New Zealand Reference Frame Case Study

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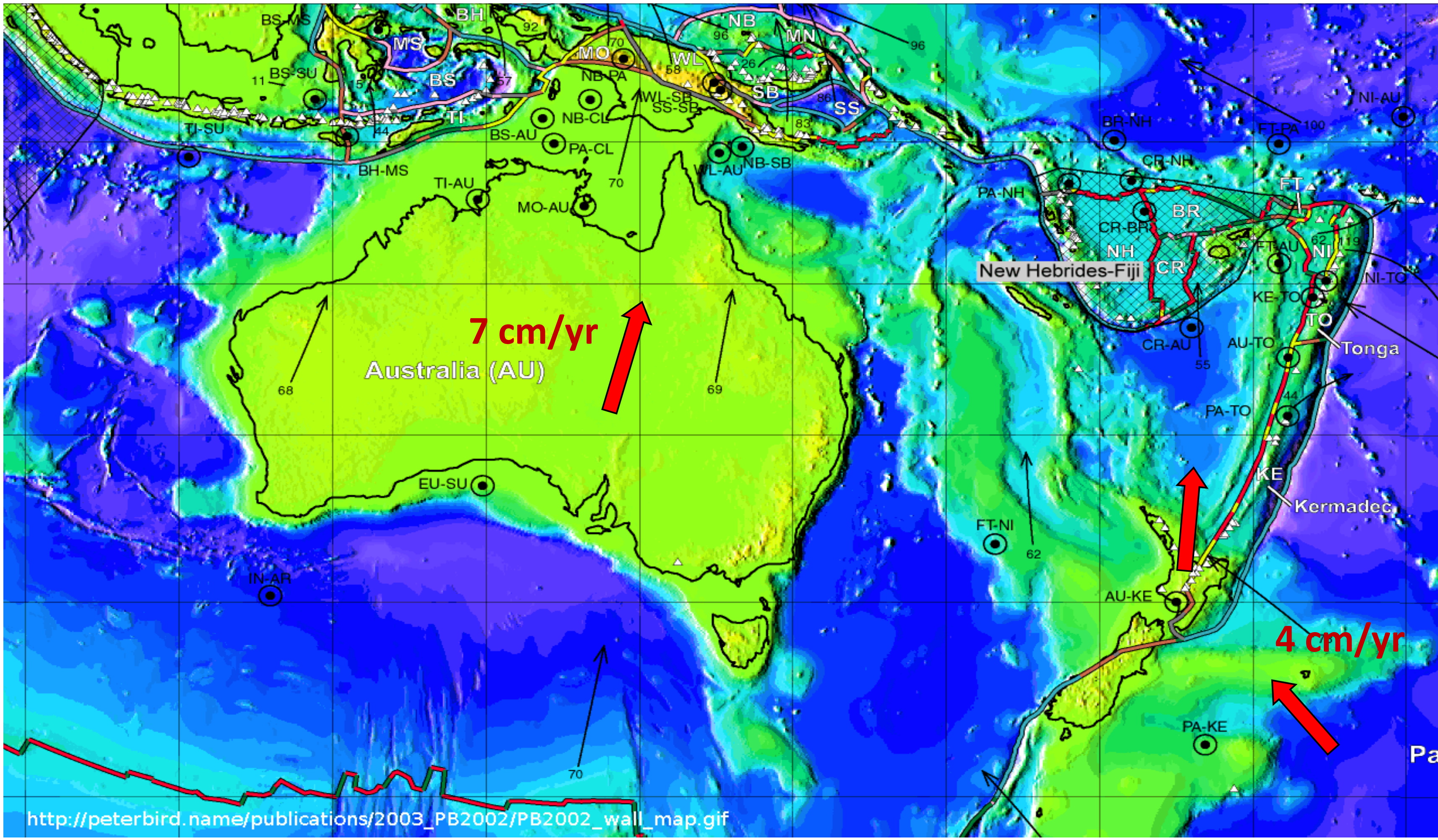
Fundamental role of the reference frame

Requirements of a National Reference System

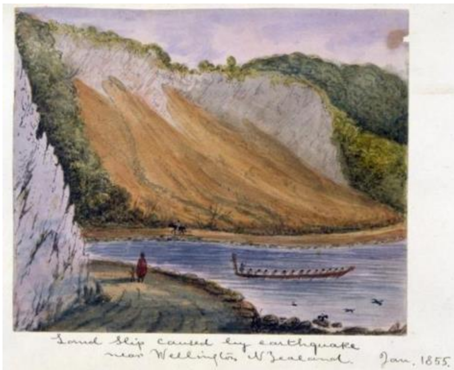
- A coordinate framework that is **accurate, stable, reliable and accessible**
- Direct **linkage** to International Reference Frames
- **Simple** for users to connect to and use
- **Physical infrastructure** may include GNSS CORS and traditional geodetic survey marks
- Systems and tools to allow connection to the coordinate reference system and **transformation** of legacy data to the current reference system

- **Tectonic setting**
- **Geodetic datum**
  - PositioNZ
  - Deformation models
- **Vertical datum**
  - NZVD2009
  - NZVD2016
  - NZIVD2018
- **Future Strategy**

Tectonic setting of New Zealand



Significant historic earthquakes



West Wairarapa 1855

Napier 1931

Edgecumbe 1987

Murchison 1929

Inangahua 1968

Christchurch 2011

Significant volcanic events

White Island

Mt Tarawera 1886

Mt Ruapehu

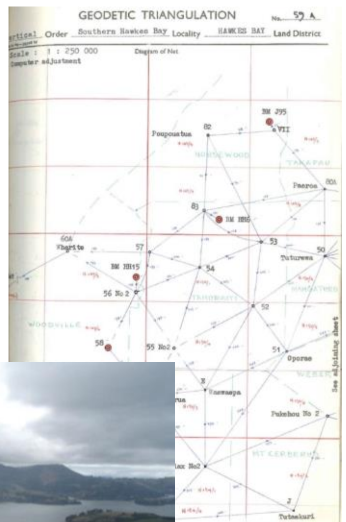
Mt Ngauruhoe

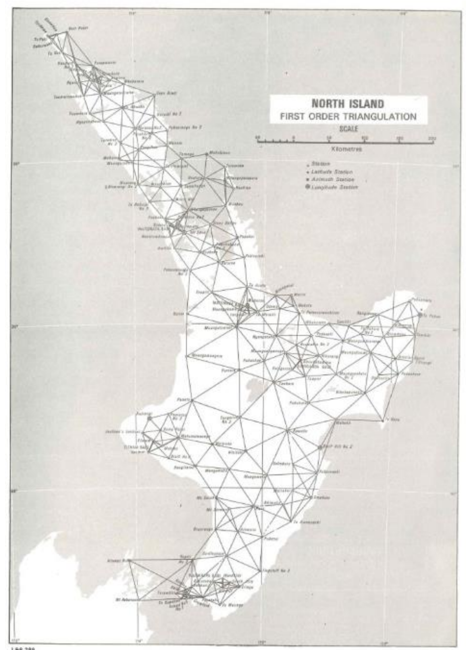
Early triangulation surveys

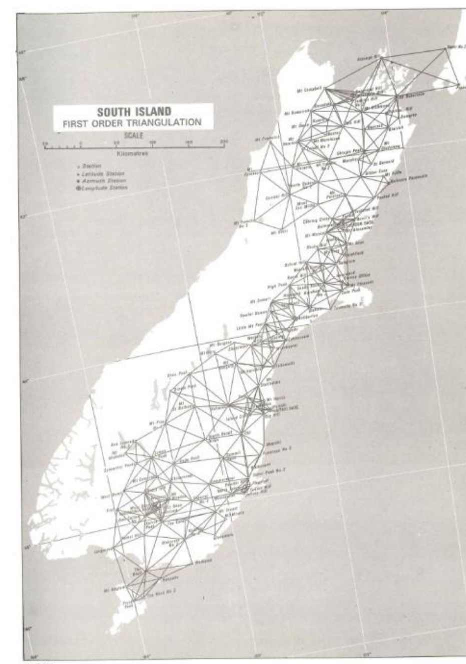
Commenced in the 1880s

1st order control completed 1940s for NZGD49

Provided a foundation for measuring crustal deformation

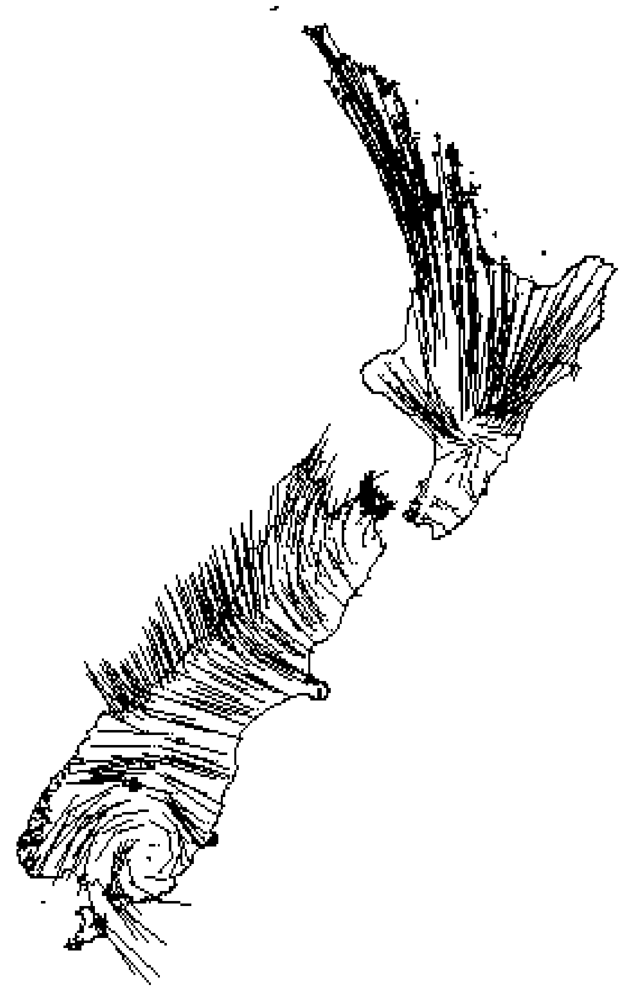






Limitations with NZGD49

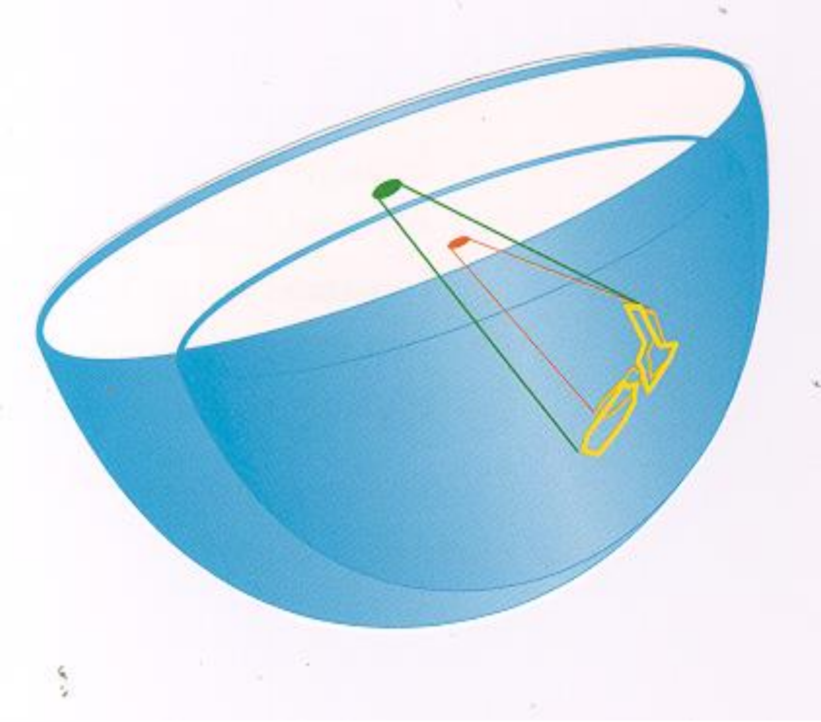
- Regional distortions up to 5m prese
- Built up in a piecemeal fashion
- Incompatible with global systems
- It is of limited spatial coverage
- It is static



