THE FUTURE OF
GLOBAL
DISASTER
RISK REDUCTION

The Global Tsunami Model – Tsunami hazard assessment at different time scales

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STRENGTHENING THE RESILIENCE of MEGACITIES THROUGH SCIENCE, TECHNOLOGY & INNOVATION

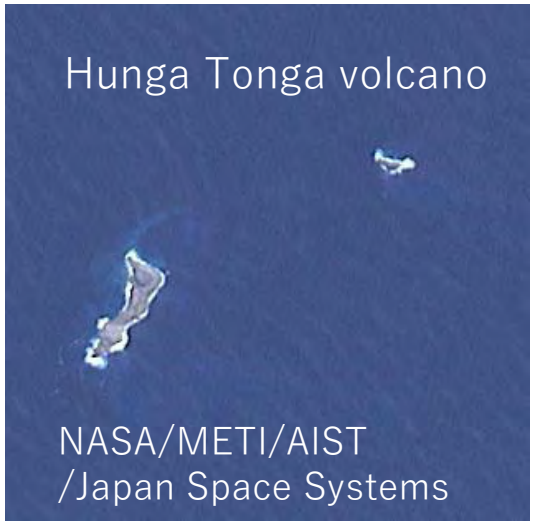

2004
Indian Ocean megathrust earthquake and tsunami
CHOO YOUN-KONG/AFP/GETTY IMAGES


2011
Tōhoku megathrust
earthquake and tsunami
KYODO / REUTERS

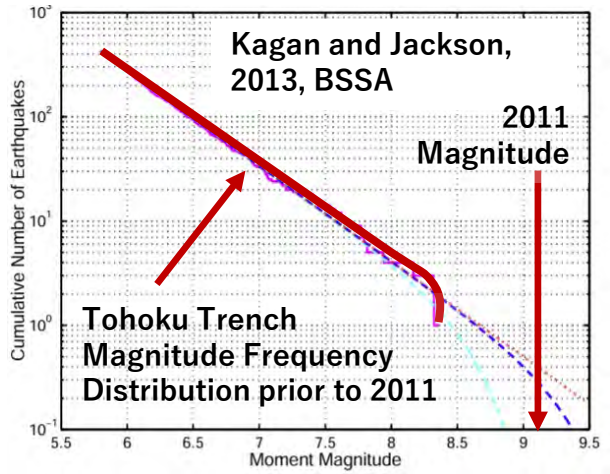
The 2004 Indian Ocean and subsequent tsunamis challenged our approach towards hazard analysis

- Massive 2004 and 2011 tsunami impact unprecedented historically
- Elements of surprise for more moderate events
  - Tsunami earthquakes: 1992, 1994, 2006, 2010
  - Unusual generation mechanisms (Palu 2018)
  - Landslide tsunamis 1998 (PNG), 2018 (Krakatau)
  - Hunga Tonga tsunami 2022
- Historical data insufficient to model hazard
- Tsunamis are different from most other perils, and call for
  - Elaborate uncertainty treatment
  - Modelling events beyond observational record
  - Interdisciplinarity

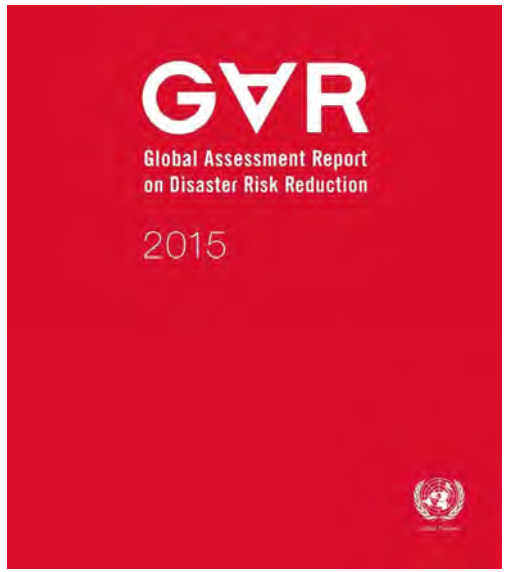
Tsunamis from non-earthquake sources



Underestimating potential earthquake magnitudes



Evolution of the GTM



- GAR: Multi-institutional work on hazard and risk for UNISDR/UNDRR
- Need for a competence center for tsunami hazard and risk assessment
- Need for a collective effort for improved understanding of global tsunami hazard and risk

