Storm Surges Congress, Hamburg, Germany
13–17 September 2010
SSC2010-98

Estimation of storm surge caused by a typhoon with the maximum potential intensity in the Seto Inland Sea, Japan

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The maximum storm surge for designing tide wall has been often estimated based on the extreme statistics, probabilistic typhoon model or the most intense typhoon such as Typhoon Vera, in Japan. In August 2004, however, Typhoon Chaba caused severe storm surges in the Seto Inland Sea, Japan. In particular, the largest sea level departure was observed in the east of the Seto Inland Sea since the observation began in 1950s. Since recent several studies suggest that global warming could increase the frequency of intense typhoon or its intensity, it would be useful to estimate the possible maximum storm surge in future for mitigating coastal disasters. Therefore, we calculated the possible storm surge in the Seto Inland Sea based on the assumption that Typhoon Chaba takes the same track as observed and develop to the maximum potential intensity (MPI) proposed by Emanuel (1988) under the global warming scenario.

We firstly estimated the MPI of Typhoon Chaba at the observed positions at 6-hour intervals, using the atmospheric and oceanic fields obtained from the Japanese 25-year Reanalysis (JRA25) data together with the tropical cyclone best track data compiled by the Japan Meteorological Agency. The MPI of the pseudo Typhoon Chaba under the global warming is calculated by combining the JRA25 reanalysis and the difference between atmosphere-ocean fields obtained from the IPCC 20th century experiment (20C3M) and those obtained from the Special Report on Emission Scenario (SRES) A1B experiment. We used the outputs from the six climate models. The wind fields of a pseudo typhoon are calculated by simple parametric typhoon model based on the gradient wind. The sea level departures were computed using the ocean model based on the Princeton Ocean Model. Then, the results using the six climate models are averaged.

The MPI of the pseudo Typhoon Chaba in the conditions during 2001-2020 is close to that obtained from the JRA25 reanalysis, though the MPI of Typhoon Chaba obtained from the JRA25 is about 10 hPa stronger than actually observed central pressure of Typhoon Chaba. However, under the conditions during 2081-2100, we can observe that the MPI of the pseudo Typhoon Chaba intensifies by up to 30 hPa compared to the observed central pressure of Typhoon Chaba. Based on the MPI of the pseudo Typhoon Chaba, we evaluate the storm surge in the Seto Inland Sea. It is found that the maximum storm surge in the western Seto Inland Sea caused by the pseudo Typhoon Chaba under the conditions during 2081-2100 increased as about 1.2 times as that caused by the Typhoon Chaba with the present MPI. The present results suggest that sea level departures caused by tropical cyclones could increase under the global warming scenario.