

The Global Tsunami Model (GTM)

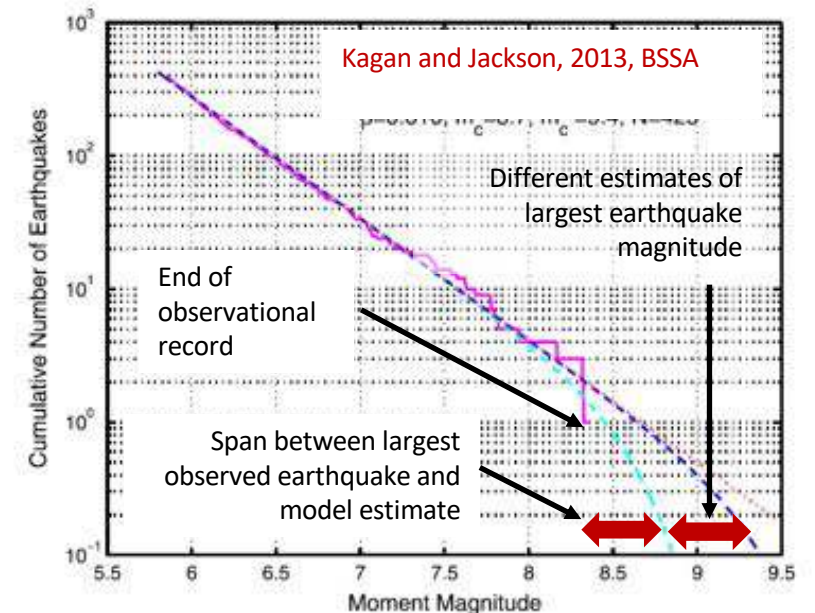
F. Løvholt (NGI), contributions from

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Infrequent tsunamis and uncertainty dominate losses and challenge risk modellers

- ✓ The tsunamis in 2004 and 2011 account for a majority of the monetary and mortality losses in the last 100 years
- ✓ Infrequent tsunamis dominate risk – return periods of hundreds to thousands of years
- ✓ The source statistics is poorly constrained at these return periods
 - Does not saturate at high return periods
 - Increasing uncertainty with higher return periods
- ✓ The understanding of the hazard from several tsunami sources are poorly understood, including
 - Tsunami earthquakes
 - Non-subduction earthquakes
 - Non-seismic sources (landslides and volcanoes)
- ✓ Standards non-existing, while consequences related to high return period tsunami hazards and their related uncertainties are formidable



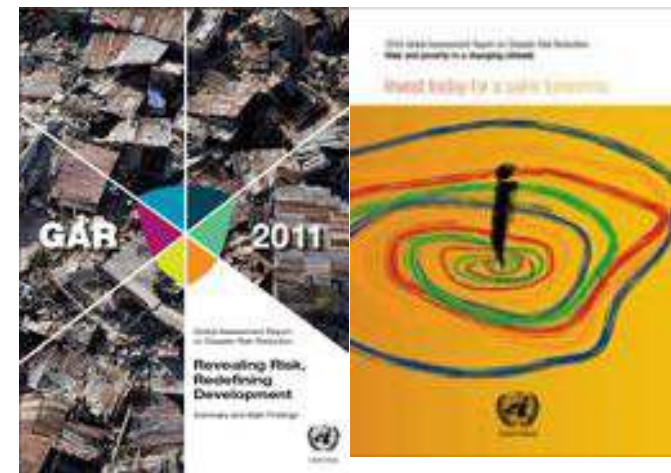
Background – why GTM?

- ✓ Multi-institutional work on hazard and risk for the UN-ISDR (Global Assessment Report, GAR)
- ✓ **Idea:** Need to gather scientific community for
 - *Collective effort for improved understanding of global tsunami hazard and risk*
 - Provide reference maps
 - Improve methods, develop guidelines and standards
 - Non-exclusive initiative ↔ open for the community
- ✓ *Initiative from the tsunami community itself*
- ✓ Ensure relevance towards stakeholders

GAR

Global Assessment Report
on Disaster Risk Reduction

2015



GTM's added values and vision

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.

- ✓ Facilitate compatibility and improve **probabilistic tsunami hazard and risk analysis methods** through the development of **standards, guidelines, methods, tools**, and identification of key research questions
- ✓ The development of regional and global **reference probabilistic tsunami hazard and risk maps**, as well as **standardized processes for developing local hazard and risk analyses**
- ✓ Establish **reference pools of experts** for completing and reviewing tsunami hazard and risk assessments from stakeholders
- ✓ The provision of a **consistent input and contribution to multi-hazard risk assessment** through high-level harmonization with organizations covering other natural hazards
- ✓ The interaction with stakeholders to ensure relevance and proper dissemination of results and **uncertainty communication to non-scientists**
- ✓ To develop the above products while **being mindful of their benefits for society**

GTM will contribute to the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030

✓ SFDRR Four priorities:

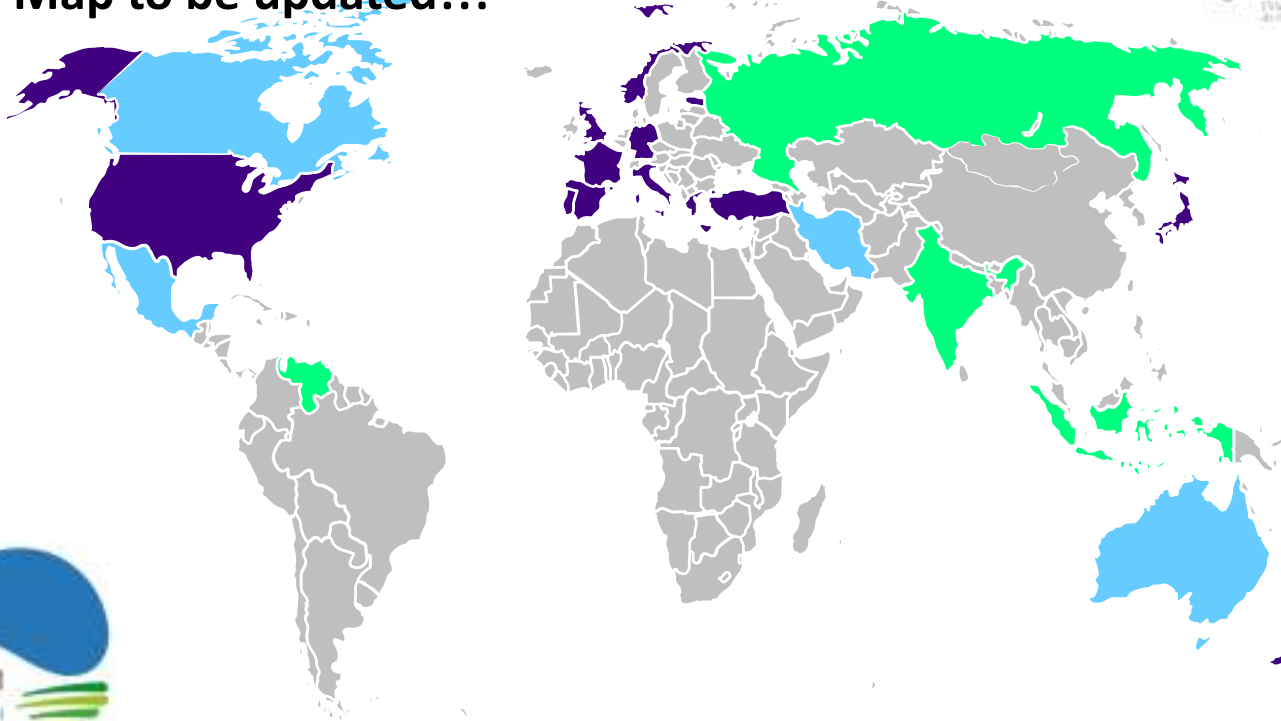
- **Priority 1. Understanding disaster risk**
- Priority 2. Strengthening disaster risk governance to manage disaster risk
- Priority 3. Investing in disaster risk reduction for resilience
- Priority 4. Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction

✓ SFDRR Seven Global Targets in brief

- Substantially reduce global disaster **mortality**
- Substantially reduce the **number of affected people** globally
- Reduce direct **disaster economic loss** in relation to global gross domestic product (GDP)
- Substantially reduce disaster **damage to critical infrastructure and disruption of basic services**, among them health and educational facilities, including through developing their resilience
- Substantially increase the number of countries with national and local disaster risk reduction strategies
- Substantially enhance **international cooperation to developing countries**
- Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to the people

Current GTM structure

- ✓ proposed to the tsunami community at IUGG June 2015, discussed among partners in several meetings since (AGU, EGU...)
- ✓ **Loose structure committing partners to the GTM through signing of Letter of Interest (LoI's)**
- ✓ **25 partners have signed LoI's, more than 30 partners interested (involved in meetings etc)**
- ✓ INGV and NGI receive LoI's on behalf of GTM and perform majority of secretary work
- ✓ **Map to be updated!!!**



Main GTM drivers / stakeholders

- ✓ The tsunami hazard and risk discipline is young and needs to adapt, in order to address recent unanticipated consequences of tsunamis
- ✓ We are currently lacking well established procedures, methods and standards
- ✓ The majority of the tsunami hazard and risk community contributes to GTM over a broad technical range
- ✓ Relevant knowledge on dealing with a low frequency / high consequence hazard that differs from most other natural hazards
- ✓ Societal relevance and endorsement from UNISDR and GFDRR

A more transparent way to manage subjectivity?

Reminescent of the issues faced by SSHAC!!!!

The SSHAC studied a large number of past PSHAs, including two landmark studies from the late 1980s known as the "Lawrence Livermore (LLNL)" study and the "Electric Power Research Institute (EPRI)" study, both of which broke important new methodological ground in attempting to characterize earthquake-caused ground motion in the broad region of the U.S. east of the Rocky Mountains. Most important, the mean seismic hazard curves presented in the reports for most sites in the eastern U.S. differed significantly. However, the median hazard results did not differ by nearly as much. We now understand that differences in both the inputs and the procedures by which the two studies dealt with the inputs were among the key reasons for the differences in the mean curves. At the time this was not understood, and the differences between the mean curves caused not only considerable consternation, but launched several efforts to understand what might underlie the differences and attempts to update the older work.

NUREG/CR-6372
UCRL-ID-122160
Vol. 1

Recommendations for

- Probabilistic Seismic Hazard Analysis: Guidance on
- Uncertainty and Use of Experts

Main Report

Manuscript Completed: April 1997
Date Published: April 1997

Prepared by
Senior Seismic Hazard Analysis Committee (SSHAC)
R. J. Budnitz (Chairman), G. Apostolakis, D. M. Boore, L. S. Cluff, K. J. Coppermith, C. A. Cornell, P. A. Morris



Suggested short term priority items for GTM

Priority items below proposed by GTM to be discussed further with our stakeholders

✓ General topics

- Framework for uncertainty treatment
- Develop standards and guidelines based on present good practices
- Produce reviewed, well-documented, reproducible, and standardized global reference maps
- Perform Hazard and Risk communication from the above products

✓ Some specific scientific topics will be prioritized

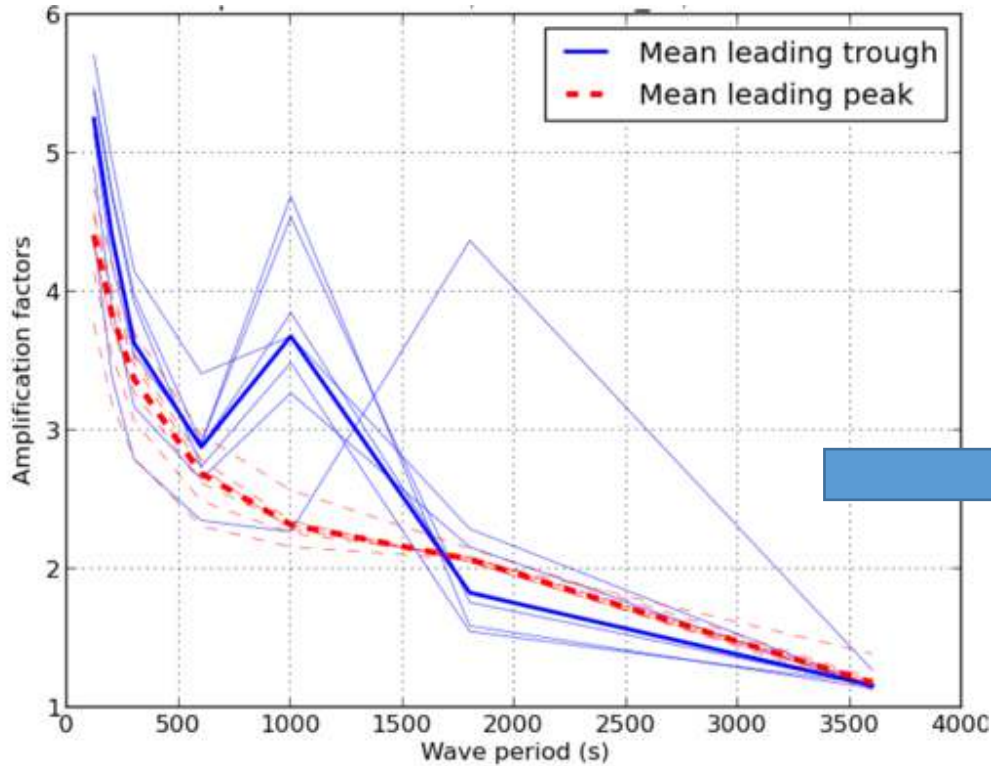
- Tsunami hazard from non-seismic sources
- Submarine fault characterization
- Homogenized global tsunami data handling

✓ In the first phase, we suggest to focus on the tsunami hazard, and develop risk products at a later phase

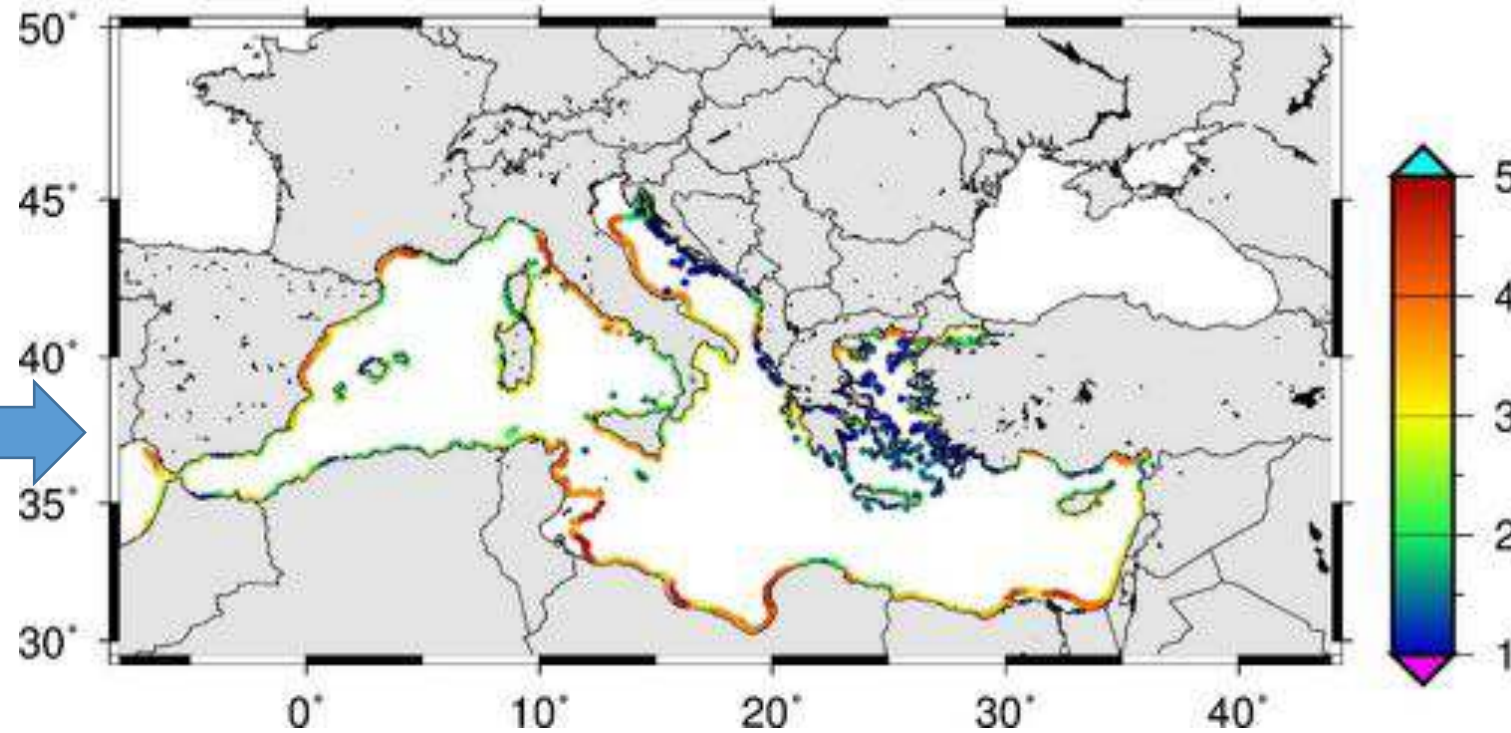
Long term goals

- ✓ Seismic source (probability and modeling)
 - Interface Global Earthquake Model (GEM)
- ✓ Non-Seismic source (probability and modeling)
 - Interface with other global models covering sources such as Global Volcano Model (GVM)
- ✓ Tsunami (probability and modelling)
- ✓ Probabilistic Tsunami Hazard Assessment, PTHA
 - Non-earthquake sources
- ✓ Vulnerability and fragility
- ✓ Probabilistic Tsunami Risk Assessment
- ✓ Development of standards and guidelines for tsunami hazard and risk quantification
- ✓ Dissemination and geoethics (transparency – uncertainty communication)

Examples of products I – amplification factors



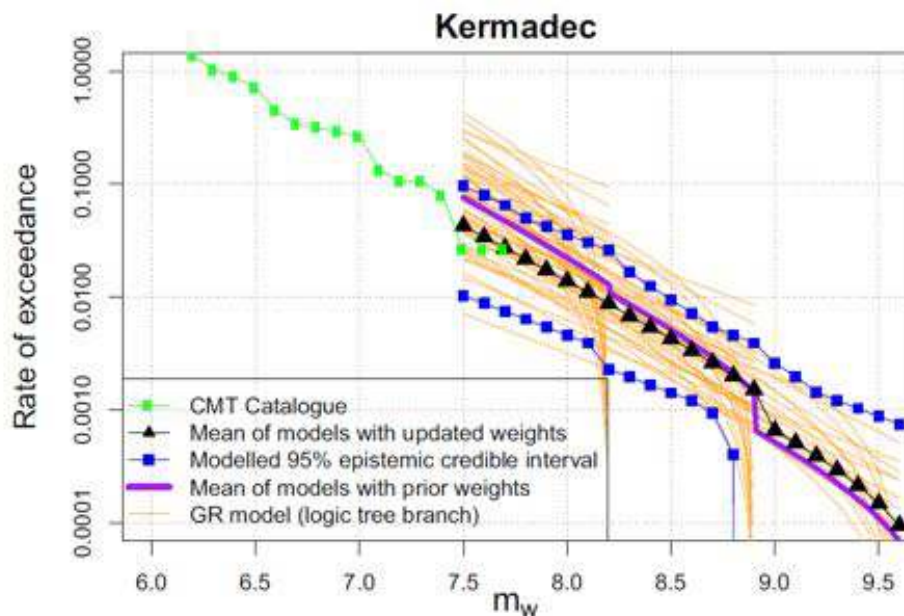
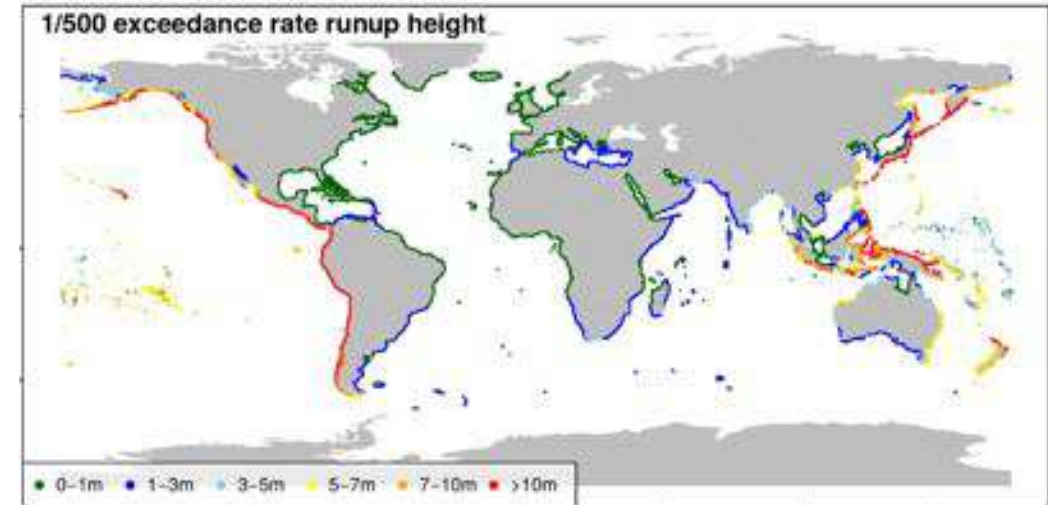
Amplification factors, pos, T=600s



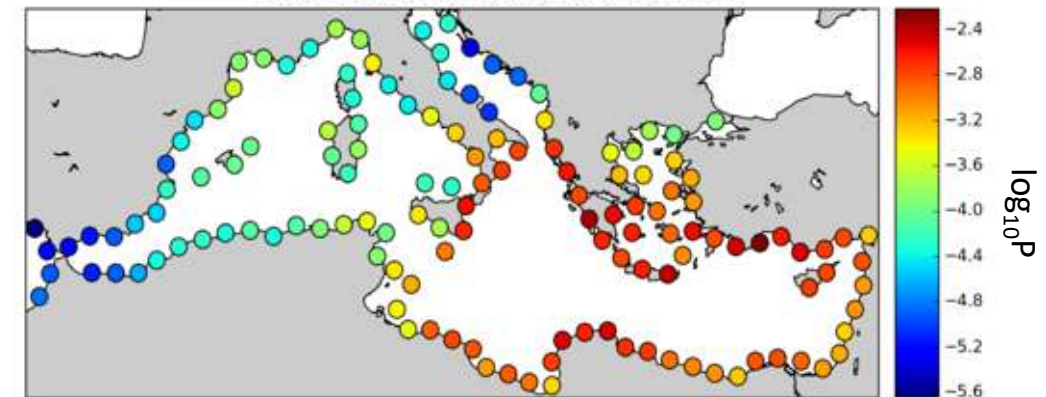
Examples of products II: Global and regional hazard maps

(Davies et al., GSL Special Publ. 2017)

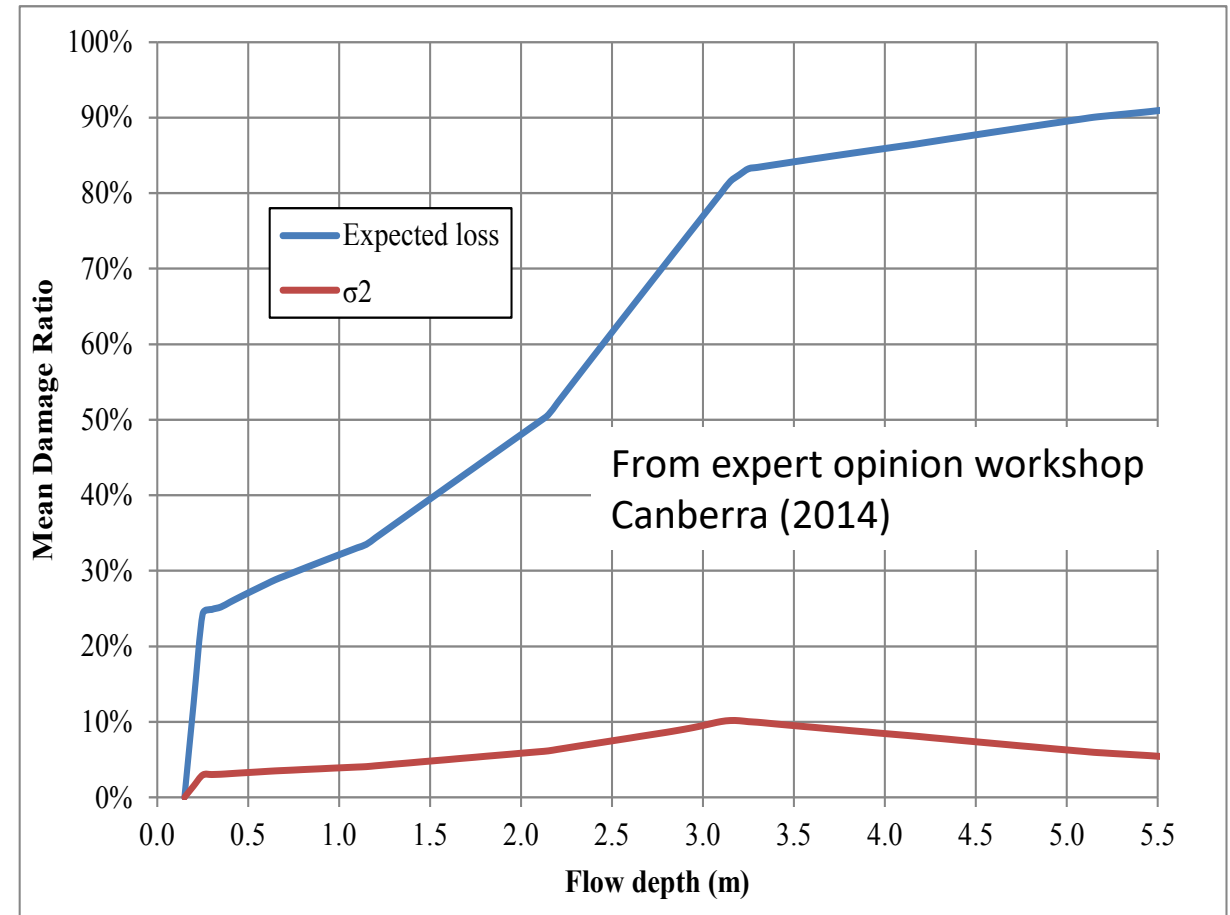
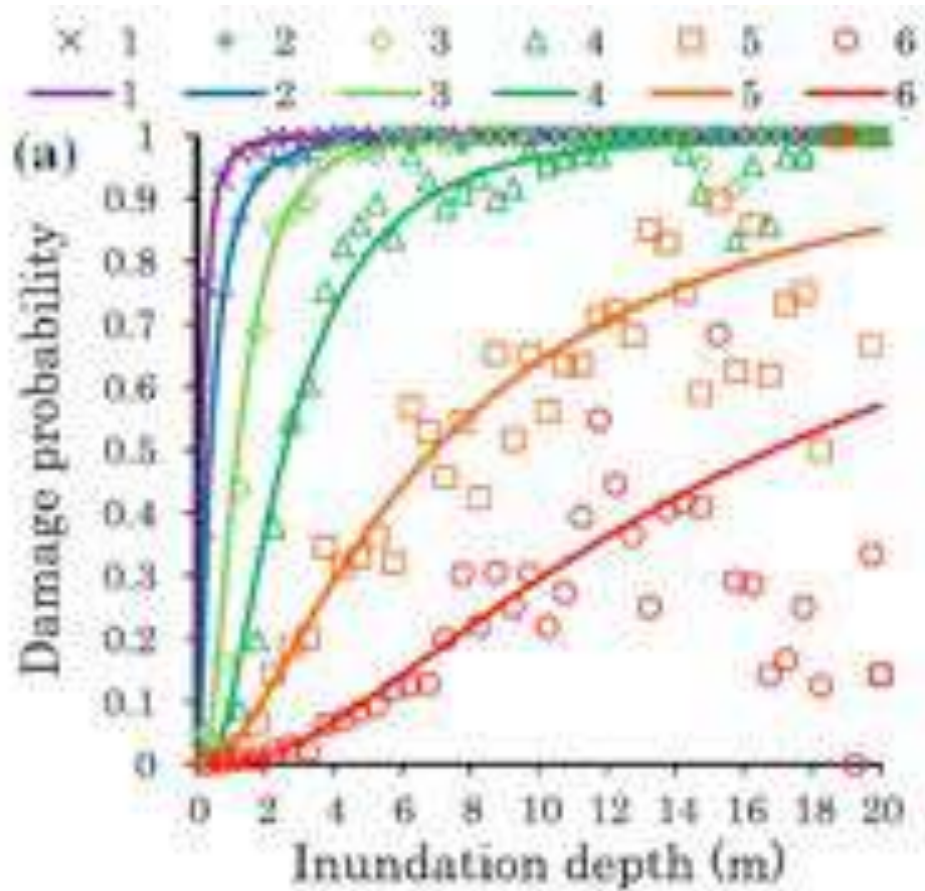
- ✓ Global hazard maps for different return periods
- ✓ TSUMAPS-NEAM
- ✓ Uncertainty estimates
 - Source model recurrence
 - Maximum inundation heights



Probability of Exceedence for project SAMPLE-POIS, seisclass BSPS
Mean value for threshold 1.00m



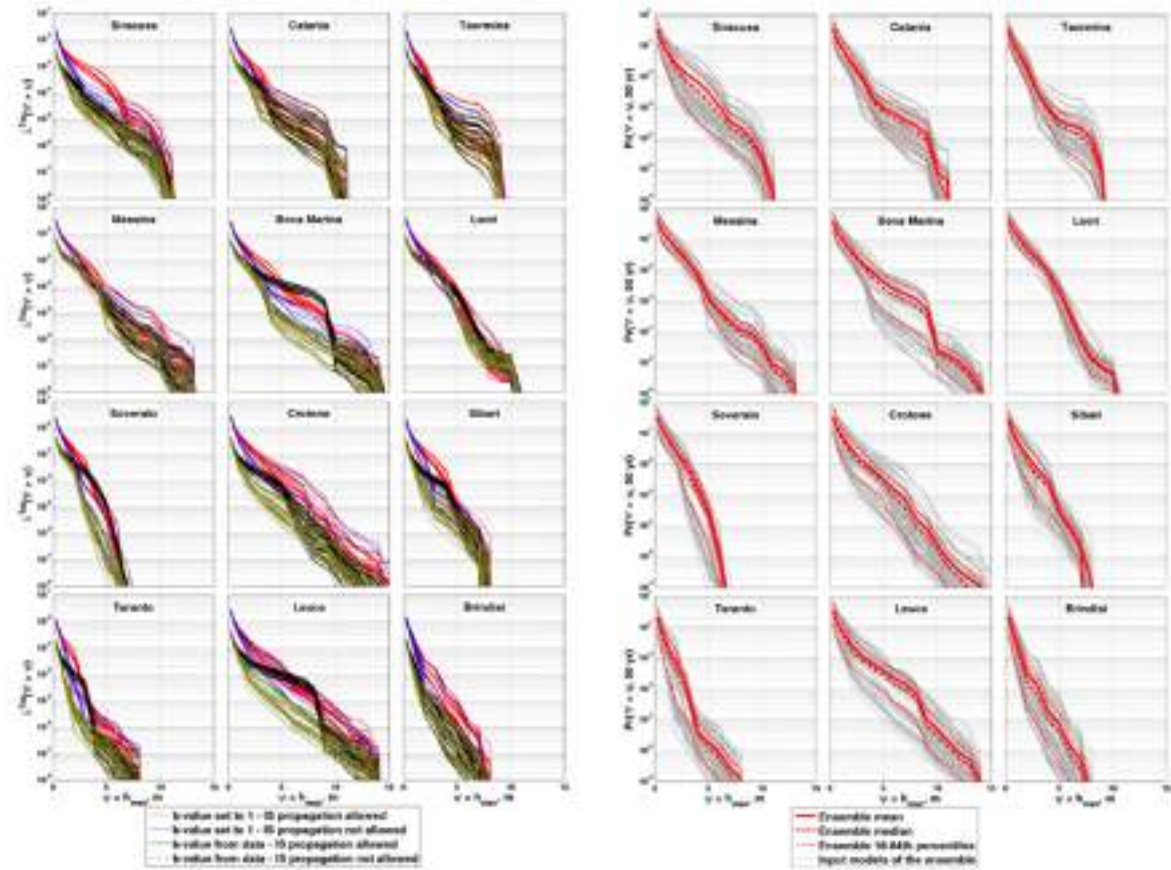
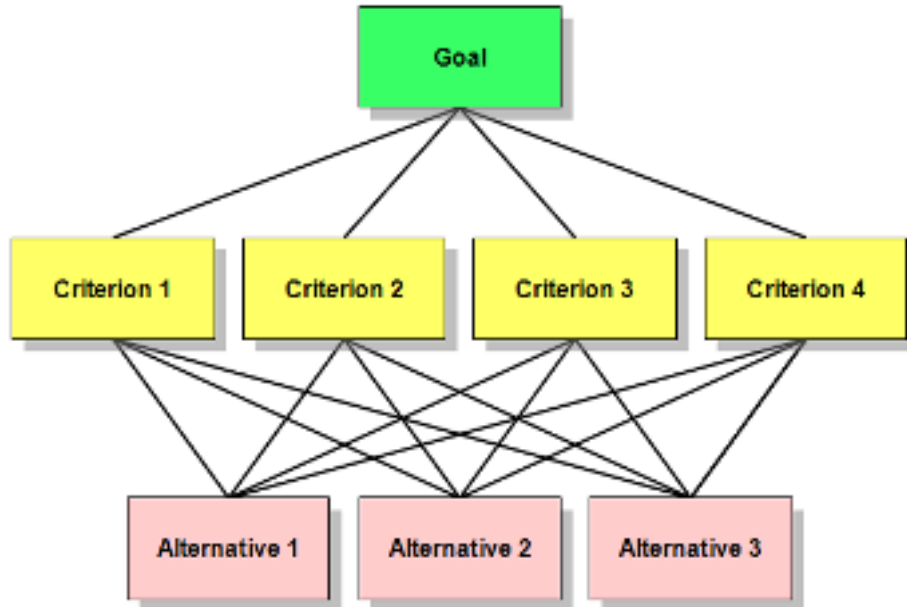
Examples of products III: physical vulnerability curves



Suppasri et al. 2013

Examples of products IV: GTM pools of expert

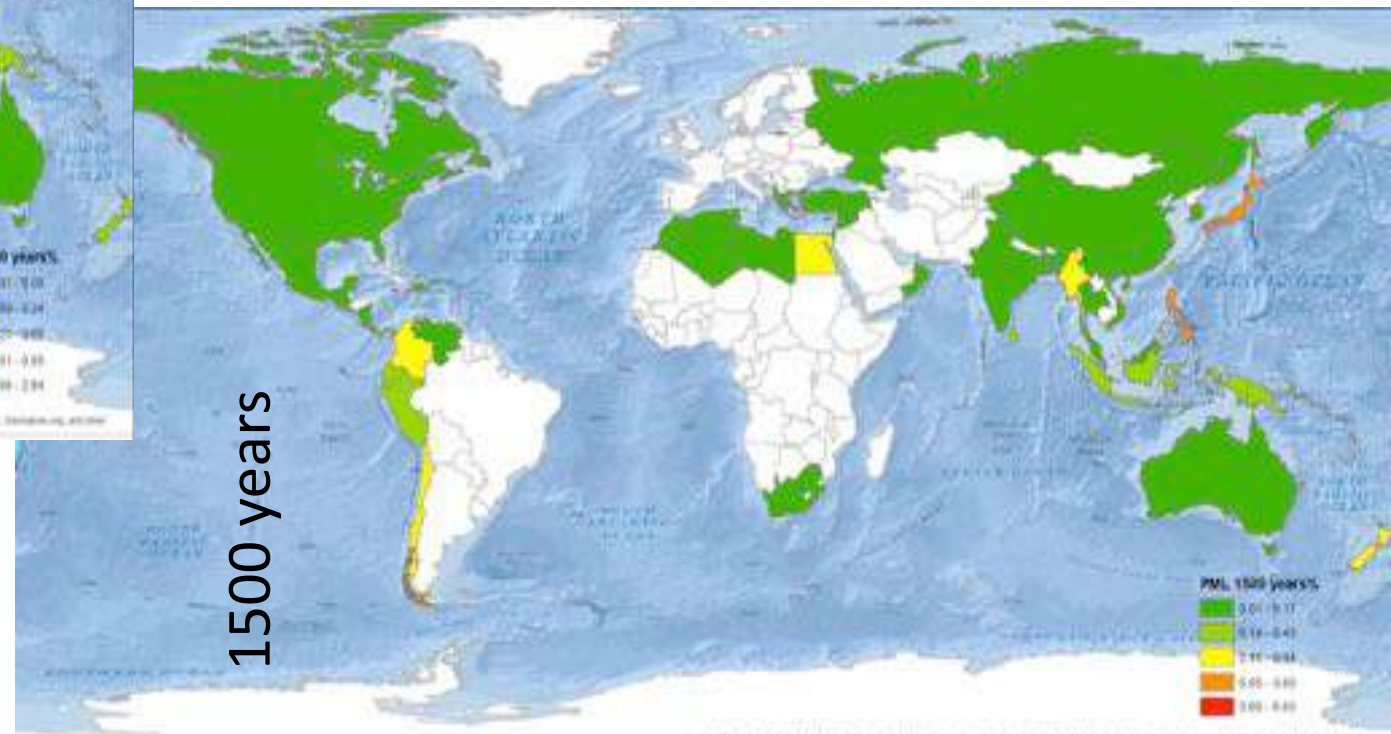
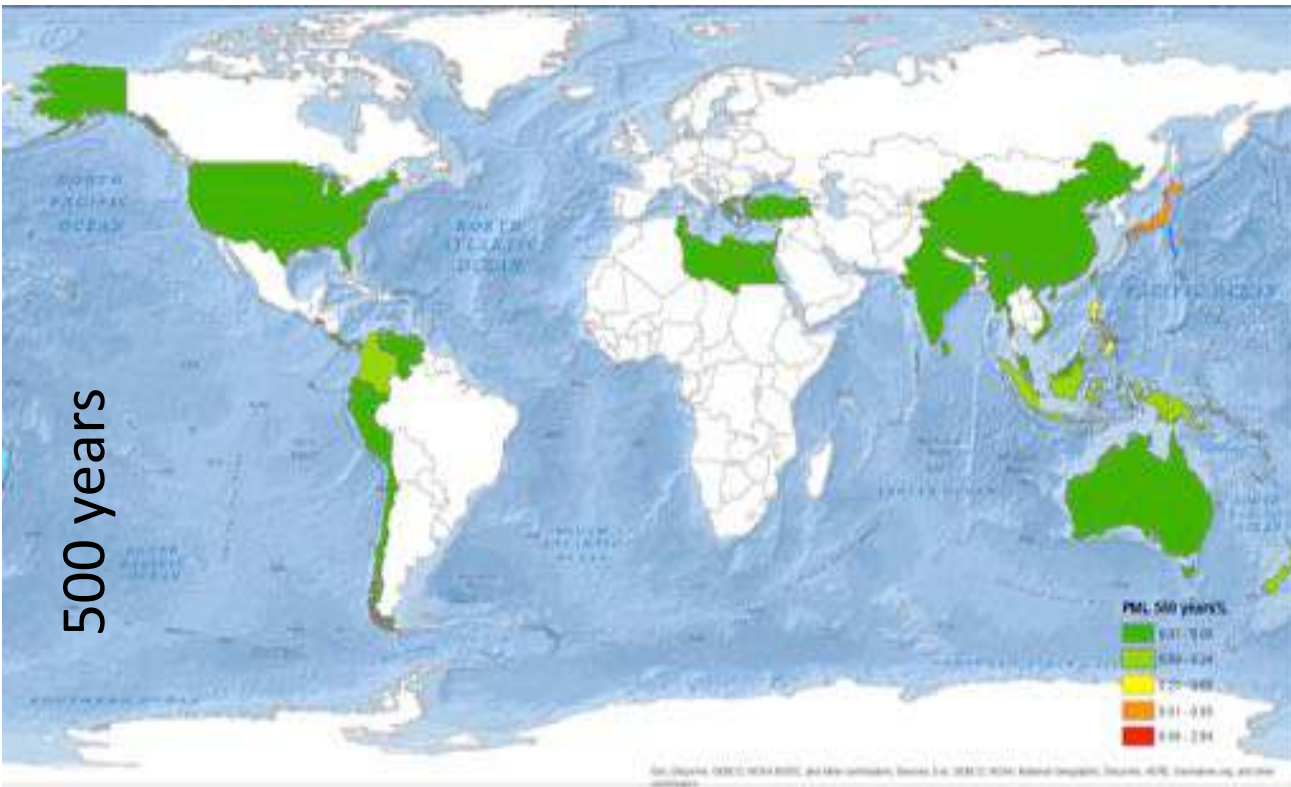
GTM provided a pool of experts to TSUMAPS-NEAM for quantifying subjective probabilities / expert choices



Examples of hazard curves from alternative models (left); ensemble modeling and ensemble statistics

Examples of products V – tsunami risk maps

Present maps from GAR15 – probable maximum loss relative to total exposed value



Interested in GTM?

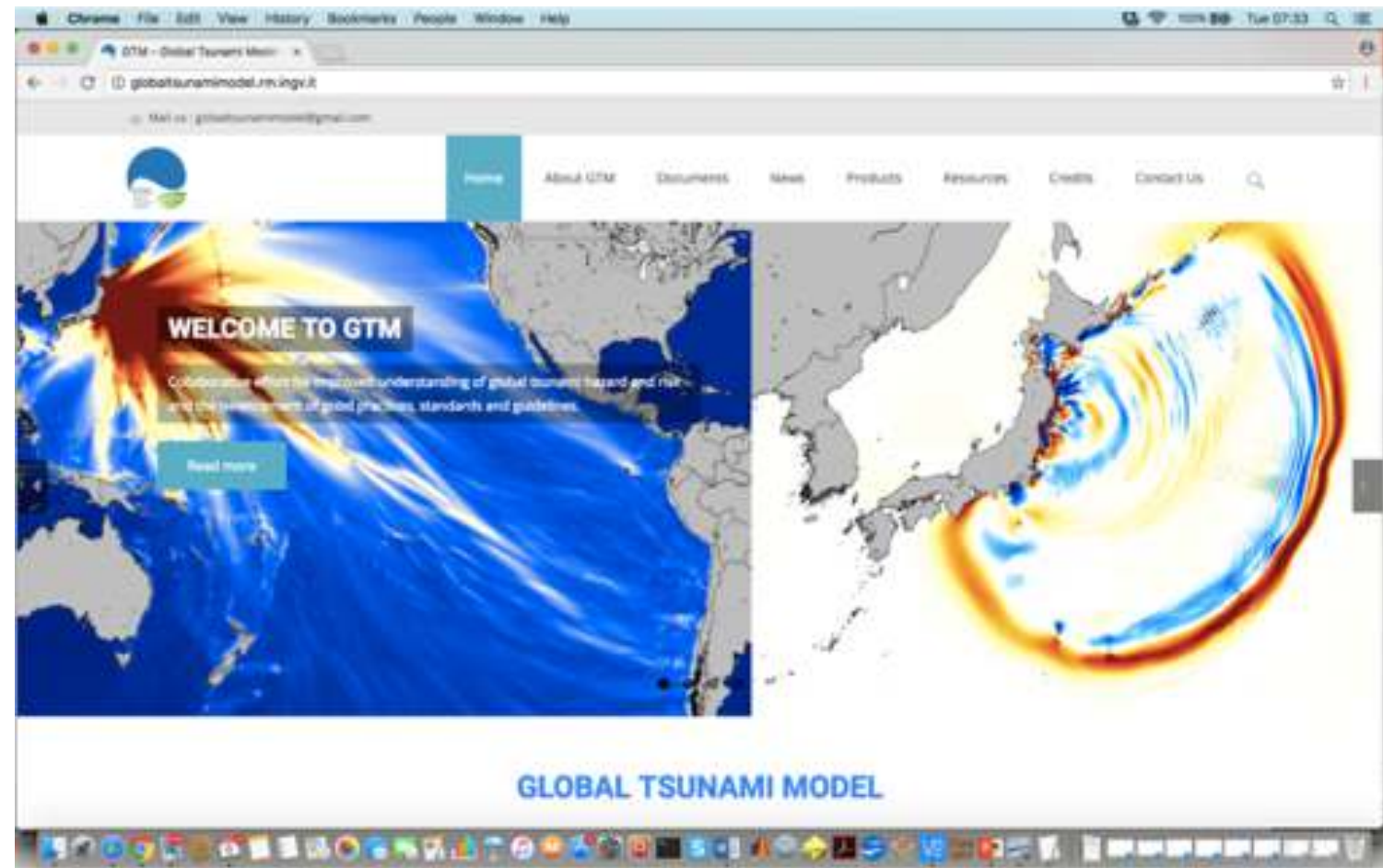
Web page:

<http://www.globaltsunamimodel.org>

Mailing list (google groups):

<https://groups.google.com/forum/#!forum/globaltsunamimodel>

Next meeting at EGU 2017



GTM business meeting

✓ Intended for:

- Participants that have signed Letters of Interest (LoI)
- Participants that otherwise have been active in the formation of GTM and work towards signing the LoI.

✓ Schedule

- Short review of news, discussion from AGU, some recent related initiatives
- EU Cost Action
- TSUMAMOS Announcement and discussion
- Possible GTM related joint publishing
- GTM webpage hosting data
- White paper
- WG initiation
- AOB

Past GTM meetings:

- ✓ **IUGG Prague June 2015 (public presentation, work meeting, discussion with IOC UNESCO) – GTM was suggested**
- ✓ **AGU December 2015 – OAKLAND (AECOM)**
- ✓ UNISDR S&T conference January 2016 – GTM poster (NGI)
- ✓ **EGU 2016**
- ✓ SSA 2016 (AECOM)
- ✓ UR forum in Venice, Multirisk session May 2016 (INGV)
- ✓ **INGV 4-6 July 2016 – work meeting**
- ✓ Pavia Nov. 2016 – Global Partnership meeting (INGV, NGI)
- ✓ **AGU Fall meeting 11 December 2016**



Recent GTM related initiatives

✓ Contact with the World Bank / GFDRR

→ Publishing global tsunami hazard maps on GFDRR's ThinkHazard platform (<http://thinkhazard.org/>)

✓ GFDRR Challenge Grant I project

→ NGI involved with small activity on tsunamis – multihazard demonstration project involving most other natural hazards (landslides, volcanoes, earthquakes)

→ NGI opt to keep tsunami hazard work open for interested collaborators – but we are awaiting feedback on the study countries to be selected by GFDRR

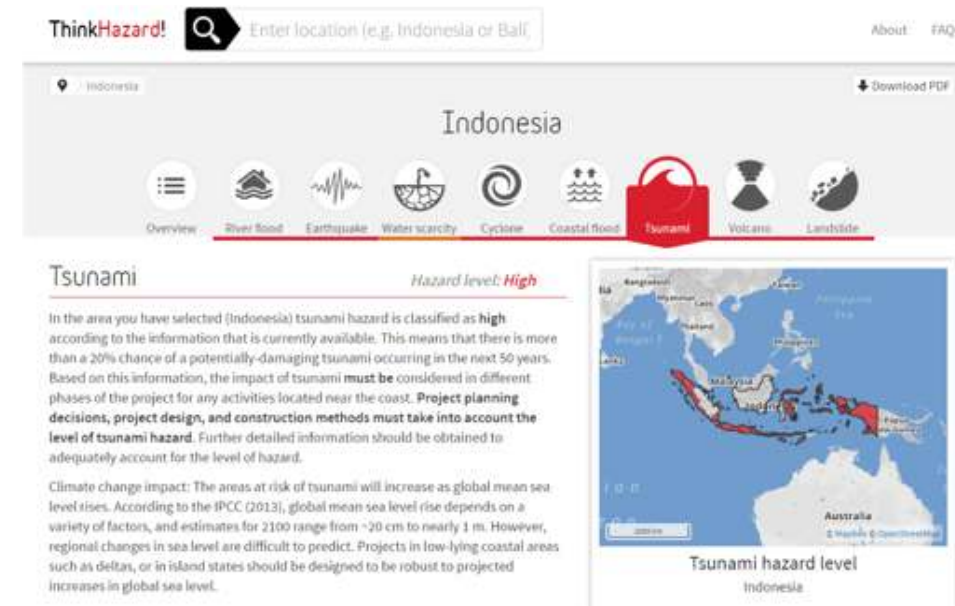
✓ Initiative towards Lloyds Foundation

→ Declined as GTM initial focus does not fall within the primary scope of the foundation

→ A later follow up can be considered – but focus would need to be different, and GTM should be more established

✓ Reviews of Geophysics paper

→ Review of PTHA methods



Review of other points discussed on AGU 2016 meeting I – based on notes from Stephanie Ross - USGS

On added values, visions and goals

- ✓ The need and **challenge for proper communication of uncertainty** and probability to practitioners was underlined and discussed
 - Need to creating acceptance among practitioners for implementing probabilistic products in practical measures
 - GTM could play important role
 - Standards are needed
- ✓ How to make **GTM striving for scientific excellence** – particular topics needs to be targeted (reflected in the short term goals identified for GTM)
- ✓ GTM should have the role as the body creating and setting standards, not just related to methods, but also use of data (both source data and **consistency between different reference data such as global tsunami databases**)
- ✓ It is still **unclear to which extent GTM should provide products themselves or facilitate their partners to do so individually**
 - Licensing an issue, both open source and paid licensing possible
 - Produced reference data (e.g. hazard and risk data) must be kept open



Review of other points discussed on AGU 2016 meeting II –

On short term priorities

- ✓ GTM should **facilitate interfaces between source data and external data providers** such as GEM
 - Products related to tsunami specific issues (e.g. heterogeneous slip, low probability recurrence ...)
 - Possible collaboration with GEM and identify synergies – for instance on subduction zone modeling (e.g. contact with Gavin Hayes)
- ✓ Identification and **construction of paleotsunami databases** was discussed – interest both in US and Australia
- ✓ Scalability of hazard products – original idea to **provide coarse maps that can be used as reference for more fine grained maps.**
- ✓ **GTM pools of experts**
 - should be more than just make critical choices in probabilistic analysis
 - providing advice in term of how to use methods and hazard models, and how not to use them.
- ✓ Need for **more research related to vulnerability.** Not just monetary losses from building damage, also mortality.
 - Social vulnerability should be a long term target, but not short term
 - Should interface Re-insurance, but we should not target doing their tasks.
 - Must not oversell the risk aspect – but be careful and state limitations

Review of other points discussed on AGU 2016 meeting III

On GTM structure

- ✓ **Amount of funding needed to achieve goals** was discussed. Need to identify differences and similarities with GEM and GVM. Identify possible projects.
- ✓ An ambition to bring in more countries inside GTM, particularly beyond North America / Europe. Some progress already done since AGU.
- ✓ **Decision making structure needed**. Possibility:
 - Advisory board
 - Science board
 - Consolidate organization – partner decisions – those signing Lol's? Allow others too?
- ✓ **Work Groups** should prepare new input ahead of next meeting
- ✓ **Work groups**
 - Stakeholders / funders (Løvholt)
 - Organization (Harbitz)
 - Science group (not priority at present, Thio)
 - Volunteer action / initiatives are needed for ensuring progress
- ✓ **Wider view of funding schemes outside North America / Europe needed**

Review of other points discussed on AGU 2016 meeting IV

- action points for Business meeting highlighted

On GTM short term action

✓ Better use of web page to keep the community updated on local / regional activities and news. Also a good way to expose your own group! Can GTM webservices be introduced?

✓ *White paper:*

- NATGEO contacted
- No definite answer

✓ *Leverage EC Cost Action initiative*

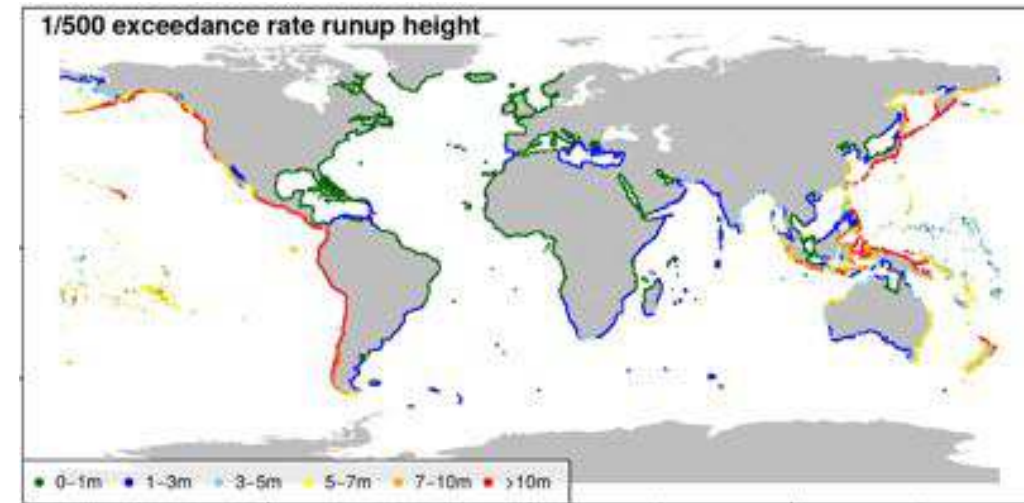
- Draft proposal presently worked out by Univ Hamburg
- Content and contributions from partners to be discussed
- Deadline – September 2017

Extra

Common grounds and first GTM products

Related project results contributing to GTM:

- ✓ GAR15 global tsunami risk maps
 - Full tsunami risk analysis, but not disaggregation of hazard
 - Focused on losses estimation for nations
- ✓ TSUMAPS-NEAM
 - Tsunami hazard maps for DG-ECHO (European Civil Protection)
 - Makes use of GTM pool of experts: elicitation on critical, subjective choices (developing and weighting alternative models)
- ✓ New global tsunami hazard assessment finalized
 - Deeper analysis on earthquake model epistemic uncertainties



Davies et al., GSL Special Publ. 2017

GTM Actions – interim products and requests

- ✓ Need for interim (at least hazard) products, in addition to the above publications; and how to make them happen
 - Integration of results from external projects
 - Tsumaps
 - Updated hazard maps from GAR
 - **Other results available?**
 - Start providing preliminary guidelines
 - Where to publish interim products guidelines etc – active use of webpage etc.
 - Other products?
 - Ownership issues related interim products
- ✓ How to handle interim external requests?
 - We need rules to be accepted by GTM partners (LoI subscribers)

White paper draft

- ✓ First draft provided by NGI 27.6 as basis for discussion
 - Comments received by a handful of contributors
- ✓ Based on ideas for GEM Nature Geoscience paper
- ✓ New revision based on first set of values / vision available
- ✓ Needs further iteration
- ✓ **Now as the webpage is launched, and official endorsements are in place, we would like to contact a high profile journal or similar to enquire about their possible interest**
 - **Nature Geoscience suggested in last meeting (Rome)**
 - **Other suggestions / better candidates?**

Key stakeholders

- ✓ Present endorsers having signed endorsement letters
 - ✓ UNISDR
 - ✓ GFDRR (World Bank)
 - ✓ Munich Re
- ✓ Possible other stakeholders
 - ✓ IOC UNESCO – offered closer interaction
 - ✓ Industry stakeholders such as the re-insurance (some contact have been held with OASIS)
 - ✓ National stakeholders
 - ✓ Regional stakeholders (EC, DG-ECHO, NTHMP US)
- ✓ Additional contact will be taken when the key challenges related to tsunami hazard and risk assessment is formulated