Visualisation for Scientific Discovery and Communication : Kaikoura Earthquake as a case study

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1. Introduction

Ground Motion (GM) Simulation involves complex calculations that produce a large collection of numerical data, which needs a good visual presentation to help better understanding of the complex dynamics of the earthquake. In this poster, we present a visualisation workflow that we developed to produce a 3D animation from the simulation data of the 2016 M7.8 Kaikoura earthquake as a case study, and discuss how it facilitated scientific discovery and communication.

2. Software and tools

Data preparation → 3D rendering → Video editing

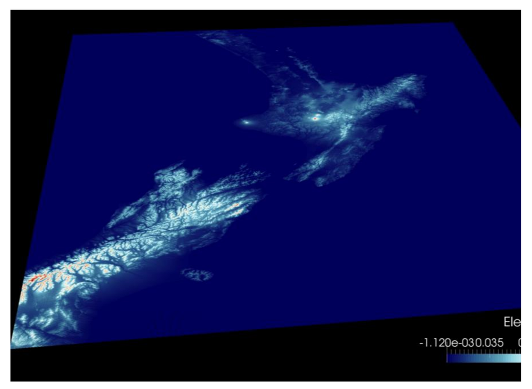
We used in-house Python code with VTK (Visualization Toolkit vtk.org) to convert the GM simulation data to a format that can be imported to ParaView (paraview.org), a powerful open-source 3D visualisation software. Most of 3D rendering is exclusively done with ParaView, then the seismic response model of Wellington buildings produced from OpenSees (opensees.berkeley.edu) is added to the 3D animation using Blender (blender.org)

3. Data preparation

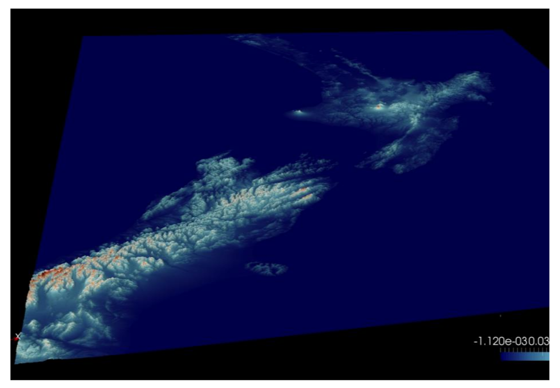
Surface visualization

GeoTIFF (LINZ Data Service http://www.linz.govt.nz/land/maps/linz-topographic-maps/map-chooser) tiles and a satellite image are used to create a 3D terrain of New Zealand. This is not event-specific, and the 3D terrain model of whole New Zealand can be used for other events. We developed a Python+VTK program for this task.

GeoTIFF files



GeoTIFF files are loaded onto ParaView and points in 3D space are drawn using the elevation data



Delaunay interpolation produces a 3D surface.

Google map satellite image is mapped onto the surface using ParaView.

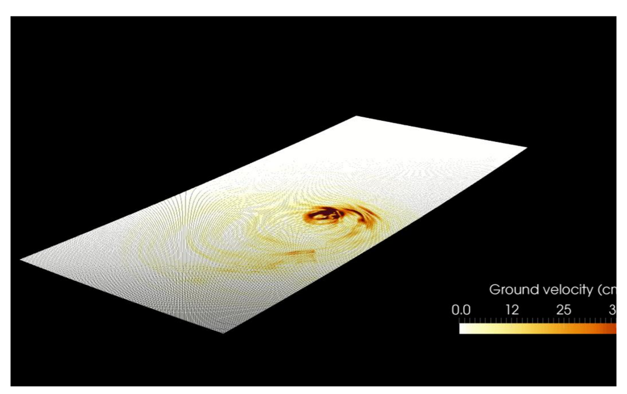
Ground Motion Simulation Data

Ground Motion Simulation was computed utilizing the High Performance Computing (HPC) facility provided by New Zealand eScience Infrastructure (NeSI). It took 12 hours using 512 POWER6 cores.

