IT'S OUR FAULT
NŌ MĀTOU TE HAPA
Increasing Our Resilience
TE WHĀKAPIKI MANAHAU
WELLINGTON EARTHQUAKE RESEARCH PROGRAMME

It's Our Fault - Tsunami Hazard & Vulnerability

Xiaoming Wang on behalf of
Jean Roger, William Power, Aleksandra Henderson, Biljana Lukovic, Aditya Gusman & others

GNS Sciences
Lower Hutt, New Zealand

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Our Team

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IOF Tsunami Hazard & Vulnerability

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William Power

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Purposes of IOF Tsunami Workstream

- **To quantify tsunami hazard** from local sources, e.g. local crustal faults and Hikurangi subduction zone

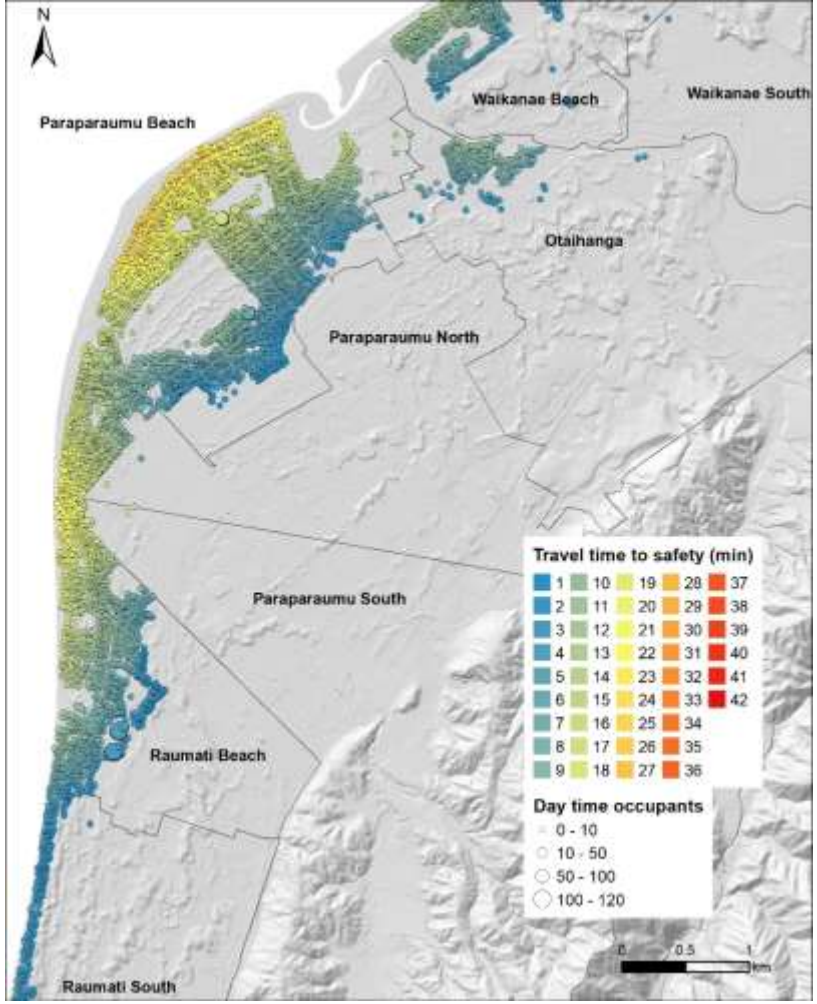
- **To estimate timing information** of local-source tsunami for evacuation planning purposes, and on the time required for residents and occupants of “at-risk” suburbs to reach safety.

- **To identify vulnerable areas** where additional work may be required to ensure that people are able to reach safety within the necessary timeframes.

Our studies in past few years

- **Tsunami travel time estimates** for
  - Wellington Harbour region suburbs,
  - Porirua and Kapiti Coast suburbs;
- **Least-cost based evacuation travel time modelling**
  - Wellington Harbour region,
  - Porirua and Kapiti Coast suburbs;
- **Agent-based evacuation modelling**
  - Wellington CBD suburbs;
  - Wellington's southern coast suburbs,
  - Porirua, Paraparaumu-Waikanae;

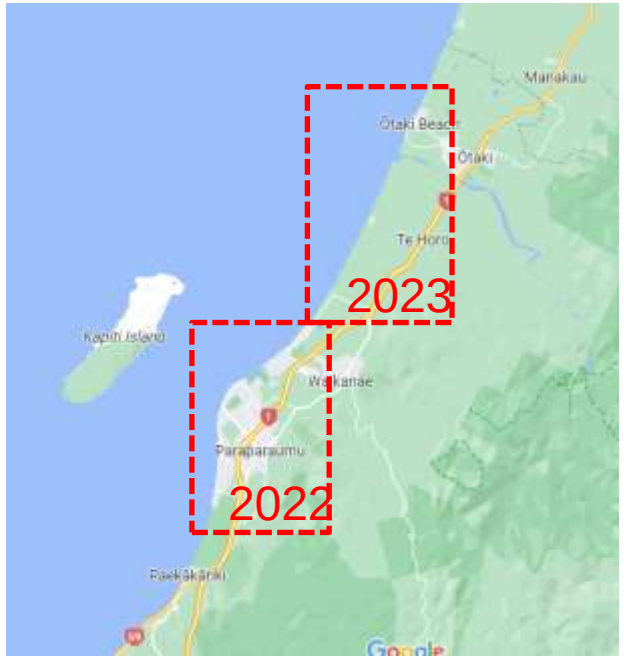
Coverages of completed agent-based evacuation modelling



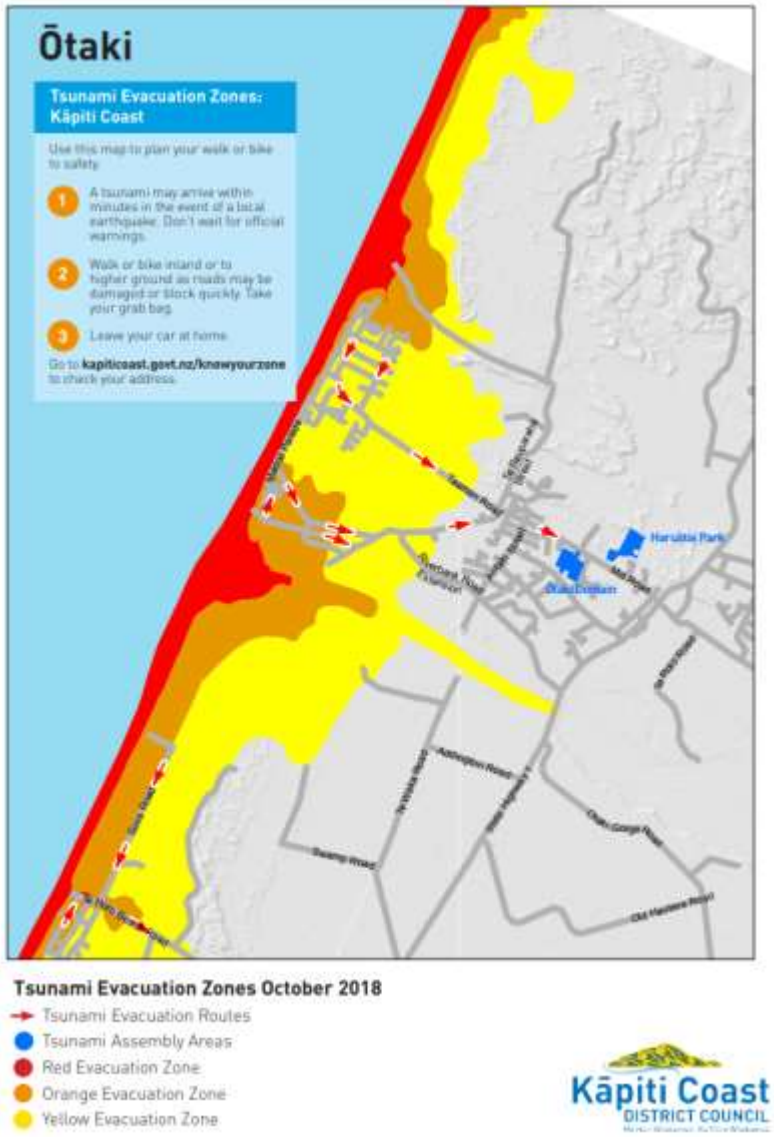
Evacuation travel time modelling (Heron et al. 2019)

