Discussion of "Dip limitations on migrated sections as a function of line length and recording time"*

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Abstract

I sent this short discussion, which relates my SEP-37 article on avoiding phase-shift artifacts to Heloise and Swavek's article on dip limitations in migration, to the editor of Geophysics.

Drs. Lynn and Deregowski nicely analyzed how recording time and line length limit the detection of dipping beds and the resolution of deeper diffractors. For migration and synthetic seismogram generation I exploited this decrease in dip spectrum at late recording times to both suppress migration artifacts and to decrease the cost of migration.

Kirchhoff or diffraction-sum migration already has this savings built into it. In this method we place at each point (t_z, x_z) of the migrated section the sum of unmigrated data along a hyperbola with apex at that location. The equation of this hyperbola is

$$t^2 = t_z^2 + \frac{4(x - x_z)^2}{V_{rms}^2(t_z)} \quad . \tag{1}$$

We see in Figure 1 how the bottom (and also the sides) of the time section truncates these hyperbolas and reduces the number of traces to sum near these edges. As the cost of computing each migrated sample is proportional to the number of traces in this sum, we see this cost decreases as t_z approaches the maximum recording time T. Setting $t = T$ in equation (1) gives us the formula

$$(x - x_z)_{max} = \frac{V_{rms}(t_z)}{2} \sqrt{T^2 - t_z^2} \tag{2}$$

* Lynn, H.B. and Deregowski, S., Geophysics, vol. 46 no. 10, pp. 1392-1397.

for this shrinking summation aperture.

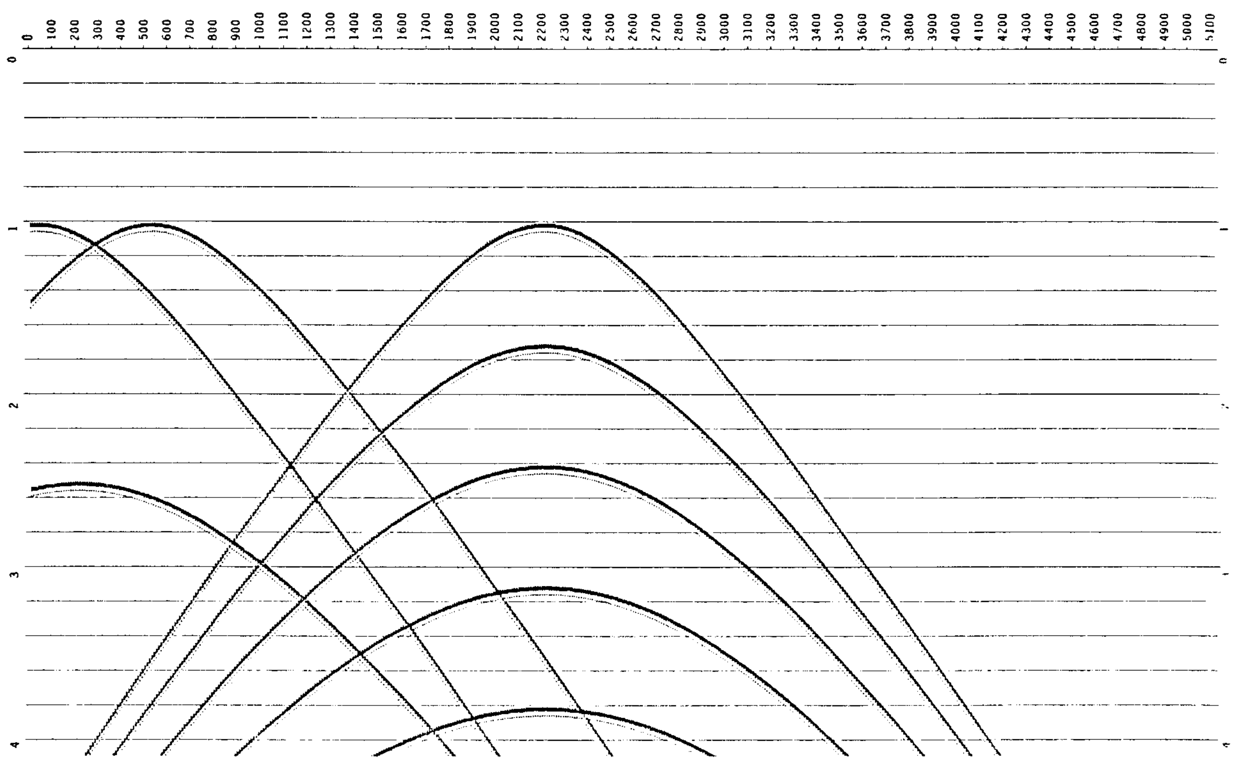

FIG. 1. Some representative Kirchoff hyperbolic summation paths. Hyperbolas with apices near the side and bottom edges span fewer traces than those in the middle of the section.

For phase shift migration reduced computation was an incidental benefit when I exploited these dip limitations. My primary purpose was to avoid wraparound artifacts in phase shift migration. I did this by applying successively smaller dip cutoffs that matched the slopes of the summation hyperbolas of figure 1 at the bottom of the section. This stopped the limbs of each hyperbola from extending any significant distance below the bottom of the section and greatly attenuated wraparound after a small amount of zero padding. I calculated this maximum slope by differentiating equation (1) and substituting equation (2) to get

$$\left(\frac{dt}{dx}\right)_{max} = \frac{2\sqrt{T^2 - t_z^2}}{T\ V_{rms}(t_z)} \quad . \tag{3}$$

Reduced migration cost arose because this maximum time dip approached zero for large t_z, allowing me to discard from the frequency-wavenumber domain all data outside the region

$$\left|\frac{k}{\omega}\right| \le \left(\frac{dt}{dx}\right)_{max} \quad . \tag{4}$$

There is room for even more savings in phase-shift migration. Drs. Lynn and Deregowski noted many factors, such as nonzero offsets, stacking response, group array response, and dynamic range, that reduce the maximum dip on a stacked section one can expect to record and use in interpretation. These additional constraints further limit the dips we need to migrate.

In summary, awareness of the effects of recording time and line length limits is not only important for proper acquisition and interpretation, but may also be useful in processing.