A Madagascar package for deblending in multiple flavours

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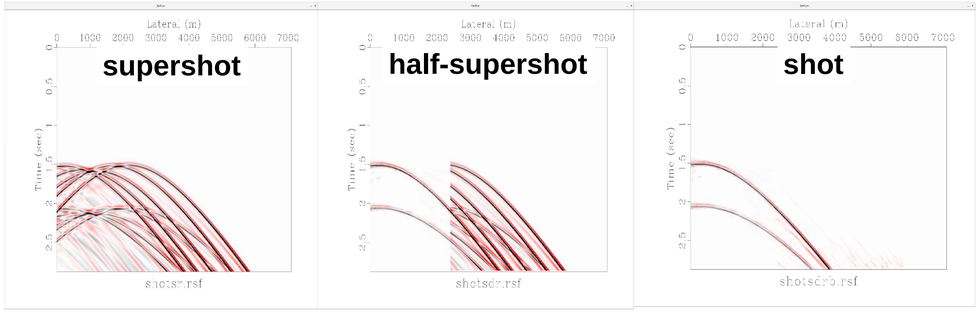
Efforts to reduce data acquisition costs usually involve either interpolation or blending.
Interpolation creates new traces from the acquired samples by using sparse transformations.
Blending, acquires more data in less time by recording several shots simultaneously.

The processing of the resulting seismic data requires either :
1) shot separation very early in the signal processing chain or
2) development of new processing/inversion capabilities that can work directly with blended data.

Considering 1), there are three main approaches: denoising, inversion, physical transforms.

Deblending by pseudo-deblending + denoising techniques:



original blended | **One third of groups (cmp/rcvr) filtered** | **All groups (cmp/rcvr) gathers filtered**

p = 1 Robust data fitting
q = 1 Sparse transform

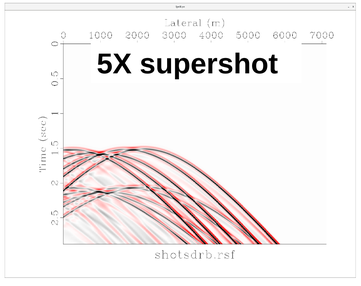
$$J = \|\tilde{\mathbf{D}} - \mathbf{L}\,\mathbf{m}\|_p^p + \mu\|\mathbf{m}\|_q^q,$$

Individual inversion on each cmp/receiver gather

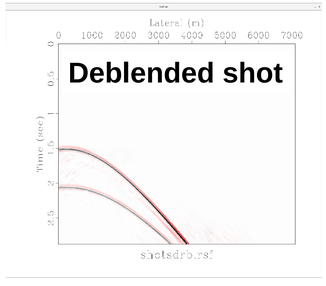
Increasing number of receiver gathers being filtered

Denoising: data are decomposed in groups, each one showing only one of the shots as coherent energy and the others as incoherent. This is usually achieved by pseudo-deblending, which does not separate the shots but makes them distinguishable. A robust data-fitting and sparse transform are required.

Deblending by LS inversion in receiver gathers (High-Res TD Radon Transform)



Blended data fitted by simultaneous models. Deblending occurs by predicting groups (cmps/receivers) from individual models



p = 2
q = 1

$$J = \|\mathbf{b} - \Gamma L \mathbf{m}\|_2^2 + \mu\|\mathbf{m}\|_1^1,$$

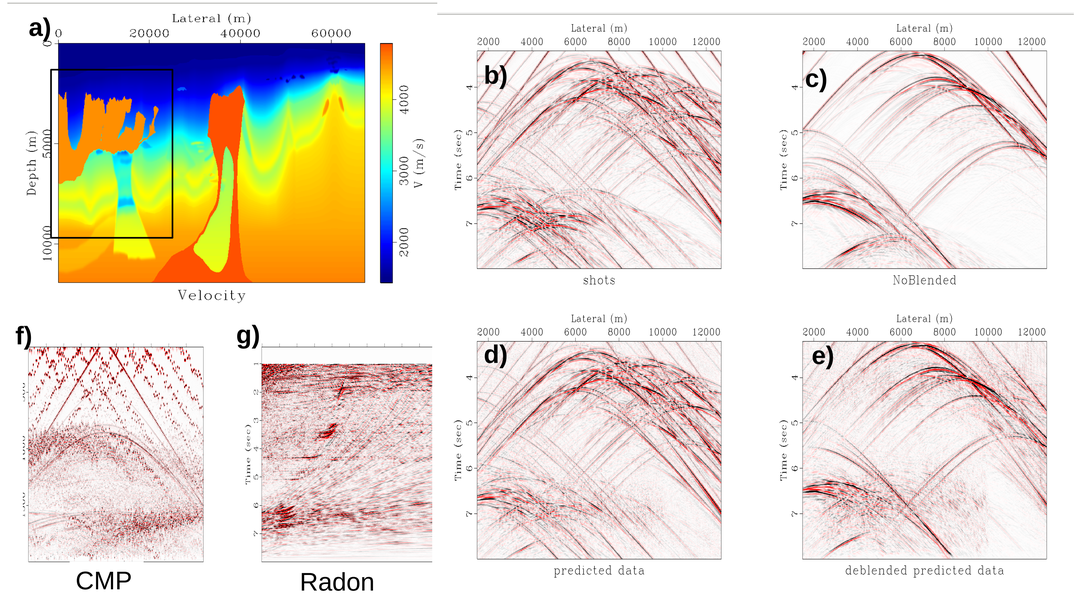
Simultaneous inversion of all blended data

All receiver gathers deblended at once

L Time domain Radon operator
r Pseudo-Deblending operator.

