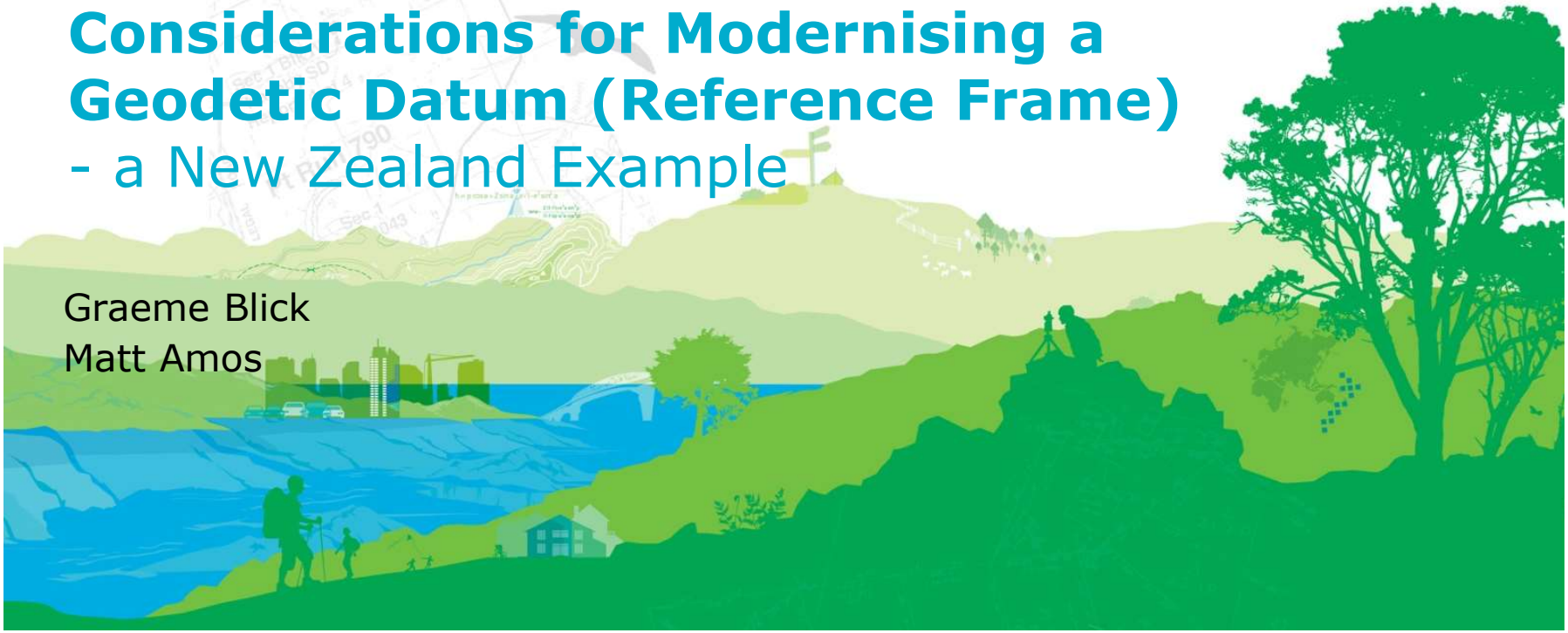
Land Information New Zealand
Toitū te whenua

Considerations for Modernising a Geodetic Datum (Reference Frame)
- a New Zealand Example



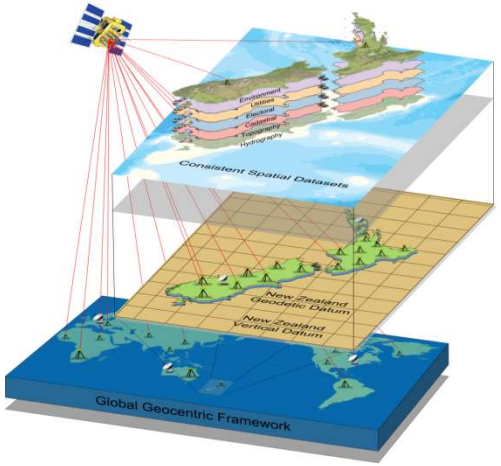
Graeme Blick
Matt Amos

Fundamental Role of Reference Frame

(is a datum a reference frame at a point in time?)

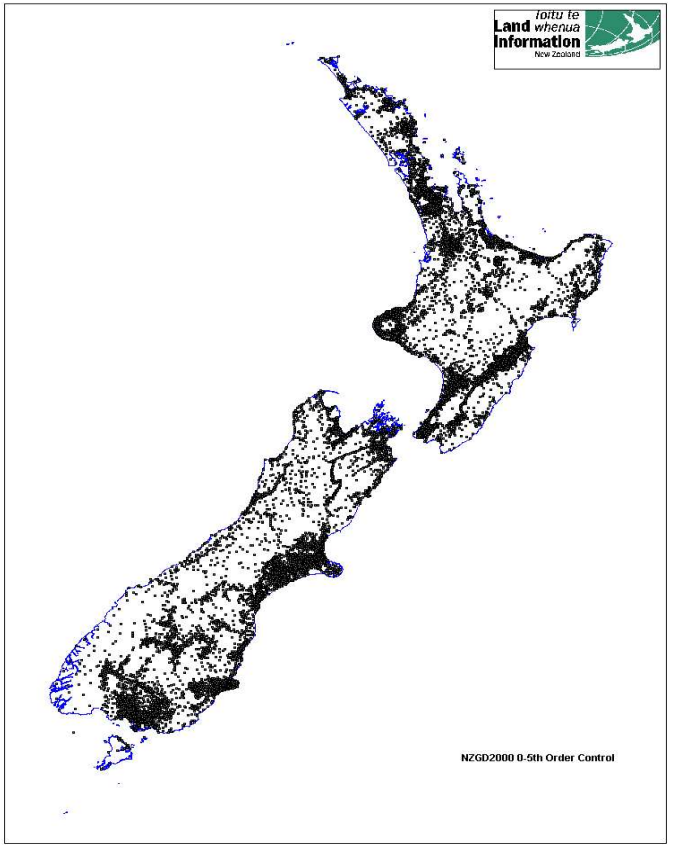
Requirements

- Enable the accurate positioning of points above, within or on the earths surface
- 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

