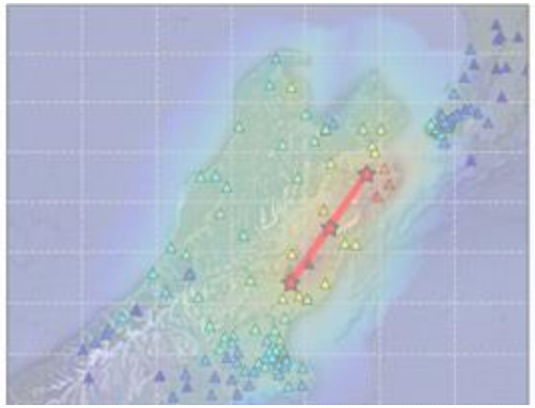
RCET
Te Whakaahuatanga Tere o ngā Rū Whenua me ngā Parawhenua

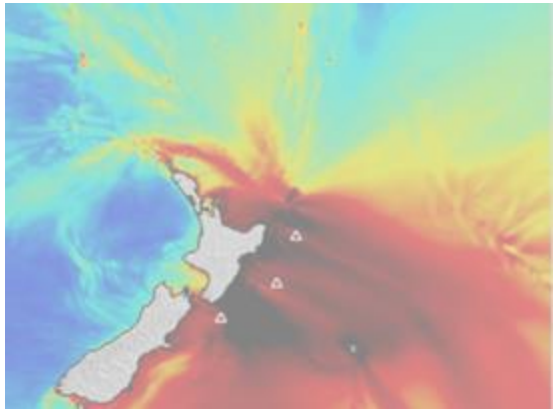
RCET-NEW

Next-Generation Early Warning

Forecasting tsunami and multi-hazard impacts as local earthquakes strike

Anna Kaiser, Bill Fry & Jen Andrews





Earth Sciences New Zealand

E mahi ana me
In collaboration with

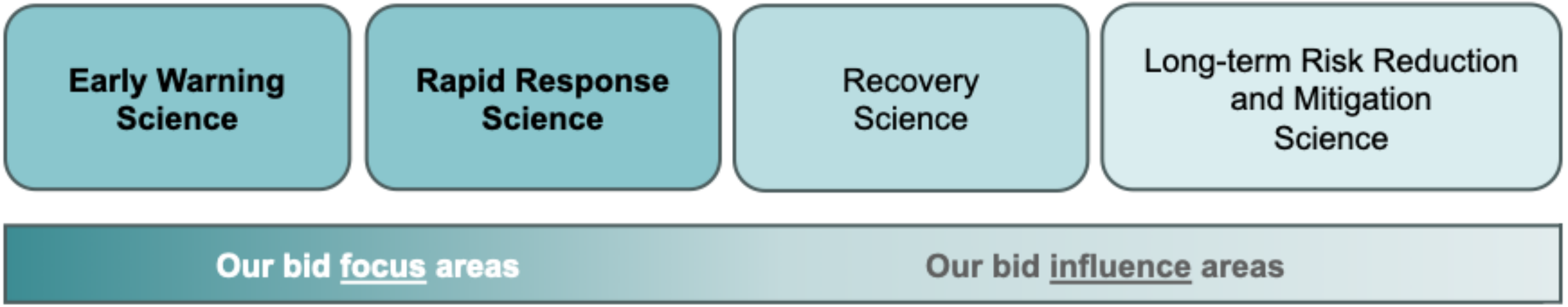
Measurement Standards Laboratory of New Zealand
Victoria University of Wellington Te Herenga Waka
University of Auckland Waipapa Taumata Rau New Zealand
NASA
Sapienza Università di Roma
UC University of Canterbury Te Whare Wānanga o Waitaha Christchurch New Zealand
Te Kunenga ki Pūrehuroa Massey University University of New Zealand
Australian Government Geoscience Australia
PMEL Pacific Marine Environmental Laboratory
ETH zürich
University of Otago Ōtākou Whakaihu Waka

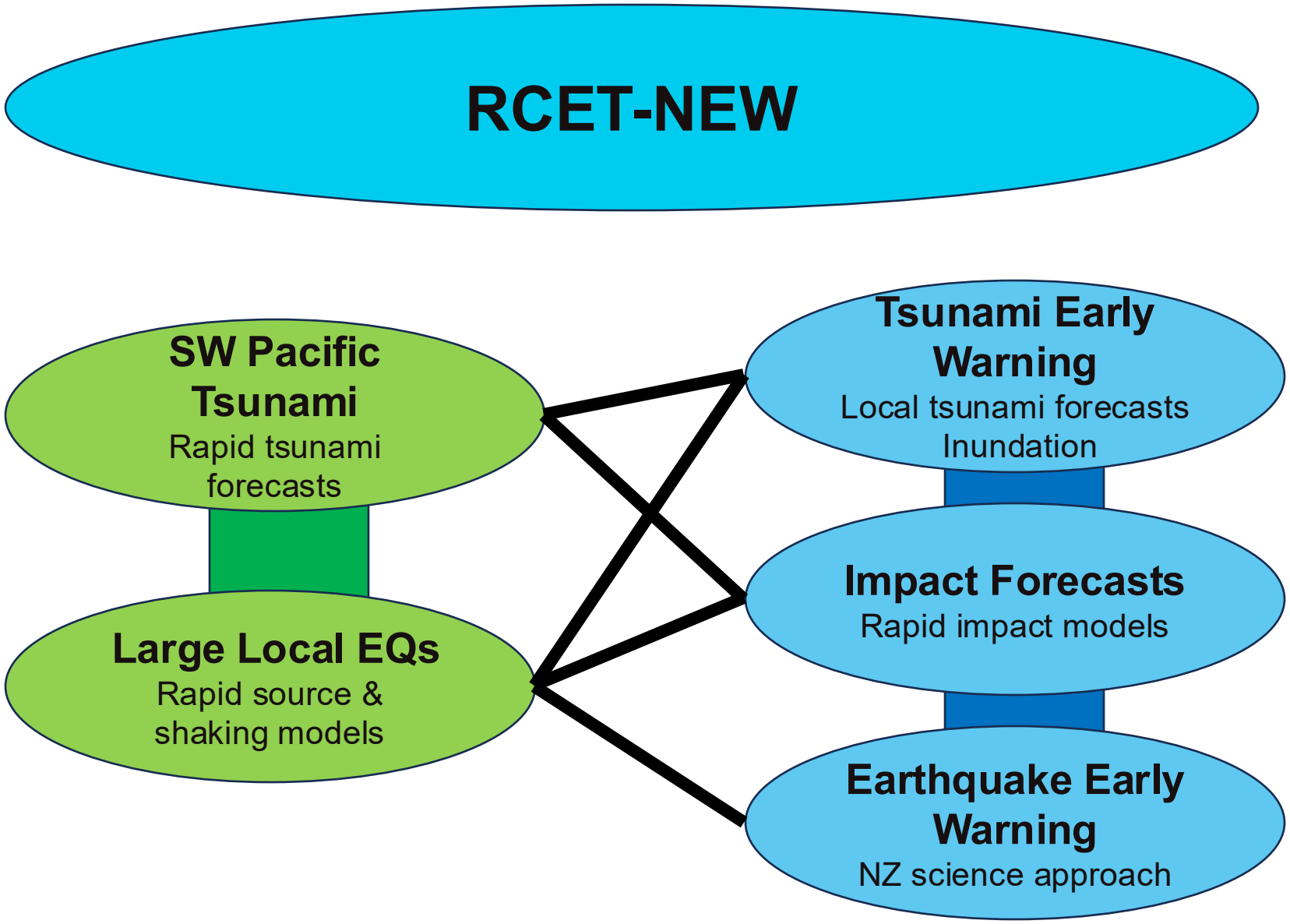
RCET

Rapid **C**haracterisation of **E**arthquakes and **T**sunami

NEW

Next-generation **E**arly **W**arning





How can we better **forecast local tsunami?**

Can we **forecast inundation** on timescales useful for response?

