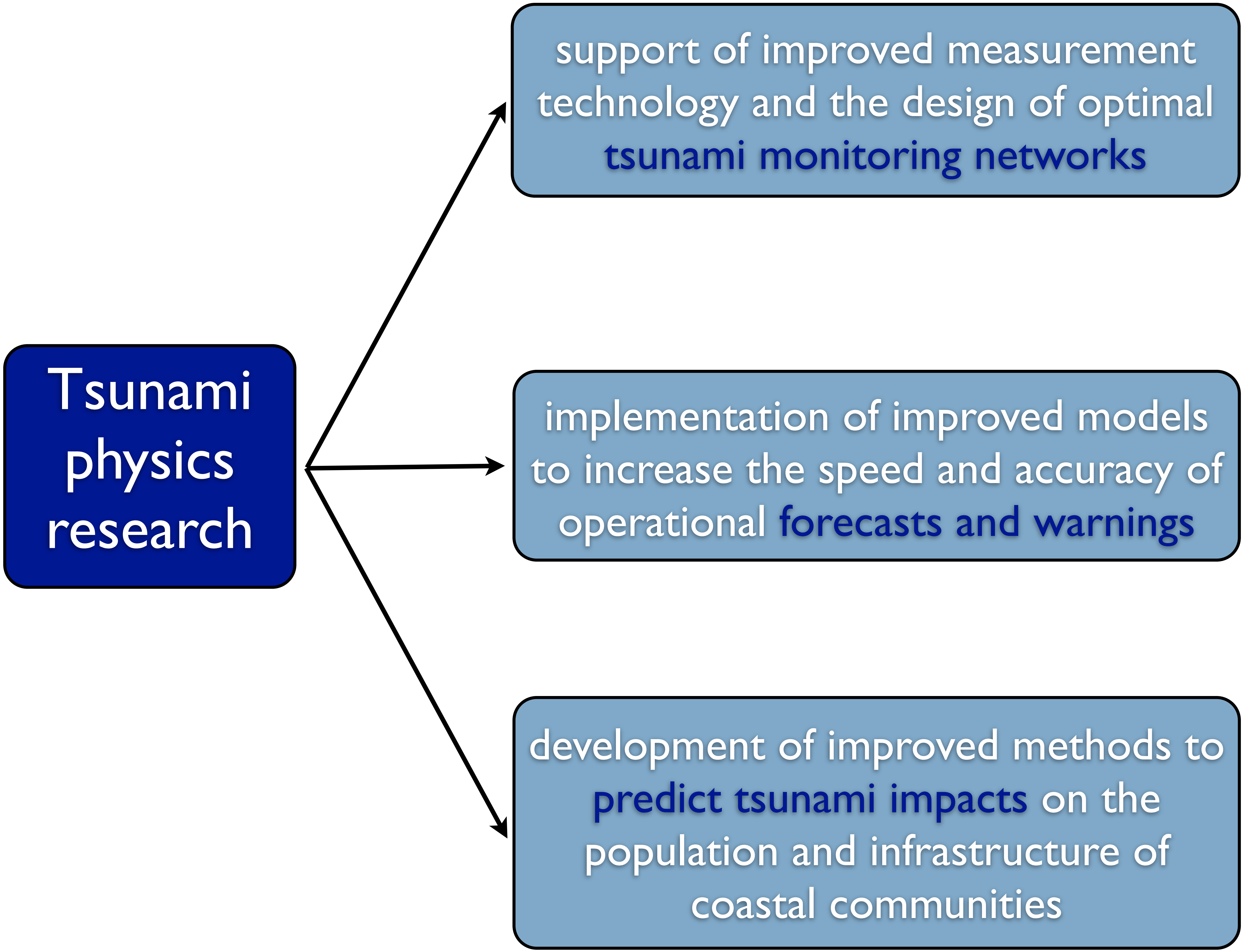

Tsunami physics research
support of improved measurement technology and the design of optimal tsunami monitoring networks
implementation of improved models to increase the speed and accuracy of operational forecasts and warnings
development of improved methods to predict tsunami impacts on the population and infrastructure of coastal communities

Tsunami modelling research

- Develop numerical models for faster and more reliable forecasts of tsunamis propagating through the ocean and striking coastal communities.
- Provide assistance to the Tsunami Warning Centers (TWC) in the form of Forecast Modeling software products specifically designed to support the Tsunami Warning Center's forecasting operations.
- Inundation Modeling to assist coastal communities in their efforts to assess the tsunami hazard and mitigate the risk.

