University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Science

of

FENGZHOU TAN

BSc (Peking University, 2017)

"Improving Beamforming-based Methodologies for Seismological Analysis"

School of Earth and Ocean Sciences

Thursday, March 28, 2019
10:00 A.M.
Bob Wright Centre
Room A319

<u>Supervisory Committee:</u>
Dr. Ed Nissen, School of Earth and Ocean Sciences, University of Victoria (Co-Supervisor)
Dr. Honn Kao, School of Earth and Ocean Sciences, UVic (Co-Supervisor)
Dr. Stan Dosso, School of Earth and Ocean Sciences, UVic (Unit Member)

<u>External Examiner:</u>
Dr. Andrew Schaeffer, Geological Survey of Canada, Natural Resources Canada

<u>Chair of Oral Examination:</u>
Dr. Robin Hicks, Department of Chemistry, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

We improved two beamforming-based methodologies for seismological analysis. The first one is a new Three-Dimensional Phase-Weighted Relative Back Projection (3-D PWBP) method to improve the spatial resolution of Back Projection results. We exploit both phase and amplitude of the seismogram signal to enhance the distinction of correlated signals. Also, we implement a 3-D velocity model to provide more accurate travel times. We vindicate these refinements with several synthetic tests and an analysis of the 1997 M_w 7.2 Zirkuh (Iran) earthquake, which we show ruptured mainly unilaterally southwards at a rupture speed of ~3.0 km/s along its ~125 km-long, mostly single-stranded surface rupture. Then, we apply the new method to the more complex case of the 2016 M_w 7.8 Kaikōura (New Zealand) earthquake, which we demonstrate is divided into two major stages separated by a gap of ~8 s and ~30–40 km. The overall rupture speed is ~1.7 km/s and the overall duration is ~84 s, considerably shorter than some earlier estimates. We see no clear evidence for continuous failure of the subduction interface that underlies the known, surface-rupturing crustal faults, though we cannot rule out its involvement in the second major stage in the northern part of the rupture area. The late (~80 s) peak in relative energy is likely a high-frequency stopping phase, and the rupture appears to terminate southwest of the offshore Needles fault.

The second methodology is a novel workflow for earthquake detection and location, named Seismicity-Scanning based on Navigated Automatic Phase-picking (S-SNAP). By taking a cocktail approach that combines Source-Scanning, Kurtosis-based Phase picking and the Maximum Intersection location technique into a single integrated workflow, this new method is capable of delineating complex spatiotemporal distributions of seismicity. It is automatic, efficiently providing earthquake locations with high comprehensiveness and accuracy. We apply S-SNAP to a dataset recorded by a dense local seismic array during a hydraulic fracturing operation to test this novel approach and to demonstrate the effectiveness of S-SNAP in comparison to existing methods. Overall, S-SNAP found nearly four times as many high-quality events as a template-matching based catalogue. All events in the previous catalogue are identified with similar epicenter, depth and magnitude, while no false detections are found by visual inspection.