Assessment Indicators – How to achieve, challenges and solutions

10.3 TR ASSESS-1: Tsunami Hazard Risk Assessment – Data Requirements, Methods, and Techniques

Dr. Charles McCreery
Pacific Tsunami Warning Center

Dr. Laura Kong
International Tsunami Information Centre (ITIC)

Tsunami Ready Indicators

unesco
Intergovernmental Oceanographic Commission

UNESCO IOC TSUNAMI READY INDICATORS	
I	**ASSESSMENT (ASSESS)**
1	ASSESS-1. Tsunami hazard zones are mapped and designated
2	ASSESS-2. The number of people at risk in the tsunami hazard zone is estimated
3	ASSESS-3. Economic, infrastructural, political, and social resources are identified
II	**PREPAREDNESS (PREP)**
4	PREP-1. Easily understood tsunami evacuation maps are approved
5	PREP-2. Tsunami information is publicly displayed
6	PREP-2. Outreach and public awareness and education resources are available and distributed
7	PREP-3. Outreach or educational activities are held at least three times a year
8	PREP-4: A community tsunami exercise is conducted at least every two years
III	**RESPONSE (RESP)**
9	RESP-1. A community tsunami emergency response plan (ERP) is approved
10	RESP-2. The capacity to manage emergency response operations during a tsunami is in place
11	RESP-3. Redundant and reliable means to timely receive 24-hour official tsunami alerts are in place
12	RESP-4. Redundant and reliable means to timely disseminate 24-hour official tsunami alerts to the public are in place

Why is this the first step?

unesco
Intergovernmental Oceanographic Commission

Tsunami hazard maps are the basis for planning evacuation routes and location of tsunami shelters

Mapping the hazard zone raises awareness of the tsunami hazard in the community

Prepares the community for tsunami events

Helps and guides the emergency response agencies on evacuation planning

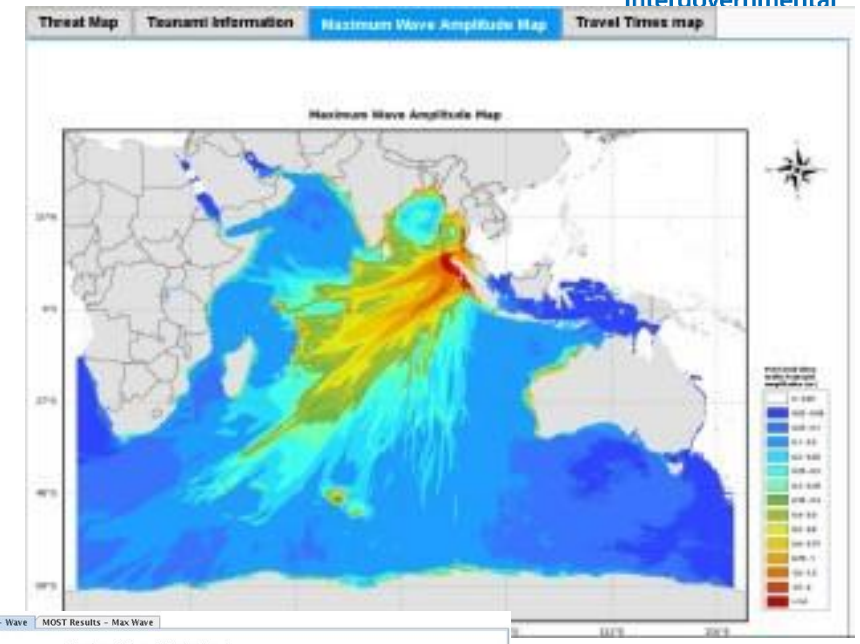
Guides mitigation measures to minimise the impact of tsunamis

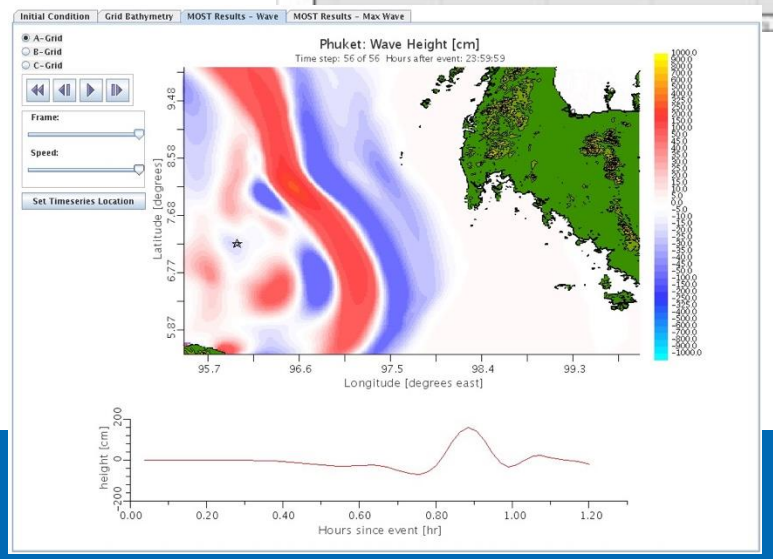
Defining tsunami impact at your location

The impact of a tsunami on the coastline **depends on the source location, directivity of the energy** moving through the water column, coastal bathymetry and topography

An **enclosed bay facing a tsunami source might get higher inundation levels than an open beach** tangential to the main directivity of the tsunami, even if both are at the same distance from the tsunami source

