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New approach to modelling the wavefield for A.V.O. analysis using the phase-screen method

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A phase-screen modelling code which accommodates diffracted and converted phases for all ray paths up to critical angle has been developed. The phase screen approach has previously been used to model scalar waves in a variety of environments, but this work builds upon the generalization of the technique for elastic waves [Wu, R.-S., 1994. Wide-angle elastic wave one-way propagation in heterogeneous media and an elastic wave complex-screen method. J. Geophys. Res. 99 (B1) 751-766; Wild, A.J., Hudson, J.A., 1998. A geometrical approach to the elastic complex-screen. J. Geophys. Res. 103, 707-726]. The phase-screen method stores the wavefield as a 2-D plane of complex values, perpendicular to primary direction of propagation. The method steps this plane through a 3-D model-space alternating between spatial and wavenumber domains. The new approach relies upon pre-scanning the model-space to assess the complexity of an individual screen. A complexity coefficient is derived accounting for the relative strength of scattering and the local dip of any acoustic impedance contrasts across the screen. This coefficient is used to select the domain transform technique for each screen. These techniques include transforming the entire wavefield in a single step, splitting the wavefield into series of Gaussian distributions and transforming each separately, and transforming each node individually. The computationally time-consuming transforms can overcome the uncertainty problem between the spatial position of the wavefield energy and the angle of incidence. This knowledge of local slowness and dip provides a complete angular picture and allows for full Zoeppritz solutions of all reflection/transmission coefficients to be determined and implemented. This enables accurate amplitude vs. offset (AVO) analysis for comparison with real data sets.

Emphasis is placed on reducing computational run-time to maintain efficiency over

other “full wavefield” modelling techniques, such as finite difference. The code has been entirely recast into c++ where the distinct class structure aids the transition between transform techniques. Furthermore, the implications for post-critical ray paths and transverse anisotropy are discussed.