Geophysical Research Abstracts
Vol. 13, EGU2011-4241-1, 2011
EGU General Assembly 2011

Uniform Asymptotic Expansions for Vector Waves

Matthew Yedlin (1) and Jean Virieux (2)

(1) Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, Canada (matt.yedlin@gmail.com), (2) LGIT, Université Joseph Fourier - Grenoble, Grenoble, France

Continued improvement in data collection and data processing both in seismology and in ground penetrating radar (GPR) supports the transition from travel-time tomography to full waveform inversion[1,2,3,4,5]. Furthermore, data acquisition in both modalities of wave propagation is obtained in vector form, with three-component recording in seismology and dual polarization recording in electromagnetics. When full waveform inversion is employed, sensitivity kernels[6,7] for vector wave propagation need to be computed, directly using finite difference methods in either the frequency or time domains. Central to the computation of these kernels are the Green's functions (or Green's tensors, in the vector case) in either two or three dimensions.

While these functions may be obtained numerically, at great expense, an alternative is to employ ray-tracing Green's functions to obtain sensitivity kernels that can be used iteratively, in an approximate full waveform inversion. Yedlin and Virieux [8] have shown how to obtain these Green's functions, in the frequency domain, for the scalar case, corresponding to acoustic wave propagation or Transverse Magnetic polarization in the electromagnetic case. These Green's functions are uniform and correctly account for the source singularities.

We propose to extend the foregoing results for the vector case for either the isotropic elastodynamic case or the isotropic electromagnetic case. We will focus exclusively on the three-dimensional case, which is algebraically simpler, due to the nature of the two-dimensional scalar Green's function which has the strange transition from a logarithmic behavior in the near field to complex exponential behavior in the far field. This is not the case for the three-dimensional Green's function. These uniformly asymptotic Green's tensors, for vector waves, will correctly take into account the source strength and polarization, and then can be used to compute the appropriate sensitivities.

References

[1] R. G. Pratt. 1999, Seismic waveform inversion in the frequency domain, part 1: Theory and verification
in a physical scale model. Geophysics 64(3), pp. 888-901.

[2] J. R. Ernst, H. Maurer, A. G. Green, and K. Holliger. 2007, Full-Waveform inversion of crosshole radar data based on 2-D finite-difference time-domain solutions of Maxwell's equations. IEEE Transactions on Geoscience and Remote Sensing, vol. 45, issue 9, pp. 2807-2828.

[3] Brossier, R., S. Operto and J. Virieux. 2010, Which data residual norm for robust elastic frequency-domain Full-Waveform Inversion? Geophysics, 75(3), pp. 37-46.

[4] G.A. Meles, J. Van der Kruk, S. A. Greenhalgh, J. R. Ernst, H. Maurer and A. G. Green. 2010, A new vector waveform inversion algorithm for simultaneous updating of conductivity and permittivity parameters from combination crosshole/borehole-to-surface GPR data. IEEE Transactions on Geoscience and Remote Sensing, vol. 48, issue 9, pp. 3391-3407.

[5] S. Kuroda, M. Takeuchi and H. J. Kim. 2007, Full-waveform inversion algorithm for interpreting crosshole radar data:
a theoretical approach. Geosciences Journal vol. 11, No. 3, p. $211-217$.

[6] H. Marquering, F. Dahlen and G. Nolet. 1999, Three-dimensional sensitivity kernels for finite-frequency traveltimes: The banana-doughnut paradox. Geophysical Journal International 137(3), pp. 805-815.

[7] J. Tromp, C. Tape and Q. Liu. 2005, Seismic tomography, adjoint methods, time reversal and banana-doughnut kernels. Geophysical Journal International 160(1), pp. 195-216.

[8] M. Yedlin and J. Virieux. 2010, Uniformly Asymptotic Frequency Domain Green's Functions for the Acoustic Equation - Theory and Applications in Two and Three Dimensions, Geophysical Research Abstracts vol. 12, EGU2010-7006-4, 2010 EGU General Assembly 2010.