Reference Frames Workshop – New Zealand Example

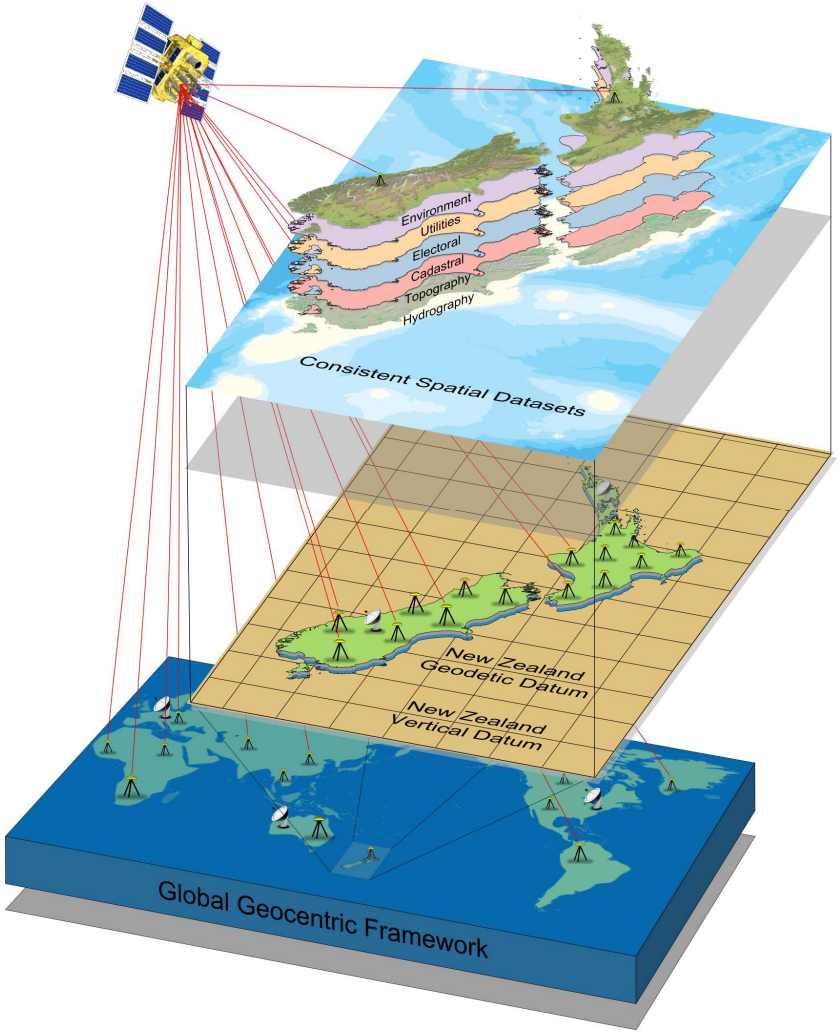
Graeme Blick

Group Manager Positioning and Resilience

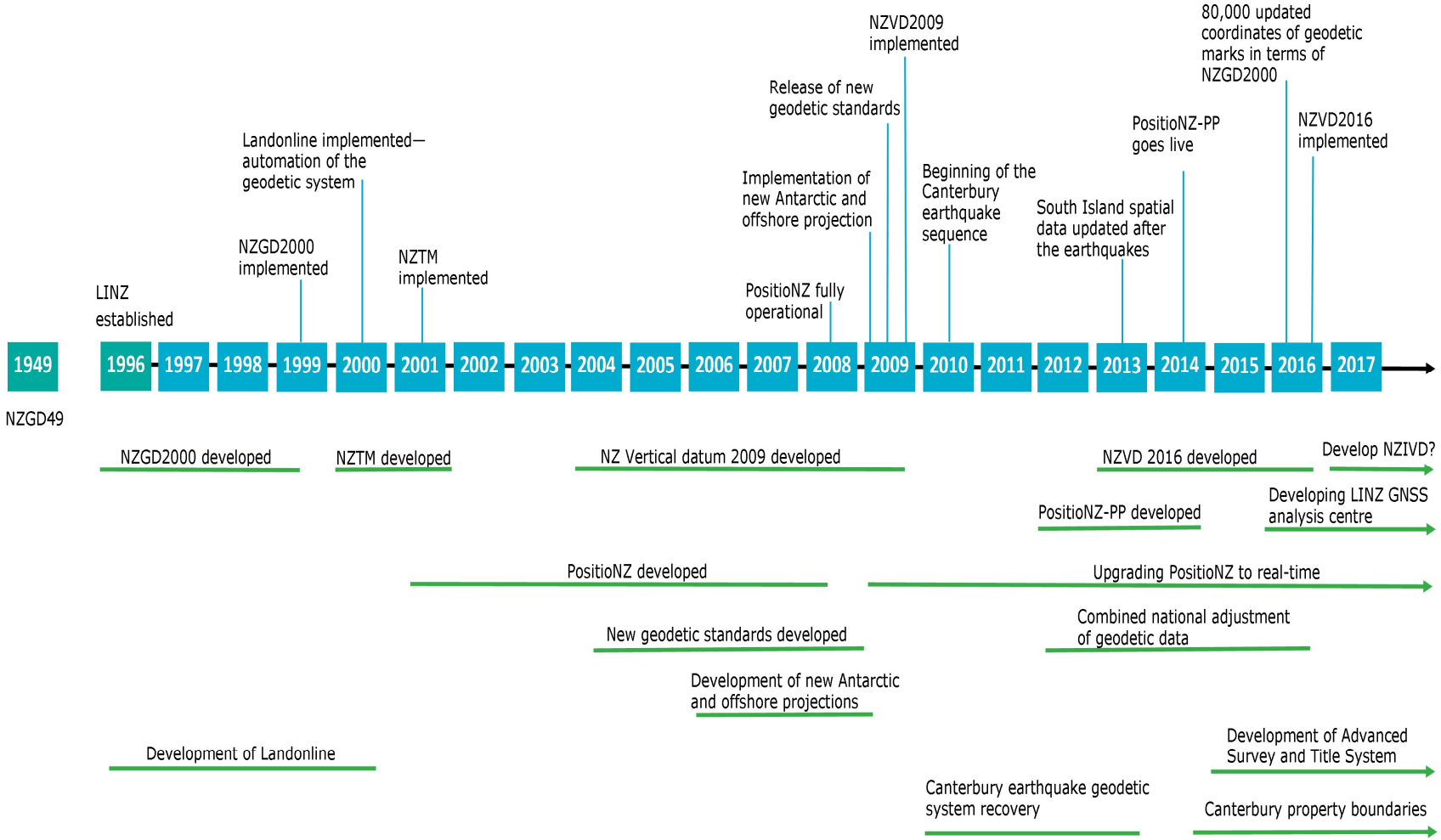
Land Information New Zealand

Reference Frames in Practice -

Reference Frames, Kinematics and Dynamic Datums



Major milestones in the development of the NZ Geodetic System



What we'll cover

Tectonic setting of New Zealand

Geodetic datums

CORS and supporting global frameworks

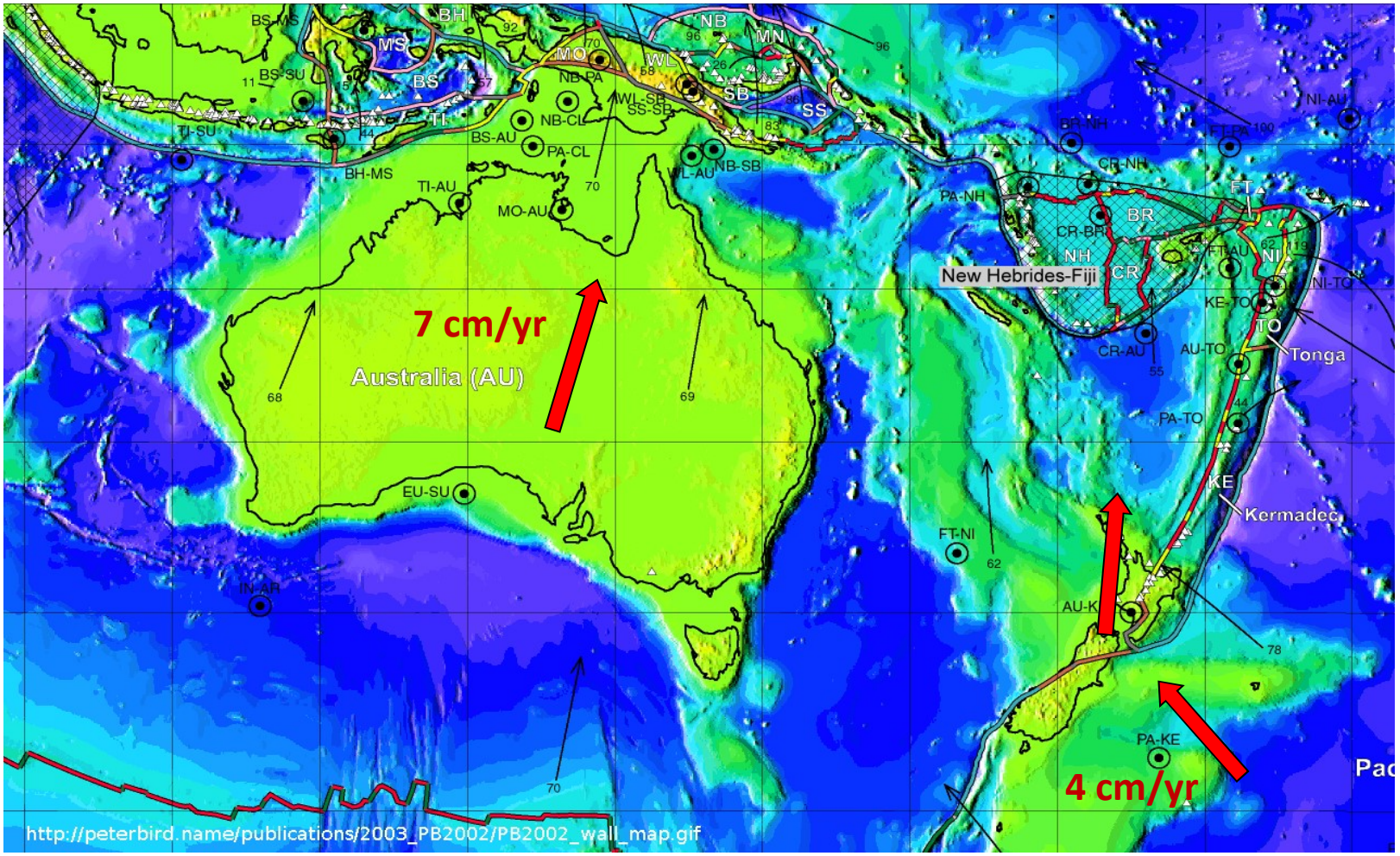
Monitoring deformation

Vertical datum

Geodetic strategy

Tectonic Setting

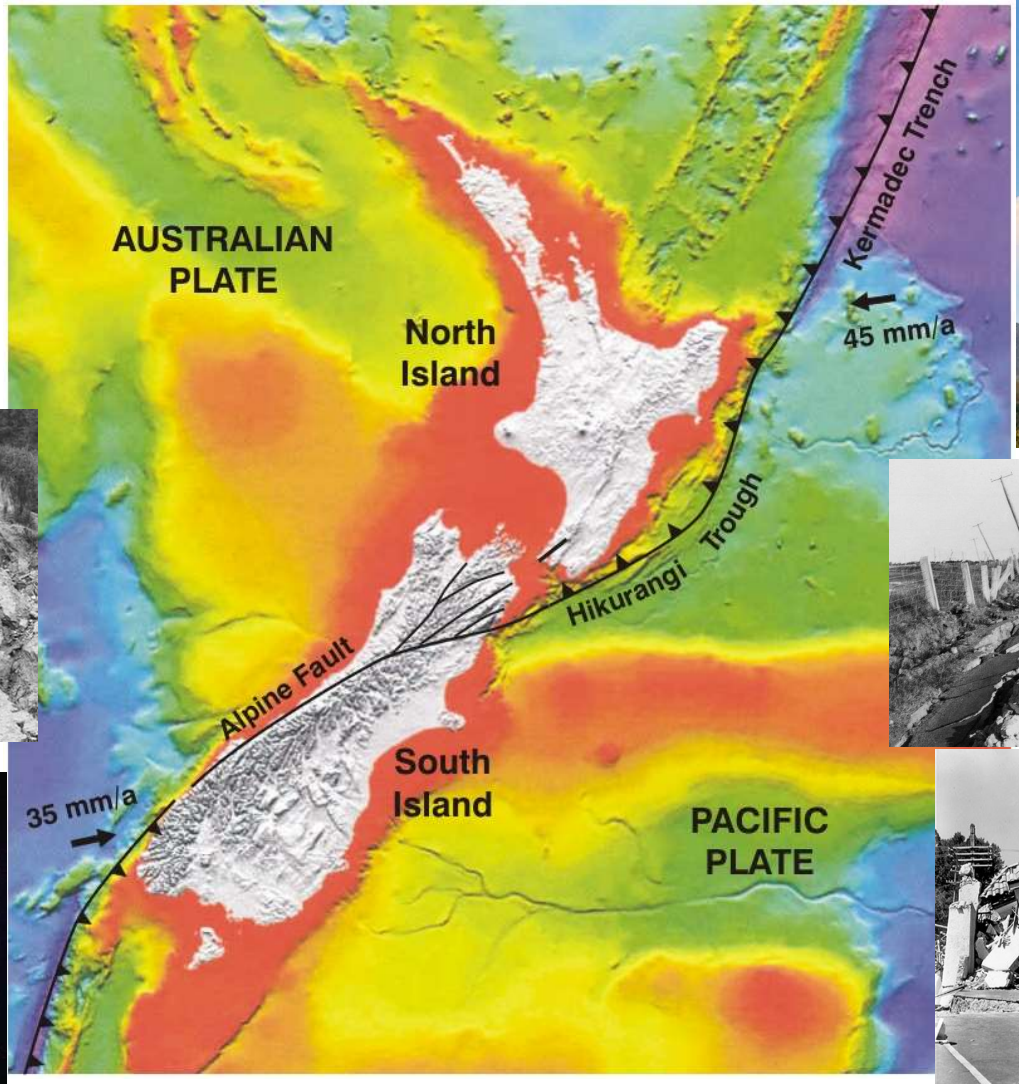
Tectonic setting of New Zealand



FIG/IAG/UN ICG/HKMO Technical Seminar

Reference Frames in Practice -

Reference Frames, Kinematics and Dynamic Datums



Sponsors: Leica Geosystems, Trimble

Istanbul, Turkey 4-5 May 2018

Recognition of plate tectonics

Professor Harold Wellman

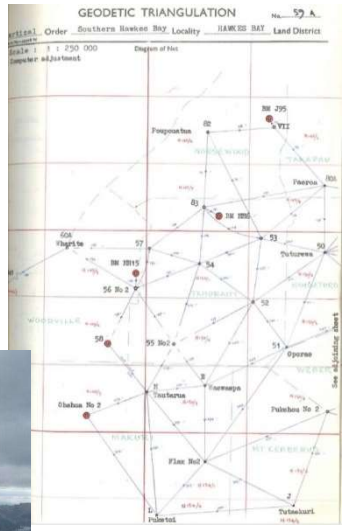
Geodetic Datums

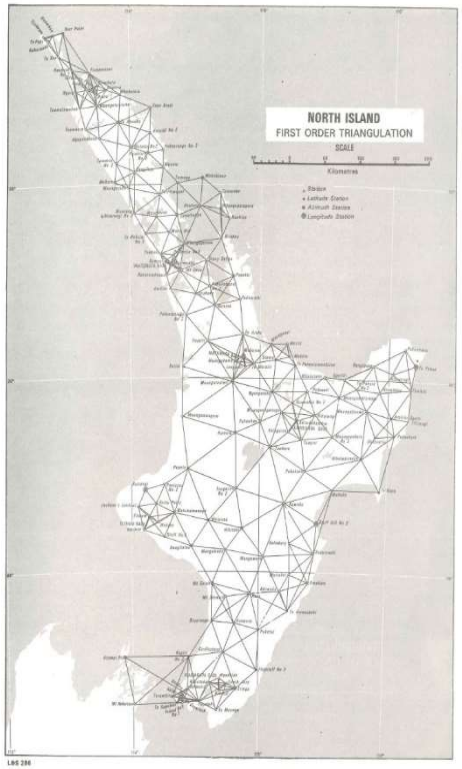
Early triangulation surveys

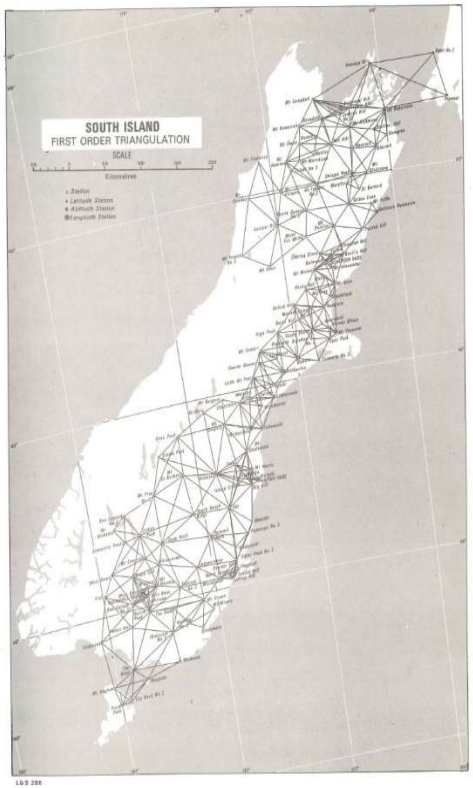
Commenced in the 1880s

1st order control completed1940s for NZGD49

Provided a foundation for measuring crustal deformation







Limitations with NZGD49

Regional distortions up to 5m present

Built up in a piecemeal fashion

Incompatible with global systems

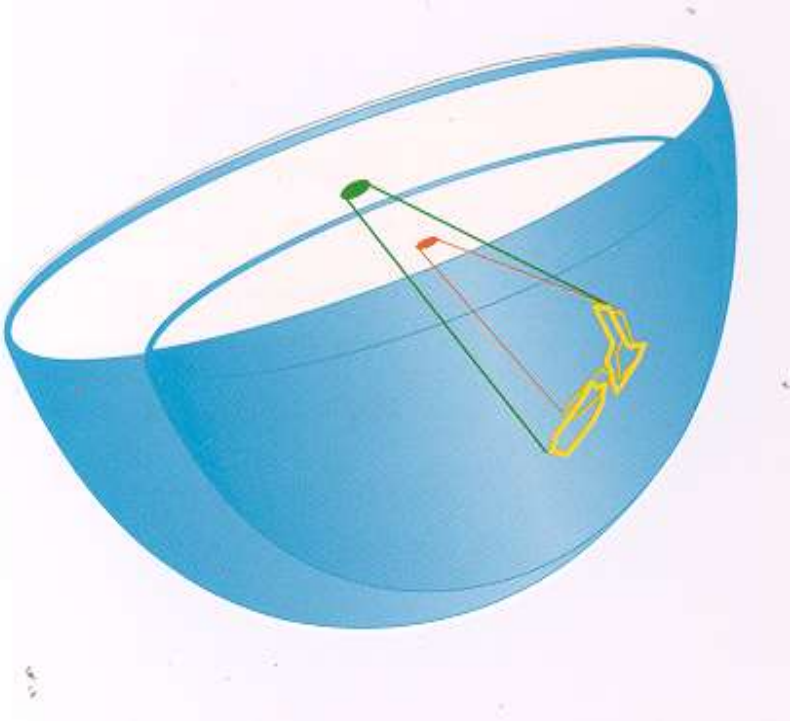
It is of limited spatial coverage

It is static

Introduction of NZGD2000

1998 – NZ introduced NZGD2000 (ref epoch 1 Jan 2000)

