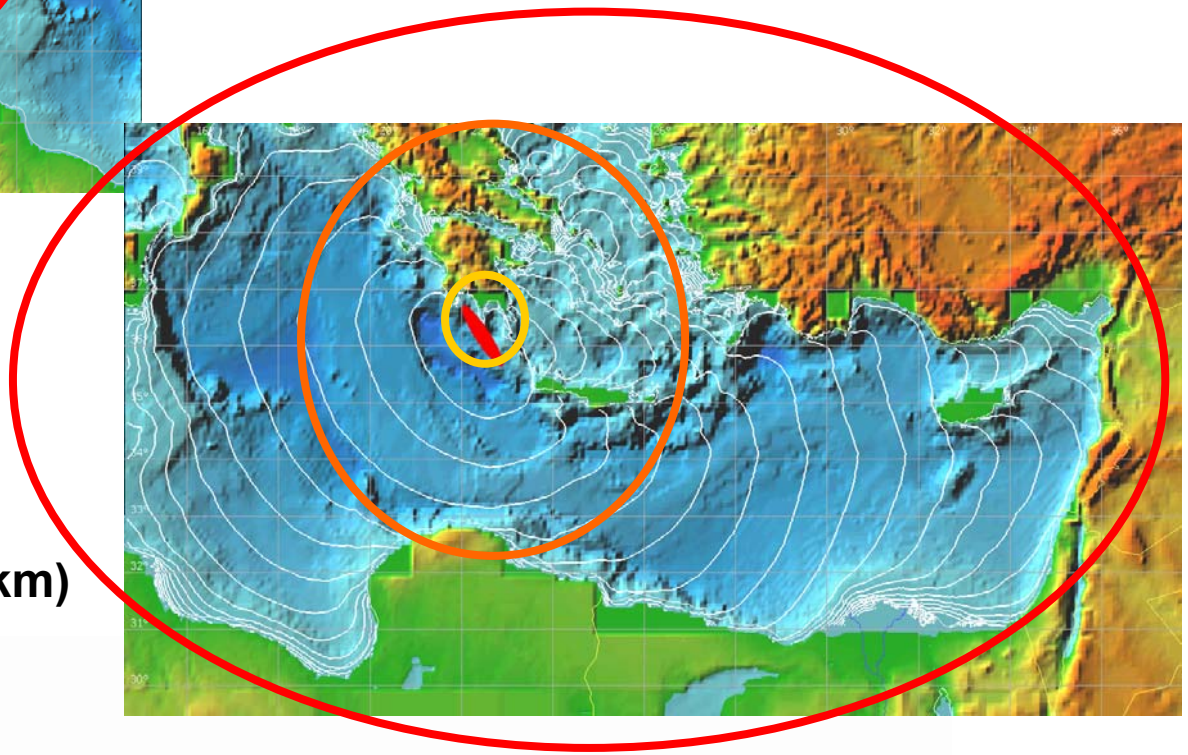


MATRIZ de DECISION Mediterraneo



Nivel de alerta depende de:

- La distancia al epicentro
- La magnitud del terremoto Mw



TSUNAMIS

- Local (< 100km)
- Regional (100 < 400 km)
- Basin (> 400 km)

MATRIZ de DECISION

2 niveles diferentes

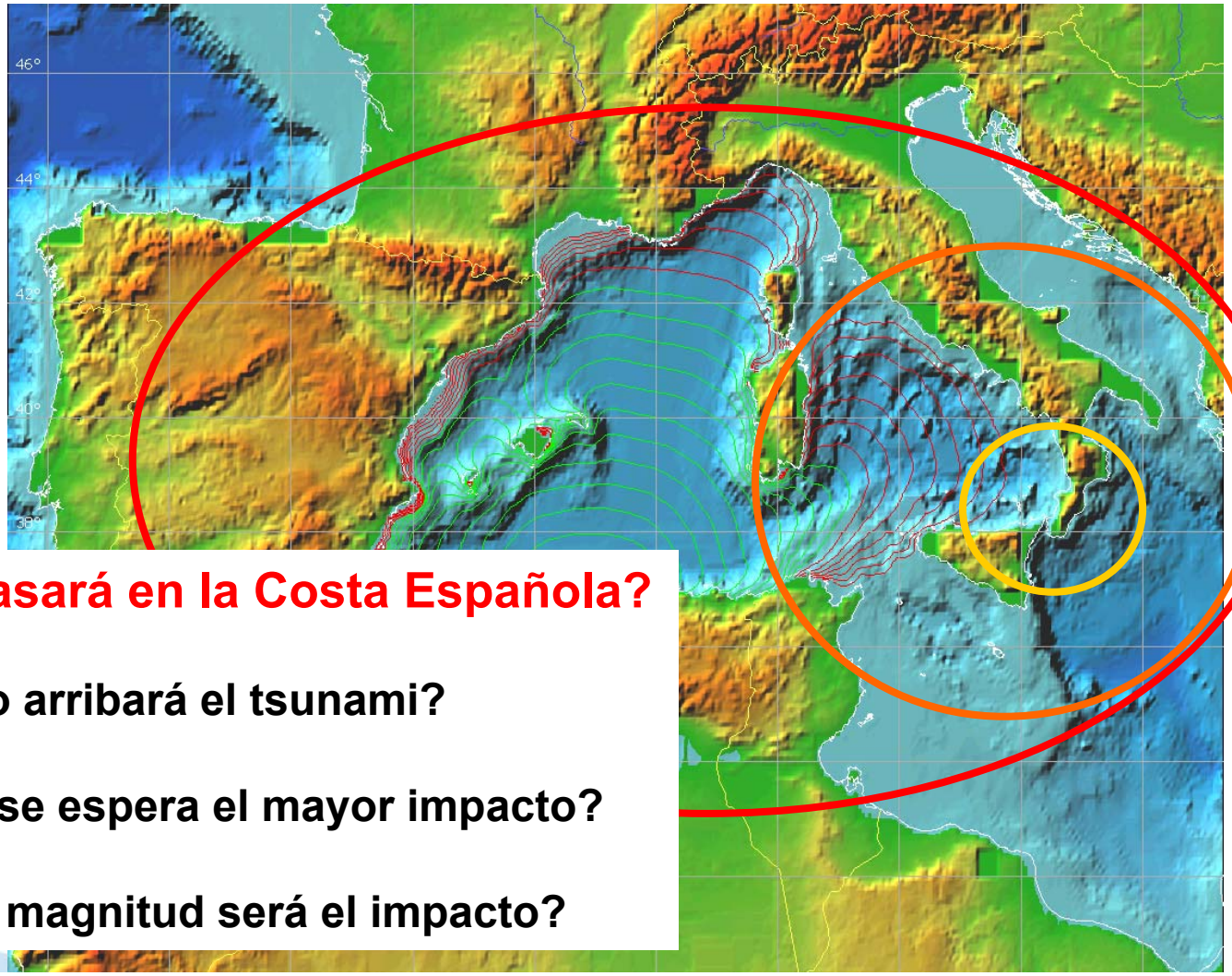
	Advisory Aviso advertencia	Watch Aviso de alerta Estar en guardia
Run-up	< 1 m	> 1 m
Amplitude	0.2 – 0.5 m	> 0.5 m
Impact	Corrientes, remolinos , destruccion en el agua, Sin inundacion o pequenas en las playas	Watch Impacto + Inundacion

Matriz de Decision Mediterraneo

Depende de parámetros sísmicos

Depth	Location	(Mw)	Tsunami Potential	Bulletin Type
< 100 km	Sub-sea or very near the sea (< 30 km)	**5.5 to 6.0**	Small potential for a local tsunami	**Information Bulletin**
		6.0 to 6.5	Potential for a destructive local tsunami < 100 km	**Regional Tsunami Advisory**
		6.5 to 7.0	Potential for a destructive regional tsunami < 400 km	**Regional Tsunami Watch Basin-wide Tsunami Advisory**
		≥ **7.0**	Potential for a destructive basin-wide tsunami > 400 km	**Basin-wide Tsunami Watch**
	Inland (> 30 km)	**5.5**	No tsunami potential	**Information Bulletin**
≥ 100 km	All Locations	≥ **5.5**	No tsunami potential	**Information Bulletin**

Se requiere de un sistema de alerta Local que de respuesta a estas preguntas durante la emergencia



Que pasará en la Costa Española?

Cuando arribará el tsunami?

Donde se espera el mayor impacto?

De que magnitud será el impacto?

Mw=7.0

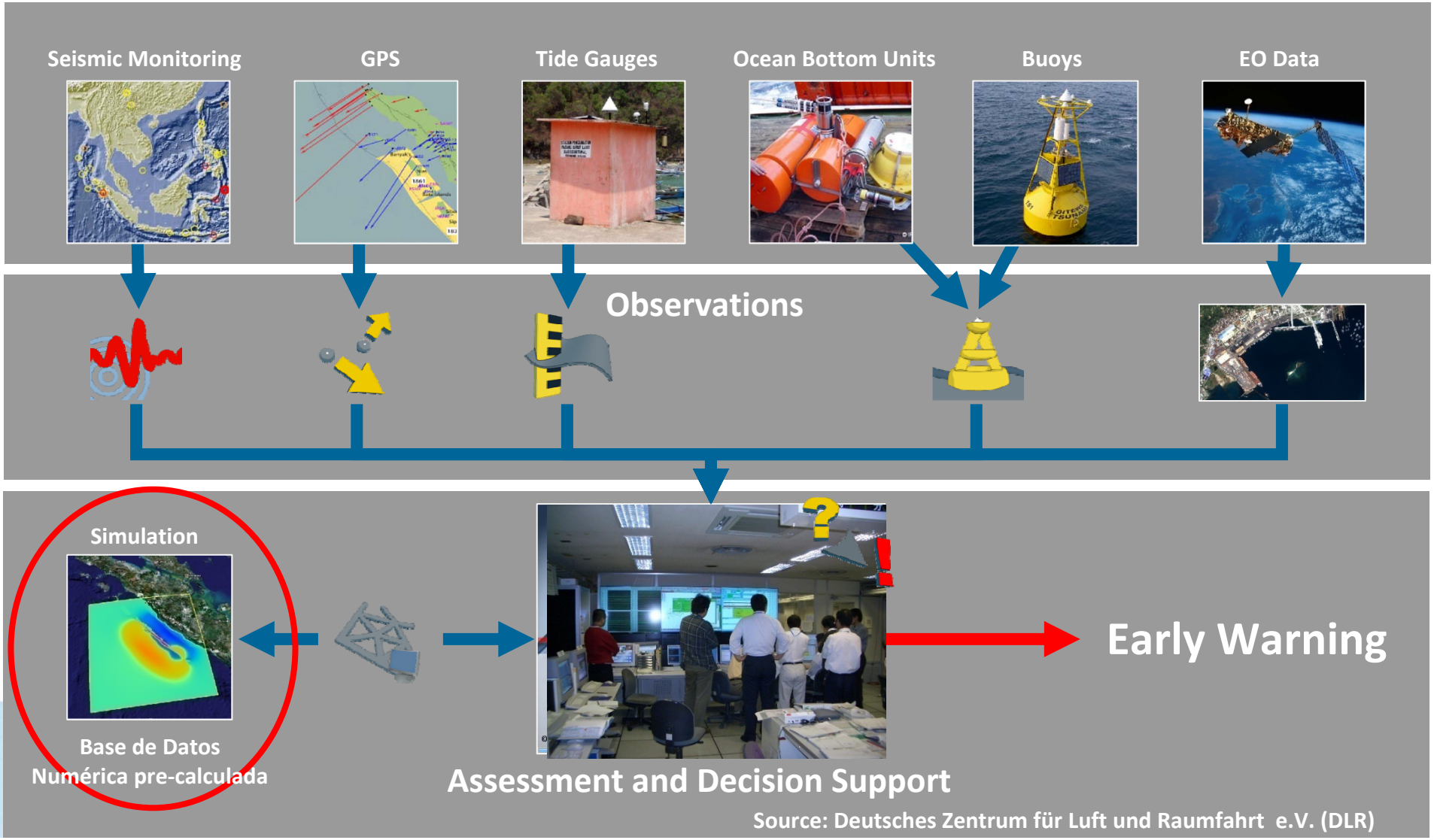
Basin: "Tsunami Watch"

Impacto + inundación

Que municipalidades deben activar planes de emergencia?

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Sistema de Alerta temprana (SAT)



Source: Deutsches Zentrum für Luft und Raumfahrt e.V. (DLR)

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Sultanate of Oman
Public Authority for Civil Aviation
Directorate General of Meteorology and Air Navigation

TSUNAMI numerical Scenario Database

For the local Tsunami Warning System in Oman

Supplying, Training, Installing and Commissioning
ASSESSMENT OF COASTAL HAZARDS, VULNERABILITY AND RISK FOR THE COAST OF OMAN

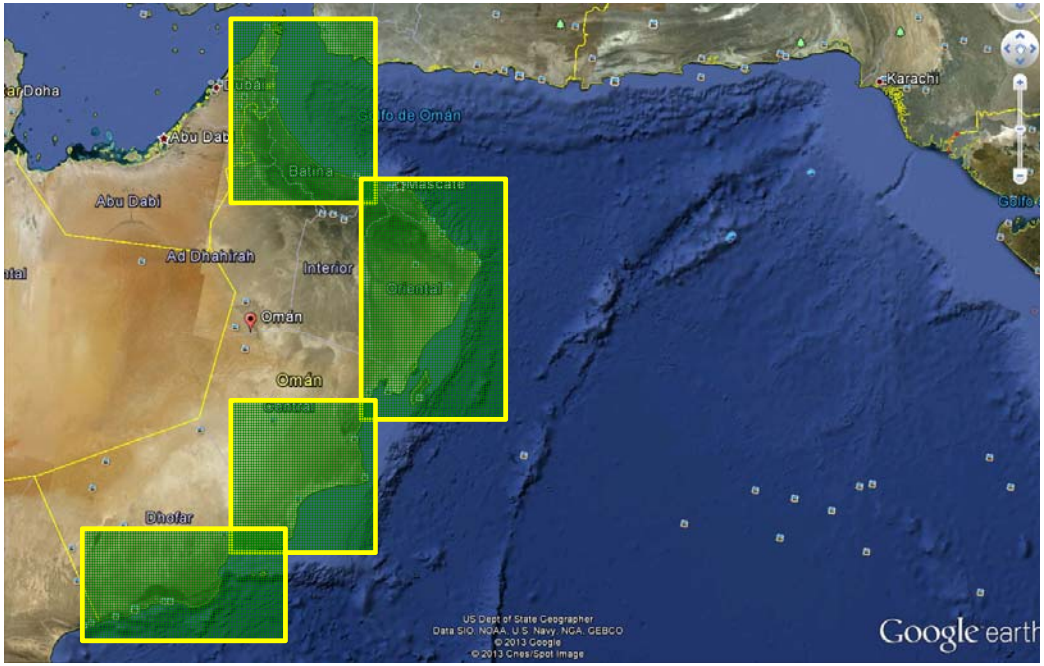
(Sultanate of Oman and UNESCO)

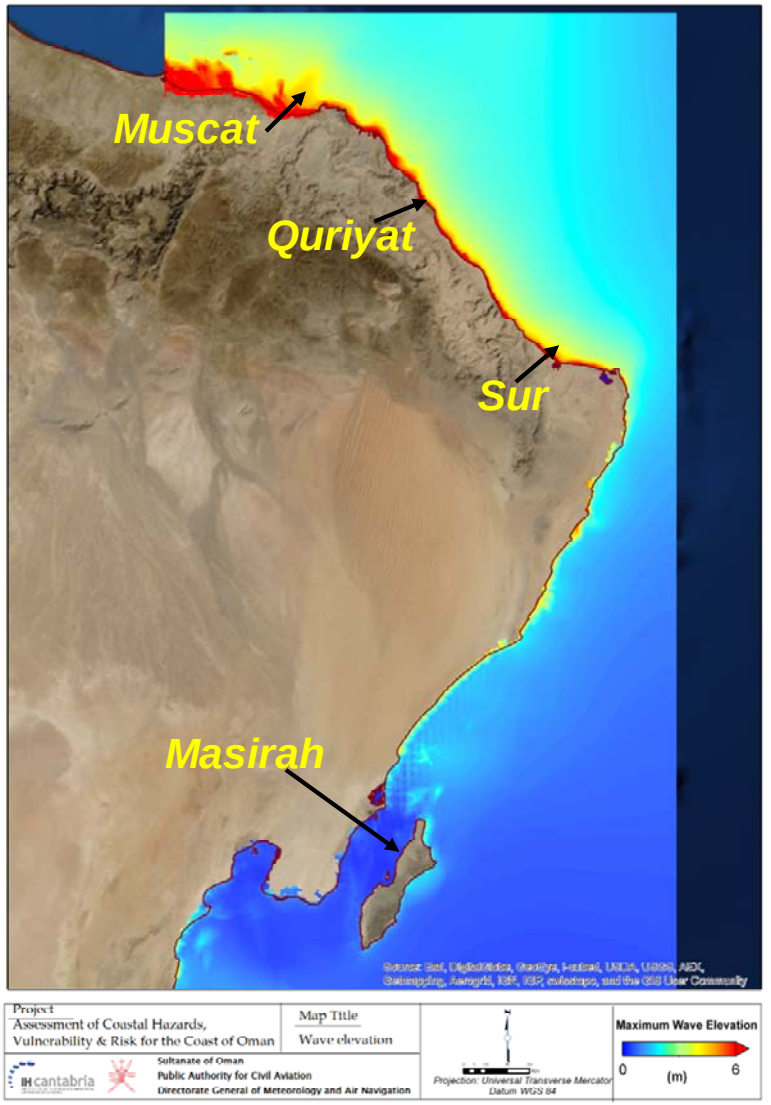
FUNDACION

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Tsunami Hazard Assessment

Mapas de Inundación a escala Nacional

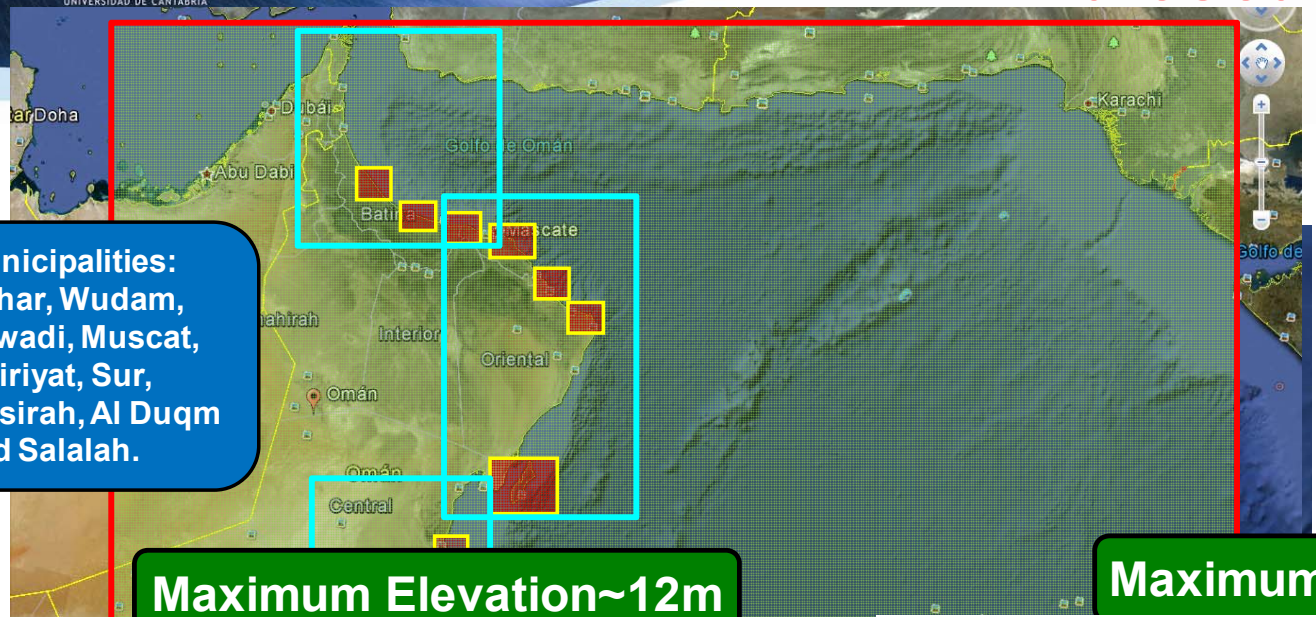




FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL

Mapas de Inundación a escala Local

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

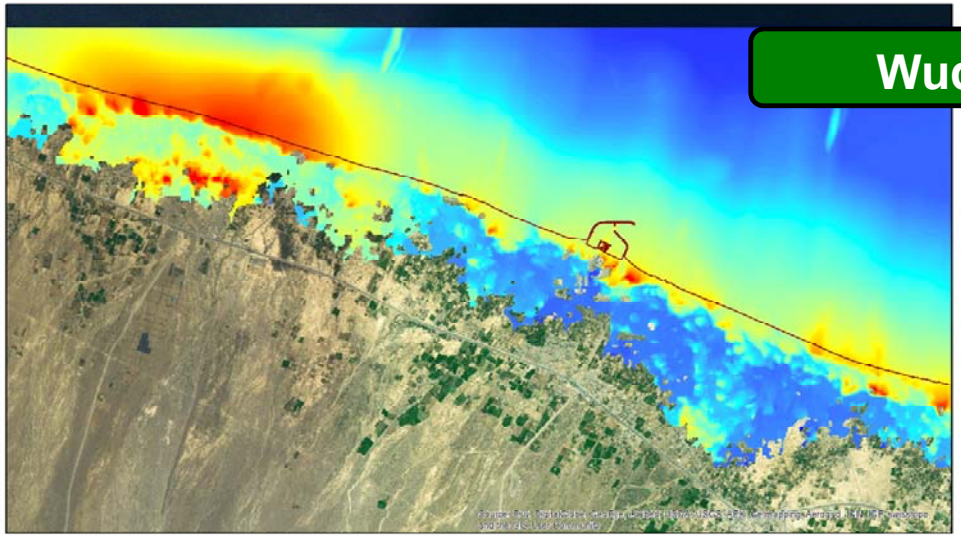


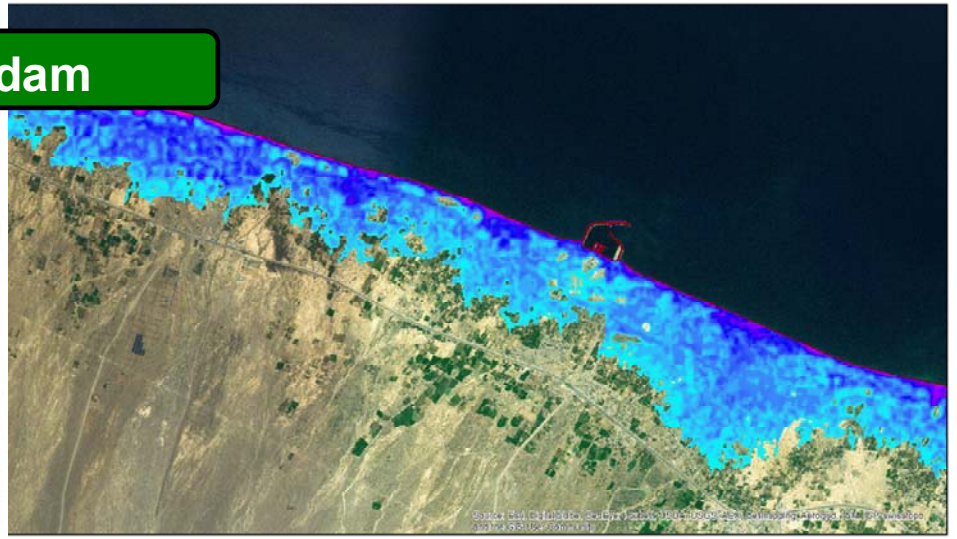
Municipalities: Sohar, Wudam, Sawadi, Muscat, Quiriyat, Sur, Masirah, Al Duqm and Salalah.