Tsunami Tasks in FY 2022-2023

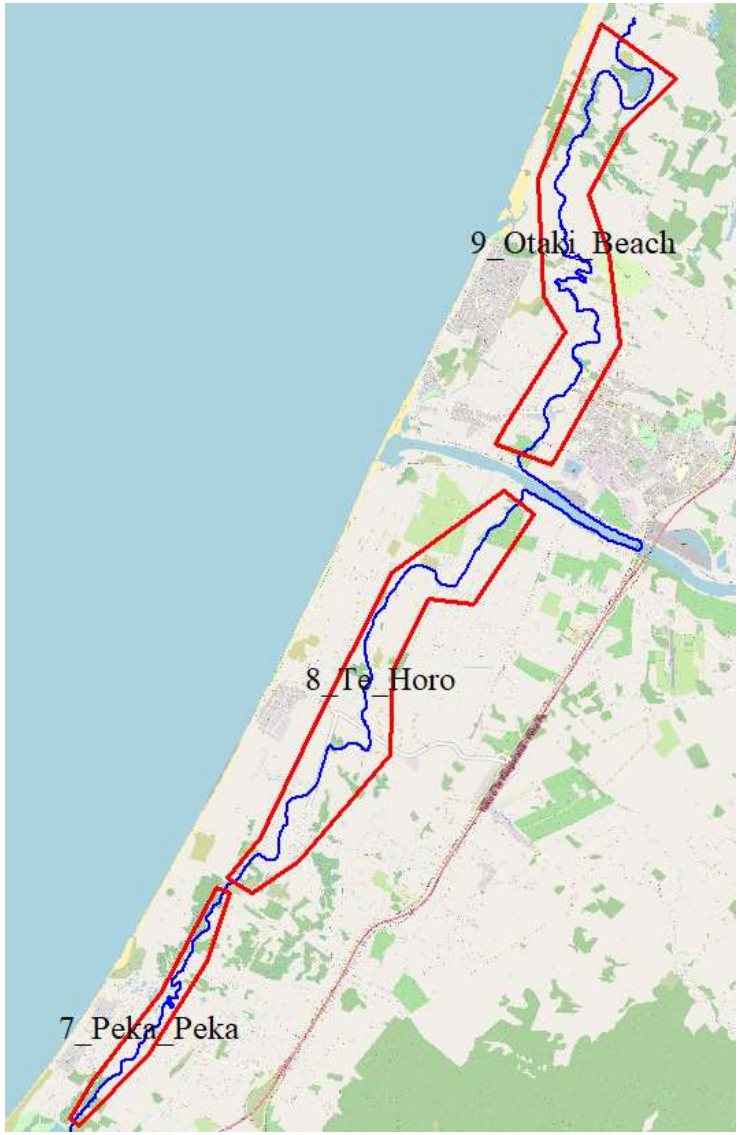
- Agent-based evacuation modelling for the northern Kāpiti Coast – Peka Peka, Te Horo Beach and Ōtāki Beach
- Impacts on coastal habitats and coastal restoration efforts
- Impacts on man-made environments – Mana Marina

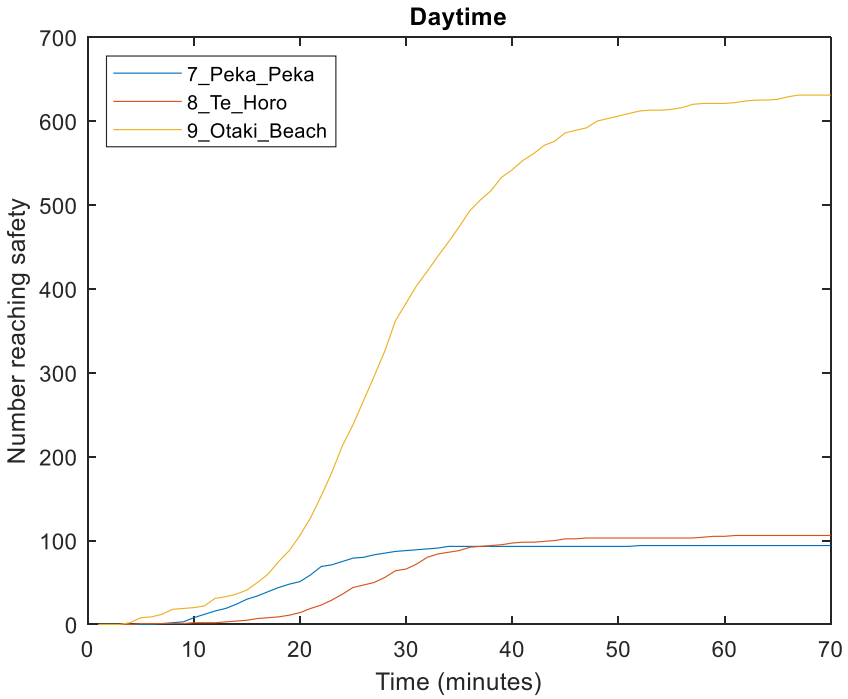


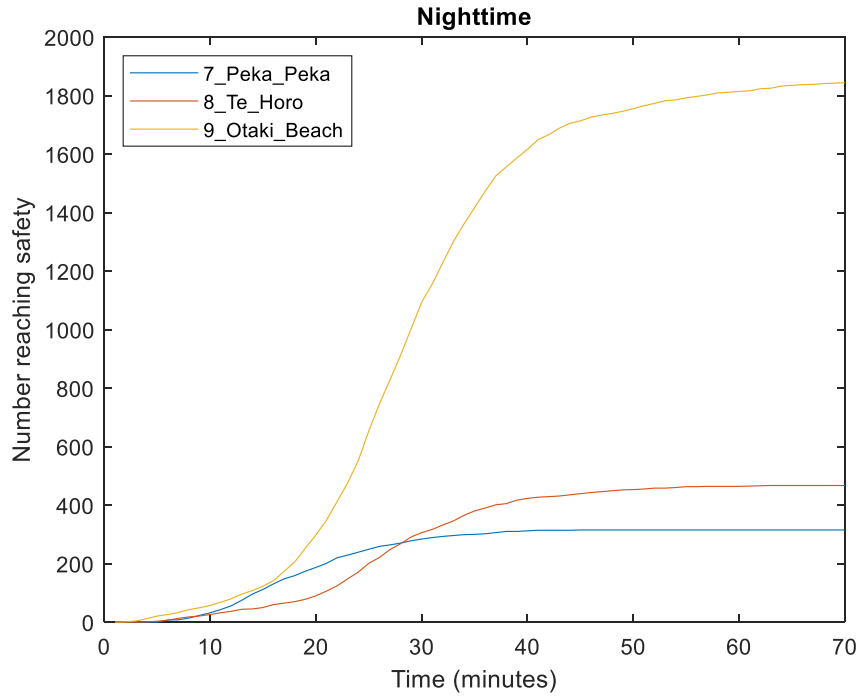
Agent-based Evacuation Modelling for northern Kapiti



Agent-based Evacuation Modelling – Initial Results



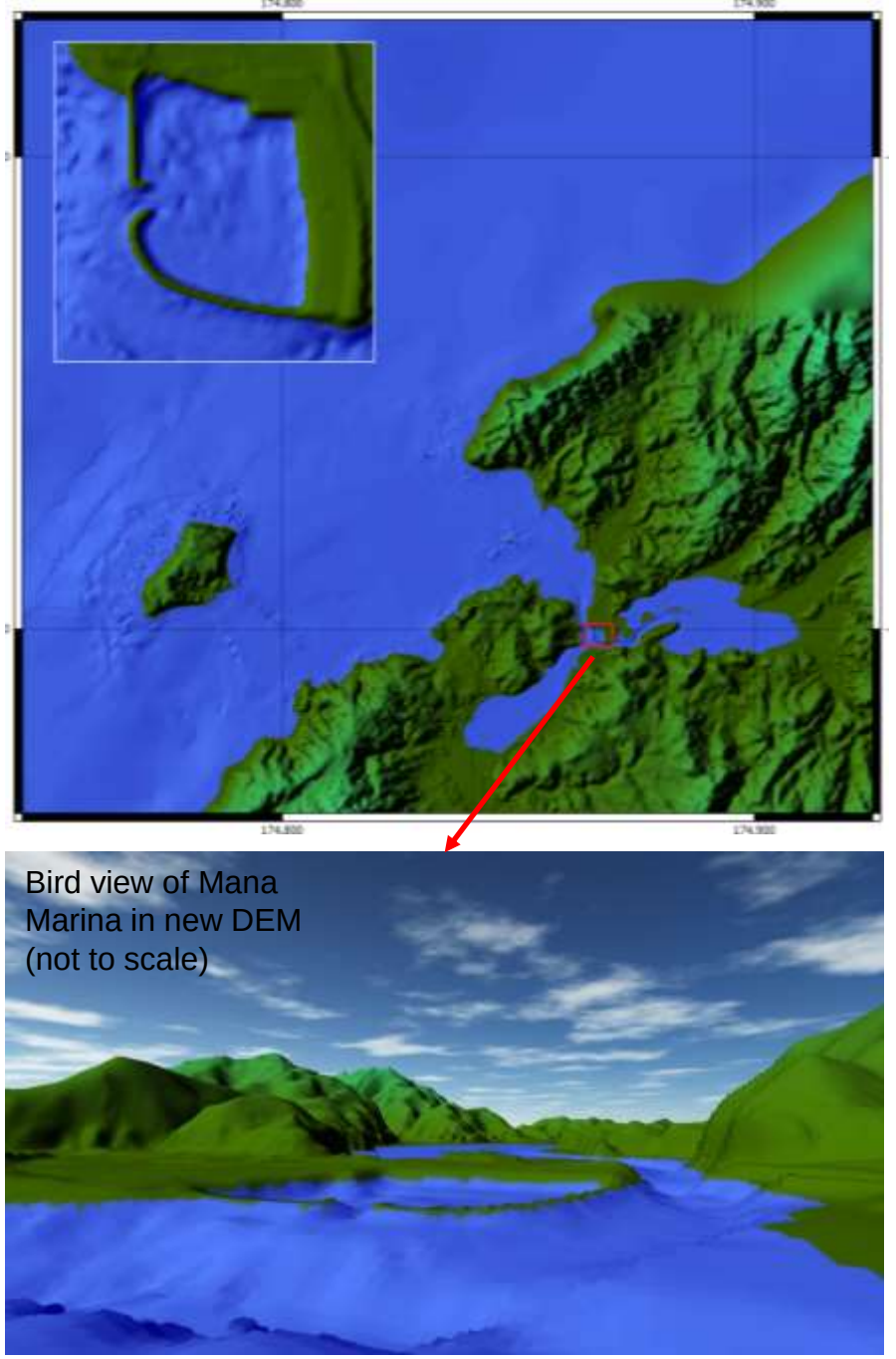




Suburb Name	Earliest Arrival Time	25th Percentile Arrival Time	50th Percentile Arrival Time	75th Percentile Arrival Time	Latest Arrival Time
	Minutes after Mainshock				
Peka Peka South	20.7	38.9	43.7	46.0	159.3
Peka Peka North	20.5	39.0	44.0	46.5	159.8
Te Horo	19.9	38.0	45.2	47.7	160.4
Te Horo Beach	19.0	38.3	46.4	50.0	163.1
Otaki South	18.7	38.0	46.3	51.3	63.2
Otaki Beach	18.0	30.7	47.6	52.9	252.6
Otaki North	17.1	30.4	46.8	54.4	208.1

