Monte-Carlo Statics on PSv data

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Summary

The calculation of surface-consistent residual statics on PSv data can be challenging. Conventional residual statics programs for PP data often create cycle-skipping due to the large magnitude of the shear wave statics. Methods which have been used to resolve the cycle-skipping issue have been based on linear inversions using either cross-correlation functions (Jin et al. 2004) or trace-to-trace coherence of the common receiver stack (Cary and Eaton, 1993). In converted wave processing, the combination of large magnitudes of the shear wave receiver statics and the high noise levels in the PSv data can still render these conventional approaches ineffective. This presentation will demonstrate that the Monte-Carlo approach using Simulated Annealing is proving to be effective in resolving PSv statics when the best results obtained using other methods contain cycle skips or lack continuity.

Introduction

The estimation of residual statics for PSv data is often based on linear inversion schemes that use cross-correlation functions (Jin et al. 2004) or the trace-to-trace coherence of the Common Receiver Stack section (Cary and Eaton, 1993). Le Meur et al. (2011) showed that estimating large magnitude residual statics on noisy data can be accomplished effectively with a Monte-Carlo approach using Simulated Annealing. In this paper, we demonstrate that the Monte-Carlo method with Simulated Annealing can resolve residual statics for PSv data despite the high levels of noise and shear wave receiver statics that are two to ten times the magnitude of the PP statics.

Method

The Monte-Carlo method with Simulated Annealing uses a cost function based on the stack coherence with robust criteria to stabilize the solution results (Le Meur and Merrer, 2006). The cooling schedule is computed as a function of the number of iterations and the initial temperature T0.   This temperature is determined during a pre-processing step of tens of iterations that precede the non-linear inversion. The whole process contains hundreds of simulations, each of which is randomly explored for all the shot points and receiver stations to avoid bias and cycle-skipping. For each shot or receiver selected, a static shift is randomly determined, and the cost function is re-calculated based on these shifts.   If the stack coherence increases the static shift is retained, otherwise the metropolis criteria is used to determine if it is kept (Vasudevan et al., 1991). One iteration is complete when random shifts for all sources and receivers have been tested. Several hundred iterations can be required to obtain the desired result such that there is no energy variation from one iteration to the next. (Le Meur et al. 2011).

