Optimum CSP gathers with fixed equivalent offset

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ABSTRACT

Input traces may be summed into a common scatter point (CSP) gather at a fixed equivalent offset. An optimum fixed equivalent offset is presented.

INTRODUCTION

CSP gathers are formed by summing input traces at the equivalent offset defined in equation (1)

$$h_e^2 = x^2 + h^2 - \frac{4x^2h^2}{T^2V^2}, \tag{1}$$

where x is the surface distance between the CSP and CMP location, h the half source receiver offset, T the input time, and V the velocity at the scatter point (T_0). The equivalent offset is time and velocity varying, and may span a range of offset bins. As T becomes large, the cross term is equation (1) tends to zero and the equivalent offset tends to an asymptotic value h_{ew} as given in equation (2).

$$h_{e\omega}^2 = x^2 + h^2, \tag{2}$$

A number of applications may ignore the time varying offset defined in equation (1) and insert the input trace at a fixed equivalent offset defined by equation (2). An example would be marine data where the largest range of offset bins is above the water bottom. The computation of transition times is eliminated, and a full trace may be summed into the gather.

QUESTION

Is there a fixed offset that provides more accurate positioning than h_{ew}?

ANSWER

Yes. The optimum offset is the average of the first used equivalent offset and the equivalent offset at maximum time.

DISCUSSION

The first usable sample on a trace comes from a scatter point located at the surface, and is defined by T_a and h_{ea}. where,

$$h_{e\alpha} = x \quad , \tag{3}$$

and

$$T_\alpha = \frac{2x}{V_0} \quad , \tag{4}$$

where V_0 is the velocity at the surface.

The prestack migration of the point at (T_a, h_{ea}) returns energy to a scatter point at the surface and is a 90-degree migration. Dip limited prestack migrations would define the first usable sample at a larger time and at a larger equivalent offset $h_{e\text{-}first}$, reducing the range of equivalent offset.

The bottom of the input trace (at maximum time) may not be at h_{ew}, but at a smaller equivalent offset $h_{e\text{-}max}$.

The resulting range of the equivalent offset is thus reduced to the difference between $h_{e\text{-}first}$ and $h_{e\text{-}max}$ with the average $h_{e\text{-}ave}$ given by

$$h_{e-ave} = \frac{h_{e-first} + h_{e-\max}}{2} \quad . \tag{5}$$

A trace summed into the CSP gathers at $h_{e\text{-}ave}$ will have an optimum equivalent offset over the range of interest.

GRAPHICAL ILLUSTRATION

Figure 1 shows the mapping of one input trace to the neighbouring CSP gathers. The energy in each CSP gather starts at time T_a.

Figure 2 includes the asymptote at h_{ew} in each CSP gather and appears as a hyperbolic cylinder. Different perspective views are included for clarity.

Figure 3 shows different projections of Figure 2, with the plan view in (c) showing the offset difference between the actual data and the asymptotic h_{ew} that appears as a hyperbola.

Figure 4 includes a radial plane the represents a dip limit that could be imposed on the CSP gathers. Note the retained data below the plane has a smaller range of equivalent offset.

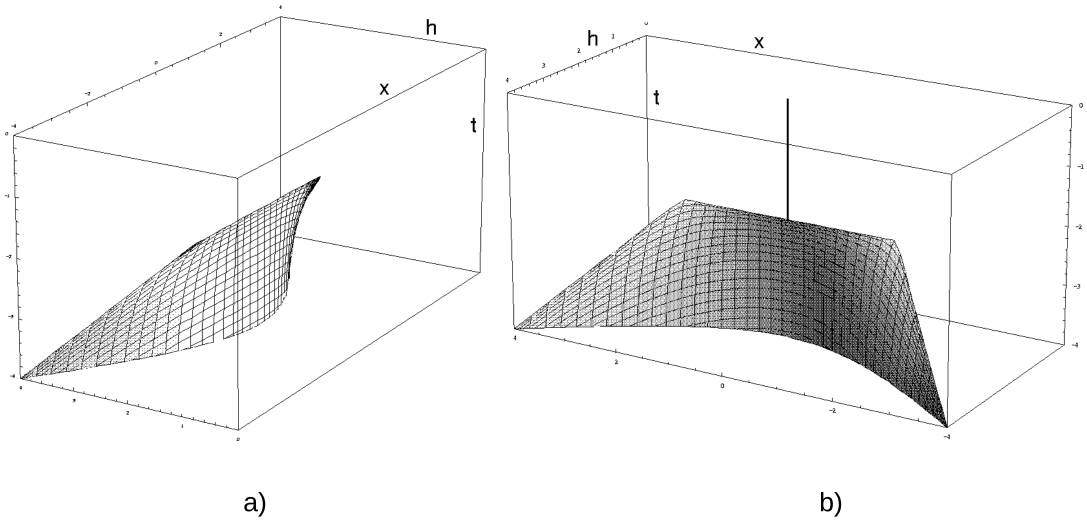

Figure 1 Prestack volume showing the location of energy from one input trace as it is spread to neighbouring traces, with a) showing a frontal view, and b) a rear view.

