Intersessional Meeting of ICG/IOTWMS Working Group 1 on Tsunami Risk, Community Awareness and Preparedness

Status: An updated Probabilistic Tsunami Hazard Assessment (PTHA) for the Indian Ocean

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ICG/IOTWMS Intersessional Meetings
Working Group 1
12 July 2022

Agenda topics

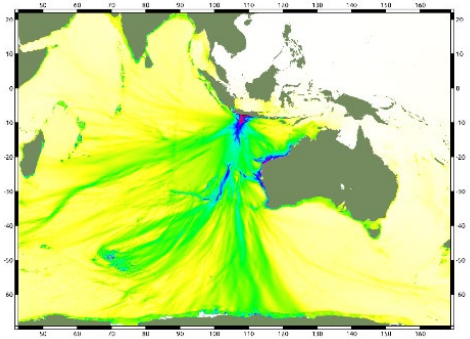
- **Updating the PTHA for the Indian Ocean**

- **Inundation PTHA in Western Australia**
  - Ongoing project 2021-2024
  - Progress in large-scale onshore PTHA

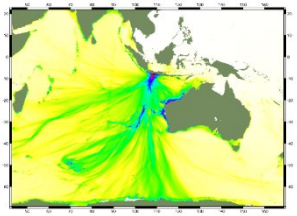
Firstly: A quick explanation of PTHA

What is PTHA?

- Tsunami hazard assessments can be *Deterministic* or *Probabilistic*
- Deterministic tsunami hazard assessment
  - Simulate one or more hypothetical tsunami scenarios
    - e.g. Java Mw 7.8 subduction earthquake-tsunami
  - Modelled impact used to infer hazard
  - Good points
    - Easy to understand
    - Relatively simple to implement
  - Weak points
    - Justification of the selected scenario(s) often difficult
      - Makran/Java → Great uncertainty in maximum earthquake magnitude
      - What about alternative earthquake locations / magnitudes / slip distributions?
    - No indication of *how likely*
      - But this is often important (e.g. NZ tsunami evacuation zones)
      - Once in 100 years, or once in 1,000,000 years?



What is PTHA?

