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Migration and demigration deblending in receiver domain

Ziguang Su* and Daniel Trad*

ziguang.su1@ucalgary.ca

Abstract

In some important cases, for example, ocean bottom node surveys(OBN), seismic acquisitions have more sources than receivers. This brings the need to develop processing and inversion techniques that work more efficiently in the receiver domain. After exchanging source and receiver location, receiver domain Reverse Time Migration (RTM) can save significant computation time compared with shot domain RTM. This problem is also interesting because some deblending techniques exploit incoherence in the receiver domain created by time delays in the shot domain to separate simultaneous sources. In this report, we investigate receiver domain RTM for both migration of regular surveys and its possible use for the deblending of simultaneous sources.

Introduction

Land surveys normally have more receivers than shots because shots are more expensive. Sometimes when needed, if converted waves are of no interest, processors assume reciprocity and create shots from the receivers. Similarly, marine streamer surveys tend to have more receivers than shots since adding more receivers to the streamer has a very small additional cost. Techniques like RTM are a good fit for these cases because of two reasons: first, each shot is a different physical experiment and can be handled naturally by the non-homogeneous wave equation; second, the computational cost is linearly proportional to the number of shots, imaging more receivers is practically free. But for some types of surveys like ocean bottom node acquisition (Zhang et al., 2013), the situation is completely reverse. Nodes are significantly more expensive than shots and are therefore located far from each other, as shown in Figure below.

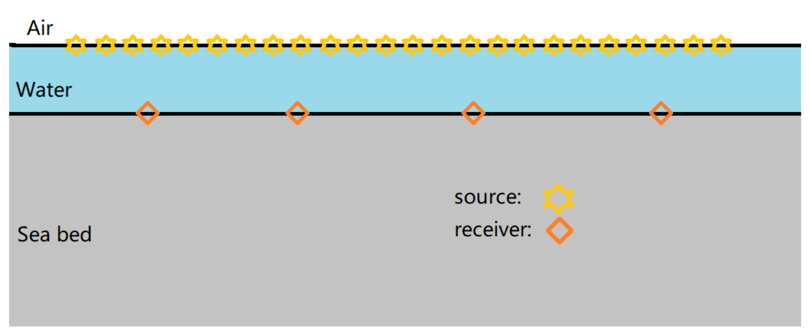

Figure: Ocean bottom node acquisition has more shots than receivers

This brings many different issues for processing and migration. First of all, the coarse sampling in the receiver domain is far larger than the coarse sampling of shots in other surveys. Nodes can be located a few hundred meters from each other, and illumination in the shallow layers under the ocean are barely illuminated. It is in this scenario that the reciprocity principle becomes very important.

Several variants of node processing have been suggested over the years. For example, often the first multiple of the data (receiver ghost) is processed and migrated instead of the primaries. Interpolation of nodes has often being attempted although with mild success only. This is particularly difficult because of time-variant midpoints due to different elevations. This problem is often addressed by some sort of datuming, which has its own difficulties due again to sampling. For PS waves, which are often the main goal of OBN surveys, the migration of multiples is not possible (S waves do not travel in water). Interpolation of PS waves is even harder because time-variant midpoints are produced by two factors, different elevations, and non-specular PS reflection angles. A large list of challenges for OBN surveys awaits to be solved.

In this report, we start investigating this list of interest for OBN surveys with two related problems. First, we address RTM in the receiver domain with the sole purpose of saving computation time. We are aware this is probably already solved done in industrial settings but nonetheless, we will discuss it briefly. Second, we investigate how to deblend shots from the receiver gathers using migration/demigration techniques. Since nodes are fixed, the cost of OBN can be substantially reduced if many ships can fire simultaneously, creating dense shot carpets. We do not assume that migration/demigration techniques are the best option to deblend OBN surveys but we believe it is an interesting option since the complexity of OBN data may be naturally handled by Green functions as opposed to parametric transforms like Fourier or Radon transforms.

Method

RTM in the receiver domain

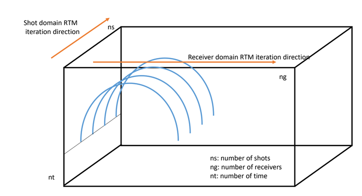

Figure: Number of iteration for shot domain RTM and receiver domain RTM

Results

Unblended acquisition in two-layer model

For unblended acquisition, there should not be difference between shot domain RTM and receiver domain RTM. We test this with a two-layered velocity model, with a geometry 97 sources and 5 receivers evenly distributed on the top of the surface. We used a 4th-order finite-difference method for the wave propagation.