Tsunami forecast model

Generation of a database of pre-computed scenarios from potential sources

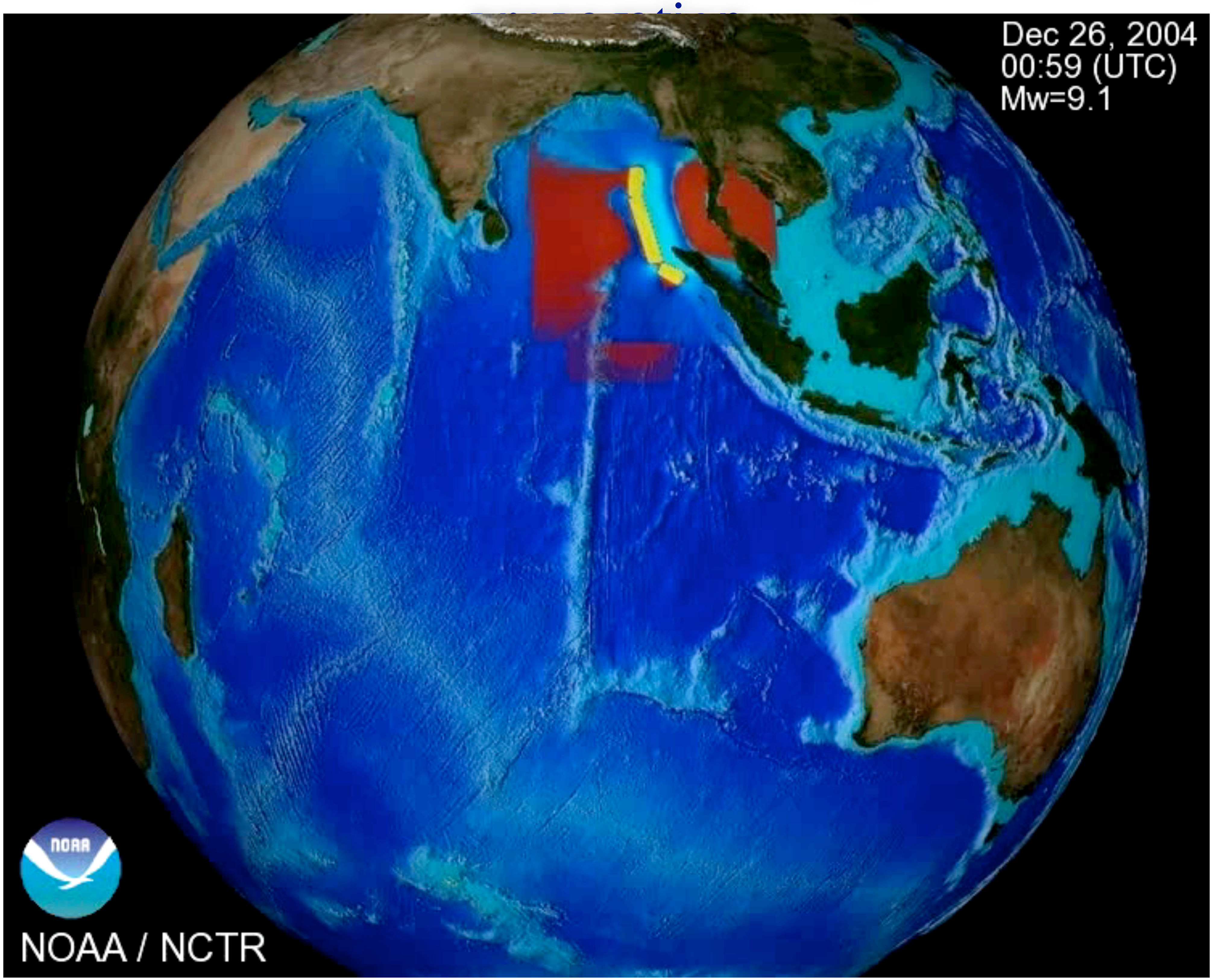
Arrival time
Height
Inundation area

Inundation modelling

Inundation maps

maximum wave height and maximum current speed as a function of location, maximum inundation line, as well as time series of wave height at different locations indicating wave arrival time

December 26, 2004 Indonesia (Sumatra) - Global tsunami propagation

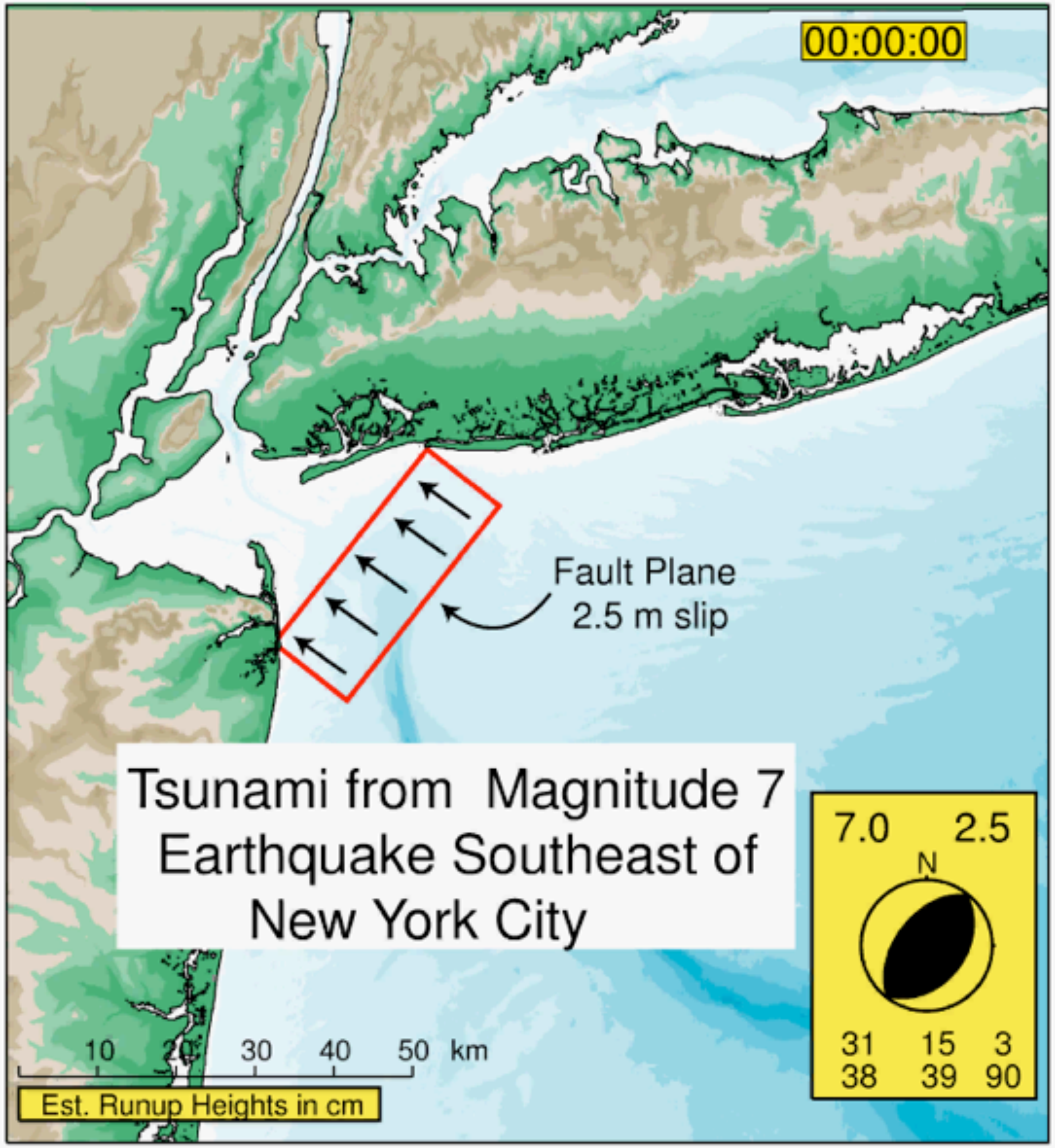


http://nctr.pmel.noaa.gov/model.html

Inundation of the Aonae peninsula during the July 12, 1993 Hokkaido-Nansei-Oki tsunami computed with the MOST inundation model.

