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Sparse inversion based deblending in CMP domain using Radon operators

Kai Zhuang*, Daniel Trad, and Amr Ibrahim
kzhuang@ucalgary.ca

Abstract

- Standard filtering based deblending suffers from limitations in removing noise without touching signal, especially in highly contaminated areas.
- Inversion based deblending is normally very resource-intensive especially using time domain apex shifted Radon.
- Frequency domain Radon suffers from aliasing issues that can be avoided in the time domain.
- We introduce inversion deblending in CMP domain to avoid the need to use an apex shifted operator, instead using a standard time domain hyperbolic operator.

Blending operator and inversion

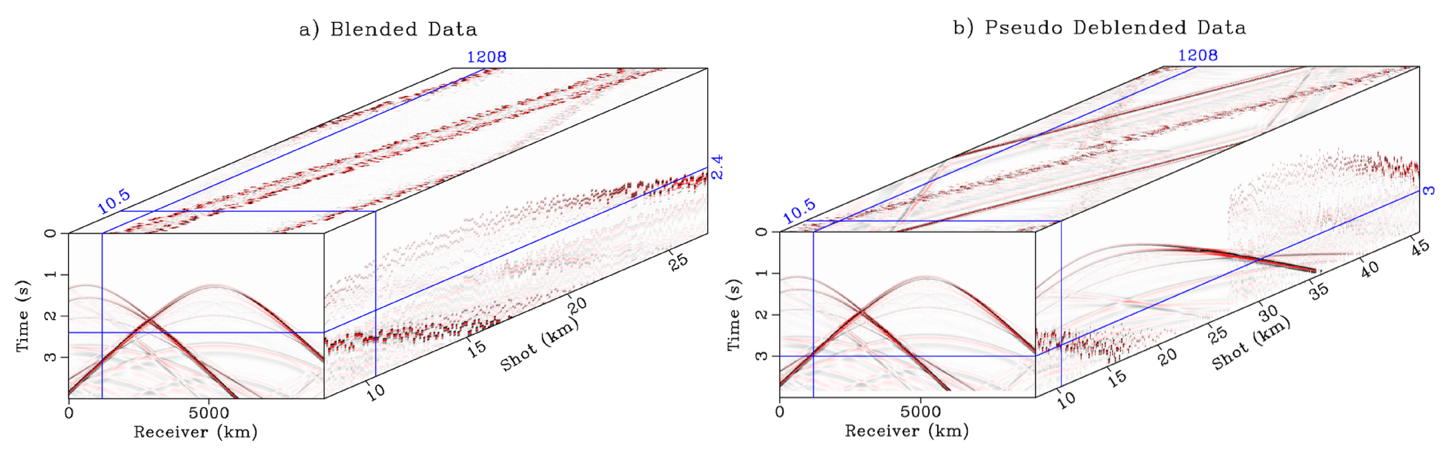

Figure 1: Blended vs pseudo deblended data: Blended data in a) and pseudo deblended data in b), it can be seen that the shots that belong to each coordinate set show up as coherent in other domains while shot interference shows up as dithered.

The blending operator and survey design are essential to the separation quality of blended data, where the random shot delay times are essential to separation of the blended data (Berkhout 2008). By posing the blending operator with the Radon operator in a inversion scheme we can seek to refit the blended data and preserve all events. The combined operator can be posed as

$$\mathbf{L} = \mathbf{\Gamma R}, \tag{1}$$

where the adjoint is represented by

$$\mathbf{L}^H = (\mathbf{\Gamma R})^H, \quad \mathbf{L}^H = \mathbf{R}^H \mathbf{\Gamma}^H. \tag{2}$$

Then placed in the inversion objective function:

$$||\mathbf{d} - \mathbf{Lm}||_p^p + \mu||\mathbf{m}||_q^q, \quad \text{where } \mathbf{L} = \mathbf{\Gamma R}, \mathbf{d} = \mathbf{D_{bl}}, \quad \text{giving us } ||\mathbf{D_{bl}} - \mathbf{\Gamma R m}||_p^p + \mu||\mathbf{m}||_q^q. \tag{3}$$