Introduction of NZGD2000

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

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



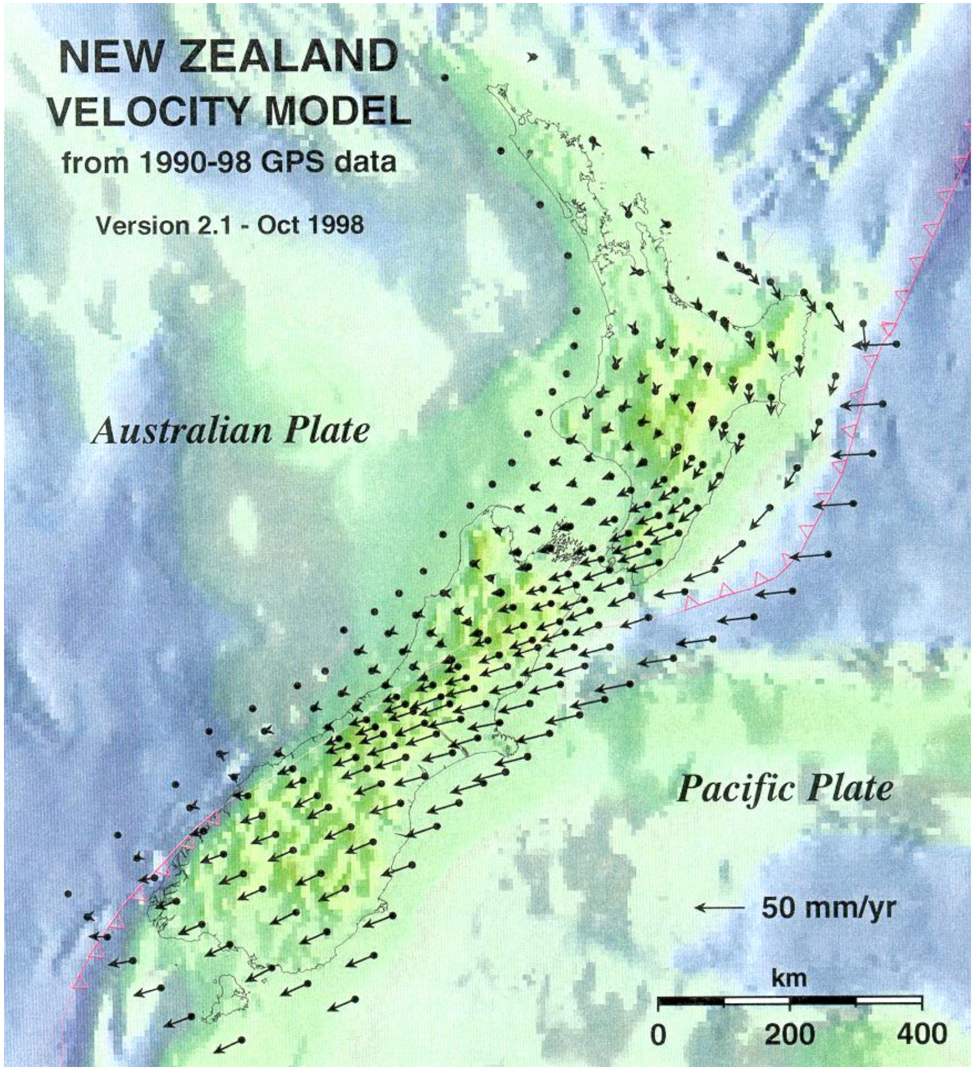
NZGD2000 - semi-dynamic datum

- generalised motion of points modelled using a deformation model

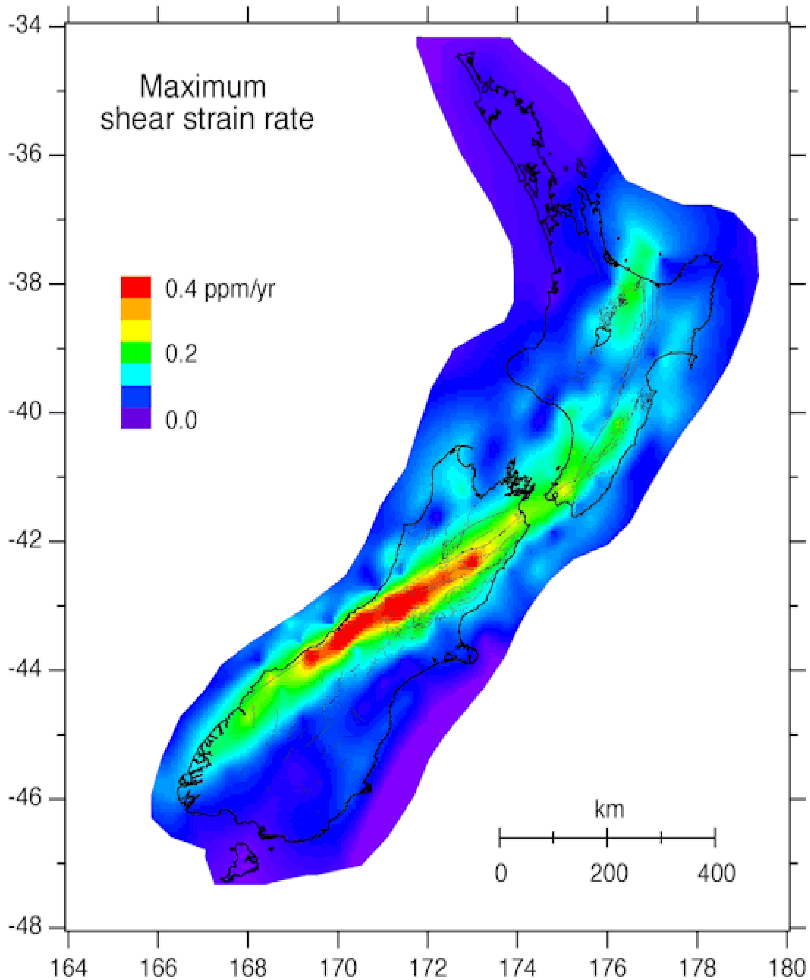
Introduction of NZGD2000

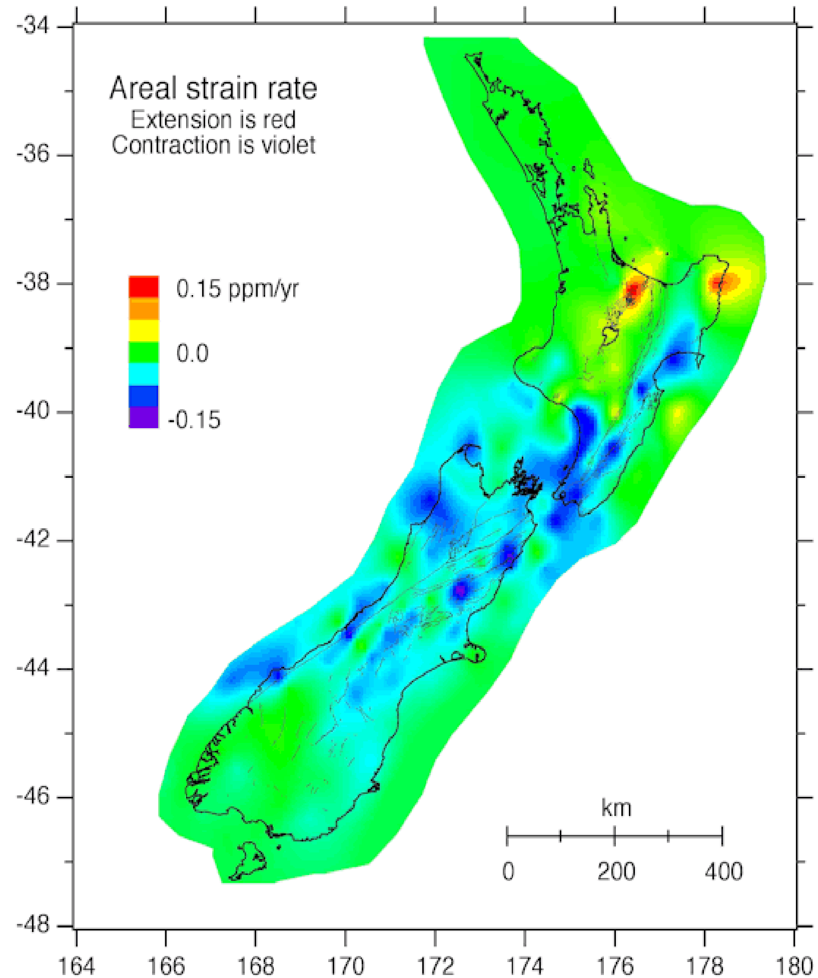
Semi-dynamic datum

- current deformation model has horizontal constant velocities only
- initially 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**