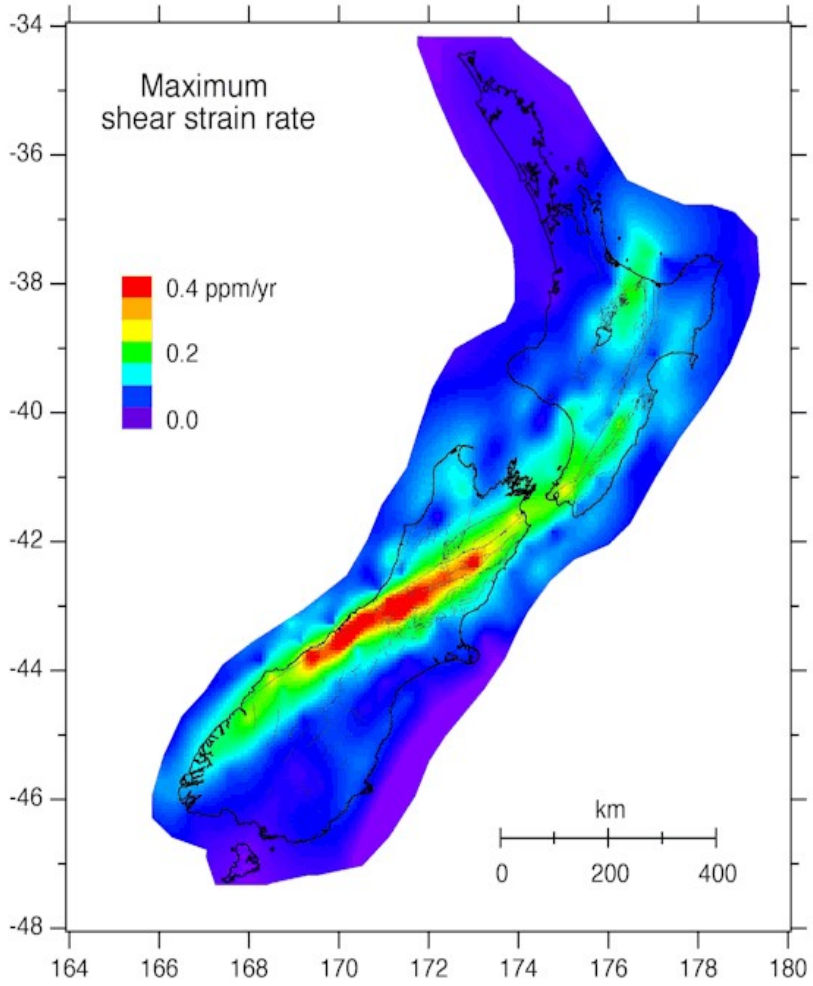
- geocentric origin
- aligned with the ITRS
- ITRF96 with epoch 2000.0 coordinates

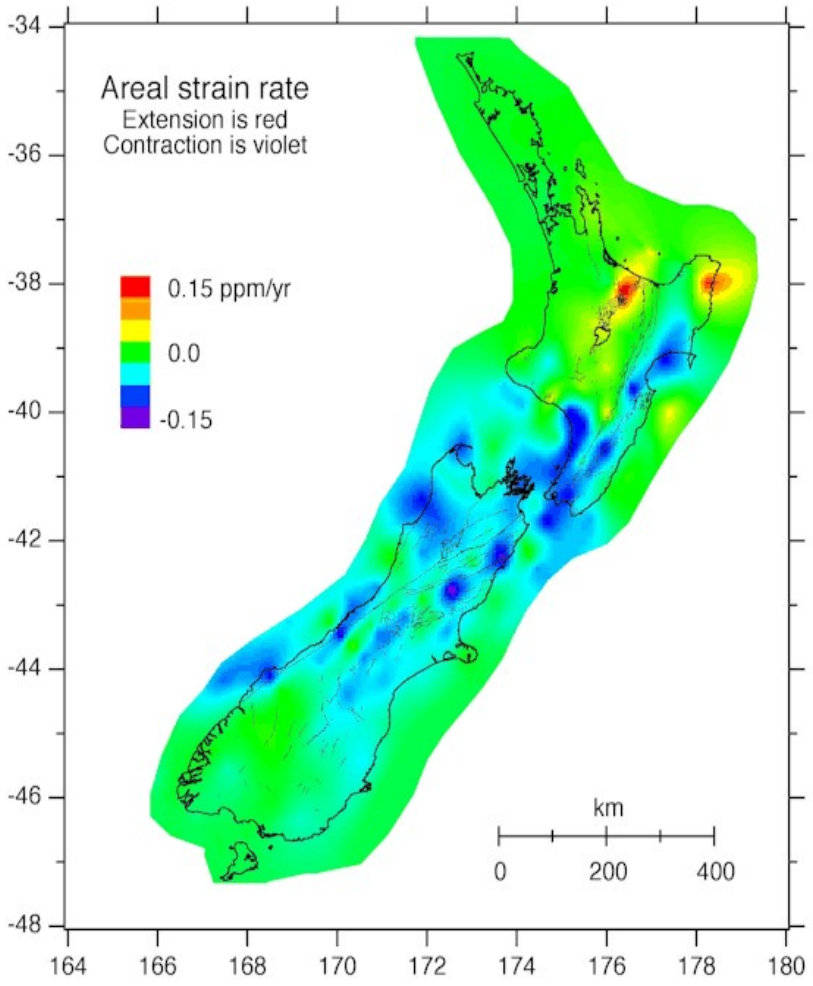


NZGD2000 - semi-dynamic datum

- generalised motion of points modelled using a deformation model

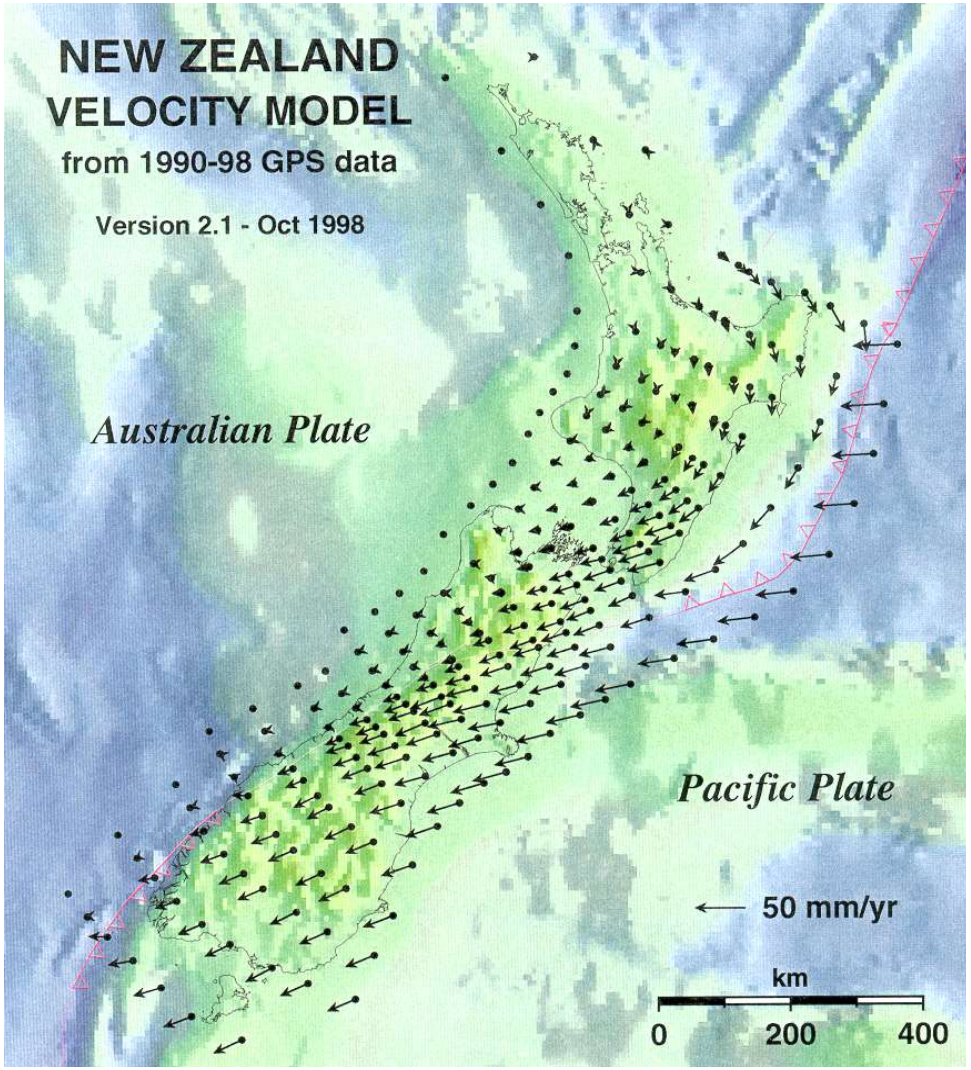
Measuring deformation - strain





Semi-dynamic datum

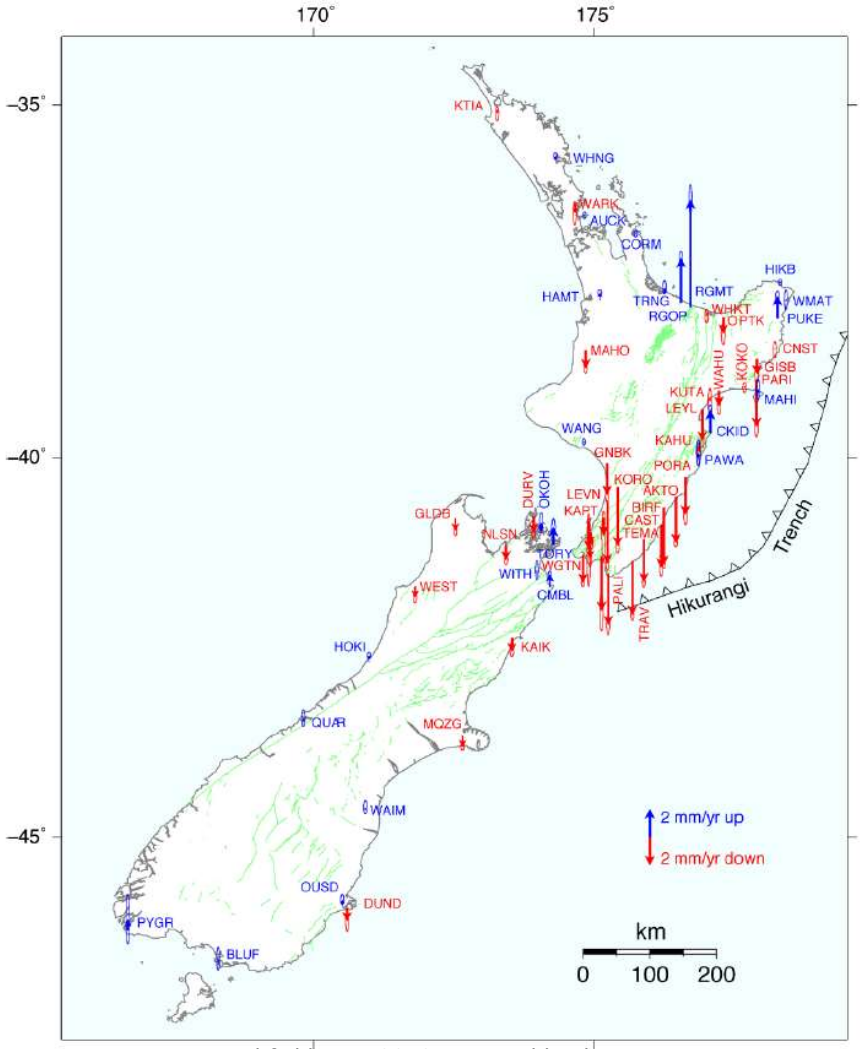
- current deformation model has horizontal constant velocities only
- generated using repeat surveys between 1992 and 1998
- enables propagation of coordinates and observations between reference epoch and observation epoch
- for many uses has the **appearance of a static datum**



Present-day vertical rates

Vertical rates estimated at near-coast GNSS sites. (GEONET/LINZ)

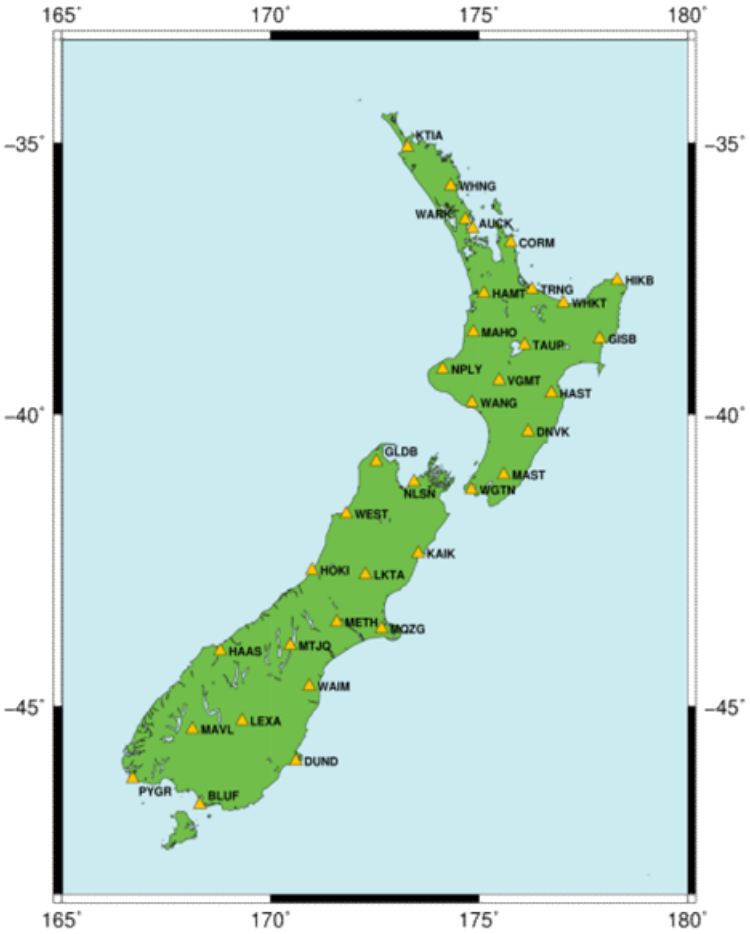
Regional trends - lower North Island subsiding at 1-3mm/year



Beavan, R.J.; Litchfield, N.J. 2012. Vertical land movement around the New Zealand coastline: implications for sea-level rise, *GNS Science Report* 2012/29