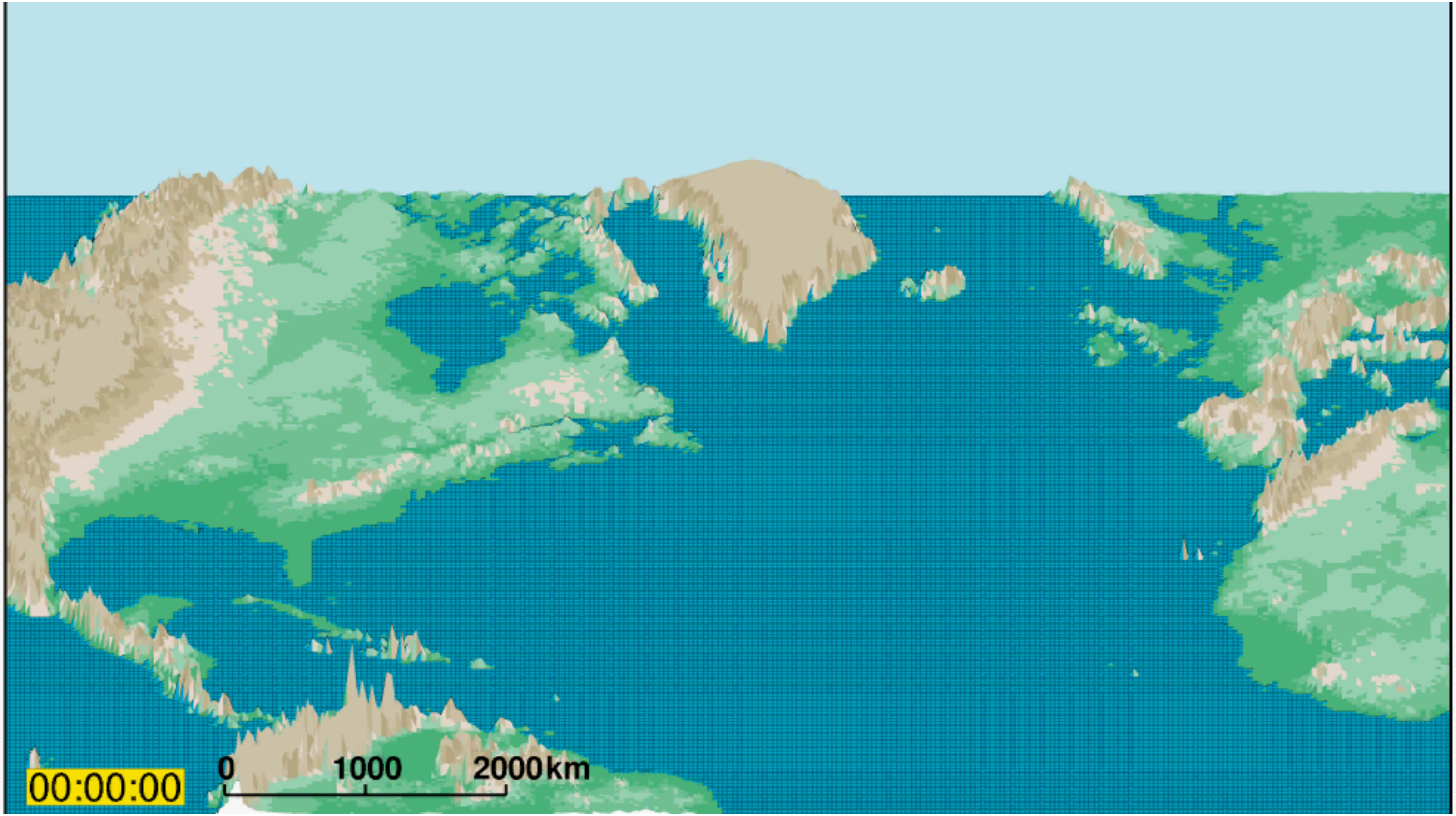
http://nctr.pmel.noaa.gov/model.html

New York City Tsunami from M7 Quake



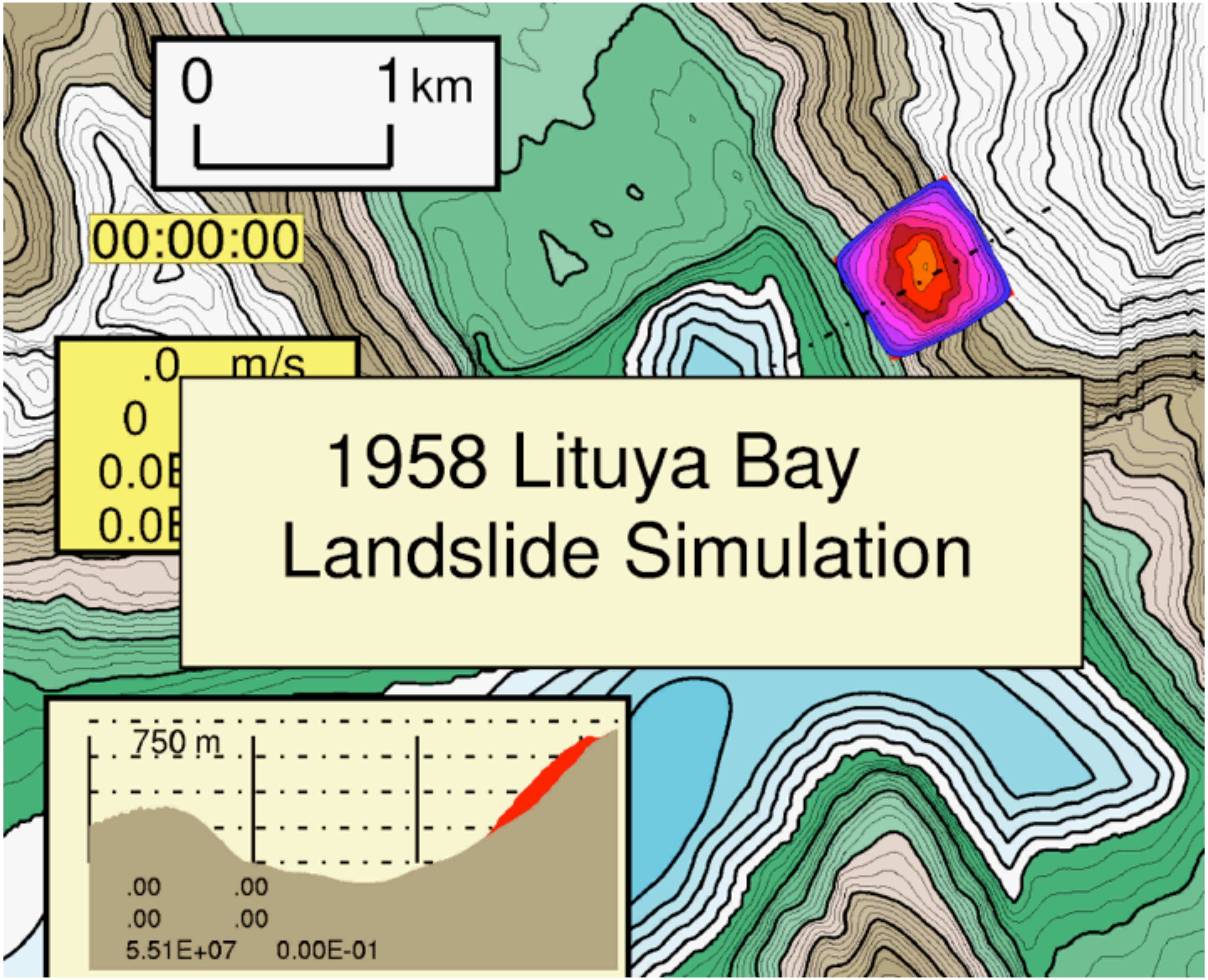
Courtesy of Steven Ward: http://www.es.ucsc.edu/~ward/