An **island in the middle of the ocean might have a lower inundation level** than a continental open beach, both located equidistant from the tsunami source



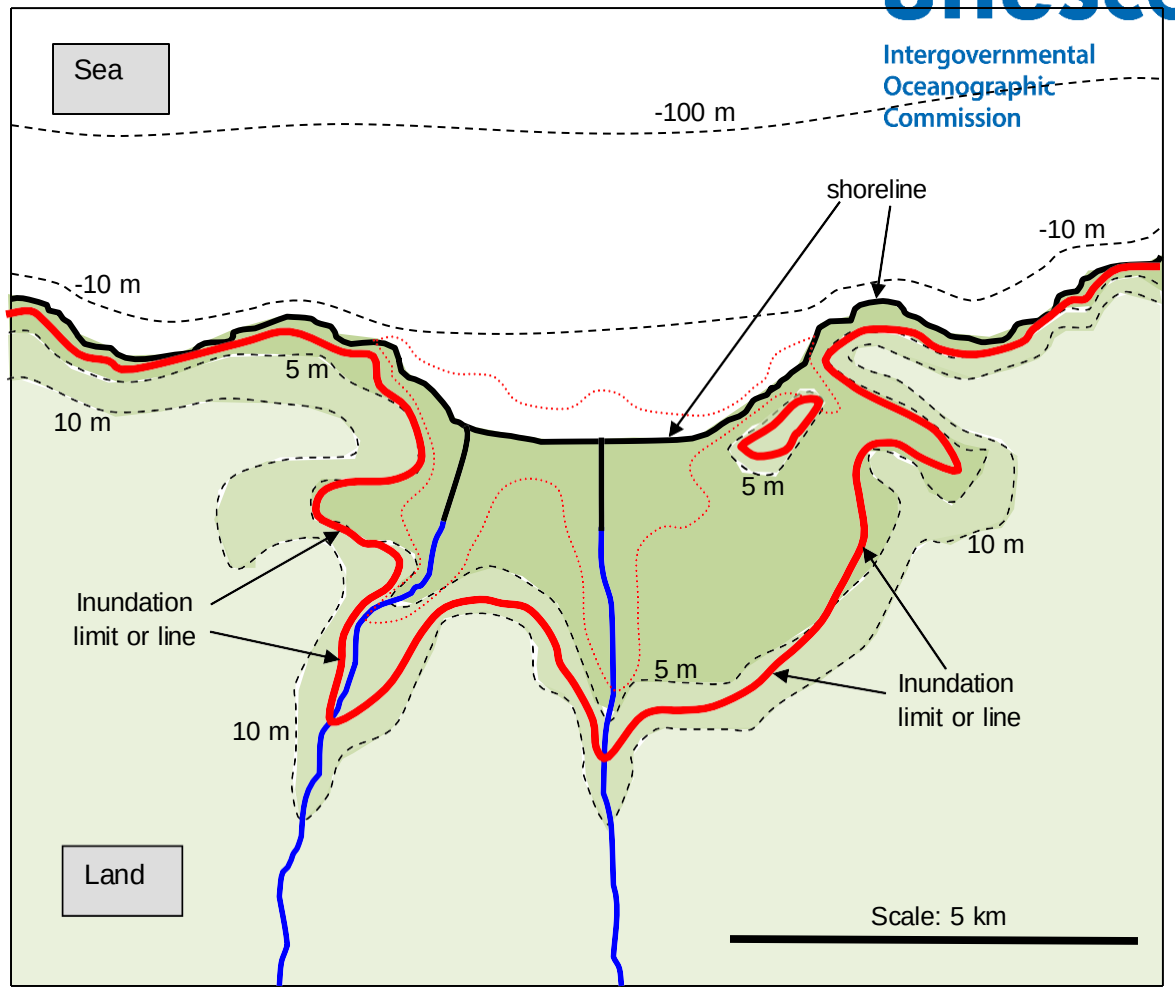


Define Tsunami hazard zone

Tsunami hazard maps depict the areas that may be flooded by a tsunami usually based on a worst-yet-credible case scenario (the worst tsunami that can impact the area)

The primary source for mapping potential tsunami hazard zones is inundation modelling, which illustrates areas expected to be flooded by the tsunami.

The result of an inundation modelling study is the tsunami inundation map depicting the tsunami hazard zone



