laboratorio di idraulica ambientale e marittima
LIam
DISAT UNIVERSITA' DEGLI STUDI DI L'AQUILA FACOLTA' DI INGEGNERIA

REGIONE ABRUZZO

University of L'Aquila
12 luglio 2005

ONDE DI MAREMOTO
Generazione, propagazione e interazione con le coste
www.tsunamis.it

UNIVERSITA' DEGLI STUDI DI ROMA TorVergata Università

Politecnico di Bari

Un. Di Roma 3

PSTd'A

Registro Italiano Dighe R I D

PROTEZIONE CIVILE NAZIONALE

APAT

University of L'Aquila
12 luglio 2005

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Master di II livello

in

INGEGNERIA DELLA PREVENZIONE DELLE EMERGENZE

University of L'Aquila
12 luglio 2005

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Welcome

Prof. Aniello Russo Spena

Dean of Engineering Faculty of L'Aquila University

University of L'Aquila
12 luglio 2005

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Generazione, propagazione e interazione con le coste
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Welcome

Prof. Roberto Volpe

Pro-Rector of L'Aquila University

University of L'Aquila
12 luglio 2005

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Welcome

Dott. M. SROUR

Assessore ai Lavori Pubblici della Regione Abruzzo

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Part I – Tsunamis Evidences

Prof. Ing. Leopoldo Franco

Un. Di Roma 3

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Generazione, propagazione e interazione con le coste
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Prof. Ing. Bernardo De Bernardinis

Protezione Civile Nazionale

University of L'Aquila
12 luglio 2005

CONGRESS INTRODUCTION
Tsunamis waves in resorvoirs and in open sea
www.tsunamis.it

Prof. Ing Paolo De Girolamo

University of L'Aquila
Laboratorio di Idraulica Ambientale e Marittima – LIAM

PRESENTATION INDEX

- The PRIN project: research team and targets
- Institutions involved in the research program
- International collaboration by exchange of researchers
- Physical aspects of tsunami waves

The PRIN project: research team

Univ. degli Studi di L'Aquila
Prof. Paolo De Girolamo

Univ. degli Studi di Roma Tre
Prof. Leopoldo Franco

Politecnico di Bari
Prof. Antonio Felice Petrillo

Univ. di Roma Tor Vergata
Prof. Paolo Sammarco - Alberto Noli

PRIN

Programma di ricerca di interesse nazionale approvato con Decreto Ministeriale 8 novembre 2004 prot. n. 174/2004

COFIN(2004) 2005-2006

ONDE DI MAREMOTO GENERATE DA FRANE IN CORPI IDRICI: MECCANICA DELLA GENERAZIONE E DELLA PROPAGAZIONE, SVILUPPO DI MODELLI PREVISIONALI E DI SISTEMI DI ALLERTA IN TEMPO REALE BASATI SU MISURE MAREOGRAFICHE

TSUNAMIS GENERATED BY LANDSLIDES: MECHANICS OF GENERATION AND PROPAGATION, DEVELOPMENT OF FORECAST MODELS AND OF REAL TIME ALLERT SYSTEMS BASED ON MEASUREMENTS

www.tsunamis.it

Coordinatore nazionale: Prof. Ing. Paolo De Girolamo
padegi@ing.univaq.it

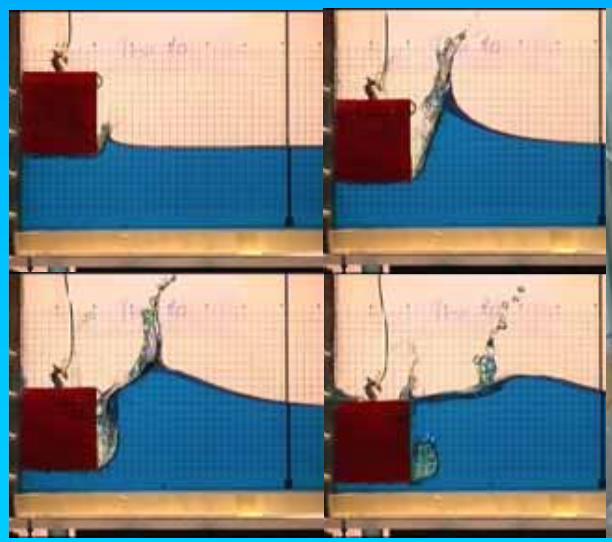
The PRIN project: research targets

Targets:

- **Set-up of formulas and forecast methods**
- **Experimental benchmarks for numerical and analytical models**
- **Analytical studies**
- **Set-up of numerical codes for the simulation of scenarios at continental scales (Mediterranean Sea)**
- **Real time methods to identify tsunamis from tide measurements**

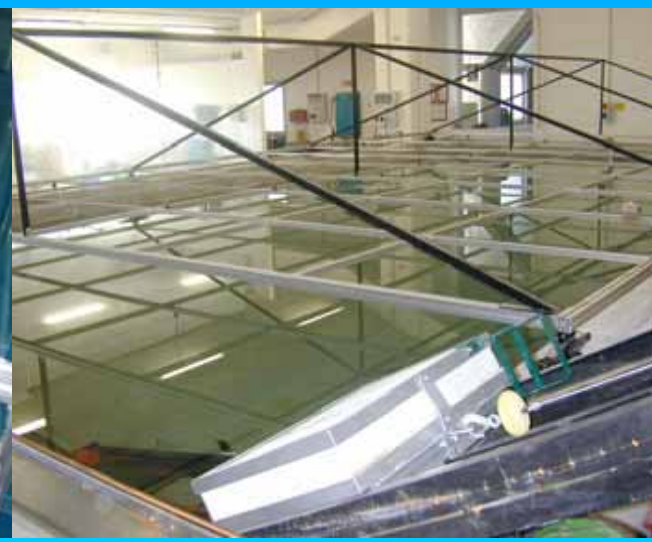
Methods : **Experimental, analytical and numerical studyes**

2D-Tests



Axial-simmetrical geometry

3D-Tests



The PRIN project: research targets

The aspects connected to geophysics and geology are not included in the project

(e.g. - identifications of tsunamis sources)

Institutions involved in the research project

Research programs founded to PRIN team on Tsunamis

- **Previsione delle onde generate da frane e vento nei serbatoi artificiali (Anno 1998)**
  Ente finanziatore: Servizio Dighe
  Responsabile Scientifico per l'Università: Alberto Noli
  Responsabie per il Servizio Dighe: Alberto Petaccia

- **Modellazione delle onde d'impulso nei serbatoi artificiali generate da frane o slavine (Anno 2000).**
  Ente finanziatore: Servizio Dighe
  Responsabile Scientifico per l'Università: Paolo De Girolamo
  Responsabie per il Servizio Dighe: Alberto Petaccia

- **Modello numerico e prove sperimentali per lo studio dell'interazione delle onde di impulso generate da frane o slavine con le strutture dei serbatoi artificiali (Anno 2002).**
  Ente finanziatore: Servizio Dighe
  Responsabile Scientifico per l'Università: Paolo De Girolamo
  Responsabie per il Servizio Dighe: Alberto Petaccia

- **Ricostruzione del campo di moto ondoso generato a Stromboli dall'evento di frana del 30/12/2002 e previsione del campo d'onda in relazione a scenari alternativi di frana (2004)**
  Ente finanziatore: Dipartimento della Protezione Civile
  Responsabile Scientifico per l'Università: Paolo De Girolamo
  Responsabie per la Protezione Civile: Bernardo De Bernardinis

International collaboration by exchange of researchers

- Johns Hopkins University – MD USA (Prof. R.A. Dalrymple)
- Delaware University - DE USA (Prof. J. Kirby)
- Cornell University - Ny USA (Prof. P. L. Liu)

Physical aspects of tsunami waves

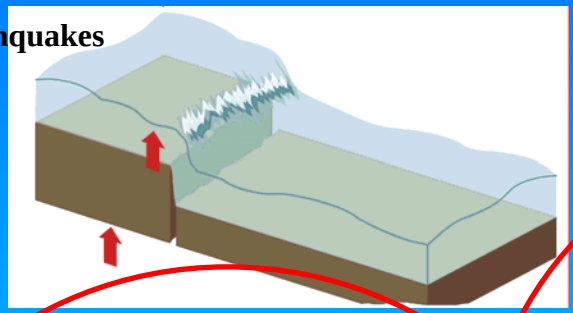
Simple schematization of the problem

Generation

Propagation

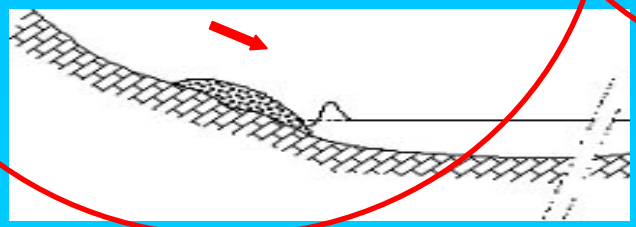
Interaction with coasts and structures

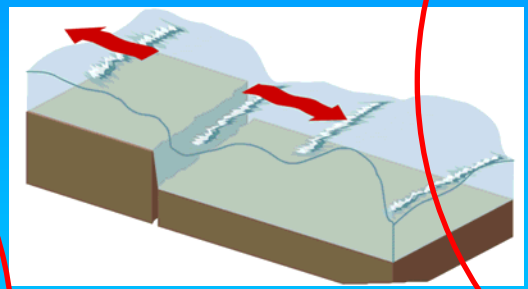
Earthquakes



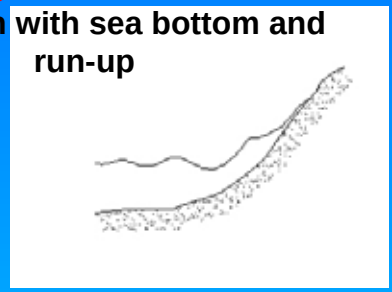
Submarine landslides

Subaerial landslides





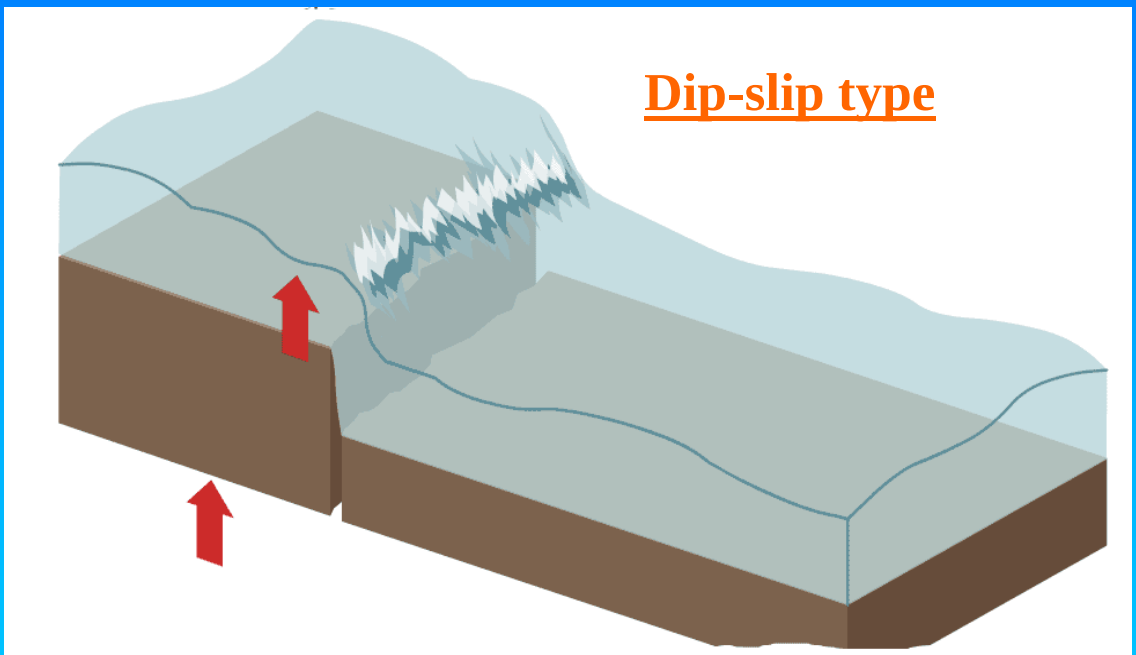
Interaction with sea bottom and run-up



Overtopping (dams)

Physical aspects of tsunami waves

Generation — **Earthquakes**



Dip-slip type

Main parameters which influence the generated tsunami characteristics:

Sea bottom displacement

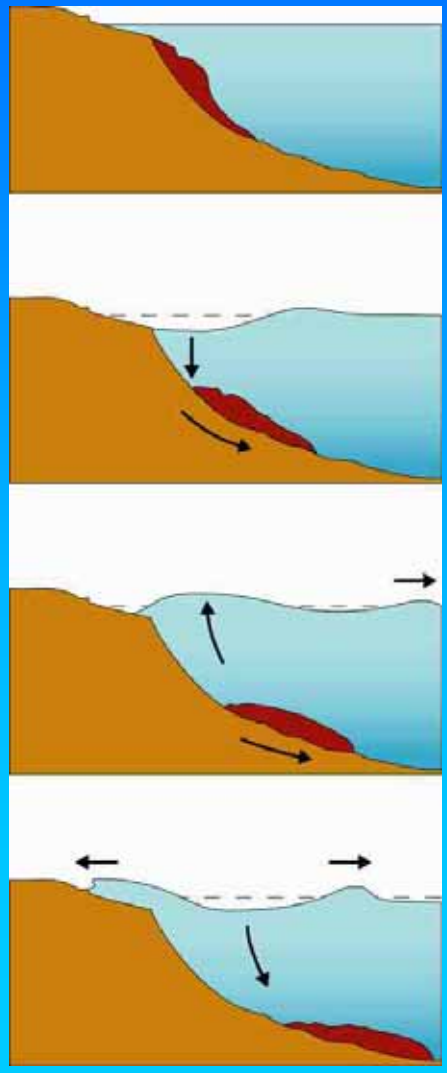
Volume of earth involved by the displacement

Elapsed time of the sea bottom displacement

Physical aspects of tsunami waves

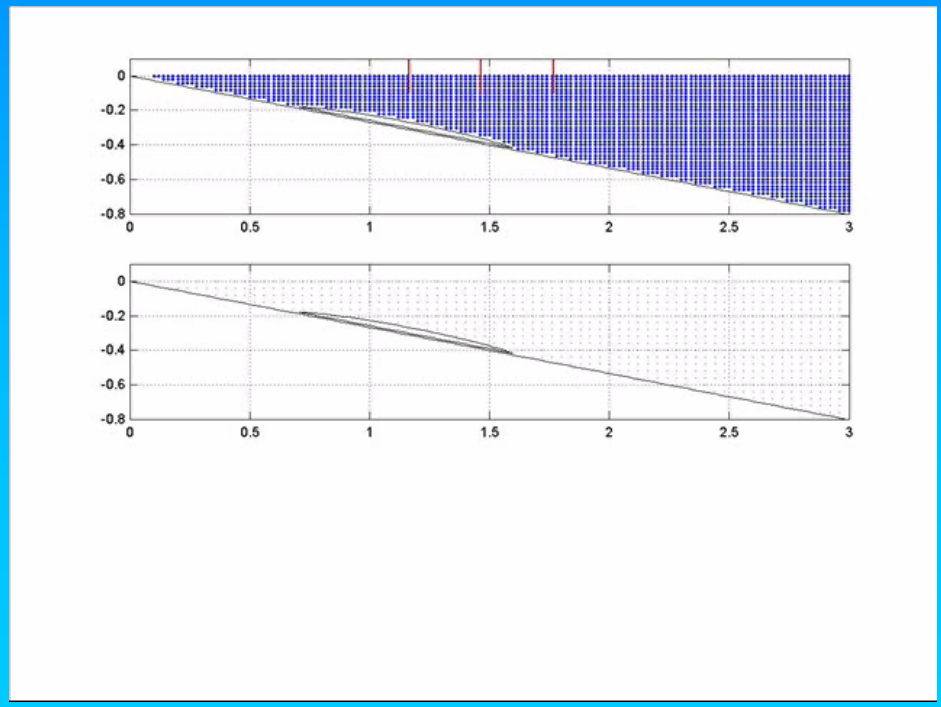
Generation

Submarine landslides



Main parameters which influence the generated tsunami characteristics:

Volume of the landslide
Length of the submarine displacement
Elapsed time of the underwater motion
Sea bottom steepness

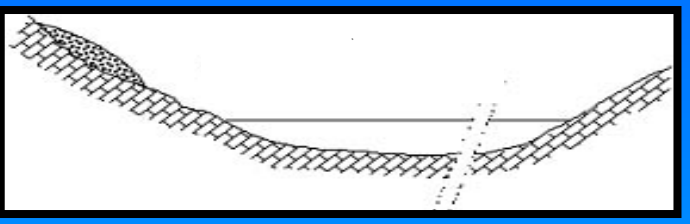


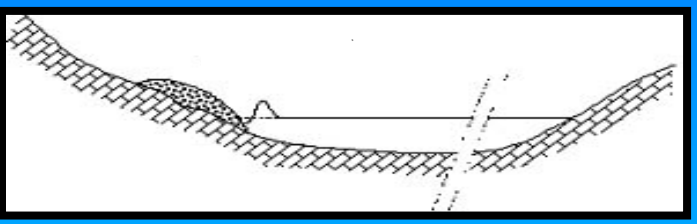
Numerical simulation by A. Panizzo (SPH code)

