THE AD 365 TSUNAMI : SOME INSIGHTS FROM NUMERICAL MODELLING

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MOTIVATION FOR THIS STUDY

A destructive tsunami at Alexandria
on 21 st July 365 AD (« day of horror »
commemorated till 7th century)

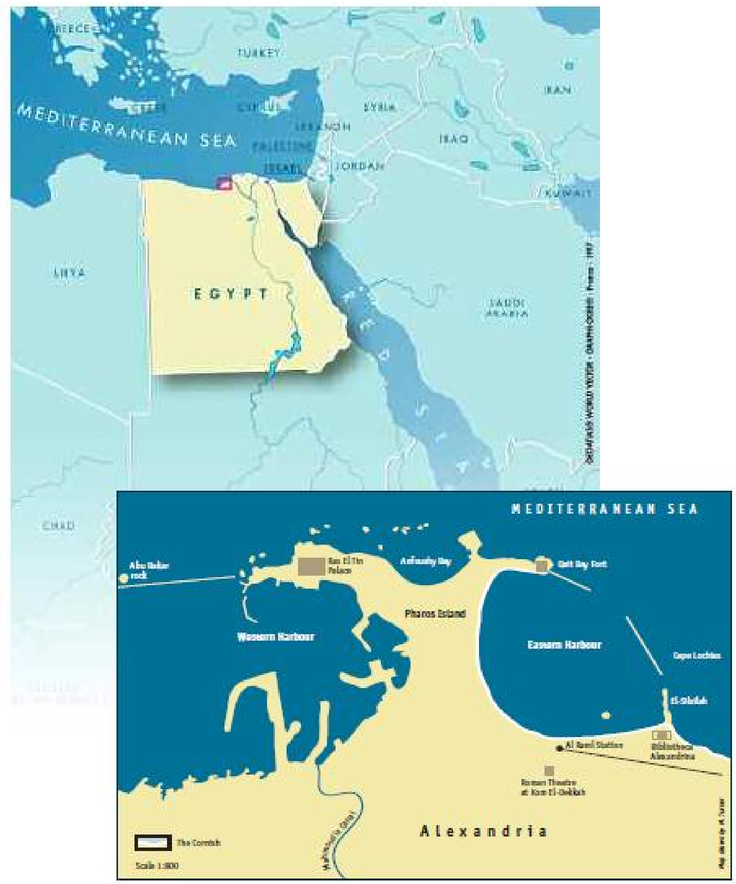
Can it be repeated ?

Data (Alexandria):
Texts (A. Marcellin, Jérôme, and others) –

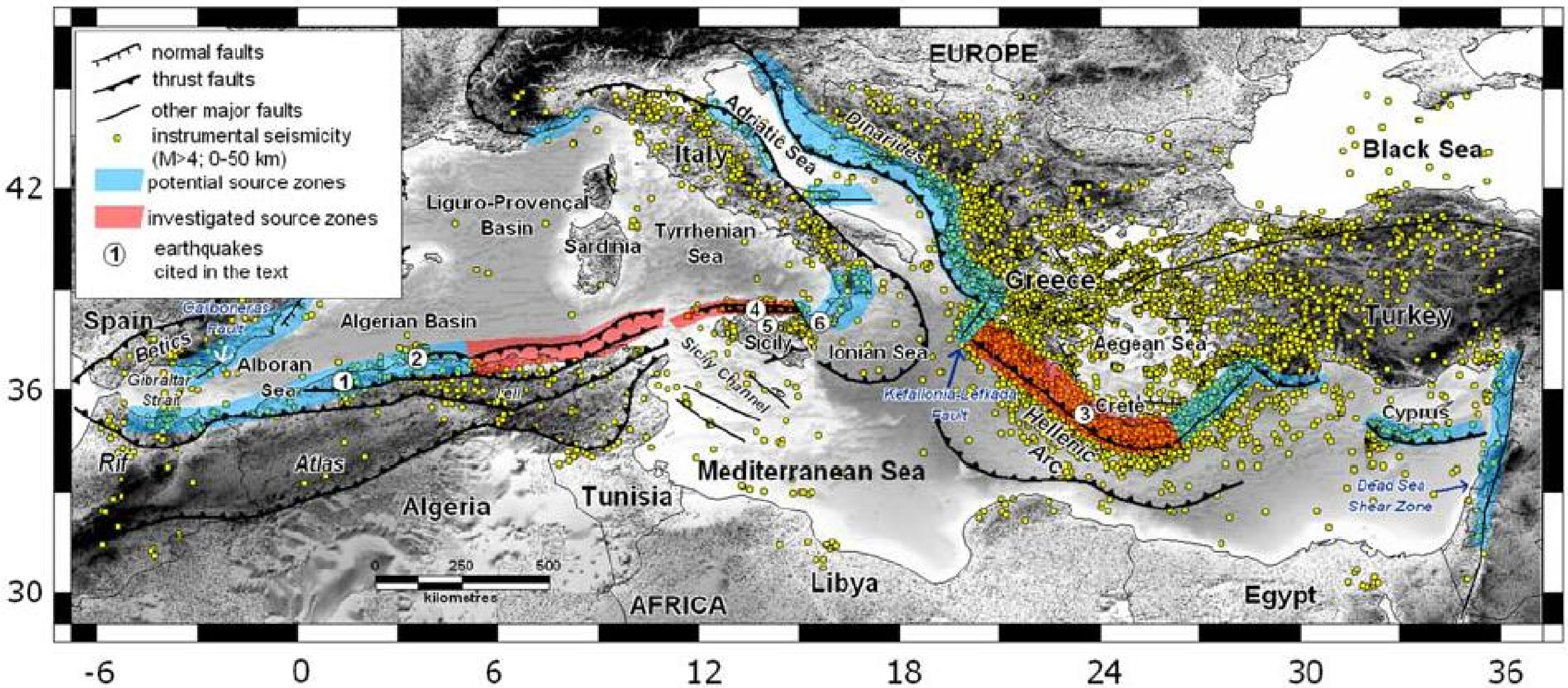
- the water retreated from the harbor before the flooding wave arrived

- the city (surrounded with walls) was extensively flooded, ships on the roofs

- no direct archaeological evidences in Alexandira (for the moment)
- neither direct geomorphological confirmations from the drilling cores



A plausible source : an earthquake in the Hellenic Arc ?