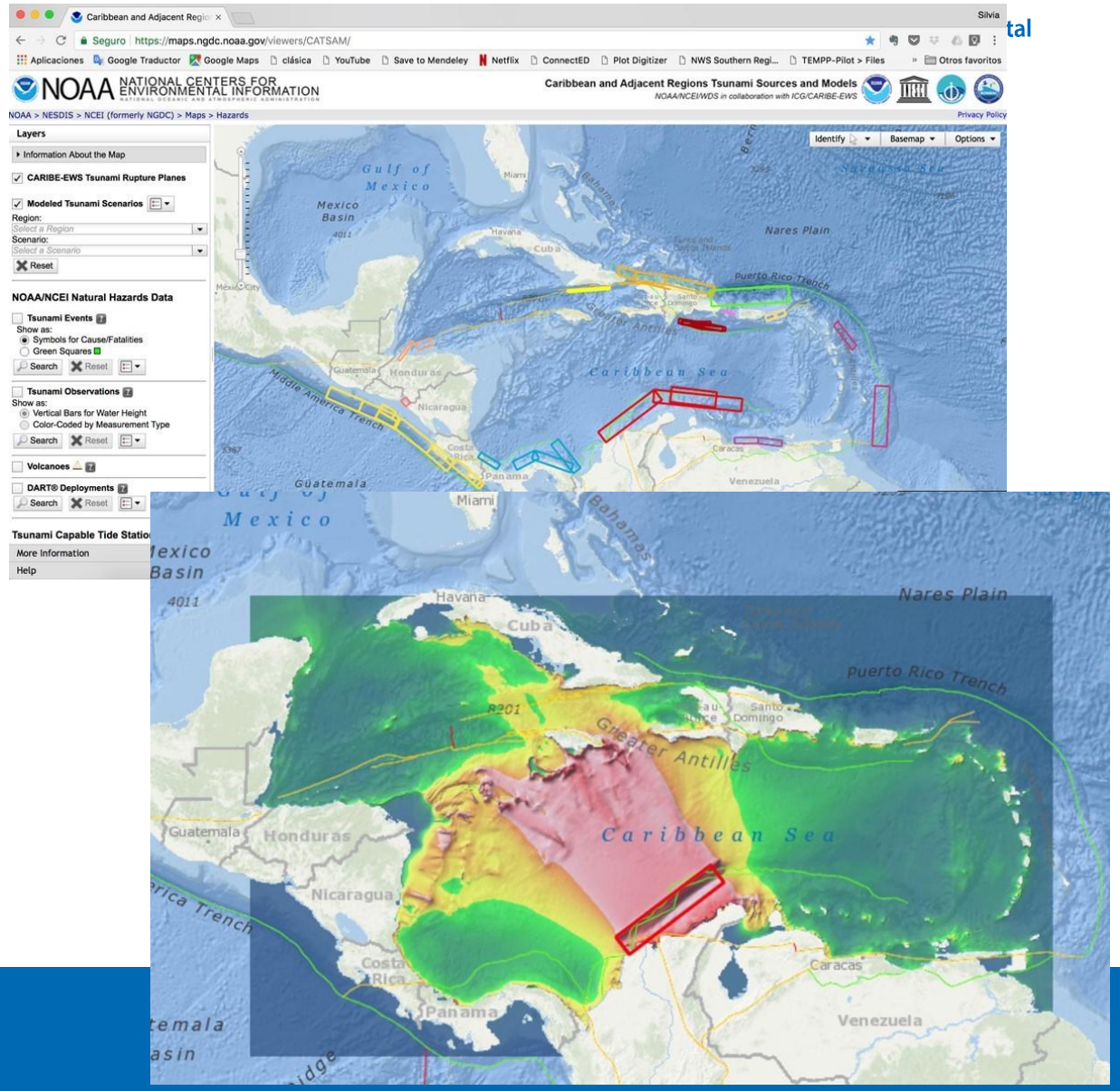
Inundation mapping (training exercise). The red line marks the maximum horizontal penetration of the tsunami. Source: UNESCO IOC and UNDP, 2009

Data requirements for inundation modelling

1. Tsunamigenic earthquake source information

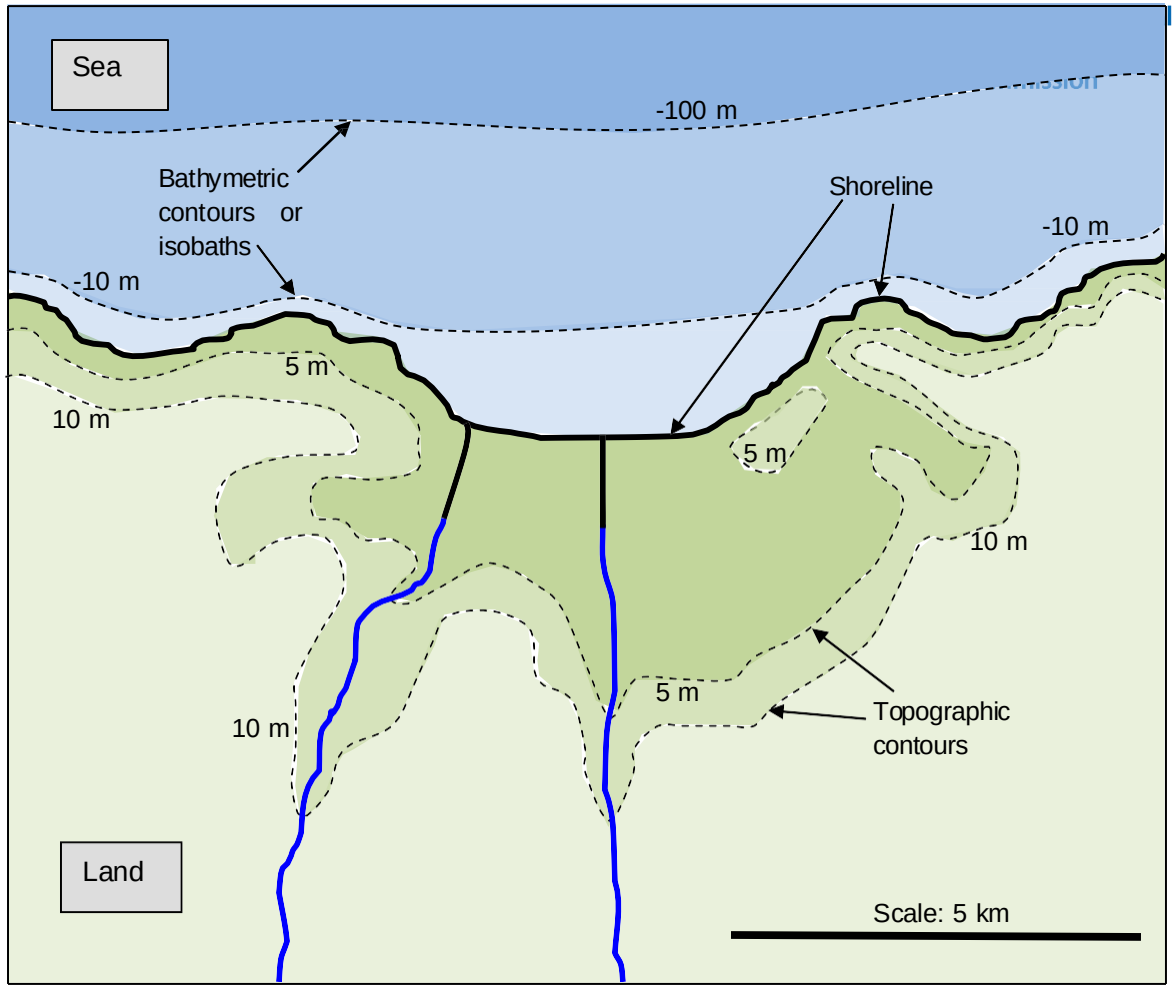
- **Sources: historical archives, tsunami researchers, seismologists at local universities**
- **If no credible earthquake source information available, worst-case scenarios need to be estimated**