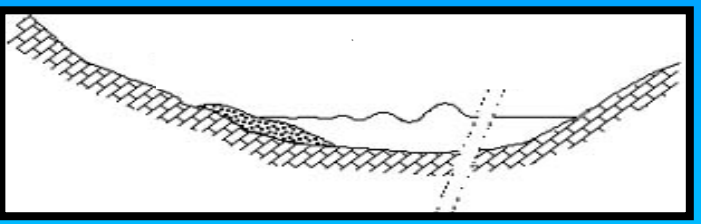
Physical aspects of tsunami waves

Generation

Subaerial landslides







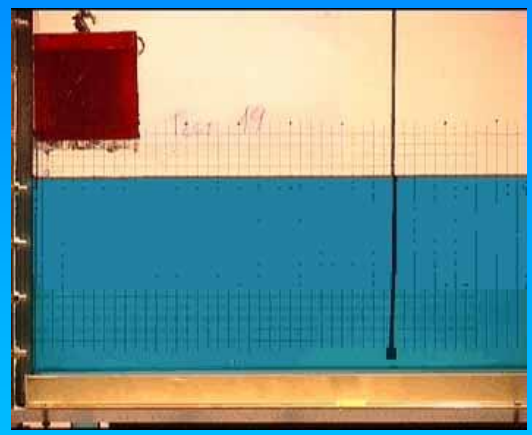
Main parameters which influence the generated tsunami characteristics:

Volume of the landslide

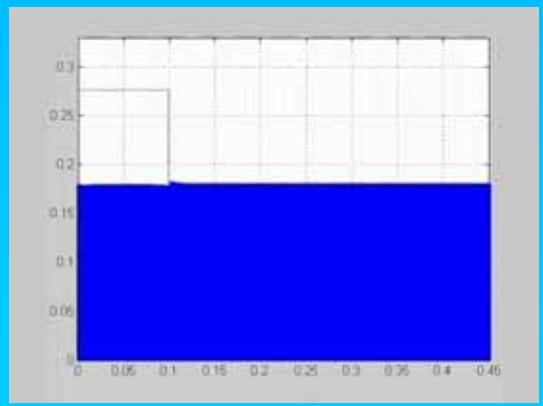
Velocity impact

Elapsed time of the underwater motion

Sea bottom steepness



Numerical simulation by A. Panizzo (SPH code)

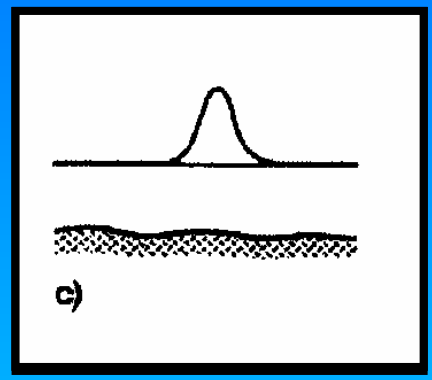


Physical aspects of tsunami waves

Generation and propagation

Types of generated waves

- **linear**
- **cnoidal**
- **solitary**

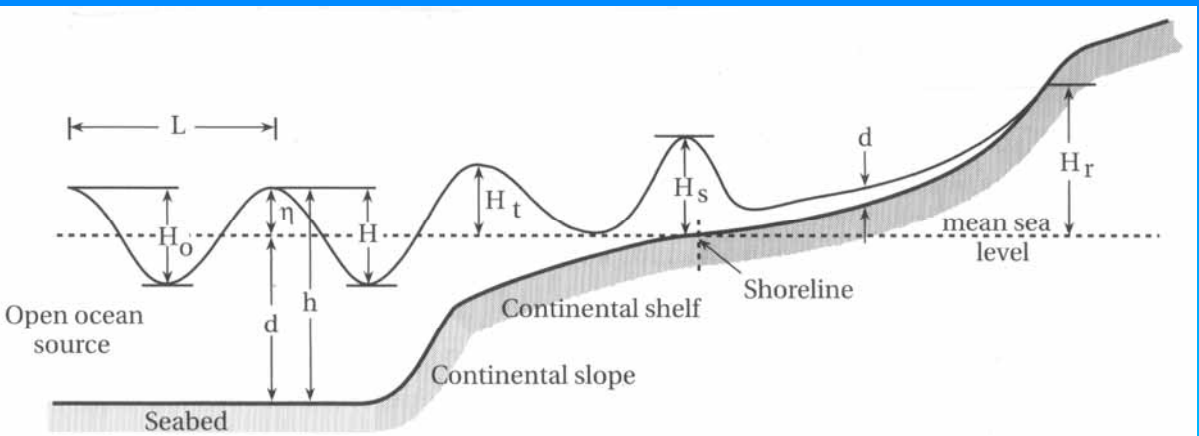


During the propagation the waves may change from one type to another

Physical aspects of tsunami waves

Propagation

Main characteristics of generated waves



2.2 Various terms used in the text to express the wave height of a tsunami.

Offshore
- small steepness
- no breaking

Inshore
- increase of steepness
- breaking possible

Bathymetry variations strongly influence tsunami waves

L = [10 – 500 Km]
T = [100 – 2000 s]
c_{fo} = [160 – 250 m/s] [600 – 900 Km/h]
c_{fs} = [10 m/s] [36 Km/h]