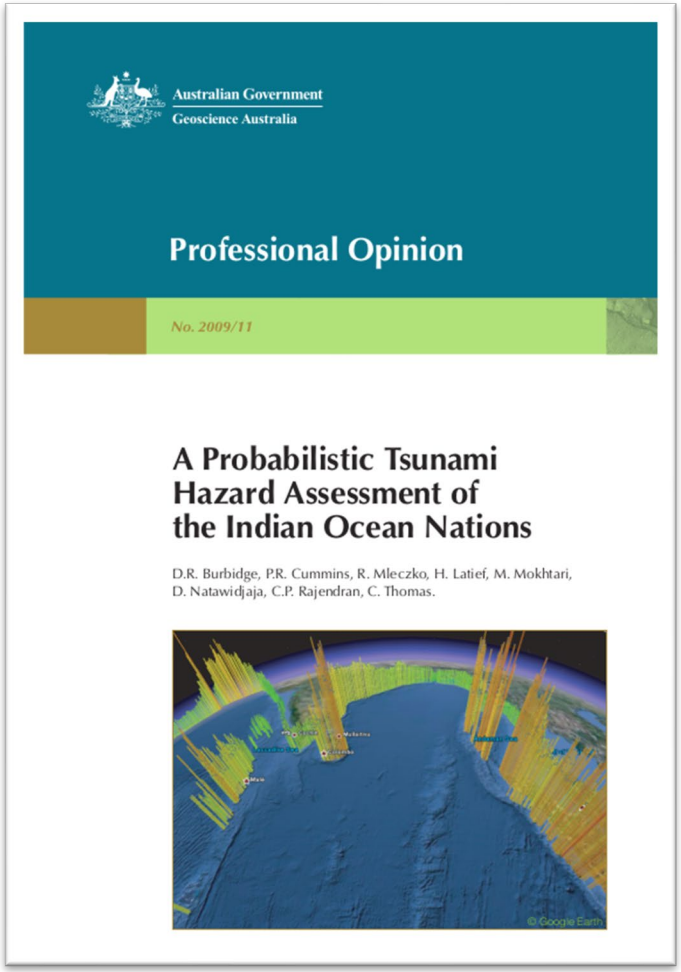


- Tsunami hazard assessments can be *Deterministic* or *Probabilistic*
- *Probabilistic tsunami hazard assessment (PTHA)*
  - Simulate many hypothetical tsunami scenarios
    - At least a few hundred (small), maybe 1000,000 (large)
  - Estimate their *rate-of-occurrence*
  - Good points
    - Explore many possible scenarios
    - Quantify uncertainties
      - e.g. There is a 50% chance that Mw > 9 earthquakes are possible
    - Means to address expert disagreement
      - Merge their opinions with different weights
    - Provides information on *how likely* tsunamis of different sizes are at any location
      - e.g. 10% chance of tsunami > 3m in 50 years at site of interest
  - Weak points
    - Complex to implement; Harder to communicate
    - Still can be sensitive to modelling approach

2009 PTHA for the Indian Ocean

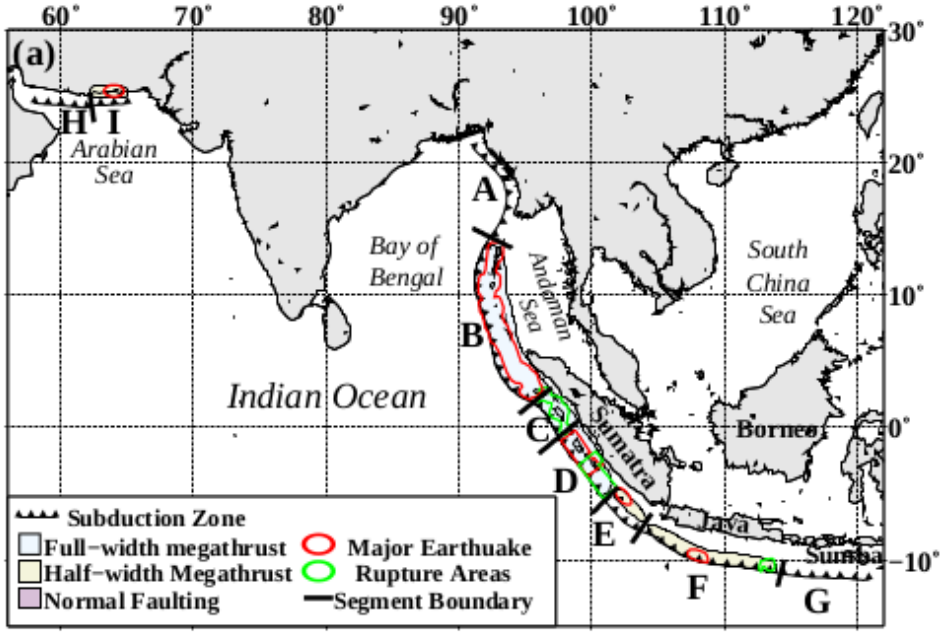
- **Existing IO PTHA (2009)**
  - Collaboratively developed by scientists from IO nations
    - Australia, Indonesia, India, Iran
  - Still in use
    - e.g. June 2018 Hyderabad tsunami modelling workshop
  - Accounted for expert disagreement on earthquake source uncertainty
    - Degree of segmentation
    - Maximum Magnitudes