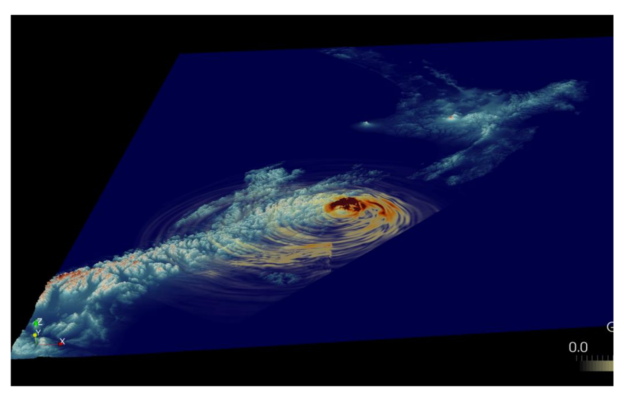
The data consists of particle velocity (cm/s) at 192,000 points (200m grid spacing) at 1 time step. Total of 2,500 time steps equivalent to 250 seconds of physical time have been loaded onto ParaView for visualization.

4. Visualisation Steps

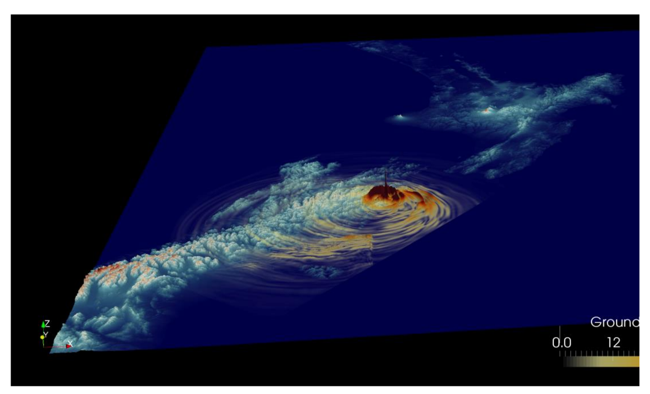
Modelling wave propagation



Color mapped velocity data is drawn on the terrain surface and 3D velocity surface is created.



Surface velocity data is first displayed as a color-mapped image on a 2D plane, and zero values are made transparent.



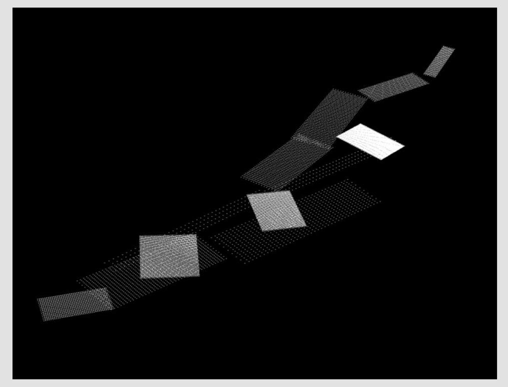
Velocity surface is further deformed in proportion to the velocity.

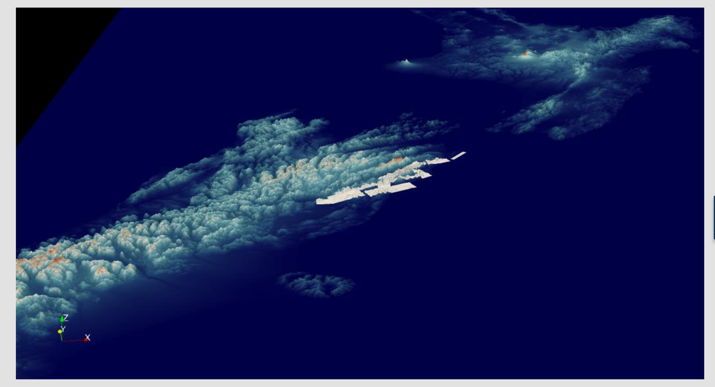
4. Visualisation Steps (continued)

Modelling wave propagation x 2,500

For each of 2,500 time steps, a velocity surface is calculated. Computationally heavy.

