

Vertical deformation in New Zealand Implications for sea level rise

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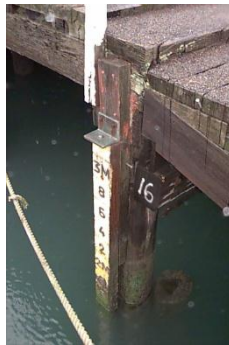
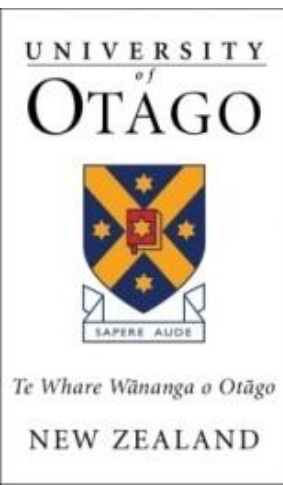
NZ Positioning Strategy Workshop

Wellington

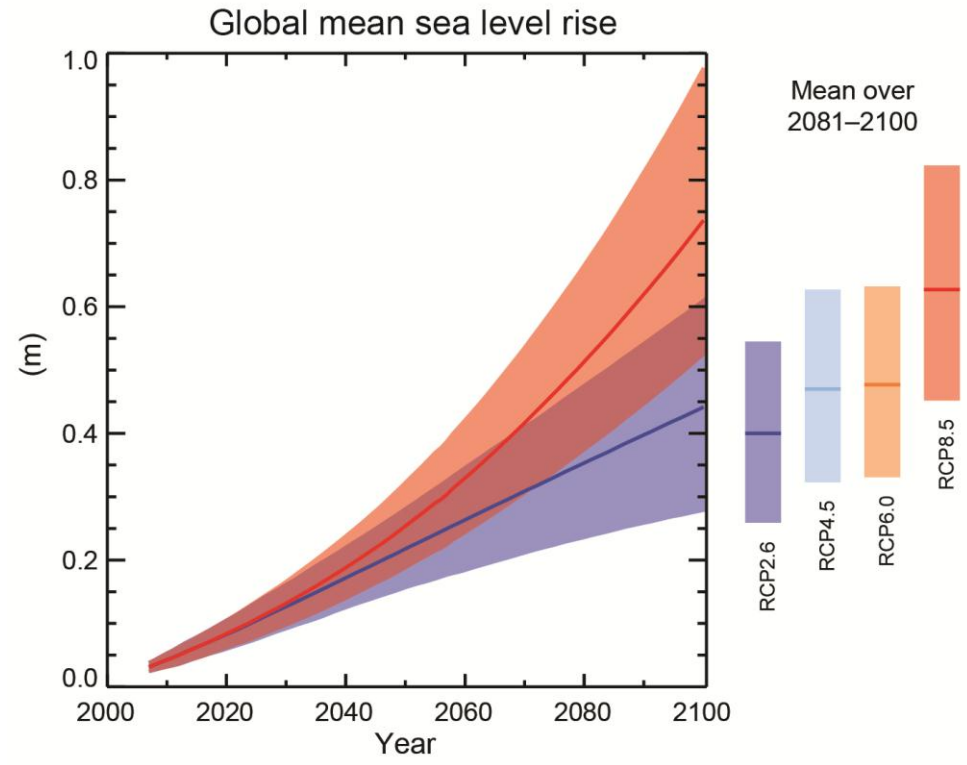
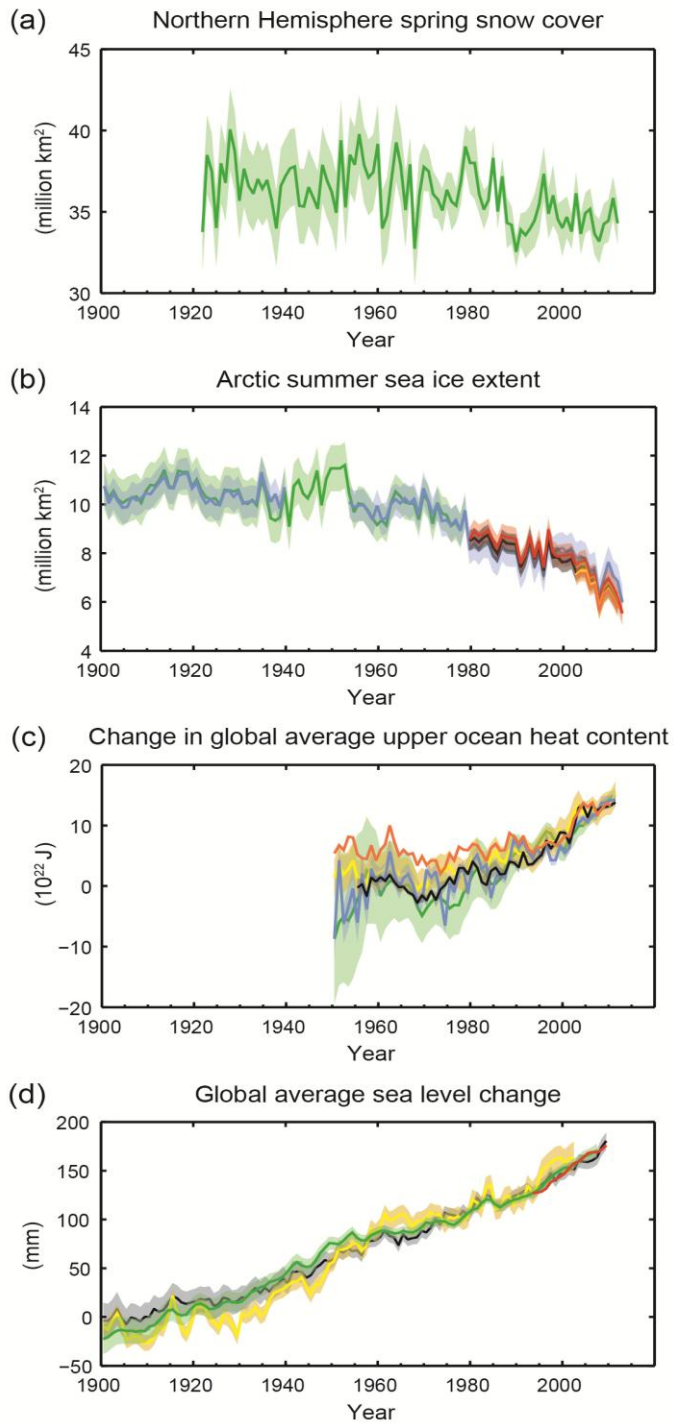
1ST DECEMBER 2014

