GNSS for Natural Hazards in Aotearoa New Zealand

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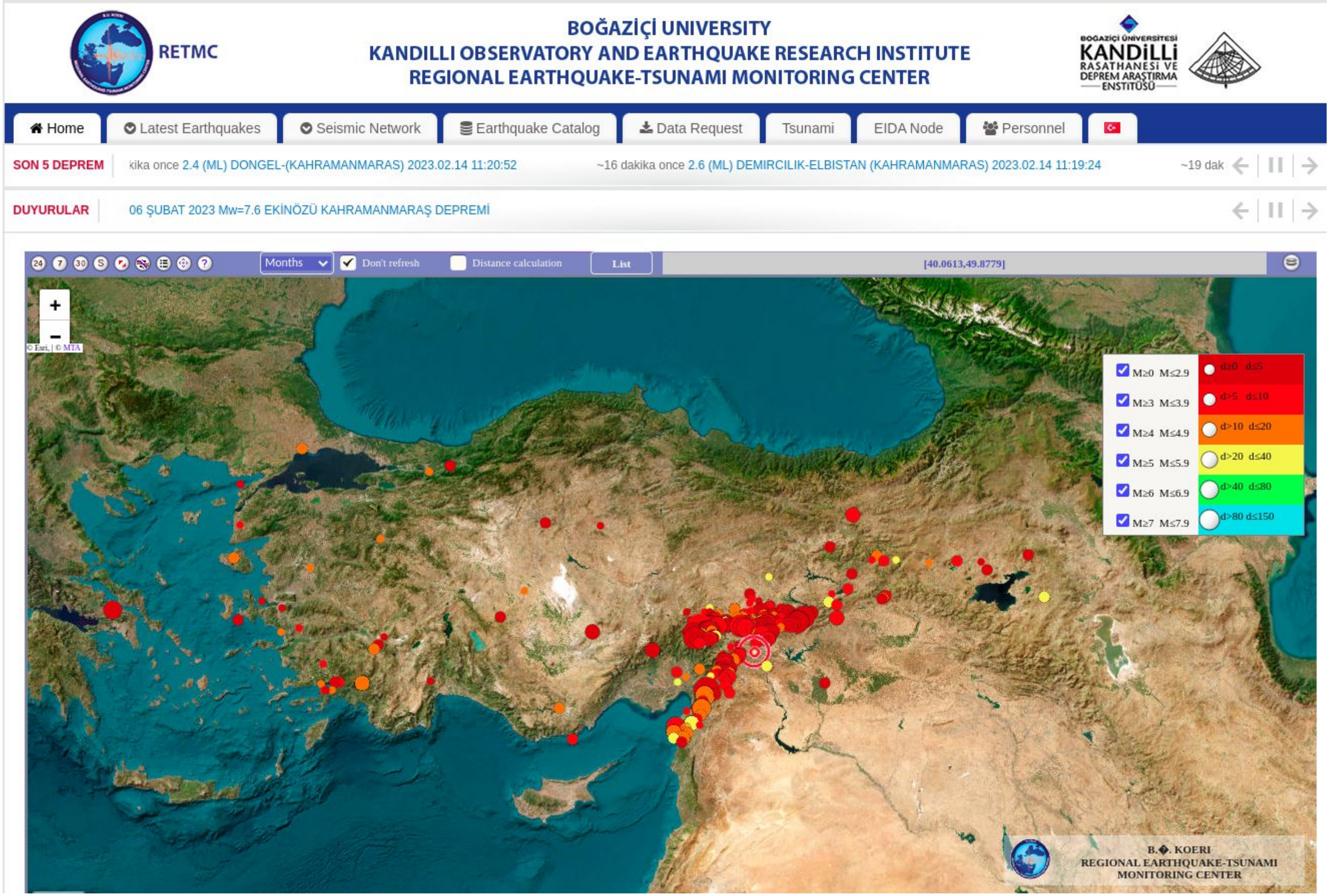
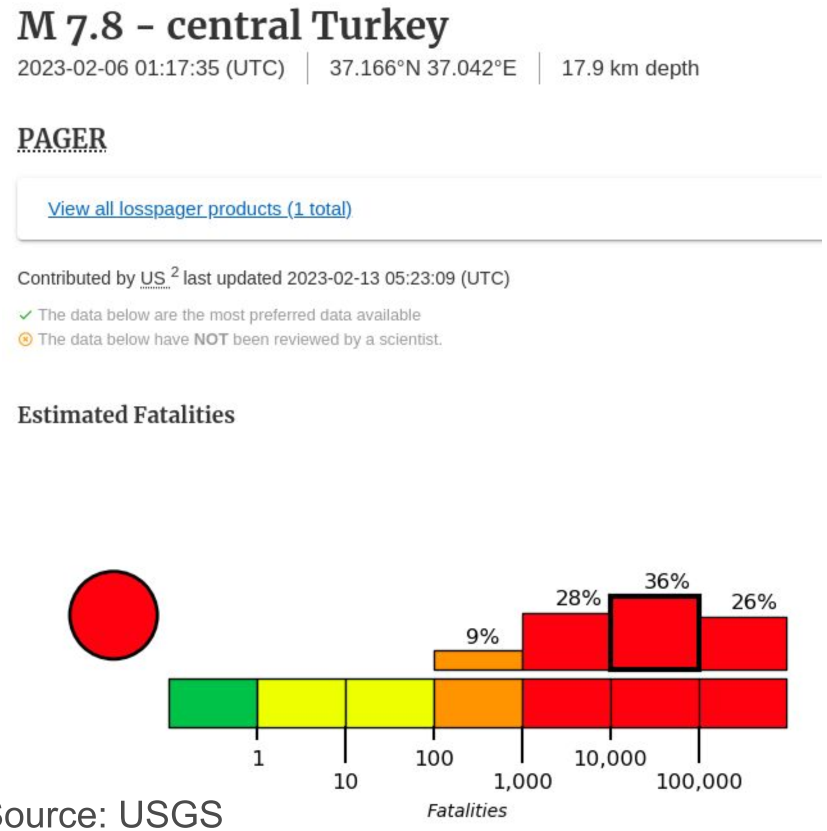
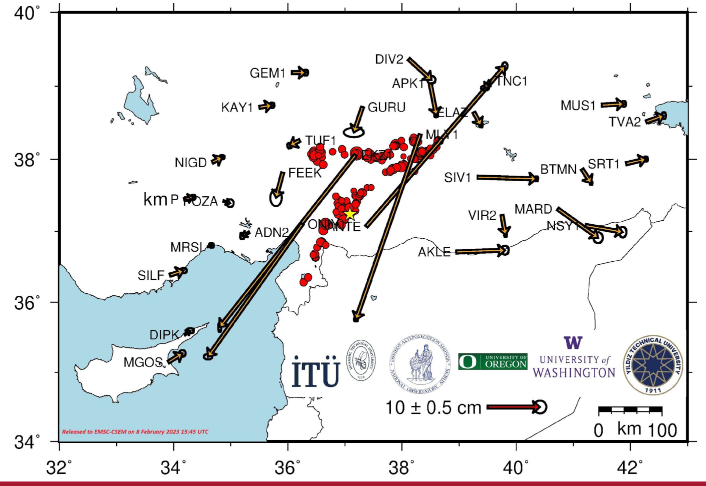


Source: KOERI

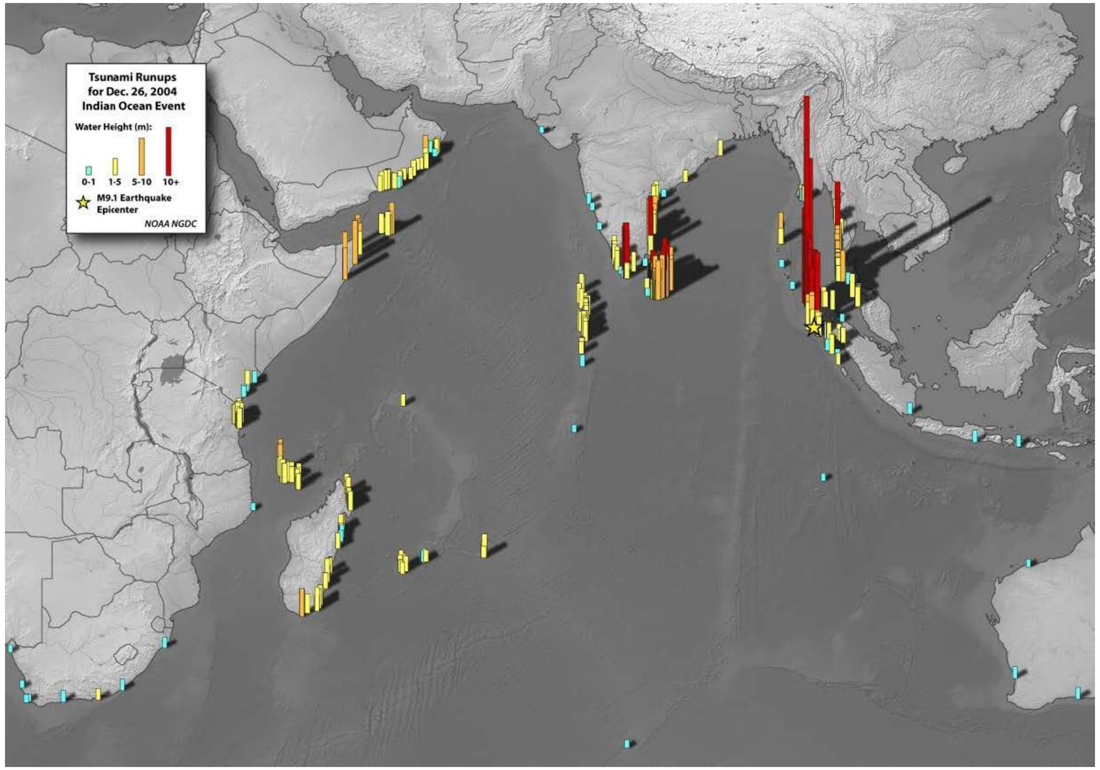


Source: USGS



Source: EMSC report

2004 Sumatra earthquake and Indian Ocean Tsunami, the wiggles knew

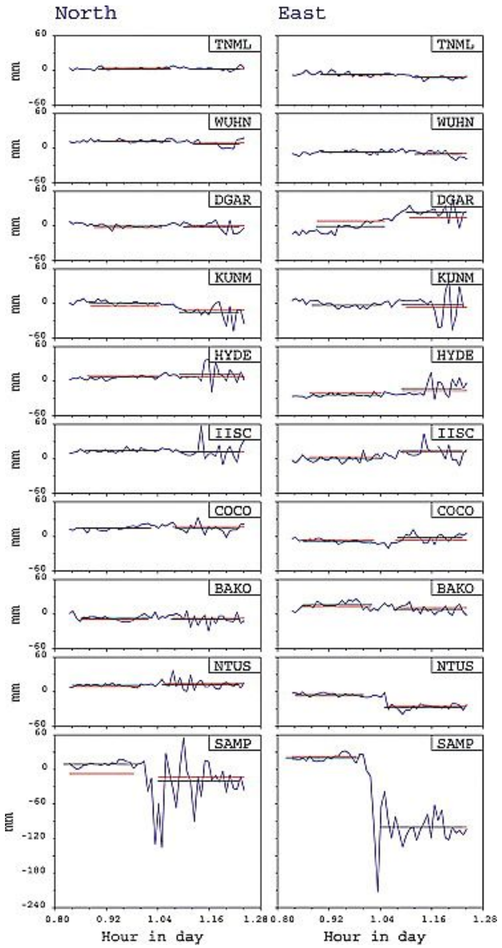


Source: ITIC/IOC

Rapid determination of earthquake magnitude using GPS for tsunami warning systems

Geoffrey Blewitt,[1] Corné Kreemer,[1] William C. Hammond,[1] Hans-Peter Plag,[1] Seth Stein,[2] and Emile Okal[2]

Received 24 February 2005; revised 25 April 2006; accepted 4 May 2006; published 13 June 2006.