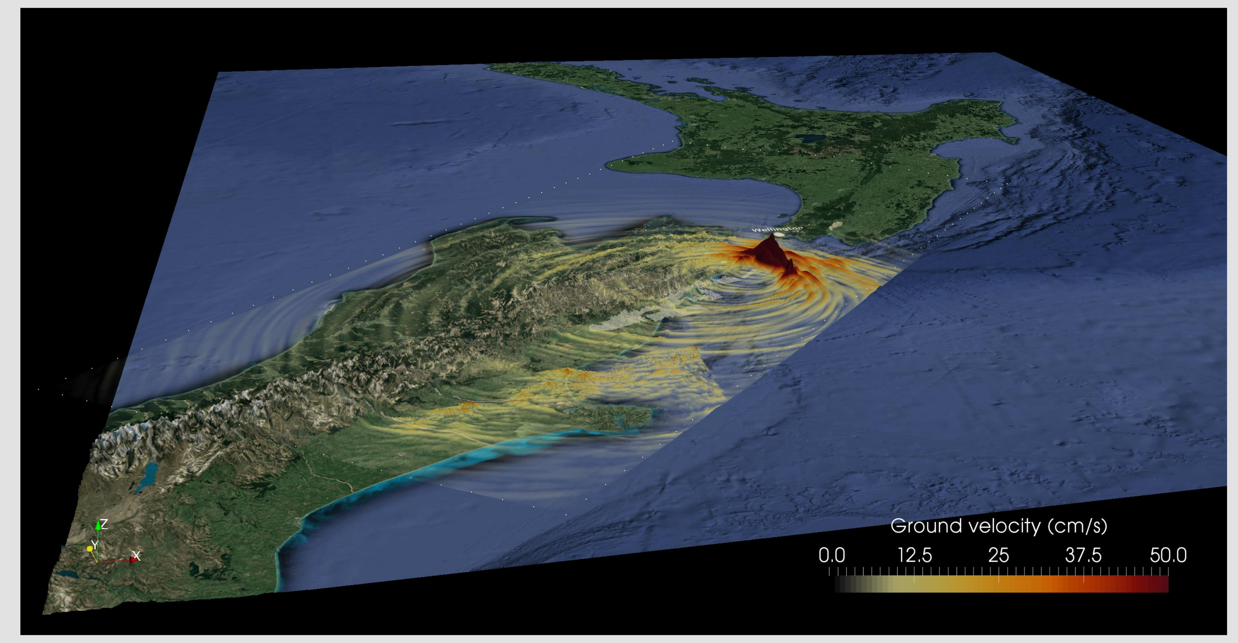
Adding faults





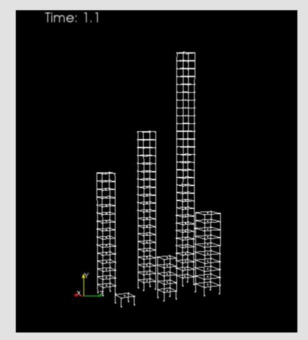
Fault planes used for the GM simulation are drawn (using in-house Python-VTK code)

Making a *basic* movie

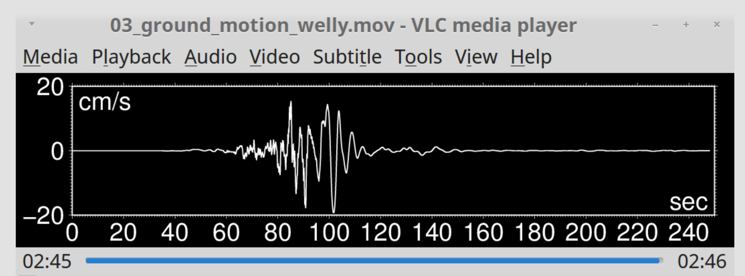


ParaView outputs a movie file out of 2,500 frames (10fps)

