R&D item

B-1. Integrated probabilistic forecasting of combined flooding hazards

Progress until FY2023

1. Outline of the project

Background: To evaluate the effectiveness of weather control, it is insufficient to check the change of meteorological variables, such as intensity of tropical cyclones. It is crucial to estimate how changes in meteorological disasters affect on society, which is called "impact-based forecasting". In the realm of impact-based forecasting, the direct assessment of flooding hazards is of paramount importance.

Objective: **We will accurately assess hydrometeorological hazards, such as flooding and storm surges, with uncertainty estimates in real time.**

Method (Fig. 1): ① To combat flooding hazards, we will incorporate the functions of flood protection infrastructures such as dams and levees into the existing global hydrodynamical model. We will specifically enhance the simulation of small and medium-scale flood events in which these flood protection infrastructures are effective.

② To address coastal hazards, we will develop a statistical typhoon model and a machine learning-based prediction model for ultra-fast storm surge and high wave predictions complemented with uncertainty estimation.

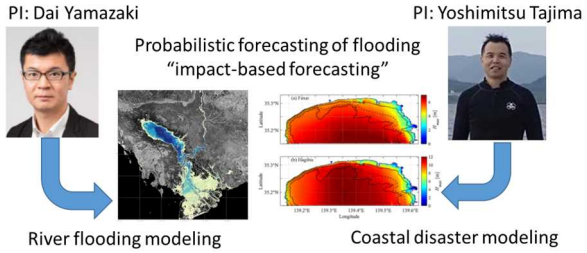

Fig. 1. Overview of this R&D theme.

2. Outcome so far

① We innovated river flood modeling by **developing a method to automatically estimate levee height in each river**. (Fig. 2). By integrating this novel method and a global hydrodynamic model, we realized **the global-scale river flooding estimation in which the effects of infrastructure were explicitly considered**.

② We successfully developed **the computationally efficient storm surge estimation method** by replacing the fluid simulation with long-short term memory (LSTM). By integrating this storm surge computation with a probabilistic typhoon model, we successfully performed **large-ensemble probabilistic forecast of typhoon-induced storm surge** (Fig. 3).

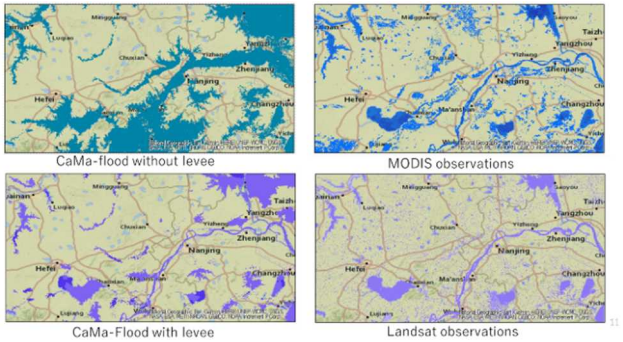

Fig. 2. Once in 100-year flood risk map in Yangtze River. (upper left) flood computation without considering levees. (lower left) flood computation with considering the effect of levees. (upper right & lower right) flood inundation maps from two different satellite observations. Our new method to explicitly consider the effect of levee successfully simulates the flood inundation realistically.

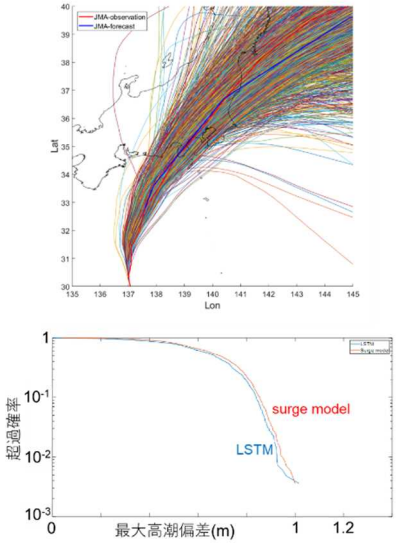

Fig. 3. (upper) The probabilistic typhoon model generating 1000 ensemble of typhoons from JMA's deterministic forecast. (lower) storm surge probabilistic estimation from a surge model (red) and LSTM (blue). Even if there are numerous ensemble size (=1000), LSTM-based storm surge computation estimates surge height very efficiently.

3. Future plans

By considering the effect of infrastructure on inundation, we enable to accurately estimate the wide range of flooding. We also developed the very efficient method to probabilistically estimate storm surge. We will fully use these novel technologies to innovate disaster prediction and contribute to the accurate estimation of the impact of weather control on our society.