Examples

We have a real data example from the North West Territories of Canada. The estimation of the PSv receiver statics are complicated by the structure in the area, which can be seen in the PP stack (Figure 1). Figures 2, 3, and 4 are comparisons of the common source point (CSP), common receiver point (CRP), and CCP stacks for the PSv data. Comparisons are done between sections where only the source statics from the PP data have been applied (Figures 2a, 3a, 4a), with added conventional receiver statics (Figures 2b,3b,4b), and with added PSv receiver statics calculated using the Monte-Carlo method (Figures 2c,3c,4c). The application of source statics from the PP data result in PSv stacks with little coherent data due to the high noise levels and large PSv receiver statics. The CRP stack easily shows variations of more than 100 ms over some sections of the line, with static shifts of 30 ms between some traces. The conventional statics do improve the stacks; however, there are still areas with poor or no continuity. The PSv stacks using the Monte-Carlo approach have much better continuity throughout, confirming that this method can resolve PSv receiver statics when other methods are not effective.
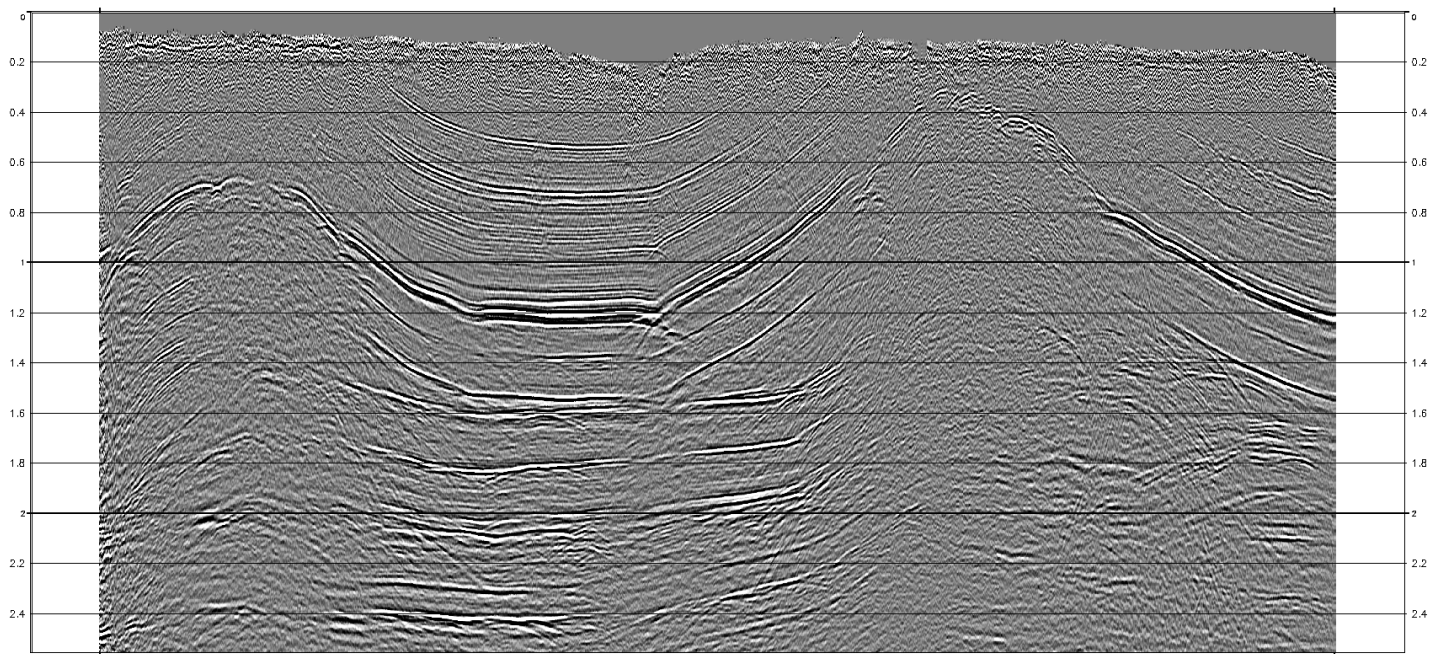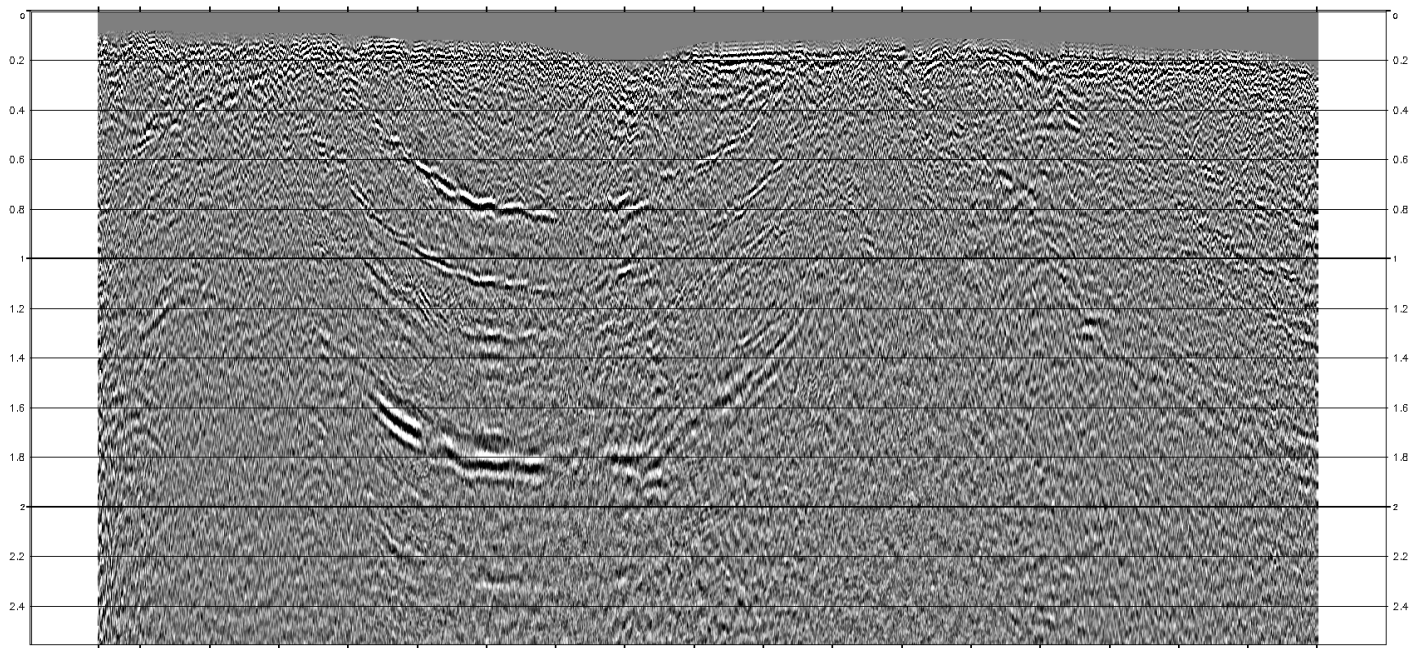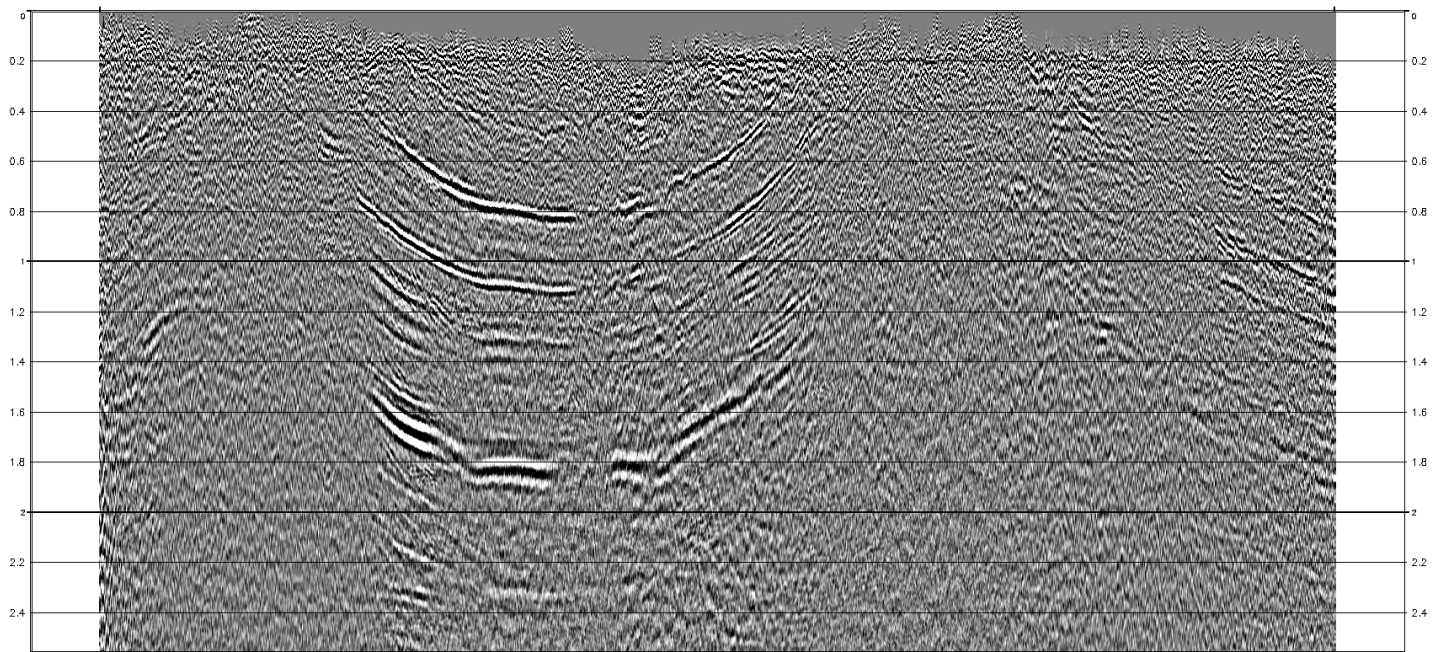

