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Inversion-based deblending using Radon operators in common receiver gathers

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Abstract

We compare the denoising-based, and inversion-based methods for deblending in common receiver gathers using Radon operators. The inversion-based method treats blending interferences as a signal, and the transformation can model this signal in the Radon domain. Synthetic and field data examples show that the inversion-based approach can produce accurate separation.

Introduction

Blended seismic acquisition is becoming a more appropriate technique to increase seismic illumination of the subsurface without increasing survey cost. Moreover, blended acquisition can reduce the need for interpolating seismic sources. Furthermore, blended acquisition can introduce an added degree of freedom in survey design.

Methods

We can incorporate Radon transform into the deblending problem by using denoising-based or an inversion-based approach. The denoising-based method treats blending interferences as random noise in common receiver gathers and results in minimizing the cost function,

$$J = \|\widetilde{\mathbf{D}} - \mathbf{L}\,\mathbf{m}\|_1^1 + \mu\|\mathbf{m}\|_1^1, \quad (1)$$

On the other hand, the inversion-based method treats blending interferences as a signal by incorporating the blending operator into inversion,

$$J = \|\mathbf{b} - \boldsymbol{\Gamma}\mathbf{L}\mathbf{m}\|_1^1 + \mu\|\mathbf{m}\|_1^1, \quad (2)$$

where $\mathbf{L}$ and $\mathbf{m}$ are the Radon operator, and Radon model of all common receiver gathers, $\boldsymbol{\Gamma}$ is the blending operator, $\mathbf{b}$ is the blended data, and $\mathbf{D}$ is the separate shots data cube, and $\widetilde{\mathbf{D}}$ is the pseudo deblended data cube. Both cost functions are minimized using Iteratively Reweighted Least Squares (IRLS) algorithm (Trad2003, Ibrahim and Sacchi 2014).

Results

We test our deblending methods using a numerically blended synthetic and field data sets. The synthetic data were modeled using the finite-difference modeling of the marmousi model. The acquisition scenario represents two source boats firing near simultaneously. On the other hand, the field data is from the Gulf of Mexico, and it simulates a single source boat traveling with a speed of about four times the normal speed. In both examples, the source firing times are dithered (randomized) to make source interferences incoherent in common receiver gathers.