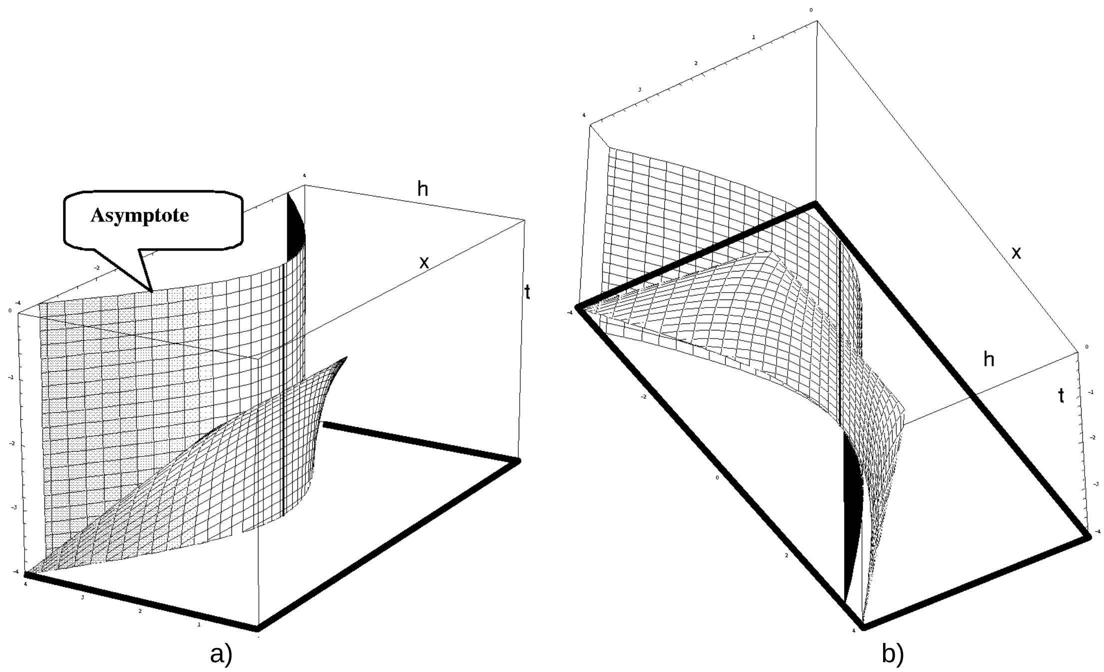

Figure 2 Prestack volume including the equivalent offset asymptote with a) showing a frontal view and b) a view from the bottom (the bottom is defined with a darker boarder).