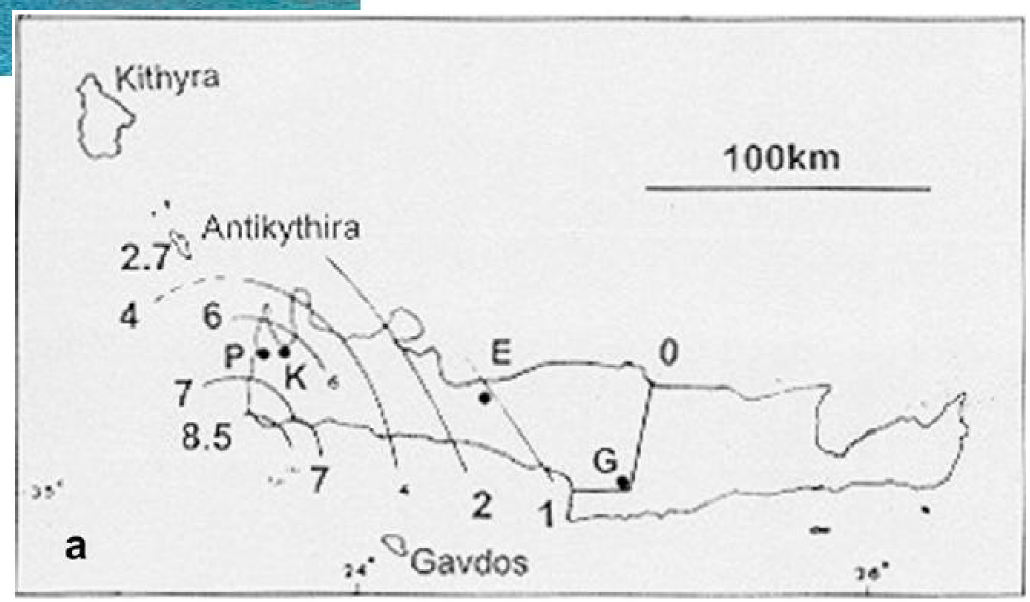


Seismicity in the Mediterranean Sea (Lorito et al, 2008)

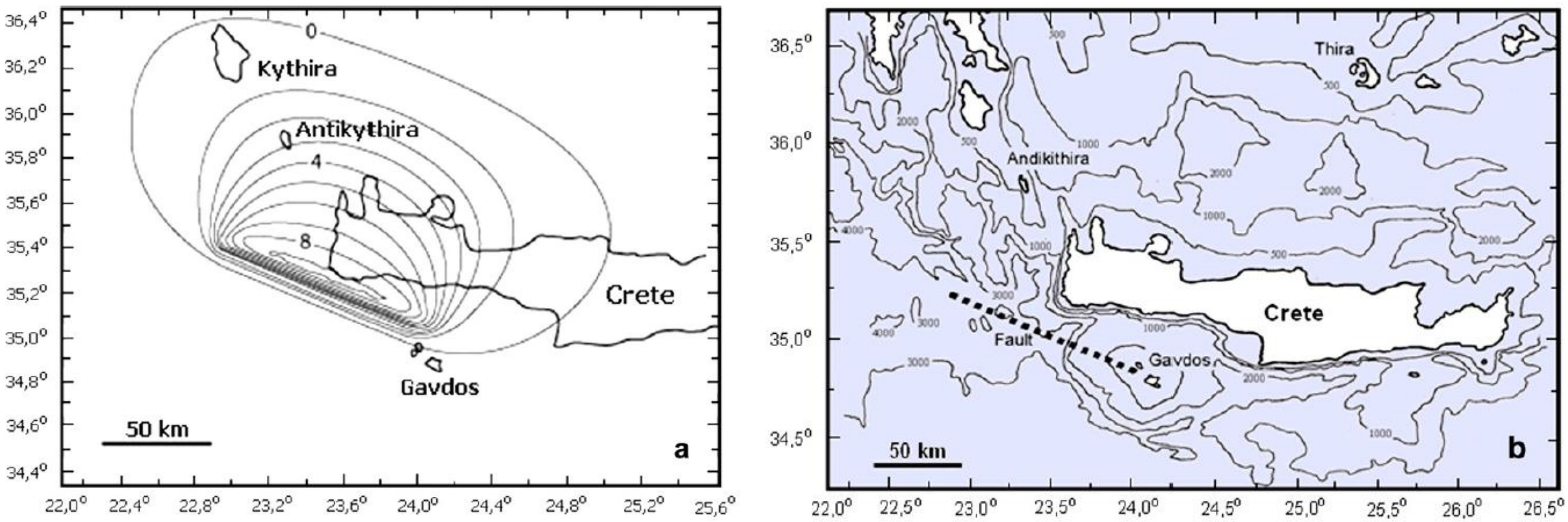
Search for the fault

Uplift of Western Crete (Stiros, 2001,2008)
Arrow = sea level mark left at about AD 365 in the SW corner of Crete

Contours of uplift dated to circa AD365 by ^{14}C (Pirazzoli, 1982)



The fault model of Stiros (2008)

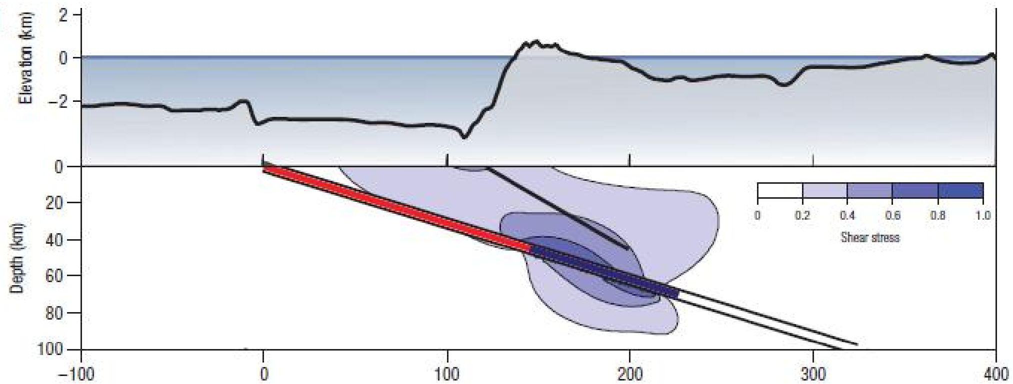


Computed parameters of the minimum length fault responsible for the uplift of Crete in AD365.