GTM – The Global Tsunami Model

Interdisciplinary EU projects provide advanced hazard and risk products

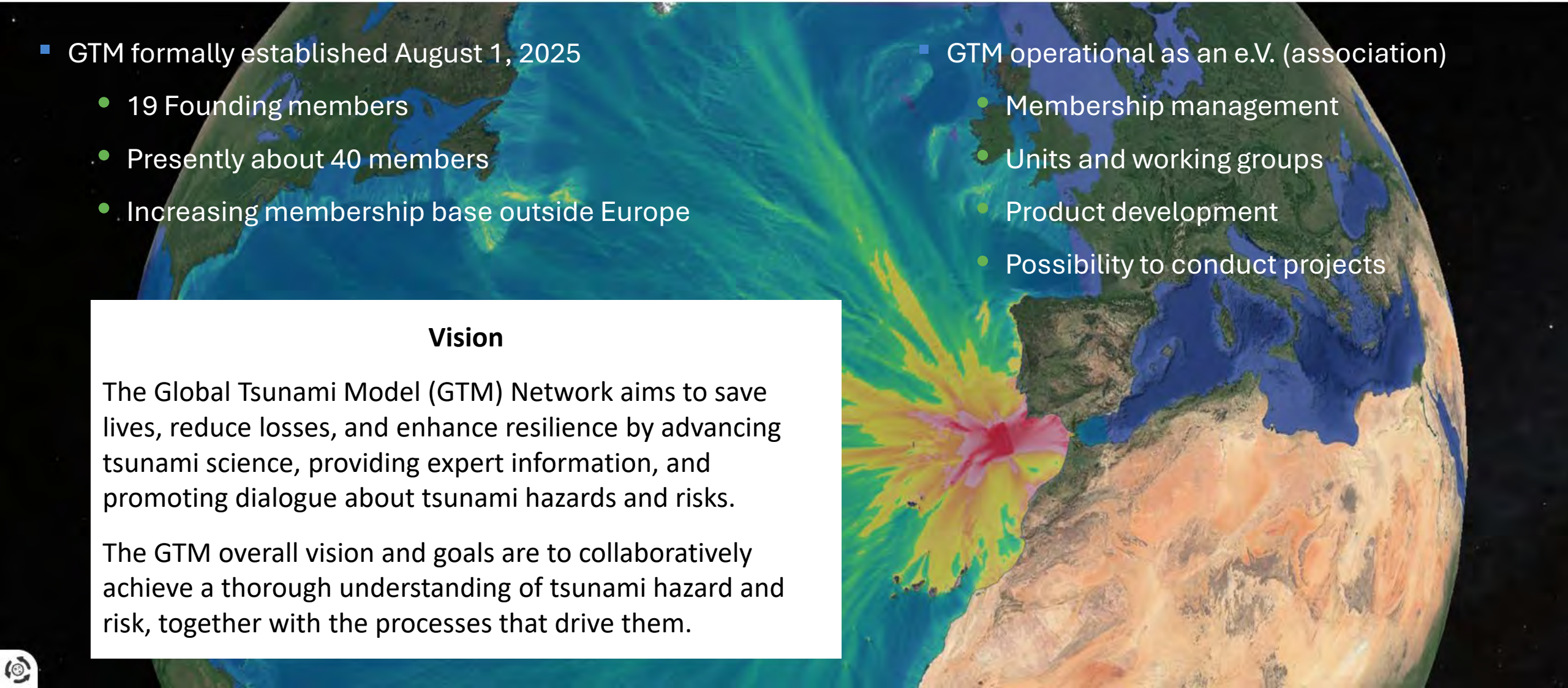
Web-page, secretariat, operational procedures established

Letter of Interest collection start

Global hazard map

2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
GAR15 Proposition of GTM	First vision statement	PTHA community paper	EPOS TCS initiation	AGITHAR startup		Collection of tsunami risk State-of the-Art review papers		Innovation COST action Scoping GTM structure		GTM e.V. founded	Legal entity formally est. 2025.08.01

https://www.globaltsunamimodel.org/



- GTM formally established August 1, 2025
  - 19 Founding members
  - Presently about 40 members
  - Increasing membership base outside Europe
- GTM operational as an e.V. (association)
  - Membership management
  - Units and working groups
  - Product development
  - Possibility to conduct projects

Vision

The Global Tsunami Model (GTM) Network aims to save lives, reduce losses, and enhance resilience by advancing tsunami science, providing expert information, and promoting dialogue about tsunami hazards and risks.

