Post-earthquake vertical land movement in Ōtautahi Christchurch

and what it means for sea-level rise

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A recent study by GNS Science has shown that sea-level rise in some parts of the Christchurch District is happening up to twice as fast as previously thought, as a result of increased land sinking following the Canterbury and Kaikoura earthquakes. The rate of this land sinking is yet to slow down. 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, like 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.

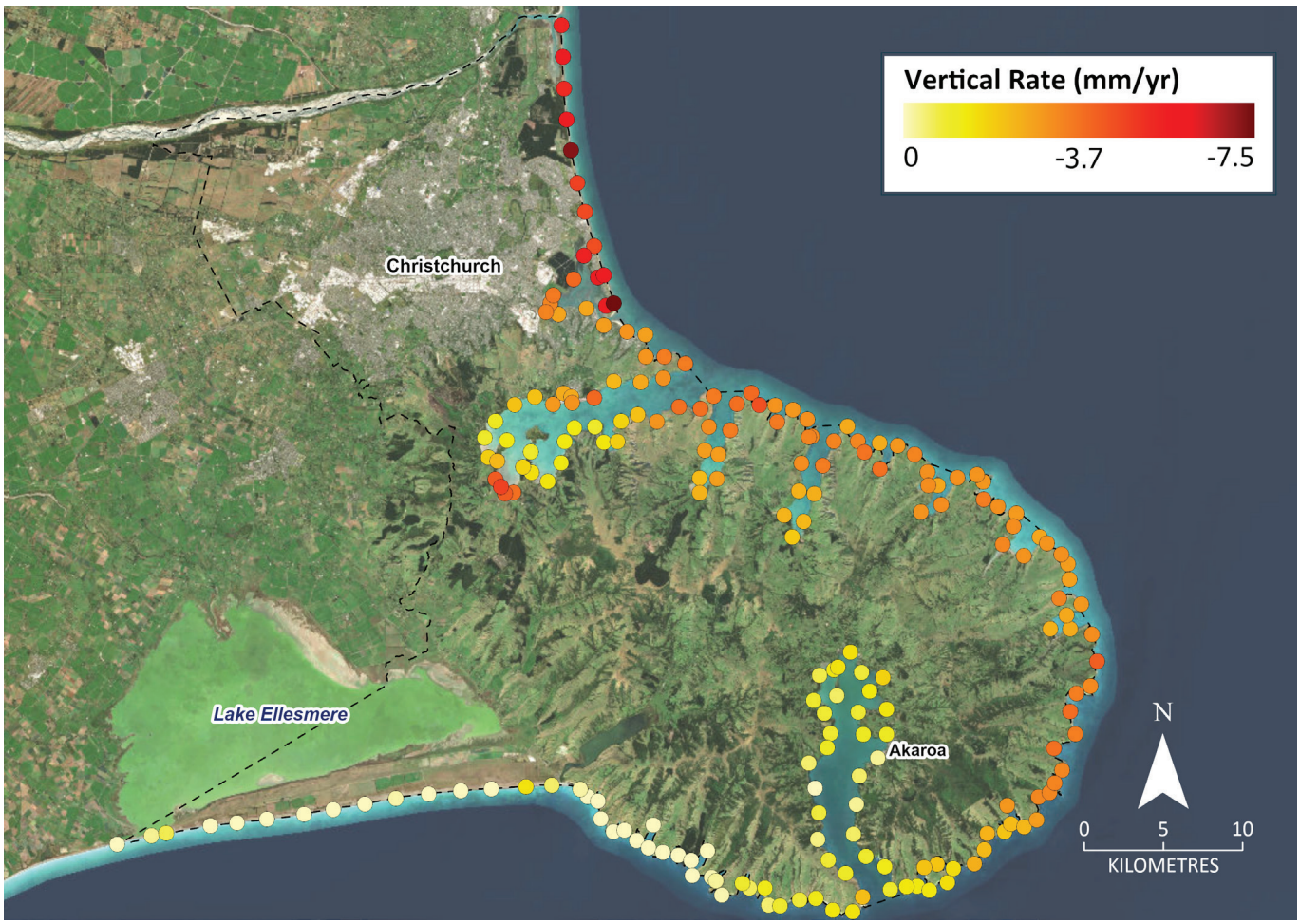
What happened after the Canterbury and Kaikoura earthquakes?

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 for the coast



The dots in this map show the rate of post-earthquake vertical land movement along the Christchurch District's coastline, with most of it sinking to varying degrees. The greatest sinking is happening along the coastline to the east of the city. This figure is based on VLM data (from satellites) between 2015 and 2024.

What does this mean for Christchurch?

Vertical land movement and sea-level rise

Sea-level rise can be described in two ways: global and local. 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 or nation wide projections would suggest.

This study shows that sea levels may impact 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.

Sea-level rise projections for New Zealand suggest we could see 14 to 23 centimetres between 2020 and 2050 , based on guidance from the Ministry for the Environment . But in places where land is sinking at almost nine 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. It is difficult to account for land sinking when thinking about future sea-level rise, because we can only make informed estimates about how the land might move in the future, based on what we have seen in the past and from similar cases around the world. As a result, the table below is an informed estimate, but could overstate or understate the influence of VLM on future sea-level rise across the district.

The table below shows projected sea-level rise, with and without vertical land movement (VLM), across different parts of the district. The right-most column assumes that post-earthquake VLM will remain at its current rates to 2050.

	Average post-earthquake VLM rate*	Projected sea-level rise for NZ (without VLM) 2020–2050	Projected local sea-level rise (with VLM) 2020–2050
Brooklands to Waimairi Beach	-5.8mm/year	14–23cm	31–40cm
Waimairi Beach to South New Brighton	-4.9mm/year		29–38cm
Southshore Spit	-6.4mm/year		33–42cm
Bromley	-4.2mm/year		27–36cm
Ferrymead	-3.7mm/year		25–34cm
Mt Pleasant to Taylors Mistake	-3.4mm/year		24–33cm
Lyttelton Harbour and Port Levy	-2.9mm/year		23–32cm
Eastern Bays (Banks Peninsula)	-3.5mm/year		24–33cm
Akaroa Harbour	-1.6mm/year		19–28cm

*Rates of VLM can vary over small areas, so the average post-earthquake VLM rates should only be taken as a guide and do not represent the most extreme VLM rates in the various locations.

This new vertical land movement information will help us to better plan and work with communities. The information could be used to inform the designing of flood protection works, plan for hazard areas in the Council's District Plan, and help the Council to better prioritise adaptation planning across the district.

You can download the full GNS Science study report **here.**

ccc.govt.nz/assets/Documents/Environment/Coast/Canterbury-VLM-and-Implications-for-Future-SLR-2025_FINAL.pdf

Christchurch City Council

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