Outline

- **Global sea level**
 - Tide Gauge
 - Altimetry
- **Sea level rise in NZ**
- **Vertical land motion**
 - GPS
 - Levelling



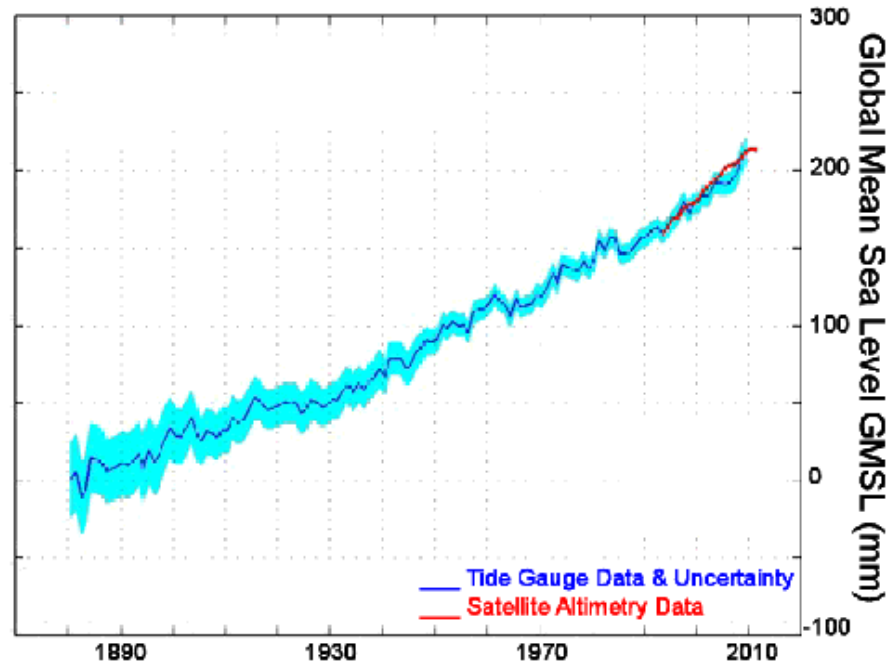
The IPCC Assessment



Source: IPCC 2013, Figure WGI_AR5_FigSPM-9

Source: IPCC 2013, Figure WGI_AR5_FigSPM-3a

Rising Global Sea Levels



Source: Church & White (2011)

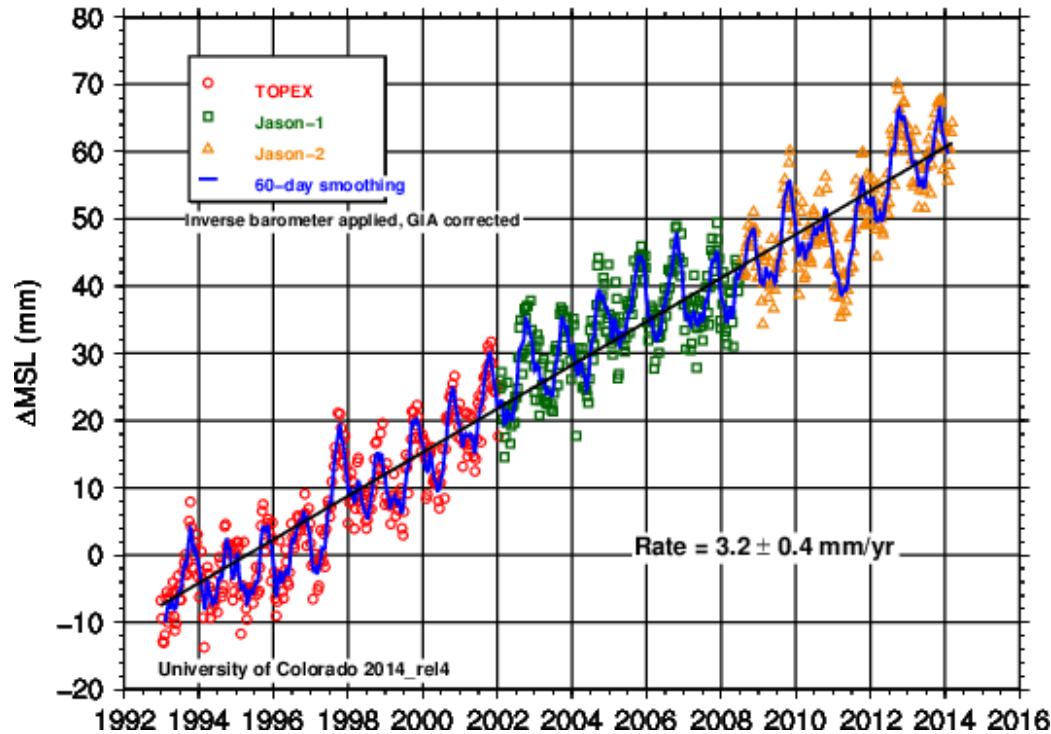
Global Network of Tide Gauges



- Globally distributed tide gauge data
 - Average since 1880 : $+1.7 \pm 0.3 \text{ mm/yr}$
- GSL has risen $\sim 20 \text{ cm}$ during the 20th century