CORS and supporting global frameworks

LINZ PositioNZ Network



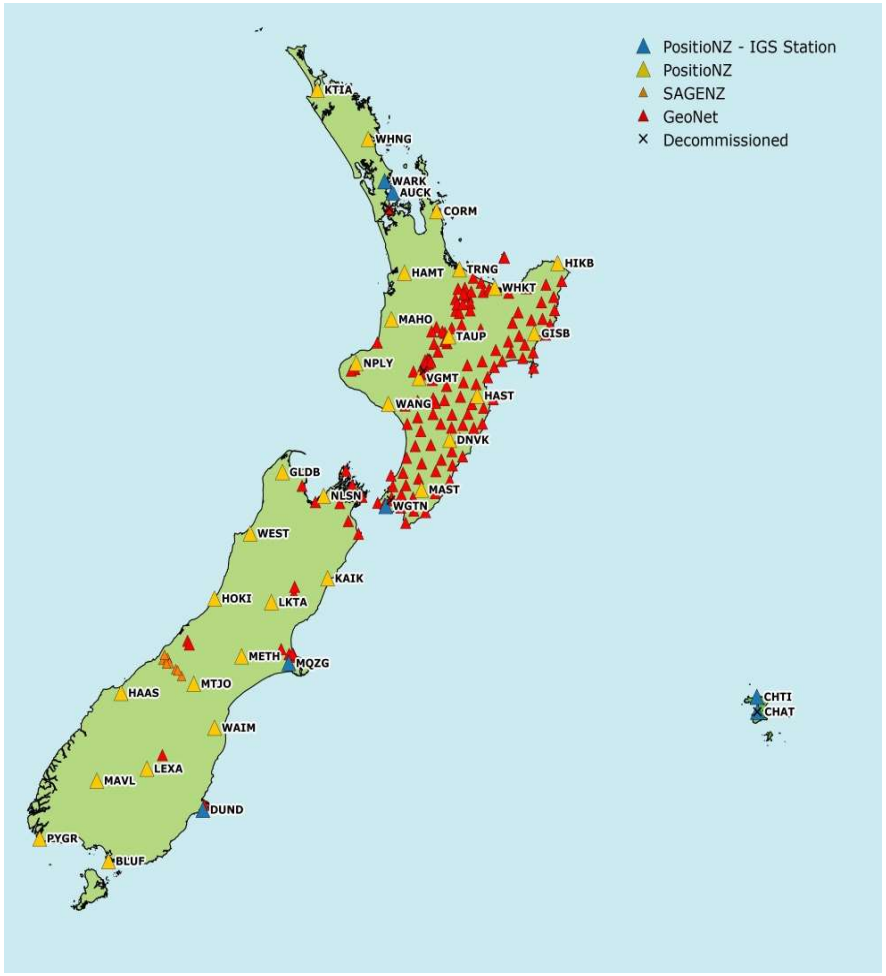
PositioNZ Network

35 on the mainland of NZ

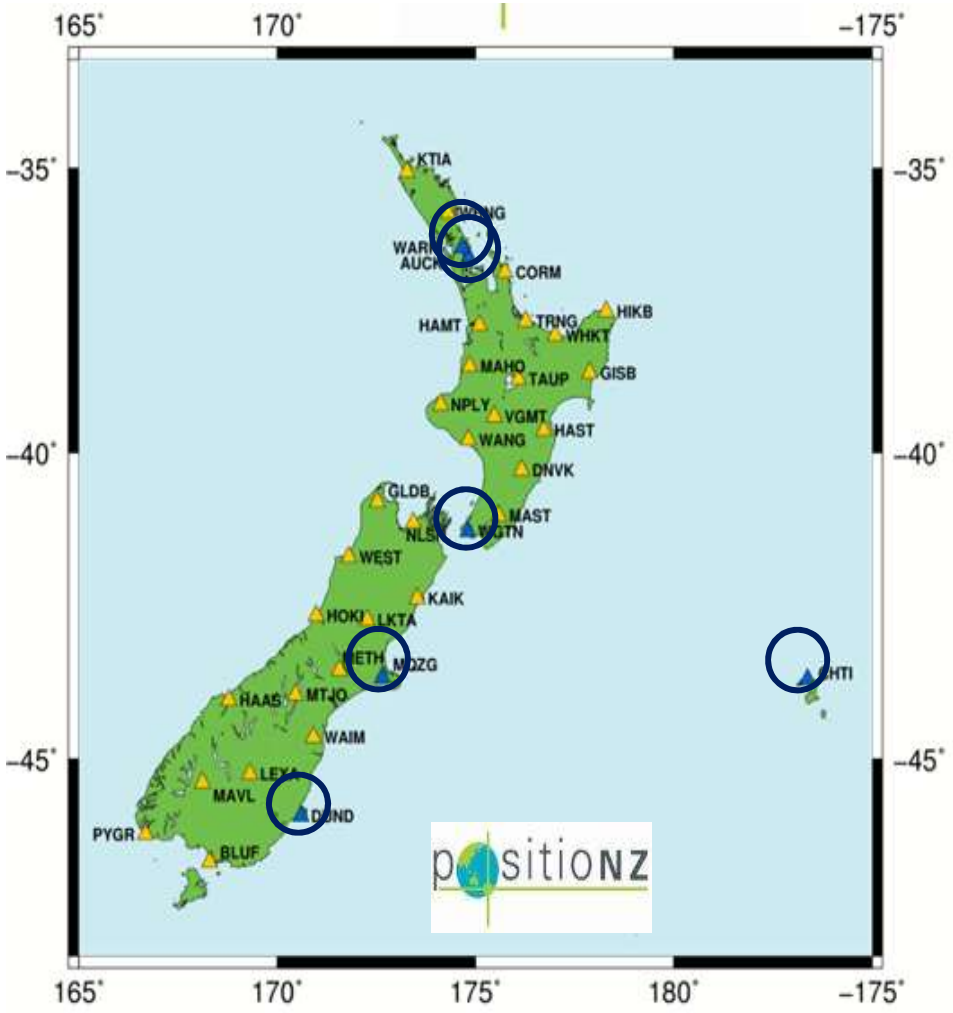
1 on the Chatham Islands

3 in Antarctica

LINZ/GNS CORS Sites



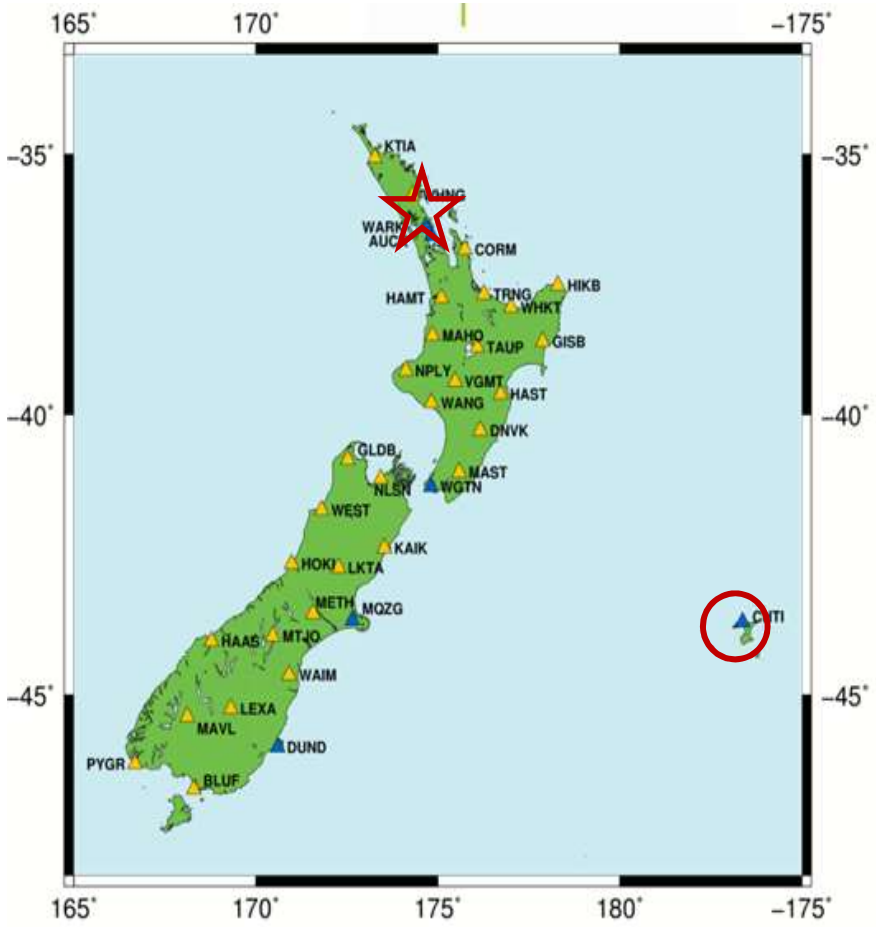
Contribution to the ITRF (CORS)



Contribution to the ITRF (VLBI and DORIS)

☆ VLBI

○ DORIS



BUT – don't underestimate the importance of passive control marks

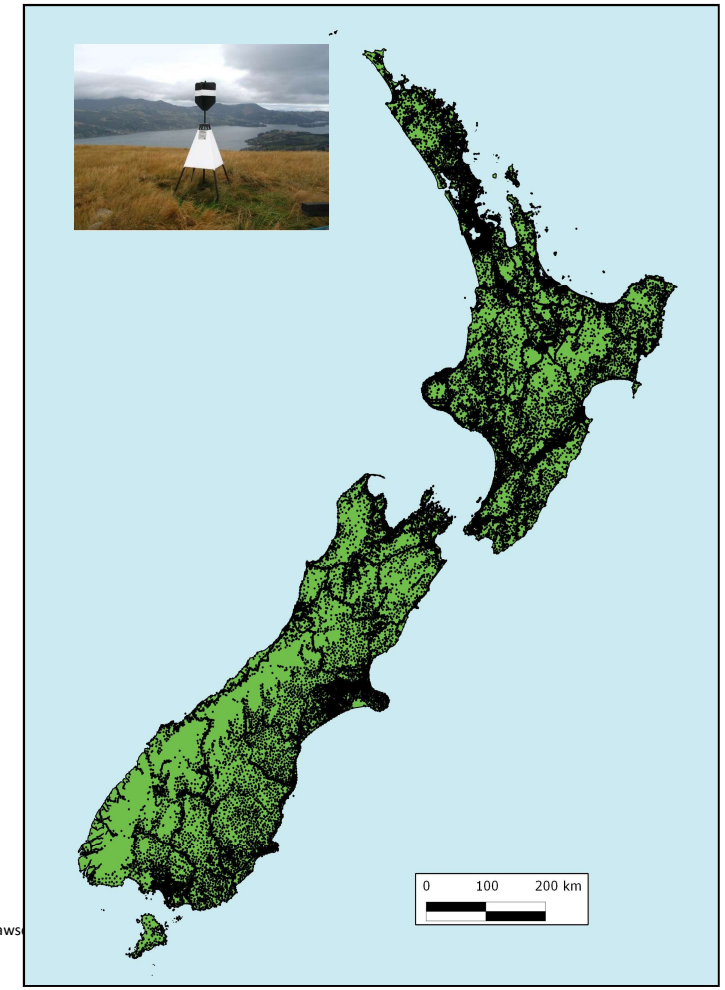
Many countries are stopping or reducing their passive survey control programmes

However, NZ has increased the numbers of marks surveyed in recent years

- to support the accurate positioning of the digital representation of the cadastre,
- reflects the desire for passive control marks near to any survey job.

The Passive Control network enables:

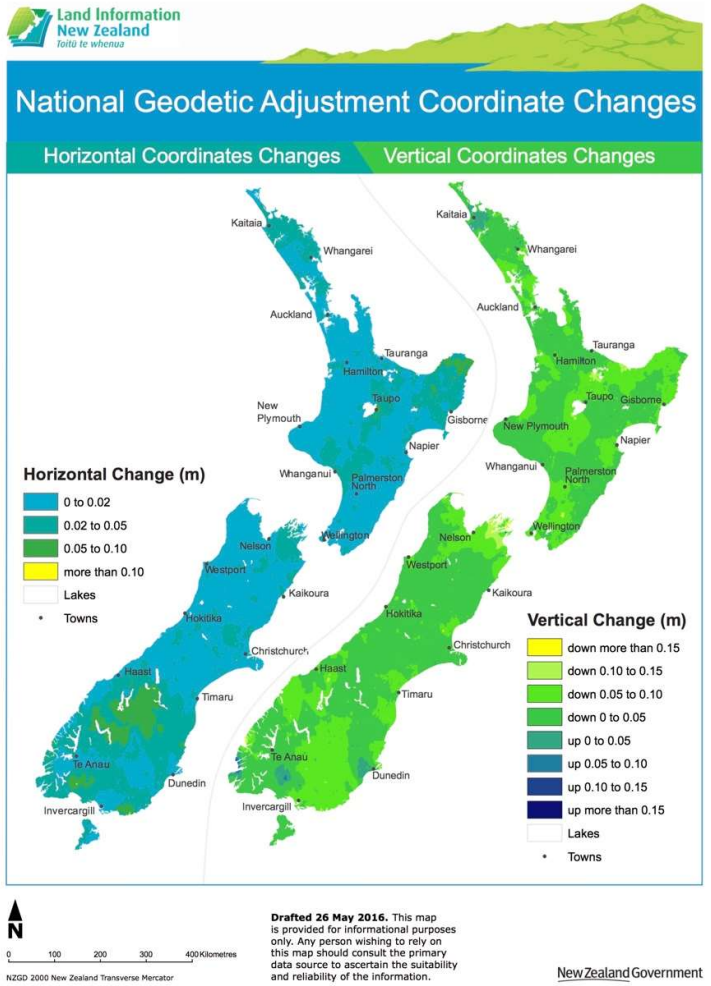
- Datum access
- Detailed deformation monitoring
- Localised transformations in deforming regions
- Realising Survey-Accurate digital cadastre
- Control for projects such as imagery



John Daws

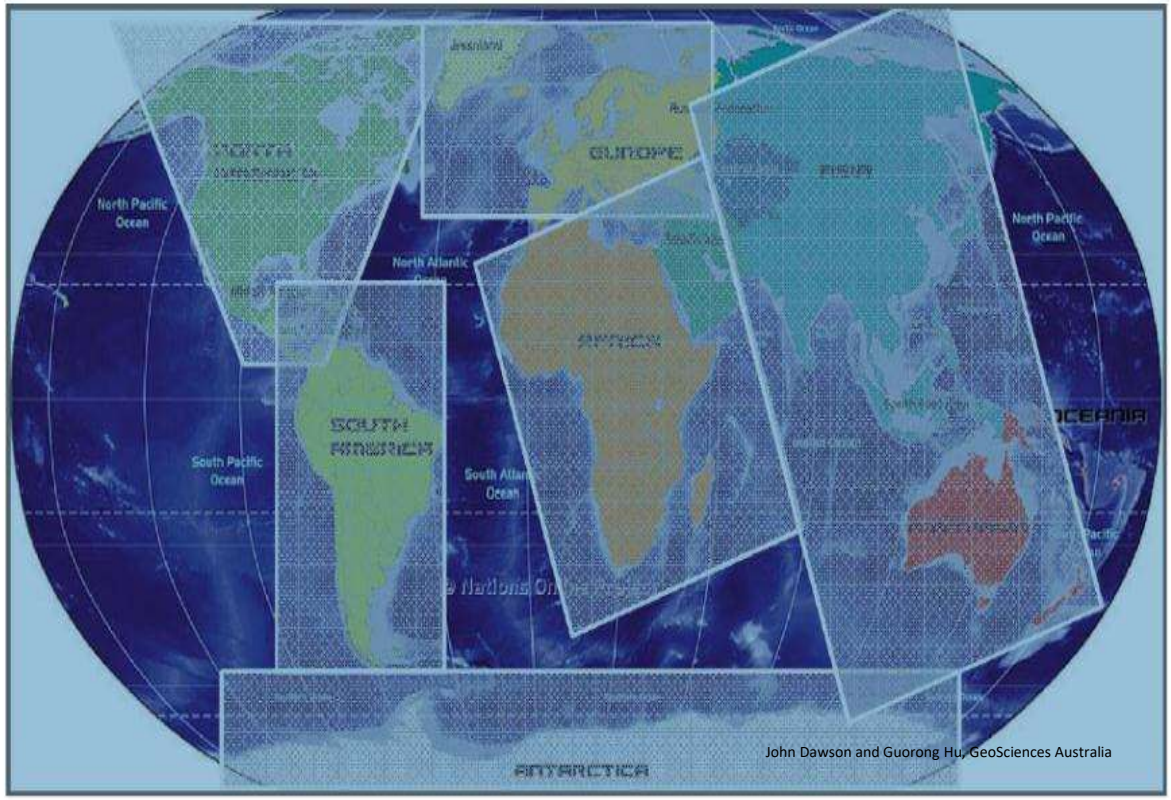
Mega adjustment (updating to datum)

- 80,000 marks updated
- Changes due to updated and new information and errors in modelled deformation