Measuring deformation - strain





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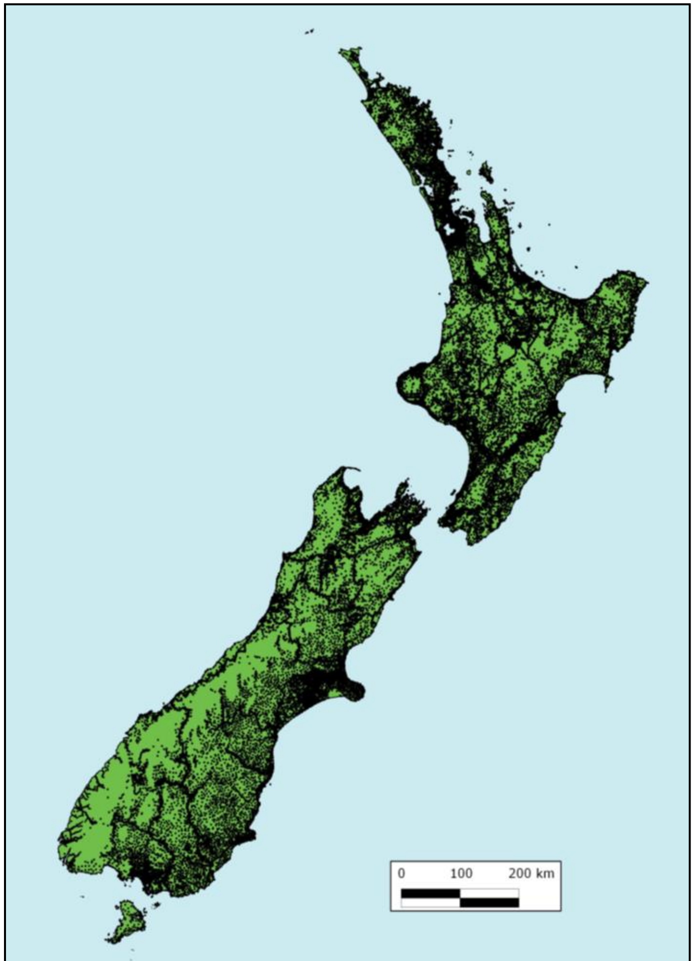
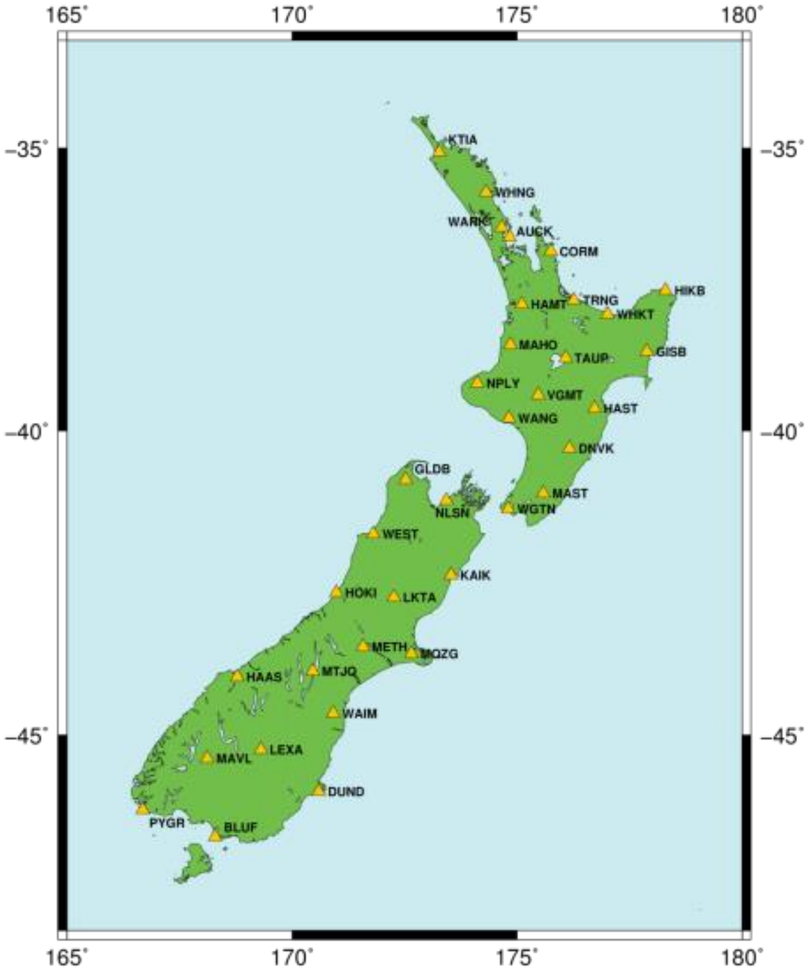
Connecting to the datum



100,000+ control marks

Connecting to the datum



PositioNZ Network

35 on the mainland of NZ

1 on the Chatham Islands

3 in Antarctica

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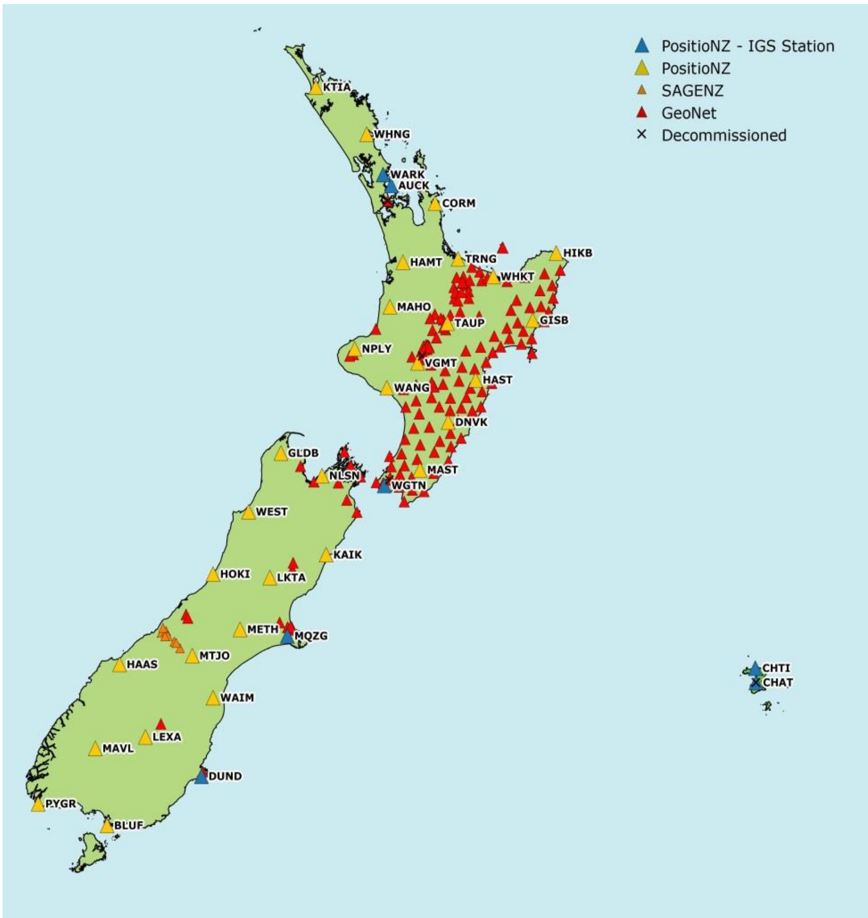
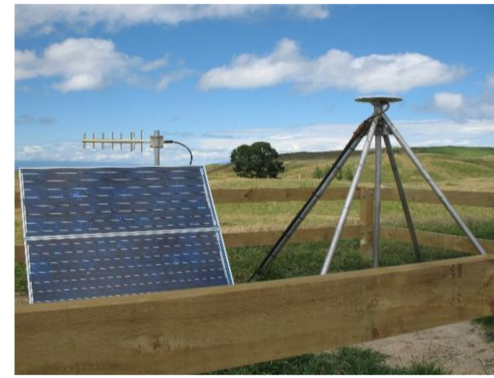
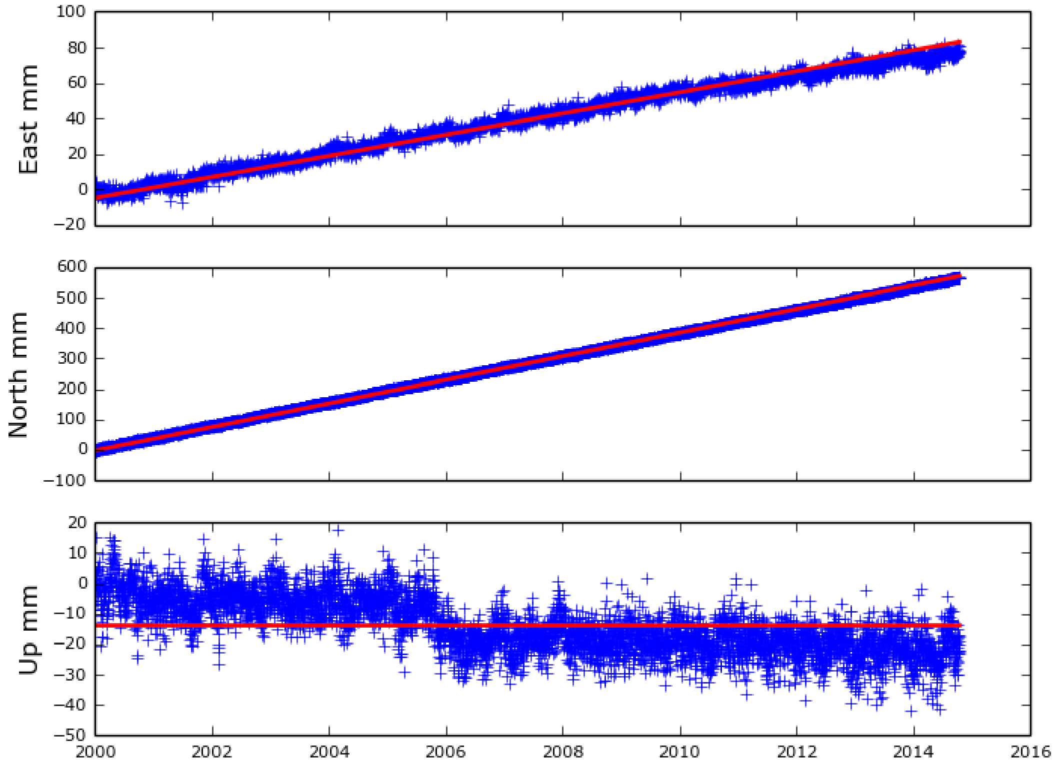
GEONET