  using High/Low parameters

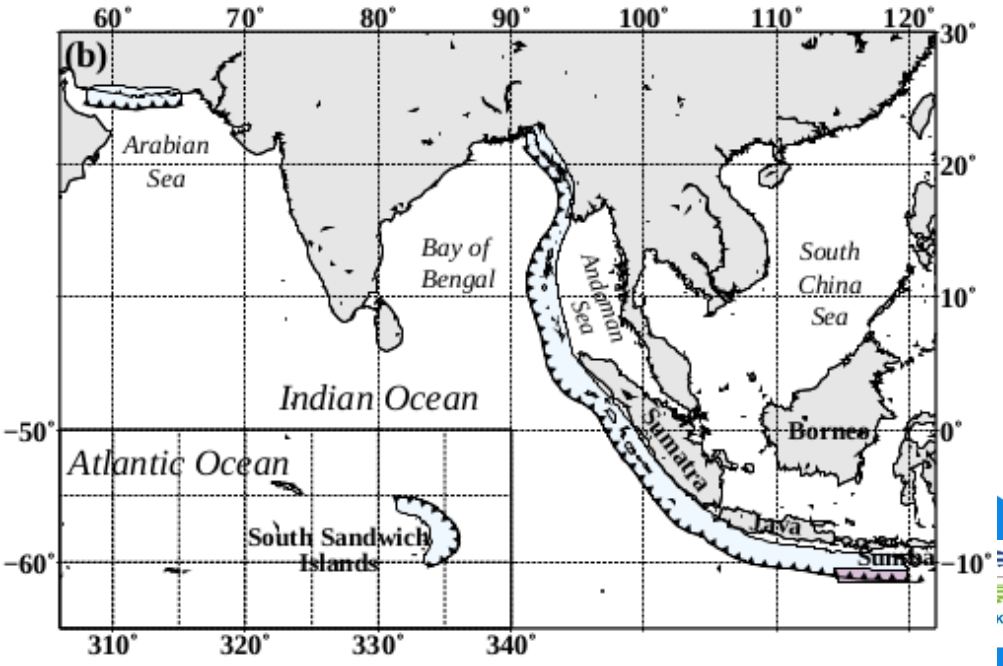


2009 study

Low hazard



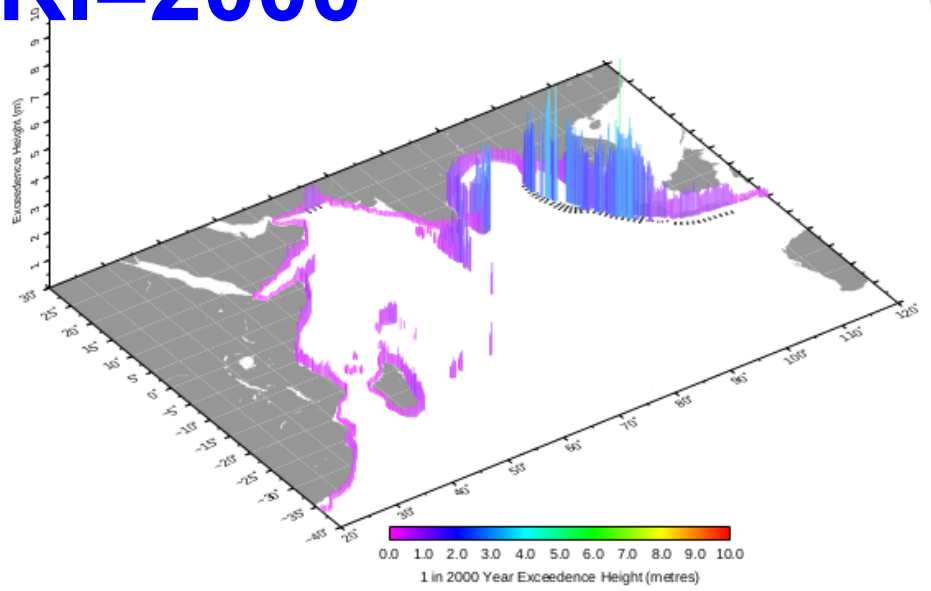
High hazard



2009 study, ARI=2000

(b)