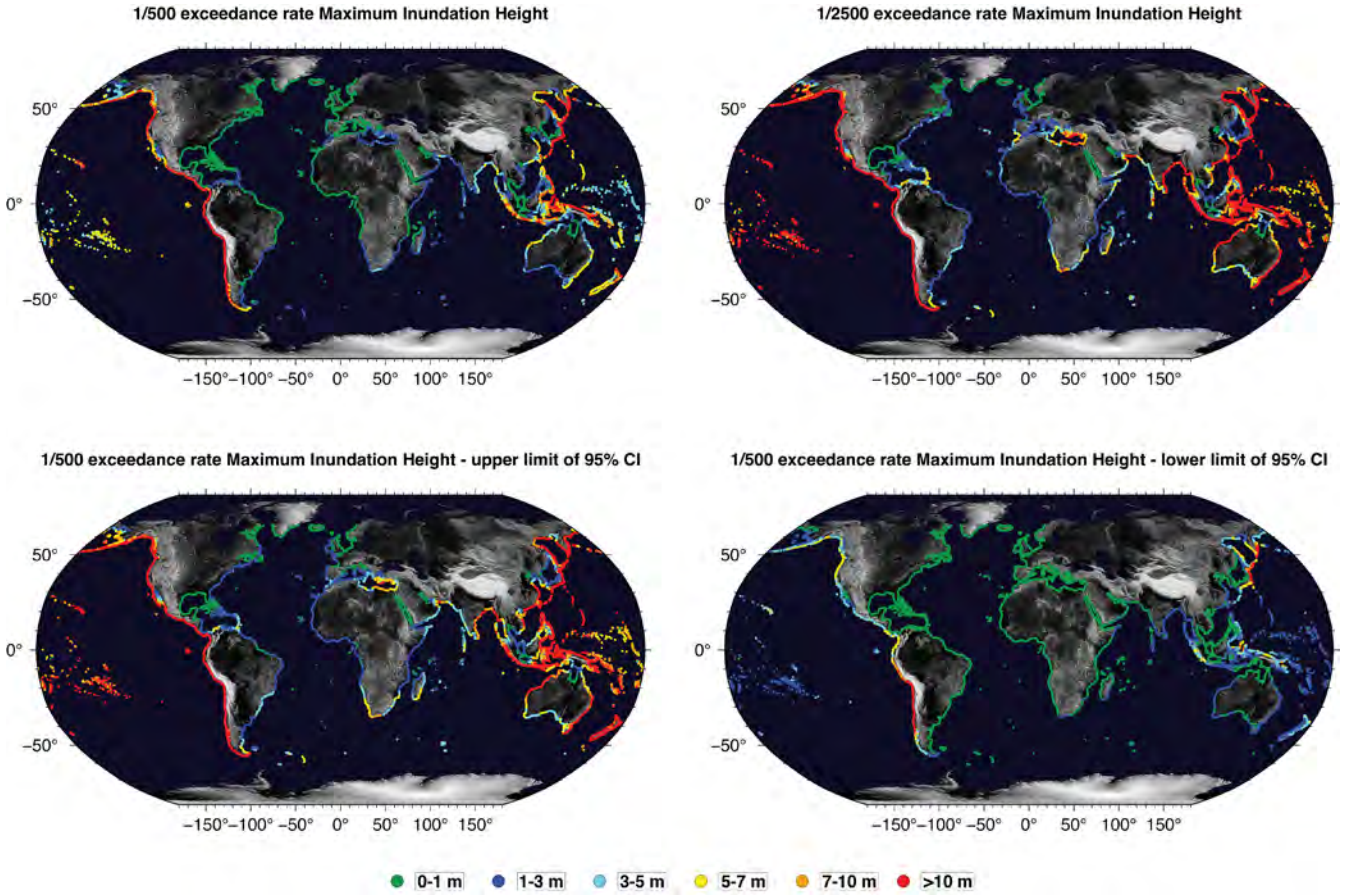
The GTM overall vision and goals are to collaboratively achieve a thorough understanding of tsunami hazard and risk, together with the processes that drive them.

