Development of stochastic typhoon model

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1. Introduction

Japanese ports, located along the country's coastal areas, often suffer damage from storm surges and high waves when typhoons approach or make landfall. Recent examples of damage to ports caused by storm surges and high waves include the damage to the Osaka Bay coast wrought by Typhoon Jebi (T1821) in 2018, and the damage to the Tokyo Bay coast inflicted by Typhoon Faxai (T1915) in 2019. In studying port disaster prevention, it is necessary to evaluate storm surges and high waves caused by typhoons. However, actual typhoon data (typhoon best track data) is only available for the roughly 70-year-period since the 1950s, and this is not sufficient to evaluate storm surges with a return period of 100 years or more. To address this problem, developing a stochastic typhoon model that uses statistical data derived from typhoon best track data to simulate hypothetical typhoons over tens of thousands of years, is an effective approach.

2. Stochastic typhoon model

While various research studies on stochastic typhoon models have been conducted, we have opted to use an autoregressive (AR) model that can take into account previous time-varying processes of typhoon attributes such as central pressure, for our research, as such a model has been proven to be effective.

To determine the distribution of the mean temporal variation of the central pressure of typhoons, Figure 1 (left) compares actual typhoon data with the stochastic typhoon model used in our research, using all best-track typhoon data. In a comparison with the actual data for areas surrounding Japan, we find that the stochastic typhoon model shows a small increase in the temporal variation of central pressure, as well as a weak typhoon attenuation trend, resulting in poor reproducibility. To address this, we improved our model to enhance the reproducibility of typhoon attenuation in areas surrounding Japan.

3. Improvements based on typhoon class

Typhoon best track data includes characteristics of storms other than typhoons, such as information on typhoons that change into extratropical cyclones and information on tropical cyclones and other storms before they develop into typhoons. With this in mind, we developed a new stochastic typhoon model based on data that excludes this information from the typhoon best track data. Figure 1 (right) displays the comparison of this improved stochastic typhoon model with actual data without this information. It shows the increase in the temporal variation of central pressure in the areas surrounding Japan is on par with the actual data, confirming the reproducibility of typhoon attenuation

has increased.

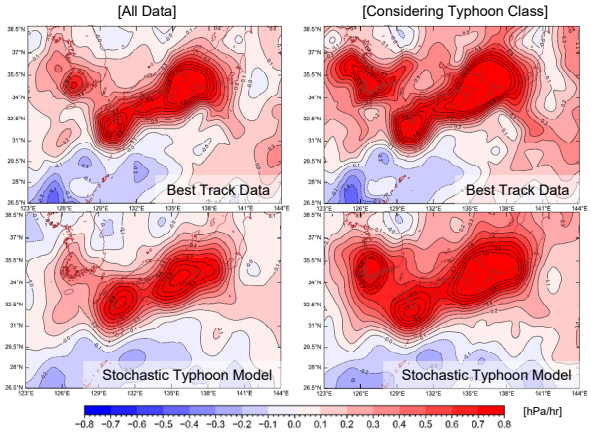

Figure 1: Mean temporal variation of central pressure of typhoons

4. In closing

In this research, we developed a stochastic typhoon model based on an AR model that takes into accounts typhoon classes, and improved the reproducibility of typhoon attenuation in areas surrounding Japan. However, the reproducibility of the typhoon occurrence area is not sufficient, so we plan to make further improvements to our model in the future. Finally, we intend to consider using our stochastic typhoon model to study the impact of climate change on storm surges with an extremely long return period.