3D SRME Practice for Better Imaging

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Abstract

Proper parameter selection is key to the success of 3D SRME. The major parameters include surface grid size and crossline aperture. We show that SRME crossline gathers can be used to determine both parameters. We also use a data example from Gulf of Mexico (GOM) to demonstrate the benefits of 3D SRME.

Introduction

In a marine environment, strong contamination from surface multiples is one of the major problems in imaging sub-surface structures. The surface related multiple elimination (SRME) technique has been effective in attenuating the multiples. Until recently, SRME was largely limited to two dimensions. Extending the method to three dimensions is straightforward in theory, but the lack of data in conventional steamer acquisition has made 3D SRME prediction very difficult. We overcome the difficulty by constructing high density and wide azimuth data from the existing steamer geometry (Lin et al, 2004). The technique has been successfully used on many datasets from around the world. In the application of this technique, we encountered several practical questions: Where do we need to apply 3D SRME instead of 2D SRME? How to determine the crossline aperture? How fine a sampling do we need in the crossline direction? Properly addressing these questions is essential to the success of 3D SRME application. This paper tries to answer these questions and to demonstrate the benefits of 3D SRME.

The key to these questions is the SRME crossline gather. Crossline gathers are constructed through summing SRME contributions along the inline direction. Each inline generates one prediction. Putting all the predictions together forms a SRME crossline gather. The central prediction is the 2D SRME prediction. The prediction with the minimum travel time (apex) is the true 3D multiple model. Summing over the gathers should reveal the apex. To have a good prediction, we need to ensure that the gathers are not aliased, and that apexes are within the gathers.

Where is 3D SRME needed?

Typically, any area with crossline direction dips requires 3D SRME. This can be seen in SRME crossline gathers. Figure 1 shows three cases of geological structures and their corresponding crossline gathers. The first case on the left shows a flat water bottom along the crossline direction, i.e. no crossline dip, and the crossline gather is symmetric. The apex is located at the target line. This means that 2D SRME prediction is sufficient in this case. In the second case, shown in the middle, the water bottom has an up-dip along the crossline direction, and the apex of the gather shifts to the right (the up-dip direction). In the last case, on the right, the water bottom has a down-dip and top of salt has an up-dip. The apexes of the corresponding multiple predictions both shift to the up-dip direction. In the last two cases when the apexes are not in the center of the gathers, and we need 3D SRME.

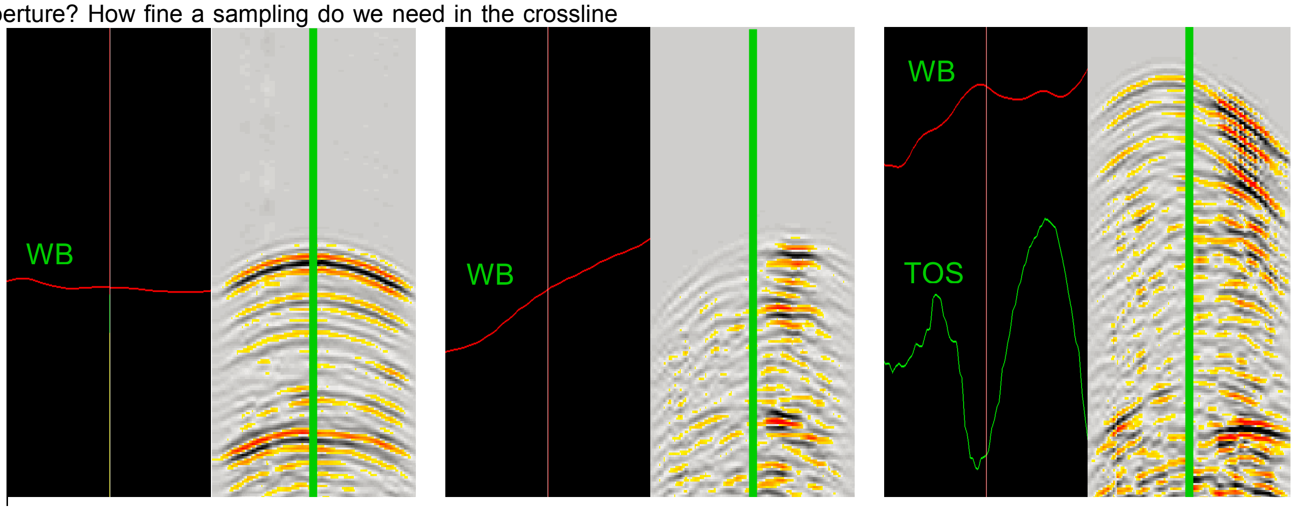

Figure 1. Topography of major multiple generators along crossline direction and their corresponding SRME crossline gathers. WB: water bottom, TOS: top of salt.

