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Tsunami-tide simulation: Early arrival time of tsunami due to tidal currents

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This study investigated influences of tides on a giant tsunami generated by the anticipated greatest scenario earthquake along the Nankai Trough by conducting tide-tsunami simulation in Osaka Bay as a pilot shallow ocean. It has been reported that Nankai Trough Earthquake will occur about 70 % of probability within 30 years in the future and drive the giant tsunami. The speed of the tsunami plus the tidal currents may exceed 2 knot (approximately 1 m/s) at many ports in the Japanese coasts facing to Pacific, in particular Seto Inland Sea. This speed can make difficult to operate the marine vehicles ships and escape from the port that the tsunami attacks according to the evacuation scenarios for ships and tsunami hazard maps. However, many tsunami simulations have hardly considered the factor of the tidal current. We conducted the tsunami simulation under the consideration of tidal current (i.e. tsunami-tide simulation) during three days from the earthquake occurrence. Our study area is Osaka Bay retaining many landfills in the nearshore area as a pilot ocean for the tsunami simulation. The high-resolution simulation with a horizontal resolution of 50 m was achieved by employing the nesting method to represent the complex coastal lines around the landfills along the bay coast. Our simulation showed that the tsunami intruding to the bay accelerates (decelerates) in the flood (ebb). As a result, the arrival time of tsunami to the coastline can be earlier (later) in the flood (ebb) than the tsunami without the tide. This indicated that the speed of tsunami intruding to the bay is enhanced (declined) by the advection of the flood (ebb) tide. We have revealed the relationship between the tidal phases and strengths of tsunami-tide interaction, demonstrating that the interaction can be significant in the strong flood and ebb tide due to the advection effect as the tidal waves enters to the coastal, shallow water regions. Further, our simulation showed that the tide-tsunami interaction was locally enhanced in the coastal oceans in front of the landfills in the eastern Osaka Bay. Thus, the tide-tsunami interaction is essential process to improve the model accuracy in the shallow coastal ocean and estimate the accurate arrival time of tsunami wave to coasts. Our results encourage that the realistic simulation of tsunami occurred in each tidal phase should be conducted to improve more safe evacuation scenarios or manuals prepared by effective and accurate hazard maps based on the time-tsunami simulation.

Keywords: Tsunami, Simulation, Tide, Marine Hazard, Nankai Trough Earthquake