Stanford Exploration Project, Report 70, December 18, 1997, pages 1–123

Stanford Exploration Project, Report 70, December 18, 1997, pages 1–123

Short Note

Uniform-amplitude DMO

Lin Zhang[1]

keywords: *DMO, amplitudes, NMO*

INTRODUCTION

In SEP–59 (Zhang, 1988), I describe a new derivation of the dip-moveout (DMO) operator in the Fourier domain. The new operator is kinematically equivalent to Hale's DMO operator but has a different amplitude spectrum. From the results of synthetic experiments, I noticed that the impulse responses of the operator have properties that agree qualitatively with wave theory: the operator tends to give a uniform amplitude response for reflectors of varying dips. However, in that study I did not attempt to make a quantitative explanation of such an amplitude phenomenon.

Black and Egan (1988) studied true-amplitude DMO by starting from the wave equation and deriving the operator in the space-time domain. Interestingly, their results agree with those I obtained in the f-k domain with a purely kinematic approach.

In this paper, I show some numerical results of the quantitative study of true-amplitude DMO. I first review the two different definitions of DMO, then I use synthetic data examples to test the theory. To avoid confusion among various definitions of true-amplitude DMO, I call this operator uniform-amplitude DMO operator.

DEFINITIONS OF DMO

Here I review the definitions of two DMO operators. The detailed derivations are given earlier by Zhang (1988).

Let $P(t, y, h)$ denote a constant offset section, $P_n(t_n, y, h)$ the section after normal moveout (NMO) corrections, and $P_0(t_0, y, h)$ the section after the NMO and DMO corrections. Figure **??** shows the coordinates of these sections.

NMO correction is a time-stretching operation:

$$P_n(t_n, y, h) = P(t, y, h), \tag{1}$$

[1]**email:** not available

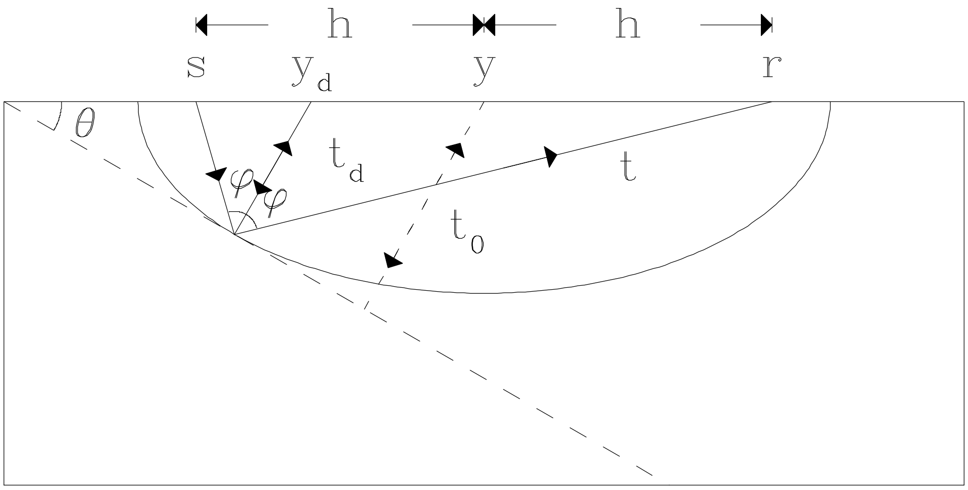

Figure 1: The geometry of the experiment: common mid-point versus common depth-point. lin4-dmogeo [NR]

where t and t_n are related by the normal moveout equation. Hale relates the DMO-corrected section to the NMO-corrected section as follow:

$$P_0(t_0, y, h) = P_n(t_n, y, h). \tag{2}$$

From Figure **??**, it is clear that the events represented by the two sides of equation (2) are not reflected from the same depth point if the dip of the reflector is nonzero. Therefore, the operator obtained from this relation may not preserve the correct amplitudes of the reflected events. To solve this problem, I define the DMO operation by explicitly relating the events reflected from the common depth points, as follows:

$$P_d(t_d, y_d, h) = P_n(t_n, y, h). \tag{3}$$

From this definition, one would expect that the DMO operator would have some desirable properties in its amplitude spectrum. And, indeed, as the next section shows, this DMO operator has a uniform amplitude spectrum with respect to dips and offsets.