Tsunami travel times from Hikurangi scenarios (Wang et al. 2021)

Tsunami Impact on Mana Marina

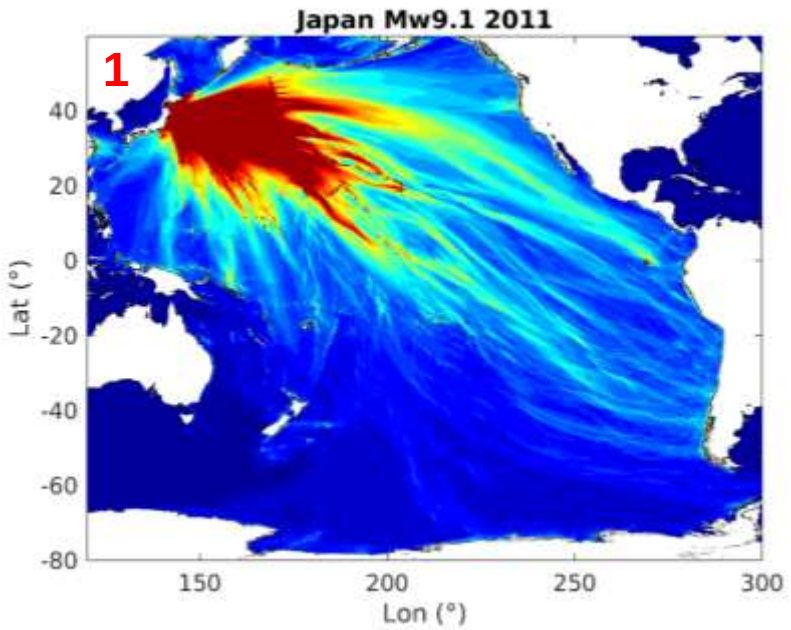


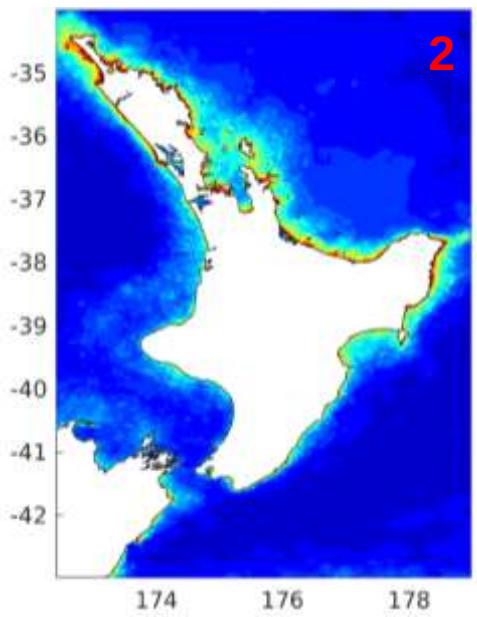
Bird view of Mana Marina in new DEM (not to scale)

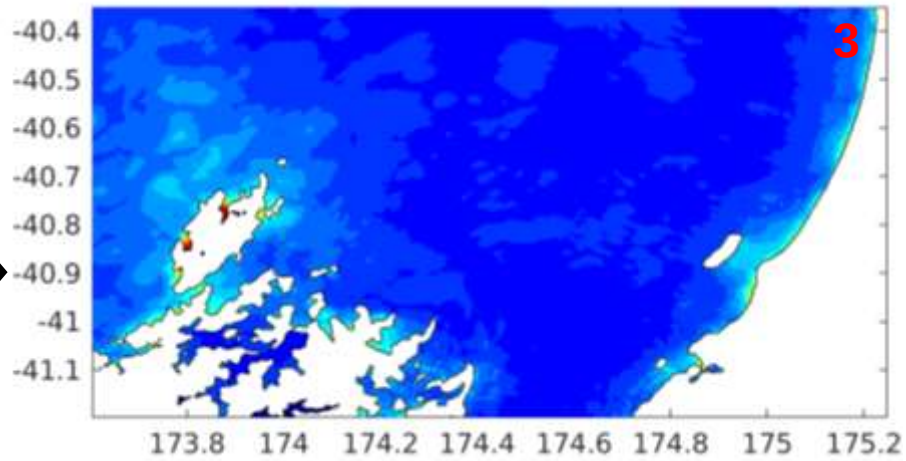
Mana Marina has experienced tsunami impact from past events, e.g. 2022 HTHH eruption.

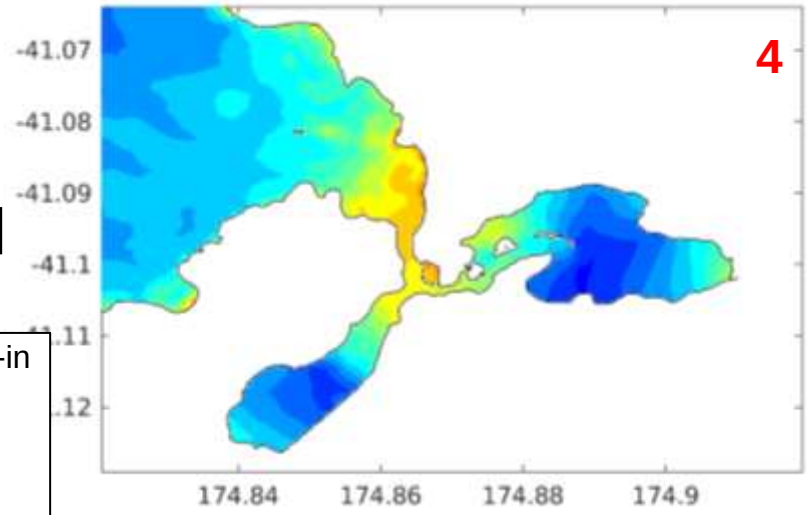
We developed new Porirua DEM, that incorporated the 2019 bathymetric survey, for Mana Marina tsunami impact modelling.

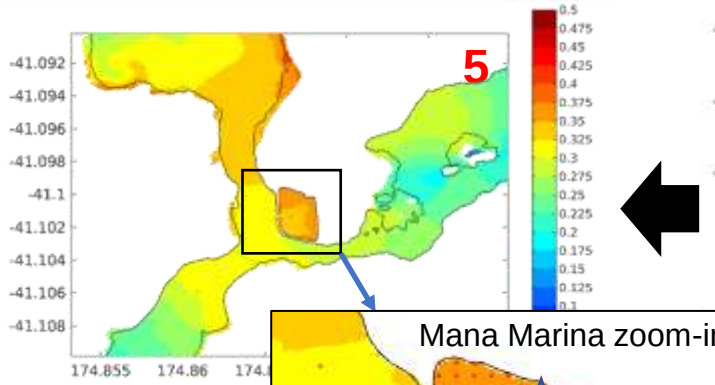
Model Setup for Mana Marina Tsunami Modelling

