Global Tsunami Model (GTM) – initial ideas and outcome of first scoping meeting

F. Løvholt[1]

On behalf of the GTM network initiative

IOC – TOWS meeting, IUGG, Prague 01.07.2015

Global tsunami hazard assessments so far: input to Global Assessment Reports «GAR»

- Issued by UN-ISDR every second year from 2009-2015
- Provides comparative basis for the risk posed by various natural hazards and joint mapping tools
- **Broad scientific involvement, including the global models (GEM, GVM)**
- Proposes policy initiatives to address gaps and challenges
- Scope and time for next version not yet decided – will be oriented towards Sendai Framework of Action (SFA)
- **Work towards GAR has motivated the initiative for a GTM**

We propose a Global Tsunami Model (GTM)

- Focus on Probabilistic Tsunami Hazard and Risk (PTHA and PTRA)
- Initial scope limited to PTHA
- Involve a broader community working towards tsunami risk
- Define good practices, guidelines, standards, openness of models, data etc.

NGI

Broad interest:

Expressed interest or present at meeting

- NGI (Løvholt, Harbitz)
- INGV (Lorito, Selva, Tonini)
- Geoscience Australia (Cummins)
- IPMA (Baptista)
- IRIDES (Imamura, Suppasri, Mas)
- GNS (Power)
- METU (Kanoglu, Yalciner)
- University of Malaga (Macias)
- AECOM (Thio)
- MMAF (Muhari)
- Univ Bologna (Tinti)
- KOERI (Özer, Necmioglu)
- MSI (Didenkulova)
- PARI (Takagawa)
- ICMMG (Giusiakov)
- Northwestern University (Okal)
- MRI/JMA (Tsushima)
- NOAA (Wei)

Non-present but expressed interest

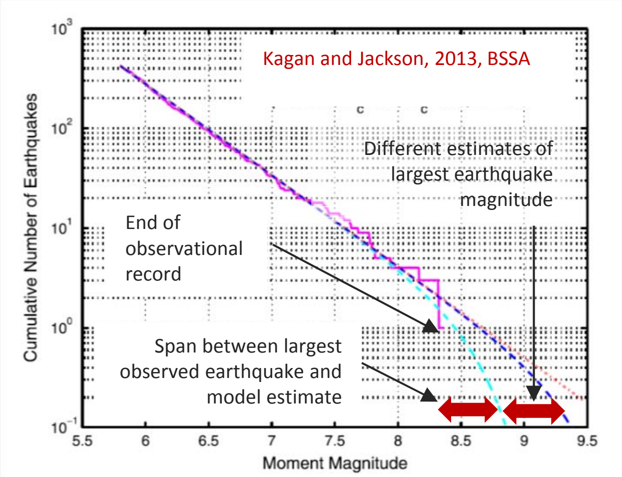
- USGS (Geist)
- GFZ (Babeyko)
- USC (Lynett)
- ITB (Latief)
- CIMNE (Bernal, Cardona)
- Univ Hamburg (Behrens)
- Univ Cantabria (Gonzalez, Gonzalez-Riancho, Aguirre-Ayerbe)
- Univ Washington (Gonzalez, Leveque)
- AUTH (Pitilakis)

“External participants” global models

- GEM (Pagani, Schneider)
- GVM (Jenkins)

Infrequent tsunamis dominate losses and challenge risk modellers

- The tsunamis in 2004 and 2011 account for a majority of the losses for the last 100 years
- Through history, the 50 most destructive tsunamis caused 97% of all lives lost
- Infrequent tsunamis expected to dominate risk – return periods beyond 100 years
- The source (earthquake) statistics is poorly constrained at these return periods, and makes the probability of the large ones uncertain



Science: tsunami probabilistic hazard or risk curves (e.g. maximum wave height, loss)

Political decisions: evacuation, mitigation

What to expect for a given Average Return Period

Eg.
Design
Fukushima walls

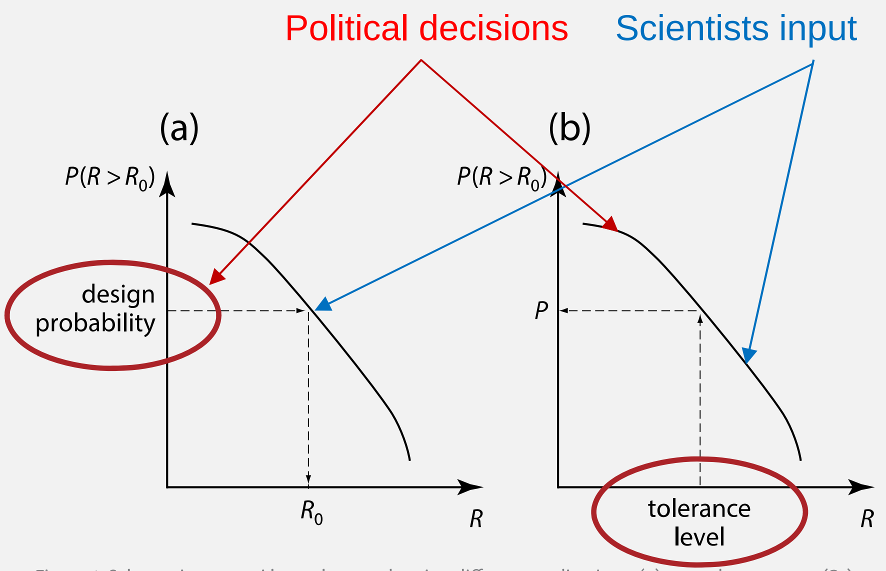
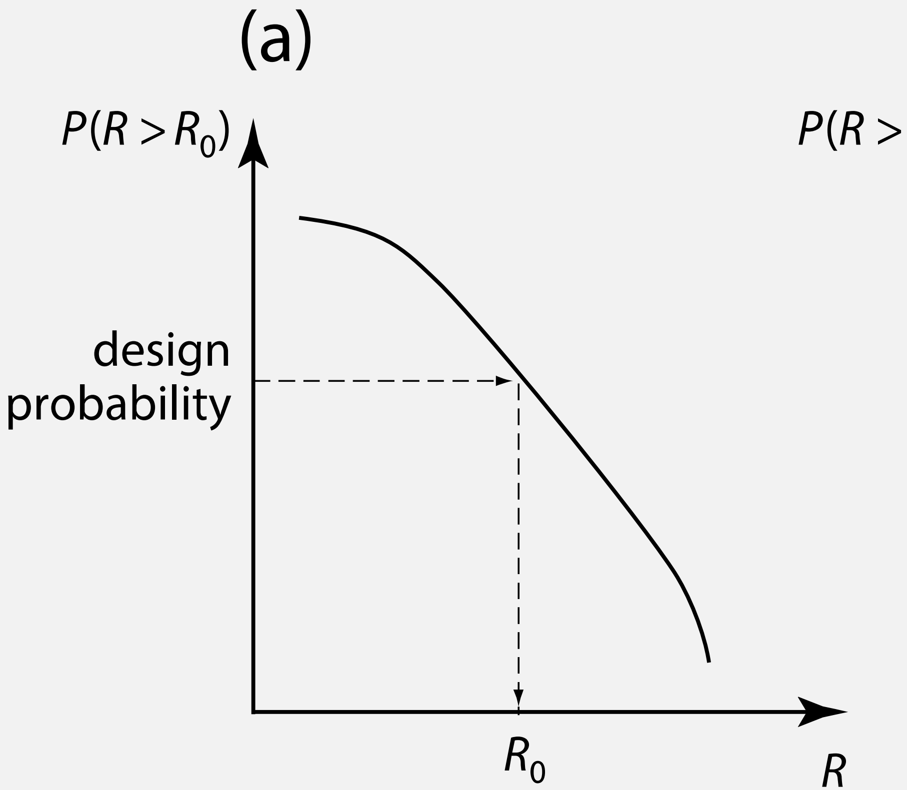


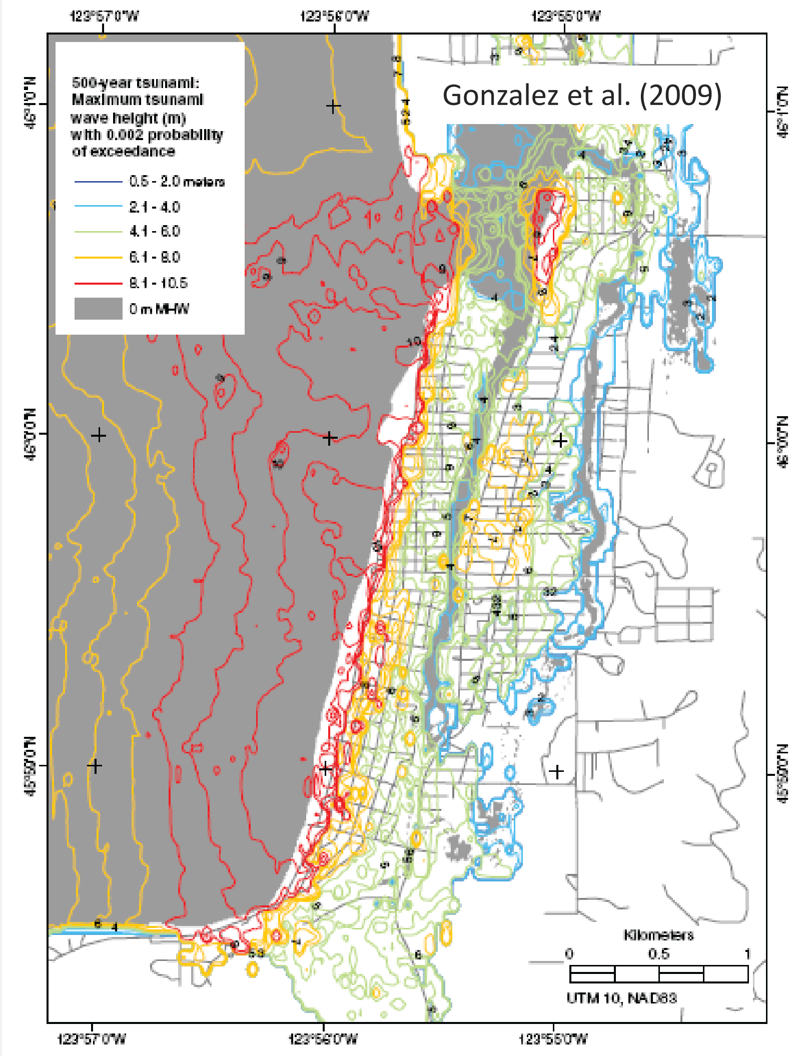
Figure 1. Schematic tsunami hazard curve showing different applications: (a) exceedance runup (R_0) determined from design probability, and (b) probability (P) determined from specified tolerance level.

from Geist and Lynett (2015)

Frequency for a given intensity Eg.
Emergency planning for a given community or type of coast
Cost/benefit analysis to define mitigation actions

Design probability



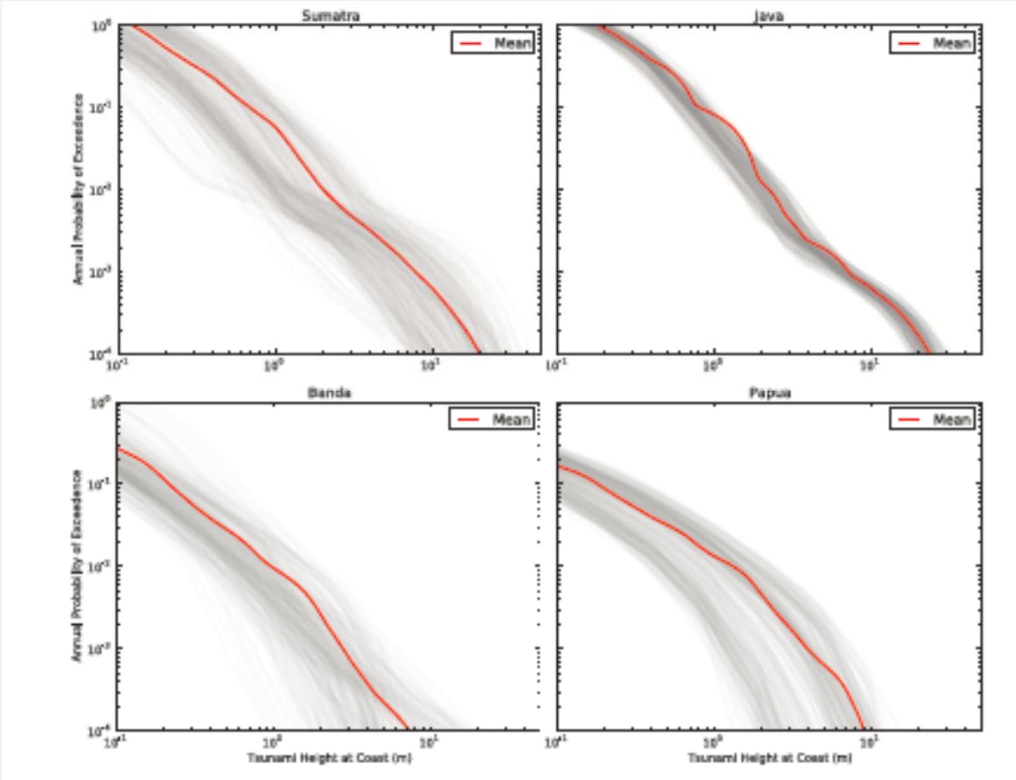


Epistemic uncertainty – different expert judgement may give different hazard curves

Need to provide:

Uncertainty communication

Risk communication

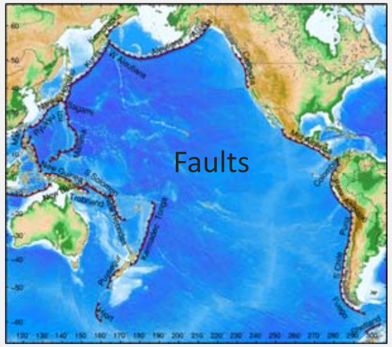


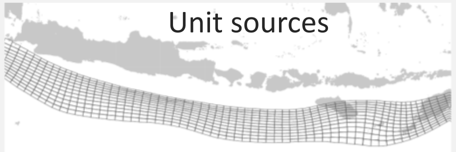
NGI

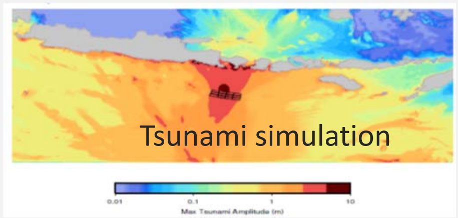
From Horspool et al. (2014), NHESS

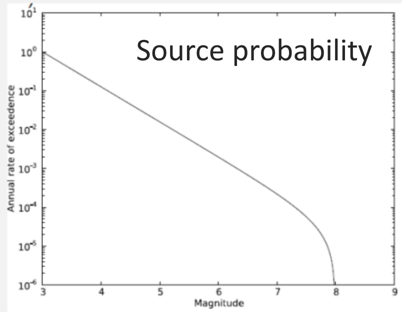
Global PTRA in brief

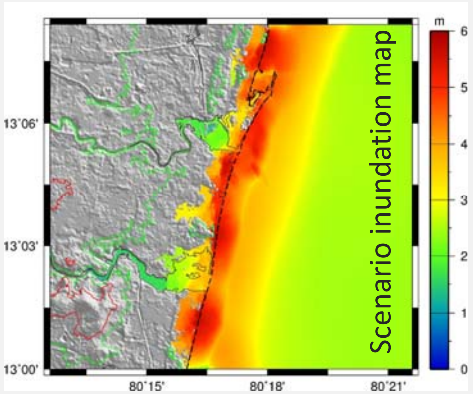
1. Define points near coast
2. Select faults and divide into unit-sources
3. Simulate the wave propagation for the unit sources
4. Create events by summing and scaling
5. Define events probabilities
6. For each scenario at each point, associate tsunami heights with event probability
7. Apply amplification factors to give the run-up
8. Extrapolate the run-up values to onshore inundation maps for each scenario
9. Overlay inundation areas with exposure datasets
10. Assign vulnerability to each exposed asset
11. Compute Loss Exceedance Curves (LEC) by convolving hazard and vulnerability
12. Quantify loss metrics from the LEC

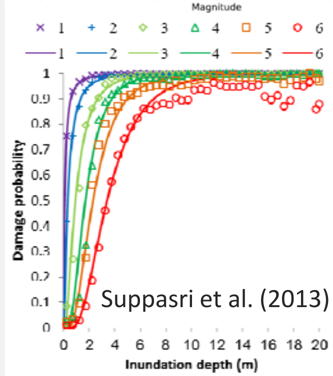






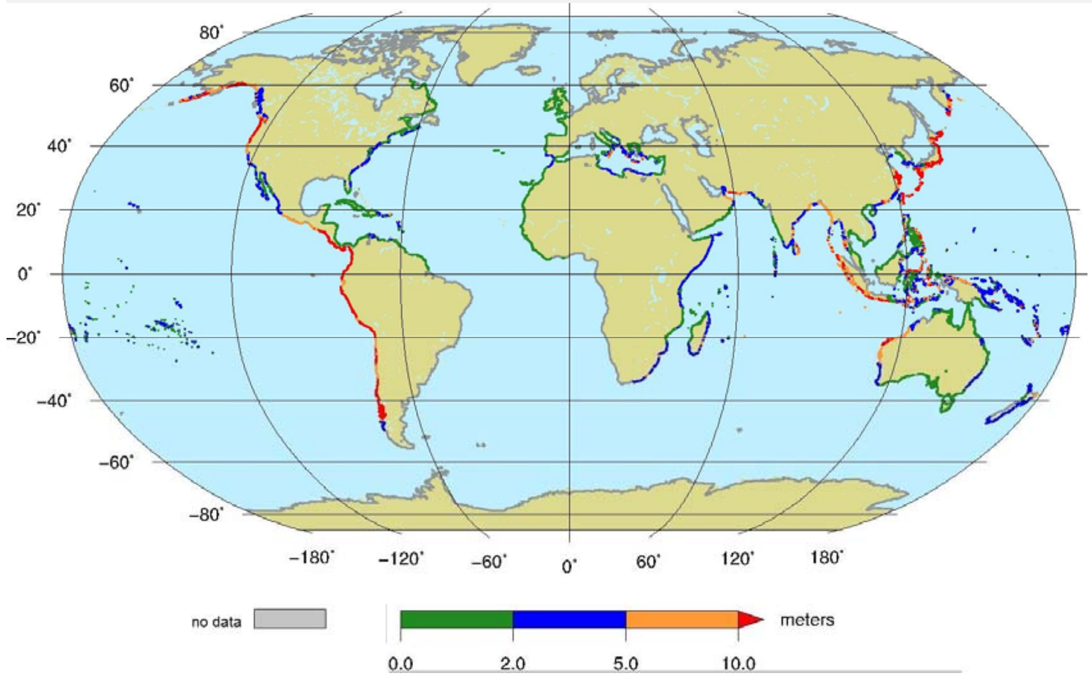




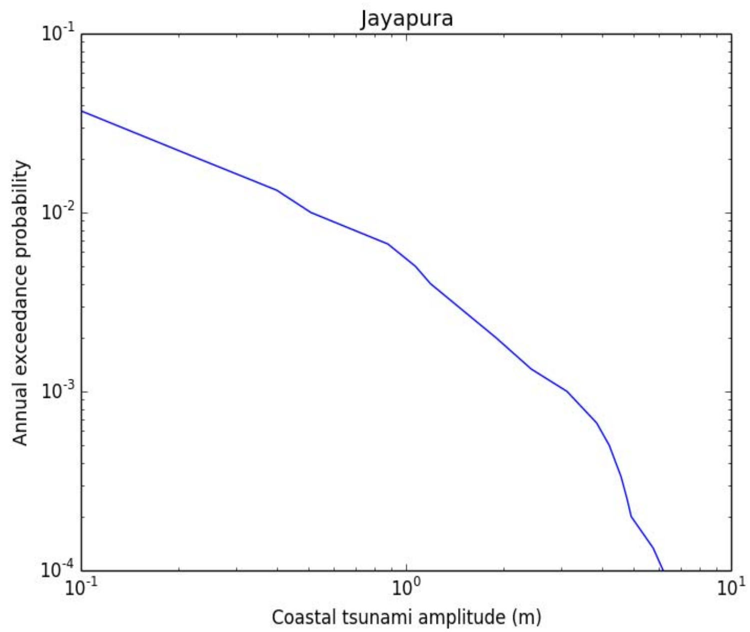


Global hazard map of run-up

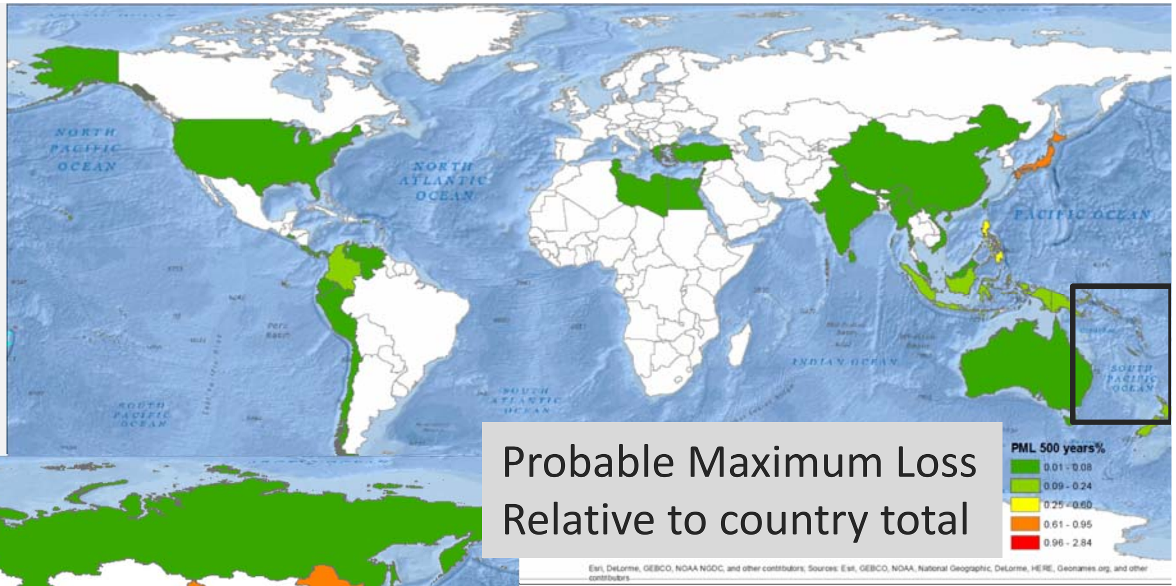
500 year hazard map – GAR13

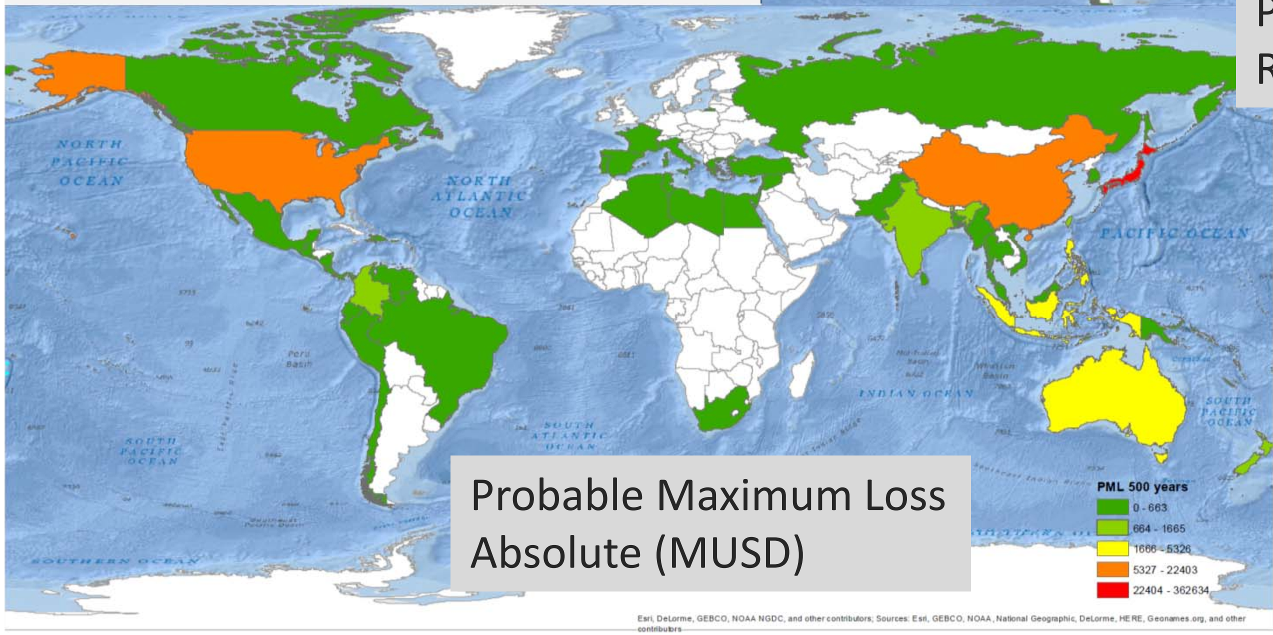


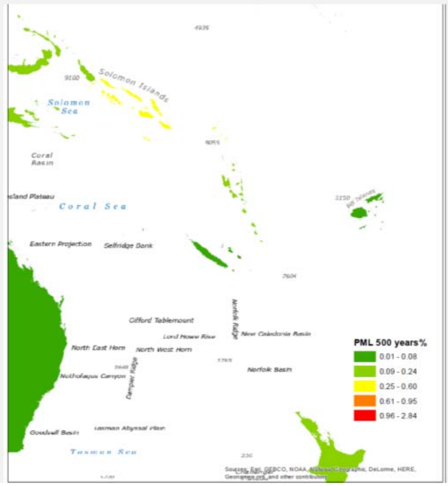
Hazard curve (Horspool et al. 2014, NHESS)



Tsunami risk for 500 year return period





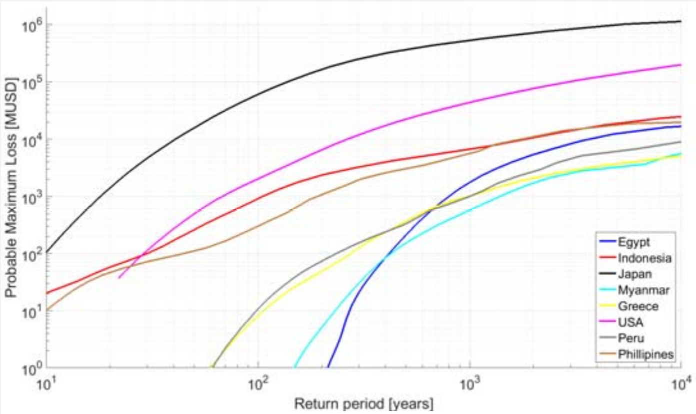


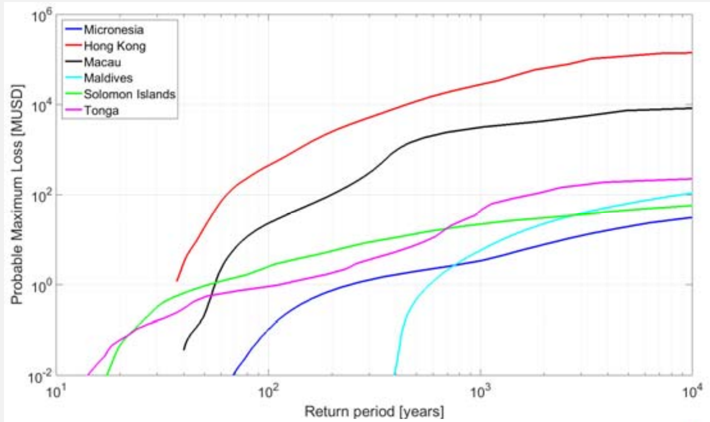
Probable maximum loss curves

Large countries

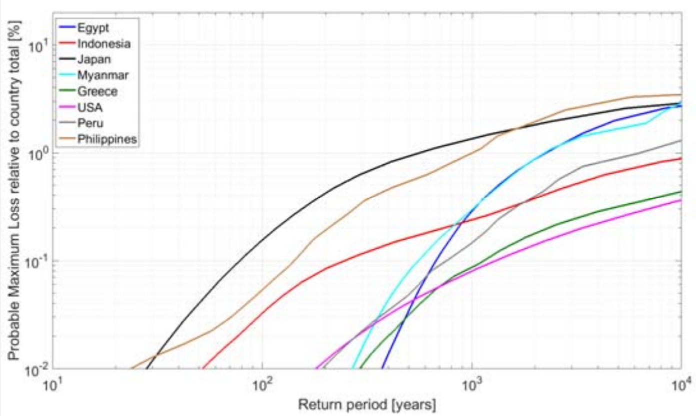
Small Islands

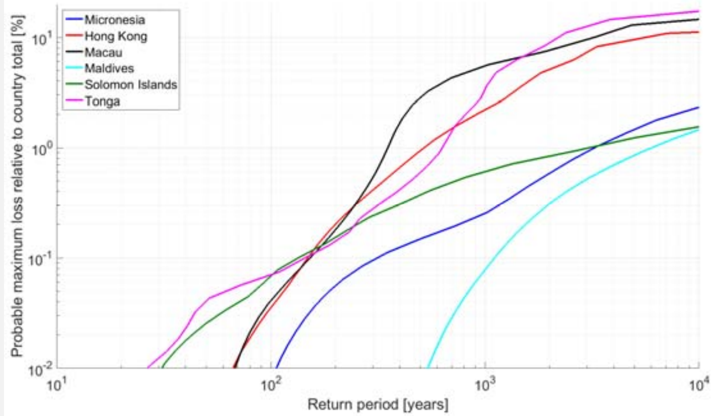
Loss in MUSD





Loss in %





Present global analysis – main limitations

- Rough representation of sources
  - Only subduction zone earthquakes with M_w >7.8
  - Return periods from plate motion rates and fault locking
  - Limited uncertainty representation, particularly epistemic
- Inundation mapping
  - Applied global digital elevation models may underestimate inundation
  - Amplification factors of limited validity in complex geometries
- Vulnerability and risk
  - Only losses due to building damage explored
  - Limited degree of sophistication and coverage of variability
  - We do not yet know what the best risk indicator is

NGI

Outcomes (I) of the GTM meeting

- Involving the full **tsunami hazard and risk community** may:
- Harmonize efforts and products
- Develop standardized and open source tools for hazard and risk analysis
- Develop guidelines and good practices
- Integrate datasets from other providers
- Become a term of reference for regional efforts (standards)
- Validation of methods – improve our understanding of the risk drivers

NGI

Outcomes (II) of the GTM meeting

- **Global and regional model should ideally give the same mean characteristics as the local ones**
- Utilize ongoing activities (local projects, stakeholders, data etc)
- Harmonized efforts (e.g. ASTARTE compilation of tsunami sources for NEAM, proposal submitted for NEAM regional PTHA)
  - Update / calibrate global models
- Discussion started with the GEM and GVM representatives regarding borderlines and collaboration

NGI

Scientific objectives from the GTM meeting

- Seismic source (probability and modeling)
  - Interfacing the GEM, adaptation for tsunami sources and recurrence
- Non Seismic source (probability and modeling)
  - Interfacing GVM
- Tsunami modelling (benchmarking)
- PTHA: framework, uncertainty, validation, testing, mapping
- Vulnerability (Fragility, mortality, uncertainty)
- PTRA: framework, uncertainty, validation, testing, mapping
- Tools (models, formats, DB, validation/verification, API – code interface, open access, open source)
- Dissemination (geoethics, transparency, risk and uncertainty communication, questioners, interfacing stakeholders, training, data exchange)

NGI

Initial scope to be further discussed

- PTHA for all kinds of sources proposed
  - Subduction earthquake sources
  - Crustal earthquake sources
  - Non-seismic sources (landslides, volcanoes)
- Involving stakeholders
- Iterative procedure to formulate initial project
- Possible next meeting, also towards organizational and funding aspects
  - Heraklion, Crete (ASTARTE, October)
  - San Francisco (prior to AGU fall meeting, possible venue, AECOM)
  - Malaga (TSUMAMOS, Spring 2016)
  - Vienna (in conjunction with EGU, 2016)

NGI