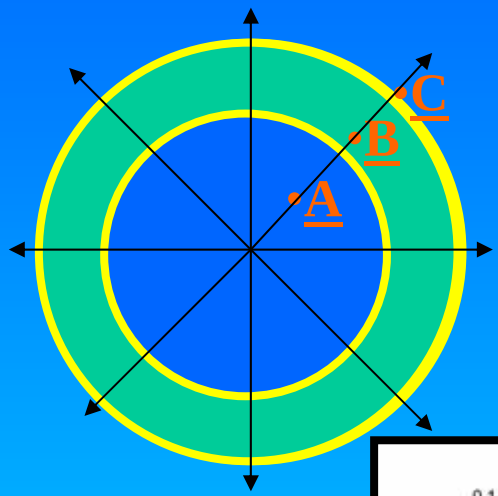
Physical aspects of tsunami waves

Propagation

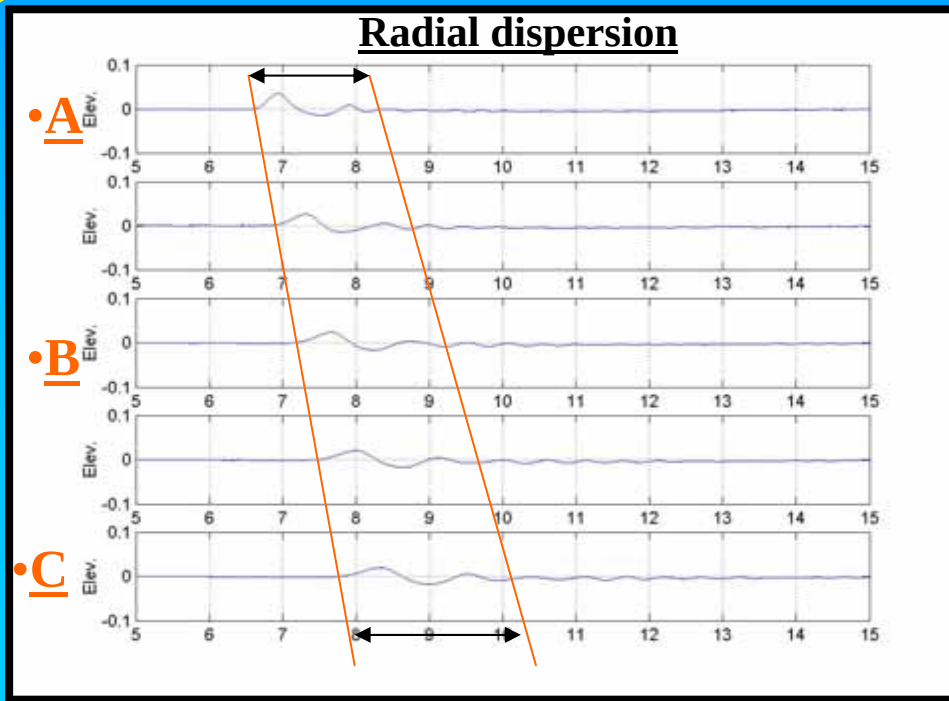
REDUCTION OF ENERGY DENSITY

Circumferential dispersion

Radial dispersion



Radial dispersion

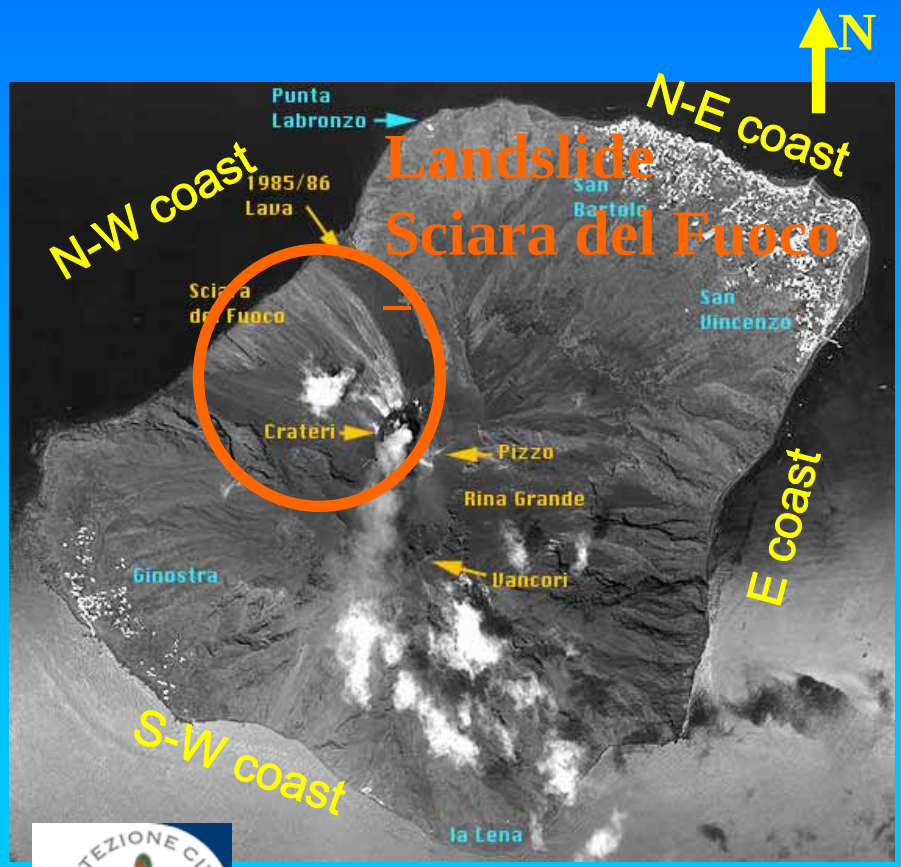


Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

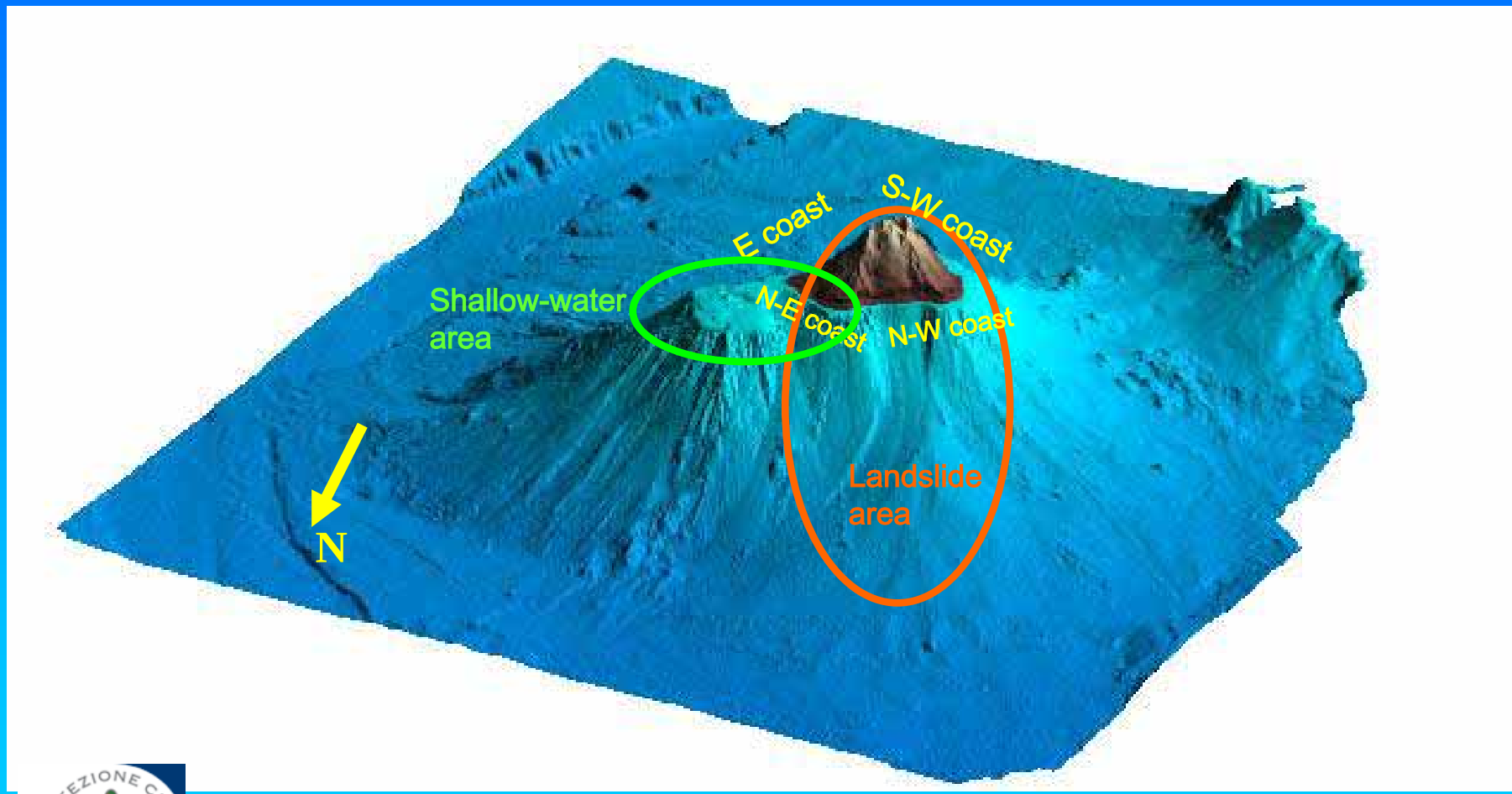
Stromboli
30 December 2002



Physical aspects involved by the tsunami waves

Propagation

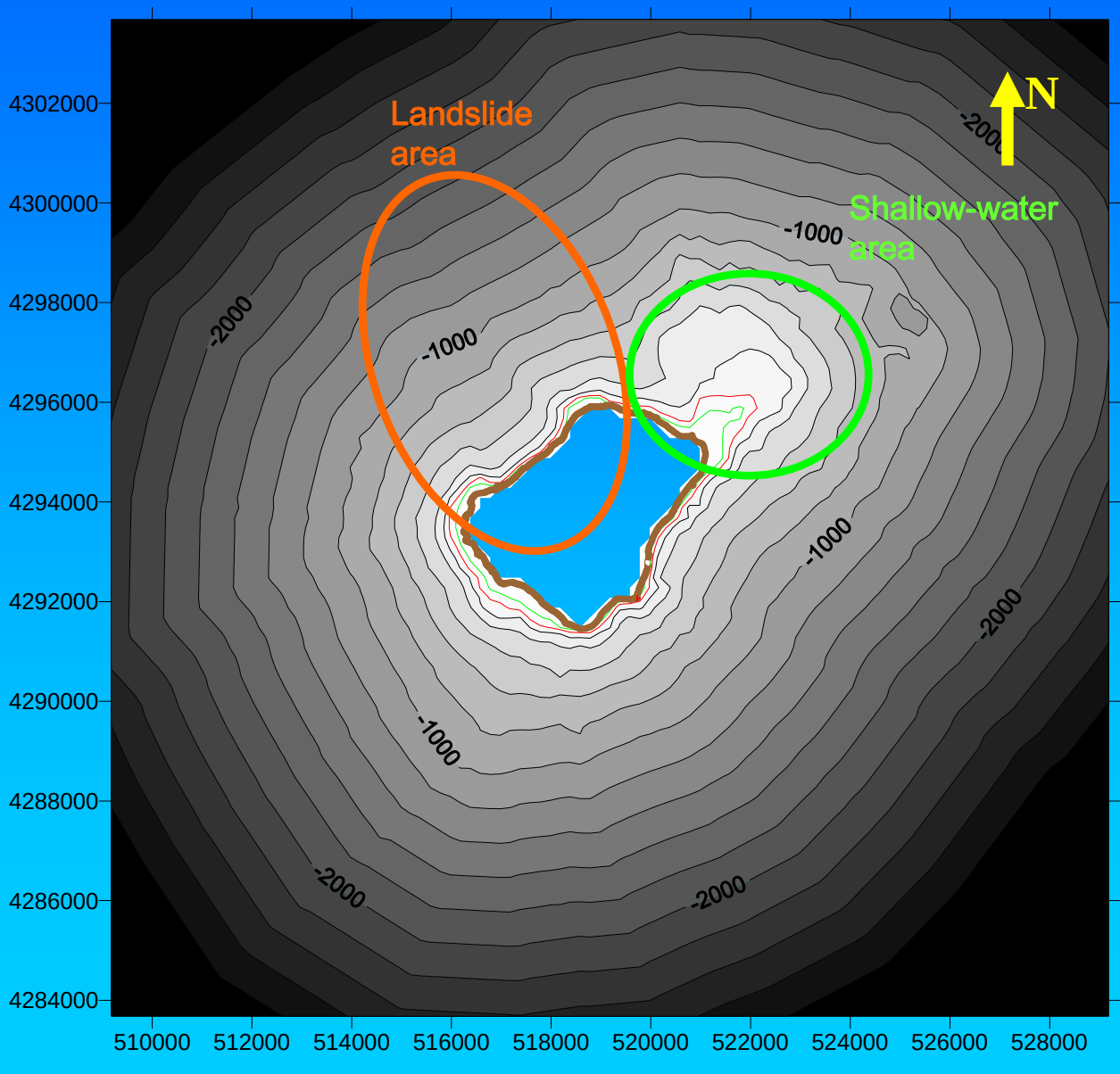
Batymetry effects



Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

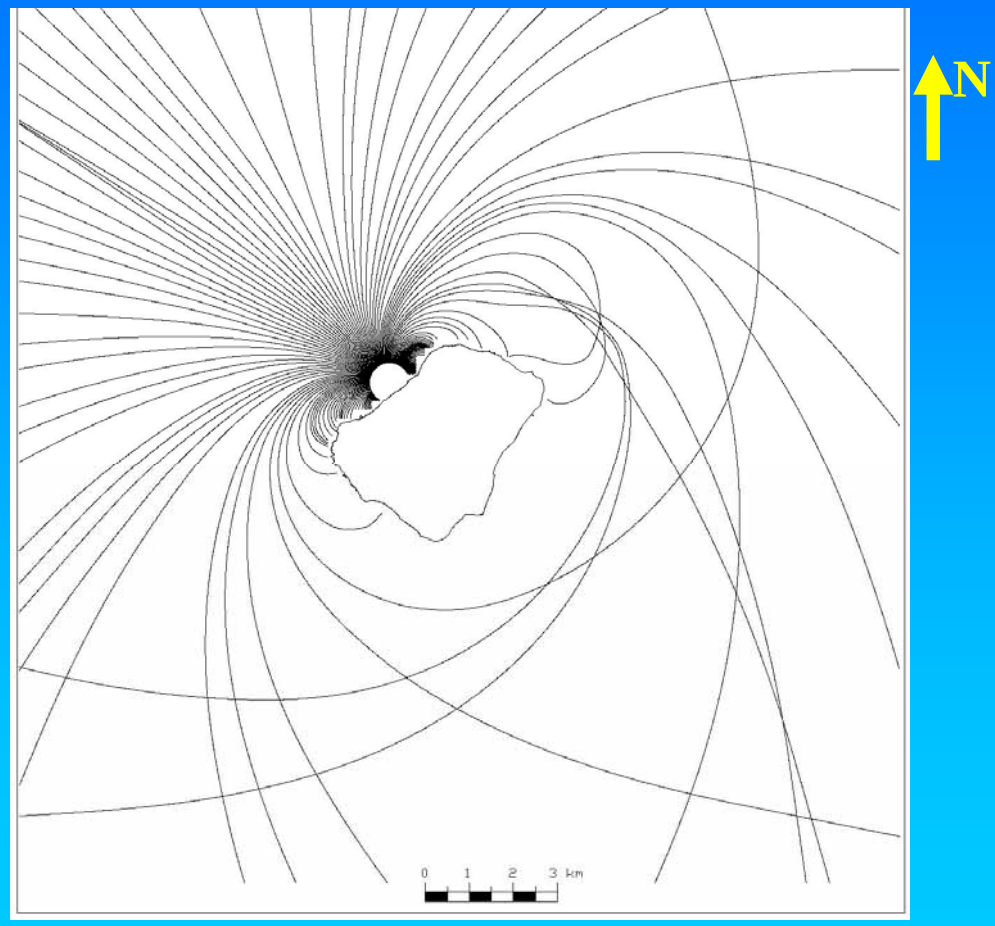


Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

Inverse rays tracking



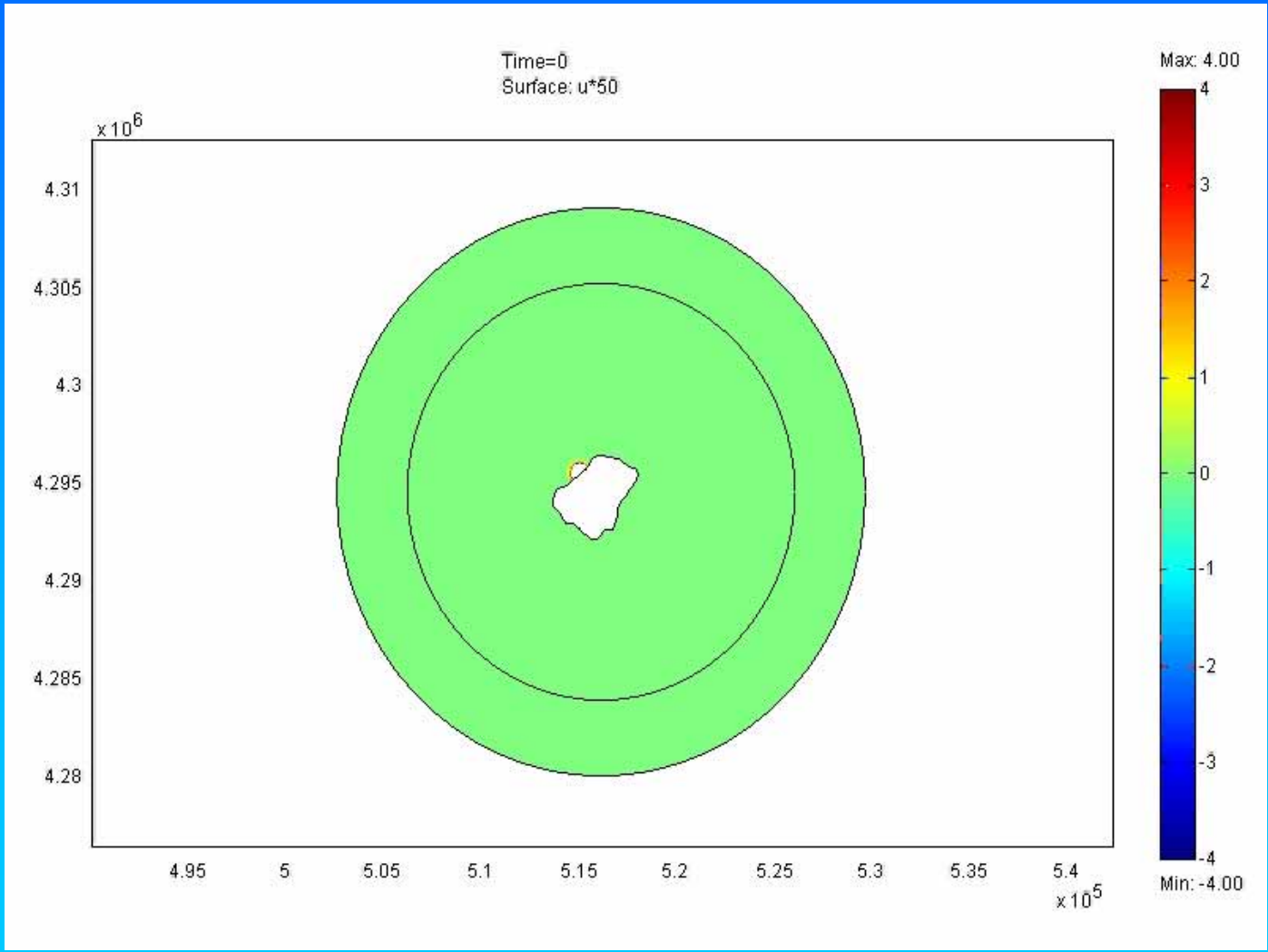
Numerical simulation by G. Bellotti (Merope code)

