Correction filter use in finite-difference elastic modelling

Peter M. Manning

ABSTRACT

Correction filtering of the finite-difference elastic wavefield has been found to be a practical and efficient process. In a particular case shown, the cost of the beneficial effects was obtained by using a minimal convolution filter with an overall size of 3 by 3 points, and this resulted in an 80 percent increase in run times. Comparable results obtained by reducing sampling intervals required a one third reduction, which cost a 180 percent increase in run times. Further tests showed that the particular corrections filter set used was still quite effective when used on velocities 25% lower than the design velocities.

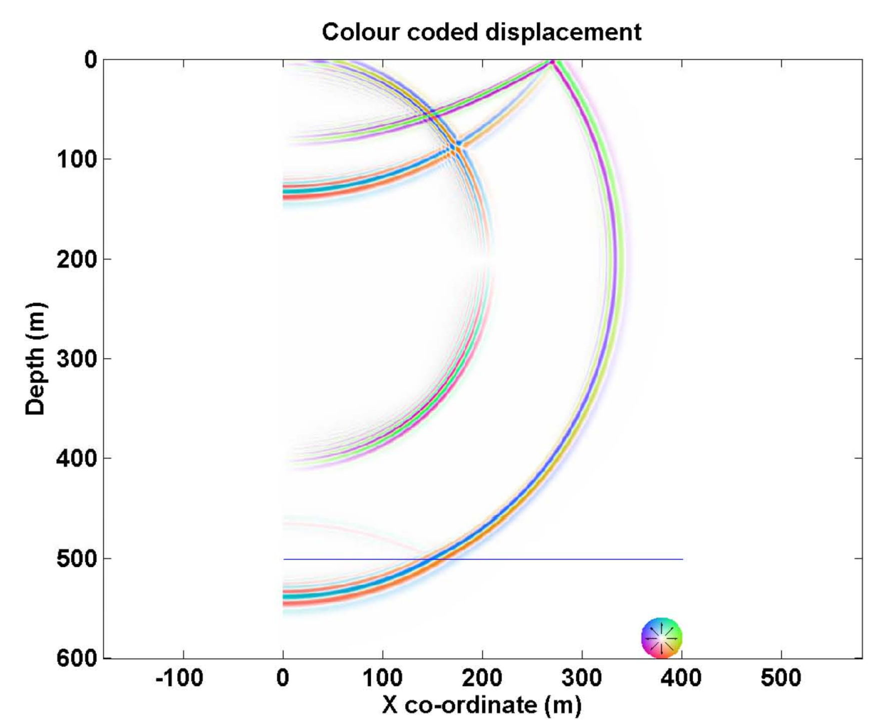

FIG. 1. Snapshot of uncorrected finite-difference wavefield propagation, where the sample rates were chosen at close to optimal for pressure waves. Numerical dispersion may be seen as wavefronts that are spread out and ringing.