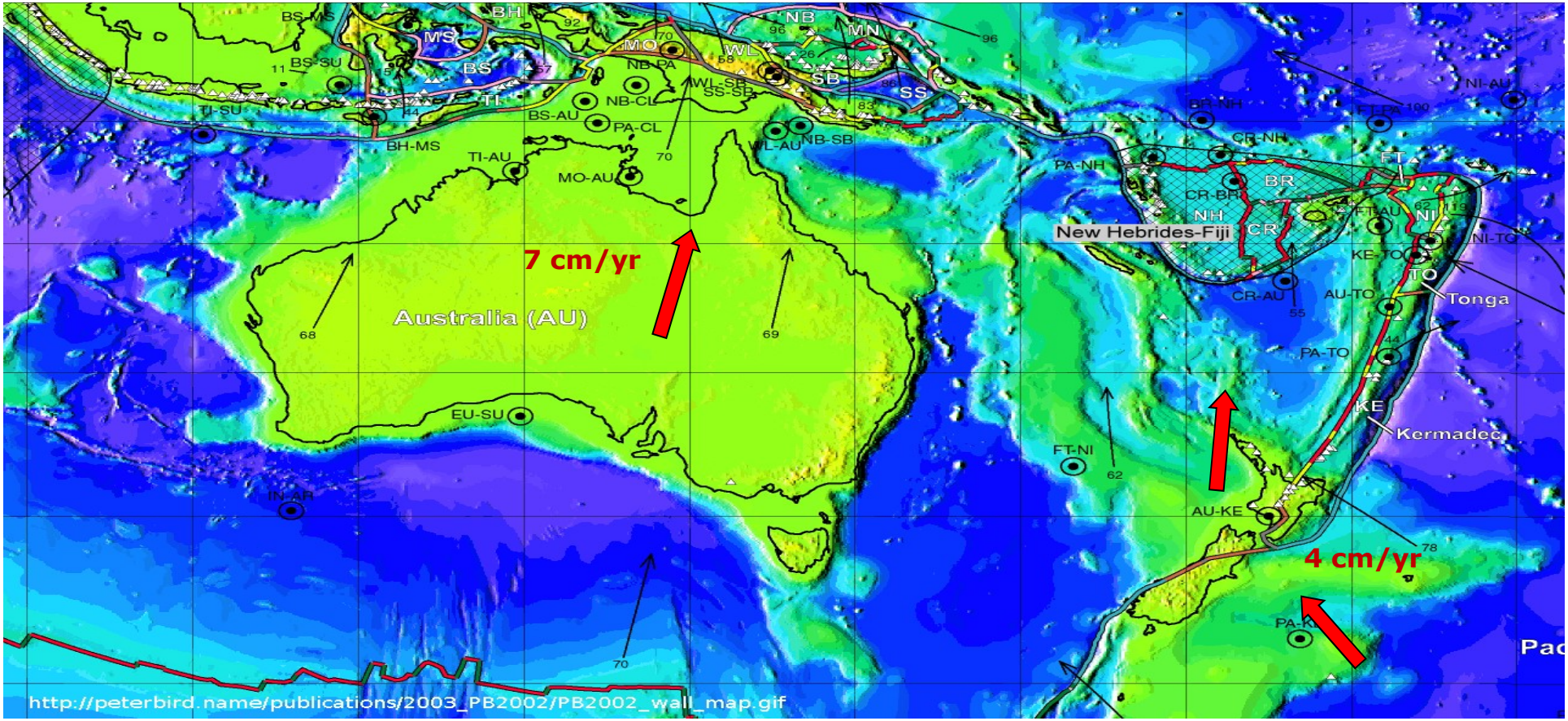


Traditional datums

- Based on a best fit to the country/area
- Based on a set of fixed points – did not account for crustal movements
- Vertical heights based on MSL
- Realised through physical ground marks