- T=200s

Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

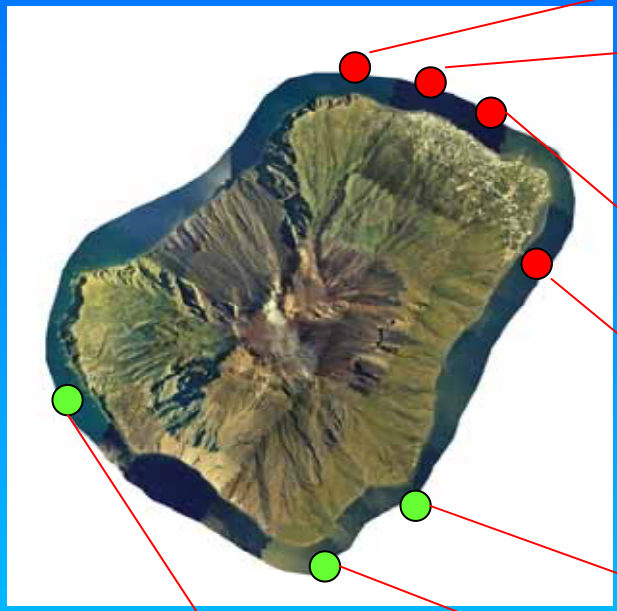


Numerical code and simulation by G. Bellotti

Physical aspects involved by the tsunami waves

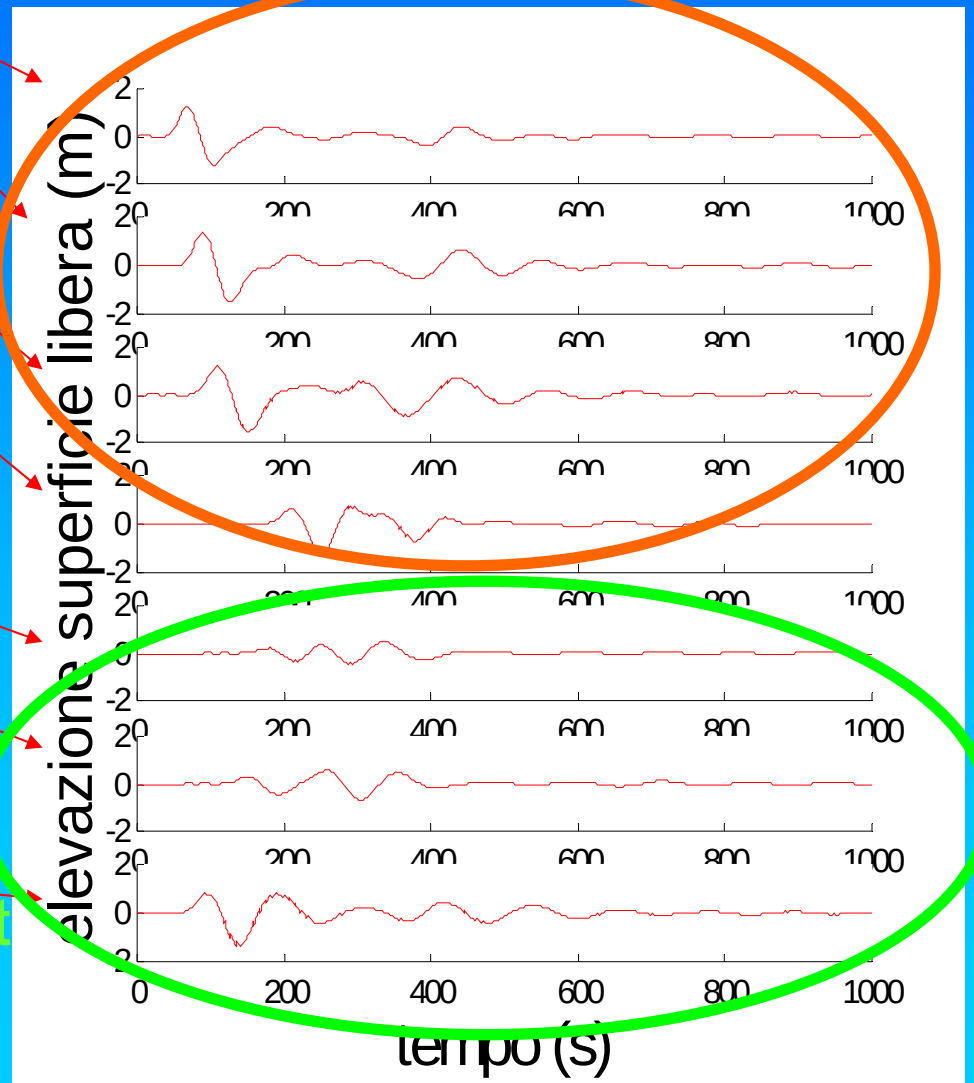
Propagation

Bathymetry effects



N-E coast

S-W coast

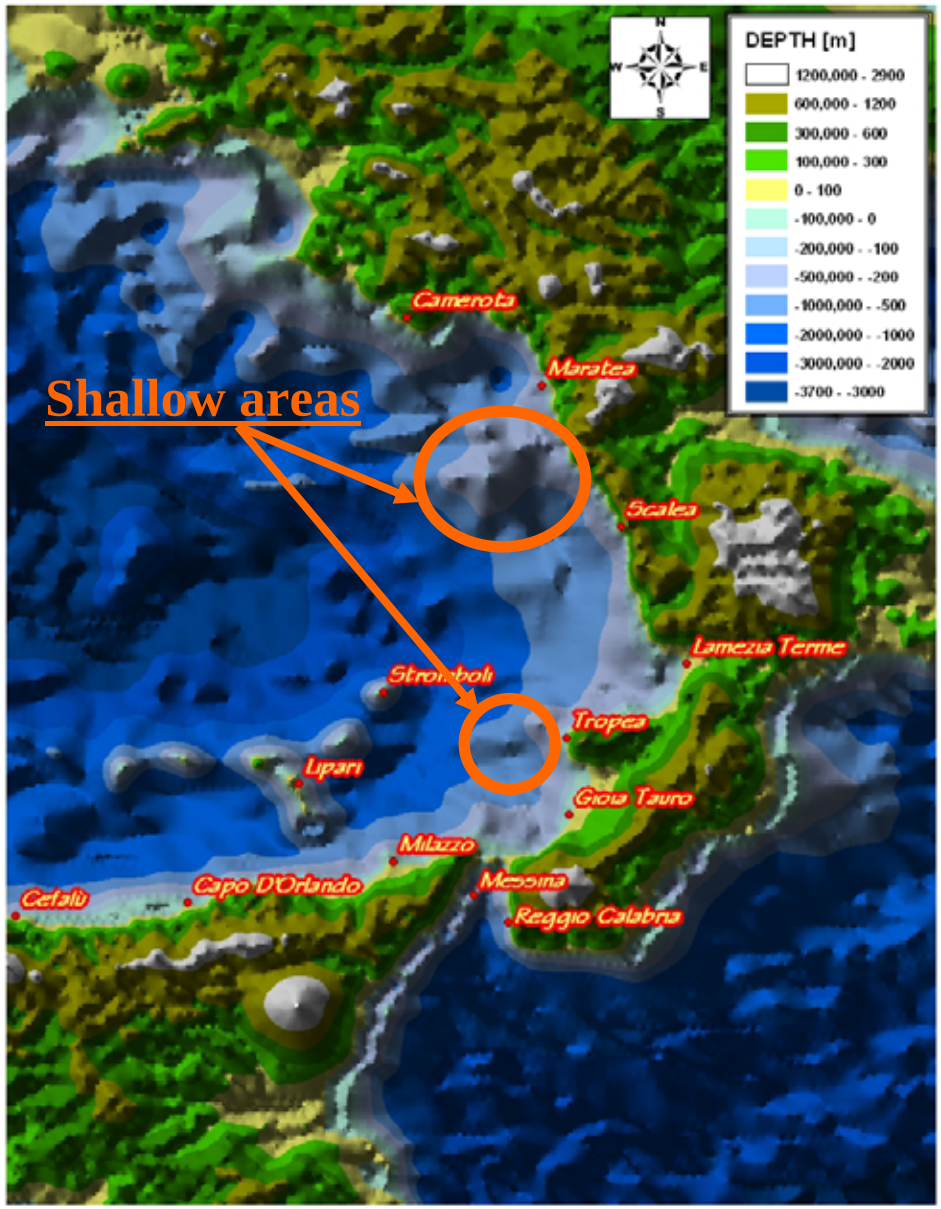


Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

SOUTH EAST TYRRHENIAN SEA BATHIMETRY



Physical aspects involved by the tsunami waves

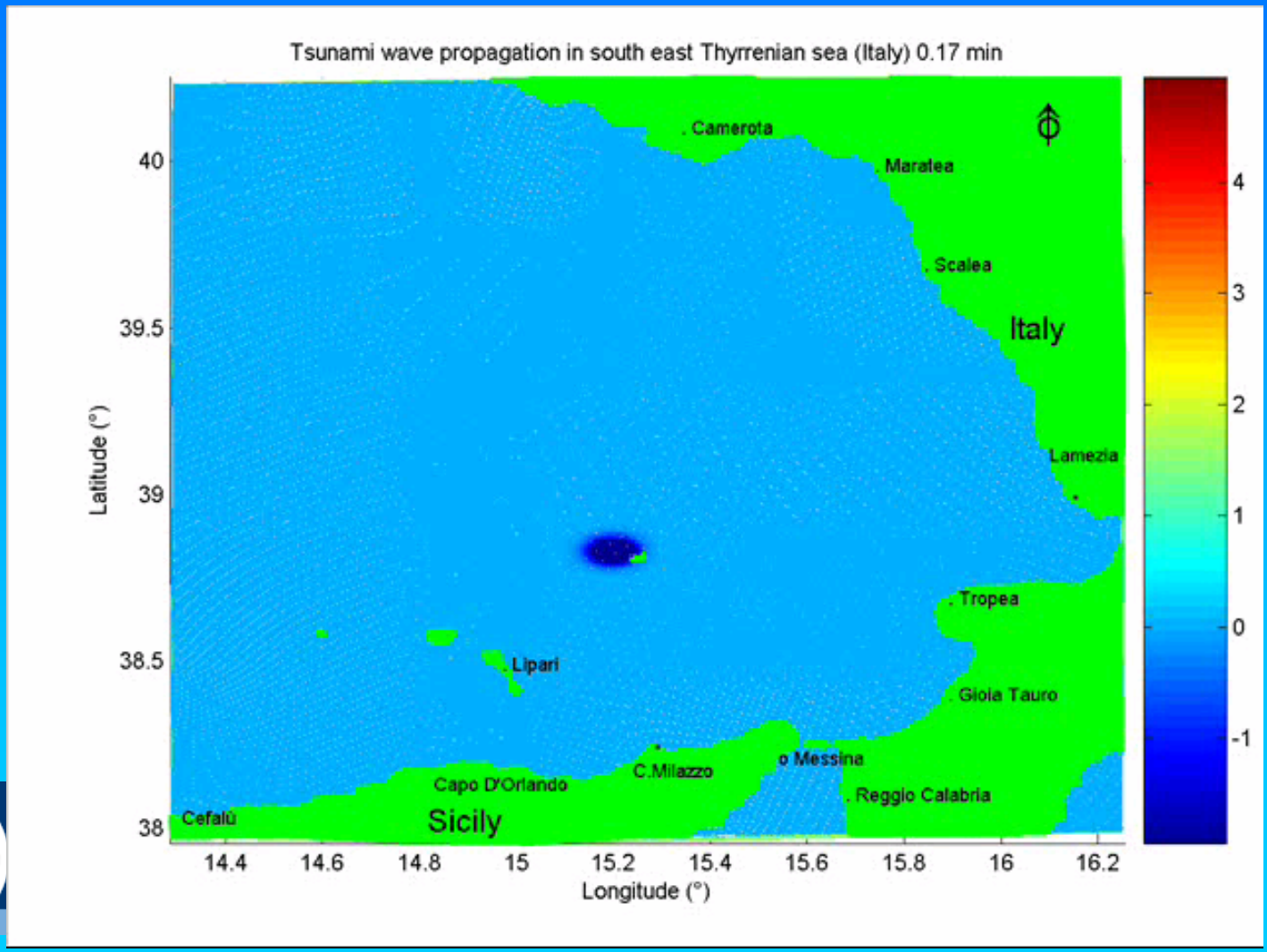
Propagation

Bathymetry effects

Fun wave code DelawareUniv. USA
Numerical simulation by A. Del Guzzo

Stromboli
30 December 2002

GENERATION
RID FORMULA
Subaerial land-slide
Stromboli-Sciara del Fuoco
Vol. : 12,8 Ml m^3
H_{max} : 7,2 m
T_{max} : 38,69 s
L_{max} : 1714,0 m



Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

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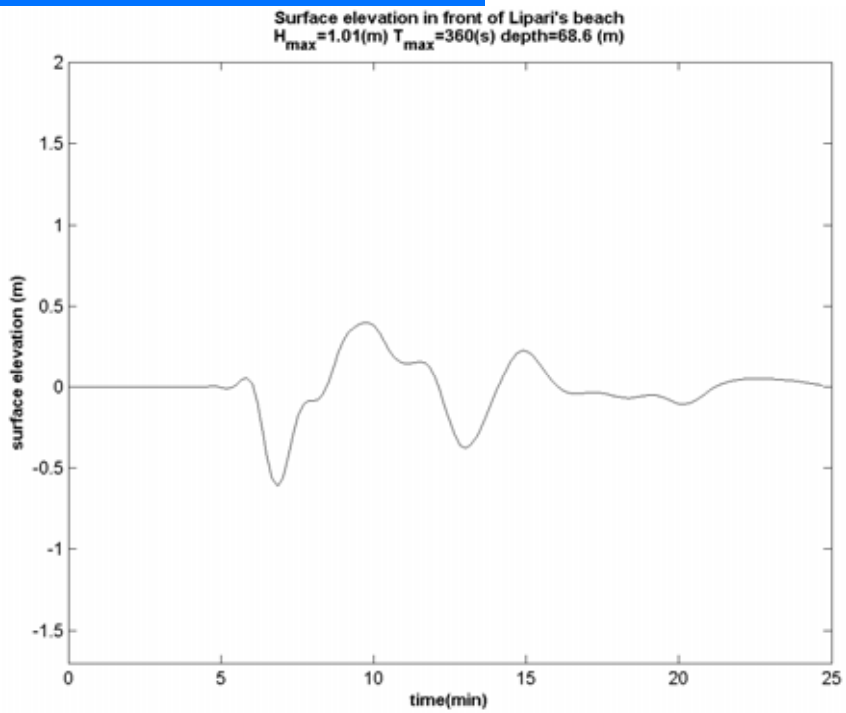
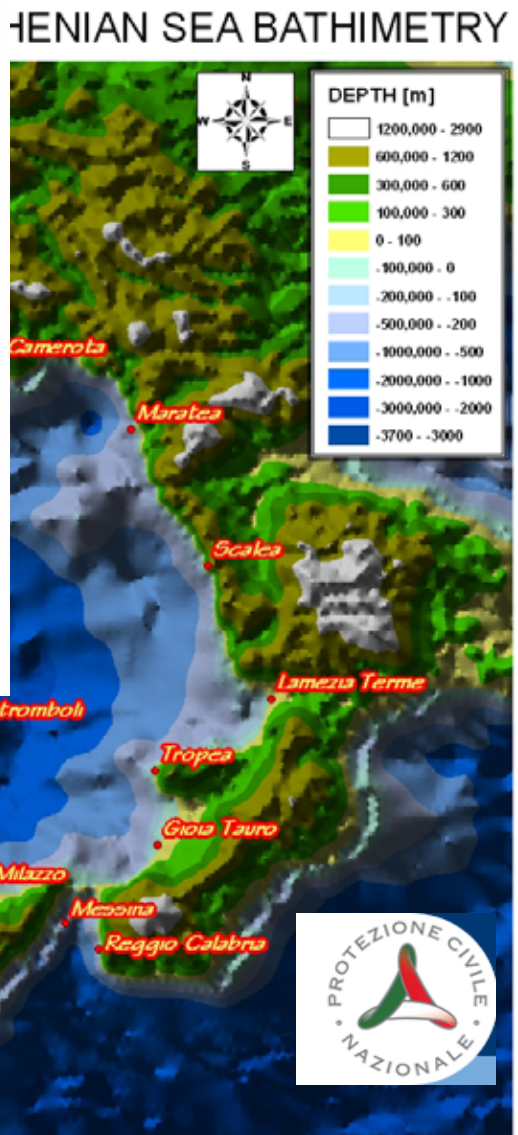
Numerical simulation by A. Del Guzzo





Surface elevation in front of:
Lipari (east coast) (depth 68 m)

H_{max}: 1.02 m
T_{max}: 360,0 s
Arrival Time 6,85 min

Stromboli
30 December 2002

GENERATION
RID FORMULA
Subaerial land-slide
Stromboli-Sciara del Fuoco
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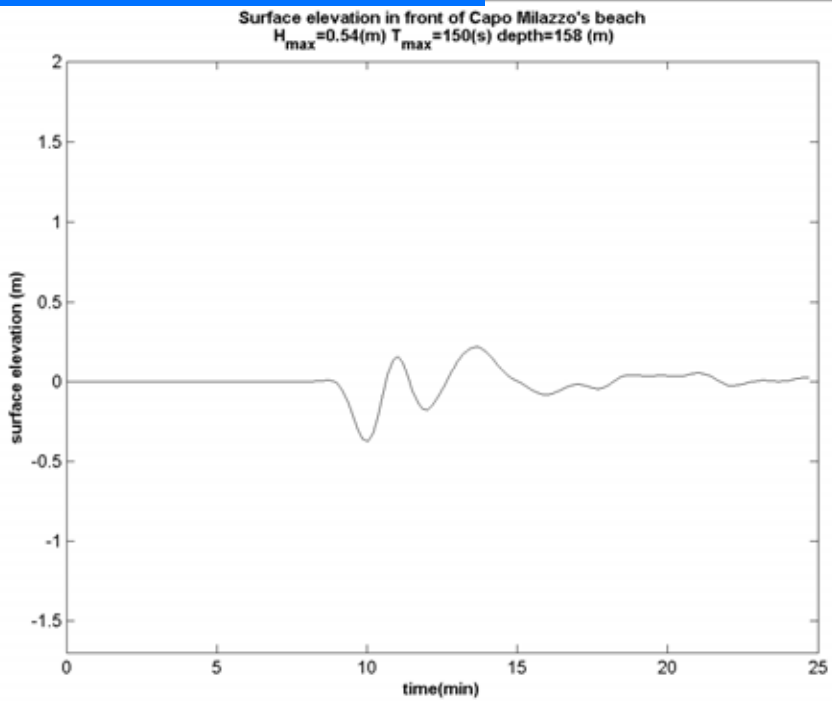
T_{max} : 38,69 s
L_{max} : 1714,0 m

Physical aspects involved by the tsunami waves

Propagation

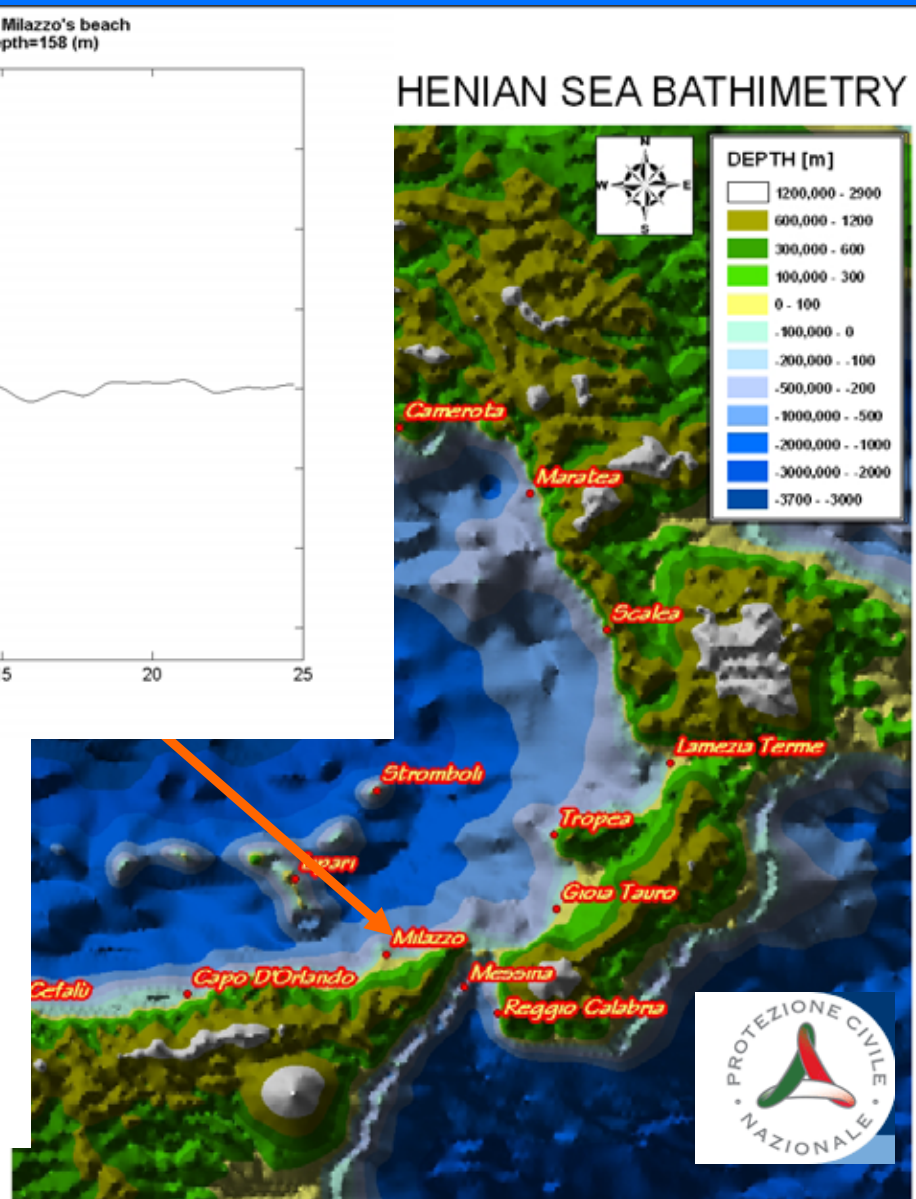
Bathymetry effects

Funwave code DelawareUniv. USA
Numerical simulation by A. Del Guzzo



Surface elevation in front of:
Capo Milazzo (depth 158 m)

H_{max}: 0.5 m
T_{max}: 150,0 s
Arrival Time 10,0 min



Stromboli
30 December 2002

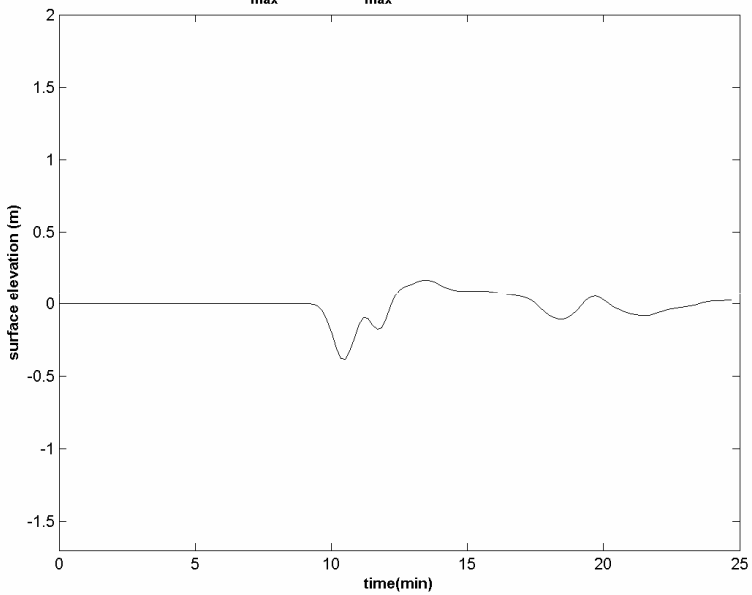
GENERATION
RID FORMULA
Subaerial land-slide
Stromboli-Sciara del Fuoco
Vol. : 12,8 Ml m^3
H_{max} : 7,2 m
T_{max} : 38,69 s
L_{max} : 1714,0 m

Physical aspects involved by the tsunami waves

Propagation

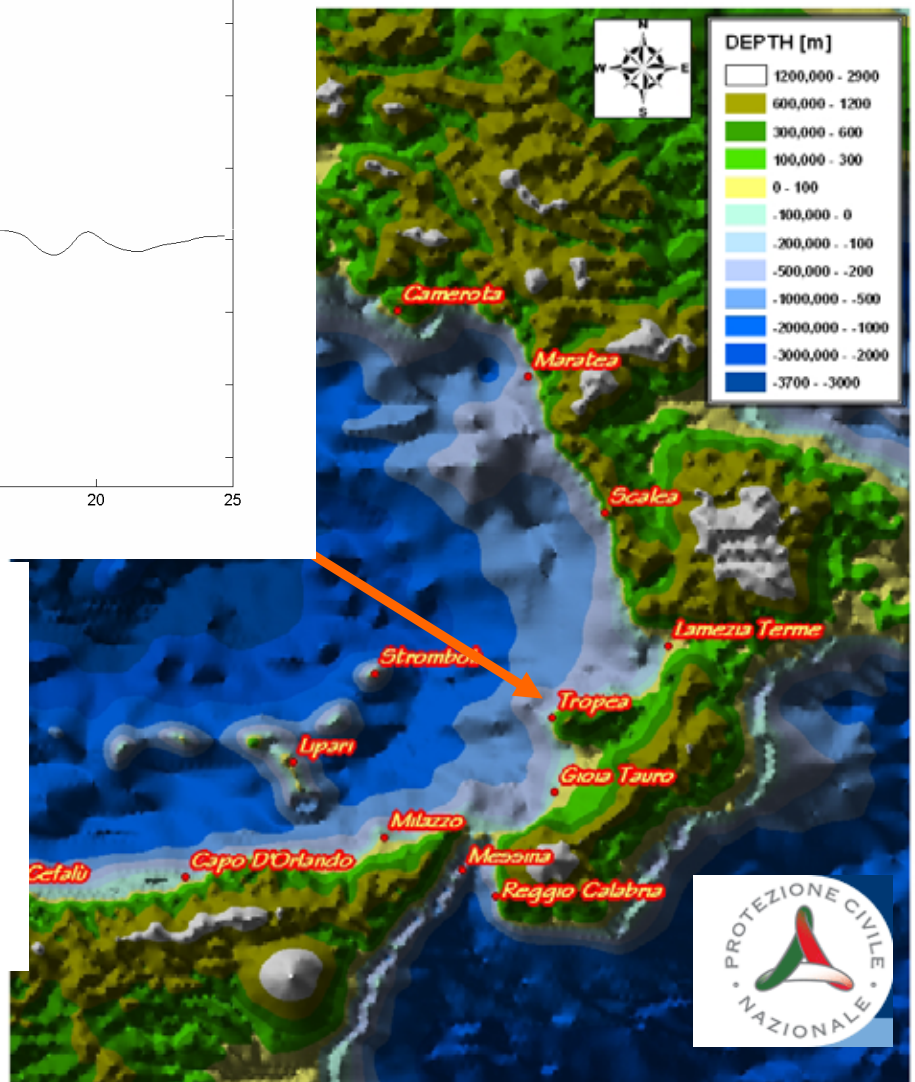
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Tropea (depth 258 m)

