Non-repeatability effects on time-lapse elastic full-waveform inversion for VSP seismic data

Xin Fu*, Kris Innanen, Scott Keating, Qi Hu
xin.fu1@ucalgary.ca

Abstract

In this study, we investigate non-repeatability effects on time-lapse elastic full-waveform inversion for VSP (vertical seismic profile) seismic data. The non-repeatabilities tested are the non-repeatability on source locations, the non-repeatability on random noises, and the non-repeatability on the near-surface properties. Four time-lapse inversion strategies, including the parallel strategy, the sequential strategy, the double-difference strategy, and the common-model strategy, are applied in each type of non-repeatability. From the investigation, we can conclude: P-wave velocity changes can be better recovered than S-wave velocity changes; except for the double-difference strategy, the other three strategies have similar performance; the double-difference strategy also has similar performance to the others when acquisition geometries for baseline and monitor surveys are identical, but it is sensitive to the non-repeatability on source locations between twice surveys; no strategies can effectively handle the case of random noise; near-surface property changes have limit impact on the recovery of time-lapse changes for VSP data.

Introduction

However, successful time-lapse seismic monitoring depends on the repeatability between baseline and monitor surveys that can be affected by variations in weather conditions, source and receiver positions, environmental noises, source wavelets, seawater or near-surface properties, etc. In this study, we will investigate non-repeatability effects on time-lapse elastic full-waveform inversion for VSP seismic data. The non-repeatabilities tested will be the non-repeatability on source locations, the non-repeatability on random noises, and the non-repeatability on the near-surface properties. Four time-lapse inversion strategies, including the parallel strategy (PRS), the sequential strategy (SQS), the double-difference strategy (DDS), and the common-model strategy (CMS), will be applied in each type of non-repeatability.

Tested present time-lapse strategies

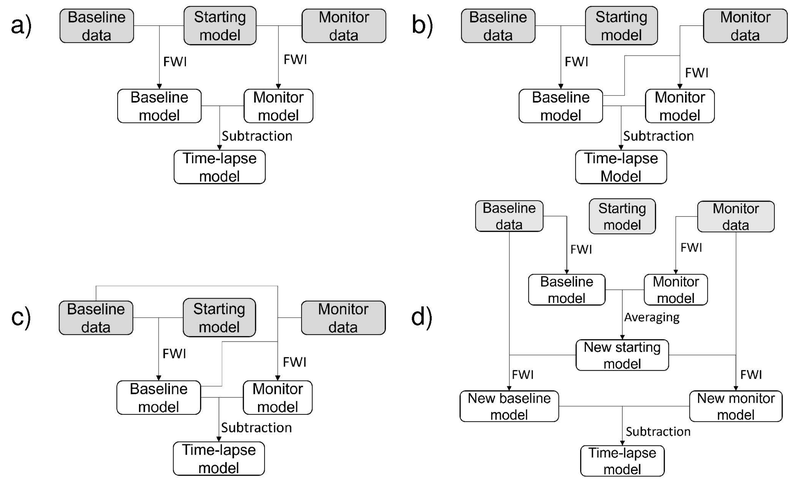

Figure: Workflows of (a) the parallel strategy (PRS), (b) the sequential strategy (SQS), (c) the double-difference strategy (DDS), and (d) the common-model strategy (CMS).

Results

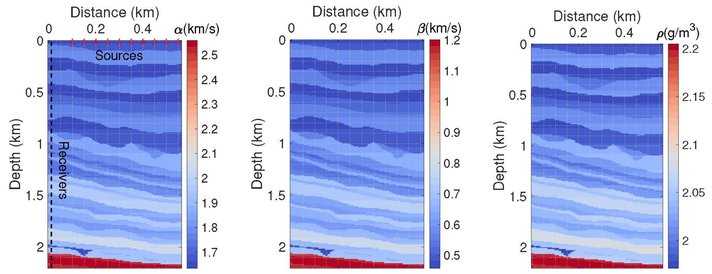

Figure: True baseline elastic models. The red stars and dash lines represent sources and receiver locations, respectively.