5 km

Figure 1: PP CMP stack

5 km

Figure 2a: PSv CCP stack with PP source statics

5 km

Figure 2b: PSv CCP stack with PP source statics and conventional PSv receiver statics.
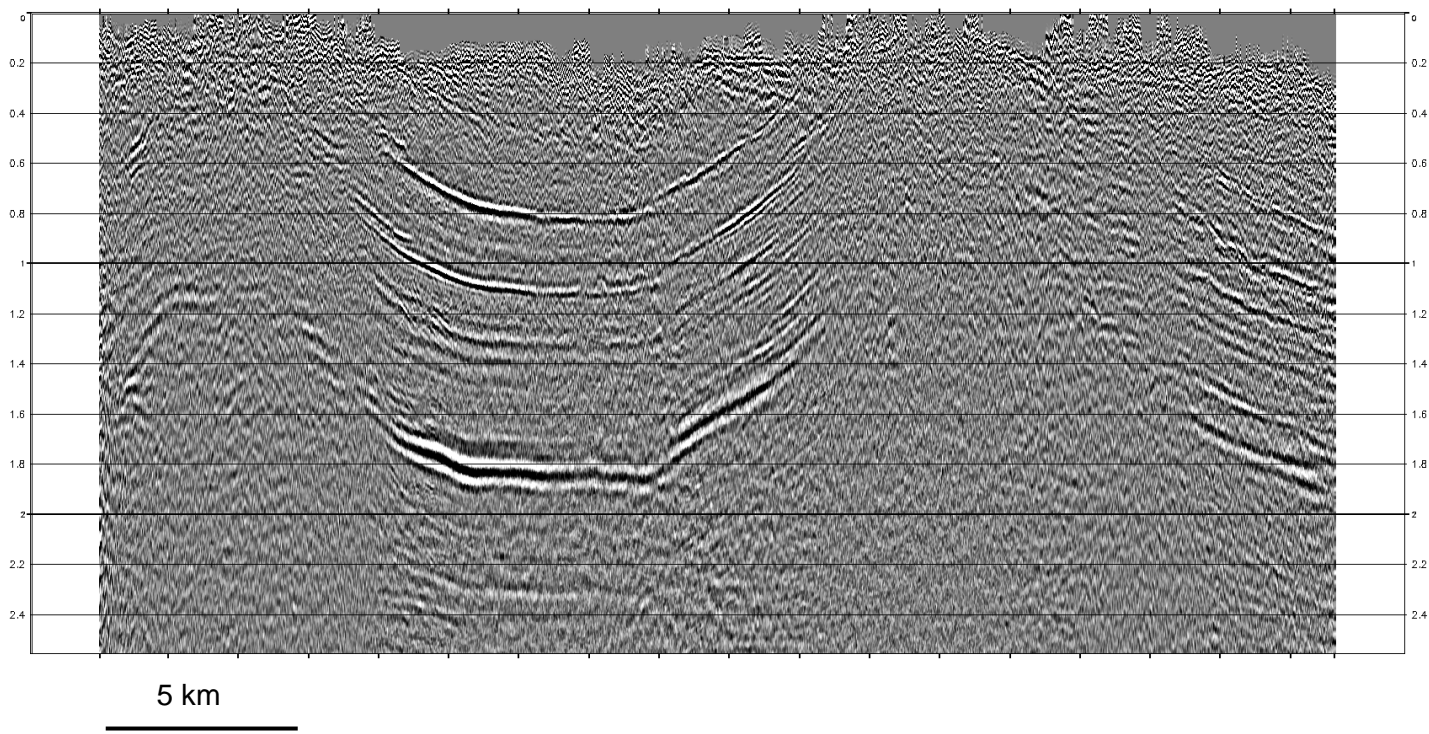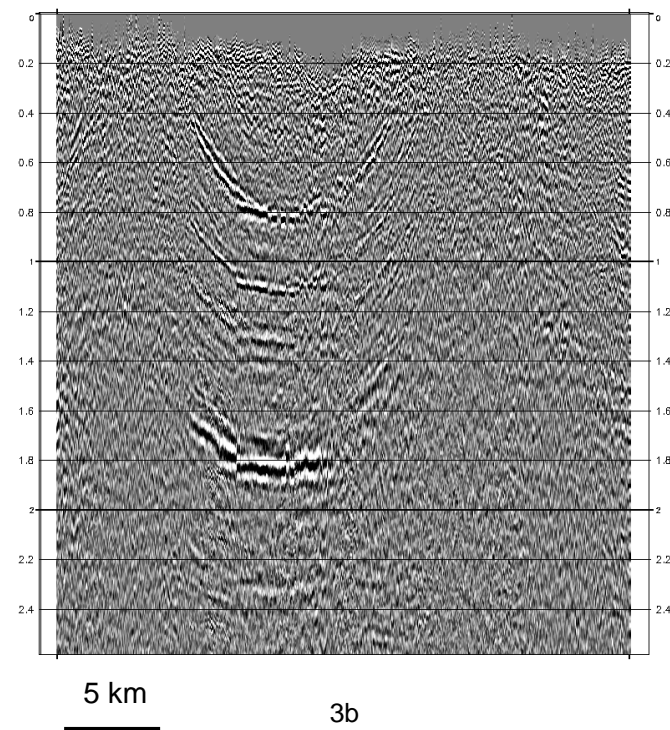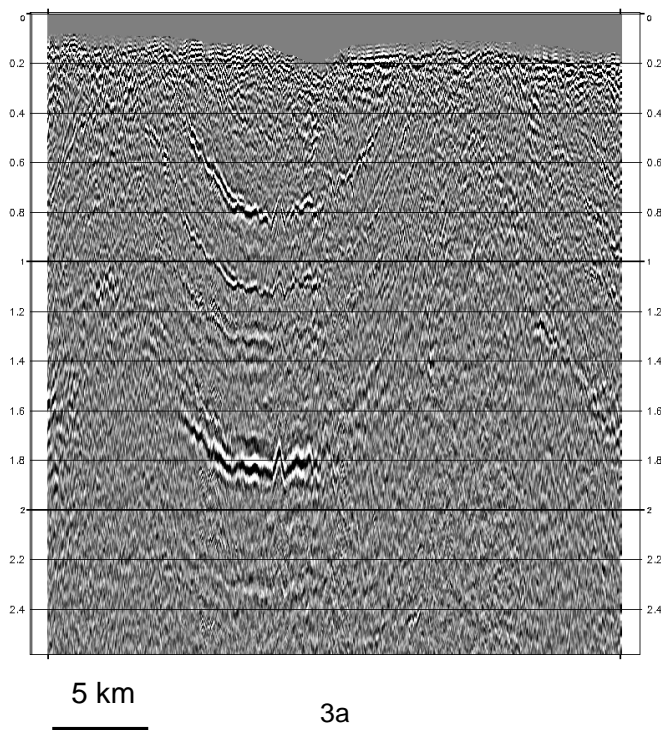
5 km