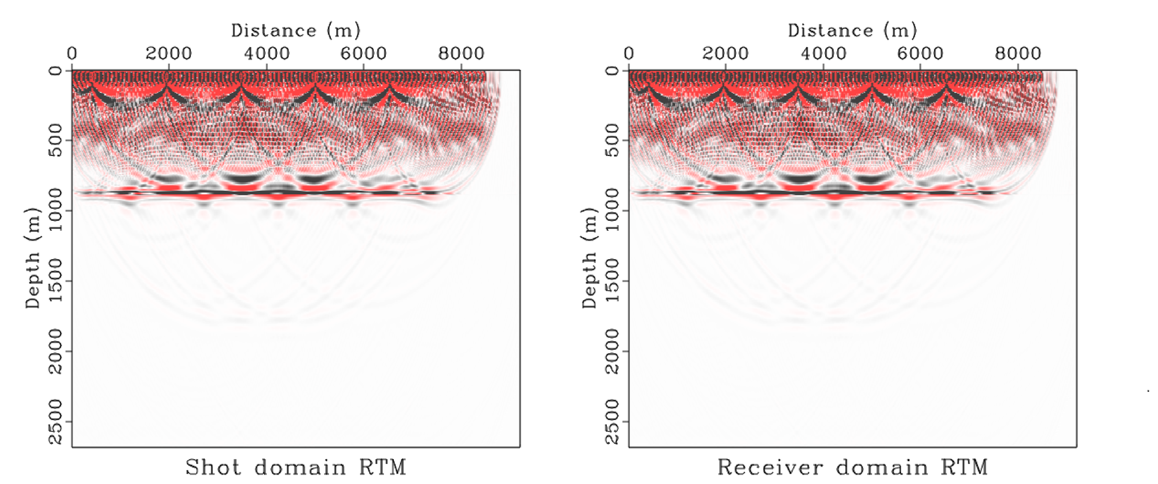

Figure: Results of shot domain RTM and receiver domain RTM for a two-layer model

Blended acquisition in two-layer model

Simultaneous sources are simulated with 4 shots per supershot. We use five receivers on the surface.

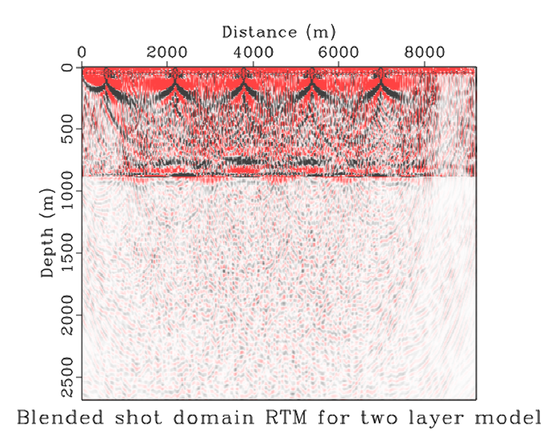

Figure: Shot domain RTM from blended data

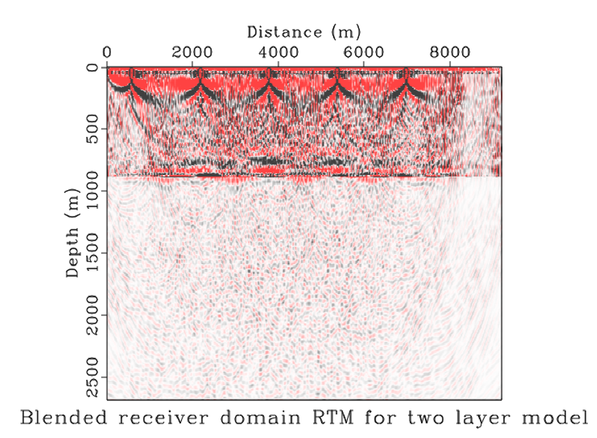

Figure: Receiver domain RTM from blended data

Results

Blended acquisition in marmousi model

We add a water layer on top of the Marmousi model to simulate an OBN survey, generate with finite differences 4th order and migrate the data with RTM in the two domains. Similar to the acquisition system in two-layered model, 95×4 shots and 5 receivers are distributed evenly on the water surface. The results of shot and receiver domain RTM are shown below.