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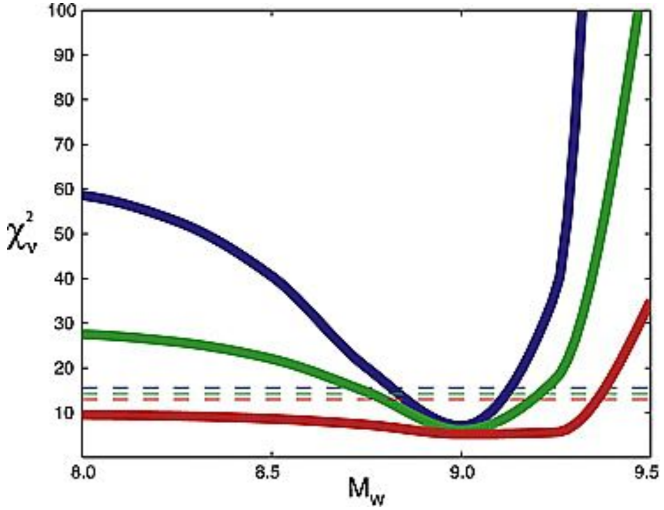
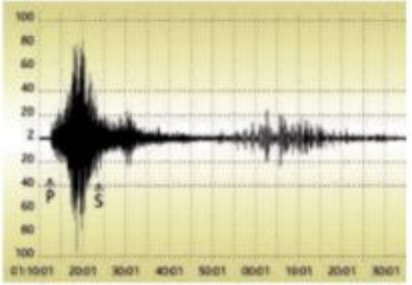


Kerr, 2005

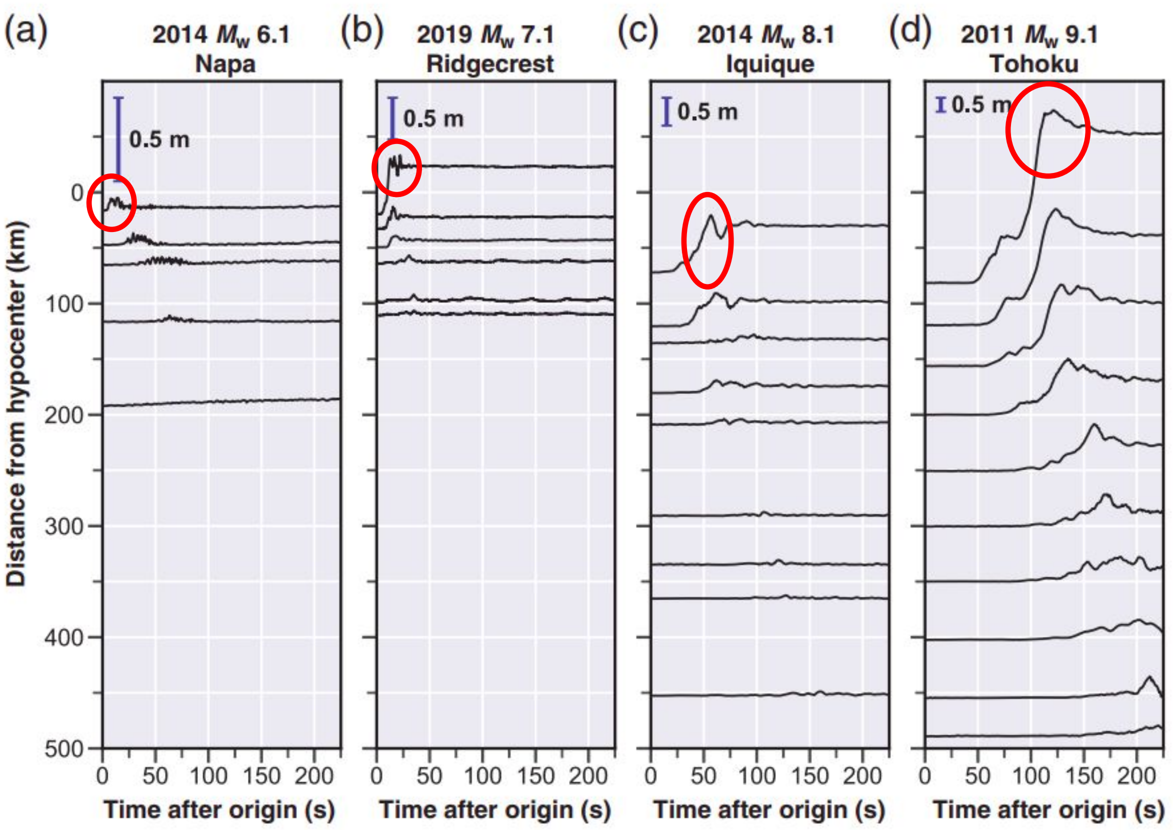
Failure to Gauge the Quake Crippled the Warning Effort

Seismologists knew within minutes that the earthquake off Sumatra must have just unleashed a tsunami, but they had no idea how huge the quake—and therefore the tsunami—really was

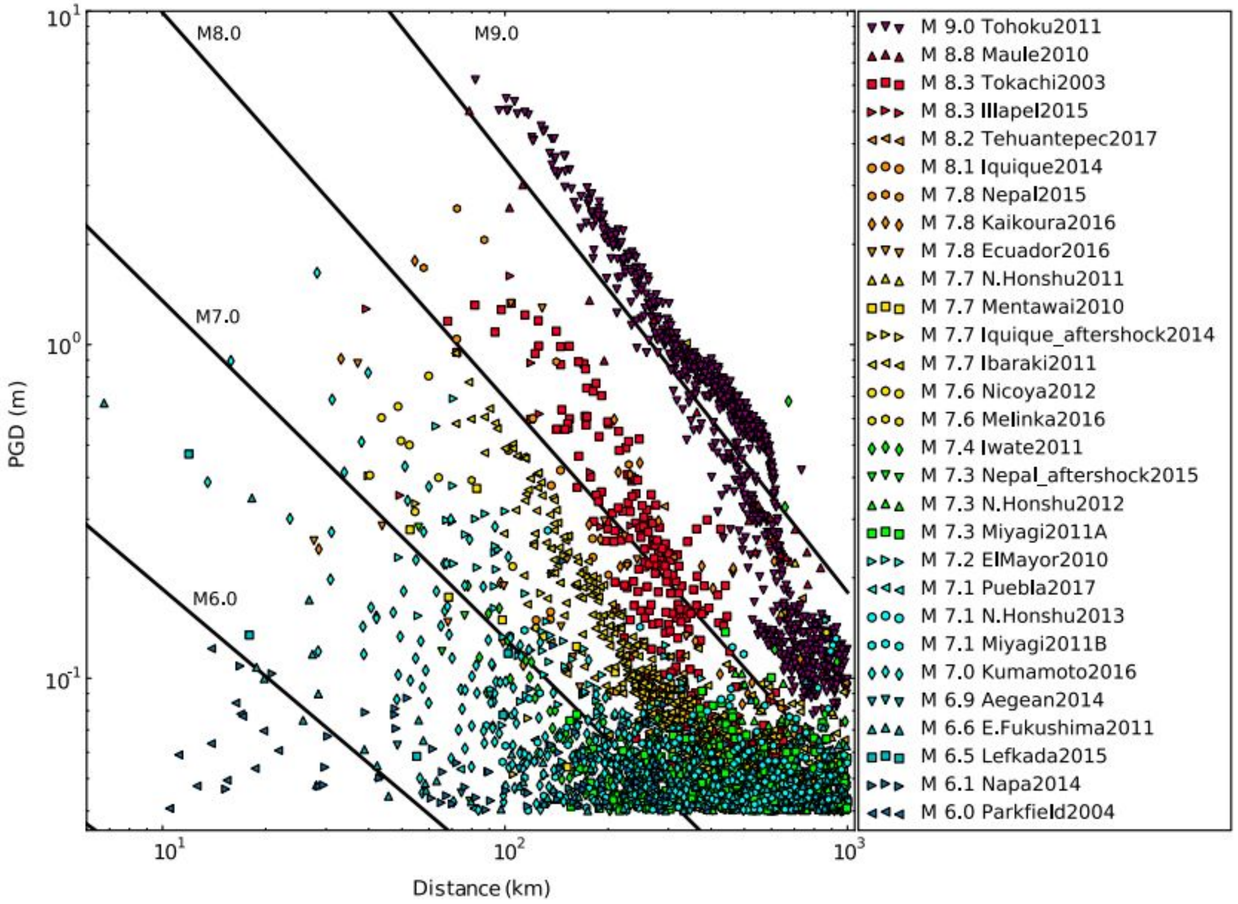


The wiggles knew. Only one technique for estimating the quake's magnitude got it right because it extracted more information from seismic waves.

Rapid earthquake magnitude estimation from GNSS Peak Ground Displacement (PGD)



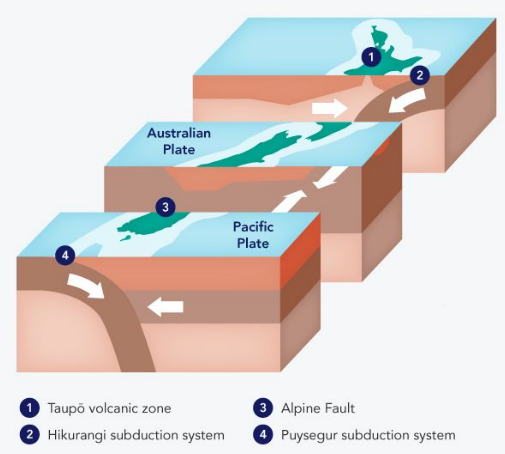
Goldberg et al, BSSA 2021



Ruhl et al, SRL 2019

Aotearoa New Zealand Natural GeoHazards

- Earthquakes
- Tsunami
- Volcanoes
- Landslides



GeoNet programme established in 2002 as partnership between government agencies

Toka Tū Ake EQC

The Earthquake Commission (EQC) has a role in research and education as a part of one of its functions under the Earthquake Commission Act 1993:

"To facilitate research and education about matters relevant to natural disaster damage, methods of reducing or preventing natural disaster damage, and insurance provided under this Act".

RESILIENCE GOAL

Our resilience goal is to inform, enable and influence the choices and decisions that reduce vulnerability and the exposure of New Zealand's built environment to natural hazard events. In simple terms the result will be stronger homes, built on better land, served by resilient infrastructure, supported by affordable risk capital.

3. Improving the current state of knowledge about New Zealand's natural hazards

Improving the depth and breadth of knowledge of natural hazard risk is successful if it results in the adoption of risk reduction behaviour and enables reinsurers to more effectively price the New Zealand risk. It includes both the application of EQC-funded research to public policy, thereby informing building standards and zoning requirements, and the raising of public awareness leading to tangible changes in behaviour in the home.

Toitū Te Whenua
Land Information New Zealand

LINZ location vision and outcome

Our 10-year vision is 'The power of where drives New Zealand's success'. Location-related decisions lie at the heart of New Zealand's economic, social, environmental and cultural prosperity.

Under this vision, LINZ has a framework of outcomes and priorities that sharpen our focus on the things that matter most for New Zealand, and guide where we put our effort and resources.

Resilience and climate change

Support efforts to prepare for, mitigate and adapt to the impacts on land and sea of climate change and one-off events (natural and human-induced).

New Zealand Positioning Strategy

The New Zealand Positioning Strategy (attachment below) sets the strategic direction for how the geodetic system will be developed within the broader positioning fundamental data theme for the next ten years.

The strategy recognises the need to maintain existing geodetic services and their accuracy, but to also better reflect new technology and support the changes in the way people use location information.

Sea level data

LINZ has established a network of sea level monitoring sites at 18 locations around New Zealand and Antarctica.

The first site was established in March 2007 and the network was completed in July 2010.

With the exception of the Antarctic site, the primary purpose of the network is to upgrade and improve New Zealand's response to tsunami hazards. However, the data generated can also be used for other purposes.

To view plots of the sea level data and for more information on the use of sea level data in a tsunami detection system, visit the GeoNet website.

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

on behalf of

National Emergency Management Agency
Te Rākau Whakamarumaru

The National Emergency Management Agency provides leadership in reducing risk, being ready for, responding to and recovering from emergencies.

National Emergency Management Agency

The National Emergency Management Agency (NEMA) provides strong, national leadership to create an emergency management system that reduces the impact of emergencies.

NEMA works with central and local government, communities, iwi, and business to make sure responses to and recoveries from emergencies are effective and integrated.

Emergencies can have consequences for people, communities, property, infrastructure, the economy and the environment. We support communities to reduce the impact of emergencies across all hazards and risks.

Depending on the emergency, we lead or support the response and recovery. We work to build the capability and capacity of the emergency management system to reduce risk, to be ready for emergencies, and to respond and recover from them.

Readiness and Response

The Agency has responsibility for maintaining the National Civil Defence Emergency Management Plan, outlining responsibilities for readiness, response and recovery tasks and procedures to be used during and after an emergency.

As part of those responsibilities we also maintain a national warning system, a 24-hour emergency communications system and an alternate communications network throughout the regions of New Zealand. The National Crisis Management Centre is equipped to monitor local or regional events and manage events of national significance.

Aotearoa New Zealand Government policies

Te Kāwanatanga o Aotearoa
New Zealand Government

data.govt.nz **Open data policies**

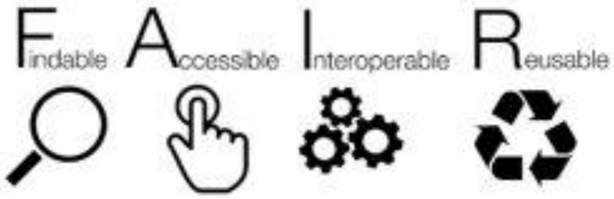
New Zealand Data and Information Management Principles

The New Zealand Data and Information Management Principles (NZDIMP) are a set of seven principles under which the New Zealand government releases its open data.

