Submission code: P67LBMA9WL

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Comparison Between the Optimization Method Using Spherical Geometric Modeling (OMSGM) and the Fast Marching Method (FMM) for Time-Domain Wave Propagation

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Introduction

The reduction of computational costs enables projects with large volumes of data. In seismic simulations, fast data processing allows for adjustments in predictions and refinement of geophysical analyses in less time. This contributes to energy sustainability, as energy consumption and financial costs associated with more complex projects are reduced. Additionally, improved computational efficiency facilitates surface imaging, optimizing reservoir characterization in hydrocarbon exploration. In this study, we applied the method to improve performance in wave propagation, using Mean Squared Error (MSE) as the evaluation metric.

Method and/or Theory

This work compares two methods for reducing computational costs in seismic wave propagation simulations: the Optimization Method Using Spherical Geometric Modeling (OMSGM) and the Fast Marching Method (FMM). The OMSGM limits the Laplacian computation to a dynamically defined region of interest, reducing unnecessary calculations within the grid. In contrast, the FMM computes first-arrival travel times by solving the Eikonal equation, efficiently propagating the wavefront in a single pass. Simulations were conducted in three-dimensional acoustic media, with variations in source positions, grid sizes, and discretization levels.

Results and Conclusions

Preliminary results show that both methods significantly reduce computational effort compared to conventional full-domain modeling approaches. The OMSGM achieved up to 34% runtime gains, while the FMM provided rapid travel-time estimation with low memory usage. These findings highlight the potential of both methods for optimizing wave propagation simulations, especially in large-scale seismic applications.