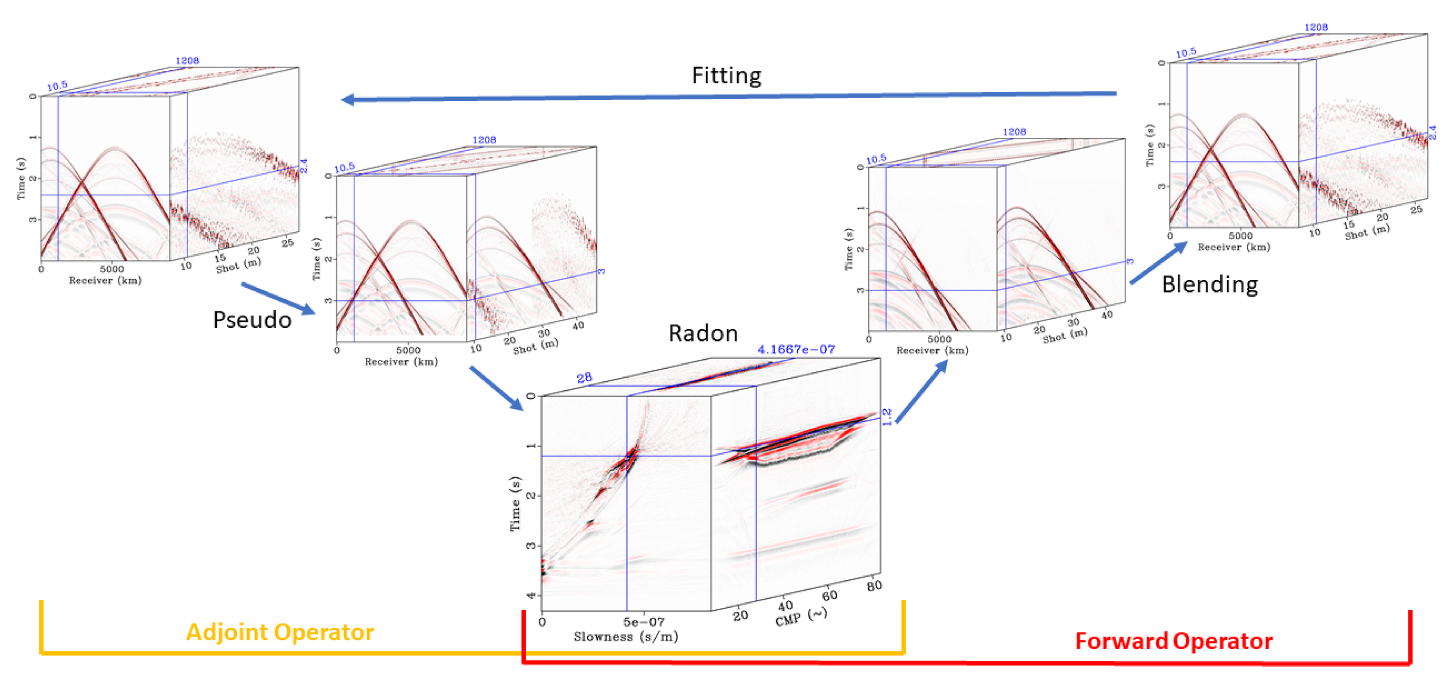

Figure 2: Illustration of the Blending operator. Where the unblended source is blended using the blending operator to output the blended data set.

Example 1

The deblending algorithm was tested with both a wedge model examples as well as a Gulf of Mexico real-world data set. The first examples contain the synthetic wedge model results.