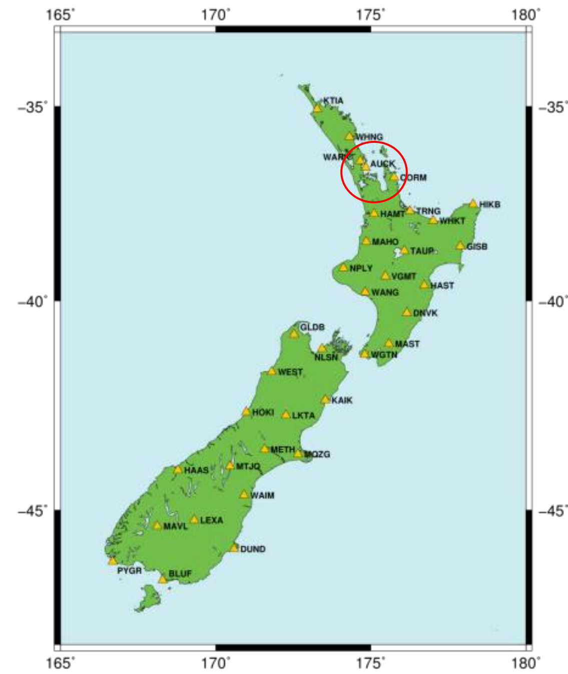

PositioNZ - IGS Station
PositioNZ
SAGENZ
GeoNet
Decommissioned
KTIA
WHNG
WARK
AUCK
CORM
HAMT
TRNG
HIKB
WHKT
MAHO
TAUP
GISB
NPLY
VGMT
HAST
WANG
DNVK
GLDB
NLSN
MAST
WGTN
WEST
KAIK
HOKI
LKTA
METH
MQZG
HAAS
MTJO
WAIM
LEXA
MAVL
DUND
PYGR
BLUF
CHTI
CHAT



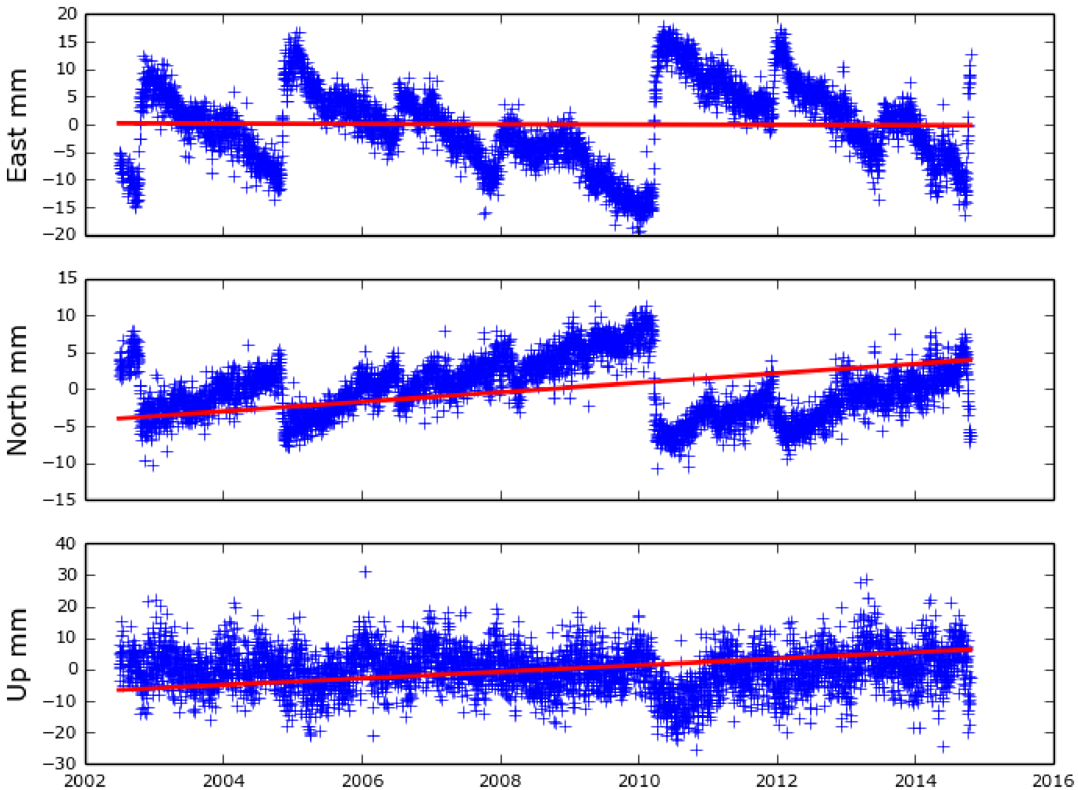

PositioNZ
GeoNet

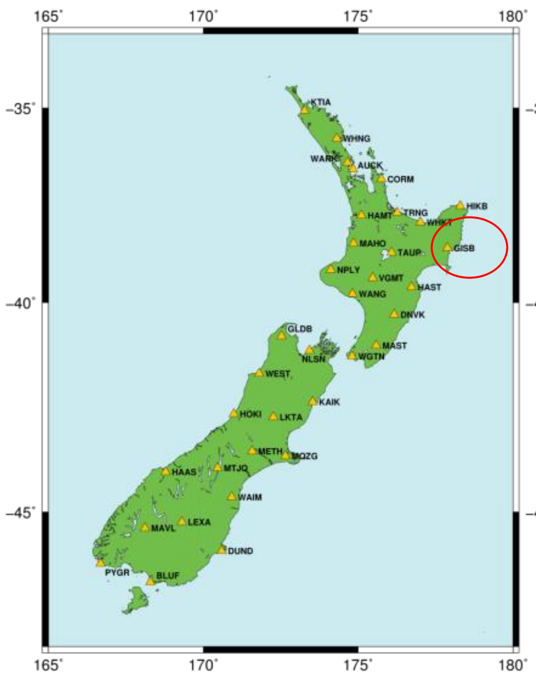
Auckland - stable





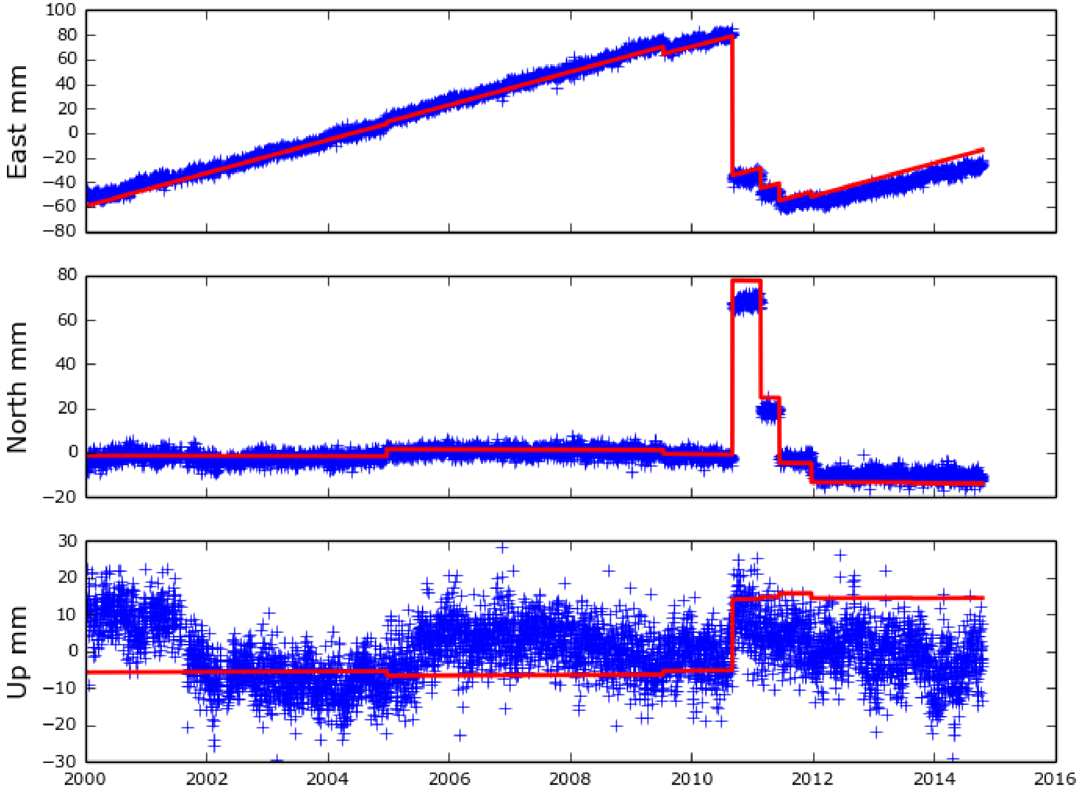
Gisborne – slow earthquakes

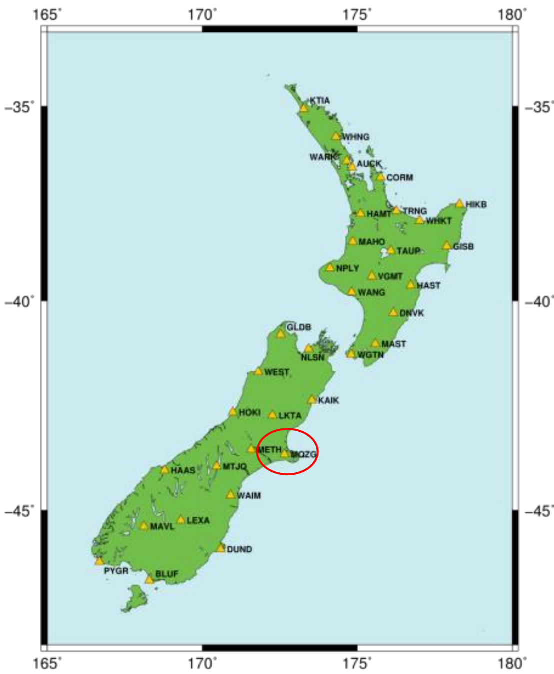




Sponsors: Land Information New Zealand Toitū te whenua; Leica Geosystems; Trimble