Low hazard



High hazard

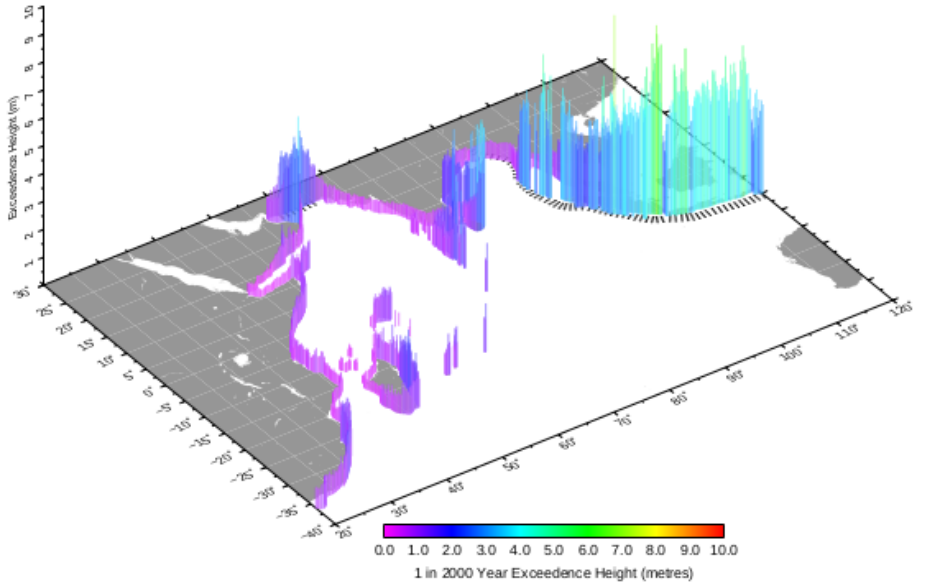


Figure 2: Regional hazard maps at the 2000 year return period for all the nations in the study for (a) the low hazard map and (b) the high hazard map.

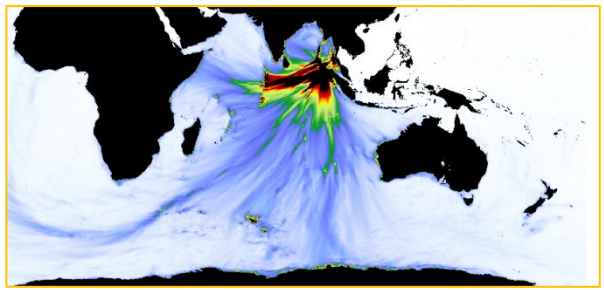
Progress in PTHA since 2009

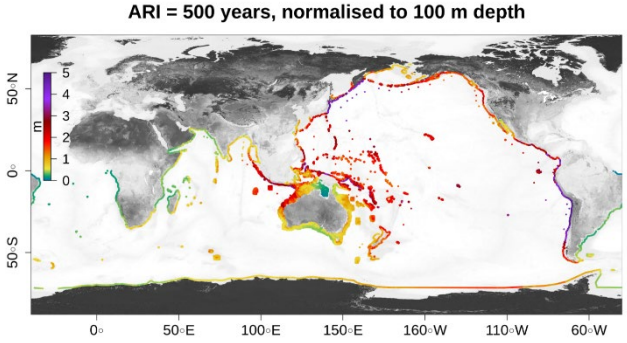
- **Learning from Tohoku 2011**
  - Compact slip / Near-trench slip
  - Under-estimation of Mw-max by most prior hazard studies
- **Better appreciation of 'tsunami-earthquakes'**
- **Continued discussion on uncertainties & quantification**
  - But this remains controversial
- **Much more observational data (+10y DART buoys)**
  - Model testing
- **Many new studies relevant to IO have been published**
  - Makran / Indonesia / India …
  - Global hazard assessments
- **PTHAs for non-earthquake sources**

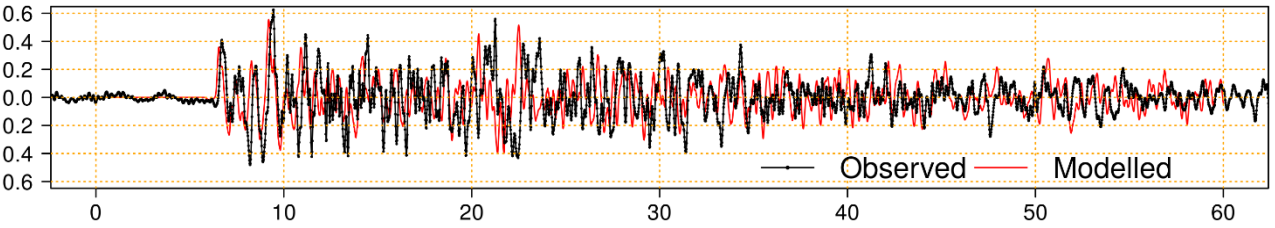
United Nations Educational, Scientific and Cultural Organization | Intergovernmental Oceanographic Commission | Indian Ocean Tsunami Information Centre | BMKG

Kish Island meeting, Iran, 03/2019

- **Decision ICG/IOTWMS-XII.1 (**Kish Island, Islamic Republic of Iran 9–12 March 2019) Requests Working Group 1 to:
  - Update the Probabilistic Tsunami Hazard Assessment (PTHA) for Indian Ocean *based on recent work by Geoscience Australia* in collaboration with relevant experts from the Member States;