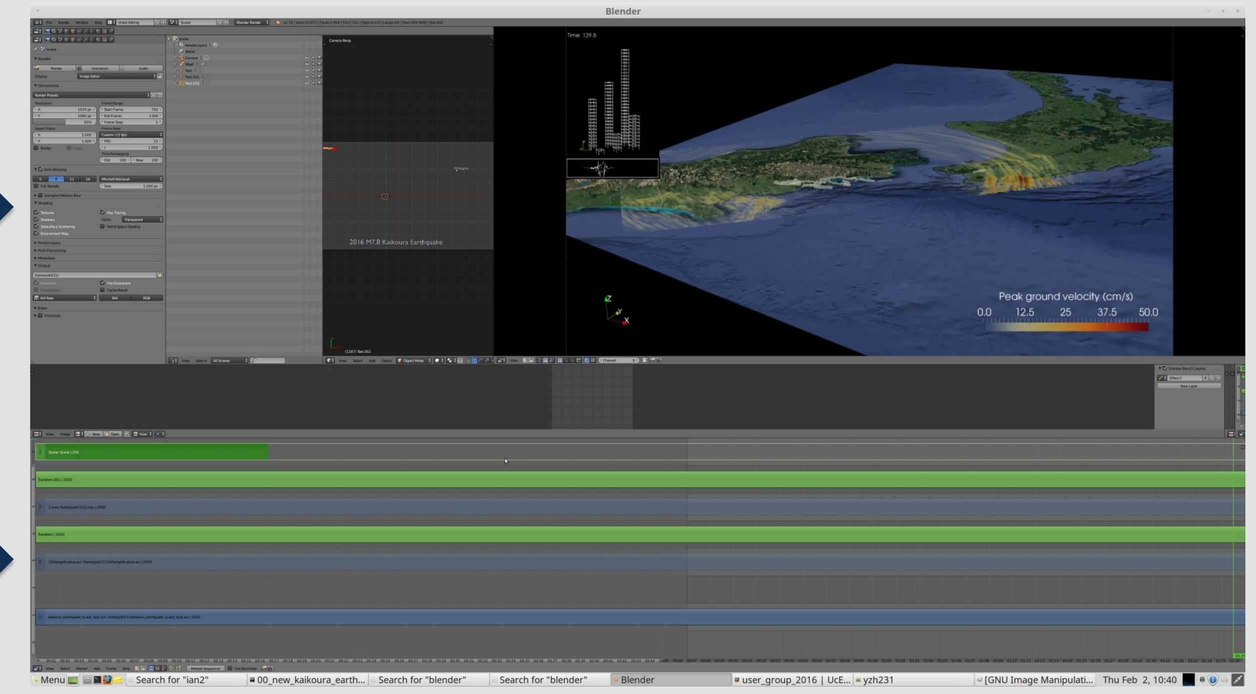
Adding more audio/visual contents



Seismic responses of Wellington buildings of varying height (OpenSees)



Simulated seismogram recorded at Wellington strong motion station



Multiple videos are mixed and synchronized using Blender. Other contents (audio/video) can be easily added if required.

5. Conclusion

The final 3D animation (Figure 1.) proved to be effective to understand the simulation data, and it improved the communication of the research output with the general public significantly. The Youtube video attracted near 20,000 views and its snap shot was frequently used in media coverage.

