Geophysical Research Abstracts
Vol. 13, EGU2011-4532, 2011
EGU General Assembly 2011


# Wavenumber sampling strategies for 2.5D frequency-domain seismic modelling in general anisotropic media

Stewart Greenhalgh (1), Bing Zhou (2), and Mark Greenhalgh (3)

(1) ETH Zurich, Institute of Geophysics, Zurich, Switzerland (gstewart@aug.ig.erdw.ethz.ch, 41446331065), (2) Department of Geology & Geophysics, University of Adelaide, Adelaide, Australia (bing.zhou@adelaide.edu.au, 61883033830), (3) Southern Geoscience Consultants, Perth, Australia (mgreenha@gmail.com, 61862545000)

The inversion of reflection seismic profile data, crosswell seismic measurements and VSP data are often performed using a 2D forward modelling technique in which the point source used in practice is replaced by a line source. This brings mathematical simplicity and computational efficiency to the problem compared to full 3D modelling. However, to make the synthetic data compatible with the observed data requires special filters or correction procedures to convert the 3D field data into line source (2D) data. Such filters are strictly only valid in the far-field for homogeneous acoustic models and may fail when there are overlapping arrivals, mode conversions and velocity gradients and/or layering present. To overcome such drawbacks one can use a 2.5D modelling technique which incorporates the 3D wavefield characteristics. The modelling and inversion can be done in either the time domain or the frequency domain, but the latter offers advantages for inversion in terms of both stability and computational efficiency. Therefore, the 2.5D modelling should also be done in the frequency domain. To obtain the frequency domain solution at each iterative update, one must compute the discrete inverse Fourier transform of the frequency-wavenumber domain wave solutions for a series of wavenumber samples. Each wavenumber-domain solution is essentially the solution of a 2D problem, which is obtained by solving a large dimensional linear equation system. Singularities occur in the wavenumber spectra at certain critical wavenumbers. There may be many such critical wavenumbers in heterogeneous, anisotropic media. Determining the distribution of wavenumber samples to avoid such singularities is crucial to successful 2.5D frequency domain seismic modelling. The computational accuracy as well as the efficiency therefore depend largely on the wavenumber sampling strategy used. This involves determining the wavenumber range and the number of the sampling points, and overcoming the singular points in the wavenumber spectrum when taking the inverse Fourier transform. In this study, we have employed our newly developed Gausssian quadrature grid numerical modelling method to extensively investigate suitable wavenumber sampling strategies for 2.5-D frequency-domain seismic wave modelling in complex media. We show analytically as well as numerically that the various components of the Green's function tensor wavenumber-domain solutions have either symmetric or anti-symmetric properties and other oscillatory characteristics, which can be fully utilised to construct effective and efficient sampling strategies for the inverse Fourier transform. We demonstrate two sampling schemes [U+F0BE] called irregular and regular sampling strategies for the 2.5-D frequency-domain seismic wave modelling technique. The former involves dividing the wavenumber range into discrete sections bracketed by the critical wavenumbers, and using a Gauss-Legendre sampling scheme to skip or avoid these critical wavenumbers. The regular sampling scheme does not require knowledge of the locations of the critical wavenumbers but introduces slight attenuation into the model via complex elastic moduli (with a small imaginary part) to damp out the pole-like behaviour. This approach essentially lifts the singular points off the real axis along which the integration is performed. The numerical results, which involve calibrations with analytic solutions and comparisons with different wavenumber sampling strategies, show that the two sampling strategies are both suitable for efficiently computing the 3-D frequency-domain wavefield in a 2-D heterogeneous, anisotropic medium. These strategies depend on the given frequency, elastic model parameters and maximum wavelength, as well as the offset distance from the source.