The world is not such a stable place



Significant natural events

Mt Tarawera 1886

Napier 1931

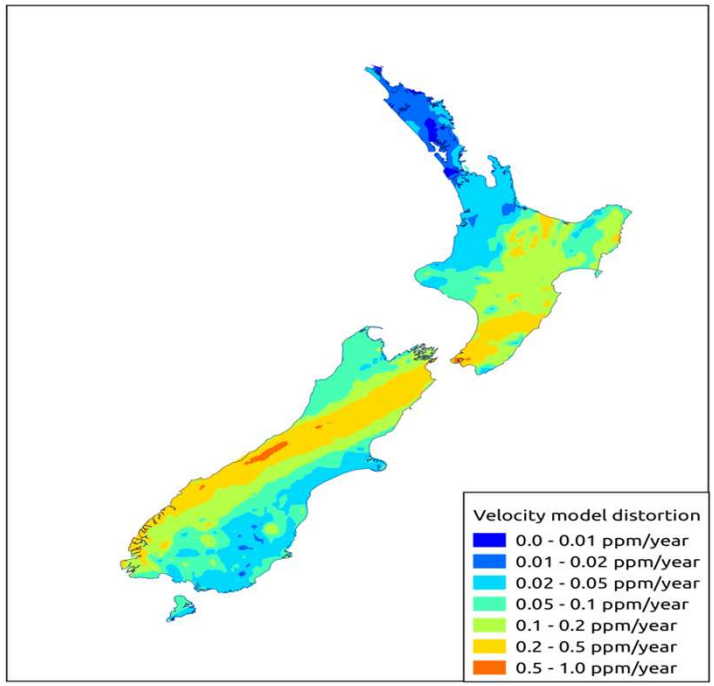
Edgecumbe 1987

Murchison 1929

Inangahua 1968

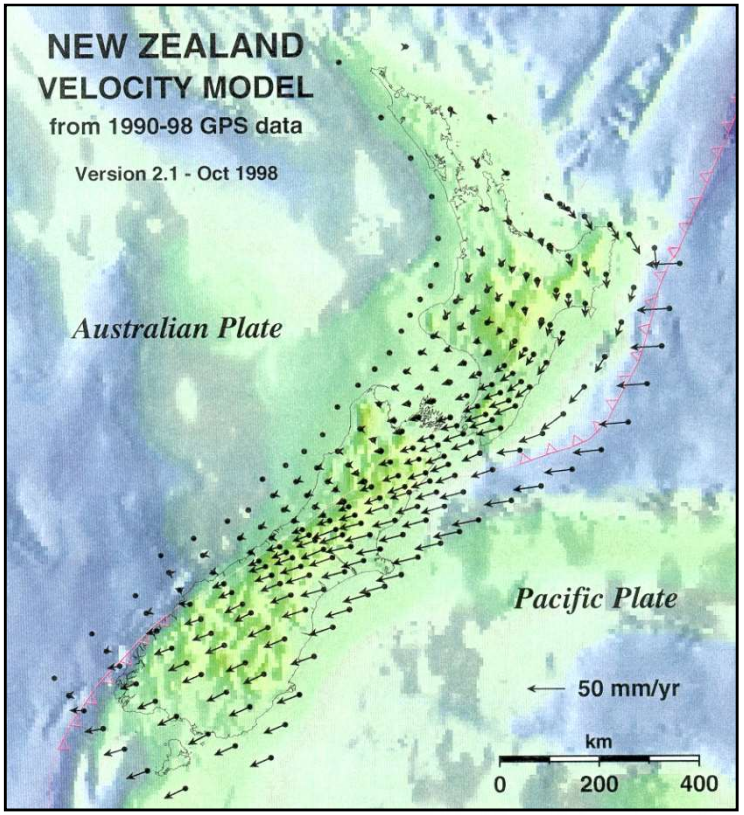
Christchurch 2011

Distortion in the NZGD2000 coordinate system



New Zealand Geodetic Datum 2000

- Nominally ITRF96
- Semi-dynamic
- Reference epoch 1 January 2000
- Horizontal deformation model
  - Updated with new observations and earthquakes effects



Implementation of NZGD2000

- 33 GNSS CORS stations
  - Datum monitoring
  - Streaming GNSS data

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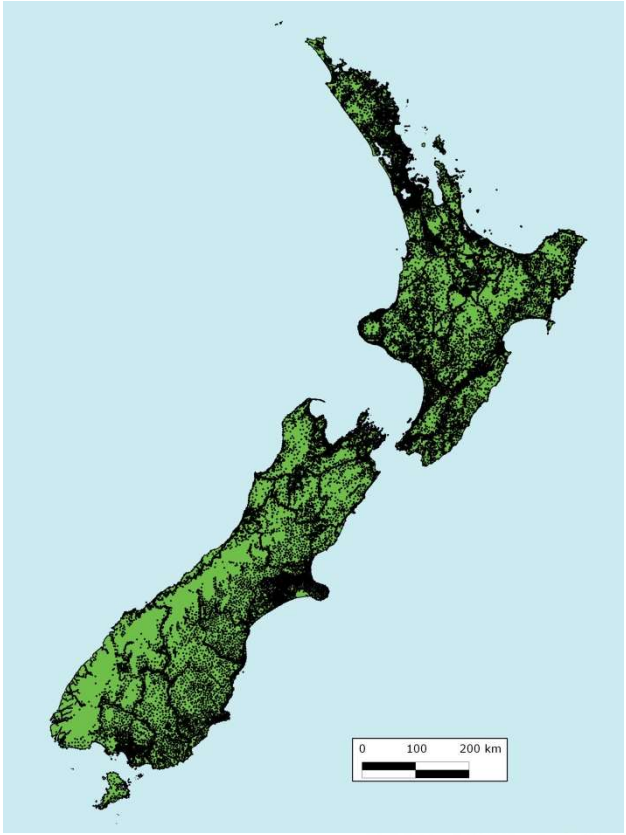
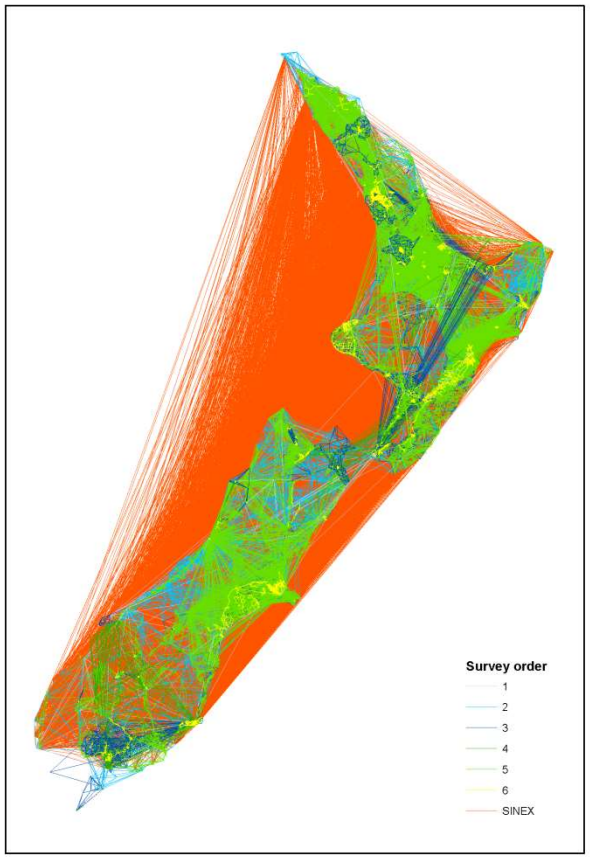
- 20,000 control marks
  - Physical realisation of datum
  - Deformation monitoring / datum recovery

