An Interpretation of the permanent deformation of the 2011 Christchurch earthquake

Philippa Cowles*, Geomatics student, Student Number 090715912, Undergraduate Vacation Scholarship

Civil Engineering and Geosciences

Introduction

The Canterbury Region of New Zealand encountered a magnitude 6.3 (Richter Scale) earthquake at 12:51 pm on Tuesday, 22 February 2011, local time (Figure 1). 181 lives were lost as a direct cause of the earthquake and significant damage caused to the buildings and infrastructure of Christchurch (Figure 2) .The earthquake also caused permanent deformation and alteration to the New Zealand land cadastral boundary system.

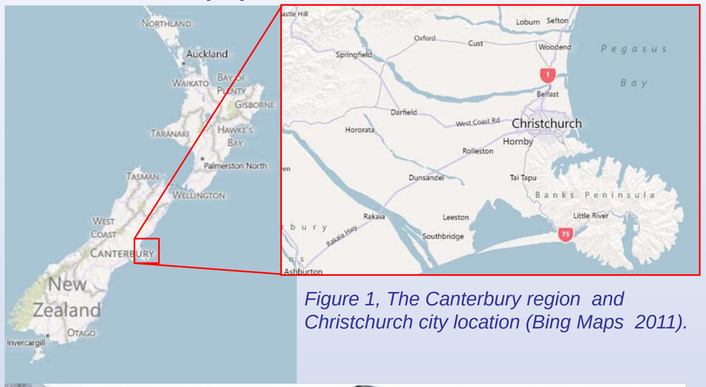

Figure 1, The Canterbury region and Christchurch city location (Bing Maps 2011).

Figure 2 damage caused by earthquake to buildings in Christchurch (BBC News website 2011)

Aim and Objectives

The aim of this project was to develop a physics-based model for the co-seismic displacement during the earthquake, and for post-seismic after slip or relaxation during the days and weeks that followed, using geodetic GPS data. Interpretation of the displacements in terms of fault plane slip and after slip, allowed the effect of uncertainties in the fault parameters on the New Zealand cadastral datum to be investigated.

Methods

- Data processing in static mode using NASA's GIPSY/OASIS software to yield measurements of the Earth surface displacement at centimeter level (Figure 3).
- Interpretation of displacements using okinv software (Clarke et al 1997) to model processed data in terms of fault plane slip and afterslip (Figure 4 and 5).
- Date processing in kinematic mode to yield displacement measurements for days after the earthquake to investigate effects of afterslip (Figure 6).

Results and conclusion

Figure 3 shows that the earthquake caused earth surface displacements in all directions to occur . The largest movements seen were from Lyttelton, the closest station to the earthquake.

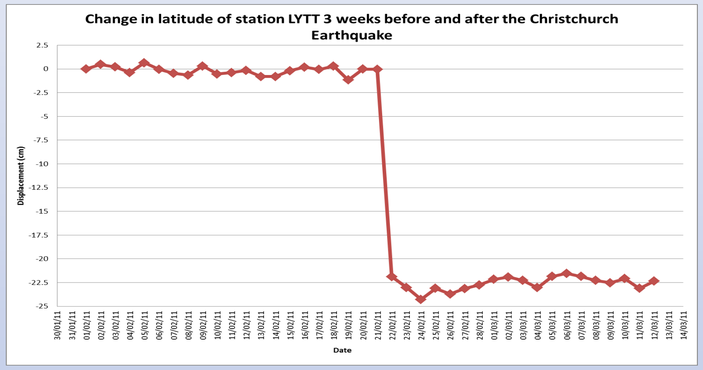

Figure 3 Time series of latitude displacements for Lyttelton (LYTT) station .

Through the modeling of the GPS data, earthquake source parameters could be computed for slip and rake. Figure 4 shows the parameters modeled that best suited the GPS data used and the known parameters derived from seismic data. As seen by the red and green arrows, no perfect model for all parameters could be created due to small number of GPS sites available for use.

Further modeling of the displacement data shows that afterslip of the faults occurred . Figure 5 shows that the majority of the slip occurred at a shallow depth between 0 and 0.47 km.

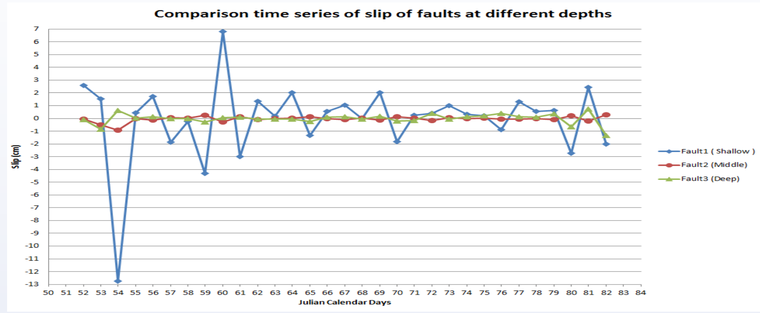

Figure 5 Time series of modelled day to day fault slips at varying depths.

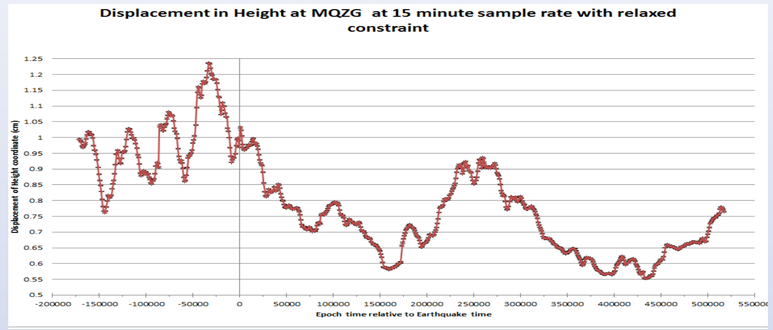

Figure 6 Time series of kinematic height displacements for McQueens (MQZG) station

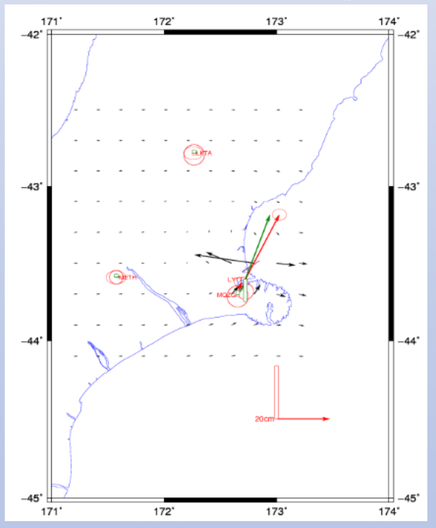

Figure 4 Modelled source parameters of the Christchurch earthquake from GPS data .

From kinematic processing it can be seen how the fault movement has caused frequent variation in station location before the earthquake. After the earthquake the fault movements gradually decrease in frequency and magnitude (Figure 6).

Acknowledgements

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References :

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