The principles state that data should be:

- open
- protected
- readily available
- trusted and authoritative
- well-managed
- reasonably priced (preferably free)
- reusable.

Unless there are identifiable reasons for its release, personal and classified data remains protected. Government data and information should also be trusted and authoritative.



International Open Data Charter

ODC Home About Charter Blog Resources FAQ

Summary

The six ODC principles were developed in 2015 by governments, civil society, and experts around the world to represent a globally-agreed set of aspirational norms for how to publish data. Below is an informal explainer of the 6 Principles:

1. Open By Default
This represents a real shift in how government operates and how it interacts with citizens. At the moment we often have to ask officials for the specific information we want. Open by default turns this on its head and says that there should be a presumption of publication for all. Governments need to justify data that's kept closed, for example for security or data protection reasons. To make this work, citizens must also feel confident that open data will not compromise their right to privacy.

2. Timely and Comprehensive
Open data is only valuable if it's still relevant. Getting information published quickly and in a comprehensive way is central to its potential for success. As much as possible governments should provide data in its original, unmodified form.

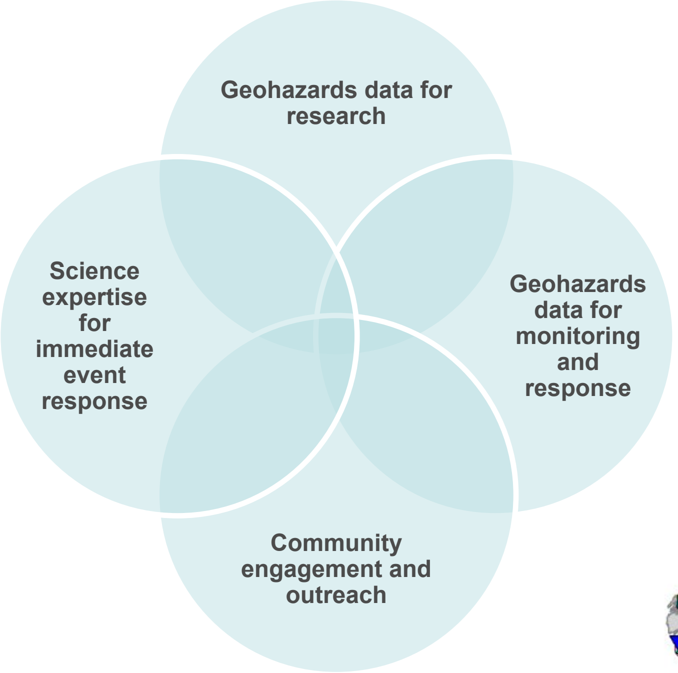
3. Accessible and Usable
Ensuring that data is machine readable and easy to find will make data go further. Portals are one way of achieving this. But it's also important to think about the user experience of those accessing data, including the file formats that information is provided. Data should be free of charge, under an open license, for example, those developed by Creative Commons.

4. Comparable and Interoperable
Data has a multiplier effect. The more quality datasets you have access to, and the easier it is for them to talk to each other, the more potential value you can get from them. Commonly-agreed data standards play a crucial role in making this happen.

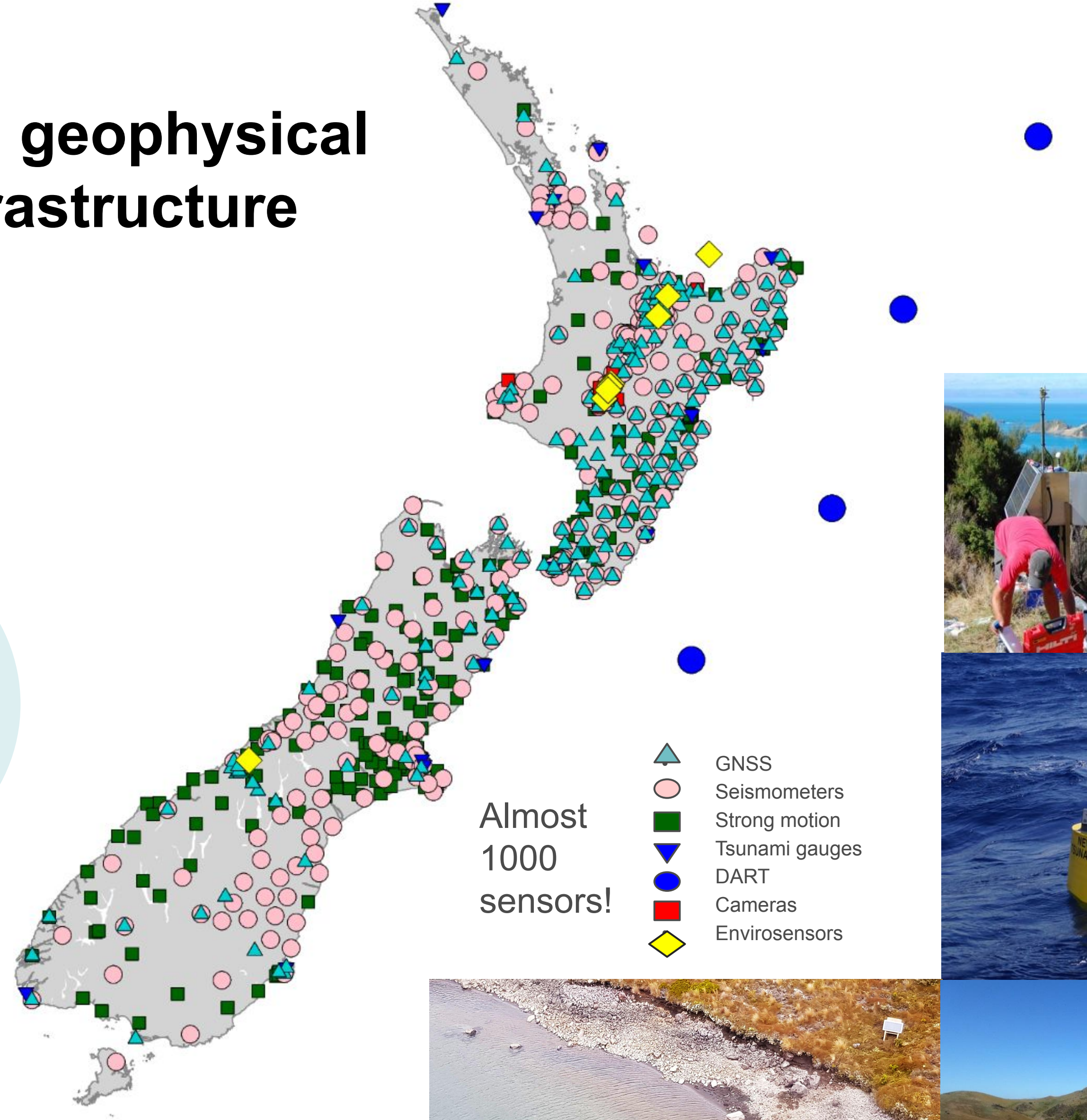
5. For Improved Governance & Citizen Engagement
Open data has the capacity to let citizens (and others in government) have a better idea of what officials and politicians are doing. This transparency can improve public services and help hold governments to account.

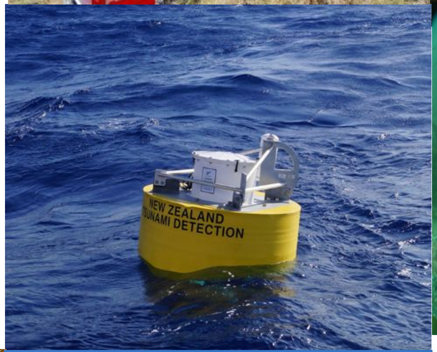
6. For Inclusive Development and Innovation
Finally, open data can help spur inclusive economic development. For example, greater access to data can make farming more efficient, or it can be used to tackle climate change. Finally, we often think of open data as just about improving government performance, but there's a whole universe out there of entrepreneurs making money off the back of open data.

GeoNet multi-domain geophysical network and data infrastructure



Data infrastructure (sensor network, communications, data centres)





GeoNet and PositioNZ continuous GNSS networks

Toitū Te Whenua Land Information New Zealand

PositioNZ stations (37): GPS, Glonass, Galileo, BeiDou, QZSS
https://www.linz.govt.nz

GeoNet

GeoNet stations: GPS, Glonass
https://www.geonet.org.nz

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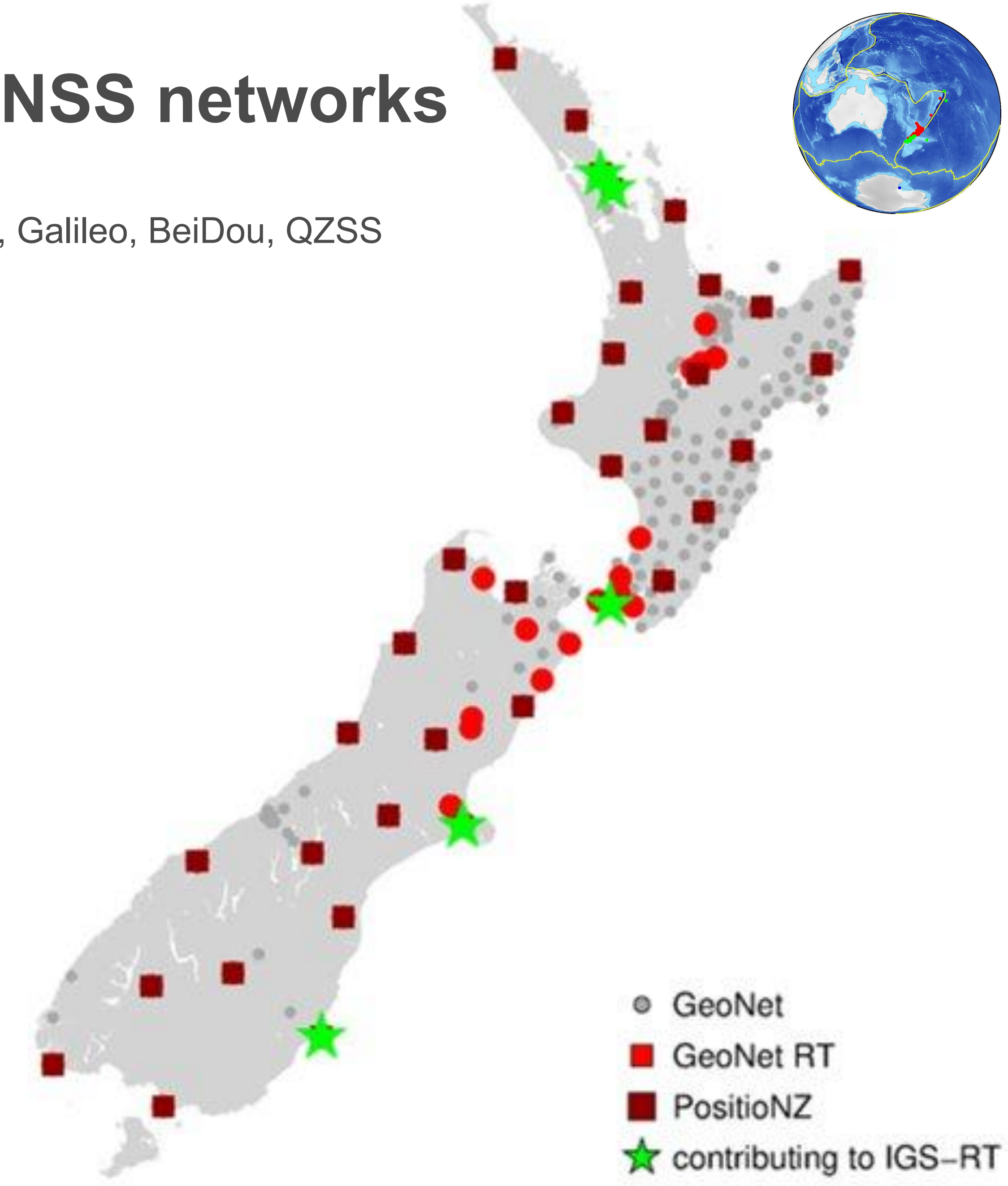
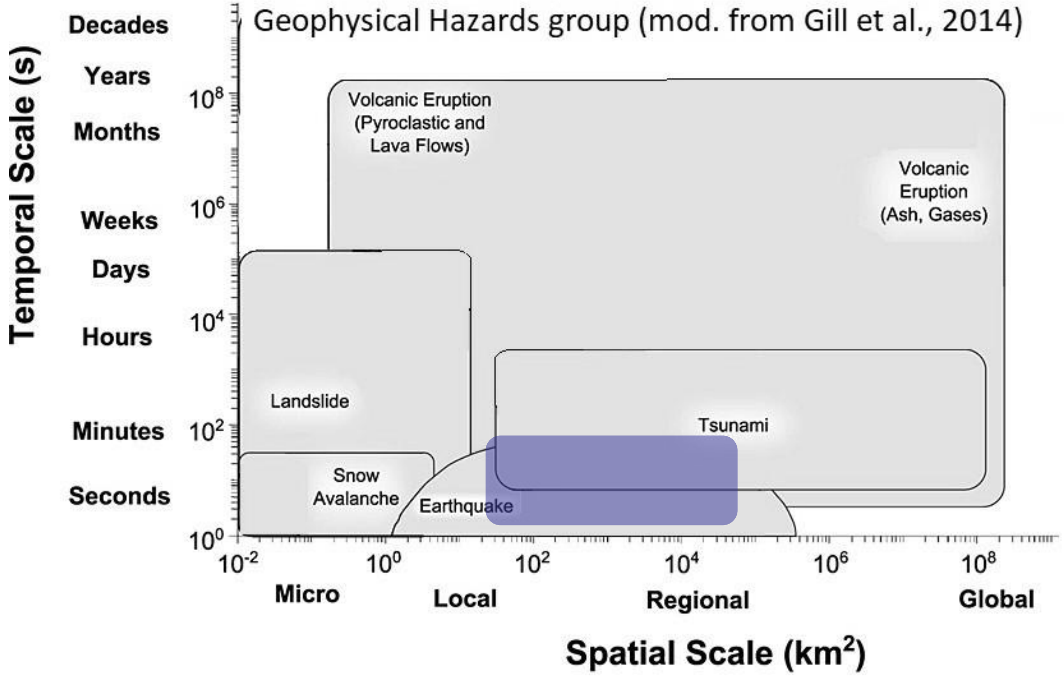
Contributing to **IGS network**
www.igs.org

