

# The Canterbury Velocity Model (CantVM) – V1 Computational implementation, South Island Extension, and Integration within the UCVM framework

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## 1. Background and Objective

This poster presents the computational implementation of the Canterbury Velocity Model (CantVM) Version 1, constructed for use in physics-based ground motion simulation.

A planned integration of CantVM within the Unified Community Velocity Model (UCVM) framework is presented which will allow researchers to generate velocity models for use in ground motion simulations using standardized approaches.

Figure 1 illustrates the CantVM region where the near surface velocity structure has been characterised to a high resolution. Figure 4 illustrates how this region integrates with a South Island velocity model, enabling ground motion simulations of faults outside of the Canterbury region to be conducted.

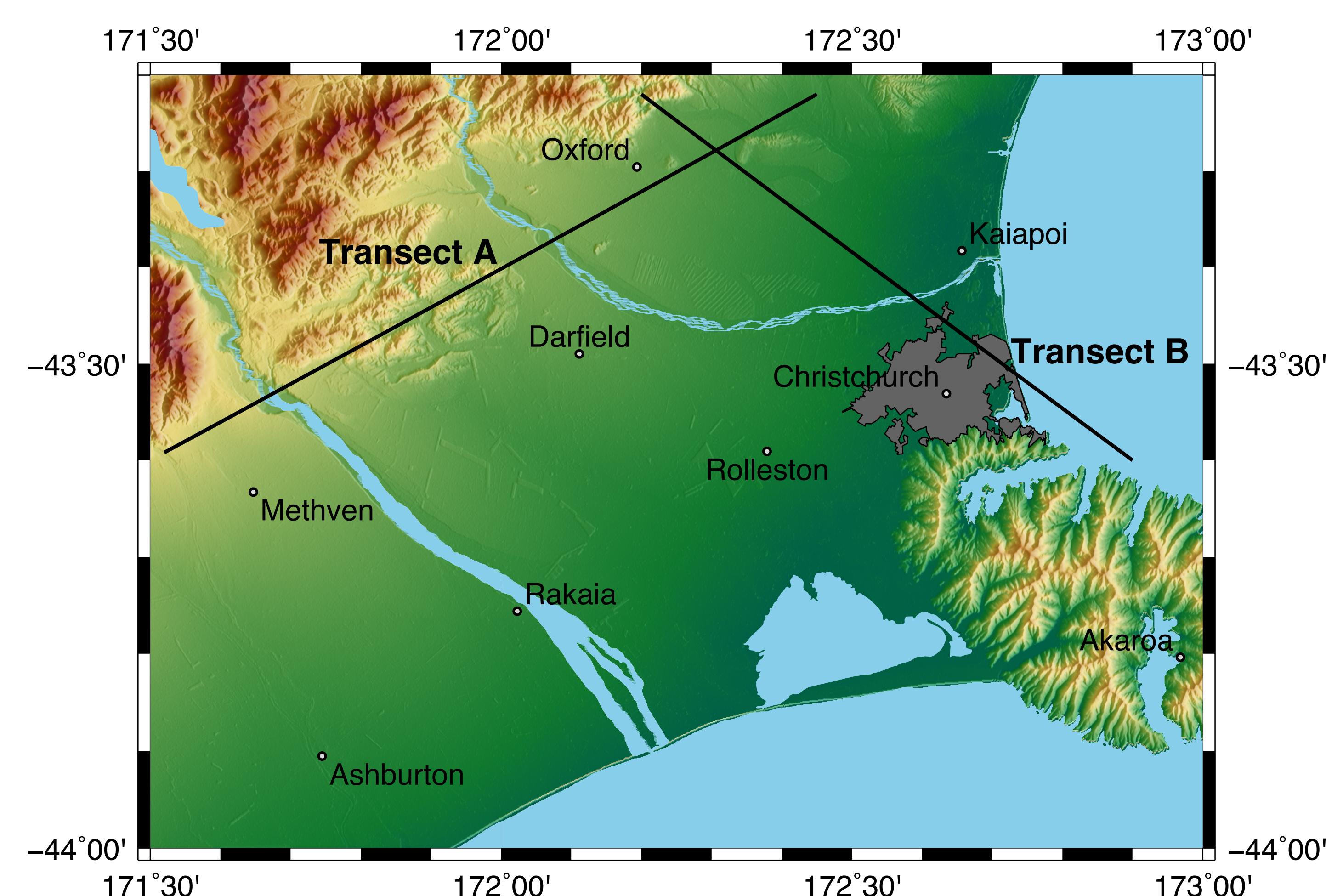


Figure 1: CantVM domain showing population centres and the Christchurch urban region. S-wave velocity cross sections corresponding to Transects A and B are shown in Figures 2 and 3 respectively