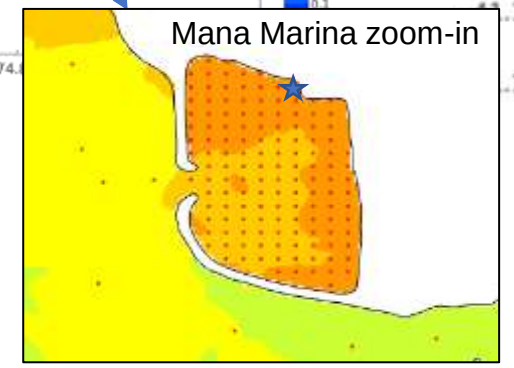










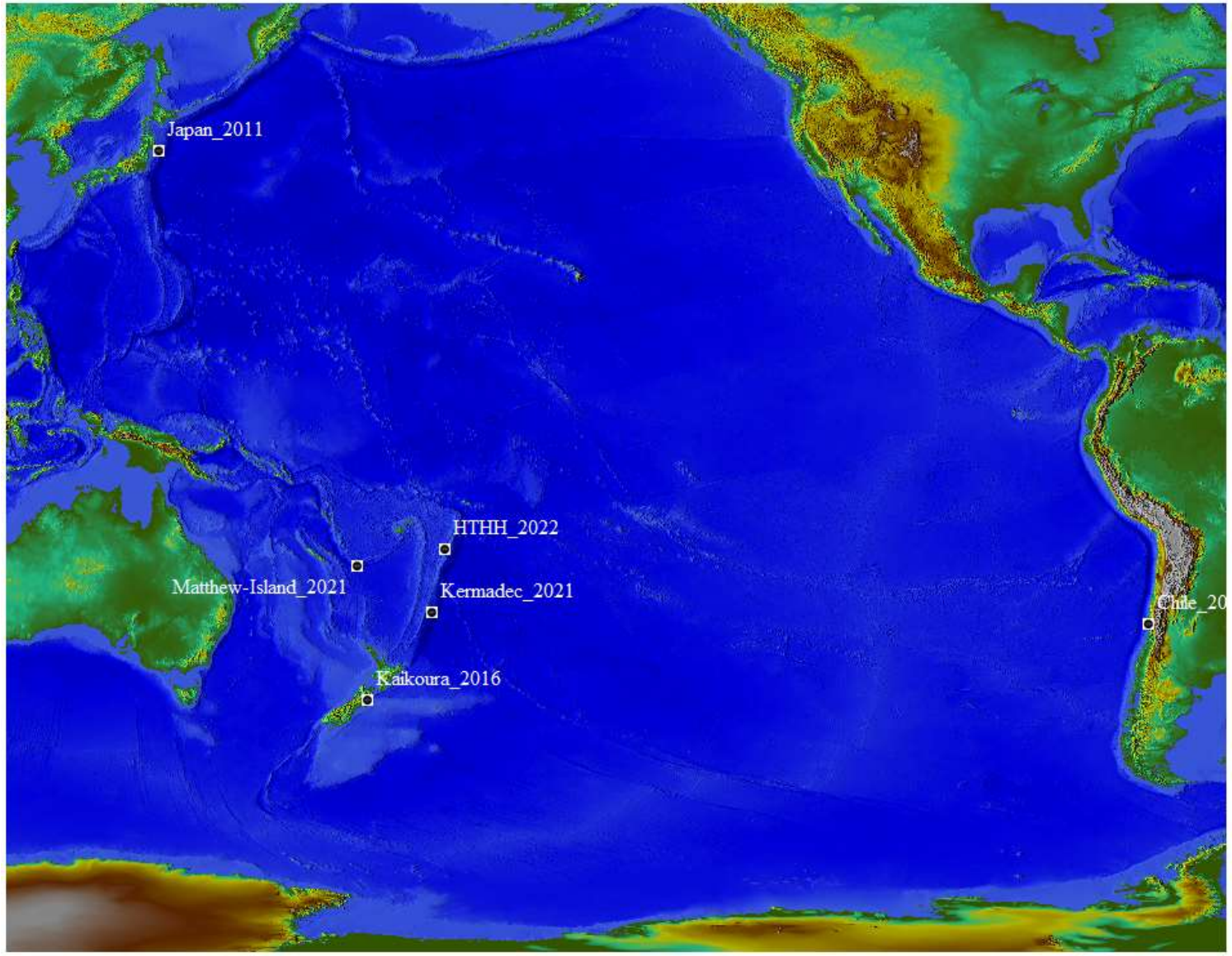


- COMCOT simulation model (Wang 2008; Wang & Power 2011)
- 5 levels of nested grids configuration
- Telescoping coverages from the Pacific (~3600m) to Porirua inlet & Mana Marina (~4m)
- Up to 48 hours of simulated tsunami
- Water level, current velocity & timeseries outputs

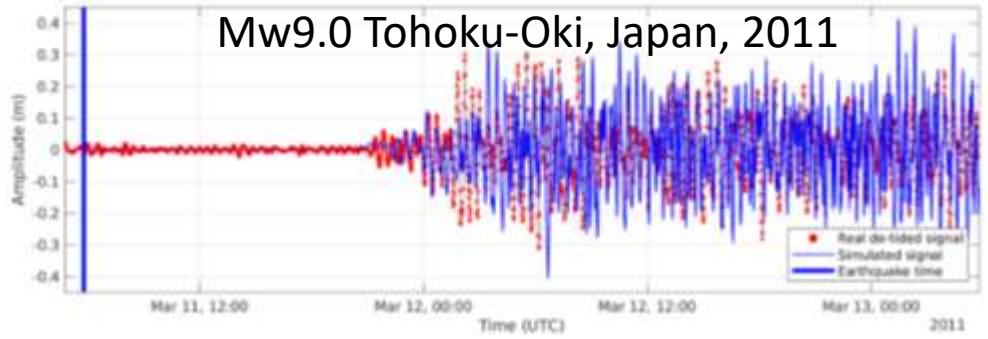
Mana Marina Tsunami Modelling – Recent & Historical Events

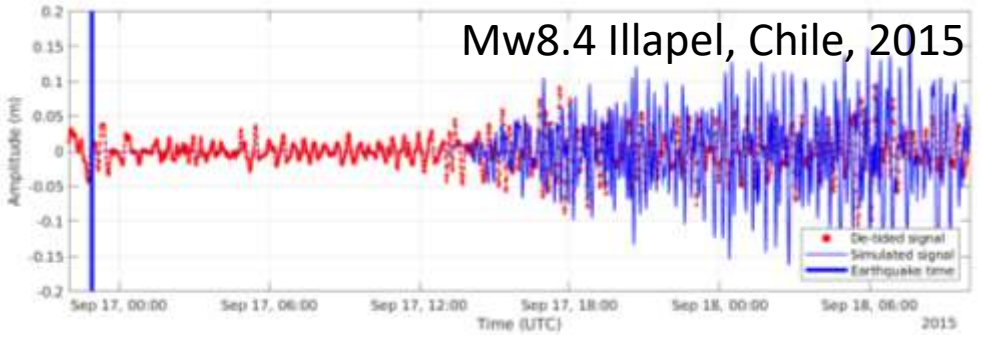
Tidal gauge records at Mana Marina show evidence of tsunami recordings during the following events:

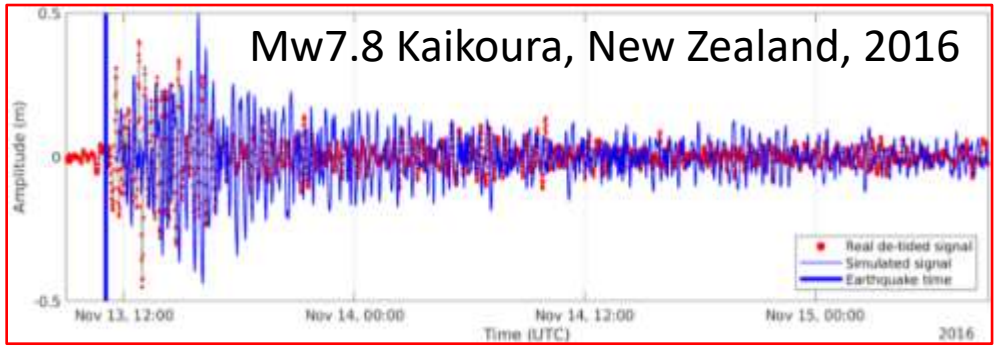
- 2011 Mw9.0 Tohuko-Oki earthquake in Japan
- 2015 Mw8.3-8.4 Illepal earthquake in Chile
- 2016 Mw7.8 Kaikoura earthquake
- 2021 Mw7.7 Matthew/Loyalty Is. earthquake
- 2021 Mw 8.1 Kermadec earthquake (“trinami”)
- 2022 Tonga HTHH volcano eruption and tsunami

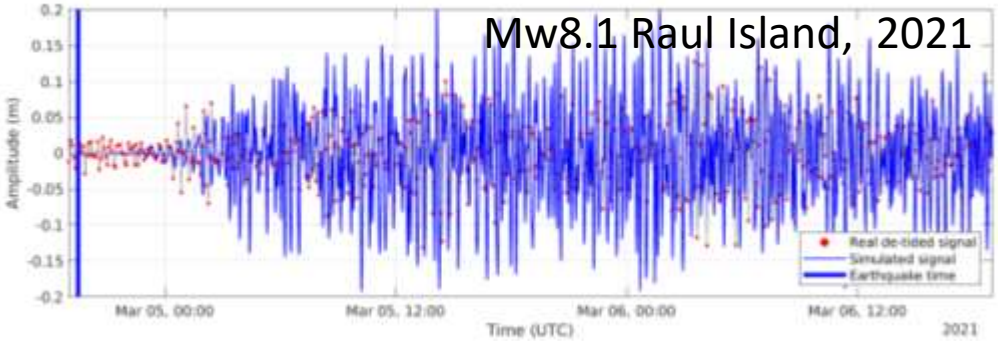


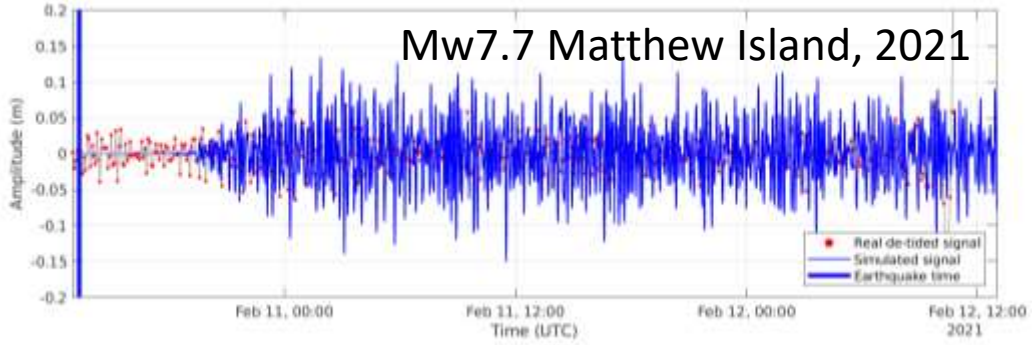
Mana Marina Tsunami Modelling – Historical Event Modelling

