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三维复杂速度模型的交切法地震定位

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An intersection method for locating earthquakes in 3-D complex velocity models

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摘要 地震定位是地震监测与减灾研究重要基础.基于均匀或横向均匀介质模型,利用震源轨迹确定震源位置的交切法具有稳健和效率高的优点,但定位精度较低,特别是震源深度.为提高震源定位精度,我们提出适用于三维复杂速度模型的地震定位交切法.将地壳速度模型由均匀或横向均匀介质模型扩展为三维复杂速度模型;均匀或横向均匀介质模型对应的原假设为球面或双曲面的震源轨迹通过最小走时树射线追踪技术予以确定.确定震源位置的震源轨迹以到时差作为约束条件;将震源定位于震源轨迹交汇最密集的点处,即总的到时差残差(RDT)最小的点处.定位结果的不确定性可通过RDT值较小节点的空间分布予以定性表示.考察了准确速度模型、扰动速度模型、扰动观测到时及地震在台网外等4种情况下改进方法的地震定位效果,结果表明改进的交切法可用于三维复杂速度模型的地震定位;综合利用P波与S波的到时差信息,可明显改善震源位置约束;使用多条震源轨迹进行定位,有助于减少由随机因素导致的定位误差.

关键词 三维复杂速度模型, 地震定位, 交切法, 震源轨迹, 最小走时树算法

Abstract: Earthquake location is critical to the research on seismicity and disaster alleviation. The location problem can be solved by an intersection method which determines a hypocenter using its focal loci. The traditional intersection method is excellent in robustness and efficiency but deficient in location accuracy especially for hypocenter depth because it is based on homogeneous or laterally homogeneous media that are far from the real Earth. In order to eliminate the disadvantage of low accuracy, we have modified it in the suitability for 3-D complex velocity models. In the modified method, focal loci are not assumed to be spherical or hyperboloidal but exactly calculated with a minimum traveltime tree algorithm for tracing rays. The focal loci are constrained with observed arrival time differences so that the problem of origin time is evaded. The hypocenter is located at the point that the focal loci most densely intersect, namely, the point with the minimal total residual of arrival time differences (RDT). The location uncertainty is qualitatively estimated by means of the distribution of nodes where RDT is smaller. The modified intersection method is verified with an earthquake in a complex model. The location tests in different cases including accurate model, perturbed model, noisy arrival times and partial observation show that the modified location method is practical for locating earthquakes in 3-D complex velocity models; integrated utilization of arrival time differences between and of P- and S- waves can remarkably improve the constraint on the hypocenter; using more focal loci can decrease the influence of random errors on earthquake location.

Keywords 3-D complex velocity model, Earthquake location, Intersection method, Focal locus, Minimum traveltime tree algorithm

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