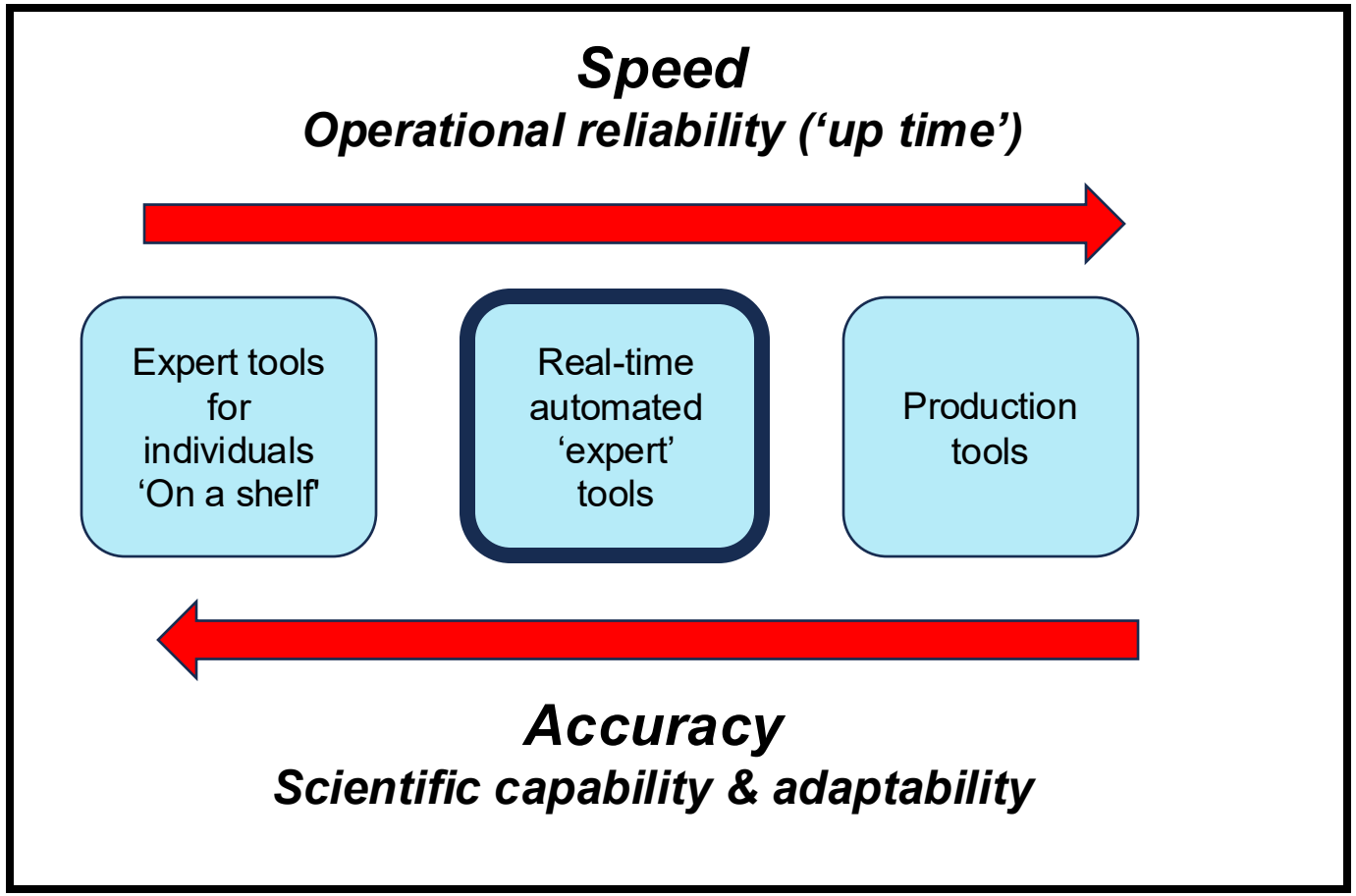
From hazard to impact information for shaking and tsunami

How will society respond under multi-hazard conditions and how can we better prepare?

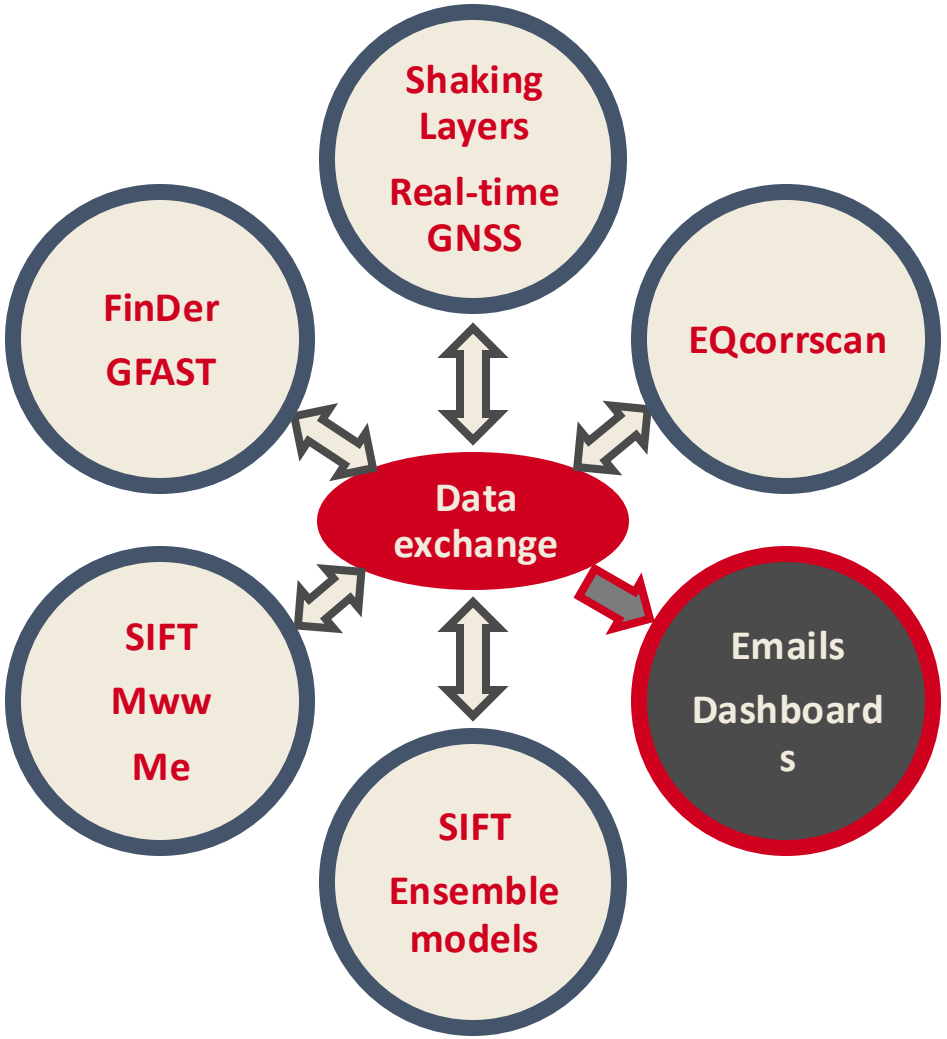
What is an optimal science approach to national **earthquake early warning** in NZ?