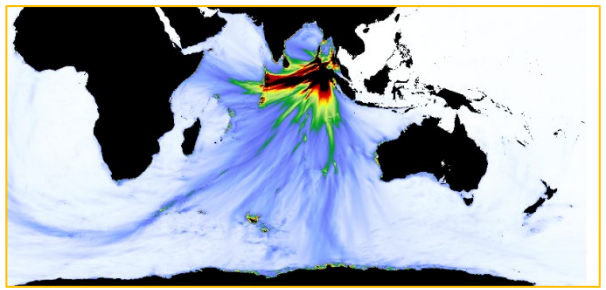


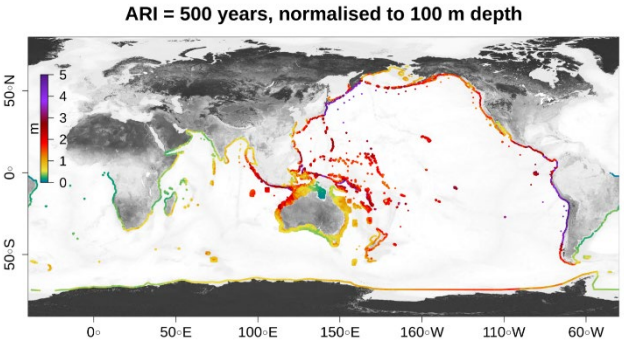


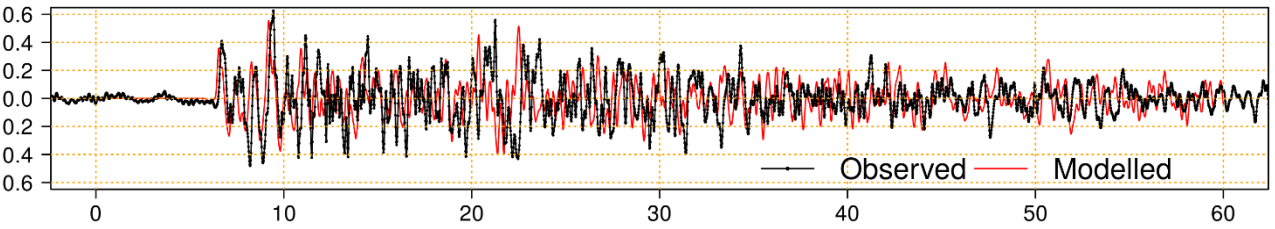


Jakarta meeting, Indonesia, 30/09/2019

- **Noted that**
  - Hazard modellers in the Indian Ocean can already use the 2018 Australian PTHA [freely available]
  - Uncertainties in earthquake source-representation favour an approach that includes multiple regional experts
    - Enhance end-user ownership & acceptance of methodology
    - This is happening in Makran







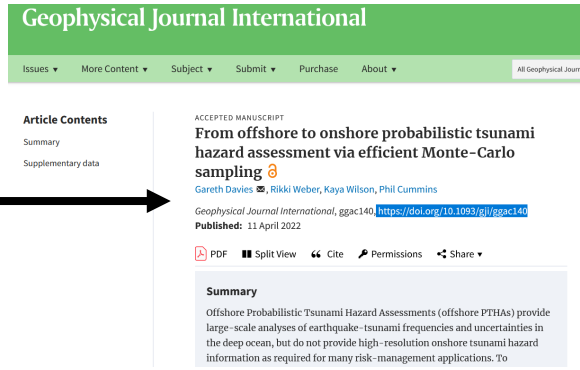
Progress since 2019

- **Collaborative development of a new Makran PTHA**
  - Strong representation of multiple regional experts & international PTHA scientists
  - Current status?