Strike (°)	Dip (°)	Depth (km)	Length (km)	Width (km)	Slip (m)
292.5	40	70	105	100	16

Magnitude = 8.5

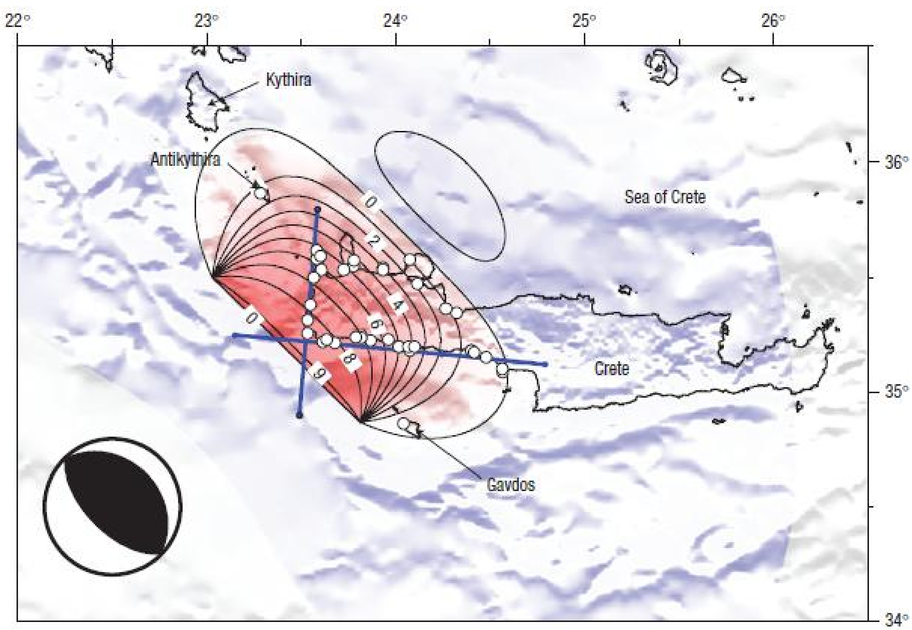
The fault model Shaw et al, 2008

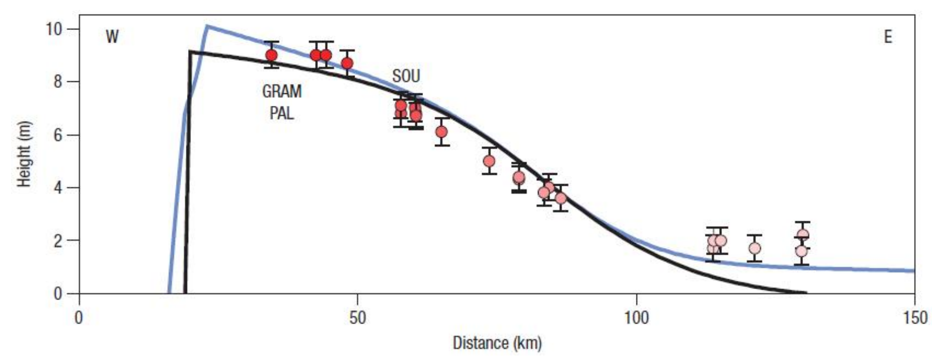


Elevation of W Crete coast> 9 m ?

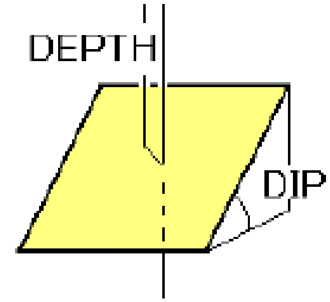
« Optimal » fault from Shaw et al, 2008:

NW-W Crete,
Length = 100 km, Dip = 30°,
Depth = 45 km, Slip = 20 m

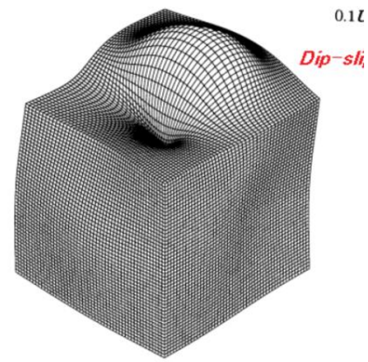




Hydrodynamics



1. Calculate the fault displacements induced by faulting (Okada).
2. Solid Earth Dispalcement = initial elevation of the sea surface.
3. Compute the propagation from 2D shallow water eqs by TELEMAC