RCET

Goal: Enhanced, timely expert advice



Real-time tool ecosystem

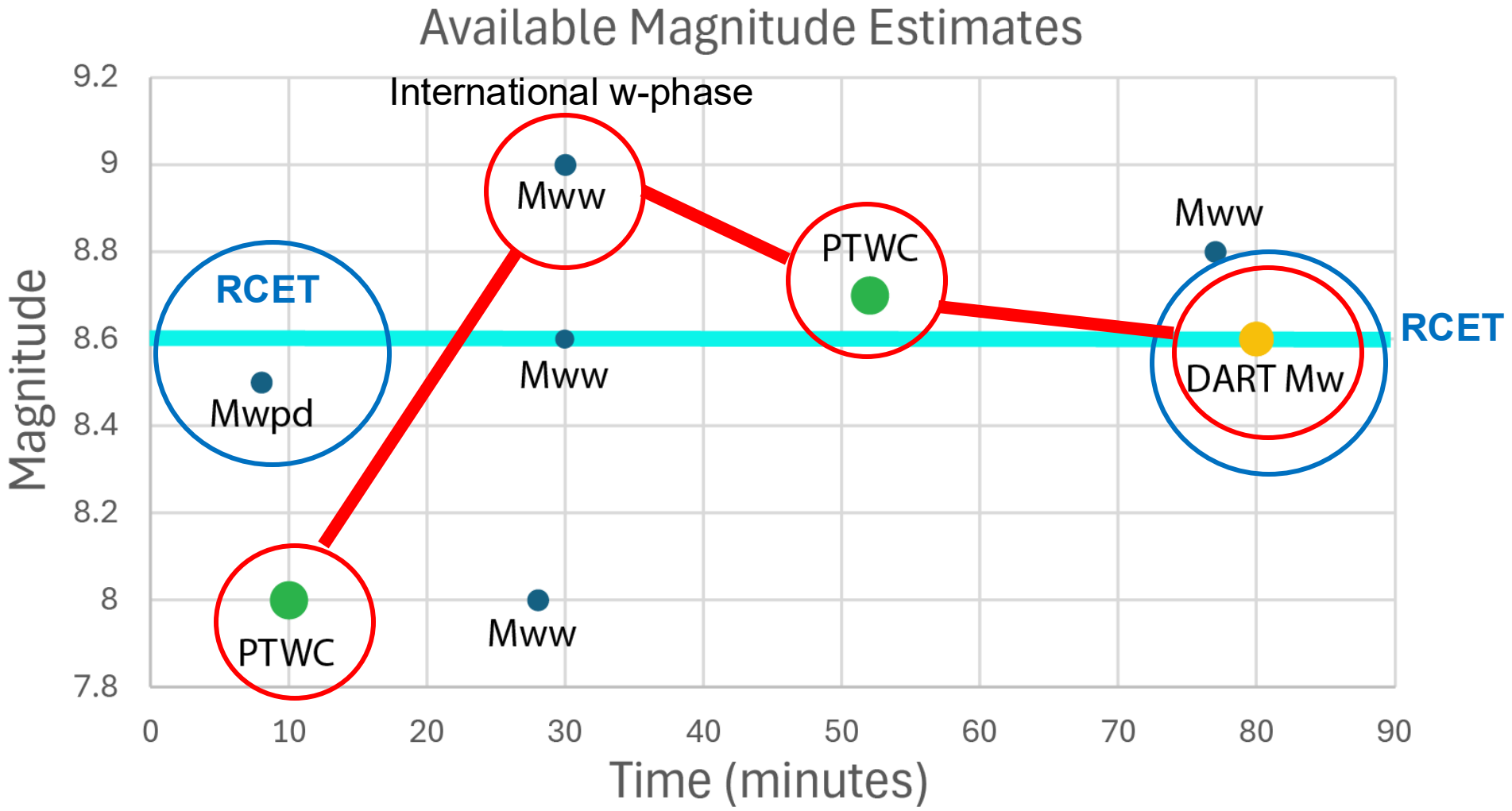


Distant / Regional Tsunami – Kamchatka example

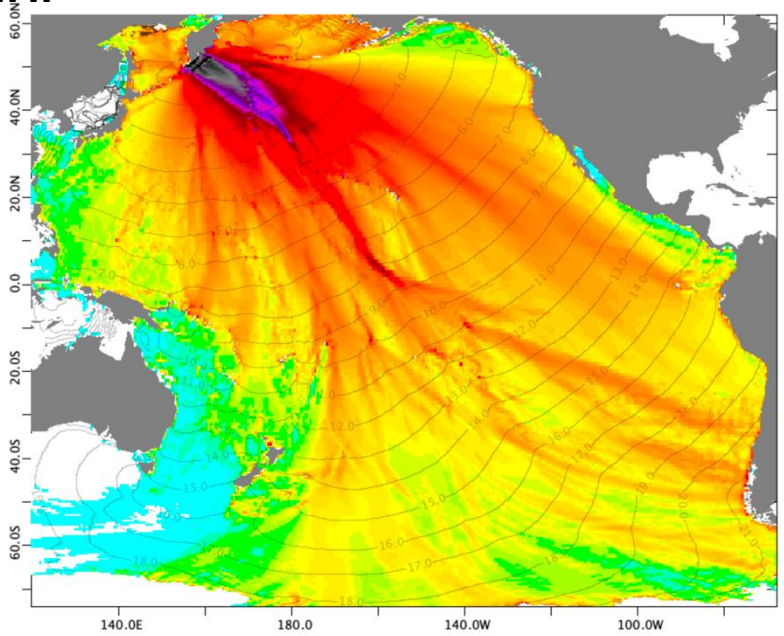
(Bill Fry, Anna Kaiser)

Kamchatka Tsunami – July 2025

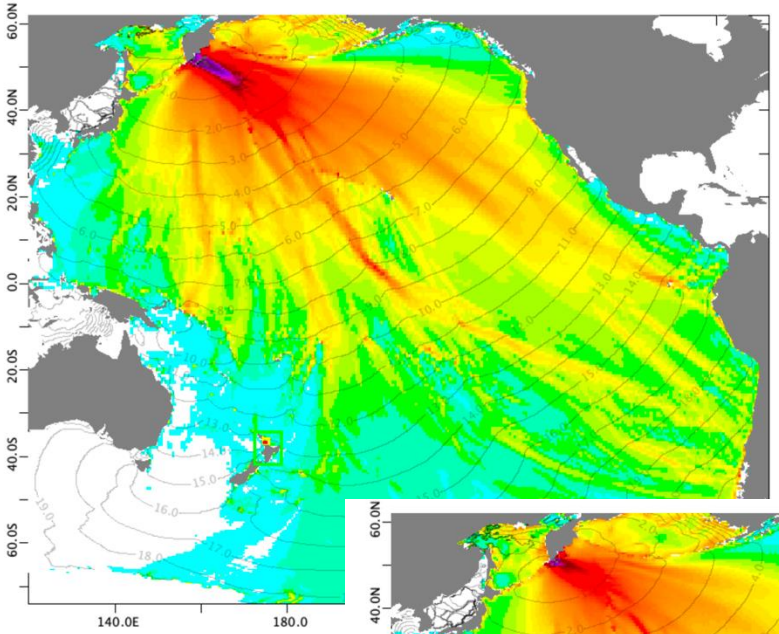
Earthquake magnitude evolution in the first ~80 minutes

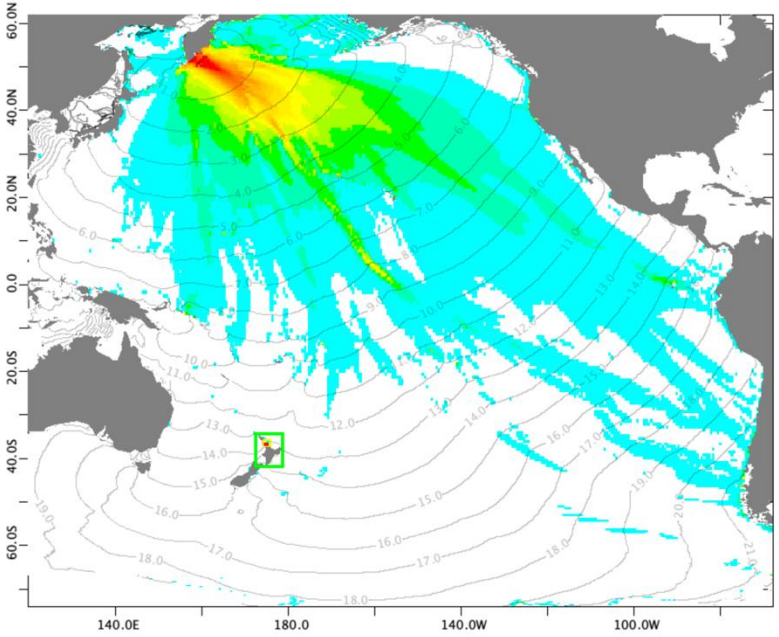


M_{ww} 9 Max Global w-phase (~30mins)



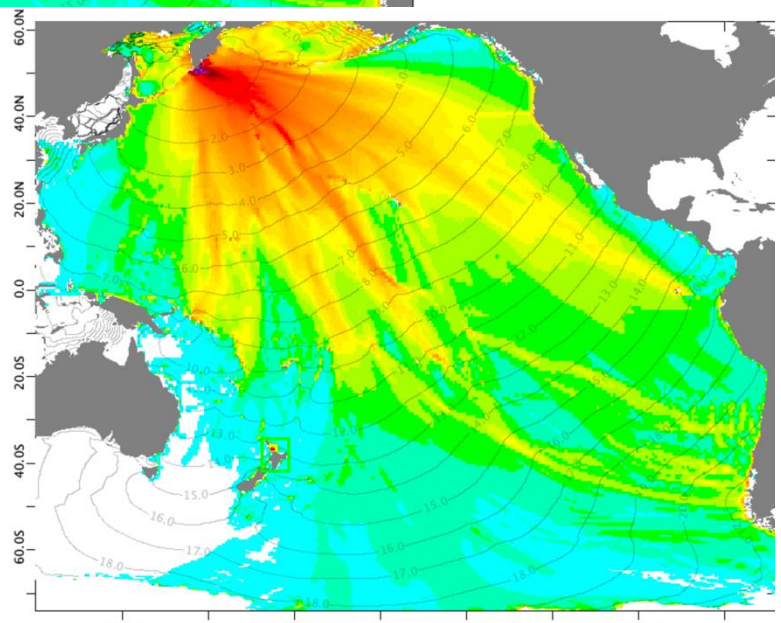
M_{ww} 8.7 (updated) (~50 mins / PTWC)



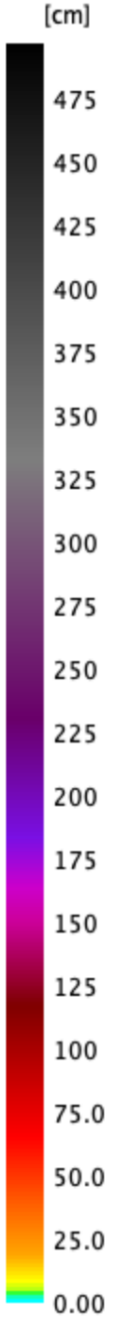


M 8.0 (PTWC, ~10 mins)

Forecast variability

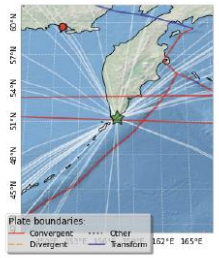


M_T 8.6 DART inversion
(RCET ~80 mins)