- **IOTWMS strategy [previous WG1 meeting]:**
  - **Aim for IO PTHA to begin after the Makran study is finished**
    - Similar process, adapt from their learning
    - Also gives some time for COVID to settle down.
  - Aim to include much of the Indian Ocean tsunami hazard community
    - Overlapping with Makran study

New project:
Inundation PTHA in Western Australia

- **Collaboration with Geoscience Australian & local emergency services (DFES)**
  - June 2021 – June 2024
- **Tsunami inundation hazard maps for Western Australia**
  - PTHA18 + Large-scale inundation model
  - Methodology from this paper



- **Design of onshore evacuation maps**
  - Strong involvement of DFES staff
  - Derived from models & DFES expertise
    - Consider practicalities of communication / action
    - As well as model results

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Intergovernmental Oceanographic Commission
Indian Ocean Tsunami Information Centre
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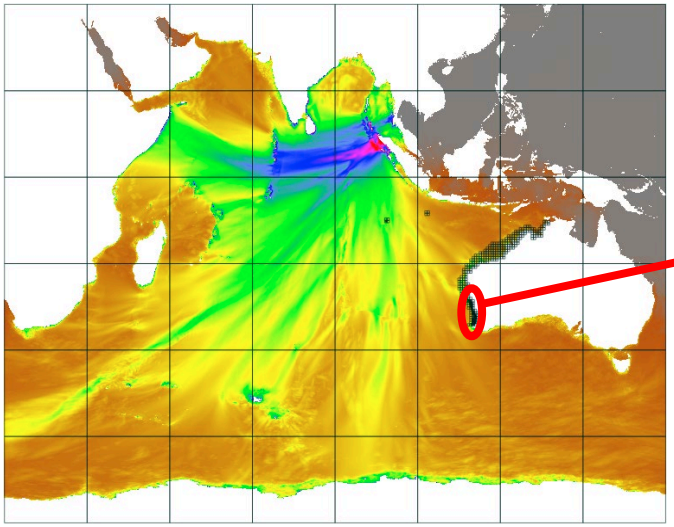
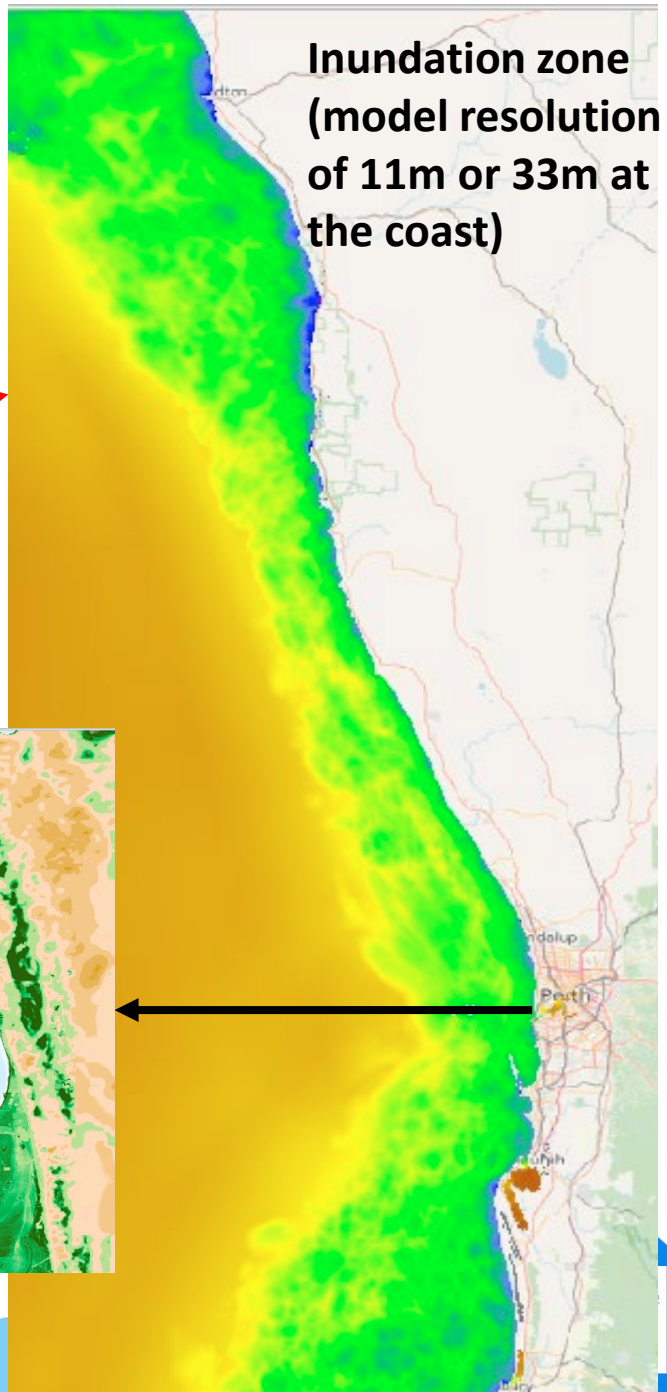
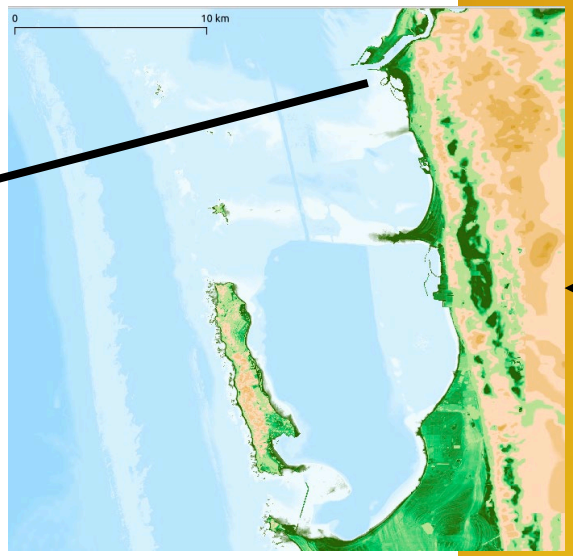
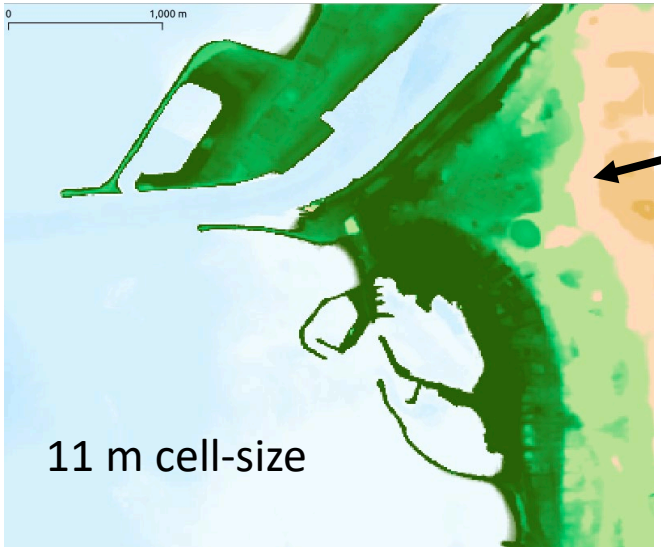
Inundation at scale





