Application of FVCOM to 2004 Indian Ocean Tsunami Focusing on Inundation in Banda Aceh, Indonesia

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Most of the tsunami computations have been based on nesting approach on a structured grid system (Koshimura *et al.*, 2009; NOAA). Recently, free and open source unstructured grid ocean circulation models are proposed and start to be applied to tsunami simulation (Zhang and BaptistaC2008). FVCOM developed by Chen *et al.* (2003) is one of the free and open source unstructured models and becoming popular among scientists and engineers because of its high performance and preparation of useful manuals. Features of the model are an adoption of finite volume method, capability of wet and dry cell treatment and efficient parallel computing based on MPI. These advantages will be effective for application to tsunami propagation and inundation problems. To our knowledge, the model has not been applied to tsunami simulation and thus the objectives of the present study are to consider the applicability of FVCOM ver. 2.6.1 to tsunami problems, including application methodology and validation of the performance.

We selected the 2004 Indian Ocean tsunami as an application target focusing on inundation in Banda Aceh. First, we slightly changed the source code to give an initial variation in surface elevation that is determined using a tsunami fault model of Mansinha and Smylie (1971) with parameters proposed by Oie *et al.* (2006). We generated unstructured grids using the bathymetric data for propagation region provided by GEBCO and the nearshore bathymetric and land elevation data of ARRIS (JICA, 2005) and ASTER GDEM. The ARRIS data includes the height of major buildings and structures in the city of Banda Aceh. The range of grid size for a propagation region varies from 50 m in the coast to 50 km in the ocean basin while it varies from 5 m to 50 m in an inundation region in Banda Aceh. Roads and structures are resolved in some local inundation area.

We simulated for two-hour clock time and computed tsunami wave profiles were compared with the measured ones at Krabi, Kuraburi and Sibolga. Although there was retardation in phase at Shibolga, the model results are mostly consistent with the measured ones in Krabi and Kuraburi, as well as with some existing numerical works. Computed time series of tsunami surface elevation at the Ulee Lheue coast was also consistent with verbal evidence given by local people interviewed just after the tsunami.

Maximal tsunami inundation heights and horizontal runup distances were compared between computed and measured values after Tsuji *et al.* (2006). The model results are consistent with measured ones in the area where roads and structures were resolved with fine grids while in most of the remaining areas the simulated results underestimate the measured ones. One of the causes of this discrepancy may attribute to the inclusion o f the height of structures in unresolved region into the elevation of grids. Thus, the model works well when the fine structure of the city is resolved, while a careful treatment is required for the region of coarse resolved areas, including an application of the resistance law with the composite equivalent roughness coefficient according to land use and building conditions rather than considering building heights directly (Koshimura *et al.*, 2009).

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