Time Dependent National Tsunami Threat Maps

V1 - Maps issued at 22:00 NZDT 30 July 2025 - Valid until 12:00 NZST 01 August 2025 (unless superceeded) - APPROVED BY THE TSUNAMI EXPERT PANEL (TEP)

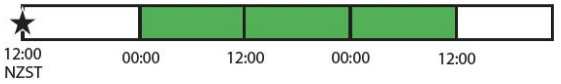


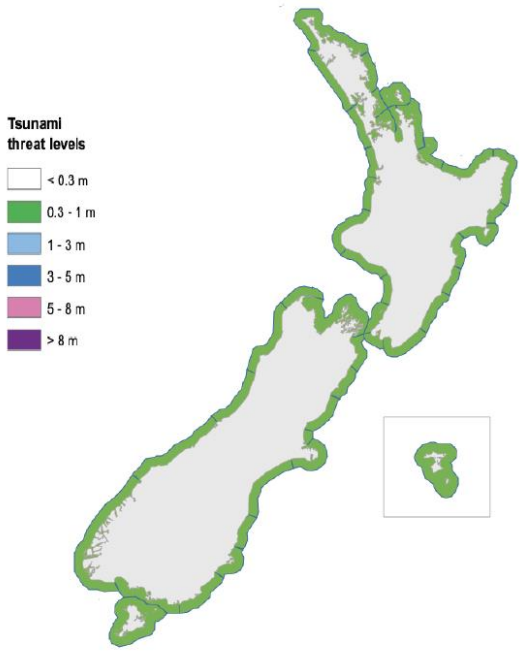
W Phase EQ Event Info

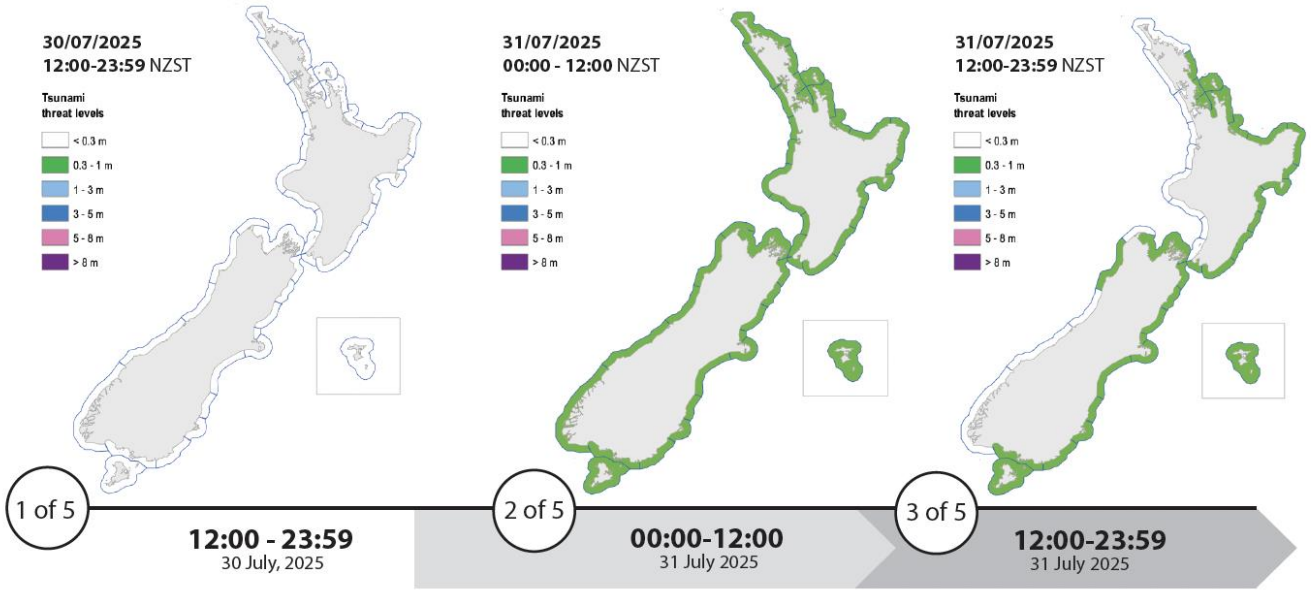
Event ID : RCET_Kam_SIFTV2
Location : Kamchatka, Russia
Mww 8.8
Depth 12 km
Time 11:24 NZST (30/7/25)

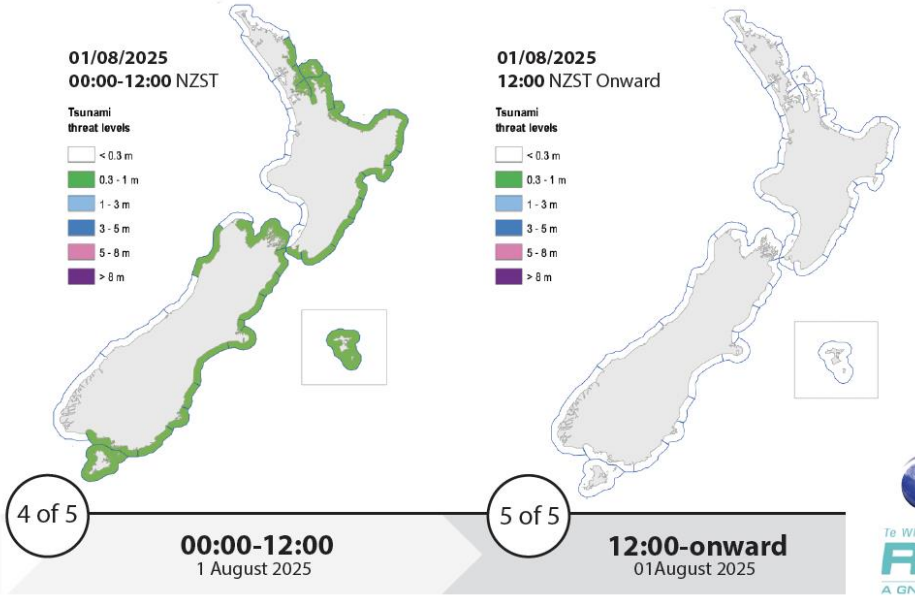
Maximum Tsunami Threat for any zone

Next 48 hrs (12:00 NZST 30 July - 12:00 1 August, 2025)









Disclaimer information

The New Zealand Earth Sciences Institute has prepared this product in an evolving emergency situation. The information in it may be incomplete or it may be out of date by the time you read it. Readers rely on this product at their own risk. This forecast has been approved by the TEP and represents best information at time of release.

TideTEW provided by R-CET: Rapid Characterization of Earthquake and Tsunamis.

Earth Sciences New Zealand
GeoNet
Te Whakaahuatanga Tere o ngā Rū Whenua me ngā Parawhenua
R-CET Rapid Characterisation of Earthquakes and Tsunamis
A GNS Science Led Research Programme

Prototype

TEP Event Advice

Max 0.3m – 1m coastal wave height for all regions of NZ.

This threat level expected to last overnight until at least midday the next day (31 July).

Likely some de-escalation between midday and midnight the next day

- west coast zones may de-escalate before east coast zones

Threat in some parts of NZ may remain above 0.3m for approx. 2 days

- Long duration associated with reflections from South America

Reflections on the Kamchatka Tsunami Response

- Test of Early Magnitude Estimates
- Successfully utilising DART to accurately forecast tsunami waves arriving in NZ
- TiDeTEW - **Ti**me-**De**pendent forecasts provided information about the likely evolution of the threat.

How do we effectively communicate tsunami forecasts for key users?