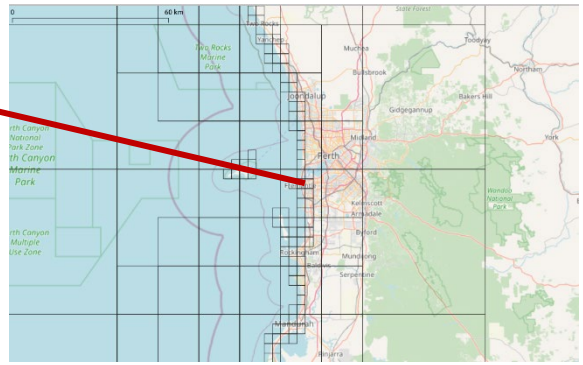




Annual probability of inundation based on PTHA18.

Figure shows chance of inundation in a small “zoom” of our model

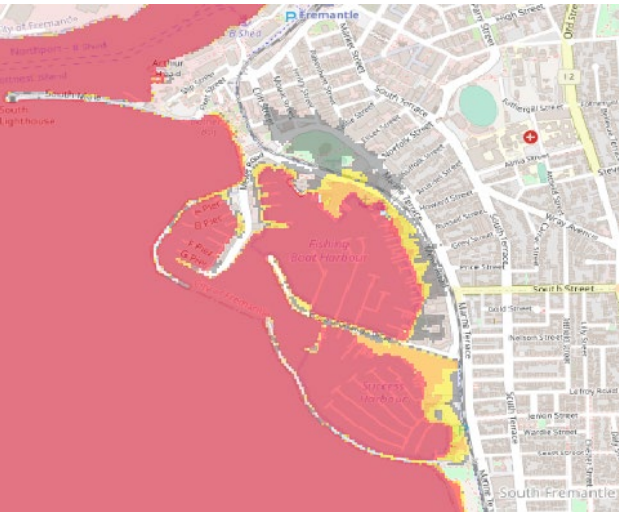
Similar products derived for hundreds of km of coast.