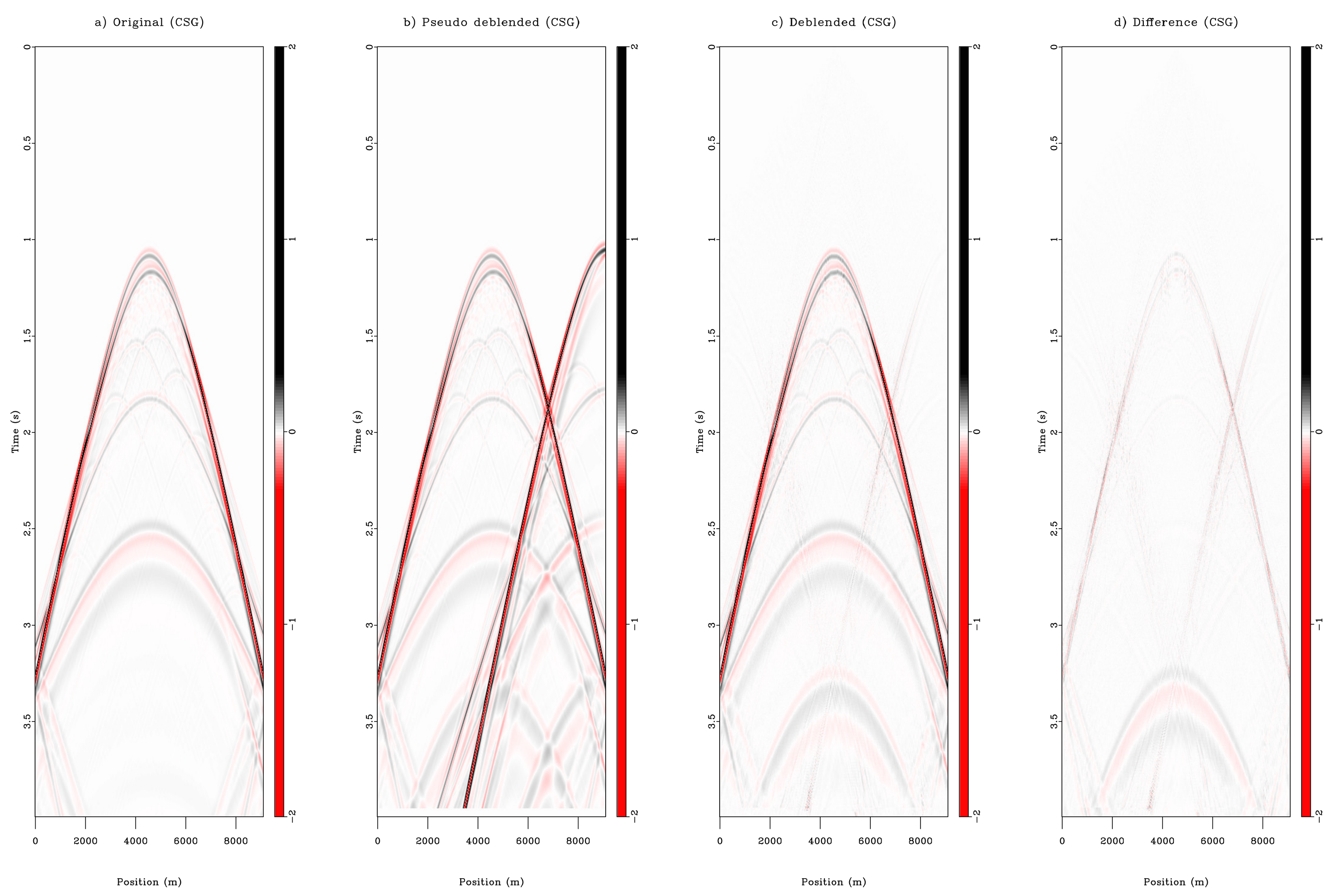

Figure 3: Wedge model results: Deblending of a two simultaneous source survey with a) unblended data, b) pseudo-deblended data, c) deblended data, and d) difference respectively.

The wedge model is created using a two-layer model with a wedge added between the two layers. A set of diffractors were also added to the model to introduce diffractions into the dataset for testing of the CMP radon model. The results show that the deblending was effective at removing the interfering signal while preserving low amplitude events covered by the blending noise.