How small should the surface grid be?

The spacing should be small enough to make crossline gathers unaliased. Figure 2 shows the effects of aliasing. The upper panel has a 40m spacing. The crossline gather is unaliased except on the steepest Flanks, and the resultant multiple model is clean even though there is some noise created by the aliased energy on the edges of the gather. If we decimate the surface grid to 80m (the lower panel), the gather is aliased at most dips. Comparison of the predicted model to the input data (not shown) shows that the 40m predicted model is better in the area indicated by the arrow. So by examining the aliasing of the crossline gathers, we should able to decide the grid size.

How big should the crossline aperture be?

Figure 3 shows that different crossline apertures create different multiple models. When the aperture is 0 m, which corresponds to 2D SRME prediction, the model is very different from the multiple in the data. Even when the aperture is increased to 800 m, which leaves the apexes out, the model is still different from the data. When the aperture reaches 1600 m and hence includes the apexes of the gathers, the model becomes very close to the multiple energy in the data. Extending the aperture out to 3200 m does not change the model significantly. Therefore, the aperture should be big enough to capture all apexes within the gather. A larger aperture does not improve the prediction significantly. Larger apertures can actually introduce additional noise by including more aliased energy on the edges of the gather as we see in Figure 2.

What are the benefits of 3D SRME?

By carefully choosing the parameters, we can make 3D SRME effective and affordable. Figure 4 shows an example of applying 3D SRME in the Gulf of Mexico. The dataset is from the Alaminos Canyon Perdido Fold Belt. The geology in this area includes extensive salt sheets. The intrusion of salt sheets creates rugose water bottom and top of salt. These are the brightest reflectors and the major multiple generators. As the multiple generation process is highly three-dimensional, 2D SRME is not adequate. We applied 3D SRME to the data, followed by Radon demultiple. In the left panels, the data has been through Radon de-multiple, and then Wave Equation (WEM) PSDM. On the right panels, the data have been processed with 3D SRME + Radon demultiple, and then WEM PSDM. From the figures, we can see that with the addition of 3D SRME to the processing flow some of the subsalt reflectors are much better imaged. Such improvements are certainly welcomed by interpreters.

Conclusions

From the discussion above, we can reach the following conclusions:

- When SRME crossline gathers are not symmetric, 3D SRME is needed.
- Crossline spacing should be small enough for crossline gathers to be unaliased.
- Crossline aperture should be big enough to capture the apexes. Bigger apertures do not help much, and sometimes can do some harm.
- 3D SRME can be helpful for better subsurface imaging