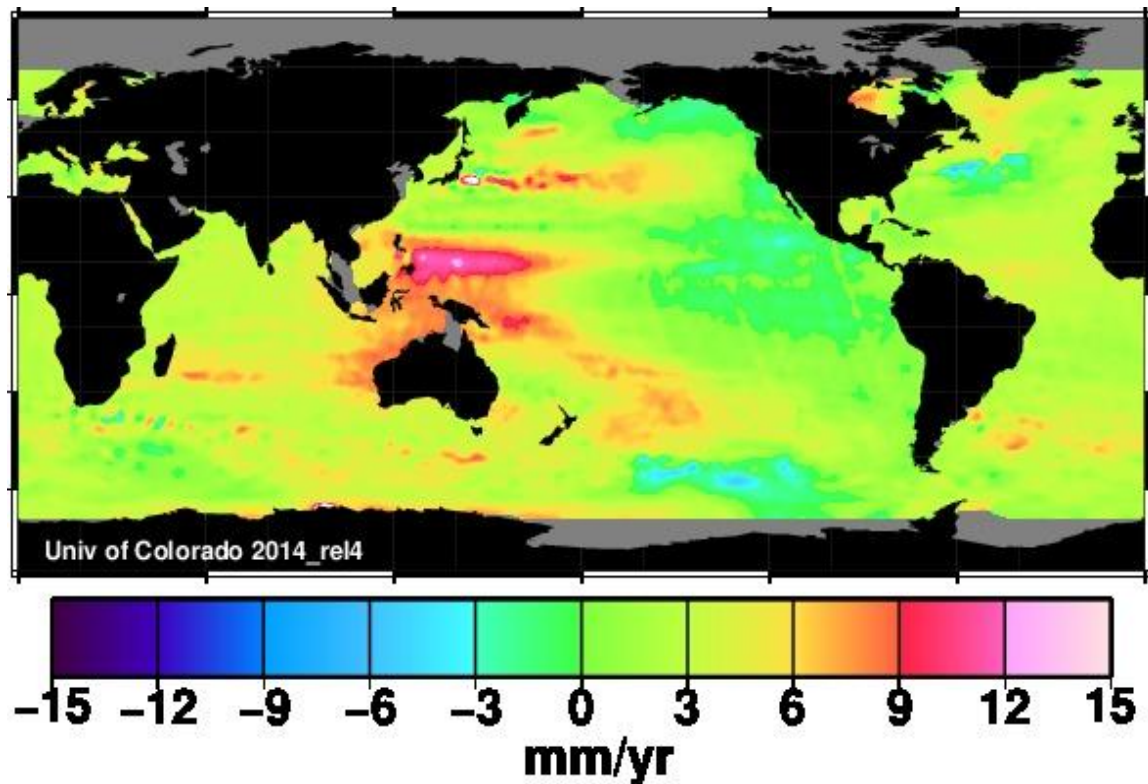
Source: www.gloss-sealevel.org

Global Mean Sea Level - Altimetry



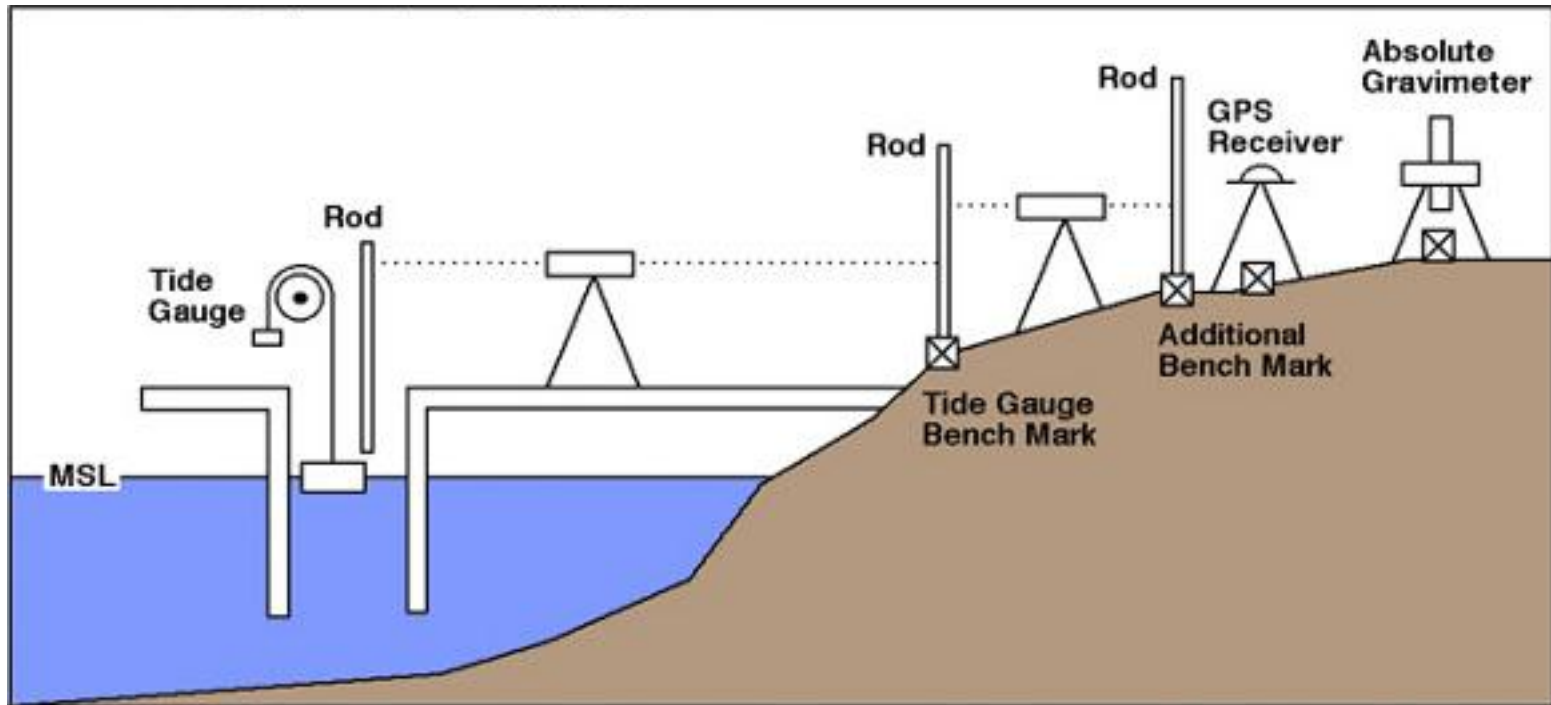
- Altimetry over the oceans – limited to $\pm 66^\circ$ latitude
 - Average for the last 20 years : **$+3.2 \pm 0.4$ mm/yr**
- An indicator of the change in the volume of water
 - land ice melt, thermal expansion
- Cannot predict RSL at coastal locations