2. Detailed topographic and bathymetric data



Topography and bathymetry

Inundation modelling requires detailed coastal topography and near shore bathymetry data ideally combined in a Digital Elevation Model (DEM)



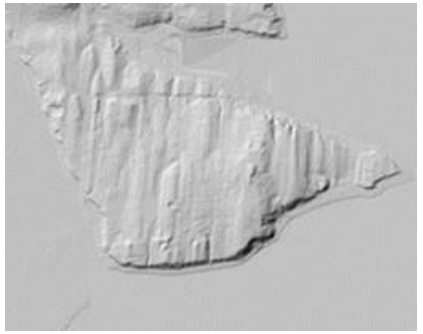
Bathymetry and topography (training exercise). Source: UNESCO IOC and UNDP, 2009

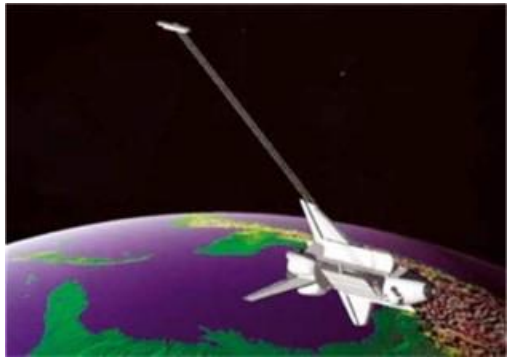
Topographic and Bathymetric Data

unesco
Intergovernmental
Oceanographic

Topographic Survey

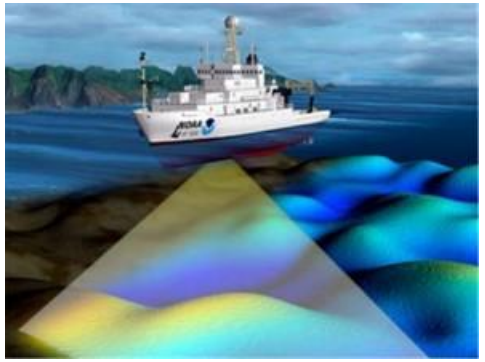
- **Photogrammetry**
- **Topographic LiDAR**
  (Light Detection and Ranging)
- **Space-based Radar (SRTM)**
  (Shuttle Radar Topography Mission)

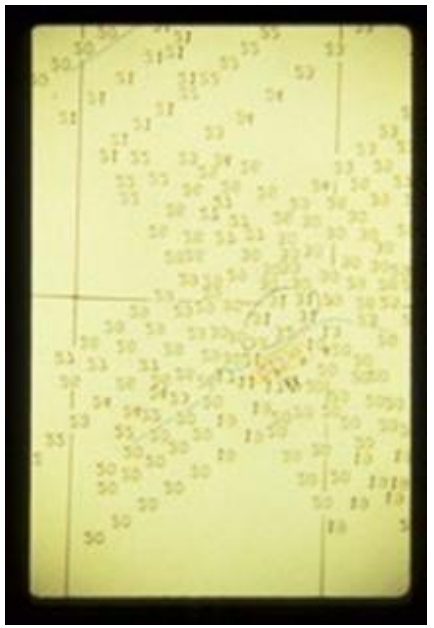


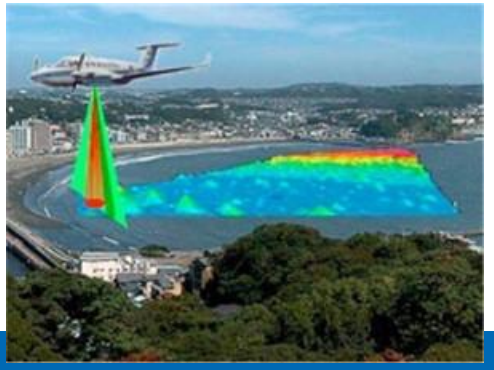


Bathymetric Survey

- **Single-beam survey**
- **Multi-beam surveys**
- **Bathymetric LiDAR**







Digital Elevation Model (DEM)