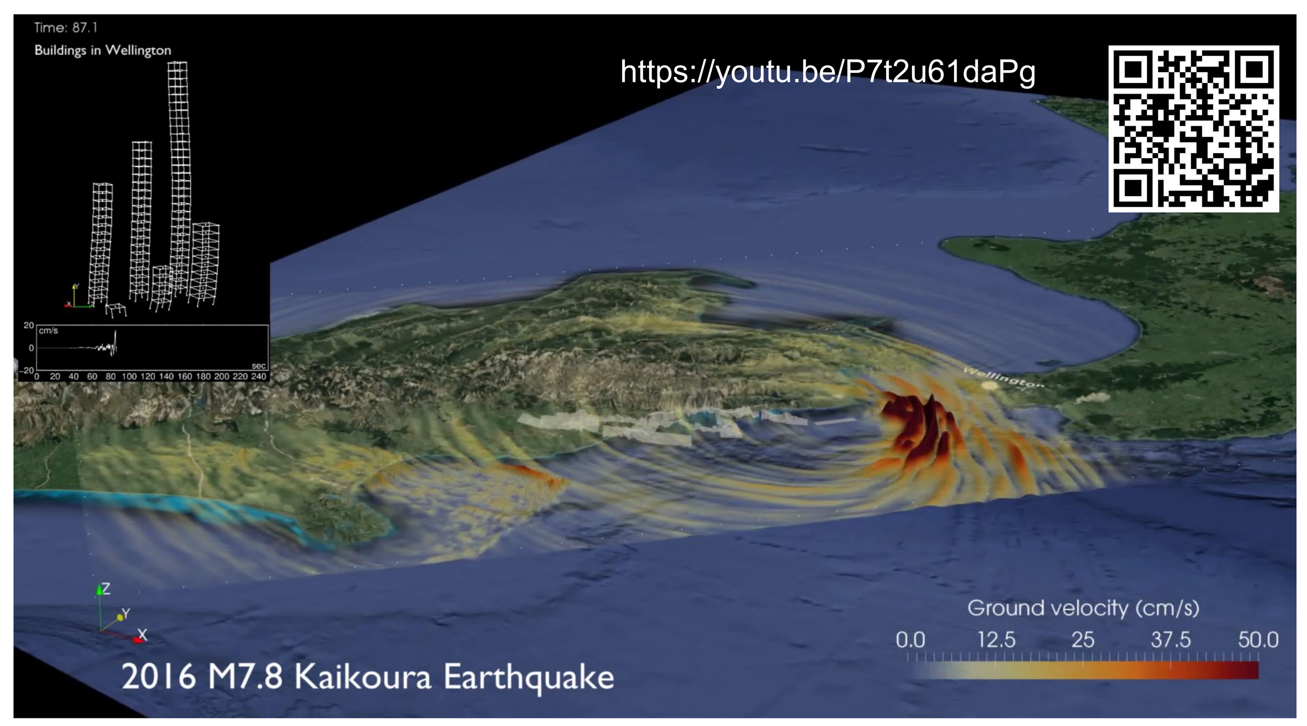


Figure 1: Final video featuring the 3D animation augmented with the seismic response model of Wellington buildings

6. Future works

We are currently visualising recovery progress of road networks as shown in Figure 2. and planning to develop a semi-automated workflow that can produce a basic movie.

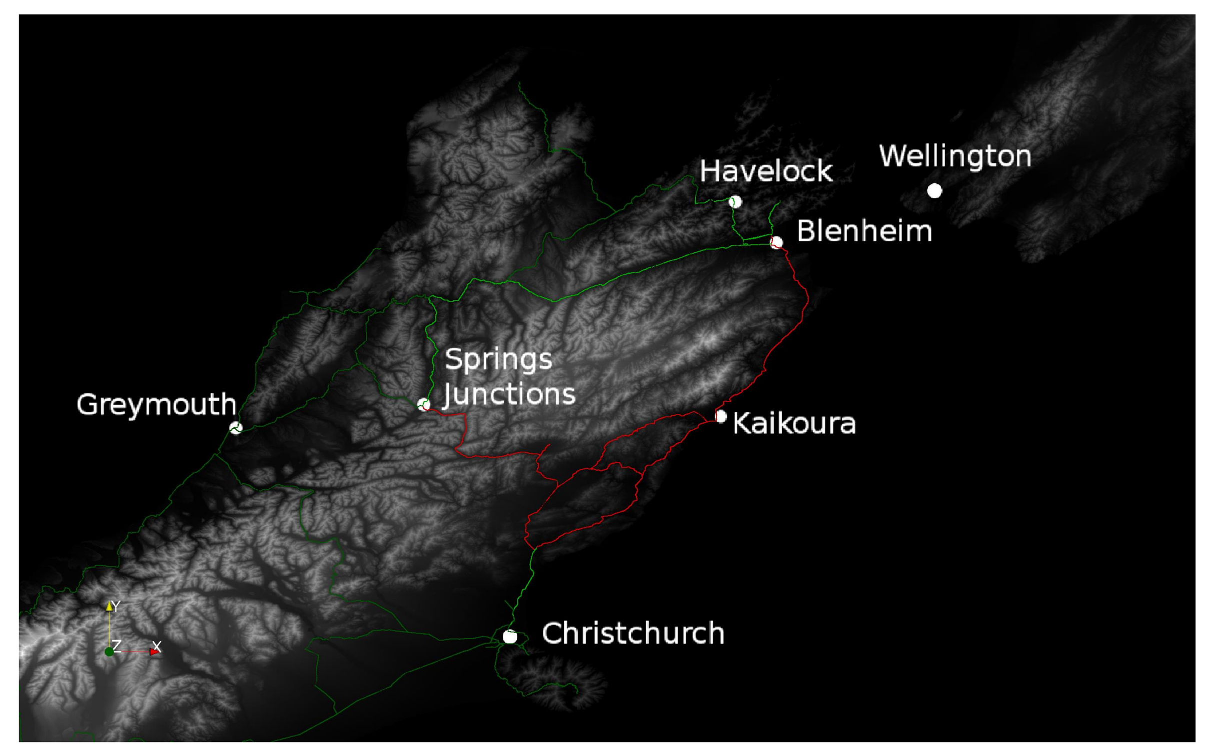


Figure 2: Post-earthquake road network status on November 14, 2016