地球物理学报 » 2010, Vol. 53 » Issue (10) :2484-2496

引用本文:
冯德山, 陈承申, 戴前伟.基于UPML边界条件的交替方向隐式有限差分法GPR全波场数值模拟[J]. 地球物理学报, 2010,V5
10.3969/j.issn.0001-5733.2010.10.022

FENG De-Shan, CHEN Cheng-Shen, DAI Qian-Wei.GPR numerical simulation of full wave field based on UP
J.Geophys. (in Chinese),2010,V53(10): 2484-2496,DOI: 10.3969/j.issn.0001-5733.2010.10.022

基于UPML边界条件的交替方向隐式有限差分法GPR全波场数值模拟

冯德山, 陈承申, 戴前伟*

中南大学信息物理工程学院,长沙 410083

GPR numerical simulation of full wave field based on UPML boundary condition of ADI-FD

FENG De-Shan, CHEN Cheng-Shen, DAI Qian-Wei*

School of Info-Physics and Geometrics Engineering,Central South University,Changsha 410083,China

摘要 交替方向隐式差分(ADI-FDTD)法突破了Courand-Friedrich-Levy(CFL)条件的约束,具有无条件稳定的特点;而单
完全匹配层(UPML)边界条件具有宽频带吸收特性,不需要对电场和磁场进行分裂,迭代公式简单,便于编程的特点.综合两者
出了基于UPML边界条件的ADI-FDTD探地雷达数值模拟算法,通过对3个二维Maxwell方程进行离散化,推导了GPR波的ADI
其UPML边界条件的两个子时间步的迭代差分公式,并分别给出了详细计算步骤.在此基础上,开发了相应的模拟程序,应用该
GPR模型进行了正演模拟,得到了两个正演模型的wiggle图、扫描图与全波场快照.通过分析这些雷达剖面图与波场快照,可
波形在空间中的传播过程及变化规律,有助于雷达资料更可靠、更准确的解释.模拟结果表明,基于UPML边界条件的ADI-FD
取较大的时间步长,消除了截断边界处的强反射,能对简单与复杂GPR模型进行快速、高效模拟.

关键词: 探地雷达 交替方向隐式有限差分法 单轴各向异性完全匹配层 数值模拟

Abstract: ADI-FDTD could break through the restriction of the CFL stability condition and is unconditio
stable. However, UPML boundary condition has the characteristic of absorbing wide frequency and witho
necessity for separating electric field from magnetic field. Its simple iterative formula is convenient for co
program. Synthesizing the merits of both methods, this paper put forward a GPR numerical simulation alg
ADI-FDTD based upon UPML boundary condition. Through the discretization of the three two-dimensiona
equations, this paper put forward two sub-time step iterative finite difference formulae of ADI-FDTD and
boundary condition of GPR wave, and gave the computing steps in detail separately. Based on this, we c
compile the corresponding program, use the program to simulate the two GPR models, get the wiggle ma
maps, and snapshots of the two models. By analyzing these section maps and snapshots of the spreadin
of GPR wave, we can learn the regularities of radar wave spreading and changing in the space, so as to
interpretation of radar data reliably and accurately. The simulation result indicated that the ADI-FDTD al
based on the UPML boundary condition eliminated the strong reflection of truncating boundaries and it c
choose larger time steps. So it could simulate GPR model efficiently, reliably and accurately.

Keywords: Ground penetrating radar Alternating direction iterative finite difference time domain Uni
perfectly matched layer Numerical simulation

Received 2010-06-08;

Fund: