Full waveform inversion reveals high-resolution crustal structure within the Southern Hikurangi Margin: Implications for physical conditions along the megathrust

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1) Rationale

Recently, the seismic signature immediately west of the Hikurangi Subduction Zone has revealed high-resolution crustal structure beneath the megathrust. Understanding the nature and extent of this high-resolution structure is crucial for predicting the potential for earthquakes. We employ a new 1D starting model and extend imaging beyond that recovered in the Arnulf et al.,[2021] study.

2) Full Waveform Inversion Workflow

We apply the hybrid FWI framework recently developed by Zhao et al.,[2022] to recover high-resolution Vp and depth domain reflection structure using a simple 1D starting model and extend imaging beyond that recovered in the Arnulf et al.,[2021] study.

3) P-wave Velocity Models

Fig 3: (a) P-wave image obtained along profile DSCM38 used for hybrid FWI workflow of Zhao et al.,[2022] using a traditional local optimisation approach. (b) P-wave image obtained in this study using a 1D starting model and the HPFWI approach over the RTM section (2), with convolutional neural network (CNN) ray tracing and a reprocessing of the pre-stack data. (c) Difference in P-wave image between hybrid and traditional approaches. (d) Difference in P-wave image between hybrid and traditional approaches.

4) Preliminary Numerical Modelling

To investigate which processes may be responsible for generating the observed LVZs imaged on profile DSCM38 (Fig. 3b), we performed numerical modelling using SULEC following a method similar to Ellis et al.,[2015]. We estimate fluid release and effective pressure and compare the porosity field derived empirically from the Vp model with that predicted from the numerical model.

5) Future work

- Perform joint MCS/ OBS inversions on the SAKE117 profile to extend the depth of penetration and improve Vp recovery.
- Implement multiparameter FWI including Vp/Vs and other properties (currently stable for synthetic data).
- Apply HPFWI to additional legacy seismic profiles (Fig. 1) to provide a holistic view of along-strike variations in forearc & plate interface structure & physical state.
- Man fault geometries in the depth domain and compare with earthquake hypocenters.
- Incorporate FWI profiles as "ground truth" within an upcoming margin-wide 3D active-source Vp tomography model.

References