X049 DMO IN CROSS-SPREAD — THE FAILURE OF EXISTING SOFTWARE TO HANDLE AMPLITUDES CORRECTLY

GIJS J.O. VERMEER
Shell International Exploration and Production BV, Research and Technology Services, PO Box 60, 2280 AB Rijswijk, The Netherlands

Introduction

The cross-spread is the basic subset of the orthogonal geometry (Fig. 1). It is a single-fold 3D dataset which is suitable for DMO (Vermeer et al., 1995). The midpoints of the traces contributing to the DMO result in an output point lie on a hyperbola (Fig. 2). In a constant velocity medium, there is always a point on the hyperbola which has illuminated the footpoint of the zero-offset trace in the output point. This is the point of stationary phase for the output point. The other traces along the hyperbola either contribute to the zone of stationary phase or to the flanks of the DMO panel.

Sampling problem

The hyperbola in Fig. 2 is computed under the assumption of continuous shot- and receiver coordinates. In actual fact these coordinates are sampled in a square grid (if shot and receiver intervals are the same). As a consequence the hyperbola for an output point runs between the sample points. In Fig. 3a and b the nearest midpoints to the hyperbola are drawn for two output points with the same x-coordinate but different y-coordinate. The corresponding shot/receiver segments of these points do run through the bin defined around the output point, but not through the output point itself. Conventional 3D DMO programs do not take these sampling problems into account. This leads to irregularly sampled DMO panels, loss of high frequencies, and erratic amplitude variations. The systematic deviation of the samples from the hyperbola in Fig. 3b is typical for points close to the acquisition lines, and leads to systematic amplitude variations.

Geometry effect

The DMO correction factor $\sqrt{1-r^2/h^2}$, used to squeeze the traveltimes of a trace, is not only dependent on half-offset h, but also on the distance r of the contributing midpoint to the output point. The behaviour of this factor varies across the cross-spread. Therefore, even if it would be possible to perfectly sample the hyperbolas, there would still be a geometry effect to cope with. This effect is strongest close to the acquisition lines.

Example

We sent a synthetic cross-spread to several contractors. Their 3D DMO results showed considerable variation, but also great similarities. Fig. 4 illustrates the horizon slice after DMO for a plane 30° dipping reflector with dip direction making an angle of 18° with the receiver axis. The amplitudes show point-to-point variations caused by the sampling problem, and also variations with a longer wavelength. The latter are caused by a combination of sampling problems and the geometry effect.

The ideal 3D DMO program

The ideal 3D DMO program would compute traces along the hyperbola of each output point, and take the geometry effect into account. Unfortunately, proper resampling is a very expensive exercise. Therefore, it looks like we have to make do with unsatisfactory DMO until we can afford prestack migration.

Conclusion

In theory cross-spreads are suitable for DMO. However, it is difficult to correctly handle the seismic amplitudes. There are two reasons for incorrect amplitudes produced by existing 3D DMO programs:

shot/receiver segments do not pass through the centre of the bins, and the cross-spread requires geometry-specific amplitude-correction factors. An alternative, output-oriented technique would be necessary to produce correct DMO amplitudes.

Reference

Vermeer, G.J.O., Den Rooijen, H.P.G.M., and Douma, J., 1995, DMO in arbitrary 3D acquisition geometries, SEG Expanded Abstracts, 1445-1448.

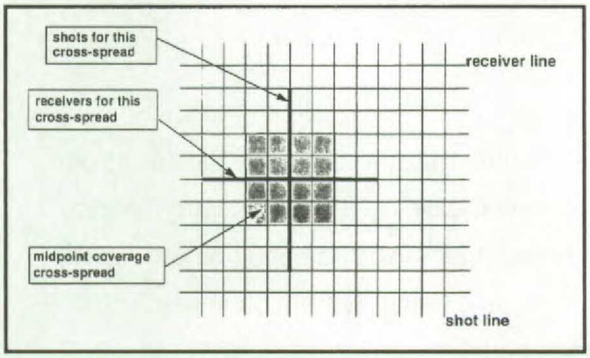


Fig. 1 Cross-spread as subset of orthogonal geometry. There is a cross-spread for each intersection between a shotline and a receiver line.