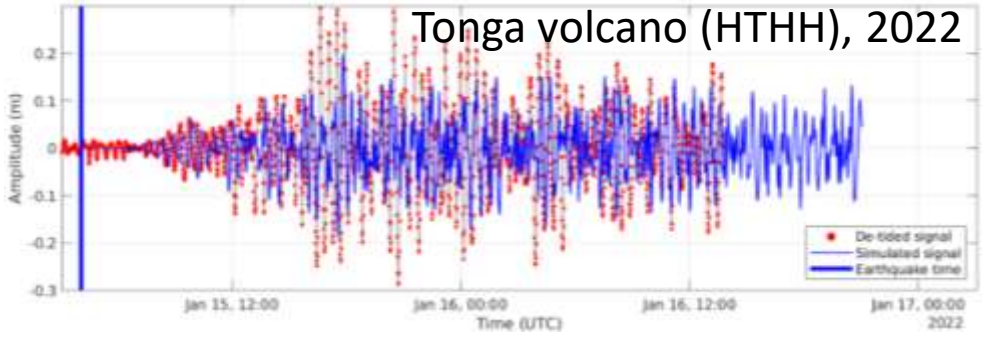






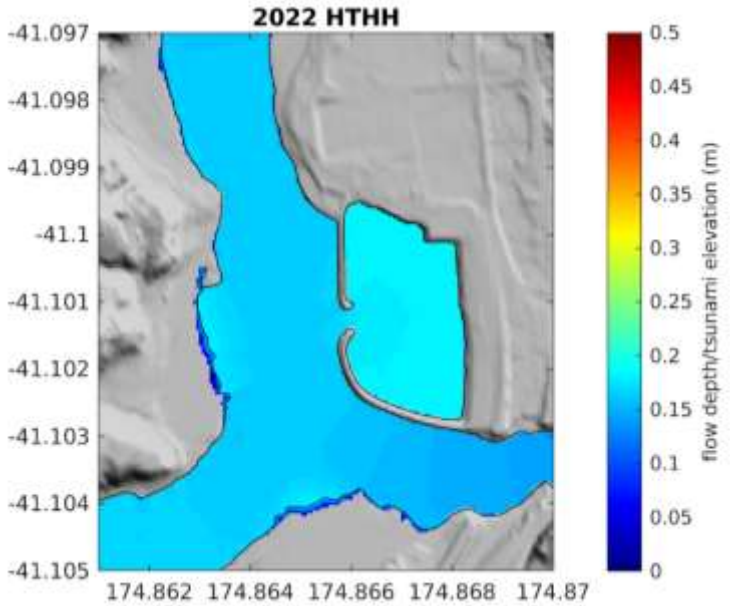




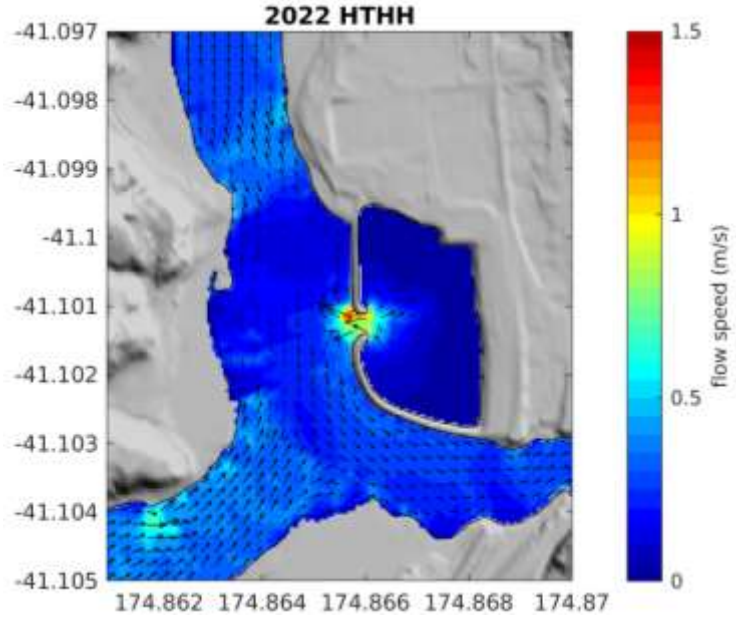


Tsunami Impact on Mana Marina – 2022/01/15 HTHH Volcanic Tsunami

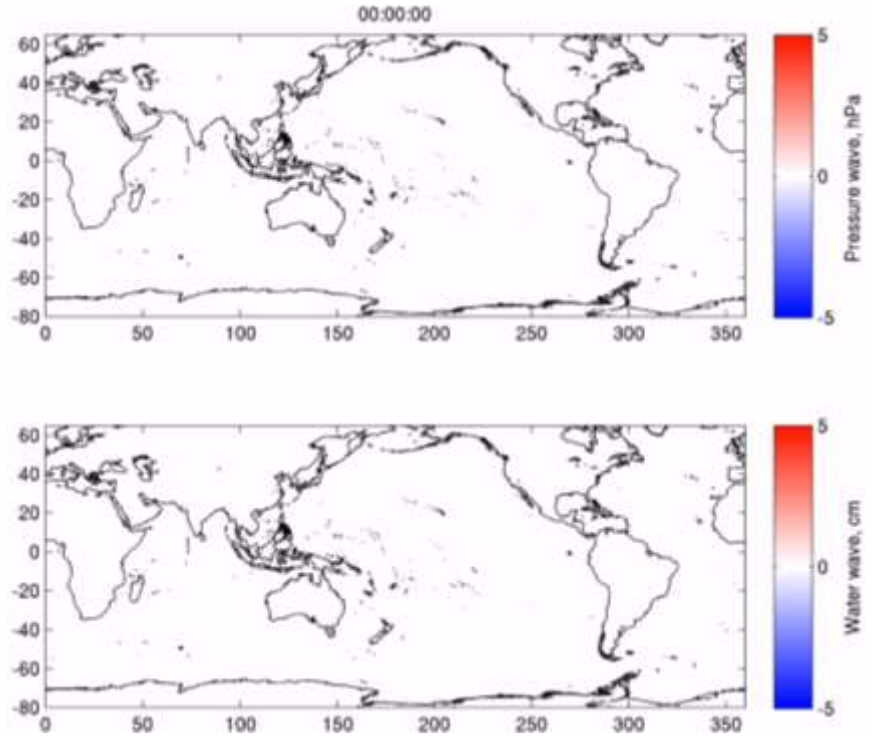
We modelled tsunami at Mana Marina generated by fast-travelling air waves from the 15/01/2022 HTHH explosive eruption, using the air wave model of Gusman et al. (2022)



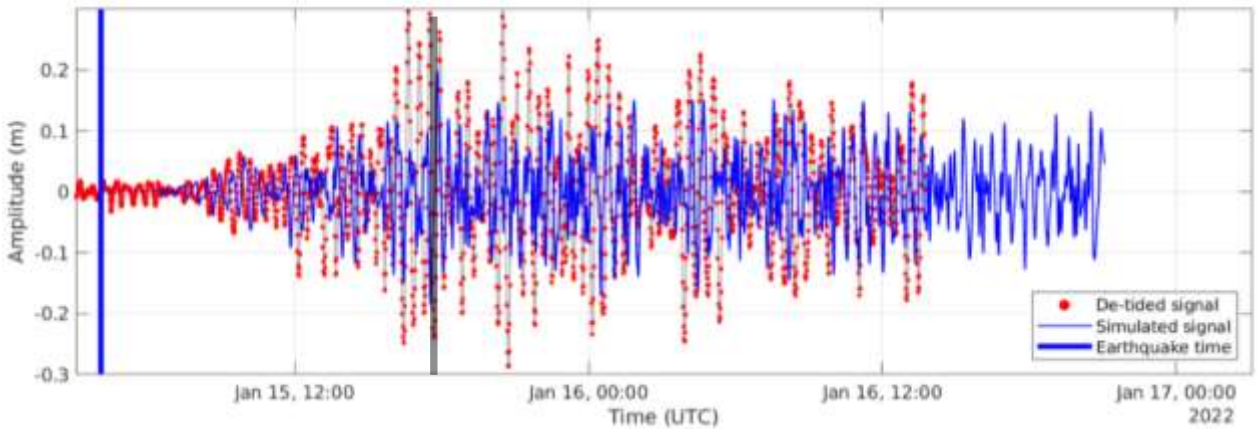
Maximum tsunami elevation



Maximum current velocity



Global simulation of air waves & tsunami



Video footage inside Mana Marina (12.5 hours after eruption)