H_{max}: 0.55 m
T_{max}: 520,0 s
Arrival Time 10,5 min



Stromboli
30 December 2002

GENERATION
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Subaerial land-slide
Stromboli-Sciara del Fuoco
Vol. : 12,8 Ml m^3
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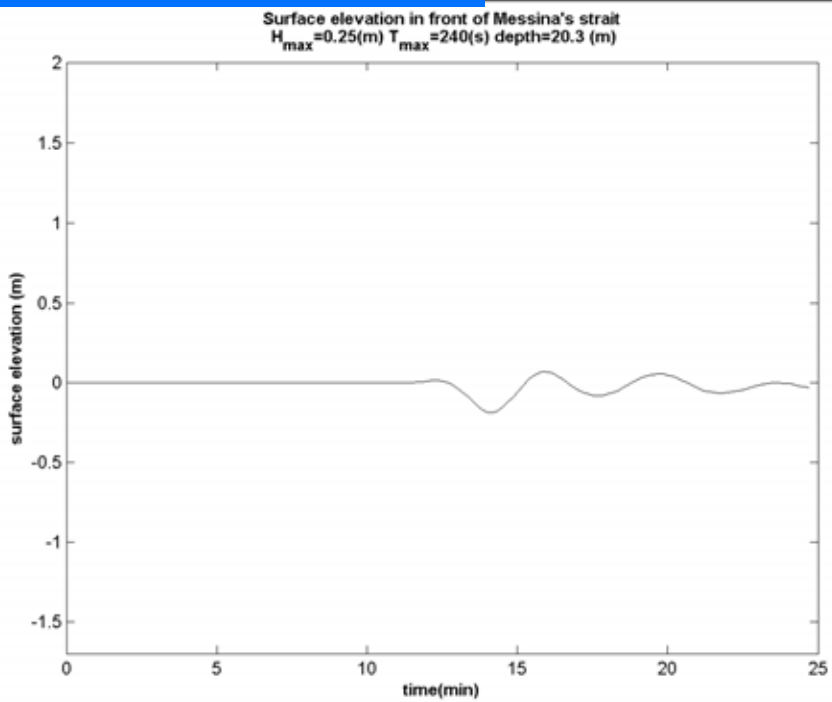
Physical aspects involved by the tsunami waves

Propagation

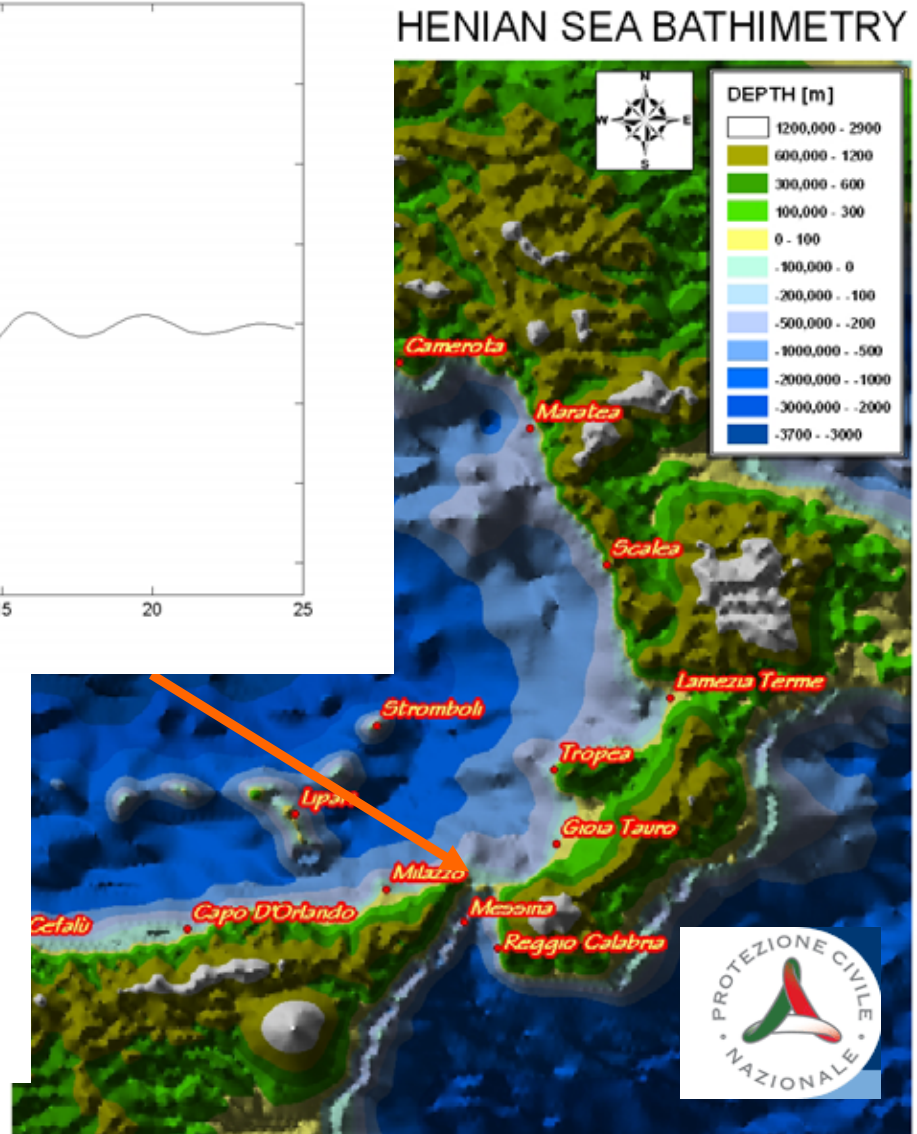
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Messina (depth 20 m)

H_{max}: 0.25 m
T_{max}: 240,0 s
Arrival Time 14,2 min



Stromboli
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Subaerial land-slide
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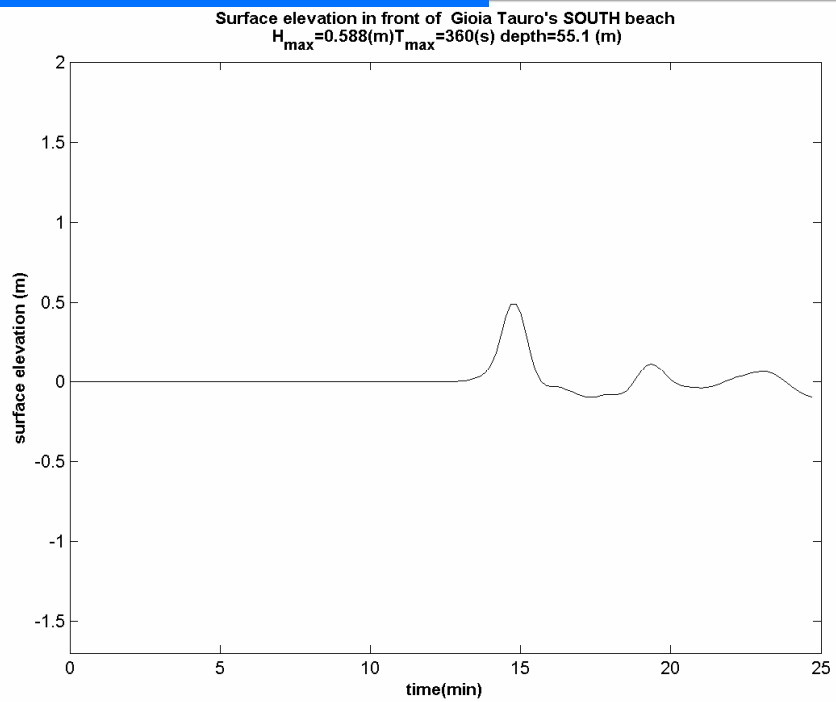
Physical aspects involved by the tsunami waves

Propagation

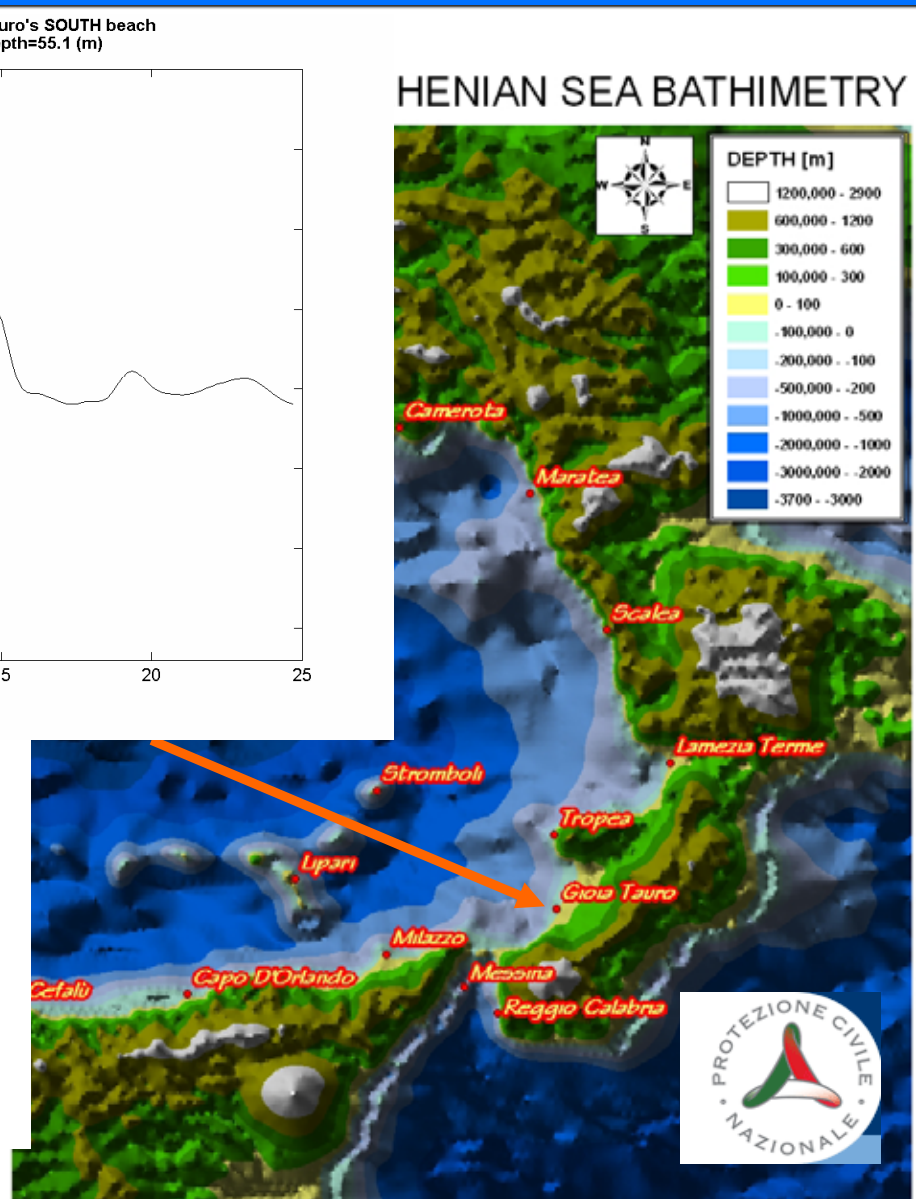
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Gioia Tauro SUD (depth 55.1 m)

H_{max}: 0.58 m
T_{max}: 360,0 s
Arrival Time 14,5 min



Stromboli
30 December 2002

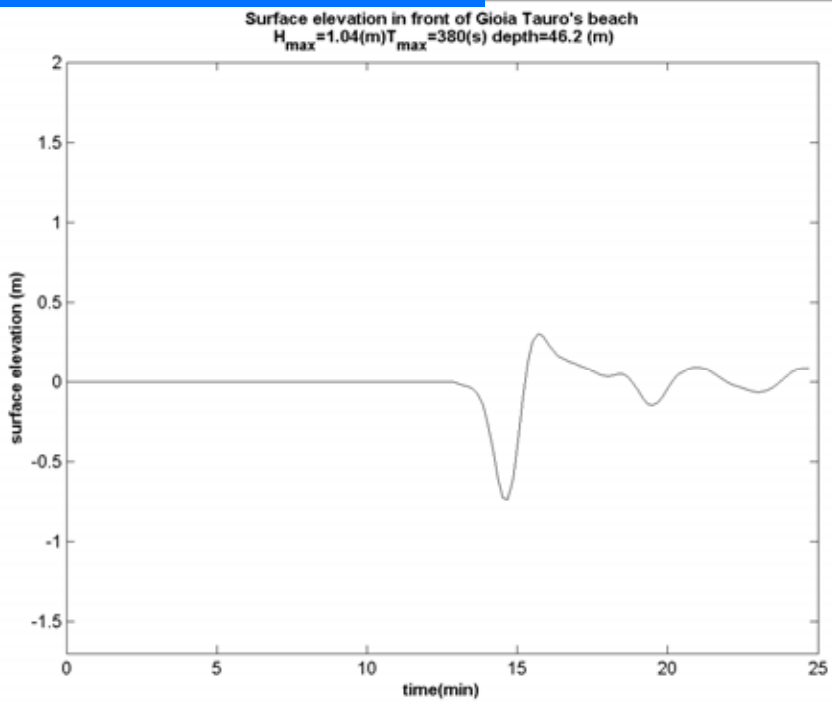
GENERATION
RID FORMULA
Subaerial land-slide
Stromboli-Sciara del Fuoco
Vol. : 12,8 Ml m^3
H_{max} : 7,2 m
T_{max} : 38,69 s
L_{max} : 1714,0 m

Physical aspects involved by the tsunami waves

Propagation

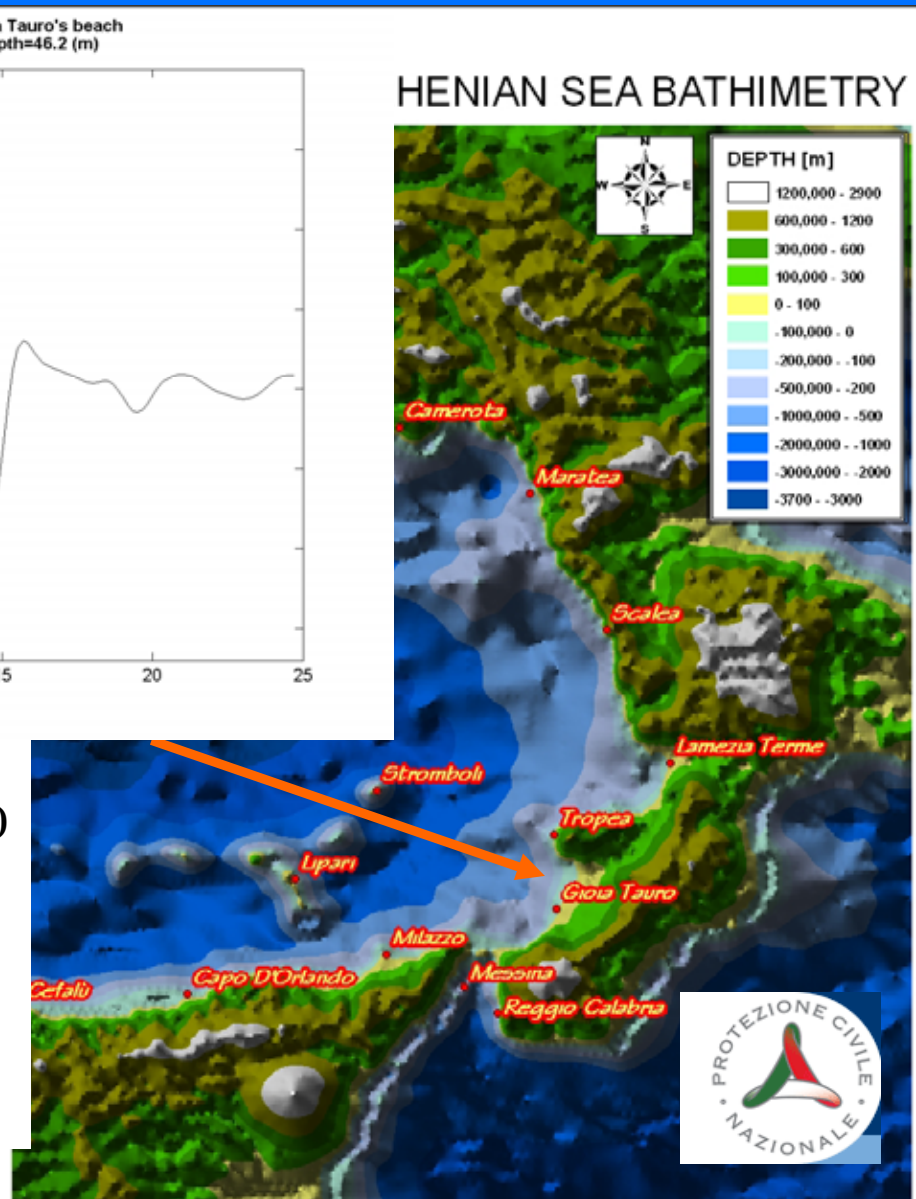
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Gioia Tauro NORD (depth 46.2 m)