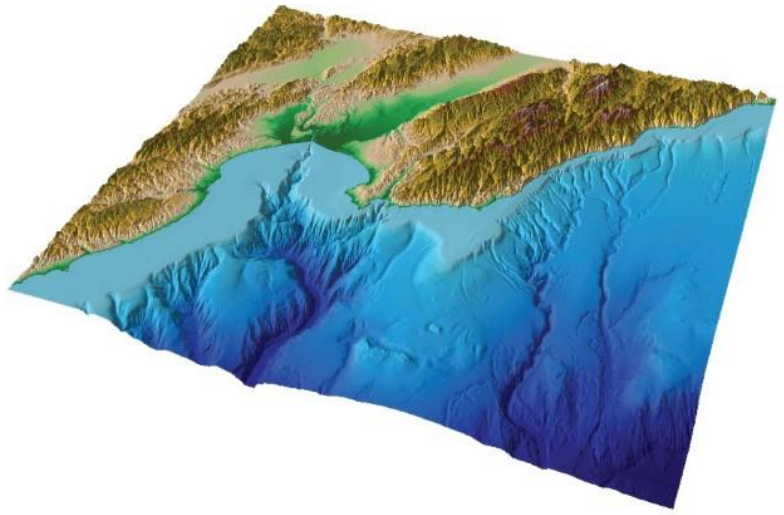
unesco
Intergovernmental
Oceanographic
Commission

A coastal DEM depicts Earth's land surface and ocean bottom. It is constructed from land and seafloor elevation data collected by federal, state and local governments, universities and private companies.

How are DEMs used?

DEMs help to plan, prepare for, and better understand ocean processes. Uses include:

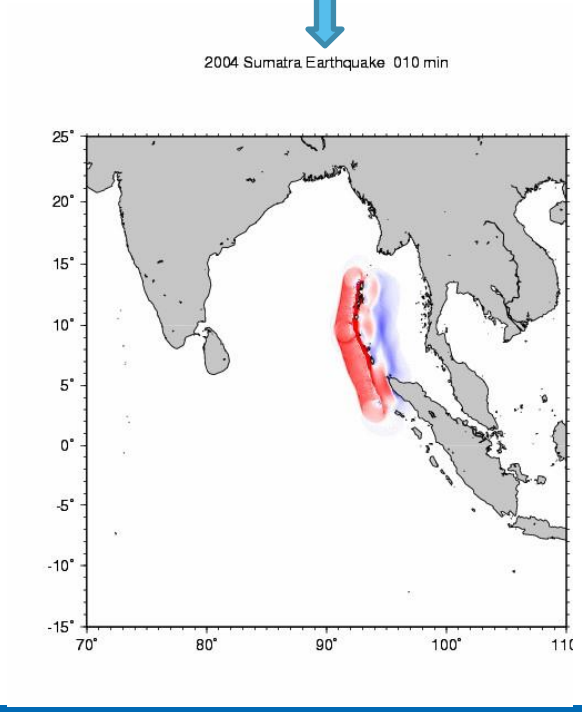
- **Real-time tsunami and storm-surge forecasting and warning**
- **Hazard mitigation and community preparedness**
- **Ecosystem management and habitat research**
- **Coastal change and terrain analysis**
- **Pollution monitoring and contaminant dispersal**
- **Map creation and Earth visualization**
- **Long-term planning**



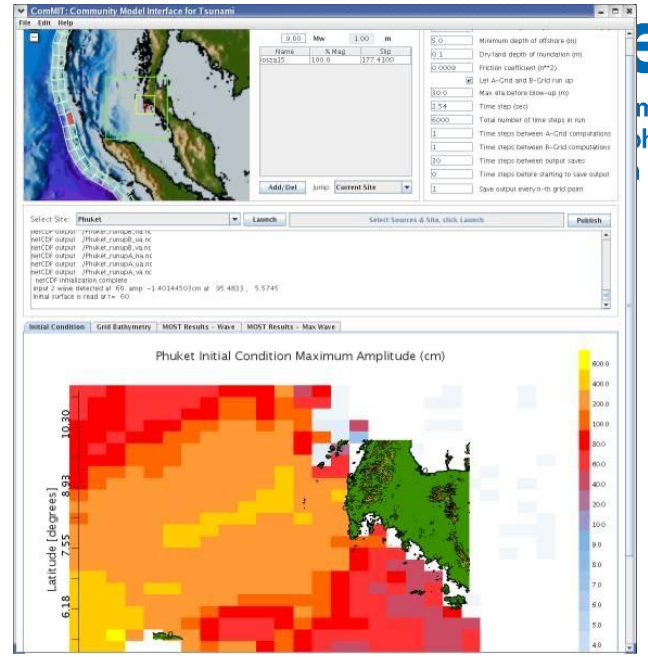
Tsunami inundation grid, Montrery Bay, California (upper) and perspective view from the southwest of Montrery (lower.) NOAA PMEL, 2012