GTM products

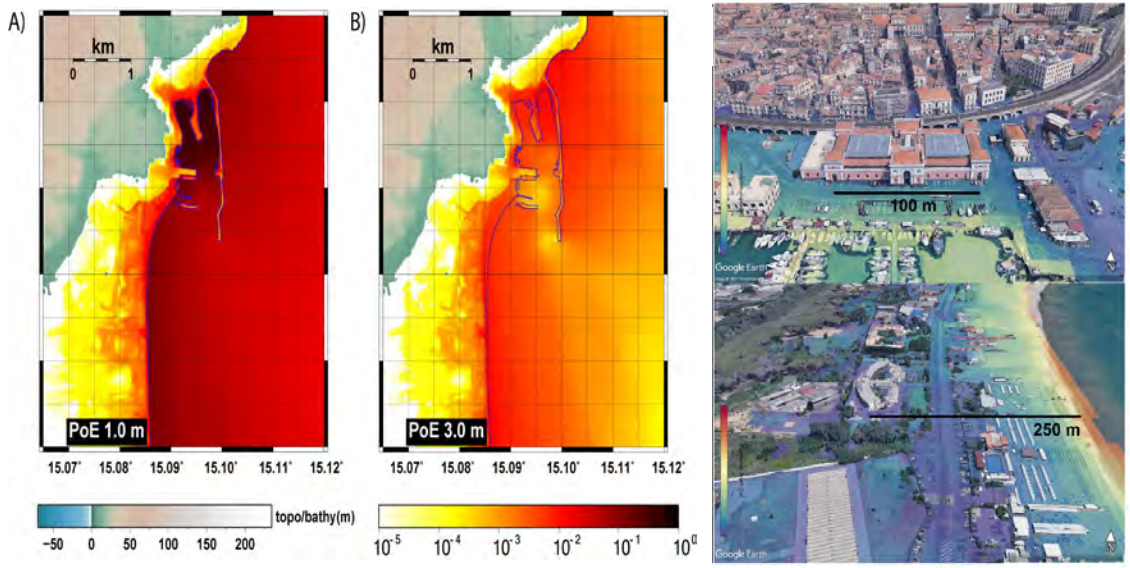
We provide the highest quality and most cost-effective tailored tsunami hazard analyses from global to local scale

GTM presently works on a new global tsunami hazard model

The previous Global Tsunami Hazard Model (Davies et al., 2017) is shown below



Workflow for local tsunami hazard analysis

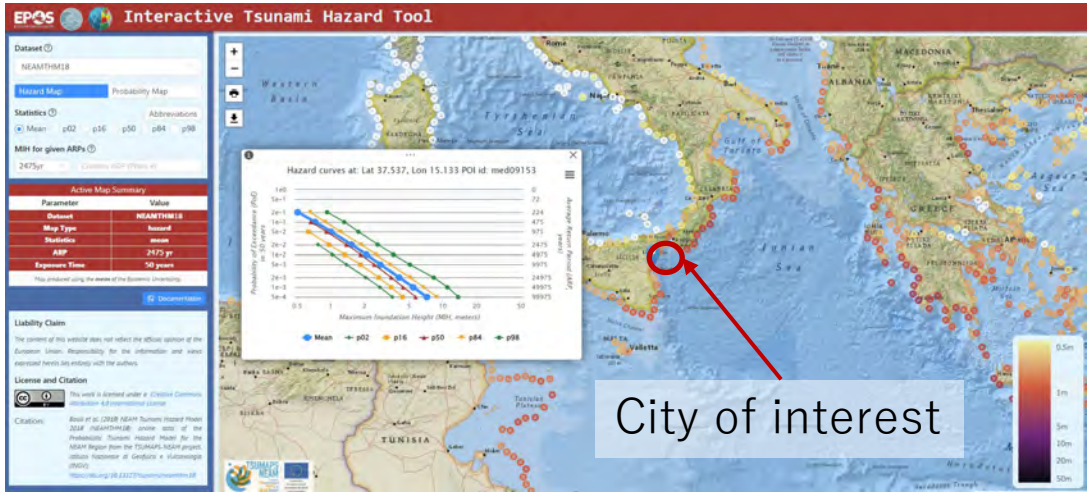


- Can zoom in on regions of high-risk
  (e.g. megacities, coastlines with critical infrastructure)
- Scenario based
  (relevant to probabilistic loss calculations)
- High spatial resolution with use of HPC