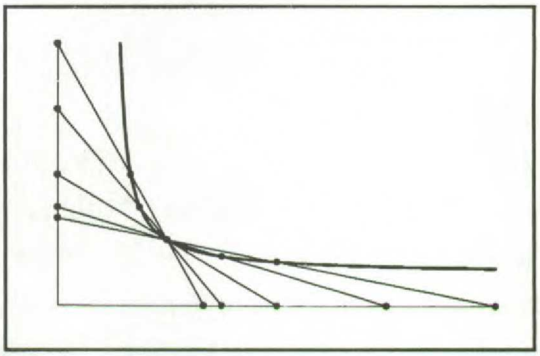
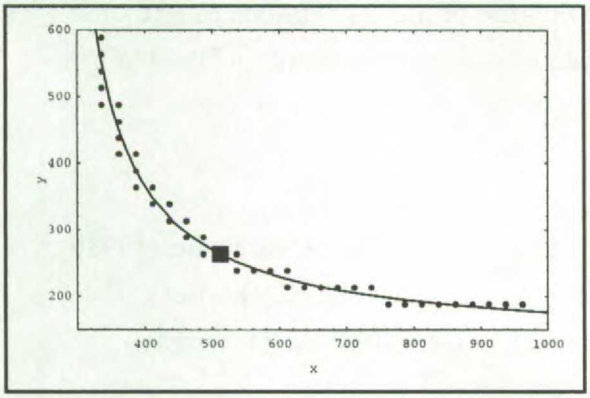
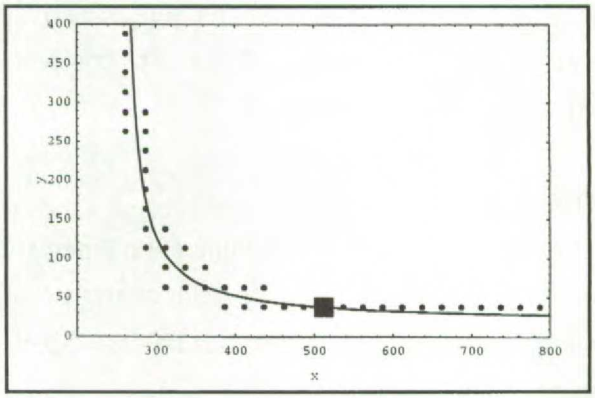


Fig. 2 The midpoints of shot/receiver pairs that can contribute to the DMO result in an output point lie on a hyperbola through that point.



(a)



(b)

Fig. 3 Midpoints contributing to bin around output point. (a) output point at (512.5, 262.5), (b) output point at (512.5, 37.5).

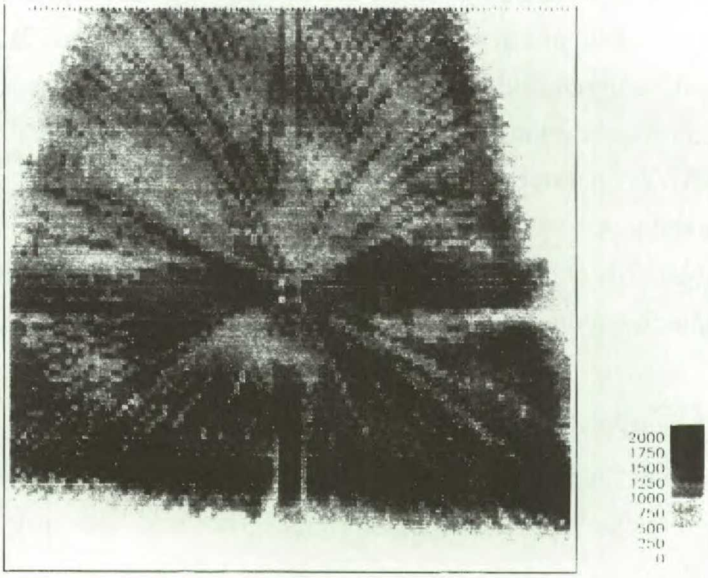


Fig. 4 Horizon slice through dipping event.