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Global Vulnerability Assessment on Storm Surges due to Tropical Cyclones in the 21st Century

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Coastal zones are one of the severely vulnerable areas in the 21st century, because of increasing impact of sea-level rise according to global warming, and population growth. Though Hoozemans et al.(1993), Robert Nichols et al.(1999), Nobuoka et al.(2007) and their later works carried out the basic assessment of coastal vulnerability in the world, the accuracy of impacts and vulnerability assessments are not enough, especially about storm surges and trend of increasing in the affected population. This paper shows increases in flooded population by storm surges due to tropical cyclones during the 21st century by use of numerical simulations, with sea-level rises and population growth according to Special Report on Emission Scenarios (SRES).

Hindcasts of storm surges on 4544 tropical cyclones in the world were implemented by use of numerical simulation of shallow water theory, of which spatial resolution was 2 arc-minutes. In addition, a method of extreme statistics analysis was employed to calculate storm surge return periods in all of the coasts. Global maps of maximum of the storm surges deviation and that of 100 years return period due to tropical cyclones were made. For impact assessment, the two types of these storm surges were downscaled in 1 arc-minute. Total impacts in the coasts were these storm surges with mean high water spring of astronomical tide calculated by ocean tide model (Nao99b) and two scenarios of rise in sea level projected by general circulation model of Meteorological Research Institute of Japan and Tokyo Universities. Comparing between impact levels and altitudes of digital elevation model of author's modified SRTM30 ver. 2.1 (Shuttle Radar Topography Mission), considering passes from coastal lines, projected the flooded areas during the 21st century. Distribution of population for counting the population in the flooded area was based on GPW ver.3 and downscaled population growth following SRES scenarios in each countries provided by CIESIN of USA.

The main results are as follows. As hindcasted storm surges are good agreement with measured/observed data, the global maps of the storm surges presented by this study are useful for global cooperation of prevention of storm surges. In the A2 scenario of SRES, which is worst scenarios, the increase in potential flood area and flooded population along the coast in the world by storm surges in 2100 becomes approximately 180,000 km2 and 600 million people, respectively. On the other hand, in A1B and B1 scenarios, the increase in the flooded population becomes a peak around the year of 2050, and this number is going to decrease by the year of 2100. The negative population growth of these scenarios from 2050 in Asia contributes to these global results of the affected population much. Impact of sea-level rise on the relative increase in the flooded population becomes clear after 2075 in Oceania and South America. These distinctions of projected-results in regions and SRES scenarios confirm us that we should select primary impact, which is population growth and/or sea-level rise in each region, for 'wise adaptation in coastal zones' in the 21st century.