Comparisons between 2D and 3D finite-difference models of near source surface waves

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ABSTRACT

Comparisons are made between nearly identical models represented in two and three dimensions. Two comparisons show that where the geological model and the acquisition are well represented in two dimensions, the results are identical except for the expected difference in amplitude attenuation with distance. Also shown is a case where acquisition in only two dimensions may be adequate for reflection data, but not for simulation of surface noise.

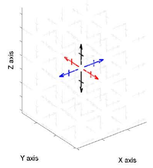

FIG. 1. The explosive source

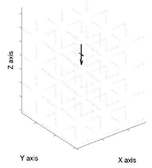

FIG. 2. The vibrator source

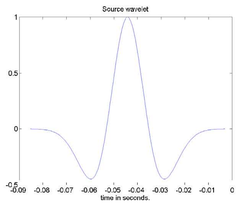

FIG. 3. The broad band 25 Hz Ricker source

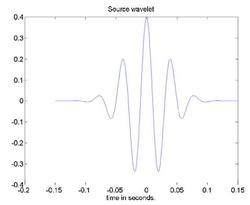

FIG. 4. The narrow band 25 Hz source

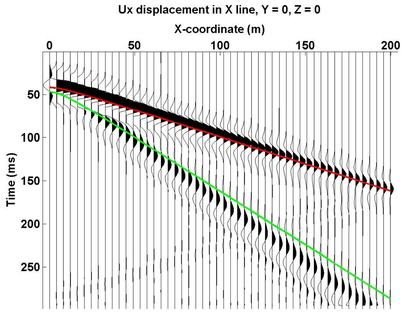

FIG. 5. An explosive source for a model in two dimensions. The source is on the left edge at 8 m depth.

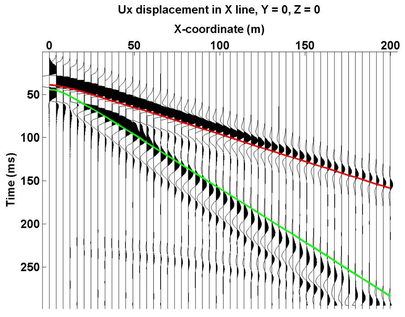

FIG. 6. An explosive source for a model in three dimensions. The amplitudes drop off more quickly with offset.

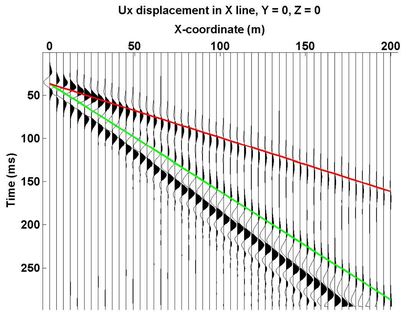

FIG. 7. A surface vibrator source for a model in two dimensions. The Rayleigh wave starts right at zero offset, and the first arrivals branch off from it.

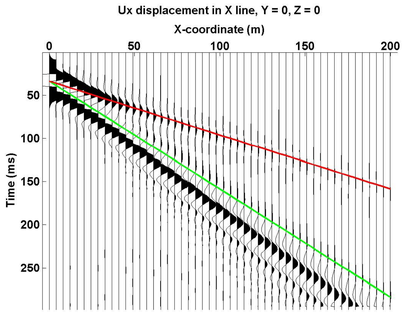

FIG. 8. A surface vibrator source for a model in three dimensions. The Rayleigh waves attenuate here, unlike that in Figure 7.

DISCUSSION ON AMPLITUDE DECAY WITH OFFSET

If the decay rates may be considered as three orders (1, $r^{-1/2}$, r^{-1}) then the first arrivals may be considered one order higher than the surface waves, and the three dimensional modelling may be considered to be one order higher than two dimensional modelling. Comparison of the decay rates within each of Figures 5-8 is consistent with the first statement, and comparison of both events in Figures 5 and 7 with 6 and 8 is consistent with the second.

SURFACE WAVE MODELLING IN 3 DIMENSIONS

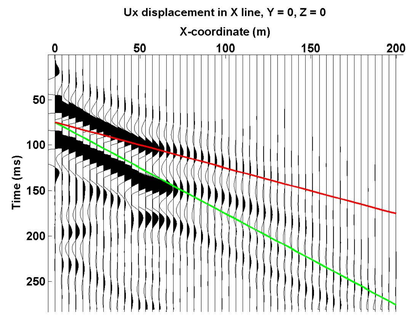

FIG. 9. Data acquired in the X-direction, perpendicular to a discontinuity at 55 m. A model in two dimensions would be adequate here.

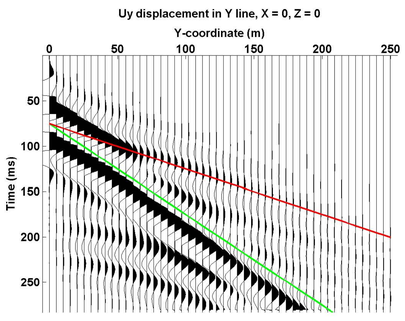

FIG. 10. Data acquired in the Y-direction, parallel to the discontinuity at 55 m in X.

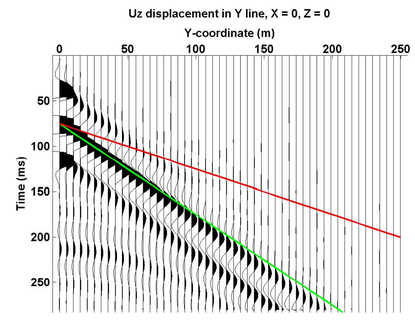

FIG. 11. Z-displacement data acquired in the Y-direction, as in Figure 10.

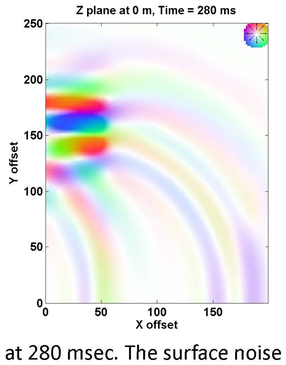

FIG. 12. A snapshot at the surface at 280 msec. The surface noise has been trapped between the discontinuity at 55 m in X, and an identical one at -55 in X. This requires a model in three dimensions.

CONCLUSIONS

Surface wave models in two dimensions are adequate where conditions may be accurately modelled in two dimensions, otherwise models in 3 dimensions might be useful.