



ChEESE

Presentation of NGI and tsunami group Expected contributions

Project kick-off meeting Barcelona,
19-20 January 2023

Finn Løvholt
Norwegian Geotechnical Institute

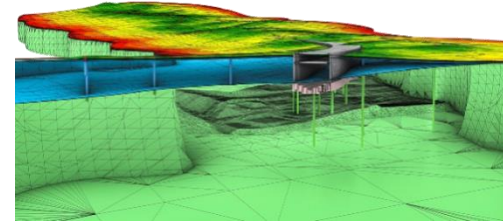


Project funded by EuroHPC under the grant agreement No 101093038.



Norwegian Geotechnical Institute (NGI) –
A national independent research foundation

- International centre for research and consultancy in engineering-related geosciences
- Integrating geotechnical, geological and geophysical expertise, complemented with numerical modelling, instrumentation and technology
- Sustainable solutions for infrastructure on land and at sea, and within environmental technology, contaminated soil and natural hazards – such as landslides and avalanches
- Tsunami research group formed in mid-late 90ties
- About 350 employees represented by 35 nationalities (2021)



NGI: project group and disciplines represented in ChEESE2

- Earthquake and landslide source modelling
- Tsunamis – generation, propagation, and inundation modelling
- Numerical modelling
- Probabilistic hazard analysis
- HPC and urgent computing
- Scientific software development

Finn Løvholt



Steven Gibbons



Sylfest Glimsdal



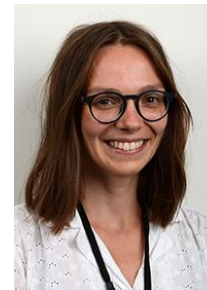
Valentina Magni



Malte Vöge



Sunniva Indrehus



Ida Norderhaug Drøsdal

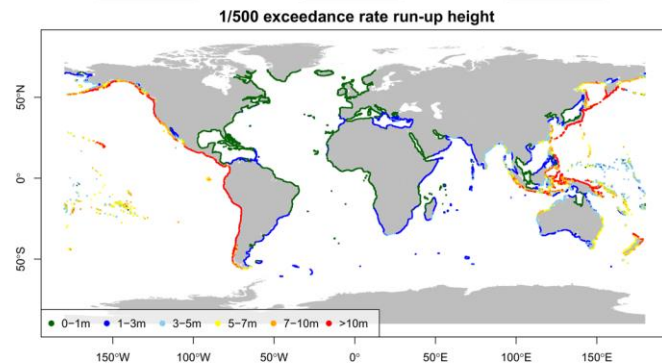
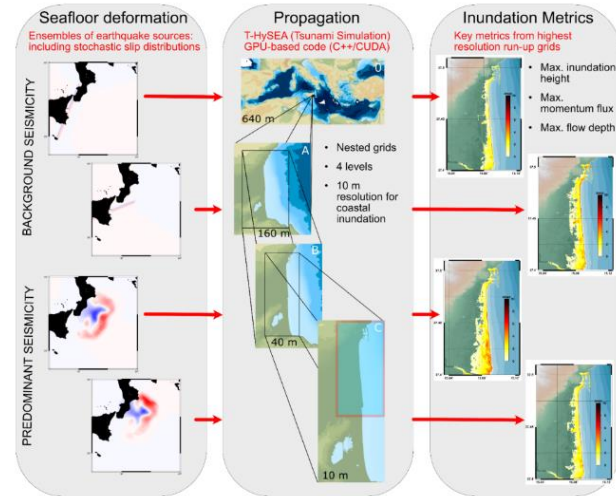