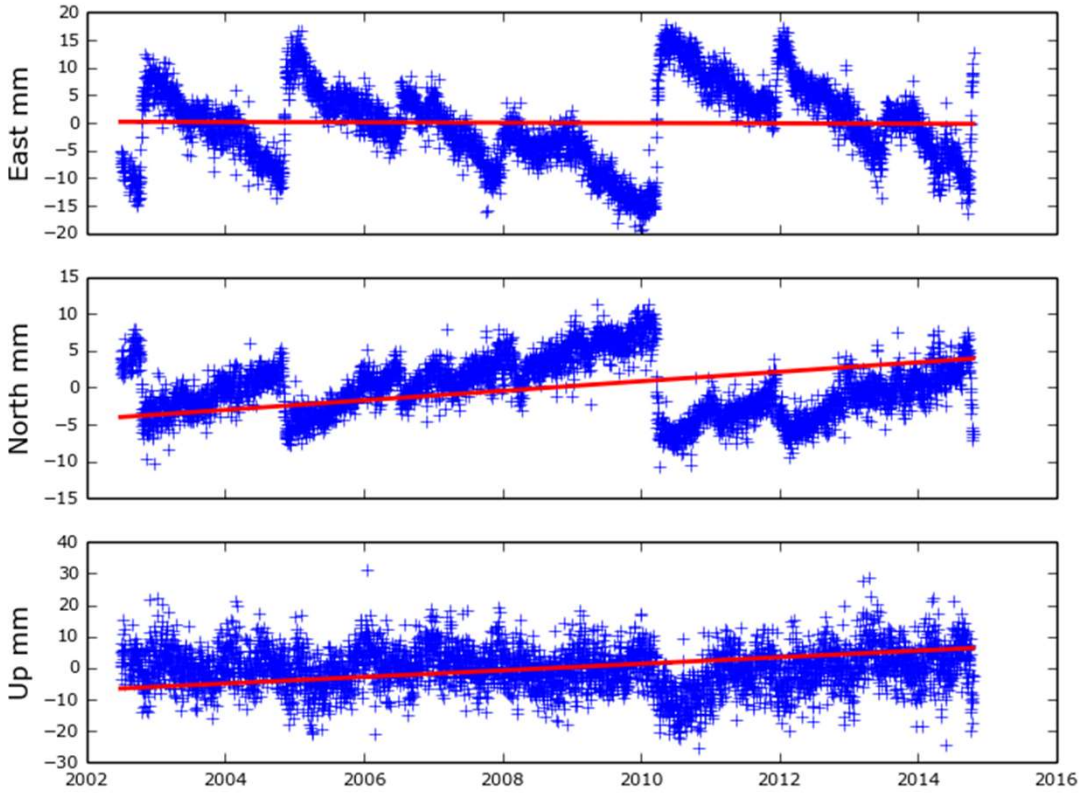


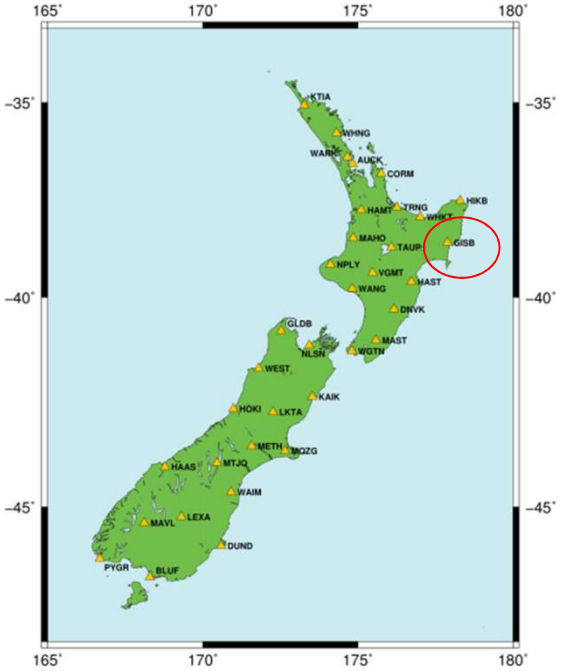
Implementation of NZGD2000

- 33 GNSS CORS stations
  - Datum monitoring
  - Streaming GNSS data
- 20,000 control marks
  - Physical realisation of datum
  - Deformation monitoring / datum recovery
- National geodetic adjustment
  - Maintains consistency with cadastre