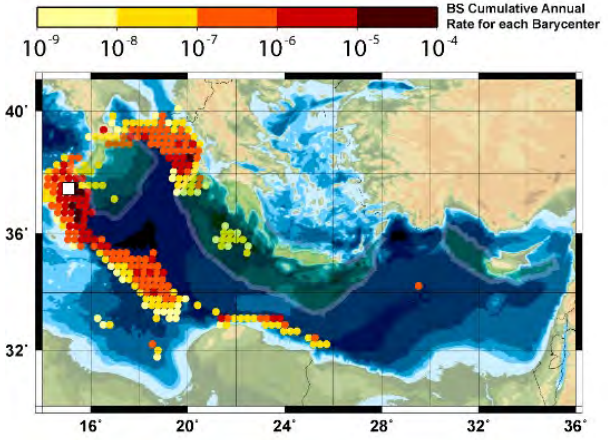
Recipe for megacity hazard analysis

- Identify cities subject to hazard
- Extract the most influential scenarios from hazard models for local impact
- Perform high resolution inundation models and provide inundation probability maps
- Applicability (exemplified in the next slides)
  - Local decision making and land use planning
  - Evacuation maps
  - Loss calculations
- Ingredients
  - Local high-resolution topography
  - For loss calculations, exposed assets and vulnerability

Regional hazard model

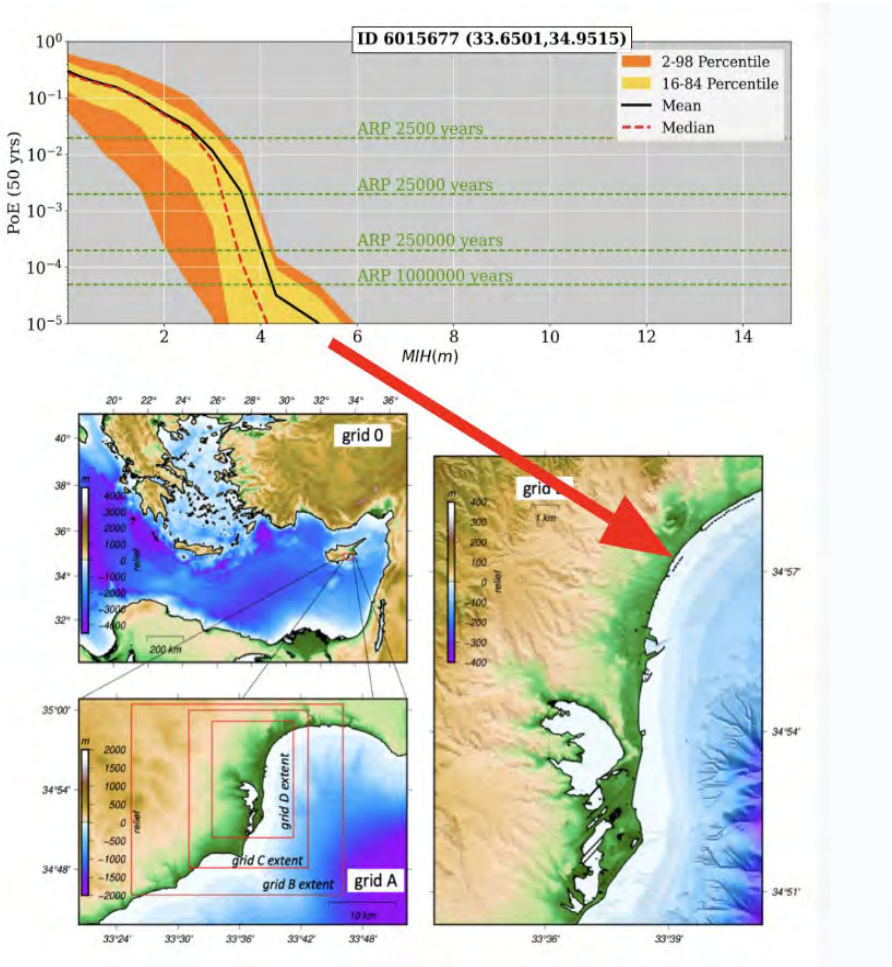


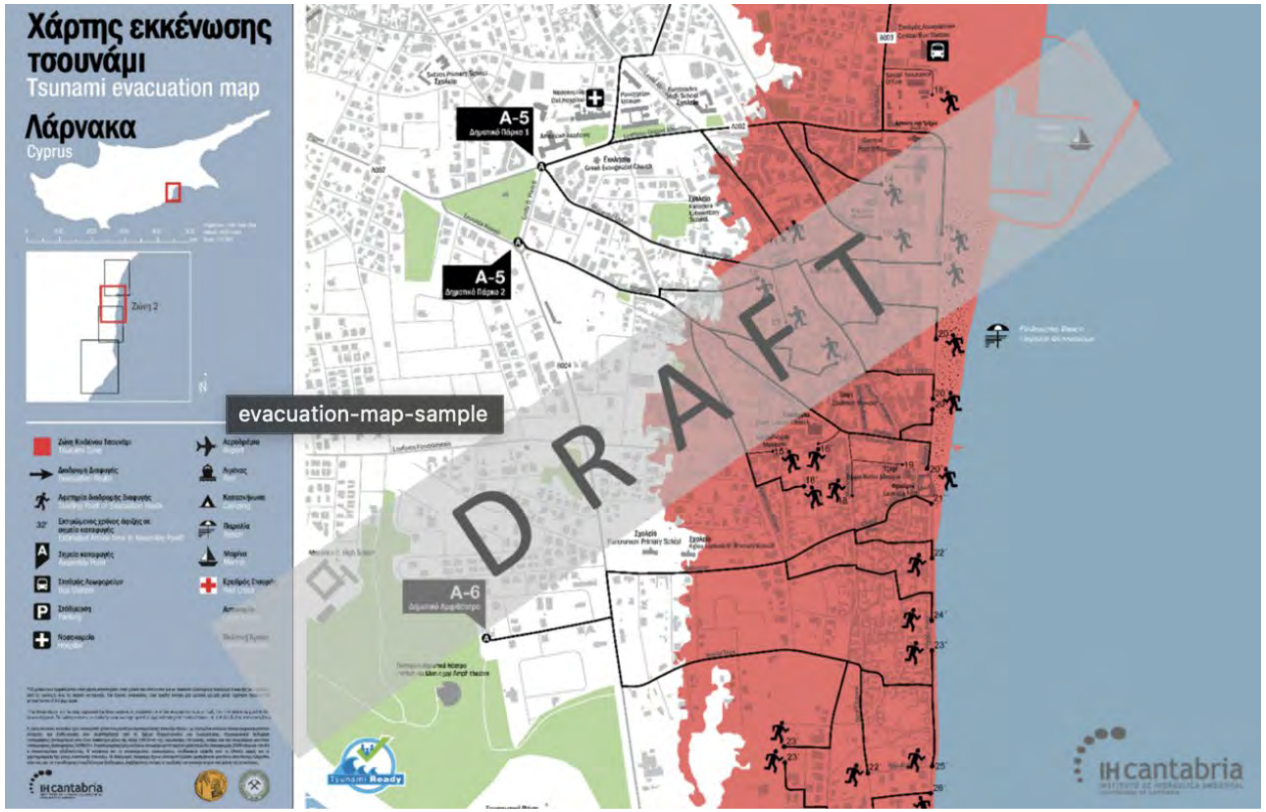
Earthquake source selection



High resolution inundation model

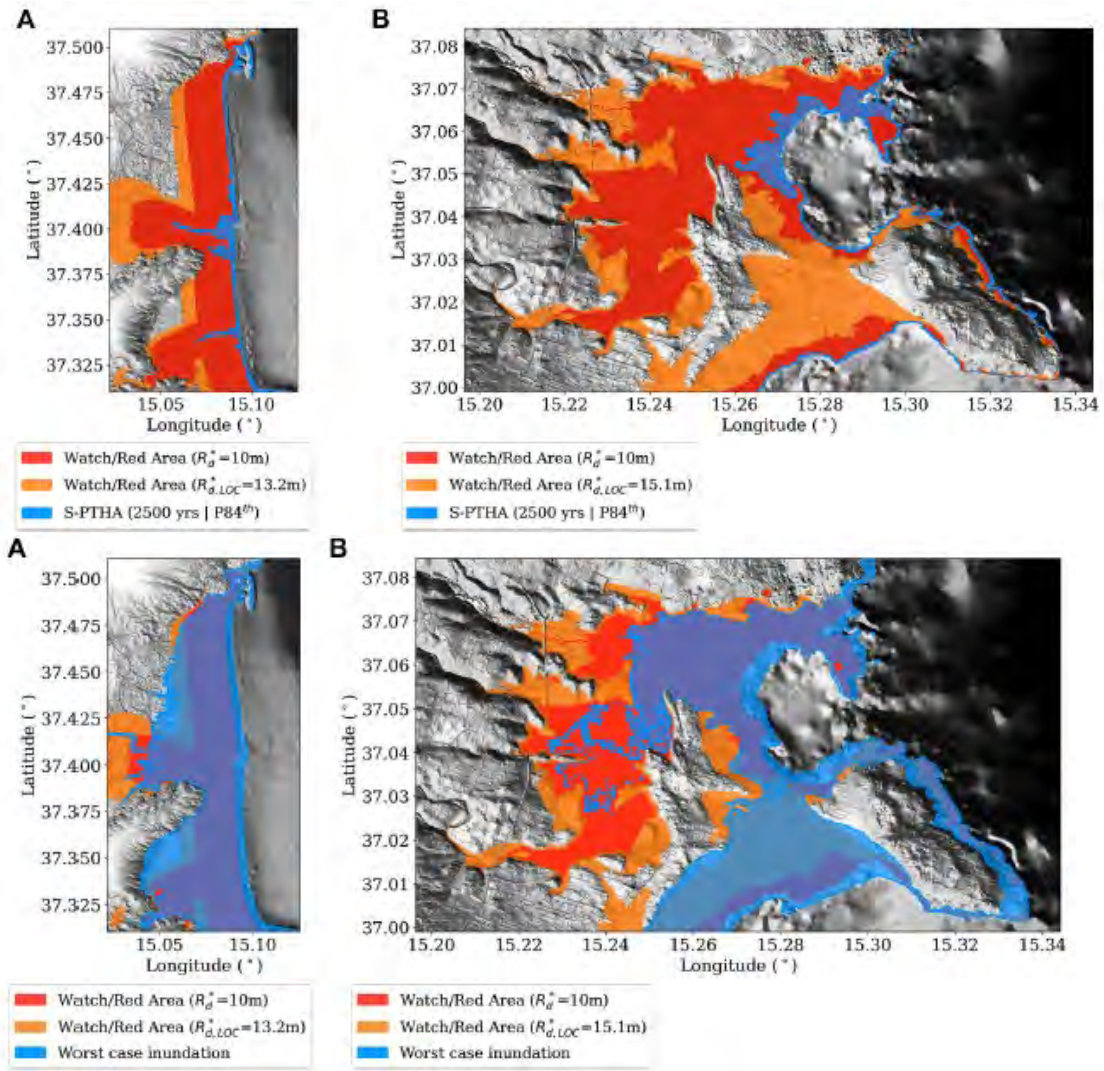
Using Probabilistic Tsunami Hazard Model for local decision making on the city scale





- PTHA to Support local decision making
- Science informed decision making, planning, and capacity building
- Models adaptable for local tsunami risk reduction

Application of PTHA results to defining evacuation maps



frontiers in Earth Science

ORIGINAL RESEARCH
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Testing Tsunami Inundation Maps for Evacuation Planning in Italy