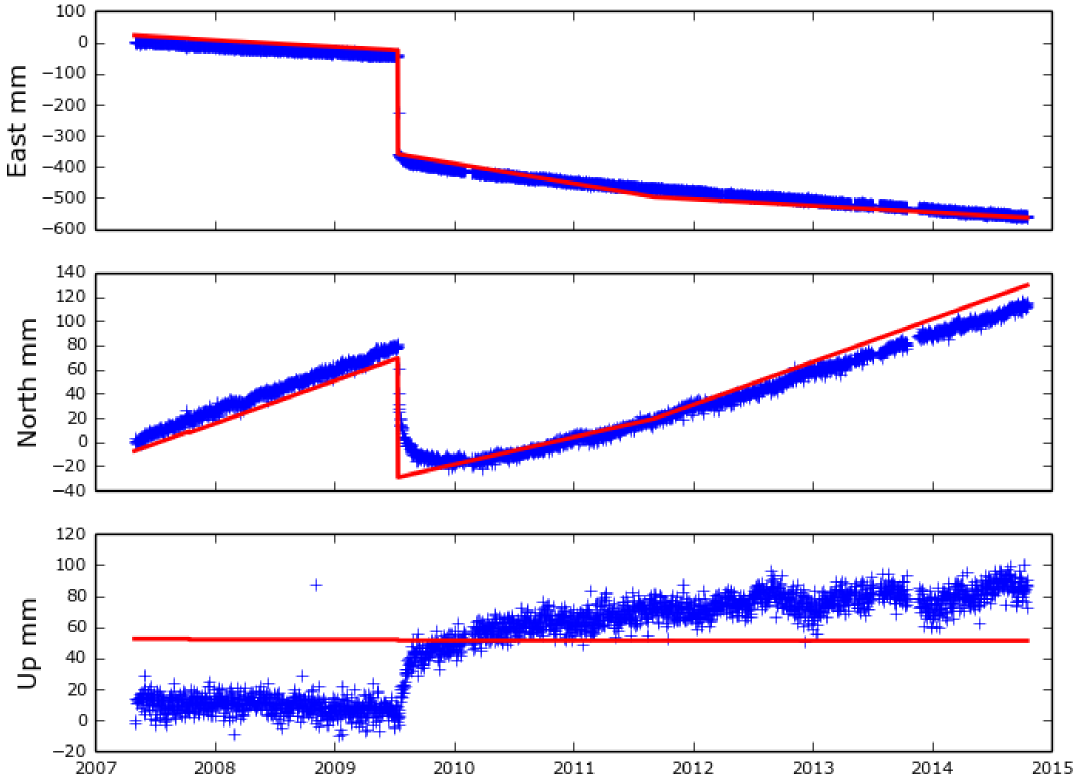
Christchurch – Canterbury earthquakes

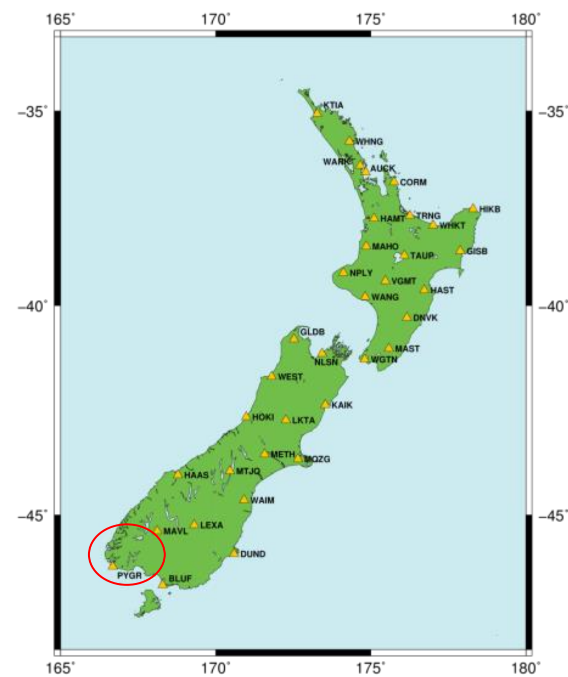




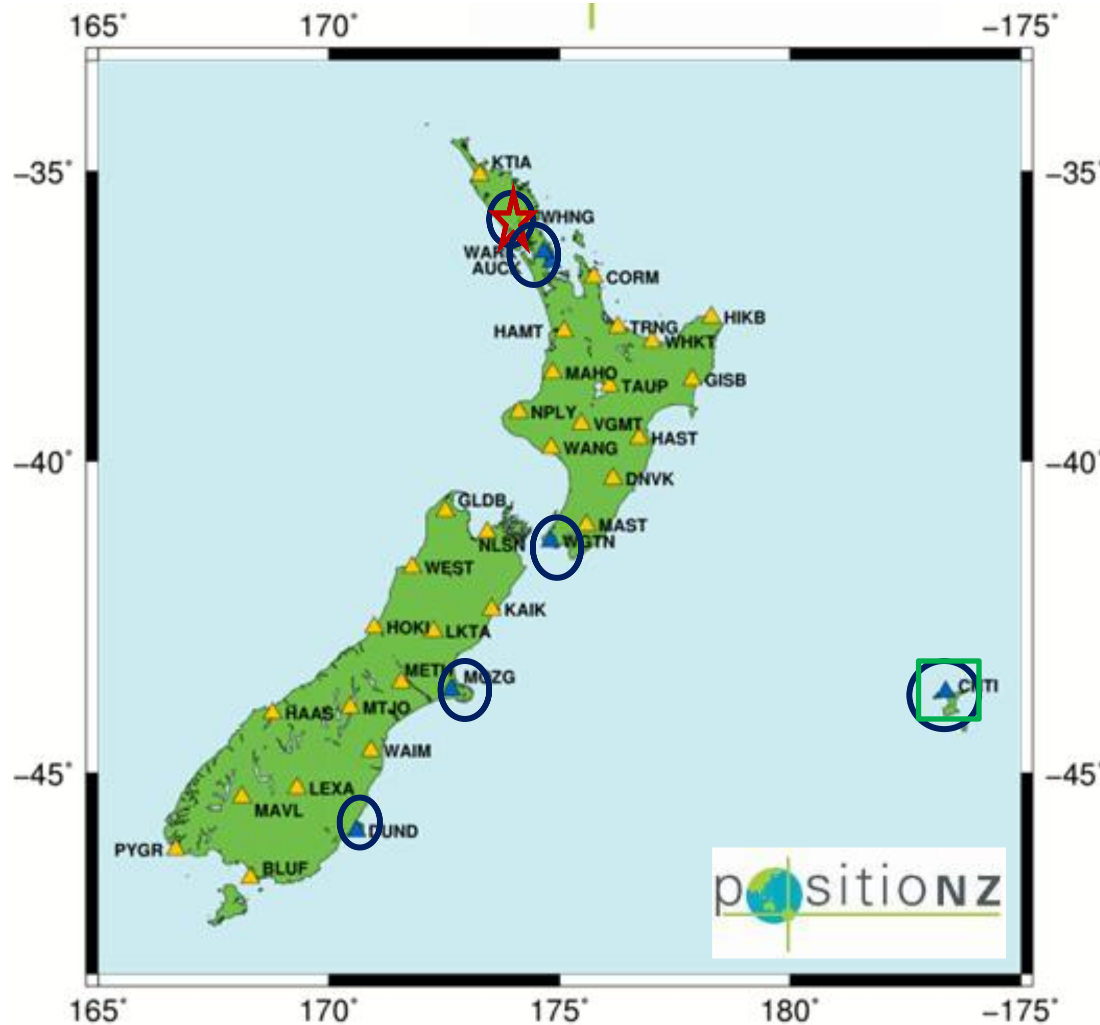
Sponsors:

Fiordland postseismic recovery





Contribution to ITRF

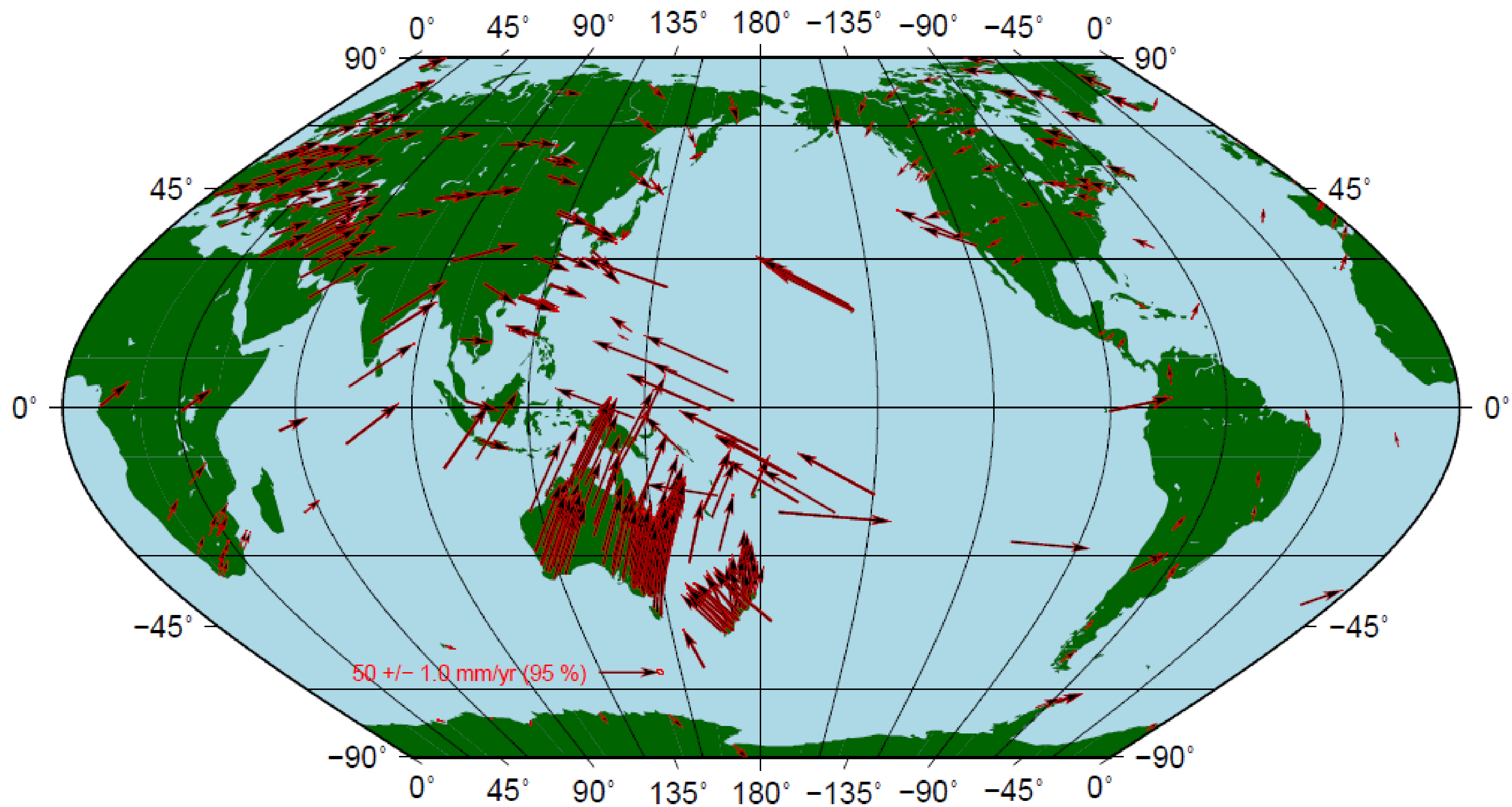


CORS

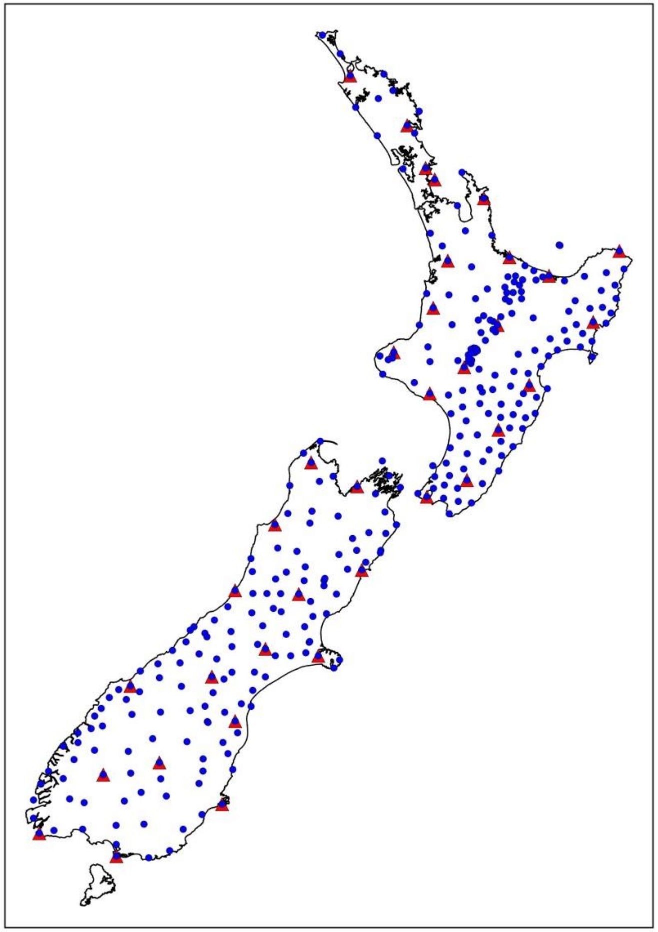
VLBI

DORIS

Contribution to Asia Pacific Reference Frame (APREF)