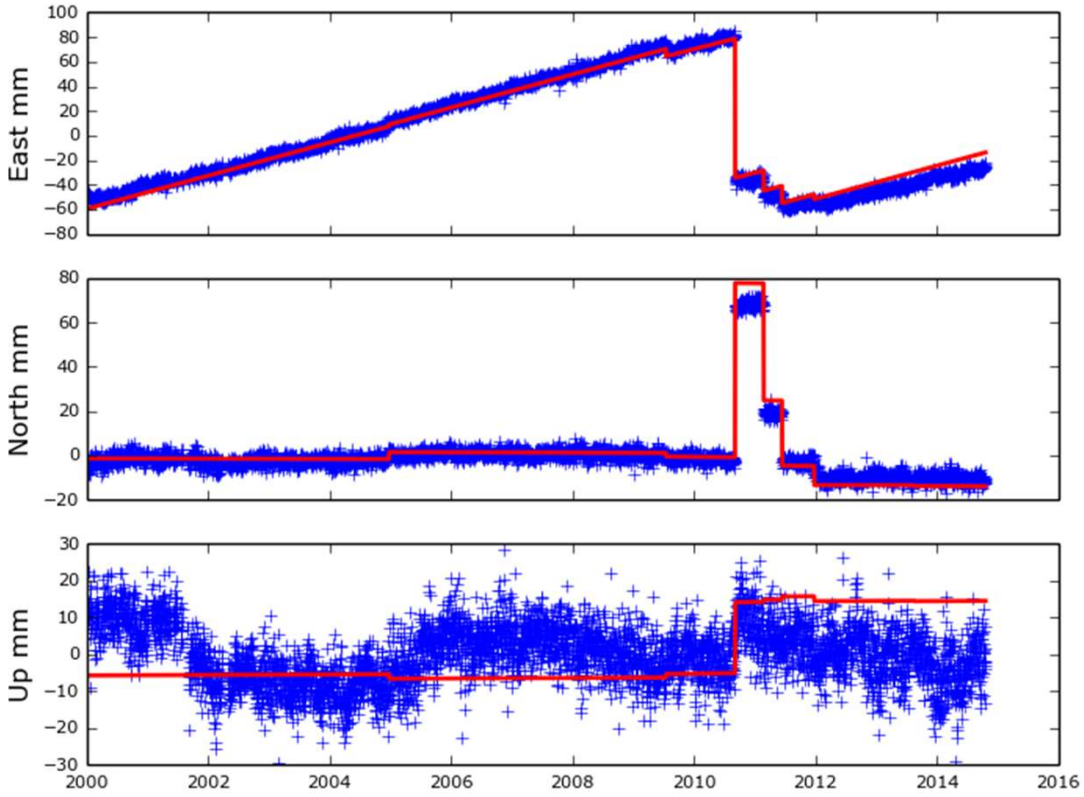


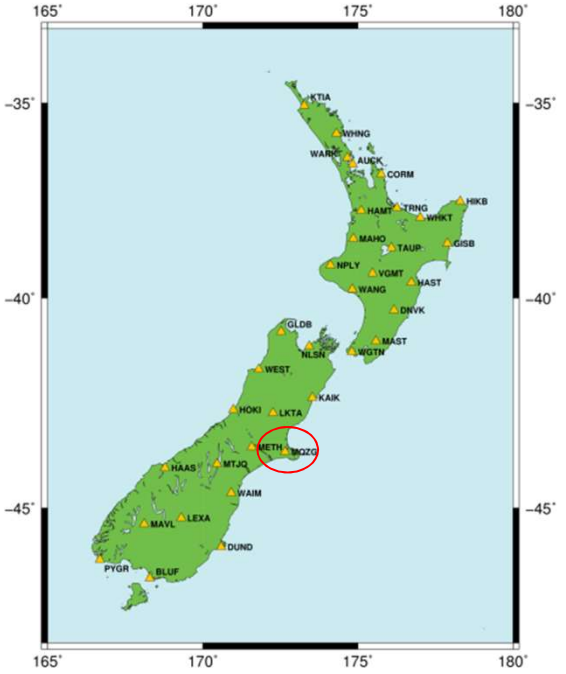
Gisborne – slow earthquakes



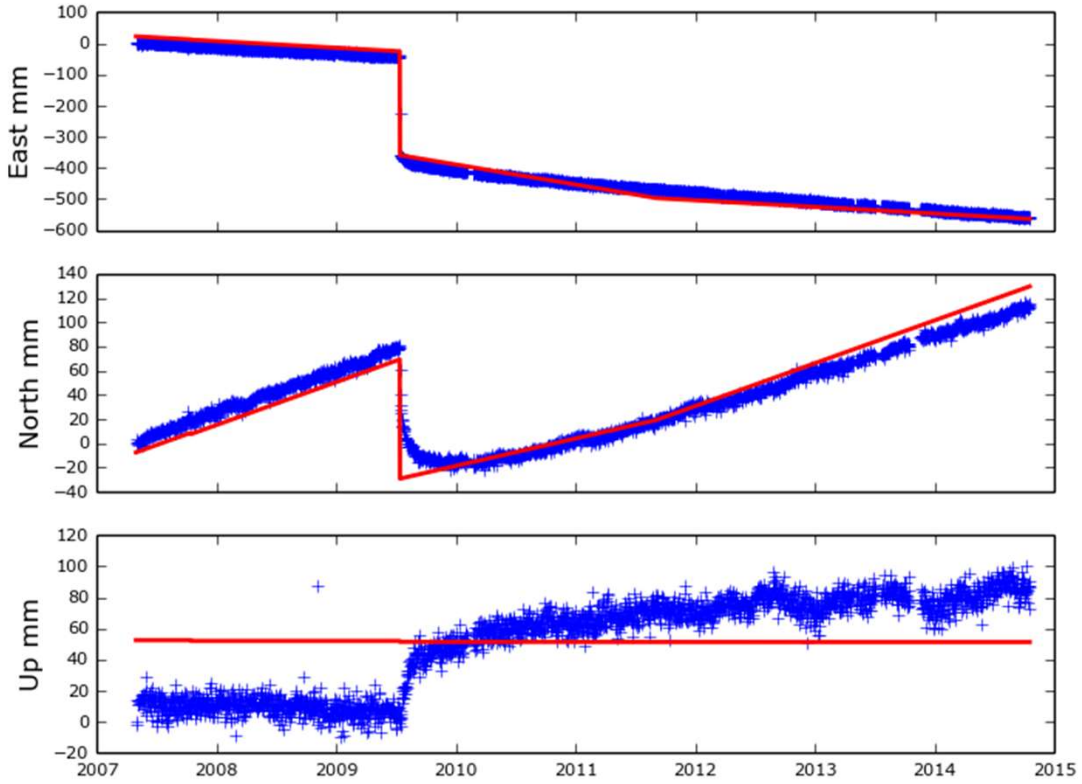


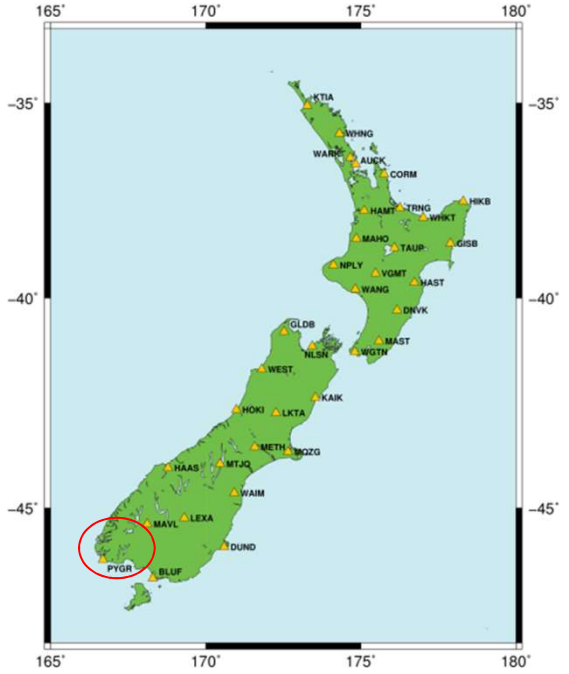
Christchurch – Canterbury earthquakes



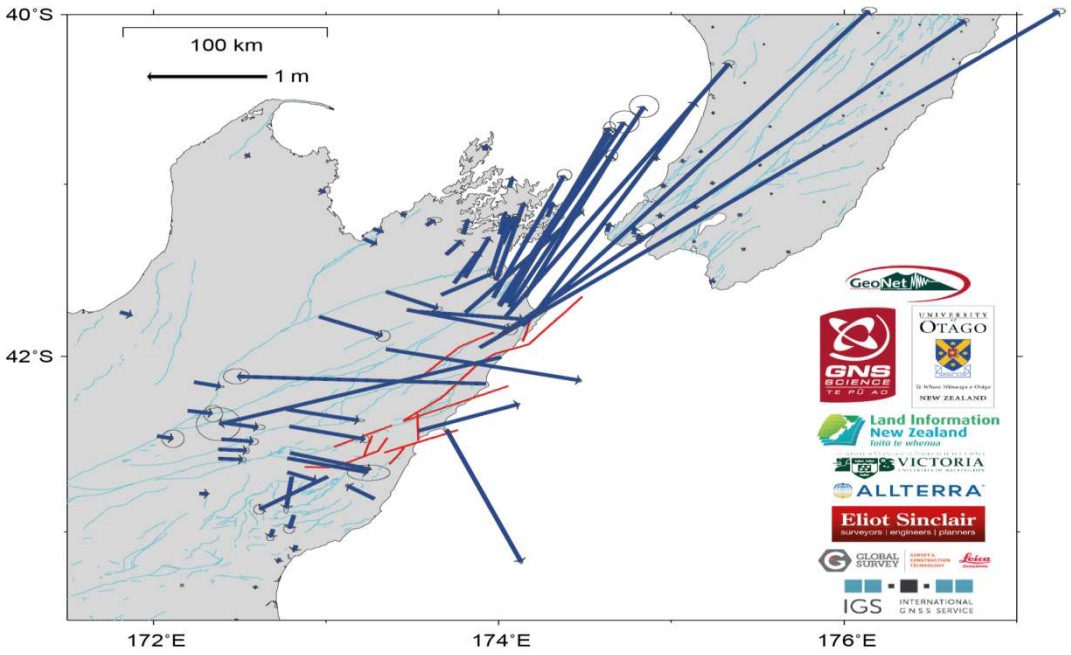


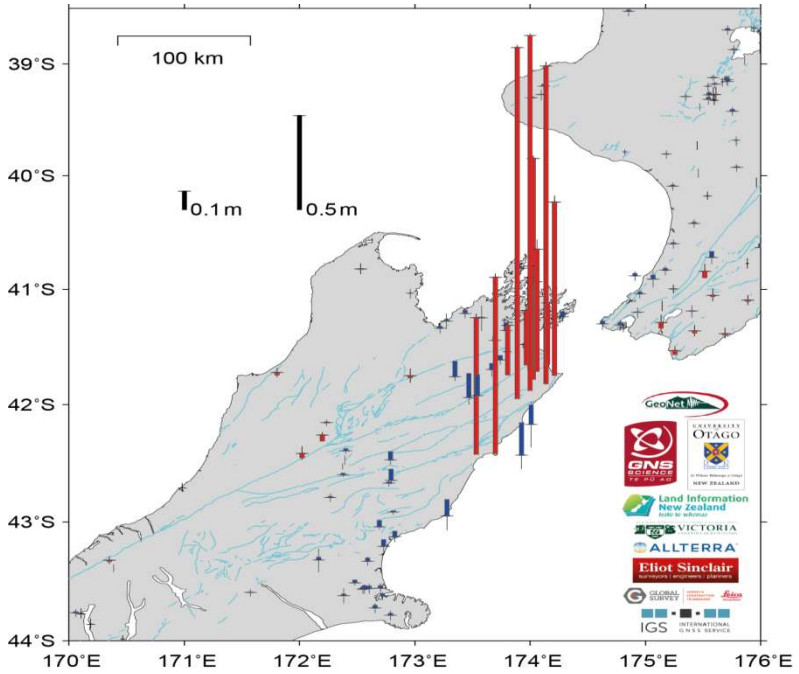
Fiordland postseismic recovery



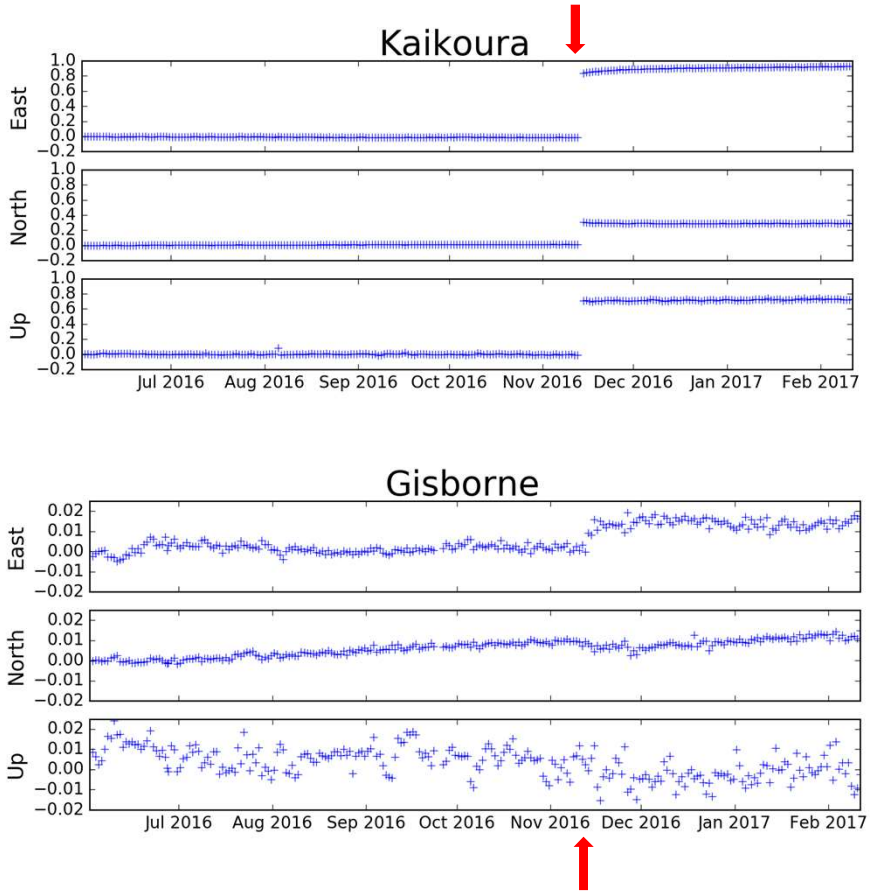


