Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

HDS026-07 Room:101 Time:May 22 15:45-16:00

Three dimensional tsunami propagation simulations based on finite element and finite difference models

Yusuke Oishi[1*], Matthew D. Piggott[2], Takuto Maeda[3], Rhodri B. Nelson[2], Gerard J. Gorman[2], Hiroaki Tsushima[4], Takashi Furumura[3]

[1]Fujitsu Laboratories of Europe Ltd., [2]Imperial College London, [3]CIDIR/ERI, The University of Tokyo, [4]Meteorological Research Institute

Tsunami propagation simulations play an important role in tsunami disaster mitigation. Such simulations are commonly based on the two dimensional linear or non-linear long-wave equations which assume the wavelength of the disturbance is large in comparison to the depth of the ocean. On the other hand, Furumura and Saito (2009) used high-performance supercomputers to solve the three dimensional Navier-Stokes equations using a finite difference method with orthogonal meshes to achieve more accurate results, e.g. regarding dispersive features of tsunamis.

The goal of our current research is to develop a highly accurate tsunami simulation model which will make use of current and future supercomputers and appropriate numerical methods for the purpose of contributing to tsunami disaster mitigation measures. In the present study, we employ unstructured meshes and solve the three-dimensional Navier-Stokes equations using a finite element method. The simulation code used is Fluidity-ICOM (http://amcg.ese.ic.ac.uk), which is a multi-purpose finite element / control volume based CFD and ocean dynamics code being developed by Imperial College London and collaborators. Fluidity-ICOM is configured to run in parallel and can make use of dynamic mesh adaptivity.

The more complete fluid dynamical equations of our model will lead to more accurate results than the conventional two dimensional equations. The unstructured meshes make it possible to accurately and efficiently represent complex coastlines and bathymetry due to their flexibility and their multi-scale resolution capabilities. This is the key advantage of the present model over the existing three dimensional modal based on a finite difference method with orthogonal meshes. Using the present tsunami simulation model together with high-performance computers, we expect an accurate representation of tsunami generation due to seafloor deformation, propagation and dispersion of tsunami in deep sea, and amplification of onshore tsunami at coastlines.

In the development of a numerical model, especially one dealing with non-linear phenomena, it is critical to compare results against those of other models, and observations where possible. In the present study, we conducted three dimensional simulations of the tsunami resulting from the off Kii peninsula earthquake of 2004 using the present finite element model. The results are compared with those obtained using a finite difference model based on the three dimensional Navier-Stokes equations (Furumura and Saito, 2009). The present model successfully reproduces the propagation of the tsunami including its dispersive feature and shows good agreement with those from the finite difference model. In this presentation, we will introduce the details of the respective models and show a comparison between their results. This will be followed by a discussion regarding the validity and characteristics of each model.

Keywords: Tsunami, Simulation, Unstructured meshes, Finite element method