Numerical models

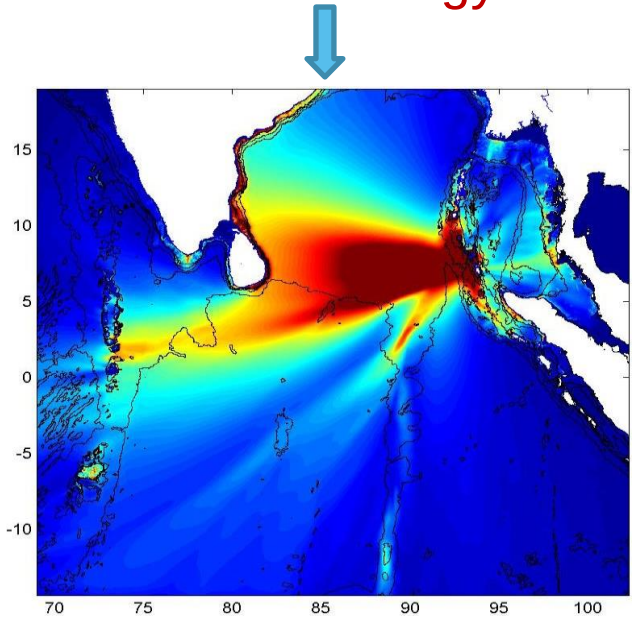
Propagation models model the movement of tsunami waves from their source across the ocean to the coastal zone (linear models)

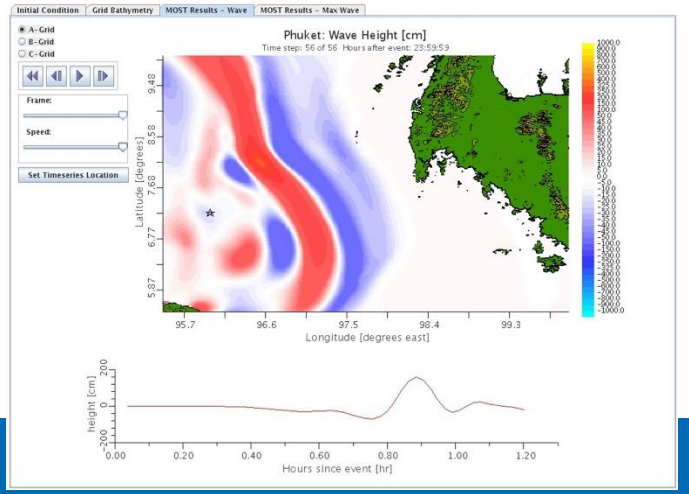


Inundation models model how the waves interact with the coastal bathymetry and topography as they arrive at the coastal zone (non-linear models)



Wave Energy





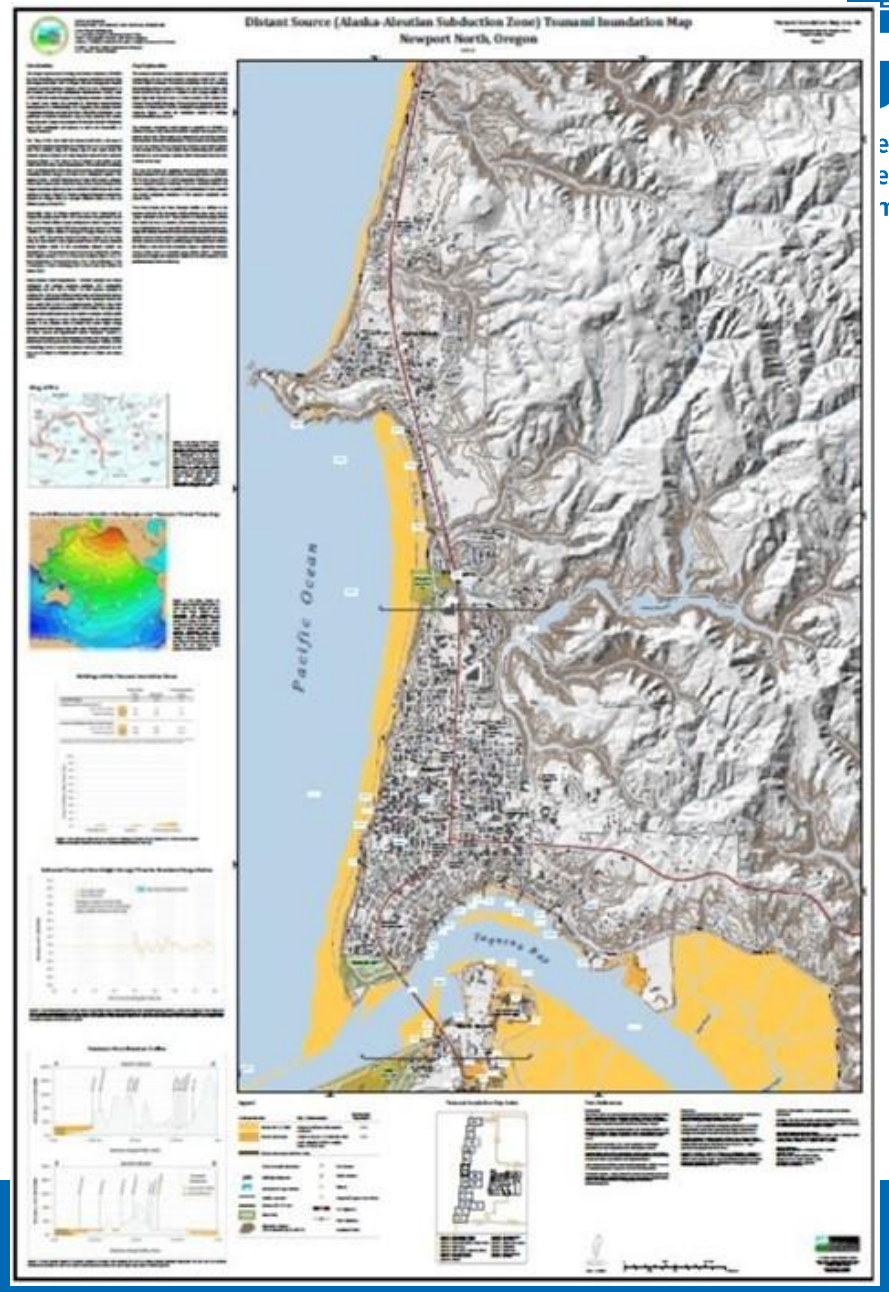
Tsunami Inundation Maps

Inundation maps should:

- Be developed using best available data for area of coverage (e.g., use highest resolution LiDAR data, best bathymetry, current deformation models, best geologic seismic data).
- Use of alternative information should be explained in documentation.

Tsunami Inundation Map
Newport North, Oregon

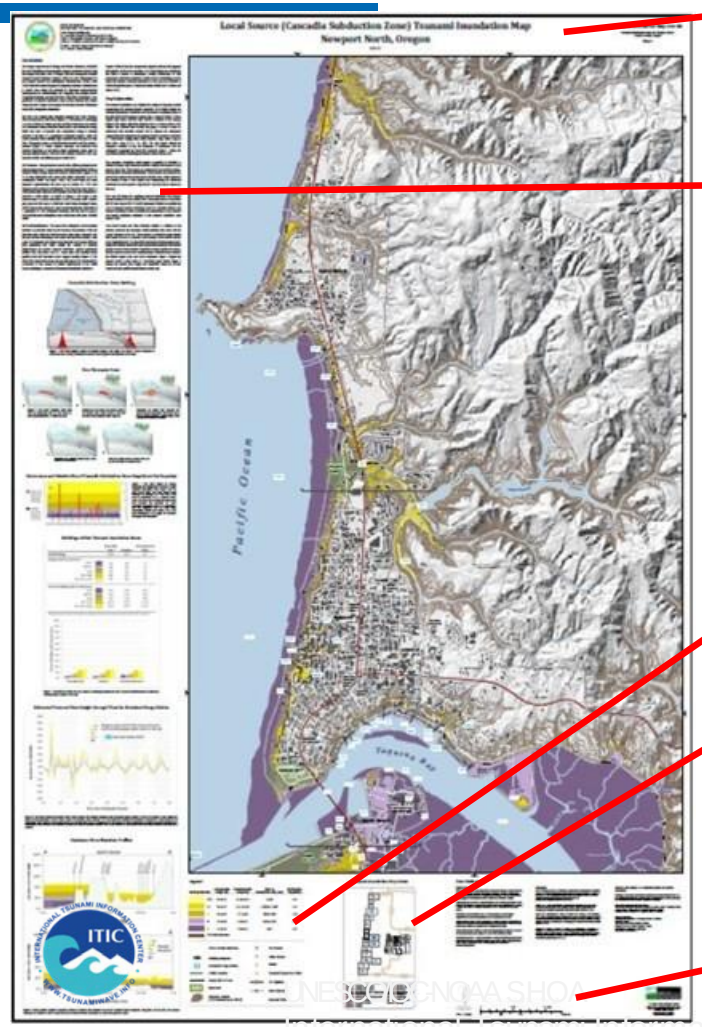
Earthquake Size	Slip / Deformation	Earthquake Magnitude
Alaska M9.2 (1964)	Vertical seafloor deformation estimate.	~9.2
Alaska Maximum	Uniform slip on 12 subfaults with each assigned values ranging from 49 to 98 feet.	~9.2



unesco
ergovernmental
eanographic
mmission

Tsunami inundation maps should include:

unesco
Intergovernmental Oceanographic Commission



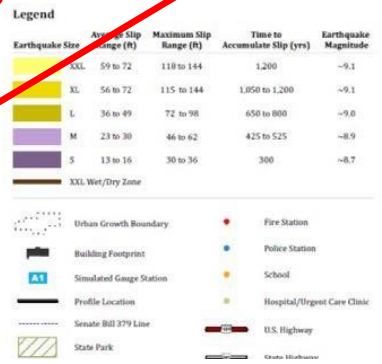
Title

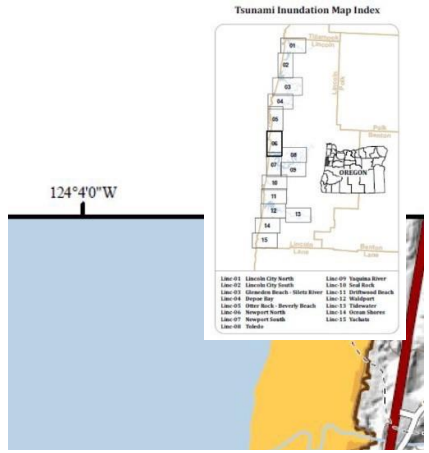
Local Source (Cascadia Subduction Zone) Tsunami Inundation Map
Newport North, Oregon
2013

Appropriate explanatory information.