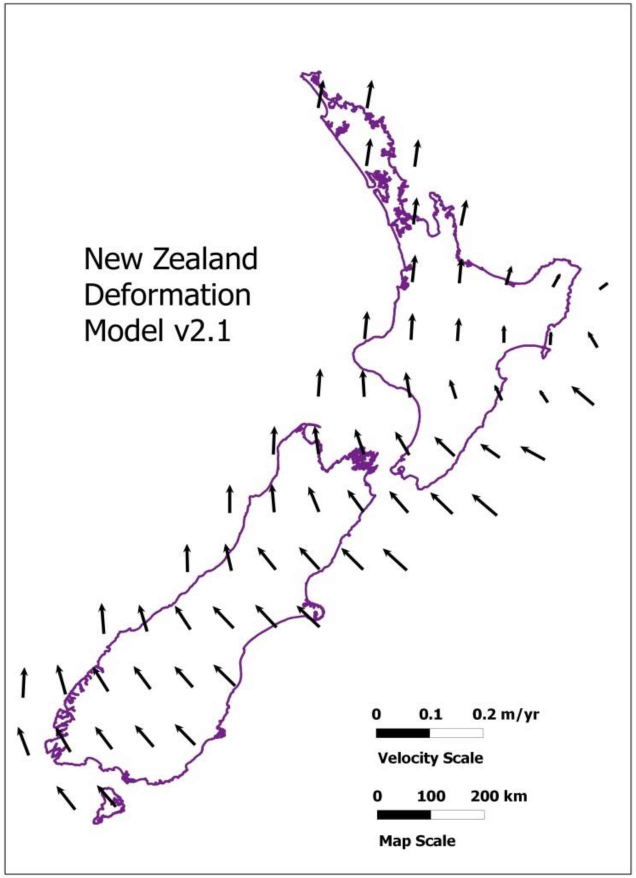


National deformation monitoring network



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

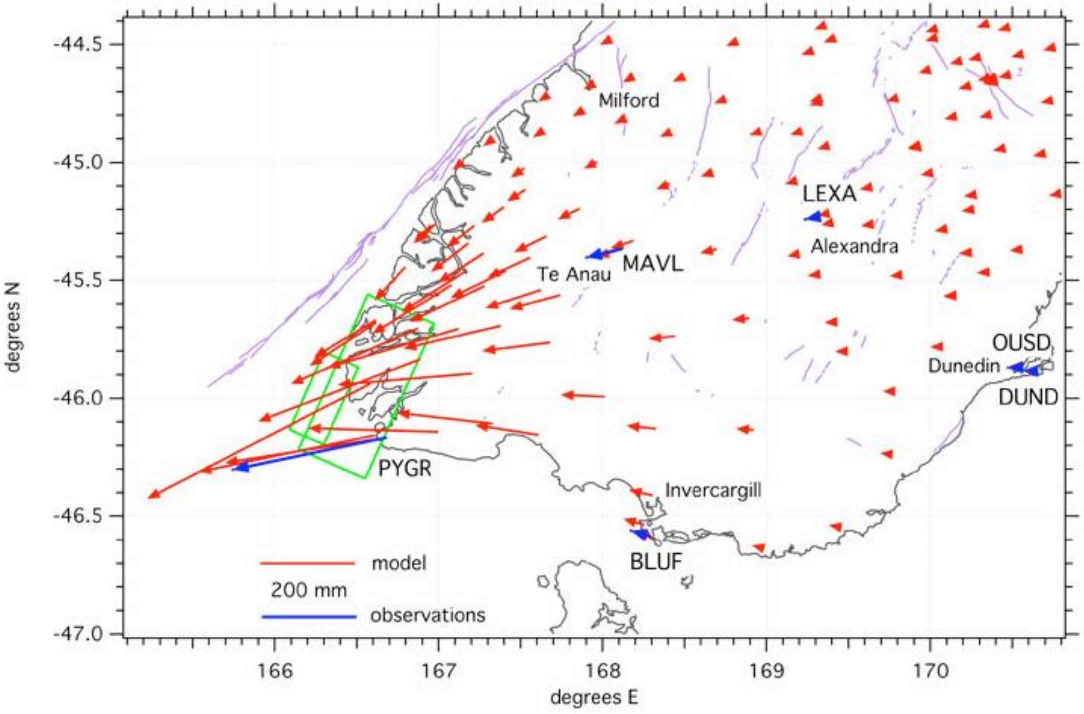
Enhancing the Deformation Model

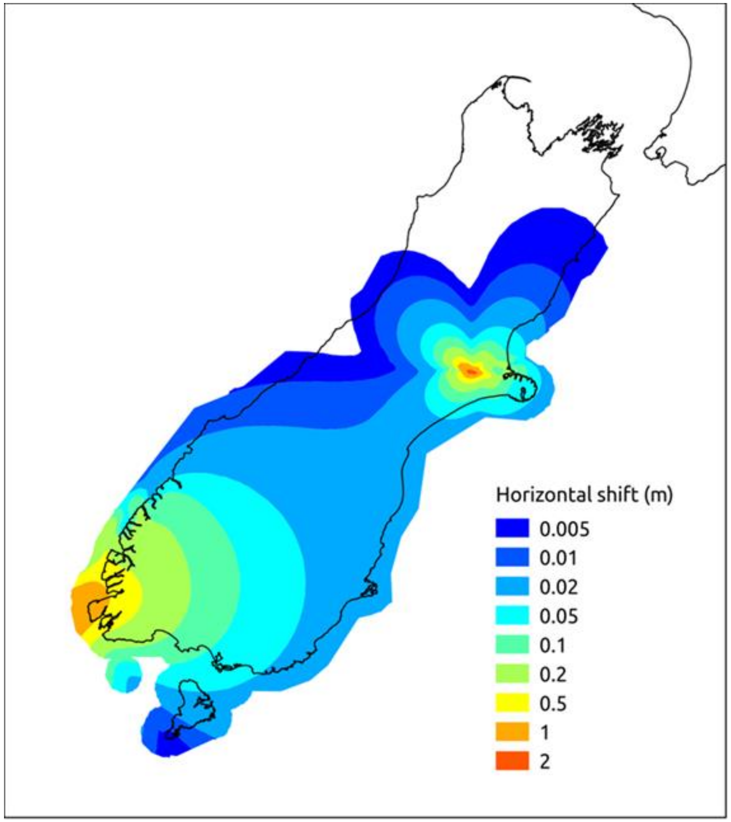


Horizontal model only

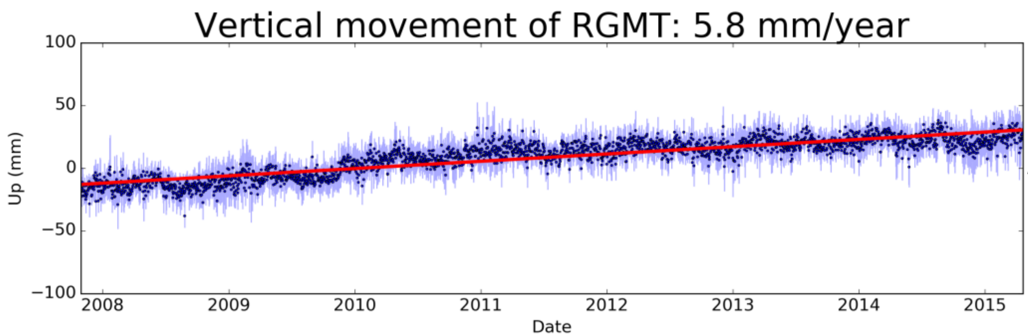
Continuously updated and refining

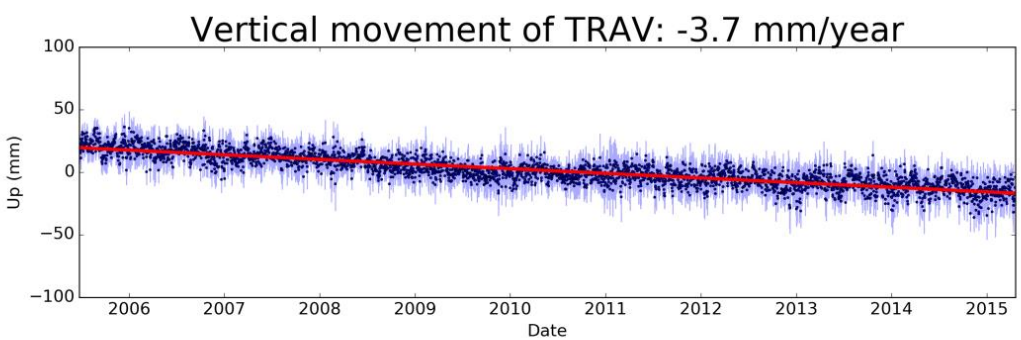
Adding patches

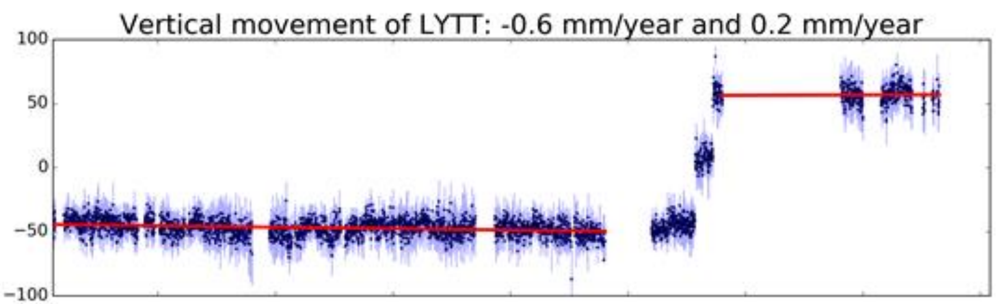


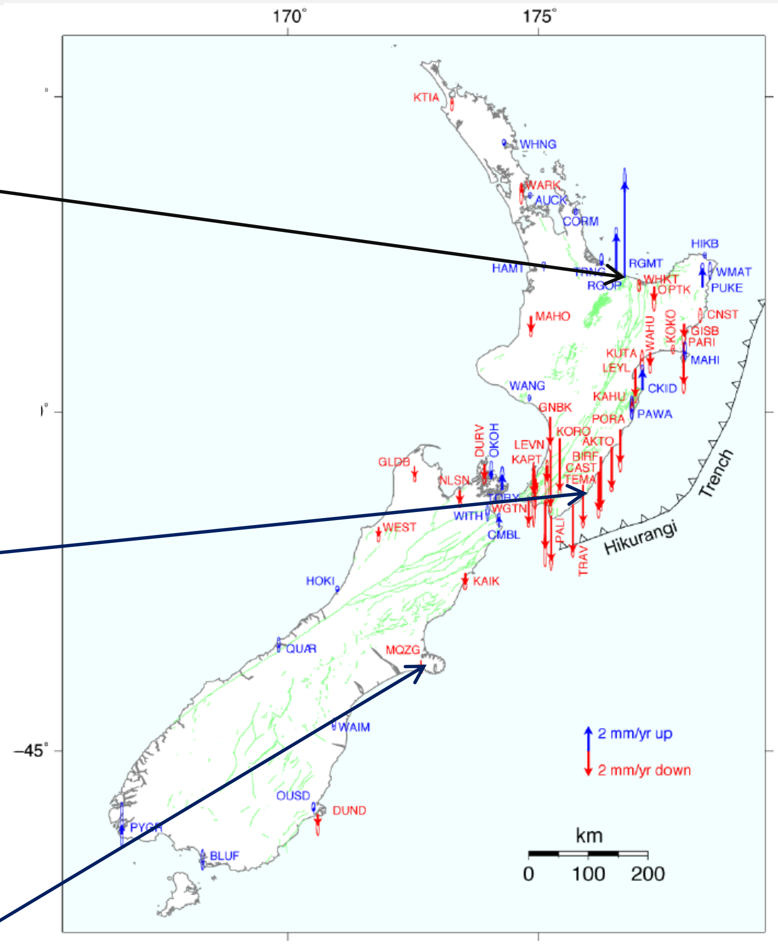


Sponsors: Land Information New Zealand Toitū te whenua Leica Geosystems Trimble









Sponsors: Land Information New Zealand Toitū te whenua; Leica Geosystems; Trimble

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

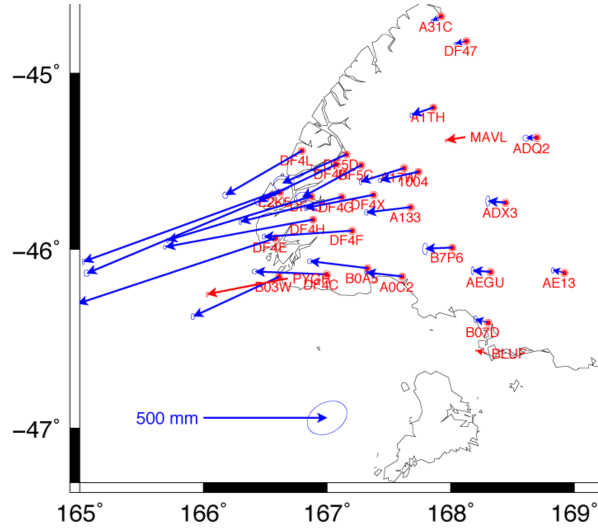
Where are we at

What has gone well

- Good user acceptance
- The incorporation of a deformation model in NZGD2000 has enabled the life of the datum to be lengthened and new observations to be integrated with old observations
- Accuracy of datum has been maintained

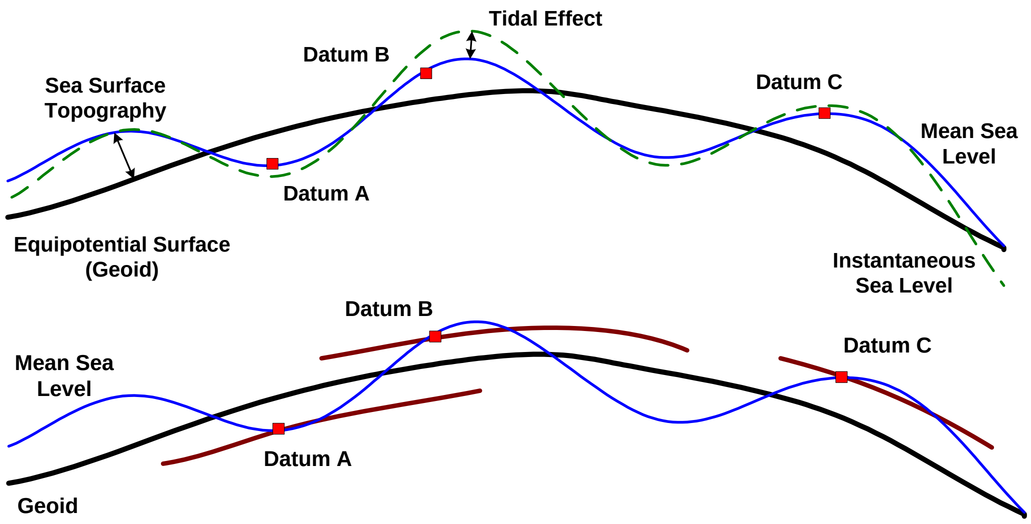
Issues

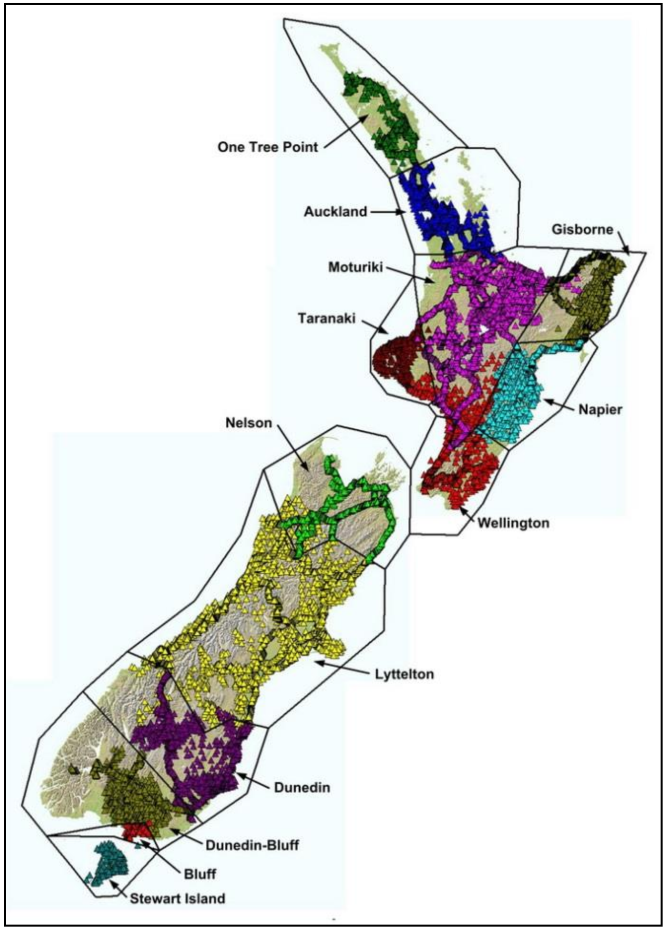