## 2. Prescription of velocities

The CantVM utilises a rule-based methodology to prescribe P- and S-wave velocities, and density values ( $V_p$ ,  $V_s$  and  $\rho$ ) to grid-points. This approach employs 3D surfaces to differentiate between geologic units of different geophysical properties depending on their depth, age and lithology.

The process for prescribing velocities at a grid-point (defined by latitude, longitude and depth) is as follows:

- The geologic surface depths at the grid-point location are determined from interpolation
- The geologic unit that the grid-point lies within is determined using the previously determined surface depths
- Rule based sub-velocity models are used to prescribe  $V_p$ ,  $V_s$  and  $\rho$

CantVM Version 1 uses three primary sub-velocity models in its construction, in order of increasing depth:

- A 1D velocity model, constructed using bore logs, is applied in the near surface region (depth  $\sim$ 500m)
- Four layers representing geologic units which are lithologically distinct are modelled, the Pliocene, Miocene, Paleogene and Banks Peninsula Volcanics (BPV). These layers are currently modelled using constant velocities while efforts to introduce depth- and age- dependencies are ongoing
- The Basement is modelled utilising travel-time tomography (Eberhart-Phillips et al. 2010).

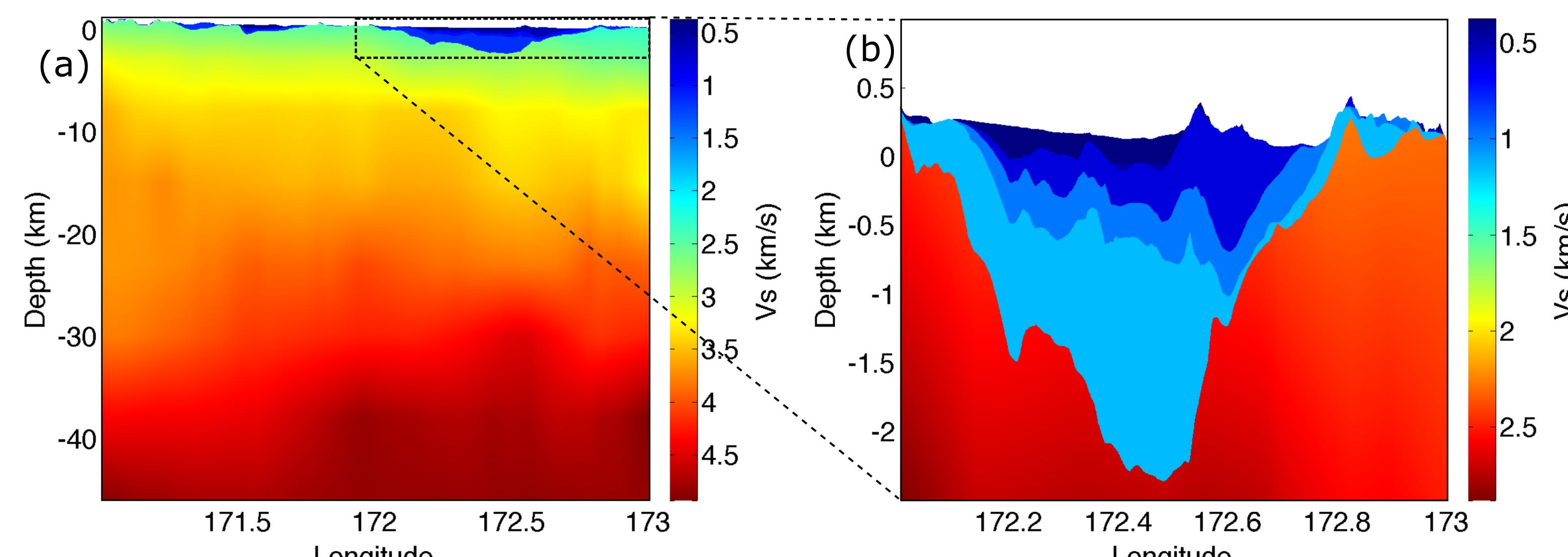


Figure 2: (a) Velocity cross section of CantVM (Transect A, in Figure 1); (b) illustrating the structure of the Pliocene, Miocene and Paleogene layers overlying the Basement