H_{max}: 1.0 m
T_{max}: 380,0 s
Arrival Time 14,5 min



Stromboli
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Stromboli-Sciara del Fuoco
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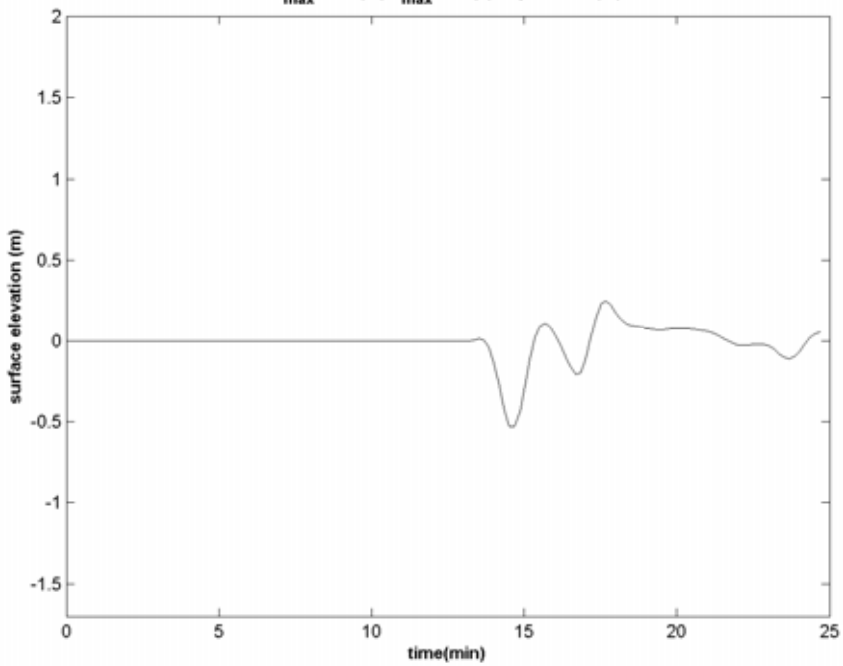

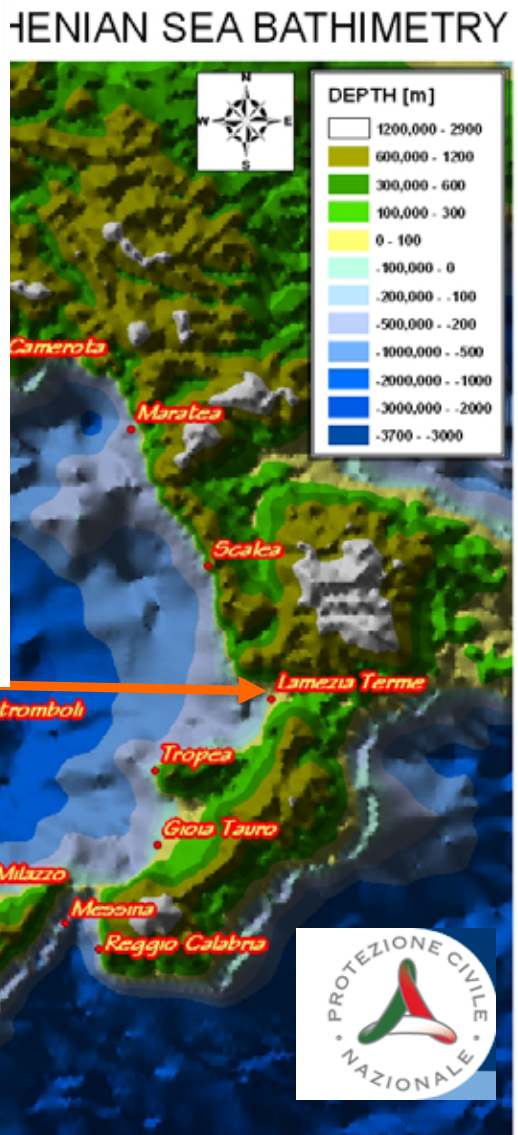

Surface elevation in front of:
Lamezia (depth 82,8 m)

H_{max}: 0.64 m
T_{max}: 140,0 s
Arrival Time 14,7 min

Stromboli
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Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

Fun – wave code DelawareUniv. USA
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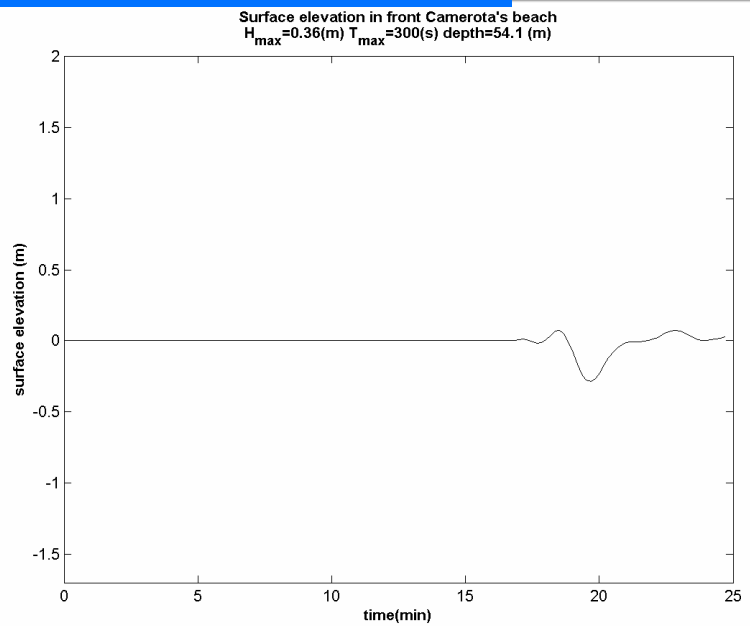
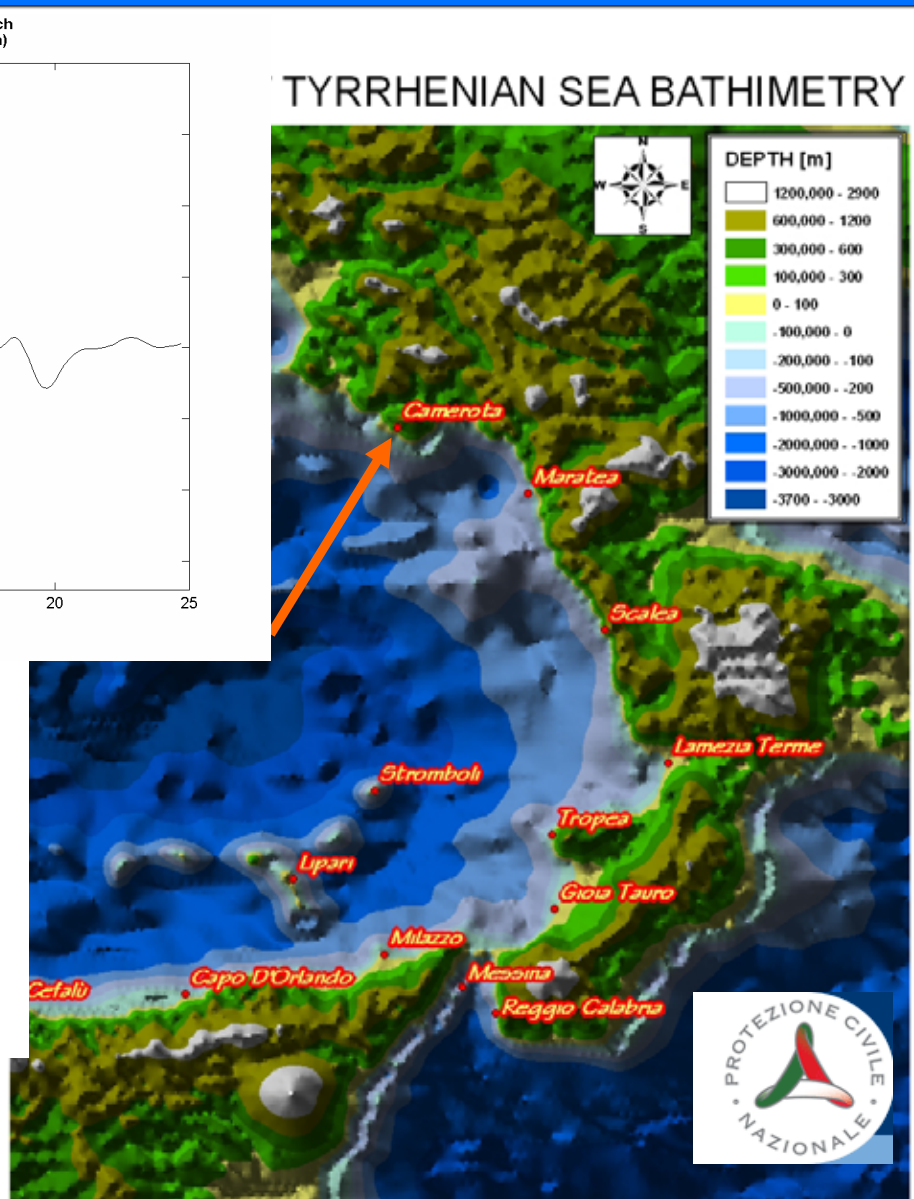


Surface elevation in front of:
Camerota (depth 54,0 m)

H_{max}: 0.36 m
T_{max}: 300,0 s
Arrival Time 19,5 min



Stromboli
30 December 2002

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RID FORMULA
Subaerial land-slide
Stromboli-Sciara del Fuoco
Vol. : 12,8 Ml m^3
H_{max} : 7,2 m
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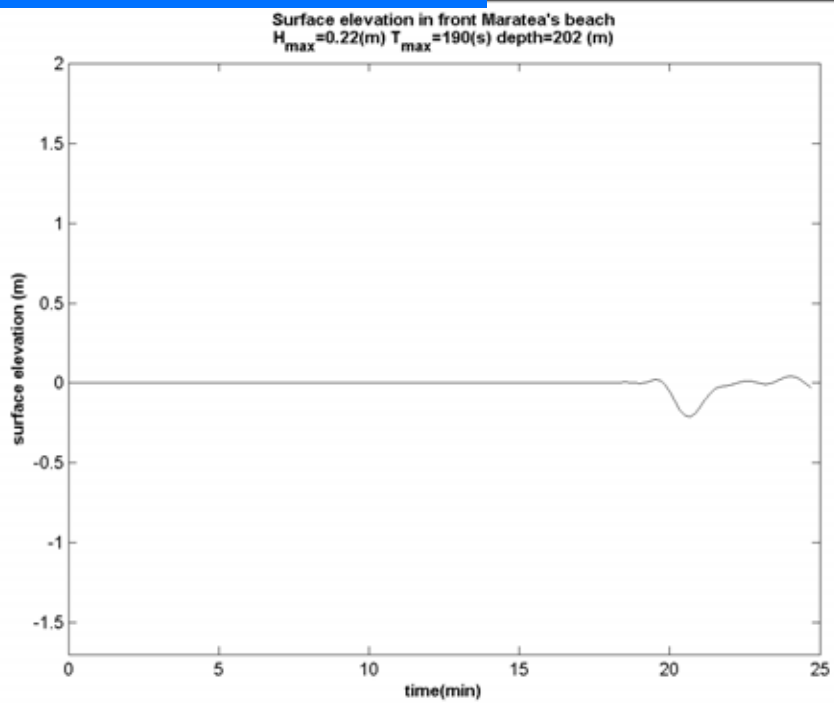
Physical aspects involved by the tsunami waves

Propagation

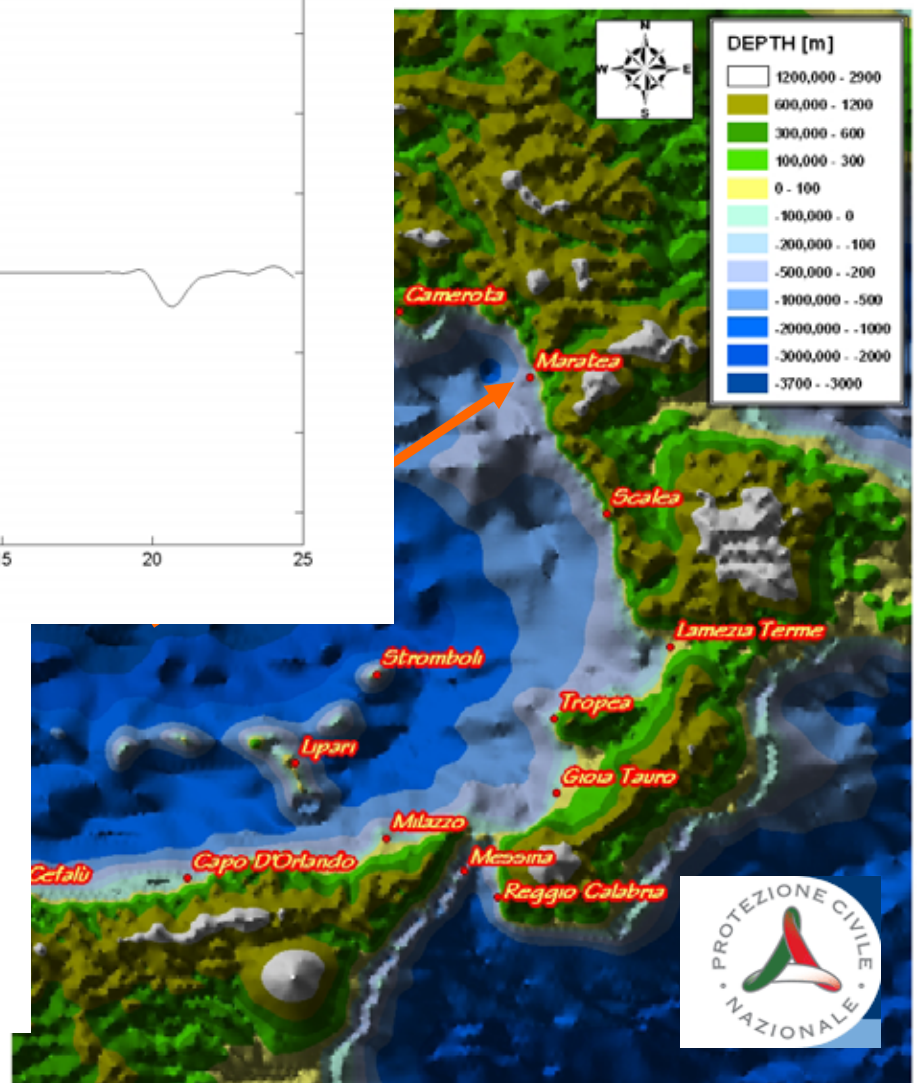
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Maratea (depth 202,0 m)

H_{max}: 0.22 m
T_{max}: 190,0 s
Arrival Time 20,7 min



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Stromboli-Sciara del Fuoco
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Physical aspects involved by the tsunami waves