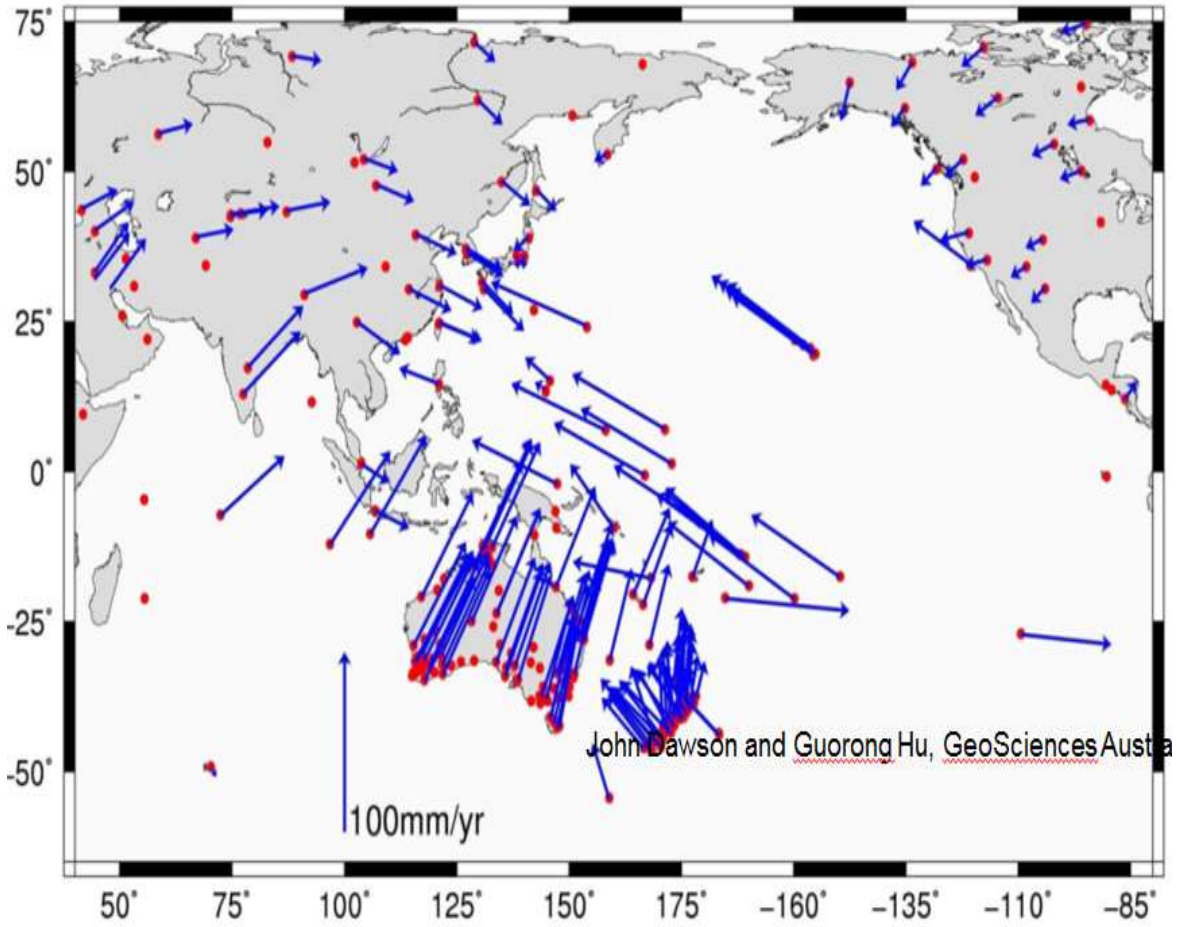
Regional Reference Frame Densification

ITRF = APREF, AFREP, EURREF, NAREF SIRGAS,...