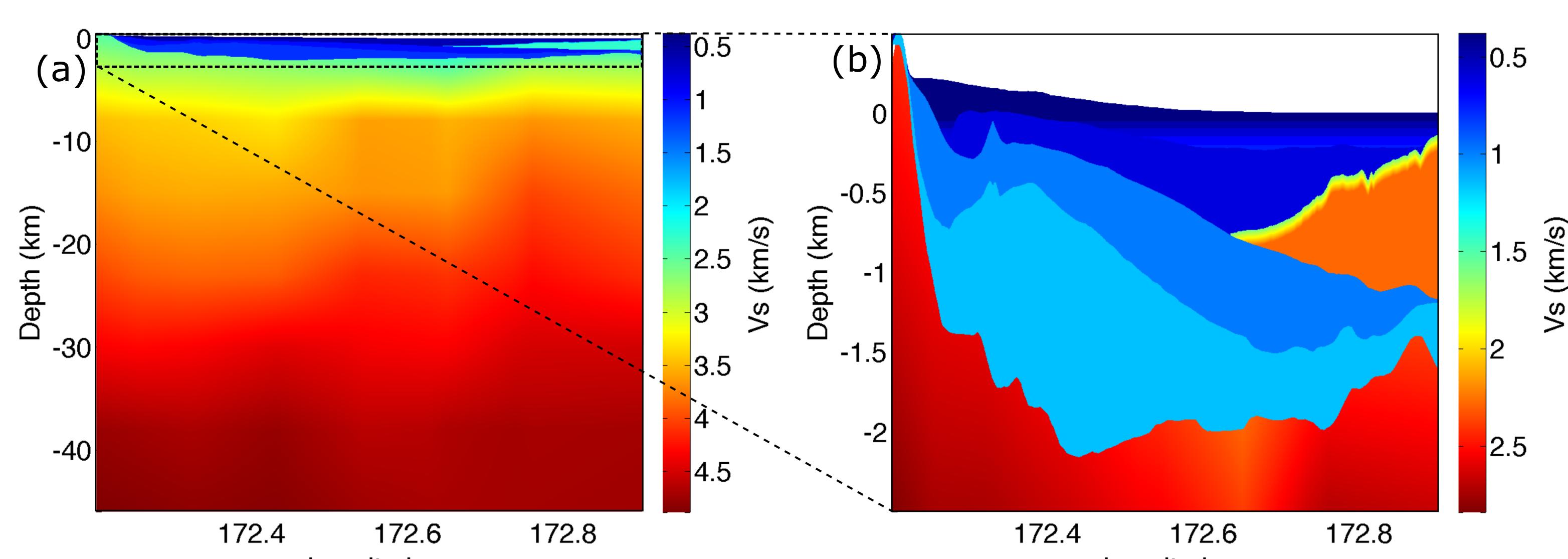


Figure 3: (a) Velocity cross section of CantVM (Transect B, in Figure 1); (b) illustrating the structure of the 1D Velocity model, Banks Peninsula Volcanics, Pliocene, Miocene and Paleogene layers overlying the Basement

## 3. Integration within the Unified Community Velocity Model framework

The Unified Community Velocity Model (UCVM) framework is an open source software package that enables researchers to query 3D velocity models through a standardised software interface.

- Originally developed for Californian velocity models (by the Southern California Earthquake Centre) but allows non-Californian models to be registered and generated
- Will allow researchers to generate the CantVM on structured and unstructured meshes for finite difference, finite element and spectral element simulation methods
- UCVM contains a collection of software tools for visualization and interrogation of velocity models. Figure 3 illustrates two inbuilt UCVM visualisation types:  $V_s$  slice at a constant depth; and a  $Z_{2.5}$  map
- Interfacing with UCVM will allow external researchers to utilise the CantVM in various physics-based ground motion simulation codes

## 4. Extension to a South Island-wide model

Recent efforts have been focused on 3D velocity modelling and ground motion simulation of the Canterbury region (in the context of the 2010-2011 Canterbury earthquakes). Extending the coverage region to encompass the South Island allows for ground motion simulations for faults outside the Canterbury region to be undertaken.