Sea Level trends



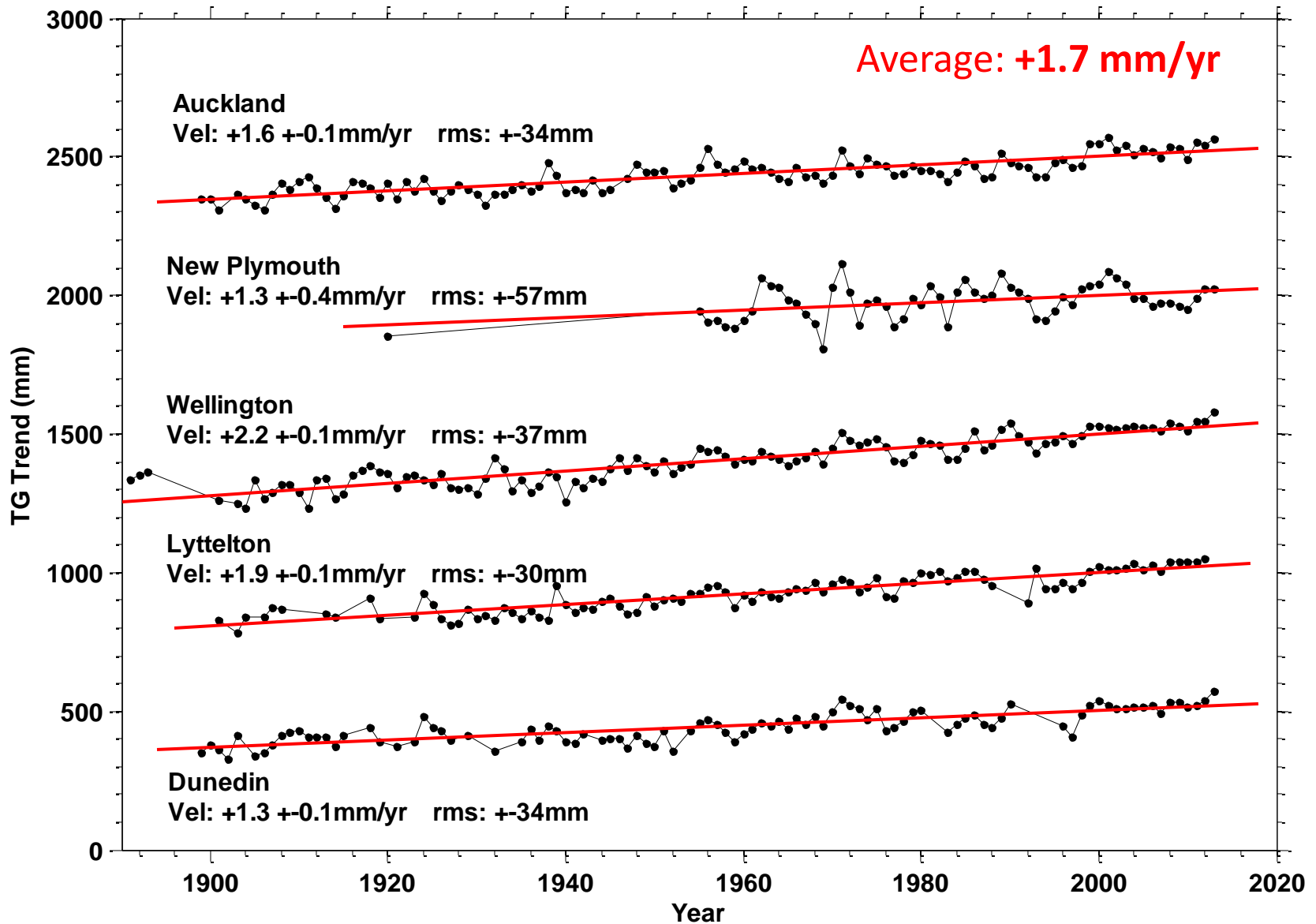
- Trends determined for the period 1993 – present
- Sea level rise is **not-uniform**
- Reflects the regional distribution of sea level rise due to decadal scale climate variability

The Tide Gauge Measurement System

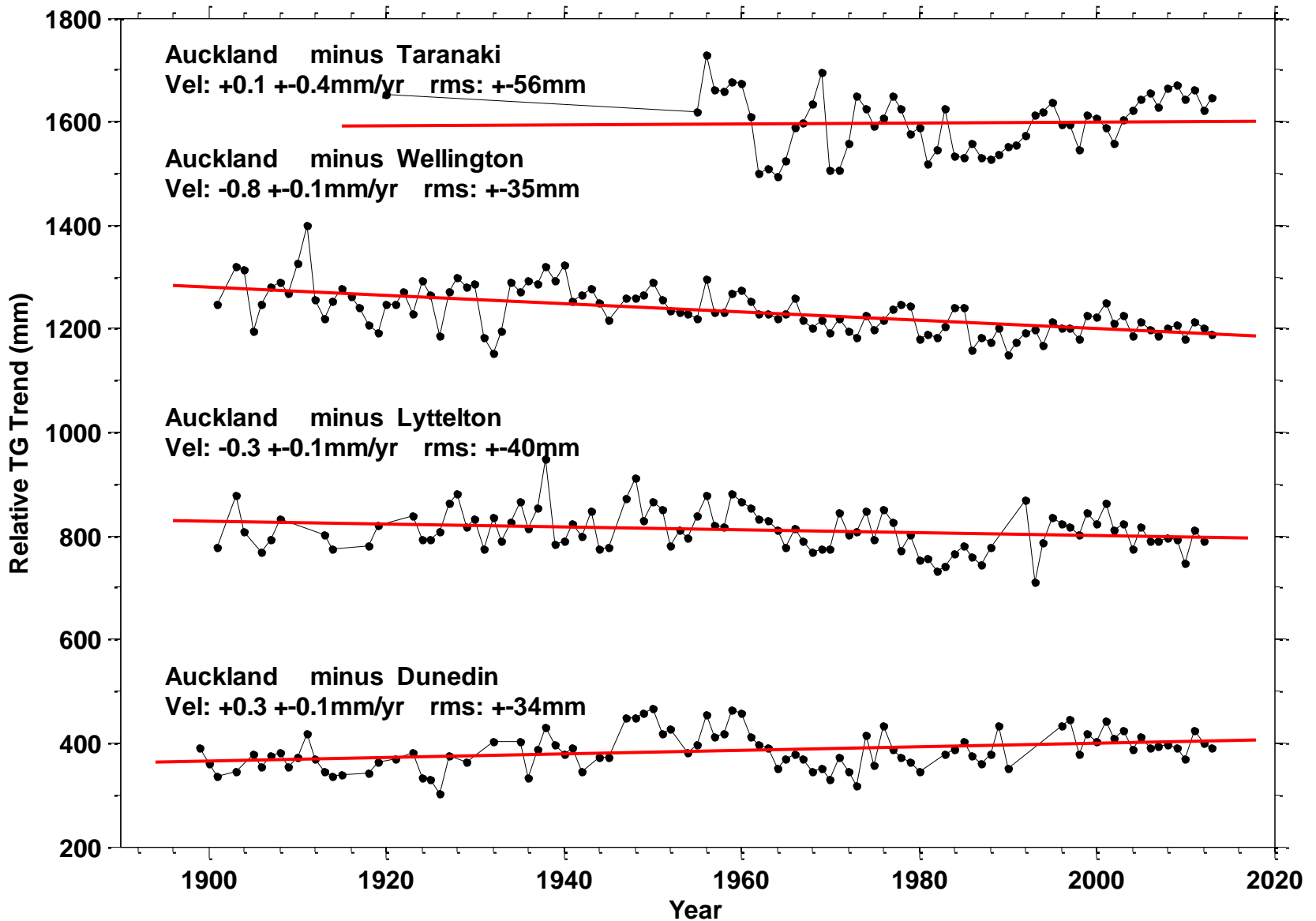


- The global network of tide gauges is a poorly distributed sea level measurement system
- **But**, it offers the only source of historical, precise, long-term sea level data