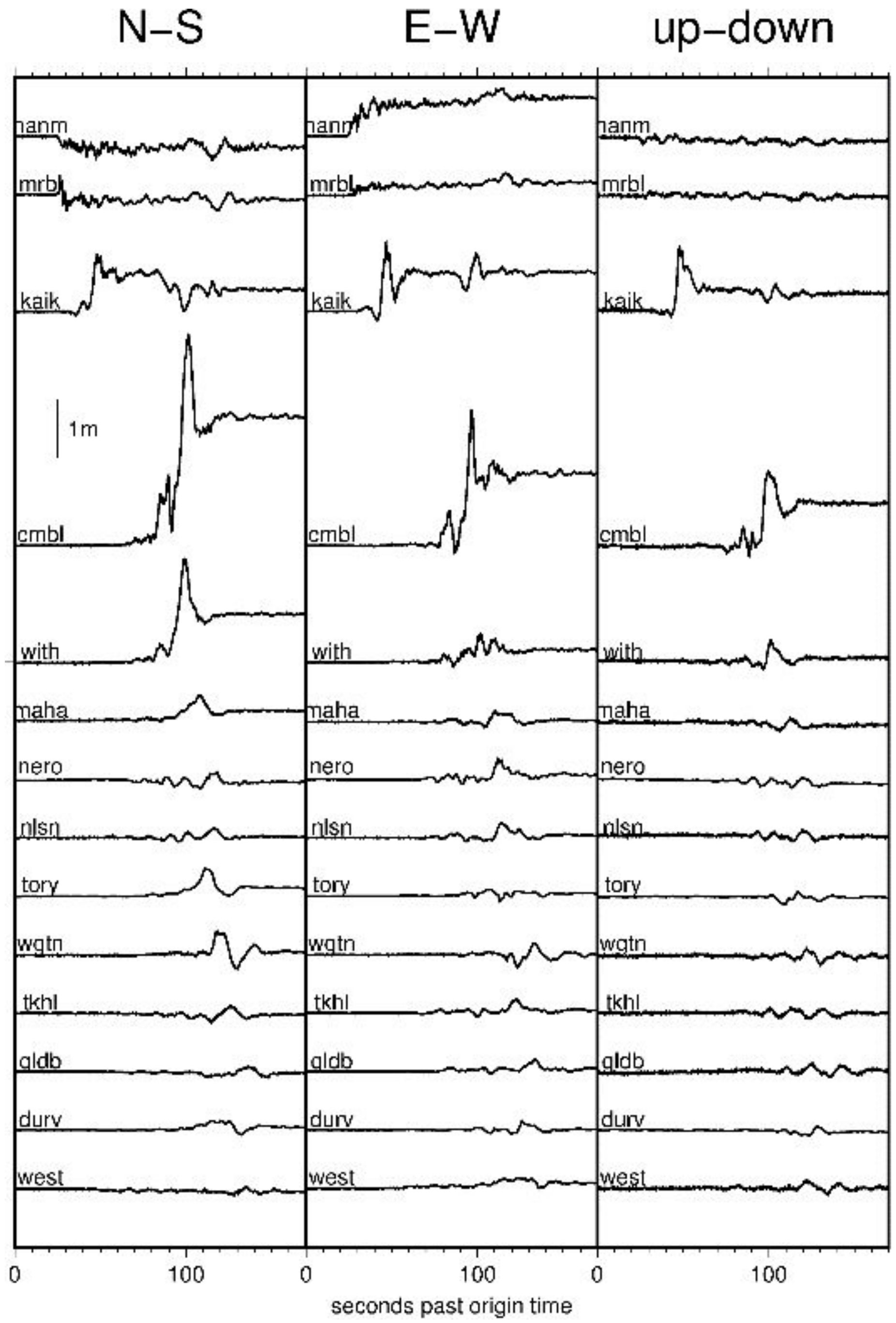


GeoNet GNSS data and products: seconds/minutes

Earthquakes

0.1s GNSS kinematic displacement (post-processed)