Maximum Elevation~12m

Maximum water depth~12m

Wudam





Project
Assessment of Coastal Hazards,
Vulnerability & Risk for the Coast of Oman

Map Title
maximum wave height

Sultanate of Oman
Public Authority for Civil Aviation
Directorate General of Meteorology and Air Navigation

Projection: Universal Transverse Mercator
Datum WGS 84

Maximum Wave Elevation
0 (m) 10

Project
Assessment of Coastal Hazards,
Vulnerability & Risk for the Coast of Oman

Map Title
water depth

Sultanate of Oman
Public Authority for Civil Aviation
Directorate General of Meteorology and Air Navigation

Projection: Universal Transverse Mercator
Datum WGS 84

Maximum water Depth
0 (m) 10

Multi Hazard Early Warning System (MHEWS)

Objectivo General

- Desarrollar una **base de datos de escenarios de tsunami** con base en simulaciones numéricas para el MHEWS

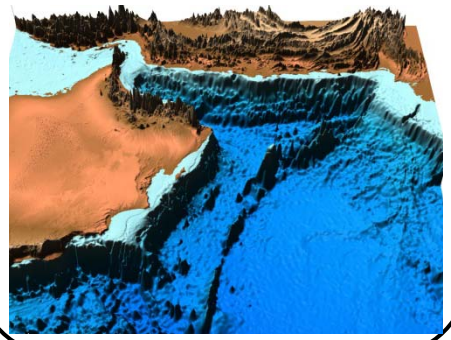
Objetivos Específicos

- Caracterización Sismotectonica de potenciales eventos de tsunami que afecten a Omán
- Modelación Numérica de escenarios
- Algoritmo automático de selección y representación de resultados en forescast points and zones in Oman

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

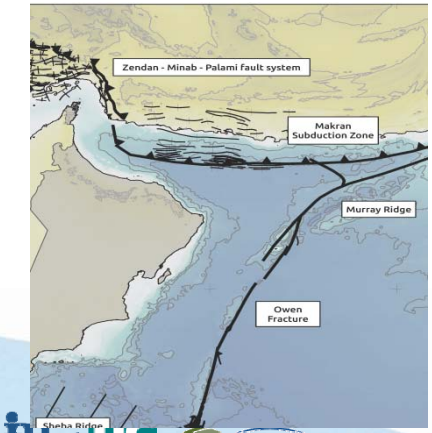
Methodology

PROPAGATION GRIDS



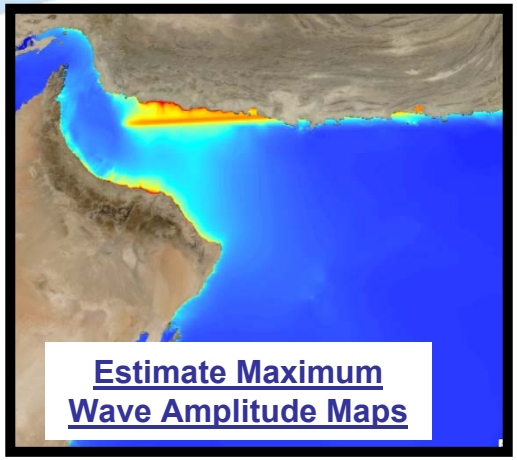
SEISMOTECTONIC

TSUNAMI EVENTS

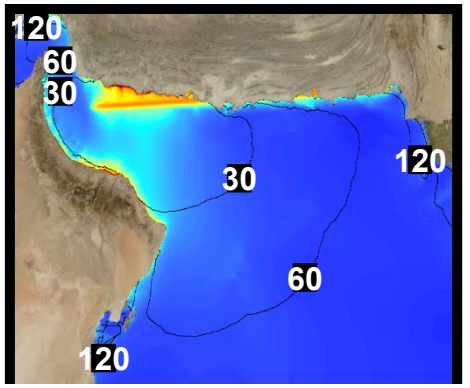


Propagation Model

C3-COMCOT



Estimate Maximum Wave Amplitude Maps

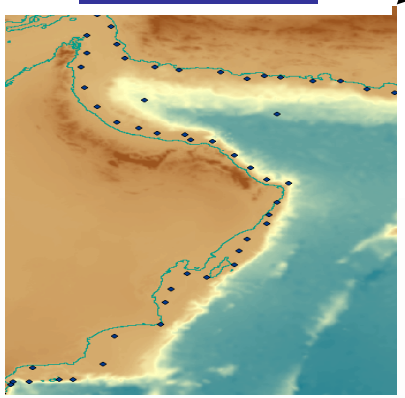


Estimate Travel Time Maps

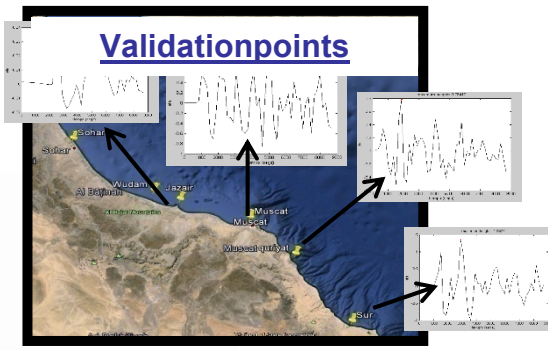
Scenarios database feed MHEWS

Selection Algorithm

Forecast points



Validationpoints



IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

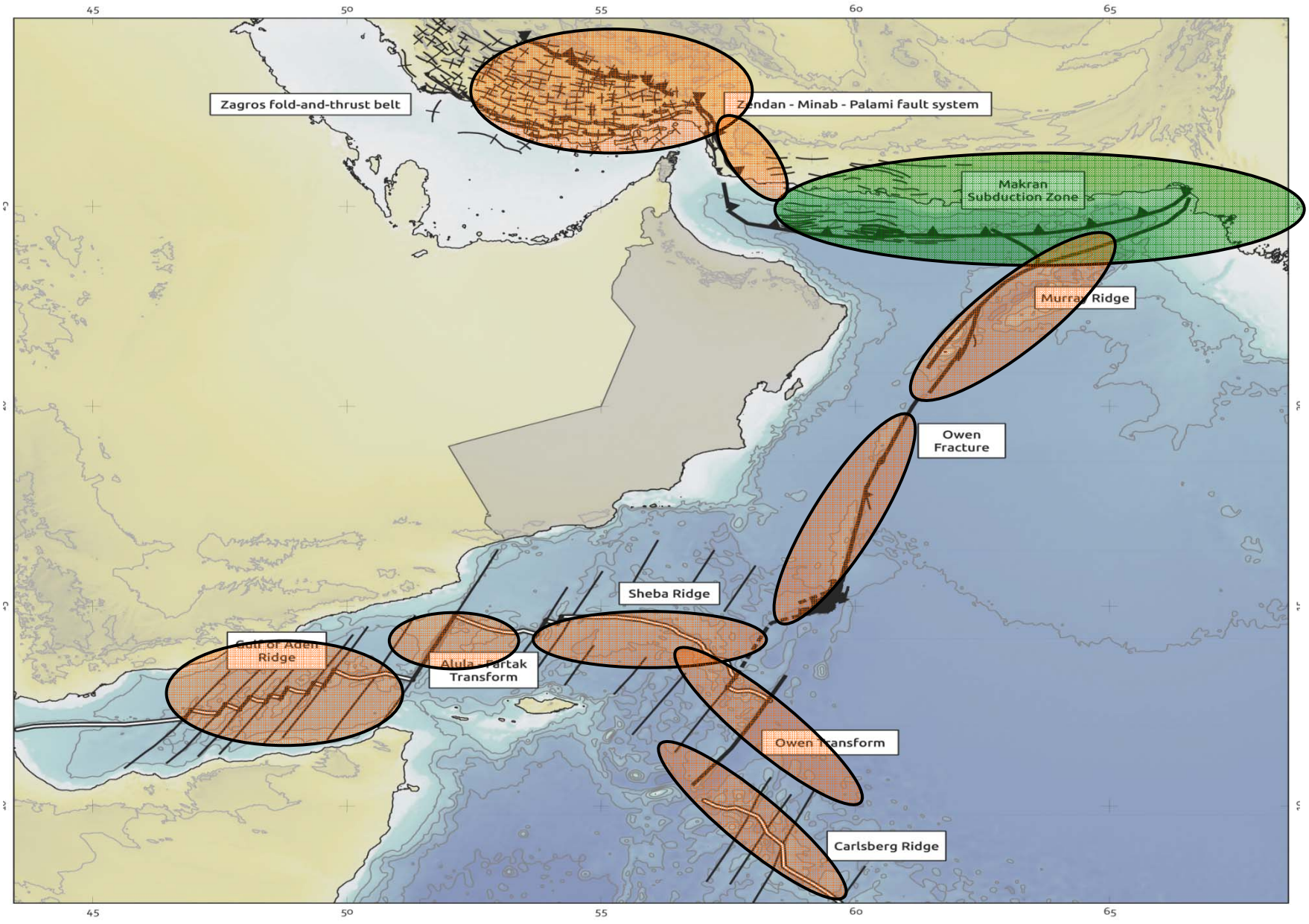
Bathymetric Grids

GRID N1
0.008º resolution
850 m

GRID N2
0.008º resolution
850 m

FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL
Agua y Energía

Source Areas



Tsunami Source Events

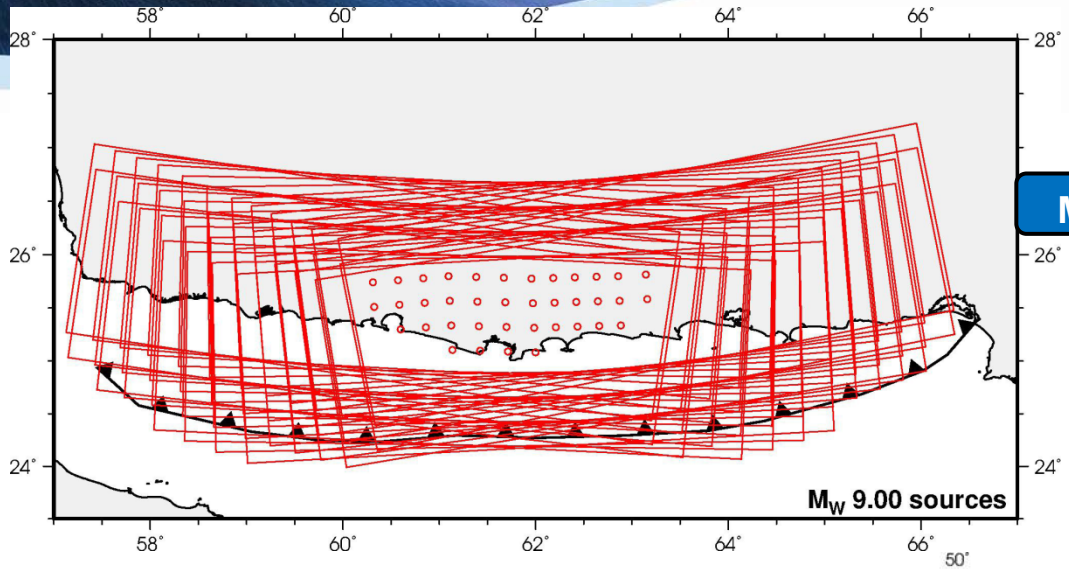
Geology Team---->sismotectonic study

- Tectonic characterization
- Focal mechanisms
- Potential rupture dimensions
- Scaling relations
  Blasser, Straser

Mw → **L,W,d**

6.5, 7.25, 7.5, 7.75, 8.0, 8.25, 8.5, 8.75, 9.0, 9.25

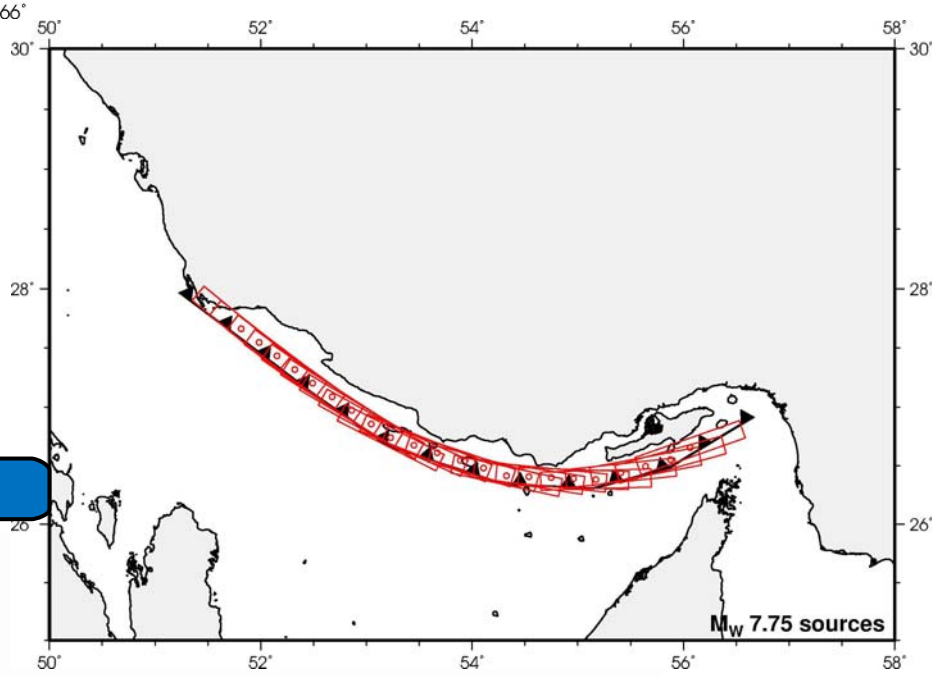
Tsunami Source Events



Makran Subduction Zone: Mw=9.0 events

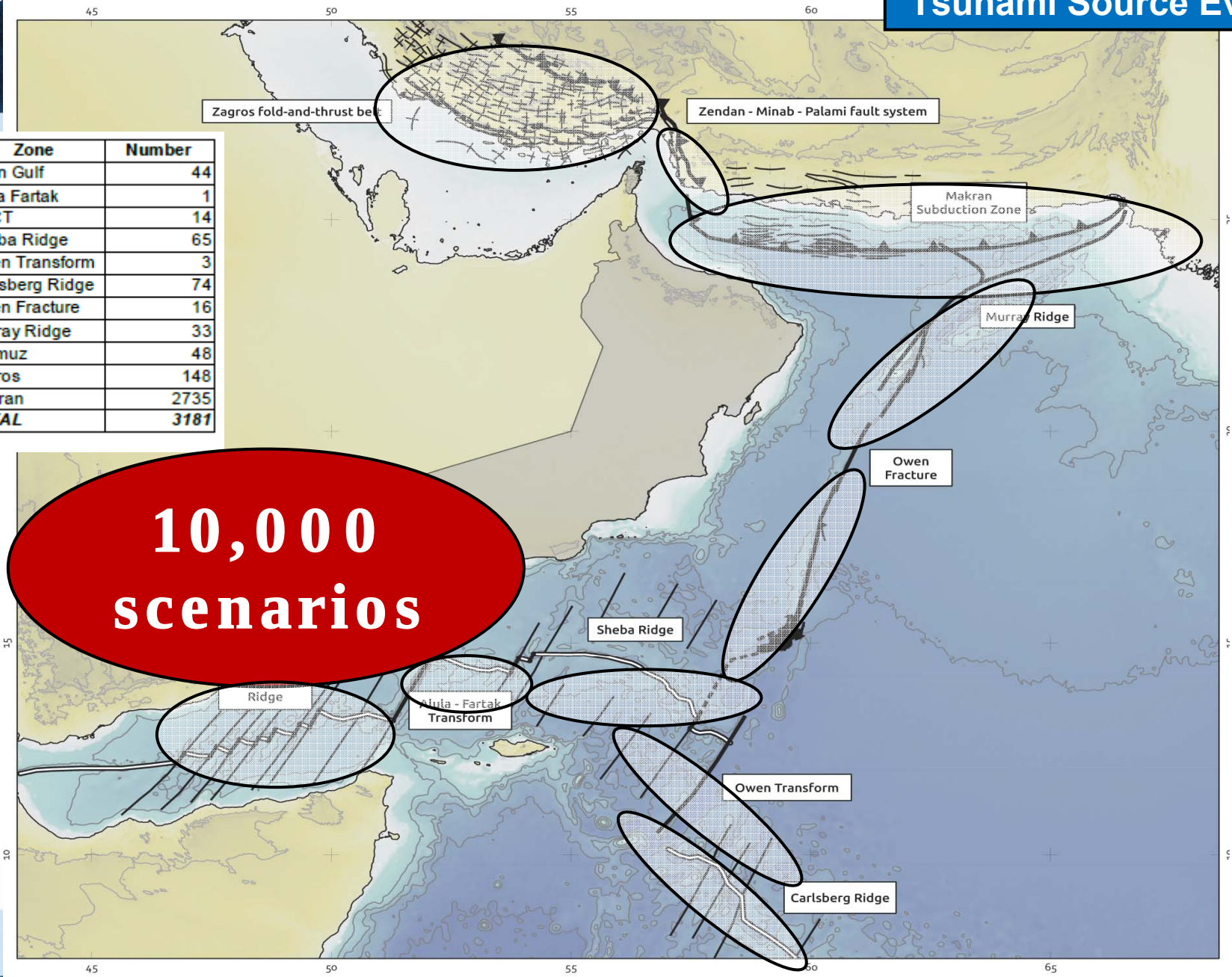
Optimizing, not taking into account those cases whose length or width is not totally within the Makran Trench area, specially in high magnitude cases.

