Post-earthquake vertical land movement in Christchurch

and what it means for sea-level rise

April 2024

A recent study by GNS Science has shown that sea-level rise in some parts of Christchurch is happening up to twice as fast as previously thought, as a result of increased land sinking following the Canterbury and Kaikoura earthquakes. This means the impacts of sea-level rise – flooding, coastal erosion and rising groundwater – will happen sooner, reinforcing the urgency and importance of planning in advance of these impacts.

What is vertical land movement?

Vertical land movement (VLM) is generally caused by movements in the earth's crust. These upward or downward movements can be very fast, during an earthquake, or slow and gradual. Local land movements can happen from other processes too, like liquefaction, which we have seen here in Christchurch.

It is common for land to keep sinking after large earthquakes. While there is no sign the sinking has slowed down in Christchurch, evidence from other parts of the world tells us that, eventually, the speed of vertical land movement will return to normal. However, it might take another few decades and will depend on whether we experience more large earthquakes.

Flooding in Southshore caused by heavy rainfall and storm surge, July 2017.

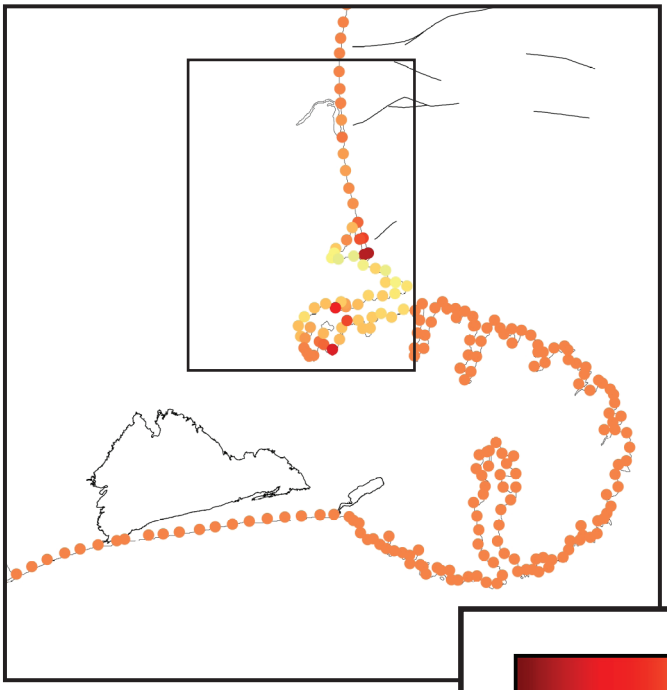
What happened after the Canterbury and Kaikoura earthquakes?

After the Canterbury and Kaikoura earthquakes, parts of Christchurch's coastline experienced increased shoreline erosion, greater tidal and storm flooding, and major changes in shoreline vegetation – particularly around the edges of Ihutai Avon Heathcote Estuary and Southshore/South New Brighton. All of this suggested these areas had dropped during the earthquakes and/or were experiencing faster sea-level rise than previously thought.

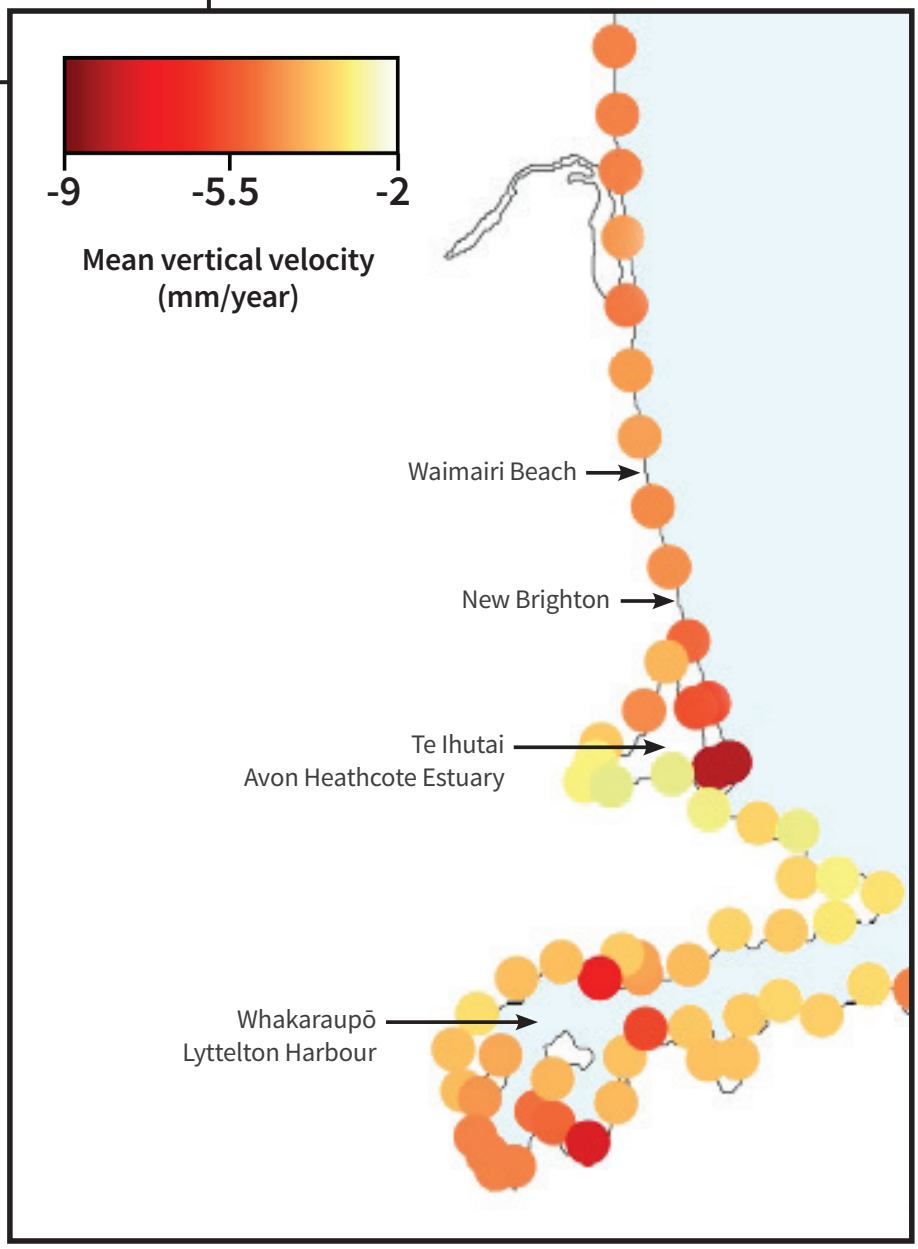
Based on these observations and in response to nationwide VLM information being released in 2022, Christchurch City Council and Environment Canterbury jointly asked GNS Science to look at the vertical land movement data from during and after the Canterbury and Kaikoura earthquakes. This helped us to see what happened and what it might mean for future sea-level rise.