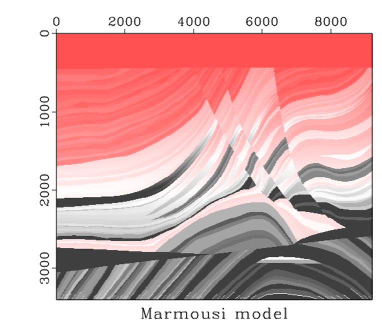

Figure: Marmousi model with water layer on the top

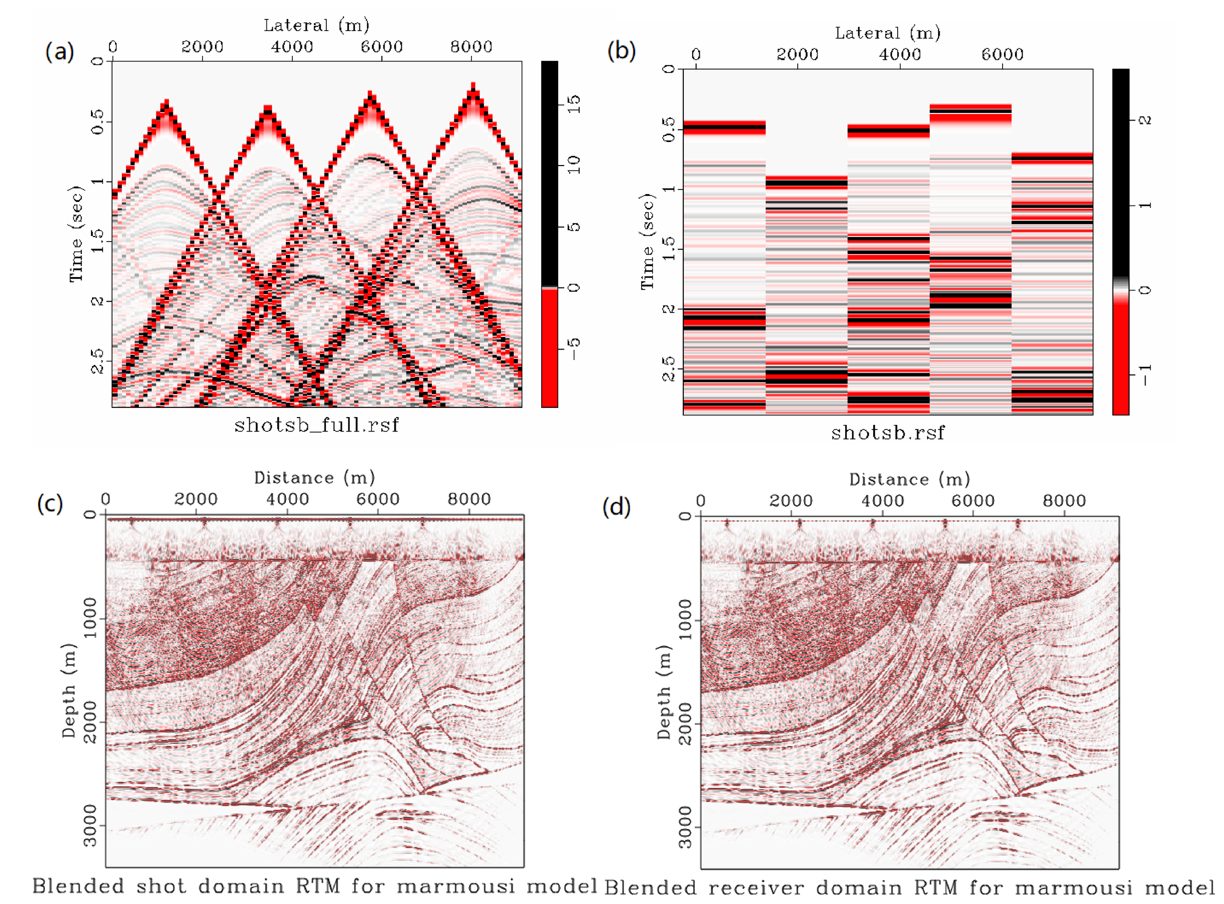

Figure: (a) is the blended shot in a shot domain, (b) is the blended shot record in a receiver domain, (c) is the result of shot domain RTM from blended data and (d) is the result of receiver domain RTM from blended data

Conclusions

Most acquisitions have more shots than receivers except for the important case of OBN. Shot domain RTM is efficient and natural for the first case, but receiver domain RTM is for OBN. We use the reciprocity principle for PP data, but not yet considered the PS case. When using simultaneous sources acquisition with time dithering, there are a few different approaches that can be taken. We have only considered one of them.

References

Zhang, Q., Abma, R., and Ahmed, I., (2013) A marine node simultaneous source acquisition trial at atlantis, gulf of mexico. *Journal of Geophysics and Engineering* , 99–103.

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UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Geoscience