Figure 2c: PSv CCP stack with PP source statics and Monte-Carlo approach receiver statics.
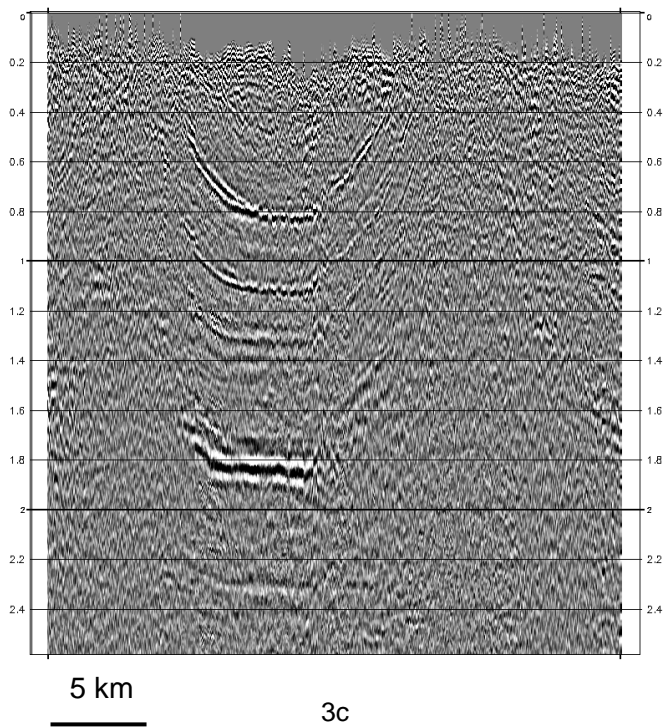

