Storm Surges Congress, Hamburg, Germany
13–17 September 2010
SSC2010-115

Dynamic Estimation for the Potential Maximum Storm Surge Height under the Present and Future Climate Scenarios

J. Yoshino (1) and T. Yasuda (2)

(1) Gifu University, 1-1 Yanagido, Gifu, 501-1193 JAPAN (jyoshino@gifu-u.ac.jp), (2) Gifu University, 1-1 Yanagido, Gifu, 501-1193 JAPAN (coyasuda@gifu-u.ac.jp)

Several climatologists indicate that the averaged intensity of global tropical cyclones in the future climate significantly increases due to the warmed sea surface by using a global climate model with CO2-warmed conditions. Historically, a tropical cyclone model, which is typically based on a 2-dimensional, empirical, statistical and parametric approach, has been used as meteorological forcing for storm surge estimation. However, the model cannot be applied to the future climate, because its empirical parameters, which are derived from present climate observations, are not necessarily consistent with the future-climate tropical cyclones. Therefore, it is necessary to substantially revise the traditional method and to improve our understanding of the potential maximum storm surge height spawned by future-climate tropical cyclones.

In this study, we develop a fully dynamic algorithm for estimating the potential maximum storm surge height under the present and future climates. The algorithm mainly consists of two essential parts: 1) Dynamic tropical cyclone initialization and 2) dynamic storm surge estimation. The first part is to initialize atmospheric conditions dynamically for an atmospheric model, using a tropical cyclone-potential vorticity bogus scheme (TCPVB) which is based on the axisymmetric tropical cyclone model (ATCM) and Ertel's potential vorticity inversion (EPVI). ATCM dynamically estimates the axisymmetric potential vorticity structure inside a tropical cyclone under the present and future climate conditions derived from ECMWF global reanalyses and CMIP3 model archives, and can simultaneously evaluate the potential maximum intensity of tropical cyclone at the initial time. EPVI inversely converts from the potential vorticity field to the initial atmospheric fields (wind, temperature, pressure and mixing ratio) which can be chosen to satisfy both of the dynamic and thermodynamic equilibrium, and can arbitrarily control the position of tropical cyclone at the initial time. The second part is to dynamically simulate storm surge evolution with high accuracy using a coupled atmosphere-ocean-wave regional model (AOWRM) with the initial conditions obtained from TCPVB. Combining TCPVB and AOWRM enables us to evaluate the potential maximum storm surge height induced by well-developed tropical cyclones with many different tracks even in future years for which no observed data currently exists.

Using the database of 40 simulations developed with this algorithm, we estimate the potential maximum storm surge height in Ise Bay, Japan, under the present and future climate scenarios. In the present climate that the averaged SST is 29.0 degree C, landfalling tropical cyclones have a central pressure of about 930hPa and the worst storm tide is +4.5m MSL at the port of Nagoya, where the maximum recorded storm surge tide is +3.55m MSL generated by Typhoon Vela (1959). In the future climate that the averaged SST is 30.2 degree C, tropical cyclones landfall with a central pressure of about 905hPa and it is found that future-climate tropical cyclones increase the worst storm tide to +6.5m MSL which exceeds the design storm surge level at the port of Nagoya.