Optimizing 3D SRME on Wide Azimuth Data

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Abstract

We discuss how to optimize our 3D SRME method to take advantage of wide azimuth (WAZ) data, while overcoming challenges posed by the data. Compared to narrow azimuth data, the main advantage of WAZ data is the wider distribution of azimuth angles. The challenge is how to handle the larger source separation and the lack of near offsets. We use a real WAZ dataset to show that the optimized 3D SRME algorithm is effective in removing multiples.
Introduction

One of the advantages of wide azimuth (WAZ) data is its stacking power over multiple energy (Regone, 2006), but it requires a high acquisition effort to effectively suppress multiples. WAZ data are also used to update velocity models. It is therefore crucial to remove multiple energy before updating the migration velocity. 3D surface related multiple elimination (SRME) can be used to alleviate some of the burdens on acquisition (VerWest and Lin, 2007), and at the same time, remove multiple energy prior to velocity updating. Therefore, 3D SRME remains an important step in the processing of WAZ data.

Different 3D SRME implementation schemes may have different challenges in handling WAZ data. Our method, which is based on multi-domain interpolation and extrapolation (Lin et al., 2004), can benefit from the wide distribution of azimuth angles (Lin et al. 2007). However, we have to improve the method in order to handle some undesirable parts of the acquisition geometry, which include larger source separation, a lack of near offsets and imperfect acquisition conditions.

In this paper, we will examine these factors in a field dataset and discuss how to optimize our 3D SRME method to make it more effective.

Acquisition Geometry and 3D SRME

There are several ways of acquiring WAZ data. We will focus on one particular configuration that involves two source boats (one head boat and one tail boat) and one streamer boat. A similar acquisition geometry has been discussed in Michell et al (2006). The maximum crossline offset is 4km, source line spacing is 500m and nominal subsurface fold is 216. Compared to regular narrow azimuth (NAZ) data, we have four times the amount of data available. This will certainly help with the data reconstruction that precedes 3D SRME predictions. The wider azimuth distribution enables us to do more interpolations instead of extrapolations, which allows us to obtain better reconstructed data for 3D SRME. There are also factors in WAZ data that are not beneficial to the effective application of 3D SRME. One factor is the sparse source locations. Multi-boat shooting and acquisition costs limit us from acquiring a dense grid. Another factor is the lack of near offsets, due to the fact that air guns and streamers are on different boats. We will use WAZ and NAZ field datasets to compare the effects of acquisition geometry. The WAZ dataset was acquired in Walker Ridge, Gulf of Mexico, using the geometry described above.

Figure 1 shows the comparison of the source location distributions between WAZ and NAZ data. The WAZ data have regular but coarser source locations compared to NAZ data. The regular distribution of source locations is favorable for wave equation migration, but not necessarily for 3D SRME. For WAZ data, the shot location for each gun is separated by 150m in the inline direction, compared to 75m for NAZ data. The 500m source line spacing in the crossline direction is also bigger than the source line spacing of most NAZ data. The sparser source distribution means more work for the interpolation. Special attention has to be paid to spatial aliasing during the interpolation stage.

Figure 2 compares the offset distribution between WAZ data and NAZ data. It is important to notice that compared to the WAZ dataset, there are more traces with offsets smaller than 1.2km in the NAZ dataset. For NAZ datasets, the nearest offset can be as small as 250m, while the nearest offset for this WAZ dataset is about 425m. Near-offset traces are critical for 3D SRME because most of the multiples are generated by convolving two near-offset traces. The lack of near offset traces in the WAZ data poses a big challenge for 3D SRME. In dealing with this problem, we try to take advantage of the wide distribution of azimuths.

In addition to the two previous problems, there are other challenges resulting from imperfect acquisition conditions such as cable feathering and water column statics. These are not unique
to WAZ data, but are more complicated and difficult to handle in a WAZ dataset. In WAZ acquisition, efforts are made to control the source location but not the subsurface coverage as in the NAZ case. Cable feathering may leave big holes in the subsurface coverage. This will make the data reconstruction very challenging. Regarding water column statics, it is difficult to determine the statics for outer tiles which are acquired with larger crossline offsets.

Overcoming these problems involves not only improving the algorithms, but also more careful processing of the data. In the next section, we will show some 3D SRME results to demonstrate how well we handle these problems.

### 3D SRME for a Wide Azimuth Dataset

The dataset was acquired in Walker Ridge, Gulf of Mexico, with the acquisition geometry described in the previous section. With the huge amount of data and the irregularities in the geometry, a lot of regularization, interpolation and extrapolation are needed before predicting the multiples. Figure 3 shows the input, multiple model and subtraction output in the channel domain. A near channel from each tile is shown. The inline offset is about 950m for all tiles, but the crossline offset increases by 1km with each tile. The total offset for the last channel is about 4km. For all four tiles, we use the same aperture to do the prediction and the same parameters in subtraction, for comparison purposes. For the first tile, the prediction is very similar to the multiple in the input data in terms of event timing, phase and amplitude. Hence, for tile 1 the majority of the multiple energy is removed from the input except for some highly diffracted and aliased residual multiples. A similar conclusion can be drawn for tiles 2 and 3 except that increasingly more residual multiples are left in the data. For tile 4, the multiples from the top of salt are not well predicted, and thus form a significant part of the residual multiple energy. Similar errors have been observed in the predictions for mid and far offsets of NAZ data. The errors may be due to the lack of aperture during the multiple prediction, and/or the inadequacy of the regularization algorithms for long offsets in a complex geological setting such as top of salt.

To see the de-multiple effects on final images, we migrated all four tiles for one source line with and without 3D SRME. The uplift from 3D SRME is obvious. It cleans up much of the multiples in the image. Naturally, if we stack more swaths (source lines) into the image, the effects may not be as dramatic. But this test does tell us that 3D SRME works well with WAZ data in spite of unfavorable factors from the acquisition geometry. We believe that further field data tests will show 3D SRME to be beneficial for subsurface imaging, especially in low illumination areas.

### Discussions

We have used a field dataset to discuss the undesirable aspects of the current WAZ acquisition geometry with respect to 3D SRME, and also to show that 3D SRME can work well for WAZ data. The remaining questions are: How do the different WAZ acquisition configurations affect 3D SRME results? How can we improve the acquisition configuration to make it more favorable for 3D SRME without incurring additional costs? Answering these questions will be an interesting future research project. In the mean time, data reconstruction schemes need further improvements to make them more suitable for WAZ data.

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Reference

Figure 1. Shot location distribution of narrow azimuth data (NAZ) and wide azimuth data (WAZ). Compared to NAZ data, WAZ data have more regular but sparser distribution of shot locations. The NAZ data were acquired with six cables.

Figure 2. Offset distributions of NAZ and WAZ data. The offset axis has been truncated to 6km. NAZ data has more near offset (<1.2km) traces than WAZ data. The nearest offset is also smaller for NAZ data.
Figure 3. Near channels from tile 1 (crossline offset = 0.8km), tile 2 (crossline offset = 1.8km), tile 3 (crossline offset = 2.8km) and tile 4 (crossline offset = 3.8km). Input data are in the top panel, 3D SRME predictions are in the middle panel and subtraction results are in the lower panel.

Figure 4. Wave Equation Migration images with and without 3D SRME. The left panel is without de-multiple and the right panel is with 3D SRME.