End-user interviews + Future Directions

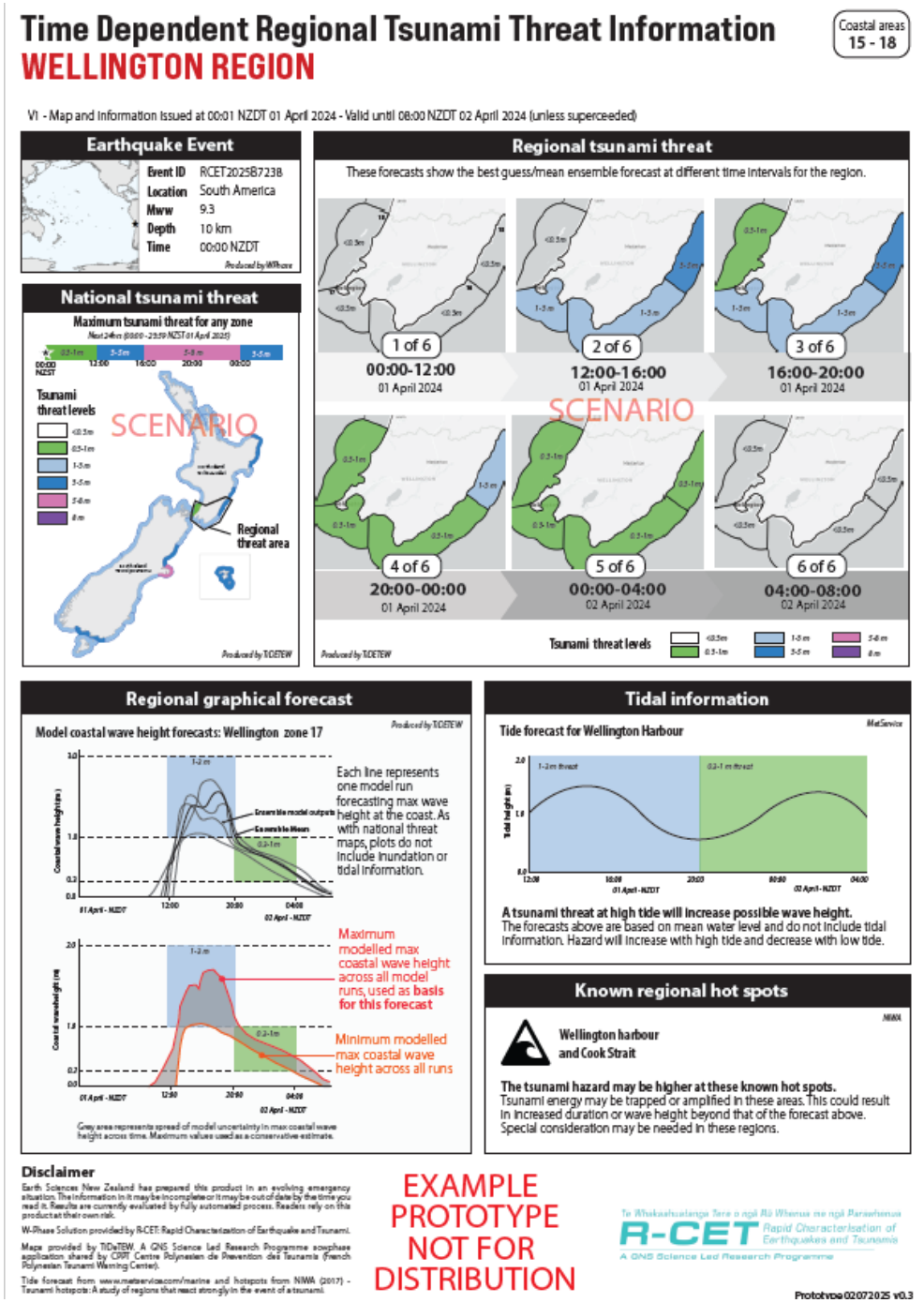
Danielle Charlton, Mary Anne Clive, Sara Harrison

Regional Time Dependent Forecast

- **V1 – Evidence-based design concept first draft**

- Qualitative research interviews with users (EM and Science)
  - Made-up hypothetical data; artistic licence with the graphs
  - Aspirational science and product
  - More data available to more levels
  - Implementation TBD, but pathway to delivering regional inundation mapping

- **V2 – Explore tool and design with RCET-NEW**



Preliminary trends

Context and setting of tsunami science advice

- **Key information needs:**
  - the size of tsunami - if there will be a land threat;
  - impact to communities;
  - wave arrival times
- **Translation of info into decisions:**
  - local science experts/translators;
  - playbooks and pre-made scenarios;
  - previous experience
- **Challenges and uncertainties:**
  - timeliness and delay of information;
  - duration of event;
  - accuracy of information;
  - communication;
  - science translation and regional/local context.

“timing is everything, right? The more time we have, the better our response will be. So, the better the information and the quicker it comes to us. The better for how we can alert our communities”

Interviewee from NZ emergency management sector

Preliminary Feedback

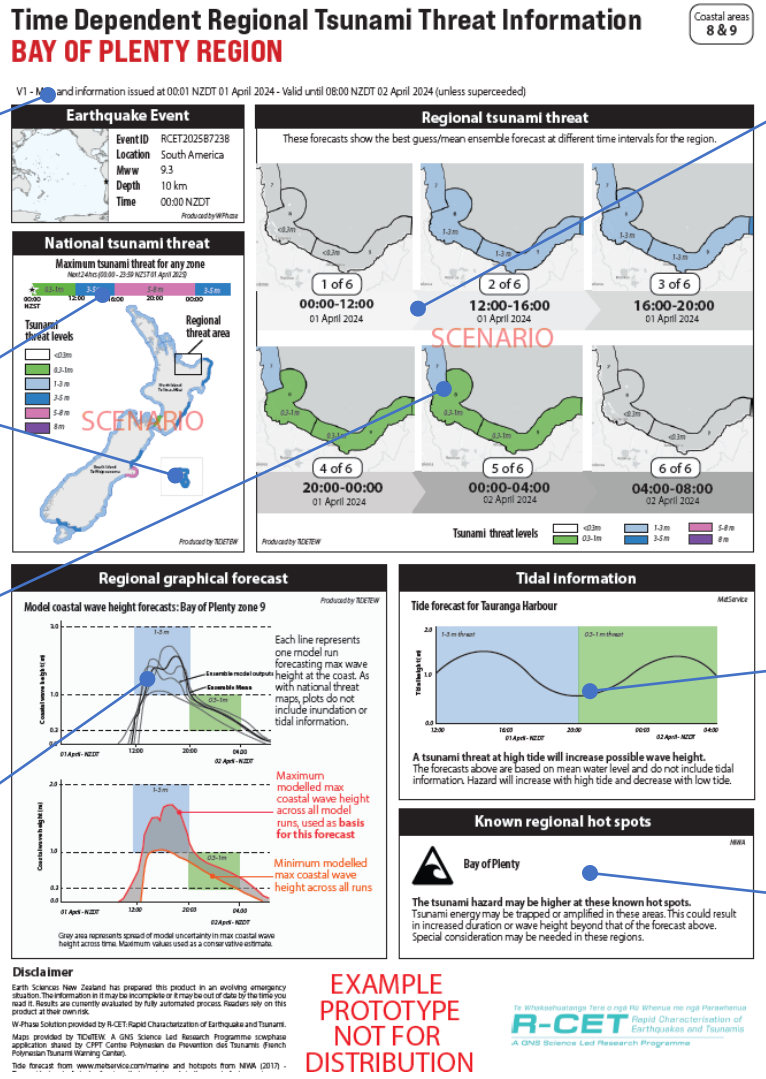
Design and format

Make time issued and valid more obvious.

Add time since earthquake too
Add Chatham Is. time

Coastal zone boundary issue highlighted more in this product

Combine graphs into one. Add multiple plots for each coastal zone. Potentially remove 'spaghetti lines'



Add more detail on the first wave arrival time for well known locations.

Add more detail on longevity of event and when it could end.

Many more maps may be needed if event is long lived.

Good, but more tide location charts needed. Note neap or spring tide. Regions have mulitple different tides.

Hotspots useful but not clear on how they were created. Could be divided by coastal zone.

" like being involved early on in the research to try and shape better outcomes so this is really exciting"

Interviewee

Local Earthquake – Kaikōura example

(Anna Kaiser, Jen Andrews + RCET EQ team)

2016

Earthquake Information at the time of the Kaikōura earthquake

Time after Earthquake Origin

seconds | minutes | hours

M6.6 > M7.4

Underestimated magnitude

Felt Reports

Unclear spatial extent

Large magnitude 6 aftershock

'Ghost quakes' appear wrongly located widely across the country, complicating the picture

High uncertainty about what has happened and the extent of impact, including tsunami.

2020

EGM advances through GeoNet

Time after Earthquake Origin

seconds | minutes | hours

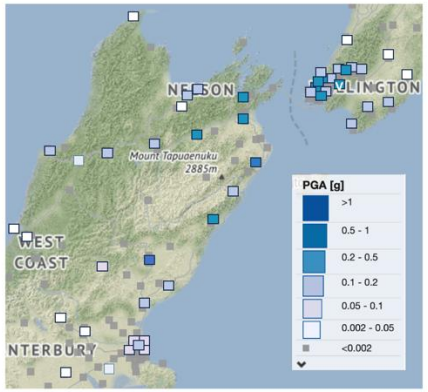
24/7 NGMC
'Eyes on glass'

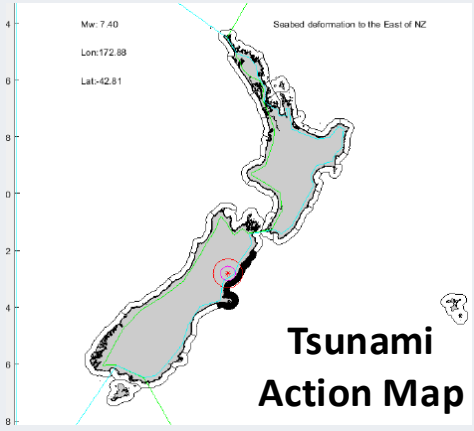
Team of immediate responders

~M7.5

Magnitude estimate

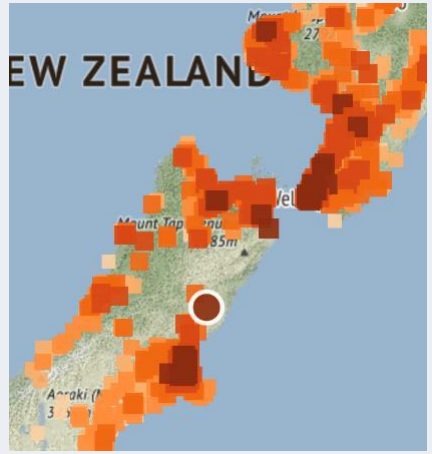
Strong Motion Info





Tsunami Action Map

Felt Reports



Manual review and location of largest earthquakes.