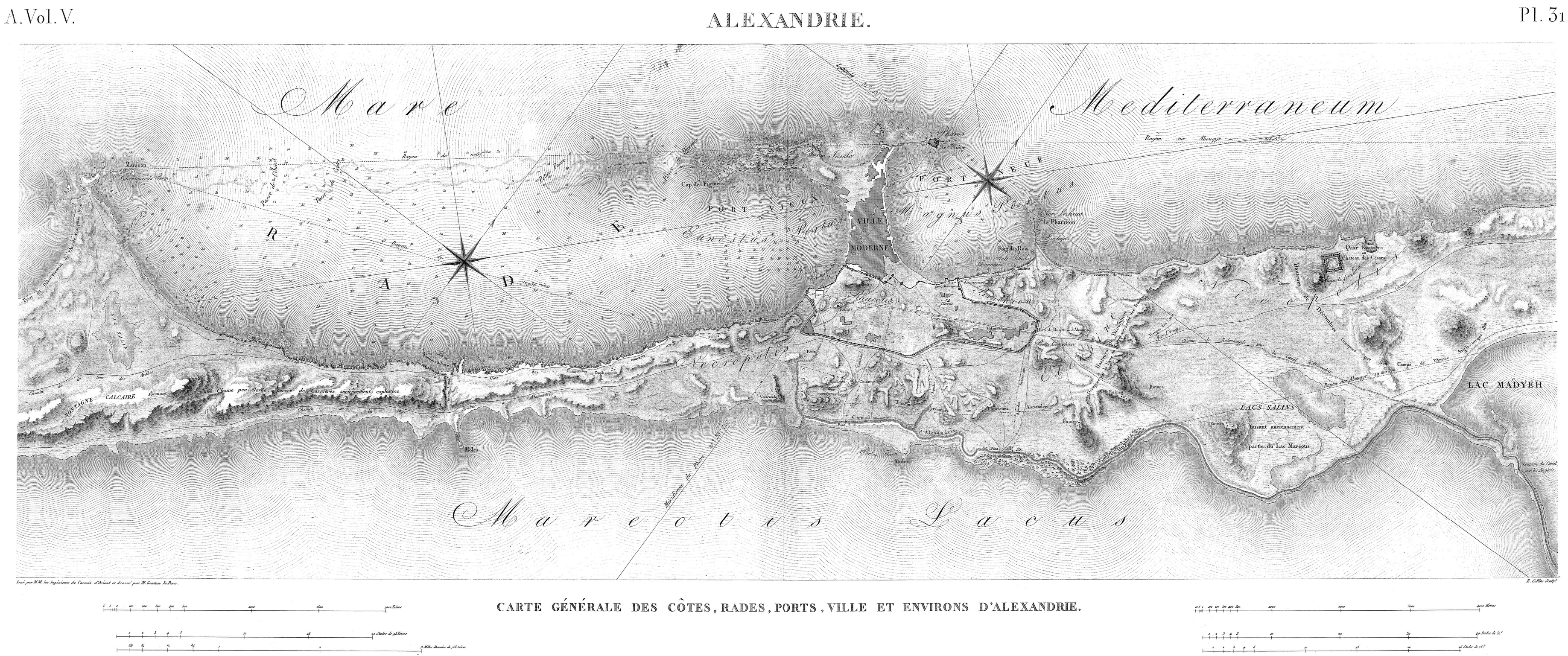


$$\frac{\partial h}{\partial t} + u \cdot \vec{\nabla}(h) + h\,div(\vec{u}) = S_h$$

$$\frac{\partial u}{\partial t} + \vec{u} \cdot \vec{\nabla}(u) = -g\frac{\partial Z}{\partial x} + S_x + \frac{1}{h}div(h\nu_t \vec{\nabla} u)$$

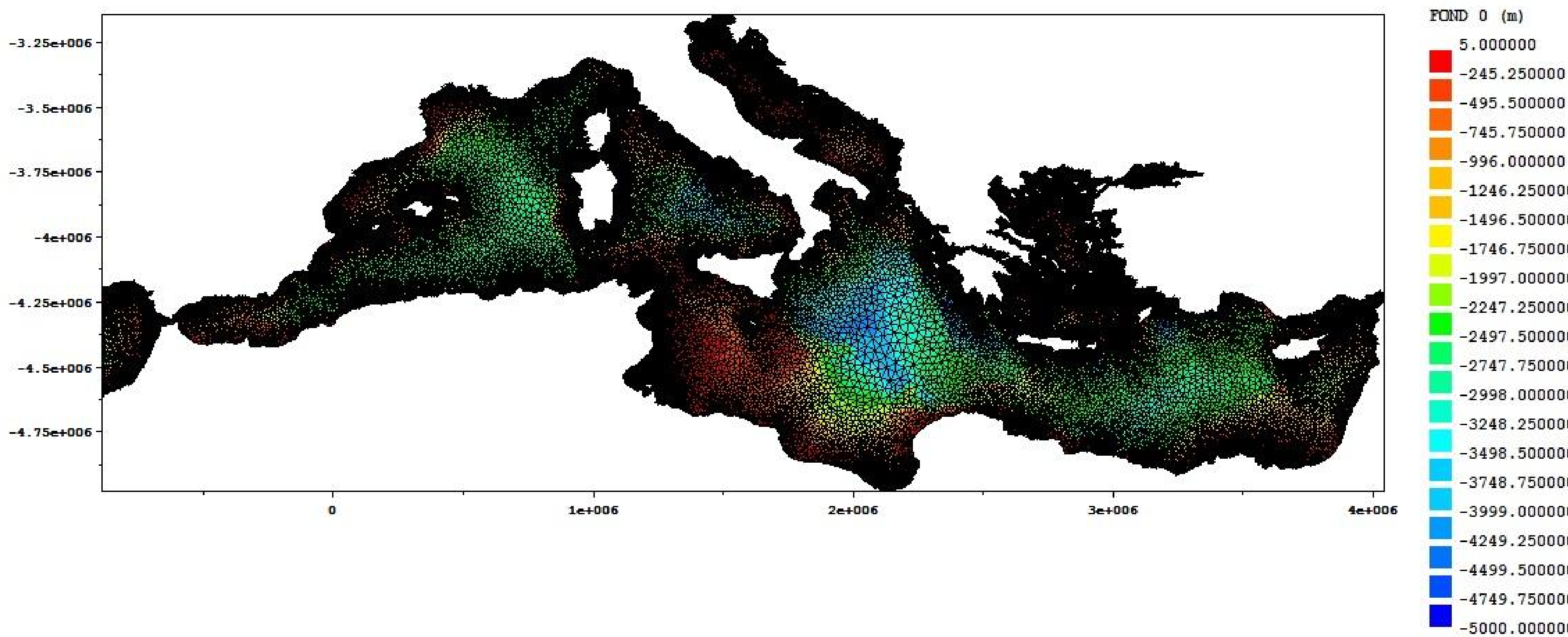
$$\frac{\partial v}{\partial t} + \vec{u} \cdot \vec{\nabla}(v) = -g\frac{\partial Z}{\partial y} + S_y + \frac{1}{h}div(h\nu_t \vec{\nabla} v)$$