John Dawson and Guorong Hu, GeoSciences Australia

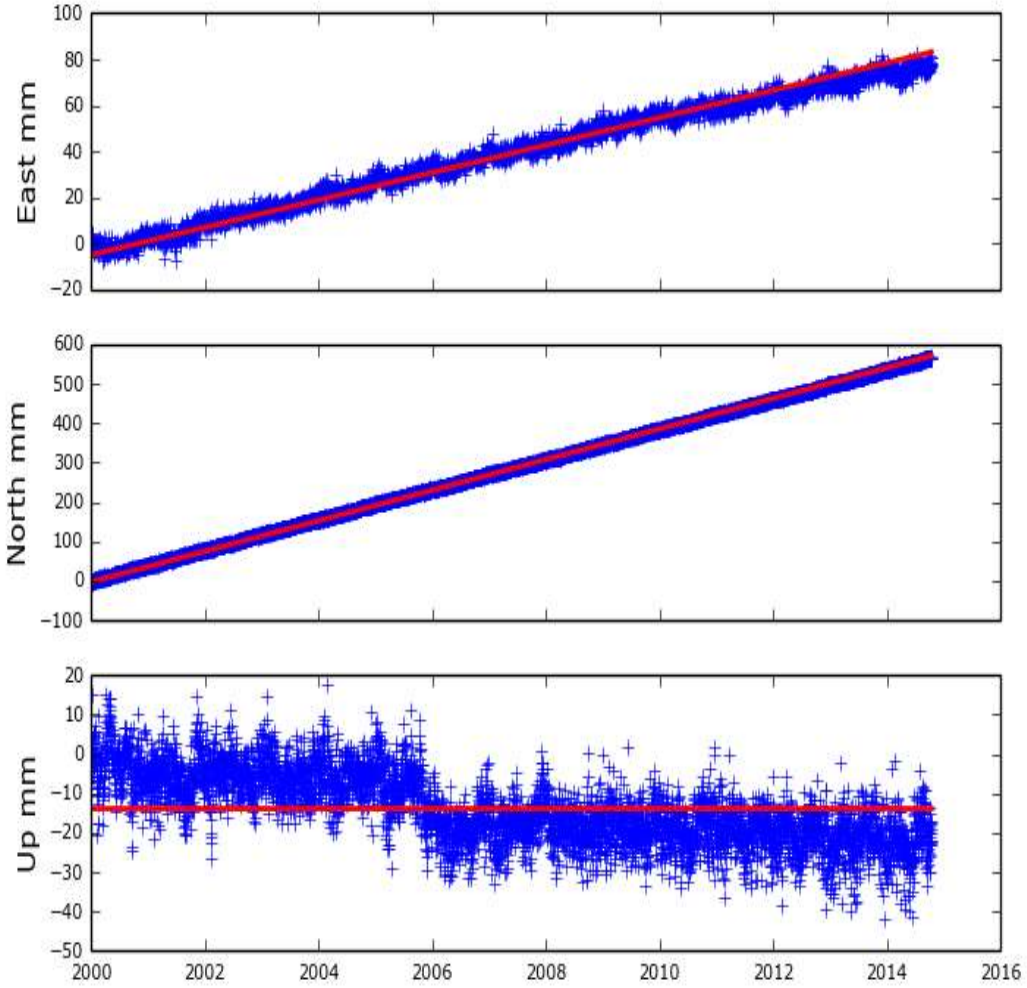
APREF velocities

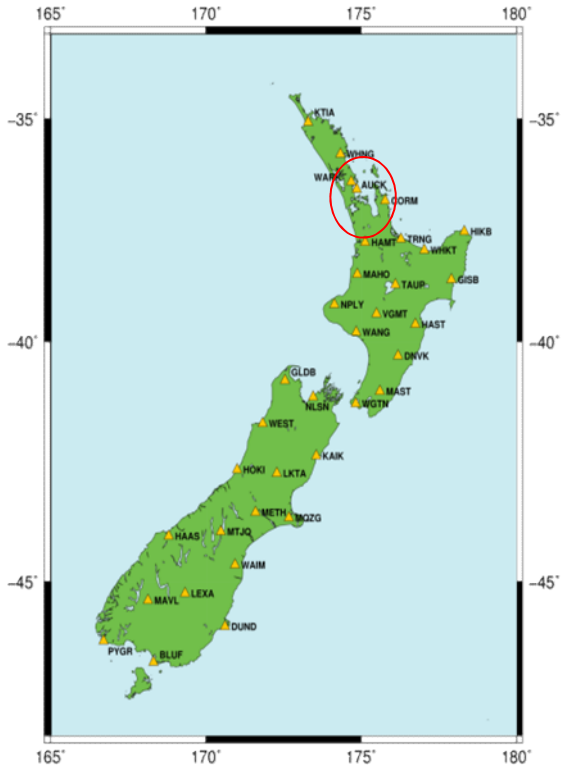


John Dawson and Guorong Hu, GeoSciences Australia

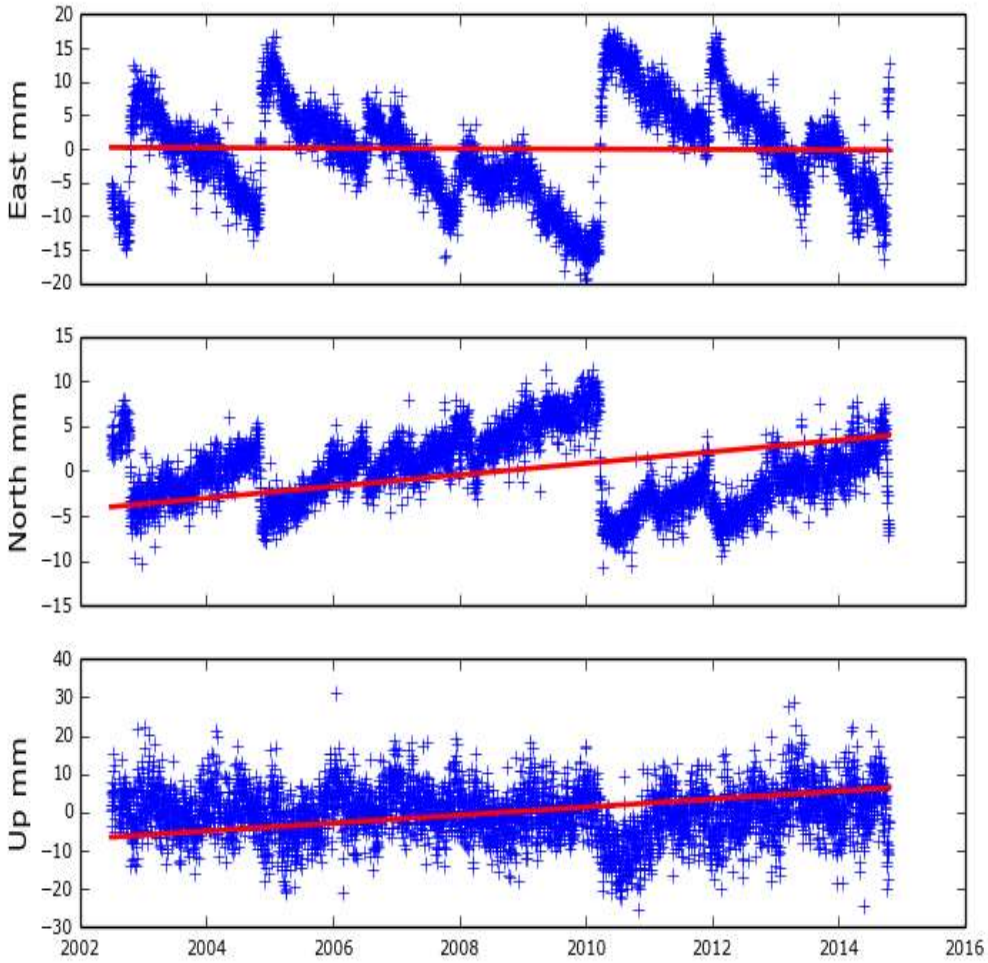
Monitoring Deformation

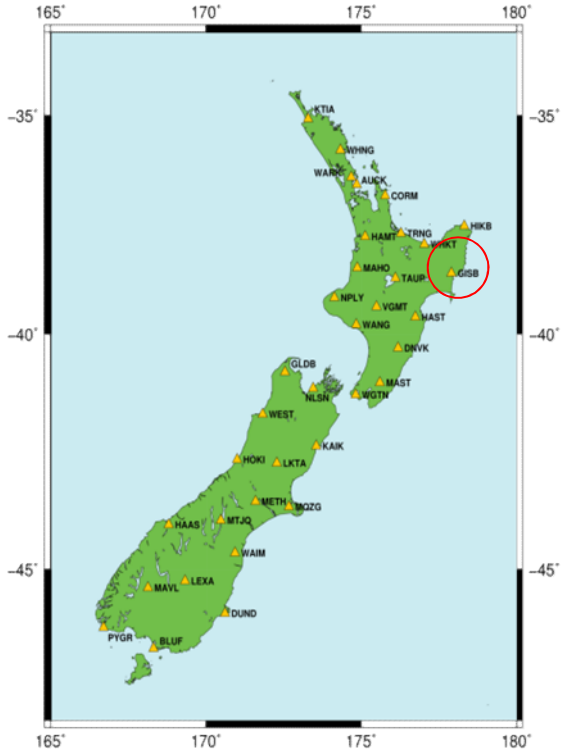
Auckland - stable



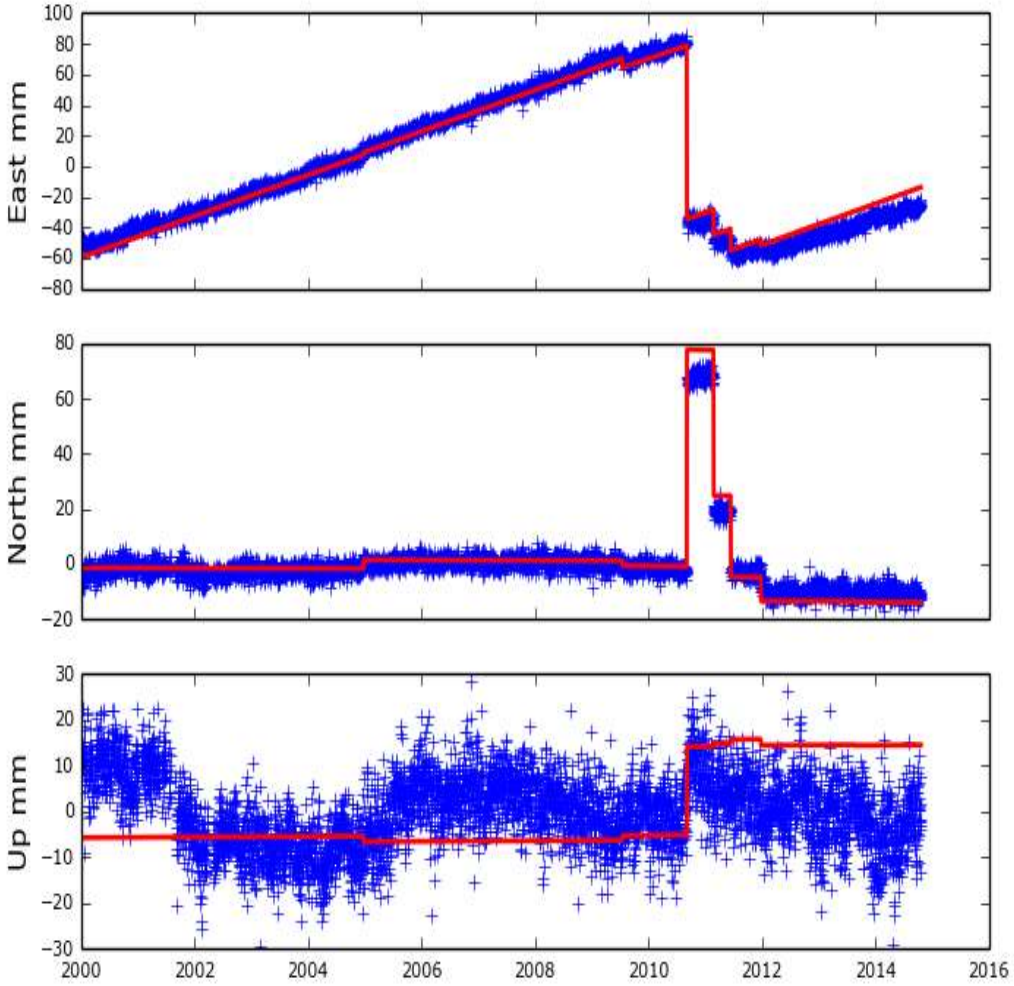


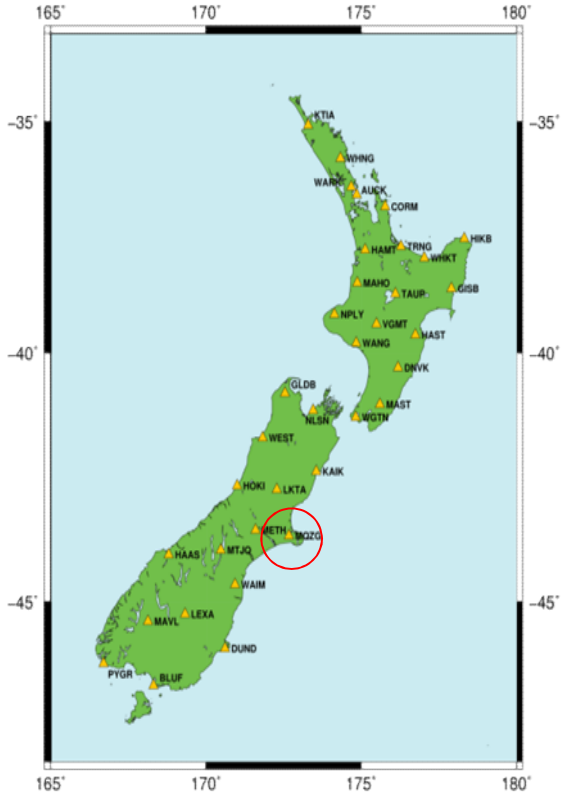
Gisborne – slow earthquakes



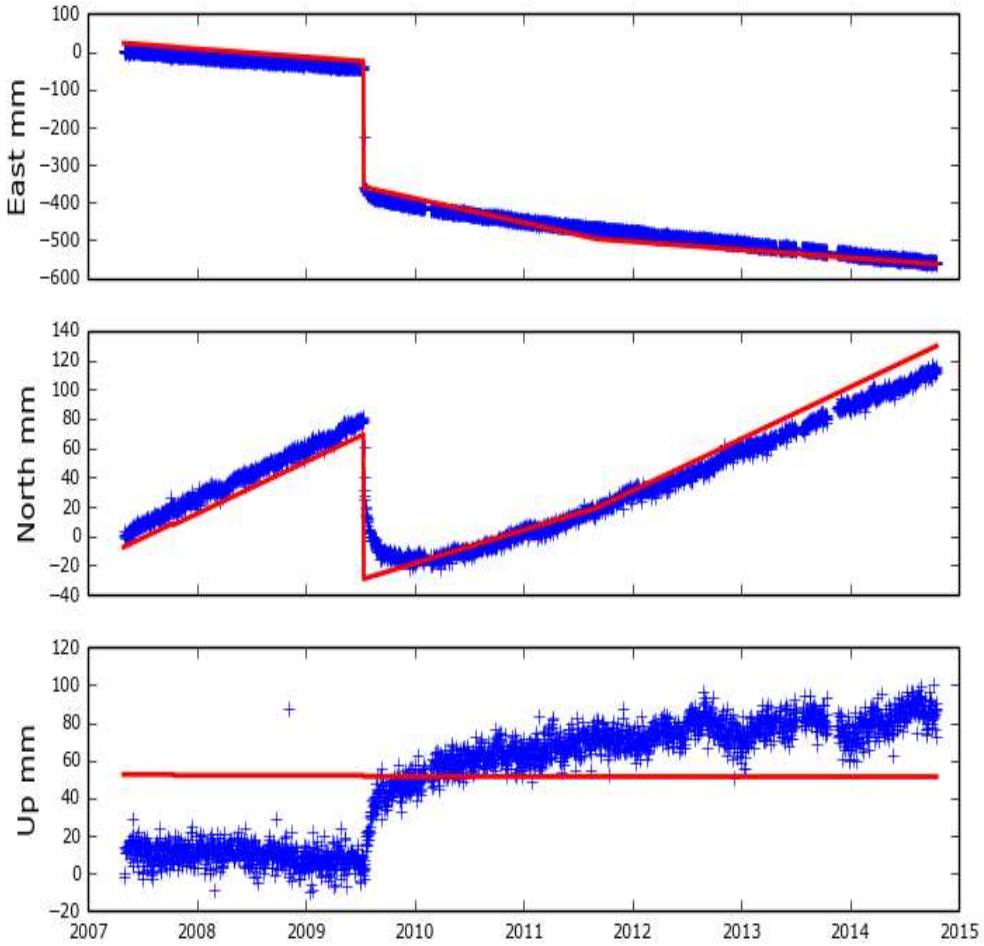


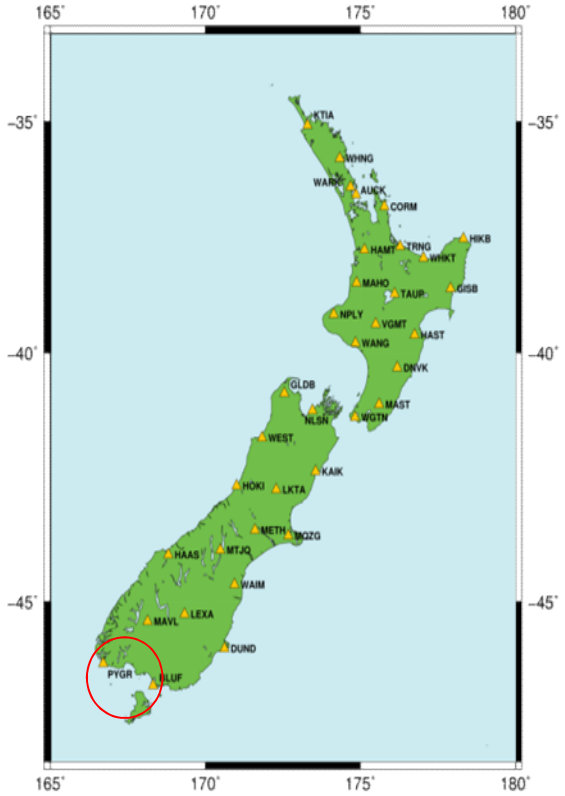
Christchurch – Canterbury earthquakes





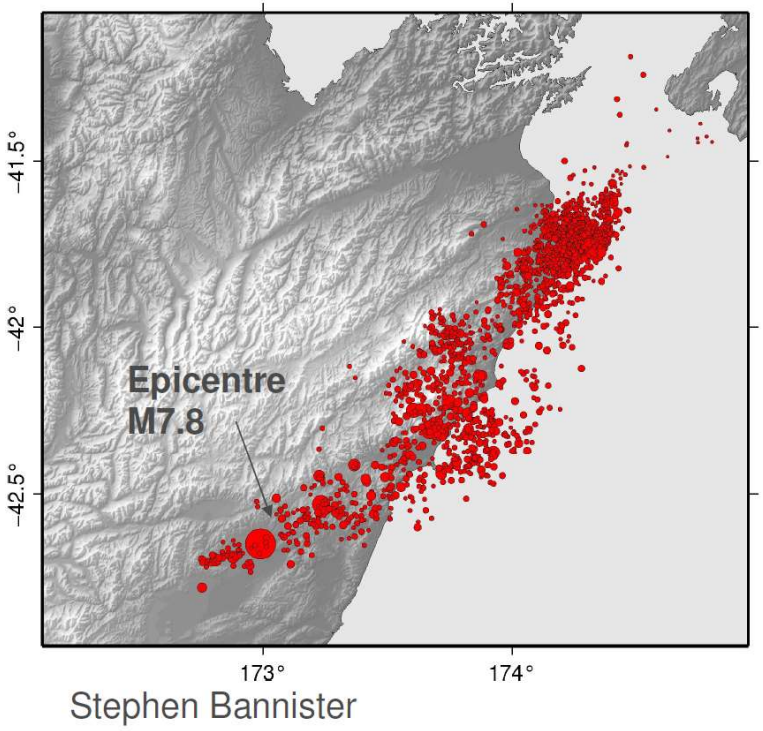
Fiordland postseismic recovery



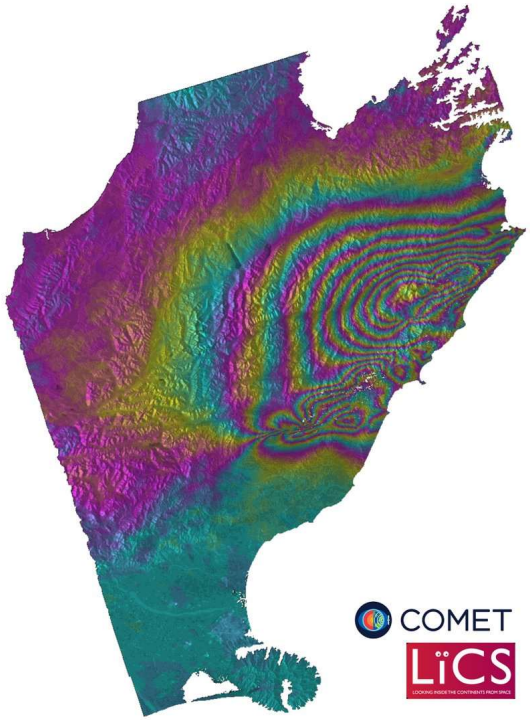


Kaikoura M7.8 Earthquake 14 November 2016

Location and aftershocks

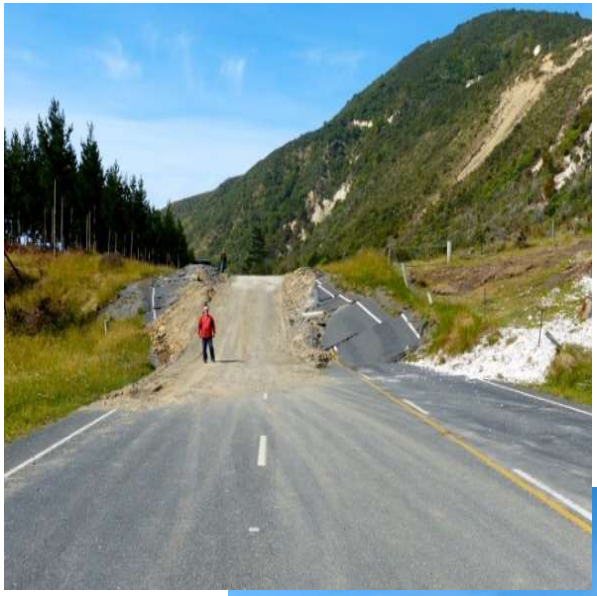


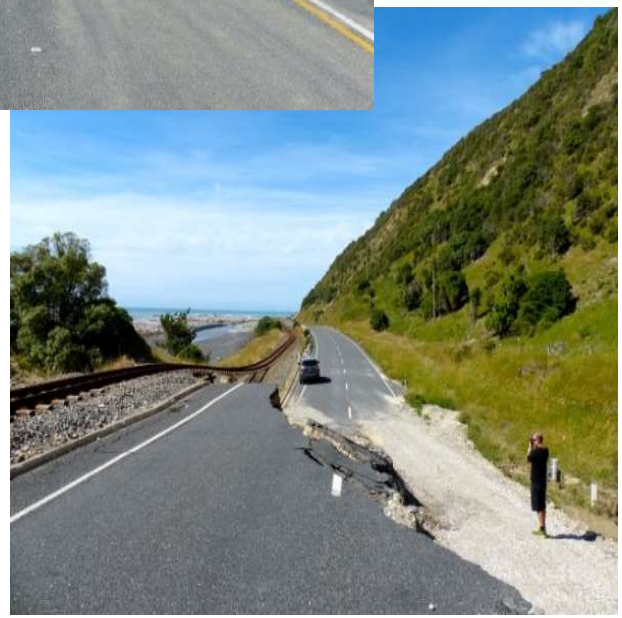
Stephen Bannister



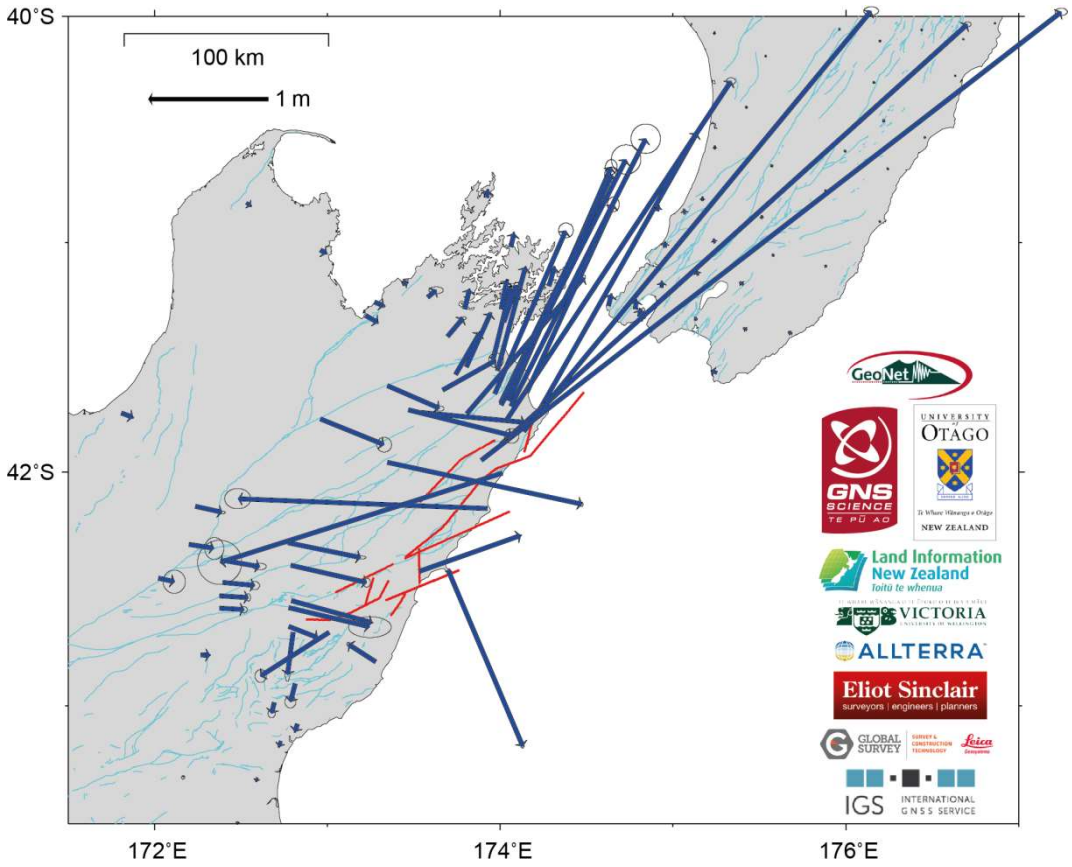
Kaikoura earthquake

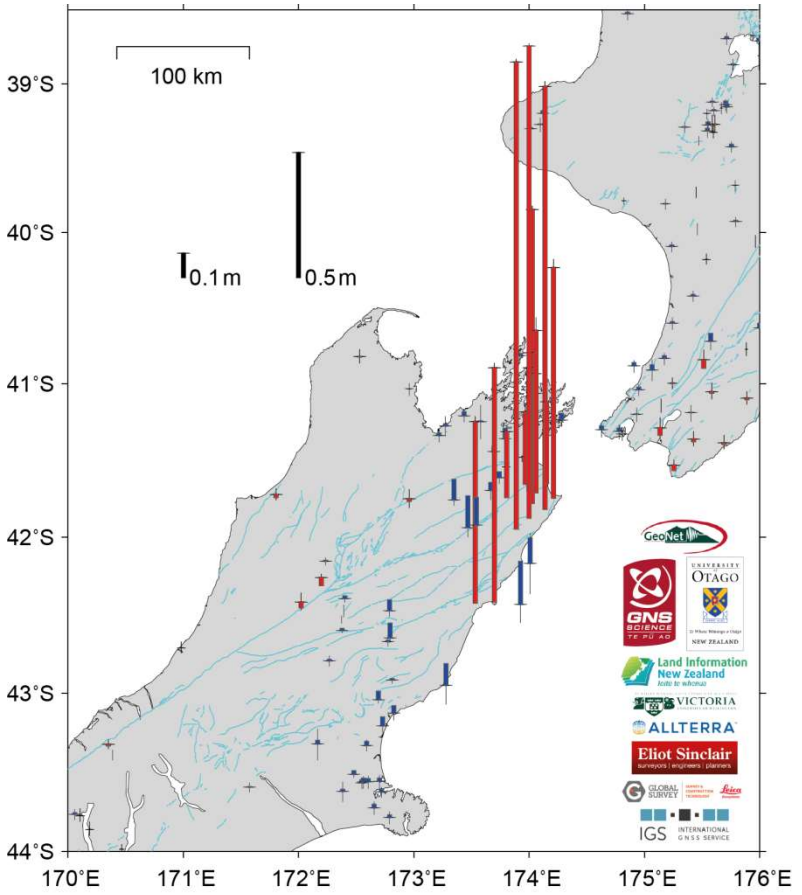
- Magnitude 7.8, 14 November 2016
- Multiple faults ruptured
- Displacements exceeding 5m (horizontal and vertical)
- Serious property and infrastructure damage