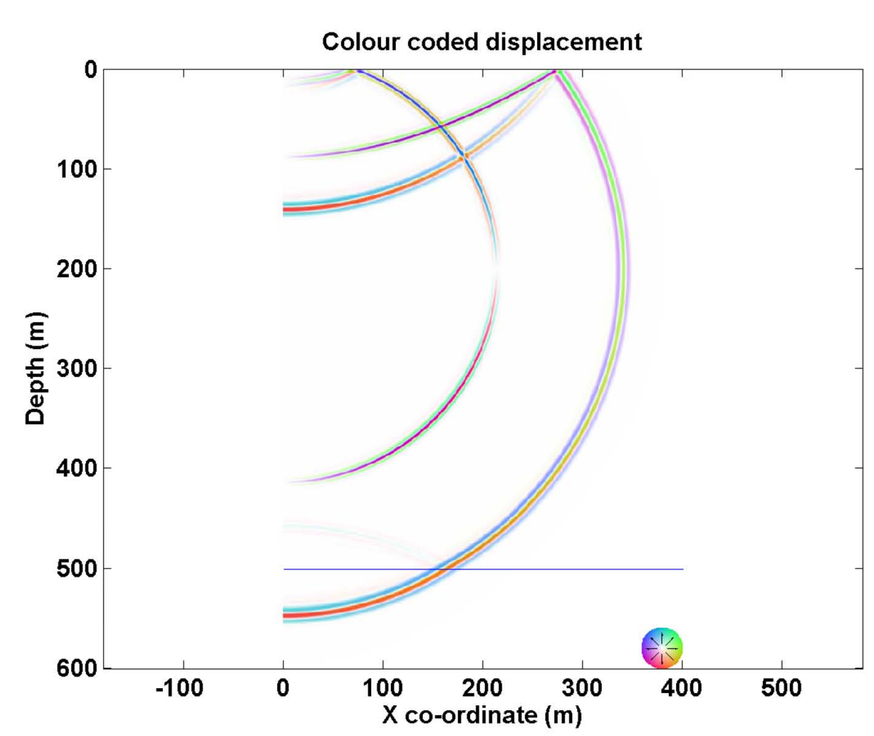

FIG. 2. Snapshot of corrected finite-difference wavefield propagation. The reduced dispersion of the wavefronts shows them as having narrow width, and preservation of the initial zero-phase character shows them as having a symmetric colour pattern..

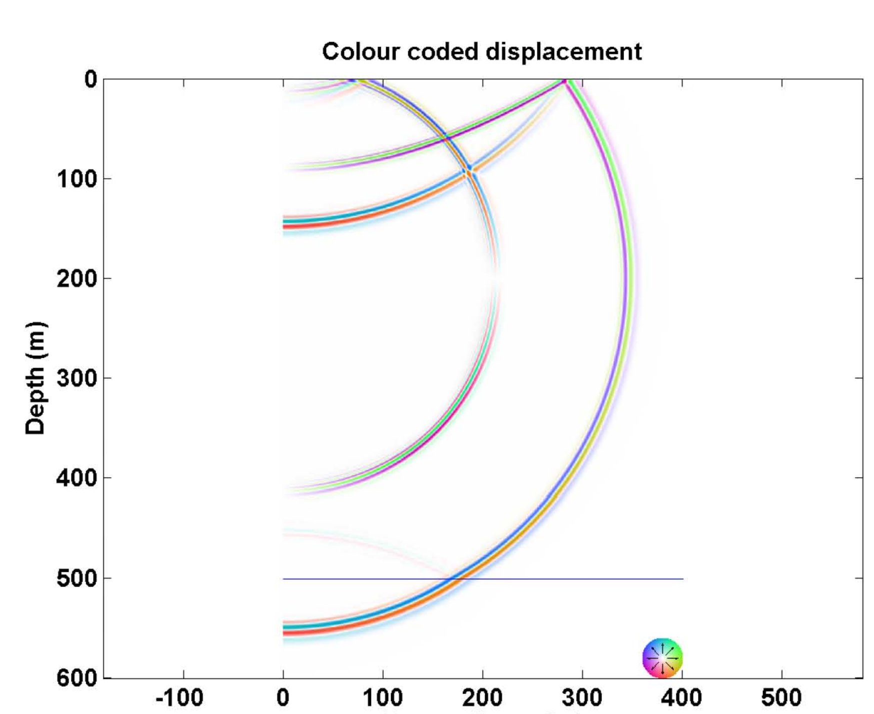

FIG. 3. Uncorrected finite-difference wavefield propagation with fine sampling. There is much less dispersion compared to Figure 1, but a little more than in Figure 2 The zero-phase character is not well preserved.