Erlend Storrøsten

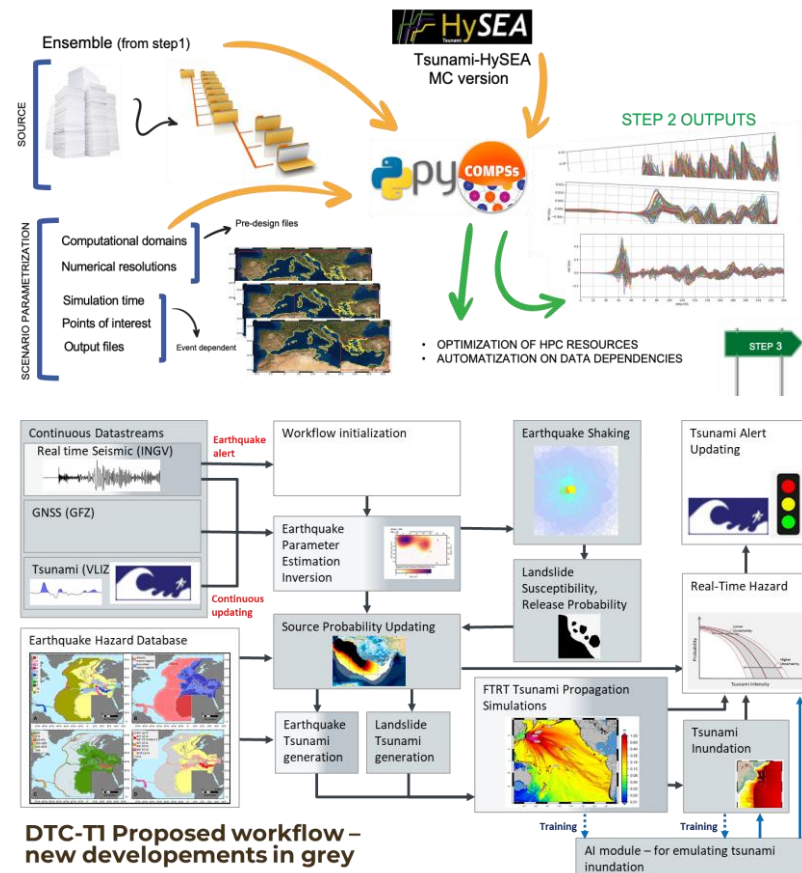


NGI tsunami group: Background experiences / past projects

- Participants in previous EU projects:
 - TRANSFER (2006-2009)
 - ASTARTE (2013-2016)
 - **TSUMAPS-NEAM (2016-2018)**
 - SLATE-ITN (2017-2022)
 - **ChEESE-1P CoE (2018-2022)** →
Local PTHA workflow input to PD3
- National Research Projects
 - CoE: International Center of Geohazards (2003-2013)
 - Three major (500-1500 k€) nationally funded research projects (2003-2017) → numerical tsunami model development
- Applied hazard projects
 - **UNDRR Global Assessment Reports** – GAR (2009-2019) →
Global Tsunami Hazard map → input to SC3.1
 - Wide range of local and regional hazard analysis in consulting



- **eFlows4HPC** (2021-2024 - EuroHPC)
 - PyCOMPSS integration with PTF
 - WaaS – AI for tsunami modelling, HDBA integration
- **GEO-Inquire** (2022- 2026, Horizon Europe)
 - Hazard related services
 - Access to BingClaw, Ampfactors, HPC based PTHA and computing resources, among others
- **DT-GEO** (2022-2025 , Horizon Europe)
 - Tsunami digital twin development and coupling
 - Relevance in particular towards multi-physics coupling
- **AGITHAR COST Action** (2019-2023)
 - Towards a Global Tsunami Model (GTM)
- **EPOS** Tsunami candidate – European node
- **ARISTOTLE** (2022-2023/2024) – Rapid inundation height estimation and exposure



- WP1 – Project management: 2 PMs
- WP4 – Simulation ecosystem: 2PMs
 - Task 4.1 Workflow implementation and optimisation
- **WP5 – Farming Pilot Demonstrators: 16 PMs**
 - Task 5.2 Development in Pilot Demonstrators
 - **PD3 – Global probabilistic hazard and uncertainty quantification**
 - **PD4 - Complex multi-source modelling**
- **WP6 – Simulation cases and service enabling using EuroHPC infrastructures: 12 PMs**
 - Task 6.1: Setup of Simulation Cases and trials
 - Task 6.2: Exascale capability simulation cases and Scientific Grand Challenges
 - **SC4.1 - Multi-source local high-resolution scenario with emphasis on the 2022 Tonga case**
 - Task 6.3: Exascale capacity simulation cases
 - **SC3.1 - The Global Tsunami Hazard Map**
- WP7 – Dissemination: 2PMs