Bathymetry



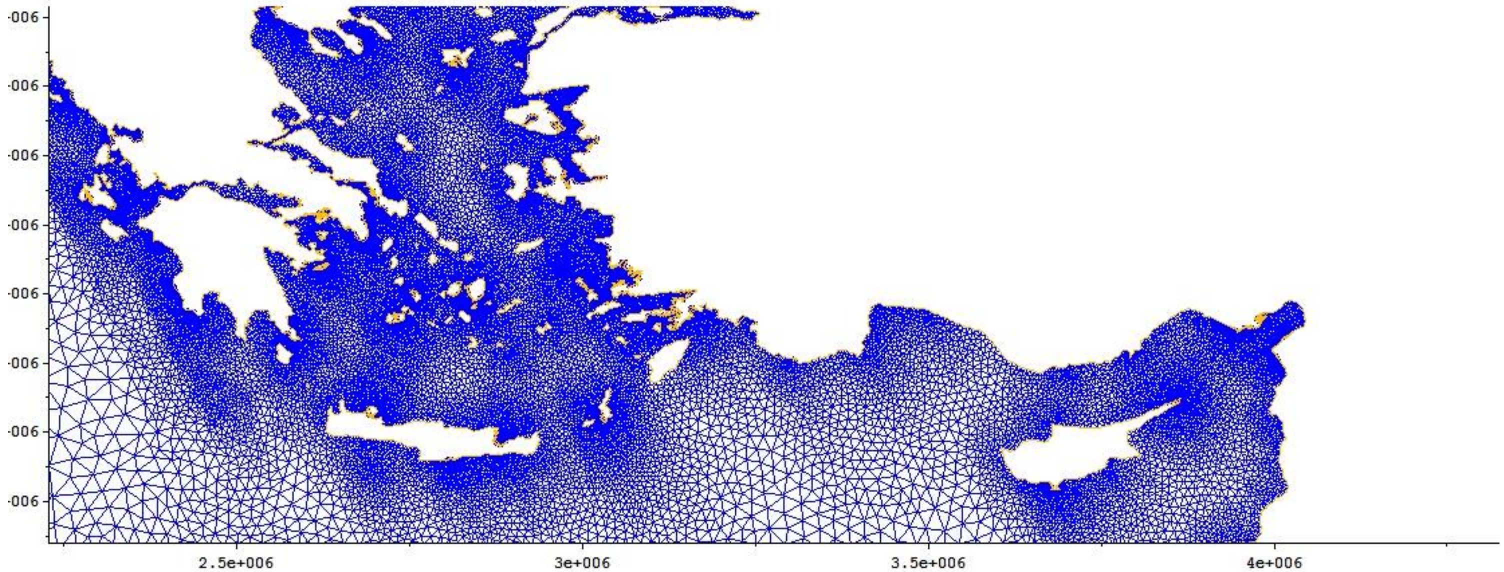
Collection of maps in the Centre d’Etudes Alexandrines (Alexandria Studies Center)
The oldest map of 1797-1801 from the Description of the Egypt
The XXth century – British Navy maps
GEBCO_08 (30’’) or ETOPO1 for the Mediterranean Sea