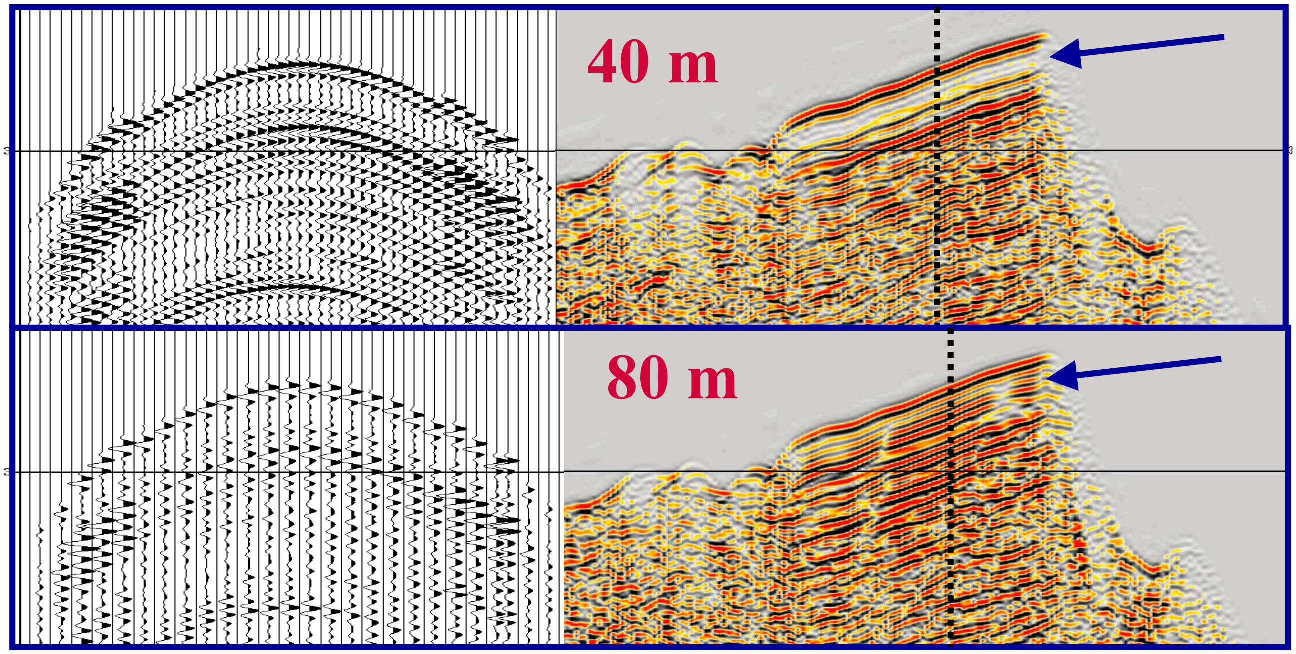

Figure 2. Crossline gathers and their corresponding multiple models. The upper panel has 40 m spacing, and the lower panel is decimated to 80 m. The blue arrow points to an area where comparison to the input data (not shown) shows that the 40m prediction is better.

References

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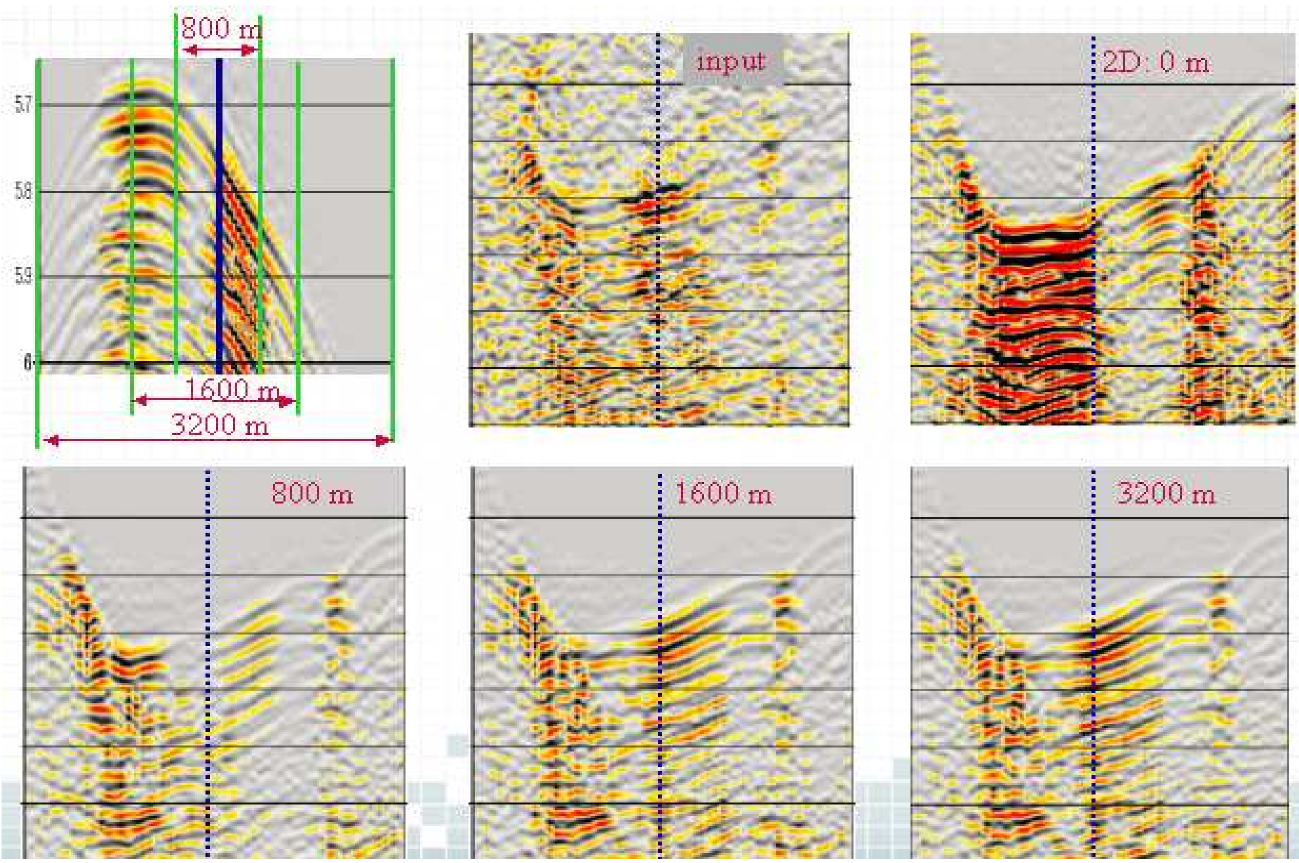

Figure 3. 3D SRME models with different apertures. Upper left: crossline gathers with different apertures overlaid; upper middle: input data with multiple; upper right: model with aperture = 0; lower left: model with aperture = 800 m; lower middle: model with aperture = 1600 m; lower right: model with aperture = 3200 m.

