

# Bias correction method for simulated storm surge height considering coastline characteristic

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## INTRODUCTION

Previous studies imply storm surge heights (SSHs) are expected to become more severe in the future climate condition because climate change is projected to increase sea surface temperature and consequently results in intensified tropical cyclones (e.g. Mori and Takemi, 2016). Therefore, The projection of potential maximum SSHs and the identification of areas vulnerable to storm surge on regional or national scales are important for policy making to prioritize where to take action and to find appropriate site-specific solutions against the SSHs in the future climate condition along the coastline (e.g. Voudoukas et al., 2016; Lapidez et al., 2015).

In order to project the potential maximum SSHs on a regional or national scale in the KP, it is necessary to perform a series of simulations of SSHs by various typhoons that have different properties such as tracks, magnitudes and moving speeds including consideration of climate change effects. Prior to evaluating these SSHs using a numerical surge model, it is necessary to validate the model. Many researchers have validated numerical models by adjusting the values of the physical parameters in the model to obtain simulated SSH values close to the observed values for a particular typhoon at a particular location/site (e.g. Shibutatni et al., 2015; Nakajo et al., 2015). However, it is not generalized for other locations, events and different model configurations. This is because hindcasting a specific typhoon-induced storm surge has uncertainties depending on topographic features, typhoon characteristics and model configurations. It is necessary to implement general bias correction of numerical results considering both spatial resolution of mesh size and coastal features for impact assessment of climate change on storm surge study.

## OBJECTIVE

We propose a new approach for model validation that can be applied to the projection of future SSHs on the regional scale. We first simulated SSHs on a regional scale in the Korean Peninsula (KP) for various historical typhoons and examined the performance of the model. Next, the bias between the simulated and observed SSHs was modified to take into account a geographic parameter, in particular the coastline complexity of each individual location/site. Finally, the effect of the bias correction on projections of the potential maximum SSH was examined through a simple test.

## SELECTION OF TARGET TYPHOONS

This study considered all typhoons from 1979 to 2021 affecting the KP.

## NUMERICAL MODEL AND MODEL SETUP

The simulated SSHs by the target typhoons were calculated using numerical model with a nonlinear shallow water equation as a government equation (Kim et al., 2008). To generate wind and pressure fields as a input variables of the numerical model, the typhoon parameters were read from the National Institute of Informatics (2014), except the radius of maximum wind ( $R_{max}$ ) which is given by an observed empirical formula (Yasuda et al., 2010).  $R_{max}$  is an indicator of the size of a typhoon and has different values for each typhoon.

## BIAS CORRECTION METHOD CONSIDERING COASTLINE COMPLEXITY

The simulated SSHs have some disagreement with observed SSHs of the target typhoon, which we attributed to simulation model bias. So we present a formula for bias correction based on an empirical model for SSH from the Japan Meteorological Agency (Unoki and Isozaki, 1966):

$$\zeta_{cal(rev)} = \zeta_{cal} + f(F_D) \times U^2 \cos \vartheta$$

where,  $f(F_D)$  [s<sup>2</sup>/m] is a tuning function of the  $F_D$  which is a dimensionless parameter. The  $F_D$  at each location in the calculation area was calculated using the concept of fractal dimension. The fractal dimension was introduced by Mandelbrot (1967) and has been used as a measure of the complexity of objects. Many researchers have applied the fractal dimension to assess complexities of coastline in different countries. We the box-counting method was adopted to determine the coastline complexities in the target area. As base data of coastline shape, images of coastline maps based on version 2.3.2 of the Global Self-consistent, Hierarchical, High-resolution Shoreline Database (Wessel and Smith, 1996) were used.

## RESULTS

In the case of the southeastern coast of the KP by six typhoons that produced SSHs over 1.0 m since 1979, it can be seen that the bias correction method considering the coastline complexity can improve the model's accuracy by 14% to 23% and prevent potential overestimation by up to 20% of the maximum SSHs considering climate change effect on the southeastern coast of the KP.