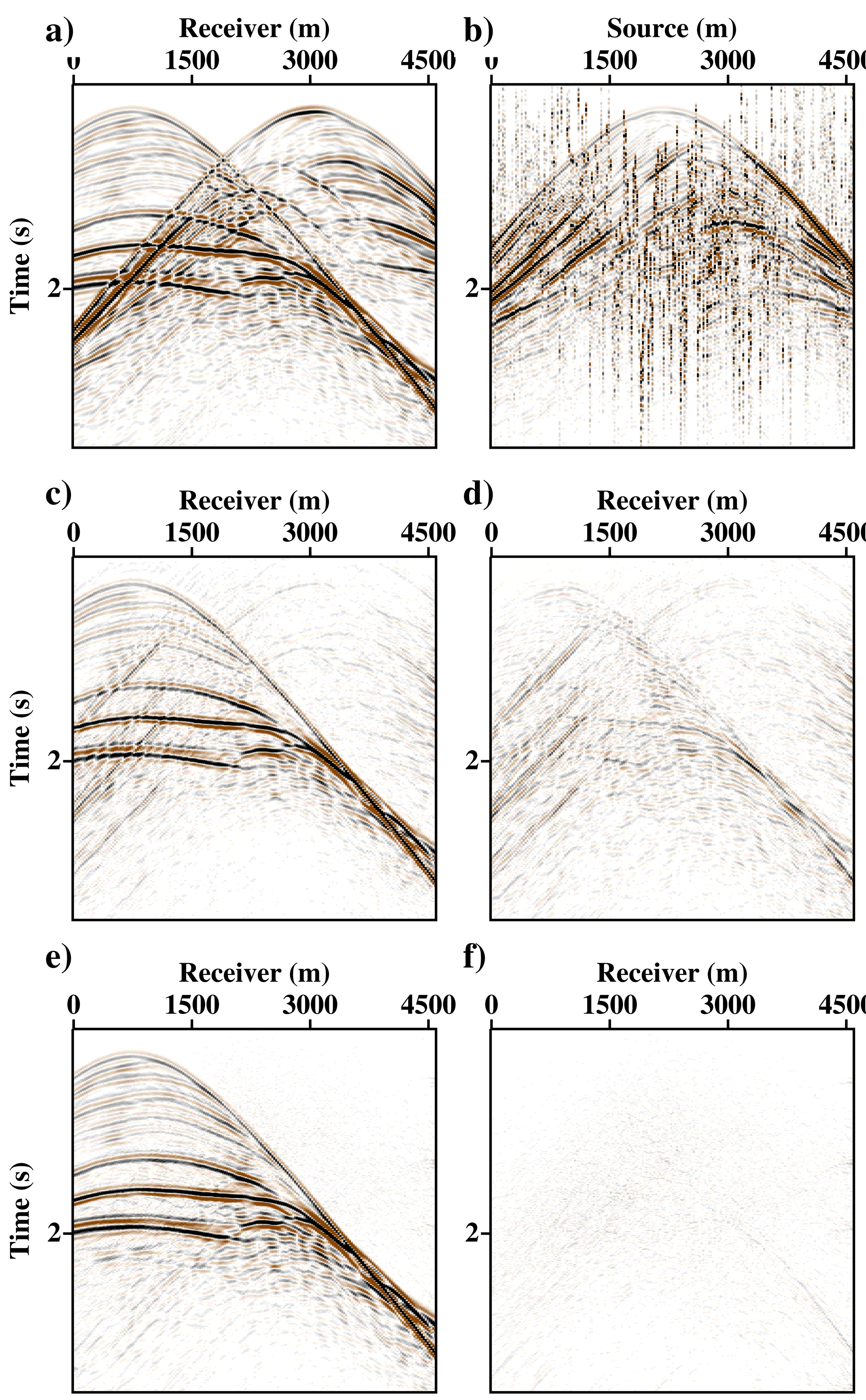

Figure: Marmousi data example. (a) Blended common shot gather (CSG). (b) Psuedo-deblended common receiver gather (CRG). (c) CSG deblended using denoising-based method. (d) Deblending error of denoising-based method. (e) CSG deblended using Inversion-based method. (f) Deblending error of inversion-based method.

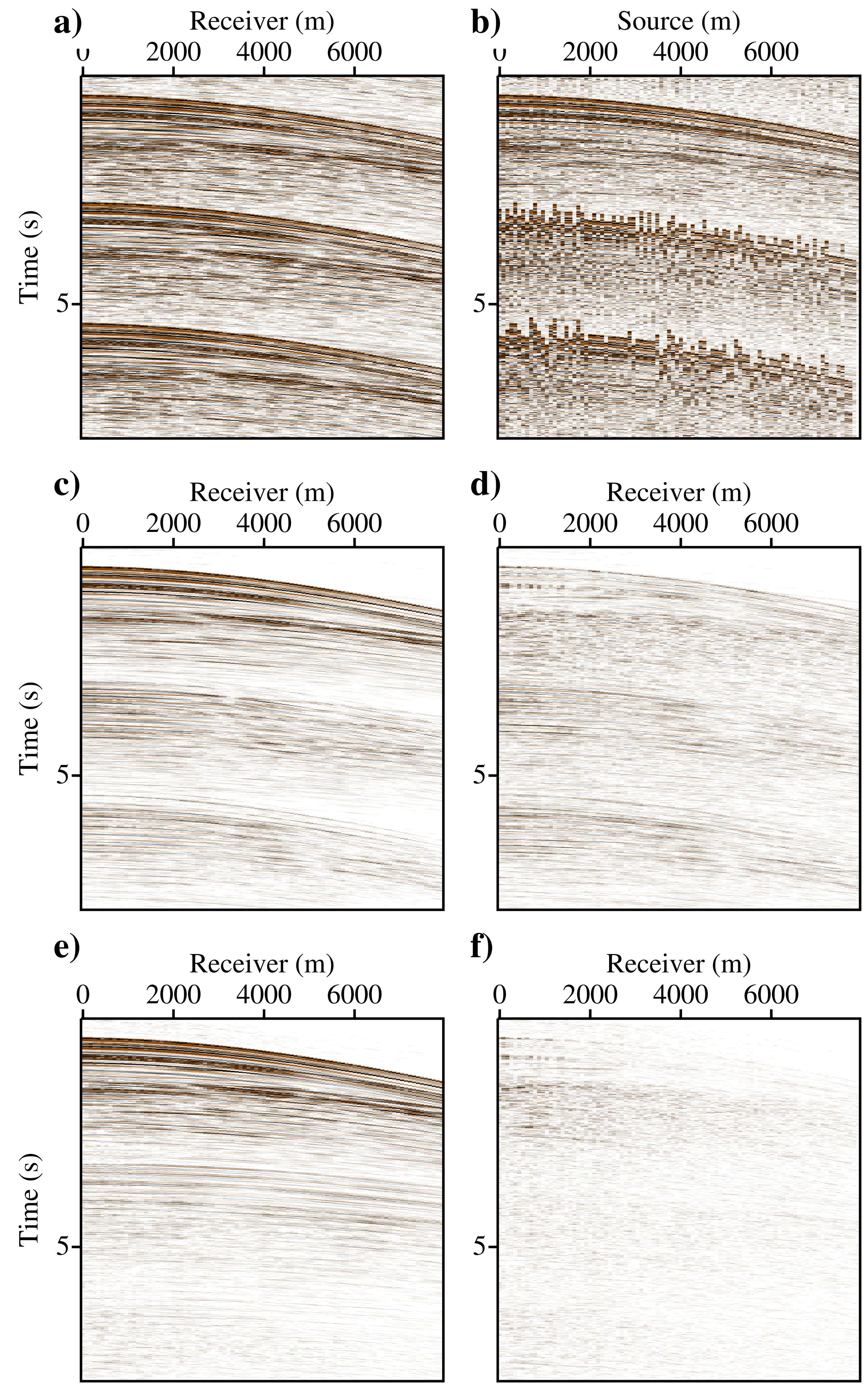

Figure: Gulf of Mexico data example. (a) Blended common shot gather (CSG). (b) Psuedo-deblended common receiver gather (CRG). (c) CSG deblended using denoising-based method. (d) Deblending error of denoising-based method. (e) CSG deblended using Inversion-based method. (f) Deblending error of inversion-based method.

Conclusions

We showed that the inversion-based approach is better in deblending, especially when operational constraints limit the dithering of the firing times. However, the inversion-based deblending require more computational resources since the blending operator is in the inversion cost function.

References

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