Relative Sea Level trends – New Zealand



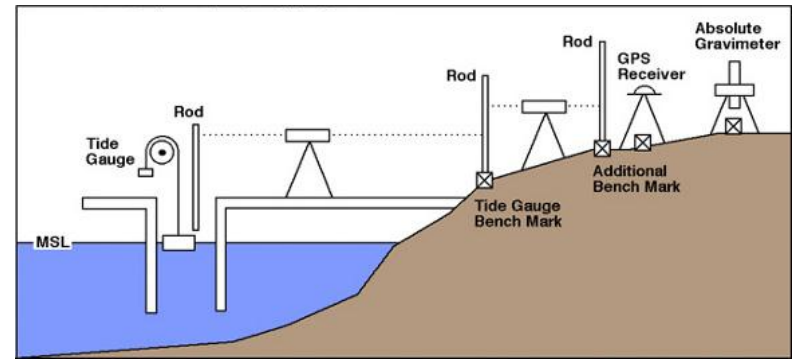
Differential RSL – New Zealand



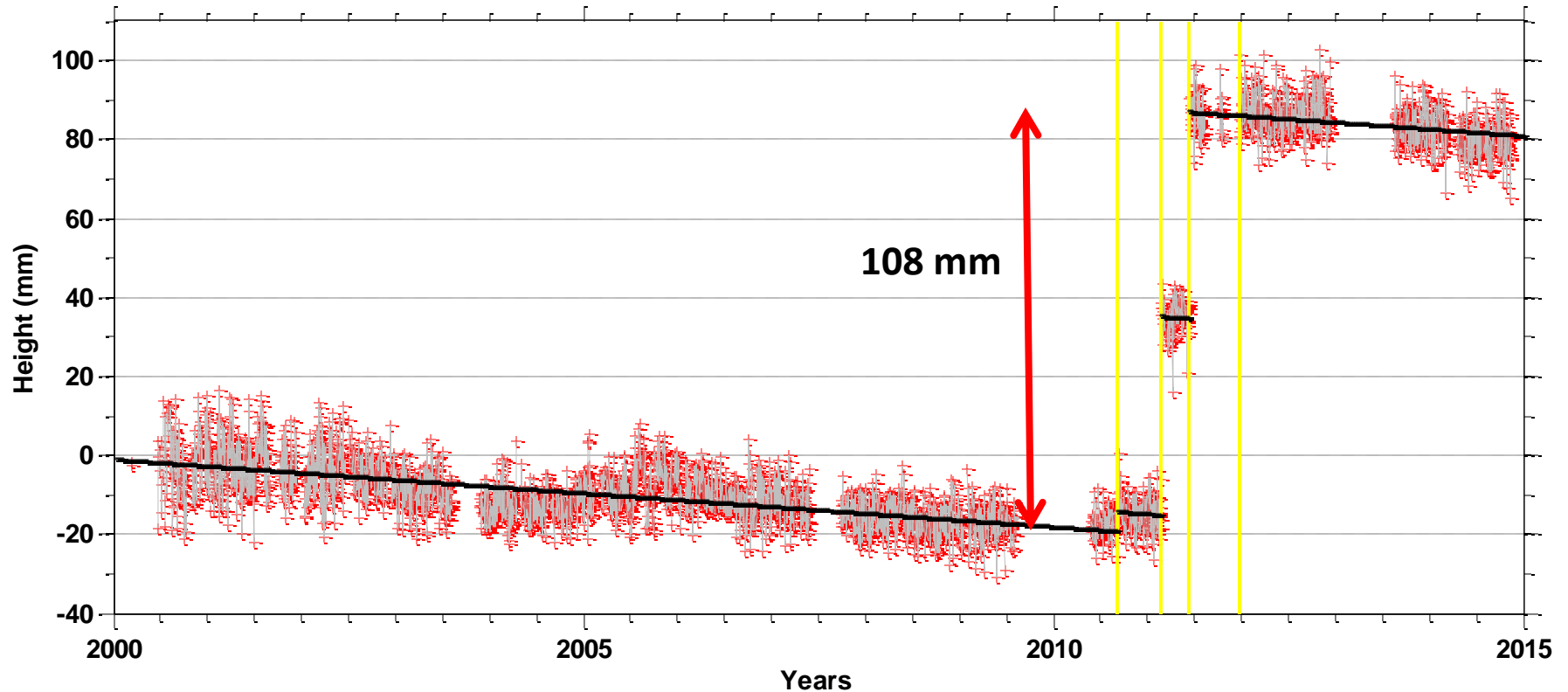
Absolute Sea Level Rise



- However
 - Tide gauges only measure **relative sea level**
 - i.e. height of sea level relative to a land based datum point
- Uplift or subsidence
 - Local or regional land motion must be taken into account
- Requires additional measurements
 - Local levelling
 - Continuous GPS/GNSS