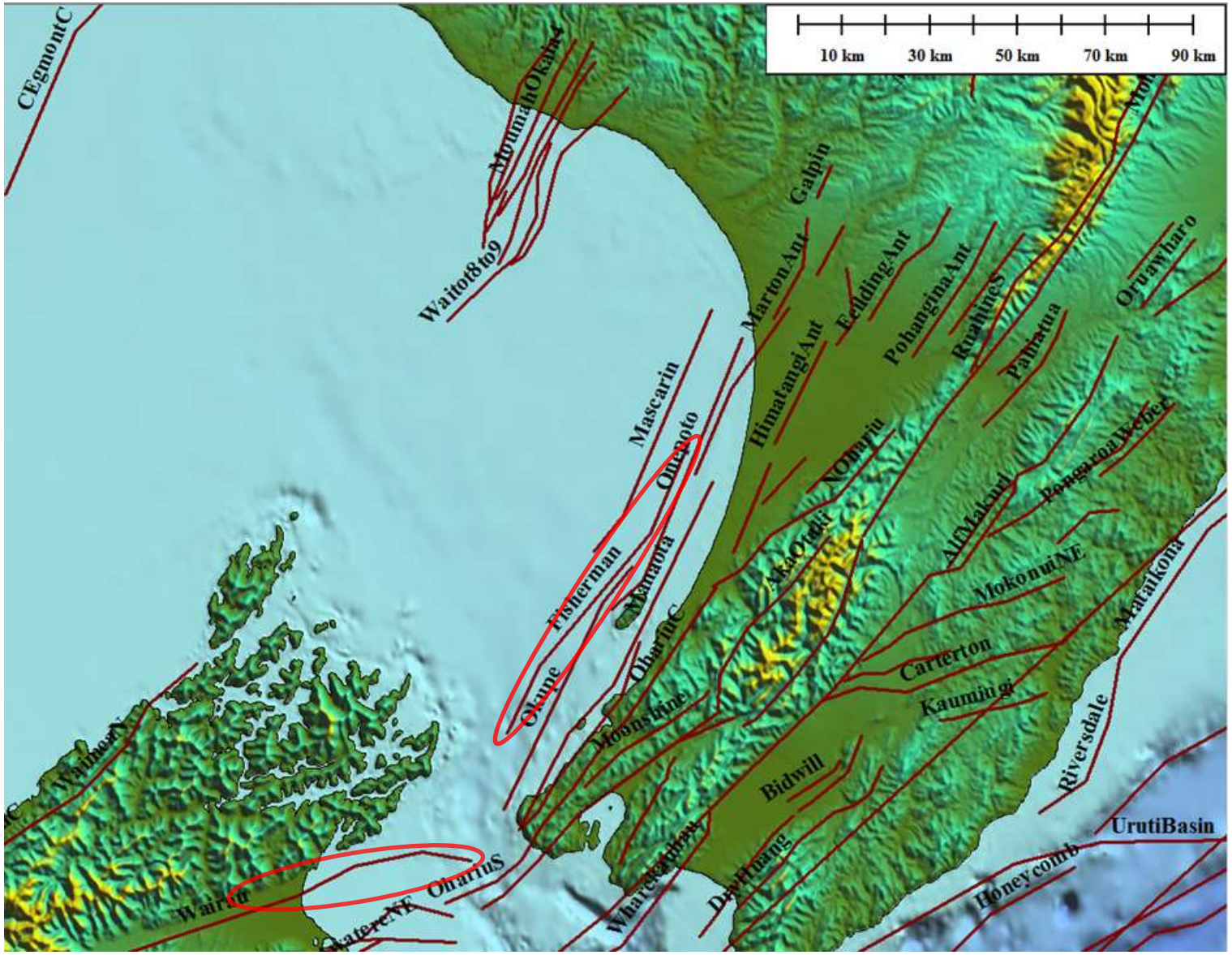
Mana Marina Tsunami Modelling – Synthetic Scenarios

Crustal fault and Subduction zone scenarios:

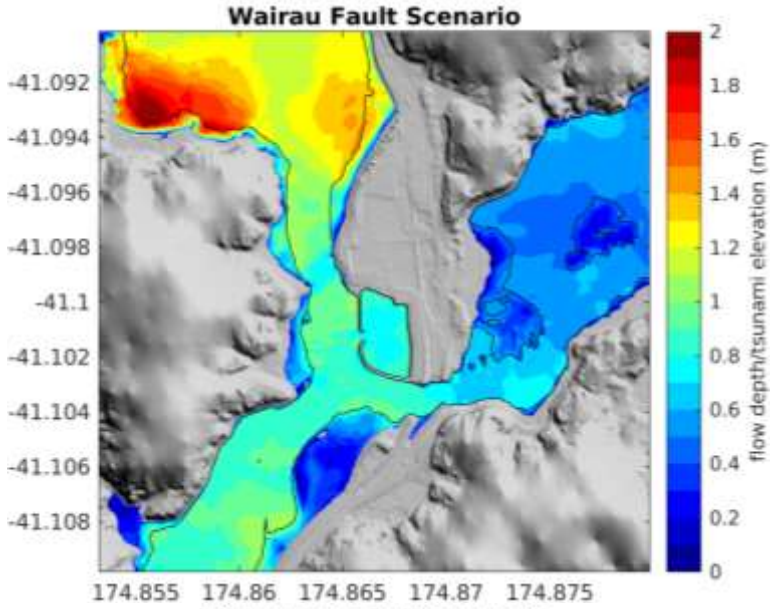
- Mw 7.8 Wairau Fault scenario
- Mw 7.5 Fisherman Fault scenario

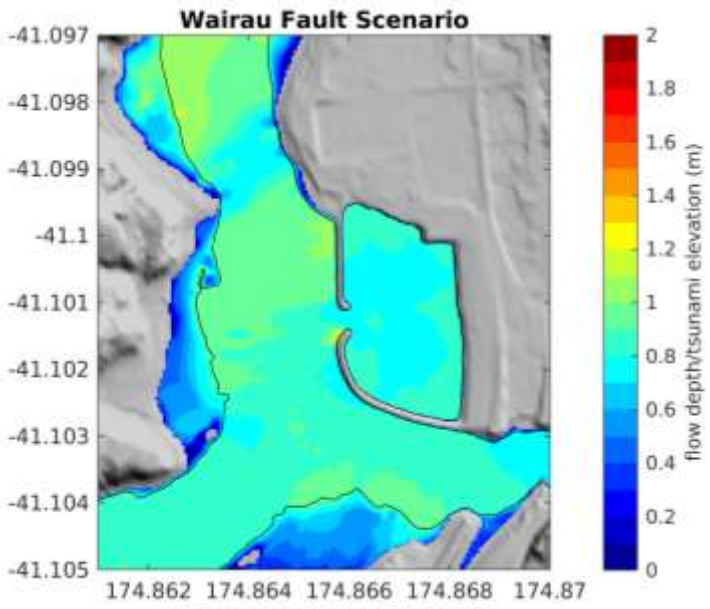
- Mw 8.9 Hikurangi Scenario
- Mw 9.3 Southern Kermadec Scenario
- Mw 9.3 Puysegur Trench Scenario

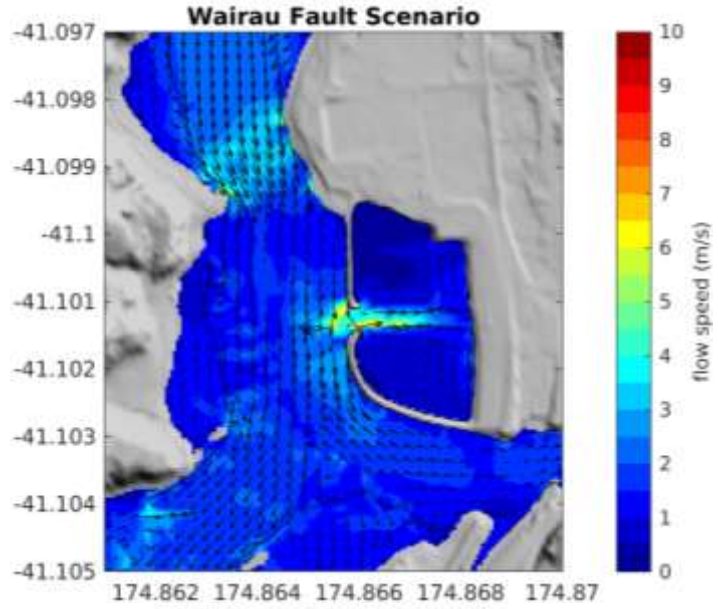
Scenarios obtained from previous studies of
Gusman et al. 2019;
Wang et al. 2021/2022;
Mueller et al. 2015/2017;