Zagros Zone: Mw=7.75 events



Tsunami Source Events

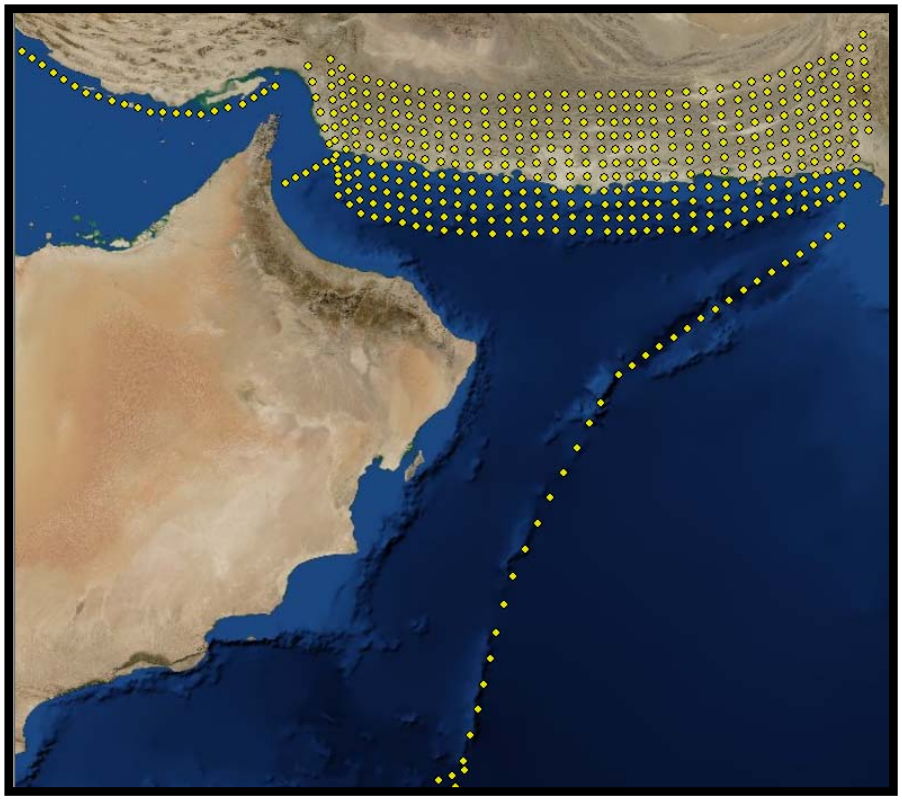
Zone	Number
Aden Gulf	44
Alula Fartak	1
AOCT	14
Sheba Ridge	65
Owen Transform	3
Carlsberg Ridge	74
Owen Fracture	16
Murray Ridge	33
Hormuz	48
Zagros	148
Makran	2735
TOTAL	***3181***



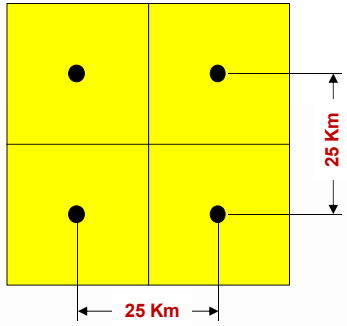
10,000 scenarios

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Tsunami Source Events



GRID N1
2966 scenarios

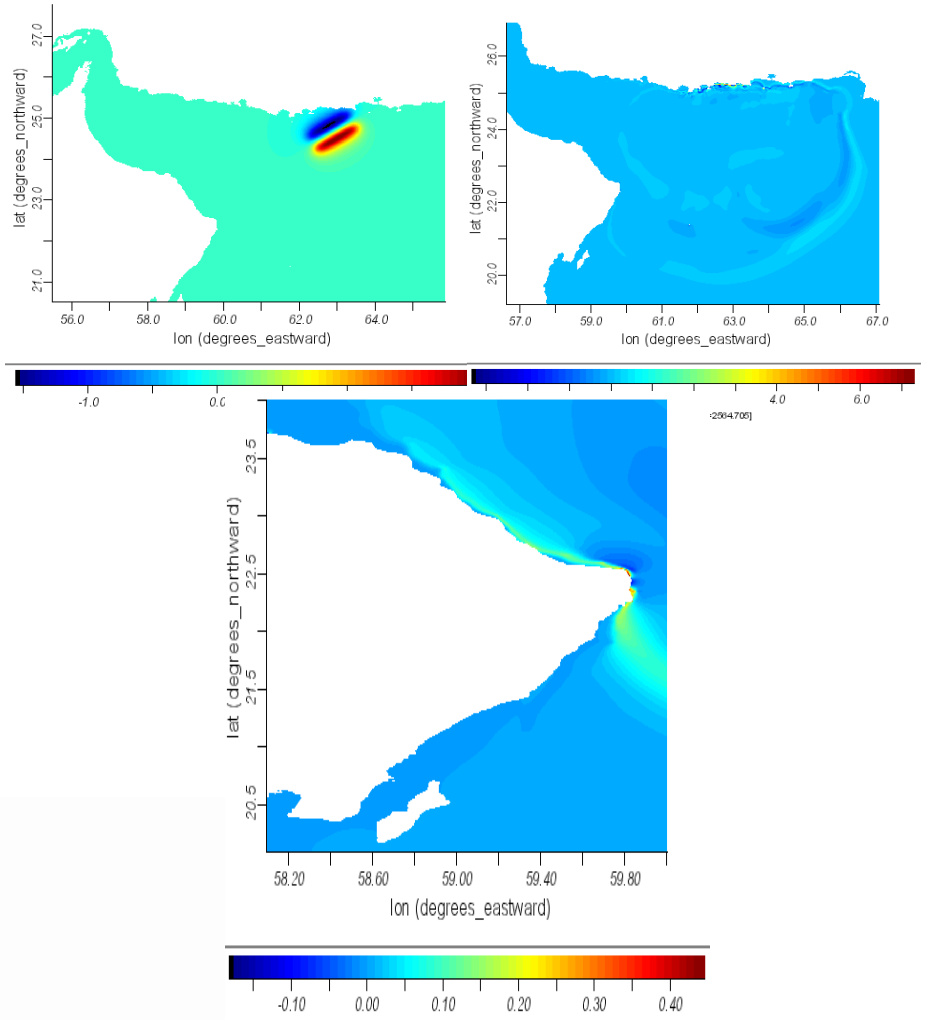


GRID N2
215 scenarios

FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL
Agua y Energía

Running with C3-COMCOT Model

- **Generate** initial surface deformation
- **Propagate** the wave from source to coast of Oman
- **NOT Flooding in Coast**



Base de Datos Numérica de Escenarios de Tsunamis

With 100 CPUs ~ 5 months

TOTAL ~ 12 Tb

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Algoritmo de selección

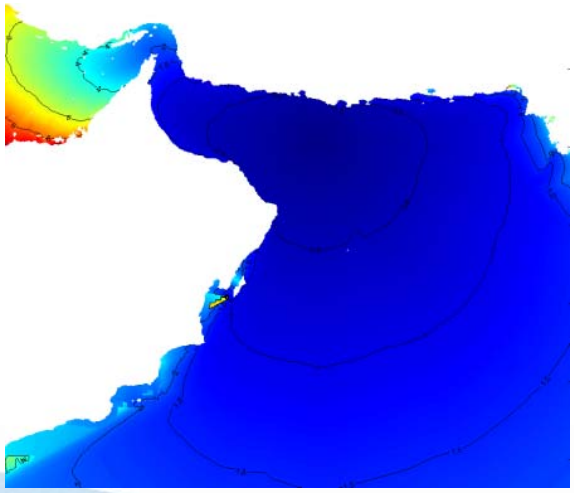
Se tiene un algoritmo que permite al MHEWS seleccionar el correspondiente escenario ya pre-ejecutado

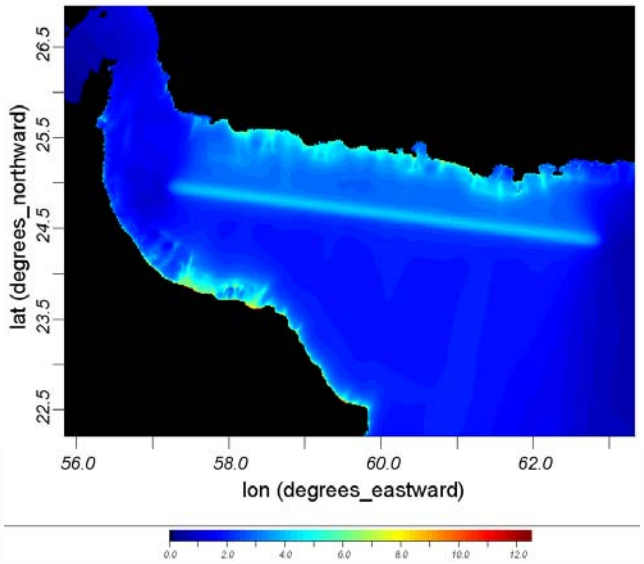
Cuando se tiene un evento real :

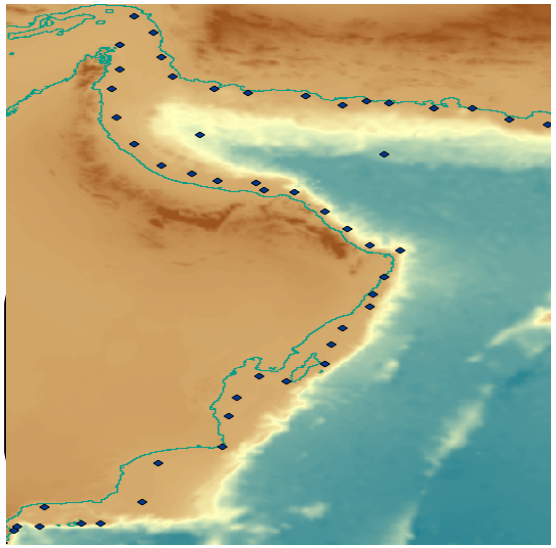
9.0

61.9, 25.3

Logical algorithm

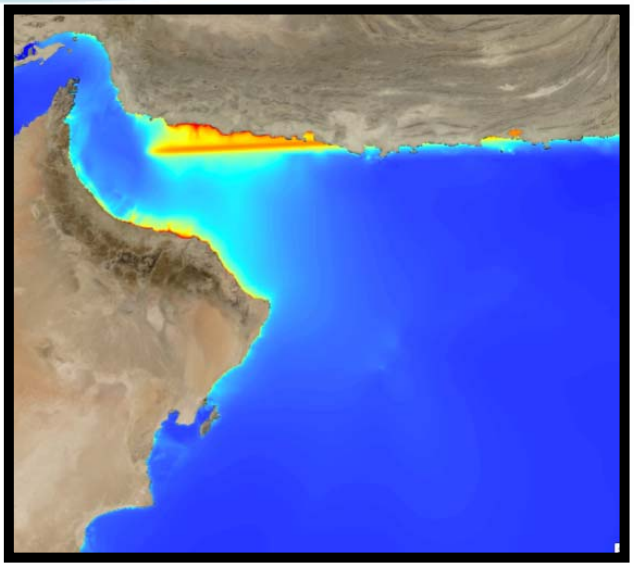






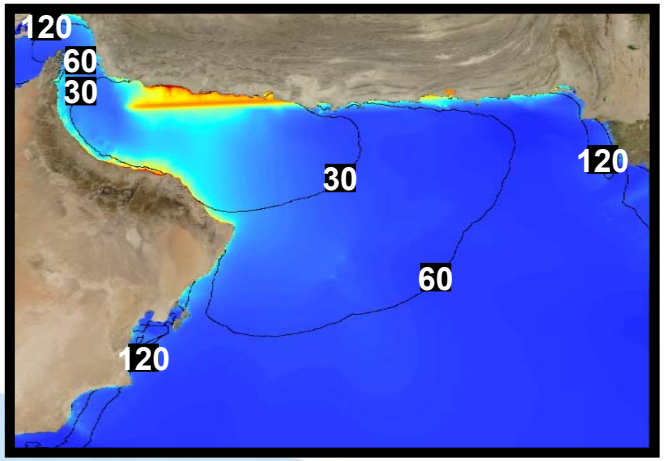
FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL

Para cada evento de la base de datos, se tiene ya construidos dos tipos de mapas:



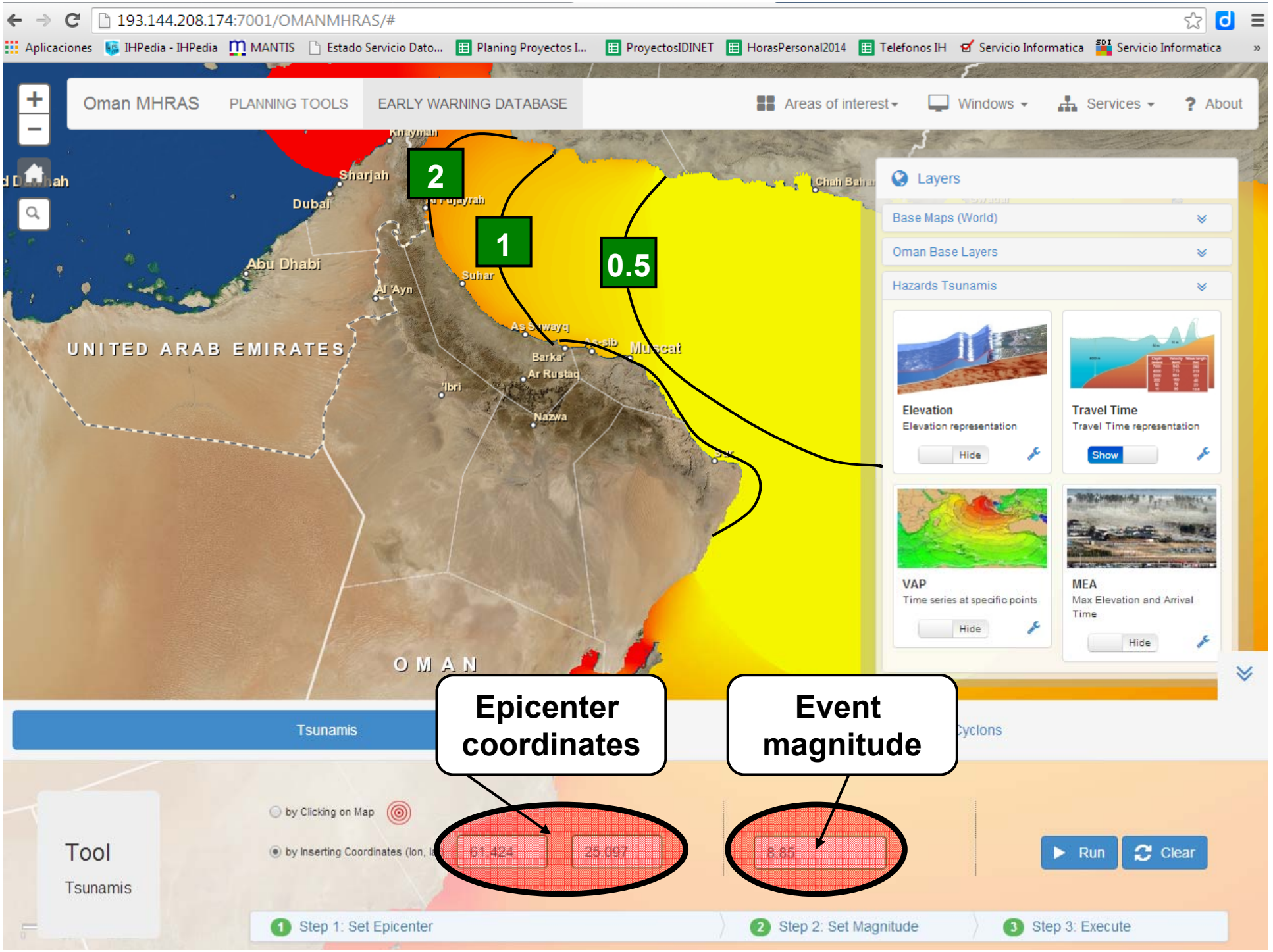
Máxima Amplitud de Ola Estimada

Estimate Maximum Wave Amplitude (EWA)



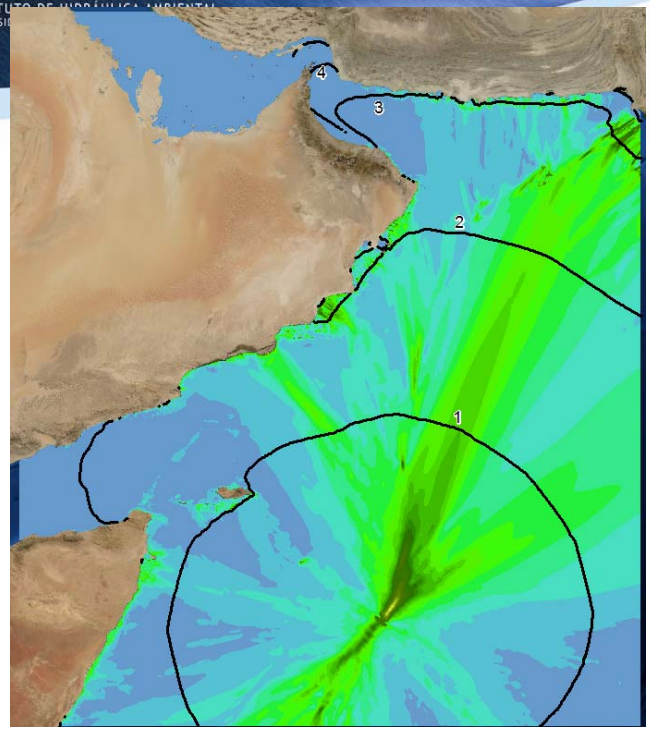
Tiempo Estimado del Arrivo del Tsunami

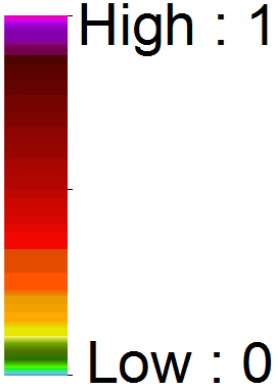
Estimate Time of Arrival (ETA)

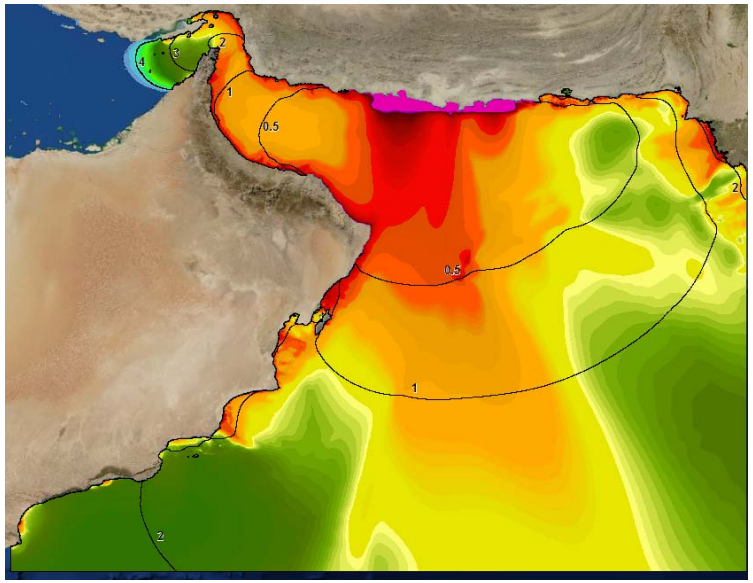

193.144.208.174:7001/OMANMHRAS/#
Oman MHRAS
PLANNING TOOLS
EARLY WARNING DATABASE
Areas of interest
Windows
Services
About
2
1
0.5
Sharjah
Dubai
Abu Dhabi
Al 'Ayn
Suhar
Barka'
Muscat
Ar Rustaq
'Ibri
Nazwa
UNITED ARAB EMIRATES
OMAN
Layers
Base Maps (World)
Oman Base Layers
Hazards Tsunamis
Elevation
Elevation representation
Hide
Travel Time
Travel Time representation
Show
VAP
Time series at specific points
Hide
MEA
Max Elevation and Arrival Time
Hide
Tsunamis
Epicenter coordinates
Event magnitude
by Clicking on Map
by Inserting Coordinates (lon, la
61.424
25.097
6.85
Run
Clear
Tool
Tsunamis
1 Step 1: Set Epicenter
2 Step 2: Set Magnitude
3 Step 3: Execute

IH cantabria

Examples







Event #	0093
Seismic area	Carlsberg
Magnitude Mw	6.75
Source Length	53 Km
Source Width	12 Km
SeaBottom Dislocation	0.9 m

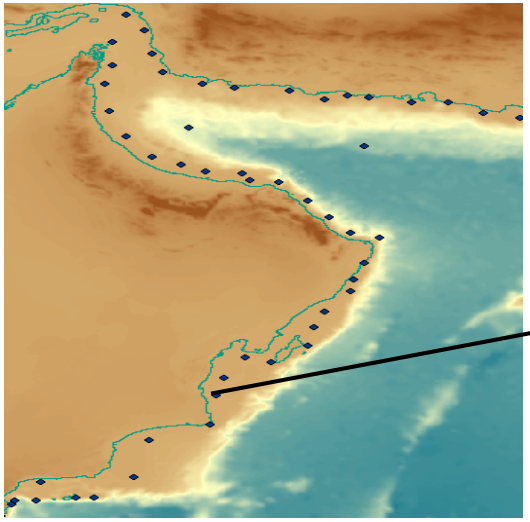
Event #	3000
Seismic area	Makran
Magnitude Mw	8.5
Source Length	313 Km
Source Width	132 Km
SeaBottom Dislocation	5.7 m