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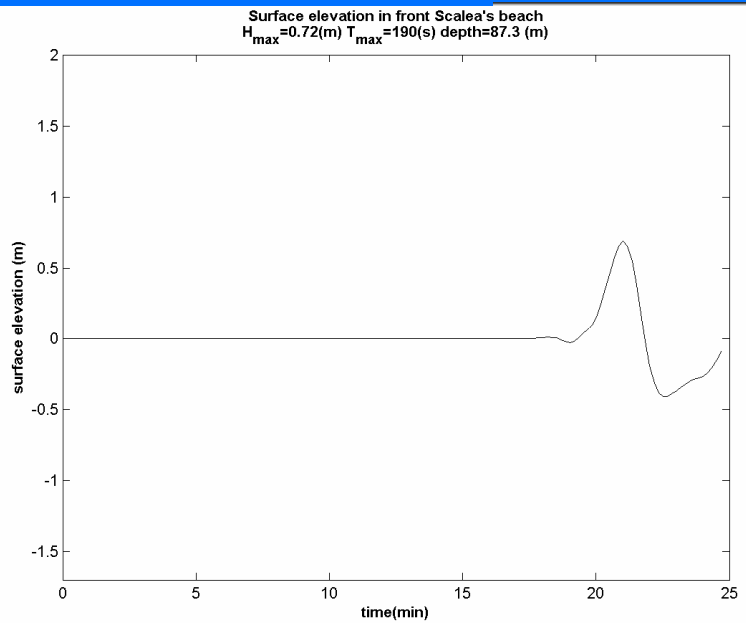
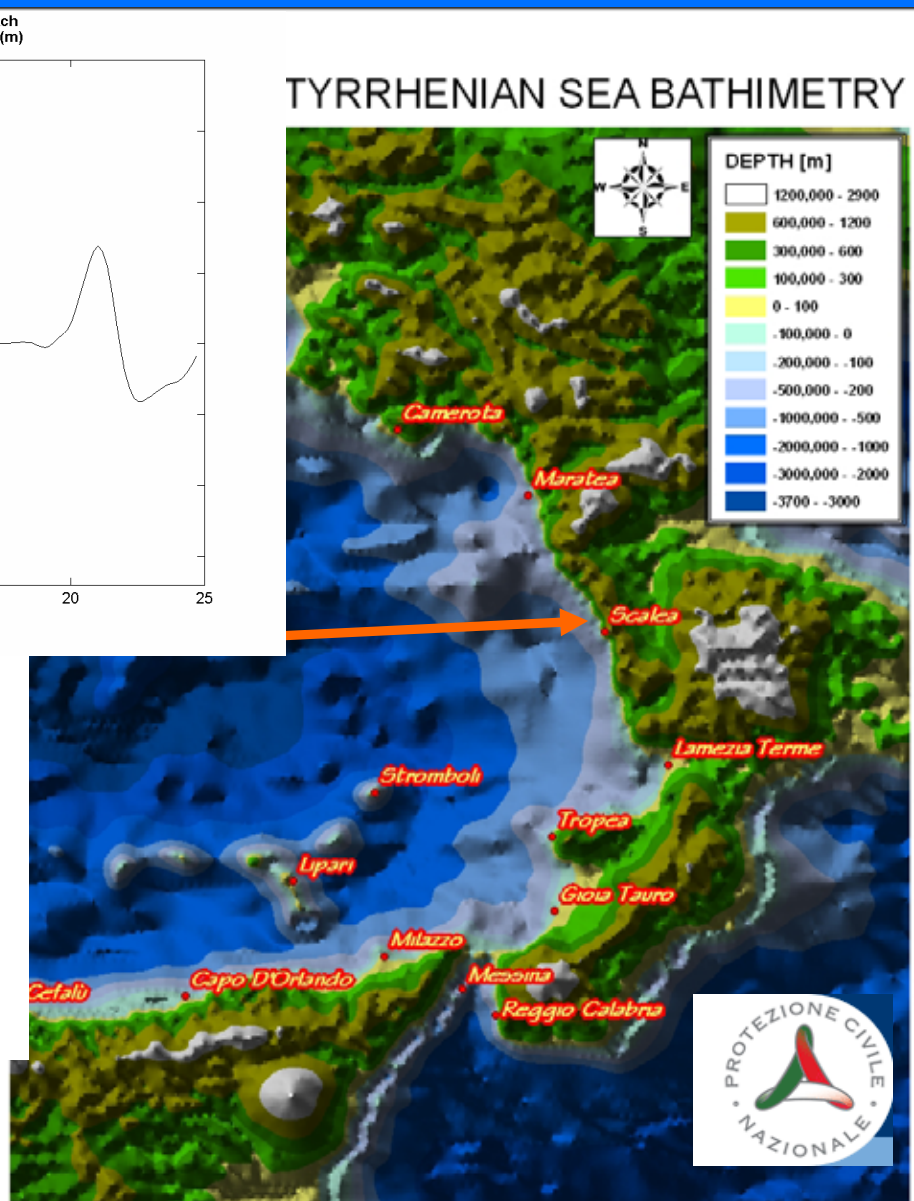
Bathymetry effects

Fun – wave code DelawareUniv. USA
Numerical simulation by A. Delguzzo



Surface elevation in front of:
Scalea (depth 87,3 m)

H_{max}: 0.72 m
T_{max}: 190,0 s
Arrival Time 21,0 min



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Stromboli-Sciara del Fuoco
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Bathymetry effects

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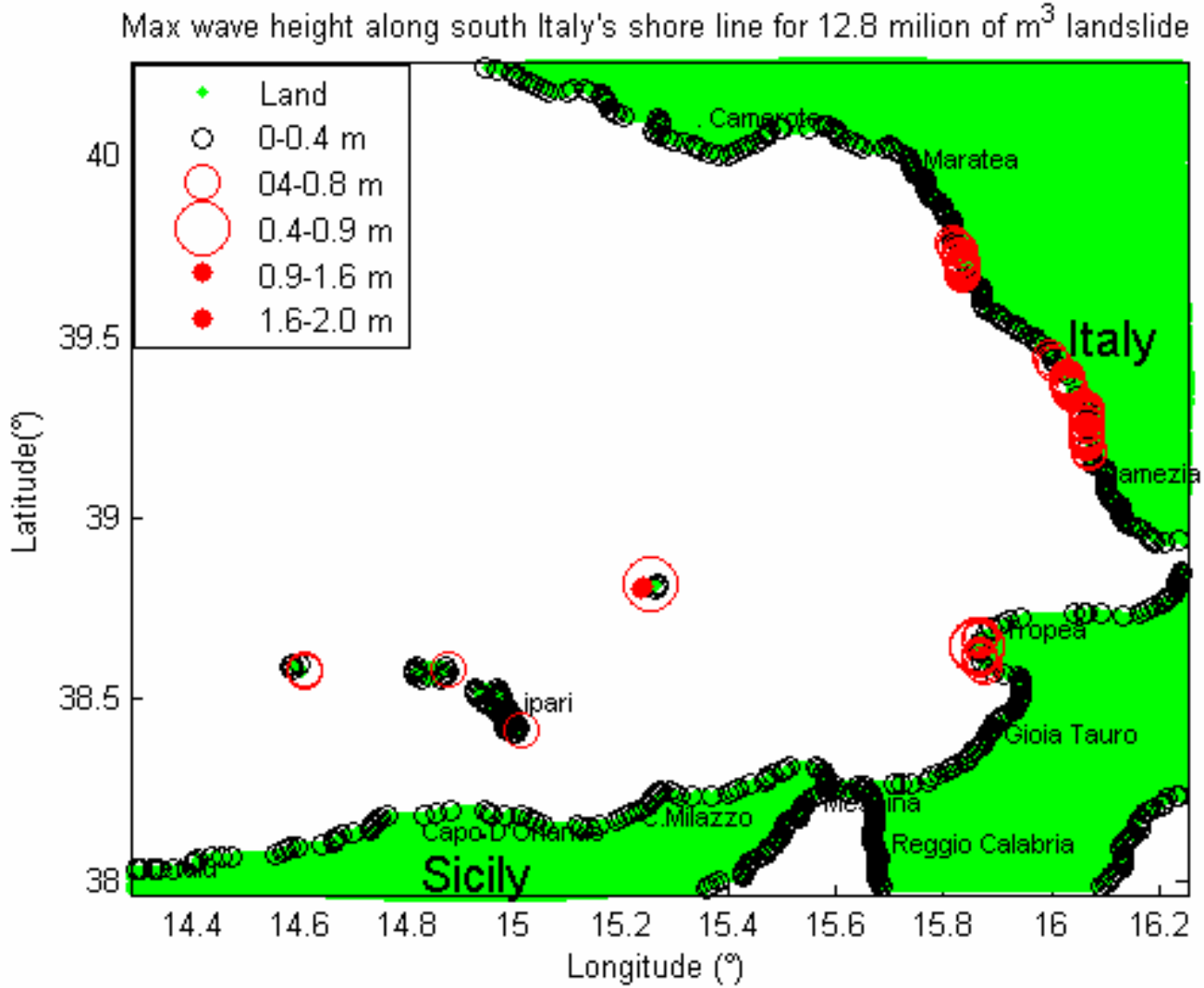

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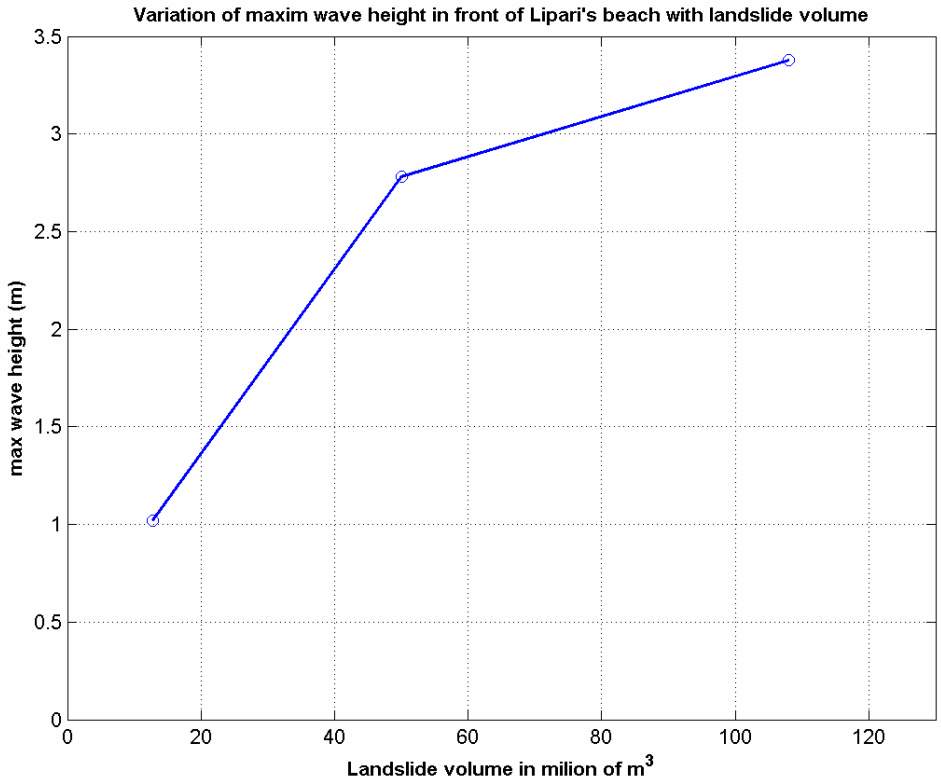
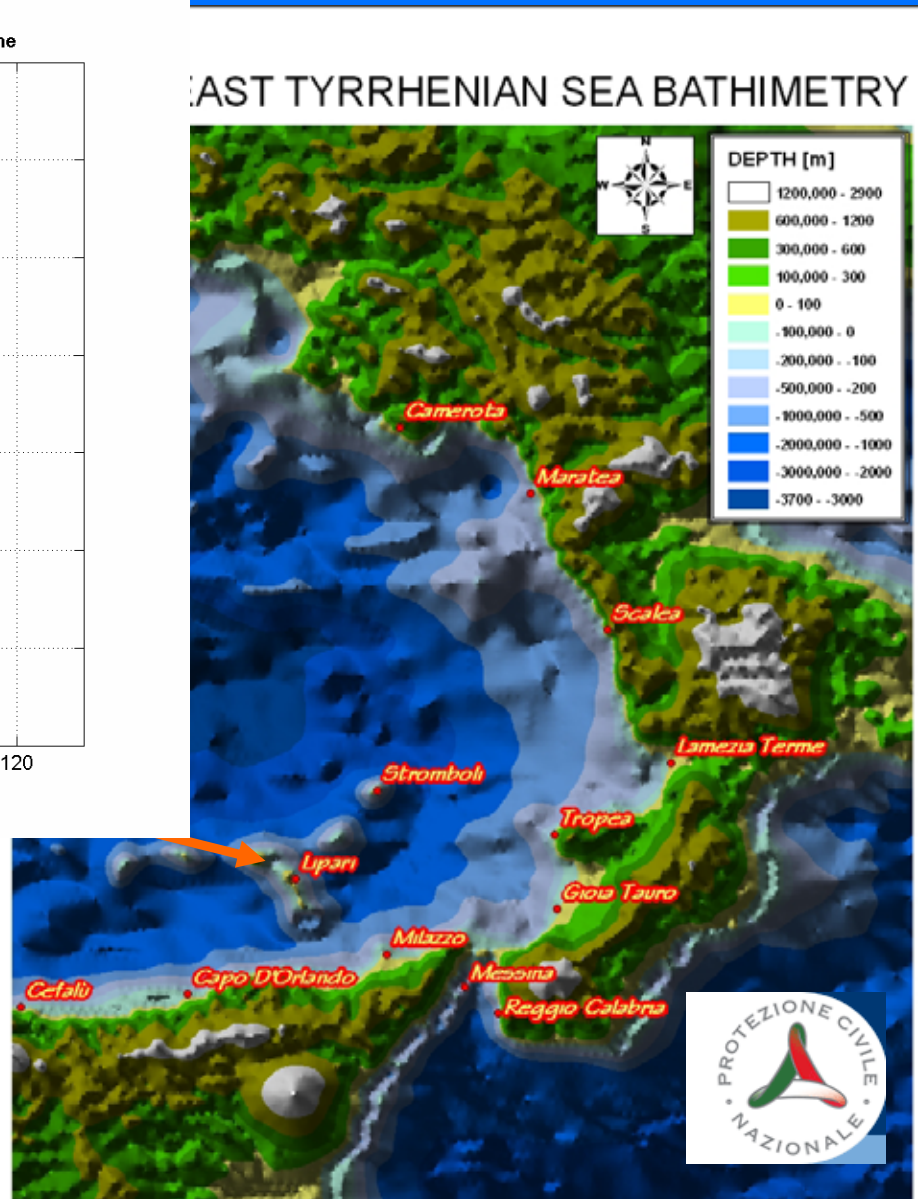


LIPARI

H_{max} (m) – Landslide volume (Mm^3)



Physical aspects involved by the tsunami waves

Propagation

Bathymetry effects

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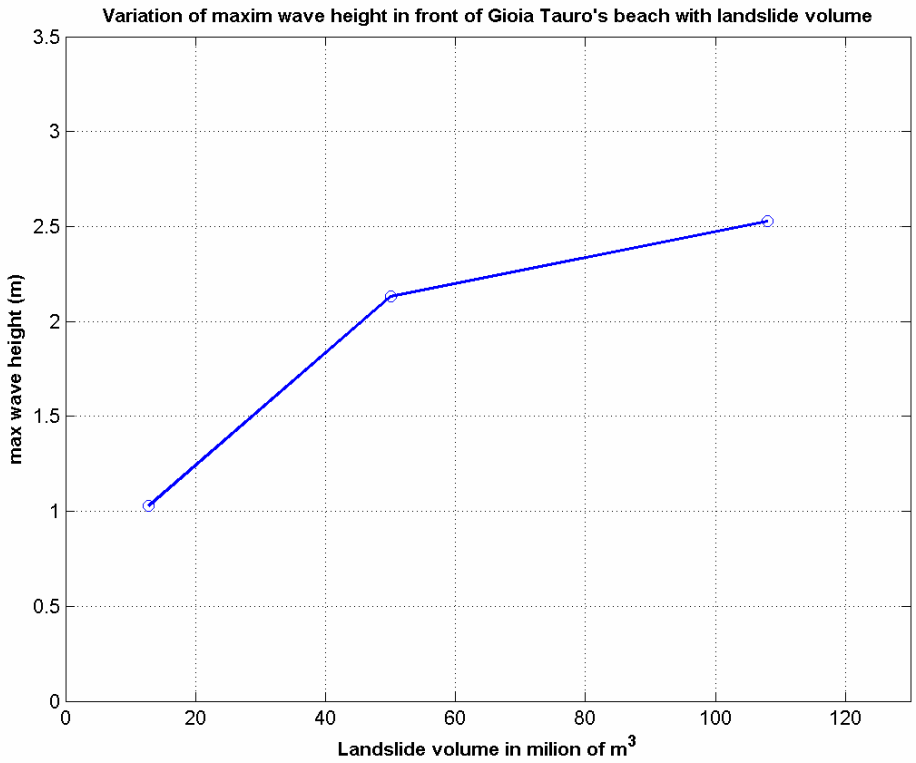
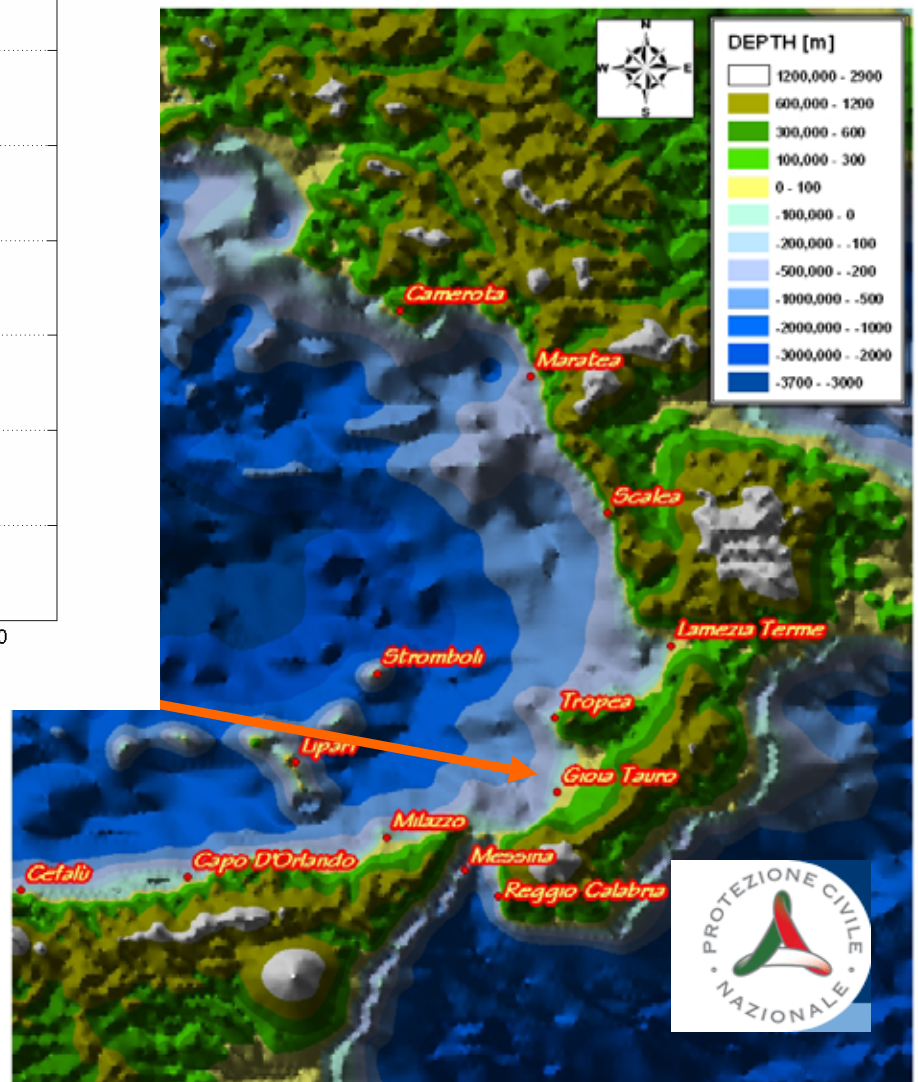
Numerical simulation by A. Delguzzo