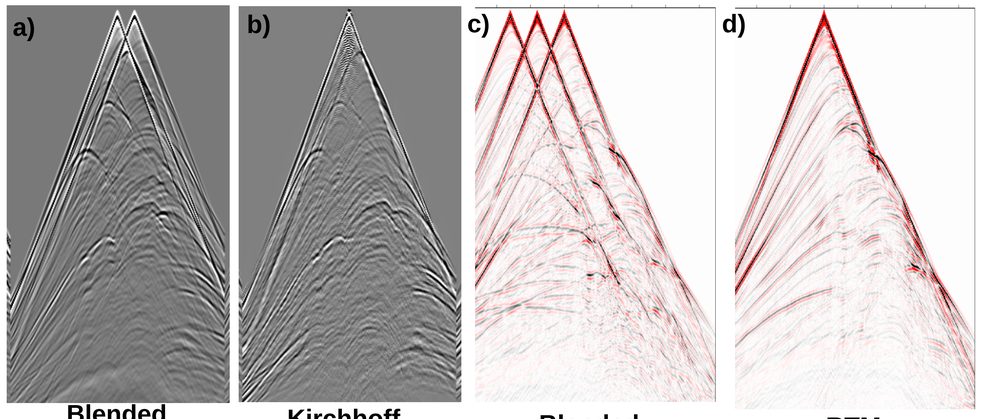
b blended data
m Radon transform (multiple panels)

Inversion: data are pseudo-deblended to groups like before, but all groups are simultaneously inverted to a transform space with a suitable operator. These groups are all fitted (predicted) by the combination of transform panels. This is a true parallel transform design, where shots are predicted simultaneously. Sparse transforms are still required, but no need for robust data fitting.



Example of deblending by inversion in a difficult data set. Although a hyperbolic Radon transform was used for all these examples, a more flexible transform may be necessary in complex cases. a) velocity, b) 5x supershot (blended), c) never-blended shot d) result of data fitting e) deblended shot, f) A pseudo-deblended CMP, g) Radon transform subpanel of f).

Deblended shots with migration/demigration



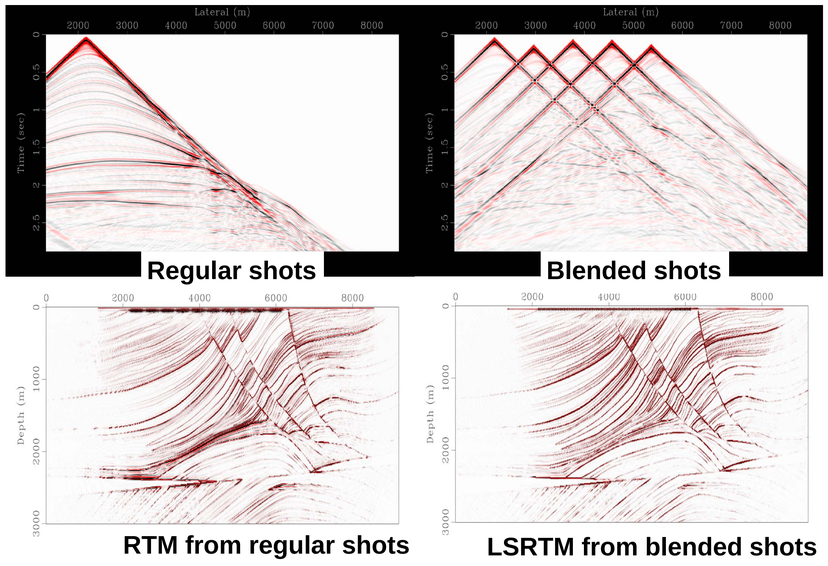
Blended shots (FD) | **Kirchhoff deblended** | **Blended shots (FD)** | **RTM deblended**

Physical transforms: use physics to map the blended data to the subsurface physical model. Once the model is built, shots can be predicted in the deblended (extended) space. a) 2x supershot b) deblended by Kirchhoff depth migration, c) 3xsupershot, d) deblended by RTM

Imaging blended data directly

It is possible to migrate blended data directly without deblending. This requires a good velocity model, which at the moment can't be obtained without deblending.
Also it requires a pre-processing which is not easy to do directly in blended data.

Hybrid approaches are possible, where the deblended data are only an intermediate step to acquire information but not used in the final image.



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