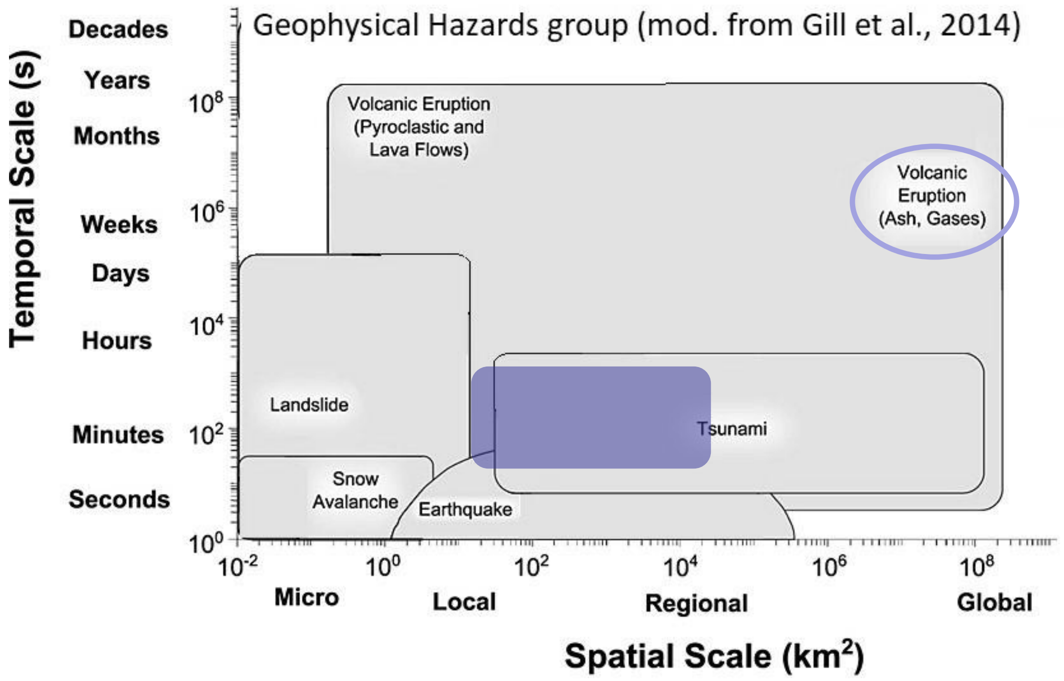




GeoNet GNSS data and products: seconds/minutes

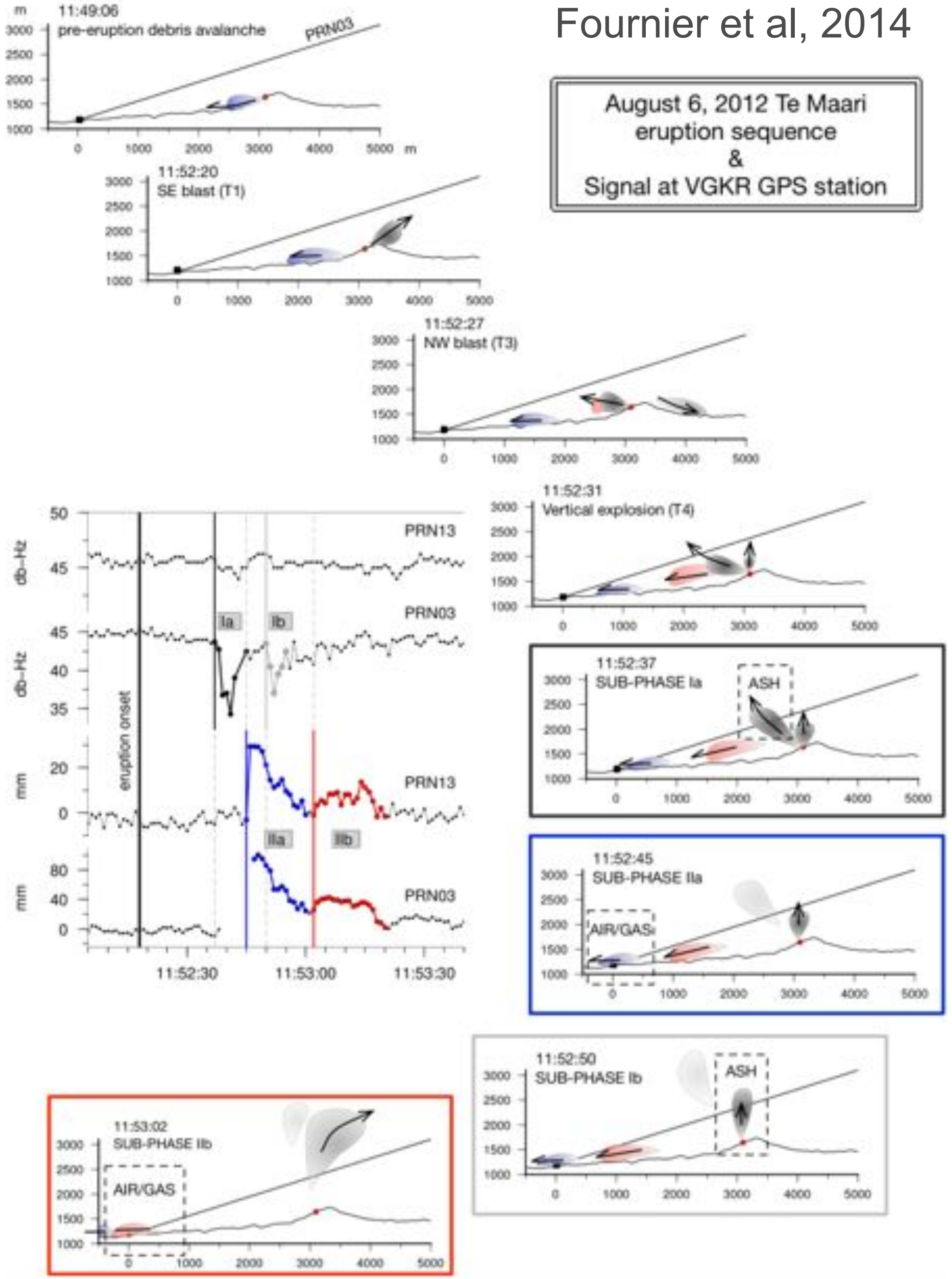
Volcanoes

1s GNSS Signal to Noise Ratio



Fournier et al, 2014

August 6, 2012 Te Maari eruption sequence & Signal at VGKR GPS station

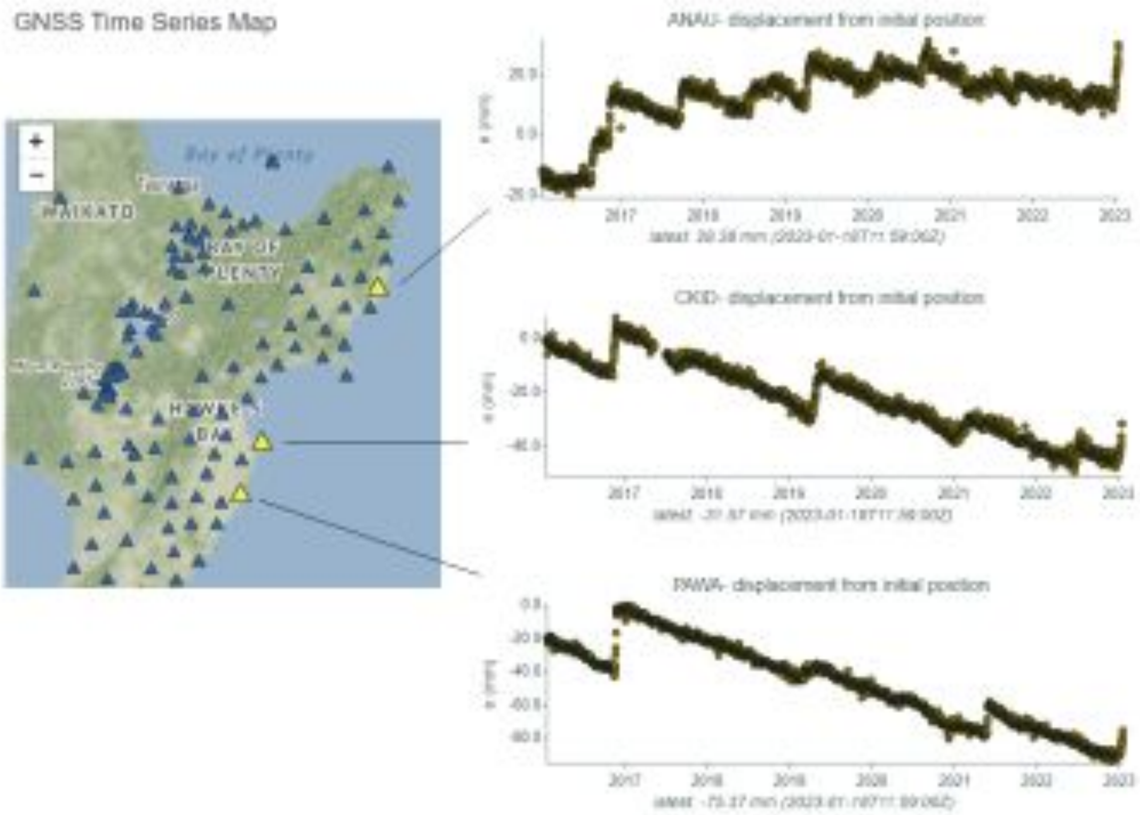


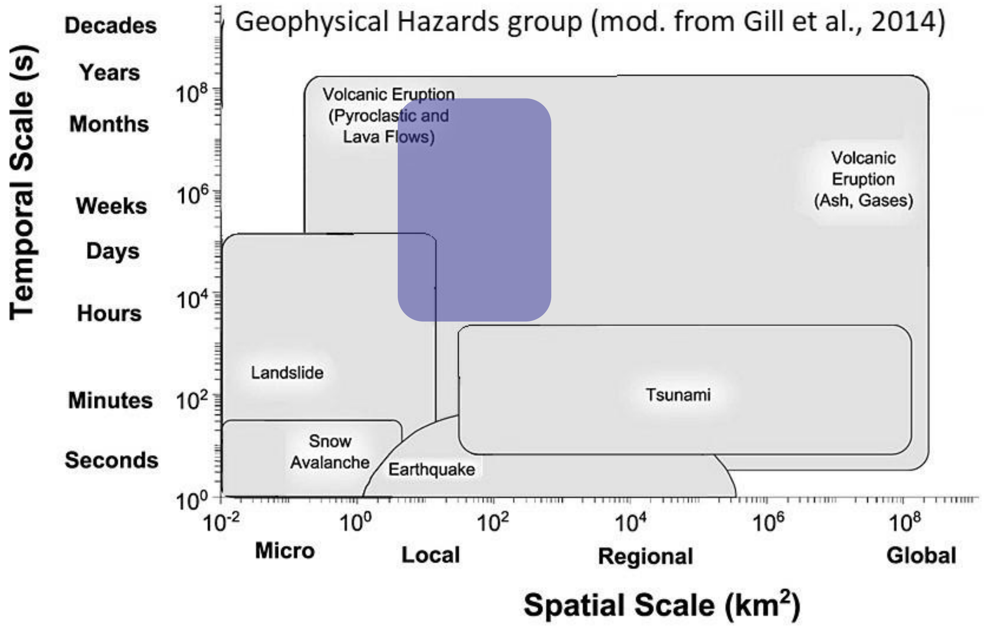
GeoNet GNSS data and products: days/weeks

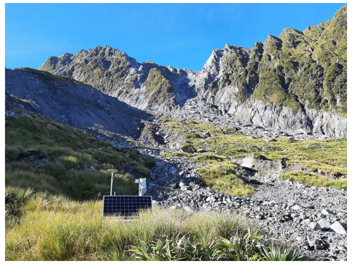
(Slow) Earthquakes

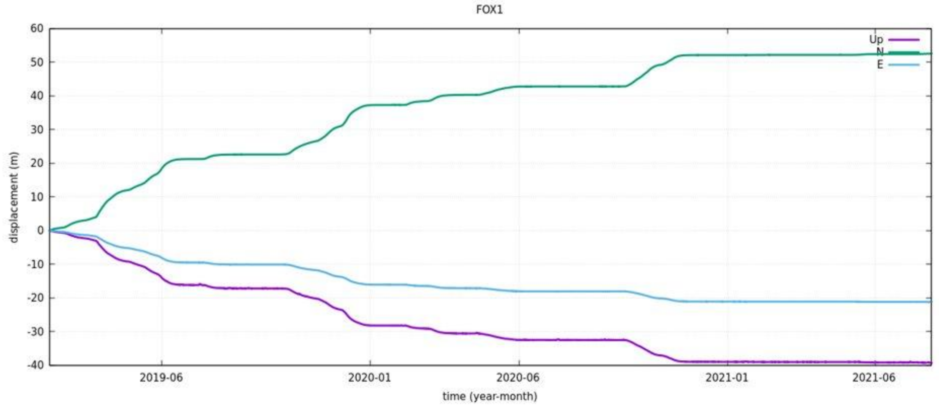
Landslides

GNSS daily displacements



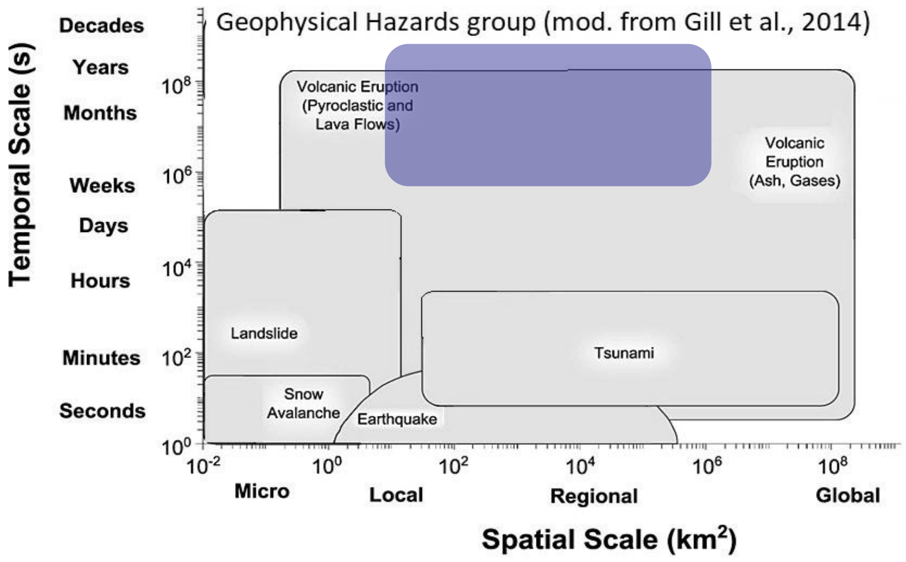


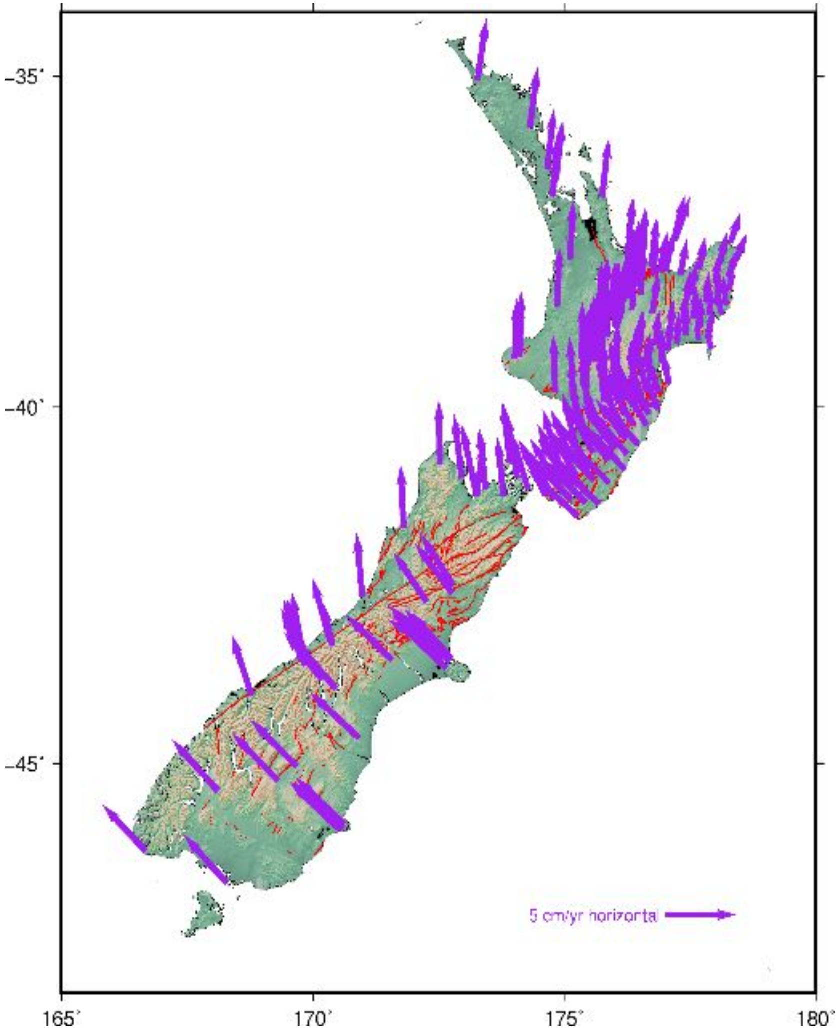


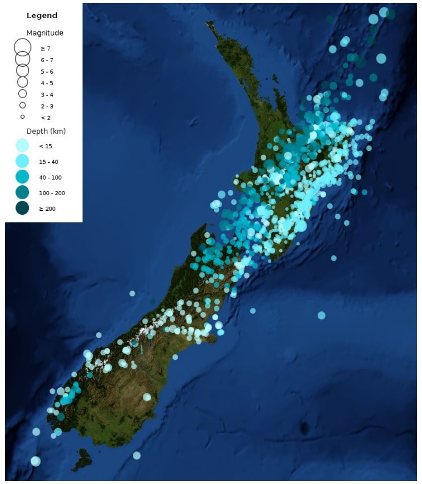


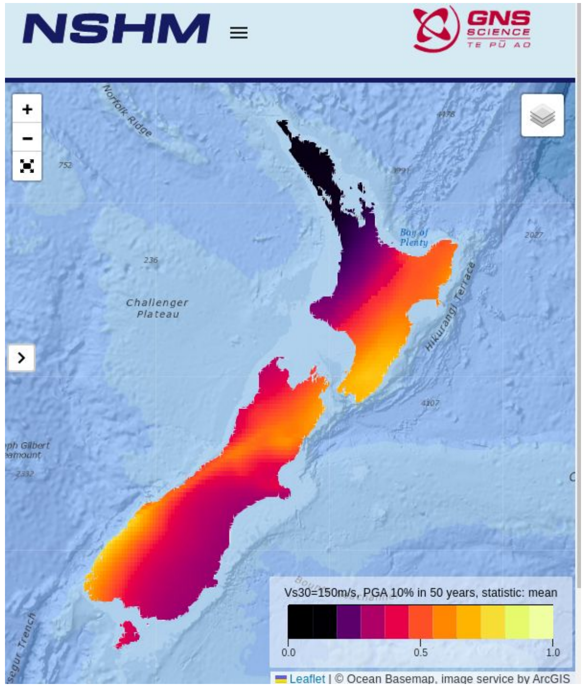
GeoNet GNSS data and products: years/decades