The data from GNS Science showed that some areas moved up and others down during the earthquakes. It also confirmed that, since the earthquakes, most parts of the Christchurch district are sinking at a faster rate than before the earthquakes. In some places, the land is sinking at more than five times the rate it was before the earthquakes – dropping nearly one centimetre per year. The greatest sinking is happening around the edges of the Ihutai Avon Heathcote Estuary, particularly around the Southshore Spit.

A snapshot of the new data



The dots in this map show post-earthquake vertical land movement along the district's coastline, all of which is sinking. Post-earthquake vertical land movement is not well understood across large parts of Te Pātaka o Rākaikautū Banks Peninsula, so an average district-wide rate of vertical land movement has been applied here.



What does this mean for Christchurch?

Vertical land movement and sea-level rise

Sea-level rise can be described in two ways – global (absolute) and local (relative). Global sea-level rise describes the height of the sea in relation to the centre of the earth. It is caused by the melting of ice sheets and glaciers and by the warming of our oceans, because water expands as it warms up.

Local sea-level rise is more useful for us to understand, because it combines global sea-level rise with the up and down movement of the land around us. It means some parts of our coast where the land is sinking will see sea-level rise happen faster than other parts, and faster than global projections would suggest.

This study shows that sea levels may start impacting our coastal areas sooner than we thought, giving us less time to put plans in place. For example, in locations where the land has dropped 10 to 20 centimetres since the earthquakes, the amount of sea-level rise previously expected to happen by 2050 could have already happened.

As another example, global sea-level rise projections suggest we could see 14 to 23 centimetres of sea-level rise by 2050 (from a 2020 baseline). But in places where land is sinking at about 9 millimetres per year, such as parts of Southshore Spit, local sea levels could rise by 41 to 50 centimetres – twice as much over the same 30-year timeframe.

	Average post-earthquake VLM rate	Projected global sea-level rise (without VLM) 2020–2050	Projected local sea-level rise (with VLM) 2020–2050
Waimairi Beach to Brooklands	-4.0mm/year	14–23cm	26–35cm
Brighton Spit	-7.5mm/year		37–46cm
Bromley	-4.0mm/year		26–35cm
Ferrymead	-2.5mm/year		22–31cm
Mt Pleasant to Taylors Mistake	-3.0mm/year		23–32cm
Lyttelton Harbour and Port Levy	-4.0mm/year		26–35cm

Projected sea-level rise with and without vertical land movement (VLM) accounted for across different parts of the district. The right hand column assumes that the post-earthquake VLM will remain at its current rate to 2050

This new vertical land movement information will help us to better plan and work with communities particularly where we will see sea-level rise happen faster. The information could be used to inform the designing of flood protection works, planning for high hazard areas in the Council's District Plan, and it will help the Council to better prioritise adaptation planning across the district.

You can download the full GNS Science study report, (Inter-seismic, co-seismic and post-seismic rates of vertical land movement in the Christchurch district and implications for future changes in sea-level), and its addendum report from our website at **ccc.govt.nz/coastalhazardsinfo**

INF7094 May 2024

Christchurch City Council