地球物理学报 » 2012, Vol. » Issue (9) :3115-3125 doi:10.6038/j.issn.0001-5733.2012.09.029
应用地球物理

引用本文(Citation):
石颖, 王维红.基于波动方程预测和双曲Radon变换联合压制表面多次波. 地球物理学报, 2012,(9): 3115-3125,doi: 10.6038/j.issn.0001-5733.2012.09.029

SHI Ying, WANG Wei-Hong.Surface-related multiple suppression approach by combining wave equation prediction and hyperbolic Radon transform.Chinese J.Geophys. (in Chinese),2012,(9): 3115-3125,doi: 10.6038/j.issn.0001-5733.2012.09.029

基于波动方程预测和双曲Radon变换联合压制表面多次波

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Surface-related multiple suppression approach by combining wave equation prediction and hyperbolic Radon transform

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摘要 基于波动方程预测的表面多次波压制方法可处理复杂地下介质的地震资料,但计算成本较高.基于滤波的多次波压制方法计算效率较高,但其成功应用仅局限于一次波和多次波有明显时差差别的地震数据,对来自速度逆转等复杂介质数据则较难获得满意的压制效果.本文将波动方程预测的反馈迭代法和滤波法有效结合,采用GPU(图形处理器)和CPU协同并行加速计算粗略预测表面多次波,随后在双曲Radon域比较分析原始数据和预测的多次波,设计合理有效的Butterworth型自适应滤波器,滤出原始数据Radon域中的多次波能量,进行Radon反变换后,在时空域将多次波从原始数据中减去,得多次波压制结果.文中对理论模拟的单炮数据、复杂的SMAART模型以及实际地震数据进行了计算,结果表明,结合基于波动方程预测和双曲Radon变换的方法有效突破了两种方法各自的局限性,可高效高精度地压制复杂地下介质的表面多次波.

关键词 表面多次波, GPU, 波动方程, 滤波法, 压制

Abstract: Surface-related multiple suppression method based on wave equation prediction can handle seismic data from complex subsurface, but the computational cost is high. For filter-based multiple suppression method, its computation efficiency is high, but it is only limited to the seismic data which has enough moveout difference between the primary and multiple. It is difficult to obtain satisfactory suppression effect for the seismic data from complex media, such as velocity reversal. The proposed algorithm combines wave equation prediction with filtering method effectively, surface-related multiple is predicted approximately by the collaborative parallel acceleration calculation from GPU(graphic processing unit) and CPU, followed by comparing and analyzing original data and predicted multiple in the hyperbolic Radon domain. We design an effective adaptive Butterworth-type filter to select the multiple energy from original data in Radon domain. After inverse Radon transform, suppression result can be obtained by subtracting multiple from original data with multiple. The theoretical single-shot data, complex SMAART model and field data are tested by the proposed algorithm. The results demonstrate that the multiple suppression method in the article can breakthrough the limitations of wave equation based method and hyperbolic Radon transform effectively, which can suppress surface-related multiples from complex subsurface efficiently and accurately.

Keywords Surface-related multiple, GPU, Wave equation, Filter method, Suppression

Received 2012-05-03;