NGI main contributions to ChEESE2

PD3 - Global probabilistic tsunami hazard and uncertainty quantification

SC3.1 - The Global Tsunami Hazard Map

Background / input

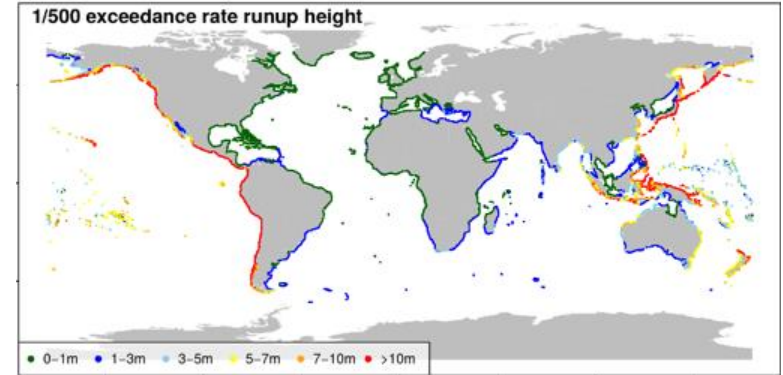
- Previous Global Tsunami Hazard model
- TSUMAPS-NEAM hazard model
- ChEESE1P – local hazard workflow

PD3: Objectives - HPC PTHA capacity workflow development:

- Exploiting tier-0 and tier-1 machines.
- Multiscale (from global to local) PTHA at any location worldwide

SC3.1 Objectives

- Based on PD3 development
- Provide a global seismic tsunami hazard map at unprecedented resolution.
- Substantially extend the resolution and uncertainty treatment to provide a new global benchmark.



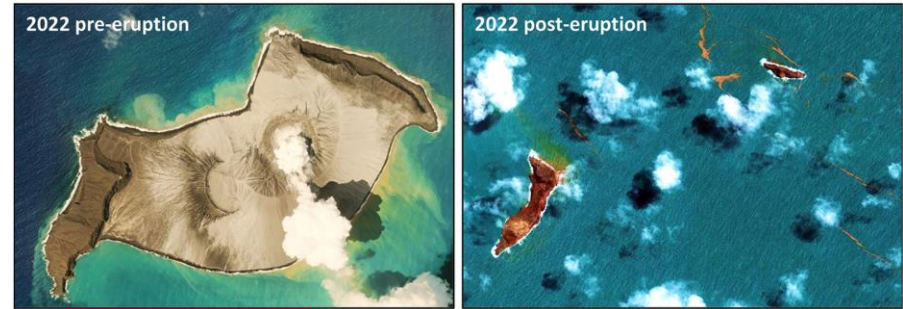
Highly collaborative activity: **INGV**, **UMA**, **NGI**, **TUM**, **LMU**

GAR
Global Assessment Report
on Disaster Risk Reduction
2015



PD4 + SC4.1 - The 2022 Hunga-Tonga volcanic eruption

- The eruption generated ocean-wide tsunamis, never before recorded in the Pacific instrumental record.
- 40+ papers up to now
- Extreme event characterised by a high level of complexity
- This event presents a unique opportunity for investigating the multiple processes contributing to volcanic tsunami-genesis as a capability modelling challenge



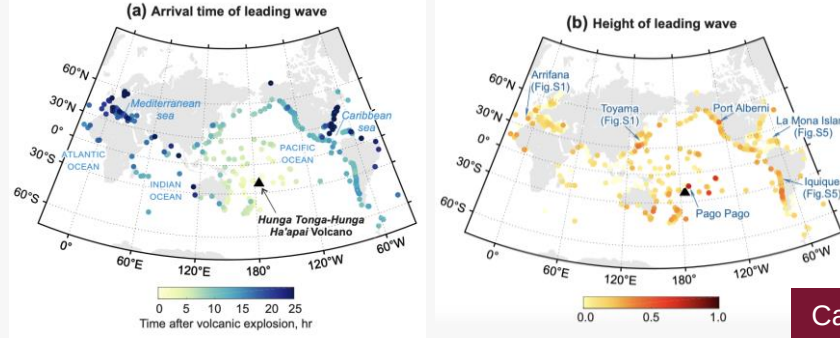
Terry et al, 2022

- VEI 5 (greater than Pinatubo 1991)
- The largest submarine eruption since 1883 Krakatau



SC4.1 - The 2022 Hunga-Tonga volcanic eruption

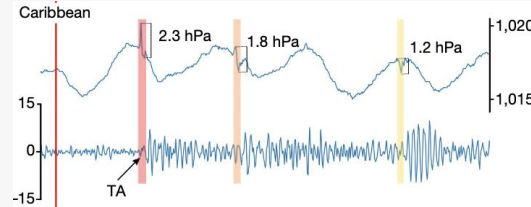
- Global tsunami propagation
- High propagation speed of the leading waves
- Low long tsunami dissipation
- Correlation between first tsunami arrival and Lamb wave passage



Leading Tsunami wave generated by the Lamb wave (coincident with the acoustic gravity wave due to the explosion)

Carvajal et al, 2022

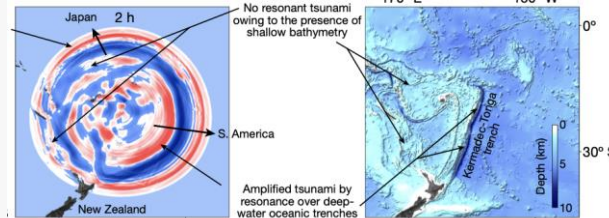
Additional air-pressure disturbances (due to following passages of the acoustic gravity waves)



Exceptional long duration

Omira et al, 2022

Amplification of the tsunami when acoustic gravity wave speed matches the speed of long wave in the ocean

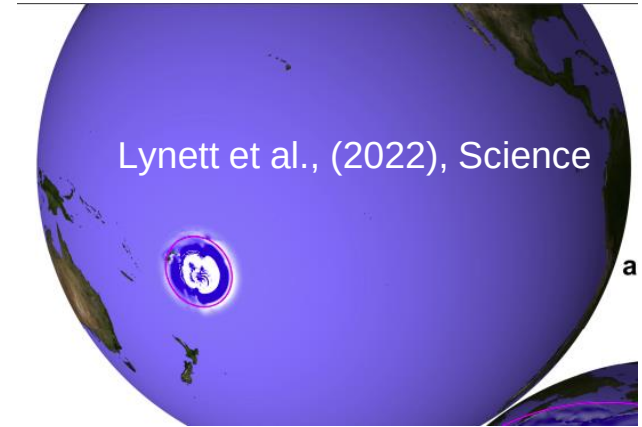


Evidence of Proudman resonance

Omira et al, 2022

NGI main contributions to ChEESE2
PD4 - Complex multi-source tsunami modeling
SC4.1 - Multi-source local high-resolution scenario with emphasis on the 2022 Tonga case

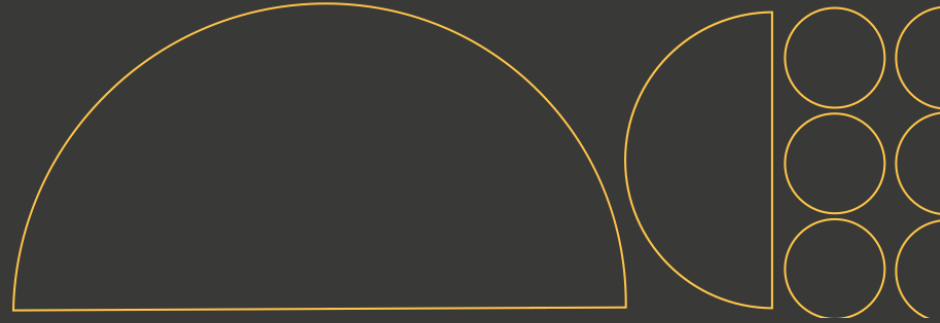
- PD4: Combine processes from earthquakes, landslides, volcanoes, and acoustic pressure and atmospheric forcing to tsunamis in a single workflow
- The related simulation case will be primarily the 2022 Hunga-Tonga case and
 - resolving the source dynamics locally
 - coupling the global pressure wave and the global tsunami propagation
- Other complex modelling candidates such as 2018 Palu may also be pursued / improved