Earthquakes



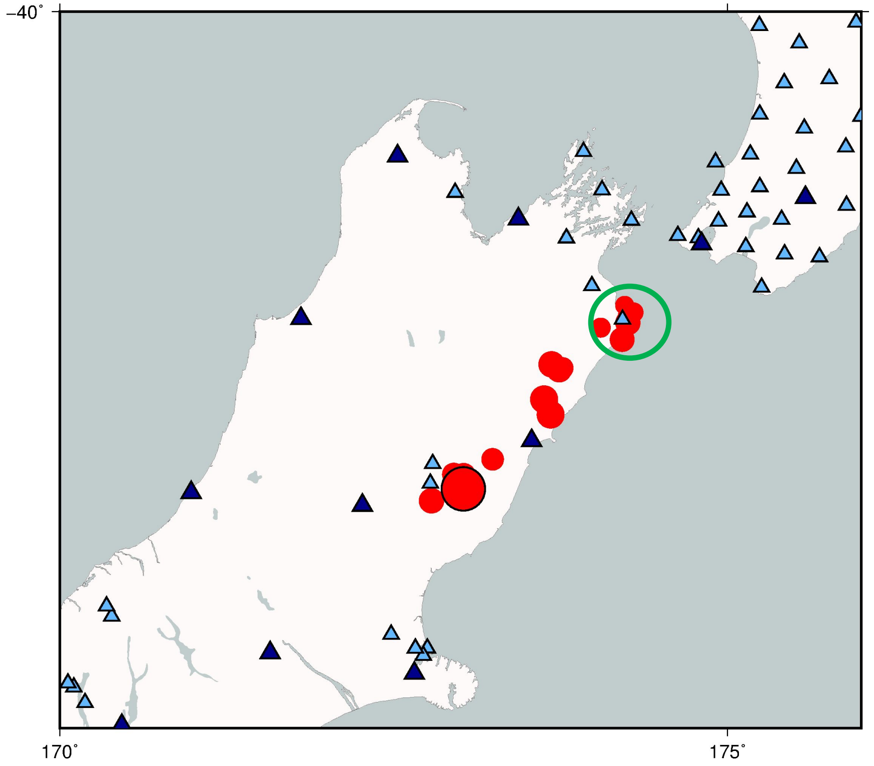






Kaikoura 2016 earthquake and tsunami, time machine

GNSS network in November 2016

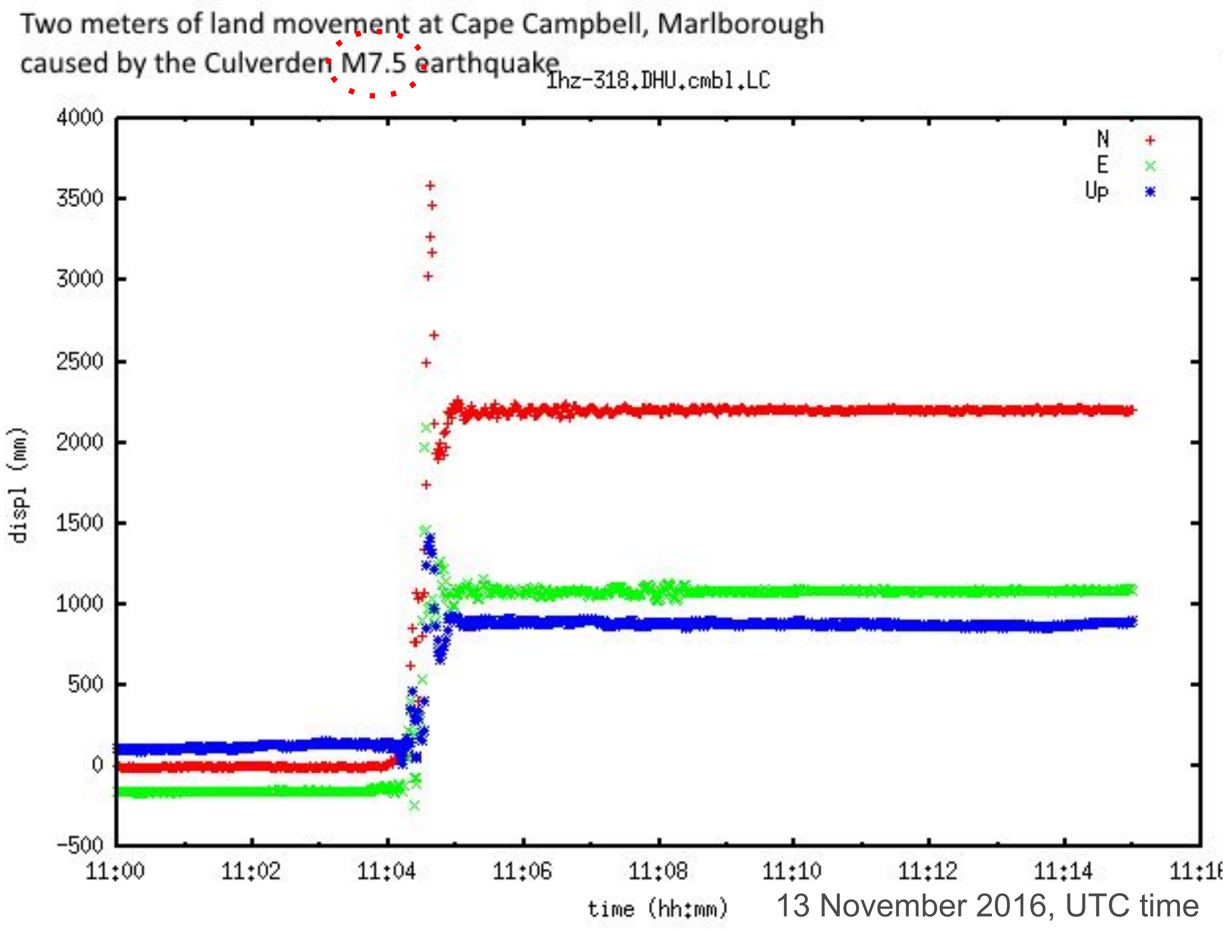


GeoNet 1s on local system memory

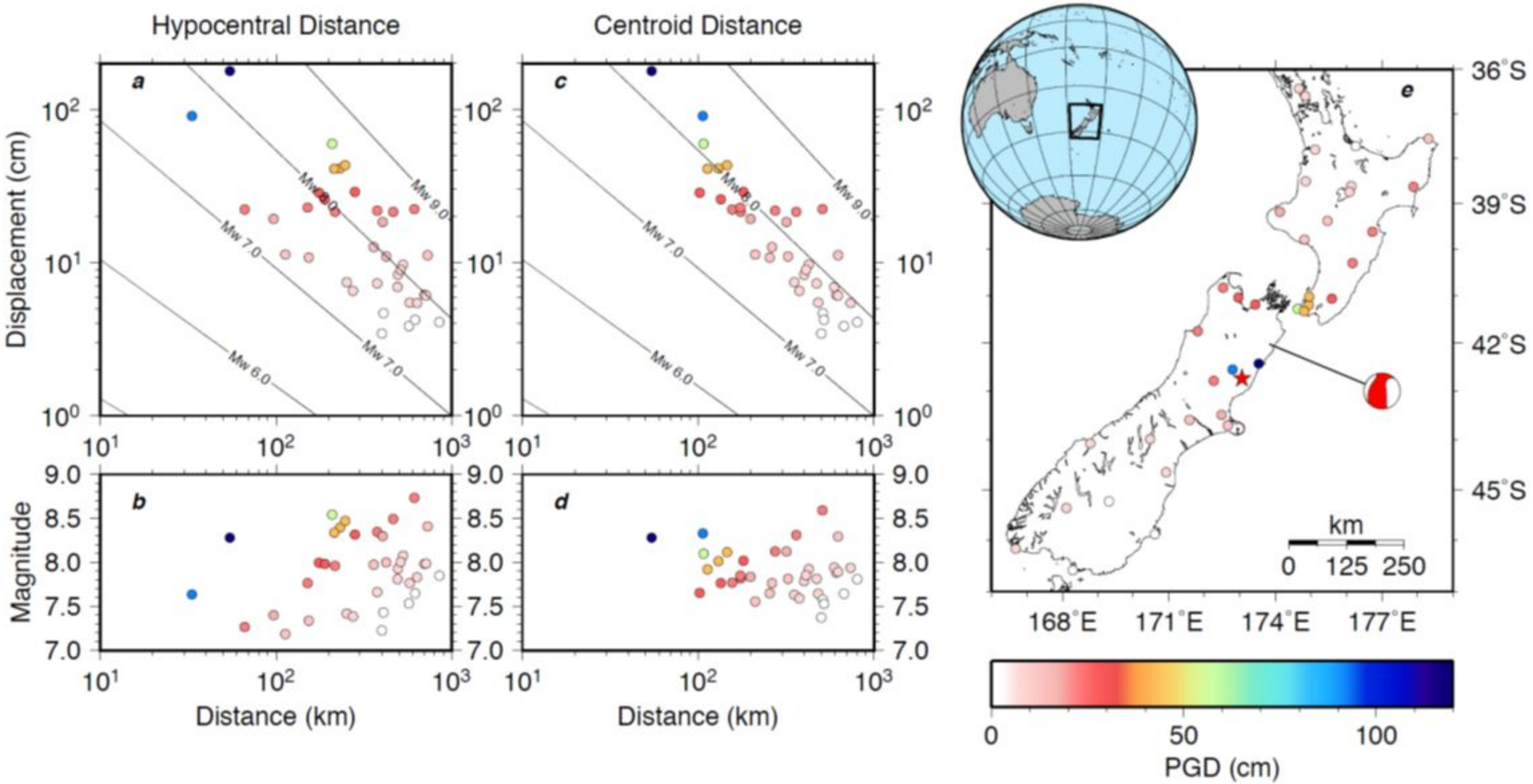
PositioNZ 1s in real time

M>4 earthquakes in the first hour after the mainshock

GNSS kinematic displacement produced manually ~2hr after the event. Earthquake magnitude was underestimated (poorly constrained by available data and modelling at the time)



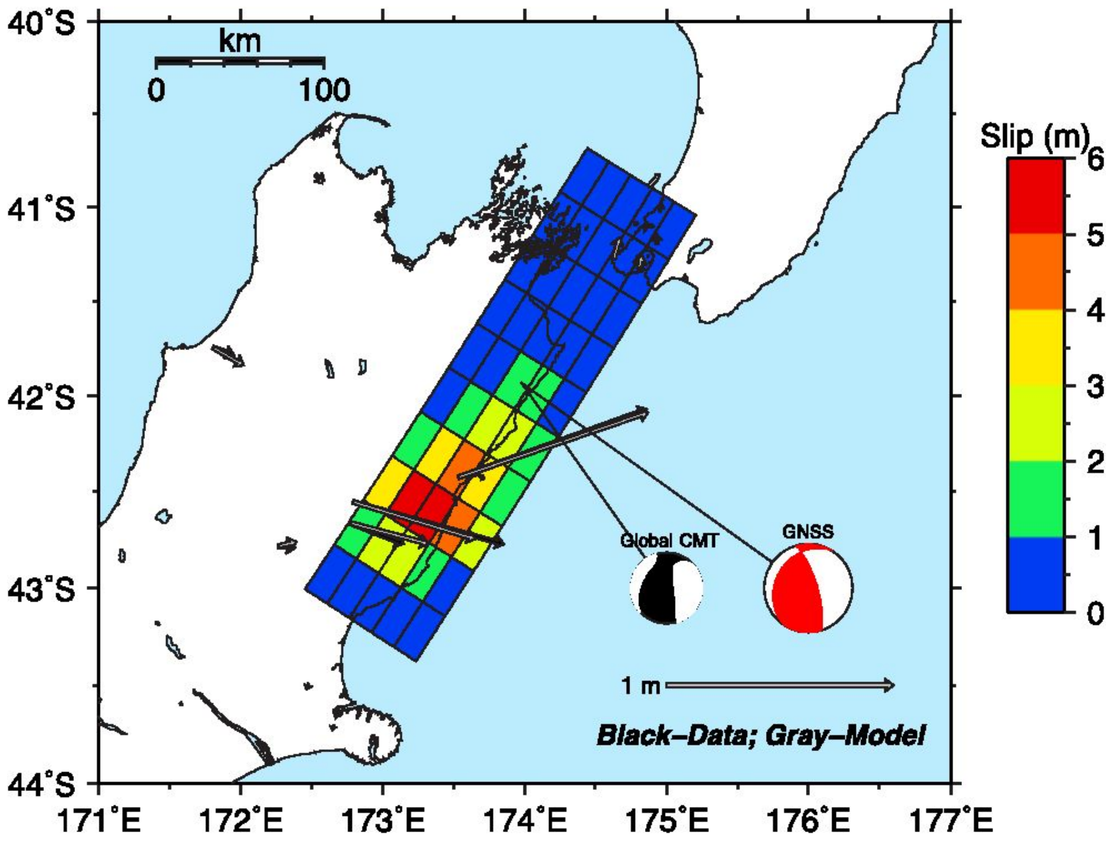
Kaikoura 2016 earthquake and tsunami, simulation (PGD)



