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Assessing Economic Impact of Storm Surge Inundations due to Climate Change: A case Study in Osaka Bay, Japan

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Storm surge inundation causes considerable impacts on communities and economies. Sea level rise due to climate change increases the occurrence of coastal flood events, creating more challenges to coastal societies. Understanding storm surge inundation risk is essential for developing countermeasures and adaptation strategies for tackling climate change. This study estimates property loss under the different Representative Concentration Pathways (RCP) scenarios of storm surge inundation to explore the economic impact of climate change on Osaka Bay, Japan. We use a statistical typhoon model to generate a large number of typhoon ensembles considering the characteristics of tropical cyclones captured by global circulation simulation under different climate conditions. Simulate the process of typhoon storm surge inundation for each typhoon case in the ensembles using a nested downscaling strategy and request a high-resolution simulation for inland inundation. Our economic loss estimation takes advantage of fine geographical scale census and economic census data that enable us to understand the spatial distribution of property as well as identify the most potentially affected areas and business. By comparing the property loss caused by different hazard scenarios, the economic impact of future climate change is estimated. The results indicate that climate change can cause Osaka Bay to experience more serious storm surge inundation. It is necessary to consider more countermeasures to adapt to climate change in this area.

Introduction

Coastal areas—the most densely populated and economically productive areas in the world—are among the primary impact sectors threatened by exposure to climate change. Sea level rise (SLR) will affect tens of millions of people living in low-lying coastal areas, threatening infrastructure, capital assets, ecosystems, and island nations (IPCC 2014). It is virtually certain that global mean SLR will continue beyond 2100 at a rate that will depend on future emissions.

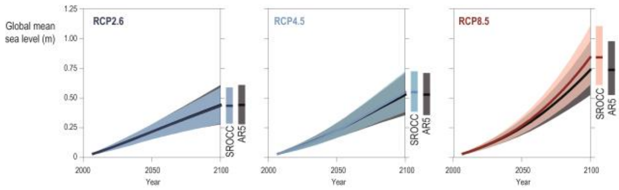

Fig1. Projected change in global average sea level during the 21st century (meters). [From: IPCC SROCC]

Methodology

The estimation of losses for each storm surge inundation case with the integration of hazard, exposure, and vulnerability. In order to conduct hazard simulations, this study conducted a series of numerical simulations of storm surges and future climate changes (Fig2).

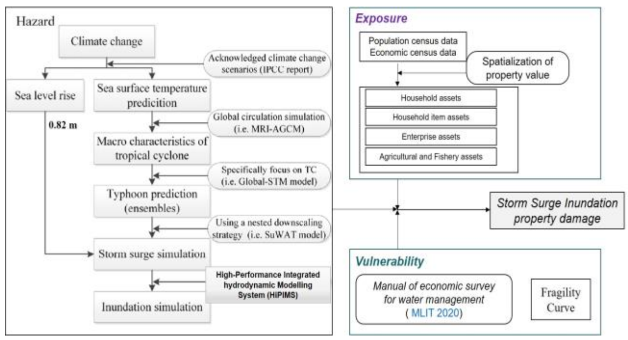

Fig2.Framework

Based on the change in sea surface temperature, climate conditions can be simulated using the super-resolution Atmospheric Global Circulation Model (AGCM). A simulation of typhoon generations for 5000 years was conducted using synthetic tropical cyclone generation model (Global-STM). The worst 100 typhoon cases were selected: ①The minimum distance to Osaka Bay was less than 100 km; ②The minimum central pressure was less than 950 hPa; ③ The velocity of the tropical cyclone at landfall was higher than 20 km/h. Four climate scenarios were considered in this paper: ①Present climate condition; ②RCP2.6, a rise of 0.43m in sea level;③RCP4.5, a rise of 0.55m in sea level;④RCP8.5, a rise of 0.84m in sea level. The storm surges were simulated taking the typhoon cases generated by the probabilistic typhoon model as input conditions (SuWAT); Inundation depth due to storm surge in the urban area was predicted by High-Performance Integrated hydrodynamic Modelling System (HiPIMS).

Exposure can be divided into different categories and vulnerability is represented by the fragility curves of these exposure categories. Loss can be estimated in terms of property damage.

A group of commonly-used fragility curves in Japan that reveal the relationship between water depth and loss ratio for each category can be found in the Manual of Economic Survey for Water Management published by MLIT.

Result