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Modeling Tsunamis from Dynamic Earthquake Sources: A High-Order Spectral Solver

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Despite progress in tsunami modeling, the role of earthquake dynamics in tsunami generation remains underexplored, as traditional models typically assume instantaneous seabed displacement. This study investigates the impact of dynamic rupture processes on tsunamigenesis, a multiscale problem involving high-frequency seismic waves and slower tsunami waves. We introduce a high-order spectral tsunami solver based on the Fourier Continuation (FC) method, which minimizes numerical dispersion, making it well-suited for long-distance and long-time wave propagation. The solver applies to the nonlinear shallow water equations, extended to include time-dependent seabed motion. Building on prior 1D studies of the 2018 Sulawesi tsunami, we develop a fully 2D version capable of modeling realistic earthquake-driven tsunamis. Numerical experiments demonstrate high-order convergence, efficiency, and accuracy through comparisons with high-order finite difference methods and validation against benchmark cases and observational data. This approach offers a promising tool for improved hazard assessment and early warning systems.

Auteur: MELKIOR, Thomas (LMPS (Laboratoire de Mécanique Paris-Saclay), CNRS)

Orateur: MELKIOR, Thomas (LMPS (Laboratoire de Mécanique Paris-Saclay), CNRS)

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