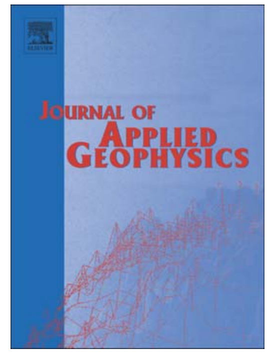
Accepted Manuscript



Spectral-difference parallel algorithm for the seismic forward modeling in the presence of complex topography

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PII: S0926-9851(15)00055-5
DOI: doi: 10.1016/j.jappgeo.2015.02.016
Reference: APPGEO 2702

To appear in: *Journal of Applied Geophysics*

Received date: 7 August 2014
Revised date: 29 January 2015
Accepted date: 1 February 2015

Please cite this article as: Terekhov, Andrew V., Spectral-difference parallel algorithm for the seismic forward modeling in the presence of complex topography, *Journal of Applied Geophysics* (2015), doi: 10.1016/j.jappgeo.2015.02.016

Spectral-difference parallel algorithm for the seismic forward modeling in the presence of complex topography.

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Abstract

A spectral-difference parallel algorithm for modeling acoustic and elastic wave fields for the 2.5D geometry in the presence of irregular surface topography is considered. The initial boundary-value problem is transformed to a series of boundary-value problems for elliptic equations via the integral Laguerre transform with respect to time. For solving difference equations, it is proposed to use efficient parallel procedures based on the fast Fourier transform and the dichotomy algorithm, the latter was designed for solving systems of linear algebraic equations (SLAEs) with tridiagonal and block-tridiagonal matrices. A modification of the dichotomy algorithm for diagonally dominant matrices, which makes it possible to reduce the time of preparatory computations and increase scalability of the method relative to the number of processors, is considered. The influence of different methods of curved boundary approximation on the quality of solution is investigated; practical evaluation of accuracy is performed. Calculations of the wave field with the use of high-resolution meshes for the Canadian Foothills medium model are presented. Implementation of the complex frequency-shifted PML boundary conditions for a dynamic elasticity problem is considered in the context of the spectral-difference approach.

Keywords: Parallel dichotomy algorithm, Domain decomposition method, Laguerre transform, Acoustic solver, Elastic solver, PML absorbing boundary condition
PACS: 02.60.Dc, 02.60.Cb, 02.70.Bf, 02.70.Hm

1. Introduction

In many cases, while solving seismic prospecting problems it is required to solve a forward problem of calculation of an acoustic or elastic wave field. This is necessary for investigating the calculation quality of static and kinematic corrections, for solving migration and inverse problems[1]. At that, the numerical model has to reproduce with good accuracy the main features of the physical medium, namely, an irregular surface topography, low velocity zones, real space-time scales, etc.

By now, modeling of the acoustic and elastic wave field dynamics presents no problems in terms of mathematics. Various classes of numerical algorithms have been developed and substantiated [2–5], namely, the finite-element, finite-difference, finite-volume methods, integral equation methods, spectral and pseudospectral methods, which, depending on the problem statement (boundary conditions, boundary geometry, elastic medium coefficients, etc.), make it possible to obtain the solutions with desired accuracy.

The presence of an irregular surface topography introduces artifacts of kinematic wave field parameters in geophysical measurements. These artifacts are minimal at small times and drastically grow with time. Various numerical algorithms were proposed for approximation of the irregular surface topography in the context of the grid approach, for example, vacuum formulation, image method, interior method [3, 6–11].

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