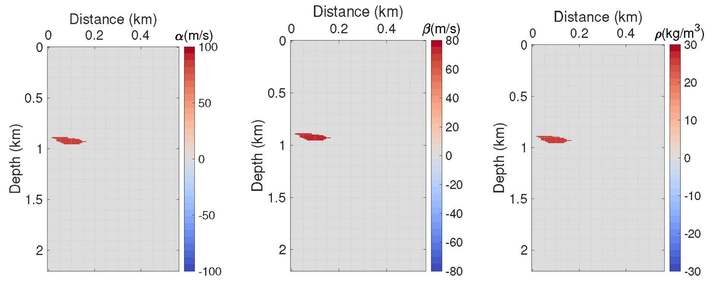

Figure: True time-lapse changes

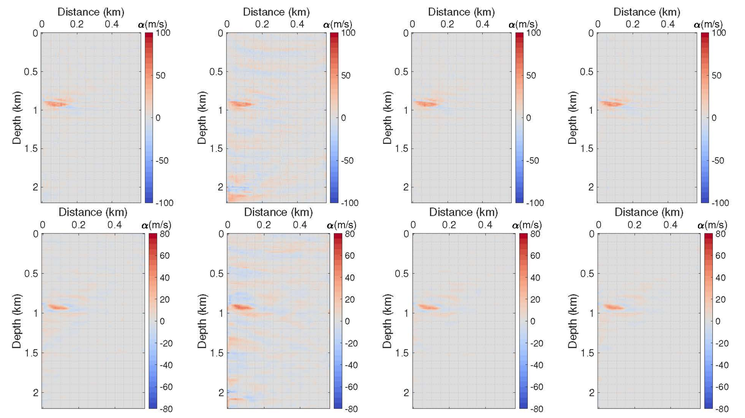

Figure: Inverted results of time-lapse changes in the case that baseline and monitor surveys are perfectly repeated. In each row, from left to right are the inverted changes of the PRS, the SQS, the DDS, and the CMS, respectively.

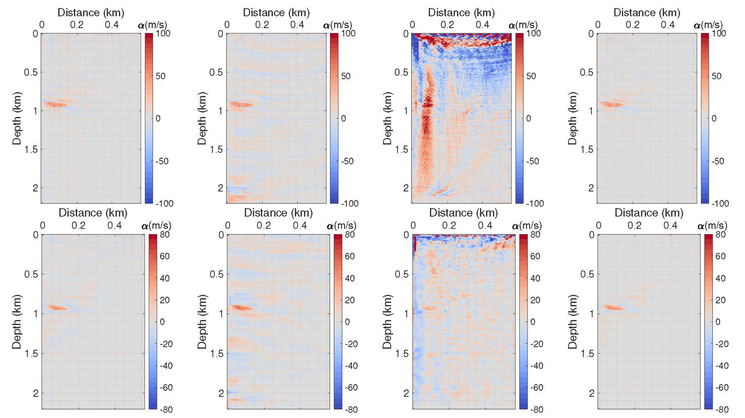

Figure: Inverted results in the case that the source locations of the monitor survey are set 20 meters to the right of the baseline survey. In each row, from left to right are the inverted changes of the PRS, the SQS, the DDS, and the CMS, respectively.

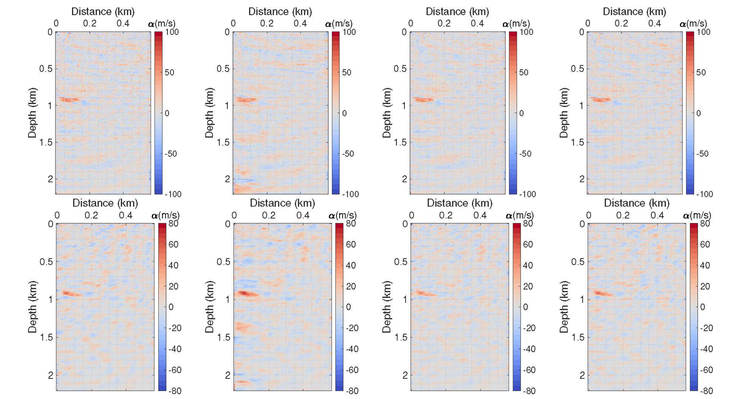

Figure: Inverted results of noisy data ($SNR = 20dB$) are added to baseline and monitor data, separately. In each row, from left to right are the inverted changes of the PRS, the SQS, the DDS, and the CMS, respectively.

ACKNOWLEDGEMENTS

We thank the sponsors of CREWES for continued support. This work was funded by CREWES industrial sponsors, NSERC (Natural Science and Engineering Research Council of Canada) through the grants CRDPJ 543578-19.