Atlantic Ocean Asteroid Tsunami Simulation - 3d



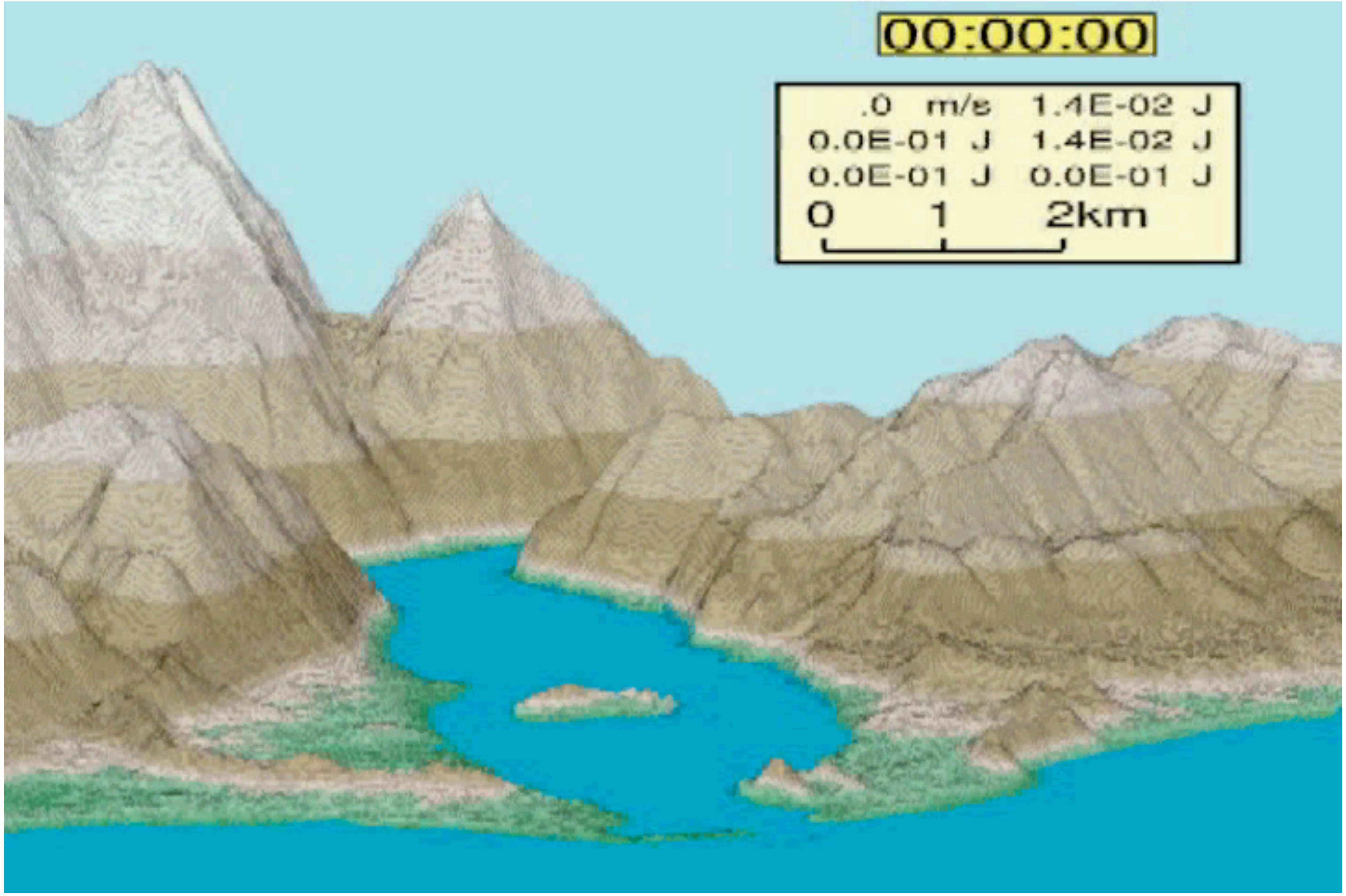
Courtesy of Steven Ward: http://www.es.ucsc.edu/~ward/

1958 Lituya Bay Landslide



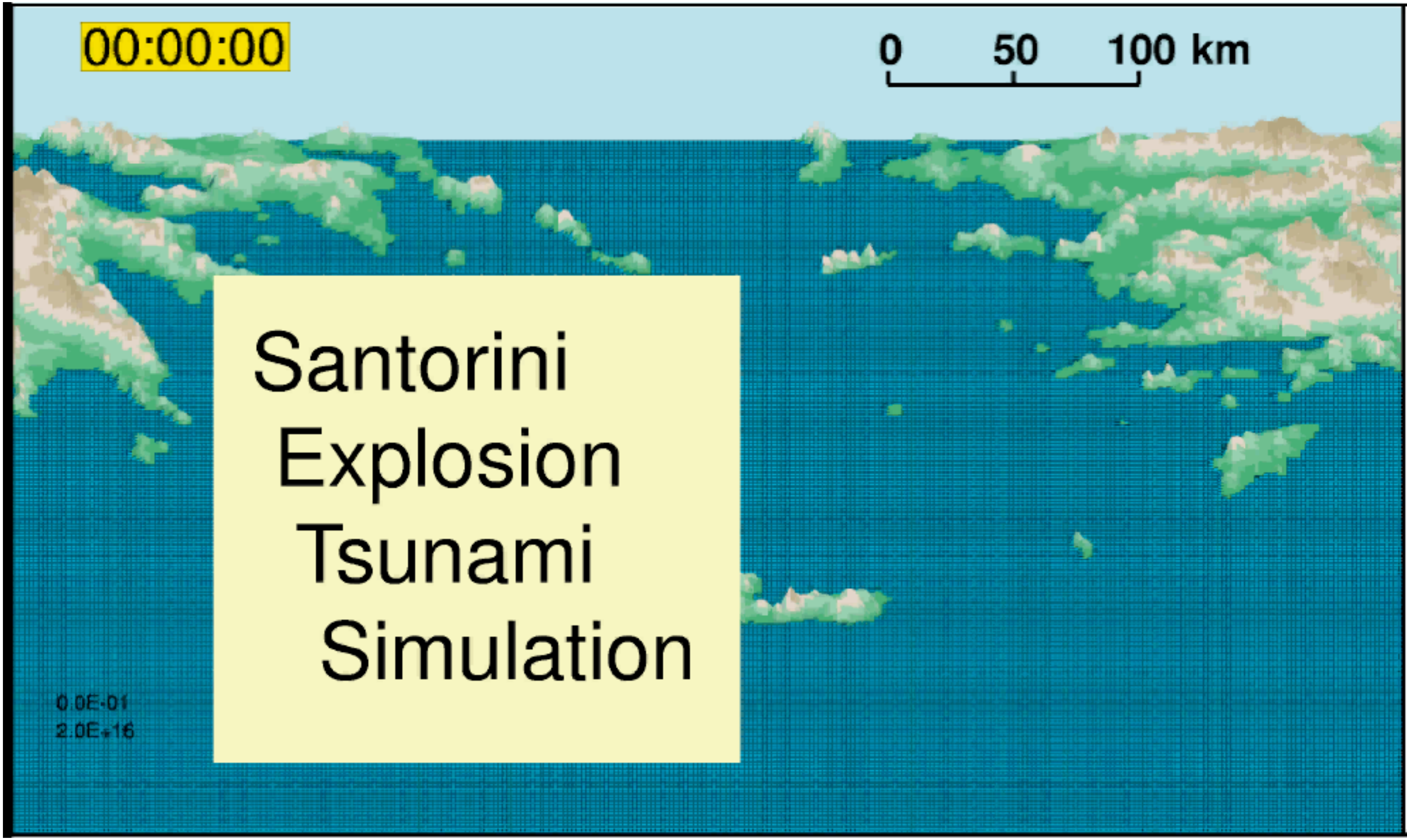
Courtesy of Steven Ward: http://www.es.ucsc.edu/~ward/

