A Study of Land Subsidence in a Tectonically Active Area: an Example from Christchurch New Zealand

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SUMMARY

Following the 2010-11 Canterbury earthquake sequence, the coastal regions of east Christchurch (New Zealand) are subject to an increased risk of sea inundation because of land subsidence. In addition, ongoing subsidence due to post-seismic relaxation might contribute to increased vulnerability to sea-level rise and storm surge events. To monitor the subsidence we established four GNSS receivers that lie on a north-south transect extending from Sumner to New Brighton. The GNSS data from these stations, as well as five other cGNSS sites located around Christchurch, have been processed using the Bernese GNSS software package to generate a position time series that has been analysed to estimate rates of change in the height component.

After three years of monitoring, the coastal suburbs between South New Brighton to Waimari Beach are currently undergoing rapid subsidence of nearly 1 cm/yr. In contrast, in the western suburbs, the rates of subsidence decrease. To-date, we have no data to determine how far to the north the high rates of subsidence extend.. The rates of subsidence appear to be related to a region underlain by unconsolidated estuarine sediments. Our site at Sumner, which is located on bedrock, does not show a significant vertical velocity at the 95% confidence level.

Over the last three years the vertical land motion in the area is complicated by the vertical displacements caused by two additional earthquakes. The Valentine's Day earthquake (14th February 2016) caused uplift while the Kaikoura earthquake (13th November 2016) caused subsidence of all the stations. Although the Kaikoura earthquake (Ml 7.8) was a far larger event

than the Valentine's Day Earthquake (Ml 5.7), the fact that the Valentine's Day Earthquake was located near our study area meant that the uplift associated with it exceeded the subsidence from the Kaikoura Earthquake in the nearby stations.

In seismically active regions, the secular (long-term) subsidence rates can be punctuated by significant seismic displacements, up or down, from earthquake coseismic and postseismic processes. While it is possible to estimate the secular (long term) subsidence; it is not possible to estimate the displacement of future earthquake events, and therefore it is difficult to incorporate into long-term land-use planning for relative sea level rise. This project provides a timely reminder of the complexities of vertical land motion and the potential effect on coastal hazard scenarios that has clear impacts on future land-use planning.