Horizontal and vertical movements

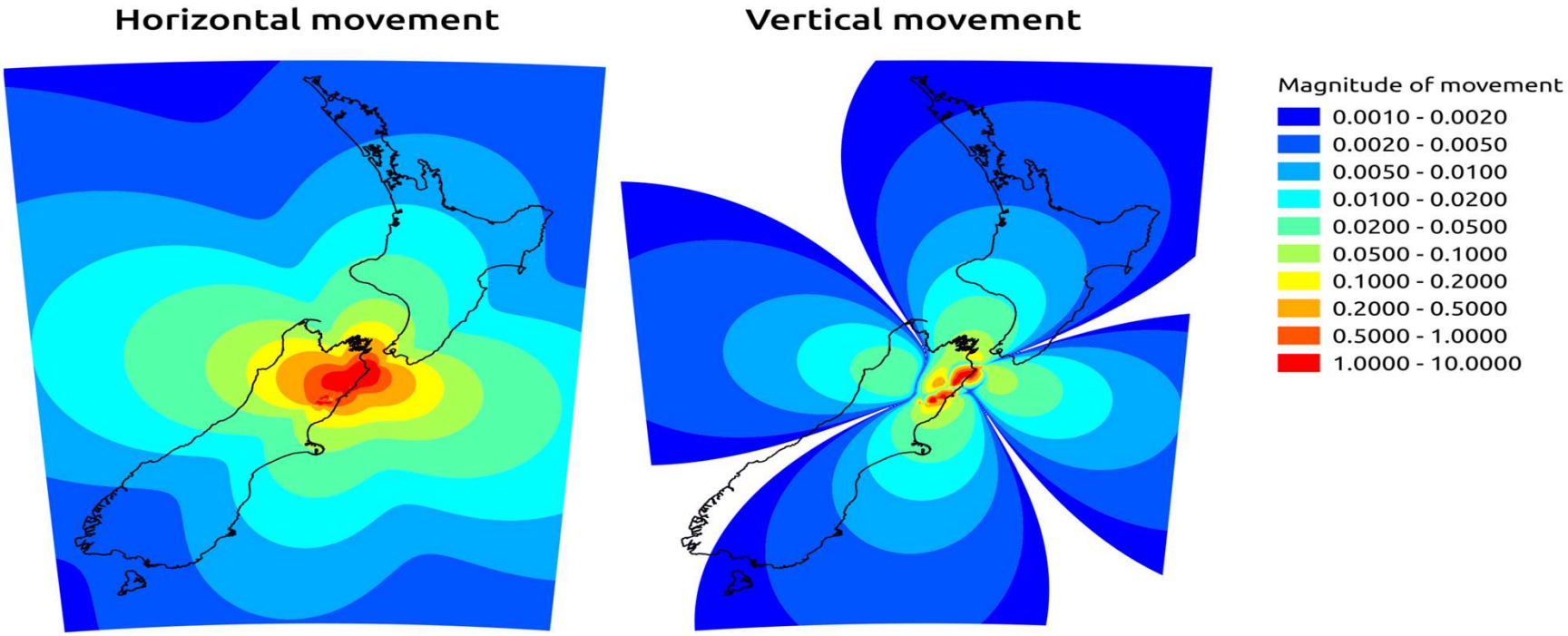




Near and far field movements



Kaikoura earthquake deformation



Forward and reverse patches

Forward patch	Reverse patch
NZGD2000 coordinates unchanged. Only deformation model updated 	NZGD2000 coordinates and deformation model updated – affects all databases of NZGD2000 coordinates 
NZGD2000 coordinates have poor **current** relative accuracy in