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Forecast Points

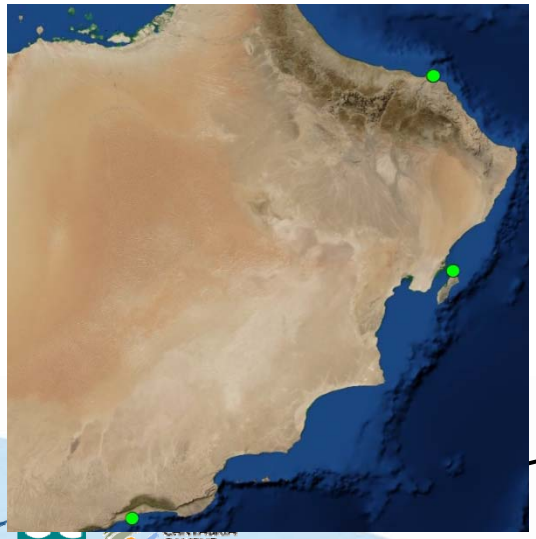
Agreed points:
- **Important cities,**
- **Important populations,**

(Key points in case of tsunami)

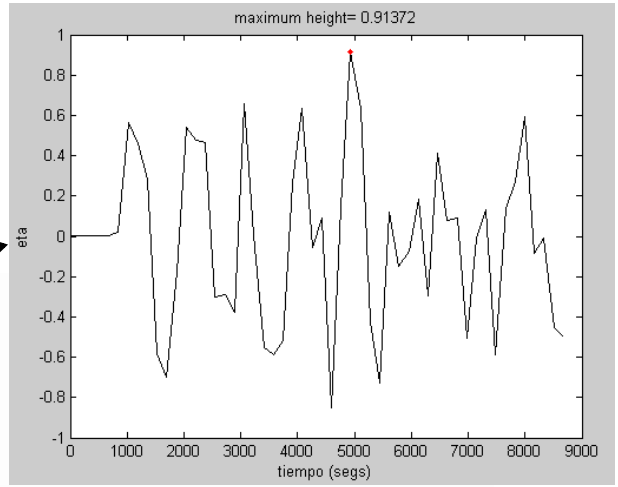


- **Estimate Maximum Wave Amplitude (EWA)**

- **Estimated Time of Arrival (ETA)**

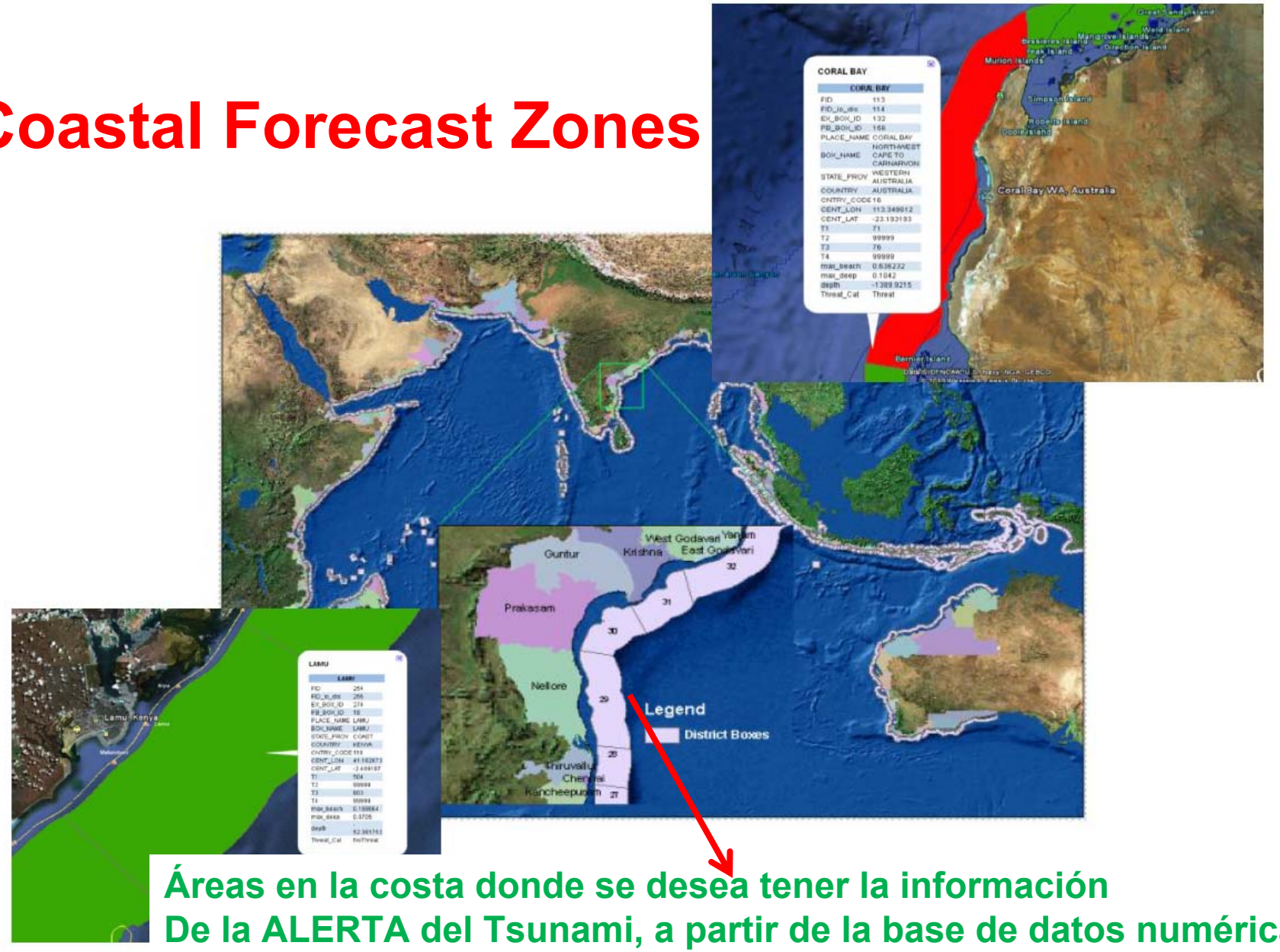


Validation Points
(surface elevation time series in tidal Gauges)



FUNDACION
UNIVERSIDAD DE CANTABRIA
CAMPUS INTERNACIONAL

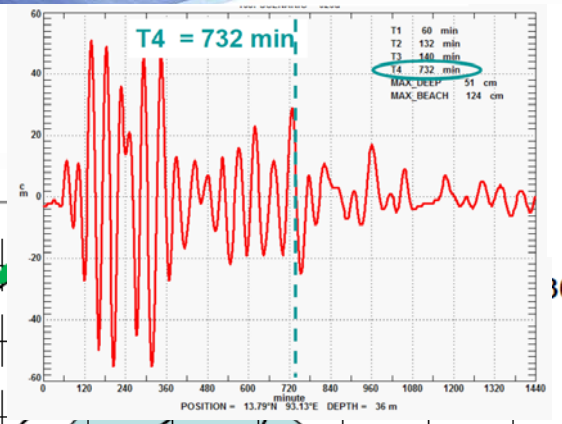
Coastal Forecast Zones



Áreas en la costa donde se desea tener la información
De la ALERTA del Tsunami, a partir de la base de datos numérica
(Áreas asociadas a municipalidades, puertos, industrias alto riesgo,….

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

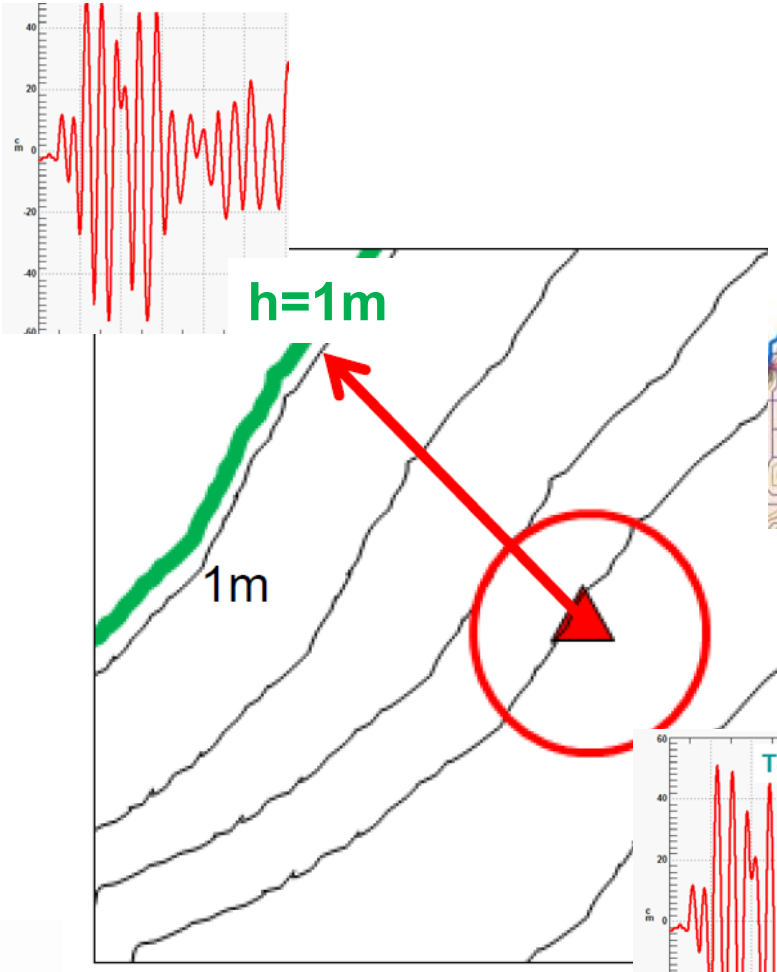
Coastal Focal Points

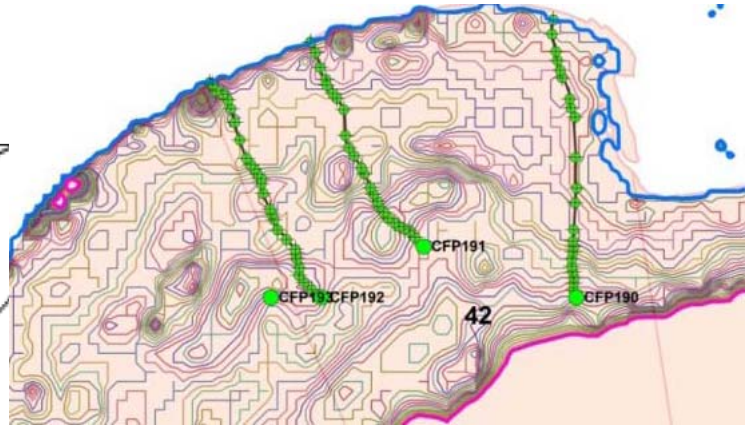


Serie temporal Para cada uno de los 10,000 Eventos (Base Datos)

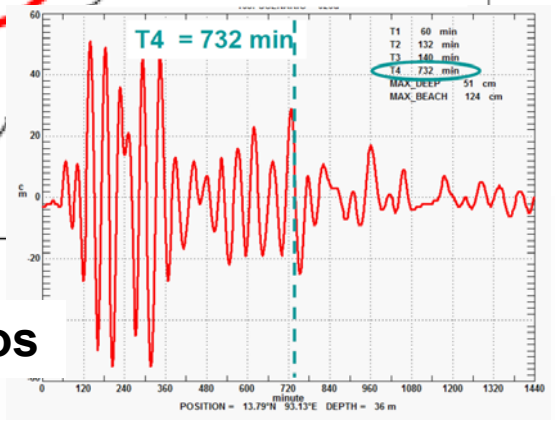
FUNDACION IH
UC UNIVERSIDAD DE CANTABRIA
CAMPUS INTERNACIONAL Agua y Energía

Para cada punto “Coastal Focal Point” se ha obtenido una Función de transferencia hasta la línea de costa

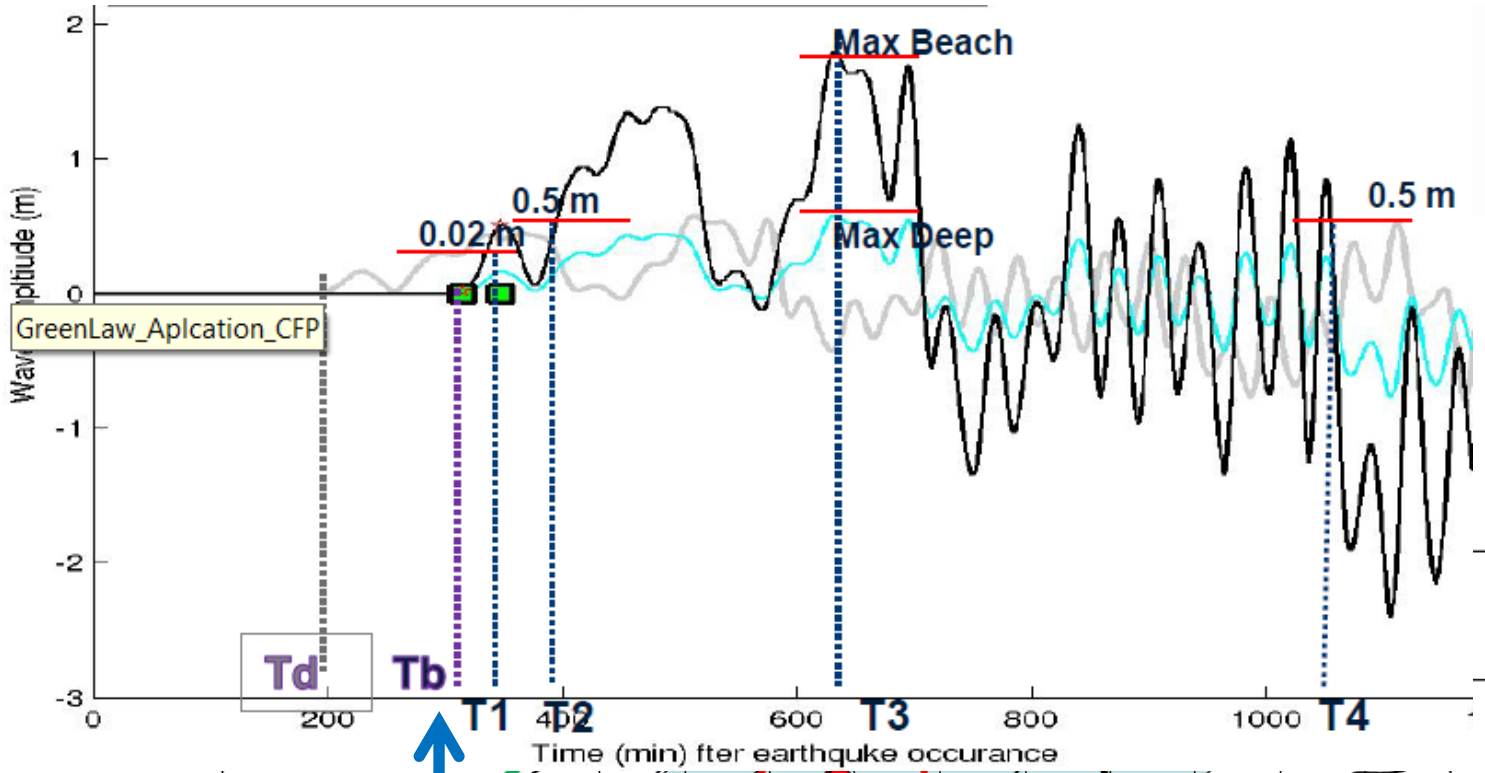




Se tiene Perfiles topográficos para cada CFP

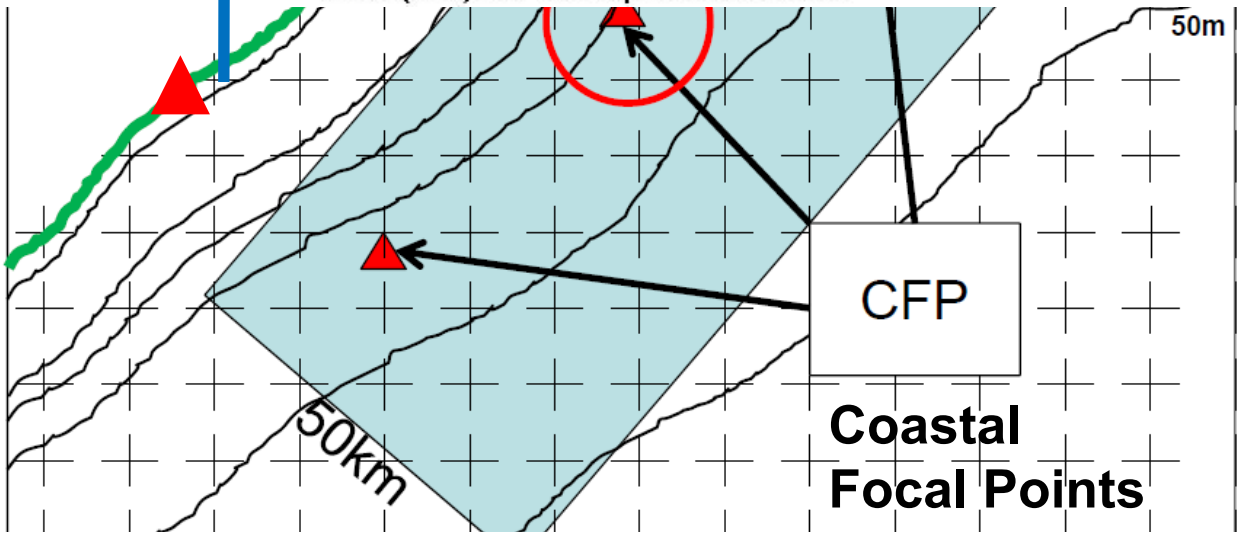


Serie temporal de la base de datos



Coastal Focal Zone

CFZ



Coastal Focal Points

Todos estos parámetros en costa, están ya en la base de datos para los 10,000 escenarios, en cada CFP and CFZ.

En el momento en que ocurre un tsunami, el algoritmo de interpolación busca de forma automática el correspondiente evento en la base de Datos.