1958 Lituya Bay Landslide



Courtesy of Steven Ward: http://www.es.ucsc.edu/~ward/

Santorini Tsunami Simulation 3D

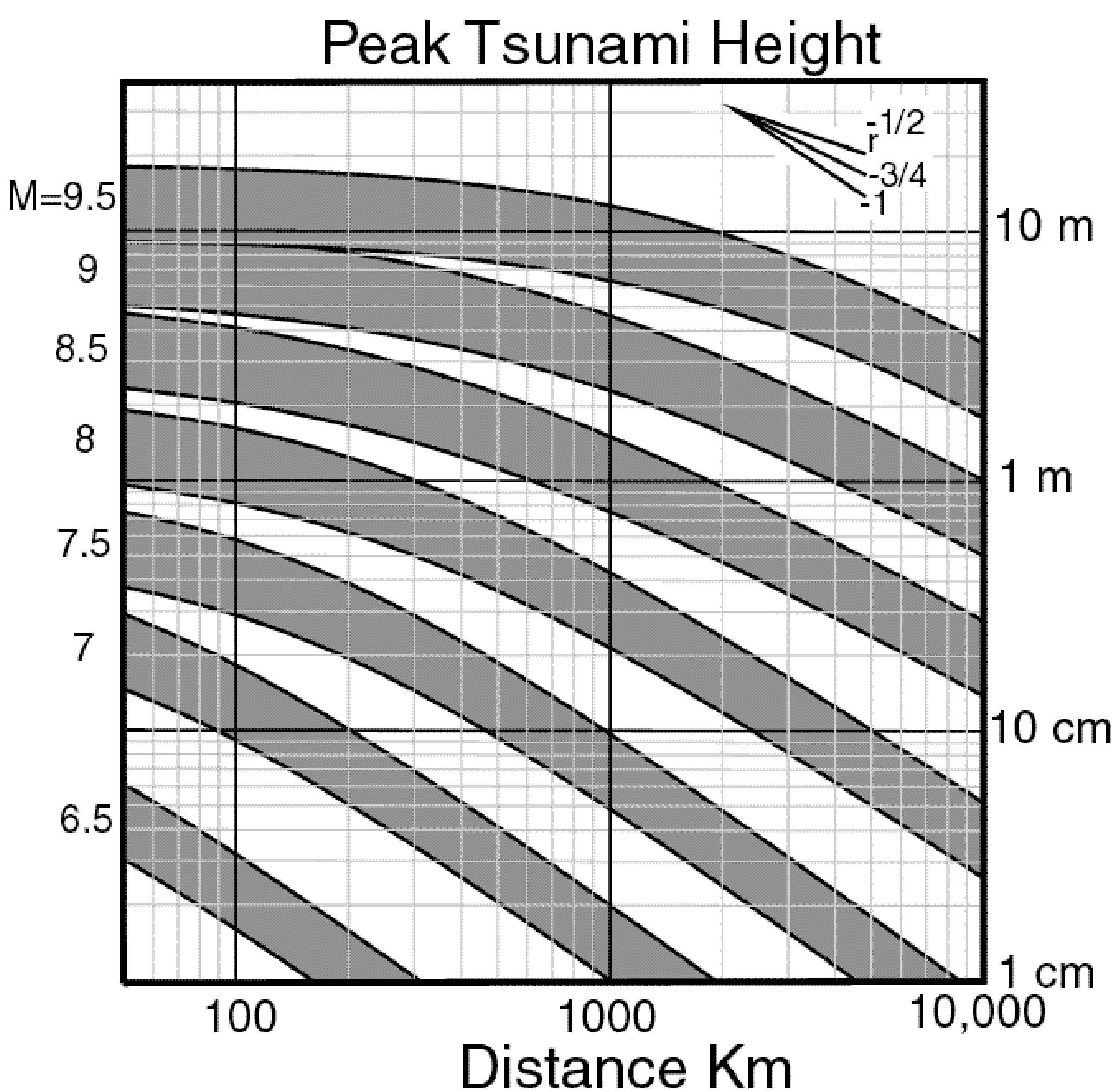


Courtesy of Steven Ward: http://www.es.ucsc.edu/~ward/

Tsunami Hazard Assessment

How does one infer the likelihood of a tsunami of a certain amplitude, striking a certain location within a certain time interval?

- 1) H(M,r)

