1) INTRODUCTION

Source representation is an essential component of physics-based ground motion simulations. However, its inherent non-uniqueness leads to different representations for the same fault rupture. For the 2010 Darfield earthquake, various source models have been proposed that primarily differ in fault geometry and rupture process.

GOALS:
- Analyze the simulated ground motion for the Darfield earthquake
- Examine the sensitivity of simulated ground motions to variations in the assumed fault geometry and slip distribution

2) SIMULATION METHODOLOGY AND PARAMETERS

Hybrid approach: based on Graves & Pitarka (2010, 2015)
- Low frequency: finite difference method using 3D velocity structure (grid spacing 100m, minimum $V_S$: 500m/s)
- High frequency: semi-empirical approach with simplified 1D structure
- Broadband ground motion: matched filtering, $V_{S30}$-based empirical site amplification

Adopted seismic source representation
- Kinematic source model
- Rupture process: generated using stochastic slip generator
- Three different fault geometries: one, four, and six fault-segments
- Ten stochastic slip realizations for each of the aforementioned fault geometries

Figure 1: Source-station geometry with three fault geometries (Hayes2010, Beavan2010)

3D Velocity structure

Figure 2: Surface projection of the cross-sections (red line) and fence diagram of the 3D shear wave down to 2.5km depth (Lee et al., 2016).

3) SIMULATED GROUND MOTION AND VALIDATION

Ground motion patterns for one rupture realization for each source geometry
- Presence of strong waveform distortion for the case of multi-fault segments
- Differences appear in the spread of seismic energy
- Directivity effects are present in all cases

Figure 3: Velocity snapshots taken at $t=8$s and $t=12$s after rupture initiation of Darfield event.

Comparison of simulated, empirical and observed ground motions
- Complexity of the fault controls ground motion duration
- All simulations reproduce the overall distance attenuation trends of the empirical GMPE
- For all cases, simulated and observed ground motion variabilities are higher compared with the empirical GMPE which affect the hazard assessment

Figure 4: Comparison of observed, empirical and simulated peak ground acceleration (PGA) and spectral acceleration (SA) for one slip realization for a given fault geometry.

4) GROUND MOTION VARIABILITY ANALYSES

Partitioning of ground motion residual (between- and within-event residuals)
- Between-event residuals: effect of both geometry and slip distributions are significant at intermediate periods, variability appears in the duration parameters ($D_{S575}, D_{S595}$)
- Apparent good performance for the one segment case for $\delta_6$ is due to the averaging which hides some features at individual station (as shown in the two $\delta_6$ cases)

Figure 5: Within- and between-event residuals for the 10 realizations and 3 fault geometries.

Correlation between intensity measures from different fault geometries
- Spectral acceleration residuals are relatively larger for stations close to the fault
- For one fault plane case, spectral acceleration residuals decrease from west to east in the intermediate period range

Figure 6: Comparison of the spectral acceleration residual distributions for one and four fault-segments.

5) CONCLUSIONS AND OUTLOOK

- Fault segmentation is required, particularly west of the fault, to better match the observed ground motion records.
- Ground motion variability is strong at intermediate periods ($T=1-3s$)
- This study can be extended by analyzing the ground motion sensitivity to temporal source parameters.