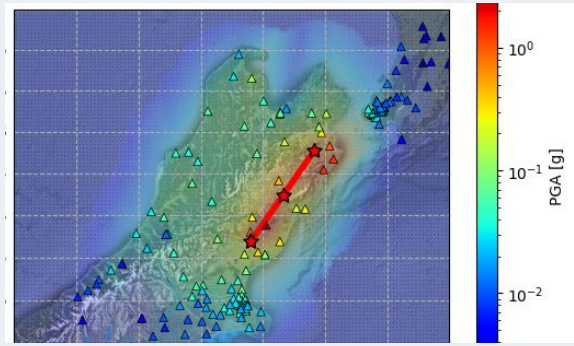
Manual elimination of ghost quakes

Now

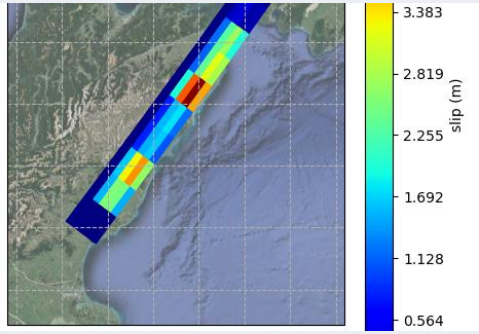
RCET Advances in Rapid Earthquake Characterisation

Time after Earthquake Origin

seconds | minutes | hours

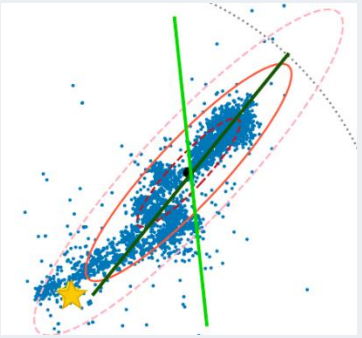


Simplified rupture extent and northwards propagation (FinDer)



Rupture detail (G-FAST)

Mww 7.8 Robust large magnitude (w-phase)



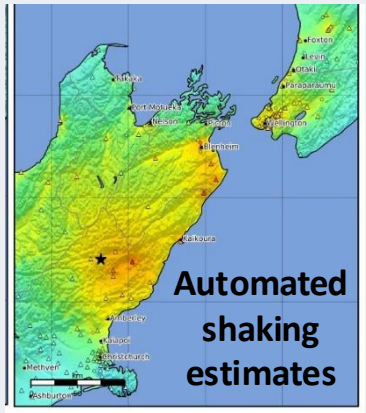
Automated Aftershock catalogues (RTEQCorrScan)

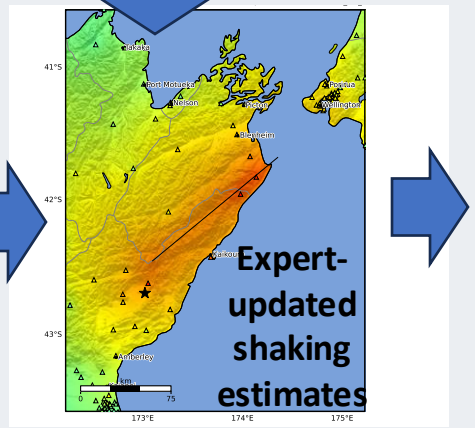
EQ Information

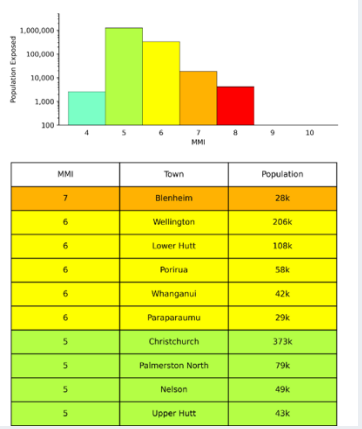
Shaking & Impact Information

TSUNAMI

Red Flag: Tsunami Potential, Magnitude >7.5, (Early-Est)







MMI	Town	Population
7	Blenheim	28k
6	Wellington	206k
6	Lower Hutt	108k
6	Porirua	58k
6	Whanganui	42k
6	Paraparaumu	29k
5	Christchurch	373k
5	Palmerston North	79k
5	Nelson	49k
5	Upper Hutt	43k

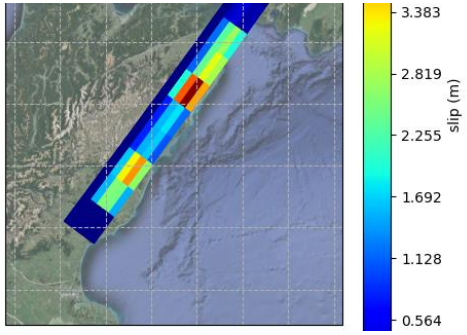
Impacted populations (RiskScapeRapid)

Future Directions

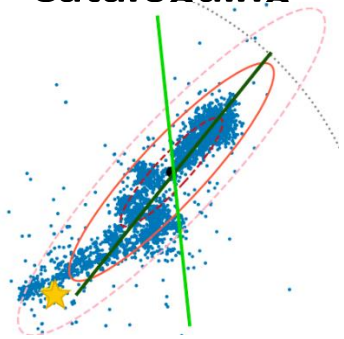
Development and utilisation of rapid EQ analysis in initial tsunami forecasts

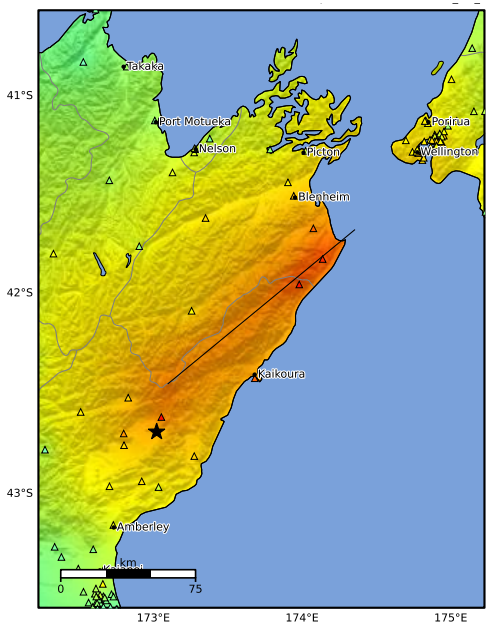
Further development of ***RiskScape Rapid*** *to rapidly* estimate EQ shaking & tsunami impacts

EQ Models



Aftershock Detection and Cataloguing





Expert-updated Shaking Layers

Our models can be used in:

- **Local tsunami forecasts**

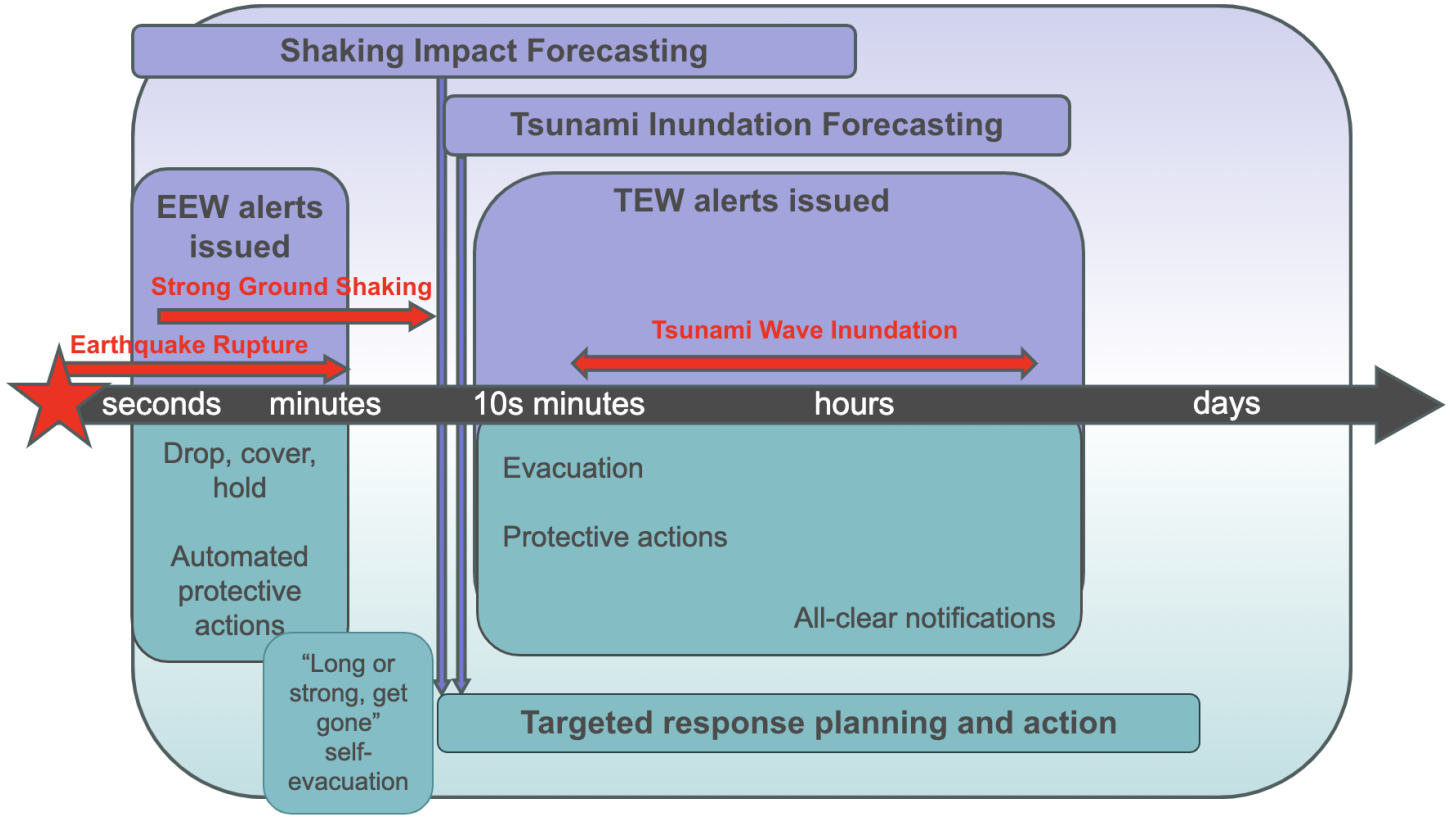
RCET-NEW

- **Impact models**
- **Earthquake early warning**
- Landslide forecasts (Sliding Lands)
- EQ forecasts & 'What might happen next'?
- NZ science sector advice

Next-Generation Early Warning Challenge

Local Earthquake + Local Tsunami

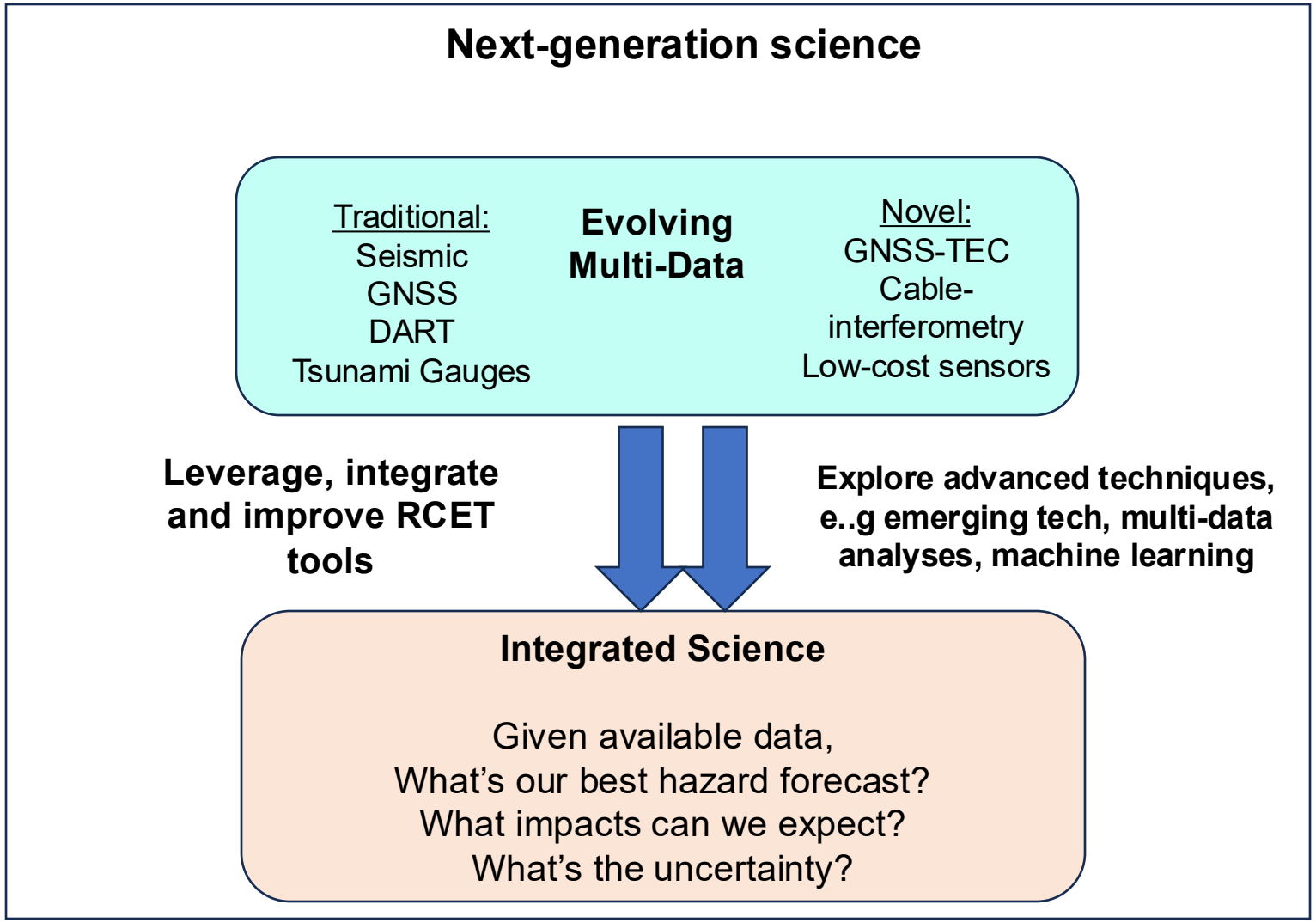
Next-generation **E**arly **W**arning

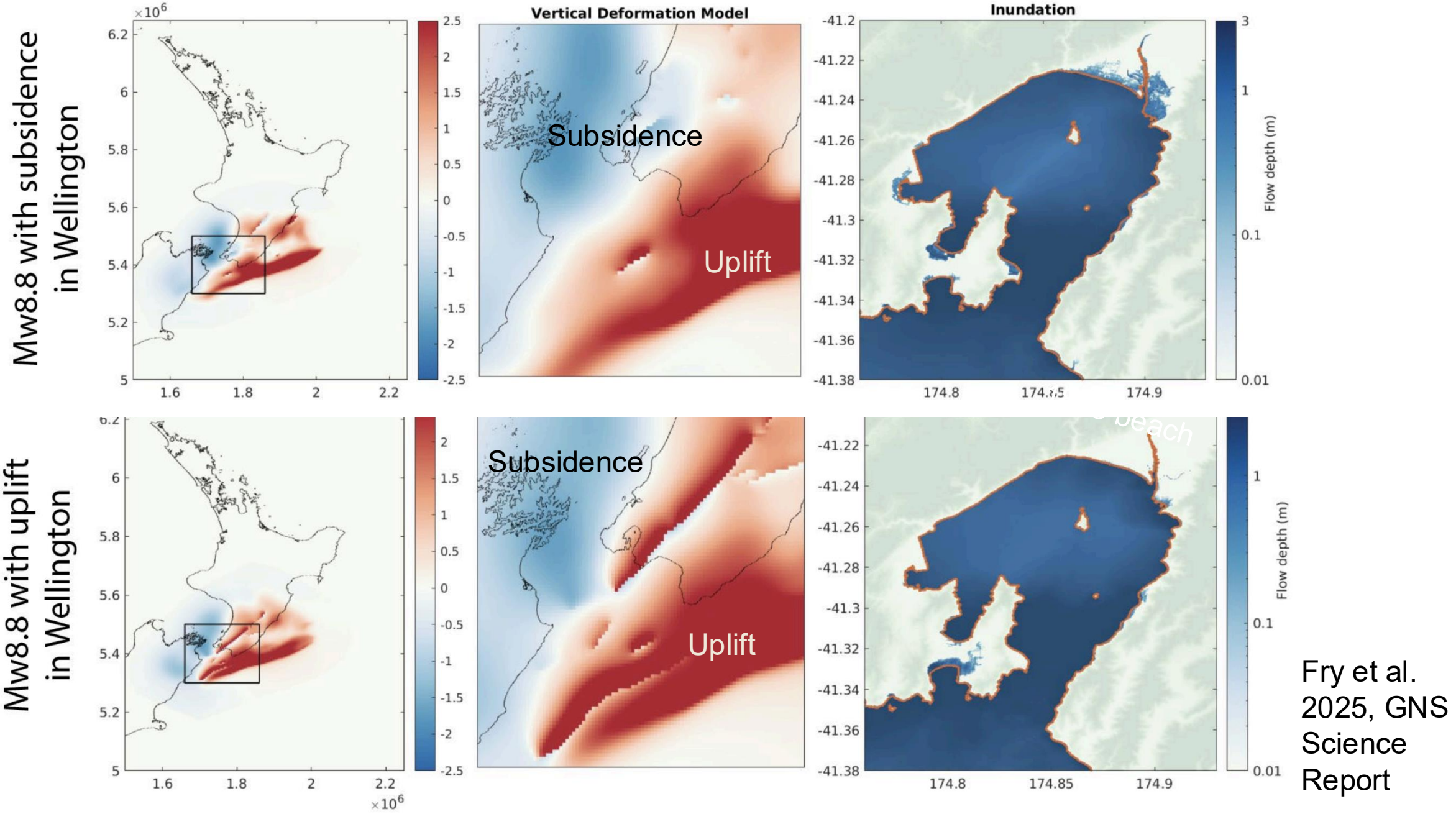


Forecasting tsunami and multi-hazard impacts as local earthquakes strike

How can we draw together evolving information to provide useful **early warning** and rapid estimation of **impacts**.