- The near surface region in Canterbury has been extensively characterised in high resolution
- Remainder of the South Island is characterised by lower resolution travel time seismic tomography (Eberhart-Phillips et al. 2010)
- Additional high resolution regions are under development and will be inserted into future versions of the South Island velocity model (SIVM)
- Figure 4 illustrates the extended domain which allows for ground motion simulations of fault ruptures outside the Canterbury region to be conducted

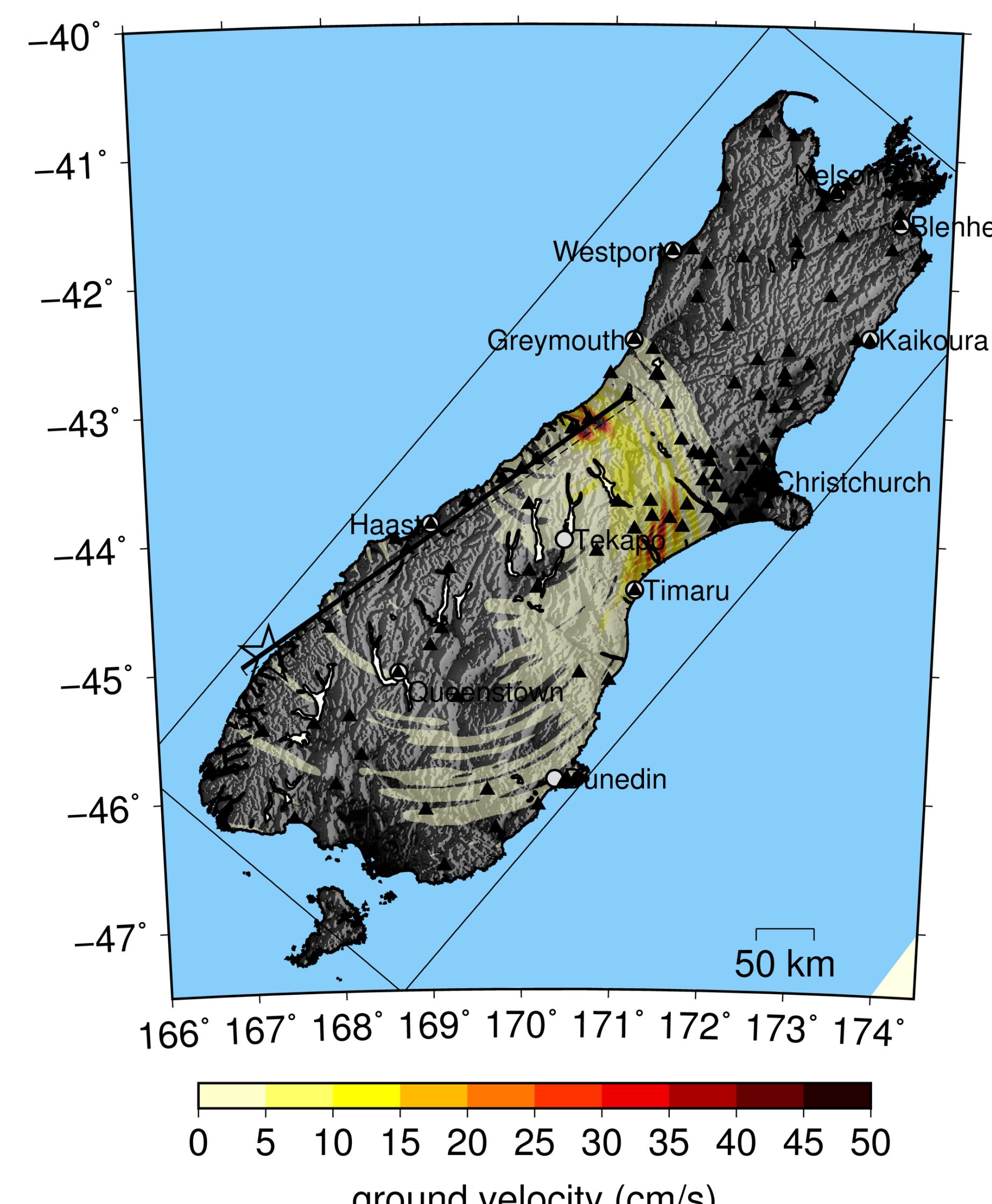


Figure 4: Ground motion simulation of an Alpine Fault rupture using a hybrid CantVM – tomography velocity model for the South Island