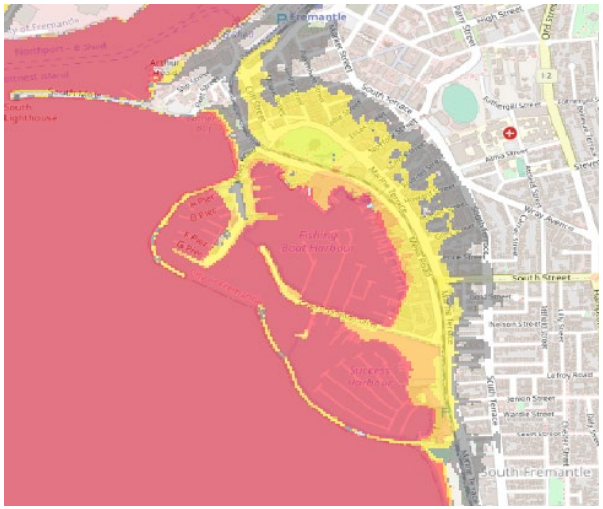
In future, zoned evacuation maps to be derived by combining models & DFES expertise

Sensitivity to uncertain large earthquake frequency

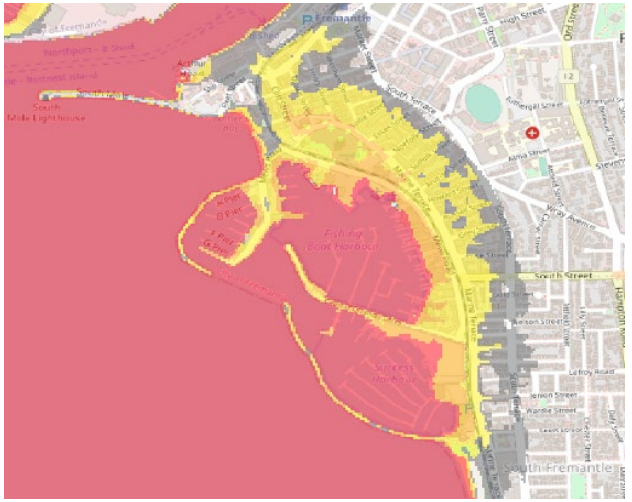
16th percentile



Mean (as previous)

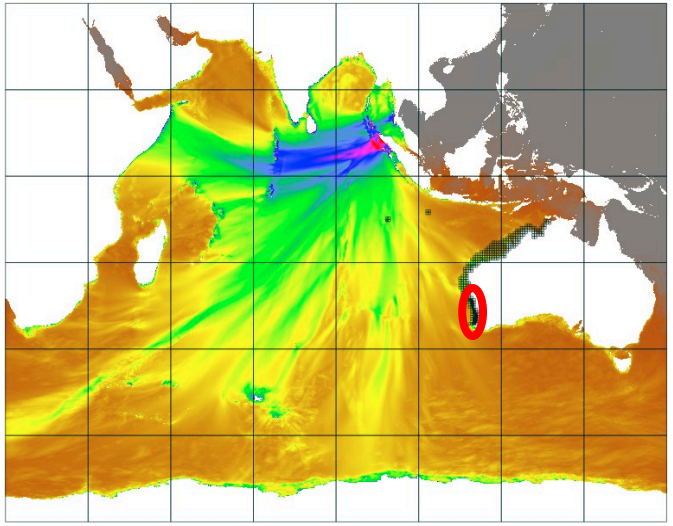


84th percentile



- Because it's based on PTHA, we can account for uncertainty in how often large earthquakes occur.
- Enables tailoring the "degree of conservatism" for different risk management applications

Key points



- **IO PTHA to follow Makran?**
  - Leverage learnings from that study
  - Overlapping community

- **Recent progress is enabling onshore PTHA to be derived from offshore PTHA <u>over large scales</u>**
  - This used to be impractical.
  - Will help us to use PTHA to inform onshore risk mitigation
    - Accounting for uncertainties in frequency
  - Implementation requires
    - Good elevation data over large areas
    - High performance computing