Local Earthquake and Tsunami Rapid Response Science



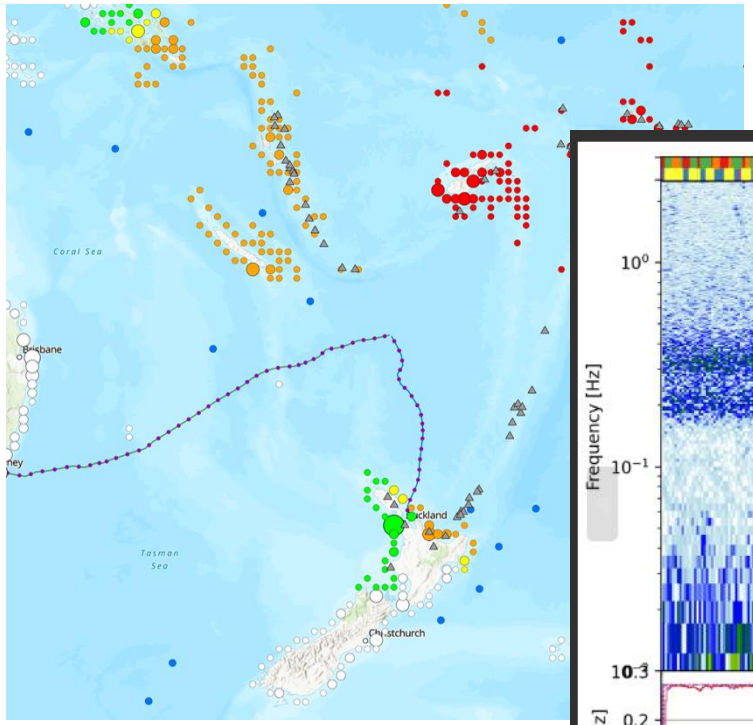


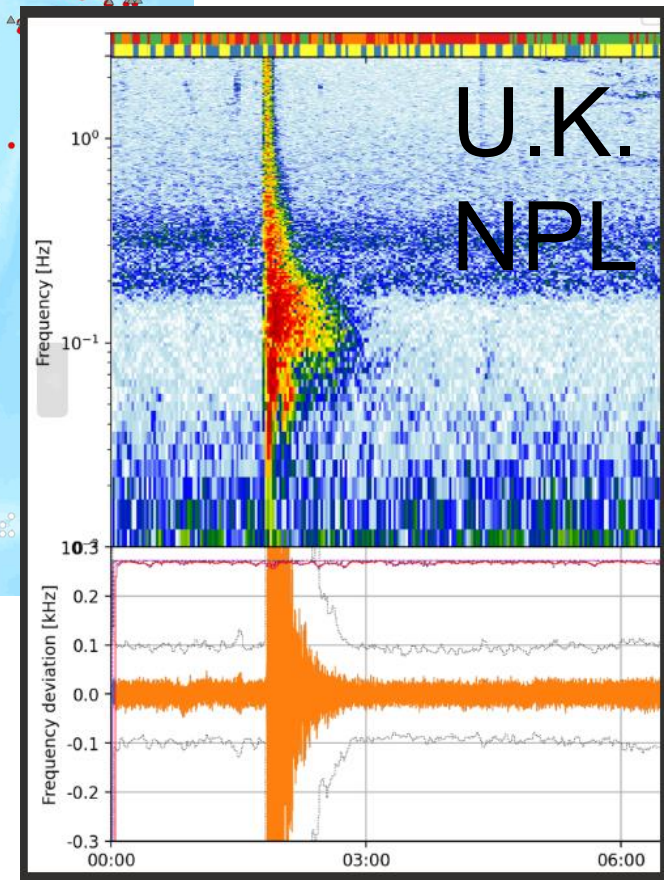
Fry et al. 2025, GNS Science Report

Leveraging National Tsunami Model (NTM) and RNC2/NHRP databases & scenarios

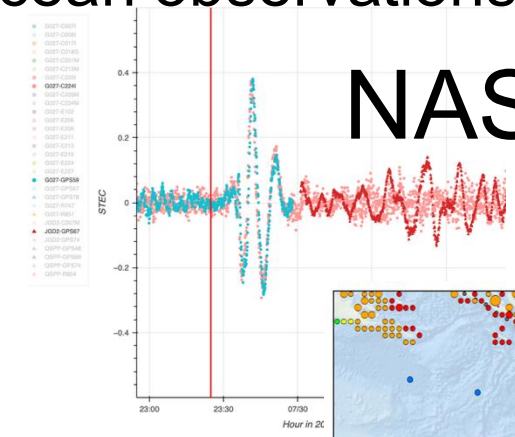
Detecting tsunami offshore

NZ can’t afford to deploy DARTs everywhere we need them, so we are exploring novel technologies to provide the ocean observations we need.

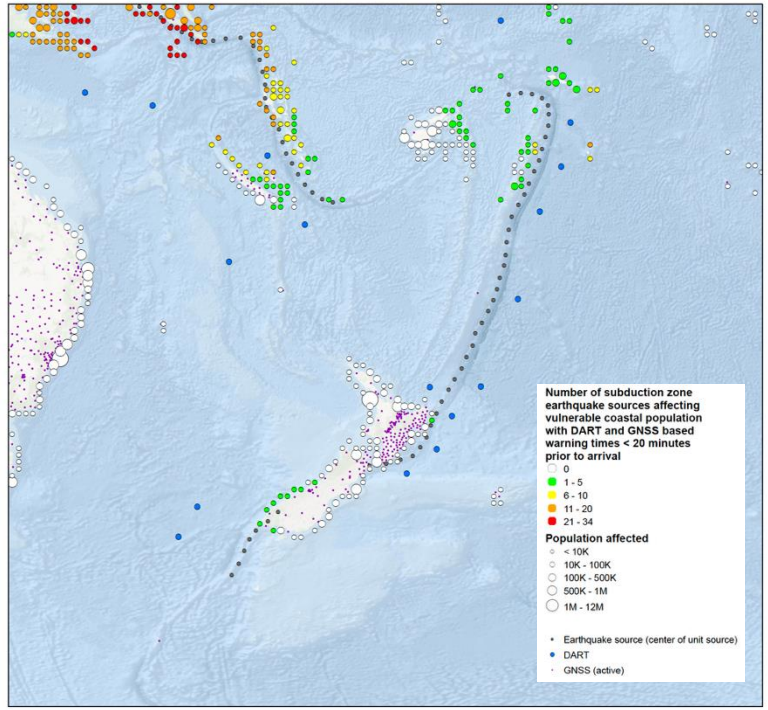




Quantum data on fibre-optic cable



NASA JPL



Satellite observations (GNSS TEC)

Social science

- **How will people respond to early warnings?**
- How will people respond under multi-hazard conditions?
- What are the barriers to evacuation?
- How can we develop and optimize our response products and communication?
- How can we support emergency managers and local communities to prepare?

Wellington Case Study

Test-case for national earthquake and tsunami early warning and impact workflows

Wellington-specific elements

- Run agent-based evacuation models (working with UoC)
- Further develop city-scale building damage assessment tools (e.g. Ghasemi et al. 2024) with UoA. Real-time implementation.
- Wellington community engagement to enhance preparedness (with Massey University, Hono & stakeholders)

Opportunity to partner, leverage and contribute to cross-programme science for Wellington (e.g. NTM, NHRP, IOF, Sliding Lands, QuakeCore etc.)

This is challenging science and active research!

Long, strong, get gone and prompt self-evacuation is key

Don’t wait for official warnings

- We are making large strides in our ability to forecast tsunami from distant sources around the Pacific and Pacific Islands
- For earthquakes closer to shore, the science is extremely challenging. First analyses of very large earthquakes are only rough – the impacts and potential for tsunami can be unclear
- We will make concrete progress, and a contribution towards long-term goals of multi-hazard impact-based early warning
- **We are just starting the new programme and keen to hear your thoughts**