- Managing the deformation model
- Accuracy of deformation model versus CORS real time positions
- Managing the spatial alignment of the cadastral system
- Misalignment of readjusted historic geodetic control with new surveyed geodetic control



Vertical datums - Traditional levelling based datums

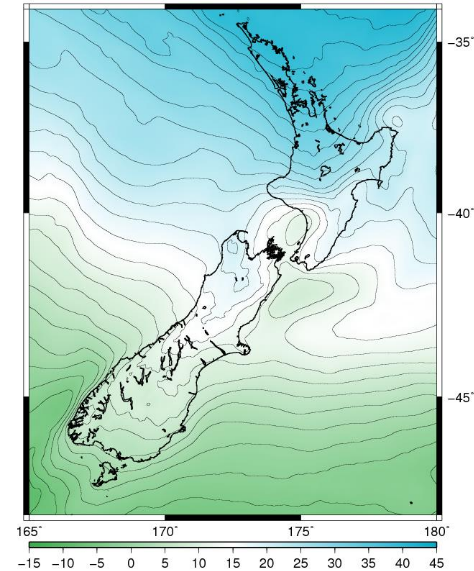
- 13 levelling based datums
- Each connected to a tide separate tide gauge based on "MSL"
- Not nationally consistent
- No national geoid
- Need local transformations





New Zealand Vertical Datum 2009

- First national vertical datum
- Based on NZGeoid2009
- 6 cm nominal accuracy
- 3-15 cm local accuracy
- Need better than 3 cm in developed areas
- Includes official offsets to 13 main local vertical datums



Datum	Offset	Std Dev
One Tree Point 1964	0.06	0.03
Auckland 1946	0.34	0.05
Moturiki 1953	0.24	0.06
Gisborne 1926	0.34	0.02
Napier 1962	0.20	0.05
Taranaki 1970	0.32	0.05
Wellington 1953	0.44	0.04
Nelson 1955	0.29	0.07
Lyttelton 1937	0.47	0.09
Dunedin 1958	0.49	0.07
Dunedin-Bluff 1960	0.38	0.04
Bluff 1955	0.36	0.05
Stewart Island 1977	0.39	0.15