Highly collaborative activity: **NGI**, **UMA**, **INGV**, **TUM**, **LMU**, **CNRS**, **IRB**, **UM**



Thank you!



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<http://cheese2.eu>



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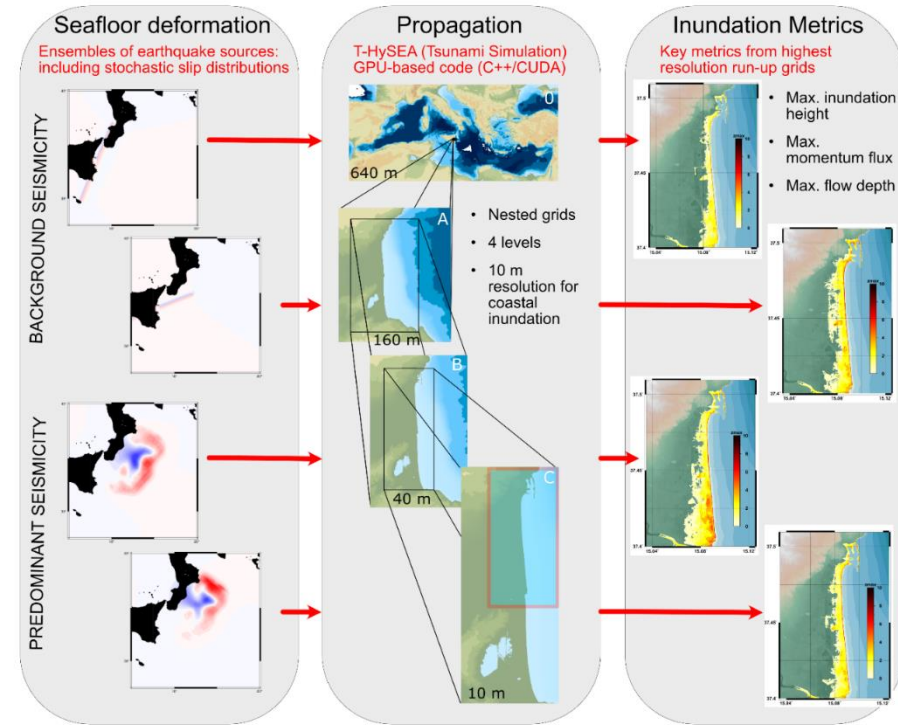


@cheese_coe@techhub.social

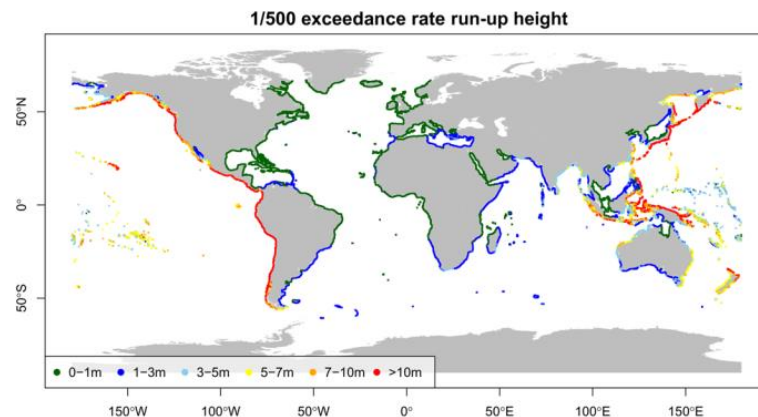
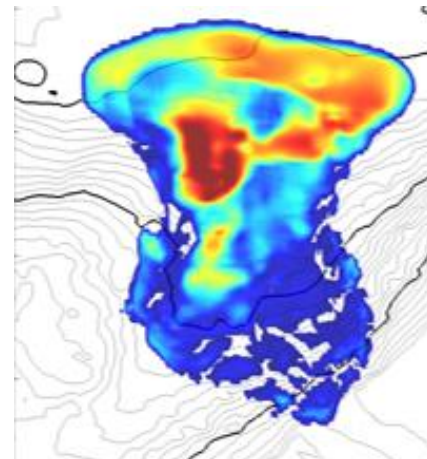