NUMERICAL EXPERIMENTS

Using traveltime relations, I generated synthetic constant offset sections that contain events reflected from plane reflectors. The velocity is 2000 m/s. I chose five offsets ranging from 0 to 2000 m. The dips of the reflectors vary from 0 to 80 degrees in increments of 20 degrees. I assume that these sections can be processed with spherical divergence and attenuation corrections so that the peak amplitudes of the wavelets are proportional to the reflection coefficients at the depth points from which these wavelets were reflected. It is important to preserve this proportionality after

NMO and DMO corrections. In my examples, I further assume that the reflection coefficients are constant along the reflectors and are independent of the angles of rays. (Although this assumption is unrealistic, it simplifies the explanation of the results.) In accordance with these assumptions, the ideal outputs of the DMO operator should have a constant peak value for all the wavelets.

Figure **??** displays constant offset sections with a fixed offset of 2000 meters. The top panel shows the result after the NMO corrections: the peak amplitudes of the wavelets should be constant. This is because NMO is a time-stretching operation that changes the shapes of wavelets but not their peak values. The middle panel shows the output of Hale's DMO operator: the amplitudes of the wavelets decrease as the dips of the reflector increase. Because the sections are small windows near the centers of large sections, the possibility of boundary effects can be ruled out. Therefore, we can conclude that this operator attenuates events with large dips. The bottom panel shows the result after applying uniform-amplitude DMO operator: the peak amplitudes of the wavelets are constant.

A better way to visualize the contrast between the outputs of the two DMO operators is to plot the peak amplitude of the wavelets as a function of offset and dip, as shown in Figures **??**a and **??**b. Evidently, uniform-amplitude DMO works as suggested. The amplitude curves are almost constant for all dips and offsets. With Hale's DMO, however, the amplitude curves drop down to about 50% when the dip is 80 degrees or the offset is 2000 meters.

CONCLUSIONS

This paper compares the amplitude effects of Hale's DMO and of what I call uniform-amplitude DMO. Numerical analysis of the synthetic examples shows that uniform-amplitude DMO has an advantage over the conventional DMO. Uniform-amplitude DMO preserves the peak values of the wavelets, while the conventional DMO attenuates the events with large dips and at large offsets. Since the applications of both DMO operators have the same cost, there is reason to replace the conventional DMO with uniform-amplitude DMO.

ACKNOWLEDGMENTS

I thank Jim Black and Carl Schleichor for many interesting discussions regarding the amplitude response of DMO operators.

REFERENCES

Black, L.J., and Egan, S.E., 1988, True-amplitude DMO in 3-D: Presented at the 58th Annual International SEG meeting in Anaheim.

