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A 3D Tracing Waves Method for the construction of seismic propagators: The 3D Global Screen Propagator.

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The numerical solution of a scattering phenomenon may involve different approaches. One of them consists of full-wave methods that are based upon the solution of the exact wave equation by using finite difference or finite element techniques. Any characteristic of the propagation is considered but the related numerical process requires a high computer memory and a high computational burden also (Komatitsch et al. 1999). Another solving approach is defined by asymptotic methods. Some of them consists in solving a parabolic approximation of the wave equation. The approximate wave equation is given by a pair of uncoupled equations which describe the wave propagation along an axis. A first method (WKB) was concerned with the derivation of the parabolic equations as a high-frequency approximation of the one-dimensional wave equation. Later, Corones (1975)improved the modeling by introducing a Bremmer series that allows to account for the reflection and transmission, as opposed to the first modeling (Bremmer 1951). Other asymptotic methods are based upon the tracing ray theory. It is also a high-frequency approach which permits a fast computation of the seismograms, as opposed to a full-wave method. However, the accuracy of ray methods decreases in singular regions and high-frequency methods are unsuitable for the wave scattering by strongly heterogeneous objects. Recently, De Hoop and its co-workers (1996, 2000) have developed a new method for solving the wave equation. It can be considered as a hybrid method between full-wave and high-frequency methods. The method is based on a system which is derived from the exact wave equation by proceeding to the micro-local analysis of the wave front set in a selected direction which can be the depth for seismic wave modelling but also the normal direction for the scattering by an object. By analogy with the formalism in ray theory, the approach is called the Tracing Wave Methods. Applying the tracing wave theory modifies the

wave equation to a system of uncoupled equations which involve the out-going and in-going Dirichlet-to-Neumann operators and coupling terms which account for the reflection and transmission. Then, the new system shows off the main role played by the square-root of the Helmholtz operator. It can be proved that the resulting model generalizes the system of Corones: the parabolic equations coupled with a Bremmer series is an approximation of the tracing wave method in case of small lateral variations of the medium velocity. Besides a lower computational burden as opposed to a full-wave method, the tracing wave method provides a numerical way to separate the multiple reflections which is of great importance for an accurate imaging of the medium by using wave

propagation. Here, we intend to apply the micro-local method for the computation of seismograms in complex structures. This provides new and more precise results as compared to Le Rousseau method where a numerical study was developed in terms of snapshots only. We derive the one-way model by using pseudo-differential techniques. Then, we will describe the numerical method and focus on its main difficulties. At last, we show the accuracy of the method as far as the kinematic is concerned but its weak spots also. We compare the seismograms calculated with GSP for a complex Andean Zone to those obtained with a parallel version of the Spectral Element Method (SEM). The calculations are much faster by an order of magnitude than those performed with a parallel version of the Spectral Element Method. GSP is less accurate but offers a very fast first approximation of the solution.