5 km

3a

5 km

3b

Figure 3: PSv CRP a) PP source statics

b) PP source statics, conventional receiver statics

c) PP source statics and Monte-Carlo approach receiver statics

5 km

3c

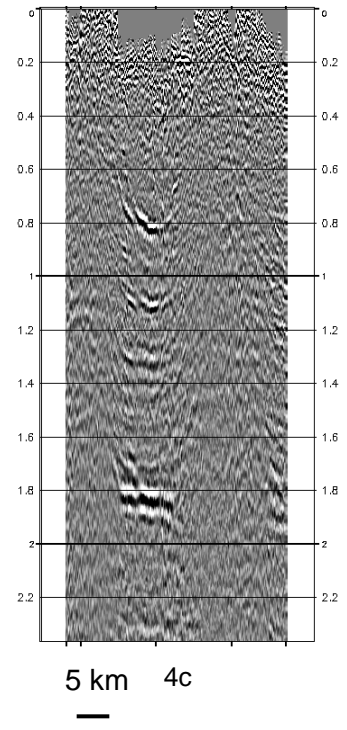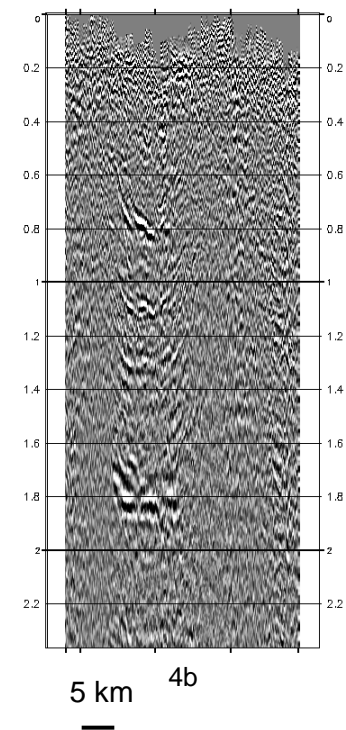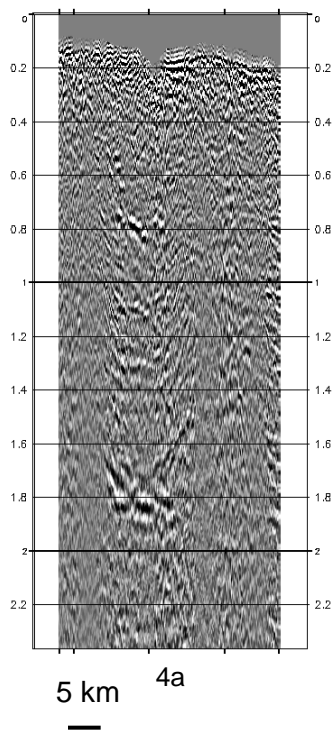5 km   4a

5 km   4b

5 km   4c

Figure 4: Psv CSP a) PP source statics   b) PP source statics and conventional PSv receiver statics

c) PP source statics Monte-Carlo approach PSv receiver statics

Conclusions

Noisy data, large residual statics, and structure all contribute to the difficulty of resolving the PSv residual receiver statics. Conventional linear inversion schemes partially resolve them, in this case resulting in statics up to 100 ms and still having areas with poor continuity in the resulting stacks. The non-linear nature of the Monte-Carlo approach using Simulated Annealing allowed the resolution of receiver statics up to 220 ms, creating stacks with much better continuity. This demonstrates that the Monte-Carlo approach using Simulated Annealing is effective in resolving PSv statics.

Acknowledgements

References

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