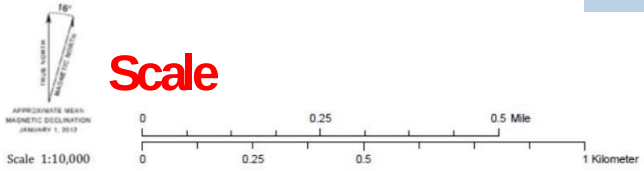
Geographic location (coordinates)

Legend





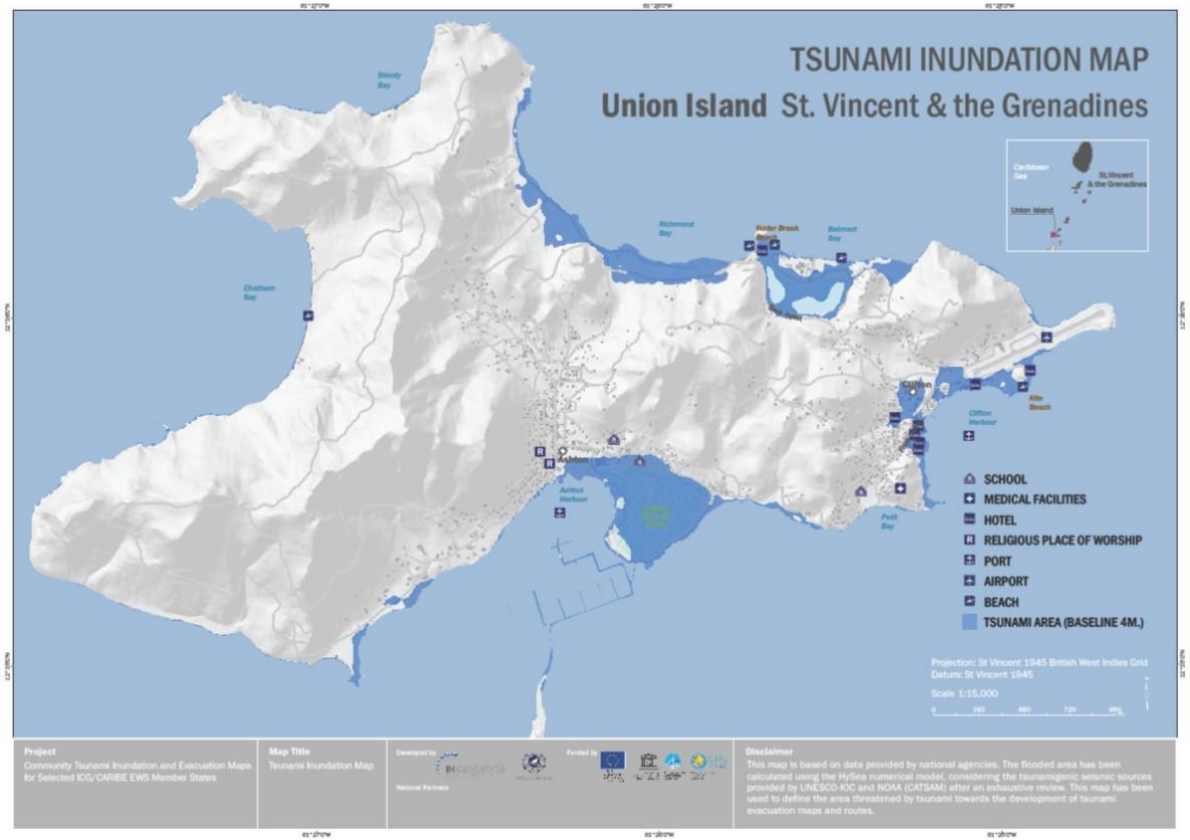
Scale



What if DEM data and inundation models are not available?

A community may not have access to high resolution digital bathymetry and/or topographic data and may not have the necessary skills to set up and run numerical inundation models.

- **A "Bathtub" model approach can be used. This assumes that an area with an elevation less than a projected runup level will be flooded like a "bathtub". A basic topographic map will still be required to map out inundation areas.**
- **Alternatively, external experts (DMOs, universities, academics, researchers and consultants) can assist in establishing the tsunami hazard zone.**
- **The guidelines in Supplement 1 of MG82 can be used. These were adapted for global use from the 2011 guidelines developed by the US National Tsunami Hazard Mitigation Program (NTHMP) Mapping and Modelling Subcommittee.**



Summary of ASSESS-1

- ✓ Mapping and designation of tsunami hazard zones provides the basis for planning evacuation routes and locations for tsunami safe zones and shelters
- ✓ Tsunami hazard maps depict the areas that may be flooded by a tsunami and are usually based on a "worst-yet-credible case" scenario
- ✓ The primary source for mapping tsunami hazard zones is inundation modelling which requires specialist technical expertise available at universities, scientific institutions and/or government agencies
- ✓ The data requirements for inundation modelling are tsunamigenic earthquake source information and detailed topographic and bathymetric data, preferably in Digital Elevation Model (DEM) format.
- ✓ Numerical models are used to predict the propagation of tsunami waves from their source across the ocean to the coastal zone (linear models) and the interaction of tsunami waves with coastal bathymetry and topography in the coastal zone (non-linear models)
- ✓ If DEM data and/or inundation modelling expertise is not available, a "bathtub" model approach can be used in which it is assumed that an area of elevation less than the projected runup level will be flooded. Alternatively, experts can assist in establishing the tsunami hazard zone based on historical and geological records

unesco
Intergovernmental
Oceanographic
Commission

Tsunami Ready
2022 - 2026

THANK YOU
Muchas gracias

For more information:

web: tsunamiready.org

e-mail: itic@unesco.org

Dr. Charles McCreery
Pacific Tsunami Warning Center

Dr. Laura Kong
International Tsunami Information Centre (ITIC)