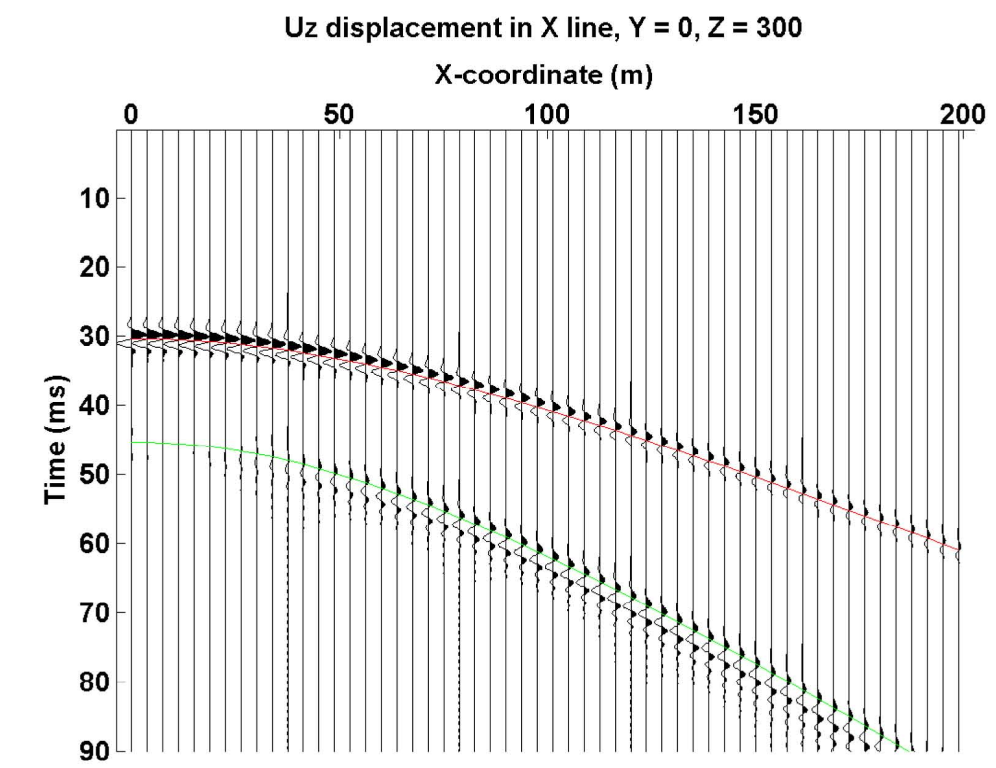

FIG. 4. Uncorrected finite-difference wavefield propagation as in Figure 1, but presented as seismic traces at Z = 300 metres. The pressure wave event arrives earlier and has minimal dispersion. The shear wave arrives later, but has definite dispersion.