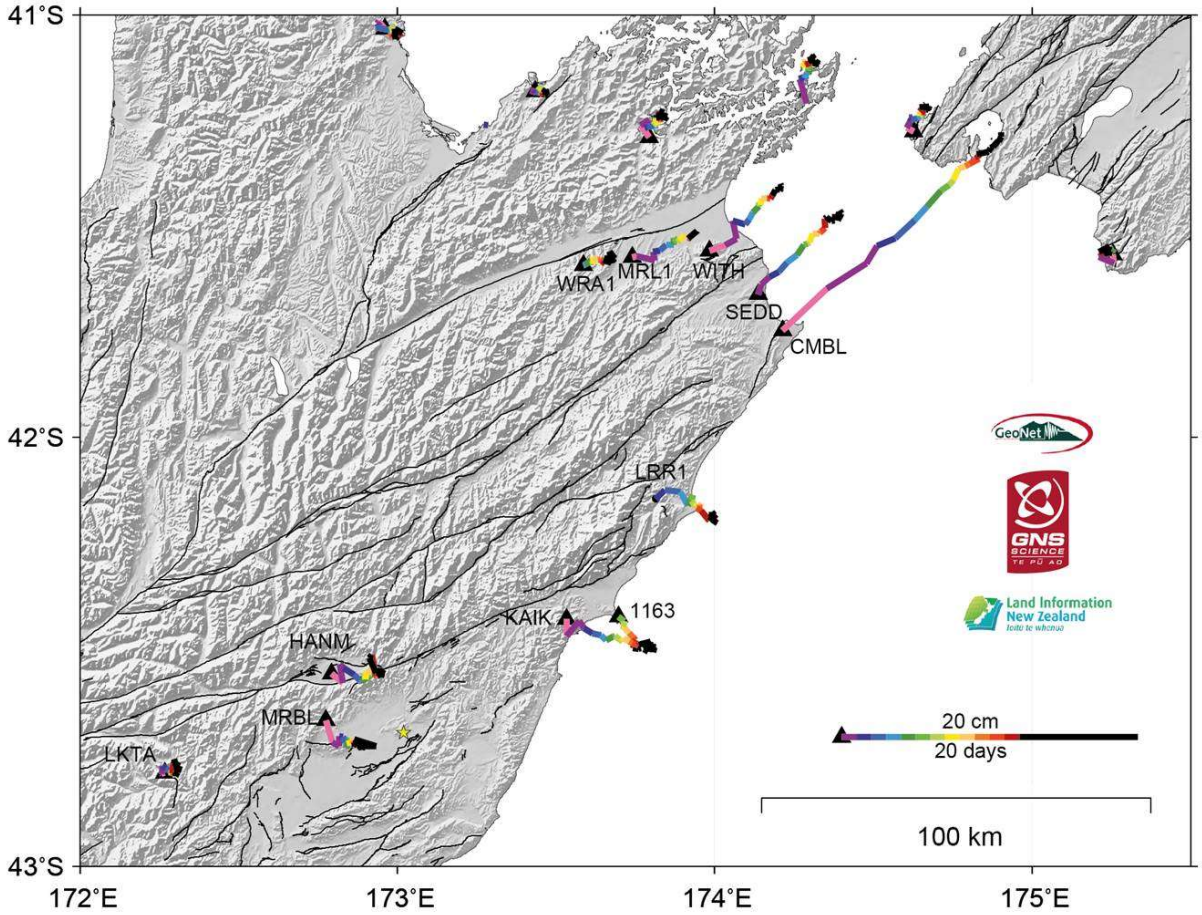


Horizontal and vertical movements

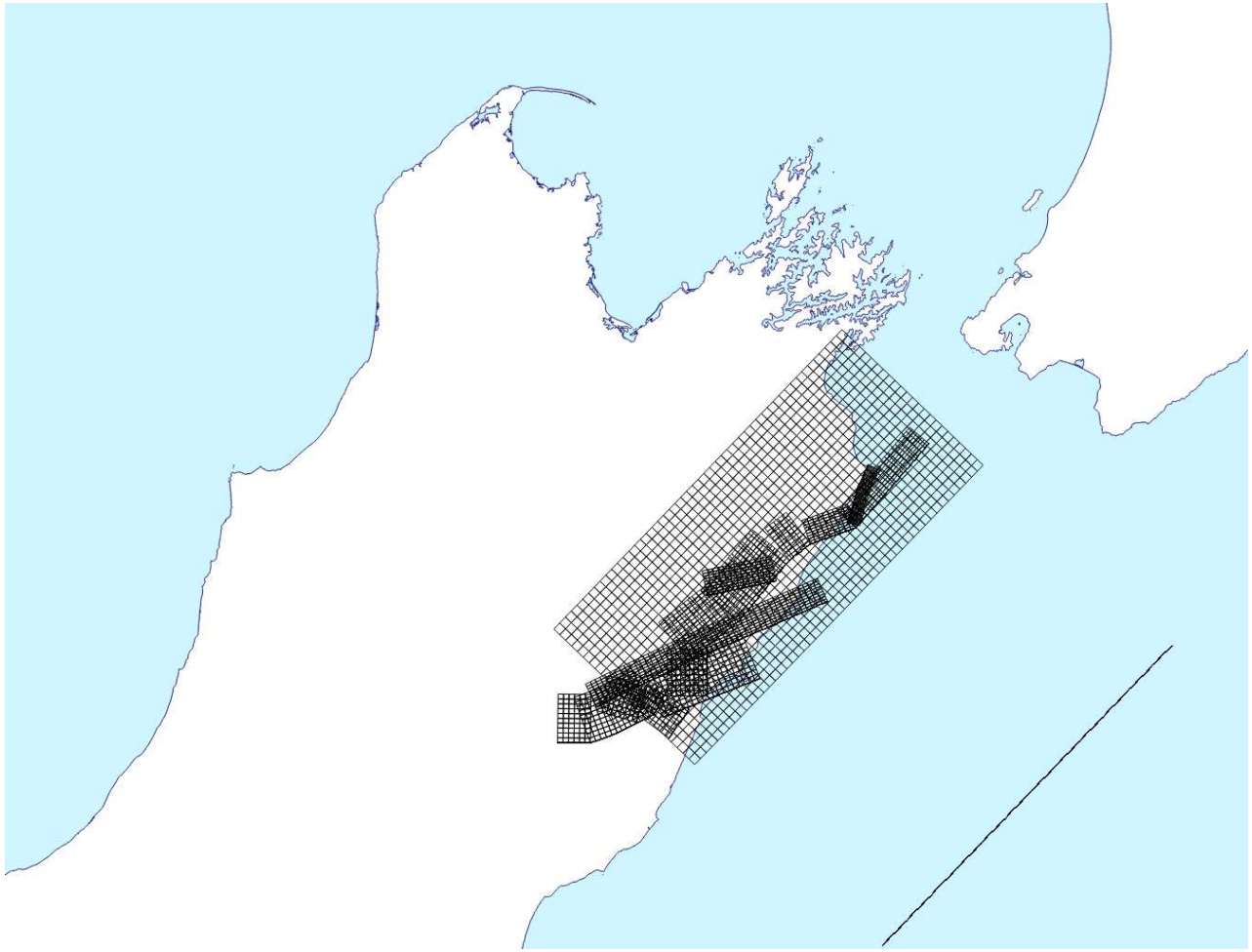




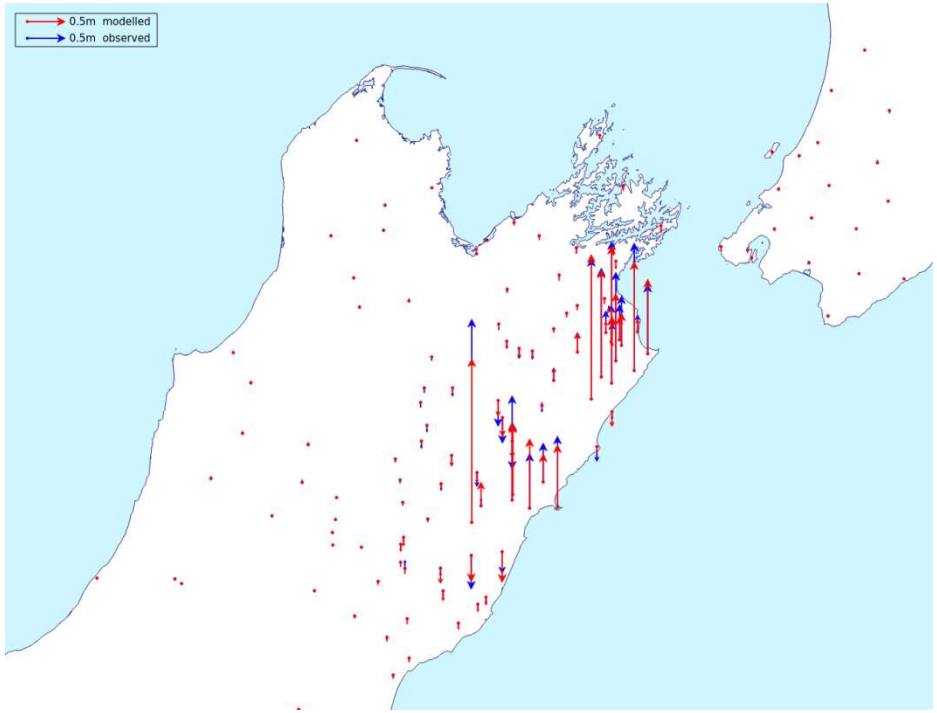
Post-seismic movements

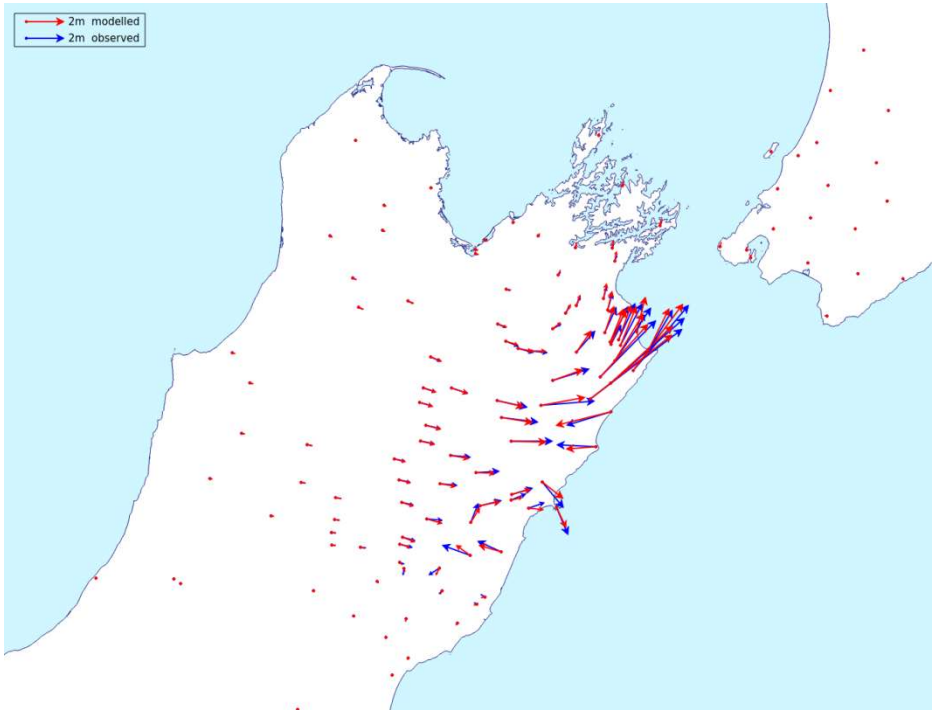


Modelling the fault ruptures

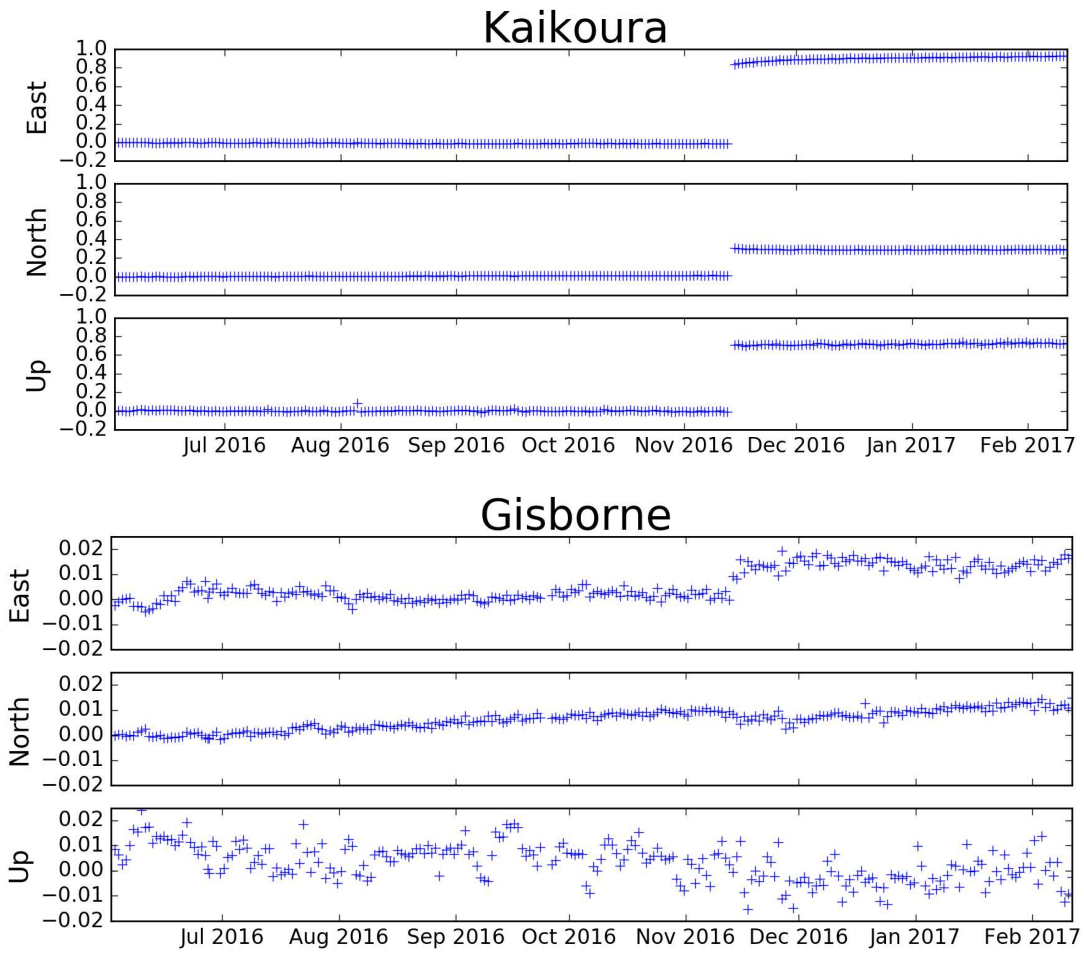


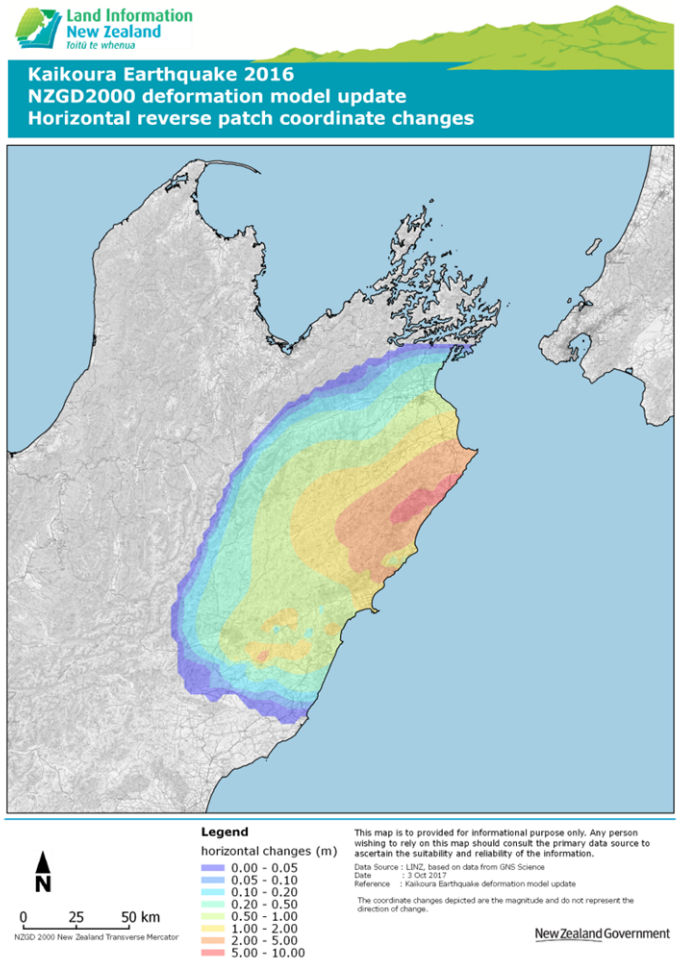
Modelled verse observed displacements



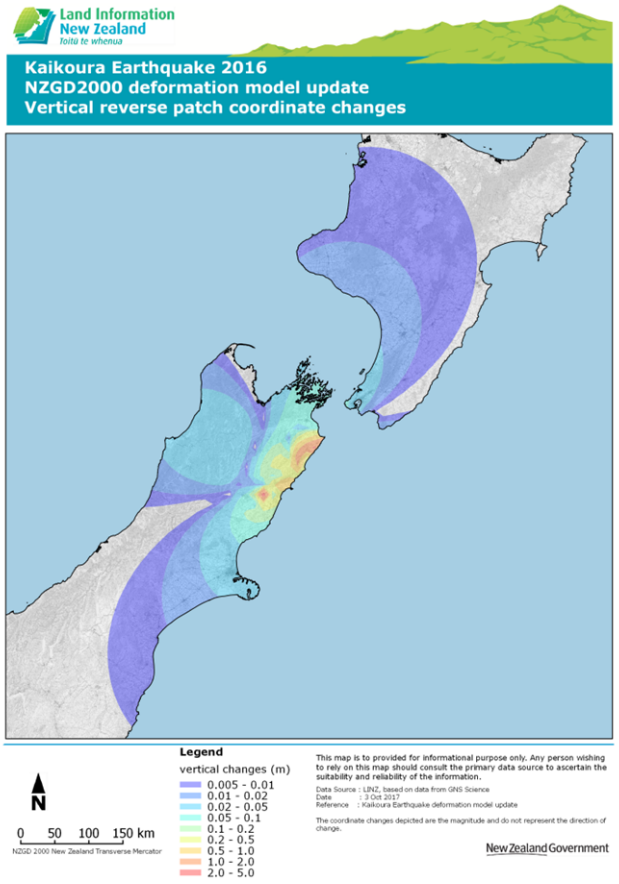


Near and far field movements



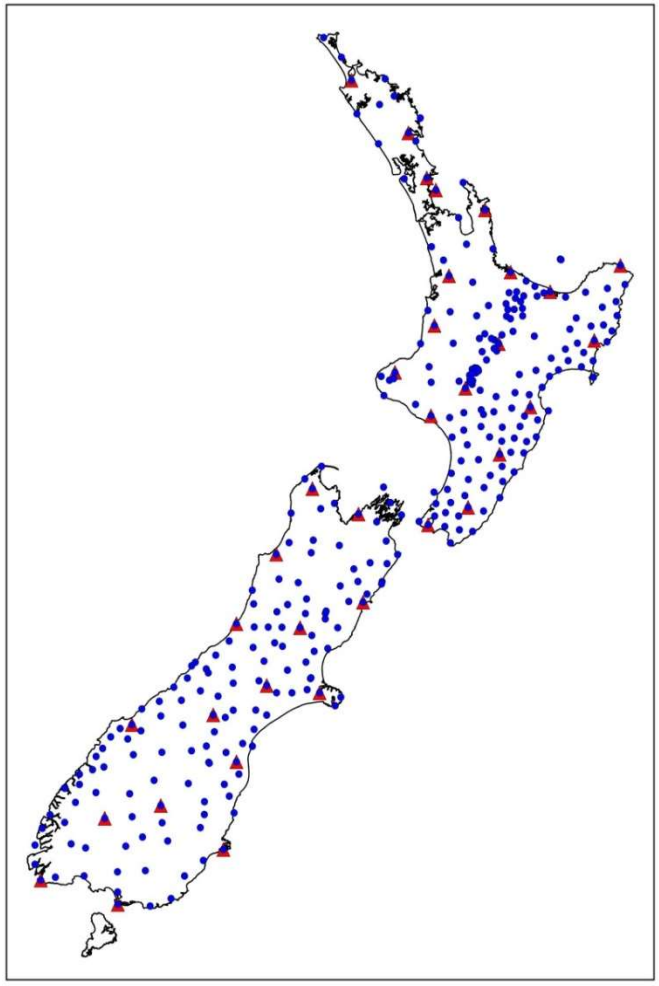


Horizontal Patch



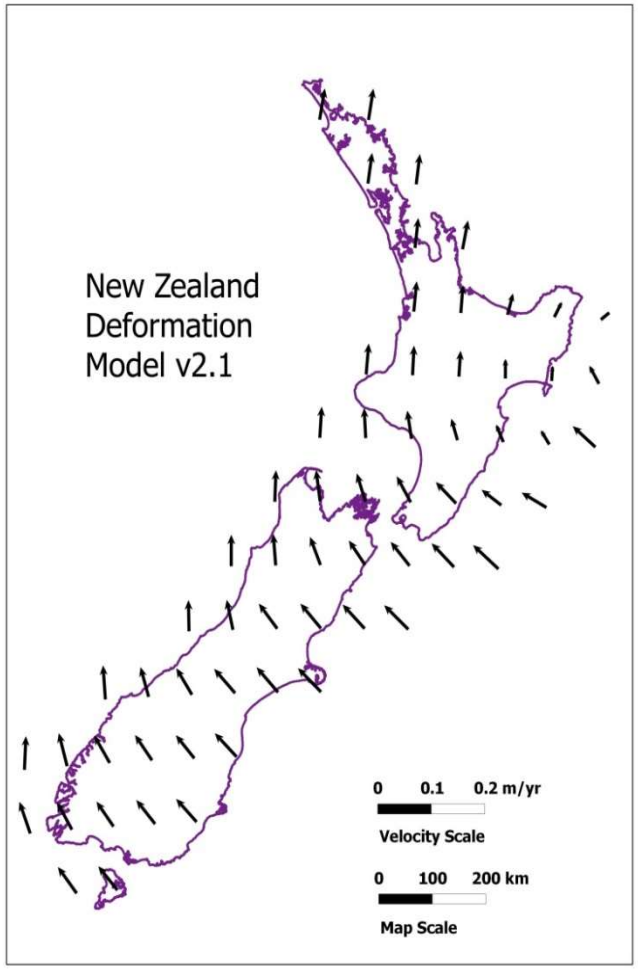
Vertical Patch

National deformation monitoring network



National Deformation Monitoring Network (NDMN), - campaign stations measured every 8 years.

Enhancing the Deformation Model



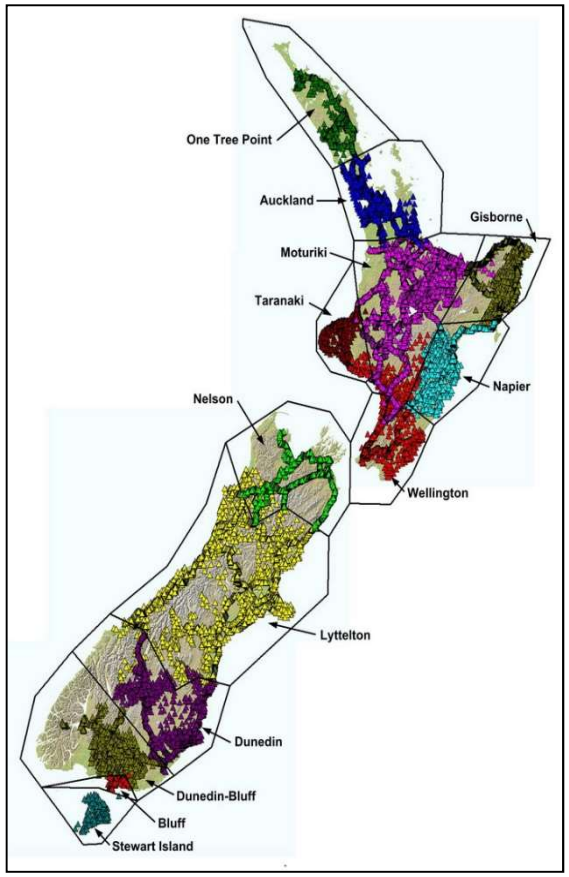
Horizontal model only

Continuously updated and refining

Vertical Datums

Levelling-based datums

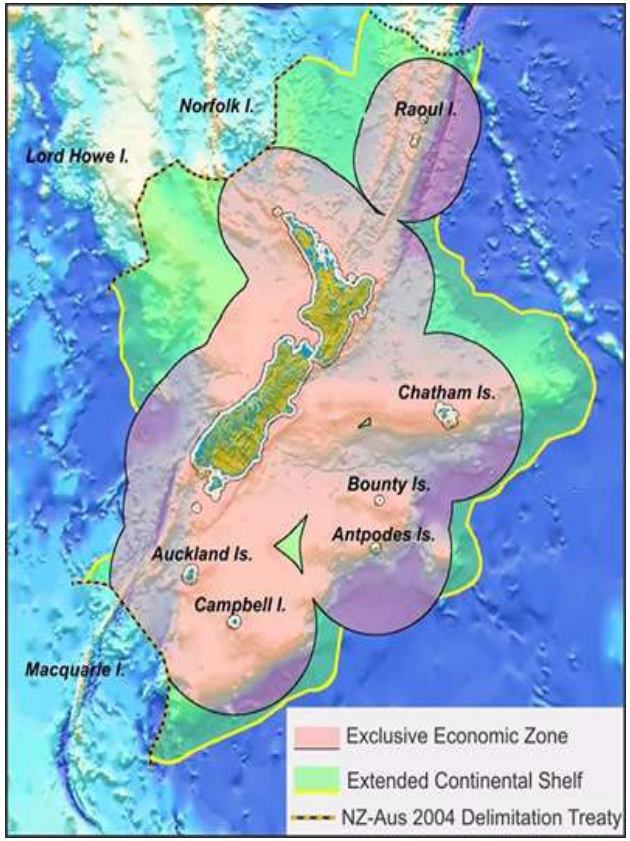
- Prior to NZVD2009
  - 13 levelling based datums
  - Based on “MSL”
- Not nationally consistent



Height Modernisation

Desirable attributes of a national vertical datum:

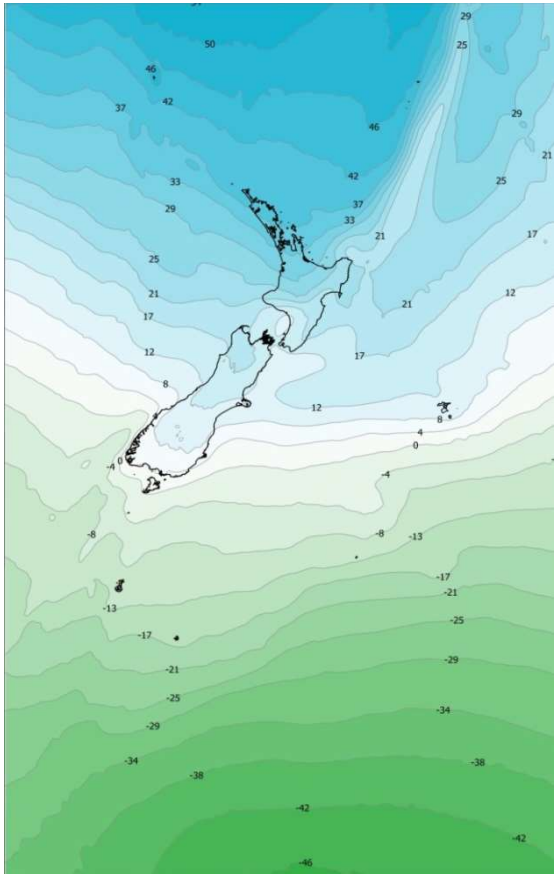