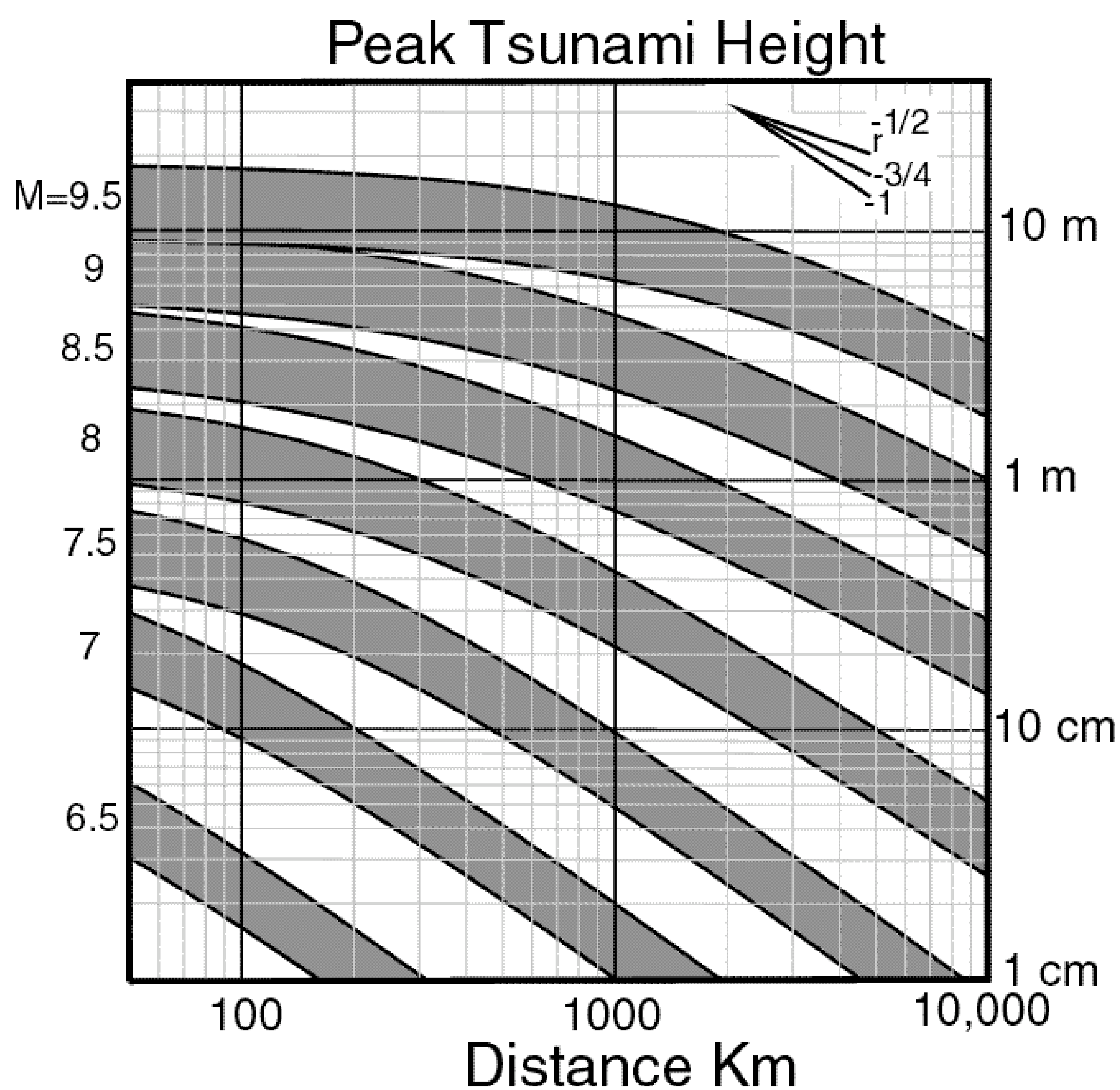


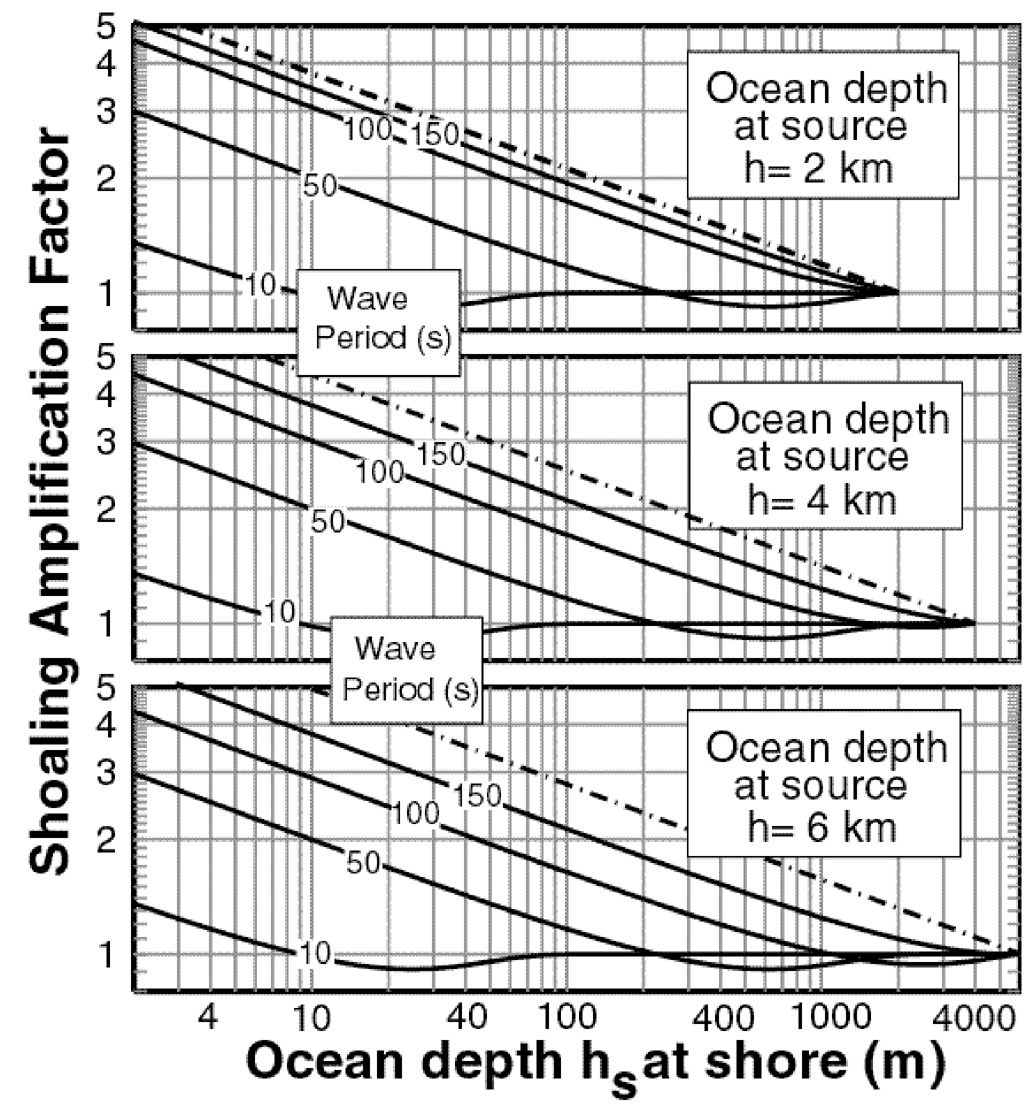
Tsunami Hazard Assessment

How does one infer the likelihood of a tsunami of a certain amplitude, striking a certain location within a certain time interval?

- 1) H(M,r)

2) $H_{crit} = H(M_c,r)(h_s/H_{crit})^{1/4}$





PTHA

How does one infer the likelihood of a tsunami of a certain amplitude, striking a certain location within a certain time interval?

- 1) $H(M,r)$

- 2) $H_{crit} = H(M_c,r)(h_s/H_{crit})^{1/4}$

- 3) $N(H_{crit},r,h_s) =$

$$\int_{M_c(r,H_c)}^{M_{max}} n(M)\,dM$$

- 4) $N(H_{crit},h_s) =$

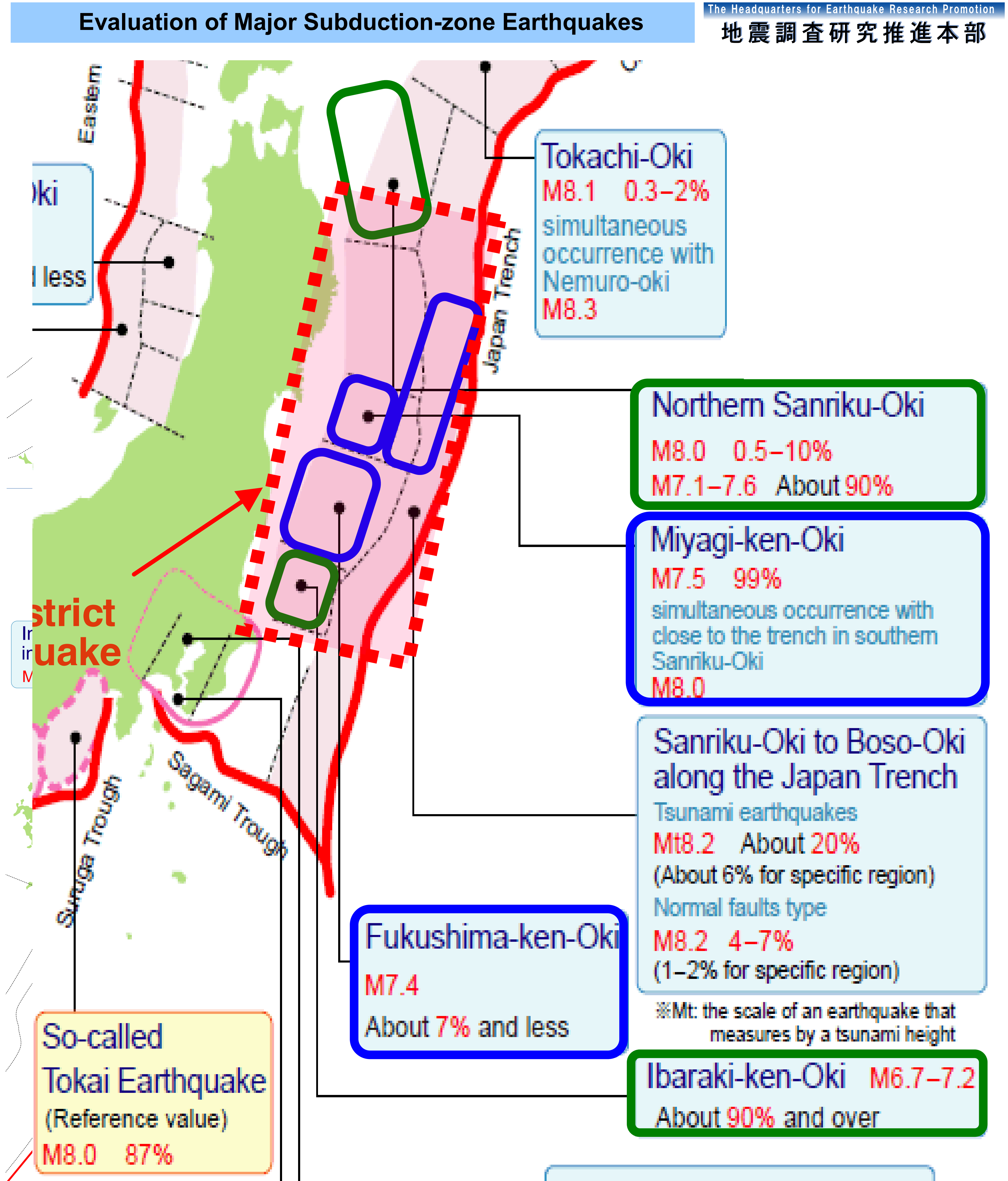
$$\int_{r(h_s)} N(H_{crit},r,h_s)\,dA$$

- 5) Poissonian probability of one or more tsunami arriving at r_s and exceeding H_{crit} in time interval T