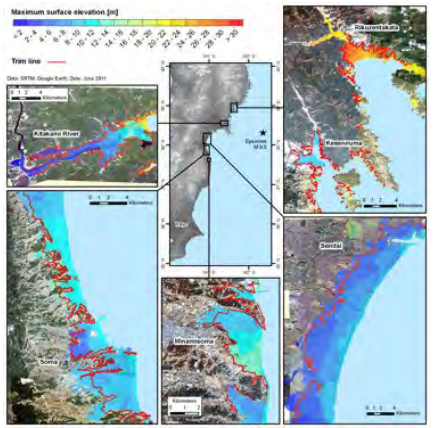
Roberto Tonini[1], Pio Di Manna[2], Stefano Lorito[1], Jacopo Selva[3], Manuela Volpe[1], Fabrizio Romano[1], Roberto Basili[1], Beatriz Brizuela[1], Manuel J. Castro[4], Marc de la Asunción[4], Daniela Di Bucci[5], Mauro Dolce[5], Alexander Garcia[3], Steven J. Gibbons[6], Sylfest Glimsdal[6], José M. González-Vida[7], Finn Løvholt[6], Jorge Macias[4], Alessio Piatanesi[1], Luca Pizzimenti[1], Carlos Sánchez-Linares[4] and Eutizio Vittori[2]*

Here, comparison of safety factors based on empirical models of run-up variability and coastal dissipation with those inferred from PTHA calculations.