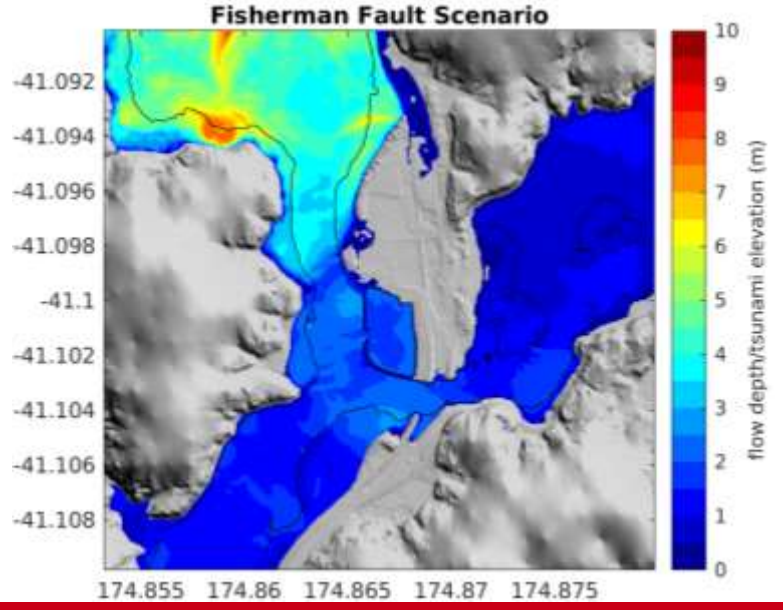


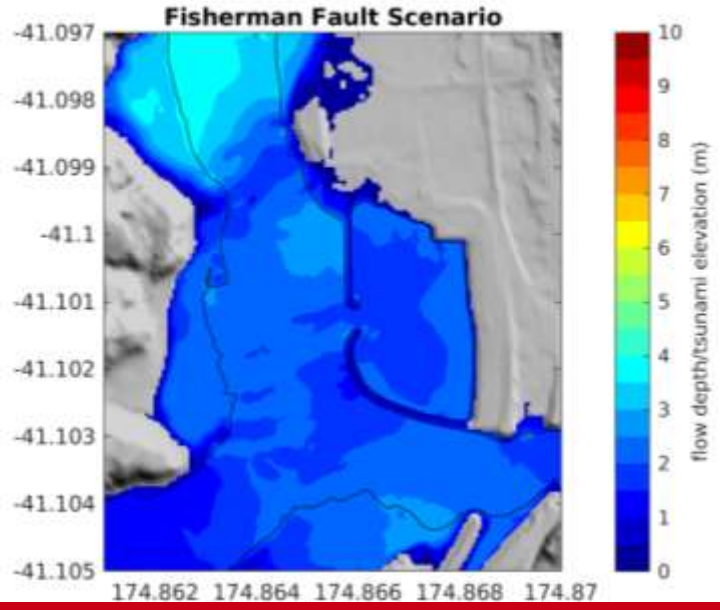
Mana Marina Tsunami Modelling – Crustal Fault Scenario Results

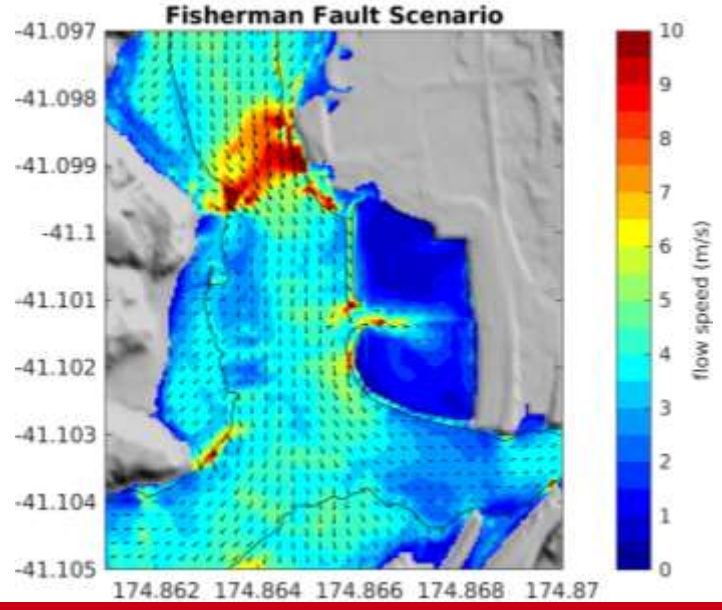




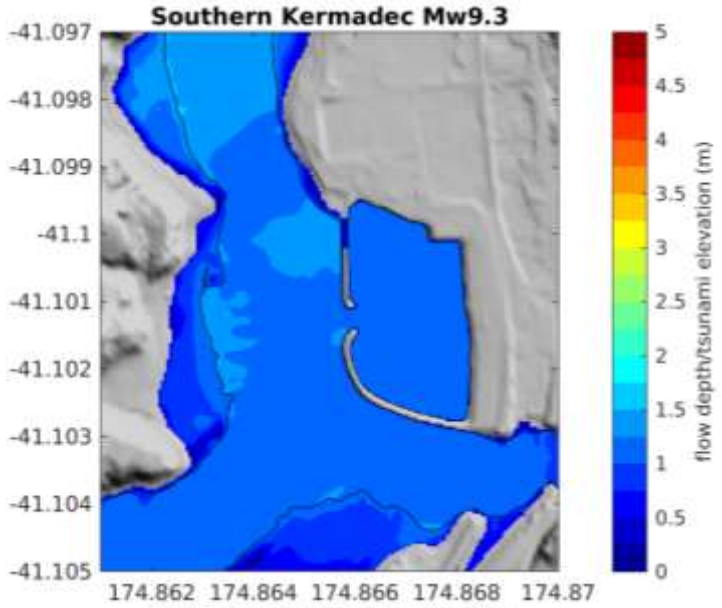


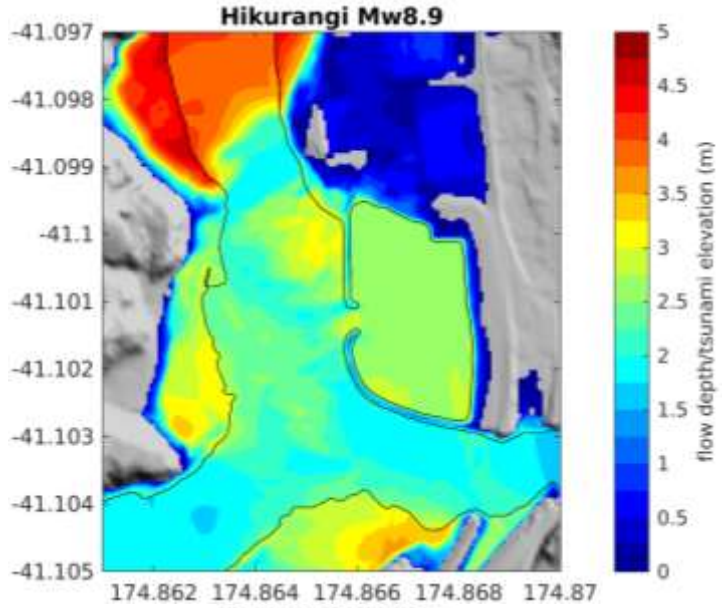


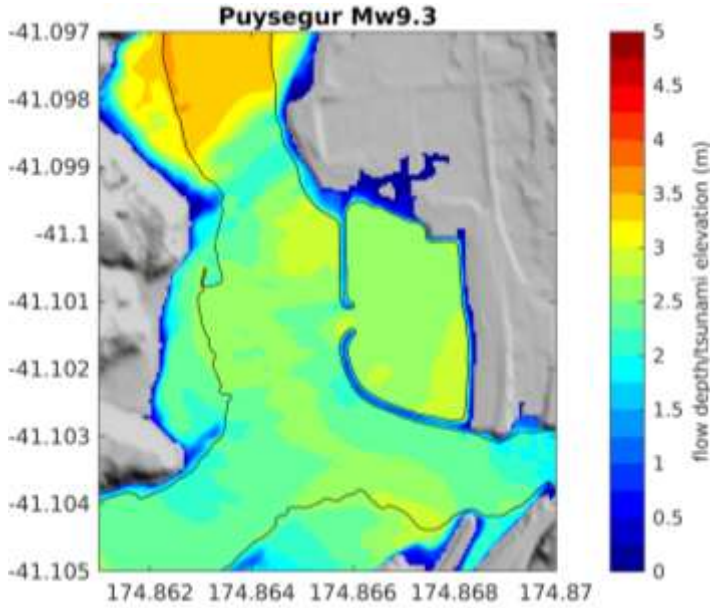


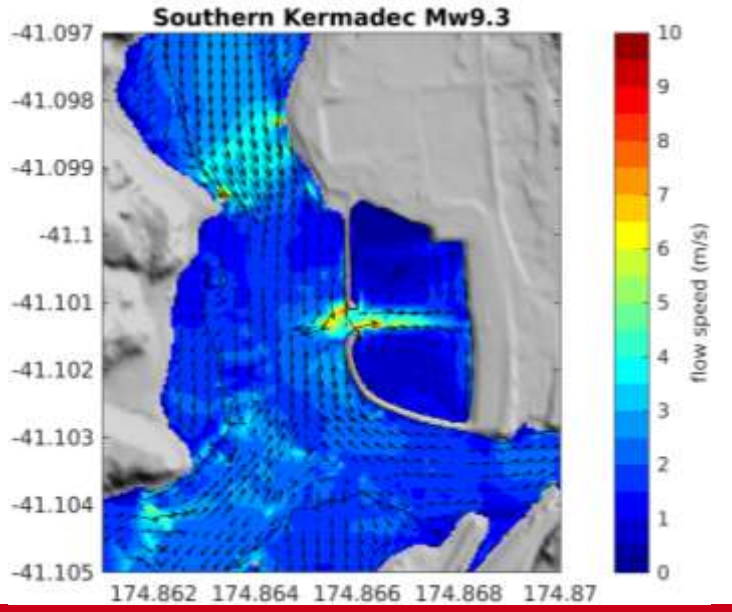


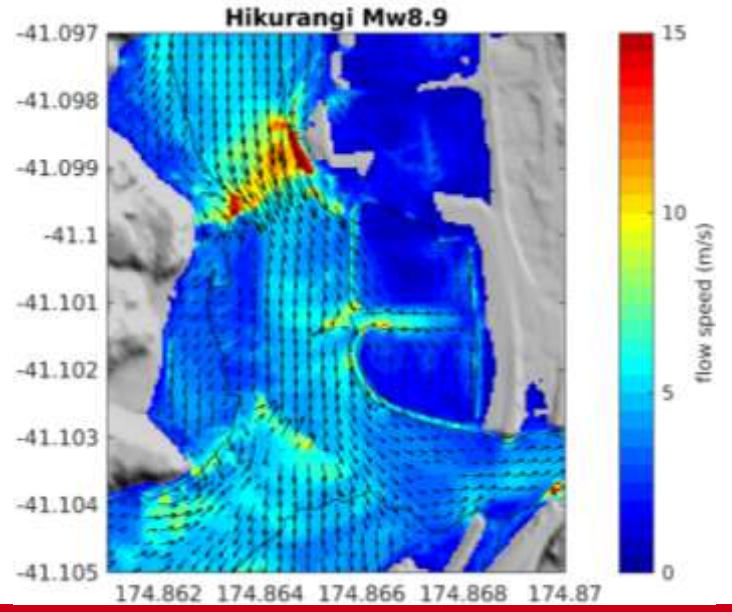
Mana Marina Tsunami Modelling – Subduction Zone Scenario Results