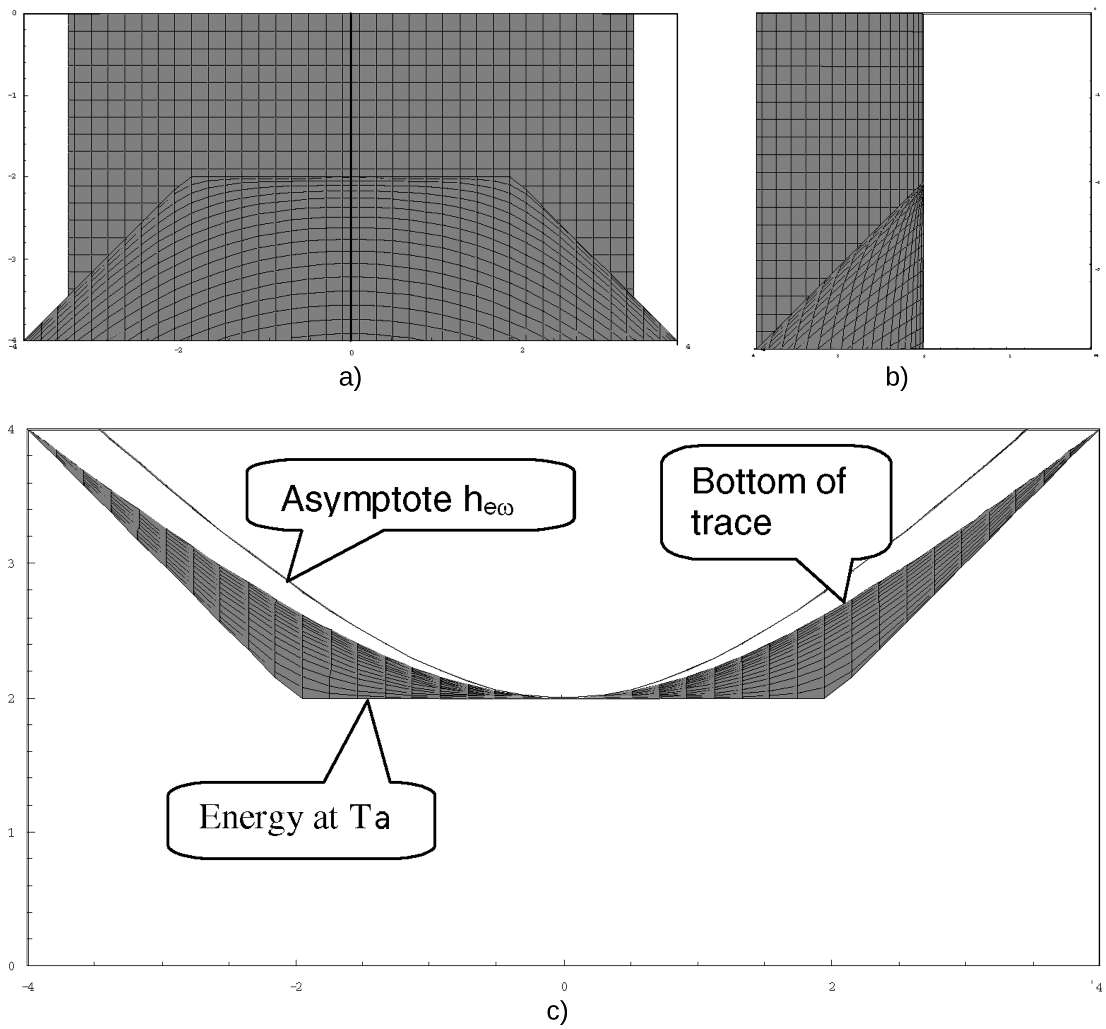

Figure 3 Prestack volume including the equivalent offset asymptote with a) showing a frontal projection (*x, t*), b) a side projection (*h, t*), and c) a top projection (*x, h*).

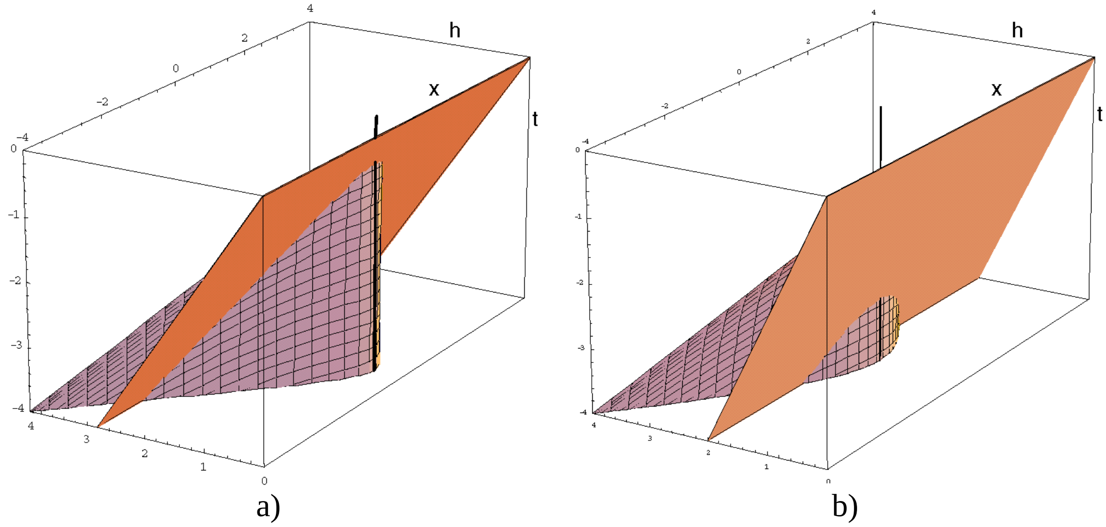

Figure 4 Radial planes in the prestack volume that represent dip limits imposed on CSP gathers with a) a large dip and b) a small dip. Note the area under the dipping plane contains nearly vertical traces indicating a small range of equivalent offset.

Contents

CONCLUSION

There is an optimum fixed equivalent offset for forming CSP gathers.

APPENDIX

Computation of the equivalent offset at maximum time.

First compute an approximate T_0 using the maximum time and velocity at maximum time, i.e.,

$$ {}_1T_{0\max}^2 = T_{\max}^2 - \frac{4\left(x^2 + h^2\right)}{V_{\max}^2} \tag{6} $$

Get the velocity V_1 at ${}_1T_{0max}$.then compute $h_{e\text{-}max1}$ from

$$ h_{e1}^2 = x^2 + h^2 - \frac{4x^2h^2}{T_{\max}^2 V_1^2}. \tag{7} $$

Compute ${}_2T_{0max}$ from

$$ {}_2T_{0\max}^2 = T_{\max}^2 - \frac{4\left(h_{e1}^2\right)}{V_1^2} \tag{8} $$

or

$$ {}_2T_{0\max}^2 = T_{\max}^2 - \frac{4\left(x^2 + h^2 - \dfrac{4x^2h^2}{T_{\max}^2 V_1^2}\right)}{V_1^2} \tag{9} $$

Using ${}_2T_{0\text{-}max}$, get a new velocity V_2 and compute a new h_{e2} using equation (7).