R&D Theme

Integrated probabilistic forecasting of combined flooding hazards

Progress until FY2022

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.

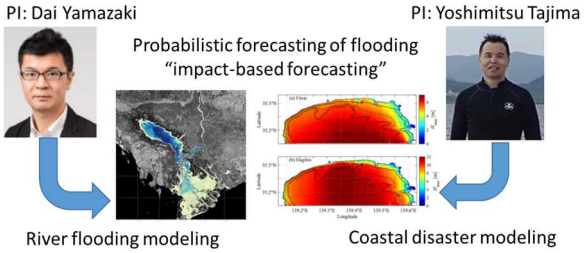

Fig. 1. Overview of this R&D theme.

2. Outcome so far

① **We have successfully integrated a computation scheme into the global hydrodynamic model, designed to simulate the operation of dams and the effects of levees**. Although it is necessary to collect the detailed information of flood protection infrastructure for future work, we have verified the proper functionality of our novel scheme in the applications in U.S (Fig. 2).

② To accelerate the computation of storm surge heights, **we have successfully replaced the expensive numerical fluid simulation with long-short term memory (LSTM).** Maintaining the accuracy of the original simulation, we can estimate water level dynamics in an instant.

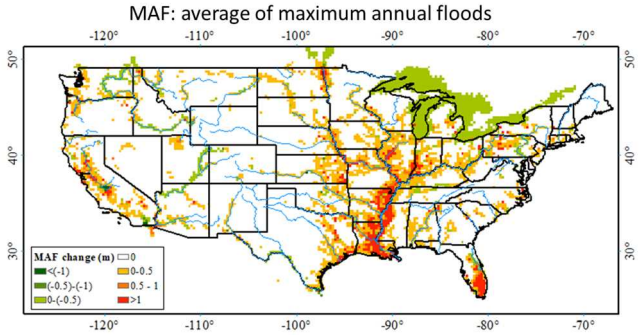

Fig. 2. The differences of estimated water levels induced by maximum annual floods between the new model which considers the effects of levees and the original model. Since levees prevent flooding, water level is overall increased by considering the effect of levees.

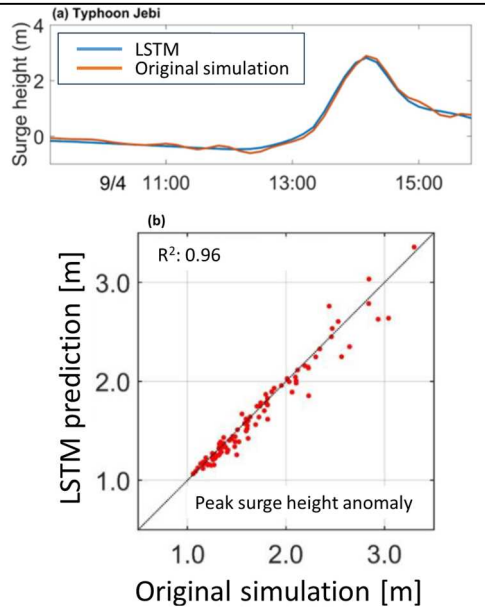

Fig. 3. Evaluation of the simulation of storm surge heights by LSTM. (a) Comparison of timeseries between LSTM and numerical fluid simulation. (b) Comparison of peak storm surge heights across many events.

3. Future plans

In flood hazard forecasting, we will estimate flood protection infrastructure objectively and globally, which will facilitate accurate flood simulations.

In terms of coastal hazard forecasting, we will consider the effects of high waves along with storm surges. In addition, we will improve the tropical cyclone prediction to drive coastal models by collaborating with other R&D themes. Our ultimate goal is to achieve ultra-fast and accurate computation of coastal disasters.

By combining all achievements, we will ultimately realize an integrated probabilistic forecasting system for combined flood hazards.