- Accessible - anywhere
- Consistent reference system
- Compatible with NZGD2000
  - GNSS heighting
- Fit for purpose
- Robust
- Maintainable and assessable



Map of New Zealand Maritime boundaries.
GNS Science (2013)

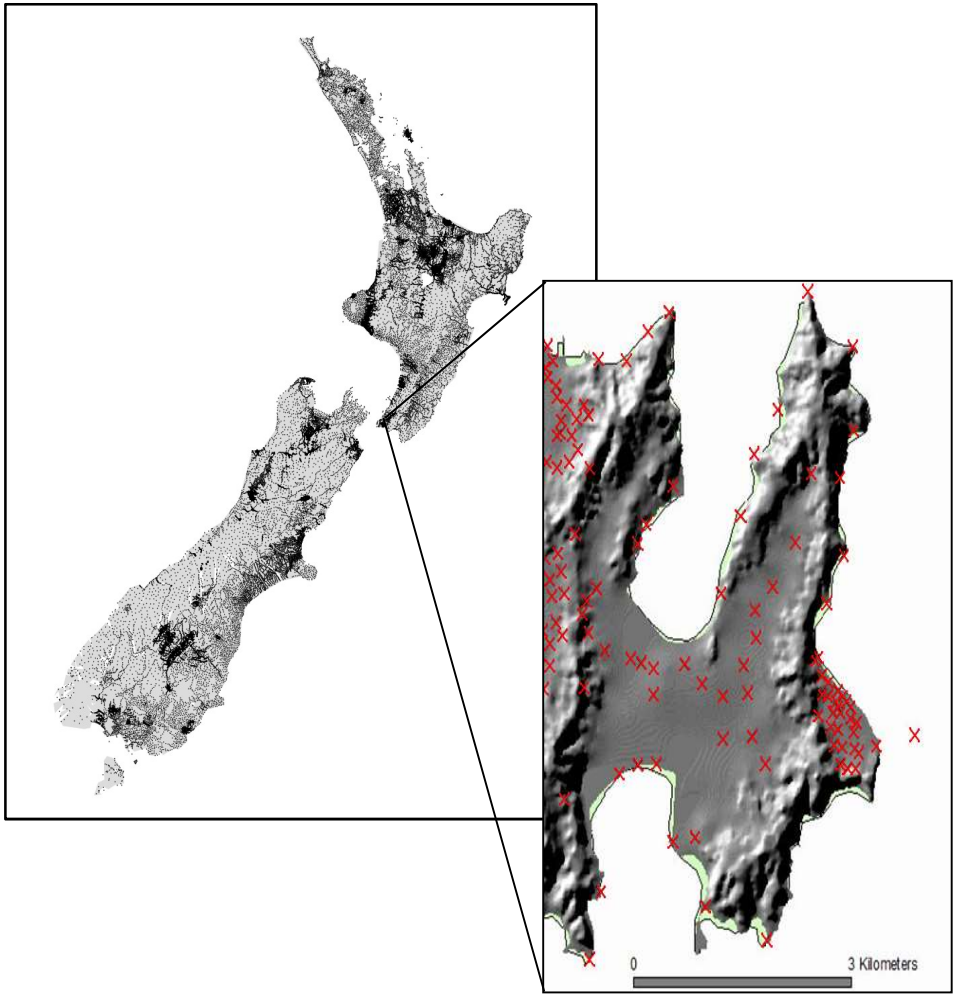
New Zealand Vertical Datum 2009

- NZ one of the first countries to adopt a geoid based vertical datum
- Provided nationally consistent vertical datum within the NZ continental shelf
- Enabled normal-orthometric heights from GNSS
- Included offsets to 13 LVD
- Nominal accuracy ±0.06m



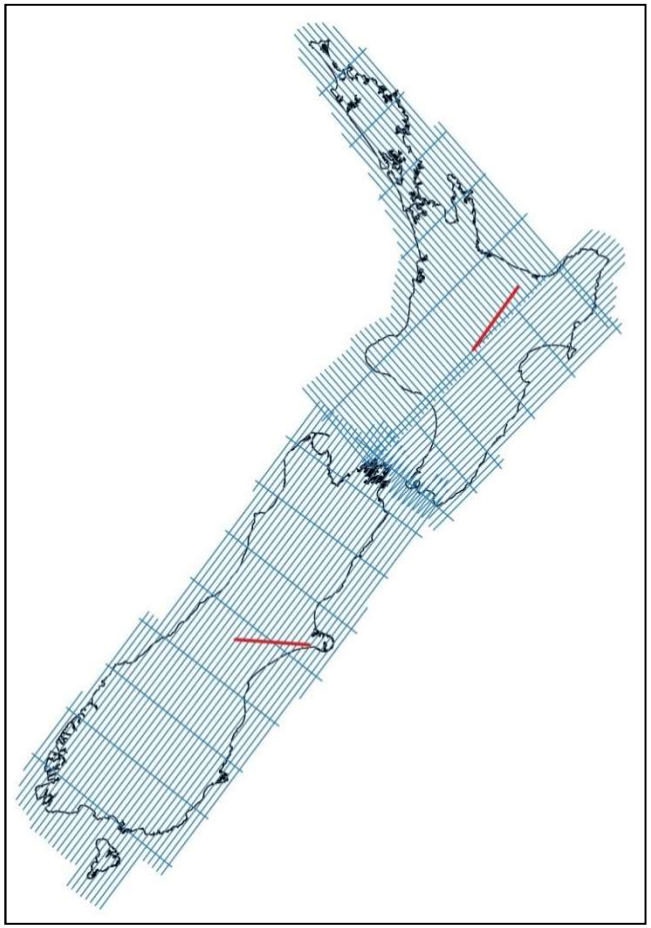
NZVD2009 limitations

- Irregular gravity coverage
- Computed from existing gravity data
- Gravity not collected for geoid determination
- Simplistic offset modelling to existing MSL datums



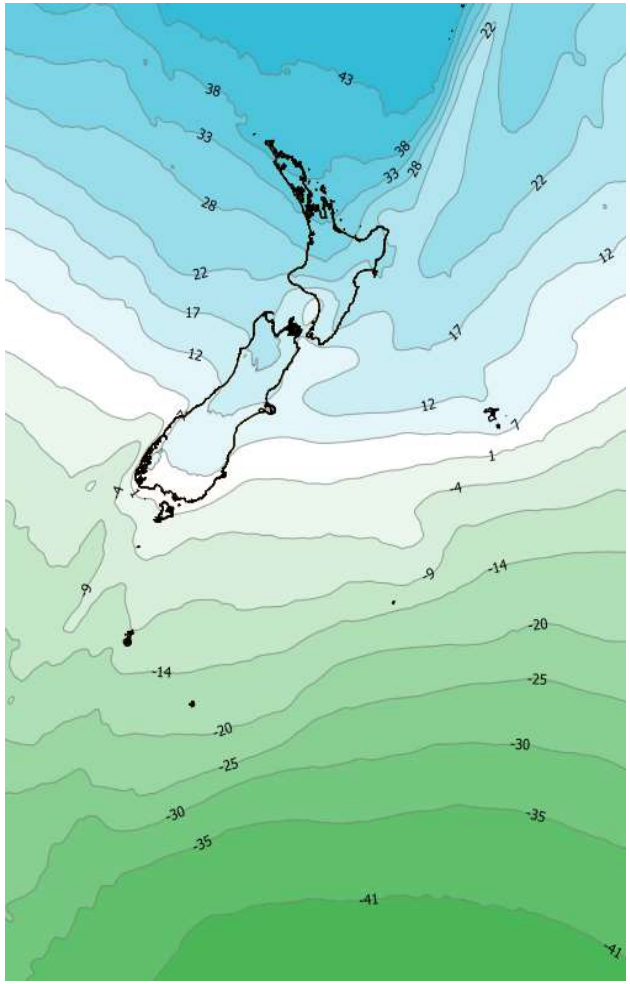
Improvements to NZVD2009

- Inclusion of airborne gravity
- Better accuracy
- Improvements to LVD offsets



New Zealand Vertical Datum 2016

- Included improved offsets to 13 LVD
- Nominal accuracy ±0.02m



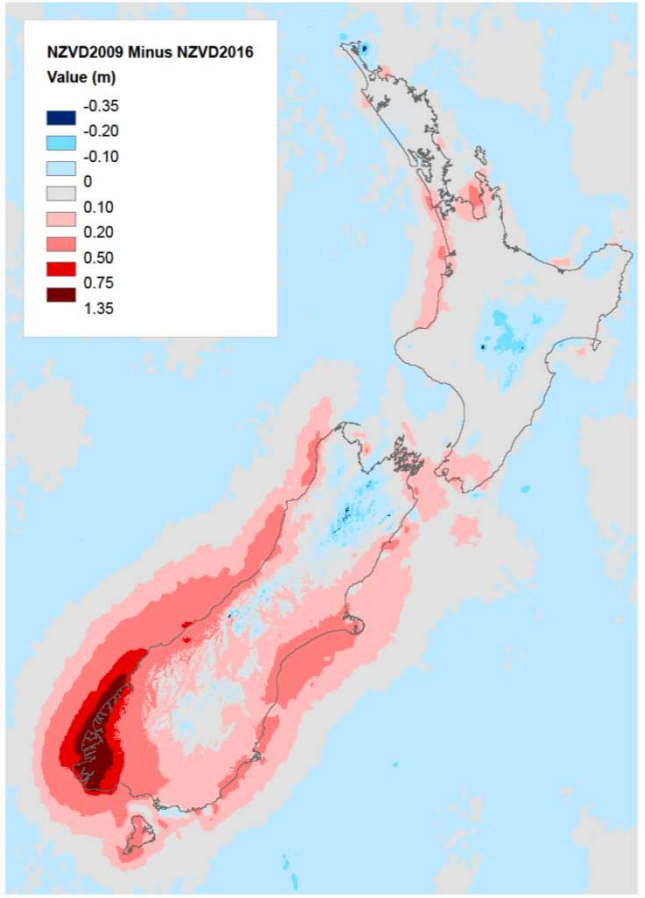
Differences between NZGeoid2009 and NZGeoid2016