NGI: Background experiences – past EU projects

- Conducted tsunami research since mid 90ties
- Participants in major previous tsunami projects
 - TRANSFER (2006-2009)
 - ASTARTE (2013-2016)
 - TSUMAPS-NEAM (2016-2018)
- Interdisciplinary projects H2020 and Horizon Europe
 - SLATE-ITN (2017-2022)
 - ChEESE-1P CoE (2018-2022)
- Related input ChEESE2P
 - Local Probabilistic Tsunami Hazard Analysis (PTHA) workflow and Software from ChEESE1P together with INGV and UMA
 - Key input to PD3 and SC3.1 in WPs5-6



- Research Council of Norway
 - TsunamiLand (2014-2017)
 - Tsunamis in fjords (2012-2016)
 - International Center of Geohazards (2003-2013)
- Other projects
 - UNDRR Global Assessment Reports – GAR (2009-2019)
 - > 20 commercial projects related to practical hazard zonation, Norway, Greenland, Offshore projects
- Related input to ChEESE2P
 - Landslide dynamics models for multi-source tsunami generation
 - Global tsunami hazard model – next generation to feature in ChEESE2P via capability modelling



Common grounds and first GTM products

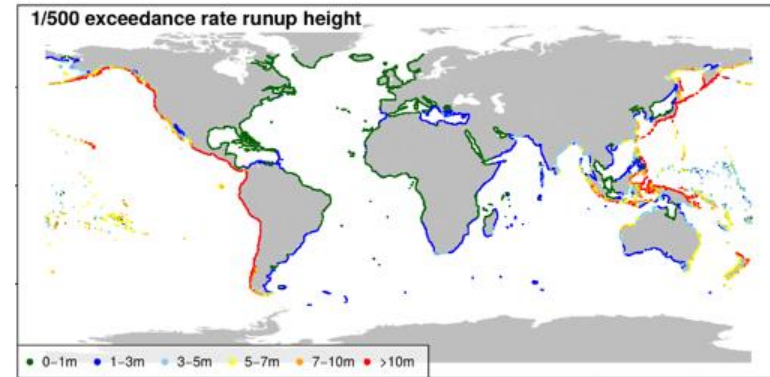
Related project results contributing to GTM:

- 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



Global Assessment Report
on Disaster Risk Reduction

2015

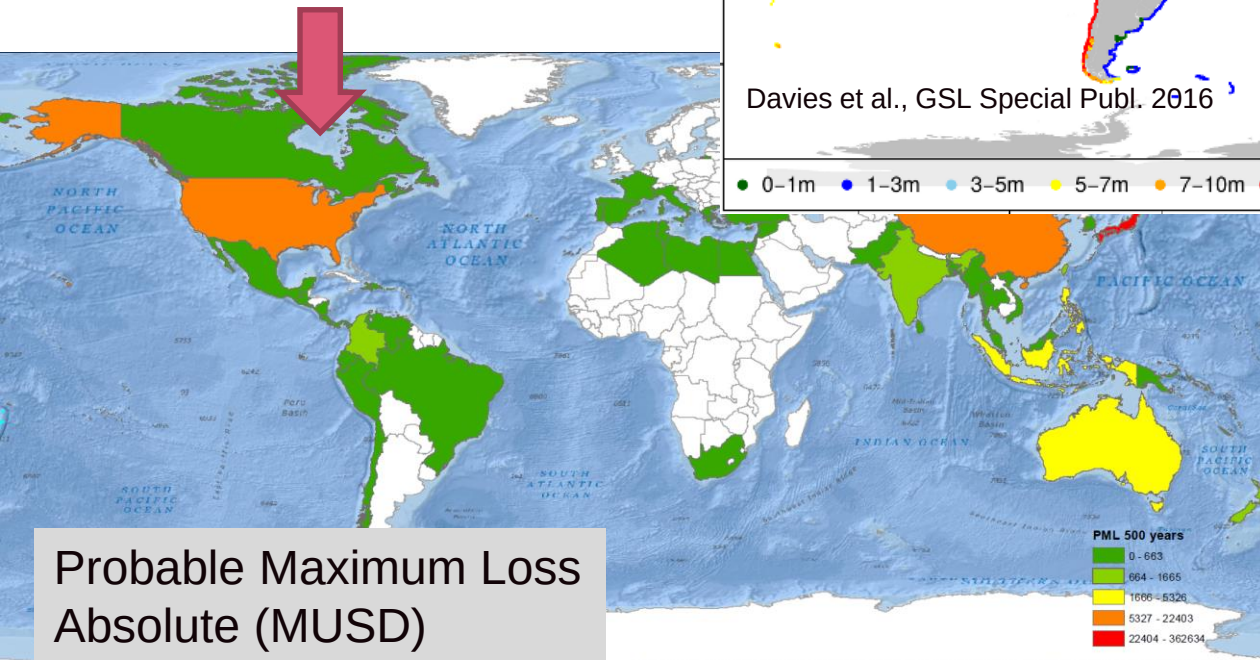


Davies et al., GSL Special Publ. 2016

GAR 15

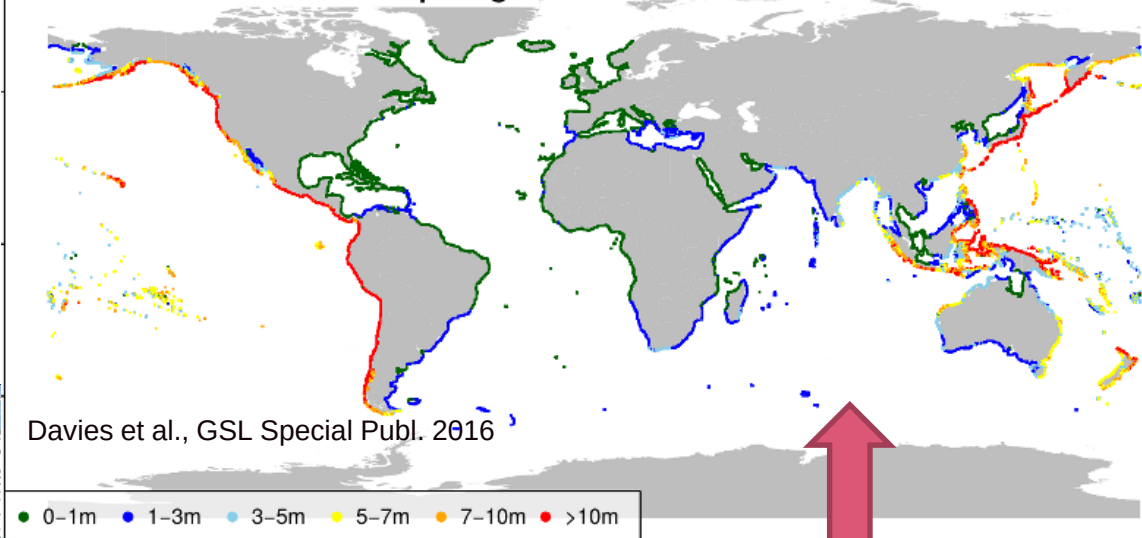
Full tsunami risk analysis, but not
disaggregation of hazard

Focused on losses estimation for nations



Probable Maximum Loss
Absolute (MUSD)

1/500 exceedance rate runup height



Davies et al., GSL Special Publ. 2016

GTM related work based
on the GAR

New global tsunami hazard
maps finalized
Deeper analysis on earthquake
model epistemic uncertainties