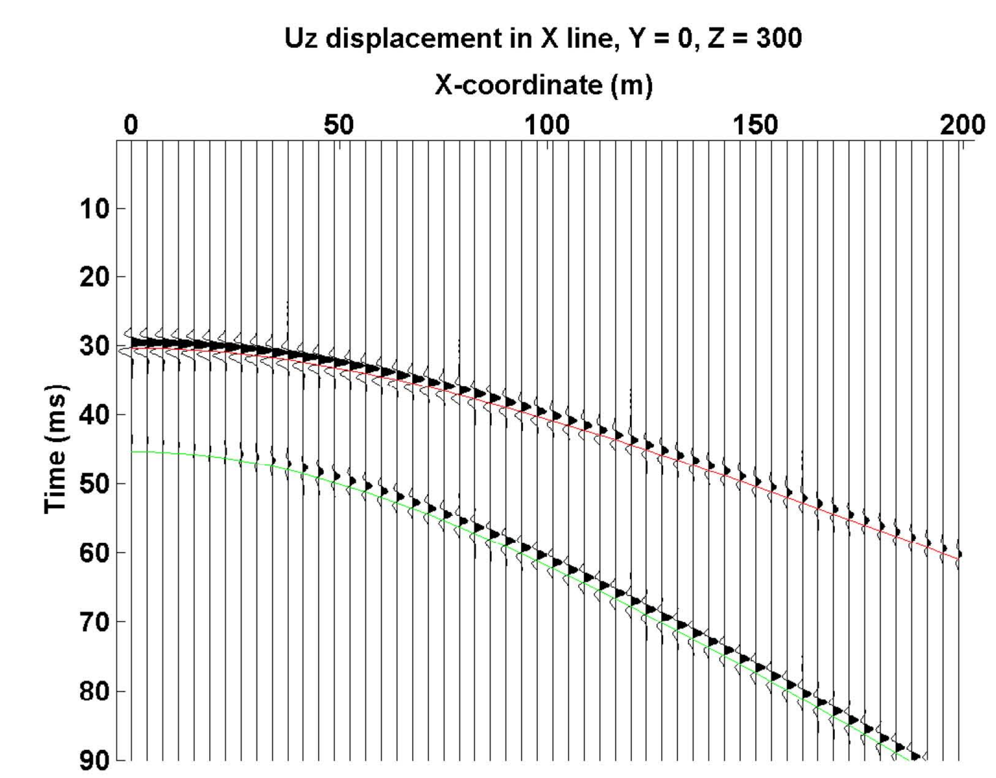

FIG. 5. Corrected finite-difference wavefield propagation using the exact velocities of the model. The wavelets are not dispersed and are almost exactly zero-phase. Notice that the waves arrive earlier, as shown by comparison with the coloured moveout lines.

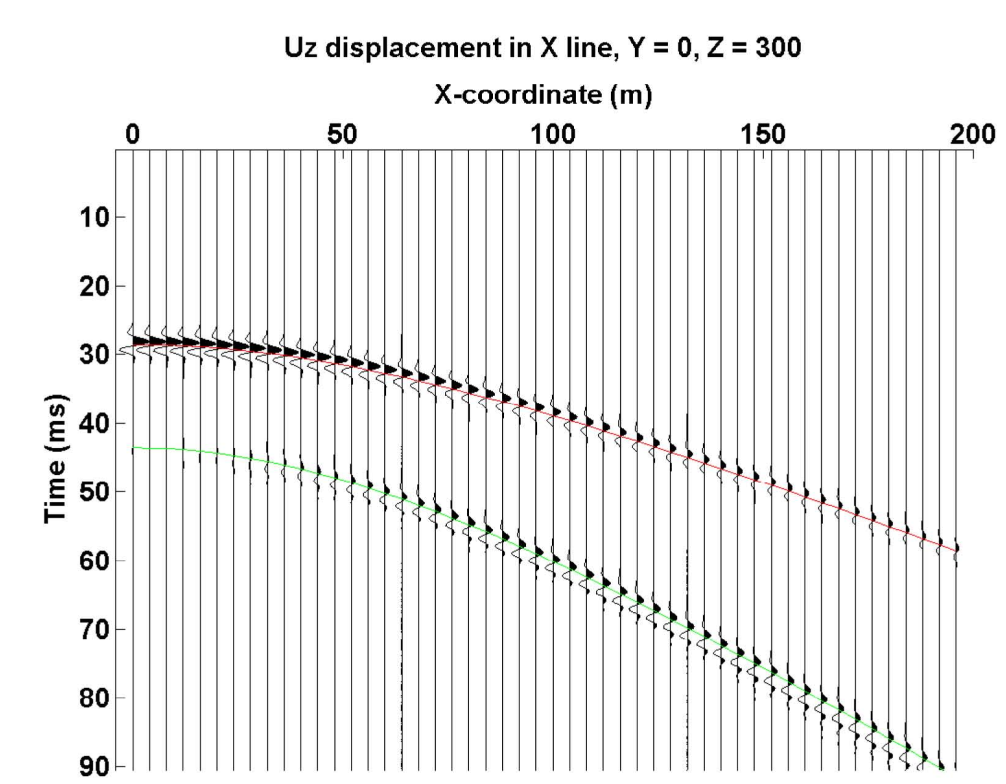

FIG. 6. Uncorrected finite-difference wavefield propagation with fine sampling. The wavelet dispersion is much less than in Figure 4, but is not reduced to the level seen in Figure 5.

