Modelling time-dependent hazard for central New Zealand following the Mw 7.8 Kaikoura, Earthquake

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The 2016 Mw 7.8 Kaikoura, New Zealand Earthquake occurred in a region of relatively high hazard in central New Zealand. Strong shaking occurred across a broad region with triggered seismicity occurring over much of the country. Aftershock activity has been light to date. Despite this, increased earthquake rates, and, hence, increased seismic hazard is expected for central New Zealand for the next decade or more. Initially to guide the rebuild of the road and rail network on the upper South Island, we have constructed a time-dependent seismic hazard model for central New Zealand: the Kaikoura Seismic Hazard Model (KSHM).

The model was built using the same framework as used for the Canterbury time-dependent model. For the KSHM there were four main components to the model development: 1) The clustering model which included multiple statistical forecasting models such as ETAS, EEPAS, and STEP and included a long-term model based on a multiplicative hybrid model that included geodetically derived strain rates; 2) a revised Hikurangi subduction zone model that allowed for the possibility for the margin to rupture south of Cook Strait –this had previously been considered to be extremely unlikely; 3) revision of the fault sources in the region to use conditional probabilities of rupture when data allowed; and 4) the use of multiple GMPEs for both crustal and subduction zone earthquakes based on recent work from Van Houtte (2017).

Across the entire region, the KSHM forecasts higher hazard than from the New Zealand National Seismic Hazard. This increase is driven by multiple factors that depend on the particular sub-region of interest. In the near-fault zone and lower North Island, the clustering model plays an important role and is mostly controlled by; 1) the EEPAS model which forecasts clustering on decadal scales; and 2) the strain-rate hybrid which forecasts higher hazard in the immediate Wellington region where seismicity rates have been low in recent decades. The highest hazard is driven by time-dependent conditional probabilities of rupture on various segments of the Hope Fault with current hazard rate estimates giving recurrence intervals as low as 130 years for M7.1. Finally, the use of modern GMPEs has significantly increased the hazard for all combinations of parameters across the region.

A final and important consideration is the method of obtaining a single earthquake rate from the time-varying rate determined from the clustering model. Based on Yeo and Cornell (2009), we have developed an equivalent constant rate by applying economic discount rates determined by the end use of the model. For example, we have used a 6% discount rate for the road and rail hazard estimates; this is the discount rate applied by New Zealand treasury for such projects. This results in a higher estimated earthquake rate than from taking a simple average across the time-period of interest (e.g, 50 or 100 years).

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