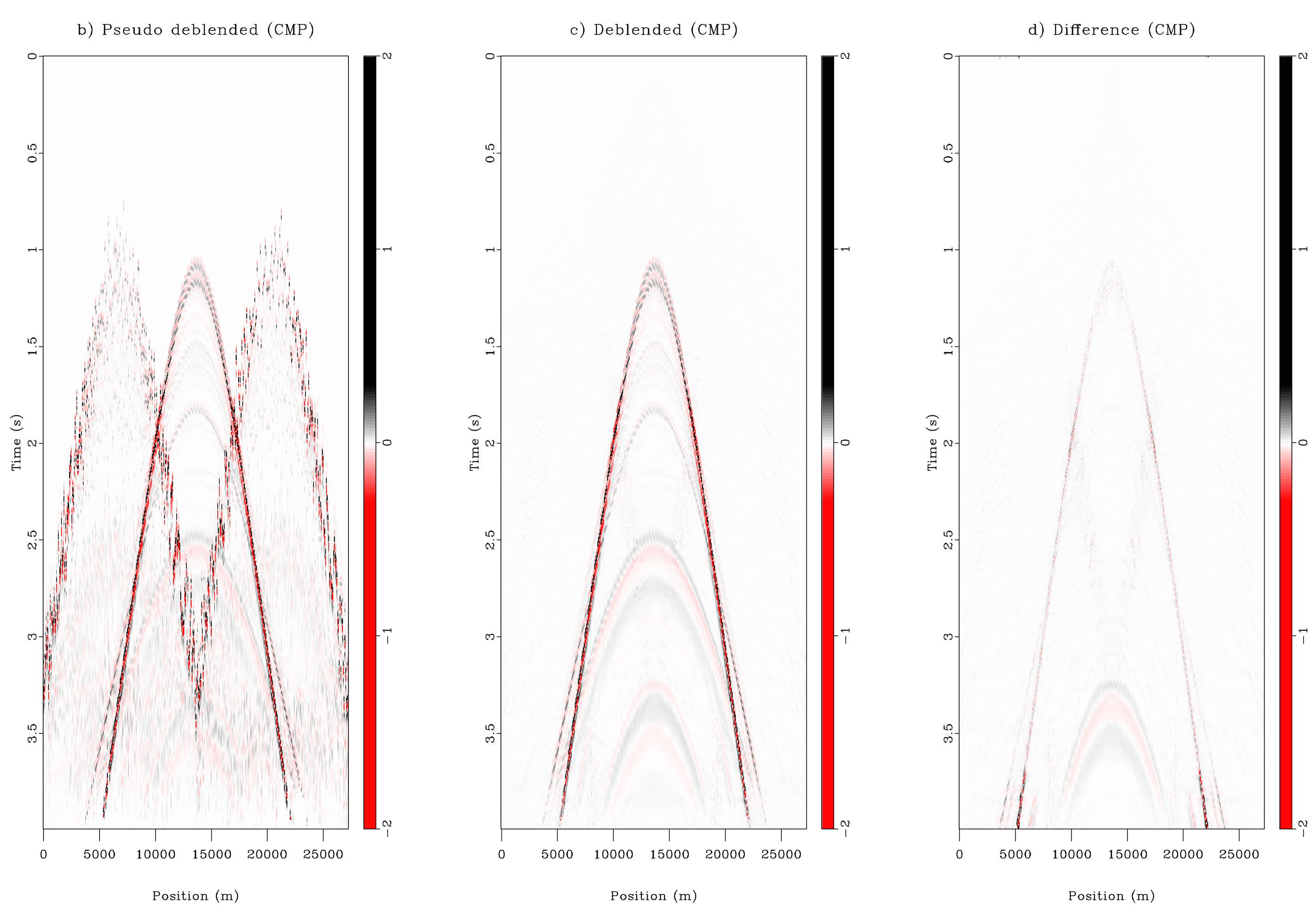

Figure 4: Wedge model results in CMP: Deblending of a two simultanious source survey in CMP domain with a) unblended data, b) pseudo-deblended data, c) deblended data, and d) differnce respectively.

Example 2

The Gulf of Mexico data serves as a real-world test of the deblending in the CMP domain, the shots were numerically blended with a 70% firing time overlap.