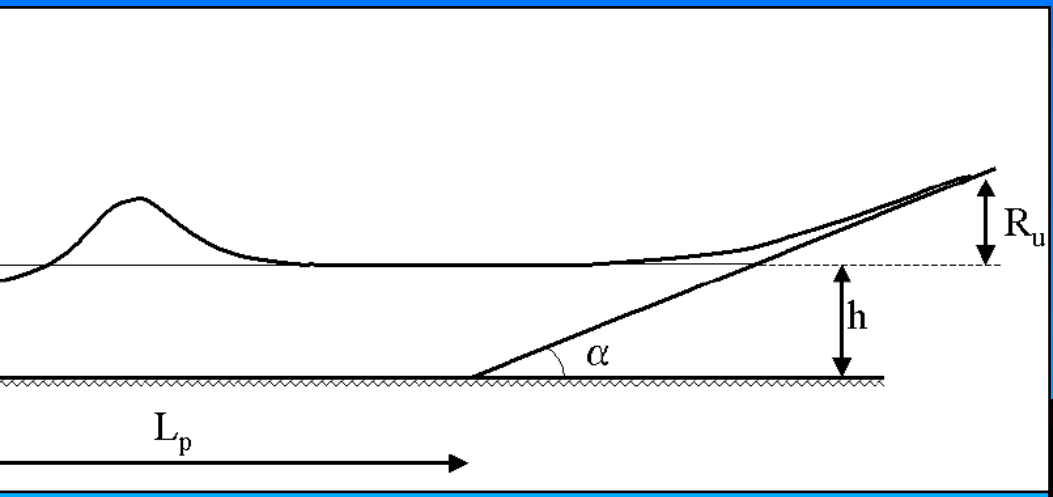
GIOIA TAURO

H_{max} (m) – Landslide volume (Mm^3)

Physical aspects involved by the tsunami waves

Interaction with coasts and structures

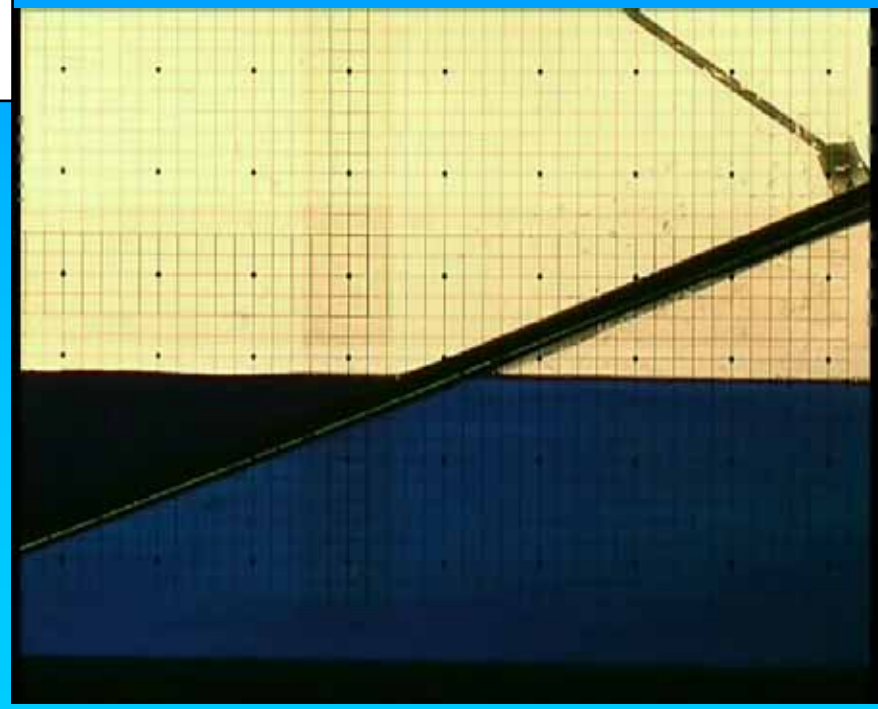
Run-up



Physical simulation by M. Di Risio

Main parameters which influence wave run-up

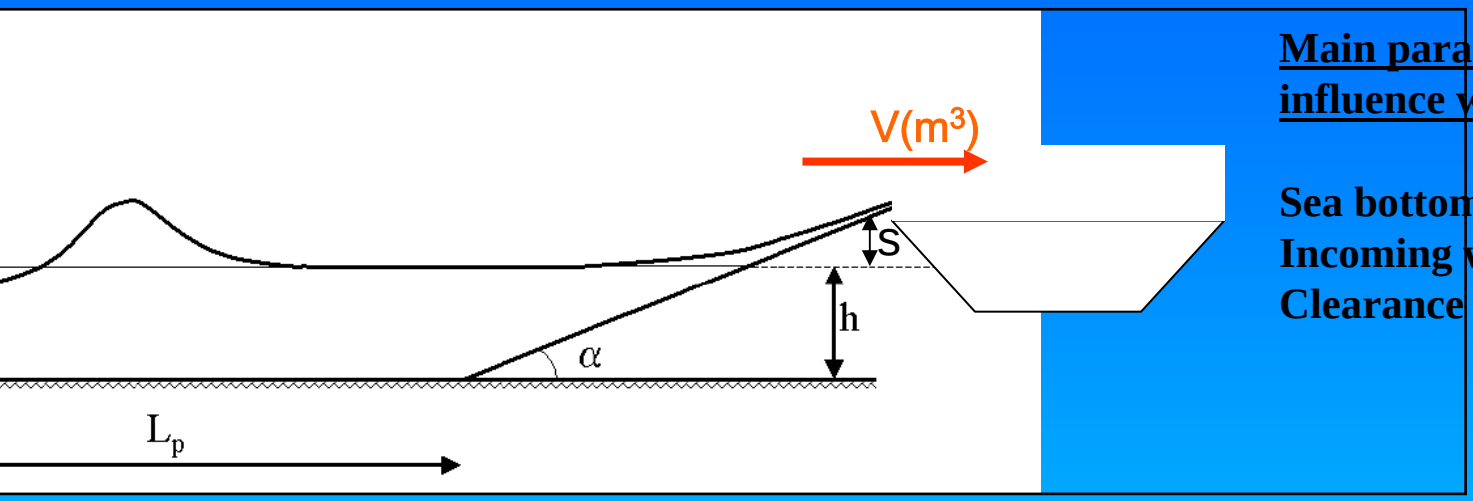
Sea bottom steepness
Incoming wave parameters



Physical aspects involved by the tsunami waves

Interaction with coasts and structures

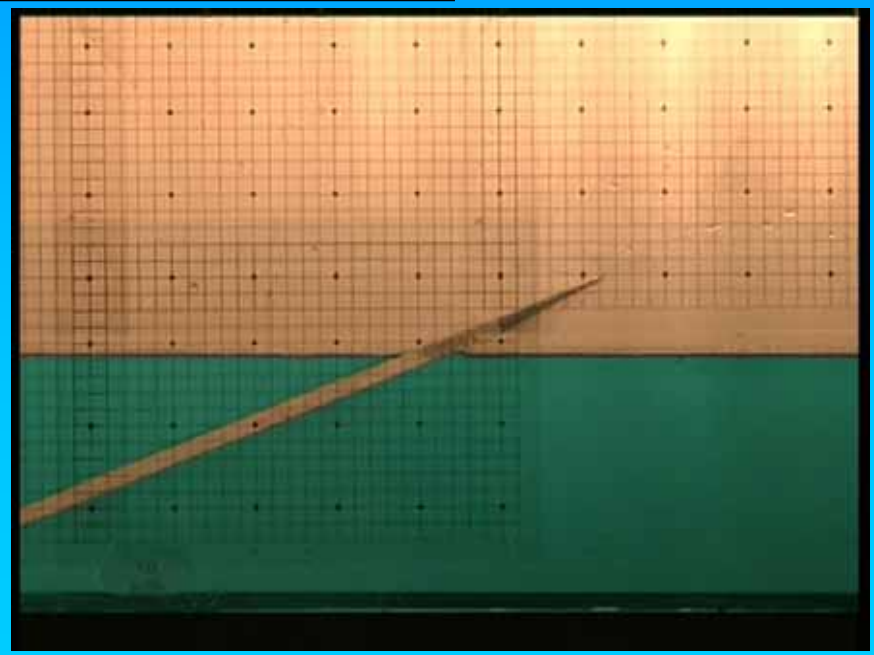
Overtopping



Main parameters which influence wave overtopping

Sea bottom steepness
Incoming wave-height
Clearance

Physical simulation by M. Di Risio

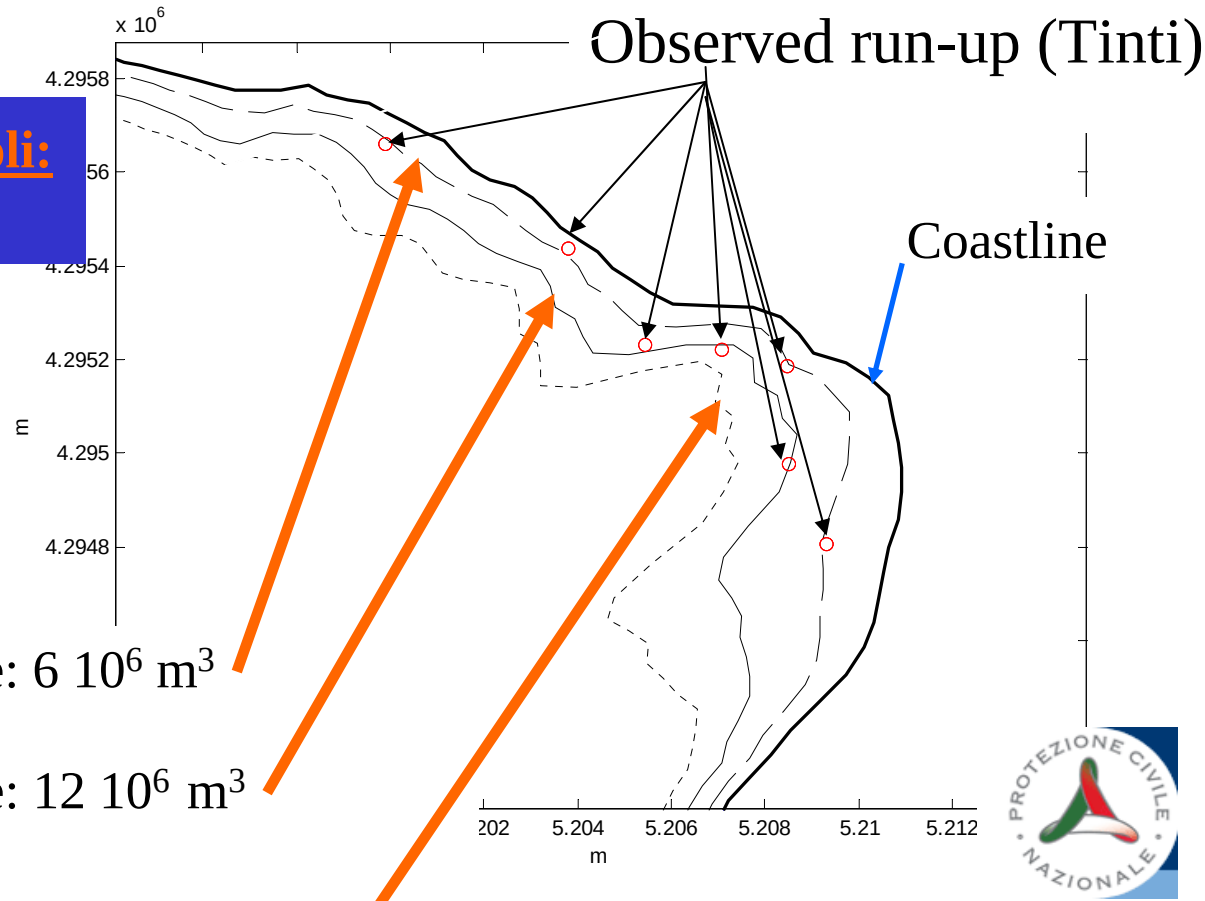


Physical aspects involved by the tsunami waves

Interaction with coasts and structures

Flooding maps

N-E coast of Stromboli: flooding map

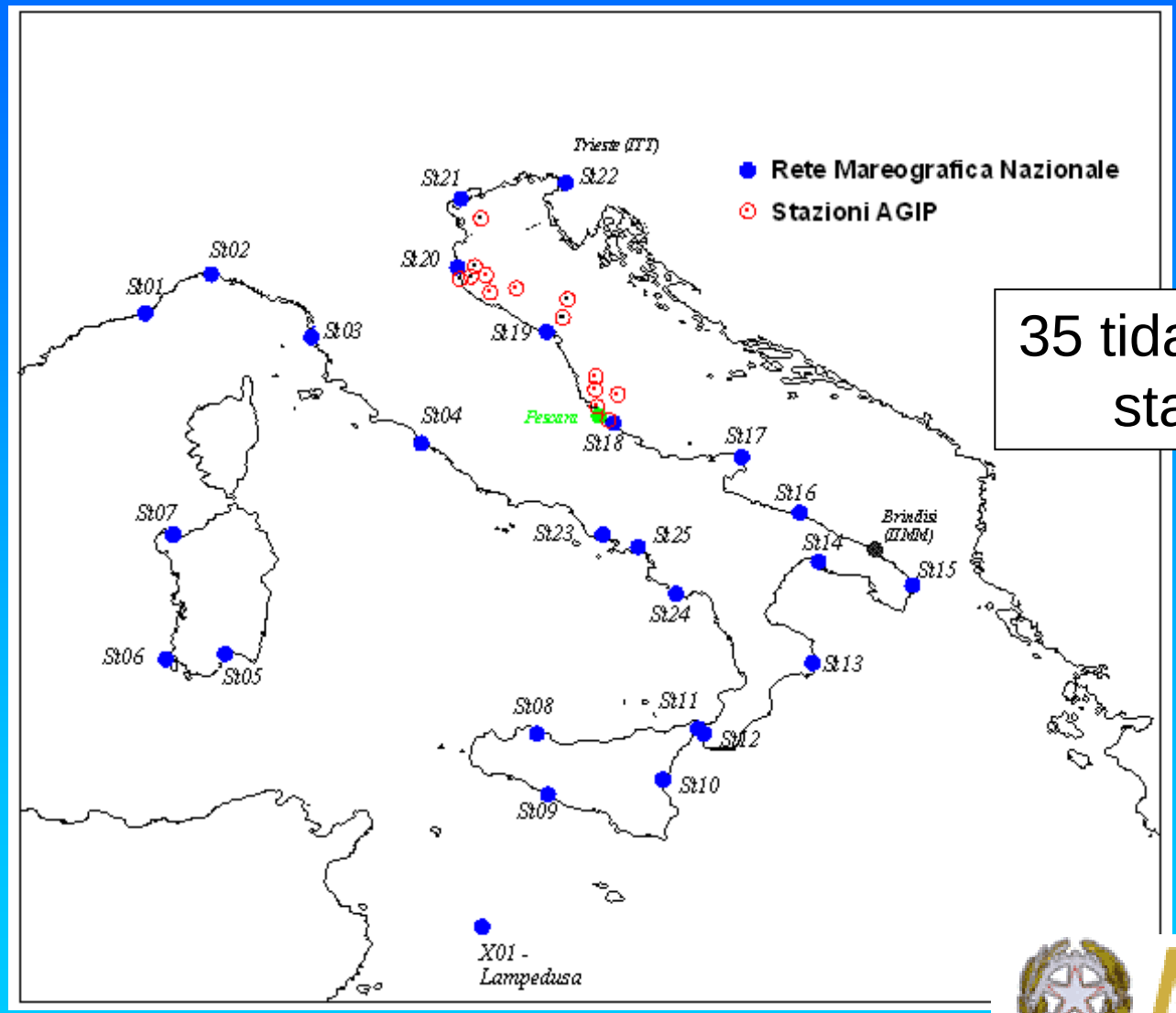


Landslide volume: 6 10^6 m^3

Landslide volume: 12 10^6 m^3

Landslide volume frana: 18 10^6 m^3

Tsunamis measurements



35 tidal coastal stations

Thanks for your attention

University of L'Aquila
12 luglio 2005

ONDE DI MAREMOTO
Generazione, propagazione e interazione con le coste
www.tsunamis.it

Welcome

Dott. Ottaviano del Turco

President of the Abruzzo Region