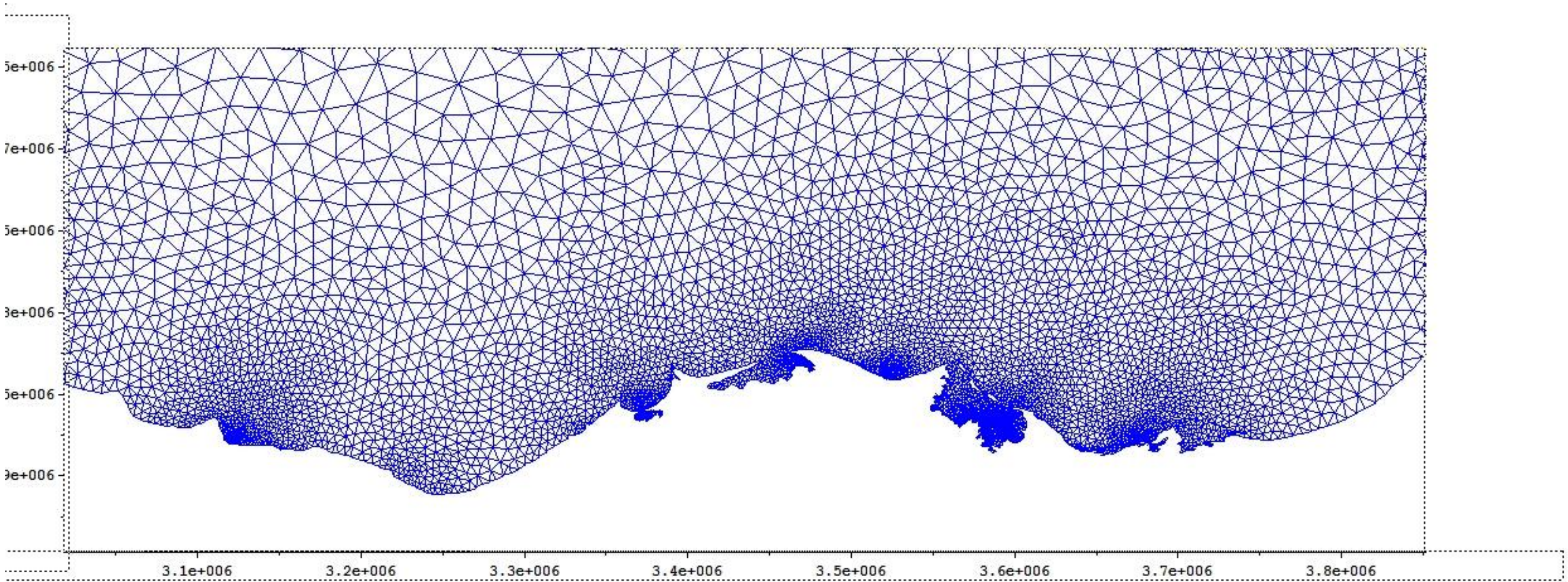
BATHYMETRY ON THE MEDSEA_E01 GRID



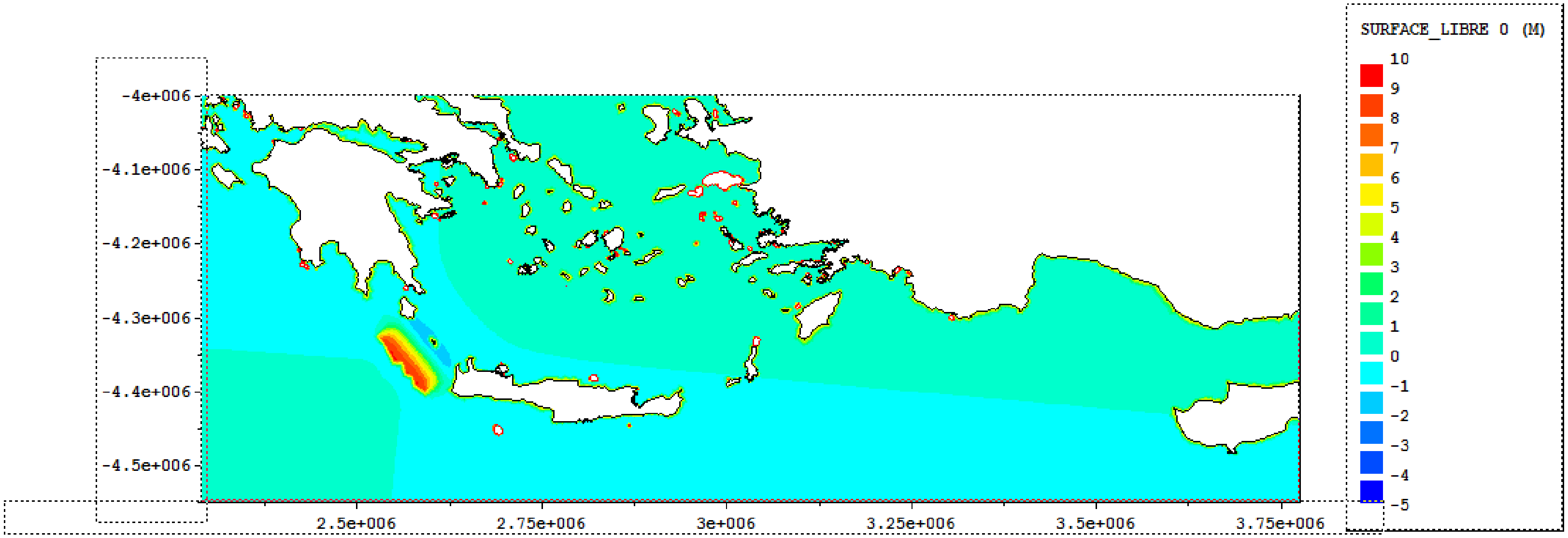
CONSTRAINTS ON THE BATHYMETRY DATA: PRECISION + RESOLUTION

The grid resolution: 10 km – deep sea -> 250 m at the Egypt coast



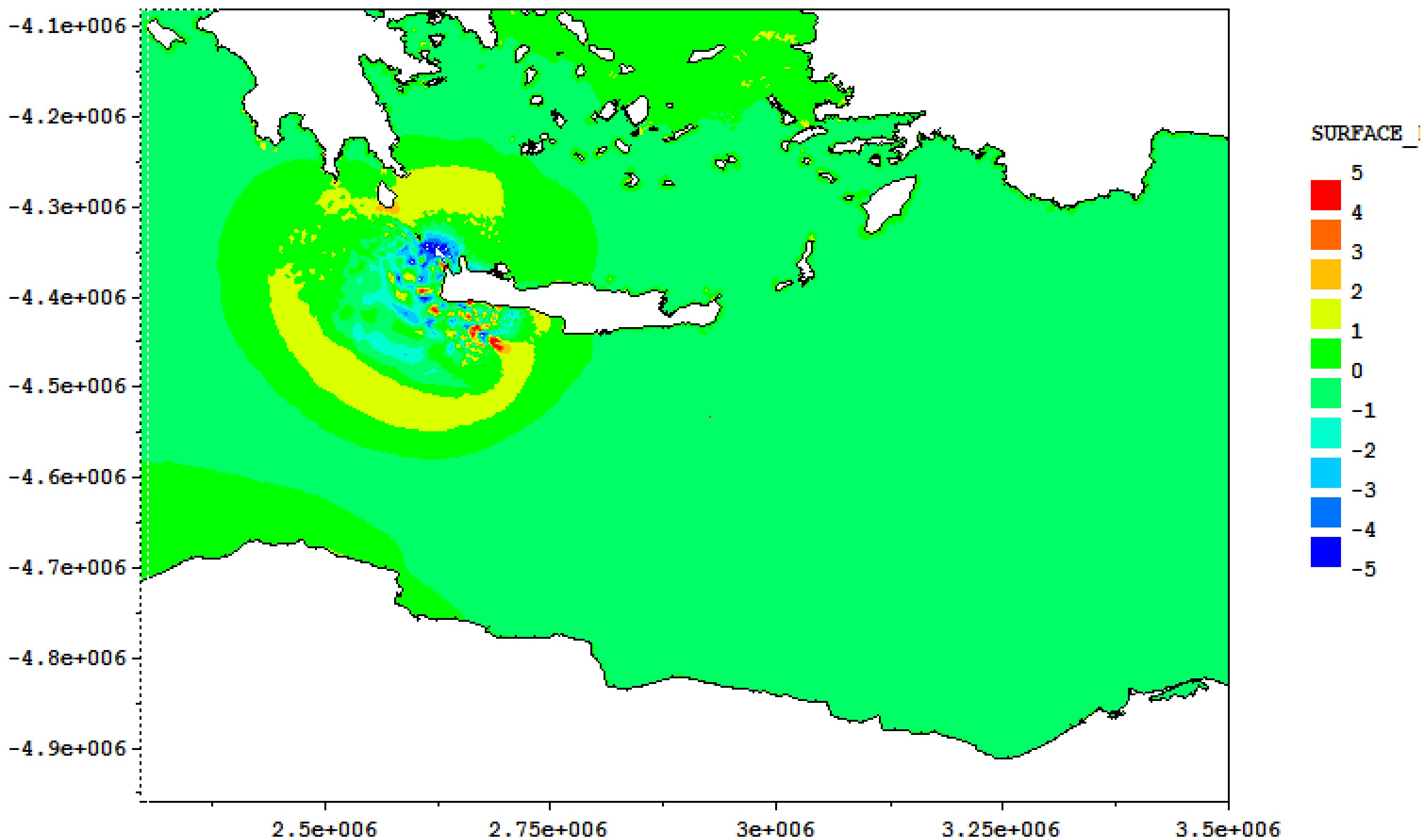


Starting the model

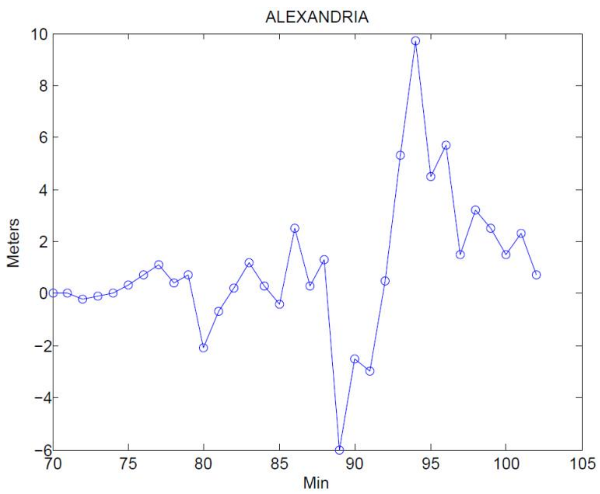


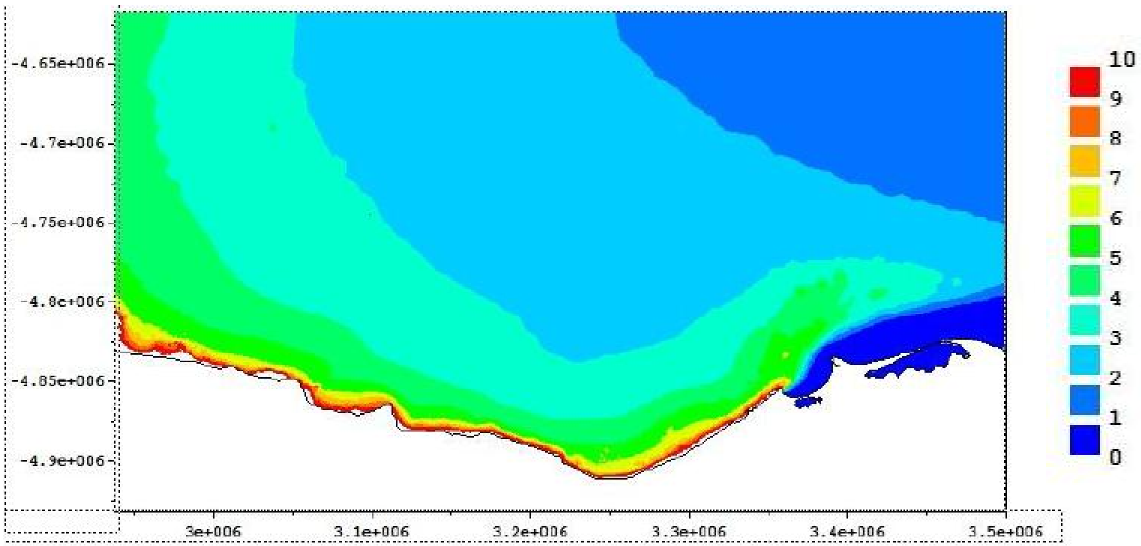