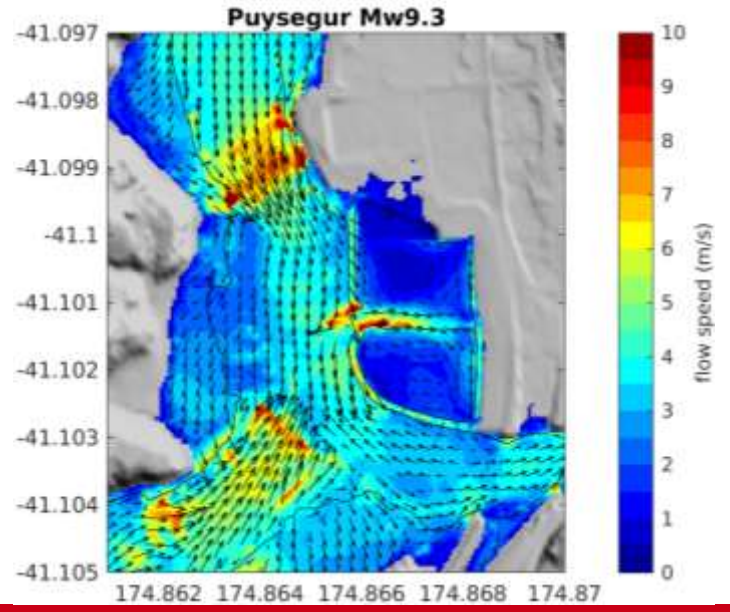




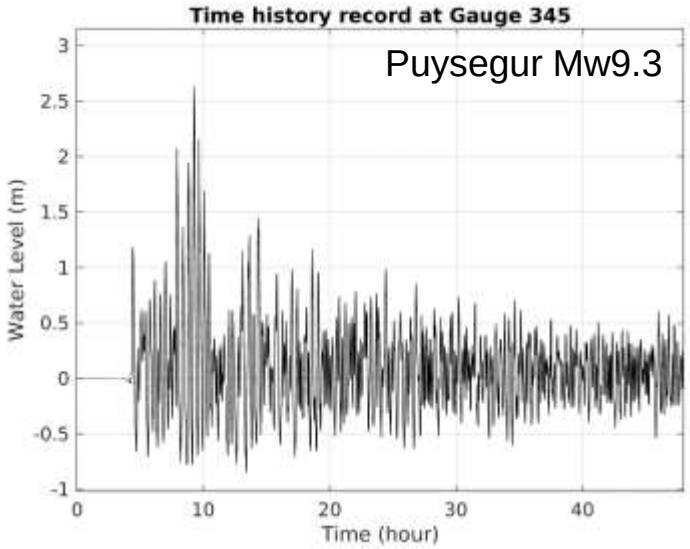


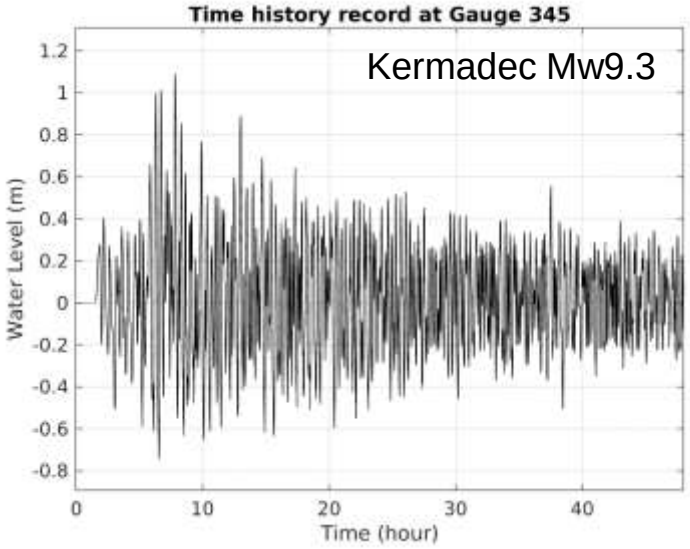


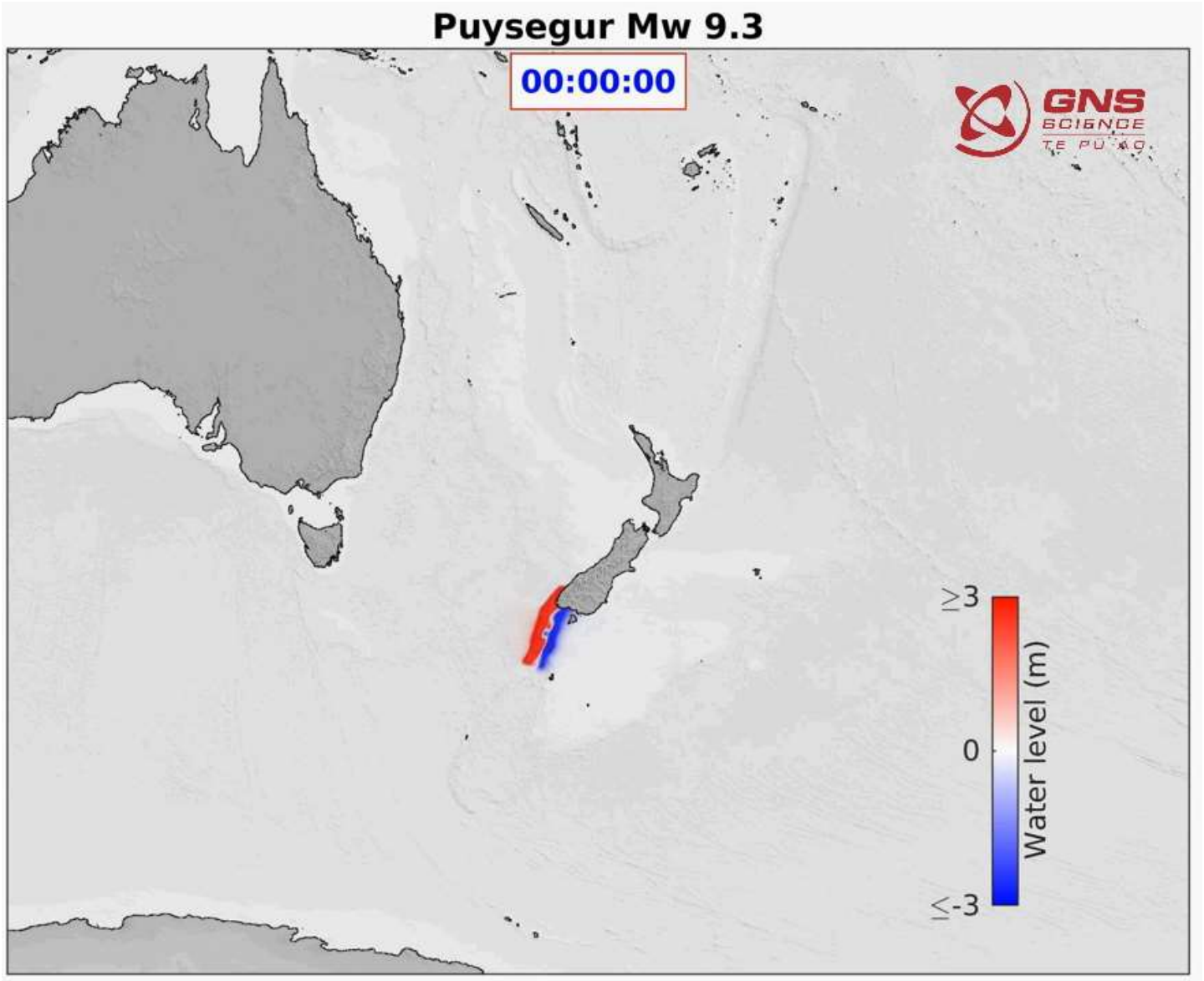




Puysegur Trench Tsunami – Reflected waves from Australian coast







IOF Tsunami Hazard & Vulnerability: What we do next?

In FY 2023-2024, We will do two tsunami projects:

- Combined impact of storm surge, tsunami, and tides in the Wellington Harbour
- Agent-based evacuation modelling for communities on the eastern side of the Wellington Harbour

THANK YOU

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