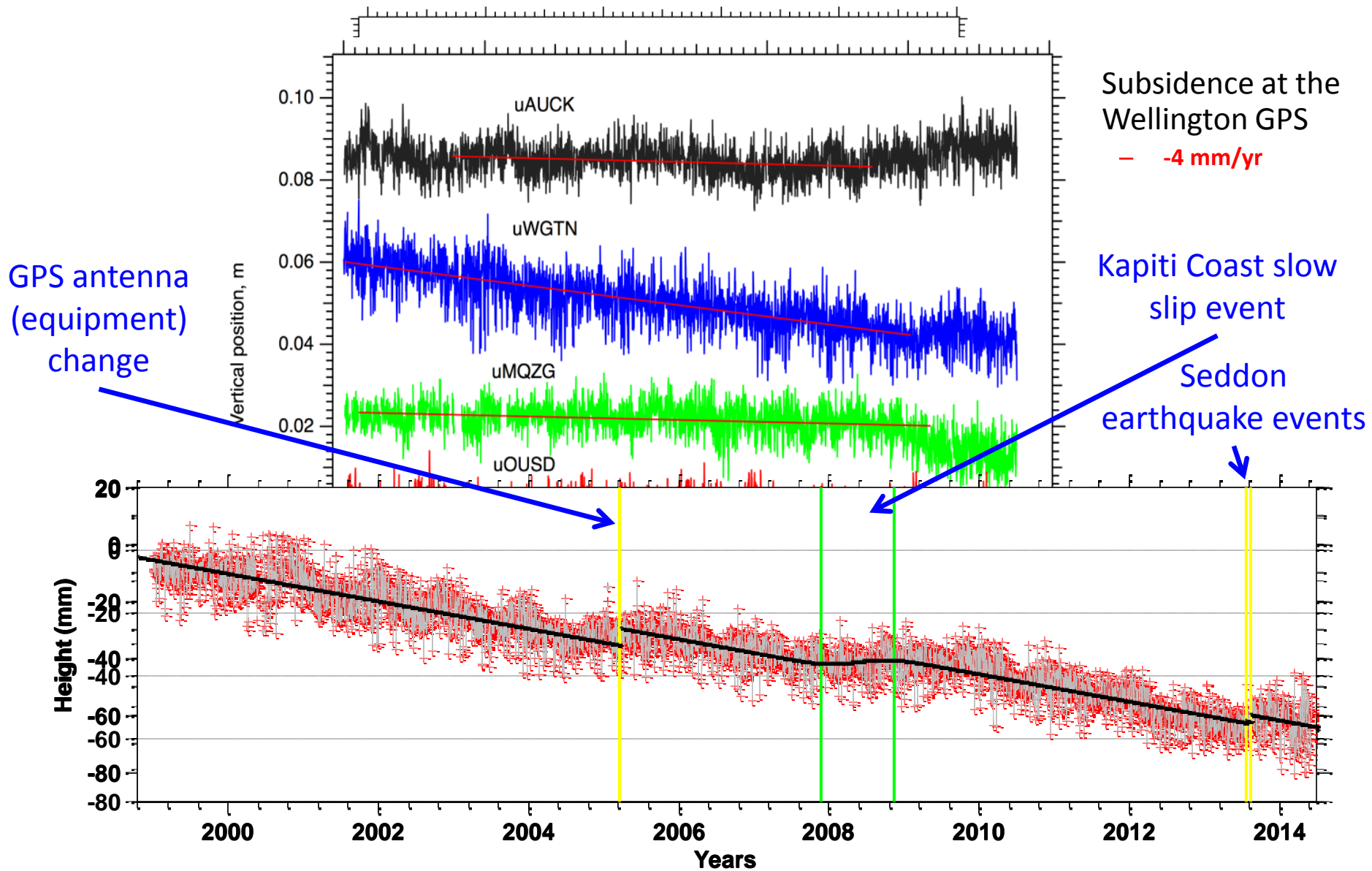


Lyttelton Tide Gauge – Christchurch Earthquake Events

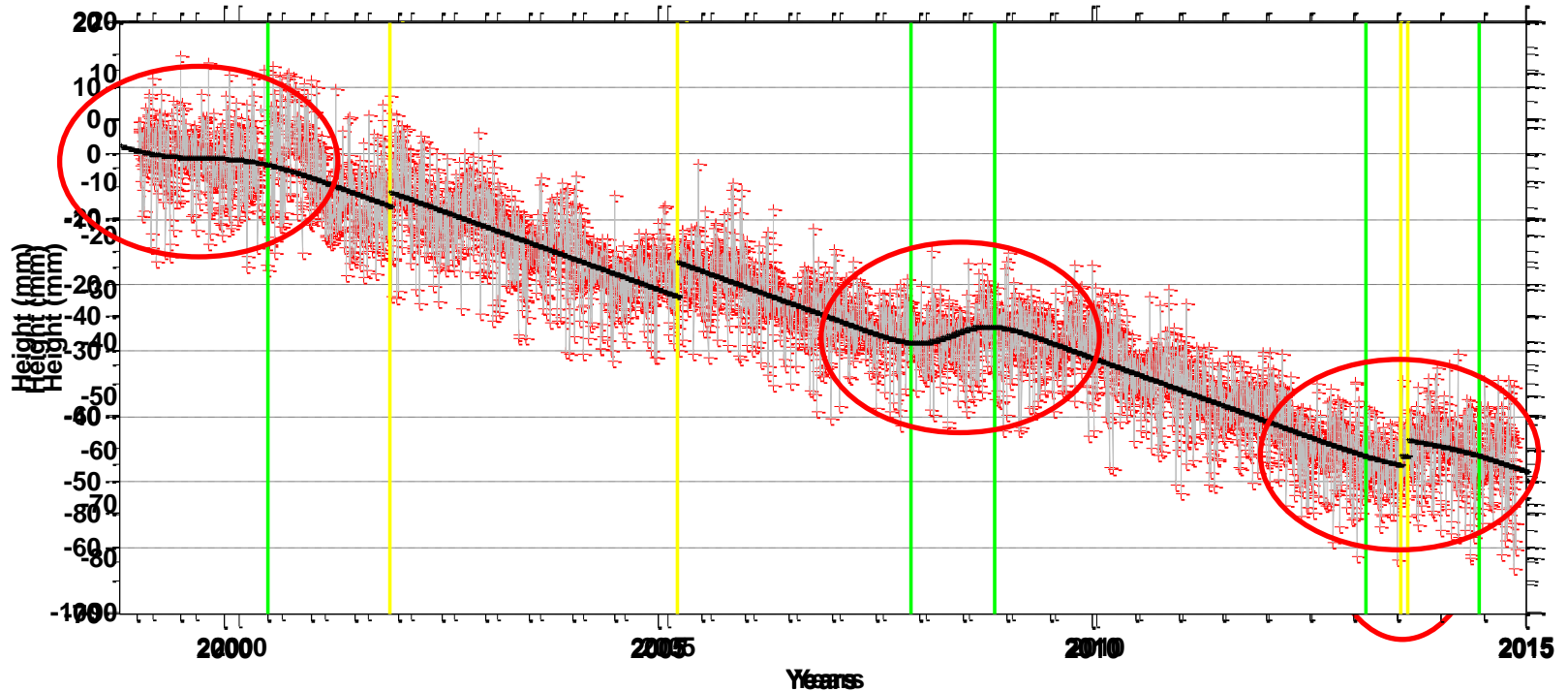


- Subsidence: - 25 mm (over ~16 years)
- ChCh Earthquake Events: +108 mm (2010-2011)
- Net uplift + 88 mm