Most significant changes:

- Coastal areas
- Mountainous regions
- New global gravity model

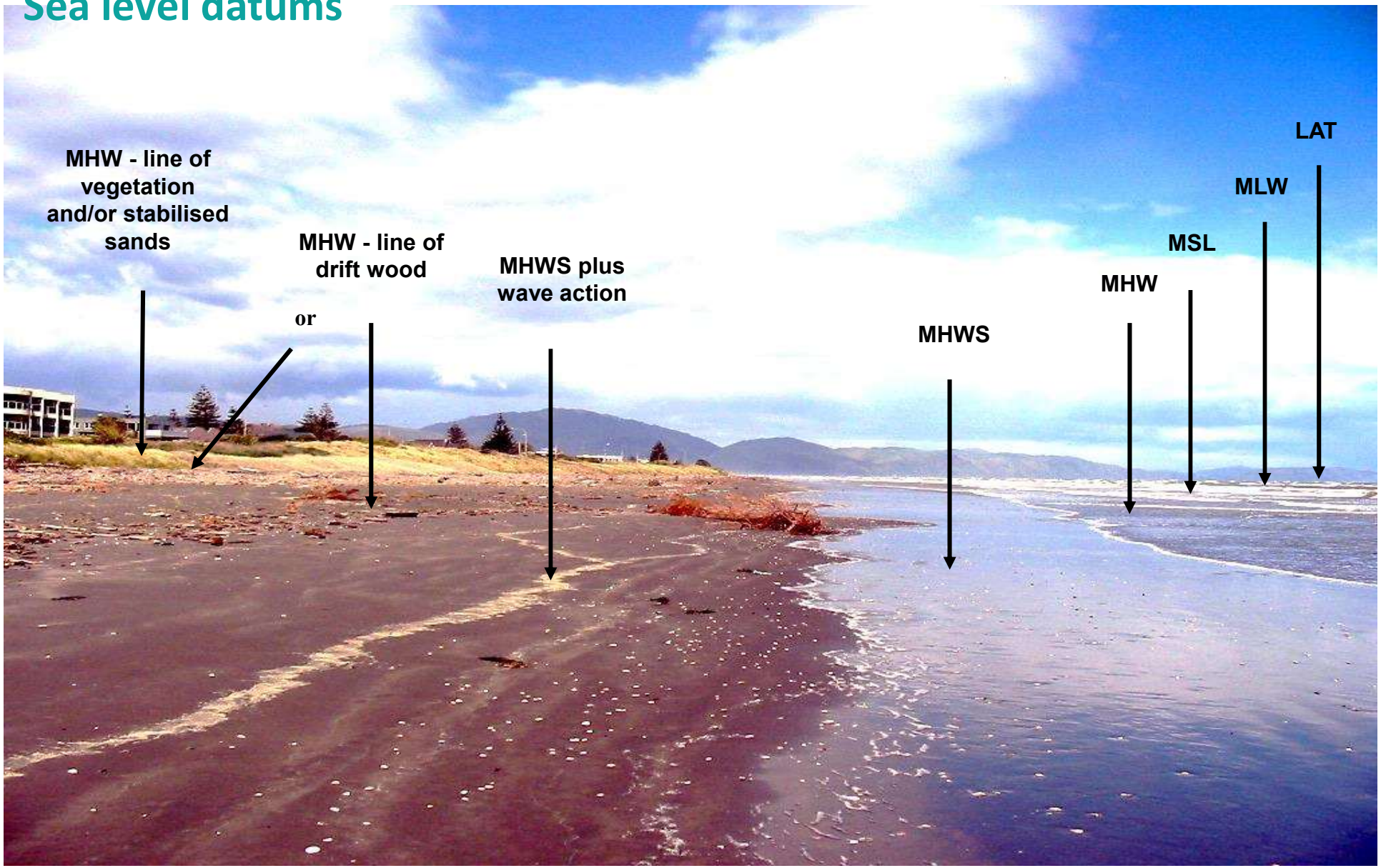
GPS/Levelling height changes:

- Average: 0.10m
- Range: -0.11m to 0.57m

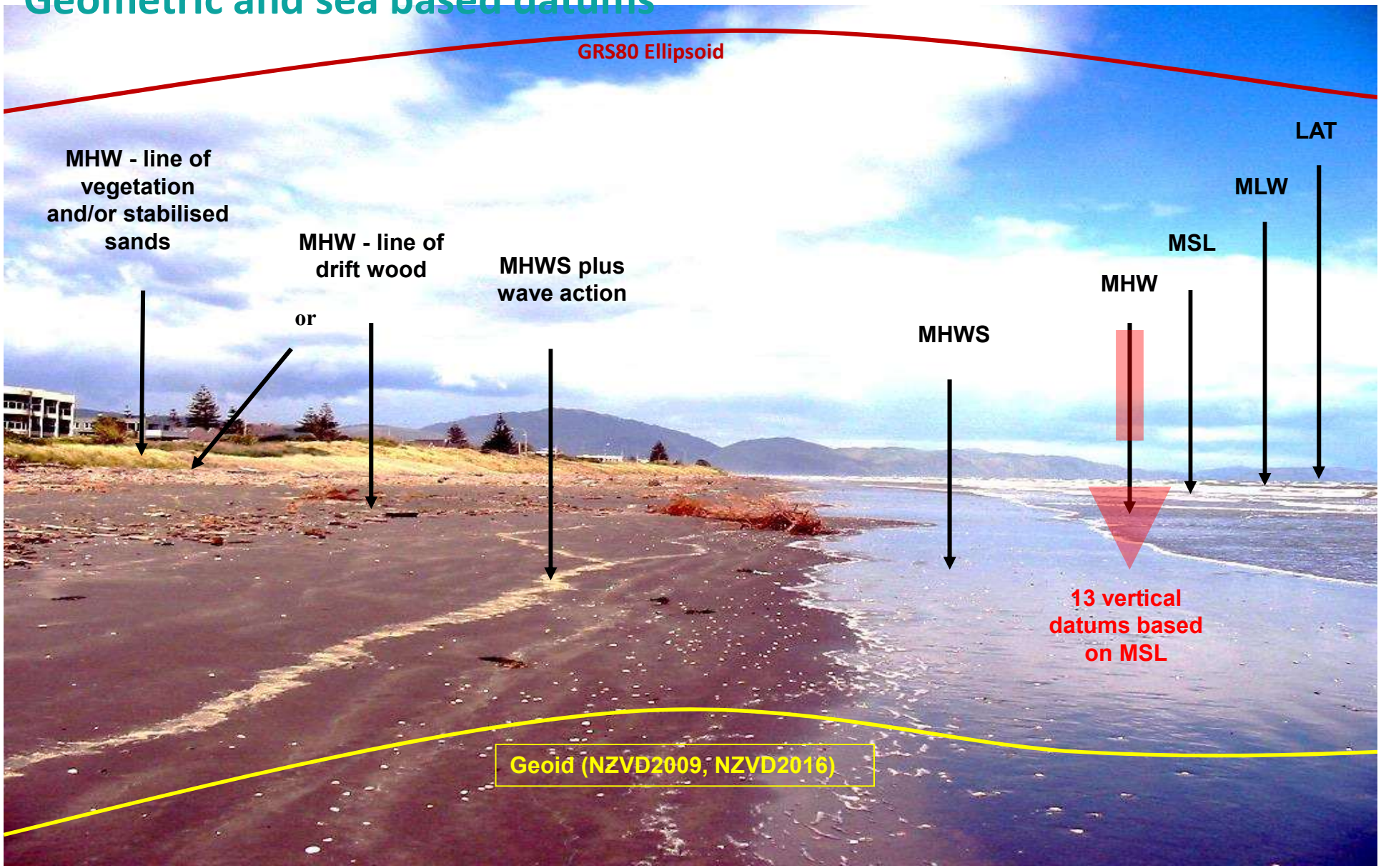


Joining land and sea (JLAS project)

Sea level datums

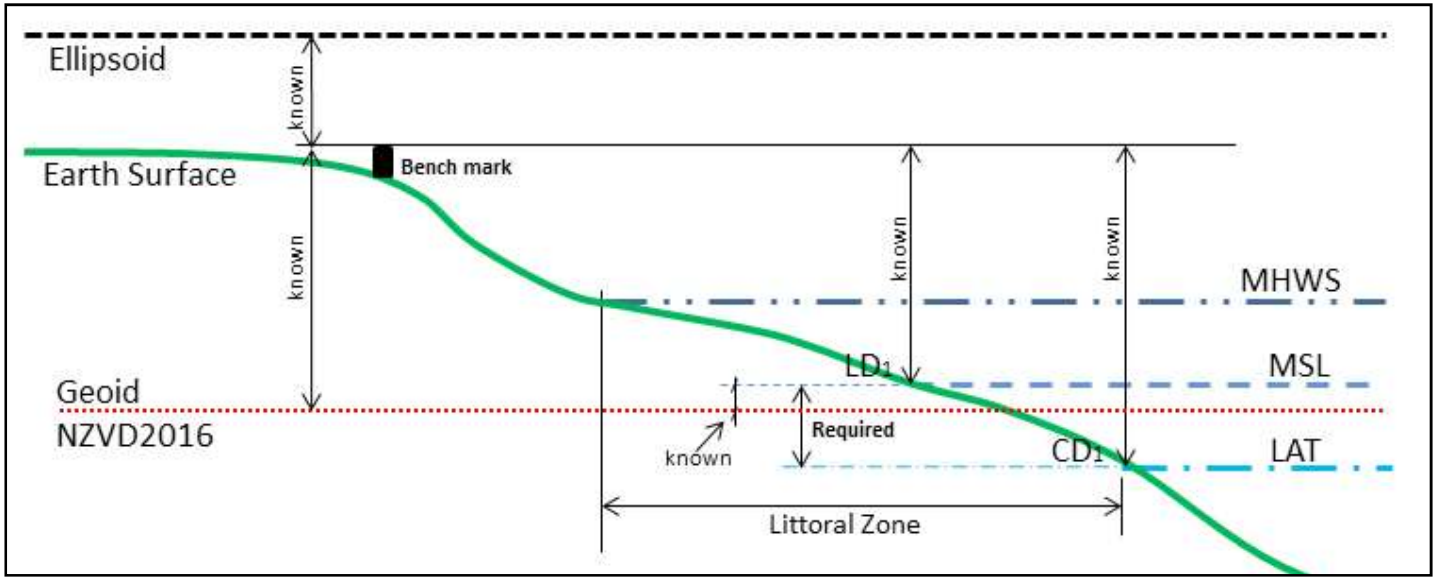


Geometric and sea based datums



Relating vertical datums

- For elevation datasets to be blended together, they must be referenced to the same vertical datum
- Joining datasets:
  - Land data surveyed on different datums
  - Depth data from different charts
  - Depth data and height data



Project summary

- There is a need for a tool that easily transforms from one VD to another
- LINZ's JLAS project developing such a tool
- The benefits to NZ include improved modelling for resiliency, combining sea and land data and gaining efficiencies in hydrographic surveying

Geodetic Strategy


Vision:
Accurately
Positioning New
Zealand for the
Future

Vision and Goals

Vision

Accurately positioning New Zealand for the future

Ten Year Goals

1. Enable the efficient definition of three-dimensional property rights through an accessible geodetic system
2. Measure temporal changes to the shape of the Earth's surface, model the gravity field and incorporate the effects into our reference frames
3. Support the maintenance of global reference frames and the connection of New Zealand's geodetic framework to them
4. Provide tools and services that enable accurate and reliable real-time positioning whenever and wherever it is required
5. Provide strong leadership in the development and use of the positioning system in New Zealand and support its development in the South-West Pacific

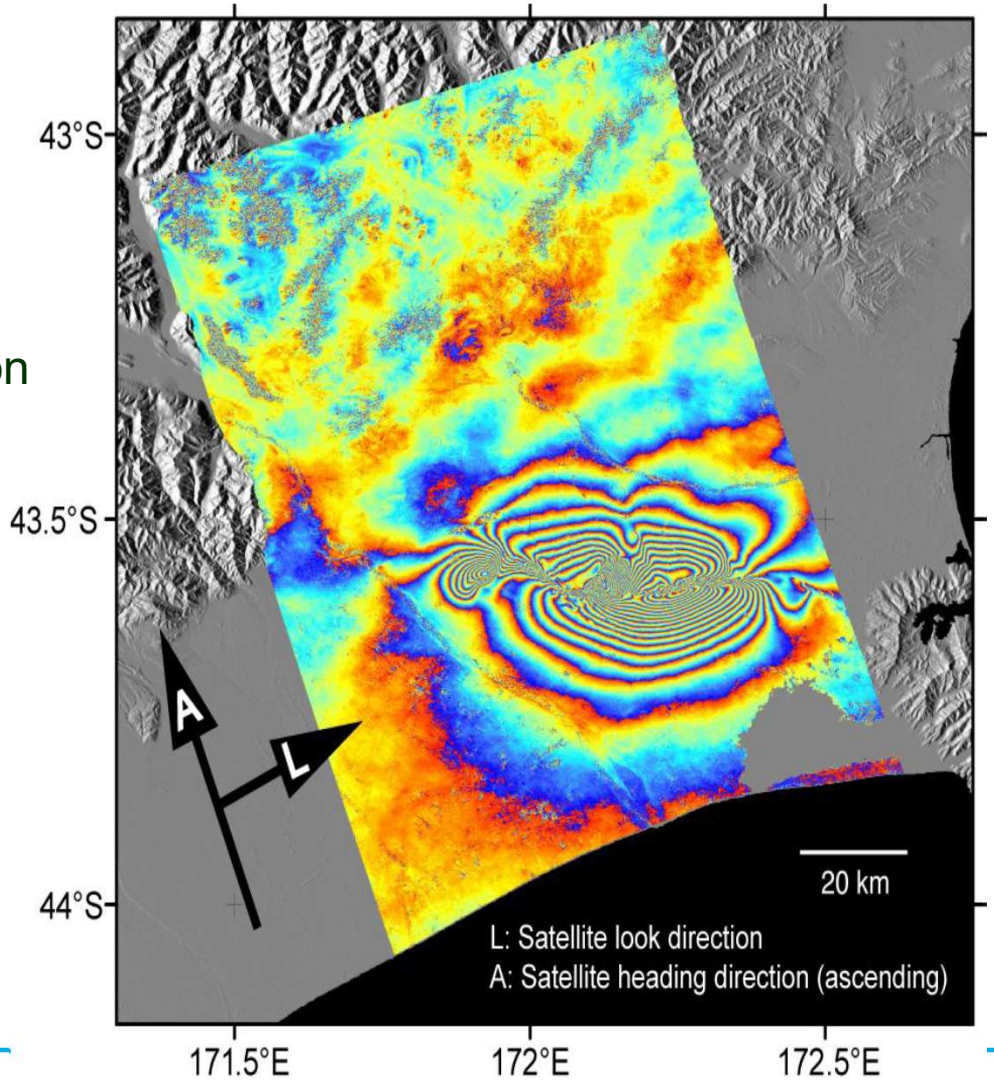
Changing Focus

- Funding split between Crown and 3rd party – in real terms it has decreased but we have a wider customer base
- Stewardship Role – LINZ has assumed stewardship of the Positioning Data Theme and is the custodian of many/most positioning datasets
- Our focus has been on the establishment of extensive networks of control marks
  - initially to support the development of Landonline
  - latterly provision of marks to improve access to NZGD2000
- We are changing our focus to:
  - maintaining the models that define our datums
  - develop new services that meet the positioning needs of a broader range of users who do not want to just use coordinates
  - a greater emphasis on supporting and maintaining global and regional reference frames

New

New technologies to monitor deformation

Vertical deformation model



10 years from

Positioning will become truly ubiquitous

Our challenges are to:

- **provide a system which is invisible to users**
- **remove complexity**
- **maintain accuracy**
- **be truly global**
- **realise real time coordinates**
- **be leaders and not followers**
- **embrace new technologies**
- **decide to what extent we support the mass market**

the power of where drives NZ's success

Land Information New Zealand
Toitū te whenua

Questions?