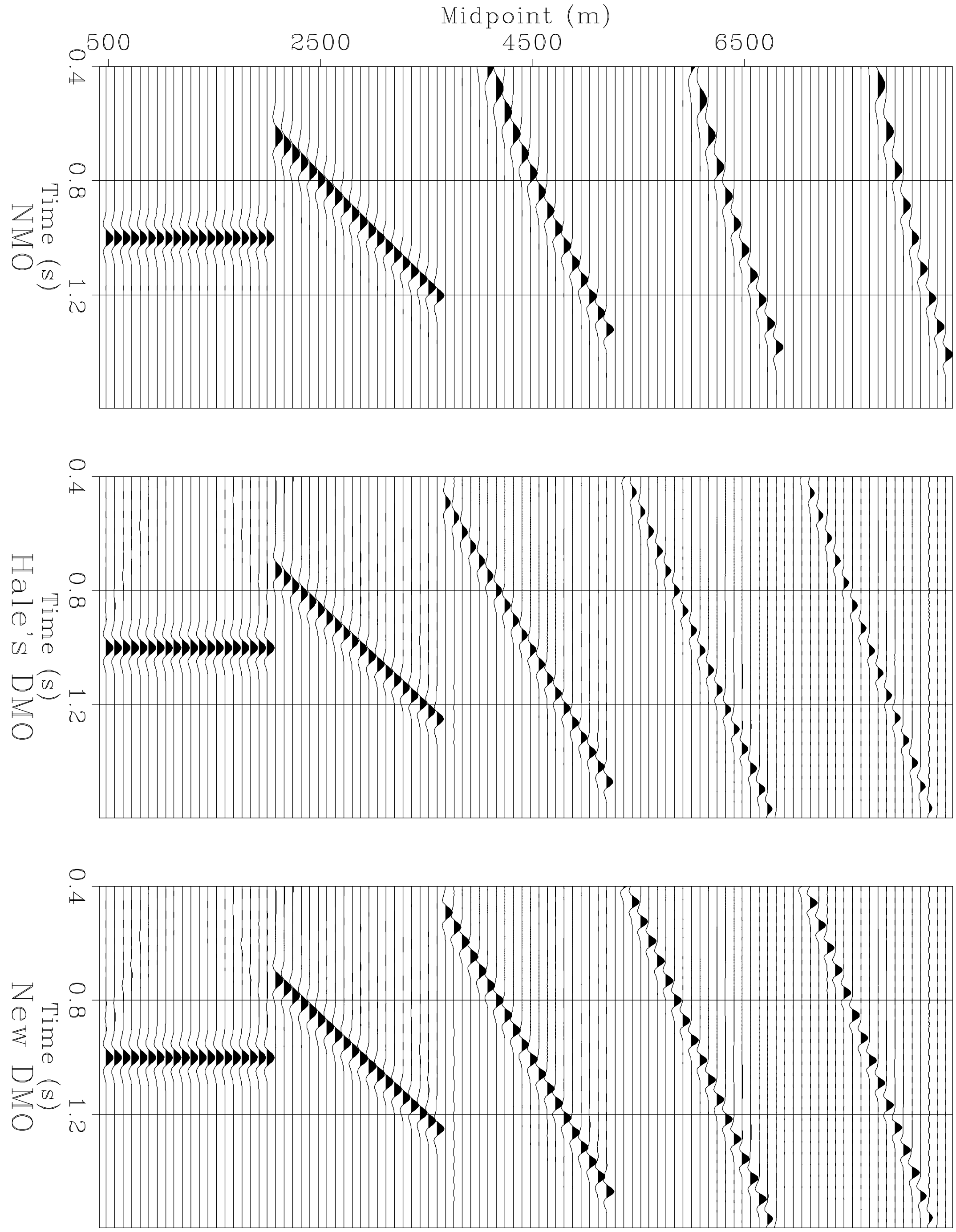

Figure 2: Common offset sections. Top: after NMO correction; middle: after the conventional DMO correction; bottom: after the uniform-amplitude DMO correction. The offset is 2000 meters, and the dips of the reflectors are 0, 20, 40, 60, 80 degrees. lin4-nmodmodip [NR]