affected area 	NZGD2000 coordinates have good **current** relative accuracy 
Patch used to convert coordinates after earthquake 	Patch only used to convert coordinates before earthquake 

- User expectation is that coordinates will change after earthquake
- If using deformation model forward and reverse patches are equivalent

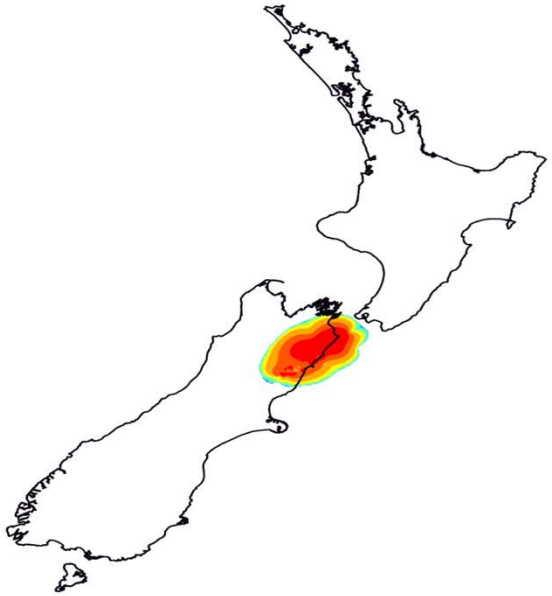
NZGD2000 versions

(is each version a new datum?)