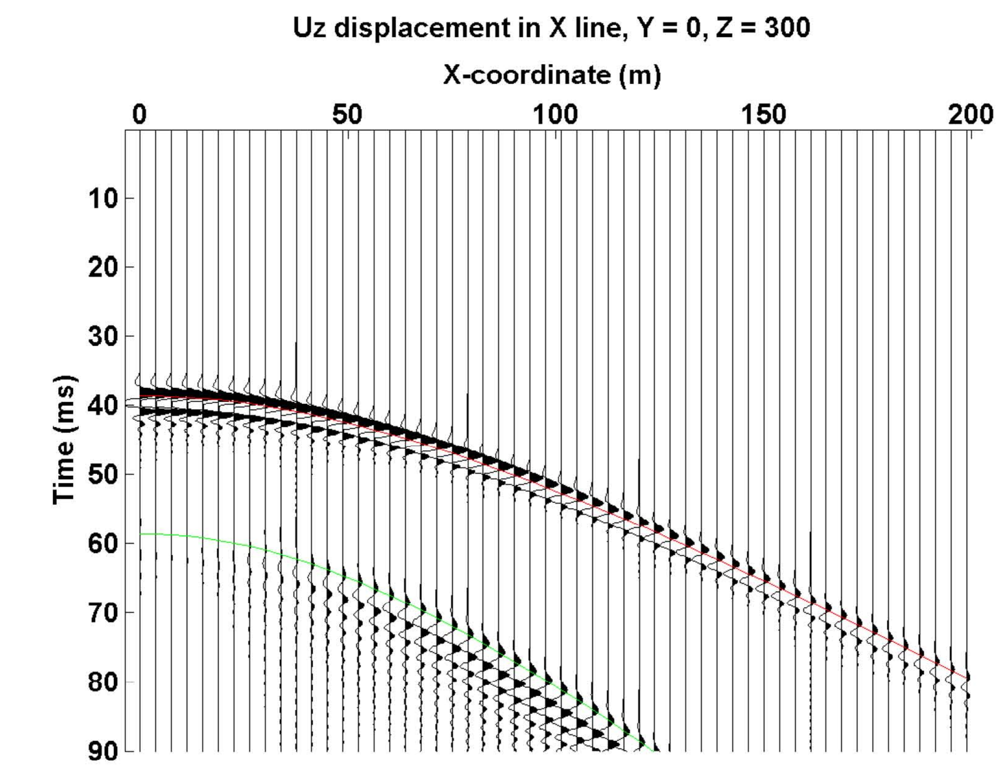

FIG. 7. Uncorrected finite-difference wavefield propagation in a 3000 m/sec medium. Dispersion is minimal on the pressure wave, but the shear wave has a very significant amount.

