Point-to-point Tsunami Ray Tracing Method

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Wave ray tracing is a commonly used tool for researches in seismology which provides important information for wave propagation, ray path, and arrival time prediction. There are two kinds of ray tracing methods: the initial value problem, and the boundary value problem. In terms of tsunami research, ray tracing is a useful method to assess the tsunami travel path and arrival time and gives us essential information for hazard prevention and mitigation.
Initial value ray tracing has been applied to tsunami researches since 1980s. Woods and Okal (1987) applied the ray tracing to tsunami propagation in an ocean to reconstruct the tsunami wavefield from the 1960 Chile earthquake. Sansanbata et al. (2018) applied the ray tracing method to dispersive tsunamis and demonstrated that the ray path of the dispersive tsunami wave is frequency-dependent.
In this study, we perform a boundary value tsunami ray tracing with the long wave assumption, where a tsunami traveltime program (TTT, Geoware) is applied in our study. Our ray tracing method (hereafter, LW method) calculates the ray path by minimizing the tsunami travel time between the source and the receiver. The LW method exhibits an explicit and efficient approach with an ignorable expected error of 0.05%. We compare the LW method to the bending method (Um and Thurber, 1987; Koketsu and Sekine, 1998) which is commonly used in seismic wave research. Two almost identical ray paths are expected by the two methods. Our result shows that the LW method utilizes a noniterative scheme and exhibits a more efficient way to an expected result. The advantage of the LW method can be obvious in transoceanic tsunami events.

Keywords: ray tracing, bending method, tsunami, long wave, travel time

