AMBIENT NOISE ADJOINT TOMOGRAPHY AND 3D SIMULATION OF WAVE PROPAGATION OF INDUCED EARTHQUAKE IN ALBERTA BASIN

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ABSTRACT

In Alberta, Canada, the town of Fox Creek recently experienced hundreds of earthquakes in connection with hydraulic fracking of shale formations. Among these events are several moderate (M>3.5) events, which raised great public concern over human ‘induced’ earthquakes and led to the suspension of injection operations in compliance with a newly adopted ‘traffic light’ protocol. Despite its significant economic and political implications, the effectiveness of this magnitude based protocol is challenged by 1) the uncertainties in earthquake parameters (e.g., location and magnitude) and 2) a lack of direct indicators of seismic risks. In this study, we seek solutions through developing 1) a high-resolution 3D basin model and 2) a real-time earthquake simulation system. The shear velocity model is inverted using ambient noise adjoint tomography, which minimizes the travel-time difference between the observed and synthetic Rayleigh waves computed using the spectral-element method (SEM). The outcome permits a detailed examination of basement structures and offers improved structural constraints for seismic source studies of induced earthquakes. Based on this model, we further develop a real-time earthquake simulation system, which simulates propagation and amplification of seismic waves in the sedimentary basin. The automatically generated shakemap (i.e., the visualization of peak ground motion) facilitates a speedy assessment of earthquake risks, which enables the regulators to take prompt actions in the event of potential hazards. In a long-term view, this study greatly improves the understanding of the nature of induced earthquakes and contribute to safe, environment-friendly energy practices.

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