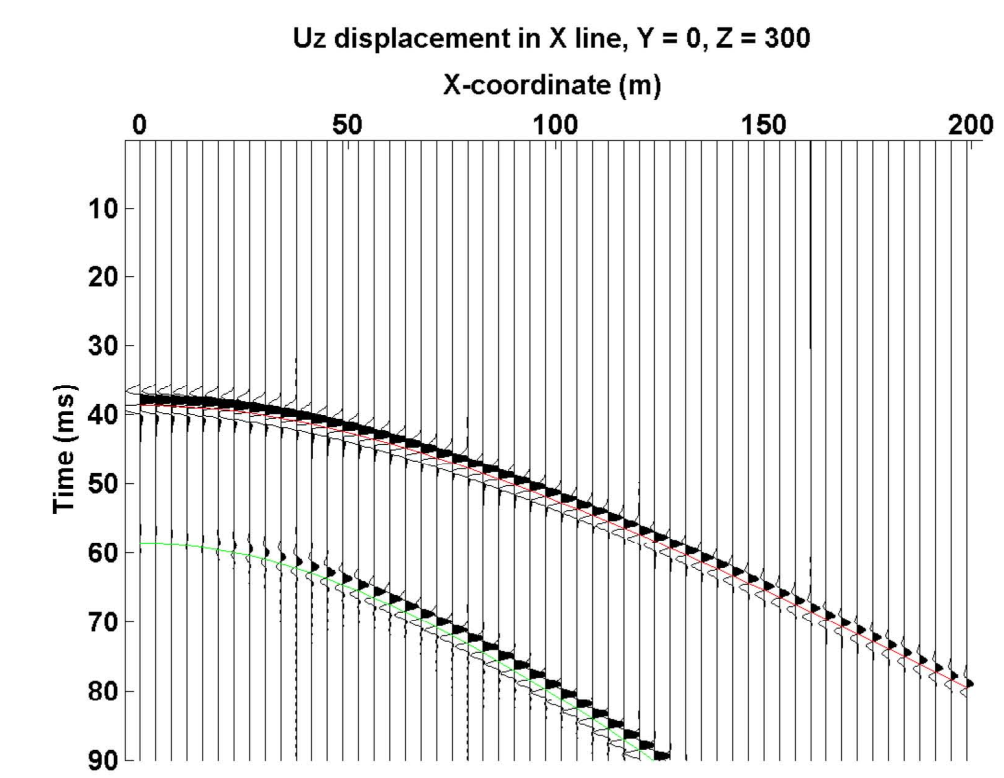

FIG. 8. Finite-difference wavefield propagation through a 3000 m/sec medium, but corrected as if it was a 3000m/sec medium. The wavelets here have had most of the dispersion eliminated, but they do not have the clean zero-phase character of a very accurate correction, as in Figure 5.

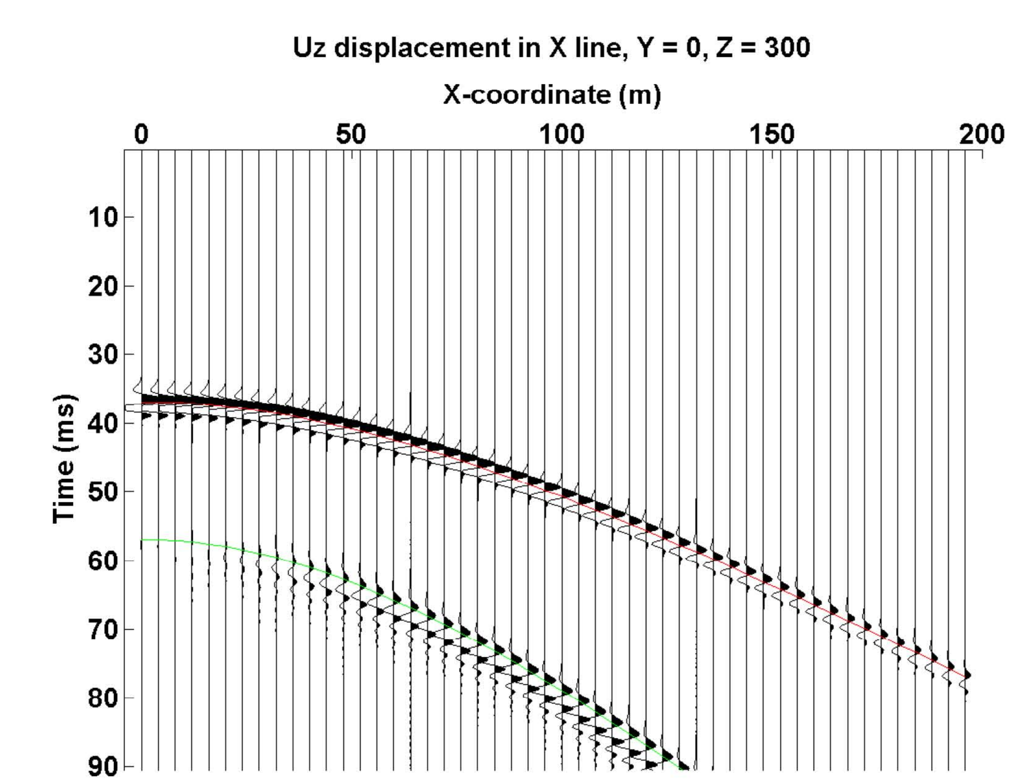

FIG. 9. Uncorrected finite-difference wavefield propagation in a 3000 m/sec medium, but with a fine sample rate. The pressure wave is almost zero-phase, but the shear wave still has some dispersion.

CONCLUSIONS

Optimum correction filters are a highly effective and efficient way to improve the results of finite-difference modelling. There is also an indication that a correction filter set may be used for a range of velocities. This was shown for velocities that ranged lower than the design velocities.