Running the model

15 min later



Modelled AD 365 Tsunami at Alexandria





Run Up = 9.7 m at Alexandria. N – wave ?

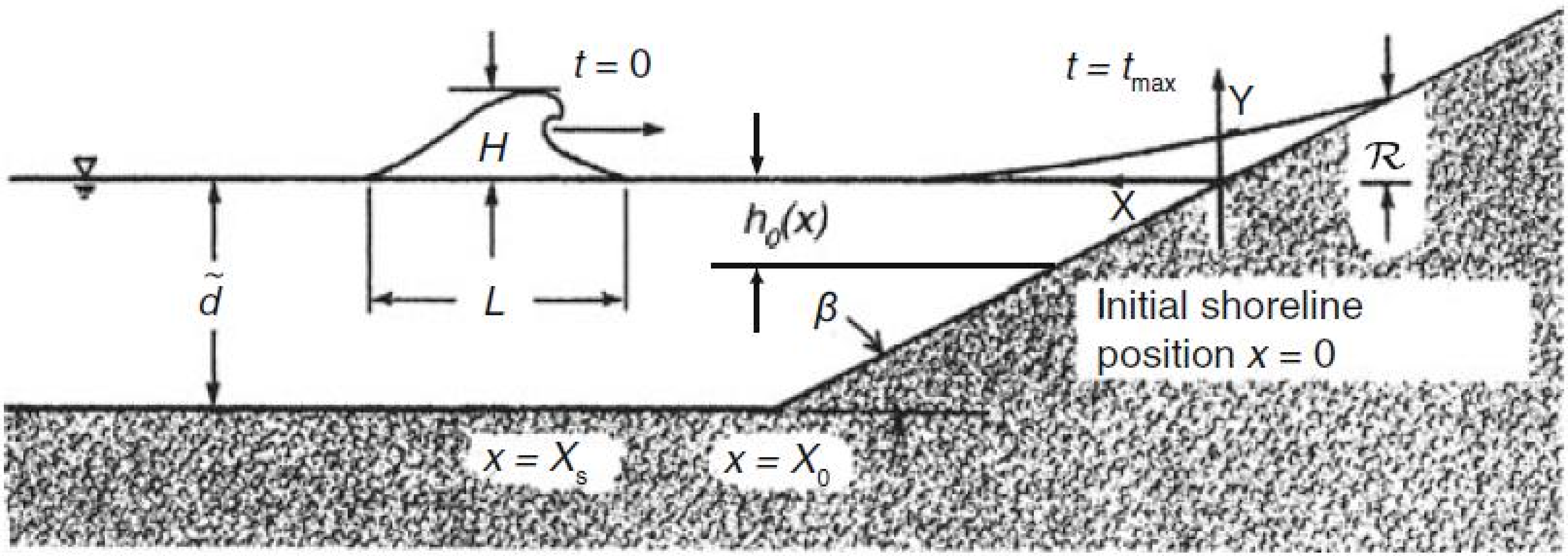
CONCLUSIONS

- A run-up of 9.7 m has been estimated at Alexandria
- Was it enough to inundate the city surrounded by a wall ?
- Perspective: Including a (simple) model of Alexandria (Falaki map ?) .