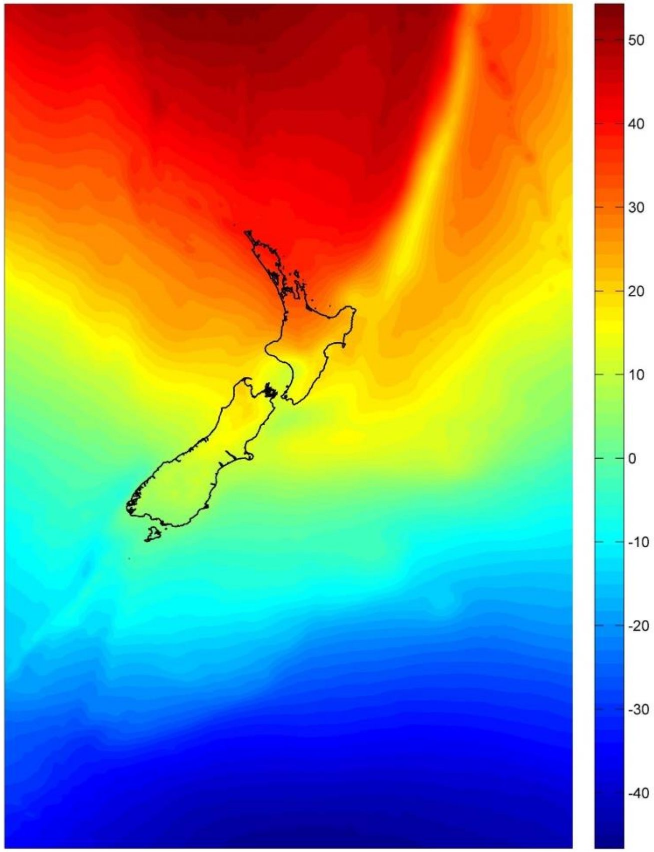
Sponsors: Land Information New Zealand Toitū te whenua; Leica Geosystems; Trimble

Accuracy Improvement

- NZGeoid2009 based on existing gravity data
- Irregular and biased locations
- Gap in near-shore areas
- Airborne gravity best solution

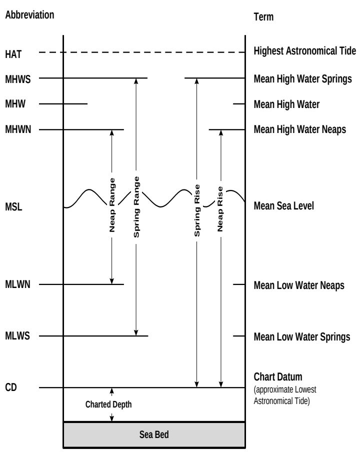
New Zealand Vertical Datum 2016

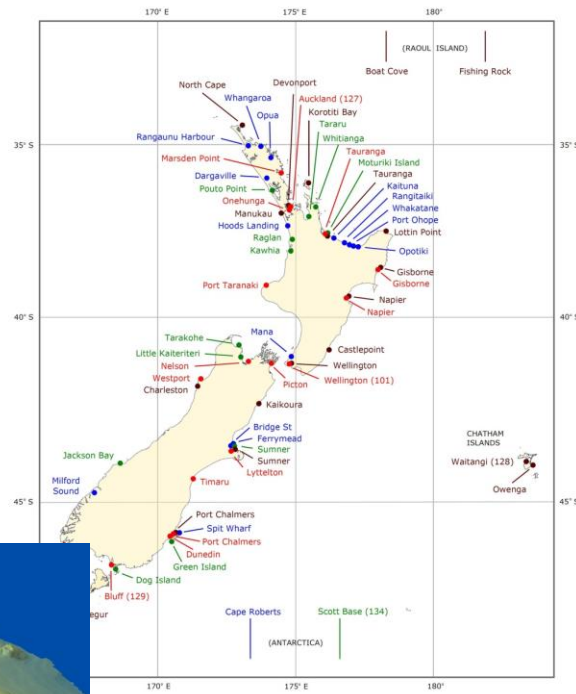
- To be published in June 2016
- Based on NZGeoid2016
- 3 cm nominal accuracy
- Transformation surfaces to local datums

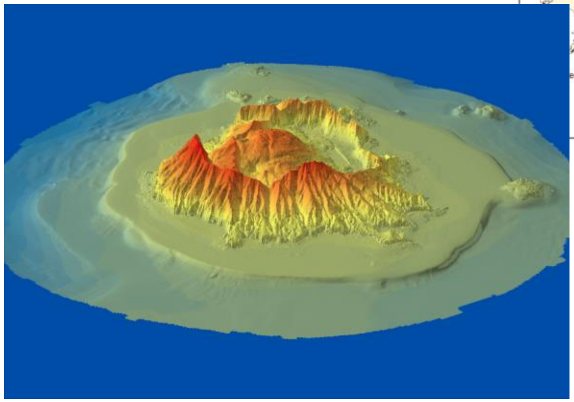


New Zealand Integrated Vertical Datum 2018?

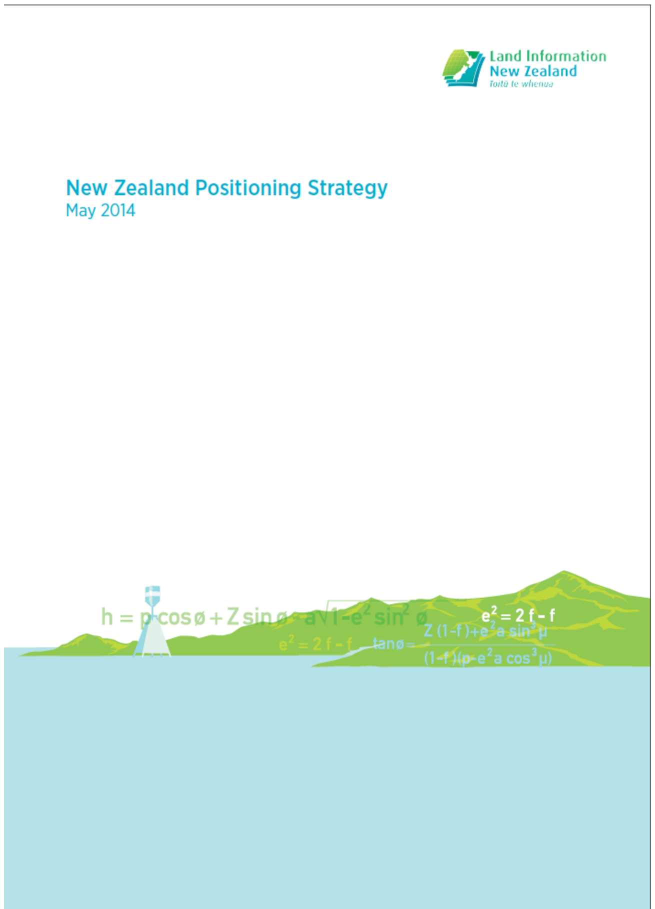
- Connecting physical datum to geometric datum and providing transformations
- Seamless mapping of the land and sea







The future


Land Information
New Zealand
Toitū te whenua
New Zealand Positioning Strategy
May 2014

FIG/IAG/UN-GGIM- AP/UN-ICG/NZIS Technical Seminar

Reference Frame in Practice

Christchurch, New Zealand, 1-2 May 2016

Vision: Accurately Positioning New Zealand for the Future

Sponsors: Land Information New Zealand Toitū te whenua · Leica Geosystems · Trimble

Vision and Goals

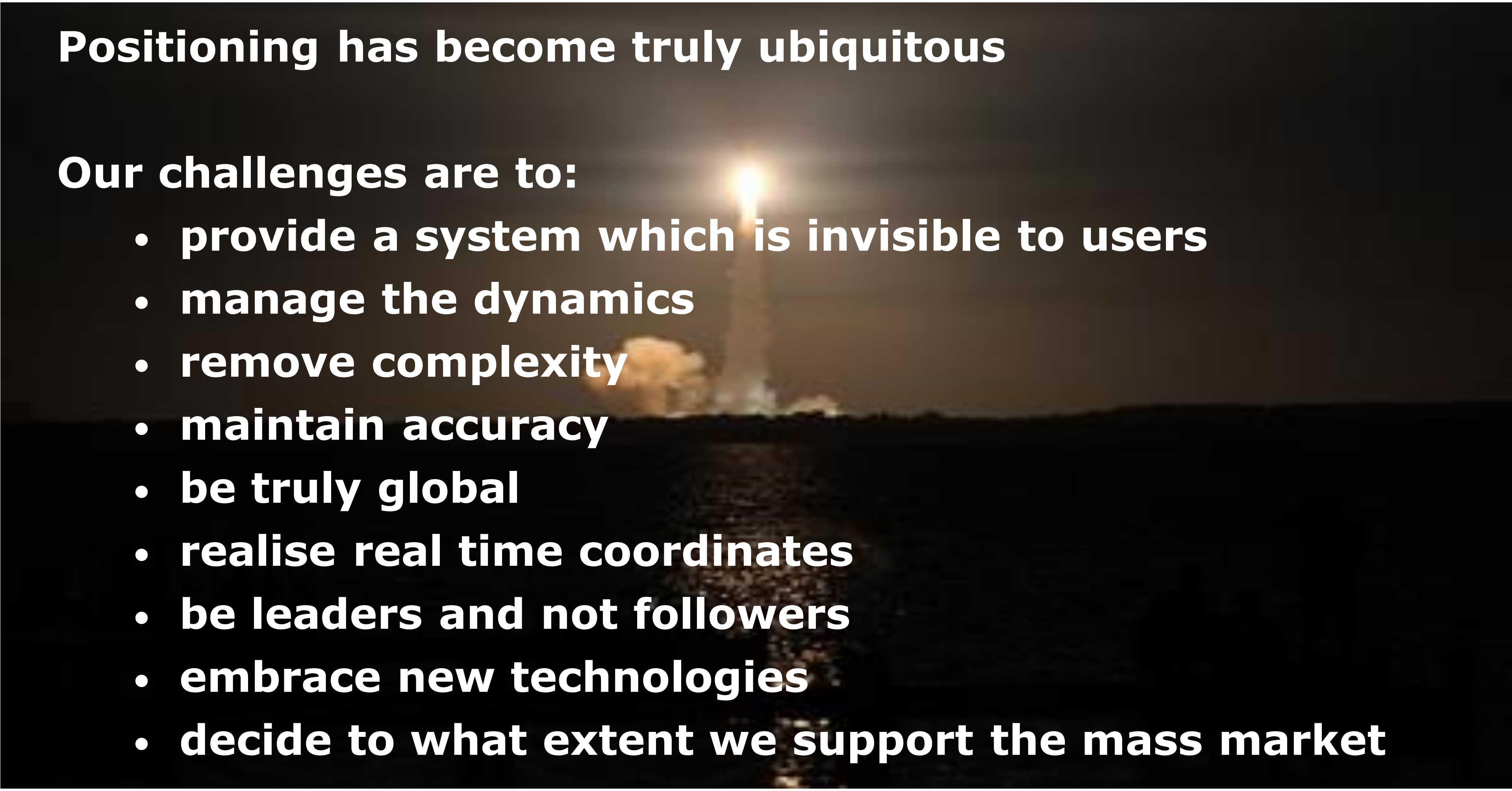
Vision

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

10 years from now



Positioning has become truly ubiquitous

Our challenges are to:

- **provide a system which is invisible to users**
- **manage the dynamics**
- **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**

Questions?