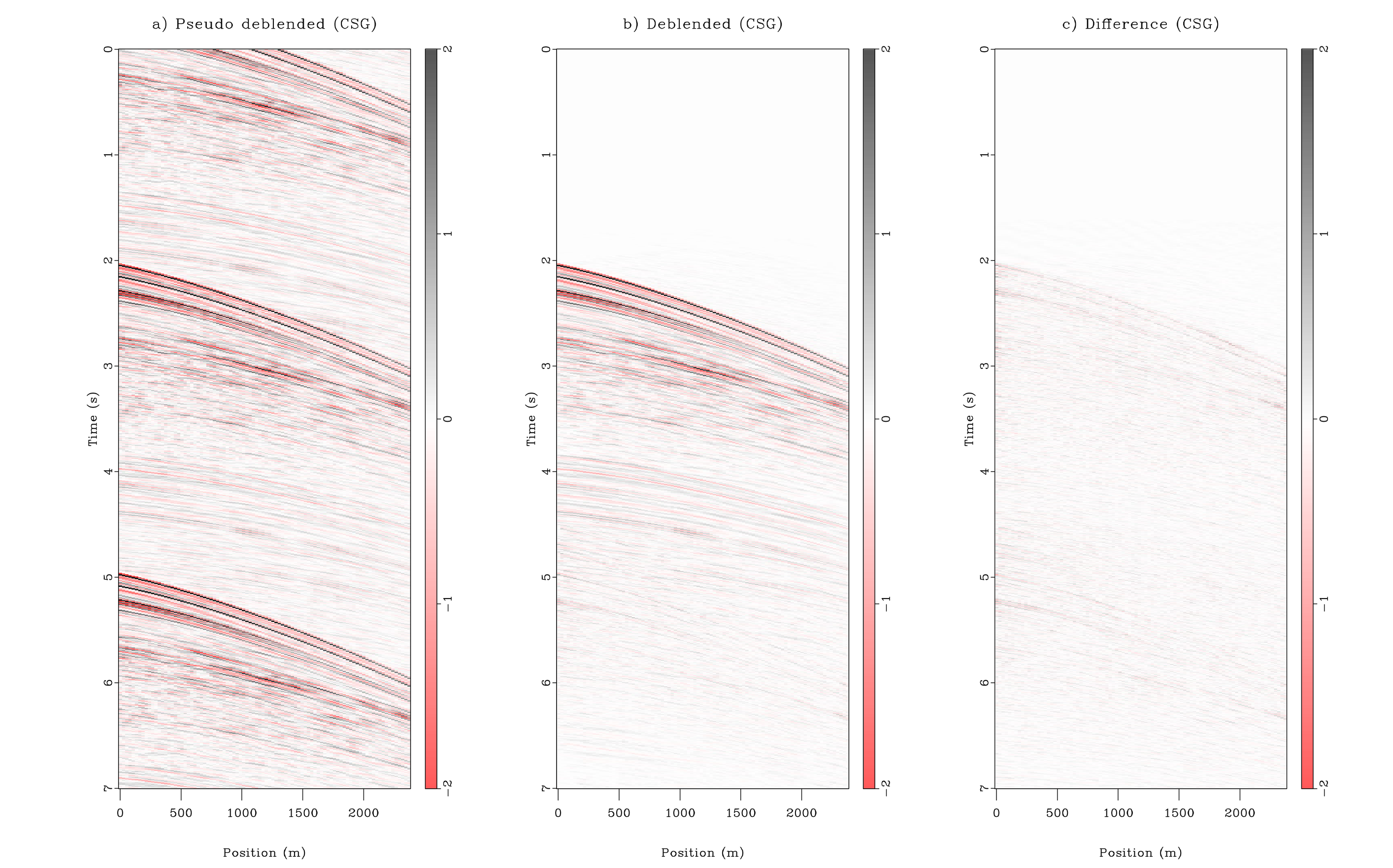

Figure 5: Gulf of Mexico data: Deblending using a gulf of Mexico marine dataset with an shot time interference of 70%, with Blended data in a), deblended in b), and difference in c).