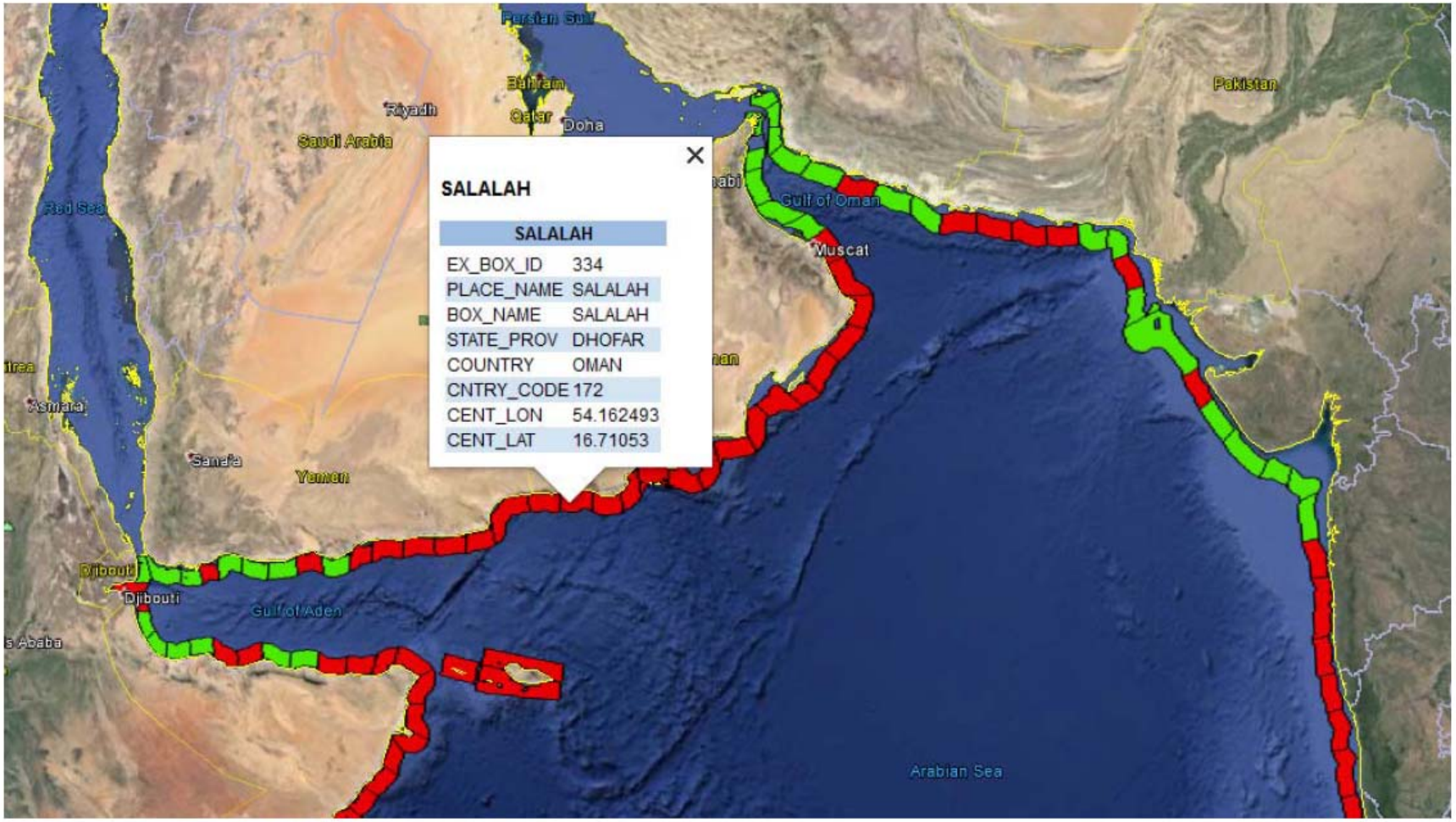
Y los Niveles de alerta asociados en cada "Forecast Zone"

Pre-run Model Scenario Results			
ETA ≤ 60 mins		ETA > 60 mins	
EWA (M)	Threat Status	EWA (M)	Threat Status
> 2	WARNING	> 2	ALERT
0.5 to 2	ALERT	0.5 to 2	WATCH
0.2 to 0.5	WATCH	0.2 to 0.5	WATCH

Actions Based on Threat Status (WARNING / ALERT / WATCH)

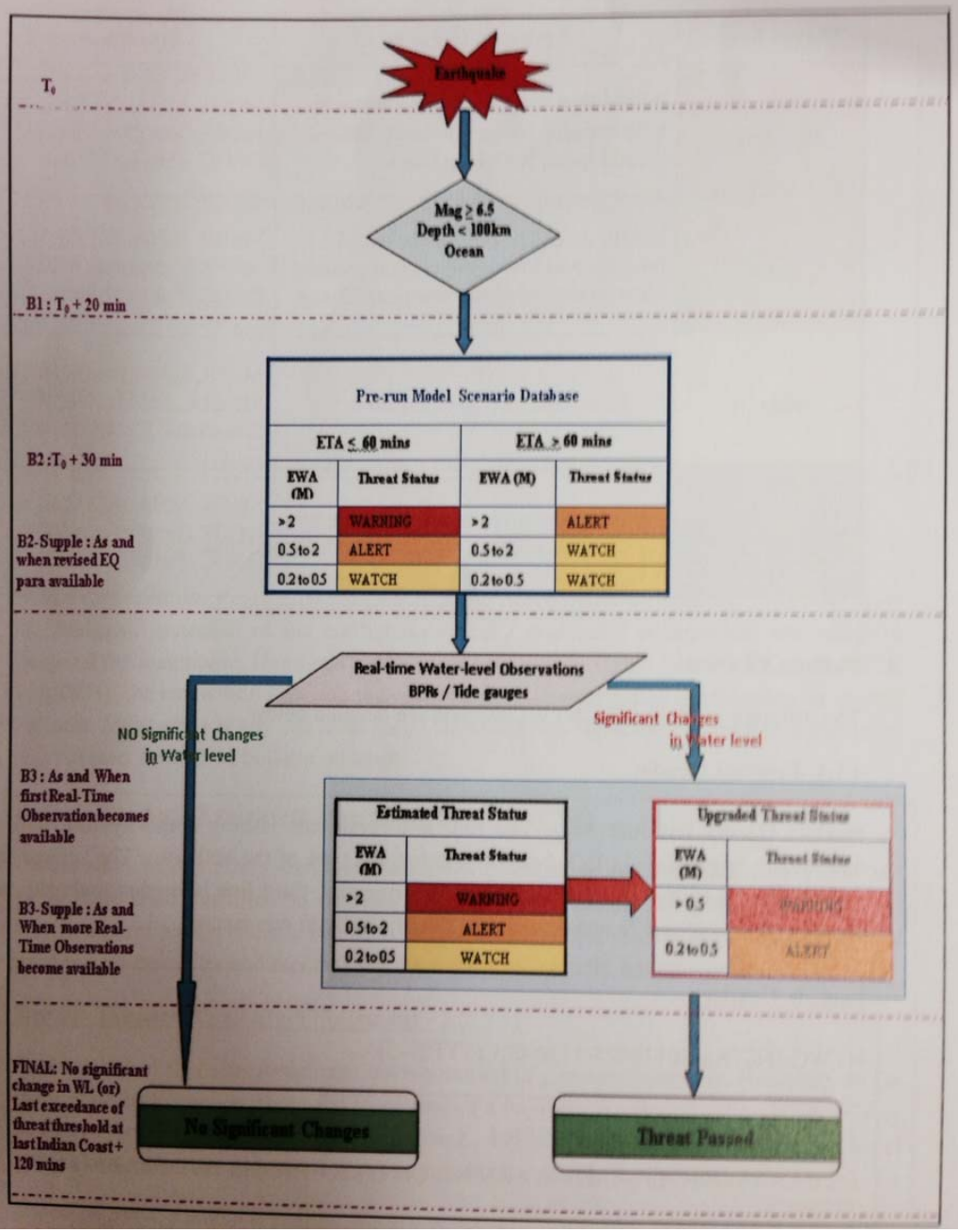
Threat Status	Action to be taken	Dissemination To
WARNING	Public should be advised to move in-land towards higher grounds. Vessels should move into deep Ocean	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media
ALERT	Public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into deep Ocean	MoES, MHA, MEDIA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media
WATCH	No immediate action is required	MoES, MHA MoES, MHA, MEDIA, NCMC, NDRF Battalions, SEOC, DEOC
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media

Table 5: Actions Based on Threat Status

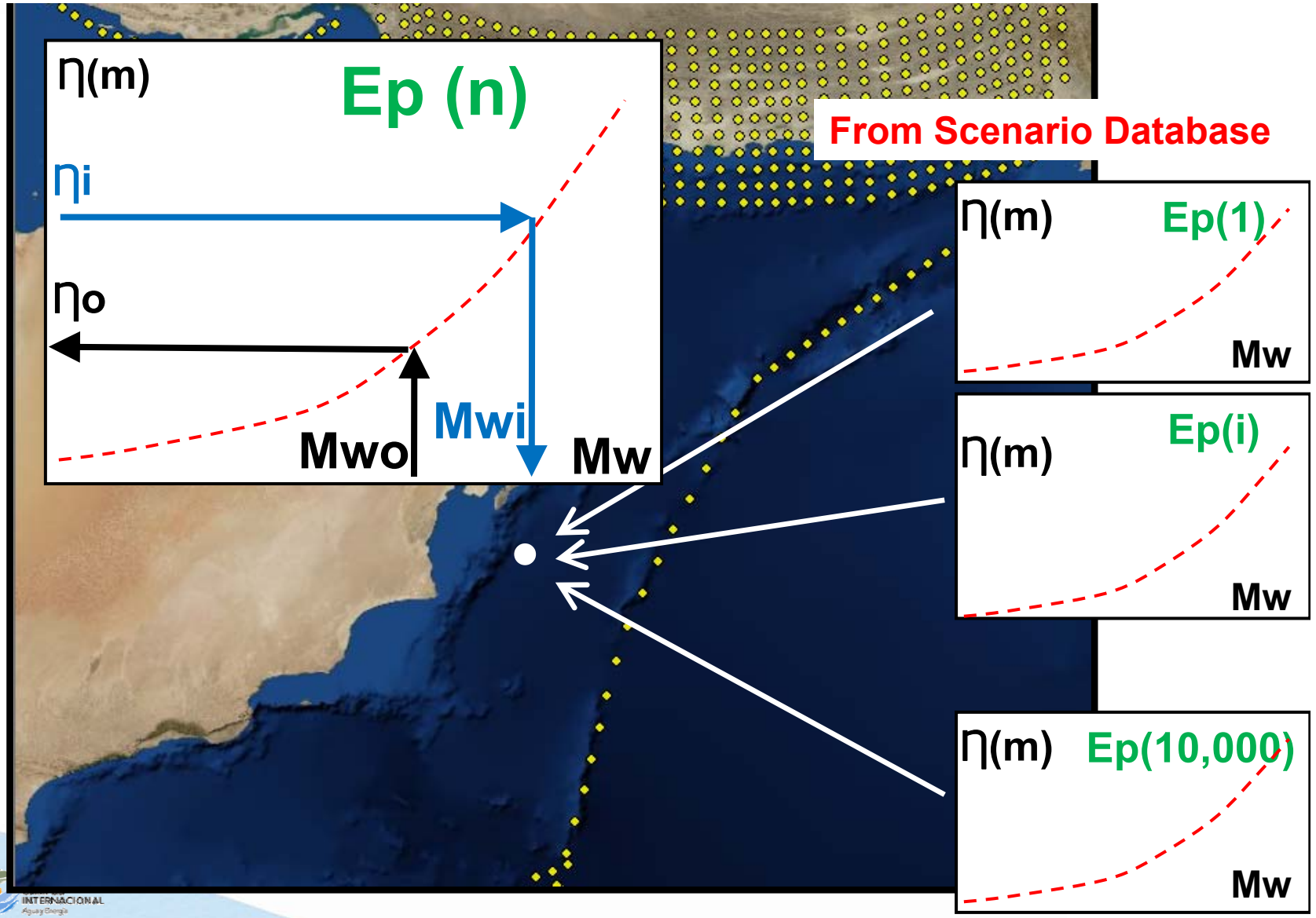


Tengo nivel de alerta para cada zona en la costa:
(municipalidades, puertos, industrias de alto riesgo, etc)

The DSS flow chart followed by ITEWC for its NTWC operations is as follows:

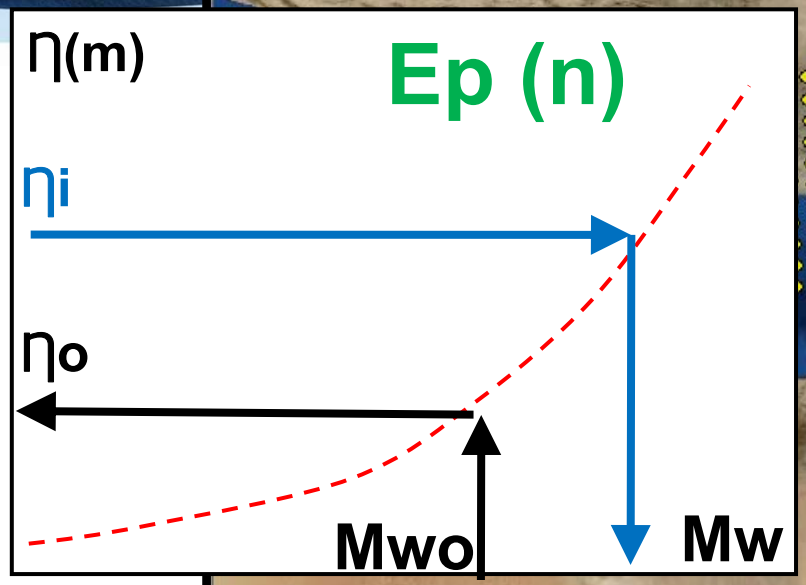


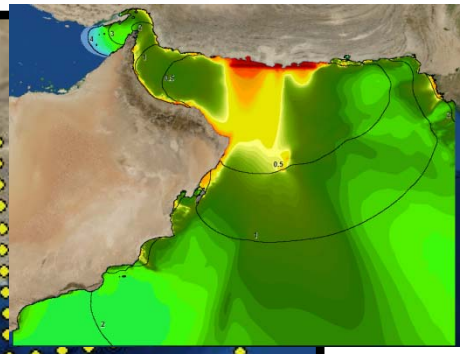
Actualizaciones de las predicciones basados en los escenarios de la base de datos y datos suministrados por sensores en el mar (mareógrafos, boyas, etc)

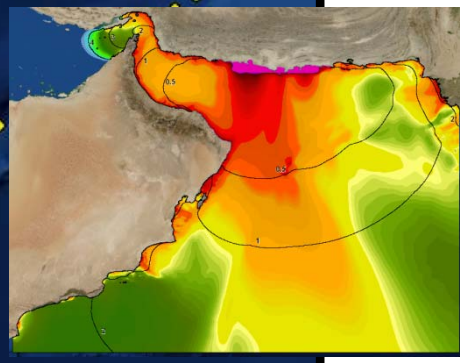


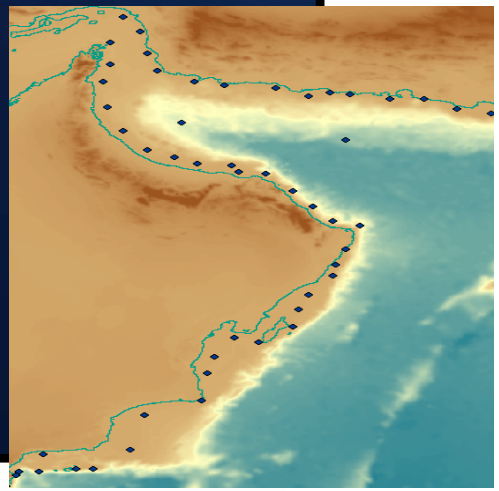
IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Tsunami Source Events

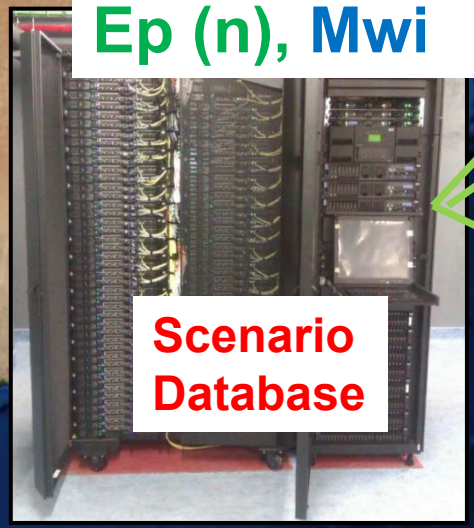








Ep (n), Mwi



FUNDACION
UC UNIVERSIDAD DE CANTABRIA
INTERNACIONAL

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

astarte
ASSESSMENTS, STRATEGY AND RISK REDUCTION FOR TSUNAMIS IN EUROPE

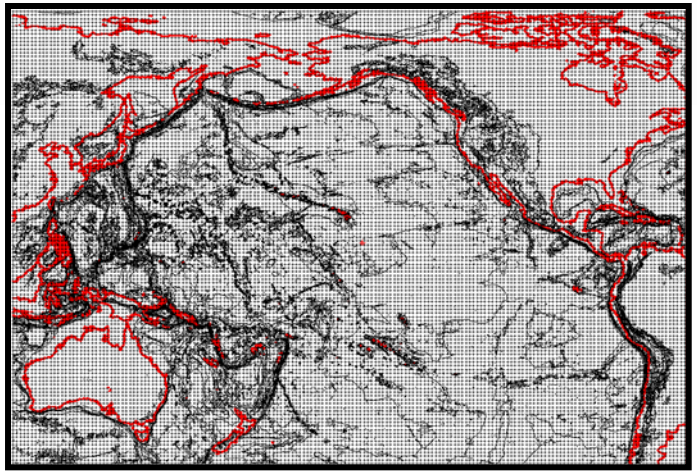
TsuSy

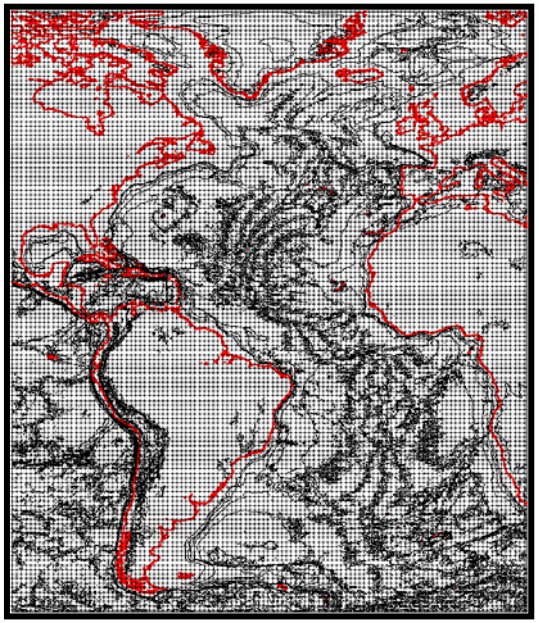
Tsunami **Sy**stem

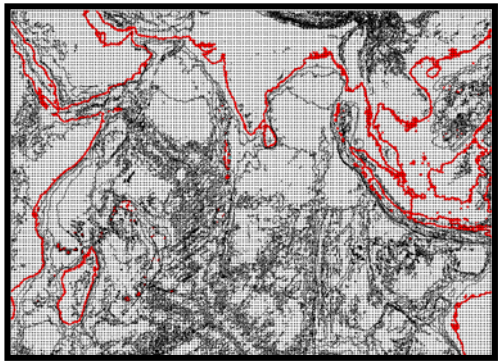
Una herramienta para la simulación numérica de tsunamis en tiempo real.

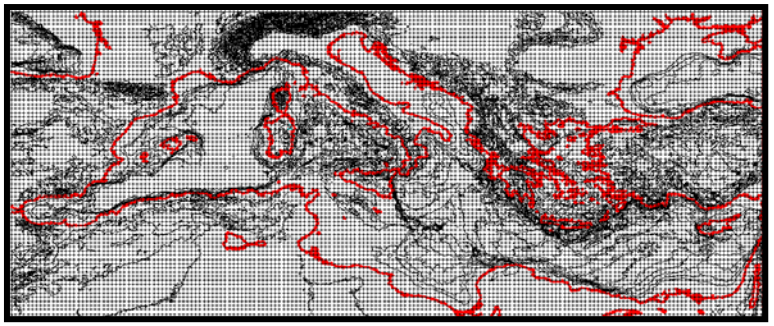
FUNDACIÓN IH
UC UNIVERSIDAD DE CANTABRIA
CANTABRIA CAMPUS INTERNACIONAL
Agua y Energía

3. Elementos del sistema



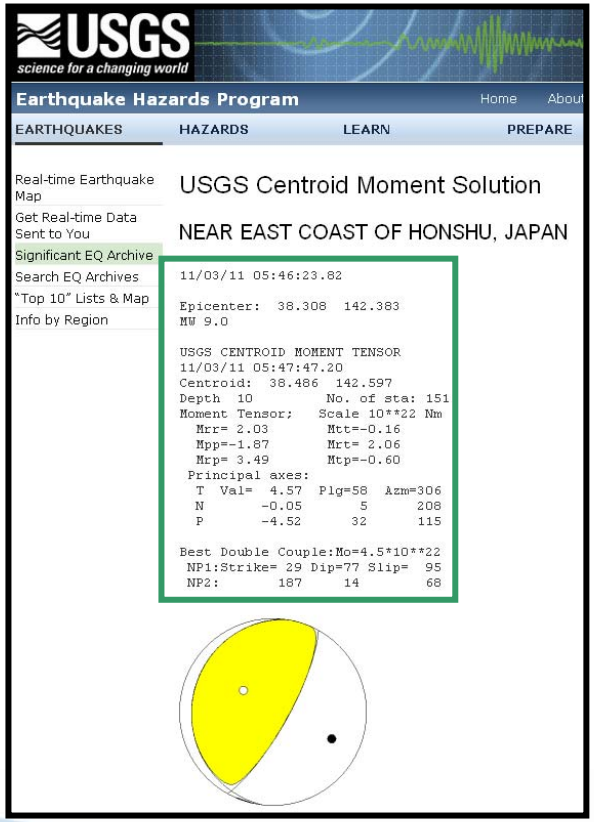


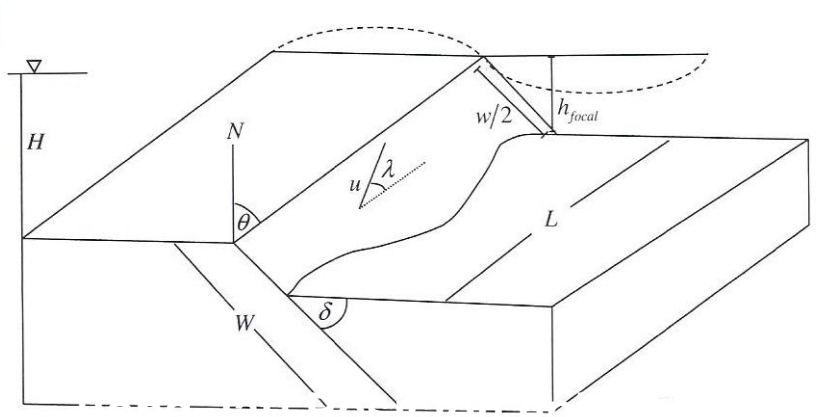




3. Elementos del sistema

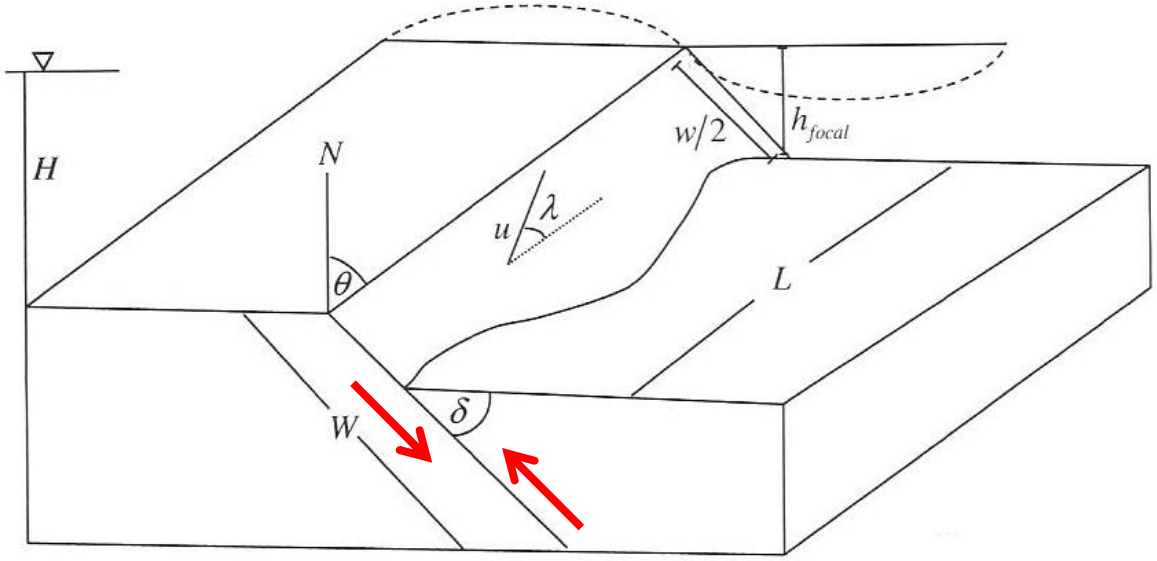
- Modelo de Falla (Blasser et al., 2011)