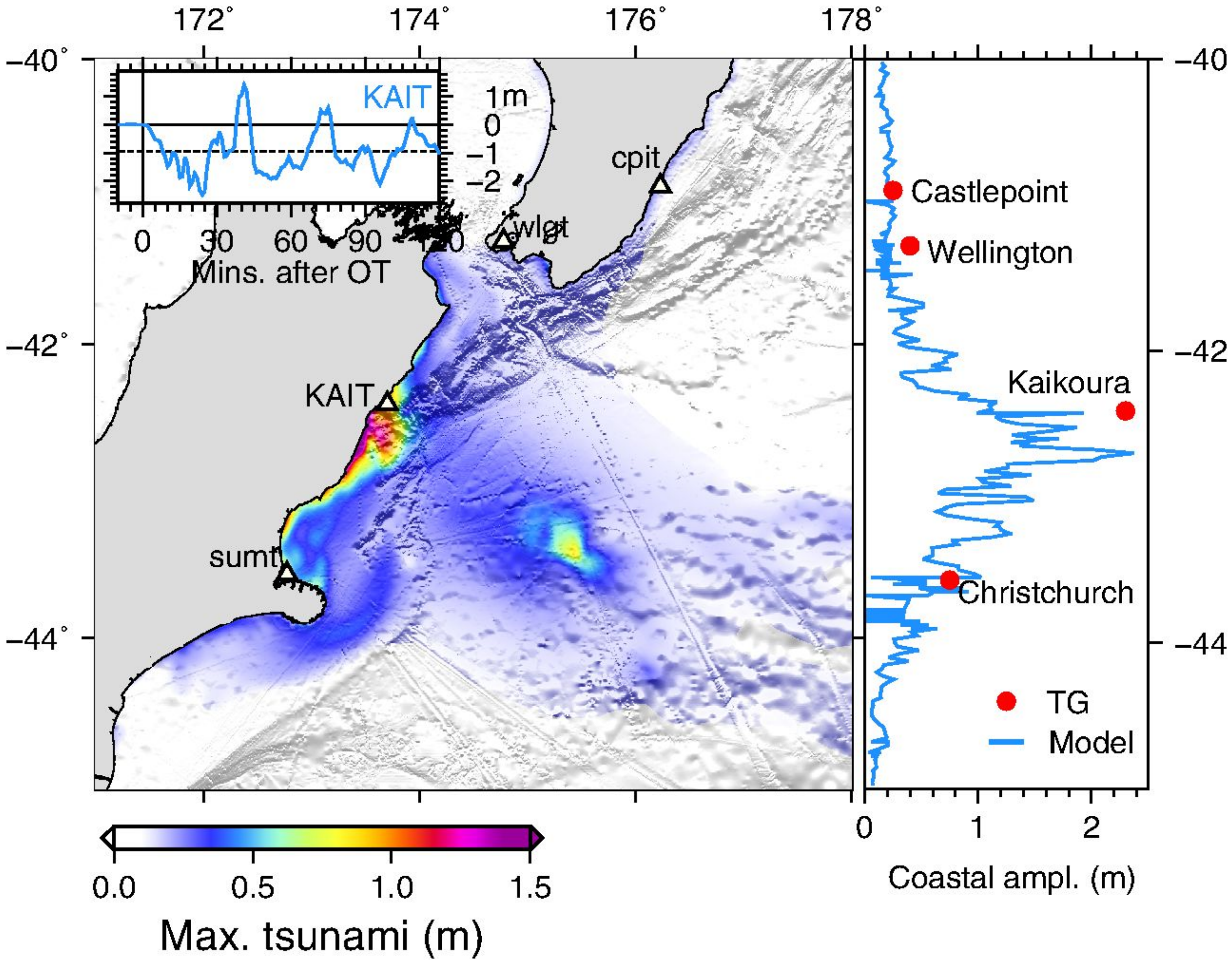
Crowell et al., 2018

Kaikoura 2016 earthquake and tsunami, simulation (finite fault and tsunami)

post-event simulation of earthquake source inversion using GNSS real time data



post-event local tsunami modelling



Crowell et al., 2018

GNSS for Rapid Earthquake Source Characterization

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

R-CET research aims:

- Rapid analysis of large local earthquakes and their impacts
- Rapid analysis of offshore earthquakes and tsunami in the Southwest Pacific
- Science to practice via education and outreach initiatives

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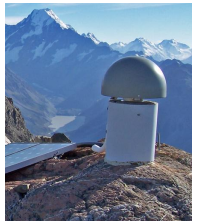
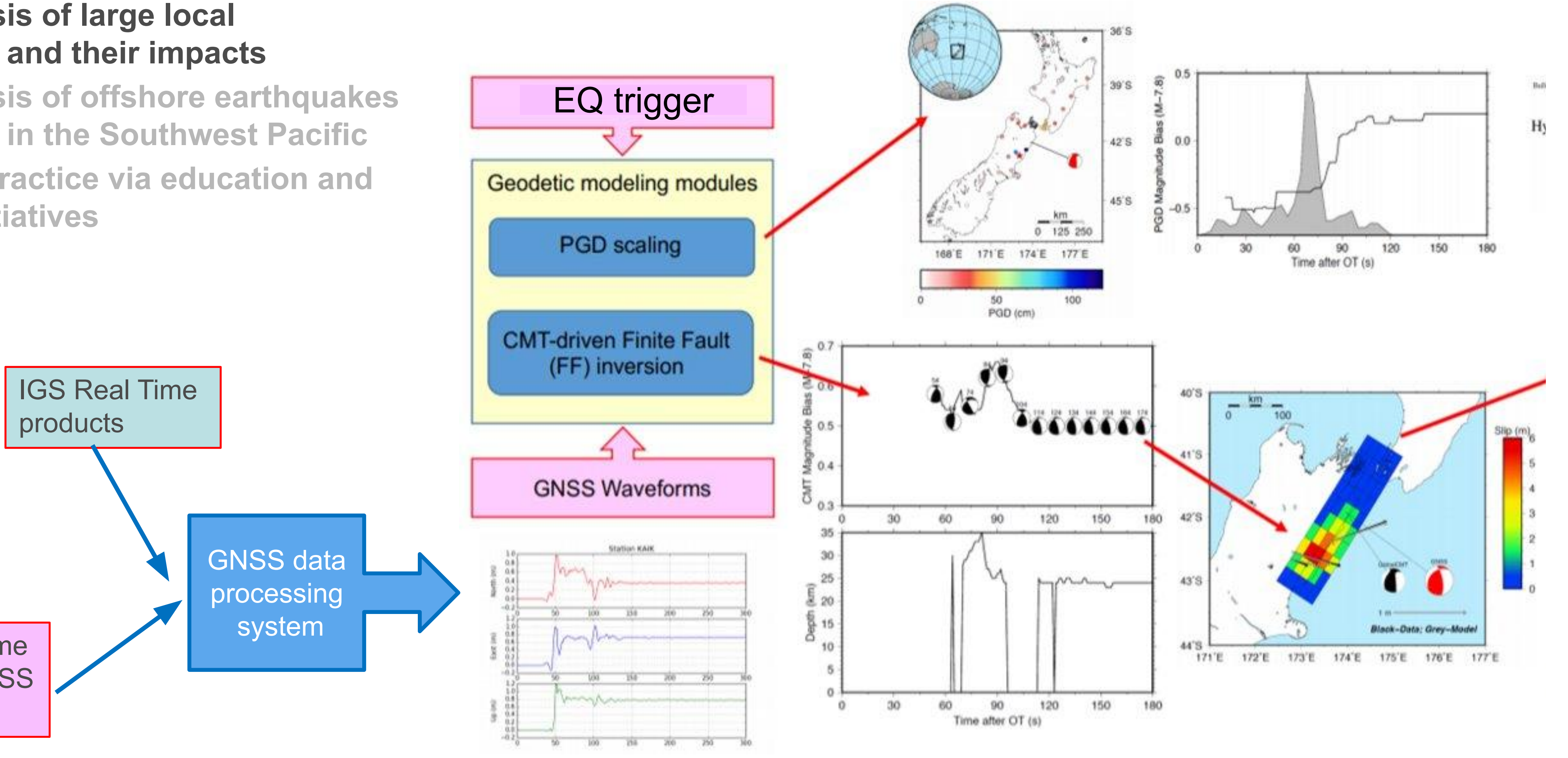




modified after Crowell et al., 2018

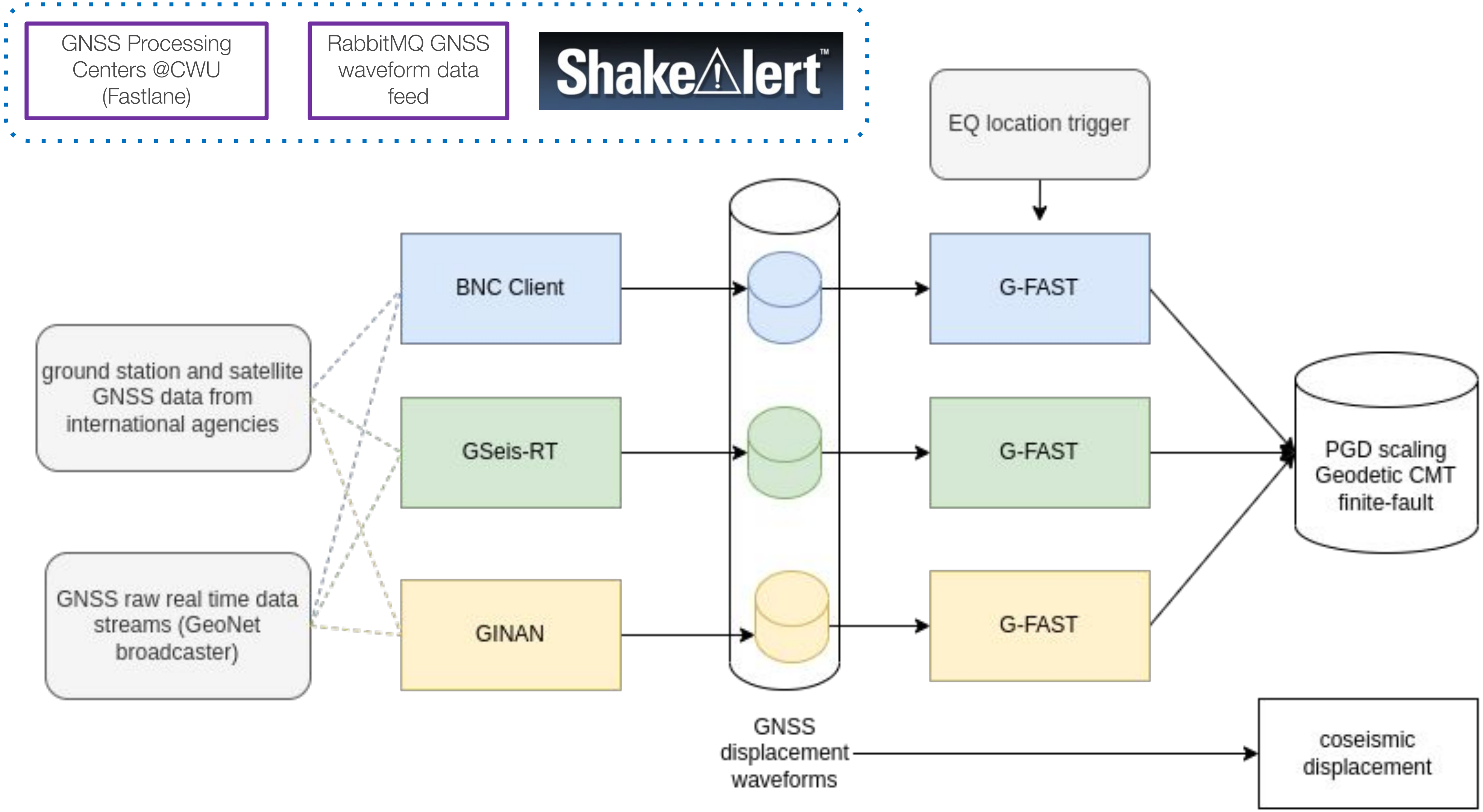
R-CET GNSS: will test and compare different GNSS real time processing solutions

In collaboration with B. Crowell (Washington University), J. Jianghui (Wuhan University), S. McClusky (Geoscience Australia) and thanks to BKG!