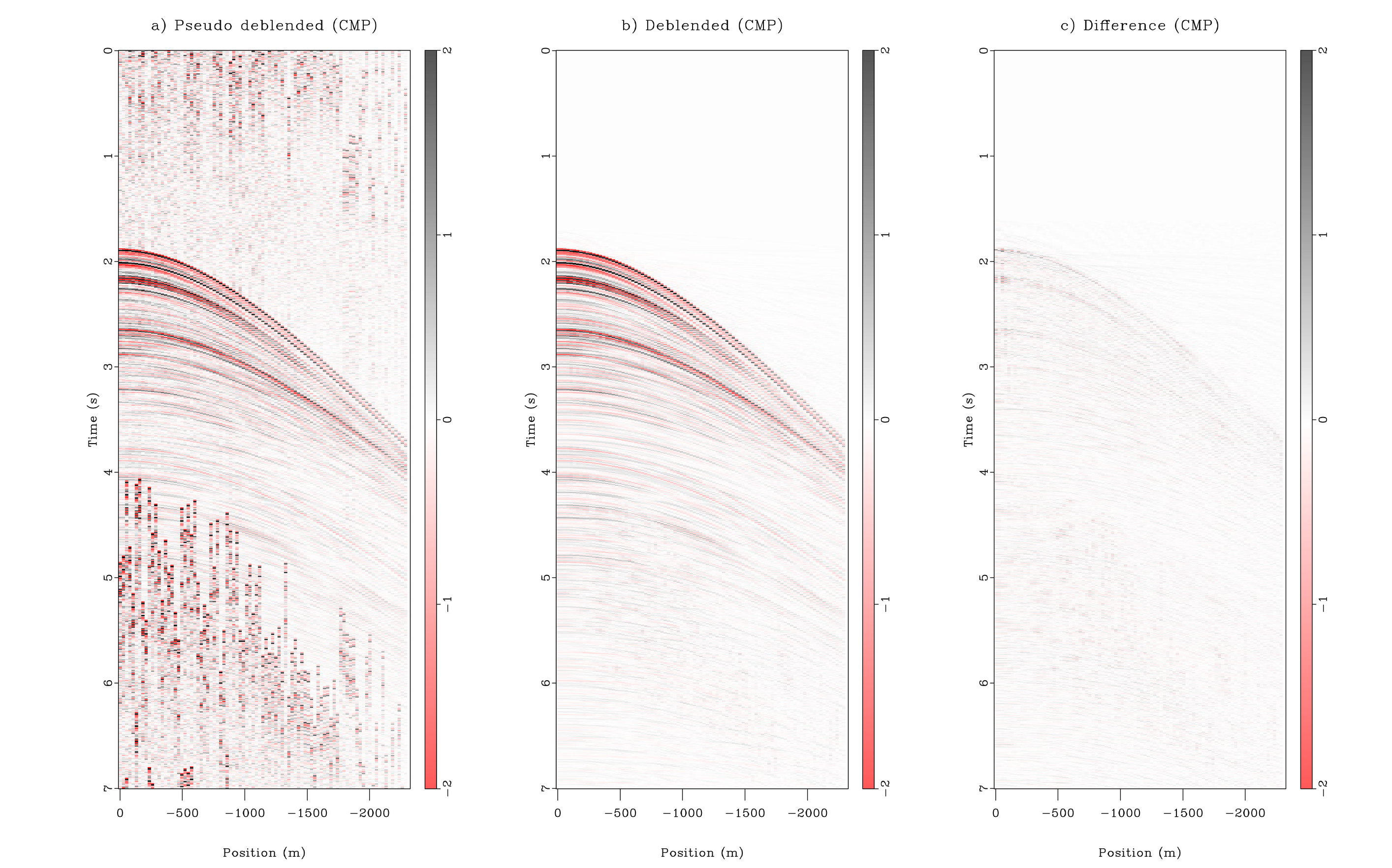

Figure 6: Gulf of Mexico data in CMP domain: Deblending using a gulf of Mexico marine dataset with results in the CMP domain, with Blended data in a), deblended in b), and difference in c).

Conclusions

- Inversion based deblending is more resource-intensive than filtering based deblending but is often better at recovering events that are buried by blending noise (source interference).
- CMP domain deblending allows the use of a less complex hyperbolic Radon operator.

Acknowledgments

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References

- A. J. Berkhout., (2008) *Changing the mindset in seismic data acquisition* The Leading Edge, 27, No. 7, 924-938.

For a list of all references please view the accompanying paper.

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