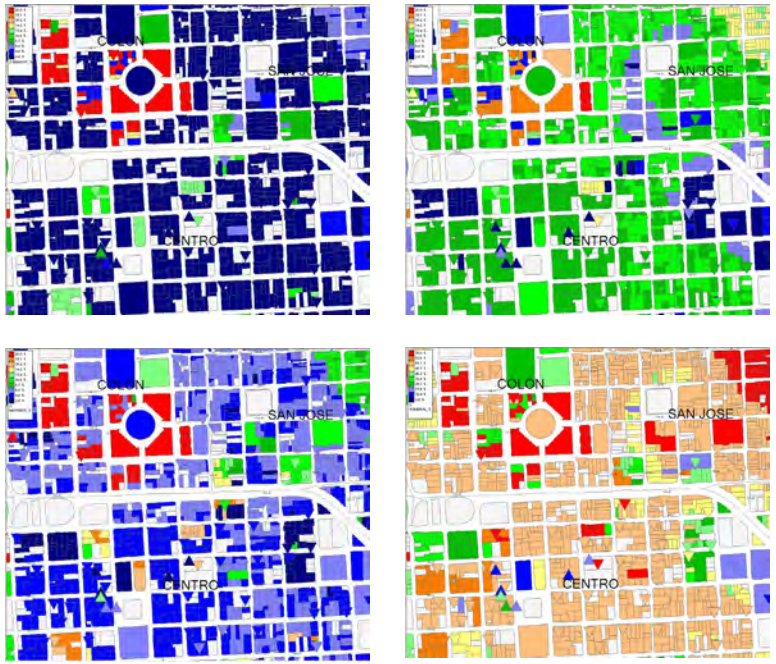
The new PTHA products can give downstream opportunities for risk analysis

Exposure databases
(e.g. collaboration with GEM)

Hazard maps



Value at Loss



- Scenario based – high resolution outputs tsunami impact metrics
- Compatibility with OpenQuake - interoperability with GEM products on hazard and risk and risk integration
- Improved hazard representation globally – integrating new hazard improvements
- Global to local scaling
- Input to improved quantitative loss models
- Better risk information
- NB – this analysis would mainly concern direct loss due to building damage
- Dialogue with Insurance sector necessary for further integration to estimate insured losses
- Potential input also to other risk metrics

Summary

- The Global Tsunami Model (GTM) is now established as a formal entity
- A main objective of GTM is to help reducing losses from tsunamis (c.f. SFDRR)
- The first technical priority in GTM is to provide a robust, updateable, and scalable Global Probabilistic Hazard model (currently updating the existing global hazard model)
- The global model should be interoperable with *OpenQuake* to provide compatibility with GEM products and more seamlessly provide risk products
- We are taking the first steps towards using the hazard products towards risk mitigation, i.e.
  - Evacuation maps
  - Rapid response analysis
  - Loss modelling
  - Vulnerability and risk analysis is a more immature discipline than PTHA
- Vital to have a risk community to improve our knowledge and procedures, and provide standards
  - This would be an important objective and the next step beyond the new global hazard model

Application to Megacities

- Long-term hazard assessment (PTHA)
  - High intensity, low probability constitute a challenge
  - Tsunamis are rare, but usually impact a large number of people when an event strike
  - Based on PTHA, we should identify megacities with high costal population prone to hazard
  - With high resolution models, carry out high resolution models using HPC
  - Provide detailed inundation maps and map the uncertainty
- Short-term hazard (after an event strikes)
  - Limited time available (often only minutes)
  - Methods for rapidly estimating impact now emerges
  - Pre-computed sources
  - Examples: ARISTOTLE (globally)
    - though Japan has more sophisticated local models for short-term impact assessment
  - High-resolution topography and demography data should be applied to megacities to improve accuracy
  - Machine Learning methods will accelerate the process further

Megacities – Tsunami hazard

- Megacities are home to tens of millions of people and critical infrastructure
- Many (e.g., Tokyo, Jakarta, Mumbai) are located near coastlines for trade and economic reasons
- Coastal megacities are increasingly vulnerable to natural hazards due to urban expansion and climate change
- High population density and dense networks of transportation, utilities, and high-rise buildings amplify damage when systems fail
- Interdependencies mean one failure (e.g., power grid) can cascade into others (e.g., water supply, communications)
- Evacuation and emergency response become extremely challenging:
  - Narrow streets, vertical development, traffic congestion hinder evacuation, little room for safe zones
  - Informal settlements often occupy the most hazard-prone areas (low-lying coastal zones, unstable slopes). Vulnerable populations have fewer resources for preparedness and recovery.
- Older buildings may not meet modern seismic standards, retrofitting is difficult to implement
- Megacities are economic hubs; damage disrupts global supply chains and financial systems
- Recovery costs can reach hundreds of billions, affecting national economies

Choo Youn-Kong/AFP/Getty Images