$$P(r_s,T,H_{crit}) = 1 - e^{-N(r_s,H_{crit})T}$$

Slides taken from Tsunamis, by S. Ward, in
"Encyclopedia of Physical Science and Technology" - Academic Press - 2002

Expectations...

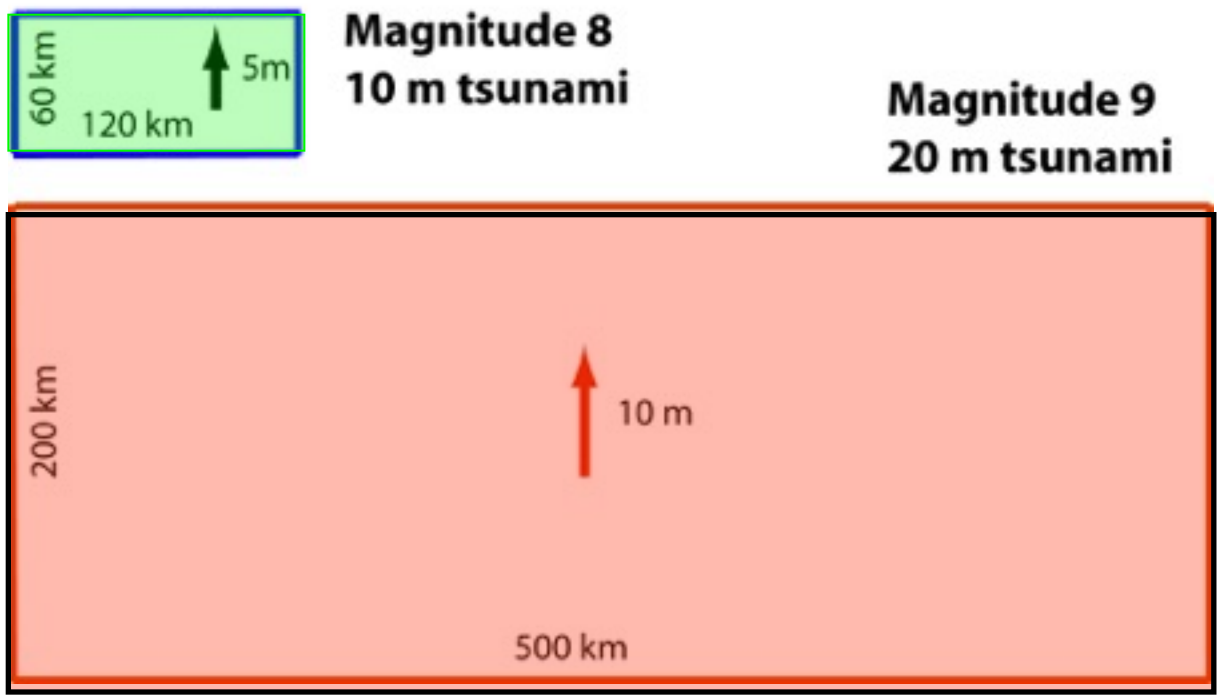


“Estimated magnitude and long-term possibilities within 30 years of earthquakes on regions of offshore based on Jan. 1, 2011.”

“Estimated magnitude and long-term possibilities within 30 years of earthquakes on regions of offshore based on Jan. 1, 2008.”

Reality...

Planning assumed maximum magnitude 8 Seawalls 5-10 m high



Tsunami runup approximately twice fault slip

M9 generates much larger tsunami

Stein, S. and E. Okal, The size of the 2011 Tohoku earthquake needn't have been a surprise, EOS, 92, 227-228, 2011.

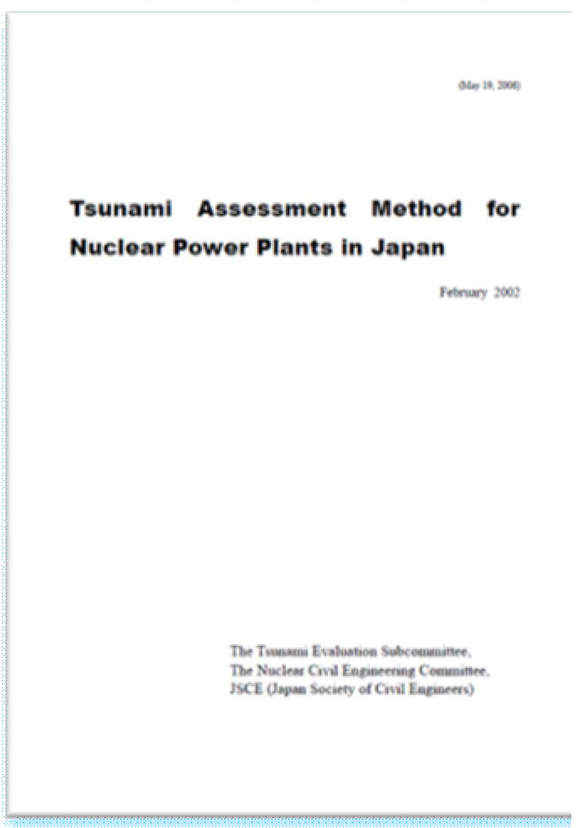
Tsunami Assessment method for NPP in JSCE, Japan

The TSUNAMI EVALUATION SUBCOMMITTEE,
Nuclear Civil Engineering Committee, JSCE

Masafumi Matsuyama (CRIEPI)

History of TES

- Phase I 1999-2000
  The maximum and minimum water levels by deterministic method
  → "Tsunami assessment method for NPP in Japan」 (2002)"
- Phase II 2003-2005
  Probabilistic Tsunami Hazard Analysis for the max. and min. water levels
  Numerical simulation of nonlinear dispersion wave theory with soliton fission and split wave-breaking
  Tsunami wave force on breakwater
- Phase III 2006-2008
  Topography change due to tsunami
  Development of probabilistic Tsunami Hazard Analysis
- Now → Phase IV 2009-2011
  Revising of 「Tsunami assessment method for NPP in Japan」


Tsunami Assessment Method for Nuclear Power Plants in Japan

February 2002

The Tsunami Evaluation Subcommittee,
The Nuclear Civil Engineering Committee,
JSCE (Japan Society of Civil Engineers)

