Importance of high-resolution 3D topography for wave simulation

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Abstract

Storm waves generated by tropical cyclones often affect people who live in the coastal area and sometimes become a huge disaster. Coastal disaster prevention is an urgent task in the present world where climate change is expected due to global warming. In order to estimate the inundation area and runup height by numerical calculation, one- or two-dimensional calculations are usually performed in coastal engineering research, although three-dimensional calculation is recently carried out if high-resolution topography data is available. However, the coastal topography such as coral reefs are very complex and storm waves are known to be deformed sensitively by reef topography. For reproducing such effect, extremely high-resolution topography is undoubtedly important to be prepared. In order to evaluate effect of resolution of topography against the wave calculation, we developed a 5-m grid resolution 3D topography from land to about 95 m water depth at the eastern coast of Kudaka Island, Japan, by wideband multi-beam bathymetric survey and aerial photogrammetric survey. As a comparison, we also used low-resolution topography (mesh size: 30 arc second = about 900 m). Using 5-m grid resolution topography, we conducted numerical wave simulation using the Boussinesq-type wave model, BOSZ (Boussinesq Ocean Surf Zone). The results of this study indicate that complex reef topography cannot be reproduced by the ~900-m grid resolution data, and therefore accurate behavior of wave propagation and deformation cannot be calculated. In contrast, the calculation with the 5-m grid resolution data show that the deformation and propagation mechanisms of the waves are highly controlled by the reef topography. However, we also realized that even higher resolution (<5 m grid) is needed to visualize reef-edge topography such as spurs and grooves. Hence, in order to carry out coastal wave modeling in the reef environment, it is necessary to conduct high-precision simulation using very high-resolution topography.