New Zealand Vertical Datum 2009

A geoid based height system for the unification of disparate local vertical datums

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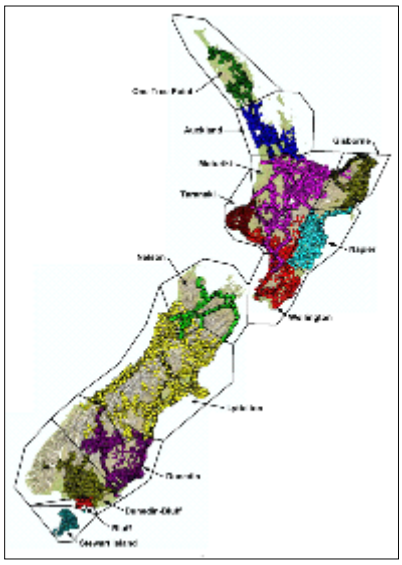
Overview

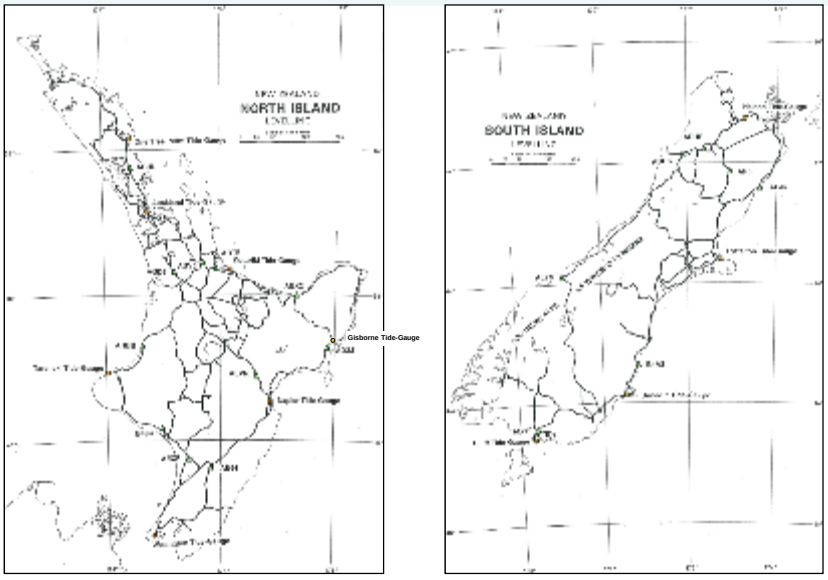
- Existing New Zealand height systems
- Limitations of current practise
- New datum options
- New Zealand Vertical Datum 2009
- Implementation of new datum

Heights in New Zealand

- 13 main regional vertical datums
- Based on local MSL at tide-gauge origins
- Extended by precise levelling along major roads
- Normal-orthometric heights (GRS67)
- Each datum independently adjusted



Local Vertical Datums



Problems with Local Datums

- Origins do not represent current MSL
  - Gauges located in harbours
  - Short-duration observations (1 – 37 years)
  - Not updated since definition (1923 – 1970)
- Datums are independent
  - Few levelling connections
  - Unknown offsets
  - No national adjustment
- Benchmarks only on roads
  - NZ has sparse road network
- Not compatible with GNSS

Desirable Vertical Datum Attributes

- Single reference system across NZ and its offshore islands
- Consistent with NZ Geodetic Datum 2000
- Compatible with GNSS heighting
- Consistent with gravity field and sea level (intuitive to use)
- Easily adopted by users

Vertical Datum by Precise Levelling

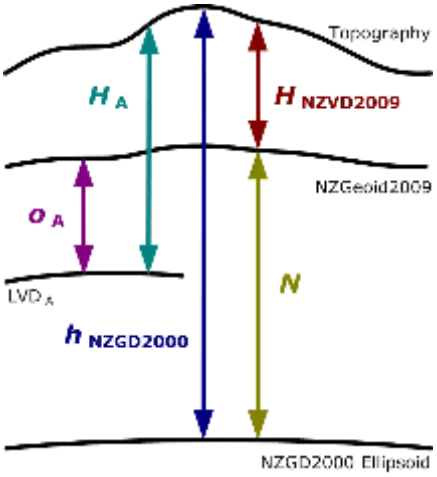
- Existing levelling combined in single adjustment
  - Fix one or many tide-gauges
  - Previous or updated MSL estimates
  - Little redundancy in adjustment
- Not practical approach for NZ today:
  - Age of levelling observations
  - Networks poorly connected and configured
  - Coverage limited to levelling routes
  - Not compatible with GNSS or NZGD2000
  - Not economic to re-level benchmarks

Vertical Datum by Gravimetric Geoid

- Geoid is datum reference surface
  - Rather than tide-gauge MSL
  - Geoid broadly coincident with level of sea at global scale
  - May be offset from local mean sea level
  - Heights generally reflect Earth's gravity field
- Heights determined by:
  - Direct levelling from bench marks
  - GNSS heighting with transformation
- Datum connection anywhere within geoid coverage
  - Consistent heights across NZ and offshore islands

New Zealand Vertical Datum 2009

- Normal-orthometric height system (GRS80)
- Zero-tide Earth-tide model
- NZGeoid2009 reference surface
- Offsets to local datums
- Transformations between local and geodetic datums

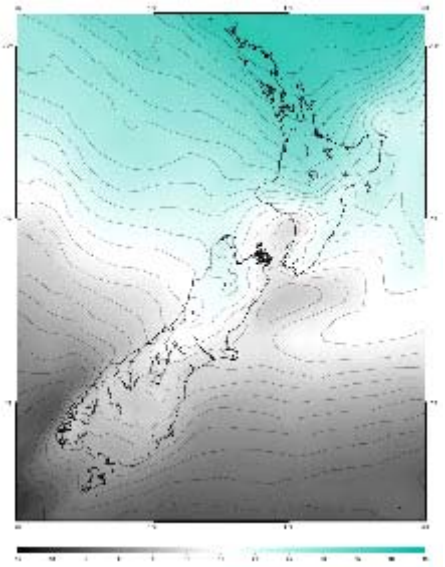


New Zealand Vertical Datum 2009

- NZ one of the first countries to adopt a national geoid based datum
- First proposed in 2001, 8 years to publish
- Provides a consistent national vertical datum anywhere within the NZ continental shelf
- Easier to maintain in areas where precise levelling is not possible or practical

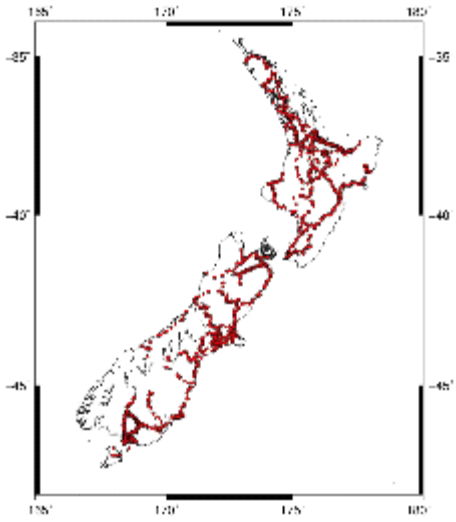
NZVD2009: Reference Surface

- NZ Quasigeoid 2009 (NZGeoid2009)
  - Actually quasigeoid
  - Geoid terminology used to avoid user confusion
  - Based on EGM2008
  - Not fitted to levelling or tide-gauges
- Characteristics:
  - 25°S–60°S, 160°E–170°W
  - 1’ x 1’ grid
  - 0m in south, 45m in north



NZVD2009: Offsets

- GPS-levelling observations used to:
  - Determine datum offsets
  - Estimate quality of the geoid
- 1422 GPS-levelling points spread among the datums
- National fit to GPS-levelling: 0.062m



NZVD2009: Offsets

Local Vertical Datum	Offset (m)	Std (m)
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
Taranaki 1970	-0.32	0.05
Napier 1962	-0.20	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

NZVD2009: Transformations

- Enables simple transformation of heights between:
  - NZVD2009
  - NZGD2000
  - 13 Local datums

$$H_{\text{NZVD2009}} = h - N \qquad H_B = H_A - o_A + o_B$$

$$H_{\text{NZVD2009}} = H_A - o_A \qquad h = H_A + N - o_A$$

(N is bi-linearly interpolated at NZGD2000 position)

NZVD2009: Implementation

- Publish NZVD2009 heights for marks with existing heights
- Provide online tools for users to convert heights
- Seminar series to inform users about new datum
- Education to encourage users to migrate data
- Existing datums not updated but not removed either

Summary

- NZ is first country to implement a national geoid based vertical datum
- NZVD2009 provides NZ with a nationally consistent height reference system
- NZVD2009 can be easily accessed by users throughout NZ using GNSS
- Geoid-based vertical datums are easier to maintain in areas with few roads or sparse population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Thank you