Continuous GPS – Regional Land Motion

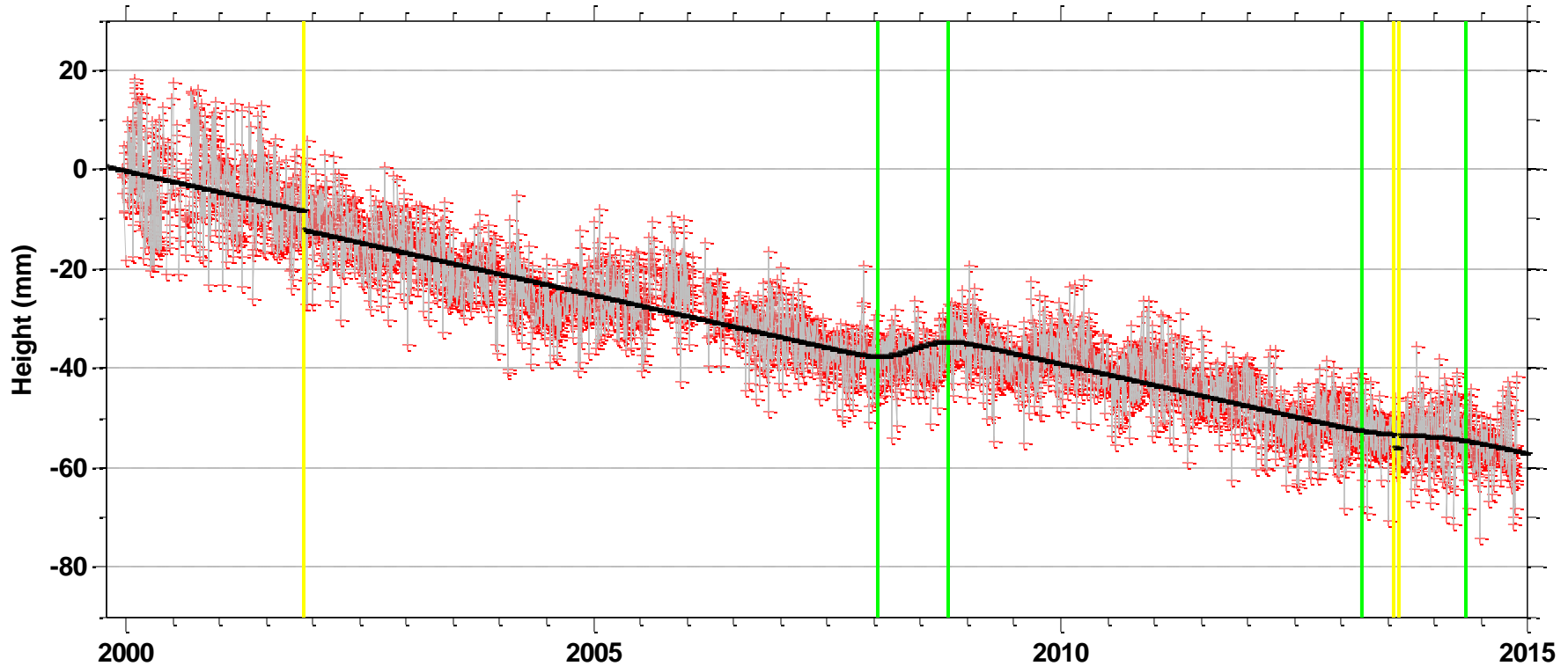


Wellington cGPS subsidence



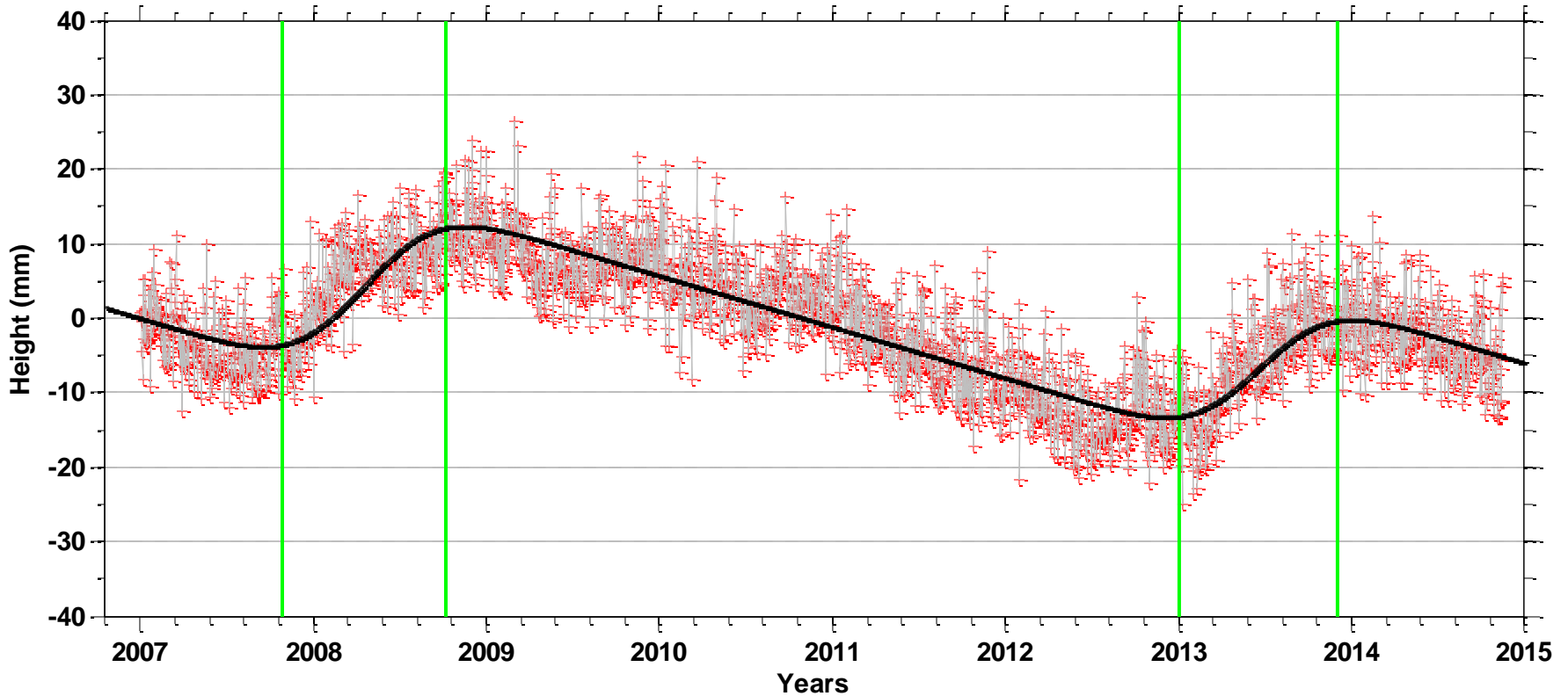
- Subsidence: - 76 mm (over ~16 years)
- Seddon Earthquake Events: + 4 mm (2013)
- Slow Slip Events: +17 mm (2000, 2008, 2013)
- Net subsidence: -55 mm

