Coastal inundation hazards simulation incorporating wave overtopping based on probabilistic synthesized typhoon tracks

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Coastal infrastructures face coastal inundation hazards owing to rising sea levels due to global warming, however prevailing storm surge numerical schemes are unable to effectively resolve overtopping induced by waves because of the related complexity in solving overtopping computations through Boussinesq equations. Time-variant nonlinear interactions between tides, waves and surges are a major factor in storm surge analyses, and therefore, should be simultaneously considered in the analyses of storm surge inundation especially including of man-made structures such as coastal dikes, levees, roads, waterfronts and harbor dock facilities. A few approaches that use the EurOtop module have been proposed; however, these approaches are restricted to an overall application of surge inundation simulation that neglects the diverse temporal variations of overtopping. Thus, there is a strong need to account for time-variant wave conditions. To address this need, we adopt unstructured SWAN coupled with the storm surge model ADCIRC for evaluating overtopping. Appropriate formulae can be automatically selected and renewed in EurOtop according to ambient wave parameters; moreover, they can be finally added and converted to weir discharges during a SWAN time step.

The wave overtopping approach was tested in an idealized basin by varying slope types of dikes and armouring conditions with sensitivity consisting of almost typical bathymetry having typical M2 tidal amplitude of 2.9 m with freeboard of 1.1 m while assigning a historical synthetic typhoon. After obtaining technical insights, a deterministic hindcasting simulation was applied to a waterfront focusing on the typhoon Maemi of 2003 that caused severe wave overtopping inundations. The simulated results showed quite reasonable agreement with spatially scattered floodwater marks and revealed that this scheme could be satisfactorily applicable in the prediction of wave overtopping inundation simulations.

This suggested wave overtopping simulation could be applied in not only real-time forecasting but also probabilistic return period analyses for coastal inundation. Thus, in order to assess the vulnerability of sea level rise in conjunction with storm tide inundation with overtopping, synthesized hypothetical frequency storms have been applied based on a statistical analysis of typhoons from 1950 to 2010. Storms synthesized using fully automated Perl script procedures were implemented as forcing functions in the ADCIRC model for the symmetric Holland type vortex with arbitrary tidal motion on an efficiently designed unstructured grid structure covering the North-West Pacific to Yellow Sea with a focus on Korean Peninsula. An automated coastal inundation probabilistic hazard analyses incorporating overtopping can be efficiently carried out based on finely resolved unstructured grids as internal barriers and yielded very affordable results.