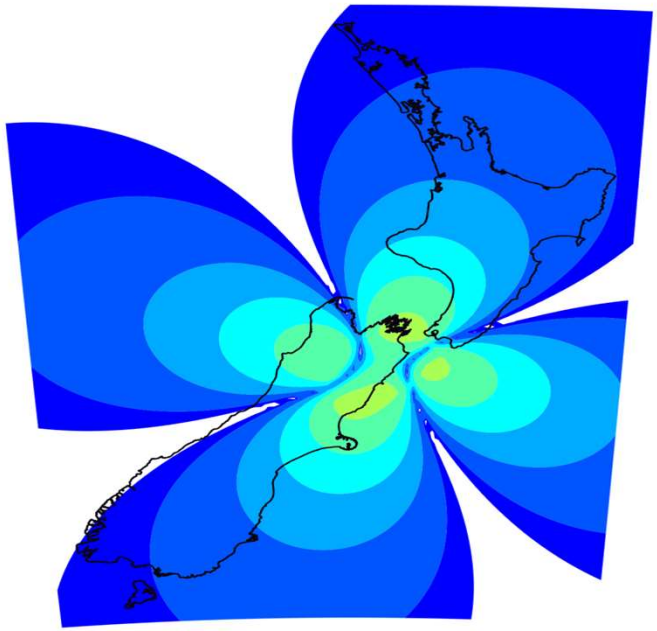
Version	Reason
20000101	National deformation model - initial version
20130801	Update of national deformation model and patches for: Reverse patches for the following events: Dusky Sound, 2009 Darfield (Christchurch), September 2010 Christchurch, February 2011 Christchurch, June 2011 Christchurch, December 2011 + 3 other earthquakes
20140201	Patches for events: Cook Strait, 17 July 2013 Lake Grassmere, 16 August 2013
20160701	Reverse patches Christchurch, 14 February 2016
20170601	*Hybrid patch for Kaikoura 14 November 2016*

Splitting the horizontal deformation

Horizontal reverse patch

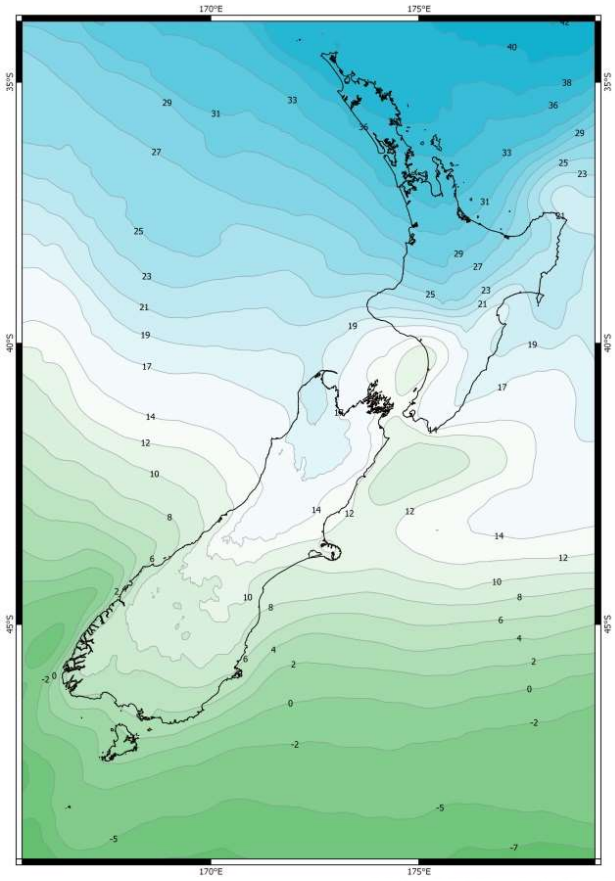


Horizontal forward patch



New Zealand Vertical Datum 2016

- NZGeoid2016 reference surface
- Consistent with NZGD2000
- Mainly GNSS based
- Heights maintained by national geodetic adjustment



What has gone well with NZGD2000?

- Widely adopted by users
- Has appearance of static datum
  - Users unaware of deformation model
  - Users do not need to update coordinates (often)
- Accuracy maintained
  - Relative accuracy between marks good
- Regular deformation model updates
- Regular national readjustment

Limitations

- NZGD2000 coordinates now 1 metre from present day
- Based on old ITRF realisation
- 3D datum but only horizontal deformation model
- Deformation model is complex
- Each deformation model update is effectively new datum
- Increased user demand for present-day coordinates
- Deformation models not supported in user software

Conflicting user requirements

- Simplicity
- Coordinates that remain static
- Hz: where things were

- Accuracy
- Coordinates that reflect reality
- Vt: where things are

General acceptance that coordinates have to change following earthquakes (just not too often)

Datum/reference frame options

- Static
- Semi-dynamic
  a) Keep NZGD2000 and continue deformation model updates
  b) New reference epoch and continue deformation model updates
  c) New datum/epoch each time a deformation model released
- Dynamic
  a) Continuous coordinate updates
  b) Regular/scheduled coordinate updates
- Combination of the above?

To modernise NZGD2000 or not?

We are not seeing a huge demand from users for a new geodetic datum (high accuracy users can manage the deformation model)

However with the improved accuracy of PPP (sub 1m) positions will differ from those of the official datum NZGD2000

The question - Should we move to a new datum or should we retain NZGD2000 for longer

- If we move we maintain alignment but it is disruptive
- If we retain NZGD2000 how do we maintain alignment between current day positions reflecting the real world with those reflecting where things were 20 years ago:
  - More education for users to use the deformation when required
  - Build the deformation model into more apps
  - Apply the deformation model on the fly as a correction
- Should we just adopt ITRF – what is unique about NZGD2000 (the deformation model and is each realisation of the deformation model a new datum?)

Datum/reference frame considerations

- Three dimensional
- ITRS alignment
  - Can decide whether to adopt new ITRF realisations
- Present-day coordinates
  - In terms of adopted ITRF
- "Fixed" coordinates
  - Which reference epoch?
  - Regularly updated deformation model
- Time tagged coordinates to enable transformation
- Dual frame attractive – which coordinate is authoritative?

Summary

- NZGD2000 has worked well but has some limitations
- NZGD2000 has evolved since 1999
- User needs are clear but conflicting
- Several options for modernisation
- Consideration is ongoing

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Thank you

Thanks for input from
Matt Amos and Chris Crook