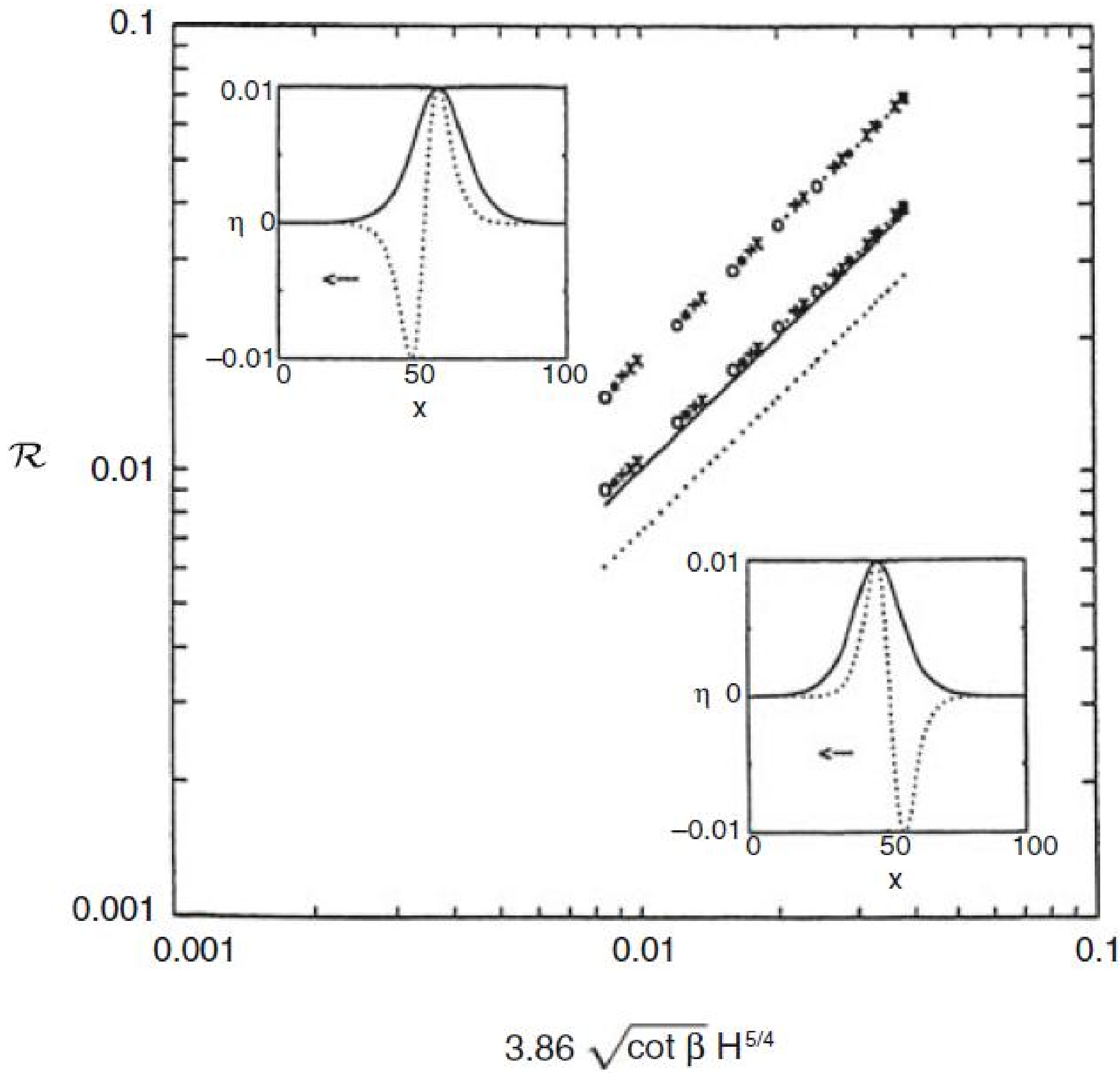
- The simulated sea height variations show a leading negative peak preceding the positive one.

  Was it an N-wave ?

  What is the fault strike contribution ?

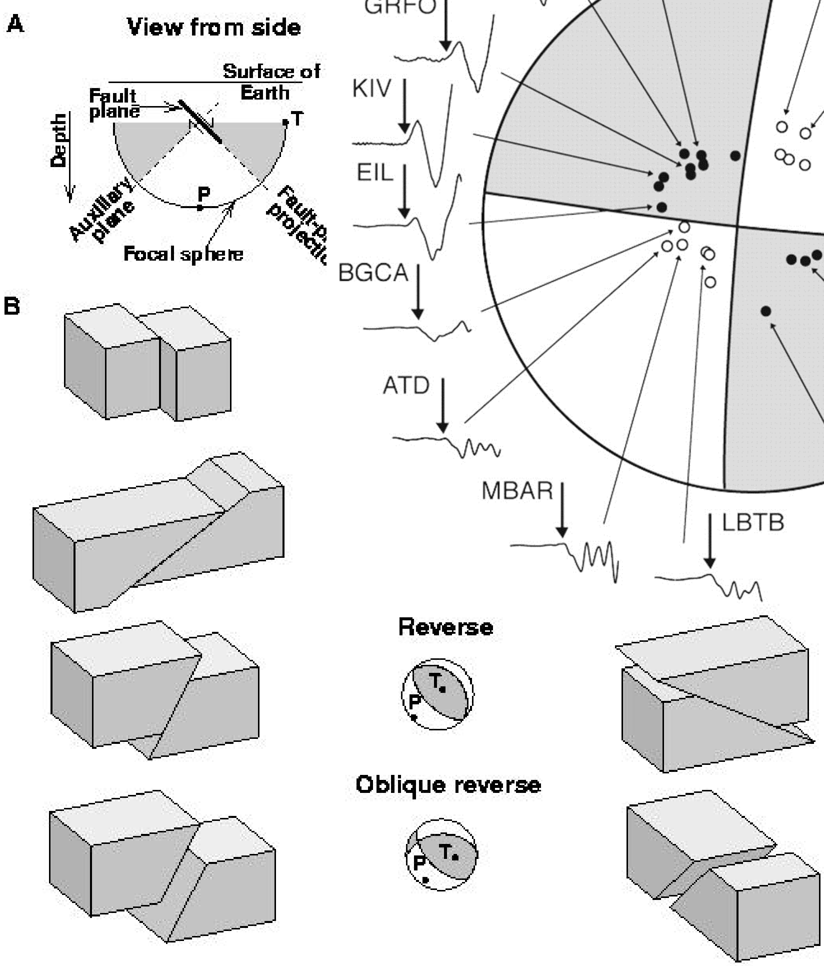


t = 0
H
L
$\tilde{d}$
$h_0(x)$
β
$t = t_{max}$
Y
X
$\mathcal{R}$
Initial shoreline
position x = 0
x = X_s
x = X_0



Maximum runup of isosceles N-waves and solitary wave. The top and lower set of points are results for the maximum runup of leading-depression and -elevation isosceles N-waves, respectively. The dotted line represents the runup of solitary wave (3). The upper and lower insets compare a solitary wave profile to a leading-depression and -elevation isosceles N-waves, respectively. After TADEPALLI and SYNOLAKIS (1994).

Schematic di



USGS, 1996