Calculation of tsunami propagation by applying ray tracing based on the shortest path method to tsunamis

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Ray tracing of seismic surface wave was already applied to tsunami propagation (Satake,1988). Here, we apply another ray tracing method based on the shortest path method. In standard ray tracing method, the ray starts at a source point and travel to an end point. However, it is difficult to reach the end point when the ray path is sensitive to velocity distribution (bathymetry distribution). Sometimes, the calculated ray is a local minimum path, not a global minimum path. When we trace the ray based on the shortest path method, there are no such problems. We calculate rays in Pacific Ocean and Japan Sea. Using 1’ by 1’ ETOPO1 data, 1 degree by 1 degree bathymetric data are obtained for trans-Pacific tsunami by applying moving average. 0.1 degree by 0.1 degree depth data are obtained for the Japan Sea tsunami. Moving average is made with neighboring +-5 degrees for the Pacific Ocean data and +-0.5 degree for the Japan Sea data. In the shortest path method, the studied area is divided into many square cells. On the cell boundary, several nodes are evenly distributed. Paths are made by connecting all combinations of two nodes of common cell by straight lines. The path of the shortest travel time from the starting point to each node is searched. At first, the cell is same as the bathymetric data grid of each of Pacific Ocean and the Japan Sea, and node number is set to be 5. Then, the cell number and the node number are multiplied by 2, respectively. When the difference of the mean travel time is less than 60 seconds, we judge the calculation is converged. The mean travel time is obtained by averaging all travel time values at 1 degree by 1 degree data grid points for the Pacific Ocean or 0.1 degree by 0.1 degree data grid point for the Japan Sea. Tsunami sources are located off the shore of Chile and at 1983 Japan Sea earthquake. Converged (cell number, node number)’s are (1,10) and (1,5), and calculation times are about 3.14s and 0.60s, respectively. Areas of depth shallower than 1,000m are excluded in the calculation of the Pacific Ocean. It is shown that travel times of all the target area can be estimated by the shortest path method within very short calculation time.

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