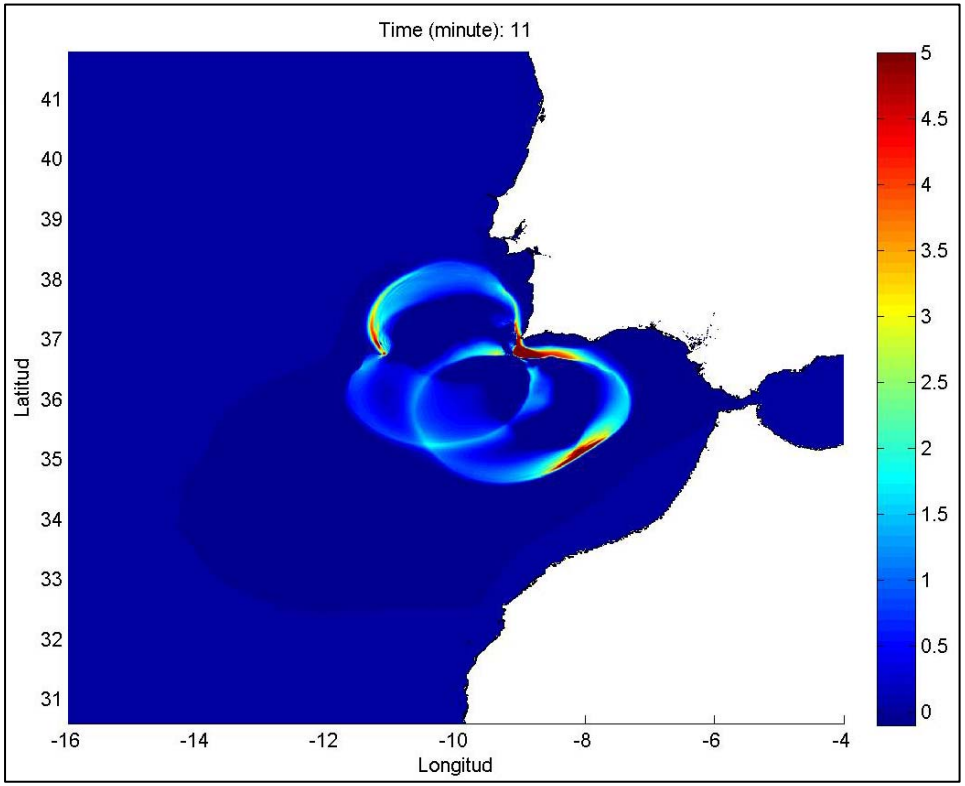
3. Elementos del sistema

- Modelo de deformación: Okada, 1985



3. Elementos del sistema

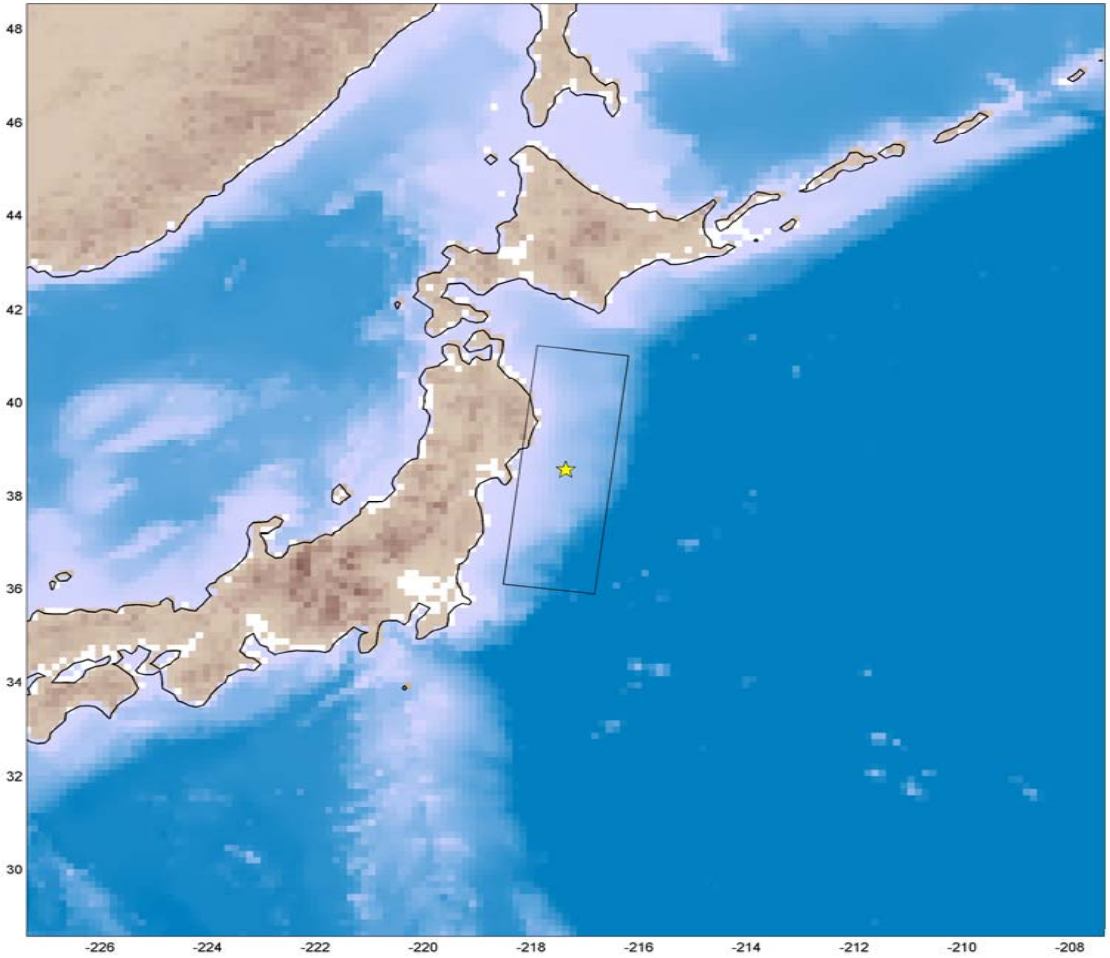
- Modelo de Propagación: C3 (Olabarrieta et al., 2008)
  - Shallow water equations
  - Coordenadas esféricas
  - Diferencias finitas
  - Anidamiento de mallas
  - Incorpora el modelo de deformación de Okada



En proceso incluir Modelo HySea, GPU (Colaboración con la Universidad de Málaga)

Salidas del sistema: INTERNET, MÓVIL, …

Mapa de condiciones iniciales



Descriptive Chart

Event ID : JAPAN_III_2011
Date : 27-Jun-2012
Simulated time : 86400 segs

Initial Conditions

WPhase Moment Sol.
date_Event: 11-Mar-2011
GMT_time: 05:47:47
Mw: 9
hfocal: 10
lon: 142.597
lat: 38.486
lonG: -217.403
Mo (x 10^22): 4.5
str1: 29
dip1: 77
rake1: 95
str2: 187
dip2: 14
rake2: 68
T: 58
N: 5
P: 32
datenum: 734573.2415

Okada Model
date_Event: 11-Mar-2011
GMT_time: 05:47:47
Mw: 9
hfocal: 23048.6
lon: 142.0002
lat: 38.5593
lonG: -217.403
ley: blaser
L: 575440
W: 190546
slip: 13.6802
strike: 187
dip: 14
rake: 68
datenum: 734573.2415

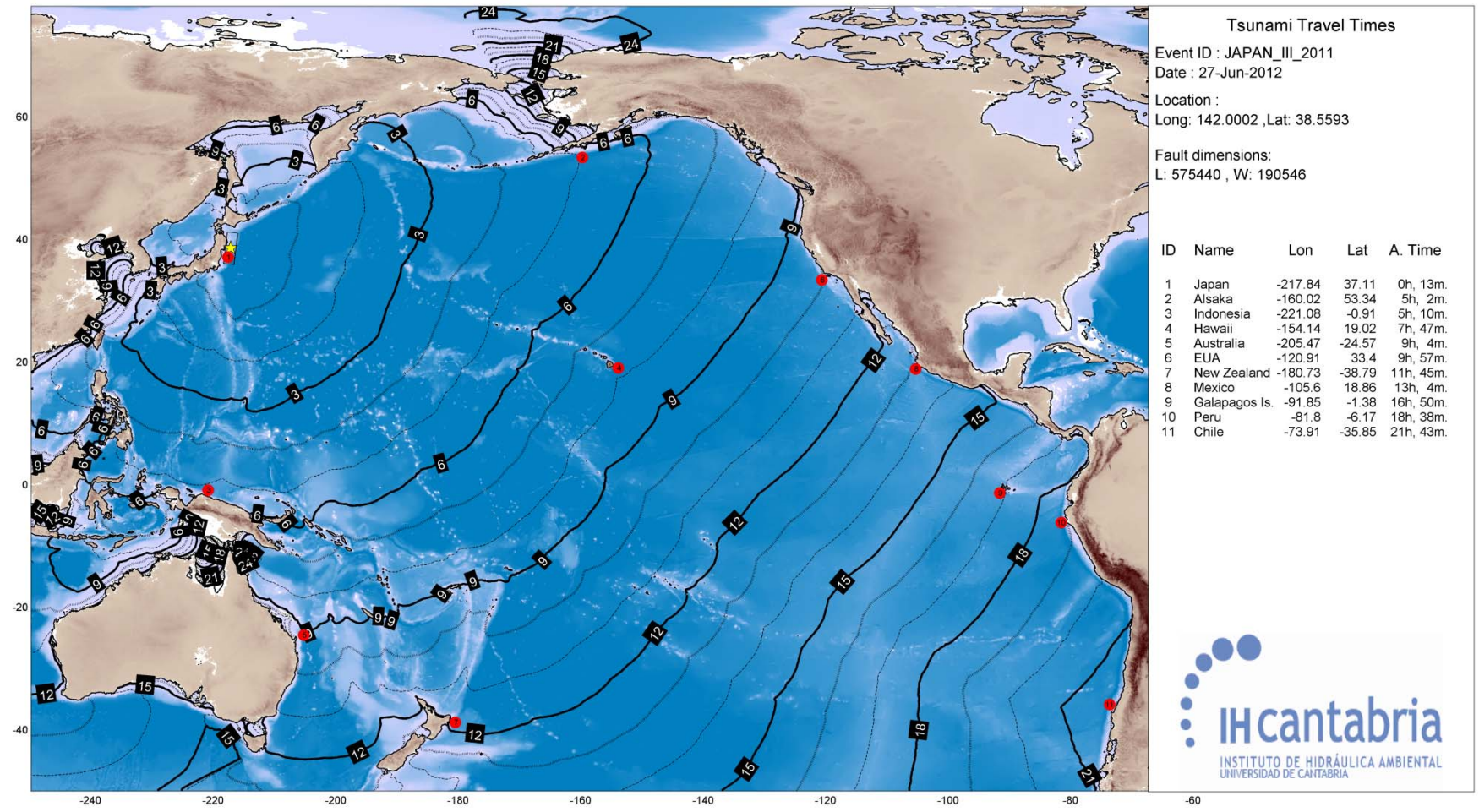
Layers

Layer 01
nom: PCF
ix: 1426
iy: 961
gridlength: 8
ratio: NaN
lon1: -250
lon2: -60
lat1: -50
lat2: 78

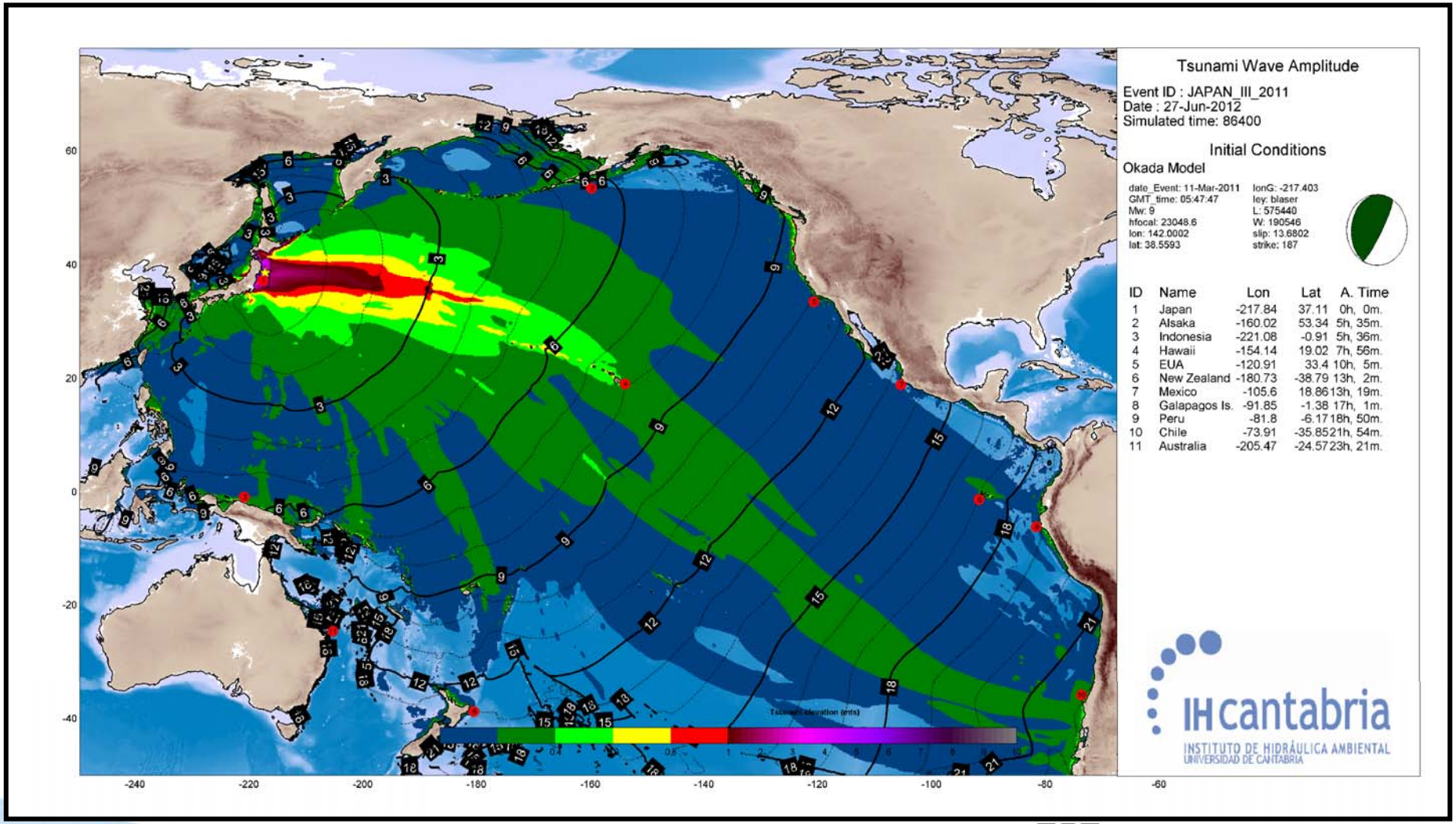
Layer 21

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Mapa de tiempos de viaje (inmediato)

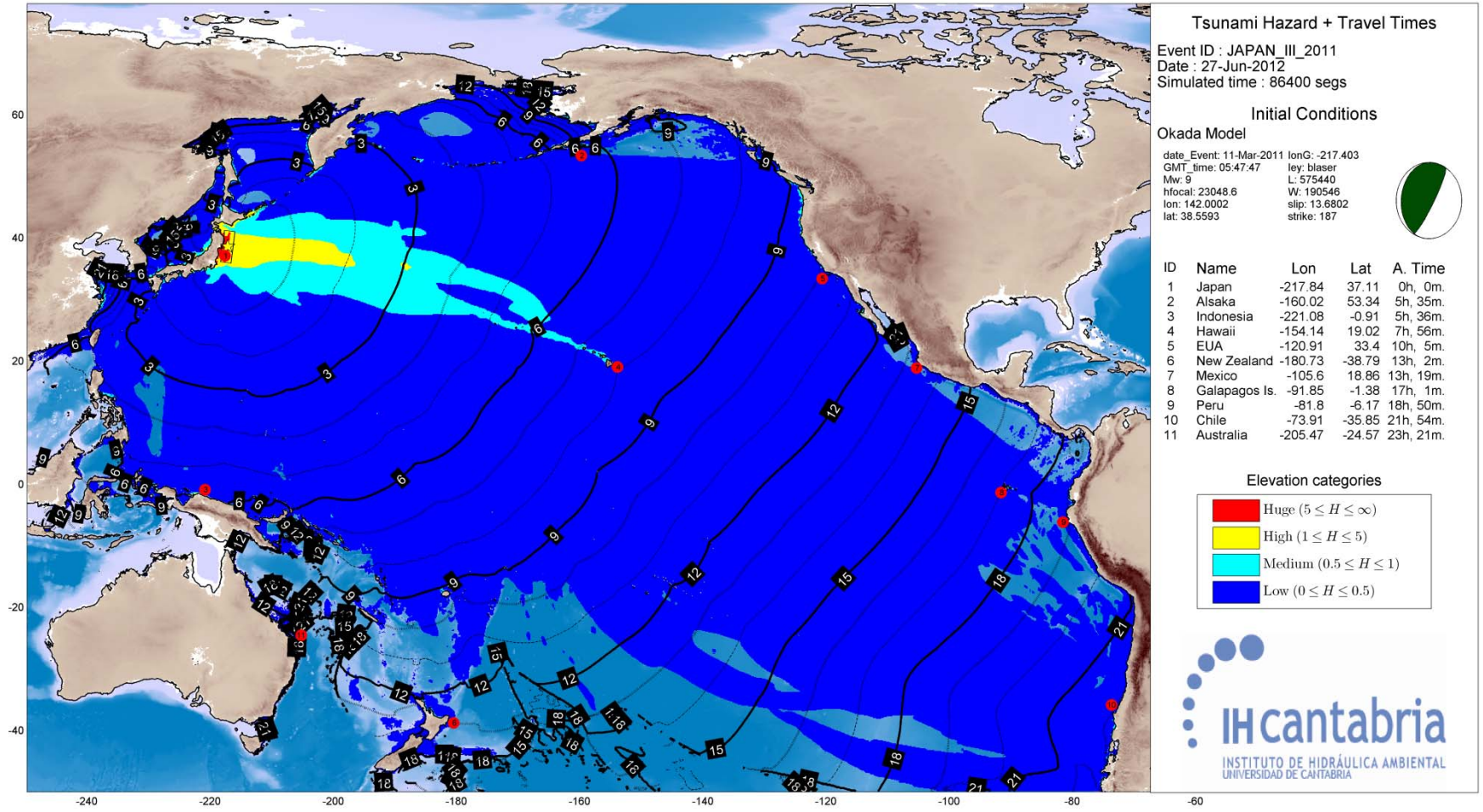


Mapa de alturas + tiempos de viaje



IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Mapa de peligrosidad + tiempos de viaje



IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

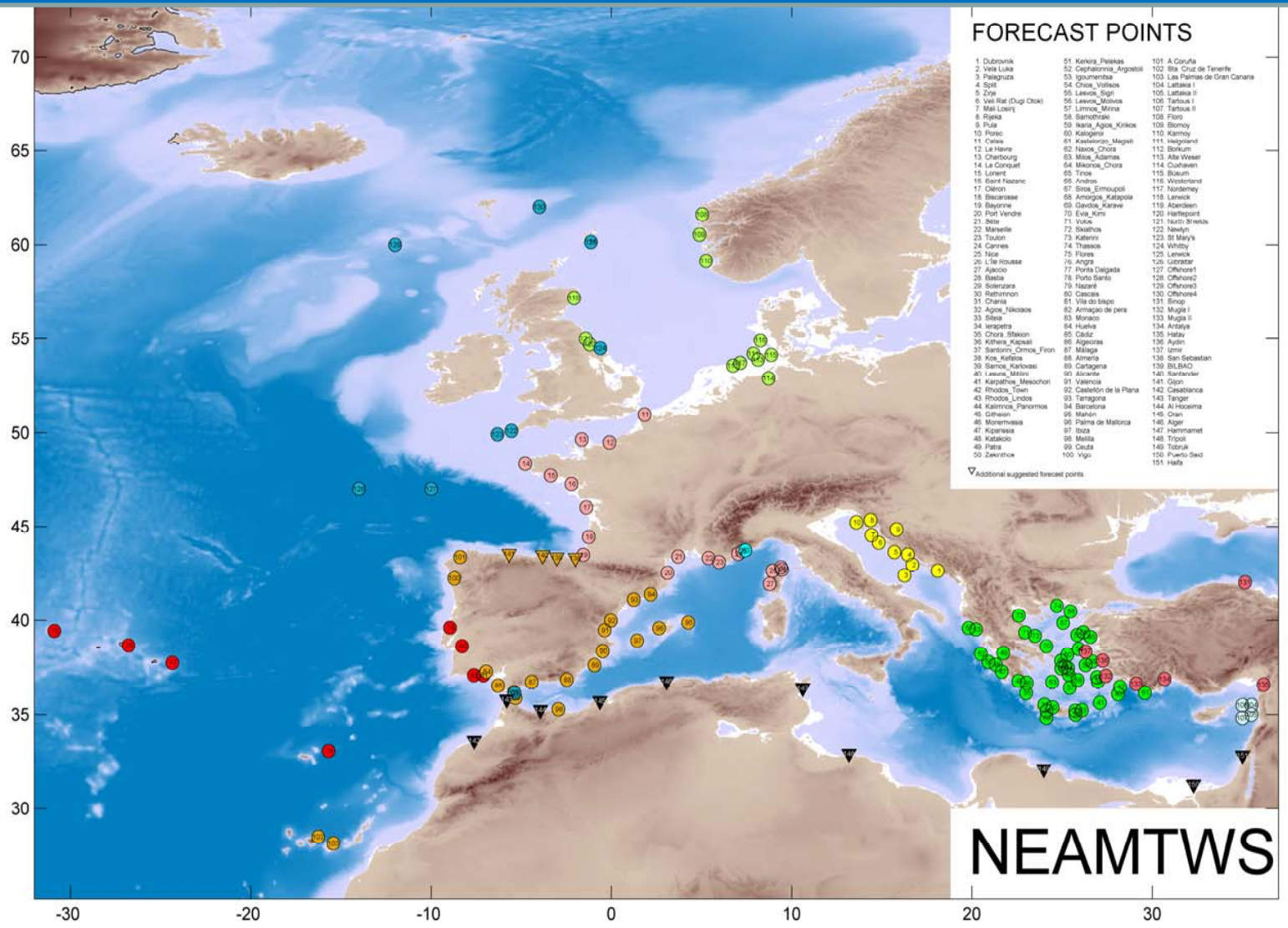
NEAR to WARN
Project for Tsunami

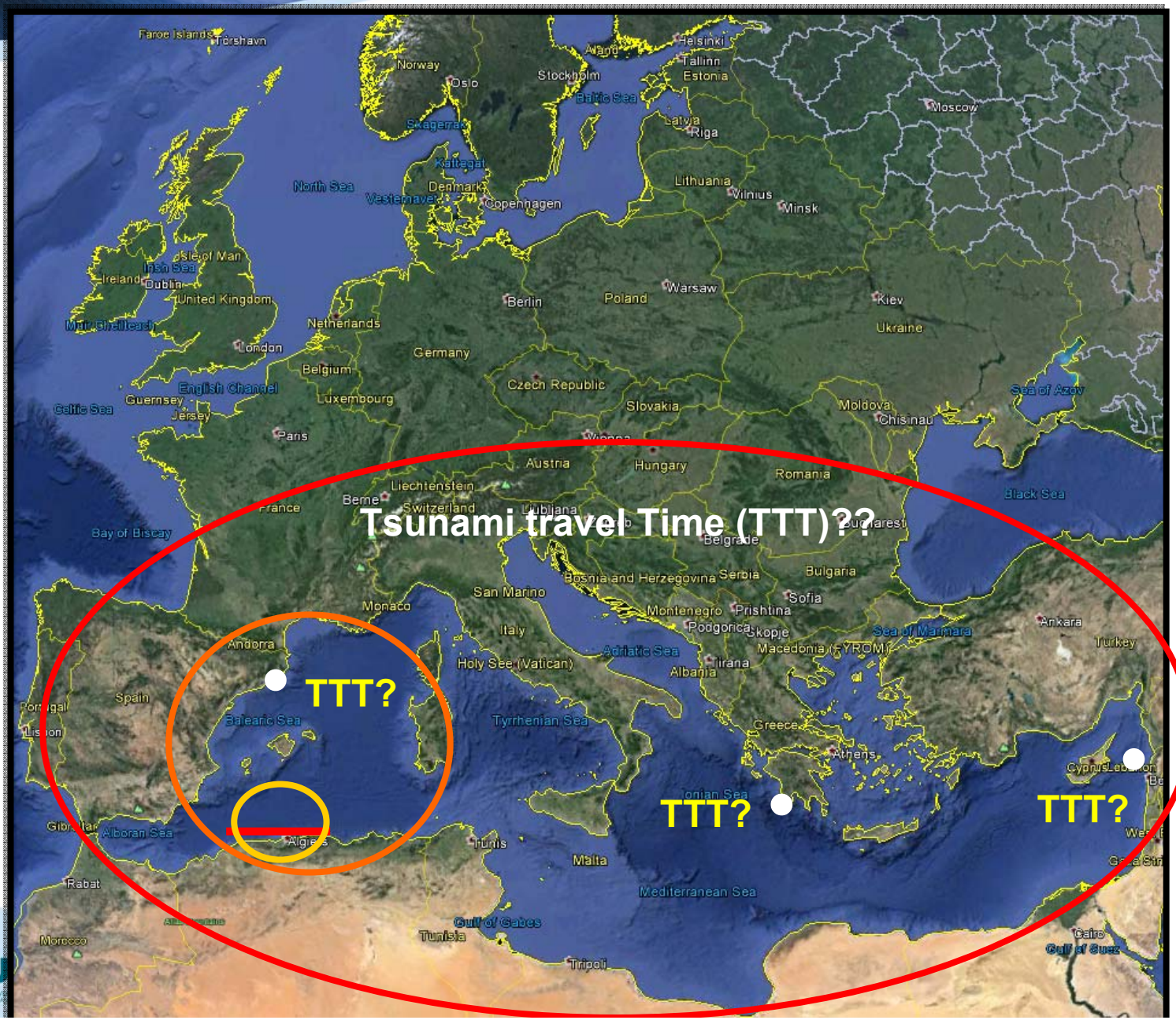
IH Cantabria

Environmental Hydraulics Institute of Cantabria
Universidad de Cantabria
Santander, Spain

FUNDACION
UC
UNIVERSIDAD DE CANTABRIA

- ***151forecast points in NEAM region(IOC-UNESCO)***




Tsunami travel Time (TTT)??
TTT?
TTT?
TTT?
Faroe Islands
Torshavn
Norway
Oslo
Stockholm
Helsinki
Tallinn
Estonia
Baltic Sea
Moscow
Latvia
Riga
Lithuania
Vilnius
Minsk
North Sea
Skagerrak
Kattegat
Denmark
Copenhagen
Isle of Man
Irish Sea
Ireland
Dublin
United Kingdom
Netherlands
London
Belgium
Germany
Berlin
Poland
Warsaw
Kiev
Ukraine
Czech Republic
Slovakia
Moldova
Chisinau
Sea of Azov
English Channel
Guernsey
Jersey
Celtic Sea
Luxembourg
Paris
Austria
Hungary
Romania
Liechtenstein
Bern
Switzerland
France
Ljubljana
Black Sea
Bay of Biscay
Belgrade
Bosnia and Herzegovina
Serbia
Bulgaria
San Marino
Monaco
Sofia
Montenegro
Prishtina
Podgorica
Skopje
Ankara
Turkey
Andorra
Italy
Adriatic Sea
Macedonia (FYROM)
Sea of Marmara
Holy See (Vatican)
Tirana
Albania
Spain
Portugal
Balearic Sea
Tyrrhenian Sea
Greece
Athens
Cyprus
Ionian Sea
Gibraltar
Alboran Sea
Algiers
Tunis
Malta
Rabat
Mediterranean Sea
Morocco
Gulf of Gabes
Tunisia
Tripoli
Cairo
Gulf of Suez

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

IH Cantabria has developed in NEARTOWARN project

- Tsunami Travel Time Maps for each country and islands in the NEAM region

- For each forecast point of NEAM region: Tsunami Travel Times from all the NEAM sources

All these results can be found in a computer tool that allows us to consult online all these issues. This viewer can be found in:

http://www.neartowarn.ihcantabria.com/

(Use Google chrome or firefox, not IE)

FUNDACION
UNIVERSIDAD DE CANTABRIA

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

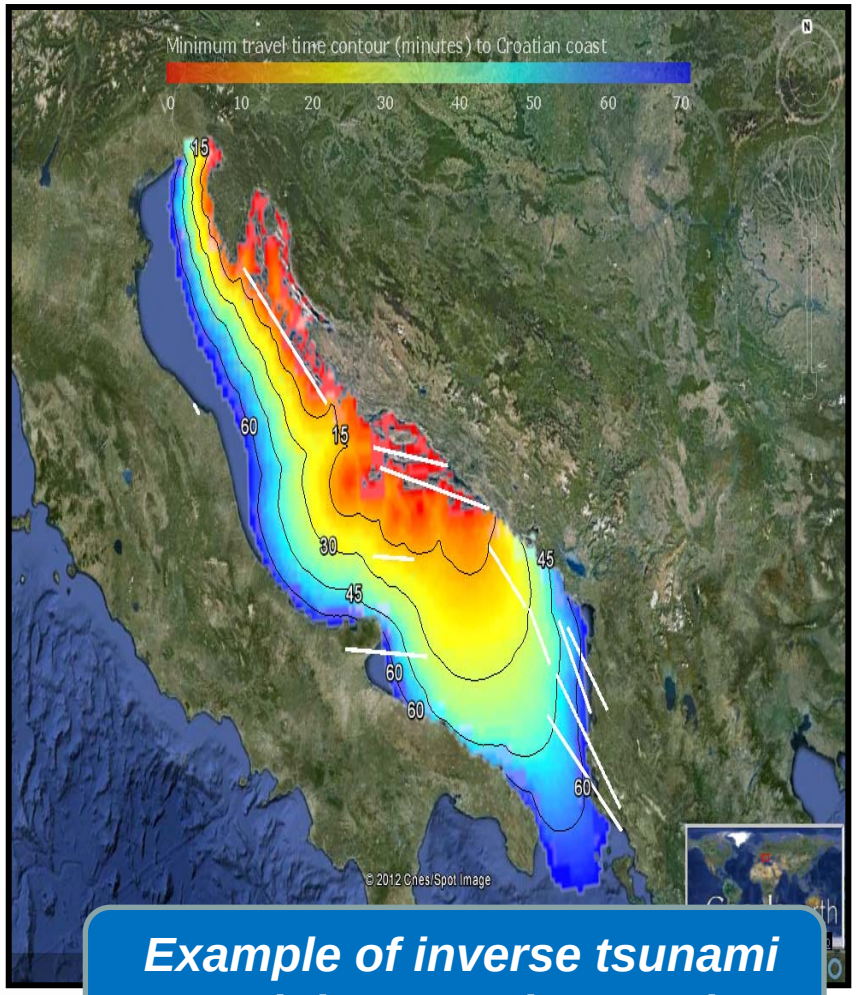
173 sources (TRANSFER Catalogue)

FUNDACION
UC
UNIVERSIDAD DE CANTABRIA

Country TTT Maps for Nearfield Tsunami sources

- Tsunami travel time calculations
- For Each country and main islands of NEAM region
- Envelope contours

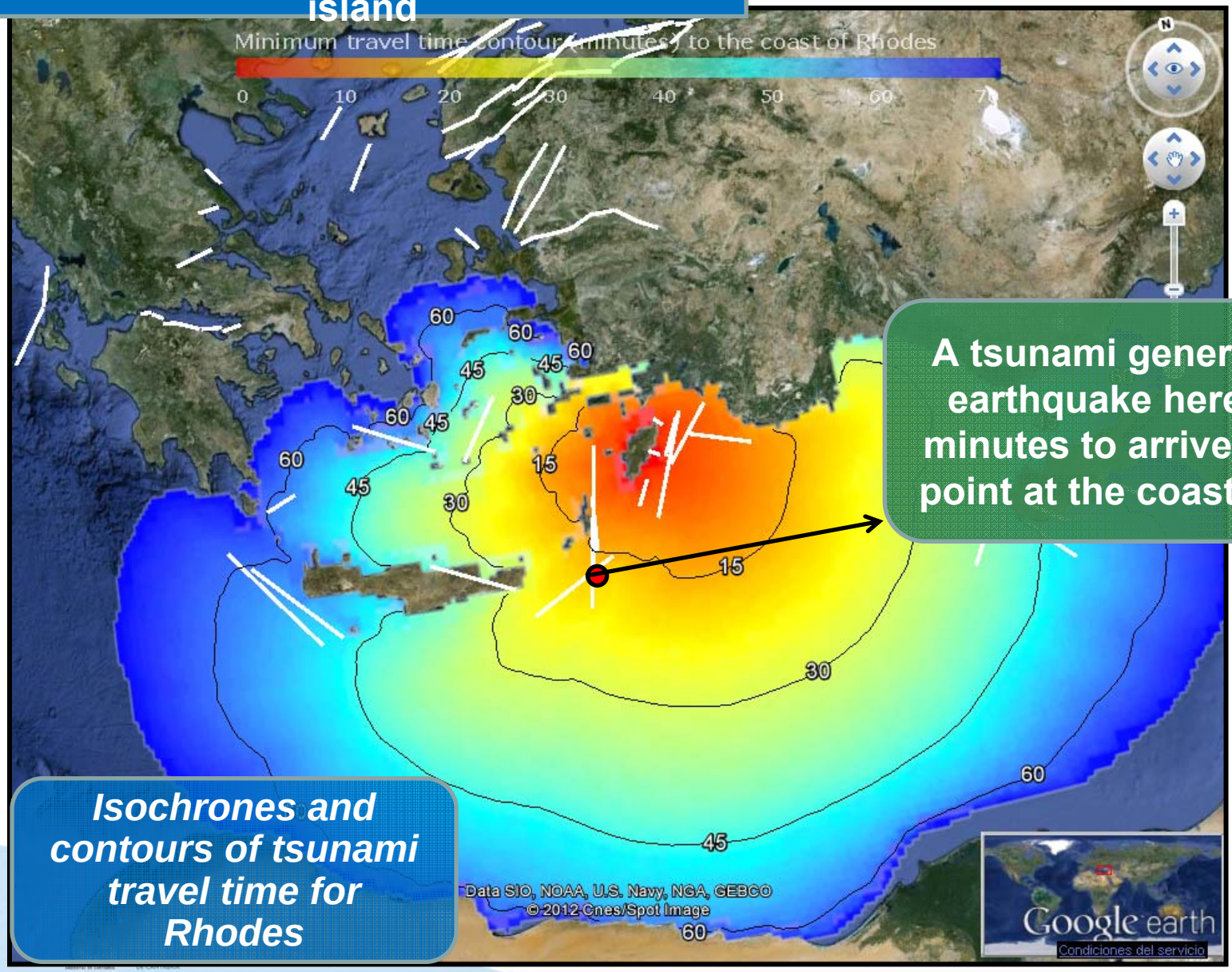
Isochrone “t” represents the tsunami sources locus whose wave takes “t” minutes to arrive to the coast of the selected country or island



Example of inverse tsunami travel time map in Croatia.

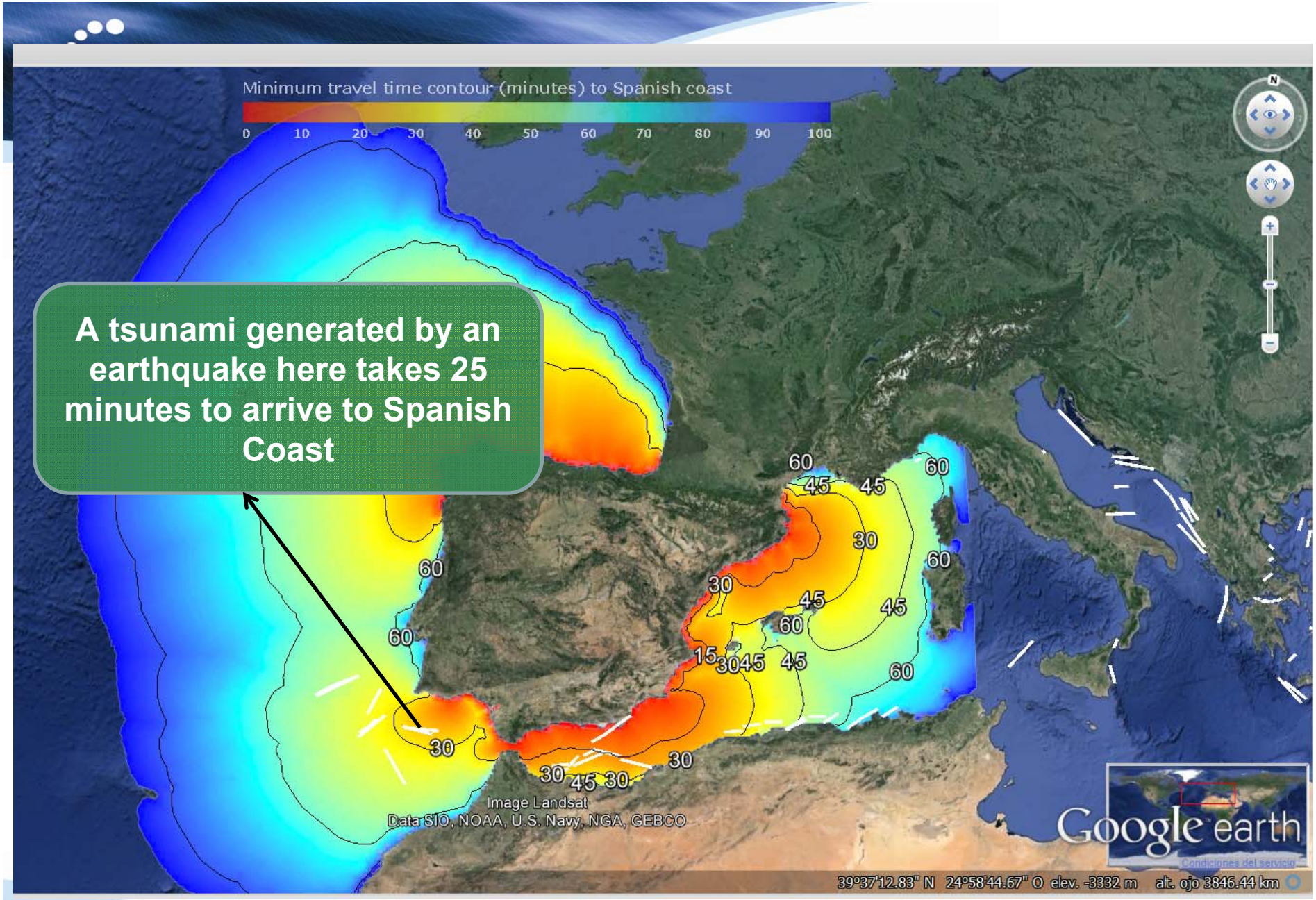
Applications

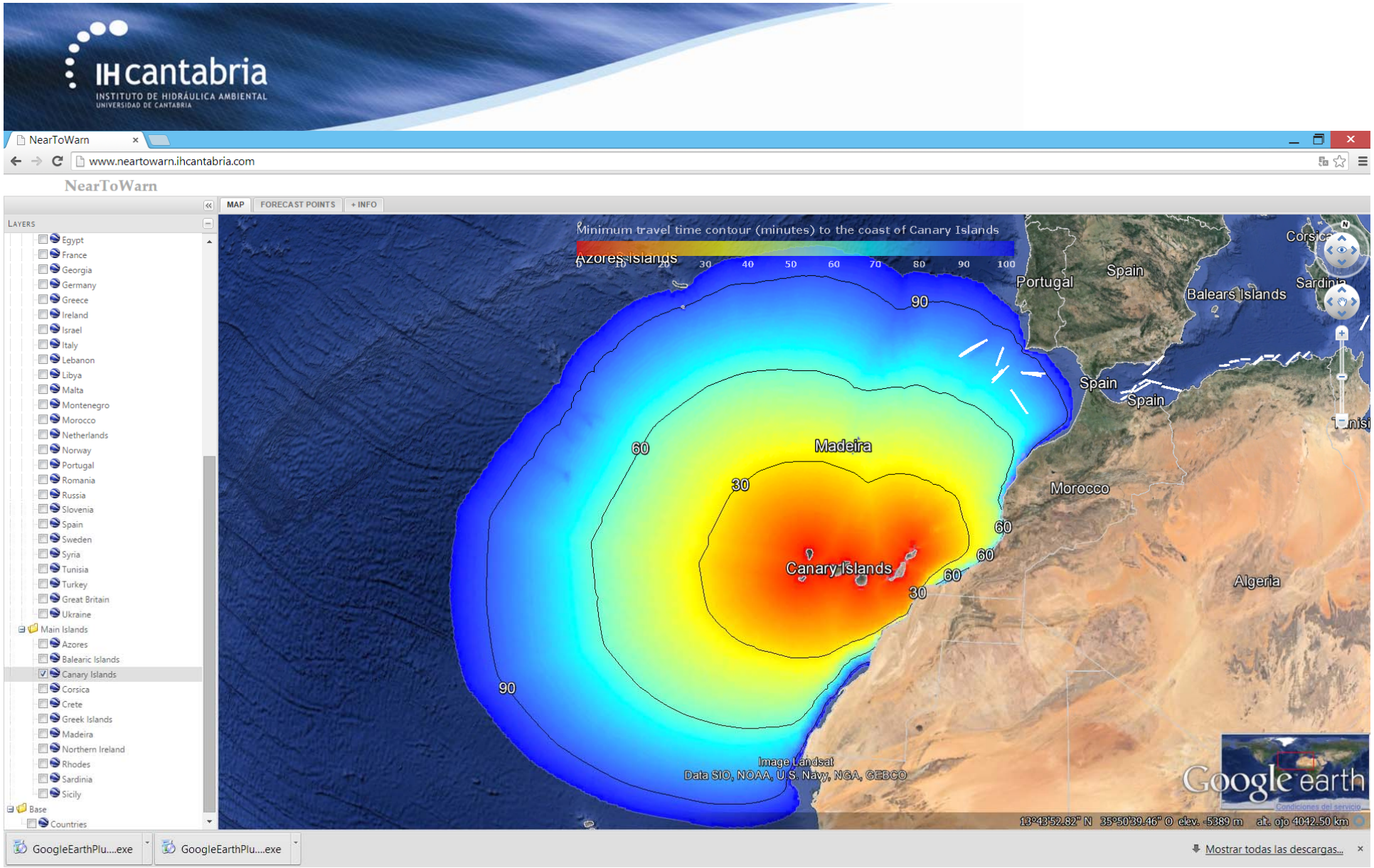
In case of tsunami, inverse tsunami travel time maps allow us to know the time untill the arrival of the wave to the first point of each country or main island



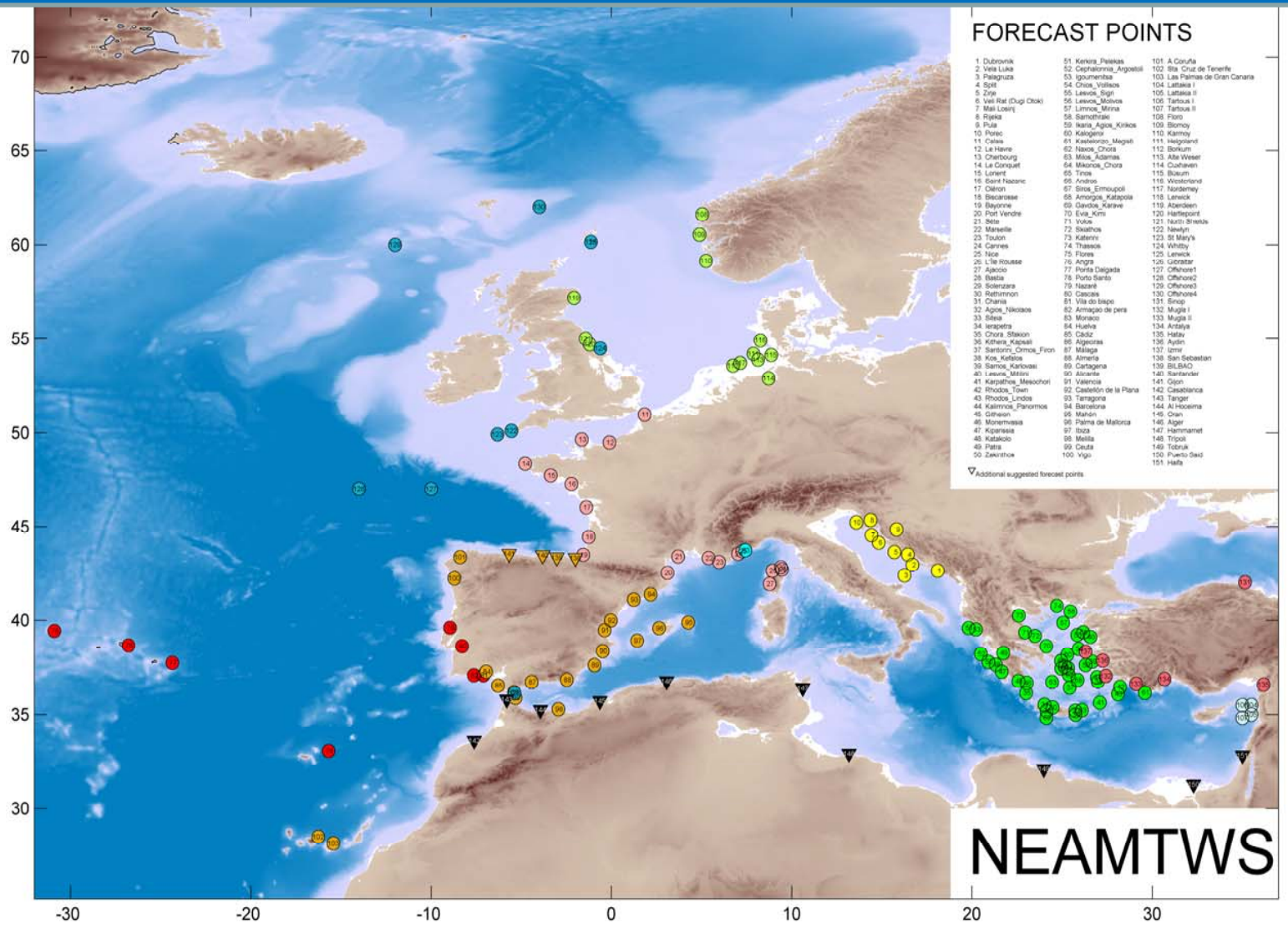
A tsunami generated by an earthquake here takes 17 minutes to arrive to the first point at the coast of Rhodes

Isochrones and contours of tsunami travel time for Rhodes

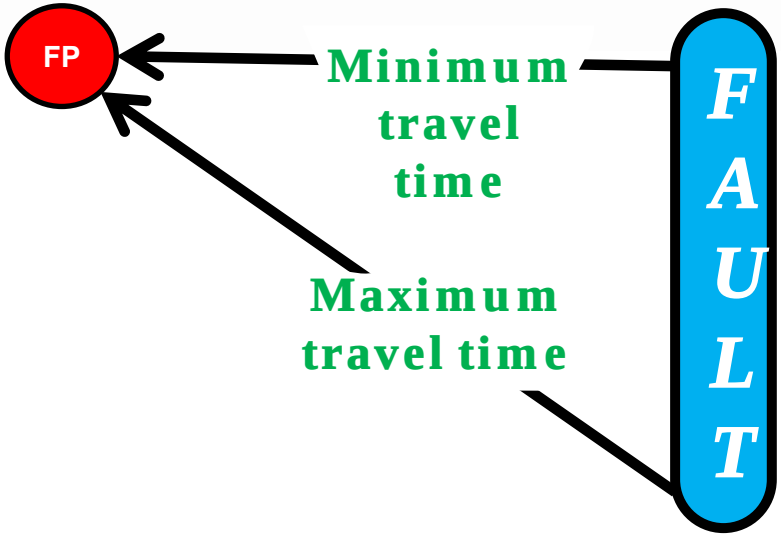

Minimum travel time contour (minutes) to Spanish coast
0 10 20 30 40 50 60 70 80 90 100
A tsunami generated by an earthquake here takes 25 minutes to arrive to Spanish Coast
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
39°37'12.83" N 24°58'44.67" O elev. -3332 m alt. ojo 3846.44 km


IHcantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA
NearToWarn
www.neartowarn.ihcantabria.com
NearToWarn
MAP
FORECAST POINTS
+ INFO
LAYERS
Egypt
France
Georgia
Germany
Greece
Ireland
Israel
Italy
Lebanon
Libya
Malta
Montenegro
Morocco
Netherlands
Norway
Portugal
Romania
Russia
Slovenia
Spain
Sweden
Syria
Tunisia
Turkey
Great Britain
Ukraine
Main Islands
Azores
Balearic Islands
Canary Islands
Corsica
Crete
Greek Islands
Madeira
Northern Ireland
Rhodes
Sardinia
Sicily
Base
Countries
Minimum travel time contour (minutes) to the coast of Canary Islands
Azores Islands
0
10
20
30
40
50
60
70
80
90
100
Portugal
Spain
Balears Islands
Corsica
Sardinia
Spain
Spain
Madeira
Morocco
Algeria
Canary Islands
90
60
30
60
60
60
30
90
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
13°43'52.82" N 35°50'39.46" O elev. -5389 m alt. ojo 4042.50 km
GoogleEarthPlu....exe
GoogleEarthPlu....exe
Mostrar todas las descargas...
FUNDACION
UC
UNIVERSIDAD DE CANTABRIA

- ***151forecast points in NEAM region(IOC-UNESCO)***



Forecast points

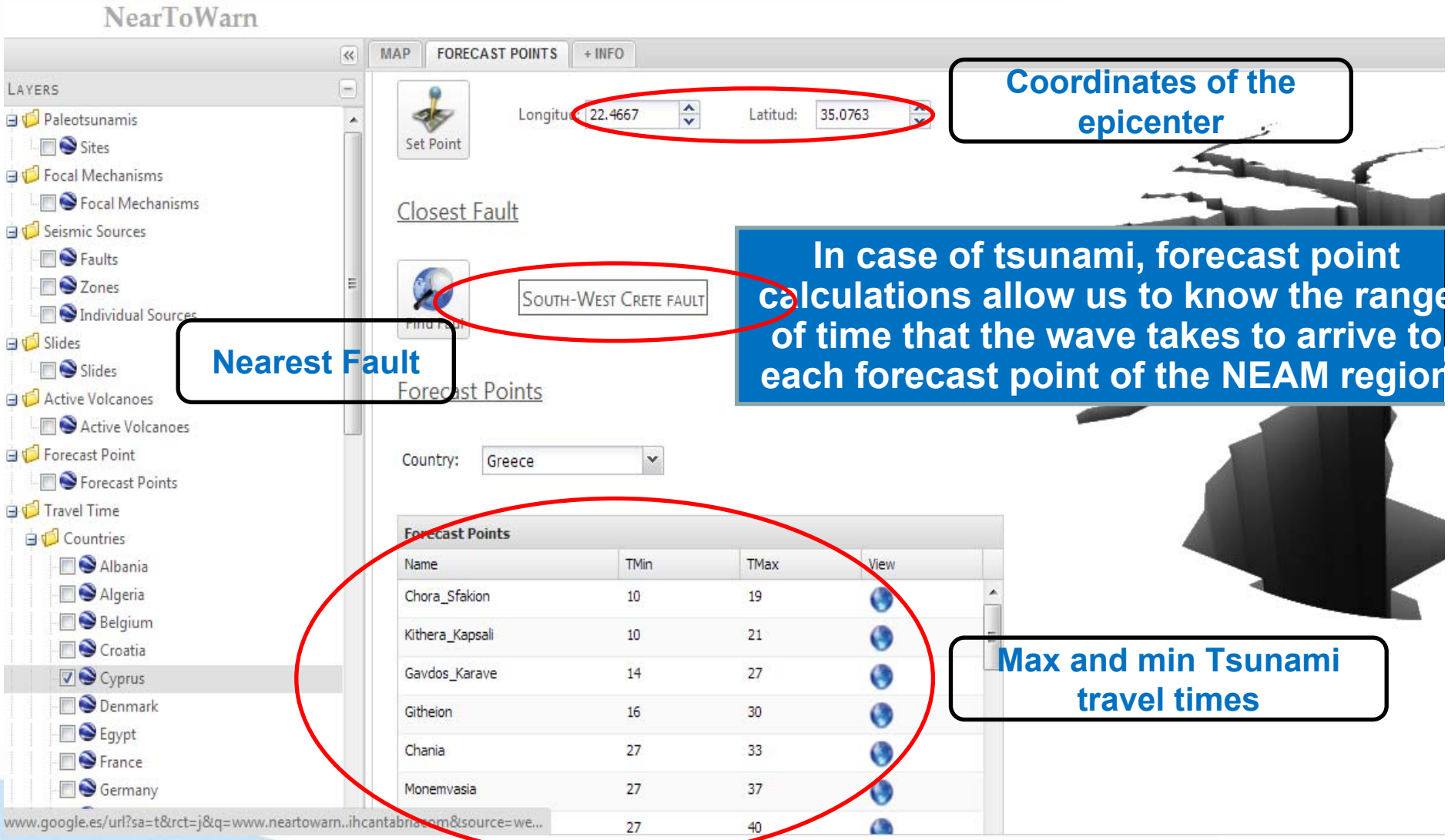


173 faults

151 forecast points

173*151 couples of Max-Min values

Applications



Coordinates of the epicenter

In case of tsunami, forecast point calculations allow us to know the range of time that the wave takes to arrive to each forecast point of the NEAM region

Nearest Fault

Max and min Tsunami travel times

Conclusiones

1. **Los modelos numéricos proporcionan herramientas valiosas, para determinar el impacto de tsunamis en la costa, en Sistemas de Alerta Temprana (SAT).**

2. **Protocolos de alerta a lo largo de la costa de un país, son difíciles de implementar** con la información que proporciona un sistema regional como el NEAMTWS, basados en tan solo parámetros sísmicos
   (Mw y distancia al picentro).

3. **Se requiere de SAT locales**, que proporcionen información de: (Nivel de alerta, tiempos de arribo y alturas de ola), **discriminando por zonas de interés de la costa** (municipios,puertos, industrias de alto riesgo, etc) CFZ.

4. Los mensajes de nivel de alerta para cada zona **(watch, alert, warning),** se basan en información de la base de datos pre-ejecutada: Alturas de ola (0.2-0.5, 0.5-2, >2), Tiempos de arribo (<1h, >1h)

5. **Las bases de datos pre-calculadas en un SAT**, **permiten de forma inmediata** obtener información de mapas e información detallada en la costa, para cada una de las zonas de interés

6. **El Riesgo de Tsunamis en la costa española es ALTO, independientemente de su baja frecuencia de ocurrencia.**

7. El Sistema de Alerta Temprana local (SAT) para la costa española, debe incluir bases de datos y herramientas numéricas que faciliten discriminar niveles de emergencia a lo largo de la costa, que faciliten la implementación y ejecución de planes de emergencia

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

JORNADA TÉCNICA SOBRE EL RIESGO DE MAREMOTOS. PROYECTO DE LA DIRECTRIZ BÁSICA DE PROTECCIÓN CIVIL ANTE EL RIESGO MAREMOTC

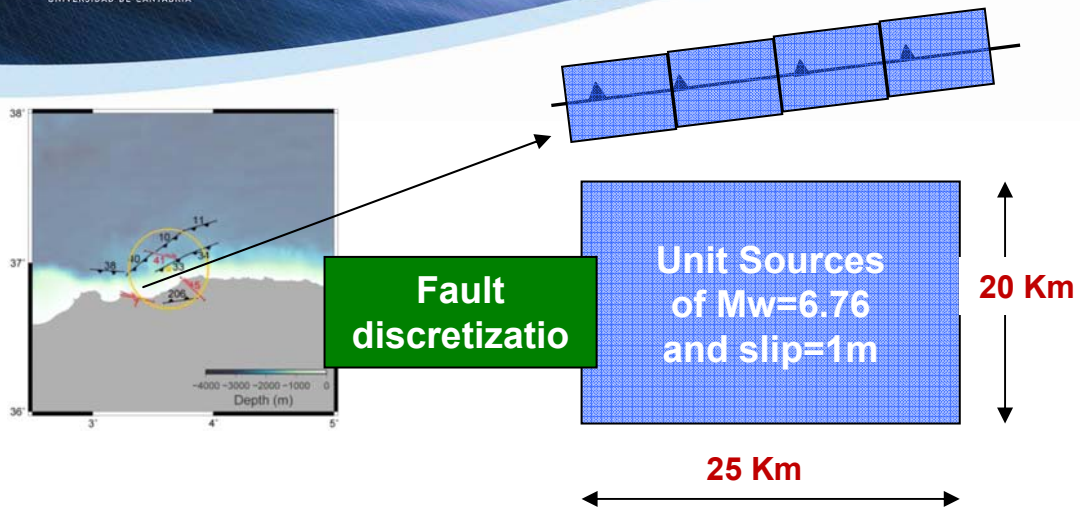
Aportaciones de las herramientas numéricas para la toma de decisiones en Sistemas de Alerta Temprana (SAT) y otras herramientas de apoyo

Mauricio González

Instituto de Hidráulica Ambiental (IH Cantabria)
Universidad de Cantabria

mauricio.gonzalez@unican.es

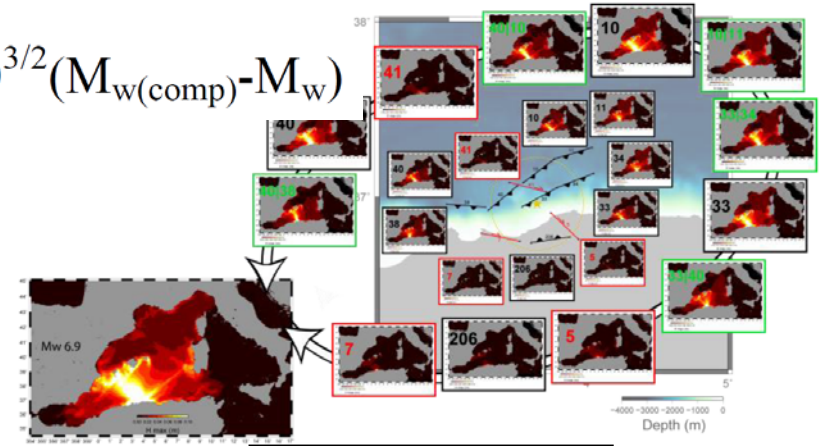
IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA



Wells and Copperfield, 1994

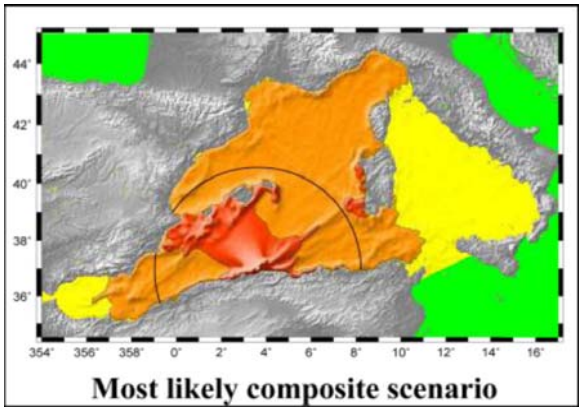
Linear Combination of unit sources propagation to get the real event magnitude

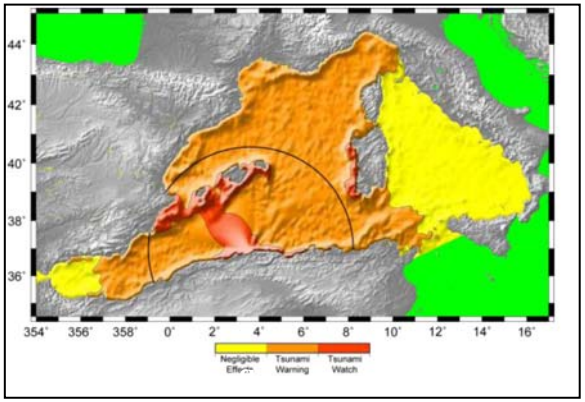
$$F_s = 10^{3/2}(M_{w(comp)}\text{-}M_w)$$



Aggreegated map

Validation





$$Mw = 4.135 + 1.679\log_{10}(L)$$

$$Mw = 4.159 + 2.160\log_{10}(W)$$