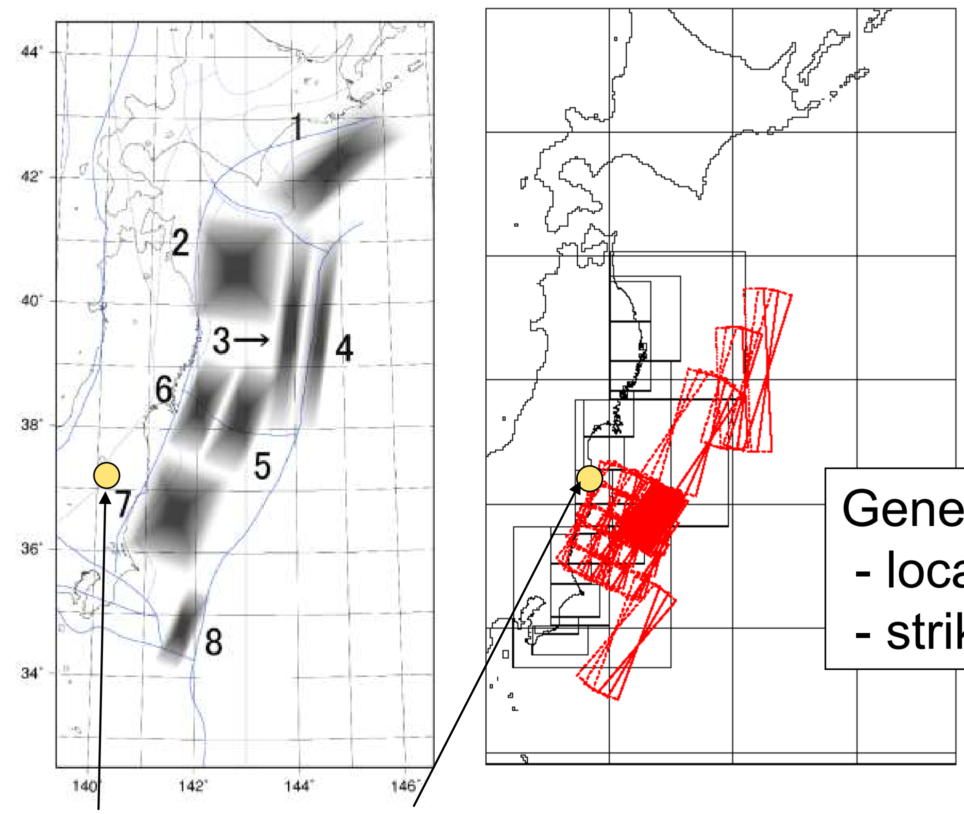
Niigata meeting, November 2010
http://www.jnes.go.jp/seismic-symposium10/presentationdata/3_sessionB.html

Tsunami Assessment method for NPP in JSCE, Japan

The TSUNAMI EVALUATION SUBCOMMITTEE,
Nuclear Civil Engineering Committee, JSCE

Masafumi Matsuyama (CRIEPI)

General parametric study in the near field



General parametric study
- location
- strike

Fukushima Daiichi NPS

Deterministic method (2002)
Main flow chart

Sub flow 1
Verification of fault model(s) and numerical calculation system on the basis of historical tsunami(s)

↓

Sub flow 2
Estimation of the design water levels on the basis of **parametric study** in terms of basis tsunamis

↓

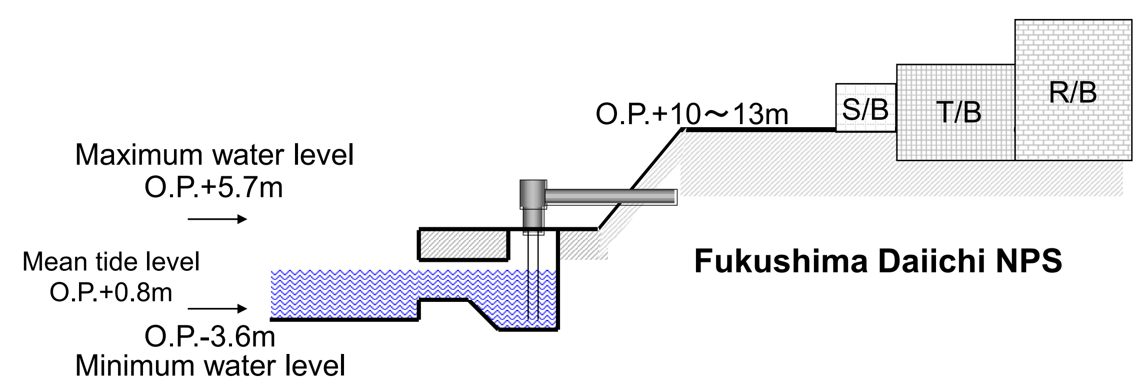
tide → Design high water level
Design low water level

↓

End

Summary of Evaluation

Maximum water level = 4.4m + O.P.＋1.3m = O.P.+5.7m
Minimum water level = -3.6m – O.P.±0.0m = O.P.-3.6m



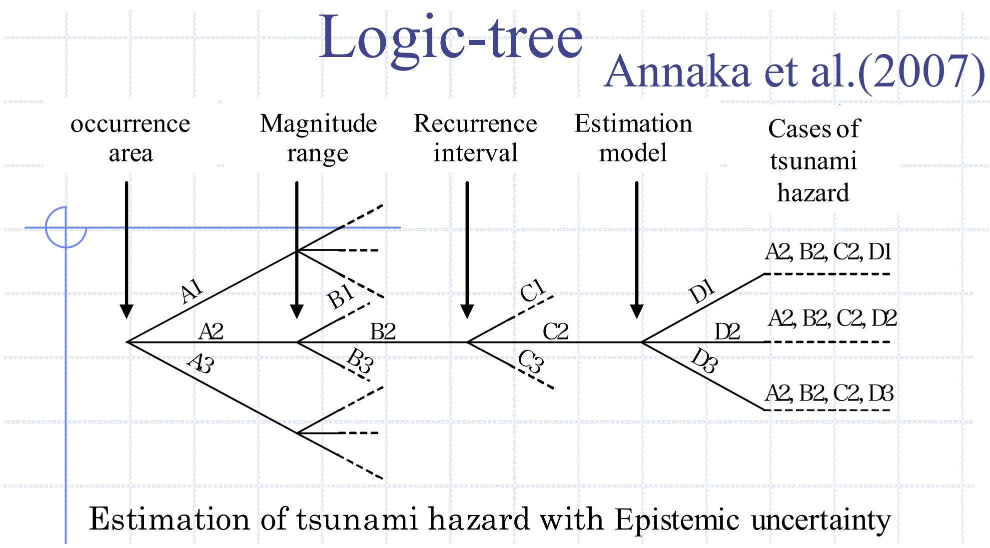
We assessed and confirmed the safety of the nuclear plants based on the JSCE method which was published in 2002.

Niigata meeting, November 2010
http://www.jnes.go.jp/seismic-symposium10/presentationdata/3_sessionB.html

Tsunami Assessment method for NPP in JSCE, Japan

The TSUNAMI EVALUATION SUBCOMMITTEE,
Nuclear Civil Engineering Committee, JSCE

Masafumi Matsuyama (CRIEPI)



Probabilistic Tsunami Hazard Analysis (PTHA)

- Probabilistic estimation of tsunami risk
  - Estimation of the deterministic design tsunamis
- Considering uncertainties in estimation
  - Errors in fault parameters
  - Errors in the numerical calculation system (numerical simulation, topography data)
  - Incomplete knowledge and data about the earthquake process