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A global tsunami model (GTM) for coordinated tsunami hazard and risk assessment

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Scope of this presentation

- Outline the first fully probabilistic and global hazard and risk analysis
  - Global Assessment Reports «GAR» - comparative basis for risk due to natural hazards
  - Methods, limitations, and results
- Based on this work, 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

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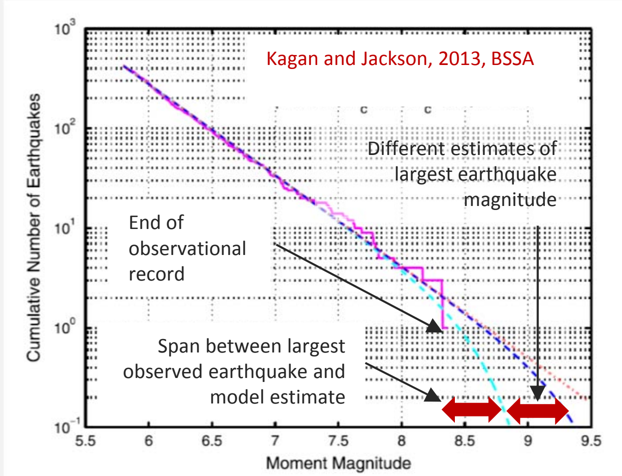
GAR
Global Assessment Report on Disaster Risk Reduction
2013

GAR
Global Assessment Report on Disaster Risk Reduction
2015

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



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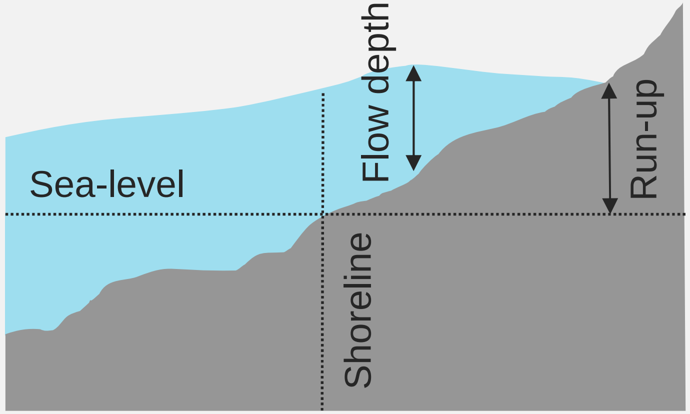
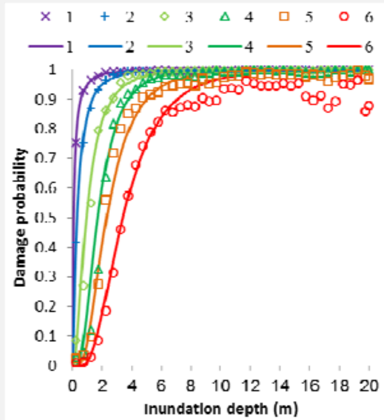
Tsunami hazard and loss computation in GAR15

- **Tsunami hazard:** The annual probability of run-up exceeding a threshold value
- **Damage metric:** The tsunami flow depth
- **Objective I:** Estimate the tsunami hazard for all coastlines globally for relevant return periods.
- **Objective II:** Overlay with exposure dataset to obtain losses
- **Losses** may be derived by combining vulnerability curves as functions of the flow depth with the hazard





Suppasri et al. (2013), Nat. Hazards:

Observed building damage probabilities in Japan from the 2011 Tohoku earthquake and tsunami

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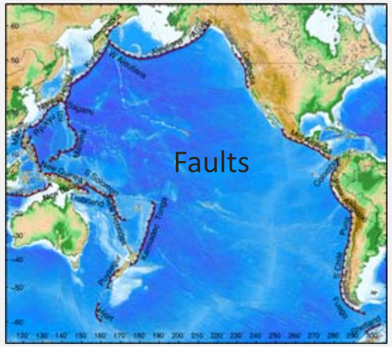
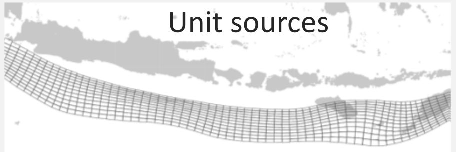
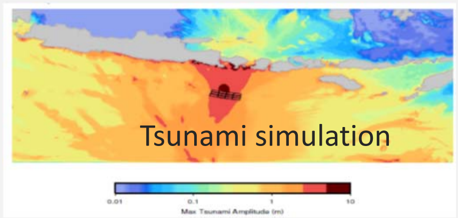
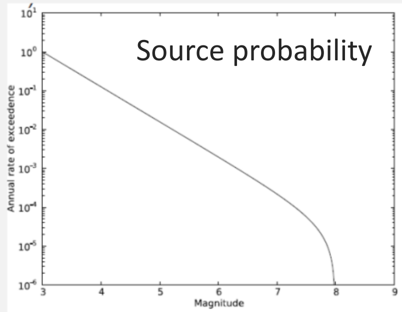
Global PTRA in brief

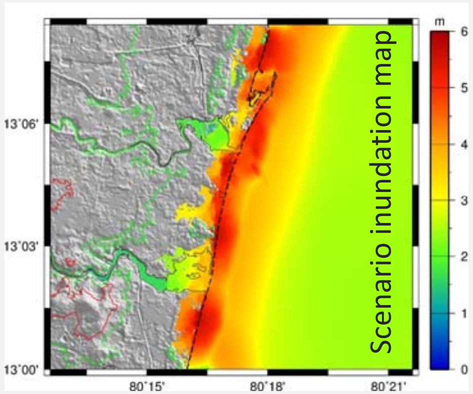
1. Define points near coast
2. Select faults and divide into unit-sources
3. Simulate the wave propagation for the unit sources
4. Create events by summing and scaling
5. Define events probabilities
6. For each scenario at each point, associate tsunami heights with event probability
7. Apply amplification 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





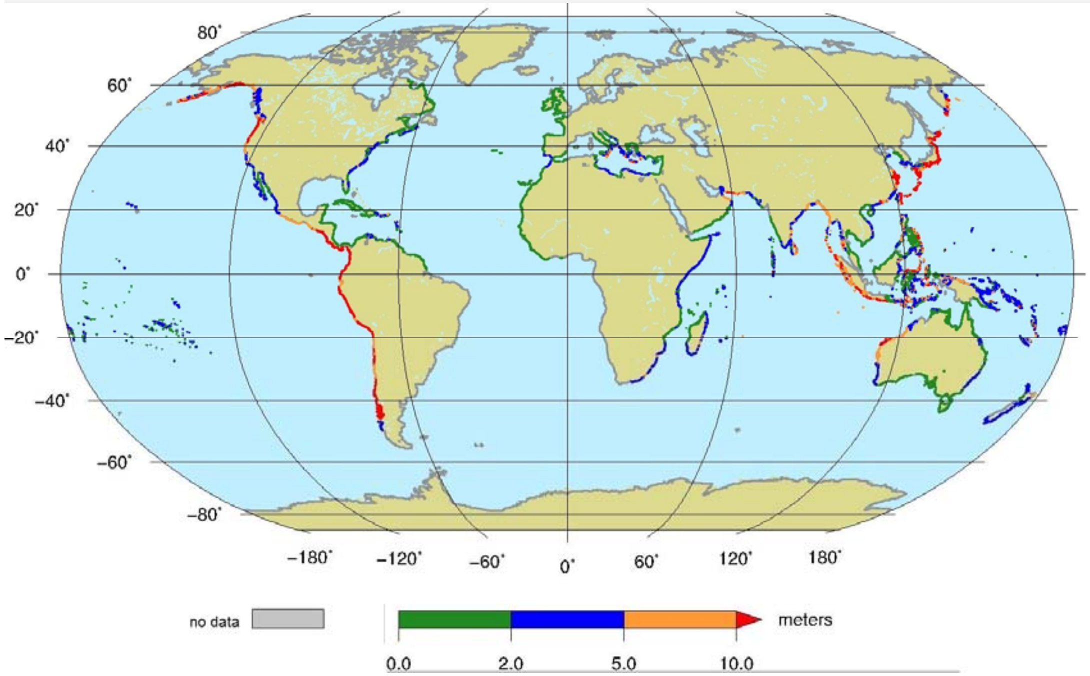




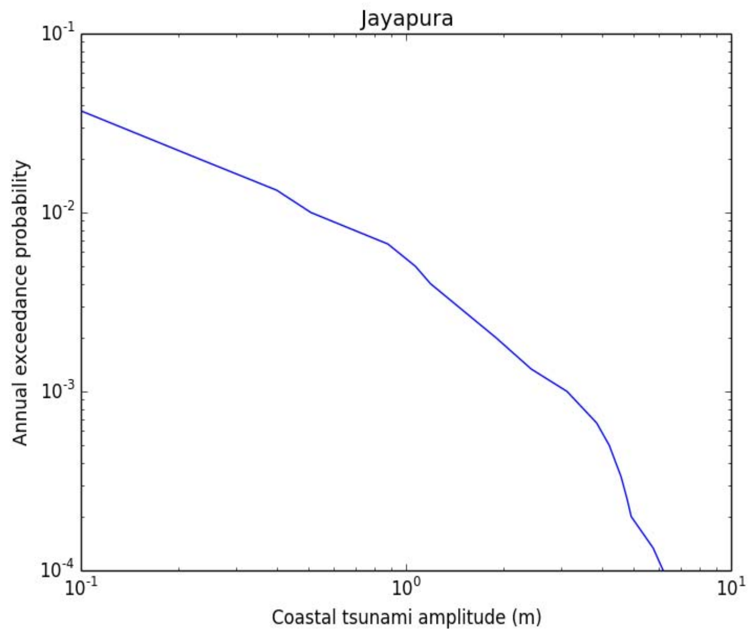


Global hazard map of run-up

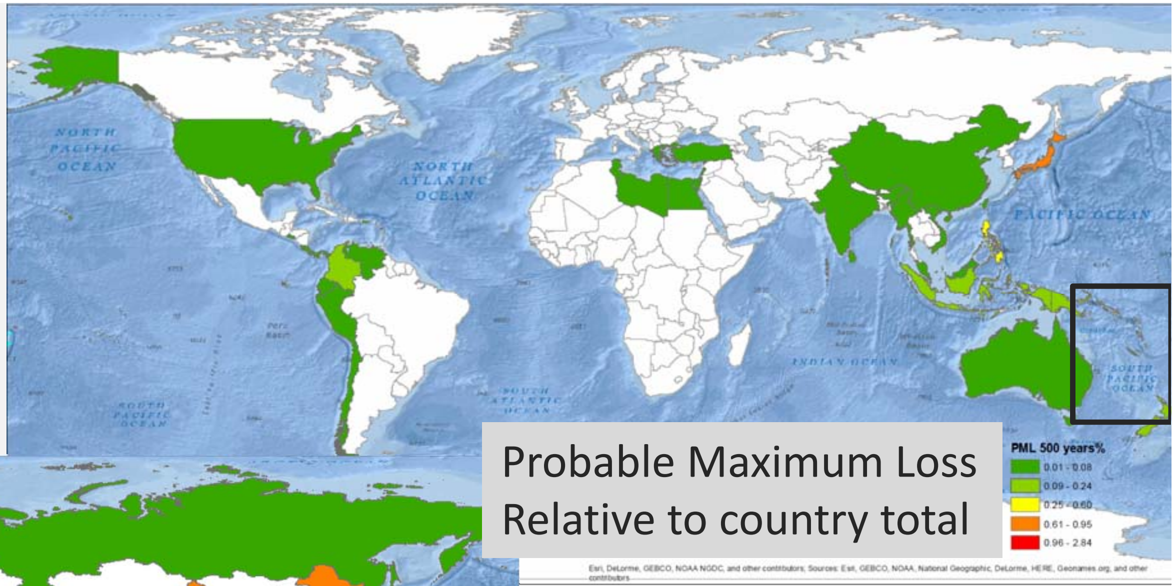
500 year hazard map – GAR13

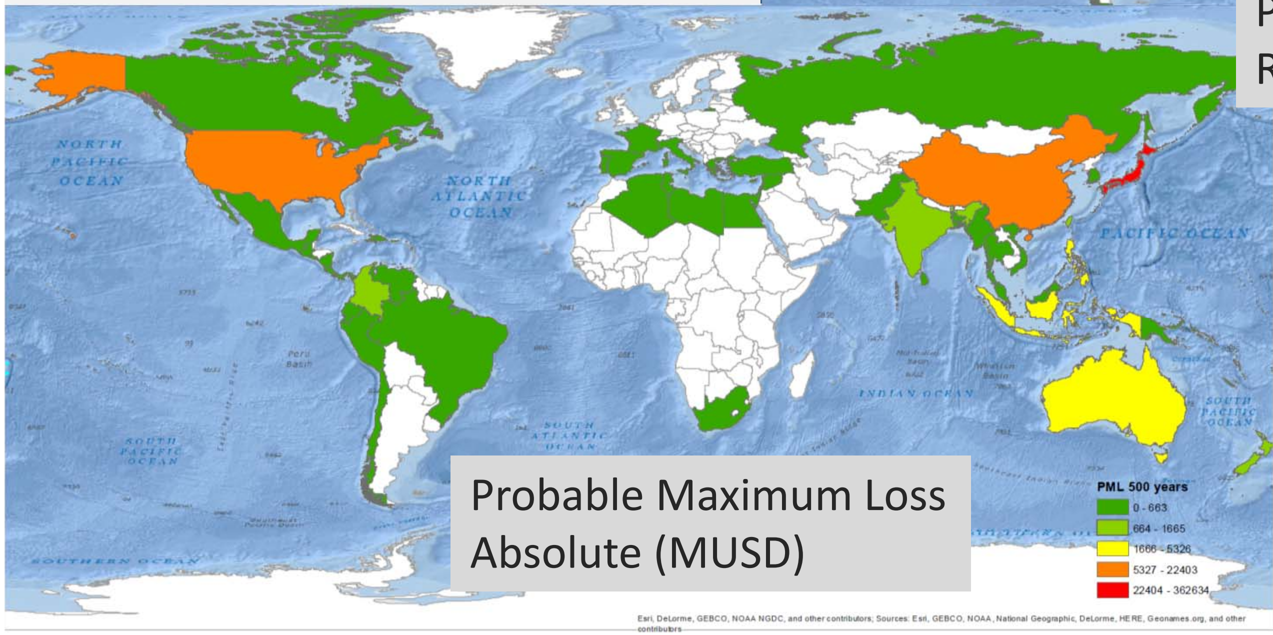


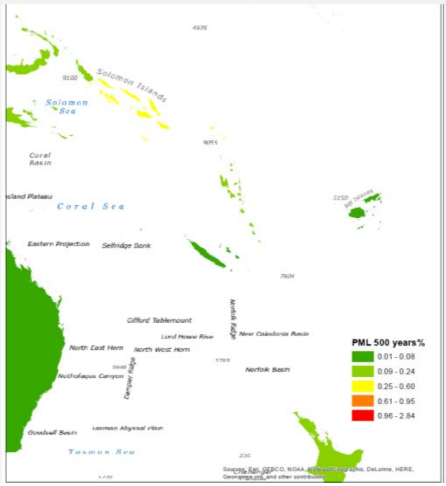
Hazard curve (Horspool et al. 2014, NHESS)



Tsunami risk for 500 year return period





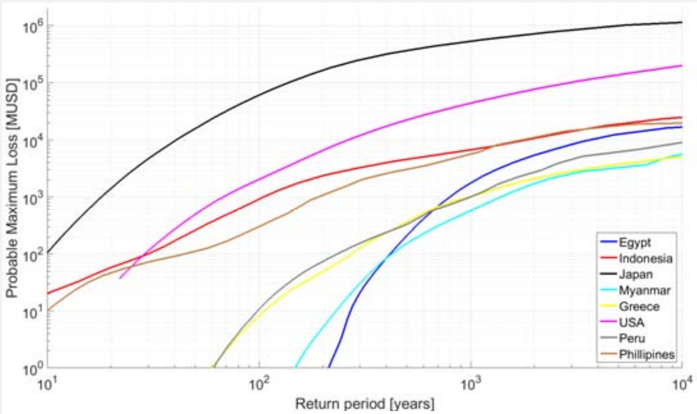


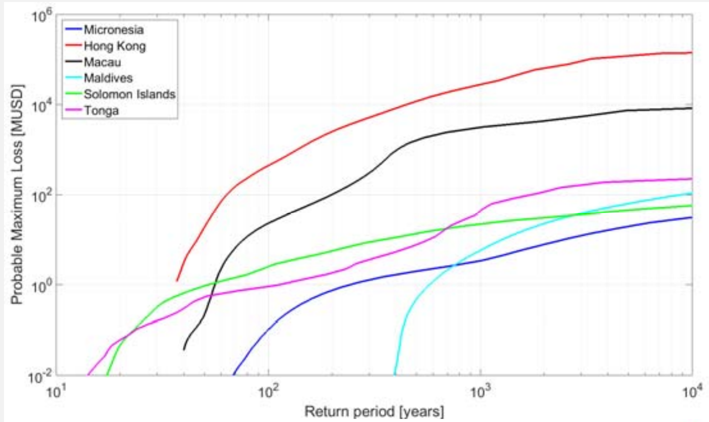
Probable maximum loss curves

Large countries

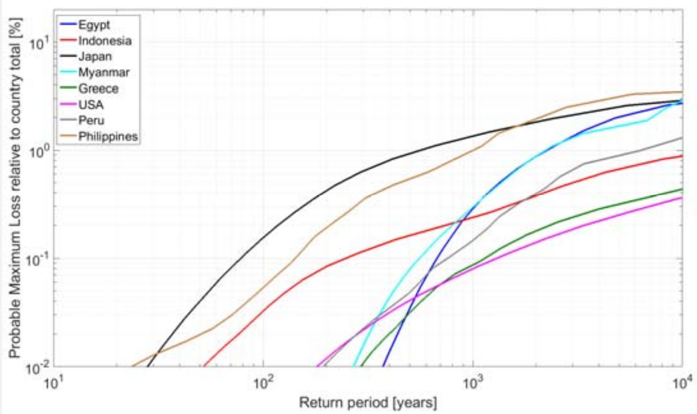
Small Islands

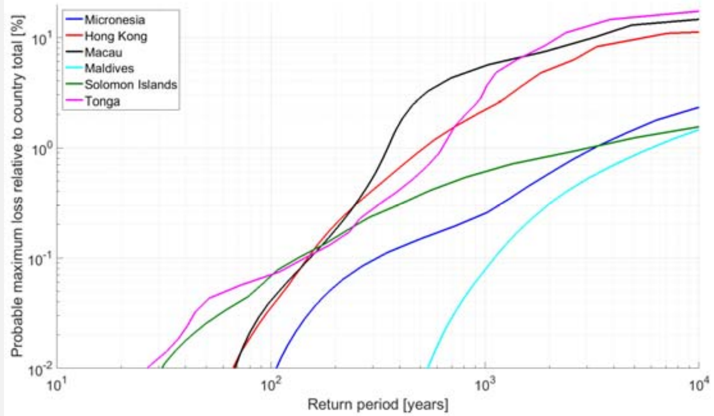
Loss in MUSD





Loss in %



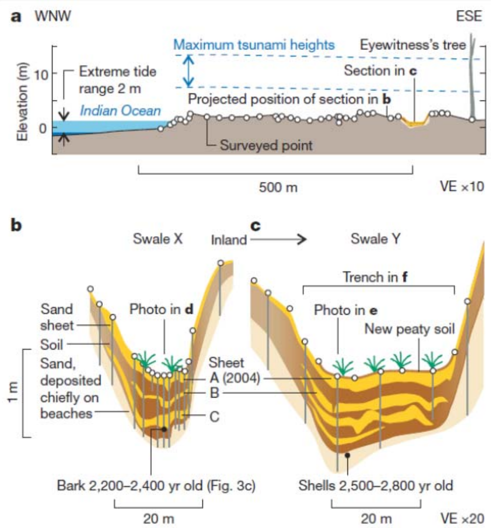


Ballpark comparisons with recent major events indicate reasonable results

- 2011 Tohoku earthquake and tsunami
  - Observed economic loss 210 BN US$ (www.emdat.be)
  - This loss corresponds to a return period of 250 years in GAR15
  - Literature estimate of earthquake return period ~500 years →
    Induced probable maximum loss in GAR 360 BN US$
- 2004 Indian Ocean tsunami
  - Observed economic loss in Indonesia 4.4 BN US$ (www.emdat.be)
  - This loss corresponds to a return period of 1000 years in GAR15
  - Evidence for past tsunamis detect in sediments in Thailand – several events last 5000 years

Evidence for past tsunamis in the Indian Ocean:

Jankaew et al. (2008), Nature



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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

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How will a Global Tsunami Model improve our understanding of the present risk situation?

- Involving the full tsunami hazard and risk community may:
  - Enable work on hazard and risk analysis on global, regional, and local scales
  - Include, within a probabilistic framework, also smaller earthquake and non-seismic sources
  - Increase model sophistication, performance and validation
  - Include a sound and feasible uncertainty treatment
  - Harmonize efforts and products
- Go beyond the scope of GAR
  - 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
  - Validation of methods – improve our understanding of the risk drivers

The GTM is not yet established!

- Constraints
  - Oriented towards tsunami hazard and risk
  - Integrate efforts in a probabilistic framework
  - First phase should focus on PTHA
- **Scoping meeting will be held at IUGG 29 June (room 1.2 10.30-13.00)**
  - Initial core group of researchers
  - Background from PTHA or vulnerability and risk assessment
  - Main emphasis – provide the scientific scope
- Aim
  - Establish a (PTHA and PTRA) tsunami hazard and risk research community
  - Community based model
  - Open initiative
  - Provide link and collaboration with other global models (e.g. GEM, GVM)

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Extras