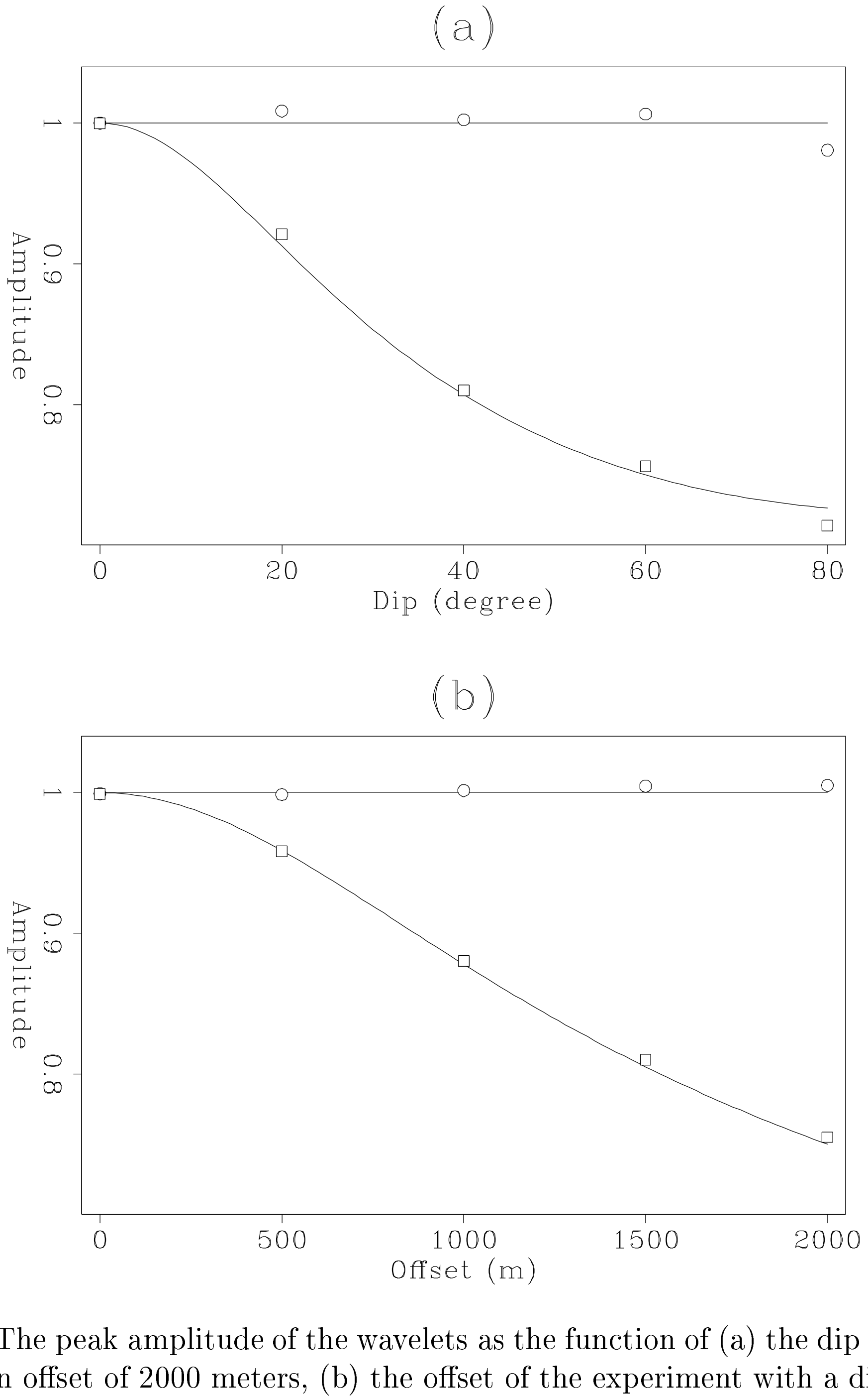

Figure 3: The peak amplitude of the wavelets as the function of (a) the dip of a reflector with an offset of 2000 meters, (b) the offset of the experiment with a dip angle of 60 degrees. The samples are picked from the wavelets at the centers of the sections. The circles indicate samples associated with uniform-amplitude DMO; the squares indicate samples associated with conventional DMO. The continuous curves are calculated with the analytical formulae of Black and Schleichor (1990). lin4-ampvall [NR]

Black, L.J., and Schleichor, C., 1990, Personal communication.

Hale, I.D., 1983, Dip-moveout by Fourier Transform: Ph.D. thesis, Stanford University.

Zhang, L., 1988, A new Jacobian for dip-moveout: SEP–**59**, 201-208.