3 open source real time GNSS processing software tested and compared for:

- robustness,
- signal to noise ratio
- optimization for Aotearoa New Zealand scenario

Solutions and G-FAST performance in NZ will be compared to the system in place within USA ShakeAlert

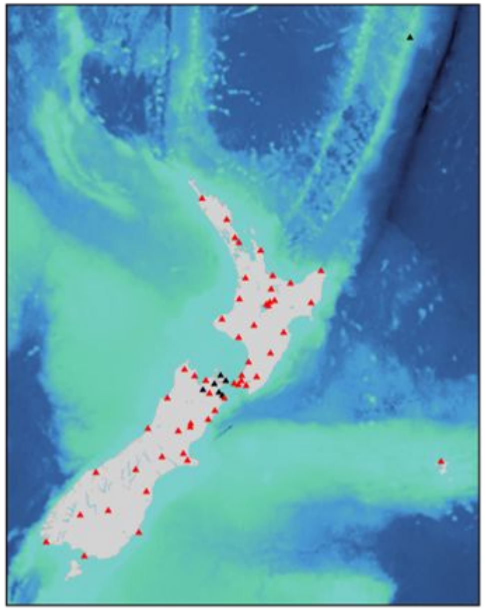


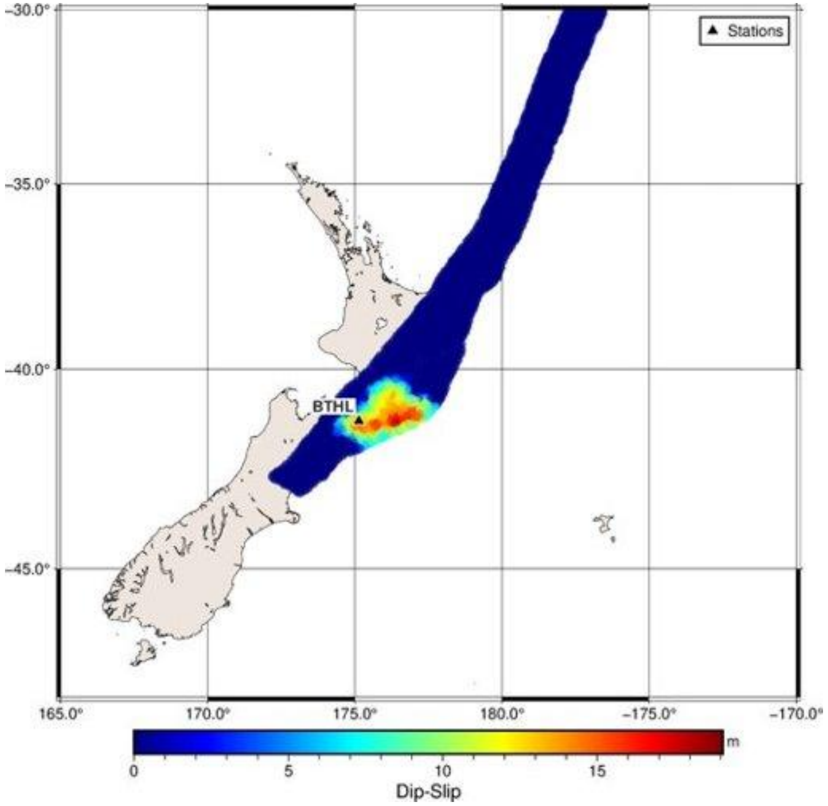
R-CET GNSS: simulations of GFAST in Aotearoa New Zealand

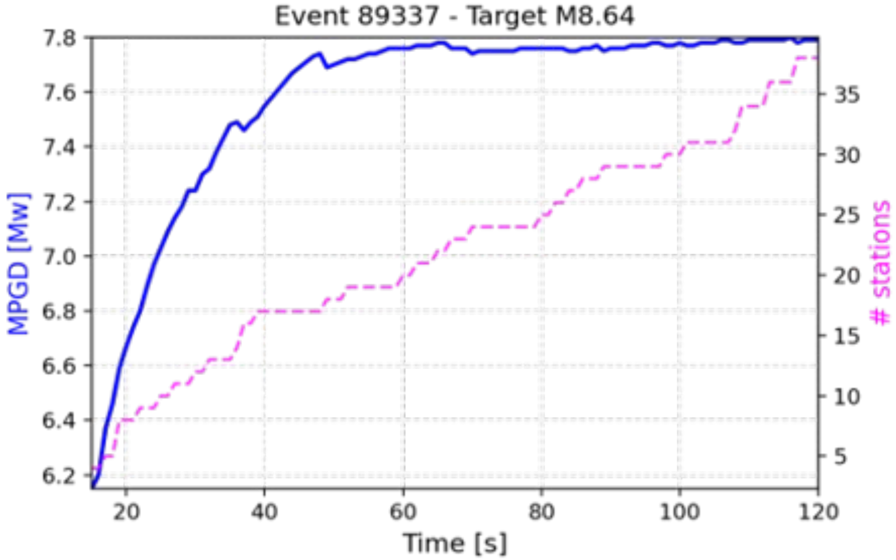
In collaboration with D. Melgar and M. Solares (Oregon University) and A. Howell (GNS Science)

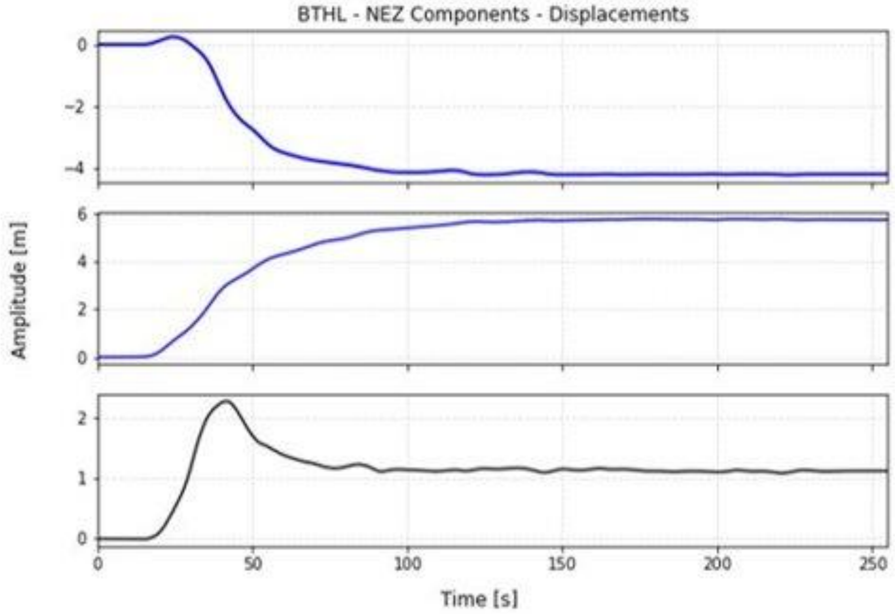
RCN2 simulated events catalogue => Synthetic GNSS waveforms

- 350 megathrust events simulated (7 < M < 9.2)
- Discretized in 3624 subfaults
- Green's functions at selected stations
- impulse response for each station-subfault pair



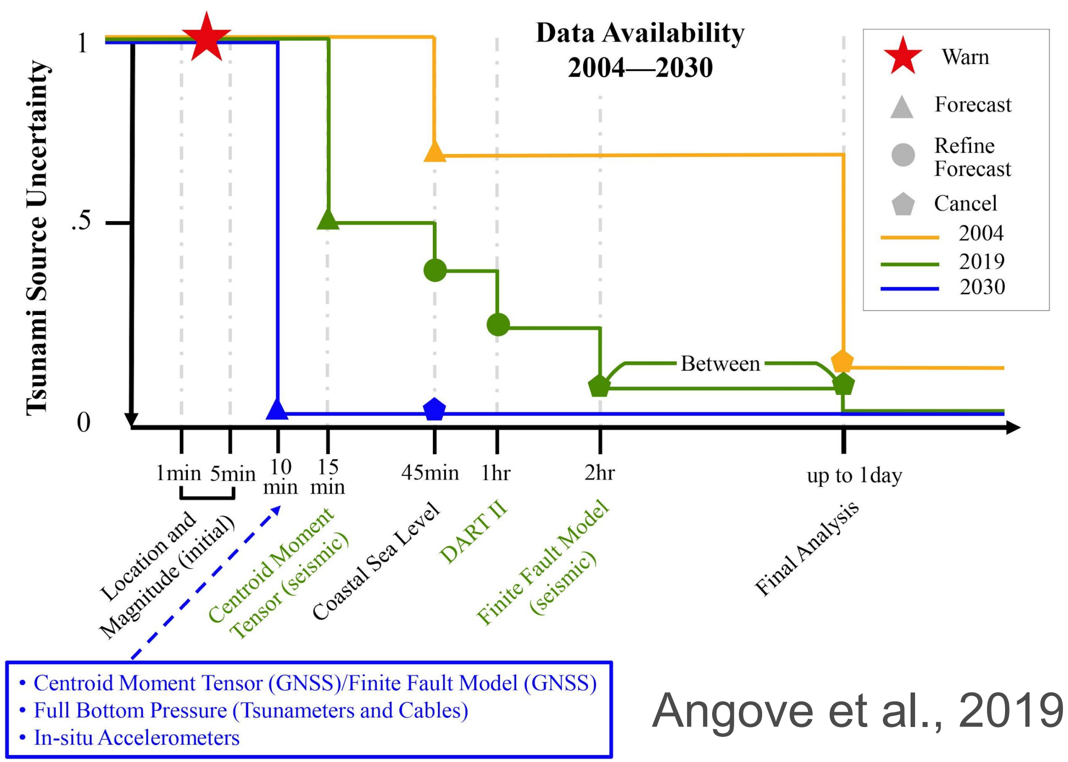




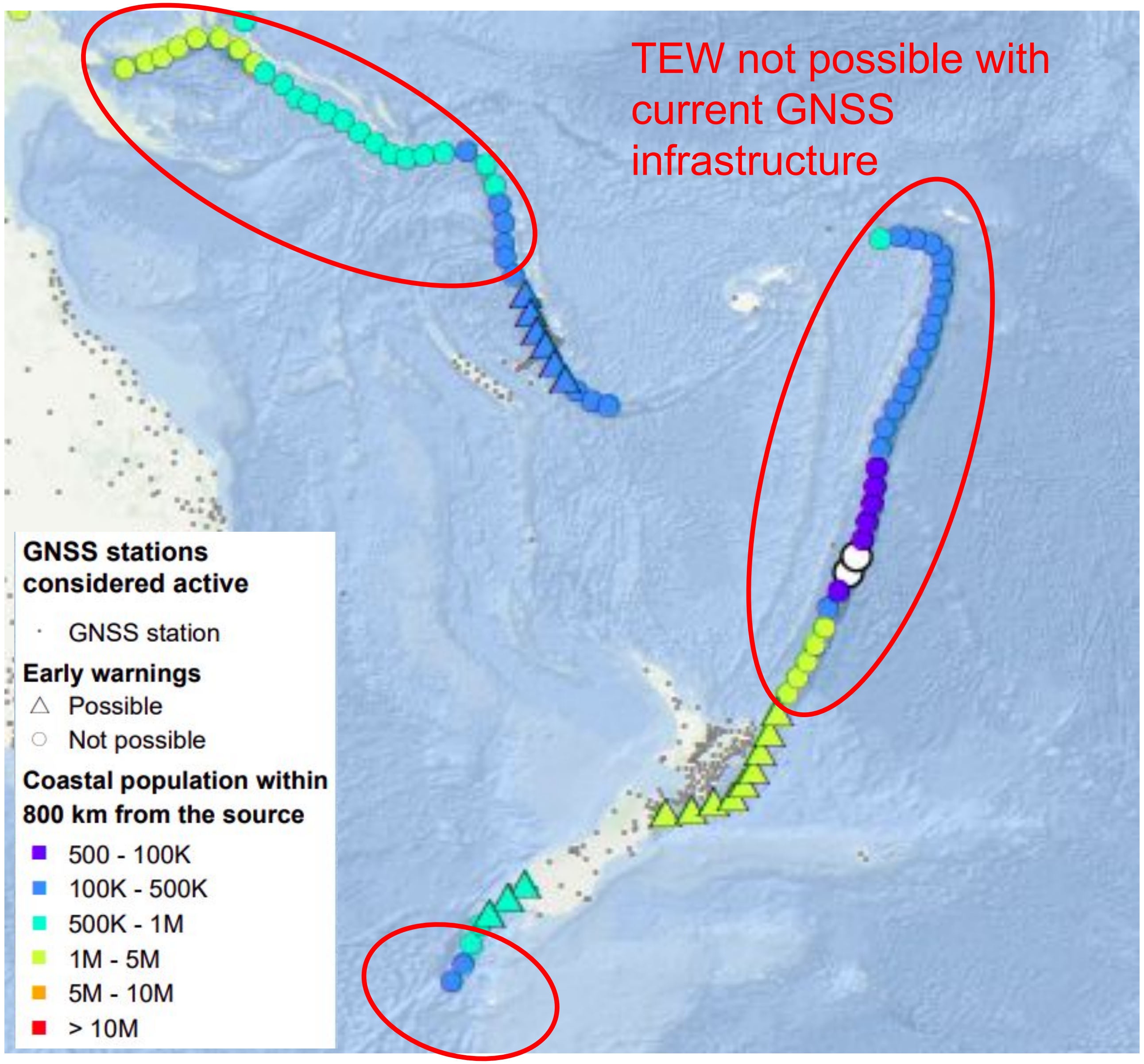


Solares-Colón et al., in prep

SW Pacific and Tsunami Early Warning target: 10 minutes for forecast



Angove et al., 2019



Courtesy of B. Lukovic and B. Fry

GNSS for Tsunami Early Warning System, the way forward

Please join us in the development of GTEWS-Oceania

First Organizational discussions to begin via Zoom March 1, 2023 at 1 PM (UTC +13) (New Zealand time zone)

Register by sending email to: jlabrecq@mac.com with the subject "GTEWS_Oceania"
Further notices to follow

Kia Ora, grazie, thank you, fa'afetai, malo 'aupito, vinaka, merci, fakafetai lasi, sulang, fakaue, kwe emmal!