Wellington Tide Gauge cGPS subsidence



- Subsidence: - 62 mm (over ~15 years)
- Seddon Earthquake Events: 0 mm (2013)
- Slow Slip Events: +10 mm (2008, 2013)
- Net subsidence: -52 mm

Kapiti cGPS subsidence

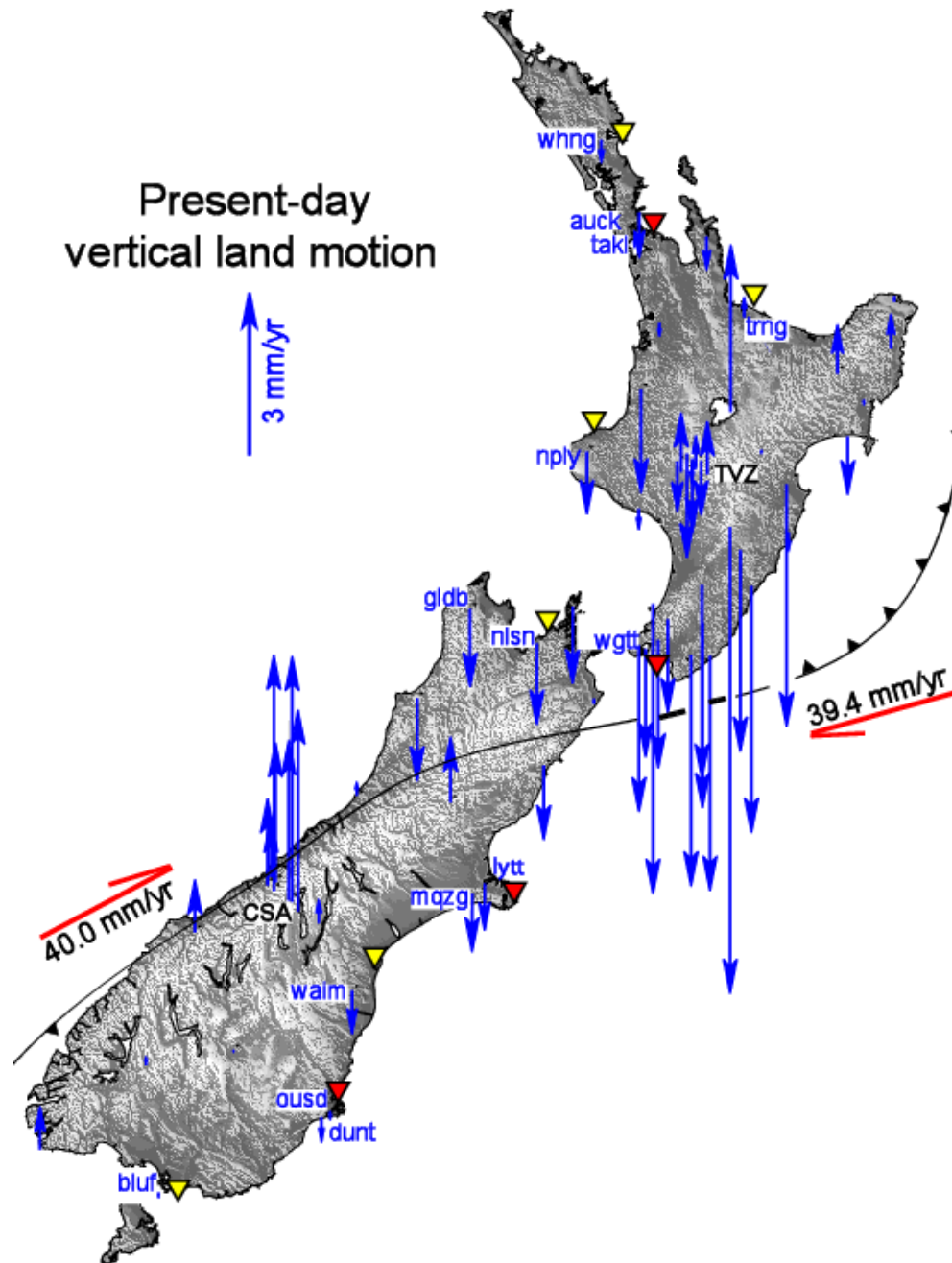


- Subsidence: - 54 mm (over ~8 years)
- Seddon Earthquake Events: 0 mm
- Slow Slip Events: +49 mm (2008, 2013)

- Net subsidence: - 5 mm

Vertical Land Motion

- Lower North Island
 - subsidence prevalent
 - highest rate : -8.5 ± 0.3 mm/yr
- Taupo Volcanic Zone (TVZ)
 - uplift and subsidence
 - attributed to active volcanisms and geothermal processes
- Southern Alps
 - uplift : 4.5 ± 0.3 mm/yr
 - agrees with [Beavan et al. \(2010\)](#) estimates
- Coastal South Island
 - uplift is coupled by slow subsidence (<1 mm/yr) on either sides of the Southern Alps



Summary

Absolute sea level trends at tide gauge sites that straddle New Zealand's deforming plate boundary

Tide gauge derived Sea Levels

- New Zealand's RSL is consistent with global trends
+1.7 mm/yr
- Land motion needs to be taken into account
 - Regional vertical motion – continuous GPS

NIWA open ocean tide gauges

- Many established in the late 1990's
 - Tide gauge LVM needs to be established
- Contribute to stability of NZGD2000
- Contribute to GGOS objectives