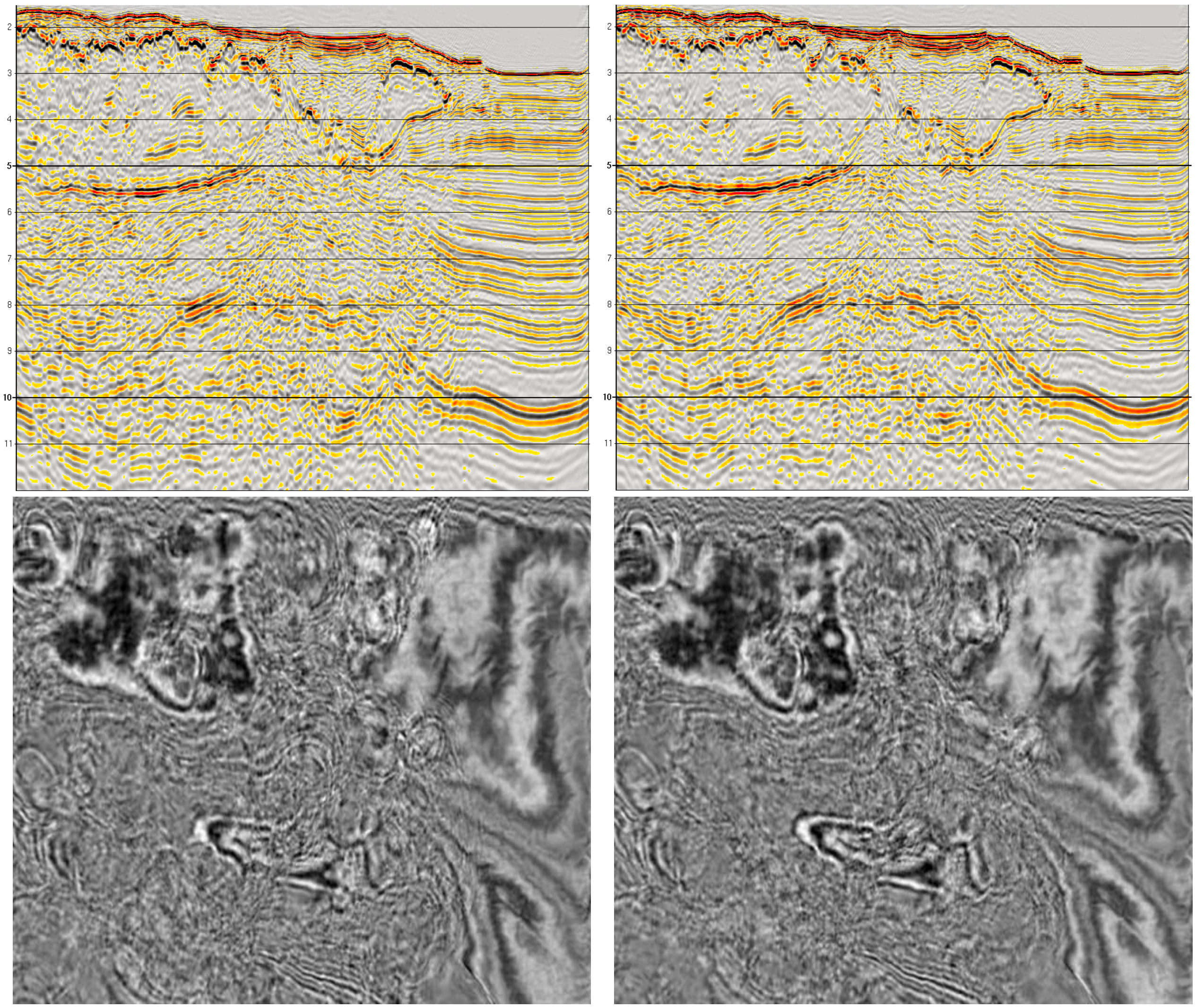

Figure 4. WEM PSDM crossline sections and depth slices. Upper left: crossline section with Radon demultiple only; Upper right: crossline section with 3D SRME + Radon demultiple; lower left: depth slice with Radon demultiple only; lower right: depth slice with 3D SRME + Radon demultiple. The depth slices were taken at the depth of 8 km.